A.2. *Chehalis River Basin Flood Control Combined Dam and Fish Passage Supplemental Design Report, FRE Dam Alternative.* September 2018.

Chehalis River Basin Flood Control

Combined Dam and Fish Passage Supplemental Design Report

FRE Dam Alternative

Updated Sep 2018

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ACRONYMS AND ABBREVIATIONS LIST

AACE	Association for the Advancement of Cost Engineering
ACI	American Concrete Institute
AEP	annual exceedance probability
AF	Acre Feet
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASR	alkali-silica reactivity
AWS	auxiliary water supply/American Welding Society
CBFS	Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species Project
CFD	Computational fluid dynamics
cfs	cubic feet per second
CHTR	collection, handling, transport, and release
cm/sec	centimeters per second
CMCE	Controlling Maximum Credible Earthquake
CM	Construction Management
CMS	conditional mean spectrum/spectra
CSZ	Cascadia Subduction Zone
D/S	Downstream
DNR	Department of Natural Resources
DSHA	deterministic seismic hazard analysis
DSO	Dam Safety Office
EIS	Environmental Impact Statement
EM	engineering manual
ER	engineering report
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FMPC	fixed multi-port collector
fps	feet per second

FOS	factor(s) of safety
FRFA	Flood Retention Flow Augmentation
FRO	Flood Retention Only
FRE	Flood Retention Expandable
FRE-FC	Flood Retention Expandable-Future Construction
FSC	floating surface collector
FTE	full-time equivalent
ft	foot/feet
ft/sec, fps	foot/feet per second
G	gravity
GERCC	grout-enriched roller compacted concrete
HDC	Hydraulic Design Criteria
HEC	Hydrologic Engineering Center
HEC-RAS	Hydrologic Engineering Center River Analysis System
HEC-ResSim	Hydrologic Engineering Center Reservoir System Simulation
HMR	Hydrometeorological Report
I-5	Interstate 5
ICOLD	International Commission on Large Dams
IDF	Inflow design flood
IEEE	Institute of Electrical and Electronics Engineers
JS	joint set
km	kilometer(s)
MCE	Maximum Credible Earthquake
MCRCC	medium cementitious roller compacted concrete
min	minimum
mm	millimeter(s)
msa	maximum-size aggregate
msl	mean sea level
Mw	Megawatt
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NEPA	National Environmental Policy Act

NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NMFS	National Marine Fisheries Service
NOHRSC	National Operational Hydrologic Remote Sensing Center
NRCS	Natural Resources Conservation Service
NTS	net transition structure
NWMLS	Northwest Multiple Listing Service
NWS	National Weather Service
O&M	operations and maintenance
OBE	operating basis earthquake
OFM	Office of Financial Management
OPCC	opinion of probable construction cost
OSHA	Occupational Safety and Health Organization
pcf	pounds per cubic foot
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PSHA	probabilistic seismic hazard analysis
psi	pounds per square inch
Qa	(modern) Quarternary alluvium
Qao	(older) Quarternary alluvium
RCC	roller compacted concrete
RCW	Revised Code of Washington
RMR	Rock Mass Rating
ROW	river outlet works
RQD	Rock Quality Designation
SEPA	State Environmental Policy Act
SPF	standard project flood
SR	State Route
SSD	saturated surface dry
Tcb	pillow basalt
Tcs	Crescent Formation siltstone/claystone
TM	Technical Memorandum

U/S	upstream
UHS	uniform hazard spectrum
UL	Underwriters Laboratories, Inc.
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WA	Washington
WDFW	Washington Department of Fish and Wildlife
Work Group	Chehalis Basin Work Group
WSDOT	Washington State Department of Transportation
WSE	Watershed Science & Engineering
WSEL	water surface elevation

EXECUTIVE SUMMARY

This supplemental report has been prepared to document the development of an additional expandable Flood Control dam option. The type of dam that has been selected for Environmental Impact Statement (EIS) analysis is known as a Flood Retention Expandable (FRE) facility, which consists of a dam with a temporary reservoir. The FRE dam would temporarily retain water in the event of a major flood. The river would flow normally during regular conditions or smaller floods. The dam would only transition to flood retention operations during a major flood. Specific flow release operations would depend on inflow and the need to hold water to relieve downstream flooding as flood water recedes.

The FRE dam is considered to be expandable because it is proposed to be built with a foundation and hydraulic structures capable of supporting future construction of a larger dam with up to 130,000 acre-feet of storage; Flood Retention Expandable-Future Construction (FRE-FC). This future expansion, which may or may be constructed, would be subject to a separate National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) process and permitting, if pursued in the future.

The FRE project is not presented in the Conceptual Dam and Fish Passage Report (HDR, 2017a). That report contains complete descriptions of the Flood Retention Only (FRO), and Flood Retention and Flow Augmentation (FRFA) alternative Roller Compacted Concrete (RCC) dam configurations. FRO and FRFA dams have been under development since October 2013 and were identified as the preferred dam types and configurations as documented by HDR (2014a). This report contains only information and discussions specifically related to the FRE (expandable) dam option including both the FRE and FRE-FC configurations. See the Conceptual Dam and Fish Passage Report (HDR, 2017a) for detailed information related to the FRO and FRFA alternatives.

The FRO and FRFA RCC dam configurations with alternative fishways, fish collector, and experimental exit structures identified during the 2014 study are still viable options for achieving CBFS Project objectives

An updated opinion of probable construction cost (OPCC) and total project development costs, with appropriate planning contingencies for all options, are provided within an appendix to this report. A summary of the estimated total direct projects costs for the FRE and fish passage systems is provided in Table ES-1. The cost estimate is for direct construction costs, including final design engineering and construction permitting, but does not include costs for EIS and Endangered Species Act (ESA) related studies and agreements or mitigation design and construction costs.

Table ES-1
Estimated Total Direct Project Costs for FRE Option

FEATURE	LOWER BOUND COST ($ MILLION)	WEIGHTED/MIDDLE COST ($ MILLION)	UPPER BOUND COST ($ MILLION)
FRE RCC Dam	$307	$358	$419
Upstream Fish Passage: CHTR Facility	$32	$43	$65
Downstream Fish Passage	Integral to dam construction		
Total	$339	**$401**	$484

Note: Includes OPCC, June 2017 dollars

Drawings and descriptions of the FRE are provided in Appendix H. Recommendations are provided for completing the next steps of project development during preliminary design. The completion of the main report and this supplemental report is intended to support selection of a preferred alternative. Based on the design team's experience with other large dam and fish passage facilities, it is anticipated that the time required to complete final design and construction would be 6 to 11 years.

Operation and maintenance (O&M) costs for the FRE and FRE-FC alternatives are expected to be similar to the costs for the FRO and FRFA, respectively, which are presented in more detail in the Combined Dam and Fish Passage report (HDR, 2017a). Those costs were developed with consideration of the requirements for replacement of dam components that are subject to wear and debris and sediment removal, as well as staffing and equipment needed for the dam and fish passage facilities. The estimated annual O&M cost (2017 dollars) are as follows:

- FRE: $628,000 per year
- FRE-FC: $2,178,000 per year

1 INTRODUCTION

1.1 Project Background

The conceptual design and opinion of probable construction costs (OPCC) for the Flood Retention Only (FRO) and Flood Retention Flow Augmentation (FRFA) dams and fish passage configurations at the proposed dam site are documented in HDR's Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a). That report, along with the Phase 2 Site Characterization Report (HDR, 2017b), document additional site characterization and engineering evaluations that were recommended in HDR's 2014 Combined Dam and Fish Passage Alternatives Technical Memorandum (HDR, 2014a) to reduce design uncertainty, refine estimated project costs, and support selection of a preferred alternative.

Subsequent to the issuance of the 2017 Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a), a third dam and fish passage configuration option was conceived as the Flood Retention Expandable (FRE) option, which has been selected for Environmental Impact Statement (EIS) analysis. The FRE dam is considered to be expandable because it is proposed to be built with a foundation and hydraulic structure capable of supporting future construction of a larger dam with up to 130,000 acre feet of storage. This future expansion, which may or may not be constructed, would be subject to a separate NEPA and SEPA process and permitting if pursued in the future and is described as the FRE future construction (FRE-FC).

The FRE dam would allow the river to flow normally during regular conditions or in smaller floods. The dam would only transition to flood retention operations during a major flood. Specific flow release operations would depend on inflow and the need to hold water to relieve downstream flooding as flood water recedes. Figure 1-1 shows the FRE dam site and the expected 100-year flood pool inundation pool limit.

The FRE project is not presented in the Dam and Fish Passage Conceptual Design Report (HDR, 2017a). That report contains complete descriptions of the Flood Retention Only (FRO), and Flood Retention and Flow Augmentation (FRFA) alternative Roller Compacted Concrete (RCC) dam configurations that have been under development since October 2013 and have been identified as the preferred dam types and configurations as documented by HDR (2014a). This report contains only information and discussions specifically related to the FRE (expandable) dam option. The FRE-FC configuration is included in the discussion to describe the potential design conditions for the larger storage dam. Refer to the Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a) for detailed information related to the FRO and FRFA alternatives.

The design storage volumes and corresponding estimated water storage elevations for the FRE and FRE-FC configurations are summarized in Table 1-1. The storage volumes and corresponding dam heights and inundation areas are subject to change as climate change and operation studies advance through the planning process.

Figure 1-1
FRE Dam Site Location and Expected 100-Year Flood Inundation Limits

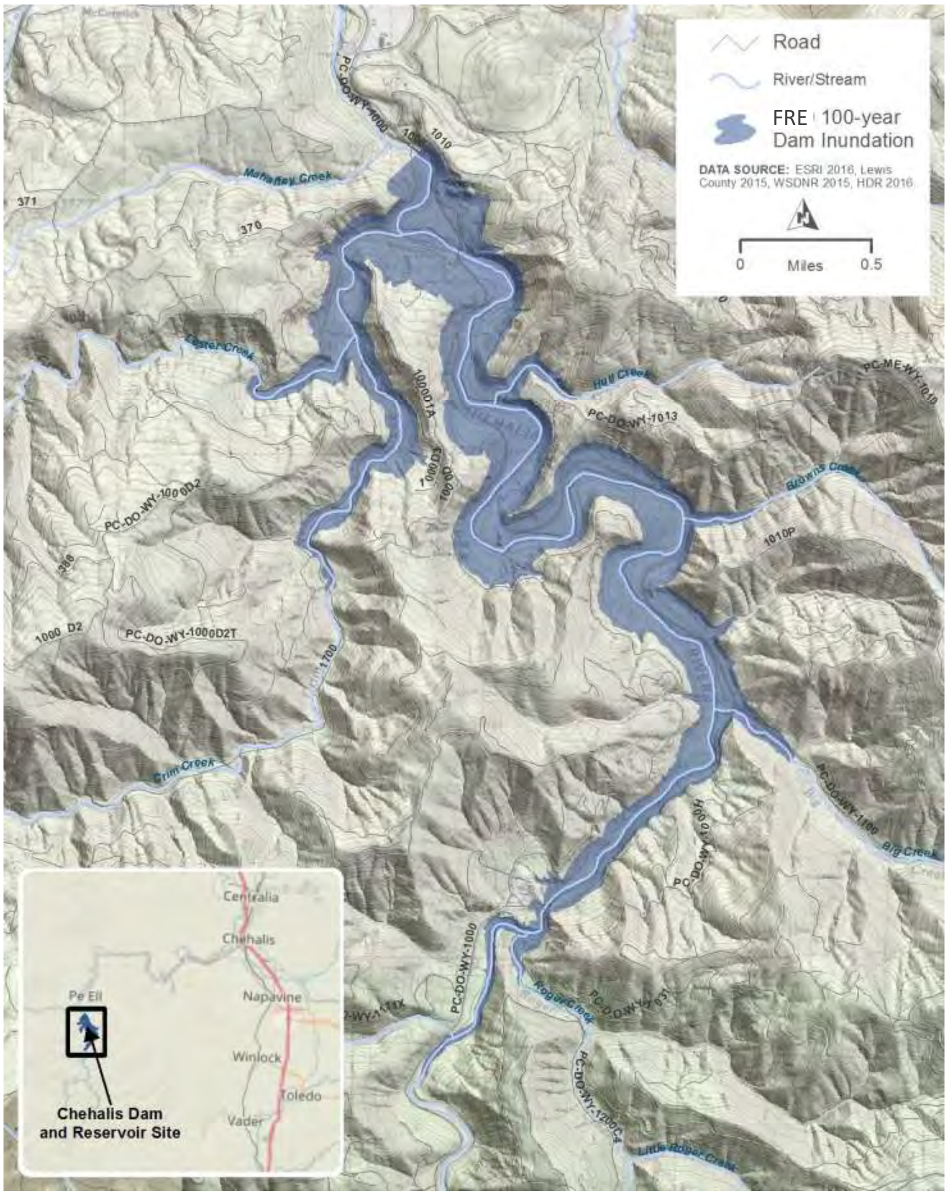


Table 1-1

Summary of Dam Storage Volumes and Maximum Water Surface Elevations

CONFIGURATION	WATER STORAGE VOLUME (ACRE FEET)	FLOOD STORAGE VOLUME (ACRE FEET)	MAXIMUM WATER STORAGE ELEVATION (FEET)	DESIGN FLOOD STORAGE ELEVATION (FEET)
FRE	0	65,000	-	628
FRE-FC	65,000	65,000	628	687

Note:
Design flood storage volumes and elevations are to spillway crest and include the routed volume for the 2007 design flood event. The flood storage volume and elevations do not include flood routing capacity between the design flood event (2007) and the Probable Maximum Flood (PMF).

1.2 Purpose and Objectives

This report is a supplement to the Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a). The primary objectives of this supplemental report are:

1. Describe and document the FRE dam option and associated fish passage configuration.
2. Present updated estimates of total project direct costs for the FRE. The updated cost estimates have a 2017 cost basis and include additional engineering and design refinements completed since issue of the Combined Dam and Fish Passage Conceptual Design Report in late 2017.
3. Describe only the specific hydraulic, structural, and cost details of the FRE that are significantly different from the FRO and FRFA options.

Detailed evaluations of design topics specific to the FRE option are included in the following attached Appendices:

- Appendix H – Maps and Drawings
- Appendix I – Hydraulic Design
- Appendix J – Construction Cost Opinion

This report is presented for use by the Flood Control Zone District (FCZD).

1.3 Scope of Services

The scope of work for this report included the following tasks:

- Development of the dam and fish passage facility conceptual design configuration for FRE configuration.

- Evaluation of foundation excavation and treatment requirements for the refined and relocated collection, handling, transport, and release (CHTR) and fish ladder facilities.
- Hydraulic analyses to support the FRE configuration and construction approach, including the conduits, spillway, water quality outlet works, and stilling basin.
- Development of the FRE dam and fish passage configuration drawings
- Development of preliminary design-level estimates of probable construction costs for the FRE project alternative.
- Development of recommendations for the next steps in project development.
- Preparation of documentation (this report) summarizing the above information.

1.4 Project Team

The following HDR personnel were involved in the various evaluations required to complete the updated conceptual designs:

Project Manager:	Beth Peterson, P.E.
Technical Manager and Lead Civil Engineer:	Keith Moen, P.E.
Lead Dam Engineer:	Keith A. Ferguson, P.E.
Lead Geotechnical Engineer:	Dan Osmun, P.E.
Geological Engineers:	Andrew Little, E.I.T. John Charlton, P.Geologist
Lead Hydraulic Engineer:	Ed Zapel, P.E.
Lead Fish Passage Designer:	Michael Garello, P.E.
Constructability and Cost Estimating:	Jeffrey Allen, P.E.
Project Support:	Carl Mannheim, P.E., Senior Civil/Hydraulic Engineer Ali Reza Firoozfar, E.I.T., Civil/Hydraulic Engineer Gokhan Inci, Ph.D., P.E. Geotechnical Engineer Mathew Prociv, P.E., Fish Passage Design Shaun Bevan, P.E., Fish Passage Design John Ferguson, Ph.D., Fish Passage Biology (Anchor QEA) John Hess, P.E. Materials Engineering Paul Oxborrow, CADD Paul Kowalki, CADD, Civil 3D Michael Austin, CADD

Additional technical staff for the project has been provided by Anchor QEA and Shannon & Wilson along with other members of the Anchor QEA consulting team for the project.

2 FRE DAM

2.1 FRE Configuration and Operational Approach

Both the FRE and FRE-FC configurations have been designed to meet downstream flood protection objectives. Each configuration has different dam hydraulic heights and operational approach. The FRE is configured to only store flood flows as identified under the current flood control objectives at the Grand Mound gage. Most of the time, the dam outlet works would remain fully open and river flows would be unregulated. The FRE-FC is configured to provide additional storage that can be used in some combination of increased flood protection that reflects hydrologic changes (e.g. effects of global warming), or as a permanent storage pool for augmentation of downstream river flows for fish and aquatic habitat enhancement. The hydraulic configuration including the permanent pool elevation (and resulting storage volume) of the FRE-FC could vary depending on annual hydrology and future water management objectives. For the purpose of this report, we have assumed that FRE-FC would use up to half the total storage capacity below the spillway crest for permanent storage and the other half for flood control.

More detailed descriptions of the operational approach of each FRE dam is presented in a separate document (Anchor QEA, 2017).

2.2 FRE

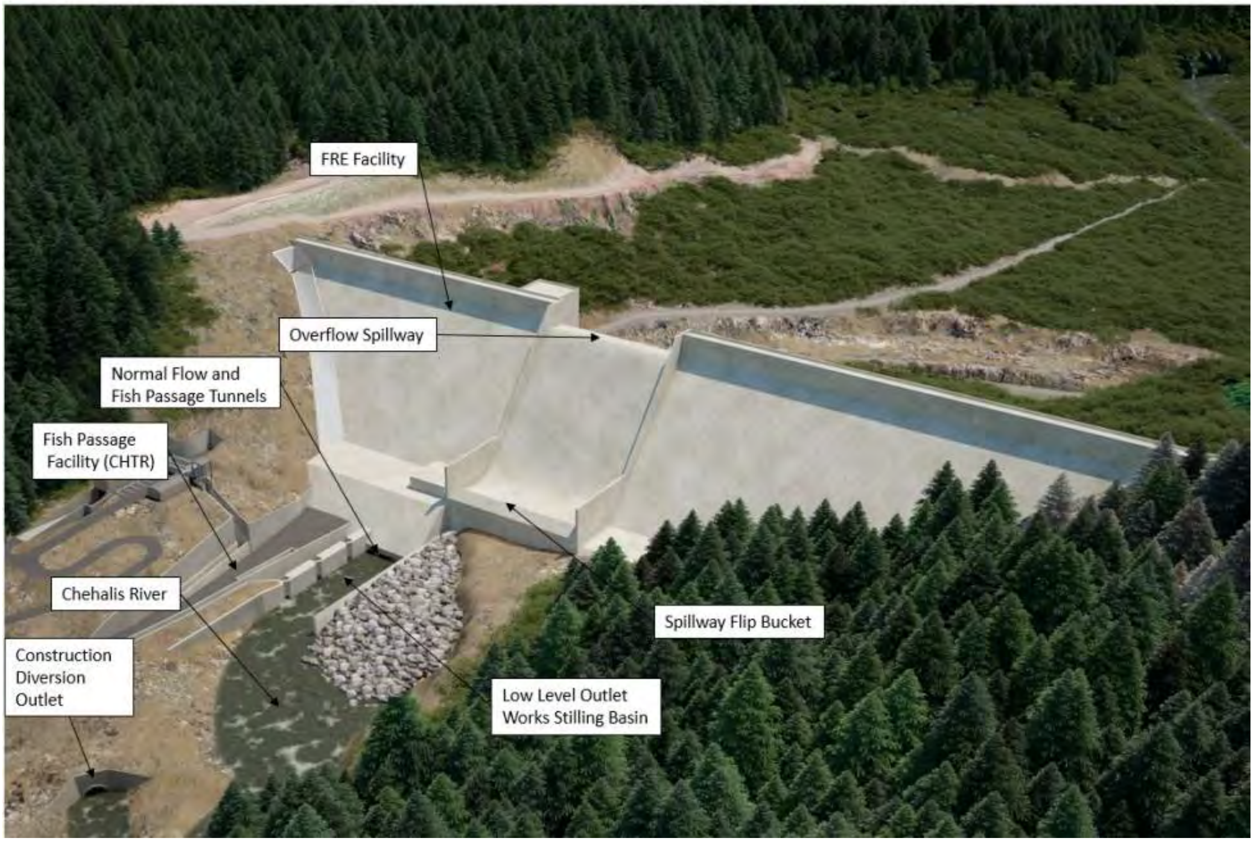
The FRE reservoir would be impounded with a primary roller compacted concrete (RCC) gravity dam structure. The configuration includes a right abutment construction (and backup normal operation) diversion tunnel, low-level fish passage and flood control outlet works, an emergency spillway, and supplemental fish passage facilities. The dam would be designed to temporarily store floodwater only when the downstream gage at Grand Mound is forecasted to rise above 38,000 cubic feet per second (cfs) within 48 hours. Such temporary storage events are estimated to have only a one in seven-year recurrence interval. After flood regulation operations are commenced and the outlet works begin regulating outflows, fish passage through the outlet works would no longer be available. Debris management operational plans and potential operational modifications associated with climate change scenarios have necessitated consideration of redundant fish passage facilities that would be operated during periods of flood retention and subsequent debris removal. At all other times, the project is expected to retain no water and to allow all river flows to pass, with only minor restriction of river flow and pool accumulation at the upstream face of the dam.

Primary components of FRE would be the following:

- An RCC dam sized for 65,000 acre feet of flood storage with estimated maximum dam structural height of 254 to 270 feet depending on final foundation elevation.
- A dam crest length of approximately 1,550 feet.
- A dam foundation excavation and treatment that would be completed to the ultimate FRE-FC configuration so that no redundant but expanded foundation treatments for the foundation grout curtain, foundation and dam drainage systems, dam jointing, dam facing systems, or dam gallery and access provisions would be required. Exposed portions of the foundation excavation for the future FRE-FC would be protected by an RCC cover.
- An overflow spillway, designed to pass flood flow up to and including the Probable Maximum Flood (PMF) without dam overtopping. The spillway includes a crest control structure, a spillway chute, flip bucket, and plunge pool. The location and configuration of the lower portion of the spillway chute, flip bucket (including pedestal) would be the same as required for the FRE-FC configuration to eliminate the need for demolition and reconstruction of these features.
- Diversion tunnel to handle flows during construction.
- Outlet works, including and low-level outlets for flood regulation and fish passage purposes.
- Fish passage facilities designed for free passage upstream and downstream prior to and after flood operations, and trap and haul during flood regulation periods.

The FRE visualization is shown in Figure 2-1. Additional conceptual design drawings of the initial construction of the FRE are included in Appendix H.

Figure 2-1
FRE Facility Visualization



2.3 FRE-FC

The FRE-FC reservoir would be impounded with a primary roller compacted concrete (RCC) gravity dam structure constructed over the FRE structure and small upper right abutment central earth core rockfill saddle dam embankment. The configuration would maintain the construction diversion tunnel constructed for the FRE along with the low-level flood control outlets. Multilevel water quality outlets would be completed for discharge to the flood control outlet stilling basin. The spillway crest for the FRE would be demolished and raised to the new level below the crest of the FRE-FC dam. All other features of the FRE would be retained and operated according to new FRE-FC objectives and procedures. The increased storage of the FRE-FC would be used to provide either additional flood storage, a permanent pool for flow augmentation, or some combination thereof. As currently configured, the FRE-FC dam would maintain a permanent pool behind the dam with a storage volume of about 65,000 acre feet and would be designed to provide water storage and releases for flow augmentation from the permanent pool to enhance certain aquatic species habitat, and a flood management pool with storage volume of 65,000 acre feet above the designated permanent pool and below the spillway crest for flood operations.

The primary components of the FRE-FC would include the following:

- A dam and reservoir sized for the combined flood and water quality storage with an estimated dam structural height of 313 to 330 feet depending on final foundation elevation.
- An RCC dam crest length of approximately 1,680 feet.
- A central earthcore rockfill embankment saddle dam on the right abutment that is approximately 850 feet long.
- An overflow crest control spillway structure designed to pass PMF without dam overtopping, including a spillway chute, flip bucket, and plunge pool.
- Multiple outlet works including a water quality inlet/outlet that draws water from multiple levels within the reservoir and a low-level flood regulation outlet.
- A recommended upstream fish passage by trap and haul; a recommended downstream fish passage by floating surface collector with trap and haul.
- A permanent reservoir pool of up to 65,000 acre feet to be used for flow augmentation in late summer and fall prior to the winter rainy season to enhance fish and certain aquatic species habitat.
- A minimum of 65,000 acre feet of flood storage volume to be activated in flood events larger than the estimated 7-year recurrence interval event.

Additional conceptual-design drawings of the FRE-FC dam and appurtenant structures configuration are included in Appendix H.

3 DESIGN CRITERIA

3.1 FRE Dam Design Criteria and Requirements

The following summarizes the hydrologic and hydraulic design criteria and requirements that are specific to the FRE configuration. For additional details, including structural, electrical, mechanical, and geotechnical design guidelines and requirements, see the Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a).

The hydrologic study performed by WSE (WSE, 2016) and the hydrologic modeling of flood storage attenuation by Anchor QEA (Anchor QEA, 2017) form the basis for hydraulic design of the FRE alternative. The following hydraulic criteria apply to both the FRE and FRE-FC configurations:

- The maximum inflow for the project inflow design flood (IDF) is the PMF, which is estimated to be 69,800 cfs (NOTE: this value is based on the recent estimate of PMF which is less than 75,000 cfs used for the design of spillways for the FRO and FRFA alternatives)
- The spillway capacity will be equal to the PMF
- Flood storage equal to 65,000 acre-feet, approximately equal to the flood volume of the 2007 flood of record

The initial construction and raised dams will vary as follows:

FRE:

- Dam crest elevation is 651 feet msl (mean sea level)
- Estimated maximum routed PMF reservoir elevation is 650 feet msl
- Spillway crest elevation is 628 feet msl
- Minimum flood storage reservoir elevation is natural riverbed elevation
- Maximum flood storage elevation with no spillway flow is 628 feet msl
- Low-level flood regulation sluices design flow is 15,000 cfs

FRE-FC:

- Dam crest elevation is 710 feet msl
- Estimated maximum routed PMF reservoir elevation is 709 feet (msl)
- Spillway crest elevation is 687 feet msl
- Minimum flood storage reservoir and maximum permanent pool elevation is 628 feet msl
- Maximum flood storage elevation with no spillway flow is 687 feet msl
- Maximum flow augmentation reservoir elevation is 628 feet msl

- Minimum flow augmentation reservoir elevation is 588 feet msl (585 feet msl with climate change scenario)
- Low-level flood regulation sluices design flow is 15,000 cfs

4 DAM FOUNDATION AND STRUCTURAL DESIGN

Design of concrete dams typically involves evaluation of a range of normal, flood (unusual), and seismic loading conditions (USACE, 1995). Suitable geotechnical and structural analyses were performed for the design of the foundation excavation objective, to set the cross-section properties for FRO and FRFA dam configurations. Specifically, the maximum design loading conditions and structural height of the dam associated with either the FRFA or FRE-FC with a maximum operating pool level were considered. Hence no additional geotechnical or structural analyses were required to establish the conceptual design level excavation and cross-section requirements for the FRE configurations. The excavation and cross-sections shown on the drawings provided in Figures FRE-S-1 and FRE-S-2 in Appendix H are therefore reasonable and conservative.

Additional geotechnical and structural analyses and modeling will be performed during preliminary design stage in order to further optimize design and construction requirements. In all cases, the designs will provide stable cross-sections for all applicable load conditions. See the Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a), and the Phase 2 Site Characterization Report (HDR, 2017b) for additional details related to the foundation and structural design for the alternative configurations.

5 HYDRAULIC DESIGN

5.1 Introduction

This section summarizes the hydraulic design criteria, reservoir storage and flow capacities, and the descriptions and hydraulic characterizations of the outlet structures: the spillway and the spillway chute; flip bucket and plunge pool; outlet works; and stilling basin.

More detailed information on the hydraulic design is included in Appendix I.

5.2 Design Criteria

Table 5-1 below summarizes the design criteria used for the hydraulic design of the FRE dam options.

Table 5-1
Hydraulic Design Criteria

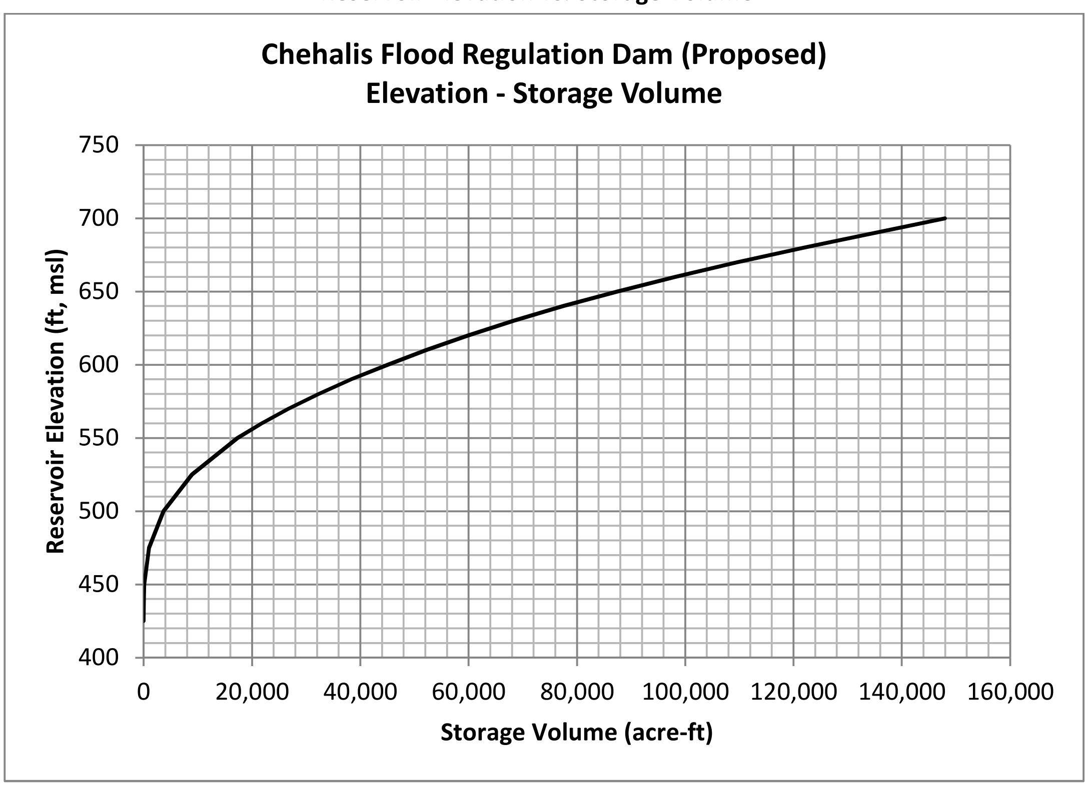
PARAMETER	DESIGN CRITERION	COMMENT/REFERENCE
Spillway Design Flood	69,800 cfs	PMF, as required by Washington State Dam Safety Guidelines (WSE, 2016)
Flood Regulation Storage	65,000 AF	Slightly greater flood volume than would have been stored in the December 2007 flood event of record; 60,250 AF (Anchor QEA, 2017)
Flow Augmentation Storage	FRE: 0 AF FRE-FC: 65,000 AF	(Anchor QEA, 2017)
Low Level Flood Regulation Outlet Works Minimum Total Flow	15,000 cfs at reservoir EL 550; total for all five conduits	Minimum flow capacity of low level flood control outlets needed to release the full equivalent flood storage volume of the 2007 flood of record hydrograph back into the river within one week
Maximum Fish Passage Flow	2,000 cfs	5 % exceedance flow; unrestricted fish passage for all flows up to 2,000 cfs
Minimum Fish Passage Flow	30 cfs	95 % exceedance flow
Minimum Water Quality Outlet Works Flow	500 cfs	Each outlet must be capable of discharging 500 cfs with a minimum of 35 feet of submergence.
Stilling Basin Design Flow	15,000 cfs	Flow at reservoir flood elevation (FRE = 628 feet; FRE-FC = 687 feet)

5.3 Flow Capacities and Reservoir Storage

The spillway design flow for both the initial construction FRE dam (FRE) and the raised FRE dam (FRE-FC) is the estimated maximum reservoir inflow during a PMF that is estimated to be 69,800 cfs (WSE, 2016), as required under the Washington State Dam Safety Office guidelines. The total proposed regulation storage reservoir volume is 65,000 acre feet. The flood storage capacity is slightly greater than the volume that would have been stored in the reservoir during the December 2007 flood event of record, the recurrence interval of which has been estimated to be between 300 and 1,000 years.

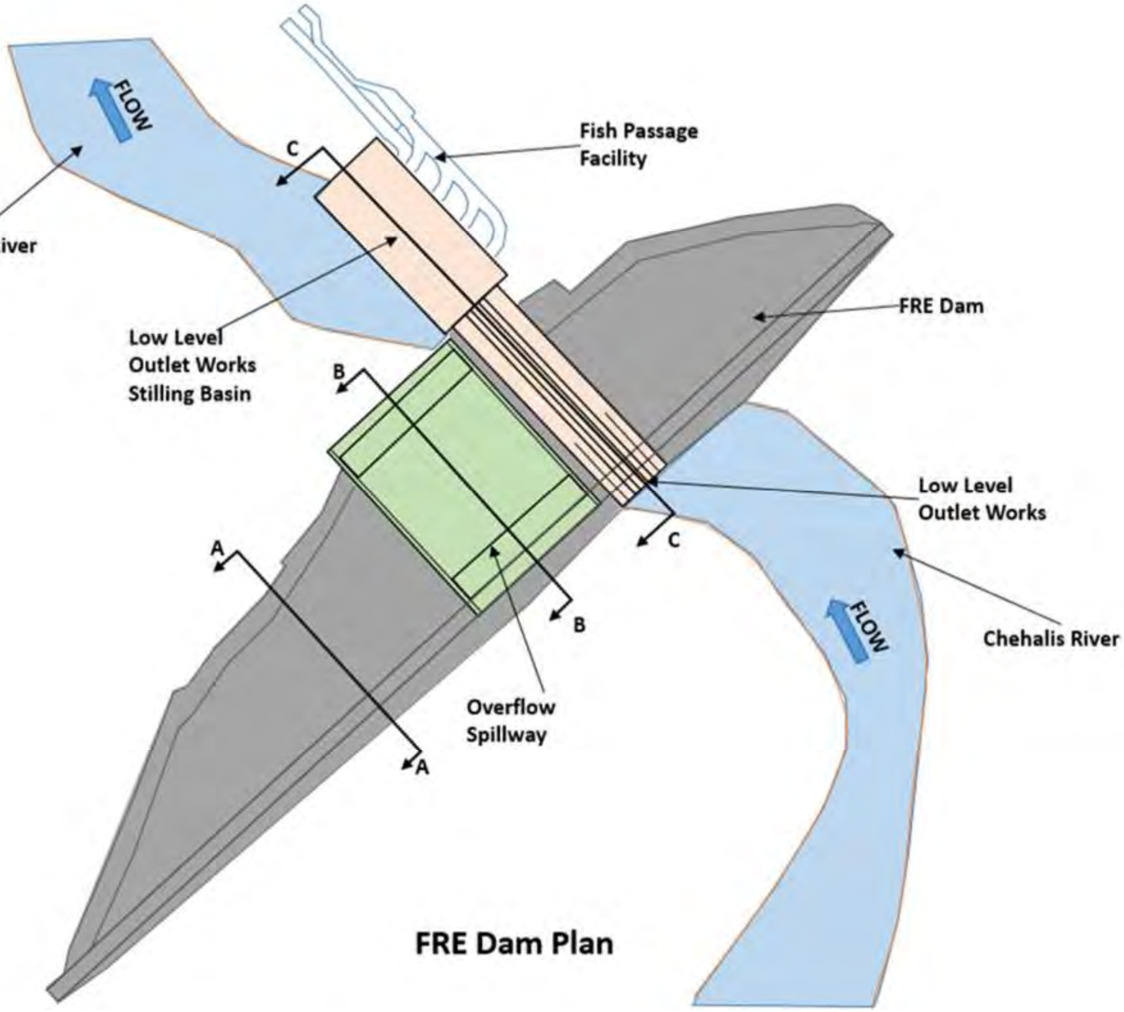
The FRE reservoir will normally be "dry"; that is, there will normally be no reservoir behind the dam, and the river flows will pass unimpeded through the dam sluices at all times until and unless a flood regulation operation is initiated. Flood storage is provided between the existing river water surface elevation and the emergency spillway crest at elevation 628 feet. The raised FRE-FC dam includes a permanent storage pool of up to 65,000 acre-feet (at elev. 628 feet) for flow augmentation and the required flood storage of 65,000 acre-feet from the reservoir elevation of 628 feet to the spillway crest elevation of 687 feet. Figure 5-1 shows the Reservoir Elevation vs. Storage Volume relationship, and Figure 5-2 illustrates how storage is provided in the FRE and FRE-FC dam alternatives.

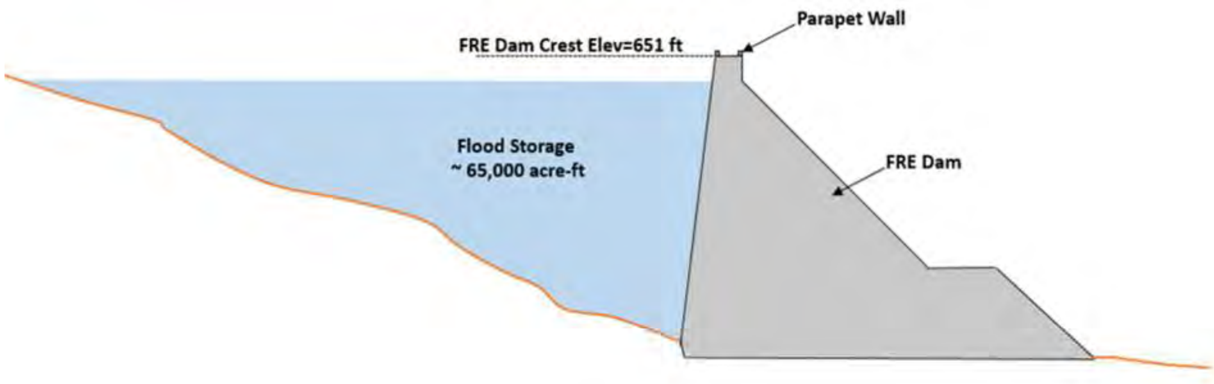
Figure 5-1
Reservoir Elevation vs. Storage Volume



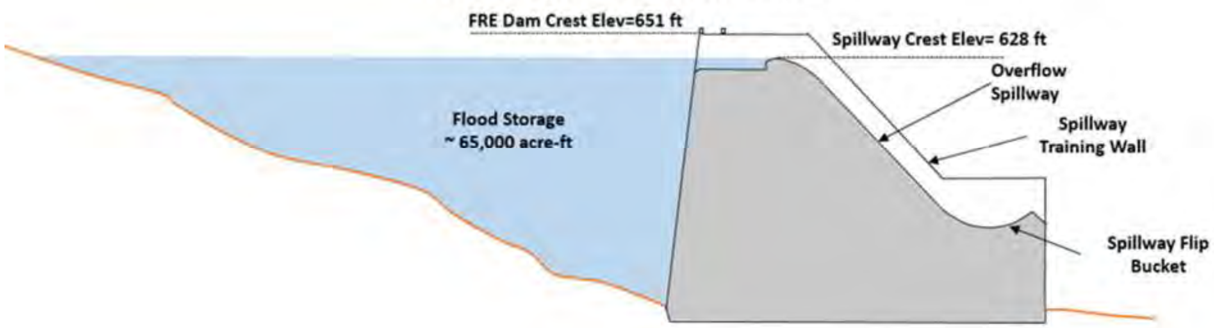
Source: Anchor QEA, 2017

Figure 5-2
FRE Schematic Layout

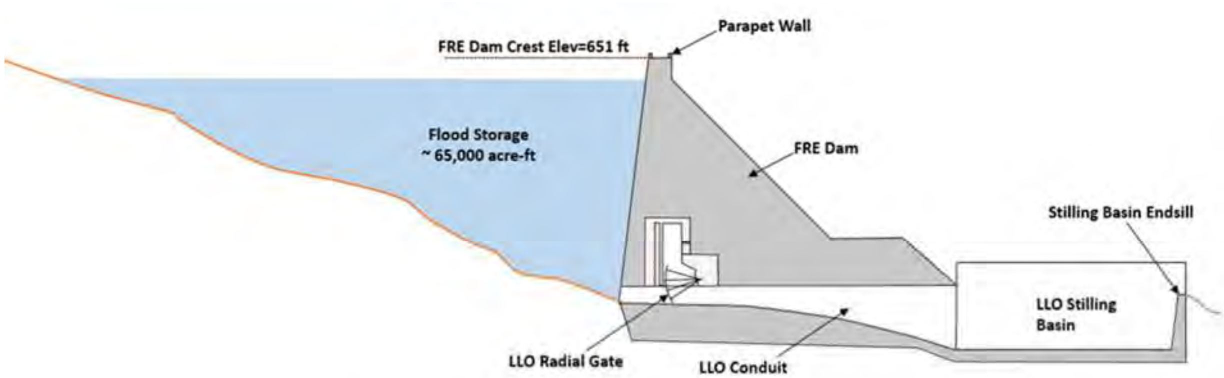




Section A-A
FRE Dam Non-Overflow Section



Section B-B
FRE Dam Overflow Spillway



Section C-C
FRE Dam Low Level Outlet Works (LLO)

The FRE dam would typically allow water from all minor high-flow events up to about 12,500 cfs to be passed through the dam with the sluice gates fully open, unless the flood regulation operation is commenced in response to larger flooding concerns downstream. All sediment and most small debris would pass through the dam unimpeded. The sluices have been designed to provide sufficient capacity at these smaller flow events to prevent developing backwater upstream of the sluices for flows up to and above a required high fish passage flow (2,000 cfs). Additionally, the low-level outlet works for both FRE and FRE-FC dams are sized to release the full equivalent flood storage volume of the 2007 flood of record hydrograph back into the river at a rate that would restore full flood storage capacity within one week.

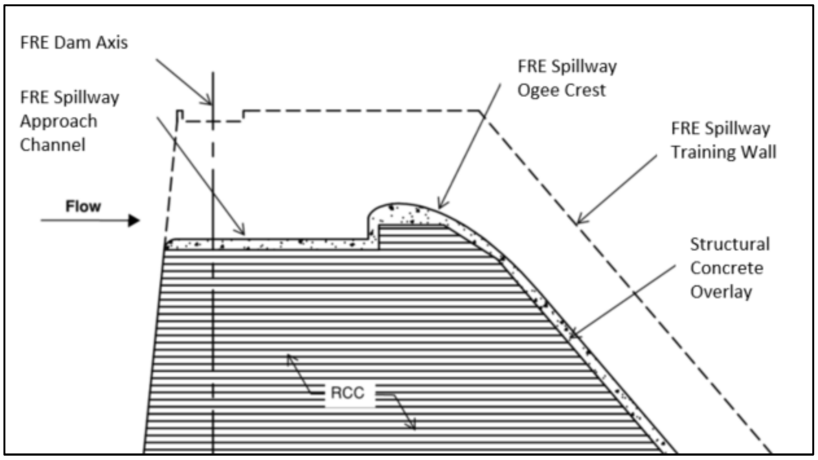
Similar to the FRFA dam alternative, the multiport water quality outlet works for the FRE-FC alternative is designed to pass up to 500 cfs from any reservoir level within the flow augmentation pool. Each of the four 48-inch-diameter conduits can discharge over 500 cfs with a minimum of 35 feet of submergence. The water quality outlet works are designed to accommodate withdrawal from multiple depths within the flow augmentation pool as needed to manage downstream release water temperatures. A larger, 84-inch diameter low-level port with a capacity of 800 cfs is included at the lowest level of the flow augmentation reservoir pool, in case additional quantities of cool stored water are required to meet downstream water temperature needs. The multiport water quality outlet works would be built during construction of the FRE, however, they will only be operational after completion of the FRE-FC.

5.4 Spillway and Spillway Chute

The spillways for the FRE and FRE-FC would be uncontrolled ogee crests, discharging to smooth-faced conventional concrete chutes cast over the top of the RCC mass dam section. Design guidance utilized in the design of the crest shape included USACE EM 1110-2-1603, Hydraulic Design of Spillways; the USACE Hydraulic Design Criteria (HDC); and the US Bureau of Reclamation (USBR) Design of Small Dams.

The FRE spillway crest is set at elevation 628 feet with a width of 200 feet, and is designed to pass up to 69,800 cfs with 4.3 feet of freeboard to the top of the upstream crest parapet wall. The equivalent unit discharge at full design capacity is 349 cfs per linear foot. The design discharge capacity has been conservatively estimated using a slightly lower discharge coefficient (C_d = 3.73) than is typically found for smooth ogee designs, to ensure adequate capacity without risk of overtopping. The FRE spillway is designed with a relatively short and shallow approach channel which positions the ogee crest approximately 50 feet downstream of the dam axis. This design and construction of the spillway chute and flip bucket structures conforms to the geometric requirements of the potential future FRE-FC dam, hence minimizing the construction effort and costs for expanding this portion of the dam. Figure 5-3 shows a schematic section view of the FRE spillway crest design.

Figure 5-3
Schematic view of FRE Spillway Crest and Chute Design



The FRE-FC spillway crest is set at elevation 687 feet with a width of 200 feet, and is designed to pass up to 69,800 cfs with 5 feet of freeboard to the top of the upstream dam parapet wall. The equivalent unit discharge at full design capacity is 349 cfs per linear foot. The design discharge capacity has been conservatively estimated using a slightly lower discharge coefficient (C_d = 3.84) than is typically found for smooth ogee designs, to ensure adequate capacity without risk of overtopping. To construct the FRE-FC spillway, the FRE spillway crest will be demolished while the flip bucket structure and a significant portion of the spillway chute will remain in place. Then, the RCC construction will proceed in lifts to facilitate the construction of the FRE-FC spillway. Figure 5-4 shows a schematic section view of the FRE-FC spillway design and construction.

Like that of the FRFA and FRO, the FRE and FRE-FC crest shapes have been designed with a design head (H_d) of 30 feet, though the maximum anticipated actual (effective) head (H_e) under the PMF event is only 22 feet. This "overdesign" permits the ogee shape to be cast on top of the underlying RCC structural outline and reach tangency with the overall downstream dam structure slope with approximately 3 feet of concrete overlay. This simplifies the dam construction process by allowing continuous RCC placement to finish the non-overflow section of the dam followed by conventional concrete overlay to construct the spillway. The crest shape shown on Figure 5-5 is used for both FRE and FRE-FC spillway designs. For this evaluation, it is assumed that the RCC construction will proceed in lifts of approximately 1 foot, which would leave a finished concrete face with 1-foot steps at the design downstream face slope of 0.85H:1V. The chute design assumes a structural overlay of concrete on the ogee crest and the face of the chute. Doweling and structural reinforcement would be required to securely anchor the structural concrete overlay to the RCC dam structure (Figure 5-3 and Figure 5-4).

Figure 5-4

FRE-FC Spillway Crest and Chute Design

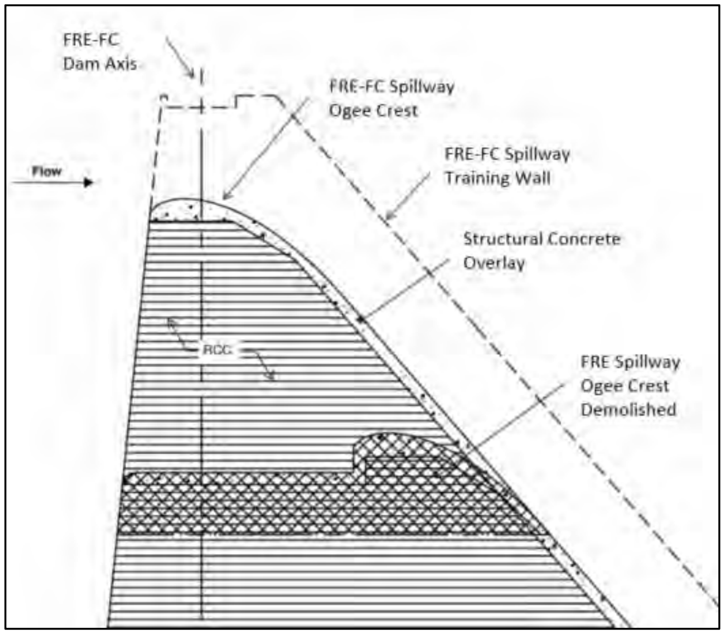
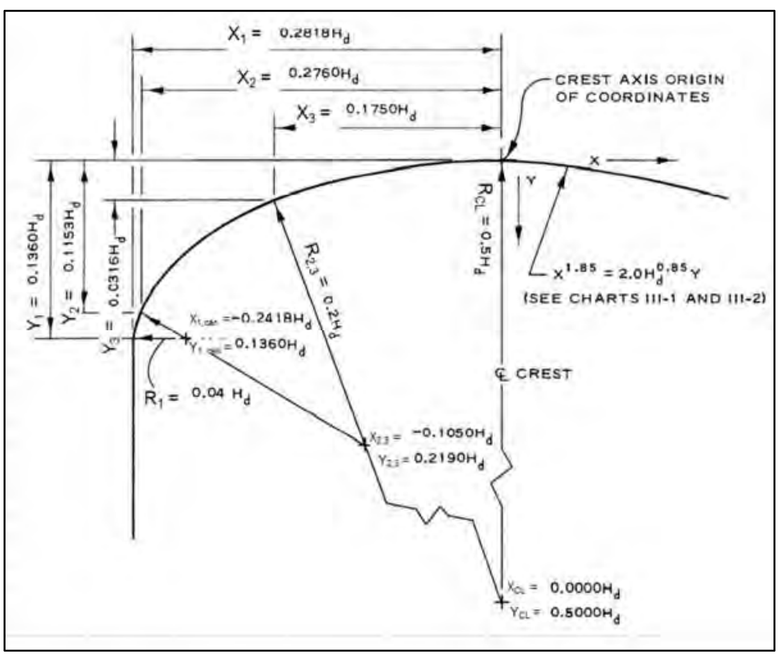


Figure 5-5

USACE Hydraulic Design Criteria 111-2/1 Design of Ogee Crest Shape



5.5 Flip Bucket and Plunge Pool

Similar to the FRO and FRFA alternatives, the FRE and FRE-FC alternatives spillway is expected to be used very rarely, and for events of very short duration. Therefore, no spillway stilling basin is provided. Rather, a flip bucket will be constructed to launch the spillway flow a safe distance downstream of the dam and to dissipate the energy in the river channel. Based on the geology of the site, the downstream rock within the flow impact area appears to be of sufficient quality and strength to provide occasional spillway flow dissipation and resist significant erosion, but that should be confirmed by geotechnical investigations prior to final design. The reservoir modeling conducted to date indicates that spill events are likely to occur with recurrence of 300 to 1000 years. Small spill discharges would be expected to cascade from the lip of the flip bucket and fall onto the rockfill material at the spillway toe adjacent to the sluice outlet stilling basin structure. Additional design refinement in the next phase of the project may include a more detailed evaluation of erosion protection for the rockfill adjacent to the sluice stilling basin. At this stage, a low containment wall about 3 to 5 feet high directs these minor spillway flows across the rockfill material adjacent to the stilling basin and to the river channel below.

For both the FRE and FRE-FC spillways, the flip bucket design is based on a unit discharge of 349 cfs/foot of width at the maximum spillway flow, with the bucket invert at elevation 475 feet and the lip at elevation 489.6 feet. The flip bucket was designed according to guidance provided in USACE EM 1110-2-1603, Hydraulic Design of Spillways, as shown on Figure 5-6 below. The flow depth at the flip bucket toe was estimated for the spillway design flow by two methods with comparable results: the first method using boundary layer development theory, and the second using the potential energy of the available hydraulic head from the reservoir level to the flip bucket toe. For the FRE, the maximum flow depth at the bucket toe is about 3.7 feet with a design flow velocity of about 100 feet per second, resulting in a minimum design bucket radius of 40.4 feet. For the FRE-FC, the maximum flow depth at the bucket toe is about 3.2 feet with a design flow velocity of about 118 feet per second, yielding a minimum design bucket radius of 47.6 feet. A bucket radius of 50 feet was selected for both the FRE and FRE-FC configurations. Simple trajectory calculations based on the USACE guidance indicated an impact location approximately 350 feet and 500 feet downstream of the lip for the FRE and FRE-FC, respectively. For unit discharges less than about 50 cfs per linear foot, energy losses down the chute would become significant and would reduce the flow velocity at the chute toe appreciably, resulting in an impact zone closer to the dam. The rockfill design in the channel downstream of the flip bucket would accommodate unit discharges of perhaps 30 to 50 cfs per foot without entrainment of stone and plucking or erosion. The specific gradation requirements for the stone surface material that will resist erosion under these flow conditions has not been determined in this conceptual design. Analysis to estimate the required riprap protection should be included as a refinement during the preliminary design phase.

Figure 5-6
Spillway Flip Bucket Design

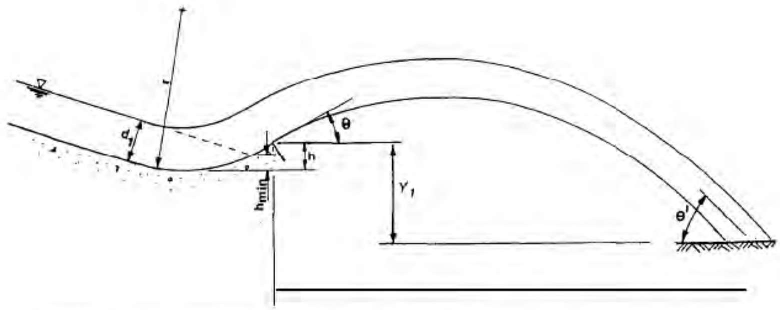


Figure 7-2. Parameters used in the design of a flip bucket

Source: USACE EM 1110-2-1603, Hydraulic Design of Spillways

5.6 Outlet Works

The FRE alternative design has five low-level sluice outlets: a single larger 12-feet-wide by 20-feet-high sluice at invert elevation 408 feet and two pairs of 10-feet-wide by 16-feet-high sluices at invert elevation 411 feet, one pair on each side of the larger center sluice. A large, full height trashrack extending from the riverbed to the dam crest will exclude most large trees from the sluice conduits and provide excess open area under all reservoir elevations to pass the desired project outflows. The larger sluice outlet in the center will be used to pass the majority of bedload sediment in the river, as well as most small debris. Some sediment is expected to pass through the smaller sluice outlets as well, but the center sluice with a lower invert elevation will intentionally receive the most wear from sediment passage over time. It is expected that repairs to the sluice floor would be required every few years to bring the sacrificial concrete floor surface back to original grade.

The two pairs of 10 foot by 16 foot sluice gates pass flow into parallel conduits separated by a center dividing wall terminating about 100 feet downstream of the gate seats. Downstream of the divider wall, the outflows from both gates combine into a 22-feet-wide by 16-feet-high single conduit. A parabolic drop of about 31 feet in the floor elevation of the sluice conduit transitions the discharge into the downstream stilling basin floor at an elevation of 377 feet.

The large 12-feet-wide by 20-feet-high center sluice is equipped with a radial gate with a radius of about 44 feet. The four smaller 10-feet-wide by 16-feet-high sluices have radial gates with a radius of about 35 feet. Hydraulic cylinder operators for each gate would provide positive closure under all flow conditions. Gate sealing would be accomplished using either inflatable (using reservoir static water pressure) side seals and top seals, or the gate trunnion would be provided with an eccentric rotator to compress the top seal. Both sealing types have been used with success in high head applications such as this. Similar to FRO and FRFA, radial gates were selected for the FRE dams for several reasons:

- They reduce the gate operator load by transmitting the hydrostatic forces to the trunnion.
- They eliminate gate slots, which, in a sediment- and debris-rich environment, can cause problems in fully seating the gate.
- They are more reliably and positively controlled than cable-hung vertical gates at these heads.
- They do not suffer from pressure regime shifts resulting from the jet attachment and detachment from the gate lip at small gate openings as do vertical gates.

Each sluice conduit is provided with an emergency bulkhead gate a few feet upstream of the radial gate, and dewatering bulkheads at the inlet and the outlet to the sluice. The emergency bulkhead gate would be a vertical panel, likely a roller gate with hydraulic operator, and would be designed to close under full flow at maximum reservoir elevation. The upstream and downstream dewatering bulkheads are simple vertically hung panels that are designed to close under no flow. They are provided to isolate and dewater each sluice conduit so that inspections and repairs can be accomplished in safe working conditions.

For the FRE dam, with all five low-level flood regulation sluice gates fully open, up to approximately 12,500 cfs can be passed through the sluices without transitioning to orifice or pressurized conduit flow in any of the sluice outlet conduits. For reservoir elevations greater than 430 feet, the sluice entrances would become submerged and flow control would shift to orifice flow, unless the radial gates are used to control the flow. The minimum required total low level flood release flow of 15,000 cfs can be discharged entirely through one pair of the 10 by 16 sluices at reservoir elevations greater than about 580 feet. Typical flood regulation operation would initiate closure of the large center sluice at any time the pool level exceeds reservoir elevation 500 feet to prevent excessive wear on the invert due to sediment entrained in high flow velocity. The two pairs of smaller sluices are expected to entrain considerably less sediment, though the specific elevation details to confirm this and establish the final higher sluice gate seat elevation would have to be evaluated using a physical laboratory scale model. Following the closure of the large center sluice gate, one pair of the smaller sluice gates would also initiate closure and the flood would only be regulated through one pair of the smaller sluices. Mud Mountain Dam on the White River in western Washington (owned by USACE) is designed similarly, and its three outlet sluices operate much like that proposed for the FRE design alternative.

At full flood storage reservoir elevation of 628 feet, each of the smaller sluice gates at 75 percent open can pass up to about 9,500 cfs, and the larger gate can pass up to about 14,200 cfs alone. The paired design of the two smaller gates was selected to ensure that finely controlled flood regulation would be available with a single gate as needed, given that the larger gate will likely be closed. Adjustment of a single 10-foot-wide gate in 6-inch typical lift increments gives just 380 cfs per increment at the maximum flood regulation reservoir elevation of 628 feet. Incremental control over downstream flows will allow the dam operator to achieve gradual increases and decreases to flow rates (ramping rates as required by the dam operations plan). Flood regulation operation would include operation of the sluices at reservoir elevations up to the spillway crest of 628 feet. At reservoir elevation above the spillway crest, sluice operation may be curtailed to avoid adverse flow conditions within the stilling basin.

The low-level outlet works constructed for the FRE would be used for the FRE-FC dam. The only modification to the outlet works for FRE-FC dam would be the extension of the large trashrack in front of the outlet works to the full height of the FRE-FC dam. The low-level flood regulation sluices would accommodate the same flow capacities as the FRE, with a maximum controlled discharge of 15,000 cfs at any reservoir elevation within the full operating range of the project (reservoir elevation 588 to 687).

At a full flood storage reservoir elevation of 687 feet, the larger and each of the smaller sluice gates at 75 percent open gate position can pass up to about 16,100 cfa and 10,700 cfs, respectively. FRE-FC flood regulation operation would include operation of the sluices at reservoir elevations up to the spillway crest of 687 feet. Similar to the FRE discussion above, at a reservoir elevation above the spillway crest, sluice operation may be curtailed to avoid adverse flow conditions within the stilling basin.

5.7 Stilling Basin

The outlet works stilling basin for the FRE alternative designs dissipates the energy in the flow from the five low-level sluice outlets. The design of the stilling basin is based on the maximum energy dissipation requirement for FRE-FC, which, due to the higher flood reservoir level, is greater than for the FRE. The stilling basin is sized to dissipate a total sluice outlet works discharge of 15,000 cfs at a reservoir level of 687 ft.

Assuming two 10-feet-wide by 16-feet-high sluices are discharging 15,000 cfs (7,500 cfs per sluice) under the flood reservoir elevation of 687 feet (FRE-FC), the flow velocity entering the basin would be approximately 140 feet per second, with a Froude number of about 12.6. Following USACE design guidelines for stilling basin design (Engineer Manual EM 1110-2-1603), a baffled stilling basin length of approximately 230 feet and a width of 102 feet would be required.

For the FRE-FC dam, the multiport low-flow outlet conduits would discharge through individual valves into the stilling basin from a valve located above the maximum expected regulating flow stilling basin water surface elevation of 433.5 feet. It is anticipated these valves would likely be of the hollow cone type, such as Howell-Bunger design, or perhaps fixed-cone valves. The design of the discharge valves for the multiport outlets will be refined in the next phase of designs. For cost estimation purposes, we have assumed Howell-Bunger valves will be selected.

5.8 FRE Hydraulic Characterization

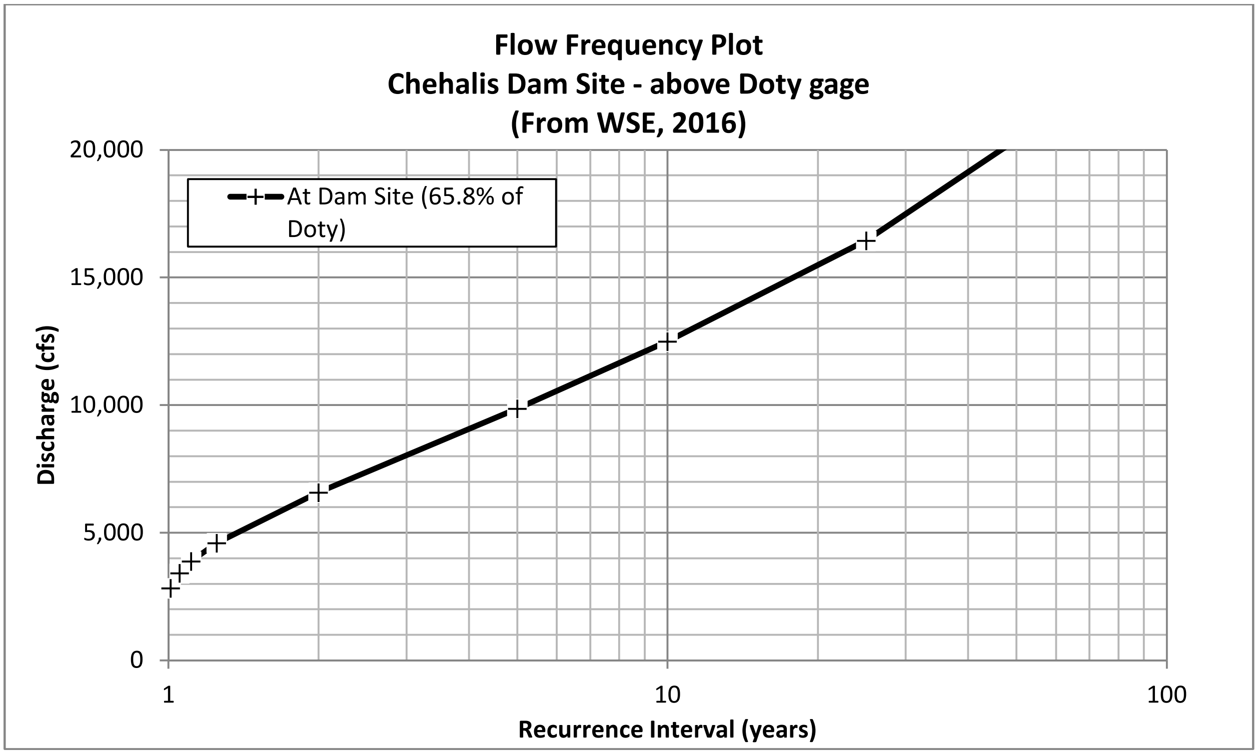
Similar to the FRO dam alternative, the FRE dam alternative is designed as a free-flowing run-of-the-river facility, where all the low level sluice gates are held fully open nearly all the time, except when forecast flood flows in the mainstem Chehalis River are expected to rise above 38,000 cfs within 48 hours. In holding all sluices fully open most of the time, and only regulating flow during events larger than approximately a 1 in 7 year recurrence interval flood event provides that most of the natural sediment transport processes will be maintained through the dam reach. Sediment is expected to freely pass through the dam, and upstream and downstream fish passage is expected to be uninterrupted. To maintain these processes in the FRE dam design, the location, number, and size of the low level sluice outlets were refined to allow replication of the typical channel conveyance, velocity, depth, and transport capacity of the natural channel to the extent possible.

5.8.1 Velocity and Depth Characterization

The existing channel reach extending roughly 1700 feet above the proposed dam site is relatively steep and comprised of bedrock step pools and has little evidence of deposition. The depth and velocity characteristics through this reach are unchanged with the FRE dam alternative, with the exception of minor flow transitions in the vicinity of the sluice gates and stilling basin, as there is no permanent impoundment to trap bedload materials. Most debris will either be passed through the sluice conduits or removed from the trashracks and hauled downstream to be released back into the river. Similarly, the reach downstream of the proposed dam is also a steep, bedrock channel with some step pools and minimal sediment deposition. Since most flows will be passed directly through the dam's fully open sluices, the flow depth and velocities are expected to be similar to the natural channel downstream of the dam.

During a large flood event of a magnitude significant enough to trigger flood regulation operations, the sluice gates would be closed and floodwaters would be impounded behind the dam. The natural flow regime is generally driven by flows between the average annual flood and the 2-year recurrence interval flood event which corresponds to flows between 3,000 and 6,000 cfs (Figure 5-7). The hydraulic analysis of the reach in the vicinity of the proposed dam site was conducted on flows less than 4,000 cfs, since the fish passage criteria maximum flow is just 2,250 cfs (see discussion in Section 5.8.3 below). Hence, the most important comparisons to be made are at those sections represented within the dam and stilling basin and a limited distance upstream and downstream. The basic hydraulics through the dam reach was assessed using a 1D HEC-RAS, a one-dimensional computer water surface profile modeling tool created by the USACE Hydrologic Engineering Center, and in common use throughout the engineering discipline for flow modeling.

Figure 5-7
Flow Frequency Plot for the Proposed Chehalis Dam Site



Source: WSE, 2016

The results of 1D-HEC-RAS modeling showed that under natural and proposed conditions, the flow depth and velocity at river discharges of 250 to 2,250 cfs range from 3 to 8 feet per second in the reaches above and below the dam site. Through the dam footprint, the natural channel velocity varies from about 1 to 5 fps across that same range of flows, while the velocities through the sluices of the FRE dam varies from about 0.5 to 1.5 fps over the same range of flows. The previously evaluated FRO dam alternative produced somewhat higher flow velocities, ranging from about 0.5 to 2 fps. The results generally show that the FRE dam alternative, with its five low level sluice outlets, provides lower flow velocities across the range of low to moderate flows than the existing channel, and also improves on the natural channel flow velocity. From a fish passage perspective, the FRE would be expected to provide easier passage for fish through the dam than the existing channel, and an improvement over the previously evaluated FRO alternative. Without intervention such as that occurring when the sluices are regulated for floods, the lower flow velocities within the sluices would likely lead to sediment deposition inside the dam conduits. Comprehensive results of the modeling analysis are provided in Appendix I (Section 2.5.1).

5.8.2 Sediment Transport Capacity and Performance

Sediment transport modeling was conducted for the existing channel condition, the FRO dam alternative with 3 sluice configuration, and the FRE with five sluice configuration. Bed shear stress of the FRO dam sluice conduits and the FRE sluice conduits were compared against the shear stress of the natural channel reach. The bed sediment transport over time was also compared (proposed vs natural conditions) by applying the natural river flow hydrograph from 1990 to 1994 to the 1-D HEC-RAS model running the Meyer-Peter Muller (MPM) transport function and the observed bed sediment gradations from samples collected at Cross Section 108.532 about 2,000 feet upstream of the dam site in a depositional reach (Dube, 2016). The MPM method provides the best agreement between calculated and observed transport rates and deposition/scour areas noted in the natural channel, and is generally best suited for rivers in which the bed substrate is dominated by gravel, as noted in the literature.

The results of the sediment transport analysis using 1D HEC-RAS reveals that the channel through the narrow scoured bedrock gorge at the proposed dam site will likely scour deeply and refill with sediment during flood events in which the substrate is mobilized. The results of the sediment transport analysis also show that the deep stilling basin downstream of the sluice conduits will similarly fill with and be scoured of sediment, particularly at the sluice outlets. The resultant river reach bed profile for the existing channel condition, FRO with three sluices configuration and FRFA with five sluices configuration following four years of hydrologic hydrograph from 1990 to 1994 are provided in Appendix I Section 2.5.2.

Through all river discharges in which the sluice gates are held fully open (i.e. no flood regulation operations), sediment will deposit throughout the sluice conduits and fill most of the stilling basin. This would represent the average condition, from a natural process and fish passage perspective. However, during a flood event in which the sluice gates would be closed or otherwise used to regulate dam discharges, any sediment that had deposited within the sluice conduits would be expected to be swept through the dam and deposited in the stilling basin or downstream in the natural channel. The action of closing the gates causes a high velocity flow jet to form immediately downstream of the gates, which would quickly clear the sluices of sediment deposits. Evaluation of the range of expected conditions within the sluice conduits indicates that the scoured areas at the cleared sluices will be much deeper than the existing natural channel, with commensurately lower flow velocities following the event. Anticipated bed sediment profiles following sluice gate regulation operations are provided in Appendix I Section 2.5.2. It should be noted that these sediment transport analyses are approximations of what should be expected. More accurate and quantifiable sediment transport, deposition, scour, and performance information would be obtained from a physical scale model of the entire dam and appurtenant outlet works that would be conducted during the next phase of design.

5.8.3 Fish Passage Considerations

Fish passage is a required objective of the Chehalis Dam project for all alternatives, including the FRE and FRE-FC Dam Alternatives covered in this Supplemental Report. The goal of the FRO Dam Alternative previously evaluated was to replicate, to the extent possible, the same hydraulic characteristics as the existing natural channel for all river flows up to about 2,250 cfs. These characteristics included flow velocity and depth (see Section 5.8.1 above), and sediment deposition (see Section 5.8.2 above), to the extent that sediment deposits and scour directly affect the lower flow velocity and depth. The original design criteria included a maximum velocity of 2 fps through all flows up to 2,250 cfs, or equal to or less than that of the existing channel. Modeling indicates that the FRE would not appreciably change the velocities and depths in the natural channel reaches upstream and downstream of the dam and stilling basin through this range of flows (up to 2,250 cfs). However, the flow characteristics in the low level flood regulating sluices will be different than that of the existing channel, given the concrete sluice geometries.

Previous modeling evaluations indicated that the FRO dam alternative would meet fish passage objectives for the project. Further analysis has been conducted using a 1-dimensional HEC-RAS model, to evaluate general hydraulic characteristics of the FRE dam design. This work built upon the earlier work completed on the FRO Dam Alternative. This additional study shows that the post-sedimentation flow velocity could be decreased by adding one or more additional sluice conduits, while maintaining similar flow depths. A second pair of 10-feet-wide by 16-feet-high sluice gates and conduits has been added to the FRO alternative (and is present in the FRE alternative) to provide the additional capacity by expanding the width of the intake trashrack about 40 feet, including a second pair of sluices to the left (facing downstream) of the large 12-feet-wide by 20-feet-high sluice, and widening the stilling basin to about 100 feet to accommodate the additional sluice discharge. The elevation of the second pair of 10-feet-wide by 16-feet-high sluice conduits on the left side of the outlet works is the same as the right pair of 10-feet-wide by 16-feet-high sluice conduits (elevation 411.0 ft msl), while the larger 12-feet-wide by 20-feet-high sluice elevation remains the same (elevation 408.0 ft msl). The HEC-RAS model was used to compare various hydraulic parameters over the range of fish passage flows from 25 cfs to 2,250 cfs, including flow velocity and depth, before and after the 4 years of the hydrologic record was applied to evaluate sediment transport processes, and with the or without clearing the sluices of sediment.

In addition to the 1-dimensional HEC-RAS modeling, a Computational Fluid Dynamic (CFD) model of the FRE geometry was developed using FLOW3D software (product of Flow Science, Inc.), with upstream boundary at the interior side of the intake trashrack and downstream boundary below the stilling basin control sill. The CFD model mapped the bed bathymetry calculated with the HEC-RAS sediment transport model following the 4 year hydrograph discussed above (1990 – 1994). The upstream boundary condition was assumed to be uniform flow, which is appropriate given that the intake trashrack would tend to distribute inflows uniformly as a result of the head loss induced across the width of the trashrack. The downstream boundary condition was assumed to be simply a conservation of mass criterion, passing flow equal to the inflow boundary. The CFD model was run in steady state condition for ten flows across the range of fish passage river discharges (100 cfs, 250 cfs, 500 cfs, 750 cfs, 1,000 cfs, 1,250 cfs, 1,500 cfs, 1,750 cfs, 2,000 cfs, and 2,200 cfs). CFD model results are provided in Appendix I Section (2.5.3).

5.9 FRE-FC Hydraulic Characterization

The FRE-FC Dam Alternative is, as discussed above, very similar to the FRFA Dam Alternative evaluated previously, with the exception that there are two additional low level flood regulation sluices, and all of the sluices are set lower in elevation than the FRFA Dam Alternative. As with the FRFA Dam Alternative, a permanent reservoir would be formed behind the FRE-FC Dam. Since a reservoir would be formed, bed sediment transport processes would be largely eliminated through the dam structure, though suspended sediment load would likely pass through the dam. The previously conducted hydraulic evaluation of the FRFA dam was used to inform design of the FRE-FC alternative. Additional detailed evaluation has not been performed for development of the FRE-FC alternative due to similarities with the FRFA configuration. If the FRE-FC Dam modification is implemented, it is likely that the second pair of 10-feet-wide by 16-feet-high sluice gates would be permanently closed and bulkheads would be placed at the sluice entrance opening, and the only operable gates would be the single large 12-feet-wide by 20-feet-high gate and the right side pair of 10-feet-wide by 16-feet-high gates. Please refer to the main report (HDR, 2017a) for specific details on the general hydraulic characteristics and performance of the FRFA, and by similarity the FRE-FC Dam Alternative.

6 CONSTRUCTION CONSIDERATIONS

6.1 Introduction

This section describes the specific construction considerations to allow future expansion of the FRE dam to a larger FRE-FC dam configuration. Typical construction considerations for the FRE, such as construction phase flood risks and flow diversion, are similar to constructing either the FRO or FRFA options and are described in the Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a). They are, therefore, not covered herein.

The main differences related to construction of the FRE dam option compared to the FRO or the FRFA options are related to configuring the FRE in a manner that is favorable for the construction of the FRE-FC enlargement at a later time. Descriptions of those specific construction issues are described below. Some additional refinements of the access and staging, compared to the FRO and FRFA, have been identified and are described in Sections 6.4 and 6.5.

6.2 FRE Construction

From a constructability and cost standpoint, the FRE dam configuration includes a number of the final FRE-FC configuration elements: 1) excavation and treatment of the FRE-FC dam footprint; 2) coverage and protection of the excavation between the limits of the FRE dam and the FRE-FC excavation up to the flood level elevation of 430 feet; 3) completion of the flood control sluice outlet works, water quality outlet penetrations through the dam, the outlet works stilling basin and basin walls, lower portion of the spillway chute and the flip bucket, and the chute training walls below elevation 651 feet.

The FRE needs greater dam and foundation seepage control than the FRO does, because the FRE must consider future construction of FRE-FC with additional storage with higher head. The FRO may allow for a lesser grout curtain, foundation drainage, or upstream facing system. If a dam raise will be considered for the FRO in the future, retrofitting the FRO foundation or dam seepage controls to accommodate the higher head raised dam might be quite costly due to limited options for performing this retrofit.

The FRE configuration would depend on the scope and extent of the FRE-FC. In the event the FRE alternative is the preferred alternative and is selected for final design and construction, the following items would need to be evaluated at the FRE and FRE-FC design stage to ensure the future FRE-FC is constructed appropriately:

- Foundation blanket or consolidation grouting
- Abutment termination details
- RCC mix strength and cured properties

- RCC mix and placed temperature control
- Dam joint spacing and construction details
- Upstream facing elements for seepage barrier
- FRE-FC downstream facing elements
- FRE downstream face treatment or preparation
- Spillway chute anchorage
- Training wall height and design
- Diversion or cofferdam requirements; tailwater, intake, and flood routing

6.3 FRE-FC Construction

The FRE-FC design configuration considers that the foundation excavation, materials, and structures are completed during the development of the FRE to allow an efficient expansion that does not require development of a new diversion, significant structure remediation, and repeated structure construction. The FRE-FC construction complexity, and, therefore, also schedule and risk, are minimized.

Constructing the FRE-FC introduces some work that is not necessary for the FRO or FRFA alternatives. Similarly, some work required in both the FRO and FRFA alternatives is approached differently for the FRE and the FRE-FC, introducing varying degrees of construction inefficiency and additional cost.

Construction of the FRE-FC includes:

- Demolition of FRE concrete; crest parapets; ogee crest; and possibly concrete related to raising the intake/trashrack structure
- Preparation of the existing downstream face and possible anchorage between the FRE and FRE-FC
- Coverage of the FRE downstream facing that required vertical and other dam formwork as well as higher cost materials to create the dam facing.

Other factors that affect the RCC, unit prices, and related work and total project costs include:

- Quarry and aggregate development split into two projects; increasing fixed cost contribution to unit prices (i.e. mobilization, setup, access)
- RCC production fixed costs similarly increasing the RCC unit pricing for each project
- Widely different RCC lift configurations and volumes as evident on the illustrations included in the cost appendix.
- Increased percentages of other work controlling or dictating daily RCC production rates; multiple starting locations and times, learning curves, higher percentages of formwork per cubic yard of RCC; and a higher percentage of narrower and longer lifts.

6.4 Access and Staging

Construction access and staging for the FRE will essentially look the same as for the FRO or FRFA. With the FRE in operation, and depending upon how much time has passed, the initial access and staging development may generally be intact, needing a degree of clearing, resurfacing, or other activities to support FRE-FC construction. Access to the left side of the dam may have to be re-established with temporary upstream or downstream crossings, or perhaps even over the FRE spillway.

6.5 Diversion during Construction

Completion of the FRE including the downstream RCC cover materials as previously described will limit downstream dam raise work to above elevation 430. This elevation should be above typical flood tailwater levels limiting construction flooding risks to the downstream work. The FRE-FC sequencing does not involve construction within the spillway until late in RCC placement. Also, flood routing through the FRE low-level sluice outlet works should minimize the risk of spill during the FRE-FC construction to more than acceptable levels (> 100-year recurrence flow). Trashrack and intake structure design should likewise seek to allow FRE-FC buildout that does not require sustained construction access to the intake tower below the FRE crest.

6.6 Concrete Aggregate

Both the FRE and FRE-FC require enough aggregate to result in favorable economies of scale and pricing for site-based production.

6.7 Construction Risk

Construction risk is very similar for the FRFA, FRO, and FRE alternatives. However, the FRE-FC construction risks are greatly reduced by essentially eliminating foundation and construction flood diversion risks, since those will already have been addressed in the design and construction of the FRE. The construction risks for the FRE-FC are reduced to those risks generally applicable to plant and heavy-civil construction, such as: safety; commercial material supply; market interest; contract form and terms; external sequencing or schedule demands; and seasonal factors.

7 FISH PASSAGE OPTIONS

7.1 Fish Passage During Operation

The fish passage options for all the FRE and FRE-FC are similar to the FRO and the FRFA fish passage alternatives, respectively. These options are described in more detail in the main Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017a) and are included herein by reference.

The FRE and FRE-FC presented in this document, and the costs used for fish passage, show a refined Collection, Handling, Transport, and Release (CHTR) facility fish passage alternative, which has been updated based on new design information since the issuance of the original draft report. The specific details of the refined CHTR are presented in the CHTR Conceptual Design Report (HDR, 2017c). A figure of the CHTR is included in Appendix H.

7.2 Fish Passage During Construction

Fish passage is required during construction of the FRE dam to reduce adverse impacts to fisheries resources present in the Chehalis River. Specific requirements will be set by federal and state agencies such as USFWS, NMFS, WDFW, and WA DOE in consultation with stakeholders including the Quinault tribe. Construction for the FRE dam is expected to require diversion of the entire river for a possible construction duration of approximately 5 years. Failing to provide fish passage for the target fish species on the Chehalis River (e.g. – Chinook, coho, and steelhead) would eliminate at least two full rearing and spawning cycles upstream of the dam location, resulting in significant adverse impacts to the populations of these species present in the river. USFWS, NMFS, WDFW, WA DOE, and the Quinault Tribe, have all expressed their position in stakeholder coordination meetings over the last several years, indicating their desire for fish passage during construction mainly for this reason. Due to the extended period of diversion and the impact to salmon populations, for the following fish passage alternatives during construction, it is assumed that the full fish passage criteria required by NMFS and WDFW must be met for the entire period of construction.

7.2.1 Alternative 1: Diversion Tunnel

One potential alternative for fish passage past the project area during construction for the FRE dam is via the construction diversion tunnel. The tunnel is anticipated to be a 20 foot by 20 foot, horseshoe-shaped, concrete lined tunnel drilled and blasted through rock. It is expected to be approximately 1,630 feet long at a slope of about 1%. Fish passage is required by the governing state and federal agencies to be between the 95% and 5% exceedance flows (16 cfs to 2,200 cfs) for the river. At these flows the anticipated flow velocity within a smooth hydraulically efficient tunnel would be expected to range from 4 feet per second (fps) to 25 fps, respectively. These velocities are well above the 2 fps maximum flow velocity criteria required by NMFS for safe, timely, and effective upstream fish passage through a tunnel structure of this nature. However, the fish passage technical committee agreed in 2016 that the final design of conduits through the dam may exceed the 2 fps criteria as long as they mimicked the flow characteristics of the natural channel in this reach. If this criteria were applied to the diversion tunnel a maximum flow velocity of about 6 fps would be acceptable. A flow velocity of 6 fps corresponds to a river flow of about 50 cfs. Even with the greater allowable flow velocity, the range of river flows that would meet fish passage requirements is a small fraction of what is required, making an unmodified alternative infeasible for upstream fish passage during construction.

To make the diversion tunnel fish passable, the tunnel must be designed to approximate the natural channel in this section of river. The design of the diversion tunnel may be modified to better match the flow conditions of the natural river channel. Modifications required would likely include some or all of the following:

- Larger tunnel with lower magnitude gradient (slope).
- Multiple smaller tunnels instead of the single tunnel currently shown.
- Flow control gates for each tunnel.
- A stilling basin or other means of providing a backwater effect to the tunnels.
- Lighting to mimic the daylight during the day.
- Pools, weirs, or other means of producing velocity refugia (means of producing low velocity pools to provide resting areas for migrating fish).

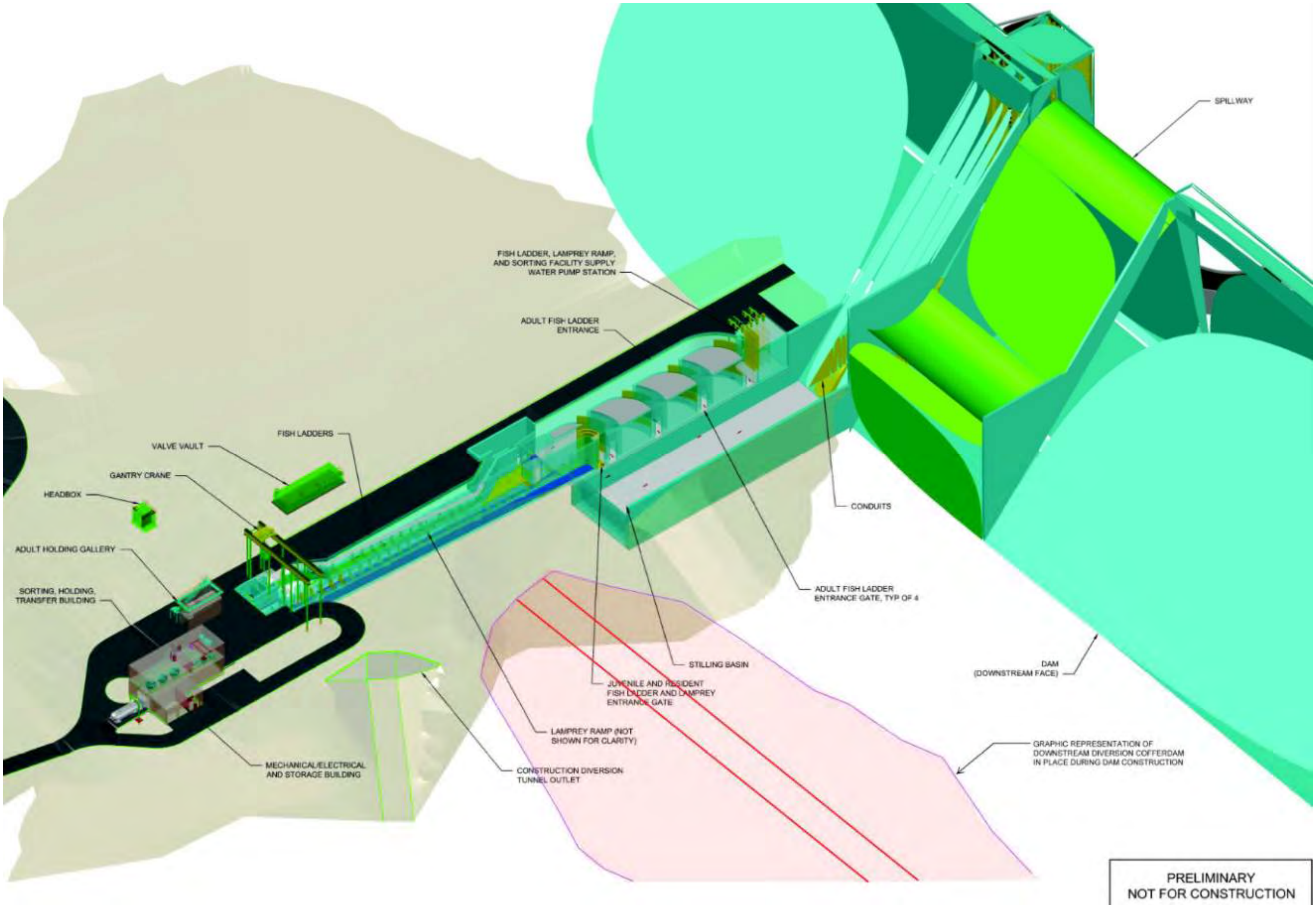
Downstream fish passage through the diversion tunnel appears feasible, although significant modifications to the tunnel design may be required to ensure flow velocities within the 95% to 5% exceedance of mean daily flow does not exceed fish passage guidance while still accommodating the conveyance target required for dam construction.

7.2.2 Alternative 2: Permanent CHTR Facility

Another alternative to provide fish passage during construction of the dam is to construct the permanent Collect, Handle, Transfer, and Release (CHTR) Facility prior to beginning dewatering and construction of the dam. This alternative provides the advantage of not constructing any additional or temporary facilities as the permanent facility would be constructed and operated during dewatering and dam construction. Unfortunately, upon preliminary examination, this alternative appears infeasible for the following reasons:

- The downstream cofferdam is located between the diversion tunnel and fish ladder entrance, preventing fish from accessing the CHTR facility.
- The flow patterns and velocities from the outlet of the diversion tunnel would adversely affect fish attraction and passage to the CHTR facility.
- The excavation footprint for the dam foundation extends well into the footprint of the CHTR facility, preventing the CHTR facility from being constructed before the dam.

Figure 7-1: Alternative 2 - CHTR Facility



7.2.3 Alternative 3: Temporary Trap and Transport Facility

Temporary trap and transport (T&T) facilities are common to provide fish passage for projects that require extensive in-water work for long duration, such as what will be required for the FRE dam. The temporary T&T facility would be installed and begin operation prior to any other in-water work. The facility would be located far enough downstream of the diversion tunnel outlet such that river flow approaching the facility would be as calm and uniform as practicable. A temporary trap and transport facility would likely consist of a temporary barrier such as picket weirs or an inflatable dam with a fish ladder on the left bank that leads to holding ponds or holding tanks at the top of the bank where they could be easily accessed by transport trucks. Auxiliary water would be provided to a temporary fish ladder entrance via a pumping system. The pumping system would likely consist of an intake on the right bank meeting fish screening criteria, a series of vertical turbine pumps, and pipelines that would supply water from the river directly to the holding ponds or tanks, the top of the fish ladder, and the auxiliary water system. This pumping system would operate 24-hours a day, 7-days a week for the full period of construction, until normal operation of the dam began. Once normal operation began, the temporary facilities in the river would be removed and the facilities above a to-be-determined high water elevation would be abandoned or removed. Based on the duration of construction and potential flood events the facility may experience, the temporary barrier would likely be primarily of concrete construction, well anchored to the river bottom, with abutments firmly keyed into the right and left banks of the river.

The trap and transport facility would provide upstream passage for the same species as the permanent CHTR facility. Aquatic species collected in the facility would be transported to release points upstream of the upstream cofferdam. Downstream fish passage would be provided via the diversion tunnel (see Alternative 1).

8 OPERATIONS AND MAINTENANCE

Operation and maintenance (O&M) costs for the FRE and FRE-FC alternatives are expected to be similar to the costs for the FRO and FRFA, respectively, which are presented in more detail in the main report (HDR, 2017a). Those costs were developed with consideration of the requirements for replacement of dam components that are subject to wear and trash and sediment removal, as well as staffing and equipment needed for the dam and fish passage facilities. The estimated annual O&M costs (2016 dollars) are as follows:

- FRE: $628,000 per year
- FRE-FC: $2,178,000 per year

9 OPINION OF PROBABLE COSTS

9.1 Introduction

This section summarizes the opinion of probable construction costs (OPCC) for the FRE option. The cost basis for the FRE-FC option is in most respects similar to the FRFA option, since the FRE includes the footprint of the FRFA. Therefore, not included herein are descriptions of the cost development for roads; land and land rights; transmission lines and substations equipment; sales tax; contingencies; engineering and construction management assistance; permitting costs; operation and maintenance; and property tax and insurance. For details on the development of those subject costs, see the main report (HDR, 2017a). The cost estimate is for direct construction costs including final design engineering and construction permitting but does not include costs for EIS and ESA related studies and agreements or mitigation design and construction costs.

It should also be noted that the CHTR fish passage facility presented herein for the FRE option represents further design development compared to the CHTR facility cost presented with the FRO option. The fish passage costs for the FRE dam options include the updated estimated costs for the CHTR. More details of the updated CHTR are presented in the updated Fish Passage Report (HDR, 2017c).

9.2 Cost Summary

Table 9-1 summarizes the opinion of probable construction costs (OPCC) for both FRE and FRE-FC, not including the fish passage facilities. Appendix J provides additional detailed information on the estimated costs of the FRE; OPC worksheets; dam placement production and sequence illustrations; RCC unit cost development; and quantity takeoffs.

Table 9-1

Concept-level Estimate of Total Direct Project Costs

	FRE	FRE-FC
Total Likely Project Cost	$ 358,000,000	$ 129,000,000
Low End Project Cost	$ 307,000,000	$ 110,000,000
High End Project Cost	$ 419,000,000	$ 154,000,000
Project Cost Range from Total Likely	82 % - 118 %	82 % - 118 %
Driving RCC Quantity	892,000 CY	467,000 CY
RCC Unit Bid – Likely	$ 103.50	$ 111.00
RCC Unit Bid Range	$ 88.00 - $ 119.00	$ 94.00 - $ 127.00
RCC - as % of Contractor Bid	39 %	61 %

Note: including OPCC, June 2017 dollars

The document ‘Guidelines for Construction Cost Estimating for Dam Engineers and Owners’ (USSD, 2012) provides a description of varying cost estimating “levels” for dam projects. Levels provide an indication as to the degree of uncertainty associated with an estimate. Significant effort has been expended on evaluating RCC materials availability, design, and construction considerations. Accordingly, the RCC portion of the dam project has a higher degree of certainty than other portions of the project. The estimate completed for the RCC portion of work is consistent with a “reconnaissance-level” OPCC. This type of estimate is generally in compliance with an Association for the Advancement of Cost Engineering (AACE) Class 3 estimate. The non-RCC components (such as clearing and grubbing, excavating, diversion tunnel, earthwork, piping, concrete, utility, and other site civil work) of the estimate are generally consistent with a “feasibility-level” OPCC. This type of estimate is generally in compliance with an AACE Class 4 estimate.

9.3 FRE Dam Construction Cost Implications

Construction of the FRE prepared for a potential future expansion introduces important cost implications as discussed below.

9.3.1 Diversion

The FRE, FRO, and FRFA options all bear nearly the same diversion requirements and risk, varying only slightly in terms of the months of diversion exposure. Constructing the full foundation and the full lower limits of RCC for the FRE, however, significantly reduces any diversion requirement for the FRE-FC. During FRE-FC construction there will be a brief period when the raise takes the FRE spillway out of service, exposing the construction to only the most extreme flood events that could not be routed through the low-level sluice outlets. A small amount of costs for nuisance dewatering and unforeseen water handling has been included in the estimated costs for the FRE-FC.

9.3.2 Hydraulic Structures, Concrete Scope and Efficiencies

The FRE option provides the majority of the concrete infrastructure required for the FRE-FC, including the spillway chute and flip bucket and outlet works systems built to the FRE-FC extents. These massive structural concrete components can be built efficiently in the FRE, leaving only the new upper spillway, upper intake structure, and dam crest for the FRE-FC. Furnishing and installing the water quality outlets in the FRE-FC is the only mechanical dam component not completed in the FRE, contributing to a simpler and more singular focus (RCC raise) of the FRE-FC construction.

In addition, the full upstream face of the FRE is now conventional concrete whereas the FRO considered a less robust grout-enriched RCC (GERCC) for the upstream facing element.

9.3.3 RCC Scope and Efficiencies

Both the FRO and FRFA have cross sections and configurations that favor RCC delivery and placement. The broad upper right abutment provides good area for staging RCC operations and a top-to-bottom delivery approach, which can benefit projects and keep RCC unit costs low. The estimated RCC unit costs for the FRE ($103.50) and FRE-FC ($111) are higher than the FRO ($93) and the FRFA ($99) for the following reasons:

- The RCC quantities are significant in both FRE and FRE-FC, but the FRE includes a higher percentage of non-RCC costs, and both include a higher percentage of non-RCC production drivers, slowing the overall pace and increasing costs.
- Increased vertical or near-vertical formwork
- More delivery resets and placement starts and stops
- Smaller and generally narrower lifts

All factors above combine to slow production and increase the unit costs. Nevertheless, both FRE and FRE-FC projects are tall and massive enough for RCC to remain economical. The RCC Quantity and Placement Summary in Appendix J provides an illustration of the lift shapes as vertical progress is made.

9.3.4 FRE Additional Costs

Temporary backfill has been added to the FRE to lightly cover the downstream RCC until the FRE-FC contract would remove it, thereby adding those costs to the FRE. Assuming a vertical chimney section for the FRE, downstream vertical formwork will be needed for construction, along with facing system concrete. These portions of the FRE work will ultimately be covered by the FRE-FC cross section. Demolition of the FRE spillway approach and ogee crest has been added to the FRE-FC estimate. Anticipating a need for adhesion of the second stage of RCC, the FRE-FC estimate includes fully treating and potentially anchoring the downstream face prior to the RCC placement. The same level of foundation grouting as the FRFA has been included for the FRE which is more robust than the grouting included and priced for the FRO. An allowance has been added to the FRE-FC for grouting to address the concept-level foundation and design uncertainty associated with the foundation near the transition from RCC to the central earth core rockfill section.

9.3.5 Contingencies and Other Factors

All estimates maintain the same below-the-line cost factors of 25 %. All costs, including the FRO and FRFA, are now presented in 2017 dollars.

10 CONSTRUCTION SCHEDULE

10.1 Construction Sequence

It is anticipated that the FRE project would have a very similar duration to the FRO and potentially the FRFA which have been considered at 6 and 7 years of design and construction, respectively. While shorter schedules for each are plausible, the important reality is that the access development, tunnel and diversion systems, aggregate development, foundation features, early hydraulic structures, and the dam are all very similar between the FRO, FRFA, and FRE. It is unlikely a schedule difference greater than 1 year could be generated between the options. Regarding the FRE-FC, which would benefit from the earlier access and staging development, earlier quarry development, and foundation completion, its construction could reasonably be completed in two years, perhaps less. Due to similarities in scheduling requirements, new construction schedules have not been developed specifically for either the FRE or FRE-FC designs.

11 ALTERNATIVES COMPARISON AND RECOMMENDATIONS

11.1 Alternatives Comparison

The evaluation performed in support of this report did not identify any fatal flaws associated with the FRO, FRFA, or FRE dam configurations. A summary of the main features of the alternative dam configurations is provided in Table 11-1. The selection of the preferred alternative will need to be based on considerations cost, risk, selected fisheries objectives, and identified environmental objectives and permitting constraints.

Table 11-1
Summary Comparison of FRO, FRFA, and FRE Alternatives

COMBINED ALTERNATIVE	FRO	FRFA	FRE	FRE-FC*
Purpose	Flood Retention Only	Flood Retention and Flow Augmentation	Flood Retention Only	Flood Retention and Flow Augmentation
Dam Type	Gravity - RCC	Gravity - RCC	Gravity - RCC	Gravity – RCC
Dam Structural Height (feet)	254	313	254	313
Water Storage Elevation (Spillway Crest Elevation, feet)	628	687	628	687
Emergency Spillway Type	Over Dam Crest	Over Dam crest	Over Dam Crest	Over Dam crest
Total Reservoir Storage Volume (1,000 AF)	65	130	65	130
Recommended Upstream Fish Passage	Flow through outlet sluices and CHTR facility	CHTR	Flow through outlet sluices and CHTR facility	CHTR
Recommended Downstream Fish Passage	Flow through outlet sluices	Floating Surface Collector	Flow through outlet sluices	Floating Surface Collector
Construction Period (years)	2.5 – 3.5	3 – 4	3 - 4	1 – 1.5

COMBINED ALTERNATIVE	FRO	FRFA	FRE	FRE-FC*
Estimated Dam and Fish Passage Project Costs (6/2017)	$341,000,000	$544,000,000	$401,000,000	$215,000,000
Estimated Annual O&M Costs ($2016)	$628,000	$2,178,000	$628,000	$2,178,000

Notes: AF = acre-feet, CHTR = collection, handling, transport, release, RCC = roller compacted concrete, NA = Not applicable O&M = operations and maintenance
* Additional cost to build FRE-FC once FRE is completed, in 2017 dollars.

11.2 Conclusions

An additional dam and fish passage configuration (FRE) has been developed and presented in this report. This alternative would construct a large foundation and a low dam, with the potential for future expansion if additional flood storage or flow augmentation water storage was desired. The benefits of this configuration include:

1. Potential for adaptation of project objectives to address uncertainties associated with climate change on flood storage and routing requirements.
2. Potential for further optimization of flow augmentation requirements and deliveries in response to better understanding of environmental changes and needs that are occurring in the basin below the dam.

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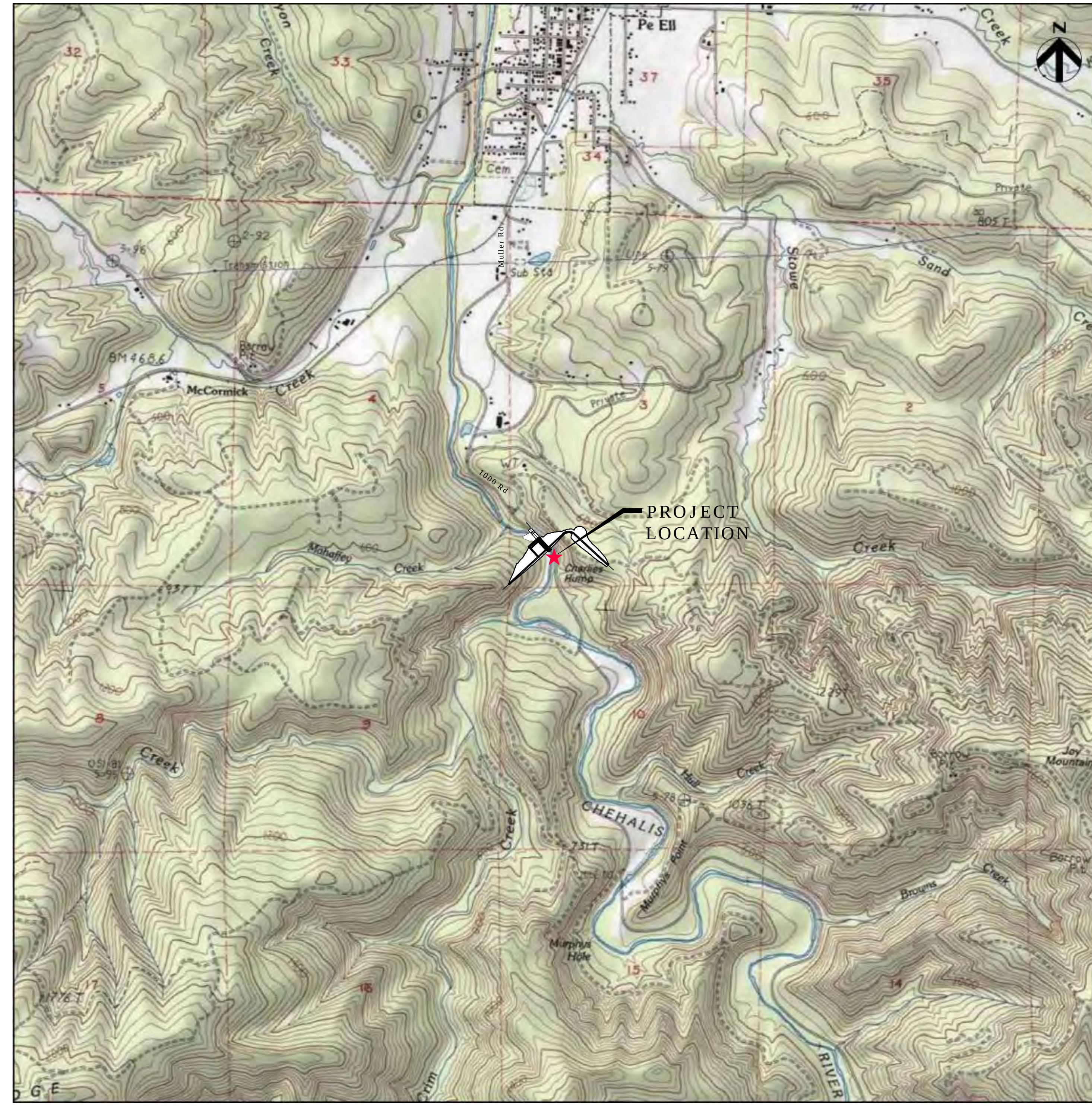
Appendix H
Maps and Drawings

CHEHALIS BASIN STRATEGY
COMBINED DAM AND FISH PASSAGE
CONCEPTUAL DESIGN

WASHINGTON STATE
SCALE: 1" = 100 mi

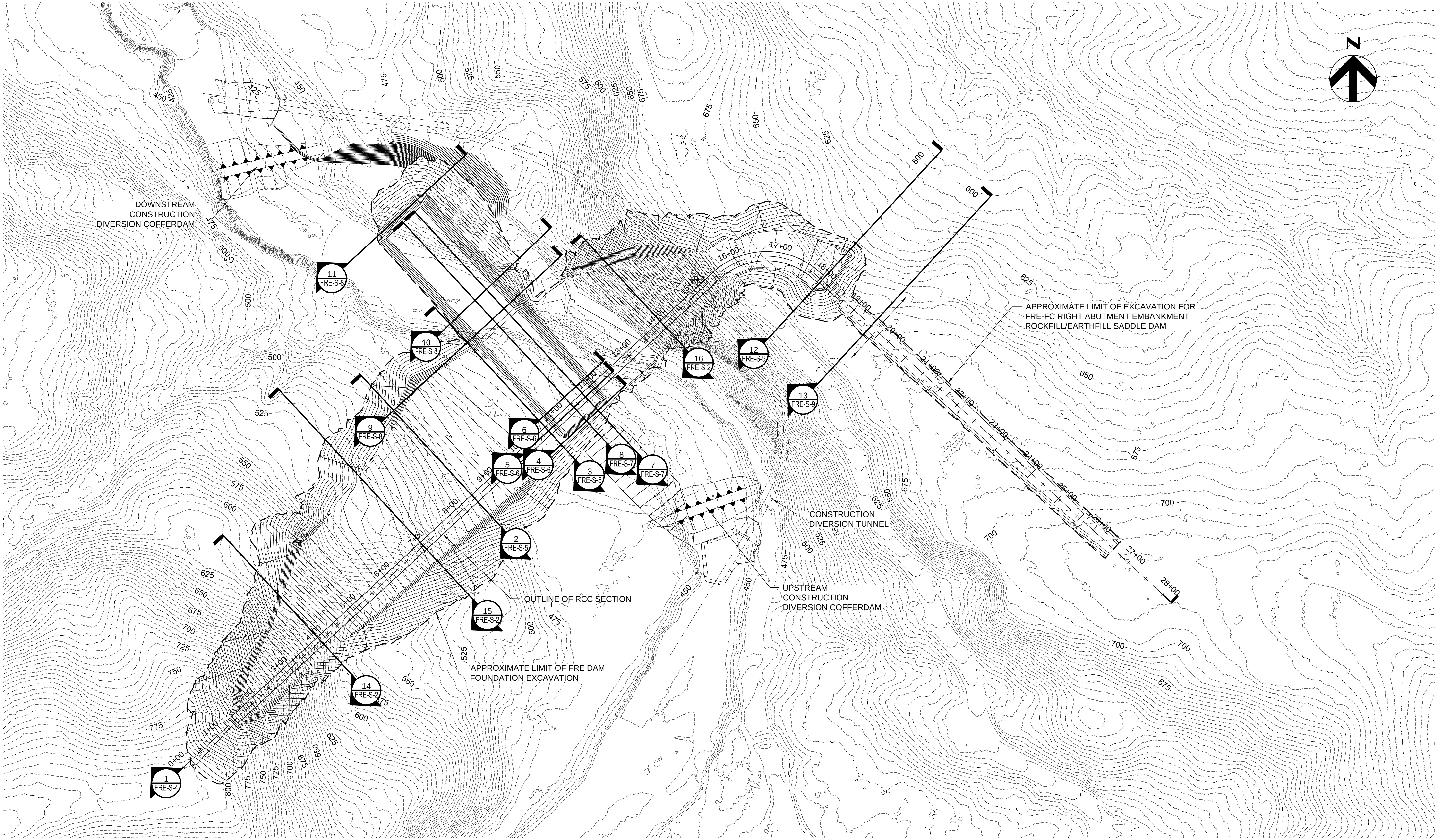
PROJECT VICINITY
SCALE: 1" = 8 mi



PROJECT LOCATION
SCALE: 1" = 0.5 mi

VICINITY AND LOCATION MAPS	DATE SEPT 2018
CHEHALIS BASIN DAM	FIGURE FRE-G-1

INDEX OF DRAWINGS



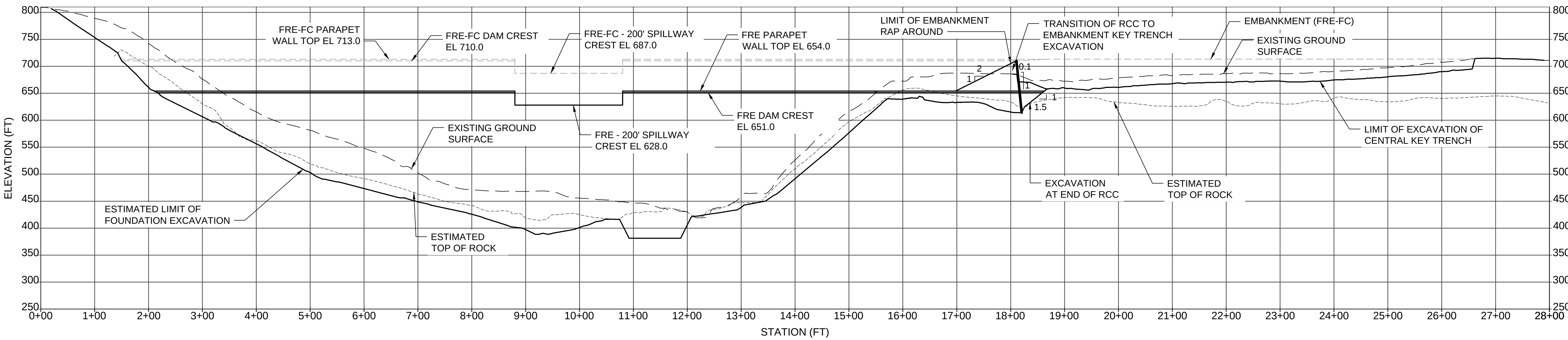
DAM EXCAVATION PLAN

0 50 100 200
SCALE IN FEET

FRE DAM
DAM EXCAVATION AND FOUNDATION TREATMENT PLAN

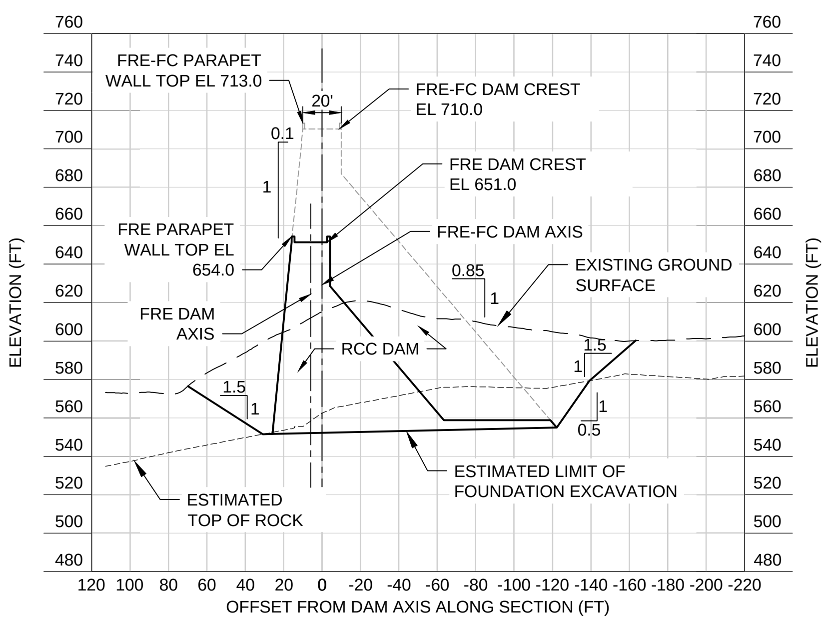
CHEHALIS BASIN DAM

DATE	SEPT 2018
FIGURE	FRE-S-1



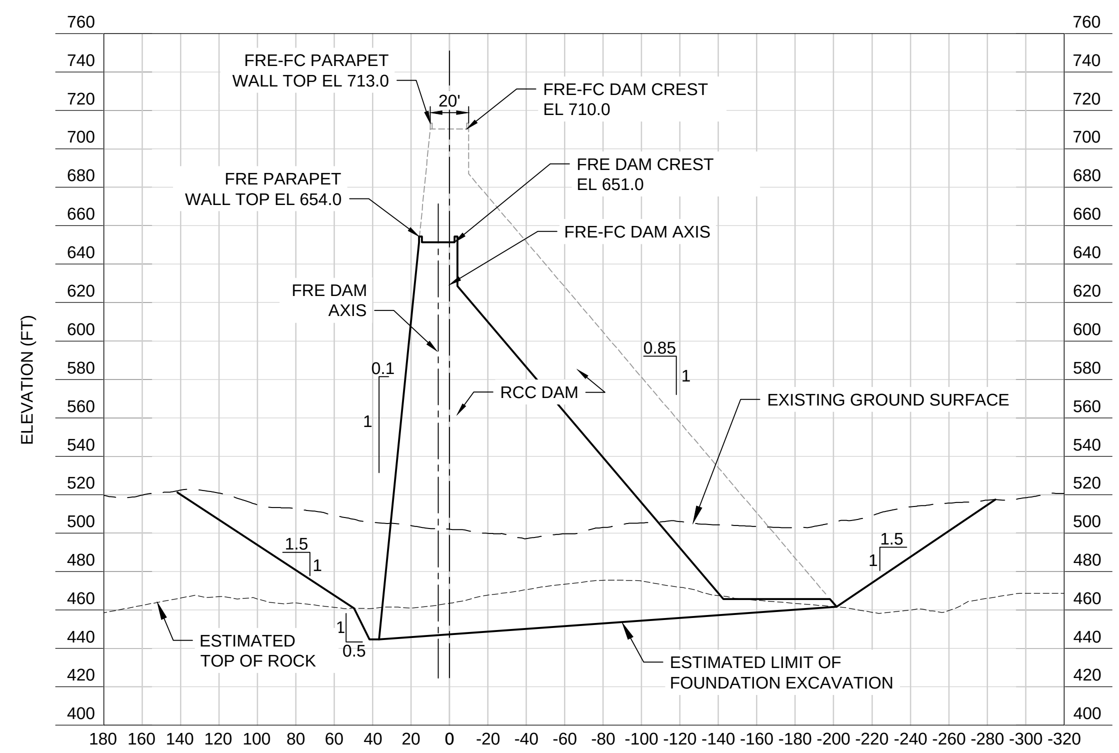
DAM EXCAVATION PROFILE 1 FRE-S-1

0 50 100 200
SCALE IN FEET



DAM EXCAVATION TYPICAL SECTION 14 FRE-S-1

0 25 50 100
SCALE IN FEET



DAM EXCAVATION TYPICAL SECTION 15 FRE-S-1

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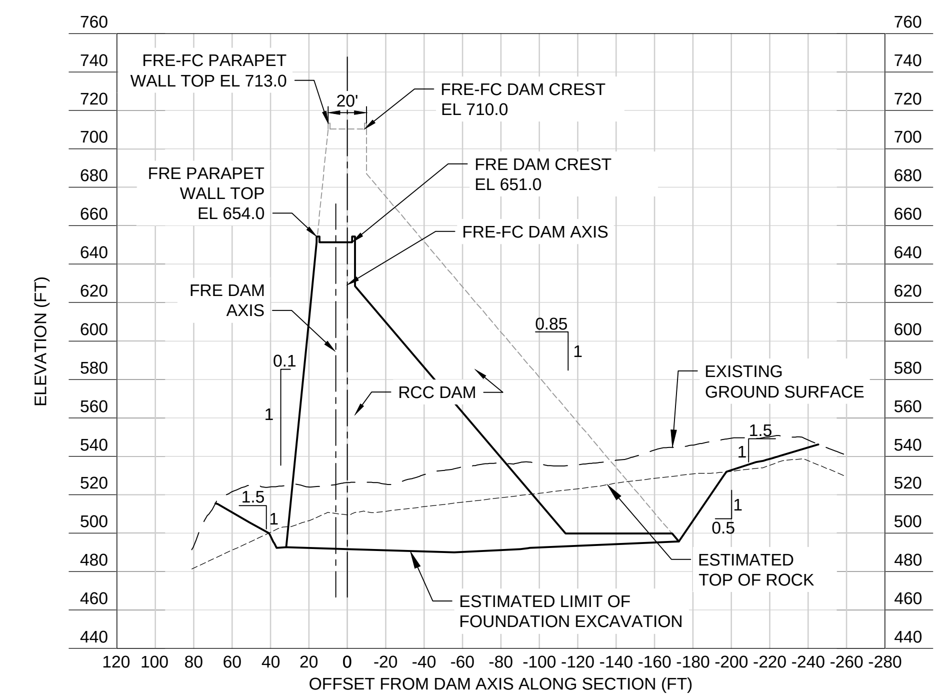
SCALE IN FEET



DAM EXCAVATION TYPICAL SECTION 16 FRE-S-1

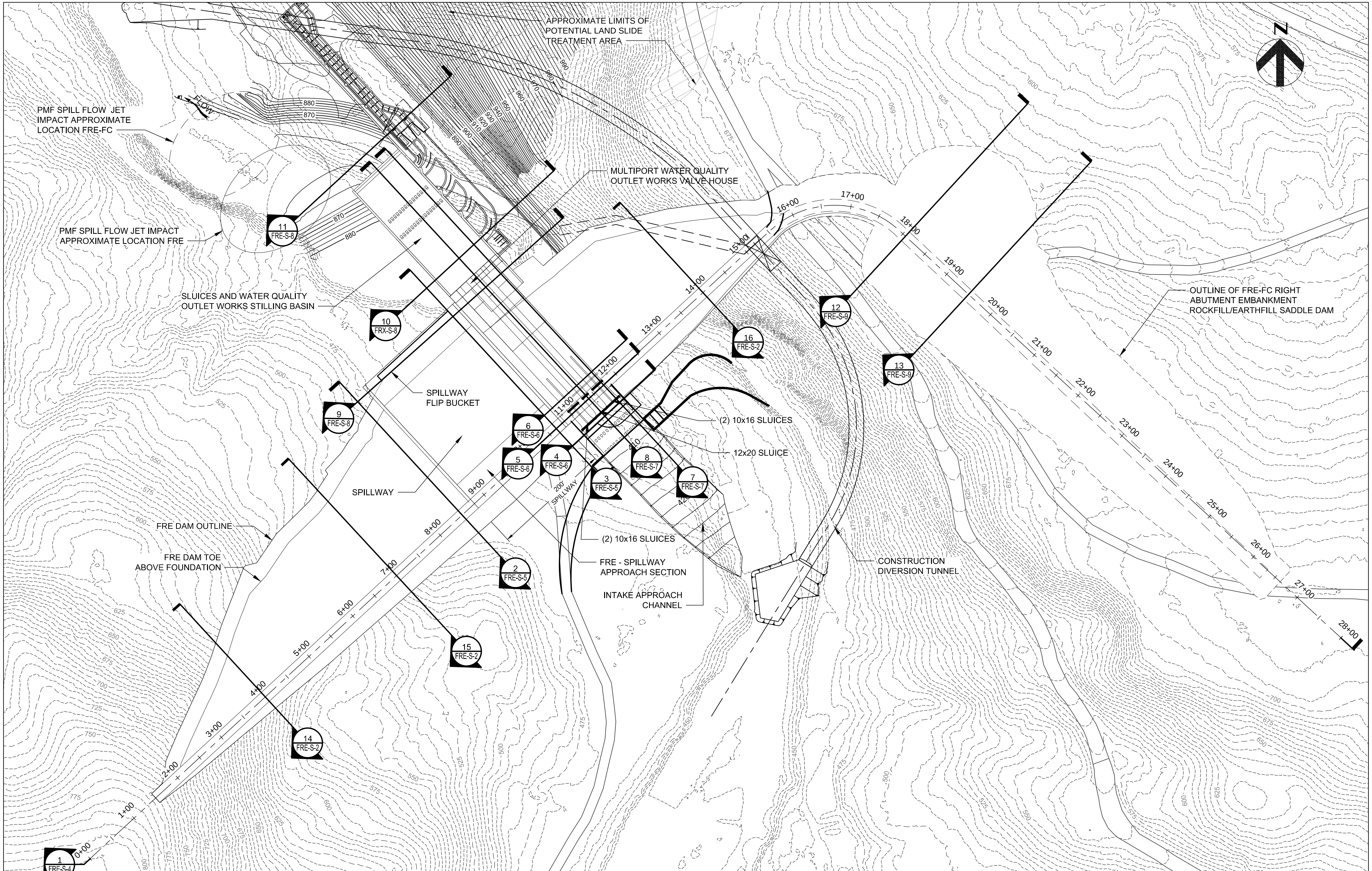
0 25 50 100
SCALE IN FEET

FRE DAM
DAM EXCAVATION PROFILE,
AND TYPICAL SECTIONS 1, 14, 15, AND 16

CHEHALIS BASIN DAM

DATE
SEPT 2018

FIGURE
FRE-S-2



PLAN

0 40 80 160
SCALE IN FEET

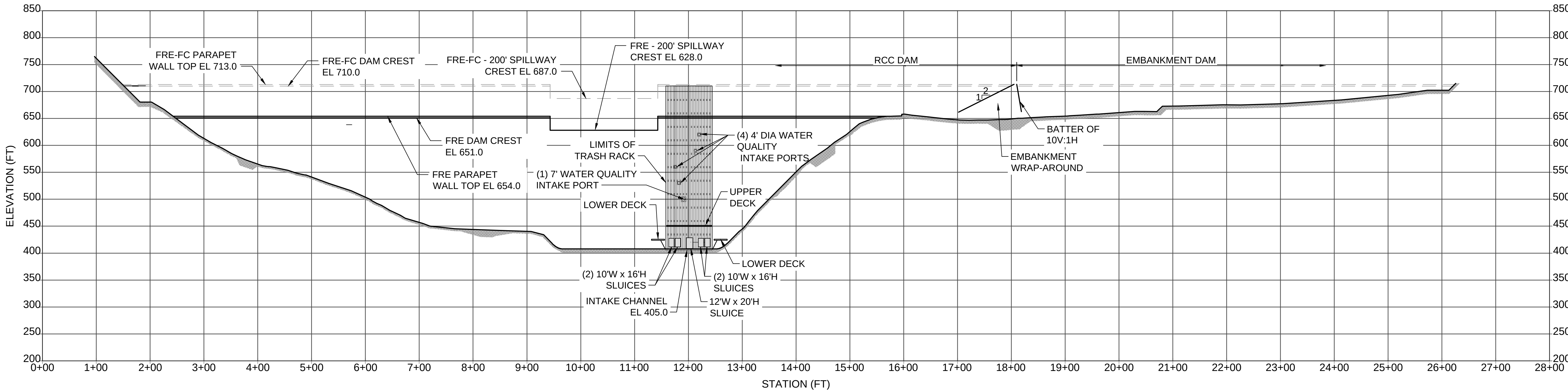
HDR

FRE DAM
DAM PLAN

CHEHALIS BASIN DAM

DATE
SEPT 2018

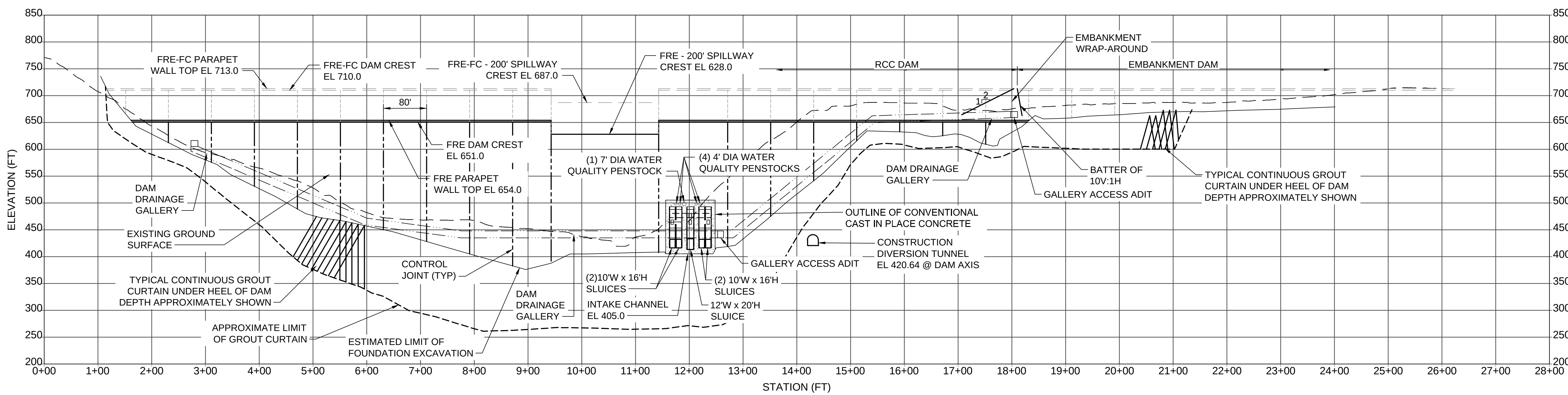
FIGURE
FRE-S-3



DAM ELEVATION VIEW

1 FRE-S-3

0 50 100 200
SCALE IN FEET



SECTION ALONG DAM AXIS

1 FRE-S-3

0 50 100 200
SCALE IN FEET

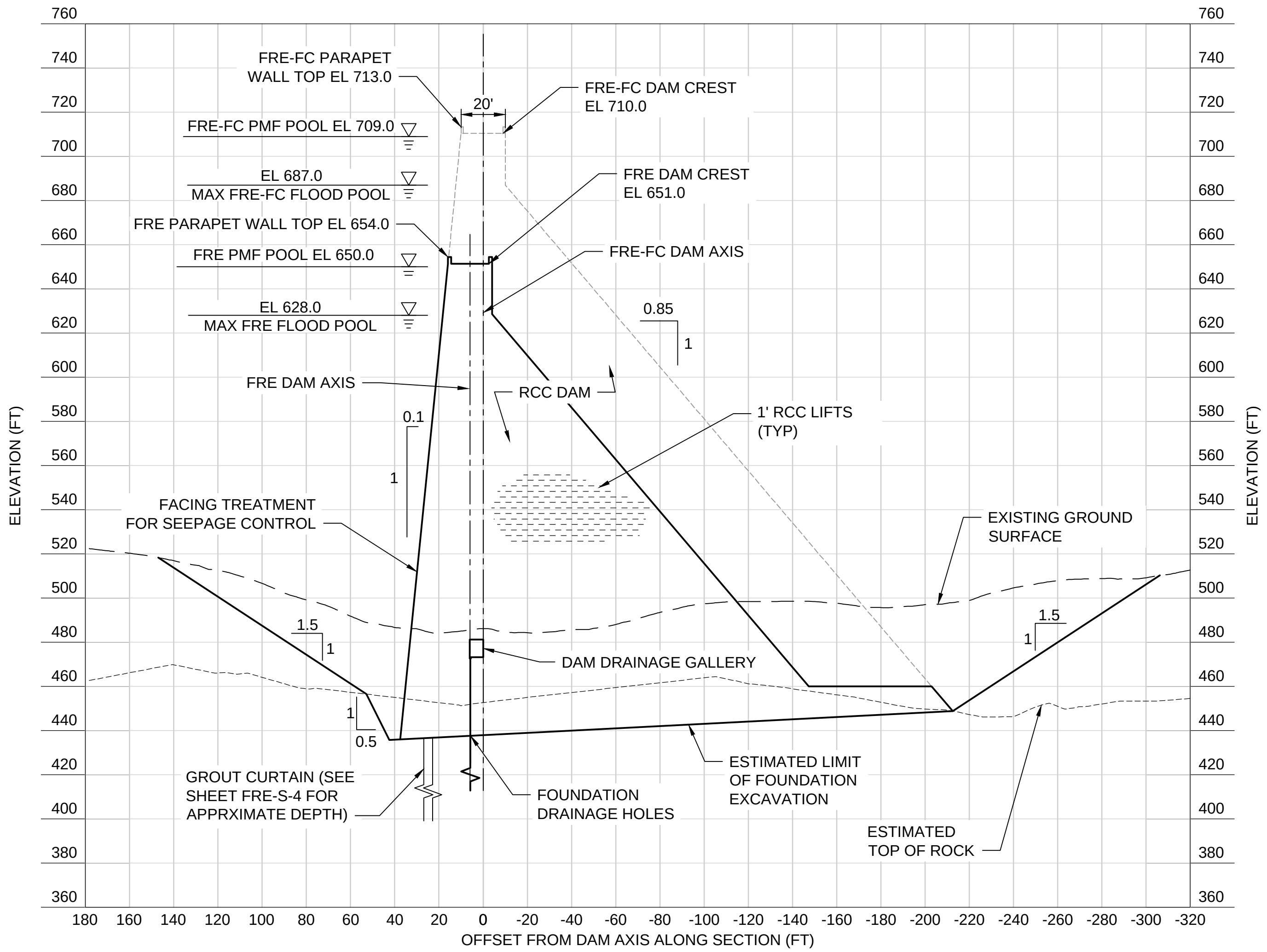
HDR

FRE DAM
DAM ELEVATION VIEW
AND DAM AXIS SECTION 1

CHEHALIS BASIN DAM

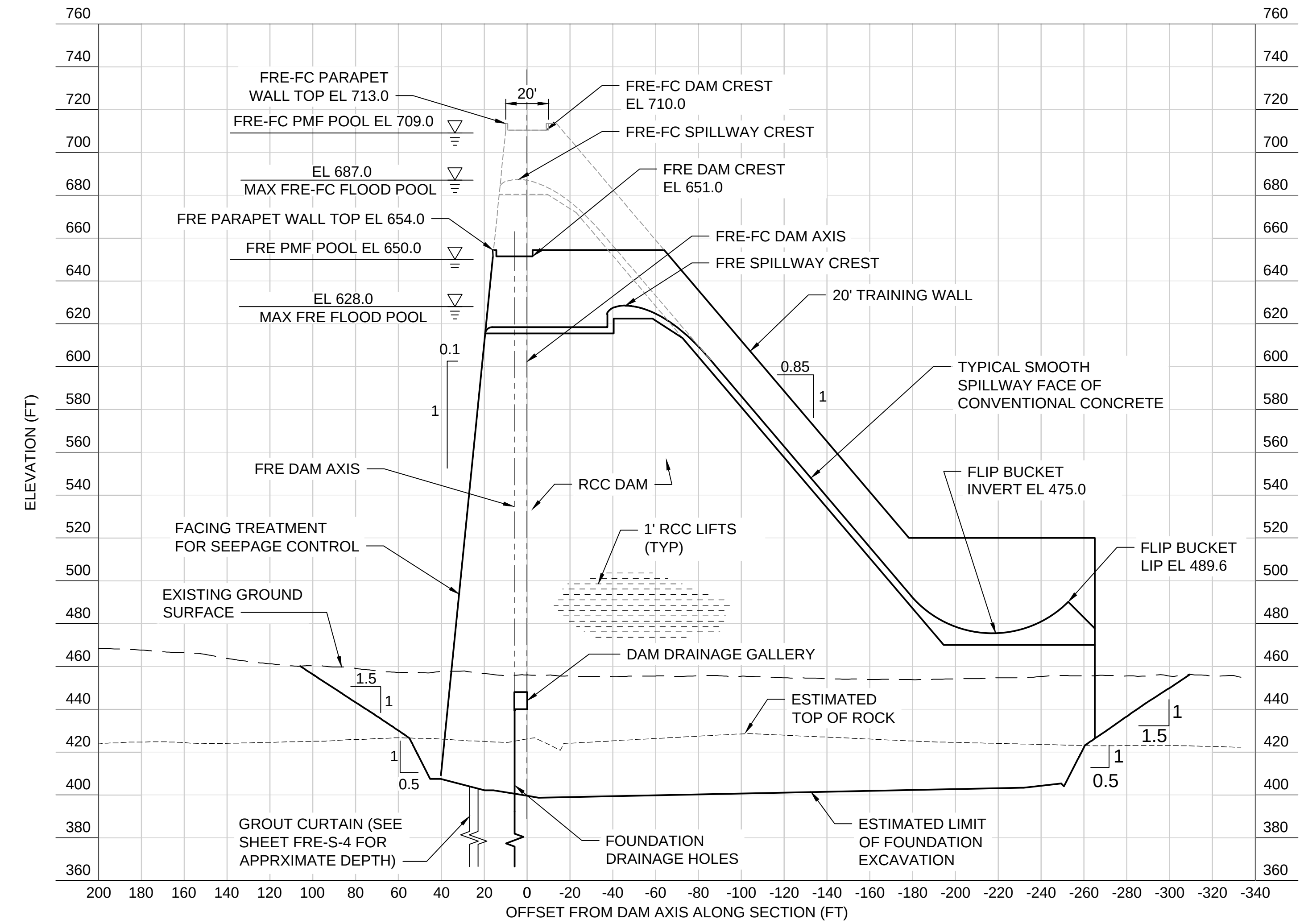
DATE
SEPT 2018

FIGURE
FRE-S-4



SECTION 2 FRE-S-3

0 20 40 80
SCALE IN FEET



SECTION 3 FRE-S-3

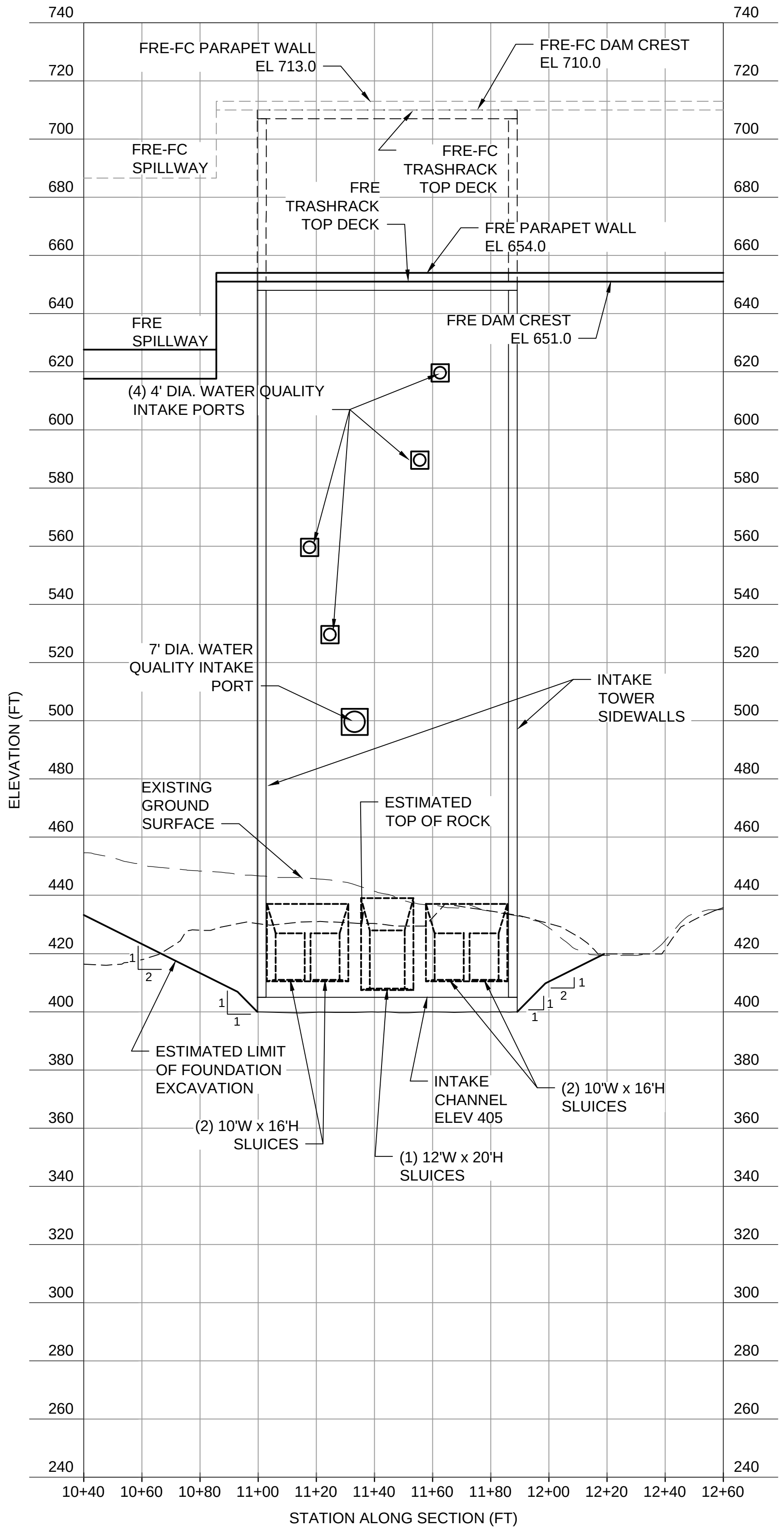
0 20 40 80
SCALE IN FEET

FRE DAM
TYPICAL DAM AND SPILLWAY
SECTIONS 2 AND 3

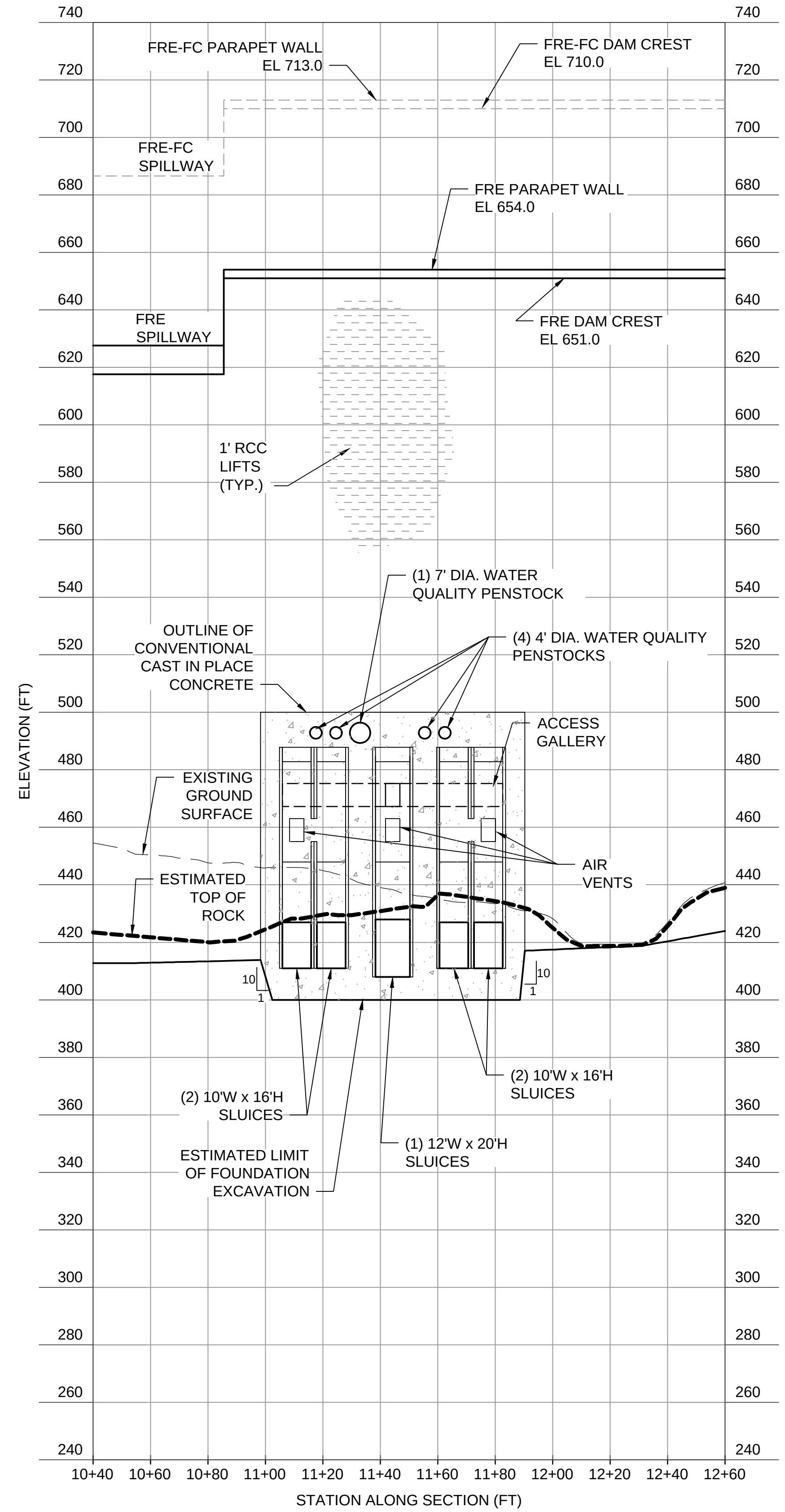
CHEHALIS BASIN DAM

DATE
SEPT 2018

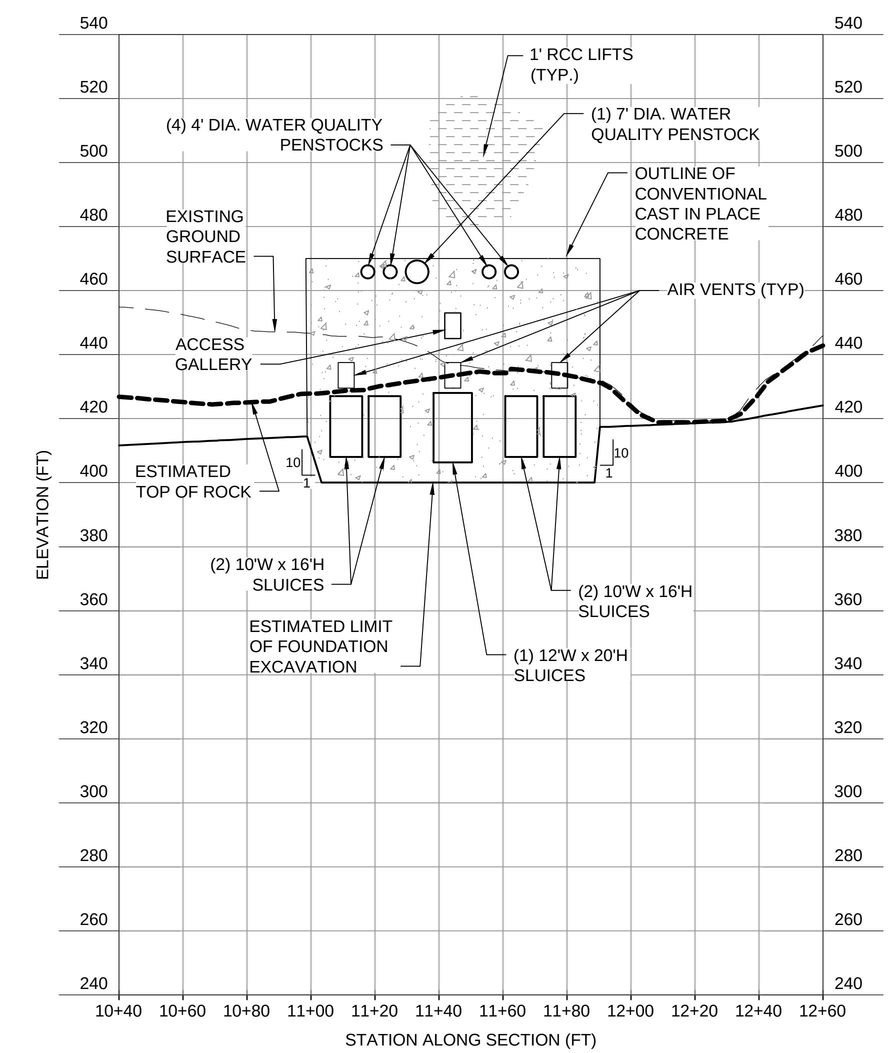
FIGURE
FRE-S-5



SECTION 4 FRE-S-3



SECTION 5 FRE-S-3



SECTION 6 FRE-S-3

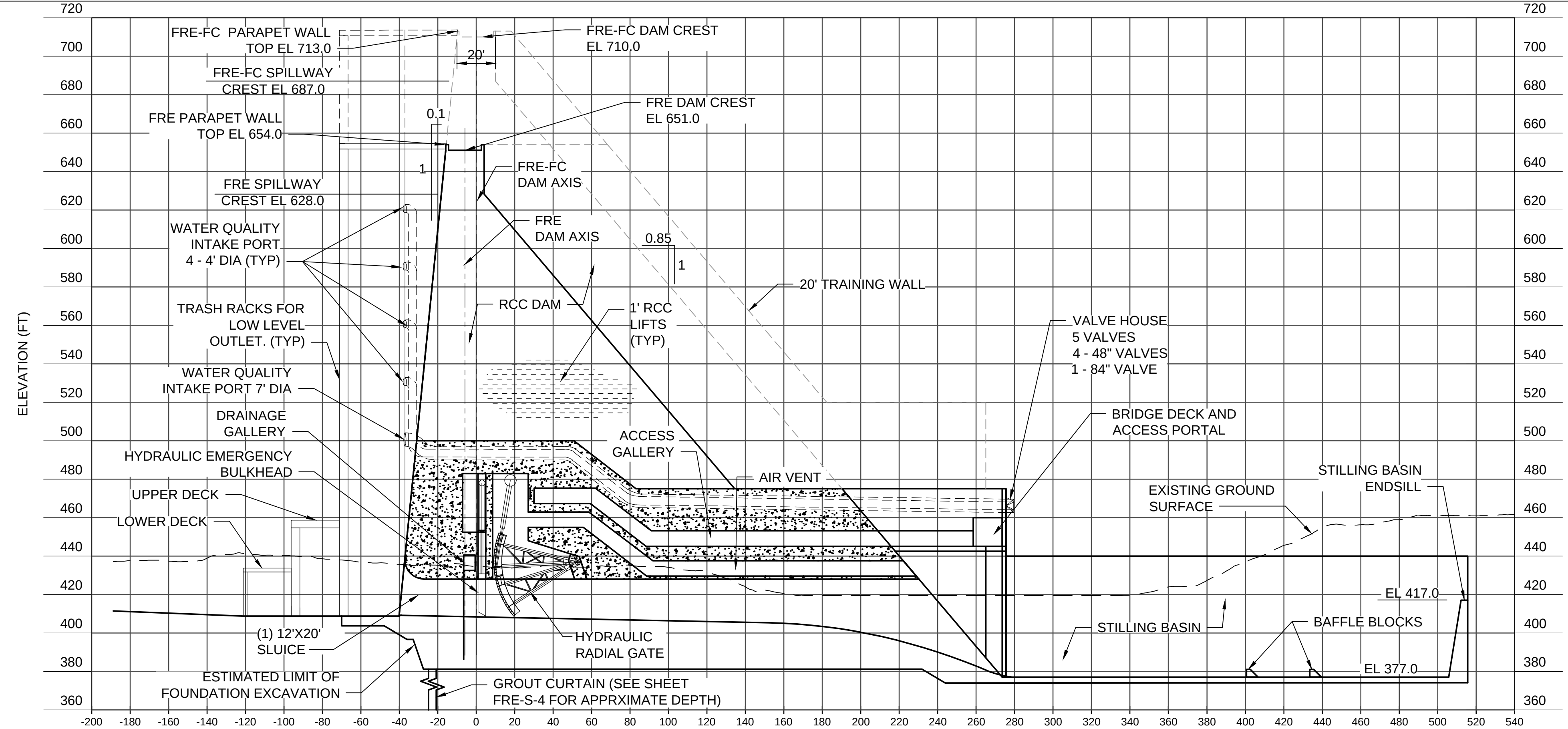
0 25 50 100
SCALE IN FEET

FRE DAM
INTAKE TOWER AND SLUICES
SECTIONS 4, 5, AND 6

CHEHALIS BASIN DAM

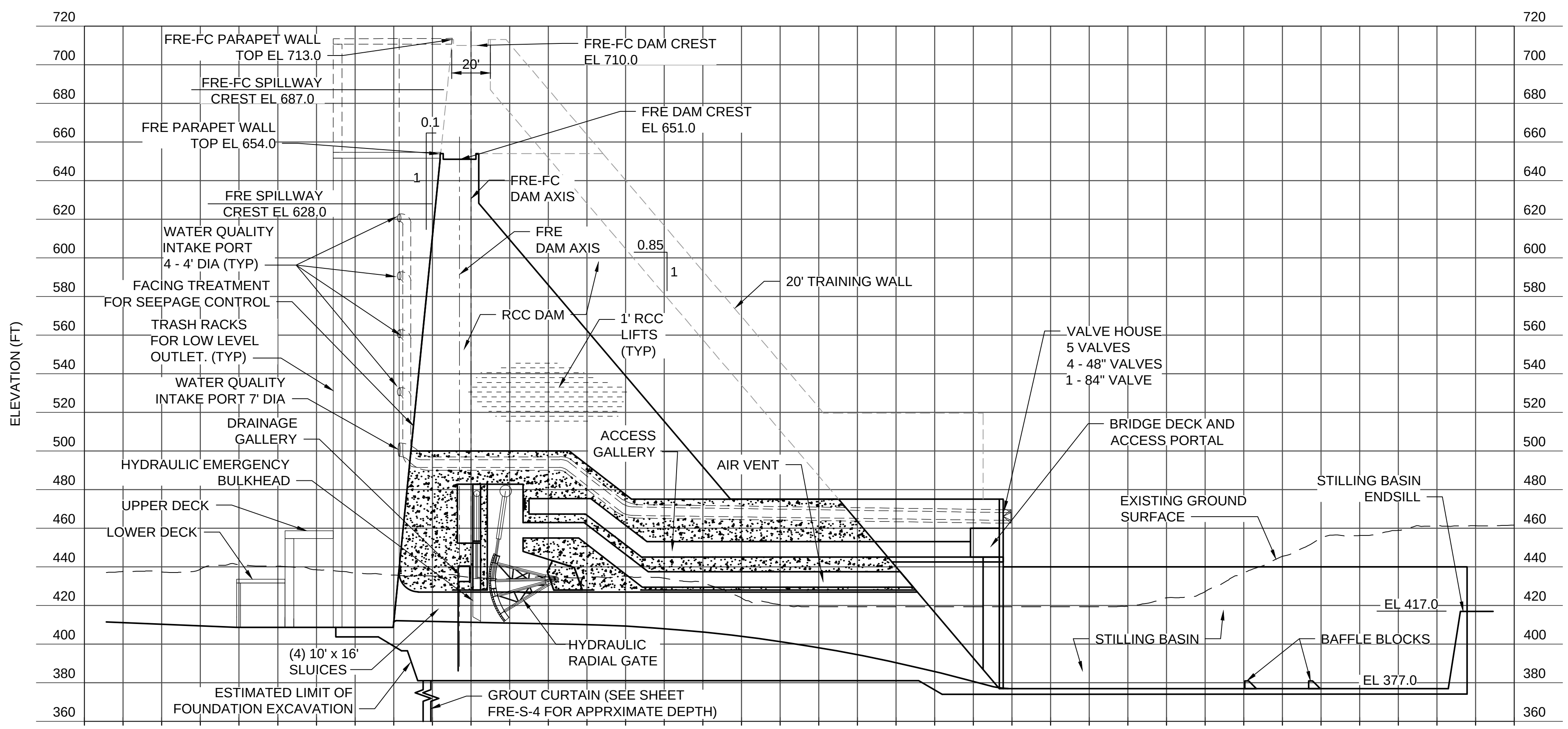
DATE: SEPT 2018

FIGURE: FRE-S-6



SECTION - 12'W x 20'H SLUICE 8 FRE-S-3

0 20 40 80
SCALE IN FEET



SECTION - 10'Wx16'H SLUICE 7 FRE-S-3

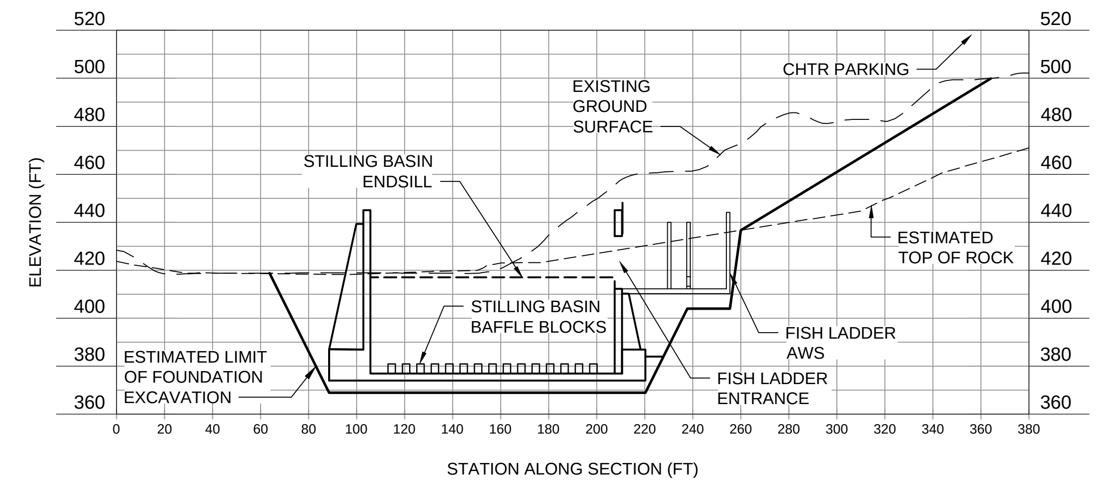
0 20 40 80
SCALE IN FEET

FRE DAM
LOW LEVEL SLUICES
LONGITUDINAL SECTIONS 7 AND 8

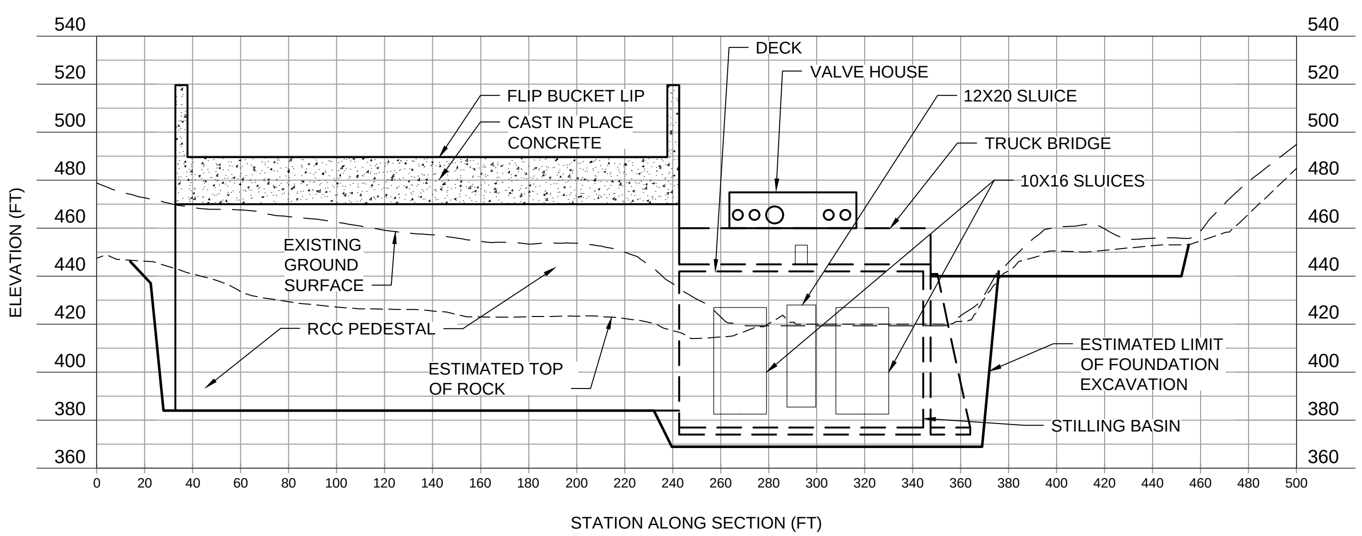
CHEHALIS BASIN DAM

DATE
SEPT 2018

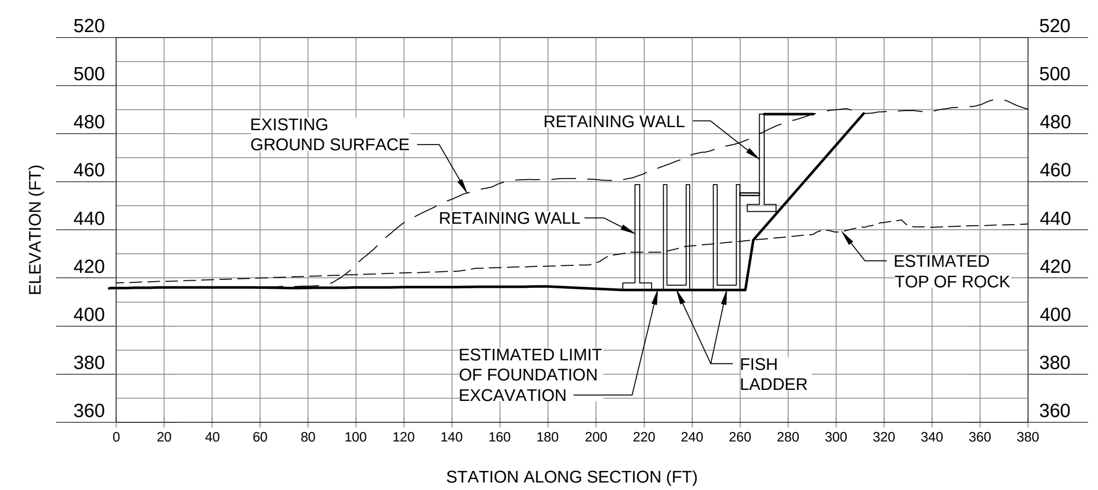
FIGURE
FRE-S-7



SECTION 10 FRE-S-3



SECTION 9 FRE-S-3



SECTION 11 FRE-S-3

NOTE:
1. REFER TO CHTR FACILITY DRAWINGS FOR DETAILED INFORMATION ON RIGHT BANK EXCAVATION AND STRUCTURES

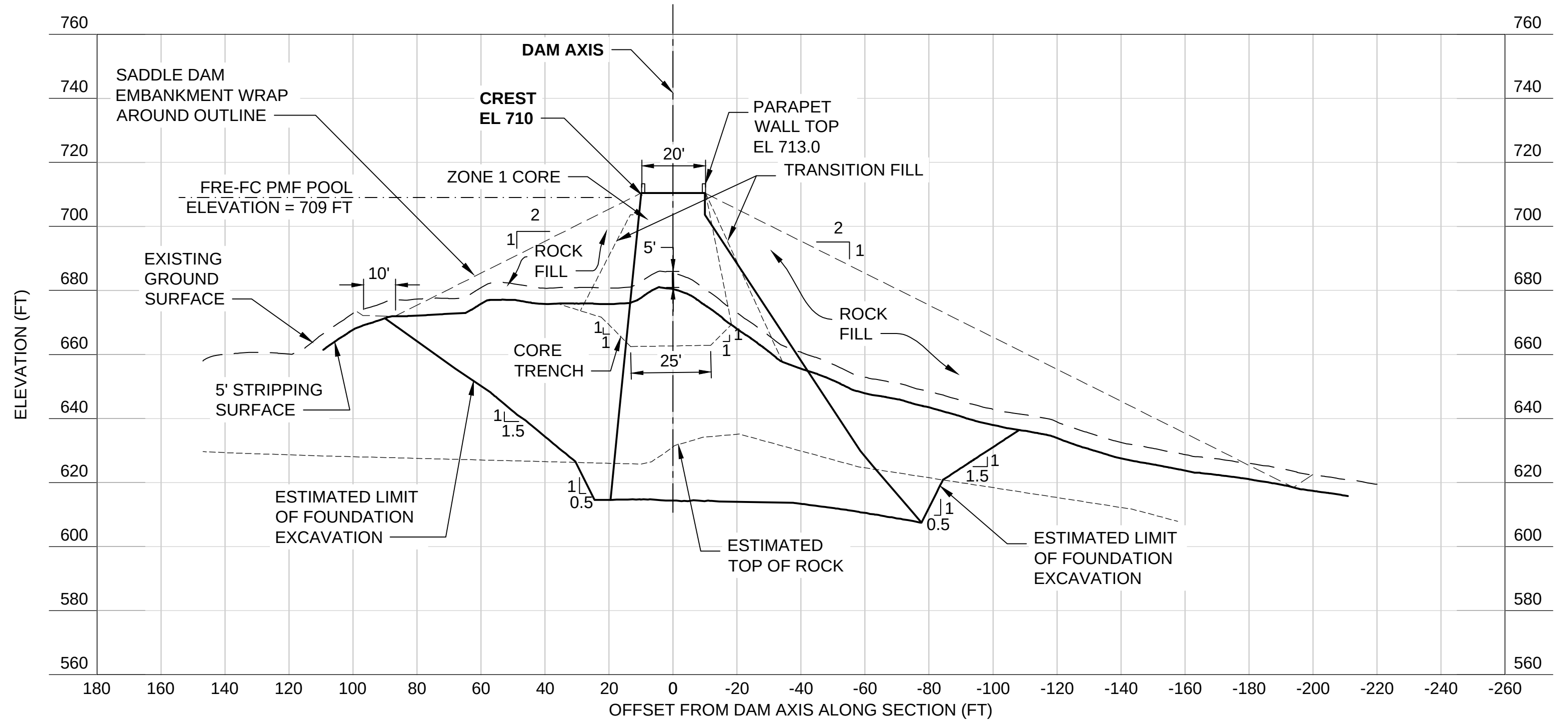
0 20 40 80
SCALE IN FEET

FRE DAM
STILLING BASIN
SECTIONS 9, 10, AND 11

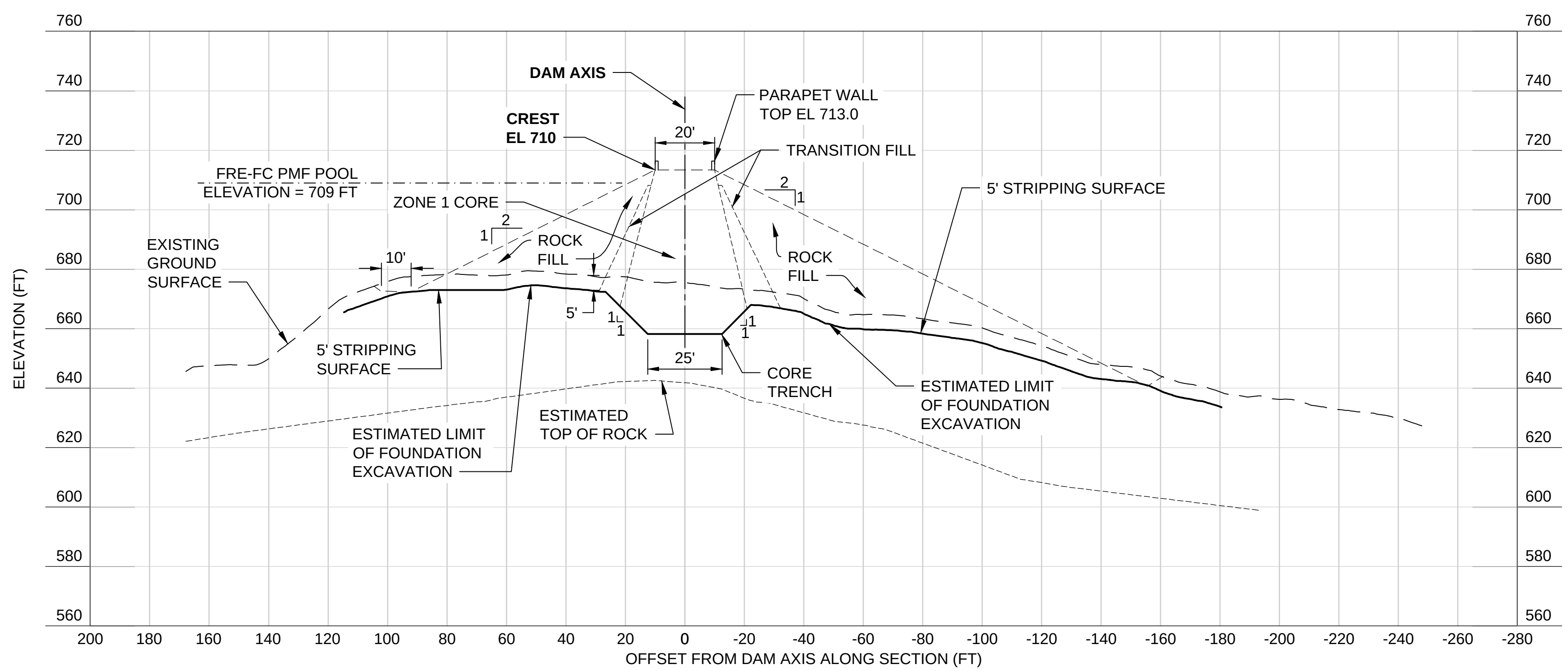
CHEHALIS BASIN DAM

DATE
SEPT 2018

FIGURE
FRE-S-8



SECTION 12 FRE-S-1



SECTION 13 FRE-S-1

0 15 30 60
SCALE IN FEET

HDR

FRE-FC DAM
RIGHT ABUTMENT
EMBANKMENT DAM TYPICAL SECTIONS
12 AND 13
CHEHALIS BASIN DAM

DATE
SEPT 2018

FIGURE
FRE-S-9

PRELIMINARY
NOT FOR CONSTRUCTION

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	
CHECKED BY	MATT PROCIV
CHECKED BY	
DRAWN BY	DON DADE
DESIGNED BY	DON DADE
DESIGNED BY	
PROJECT NUMBER	268421

THE SEAL OF THE STATE OF WASHINGTON 1889

STATE OF WASHINGTON
OLYMPIA
CHEHALIS BASIN STRATEGY

CHTR FISH PASAGE FACILITY

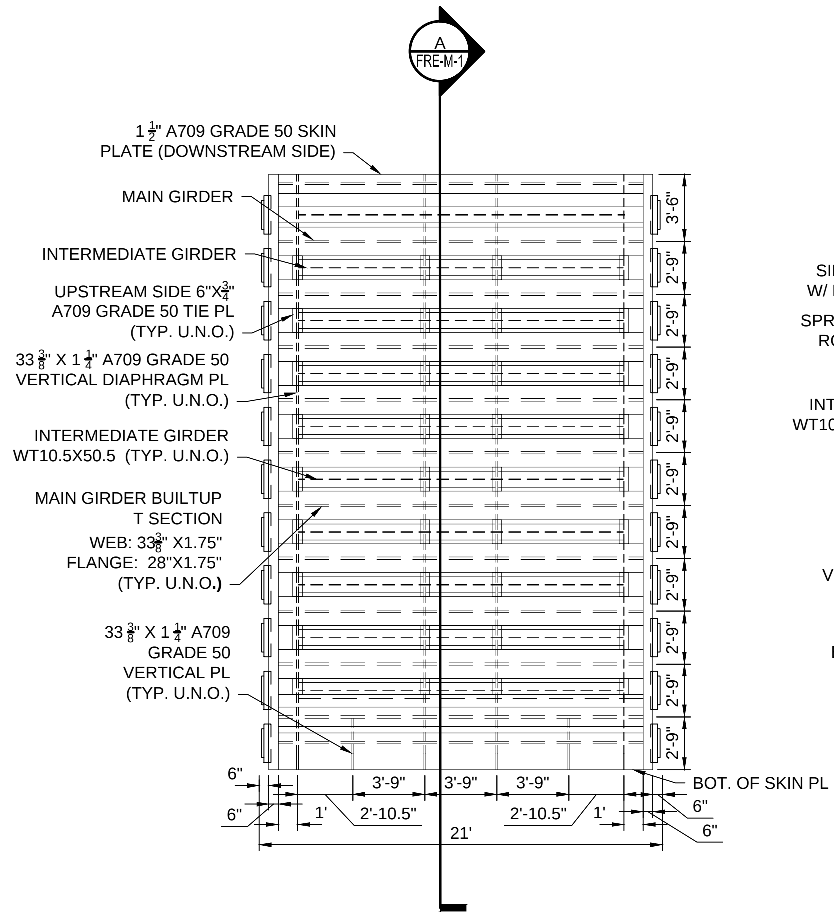
GENERAL

FACILITY ISOMETRIC - AERIAL

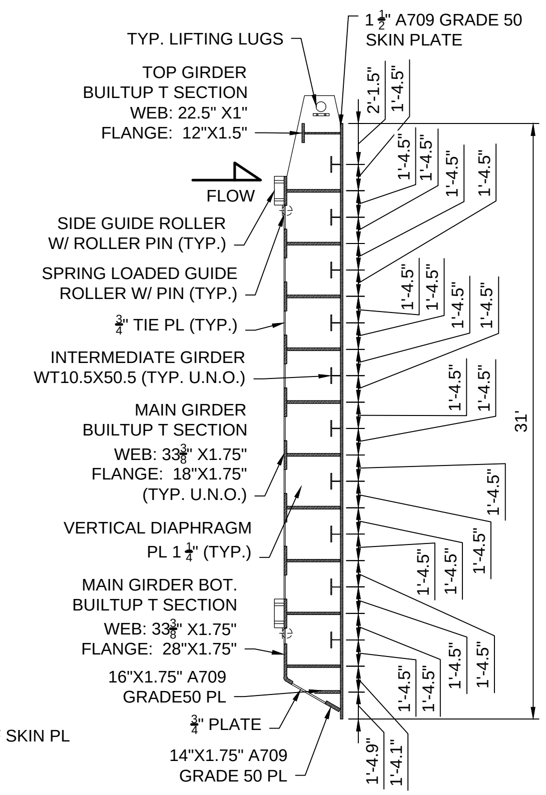
0 1" 2"

DATE JUNE, 2017
SCALE NTS

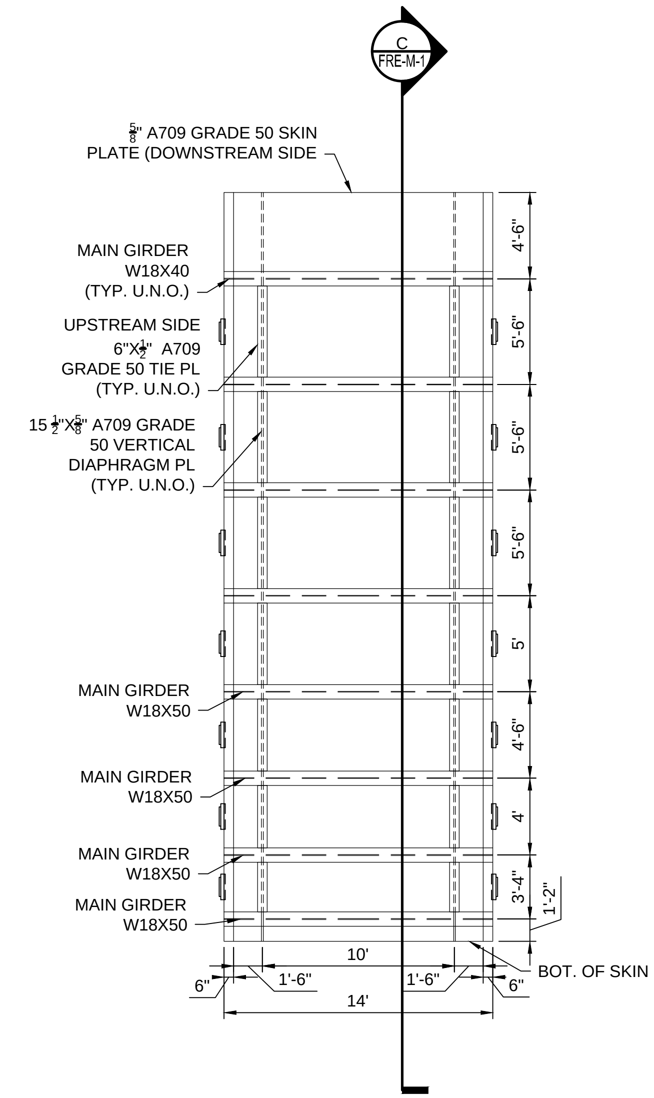
SHEET G-6



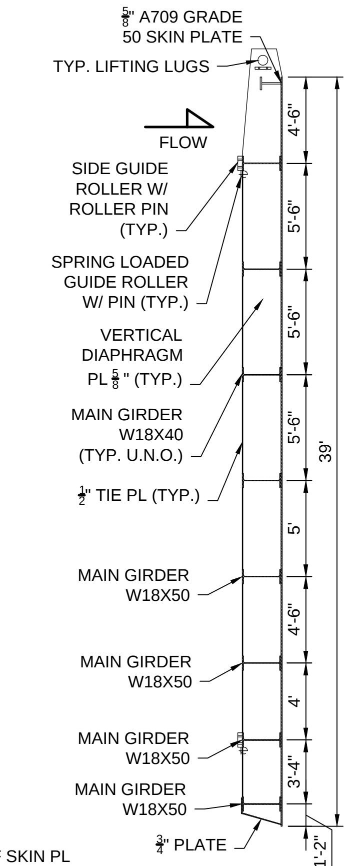
ELEVATION UPSTREAM DEWATERING BULKHEAD 1 FRE-M-1



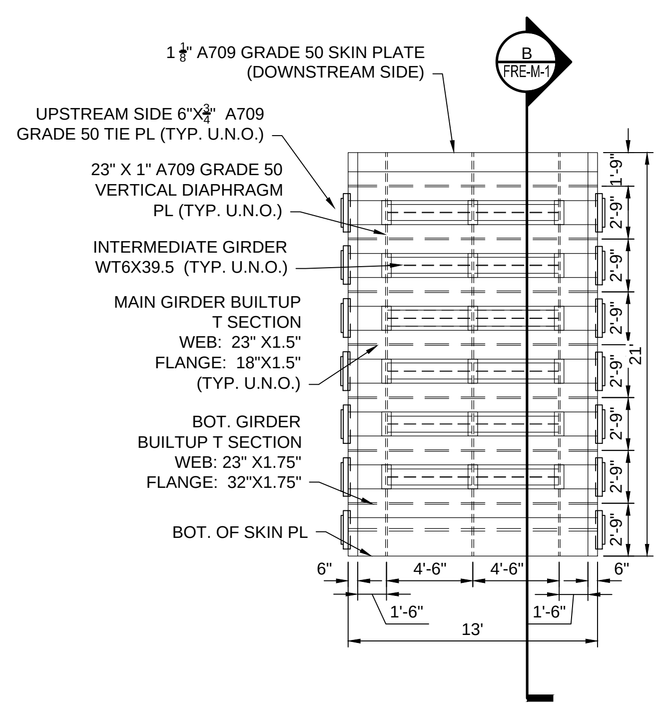
SECTION A FRE-M-1



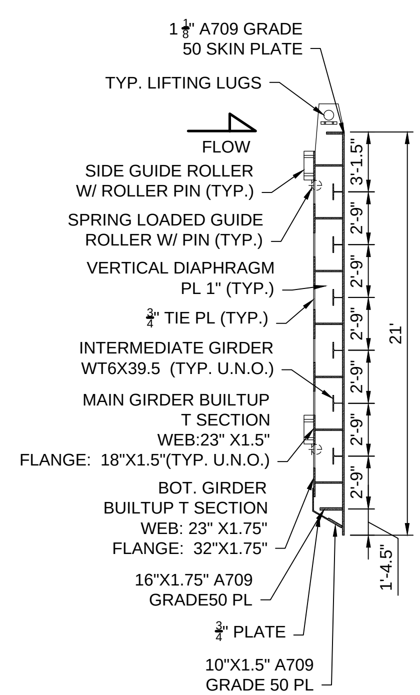
ELEVATION DOWNSTREAM DEWATERING BULKHEAD 3 FRE-M-1



SECTION C FRE-M-1



ELEVATION EMERGENCY CLOSURE GATE 3 FRE-M-1



SECTION B FRE-M-1

0 2.5 5 10
SCALE IN FEET

FRE DAM
LOW LEVEL SLUICES
GATES AND BULKHEADS DETAILS
12' x 20' SLUICE
CHEHALIS BASIN DAM

DATE	SEPT 2018
FIGURE	FRE-M-1

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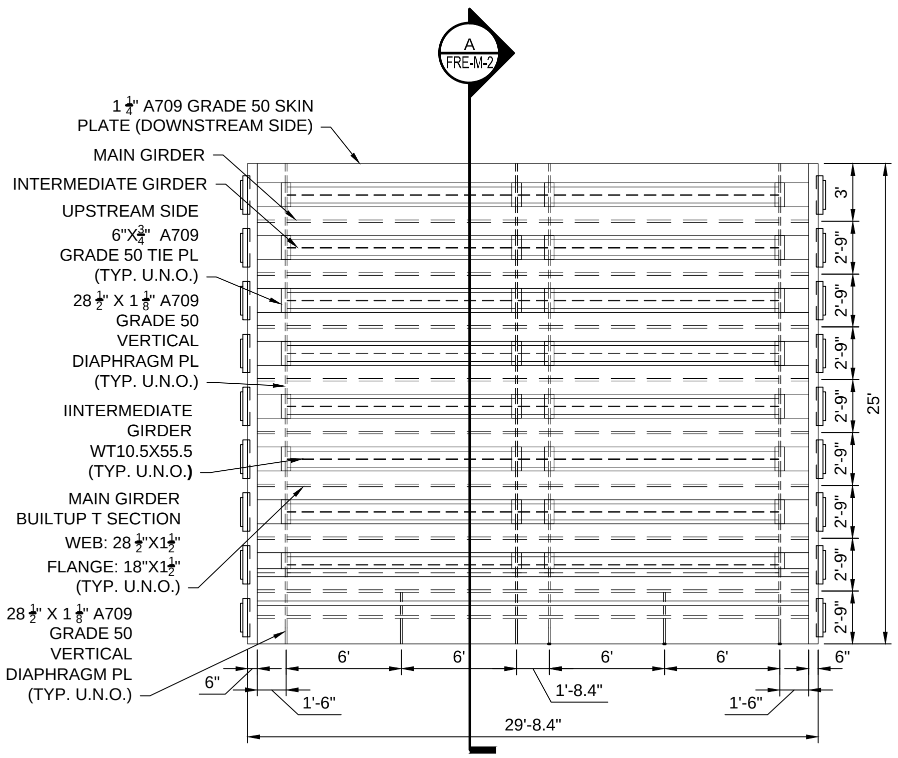
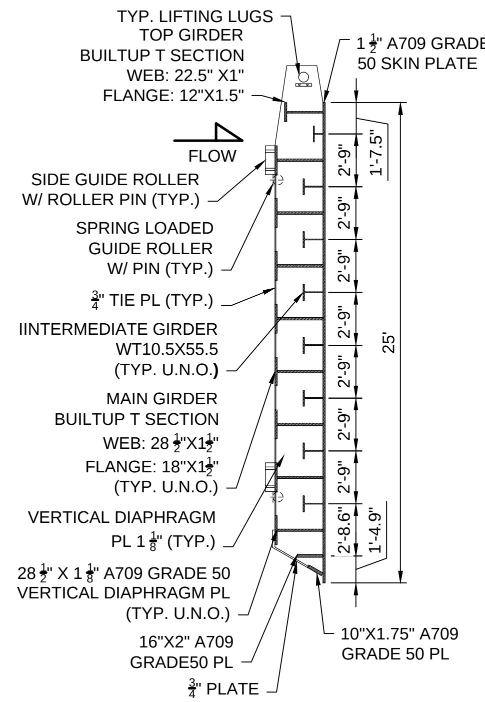
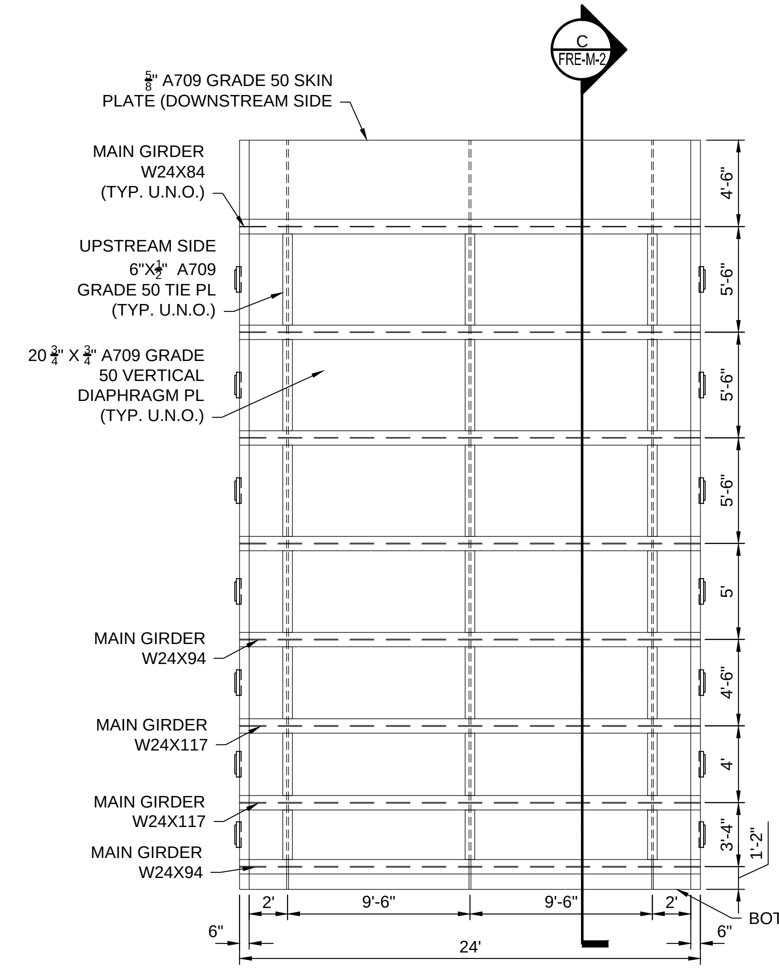


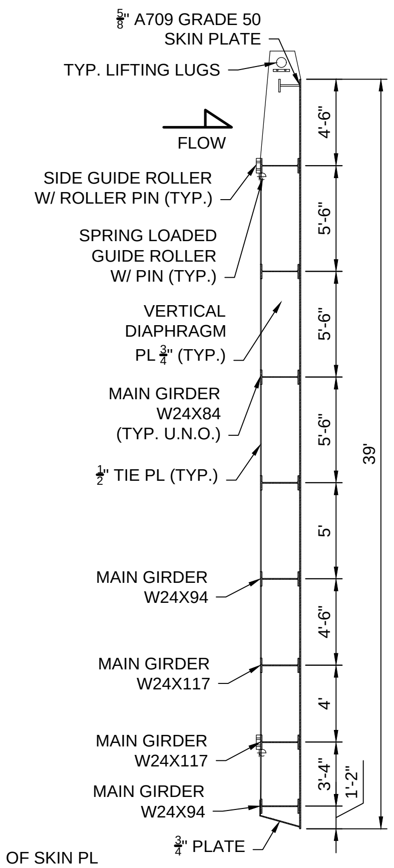
ELEVATION UPSTREAM DEWATERING BULKHEAD (1, FRE-M-2)



SECTION (A, FRE-M-2)



ELEVATION DOWNSTREAM DEWATERING BULKHEAD (3, FRE-M-2)



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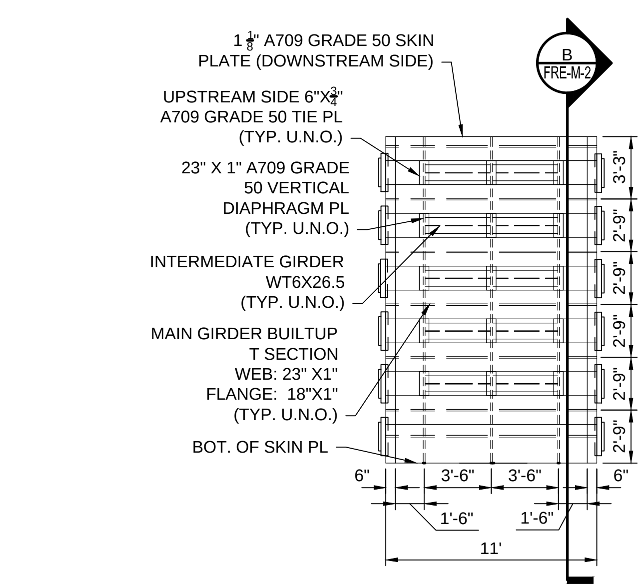
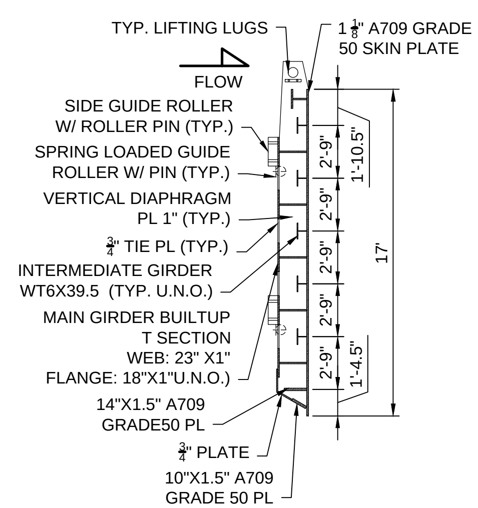
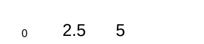


ELEVATION EMERGENCY CLOSURE GATE (3, FRE-M-2)

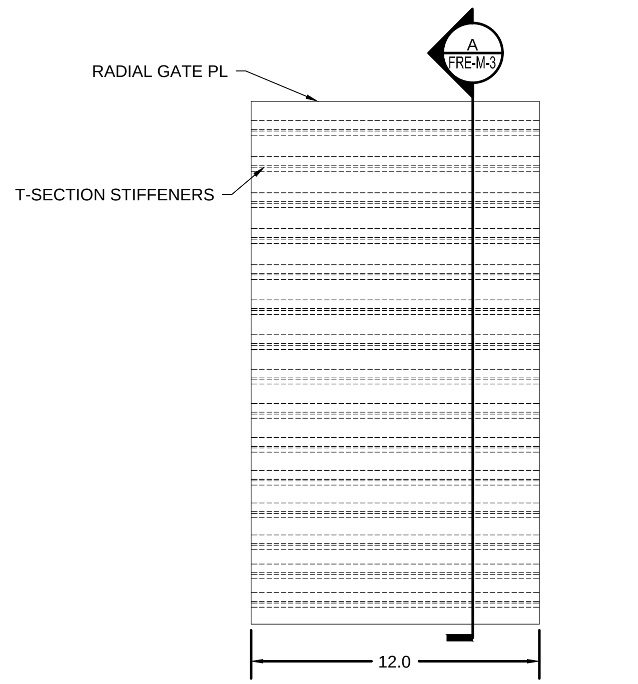


SECTION (B, FRE-M-2)

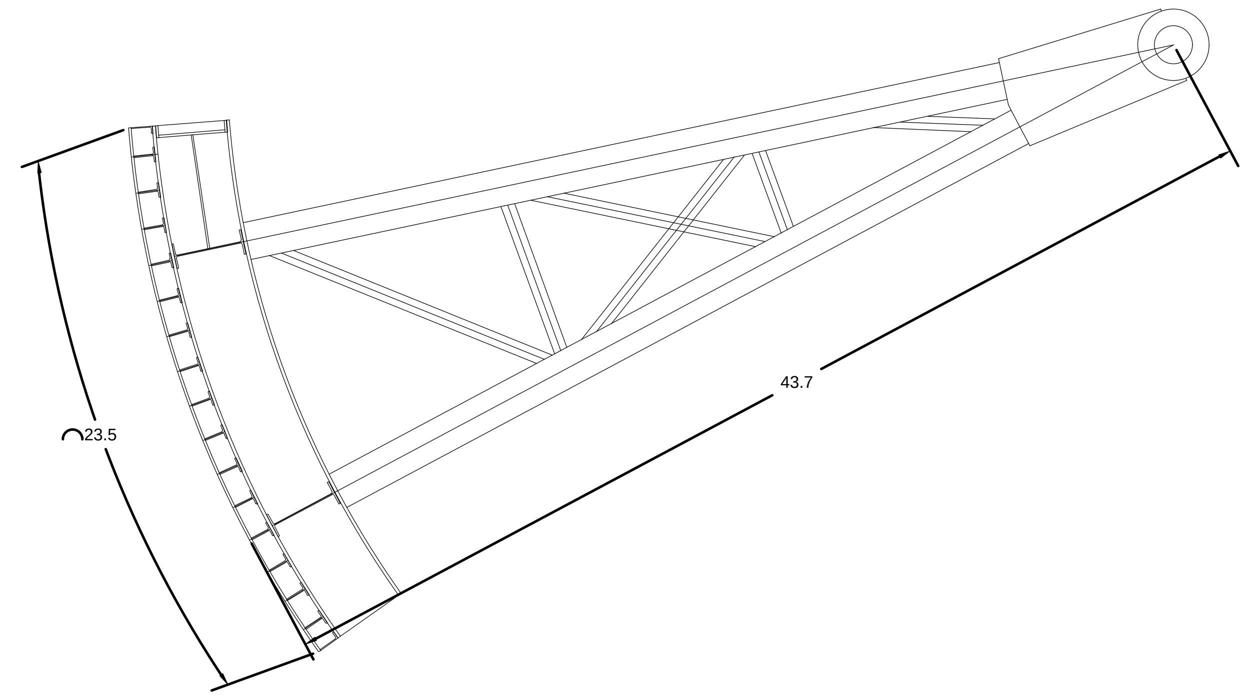


FRE DAM
LOW LEVEL SLUICES
GATES AND BULKHEADS DETAILS
10' x 16' SLUICE
CHEHALIS BASIN DAM

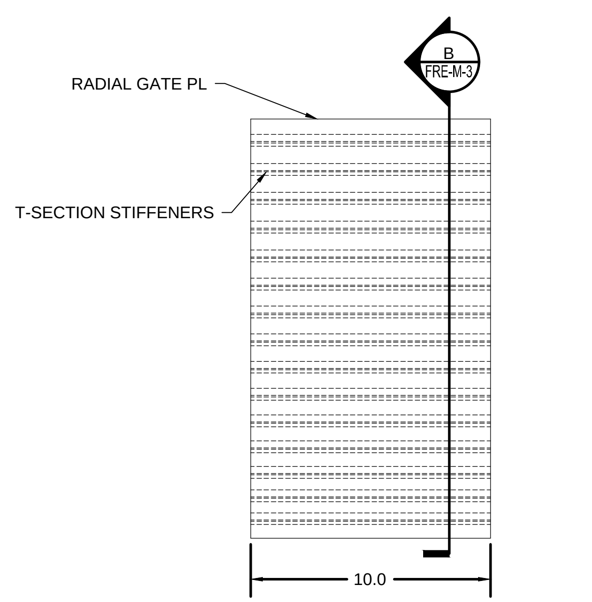
DATE	SEPT 2018
FIGURE	FRE-M-2



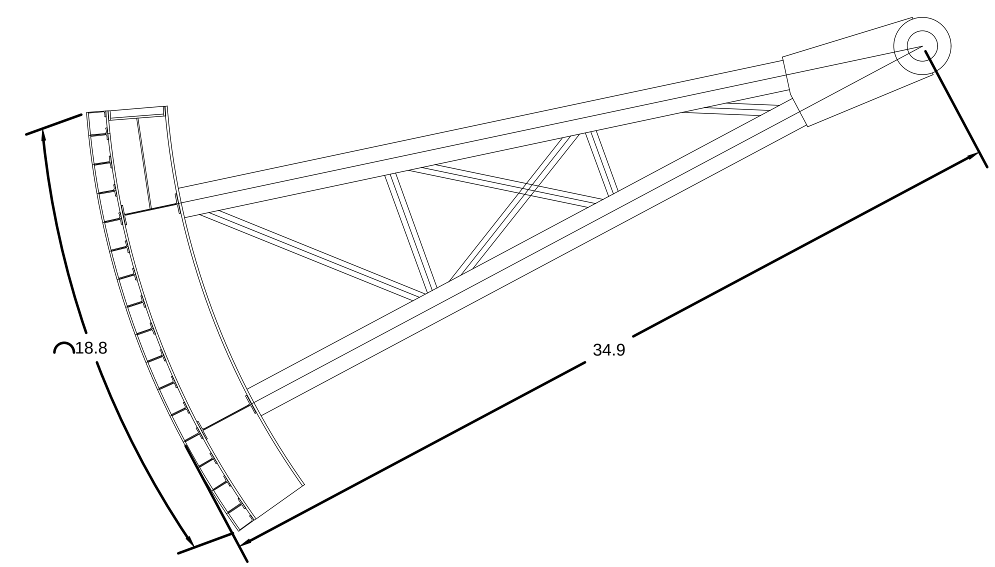
FRONT ELEVATION 12'X20'
RADIAL SLUICE GATE
1
FRE-M-3



SECTION
A
FRE-M-3



FRONT ELEVATION 10'X16'
RADIAL SLUICE GATE
2
FRE-M-3



SECTION
B
FRE-M-3

0 2 4 8
SCALE IN FEET

FRE DAM
LOW LEVEL SLUICES GATES DETAILS
12' x 20' AND 10' x 16' RADIAL GATES

CHEHALIS BASIN DAM

DATE	SEPT 2018
FIGURE	FRE-M-3

Appendix I
Hydraulic Design

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ACRONYMS AND ABBREVIATIONS

AEP	annual exceedance probability
AW	Ackers-White
cfs	cubic feet per second
EM	engineering manual
ER	engineering report
FRFA	flood retention flow augmentation
FRO	flood retention only
FRE	flood retention expandable
FRE-FC	flood retention expandable-future configuration
ft	foot/feet
HDC	Hydraulic Design Criteria
HEC	Hydrologic Engineering Center
LiDAR	Light Detection and Ranging
msl	Mean sea level
MPM	Meyer-Peter-Mueller
PMF	probable maximum flood
PMP	Probable maximum precipitation
RCC	roller-compacted concrete
USACE	U.S. Army Corps of Engineers
USBUREC	U.S. Bureau of Reclamation
WSE	Watershed Science & Engineering

1 DAM ALTERNATIVE DESCRIPTION

1.1 Flood Retention Expandable (FRE) Alternative

The FRE dam and fish passage configuration was conceived from a combination of the Flood Retention Only (FRO) and Flood Retention and Flow Augmentation (FRFA) alternatives. The FRE is designed to facilitate potential future expansion of the dam, if desired. The future configuration is referred as FRE-FC in this report. The FRE and FRE-FC are both designed to provide downstream flood protection benefits, but have different dam heights, operational approach, and potential storage volumes. The FRE configuration would be constructed within the FRFA dam foundation footprint to the height of the FRO dam and fish passage configuration. The FRE-FC configuration would involve building upon the FRE dam to raise the dam to the full FRFA dam height and would allow the dam to function in accordance with the FRFA alternative. The FRE dam is designed to only store flood flows as needed to control downstream river flows to the desired Grand Mound gage control flow. The FRE-FC dam is designed to provide augmentation of downstream river flows during low flow periods for certain fish species and aquatic habitat enhancement as well. The specific control flow downstream of 38,000 cfs at the Grand Mound gage, or about a 1 in 7 year flood event, has been identified in preliminary assessments, but that value may change as the larger study progresses.

1.1.1 FRE Dam

Similar to the FRO alternative, the FRE dam would be a Roller Compacted Concrete (RCC) gravity dam. The Dam would typically not impound Chehalis River flows until and unless a large flood is forecasted to occur. The dam would be equipped with spillway structure, low level outlet works, stilling basin and fish passage facility. Under typical operation whenever flood flow regulation is not needed, there would be no reservoir impoundment, as the sluice gates would be held fully open to pass all inflows without retention. The low level sluices would be large in size to provide relatively unimpeded fish passage through the sluice conduits at all typical flows less than about 2,000 cfs. The FRE dam is designed to only store flood flows as needed to regulate downstream river flows to the desired Grand Mound gage control flow. The FRE dam operation is patterned after the Seattle District of the US Army Corps of Engineers' Mud Mountain Dam on the White River, near Enumclaw, Washington.

1.1.2 FRE-FC Dam

The FRE-FC will be constructed by raising the FRE dam through placement of additional roller compacted concrete to the height of the FRFA dam alternative. The FRE-FC dam is designed to provide a permanent storage pool to allow augmentation of downstream river flows during low flow periods for fish and aquatic habitat enhancement, while also providing additional storage volume above the permanent pool for floodwater storage to accommodate extreme precipitation and runoff events. The dam would be equipped with a spillway structure, low level outlet works, water quality outlet works, stilling basin and fish passage facilities.

2 DAM ALTERNATIVE DESIGN

2.1 FRE Configuration

The currently envisioned FRE alternative's primary characteristics include the following:

- A Roller Compacted Concrete (RCC) dam of 254 to 270 feet estimated maximum dam structural height depending on final foundation elevation and a large foundation footprint to accommodate the potential future construction of FRE-FC
- Dam crest length of approximately 1,225 feet to span the Chehalis valley
- Uncontrolled overflow spillway approximately 200 ft wide, with crest elevation 628 ft designed to pass the Probable Maximum Flood (PMF) event, but expected to operate very infrequently
- Smooth spillway ogee and chute cast over the RCC dam section. Chute would have training/containment walls approximately 20 feet in height.
- Spillway terminus flip bucket to eject jet well out and away from the dam structure
- Spillway discharge plunge pool well downstream of the toe of the dam
- Single 12 ft wide by 20 ft high low level sluice to pass sediment and low head flood flows, with invert elevation approximately at existing river channel bed elevation. This sluice floor would be expected to be repaired regularly due to sediment abrasion and erosion, much like Mud Mountain Dam.
- Two pairs of large 10 ft wide by 16 ft high low level sluices to pass high head flood flows, with invert elevation about 3 feet higher than the existing river channel bed elevation. These would be used to pass flow when the reservoir exceeded about 50 feet of head and sediment would no longer be actively moving through the dam
- Multiport water quality inlets/outlets that draw water from multiple levels within the reservoir and a low-level flood control outlet. The water quality outlet work will be constructed during the FRE to simplify the future potential development to FRE-FC dam. The multiport outlet works could potentially be operated in FRE dam for flood regulation purposes, though, they are currently envisioned to only be functional in FRE-FC dam for water quality purposes.
- A full height trashrack upstream of the outlet works to capture large wooden debris. The lower 50 ft of trashrack is offset about 25 ft upstream of the upper portion to accommodate and simplify the debris removal process.
- Construction diversion tunnel about 20 ft in diameter through the right abutment. The tunnel floor would be lined with concrete to provide a smooth invert wear layer for sediment passage during construction, and would be plugged following completion of the low level outlet sluices but provided with a drain valve to evacuate the reservoir if needed

- Hydraulic jump-type energy dissipating stilling basin approximately 240 feet long by 100 ft wide and 40 feet deep with baffle blocks to contain and dissipate flow energy from the low level outlet sluices. The stilling basin would be concrete lined, and would have an end sill elevation roughly the same elevation as the downstream river channel
- Fish ladder and collection channel with entrances along the right wall of the stilling basin to attract and pass upstream migrating fish to the trap and haul facility
- Initial target flood storage pool volume of 65,000 acre-ft, to be activated in flood events larger than the estimated 7-year recurrence interval event. This value may change as the economic benefit-to-cost studies progress to identify the preferred storage volume

The flood regulation operation is achieved by radial sluice gates controlling sluice discharge when required under the prescribed operation plan. The reservoir would not be impounded unless the Chehalis River at the Grand Mound gage was forecasted to rise above 38,000 cfs, at which point the sluices would be gradually closed to retain flood flows. When the Grand Mound gage flow is predicted to fall below 38,000 cfs, the sluices would be gradually opened to draft the reservoir. Except during flood control operations, the sluice gates are to remain fully open, freely passing sediment, smaller woody debris that can readily pass through the trashrack, and fish both upstream and downstream. Larger woody debris that becomes lodged against the trashrack would be removed as needed to keep the channel clear and permit unfettered fish passage and maintain sediment transport continuity through the dam.

A good analogous existing dam would be the Mud Mountain Dam on the White River in western Washington State, owned and operated by the US Army Corps of Engineers in a very similar fashion. The Mud Mountain Dam on the White River in western Washington State, owned and operated by the US Army Corps of Engineers, has been operating successfully since the late 1940's and operates in a very similar fashion. Similar to the proposed FRE dam alternative for Chehalis River, the Mud Mountain dam is a run-of-river type dam which does not typically impound the river flows unless a large flood is forecasted to occur. In this case, the flood regulation operation will commence by closing the low level outlets, holding back water and slowly releasing water back into the river after the flood wave is dampened. However, unlike the FRE dam alternative, the Mud Mountain Dam does not pass upstream migrant fish through the low level outlet sluices, and instead utilizes a separate downstream low barrier weir and trap and haul facility operated continuously to collect and transport upstream migrating fish from all five species of Pacific salmonids to the extensive watershed habitat above the dam.

Similar to FRO, when flood regulation operation is commenced, the sluice gates would be throttled as needed to reduce mainstem flow sufficiently to hold the Grand Mound gage at or below 38,000 cfs. Once flood control operations begin, fish passage would be limited or temporarily suspended as a result of the high flow velocities within the low level sluice conduits. However, coincident with the commencement of flood regulation operation, the fish ladder would be opened and fish would be attracted to the ladder and collection facility instead of the low level sluices. A trap and haul facility would begin operations to move upstream migrating fish above the dam to a release point above the reservoir. Downstream fish passage would still be possible through the low level sluice conduits, though the rising reservoir would at some point cause the submergence of the sluices to be too excessive for downstream migrating fish to readily find it. Once the flood has passed and the reservoir is evacuated, downstream fish passage would resume as the submergence over the low level sluice outlets decreases. Upstream fish passage would be provided by the fish ladder and trap and haul facility until the reservoir was fully drained and woody debris and sediment could be cleared from the trashrack opening to permit free flow again. Larger flood events that carry significant volumes of debris to the reservoir may require that the pool to be maintained for a longer time than what is required for flood regulation to corral and move floating debris to containment areas before complete draw down.

2.2 FRE-FC Configuration

The currently envisioned FRE-FC alternative's primary characteristics include the following:

- An estimated maximum dam structural height of 313 to 330 feet depending on final foundation elevation
- Dam crest length of approximately 1,225 feet spanning the Chehalis valley, in addition to a right abutment RCC and rockfill section about 900 feet in length to carry the dam crest closure to high ground
- Uncontrolled overflow spillway approximately 200 ft wide, with crest elevation 687 ft designed to pass the PMF event, but expected to operate very infrequently
- Smooth spillway ogee and chute cast over the RCC dam section. Chute would have training/containment walls approximately 20 feet in height
- Spillway terminus flip bucket to eject the jet well out and away from the dam structure
- Spillway discharge plunge pool well downstream of the toe of the dam
- Single 12 ft wide by 20 ft high low level sluice with invert elevation approximately at existing river channel bed elevation.
- Two pairs of large 10 ft wide by 16 ft high low level sluices to pass flood flows, with invert elevation about 3 feet higher than the existing river channel bed elevation. These would be used to pass flow whenever the discharge requirements exceeded the capacity of the multilevel outlet ports, and could be used at any reservoir elevation.
- A full height trashrack upstream of the outlet works to capture large wooden debris.
- Construction diversion tunnel about 20 ft in diameter through the right abutment. The tunnel floor would be lined with concrete to provide a smooth invert wear layer for sediment passage during construction, and would be plugged following completion of the low level outlet sluices but provided with a drain valve to evacuate the reservoir if needed

- Hydraulic jump-type energy dissipating stilling basin approximately 240 feet long by 70 ft wide and 40 feet deep with baffle blocks to capture and dissipate flow energy from the low level outlet sluices. The stilling basin would be concrete lined, and would have an end sill elevation roughly the same elevation as the downstream river channel
- Multiport water quality outlet works that draw water from multiple levels within the reservoir
- Fish ladder and collection channel with entrances along the right wall of the stilling basin to attract and pass upstream migrating fish to the trap and haul facility
- Floating fish collection and dewatering screened facility in the reservoir to collect downstream migrating fish, transport and release in the river downstream of the dam
- A permanent reservoir pool of up to 65,000 acre-ft to be used for flow augmentation in late summer and fall prior to the winter rainy season to enhance fish habitat. This value may change as the biological benefit-to-cost studies progress to identify the preferred storage volume
- Up to 65,000 acre-ft of flood storage volume to be activated in flood events larger than the estimated 7-year recurrence interval event. This value may change as the economic benefit-to-cost studies progress to identify the preferred storage volume

Unlike FRE, the FRE-FC dam would maintain a permanent pool behind the dam and be designed to provide water storage and releases for flow augmentation from the permanent pool to enhance certain aquatic species habitat, and a flood management pool between the designated permanent pool level and the spillway crest for flood operations. During the flood control season, the low level sluices would typically be used to pass flows that could not be discharged through the smaller multiport outlets due to capacity limitations. A good analogous existing dam would be the Howard A. Hanson Dam on the Green River in western Washington State, owned and operated by the U.S. Army Corps of Engineers in a very similar fashion.

Similar to FRFA, seasonal operation of the FRE-FC dam would typically include adherence to an operational rule curve, which establishes a desired reservoir level during each part of the season, and includes reservoir drawdown and filling rates, as well as limitations on downstream rising and falling ramping rates to protect aquatic species and provide for human safety in the event of ramping operations. The FRFA seasonal operational approach is explained in Appendix B (Section 2.3) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017)

The permanent pool of the FRE-FC dam would entirely prevent the free passage of upstream- and downstream-migrating fish that is accommodated by the FRE alternative. Therefore separate upstream and downstream migrating fish passage facility are required for FRE-FC alternative. The upstream migrating fish passage facility constructed for the FRE would continue to be utilized to move fish to the upstream of the dam. This Collection, Handling, Transport, and Release (CHTR) system is comprised of a fish collection channel adjacent to the outlet works stilling basin, a short length of fish ladder leading to a sorting, holding, and transfer facility, and tank truck hauling operation to the upper watershed.

Downstream-migrating fish would be collected in the reservoir with a floating collection facility similar to the upper or lower Baker Lake floating collector, or any one of the several similar fish collectors deployed on a number of Pacific Northwest reservoirs.

2.3 Hydraulic Design Guidelines

Federal agencies have well established guidelines for developing the design of concrete gravity dams such as the Roller Compacted Concrete (RCC) dam structure proposed for the Chehalis Flood Storage Dam project. The US Army Corps of Engineers (USACE) and the US Bureau of Reclamation (USBUREC) provide the most applicable and comprehensive design guidance for large concrete gravity dams. Though the Federal Energy Regulatory Commission (FERC) provides additional dam safety guidance for hydropower dams, this project would not fall under FERC regulatory jurisdiction. If hydropower is added as a project feature in the future, the dam would fall under FERC's jurisdiction and those criteria would apply. Similarly, the Natural Resources Conservation Resources Service (NRCS) provides additional guidance for the design of dams. However, the NRCS guidance focuses primarily on embankment dams and is not particularly applicable to the Chehalis Flood Storage Dam project, and therefore the NRCS guidance was not used.

2.3.1 U.S. Army Corps of Engineers (USACE)

The US Army Corps of Engineers (USACE) has developed comprehensive design guidance in the form of Engineer Manuals (EMs) and Engineer Regulations (ERs) based on decades of experience and many empirical data sets collected at numerous projects around the United States. Those specifically used in this design evaluation of the dam hydraulic structures include those provided in Section 2.12 below.

2.3.2 U.S. Bureau of Reclamation (USBUREC)

In addition to publishing numerous dam design texts and guidelines, the US Bureau of Reclamation (USBUREC) has been a leader in developing and incorporating risk-informed dam safety and design methods and guidelines. As for the USACE guidance, the USBUREC guidance is based on many decades of direct experience and many constructed dam projects around the United States. Those specifically used in this design evaluation of the dam hydraulic structures include those provided in Section 2.12 below.

2.4 Hydrologic Conditions

2.4.1 Basin Hydrology

The hydrologic analysis supporting the development of the Chehalis dam alternatives was conducted by Watershed Science & Engineering (WSE). This information was provided in three cited sources (WSE, 2014; WSE, 2016a; WSE, 2016b). Also, a summary discussion of these three reports has been provided in the Appendix B (Section 2.5.1) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

2.4.2 Spillway Design Flood

Since the FRE dam and fish passage configuration was conceived from a combination of the FRO and FRFA at the same site representing a phased approach, the spillway hydraulic design criteria is similar to FRO and FRFA which is explained in detail in Appendix B (Section 2.5.2) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

2.4.3 Hydrologic Modeling of Flood Regulation Operations

Modeling of the reservoir operations was conducted by Anchor QEA, and is briefly summarized in Appendix B (Section 2.5.3) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017). More detailed information is provided in Anchor's report (Anchor QEA, 2016).

2.5 FRE Hydraulic Characterization

An important consideration of the alternatives designs is the hydraulic flow characteristics and sediment transport processes in the Chehalis River upstream, downstream and through the dam. Sediment gradations and incoming bed load transport data were provided by others (Dube, 2016), based on sampling data from gravel bars exposed in the vicinity of River Mile 108.532. The FRE dam alternative is designed to pass all flow, suspended and bed sediment through the open sluices without delay at all times until and unless the sluice gates are regulating flow and a reservoir forms. On the other hand, the FRE-FC dam design retains a permanent reservoir and will prevent the continuity of bed load sediment transport through the dam. It is likely that suspended sediments will largely pass through the dam during the winter flood months as a consequence of the smaller reservoir volume and rapid transit time.

The primary focus on the dam low level outlet works hydraulic modeling and sediment transport analysis was exclusively on the sediment transport and fish passage characteristics of flow through the FRE dam when no reservoir is impounded. The analysis focuses on the near-dam reach hydraulic and sediment transport processes between River Mile 108.532 above the dam site and River Mile 107.62 below the dam site. The results of hydraulic and sediment transport simulations are discussed in the following sections.

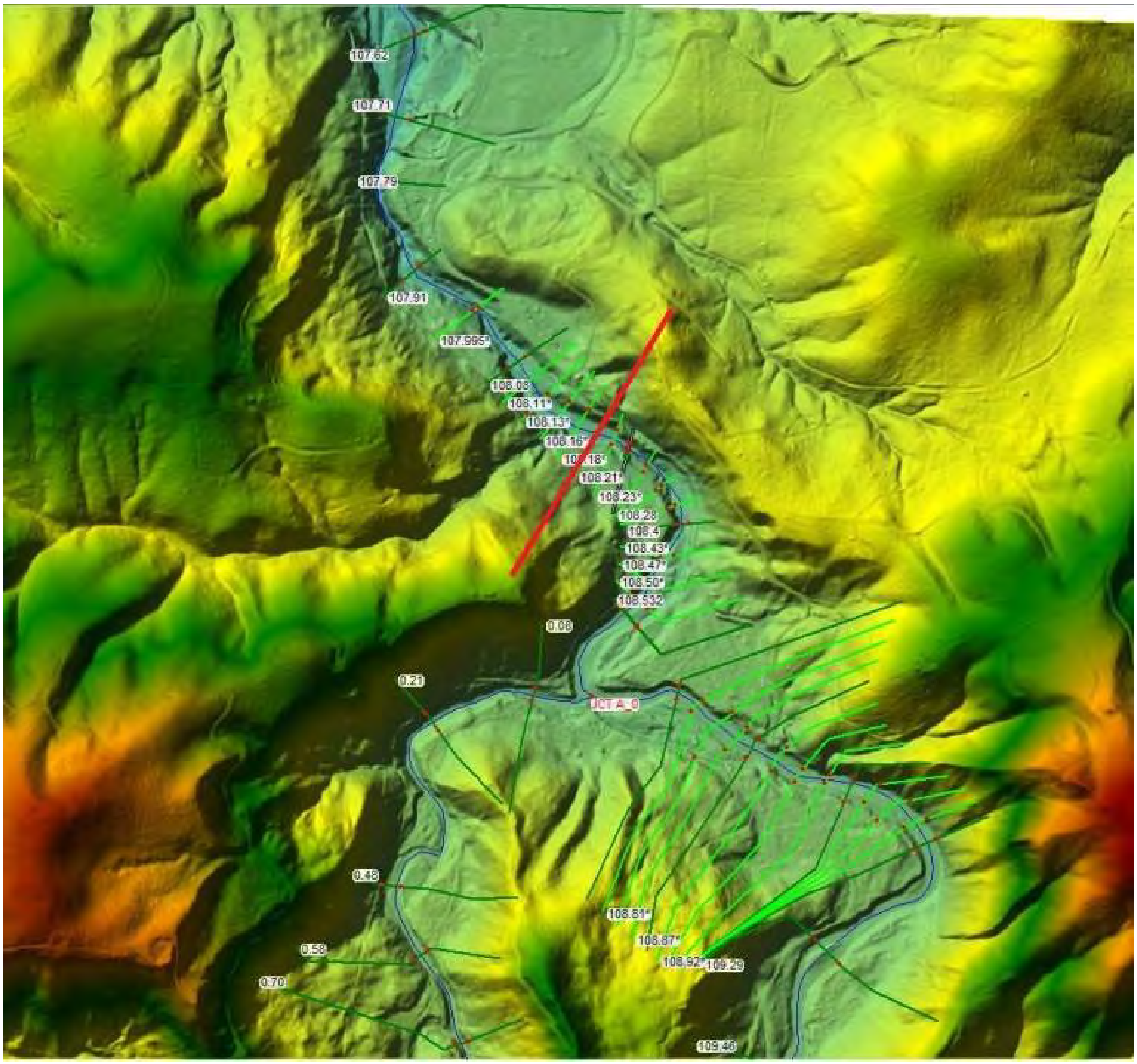
2.5.1 Velocity and Depth Characterization

The hydraulic modeling analysis was conducted using a combination of tools, including analytical evaluation of outlet works capacity, velocity, gate operation, sediment throughput, as well as computational numerical modeling tools. Similar to FRO dam alternative, the basic hydraulics through the dam reach was assessed using 1D HEC-RAS, a one-dimensional computer water surface profile modeling tool created by the US Army Corps of Engineers' (USACE) Hydrologic Engineering Center, and in common use throughout the engineering discipline for flow modeling in preliminary design evaluations. The model geometry construction and calibration process is discussed in detail in Appendix B (Section 2.6.1) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

Figure 2-1 and Figure 2-2 show the cross section location and topography of the reach utilized to construct the 1D HEC-RAS model geometry.

Figure 2-1
Sediment Sample Location, HEC-RAS Cross Sections (Dam Axis Shown as Red Line)

Figure 2-2
LiDAR Topography with HEC-RAS Sections (Dam Axis Shown as Red Line)



The results of 1D HEC-RAS model generally showed that the FRE dam alternative, with its five low level sluice outlets, provides lower flow velocity across the range of low to moderate flows than the existing channel. From a fish passage perspective, the FRE would be expected to provide slower flow passage for fish through the dam than the existing channel, and an improvement over the previously evaluated FRO alternative with three sluices configuration. Without intervention such as that occurring when the sluices are regulated for floods, the lower flow velocities within the sluices would likely lead to sediment deposition inside the dam. A sample comparison of the flow velocity and depth for existing channel condition, FRO alternative with three sluices configuration (a single larger 12’Wx20’H sluice at elevation

408 ft and a pair of 10’Wx16’H at invert elevation 411 ft) and FRE alternative with five sluices configuration (a single larger 12’Wx20’H sluice at elevation 408 ft and two pairs of 10’Wx16’H at invert elevation 411 ft) is presented in Figure 2-3 And Figure 2-4.

The comprehensive results of 1D HEC-RAS modeling (flow velocity and depth) for existing channel condition, FRO alternative with three sluices configuration and FRE alternative with five sluices configuration for all the cross sections are provided in Section 3.1.1 in Figure 3-1 through Figure 3-14.

Figure 2-3
Comparison of Flow Velocity at Cross Section 108.30 under Typical Conditions, about Midway through the Flood Regulating Sluices

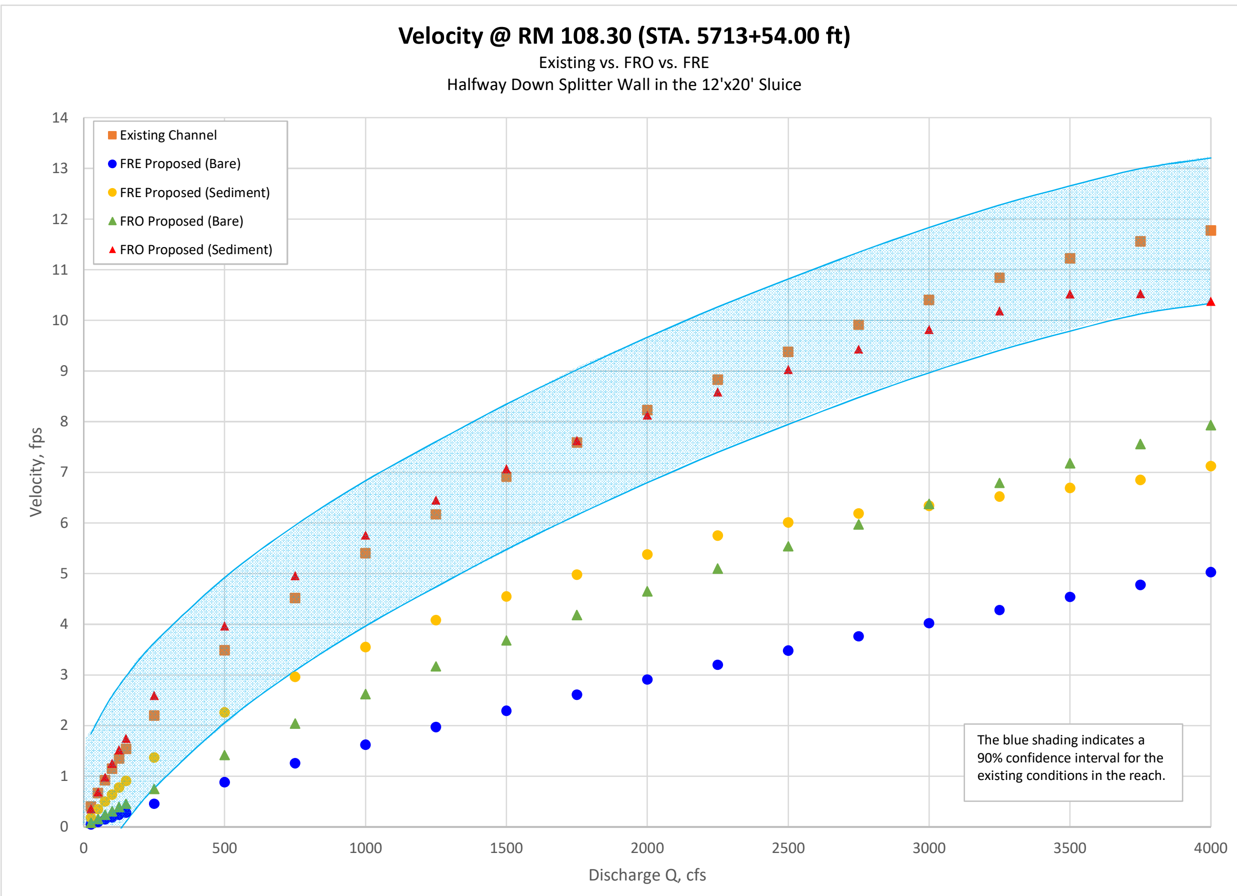
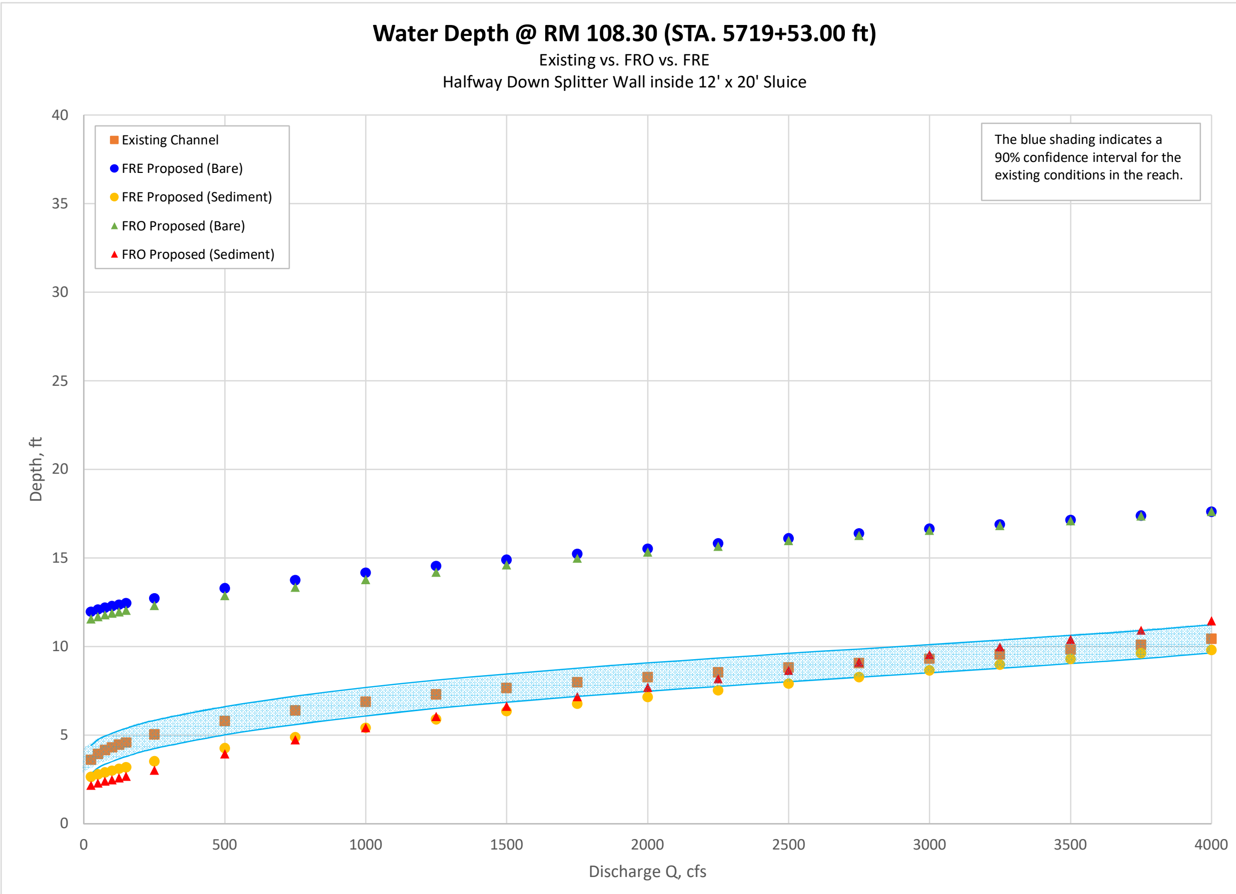


Figure 2-4
Comparison of Flow Depth at Cross Section 108.30 under Typical Conditions, about Midway through the Flood Regulating Sluices

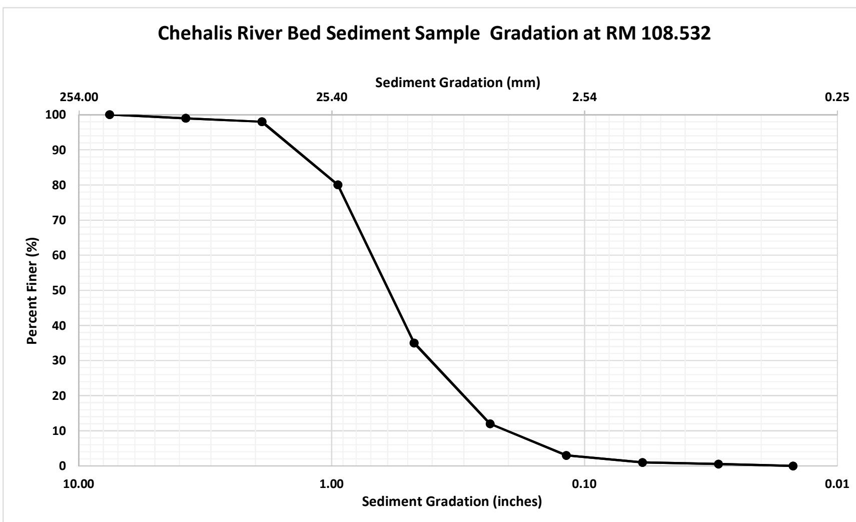


2.5.2 Sediment Transport Capacity and Performance

Sediment transport through the dam reach was evaluated using the same 1D HEC-RAS model by activating the sediment transport module available in the software. The model input parameters included a bed sediment sample gradation (Figure 2-5) and a hydrograph comprised of four years of flow data for the dam site from 1990 to 1994, based on existing hydrologic records observed at the Doty gage site and scaled to the basin area at the dam site. This period was selected for the analysis, as it comprised several larger flood events and the average annual hydrographs over these 4 years of record were fairly typical for the Chehalis River at the dam site. The sediment model calibration process is explained in detail in Appendix B (Section 2.6.2) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017). It should be noted that the model calibration was done based on visual observation and estimates of actual river bed elevation. No detailed ground penetrating radar or geophysical investigation was conducted through this scour reach in this phase of the study, and as a result we must consider the Existing Conditions Sediment model to be only roughly approximate, and only useful to compare against the With-Project Condition Sediment model which reflects the effect of flow and sediment passing through the proposed dam sluice outlets.

The particular sediment gradation samples collected from the river channel and the stability of the Meyer-Peter-Mueller (MPM) method in HEC-RAS suggested MPM would be the most appropriate. The inflow and outflow sediment loads were assumed to be in equilibrium for the purpose of these simulations, since there was no strong indication that the reach was sediment limited or, conversely, sediment oversupplied. Additional variables adjusted during the HEC-RAS model construction are not mentioned here, but were modified slightly to achieve a reasonable simulation of transport processes.

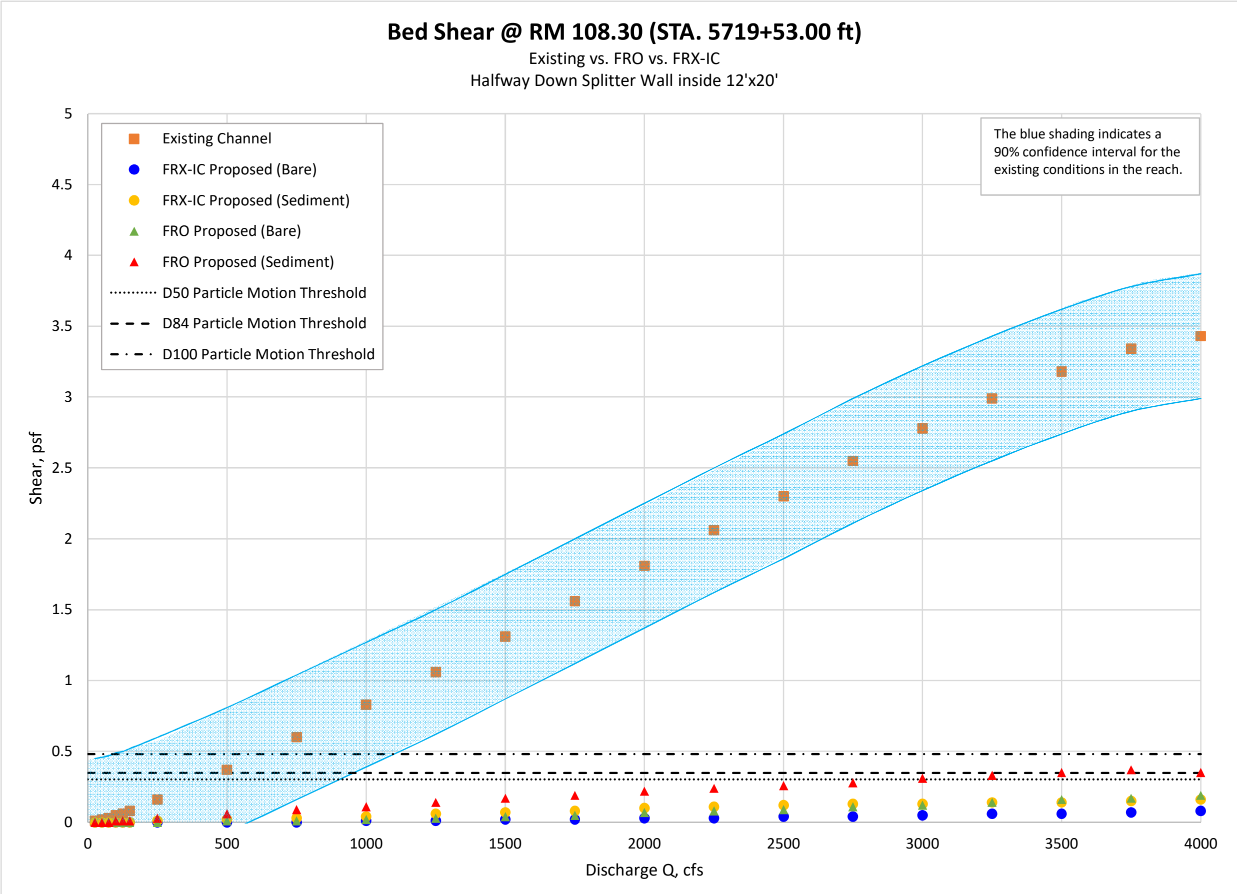
Figure 2-5
Sediment Sample Gradation near HEC-RAS Cross Section 108.532 used as Input to the Sediment Transport Modeling



Source: Dube, 2016

The primary measure of sediment transport capacity is usually the bed shear stress, which relates the hydraulic tractive force applied to the bed and to sediment particles. Bed shear stress is a function of discharge, hence with higher discharge comes greater shear stress and greater capacity for moving sediment particles. We compared bed shear stress for the existing channel, the FRO dam sluice conduits, and the FRE sluice conduits to relate the proposed dam alternatives to the natural channel reach. Bed shear stress was investigated for the FRE Dam Alternative and compared to that previously developed for the FRO and Existing Channel. A comparison of the bed shear stress between the three different models for Cross Section 108.30 is provided in below Figure 2-6. The comparisons of bed shear stress for all other cross sections are provided in Section 3.1.2 in Figure 3-15 through Figure 3-21.

Figure 2-6
Bed Shear Stress Comparison at Cross Section 108.30 about Midway through the Sluices between Existing Channel, FRO Dam Alt and FRE Dam Alt



The results of the sediment transport analysis using HEC-RAS reveals interesting and important evidence that the observed channel through the narrow scoured bedrock gorge at the proposed dam site will scour deeply and refill with sediment during flood events in which the substrate is mobilized. The results of the sediment transport analysis also show that the deep stilling basin downstream of the sluice conduits will similarly fill with sediment, and occasionally deeply scour these deposits, particularly at the sluice outlets. We compared the bed sediment elevations between the Existing natural channel (Figure 2-7), the previously evaluated FRO alternative with three sluices (Figure 2-8), and the FRE alternative (Figure 2-9) following four years of the hydrologic record from 1990 to 1994.

Figure 2-7
Bed Sediment Profile of Existing Channel following 4 years of Hydrologic Record (1990-1994)

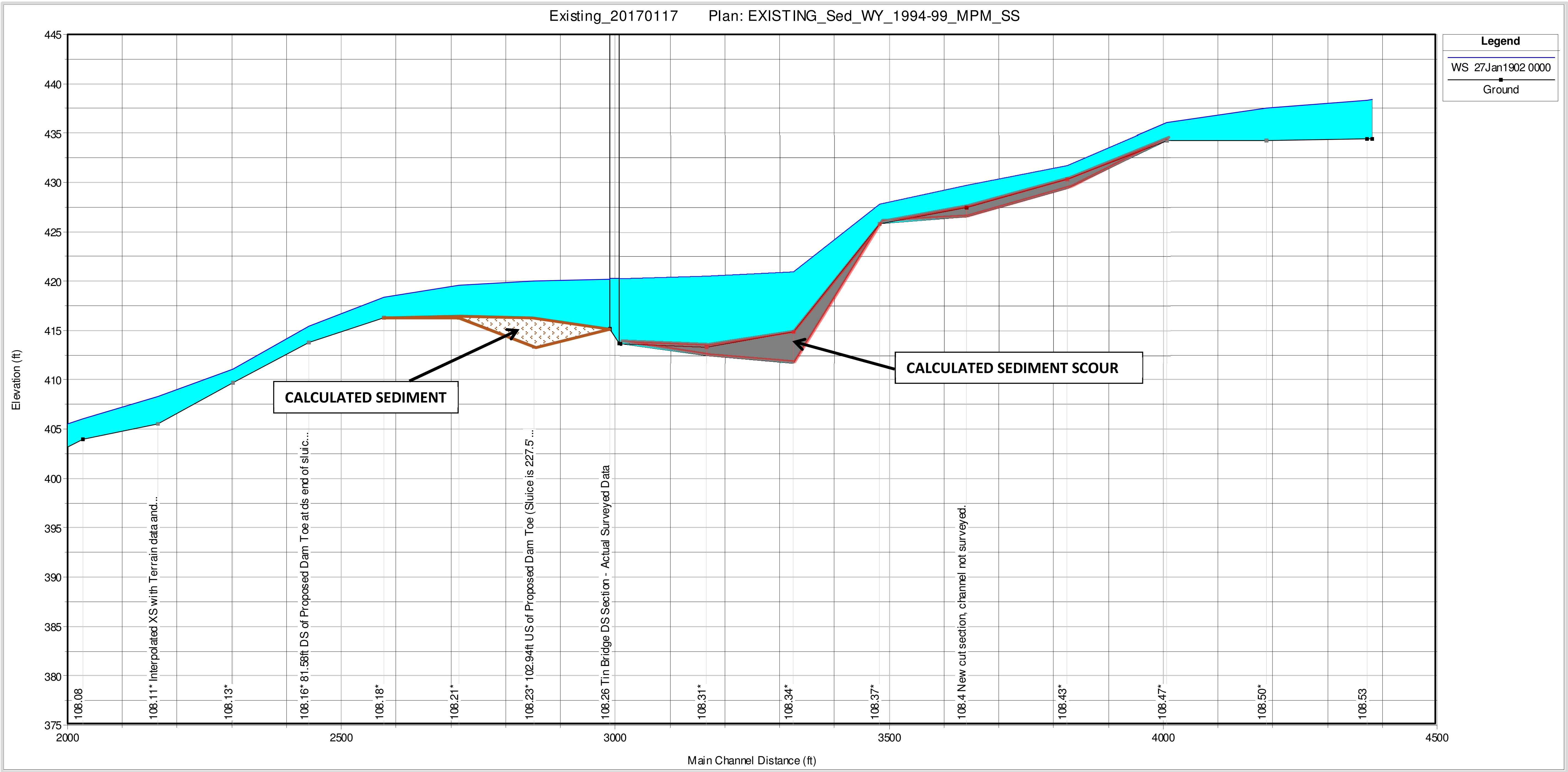


Figure 2-8
Bed Sediment Profile of the FRO Dam Alternative Following 4 Years of Hydrologic Record (1990-1994)

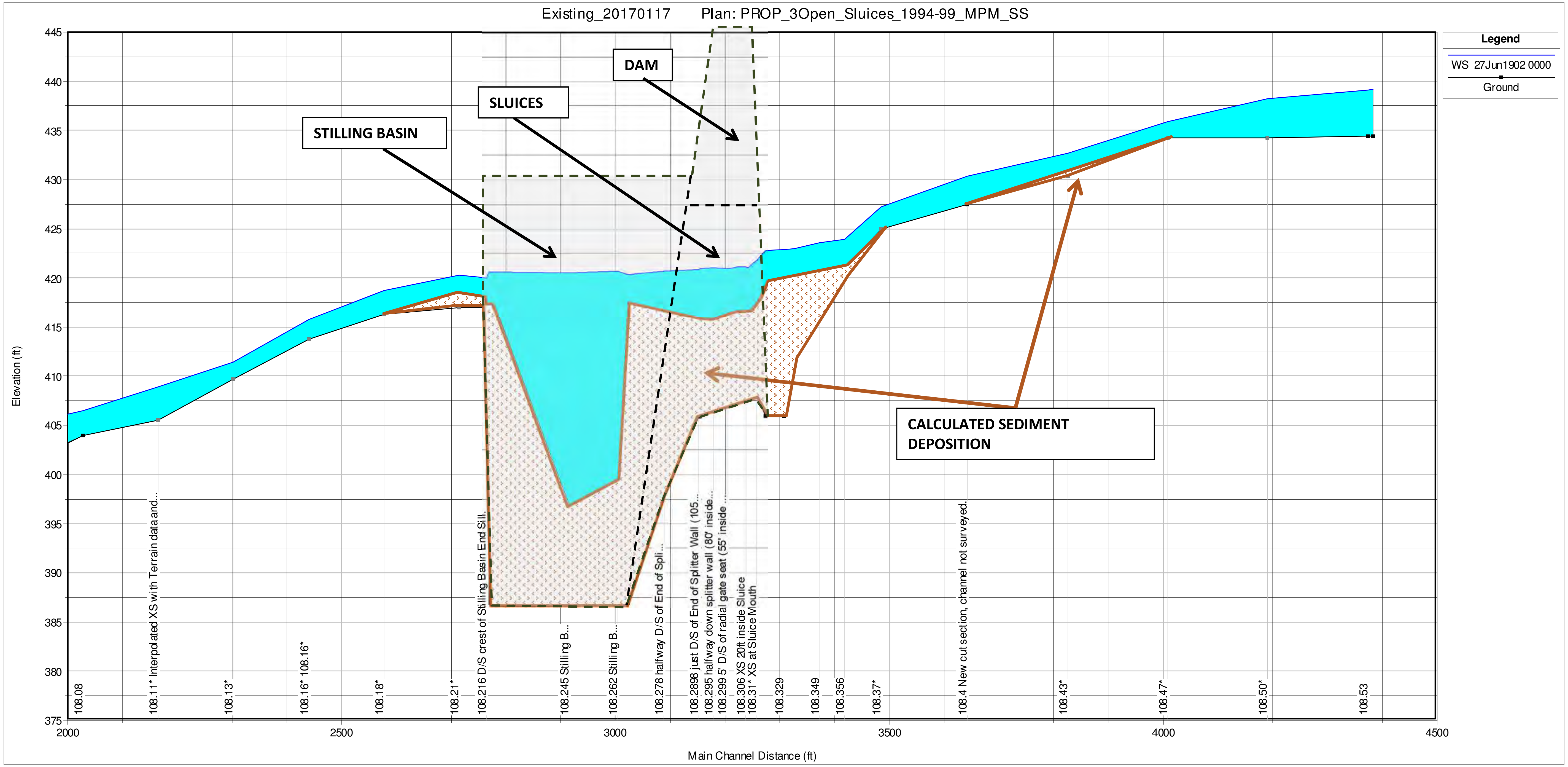
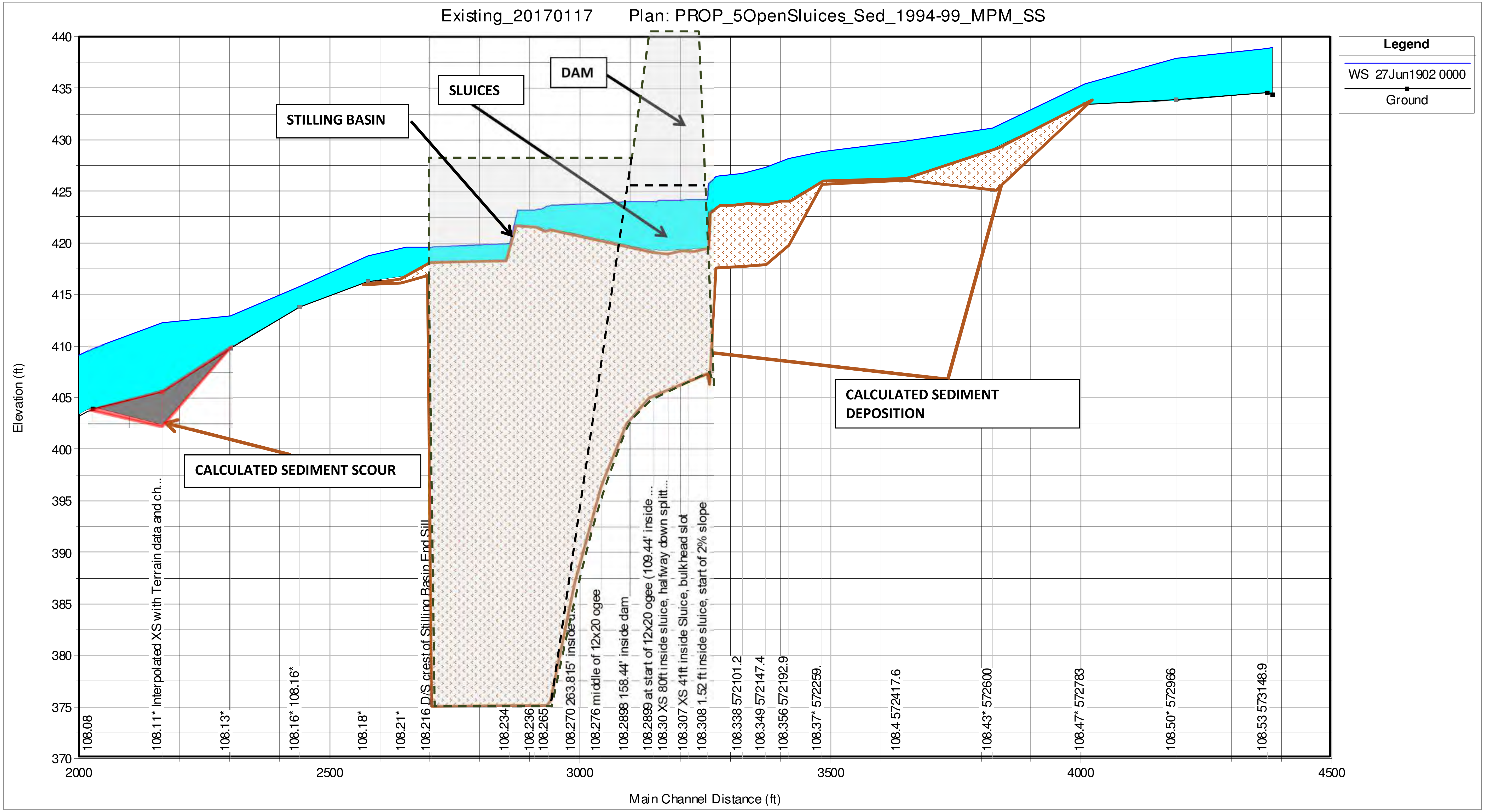


Figure 2-9
Bed Sediment Profile of the FRE Dam Alternative Following 4 Years of Hydrologic Record (1990-1994)



Through all river discharges in which the sluice gates are held fully open (i.e. no flood regulation operations), sediment will deposit throughout the sluice conduits and largely fill the stilling basin. This would represent the average condition, from a natural process and fish passage perspective. However, during a flood event in which the sluice gates would be closed or otherwise used to regulate dam discharges, any sediment that had deposited within the sluice conduits would be expected to be swept through the dam and deposit in the stilling basin or downstream in the natural channel. The action of closing the gates causes a high velocity flow jet to form immediately downstream of the gates, which would clear the sluices of deposits quickly. We evaluated both conditions numerically using the 1D HEC-RAS modeling to determine the range of expected conditions within the sluice conduits. As expected, the cleared sluices are much deeper than the existing natural channel, with commensurately lower flow velocities following the event. Bed sediment profiles following sluice gate regulation operations are provided in Figure 2-10 and Figure 2-11 below, for the FRO Dam Alternative and the FRE Dam Alternative, respectively. It should be noted that these sediment transport analyses are approximate only. More accurate and quantifiable sediment transport, deposition, scour, and performance information would be obtained from a physical scale model of the entire dam and appurtenant outlet works that will be conducted during the next phase of design.

Figure 2-10
Bed Sediment Profile for the FRO Dam Alternative Following Flood Regulation Operation

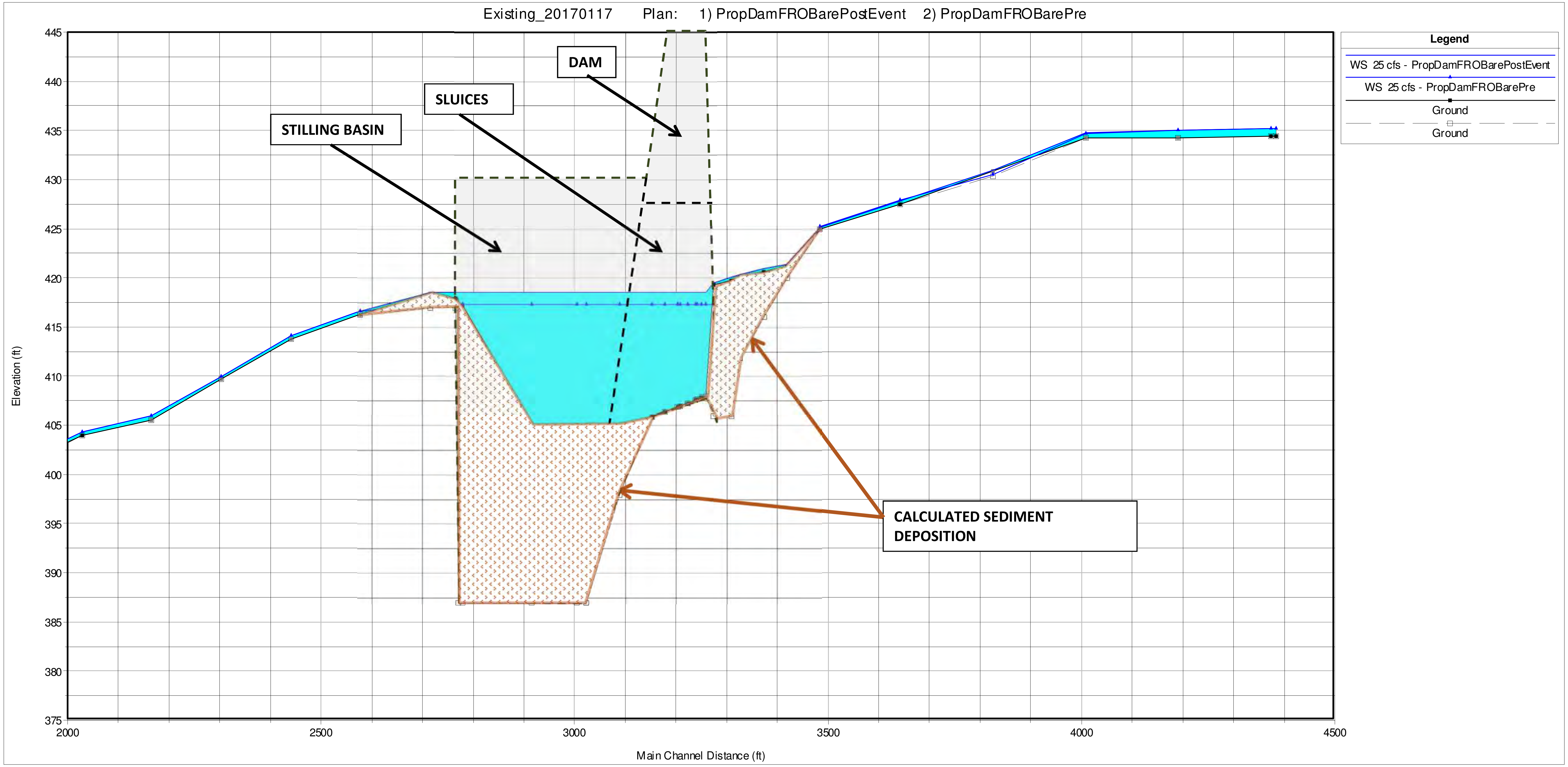
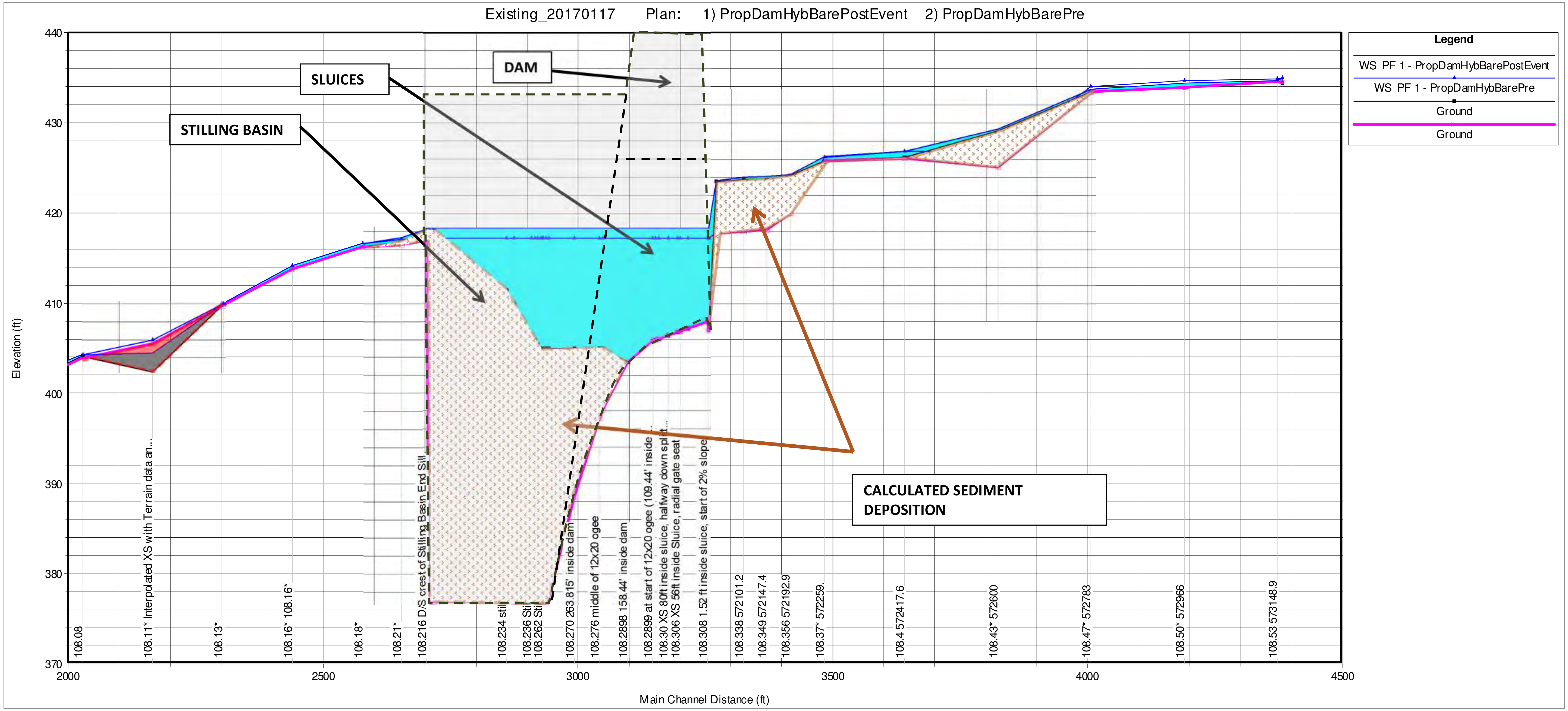


Figure 2-11
Bed Sediment Profile for the FRE Dam Alternative Following Flood Regulation Operation



2.5.3 Computational Fluid Dynamic (CFD) Modeling

A Computational Fluid Dynamic (CFD) model of the FRE geometry, with upstream boundary at the interior side of the intake trashrack and downstream boundary below the stilling basin control sill was constructed using FLOW3D software (product of Flow Science, Inc.). The CFD model mapped the bed bathymetry calculated with the HEC-RAS sediment transport model following the 4 year hydrograph discussed above (1990 – 1994). The upstream boundary was assumed to be a uniform flow boundary, which is appropriate given that the intake trashrack would tend to distribute inflows uniformly as result of the head loss induced across the width of the trashrack. The downstream boundary was assumed to be simply a flow boundary meeting the conservation of mass criteria by passing equal flow to the inflow boundary. The CFD model was run in steady state condition for 9 flows across the range of fish passage river discharges (100 cfs, 250 cfs, 500 cfs, 750 cfs, 1,000 cfs, 1,250 cfs, 1,500 cfs, 1,750 cfs, 2,000 cfs, and 2,200 cfs). Typical CFD model results are shown below for 750 cfs and 2200 cfs in Figure 2-12 through Figure 2-15, illustrating the flow velocity contours through the sluice conduits and stilling basin. The CFD modeling results for all other discharges are presented in Section (3.1.3) in Figure 3-22 through

Figure 3-39.

Figure 2-12
Isometric View of Velocity Contours for 750 cfs Discharge through Low Level Outlets

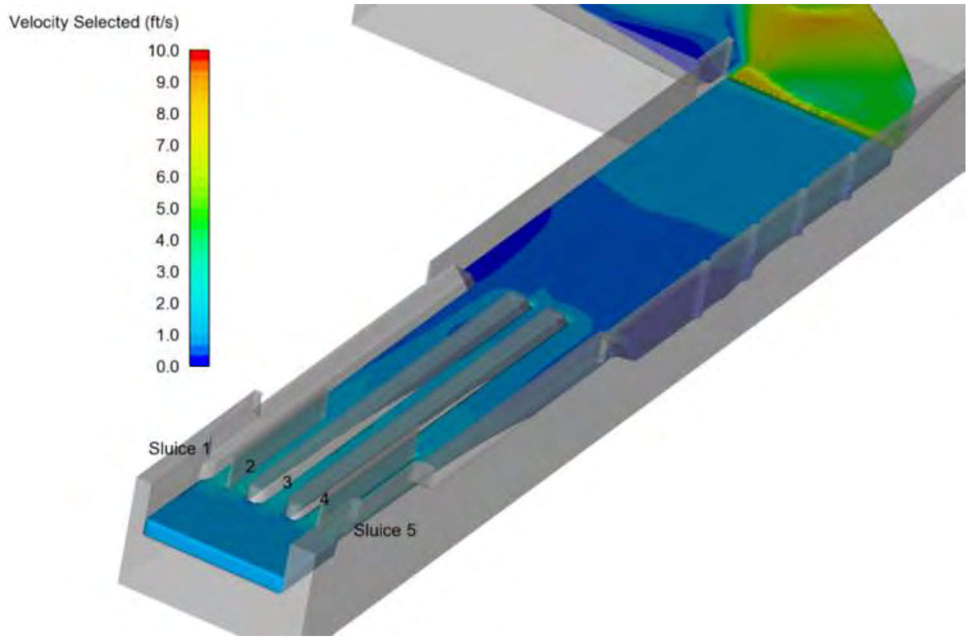


Figure 2-13
Profile View of Velocity Contours for 750 cfs Discharge through Low Level Outlets

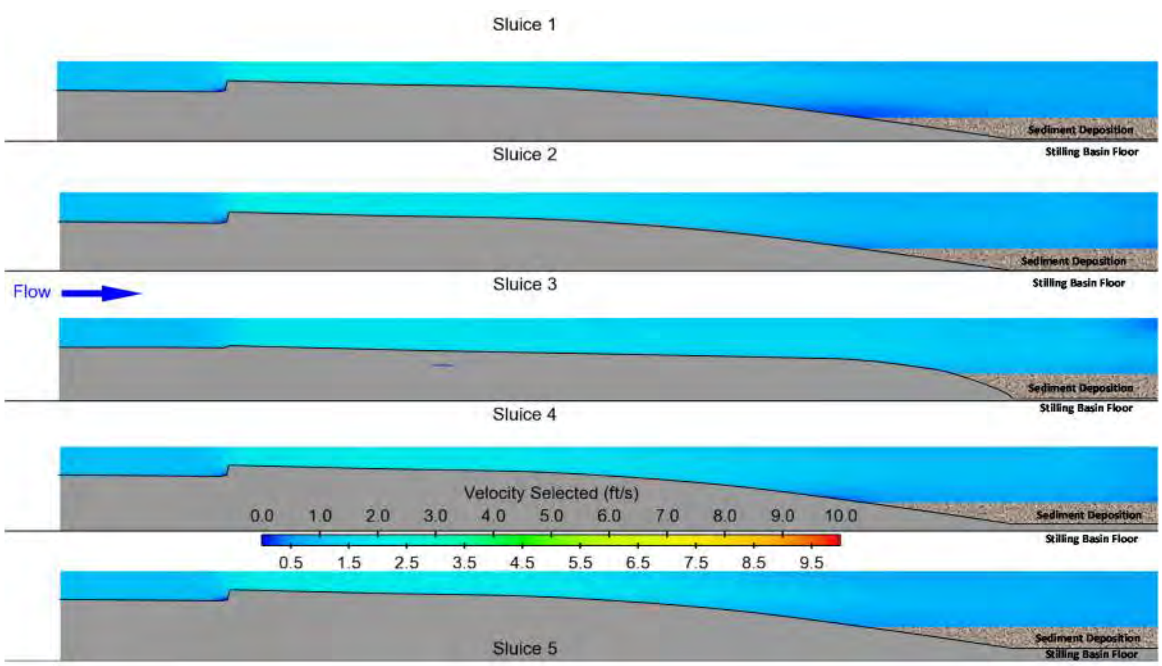


Figure 2-14
Isometric View of Velocity Contours For 2,200 cfs Discharge through Low Level Outlets

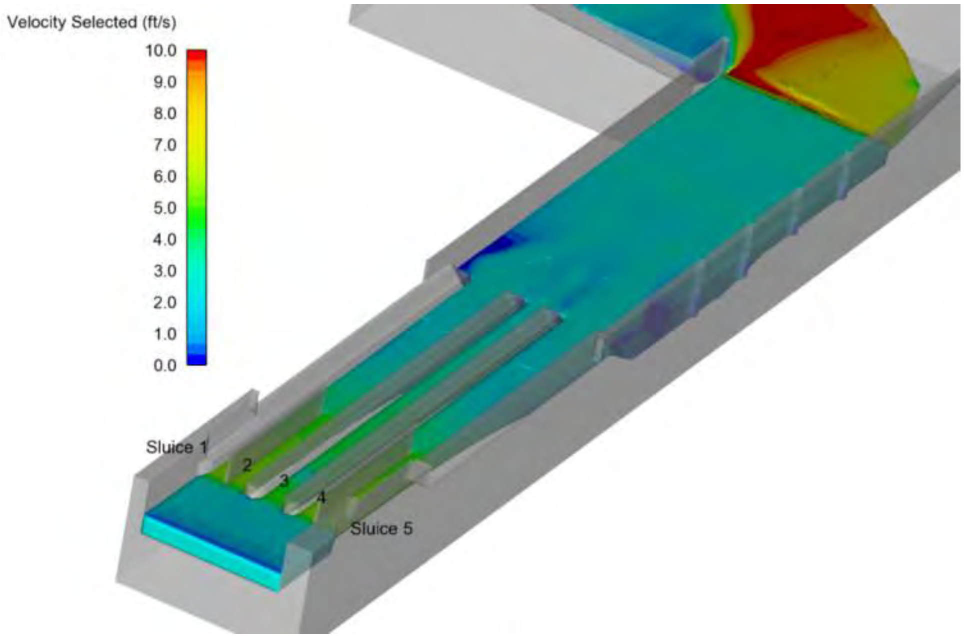
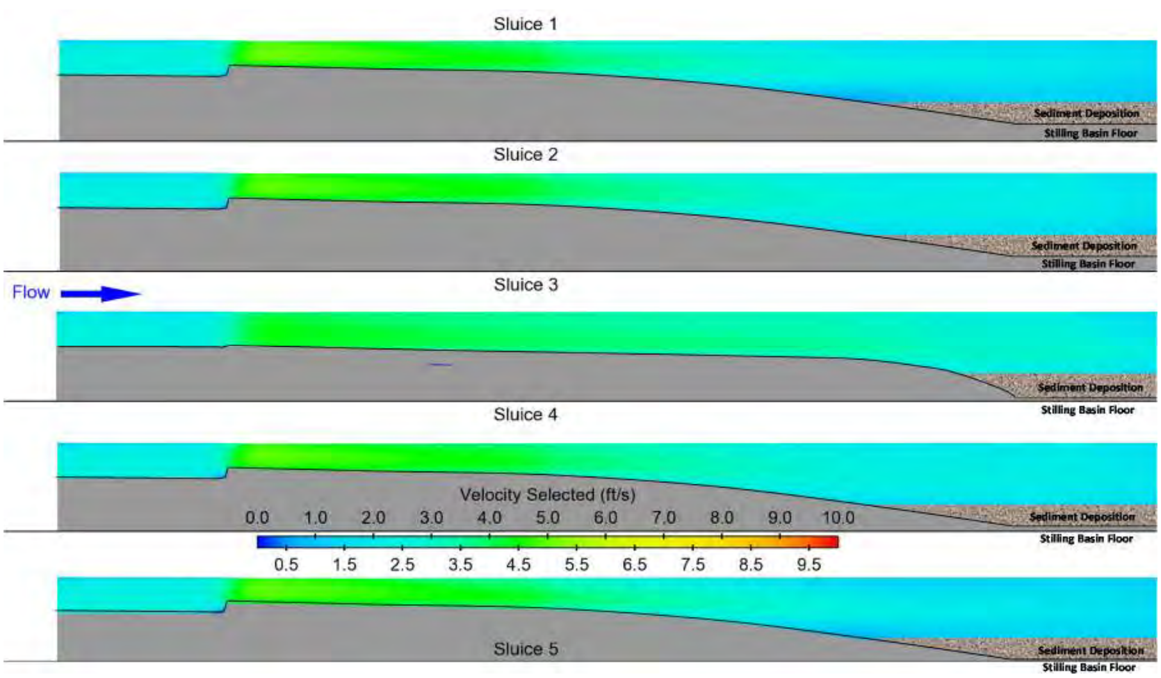


Figure 2-15
Profile View of Velocity Contours for 2,200 cfs Discharge through Low Level Outlets



2.6 Fish Passage

Similar to FRO, the FRE Dam alternative is designed to permit unimpeded fish passage upstream and downstream through the large low level sluice conduits, achieved by holding the sluice gates fully open under all flow conditions except when anticipated flood discharge is forecast to increase above the specified 38,000 cfs threshold at the Grand Mound gage. At and above this threshold, the low level flood regulating sluice gates would be closed as needed to store flood water in the reservoir. When the low level flood regulating sluice gates are closed or under operation, a fish ladder and trap and truck facility would commence operation to collect fish from the dam stilling basin and move them upstream as needed. No downstream migrant fish collection facilities are proposed for the FRE dam alternative.

The FRE-FC Dam alternative upstream migrating fish facility is the same as the FRE dam during flood regulation operation mode. However, unlike the FRE dam the sluices cannot be utilized for fish passage given the permanent reservoir. Therefore, the downstream migrating fish would be collected using a floating collector in the reservoir, then trucked downstream to be released into the river in FRE-FC dam alternative. The FRE dam alternative upstream migrating fish facility is similar to FRO and FRFA in size and configuration, as discussed in main body of the Draft Combined Dam and Fish Passage Conceptual Design Report. The remainder of this text will focus on the FRE Dam fish passage only.

The low level outlet works configuration for the FRO dam was determined by evaluating the hydraulic conditions of the flow through the sluices for various configurations. The final design of the FRO dam consists of a single large 12’ W x 20’ H sluice conduit at invert elevation of 408 ft, and a pair of 10’W x 16’ sluice conduits at invert elevation of 411 ft. The HEC-RAS clear-water simulations (no sediment transport) of the flow through the sluices for full open gate and open channel conditions showed that this configuration results in a flow velocities similar to that of the preexisting river channel conditions across the full range of fish passage discharges from 25 to 2,200 cfs. This met the Washington Department of Fish & Wildlife fish passage criteria of the flow velocity through the conduits shall not exceed the preexisting river velocity at the project location. This concept of a slightly lower, larger sluice gate and conduit was based on the Mud Mountain Dam analogous outlet works, where the lowest sluice intentionally passes the majority of bed load sediment in order to isolate erosion damage to a single outlet that can be readily repaired.

Following the FRO low level outlet work configuration design, it was decided to add a second pair of 10’W by 16’H sluice conduits at the invert elevation of 411 ft to the FRE dam alternative to reduce the flow velocities in the sluices. This effort was made to investigate the possibility of achieving 2 fps flow velocity over the range of fish passage discharges through the sluices which was initially the target criteria provided by the Washington Department of Fish & Wildlife fish passage.

The refined sluice outlet configuration for the FRE dam alternative was modeled using the HEC-RAS 1D and CFD models to examine more detailed velocity and depth characteristics, as discussed above in

Section (2.5). As expected, the addition of second pair of 10'W x 16'H in FRE alternative design reduced the flow velocities through the conduits compare to the three conduits configuration for FRO.

2.7 Construction Diversion

Construction diversion is arguably the highest risk construction component of the project, in terms of both cost and schedule. Constructing the diversion is critical-path work, as is much of the work that relies on that diversion. Since the FRE dam alternative is a phased approach combination of the FRO and FRFA, the previously designed construction diversion structure for FRO and FRFA alternatives would provide satisfactory performance for the FRE alternative as well. The construction diversion design procedure is presented in detail in the Appendix B (Section 2.8) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

2.8 Spillway Design

Spillway provides safe conveyance from reservoir to the downstream of the dam for all flood discharges up to the spillway design flood. Design guidance utilized in the design of the spillway included USACE EM 1110-2-1603, Hydraulic Design of Spillways; the USACE Hydraulic Design Criteria (HDC); and the USBUREC Design of Small Dams. Similar to FRO and FRFA spillways, the FRE alternative spillway is an uncontrolled ogee spillway. The Ogee spillway shape design procedure is presented in detail in the Appendix B (Section 2.9) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

The FRE spillway crest is set at elevation 628 ft with a width of 200 feet, and is designed to pass up to 69,800 cfs with 4.3 feet of freeboard to the top of the upstream crest parapet wall. The equivalent unit discharge at full design capacity is 349 cfs per linear foot. The design discharge capacity has been conservatively estimated using a slightly lower discharge coefficient (C_d = 3.73) than is typically found for smooth ogee designs, to ensure adequate capacity without risk of overtopping. The FRE spillway is designed with a relatively short and shallow approach channel which positions the ogee crest approximately 50 ft downstream of the dam crest. The optimal depth of approach channel was selected to provide subcritical flow condition in the channel. The 10 ft deep approach channel resulted in Froude number values less than 0.5 for the range of spill flows up to PMF. This ensures that the critical depth control condition only occurs at the spillway crest for all flows and there would not be any control shift phenomenon from the crest to the approach channel entrance section. The flow depth and velocity at the toe of spillway just before entering the energy dissipation structure are estimated using the turbulent boundary layer development method. The flow leaving the spillway chute has a depth and velocity of about 3.7 ft and 99.9 ft/s, respectively, and an equivalent energy head loss of about 11 ft. Figure 2-16 shows the FRE spillway rating curve.

The FRE-FC spillway crest is set at elevation 687 feet with a width of 200 feet, and is designed to pass up to 69,800 cfs with 5 feet of freeboard to the top of the upstream dam parapet wall. The equivalent unit discharge at full design capacity is 349 cfs per linear foot. The design discharge capacity has been conservatively estimated using a slightly lower discharge coefficient (C_d = 3.84) than is typically found for smooth ogee designs, to ensure adequate capacity without risk of overtopping. To construct the FRE-FC spillway, the FRE spillway crest will be demolished while the flip bucket structure and a significant portion of the spillway chute will remain in place. Then, the RCC construction will proceed in lifts to facilitate the construction of the FRE-FC spillway. The flow depth and velocity at the toe of spillway just before entering the energy dissipation structure are estimated using the turbulent boundary layer development method. The flow leaving the spillway chute has a depth and velocity of about 3.2 ft and 117.5 ft/s, respectively, and an equivalent energy head loss of about 22.5 ft. Figure 2-17 shows the FRE-FC spillway rating curve.

Figure 2-16
FRE Spillway Discharge Curve

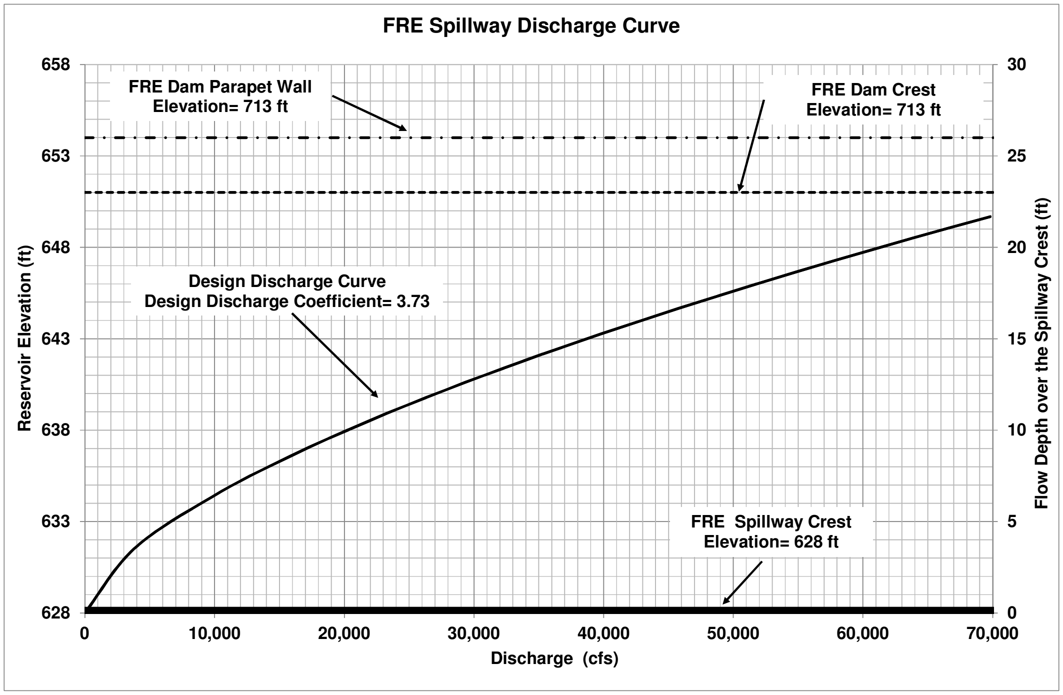
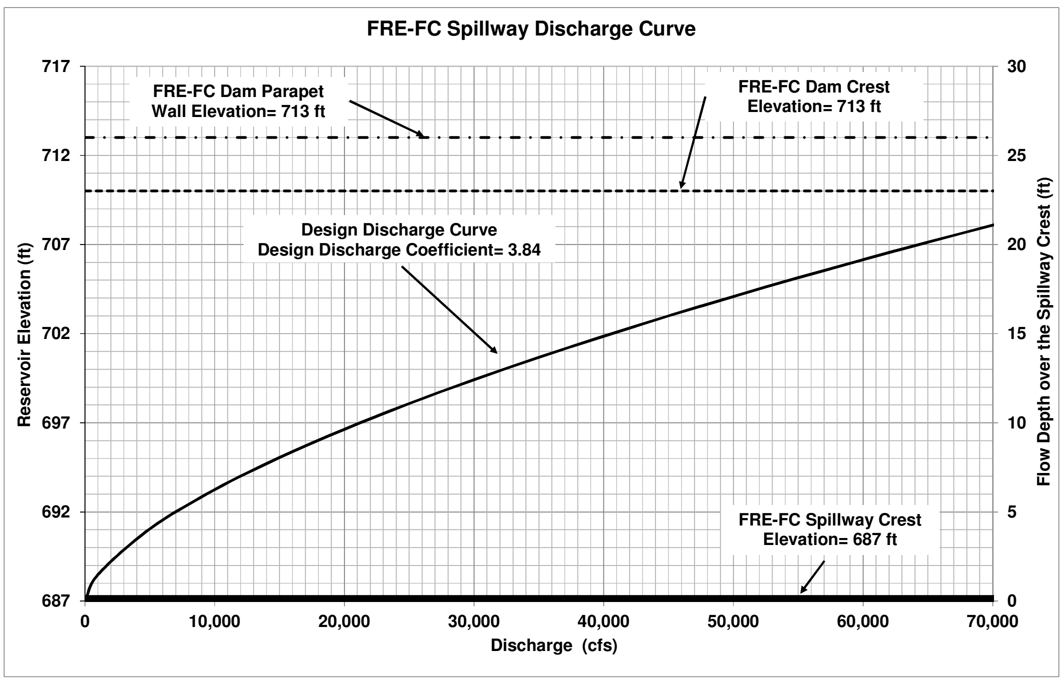


Figure 2-17
FRE-FC Spillway Discharge Curve



2.9 Flip Bucket and Plunge Pool

Flip bucket is part of the energy dissipation system which directs the incoming high velocity flow down the spillway chute away from the dam. After the flow leaves the flip bucket, extreme turbulence and consequently large quantity of air entrainment into the jet helps to dissipate its energy.

Similar to FRO and FRFA, the FRE alternative spillway is expected to be used very rarely, and for events of very short duration. Therefore, no spillway stilling basin is provided. Rather, a flip bucket and preformed impact plunge pool will be constructed to dissipate the energy of spillway flows.

Design guidance utilized in the design of the flip bucket geometry included USACE EM 1110-2-1603, Hydraulic Design of Spillways and the USACE Hydraulic Design Criteria (HDC). The FRE alternative flip bucket structure design procedure is similar to FRFA and FRO. A sample design calculation for FRFA alternative is explained in detail in Appendix B (Section 2.10) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

For the FRE dam alternative (both FRE and FRE-FC), the flip bucket design is based on the unit discharge of 349 cfs per linear foot of width at maximum spillway flow (PMF), with the bucket invert at elevation 475 ft and the lip at elevation 489.6 ft.

For the FRE dam, the flow profile down the spillway chute was evaluated using the turbulent boundary layer development method, with the result that at maximum discharge (PMF) the toe velocity is about 99.9 feet per second and depth of about 3.7 feet, yielding a minimum bucket radius of 40.4 ft.

For the FRE-FC dam, the flow profile down the spillway chute was also evaluated using the turbulent boundary layer development method, with the result that at maximum discharge (PMF) the toe velocity is about 117.5 feet per second and depth of about 3.2 feet, yielding a minimum bucket radius of 48.0 ft.

However, we have used the same 50-foot radius for both the FRE and FRE-FC flip bucket designs for simplicity. The trajectory angle of 45 degree was considered to achieve a maximum jet trajectory distance. Figure 2-18 shows the PMF water surface profile down the FRE spillway and jet trajectory leaving the flip bucket. Trajectory calculations determined an approximate impact zone of about 350 feet downstream of the bucket lip.

Figure 2-19 shows the PMF water surface profile down the FRE-FC spillway and jet trajectory leaving the flip bucket. Trajectory calculations determined an approximate impact zone about 500 feet downstream of the lip. The rockfill design below the flip bucket would be developed during the next phase of the study.

Figure 2-18
FRE Spillway and PMF Water Surface Profile

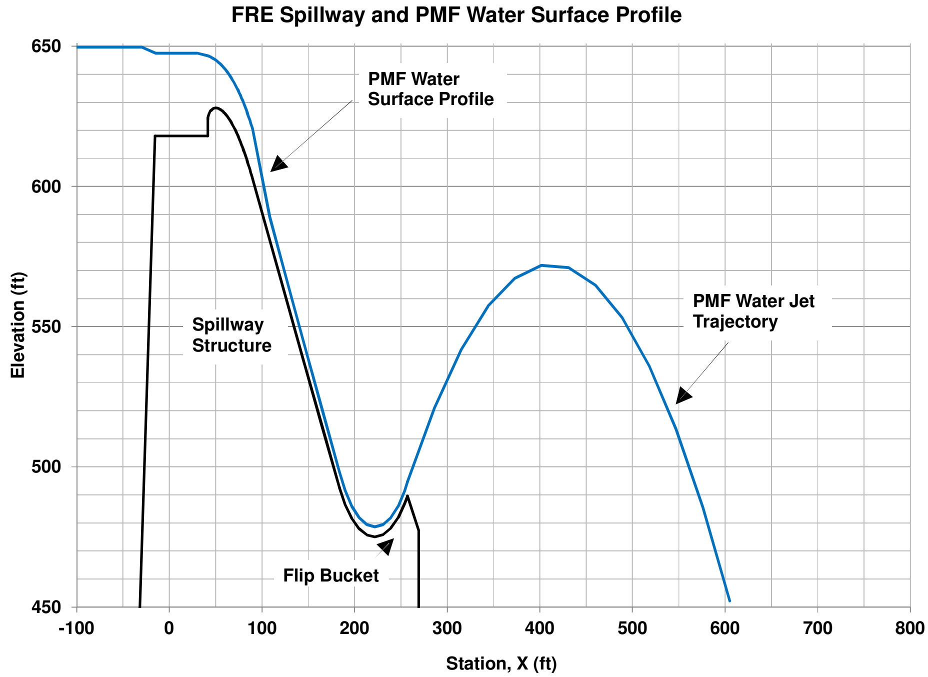
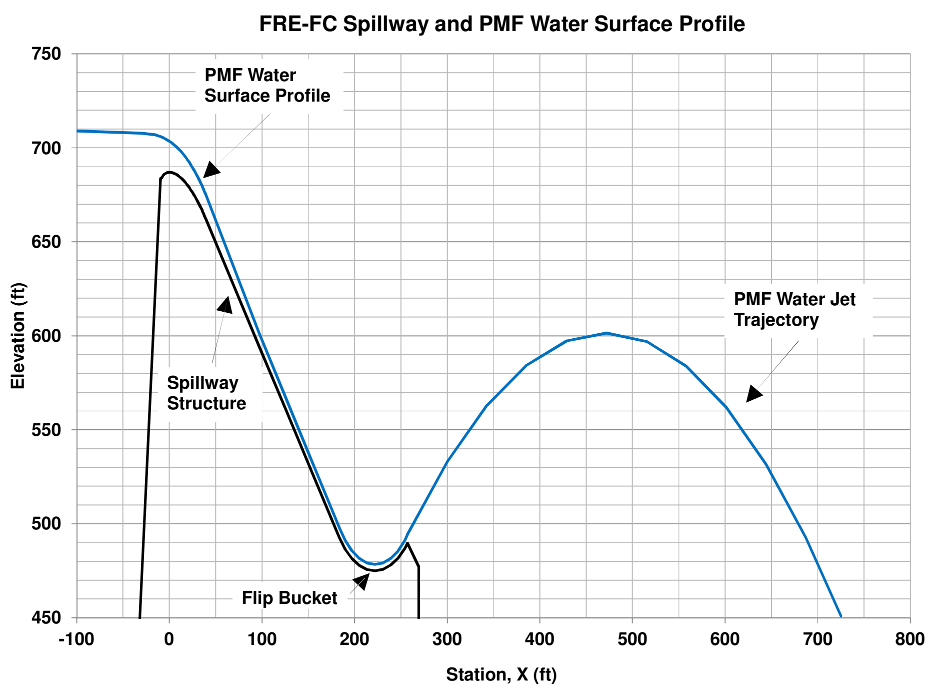


Figure 2-19
FRE-FC Spillway and PMF Water Surface Profile



2.10 Flood Regulation Outlets

Flood regulation outlets are designed to pass relatively large flows and can be gated to provide close regulation of the flow. USACE EM 1110-2-1602, Hydraulic Design of Reservoir Outlet Works, was utilized as the design guidance in the design of the outlet works. Rating curves were generated for each potential sluice size and elevation to determine the proper design that would work best if implemented. These rating curves were compared with the design discharge, and the sluice sizes were iterated to meet the discharge required for flood control outlets as well as to function as effective fish passage conduits, matching the velocities of the existing channel.

The FRE alternative design has five low-level sluice outlets, consisting of a single larger 12’ W x 20’ H sluice at invert elevation 408 ft and two pairs of 10’ W x 16’ H sluices at invert elevation 411 ft on each side of the larger sluice. A large, full height trashrack extending from the riverbed to the dam crest will exclude most large trees from the sluice conduits and provide excess open area under all reservoir elevations to pass the desired project outflows. The partial and full open gate rating curves for the single large 12’ W x 20’ H sluice gate, single and double 10’ W x 16’ H sluice gates are provided in Figure 2-20 through Figure 2-22.

For FRE dam, with all five low-level flood regulation sluice gates fully open, up to approximately 12,500 cfs can be passed through the sluices without transitioning to orifice or pressure flow in any of the sluice openings, with reservoir elevation at 426 ft. The 15,000 cfs project design outflow can be passed entirely through one pair of 10’ W x 16’ H sluices at reservoir elevations greater than about 580 ft with the gate fully open. Typical flood regulation operation would initiate closure of the larger sluice at any time the pool levels exceed about 72 feet in depth over the sluice ceiling (i.e., reservoir elevation 500 ft), to prevent excessive wear on the large sluice floor due to bed sediments entrained in high flow velocity. The higher gates (the two pairs of 10’ W x 16’ H sluices) are expected to entrain considerably less sediment, though the specific elevation details to confirm this and establish the final higher sluice gate seat elevation would have to be evaluated using a physical laboratory scale model. Following the closure of the larger 12’ W x 20’ H sluice gate, one pair of the 10’ W x 16’ H sluice gates would also initiate closure and the flood would only be regulated through one pair of the 10’ W x 16’ H ft sluices.

The smaller 10’ W x 16’ H sluice gates are designed to pass up to 3,000 cfs each with 23 feet of static head on the gate at the 75 percent open setting, while the larger 12’ W x 20’ H gate can pass the same 3,000 cfs with 13 feet of static head on the gate at the 75 percent open setting. This ensures that the full 15,000 cfs desired sluice discharge capacity is available at reservoir elevations as low as 440 ft in a fully controlled manner, which is about 188 feet below the spillway crest.

At full flood storage reservoir elevation of 628 ft, each of the smaller sluice gates at 75 percent open can pass up to about 9,500 cfs, and the larger gate can pass up to about 14,200 cfs alone. The paired design of the two smaller gates was selected to ensure that finely controlled flood regulation would be available with a single gate as needed, given that the larger gate will likely be closed. Adjustment of a single 10 ft wide gate in 6-inch typical lift increments gives just 380 cfs per increment at the maximum flood regulation reservoir elevation of 628 ft. The importance of controlling downstream flows is that required ramping rates can be achieved. Flood regulation operation would include operation of the sluices at reservoir elevations up to the spillway crest of 628 ft. At reservoir elevation above the spillway crest, sluice operation may be curtailed to avoid adverse flow conditions within the stilling basin.

For the FRE-FC dam, the low-level outlet works are identical to the FRE. The only modification to accommodate the FRE-FC dam outlet works would be extending the large trashrack in front of the outlet works to the full height of the FRE-FC dam. As described above, the low-level flood regulation sluices are designed for a controlled discharge of 15,000 cfs at any reservoir elevation within the full operating range of the project (reservoir elevation 588 ft to 687 ft). At minimum operational reservoir elevation of the project (reservoir elevation of 588 ft) each of the smaller sluice gates at 75 percent open can pass up to about 8,500 cfs, and the larger gate can pass up to about 12,800 cfs alone. At full flood storage reservoir elevation of 687 ft each of the smaller sluice gates at 75 percent open can pass up to about 10,700 cfs, and the larger gate can pass up to about 16,100 cfs alone. FRE-FC flood regulation operation would include operation of the sluices at reservoir elevations up to the spillway crest of 687 ft. At reservoir elevation above the spillway crest, sluice operation may be curtailed to avoid adverse flow conditions within the stilling basin.

Figure 2-20
FRE Alternative Single 12 ft wide by 20 ft high Sluice Gate Rating Curves

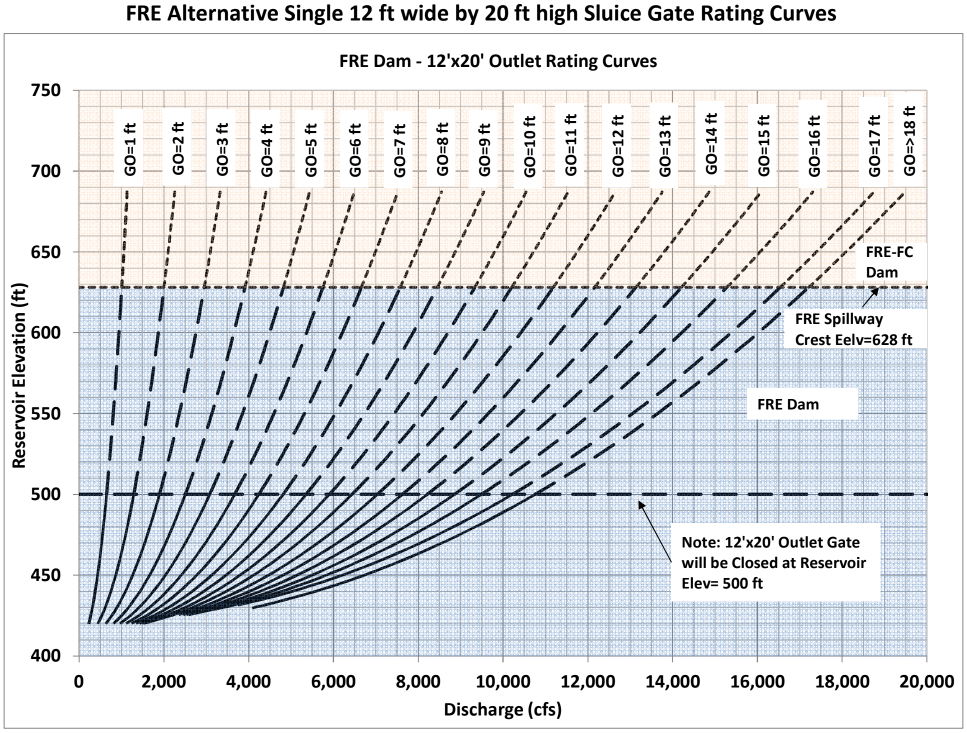


Figure 2-21
FRE Alternative Single 10 ft wide by 16 ft high Sluice Gate Rating Curves

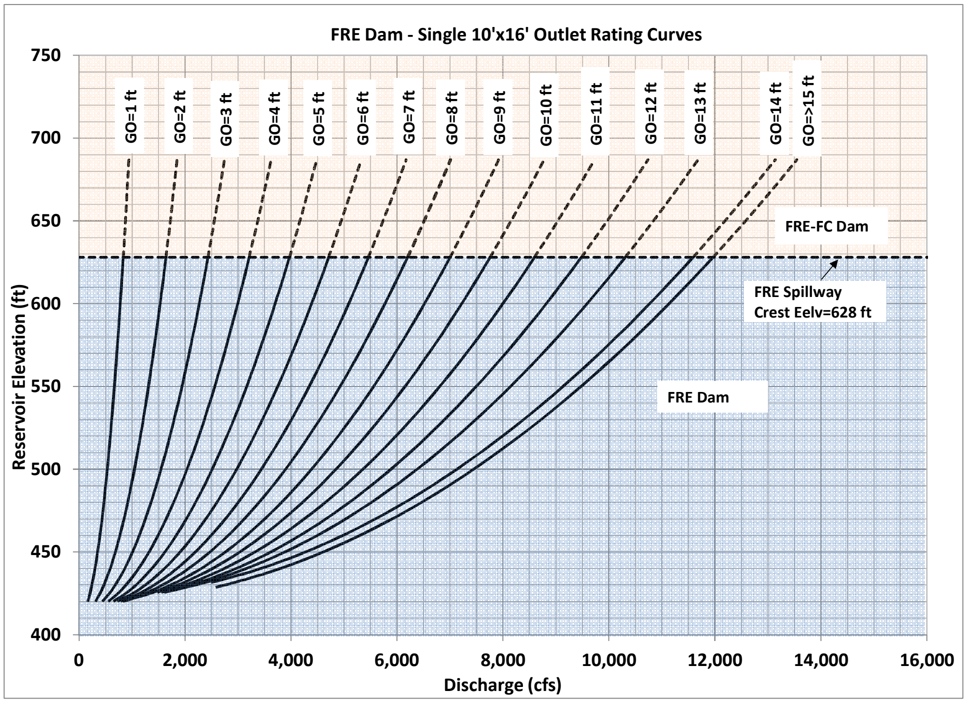
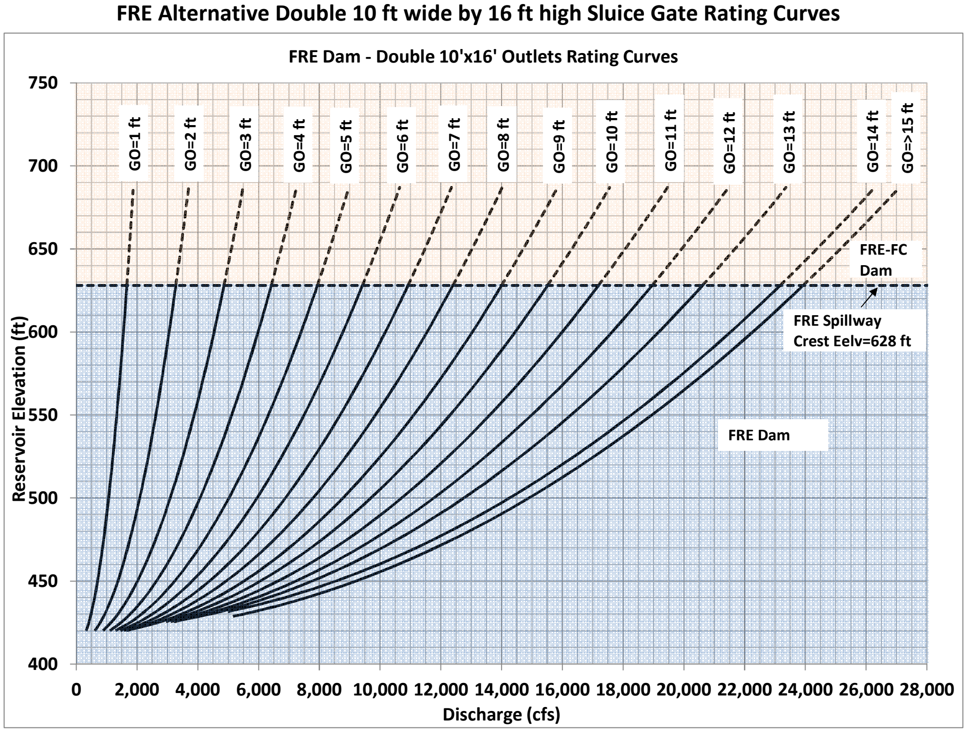


Figure 2-22
FRE Alternative Double 10 ft wide by 16 ft high Sluice Gate Rating Curves



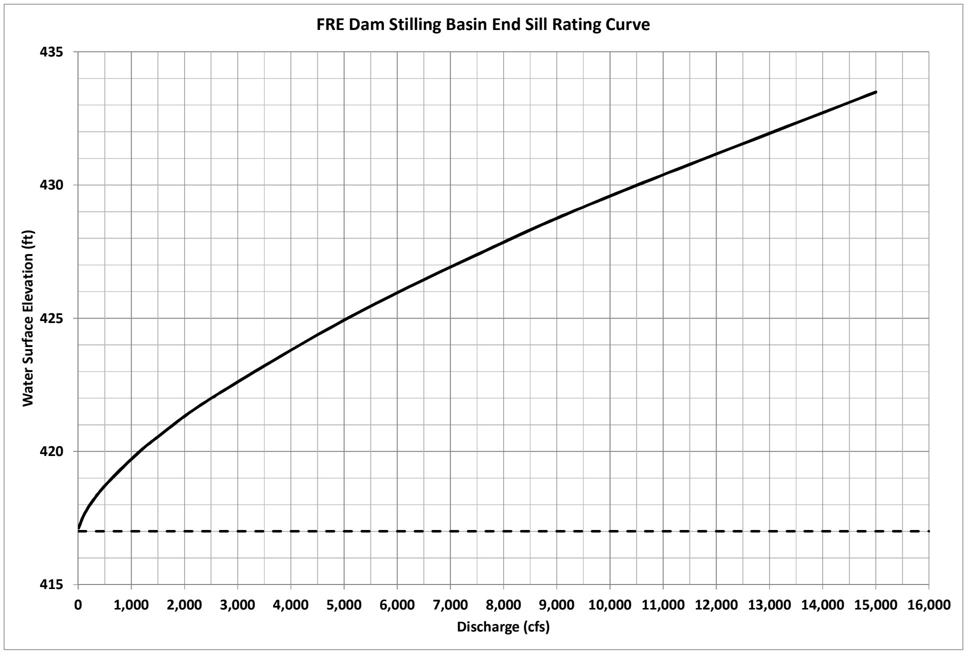
2.11 Stilling Basin

To dissipate the high energy of flowing water exiting the outlet work structure a stilling basin is required. Stilling basin produces a hydraulic jump and consequently dissipates the flow energy. Design guidance utilized in the design of the outlet works stilling basin is USACE EM 1110-2-1602, Hydraulic Design of Reservoir Outlet Works. A sample of the stilling basin design procedure is presented in detail in the Appendix B (Section 2.12) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

The stilling basin for the FRE alternative design receives flood regulation outflows from the 12’ W x 20’ H gate at reservoir elevations up to about 500 ft and also discharges from the two pairs of 10’ W x 16’ H sluice gates, up to a design discharge of 15,000 cfs at maximum reservoir elevation at the spillway crest elevation of 628 ft and 687 ft for the FRE and FRE-FC, respectively. The design for the FRE-FC stilling basin handles water under higher heads and was used to define the design dimensions, which are conservative for the outflows expected from the FRE.

Assuming one pair of 10’ W x 16’ H sluices is discharging 15,000 cfs under the maximum reservoir elevation of 687 ft for FRE-FC, the flow velocity entering the basin would be approximately 140 feet per second, with a Froude number of about 12.6. Following USACE guidance, a baffled stilling basin length of approximately 230 ft is obtained, assuming a 102-foot width overall. The end sill elevation was selected to be commensurate with the natural bedrock-controlled stream bed elevation of about 417 ft, and the width of 102 feet provides a water surface profile of about 430 ft at the full sluice outlet discharge of 15,000 cfs. HEC-RAS modeling of the natural downstream channel indicates that the natural water surface at the end sill location is about 422 ft at the maximum stilling basin capacity of 15,000 cfs, ensuring hydraulic control by the end sill, since submergence of the end sill is just 5 feet against a driving head of 13 ft. The downstream conjugate depth at 15,000 cfs is approximately 66 ft, yielding a basin floor elevation of 377 ft, which provides adequate energy dissipation within the basin. Currently, the endsill is considered to be a broad crest weir. However for fish passage purposes, the flow pattern through the stilling basin could favorably be altered by designing a compound endsill configuration. The endsill configuration will be refined in the next phase of study. Figure 2-23 shows the stilling basin end sill rating curve.

Figure 2-23
FRE Dam Alternative Stilling Basin End Sill Rating Curve



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3 CALCULATIONS, TABLES AND FIGURES

3.1 FRE Hydraulic Characterization

3.1.1 Velocity and Depth Characterization

Figure 3-1

Flow Velocity Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Project Site (RM 108.47)

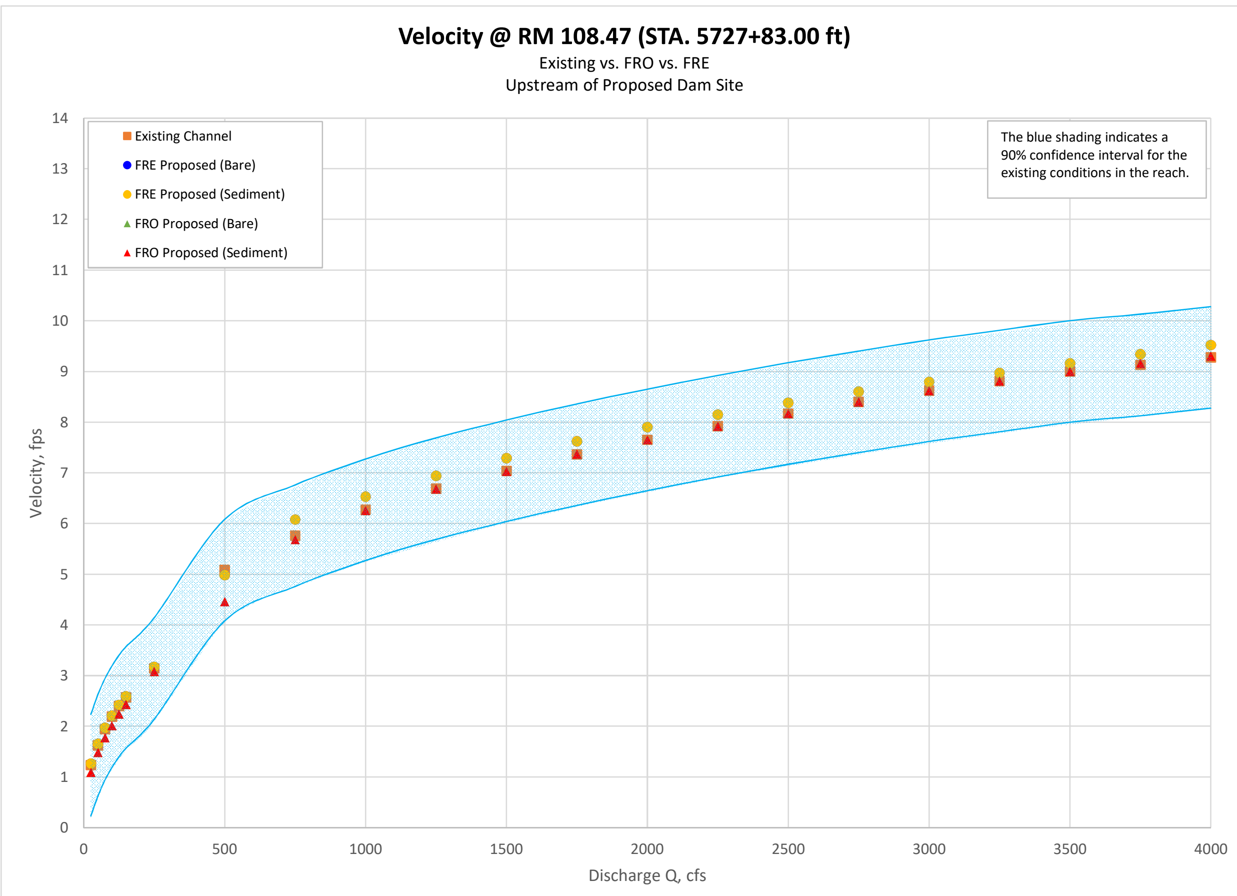


Figure 3-2

Flow Velocity Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Project Location (RM 108.37)

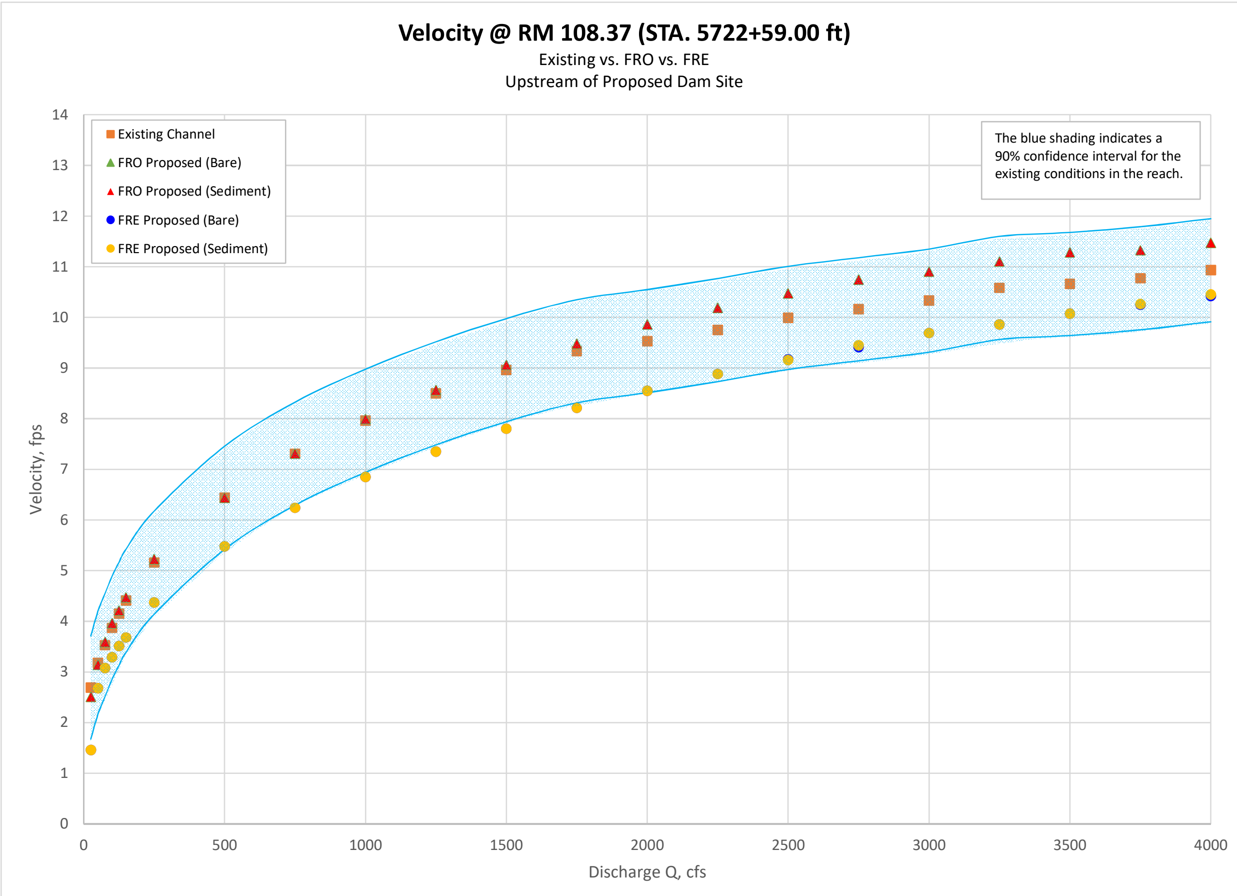


Figure 3-3

Flow Velocity Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations at the 12'x20' Sluice Mouth (RM 108.31)

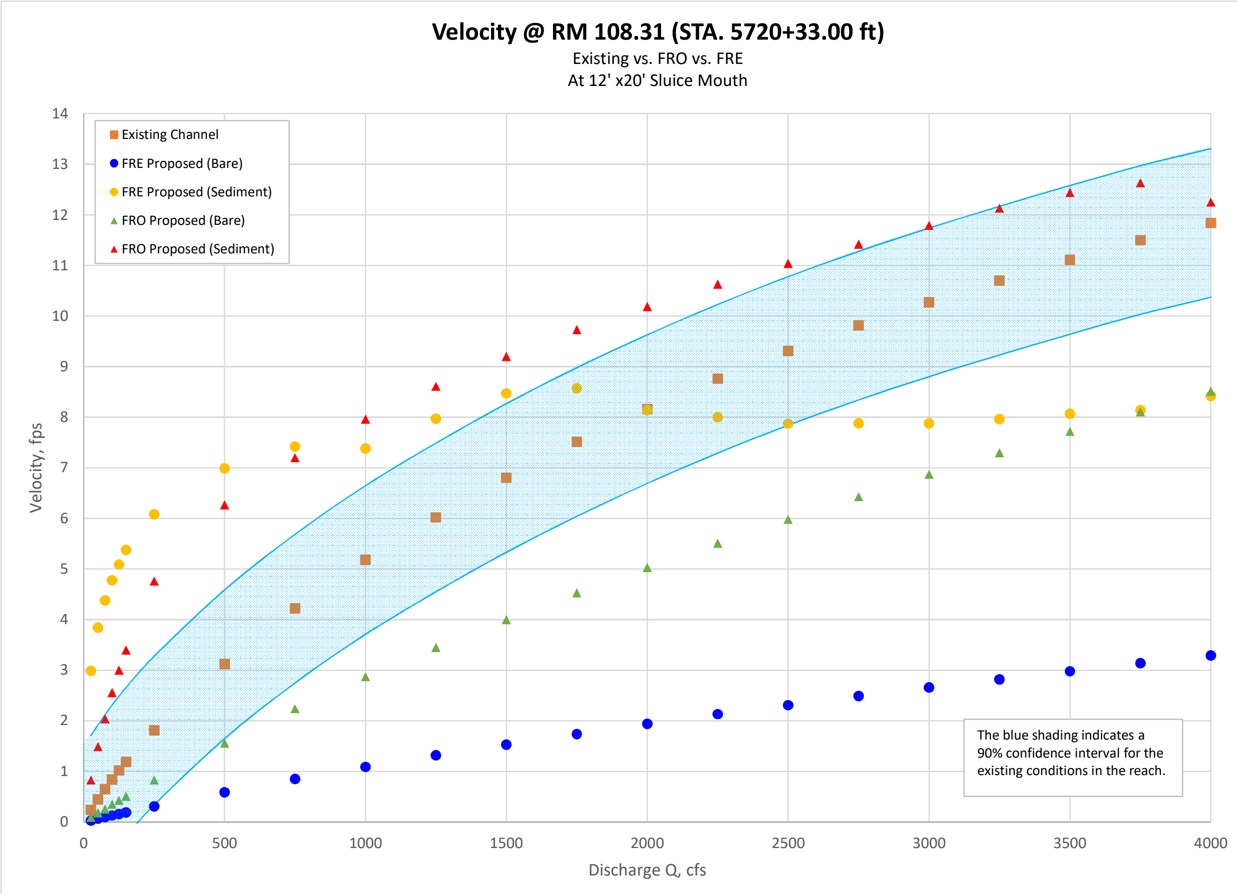


Figure 3-4

Flow Velocity Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Inside the 12'x20' Sluice (RM 108.30)

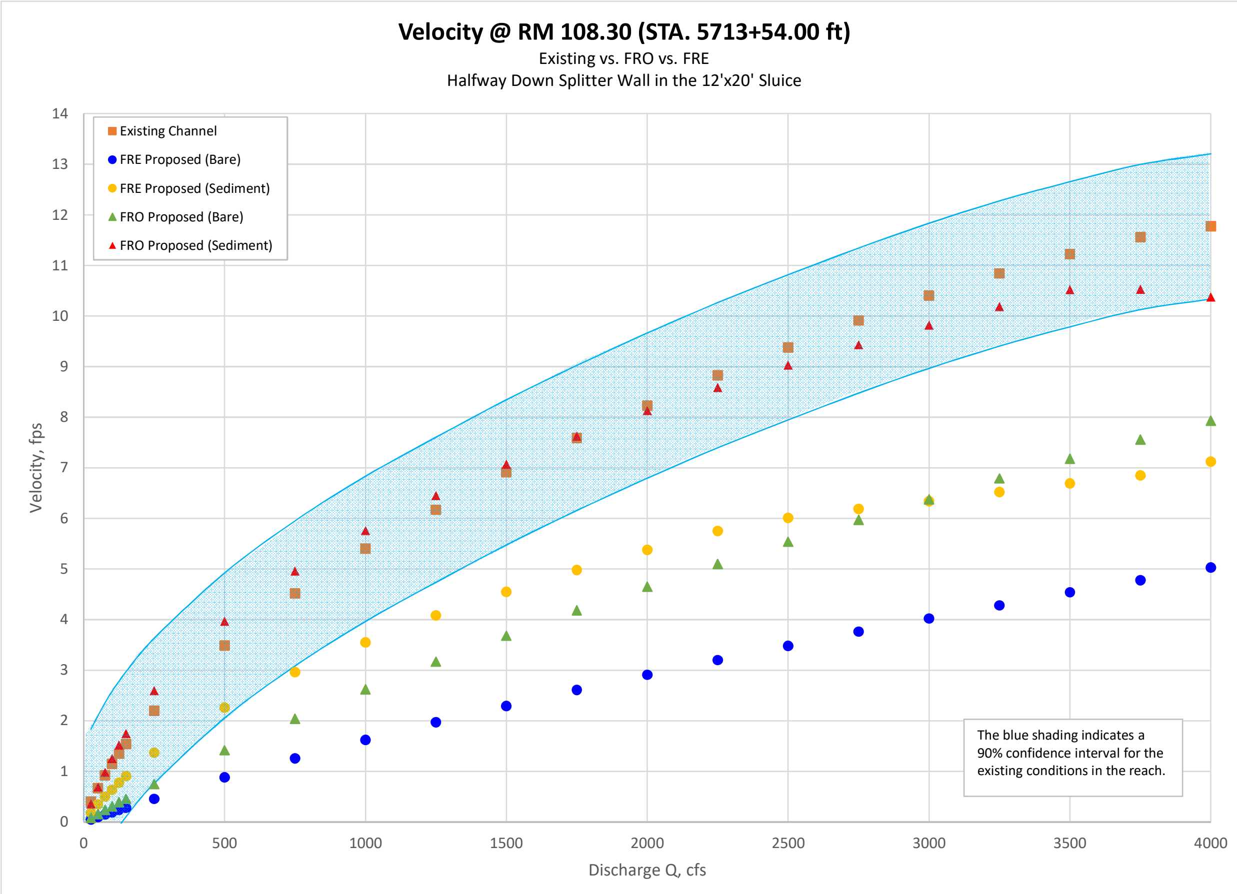


Figure 3-5
Flow Velocity Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Downstream of the 12’x20’ Sluice (RM 108.27)

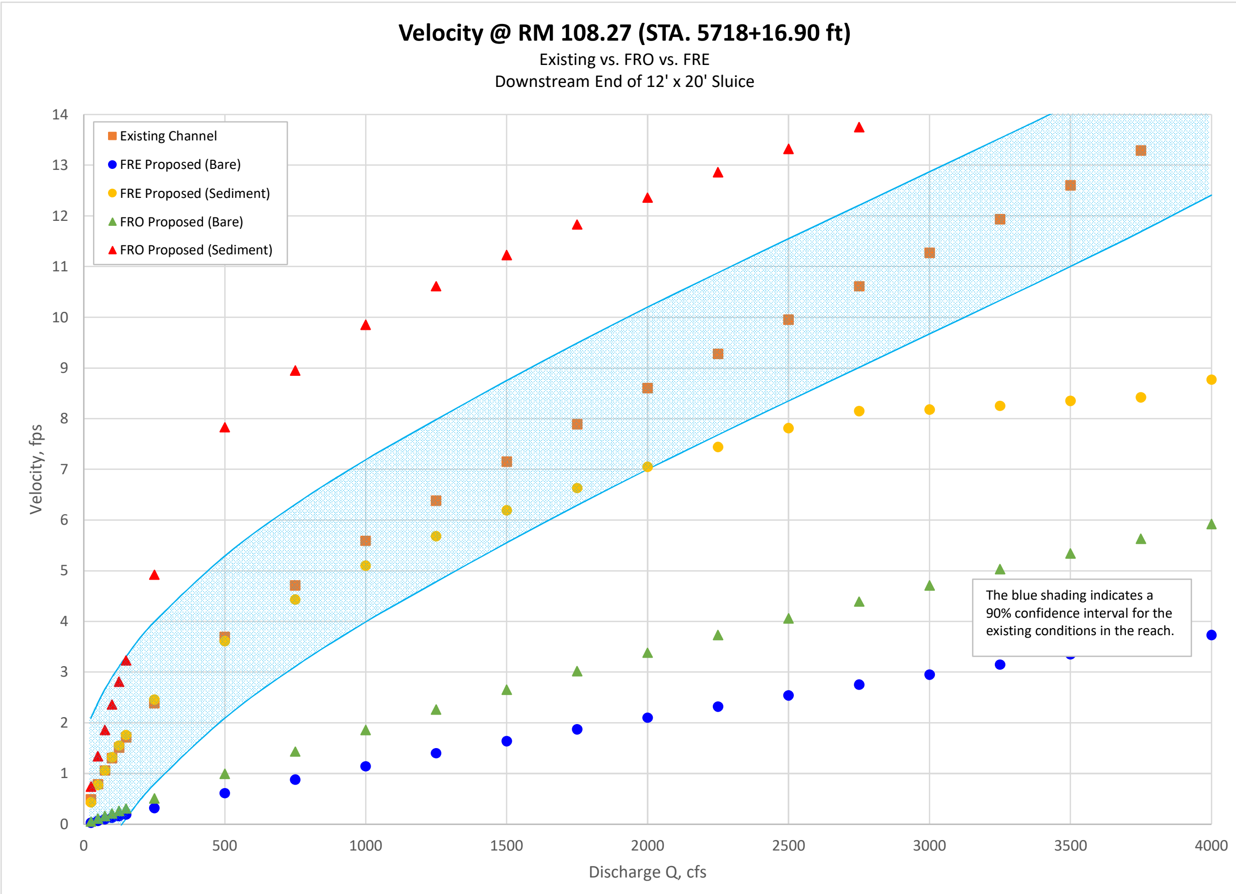


Figure 3-6

Flow velocity Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Stilling Basin Endsill (RM 108.23)

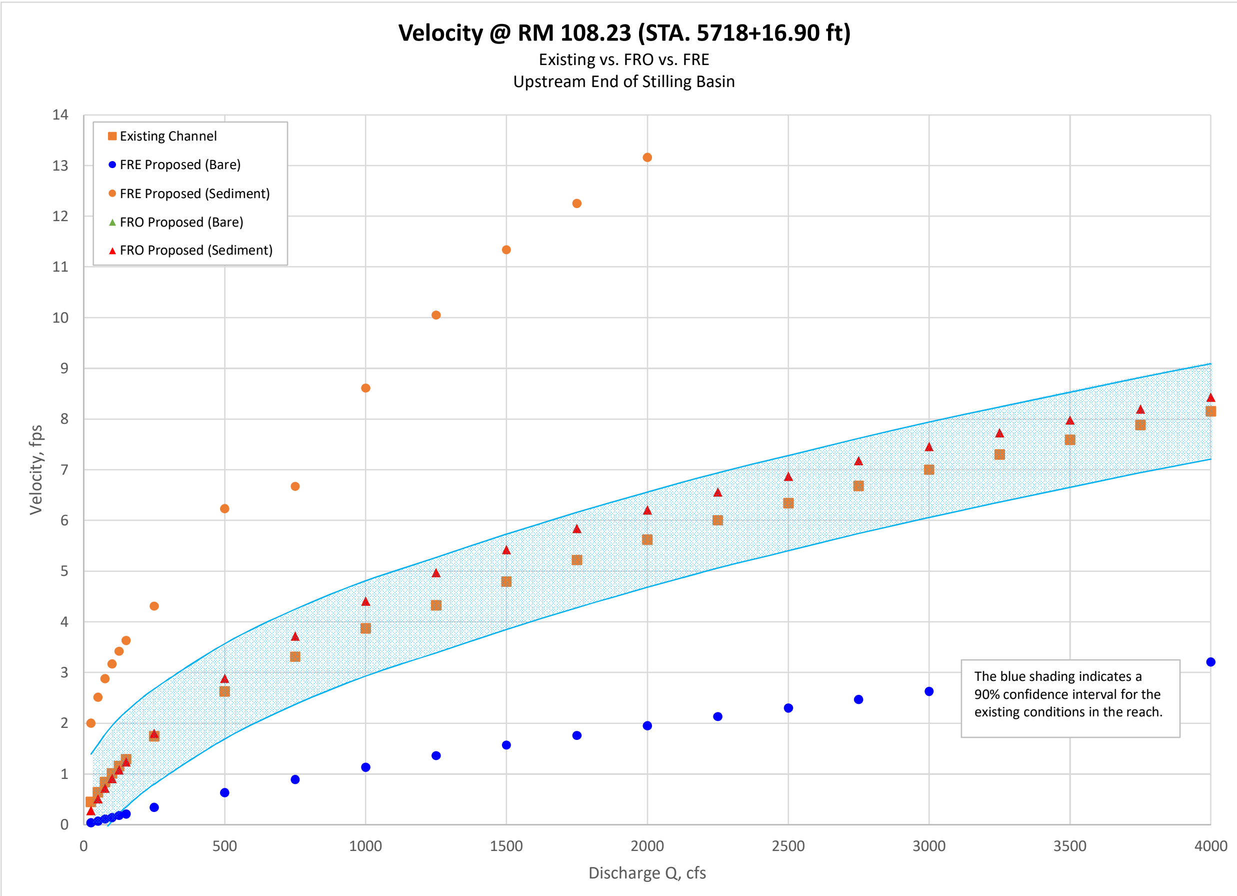


Figure 3-7

Flow Velocity Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Downstream of the Project Location (RM 108.18)

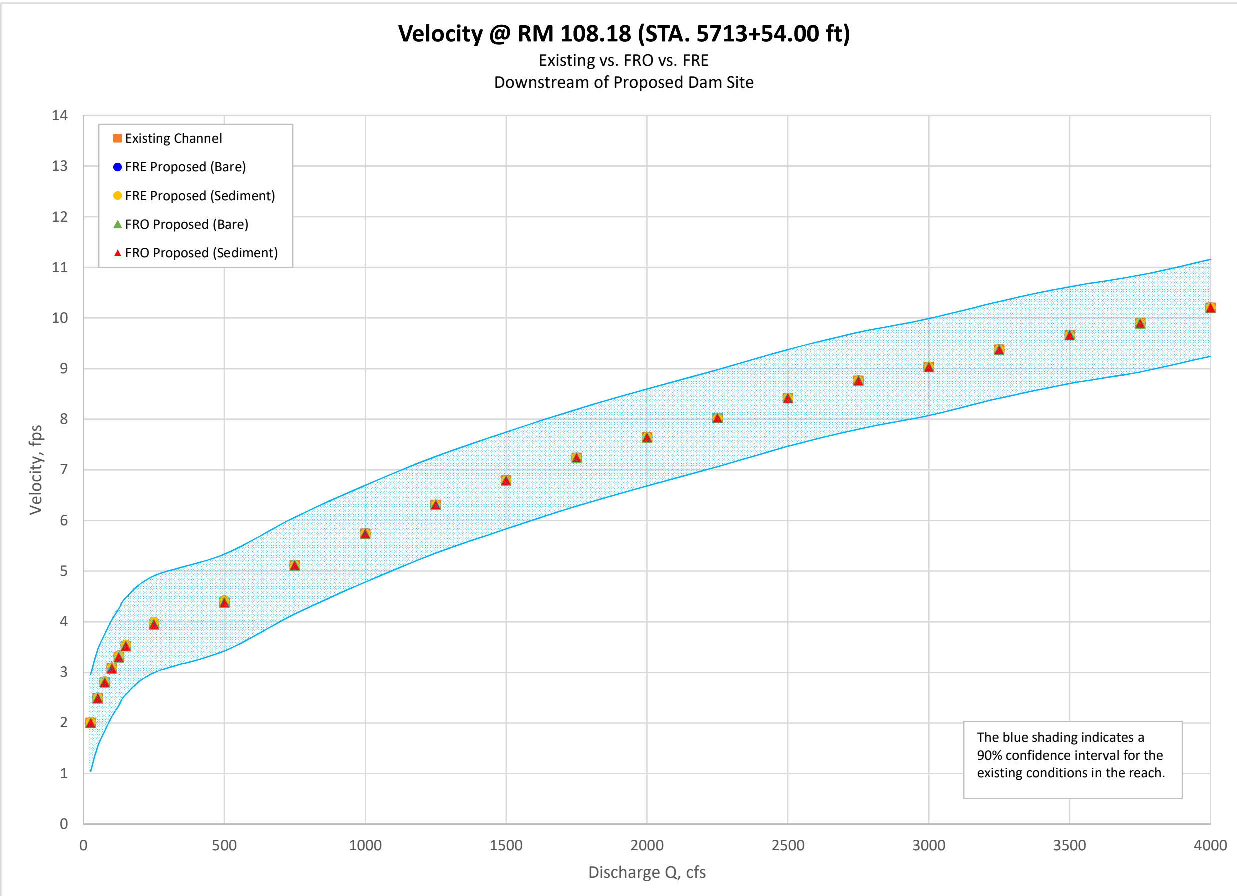


Figure 3-8

Flow Depth Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Project Site (RM 108.47)

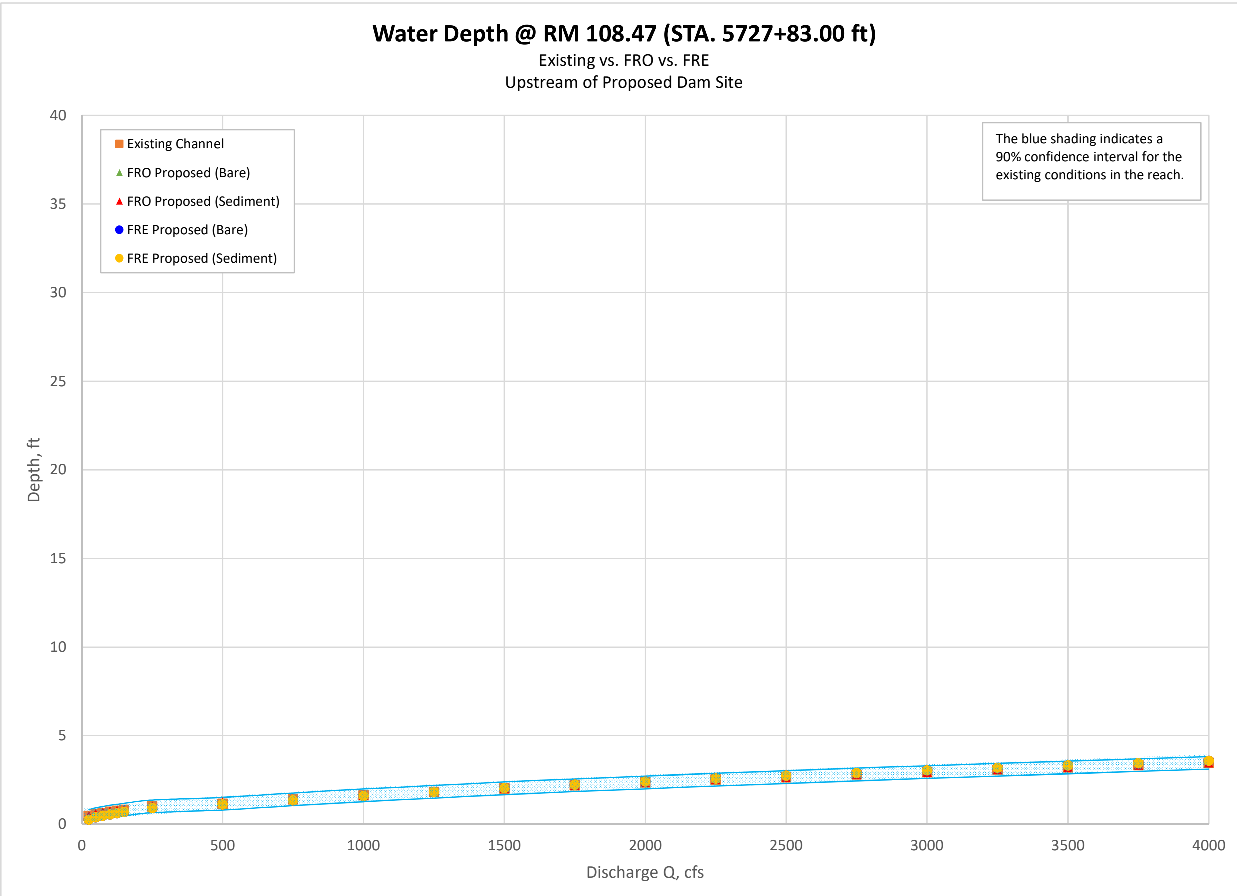


Figure 3-9

Flow Depth Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Project Location (RM 108.37)

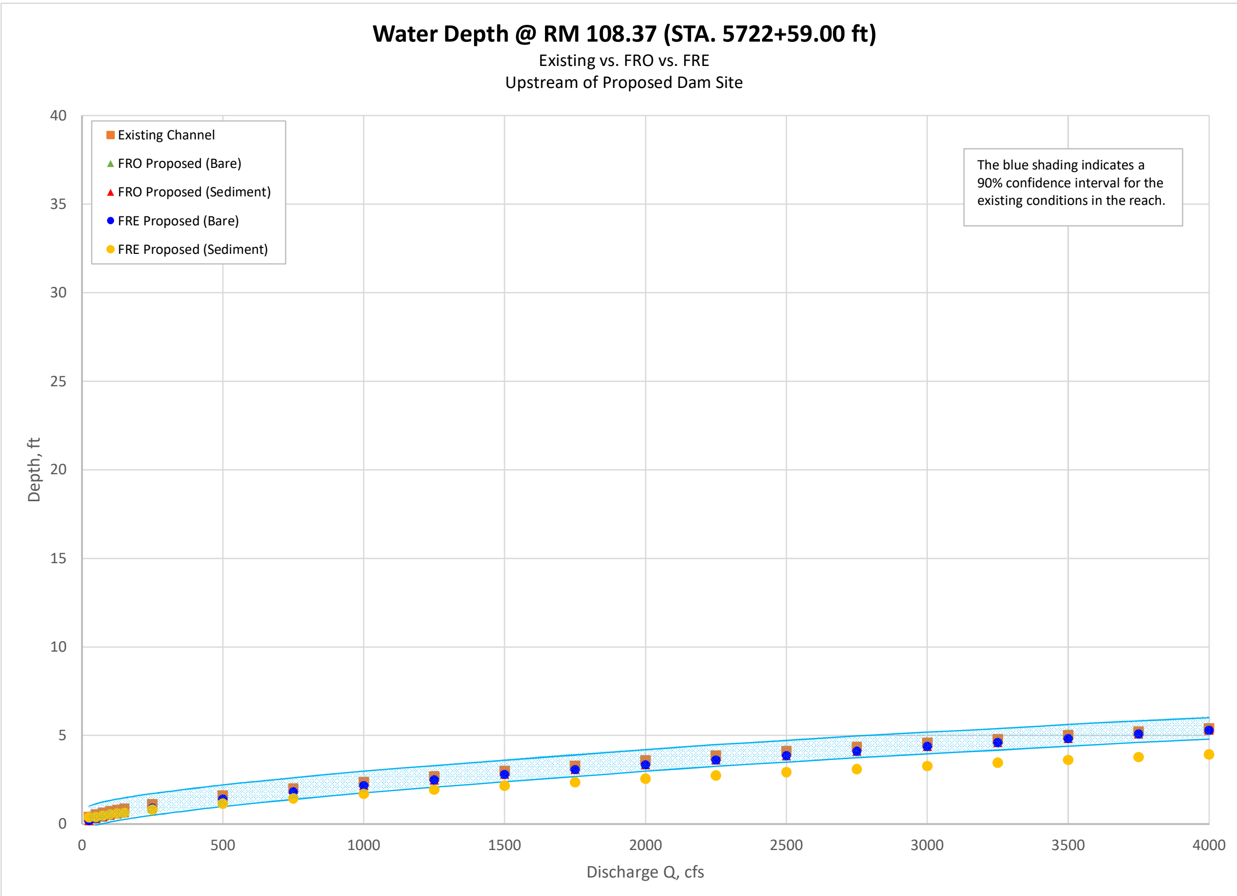


Figure 3-10

Flow Depth Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations at the 12'x20' Sluice Mouth (RM 108.31)

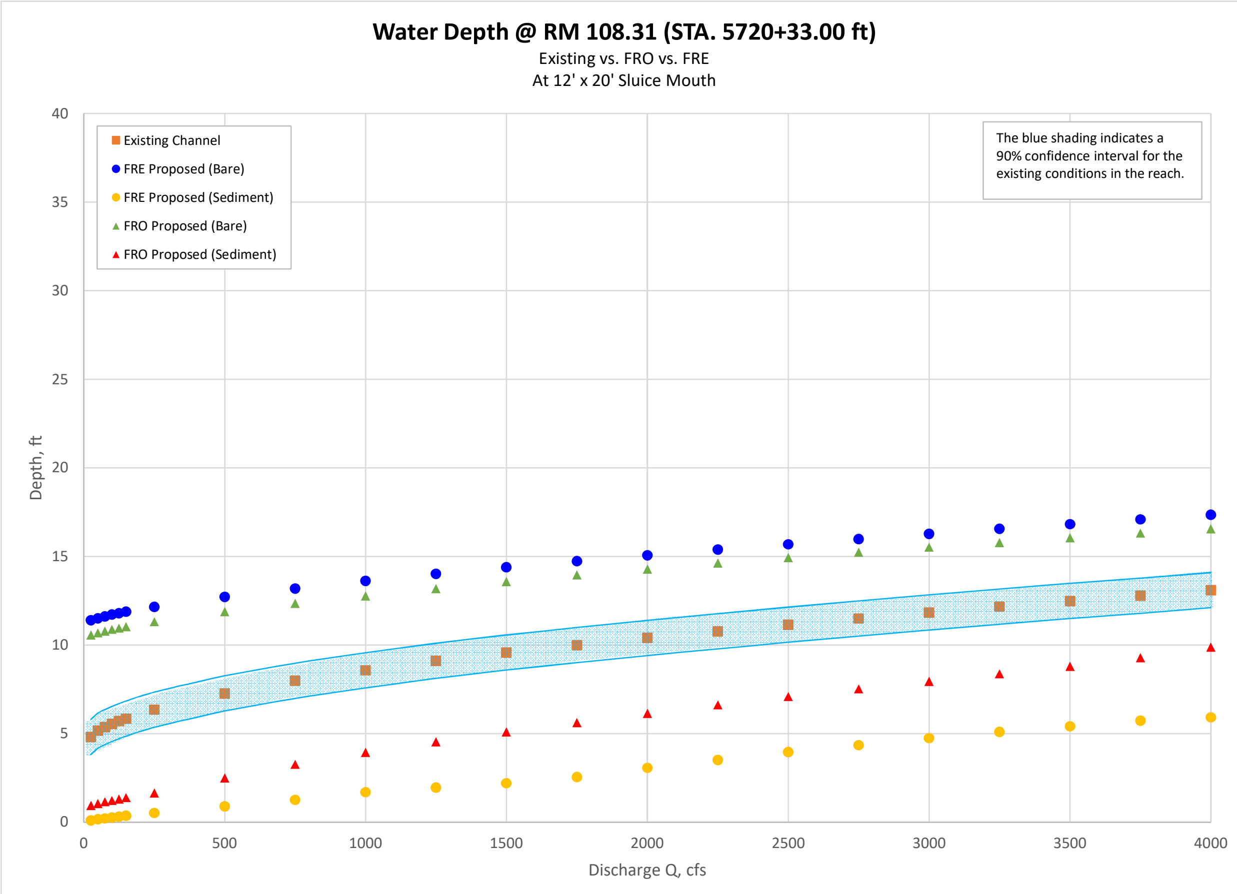


Figure 3-11

Flow Depth Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Inside the 12’x20’ Sluice (RM 108.30)

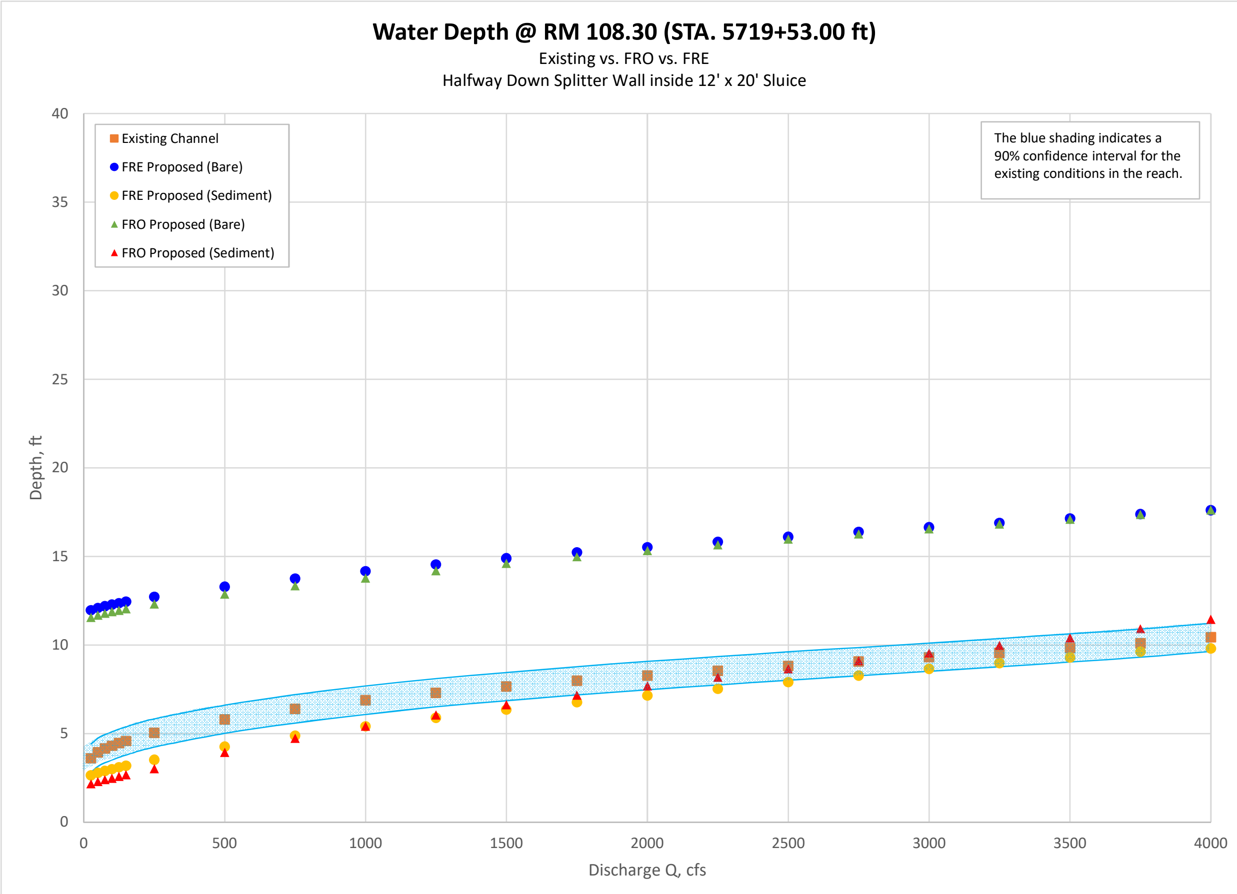


Figure 3-12

Flow Depth Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Downstream of the 12'x20' Sluice (RM 108.27)

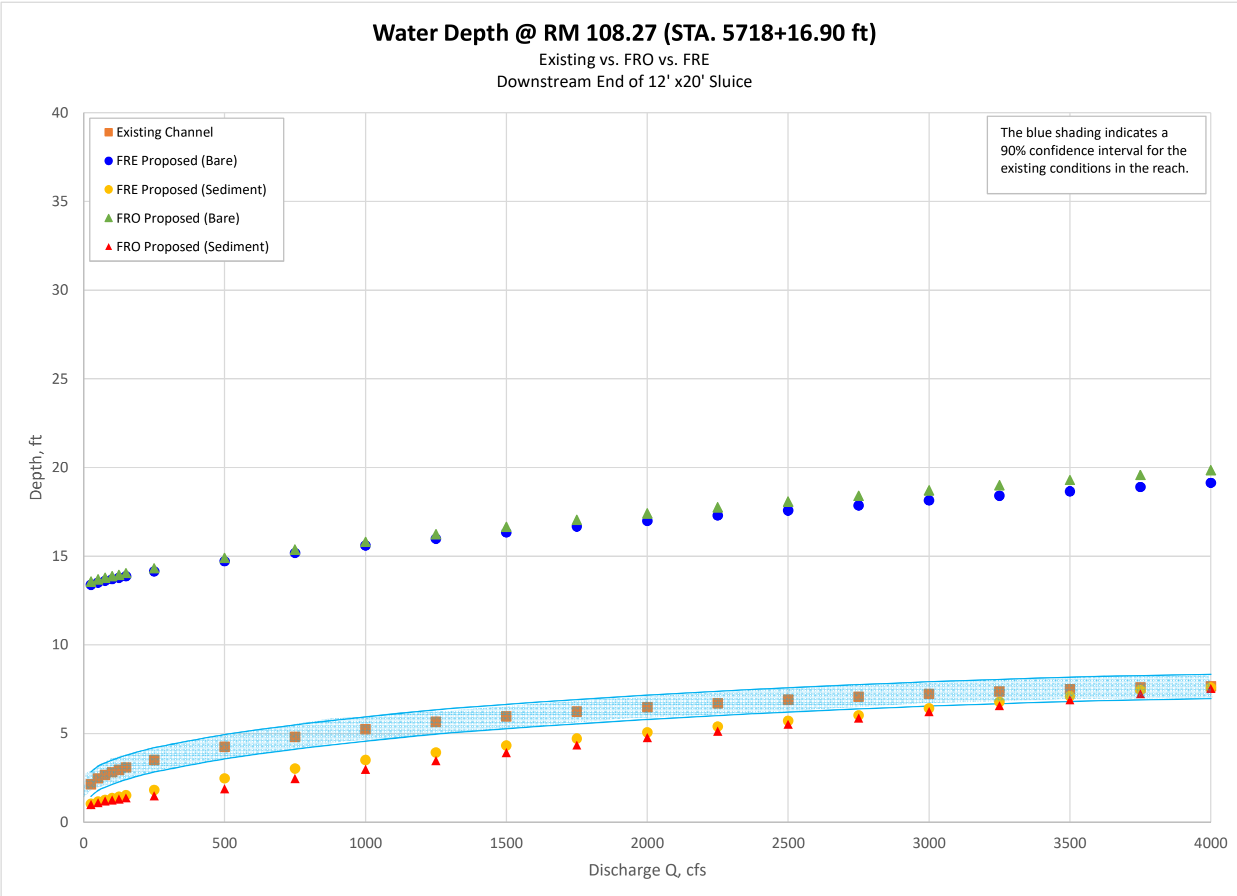


Figure 3-13

Flow Depth Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Stilling Basin Endsill (RM 108.23)

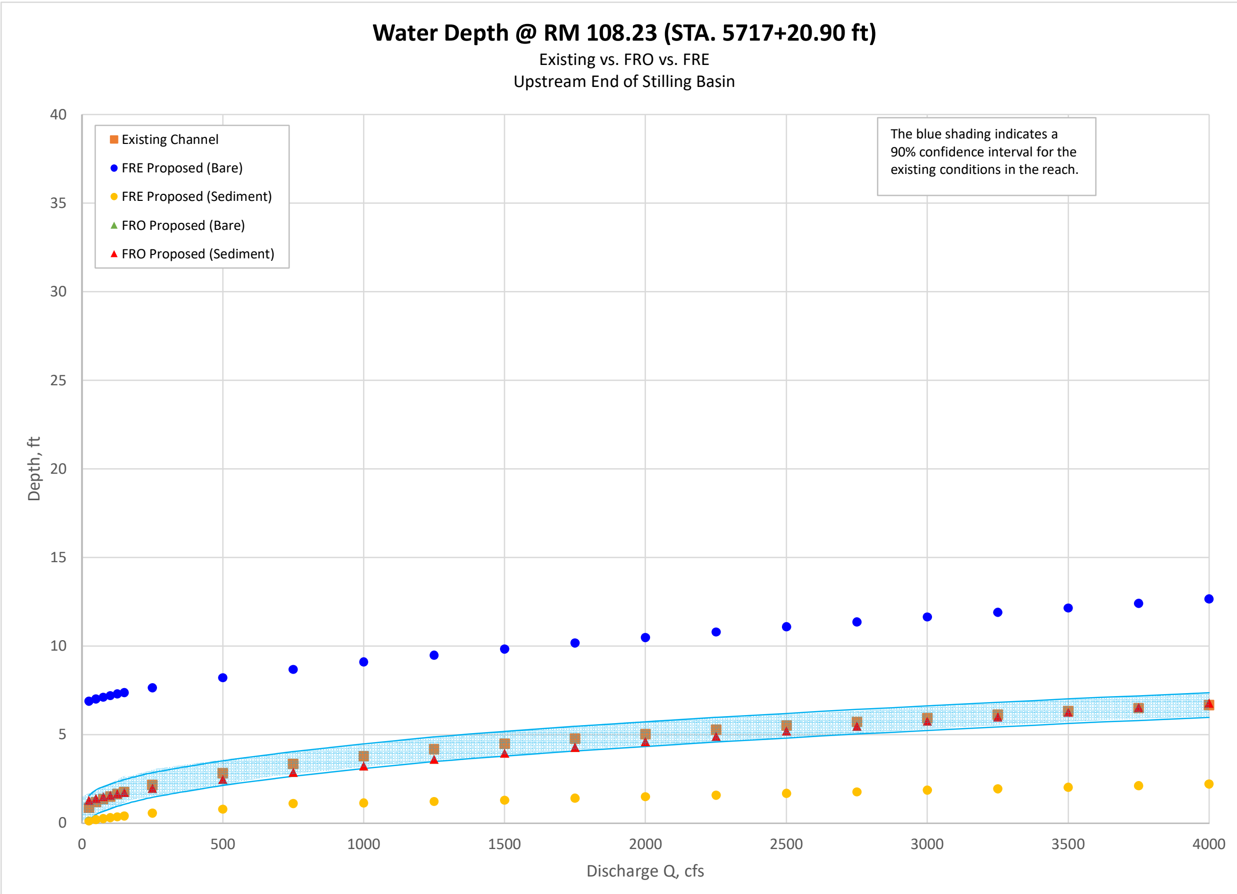
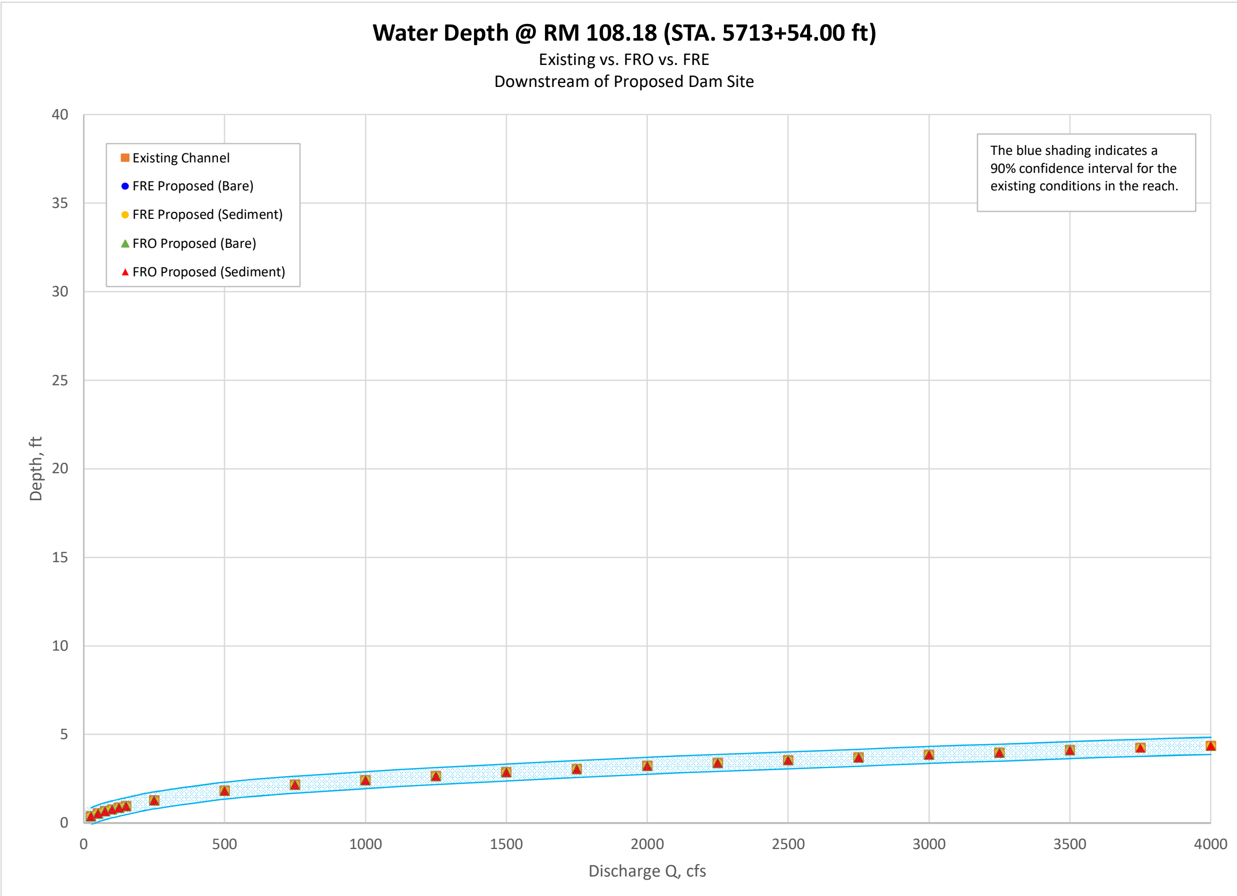


Figure 3-14

Flow Depth Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Downstream of the Project Location (RM 108.18)



3.1.2 Sediment Transport Capacity and Performance

Figure 3-15

Bed Shear Stress Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Project Site (RM 108.47)

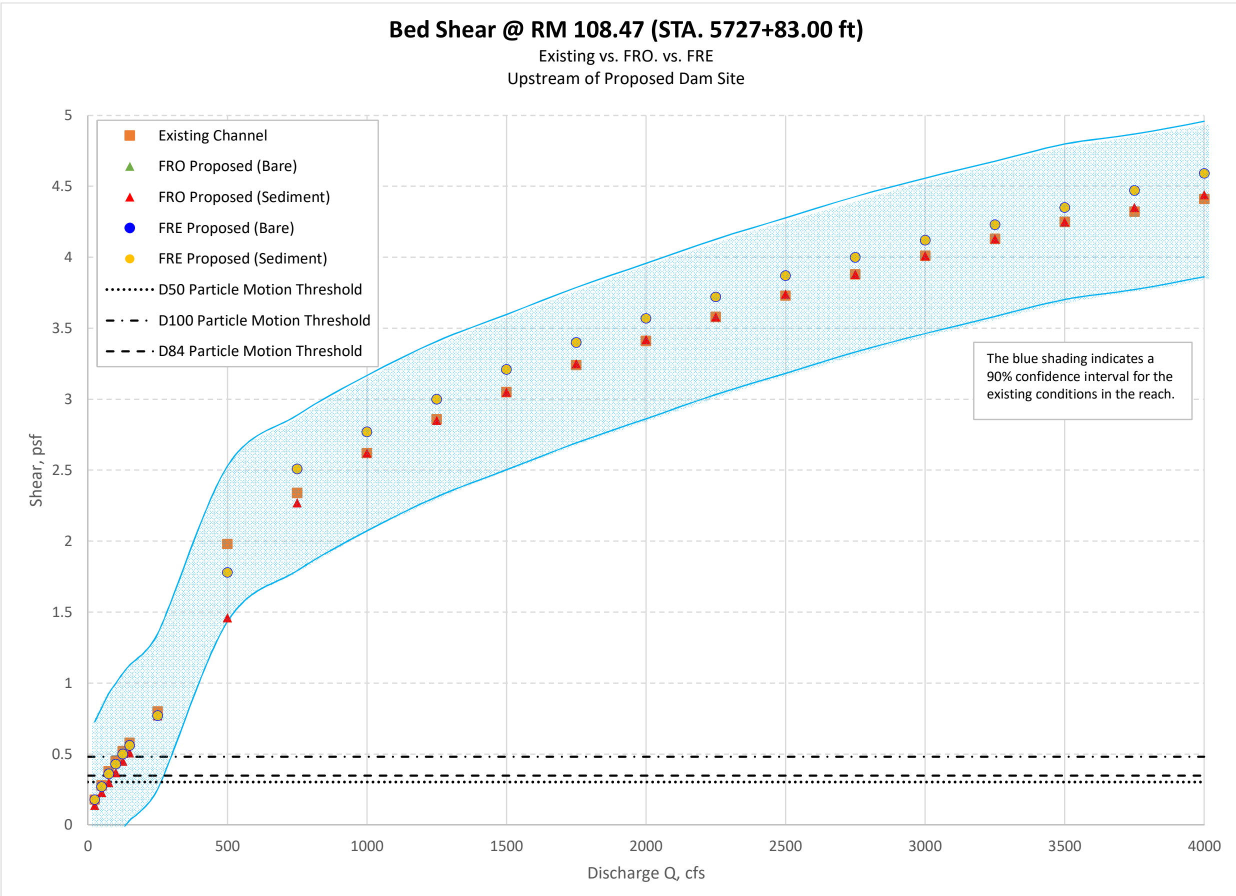


Figure 3-16

Bed Shear Stress Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Project Location (RM 108.37)

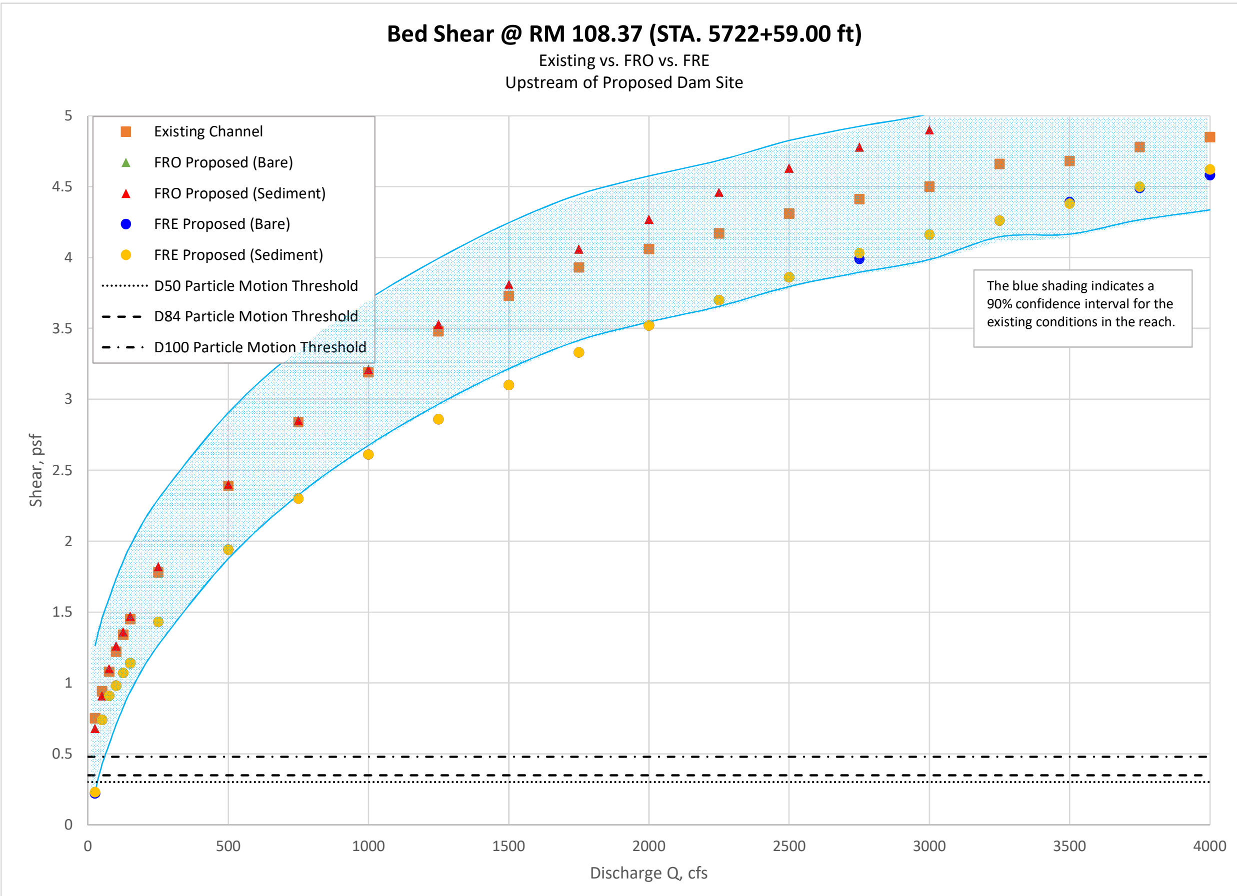


Figure 3-17

Bed Shear Stress Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations at the 12'x20' Sluice Mouth (RM 108.31)

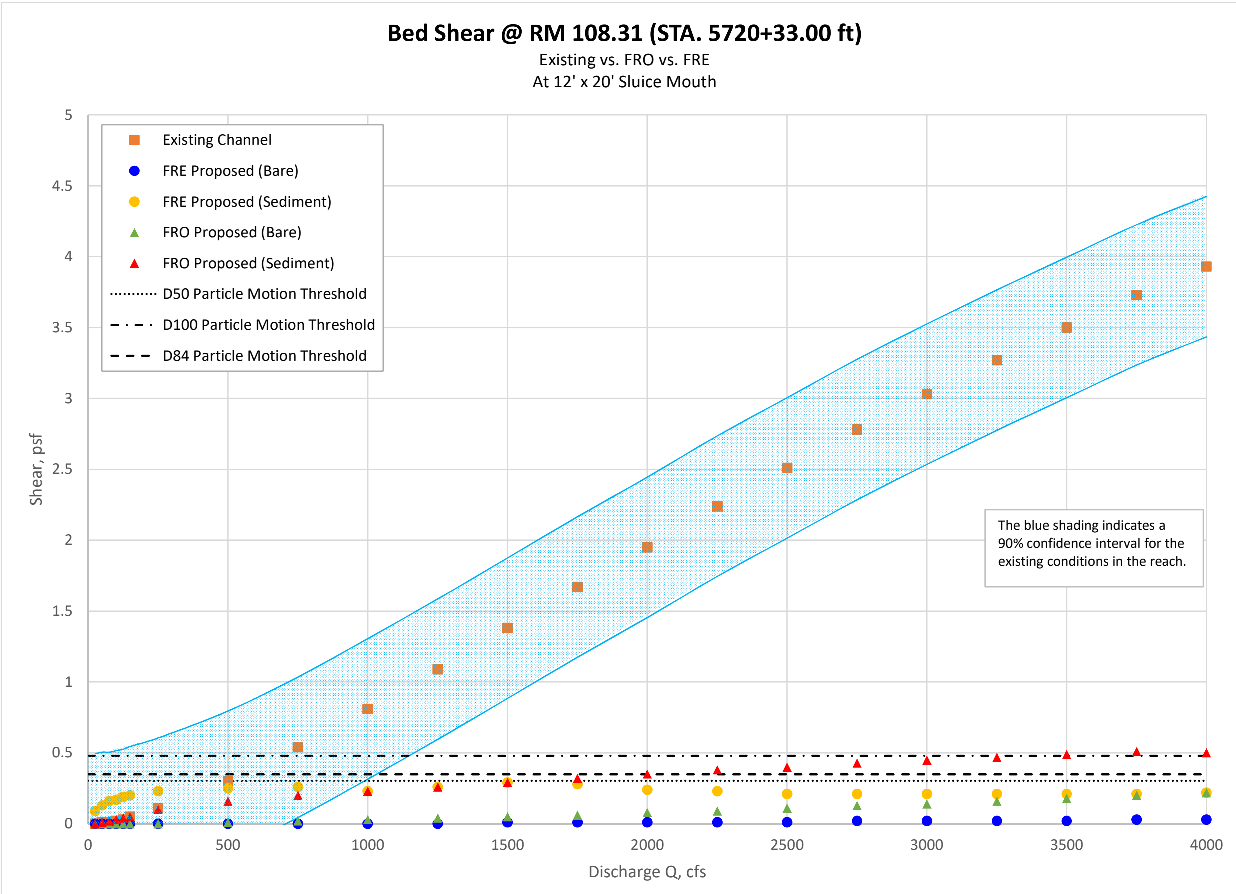


Figure 3-18

Bed Shear Stress Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Inside the 12'x20' Sluice (RM 108.30)

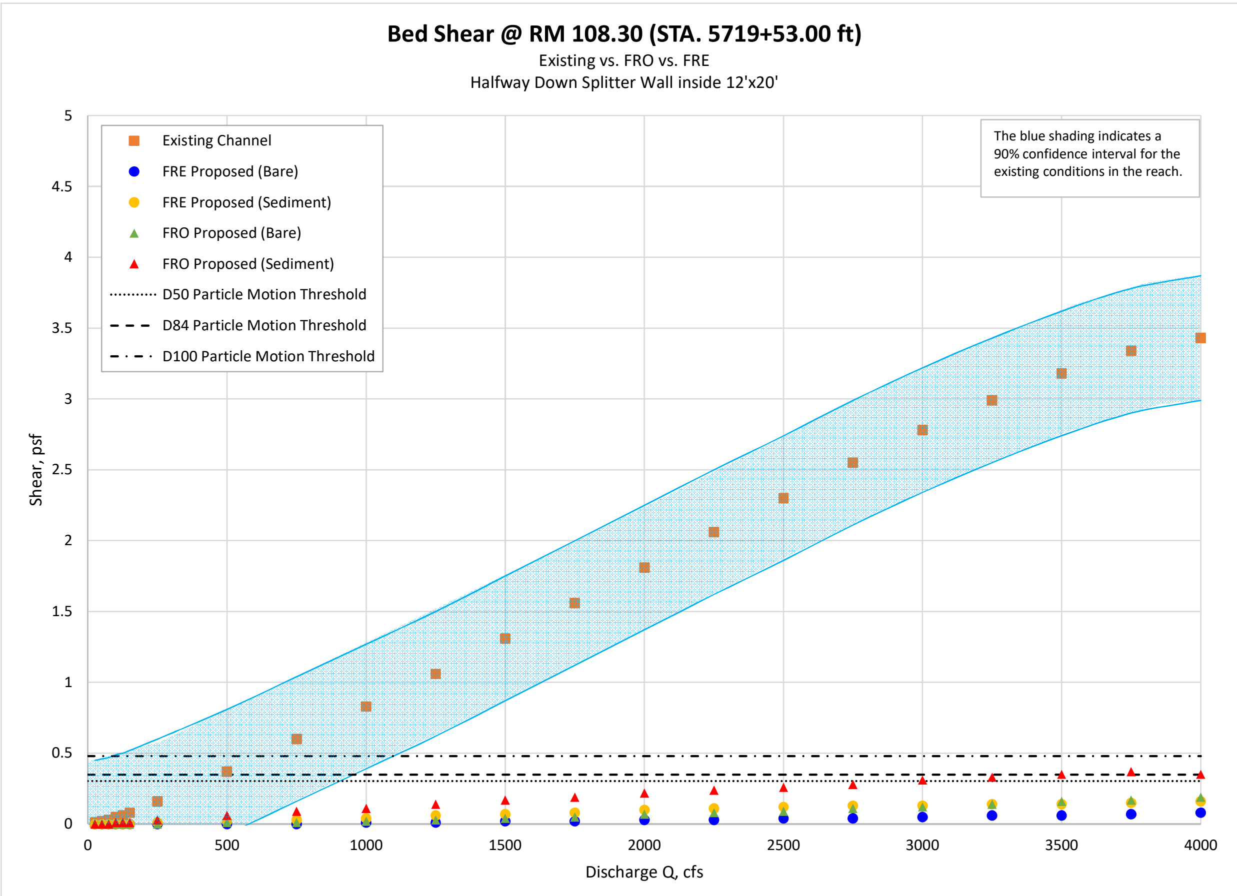


Figure 3-19
Bed Shear Stress Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Downstream of the 12’x20’ Sluice (RM 108.27)

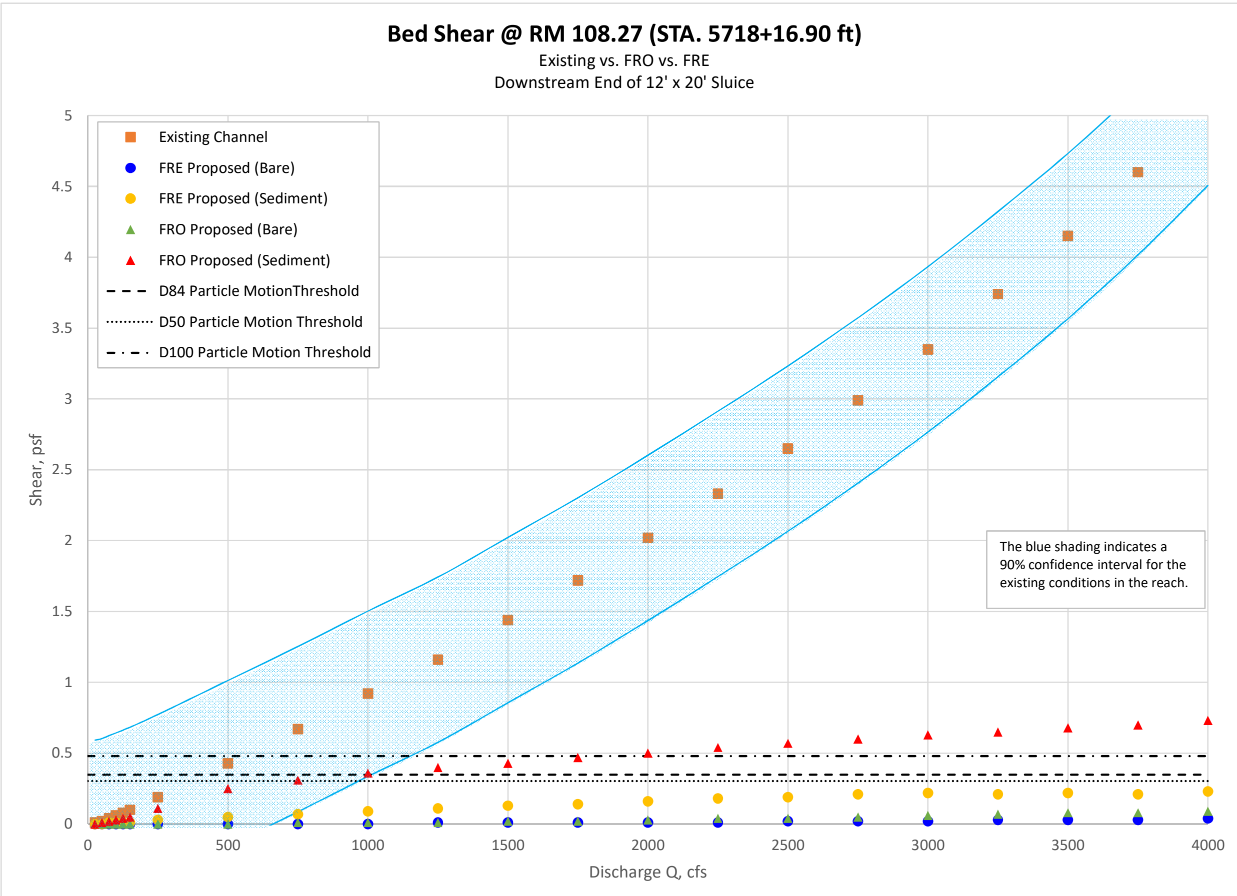


Figure 3-20

Bed Shear Stress Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Upstream of the Stilling Basin Endsill (RM 108.23)

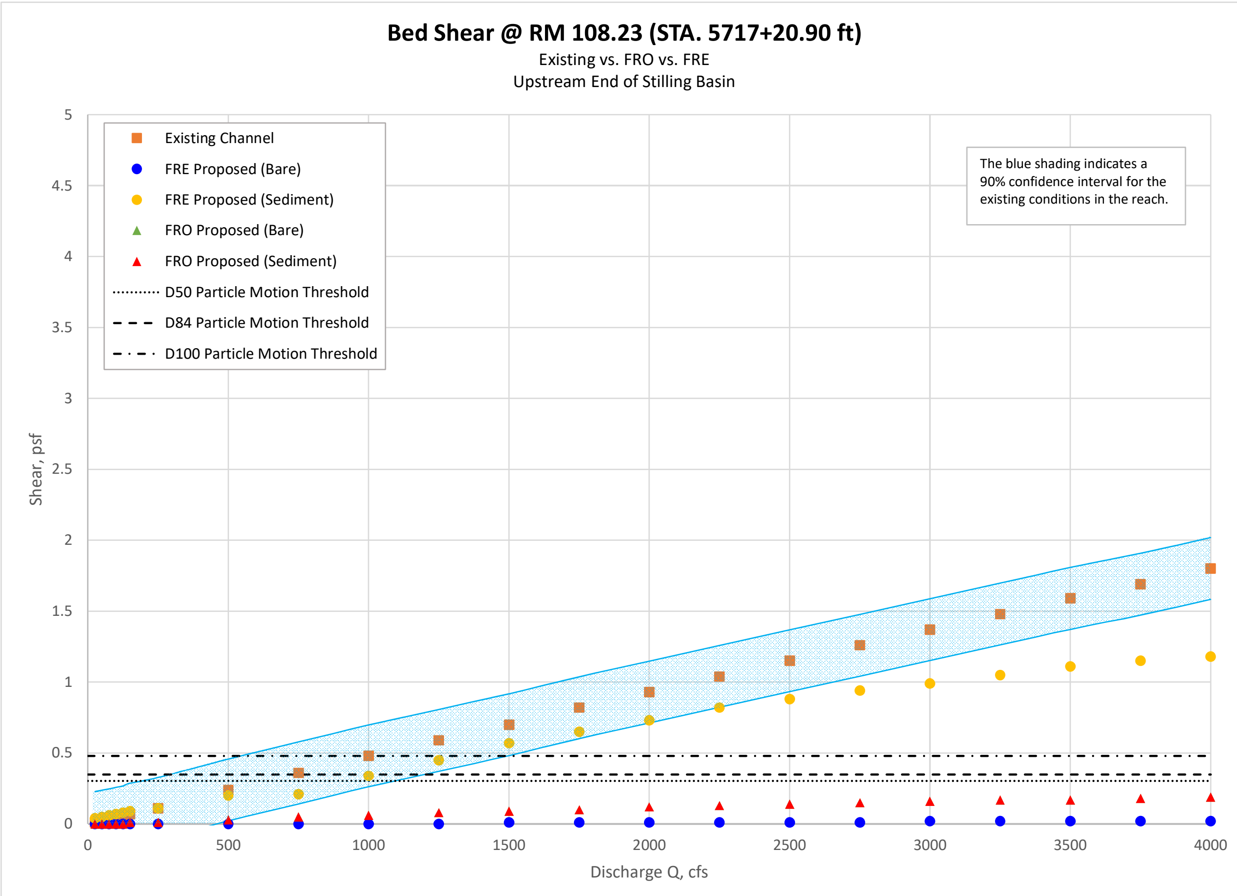
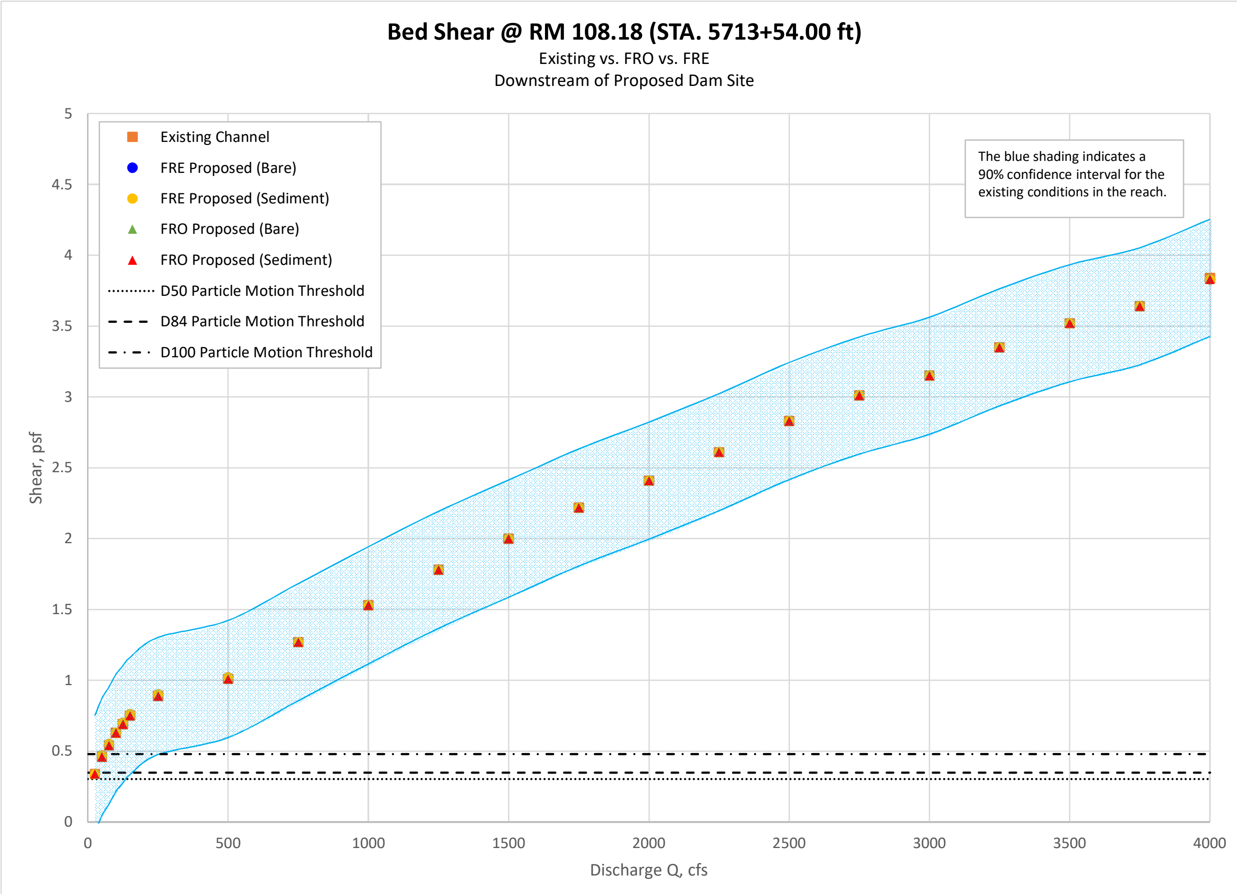


Figure 3-21

Bed Shear Stress Comparison for the Existing Condition, FRO and FRE Proposed Sluice Configurations Downstream of the Project Location (RM 108.18)



3.1.3 Computational Fluid Dynamic (CFD) Modeling

Figure 3-22
Isometric View of Velocity Contours for 100 Cfs Discharge Through Low Level Outlets

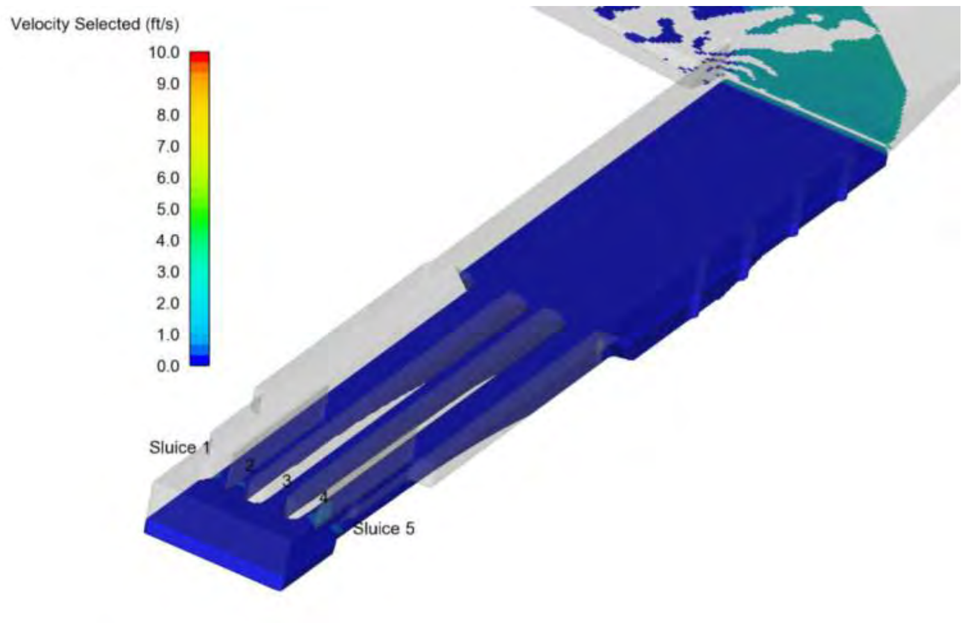


Figure 3-23

Profile View of Velocity Contours for 100 cfs Discharge Through Low Level Outlets

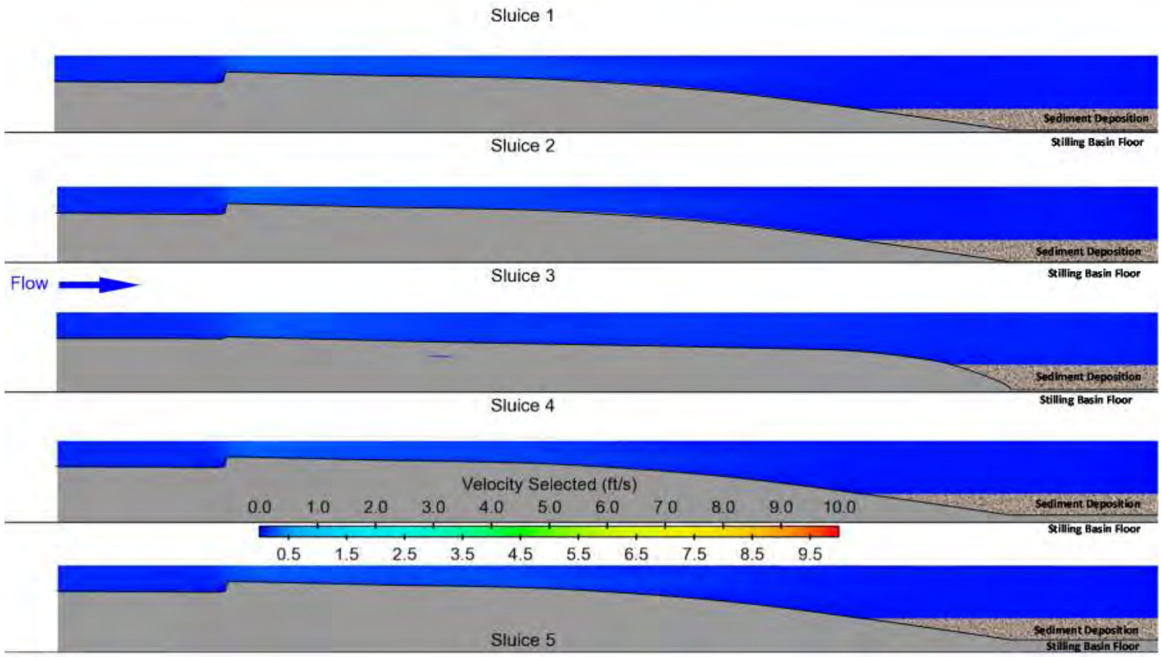


Figure 3-24

Isometric View of Velocity Contours for 250 cfs Discharge Through Low Level Outlets

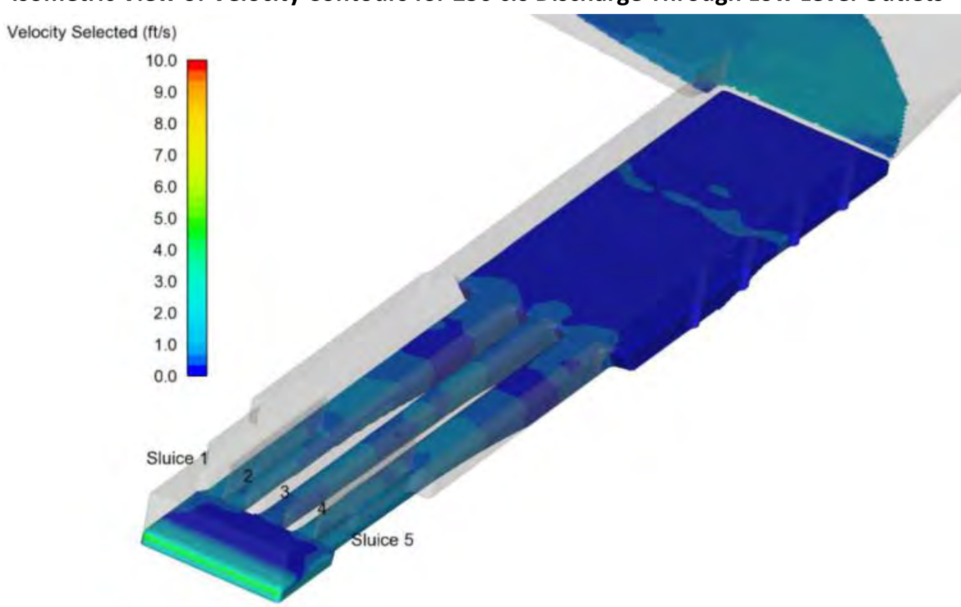


Figure 3-25

Profile View of Velocity Contours for 250 cfs Discharge Through Low Level Outlets

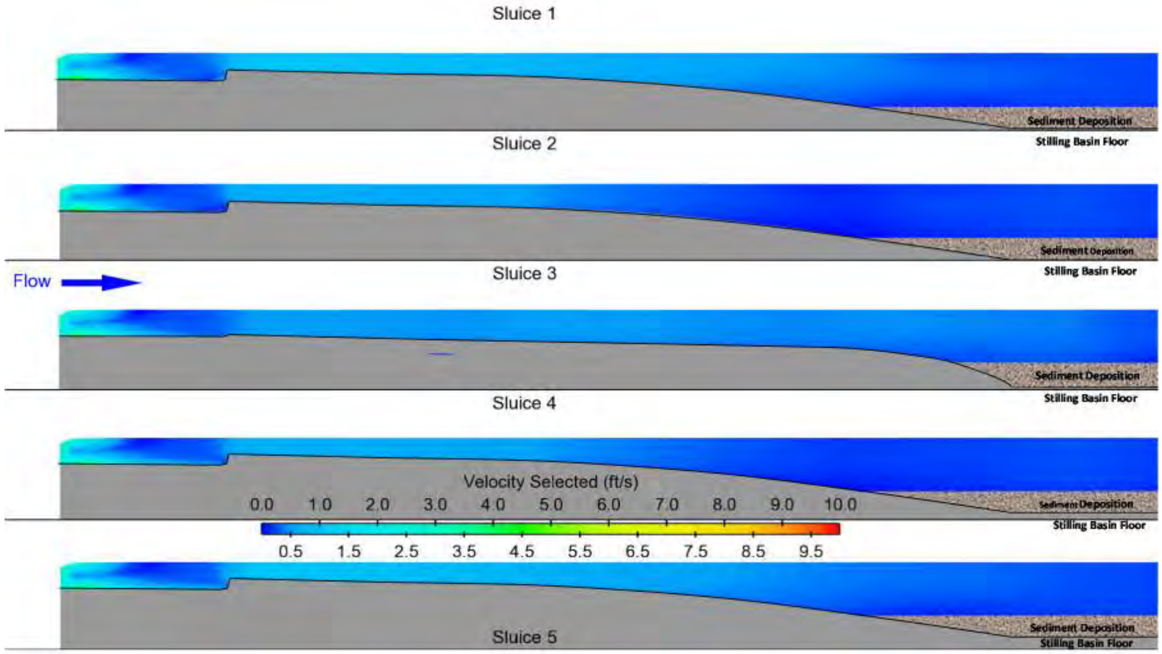


Figure 3-26
Isometric View of Velocity Contours for 500 cfs Discharge Through Low Level Outlets

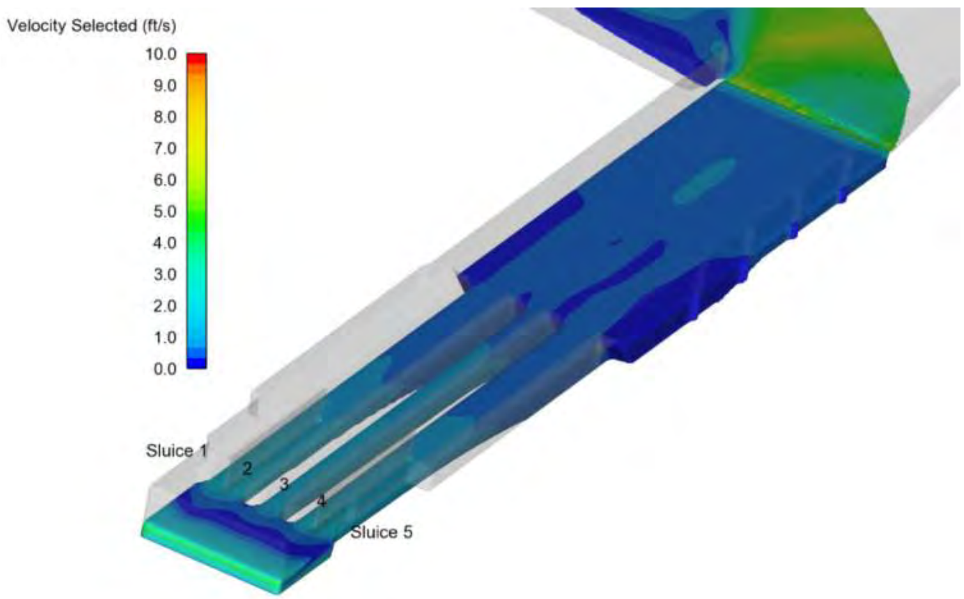


Figure 3-27
Profile View of Velocity Contours for 500 cfs Discharge Through Low Level Outlets

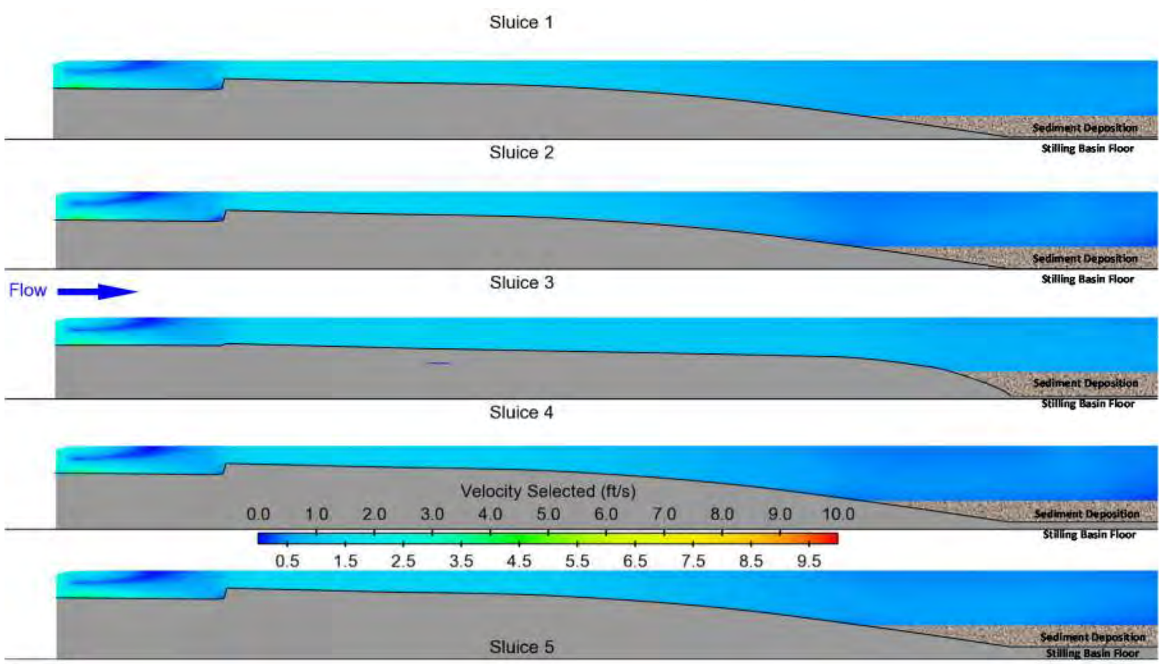


Figure 3-28
Isometric View of Velocity Contours for 1,000 cfs Discharge Through Low Level Outlets

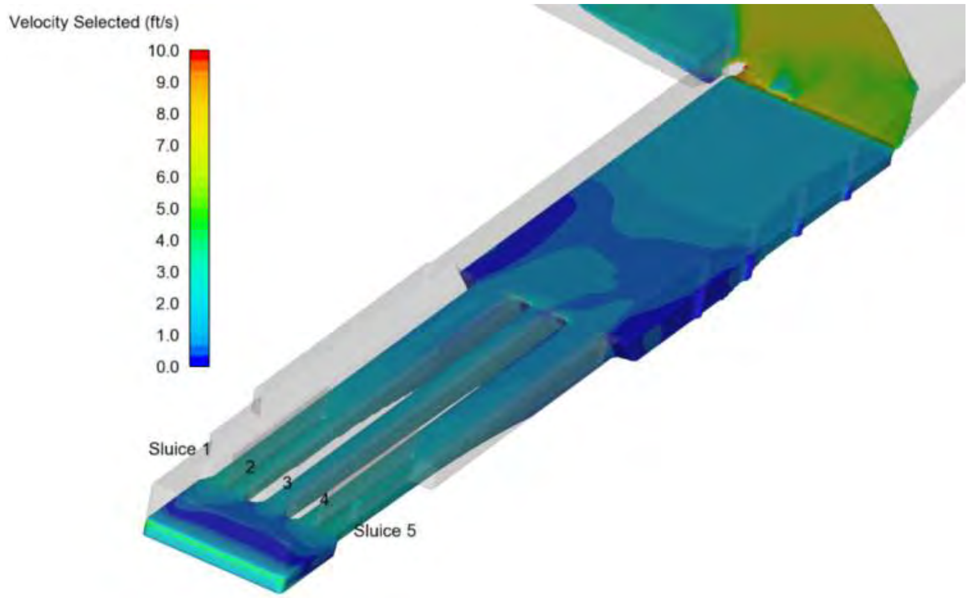


Figure 3-29
Profile View of Velocity Contours for 1,000 cfs Discharge Through Low Level Outlets

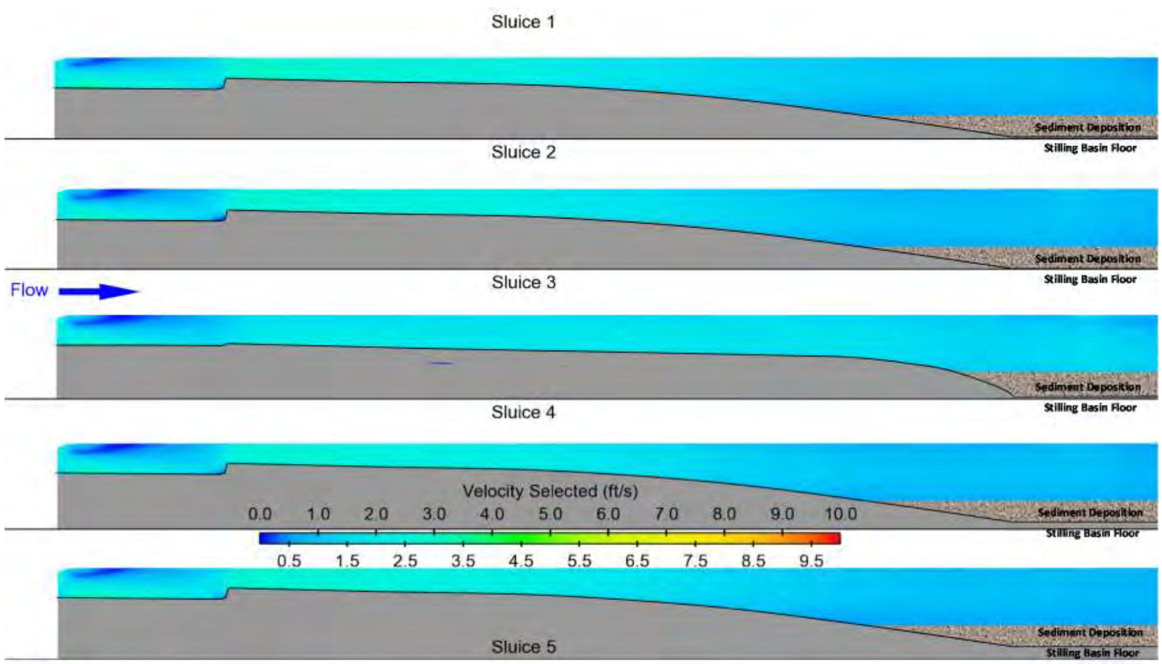


Figure 3-30

Isometric View of Velocity Contours for 1,250 cfs Discharge Through Low Level Outlets

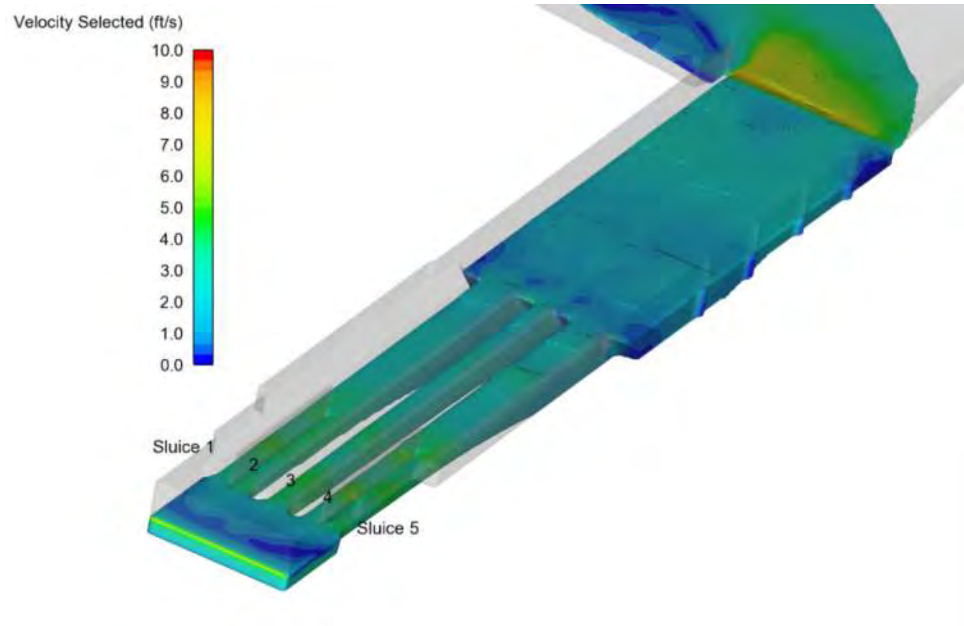


Figure 3-31

Profile View of Velocity Contours for 1,250 cfs Discharge Through Low Level Outlets

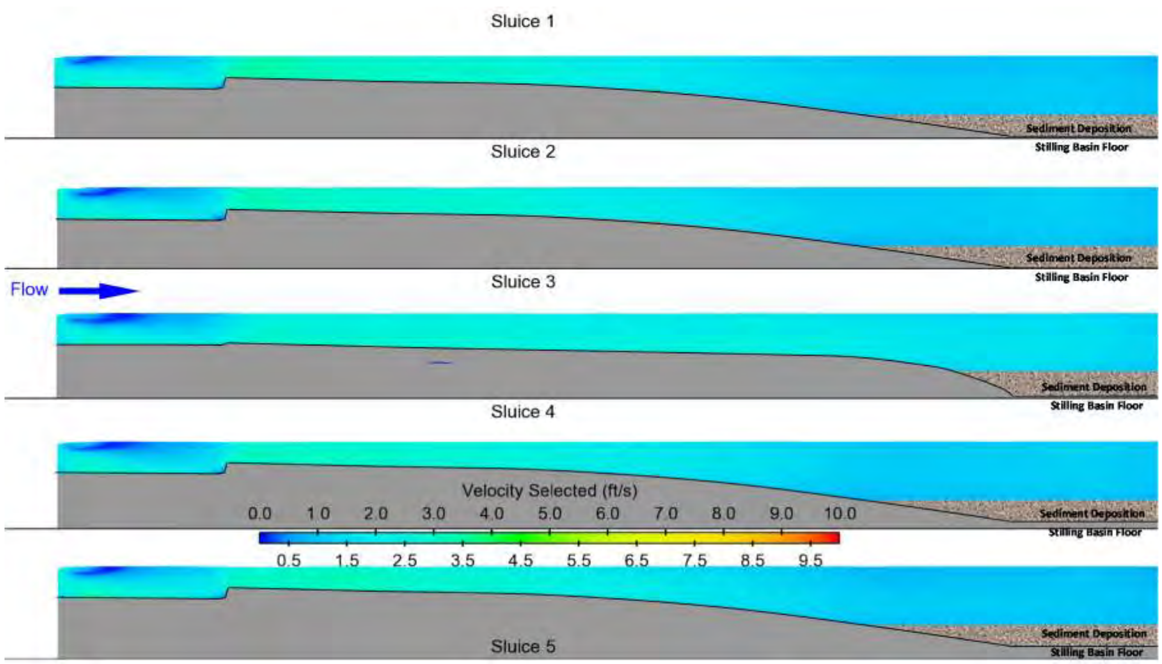


Figure 3-32
Isometric View of Velocity Contours for 1,500 cfs Discharge Through Low Level Outlets

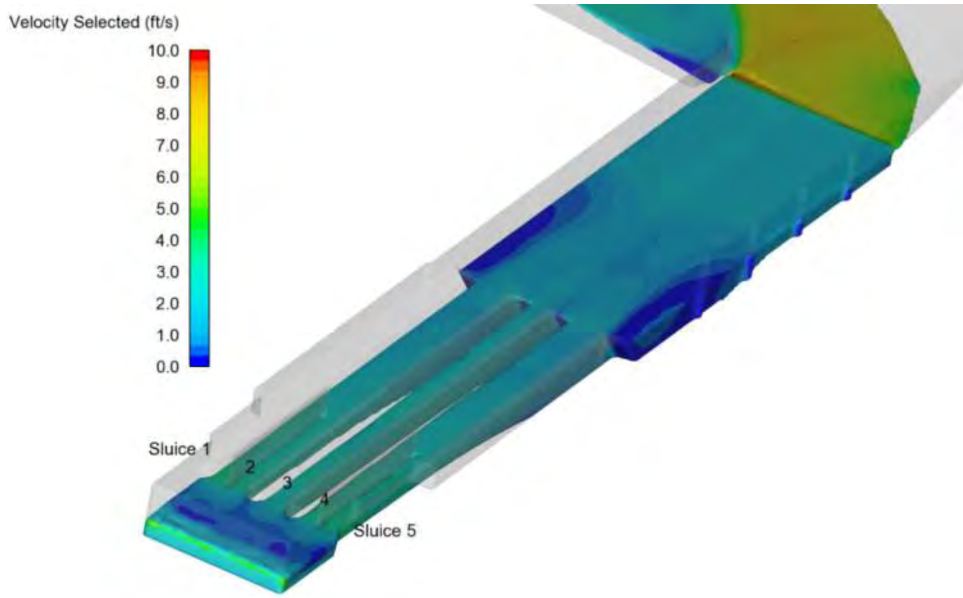


Figure 3-33
Profile View of Velocity Contours for 1,500 cfs Discharge Through Low Level Outlets

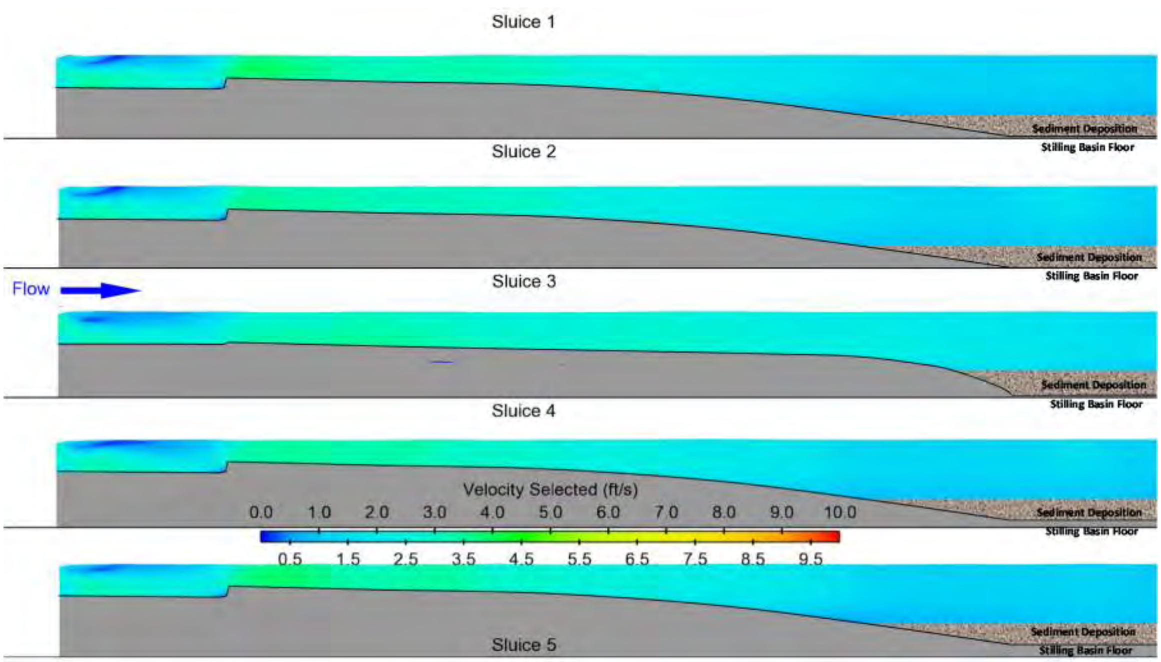


Figure 3-34
Isometric View of Velocity Contours For 1,500 cfs Discharge Through Low Level Outlets

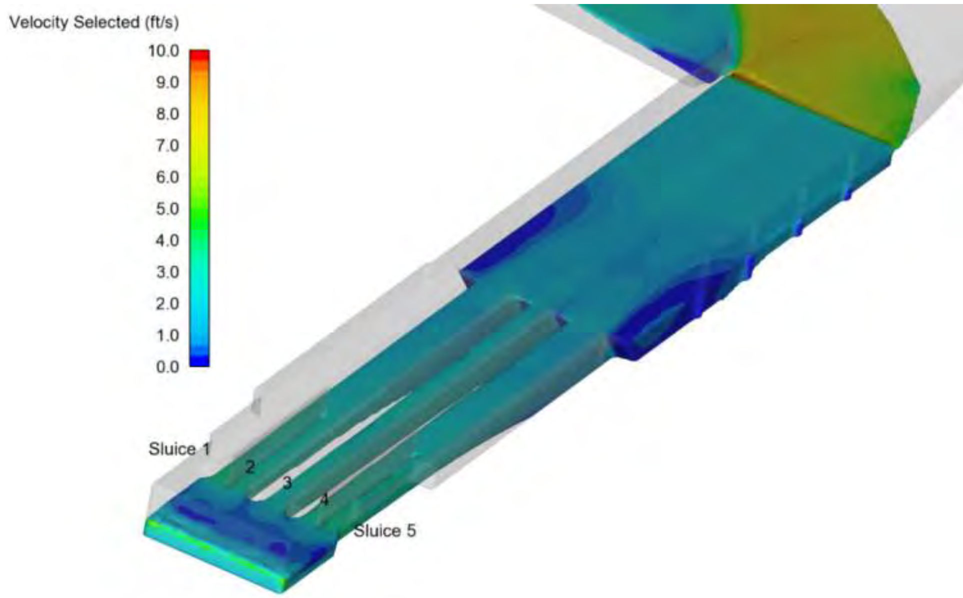


Figure 3-35
Profile View of Velocity Contours for 1,500 cfs Discharge Through Low Level Outlets

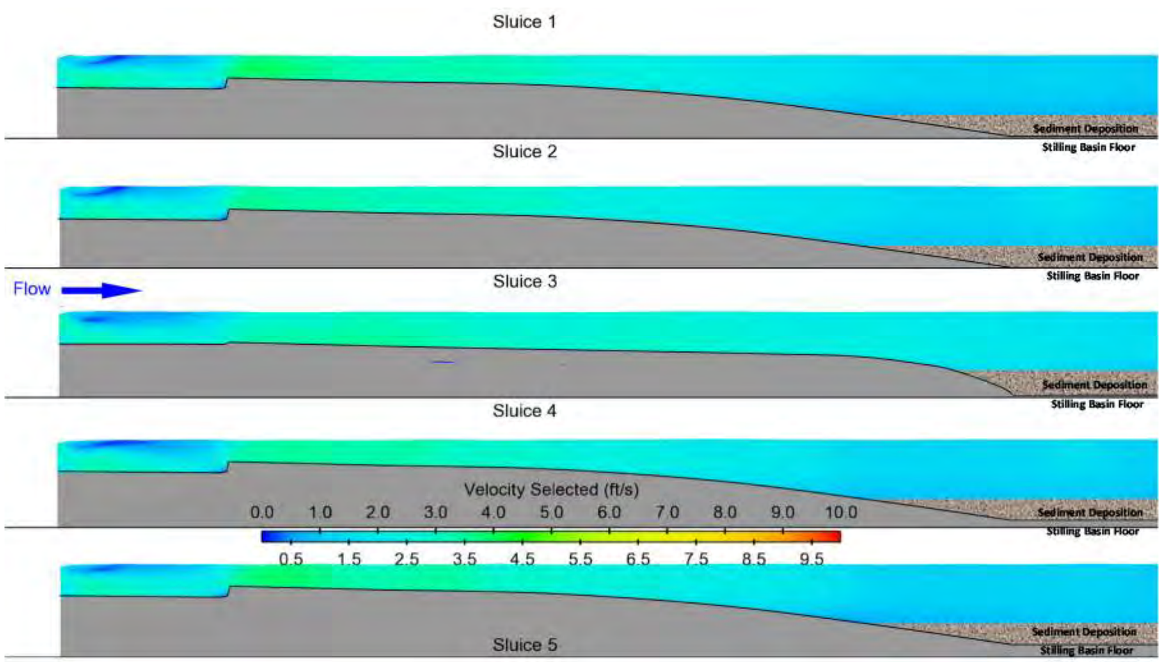


Figure 3-36

Isometric View of Velocity Contours for 1,750 cfs Discharge Through Low Level Outlets

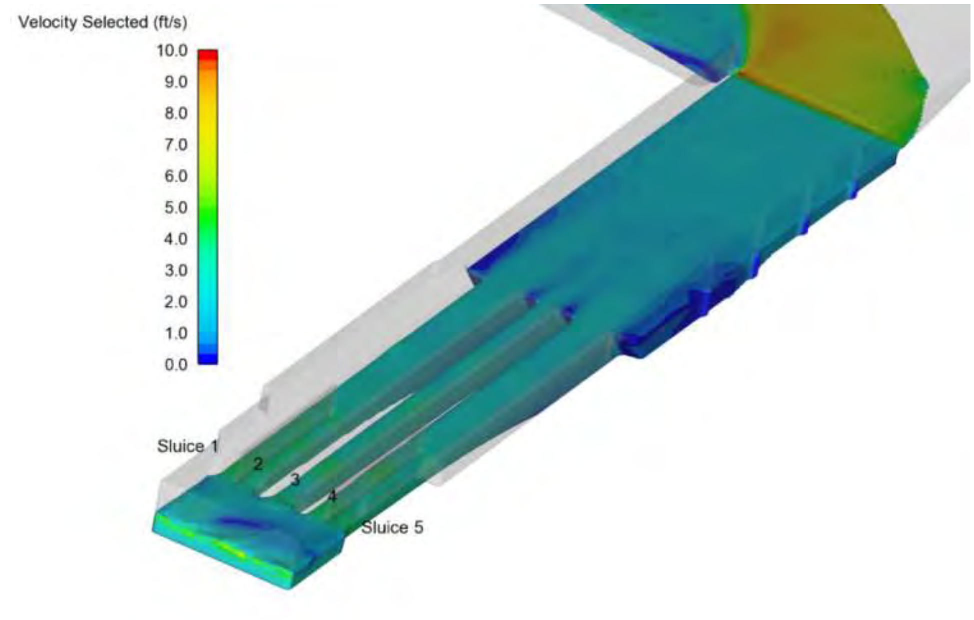


Figure 3-37

Profile View of Velocity Contours for 1,750 cfs Discharge Through Low Level Outlets

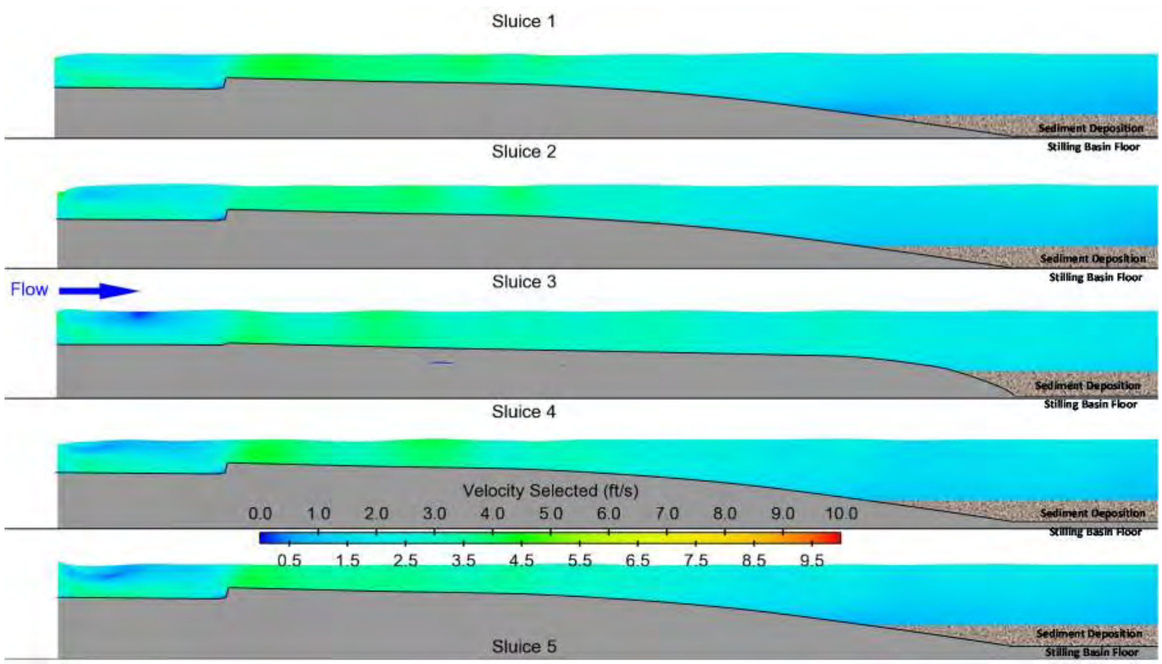


Figure 3-38

Isometric View of Velocity Contours For 2,000 cfs Discharge Through Low Level Outlets

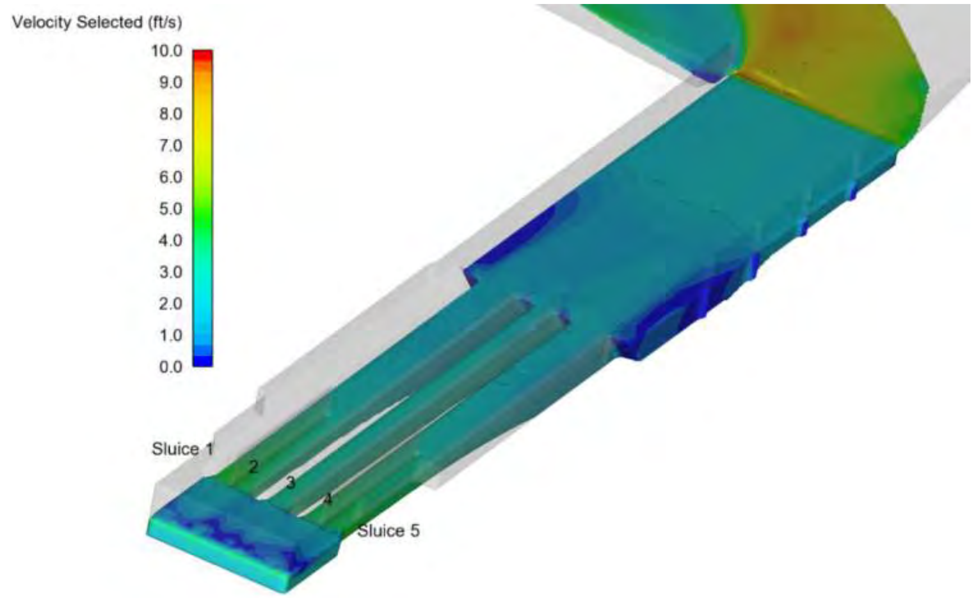
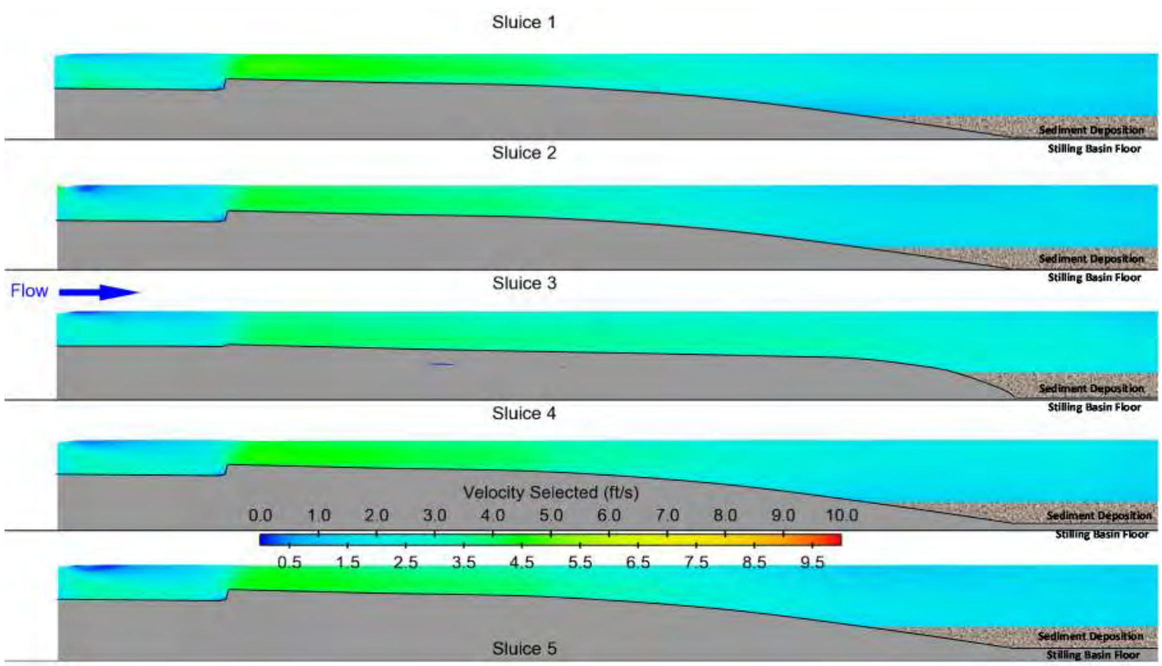


Figure 3-39

Profile View of Velocity Contours For 2,000 cfs Discharge Through Low Level Outlets



3.2 Diversion Tunnel Rating

The hydraulic design calculation of the diversion tunnel rating curve for the FRO, FRFA and FRE alternatives is identical and presented in detail in the Appendix B (Section 3.2) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

3.3 Spillway Design

The spillway design procedure and calculation for FRFA, FRO and FRE alternatives are similar. As an example, the spillway shape design calculation for FRFA dam alternatives is presented in detail in the Appendix B (Section 3.3) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017). The Ogee spillway shape of the FRE is identical to the FRO spillway shape and geometry with the addition of a short and shallow approach channel. The spillway shape and geometry for FRE-FC is identical to FRFA. The detail geometry of FRE and FRE-FC spillways are presented in Table 3-1 and Table 3-2. The spillway geometry design parameters are shown in Figure 3-40.

Table 3-1
Ogee Spillway Upstream Quadrant Profile Parameters for FRE Dam FRE (Left) and FRE-FC (Right)

R_{CL}(ft)	15.0
X_{CL} (ft)	50.0
Y_{CL}(ft)	613.0
$R_{2,3}$(ft)	6.0
$X_{2,3}$ (ft)	46.9
$Y_{2,3}$ (ft)	621.4
R_1(ft)	1.2
$X_{1,CEN}$ (ft)	42.7
$Y_{1,CEN}$ (ft)	623.9
X_1(ft)	58.5
Y_1 (ft)	623.9
X_2(ft)	58.3
Y_2(ft)	624.5
X_3(ft)	55.3
Y_3 (ft)	627.1

R_{CL}(ft)	15.0
X_{CL} (ft)	0.0
Y_{CL}(ft)	672.0
$R_{2,3}$(ft)	6.0
$X_{2,3}$ (ft)	-3.2
$Y_{2,3}$ (ft)	680.4
R_1(ft)	1.2
$X_{1,CEN}$ (ft)	-8.5
$Y_{1,CEN}$ (ft)	682.9
X_1(ft)	8.5
Y_1 (ft)	682.9
X_2(ft)	8.3
Y_2(ft)	683.5
X_3(ft)	5.3
Y_3 (ft)	686.1

Figure 3-40
USACE Hydraulic Design Criteria 111-2/1 Design of Ogee Crest Shape

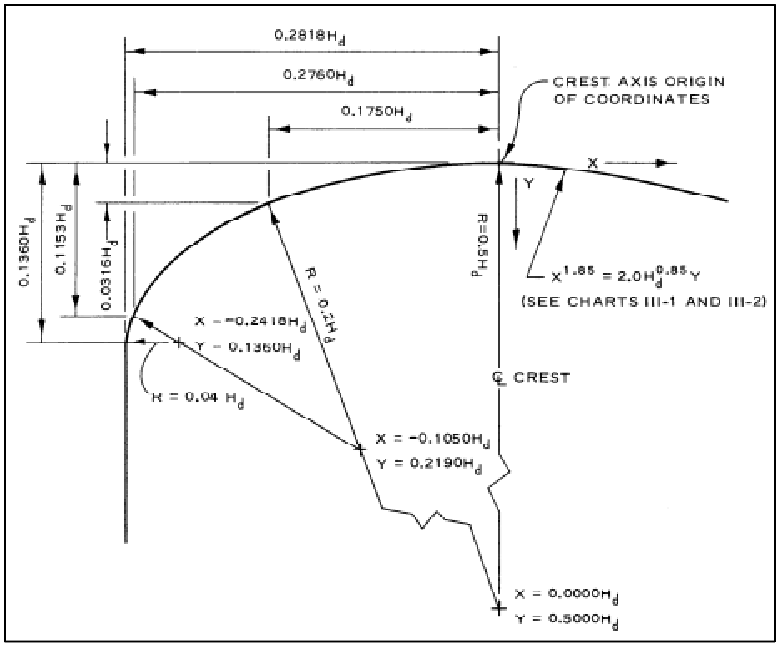


Table 3-2

Spillway Shape Downstream Quadrant for FRE (left) FRE-FC (right)

X (ft)	Y (ft)	Elevation (ft)	Slope	Location
50.0	0.0	628.0	--	Downstream Qudrant
52.0	0.1	627.9	19.99	
52.9	0.2	627.8	8.71	
53.6	0.3	627.7	7.51	
54.2	0.4	627.6	6.09	
54.8	0.5	627.5	5.42	
55.3	0.6	627.4	4.94	
55.7	0.7	627.3	4.58	
56.2	0.8	627.2	4.28	
56.6	0.9	627.1	4.04	
56.9	1.0	627.0	3.84	
57.3	1.1	626.9	3.67	
57.7	1.2	626.8	3.52	
58.0	1.3	626.7	3.39	
58.3	1.4	626.6	3.27	
58.6	1.5	626.5	3.16	
58.9	1.6	626.4	3.07	
59.2	1.7	626.3	2.98	
59.5	1.8	626.2	2.90	
59.8	1.9	626.1	2.83	
60.1	2.0	626.0	2.76	
60.4	2.1	625.9	2.70	
62.8	3.1	624.9	2.43	
64.9	4.1	623.9	2.09	
66.7	5.1	622.9	1.86	
68.4	6.1	621.9	1.70	
70.0	7.1	620.9	1.58	
71.5	8.1	619.9	1.48	
72.9	9.1	618.9	1.40	
74.2	10.1	617.9	1.33	
75.5	11.1	616.9	1.27	
76.7	12.1	615.9	1.22	
77.9	13.1	614.9	1.17	
79.0	14.1	613.9	1.13	
80.1	15.1	612.9	1.09	
81.2	16.1	611.9	1.06	
82.2	17.1	610.9	1.03	
83.2	18.1	609.9	1.00	
84.2	19.1	608.9	0.98	
85.1	20.1	607.9	0.96	
86.1	21.1	606.9	0.93	
87.0	22.1	605.9	0.91	
87.9	23.1	604.9	0.90	
88.8	24.1	603.9	0.88	
89.8	25.3	602.7	0.85	Point of Tangancy
108.5	47.3	580.7	0.85	Spillway Chute
127.2	69.3	558.7	0.85	
145.9	91.3	536.7	0.85	
164.6	113.3	514.7	0.85	
183.6	25.3	492.7	0.85	

X (ft)	Y (ft)	Elevation (ft)	Slope	Location
0.0	0.0	687.0	--	Downstream Qudrant
2.0	0.1	686.9	19.99	
2.9	0.2	686.8	9.09	
3.6	0.3	686.7	7.13	
4.2	0.4	686.6	6.09	
4.8	0.5	686.5	5.42	
5.3	0.6	686.4	4.94	
5.7	0.7	686.3	4.58	
6.2	0.8	686.2	4.28	
6.6	0.9	686.1	4.04	
6.9	1.0	686.0	3.84	
7.3	1.1	685.9	3.67	
7.7	1.2	685.8	3.52	
8.0	1.3	685.7	3.39	
8.3	1.4	685.6	3.27	
8.6	1.5	685.5	3.16	
8.9	1.6	685.4	3.07	
9.2	1.7	685.3	2.98	
9.5	1.8	685.2	2.90	
9.8	1.9	685.1	2.83	
10.1	2.0	685.0	2.76	
10.4	2.1	684.9	2.70	
12.8	3.1	683.9	2.43	
14.9	4.1	682.9	2.09	
16.7	5.1	681.9	1.86	
18.4	6.1	680.9	1.70	
20.0	7.1	679.9	1.58	
21.5	8.1	678.9	1.48	
22.9	9.1	677.9	1.40	
24.2	10.1	676.9	1.33	
25.5	11.1	675.9	1.27	
26.7	12.1	674.9	1.22	
27.9	13.1	673.9	1.17	
29.0	14.1	672.9	1.13	
30.1	15.1	671.9	1.09	
31.2	16.1	670.9	1.06	
32.2	17.1	669.9	1.03	
33.2	18.1	668.9	1.00	
34.2	19.1	667.9	0.98	
35.1	20.1	666.9	0.96	
36.1	21.1	665.9	0.93	
37.0	22.1	664.9	0.91	
37.9	23.1	663.9	0.90	
38.8	24.1	662.9	0.88	
39.8	25.3	661.7	0.85	Point of Tangancy
68.5	59.1	627.9	0.85	Spillway Chute
97.3	92.9	594.1	0.85	
126.0	126.8	560.2	0.85	
154.8	160.6	526.4	0.85	
183.5	194.4	492.6	0.85	

The spillway rating curve is calculated following the procedure provided in USACE Hydraulic Design Criteria Sheet 111-3/3. Table 3-3 presents the spillway rating curve calculations for FRE and FRE-FC dams.

Table 3-3
Spillway Rating Curve for FRE (Left) and FRE-FC (Right)

Q (cfs)	H_e (ft)	WSE (ft)
69800	21.7	649.7
65000	20.7	648.7
59000	19.5	647.5
53000	18.3	646.3
47000	16.9	644.9
41000	15.5	643.5
35000	14.1	642.1
29000	12.5	640.5
23000	10.8	638.8
17000	9.0	637.0
11000	6.8	634.8
5000	4.2	632.2
0	0.0	628.0

Q (cfs)	H_e (ft)	WSE (ft)
69800	21.0	708.0
65000	20.1	707.1
60000	19.1	706.1
55000	18.1	705.1
50000	17.1	704.1
45000	16.0	703.0
40000	14.9	701.9
35000	13.7	700.7
30000	12.4	699.4
25000	11.1	698.1
20000	9.6	696.6
15000	8.0	695.0
10000	6.2	693.2
5000	4.1	691.1
0	0.0	687.0

Notes: Q= discharge, H_e= effective head, WSE= water surface elevation

The 10 ft deep spillway approach channel for FRE was designed to provide satisfactory hydraulic performance for the range of flows up to PMF. The Froude number calculation presented in Table 3-4 shows that the flow is subcritical and no control transitioning will occur in the approach channel.

Table 3-4
FRE Spillway Approach Channel Flow Regime Calculation

Q (cfs)	Reservoir Elev (ft)	Depth (ft)	V (ft/s)	Fr
69800.0	649.7	31.7	11.0	0.34
63800.0	648.5	30.5	10.5	0.33
57800.0	647.3	29.3	9.9	0.32
51800.0	646.0	28.0	9.3	0.31
45800.0	644.7	26.7	8.6	0.29
39800.0	643.3	25.3	7.9	0.28
33800.0	641.8	23.8	7.1	0.26
27800.0	640.2	22.2	6.3	0.23
21800.0	638.5	20.5	5.3	0.21
15800.0	636.6	18.6	4.3	0.17
9800.0	634.4	16.4	3.0	0.13
3800.0	631.5	13.5	1.4	0.07

3.4 Flip Bucket

The flip buck design procedure and calculation for FRFA, FRO and FRE alternatives are similar. As an example, the flip bucket design calculation for FRFA dam alternatives is presented in detail in the Appendix B (Section 3.4) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017). The jet trajectory leaving the flip bucket was evaluated using the equation for trajectory of a projectile. Table 3-5 presents the water jet trajectory for FRE and FRE-FC dams.

Table 3-5
Water Jet Trajectory Leaving the Flip Buck for FRE (Left) and FRE-FC (Right)

X (ft)	Elevation (ft)
257.0	494.64
286.0	520.93
315.0	541.80
344.0	557.24
373.0	567.26
402.0	571.85
431.0	571.03
460.0	564.78
489.0	553.10
518.0	536.01
547.0	513.49
576.0	485.55
605.0	452.18

X (ft)	Elevation (ft)
257.0	494.37
300.0	533.05
343.0	563.10
386.0	584.52
429.0	597.30
472.0	601.44
515.0	596.96
558.0	583.83
601.0	562.08
644.0	531.69
687.0	492.66
725.0	450.99

3.5 Flood Regulation Outlets Rating Curves

The rating curves for flood regulating outlet works were calculated using the radial gate discharge equation when inlet control exists at the gate location. The calculation procedure is similar for FRO, FRFA, and FRE alternatives. A sample calculation for the FRFA dam alternative flood regulation outlet works rating curve is presented in the Appendix B (Section 3.5) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017).

3.6 Stilling Basin

Stilling basin is designed for the maximum design flow and head to ensure a satisfactory performance under the range of outlet works operational flow. The stilling basin floor elevation of 377 ft was selected for the final design calculation. The design calculation procedure of the stilling basin size and elevation is similar to the FRO, FRFA alternatives. A sample calculation of the FRFA dam alternative stilling basin is presented in the Appendix B (Section 3.6) of the Draft Combined Dam and Fish Passage Conceptual Design Report (HDR, 2017). Table 3-6 presents the stilling basin endsill rating curve.

Table 3-6
Stilling Basin End Sill Rating Curve

Discharge (cfs)	H (ft)	WSE (ft)
10	0.1	417.1
100	0.6	417.6
250	1.1	418.1
500	1.7	418.7
1000	2.7	419.7
1500	3.6	420.6
2500	5.0	422.0
5000	7.9	424.9
7500	10.4	427.4
10000	12.6	429.6
15000	16.5	433.5

Notes: H= water head, WSE= water surface elevation

Appendix J
Construction Cost Opinion

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EXECUTIVE SUMMARY

Based on prior FRO and FRFA costs developed and brought current to June 2017, an opinion of probable costs (OPC) has been developed for constructing the flood retention expandable (FRE) alternative broken into an initial construction phase (FRE), and a future construction phase (FRE-FC), if desired. The following attachments summarize and provide support for the FRE cost development:

Attachment 1 – Summary of Costs and Key Information; 1 page

Attachment 2 – FRO and FRFA OPC Refinement for Comparison to the FRE ; 1 page

Attachment 3 – FRE, FRE-FC, and updated FRO and FRFA Cost Sheets; 8 pages

Attachment 4 – FRE RCC Placement Analysis Summary; 2 pages

Attachment 5 – FRE, FRE-FC, and updated FRO and FRFA RCC Unit Cost Development; 4 pages

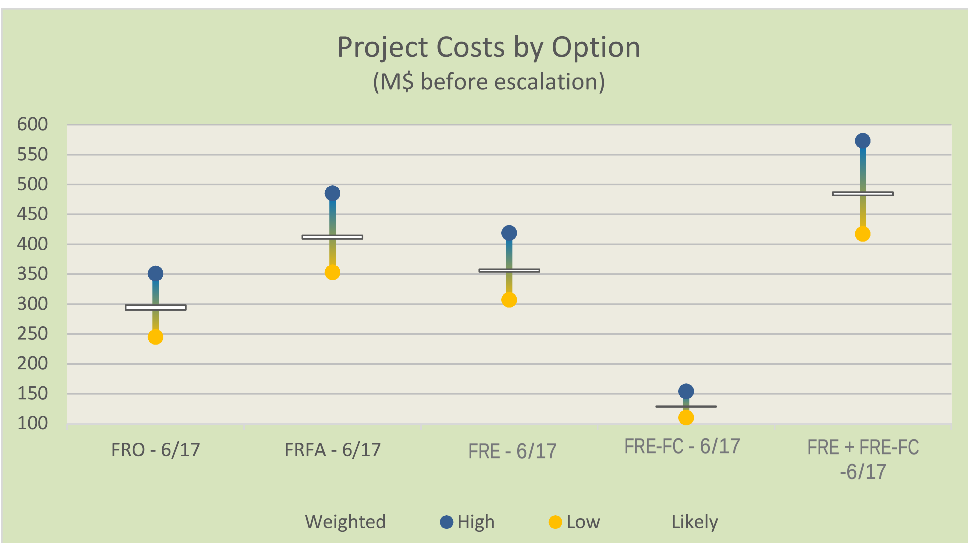
Attachment 6 – Drawing Sheets Illustrating FRE RCC Progression and Quantity Takeoff Support; 16 pages

1 SUMMARY OF COSTS AND KEY INFORMATION

Summary of costs and key information for different alternatives are provided in the following page.

Table 13-1: Concept-Level Opinion of Probable Costs: Summary of Key Information

Summary Information	FRO	FRFA	FRE	FRE-FC	FRE & FRE-FC
Costs Prior to Escalation					
Low End Project Cost[1]	245,000,000	353,000,000	307,000,000	110,000,000	417,000,000
Likely Project Cost[1]	298,000,000	415,000,000	358,000,000	129,000,000	487,000,000
High End Project Cost[1]	351,000,000	485,000,000	419,000,000	154,000,000	573,000,000
Project Cost Range from Likely	82% - 118%	85% - 117%	82% - 118%	82% - 118%	86% - 118%
Costs Applying Escalation					
Low End Project Cost[2]	311,000,000	457,000,000	390,000,000	140,000,000	530,000,000
Likely Project Cost[2]	379,000,000	537,000,000	456,000,000	164,000,000	620,000,000
High End Project Cost[2]	447,000,000	628,000,000	533,000,000	196,000,000	729,000,000
Escalation period from Jun-2017[3]	7.0 yr	7.5 yr	7.0 yr	7.0 yr	7.0 yr
Escalation to presumed midpoint of construction[4]	1-Jun-24	1-Dec-24	1-Jun-24	1-Jun-24	1-Jun-24
Select Cost Estimate Information [1]					
Driving RCC quantity	810,000 cy	1,360,000 cy	892,000 cy	467,000 cy	1,359,000 cy
RCC Unit Bid - Likely (FRO GERCC, FRFA U/S conv.)	$ 93.00	$ 99.00	$ 103.50	$ 111.00	$ 106.08
RCC Unit Bid Range	$ 76.50 - $ 109.50	$ 83.50 - $ 113.50	$ 88.00 - $ 119.00	$ 94.00 - $ 127.00	
RCC Scope - as % of Contractor Bid	38%	49%	39%	61%	45%
Notes: 1 - prior to escalation; 2 - 3.5% annual; 3 - mid 2021 presumed NTP, then to midpoint of construction; 4 - FRX-FC escalation to midpoint of FRX-IC					0%



2 FRO AND FRFA OPINION OF PROBABLE COST REFINEMENT FOR COMPARISON TO THE FRE

Opinion of probable cost of FRO and FRFA dam alternatives were refined to provide a realistic comparison with the OPC of FRE alternative. The FRO and FRFA refinement process rationale and key information are provided in the following page.

Chehalis Judgment-Level Cost Opinion
FRO-FRFA June 2017 Cost Adjustments

Item #	Adjustment ($)	Estimate Refinement Rationale
FRFA Adjustments		
3.01	1,080,000	Increased the length of the diversion tunnel to consider some uncertainty related the ground conditions and handling those conditions near the downstream portal.
5.03	(6,960,000)	Adjust RCC quantity from 1,475,000 cy to 1,360,000 cy and the unit price from $96 to $99 to reflect excavation surface refined for the FRE and to increase some material components of the RCC unit price bringing the pricing to a June 2017 price level.
5.04	(500,500)	Adjust backfill quantity form full FRE QTO; 375,000 cy to 260,000 cy.
Various	12,858,750	Adjusted and reorganized dam and hydaulic structure concrete to reflect FRE and hydraulic modeling: 68,500 cy to 85,500 cy; and composite unit pricing from $537.32/cy to $580.88 Items- 5.05-5.07, 5.10, 5.17-5.18, 5.20, 6.01-6.02, 7.04-7.05.
Various	(1,563,840)	Adjusted project control gates, valves, and trashrack steel to reflect FRE and hydraulic modeling and . Items- 5.11-5.16, 5.19.
Various	1,803,333	Adjusted wing dam earthwork quantities and unit prices to better reflect the excavation surface developed for the FRE and a composite embankment unit price. Items- 8.01-8.04
		keep cell
		keep cell
		keep cell
		keep cell
		keep cell
		keep cell
		keep cell
		keep cell
Subtotal	**6,717,743**	**Subtotal line-item cost adjustments**
	839,718	Design and procurement contingencies; remaining at 12.5% (unchanged)
Subtotal	7,557,461	Net cost additions to the "likely" estimate; before construction contingencies and non-contract cost factor
	35%	Construction contingency and non-contract cost factor to arrive at total adjustments before escalation (unchanged)
	2,645,111	
Total	**10,202,573**	**Total cost adjustments to likely estimate, before escalation**
	11,000,000	Rounded comparison from summary
FRO Adjustments		
2.04	4,000	Typo correction in initial quantity
3.01	1,080,000	Increased the length of the diversion tunnel to consider some uncertainty related the ground conditions and handling those conditions near the downstream portal.
5.03	(3,840,000)	Adjust RCC quantity from 870,000 10cy to 8,000 cy and the unit price from $91 to $93 to reflect excavation surface refined for the FRE and to increase some material components of the RCC unit price bringing the pricing to a June 2017 price level.
5.06	(302,500)	Adjust backfill quantity form full FRE QTO; 375,000 cy to 265,000 cy.
Various	20,374,750	Adjusted and reorganized dam and hydaulic structure concrete to reflect FRE and hydraulic modeling: 50,200 cy to 84,510 cy; and composite unit pricing from $561.33/cy to $574.53 Items- 5.05-5.07, 5.10, 5.17-5.18, 5.20, 6.01-6.02, 7.04-7.05.
Various	724,200	Adjusted project control gates, valves, and trashrack steel to reflect FRE and hydraulic modeling and . Items- 5.11-5.16, 5.19.
Subtotal	**18,040,450**	**Subtotal line-item cost adjustments**
	2,255,056	Design and procurement contingencies; remaining at 12.5% (unchanged)
Subtotal	20,295,506	Net cost additions to the "likely" estimate; before construction contingencies and non-contract cost factor
	35%	Construction contingency and non-contract cost factor to arrive at total adjustments before escalation (unchanged)
	7,103,427	
Total	**27,398,933**	**Total cost adjustments to likely estimate, before escalation**
	27,000,000	Rounded comparison from summary

3 FRE, FRE-FC, AND UPDATED FRO AND FRFA COST SHEETS

Detailed cost break down sheets for FRE, FRE-FC, and updated FRO and FRFA alternatives are provided in the following pages.

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: ***Chehalis Dam***
Alternative: ***FRE***

Pricing - contractor cost basis 1 or bid basis 2: **2**

Range Driver - 1 = %, 2 = Q & $, 3 = Combination: **3**
Default Low ⇨ **80%** **Default High ⇨** **120%**

Weighting ⇨	20% low	70% likely	10% high	20% low	70% likely	10% high
$293M - Jul-16	Low End	$306,543,571		Low End	$390,083,824	
	Likely	$358,397,146		Likely	$456,068,705	
$454M - Jul-18	High End	$419,217,088		High End	$533,463,496	
	Weighted	$354,108,425		Weighted	$450,611,208	

Quantity references: "FRE - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

		Base or Likely Cost Case					Range Development: Driven by Percent				Driven by Q & Unit $						Driven by Combo	
Work Item	**Description**	**Quantity**	**Unit**	**Unit Price [1]**	**Total $**	**Estimate Notes & Considerations (Notes prior to FRE eval grayed out)**	**Low End % (def=80%)**	**High End % (def=120%)**	**Low % Total $**	**High % Total $**	**Low End Q**	**Low End Unit $**	**Low End Total $**	**High End Q**	**High End Unit $**	**High End Total $**	**Low End Tot $**	**High End Tot $**
	Phase 1 - Site Development, Diversion Constrruction,				$0				$0	$0			info?			info?	$0	$0
0	**Mobilization**								$0	$0			info?			info?	$0	$0
	Mobilization	1	LS	$5,000,000.00	$5,000,000	**No change for FRE.** Contractor mob bid; balance of project overhead in below-the-line factors	100%	140%	$5,000,000	$7,000,000			info?			info?	$5,000,000	$7,000,000
1	**Clearing & Grubbing**				$0				$0	$0			info?			info?	$0	$0
1.01	Clearing and grubbing, stripping topsoil, reclamation of disturbed areas	30	Acre	$30,000.00	$900,000	**No change for FRE.**			$720,000	$1,080,000	25	$30,000.00	$750,000	35	$25,000.00	$875,000	$750,000	$875,000
1.02	Reservoir Clearing to 100-yr Flood Stage	362	Acre	$6,000.00	$2,170,800	**Assumed 30% FRE and 70% FRE-FC from orig FRFA of 1206 ac @ $6K/ac.** Potentially in Phase 2 or possibly Phase 3 contract			$1,736,640	$2,604,960		$5,000.00	$1,809,000		$7,500.00	$2,713,500	$1,809,000	$2,713,500
2	**Temporary Access & Staging**				$0				$0	$0			info?			info?	$0	$0
2.01	Construction Surveying & Layout	35	Acre	$10,000.00	$350,000	**No change for FRE.** Under temporary access & staging; i.e. temporary works only, predominant surveys and layout in unallocated contractor project overhead expense (already in the unit pricing)	100%	150%	$350,000	$525,000			info?			info?	$350,000	$525,000
2.02	Pioneer/Access Roads (e.g. dam site, abutments, quarry site, etc.)	3	Mile	$700,000.00	$2,100,000	**No change for FRE. Changes for final: increase access road development by adding 1 mile, from 2 to 3.** dependent upon aggregate sourcing, staging locations, contractor approach. Reference Chehalis_All_Figs_2016-10-19.pdf drawing G-3, for site, non-quarry access concepts, totaling about 10,000lf of new access, say 5000lf of upgraded access. Say 50% new and full access development, 20% construction & track access only, 30% improved existing. Consider quarry acces costs in aggregate price range.			$1,680,000	$2,520,000	2.5	$750,000.00	$1,875,000	3.5	$800,000.00	$2,800,000	$1,875,000	$2,800,000
2.03	Material Laydown Area Prep (minor excavation, grading, surfacing, drainage	20	Acre	$25,000.00	$500,000	**No change for FRE.** 1 acre at 5' avg cut to 5' average fill = 4000cy cut to fill; @ $6/cy cut to fill = $24,200/ac; 1ac surfacing at 6" & 30% surfaced = 430ton, @ 10/tn = $4.5k/ac			$400,000	$600,000	15	$30,000.00	$450,000	25		$625,000	$450,000	$625,000
2.04	Temporary construction site access security control facilities (e.g. fencing, gates, etc.)	2,200	LF	$20.00	$44,000	**No change for FRE.** 'predominant security expense in unallocated contractor project overhead expense			$35,200	$52,800			info?			info?	$35,200	$52,800
3	**Diversion & Dewatering**				$0				$0	$0			info?			info?	$0	$0
3.01	Diversion Tunnel 20 ft modified horseshoe	1,635	LF	$8,000.00	$13,080,000	**Increased length for FRE and both FRO and FRFA, from 1500. Changes for final: increase length of tunnel to better reflect final drawing alignment.** increase high end for variability in linnig limits, portaling, tunnel plug adit construction, vent construction, etc.	90%	125%	$11,772,000	$16,350,000			info?			info?	$11,772,000	$16,350,000
3.02	Conventional Concrete Non-Reinforced Mass Concrete (100' plug following construction)	1,200	CY	$600.00	$720,000	**No change for FRE.** low end 30'plug but include mechanical.			$576,000	$864,000			info?		$650.00	$780,000	$576,000	$780,000
3.03	Coffer Dams (2) - Fill cells u/s and d/s + toe slopes	14,000	CY	$40.00	$560,000	**No change for FRE.** check Q's with new crest heights, say 8,000 cy RCC @ 70 + 6,000 cy Rockfill @ 15. = 650KHigh end if pushed to 480 and rockfill - say 45kcy = $675K.			$448,000	$672,000			info?			info?	$448,000	$672,000
3.04	Foundation Excavation - seepage key (assume 20'wide x 150' long x 4' deep	450	CY	$8.00	$3,600	**No change for FRE.** Cofferdam key allowance		300%	$2,880	$10,800			info?			info?	$2,880	$10,800
3.05	Foundation Dewatering - assume several dewatering pump systems operating selectively 24/7 over 12 month foundation construction exposure	360	Day	$2,800.00	$1,008,000	**No change for FRE. Changes for final: increase foundation exposure from 6 to 12 months.** 2nd contract may add unwaterring and time for dewatering for RCC foundation		150%	$806,400	$1,512,000			info?			info?	$806,400	$1,512,000
3.06	Coffer Dams - Other assume 25' high x 150 top length, 35' base length, cell construction (e.g. sheet pile, steel, other fabricated metal items)	7,000	SF	$30	$210,000	**No change for FRE.** may include isolation of portal structures, tailwater structures, peripheral dewatering stages			$168,000	$252,000			info?			info?	$168,000	$252,000
3.07	Coffer Dams - Risk contingency for overtopping	1	LS	$1,000,000.00	$1,000,000	**No change for FRE.** contemplates partial or threshold-bound contractor responsibility, risk apportioned cost of event recovery, rework, delay			$800,000	$1,200,000			info?			info?	$800,000	$1,200,000
4	**Lands and Easements**				$0				$0	$0			info?			info?	$0	$0
4.01	Reservoir Extents Fee Title	1,200	Acre	$4,400	$5,280,000	**No change for FRE.** Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.	100%	100%	$5,280,000	$5,280,000			info?			info?	$5,280,000	$5,280,000
4.02	Reservoir Extents/Flood Easement	110	Acre	$4,400	$484,000	**No change for FRE.** Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.	100%	100%	$484,000	$484,000			info?			info?	$484,000	$484,000
4.03	Reservoir orphaned access roadway reconnection allowance (to WeyCo?)	5	Mile	$1,000,000	$5,000,000	**No change for FRE.** Unit price potentially higher for permanent versus constuction roads. Line item also perhaps better considered under non-contract cost factor.		110%	$4,000,000	$5,500,000			info?			info?	$4,000,000	$5,500,000
	Phase 2 - Main Dam																$0	$0
5	**Main Dam Structure**				$0				$0	$0			info?			info?	$0	$0
5.01	Excavation - Foundation General	710,000	CY	$6.50	$4,615,000	**No change for FRE - pending Q verification. Changes for final: revised quantities.** Reference FRFA S-1 annotated from Chehalis_All_Figs_2016-10-19.pdf, also this worksheet FRFA Exc Guess tab.			$3,692,000	$5,538,000		$5.50	$3,905,000		$7.50	$5,325,000	$3,905,000	$5,325,000
5.02	Excavation - Foundation Rock	210,000	CY	$27.00	$5,670,000	**No change for FRE - pending Q verification. Changes for final: revised quantities.** Reference FRFA S-1 annotated from Chehalis_All_Figs_2016-10-19.pdf, also this worksheet FRFA Exc Guess tab. Some rock will be structural exc in fresh rock, most will be foundation footprint, getting to good rock below the rock contact; i.e potentially a high degree ripable.			$4,536,000	$6,804,000		$25.00	$5,250,000		$30.00	$6,300,000	$5,250,000	$6,300,000
5.03	Roller Compacted Concrete - Composite Scope	892,000	CY	$103.50	$92,322,000	**Revised RCC Q (1,475k to 892k) for FRE that fully preps FRE-FC foundation. Revised unit pricing ($96 to $103.50) to reflect slightly higher aggregate and cementitous materials to reflect Jun 2017 pricing, increased fixed costs for delivery adjustments, slower productivity, increased formwork. Changes for final: revised quantities. Expanded RCC unit cost development work breakdown, revisited unit pricing, and increased unit pricing to reflect upstream conventional face and downstream GERCC.** RCC unit pricing includes aggregate, cement-fly ash, lift bedding, abutment bedding, dam joints, and **2.5' upstream conventional face and downstream GERCC.** Conventional concrete spillway face - included elsewhere.			$73,857,600	$110,786,400		$88.00	$78,496,000		$119.00	$106,148,000	$78,496,000	$106,148,000
5.04	Fill - Foundation Backfill	127,000	CY	$5.50	$698,500	**Adjusted Q's for full upstream groin fill (112kcy) plus 5' RCC apron cover downstream (15kcy); Pending Q verification. Changes for final: revised quantities.**			$558,800	$838,200			info?			info?	$558,800	$838,200
5.05	Conventional Concrete Reinforced (miscellaneous)	0	CY	$850.00	$0	**Item not used in FRE estimate. Q was 750cy @ $850.** Refine quantities along with all structures next phase.			$0	$0			info?			info?	$0	$0
5.06	Outlet works encasement: sluicing conduits, river outlet works conduits, gate chamber, vent and gallery passages	60,000	CY	$450.00	$27,000,000	**Prior item mixed dam items integral with RCC composite unit price, and OW massive encasement. FRE estimate considers this item now fully the OW and sluiceway enasement and gate chamber. Q was 15,000cy @ $400. Consider the quantities as drawn to represent the high side anticipating optimization from 70,000cy down to 60,000cy. This 10kcy Q difference would need to be replaced with RCC; approx 10,000cy @ $100/cy / 1.36Mcy = $0.75/cy RCC, which has not been accounted for in the estimate. Ref "FRE - Annotated Dwgs Supporting OPC.pdf" FRE S-6-S-7 sheets.** Refine quantities along with all structures next phase.			$21,600,000	$32,400,000	55,000		$24,750,000	70,000		$31,500,000	$24,750,000	$31,500,000
5.07	Concrete - Dam Crest Slab & Parapet and unlisted dam concrete structures	5,400	CY	$750.00	$4,050,000	**Prior item included "Dam and Crest Spillway". For FRE, item has been changed to reflect the dam crest, and parapet walls plus 4,000cy of dam conventional concrete not yet itemized (adit entrances, spillway end walls, diversion plug conversion to operating chamber, etc.) Item was 6500cy @ $750. Changes for final: None. Consider this item only as upper spillway.** No facing should be included if flip bucket chute face is elsewhere. Leave in for ogee, spillway approach walls, piers.	70%	110%	$2,835,000	$4,455,000			info?			info?	$2,835,000	$4,455,000

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: ***Chehalis Dam***
Alternative: ***FRE***

	Weighting ⇨	20% low	70% likely	10% high	20% low	70% likely	10% high
$293M - Jul-16		**Low End**	**$306,543,571**		**Low End**	**$390,083,824**	
		Likely	**$358,397,146**		**Likely**	**$456,068,705**	
$454M - Jul-18		**High End**	**$419,217,088**		**High End**	**$533,463,496**	
		Weighted	**$354,108,425**		**Weighted**	**$450,611,208**	

Pricing - contractor cost basis 1 or bid basis 2:	**2**		
Range Driver - 1 = %, 2 = Q & $, 3 = Combination:	**3**		
Default Low ⇨	**80%**	**Default High ⇨**	**120%**

Quantity references: "FRE - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

		Base or Likely Cost Case					Range Development: Driven by Percent				Driven by Q & Unit $						Driven by Combo	
Work Item	**Description**	**Quantity**	**Unit**	**Unit Price [1]**	**Total $**	**Estimate Notes & Considerations (Notes prior to FRE eval grayed out)**	**Low End % (def=80%)**	**High End % (def=120%)**	**Low % Total $**	**High % Total $**	**Low End Q**	**Low End Unit $**	**Low End Total $**	**High End Q**	**High End Unit $**	**High End Total $**	**Low End Tot $**	**High End Tot $**
5.08	Foundation Treatment - Grout Curtain Drilling	50,000	LF	$45.00	$2,250,000	**FRE is 1780' of foundation contact. No change to Q or unit pricing.** revisited pricing; 1700lf @ 10', plus 50% secondary, plus 25% tertiary @ 80' deep = 298 holes @ 90' = 26,820lf; if consolidation grouting - add 220,000 sf @ 400sf/ hole @ 20' deep = 11,000lf = 37,820 lf. If double curtain plus 25% extra = 383 holes @ 90' = 34,470lf, plus 11k consolidation grouting = 45,470lf. Use 50k lf. Depth: 300' at 35'+300' at 85'+500' at 140' +			$1,800,000	$2,700,000			info?			info?	$1,800,000	$2,700,000
5.09	Foundation Treatment - Grout Curtain Cement	35,000	Sack	$40.00	$1,400,000	**FRE is 1780' of foundation contact. No change to Q or unit pricing.** **Changes for final: revised quantity, increased unit price.** Assume 0.7 bag per lf			$1,120,000	$1,680,000			info?			info?	$1,120,000	$1,680,000
5.1	Flood Regulating Conduit Control Structures - Reinforced Concrete	0	CY	$800.00	$0	**Now in item 5.06. Was 5800cy @ $850.** Assume 2' thick around perimeter of sluices & air shafts. Refine quantities along with all structures next phase; include inside and downstream of dam; include control building on crest or at downstream, depending on final concept drawings			$0	$0			info?			info?	$0	$0
5.11	Flood Regulating Conduit Control Gates - Fab and Construct	320,000	LB	$15.00	$4,800,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 120,000# @ $15.00.** Assume 2 @ 30 tons.			$3,840,000	$5,760,000			info?			info?	$3,840,000	$5,760,000
5.12	Emergency, flood regulating, & WQ bulkhead gates	976,000	LB	$10.00	$9,760,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 300,000# @ $15.00.** Assume 2 @ 25 tons, and 2 @ 50 tons			$7,808,000	$11,712,000			info?			info?	$7,808,000	$11,712,000
5.13	Hoists, cylinders, machinery	300,000	LB	$15.00	$4,500,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 200,000# @ $15.00.**			$3,600,000	$5,400,000			info?			info?	$3,600,000	$5,400,000
5.14	Reservoir drain valve in tunnel plug (assume 4x4' knife valve)	1	Each	$200,000.00	$200,000	**No change for FRE.**	50%	100%	$100,000	$200,000			info?			info?	$100,000	$200,000
5.15	WQ Regulating Outlets w/ hollow cone valves (4 - 4'dia)	0	Each	$375,000.00	$0	**FRE does not furnish or install the WQ outlet valves. Item was 4 each at $375k.**			$0	$0			info?			info?	$0	$0
5.16	WQ Regulating Outlet w/ hollow cone valves (1 - 7'dia)	0	Each	$100,000.00	$0	**FRE does not furnish or install the WQ outlet valves. Item was 1 each at 1,100k.**			$0	$0			info?			info?	$0	$0
5.17	WQ Intake Tower / concrete sidewall & decking - Conventional Concrete Reinforced	5,800	CY	$850.00	$4,930,000	**Items 5.17 and 5.18 prior, totaled 14,000cy (2800 @ $750 and 11,200 @ $400). All intake concrete is now in this item; ref "FRE - Annotated Dwgs Supporting OPC.pdf" FRE S-6-S-7 sheets.**			$3,944,000	$5,916,000			info?			info?	$3,944,000	$5,916,000
5.18	Unused	0	CY	$400.00	$0	**Now in item 5.17. Was 11,200cy @ $400.** **Refine quantities along with all structures next phase.**	100%		$0	$0			info?			info?	$0	$0
5.19	Trashrack steel framing	1,769,040	LB	$6.50	$11,498,760	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 1,360,000# @ $6.50.** Assume 300 ft high, 10 members 3' dia x 4.5'deep, steel column			$9,199,008	$13,798,512			info?			info?	$9,199,008	$13,798,512
5.2	unused	0	CY	$850.00	$0	**Now in item 5.17. Was 2000cy @ $850.**			$0	$0			info?			info?	$0	$0
6	**Spillway**				$0				$0	$0			info?			info?	$0	$0
6.01	Flip Bucket Conventional Concrete - surface	5,800	CY	$650.00	$3,770,000	**Adjust based on 5' minimum structure overlying RCC block to elev 470. Q prior was 7800cy at $700.**			$3,016,000	$4,524,000			info?			info?	$3,016,000	$4,524,000
6.02	Conventional Concrete - spillway approach, ogee, chute slab, and training walls	8,700	CY	$850.00	$7,395,000	**Line item prior contemplated the foundation block beneath the Ogee. Use item now for spillway training walls, chute slab, approach and ogee. Q was 9,750cy at $225. RCC foundation is now in RCC item.** unit price - accomodates higher RCC placement and utilization of some mass conventional concrete	90%	110%	$6,655,500	$8,134,500			info?			info?	$6,655,500	$8,134,500
7	**Sluice Stilling Basin**				$0				$0	$0			info?			info?	$0	$0
7.01	Excavation - Foundation General	20,000	CY	$8.00	$160,000	Refine all excavation and backfill quantities next phase			$128,000	$192,000			info?			info?	$128,000	$192,000
7.02	Excavation - Foundation Rock	10,000	CY	$30.00	$300,000				$240,000	$360,000			info?			info?	$240,000	$360,000
7.03	Fill - Foundation Backfill	18,000	CY	$9.00	$162,000				$129,600	$194,400			info?			info?	$129,600	$194,400
7.04	Conventional Concrete Reinforced	8,600	CY	$750.00	$6,450,000	**Reference "FRE - Annotated Dwgs Supporting OPC.pdf", sheets FRE S-06, S07. Was 4900 @ $8700 and item 7.04 2000cy at $400.**			$5,160,000	$7,740,000			info?			info?	$5,160,000	$7,740,000
7.05	Conventional Concrete Non-Reinforced	1,600	CY	$400.00	$640,000		70%		$448,000	$768,000			info?			info?	$448,000	$768,000
8	**Wing Dam Structure**				$0				$0	$0			info?			info?	$0	$0
8.01	Excavation - Foundation General	0	CY	$6.50	$0	**Not in FRE; was 33,333 cy**			$0	$0			info?			info?	$0	$0
8.02	Excavation Cutoff Trench - Foundation Rock (assume trench 30 ft wide x 20 ft deep)	0	CY	$30.00	$0	**Not in FRE; was 13,333 cy**			$0	$0			info?			info?	$0	$0
8.03	Fill - Wingdam Embankment	0	CY	$15.00	$0	**Not in FRE; was 120,000 cy**	90%		$0	$0			info?			info?	$0	$0
8.04	Fill - Wingdam Riprap Facing (assume 5' blanket U/S and D/S)	0	CY	$65.00	$0	**Not in FRE; was 8,000 cy**			$0	$0			info?			info?	$0	$0
	Composite & Unlisted Work																	
55	Fish passage structure - costs not included	1	ls	$0	$0	Costs independently assessed in report			$0	$0			info?			info?	$0	$0
56	Unlisted Work	1	ls	$5,000,000	$5,000,000	**No change for FRE.**	85%	115%	$4,250,000	$5,750,000			info?			info?	$4,250,000	$5,750,000
57					$0				$0	$0			info?			info?	$0	$0
58					$0				$0	$0			info?			info?	$0	$0
59					$0				$0	$0			info?			info?	$0	$0
60					$0				$0	$0			info?			info?	$0	$0
61					$0				$0	$0			info?			info?	$0	$0
62					$0				$0	$0			info?			info?	$0	$0
63					$0				$0	$0			info?			info?	$0	$0
64					$0				$0	$0			info?			info?	$0	$0
65					$0				$0	$0			info?			info?	$0	$0
					$0				$0	$0			info?			info?	$0	$0
Subtotal without mobilization & general expense					**$235,981,660**		**$192,776,628**	**$282,158,572**	**$192,776,628**	**$282,158,572**			**$117,285,000**			**$157,066,500**	**$201,839,388**	**$276,027,712**
Mobilization & project indirect expense			0%		$0	unallocated project indirect or jobsite overhead assumed in unit pricing												
Contractor Cost					**$235,981,660**	Note 1: Unit prices as noted in header, either reflect a bid price basis (no factor application of corporate OH & profit), or a contractor cost basis requiring a corporate OH & profit to get to a bid total												
Contractor Margin - corporate overhead & profit			~~0%~~	Bid Basis	$0	Note 2: NA - not applicable to project; NE - not evident in estimate; NI - noted but not itemized in estimate												
Contractor Bid - before design/procurement contingencies					**$235,981,660**													
Contract Contingencies - design and procurement contingencies			12.5%		$29,497,708	⇦ RCC estimate dominance, work breakdown thoroughness, and work understanding support a design contingency lower than typical (i.e. 20%) at this early design level												
Contract Cost - contractor bid with design & procurement contingencies					**$265,479,368**													
Construction Contingency: post-award change & dispute factor			10%		$26,547,937													
Non-Contract Costs: PM, planning, design, CM ...			25%		$66,369,842	⇦ permitting, site characterization, CM during construction,etc.												
Total Project Cost - before escalation					**$358,397,146**	**Compares to $293M low bound, and $454M high bound July 2016**												
Escalation - annual %; from; to		3.5%	1-Jun-17	1-Jun-24	$97,671,559	⇦ **Presume NTP - mid 2021, say 6 years construction = 4 years + 1/2 of 6 years = 7.0 years. Was early 2019, 7 years construction, 2.5 + 3.75 = 6.25**												
Total Project Cost - including escalation				**7.0 yr**	**$456,068,705**	**<< 193% above total w/o mobilization**												

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: *Chehalis Dam*
Alternative: *FRE-FC*

Pricing - contractor cost basis 1 or bid basis 2:	2

Range Driver - 1 = %, 2 = Q & $, 3 = Combination:			3
Default Low ⇨	80%	Default High ⇨	120%

Weighting ⇨	20% low	70% likely	10% high	20% low	70% likely	10% high
$293M - Jul-16	Low End	$110,099,910		Low End	$140,104,697	
	Likely	$128,809,987		Likely	$163,913,704	
$454M - Jul-18	High End	$154,389,521		High End	$196,464,257	
	Weighted	$127,625,925		Weighted	$162,406,958	

Quantity references: "FRE - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

		Base or Likely Cost Case					Range Development											
							Driven by Percent				Driven by Q & Unit $						Driven by Combo	
Work Item	Description	Quantity	Unit	Unit Price [1]	Total $	Estimate Notes & Considerations (Notes prior to FRE eval grayed out)	Low End % (def=80%)	High End % (def=120%)	Low % Total $	High % Total $	Low End Q	Low End Unit $	Low End Total $	High End Q	High End Unit $	High End Total $	Low End Tot $	High End Tot $
	Phase 1 - Site Development, Diversion Constrruction,				$0				$0	$0			info?			info?	$0	$0
0	**Mobilization**								$0	$0			info?			info?	$0	$0
	Mobilization	1	LS	$5,000,000.00	$5,000,000	**No change for FRE-FC.** Contractor mob bid; balance of project overhead in below-the-line factors	100%	140%	$5,000,000	$7,000,000			info?			info?	$5,000,000	$7,000,000
1	**Clearing & Grubbing**				$0				$0	$0			info?			info?	$0	$0
1.01	Clearing and grubbing, stripping topsoil, reclamation of disturbed areas	15	Acre	$8,000.00	$120,000	**Was 30 ac in FRE and $30k /ac. Presumably all clearing would be completed in FRE; but unspecified return growth would need to be recleared for FRE-FC.**			$96,000	$144,000			info?			info?	$96,000	$144,000
1.02	Reservoir Clearing to 100-yr Flood Stage	844	Acre	$6,000.00	$5,065,200	**Assumed 30% FRE and 70% FRE-FC from orig FRFA of 1206 ac @ $6K/ac.** Potentially in Phase 2 or possibly Phase 3 contract			$4,052,160	$6,078,240		$5,000.00	$4,221,000		$7,500.00	$6,331,500	$4,221,000	$6,331,500
2	**Temporary Access & Staging**				$0				$0	$0			info?			info?	$0	$0
2.01	Construction Surveying & Layout	0	Acre	$10,000.00	$0	**Fully assigned to FRE, assume FRE-FC survey and layout in general expense (project indirect costs).** Under temporary access & staging; i.e. temporary works only, predominant surveys and layout in unallocated contractor project overhead expense (already in the unit pricing)	100%	150%	$0	$0			info?			info?	$0	$0
2.02	Restore FRE and left-side access. Pioneer/Access Roads (e.g. dam site, abutments, quarry site, etc.)	1.0	LS	$400,000.00	$400,000	**All access constructed under FRE. Consider $350k restore and maintain under FRE-FC. Was 3 mi @ $700k. Changes for final: increase access road development by adding 1 mile, from 2 to 3.** dependent upon aggregate sourcing, staging locations, contractor approach. Reference Chehalis_All_Figs_2016-10-19.pdf drawing G-3, for site, non-quarry access concepts, totaling about 10,000lf of new access, say 5000lf of upgraded access. Say 50% new and full access development, 20% construction & track access only, 30% improved existing. Consider quarry acces costs in aggregate price range.			$320,000	$480,000			info?	3.5	$800,000.00	$2,800,000	$320,000	$2,800,000
2.03	Material Laydown Area Prep (minor excavation, grading, surfacing, drainage	20	Acre	$5,000.00	$100,000	**All staging constructed under FRE. Consider $100k restore and maintain under FRE-FC. Was 20 ac @ $25k. .** 1 acre at 5' avg cut to 5' average fill = 4000cy cut to fill; @ $6/cy cut to fill = $24,200/ac; 1ac surfacing at 6" & 30% surfaced = 430ton, @ 10/tn = $4.5k/ac			$80,000	$120,000		$30,000.00	$600,000			info?	$600,000	$120,000
2.04	Temporary construction site access security control facilities (e.g. fencing, gates, etc.)	2,200	LF	$20.00	$44,000	**No change for FRE-FC.** 'predominant security expense in unallocated contractor project overhead expense			$35,200	$52,800			info?			info?	$35,200	$52,800
3	**Diversion & Dewatering**				$0				$0	$0			info?			info?	$0	$0
3.01	Diversion Tunnel 20 ft modified horseshoe	0	LF	$8,000.00	$0	**No diversion tunnel or low-level drawdown gate changes in FRE-FC. Changes for final: increase length of tunnel to better reflect final drawing alignment.** increase high end for variability in linnig limits, portaling, tunnel plug adit construction, vent construction, etc.	90%	125%	$0	$0			info?			info?	$0	$0
3.02	Conventional Concrete Non-Reinforced Mass Concrete (100' plug following construction)	0	CY	$600.00	$0	**No costs for FRE-FC.** low end 30'plug but include mechanical.			$0	$0			info?			info?	$0	$0
3.03	Coffer Dams (2) - Fill cells u/s and d/s + toe slopes	0	CY	$40.00	$0	**No costs for FRE-FC.** check Q's with new crest heights, say 8,000 cy RCC @ 70 + 6,000 cy Rockfill @ 15. = 650KHigh end if pushed to 480 and rockfill - say 45kcy = $675K.			$0	$0			info?			info?	$0	$0
3.04	Foundation Excavation - seepage key (assume 20'wide x 150' long x 4' deep	0	CY	$8.00	$0	**No costs for FRE-FC.** Cofferdam key allowance		300%	$0	$0			info?			info?	$0	$0
3.05	Foundation Dewatering - assume several dewatering pump systems operating selectively 24/7 over 12 month foundation construction exposure	0	Day	$2,800.00	$0	**No costs for FRE-FC. Changes for final: increase foundation exposure from 6 to 12 months.** 2nd contract may add unwaterring and time for dewatering for RCC foundation		150%	$0	$0			info?			info?	$0	$0
3.06	Coffer Dams - Other assume 25' high x 150 top length, 35' base length, cell construction (e.g. sheet pile, steel, other fabricated metal items)	0	SF	$30	$0	**No costs for FRE-FC.** may include isolation of portal structures, tailwater structures, peripheral dewatering stages			$0	$0			info?			info?	$0	$0
3.07	All project Care-of-Water Coffer Dams - Risk contingency for overtopping	1	LS	$400,000	$400,000	**Full allowance for FRE-FC dewater and diversion considerations, including risk.** contemplates partial or threshold-bound contractor responsibility, risk apportioned cost of event recovery, rework, delay			$320,000	$480,000			info?			info?	$320,000	$480,000
4	**Lands and Easements**				$0				$0	$0			info?			info?	$0	$0
4.01	Reservoir Extents Fee Title	0	Acre	$4,400	$0	**Presumed fully settled in FRE.** Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.	100%	100%	$0	$0			info?			info?	$0	$0
4.02	Reservoir Extents/Flood Easement	0	Acre	$4,400	$0	**Presumed fully settled in FRE.** Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.	100%	100%	$0	$0			info?			info?	$0	$0
4.03	Reservoir orphaned access roadway reconnection allowance (to WeyCo?)	0	Mile	$1,000,000	$0	**Presumed fully settled in FRE.** Unit price potentially higher for permanent versus constuction roads. Line item also perhaps better considered under non-contract cost factor.		110%	$0	$0			info?			info?	$0	$0
	Phase 2 - Main Dam																$0	$0
5	**Main Dam Structure**				$0				$0	$0			info?			info?	$0	$0
5.01	Excavation - Foundation General	15,000	CY	$15	$225,000	**Wing excavation in item 8.01. Excavation for FRE-FC dam includes temporary backfill of downstream groin. Changes for final: revised quantities.** Reference FRFA S-1 annotated from Chehalis_All_Figs_2016-10-19.pdf, also this worksheet FRFA Exc Guess tab.			$180,000	$270,000		$5.50	$82,500		$7.50	$112,500	$82,500	$112,500
5.02	Excavation - Foundation Rock	0	CY	$27	$0	**No costs for FRE-FC. Changes for final: revised quantities.** Reference FRFA S-1 annotated from Chehalis_All_Figs_2016-10-19.pdf, also this worksheet FRFA Exc Guess tab. Some rock will be structural exc in fresh rock, most will be foundation footprint, getting to good rock below the rock contact; i.e potentially a high degree ripable.			$0	$0		$25.00	$0		$30.00	$0	$0	$0
5.03	Roller Compacted Concrete - Composite Scope	467,000	CY	$111	$51,837,000	**RCC quantity from RCC Dam Q-s & Placement Plan - R09.xls; composite unit price development from Con-Sked-$ Support - FRE Chehalis - R01.xls. Changes for final: revised quantities. Expanded RCC unit cost development work breakdown, revisited unit pricing, and increased unit pricing to reflect upstream conventional face and downstream GERCC.** RCC unit pricing includes aggregate, cement-fly ash, lift bedding, abutment bedding, dam joints, and **2.5' upstream conventional face and downstream**			$41,469,600	$62,204,400		$94.00	$43,898,000		$127.00	$59,309,000	$43,898,000	$59,309,000
5.04	Fill - Foundation Backfill	126,000	CY	$6	$693,000	**includes backfull of upper abutments and downstream groin after FRE-FC construction; Reference "FRE - Annotated Dwgs Supporting OPC.pdf"; Pending Q verification. Changes for final: revised quantities.**			$554,400	$831,600			info?			info?	$554,400	$831,600
5.05	Conventional Concrete Reinforced (miscellaneous)	0	CY	$850	$0	**Item not used in FRE estimate. Q was 750cy @ $850.** Refine quantities along with all structures next phase.			$0	$0			info?			info?	$0	$0
5.06	Outlet works encasement: sluicing conduits, river outlet works conduits, gate chamber, vent and gallery passages	0	CY	$450	$0	**No costs for FRE-FC.** Refine quantities along with all structures next phase.			$0	$0			info?			info?	$0	$0
5.07	Concrete - Dam Crest Slab & Parapet and unlisted dam concrete structures	2,460	CY	$750	$1,845,000	**FRE-FC crest and parapet walls plus 1000cy unlisted. Changes for final: None. Consider this item only as upper spillway.** No facing should be included if flip bucket chute face is elsewhere. Leave in for ogee, spillway approach walls, piers.	70%	110%	$1,291,500	$2,029,500			info?			info?	$1,291,500	$2,029,500

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: ***Chehalis Dam***
Alternative: ***FRE-FC***

Weighting ⇨	**20% low**	**70% likely**	**10% high**	**20% low**	**70% likely**	**10% high**
$293M - Jul-16	**Low End**	**$110,099,910**		**Low End**	**$140,104,697**	
	Likely	**$128,809,987**		**Likely**	**$163,913,704**	
$454M - Jul-18	**High End**	**$154,389,521**		**High End**	**$196,464,257**	
	Weighted	**$127,625,925**		**Weighted**	**$162,406,958**	

Range Driver - 1 = %, 2 = Q & $, 3 = Combination:			**3**
Default Low ⇨	**80%**	**Default High ⇨**	**120%**

Pricing - contractor cost basis 1 or bid basis 2: **2**

Quantity references: "FRE - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

		Base or Likely Cost Case					Range Development: Driven by Percent				Driven by Q & Unit $						Driven by Combo	
Work Item	**Description**	**Quantity**	**Unit**	**Unit Price [1]**	**Total $**	**Estimate Notes & Considerations** (Notes prior to FRE eval grayed out)	**Low End % (def=80%)**	**High End % (def=120%)**	**Low % Total $**	**High % Total $**	**Low End Q**	**Low End Unit $**	**Low End Total $**	**High End Q**	**High End Unit $**	**High End Total $**	**Low End Tot $**	**High End Tot $**
5.08	Foundation Treatment - Grout Curtain Drilling	1	LS	$350,000	$350,000	**FRE grout limits are very near adequate for FRE-FC. Add upper left abutment lump sum grouting allowance.** revisited pricing; 1700lf @ 10', plus 50% secondary, plus 25% tertiary @ 80' deep = 298 holes @ 90' = 26,820lf; if consolidation grouting - add 220,000 sf @ 400sf/ hole @ 20' deep = 11,000lf = 37,820 lf. If double curtain plus 25% extra = 383 holes @ 90' = 34,470lf, plus 11k consolidation grouting = 45,470lf. Use 50k lf. Depth: 300' at 35'+300'			$280,000	$420,000			info?			info?	$280,000	$420,000
5.09	Foundation Treatment - Grout Curtain Cement	0	Sack	$40	$0	**In 5.08 allowance. Changes for final: revised quantity, increased unit price.** Assume 0.7 bag per lf			$0	$0			info?			info?	$0	$0
5.1	Flood Regulating Conduit Control Structures - Reinforced Concrete	0	CY	$800	$0	**No costs for FRE-FC.** Assume 2' thick around perimeter of sluices & air shafts. Refine quantities along with all structures next phase; include inside and downstream of dam; include control building on crest or at downstream, depending on final concept drawings			$0	$0			info?			info?	$0	$0
5.11	Flood Regulating Conduit Control Gates - Fab and Construct	0	LB	$15	$0	**No costs for FRE-FC.** Assume 2 @ 30 tons.			$0	$0			info?			info?	$0	$0
5.12	Emergency, flood regulating, & WQ bulkhead gates	0	LB	$10	$0	**No costs for FRE-FC.** Assume 2 @ 25 tons, and 2 @ 50 tons			$0	$0			info?			info?	$0	$0
5.13	Hoists, cylinders, machinery	0	LB	$15	$0	**No costs for FRE-FC.**			$0	$0			info?			info?	$0	$0
5.14	Reservoir drain valve in tunnel plug (assume 4x4' knife valve)	0	Each	$200,000	$0	**No costs for FRE-FC.**	50%	100%	$0	$0			info?			info?	$0	$0
5.15	WQ Regulating Outlets w/ hollow cone valves (4 - 4'dia)	4	Each	$450,000	$1,800,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Increase for to accommodate removing bulkheads and installing in the existing config**			$1,440,000	$2,160,000			info?			info?	$1,440,000	$2,160,000
5.16	WQ Regulating Outlet w/ hollow cone valves (1 - 7'dia)	1	Each	$1,250,000	$1,250,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls".**			$1,000,000	$1,500,000			info?			info?	$1,000,000	$1,500,000
5.17	WQ Intake Tower / concrete sidewall & decking - Conventional Concrete Reinforced	1,350	CY	$1,000	$1,350,000	**Reference "RCC FRE-FC Section - FRE Draft" sheet of "FRE - Annotated Dwgs Supporting OPC.pdf".**			$1,080,000	$1,620,000			info?			info?	$1,080,000	$1,620,000
5.18	unused	0	CY	$400	$0	**Now in item 5.17.**	100%		$0	$0			info?			info?	$0	$0
5.19	Trashrack steel framing	294,840	LB	$7	$1,916,460	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls".** Assume 300 ft high, 10 members 3' dia x 4.5'deep, steel column			$1,533,168	$2,299,752			info?			info?	$1,533,168	$2,299,752
5.2	unused	0	CY	$850	$0	**Now in item 5.17.**			$0	$0			info?			info?	$0	$0
6	**Spillway**				$0				$0	$0			info?			info?	$0	$0
6.01	Flip Bucket Conventional Concrete - surface	0	CY	$650	$0	**No costs for FRE-FC.**			$0	$0			info?			info?	$0	$0
6.02	Conventional Concrete - spillway approach, ogee, chute slab, and training walls	3,600	CY	$850	$3,060,000	**No costs for FRE-FC.** unit price - accomodates higher RCC placement and utilization of some mass conventional concrete	90%	110%	$2,754,000	$3,366,000			info?			info?	$2,754,000	$3,366,000
7	**Sluice Stilling Basin**				$0				$0	$0			info?			info?	$0	$0
7.01	Excavation - Foundation General	0	CY	$8	$0	**No costs for FRE-FC.**			$0	$0			info?			info?	$0	$0
7.02	Excavation - Foundation Rock	0	CY	$30	$0	**No costs for FRE-FC.**			$0	$0			info?			info?	$0	$0
7.03	Fill - Foundation Backfill	0	CY	$9	$0	**No costs for FRE-FC.**			$0	$0			info?			info?	$0	$0
7.04	Conventional Concrete Reinforced	0	CY	$800	$0	**No costs for FRE-FC.**			$0	$0			info?			info?	$0	$0
7.05	Conventional Concrete Non-Reinforced	0	CY	$400	$0	**No costs for FRE-FC.**	70%		$0	$0			info?			info?	$0	$0
8	**Wing Dam Structure**				$0				$0	$0			info?			info?	$0	$0
8.01	Excavation - Foundation General (assume footprint 270' @ widest x 10 ft deep)	70,000	CY	$10	$700,000	**Consider as all excavation and unclassified, all should be ripable rock at the worst; was 33,333 cy**			$560,000	$840,000			info?			info?	$560,000	$840,000
8.02	Excavation Cutoff Trench - Foundation Rock (assume trench 30 ft wide x 20 ft deep)	0	CY	$30	$0	**Included in item 8.01; was 13,333 cy**			$0	$0			info?			info?	$0	$0
8.03	Fill - Wingdam Embankment	176,000	CY	$20	$3,520,000	**Composite fill unit price and quantity; pending more detailed QTO; increased unit price to accommodate zones; was 120,000 cy @ $15.**	90%		$3,168,000	$4,224,000			info?			info?	$3,168,000	$4,224,000
8.04	Fill - Wingdam Riprap Facing (assume 5' blanket U/S and D/S)	8,000	CY	$65	$520,000				$416,000	$624,000			info?			info?	$416,000	$624,000
	Composite & Unlisted Work																	
55	Fish passage structure - costs not included	1	ls	$0	$0	Costs independently assessed in report			$0	$0			info?			info?	$0	$0
56	Unlisted Work	1	ls	$3,000,000	$3,000,000		85%	115%	$2,550,000	$3,450,000			info?			info?	$2,550,000	$3,450,000
57	**Added for FRE Alternative - FRE-FC specific**				$0				$0	$0			info?			info?	$0	$0
58	FRE-FC - Add Concrete demo	4,350	cy	$50	$217,500	**Reference "RCC FRE-FC Section - FRE Draft" sheet of "FRE - Annotated Dwgs Supporting OPC.pdf".**			$174,000	$261,000			info?			info?	$174,000	$261,000
59	FRE-FC - Add Existing FRE d/s face surface prep; anchor allowance	250,000	sf	$4	$1,000,000	**Downstream and vert form sf of FRE x 1.25 (adj for sloping portion) - 260'x200' (full spillway slope built to FRE-FC limits) = 236k * 1.25 - 52k = 243k; use 250k sf**			$800,000	$1,200,000			info?			info?	$800,000	$1,200,000
60	FRE-FC - Include wing dam seepage mitigation allowance	1	ls	$400,000	$400,000	**assume 400' x 20' = 8000sf, or 750cy @ 2.5';**			$320,000	$480,000			info?			info?	$320,000	$480,000
61					$0				$0	$0			info?			info?	$0	$0
62					$0				$0	$0			info?			info?	$0	$0
63					$0				$0	$0			info?			info?	$0	$0
64					$0				$0	$0			info?			info?	$0	$0
65					$0				$0	$0			info?			info?	$0	$0
					$0				$0	$0			info?			info?	$0	$0
Subtotal without mobilization & general expense					**$84,813,160**		**$69,474,028**	**$102,135,292**	**$69,474,028**	**$102,135,292**			**$48,801,500**			**$68,553,000**	**$72,493,768**	**$101,655,652**
Mobilization & project indirect expense			0%		$0	unallocated project indirect or jobsite overhead assumed in unit pricing												
Contractor Cost					**$84,813,160**	Note 1: Unit prices as noted in header, either reflect a bid price basis (no factor application of corporate OH & profit), or a contractor cost basis requiring a corporate OH & profit to get to a bid total												
Contractor Margin - corporate overhead & profit			~~0%~~	Bid Basis	$0	Note 2: NA - not applicable to project; NE - not evident in estimate; NI - noted but not itemized in estimate												
Contractor Bid - before design/procurement contingencies					**$84,813,160**													
Contract Contingencies - design and procurement contingencies			12.5%		$10,601,645	⇦ RCC estimate dominance, work breakdown thoroughness, and work understanding support a design contingency lower than typical (i.e. 20%) at this early design level												
Contract Cost - contracator bid with design & procurement contingencies					**$95,414,805**													
Construction Contingency: post-award change & dispute factor			10%		$9,541,481													
Non-Contract Costs: PM, planning, design, CM ...			25%		$23,853,701	⇦ permitting, site characterization, CM during construction,etc.												
Total Project Cost - before escalation					**$128,809,987**	**Compares to $293M low bound, and $454M high bound July 2016**												
Escalation - annual %; from; to		3.5%	1-Jun-17	1-Jun-24	$35,103,718	⇦ **Presume NTP - mid 2021, say 6 years construction = 4 years + 1/2 of 6 years = 7.0 years. Was early 2019, 7 years construction, 2.5 + 3.75 = 6.25**												
Total Project Cost - including escalation				**7.0 yr**	**$163,913,704**	**<< 193% above total w/o mobilization**												

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: ***Chehalis Dam***
Alternative: ***FRO*** ***Comparison for FRE Evaluation***

Pricing - contractor cost basis 1 or bid basis 2:	2

Range Driver - 1 = %, 2 = Q & $, 3 = Combination:	3		
Default Low ⇦	80%	Default High ⇨	120%

Weighting ⇨	20% low	75% likely	5% high	20% low	75% likely	5% high
$201M - Jul-16	Low End		$244,615,783	Low End		$311,279,274
	Likely		$298,050,587	Likely		$379,276,305
$319M - Jul-18	High End		$351,140,680	High End		$446,834,684
	Weighted		$290,018,131	Weighted		$369,054,818

Quantity references: "FRX - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

		Base or Likely Cost Case					Range Development: Driven by Percent				Driven by Q & Unit $						Driven by Combo	
Work Item	Description	Quantity	Unit	Unit Price[1]	Total $	Estimate Notes & Considerations (Notes prior to FRX eval grayed out)	Low End % (def=80%)	High End % (def=120%)	Low % Total $	High % Total $	Low End Q	Low End Unit $	Low End Total $	High End Q	High End Unit $	High End Total $	Low End Tot $	High End Tot $
	Phase 1 - Site Development, Diversion Constrruction,				$0				$0	$0			info?			info?	$0	$0
0	**Mobilization**								$0	$0			info?			info?	$0	$0
	Mobilization	1	LS	$3,500,000.00	$3,500,000	Contractor mob bid; balance of project overhead in below-the-line factors	100%	140%	$3,500,000	$4,900,000			info?			info?	$3,500,000	$4,900,000
1	**Clearing & Grubbing**				$0				$0	$0			info?			info?	$0	$0
1.01	Clearing and grubbing, stripping topsoil, reclamation of disturbed areas	25	Acre	$30,000.00	$750,000				$600,000	$900,000	18	$30,000.00	$540,000	25	$25,000.00	$625,000	$540,000	$625,000
1.02	Reservoir Clearing to 100-yr Flood Stage	756	Acre	$6,000.00	$4,536,000	Potentially in Phase 2 or possibly Phase 3 contract			$3,628,800	$5,443,200		$5,000.00	$3,780,000		$7,500.00	$5,670,000	$3,780,000	$5,670,000
2	**Temporary Access & Staging**				$0				$0	$0			info?			info?	$0	$0
2.01	Construction Surveying & Layout	25	Acre	$10,000.00	$250,000	Under temporary access & staging; i.e. temporary works only, predominant surveys and layout in unallocated contractor project overhead expense (already in the unit pricing)	100%	150%	$250,000	$375,000			info?			info?	$250,000	$375,000
2.02	Pioneer/Access Roads (e.g. dam site, abutments, quarry site, etc.)	2.0	Mile	$700,000.00	$1,400,000	**Changes for final: increase access road development by adding 0.5 mile from 1.5 to 2 miles.** dependent upon aggregate sourcing, staging locations, contractor approach. Reference G-4_ETZ_21Sept2016 - JCA markups 01.pdf for site, non-quarry access concepts, totaling about 13,500lf. Say 50% new and full access development, 20% construction & track access only, 30% improved existing. Consider quarry acces costs in aggregate price range.			$1,120,000	$1,680,000	1.5	$750,000.00	$1,125,000	2.25	$800,000.00	$1,800,000	$1,125,000	$1,800,000
2.03	Material Laydown Area Prep (minor excavation, grading, surfacing, drainage	18	Acre	$25,000.00	$450,000	1 acre at 5' avg cut to 5' average fill = 4000cy cut to fill; @ $6/cy cut to fill = $24,200/ac; 1ac surfacing at 6" & 30% surfaced = 430ton, @ 10/tn = $4.5k/ac			$360,000	$540,000	13	$30,000.00	$390,000	22		$550,000	$390,000	$550,000
2.04	Temporary construction site access security control facilities (e.g. fencing, gates, etc.)	2,200	LF	$20.00	$44,000	predominant security expense in unallocated contractor project overhead expense			$35,200	$52,800			info?			info?	$35,200	$52,800
3	**Diversion & Dewatering**				$0				$0	$0			info?			info?	$0	$0
3.01	Diversion Tunnel 20 ft modified horseshoe	1,635	LF	$8,000.00	$13,080,000	**Increased length for FRE and both FRO and FRFA, from 1500. Changes for final: increase length of tunnel to better reflect final drawing alignment.** increase high end for variability in linnig limits, portaling, tunnel plug adit construction, vent construction, etc.	90%	125%	$11,772,000	$16,350,000			info?			info?	$11,772,000	$16,350,000
3.02	Conventional Concrete Non-Reinforced Mass Concrete (100' plug following construction)	1,200	CY	$600.00	$720,000	low end 30'plug but include mechanical.			$576,000	$864,000		$450.00	$540,000		$650.00	$780,000	$540,000	$780,000
3.03	Coffer Dams (2) - Fill cells u/s and d/s + toe slopes	14,000	CY	$40.00	$560,000	check Q's with new crest heights, say 8,000 cy RCC @ 70 + 6,000 cy Rockfill @ 15. = 650KHigh end if pushed to 480 and rockfill - say 45kcy = $675K.			$448,000	$672,000			info?			info?	$448,000	$672,000
3.04	Foundation Excavation - seepage key (assume 20'wide x 150' long x 4' deep	450	CY	$8.00	$3,600	Cofferdam key allowance		300%	$2,880	$10,800			info?			info?	$2,880	$10,800
3.05	Foundation Dewatering - assume several dewatering pump systems operating selectively 24/7 over 6 month foundation construction period	270	Day	$2,800.00	$756,000	**Changes for final: increase foundation exposure from 6 to 9 months.** 2nd contract may add unwaterring and time for dewatering for RCC foundation		150%	$604,800	$1,134,000			info?			info?	$604,800	$1,134,000
3.06	Coffer Dams - Other assume 25' high x 150 top length, 35' base length, cell construction (e.g. sheet pile, steel, other fabricated metal items)	7,000	SF	$30	$210,000	may include isolation of portal structures, tailwater structures, peripheral dewatering stages			$168,000	$252,000			info?			info?	$168,000	$252,000
3.07	Coffer Dams - Risk contingency for overtopping	1	LS	$750,000.00	$750,000	contemplates partial or threshold-bound contractor responsibility, risk apportioned cost of event recovery, rework, delay			$600,000	$900,000			info?			info?	$600,000	$900,000
4	**Lands and Easements**				$0				$0	$0			info?			info?	$0	$0
4.01	Reservoir Extents Fee Title	750	Acre	$4,400	$3,300,000	Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.	100%	100%	$3,300,000	$3,300,000			info?			info?	$3,300,000	$3,300,000
4.02	Reservoir Extents/Flood Easement	55	Acre	$4,400	$242,000	Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.	100%	100%	$242,000	$242,000			info?			info?	$242,000	$242,000
4.03	Reservoir orphaned access roadway reconnection allowance (to WeyCo?)	4.5	Mile	$1,000,000	$4,500,000	Unit price potentially higher for permanent versus constuction roads. Line item also perhaps better considered under non-contract cost factor.		110%	$3,600,000	$4,950,000			info?			info?	$3,600,000	$4,950,000
	Phase 2 - Main Dam																$0	$0
5	**Main Dam Structure**				$0				$0	$0			info?			info?	$0	$0
5.01	Excavation - Foundation General	460,000	CY	$6.50	$2,990,000			110%	$2,392,000	$3,289,000		$5.50	$2,530,000		$7.50	$3,450,000	$2,530,000	$3,450,000
5.02	Excavation - Foundation Rock	110,000	CY	$25.00	$2,750,000	Some rock will be structural exc in fresh rock, most will be foundation footprint, getting to good rock below the rock contact; i.e potentially a high degree ripable.		110%	$2,200,000	$3,025,000		$25.00	$2,750,000		$30.00	$3,300,000	$2,750,000	$3,300,000
5.03	Roller Compacted Concrete - Composite Scope	810,000	CY	$93.00	$75,330,000	**Updated RCC quantity to FRE foundation & max section. Increased RCC unit price to bring to Jun 2017 cost basis, including high and low range. Changes for final: revised quantity to reflect QTO after CDR drawings, adjusted unit prices to reflect only GERCC; expanded RCC unit cost development composite workbreakdown, and revisited RCC unit pricing.** RCC unit pricing includes aggregate, cemen-fly ash, lift bedding, abutment bedding, dam joints, and full GERCC for both upstream and downstream			$60,264,000	$90,396,000		$76.50	$61,965,000		$109.50	$88,695,000	$61,965,000	$88,695,000
5.04	Fill - Foundation Backfill	260,000	CY	$5.50	$1,430,000	**Revised backfill Q from full FRE QTO. Changes for final: none.**			$1,144,000	$1,716,000			info?			info?	$1,144,000	$1,716,000
5.05	Conventional Concrete Reinforced (miscellaneous)	0	CY	$850.00	$0	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.** Refine quantities along with all structures next phase.			$0	$0			info?			info?	$0	$0
5.06	Outlet works encasement: sluicing conduits, river outlet works conduits, gate chamber, vent and gallery passages	50,000	CY	$450.00	$22,500,000	**Reference same item in FRE - OPC and "FRE - Annotated Dwgs Supporting OPC.pdf" FRE S-6-S-7 sheets. Similarly use the high end quantity for both FRO and FRFA at 58,000cy and reduced to 50,000cy for each for optimization for the likely cases. Q was 15,000cy @ $400.** Refine quantities along with all structures next phase.			$18,000,000	$27,000,000	45,000	$400.00	$18,000,000	58,000	$450.00	$26,100,000	$18,000,000	$26,100,000
5.07	Concrete - Dam Crest Slab & Parapet and unlisted dam concrete structures	5,400	CY	$750.00	$4,050,000	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures. Changes for final: None. Consider this item only as upper spillway. Use a lower low end considering potential for less spillway quantity for FRO.** No facing should be included if flip bucket chute face is elsewhere. Leave in for ogee, spillway approach walls, piers.	60%	110%	$2,430,000	$4,455,000			info?			info?	$2,430,000	$4,455,000
5.08	Foundation Treatment - Grout Curtain Drilling	23,000	LF	$45.00	$1,035,000	**Changes for final: adjust quantity from 22,500 to 23,000lf, and slight increase to cement for grouting.** revisited pricing; 1200lf @ 10', plus 50% secondary, plus 25% tertiary @ 70' deep = 14,700lf; plus say 170,000 sf @ 400sf/ hole @ 20' deep = 8,500lf = 23,200 lf;	70%	110%	$724,500	$1,138,500			info?			info?	$724,500	$1,138,500
5.09	Foundation Treatment - Grout Curtain Cement	16,000	Sack	$40.00	$640,000	**Changes for final: increase sacks to 0.7 sack per lf. Lower range considered for both drilling and cement for grouting operations based on limited exposure of structure under stored water service conditions.**	70%	110%	$448,000	$704,000			info?			info?	$448,000	$704,000
5.1	Flood Regulating Conduit Control Structures - Reinforced Concrete	0	CY	$800.00	$0	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.** Assume 2' thick around perimeter of sluices & air shafts. Refine quantities along with all structures next phase; include inside and downstream of dam; include control building on crest or at downstream, depending on final concept drawings			$0	$0			info?			info?	$0	$0
5.11	Flood Regulating Conduit Control Gates - Fab and Construct	200,000	LB	$15.00	$3,000,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 200,000# @ $15.00.** Assume 2 @ 30 tons, 1 @ 40 tons			$2,400,000	$3,600,000			info?			info?	$2,400,000	$3,600,000
5.12	Emergency & sluice dewatering bulkhead gates	780,000	LB	$10.00	$7,800,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 570,000# @ $15.00.** Assume 2 @ 25 tons, 1 @ 35 tons and 4 @ 50 tons			$6,240,000	$9,360,000			info?			info?	$6,240,000	$9,360,000
5.13	Hoists, cylinders, machinery	300,000	LB	$15.00	$4,500,000				$3,600,000	$5,400,000			info?			info?	$3,600,000	$5,400,000
5.14	Reservoir drain valve in tunnel plug (assume 4x4' knife valve)	1	Each	$200,000.00	$200,000		50%	100%	$100,000	$200,000			info?			info?	$100,000	$200,000
5.15	Unused	0	Each	$0.00	$0				$0	$0			info?			info?	$0	$0

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: *Chehalis Dam*
Alternative: *FRO Comparison for FRE Evaluation*

Weighting ⇨	20% low	75% likely	5% high	20% low	75% likely	5% high
$201M - Jul-16	Low End		$244,615,783	Low End		$311,279,274
	Likely		$298,050,587	Likely		$379,276,305
$319M - Jul-18	High End		$351,140,680	High End		$446,834,684
	Weighted		$290,018,131	Weighted		$369,054,818

Range Driver - 1 = %, 2 = Q & $, 3 = Combination:			3
Default Low ⇦	80%	Default High ⇨	120%

Pricing - contractor cost basis 1 or bid basis 2:	2

Quantity references: "FRX - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

		Base or Likely Cost Case					Range Development: Driven by Percent				Driven by Q & Unit $						Driven by Combo	
Work Item	Description	Quantity	Unit	Unit Price [1]	Total $	Estimate Notes & Considerations (Notes prior to FRX eval grayed out)	Low End % (def=80%)	High End % (def=120%)	Low % Total $	High % Total $	Low End Q	Low End Unit $	Low End Total $	High End Q	High End Unit $	High End Total $	Low End Tot $	High End Tot $
5.16	Unused	0	Each	$0.00	$0				$0	$0			info?			info?	$0	$0
5.17	WQ Intake Tower / concrete sidewall & decking - Conventional Concrete Reinforced	5,650	CY	$850.00	$4,802,500	**Reference note in this cell FRE - OPC tab, and "FRE - Annotated Dwgs Supporting OPC.pdf", sheets FRE S-6, S7.**			$3,842,000	$5,763,000			info?			info?	$3,842,000	$5,763,000
5.18	Unused	0	CY	$0.00	$0				$0	$0			info?			info?	$0	$0
5.19	Trashrack steel framing	1,360,800	LB	$6.50	$8,845,200	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 1,134,000# @ $6.50.** Assumes 250 ft high, 10 members 3' dia x 4.5'deep, steel columns.			$7,076,160	$10,614,240			info?			info?	$7,076,160	$10,614,240
5.2	Unused	0	CY	$850.00	$0	**Item moved to 5.17 to be consistent with other alts.**			$0	$0			info?			info?	$0	$0
6	**Spillway**				$0				$0	$0			info?			info?	$0	$0
6.01	Flip Bucket Conventional Concrete - surface	5,800	CY	$650.00	$3,770,000	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.**			$3,016,000	$4,524,000			info?			info?	$3,016,000	$4,524,000
6.02	Conventional Concrete - spillway approach, ogee, chute slab, and training walls	7,460	CY	$850.00	$6,341,000	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.** Unit price - accomodates higher RCC placement and utilization of some mass conventional concrete. Lower range due to strong potential for this volume to be less for FRO	75%	100%	$4,755,750	$6,341,000			info?			info?	$4,755,750	$6,341,000
7	**Sluice Stilling Basin**				$0				$0	$0			info?			info?	$0	$0
7.01	Excavation - Foundation General	20,000	CY	$8.00	$160,000				$128,000	$192,000			info?			info?	$128,000	$192,000
7.02	Excavation - Foundation Rock	10,000	CY	$30.00	$300,000				$240,000	$360,000			info?			info?	$240,000	$360,000
7.03	Fill - Foundation Backfill	18,000	CY	$9.00	$162,000				$129,600	$194,400			info?			info?	$129,600	$194,400
7.04	Conventional Concrete Reinforced	8,600	CY	$750.00	$6,450,000	**Reference "FRE - Annotated Dwgs Supporting OPC.pdf", sheets FRE S-06, S07. Was 4900 @ $8700 and item 7.04 2000cy at $400.**			$5,160,000	$7,740,000			info?			info?	$5,160,000	$7,740,000
7.05	Conventional Concrete Non-Reinforced	1,600	CY	$400.00	$640,000	Refine quantities after drawings are complete; must schedule after dam is up; include control building on crest;			$512,000	$768,000			info?			info?	$512,000	$768,000
8	**Wing Dam Structure**				$0				$0	$0			info?			info?	$0	$0
8.01	Unused	0	ls	$0.00	$0				$0	$0			info?			info?	$0	$0
8.02	Unused	0	ls	$0.00	$0				$0	$0			info?			info?	$0	$0
8.03	Unused	0	ls	$0.00	$0				$0	$0			info?			info?	$0	$0
8.04	Unused	0	ls	$0.00	$0				$0	$0			info?			info?	$0	$0
	Composite & Unlisted Work																	
55	Fish passage structure - costs not included	1	ls	$0	$0	Costs independently assessed in report			$0	$0			info?			info?	$0	$0
56	Unlisted Work	1	ls	$3,500,000	$3,500,000		85%	115%	$2,975,000	$4,025,000			info?			info?	$2,975,000	$4,025,000
57					$0				$0	$0			info?			info?	$0	$0
58					$0				$0	$0			info?			info?	$0	$0
59					$0				$0	$0			info?			info?	$0	$0
60					$0				$0	$0			info?			info?	$0	$0
61					$0				$0	$0			info?			info?	$0	$0
62					$0				$0	$0			info?			info?	$0	$0
63					$0				$0	$0			info?			info?	$0	$0
64					$0				$0	$0			info?			info?	$0	$0
65					$0				$0	$0			info?			info?	$0	$0
					$0				$0	$0			info?			info?	$0	$0
Subtotal without mobilization & general expense					**$196,247,300**				**$158,584,690**	**$233,370,940**			**$91,620,000**			**$130,970,000**	**$161,063,890**	**$231,203,740**
Mobilization & project indirect expense			0%		$0	unallocated project indirect or jobsite overhead assumed in unit pricing												
Contractor Cost					**$196,247,300**	Note 1: Unit prices as noted in header, either reflect a bid price basis (no factor application of corporate OH & profit), or a contractor cost basis requiring a corporate OH & profit to get to a bid total												
Contractor Margin - corporate overhead & profit			~~0%~~	Bid Basis	$0	Note 2: NA - not applicable to project; NE - not evident in estimate; NI - noted but not itemized in estimate												
Contractor Bid - before design/procurement contingencies					**$196,247,300**													
Contract Contingencies - design and procurement contingencies			12.5%		$24,530,913	⇦ RCC estimate dominance, work breakdown thoroughness, and work understanding support a design contingency lower than typical (i.e. 20%) at this early design level												
Contract Cost - contractor bid with design & procurement contingencies					**$220,778,213**													
Construction Contingency: post-award change & dispute factor			10%		$22,077,821													
Non-Contract Costs: PM, planning, design, CM ...			25%		$55,194,553	⇦ permitting, site characterization, CM during construction,etc.												
Total Project Cost - before escalation					**$298,050,587**	**Compares to $201M low bound, and $319M high bound July 2016**												
Escalation - annual %; from; to		3.5%	1-Jun-17	1-Jun-24	$81,225,718	**⇦ Presume NTP - mid 2021, say 6 years construction = 4.0 years + 3 years = 7.0 years**												
Total Project Cost - including escalation				**7.0 yr**	**$379,276,305**	**<< 193% above total w/o mobilization**												

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: *Chehalis Dam*
Alternative: *FRFA Comparison for FRE Evaluation*

Weighting ⇨	20% low	70% likely	10% high	20% low	70% likely	10% high
$293M - Jul-16	Low End	$352,951,969		Low End	$457,019,556	
	Likely	$414,642,686		Likely	$536,899,728	
$454M - Jul-18	High End	$484,932,003		High End	$627,913,791	
	Weighted	$409,333,474		Weighted	$530,025,100	

Range Driver - 1 = %, 2 = Q & $, 3 = Combination:	3
Default Low ⇨ 80%	Default High ⇨ 120%

Pricing - contractor cost basis 1 or bid basis 2: 2

Quantity references: "FRE - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

Work Item	Description	Base or Likely Cost Case: Quantity	Unit	Unit Price [1]	Total $	Estimate Notes & Considerations *(Notes prior to FRE eval grayed out)*
	Phase 1 - Site Development, Diversion Constrruction,				$0	
0	**Mobilization**					
	Mobilization	1	LS	$5,000,000.00	$5,000,000	Contractor mob bid; balance of project overhead in below-the-line factors
1	**Clearing & Grubbing**				$0	
1.01	Clearing and grubbing, stripping topsoil, reclamation of disturbed areas	30	Acre	$30,000.00	$900,000	
1.02	Reservoir Clearing to 100-yr Flood Stage	1,206	Acre	$6,000.00	$7,236,000	Potentially in Phase 2 or possibly Phase 3 contract
2	**Temporary Access & Staging**				$0	
2.01	Construction Surveying & Layout	35	Acre	$10,000.00	$350,000	Under temporary access & staging; i.e. temporary works only, predominant surveys and layout in unallocated contractor project overhead expense (already in the unit pricing)
2.02	Pioneer/Access Roads (e.g. dam site, abutments, quarry site, etc.)	3	Mile	$700,000.00	$2,100,000	**Changes for final: increase access road development by adding 1 mile, from 2 to 3.** dependent upon aggregate sourcing, staging locations, contractor approach. Reference Chehalis_All_Figs_2016-10-19.pdf drawing G-3, for site, non-quarry access concepts, totaling about 10,000lf of new access, say 5000lf of upgraded access. Say 50% new and full access development, 20% construction & track access only, 30% improved existing. Consider quarry acces costs in aggregate price range.
2.03	Material Laydown Area Prep (minor excavation, grading, surfacing, drainage	20	Acre	$25,000.00	$500,000	1 acre at 5' avg cut to 5' average fill = 4000cy cut to fill; @ $6/cy cut to fill = $24,200/ac; 1ac surfacing at 6" & 30% surfaced = 430ton, @ 10/tn = $4.5k/ac
2.04	Temporary construction site access security control facilities (e.g. fencing, gates, etc.)	2,200	LF	$20.00	$44,000	predominant security expense in unallocated contractor project overhead expense
3	**Diversion & Dewatering**				$0	
3.01	Diversion Tunnel 20 ft modified horseshoe	1,635	LF	$8,000.00	$13,080,000	**Increased length for FRE and both FRO and FRFA, from 1500. Changes for final: increase length of tunnel to better reflect final drawing alignment.** increase high end for variability in linnig limits, portaling, tunnel plug adit construction, vent construction, etc.
3.02	Conventional Concrete Non-Reinforced Mass Concrete (100' plug following construction)	1,200	CY	$600.00	$720,000	low end 30'plug but include mechanical.
3.03	Coffer Dams (2) - Fill cells u/s and d/s + toe slopes	14,000	CY	$40.00	$560,000	check Q's with new crest heights, say 8,000 cy RCC @ 70 + 6,000 cy Rockfill @ 15. = 650KHigh end if pushed to 480 and rockfill - say 45kcy = $675K.
3.04	Foundation Excavation - seepage key (assume 20'wide x 150' long x 4' deep	450	CY	$8.00	$3,600	Cofferdam key allowance
3.05	Foundation Dewatering - assume several dewatering pump systems operating selectively 24/7 over 12 month foundation construction exposure	360	Day	$2,800.00	$1,008,000	**Changes for final: increase foundation exposure from 6 to 12 months.** 2nd contract may add unwaterring and time for dewatering for RCC foundation
3.06	Coffer Dams - Other assume 25' high x 150 top length, 35' base length, cell construction (e.g. sheet pile, steel, other fabricated metal items)	7,000	SF	$30.00	$210,000	may include isolation of portal structures, tailwater structures, peripheral dewatering stages
3.07	Coffer Dams - Risk contingency for overtopping	1	LS	$1,000,000.00	$1,000,000	contemplates partial or threshold-bound contractor responsibility, risk apportioned cost of event recovery, rework, delay
4	**Lands and Easements**				$0	
4.01	Reservoir Extents Fee Title	1,200	Acre	$4,400.00	$5,280,000	Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.
4.02	Reservoir Extents/Flood Easement	110	Acre	$4,400.00	$484,000	Best to be considered in non-contract costs. Perhaps cost conservatively overlaps with non-contract cost factor below.
4.03	Reservoir orphaned access roadway reconnection allowance (to WeyCo?)	5	Mile	$1,000,000.00	$5,000,000	Unit price potentially higher for permanent versus constuction roads. Line item also perhaps better considered under non-contract cost factor.
	Phase 2 - Main Dam					
5	**Main Dam Structure**				$0	
5.01	Excavation - Foundation General	710,000	CY	$6.50	$4,615,000	**Changes for final: revised quantities.** Reference FRFA S-1 annotated from Chehalis_All_Figs_2016-10-19.pdf, also this worksheet FRFA Exc Guess tab.
5.02	Excavation - Foundation Rock	210,000	CY	$27.00	$5,670,000	**Changes for final: revised quantities.** Reference FRFA S-1 annotated from Chehalis_All_Figs_2016-10-19.pdf, also this worksheet FRFA Exc Guess tab. Some rock will be structural exc in fresh rock, most will be foundation footprint, getting to good rock below the rock contact; i.e potentially a high degree ripable.
5.03	Roller Compacted Concrete - Composite Scope	1,360,000	CY	$99.00	$134,640,000	**Updated RCC quantity to FRE foundation & max section. Increased RCC unit price to bring to Jun 2017 cost basis, including high and low range. Changes for final: revised quantities. Expanded RCC unit cost development work breakdown, revisited unit pricing, and increased unit pricing to reflect upstream conventional face and downstream GERCC.** RCC unit pricing includes aggregate, cement-fly ash, lift bedding, abutment bedding, dam joints, and **2.5' upstream conventional face and downstream GERCC.** Conventional concrete spillway face - included elsewhere.
5.04	Fill - Foundation Backfill	284,000	CY	$5.50	$1,562,000	**Revised backfill Q from full FRE QTO. Changes for final: revised quantities.**
5.05	Conventional Concrete Reinforced (miscellaneous)	0	CY	$850.00	$0	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.** Refine quantities along with all structures next phase.
5.06	Outlet works encasement: sluicing conduits, river outlet works conduits, gate chamber, vent and gallery passages	50,000	CY	$450.00	$22,500,000	**Reference same item in FRE and "FRE - Annotated Dwgs Supporting OPC.pdf" FRE S-6-S-7 sheets. Similarly use the high end quantity for both FRO and FRFA at 58,000cy and reduced to 50,000cy for each for optimization for the likely cases. Q was 15,000cy @ $400.** Refine quantities along with all structures next phase.
5.07	Concrete - Dam Crest Slab & Parapet and unlisted dam concrete structures	5,400	CY	$750.00	$4,050,000	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures. Changes for final: None. Consider this item only as upper spillway.** No facing should be included if flip bucket chute face is elsewhere. Leave in for
5.08	Foundation Treatment - Grout Curtain Drilling	50,000	LF	$45.00	$2,250,000	revisited pricing; 1700lf @ 10', plus 50% secondary, plus 25% tertiary @ 80' deep = 298 holes @ 90' = 26,820lf; if consolidation grouting - add 220,000 sf @ 400sf/ hole @ 20' deep = 11,000lf = 37,820 lf. If double curtain plus 25% extra = 383 holes @ 90' = 34,470lf, plus 11k consolidation grouting = 45,470lf. Use 50k lf. Depth: 300' at 35'+300' at 85'+500' at 140' + 200' at 130' + 400' at 55' = 154,000 / 1700' = 90'.
5.09	Foundation Treatment - Grout Curtain Cement	35,000	Sack	$40.00	$1,400,000	**Changes for final: revised quantity, increased unit price.** Assume 0.7 bag per lf
5.1	Flood Regulating Conduit Control Structures - Reinforced Concrete	0	CY	$800.00	$0	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.** Assume 2' thick around perimeter of sluices & air shafts. Refine quantities along with all structures next phase; include inside and downstream of dam; include control building on crest or at downstream, depending on final concept drawings
5.11	Flood Regulating Conduit Control Gates - Fab and Construct	120,000	LB	$15.00	$1,800,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 120,000# @ $15.00.** Assume 2 @ 30 tons.
5.12	Emergency & sluice dewatering bulkhead gates	440,000	LB	$10.00	$4,400,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 300,000# @ $15.00.** Assume 2 @ 25 tons, and 2 @ 50 tons
5.13	Hoists, cylinders, machinery	200,000	LB	$15.00	$3,000,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 200,000# @ $15.00.**

Work Item	Description	Range Development – Driven by Percent: Low End % (def=80%)	High End % (def=120%)	Low % Total $	High % Total $	Driven by Q & Unit $: Low End Q	Low End Unit $	Low End Total $	High End Q	High End Unit $	High End Total $	Driven by Combo: Low End Tot $	High End Tot $
	Phase 1 - Site Development, Diversion Constrruction,			$0	$0			info?			info?	$0	$0
0	**Mobilization**			$0	$0			info?			info?	$0	$0
	Mobilization	100%	140%	$5,000,000	$7,000,000			info?			info?	$5,000,000	$7,000,000
1	**Clearing & Grubbing**			$0	$0			info?			info?	$0	$0
1.01	Clearing and grubbing, stripping topsoil, reclamation of disturbed areas			$720,000	$1,080,000	25	$30,000.00	$750,000	35	$25,000.00	$875,000	$750,000	$875,000
1.02	Reservoir Clearing to 100-yr Flood Stage			$5,788,800	$8,683,200		$5,000.00	$6,030,000		$7,500.00	$9,045,000	$6,030,000	$9,045,000
2	**Temporary Access & Staging**			$0	$0			info?			info?	$0	$0
2.01	Construction Surveying & Layout	100%	150%	$350,000	$525,000			info?			info?	$350,000	$525,000
2.02	Pioneer/Access Roads (e.g. dam site, abutments, quarry site, etc.)			$1,680,000	$2,520,000	2.5	$750,000.00	$1,875,000	3.5	$800,000.00	$2,800,000	$1,875,000	$2,800,000
2.03	Material Laydown Area Prep (minor excavation, grading, surfacing, drainage			$400,000	$600,000	15	$30,000.00	$450,000	25		$625,000	$450,000	$625,000
2.04	Temporary construction site access security control facilities (e.g. fencing, gates, etc.)			$35,200	$52,800			info?			info?	$35,200	$52,800
3	**Diversion & Dewatering**			$0	$0			info?			info?	$0	$0
3.01	Diversion Tunnel 20 ft modified horseshoe	90%	125%	$11,772,000	$16,350,000			info?			info?	$11,772,000	$16,350,000
3.02	Conventional Concrete Non-Reinforced Mass Concrete (100' plug following construction)			$576,000	$864,000			info?		$650.00	$780,000	$576,000	$780,000
3.03	Coffer Dams (2) - Fill cells u/s and d/s + toe slopes			$448,000	$672,000			info?			info?	$448,000	$672,000
3.04	Foundation Excavation - seepage key (assume 20'wide x 150' long x 4' deep		300%	$2,880	$10,800			info?			info?	$2,880	$10,800
3.05	Foundation Dewatering - assume several dewatering pump systems operating selectively 24/7 over 12 month foundation construction exposure		150%	$806,400	$1,512,000			info?			info?	$806,400	$1,512,000
3.06	Coffer Dams - Other assume 25' high x 150 top length, 35' base length, cell construction (e.g. sheet pile, steel, other fabricated metal items)			$168,000	$252,000			info?			info?	$168,000	$252,000
3.07	Coffer Dams - Risk contingency for overtopping			$800,000	$1,200,000			info?			info?	$800,000	$1,200,000
4	**Lands and Easements**			$0	$0			info?			info?	$0	$0
4.01	Reservoir Extents Fee Title	100%	100%	$5,280,000	$5,280,000			info?			info?	$5,280,000	$5,280,000
4.02	Reservoir Extents/Flood Easement	100%	100%	$484,000	$484,000			info?			info?	$484,000	$484,000
4.03	Reservoir orphaned access roadway reconnection allowance (to WeyCo?)		110%	$4,000,000	$5,500,000			info?			info?	$4,000,000	$5,500,000
	Phase 2 - Main Dam											$0	$0
5	**Main Dam Structure**			$0	$0			info?			info?	$0	$0
5.01	Excavation - Foundation General			$3,692,000	$5,538,000		$5.50	$3,905,000		$7.50	$5,325,000	$3,905,000	$5,325,000
5.02	Excavation - Foundation Rock			$4,536,000	$6,804,000		$25.00	$5,250,000		$30.00	$6,300,000	$5,250,000	$6,300,000
5.03	Roller Compacted Concrete - Composite Scope			$107,712,000	$161,568,000		$83.50	$113,560,000		$113.50	$154,360,000	$113,560,000	$154,360,000
5.04	Fill - Foundation Backfill			$1,249,600	$1,874,400			info?			info?	$1,249,600	$1,874,400
5.05	Conventional Concrete Reinforced (miscellaneous)			$0	$0			info?			info?	$0	$0
5.06	Outlet works encasement: sluicing conduits, river outlet works conduits, gate chamber, vent and gallery passages			$18,000,000	$27,000,000	45,000		$20,250,000	58,000	$450.00	$26,100,000	$20,250,000	$26,100,000
5.07	Concrete - Dam Crest Slab & Parapet and unlisted dam concrete structures		120%	$3,240,000	$4,860,000			info?			info?	$3,240,000	$4,860,000
5.08	Foundation Treatment - Grout Curtain Drilling			$1,800,000	$2,700,000			info?			info?	$1,800,000	$2,700,000
5.09	Foundation Treatment - Grout Curtain Cement			$1,120,000	$1,680,000			info?			info?	$1,120,000	$1,680,000
5.1	Flood Regulating Conduit Control Structures - Reinforced Concrete			$0	$0			info?			info?	$0	$0
5.11	Flood Regulating Conduit Control Gates - Fab and Construct			$1,440,000	$2,160,000			info?			info?	$1,440,000	$2,160,000
5.12	Emergency & sluice dewatering bulkhead gates			$3,520,000	$5,280,000			info?			info?	$3,520,000	$5,280,000
5.13	Hoists, cylinders, machinery			$2,400,000	$3,600,000			info?			info?	$2,400,000	$3,600,000

Judgment-Level Cost Opinion
Pricing/Work Breakdown Summary

Project: ***Chehalis Dam***
Alternative: ***FRFA*** ***Comparison for FRE Evaluation***

Weighting ⇨	20% low	70% likely	10% high	20% low	70% likely	10% high
$293M - Jul-16	**Low End**	**$352,951,969**		**Low End**	**$457,019,556**	
	Likely	**$414,642,686**		**Likely**	**$536,899,728**	
$454M - Jul-18	**High End**	**$484,932,003**		**High End**	**$627,913,791**	
	Weighted	**$409,333,474**		**Weighted**	**$530,025,100**	

Range Driver - 1 = %, 2 = Q & $, 3 = Combination:			3	
Default Low ⇨	80%	**Default High ⇨**	120%	

Pricing - contractor cost basis 1 or bid basis 2: 2

Quantity references: "FRE - Annotated Dwgs Supporting OPC.pdf" (concrete & misc);"RCC Dam Q-s & Placement Plan - R09.xls" (RCC);"2017_Chehalis_Construction_Costs_DRAFT_06082017.xls" (mechanical and steel); and this sheets notes and considerations

		Base or Likely Cost Case					Range Development: Driven by Percent				Driven by Q & Unit $						Driven by Combo	
Work Item	**Description**	**Quantity**	**Unit**	**Unit Price [1]**	**Total $**	**Estimate Notes & Considerations** (Notes prior to FRE eval grayed out)	**Low End % (def=80%)**	**High End % (def=120%)**	**Low % Total $**	**High % Total $**	**Low End Q**	**Low End Unit $**	**Low End Total $**	**High End Q**	**High End Unit $**	**High End Total $**	**Low End Tot $**	**High End Tot $**
5.14	Reservoir drain valve in tunnel plug (assume 4x4' knife valve)	1	Each	$200,000.00	$200,000		50%	100%	$100,000	$200,000			info?			info?	$100,000	$200,000
5.15	WQ Regulating Outlets w/ hollow cone valves (4 - 4'dia)	4	Each	$450,000.00	$1,800,000	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 4ea @ $375,000.**			$1,440,000	$2,160,000			info?			info?	$1,440,000	$2,160,000
5.16	WQ Regulating Outlet w/ hollow cone valves (1 - 7'dia)	1	Each	$1,100,000.00	$1,100,000				$880,000	$1,320,000			info?			info?	$880,000	$1,320,000
5.17	WQ Intake Tower / concrete sidewall & decking - Conventional Concrete Reinforced	5,400	CY	$900.00	$4,860,000	**Items 5.17 and 5.18 prior, totaled 14,000cy (2800 @ $750 and 11,200 @ $400). All intake concrete is now in this item; ref "FRE - Annotated Dwgs Supporting OPC.pdf" FRE S-6-S-7 sheets.**			$3,888,000	$5,832,000			info?			info?	$3,888,000	$5,832,000
5.18	unused	0	CY	$400.00	$0	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.** Refine quantities along with all structures next phase.	100%		$0	$0			info?			info?	$0	$0
5.19	Trashrack steel framing	1,088,640	LB	$6.50	$7,076,160	**Adjust to "2017_Chehalis_Construction_Costs_DRAFT_06082017.xls". Item was 1,360,000# @ $6.50.** Assume 300 ft high, 10 members 3' dia x 4.5'deep, steel column			$5,660,928	$8,491,392			info?			info?	$5,660,928	$8,491,392
5.2	unused	0	CY	$850.00	$0	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.**			$0	$0			info?			info?	$0	$0
6	**Spillway**				$0				$0	$0			info?			info?	$0	$0
6.01	Flip Bucket Conventional Concrete - surface	5,800	CY	$650.00	$3,770,000	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.**			$3,016,000	$4,524,000			info?			info?	$3,016,000	$4,524,000
6.02	Conventional Concrete - spillway approach, ogee, chute slab, and training walls	8,700	CY	$850.00	$7,395,000	**Reference note in this cell FRE - OPC tab, adjusting FRO and FRFA to better reflect anticipated structures.** unit price - accomodates higher RCC placement and utilization of some mass conventional concrete	85%		$6,285,750	$8,874,000			info?			info?	$6,285,750	$8,874,000
7	**Sluice Stilling Basin**				$0				$0	$0			info?			info?	$0	$0
7.01	Excavation - Foundation General	20,000	CY	$8.00	$160,000	Refine all excavation and backfill quantities next phase			$128,000	$192,000			info?			info?	$128,000	$192,000
7.02	Excavation - Foundation Rock	10,000	CY	$30.00	$300,000				$240,000	$360,000			info?			info?	$240,000	$360,000
7.03	Fill - Foundation Backfill	18,000	CY	$9.00	$162,000				$129,600	$194,400			info?			info?	$129,600	$194,400
7.04	Conventional Concrete Reinforced	8,600	CY	$750.00	$6,450,000	**Reference "FRE - Annotated Dwgs Supporting OPC.pdf", sheets FRE S-06, S07. Was 4900 @ $8700 and item 7.04 2000cy at $400.**			$5,160,000	$7,740,000			info?			info?	$5,160,000	$7,740,000
7.05	Conventional Concrete Non-Reinforced	1,600	CY	$400.00	$640,000				$512,000	$768,000			info?			info?	$512,000	$768,000
8	**Wing Dam Structure**				$0				$0	$0			info?			info?	$0	$0
8.01	Excavation - Foundation General (assume footprint 270' @ widest x 10 ft deep)	70,000	CY	$10.00	$700,000	**Consider as all excavation and unclassified, all should be ripable rock at the worst; was 33,333 cy**			$560,000	$840,000			info?			info?	$560,000	$840,000
8.02	Excavation Cutoff Trench - Foundation Rock (assume trench 30 ft wide x 20 ft deep)	0	CY	$30.00	$0	**Included in item 8.01; was 13,333 cy**			$0	$0			info?			info?	$0	$0
8.03	Fill - Wingdam Embankment	176,000	CY	$20.00	$3,520,000	**Composite fill unit price and quantity; pending more detailed QTO; increased unit price to accommodate riprap item being included; was 120,000 cy @ $15.**	90%		$3,168,000	$4,224,000			info?			info?	$3,168,000	$4,224,000
8.04	Fill - Wingdam Riprap Facing (assume 5' blanket U/S and D/S)	8,000	CY	$65.00	$520,000				$416,000	$624,000			info?			info?	$416,000	$624,000
	Composite & Unlisted Work																	
55	Fish passage structure - costs not included	1	ls	$0	$0	Costs independently assessed in report			$0	$0			info?			info?	$0	$0
56	Unlisted Work	1	ls	$5,000,000	$5,000,000		85%	115%	$4,250,000	$5,750,000			info?			info?	$4,250,000	$5,750,000
57					$0				$0	$0			info?			info?	$0	$0
58					$0				$0	$0			info?			info?	$0	$0
59					$0				$0	$0			info?			info?	$0	$0
60					$0				$0	$0			info?			info?	$0	$0
61					$0				$0	$0			info?			info?	$0	$0
62					$0				$0	$0			info?			info?	$0	$0
63					$0				$0	$0			info?			info?	$0	$0
64					$0				$0	$0			info?			info?	$0	$0
65					$0				$0	$0			info?			info?	$0	$0
					$0				$0	$0			info?			info?	$0	$0
Subtotal without mobilization & general expense					**$273,015,760**		**$222,855,158**	**$327,743,992**	**$222,855,158**	**$327,743,992**			**$152,070,000**			**$206,210,000**	**$232,396,358**	**$319,296,792**
Mobilization & project indirect expense			0%		$0	unallocated project indirect or jobsite overhead assumed in unit pricing												
Contractor Cost					**$273,015,760**	Note 1: Unit prices as noted in header, either reflect a bid price basis (no factor application of corporate OH & profit), or a contractor cost basis requiring a corporate OH & profit to get to a bid total												
Contractor Margin - corporate overhead & profit			~~0%~~	Bid Basis	$0	Note 2: NA - not applicable to project; NE - not evident in estimate; NI - noted but not itemized in estimate												
Contractor Bid - before design/procurement contingencies					**$273,015,760**													
Contract Contingencies - design and procurement contingencies			12.5%		$34,126,970	⇦ RCC estimate dominance, work breakdown thoroughness, and work understanding support a design contingency lower than typical (i.e. 20%) at this early design level												
Contract Cost - contracator bid with design & procurement contingencies					**$307,142,730**													
Construction Contingency: post-award change & dispute factor			10%		$30,714,273													
Non-Contract Costs: PM, planning, design, CM ...			25%		$76,785,683	⇦ permitting, site characterization, CM during construction,etc.												
Total Project Cost - before escalation					**$414,642,686**	**Compares to $293M low bound, and $454M high bound July 2016**												
Escalation - annual %; from; to		3.5%	1-Jun-17	1-Dec-24	$122,257,043	⇦ Presume NTP - mid 2021, say 7 years construction = 4.0 + 3.5 years = 7.5 years												
Total Project Cost - including escalation				**7.5 yr**	**$536,899,728**	**<< 197% above total w/o mobilization**												

4 FRE RCC PLACEMENT ANALYSIS SUMMARY

RCC placement analysis for FRE and FRE-FC alternatives are provided in the following pages.

Chehalis Dam
Concept-Level RCC Placement Analysis

Flood Retention Expandable (FRE) RCC Quantity & Placement Summary

FRE Quantities by Phase & Sequence

The Flood Retention Expandable project **(FRE)** has an initial construction phase **(FRE)** and a potential future construction phase **(FRE-FC).** Phase I or PHI should be read as **(FRE)** and Phase II or PHII should be read as **(FRE-FC)**.

	Starting Elev	No. of Lifts	Ending Elev	Lift Volume	Avg Lift Volume	Starting Forms to RCC ratio	Ending Forms to RCC ratio	Likley Prod Control	Vert Adv per Day	Days in Sequence	Weeks at 5.5 dy/wk (adj for weather)	Months @ 19dy/mo
Phase I												
PHI - 1 Full	395	23	418	38,855	1,689	0.2 : 1	0.2 : 1	foundation & learning curve	2	12.0	2.2	0.6
PHI - 1 Left	418	13	431	41,697	3,207	0.2 : 1	0.2 : 1	foundation & learning curve	3	5.0	0.9	0.3
PHI - 2a Right	420	11	431	5,551	505	0.2 : 1	0.2 : 1	foundation & learning curve	3	4.0	0.7	0.2
PHI - 2b Right	431	40	471	42,338	1,058	0.2 : 1	0.3 : 1	foundation & small lift size	4	10.0	1.8	0.5
PHI - 3 Left	431	40	471	148,556	3,714	0.2 : 1	0.3 : 1	mix & deliver RCC	3	14.0	2.5	0.7
PHI - 4 Full	471	30	501	152,828	5,094	0.3 : 1	0.4 : 1	mix & deliver RCC	1.5	20.0	3.6	1.1
PHI - 5 Full	501	115	616	444,475	3,865	0.4 : 1	1.9 : 1	mix & deliver RCC; length & facing	1.5	77.0	14.0	4.1
PHI - 6 Right	616	36	651	20,149	560	1.9 : 1	3.2 : 1	length & facing; constricted geometry	3	12.0	2.2	0.6
PHI - 7 Left	616	36	651	18,492	514	1.9 : 1	3.2 : 1	length & facing; RCC delivery, constricted geometry	3	12.0	2.2	0.6
Phase I Subtotals		344		912,941	2,654					166.0	31.0	9.0
Delivery resets								4 each @ 2 shifts = 4 days		4.0	0.7	0.2
Vertical form transitions								2 each @ 4 shifts = 4 days		4.0	0.7	0.2
Phase I Totals										**174.0**	**32.5**	**9.4**
									2.0 ft/dy	**5,247 cy/dy**	**28,130 cy/wk**	**96,904 cy/mo**
Phase II												
PHII - 1a Right	431	40	471	11,458	286	0.5 : 1	0.5 : 1	learning curve; constricted geometry & delivery	3	14.0	2.5	0.7
PHII - 1b Right	471	30	501	18,955	632	0.5 : 1	0.5 : 1	learning curve; constricted geometry & delivery	4	8.0	1.5	0.4
PHII - 2 Right	501	115	616	92,865	808	0.5 : 1	0.5 : 1	mix & delivery, constricted geometry	4	29.0	5.3	1.5
PHII - 3 Left	431	185	616	147,505	797	0.5 : 1	0.5 : 1	mix & delivery, constricted geometry	4	47.0	8.5	2.5
PHII - 4 Full	616	35	651	94,565	2,702	0.5 : 1	0.5 : 1	mix & delivery, length & facing	4	9.0	1.6	0.5
PHII - 5 Full	651	30	681	75,846	2,528	0.5 : 1	2.2 : 1	mix & delivery, length & facing	3	10.0	1.8	0.5
PHII - 6 Right	681	30	710	17,857	595	2.2 : 1	4.7 : 1	length & facing; RCC delivery, constricted geometry	3	10.0	1.8	0.5
PHII - 7 Left	681	30	710	17,414	580	2.2 : 1	4.7 : 1	length & facing; RCC delivery, constricted geometry	3	10.0	1.8	0.5
Phase II Subtotals		495		476,465	963					137.0	25.0	8.0
Delivery resets								5 each @ 2 shifts; say 5 days		5.0	0.9	0.3
Vertical form transitions								2 each @ 4 shifts = 4 days		4.0	0.7	0.2
Phase II Totals										**146.0**	**26.6**	**8.5**
									3.4 ft/dy	**3,263 cy/dy**	**17,888 cy/wk**	**56,229 cy/mo**

FRE Quantities by Vertical Section

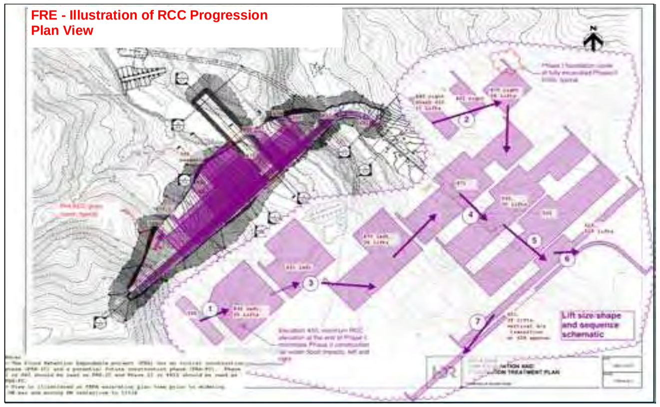
Row Labels	Min of Elev	Max of Elev	Max of Top of Lift #	Max of PHI non-overflow lift width	Max of PHII full non-overflow elev width	Max of PHI lift width in spillway	Min of Left Abut Contact	Max of Rt Abut Contact	Sum of PHI - Lift Volume - cy	Max of PHI - Lift Volume - cy	Sum of PHI - U/S Facing Element - cy	Max of PHI - U/S Facing Element - cy	Sum of PHI - D/S Facing Element - cy	Max of PHI - D/S Facing Element - cy	Sum of PHII - Lift Volume - cy	Max of PHII - Lift Volume - cy	Sum of PHII - U/S Facing Element - cy2	Max of PHII - U/S Facing Element - cy	Sum of PHII - D/S Facing Element - cy	Max of PHII - D/S Facing Element - cy2	Max of PHI Form sf : cy RCC	Max of PHII Form sf : cy RCC
1 - below 431	395	430	35	299	299	307	7+80	12+66	86,103	4,213	727	37	874	44	0	0	0	0	0	0	0.2 : 1	0.0 : 1
2 - 431 thru 470	431	470	75	209	265	303	6+06	13+74	190,894	5,378	2,040	63	2,443	76	25,367	910	0	0	1,131	41	0.3 : 1	0.5 : 1
3 - 470 thru 615	471	615	220	171	227	227	2+83	15+43	597,303	5,231	13,641	117	13,641	117	245,416	2,163	0	0	10,946	96	1.3 : 1	0.5 : 1
4 - 616 thru 651	616	651	256	33	89	0	2+16	18+19	38,641	1,556	4,054	130	4,539	140	97,889	3,324	667	19	4,674	148	3.2 : 1	0.8 : 1
5 - 652 thru 680	652	680	285	0	55	0	1+82	18+17	0	0	0	0	224	10	72,523	3,269	4,342	151	4,342	151		2.1 : 1
6 - 681 thru 710	681	710	315	0	28	0	1+50	18+14	0	0	0	0	122	5	35,271	1,462	4,018	135	4,018	135		4.7 : 1
Grand Total	**395**	**710**	**315**	**299**	**299**	**307**	**1+50**	**18+19**	**912,941**	**5,378**	**20,462**	**130**	**21,844**	**140**	**476,465**	**3,324**	**9,027**	**151**	**25,112**	**151**	**3.2 : 1**	**4.7 : 1**

Chehalis Dam
Concept-Level RCC Placement Analysis

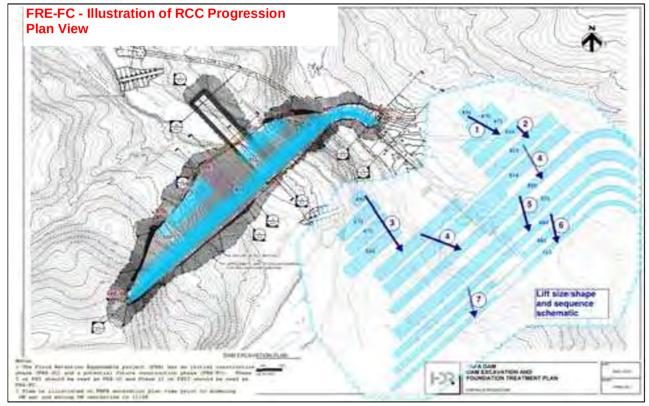
FRE RCC Quantity & Placement Summary

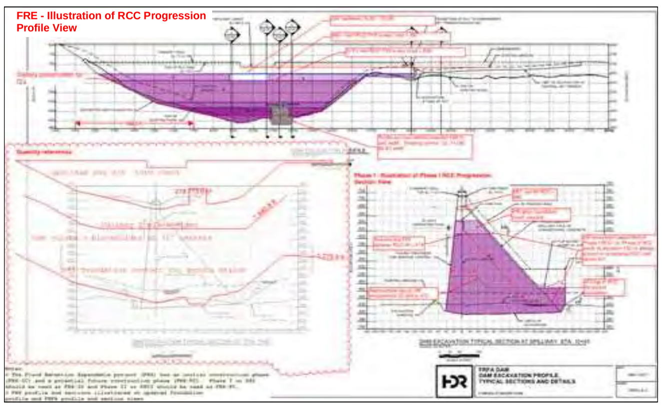
The Flood Retention Expandable project **(FRE)** has an initial construction phase **(FRE)** and a potential future construction phase **(FRE-FC).** Phase I or PHI should be read as **(FRE)** and Phase II or PHII should be read as **(FRE-FC)**.

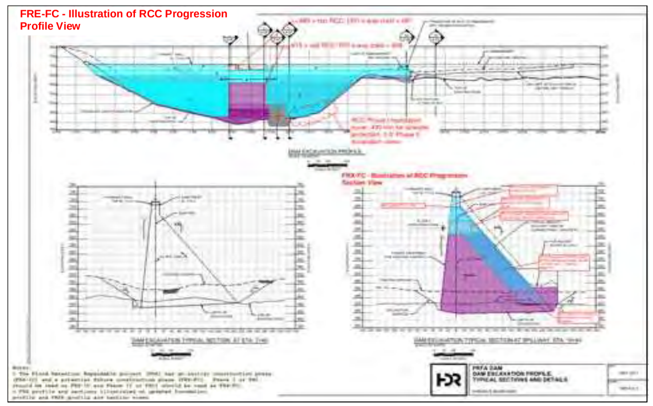
FRE RCC Lift Shape & Sequence Illustration



FRE-FC RCC Lift Shape & Sequence Illustration



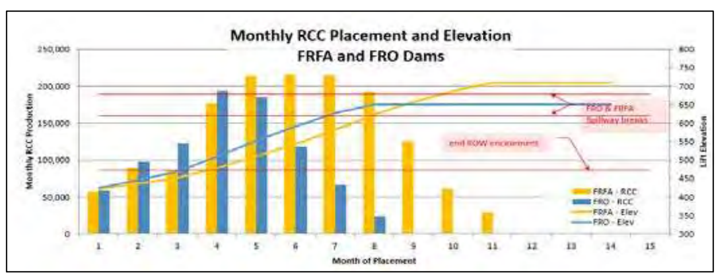




RCC FRE Estimate Basis

- > PHI upstream CIP face; downstream GERCC
- > PHII upstream CIP face; downstream GERCC
- > PHI & II abutment contact - GERCC
- > PHI fully excavates for PHII and covers exposed groin with 4' min RCC
- > PHI places all PHII RCC thru elev 430 to exceed tailwater for PHII
- > PHI fully backfills the U/S groin and 3-5' of fill over RCC groin
- > PHII removes fill in RCC groin, and backfills d/s to orig grade
- > PHII removes approach, ogee, and crest parapets
- > PHII preps the PHI downstream and interface surfaces
- > PHII has a upper right abutment treatment allowance in lieu of grouting
- > PHI fully completes the PHII sluice and river OW below 651
- > PHI fully constructs the chute and flip bucket below 620
- > PHI OW encasement top is elev. 500 u/s & 470 d/s
- > PHI flip bucket foundation block is RCC up to 470

Reference from FRO and FRFA RCC Production Assessment



5 FRE, FRE-FC, AND UPDATED FRO AND FRFA RCC UNIT COST DEVELOPMENT

Unit cost development for FRE, FRE-FC, updated FRO and FRFA alternatives are presented in the following pages.

Chehalis Dam - Constructability, Schedule and Cost Support
FRE RCC - Jugdment Level Cost Breakdown

The Flood Retention Expandable project **(FRE)** has an initial construction phase **(FRE)** and a potential future construction phase **(FRE-FC).** Phase I or PHI should be read as **(FRE)** and Phase II or PHII should be read as **(FRE-FC)**.

FRE

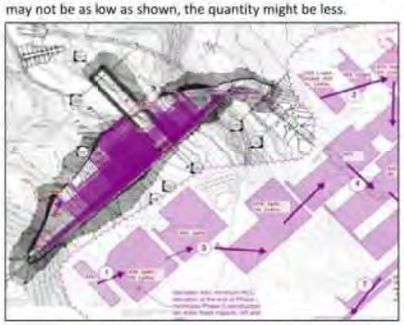
Driving RCC Quantity **892,000 cy** *(Driven off of " FRE Lift Chart" tab of "RCC Dam Q-s & Placement Plan - R09.xls"; and drawings as noted in "FRE-Annotated Dwgs Supporting OPC.pdf")*

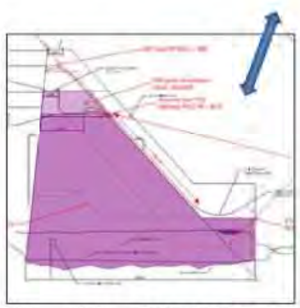
RCC Unit Cost Development by Component

Cost Component	Qty Determination	Ref Qty	Priced Qty	Unit	Low	Likely	High	Likely Total	RCC Unit Contribution
Aggregate	3,550 #/cy w/1.05%		1,662,465	ton	12.25	14.75	17.75	$ 24,521,359	$ 27.49 /cy
Cement & FA	285 #/cy w/1.03%		130,923	ton	115.00	135.00	145.00	$ 17,674,646	$ 19.81 /cy
Other materials	RCC		892,000	cy	0.75	1.00	1.25	$ 892,000	$ 1.00 /cy
RCC test section	ls		1	ls	125,000	250,000	300,000	$ 250,000	$ 0.28 /cy
RCC plant & delivery mob-setup-demob	ls		1	ls	400,000	450,000	600,000	$ 450,000	$ 0.50 /cy
Mix	RCC		892,000	cy	5.50	6.00	6.50	$ 5,352,000	$ 6.00 /cy
Mix Cooling	240,000 cy @ 5-10 def F cooling		240,000	cy	2.50	3.50	4.50	$ 840,000	$ 0.94 /cy
Deliver	RCC	4 months @ 60kcy / mo = 240k cy	892,000	cy	4.50	5.50	6.00	$ 4,906,000	$ 5.50 /cy
Place	RCC		892,000	cy	4.50	5.00	5.50	$ 4,460,000	$ 5.00 /cy
Dam Joints	75 ft on center		321,120	sf	2.75	3.00	3.50	$ 963,360	$ 1.08 /cy
Bedding	12.5% of RCC @ 1/2in		4,646	cy	275.00	300.00	325.00	$ 1,393,750	$ 1.56 /cy
Facing & S-way block forming - slope + vert	full u/s & d/s from "FRX - Lift Chart"		457,000	sf	4.00	5.00	6.00	$ 2,285,000	$ 2.56 /cy
Facing options:									
Base - GERCC (all faces)	0.75 gal/sf of all faces	42,315 cy	1,695	cy	650.00	700.00	800.00	$ 1,186,397	$ 1.33 /cy
Option 1 - u/s conventional	2.5 ft thick - on all formwork	221,000 sf	20,463	cy	250.00	290.00	320.00	$ 5,934,259	$ 6.65 /cy
Option 1 - d/s GERCC face	0.75 gal/sf of d/s and other formwork	236,000 sf	875	cy	650.00	700.00	800.00	$ 612,669	$ 0.69 /cy
Option 2 - Facing (u/s & d/s conventional)	2.5 ft thick - on all formwork		42,315	cy	250.00	290.00	320.00	$ 12,271,296	$ 13.76 /cy
GERCC - abutment contact	0.75 gal/sf of abut surface x 150%	19,056 cy	1,780	cy	650.00	700.00	800.00	$ 1,246,106	$ 1.40 /cy
Gallery	1,480' + 2 adits @ 50'+ 1 @ 180'		1,720	lf	800.00	900.00	1100.00	$ 1,548,000	$ 1.74 /cy
Other drain features	RCC		892,000	cy	0.50	0.75	1.25	$ 669,000	$ 0.75 /cy
Total with Base Facing (GERCC all faces)	343,000 sf abutment contact x 1.5' thick				$ 58,218,812	$ 68,637,617	$ 78,806,451		
					$ 65.27 /cy	$ 76.95 /cy	$ 88.35 /cy		$ 76.95 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 72,800,000**	**$ 85,800,000**	**$ 98,500,000**		
Total RCC - inclusive bid					**$81.61 /cy**	**$96.19 /cy**	**$110.43 /cy**		
Cementitious materials - bid			on 127,110 tn		**$148.06 /tn**	**$173.81 /tn**	**$186.69 /tn**		
Aggregate materials - bid			on 1,583,300 tn		**$16.08 /tn**	**$19.36 /tn**	**$23.30 /tn**		
Facing elements - form & place - bid			on 892,000 cy		**$3.28 /cy**	**$3.89 /cy**	**$4.59 /cy**		
Mix - Deliver - Place - Other - bid			on 892,000 cy		**$28.69 /cy**	**$33.17 /cy**	**$37.88 /cy**		
RCC - w/out cementitious - bid			on 892,000 cy		**$60.52 /cy**	**$71.42 /cy**	**$83.82 /cy**	Use Option 1) u/s conventional & d/s GERCC, as basis for estimate	
Check					**$72,800,000**	**$85,800,000**	**$98,500,000**		
Total with full conventional facings (Option 2)					$ 67,695,862	$ 79,722,516	$ 90,991,310		
					$75.89 /cy	$89.38 /cy	$102.01 /cy		$89.38 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 84,600,000**	**$ 99,700,000**	**$ 113,700,000**		
Contractor Bid Unit Prices					**$94.84 /cy**	**$111.77 /cy**	**$127.47 /cy**		
Contractor Bid Unit Prices (Option 1)					**$88.01 /cy**	**$103.70 /cy**	**$118.69 /cy**		
			Compares to Current FRO @		**$76.30 /cy**	**$93.09 /cy**	**$109.63 /cy**		
			Compares to Current FRFA @		**$83.53 /cy**	**$98.84 /cy**	**$113.54 /cy**		

Cost Development Qualifications

1) Cost judgment contemplates 2017 costs
2) The unit costs and cost ranges reflect industry experience and judgment, not developed estimates
3) The quantities reflect rough estimates of preliminary drawings, and anticipated design details
4) The low and high ranges intend to reflect design development and choices that might affect both the quantity and nature of the work, within the context of the given dam size. For example, while the low cement and pozzolan price may not be as low as shown, the quantity might be less.





Quantity Development - supporting parameters and numbers

Quantity Development Check Not Used in Hybrid Quick Cost. Reference drawing pdf's referenced in table note.

	Max	NA	NA
Approx crest length	1,650		
Crest width			
Crest elev			
U/S work point elev			
Foundation elev			
U/S slope	0.1		
D/S slope	0.85		
Joint spacing	75		
Approx vertical profile sf	335,537		
Structure H	311	0	0
H of D/S chimney	23.5	#DIV/0!	#DIV/0!
Elev of D/S chimney break	686.5	#DIV/0!	#DIV/0!
Base width	295.5	0.0	0.0
Area - max	46,178 sf	#DIV/0!	#DIV/0!
Volume / lf of dam	1,710 cy	#DIV/0!	#DIV/0!
U/S face vertical length	312.6	0	0
U/S face length as % of H	100.5%	#DIV/0!	#DIV/0!
D/S face length	401	#DIV/0!	#DIV/0!
D/S face length as % of H	128.9%	#DIV/0!	#DIV/0!
full joint sf / cy of dam	0.36 sf/cy	#DIV/0!	#DIV/0!
Approx RCC Check	890 lf	46,178 full sf	1,530,000 cy

Chehalis Dam - Constructability, Schedule and Cost Support
FRE-FC RCC - Judgment Level Cost Breakdown

The Flood Retention Expandable project **(FRE)** has an initial construction phase **(FRE)** and a potential future construction phase **(FRE-FC)**. Phase I or PHI should be read as **(FRE)** and Phase II or PHII should be read as **(FRE-FC)**.

FRE-FC

Driving RCC Quantity ***467,000 cy*** ***(Driven off of " FRE Lift Chart" tab of "RCC Dam Q-s & Placement Plan - R09.xls"; and drawings as noted in " FRE-Annotated Dwgs Supporting OPC.pdf")***

RCC Unit Cost Development by Component

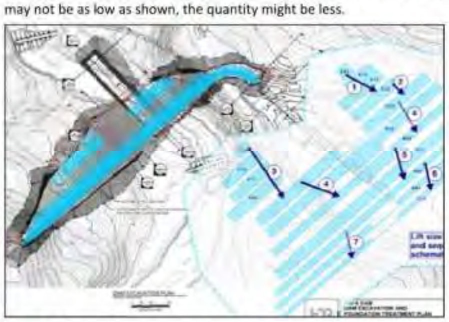
Cost Component	Qty Determination	Ref Qty	Priced Qty	Unit	Low	Likely	High	Likely Total	RCC Unit Contribution
Aggregate	3,550 #/cy w/1.05%		870,371	ton	12.25	14.75	17.75	$ 12,837,976	$ 27.49 /cy
Cement & FA	285 #/cy w/1.03%		68,544	ton	115.00	135.00	145.00	$ 9,253,430	$ 19.81 /cy
Other materials	RCC		467,000	cy	0.75	1.00	1.25	$ 467,000	$ 1.00 /cy
RCC test section	ls		1	ls	100,000	200,000	275,000	$ 200,000	$ 0.43 /cy
RCC plant & delivery mob-setup-demob	ls		1	ls	300,000	350,000	450,000	$ 350,000	$ 0.75 /cy
Mix	RCC		467,000	cy	5.50	6.00	6.50	$ 2,802,000	$ 6.00 /cy
Mix Cooling	300,000 cy @ 5-10 def F cooling		300,000	cy	3.00	4.00	5.00	$ 1,200,000	$ 2.57 /cy
Deliver	RCC		467,000	cy	5.50	6.50	7.00	$ 3,035,500	$ 6.50 /cy
Place	RCC		467,000	cy	5.00	6.00	6.50	$ 2,802,000	$ 6.00 /cy
Dam Joints	75 ft on center		168,120	sf	2.75	3.00	3.50	$ 504,360	$ 1.08 /cy
Bedding	12.5% of RCC @ 1/2in		2,432	cy	275.00	300.00	325.00	$ 729,688	$ 1.56 /cy
Facing & S-way block forming - slope + vert	full u/s & d/s from "FRX - Lift Chart"		368,500	sf	3.75	4.50	5.50	$ 1,658,250	$ 3.55 /cy
Facing options:									
Base - GERCC (all faces)	0.75 gal/sf of all faces	34,120 cy	1,367	cy	650.00	700.00	800.00	$ 956,646	$ 2.05 /cy
Option 1 - u/s conventional	2.5 ft thick - on all formwork	97,500 sf	9,028	cy	250.00	290.00	320.00	$ 2,618,056	$ 5.61 /cy
Option 1 - d/s GERCC face	0.75 gal/sf of d/s and other formwork	271,000 sf	1,005	cy	650.00	700.00	800.00	$ 703,531	$ 1.51 /cy
Option 2 - Facing (u/s & d/s conventional)	2.5 ft thick - on all formwork		34,120	cy	250.00	290.00	320.00	$ 9,894,907	$ 21.19 /cy
GERCC - abutment contact	0.75 gal/sf of abut surface x 150%	261 cy	1,780	cy	650.00	700.00	800.00	$ 1,246,106	$ 2.67 /cy
Gallery	Lump sum modification of PHI		1	ls	150,000	300,000	350,000	$ 300,000	$ 0.64 /cy
Other drain features	RCC		467,000	cy	0.50	0.75	1.25	$ 350,250	$ 0.75 /cy
Total with Base Facing (GERCC all faces)	4700 sf abutment contact x 1.5' thick				$ 32,608,847	$ 38,693,205	$ 44,393,554		
					$ 69.83 /cy	$ 82.85 /cy	$ 95.06 /cy		$ 82.85 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 40,800,000**	**$ 48,400,000**	**$ 55,500,000**		
Total RCC - inclusive bid					**$87.37 /cy**	**$103.64 /cy**	**$118.84 /cy**		
Cementitious materials - bid			on 66,548 tn		**$148.06 /tn**	**$173.81 /tn**	**$186.69 /tn**		
Aggregate materials - bid			on 828,925 tn		**$16.08 /tn**	**$19.36 /tn**	**$23.30 /tn**		
Facing elements - form & place - bid			on 467,000 cy		**$4.86 /cy**	**$5.60 /cy**	**$6.68 /cy**		
Mix - Deliver - Place - Other - bid			on 467,000 cy		**$32.87 /cy**	**$38.91 /cy**	**$44.21 /cy**		
RCC - w/out cementitious - bid			on 467,000 cy		**$66.27 /cy**	**$78.87 /cy**	**$92.24 /cy**		
Check					**$40,800,000**	**$48,400,000**	**$55,500,000**		
Total with full conventional facings (Option 2)					$ 40,250,625	$ 47,631,467	$ 54,218,763		
					$86.19 /cy	$101.99 /cy	$116.10 /cy		$101.99 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 50,300,000**	**$ 59,500,000**	**$ 67,800,000**		
Contractor Bid Unit Prices					**$107.71 /cy**	**$127.41 /cy**	**$145.18 /cy**		
Contractor Bid Unit Prices (Option 1)					**$92.69 /cy**	**$109.90 /cy**	**$125.78 /cy**		
			Compares to Current FRC		**$76.30 /cy**	**$93.09 /cy**	**$109.63 /cy**		
			Compares to Current FRF		**$83.53 /cy**	**$98.84 /cy**	**$113.54 /cy**		

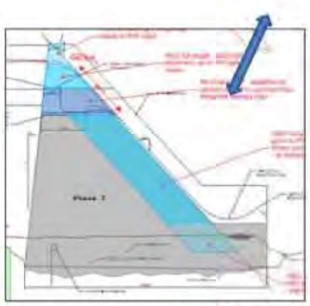
assume more aggressive cooling for Ph II to ensure monolith behavior and lower risk of poor existing adhesion

Use Option 1) u/s conventional & d/s GERCC, as basis for estimate

Cost Development Qualifications

1) Cost judgement contemplates 2017 costs
2) The unit costs and cost ranges reflect industry experience and judgment, not developed estimates
3) The quantities reflect rough estimates of preliminary drawings, and anticipated design details
4) The low and high ranges intend to reflect design development and choices that might affect both the quantity and nature of the work, within the context of the given dam size. For example, while the low cement and pozzolan price may not be as low as shown, the quantity might be less.





Quantity Development - supporting parameters and numbers

Quantity Development Check Not Used in Hybrid Quick Cost. Reference drawing pdf's referenced in table note.

	Max	NA	NA
Approx crest length	[illegible]		
Crest width			
Crest elev			
U/S work point elev			
Foundation elev			
U/S slope	0.1		
D/S slope	0.85		
Joint spacing	75		
Approx vertical profile sf	335,537		
Structure H	311	0	0
H of D/S chimney	23.5	#DIV/0!	#DIV/0!
Elev of D/S chimney break	686.5	#DIV/0!	#DIV/0!
Base width	295.5	0.0	0.0
Area - max	46,178 sf	#DIV/0!	#DIV/0!
Volume / lf of dam	1,710 cy	#DIV/0!	#DIV/0!
U/S face vertical length	312.6	0	0
U/S face length as % of H	100.5%	#DIV/0!	#DIV/0!
D/S face length	401	#DIV/0!	#DIV/0!
D/S face length as % of H	128.9%	#DIV/0!	#DIV/0!
full joint sf / cy of dam	0.36 sf/cy	#DIV/0!	#DIV/0!
Approx RCC Check	890 lf	46,178 full sf	1,530,000 cy

Chehalis Dam - Constructability, Schedule and Cost Support — **FRO Refreshed for FRE Eval**

FRO RCC - Judgment Level Cost Breakdown

Driving RCC Quantity — ***810,000 cy*** *(driven off of lift chart; RCC Dam Q-s & Placement Plan - R09.xls, Tab RCC - Lift Chart - 3D; dwgs - Chehalis_All_Figs_2016-10-19.pdf, updated by foundation profile generated for Hybrid)*

RCC Unit Cost Development by Component

Cost Component	Qty Determination	Ref Qty	Priced Qty	Unit	Low	Likely	High	Likely Total	RCC Unit Contribution
Aggregate	3,550 #/cy w/1.05%		1,509,638	ton	12.25	14.75	17.75	$ 22,267,153	$ 27.49 /cy
Cement & FA	285 #/cy w/1.03%		118,888	ton	115.00	135.00	145.00	$ 16,049,846	$ 19.81 /cy
Other materials	RCC		810,000	cy	0.00	0.50	1.25	$ 405,000	$ 0.50 /cy
RCC test section	ls		1	ls	125,000	250,000	300,000	$ 250,000	$ 0.31 /cy
RCC plant & delivery mob-setup-demob	ls		1	ls	200,000	350,000	450,000	$ 350,000	$ 0.43 /cy
Mix	RCC		810,000	cy	5.50	6.00	6.50	$ 4,860,000	$ 6.00 /cy
Mix Cooling	200,000 cy @ 5-10 def F cooling		200,000	cy	0.00	3.00	5.00	$ 600,000	$ 0.74 /cy
Deliver	RCC		810,000	cy	4.00	4.50	5.50	$ 3,645,000	$ 4.50 /cy
Place	RCC		810,000	cy	4.00	4.50	5.50	$ 3,645,000	$ 4.50 /cy
Dam Joints	75 ft on center		291,600	sf	3.00	3.50	4.00	$ 1,020,600	$ 1.26 /cy
Bedding	12.5% of RCC @ 1/2in		4,219	cy	275.00	300.00	325.00	$ 1,265,625	$ 1.56 /cy
Facing forming (slope u/s, vert d/s)	full u/s & d/s from "RCC - Lift Chart"		447,442	sf	3.00	3.75	5.00	$ 1,677,908	$ 2.07 /cy
Facing options:									
Base - GERCC (all faces)	0.75 gal/sf of all faces	41,430 cy	1,659	cy	450.00	700.00	800.00	$ 1,161,584	$ 1.43 /cy
Option 1 - u/s conventional (@1/2 facing)	2.5 ft thick - on 1/2 formwork		20,715	cy	250.00	290.00	320.00	$ 6,007,323	$ 7.42 /cy
Option 1 - d/s GERCC face	0.75 gal/sf of 1/2 formwork		830	cy	650.00	700.00	800.00	$ 580,792	$ 0.72 /cy
Option 2 - Facing (u/s & d/s conventional)	2.5 ft thick - on all formwork		41,430	cy	250.00	290.00	320.00	$ 12,014,646	$ 14.83 /cy
GERCC - abutment contact	0.75 gal/sf of projected abut x 150%	13,778 cy	1,380	cy	650.00	700.00	800.00	$ 965,732	$ 1.19 /cy
Gallery	1330' + 2 adits @ 100'		1,530	lf	500.00	1000.00	1200.00	$ 1,530,000	$ 1.89 /cy
Other drain features	RCC		810,000	cy	0.25	0.75	1.25	$ 607,500	$ 0.75 /cy
Total with Base Facing (GERCC all faces)	248,000 sf abutment contact x 1.5' thick				$ 49,413,416	$ 60,300,948	$ 71,026,711		
					$ 61.00 /cy	$ 74.45 /cy	$ 87.69 /cy		$ 74.45 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 61,800,000**	**$ 75,400,000**	**$ 88,800,000**		
Total RCC - inclusive bid					**$76.30 /cy**	**$93.09 /cy**	**$109.63 /cy**		
Cementitious materials - bid			on 115,425 tn		**$148.06 /tn**	**$173.81 /tn**	**$186.69 /tn**		
Aggregate materials - bid			on 1,437,750 tn		**$16.08 /tn**	**$19.36 /tn**	**$23.30 /tn**		
Facing elements - form & place - bid			on 810,000 cy		**$2.58 /cy**	**$3.51 /cy**	**$4.40 /cy**		
Mix - Deliver - Place - Other - bid			on 810,000 cy		**$24.08 /cy**	**$30.45 /cy**	**$37.27 /cy**		
RCC - w/out cementitious - bid			on 810,000 cy		**$55.20 /cy**	**$68.32 /cy**	**$83.03 /cy**		
Check					**$61,800,000**	**$75,400,000**	**$88,800,000**		
Total with full conventional facings (Option 2)					$ 59,024,138	$ 71,154,010	$ 82,956,728		
					$72.87 /cy	$87.84 /cy	$102.42 /cy		$87.84 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 73,800,000**	**$ 88,900,000**	**$ 103,700,000**		
Contractor Bid Unit Prices					**$91.11 /cy**	**$109.75 /cy**	**$128.02 /cy**		
Contractor Bid Unit Prices (Option 1)					**$83.93 /cy**	**$101.43 /cy**	**$118.81 /cy**		

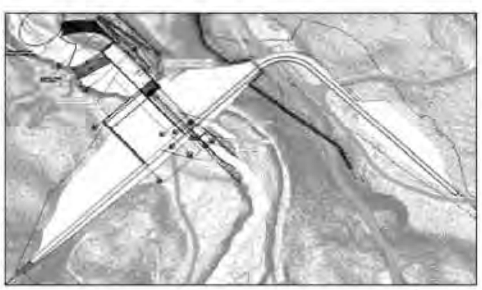
For FRO, no planned or long-term storage; low range - 1) no cooling, 2) no admixture or other material, 3) reduced GERCC application or utilization, 4) potentially reduced gallery and drain features.

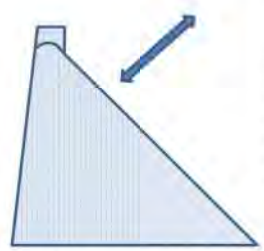
8-9 month window, potentially more flexibility to avoid hot weather; say 2 months @ 100kcy / mo = 200k cy

Use Base - all faces GERCC, as basis for estimate; FRO facing and water retention not as critical as with FRFA

Cost Development Qualifications

1) Cost judgement contemplates 2017 costs
2) The unit costs and cost ranges reflect industry experience and judgment, not developed estimates
3) The quantities reflect rough estimates of preliminary drawings, and anticipated design details
4) The low and high ranges intend to reflect design development and choices that might affect both the quantity and nature of the work, within the context of the given dam size. For example, while the low cement and pozzolan price may not be as low as shown, the quantity might be less.





Quantity Development - supporting parameters and numbers

Quantity Development Check Not Used in FRO/FRFA update. Reference drawing pdf's referenced in table note.

	Max	NA	NA
Approx crest length	1,400		
Crest width			
Crest elev			
U/S work point elev			
Foundation elev			
U/S slope	0.1		
D/S slope	0.85		
Joint spacing	75		
Approx vertical profile sf	238,215		
Structure H	252	0	0
H of D/S chimney	23.5	#DIV/0!	#DIV/0!
Elev of D/S chimney break	627.5	#DIV/0!	#DIV/0!
Base width	239.4	0.0	0.0
Area - max	30,400 sf	#DIV/0!	#DIV/0!
Volume / lf of dam	1,126 cy	#DIV/0!	#DIV/0!
U/S face vertical length	253.3	0	0
U/S face length as % of H	100.5%	#DIV/0!	#DIV/0!
D/S face length	323	#DIV/0!	#DIV/0!
D/S face length as % of H	128.3%	#DIV/0!	#DIV/0!
full joint sf / cy of dam	0.36 sf/cy	#DIV/0!	#DIV/0!
Approx RCC Check	775 lf	30,400 full sf	880,000 cy

Chehalis Dam - Constructability, Schedule and Cost Support

FRFA RCC - Jugdment Level Cost Breakdown

FRFA Refreshed for FRE Eval

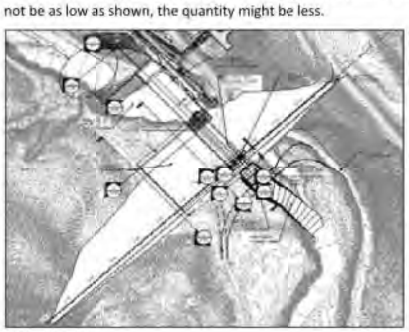
Driving RCC Quantity **1,360,000 cy** *(driven off of lift chart; RCC Dam Q-s & Placement Plan - R09.xls, Tab RCC - Lift Chart - 3D; dwgs - Chehalis_All_Figs_2016-10-19.pdf, updated by foundation profile generated for Hybrid)*

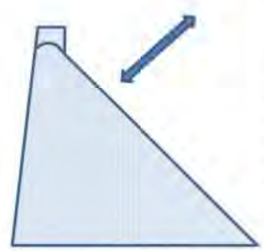
RCC Unit Cost Development by Component

Cost Component	Qty Determination	Ref Qty	Priced Qty	Unit	Low	Likely	High	Likely Total	RCC Unit Contribution
Aggregate	3,550 #/cy w/1.05%		2,534,700	ton	12.25	14.75	17.75	$ 37,386,825	$ 27.49 /cy
Cement & FA	285 #/cy w/1.03%		199,614	ton	115.00	135.00	145.00	$ 26,947,890	$ 19.81 /cy
Other materials	RCC		1,360,000	cy	0.75	1.00	1.25	$ 1,360,000	$ 1.00 /cy
RCC test section	ls		1	ls	125,000	250,000	300,000	$ 250,000	$ 0.18 /cy
RCC plant & delivery mob-setup-demob	ls		1	ls	300,000	400,000	500,000	$ 400,000	$ 0.29 /cy
Mix	RCC		1,360,000	cy	5.00	5.50	6.00	$ 7,480,000	$ 5.50 /cy
Mix Cooling	390,000 cy @ 5-10 def F cooling		390,000	cy	2.50	3.50	4.50	$ 1,365,000	$ 1.00 /cy
Deliver	RCC 3 months @ 130kcy / mo = 390k cy		1,360,000	cy	4.00	5.00	5.50	$ 6,800,000	$ 5.00 /cy
Place	RCC		1,360,000	cy	4.00	4.50	5.00	$ 6,120,000	$ 4.50 /cy
Dam Joints	75 ft on center		489,600	sf	2.75	3.00	3.50	$ 1,468,800	$ 1.08 /cy
Bedding	12.5% of RCC @ 1/2in		7,083	cy	275.00	300.00	325.00	$ 2,125,000	$ 1.56 /cy
Facing forming (slope u/s, vert d/s)	full u/s & d/s from "RCC - Lift Chart"		642,884	sf	3.00	3.75	5.00	$ 2,410,815	$ 1.77 /cy
Facing options:									
Base - GERCC (all faces)	0.75 gal/sf of all faces	59,526 cy	2,384	cy	650.00	700.00	800.00	$ 1,668,962	$ 1.23 /cy
Option 1 - u/s conventional (@1/2 facing)	2.5 ft thick - on 1/2 formwork		29,763	cy	250.00	290.00	320.00	$ 8,631,313	$ 6.35 /cy
Option 1 - d/s GERCC face	0.75 gal/sf of 1/2 formwork		1,192	cy	650.00	700.00	800.00	$ 834,481	$ 0.61 /cy
Option 2 - Facing (u/s & d/s conventional)	2.5 ft thick - on all formwork		59,526	cy	250.00	290.00	320.00	$ 17,262,626	$ 12.69 /cy
GERCC - abutment contact	0.75 gal/sf of projected abut x 150%	17,778 cy	1,780	cy	650.00	700.00	800.00	$ 1,246,106	$ 0.92 /cy
Gallery	1,600' + 2 adits @ 50'+ 1 @ 180'		1,880	lf	800.00	900.00	1100.00	$ 1,692,000	$ 1.24 /cy
Other drain features	RCC		1,360,000	cy	0.50	0.75	1.25	$ 1,020,000	$ 0.75 /cy
Total with Base Facing (GERCC all faces)	320,000 sf abutment contact x 1.5' thick				$ 84,219,502	$ 99,741,397	$ 114,959,564		
					$ 61.93 /cy	$ 73.34 /cy	$ 84.53 /cy		$ 73.34 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 105,300,000**	**$ 124,700,000**	**$ 143,700,000**		
Total RCC - inclusive bid					**$77.43 /cy**	**$91.69 /cy**	**$105.66 /cy**		
Cementitious materials - bid			on 193,800 tn		**$148.06 /tn**	**$173.81 /tn**	**$186.69 /tn**		
Aggregate materials - bid			on 2,414,000 tn		**$16.08 /tn**	**$19.36 /tn**	**$23.30 /tn**		
Facing elements - form & place - bid			on 1,360,000 cy		**$2.56 /cy**	**$3.00 /cy**	**$3.77 /cy**		
Mix - Deliver - Place - Other - bid			on 1,360,000 cy		**$25.23 /cy**	**$29.56 /cy**	**$33.94 /cy**		
RCC - w/out cementitious - bid			on 1,360,000 cy		**$56.33 /cy**	**$66.92 /cy**	**$79.06 /cy**	Use Option 1) u/s conventional & d/s GERCC, as basis for estimate	
Check					**$105,300,000**	**$124,700,000**	**$143,700,000**		
Total with full conventional facings (Option 2)					$ 97,551,326	$ 115,335,062	$ 132,100,594		
					$71.73 /cy	$84.81 /cy	$97.13 /cy		$84.81 /cy
with contractor unallocated indirect expense (15%) and overhead & profit 15%)			25%		**$ 121,900,000**	**$ 144,200,000**	**$ 165,100,000**		
Contractor Bid Unit Prices					**$89.63 /cy**	**$106.03 /cy**	**$121.40 /cy**		
Contractor Bid Unit Prices (Option 1)					**$83.53 /cy**	**$98.84 /cy**	**$113.54 /cy**		
					81.11	96.25	110.76		

Cost Development Qualifications

1) Cost judgement contemplates 2017 costs
2) The unit costs and cost ranges reflect industry experience and judgment, not developed estimates
3) The quantities reflect rough estimates of preliminary drawings, and anticipated design details
4) The low and high ranges intend to reflect design development and choices that might affect both the quantity and nature of the work, within the context of the given dam size. For example, while the low cement and pozzolan price may not be as low as shown, the quantity might be less.





Quantity Development - supporting parameters and numbers

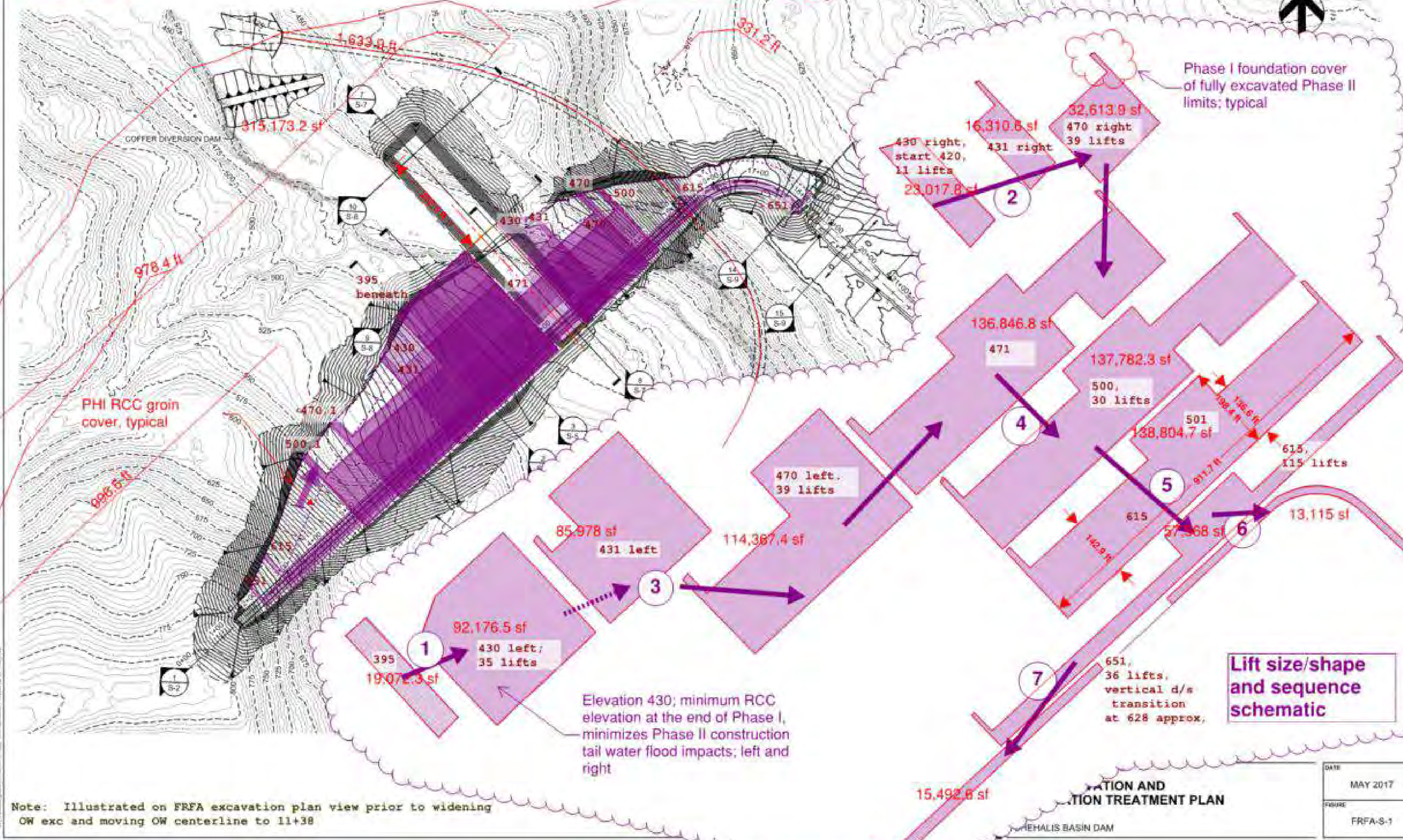
Quantity Development Check Not Used in FRO/FRFA update. Reference drawing pdf's referenced in table note.

	Max	NA	NA
Approx crest length	1,650		
Crest width			
Crest elev			
U/S work point elev			
Foundation elev			
U/S slope	0.1		
D/S slope	0.85		
Joint spacing	75		
Approx vertical profile sf	335,537		
Structure H	311	0	0
H of D/S chimney	23.5	#DIV/0!	#DIV/0!
Elev of D/S chimney break	686.5	#DIV/0!	#DIV/0!
Base width	295.5	0.0	0.0
Area - max	46,178 sf	#DIV/0!	#DIV/0!
Volume / lf of dam	1,710 cy	#DIV/0!	#DIV/0!
U/S face vertical length	312.6	0	0
U/S face length as % of H	100.5%	#DIV/0!	#DIV/0!
D/S face length	401	#DIV/0!	#DIV/0!
D/S face length as % of H	128.9%	#DIV/0!	#DIV/0!
full joint sf / cy of dam	0.36 sf/cy	#DIV/0!	#DIV/0!
Approx RCC Check	890 lf	46,178 full sf	1,530,000 cy

6 DRAWING SHEET ILLUSTRATING FRE RCC PROGRESSION AND QUANTITY TAKEOFF SUPPORT

RCC placement progression and quantity takeoff analysis FRE dam alternative are illustrated on the drawing sheets presented in the following pages.

Phase I - Illustration of Phase I RCC Progression
Plan View



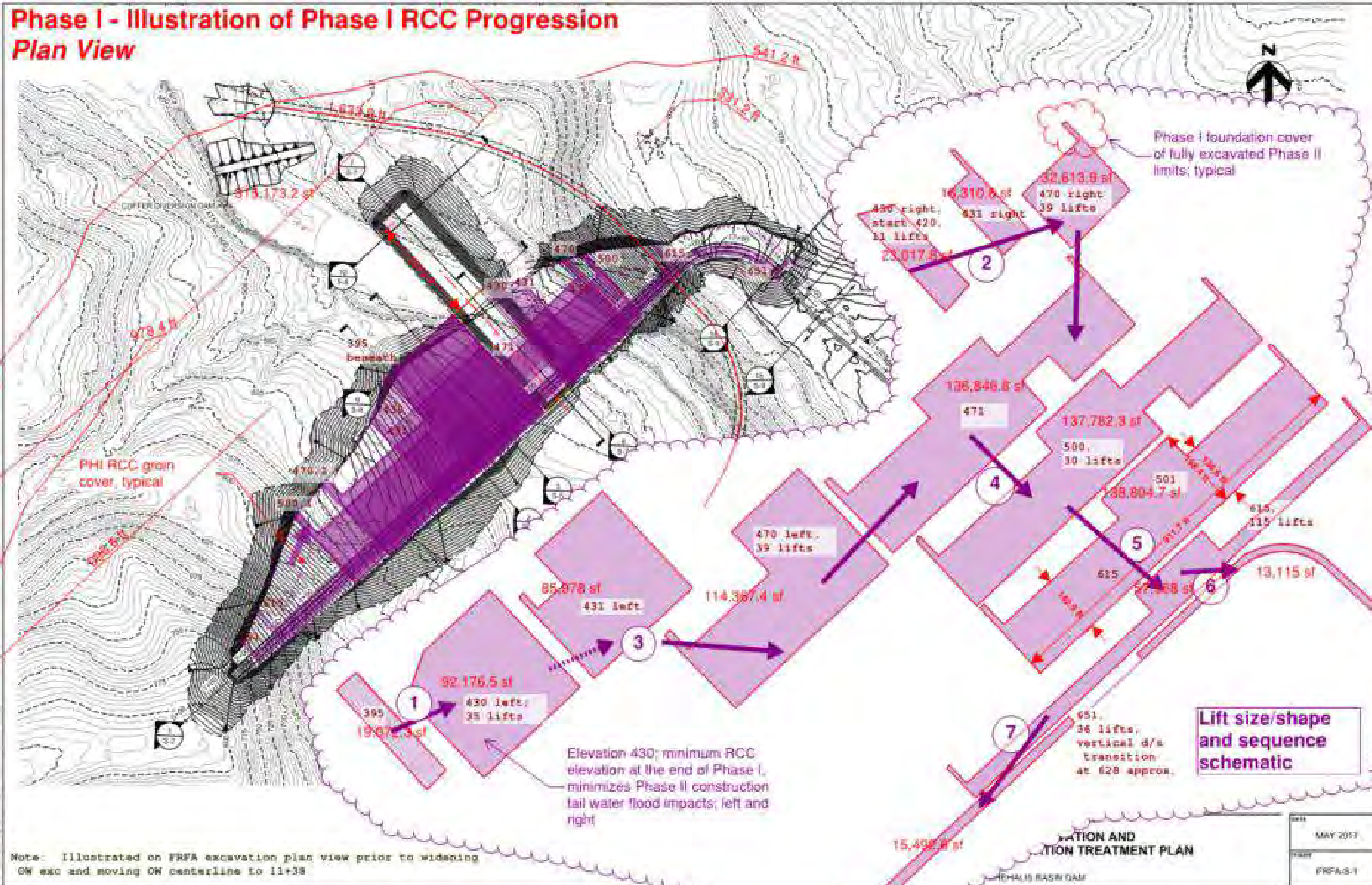
Note: Illustrated on FRFA excavation plan view prior to widening OW exc and moving OW centerline to 11+38

...ATION AND ...TION TREATMENT PLAN

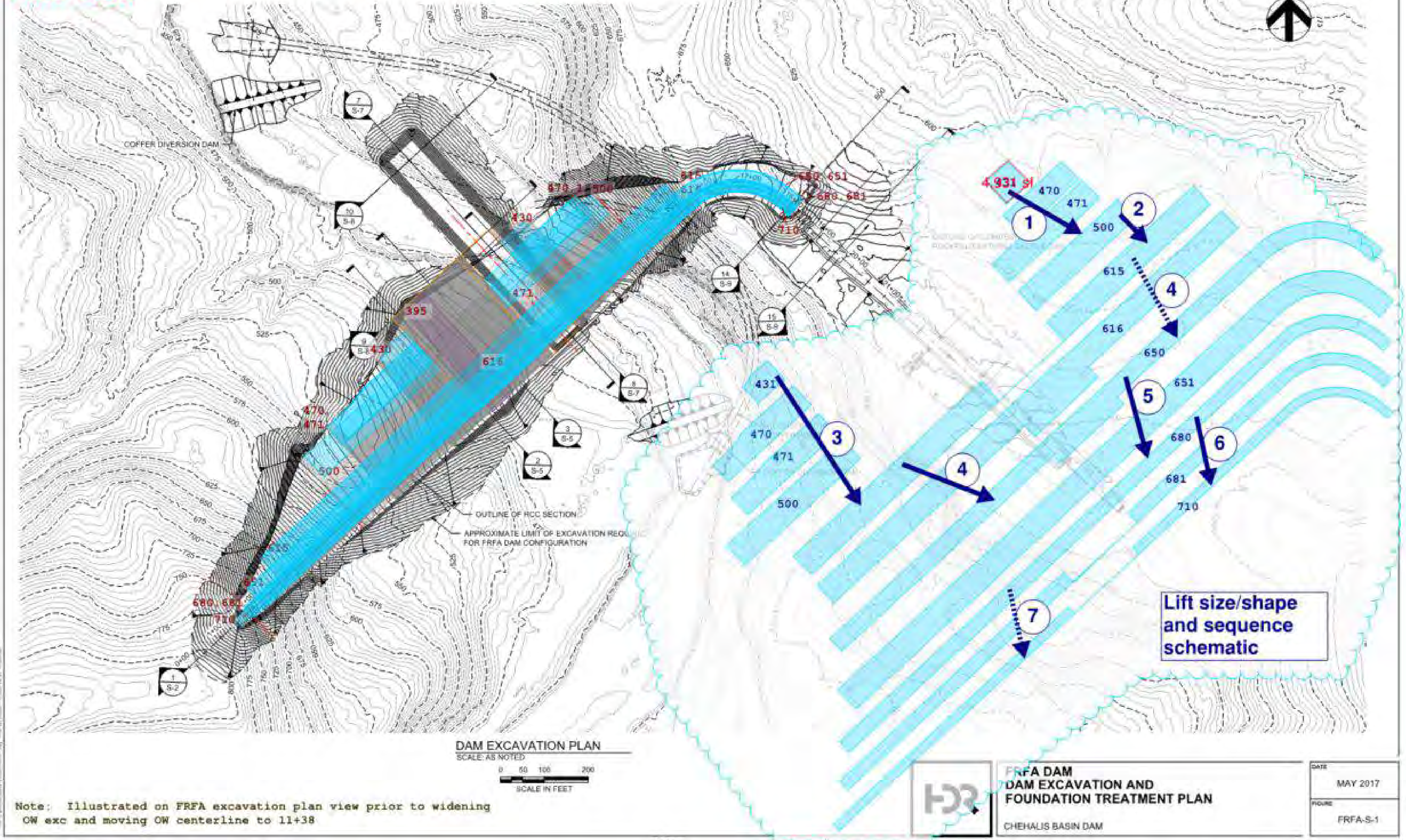
...HEHALIS BASIN DAM

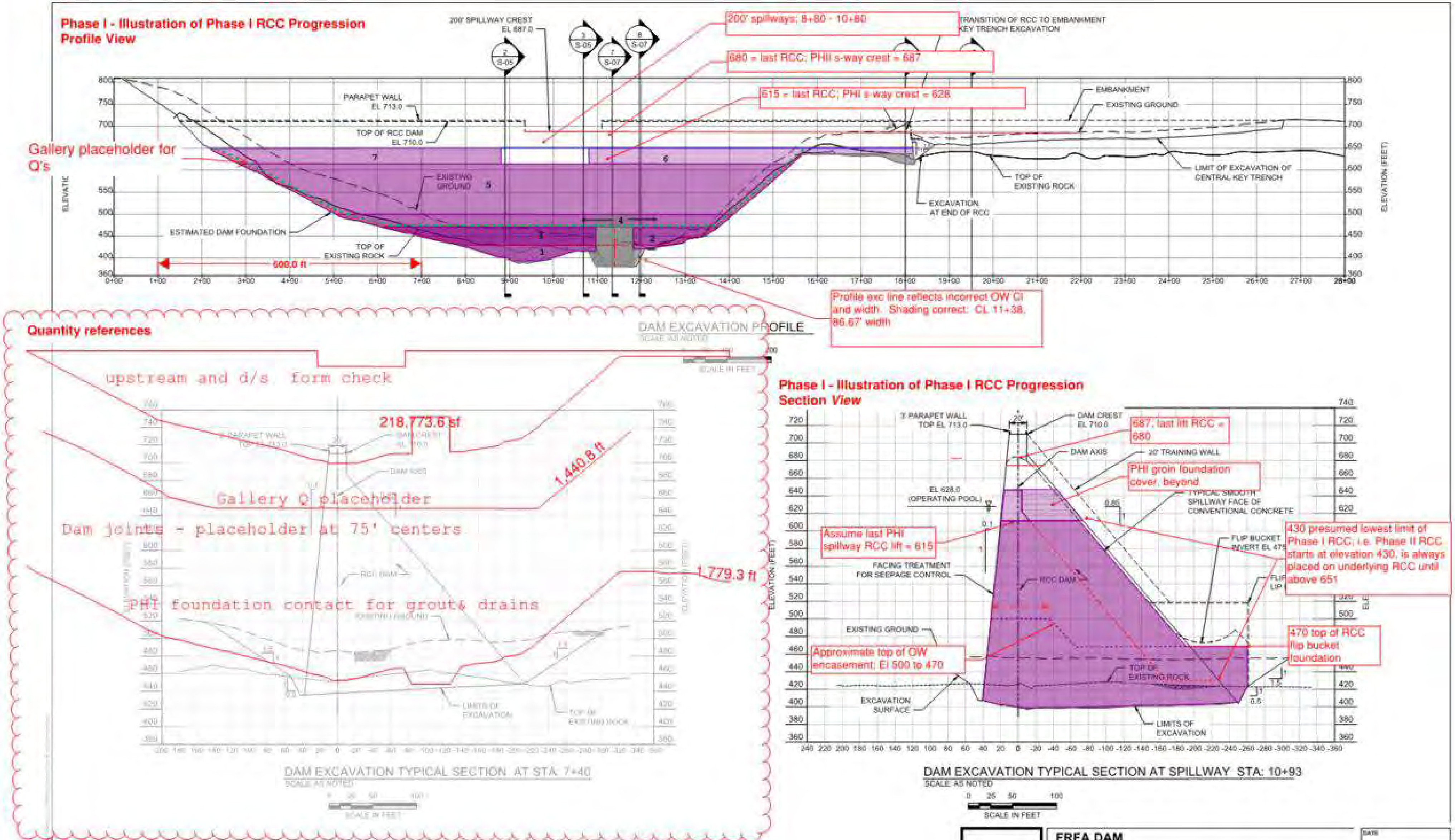
DATE	MAY 2017
FIGURE	FRFA-S-1

Phase I - Illustration of Phase I RCC Progression
Plan View



Phase II - Illustration of Phase II RCC Progression
Plan View





Note: Hybrid profile and sections illustrated on updated foundation profile and FRFA profile and section views

HDR

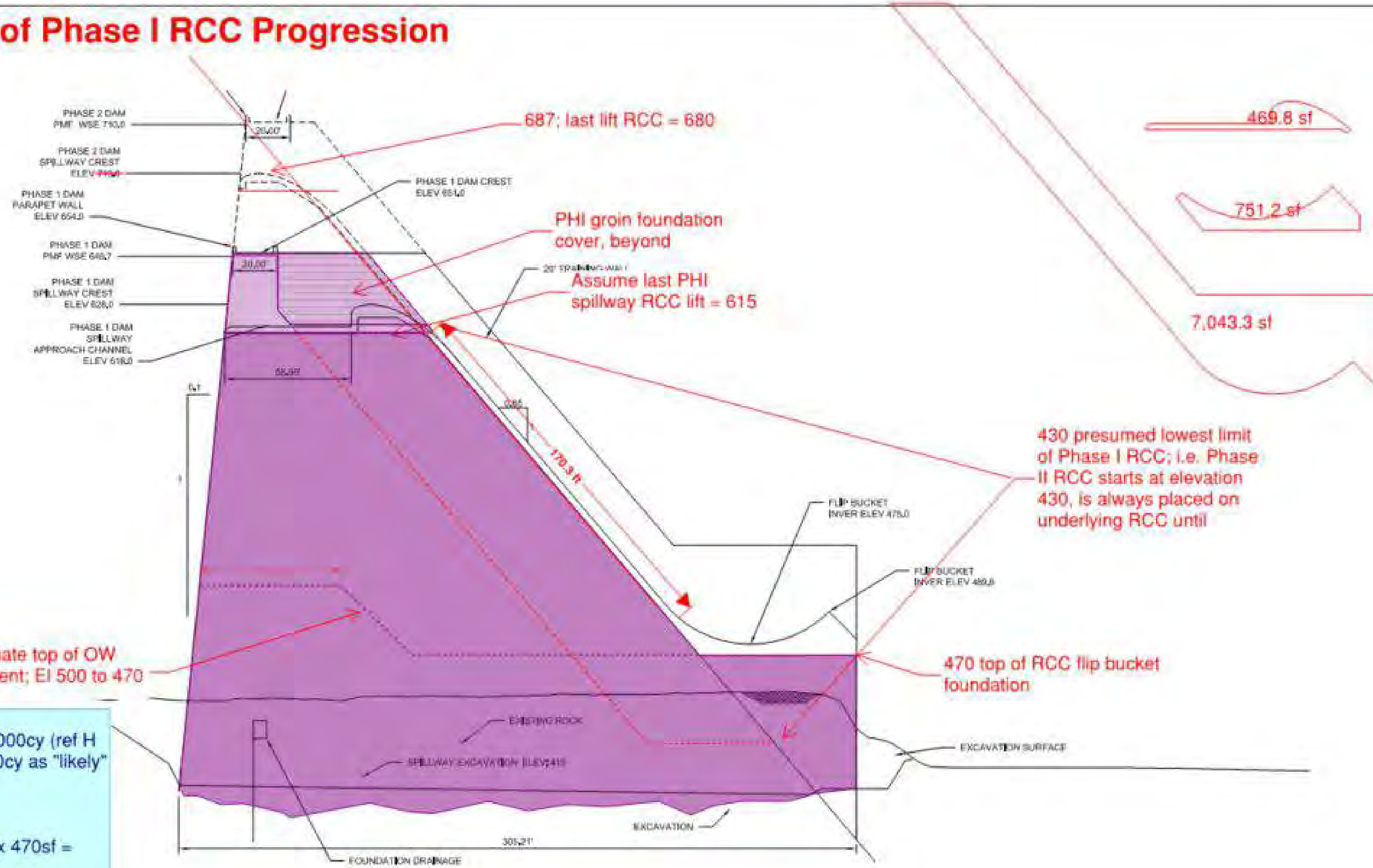
FRFA DAM
DAM EXCAVATION PROFILE, TYPICAL SECTIONS AND DETAILS

CHEHALIS BASIN DAM

DATE: MAY 2017

FIGURE: FRFA-S-2

Phase I - Illustration of Phase I RCC Progression
Section *View*



PHI Concrete Structure Quantities
1) Outlet encasement: 7400sf x 300' = 82kcy; 70,000cy (ref H S-6-7 QTO; with potential to optimize); use 60,000cy as "likely" case
2) Flip: 751sf x 210' = 5,800cy
3) PHI sloped face = 210' x 3' x 170' = 4,000cy
4) PHI approach, and ogee to sloped face = 210' x 470sf = 3,650cy
5) Crest: (20'x1' +(3.5' +3.5')x1') x (18+10-2+20 - 200') = 1,400cy
6) Stilling basin: 120% x (95' x 40' - 85' x 36') x 250' = 8,200cy; 8600cy ref H S-6,7; plus add 2' leveling = 1600cy
7) Intake and trashrack: 100% x (95' x 40' - 85' x 38') x 260' = 5,500cy. See H S-06-07, use 5800cy.
8) Spillway training walls: 7043sf x 2' x 2each = 1,050cy
9) Other - not otherwise identified: 4,000cy
Total all structures (without Fish Passage) = 105,900cy: use as max; 95,900cy as likely; and 80,000 cy as low range. adjusting in item 1).

arly draft hybrid section views

HDR

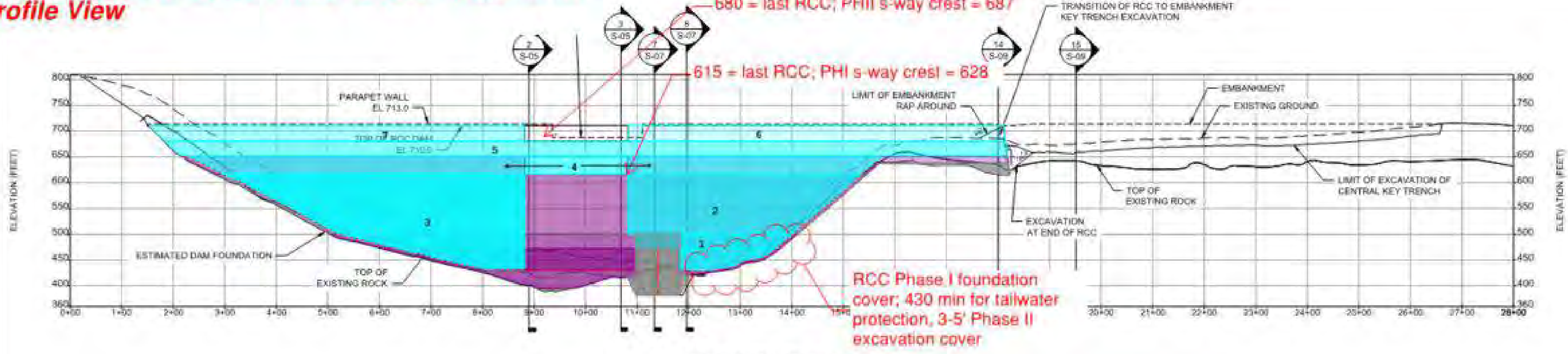
HYB DAM
SPILLWAY SECTION

CHEHALIS BASIN DAM

DATE
MAY 2017

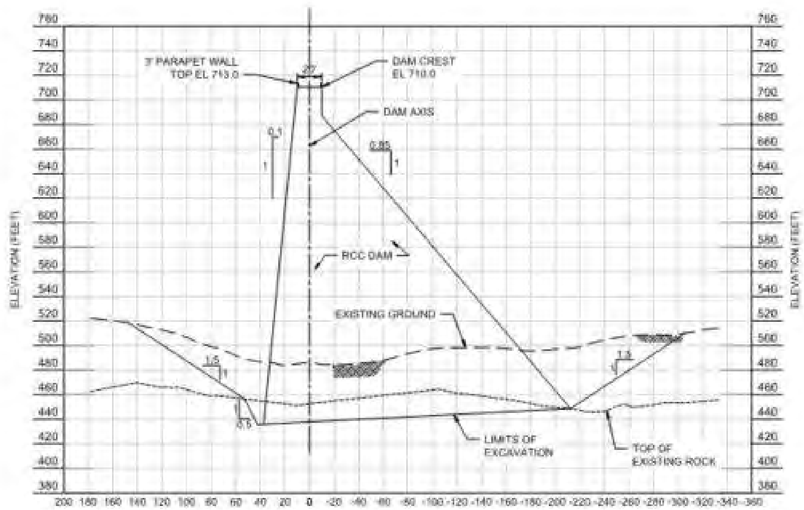
FIGURE
X_HYB_Spillway_Section_Struct

Phase II - Illustration of Phase II RCC Progression
Profile View

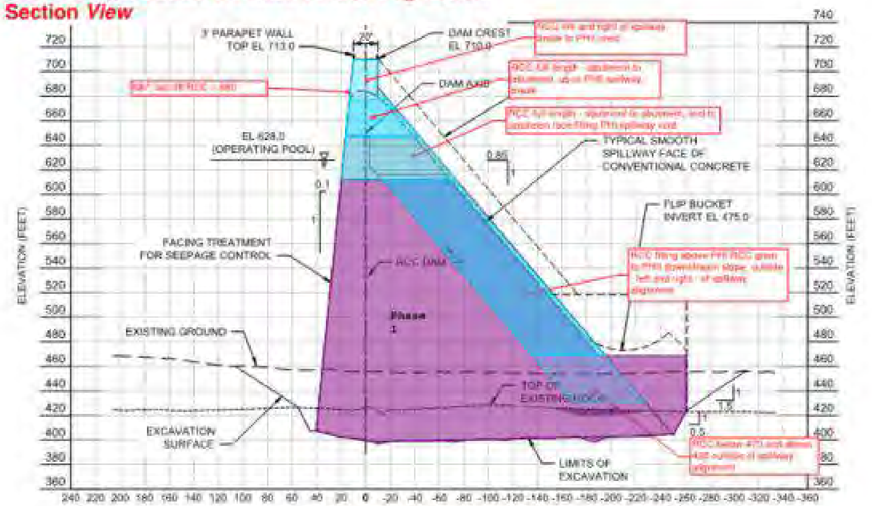


DAM EXCAVATION PROFILE
SCALE: AS NOTED
SCALE IN FEET

Phase II - Illustration of Phase II RCC Progression
Section *View*



DAM EXCAVATION TYPICAL SECTION AT STA: 7+40
SCALE: AS NOTED
SCALE IN FEET

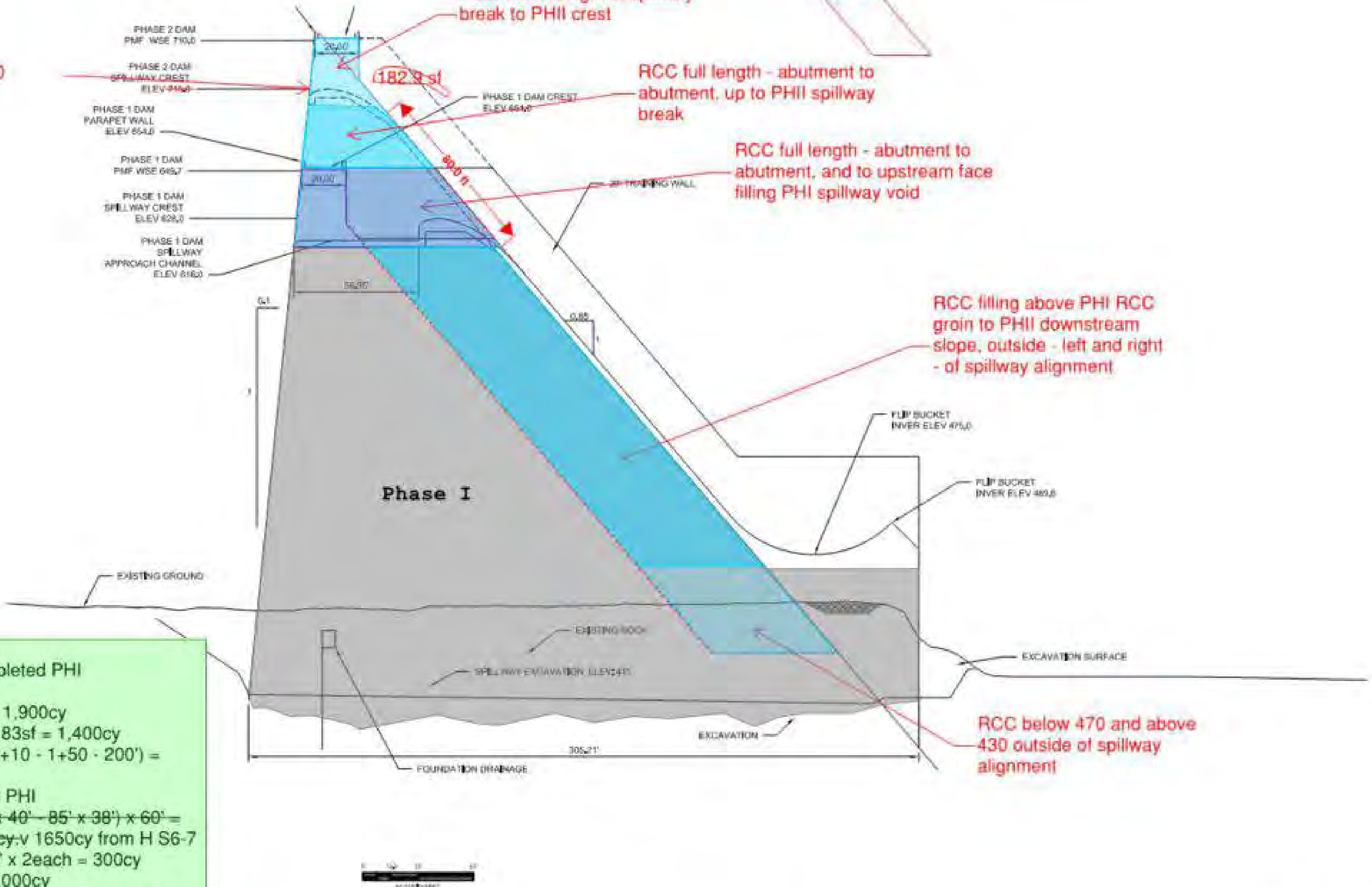


DAM EXCAVATION TYPICAL SECTION AT SPILLWAY STA: 10+93
SCALE: AS NOTED
SCALE IN FEET

Note: Hybrid profile and sections illustrated on updated foundation profile and FRFA profile and section views

HDR	FRFA DAM DAM EXCAVATION PROFILE, TYPICAL SECTIONS AND DETAILS CHEHALIS BASIN DAM	DATE: MAY 2017 FIGURE: FRFA-S-2

Phase II - Illustration of Phase II RCC Progression
Section *View*



PHII Concrete Structure Quantities

1) Outlet encasement: 0 cy; fully completed PHI
2) Flip: 0 cy; fully completed PHI
3) PHII sloped face = 210' x 3' x 80' = 1,900cy
4) PHII ogee to sloped face = 210' x 183sf = 1,400cy
5) Crest: (20'x1' +(3.5' +3.5')x1') x (18+10 - 1+50 - 200') = 1,460cy
6) Stilling basin: 0 cy; fully completed PHI
7) Intake and trashrack: ~~100% x (95' x 40' - 85' x 38') x 60' = 5,500cy + 1000cy in features = 2,300cy.~~v 1650cy from H S6-7
8) Spillway training walls: 1416sf x 2' x 2each = 300cy
9) Other - not otherwise identified: 1,000cy
10) Demo Phase I - assume 1/2 crest and approach and ogee = 3650cy, totaling 4350cy

Total all structures (without Fish Passage) = 8,360cy: use as likely

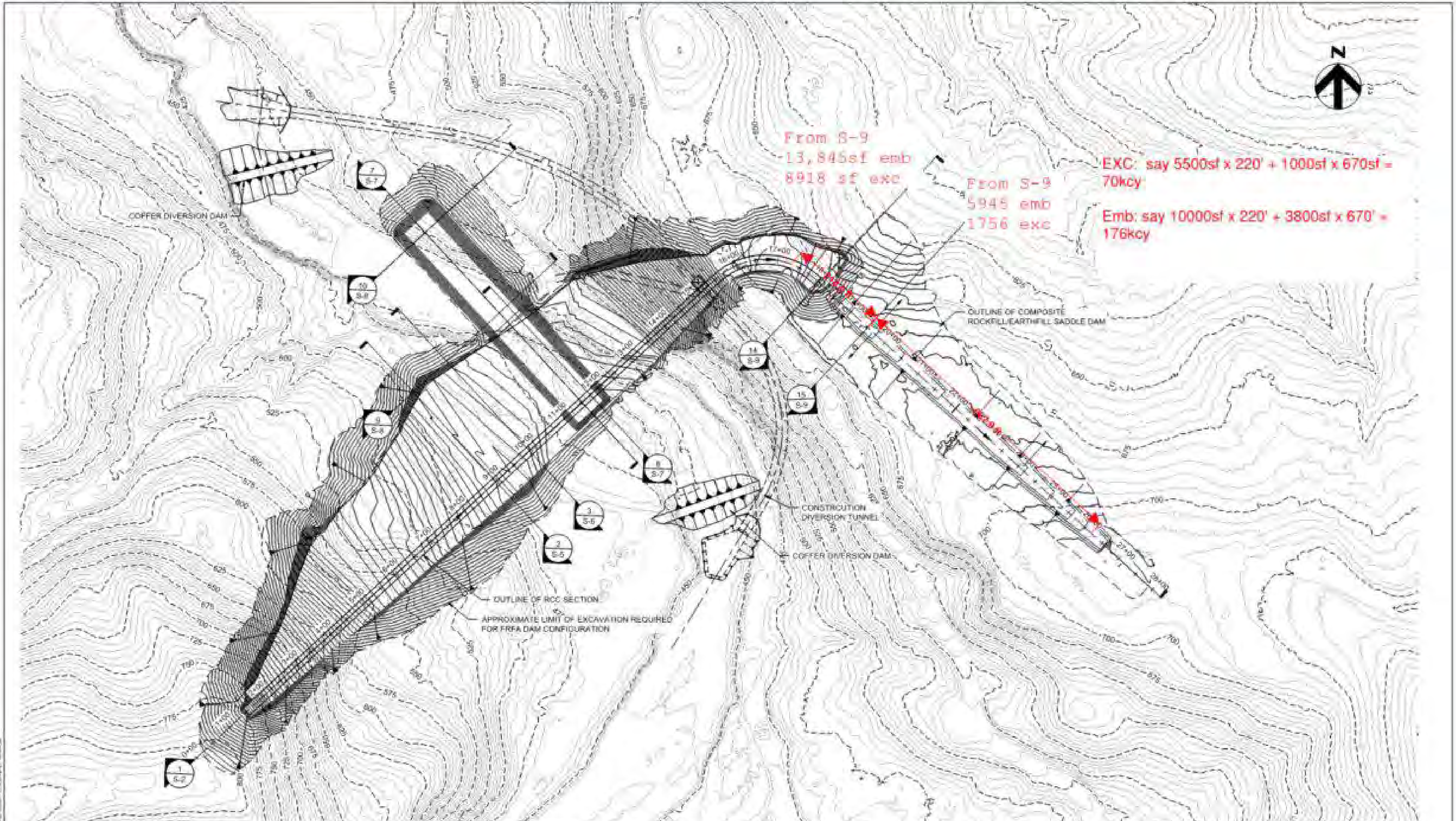
Note: Hybrid sections illustrated on early draft hybrid section views

HDR

HYB DAM
SPILLWAY SECTION

CHEHALIS BASIN DAM

DATE
MAY 2017
FIGURE
X_HYB_Spillway_Section_Struct



DAM EXCAVATION PLAN

SCALE: AS NOTED

0 50 100 200

SCALE IN FEET

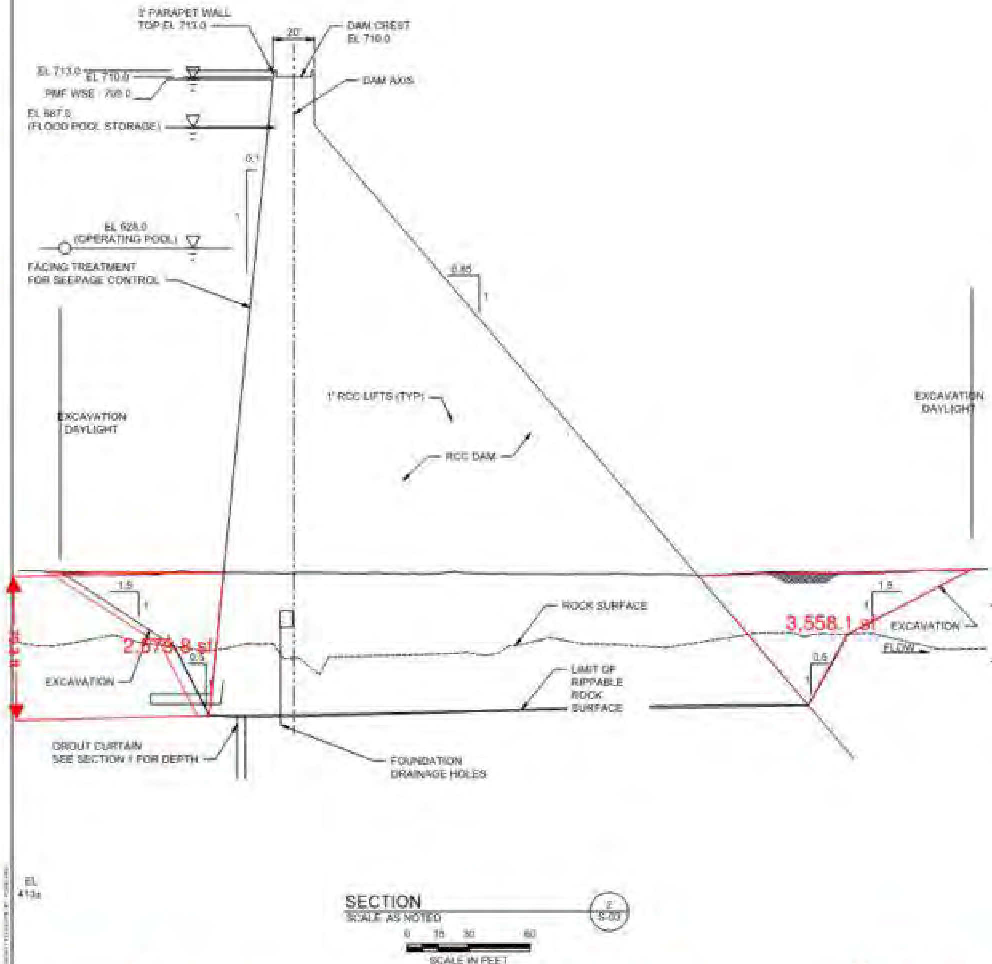
HDR

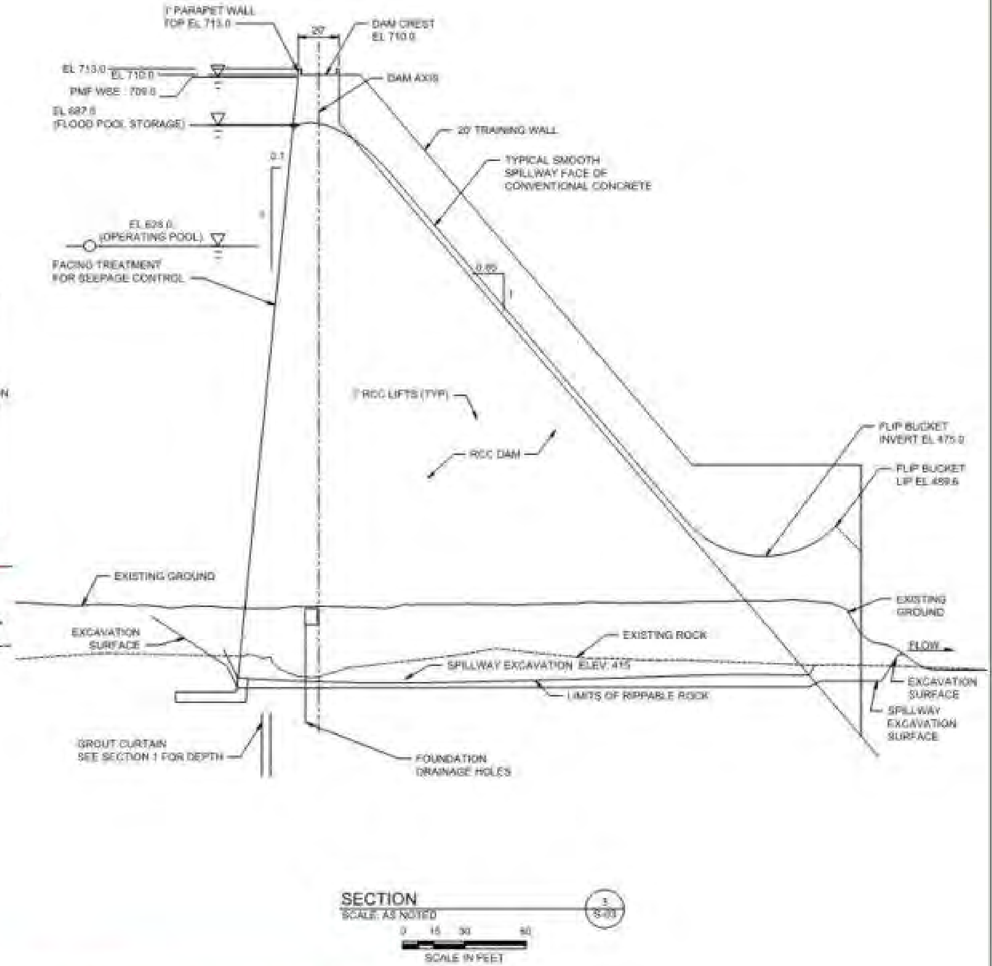
FRFA DAM
DAM EXCAVATION AND FOUNDATION TREATMENT PLAN

CHEHALIS BASIN DAM

DATE: MAY 2017

FIGURE: FRFA-S-1





Backfill - PHI
2580sf x (990'+330'-150')
upstream = 112kcy; 350sf x
(978'+341' - 150') = 15kcy of
5' cover over PHI RCC

PHII - exc 15k PHI backfill + wing.
PHII Backfill -
2580sf x 150' = 14kcy upstream; + 2580sf x
978'+341') = 126kcy downstream full groin
backfill after 5' cover over is removed

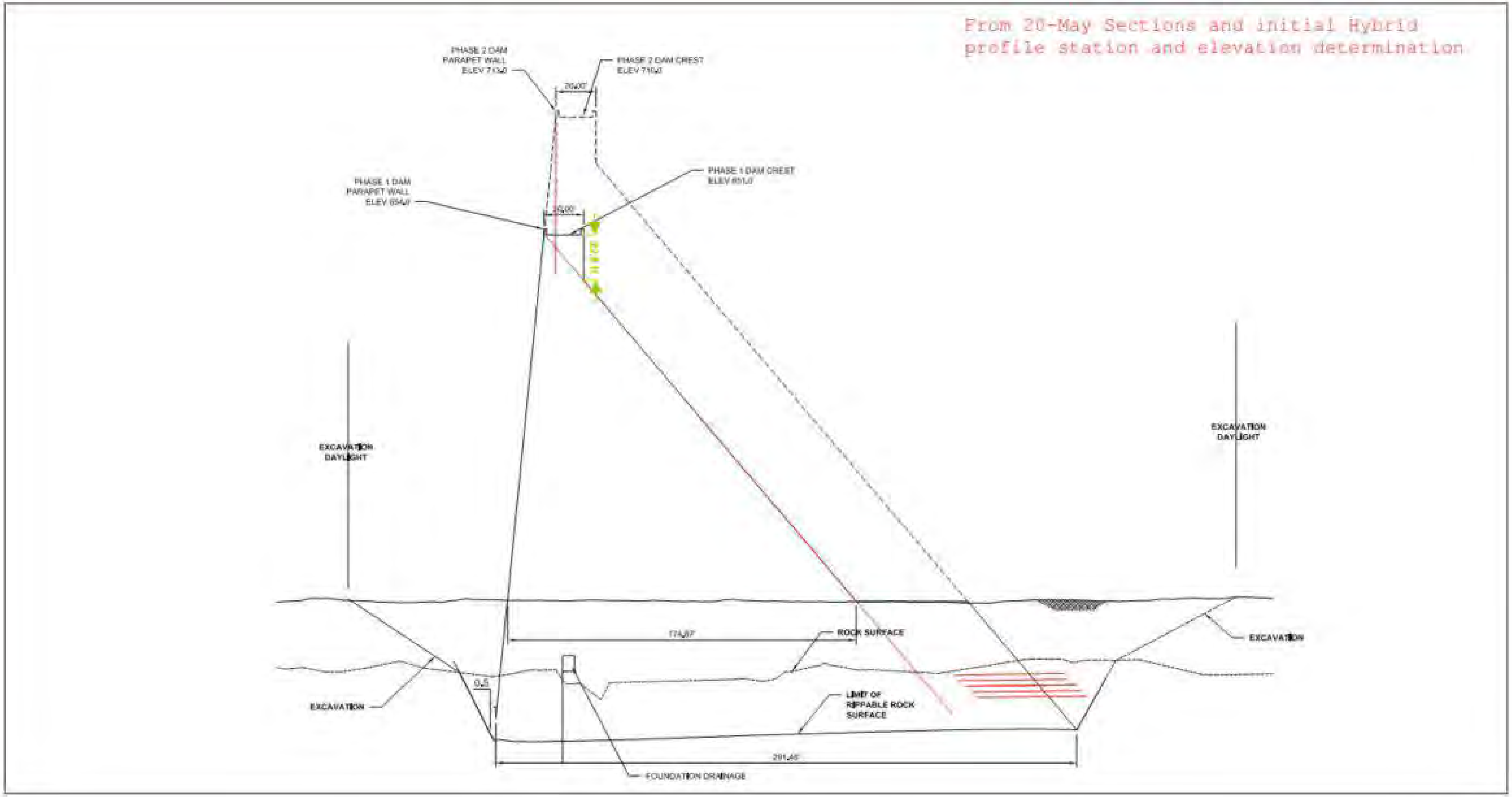
FRO Backfill
(2574sf x (997+331) + 3558sf x (978+541))/27 = 327kcy
say 80% for cross section reduction from section area =
260k cy
FRFA Backfill - say add 2*2574*125' = +24,000cy; totaling
284k cy

FRFA DAM
SPILLWAY AND TYPICAL DAM
SECTIONS 2 & 3

CHEHALIS BASIN DAM

DATE
MAY 2017

FIGURE
FRFA-S-5

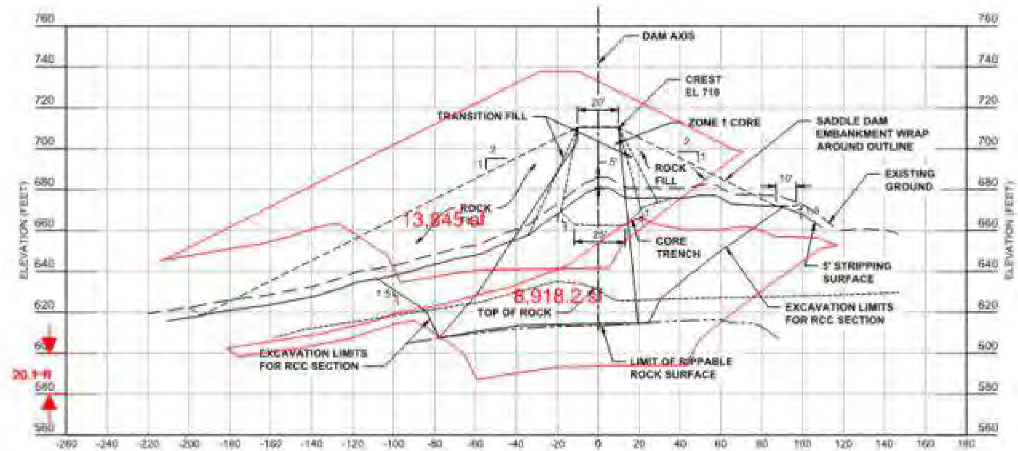


HYB DAM
NON-OVERFLOW DAM SECTION

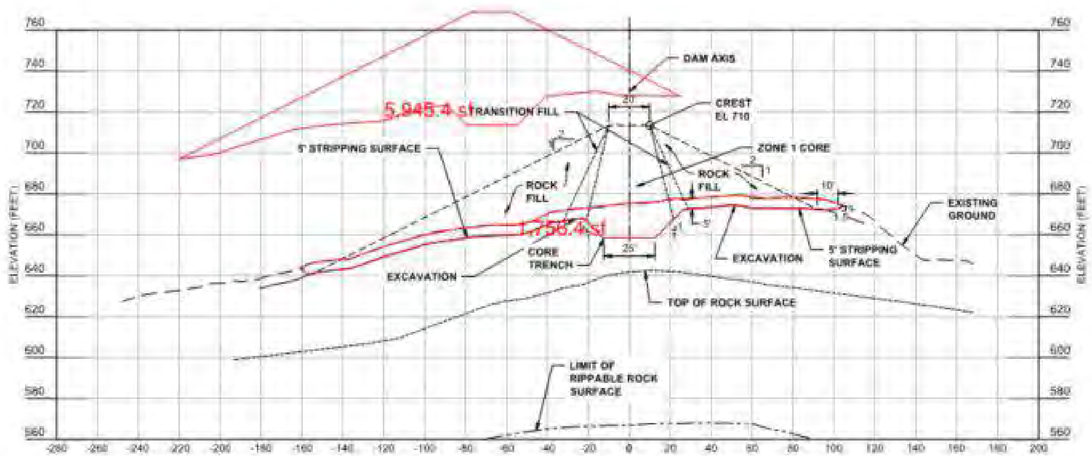
CHEHALIS BASIN DAM

DATE
MAY 2017

FIGURE
X_HYB_Spillway_Section_Struct



SECTION
SCALE: AS NOTED
14
S-01



SECTION
SCALE: AS NOTED
15
S-01

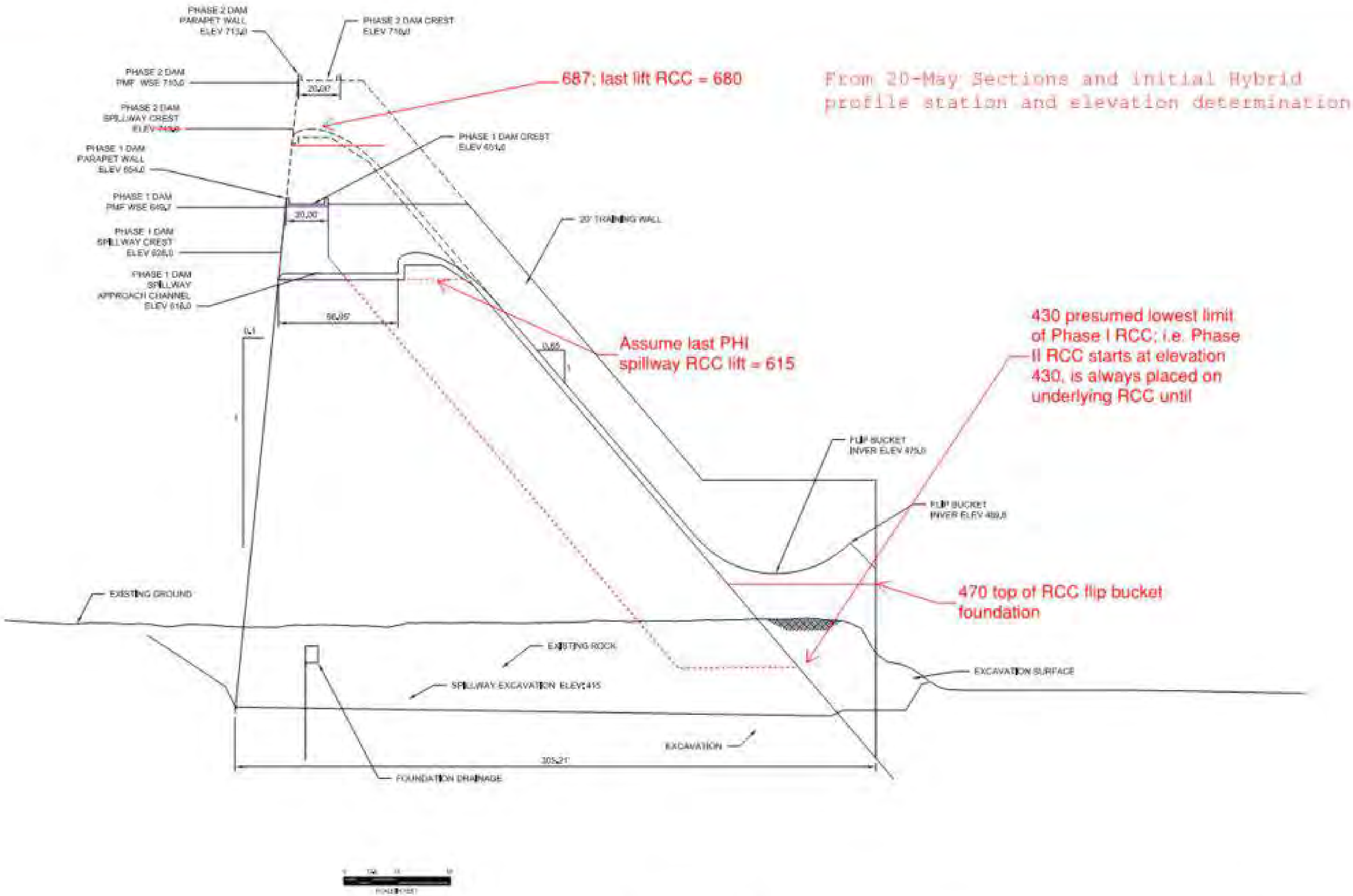
0 15 30 60
SCALE IN FEET

FRFA DAM
RIGHT ABUTMENT
EMBANKMENT DAM TYPICAL SECTIONS

CHEHALIS BASIN DAM

DATE
MAY 2017

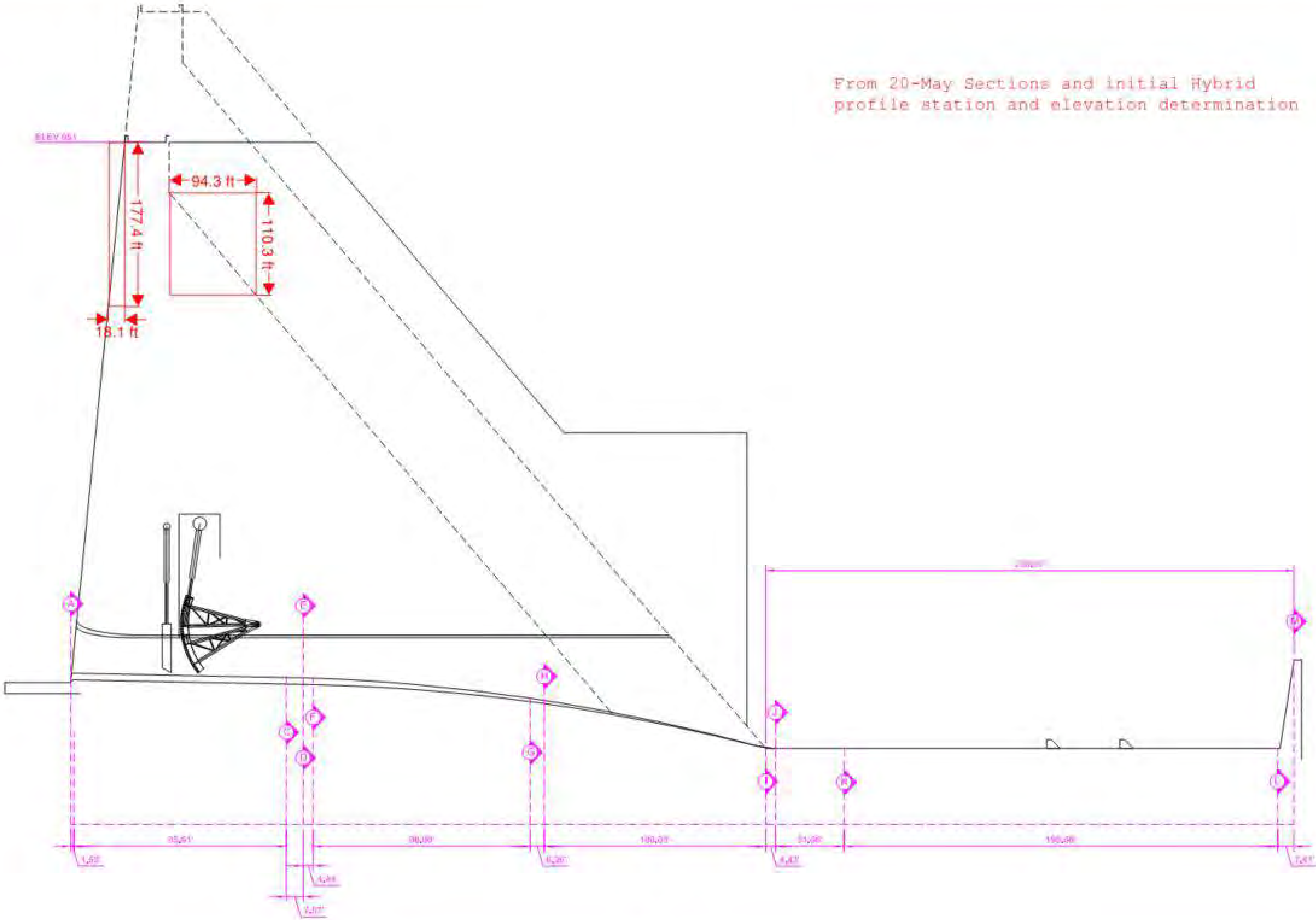
FIGURE
FRFA-S-9

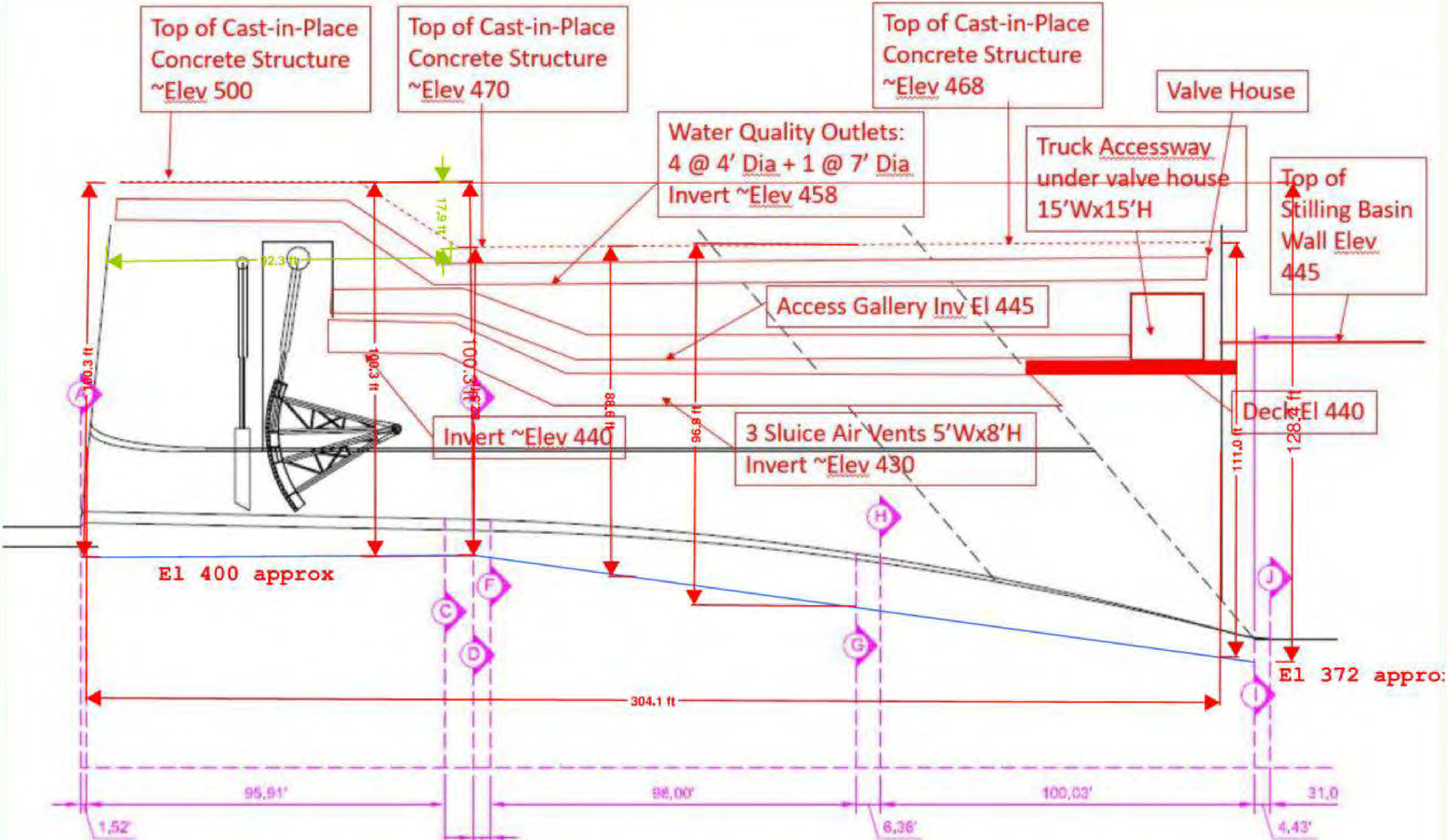


HYB DAM
SPILLWAY SECTION

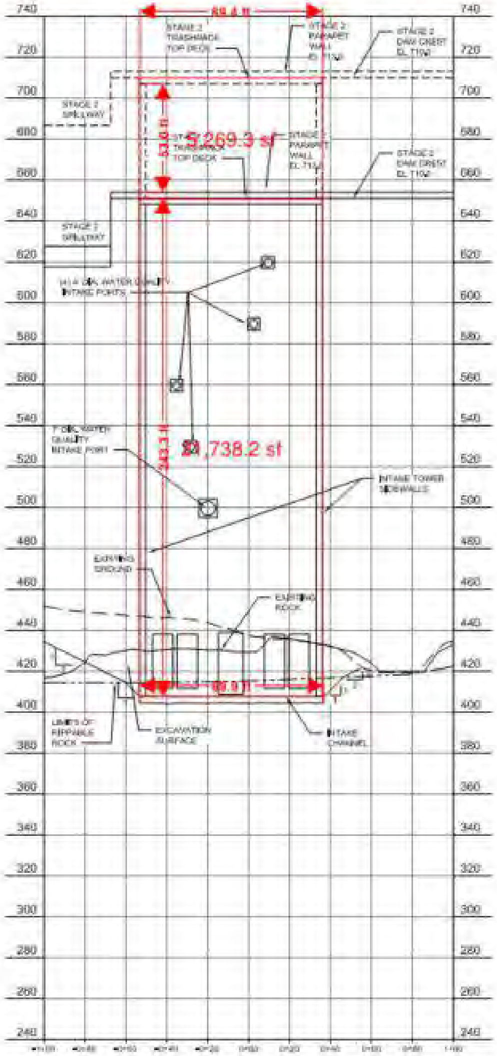
CHEHALIS BASIN DAM

DATE	MAY 2017
FIGURE	X_HYB_Spillway_Section_Struct

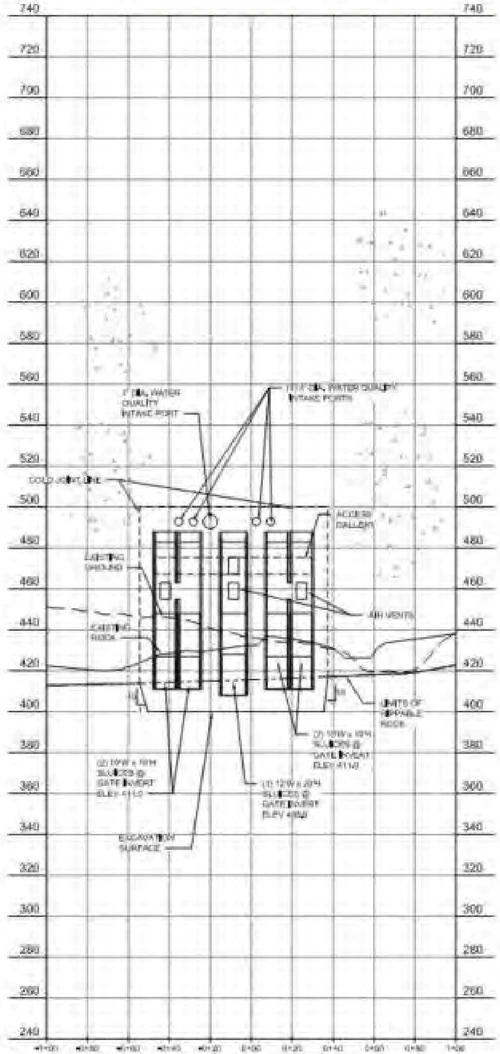

From 20-May Sections and initial Hybrid
profile station and elevation determination
94.3 ft
110.3 ft
177.4 ft
18.1 ft



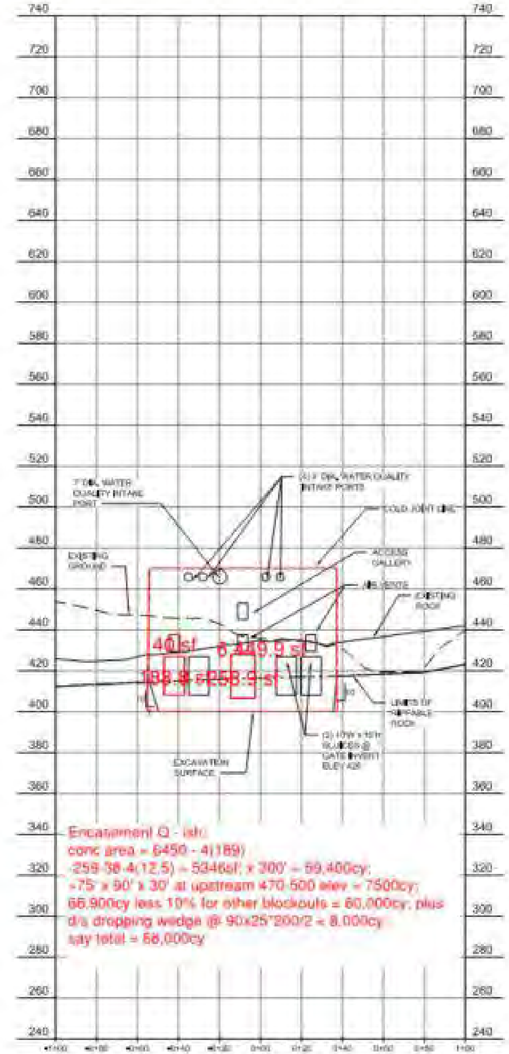
From 20-May Sections and initial Hybrid profile station and elevation determination



SECTION



SECTION



SECTION

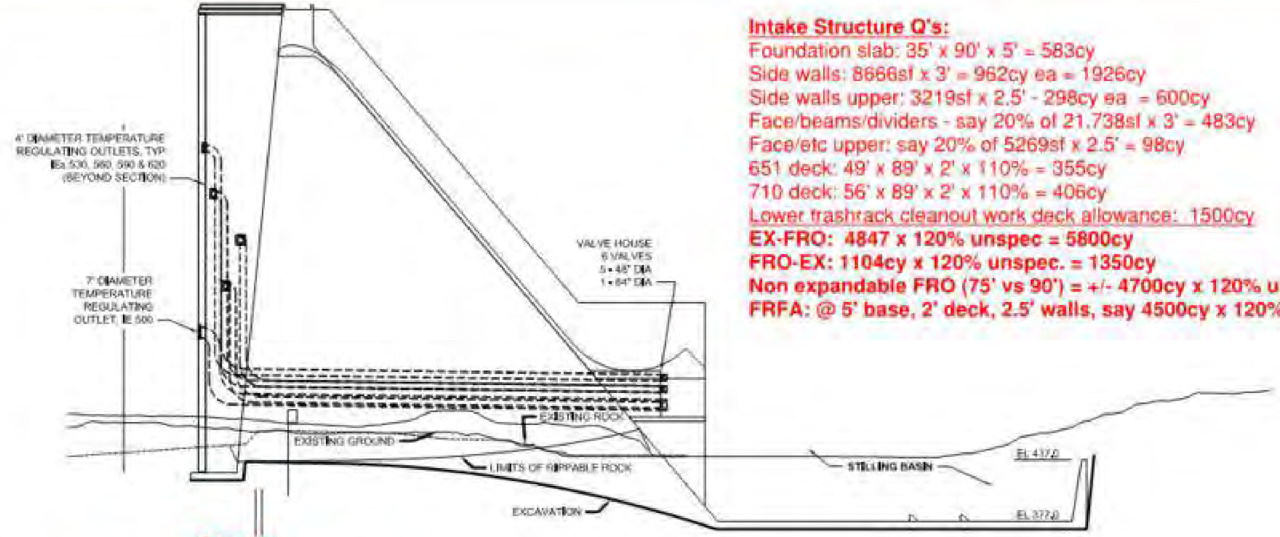
HDR

HYBRID DAM
INTAKE TOWER
SECTIONS 4, 5, & 6 & DETAILS

CHEHALIS BASIN DAM

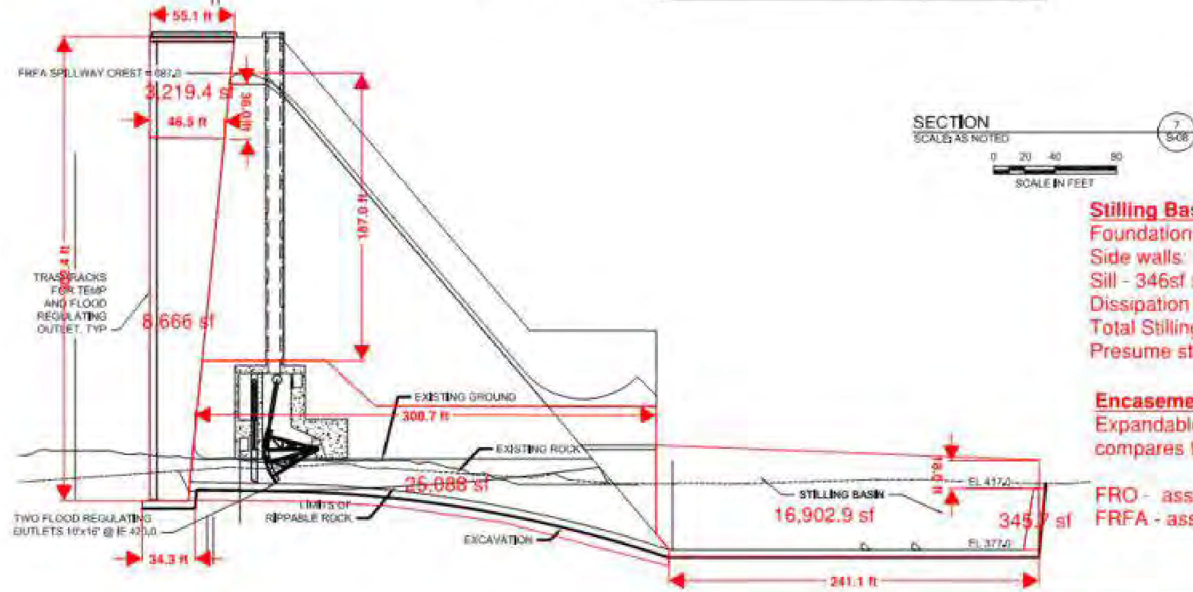
DATE: June 2017

FIGURE: HYBRID-S-6



Intake Structure Q's:

Foundation slab: 35' x 90' x 5' = 583cy
Side walls: 8666sf x 3' = 962cy ea = 1926cy
Side walls upper: 3219sf x 2.5' - 298cy ea = 600cy
Face/beams/dividers - say 20% of 21,738sf x 3' = 483cy
Face/etc upper: say 20% of 5269sf x 2.5' = 98cy
651 deck: 49' x 89' x 2' x 110% = 355cy
710 deck: 56' x 89' x 2' x 110% = 406cy
Lower trashrack cleanout work deck allowance: 1500cy
EX-FRO: 4847 x 120% unspec = 5800cy
FRO-EX: 1104cy x 120% unspec. = 1350cy
Non expandable FRO (75' vs 90') = +/- 4700cy x 120% unspec. = 5650cy
FRFA: @ 5' base, 2' deck, 2.5' walls, say 4500cy x 120% unspec = 5400cy



Stilling Basin Q's (say same for all 4 alts):

Foundation slab: 241' x 90' x 3.5' = 2811cy
Side walls: 16,903sfsf x 2.5' = 962cy ea = 3130cy
Sill - 346sf x 90' = 1153cy
Dissipation blocks & fish passage integ. = say 1500cy
Total Stilling Basin: 8600 cy
Presume stilling basin leveling at 2' = 1600cy

Encasement Q's - Version 2:

Expandable: 25088sf x 90' x 85% full = 71,000cy
compares to 68K from S-6; Use 70K cy

FRO - assume 75/90 reduction o3 83% = 58000cy
FRFA - assume same as FRO = 58000cy

HDR

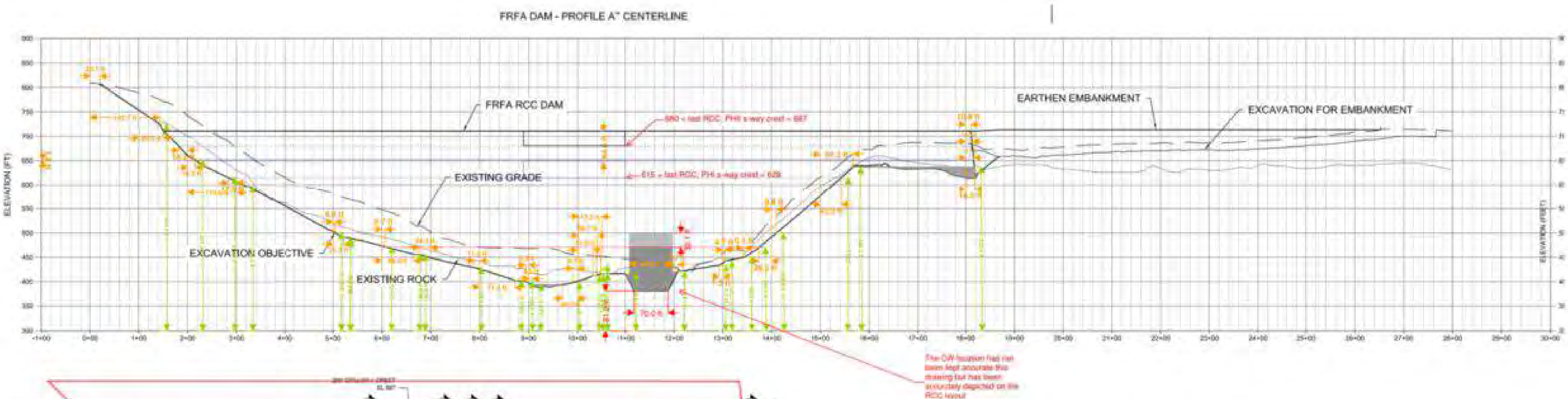
HYBRID DAM
FLOOD CONTROL AND FISH PASSAGE
SLUICES LONGITUDINAL SECTIONS 7 & 8

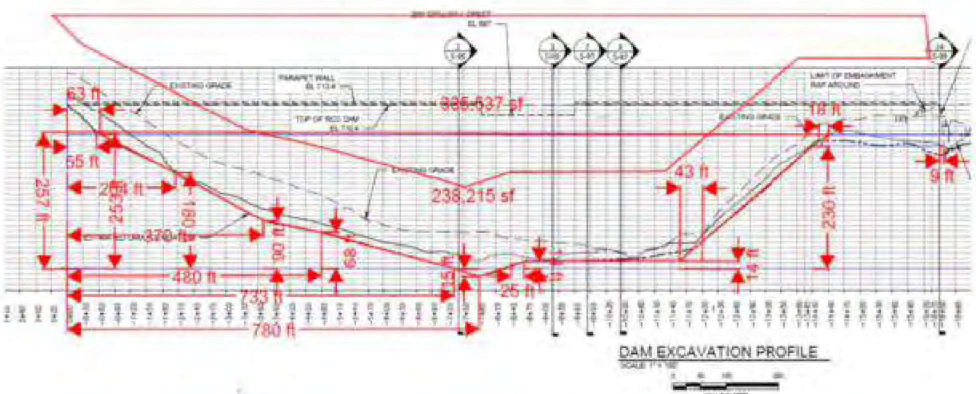
CHEHALIS BASIN DAM

DATE: June 2017

FIGURE: HYBRID-S-7

Excavation surfaces - profile station and elevation capture for illustration support only





A.3. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification. November 30, 2018.

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

2025 NE Kresky Ave
Chehalis, WA 98532-1900

November 30, 2018

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Janelle Leeson
PO Box 3755, Seattle, WA 98124-3755

RE: Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification

Mr. Thomas and Ms. Leeson:

This letter is written in response to the letter received by the Flood Control Zone District (District) on November 5th, 2018. It is our understanding that the Army Corps of Engineers is requesting clarification on the project Purpose and Need, specifically relating to 1) the rational for the selection of the targeted geographic area of Pe Ell and Centralia relative to other areas within the Chehalis River Basin; and 2) the rationale for choosing the specific stream gage metrics and location for flood elevation reduction relative to other gauges within the Chehalis River Basin.

We stated in the Purpose and Need Letter that the objective of the flood retention project is to reduce peak flood levels during a 100-year flood or greater from Pe Ell to Centralia for the protection of families, communities, schools, businesses, churches, farms, industry, and major federal, state, and local infrastructure. This goal is in line with the goal of the Chehalis Basin Strategy to significantly reduce flood damages across a larger geographic area. The Dam plays a part in the Strategy by reducing severity and duration from periodic catastrophic flooding triggered by rainfall emanating from the Willapa Hills, but it is not intended to address flooding in all parts of the basin or tributaries. No single project can achieve that effect, which is why this project has been developed as a cohesive element in a basin wide approach that will utilize other projects to fully address the Chehalis River flooding problem.

The project has a long history, and many decisions have been informed by the various studies and reports evaluating hydrology, hydraulics, geology, environment, economics, and more. In an attempt to summarize the abundance of information, we have extracted pertinent conclusions and added abbreviated supporting quotations from these previous works that have helped form the foundation of the project selections. These studies are also listed at the end of the letter for further reference.

The rationale for the selection of the targeted geographic area of Pe Ell and Centralia relative to other areas within the Chehalis River Basin.

Centralia was selected as a particular area of interest because:

1. The Upper Chehalis floodplain has a history of catastrophic floods (Pe Ell to Centralia). The annual peak flow record at the Chehalis River gage near Doty indicates that significant floods (greater than

20,000 cfs) occurred in January 1972, January 1990, November 1990, February 1996, December 2007, and January 2009.

In the past 60 years, major floods occurred eight separate times starting in 1972, with flood levels and flood damage in the Chehalis Basin increasing. The 1996, 2007, and 2009 floods are the three largest floods on record. The 2007 and 2009 floods occurred only 13 months apart, with minimal opportunity to restore the area between floods.
Peak annual flows from the 1996, 2007, and 2009 floods rank in the top five at stream gages at the Chehalis River near Grand Mound, the Newaukum River near Chehalis, and the South Fork Chehalis River. These extreme floods caused the losses of homes, farms, and businesses, and floodwater inundation resulted in the closure of Interstate 5 (I-5) for several days. The majority of the flood damage occurred in the cities of Chehalis and Centralia where there is more intensive development in the floodplain (PEIS 1.2 pg 4-5)

2. Centralia is centered around Interstate 5. I-5 is of statewide importance as it connects Portland to Seattle and is particularly vulnerable in the Centralia area. In the 1996, 2007, and 2009 floods, the interstate was underwater near the Centralia area, halting commerce, delaying emergency response, and provided a major barrier for travelers.

   The flooding of I-5 is a national, regional, and local issue because the roadway is a major corridor for the movement of people and goods, as well as a primary route for local trips. Flooding in the Chehalis Basin has affected access to I-5, closing it for 4 days in 1996 and 2007, and 2 days in 2009 (WSDOT 2014). WSDOT estimated the total cost of freight delays along I-5 in 2007 in the tens of millions of dollars (Ruckelshaus Center 2012). This amount includes estimates for freight-related business losses and associated reductions in economic output, as well as an estimate of state-wide economic impact, such as employment, personal income, and sales tax receipts. It does not include local economic impacts, impacts due to passenger vehicle delay, BNSF rail closures, or roadway maintenance and repair. WSDOT also modeled the costs of I-5 closure that would occur with a modeled 100-year flood (WSDOT 2014). The predicted costs for a 5-day closure of I-5 are more than $11 million, including costs of additional time and mileage for those who travel on detour routes." (PEIS 3.1.3.1 pg 217)

3. Centralia is in close proximity to Chehalis with a combined population of 23,595 people. Together, the cities constitute one of the highest populations in the Chehalis Basin and consequently, represent one of the highest risk areas to life and property due to flooding. Critical life and safety facilities are located in the metro center, serving the surrounding small towns and rural region.

   The Chehalis-Centralia area has the highest concentration of residential and commercial structures in the Chehalis River floodplain and sustains the most damage during a major flood. (PEIS 3.1.2.2 pg 85)

   Roads in the cities of Centralia and Chehalis (Twin Cities) have experienced some of the most substantial flooding and flood damage in the Chehalis Basin. The Chehalis-Centralia Twin City Town Center has been inundated by floodwaters. At the height of the December 2007 storm, 20

> *square blocks near downtown Centralia were flooded, with resulting access limitations. (PEIS 3.13.2.1 pg 219)*
>
> *...during past flooding events in the Chehalis Basin, access to the Providence Centralia Hospital has been restricted for days at a time (PEIS 3.14.1.4 pg 226).*

Multiple feasibility studies have been conducted to narrow the possible dam locations. Ultimately, Pe Ell was selected as the site for the water retention facility because:

1. The Willapa Hills is the wettest part of the upper Chehalis Basin and high flows in this area are well correlated with the large flooding events in the downstream portions of the basin. Additionally, it was found that flooding on the other main tributaries did not always translate to flooding on the Chehalis River Mainstem.

> *In the Chehalis River headwaters, the Willapa Hills average more than 120 inches of precipitation per year. Previous studies estimate an average rainfall of 73 inches for the entire Chehalis Basin, including its tributaries. (PEIS 3.1.1 pg 77)*
>
> *In an effort to further understand the variability of Chehalis River floods, WSE analyzed data from the top ten annual peaks at the USGS Grand Mound gage (just downstream of Centralia and Chehalis) and the corresponding peaks at major upstream USGS gages, including the South Fork of the Chehalis River at Doty, the Newaukum River, and the Skookumchuck River at Bucoda. A key finding of this analysis is that extreme flood events near Grand Mound are always accompanied by high flows in the Chehalis River headwaters above Doty. WSE made the following observations:*
>
> *1. A large flow on the Chehalis at Grand Mound has never been observed without a correspondingly large flow upstream on the Chehalis River at Doty.*
>
> *2. A large flow at Doty is a reliable (although not perfect) indicator of a large flow downstream at Grand Mound.*
>
> *3. A large flow on the Chehalis at Grand Mound can happen with or without a significant flow contribution from the Skookumchuck River. A large flow on the Skookumchuck is not a very good indicator of large flows downstream at Grand Mound.*
>
> *4. Peak flows on the Newaukum River and South Fork Chehalis are similarly correlated to the downstream flows at Grand Mound; less so than the Doty flows but more so than the Skookumchuck flows.*
>
> *5. Major flood events can be isolated on a single tributary or set of tributaries, and not affect the whole Basin. For example, the 1997 flood on the Satsop was the highest flood on record there, but did not cause major flooding anywhere else in the Basin (Chehalis River Hydraulic Model Development Project pg 454, WSE 2012)*

When storms are centered over the Black Hills and Cascade foothills, they can cause flooding in the Skookumchuck and Newaukum Rivers and locally near the confluence of these rivers with the Chehalis in the Centralia/Chehalis area; however, they generally do not cause major flooding downstream on the Chehalis. (CBFHM Alternatives Report, pg 20, Rucklehaus 2012)

...[It is true that] portions of the basin can see extreme floods while other portions see smaller flood events [the analysis] also supports the conclusion that a basin-wide extreme flood (as determined using the gage at Grand Mound) is only possible with a large contribution from the Upper Chehalis basin. (Chehalis River Hydraulic Model Development Project pg 511, WSE 2012)

2. The reservoir is compatible with the surrounding land uses. The temporary reservoir that would be created will not flood any homes or displace any people. The Dam and associated reservoir will be located on commercial forestland and the land adjacent to the reservoir would continue to remain as working forestland.

   The property immediately surrounding the Flood Retention Facility would remain in use as commercial forestland, and the use of the Flood Retention Facility would be compatible with surrounding land uses. No other changes in land use, including new residential or community development, are anticipated within or adjacent to the reservoir area. (PEIS 4.2.10.2 pg 321)

3. A multi-stage site characterization study found that the geologic conditions at the selected site has favorable geology for a dam.

   Results of the Phase 1 Site Characterization work at the potential Chehalis Dam site have confirmed that foundation conditions are suitable for construction of either an RCC or rockfill dam type. (Phase 1 Site Characterization, Conclusions and Recommendations pg 55)

   Results of the Phase 2 Site Characterization work at the potential Chehalis Dam site have reinforced that foundation conditions are suitable for construction of either an RCC or rockfill dam type with the RCC dam type being preferred. (Phase 2 Site Characterization, Conclusions and Recommendations pg 79)

The rationale for choosing the specific stream gage metrics and location for flood elevation reduction relative to other gauges within the Chehalis River Basin.

The location for the stream gages were selected because:

1. High flows at the Doty gage are strongly correlated with flooding along the Chehalis River Mainstem through Centralia/ Chehalis (explanation provided in #2 above).

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

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2. The Doty gage was used as a reference because it has long history of reliable streamflow data and is near the proposed Dam location.

   There are nine active U.S. Geological Survey (USGS) gages (see Figure 3.1-2) on the Chehalis River that provide information on streamflow rates and water surface elevations. Additionally, there are 15 other active USGS gages and five active Ecology gages in the Chehalis Basin on other rivers and streams. Multiple other gages collected streamflow data in the past, but are currently inactive. Three of the active gages, which have been measuring streamflows for more than 60 years, are referred to as primary USGS gages and are typically used to define the flow of the Chehalis River. These three gages are identified as follows:
   - *Doty – USGS Gage No. 12020000*
   - *Grand Mound – USGS Gage No. 12027500*
   - *Porter – USGS Gage No. 12031000 (PEIS 3.1.2.1)*

3. The Centralia gage is located at the Mellen St. bridge over the Chehalis River, which is adjacent to I-S and a main route to the Centralia Providence Hospital. It is also near business districts, schools, fire stations, and police stations.

The metrics were selected because:

1. They represent a reduction in flood levels at all locations in the basin, with no corresponding increases in flooding. It was important that the project metrics reflected no 'redirected impacts'. In addition, reducing flows in mainstem may allow tributaries to evacuate faster by eliminating backwater. (*See Table 1: Effect of Potential Mainstem Dam Flood Relief Alternative, pg 70 CRBFHM Alternatives Report, Rucklehaus 2012)*

2. It is projected with the proposed reduction levels that I-5 will have only a 1-day shutdown time in the 100-year flood, which was determined to be the most cost effective scenario.

   After careful evaluation, and in consultation with the Washington State Department of Transportation, the Work Group has concluded that additional efforts to protect Interstate 5 from flooding through walls, levees, or raising the road bed from flooding are not cost-effective. With water retention and improvements to the Airport Levee, I-5 would be closed less than one day in a 100-year flood, compared to the current five days. WSDOT has created a detour route in the case I-5 is closed. WSDOT estimated that the direct cost of closing down I-5 in a 100-year flood event is $21.0 million based on detour costs. If a dam is built, the direct cost of closing down I-5 in a 100-year flood event is reduced to $4.8 million, or a net benefit of $16.2 million assuming a portion of the traffic detours.4 Given these factors, the significant expense ($90– $110 million) associated with an I-5 levees and walls project outweighs the incremental benefit of one less day of flooded interstate highway. (Governor's Work Group Recommendation, pg 4, 2014)

3. Based on hydraulic modeling study, the selected metrics appear to be achievable.

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• The Chehalis HEC-RAS model predicts that in a simulated 100-year flood the project lowers flood elevations in the upper watershed 4-10 feet, 2-3 feet in Twin Cities, 1-2 feet at other locations on the mainstem downstream of the Twin Cities, and 0.7 feet at Montesano.
• The Chehalis HEC-RAS model predicts that in the 2007 flood the project lowers flood elevations in the upper watershed 6-12 feet, 3-4 feet in Twin Cities, 2-3 feet at other locations on the mainstem downstream of the Twin Cities, and 1.7 feet at Montesano. (CRBFHM Alternatives Report, pg. 69, Rucklehaus 2012)

If you would like any further information or clarification please do not hesitate to contact me at erik.martin@lewiscountywa.gov or (360) 740-2697.

Sincerely,

Erik Martin, PE

Cc: Board of Supervisors, Chehalis River Basin FCZD

1. Chehalis Basin Strategy Programmatic Environmental Impact Statement, Department of Ecology, September 2016

2. Chehalis Basin Flood Hazard Mitigation Alternatives Report Rucklehaus Center, July 2012

3. Draft Report - Chehalis River Hydraulic Model Development Project (Appendix to Chehalis Basin Flood Hazard Mitigation Alternatives Report December 2012 Rucklehaus Center), Watershed Science and Engineering and West Consultants, July 2012

4. Shannon & Wilson. October 2009, Reconnaissance-Level Geotechnical Report Proposed Chehalis River and South Fork Structure Site

5. Shannon & Wilson. September 2015, Phase 1 Site Characterization Technical Memorandum

6. Shannon & Wilson. September 2016, Phase 2 Site Characterization Technical Memorandum

7. Governor's Chehalis Basin Work Group 2014 Recommendation Report, November 2014

A.4. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification. January 11, 2019.

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

2025 NE Kresky Ave
Chehalis, WA 98532-1900

January 11, 2019

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Janelle Leeson
PO Box 3755, Seattle, WA 98124-3755

RE: Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification

Ms. Leeson:

The Chehalis River and floodplain has been modeled multiple times, each model with increasing complexity and detail. The FEMA flood maps were adopted in 1981, a 1D HEC-RAS model was originally completed in 2012, updated with new LiDAR and cross section data in 2014, and refined with additional data in 2016. More recently a RiverFlow2D hydraulic model was developed in 2018. Each of these models will result in somewhat different flood elevations due to the model technology and topographic and cross section input data used in the model. The vertical datum used in all of these models (NAVD) which is different than that used on many FEMA maps (NGVD) and at some water level gages (local datum). USGS stream gages are another source of flood elevation data but it must be recognized that water levels at these gages can change over time as a result of real time changes in geomorphology and other factors.

Because of the potential confusion resulting from the model and datum issues described above we find it easier to describe the proposal as lowering the flood level by a number of feet, as opposed to providing specific elevations. However, we recognize that for your analysis you will need the flood level reduction to be tied to specific elevations. In Section 5 of this letter we have provided the corresponding elevations from several of the sources listed above.

1. **Map and detailed description of the geographic area and flood elevations for a 100-year flood event under current conditions.**

The attached figure show the floodplain area from Pe Ell to Centralia in a 100 year flood. The flood extents were generated by the HEC-RAS hydraulic model that was produced by Watershed Science and Engineering in 2016. GIS shapefiles are also available for your use, and can be transmitted upon request.

The flood elevations listed in Table 1 are also from the HEC-RAS hydraulic model.

Table 1 Current 100 year Flood Elevations

USGS Stream Gage Location (Station Number)	Elevation (ft msl)
Doty (12020525)	328.8
Adna (12021800)	218.8
Chehalis WWTP (12025100)	183.0
Centralia at Mellen St (12025500)	177.7

2. Map and detailed description of the geographic area and flood elevations anticipated from the proposal.

A map of the proposed area is attached and key flood elevations are in Table 2.

Table 2 Proposed Condition 100 year Flood Elevations

USGS Stream Gage Location (Station Number)	Elevation (ft msl)
Doty (12020525)	317.5
Adna (12021800)	214.4
Chehalis WWTP (12025100)	182.1
Centralia at Mellen St (12025500)	176.1

3. Flood elevation that would result in a 24-hour closure of Interstate 5

The flood elevations listed in Table 2 result in a 24-hour I-5 closure.

4. An explanation of why the targeted maximum closure time of Interstate 5 is 24 hours

The current estimated closure time for I-5 in a 100 year flood is 5 days. Previous study has predicted that the 5 day closure would result in an estimated loss of $11.5 to $20.6 million. A single day closure has an estimated loss of $2.5 million ($1.24 M for each direction).

With the Dam in place, WSDOT would not have to invest any additional funds to achieve the single day closure, which has the highest cost-benefit of any of the options analyzed. However, additional projects by WSDOT may be completed in the future that will bring the closure time to zero. These projects are currently conceptual in nature and are not ready for inclusion in the project application. Future widening of I-5 is anticipated; constructing the additional flood features with the widening project would be an efficient use of public funds.

5. An explanation of how the aforementioned stream gage metrics correspond to targeted flood elevations.

The major flood stage corresponds to a flowrate of approximately 78,000 cfs at Grand Mound which is considered a Phase 3 flood in Lewis County. The following table lists the 100 year flood elevations and the targeted flood reductions that should be subtracted from each elevation to obtain the targeted flood elevations.

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Table 3 Current 100 year Flood Elevation Comparison

River Gage	Existing Phase 3 Flood Elevation[1]	FEMA 100 yr Flood Elevation[2]	HEC RAS Modeled 100 yr Flood Elevation[3]	Targeted Flood Reduction
Doty	323.3	Not Available	328.8	-10 ft
Mellen	175.3	173	177.6	- 1 ft

1. NAVD88 Datum, Data obtained from Lewis County River Reading Website at: http://rivers.lewiscountywa.gov/#/
2. NAVD29 Datum, Data from FEMA Flood Maps
3. NAVD88 Datum, Data from 2016 HEC_RAS 1D Model (WSE)

If you would like any further information or clarification please do not hesitate to contact me at erik.martin@lewiscountywa.gov or (360) 740-2697.

Sincerely,

Erik Martin, PE

Cc: Board of Supervisors, Chehalis River Basin FCZD

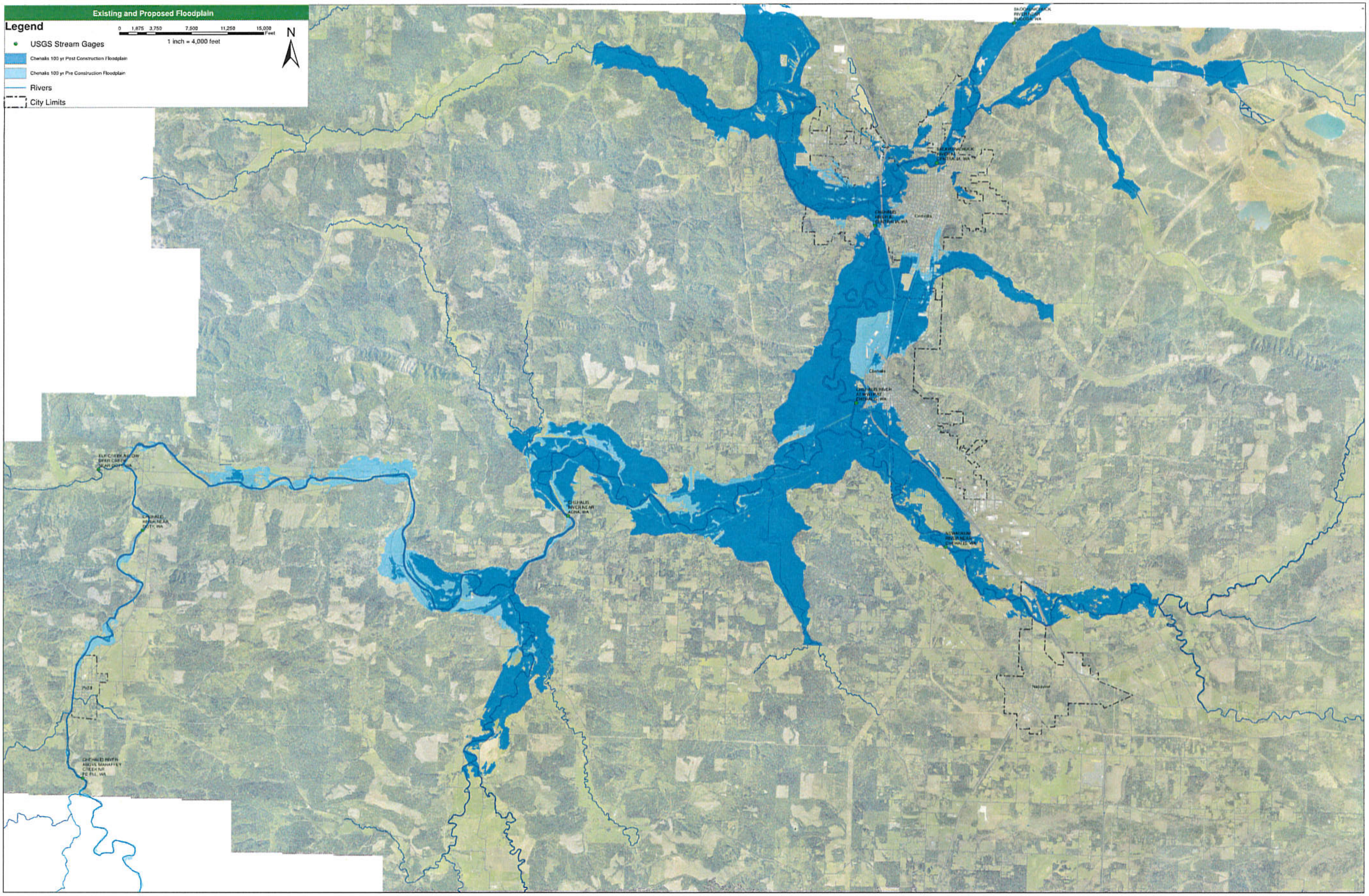
Erik P. Martin, P.E., District Administrator

2025 NE Kresky Ave
Chehalis, WA 98532-1900

1. Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species – development and Calibration of Hydraulic Model, Watershed Science and Engineering, July 2014

2. Comparison of Alternatives Report, EES Consulting Inc. and HDR, Inc., September 2014

3. Chehalis River Basin I-5 Flood Protection near Centralia and Chehalis, Washington Department of Transportation, November 2014


Existing and Proposed Floodplain
Legend
USGS Stream Gages
Chehalis 100 yr Post Construction Floodplain
Chehalis 100 yr Pre Construction Floodplain
Rivers
City Limits
0 1,875 3,750 7,500 11,250 15,000 Feet
1 inch = 4,000 feet
N

A.5. Letter from Betsy Dillin (Chehalis River Basin Flood Control Zone District) to Diane Butorac (Washington Department of Ecology) and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Flood Control Zone District Project Description Clarification. January 14, 2019.

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

2025 NE Kresky Ave
Chehalis, WA 98532-1900

January 14, 2019

Washington State Department of Ecology
Attn: Diane Butorac
PO Box 47600
Olympia, WA 98504-7600

And

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Janelle Leeson
PO Box 3755,
Seattle, WA 98124-3755

RE: Chehalis River Basin Flood Control Zone District Project Description Clarification

The Chehalis River Basin FCZD (District) wishes to clarify and provide more information to aspects of the project that was described in a letter to the WA DOE and USACE dated September 9, 2018.
Specifically, this letter will:

- Identify the quarries and staging areas for the proposed project, including temporary access roads.
- Identify the fish passage plans during construction.
- Identify if the bypass road will be a permanent road.
- Confirm refinements to the pre-construction vegetation management plan.
- Clarify the proposed airport levee proposal.
- Clarify the recurrence interval when the dam will be operated.
- Provide information regarding the estimated timeframe for construction and operation.

Quarries and Staging Areas

The most recent Rock Quarry Characterization study was published in December 2018 by Shannon & Wilson (S&W). The study investigated four potential quarry sites:

- Rock Creek
- Huckleberry Ridge
- North
- South

Of the potential sites, the Rock Creek quarry was not recommended as a viable quarry site, and it has been eliminated from further consideration. The locations of the sites can be seen in the accompanying Figure 1 from the S&W study, and the corresponding APE's can be seen in Figure 2 from the Archaeological Survey and Built Environment Assessment. Both Reports are attached.

The construction site plan has also been revised to eliminate the staging areas and associated access roads to the northwest of the dam location. They were eliminated due to interference with the ordinary high water mark. The revised Site Plan shown in Figure G-4 is attached.

Additional information about the temporary access roads that are associated with the quarries and staging areas is in a Draft Study that is currently under review. This study should be available by the end of January, and the Distict will transmit this study when it becomes available.

Fish Passage

The construction and permanent fish passage facilities are addressed in the attached Technical Memorandum prepared by HDR.

Bypass Road

The District planning to utilize the planned bypass road FR 1000 to access the reservoir area on a permanent basis. However, during flood operations it will experience some temporary inundation. The District envisions that improvements will be made to FR 1000 to make it usable for our purposes.

Vegetation Management

The vegetation management plan will include an integrated harvest and replanting program that will add an additional outcome of minimizing temperature impacts on the river to the vegetation management plan. The harvesting of the current trees along the river that are not water tolerant will be pursued over a multi-year timeframe. Those areas adjacent to the river will be replanted at the same time with water tolerant fast growing trees. We envision the species of trees being willows, cottonwoods and red alder.
Existing conifers further back from the river which would be affected only by a maximum use of the facility and the longest holding and release period could remain until such an event has occurred, if they contributed to providing shade while the replacement species are growing. The remainder of the Vegetation Plan will remain unchanged.

Airport Levee

The Airport Levee remains as it is described in the original Project Description and Programmatic EIS. There has been ongoing discussion within the District of the necessity for the levee to 'bump out' at the northwest corner. The area surrounding this area of the levee has been identified as wetlands and the District would like to avoid these impacts if at all possible. However, there is not enough information or design completed at this time to change the current proposal. The most thorough approach from an environmental impact standpoint would be to keep the bump out as it is planned.

An additional question regarding the Airport Levee is the issue of a floodwall along I-5 that would act as an additional barrier to possible backwater flooding. These floodwalls are only at a conceptual level and have not been designed, and are therefore not included in this project proposal. These floodwalls, along with other small floodwalls or barriers, may be completed in the future by WSDOT; however, the District is not aware of any current budget or proposal for these projects.

Operation

The details of the anticipated operation of the Dam is best described in the Operation Plan for Flood Retention Facilities Report prepared by Anchor QEA, June 2017, attached. Section 2.2.1 describes the threshold for operations.

Grand Mound is a long distance downstream from the Dam site location, so the operators of the Dam will utilize flooding predictions from NOAA and the National Weather Service up to four days in advance. This will cause the operators to operate the Dam on a more frequent interval than the expected 100 year flood recurrence interval. The flow threshold for Dam operations is 38,800 cfs at the Ground Mound gage, which translates to a 7 year recurrent flood interval. This flow rate is approximately 3 feet below the 100 year flood stage at that gage.

Timeline

The long-range funding projections developed for the Office of the Chehalis Basin Board has estimated the start for construction in 2025 and for operation in 2030. This is the best information currently available, the District has not prepared a more detailed timeline.

If you would like any further information or clarification please do not hesitate to contact me at Betsy.Dillin@lewiscountywa.gov or (360) 740-1138.

Sincerely,

Betsy Dillin

Betsy Dillin, PE

Cc: Erik Martin, Chehalis River Basin FCZD Administrator
Board of Supervisors, Chehalis River Basin FCZD

Figure 1
Vicinity Map

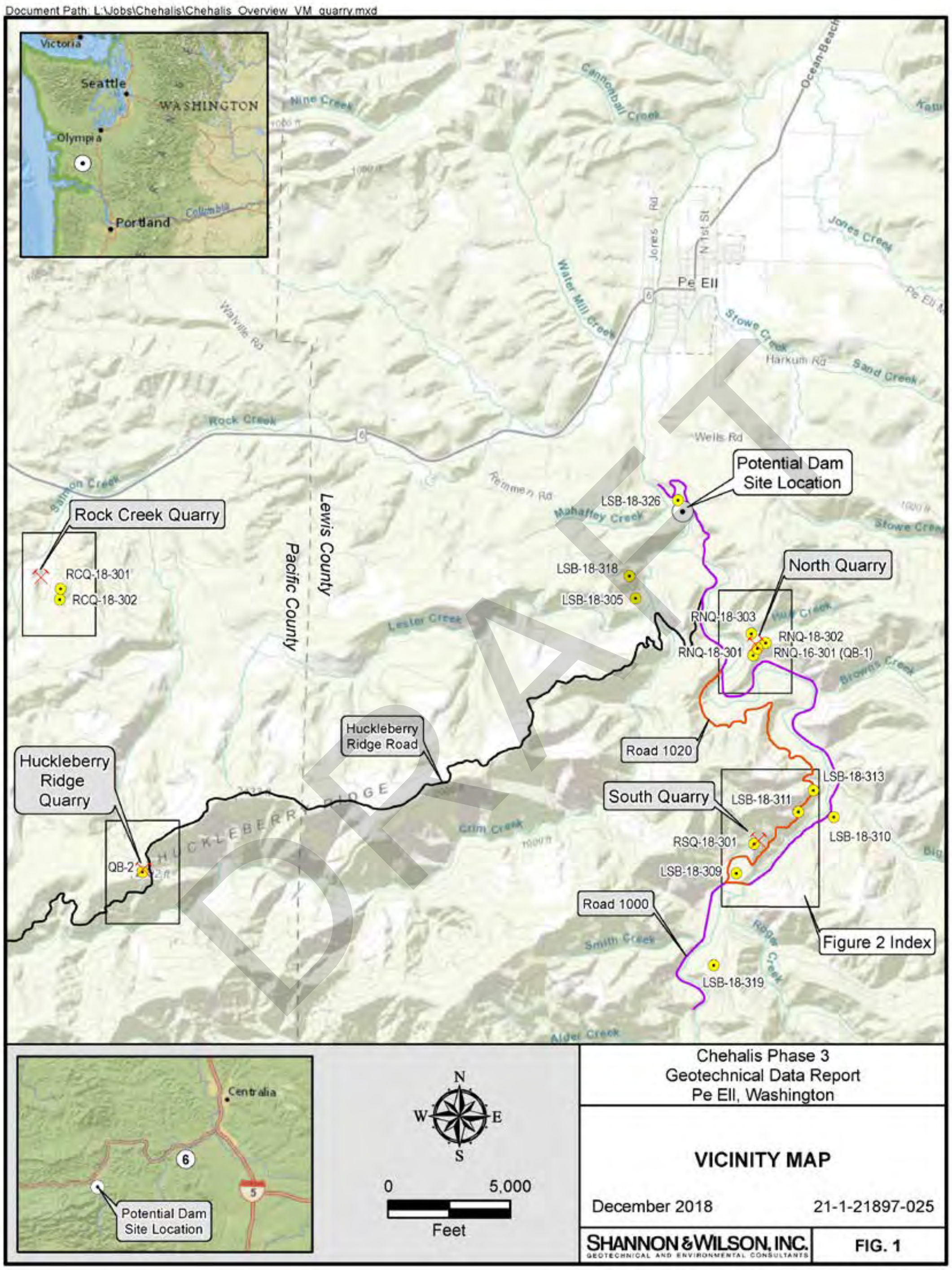
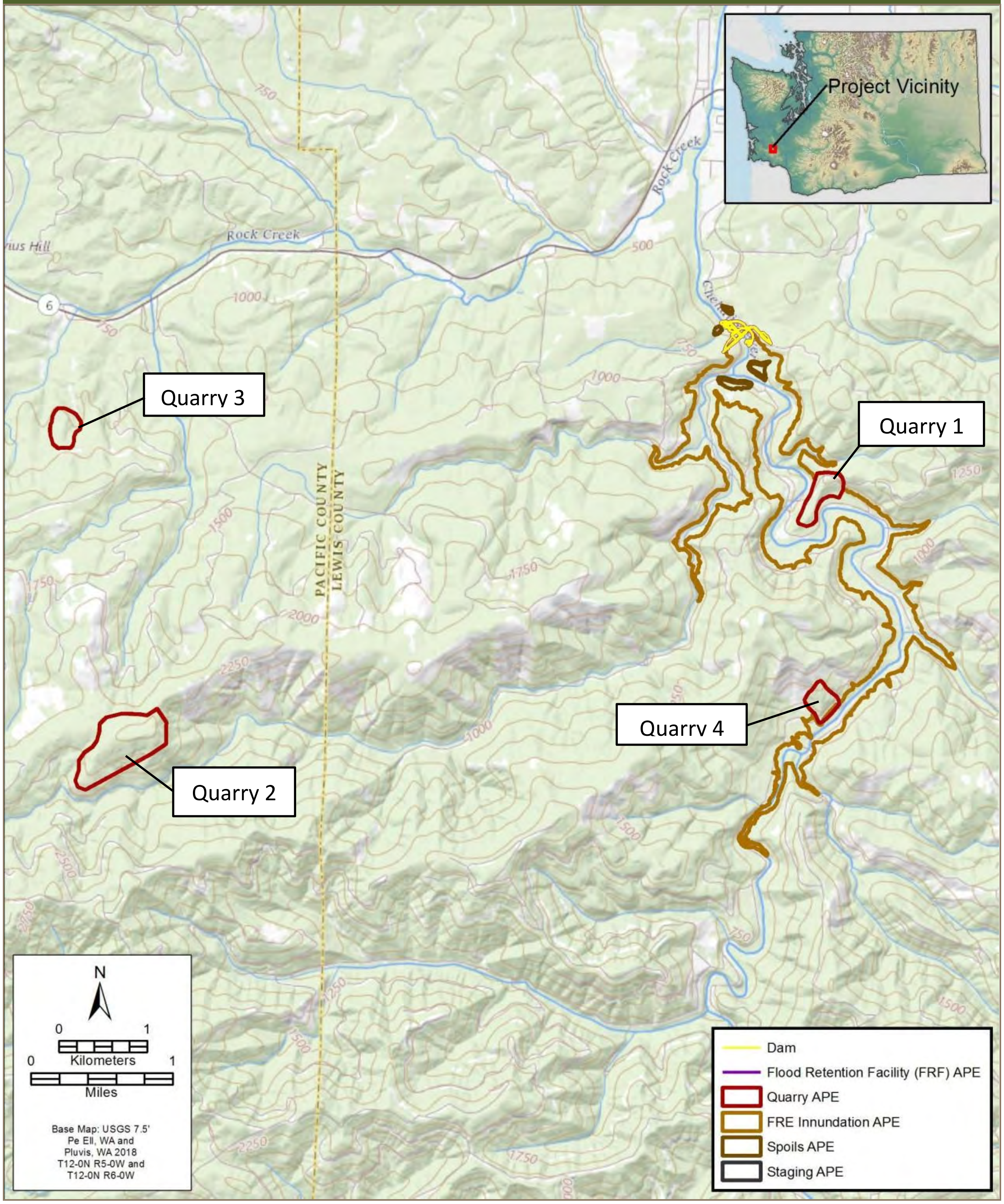
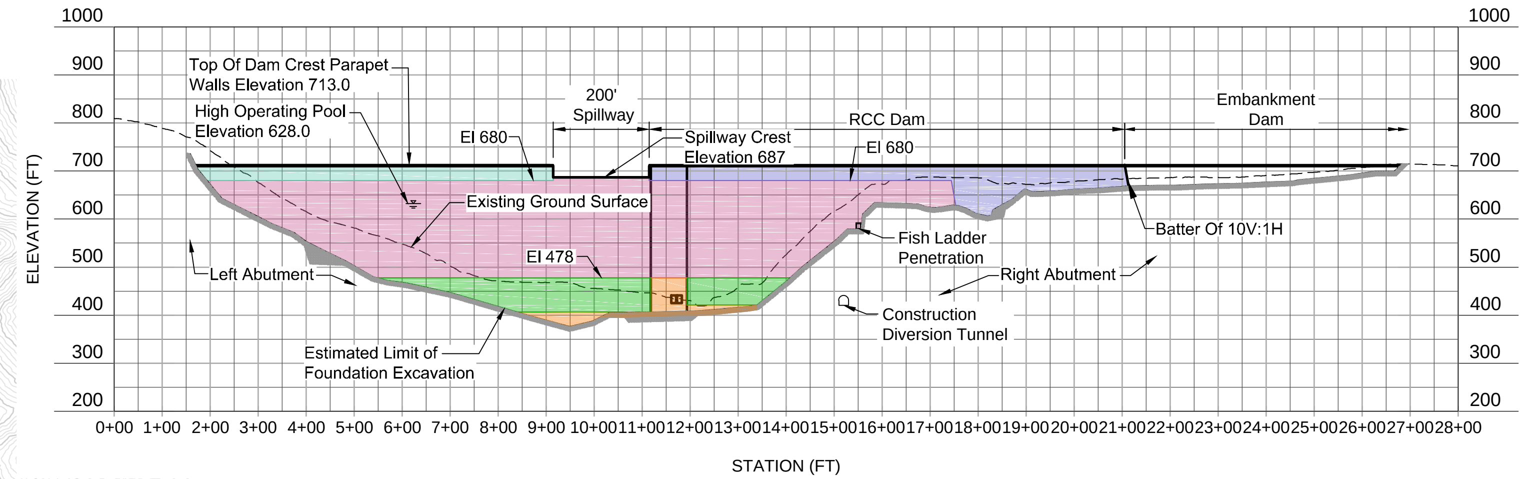


Figure 2
Flood Retention Expandable Areas of Potential Effects

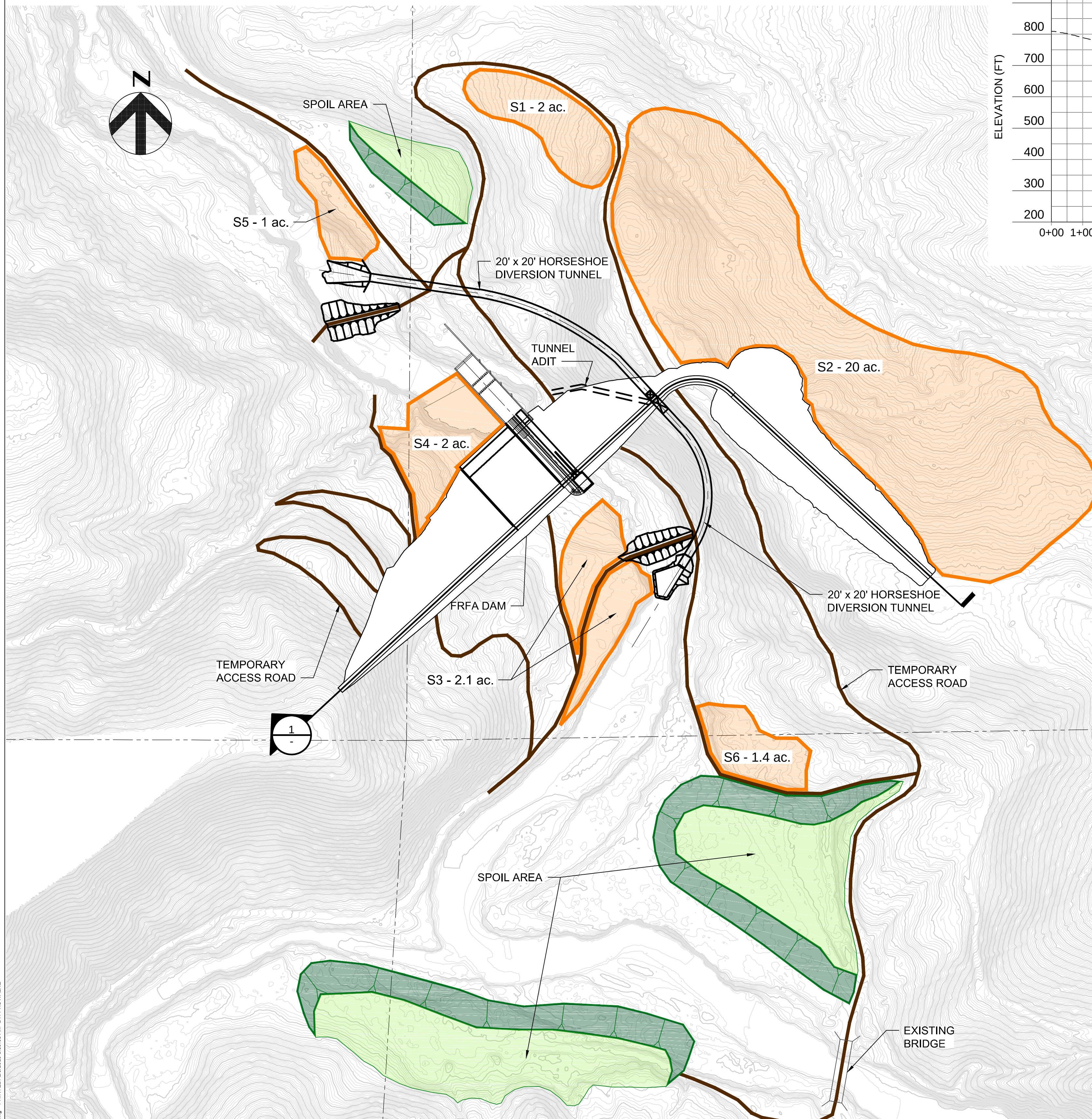




PROFILE LEGEND:

- Phase 1 : Complete foundation leveling concrete, intake and river outlet works encasement that passes through the dam.
- Phase 2 : Place RCC to the top of outlet works encasement .
- Phase 3 : Place RCC to the spillway crest.
- Phase 4 : Place RCC to the dam crest, right of spillway and filling the wing.
- Phase 5 : Place RCC to the crest, left of spillway.

POSSIBLE PHASING PROFILE 1/-



PLAN
(FRFA ALTERNATIVE SHOWN)

0 100 200 400
SCALE IN FEET

PLAN LEGEND:

- S1 - OFFICES, RECEIVING, SECURITY.
- S2 - 1) RCC PLANT, CONVENTIONAL CONCRETE PLANT, COOLING SYSTEMS, CEMENT & FLY ASH STORAGE, SUPPLEMENTARY AGGREGATE STOCKPILES.
  2) FABRICATION & MAINTENANCE.
  3) GATES & MECHANICAL STAGING.
- S3 - STRUCTURE & DAM STAGING
- S4 - (S2 - S3) SUPPLEMENTAL STRUCTURE & DAM STAGING.
- S5 - DOWNSTREAM PORTAL STAGING.
- S6 - UPSTREAM PORTAL STAGING.
- SPOIL AREA
- TEMPORARY ACCESS ROAD

HDR

SITE PLAN, CONSTRUCTION PHASING AND WORK AREAS

CHEHALIS BASIN DAM

DATE: JULY 2017

FIGURE: G-4

Figure 181
Chehalis-Centralia Airport Levee Improvements – Proposed Bump-out Area

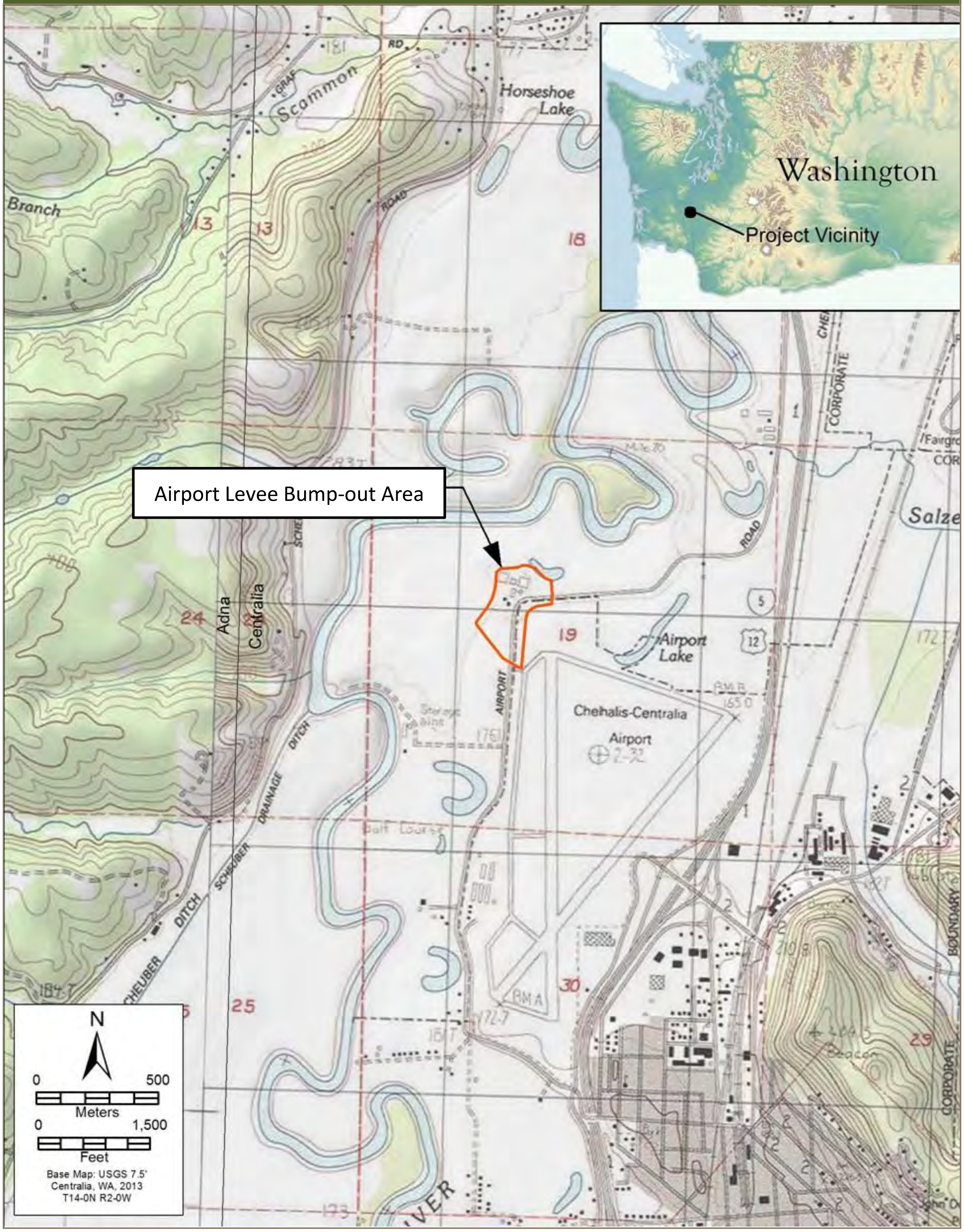
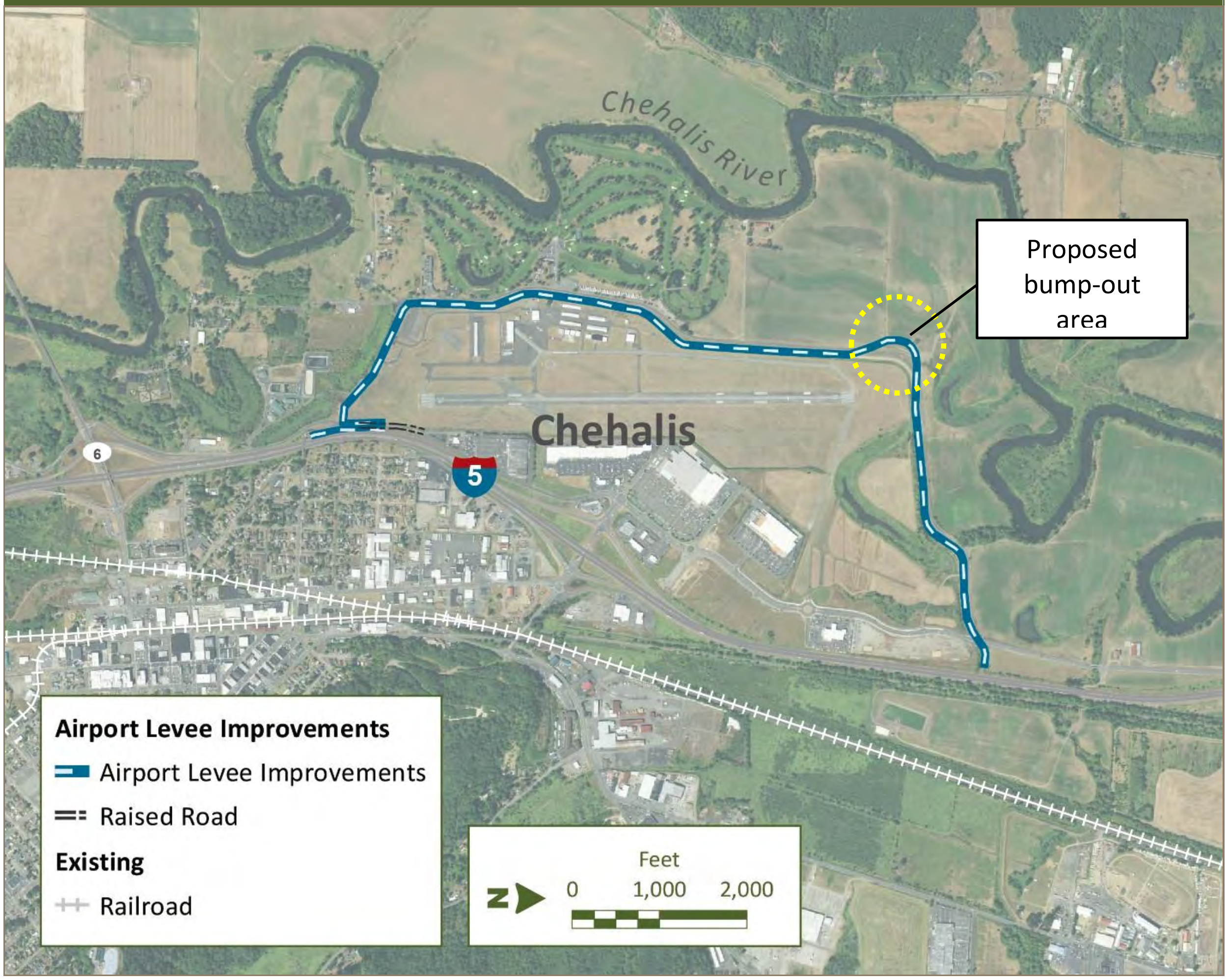


Figure 182
Chehalis-Centralia Airport Levee Improvements



3.2 Cultural Setting

3.2.1 Ethnographic

The Chehalis-Centralia Airport is within the traditional territory of the *qʷayaił*, or Upper Chehalis people, who traditionally spoke the Upper Chehalis language (Marr et al. 1980; Spier 1936). The subgroup of Upper Chehalis who lived near the townsite of Chehalis was known as the *ʔílawiqs* (Hajda 1990). The Upper Chehalis are considered to be part of the larger shared cultural group of Southwestern Coast Salish people (Hajda 1990).

Upper Chehalis villages were often located along *nsulápš* (the Chehalis River) and its tributaries. Permanent winter villages consisted of cedar plank houses that could be occupied by up to 8 or 10 families. A village known as *téw̓tn̓* was located approximately one mile above (upriver) from the mouth of the Skookumchuck River, which would be near today's Chehalis-Centralia Airport. Many other villages

DRAFT Technical Memorandum

To:	Erik Martin, Betsy Dillin, and Jim Waldo, Chehalis Basin Flood Control Zone District (FCZD)
From:	Matt Prociv and Mike Garello, HDR
Project:	Chehalis River Basin Flood Damage Reduction
Date:	1/9/2019
Subject:	Simple Description of Fish Passage Operation

The content of this memorandum describes the proposed fish passage strategy during construction and normal operation of the potential Flood Retention Facility – Expandable (FRE) on the Chehalis River near Pe Ell, Washington. A more detailed description of the possible permanent fish passage[1] facility may be found in the *Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Fish Passage: CHTR Preliminary Design Report* (December 2017).

1.0 Need for Fish Passage

The Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species Project (CBFS Project) initiated by the State of Washington is evaluating the feasibility of mitigating flood hazards within the basin while exploring opportunities to enhance ecological conditions, aquatic habitat, and the abundance of fish in the basin. One of the proposed avenues to mitigate flood hazards within the basin is construction of the FRE. The FRE is a channel spanning structure which is anticipated to impede fish passage during the construction period and portions of normal operation. The Chehalis Basin contains diverse populations of resident, anadromous, and fluvial fish species, under the purview of the USFWS[2], WDFW[3], and NMFS[4]. The integration of fish passage systems is a component of the flood mitigation structure design required by the governing agencies to reduce the impact of the facility on existing fish populations in the Chehalis Basin. Fish passage is also required by the State of Washington's regulatory authority defined in Revised Code of Washington (RCW) 77.57.030, *Fishways required in dams, obstructions – penalties, remedies for failure,* which requires that dam owners provide safe and timely fish passage for all fish species and fish life stages present in an affected area.

The potential FRE dam on the Chehalis River is designed to minimize impacts to natural fish passage by operating as a run-of-river structure during normal operating conditions. The flood mitigation structure is anticipated to allow for unimpeded passage of aquatic species upstream and downstream of the project site. Passage of aquatic species is expected to be impeded only during construction of the FRE facility and during infrequent impoundment events. Construction is anticipated to occur over a period of about 3 years while flood retention (impoundment events) are anticipated to occur for periods of three to four weeks statistically once in every 7 years. The

[1] Fish passage throughout this document refers to the upstream and downstream passage of endangered, threatened, and unlisted adult and juvenile salmonids, anadromous trout (steelhead, cutthroat), resident fish species, and lamprey.
[2] USFWS: United States Fish and Wildlife Service
[3] WDFW: Washington State Department of Fish and Wildlife
[4] NMFS: National Marine Fisheries Service

duration of construction is long enough that impeding passage for the construction period could adversely impact fish health and species abundance. Impoundment periods during operation of the FRE are of short duration and delay in downstream passage is not anticipated to impact fish health or abundance enough to necessitate downstream passage facilities. However, these periods are anticipated to be of long enough duration that salmon and steelhead moving upstream may delay arrival at their spawning grounds and impact their ability to successfully spawn if no passage avenue is provided. There is the possibility that several impoundment events could occur in adjacent years or in the same year. If the duration and frequency of these events impact their ability to spawn, it may result in substantial negative impact to the population for that generation and subsequent generations. As such, temporary upstream fish passage facilities are proposed during construction and permanent upstream passage facilities are proposed for the operating FRE. An additional benefit of having both temporary and permanent fish passage facilities is that it provides the opportunity for scientists to collect and examine aquatic species in the Chehalis River to evaluate biometrics, population distribution, and behavior.

2.0 Fish Passage During Construction

The most pragmatic and cost effective strategy to provide fish passage past the project site during construction is to utilize the construction diversion tunnel for downstream passage and construct a temporary trap and transport facility downstream of the construction diversion tunnel outlet to facilitate the upstream passage of fish. The construction diversion tunnel will be used to provide a safe, timely, and effective passage route downstream past the construction site for aquatic species. However, velocity in the tunnel prevents its use as a viable upstream passage route. As such, a temporary trap and transport facility (TTT) will be needed. The TTT will include a fish passage barrier downstream of the tunnel outlet direct all the fish passing upstream into the fish trap. The fish trap is anticipated to collect adult target species[5], resident fish, and lamprey. Once in the trap, species will be transferred to tanks specially designed for transporting them. Personnel will drive the tanks upstream to pre-determined release sites selected by fisheries biologists. The species will be released back into the river to continue their migration upstream. Once construction is complete and the FRE begins normal run-of-river operation, the TTT will be removed.

3.0 Permanent Fish Passage

3.1 Fish Passage Operation During Normal River Conditions

The FRE dam is designed so fish may pass upstream and downstream through the dam in conditions that mimic or improve upon the natural rock canyon through which the Chehalis River now passes at the project location. Under most flows fish will pass through the dam via five (5) outlet conduits – one (1) 12 foot wide by 20 foot high, and four (4) 10 foot wide by 16 foot high. Conduits will be closed and opened, depending on river flow, using radial control gates, to maintain optimum fish passage conditions in the conduits. The conduits discharge into a 240 foot long stilling basin. Most of the year, when no impoundment is occurring, aquatic species passing upstream will be able to move from the river, into the stilling basin, through the conduits, and back into the river upstream of the FRE. Species passing downstream will follow the same path in the opposite direction. A

[5] Target species are species that are listed as endangered, threatened, or species of concern by the National Marine Fisheries Service (NMFS) and the Washington state Department of Fish and Wildlife (WDFW).

section of the FRE illustrating run-of-river operation through the conduits and stilling basin is show in Figure 1 below.

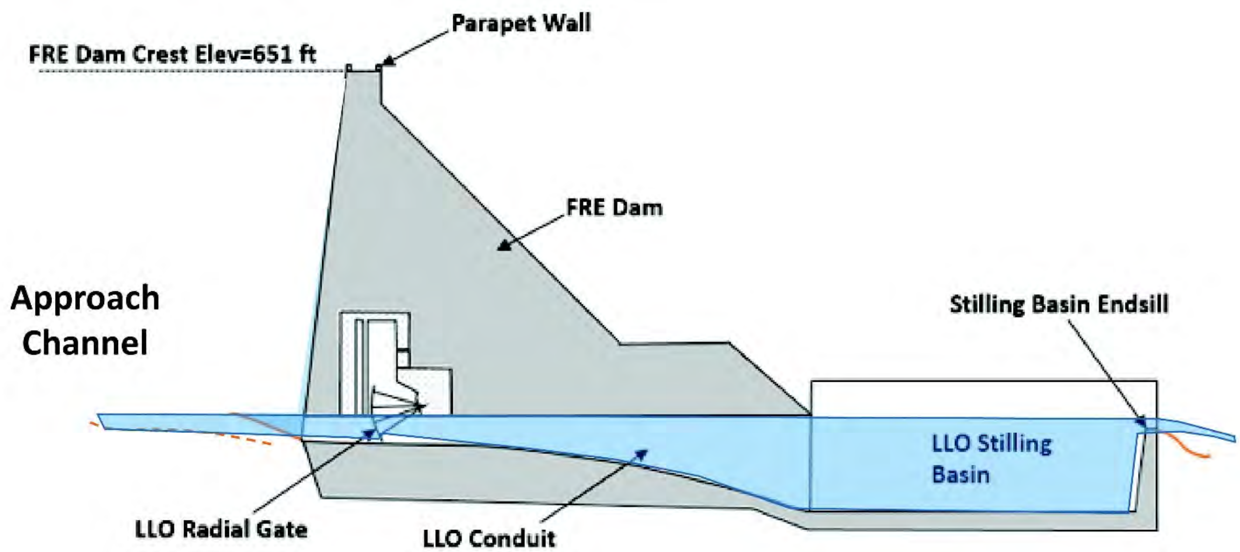


Figure 1: FRE Dam Section Showing Flow Through the Structures

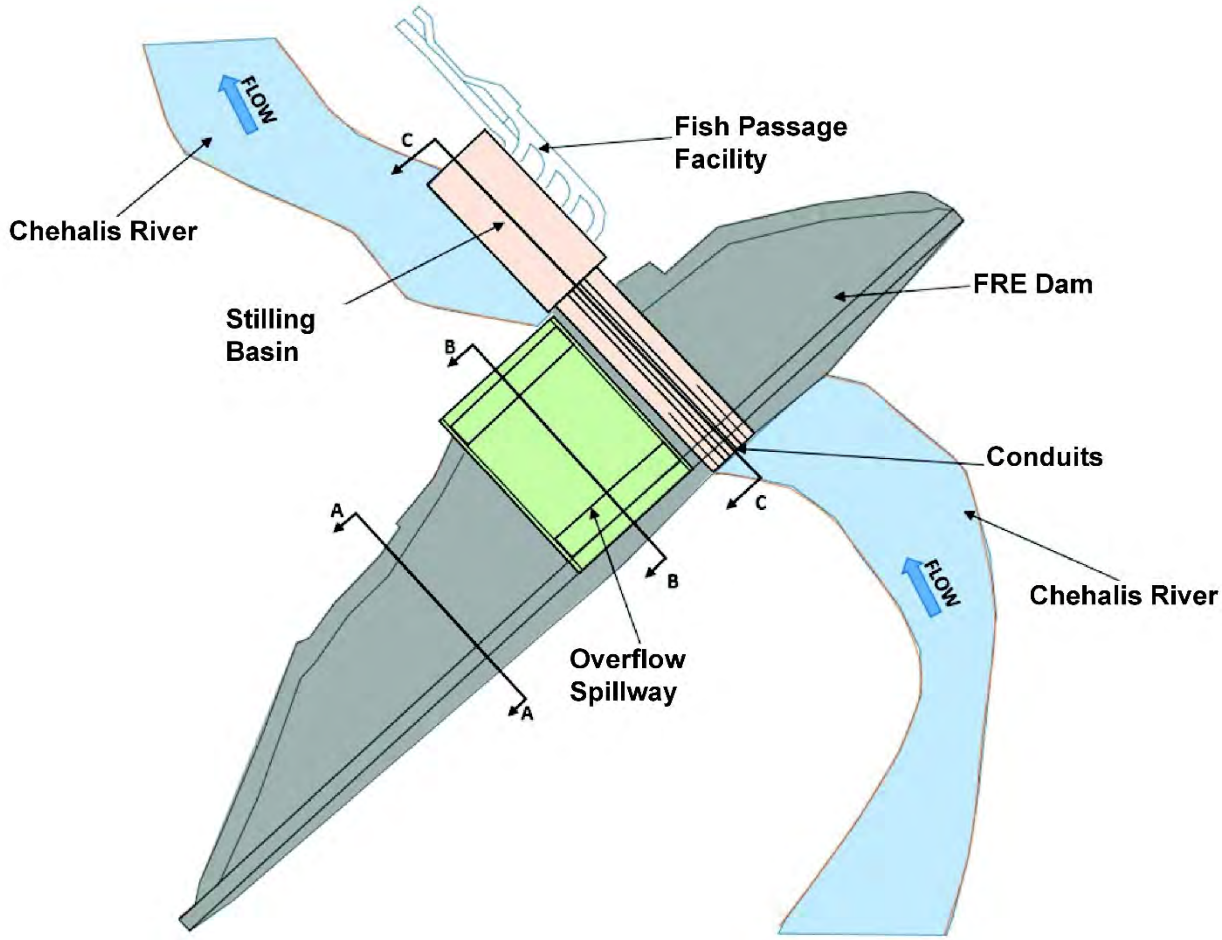


Figure 2: FRE Dam and Fish Passage Facility Overhead View

3.2 Fish Passage Operation During Impoundment Events

Once every seven years, on average, a rainfall event is expected to occur that will trigger the FRE dam to change from its normal run-of-river operation to impound water. Water is impounded during these events to reduce flooding downstream. While water is stored behind the FRE dam and as it is released following the impoundment period, fish will not be able to pass through the dam via the conduits. To prevent such a negative impact, a trap and transport facility adjacent to the stilling basin will be operated to collect fish and transport them to pre-selected release sites upstream of the dam.

The permanent trap and transport facility is referred to as the Collect, Handle, Transfer, and Release facility, or CHTR. The CHTR consists of an attraction water supply to draw fish into the facility, fish ladders and a lamprey ramp to guide them to the fish traps, trap and holding facilities, a fish sorting building, fish transport tanks and trucks, and ancillary support structures, as shown in Figure 3. During an impoundment event, the radial gates in the dam conduits are closed or mostly closed. Water is supplied to the fish ladders, attraction water supply, and holding and sorting facilities via a gravity pipeline from the stored water upstream or the pump intake. The attraction water attracts fish passing upstream from the river, into the stilling basin, and into the fish ladders. Water supplied to the fish ladders and lamprey ramp entice fish and lamprey to pass upstream to the traps where they are held. Design of the juvenile/resident fish ladder and lamprey ramp are based on the best available science, including studies published as recently as 2018. Once trapped, fish may be sorted or passed into transport tanks and moved upstream of the dam. Upstream of the dam, fish are released into the river at locations determined by fisheries and lamprey biologists.

Operation of the CHTR facility will begin when a flow determined by the FCZD occurs at the stream gage downstream at Grand Mound. Immediately prior to the closure of the conduit radial gates, the CHTR facility will begin operation, attracting and trapping fish and lamprey. Operation of the CHTR will continue through impoundment of water behind the FRE dam, as the reservoir is evacuated, as release from the reservoir is slowed for debris management, and as the last remaining water in the reservoir is released. This process can last several weeks. An example hydrograph of the January 2009 flood event is provided in Figure 4 below, indicating how the CHTR would have operated during that flow event. Once the reservoir is evacuated and the FRE dam returns to normal run-of-river operation through the conduits, the CHTR facility will be shut down. As part of the shutdown of the CHTR facility, any remaining fish will be safely removed and returned to the river, the fish ladder entrance gates will be closed, and the water supply turned off. The CHTR facility will be cleaned, prepared for the coming extended dormant period, and secured.

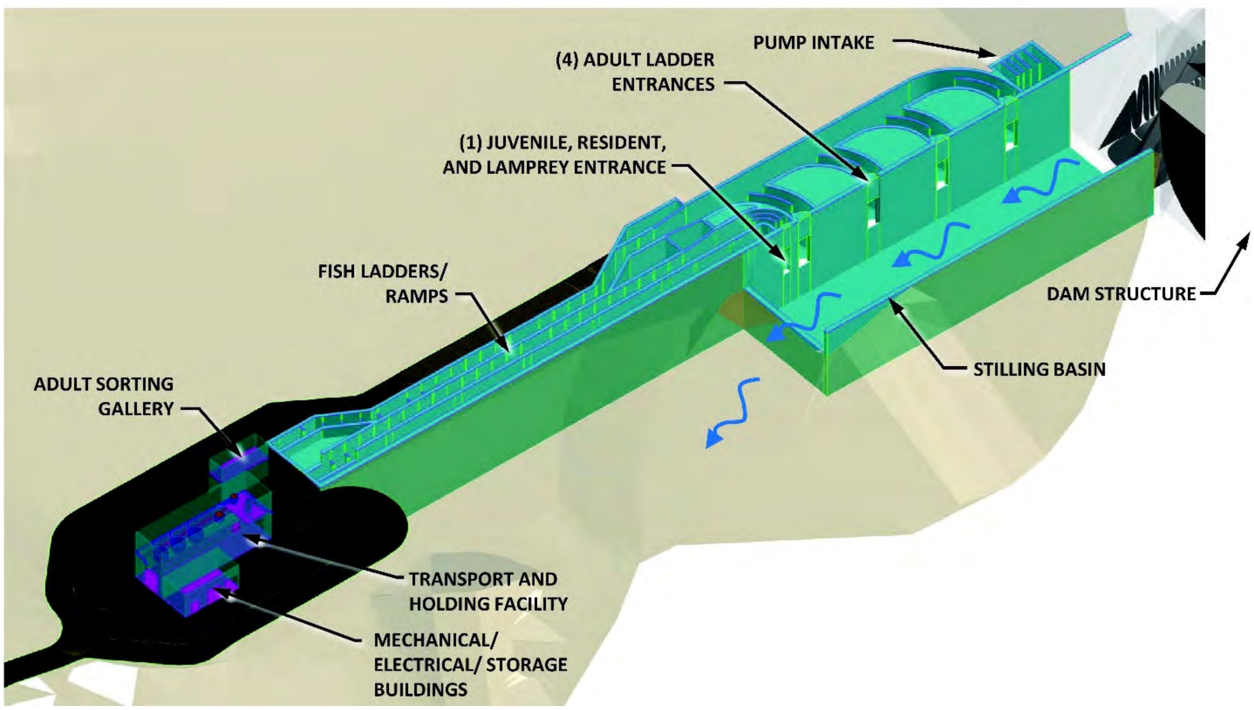


Figure 3: Isometric View of CHTR Fish Passage Facility

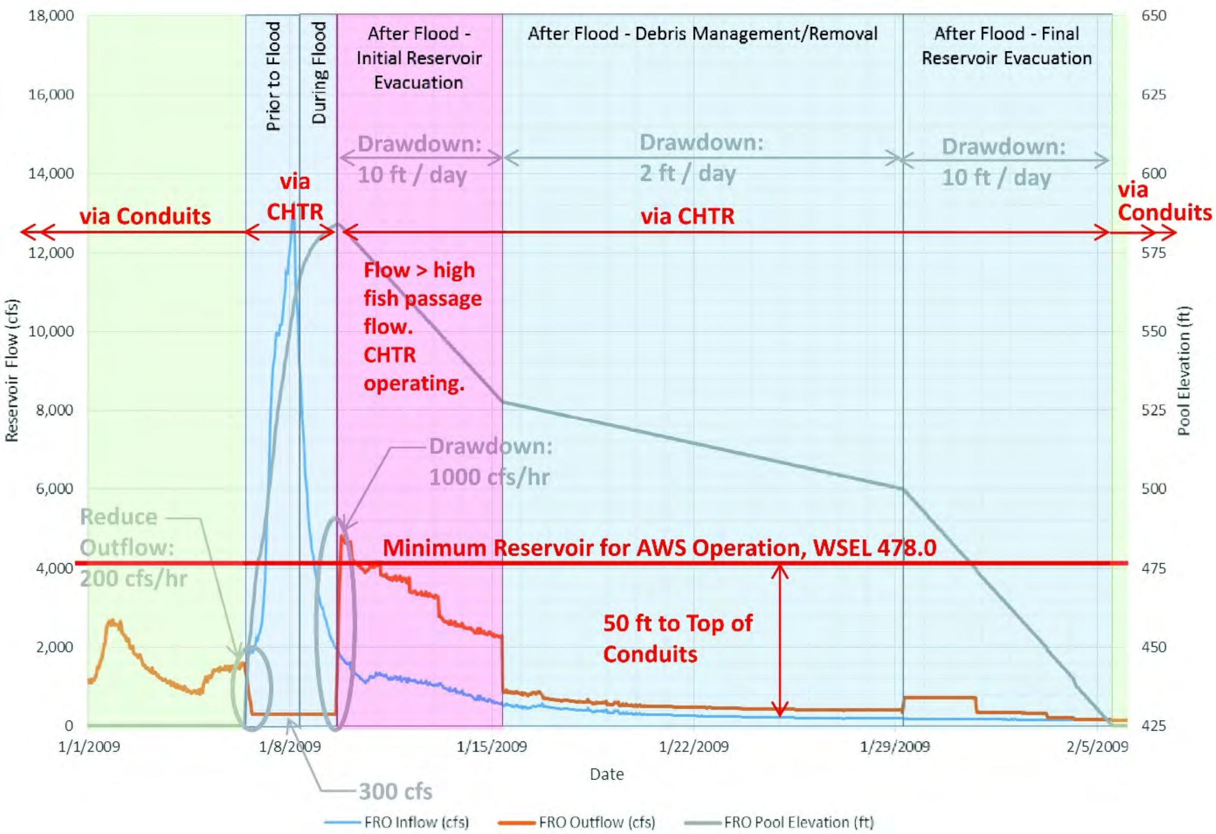


Figure 4: Example January 2009 Flood Event Hydrograph with CHTR Operation Overlay

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Chehalis Basin Strategy

Operations Plan for Flood Retention Facilities

Reducing Flood Damage and
Restoring Aquatic Species Habitat

Prepared by
Anchor QEA, LLC

June 2017

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ACRONYMS AND ABBREVIATIONS LIST

cfs	cubic feet per second
CIG	Climate Impacts Group
FRFA	flood retention flow augmentation
FRO	flood retention only
GCM	Global Climate Model
I-5	Interstate 5
NOAA	National Oceanic and Atmospheric Administration
NGVD29	National Geodetic Vertical Datum of 1929
PHABSIM	Physical Habitat Simulation
RM	river mile
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WUA	weighted usable area

EXECUTIVE SUMMARY

The purpose of this technical report is to present the Operations Plan for the flood retention only (FRO) and flood retention flow augmentation (FRFA) dams. The major considerations in developing an Operations Plan for the reservoirs are:

- Provide flood reduction in downstream areas
- Preserve geomorphic processes downstream
- Maintain slope stability in reservoir
- Keep rate of change in flow rates downstream within accepted limits
- Provide for debris management/removal in reservoir after floods
- Provide additional instream flows and cooler water during periods of low flow (FRFA only)

The FRO facility would retain river flows temporarily, only during floods that have a flow rate exceeding 38,800 cubic feet per second (cfs) at the Chehalis River at Grand Mound, Washington, gage operated by the U.S. Geological Survey. A flow rate of 38,800 cfs is equivalent to about a 7-year recurrence interval event at that gage (15% chance of occurrence in any year). After flooding diminishes, the reservoir contents would be discharged. In non-flood conditions the reservoir is empty and the Chehalis River flows through the reservoir footprint unimpeded. During the beginning stages of operations, flow and river stage changes in the Chehalis River downstream of the reservoir would be controlled to 2 inches per hour stage reduction to reduce the potential for fish stranding. When draining the reservoir after a flood, the discharge rate from the reservoir would be increased to about 5,000 to 6,500 cfs to help maintain downstream geomorphic processes. The rate of reservoir drawdown would be kept within safe operating rates (estimated to be 10 feet per day) for slope stability. Debris management would be accomplished during reservoir drawdown by slowing the rate of drawdown and collecting debris in one area for disposal or use elsewhere. The volume available for flood storage would be 65,000 acre-feet.

With FRO operations, flows above about 5,000 cfs at the dam site and at Doty gage are significantly reduced. Most flows (about 99%) are not significantly changed due to FRO operations. Significant flood reduction would occur in downstream areas; the peak flow at the Grand Mound gage was predicted to be reduced by 15% to 27% when three historical floods (occurring in 1996, 2007, and 2009) were analyzed with the FRO dam in operation.

The FRFA facility would operate under similar procedures as the FRO facility during major floods and would have similar flood reduction benefits. Additionally, the FRFA facility would include a conservation pool that would provide a 65,000-acre-foot supplemental volume of storage. The conservation pool would be used to provide instream flows and cooler water in the upper Chehalis River during periods of low flow and high river temperatures, which can occur in late spring to early fall. The flood pool, located above the conservation pool, would also have 65,000 acre-feet of storage.

Operational analyses were performed for different FRFA operating scenarios using the HEC-ResSim model. The scenarios were also informed by water quality modeling of the reservoir (Anchor QEA 2016a) and the Chehalis River (PSU 2016) along with instream flow analyses (Anchor QEA 2012; Beecher 2015) performed for the Chehalis River. A balance between releases from the dam, reservoir water temperatures, and instream flow benefits was achieved through one operational scenario that is proposed for the FRFA reservoir. That scenario proposes releasing frequently occurring peak flows from the reservoir and maintaining a minimum level of flow in the Chehalis River when natural flows are not sufficient in the late spring to early fall. That time period also coincides with high Chehalis River temperatures, which affect aquatic species. Releases would be made at different levels in the reservoir to obtain cool water but maintain a sufficient pool so that cool water could be released until fall when atmospheric and river temperatures drop due to colder weather.

The weighted usable area (WUA), a measure of habitat available in the Chehalis River downstream of the dam, is predicted to substantially increase during summer months. A calculation for the rearing life stage of Chinook salmon for conditions experienced in July 2013 in the Chehalis River between Pe Ell and Elk Creek showed an increase of 400% in WUA due to the cool water and greater flow discharged from the FRFA facility.

With FRFA operations, flows are increased compared to existing conditions about one-half of the time. Flows above 8,000 cfs at the dam site and 10,000 cfs at the Doty gage are significantly reduced.

The operations of the dams under future climate change conditions was also reviewed. Peak flow changes were estimated by the Climate Impacts Group (CIG; Mauger et al. 2016) and Watershed Science and Engineering (Karpack 2016a). The future 100-year peak flow under climate change conditions is estimated to be 66% greater than existing conditions. Under those conditions, the entire reservoir volume would be utilized and water would be spilling 3 feet over the spillway crest. A large flood reduction benefit would still be realized in downstream areas, as the flow over the spillway would occur after the peak of the flood occurs, and the spillway flow would still be much less than the peak inflow. The peak flow reduction at the Grand Mound gage under climate change conditions is estimated to be 21%, slightly more than current conditions; however, the peak flow experienced (108,600 cfs) would be much higher than the peak flow under current conditions (75,100 cfs) for a 100-year flood.

1 INTRODUCTION

1.1 Purpose

The purpose of this technical report is to present the Operations Plan for the flood retention only (FRO) and flood retention flow augmentation (FRFA) dams. The Operations Plan refines the preliminary Operations Plan previously developed (Anchor QEA 2014) and uses data and information collected since that time, including water quality data, water quality modeling results, fisheries data and modeling, and additional flow data from gages.

2 FLOOD RETENTION ONLY OPERATIONS

2.1 Introduction

Located in the upper Chehalis Basin, the FRO facility would retain river flows during major floods. Major floods have a flow rate exceeding 38,800 cubic feet per second (cfs) at the Grand Mound, Washington, gage operated by the U.S. Geological Survey (USGS). A flow rate of 38,800 cfs is equivalent to about a 7-year recurrence interval event at that gage (15% chance of occurrence in any year). A description of a major flood is provided in Section 2.2. The FRO facility would not retain water during smaller floods. The major considerations in developing an Operations Plan for the FRO are:

- Provide flood reduction in downstream areas
- Preserve geomorphic processes downstream
- Maintain slope stability in reservoir
- Keep rate of change in flow rates downstream within accepted limits
- Provide for debris management/removal in reservoir after floods

The FRO facility would operate systematically. Flood flows would be predicted and outlet gates adjusted to retain major flood flows temporarily. After flooding diminishes, the reservoir contents would be discharged. In non-flood conditions the reservoir is empty and the Chehalis River flows through the reservoir footprint unimpeded. The different stages of operation are listed as follows and described in the following sections:

- Threshold for operations
- Operations prior to and during floods
- Initial drawdown after floods
- Debris management
- Drawdown after debris management
- Operations outside of flood storage periods

2.2 Stages of Operation

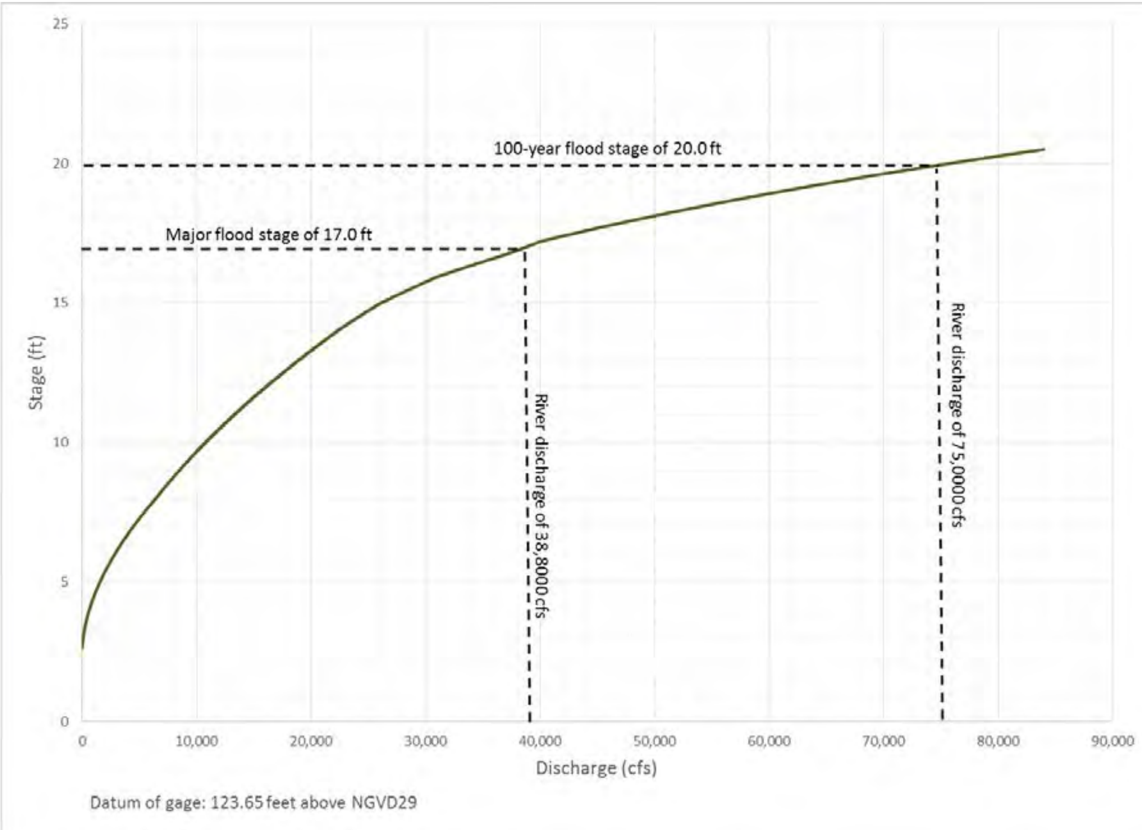
2.2.1 Threshold for Operations

The threshold for operation of the FRO facility was determined by using information on flooding available from Thurston County and the National Oceanic and Atmospheric Administration (NOAA). Thurston County and NOAA define flood categories that describe the severity of flood impacts in the Chehalis River. Major flooding is a definition both agencies use. NOAA has defined major flooding as extensive inundation of structures and roads; significant evacuations of people and/or transfer of property to higher elevations (Caldwell 2012). Major floods are defined by Thurston County Emergency Management as the Chehalis River in Thurston County will cause major flooding, inundating roads and farm lands in Independence Valley; deep and swift flood waters will cover State Route 12 and James, Independence, and Moon roads; flooding will occur all along the river including headwaters, tributaries, and other streams within and near the Chehalis Basin (Thurston County 2016). USGS develops rating curves at their gages that describe a stage-discharge relationship. This is done by translating a continuous record of stage to river discharge. The rating curve for the USGS gage site at Grand Mound is shown in Figure 2.1. For the Chehalis River near Grand Mound gage, a stage of 17.0 feet (datum of gage: 123.65 feet above National Geodetic Vertical Datum of 1929 [NGVD29]) is defined by Thurston County and NOAA as the threshold for a major flood. Extensive flooding would also occur upstream of Grand Mound in Lewis County during a major flood. The 100-year flood stage at the Grand Mound gage is 3 feet above the 38,800 cfs threshold for operation of the FRO.

Using the stage threshold for major flooding, a discharge prediction of 38,800 cfs at Grand Mound is the point at which flood retention is initiated. When the prediction exceeds 38,800 cfs, water retention would begin within 48 hours of the forecasted flood peak. A 48-hour time period gives a reasonable amount of time to predict flows with confidence while also providing enough time to reduce flow rates to designated minimum release rates before major flood flows occur. Flow conditions that trigger water retention (38,800 cfs) have a 15% probability of occurrence in any given year, which is approximately a 7-year flood.

The source of the forecast for major flooding would be the Northwest River Forecast Center operated by NOAA. The Northwest River Forecast Center uses the National Weather Service Community Hydrologic Prediction System to simulate soil, snow, and stream channel and reservoir conditions. Daily forecasts are made using observations of temperature and precipitation. Forecast of meteorological parameters are included in the river forecast model (NOAA 2016). It is anticipated that additional resources would be put into flood forecasting in the Chehalis Basin to improve the accuracy of the forecasts. Those resources may include additional meteorological stations and an updated hydrologic model.

Figure 2.1
Rating Curve – USGS Gage #12027500 – Chehalis River near Grand Mound, Washington

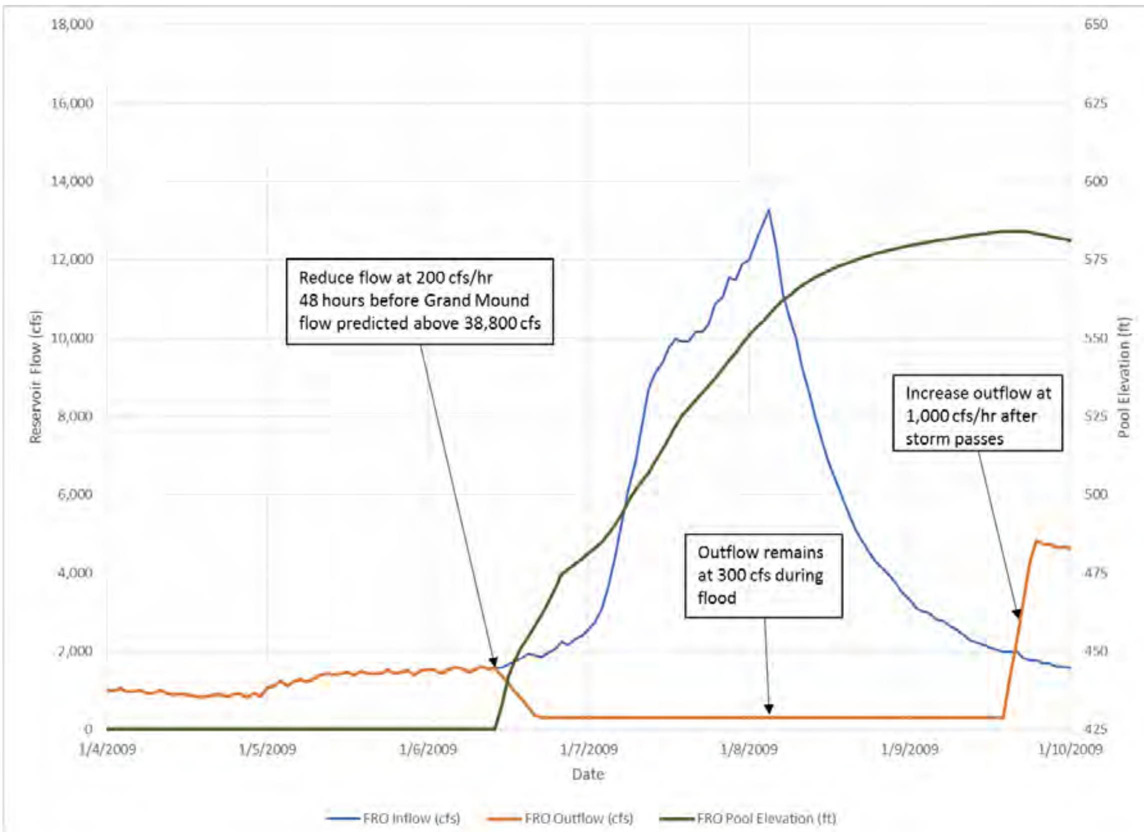


2.2.2 Operations Prior to and During Floods

Once flood operations are triggered, flow retention would begin by partially closing the reservoir outlet gates. Dam outflow would be reduced at a rate of 200 cfs per hour 2 days prior to when major flooding is predicted to occur. A maximum rate of change in reservoir outflow of 200 cfs per hour was selected for this period to minimize the potential for fish stranding downstream of the reservoir. Fish stranding is the separation of fish from flowing surface water as a result of declining river stage, which has been widely documented in Washington and Oregon downstream of hydropower operations. Salmonid fry are poor swimmers and settle along shallow river margins. By pacing the reduction of outflow, the salmonids have sufficient time to re-enter flowing sections of the river (Hunter 1992). The criteria for the rate of reduction in stage due to hydropower operations along rivers is 2 inches per hour (Hunter 1992). The 200 cfs per hour rate was determined by applying a 2-inch per hour decline in river stage downstream of the dam using the HEC-RAS model developed for the Chehalis Basin Strategy (WSE 2014a). The flow rate used for that calculation was 1,000 cfs, the median flow for November to March during which most floods occur. That rate of change would be adjustable and can be adaptively managed during operations.

Dam outflows would decrease at 200 cfs per hour until reaching 300 cfs, which is the minimum outflow during flood operations. A 300 cfs flow is also a low flow that typically occurs in winter. The 300 cfs outflow would exist for only a short distance downstream of the dam as tributary inflow entering the Chehalis River would increase flows. The 300 cfs outflow would continue until the peak of the flood passes Grand Mound, which is typically 48 to 72 hours. A typical example of FRO flood operations is presented in Figure 2.2.

Figure 2.2
FRO Example Flood Operations – Prior to and During January 2009 Flood



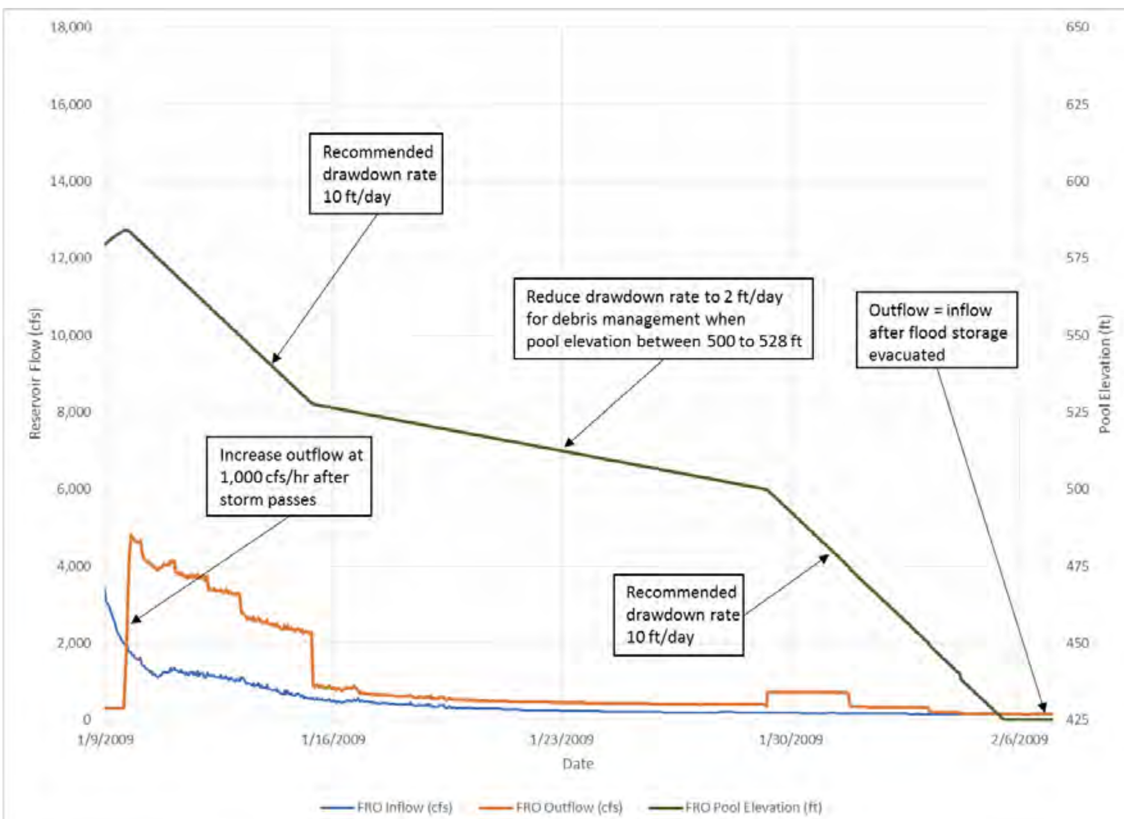
2.2.3 Initial Drawdown after Floods

In order to evacuate the reservoir, the reservoir gates would open and increase outflow by 1,000 cfs per hour, causing a drawdown of the reservoir from its peak water surface elevation. Drawdown rates would be limited to 10 feet per day (5 inches per hour) due to risks of landslides, which would limit the duration of the flow increases to about 5 hours (for the 2009 flood, as shown in Figure 2.2). A maximum outflow rate would be reached (4,830 cfs for the 2009 flood, as shown in Figures 2.2 and 2.3) in that time period and would decrease as the reservoir is drawn down because there is less storage volume per foot of drawdown as the reservoir level drops. The inflow to the reservoir during drawdown could also affect the discharge, as the greater the inflow, the greater the discharge from the reservoir.

Landslide risks come from a rapid drop in water level at a reservoir, also called rapid drawdown. External water pressure acting on the face of a slope provides a stabilizing effect. If the water level drops, the stabilizing influence is reduced, and the shear stresses within the soil increase. When this occurs rapidly, and the pore pressures within the slope do not decline at the same rate as the outside water level, the slope is made less stable. Rapid drawdown takes place when the water level outside a slope drops so quickly that soils within the slope do not have sufficient time to drain. This is a severe loading condition that can cause failure of slopes that are stable before drawdown (Duncan et al. 2014). A landslide evaluation was completed by Shannon & Wilson, Inc., to identify unstable slopes in the proposed reservoir area that could be affected by the rising and falling of reservoir water levels and assess the impacts the unstable slopes could have on the proposed reservoir. Shannon & Wilson determined that 10 feet per day is an effective drawdown rate that minimizes potential for mass slope failure (Shannon & Wilson 2014).

Figure 2.3 presents the initial drawdown rate and dam outflows, as well as the debris management operations, which is described in the next section.

Figure 2.3
FRO Example Flood Operations – Drawdown after January 2009 Flood

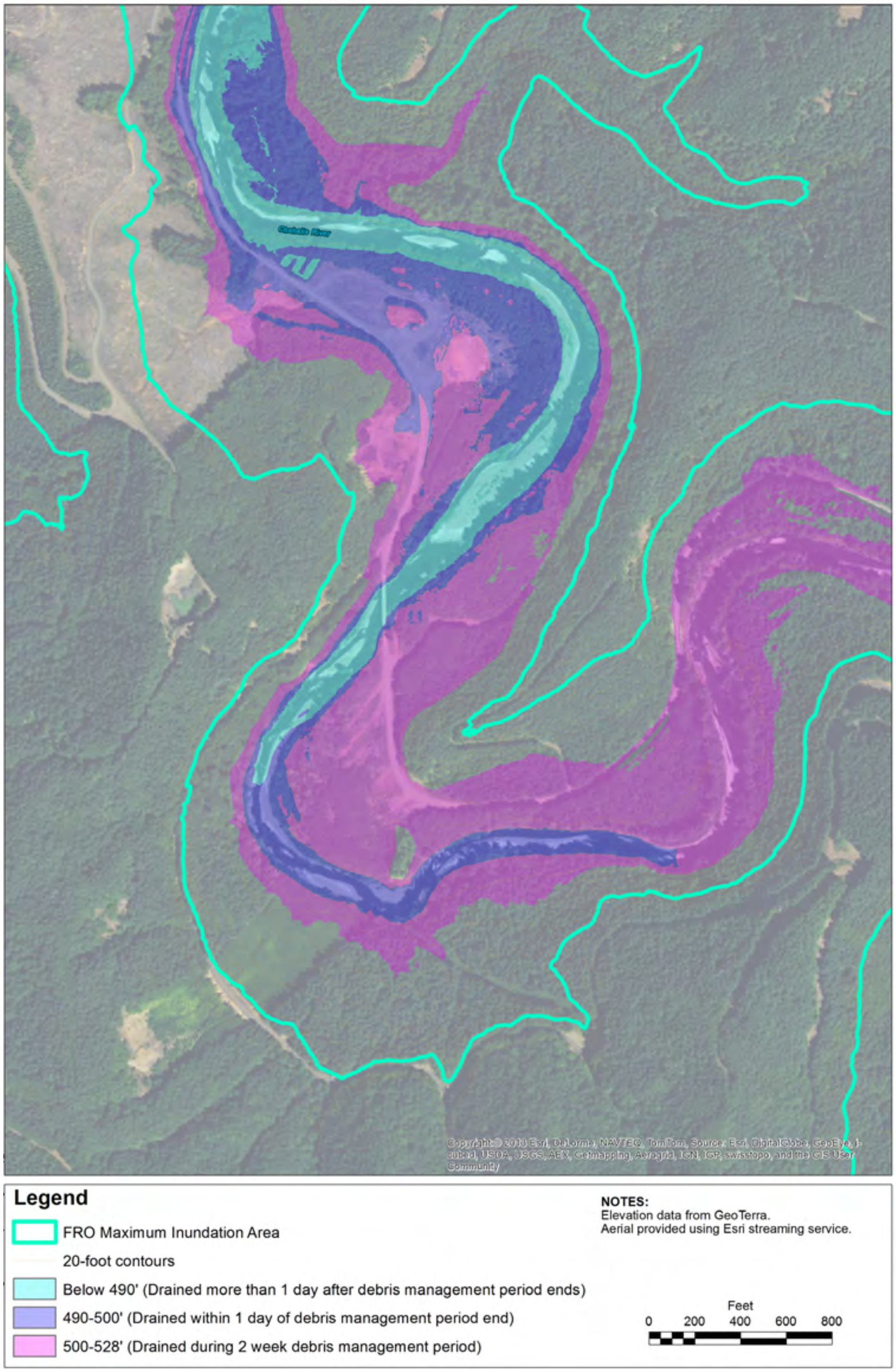


2.2.4 Debris Management

When major floods and reservoir operations occur, debris from tributaries and hillsides surrounding the reservoir would be transported into the reservoir. Estimates of debris loading were prepared (Watershed GeoDynamics and Anchor QEA 2014; Dubé 2016). The concern is that large wood debris could affect the operations of the dam by obstructing the outlets. Some debris can pass through the outlets (estimated to be sizes up to 3 feet in diameter and 15 feet in length) but large accumulations are expected during flood operations.

Debris management procedures are included in the Operations Plan so that large debris entering the reservoir during a flood can be moved to a location where they can be transported by truck away from the reservoir. The location identified is an old sorting yard for logs previously operated by Weyerhaeuser on the west bank of the Chehalis River between river mile (RM) 109.6 and 109.9. It was selected because of its relatively flat topography, ground elevation, and proximity to existing roadways. Figure 2.4 presents a map of the specified location.

Figure 2.4
Sorting Yard Location



The log sorting yard provides a favorable location for boats to manually move large debris for handling. To give boats time to move logs to the sorting yard location, drawdown rates would be slowed to 2 feet per day (1 inch per hour) for a 2-week period. The decrease in drawdown rate would occur when the storage pool elevation reaches approximately 528 feet. At a storage pool elevation of 528 feet, debris could be readily moved to the designated sorting yard. After corralling the debris onto the sorting yard location, drawdown would continue and the sorting yard would no longer be inundated. Debris can then be either cut-up and disposed of or wood suitable for habitat projects in the Chehalis Basin can be sorted and trucked out of the reservoir area. The removal of the wood debris can occur well after the reservoir is drained and when the ground dries out enough to allow heavy equipment onto the sorting yard. The operation of the reservoir (length of time water is retained) to manage debris accumulations would be adaptive and depend on the amount of wood accumulated and the ability of operations personnel to move wood to the sorting yard location. The length of time the reservoir holds water may be shorter or longer than described in this Operations Plan.

2.2.5 Drawdown after Debris Management

Drawdown rates would increase to 10 feet per day (5 inches per hour) when debris management operations have concluded and the storage pool elevation reaches 500 feet, the ground elevation of the sorting yard. Drawdown rates would continue at this rate until the storage pool is emptied (pool elevation of 425 feet). At this point, the reservoir would no longer be impounding water and the Chehalis River would return to a free-flowing state.

2.2.6 Operations Outside of Flood Storage Periods

FRO operations would be triggered by prediction of a major flood at the Grand Mound gage. Outside of that period, the inflow to the reservoir would be discharged through the dam without regulation for flows up to 15,000 cfs, which is the capacity of the tunnels at the top (crown) of the tunnel openings. A flow of 15,000 cfs has a recurrence interval of 13 years at the dam site. For flows greater than 15,000 cfs some ponding would occur at the entrance to the tunnels, causing a small reduction in peak flows as additional head (water surface elevation) is needed to discharge flows greater than 15,000 cfs through the tunnels. The outlet tunnel rating curves are contained in the *Draft Combined Dam and Fish Passage Conceptual Design Report* (HDR 2016).

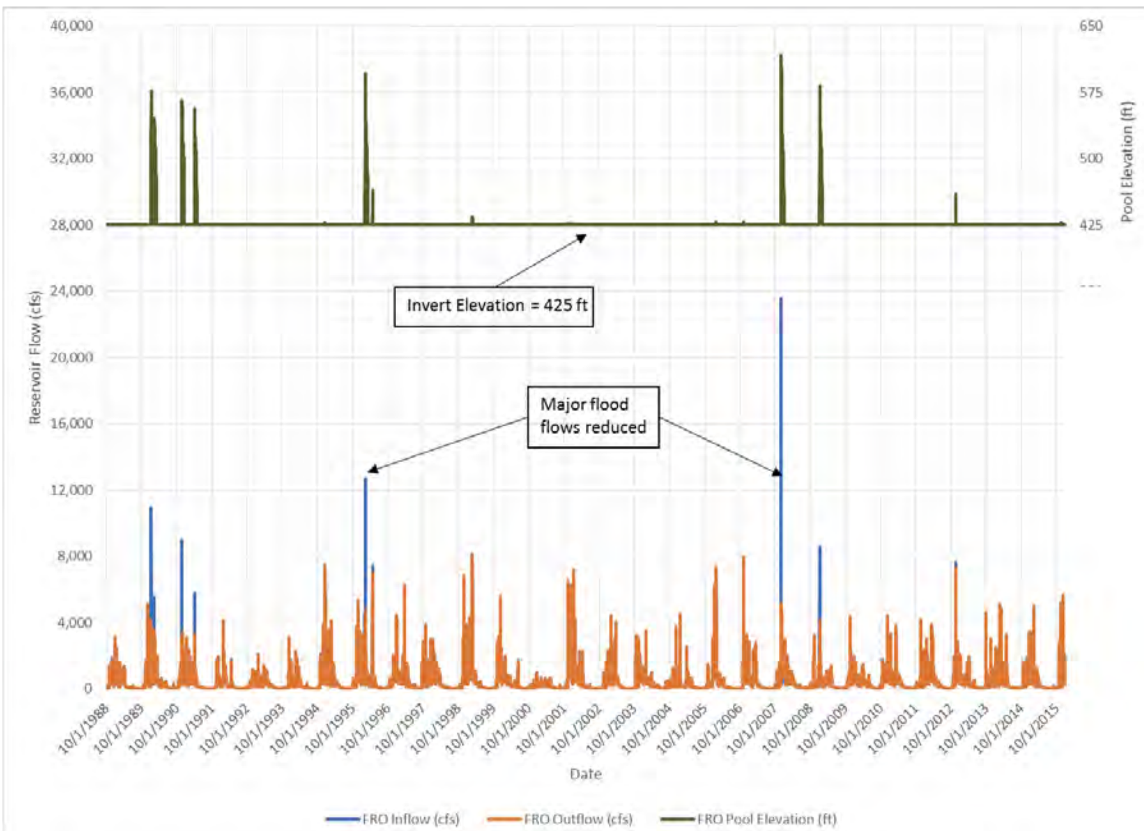
2.3 FRO Performance

The performance of the FRO facility was analyzed using HEC-ResSIM, a reservoir system simulation software program developed by the U.S. Army Corps of Engineers. The software is used to model reservoir operations at one or more reservoirs for a variety of operational goals and constraints (USACE 2013). Hydrologic data and the FRO facility Operations Plan were used to simulate reservoir operations during various historical conditions. Output results from the HEC-ResSIM model include inflow into reservoir, outflow out of reservoir, pool elevation, and storage volume.

2.3.1 Period of Record

The period of record for the historical data begins in October 1988 and extends into 2015. Chehalis River flow at the proposed dam (inflow) was estimated using the USGS gage at Doty flow record and multiplying by 66% (WSE 2014a; Anchor QEA 2016b). Reservoir outflow and pool elevation were estimated using the HEC-ResSIM model and operational rules described in previous sections and are plotted for the period of record in Figure 2.5.

Figure 2.5
FRO Operation Modeling – Water Years 1989 to 2015



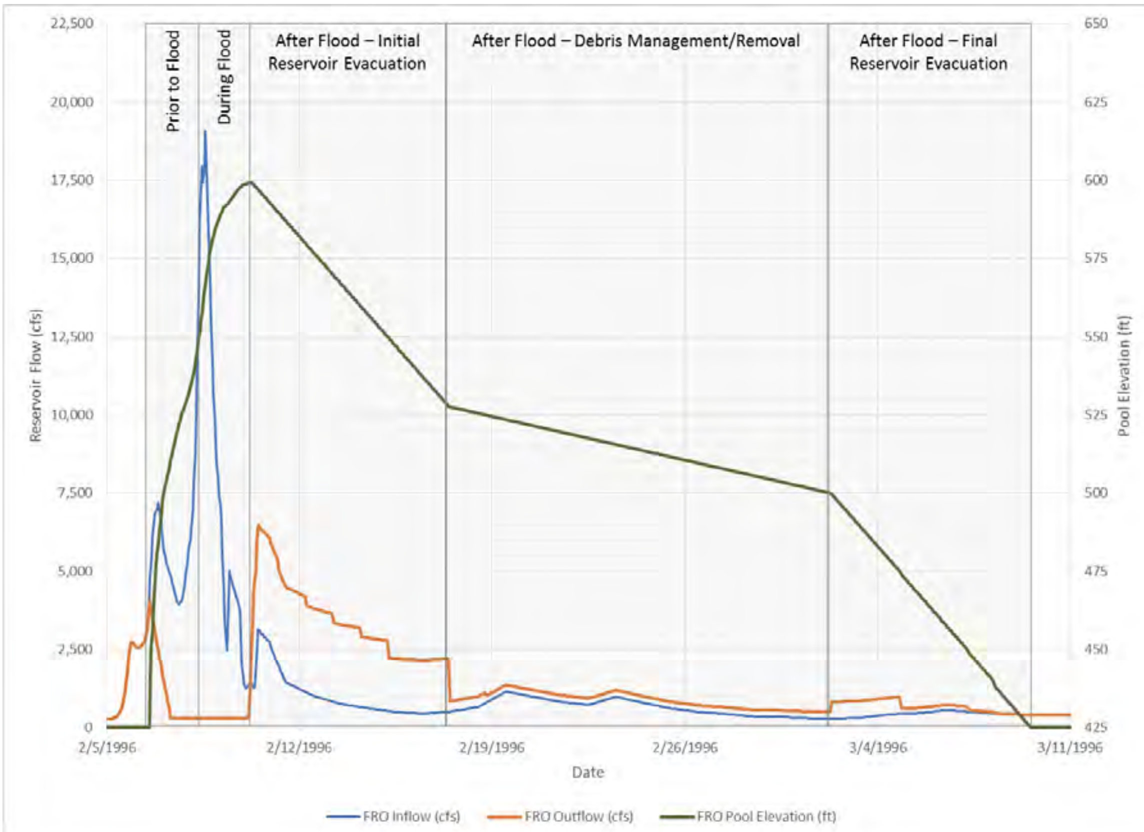
A description of the performance of the FRO facility under historical flood conditions is provided in the following sections. Three major floods are described: February 1996, December 2007, and January 2009.

2.3.1.1 1996 Flood

A 100-year flood occurred on the Chehalis River in February 1996. It was a large frontal storm with very broad rainfall distribution throughout the Chehalis River basin with 24-hour rainfall totals ranging from 10-plus to 100-plus-year recurrence. The resulting flood was the second largest in the historical record for gages at Grand Mound, Porter, and Doty (WSE 2014b). The storm caused massive flooding and closed Interstate 5 (I-5) for 4 days with peak flows in the Chehalis River at Doty reaching an estimated

28,900 cfs (Poor 2008). Figure 2.6 presents the estimated results of FRO operations during the flow conditions of the February 1996 flood.

Figure 2.6
FRO Operation Modeling – February 1996 Flood

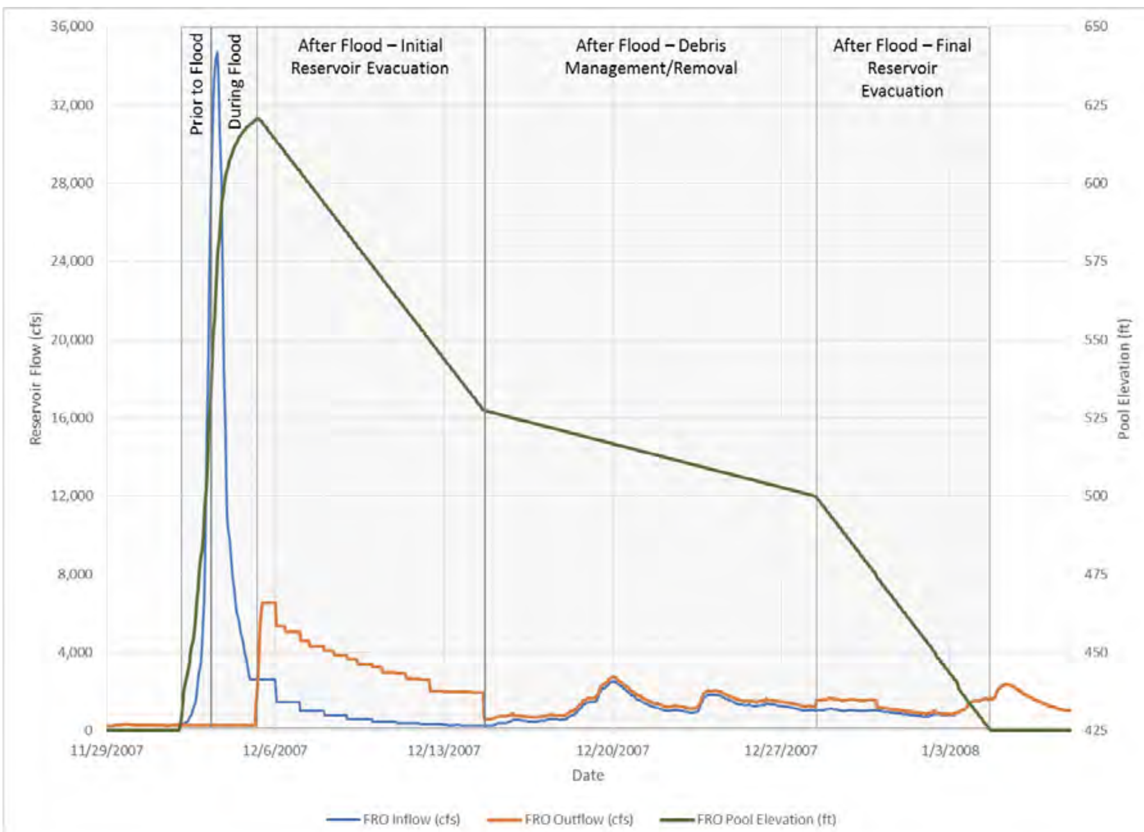


With the FRO facility, flood operations during the February 1996 flood would have lasted 30.7 days, or 736 hours. The reservoir would have been in use for just over 8.4% of 1996. The maximum reservoir flow release with FRO operations with this flood would have been about 6,500 cfs, compared to an estimated inflow at the dam of more than 19,000 cfs. That maximum flow would have been released after flood peaks occurred downstream and would not contribute to flooding. The purpose of maximizing the flow release after a flood would be to maintain geomorphic processes in the Chehalis River downstream of the dam. The FRO facility would have decreased peak flows at the dam area by more than 60%. The reservoir would have inundated 650 acres at peak storage, inundating almost 6 miles of the Chehalis River while storing a maximum volume of 44,500 acre-feet during the storm. Pool elevations during the storm would have ranged from 425 to 600 feet with a median pool elevation estimated at 515.7 feet. An analysis of peak flow reduction at Grand Mound was also completed with a HEC-RAS model. Preliminary results indicate that the FRO operations would reduce peak flows at Grand Mound by nearly 15% from 73,300 to 63,200 cfs (WSE 2014a; Karpack 2016b).

2.3.1.2 2007 Flood

Record rainfall in the upper Chehalis Basin caused significant flooding throughout the Chehalis River in December 2007. Flooding inundated I-5, closing it for several days (WSDOT 2014). The 2007 flood had a narrower path of rainfall than the broad Basin-wide rainfall experienced in 1996. The highest rainfall was concentrated in the Willapa Hills in the upper Chehalis Basin. The 2007 storm set records for 24-hour precipitation in the upper Chehalis Basin at gages in Grand Mound, Porter, Doty, and South Fork Chehalis. Peak discharges on the Chehalis River at Doty reached an estimated 52,600 cfs (nearly double the peak flows in the 1996 flood) and was approximately 50% greater than the current estimate of the 100-year flood (WSE 2014b). Figure 2.7 presents the predicted results of FRO operations during the 2007 flood.

Figure 2.7
FRO Operation Modeling – December 2007 Flood

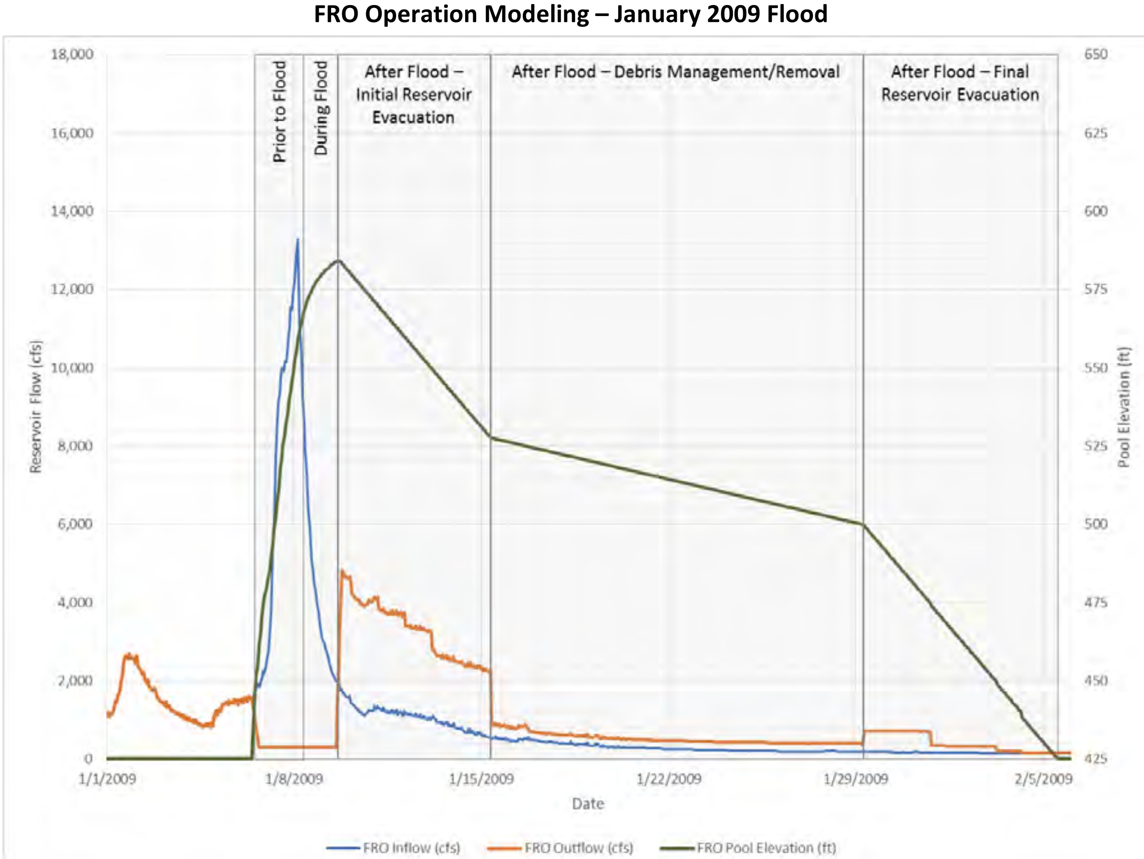


With FRO operations, flood operations during the December 2007 flood would have lasted 32.3 days, or 776 hours. The reservoir would have been in use for just over 8.8% of 2007. The maximum reservoir flow release would have been about 6,500 cfs, compared to an estimated inflow at the dam of more than 34,700 cfs. The maximum flow would be released after peak flows occur in downstream areas. The FRO facility would have decreased peak flows at the dam area by more than 80%. The reservoir would have inundated 778 acres at peak storage, inundating more than 6 miles of the Chehalis River while storing a maximum volume of 60,253 acre-feet during the storm. Pool elevations during the storm would have ranged from 425 to 620 feet, with a median pool elevation estimated at 516.7 feet. An analysis of peak flow reduction at Grand Mound from FRO operations was also completed with a HEC-RAS model. Model results indicated that the FRO operations would have reduced peak flows at Grand Mound by more than 27% (from 71,100 to 52,100 cfs) during the 2007 flood (WSE 2014a).

2.3.1.3 2009 Flood

Heavy rainfall in the eastern and northern portions of the Chehalis Basin caused flooding in January 2009. A 20-mile stretch of I-5 was inundated under several feet of water and with mountain passes closed because of weather conditions; no formal detour information was available. Flooding of I-5 was caused by high flows on the Newaukum system, which peaked well in advance of the arrival of the peak Chehalis River flow from the upper Chehalis Basin. Many of the lower Chehalis Basin tributaries, such as the Satsop, Black, and Wynoochee rivers, experienced high flows with rainfall more concentrated in the northern portion of the Chehalis Basin than previous storms. Considering the high flows from lower tributaries, the January 2009 flood is estimated to be the second largest flood in the historical record downstream of Montesano (WSE 2014b). Figure 2.8 presents the predicted results of FRO operations during the flow conditions of the January 2009 flood.

Figure 2.8
FRO Operation Modeling – January 2009 Flood



With FRO operations, flood operations during the January 2009 flood would have lasted 28.7 days, or 690 hours. The reservoir would have been in use for just over 7.9% of 2007. The maximum reservoir flow release with FRO operations would have been about 4,800 cfs, compared to an estimated inflow at the dam of about 13,300 cfs. The maximum flow would be released after peak flows occur in downstream areas. The FRO facility would have decreased peak flows at the dam area by more than 64%. The reservoir would have inundated 576 acres at peak storage, inundating 5.4 miles of the Chehalis River while storing a maximum volume of 34,830 acre-feet during the storm. Pool elevations during the storm would have ranged from 425 to 584 feet, with a median pool elevation estimated at 513.5 feet. An analysis of peak flow reduction at Grand Mound was also completed with a HEC-RAS model. It is estimated that the FRO operations would have reduced peak flows on the Chehalis River at Grand Mound by more than 15% from 58,700 to 48,600 cfs.

2.4 Flow Exceedance Calculations

Flow exceedance curves were calculated for existing conditions and with the FRO facility in operations. The curves are shown in Figure 2.9. The curves are based upon hourly flows recorded at the Doty gage for the 27-year period of record that was used in the operations modeling. As described in the *Stream Gage Comparison for Reservoir Hydrologic Model* technical memorandum (Anchor QEA 2016b) the Doty gage flow record was multiplied by 66% to estimate flows at the proposed dam site. A newer USGS gage is located near the dam site (USGS Chehalis River at Mahaffey Creek, Site Number 12019310) but the period of record for that gage is short (2013-present) so the longer gage record from the Doty gage provides a better representation of changes in flow that would be caused by the proposed reservoir. The flow exceedance curves for existing conditions and with the FRO facility in operation at the Doty gage is presented in Figure 2.10.

With FRO operations, flows above about 5,000 cfs at the dam site and at Doty gage are reduced. Most flows (about 99%) are not significantly changed due to FRO operations.

Figure 2.9
Flow Exceedance Curve for FRO Facility at Dam Site

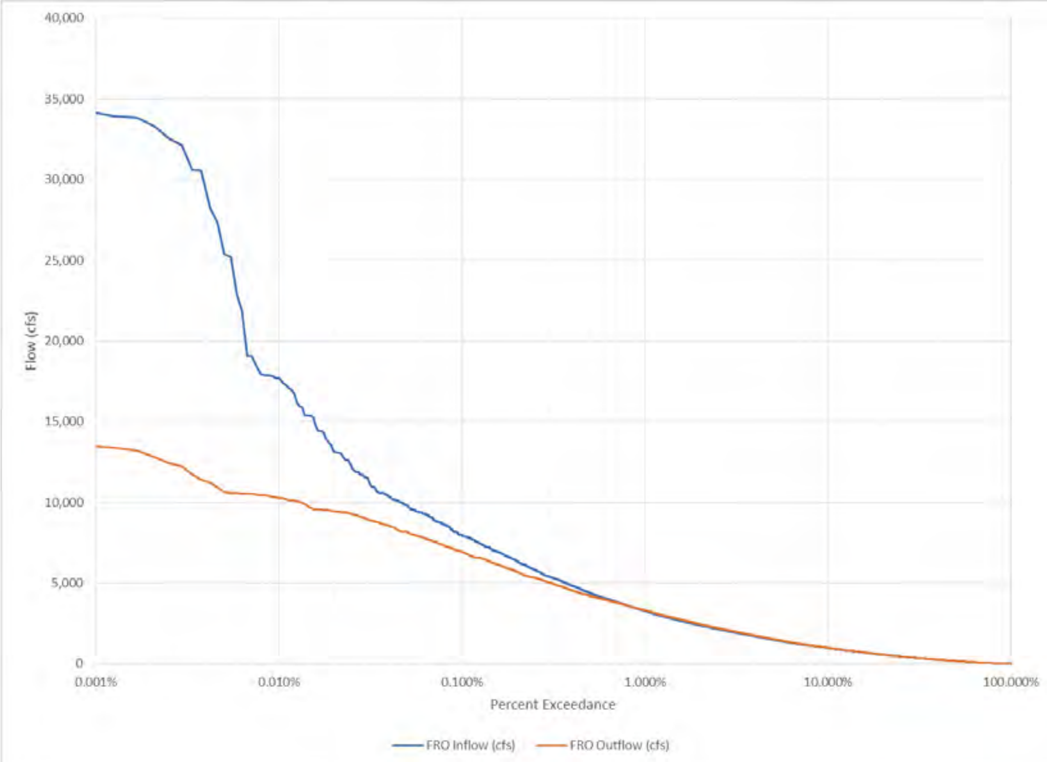
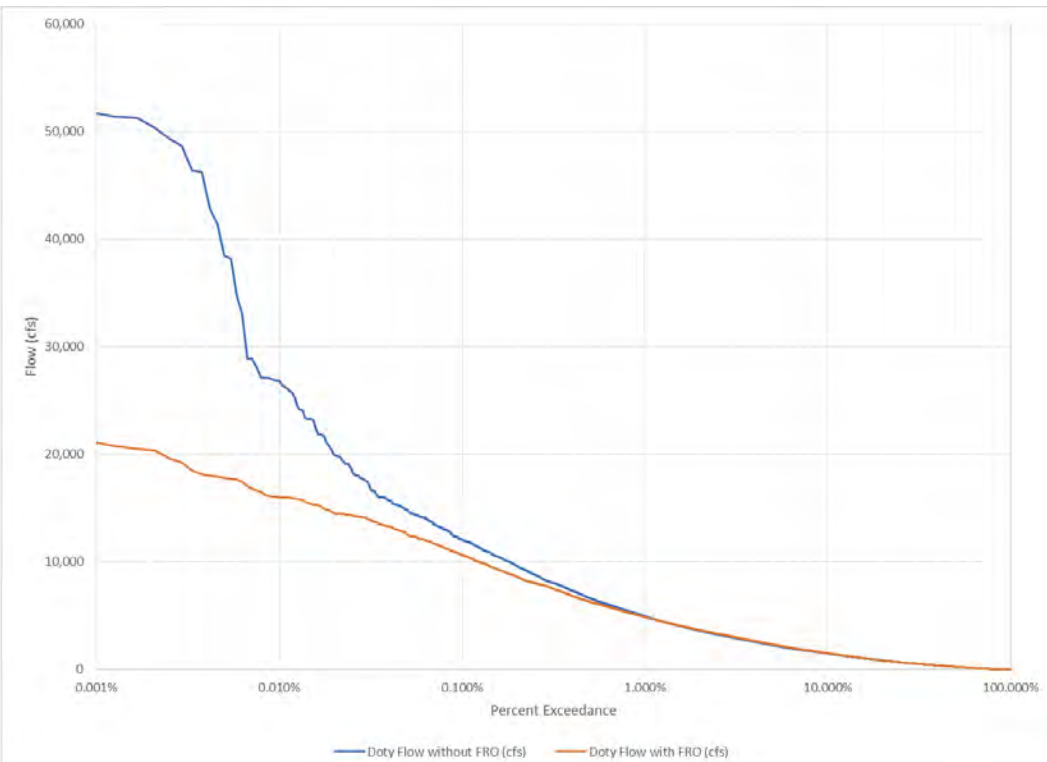


Figure 2.10
Flow Exceedance Curve for FRO Facility at Doty Gage



3 FLOOD RETENTION FLOW AUGMENTATION OPERATIONS

3.1 Introduction

The FRFA facility would operate under similar procedures as the FRO facility during major floods. Additionally, the FRFA facility would include a conservation pool that would provide a supplemental volume of storage. The conservation pool would be used to provide instream flows and cooler water in the upper Chehalis River during periods of low flow and high river temperatures, which can occur in late spring to early fall. The major considerations in developing an Operations Plan for the FRFA facility are:

- Provide flood reduction in downstream areas
- Preserve geomorphic processes downstream
- Maintain slope stability in reservoir
- Keep rate of change in flow rates downstream within accepted limits
- Provide additional instream flows and cooler water during periods of low flow

The three stages of operation are listed as follows and described in the following sections:

- Flood retention operations
- Non-flood operations and conservation pool filling
- Flow augmentation operations

3.2 Stages of Operation

3.2.1 Flood Retention Operations

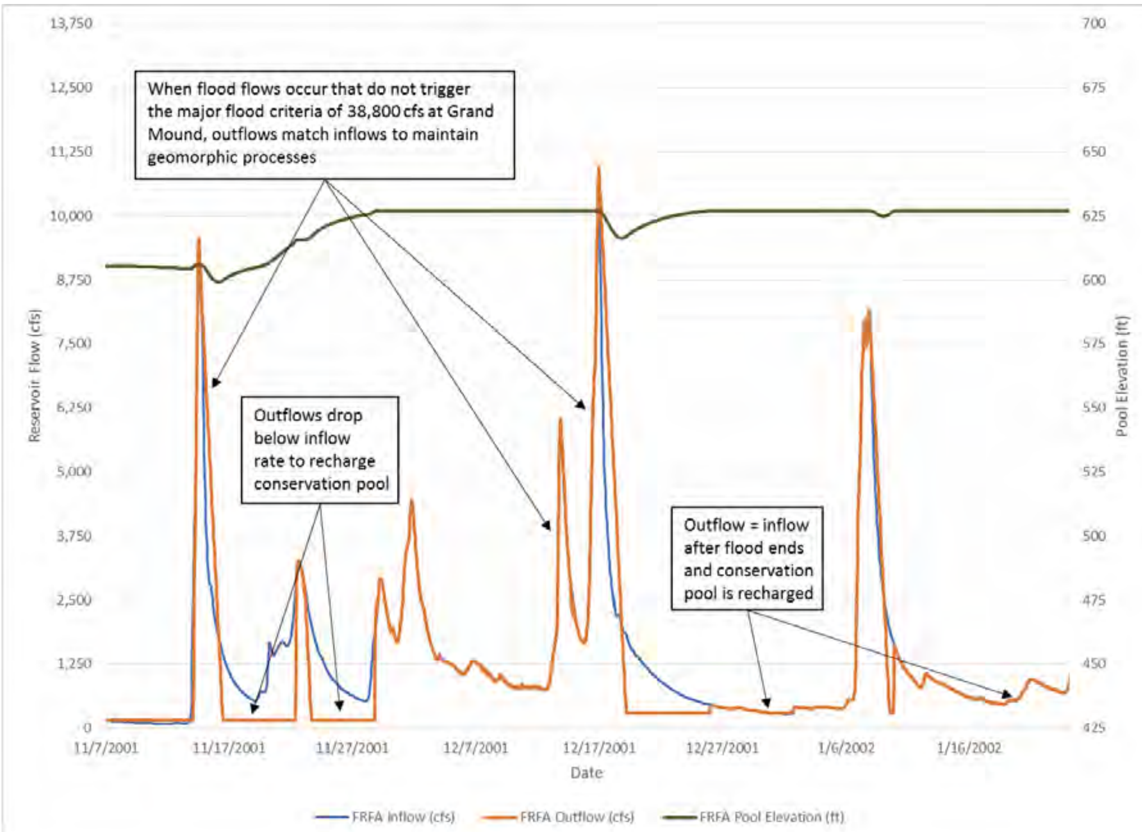
The FRFA facility would operate the same as the FRO facility during major floods, except the FRFA facility would not need to reduce the reservoir drawdown rate after a flood for debris management as a permanent pool would exist, allowing debris removal over a longer time period. The reservoir would typically be drawn down after a flood to the conservation pool level (elevation 628 feet) using a maximum drawdown rate of 10 feet per day. The reservoir operations after a flood would be managed adaptively to minimize environmental impacts. This could include releasing high flows to transport sediment or wood in the Chehalis River downstream of the dam and to maintain the current channel geomorphology.

3.2.2 Non-flood Operations and Conservation Pool Filling

The FRFA facility includes a conservation pool of 65,000 acre-feet and a flood storage pool with 65,000 acre-feet of capacity (same as the FRO facility). The conservation pool's primary purpose is storage for flow augmentation and temperature reduction in the Chehalis River downstream of the dam. Pool elevations in the conservation pool would range from 425 to 628 feet. The length of the conservation pool when it is full is 6.3 miles. Inflow into the FRFA facility would fill the conservation pool in late fall and winter. During filling operations, it would be desirable to release frequently occurring high flows to preserve geomorphic processes in the Chehalis River downstream of the dam. Operations analyses were performed assuming flows exceeding the annual flood would be released when annual floods or greater are experienced. The 1.01-year frequency peak flow (annual flood) at the Doty gage is 4,300 cfs (WSE 2014c). The expected flow rate at the dam would be 66% of that peak flow, or 2,800 cfs.

The operating rule used in reservoir operations modeling was to match peak flows for small floods (2,800 cfs and greater) except when the reservoir needs to retain water during major floods. After the peak of the small flood occurs, the outflow would be reduced at a rate not to exceed 200 cfs per hour until the minimum flow releases are reached. Those minimum flow releases are described in the following section. The minimum flows would be released until the next peak flow occurs or until the conservation pool is filled (elevation 628). When the conservation pool is full the inflow and outflow from the reservoir would be the same, unless a major flood is experienced. Figure 3.1 presents a graphical representation of the FRFA operations during frequently occurring floods.

Figure 3.1
FRFA Hourly Flows and Elevations – Frequent Flooding Operations



The FRFA facility would allow small flood peaks to pass through unregulated, then fill the conservation pool. This operation helps maintain natural geomorphic processes in the river while storing water needed for low-flow releases. The same forecasting tool described in Section 2.1 (Northwest River Forecast Center) would also be used to predict frequently occurring floods and operations could also respond to real-time data on reservoir inflows to match small flood peaks.

3.2.3 Flow Augmentation Operations

The purpose of retaining a conservation pool in the FRFA facility is to improve instream flow and reduce temperatures in the Chehalis River downstream of the dam location. The conservation pool is 65,000 acre-feet. The operational goal would be to have the conservation pool full in spring in order to meet flow demands that could start in late spring. Another operational goal is to have a sufficiently large (deep) conservation pool that would provide low temperature releases late into the summer. The flow releases in late spring to early fall need to be balanced with the volume remaining in the reservoir to ensure the most habitat benefit is realized with flow augmentation operations. Two scenarios for flow augmentation in late spring to early fall were reviewed and are described in the following sections.

3.2.3.1 *Instream Flow Release Schedule*

The primary purpose of setting minimum flow releases is to provide supplemental in-stream flow during periods of low flow (typically from late spring to early fall). During fall and winter when the conservation pool is filling, minimum flow releases may also occur; the minimum flow releases would also provide supplemental instream flow during periods of low flows in fall and winter.

An instream flow study was performed for this project in 2012 by Normandeau Associates (Anchor QEA 2012). The Physical Habitat Simulation (PHABSIM) process was used to develop a fish habitat index called weighted usable area (WUA) for various reaches in the Chehalis River from the dam site to Porter. WUA estimates the amount of habitat available to different life stages of fish at different river flows based on the fish's preferences for water depth, velocity, substrate, cover, and water temperature. WUA is reported as square feet of habitat available per 1,000 feet of river length. The process of developing PHABSIM and WUA was performed in conjunction with the Washington Department of Fish and Wildlife (WDFW) and Washington State Department of Ecology. Examples for some species and life stages are provided in Table 3.1.

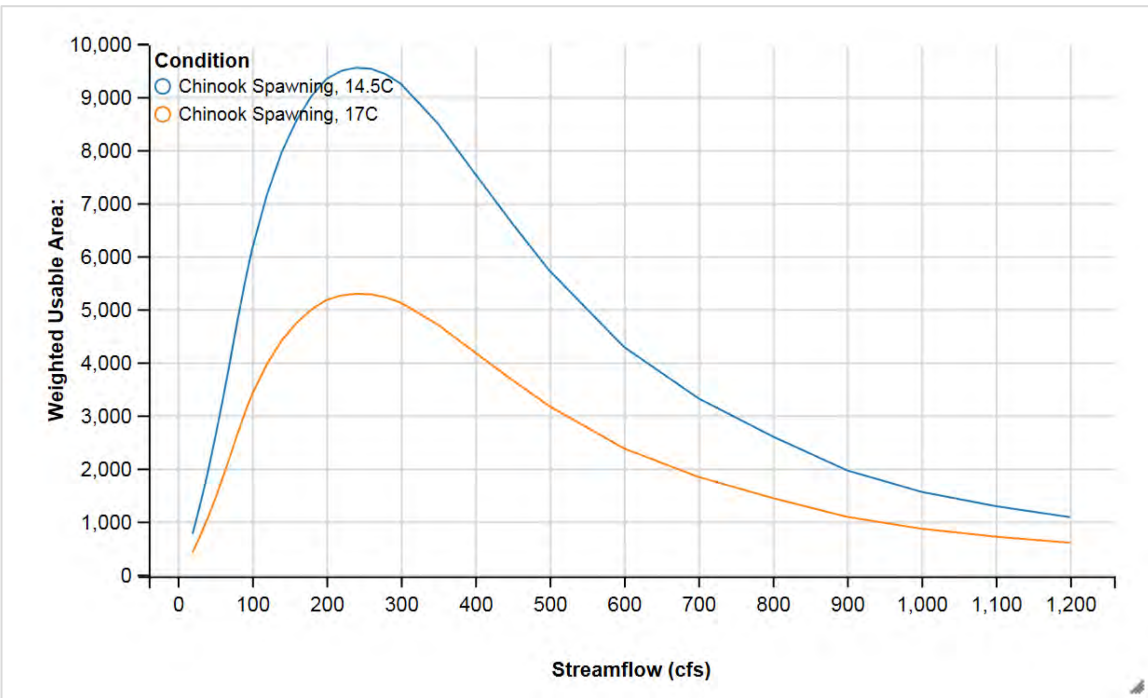
Table 3.1
Flow by Stream Reach and Life Stage Where Maximum Usable Habitat Occurs

	FLOW (cfs) AT MAXIMUM USABLE HABITAT (80% RANGE)[1]				
STUDY REACH	CHINOOK SPAWNING	CHINOOK JUVENILE	STEELHEAD SPAWNING	STEELHEAD JUVENILE	COHO SPAWNING
Dam Site to Pe Ell	160 (90 to 240)	130 (60 to 350)	190 (130 to 290)	170 (70 to 350)	220 (130 to 350)
Pe Ell to Elk Creek	260 (140 to 400)	240 (100 to 400)	300 (180 to 450)	240 (140 to 450)	350 (200 to 600)
Elk Creek to South Fork Chehalis	300 (125 to 490)	350 (150 to 650)	400 (200 to 600)	400 (200 to 750)	400 (275 to 650)
South Fork Chehalis to Newaukum R	350 (160 to 600)	450 (225 to 850)	400 (225 to 850)	550 (275 to 1,000)	500 (200 to 850)
Newaukum R to Skookumchuck R	3,200 (1,600 to 4,300)	1,800 (700 to 5,000+)	1,600 (850 to 3,000)	4,200 (1,100 -5,000+)	2,000 (700 to 3,000)
Skookumchuck R to Black R	2,200 (1,100 to 4,750)	1,000 (400 to 2,400)	700 (350 to 1,700)	1,600 (600 to 2,800)	800 (350 to 1,700)
Black R to Porter	2,000 (900 to 3,750)	800 (250 to 1,700)	600 (300 to 1,400)	900 (350 to 1,900)	600 (250 to 1,400)

Notes:
1. Range of usable habitat within 80% of the maximum in parentheses.
R = river

A shortcoming of the 2012 study was that the results were based upon a single, optimum temperature. River temperature has a large effect on the suitability of habitat. In 2015, WDFW adjusted the WUA relationships for temperature and also added species to the WUA relationships (Beecher 2015). Generally, WUA increases as water temperature decreases and streamflow increases (up to a certain limit). As an example, Figure 3.2 shows a flow to WUA relationship for two temperatures for the Chinook salmon spawning life stage in the reach between Pe Ell and Elk Creek. The WUA at 14.5°C is about 80% greater than at 17.5°C at a flow of 260 cfs (flow at which maximum usable habitat occurs; see Table 3.1).

Figure 3.2
WUA Data for Chinook Spawning in the Pe Ell to Elk Creek Study Reach



Instream flow recommendations were prepared in previous studies (Anchor QEA 2012) and carried forward in operations modeling to date. The instream flow recommendations that were used in operations modeling up to this study are shown in Table 3.2. Those recommendations did not account for temperature in the Chehalis River.

Table 3.2
Previous Recommended Instream Flows – FRFA

TIME PERIOD	FLOW
January to February	290 cfs
March to June 15	250 cfs
June 16 to August 15	190 cfs
August 16 to December 15	160 cfs
December 16 to 31	290 cfs

Temperature models for the reservoir and Chehalis River were prepared in conjunction with this report (Anchor QEA 2016a; PSU 2016). Preliminary water quality model runs completed for this Operations Plan provided the outflow temperatures for the flow rates described above. An issue found in the reservoir modeling with these flows was reservoir outflow temperatures may exceed water quality criteria in fall as the reservoir is drawn down. To improve temperature conditions in the reservoir, less water would need to be released during the low-flow season from late spring to early fall. Hydrologic analyses were conducted using HEC-ResSim to identify a flow release schedule that most closely provides the target flows given the amount of cool water available in the reservoir over the course of the year. The WUA relationships were reviewed for different release schedules (and temperatures) to improve the usable habitat downstream of the dam as much as possible. Table 3.3 presents the flow release schedule that maximizes fish habitat given the available cool water.

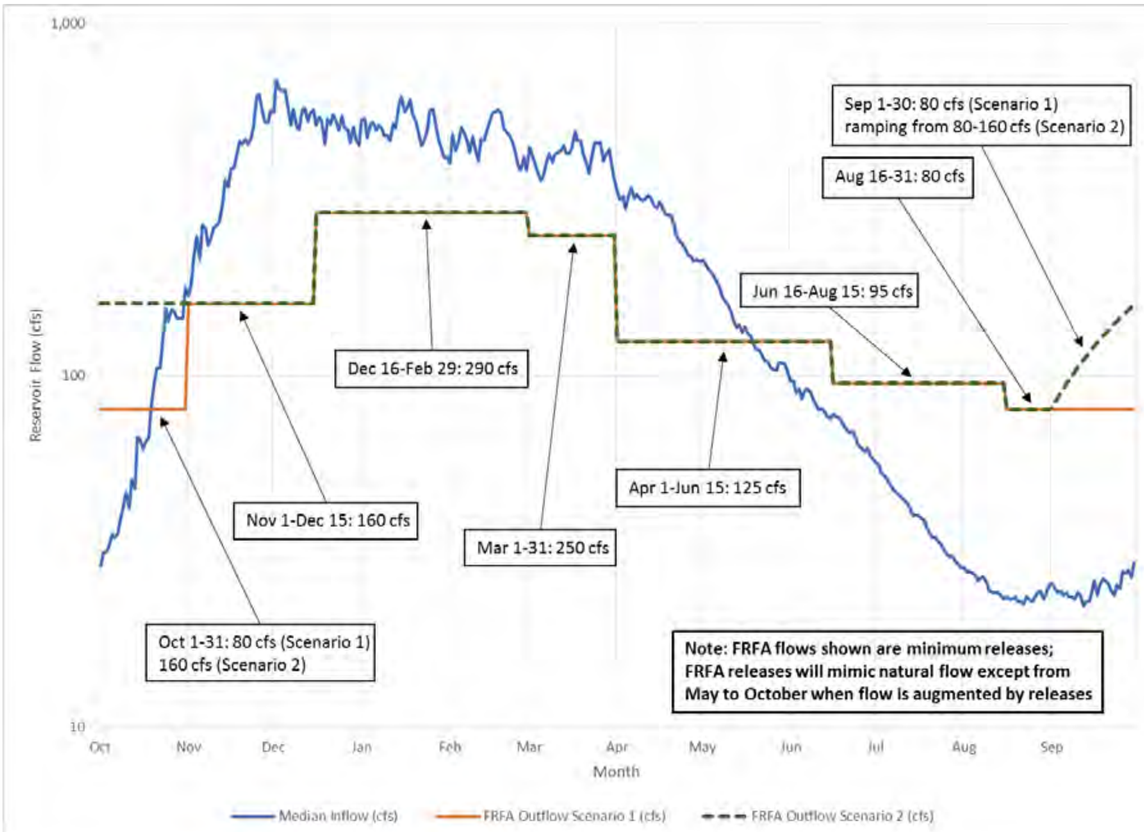
Table 3.3
Proposed Minimum Instream Flow Releases – FRFA

DATE	MINIMUM RELEASE (cfs)
January 1 to February 29	290
March 1 to 31	250
April 1 to June 15	125
June 16 to August 15	95
August 16 to 31	80
September 1 to 30	80 – 160[a]
October 1 to 31	160
November 1 to December 15	160
December 16 to 31	290

Note:
a. Flow releases ramp from 80 cfs on September 1 to 160 cfs on September 30 for Scenario 2.

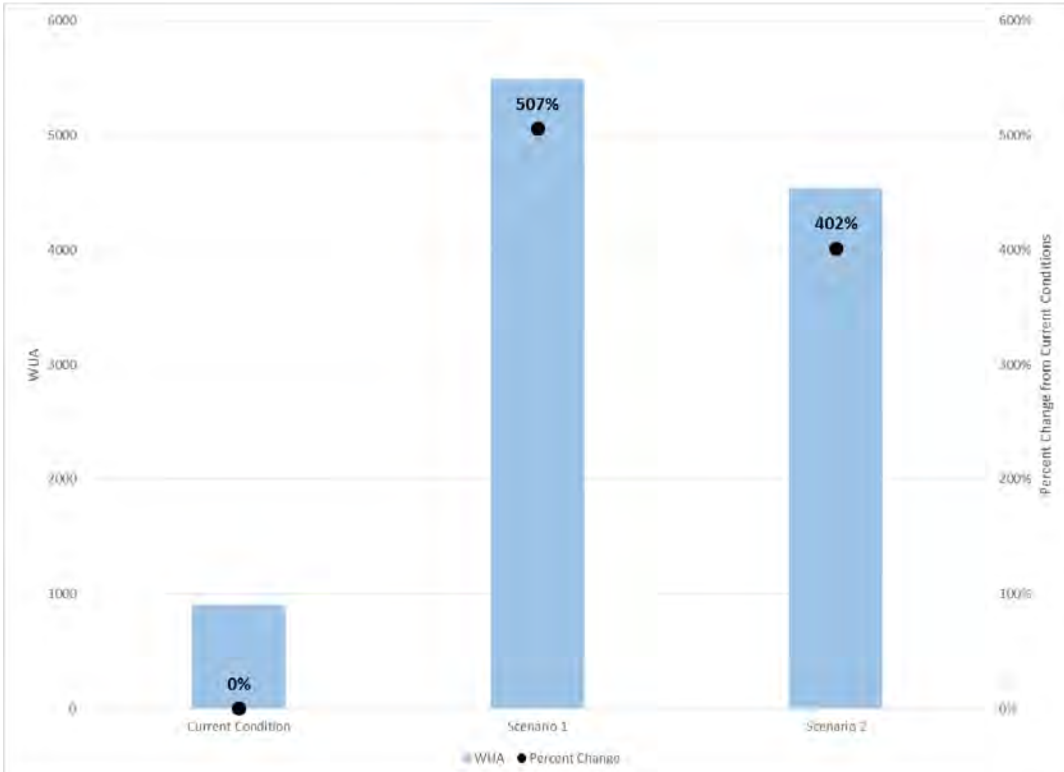
Figure 3.3 shows a comparison of median reservoir inflow to minimum instream flow releases listed in Table 3.3. The minimum flow releases shown are only the minimum to be released; the releases would often match the inflow as described in Section 3.2. The two operational scenarios are shown in Figure 3.3. They differ in that instream flows would be increased starting September 1 (for Scenario 2) to provide additional spawning habitat downstream of the dam (see Figure 3.3).

Figure 3.3
FRFA Example Flood Operations – Minimum Releases and Median Inflows



The effect of the releases on temperature in the Chehalis River are shown in Appendix A for 2013 and 2014, which were years modeled by PSU. Results are provided for Scenarios 1 and 2. A comparison of WUA for current and proposed conditions in the Chehalis River is provided in Appendix B for Scenarios 1 and 2. Figure 3.4 shows the results for one species, life stage, and reach—Chinook salmon rearing in July 2013 in the Pe Ell to Elk Creek Reach. The plot illustrates the large increase in WUA that would result from the FRFA facility downstream of the dam where temperatures are decreased significantly in late spring to early fall. Appendix B provides tables of changes in WUA for PHABSIM reaches and various species and life stages for 2013 and 2014 along the Chehalis River.

Figure 3.4
Change in WUA in Pe Ell to Elk Creek Reach for Chinook Salmon Rearing – July 2013



Based upon the flow, temperature, and WUA analyses, it is proposed that Scenario 2 be used for operations of the FRFA facility. However, the intent is to adaptively manage the operations based upon fisheries information, patterns of runoff, and temperature requirements in the Chehalis River. Scenario 2 should be viewed as a framework for operations at this stage of design for the project.

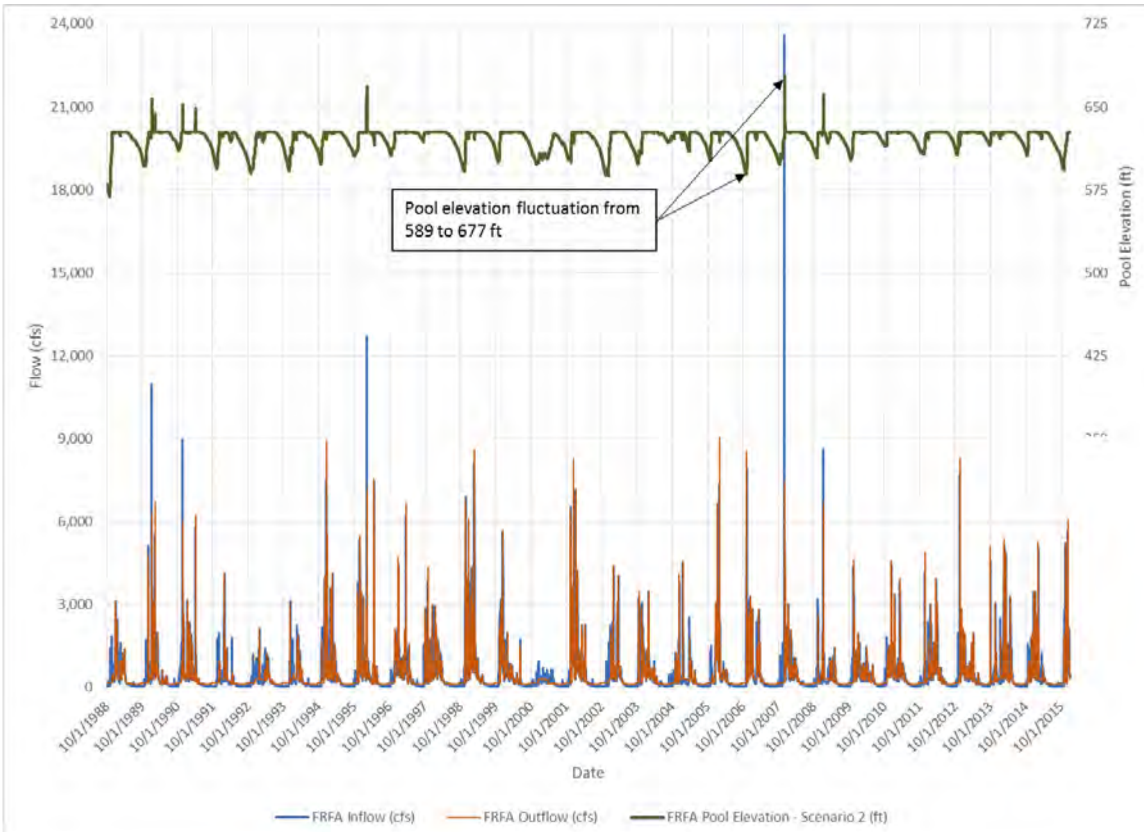
3.3 FRFA Performance

The performance of the FRFA facility operations was analyzed using the HEC-ResSIM model. Hydrologic data and the FRFA facility Operations Plan were used to simulate reservoir operations during historical hydrologic conditions. Output results from the HEC-ResSIM model include inflow into reservoir, outflow out of reservoir, pool elevation, and storage volume. Only Scenario 2 results are provided in this section, as it is the recommended operational scenario for the conservation pool.

3.3.1 Period of Record

The period of record for the historical data begins in October 1988 and extends into 2015. Modeled FRFA facility operational reservoir flows and pool elevation are plotted for the period of record in Figure 3.5.

Figure 3.5
FRFA Operations Modeling – Water Years 1989 to 2015



Storage in the FRFA reservoir would range from 36,800 to 121,700 acre-feet, with an annual minimum storage range from 36,800 to 58,800 acre-feet. The annual drawdown would range from 8 to 40 feet. The pool elevation during the period of record fluctuates between 589 to 677 feet. The full conservation pool elevation is 628 feet and the overflow (spillway) elevation is 687 feet. The pool elevation exceeds 628 feet during major floods while water is being retained. The highest pool elevation estimated during the period of record was 677 feet and occurred during the December 2007 flood. Within the 26-year period of record for the modeling analysis, seven major floods occurred that triggered flood operations. There is a 15% probability flood storage is utilized within any given year as described in Section 2.1.

3.3.1.1 Median Flows

The median flow during the period of record was computed using results of the HEC-ResSim model and the operational rules described in this section. Table 3.4 provides a comparison of existing flows in the Chehalis River below the dam to flows with the FRFA facility. The table presents the flow by month. The greatest increase would occur during the June to October time period when flow augmentation occurs. When the conservation pool is filling, flows are decreased between November and March. April and May flows are about the same for existing and with FRFA facility conditions.

Table 3.1
FRFA Median Flow – Scenario 2

MONTH	EXISTING CONDITIONS (cfs)	WITH FRFA – SCENARIO 2 (cfs)	DIFFERENCE (cfs)
January	554	485	-69
February	420	367	-53
March	442	419	-23
April	272	264	-8
May	145	134	-11
June	82	125	+43
July	40	95	+55
August	23	80	+57
September	20	120	+100
October	57	160	+103
November	371	160	-211
December	539	400	-139

During low flow years, the conservation pool storage is used to a greater extent. The large conservation pool volume ensures that even during periods of extreme low flow, the conservation pool can still provide enough water to meet instream flow needs. Table 3.5 presents a comparison of average model results to existing conditions in the Chehalis River during low flow years with a recurrence interval of 10 years.

Table 3.5
FRFA 90% (Low Flow) – Scenario 2

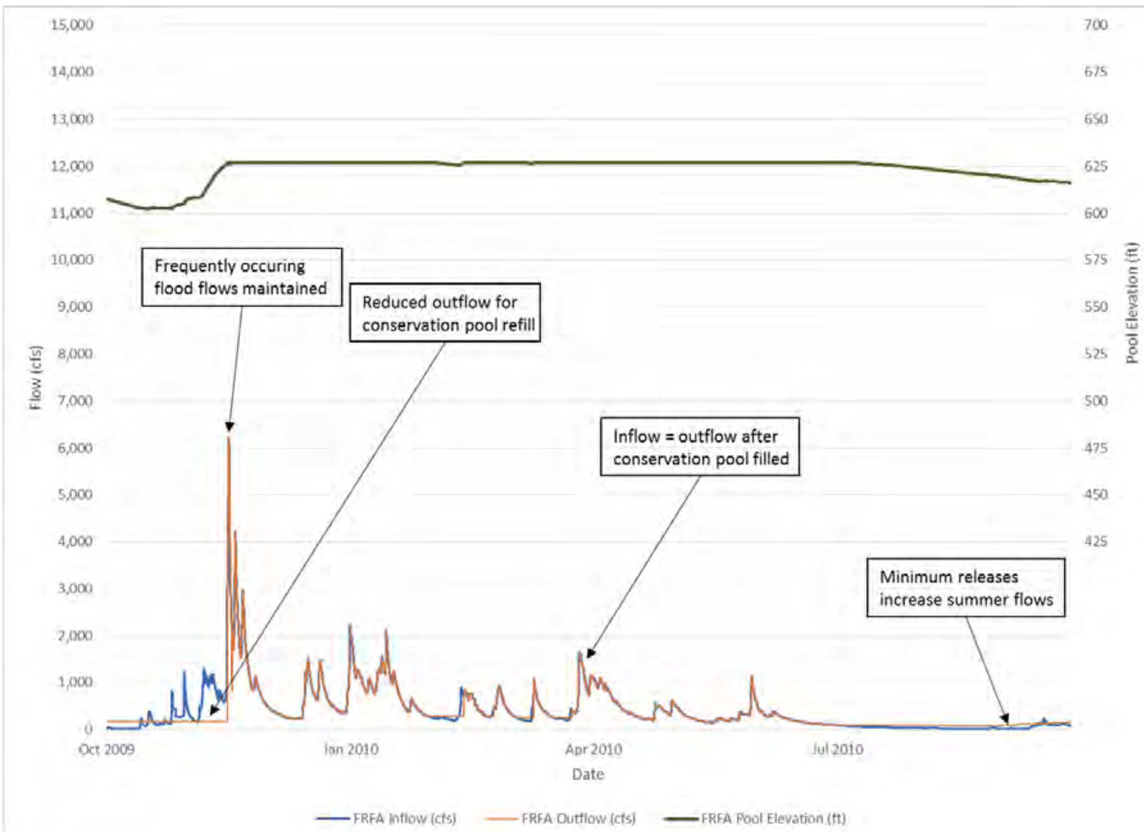
MONTH	EXISTING CONDITIONS (cfs)	WITH FRFA – SCENARIO 2 (cfs)	DIFFERENCE (cfs)
January	213	290	+77
February	153	290	+137
March	176	250	+74
April	150	125	-25
May	77	125	+48
June	46	95	+49
July	23	95	+72
August	16	80	+64
September	14	88	+74
October	16	160	+144
November	70	160	+90
December	164	160	-4

All months except for April and December would experience increases in outflow with FRFA operations to continuously keep minimum instream flows in the Chehalis River.

3.3.1.2 Non-major Flood Year (2010)

Figure 3.6 presents the model results for the water year 2010, a fairly typical non-major flood year. The conservation pool elevation varied between 600 and 628 feet. The figure illustrates that frequently occurring high flows (greater than 2,800 cfs) are preserved and how after the conservation pool is filled, the reservoir inflow equals outflow until needed for flow augmentation.

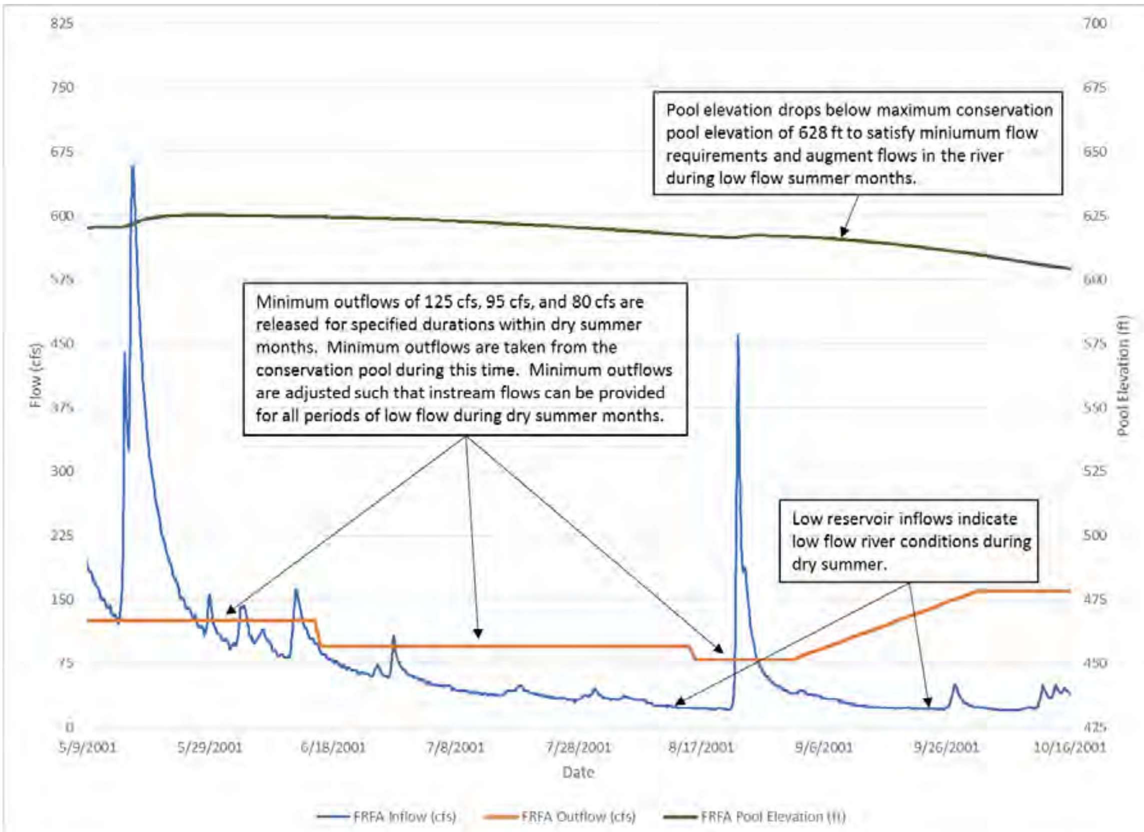
Figure 3.6
FRFA Operations Modeling – Water Year 2010



3.3.1.3 Dry Year (2001)

Winter 2001 was the worst drought in Washington since 1976. Salmon populations are affected by droughts from lower flows, creating smaller areas of rearing and spawning habitat, as well as less flow during outmigration periods and the potential for fish passage barriers due to low flow. The data from 2001 was modeled in FRFA operations to determine how flow conditions would change with FRFA flow augmentation operations. Figure 3.7 presents FRFA flows and pool elevations during a segment of 2001 when minimum flow operations are in place.

Figure 3.7
FRFA Operations Modeling – Minimum Flows During Summer 2001

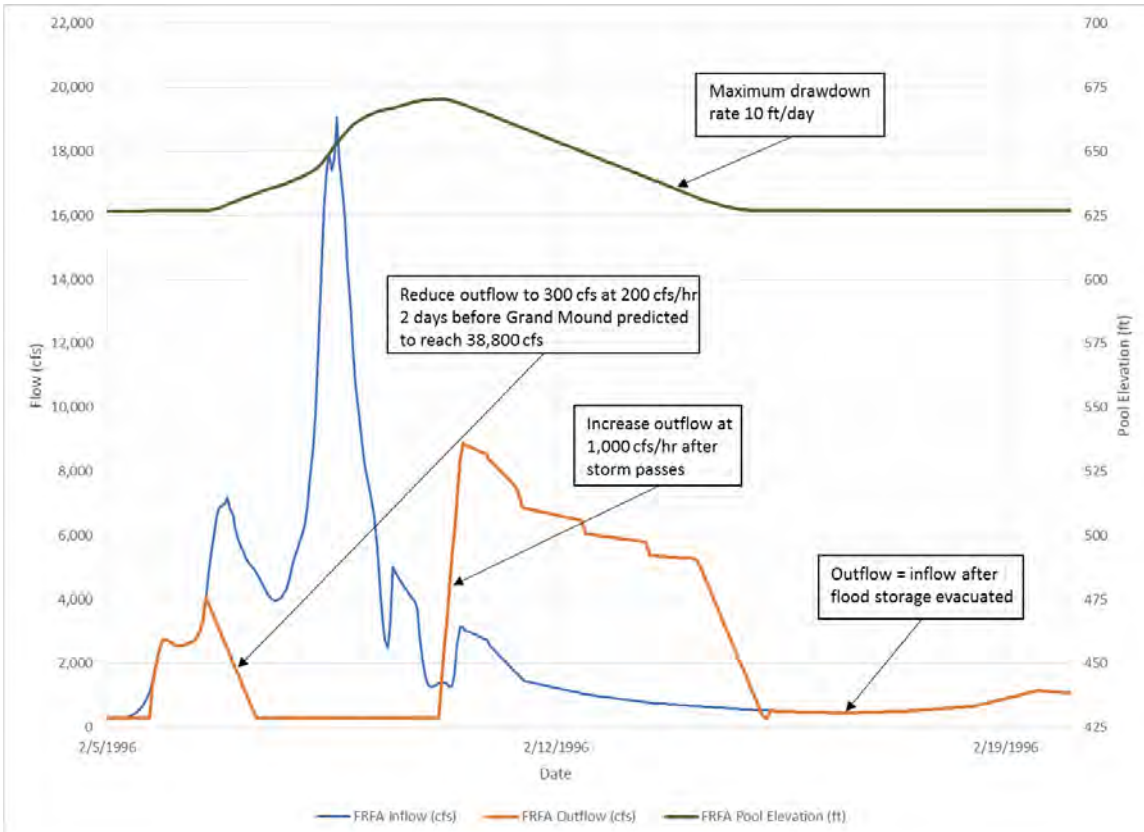


The instream flow releases during summer 2001 would have been 125 cfs from April 1 to June 15, 95 cfs from June 16 to August 15, and 80 cfs from August 16 to 31. Inflows into the reservoir from the end of May to September were historically low; therefore, water in the conservation pool would be used to supplement river flows and meet the minimum flow criteria. The pool elevation drops until a smaller flood (below major flood levels) can be used to recharge the conservation pool. Flows during summer 2001 would increase by as much as 70 to 80 cfs, increasing habitat for salmonids and other aquatic species.

3.3.1.4 1996 Flood

Figure 3.8 presents the estimated results of FRFA operations during the February 1996 flood.

Figure 3.8
FRFA Operations Modeling – February 1996 Flood

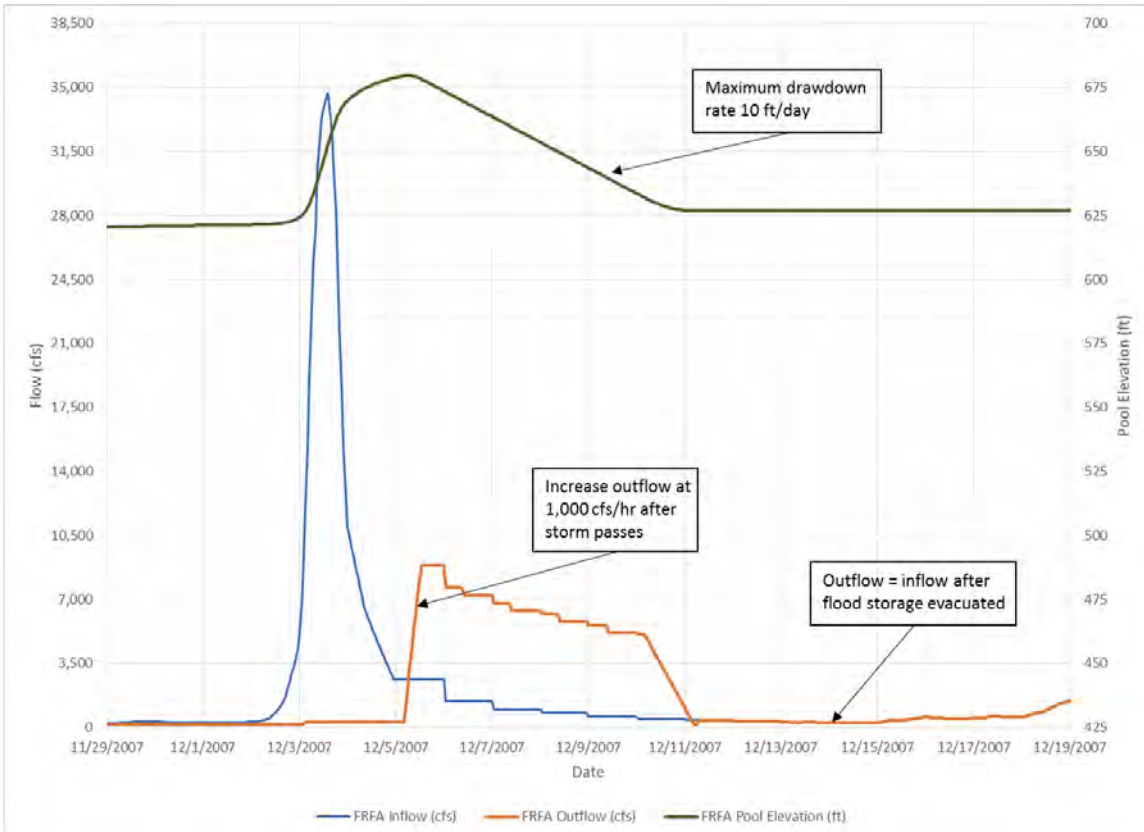


With FRFA operations, peak reservoir releases after storms would increase due to a greater amount of water available. Peak releases after the February 1996 flood would have been about 8,900 cfs for the FRFA facility, compared to 6,500 cfs for the FRO facility, which is a 38% difference. The higher releases after the flood could help maintain sediment transport conditions downstream of the dam. The peak flows would be released after the peak of the flood passes downstream areas most affected by major floods. The reservoir would inundate up to a maximum elevation of 670.5 feet, spanning a length of 7.3 miles. The reduction in peak flows downstream of the dam during this flood would be the same as presented for the FRO facility.

3.3.1.5 2007 Flood

Figure 3.9 presents the estimated results of FRFA operations during the December 2007 flood.

Figure 3.9
FRFA Operations Modeling – December 2007 Flood

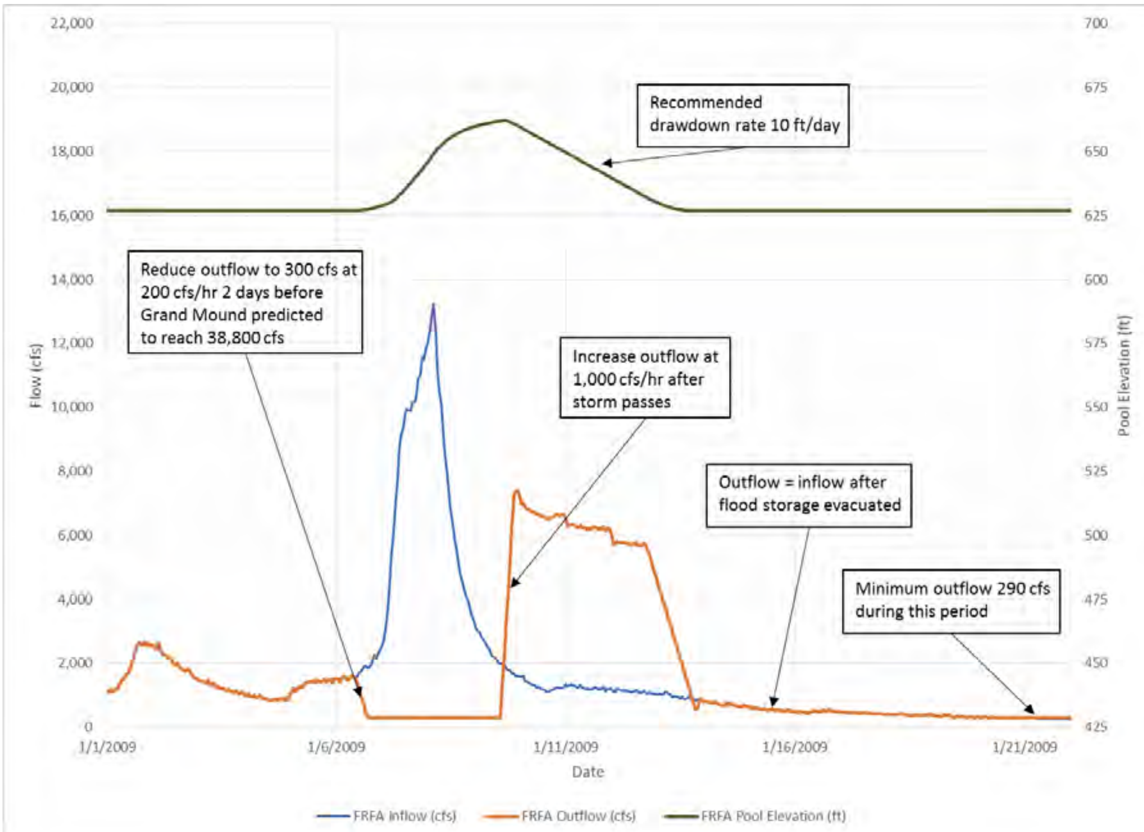


Peak releases after the December 2007 flood would have been about 8,900 cfs for the FRFA facility, compared to 6,500 cfs for the FRO facility, which is a 36% difference. The reservoir would inundate up to a maximum elevation of 683.1 feet, spanning a length of 7.6 miles. The reduction in peak flows downstream of the dam during this flood would be the same as presented for the FRO facility.

3.3.1.6 2009 Flood

Figure 3.10 presents the estimated results of FRFA operations during the January 2009 flood.

Figure 3.10
FRFA Operations Modeling –January 2009 Flood



Peak releases after the January 2009 flood would have been about 7,400 cfs for the FRFA facility, compared to 4,800 cfs for the FRO facility, which is a 53% difference. The reservoir would inundate up to a maximum elevation of 662.1 feet, spanning a length of 7.3 miles. The reduction in peak flows downstream of the dam during this flood would be the same as presented for the FRO facility.

3.4 Flow Exceedance Calculations

Flow exceedance curves were calculated for existing conditions and with the FRFA facility in operation. The curves are shown in Figure 3.11. The methodology to produce the curves was the same as described for the FRO facility. The flow exceedance curves for existing conditions and with the FRFA facility in operation at the Doty gage is presented in Figure 3.12.

With FRFA operations, about one-half of the time, flows are increased compared to existing conditions. Flows above 8,000 cfs at the dam site and 10,000 cfs at the Doty gage are significantly reduced.

Figure 3.11
Flow Exceedance Curve for FRFA Facility at Dam Site

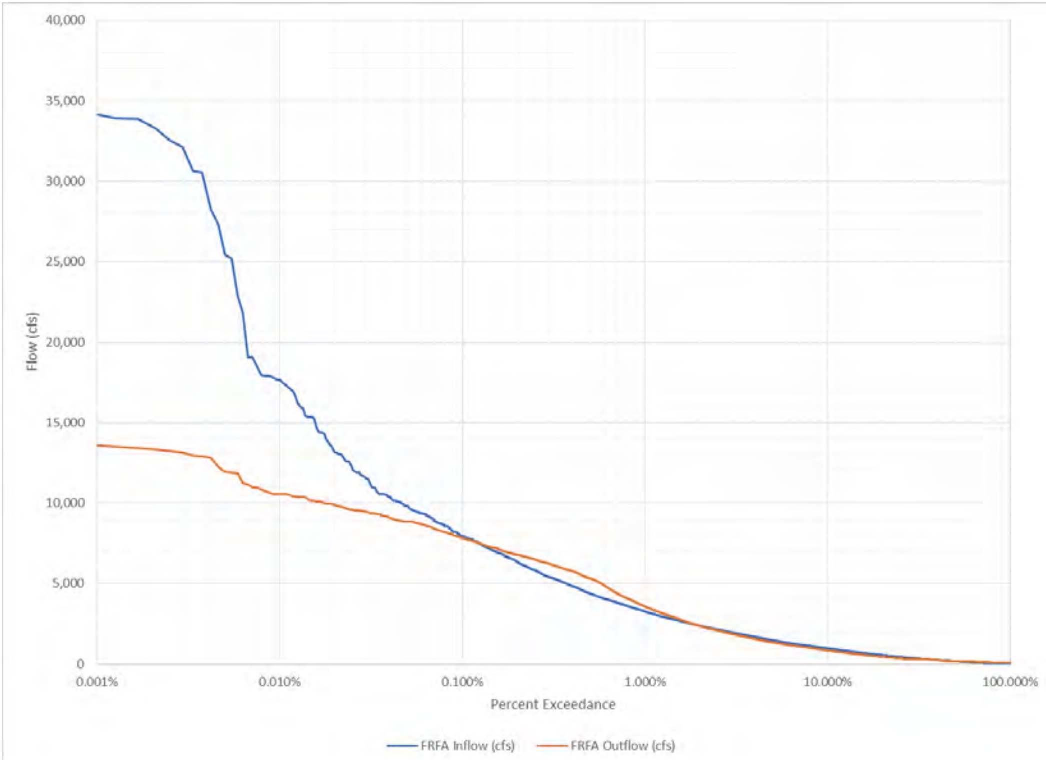
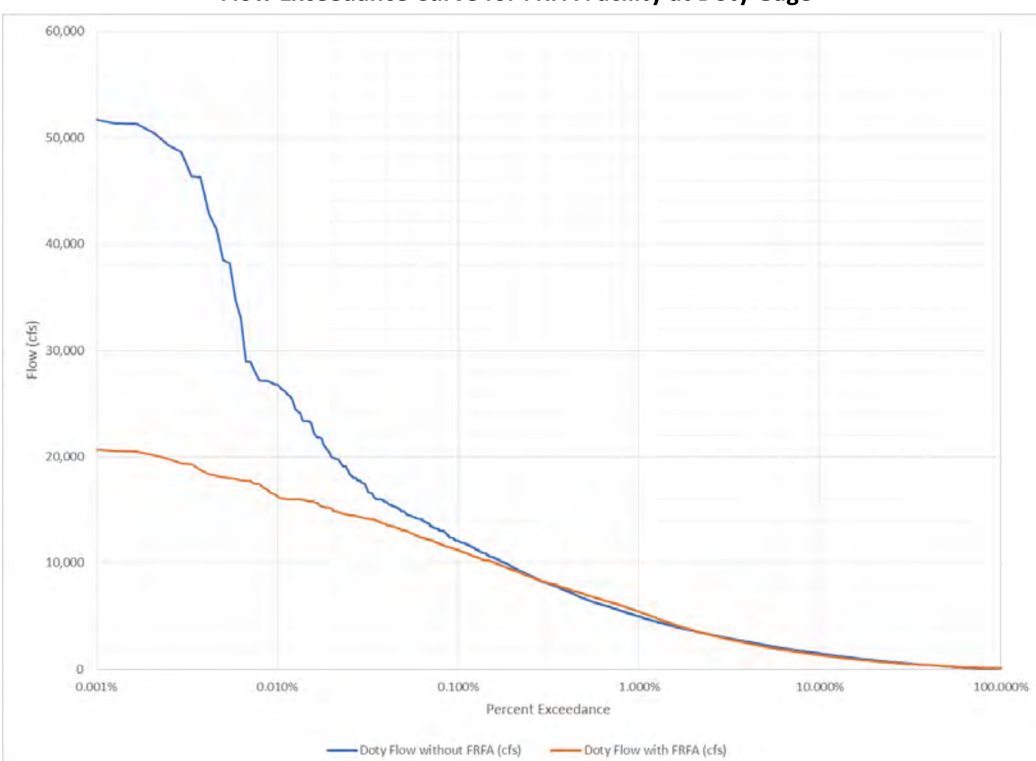


Figure 3.12
Flow Exceedance Curve for FRFA Facility at Doty Gage



4 CLIMATE CHANGE EFFECTS ON OPERATIONS

The effects of climate change on operations of the FRO and FRFA facilities were analyzed. The methodology used was to develop future inflows and run the HEC-ResSim operations model using the same operating scenarios described in previous sections. This analysis describes operations during floods for the FRO facility and annual operations for the FRFA facility. Though this analysis provides an assessment of potential impacts from climate change, we assume a flood retention facility would be operated adaptively and the operations described in previous sections may not reflect future operations.

4.1 Development of Streamflows Under Climate Change

The process for predicting future peak and non-peak stream flows was led by the Climate Impacts Group (CIG) at the University of Washington and involved assimilating and scaling data from existing forecasting models. These models included several hydrologic models and 12 different Global Climate Models (GCMs), several different future timeframes, and three different greenhouse gas emission scenarios—all of which were modified and applied to numerous sites in the Chehalis Basin (Mauger et al. 2016; Karpack 2016a). The results of the modeling produced a range of potential hydrologic responses to climate change. Discussions were held with CIG and the State and a recommendation to use a single set of hydrologic responses for purposes of the Operations Plan and related studies was agreed upon (Karpack 2016a). The approaches used by CIG in their climate change modeling are presented in Table 4.1.

Table 4.1
Methodologies Used in Climate Change Modeling

DATA	METHODOLOGY USED – PEAK FLOWS	METHODOLOGY USED – MONTHLY FLOWS
Hydrologic Model	Variable Infiltration Capacity (VIC) model	
Meteorological Inputs	Average of ten GCMs	
Downscaling	Multivariate Adaptive Constructed Analog (MACA) statistical downscaling	
Flow Bias Correction	Daily bias corrected flows	
Flow Locations	**Seven Key Sites** • Chehalis River at Doty • Chehalis River at Grand Mound • Chehalis River at Porter • Newaukum River near Chehalis • Skookumchuck River at Bucoda • Satsop River near Satsop • Wynoochee River above Black Creek	**Three Key Sites** • Chehalis River at Doty • Chehalis River at Grand Mound • Chehalis River at Porter
Historical Period	Simulations for 1951 to 2005	
Future Period	Simulations for 2040 to 2099	
Forecasted Change	Percent change in flood frequency flow	Percent change in monthly average flow

The recommended percentage increase for peak flows is presented in Table 4.2. The peak flow increases were applied to the existing peak inflows to the FRO reservoir to develop estimated future peak inflows, which are also summarized in Table 4.2.

Table 4.2
Peak Flows for Existing and Future Conditions for FRO

FLOOD OCCURRENCE	PERCENT INCREASE UNDER CLIMATE CHANGE	PEAK FLOWS (cfs)	
		EXISTING	FUTURE
2-year	16%	6,920	8,027
10-year	35%	13,061	17,633
20-year	45%	16,053	23,276
100-year	66%	24,223	40,211
500-year	94%	35,688	69,234

Multipliers for monthly flows were also derived from the CIG modeling to be used in modeling the FRFA reservoir. As with the peak flows, CIG provided a range of hydrologic responses to climate change. A recommendation to use a single set of multipliers was agreed to (Karpack 2016a). Table 4.3 lists the multipliers developed for period of record future flows at the dam site.

Table 4.3
Monthly Flow Changes under Climate Change Conditions for FRFA

MONTH	PERCENT CHANGE	MULTIPLIER
January	12.9%	1.129
February	8.5%	1.085
March	-0.6%	0.994
April	-6.2%	0.938
May	-11.1%	0.889
June	-14.9%	0.851
July	-18.3%	0.817
August	-21.5%	0.785
September	-18.7%	0.813
October	5.5%	1.055
November	5.8%	1.058
December	14.5%	1.145

4.2 Effects on FRO Operations

The 100-year floods for existing and future conditions were run through the HEC-ResSim model for the FRO facility using operations described in previous sections. Figure 4.1 shows FRO flows and elevations for the current 100-year flood, and Figure 4.2 shows FRO flows and elevations for a future 100-year flood.

Figure 4.1
FRO Flows and Elevations – Current 100-year Flood

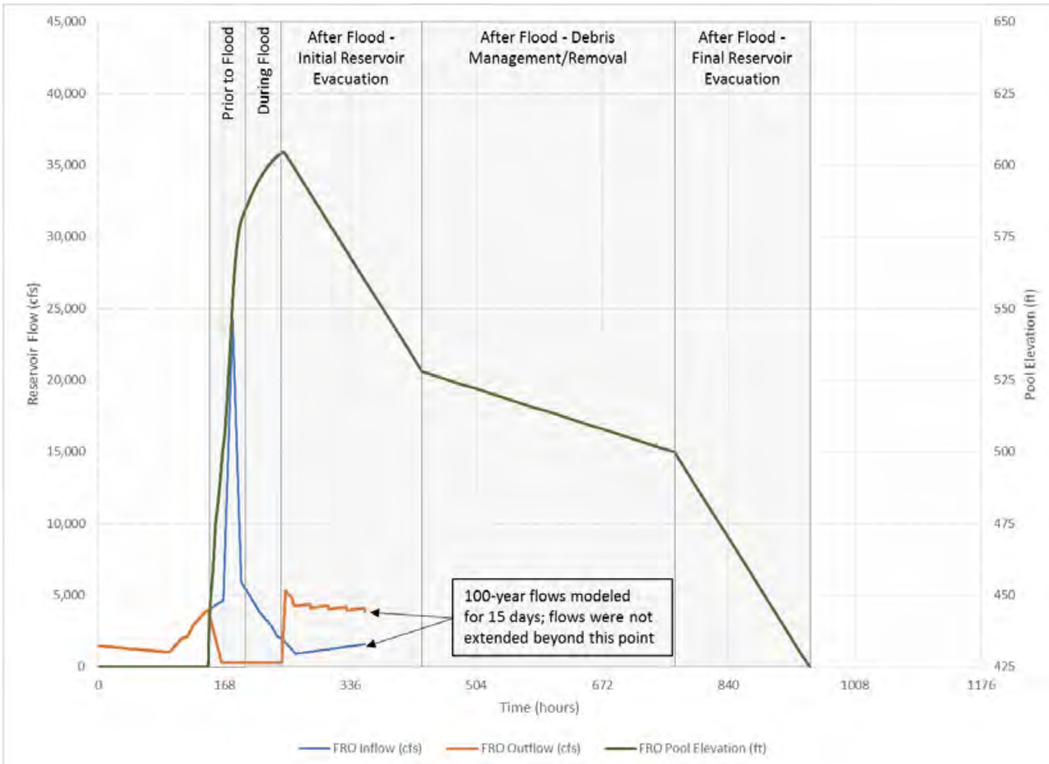
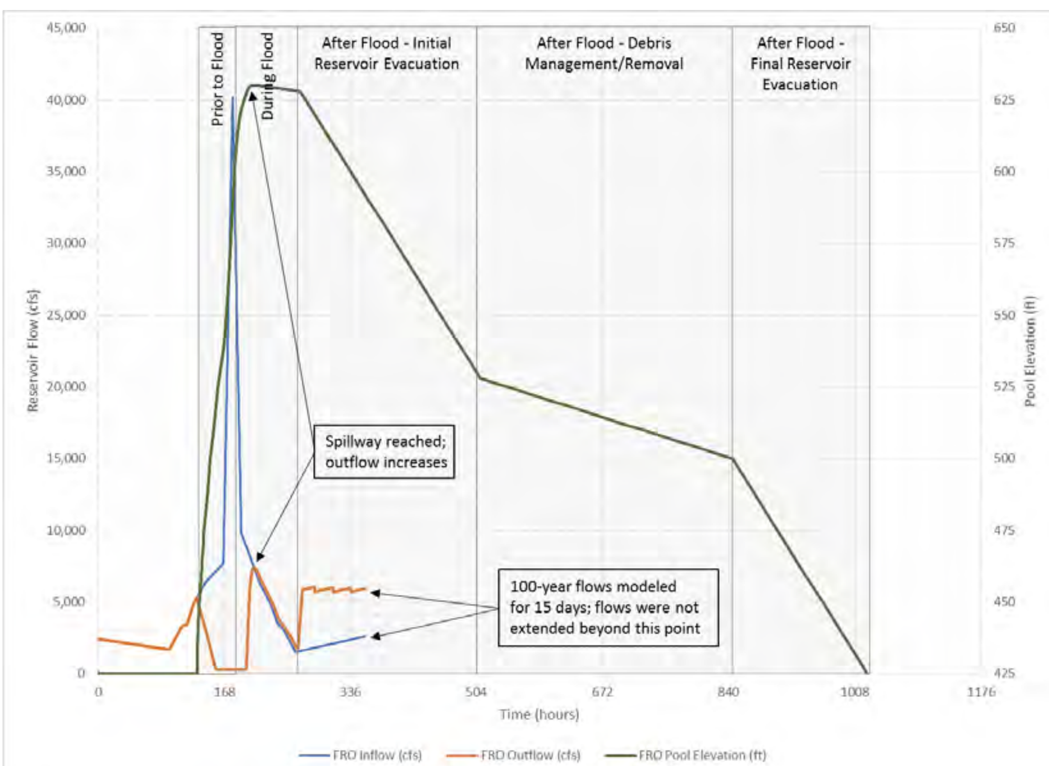


Figure 4.2
FRO Flows and Elevations – Future 100-Year Flood



The future 100-year flood under climate change conditions would cause the entire flood storage volume to be utilized. The peak stage in that flood would be 630 feet, which is 3 feet over the spillway crest. A large flood reduction benefit would still be realized, as the flow over the spillway would occur after the peak of the flood occurs and the spillway flow would still be much less than the peak inflow. Table 4.4 compares the difference in peak flows at the dam site, at Doty, and at Grand Mound for current and future conditions.

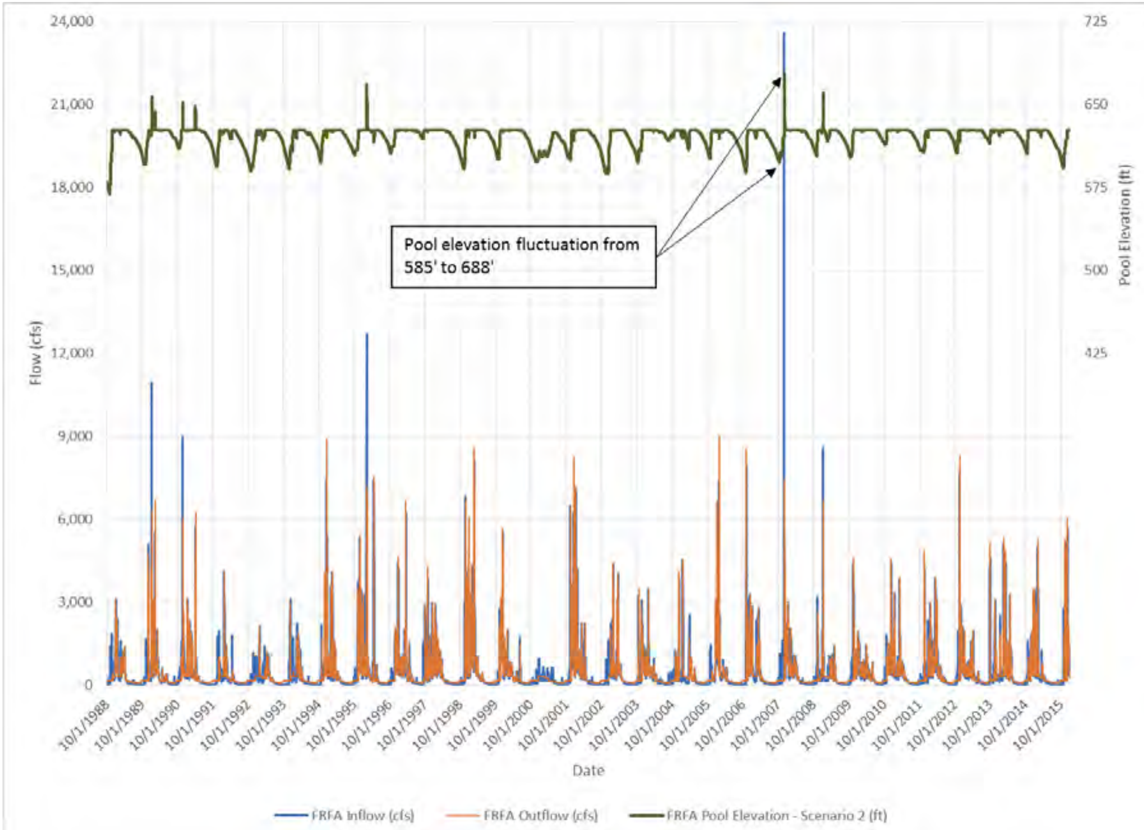
Table 4.4
Current and Future 100-year Flood Peak Flows With and Without FRO Facility

LOCATION	ALTERNATIVE	EXISTING 100-YEAR PEAK FLOW (cfs)	100-YEAR PEAK FLOW WITH CLIMATE CHANGE (cfs)
At Dam	Without Dam	24,200	40,200
	With Dam	300	7,400
	% Difference	-99%	-82%
At Doty	Without Dam	36,700	60,900
	With Dam	12,800	21,000
	% Difference	-65%	-66%
At Grand Mound	Without Dam	75,100	137,900
	With Dam	62,900	108,600
	% Difference	-16%	-21%

4.3 Effects on FRFA Operations

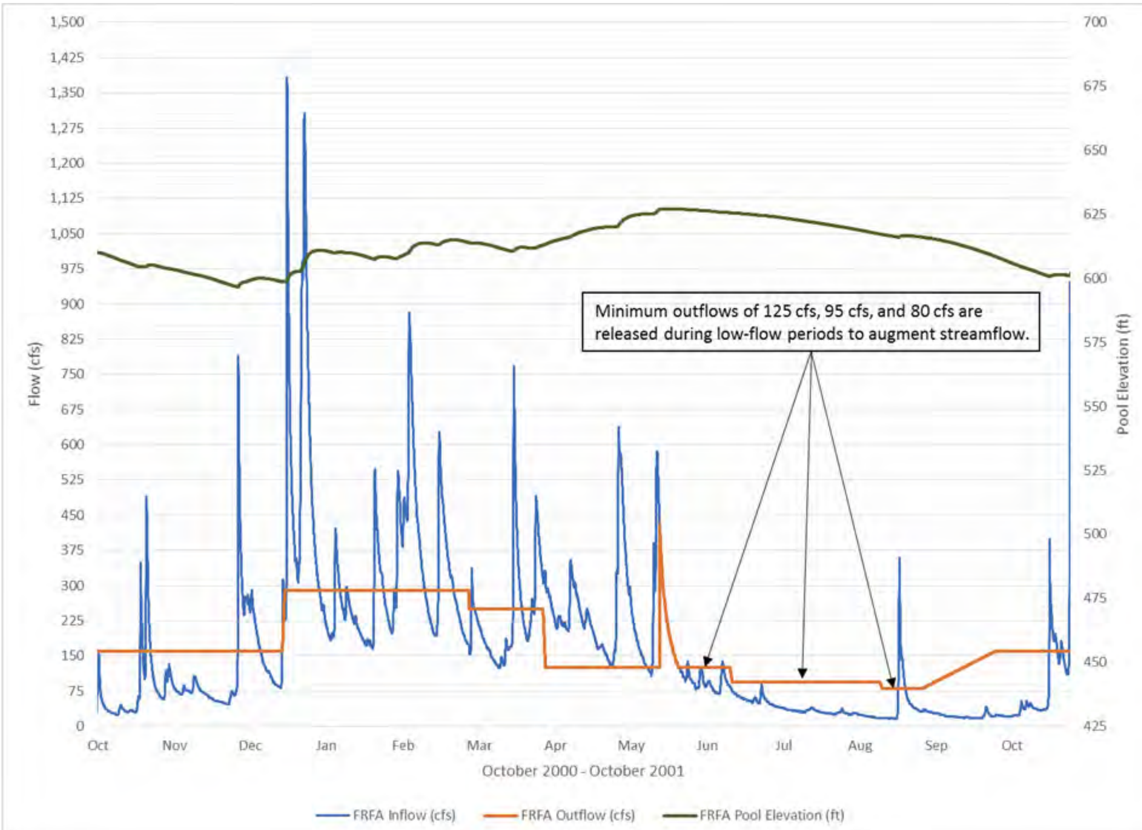
FRFA operations for future conditions were simulated using the HEC-ResSim model with hourly period of record inflows adjusted using the monthly flow change multiplier described previously. Floods (such as those in 1990, 1991, 1996, 2007, and 2009) were not further modified. Modeled FRFA operational reservoir flows and pool elevation are plotted for the period of record with climate change in Figure 4.3.

Figure 4.3
FRFA Operations Modeling – Water Years 1989 to 2015 (with Climate Change Conditions)



With climate change, the FRFA facility would drawdown to elevation 585 feet, or 4 feet lower than without climate change. The 2007 flood would have caused the pool elevation to rise enough that the spillway would be in use, which would not have been the case in existing climate conditions. Figure 4.4 shows operations during a drought year (2001 with climate change multipliers applied) illustrating that minimum outflows could be maintained through the May to October time period even with reduced inflow to the reservoir. Figure 4.4 can be compared to Figure 3.7, which shows operations during 2001 for existing climate conditions.

Figure 4.4
FRFA Operations Modeling During Drought Year (2001 with Climate Change Multipliers)



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Appendix A
Summary of Water Temperature Analyses

SUMMARY OF WATER TEMPERATURE ANALYSES PERFORMED BY PORTLAND STATE UNIVERSITY

The Washington State Department of Ecology contracted Portland State University (PSU) to develop a water quality model based on the CE-QUAL-W2 modeling framework to meet project objectives and to provide technical assistance in the use of the model. The CE-QUAL-W2 modeling framework is a water quality and hydrodynamic model in 2-D (longitudinal-vertical) for rivers, estuaries, lakes, reservoirs, and river basin systems. It models basic eutrophication processes, such as temperature-nutrient-algae-dissolved oxygen-organic matter and sediment relationships. For the Chehalis Basin project, PSU developed input data and calibrated a model for temperature (and dissolved oxygen) for the Chehalis River from the proposed retention structure site upstream of the town of Pe Ell to the downstream outlet of Water Resource Inventory Area (WRIA) 23 at the U.S. Geological Survey (USGS) gage in Porter, WA.

Preliminary results were obtained for river conditions in 2013 and 2014. PSU modeled conditions in 2013 and 2014 for existing conditions, flood retention flow augmentation (FRFA) Scenario 1, and FRFA Scenario 2 conditions. The results from the model were analyzed in order to compare water quality results between all three conditions. The data was averaged by month; Tables A.1 through A.4 presents these results. January, April, July, and October were selected as representative months for different times of the year. Cross-sections at RM 107, 90, 75.4, 67.5, 54.2, and 33.3 were selected as representative cross-sections for the analysis; other cross-sections were also modeled by PSU.

Table A.1

Monthly Averaged Water Temperatures – 2013

GAGE	RM	EXISTING JAN	EXISTING APR	EXISTING JUL	EXISTING OCT	FRFA – SCENARIO 1 JAN	FRFA – SCENARIO 1 APR	FRFA – SCENARIO 1 JUL	FRFA – SCENARIO 1 OCT	FRFA – SCENARIO 2 JAN	FRFA – SCENARIO 2 APR	FRFA – SCENARIO 2 JUL	FRFA – SCENARIO 2 OCT
Chehalis Upstream of Pe Ell	107	5.2	12.1	19.7	10.6	5.0	8.7	13.6	10.6	5.0	8.8	14.2	10.5
Chehalis Mainstem Upstream of South Fork	90	5.1	11.8	24.1	10.6	5.1	10.5	23.2	10.6	5.1	10.6	23.4	10.6
Chehalis Mainstem Upstream Newaukum	75.4	5.3	11.3	23.2	10.6	5.3	10.7	22.6	10.6	5.3	10.8	22.7	10.6
Chehalis Upstream of Skookumchuck	67.5	5.5	11.2	22.6	10.6	5.5	10.9	22.3	10.6	5.5	10.9	22.3	10.6
Chehalis Upstream of Black River	54.2	5.6	12.3	23.7	11.2	5.6	12.1	23.5	11.2	5.6	12.1	23.5	11.2
Near Porter, Washington	33.3	5.6	12.2	23.6	11.0	5.6	12.1	23.5	11.0	5.6	12.1	23.5	11.0

Table A.2

Monthly Averaged Water Temperatures – 2013 – Percent Change

GAGE	RM	EXISTING JAN	EXISTING APR	EXISTING JUL	EXISTING OCT	FRFA – SCENARIO 1 JAN	FRFA – SCENARIO 1 APR	FRFA – SCENARIO 1 JUL	FRFA – SCENARIO 1 OCT	FRFA – SCENARIO 2 JAN	FRFA – SCENARIO 2 APR	FRFA – SCENARIO 2 JUL	FRFA – SCENARIO 2 OCT
Chehalis Upstream of Pe Ell	107	-4.3%	-49.6%	-65.2%	-0.6%	-5.2%	-31.4%	-32.4%	-1.3%	-4.3%	-49.6%	-65.2%	-0.6%
Chehalis Mainstem Upstream of South Fork	90	-0.4%	-16.8%	-6.7%	0.0%	-0.7%	-11.0%	-2.9%	-0.4%	-0.4%	-16.8%	-6.7%	0.0%
Chehalis Mainstem Upstream Newaukum	75.4	0.2%	-6.8%	-3.8%	0.0%	0.0%	-4.6%	-1.9%	0.1%	0.2%	-6.8%	-3.8%	0.0%
Chehalis Upstream of Skookumchuck	67.5	0.1%	-4.4%	-2.7%	0.1%	0.0%	-3.0%	-1.3%	-0.2%	0.1%	-4.4%	-2.7%	0.1%
Chehalis Upstream of Black River	54.2	0.2%	-2.5%	-1.2%	0.0%	0.2%	-1.7%	-0.6%	0.0%	0.2%	-2.5%	-1.2%	0.0%
Near Porter, Washington	33.3	0.1%	-2.0%	-1.0%	-0.2%	0.1%	-1.3%	-0.5%	-0.2%	0.1%	-2.0%	-1.0%	-0.2%

Table A.3

Monthly Averaged Water Temperatures – 2014

GAGE	RM	EXISTING JAN	EXISTING APR	EXISTING JUL	EXISTING OCT	FRFA – SCENARIO 1 JAN	FRFA – SCENARIO 1 APR	FRFA – SCENARIO 1 JUL	FRFA – SCENARIO 1 OCT	FRFA – SCENARIO 2 JAN	FRFA – SCENARIO 2 APR	FRFA – SCENARIO 2 JUL	FRFA – SCENARIO 2 OCT
Chehalis Upstream of Pe Ell	107	5.5	11.4	20.1	12.0	5.1	8.5	13.2	11.0	5.0	8.5	13.9	10.9
Chehalis Mainstem Upstream of South Fork	90	5.3	11.5	23.5	11.8	5.2	10.3	23.1	12.0	5.1	10.3	23.4	11.7
Chehalis Mainstem Upstream Newaukum	75.4	5.5	11.2	23.1	11.7	5.4	10.7	22.5	11.7	5.4	10.7	22.6	11.7
Chehalis Upstream of Skookumchuck	67.5	5.6	11.2	22.6	11.9	5.5	10.9	22.2	11.8	5.5	10.9	22.3	11.8
Chehalis Upstream of Black River	54.2	5.7	12.2	23.6	12.6	5.7	12.0	23.5	12.6	5.7	12.0	23.5	12.5
Near Porter, Washington	33.3	5.7	12.2	23.5	12.4	5.6	12.1	23.4	12.3	5.6	12.1	23.4	12.3

Table A.4

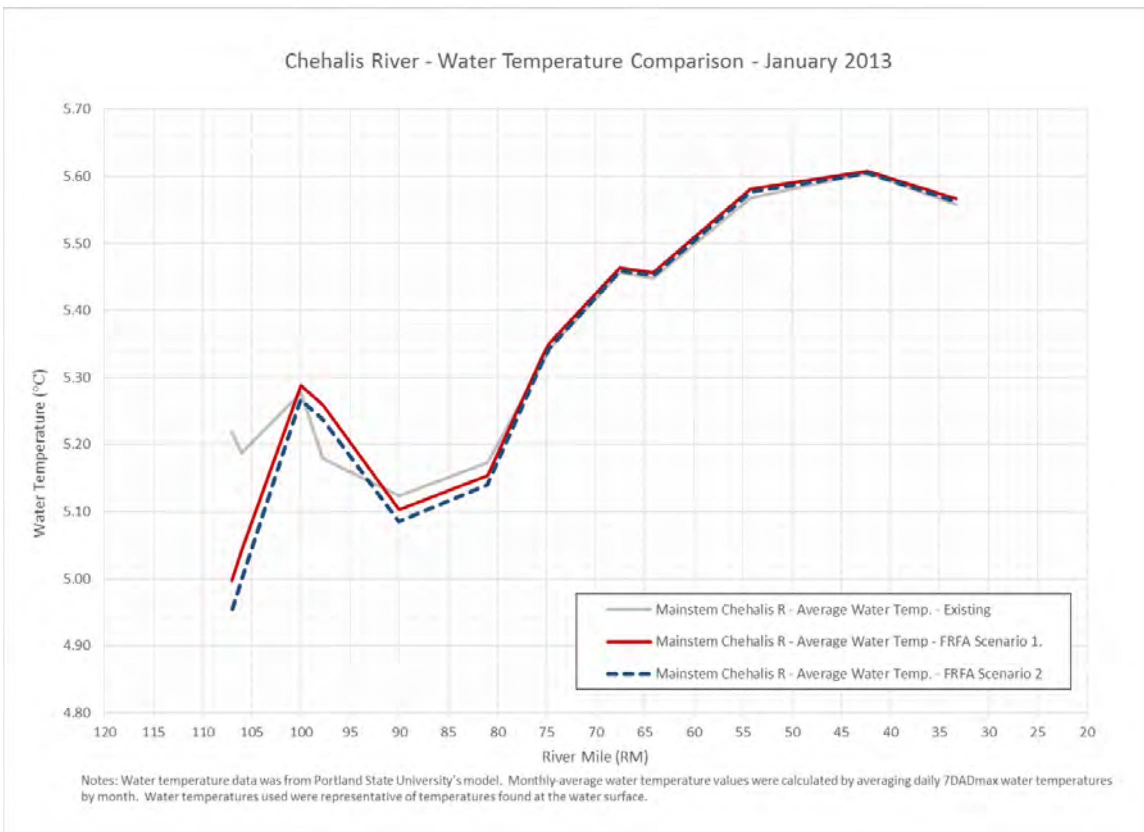
Monthly Averaged Water Temperatures – 2014 – Percent Change

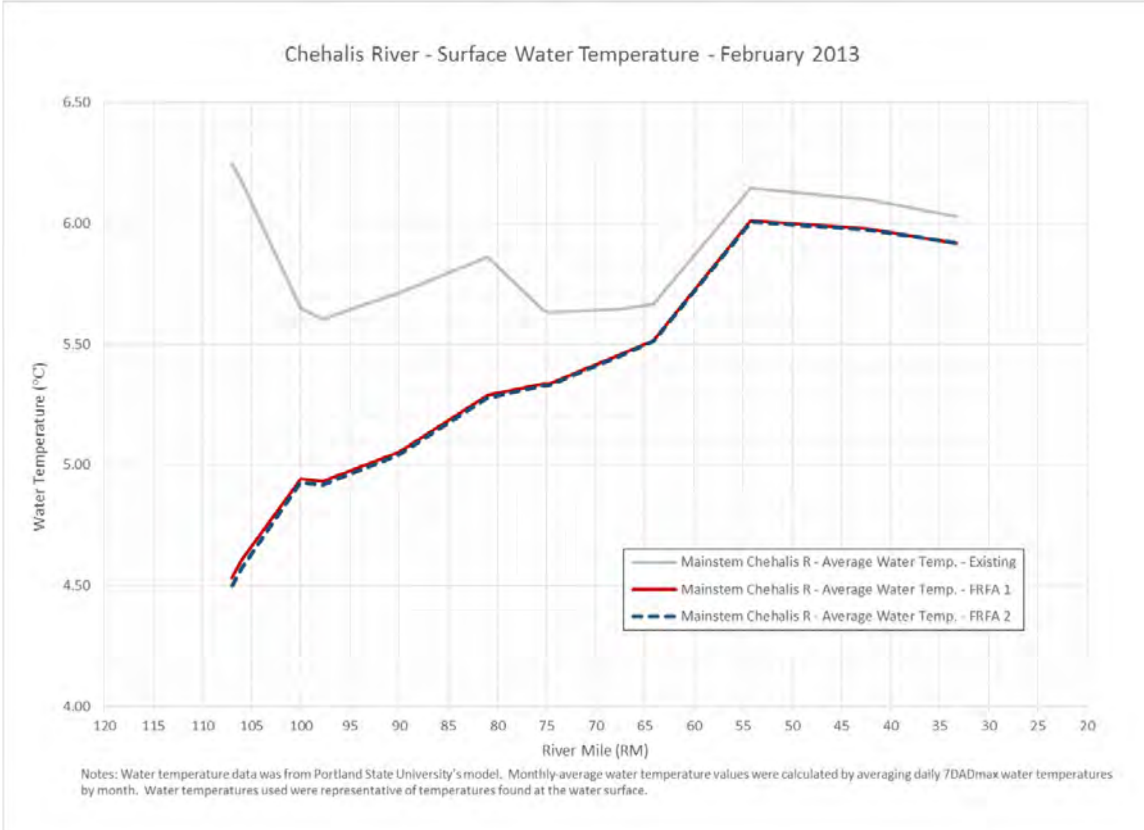
GAGE	RM	EXISTING JAN	EXISTING APR	EXISTING JUL	EXISTING OCT	FRFA – SCENARIO 1 JAN	FRFA – SCENARIO 1 APR	FRFA – SCENARIO 1 JUL	FRFA – SCENARIO 1 OCT	FRFA – SCENARIO 2 JAN	FRFA – SCENARIO 2 APR	FRFA – SCENARIO 2 JUL	FRFA – SCENARIO 2 OCT
Chehalis Upstream of Pe Ell	107	-7.1%	-42.4%	-75.0%	-12.3%	-9.5%	-29.4%	-36.7%	-9.4%	-7.1%	-42.4%	-75.0%	-12.3%
Chehalis Mainstem Upstream of South Fork	90	-1.7%	-15.1%	-2.7%	2.1%	-2.6%	-10.7%	-0.3%	-0.8%	-1.7%	-15.1%	-2.7%	2.1%
Chehalis Mainstem Upstream Newaukum	75.4	-1.3%	-5.9%	-4.7%	-0.4%	-1.6%	-4.3%	-2.3%	-0.5%	-1.3%	-5.9%	-4.7%	-0.4%
Chehalis Upstream of Skookumchuck	67.5	-0.9%	-3.8%	-3.0%	-0.9%	-1.1%	-2.8%	-1.5%	-0.9%	-0.9%	-3.8%	-3.0%	-0.9%
Chehalis Upstream of Black River	54.2	-0.5%	-2.5%	-0.9%	-0.7%	-0.7%	-1.8%	-0.4%	-0.9%	-0.5%	-2.5%	-0.9%	-0.7%
Near Porter, Washington	33.3	-0.5%	-1.8%	-0.7%	-0.2%	-0.6%	-1.3%	-0.4%	-0.3%	-0.5%	-1.8%	-0.7%	-0.2%

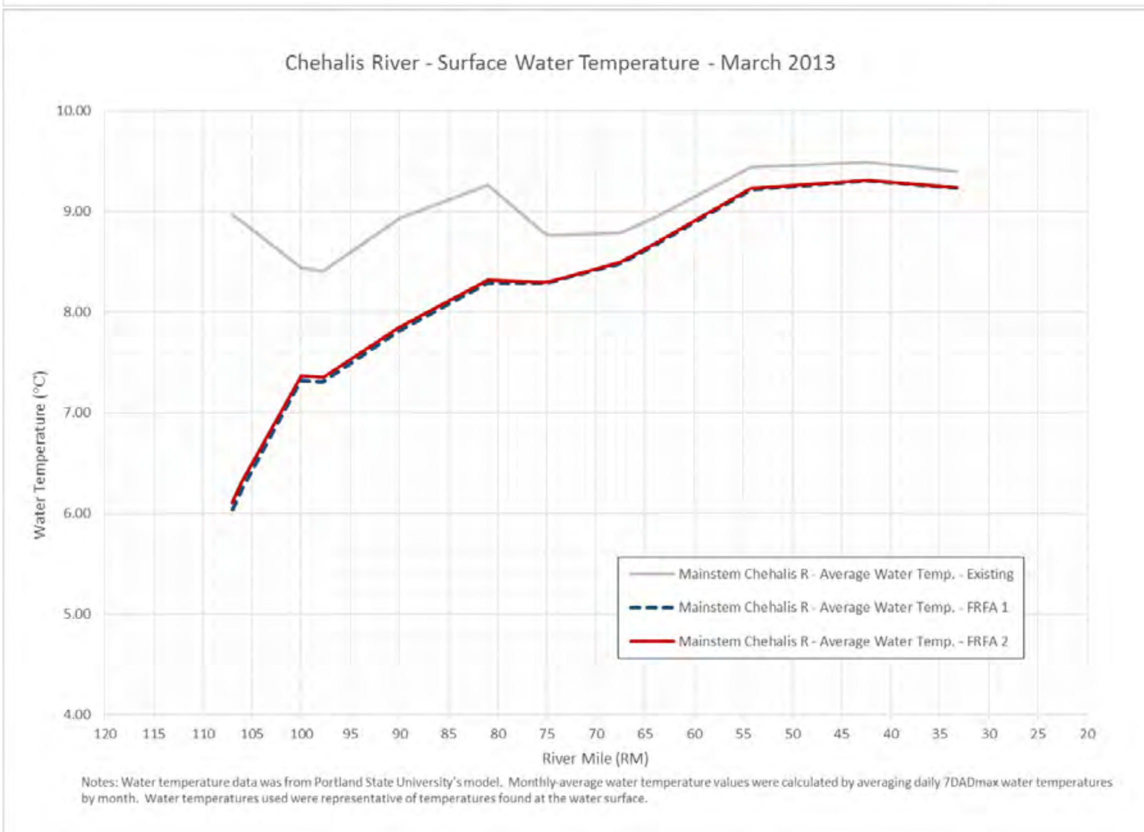
Generally, the FRFA model results show a decrease in water temperature in comparison to current conditions. Temperature decreases are highest in the upper reaches of the Chehalis River and the differences fade in a downstream direction. The months of April and July see the greatest differences however July temperatures are more critical because they affect the habitat suitability in the Chehalis River.

The following figures show monthly average temperatures in the Chehalis River for 2013 and 2014, as obtained from the PSU modeling results.

Figures




Chehalis River - Surface Water Temperature - February 2013
Water Temperature (°C)
6.50
6.00
5.50
5.00
4.50
4.00
120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.


Chehalis River - Surface Water Temperature - March 2013
Water Temperature (°C)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
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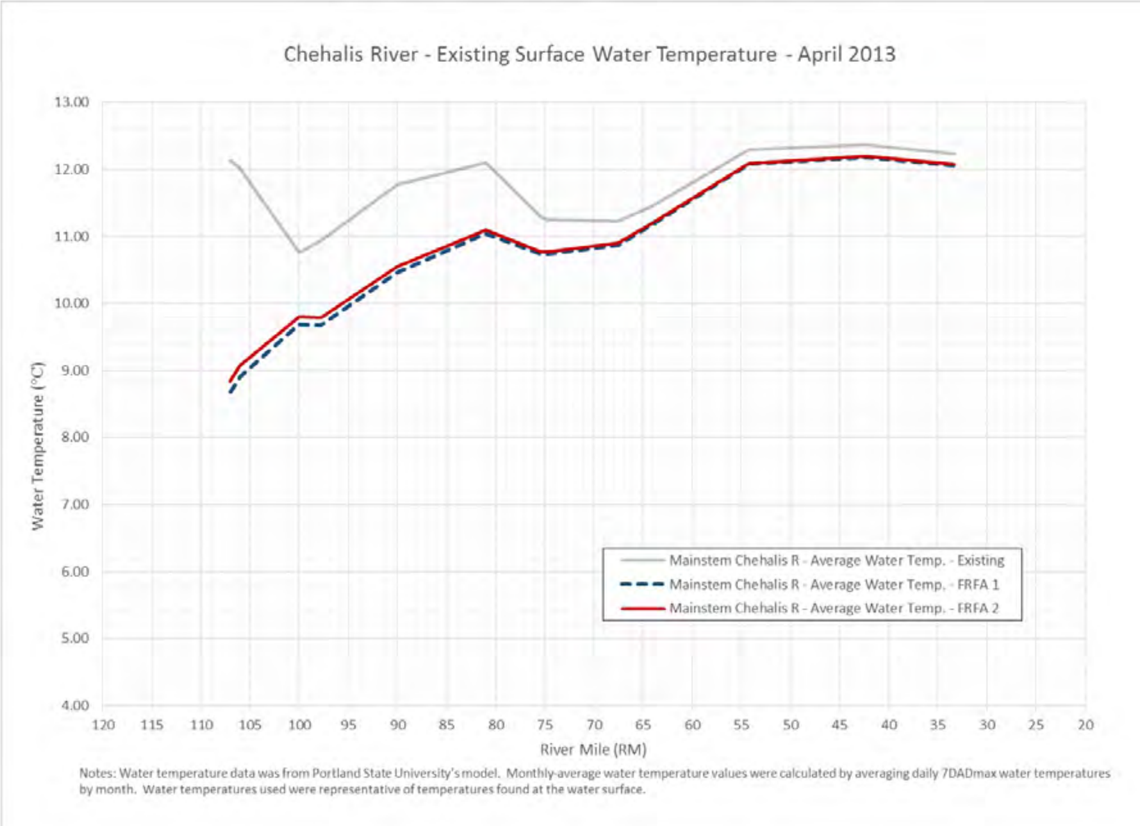
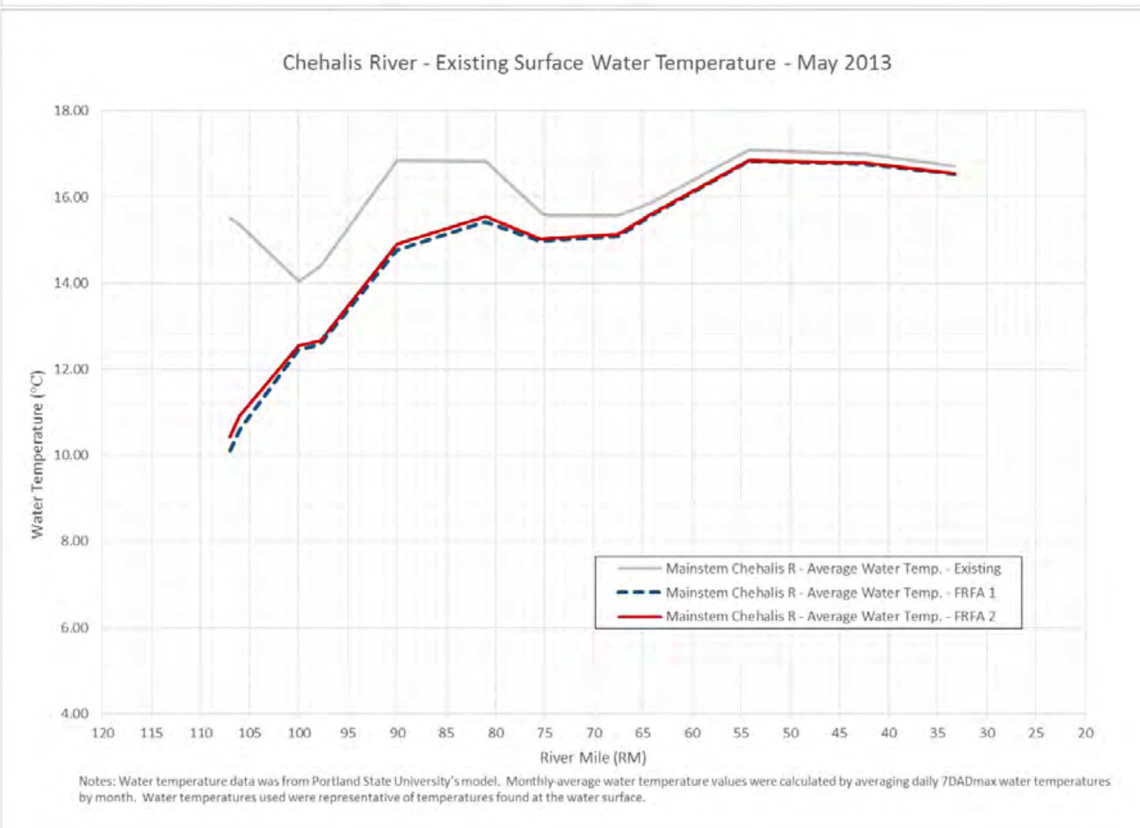
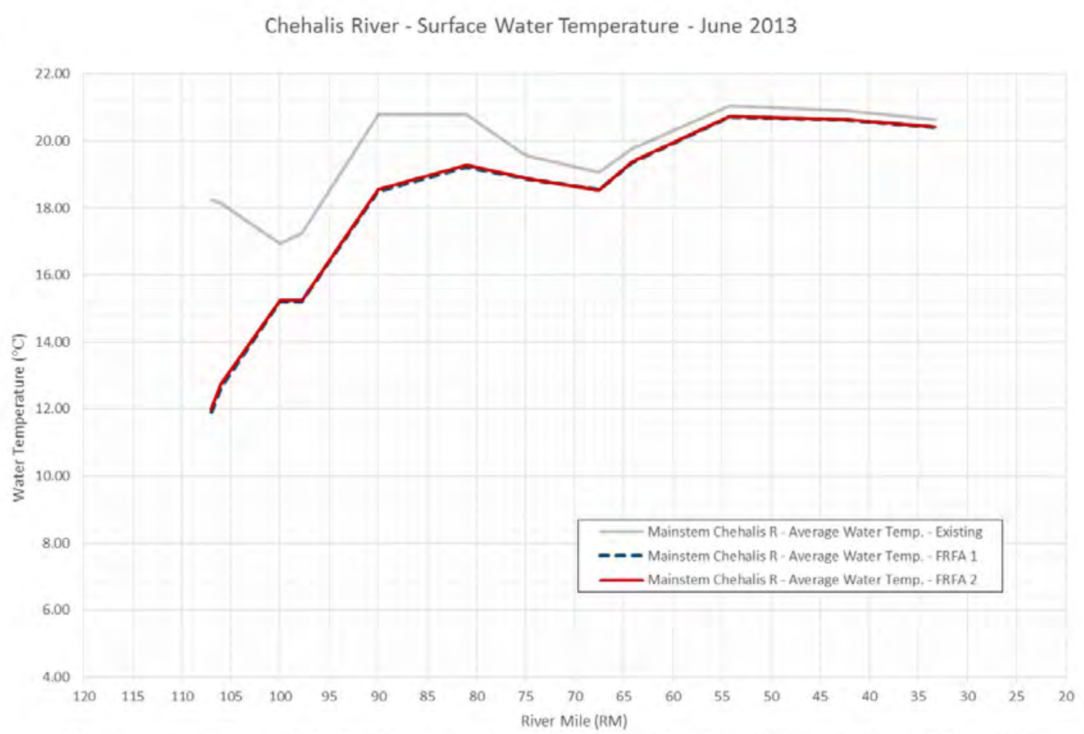

Chehalis River - Existing Surface Water Temperature - April 2013
Water Temperature (°C)
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.


Chehalis River - Existing Surface Water Temperature - May 2013
Water Temperature (°C)
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.



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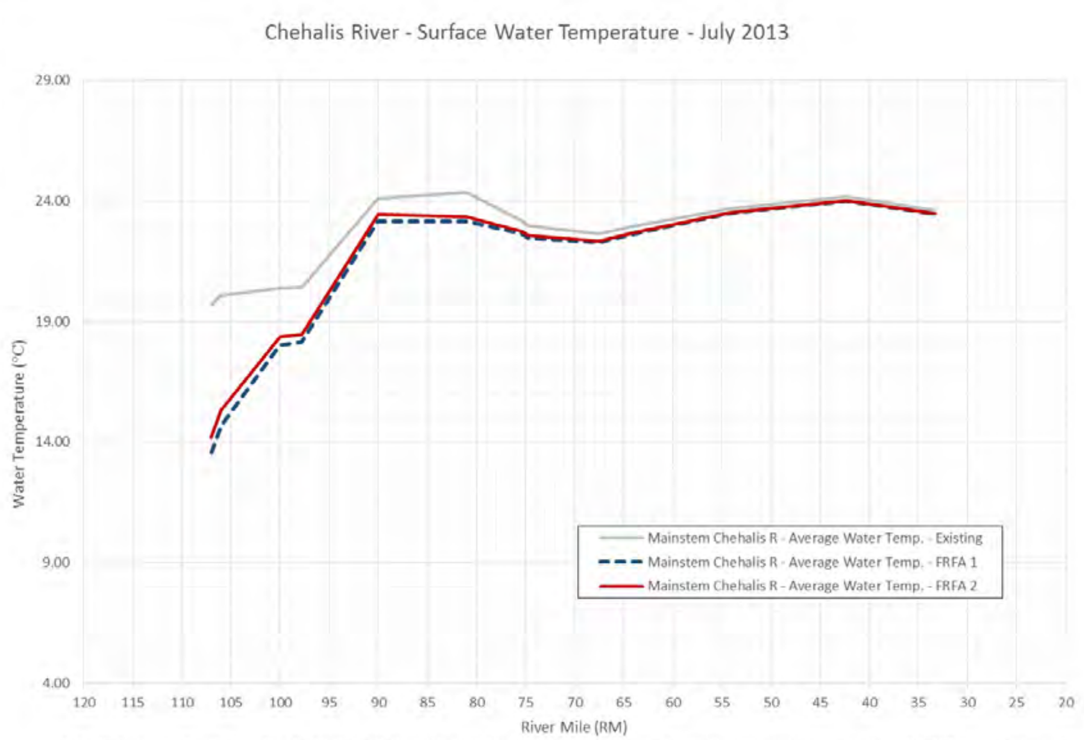

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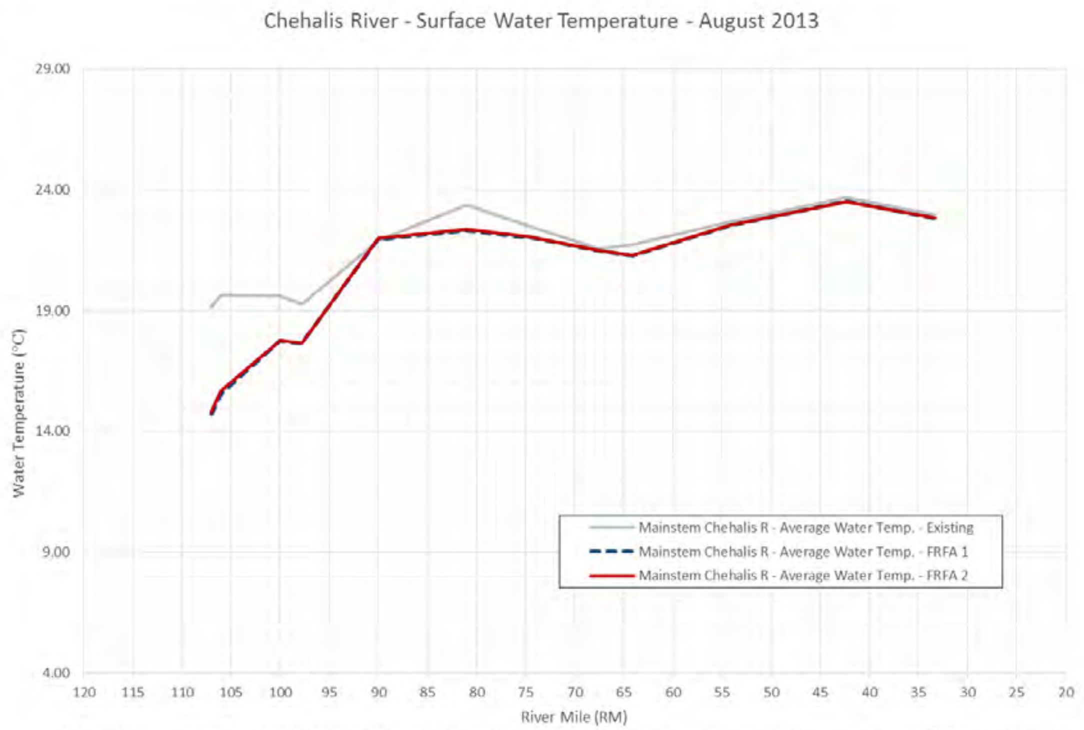

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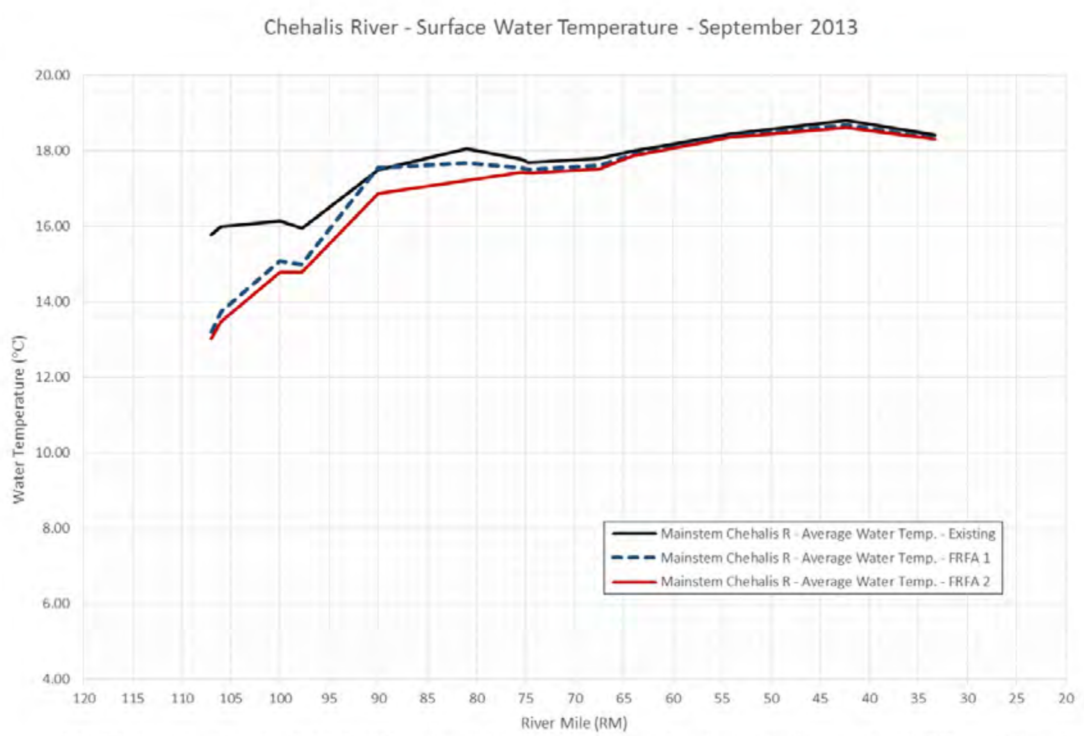

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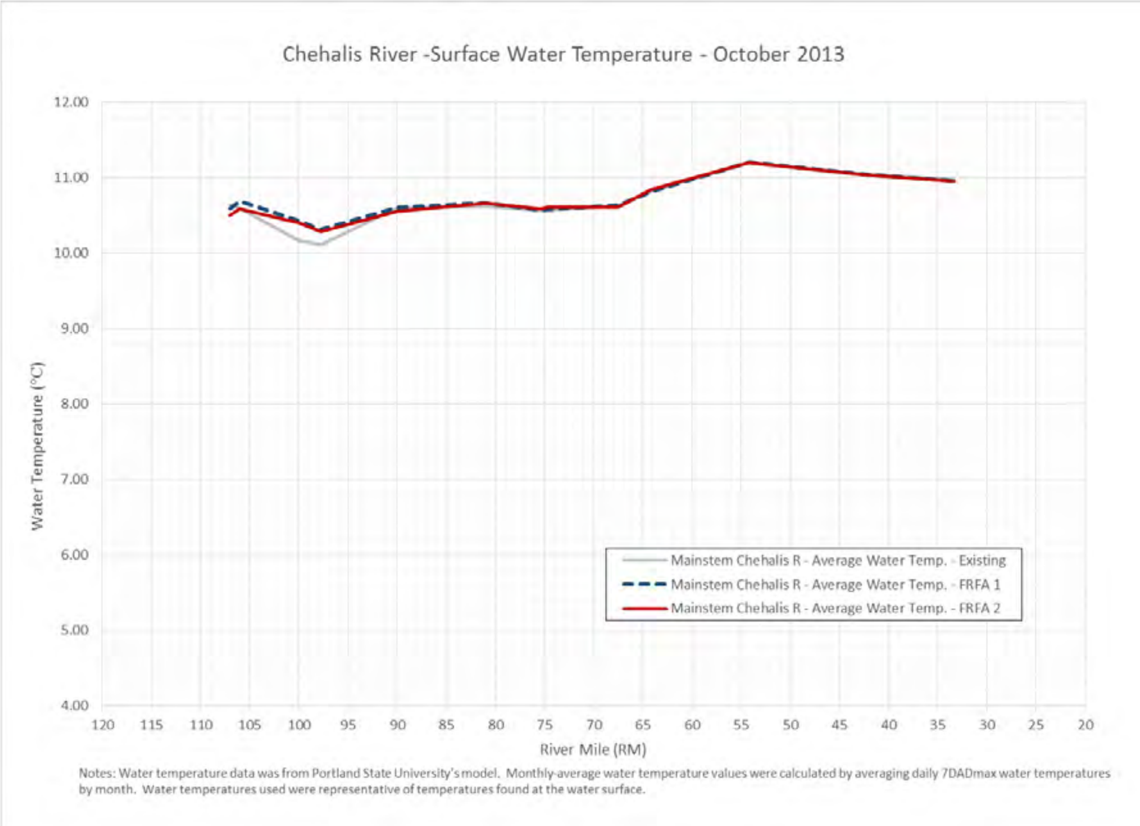
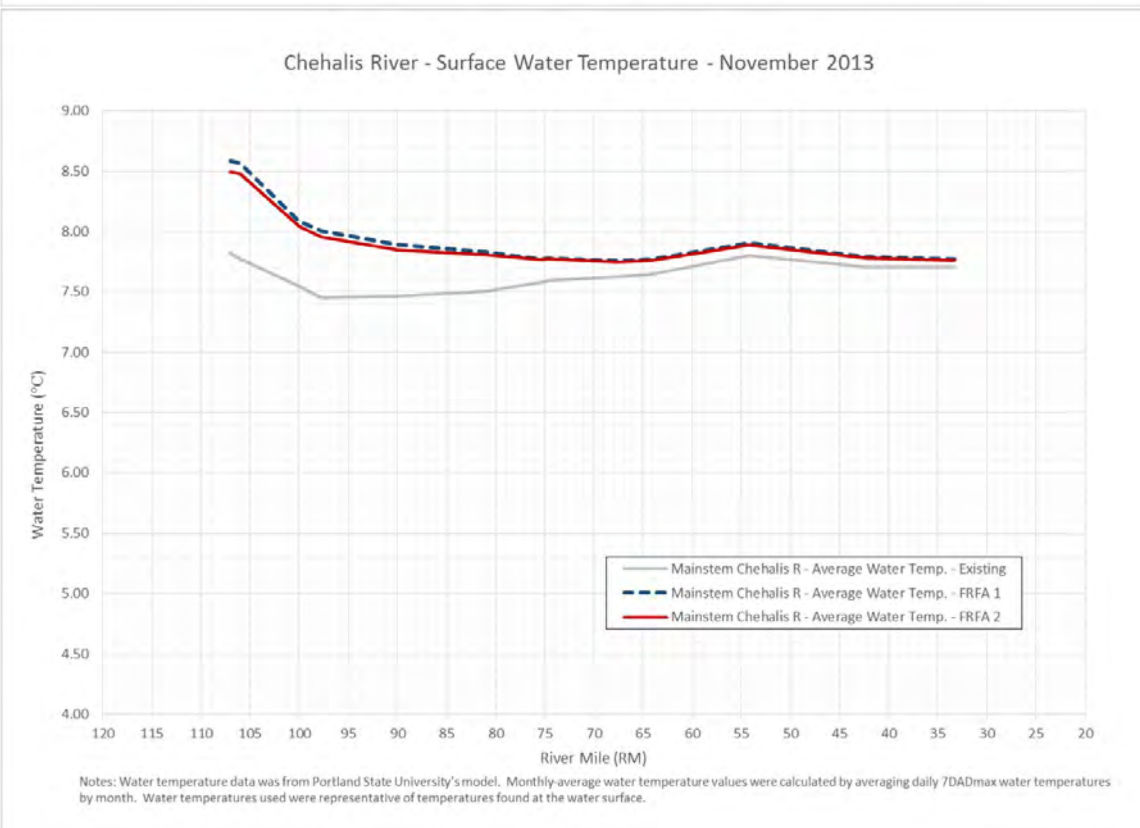
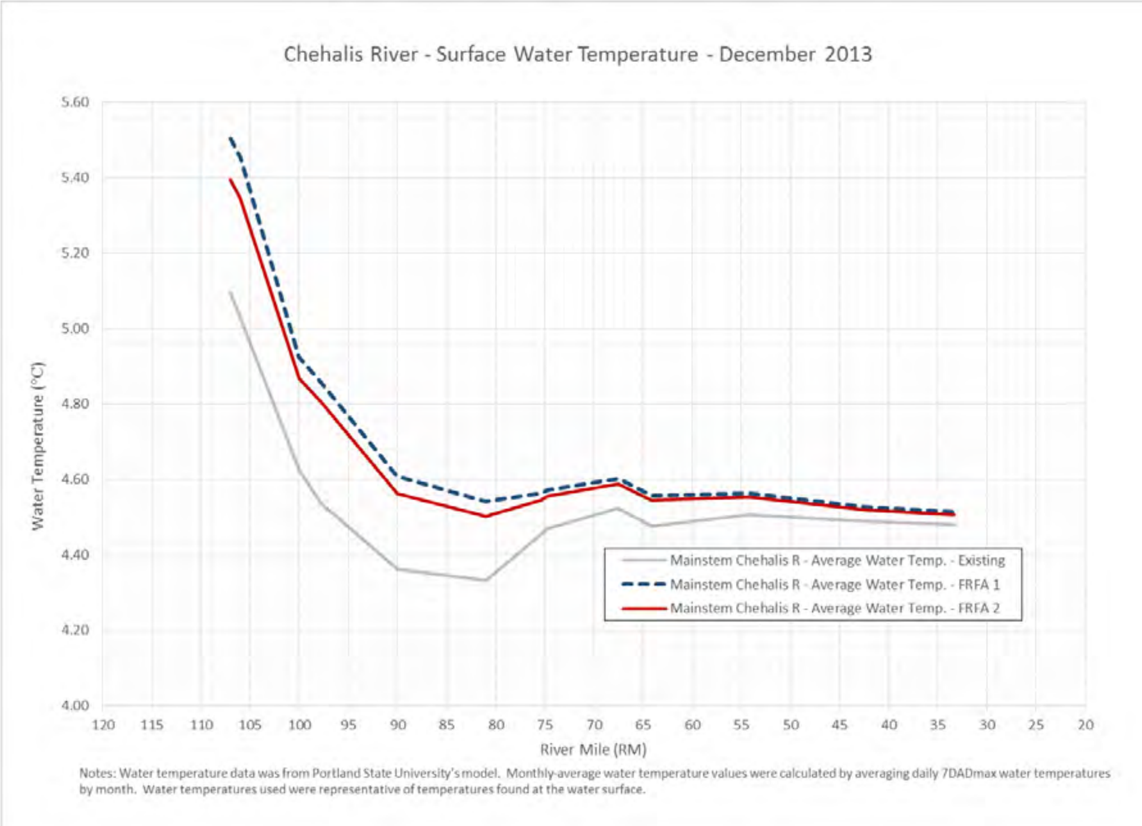
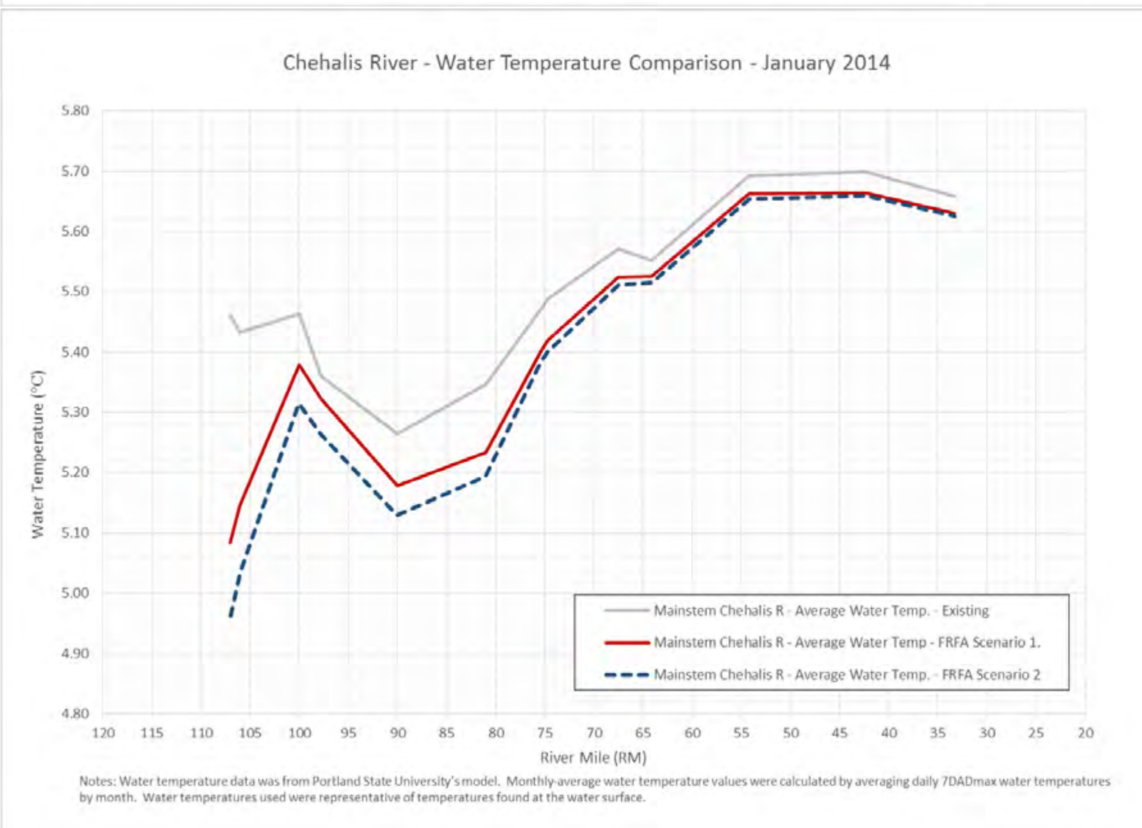


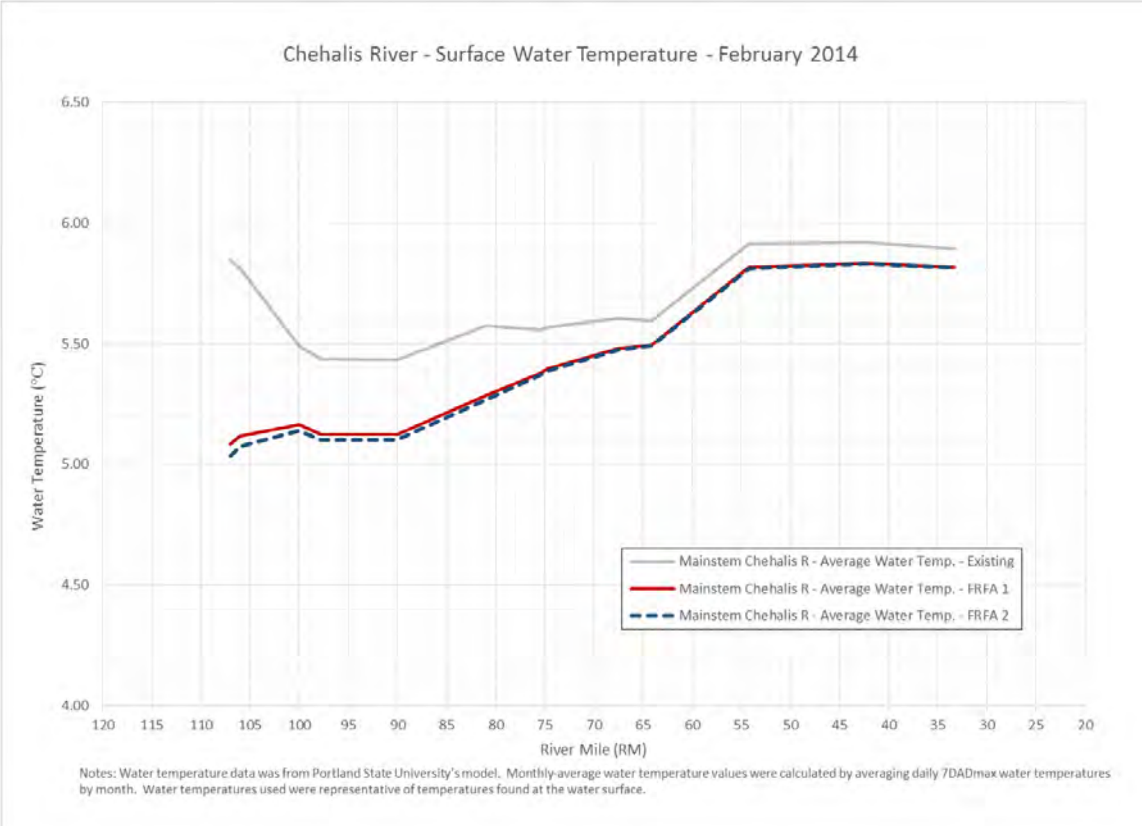
Chehalis River -Surface Water Temperature - October 2013
Water Temperature (°C)
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.



Chehalis River - Surface Water Temperature - November 2013
Water Temperature (°C)
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.


Chehalis River - Surface Water Temperature - December 2013
Water Temperature (°C)
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.


Chehalis River - Water Temperature Comparison - January 2014
Water Temperature (°C)
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp - FRFA Scenario 1.
Mainstem Chehalis R - Average Water Temp. - FRFA Scenario 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.


Chehalis River - Surface Water Temperature - February 2014
Water Temperature (°C)
6.50
6.00
5.50
5.00
4.50
4.00
120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
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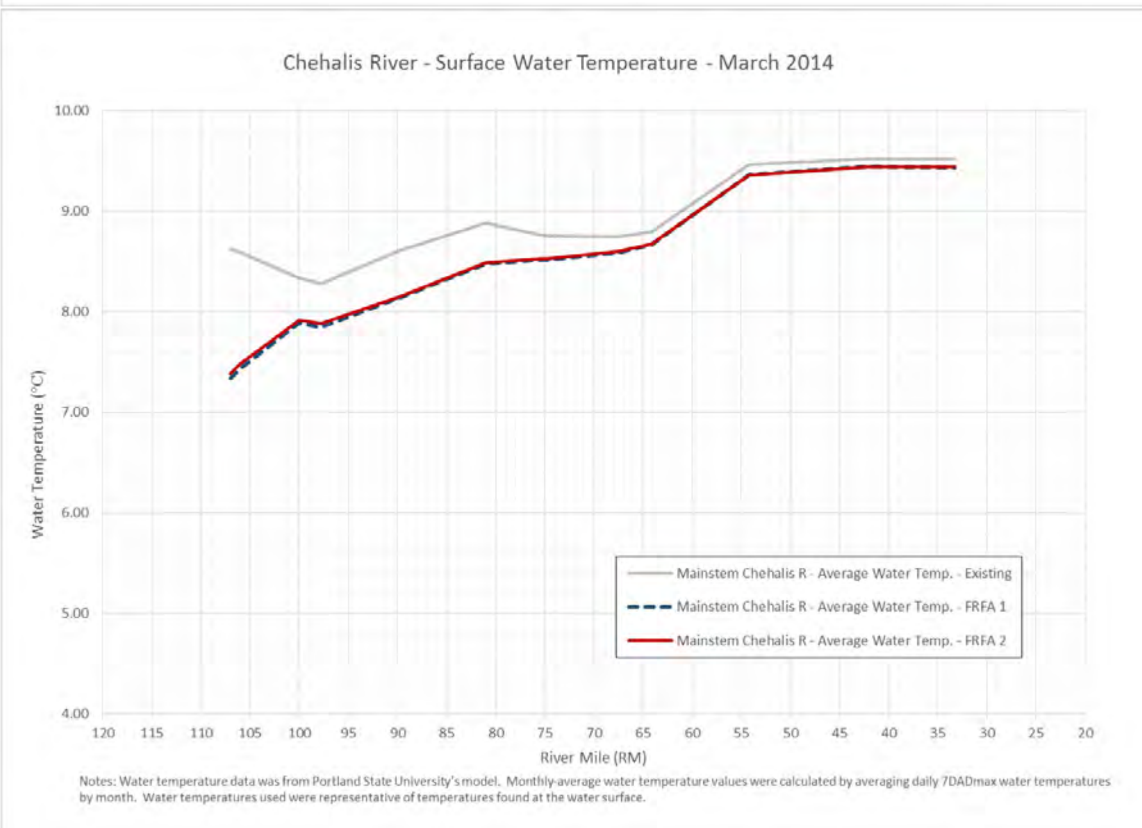
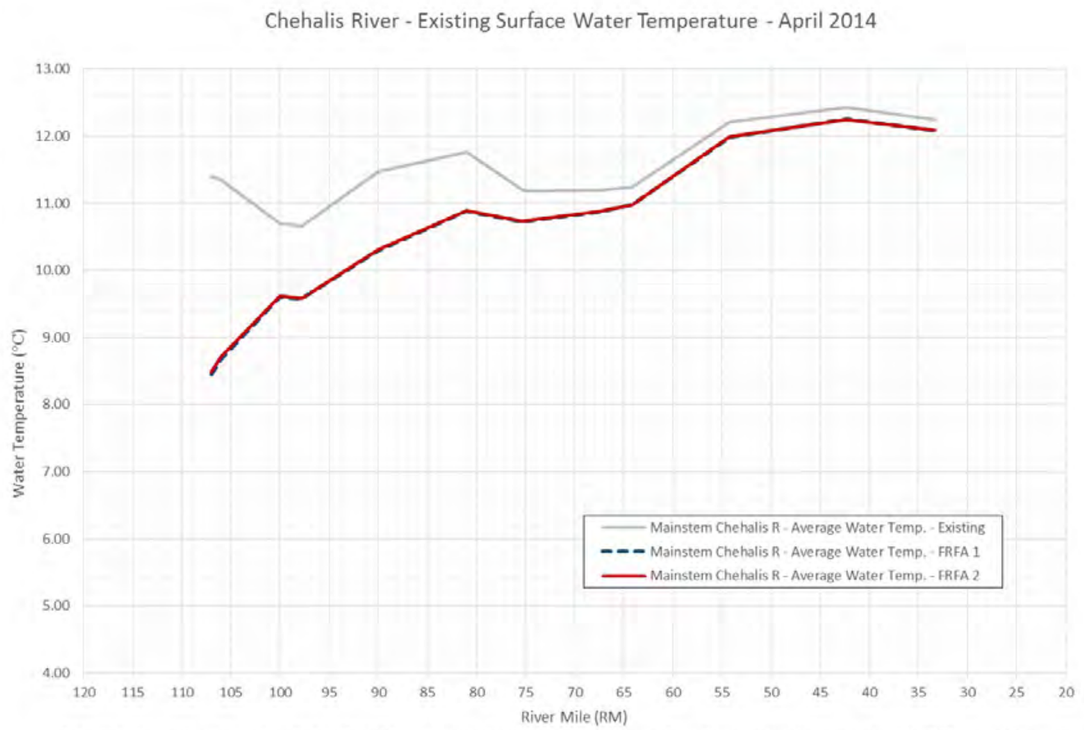

Chehalis River - Surface Water Temperature - March 2014
Water Temperature (°C)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20
River Mile (RM)
Mainstem Chehalis R - Average Water Temp. - Existing
Mainstem Chehalis R - Average Water Temp. - FRFA 1
Mainstem Chehalis R - Average Water Temp. - FRFA 2
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.



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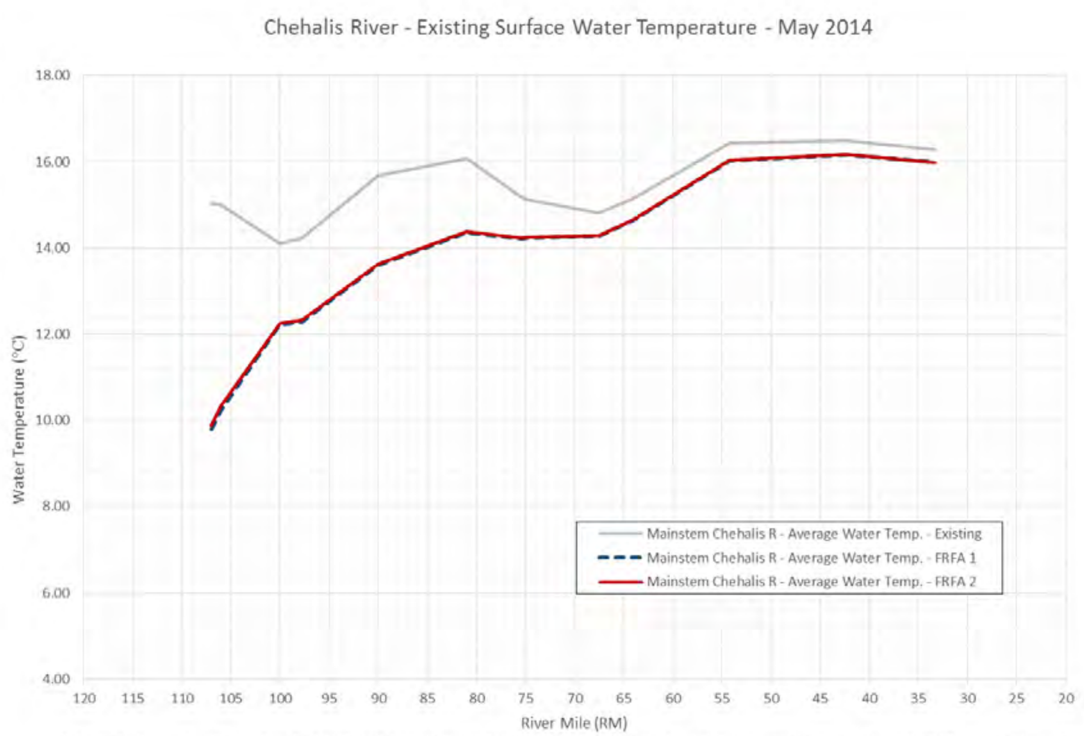

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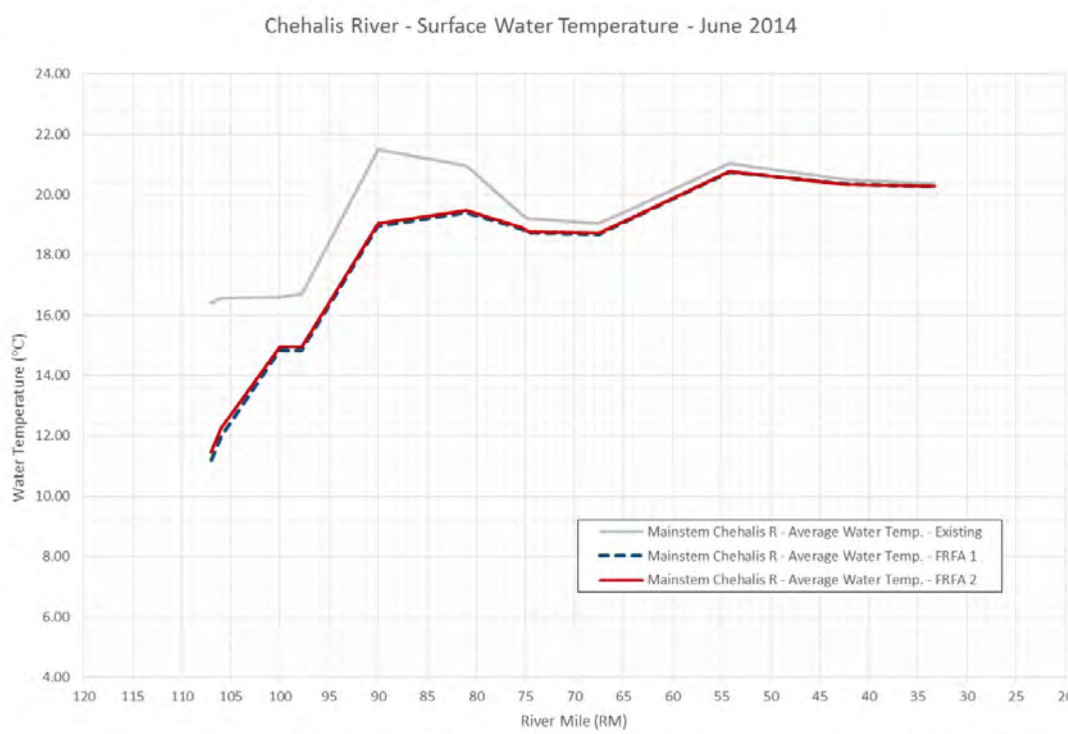
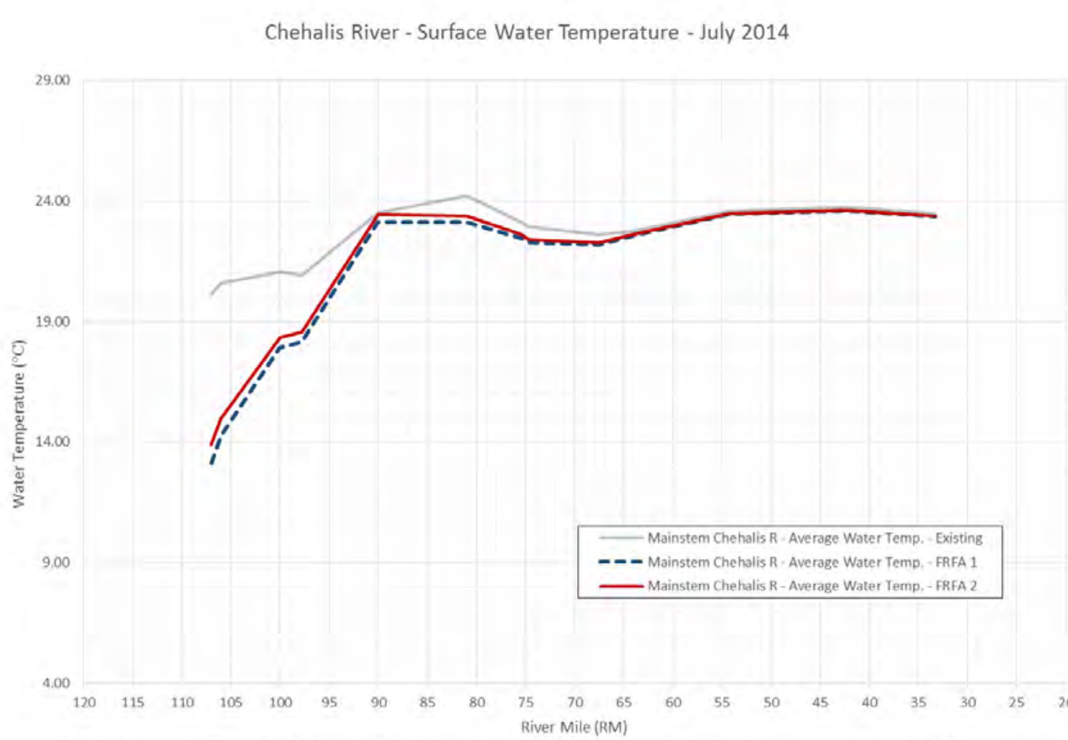


Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.



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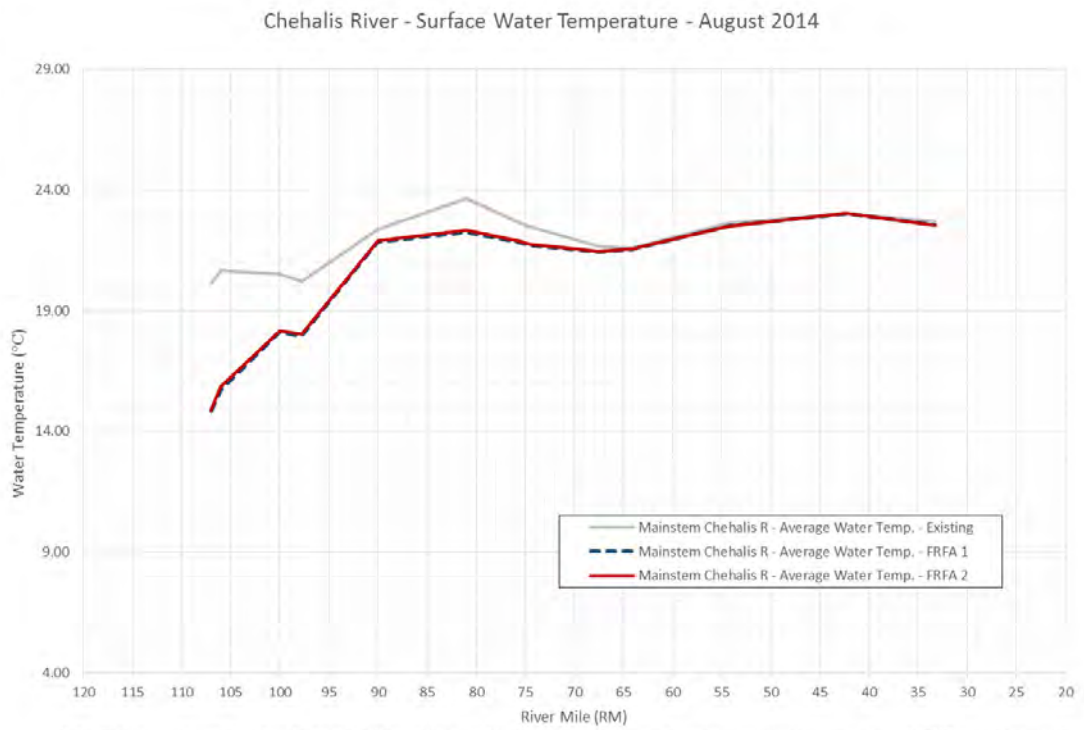
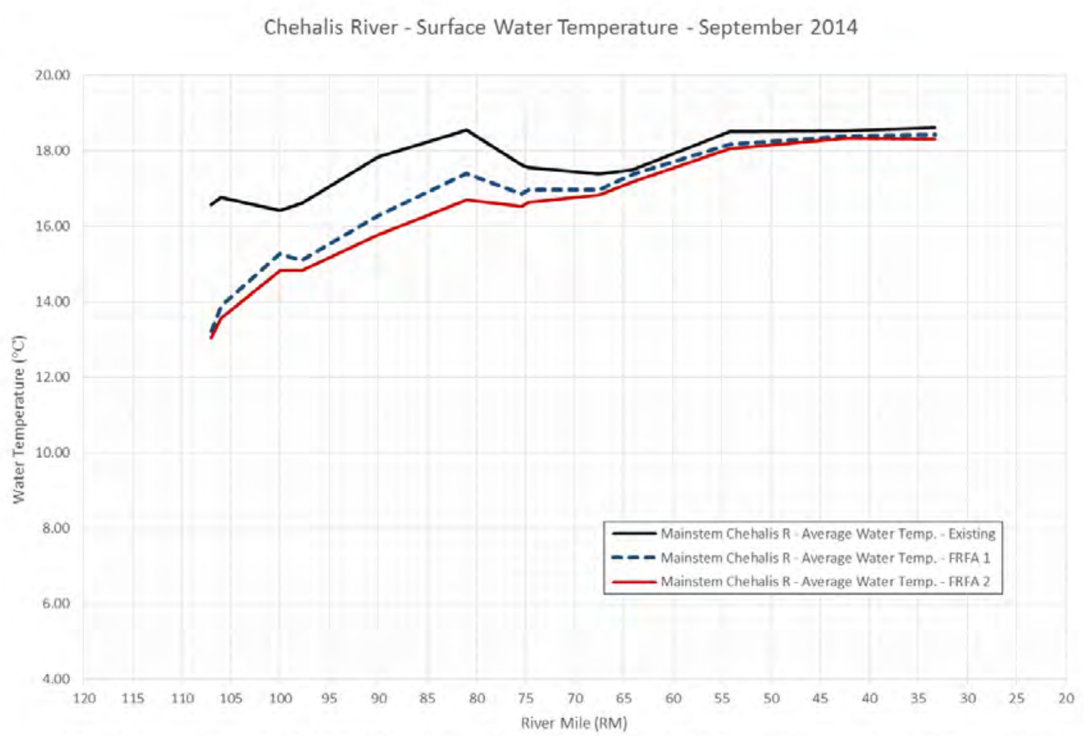
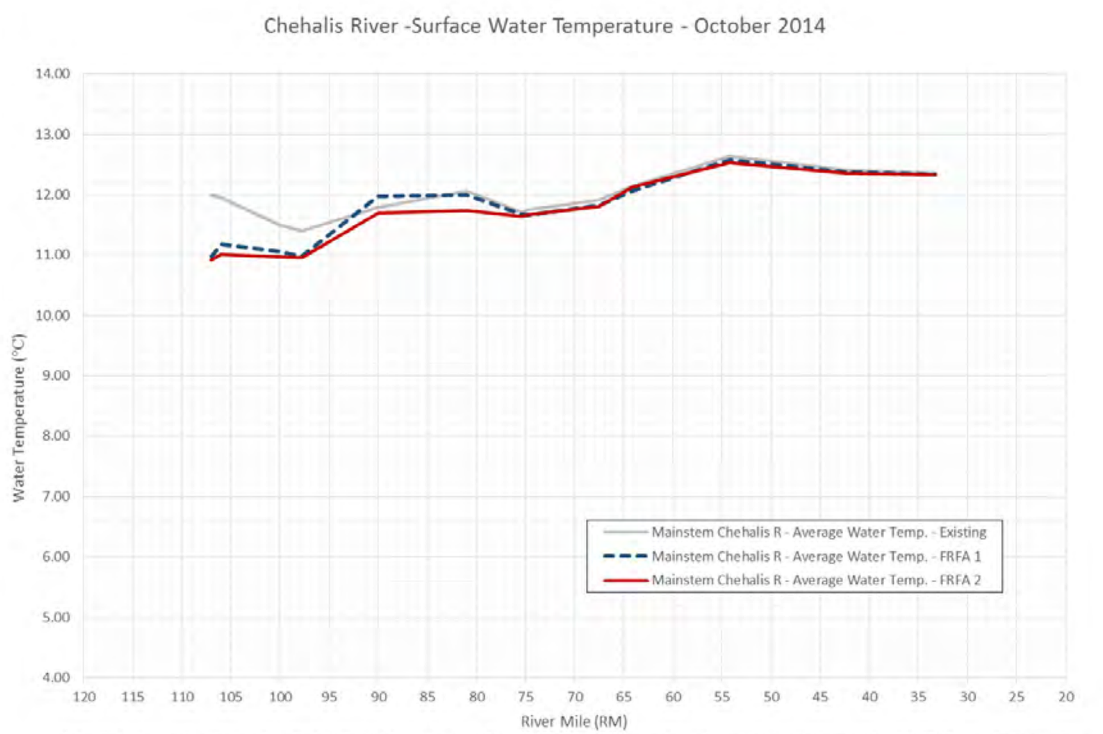


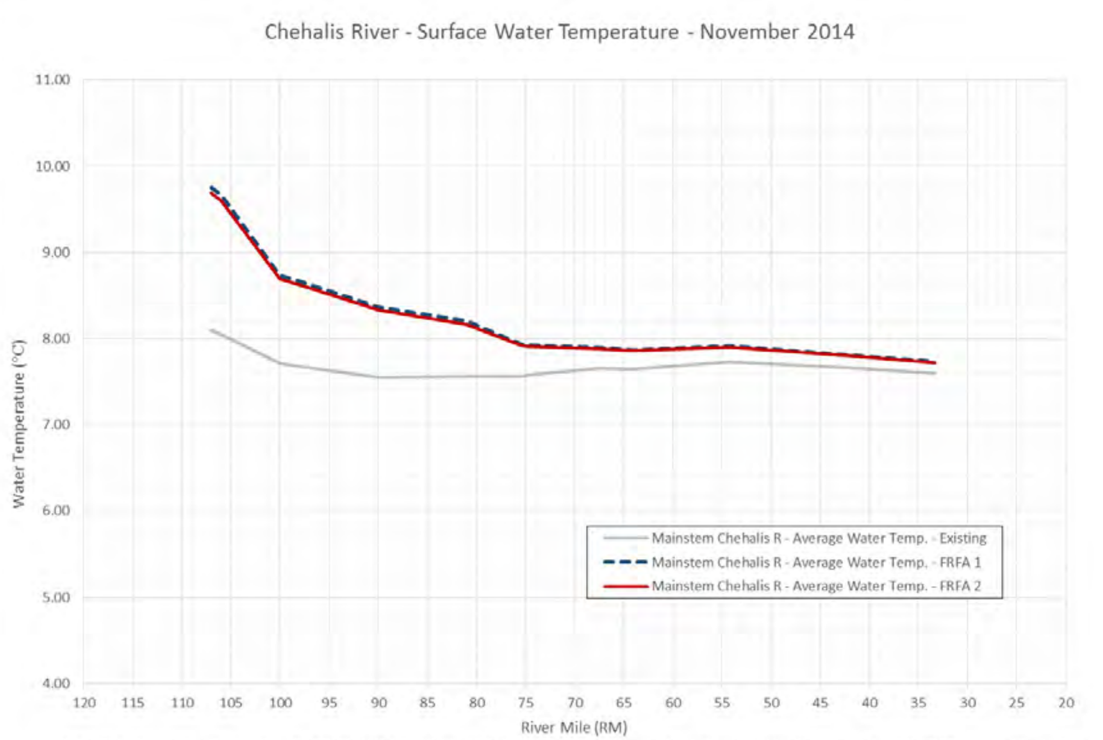
Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.



Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.



Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.



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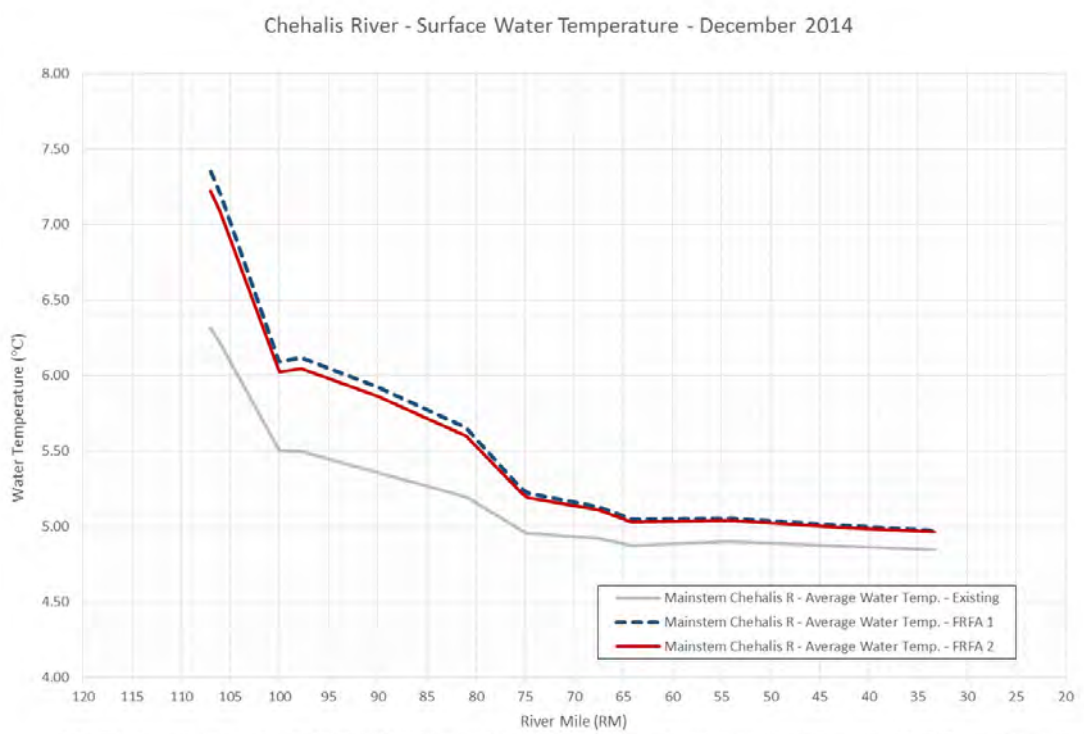

Notes: Water temperature data was from Portland State University's model. Monthly-average water temperature values were calculated by averaging daily 7DADmax water temperatures by month. Water temperatures used were representative of temperatures found at the water surface.

Appendix B
Weighted Usable Area Comparison

Species	Chinook							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
Upper Chehalis	**2013**	**Jan**	**Rearing**	1,979	1,979	1,979	0%	0%
			Spawning	10,470	10,470	10,470	0%	0%
		Feb	**Rearing**	2,262	1,838	1,838	-19%	-19%
			Spawning	11,779	9,816	9,816	-17%	-17%
		Mar	**Rearing**	2,901	2,262	2,262	-22%	-22%
			Spawning	13,088	11,779	11,779	-10%	-10%
		Apr	**Rearing**	4,285	2,901	2,901	-32%	-32%
			Spawning	13,088	13,088	13,088	0%	0%
		May	**Rearing**	3,572	4,628	4,628	30%	30%
			Spawning	6,458	20,893	20,893	224%	224%
		Jun	**Rearing**	1,667	4,878	4,878	193%	193%
			Spawning	3,571	21,425	21,425	500%	500%
		Jul	**Rearing**	759	4,430	4,134	483%	444%
			Spawning	357	12,784	7,108	3481%	1891%
		Aug	**Rearing**	783	4,032	3,698	415%	372%
			Spawning	354	6,425	5,952	1716%	1582%
		Sep	**Rearing**	2,923	3,859	3,859	32%	32%
			Spawning	3,599	9,031	9,031	151%	151%
		Oct	**Rearing**	4,158	4,379	4,420	5%	6%
			Spawning	13,088	16,178	16,751	24%	28%
		Nov	**Rearing**	2,827	2,866	2,866	1%	1%
			Spawning	13,088	13,088	13,088	0%	0%
		Dec	**Rearing**	1,979	2,120	2,120	7%	7%
			Spawning	10,470	11,125	11,125	6%	6%
	2014	**Jan**	**Rearing**	2,120	1,979	1,979	-7%	-7%
			Spawning	11,125	10,470	10,470	-6%	-6%
		Feb	**Rearing**	2,262	1,979	1,979	-13%	-13%
			Spawning	11,779	10,470	10,470	-11%	-11%
		Mar	**Rearing**	2,866	2,686	2,686	-6%	-6%
			Spawning	13,088	13,088	13,088	0%	0%
		Apr	**Rearing**	4,212	2,866	2,866	-32%	-32%
			Spawning	13,088	13,088	13,088	0%	0%
		May	**Rearing**	3,480	4,184	4,184	20%	20%
			Spawning	4,221	13,088	13,088	210%	210%
		Jun	**Rearing**	2,967	5,111	5,200	72%	75%
			Spawning	5,550	23,245	23,245	319%	319%
		Jul	**Rearing**	611	4,412	4,260	622%	597%
			Spawning	179	12,263	9,541	6770%	5245%
		Aug	**Rearing**	522	3,698	3,698	608%	608%
			Spawning	118	5,952	5,952	4946%	4946%
		Sep	**Rearing**	1,864	4,471	4,683	140%	151%
			Spawning	2,359	13,748	16,039	483%	580%
		Oct	**Rearing**	4,285	4,262	4,394	-1%	3%
			Spawning	13,088	15,100	16,751	15%	28%
		Nov	**Rearing**	2,827	3,565	3,565	26%	26%
			Spawning	13,088	13,088	13,088	0%	0%
		Dec	**Rearing**	2,403	2,686	2,544	12%	6%
			Spawning	12,434	13,088	13,088	5%	5%
PeEll to Elk Cr	**2013**	**Jan**	**Rearing**	1,880	1,880	1,880	0%	0%
			Spawning	1,915	1,915	1,915	0%	0%
		Feb	**Rearing**	2,327	2,036	1,891	-13%	-19%
			Spawning	3,108	2,762	2,590	-11%	-17%
		Mar	**Rearing**	2,809	2,494	2,494	-11%	-11%
			Spawning	2,855	2,855	2,855	0%	0%
		Apr	**Rearing**	4,128	3,494	3,494	-15%	-15%
			Spawning	2,855	2,855	2,855	0%	0%
		May	**Rearing**	7,487	9,217	9,217	23%	23%
			Spawning	5,394	16,727	16,727	210%	210%
		Jun	**Rearing**	3,696	9,415	9,415	155%	155%
			Spawning	3,074	9,247	9,247	201%	201%
		Jul	**Rearing**	905	5,490	4,543	507%	402%
			Spawning	0	4,745	3,796	0%	0%
		Aug	**Rearing**	677	4,095	4,095	504%	504%
			Spawning	0	3,173	3,173	0%	0%
		Sep	**Rearing**	2,989	4,425	4,579	48%	53%
			Spawning	1,840	1,860	2,602	1%	41%
		Oct	**Rearing**	5,860	7,696	7,696	31%	31%
			Spawning	7,361	12,682	12,682	72%	72%
		Nov	**Rearing**	3,034	3,238	3,238	7%	7%
			Spawning	4,349	4,349	4,349	0%	0%
		Dec	**Rearing**	2,789	2,988	2,789	7%	0%
			Spawning	5,889	6,257	5,889	6%	0%
	2014	**Jan**	**Rearing**	2,078	1,940	1,940	-7%	-7%
			Spawning	2,427	2,284	2,284	-6%	-6%
		Feb	**Rearing**	2,014	1,880	1,880	-7%	-7%
			Spawning	2,035	1,915	1,915	-6%	-6%
		Mar	**Rearing**	2,722	2,551	2,686	-6%	-1%
			Spawning	2,394	2,394	2,394	0%	0%
		Apr	**Rearing**	3,926	3,386	3,386	-14%	-14%
			Spawning	2,394	2,394	2,394	0%	0%
		May	**Rearing**	4,425	5,355	5,355	21%	21%
			Spawning	1,860	5,767	5,767	210%	210%
		Jun	**Rearing**	5,653	10,137	10,137	79%	79%
			Spawning	4,997	12,200	12,200	144%	144%
		Jul	**Rearing**	553	5,490	4,543	893%	721%
			Spawning	0	4,745	3,796	0%	0%
		Aug	**Rearing**	349	3,298	3,298	845%	845%

Note: Values with green highlights denote an increase in WUA compared to Current Conditions.
Values with orange highlights denote a decrease in WUA compared to Current Conditions.

Species	Chinook							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
		Aug	**Spawning**	0	2,379	2,379	0%	0%
		Sep	**Rearing**	2,330	8,121	9,322	249%	300%
			Spawning	1,055	5,116	8,564	385%	712%
		Oct	**Rearing**	6,039	6,794	7,696	12%	27%
			Spawning	7,361	9,505	12,682	29%	72%
		Nov	**Rearing**	2,686	3,386	3,386	26%	26%
			Spawning	2,394	2,394	2,394	0%	0%
		Dec	**Rearing**	2,148	2,417	2,283	13%	6%
			Spawning	2,155	2,394	2,274	11%	6%
Elk Cr to S Fk	**2013**	**Jan**	**Rearing**	2,220	2,220	2,220	0%	0%
			Spawning	566	566	566	0%	0%
		Feb	**Rearing**	3,780	3,528	3,528	-7%	-7%
			Spawning	2,689	2,531	2,531	-6%	-6%
		Mar	**Rearing**	4,662	4,370	4,370	-6%	-6%
			Spawning	2,605	2,605	2,605	0%	0%
		Apr	**Rearing**	6,725	6,807	6,807	1%	1%
			Spawning	2,605	2,605	2,605	0%	0%
		May	**Rearing**	9,963	12,047	12,047	21%	21%
			Spawning	3,871	8,940	8,940	131%	131%
		Jun	**Rearing**	4,120	8,413	8,413	104%	104%
			Spawning	1,608	4,220	4,220	163%	163%
		Jul	**Rearing**	1,053	2,262	2,262	115%	115%
			Spawning	0	389	389	0%	0%
		Aug	**Rearing**	1,319	2,864	2,864	117%	117%
			Spawning	241	706	706	192%	192%
		Sep	**Rearing**	6,319	7,038	7,686	11%	22%
			Spawning	1,860	1,699	1,845	-9%	-1%
		Oct	**Rearing**	10,012	11,585	11,585	16%	16%
			Spawning	6,177	9,254	9,254	50%	50%
		Nov	**Rearing**	5,214	5,488	5,488	5%	5%
			Spawning	3,932	3,932	3,932	0%	0%
		Dec	**Rearing**	4,630	4,765	4,425	3%	-4%
			Spawning	5,313	4,942	4,633	-7%	-13%
	2014	**Jan**	**Rearing**	3,450	3,450	3,220	0%	-7%
			Spawning	2,214	2,214	2,084	0%	-6%
		Feb	**Rearing**	2,134	1,992	1,992	-7%	-7%
			Spawning	237	223	223	-6%	-6%
		Mar	**Rearing**	2,884	2,845	2,845	-1%	-1%
			Spawning	279	279	279	0%	0%
		Apr	**Rearing**	5,726	5,796	5,796	1%	1%
			Spawning	1,754	1,754	1,754	0%	0%
		May	**Rearing**	7,505	8,920	8,621	19%	15%
			Spawning	1,581	4,413	3,922	179%	148%
		Jun	**Rearing**	4,025	9,579	8,220	138%	104%
			Spawning	1,636	4,500	4,295	175%	163%
		Jul	**Rearing**	872	2,262	2,262	159%	159%
			Spawning	0	389	389	0%	0%
		Aug	**Rearing**	821	2,864	2,419	249%	195%
			Spawning	0	706	530	0%	0%
		Sep	**Rearing**	3,790	8,663	9,447	129%	149%
			Spawning	2,415	4,219	4,554	75%	89%
		Oct	**Rearing**	10,611	12,318	12,519	16%	18%
			Spawning	7,084	10,446	11,968	47%	69%
		Nov	**Rearing**	4,370	4,238	4,238	-3%	-3%
			Spawning	2,605	2,160	2,160	-17%	-17%
		Dec	**Rearing**	2,213	2,360	2,360	7%	7%
			Spawning	383	405	405	6%	6%
S Fk to Newaukum	**2013**	**Jan**	**Rearing**	2,224	2,224	2,224	0%	0%
			Spawning	307	307	307	0%	0%
		Feb	**Rearing**	2,933	2,567	2,567	-13%	-13%
			Spawning	505	449	449	-11%	-11%
		Mar	**Rearing**	3,763	3,667	3,667	-3%	-3%
			Spawning	561	561	561	0%	0%
		Apr	**Rearing**	5,557	5,361	5,361	-4%	-4%
			Spawning	561	561	561	0%	0%
		May	**Rearing**	5,703	8,583	8,583	50%	50%
			Spawning	803	959	959	20%	20%
		Jun	**Rearing**	1,490	3,422	3,422	130%	130%
			Spawning	0	241	241	0%	0%
		Jul	**Rearing**	152	488	488	222%	222%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	569	811	811	42%	42%
			Spawning	0	0	0	0%	0%
		Oct	**Rearing**	7,177	7,177	7,777	0%	8%
			Spawning	1,054	1,054	1,435	0%	36%
		Nov	**Rearing**	4,636	4,880	4,880	5%	5%
			Spawning	1,054	1,054	1,054	0%	0%
		Dec	**Rearing**	3,437	3,437	3,437	0%	0%
			Spawning	1,076	1,076	1,076	0%	0%
	2014	**Jan**	**Rearing**	2,750	2,567	2,567	-7%	-7%
			Spawning	477	449	449	-6%	-6%
		Feb	**Rearing**	2,264	2,264	2,113	0%	-7%
			Spawning	208	208	196	0%	-6%
		Mar	**Rearing**	3,098	3,060	3,060	-1%	-1%
			Spawning	245	245	245	0%	0%
		Apr	**Rearing**	5,011	5,361	5,361	7%	7%
			Spawning	470	561	561	19%	19%

Note: Values with green highlights denote an increase in WUA compared to Current Conditions.
Values with orange highlights denote a decrease in WUA compared to Current Conditions.

Species	Chinook							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
		May	**Rearing**	5,467	6,978	6,736	28%	23%
			Spawning	395	832	648	111%	64%
		Jun	**Rearing**	1,723	3,343	3,343	94%	94%
			Spawning	0	262	262	0%	0%
		Jul	**Rearing**	314	488	488	55%	55%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	365	736	736	102%	102%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	3,094	6,042	7,868	95%	154%
			Spawning	596	274	1,968	-54%	230%
		Oct	**Rearing**	10,142	11,522	11,951	14%	18%
			Spawning	2,476	3,211	3,464	30%	40%
		Nov	**Rearing**	3,483	3,667	3,667	5%	5%
			Spawning	561	561	561	0%	0%
		Dec	**Rearing**	2,113	2,264	2,264	7%	7%
			Spawning	196	208	208	6%	6%
Newaukum to Skookumchuck	**2013**	**Jan**	**Rearing**	3,954	3,954	3,954	0%	0%
			Spawning	4,680	4,680	4,680	0%	0%
		Feb	**Rearing**	4,086	4,086	4,086	0%	0%
			Spawning	6,664	6,664	6,664	0%	0%
		Mar	**Rearing**	5,434	5,434	5,434	0%	0%
			Spawning	6,715	6,715	6,715	0%	0%
		Apr	**Rearing**	7,887	7,887	7,887	0%	0%
			Spawning	7,330	7,330	7,330	0%	0%
		May	**Rearing**	6,441	7,023	7,023	9%	9%
			Spawning	2,038	2,200	2,200	8%	8%
		Jun	**Rearing**	2,033	2,366	2,366	16%	16%
			Spawning	276	551	551	100%	100%
		Jul	**Rearing**	379	379	379	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	441	552	552	25%	25%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	3,541	3,541	3,541	0%	0%
			Spawning	1,365	1,365	1,365	0%	0%
		Oct	**Rearing**	7,982	8,037	8,037	1%	1%
			Spawning	8,539	8,442	8,442	-1%	-1%
		Nov	**Rearing**	5,156	5,428	5,428	5%	5%
			Spawning	8,539	8,539	8,539	0%	0%
		Dec	**Rearing**	3,572	3,572	3,572	0%	0%
			Spawning	6,211	6,211	6,211	0%	0%
	2014	**Jan**	**Rearing**	4,109	4,109	4,109	0%	0%
			Spawning	7,018	7,018	7,018	0%	0%
		Feb	**Rearing**	3,908	3,908	3,908	0%	0%
			Spawning	4,205	4,205	4,205	0%	0%
		Mar	**Rearing**	5,281	5,281	5,281	0%	0%
			Spawning	4,947	4,947	4,947	0%	0%
		Apr	**Rearing**	7,837	7,837	7,837	0%	0%
			Spawning	6,715	6,715	6,715	0%	0%
		May	**Rearing**	6,728	6,961	6,961	3%	3%
			Spawning	2,723	3,809	3,809	40%	40%
		Jun	**Rearing**	1,843	2,145	2,145	16%	16%
			Spawning	203	406	406	100%	100%
		Jul	**Rearing**	379	471	379	24%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	441	552	552	25%	25%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	2,411	3,016	3,566	25%	48%
			Spawning	150	336	352	124%	135%
		Oct	**Rearing**	8,646	8,552	8,552	-1%	-1%
			Spawning	6,823	6,306	6,306	-8%	-8%
		Nov	**Rearing**	5,205	5,479	5,479	5%	5%
			Spawning	8,256	8,256	8,256	0%	0%
		Dec	**Rearing**	3,647	3,647	3,647	0%	0%
			Spawning	3,958	3,958	3,958	0%	0%
Skookumchuck to Black	**2013**	**Jan**	**Rearing**	5,437	5,437	5,437	0%	0%
			Spawning	30,527	30,527	30,527	0%	0%
		Feb	**Rearing**	8,241	8,241	8,241	0%	0%
			Spawning	49,329	49,329	49,329	0%	0%
		Mar	**Rearing**	10,182	8,287	8,287	-19%	-19%
			Spawning	42,251	42,251	42,251	0%	0%
		Apr	**Rearing**	13,729	13,494	13,729	-2%	0%
			Spawning	48,658	48,658	48,658	0%	0%
		May	**Rearing**	20,348	20,348	20,348	0%	0%
			Spawning	18,693	18,693	18,693	0%	0%
		Jun	**Rearing**	5,463	6,791	6,791	24%	24%
			Spawning	847	1,694	1,694	100%	100%
		Jul	**Rearing**	1,926	1,926	1,926	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	2,860	3,632	3,632	27%	27%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	13,002	13,002	13,002	0%	0%
			Spawning	10,166	10,166	10,166	0%	0%
		Oct	**Rearing**	19,348	19,348	19,348	0%	0%
			Spawning	64,292	64,292	64,292	0%	0%
		Nov	**Rearing**	12,572	13,234	13,234	5%	5%
			Spawning	64,292	64,292	64,292	0%	0%
		Dec	**Rearing**	10,048	10,048	10,048	0%	0%

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Species	Chinook							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2013	Dec	Spawning	50,205	50,205	50,205	0%	0%
	2014	Jan	Rearing	7,726	7,726	7,726	0%	0%
			Spawning	46,589	46,589	46,589	0%	0%
		Feb	Rearing	4,587	4,301	4,301	-6%	-6%
			Spawning	19,442	18,362	18,362	-6%	-6%
		Mar	Rearing	5,885	5,885	5,885	0%	0%
			Spawning	21,602	21,602	21,602	0%	0%
		Apr	Rearing	13,729	13,494	13,494	-2%	-2%
			Spawning	48,658	48,658	48,658	0%	0%
		May	Rearing	15,981	17,454	17,454	9%	9%
			Spawning	18,409	19,998	19,998	9%	9%
		Jun	Rearing	5,739	7,135	7,135	24%	24%
			Spawning	755	1,511	1,511	100%	100%
		Jul	Rearing	1,926	1,926	1,926	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	3,452	3,632	3,009	5%	-13%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	16,432	16,432	16,432	0%	0%
			Spawning	7,303	7,303	7,303	0%	0%
		Oct	Rearing	36,620	38,049	38,049	4%	4%
			Spawning	62,865	60,996	60,996	-3%	-3%
		Nov	Rearing	12,572	13,234	13,234	5%	5%
			Spawning	64,292	64,292	64,292	0%	0%
		Dec	Rearing	4,647	4,647	4,647	0%	0%
			Spawning	24,116	24,116	24,116	0%	0%
Black to Porter	2013	Jan	Rearing	4,403	4,403	4,403	0%	0%
			Spawning	10,904	10,904	10,904	0%	0%
		Feb	Rearing	4,500	4,500	4,500	0%	0%
			Spawning	16,450	16,450	16,450	0%	0%
		Mar	Rearing	7,248	7,248	7,248	0%	0%
			Spawning	15,089	15,089	15,089	0%	0%
		Apr	Rearing	8,411	8,712	8,712	4%	4%
			Spawning	13,580	15,089	15,089	11%	11%
		May	Rearing	5,133	6,070	6,070	18%	18%
			Spawning	12,408	13,029	13,029	5%	5%
		Jun	Rearing	1,284	1,661	1,661	29%	29%
			Spawning	0	632	632	0%	0%
		Jul	Rearing	334	334	334	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	519	521	521	1%	1%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	3,434	3,434	3,434	0%	0%
			Spawning	5,055	5,055	5,055	0%	0%
		Oct	Rearing	8,034	8,034	8,034	0%	0%
			Spawning	32,283	32,283	32,283	0%	0%
		Nov	Rearing	5,220	5,495	5,495	5%	5%
			Spawning	32,283	32,283	32,283	0%	0%
		Dec	Rearing	3,580	3,580	3,580	0%	0%
			Spawning	28,522	28,522	28,522	0%	0%
	2014	Jan	Rearing	4,219	4,219	4,219	0%	0%
			Spawning	15,536	15,536	15,536	0%	0%
		Feb	Rearing	4,890	4,890	4,890	0%	0%
			Spawning	9,324	9,324	9,324	0%	0%
		Mar	Rearing	7,707	7,707	7,707	0%	0%
			Spawning	10,360	10,360	10,360	0%	0%
		Apr	Rearing	8,231	8,527	8,527	4%	4%
			Spawning	16,450	18,278	18,278	11%	11%
		May	Rearing	4,885	5,693	5,693	17%	17%
			Spawning	9,983	10,458	10,458	5%	5%
		Jun	Rearing	2,017	2,017	2,017	0%	0%
			Spawning	579	579	579	0%	0%
		Jul	Rearing	521	519	519	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	716	716	716	0%	0%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	4,401	4,401	4,423	0%	1%
			Spawning	3,167	3,167	3,521	0%	11%
		Oct	Rearing	11,566	11,566	12,219	0%	6%
			Spawning	45,494	45,494	44,881	0%	-1%
		Nov	Rearing	5,237	5,513	5,513	5%	5%
			Spawning	26,829	26,829	26,829	0%	0%
		Dec	Rearing	4,278	4,278	4,278	0%	0%
			Spawning	8,288	8,288	8,288	0%	0%

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Species	Chum							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
Black to Porter	2013	Jan	Spawning	1,997	1,997	1,997	0%	0%
		Feb	Spawning	3,351	3,351	3,351	0%	0%
		Mar	Spawning	2,178	2,178	2,178	0%	0%
		Apr	Spawning	1,743	1,859	1,859	7%	7%
		May	Spawning	0	0	0	0%	0%
		Jun	Spawning	0	0	0	0%	0%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	0	0	0	0%	0%
		Oct	Spawning	6,540	6,540	6,540	0%	0%
		Nov	Spawning	7,176	7,086	7,086	-1%	-1%
		Dec	Spawning	7,256	7,256	7,256	0%	0%
	2014	Jan	Spawning	3,351	3,351	3,351	0%	0%
		Feb	Spawning	2,030	2,030	2,030	0%	0%
		Mar	Spawning	1,903	1,903	1,903	0%	0%
		Apr	Spawning	2,513	2,681	2,681	7%	7%
		May	Spawning	0	0	0	0%	0%
		Jun	Spawning	0	0	0	0%	0%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	0	0	0	0%	0%
		Oct	Spawning	12,342	12,342	12,891	0%	4%
		Nov	Spawning	6,849	6,762	6,762	-1%	-1%
		Dec	Spawning	2,030	2,030	2,030	0%	0%

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Species	Coho							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
Upper Chehalis	**2013**	**Jan**	**Spawning**	18,619	18,619	18,619	0%	0%
		Feb	**Spawning**	18,619	17,455	17,455	-6%	-6%
		Mar	**Spawning**	18,619	18,619	18,619	0%	0%
		Apr	**Spawning**	12,102	18,619	18,619	54%	54%
		May	**Spawning**	2,683	17,194	17,194	541%	541%
		Jun	**Spawning**	501	9,012	9,012	1700%	1700%
		Jul	**Spawning**	0	3,158	2,368	0%	0%
		Aug	**Spawning**	47	2,046	1,705	4256%	3530%
		Sep	**Spawning**	1,862	4,189	4,189	125%	125%
		Oct	**Spawning**	14,895	16,379	16,574	10%	11%
		Nov	**Spawning**	18,619	18,619	18,619	0%	0%
		Dec	**Spawning**	18,619	18,619	18,619	0%	0%
	2014	**Jan**	**Spawning**	18,619	18,619	18,619	0%	0%
		Feb	**Spawning**	18,619	18,619	18,619	0%	0%
		Mar	**Spawning**	18,619	18,619	18,619	0%	0%
		Apr	**Spawning**	13,499	18,619	18,619	38%	38%
		May	**Spawning**	2,793	14,895	14,895	433%	433%
		Jun	**Spawning**	1,104	12,798	11,474	1059%	939%
		Jul	**Spawning**	0	2,945	2,577	0%	0%
		Aug	**Spawning**	0	1,705	1,705	0%	0%
		Sep	**Spawning**	376	3,068	3,972	717%	957%
		Oct	**Spawning**	12,102	15,943	16,574	32%	37%
		Nov	**Spawning**	18,619	16,757	16,757	-10%	-10%
		Dec	**Spawning**	18,619	18,619	18,619	0%	0%
PeEll to Elk Cr	**2013**	**Jan**	**Spawning**	6,816	6,816	6,816	0%	0%
		Feb	**Spawning**	8,924	8,924	8,366	0%	-6%
		Mar	**Spawning**	7,809	7,809	7,809	0%	0%
		Apr	**Spawning**	5,662	7,028	7,028	24%	24%
		May	**Spawning**	2,805	12,153	12,153	333%	333%
		Jun	**Spawning**	471	3,295	3,295	600%	600%
		Jul	**Spawning**	0	657	492	0%	0%
		Aug	**Spawning**	0	404	404	0%	0%
		Sep	**Spawning**	658	1,713	1,998	160%	204%
		Oct	**Spawning**	10,530	13,735	13,735	30%	30%
		Nov	**Spawning**	10,182	10,182	10,182	0%	0%
		Dec	**Spawning**	13,162	13,162	13,162	0%	0%
	2014	**Jan**	**Spawning**	7,809	7,809	7,809	0%	0%
		Feb	**Spawning**	6,816	6,816	6,816	0%	0%
		Mar	**Spawning**	6,816	6,816	6,816	0%	0%
		Apr	**Spawning**	5,453	6,134	6,134	13%	13%
		May	**Spawning**	1,713	8,279	8,279	383%	383%
		Jun	**Spawning**	711	3,239	3,239	355%	355%
		Jul	**Spawning**	0	657	492	0%	0%
		Aug	**Spawning**	0	269	269	0%	0%
		Sep	**Spawning**	149	1,615	2,298	984%	1443%
		Oct	**Spawning**	8,555	10,989	13,735	28%	61%
		Nov	**Spawning**	6,816	6,134	6,134	-10%	-10%
		Dec	**Spawning**	6,816	6,816	6,816	0%	0%
Elk Cr to S Fk	**2013**	**Jan**	**Spawning**	2,833	2,833	2,833	0%	0%
		Feb	**Spawning**	6,792	6,792	6,792	0%	0%
		Mar	**Spawning**	5,912	5,912	5,912	0%	0%
		Apr	**Spawning**	4,730	4,730	4,730	0%	0%
		May	**Spawning**	1,762	3,172	3,172	80%	80%
		Jun	**Spawning**	280	1,118	1,118	300%	300%
		Jul	**Spawning**	0	0	0	0%	0%
		Aug	**Spawning**	0	108	108	0%	0%
		Sep	**Spawning**	780	979	1,224	26%	57%
		Oct	**Spawning**	7,831	9,504	9,504	21%	21%
		Nov	**Spawning**	7,773	7,773	7,773	0%	0%
		Dec	**Spawning**	9,750	9,789	9,177	0%	-6%
	2014	**Jan**	**Spawning**	5,912	5,912	5,912	0%	0%
		Feb	**Spawning**	1,750	1,750	1,750	0%	0%
		Mar	**Spawning**	1,750	1,750	1,750	0%	0%
		Apr	**Spawning**	3,595	3,595	3,595	0%	0%
		May	**Spawning**	1,311	3,934	2,186	200%	67%
		Jun	**Spawning**	246	1,314	985	433%	300%
		Jul	**Spawning**	0	0	0	0%	0%
		Aug	**Spawning**	0	108	54	0%	0%
		Sep	**Spawning**	261	1,082	1,298	315%	398%
		Oct	**Spawning**	7,540	9,183	10,753	22%	43%
		Nov	**Spawning**	5,912	5,138	5,138	-13%	-13%
		Dec	**Spawning**	2,211	2,211	2,211	0%	0%
S Fk to Newaukum	**2013**	**Jan**	**Spawning**	1,446	1,446	1,446	0%	0%
		Feb	**Spawning**	1,953	1,953	1,953	0%	0%
		Mar	**Spawning**	1,953	1,953	1,953	0%	0%
		Apr	**Spawning**	1,269	1,562	1,562	23%	23%
		May	**Spawning**	279	697	697	150%	150%
		Jun	**Spawning**	0	89	89	0%	0%
		Jul	**Spawning**	0	0	0	0%	0%

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Species	Coho							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2013	Aug	Spawning	0	0	0	0%	0%
		Oct	Spawning	2,438	2,438	2,816	0%	15%
		Nov	Spawning	3,048	3,048	3,048	0%	0%
		Dec	Spawning	3,300	3,300	3,300	0%	0%
	2014	Jan	Spawning	1,953	1,953	1,953	0%	0%
		Feb	Spawning	1,093	1,093	1,093	0%	0%
		Mar	Spawning	1,093	1,093	1,093	0%	0%
		Apr	Spawning	1,218	1,562	1,562	28%	28%
		May	Spawning	352	704	616	100%	75%
		Jun	Spawning	0	51	51	0%	0%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	109	328	533	201%	389%
		Oct	Spawning	3,073	3,626	3,819	18%	24%
		Nov	Spawning	1,953	1,953	1,953	0%	0%
		Dec	Spawning	1,093	1,093	1,093	0%	0%
Newaukum to Skookumchuck	2013	Jan	Spawning	497	497	497	0%	0%
		Feb	Spawning	682	682	682	0%	0%
		Mar	Spawning	574	574	574	0%	0%
		Apr	Spawning	501	501	501	0%	0%
		May	Spawning	151	181	181	20%	20%
		Jun	Spawning	14	21	21	50%	50%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	45	45	45	0%	0%
		Oct	Spawning	842	898	898	7%	7%
		Nov	Spawning	1,053	1,053	1,053	0%	0%
		Dec	Spawning	1,102	1,102	1,102	0%	0%
	2014	Jan	Spawning	744	744	744	0%	0%
		Feb	Spawning	466	466	466	0%	0%
		Mar	Spawning	466	466	466	0%	0%
		Apr	Spawning	459	459	459	0%	0%
		May	Spawning	168	196	196	17%	17%
		Jun	Spawning	14	22	22	50%	50%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	30	46	69	51%	126%
		Oct	Spawning	783	742	742	-5%	-5%
		Nov	Spawning	744	744	744	0%	0%
		Dec	Spawning	466	466	466	0%	0%
Skookumchuck to Black	2013	Jan	Spawning	8,896	8,896	8,896	0%	0%
		Feb	Spawning	12,000	12,000	12,000	0%	0%
		Mar	Spawning	8,705	9,672	9,672	11%	11%
		Apr	Spawning	6,956	7,758	6,956	12%	0%
		May	Spawning	1,494	1,494	1,494	0%	0%
		Jun	Spawning	0	0	0	0%	0%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	558	558	558	0%	0%
		Oct	Spawning	12,249	12,249	12,249	0%	0%
		Nov	Spawning	15,311	15,311	15,311	0%	0%
		Dec	Spawning	15,998	15,998	15,998	0%	0%
	2014	Jan	Spawning	12,000	12,000	12,000	0%	0%
		Feb	Spawning	7,764	7,764	7,764	0%	0%
		Mar	Spawning	7,764	7,764	7,764	0%	0%
		Apr	Spawning	6,956	7,758	7,758	12%	12%
		May	Spawning	1,707	2,133	2,133	25%	25%
		Jun	Spawning	0	0	0	0%	0%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	984	984	984	0%	0%
		Oct	Spawning	9,543	10,052	10,052	5%	5%
		Nov	Spawning	15,311	15,311	15,311	0%	0%
		Dec	Spawning	8,380	8,380	8,380	0%	0%
Black to Porter	2013	Jan	Spawning	1,953	1,953	1,953	0%	0%
		Feb	Spawning	2,648	2,648	2,648	0%	0%
		Mar	Spawning	1,995	1,995	1,995	0%	0%
		Apr	Spawning	998	1,441	1,441	44%	44%
		May	Spawning	463	695	695	50%	50%
		Jun	Spawning	0	0	0	0%	0%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	195	195	195	0%	0%
		Oct	Spawning	4,446	4,446	4,446	0%	0%
		Nov	Spawning	5,558	5,558	5,558	0%	0%
		Dec	Spawning	6,694	6,694	6,694	0%	0%
	2014	Jan	Spawning	2,648	2,648	2,648	0%	0%
		Feb	Spawning	1,703	1,703	1,703	0%	0%
		Mar	Spawning	1,533	1,533	1,533	0%	0%

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Species	Coho							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
		Apr	Spawning	1,192	1,721	1,721	44%	44%
		May	Spawning	536	714	714	33%	33%
		Jun	Spawning	0	0	0	0%	0%
		Jul	Spawning	0	0	0	0%	0%
		Aug	Spawning	0	0	0	0%	0%
		Sep	Spawning	290	290	287	0%	-1%
		Oct	Spawning	4,685	4,685	5,011	0%	7%
		Nov	Spawning	4,236	4,236	4,236	0%	0%
		Dec	Spawning	1,703	1,703	1,703	0%	0%

Note: Values with green highlights denote an increase in WUA compared to Current Conditions.
Values with orange highlights denote a decrease in WUA compared to Current Conditions.

Species	Largemouth Bass							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
PeEll to Elk Cr	**2013**	**Jan**	**Rearing**	356	356	356	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	348	348	348	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	339	352	352	4%	4%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	965	475	475	-51%	-51%
			Spawning	24	0	0	-100%	-100%
		May	**Rearing**	1,322	930	930	-30%	-30%
			Spawning	437	52	52	-88%	-88%
		Jun	**Rearing**	1,363	1,254	1,254	-8%	-8%
			Spawning	1,665	312	312	-81%	-81%
		Jul	**Rearing**	1,331	1,425	1,416	7%	6%
			Spawning	1,766	1,927	1,927	9%	9%
		Aug	**Rearing**	1,778	1,537	1,537	-14%	-14%
			Spawning	1,876	1,859	1,859	-1%	-1%
		Sep	**Rearing**	1,469	1,421	1,365	-3%	-7%
			Spawning	1,748	439	329	-75%	-81%
		Oct	**Rearing**	678	741	741	9%	9%
			Spawning	0	0	0	0%	0%
		Nov	**Rearing**	340	328	328	-3%	-3%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	323	323	323	0%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	352	352	352	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	356	356	356	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	344	356	356	4%	4%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	868	481	481	-45%	-45%
			Spawning	0	0	0	0%	0%
		May	**Rearing**	1,421	905	905	-36%	-36%
			Spawning	439	26	26	-94%	-94%
		Jun	**Rearing**	1,409	1,193	1,193	-15%	-15%
			Spawning	1,906	226	226	-88%	-88%
		Jul	**Rearing**	1,347	1,425	1,416	6%	5%
			Spawning	1,551	1,927	1,927	24%	24%
		Aug	**Rearing**	1,603	1,528	1,528	-5%	-5%
			Spawning	1,580	1,859	1,859	18%	18%
		Sep	**Rearing**	1,850	1,463	1,295	-21%	-30%
			Spawning	1,928	465	361	-76%	-81%
		Oct	**Rearing**	978	857	741	-12%	-24%
			Spawning	52	27	0	-49%	-100%
		Nov	**Rearing**	356	481	481	35%	35%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	356	356	356	0%	0%
			Spawning	0	0	0	0%	0%
Elk Cr to S Fk	**2013**	**Jan**	**Rearing**	337	337	337	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	411	411	411	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	384	398	398	4%	4%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	970	693	693	-29%	-29%
			Spawning	0	0	0	0%	0%
		May	**Rearing**	2,532	2,133	2,133	-16%	-16%
			Spawning	815	161	161	-80%	-80%
		Jun	**Rearing**	2,840	2,910	2,910	2%	2%
			Spawning	1,979	1,682	1,682	-15%	-15%
		Jul	**Rearing**	3,836	3,257	3,257	-15%	-15%
			Spawning	3,236	3,011	3,011	-7%	-7%
		Aug	**Rearing**	8,854	4,336	4,336	-51%	-51%
			Spawning	4,396	3,407	3,407	-23%	-23%
		Sep	**Rearing**	1,448	2,111	2,047	46%	41%
			Spawning	1,188	927	629	-22%	-47%
		Oct	**Rearing**	965	1,044	1,044	8%	8%
			Spawning	0	0	0	0%	0%
		Nov	**Rearing**	423	423	423	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	317	459	459	45%	45%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	398	398	398	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	312	312	312	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	301	312	312	4%	4%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	911	651	651	-29%	-29%
			Spawning	0	0	0	0%	0%
		May	**Rearing**	1,912	1,461	1,569	-24%	-18%
			Spawning	298	55	75	-82%	-75%
		Jun	**Rearing**	3,010	3,097	3,083	3%	2%
			Spawning	2,564	1,795	2,180	-30%	-15%

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Species	Largemouth Bass							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
		Jul	Rearing	3,707	3,257	3,257	-12%	-12%
			Spawning	3,066	3,011	3,011	-2%	-2%
		Aug	Rearing	8,261	4,336	4,296	-48%	-48%
			Spawning	4,396	3,407	3,407	-23%	-23%
		Sep	Rearing	9,266	4,361	4,216	-53%	-55%
			Spawning	4,396	1,618	852	-63%	-81%
		Oct	Rearing	869	1,434	1,330	65%	53%
			Spawning	21	24	0	15%	-100%
		Nov	Rearing	398	373	373	-6%	-6%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	323	323	323	0%	0%
			Spawning	0	0	0	0%	0%
S Fk to Newaukum	2013	Jan	Rearing	598	598	598	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	576	576	576	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	538	576	576	7%	7%
			Spawning	0	0	0	0%	0%
		Apr	Rearing	1,747	1,405	1,405	-20%	-20%
			Spawning	64	0	0	-100%	-100%
		May	Rearing	2,085	2,040	2,040	-2%	-2%
			Spawning	1,704	809	809	-53%	-53%
		Jun	Rearing	2,111	2,303	2,303	9%	9%
			Spawning	1,741	1,741	1,741	0%	0%
		Jul	Rearing	4,820	5,166	5,166	7%	7%
			Spawning	1,284	1,481	1,481	15%	15%
		Aug	Rearing	8,911	7,171	7,171	-20%	-20%
			Spawning	2,387	1,837	1,837	-23%	-23%
		Oct	Rearing	1,082	1,082	1,013	0%	-6%
			Spawning	0	0	0	0%	0%
		Nov	Rearing	515	515	515	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	482	482	482	0%	0%
			Spawning	0	0	0	0%	0%
	2014	Jan	Rearing	576	576	576	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	634	634	634	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	591	612	612	3%	3%
			Spawning	0	0	0	0%	0%
		Apr	Rearing	1,609	1,405	1,405	-13%	-13%
			Spawning	32	0	0	-100%	-100%
		May	Rearing	2,216	1,909	1,997	-14%	-10%
			Spawning	1,635	292	438	-82%	-73%
		Jun	Rearing	2,803	3,030	3,030	8%	8%
			Spawning	1,857	1,857	1,857	0%	0%
		Jul	Rearing	4,993	5,166	5,166	3%	3%
			Spawning	1,383	1,481	1,481	7%	7%
		Aug	Rearing	10,746	9,220	9,220	-14%	-14%
			Spawning	3,966	2,537	2,537	-36%	-36%
		Sep	Rearing	14,058	11,481	8,968	-18%	-36%
			Spawning	5,288	2,984	1,837	-44%	-65%
		Oct	Rearing	1,350	1,387	1,417	3%	5%
			Spawning	56	51	52	-9%	-8%
		Nov	Rearing	576	576	576	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	634	634	634	0%	0%
			Spawning	0	0	0	0%	0%
Newaukum to Skookumchuck	2013	Jan	Rearing	3,589	3,589	3,589	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	3,841	3,841	3,841	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	3,585	3,585	3,585	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	Rearing	9,202	9,202	9,202	0%	0%
			Spawning	0	0	0	0%	0%
		May	Rearing	28,546	27,599	27,599	-3%	-3%
			Spawning	6,908	3,636	3,636	-47%	-47%
		Jun	Rearing	36,168	36,436	36,436	1%	1%
			Spawning	16,592	16,592	16,592	0%	0%
		Jul	Rearing	52,309	52,309	52,309	0%	0%
			Spawning	21,433	21,433	21,433	0%	0%
		Aug	Rearing	58,471	58,207	58,207	0%	0%
			Spawning	25,026	25,311	25,311	1%	1%
		Sep	Rearing	28,993	28,993	28,993	0%	0%
			Spawning	14,543	14,543	14,543	0%	0%
		Oct	Rearing	9,141	9,459	9,459	3%	3%
			Spawning	0	0	0	0%	0%
		Nov	Rearing	4,351	4,351	4,351	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	4,678	4,678	4,678	0%	0%
			Spawning	0	0	0	0%	0%
	2014	Jan	Rearing	3,919	3,919	3,919	0%	0%
			Spawning	0	0	0	0%	0%

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Species	Largemouth Bass							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
	2014	**Feb**	**Rearing**	3,539	3,539	3,539	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	3,416	3,416	3,416	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	9,049	9,049	9,049	0%	0%
			Spawning	0	0	0	0%	0%
		May	**Rearing**	19,400	18,638	18,638	-4%	-4%
			Spawning	2,788	2,091	2,091	-25%	-25%
		Jun	**Rearing**	46,988	47,337	47,337	1%	1%
			Spawning	19,444	19,444	19,444	0%	0%
		Jul	**Rearing**	52,309	54,186	52,309	4%	0%
			Spawning	21,433	22,694	21,433	6%	0%
		Aug	**Rearing**	58,471	58,207	58,207	0%	0%
			Spawning	25,026	25,311	25,311	1%	1%
		Sep	**Rearing**	69,847	67,627	67,912	-3%	-3%
			Spawning	27,807	26,643	22,646	-4%	-19%
		Oct	**Rearing**	19,416	21,582	21,582	11%	11%
			Spawning	436	465	465	7%	7%
		Nov	**Rearing**	3,919	3,919	3,919	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	3,539	3,539	3,539	0%	0%
			Spawning	0	0	0	0%	0%
Skookumchuck to Black	**2013**	**Jan**	**Rearing**	3,649	3,649	3,649	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	3,841	3,841	3,841	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	5,017	3,465	3,465	-31%	-31%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	11,447	10,363	11,447	-9%	0%
			Spawning	261	130	261	-50%	0%
		May	**Rearing**	24,933	24,933	24,933	0%	0%
			Spawning	11,058	11,058	11,058	0%	0%
		Jun	**Rearing**	29,916	30,989	30,989	4%	4%
			Spawning	15,495	15,495	15,495	0%	0%
		Jul	**Rearing**	47,861	47,861	47,861	0%	0%
			Spawning	18,936	18,936	18,936	0%	0%
		Aug	**Rearing**	56,258	56,063	56,063	0%	0%
			Spawning	23,979	23,955	23,955	0%	0%
		Sep	**Rearing**	32,037	32,037	32,037	0%	0%
			Spawning	15,495	15,495	15,495	0%	0%
		Oct	**Rearing**	9,762	9,762	9,762	0%	0%
			Spawning	0	0	0	0%	0%
		Nov	**Rearing**	4,006	4,006	4,006	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	4,215	4,215	4,215	0%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	3,841	3,841	3,841	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	3,539	3,539	3,539	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	3,302	3,302	3,302	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	11,447	10,363	10,363	-9%	-9%
			Spawning	261	130	130	-50%	-50%
		May	**Rearing**	19,366	18,785	18,785	-3%	-3%
			Spawning	7,379	5,007	5,007	-32%	-32%
		Jun	**Rearing**	40,660	42,119	42,119	4%	4%
			Spawning	18,136	18,136	18,136	0%	0%
		Jul	**Rearing**	47,861	47,861	47,861	0%	0%
			Spawning	18,936	18,936	18,936	0%	0%
		Aug	**Rearing**	58,207	56,063	54,186	-4%	-7%
			Spawning	25,311	23,955	22,694	-5%	-10%
		Sep	**Rearing**	64,729	64,729	64,729	0%	0%
			Spawning	25,216	25,216	25,216	0%	0%
		Oct	**Rearing**	21,087	23,439	23,439	11%	11%
			Spawning	673	717	717	7%	7%
		Nov	**Rearing**	4,006	4,006	4,006	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	3,589	3,589	3,589	0%	0%
			Spawning	0	0	0	0%	0%
Black to Porter	**2013**	**Jan**	**Rearing**	1,362	1,362	1,362	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	1,146	1,146	1,146	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	1,710	1,710	1,710	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	4,167	3,837	3,837	-8%	-8%
			Spawning	248	161	161	-35%	-35%
		May	**Rearing**	5,886	5,911	5,911	0%	0%
			Spawning	4,508	3,832	3,832	-15%	-15%
		Jun	**Rearing**	6,823	7,059	7,059	3%	3%
			Spawning	5,601	5,601	5,601	0%	0%
		Jul	**Rearing**	8,584	8,584	8,584	0%	0%
			Spawning	5,055	5,055	5,055	0%	0%

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Species	Largemouth Bass							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
Black to Porter	**2013**	**Aug**	**Rearing**	10,748	9,768	9,768	-9%	-9%
			Spawning	6,601	5,911	5,911	-10%	-10%
		Sep	**Rearing**	7,501	7,501	7,501	0%	0%
			Spawning	5,601	5,601	5,601	0%	0%
		Oct	**Rearing**	2,355	2,355	2,355	0%	0%
			Spawning	0	0	0	0%	0%
		Nov	**Rearing**	966	966	966	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	975	975	975	0%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	1,146	1,146	1,146	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	1,469	1,469	1,469	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	1,984	1,984	1,984	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	3,773	3,474	3,474	-8%	-8%
			Spawning	230	149	149	-35%	-35%
		May	**Rearing**	4,461	4,481	4,481	0%	0%
			Spawning	3,513	2,893	2,893	-18%	-18%
		Jun	**Rearing**	8,476	8,476	8,476	0%	0%
			Spawning	6,184	6,184	6,184	0%	0%
		Jul	**Rearing**	9,768	8,882	8,882	-9%	-9%
			Spawning	5,911	5,416	5,416	-8%	-8%
		Aug	**Rearing**	11,134	11,134	11,134	0%	0%
			Spawning	7,041	7,041	7,041	0%	0%
		Sep	**Rearing**	14,060	14,060	12,778	0%	-9%
			Spawning	8,801	8,801	7,881	0%	-10%
		Oct	**Rearing**	5,531	5,531	5,841	0%	6%
			Spawning	259	259	268	0%	3%
		Nov	**Rearing**	968	968	968	0%	0%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	1,469	1,469	1,469	0%	0%
			Spawning	0	0	0	0%	0%

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Species	Largescale Sucker							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
PeEll to Elk Cr	**2013**	**Jan**	**Rearing**	6,328	6,328	6,328	0%	0%
			Spawning	278	278	278	0%	0%
		Feb	**Rearing**	6,562	6,152	5,947	-6%	-9%
			Spawning	560	280	140	-50%	-75%
		Mar	**Rearing**	7,403	7,046	7,046	-5%	-5%
			Spawning	2,974	1,101	1,101	-63%	-63%
		Apr	**Rearing**	6,500	7,280	7,280	12%	12%
			Spawning	4,075	3,635	3,635	-11%	-11%
		May	**Rearing**	5,510	6,784	6,784	23%	23%
			Spawning	14,072	13,369	13,369	-5%	-5%
		Jun	**Rearing**	3,275	4,172	4,172	27%	27%
			Spawning	2,763	22,107	22,107	700%	700%
		Jul	**Rearing**	5,226	6,965	6,724	33%	29%
			Spawning	0	8,386	6,289	0%	0%
		Aug	**Rearing**	6,575	8,113	8,113	23%	23%
			Spawning	0	6,416	6,416	0%	0%
		Sep	**Rearing**	4,367	5,041	5,215	15%	19%
			Spawning	1,393	4,891	4,891	251%	251%
		Oct	**Rearing**	6,848	6,959	6,959	2%	2%
			Spawning	4,875	8,397	8,397	72%	72%
		Nov	**Rearing**	7,165	7,312	7,312	2%	2%
			Spawning	1,843	3,110	3,110	69%	69%
		Dec	**Rearing**	6,111	6,315	6,111	3%	0%
			Spawning	348	522	348	50%	0%
	2014	**Jan**	**Rearing**	6,425	6,217	6,217	-3%	-3%
			Spawning	413	275	275	-33%	-33%
		Feb	**Rearing**	6,539	6,328	6,328	-3%	-3%
			Spawning	417	278	278	-33%	-33%
		Mar	**Rearing**	7,534	7,382	7,593	-2%	1%
			Spawning	3,005	1,781	2,448	-41%	-19%
		Apr	**Rearing**	6,853	7,409	7,409	8%	8%
			Spawning	4,006	3,673	3,673	-8%	-8%
		May	**Rearing**	5,041	6,421	6,421	27%	27%
			Spawning	4,891	4,524	4,524	-7%	-7%
		Jun	**Rearing**	6,486	7,207	7,207	11%	11%
			Spawning	8,120	29,517	29,517	264%	264%
		Jul	**Rearing**	4,782	6,965	6,724	46%	41%
			Spawning	0	8,386	6,289	0%	0%
		Aug	**Rearing**	4,883	7,841	7,841	61%	61%
			Spawning	0	4,277	4,277	0%	0%
		Sep	**Rearing**	9,221	9,654	8,278	5%	-10%
			Spawning	2,970	34,217	33,543	1052%	1030%
		Oct	**Rearing**	6,175	6,550	6,959	6%	13%
			Spawning	5,293	6,262	8,397	18%	59%
		Nov	**Rearing**	7,593	7,409	7,409	-2%	-2%
			Spawning	2,448	3,673	3,673	50%	50%
		Dec	**Rearing**	6,750	7,172	6,961	6%	3%
			Spawning	556	1,113	835	100%	50%
Elk Cr to S Fk	**2013**	**Jan**	**Rearing**	6,757	6,757	6,757	0%	0%
			Spawning	247	247	247	0%	0%
		Feb	**Rearing**	8,183	7,919	7,919	-3%	-3%
			Spawning	368	245	245	-33%	-33%
		Mar	**Rearing**	9,108	8,924	8,924	-2%	-2%
			Spawning	2,561	1,517	1,517	-41%	-41%
		Apr	**Rearing**	8,285	8,879	8,879	7%	7%
			Spawning	3,414	3,224	3,224	-6%	-6%
		May	**Rearing**	9,815	11,274	11,274	15%	15%
			Spawning	7,285	9,713	9,713	33%	33%
		Jun	**Rearing**	10,848	12,461	12,461	15%	15%
			Spawning	1,364	5,455	5,455	300%	300%
		Jul	**Rearing**	14,725	16,377	16,377	11%	11%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	21,493	20,613	20,613	-4%	-4%
			Spawning	0	1,365	1,365	0%	0%
		Sep	**Rearing**	7,011	6,998	7,240	0%	3%
			Spawning	2,128	2,612	3,918	23%	84%
		Oct	**Rearing**	10,239	11,661	11,661	14%	14%
			Spawning	4,571	6,033	6,033	32%	32%
		Nov	**Rearing**	9,624	9,899	9,899	3%	3%
			Spawning	1,694	2,330	2,330	38%	38%
		Dec	**Rearing**	9,168	9,138	8,833	0%	-4%
			Spawning	177	327	163	84%	-8%
	2014	**Jan**	**Rearing**	7,905	7,905	7,650	0%	-3%
			Spawning	356	356	237	0%	-33%
		Feb	**Rearing**	6,552	6,341	6,341	-3%	-3%
			Spawning	346	231	231	-33%	-33%
		Mar	**Rearing**	7,549	7,609	7,609	1%	1%
			Spawning	2,494	2,032	2,032	-19%	-19%
		Apr	**Rearing**	7,860	8,425	8,425	7%	7%
			Spawning	3,503	3,308	3,308	-6%	-6%
		May	**Rearing**	7,083	8,418	8,136	19%	15%
			Spawning	4,650	4,534	4,650	-3%	0%
		Jun	**Rearing**	15,273	18,174	17,544	19%	15%
			Spawning	1,751	9,337	7,003	433%	300%
		Jul	**Rearing**	13,394	16,377	16,377	22%	22%

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Species	Largescale Sucker							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
		Jul	**Spawning**	0	0	0	0%	0%
		Aug	**Rearing**	18,048	20,613	19,899	14%	10%
			Spawning	0	1,365	683	0%	0%
		Sep	**Rearing**	26,461	26,257	27,199	-1%	3%
			Spawning	5,030	16,383	21,844	226%	334%
		Oct	**Rearing**	9,915	11,430	12,499	15%	26%
			Spawning	5,249	7,095	7,746	35%	48%
		Nov	**Rearing**	8,924	8,888	8,888	0%	0%
			Spawning	1,517	2,570	2,570	69%	69%
		Dec	**Rearing**	6,784	7,003	7,003	3%	3%
			Spawning	360	479	479	33%	33%
S Fk to Newaukum	**2013**	**Jan**	**Spawning**	130	130	130	0%	0%
		Feb	**Spawning**	272	136	136	-50%	-50%
		Mar	**Spawning**	1,741	1,197	1,197	-31%	-31%
		Apr	**Spawning**	2,067	1,959	1,959	-5%	-5%
		May	**Rearing**	6,308	6,995	6,995	11%	11%
			Spawning	1,707	5,120	5,120	200%	200%
		Jun	**Rearing**	6,697	8,548	8,548	28%	28%
			Spawning	0	588	588	0%	0%
		Jul	**Rearing**	7,862	9,958	9,958	27%	27%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	13,558	13,706	13,706	1%	1%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	5,145	5,145	5,323	0%	3%
		Oct	**Rearing**	8,640	8,640	8,622	0%	0%
			Spawning	3,459	3,459	3,508	0%	1%
		Nov	**Rearing**	8,996	9,253	9,253	3%	3%
			Spawning	1,581	2,174	2,174	38%	38%
		Dec	**Rearing**	7,439	7,439	7,439	0%	0%
			Spawning	125	125	125	0%	0%
	2014	**Jan**	**Spawning**	204	136	136	-33%	-33%
		Feb	**Spawning**	210	210	140	0%	-33%
		Mar	**Spawning**	1,789	1,510	1,510	-16%	-16%
		Apr	**Spawning**	1,857	1,959	1,959	5%	5%
		May	**Rearing**	5,893	6,769	6,535	15%	11%
			Spawning	2,005	4,009	4,009	100%	100%
		Jun	**Rearing**	10,611	13,074	13,074	23%	23%
			Spawning	0	291	291	0%	0%
		Jul	**Rearing**	8,885	9,958	9,958	12%	12%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	13,281	15,029	15,029	13%	13%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	28,896	29,356	27,700	2%	-4%
			Spawning	1,012	2,703	3,971	167%	293%
		Oct	**Rearing**	7,953	8,921	10,296	12%	29%
			Spawning	4,335	6,486	7,300	50%	68%
		Nov	**Spawning**	870	1,197	1,197	38%	38%
		Dec	**Spawning**	140	210	210	50%	50%
Newaukum to Skookumchuck	**2013**	**Jan**	**Rearing**	44,733	44,733	44,733	0%	0%
			Spawning	26	26	26	0%	0%
		Feb	**Rearing**	50,099	50,099	50,099	0%	0%
			Spawning	21	21	21	0%	0%
		Mar	**Rearing**	54,325	54,325	54,325	0%	0%
			Spawning	154	154	154	0%	0%
		Apr	**Rearing**	50,863	50,863	50,863	0%	0%
			Spawning	196	196	196	0%	0%
		May	**Rearing**	79,705	82,565	82,565	4%	4%
			Spawning	101	135	135	33%	33%
		Jun	**Rearing**	71,139	73,604	73,604	3%	3%
			Spawning	10	15	15	50%	50%
		Jul	**Rearing**	46,867	46,867	46,867	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	52,308	57,205	57,205	9%	9%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	69,387	69,387	69,387	0%	0%
			Spawning	25	25	25	0%	0%
		Oct	**Rearing**	67,495	71,573	71,573	6%	6%
			Spawning	248	228	228	-8%	-8%
		Nov	**Rearing**	70,275	72,283	72,283	3%	3%
			Spawning	114	156	156	38%	38%
		Dec	**Rearing**	65,897	65,897	65,897	0%	0%
			Spawning	7	7	7	0%	0%
	2014	**Jan**	**Rearing**	51,947	51,947	51,947	0%	0%
			Spawning	22	22	22	0%	0%
		Feb	**Rearing**	43,776	43,776	43,776	0%	0%
			Spawning	29	29	29	0%	0%
		Mar	**Rearing**	50,439	50,439	50,439	0%	0%
			Spawning	209	209	209	0%	0%
		Apr	**Rearing**	49,416	49,416	49,416	0%	0%
			Spawning	206	206	206	0%	0%
		May	**Rearing**	52,426	54,242	54,242	3%	3%
			Spawning	261	261	261	0%	0%
		Jun	**Rearing**	76,549	79,201	79,201	3%	3%
			Spawning	19	29	29	50%	50%
		Jul	**Rearing**	46,867	51,786	46,867	10%	0%

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Species	Largescale Sucker							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2014	Jul	Spawning	0	0	0	0%	0%
		Aug	Rearing	52,308	57,205	57,205	9%	9%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	89,265	91,990	95,177	3%	7%
			Spawning	96	147	221	53%	129%
		Oct	Rearing	101,650	108,799	108,799	7%	7%
			Spawning	129	131	131	2%	2%
		Nov	Rearing	58,650	60,325	60,325	3%	3%
			Spawning	95	131	131	38%	38%
		Dec	Rearing	42,364	42,364	42,364	0%	0%
			Spawning	19	19	19	0%	0%
Skookumchuck to Black	2013	Jan	Rearing	45,888	45,888	45,888	0%	0%
			Spawning	23	23	23	0%	0%
		Feb	Rearing	51,715	51,715	51,715	0%	0%
			Spawning	27	27	27	0%	0%
		Mar	Rearing	53,427	53,925	53,925	1%	1%
			Spawning	189	183	183	-3%	-3%
		Apr	Rearing	47,457	49,101	47,457	3%	0%
			Spawning	207	202	207	-3%	0%
		May	Rearing	63,680	63,680	63,680	0%	0%
			Spawning	63	63	63	0%	0%
		Jun	Rearing	57,307	62,488	62,488	9%	9%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	42,027	42,027	42,027	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	52,038	56,929	56,929	9%	9%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	71,780	71,780	71,780	0%	0%
			Spawning	17	17	17	0%	0%
		Oct	Rearing	56,572	56,572	56,572	0%	0%
			Spawning	239	239	239	0%	0%
		Nov	Rearing	60,942	62,683	62,683	3%	3%
			Spawning	106	146	146	38%	38%
		Dec	Rearing	55,309	55,309	55,309	0%	0%
			Spawning	9	9	9	0%	0%
	2014	Jan	Rearing	50,099	50,099	50,099	0%	0%
			Spawning	21	21	21	0%	0%
		Feb	Rearing	45,189	43,776	43,776	-3%	-3%
			Spawning	39	29	29	-25%	-25%
		Mar	Rearing	50,068	50,068	50,068	0%	0%
			Spawning	248	248	248	0%	0%
		Apr	Rearing	47,457	49,101	49,101	3%	3%
			Spawning	207	202	202	-3%	-3%
		May	Rearing	43,816	45,334	45,334	3%	3%
			Spawning	146	219	219	50%	50%
		Jun	Rearing	64,127	69,925	69,925	9%	9%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	42,027	42,027	42,027	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	57,205	56,929	51,786	0%	-9%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	88,374	88,374	88,374	0%	0%
			Spawning	106	106	106	0%	0%
		Oct	Rearing	98,128	105,030	105,030	7%	7%
			Spawning	132	134	134	2%	2%
		Nov	Rearing	60,942	62,683	62,683	3%	3%
			Spawning	106	146	146	38%	38%
		Dec	Rearing	43,290	43,290	43,290	0%	0%
			Spawning	18	18	18	0%	0%
Black to Porter	2013	Jan	Rearing	17,529	17,529	17,529	0%	0%
			Spawning	152	152	152	0%	0%
		Feb	Rearing	17,032	17,032	17,032	0%	0%
			Spawning	325	325	325	0%	0%
		Mar	Rearing	19,231	19,231	19,231	0%	0%
			Spawning	1,436	1,436	1,436	0%	0%
		Apr	Rearing	16,021	16,596	16,596	4%	4%
			Spawning	1,698	1,654	1,654	-3%	-3%
		May	Rearing	24,074	24,908	24,908	3%	3%
			Spawning	1,190	1,785	1,785	50%	50%
		Jun	Rearing	22,902	25,012	25,012	9%	9%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	16,802	16,802	16,802	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	20,730	19,818	19,818	-4%	-4%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	30,243	30,243	30,243	0%	0%
			Spawning	594	594	594	0%	0%
		Oct	Rearing	17,880	17,880	17,880	0%	0%
			Spawning	3,140	3,140	3,140	0%	0%
		Nov	Rearing	19,261	19,811	19,811	3%	3%
			Spawning	1,396	1,919	1,919	38%	38%
		Dec	Rearing	16,347	16,347	16,347	0%	0%
			Spawning	105	105	105	0%	0%
	2014	Jan	Rearing	16,500	16,500	16,500	0%	0%
			Spawning	244	244	244	0%	0%

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Species	Largescale Sucker							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2014	Feb	Rearing	19,013	19,013	19,013	0%	0%
			Spawning	233	233	233	0%	0%
		Mar	Rearing	20,872	20,872	20,872	0%	0%
			Spawning	1,538	1,538	1,538	0%	0%
		Apr	Rearing	15,576	16,135	16,135	4%	4%
			Spawning	2,539	2,474	2,474	-3%	-3%
		May	Rearing	12,502	12,950	12,950	4%	4%
			Spawning	1,263	1,684	1,684	33%	33%
		Jun	Rearing	28,982	28,982	28,982	0%	0%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	19,818	18,832	18,832	-5%	-5%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	23,126	23,126	23,126	0%	0%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	45,103	45,103	43,119	0%	-4%
			Spawning	810	810	780	0%	-4%
		Oct	Rearing	45,840	45,840	48,156	0%	5%
			Spawning	6,177	6,177	6,474	0%	5%
		Nov	Rearing	18,900	19,440	19,440	3%	3%
			Spawning	1,429	1,964	1,964	38%	38%
		Dec	Rearing	17,825	17,825	17,825	0%	0%
			Spawning	117	117	117	0%	0%

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Species	Mountain Whitefish							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
PeEll to Elk Cr	**2013**	**Jan**	**Rearing**	7,026	7,026	7,026	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	8,533	8,031	7,780	-6%	-9%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	8,822	8,435	8,435	-4%	-4%
			Spawning	1,074	0	0	-100%	-100%
		Apr	**Rearing**	7,165	8,442	8,442	18%	18%
			Spawning	9,669	3,760	3,760	-61%	-61%
		May	**Rearing**	5,256	7,684	7,684	46%	46%
			Spawning	1,706	13,645	13,645	700%	700%
		Jun	**Rearing**	2,878	4,653	4,653	62%	62%
			Spawning	0	2,224	2,224	0%	0%
		Jul	**Rearing**	535	1,628	1,515	204%	183%
			Spawning	0	200	100	0%	0%
		Aug	**Rearing**	231	1,003	1,003	335%	335%
			Spawning	0	72	72	0%	0%
		Sep	**Rearing**	4,382	5,598	5,973	28%	36%
			Spawning	425	1,707	2,560	302%	503%
		Oct	**Rearing**	9,816	9,373	9,373	-5%	-5%
			Spawning	9,199	11,485	11,485	25%	25%
		Nov	**Rearing**	10,001	10,176	10,176	2%	2%
			Spawning	0	1,287	1,287	0%	0%
		Dec	**Rearing**	9,344	9,636	9,344	3%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	7,732	7,498	7,498	-3%	-3%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	7,245	7,026	7,026	-3%	-3%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	8,266	8,124	8,343	-2%	1%
			Spawning	978	0	0	-100%	-100%
		Apr	**Rearing**	7,133	7,910	7,910	11%	11%
			Spawning	7,826	3,424	3,424	-56%	-56%
		May	**Rearing**	5,598	8,691	8,691	55%	55%
			Spawning	1,707	12,288	12,288	620%	620%
		Jun	**Rearing**	1,909	3,670	3,670	92%	92%
			Spawning	229	2,343	2,343	925%	925%
		Jul	**Rearing**	335	1,628	1,515	386%	352%
			Spawning	0	200	100	0%	0%
		Aug	**Rearing**	175	934	934	433%	433%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	463	1,415	2,280	206%	392%
			Spawning	0	596	1,252	0%	0%
		Oct	**Rearing**	8,410	8,990	9,373	7%	11%
			Spawning	14,152	12,964	11,485	-8%	-19%
		Nov	**Rearing**	8,343	7,910	7,910	-5%	-5%
			Spawning	0	3,424	3,424	0%	0%
		Dec	**Rearing**	7,465	7,904	7,685	6%	3%
			Spawning	0	0	0	0%	0%
Elk Cr to S Fk	**2013**	**Jan**	**Rearing**	10,574	10,574	10,574	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	16,459	15,960	15,960	-3%	-3%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	18,103	17,791	17,791	-2%	-2%
			Spawning	1,970	0	0	-100%	-100%
		Apr	**Rearing**	15,622	16,743	16,743	7%	7%
			Spawning	15,760	9,850	9,850	-38%	-38%
		May	**Rearing**	7,055	9,150	9,150	30%	30%
			Spawning	1,704	6,815	6,815	300%	300%
		Jun	**Rearing**	3,164	4,216	4,216	33%	33%
			Spawning	0	594	594	0%	0%
		Jul	**Rearing**	677	1,250	1,250	85%	85%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	394	1,018	1,018	159%	159%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	8,004	8,742	9,346	9%	17%
			Spawning	1,010	1,373	2,059	36%	104%
		Oct	**Rearing**	17,055	15,673	15,673	-8%	-8%
			Spawning	14,276	13,729	13,729	-4%	-4%
		Nov	**Rearing**	18,952	19,464	19,464	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	15,431	16,235	15,728	5%	2%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	15,867	15,867	15,386	0%	-3%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	9,222	8,943	8,943	-3%	-3%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	10,521	10,619	10,619	1%	1%
			Spawning	1,209	0	0	-100%	-100%
		Apr	**Rearing**	14,025	15,031	15,031	7%	7%
			Spawning	14,526	9,079	9,079	-38%	-38%
		May	**Rearing**	10,169	13,974	13,141	37%	29%
			Spawning	2,722	16,334	10,890	500%	300%
		Jun	**Rearing**	2,129	3,040	2,837	43%	33%
			Spawning	0	551	408	0%	0%
		Jul	**Rearing**	620	1,250	1,250	102%	102%

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Species	Mountain Whitefish							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
		Jul	Spawning	0	0	0	0%	0%
		Aug	Rearing	334	1,018	942	205%	182%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	617	1,675	1,791	171%	190%
			Spawning	73	453	604	523%	731%
		Oct	Rearing	15,222	13,527	13,431	-11%	-12%
			Spawning	19,654	18,408	15,528	-6%	-21%
		Nov	Rearing	17,791	17,281	17,281	-3%	-3%
			Spawning	0	1,896	1,896	0%	0%
		Dec	Rearing	9,965	10,267	10,267	3%	3%
			Spawning	0	0	0	0%	0%
S Fk to Newaukum	2013	Jan	Rearing	8,360	8,360	8,360	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	10,859	10,220	10,220	-6%	-6%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	11,919	12,136	12,136	2%	2%
			Spawning	2,090	0	0	-100%	-100%
		Apr	Rearing	9,198	10,376	10,376	13%	13%
			Spawning	10,452	8,362	8,362	-20%	-20%
		May	Rearing	7,023	8,623	8,623	23%	23%
			Spawning	551	1,723	1,723	213%	213%
		Jun	Rearing	3,350	4,618	4,618	38%	38%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	656	812	812	24%	24%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	488	751	751	54%	54%
			Spawning	0	0	0	0%	0%
		Oct	Rearing	14,865	14,865	15,731	0%	6%
			Spawning	10,404	10,404	11,400	0%	10%
		Nov	Rearing	16,361	16,803	16,803	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	14,507	14,507	14,507	0%	0%
			Spawning	0	0	0	0%	0%
	2014	Jan	Rearing	10,539	10,220	10,220	-3%	-3%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	7,279	7,279	7,059	0%	-3%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	8,233	8,305	8,305	1%	1%
			Spawning	1,320	660	660	-50%	-50%
		Apr	Rearing	8,725	10,376	10,376	19%	19%
			Spawning	8,285	8,362	8,362	1%	1%
		May	Rearing	8,063	10,497	9,836	30%	22%
			Spawning	1,096	4,385	3,289	300%	200%
		Jun	Rearing	2,499	3,187	3,187	28%	28%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	732	812	812	11%	11%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	299	536	536	79%	79%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	706	1,293	1,942	83%	175%
			Spawning	0	126	256	0%	0%
		Oct	Rearing	13,992	13,480	13,230	-4%	-5%
			Spawning	19,229	18,375	17,962	-4%	-7%
		Nov	Rearing	11,817	12,136	12,136	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	7,059	7,279	7,279	3%	3%
			Spawning	0	0	0	0%	0%
Newaukum to Skookumchuck	2013	Jan	Rearing	4,781	4,781	4,781	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	4,597	4,597	4,597	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	5,432	5,432	5,432	0%	0%
			Spawning	153	153	153	0%	0%
		Apr	Rearing	4,619	4,619	4,619	0%	0%
			Spawning	1,271	1,271	1,271	0%	0%
		May	Rearing	2,075	2,219	2,219	7%	7%
			Spawning	241	321	321	33%	33%
		Jun	Rearing	993	1,071	1,071	8%	8%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	196	196	196	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	134	192	192	43%	43%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	1,573	1,573	1,573	0%	0%
			Spawning	39	39	39	0%	0%
		Oct	Rearing	4,275	4,216	4,216	-1%	-1%
			Spawning	1,307	1,377	1,377	5%	5%
		Nov	Rearing	4,705	4,832	4,832	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	3,835	3,835	3,835	0%	0%
			Spawning	0	0	0	0%	0%
	2014	Jan	Rearing	4,501	4,501	4,501	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	4,726	4,726	4,726	0%	0%
			Spawning	0	0	0	0%	0%

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Species	Mountain Whitefish							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2014	Mar	Rearing	5,392	5,392	5,392	0%	0%
			Spawning	132	132	132	0%	0%
		Apr	Rearing	4,688	4,688	4,688	0%	0%
			Spawning	1,224	1,224	1,224	0%	0%
		May	Rearing	2,471	2,636	2,636	7%	7%
			Spawning	265	397	397	50%	50%
		Jun	Rearing	634	683	683	8%	8%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	196	215	196	10%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	134	192	192	43%	43%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	275	386	414	40%	50%
			Spawning	9	23	35	147%	281%
		Oct	Rearing	3,244	3,003	3,003	-7%	-7%
			Spawning	2,568	2,528	2,528	-2%	-2%
		Nov	Rearing	5,047	5,183	5,183	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	4,583	4,583	4,583	0%	0%
			Spawning	0	0	0	0%	0%
Skookumchuck to Black	2013	Jan	Rearing	4,789	4,789	4,789	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	4,736	4,736	4,736	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	5,198	5,385	5,385	4%	4%
			Spawning	535	306	306	-43%	-43%
		Apr	Rearing	4,094	4,347	4,094	6%	0%
			Spawning	1,589	1,430	1,589	-10%	0%
		May	Rearing	1,926	1,926	1,926	0%	0%
			Spawning	119	119	119	0%	0%
		Jun	Rearing	920	999	999	9%	9%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	211	211	211	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	176	235	235	34%	34%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	1,356	1,356	1,356	0%	0%
			Spawning	0	0	0	0%	0%
		Oct	Rearing	4,344	4,344	4,344	0%	0%
			Spawning	1,408	1,408	1,408	0%	0%
		Nov	Rearing	4,947	5,080	5,080	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	3,999	3,999	3,999	0%	0%
			Spawning	0	0	0	0%	0%
	2014	Jan	Rearing	4,597	4,597	4,597	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	4,869	4,726	4,726	-3%	-3%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	5,345	5,345	5,345	0%	0%
			Spawning	263	263	263	0%	0%
		Apr	Rearing	4,094	4,347	4,347	6%	6%
			Spawning	1,589	1,430	1,430	-10%	-10%
		May	Rearing	2,223	2,376	2,376	7%	7%
			Spawning	119	179	179	50%	50%
		Jun	Rearing	588	638	638	9%	9%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	211	211	211	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	192	235	215	23%	12%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	441	441	441	0%	0%
			Spawning	13	13	13	0%	0%
		Oct	Rearing	3,049	2,823	2,823	-7%	-7%
			Spawning	1,926	1,896	1,896	-2%	-2%
		Nov	Rearing	4,947	5,080	5,080	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	4,636	4,636	4,636	0%	0%
			Spawning	0	0	0	0%	0%
Black to Porter	2013	Jan	Rearing	11,398	11,398	11,398	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	15,699	15,699	15,699	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	14,278	14,278	14,278	0%	0%
			Spawning	1,942	1,942	1,942	0%	0%
		Apr	Rearing	10,728	11,413	11,413	6%	6%
			Spawning	4,161	5,548	5,548	33%	33%
		May	Rearing	6,417	6,877	6,877	7%	7%
			Spawning	413	637	637	54%	54%
		Jun	Rearing	2,697	2,929	2,929	9%	9%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	970	970	970	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	874	974	974	11%	11%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	4,006	4,006	4,006	0%	0%

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Species	Mountain Whitefish							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2013	Sep	Spawning	0	0	0	0%	0%
		Oct	Rearing	19,653	19,653	19,653	0%	0%
			Spawning	11,381	11,381	11,381	0%	0%
		Nov	Rearing	22,381	22,986	22,986	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	18,824	18,824	18,824	0%	0%
			Spawning	0	0	0	0%	0%
	2014	Jan	Rearing	15,238	15,238	15,238	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	10,425	10,425	10,425	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	11,047	11,047	11,047	0%	0%
			Spawning	1,158	1,158	1,158	0%	0%
		Apr	Rearing	12,499	13,298	13,298	6%	6%
			Spawning	5,670	7,560	7,560	33%	33%
		May	Rearing	9,764	10,463	10,463	7%	7%
			Spawning	687	928	928	35%	35%
		Jun	Rearing	2,418	2,418	2,418	0%	0%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	974	1,076	1,076	10%	10%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	966	966	966	0%	0%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	2,060	2,060	2,295	0%	11%
			Spawning	0	0	0	0%	0%
		Oct	Rearing	8,987	8,987	8,509	0%	-5%
			Spawning	8,727	8,727	8,363	0%	-4%
		Nov	Rearing	22,189	22,789	22,789	3%	3%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	9,812	9,812	9,812	0%	0%
			Spawning	0	0	0	0%	0%

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Species	Pacific Lamprey							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
PeEll to Elk Cr	2013	Jan	Rearing	1,055	1,055	1,055	0%	0%
			Spawning	17,630	17,630	17,630	0%	0%
		Feb	Rearing	1,429	1,144	1,001	-20%	-30%
			Spawning	23,193	19,327	17,394	-17%	-25%
		Mar	Rearing	1,995	1,653	1,653	-17%	-17%
			Spawning	31,401	25,859	25,859	-18%	-18%
		Apr	Rearing	2,161	2,110	2,110	-2%	-2%
			Spawning	36,942	35,095	35,095	-5%	-5%
		May	Rearing	1,485	1,828	1,828	23%	23%
			Spawning	40,844	40,844	40,844	0%	0%
		Jun	Rearing	1,219	1,634	1,634	34%	34%
			Spawning	29,786	37,233	37,233	25%	25%
		Jul	Rearing	693	1,313	1,236	89%	78%
			Spawning	7,898	23,346	22,049	196%	179%
		Aug	Rearing	907	1,372	1,372	51%	51%
			Spawning	5,265	17,901	17,901	240%	240%
		Sep	Rearing	1,326	1,658	1,716	25%	29%
			Spawning	38,751	41,870	41,870	8%	8%
		Oct	Rearing	1,975	1,847	1,847	-6%	-6%
			Spawning	43,056	42,820	42,820	-1%	-1%
		Nov	Rearing	1,867	2,079	2,079	11%	11%
			Spawning	30,227	34,258	34,258	13%	13%
		Dec	Rearing	990	1,113	990	13%	0%
			Spawning	21,528	23,681	21,528	10%	0%
	2014	Jan	Rearing	1,240	1,102	1,102	-11%	-11%
			Spawning	20,318	18,471	18,471	-9%	-9%
		Feb	Rearing	1,187	1,055	1,055	-11%	-11%
			Spawning	19,393	17,630	17,630	-9%	-9%
		Mar	Rearing	1,909	1,714	1,846	-10%	-3%
			Spawning	29,971	26,445	28,208	-12%	-6%
		Apr	Rearing	2,142	2,019	2,019	-6%	-6%
			Spawning	35,259	33,496	33,496	-5%	-5%
		May	Rearing	1,658	2,112	2,112	27%	27%
			Spawning	41,870	41,870	41,870	0%	0%
		Jun	Rearing	1,289	1,598	1,598	24%	24%
			Spawning	25,343	32,077	32,077	27%	27%
		Jul	Rearing	603	1,313	1,236	118%	105%
			Spawning	3,446	23,346	22,049	578%	540%
		Aug	Rearing	629	1,292	1,292	105%	105%
			Spawning	1,755	16,848	16,848	860%	860%
		Sep	Rearing	1,483	1,674	1,561	13%	5%
			Spawning	11,650	21,060	25,940	81%	123%
		Oct	Rearing	1,875	1,809	1,847	-4%	-1%
			Spawning	43,056	43,574	42,820	1%	-1%
		Nov	Rearing	1,846	2,019	2,019	9%	9%
			Spawning	28,208	33,496	33,496	19%	19%
		Dec	Rearing	1,318	1,582	1,450	20%	10%
			Spawning	21,156	24,682	22,919	17%	8%
Elk Cr to S Fk	2013	Jan	Rearing	842	842	842	0%	0%
			Spawning	16,335	16,335	16,335	0%	0%
		Feb	Rearing	1,323	1,176	1,176	-11%	-11%
			Spawning	21,819	19,835	19,835	-9%	-9%
		Mar	Rearing	1,926	1,729	1,729	-10%	-10%
			Spawning	33,040	29,153	29,153	-12%	-12%
		Apr	Rearing	2,161	2,085	2,085	-4%	-4%
			Spawning	38,871	38,871	38,871	0%	0%
		May	Rearing	2,244	2,578	2,578	15%	15%
			Spawning	39,829	39,829	39,829	0%	0%
		Jun	Rearing	1,886	2,343	2,343	24%	24%
			Spawning	26,913	34,089	34,089	27%	27%
		Jul	Rearing	1,888	1,921	1,921	2%	2%
			Spawning	8,868	16,533	16,533	86%	86%
		Aug	Rearing	4,575	3,110	3,110	-32%	-32%
			Spawning	10,060	16,553	16,553	65%	65%
		Sep	Rearing	1,833	1,848	1,912	1%	4%
			Spawning	39,163	41,124	41,124	5%	5%
		Oct	Rearing	2,569	2,701	2,701	5%	5%
			Spawning	41,124	41,107	41,107	0%	0%
		Nov	Rearing	1,961	2,112	2,112	8%	8%
			Spawning	30,221	32,235	32,235	7%	7%
		Dec	Rearing	1,157	1,287	1,126	11%	-3%
			Spawning	18,551	20,562	18,506	11%	0%
	2014	Jan	Rearing	1,197	1,197	1,064	0%	-11%
			Spawning	21,379	21,379	19,435	0%	-9%
		Feb	Rearing	767	681	681	-11%	-11%
			Spawning	15,827	14,388	14,388	-9%	-9%
		Mar	Rearing	1,233	1,193	1,193	-3%	-3%
			Spawning	24,459	23,021	23,021	-6%	-6%
		Apr	Rearing	2,100	2,026	2,026	-4%	-4%
			Spawning	36,935	36,935	36,935	0%	0%
		May	Rearing	1,867	2,219	2,145	19%	15%
			Spawning	40,781	40,781	40,781	0%	0%
		Jun	Rearing	2,116	2,722	2,627	29%	24%
			Spawning	23,184	30,912	29,366	33%	27%

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Species	Pacific Lamprey							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
		Jul	Rearing	1,684	1,921	1,921	14%	14%
			Spawning	5,912	16,533	16,533	180%	180%
		Aug	Rearing	3,735	3,110	2,835	-17%	-24%
			Spawning	8,383	16,553	15,371	97%	83%
		Sep	Rearing	7,040	4,402	4,560	-37%	-35%
			Spawning	15,090	23,647	23,647	57%	57%
		Oct	Rearing	2,592	2,684	2,889	4%	11%
			Spawning	41,225	40,829	40,424	-1%	-2%
		Nov	Rearing	1,729	1,884	1,884	9%	9%
			Spawning	29,153	32,243	32,243	11%	11%
		Dec	Rearing	894	993	993	11%	11%
			Spawning	16,887	18,422	18,422	9%	9%
S Fk to Newaukum	2013	Jan	Rearing	1,463	1,463	1,463	0%	0%
			Spawning	20,893	20,893	20,893	0%	0%
		Feb	Rearing	1,822	1,457	1,457	-20%	-20%
			Spawning	28,258	23,549	23,549	-17%	-17%
		Mar	Rearing	2,720	2,551	2,551	-6%	-6%
			Spawning	42,387	37,678	37,678	-11%	-11%
		Apr	Rearing	2,761	2,960	2,960	7%	7%
			Spawning	47,097	47,097	47,097	0%	0%
		May	Rearing	1,854	2,056	2,056	11%	11%
			Spawning	53,838	59,820	59,820	11%	11%
		Jun	Rearing	1,089	1,609	1,609	48%	48%
			Spawning	28,354	39,696	39,696	40%	40%
		Jul	Rearing	1,137	1,567	1,567	38%	38%
			Spawning	1,905	3,810	3,810	100%	100%
		Aug	Rearing	2,614	2,446	2,446	-6%	-6%
			Spawning	4,142	6,960	6,960	68%	68%
		Oct	Rearing	2,627	2,627	2,677	0%	2%
			Spawning	55,473	55,473	57,687	0%	4%
		Nov	Rearing	2,139	2,304	2,304	8%	8%
			Spawning	41,605	44,378	44,378	7%	7%
		Dec	Rearing	1,173	1,173	1,173	0%	0%
			Spawning	25,959	25,959	25,959	0%	0%
	2014	Jan	Rearing	1,640	1,457	1,457	-11%	-11%
			Spawning	25,903	23,549	23,549	-9%	-9%
		Feb	Rearing	1,684	1,684	1,497	0%	-11%
			Spawning	20,291	20,291	18,446	0%	-9%
		Mar	Rearing	2,793	2,709	2,709	-3%	-3%
			Spawning	33,203	31,358	31,358	-6%	-6%
		Apr	Rearing	2,933	2,960	2,960	1%	1%
			Spawning	44,408	47,097	47,097	6%	6%
		May	Rearing	1,925	2,212	2,135	15%	11%
			Spawning	57,687	57,687	57,687	0%	0%
		Jun	Rearing	1,517	2,043	2,043	35%	35%
			Spawning	25,047	32,561	32,561	30%	30%
		Jul	Rearing	1,346	1,567	1,567	16%	16%
			Spawning	2,540	3,810	3,810	50%	50%
		Aug	Rearing	2,774	2,975	2,975	7%	7%
			Spawning	2,681	6,213	6,213	132%	132%
		Sep	Rearing	8,063	7,925	6,740	-2%	-16%
			Spawning	21,451	29,822	35,264	39%	64%
		Oct	Rearing	2,558	2,622	2,602	2%	2%
			Spawning	60,324	59,820	59,470	-1%	-1%
		Nov	Rearing	2,368	2,551	2,551	8%	8%
			Spawning	35,323	37,678	37,678	7%	7%
		Dec	Rearing	1,497	1,684	1,684	13%	13%
			Spawning	18,446	20,291	20,291	10%	10%
Newaukum to Skookumchuck	2013	Jan	Rearing	7,778	7,778	7,778	0%	0%
			Spawning	15,331	15,331	15,331	0%	0%
		Feb	Rearing	8,183	8,183	8,183	0%	0%
			Spawning	15,348	15,348	15,348	0%	0%
		Mar	Rearing	12,672	12,672	12,672	0%	0%
			Spawning	23,746	23,746	23,746	0%	0%
		Apr	Rearing	14,494	14,494	14,494	0%	0%
			Spawning	27,948	27,948	27,948	0%	0%
		May	Rearing	19,614	20,318	20,318	4%	4%
			Spawning	23,846	23,846	23,846	0%	0%
		Jun	Rearing	17,478	18,586	18,586	6%	6%
			Spawning	15,566	16,678	16,678	7%	7%
		Jul	Rearing	12,782	12,782	12,782	0%	0%
			Spawning	3,257	3,257	3,257	0%	0%
		Aug	Rearing	14,901	16,401	16,401	10%	10%
			Spawning	3,792	6,126	6,126	62%	62%
		Sep	Rearing	16,648	16,648	16,648	0%	0%
			Spawning	20,270	20,270	20,270	0%	0%
		Oct	Rearing	16,669	17,368	17,368	4%	4%
			Spawning	27,014	26,664	26,664	-1%	-1%
		Nov	Rearing	13,572	14,616	14,616	8%	8%
			Spawning	20,261	21,611	21,611	7%	7%
		Dec	Rearing	7,929	7,929	7,929	0%	0%
			Spawning	11,815	11,815	11,815	0%	0%
	2014	Jan	Rearing	8,292	8,292	8,292	0%	0%
			Spawning	15,299	15,299	15,299	0%	0%

Note: Values with green highlights denote an increase in WUA compared to Current Conditions.
Values with orange highlights denote a decrease in WUA compared to Current Conditions.

Species	Pacific Lamprey							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
	2014	**Feb**	**Rearing**	7,706	7,706	7,706	0%	0%
			Spawning	15,299	15,299	15,299	0%	0%
		Mar	**Rearing**	12,398	12,398	12,398	0%	0%
			Spawning	23,644	23,644	23,644	0%	0%
		Apr	**Rearing**	14,216	14,216	14,216	0%	0%
			Spawning	27,937	27,937	27,937	0%	0%
		May	**Rearing**	13,391	13,855	13,855	3%	3%
			Spawning	26,664	26,664	26,664	0%	0%
		Jun	**Rearing**	22,161	23,566	23,566	6%	6%
			Spawning	14,337	15,361	15,361	7%	7%
		Jul	**Rearing**	12,782	14,444	12,782	13%	0%
			Spawning	3,257	4,343	3,257	33%	0%
		Aug	**Rearing**	14,901	16,401	16,401	10%	10%
			Spawning	3,792	6,126	6,126	62%	62%
		Sep	**Rearing**	33,057	34,489	35,684	4%	8%
			Spawning	12,893	14,703	15,520	14%	20%
		Oct	**Rearing**	25,014	27,860	27,860	11%	11%
			Spawning	23,846	23,132	23,132	-3%	-3%
		Nov	**Rearing**	11,978	12,899	12,899	8%	8%
			Spawning	20,862	22,253	22,253	7%	7%
		Dec	**Rearing**	6,850	6,850	6,850	0%	0%
			Spawning	13,908	13,908	13,908	0%	0%
Skookumchuck to Black	**2013**	**Jan**	**Rearing**	7,827	7,827	7,827	0%	0%
			Spawning	15,349	15,349	15,349	0%	0%
		Feb	**Rearing**	9,093	9,093	9,093	0%	0%
			Spawning	16,744	16,744	16,744	0%	0%
		Mar	**Rearing**	13,400	13,064	13,064	-3%	-3%
			Spawning	26,540	25,143	25,143	-5%	-5%
		Apr	**Rearing**	13,523	13,992	13,523	3%	0%
			Spawning	27,948	27,948	27,948	0%	0%
		May	**Rearing**	14,846	14,846	14,846	0%	0%
			Spawning	23,682	23,682	23,682	0%	0%
		Jun	**Rearing**	11,585	12,801	12,801	10%	10%
			Spawning	12,723	13,879	13,879	9%	9%
		Jul	**Rearing**	11,095	11,095	11,095	0%	0%
			Spawning	2,283	2,283	2,283	0%	0%
		Aug	**Rearing**	14,632	16,190	16,190	11%	11%
			Spawning	4,084	6,514	6,514	60%	60%
		Sep	**Rearing**	17,462	17,462	17,462	0%	0%
			Spawning	18,506	18,506	18,506	0%	0%
		Oct	**Rearing**	15,316	15,316	15,316	0%	0%
			Spawning	27,701	27,701	27,701	0%	0%
		Nov	**Rearing**	12,256	13,199	13,199	8%	8%
			Spawning	20,776	22,161	22,161	7%	7%
		Dec	**Rearing**	7,044	7,044	7,044	0%	0%
			Spawning	12,288	12,288	12,288	0%	0%
	2014	**Jan**	**Rearing**	8,183	8,183	8,183	0%	0%
			Spawning	15,348	15,348	15,348	0%	0%
		Feb	**Rearing**	8,562	7,706	7,706	-10%	-10%
			Spawning	16,690	15,299	15,299	-8%	-8%
		Mar	**Rearing**	12,782	12,782	12,782	0%	0%
			Spawning	25,035	25,035	25,035	0%	0%
		Apr	**Rearing**	13,523	13,992	13,992	3%	3%
			Spawning	27,948	27,948	27,948	0%	0%
		May	**Rearing**	11,560	11,960	11,960	3%	3%
			Spawning	27,306	27,306	27,306	0%	0%
		Jun	**Rearing**	15,561	17,195	17,195	10%	10%
			Spawning	11,613	12,669	12,669	9%	9%
		Jul	**Rearing**	11,095	11,095	11,095	0%	0%
			Spawning	2,283	2,283	2,283	0%	0%
		Aug	**Rearing**	16,401	16,190	14,444	-1%	-12%
			Spawning	6,126	6,514	4,343	6%	-29%
		Sep	**Rearing**	32,044	32,044	32,044	0%	0%
			Spawning	14,766	14,766	14,766	0%	0%
		Oct	**Rearing**	24,147	26,895	26,895	11%	11%
			Spawning	23,846	23,132	23,132	-3%	-3%
		Nov	**Rearing**	12,256	13,199	13,199	8%	8%
			Spawning	20,776	22,161	22,161	7%	7%
		Dec	**Rearing**	6,914	6,914	6,914	0%	0%
			Spawning	13,937	13,937	13,937	0%	0%
Black to Porter	**2013**	**Jan**	**Rearing**	3,256	3,256	3,256	0%	0%
			Spawning	18,877	18,877	18,877	0%	0%
		Feb	**Rearing**	3,167	3,167	3,167	0%	0%
			Spawning	24,047	24,047	24,047	0%	0%
		Mar	**Rearing**	5,282	5,282	5,282	0%	0%
			Spawning	35,167	35,167	35,167	0%	0%
		Apr	**Rearing**	5,047	5,229	5,229	4%	4%
			Spawning	37,018	37,018	37,018	0%	0%
		May	**Rearing**	4,067	4,208	4,208	3%	3%
			Spawning	38,149	40,268	40,268	6%	6%
		Jun	**Rearing**	2,893	3,207	3,207	11%	11%
			Spawning	19,354	21,290	21,290	10%	10%
		Jul	**Rearing**	1,856	1,856	1,856	0%	0%
			Spawning	2,060	2,060	2,060	0%	0%

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Species	Pacific Lamprey							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
Black to Porter	**2013**	**Aug**	**Rearing**	2,482	2,292	2,292	-8%	-8%
			Spawning	2,866	2,980	2,980	4%	4%
		Sep	**Rearing**	4,543	4,543	4,543	0%	0%
			Spawning	29,031	29,031	29,031	0%	0%
		Oct	**Rearing**	4,651	4,651	4,651	0%	0%
			Spawning	46,240	46,240	46,240	0%	0%
		Nov	**Rearing**	3,722	4,008	4,008	8%	8%
			Spawning	34,680	36,992	36,992	7%	7%
		Dec	**Rearing**	1,979	1,979	1,979	0%	0%
			Spawning	20,904	20,904	20,904	0%	0%
	2014	**Jan**	**Rearing**	2,850	2,850	2,850	0%	0%
			Spawning	22,043	22,043	22,043	0%	0%
		Feb	**Rearing**	3,785	3,785	3,785	0%	0%
			Spawning	19,408	19,408	19,408	0%	0%
		Mar	**Rearing**	5,795	5,795	5,795	0%	0%
			Spawning	30,729	30,729	30,729	0%	0%
		Apr	**Rearing**	4,634	4,800	4,800	4%	4%
			Spawning	40,078	40,078	40,078	0%	0%
		May	**Rearing**	3,135	3,247	3,247	4%	4%
			Spawning	44,130	46,453	46,453	5%	5%
		Jun	**Rearing**	3,817	3,817	3,817	0%	0%
			Spawning	19,869	19,869	19,869	0%	0%
		Jul	**Rearing**	2,292	2,161	2,161	-6%	-6%
			Spawning	2,980	3,090	3,090	4%	4%
		Aug	**Rearing**	2,857	2,857	2,857	0%	0%
			Spawning	3,821	3,821	3,821	0%	0%
		Sep	**Rearing**	7,215	7,215	6,663	0%	-8%
			Spawning	22,927	22,927	23,842	0%	4%
		Oct	**Rearing**	7,445	7,445	7,877	0%	6%
			Spawning	38,709	38,709	37,945	0%	-2%
		Nov	**Rearing**	3,801	4,094	4,094	8%	8%
			Spawning	34,457	36,754	36,754	7%	7%
		Dec	**Rearing**	3,028	3,028	3,028	0%	0%
			Spawning	16,173	16,173	16,173	0%	0%

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Species	Smallmouth Bass							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
PeEll to Elk Cr	**2013**	**Jan**	**Rearing**	438	438	438	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	493	394	394	-20%	-20%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	804	625	625	-22%	-22%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	939	891	891	-5%	-5%
			Spawning	573	0	0	-100%	-100%
		May	**Rearing**	683	673	673	-2%	-2%
			Spawning	981	657	657	-33%	-33%
		Jun	**Rearing**	634	651	651	3%	3%
			Spawning	1,352	1,352	1,352	0%	0%
		Jul	**Rearing**	811	768	764	-5%	-6%
			Spawning	0	3,750	3,750	0%	0%
		Aug	**Rearing**	1,262	936	936	-26%	-26%
			Spawning	0	4,468	4,468	0%	0%
		Sep	**Rearing**	797	839	839	5%	5%
			Spawning	920	969	969	5%	5%
		Oct	**Rearing**	772	699	699	-9%	-9%
			Spawning	152	290	290	91%	91%
		Nov	**Rearing**	612	727	727	19%	19%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	350	394	350	13%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	469	417	417	-11%	-11%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	492	438	438	-11%	-11%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	845	711	766	-16%	-9%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	978	936	936	-4%	-4%
			Spawning	404	0	0	-100%	-100%
		May	**Rearing**	839	819	819	-2%	-2%
			Spawning	969	484	484	-50%	-50%
		Jun	**Rearing**	715	660	660	-8%	-8%
			Spawning	3,316	2,523	2,523	-24%	-24%
		Jul	**Rearing**	890	768	764	-14%	-14%
			Spawning	0	3,750	3,750	0%	0%
		Aug	**Rearing**	1,138	931	931	-18%	-18%
			Spawning	0	4,468	4,468	0%	0%
		Sep	**Rearing**	1,303	955	779	-27%	-40%
			Spawning	2,280	4,468	3,750	96%	64%
		Oct	**Rearing**	796	752	699	-6%	-12%
			Spawning	616	442	290	-28%	-53%
		Nov	**Rearing**	766	936	936	22%	22%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	547	657	602	20%	10%
			Spawning	0	0	0	0%	0%
Elk Cr to S Fk	**2013**	**Jan**	**Rearing**	375	375	375	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	420	373	373	-11%	-11%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	713	600	600	-16%	-16%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	825	804	804	-3%	-3%
			Spawning	485	0	0	-100%	-100%
		May	**Rearing**	1,067	1,068	1,068	0%	0%
			Spawning	3,913	3,913	3,913	0%	0%
		Jun	**Rearing**	1,368	1,401	1,401	2%	2%
			Spawning	2,503	5,005	5,005	100%	100%
		Jul	**Rearing**	2,512	2,251	2,251	-10%	-10%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	3,093	2,839	2,839	-8%	-8%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	923	913	916	-1%	-1%
			Spawning	2,604	2,423	2,423	-7%	-7%
		Oct	**Rearing**	877	921	921	5%	5%
			Spawning	400	500	500	25%	25%
		Nov	**Rearing**	619	667	667	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	404	398	398	-1%	-1%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	415	415	369	0%	-11%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	2,239	1,990	1,990	-11%	-11%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	3,842	3,482	3,482	-9%	-9%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	826	805	805	-3%	-3%
			Spawning	384	0	0	-100%	-100%
		May	**Rearing**	899	891	895	-1%	0%
			Spawning	2,098	1,752	2,098	-17%	0%
		Jun	**Rearing**	1,908	1,963	1,954	3%	2%
			Spawning	2,830	5,659	5,659	100%	100%
		Jul	**Rearing**	2,428	2,251	2,251	-7%	-7%

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Species	Smallmouth Bass							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
		Jul	**Spawning**	0	0	0	0%	0%
		Aug	**Rearing**	2,939	2,839	2,787	-3%	-5%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	3,296	2,950	2,958	-10%	-10%
			Spawning	4,878	5,842	5,842	20%	20%
		Oct	**Rearing**	910	960	984	6%	8%
			Spawning	1,302	1,636	1,180	26%	-9%
		Nov	**Rearing**	600	714	714	19%	19%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	435	483	483	11%	11%
			Spawning	0	0	0	0%	0%
S Fk to Newaukum	**2013**	**Jan**	**Rearing**	908	908	908	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	1,009	808	808	-20%	-20%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	1,695	1,413	1,413	-17%	-17%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	1,836	1,804	1,804	-2%	-2%
			Spawning	344	170	170	-51%	-51%
		May	**Rearing**	868	878	878	1%	1%
			Spawning	1,460	1,460	1,460	0%	0%
		Jun	**Rearing**	880	960	960	9%	9%
			Spawning	0	0	0	0%	0%
		Jul	**Rearing**	2,070	2,219	2,219	7%	7%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	3,184	2,772	2,772	-13%	-13%
			Spawning	0	0	0	0%	0%
		Oct	**Rearing**	1,231	1,231	1,076	0%	-13%
			Spawning	128	128	142	0%	11%
		Nov	**Rearing**	907	977	977	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	488	488	488	0%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	908	808	808	-11%	-11%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	1,085	1,085	965	0%	-11%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	2,025	1,862	1,862	-8%	-8%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	1,960	1,804	1,804	-8%	-8%
			Spawning	220	170	170	-23%	-23%
		May	**Rearing**	1,120	1,126	1,126	1%	0%
			Spawning	862	862	862	0%	0%
		Jun	**Rearing**	1,508	1,616	1,616	7%	7%
			Spawning	0	0	0	0%	0%
		Jul	**Rearing**	2,144	2,219	2,219	3%	3%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	3,654	3,295	3,295	-10%	-10%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	4,780	4,103	3,466	-14%	-27%
			Spawning	3,258	6,095	5,734	87%	76%
		Oct	**Rearing**	874	867	871	-1%	0%
			Spawning	765	978	1,040	28%	36%
		Nov	**Rearing**	1,312	1,413	1,413	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	965	1,085	1,085	13%	13%
			Spawning	0	0	0	0%	0%
Newaukum to Skookumchuck	**2013**	**Jan**	**Rearing**	4,083	4,083	4,083	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	4,297	4,297	4,297	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	7,168	7,168	7,168	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	8,400	8,400	8,400	0%	0%
			Spawning	1,117	1,117	1,117	0%	0%
		May	**Rearing**	13,417	13,450	13,450	0%	0%
			Spawning	6,917	6,917	6,917	0%	0%
		Jun	**Rearing**	13,742	13,844	13,844	1%	1%
			Spawning	0	4,590	4,590	0%	0%
		Jul	**Rearing**	12,910	12,910	12,910	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	15,057	14,737	14,737	-2%	-2%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	13,187	13,187	13,187	0%	0%
			Spawning	6,917	6,917	6,917	0%	0%
		Oct	**Rearing**	9,399	9,760	9,760	4%	4%
			Spawning	719	740	740	3%	3%
		Nov	**Rearing**	6,924	7,456	7,456	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	4,619	4,619	4,619	0%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	4,372	4,372	4,372	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	4,047	4,047	4,047	0%	0%
			Spawning	0	0	0	0%	0%

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Species	Smallmouth Bass							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2014	Mar	Rearing	6,945	6,945	6,945	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	Rearing	8,293	8,293	8,293	0%	0%
			Spawning	1,050	1,050	1,050	0%	0%
		May	Rearing	10,212	10,214	10,214	0%	0%
			Spawning	4,486	4,486	4,486	0%	0%
		Jun	Rearing	14,205	14,310	14,310	1%	1%
			Spawning	0	5,185	5,185	0%	0%
		Jul	Rearing	12,910	13,373	12,910	4%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	15,057	14,737	14,737	-2%	-2%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	17,987	17,122	17,194	-5%	-4%
			Spawning	10,785	10,560	10,560	-2%	-2%
		Oct	Rearing	13,247	13,727	13,727	4%	4%
			Spawning	4,635	5,369	5,369	16%	16%
		Nov	Rearing	6,315	6,800	6,800	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	3,597	3,597	3,597	0%	0%
			Spawning	0	0	0	0%	0%
Skookumchuck to Black	2013	Jan	Rearing	4,128	4,128	4,128	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	4,775	4,775	4,775	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	7,942	7,794	7,794	-2%	-2%
			Spawning	0	0	0	0%	0%
		Apr	Rearing	8,550	8,478	8,550	-1%	0%
			Spawning	2,267	1,692	2,267	-25%	0%
		May	Rearing	12,117	12,117	12,117	0%	0%
			Spawning	5,525	5,525	5,525	0%	0%
		Jun	Rearing	12,572	12,906	12,906	3%	3%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	11,786	11,786	11,786	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	14,244	13,836	13,836	-3%	-3%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	13,585	13,585	13,585	0%	0%
			Spawning	8,014	8,014	8,014	0%	0%
		Oct	Rearing	8,836	8,836	8,836	0%	0%
			Spawning	1,305	1,305	1,305	0%	0%
		Nov	Rearing	6,428	6,923	6,923	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	4,133	4,133	4,133	0%	0%
			Spawning	0	0	0	0%	0%
	2014	Jan	Rearing	4,297	4,297	4,297	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	4,496	4,047	4,047	-10%	-10%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	7,551	7,551	7,551	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	Rearing	8,550	8,478	8,478	-1%	-1%
			Spawning	2,267	1,692	1,692	-25%	-25%
		May	Rearing	9,495	9,517	9,517	0%	0%
			Spawning	4,224	4,224	4,224	0%	0%
		Jun	Rearing	13,237	13,589	13,589	3%	3%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	11,786	11,786	11,786	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	14,737	13,836	13,373	-6%	-9%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	15,975	15,975	15,975	0%	0%
			Spawning	10,494	10,494	10,494	0%	0%
		Oct	Rearing	13,321	13,804	13,804	4%	4%
			Spawning	5,776	6,692	6,692	16%	16%
		Nov	Rearing	6,428	6,923	6,923	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	Rearing	3,629	3,629	3,629	0%	0%
			Spawning	0	0	0	0%	0%
Black to Porter	2013	Jan	Rearing	2,690	2,690	2,690	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	Rearing	2,492	2,492	2,492	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	Rearing	4,658	4,658	4,658	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	Rearing	4,978	4,951	4,951	-1%	-1%
			Spawning	2,373	1,904	1,904	-20%	-20%
		May	Rearing	8,813	8,850	8,850	0%	0%
			Spawning	15,658	15,658	15,658	0%	0%
		Jun	Rearing	11,947	12,250	12,250	3%	3%
			Spawning	0	0	0	0%	0%
		Jul	Rearing	14,555	14,555	14,555	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	17,035	16,045	16,045	-6%	-6%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	13,134	13,134	13,134	0%	0%

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Species	Smallmouth Bass							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
	2013	**Sep**	**Spawning**	10,592	10,592	10,592	0%	0%
		Oct	**Rearing**	4,428	4,428	4,428	0%	0%
			Spawning	1,896	1,896	1,896	0%	0%
		Nov	**Rearing**	3,221	3,469	3,469	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	2,021	2,021	2,021	0%	0%
			Spawning	0	0	0	0%	0%
	2014	**Jan**	**Rearing**	2,242	2,242	2,242	0%	0%
			Spawning	0	0	0	0%	0%
		Feb	**Rearing**	3,251	3,251	3,251	0%	0%
			Spawning	0	0	0	0%	0%
		Mar	**Rearing**	5,564	5,564	5,564	0%	0%
			Spawning	0	0	0	0%	0%
		Apr	**Rearing**	4,557	4,532	4,532	-1%	-1%
			Spawning	2,851	2,288	2,288	-20%	-20%
		May	**Rearing**	4,623	4,644	4,644	0%	0%
			Spawning	6,128	6,128	6,128	0%	0%
		Jun	**Rearing**	15,026	15,026	15,026	0%	0%
			Spawning	0	0	0	0%	0%
		Jul	**Rearing**	16,045	15,059	15,059	-6%	-6%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	17,647	17,647	17,647	0%	0%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	22,285	22,285	20,989	0%	-6%
			Spawning	14,552	14,552	14,075	0%	-3%
		Oct	**Rearing**	13,451	13,451	14,396	0%	7%
			Spawning	17,688	17,688	18,466	0%	4%
		Nov	**Rearing**	3,179	3,423	3,423	8%	8%
			Spawning	0	0	0	0%	0%
		Dec	**Rearing**	2,601	2,601	2,601	0%	0%
			Spawning	0	0	0	0%	0%

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Species	Speckled Dace							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
PeEll to Elk Cr	2013	Jan	Rearing	3,800	3,800	3,800	0%	0%
		Feb	Rearing	4,301	3,970	3,805	-8%	-12%
		Mar	Rearing	4,843	4,531	4,531	-6%	-6%
		Apr	Rearing	4,695	4,810	4,810	2%	2%
		May	Rearing	5,727	6,698	6,698	17%	17%
		Jun	Rearing	5,565	7,089	7,089	27%	27%
		Jul	Rearing	5,806	8,290	8,003	43%	38%
		Aug	Rearing	5,786	8,512	8,512	47%	47%
		Sep	Rearing	3,844	4,271	4,419	11%	15%
		Oct	Rearing	5,275	5,977	5,977	13%	13%
		Nov	Rearing	4,874	5,030	5,030	3%	3%
		Dec	Rearing	4,304	4,484	4,304	4%	0%
	2014	Jan	Rearing	4,046	3,884	3,884	-4%	-4%
		Feb	Rearing	3,958	3,800	3,800	-4%	-4%
		Mar	Rearing	4,738	4,591	4,750	-3%	0%
		Apr	Rearing	4,629	4,706	4,706	2%	2%
		May	Rearing	4,271	5,032	5,032	18%	18%
		Jun	Rearing	7,938	8,896	8,896	12%	12%
		Jul	Rearing	3,950	8,290	8,003	110%	103%
		Aug	Rearing	2,899	8,227	8,227	184%	184%
		Sep	Rearing	7,970	10,129	9,853	27%	24%
		Oct	Rearing	5,165	5,457	5,977	6%	16%
		Nov	Rearing	4,750	4,706	4,706	-1%	-1%
		Dec	Rearing	4,116	4,433	4,275	8%	4%
Elk Cr to S Fk	2013	Jan	Rearing	2,636	2,636	2,636	0%	0%
		Feb	Rearing	3,920	3,763	3,763	-4%	-4%
		Mar	Rearing	4,398	4,262	4,262	-3%	-3%
		Apr	Rearing	4,297	4,350	4,350	1%	1%
		May	Rearing	7,830	8,995	8,995	15%	15%
		Jun	Rearing	8,449	9,705	9,705	15%	15%
		Jul	Rearing	8,875	9,992	9,992	13%	13%
		Aug	Rearing	12,166	11,734	11,734	-4%	-4%
		Sep	Rearing	4,869	4,740	4,904	-3%	1%
		Oct	Rearing	6,068	7,472	7,472	23%	23%
		Nov	Rearing	4,907	5,076	5,076	3%	3%
		Dec	Rearing	5,050	4,951	4,745	-2%	-6%
	2014	Jan	Rearing	3,674	3,674	3,527	0%	-4%
		Feb	Rearing	2,422	2,326	2,326	-4%	-4%
		Mar	Rearing	2,900	2,907	2,907	0%	0%
		Apr	Rearing	3,794	3,840	3,840	1%	1%
		May	Rearing	4,568	5,293	5,247	16%	15%
		Jun	Rearing	10,136	12,061	11,644	19%	15%
		Jul	Rearing	7,625	9,992	9,992	31%	31%
		Aug	Rearing	11,351	11,734	11,327	3%	0%
		Sep	Rearing	14,978	14,946	15,483	0%	3%
		Oct	Rearing	6,370	7,993	8,790	25%	38%
		Nov	Rearing	4,262	4,107	4,107	-4%	-4%
		Dec	Rearing	2,582	2,685	2,685	4%	4%
S Fk to Newaukum	2013	Jan	Rearing	2,353	2,353	2,353	0%	0%
		Feb	Rearing	2,746	2,535	2,535	-8%	-8%
		Mar	Rearing	3,153	3,169	3,169	0%	0%
		Apr	Rearing	3,042	3,088	3,088	2%	2%
		May	Rearing	3,585	3,975	3,975	11%	11%
		Jun	Rearing	3,520	4,043	4,043	15%	15%
		Jul	Rearing	2,331	2,793	2,793	20%	20%
		Aug	Rearing	3,746	4,534	4,534	21%	21%
		Oct	Rearing	3,701	3,701	3,874	0%	5%
		Nov	Rearing	3,649	3,774	3,774	3%	3%
		Dec	Rearing	3,029	3,029	3,029	0%	0%
	2014	Jan	Rearing	2,640	2,535	2,535	-4%	-4%
		Feb	Rearing	2,296	2,296	2,204	0%	-4%
		Mar	Rearing	2,742	2,748	2,748	0%	0%
		Apr	Rearing	2,952	3,088	3,088	5%	5%
		May	Rearing	3,026	3,476	3,355	15%	11%
		Jun	Rearing	4,878	5,410	5,410	11%	11%
		Jul	Rearing	2,557	2,793	2,793	9%	9%
		Aug	Rearing	3,813	5,038	5,038	32%	32%
		Sep	Rearing	11,353	11,355	10,573	0%	-7%
		Oct	Rearing	4,224	4,816	5,042	14%	19%
		Nov	Rearing	3,063	3,169	3,169	3%	3%
		Dec	Rearing	2,204	2,296	2,296	4%	4%
Newaukum to Skookumchuck	2013	Jan	Rearing	2,466	2,466	2,466	0%	0%
		Feb	Rearing	2,560	2,560	2,560	0%	0%
		Mar	Rearing	2,983	2,983	2,983	0%	0%
		Apr	Rearing	2,940	2,940	2,940	0%	0%
		May	Rearing	4,941	5,119	5,119	4%	4%
		Jun	Rearing	4,425	4,578	4,578	3%	3%
		Jul	Rearing	2,638	2,638	2,638	0%	0%
		Aug	Rearing	3,146	3,881	3,881	23%	23%
		Sep	Rearing	4,302	4,302	4,302	0%	0%
		Oct	Rearing	3,744	3,916	3,916	5%	5%
		Nov	Rearing	3,691	3,818	3,818	3%	3%
		Dec	Rearing	3,216	3,216	3,216	0%	0%
	2014	Jan	Rearing	2,644	2,644	2,644	0%	0%

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Species	Speckled Dace							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
	2014	**Feb**	**Rearing**	2,450	2,450	2,450	0%	0%
		Mar	**Rearing**	2,932	2,932	2,932	0%	0%
		Apr	**Rearing**	2,915	2,915	2,915	0%	0%
		May	**Rearing**	3,278	3,392	3,392	3%	3%
		Jun	**Rearing**	4,756	4,921	4,921	3%	3%
		Jul	**Rearing**	2,638	3,363	2,638	27%	0%
		Aug	**Rearing**	3,146	3,881	3,881	23%	23%
		Sep	**Rearing**	5,369	5,895	6,099	10%	14%
		Oct	**Rearing**	5,987	6,434	6,434	7%	7%
		Nov	**Rearing**	3,067	3,173	3,173	3%	3%
		Dec	**Rearing**	2,352	2,352	2,352	0%	0%
Skookumchuck to Black	**2013**	**Jan**	**Rearing**	2,476	2,476	2,476	0%	0%
		Feb	**Rearing**	2,662	2,662	2,662	0%	0%
		Mar	**Rearing**	2,963	2,976	2,976	0%	0%
		Apr	**Rearing**	2,896	2,917	2,896	1%	0%
		May	**Rearing**	3,874	3,874	3,874	0%	0%
		Jun	**Rearing**	3,755	3,890	3,890	4%	4%
		Jul	**Rearing**	1,947	1,947	1,947	0%	0%
		Aug	**Rearing**	3,335	3,914	3,914	17%	17%
		Sep	**Rearing**	4,468	4,468	4,468	0%	0%
		Oct	**Rearing**	3,232	3,232	3,232	0%	0%
		Nov	**Rearing**	3,205	3,315	3,315	3%	3%
		Dec	**Rearing**	2,780	2,780	2,780	0%	0%
	2014	**Jan**	**Rearing**	2,560	2,560	2,560	0%	0%
		Feb	**Rearing**	2,548	2,450	2,450	-4%	-4%
		Mar	**Rearing**	2,925	2,925	2,925	0%	0%
		Apr	**Rearing**	2,896	2,917	2,917	1%	1%
		May	**Rearing**	2,776	2,873	2,873	3%	3%
		Jun	**Rearing**	4,177	4,327	4,327	4%	4%
		Jul	**Rearing**	1,947	1,947	1,947	0%	0%
		Aug	**Rearing**	3,881	3,914	3,363	1%	-13%
		Sep	**Rearing**	5,739	5,739	5,739	0%	0%
		Oct	**Rearing**	5,931	6,375	6,375	7%	7%
		Nov	**Rearing**	3,205	3,315	3,315	3%	3%
		Dec	**Rearing**	2,367	2,367	2,367	0%	0%
Black to Porter	**2013**	**Jan**	**Rearing**	4,426	4,426	4,426	0%	0%
		Feb	**Rearing**	4,732	4,732	4,732	0%	0%
		Mar	**Rearing**	5,180	5,180	5,180	0%	0%
		Apr	**Rearing**	4,972	5,019	5,019	1%	1%
		May	**Rearing**	6,504	6,730	6,730	3%	3%
		Jun	**Rearing**	6,288	6,506	6,506	3%	3%
		Jul	**Rearing**	2,948	2,948	2,948	0%	0%
		Aug	**Rearing**	3,595	3,404	3,404	-5%	-5%
		Sep	**Rearing**	7,473	7,473	7,473	0%	0%
		Oct	**Rearing**	5,764	5,764	5,764	0%	0%
		Nov	**Rearing**	5,717	5,914	5,914	3%	3%
		Dec	**Rearing**	4,643	4,643	4,643	0%	0%
	2014	**Jan**	**Rearing**	4,550	4,550	4,550	0%	0%
		Feb	**Rearing**	4,695	4,695	4,695	0%	0%
		Mar	**Rearing**	5,367	5,367	5,367	0%	0%
		Apr	**Rearing**	5,193	5,241	5,241	1%	1%
		May	**Rearing**	4,477	4,638	4,638	4%	4%
		Jun	**Rearing**	7,275	7,275	7,275	0%	0%
		Jul	**Rearing**	3,404	3,220	3,220	-5%	-5%
		Aug	**Rearing**	3,920	3,920	3,920	0%	0%
		Sep	**Rearing**	10,702	10,702	10,135	0%	-5%
		Oct	**Rearing**	11,044	11,044	11,461	0%	4%
		Nov	**Rearing**	5,590	5,782	5,782	3%	3%
		Dec	**Rearing**	4,333	4,333	4,333	0%	0%

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Species	Steelhead							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
Upper Chehalis	**2013**	**Jan**	**Rearing**	2,251	2,251	2,251	0%	0%
			Spawning	10,272	10,272	10,272	0%	0%
		Feb	**Rearing**	2,729	2,012	2,012	-26%	-26%
			Spawning	11,720	9,526	9,526	-19%	-19%
		Mar	**Rearing**	4,456	2,729	2,729	-39%	-39%
			Spawning	13,169	11,720	11,720	-11%	-11%
		Apr	**Rearing**	4,757	4,456	4,456	-6%	-6%
			Spawning	10,667	13,169	13,169	23%	23%
		May	**Rearing**	4,189	5,560	5,560	33%	33%
			Spawning	10,512	16,997	16,997	62%	62%
		Jun	**Rearing**	2,261	5,774	5,774	155%	155%
			Spawning	5,582	14,513	14,513	160%	160%
		Jul	**Rearing**	928	5,195	4,362	460%	370%
			Spawning	762	9,857	8,449	1194%	1009%
		Aug	**Rearing**	842	4,122	3,869	389%	359%
			Spawning	646	6,670	6,114	933%	847%
		Sep	**Rearing**	3,330	4,657	4,657	40%	40%
			Spawning	6,585	9,548	9,548	45%	45%
		Oct	**Rearing**	4,759	5,064	5,133	6%	8%
			Spawning	11,951	14,738	15,006	23%	26%
		Nov	**Rearing**	4,093	4,281	4,281	5%	5%
			Spawning	13,169	13,169	13,169	0%	0%
		Dec	**Rearing**	2,251	2,490	2,490	11%	11%
			Spawning	10,272	10,996	10,996	7%	7%
	2014	**Jan**	**Rearing**	2,490	2,251	2,251	-10%	-10%
			Spawning	10,996	10,272	10,272	-7%	-7%
		Feb	**Rearing**	2,729	2,251	2,251	-18%	-18%
			Spawning	11,720	10,272	10,272	-12%	-12%
		Mar	**Rearing**	4,281	3,752	3,752	-12%	-12%
			Spawning	13,169	13,169	13,169	0%	0%
		Apr	**Rearing**	4,761	4,281	4,281	-10%	-10%
			Spawning	11,095	13,169	13,169	19%	19%
		May	**Rearing**	3,779	4,751	4,751	26%	26%
			Spawning	7,901	12,379	12,379	57%	57%
		Jun	**Rearing**	3,404	5,661	5,656	66%	66%
			Spawning	5,635	13,597	13,073	141%	132%
		Jul	**Rearing**	768	5,064	4,644	559%	505%
			Spawning	381	8,765	8,139	2201%	2037%
		Aug	**Rearing**	589	3,869	3,869	556%	556%
			Spawning	215	6,114	6,114	2741%	2741%
		Sep	**Rearing**	1,879	5,079	5,537	170%	195%
			Spawning	1,722	8,059	11,701	368%	580%
		Oct	**Rearing**	4,757	4,944	5,141	4%	8%
			Spawning	10,667	13,479	14,469	26%	36%
		Nov	**Rearing**	4,093	4,608	4,608	13%	13%
			Spawning	13,169	12,774	12,774	-3%	-3%
		Dec	**Rearing**	3,070	3,752	3,411	22%	11%
			Spawning	12,445	13,169	13,169	6%	6%
PeEll to Elk Cr	**2013**	**Jan**	**Rearing**	1,929	1,929	1,929	0%	0%
			Spawning	2,590	2,590	2,590	0%	0%
		Feb	**Rearing**	2,651	2,187	1,955	-18%	-26%
			Spawning	3,839	3,365	3,120	-12%	-19%
		Mar	**Rearing**	3,890	3,100	3,100	-20%	-20%
			Spawning	3,739	3,739	3,739	0%	0%
		Apr	**Rearing**	4,326	4,188	4,188	-3%	-3%
			Spawning	3,150	3,627	3,627	15%	15%
		May	**Rearing**	7,711	9,704	9,704	26%	26%
			Spawning	11,245	15,180	15,180	35%	35%
		Jun	**Rearing**	4,325	9,515	9,515	120%	120%
			Spawning	6,076	13,164	13,164	117%	117%
		Jul	**Rearing**	1,082	5,856	4,900	441%	353%
			Spawning	0	5,693	4,982	0%	0%
		Aug	**Rearing**	709	4,126	4,126	482%	482%
			Spawning	0	3,554	3,554	0%	0%
		Sep	**Rearing**	3,666	4,504	4,919	23%	34%
			Spawning	3,828	4,514	4,891	18%	28%
		Oct	**Rearing**	6,362	8,364	8,364	31%	31%
			Spawning	8,686	13,457	13,457	55%	55%
		Nov	**Rearing**	3,962	4,520	4,520	14%	14%
			Spawning	5,381	5,381	5,381	0%	0%
		Dec	**Rearing**	3,010	3,329	3,010	11%	0%
			Spawning	7,465	7,992	7,465	7%	0%
	2014	**Jan**	**Rearing**	2,263	2,046	2,046	-10%	-10%
			Spawning	3,122	2,916	2,916	-7%	-7%
		Feb	**Rearing**	2,134	1,929	1,929	-10%	-10%
			Spawning	2,773	2,590	2,590	-7%	-7%
		Mar	**Rearing**	3,668	3,215	3,508	-12%	-4%
			Spawning	3,321	3,321	3,321	0%	0%
		Apr	**Rearing**	4,084	3,949	3,949	-3%	-3%
			Spawning	2,906	3,221	3,221	11%	11%

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Species	Steelhead							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
		May	Rearing	4,504	5,674	5,674	26%	26%
			Spawning	4,514	6,339	6,339	40%	40%
		Jun	Rearing	6,166	10,629	10,629	72%	72%
			Spawning	6,108	12,573	12,573	106%	106%
		Jul	Rearing	588	5,856	4,900	896%	733%
			Spawning	0	5,693	4,982	0%	0%
		Aug	Rearing	284	3,375	3,375	1087%	1087%
			Spawning	0	3,046	3,046	0%	0%
		Sep	Rearing	2,157	6,798	8,816	215%	309%
			Spawning	1,614	6,092	9,251	277%	473%
		Oct	Rearing	6,359	7,220	8,364	14%	32%
			Spawning	7,753	10,306	13,457	33%	74%
		Nov	Rearing	3,508	3,949	3,949	13%	13%
			Spawning	3,321	3,221	3,221	-3%	-3%
		Dec	Rearing	2,338	2,923	2,631	25%	13%
			Spawning	2,956	3,321	3,138	12%	6%
Elk Cr to S Fk	2013	Jan	Rearing	2,358	2,358	2,358	0%	0%
			Spawning	863	863	863	0%	0%
		Feb	Rearing	4,076	3,685	3,685	-10%	-10%
			Spawning	2,816	2,631	2,631	-7%	-7%
		Mar	Rearing	6,459	5,662	5,662	-12%	-12%
			Spawning	2,826	2,826	2,826	0%	0%
		Apr	Rearing	7,191	7,169	7,169	0%	0%
			Spawning	2,473	2,656	2,656	7%	7%
		May	Rearing	9,335	12,255	12,255	31%	31%
			Spawning	7,749	10,215	10,215	32%	32%
		Jun	Rearing	4,476	8,226	8,226	84%	84%
			Spawning	3,728	6,711	6,711	80%	80%
		Jul	Rearing	1,141	2,339	2,339	105%	105%
			Spawning	0	1,235	1,235	0%	0%
		Aug	Rearing	1,226	2,716	2,716	122%	122%
			Spawning	487	2,006	2,006	312%	312%
		Sep	Rearing	6,712	7,090	7,551	6%	13%
			Spawning	3,505	3,392	3,731	-3%	6%
		Oct	Rearing	10,130	11,343	11,343	12%	12%
			Spawning	6,156	9,505	9,505	54%	54%
		Nov	Rearing	6,700	7,309	7,309	9%	9%
			Spawning	4,250	4,250	4,250	0%	0%
		Dec	Rearing	4,464	4,793	4,284	7%	-4%
			Spawning	5,633	5,292	4,907	-6%	-13%
	2014	Jan	Rearing	3,757	3,757	3,397	0%	-10%
			Spawning	2,360	2,360	2,204	0%	-7%
		Feb	Rearing	2,294	2,074	2,074	-10%	-10%
			Spawning	569	531	531	-7%	-7%
		Mar	Rearing	3,944	3,771	3,771	-4%	-4%
			Spawning	681	681	681	0%	0%
		Apr	Rearing	6,217	6,198	6,198	0%	0%
			Spawning	1,858	1,996	1,996	7%	7%
		May	Rearing	7,376	9,351	9,414	27%	28%
			Spawning	3,229	4,198	4,037	30%	25%
		Jun	Rearing	4,118	8,330	7,568	102%	84%
			Spawning	3,446	6,891	6,202	100%	80%
		Jul	Rearing	981	2,339	2,339	139%	139%
			Spawning	0	1,235	1,235	0%	0%
		Aug	Rearing	817	2,716	2,331	232%	185%
			Spawning	0	2,006	1,505	0%	0%
		Sep	Rearing	3,235	6,728	7,168	108%	122%
			Spawning	1,947	5,518	6,019	183%	209%
		Oct	Rearing	10,560	11,742	12,164	11%	15%
			Spawning	6,561	9,851	11,372	50%	73%
		Nov	Rearing	5,662	5,984	5,984	6%	6%
			Spawning	2,826	2,403	2,403	-15%	-15%
		Dec	Rearing	2,430	2,663	2,663	10%	10%
			Spawning	653	696	696	7%	7%
S Fk to Newaukum	2013	Jan	Rearing	2,109	2,109	2,109	0%	0%
			Spawning	557	557	557	0%	0%
		Feb	Rearing	3,028	2,498	2,498	-18%	-18%
			Spawning	929	814	814	-12%	-12%
		Mar	Rearing	4,945	4,543	4,543	-8%	-8%
			Spawning	1,044	1,044	1,044	0%	0%
		Apr	Rearing	5,279	5,289	5,289	0%	0%
			Spawning	846	914	914	8%	8%
		May	Rearing	6,376	8,249	8,249	29%	29%
			Spawning	1,830	2,517	2,517	38%	38%
		Jun	Rearing	1,858	3,842	3,842	107%	107%
			Spawning	0	1,229	1,229	0%	0%
		Jul	Rearing	232	414	414	79%	79%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	451	802	802	78%	78%
			Spawning	0	0	0	0%	0%

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Species	Steelhead							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
	2013	Oct	Rearing	7,157	7,157	7,842	0%	10%
			Spawning	1,806	1,806	2,407	0%	33%
		Nov	Rearing	5,644	6,157	6,157	9%	9%
			Spawning	1,990	1,990	1,990	0%	0%
		Dec	Rearing	3,316	3,316	3,316	0%	0%
			Spawning	1,918	1,918	1,918	0%	0%
	2014	Jan	Rearing	2,763	2,498	2,498	-10%	-10%
			Spawning	872	814	814	-7%	-7%
		Feb	Rearing	2,158	2,158	1,951	0%	-10%
			Spawning	344	344	321	0%	-7%
		Mar	Rearing	3,862	3,710	3,710	-4%	-4%
			Spawning	412	412	412	0%	0%
		Apr	Rearing	4,810	5,289	5,289	10%	10%
			Spawning	761	914	914	20%	20%
		May	Rearing	5,488	7,417	6,802	35%	24%
			Spawning	1,326	1,856	1,724	40%	30%
		Jun	Rearing	1,948	3,457	3,457	77%	77%
			Spawning	0	1,044	1,044	0%	0%
		Jul	Rearing	267	414	414	55%	55%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	270	700	700	159%	159%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	2,547	5,124	6,481	101%	154%
			Spawning	1,001	2,151	2,667	115%	166%
		Oct	Rearing	9,720	11,062	11,415	14%	17%
			Spawning	3,003	3,707	3,973	23%	32%
		Nov	Rearing	4,164	4,543	4,543	9%	9%
			Spawning	1,044	1,044	1,044	0%	0%
		Dec	Rearing	1,951	2,158	2,158	11%	11%
			Spawning	321	344	344	7%	7%
Newaukum to Skookumchuck	2013	Jan	Rearing	2,730	2,730	2,730	0%	0%
			Spawning	403	403	403	0%	0%
		Feb	Rearing	2,746	2,746	2,746	0%	0%
			Spawning	630	630	630	0%	0%
		Mar	Rearing	4,731	4,731	4,731	0%	0%
			Spawning	535	535	535	0%	0%
		Apr	Rearing	5,270	5,270	5,270	0%	0%
			Spawning	551	551	551	0%	0%
		May	Rearing	3,397	3,619	3,619	7%	7%
			Spawning	963	1,050	1,050	9%	9%
		Jun	Rearing	1,296	1,490	1,490	15%	15%
			Spawning	337	421	421	25%	25%
		Jul	Rearing	229	229	229	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	254	333	333	31%	31%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	2,197	2,197	2,197	0%	0%
			Spawning	613	613	613	0%	0%
		Oct	Rearing	4,995	4,944	4,944	-1%	-1%
			Spawning	1,252	1,308	1,308	4%	4%
		Nov	Rearing	3,939	4,297	4,297	9%	9%
			Spawning	1,380	1,380	1,380	0%	0%
		Dec	Rearing	2,067	2,067	2,067	0%	0%
			Spawning	1,092	1,092	1,092	0%	0%
	2014	Jan	Rearing	2,732	2,732	2,732	0%	0%
			Spawning	767	767	767	0%	0%
		Feb	Rearing	2,712	2,712	2,712	0%	0%
			Spawning	372	372	372	0%	0%
		Mar	Rearing	4,662	4,662	4,662	0%	0%
			Spawning	446	446	446	0%	0%
		Apr	Rearing	5,267	5,267	5,267	0%	0%
			Spawning	468	468	468	0%	0%
		May	Rearing	3,927	4,289	4,289	9%	9%
			Spawning	865	937	937	8%	8%
		Jun	Rearing	1,164	1,338	1,338	15%	15%
			Spawning	305	381	381	25%	25%
		Jul	Rearing	229	316	229	38%	0%
			Spawning	0	0	0	0%	0%
		Aug	Rearing	254	333	333	31%	31%
			Spawning	0	0	0	0%	0%
		Sep	Rearing	1,128	1,517	1,674	34%	48%
			Spawning	210	276	311	31%	48%
		Oct	Rearing	4,555	4,451	4,451	-2%	-2%
			Spawning	1,418	1,387	1,387	-2%	-2%
		Nov	Rearing	4,117	4,491	4,491	9%	9%
			Spawning	919	919	919	0%	0%
		Dec	Rearing	2,452	2,452	2,452	0%	0%
			Spawning	348	348	348	0%	0%
Skookumchuck to Black	2013	Jan	Rearing	5,699	5,699	5,699	0%	0%
			Spawning	4,303	4,303	4,303	0%	0%

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Species	Steelhead							
Reach	Year	Month	Lifestage	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
Skookumchuck to Black	**2013**	**Feb**	**Rearing**	8,221	8,221	8,221	0%	0%
			Spawning	7,539	7,539	7,539	0%	0%
		Mar	**Rearing**	11,457	11,077	11,077	-3%	-3%
			Spawning	5,729	5,906	5,906	3%	3%
		Apr	**Rearing**	12,911	12,923	12,911	0%	0%
			Spawning	5,489	5,710	5,489	4%	0%
		May	**Rearing**	18,401	18,401	18,401	0%	0%
			Spawning	8,676	8,676	8,676	0%	0%
		Jun	**Rearing**	5,725	6,919	6,919	21%	21%
			Spawning	1,143	2,286	2,286	100%	100%
		Jul	**Rearing**	1,382	1,382	1,382	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	2,625	3,278	3,278	25%	25%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	12,489	12,489	12,489	0%	0%
			Spawning	6,857	6,857	6,857	0%	0%
		Oct	**Rearing**	18,193	18,193	18,193	0%	0%
			Spawning	11,677	11,677	11,677	0%	0%
		Nov	**Rearing**	14,325	15,627	15,627	9%	9%
			Spawning	13,345	13,345	13,345	0%	0%
		Dec	**Rearing**	8,796	8,796	8,796	0%	0%
			Spawning	11,100	11,100	11,100	0%	0%
	2014	**Jan**	**Rearing**	7,502	7,502	7,502	0%	0%
			Spawning	7,073	7,073	7,073	0%	0%
		Feb	**Rearing**	4,964	4,530	4,530	-9%	-9%
			Spawning	4,711	4,420	4,420	-6%	-6%
		Mar	**Rearing**	8,105	8,105	8,105	0%	0%
			Spawning	5,293	5,293	5,293	0%	0%
		Apr	**Rearing**	12,911	12,923	12,923	0%	0%
			Spawning	5,489	5,710	5,710	4%	4%
		May	**Rearing**	14,557	15,504	15,504	7%	7%
			Spawning	7,673	8,440	8,440	10%	10%
		Jun	**Rearing**	5,623	6,795	6,795	21%	21%
			Spawning	1,263	2,527	2,527	100%	100%
		Jul	**Rearing**	1,382	1,382	1,382	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	3,056	3,278	2,816	7%	-8%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	12,495	12,495	12,495	0%	0%
			Spawning	9,649	9,649	9,649	0%	0%
		Oct	**Rearing**	31,358	31,897	31,897	2%	2%
			Spawning	16,888	17,828	17,828	6%	6%
		Nov	**Rearing**	14,325	15,627	15,627	9%	9%
			Spawning	13,345	13,345	13,345	0%	0%
		Dec	**Rearing**	4,752	4,752	4,752	0%	0%
			Spawning	3,878	3,878	3,878	0%	0%
Black to Porter	**2013**	**Jan**	**Rearing**	3,287	3,287	3,287	0%	0%
			Spawning	1,257	1,257	1,257	0%	0%
		Feb	**Rearing**	3,590	3,590	3,590	0%	0%
			Spawning	1,490	1,490	1,490	0%	0%
		Mar	**Rearing**	6,026	6,026	6,026	0%	0%
			Spawning	11,174	11,174	11,174	0%	0%
		Apr	**Rearing**	6,266	6,220	6,220	-1%	-1%
			Spawning	8,986	9,331	9,331	4%	4%
		May	**Rearing**	4,977	5,492	5,492	10%	10%
			Spawning	3,413	3,839	3,839	13%	13%
		Jun	**Rearing**	1,479	1,836	1,836	24%	24%
			Spawning	0	543	543	0%	0%
		Jul	**Rearing**	291	291	291	0%	0%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	430	445	445	3%	3%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	3,516	3,516	3,516	0%	0%
			Spawning	2,716	2,716	2,716	0%	0%
		Oct	**Rearing**	6,616	6,616	6,616	0%	0%
			Spawning	3,497	3,497	3,497	0%	0%
		Nov	**Rearing**	5,209	5,683	5,683	9%	9%
			Spawning	3,996	3,996	3,996	0%	0%
		Dec	**Rearing**	2,857	2,857	2,857	0%	0%
			Spawning	3,865	3,865	3,865	0%	0%
	2014	**Jan**	**Rearing**	3,276	3,276	3,276	0%	0%
			Spawning	1,398	1,398	1,398	0%	0%
		Feb	**Rearing**	3,662	3,662	3,662	0%	0%
			Spawning	1,297	1,297	1,297	0%	0%
		Mar	**Rearing**	6,184	6,184	6,184	0%	0%
			Spawning	1,413	1,413	1,413	0%	0%
		Apr	**Rearing**	6,303	6,258	6,258	-1%	-1%
			Spawning	1,306	1,356	1,356	4%	4%
		May	**Rearing**	4,295	4,728	4,728	10%	10%
			Spawning	2,404	2,672	2,672	11%	11%

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Values with orange highlights denote a decrease in WUA compared to Current Conditions.

Species	Steelhead							
Reach	**Year**	**Month**	**Lifestage**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
		Jun	**Rearing**	2,137	2,137	2,137	0%	0%
			Spawning	738	738	738	0%	0%
		Jul	**Rearing**	445	452	452	2%	2%
			Spawning	0	0	0	0%	0%
		Aug	**Rearing**	594	594	594	0%	0%
			Spawning	0	0	0	0%	0%
		Sep	**Rearing**	4,055	4,055	4,194	0%	3%
			Spawning	4,231	4,231	4,169	0%	-1%
		Oct	**Rearing**	10,231	10,231	10,866	0%	6%
			Spawning	8,472	8,472	9,463	0%	12%
		Nov	**Rearing**	5,079	5,540	5,540	9%	9%
			Spawning	2,753	2,753	2,753	0%	0%
		Dec	**Rearing**	3,021	3,021	3,021	0%	0%
			Spawning	1,136	1,136	1,136	0%	0%

Note: Values with green highlights denote an increase in WUA compared to Current Conditions.
Values with orange highlights denote a decrease in WUA compared to Current Conditions.

Species	Western Toad						
Reach	Year	Month	Current Conditions	FRFA Scenario 1	FRFA Scenario 2	FRFA Scenario 1 Pct Change	FRFA Scenario 2 Pct Change
PeEll to Elk Cr	**2013**	**Jan**	1,159	1,159	1,159	0%	0%
		Feb	1,411	1,210	1,109	-14%	-21%
		Mar	1,802	1,572	1,572	-13%	-13%
		Apr	1,926	1,858	1,858	-4%	-4%
		May	2,037	2,037	2,037	0%	0%
		Jun	2,067	2,147	2,147	4%	4%
		Jul	2,351	2,505	2,486	7%	6%
		Aug	2,919	2,869	2,869	-2%	-2%
		Sep	2,002	2,040	2,045	2%	2%
		Oct	2,005	1,985	1,985	-1%	-1%
		Nov	1,750	1,888	1,888	8%	8%
		Dec	1,245	1,349	1,245	8%	0%
	2014	**Jan**	1,277	1,179	1,179	-8%	-8%
		Feb	1,256	1,159	1,159	-8%	-8%
		Mar	1,772	1,642	1,739	-7%	-2%
		Apr	1,883	1,827	1,827	-3%	-3%
		May	2,040	2,030	2,030	0%	0%
		Jun	2,389	2,298	2,298	-4%	-4%
		Jul	2,240	2,505	2,486	12%	11%
		Aug	2,369	2,848	2,848	20%	20%
		Sep	3,299	2,953	2,564	-10%	-22%
		Oct	2,044	2,011	1,985	-2%	-3%
		Nov	1,739	1,827	1,827	5%	5%
		Dec	1,353	1,546	1,449	14%	7%
Elk Cr to S Fk	**2013**	**Jan**	826	826	826	0%	0%
		Feb	1,262	1,165	1,165	-8%	-8%
		Mar	1,636	1,517	1,517	-7%	-7%
		Apr	1,739	1,709	1,709	-2%	-2%
		May	2,281	2,303	2,303	1%	1%
		Jun	2,972	3,064	3,064	3%	3%
		Jul	3,646	3,512	3,512	-4%	-4%
		Aug	6,600	4,339	4,339	-34%	-34%
		Sep	2,163	2,132	2,141	-1%	-1%
		Oct	2,110	2,251	2,251	7%	7%
		Nov	1,748	1,851	1,851	6%	6%
		Dec	1,226	1,310	1,201	7%	-2%
	2014	**Jan**	1,160	1,160	1,071	0%	-8%
		Feb	790	729	729	-8%	-8%
		Mar	1,115	1,094	1,094	-2%	-2%
		Apr	1,532	1,505	1,505	-2%	-2%
		May	2,102	2,108	2,113	0%	1%
		Jun	3,484	3,614	3,592	4%	3%
		Jul	3,524	3,512	3,512	0%	0%
		Aug	6,158	4,339	4,188	-30%	-32%
		Sep	7,313	4,560	4,580	-38%	-37%
		Oct	2,185	2,359	2,417	8%	11%
		Nov	1,517	1,524	1,524	0%	0%
		Dec	830	894	894	8%	8%
S Fk to Newaukum	**2013**	**Jan**	1,802	1,802	1,802	0%	0%
		Feb	2,124	1,821	1,821	-14%	-14%
		Mar	2,832	2,731	2,731	-4%	-4%
		Apr	2,990	2,958	2,958	-1%	-1%
		May	2,410	2,449	2,449	2%	2%
		Jun	2,054	2,360	2,360	15%	15%
		Jul	2,002	2,432	2,432	21%	21%
		Aug	4,961	3,960	3,960	-20%	-20%
		Oct	2,825	2,825	2,857	0%	1%
		Nov	2,485	2,631	2,631	6%	6%
		Dec	1,626	1,626	1,626	0%	0%
	2014	**Jan**	1,973	1,821	1,821	-8%	-8%
		Feb	1,867	1,867	1,724	0%	-8%
		Mar	2,680	2,635	2,635	-2%	-2%
		Apr	2,987	2,958	2,958	-1%	-1%
		May	2,886	2,925	2,918	1%	1%
		Jun	2,380	2,640	2,640	11%	11%
		Jul	2,212	2,432	2,432	10%	10%
		Aug	6,040	5,418	5,418	-10%	-10%
		Sep	9,798	7,519	5,528	-23%	-44%
		Oct	2,728	2,461	2,418	-10%	-11%
		Nov	2,580	2,731	2,731	6%	6%
		Dec	1,724	1,867	1,867	8%	8%
Newaukum to Skookumchuck	**2013**	**Jan**	8,252	8,252	8,252	0%	0%
		Feb	8,772	8,772	8,772	0%	0%
		Mar	11,979	11,979	11,979	0%	0%
		Apr	12,935	12,935	12,935	0%	0%
		May	20,050	20,140	20,140	0%	0%
		Jun	23,139	23,342	23,342	1%	1%
		Jul	33,804	33,804	33,804	0%	0%

Note: Values with green highlights denote an increase in WUA compared to Current Conditions.
Values with orange highlights denote a decrease in WUA compared to Current Conditions.

Species	Western Toad						
Reach	**Year**	**Month**	**Current Conditions**	**FRFA Scenario 1**	**FRFA Scenario 2**	**FRFA Scenario 1 Pct Change**	**FRFA Scenario 2 Pct Change**
	2013	**Aug**	43,859	41,773	41,773	-5%	-5%
		Sep	19,570	19,570	19,570	0%	0%
		Oct	14,740	15,143	15,143	3%	3%
		Nov	12,964	13,727	13,727	6%	6%
		Dec	8,897	8,897	8,897	0%	0%
	2014	**Jan**	8,939	8,939	8,939	0%	0%
		Feb	8,125	8,125	8,125	0%	0%
		Mar	11,463	11,463	11,463	0%	0%
		Apr	12,732	12,732	12,732	0%	0%
		May	15,433	15,468	15,468	0%	0%
		Jun	29,040	29,295	29,295	1%	1%
		Jul	33,804	36,860	33,804	9%	0%
		Aug	43,859	41,773	41,773	-5%	-5%
		Sep	55,386	51,388	51,692	-7%	-7%
		Oct	20,146	21,941	21,941	9%	9%
		Nov	11,690	12,377	12,377	6%	6%
		Dec	7,500	7,500	7,500	0%	0%
Skookumchuck to Black	**2013**	**Jan**	8,369	8,369	8,369	0%	0%
		Feb	9,446	9,446	9,446	0%	0%
		Mar	12,354	12,188	12,188	-1%	-1%
		Apr	13,074	13,007	13,074	-1%	0%
		May	17,699	17,699	17,699	0%	0%
		Jun	18,716	19,387	19,387	4%	4%
		Jul	27,856	27,856	27,856	0%	0%
		Aug	40,374	38,137	38,137	-6%	-6%
		Sep	21,157	21,157	21,157	0%	0%
		Oct	13,724	13,724	13,724	0%	0%
		Nov	11,969	12,673	12,673	6%	6%
		Dec	8,160	8,160	8,160	0%	0%
	2014	**Jan**	8,772	8,772	8,772	0%	0%
		Feb	8,749	8,125	8,125	-7%	-7%
		Mar	11,662	11,662	11,662	0%	0%
		Apr	13,074	13,007	13,007	-1%	-1%
		May	14,485	14,546	14,546	0%	0%
		Jun	23,913	24,771	24,771	4%	4%
		Jul	27,856	27,856	27,856	0%	0%
		Aug	41,773	38,137	36,860	-9%	-12%
		Sep	46,548	46,548	46,548	0%	0%
		Oct	20,196	21,995	21,995	9%	9%
		Nov	11,969	12,673	12,673	6%	6%
		Dec	7,617	7,617	7,617	0%	0%
Black to Porter	**2013**	**Jan**	3,936	3,936	3,936	0%	0%
		Feb	3,640	3,640	3,640	0%	0%
		Mar	5,328	5,328	5,328	0%	0%
		Apr	5,564	5,550	5,550	0%	0%
		May	4,858	4,887	4,887	1%	1%
		Jun	4,827	4,994	4,994	3%	3%
		Jul	4,257	4,257	4,257	0%	0%
		Aug	5,498	5,047	5,047	-8%	-8%
		Sep	5,593	5,593	5,593	0%	0%
		Oct	4,314	4,314	4,314	0%	0%
		Nov	3,762	3,983	3,983	6%	6%
		Dec	2,401	2,401	2,401	0%	0%
	2014	**Jan**	3,380	3,380	3,380	0%	0%
		Feb	4,602	4,602	4,602	0%	0%
		Mar	6,218	6,218	6,218	0%	0%
		Apr	5,136	5,123	5,123	0%	0%
		May	4,236	4,262	4,262	1%	1%
		Jun	5,684	5,684	5,684	0%	0%
		Jul	5,047	4,680	4,680	-7%	-7%
		Aug	6,030	6,030	6,030	0%	0%
		Sep	8,918	8,918	8,188	0%	-8%
		Oct	5,869	5,869	6,085	0%	4%
		Nov	3,817	4,041	4,041	6%	6%
		Dec	3,945	3,945	3,945	0%	0%

Note: Values with green highlights denote an increase in WUA compared to Current Conditions.
Values with orange highlights denote a decrease in WUA compared to Current Conditions.

A.6. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection. February 12, 2019.

February 12, 2019

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Janelle Leeson
PO Box 3755, Seattle, WA 98124-3755

RE: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection

Ms. Leeson:

The purpose of this letter is to answer questions presented in the January 31, 2019 Information Request regarding the Airport Levee and Dam alternatives and project objectives. We have also included a clarification to the scope of the Airport Levee.

This letter references many previous studies to provide history and context. All of the referenced studies are available on the "EIS Supporting Documents" page on the District website at: www.chehalisriverbasinfczd.com

Project Objective Clarifications

1. Which of the project objectives as stated in the undated letter "*Chehalis River Basin Flood Damage Reduction Project*," provided on September 14, 2018, do the Airport Levee Improvements achieve?

The airport levee contributes to all three of the project objectives.

1. *Reduce the closure due to overtopping of Interstate 5 freeway to 24 hours or less during a 100-year flood or greater. (Emphasis added).*

The 2007 flood was notably above the 100 year flood level, but probably less than the 500-year flood,[1] which is why "or greater" is included in this objective.

In a scenario with the dam, but without levee improvements, hydraulic modeling shows some levee overtopping in the airport area, but does not indicate that I-5 would be flooded within the airport levee area in the 100-year event. However, hydraulic modeling showed that water levels near the airport levee in the 500-year flood with the retention facility were approximately 3 feet higher than water levels in the 100-year flood. Thus, we would expect that the 500-year flood with the retention facility, but without the airport levee raise, would result in significant overtopping of the levee and widespread flooding within the airport area, including flooding of I-5. With the proposed project, including the retention facility and the airport levee raise, we would not expect overtopping of the airport levee in the 500-year event.[2] As noted in the District objectives letter the proposed project is intended to protect against flooding during a 100-year flood or greater. Raising the airport levee is a critical element for flood reduction in events greater than a 100-year flood. The estimates of flood levels are exasperated further when climate change predictions are factored in, which is discussed in the third objective.

It is important to note that analyses of flooding within the airport levee assume that the levee remains intact throughout the 100- and 500-year floods. Overtopping of levees increases the potential for breaching and a breach of the airport levee could lead to flooding of I-5, even during a 100-year flood event. Hydraulic modeling of the 100-year flood shows that with the retention facility but without raising the airport levee there would be some overtopping of the airport levee, specifically on the portion of the levee that includes Airport Road NW. The simulations show that this overtopping would be between 6 inches and 1 foot deep. Raising the levee provides additional protection in maintaining the integrity of the levees.

2. *Reduce damage from major flooding along the Chehalis River main stem to the greatest extent feasible. The District believes maximum flood reduction can be achieved by lowering peak flood levels at the Doty gauge by 10 feet or more and at the Mellen Street gauge in Centralia by 1 foot or more. This level of reduction in flood levels translates to a decrease in the severity of flooding on more than 4,000 acres, and more than $900 million in flood reduction impacts.*

The above statement is intended to convey that flood levels will be reduced at all locations, no location will experience an increased flood stage. The addition of the levee does not cause any redirected impacts, it removes land area and valuable real estate from the flood hazards without increasing flooding severity elsewhere.[2]

3. *Provide future leaders in the Chehalis Basin the flexibility to address additional increases in peak flood levels and decreases in stream flow during summer months through an adaptable design approach.*

Past and present evaluations have concluded that climate change is likely to increase peak flows on the Chehalis River.[3] With increased flows there would be higher levels of overtopping of the Airport Levee in the 100-year event in the future, and even higher levels in the 500-year event.

2. What is the geographic area targeted for flood damage reduction by the Airport Levee Improvements and what are the anticipated changes in predicted flood levels within this area?

The Airport Levee will impact the Chehalis-Centralia Airport, the commercial center adjacent to the Airport that includes Wal-Mart, Home Depot, and other retail stores, and the area of I-5 from mile markers 78.6 to 80. The flooded areas can also be seen in the attached figures for the 100 year and the 2007 floods. The change in predicted flood levels for the 100 year event are described in the following table, and can be seen in the attached figures.

Location	Change in Water Surface Elevation (ft)*
Newaukum Confluence	-1.6
Along Airport Levee	-1.4
Mellen St.	-1.6

*The predicted flood levels include the Dam and the Airport Levee.[2]

3. What actions besides the Airport Levee Improvements were considered to achieve this level and extent of flood damage reduction. For example, were additional levees or floodwalls along I-5 considered, and if so, why were they eliminated from further consideration?

Multiple alternatives analyses have been performed over the years and no single study contains the full analyses. The work completed is most succinctly stated in the Governor's Work Group 2014 Recommendation Report:

A report was prepared in 2012 by the William D. Ruckelshaus Center at the request of the Governor that summarized previous efforts to address flood damage. Past efforts have evaluated a full range of alternatives to reduce flood damages. This includes detailed evaluation of barrier removal, reducing bridges and constrictions, dredging, changing logging practices, buying flood easements from land owners, multiple smaller water retention facilities, protection of I-5 though raising the freeway, and various combinations of walls and levees. None of those measures provide the Basin-wide flood protection of the water retention facility and floodproofing proposed here, and none pass the state or federal benefit-cost test. For more information on alternatives analysis, see the Chehalis Basin Flood Hazard Mitigation Alternatives Report, available from the Publications page of the Ruckelshaus Center website at www.ruckelshauscenter.wsu.edu.[4]

Alternatives can be found in these reports as well (full references are located at the end of this letter):

- 2012 Rucklehaus Report- considered a water retention structure on the mainstem, I-5 protection projects, USACE levee system around Centralia and Chehalis, and alternative combinations.
- 2012 Hydraulic Model – considered mainstem Chehalis River dam, Corps Twin City levee, Mellen Street bypass, Scheuber bypass, dredging/channel excavation, bridge removal, I-5 walls and levees, localized I-5 protection and airport levee improvements, Skookumchuck levees, and possible combinations of alternatives.
- 2014 WSDOT Reports – considered I-5 levees and walls, raise and widen I-5, express lanes, temporary bypass, viaduct, and relocation.
- 2003 USACE Report – considered Skookumchuck Dam modifications, overbank excavations and flowway bypass, levee system, upstream flow restriction structures, upstream storage, non-structural actions, and an interagency committee alternative.
- 1998 PIE Report – considered non-structural actions, hydraulic capacity improvements, floodway and floodplain excavation, bypass channel, flood control dams, small headwaters dams, and flood storage dikes on floodplains.
- 1982 USACE Report – considered floodproof structures, multipurpose storage, small headwater dams, watershed management, channel clearing, channel excavation, channel excavation with levees, urban area levees, levees with river modifications, and non-structural measures.

4. In your response letter dated November 30, 2018, you state that, "Peak flows on the Newaukum River and South Fork Chehalis are similarly correlated to the downstream flows at Grand Mound: less so than the Doty flows but more so than the Skookumchuck flows." Would a flood retention facility on either of these rivers achieve the objectives of reducing the 100-year flood at Mellen Street by 1 foot? Please provide what factors were evaluated that resulted in the elimination of those locations.

In selecting the site for the proposed water storage facility in this application the District was informed by almost 90 years of prior studies. Water storage for flooding in the upper Chehalis basin has been evaluated by government agencies going back at least to 1931. The Army Corp of Engineers has been authorized by Congress in 1931, and several times since, to evaluate flood damage reduction measures in the Chehalis basin. In 1935 the Army Corps evaluated water retention sites at Centralia-Galvin, Oakville, Malone and Porter. These were determined not to be economically feasible. In 1982 the Army Corps published its evaluation of five locations for potential water storage including two sites on the Newaukum River, one site on the South Fork Chehalis River, and two sides on the mainstem of the Chehalis River upstream of the confluence with the Newaukum River. [5]

In 2003 Tetratech was retained by the Chehalis Basin Partnership to evaluate potential flood control measures. This study looked at water storage in eight potential sites including three on the South Fork Chehalis River, one on the Newaukum and one on the main stem, essentially the same site that the district is proposing. [6]

In 2008 through 2011 additional study looking at water storage potential sites was conducted by EES Consulting looking at three potential sites including the site proposed by the District. [7]

The Army Corps in 2003 rejected the Newaukum River and South Fork water storage sites "The flood state reduction provided by the Newaukum River or South Fork Chehalis dams would be small, and construction costs would be high. For these two dams, 100 year flood stage reductions on the Chehalis River near the Mellen Street bridge were estimated to range from 0.3 to 0.7 foot." "The mainstem Chehalis dams would provide greater stage reduction, 2.3 to 3.4 feet at the Mellen Street bridge." [8]

All of the prior analysis point to the site selected as the most feasible and the most effective single water storage location for significantly reducing flood damage downstream in the Chehalis basin. It is our understanding that all the studies boil down to a few simple but major factors. Essentially, the site was selected because:

1) It is the greatest hydrologic impact.
2) It has a positive cost benefit ratio.
3) It has favorable geology.
4) It is located upstream of all communities, therefore the reservoir created will not displace any humans or cause other community impacts.

Airport Levee Clarification

We would also like to take this opportunity to clarify the scope of the Airport Levee proposal. The 2012 Hydraulic Model study (Reference 2) was a very important driver of the decisions of what alternatives progressed further and incorporated into the overall Chehalis Basin Strategy and corresponding Programmatic EIS. The study included a Localized I-5 Protection and Airport Levee Improvements alternative which included the Airport Levee improvements consistent with how they are described in the Project Description letter that was submitted to the USACE in November 2018. This alternative also included additional localized flood protection improvements along I-5. With the Dam in place, additional floodwall improvements are not necessary to protect the Airport area from the 100-year flood and were not included in the Programmatic EIS description. They are also not included in this project application. We are currently developing more detailed drawings to provide to the USACE that will be submitted in a subsequent letter along with more information about the construction of the levee.

If you would like any further information or clarification please do not hesitate to contact erik.martin@lewiscountywa.gov or (360) 740-2697.

Sincerely,

Erik Martin, PE

Cc: Diane Butorac, Department of Ecology
Board of Supervisors, Chehalis River Basin FCZD

References:

1. Pg. 13, Lewis County Recovery Strategy, Lewis County, April 2009.

2. Table 8: Comparison of Water Surface Elevation Changes with Flood Relief Alternatives – December 2007 and 100-year Storm Events, Chehalis River Hydraulic Model Development Project, Watershed Science and Engineering and WEST Consultants. July 2012.

3. Effect of Climate Change on the Hydrology of the Chehalis Basin, Climate Impacts Group University of Washington, July 2016.

4. Pg 6, Governor's Chehalis Basin Work Group Recommendation Report, Ruckelshaus Center, November 2014.

5. Centralia, Washington Flood Damage Reduction, Army Corp of Engineers, September 1982

6. Pg 2-3, Multi-Purpose Water Storage Assessment, Tetra Tech and Triangle Associates, September 2003.

7. Chehalis River Flood Water Retention Project Phase I, IIA, and IIB, Feasibility Study, EES Consulting 2008 – 2011.

8. Pg 35, Centralia Flood Damage Reduction Project Chehalis River, Washington General Reevaluation Study, Final Environmental Impact Statement, United States Army Corps of Engineers Seattle District, June 2003

Alternative Analysis Reports:

2012 Ruckleshaus Report – Chehalis Basin Flood Hazard Mitigation Alternatives Report, The William D. Ruchelshaus Center, December 2012

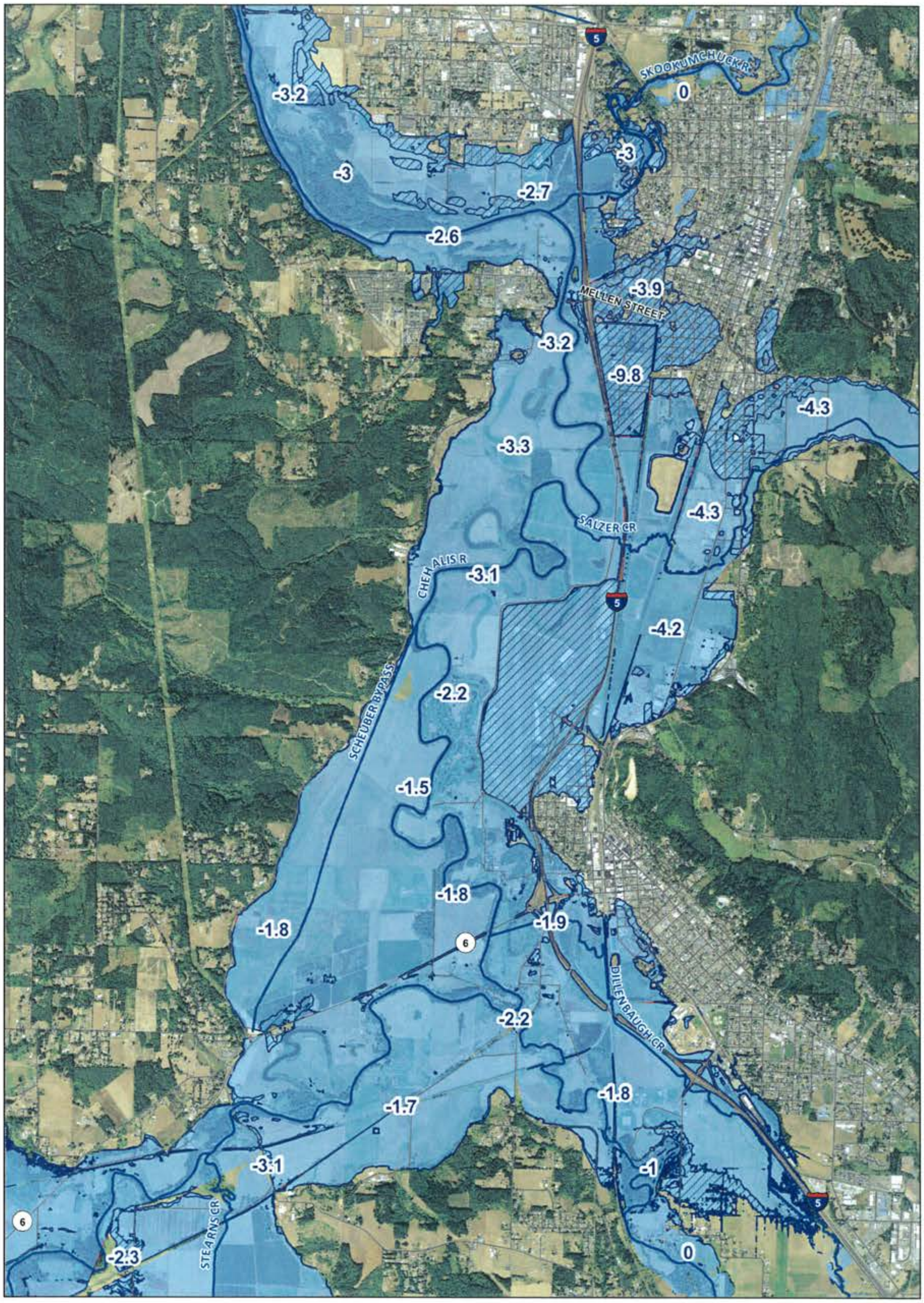
2012 Hydraulic Model - Reference 2

2014 WSDOT I5 Reports – Chehalis River Basin I-5 Flood Protection near Centralia and Chehalis, Washington Department of Transportation, November 2014

2003 USACE Report – Reference 8

1998 PIE Report – Chehalis River Basin Flood Reduction Project, Pacific International Engineering, December 1998

1982 USACE Report – Reference 5



Legend

+0.3 / -0.3 Change in Water Surface from Baseline

Roads

Rivers and Streams

Dec 2007 Floodplain

Approximate Area Protected from Flooding (Dec 2007 DamLev)

Approximate Area of Increased Flooding (Dec 2007 DamLev)

*Aerial Image Source: 2009 USDA NAIP Lewis County Ortho

Location Map

Chehalis River Basin Flood Authority

Mainstem Dam and Airport Levee Improvements

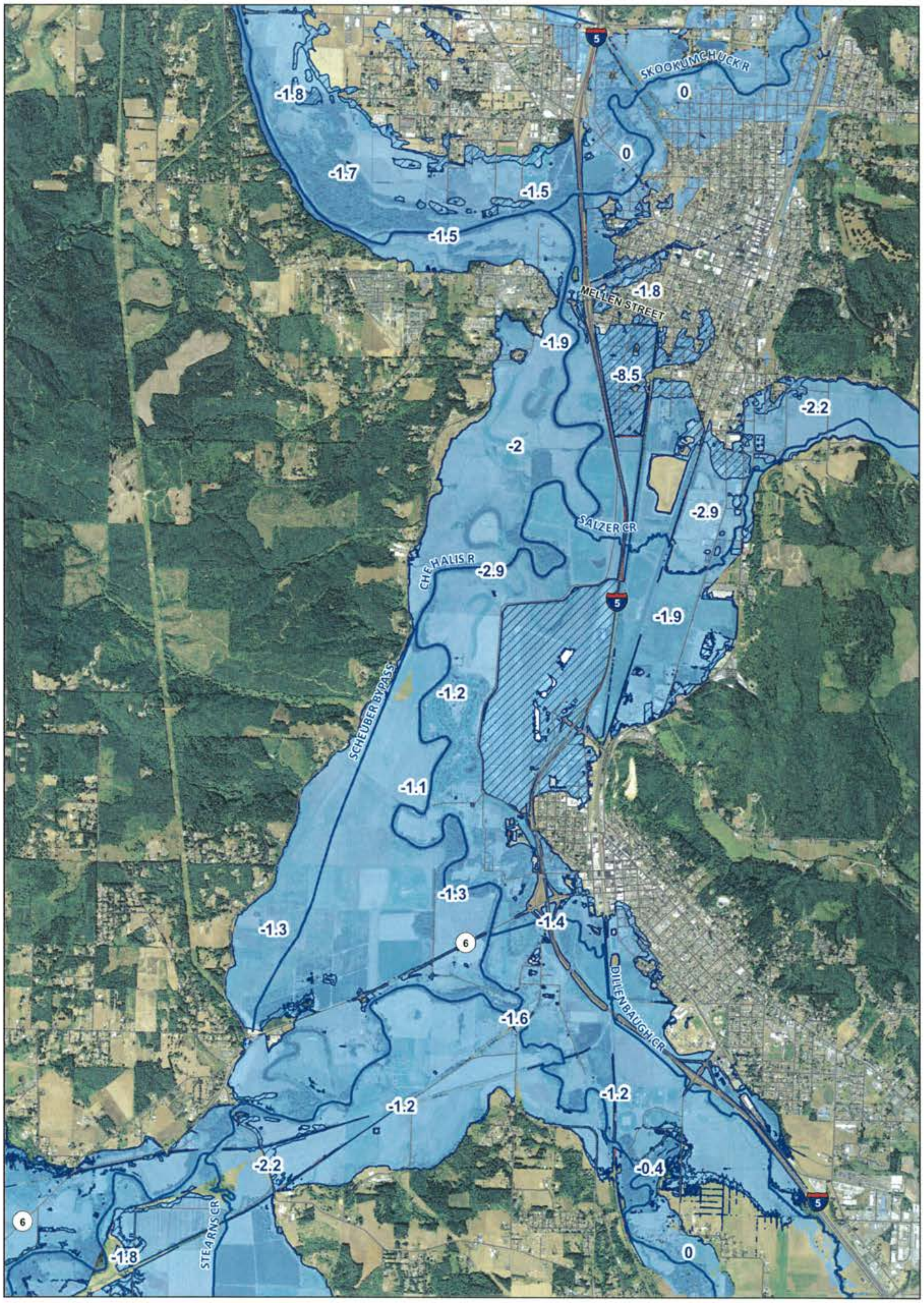
Scale - 1:36,000

0 1,500 3,000 6,000 Feet

N

WATERSHED Science & Engineering | project no. 11-023 | 13-Jun-2012

Figure XX



Legend

- Roads
- Rivers and Streams
- 100-year Floodplain
- Approximate Area Protected from Flooding (100-year DamLev)
- Approximate Area of Increased Flooding (100-year DamLev)

*Aerial Image Source: 2009 USDA NAIP Lewis County Ortho

Location Map

Chehalis River Basin Flood Authority

Flood Authority Model Simulation
100-year Dam and Levee

Scale - 1:36,000

0 1,500 3,000 6,000 Feet

N

WATERSHED Science & Engineering | project no. 11-023 | 05-Jun-2012

Figure XX

A.7. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection. March 1, 2019.

This file contains the March 1, 2019 Chehalis River Basin Flood Control Zone District's response to the Army Corps or Engineers inquiry dated January 31, 2019, requesting additional information regarding the proposed flood retention facility and airport levee raise.

Update March 5, 2019:
FCZD will be providing a follow-up letter addressing the items below (referenced with the numbering in the letter). The follow-up letter should be sent within the next two weeks.

- 1. FCZD will provide a map with the general location of the FR1000 bypass road.
- 4. FCZD will talk with HDR about the FRE tunnel since this is longer than the tunnel analyzed by the Subcommittee for the FRO. The question is, was fish passage and lighting considered for the longer tunnel for the expandable base.
- 9.c. Discussed that in-water work includes diversion of water during construction. FCZD will address this in their follow-up letter and also provide dates for the in-water work and identify where the water will come from for construction.
- 10.c. The widening of the levee base that has not been done does impact a jurisdictional ditch. In Phase 1, walls were put in for this area and those would need to be removed before the levee could be widened.
- 10.d. FCZD will check if the footprint of Airport Road would change.
- Quarry attachment. FCZD will see if a shape file is available for the location of the roads to the three quarries. There is map in the attachment but it is difficult to read.

March 1, 2019

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Janelle Leeson
PO Box 3755, Seattle, WA 98124-3755

RE: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection

Ms. Leeson:

This letter is providing responses to your inquiry dated January 31, 2019, requesting additional information regarding the proposed flood retention facility and airport levee raise.

1. **What improvements are proposed for the bypass road for Forest Road (FR) 1000 to be used during operation (including location, dimensions, fill, maintenance needs)?**

Regarding the permanent improvements to FR 1000, the most recent Cost Opinion included a four and a half million dollar line item for reservoir orphaned access roadway reconnection allowance. The Chehalis Basin Strategy Combined Dam and Fish Passage Conceptual Design Report, June 2017, Section 13.3.1 describes the approach (copied below for convenience).

> "Access to lands affected by the reservoir will remain via alternate routes to forest harvest and management areas via existing forest roads. However, access to some parcels will be somewhat restricted without construction of new roads or extensions to existing road networks, which will increase the cost for timber maintenance and harvest. These costs have been included in the direct dam construction costs as an allowance for a nominal amount per mile of affected access roadways."

The specific locations and extent of improvements were not part of the Cost Opinion and will be defined during the next phase of design in conjunction with and in preparation for permitting.

Temporary improvements will also be needed to access the quarry. A road evaluation has been recently completed to determine the extent of the temporary improvements, and that report is attached to this letter.

2. Provide information regarding the reservoir vegetation management plan:

Note that the Pre-construction Vegetation Management Plan mentioned in the responses below discusses the FRO because operations are the same as the FRE related to the temporary reservoir, the same information holds true for the FRE.

a. Define the vegetation removal areas.

Proposed vegetation removal areas within the proposed FRE reservoir footprint are defined in Table 1 (see FRO) of the August 31, 2016 Technical Memorandum on Proposed Flood Retention Facility Pre-Construction Vegetation Management Plan (Appendix J in the PEIS). As indicated in that table, non-flood tolerant vegetation would be selectively harvested from the portion of the proposed reservoir footprint that has a 10% change of being flooded in a given year (10-year event) where inundation could remain for up to 25 days when flooded. This area is estimated to be approximately 405 acres in size and generally occurs between elevations of 424 and 567 feet, North American Vertical Datum of 1988 (NAVD88). It corresponds with the "Deciduous Riparian Shrubland" expected vegetation community type shown on Figure 1 of the Pre-Construction Vegetation Management Plan. No vegetation removal would occur in the remaining portions of the proposed reservoir.

b. Identify the area to be affected, including what species/sizes would be removed?

The area of the proposed FRE reservoir that would be affected by vegetation clearing is identified in Table 1 (see FRO) of the Pre-Construction Vegetation Management and corresponds with the area described in the above response to question 2(a). This area includes riparian areas along the mainstem Chehalis River and several of its tributaries in the proposed reservoir area. Species that would be removed include those that are unable to survive more than a few days of flooding during the growing season without significant mortality as defined by Whitlow and Harris's 1979 article, *Flood Tolerance in Plants: A State-of-the-Art Review*, which was published by the U.S. Army Corps of Engineers Waterways Experiment Station (Whitlow and Harris 1979). Douglas fir (*Pseudotsuga menziesii*) would be the primary species affected. Tree sizes would vary and have not been delineated for this level of environmental review.

c. Provide information related to routine vegetation maintenance, including guidelines for cutting, trimming, or removal of live vegetation after initial dam construction.

Routine reservoir limit clearing activities is expected to be confined to removal of trees larger than about 6 inches DBH below the 100-yr flood stage, should they re-grow. A periodic clearing activity about every 7 to 10 years in which trees larger than that diameter would be felled and either left to decay or salvaged for biomass. The cost of this effort is considered in the estimated annual O&M cost of the project. This is commensurate with other similar projects in the region including Mud Mountain Dam and Howard Hanson Dam.

d. Describe post-construction re-vegetation efforts.

As discussed on page 7 of the Pre-Construction Vegetation Management Plan, supplemental native plantings are proposed to be installed in many of the post-construction vegetation community zones. Plant selection would be based on flood tolerance and could include the following species:

- Douglas fir (*Pseudotsuga menziesii*) and vine maple (*Acer circinatum*) in areas where inundation duration would be 1 to 5 days or less
- Black cottonwood black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), Oregon ash (*Fraxinus latifolia*), red elderberry (*Sambucus racemosa*), and snowberry (*Symphoricarpos albus*) in areas where inundation duration would be 6 to 10 days
- Red-osier dogwood (*Cornus sericea*), willows (*Salix* spp.), and western red cedar (*Thuja plicata*) in areas where inundation would be 10 to 30+ days

e. Describe post-construction vegetation monitoring.

A detailed post-construction vegetation management plan for avoiding, minimizing, and mitigating impacts is expected to be developed during the future phases of design.

f. Describe adaptive management approaches.

Reservoir regrowth will be mediated by the periodic and regular inundation (both time and level). Adaptive management of reservoir inundation limit regrowth and periodic management activities will focus primarily on temperature effects on aquatic resources, reduction of potential woody debris accumulation at the outlet works, and vegetation that provides slope stability. In addition, the adaptive management program will focus on maintenance of inundation-tolerant vegetation that does not produce large woody debris, or experience large-scale die-off in response to extended submergence during the flood season or during the growing season. At the same time, natural species selection will be monitored over time to determine which natives persist well in this changing environment, and encouragement of these species.

3. **Would the proposed project flow releases during/following flood events be the same as those stated for the Flood Retention Only option in the Operations Plan (Chehalis Basin Strategy, Operations Plan for Flood Retention Facilities, June 2017)? If not, identify the differences.**

The proposed Flood Retention Expandable (FRE) configuration has the same project flow release during and following a flood event as those stated for the Flood Retention Only configuration (FRO) in the 2017 Operations Plan document. The facility would retain river flows temporarily, and only during floods that are projected to exceed 38,800 cubic feet per second (cfs) at the Chehalis River Grand Mound, Washington gage operated by the U.S. Geological Survey. After the inflow hydrograph declines and the Grand Mound gage is projected to fall below the 38,000 cfs limit, the reservoir contents would be evacuated. In non-flood conditions the reservoir is empty and the Chehalis River flows through the reservoir footprint unimpeded. The volume available for flood storage would be 65,000 acre-feet.

4. **Would there be lighting in the tunnels of the outlet works and construction diversion tunnel to facilitate fish passage?**

Lighting is not planned for the outlet works and construction diversion tunnels. Lighting of these tunnels was considered by the Fish Passage Technical Subcommittee (Subcommittee). The Subcommittee consisted of representatives from National Marine Fisheries Service (NMFS), United States Fish and Wildlife Service (USFWS), Washington State Department of Fish and Wildlife (WDFW), Washington State Department of Ecology (DOE), the Quinault Indian Nation, HDR Engineering, and Anchor QEA. The Subcommittee determined that the fish passing the dam site move primarily at night, based on studies and communication with biologists at other fish passage facilities passing the same species of fish. It was agreed that lighting the tunnels would add little, if any, benefit to passage. Additionally, lighting the tunnels would add complexity, maintenance, and risk of damage to the lights and associated electrical features due to the proposed operation of the tunnel and expected debris. The Subcommittee agreed that lighting for the tunnels was not necessary.

5. **What are the specific locations fish would be released upstream of the dam during collect, handle, transfer, and release (CHTR) operations?**

Potential release points have not yet been sited. The design of the dam, its operation, and potential changes to the riparian corridor upstream have not been developed to provide sufficient detail to assess potential release sites. The potential release sites that have the highest benefit for aquatic resources will be located in future phases of design development in conjunction with and in preparation for permitting.

6. **When the outlet works are closed, and upstream fish passage is provided by the CHTR facility, would downstream passage be provided and if so, how?**

No, anadromous and resident fish species known to occur within the influence of the dam, in the inundation area of the associated reservoir, and upstream of the reservoir were selected for upstream passage only. Simulation models of dam operation indicate impoundment events will occur once every 5 to 7 years on average. The model results indicate that the CHTR could operate for approximately 4 – 8 weeks during an event. Based on the anticipated frequency and duration of CHTR operation, downstream passage during impoundment events was deemed not required by the Fish Passage Technical Subcommittee.

7. **The Corps has received inconsistent flood retention facility design specifications. What is the proposed height of the flood retention facility?**

The proposed Flood Retention Expandable (FRE) configuration has an RCC dam which is sized for 65,000 acre feet of flood storage with dam crest elevation of 651 feet and estimated maximum dam structural height of 254 to 270 feet depending on the final foundation elevation determined during final design. The hydraulic height of the FRE configuration would be about 234 feet.

8. Would the emergency spillway discharge to a 70-foot stilling basin, or to a flip bucket to launch the flow downstream? Applicant-provided information is inconsistent with the design report information.

The proposed FRE configuration has a 200 foot wide uncontrolled ogee crest spillway designed to pass the PMF without dam crest overtopping. The spillway has a concrete lined chute with a flip bucket type terminal structure discharging flows into a preformed plunge pool area about 400-500 feet downstream of the flip lip (at maximum design discharge). Lesser spillway flows may impact the revetted ground surface between the flip bucket lip and full-flow plunge pool zone. The flip bucket terminal structure was selected over a hydraulic jump type stilling basin due to expected infrequent operation of spillway structure and the high terminal velocity that might be expected at the toe of a conventional spillway chute discharging into a hydraulic jump-type stilling basin. Only the low level regulating/fish passage sluices would discharge into the conventional 70 foot wide hydraulic jump-type stilling basin.

9. Provide detailed information related to flood retention facility construction:

a. What equipment would be used?

The equipment employed on the project will include the following, however the list of equipment will be refined as the project progresses into the permitting phase:

- A range of mid to large size of "yellow" iron: dozers, track excavators, front end loaders, off-road fixed wheel and articulated haul trucks, integrated tool carriers, rollers, etc.
- A range of cranes; boom trucks, hydraulic truck and rough terrain, and track mounted cranes; up to 250 ton or larger.
- Quarry and material processing equipment: Track drills - pneumatic and hydraulic; blasting product storage and transfer; crushing plants – feeders, primary (jaw), secondary (cone) and tertiary crushers (vsi), utility and potentially overland conveyors, screen decks, potentially wash plants, large generators, electrical control and parts vans, etc.
- Concrete production and delivery equipment: generators, compressors, mobile to semi-mobile concrete plants, feeders, water chillers, ice plants, nitrogen systems, cement storage silos or trailers, conveyors, overland conveyors, specialty fabricated equipment, etc.

- Support equipment: trucks - vacuum trucks, water, mechanic's, fuel and lube, boom, flatbed, etc.; storage – vans, conex boxes, temporary buildings; other – generators, welders, compressors, pumps, office trailers.

b. What is the general description of any soil movement or placement?

Excavation and earthwork operations, or "soil" movement will involve both overburden and loose soils as well as varying degrees of foundation rock excavation. Embankments or fills will include placing excavated materials as well as controlled embankment or fill zones with select or perhaps processed materials. Typical excavation equipment will involve large dozers, large track excavators, large wheeled loaders, fixed and articulated off-road haul trucks. Placement equipment would include dozers, compaction equipment, water trucks, motor graders. Blasting equipment will include hydraulic and air track drills, explosive handling and storage equipment. Production rates for earthwork operations will vary considerable with the specific operation and is likely to peak less than 5000cy per day.

c. When and for how long would in-water work occur?

In-water work could be considered as under-water work, barge-staged work, or work within the active river channel. The project does not plan for any underwater or barge-staged work, with the exception of a limited number days of mechanical equipment (gate) inspection or adjustment well after initial filling. Active-river channel work would be limited to a few periods of a few days through the course of the project to permit tunnel portal isolation, establish crossings, cofferdam construction, establishing the tunnel diversion, and establishing final river routing through the completed works. More specific planning for in water work will occur in future phases of design development in conjunction with and in preparation for permitting.

d. How would construction equipment/vehicles (including dump trucks from quarries) access the dam site? How many trips would be needed?

Accessing the construction is anticipated via Muller and 1000 Roads. Trips to and from the project site have not been evaluated but would include labor and project support; all permanent materials such as cement, fly ash, some aggregates, steel, gates, etc; consumable materials, such as fuel and forms; and construction equipment. A rough range for 2-axle round trips would be between 100,000 and 180,000 trips and 3 axle or larger truck loads between 16,000 and 26,000 loads. On-site hauling of earthwork and quarried aggregates will use site-developed roads dedicated for construction use. These estimates will be refined in future phases of design development in conjunction with and in preparation for permitting.

e. Would construction sequencing for the proposed project follow Table 14-1 in the dam design report (Chehalis Basin Strategy, Combined Dam and Fish Passage Conceptual Design Report. June 2017)?

As developed and stated in Table 14-1 of the dam design report (Chehalis Basin Strategy, Combined Dam and Fish Passage Conceptual Design Report. June 2017) is presented as a framework for understanding key project work relationships (attached for reference). For example, establishing the diversion must be completed before significant work can begin on the dam, the dam's foundation must precede the dam, low-level outlet works structure construction is closely related to completing the dam RCC thru that elevation, final fish passage completion cannot occur until the dam and river outlet works is complete. Work components that are not on the critical path could vary considerably, for example, components of the fish passage may be worked on well in advance of completing the dam. A more detailed schedule including the non-critical path components will be defined at a later stage of engineering in preparation for permitting.

10. Define details of the Airport Levee Improvements:

We are presenting work that has been completed on the Airport Levee that is currently available. We would like to inform you that work is ongoing to progress the design with a focus on minimizing impacts to the environment, to tribal and cultural concerns, to airport operations, and to the airport's aviation classification. What is being presented to the USACE is a conservative plan from the standpoint of environmental impacts.

a. Is the bump out part of the proposed project?

Yes. We have been having ongoing discussions about the appropriate level of freeboard and final elevation of the levee in this area. However, we can provide a conservative alignment that is calculated using 3 feet of freeboard above the existing 100 year WSEL. This alignment is shown in the attached figure labeled 'Airport Levee Phase Two, Three Feet of Freeboard.'

b. What are the proposed dimensions of the levee in this area?

The levee cross section in the bump out area is represented at the 58+00 cross section of the attached cross section plan set.

c. Would any of the existing levee base be widened?

Yes. In 2013 Lewis County Public Works completed a 'Phase 1' of this project which included widening the base of most of the levee in anticipation of a future raise. There were a few constrictions discovered at that time regarding wetlands, right of way, and drainage, which did not allow the entire levee to be widened. Temporary walls were placed in the areas that were identified to be widened in a future phase of the project. The attached Figure 1 shows red lines where the temporary walls were placed, the levee will need to be widened in these areas.

d. What are the design specifications of raising 1,700 feet of Airport Road that may require changing the existing footprint of the roadway?

The design of the levees follows the US Army Corps of Engineers Engineering and Design Guidance – Design and Construction of Levees, EM1110-2-1913. Washington State Department of Transportation Aviation Division and the Federal Aviation Administration Standards govern the height of structures near airports. The Civil Airport Imaginary Surfaces figure by WSDOT is attached to this letter. Chapter 12 of the City of Chehalis Code and Chapter 12 of the Lewis County Code have road standards that will also be followed for the sections of roadway that will be modified.

11. How would the Airport Levee Improvements be constructed?

a. Equipment types

The equipment employed on the project will include the following, however the list of equipment will be refined as the project progresses in conjunction with and in preparation for permitting:

- A range trending on the mid to large size of "yellow" iron: dozers, track excavators, front end loaders, off-road fixed wheel and articulated haul trucks, integrated tool carriers, rollers, etc.
- Support equipment: trucks –various dump trucks, water, mechanic's, fuel and lube, flatbed, etc.; storage – vans, conex boxes, temporary buildings; other – generators, compressors, pumps, office trailers.

b. Schedule/sequencing of major phases

We expect the schedule of work to follow this general sequence:

- Additional engineering and assessment to avoid impacts
- Mobilization
- Erosion control, clearing and grubbing
- Removal of structures or obstructions

- Material placement and compaction
- Trimming and cleanup, sod placement

c. General description of any soil movement or placement

Soil placement will be fill material brought in from offsite. Material removal will include the temporary walls that were placed in Phase 1, the crushed top course that is currently on top of the levee, and any excavation needed to place hydraulic structures such as culverts. No new quarries or borrow pits will be developed, only existing sources will be evaluated for acceptable fill material. Typically, soil will only be displaced in areas where benching may occur or in areas of culvert placement. We are expecting construction to follow Division 2 of the WSDOT Standard Specifications M 41-10.

d. Access/haul routes and trips

We expect the haul routes to be similar to the haul routes that were used for Phase 1. Airport Road and to top of the levee were used for site access. Louisiana Avenue to the south is the preferred route off-site to avoid the conjected traffic area to east of the airport. An attached figure labeled 'Rebid Airport Levee Improvement Project Haul Route' shows the previous routes used in Phase 1, and are anticipated to be used again in the next phase.

If you would like any further information or clarification please do not hesitate to contact erik.martin@lewiscountywa.gov or (360) 740-2697, or Betsy Dillin at betsy.dillin@lewiscountywa.gov or (360) 740-1138.

Sincerely,

Laura McRea on behalf of Erik Martin

Erik Martin, PE

Cc: Diane Butorac, Department of Ecology
Board of Supervisors, Chehalis River Basin FCZD

Attachment 1

Pacific Forest Resources, Inc.
Engineering and Forest Management

To: Bob Montgomery - Anchor, QEA
From: Steve Faulkner, PE
Date: January 9, 2019

RE: Chehalis Dam Feasibility Study - Road Improvement Requirements for Dam Construction

Per the DRAFT Chehalis Basin Strategy Report dated 12/13/18 (provided by Anchor QEA), it was recommended that at least one rock quarry (North Quarry) be developed as source material for Roller-Compacted-Concrete (RCC) for the proposed Chehalis Dam construction. Additionally, a second pit (South Quarry), or even third pit (Huckleberry Ridge Quarry), could be developed to supply the needed material (estimated to be 1.66± MM tons/937,000± CY) for the proposed project, if required.

Due to the large quantity of material needed, large off-highway earth moving equipment, such as a Caterpillar 769C, would likely be used to economically transport the RCC material to the dam site. The existing road systems will require improvements to the subgrade, surfacing and travel width in order to support the increased heavy loads and two-way traffic. All roads discussed in this report are currently classified as low-volume aggregate surfaced roads owned by Weyerhaeuser Company.

This memo outlines the road improvements required to access the three quarries and their respective cost estimates.

North Quarry
As recommended in the DRAFT Chehalis Basin Strategy Report, a vast majority of the RCC material would likely be derived from the North Quarry. The total haul distance from this quarry to the proposed dam site is 2.7± miles, of which 2.1+ miles are located on the 1000 Mainline Road and the remainder are on the 1000G Road.

Because a majority of the existing 1000 Mainline Road is close to the required double-lane width (18 to 22 feet wide), most of the improvements needed for this road (1.9± miles) would consist of widening the roadway to 24+ feet in selective locations in order to pass two-way off-highway loads and additional aggregate surfacing. An additional 0.3± miles of the 1000 mainline will also require moderate improvements to the subgrade.

The 1000G Road will require 0.6± miles of upgrades (0.2+ miles of which will require more moderate to complex improvements). The 1000G Road is typically 16± feet wide, so it would require significantly more widening and surfacing than the 1000 Mainline Road.

The estimated overall road cost to access the proposed dam site from the North Quarry is $364,000±. It is also important to note that there are two existing single lane bridges on this route that will only support low speed, "One-Way" traffic for haul trucks accessing the dam, thus haul-truck speeds for this route should be estimated at no more than 20 mph.. Overall, this quarry option will require 3.65± acres of additional right-of-way (R/W) clearing (including the improvements to the 1000 Mainline).

South Quarry

As also discussed in the DRAFT report, additional RCC material may need to be sourced from the South Quarry site. The total haul distance from this quarry to the proposed dam site is 6.5± miles (most of which is "mainline" type roadway, including part of the North Quarry haul route noted above). This route also includes two more single-lane bridges that will support only "One-Way" traffic, however due to the longer distances of mainline road, the travel speed of haul-trucks should still average upwards to 25 mph.

Accessing this site will require minor improvements (similar to those mentioned above) to an additional 3.4± miles of the existing 1000 Mainline Road as well as moderate upgrades to 0.9± miles of the quarry access roads (1000 & 1020 roads). The existing access road is only 14' to 16' wide, therefore there will be significant widening needed, including sections of heavy cuts and fills. The estimated cost of the roadway improvement to the South Quarry is $407,000±. This access route will require 5.0± acres of R/W clearing in addition to that noted above for the North Quarry.

Huckleberry Ridge Quarry

Should an additional material source be required, the third option identified is the Huckleberry Ridge Quarry. The road to this quarry site is much more difficult and expensive to construct (and haul on) than the other two options. This 6.74± mile access route (Huckleberry Ridge Road) is locally very steep (17%+ in areas) and contains segments of steep (70+%) side slopes and solid rock. The existing road is windy and narrow (12 feet) in sections that will require major widening and subgrade reinforcement.

Approximately 3 miles of this route would be simple improvement with fairly flat sideslopes and minimal excavation. Another 2.9± miles of this route will require more moderate improvement work. These moderate sections have steeper sideslopes and will require significantly more excavation to facilitate an adequate road width. There are also 0.8± miles of road that require "complex" improvements to facilitate off-highway haul trucks. This "complex" road type is on very steep, potentially unstable ground that will require heavy excavation into the bank to create a full-bench road, including end-haul of all excavated material for roadway stability. A significant portion of this excavation will likely require drilling & shooting, thereby significantly increasing costs. The estimated cost of the Huckleberry Ridge Road improvements is $1,887,000. This route will require 12.5± acres of R/W clearing to facilitate the requisite road improvements.

In addition, there are several sections of the road that cannot be adequately widened to preferred widths due to existing topography (very steep sideslopes), poor existing road alignment and/or existing barriers (i.e. Crim Creek Bridge), therefore there will be several "One-Way" road segments which will further reduce overall haul-truck speed and increase haul time to get the RCC material to the project site.

Due to the extensive road improvement work and costs required, and the inferior finished product (steep, curvy, complex), this is considered to be the least preferred option for material transport. The total haul distance from the Huckleberry Ridge Quarry to the proposed dam site is 8.2± miles (of which only 1.4± miles is "mainline" type roadway), because of the steep grades and segments of reduced road widths, a travel speed of 8 to 10 mph is most appropriate for cost estimating purposes from this source.

Potential Bridge Improvements Required Following Dam Completion

As noted in the attached opinion report from McGee Engineering regarding the suitability of the bridges to sustain construction/hauling equipment, it was determined that all bridges have acceptable load ratings for the such equipment, provided that haul-equipment speeds over the bridges be limited to around 5 mph.

It was further recommended that the Panseko Bridge have 4" vent holes drilled into the deck to relieve potential uplifting pressures from routine flooding (estimated to be 100± feet deep at times). In addition, the approaches to the Panesko Bridge should be paved 150± feet each direction to reduce sedimentation onto the bridge, which could be deposited into the stream via surface drainage through vent holes.

Respectfully submitted -

Steve Faulkner, PE

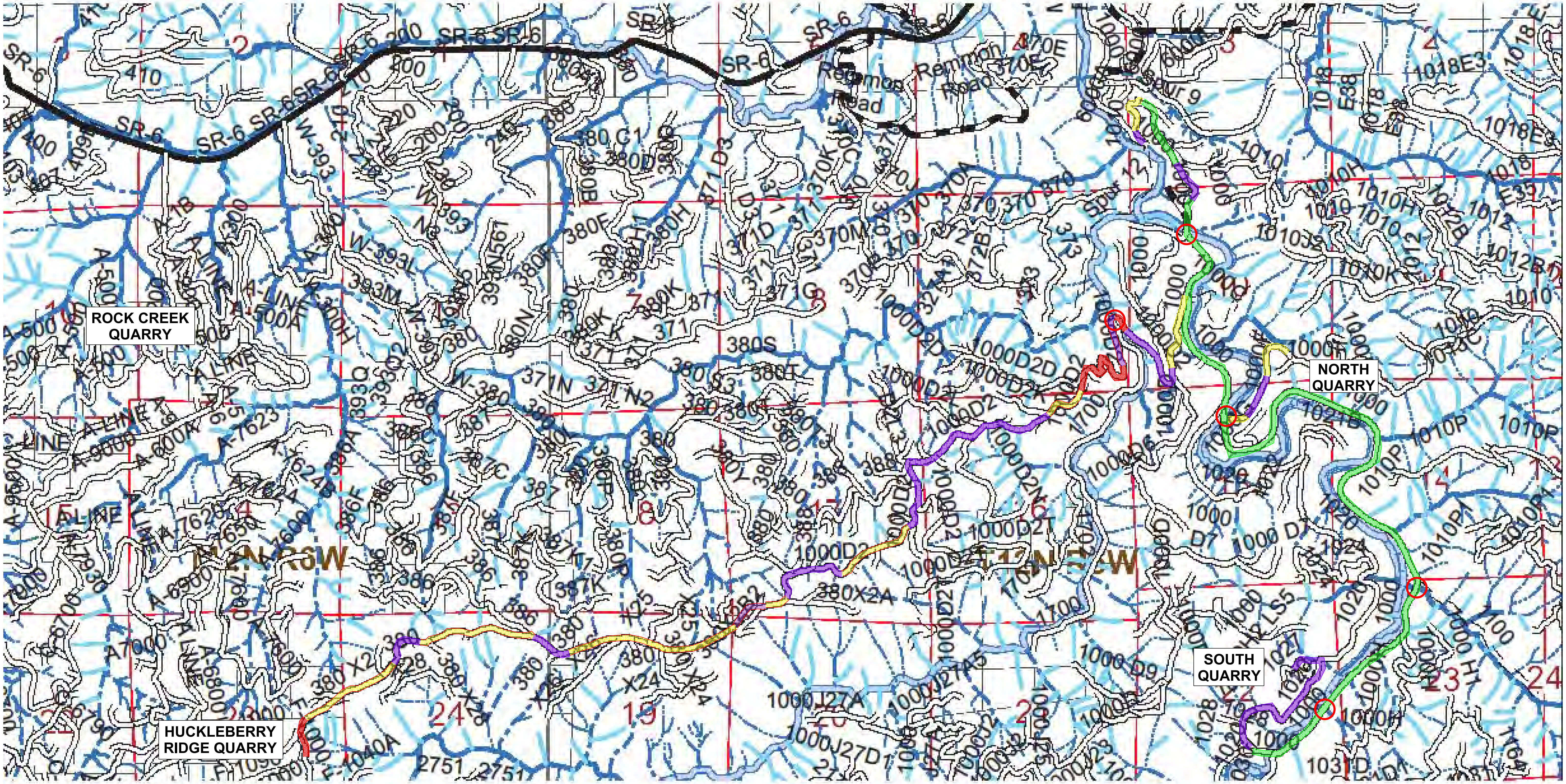
Attachments

- Road Type Map & Cost Estimates
- Bridge Evaluation (McGee Engineering)
- Road reconnaissance notes (Bill Laprade @ Shannon & Wilson)

Chehalis Dam Road Access Feasibility Evaluation

Road Type Map & Cost Estimates

PROPOSED CHEHALIS DAM
HAUL ROUTE ROAD CATEGORIES



SIMPLE/MINOR ROAD IMPROVEMENT

MODERATE ROAD IMPROVEMENT

COMPLEX ROAD IMPROVEMENT

MAINLINE TYPE ROAD UPGRADE

SCALE: 1" = ½± MILE

0 ½ MI 1 MI

Chehalis Dam - Road Segment Cost Estimate

12/24/2018

Road Segments & Total Costs

REQUIRED

Segment #1 **1000 Rd (Dam - Huck Ridge Rd Jct)**

Total Length:	**1.42**	Mile		
1000 Rd:	0.91	mile	$ 37,021	
Simple:	0.21	mile	$ 44,568	
Moderate:	0.30	mile	$ 84,804	
Complex:	0	mile	$ -	
			$ 166,393	
			$ 117,592	/Mile

REQUIRED

Segment #2 **1000 Rd (Huck Ridge Rd Jct - Sort Yard Jct (Seg 3 Jct)**

Total Length:	**0.72**	Mile		
1000 Rd:	0.72	mile	$ 29,291	
Simple:	0	mile	$ -	
Moderate:	0	mile	$ -	
Complex:	0	mile	$ -	
			$ 29,291	
			$ 40,682	/Mile

Segment #3 **North Pit Road (Sort Yard Jct to North Pit)**

Total Length:	**0.59**	Mile		
Simple:	0.37	mile	$ 78,525	
Moderate:	0.1	mile	$ 28,747	
Complex:	0.12	mile	$ 60,721	
			$ 167,994	
			$ 284,735	/Mile

Segment #4 **1000 Rd (Sort Yard Jct to South Pit)**

Total Length:	**4.35**	Mile		
1000 Rd:	3.42	mile	$ 138,930	
Simple:	0	mile	$ -	
Moderate:	0.93	mile	$ 268,498	
Complex:	0	mile	$ -	
			$ 407,428	
			$ 93,683	/Mile

Segment #5 **Huckleberry Ridge Road**

Total Length:	**6.74**	Mile		
Simple:	3.01	mile	$ 638,814	
Moderate:	2.93	mile	$ 840,852	
Complex:	0.81	mile	$ 407,340	
			$ 1,887,006	
			$ 279,971	/Mile

Chehalis Dam - Road Type & Cost Estimate

12/24/2018

Road Classes & Costs

Simple/Minor Road Improvement

Minimal widening; Shallow side slopes w/no waste; Easy cut/fill; Simple access
Typical existing widths 18' - 20', widen to 24'+ as needed

Excavation:	200	cy/sta @	$ 2.00	/cy =	$	400	/sta	
Cut & Misc:					$	50		
End-Haul:	0	cy/sta @	$ 5.00	/cy =	$	-		
Drill & Shoot:	0	cy/sta @	$ 3.50	/cy =	$	-		
Ballast (12" in-place):	107	cy/sta @	$ 15.18	/cy =	$	1,624		Ballast & Surfacing = $ 188,471 /mile
Surfacing (12"):	107	cy/sta @	$ 18.18	/cy =	$	1,945		
					$	4,020	/sta	
					$	212,231	/mile	

Moderate Road Improvement

Extra widening required; Steeper side slopes with moderate end-haul; Moderate cut/fill w/significant waste (end-haul)
Typical existing widths 14' - 18', widen to 24'+ as needed (bigger cuts)

Excavation:	600	cy/sta @	$ 2.00	/cy =	$	1,200	/sta
Cut & Misc:					$	75	
End-Haul (20%):	120	cy/sta @	$ 5.00	/cy =	$	600	
Drill & Shoot:	0	cy/sta @	$ 3.50	/cy =	$	-	
Ballast (12" in-place):	107	cy/sta @	$ 15.18	/cy =	$	1,624	
Surfacing (12"):	107	cy/sta @	$ 18.18	/cy =	$	1,945	
					$	5,445	/sta
					$	287,471	/mile

Typical Haul, Load, Crush costs

Ballast	$ 7.00	$ 15.18	In place
Crush	$ 10.00	$ 18.18	
Haul cost	$ 6.18		
Load/Sprea	$ 2.00		

Ballast & Surfacing = $ 188,471 /mile

Complex Road Improvement

Extreme widening; Very steep side slopes (typically full-bench w/heavy end-haul); High cut banks; Potentially unstable slope; Drill & Shooy; Difficult access
Typical existing widths 12' - 14', widen to 24'+ if possible (large/high cuts)

Excavation:	900	cy/sta @	$ 2.00	/cy =	$	1,800	/sta
Cut & Misc:					$	150	
End-Haul (75%):	675	cy/sta @	$ 5.00	/cy =	$	3,375	
Drill & Shoot (60% EH):	540	cy/sta @	$ 3.50	/cy =	$	1,890	
Ballast (8" in-place):	71	cy/sta @	$ 15.18	/cy =	$	1,078	
Surfacing (8"):	71	cy/sta @	$ 18.18	/cy =	$	1,291	
					$	9,584	/sta
					$	506,012	/mile

Ballast & Surfacing = $ 125,060 /mile
assume heavy D&S

1000 Mainline Road Improvement

Minimal widening & excavation; Reduced ballast & surfacing
Typical existing widths 18' - 22', widen to 24'+ if reasonable

Excavation:	50	cy/sta @	$ 2.00	/cy =	$	100	/sta
Cut & Misc:					$	-	
End-Haul (25%):	12.5	cy/sta @	$ 5.00	/cy =	$	63	
Drill & Shoot (0% EH):	0	cy/sta @	$ 3.50	/cy =	$	-	
Ballast (5' x 12"):	22	cy/sta @	$ 13.85	/cy =	$	305	
Surfacing (4' x12"):	18	cy/sta @	$ 16.85	/cy =	$	303	
					$	771	/sta
					$	40,682	/mile

1000 Rd Costs (Mainline improvement)

Ballast	$ 7.00	$ 13.85	In place
Crush	$ 10.00	$ 16.85	
Haul cost	$ 4.85		
Load/sprea	$ 2.00		

Ballast & Surfacing = $ 32,102 /mile

Chehalis Dam Road Access Feasibility Evaluation

Existing Bridges Evaluation

McGee Engineering, Inc

Alex Dunn, P.E. *President*

Office: (541) 757-1270
Fax: (541) 758-6585
alexdunn@mcgee-engineering.com

804 D NW Buchanan Ave. Corvallis, OR 97330
P.O. Box 1067 Corvallis, OR 97339
www.mcgee-engineering.com

September 19, 2018

Pacific Forest Resources, Inc.
29322 SE 374th Street
Enumclaw, WA 98022

ATTN: Steve Faulkner, P.E.

RE: Pe Ell Bridge Evaluations

Steve,

As part of your analysis in the Chehalis Dam feasibility study, you asked us to evaluate the live load capacity of five bridges on the Weyerhaeuser road system.

EVALUATION METHOD

Design or as-constructed plans are available in Weyerhaeuser archives. We were able to obtain bridge geometry and design loadings for each structure, except for the Sort Yard Bridge and High Bridge. We have plans for the steel approach span on the Sort Yard Bridge, but not the concrete spans. We have plans for the High Bridge, but were unable to determine whether the spans are continuous or simple. We evaluated the High bridge for both scenarios, and our analysis of the other bridges is consistent enough for us to be confident that our conclusions would not be affected by the missing information. We can make a site visit to the two bridges to fill in missing information if you would like.

Our analysis compared the live load shear and moment envelopes of the proposed off-highway dump trucks to the original design vehicles as follows:

- All bridges are single lane width, so a full lane of live load was compared. Load distribution for individual girder analysis was not considered; all bridges are multi-beam with deck and diaphragm systems which appear to be providing adequate load distribution.
- Original design vehicles were indicated on the plans for each bridge:
  Older bridges (Crim Creek, Big Creek, High Bridge) were designed for:
  - Design Vehicle: 75-Ton Truck with 30% Impact
  - Overload Vehicle: 148 Ton Loader with no Impact

  Newer bridges (Panseko, Sort Yard Span 1) were designed for:
  - Design Vehicle: U-80 Truck with 30% Impact
  - Overload Vehicle: BU-99 Yarder with 15% Impact
- Proposed off highway dump trucks were considered in the following order:
  - CAT 769C with 35 Ton payload and 30% Impact
  - CAT 769C with 35 Ton payload and no Impact (5 mph max. speed)
  - CAT 769C with 25 Ton payload and 30% Impact

The load effect of each proposed vehicle was compared with the original Design and Overload vehicles. The Design vehicles represent the bridge operating at a stress level which does not affect the service life, while the Overload vehicles represent the bridge operating at a stress level where the service life may be reduced if those vehicles use the bridge regularly.

ANALYSIS RESULTS

We understand that you expect 300-400 truck trips each day and will expect consistent performance from the structures for a lengthy period. For that reason, we primarily considered the comparison to Design vehicles.

The load effect of the CAT 769C with 35-Ton payload and 30% impact exceeded the Design vehicles by approximately 20%, except for the Panseko Bridge which has adequate capacity (probably due to the long span). For all other bridges, the proposed loading was more closely equivalent to Overload vehicles.

Secondary analysis shows that 1) reducing the payload to 25-Tons, or 2) eliminating vehicle impact on the 35-Ton payload, have similar effects. All bridges have adequate capacity for either of these scenarios (see attached summary table). Considering the high production rate required for this project, we believe that a 5mph posted speed (to eliminate impact) would be difficult to enforce.

Changing to a 3-axle configuration (CAT 735B) reduces the load effect approximately 10% by spreading the load over a longer length of span.

CONCLUSION

For preliminary planning purposes, we recommend that you use the CAT 769C with 25-Ton payload and 30% impact (no speed reduction at bridges) to maintain bridge stresses in the ordinary working range. Aggressively, you could consider the CAT 735B with 35-Ton payload and 30% impact (no speed reduction at bridges) expecting bridge stresses in the higher range, which could reduce the lifespan of the bridges.

Please keep in mind that our analysis is an order-of-magnitude analysis which we believe is appropriate for your current planning efforts. Before physically implementing your plan, each bridge should receive a detailed condition inspection and evaluation of the specific vehicle/loading effects.

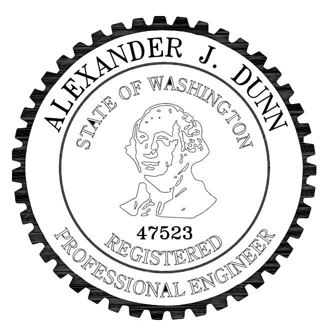
PANSEKO BRIDGE COMMENTS

We understand that the Panseko bridge may be flooded at times, with water up to 100’ deep. In our experience, the most damaging concerns are scour of the approach embankments and channel changes (aggradation/degradation) while the water level is rising or lowering. These impacts vary with the speed of the water, but in a flood control situation we would expect these effects to be relatively minor. You may consider drilling vent holes in the deck to prevent air entrapment during flooding. Several 4” diameter holes along the interior deck joints should suffice.

As you review this report, please do not hesitate to contact me with any questions or to discuss our recommendations. Thank you for the opportunity to work with you on this project.

Sincerely,

Alex Dunn, P.E.



ATTACHED: Loading Summary Table

Panseko Bridge

	(140' Span)	Original Loading		Proposed Loading		
		Design	Overload			
		U-80 Truck	BU-99 Yarder	CAT769C (35T)	CAT769C (35T)	CAT769C (25T)
	Impact	1.30	1.15	1.30	1.00	1.30
Moment	Lane (k-ft)	6256	7490	5881	4524	5007
	Ratio (Design)			0.9	0.7	0.8
	Ratio (Overload)			0.8	0.6	0.7
Shear	Lane (kips)	187	223	173	133	148
	Ratio (Design)			0.9	0.7	0.8
	Ratio (Overload)			0.8	0.6	0.7

Sort Yard (Span 1)

	(48.5' Span)	Original Loading		Proposed Loading		
		Design	Overload			
		U-80 Truck	BU-99 Yarder	CAT769C (35T)	CAT769C (35T)	CAT769C (25T)
	Impact	1.30	1.15	1.30	1.00	1.30
Moment	Lane (k-ft)	1520	1992	1799	1384	1519
	Ratio (Design)			1.2	0.9	1.0
	Ratio (Overload)			0.9	0.7	0.8
Shear	Lane (kips)	148	188	162	125	138
	Ratio (Design)			1.1	0.8	0.9
	Ratio (Overload)			0.9	0.7	0.7

Crim Creek

	(43' Span)	Original Loading		Proposed Loading		
		Design	Overload			
		75 Ton Truck	148 Ton Loader	CAT769C (35T)	CAT769C (35T)	CAT769C (25T)
	Impact	1.30	1.00	1.30	1.00	1.30
Moment	Lane (k-ft)	1137	1583	1551	1193	1307
	Ratio (Design)			1.4	1.0	1.2
	Ratio (Overload)			1.0	0.8	0.8
Shear	Lane (kips)	131	163	160	123	136
	Ratio (Design)			1.2	0.9	1.0
	Ratio (Overload)			1.0	0.8	0.8

Big Creek

	(60' Span)	Original Loading		Proposed Loading		
		Design	Overload			
		75 Ton Truck	148 Ton Loader	CAT769C (35T)	CAT769C (35T)	CAT769C (25T)
	Impact	1.30	1.00	1.30	1.00	1.30
Moment	Lane (k-ft)	1940	2283	2307	1775	1953
	Ratio (Design)			1.2	0.9	1.0
	Ratio (Overload)			1.0	0.8	0.9
Shear	Lane (kips)	148	197	166	127	141
	Ratio (Design)			1.1	0.9	1.0
	Ratio (Overload)			0.8	0.6	0.7

High Bridge (Span 1 Simply Supported)

	(49.1' Span)	Original Loading		Proposed Loading		
		Design	Overload			
		75 Ton Truck	148 Ton Loader	CAT769C (35T)	CAT769C (35T)	CAT769C (25T)
	Impact	1.30	1.00	1.30	1.00	1.30
Moment	Lane (k-ft)	1412	1834	1822	1402	1539
	Ratio (Design)			1.3	1.0	1.1
	Ratio (Overload)			1.0	0.8	0.8
Shear	Lane (kips)	138	178	163	125	138
	Ratio (Design)			1.2	0.9	1.0
	Ratio (Overload)			0.9	0.7	0.8

High Bridge (Span 2 Simply Supported)

	(113.7' Span)	Original Loading		Proposed Loading		
		Design	Overload			
		75 Ton Truck	148 Ton Loader	CAT769C (35T)	CAT769C (35T)	CAT769C (25T)
	Impact	1.30	1.00	1.30	1.00	1.30
Moment	Lane (k-ft)	4552	5936	4705	3619	4002
	Ratio (Design)			1.0	0.8	0.9
	Ratio (Overload)			0.8	0.6	0.7
Shear	Lane (kips)	170	243	172	132	147
	Ratio (Design)			1.0	0.8	0.9
	Ratio (Overload)			0.7	0.5	0.6

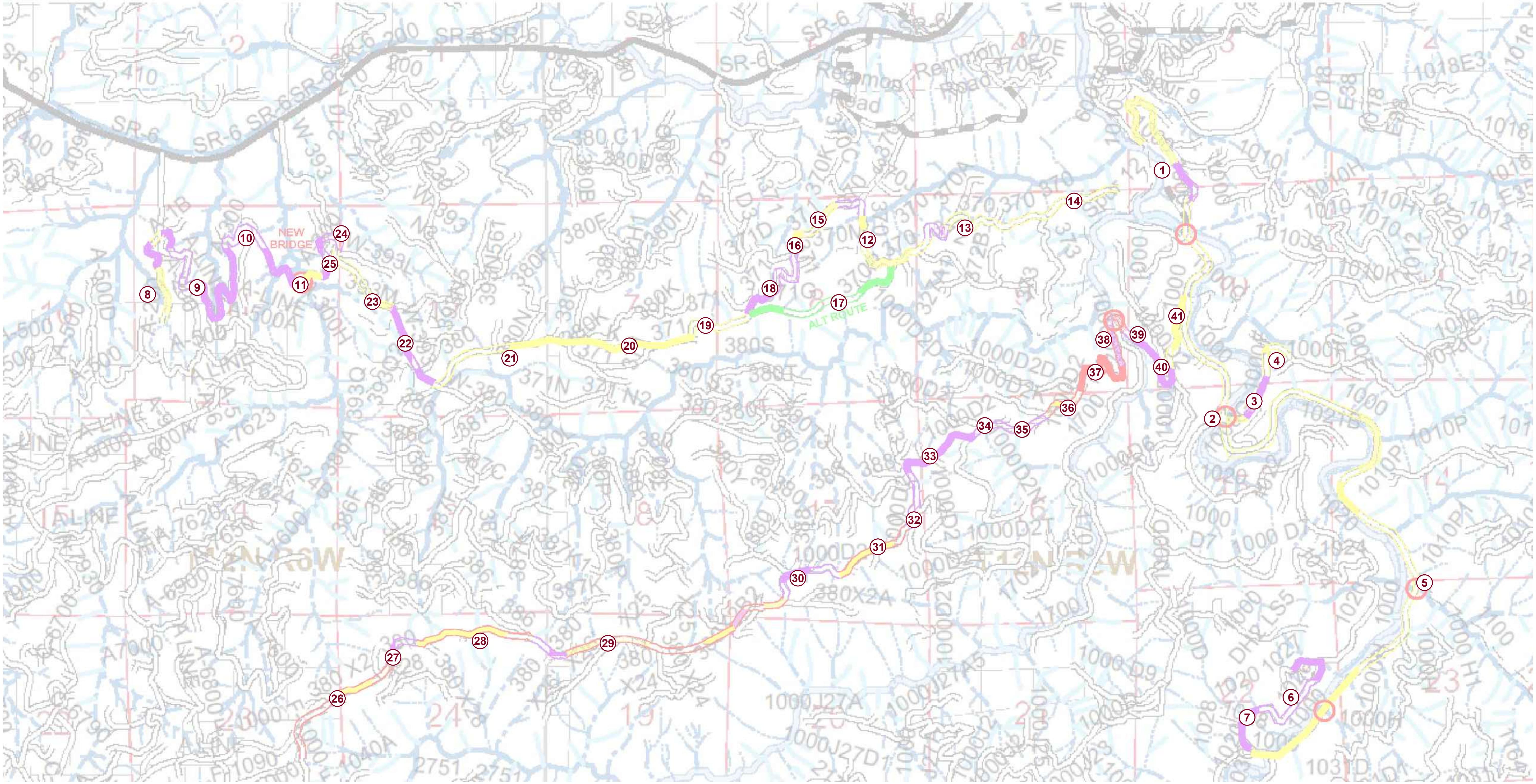
High Bridge (Continuous)

	(49.1'-113.7' Spans)	Original Loading		Proposed Loading		
		Design	Overload			
		75 Ton Truck	148 Ton Loader	CAT769C (35T)	CAT769C (35T)	CAT769C (25T)
	Impact	1.30	1.00	1.30	1.00	1.30
(+) M	Lane (k-ft)	3315	4383	3584	2757	3041
	Ratio (Design)			1.1	0.8	0.9
	Ratio (Overload)			0.8	0.6	0.7
(-) M	Lane (k-ft)	2800	3818	2674	2057	2285
	Ratio (Design)			1.0	0.7	0.8
	Ratio (Overload)			0.7	0.5	0.6
Shear	Lane (kips)	173	245	173	133	148
	Ratio (Design)			1.0	0.8	0.9
	Ratio (Overload)			0.7	0.5	0.6

Chehalis Dam Road Access Feasibility Evaluation

Road Reconnaissance Notes

August 22 -23, 2018
Bill Laprade - Shannon & Wilson



0 0.5 1

Approximate Scale in Feet

N

NOTE

Base map provided by Weyerhaeuser Company, received August 2018.

LEGEND

(1) Field Sites Referred to in Text

Chehalis Basin Flood Mitigation
Lewis County, Washington

HAUL ROAD RECONNAISSANCE

September 2018 21-1-21897-025

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1

Filename: J:\211\21897\025\21-1-21897-025 Haul Road Reconnaissance.dwg Layout: Layout Date: 09-13-2018 Login: sac

Road Reconnaissance Notes (WTL and Steve Faulkner, 8-22 and 8-23-18)

1. Abandoned 1000 Road destroyed by 2007 flood. Existing road is 5'-7' of talus fill over basalt, with very steep undercut slope on the river side. Talus slope on the inboard side. Road improvement would need to be on the inboard side by excavating the talus back to the bedrock cliff. Would need a barrier on the outboard edge.
2. Sorting Yard Bridge, 18' wide
3. Gentle slope on the uphill side; no problem. Move road into hillside
4. Basalt outcrop on inboard side. Shoot rock for 10'-20' for full-bench road width.
5. Big Creek Bridge, 18' wide
6. South Quarry road. Presently 14' wide and ½ bench road. Need to blast rock outcrop on inboard side for full-bench road width.
7. Relatively level ground. Double the present width easily.
8. Existing Rock Creek Quarry road. Narrow (12') and rutted. Need complete rebuilt with much rock. Move into inboard as there is a creek on the outboard side.
9. Steep on both sides. Need to make one-way with pull-outs at strategic spots.
10. Complete rebuild for double wide. Presently 14' wide and rutted. Cut slopes are weathered bedrock and raveling. Move into inboard side, but a little fill possible on outboard.
11. Bridge out; need new bridge about 95'-100' long. Channel about 20'-25' wide
12. 11'-12' wide existing road. Several drainage swales that are wet and muddy in the spring. Slopes are gentle, so easy to widen to double width on both sides. Complete rebuild
13. 11'-12' wide existing road. 6'-8' high bank on inboard and gentle slope on the outboard. Many places no inboard bank at all. Easy complete rebuild.
14. Easy complete rebuild both sides. No cut or fill.
15. On a ridge. Flat both sides. Good existing road 16' wide. Widen both sides.

16. On side slope. Steep outboard edge. Cut into 6'-10' high bank on inboard side for double width. Existing road 16' wide. Good road base.
17. Possibly connect the two roads across for shortcut.
18. On side slope. Steep on outboard. Keep widening to the inboard side into 6'-10' high bank. Good road base.
19. Existing road 15' wide on ridge top. Level both sides. Expand both sides easily.
20. Alternate connector road to the 380 Road. Fewer curves and on ridge top. Good road base.
21. Ridge top road. Almost all level both sides. Easy expansion to double the width. Road needs more rock.
22. Grade down to the north on side slope. Cut slope 4'-12' high on inboard side. Steep slope on the outboard side. Need to cut on the inboard; easy.
23. Ridge top road, but with short sections of cut slope on inboard side. Existing road good, easy rebuild to double width.
24. Sharp curve. Need to fill in swale to west and create larger radius curve for trucks.
25. Steep 10-14% grade road with cut slope 10'-12' high. Need to cut on inboard side into weathered siltstone.
26. Ridge top road. Easily widen to double both sides. Weak subgrade, scattered potholes.
27. Short section off ridge top to lower road gradient. Need to cut into 8'10' high cut slope on inboard side.
28. Ridge top road. Plenty of room to widen to double width both sides
29. Ridge top road 18' wide. Widen both sides easily.
30. Curve around rock knob. Enough room to widen to double width in existing cleared width.
31. Ridge top road. Expand to double width easily both sides.
32. 16% downgradient road with 4'-6' banks on inboard side. Steep slope on outboard side. Need to cut into cut slope for double width.
33. Steep gradients, 16-18%, down and up. Plenty of room to widen to double width.
34. Steep slope outboard side. Cut into inside cut slope.

35. 6’-15’ high new road cut for landslide bypass on 1000D2 Road to the south. Not steep on outboard side. Can cut into weathered basalt on inboard side.
36. Ridge top road. Widen easily to double width both sides.
37. Sharp curves with steep slopes on inboard side. Road 10-15% gradient. Need to realign road to decrease curves by cutting on the inboard side and using material to smooth road gradient.
38. 13’ wide road with 8’-10’ high cut slope. Need to cut into cut slope to widen road to double width.
39. Cut slope 10’15’ high on inboard side. Steep slope down to Crim Creek on outboard side. Need to widen into cut slop; intermittent colluvium and bedrock.
40. 20’ high rock cut on inboard side in weathered to fresh basalt. Road 14’ wide. Steep slope down to Crim Creek on outboard side. Widen into rock cut slope for full width.
41. 16’ wide road with 10’-20’ high cut slope in weathered basalt. Steep outboard slope. Cut into inboard slope, but can fill a little on outboard. Easy cut/fill.

General Notes:

1000 Mainline Road 22’ wide

Panesko Bridge 18’ wide

Crim Creek Bridge 18.5’ wide. Need to cut slope east of bridge for proper radius.

Attachment 2

14 CONSTRUCTION SCHEDULE

14.1 Construction Sequence

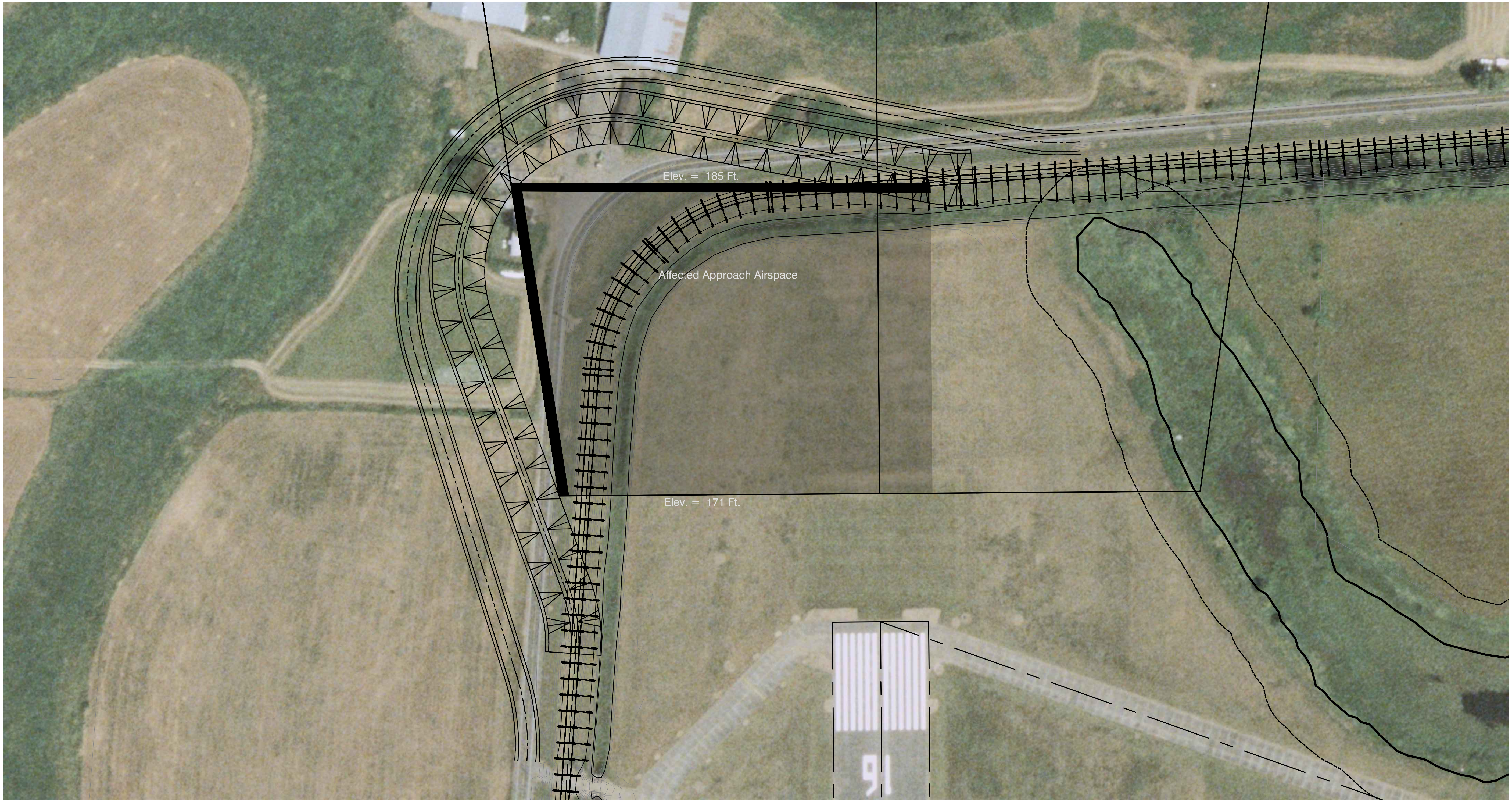
A conceptual sequence for construction is described in Table 14-1. As illustrated by the sequence, construction schedule could be significantly influenced by flow conditions, and there are numerous schedule dependencies that would influence the completion date for the project.

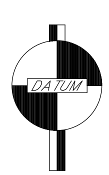
Table 14-1
Preliminary Construction Sequence

WORK BREAKDOWN	SEQUENCE CONSIDERATIONS
TUNNEL CONSTRUCTION & INITIAL DIVERSION	
• Isolate portal areas from river flow	Low-flow limitation
• Slowly dewater and "fish" portal areas	Manually and safely remove fish from the areas to be dewatered and return them to the active river system
• Construct tunnel portals	Low-flow limitation
• Build the diversion tunnel by advancing from the downstream side portal to the upstream side portal	Low-flow limitation during completion of tunnel at upstream end.
• Build temporary berm to divert low flows through tunnel	River diverted – low flow
CONSTRUCT COFFERDAMS	
• Prepare flow diversion cofferdam foundation	Low-flow limitation
• Construct cofferdams, RCC upstream	Diversion ready for capacity flows; probable low-flow limitation; start flood risk
• Slowly dewater and "fish" areas behind cofferdams	Manually and safely remove fish from the areas to be dewatered and return them to the active river system
FOUNDATION PREPARATION	
• Excavate abutments & bottom	Emphasize right side to allow structure starts
• Prepare river outlet foundation	Start primary flood risk. Consider grout curtain continuity, avoid undercut
• Perform curtain grout	Include consolidation grouting, if required
• Foundation treatments & dental concrete	Prudent to allow some schedule contingency
LOWER-LEVEL HYDRAULIC STRUCTURES	
• Construct lower-level river outlet works (ROW)	Precedes RCC, through encasement. Includes flood control conduit/passage, ROW piping
• Construct initial energy dissipation, stilling basin	
• Construct lower-level fish passage	
RCC AND DAM	
• Place RCC – bottom to top of ROW encasement	Preceded by quarry development, initial aggregate processing, plant and delivery setup, trial section

WORK BREAKDOWN	SEQUENCE CONSIDERATIONS
• Place RCC – top of ROW to spillway break, include flip bucket mass block	RCC concurrent activities; aggregate processing, instrumentation, gallery construction, face and drain system construction, abutment preparation, ongoing ROW, stilling basin, fish passage construction. Primary flood risk complete
• Place RCC – right wing	
• Place RCC – right side to crest	
• Place RCC – left side to crest	
RIVER OUTLET WORKS	
• Complete intake, gate & service shaft, control structures	Gate & service shaft likely to precede RCC, but formed void could be considered
• Install flood regulating gate	
• Install river outlet gates	
• Install river outlet trash racks & metals	
• Complete ROW & flood regulating mechanical & controls	
• Complete control structure – electrical, mechanical & building trades	ROW ready for re-divert & tunnel plug
SPILLWAY	
• Complete stilling basin & energy dissipation structures	
• Complete plunge pool preparation	Spillway ready for re-divert & tunnel plug
• Construct spillway training walls	
• Construct spillway chute and flip	
• Construct spillway ogee	
• Construct spillway piers & bridge	
FISH PASSAGE	
• Complete downstream fish passage and mechanical	Fish passage ready for re-divert and tunnel plug
• Complete upstream fish passage	
• Complete fish passage conveyance	
• Complete fish passage mechanical & controls, building trades	
COMMISSIONING & RESTORATION	
• Complete electrical & mechanical commissioning	
• Final ROW access & grading construction	
• Breech cofferdams & re-divert river	Final flood risk complete
• Construct plug tunnel	
• Dam backfill, downstream and abutment grading	
• Complete quarry, access, & staging restoration	Preceded by reservoir clearing
• Project schedule contingency	

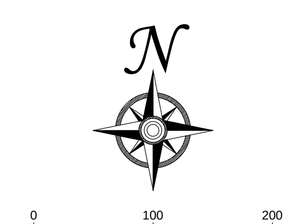
Attachment 3





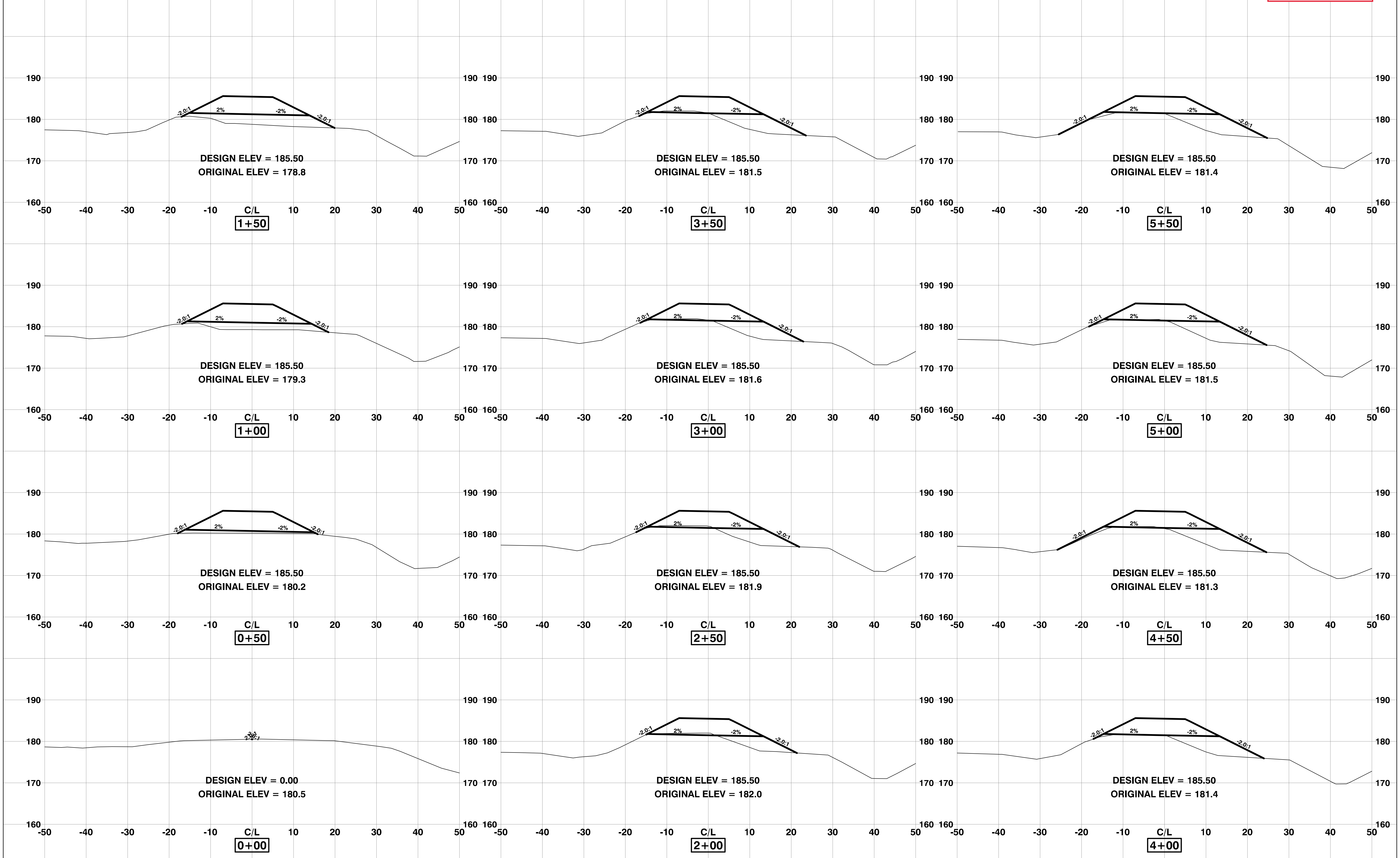
Lewis County
Department of Public Works

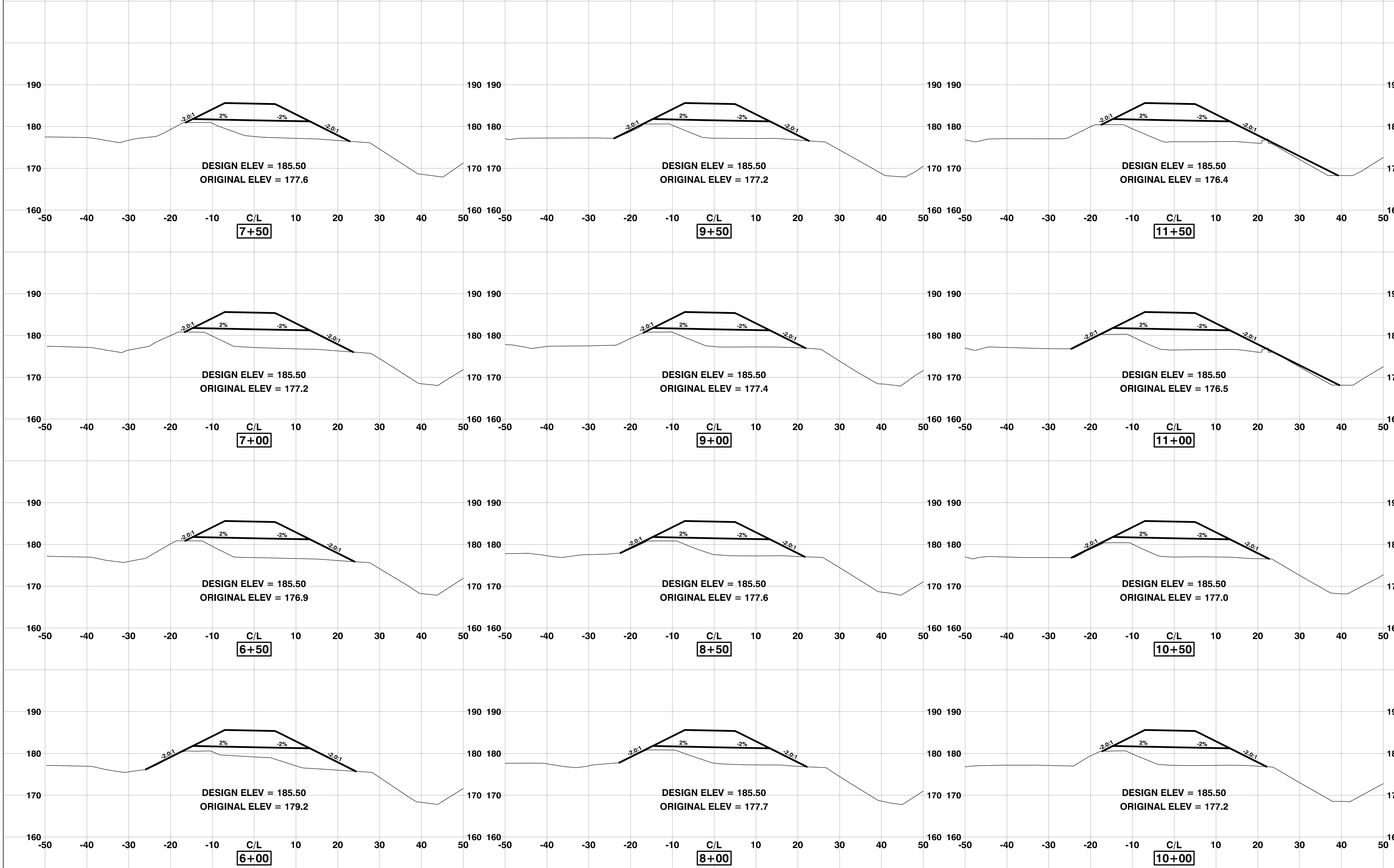
Airport Levee Phase Two, Three Feet of Free Board
No Approach Interference



AIRPORT LEVEE 1-A (SHEET 1 OF 20)

Attachment 4

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ORIGINAL ELEV = 177.6
7+50
DESIGN ELEV = 185.50
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9+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 176.4
11+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 177.2
7+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 177.4
9+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 176.5
11+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 176.9
6+50
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ORIGINAL ELEV = 177.6
8+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 177.0
10+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 179.2
6+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 177.7
8+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 177.2
10+00
-2.0:1
2%
-2%
C/L
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180
170
160
-50
-40
-30
-20
-10
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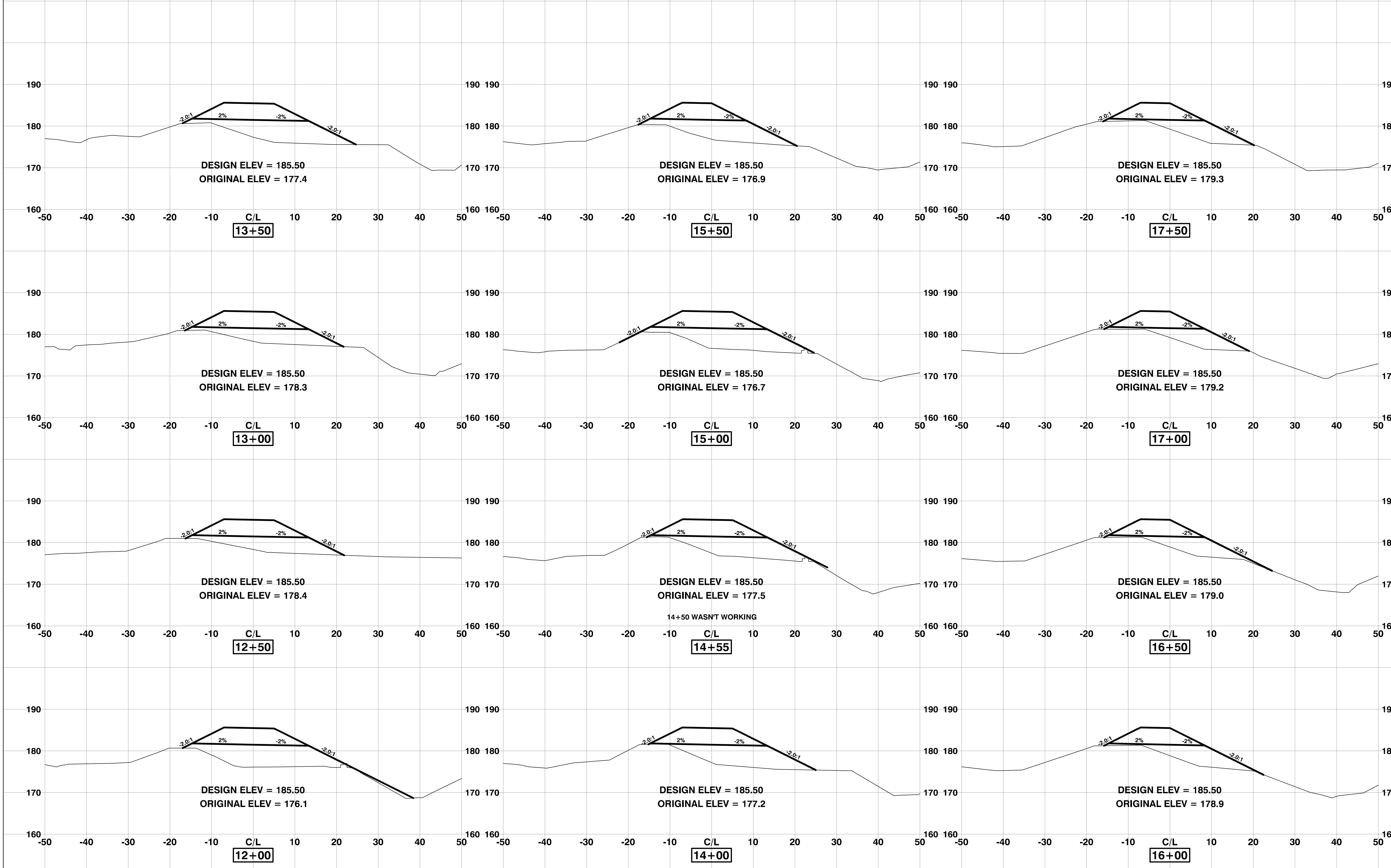
20
30
40
50


13+50
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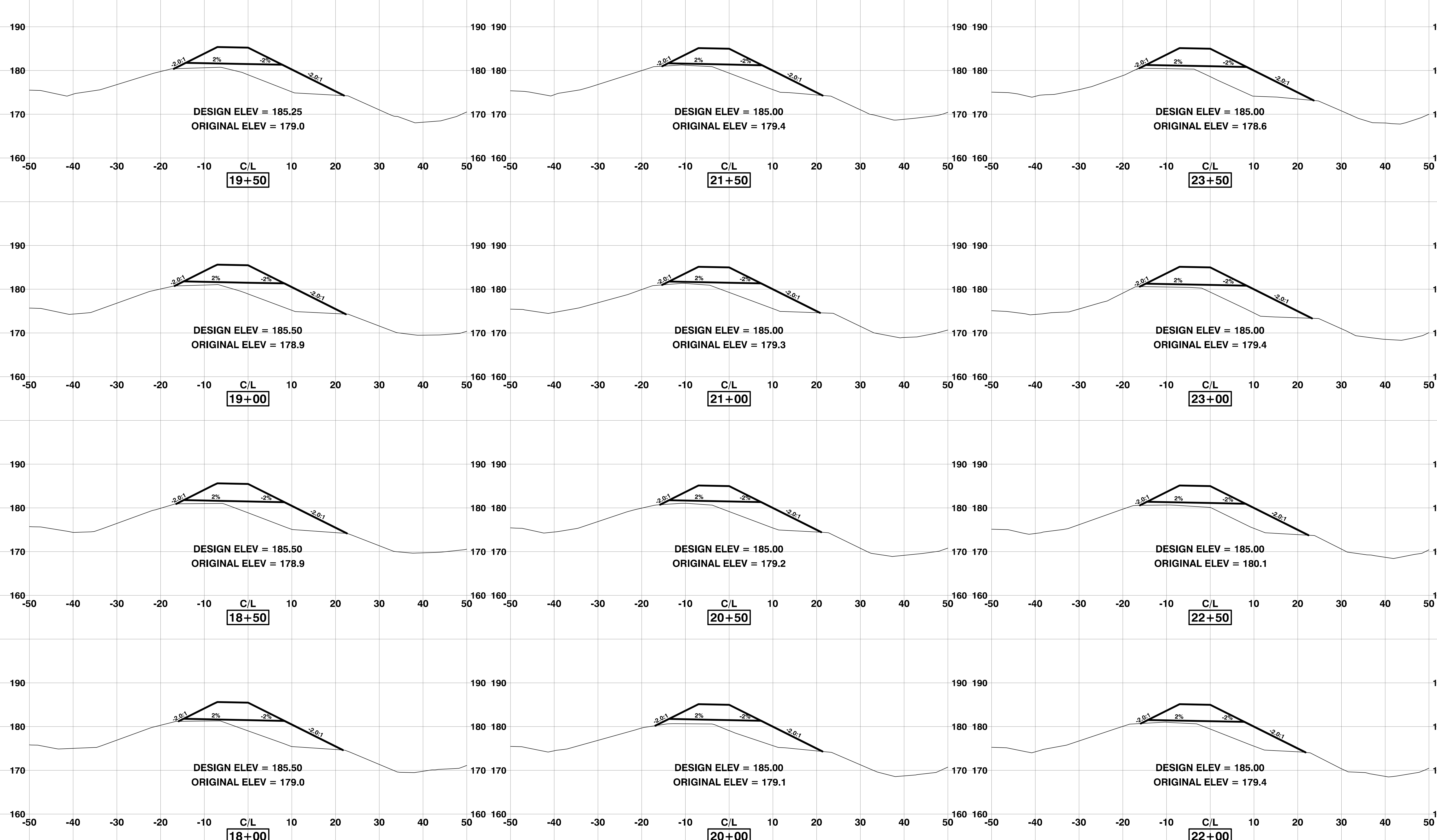
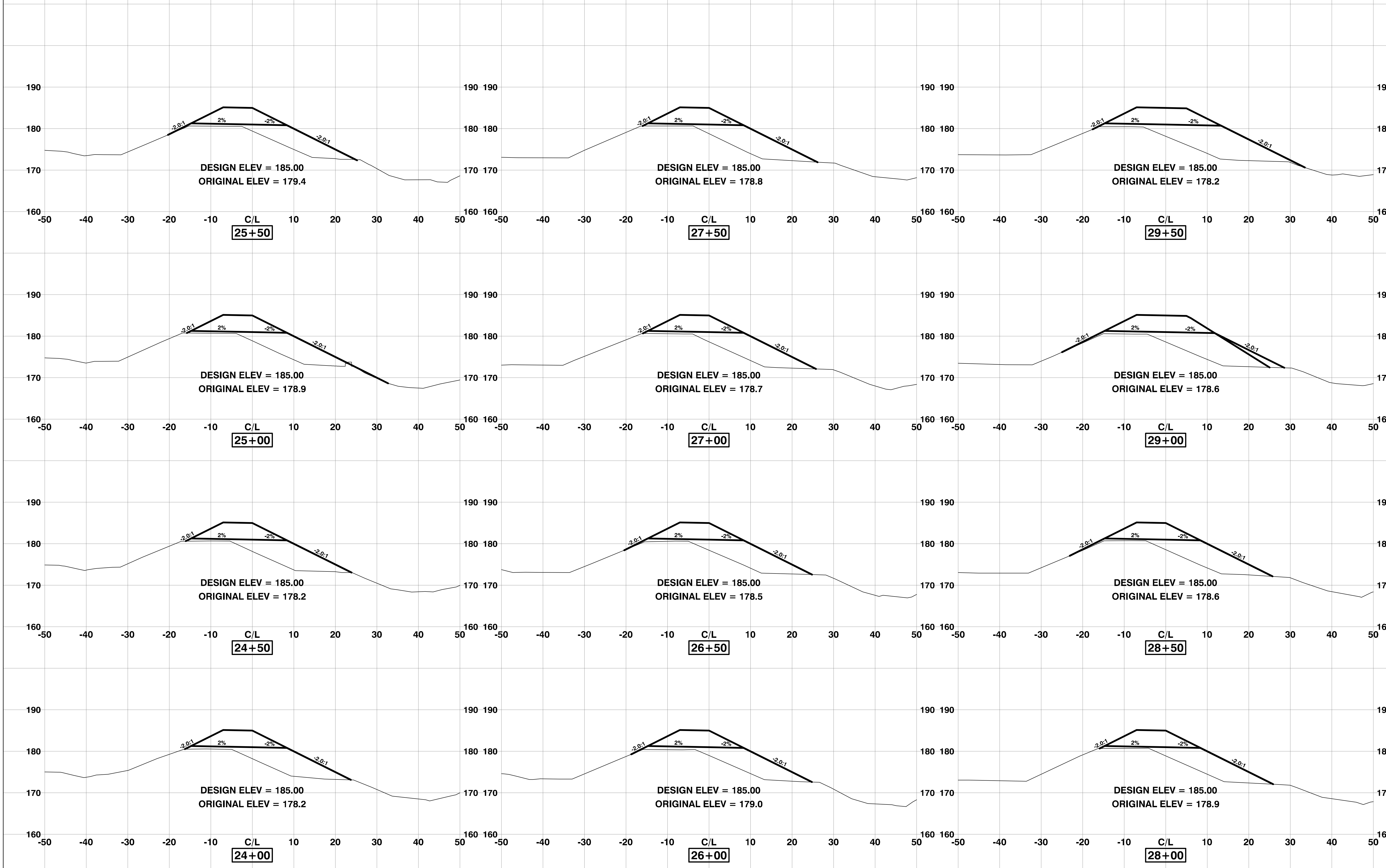
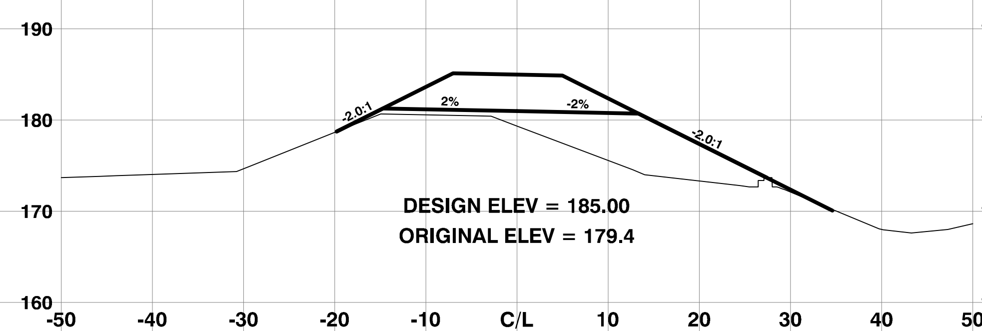
ORIGINAL ELEV = 177.4
15+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 176.9
17+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 179.3
13+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 178.3
15+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 176.7
17+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 179.2
12+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 178.4
14+55
DESIGN ELEV = 185.50
ORIGINAL ELEV = 177.5
14+50 WASN'T WORKING
16+50
DESIGN ELEV = 185.50
ORIGINAL ELEV = 179.0
12+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 176.1
14+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 177.2
16+00
DESIGN ELEV = 185.50
ORIGINAL ELEV = 178.9
-2.0:1
2%
-2%
C/L
190
180
170
160
-50
-40
-30
-20
-10
10
20
30
40
50

AIRPORT LEVEE 1-A (SHEET 4 OF 20)



AIRPORT LEVEE 1-A (SHEET 5 OF 20)





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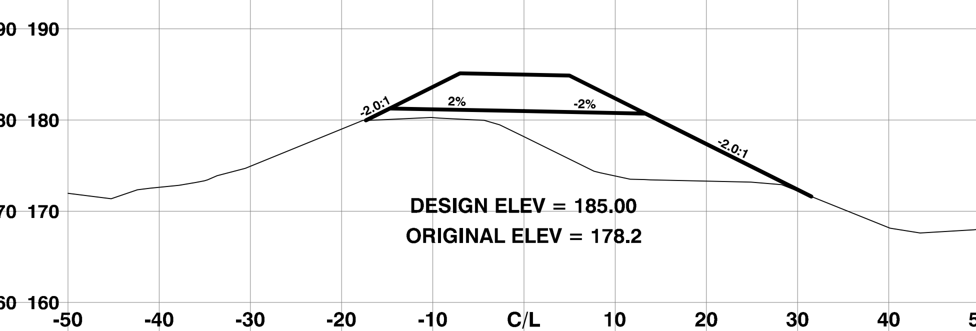

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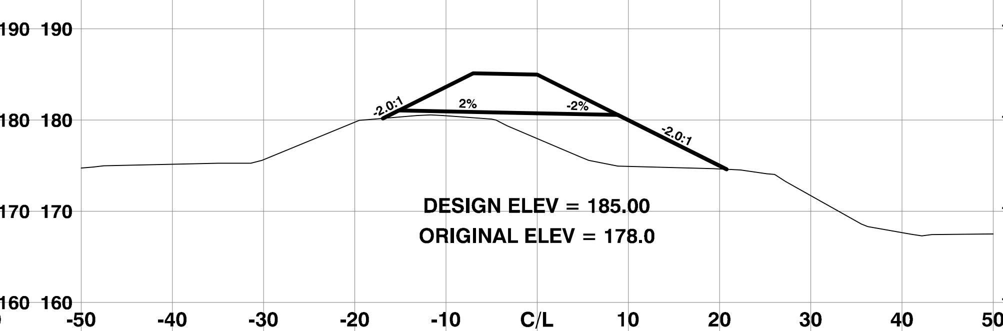

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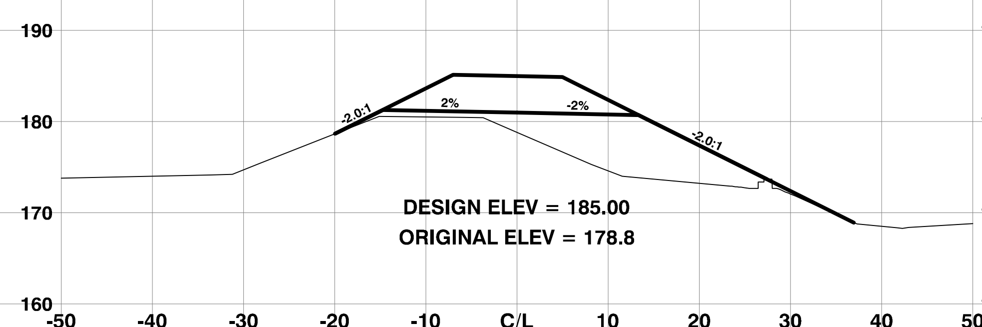

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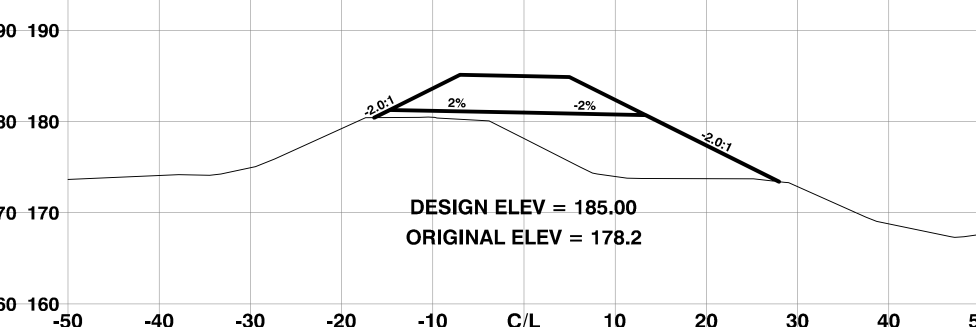

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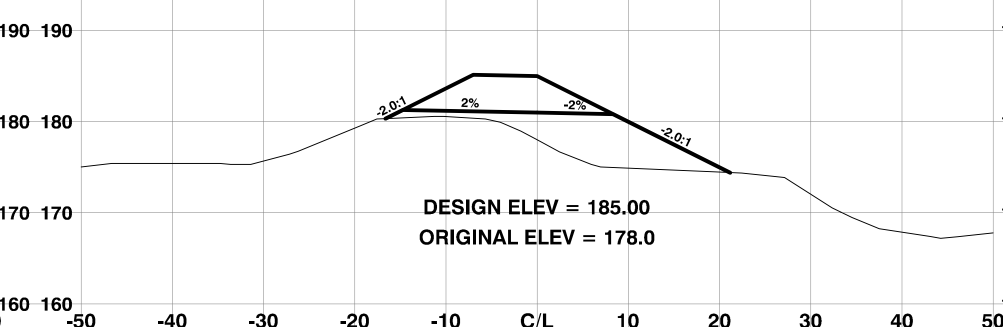

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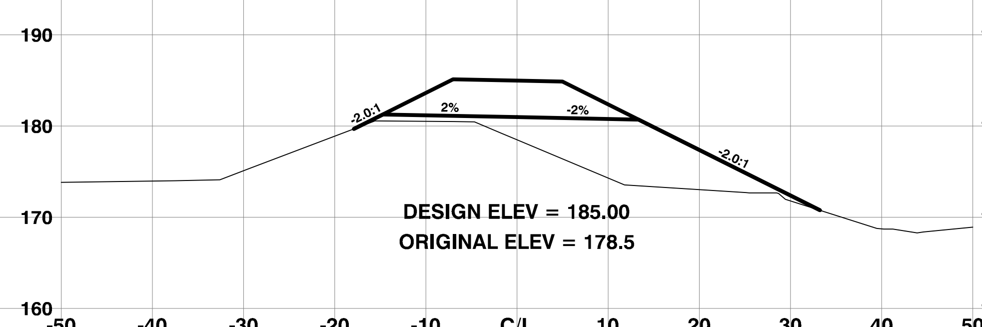

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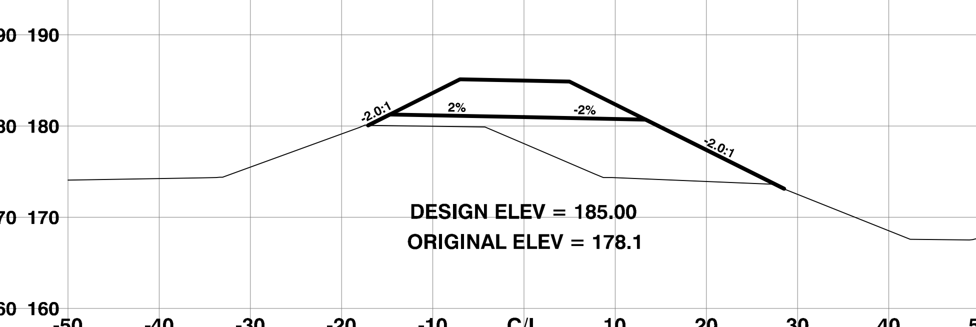

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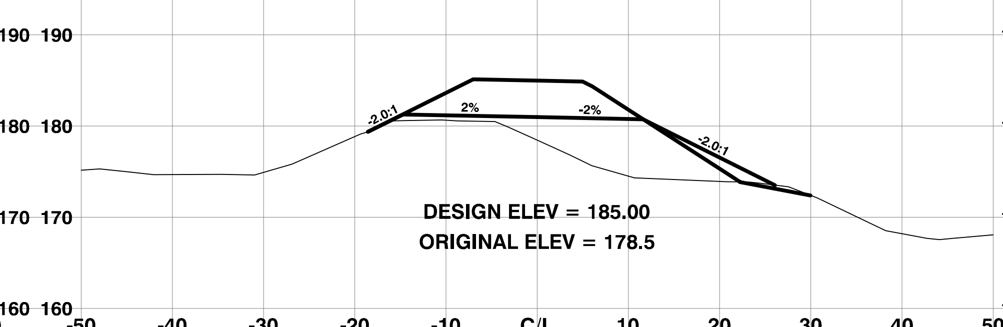

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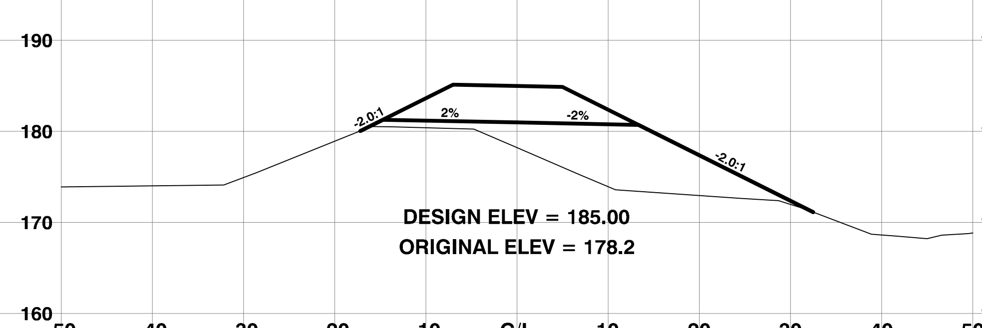

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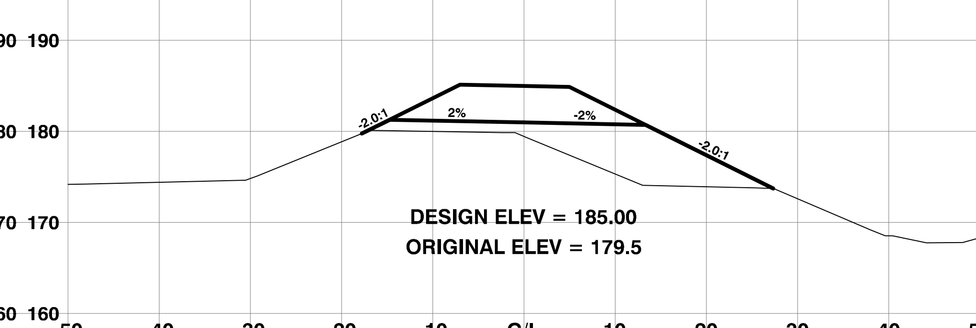

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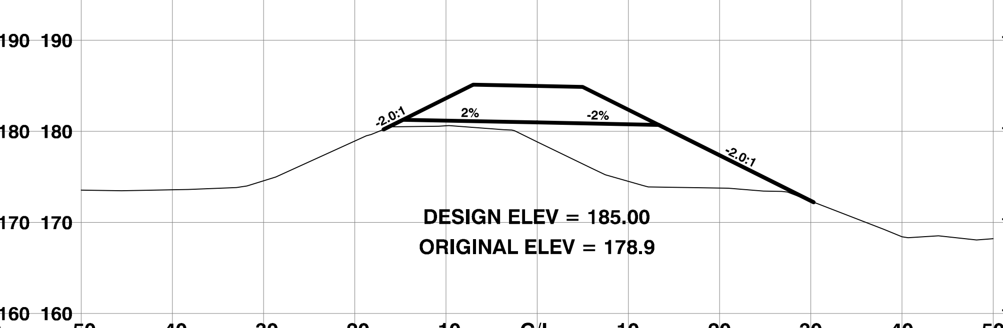

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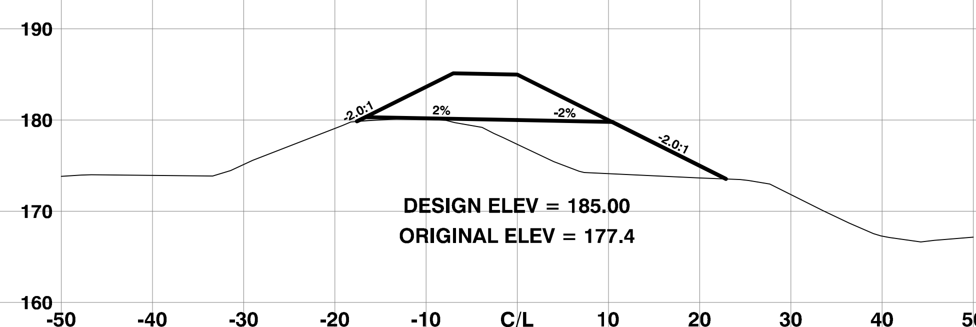

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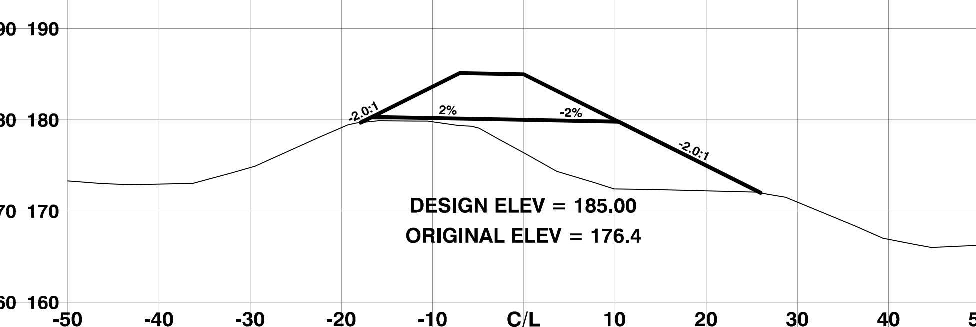

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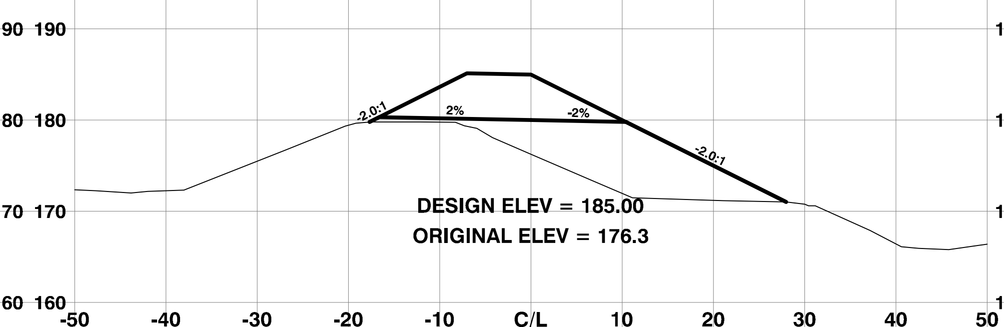

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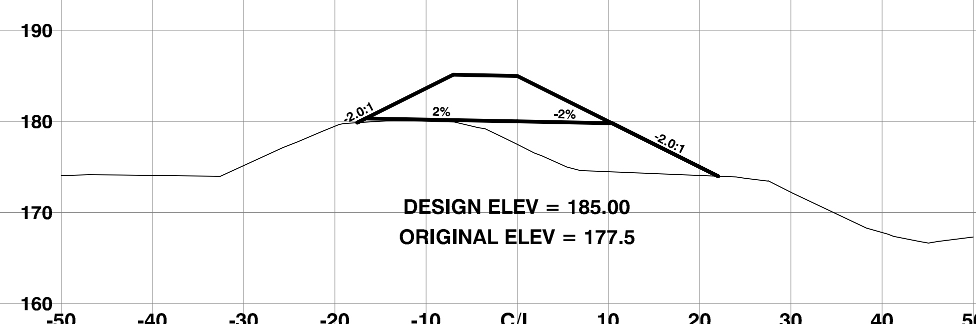

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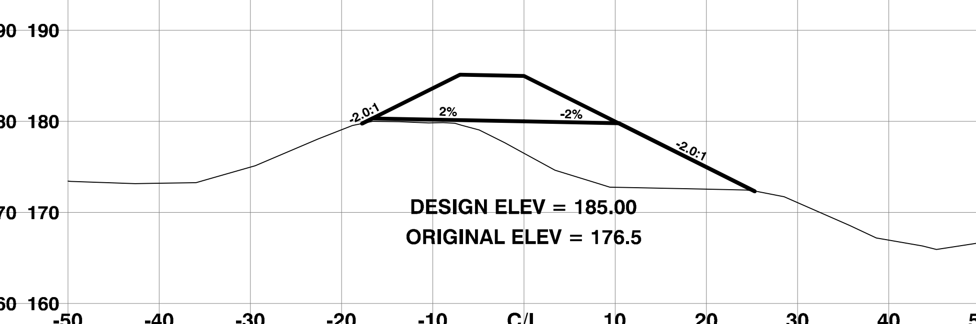

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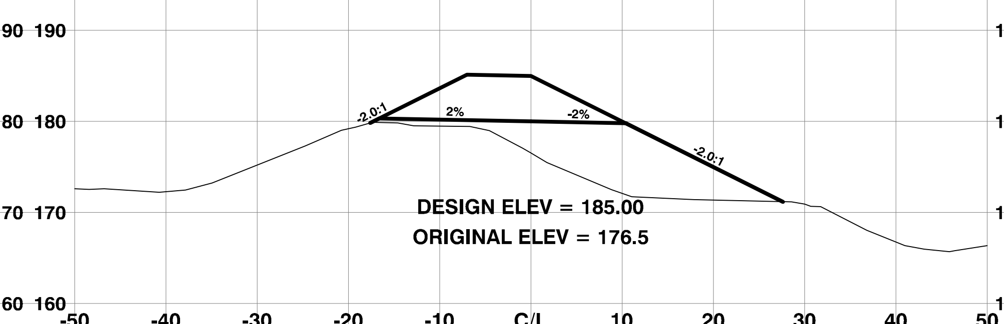

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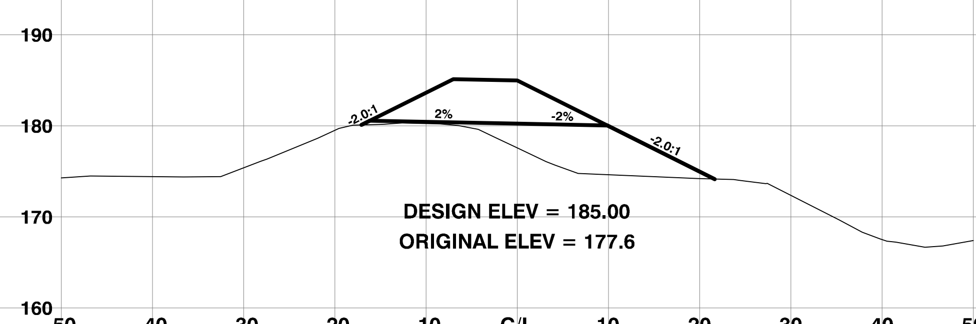

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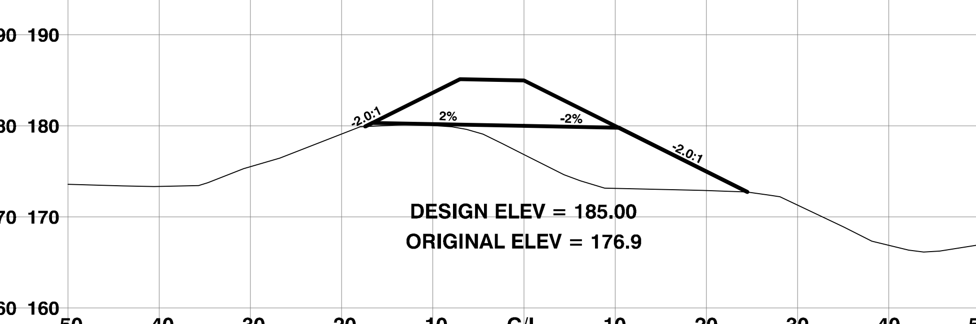

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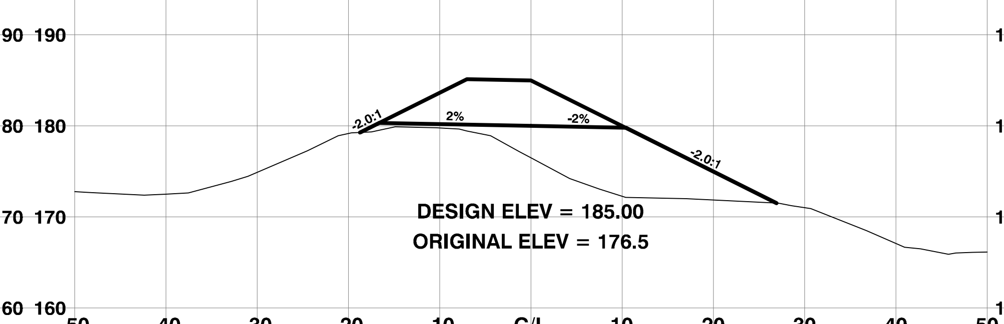

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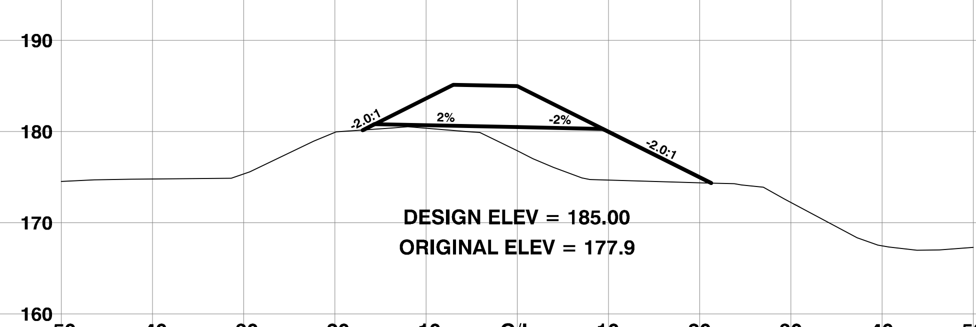

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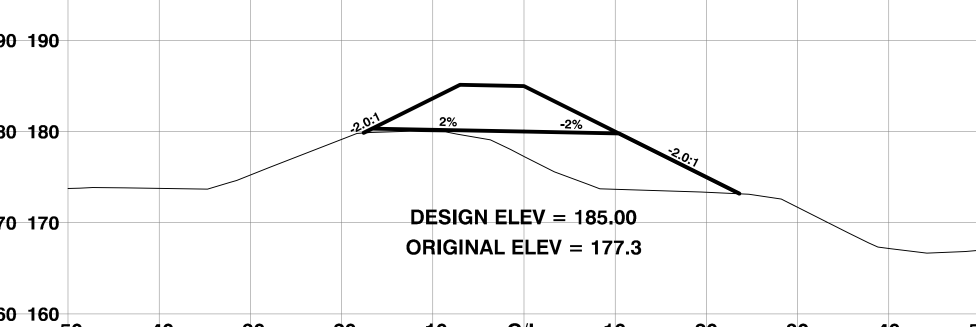

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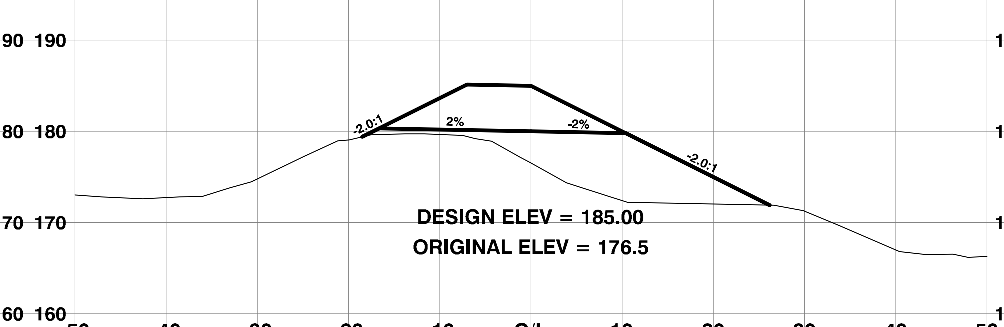

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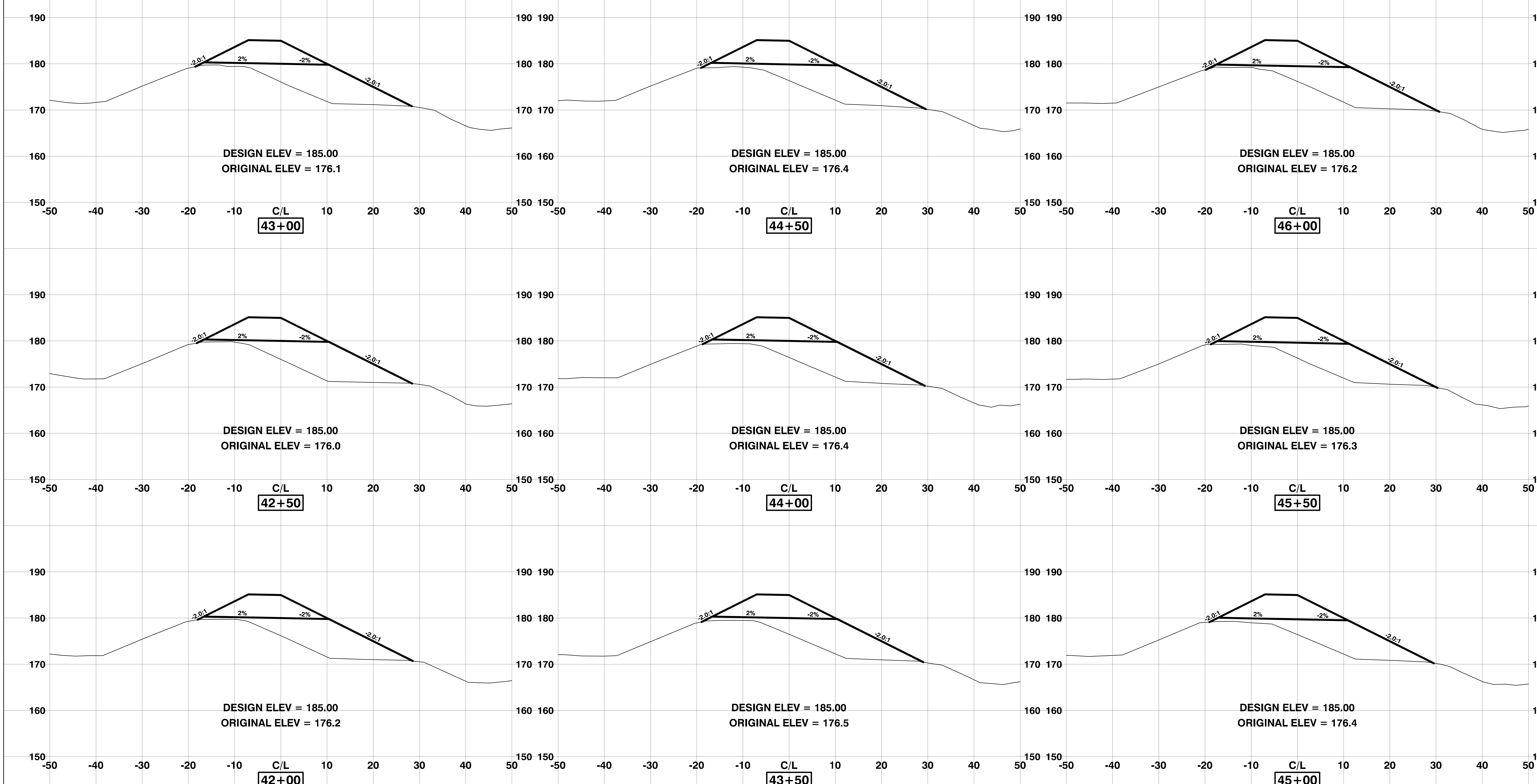
AIRPORT LEVEE 1-A (SHEET 8 OF 20)

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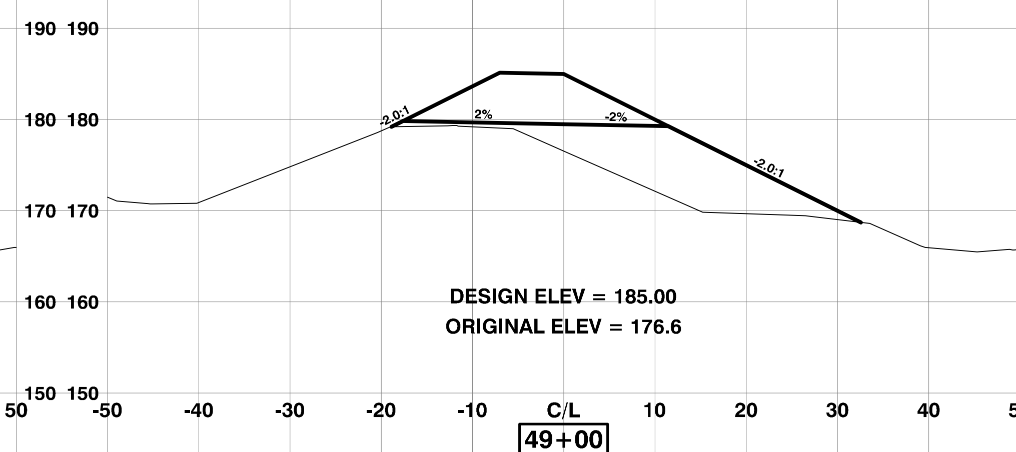
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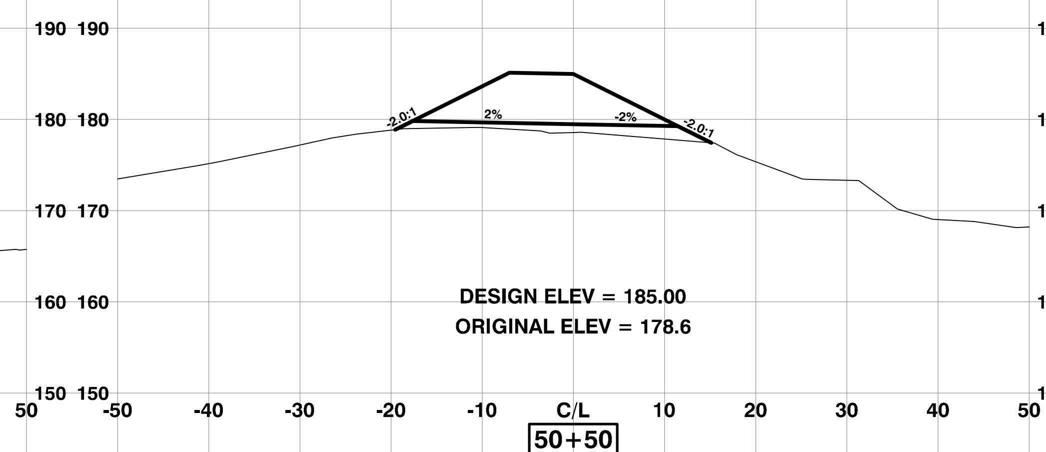
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C/L
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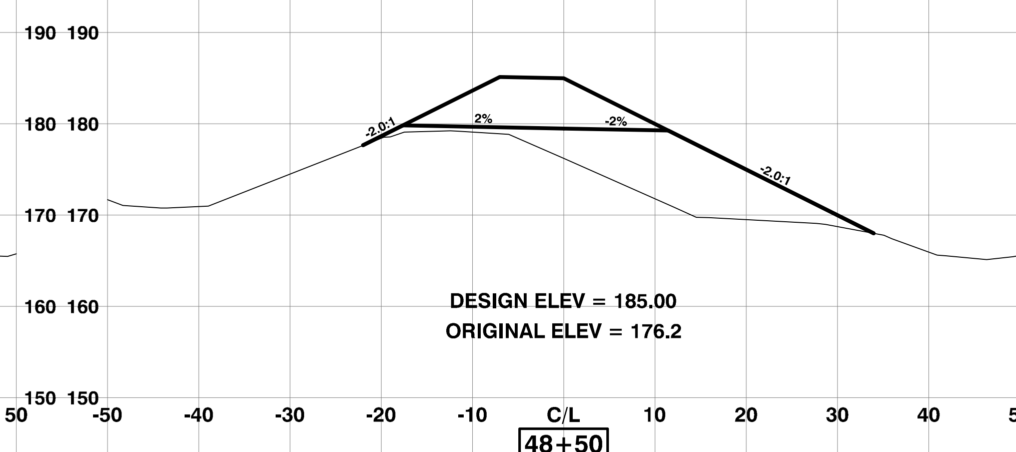
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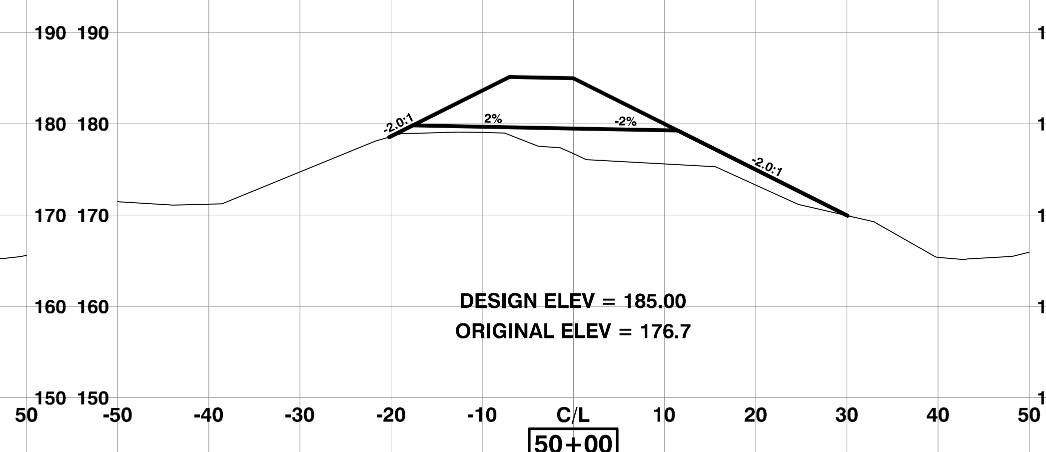
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C/L
50+00


-2.0:1
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-2%
-2.0:1
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C/L
46+50


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-2%
-2.0:1
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ORIGINAL ELEV = 176.4
C/L
48+00


-2.0:1
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C/L
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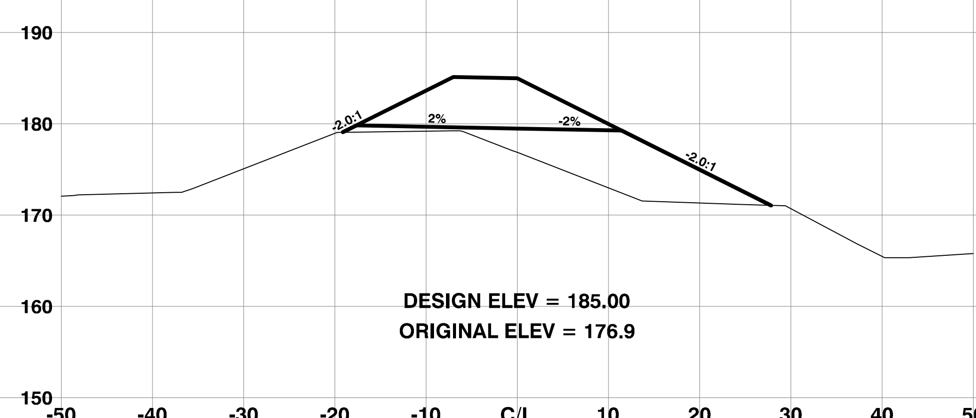
52+00

53+50

55+00



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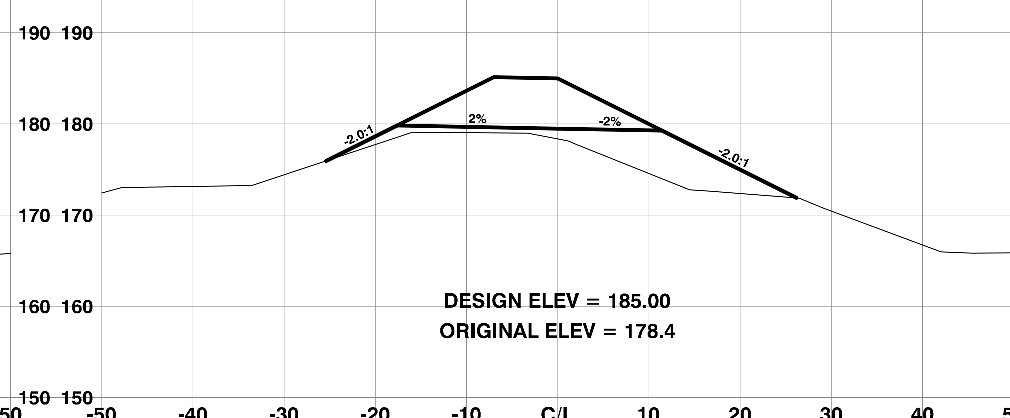

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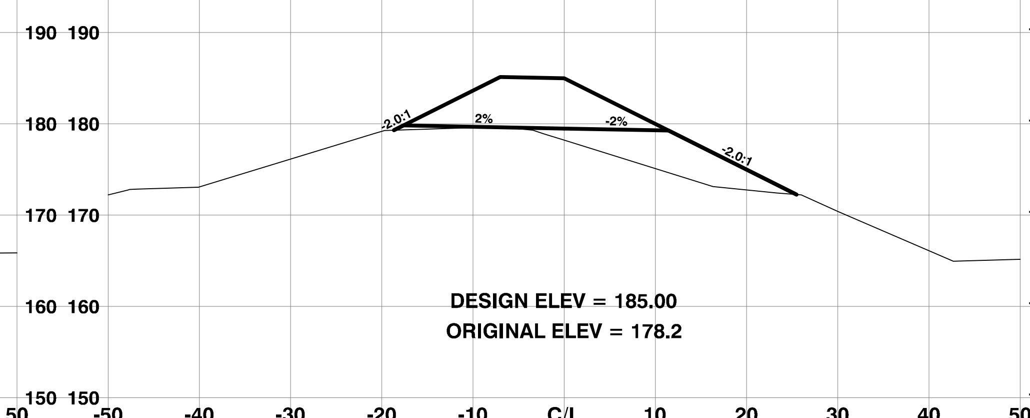

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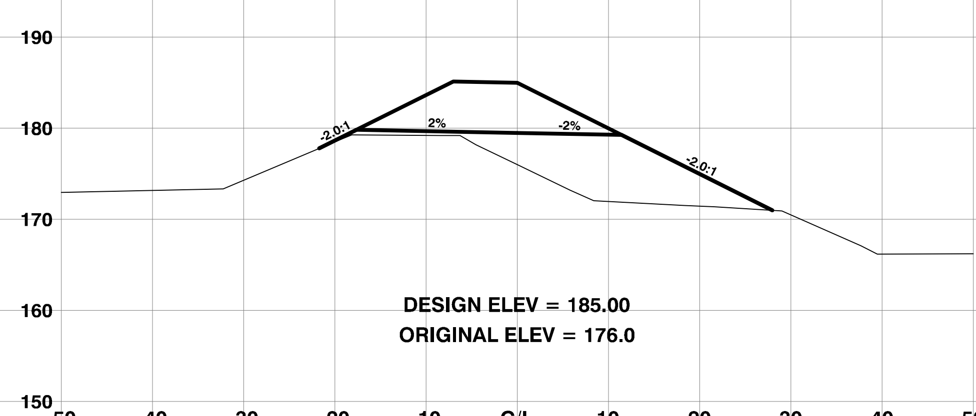

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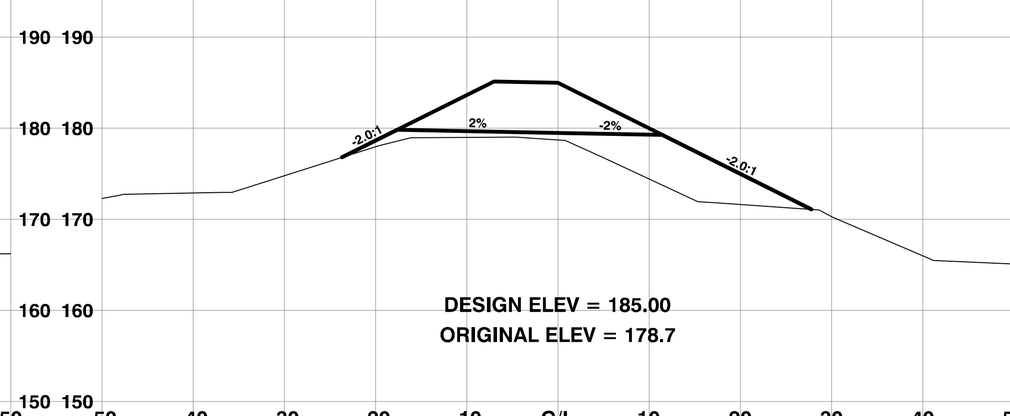

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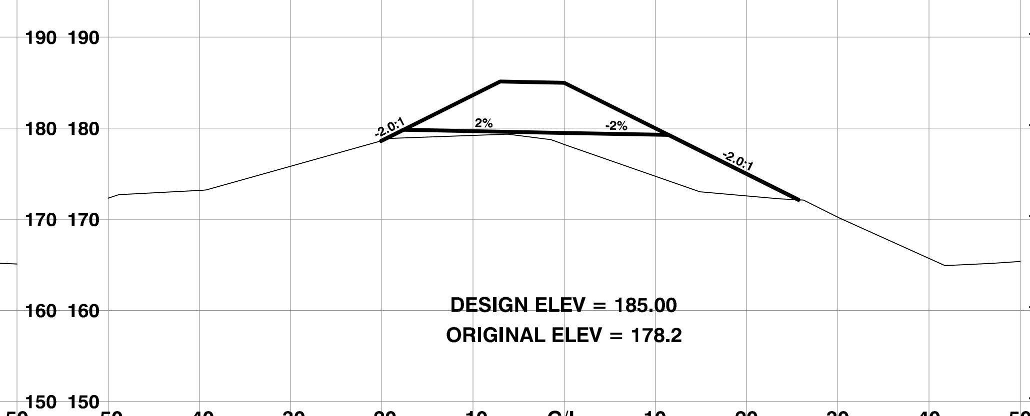

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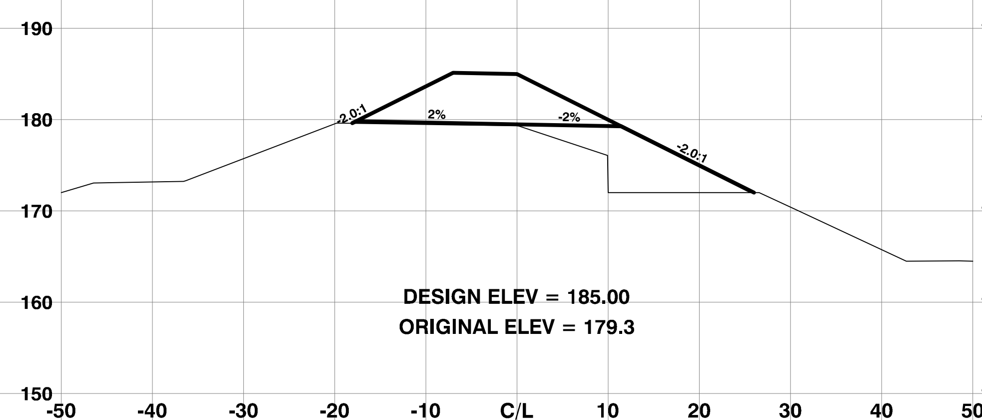

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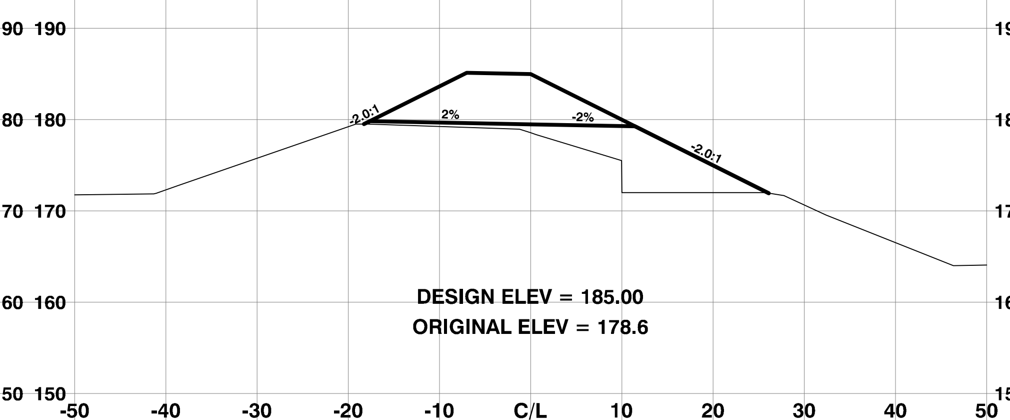

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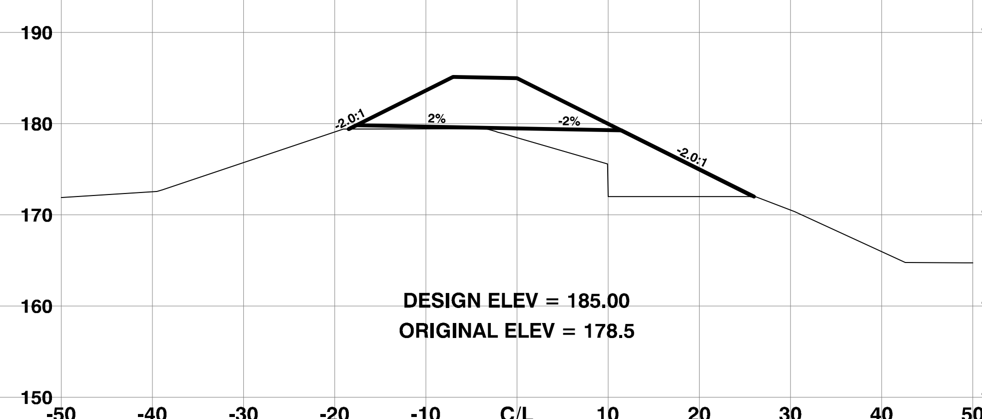

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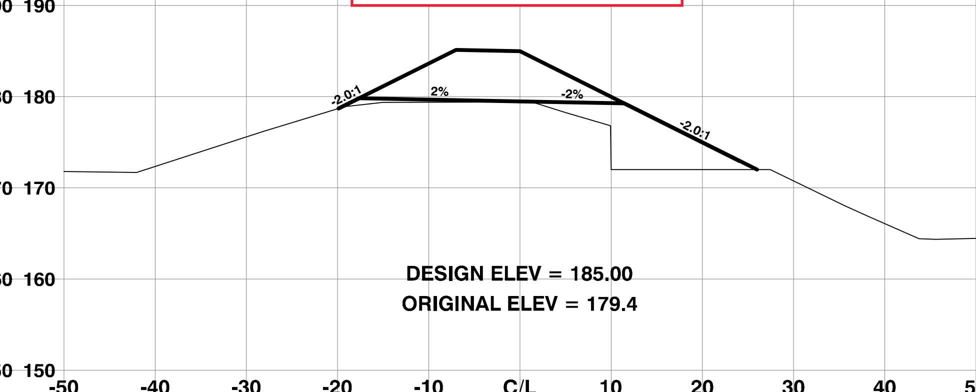

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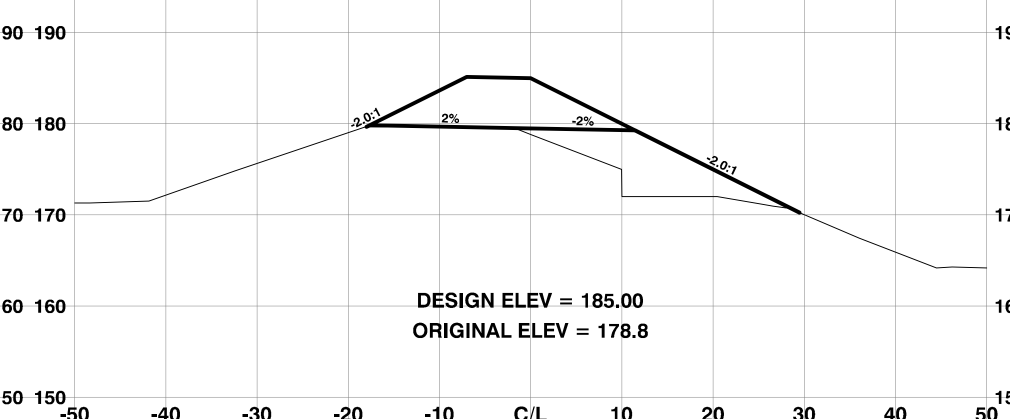

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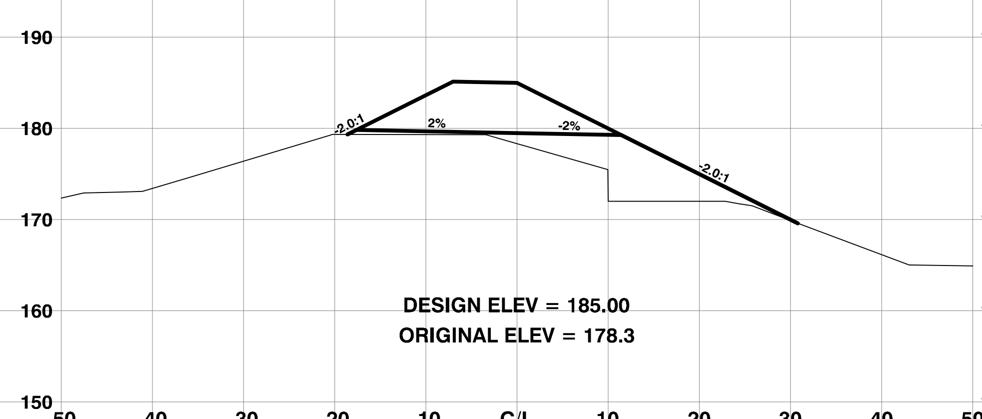

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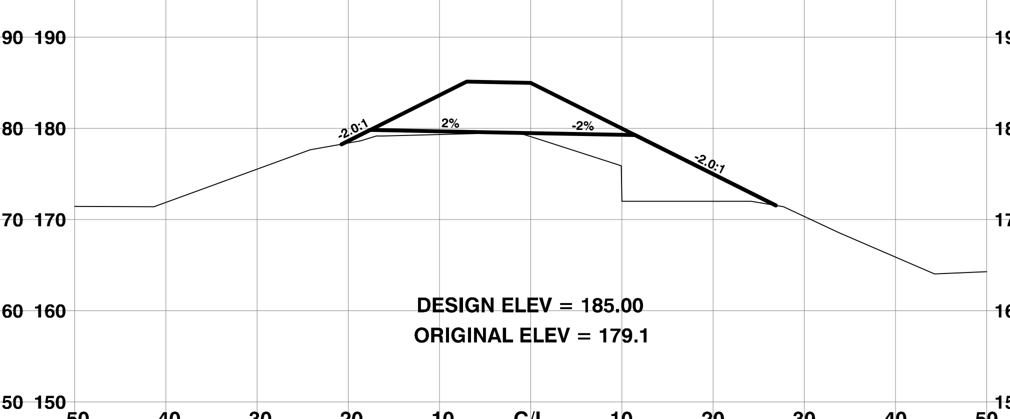

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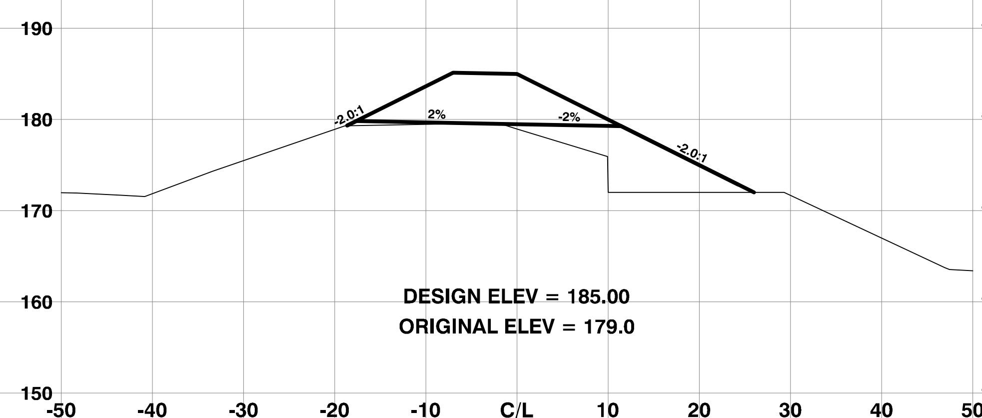

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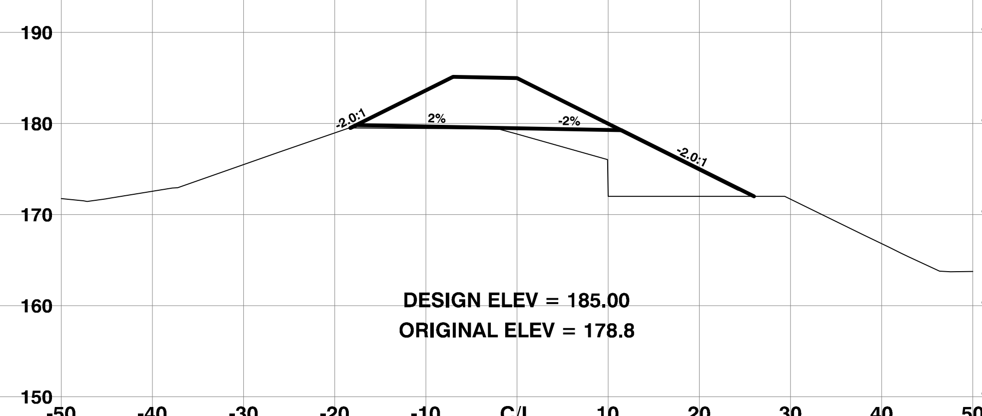

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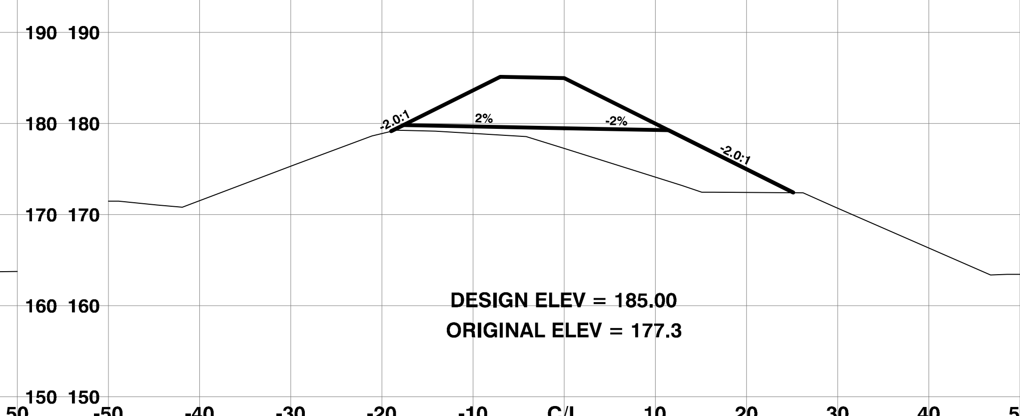

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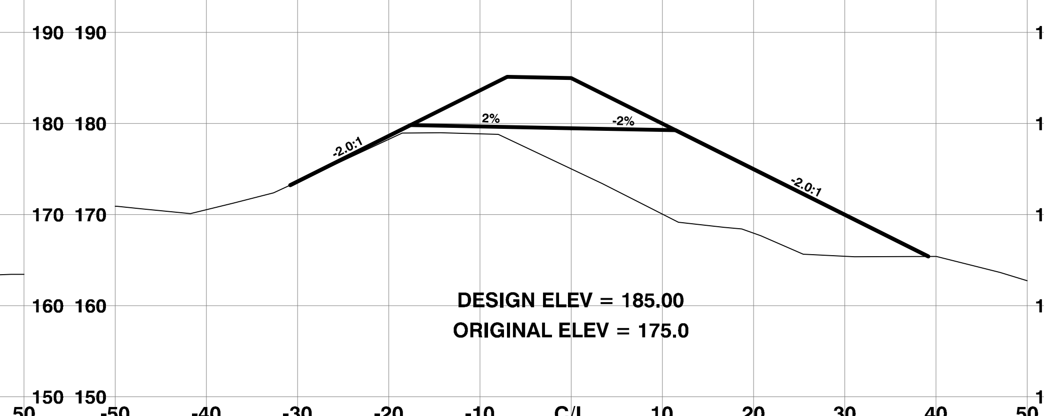

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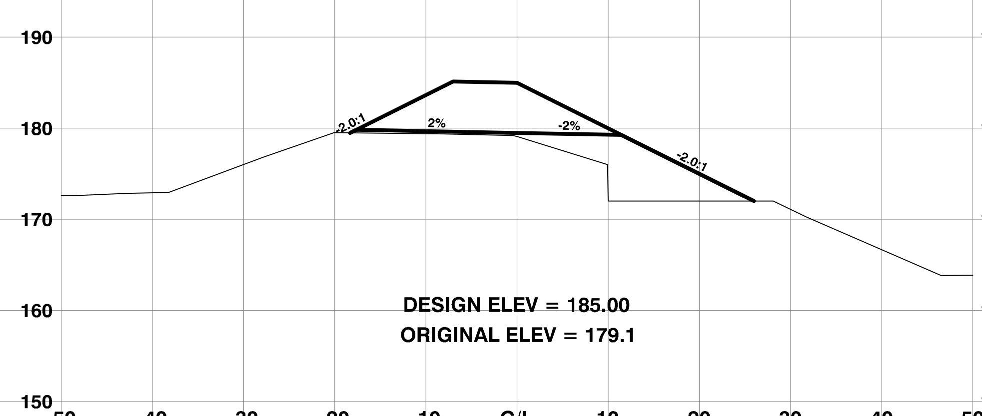

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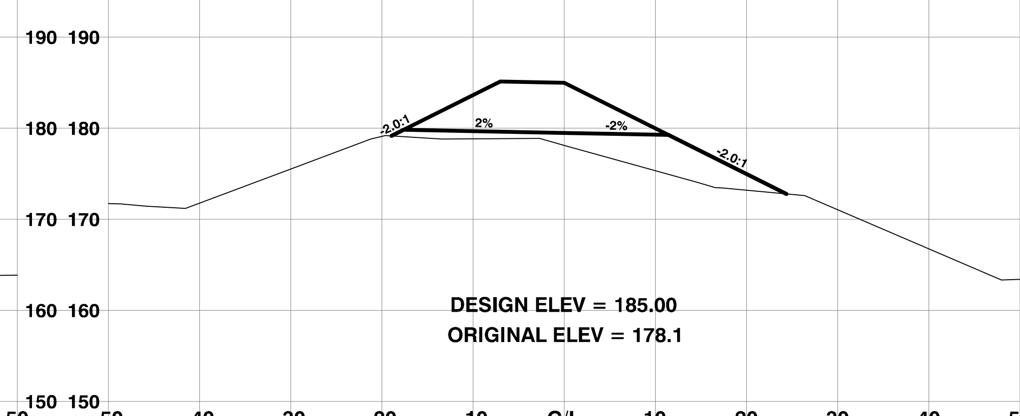

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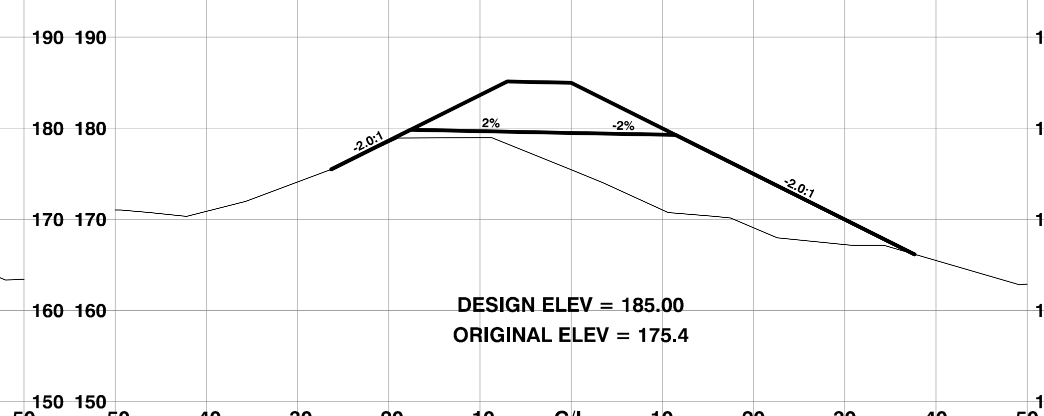

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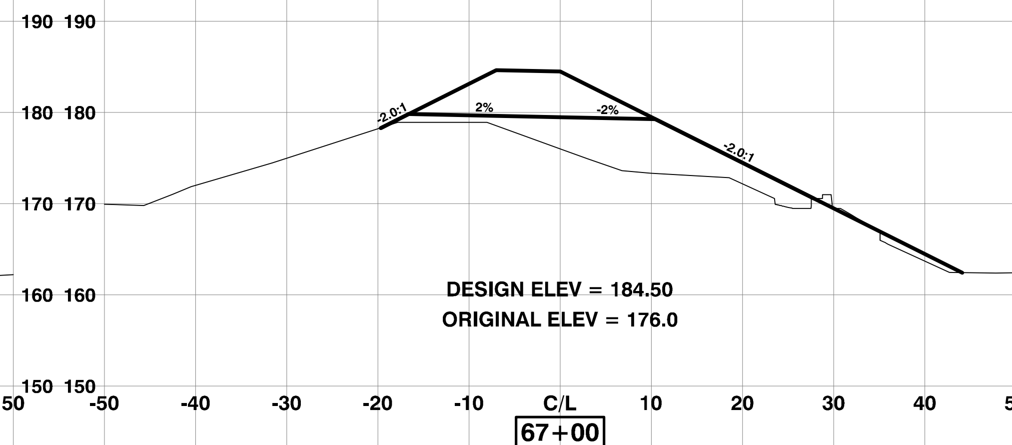
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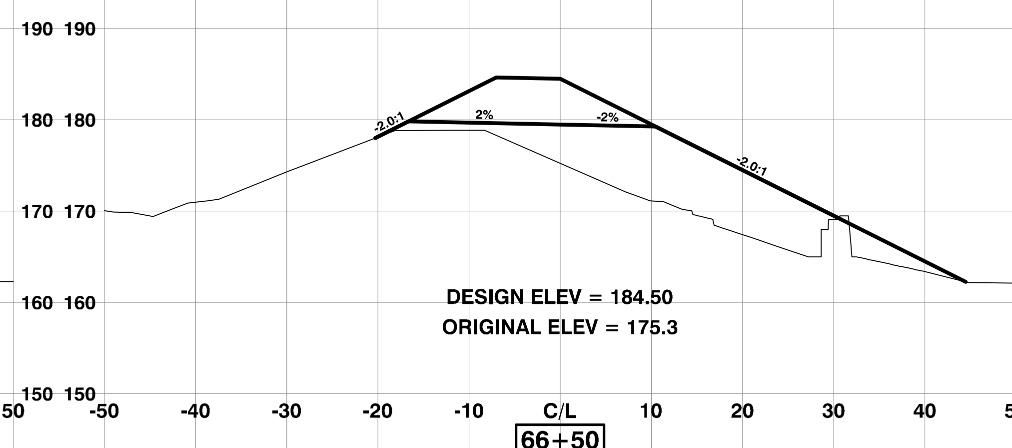
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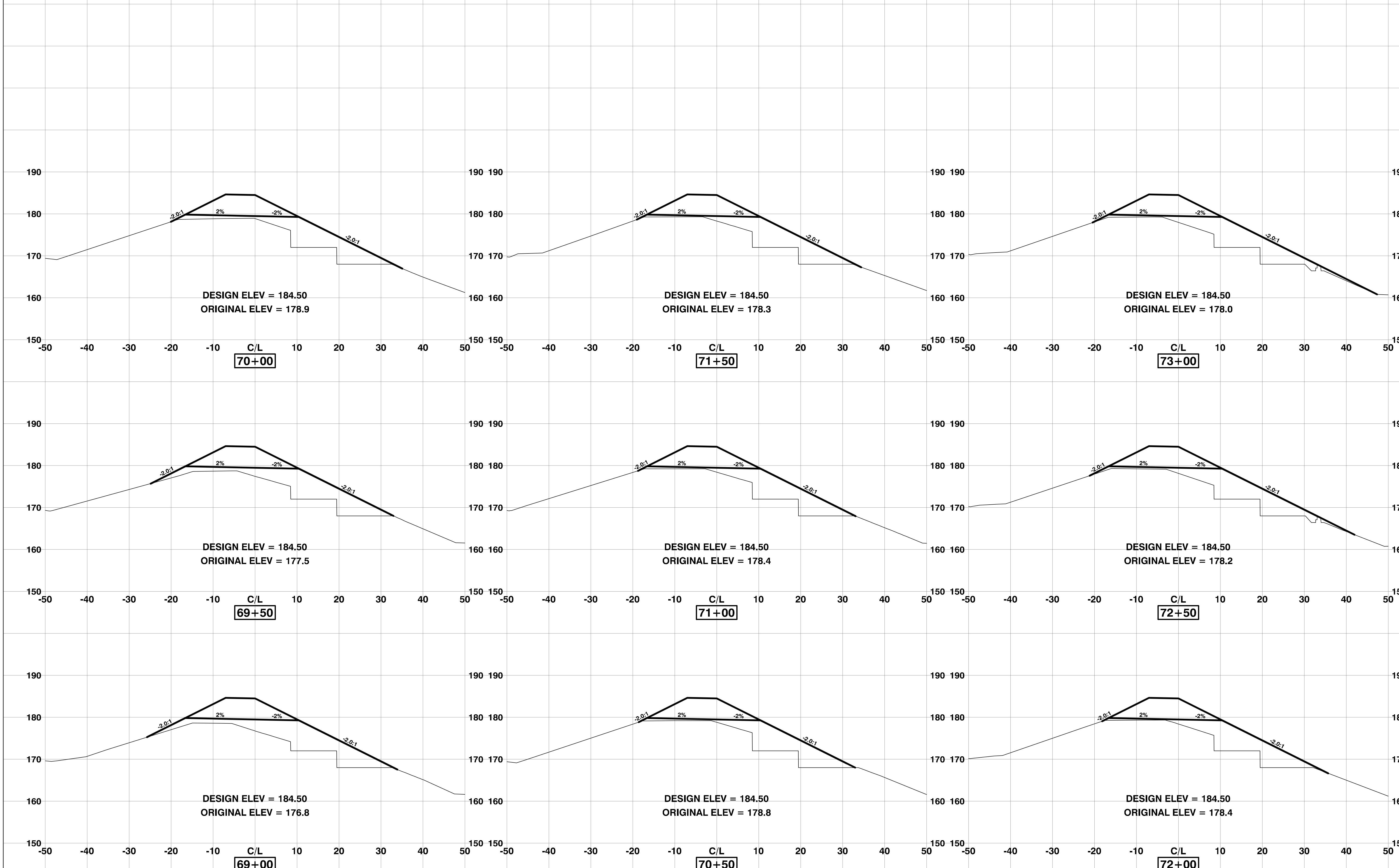
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72+00
2%
-2%
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C/L
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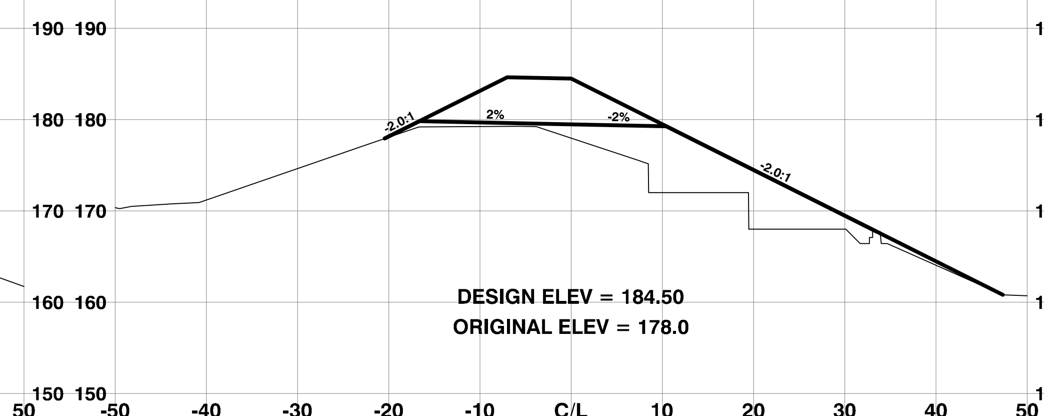
70+00

71+50



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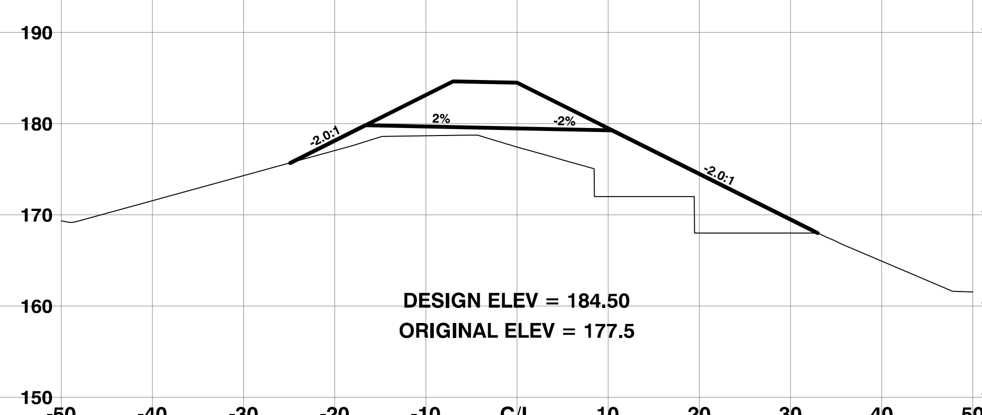

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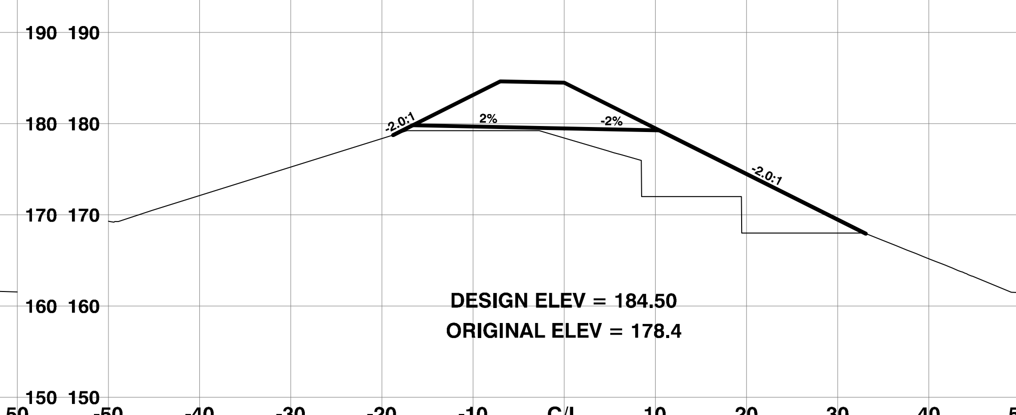

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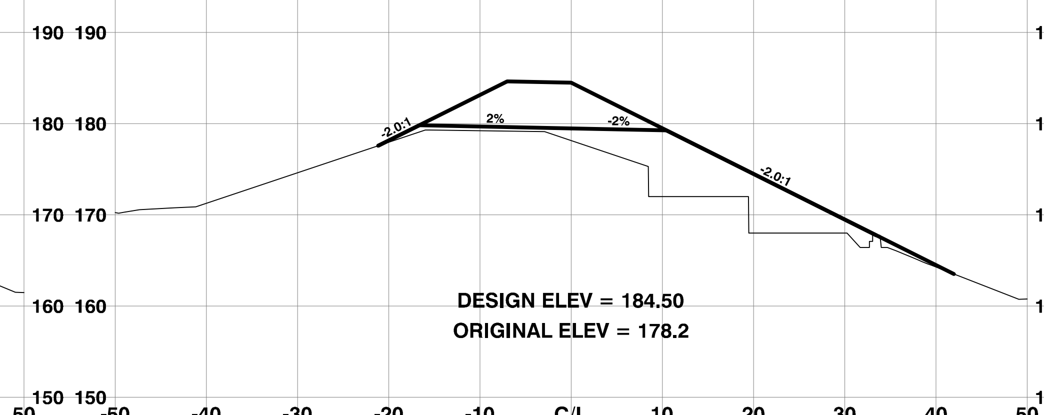

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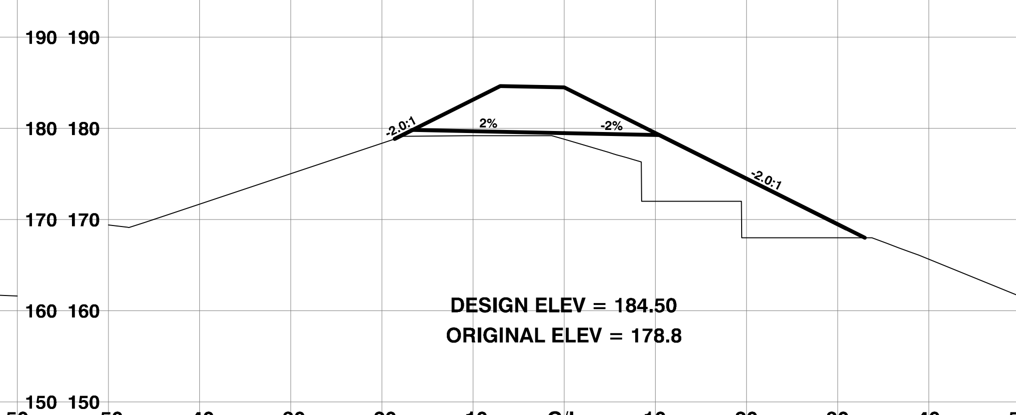

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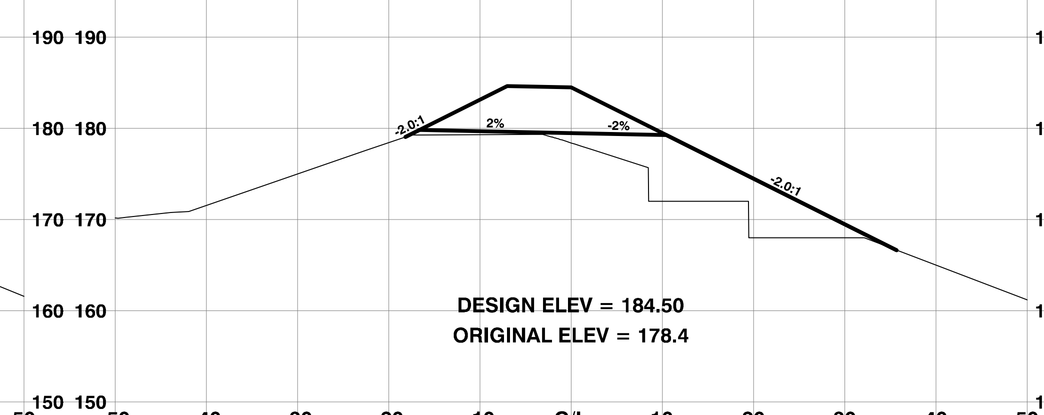

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76+00

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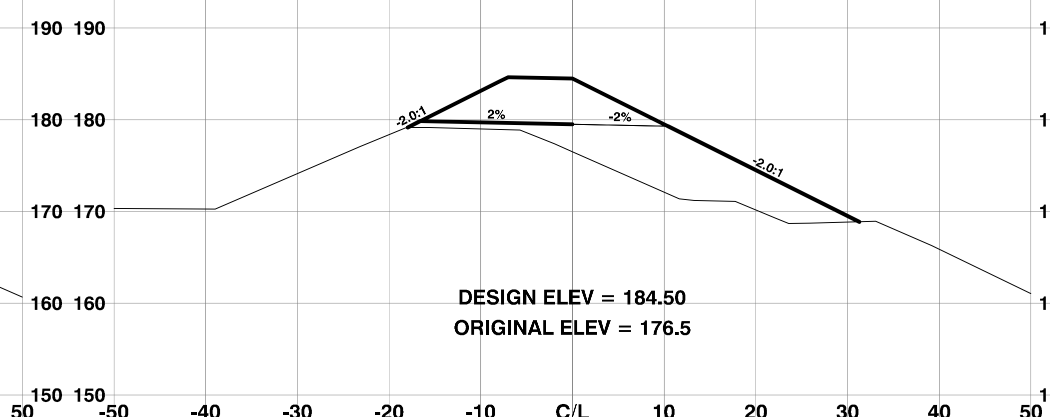
74+00

75+50



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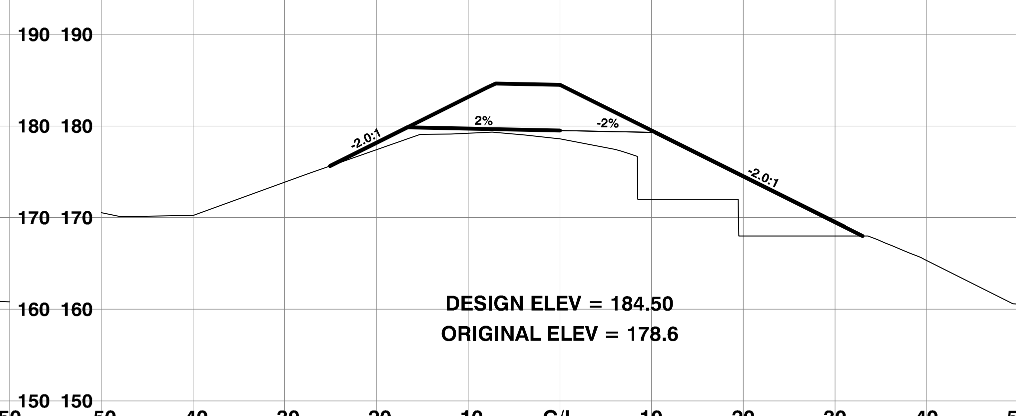

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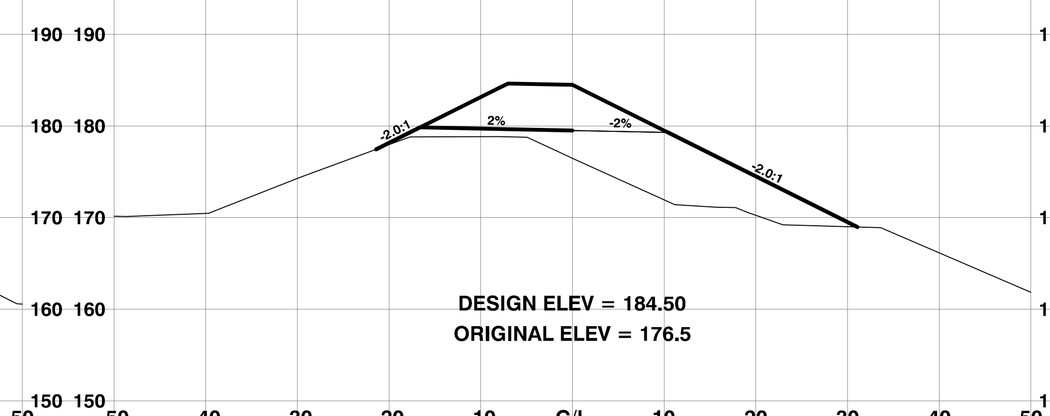

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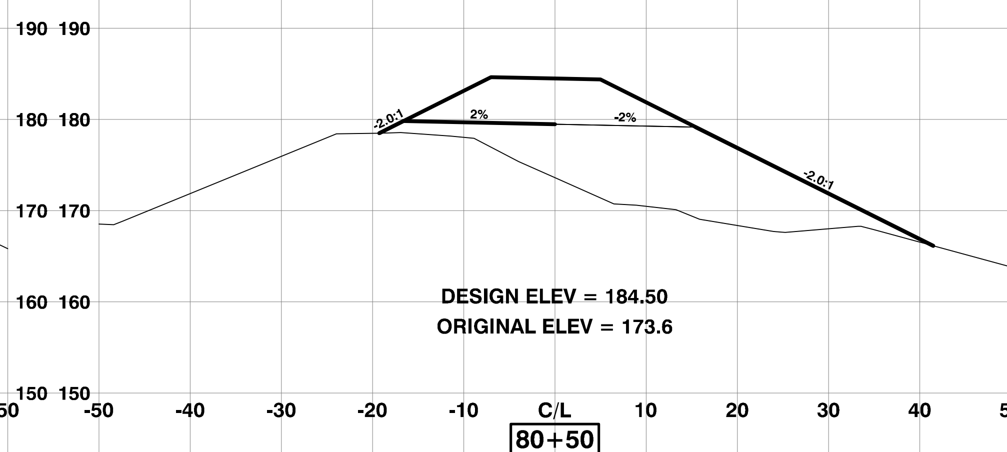
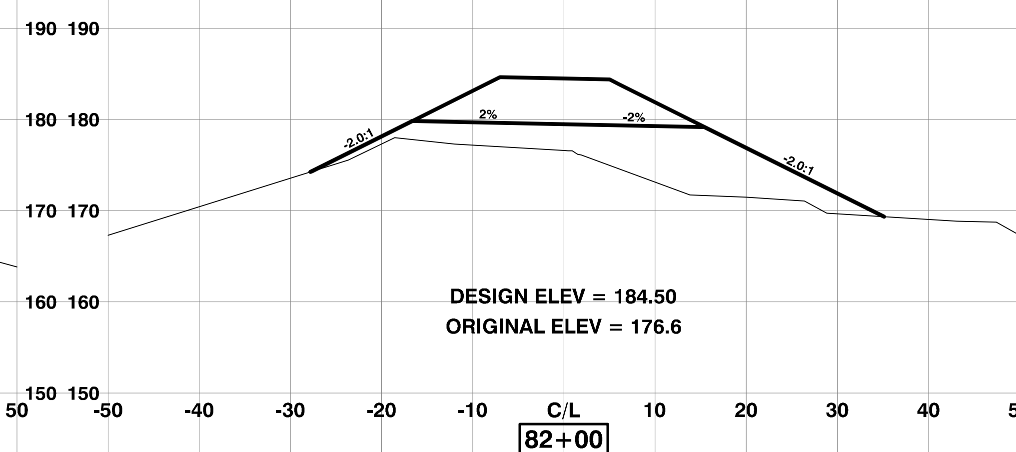
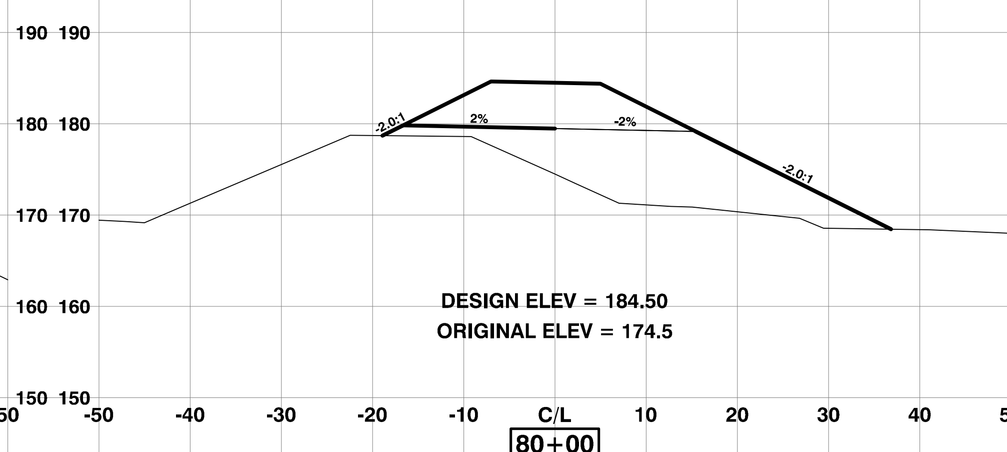
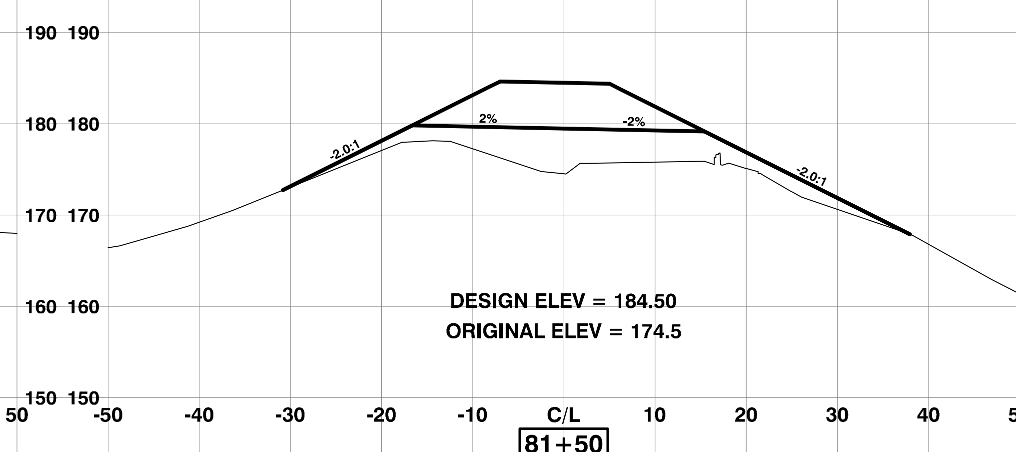
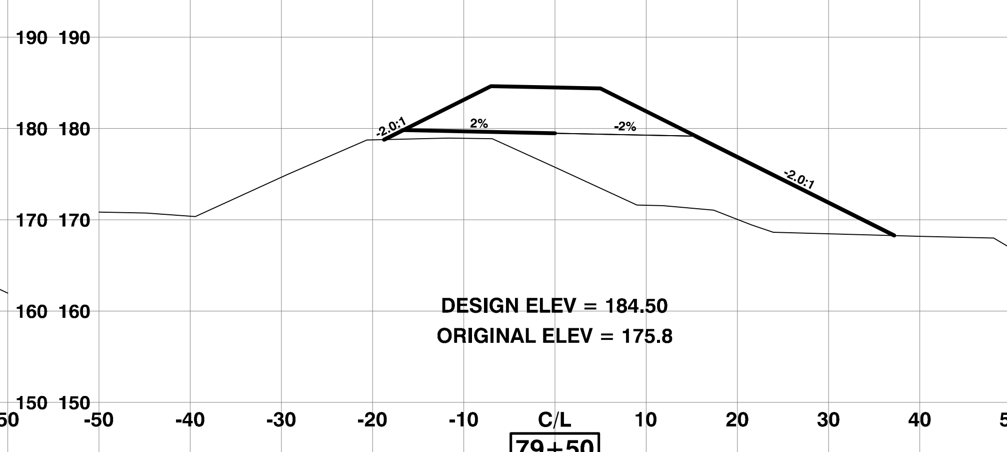
AIRPORT LEVEE 1-A (SHEET 16 OF 20)

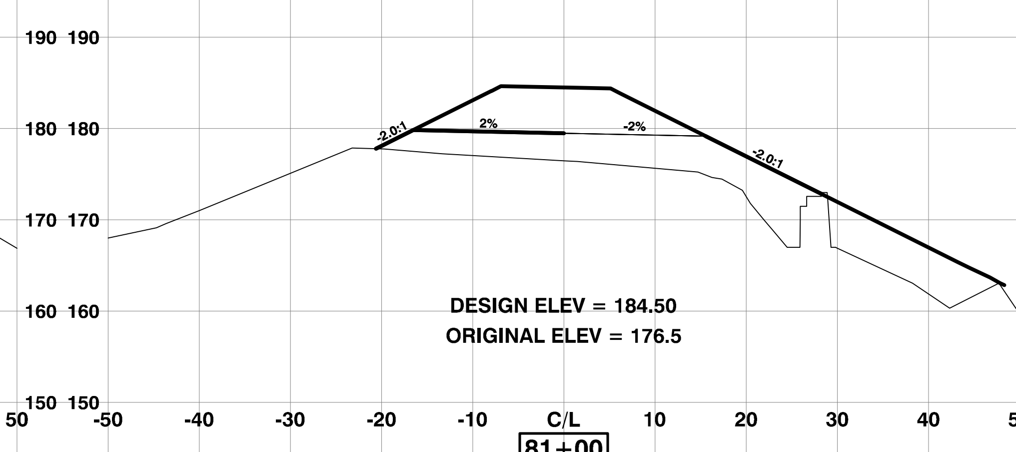












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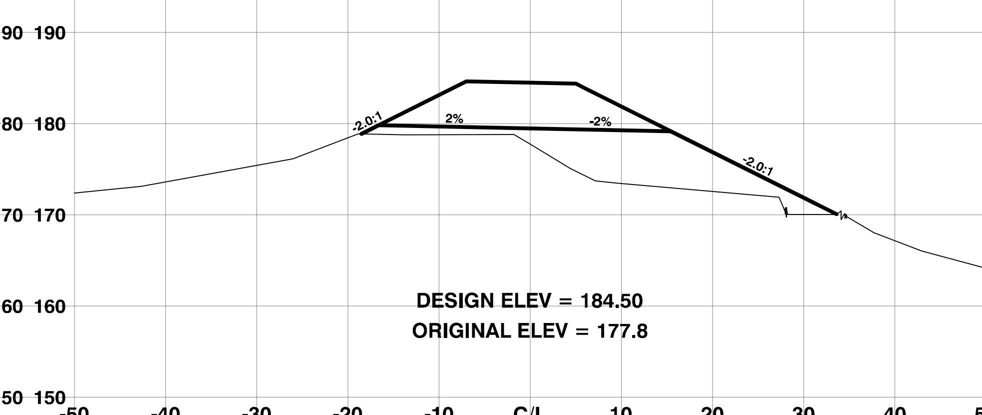

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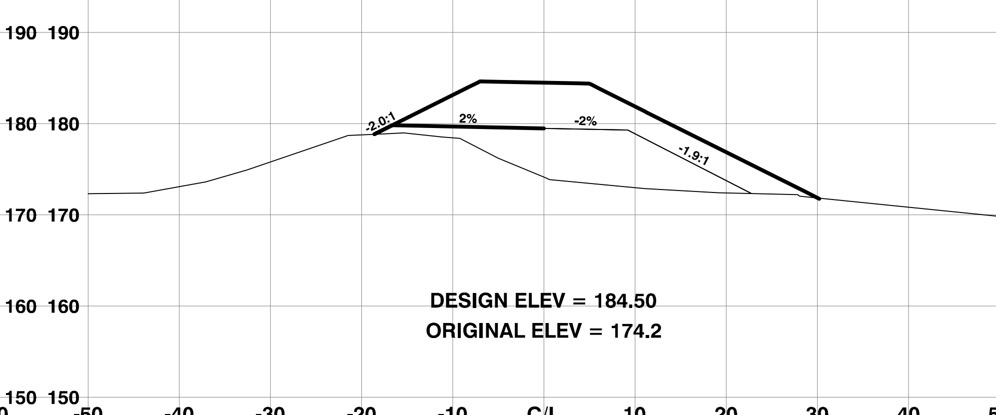

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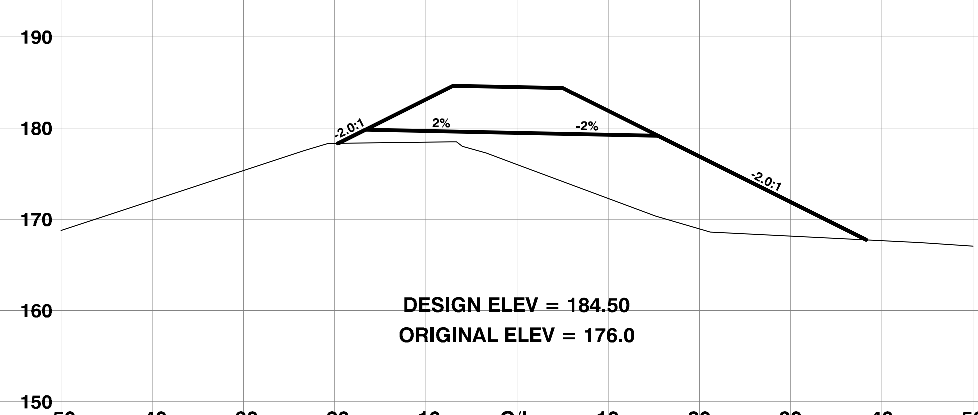

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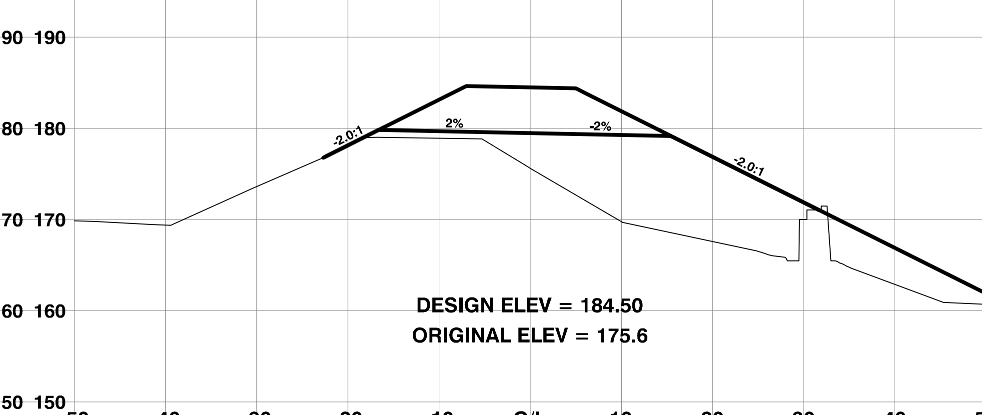

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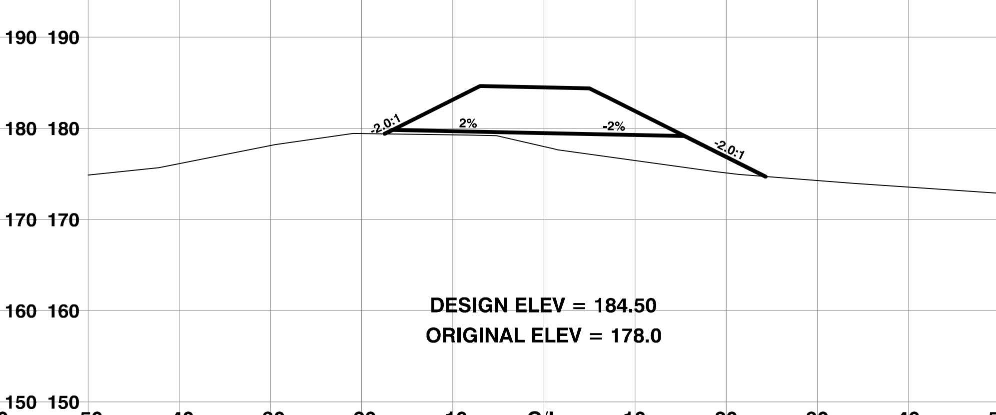

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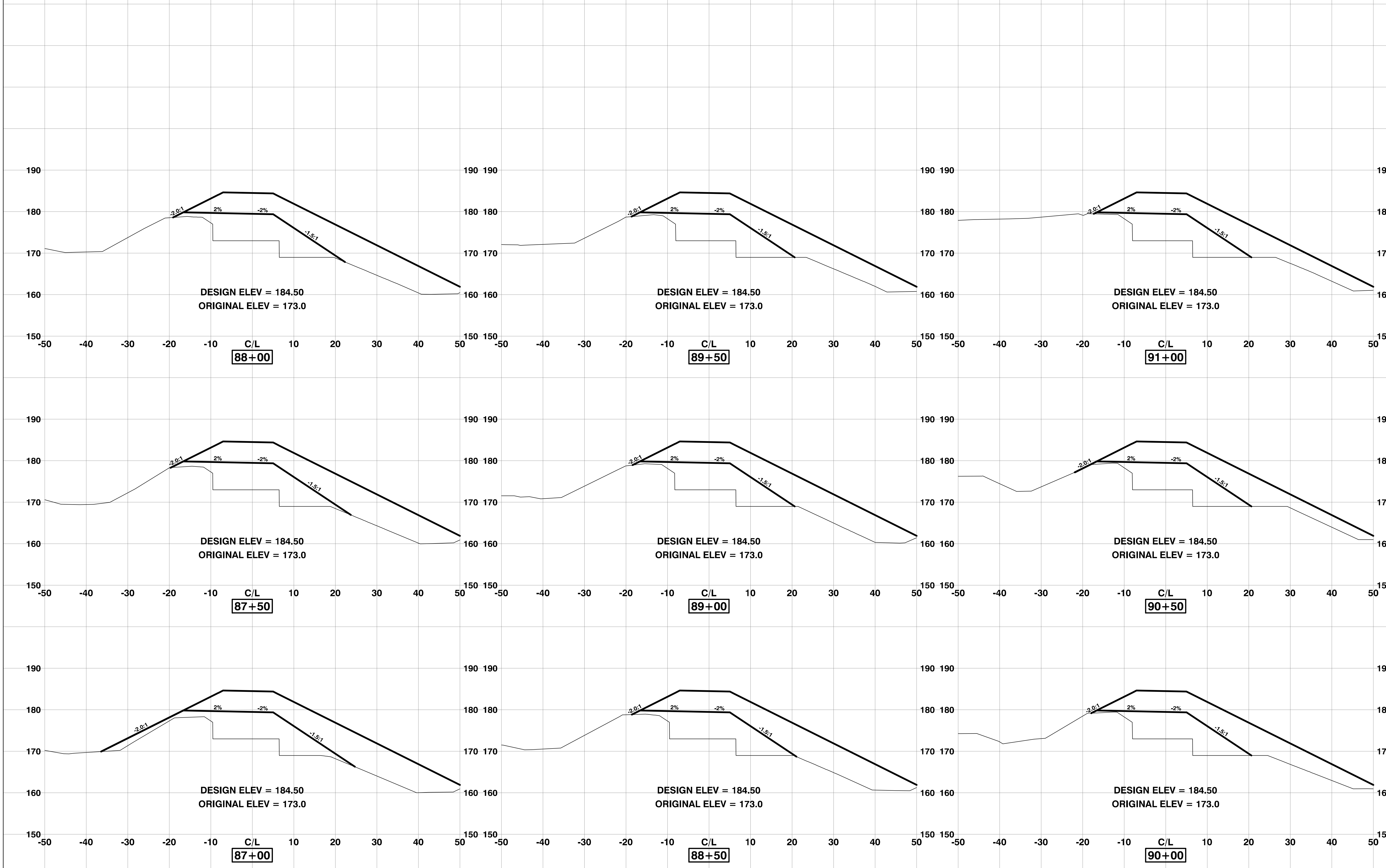

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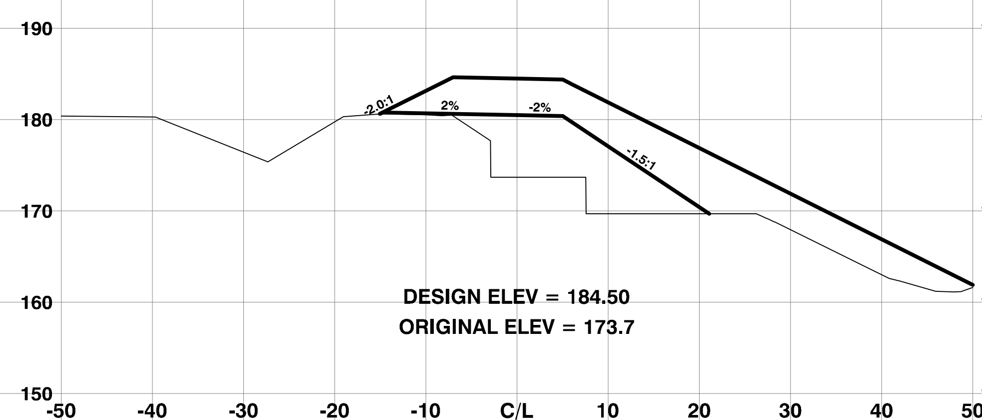

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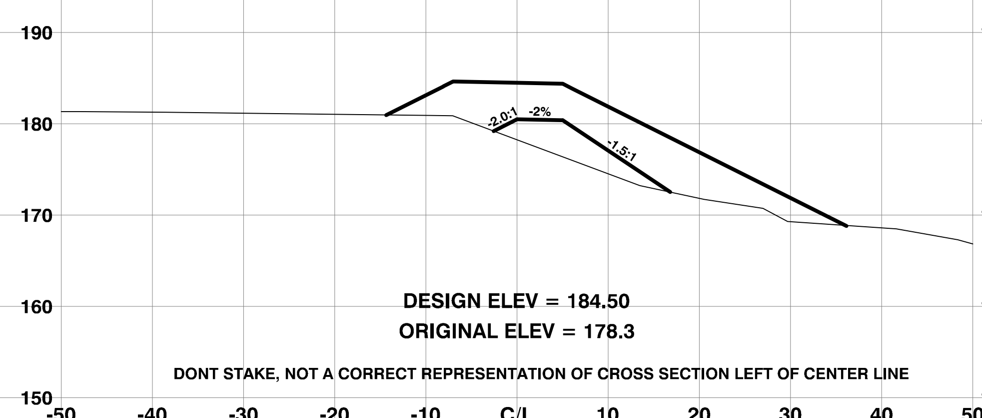

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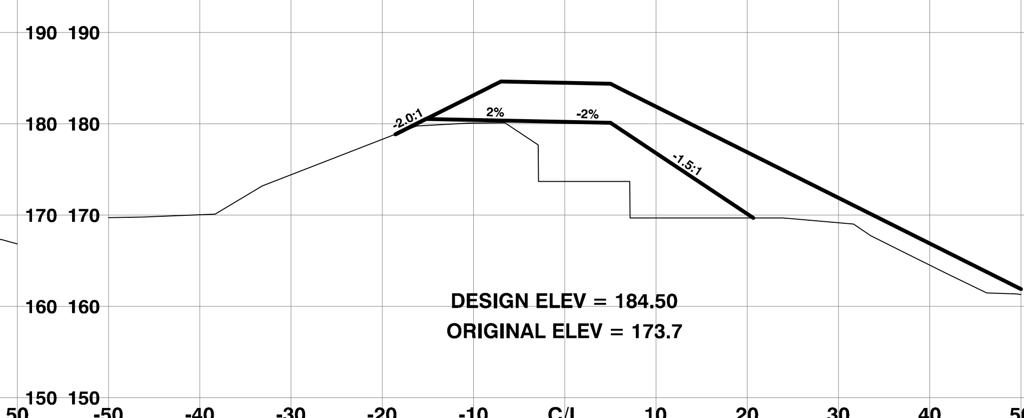

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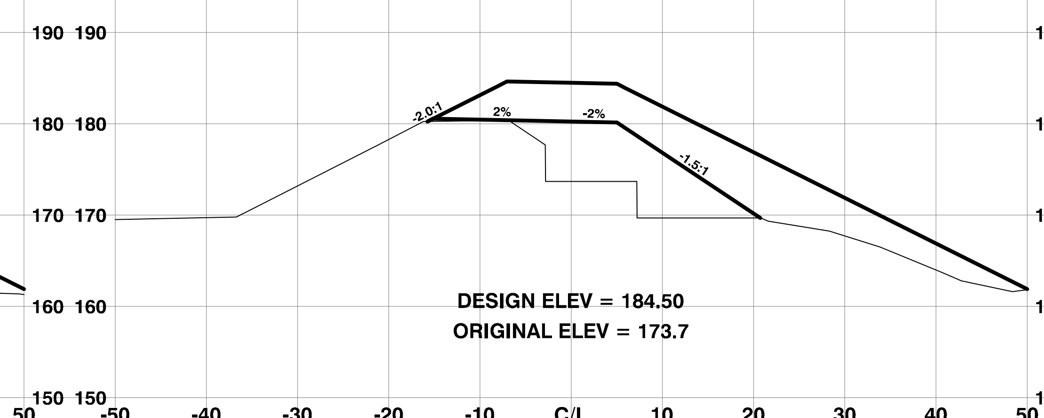

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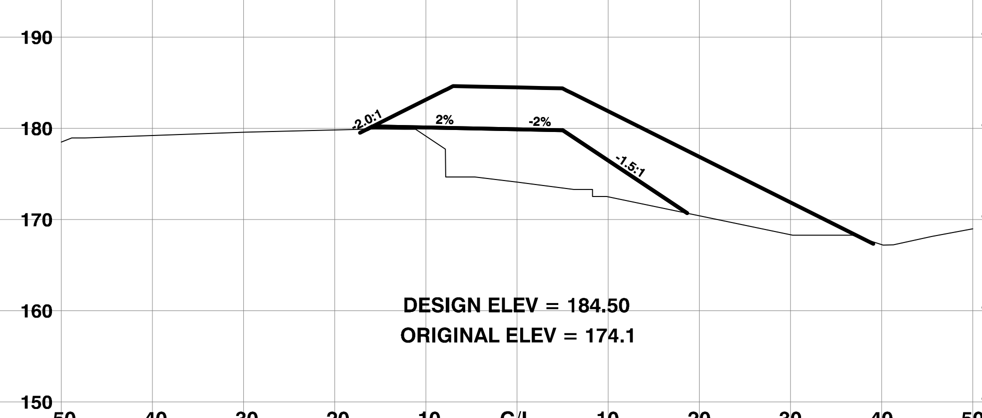

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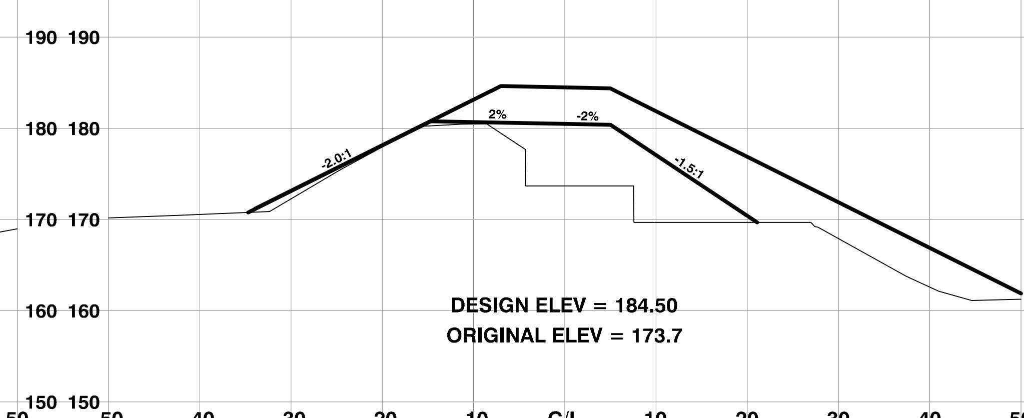

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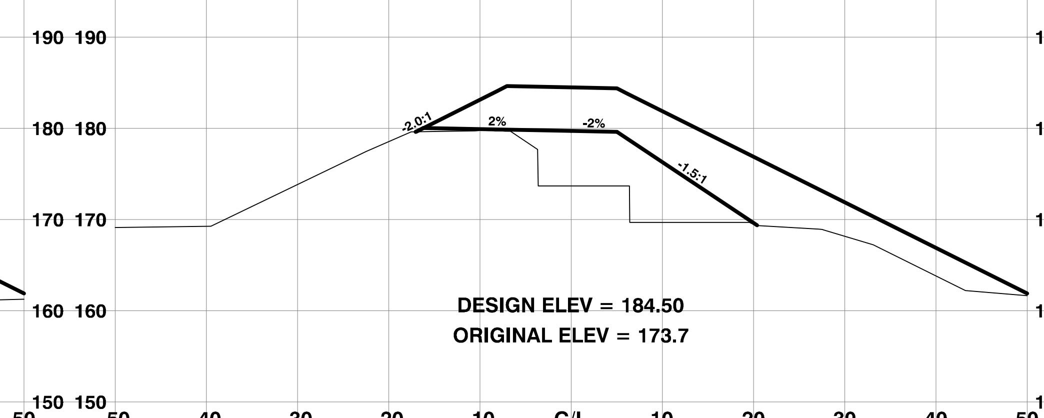

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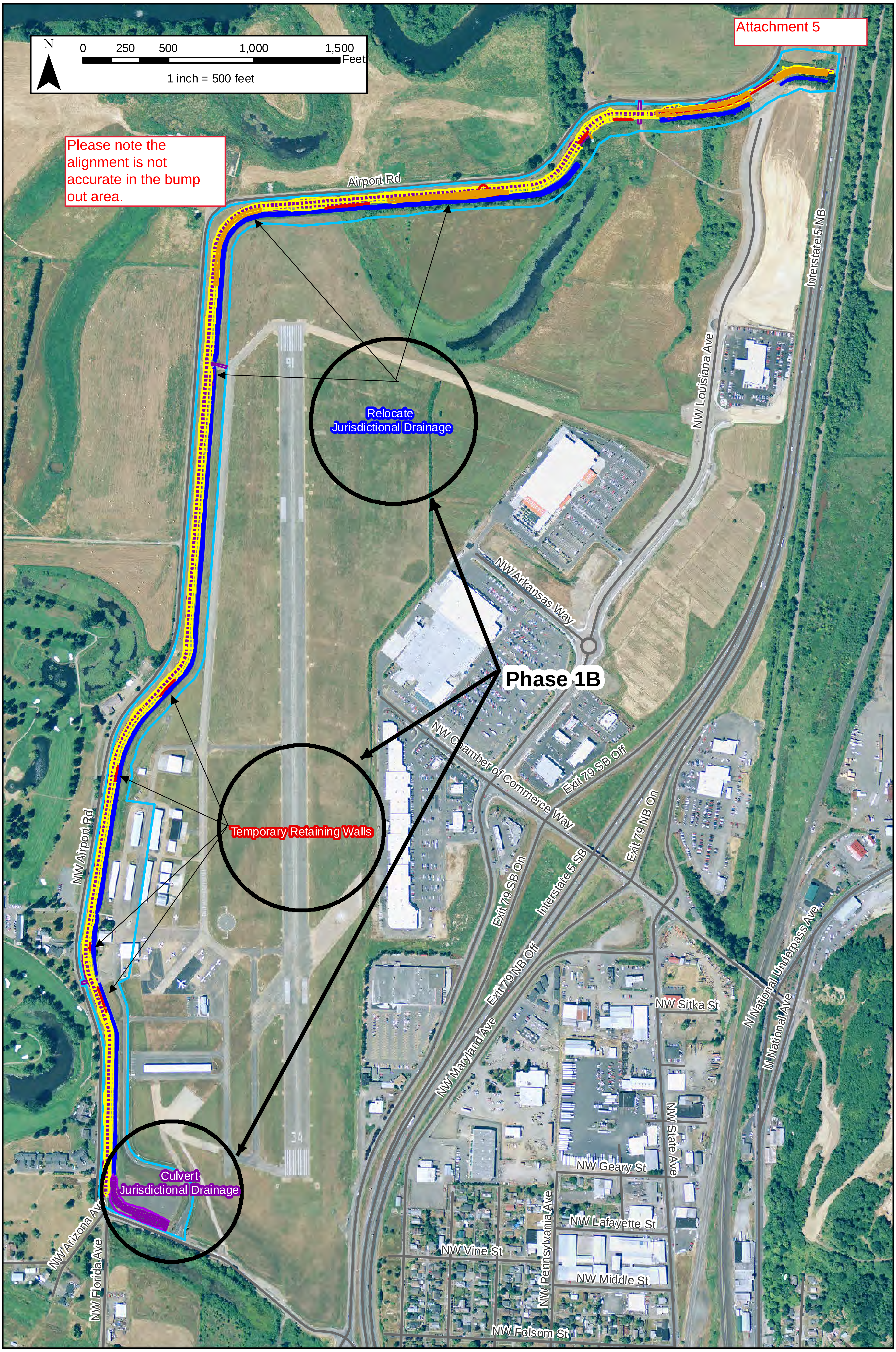


Legend

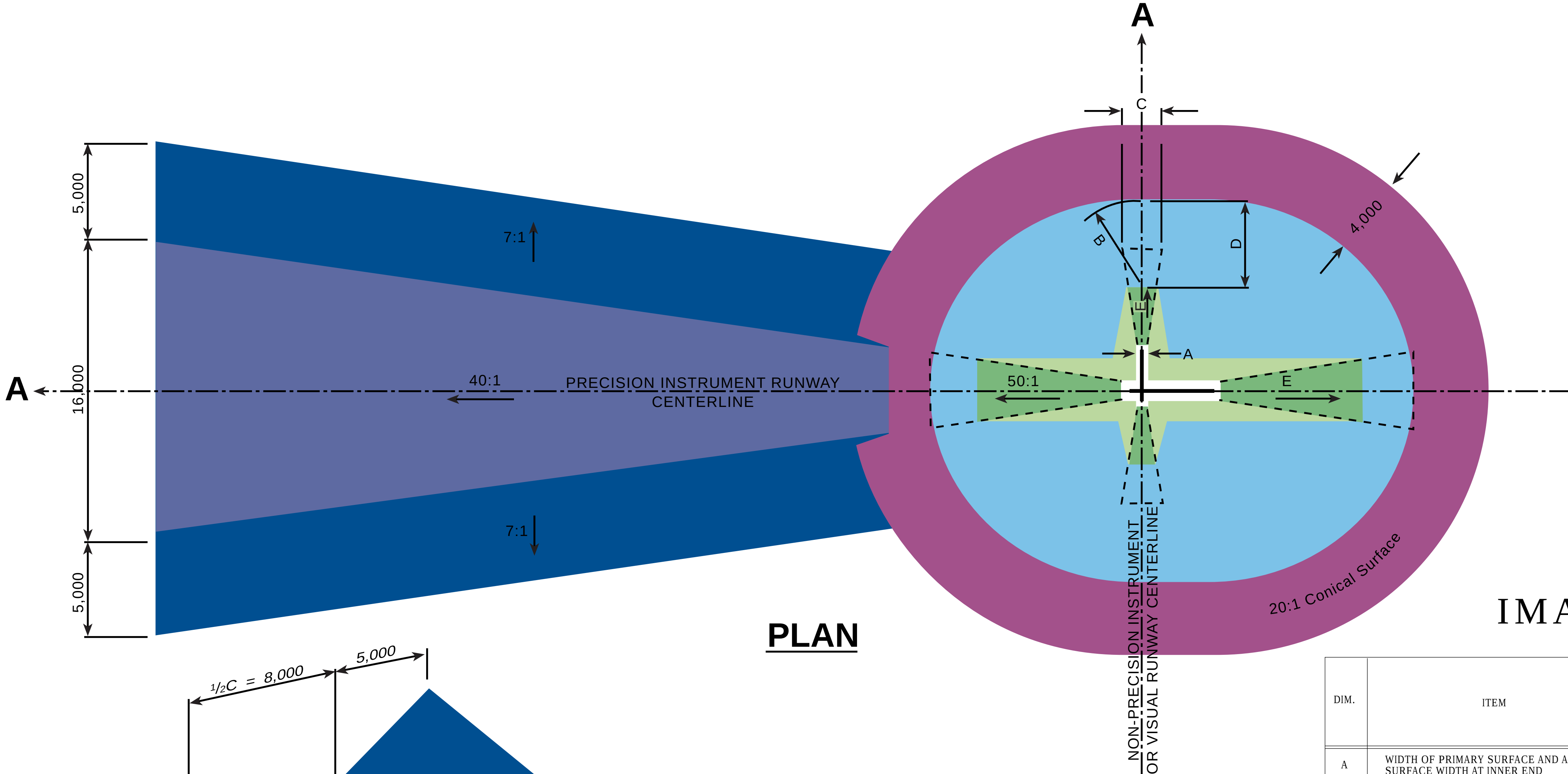
- Cut/Fill Limits for Phase 1A
- Benching for Phase 1A
- Gravity Block Wall for Phase 1A
- Proposed Area of Potential Impacts
- Jurisdictional Drainage
- Roads

Figure 1: Project Site

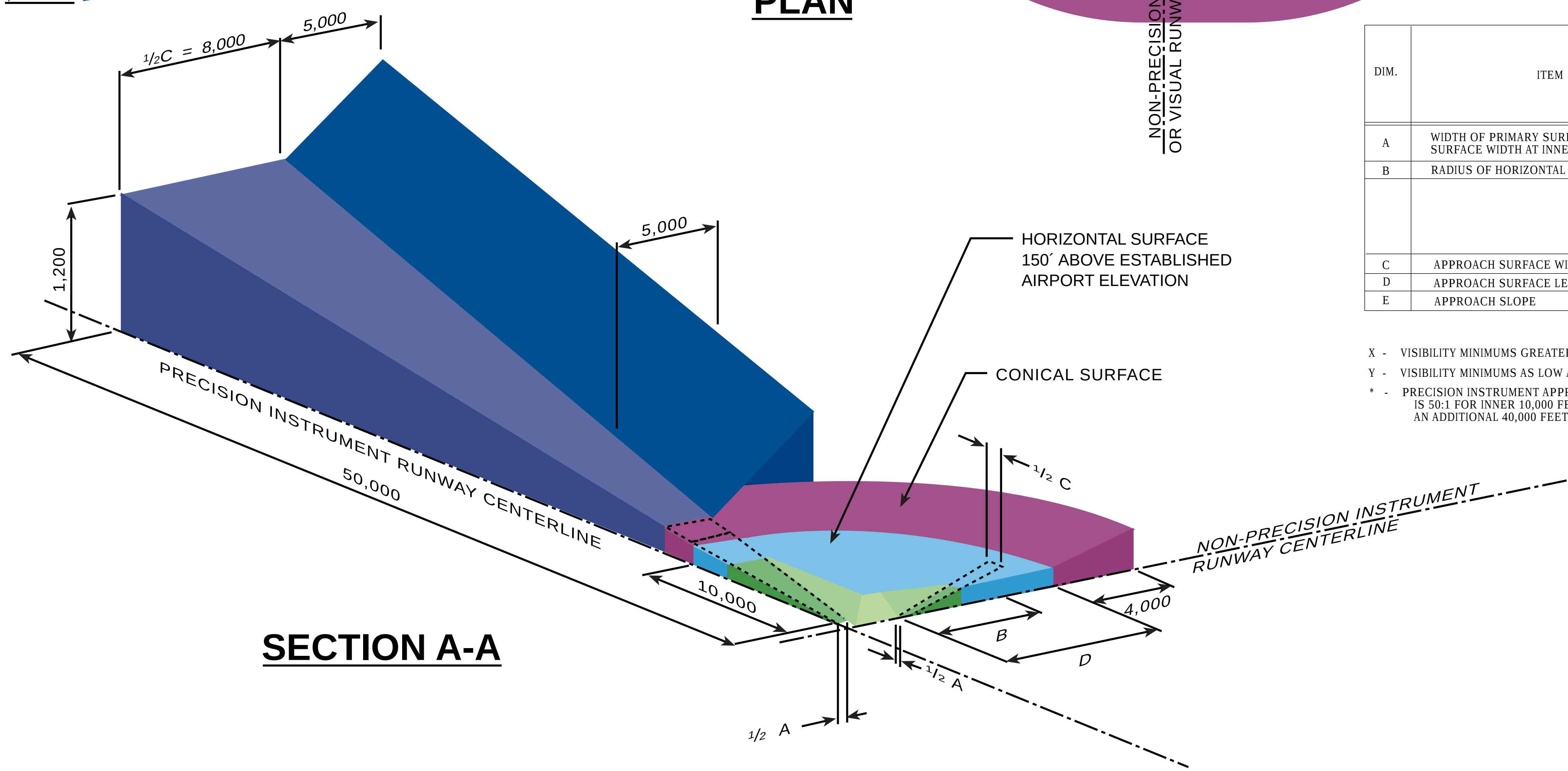
Chehalis-Centralia Airport Levee Base Widening Project
Sections 19, and 30, Township 14 North, Range 2 West

July 9, 2013

Attachment 6



PLAN



SECTION A-A

SURFACE SLOPE KEY

- HORIZONTAL SURFACE
- 20:1
- 7:1
- 7:1
- VARIES (SEE "E" VALUE IN TABLE BELOW)
- 40:1 (PRECISION INSTRUMENT RUNWAY ONLY)

CIVIL AIRPORT IMAGINARY SURFACES

DIM.	ITEM	DIMENSIONAL STANDARDS (FEET)					
		VISUAL RUNWAY		NON-PRECISION INSTRUMENT RUNWAY			PRECISION INSTRUMENT RUNWAY
		UTILITY	LARGER THAN UTILITY	UTILITY	LARGER THAN UTILITY X	LARGER THAN UTILITY Y	
A	WIDTH OF PRIMARY SURFACE AND APPROACH SURFACE WIDTH AT INNER END	250	500	500	500	1,000	1,000
B	RADIUS OF HORIZONTAL SURFACE	5,000	5,000	5,000	10,000	10,000	10,000
		VISUAL APPROACH		NON-PRECISION INSTRUMENT APPROACH			PRECISION INSTRUMENT APPROACH
		UTILITY	LARGER THAN UTILITY	UTILITY	LARGER THAN UTILITY X	LARGER THAN UTILITY Y	
C	APPROACH SURFACE WIDTH AT END	1,250	1,500	2,000	3,500	4,000	16,000
D	APPROACH SURFACE LENGTH	5,000	5,000	5,000	10,000	10,000	*
E	APPROACH SLOPE	20:1	20:1	20:1	34:1	34:1	*

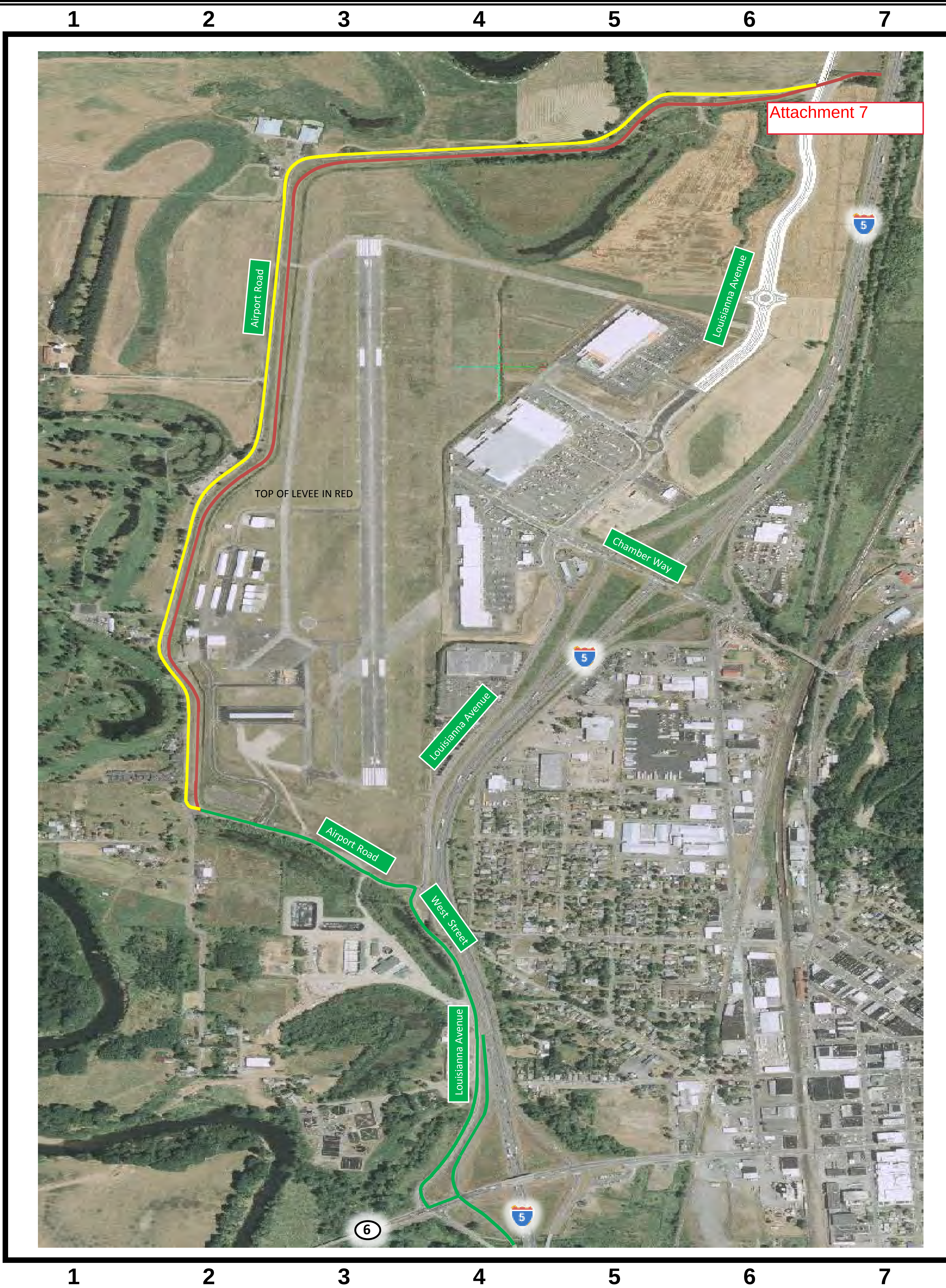
X - VISIBILITY MINIMUMS GREATER THAN 3/4 MILE

Y - VISIBILITY MINIMUMS AS LOW AS 3/4 MILE

* - PRECISION INSTRUMENT APPROACH SLOPE IS 50:1 FOR INNER 10,000 FEET AND 40:1 FOR AN ADDITIONAL 40,000 FEET

AVIATION DIVISION

Washington State Department of Transportation



Lewis County, Washington

REBID-AIRPORT LEVEE IMPROVEMENT PROJECT

HAUL ROUTE

Green Line Loaded and Empty Haul
Red Line Loaded (or Empty) Haul
Yellow Line Empty Haul ONLY
No haul on Louisiana Ave. north of West Street.

Lewis County
Department of Public Works

A.8. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection. March 7, 2019.

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

351 NW North St
Chehalis, WA 98532-1900

March 7, 2019

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Janelle Leeson
PO Box 3755, Seattle, WA 98124-3755

RE: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection

Ms. Leeson:

The following letter provides information and clarifications that have been previously discussed verbally between the USACE and the Chehalis River Basin Flood Control District (District). We are sending this communication to provide a clear record of our position on these matters.

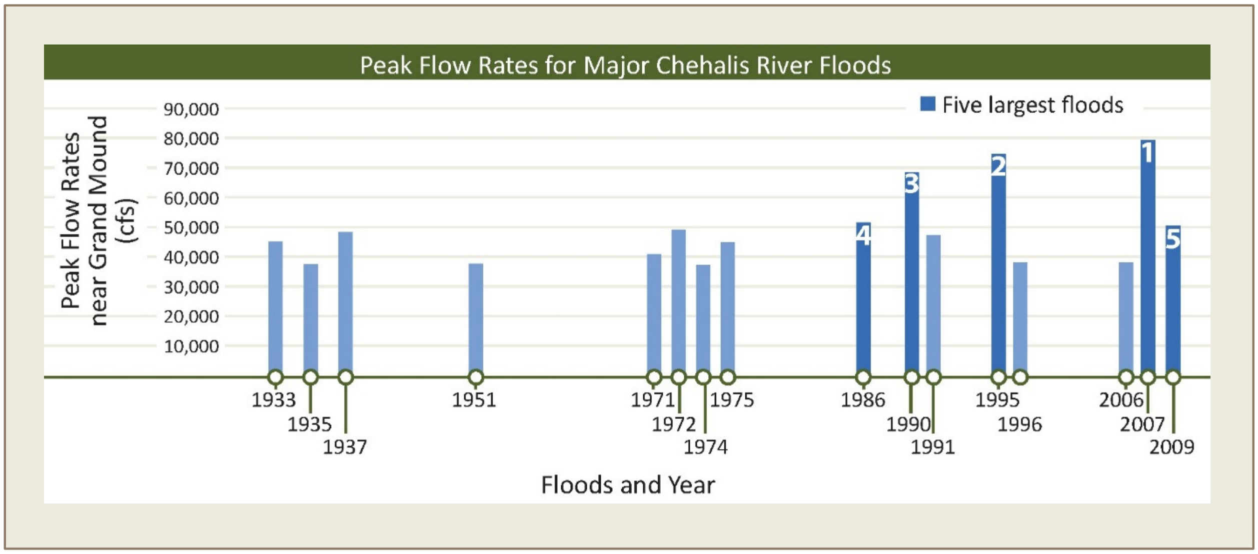
Project Objective Design Storm Clarifications

The first objective presented in the Purpose and Need seeks to reduce the closure due to overtopping of Interstate 5 to 24 hours or less during a 100-year flood or greater. We recognize that the words 'or greater' are vague and do not provide clear design criteria to be used in the evaluation of the project by the USACE. We would like to clarify that we expect that the 100-year storm flow rate will be used for design and evaluation.

The 2007 flood and other basin floods greater that the project design event are realities that members of the public can relate to and understand better than probabilistic, hypothetical floods. These actual events are often used to discuss the need for the project with the public. The District does recognize the need for a consistent and measureable design criteria, which will be the 100 year event. The District will continue evaluate the storms greater than 100-year, but for informational purposes only.

The Need for Flexibility as a Project Objective

The third objective presented in the Purpose and Need stated that the proposed project should provide future leaders in the Chehalis Basin the flexibility to address potential future increases in peak flood levels and decreases in stream flow during summer months through an adaptable design approach. It is not the position of the District to take any stances on the subject of climate change or assert any expertise in the area of climate science. Regardless of future climate predictions, we do feel that is immensely important to plan ahead for an uncertain future. We would also like to point to the objective reality of the streamflow pattern that has shown increasing flood peaks over the last 30 years. The streamflow has been measured at the Ground Mound gage about 90 years and has shown that the five largest flood peaks have occurred since 1985. This is illustrated in a figure from Section 3.1.2.2 Flooding and Floodplains from the Chehalis Basin Strategy Programmatic EIS (PEIS), reproduced below. The observed flow pattern may or may not continue into the future, and it is for future leaders to decide whether additional flood retention or possible flow augmentation will be beneficial. This uncertainty is exactly why we have chosen not to include the final construction version in this permitting process; it may never be needed or built.



It is estimated that adding a larger base to the flood retention facility will cost an additional $100 million above the FRO version to construct. If this adaptability is not built into the project, the current facility would need to be removed and another constructed, the costs of which would likely be prohibitively large. Adding this adaptability to be built into the project construction will allow a future generation the choice to address future problems that are unforeseeable today at a potentially much more attainable cost than full reconstruction.

Dam Configuration Selection History

Three configurations were considered for the dam: Flood Retention Flow Augmentation (FRFA), Flood Retention Only (FRO), and Flood Retention Expandable (FRE). A very brief description of the facility types are:

FRFA – This type of facility would be designed to have the ability to retain a permanent reservoir. In addition to reducing flood damage during major events, the water from the reservoir could be released in warmer months to augment flows and potential lower streamflow temperatures downstream of the facility.

FRO – This type of facility would be designed to temporarily hold back water only during major floods. There would not be a permanent pool of water. The river would flow normally during regular conditions or smaller flood flows. The foundation would not allow for modification to another dam type.

FRE – This type of facility would be designed to temporarily hold back water only during major floods, and like the FRO option, there would not be a permanent pool of water. The river would flow normally during regular conditions or smaller flood flows. The foundation would be constructed large enough to allow for future expansion up to the FRFA level.

More detailed descriptions of the FRFA and the FRO are discussed in the Conceptual Combined Dam and Fish Passage Design Report (2017 HDR). The FRE is discussed in the FRE Alternative Supplemental Design Report (2018 HDR). Both reports can be found on the EIS Supporting Documents Page on the FCZD website (https://www.chehalisriverbasinfczd.com/).

To assist the District supervisors and staff make a decision on which facility type to sponsor for permits, the District formed an advisory committee with qualified members of the public. The facility types were reviewed and discussed verbally in meetings.

The FRO was ruled out because it did not meet our third project objective of allowing flexibly for future generations to have the options of expanding the facility.

The FRFA was ruled out because it was generally agreed within the advisory committee and other stakeholders within the basin that the FRFA would present unnecessary environmental impacts. The benefit of summertime flow augmentation or additional wintertime flood retention could not be shown to undeniably outweigh the impacts.

The advisory committee ultimately recommended to move forward with the FRE facility, and the District Supervisors heeded that recommendation and formally identified the facility type to be sponsored in a resolution passed on 10/11/2017, attached.

Another separate major alternative that has been considered by the Office of the Chehalis Basin is an option known as the 'Restorative Flood Protection Alternative' (RFP). As described in the PEIS:

Restorative Flood Protection is intended to rebuild the natural flood storage capacity of the Chehalis Basin by reversing landscape changes that contribute to downstream flooding and erosion. Restorative Flood Protection would increase the flood storage capacity of the Chehalis Basin by adding engineered large wood and plantings to crease 'roughness' (or resistance to flow) to river and stream channels and the floodplain, and by reconnecting river channels to floodplain storage. This strategy would necessitate individual actions be taken on a large scale and linked, which requires voluntary participation from many landowners within the Chehalis Basin. (Section 2.3.3.1 Large-scale Flood Damage Reduction Actions, pg 36, PEIS)

Further study completed subsequently to the PEIS publication indicated that the downstream flood level as measured at Chehalis-Centralia was one quarter of what was estimated in the PEIS. This updated analysis found that the RFP, after full implementation, would lower the 100-year flood elevation between 1-2 inches near Chehalis-Centralia. The Board of the Office of the Chehalis Basin has redirected the work effort of the RFP alternative to flood-proofing and the Community Assistance & Resilience Program.

We would also like to mention that we have relied upon information contained in, and prepared for, the Programmatic EIS that was published by the WA Department of Ecology, and unless otherwise noted, we consider it to contain the most factual and up to date information on the District's proposed project as well as the other major actions taking place in the Chehalis Basin.

If you would like any further information or clarification please do not hesitate to contact Erik Martin at erik.martin@lewiscountywa.gov or (360) 740-2697, or Betsy Dillin at betsy.dillin@lewiscountywa.gov or (360)740-1138.

Sincerely,

Erik Martin, PE
FCZD Administrator

Cc: Diane Butorac, Department of Ecology
Board of Supervisors, Chehalis River Basin FCZD

BEFORE THE BOARD OF SUPERVISORS OF THE CHEHALIS RIVER BASIN FLOOD CONTROL ZONE DISTRICT

RESOLUTION TO IDENTIFY A WATER RETENTION FACILITY TYPE TO BE SPONSORED AND TO AUTHORIZE THE DISTRICT ADMINISTRATOR TO PREPARE AND TRANSMIT A PURPOSE AND NEED STATEMENT TO THE UNITED STATES ARMY CORPS OF ENGINEERS	)	**RESOLUTION NO. 17-004**

WHEREAS, the Governor, the legislature, state and federal agencies, tribes, and communities within the basin represented by the Chehalis River Basin Flood Authority (Flood Authority), have joined together in an organized process, the development of the Chehalis Basin Strategy, to produce the best science for solutions to the problem of reducing catastrophic flood damage and to enhance habitat for aquatic species within the basin; and

WHEREAS, a water retention facility has been evaluated as part of this basin-wide strategy reduce flood damage to public health, public safety, public infrastructure, homes and homeowners, agricultural land and operations, businesses, schools, churches, and damage to the overall vitality of the communities in the Chehalis Basin; and

WHEREAS, the Chehalis Basin Strategy also includes near term actions such as flood proofing of homes and other structures vulnerable to flooding, other local flood damage reduction projects, land use actions by local governments to ensure new floodplain development does not impact ecological function or cause harm to residents and structures that are located in the floodplain, and buying out homes and other structures subject to repeated flood damage; and

WHEREAS, permit applications, triggering a project-level State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS), are now needed in order to complete the process of developing the best science to determine whether the Project can be built consistent with local, state and federal regulations and with the overall objectives of the Chehalis Basin Strategy; and

WHEREAS, this Board of Supervisors of the Chehalis River Basin Flood Control Zone District (District) has agreed to authorize the District to act as sponsor of a project that includes a water retention facility and associated facilities on the main stem of the Chehalis River south of the Town of Pe Ell per Resolution 17-001 ; and

WHEREAS, the United States Army Corps of Engineers and the Washington State Department of Ecology, in order to create a scope for the EIS and conduct the environmental review, need to be presented with a specific type of water retention facility to evaluate against other alternatives to determine significant impacts; and

WHEREAS, accompanying the submittal of a specific type of water retention facility would be a statement of purpose and need for the project; and

WHEREAS, the District has conducted a thorough and thoughtful review of available data on possible water retention facility types including but not limited to presentations and a tour of a proposed site led by engineering consultant experts who have studied and been working on designs the project, and

WHEREAS, the District has conducted a coordinated and specific outreach to the public in the Chehalis Basin, community leaders affected by flooding, and the Office of the Chehalis Basin Board; and

WHEREAS, the District has asked for and received a recommendation on water retention facility type from the Chehalis River Basin Flood Control Zone District Advisory Committee.

NOW THEREFORE, BE IT RESOLVED by the Board of Supervisors of the Chehalis River Basin Flood Control Zone District, as follows:

1. The District, as the project sponsor, endorses the facility type commonly known as a Flood Retention Only – Expandable, which would allow for:
   A. A free-flowing river condition under normal flow conditions.
   B. Stormwater control under flood conditions and impoundment of up to 65,000 acre-ft of flood storage.
   C. An enlarged foundation and increased geotechnical exploration and design to allow for future expansion of the facility with the understanding that expansion for additional flood control or streamflow augmentation requires a full permitting and environmental review process.
2. The District authorizes the District Administrator to send a letter to the United States Army Corps of Engineers and the Washington State Department of Ecology specifying a facility type and describing the purpose and need for the project.

The foregoing resolution was ADOPTED by the Board of Supervisors of the Chehalis River Basin Flood Control Zone District at a regular open public meeting this 11 day of October, 2017.

APPROVED AS TO FORM:

By: Interim District Counsel

ATTEST:

Lara Seiler

Lara Seiler, Interim Clerk of the Board

BOARD OF SUPERVISORS OF CHEHALIS RIVER BASIN FLOOD CONTROL ZONE DISTRICT

Edna J Fund

Edna J. Fund, Chair

Robert C. Jackson, Vice Chair

G. Stamper

Gary Stamper, Supervisor

LARA SEILER
COMMISSION EXPIRES
NOTARY
PUBLIC
1-09-21
STATE OF WASHINGTON

A.9. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection. March 15, 2019.

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

351 NW North St
Chehalis, WA 98532-1900

March 15, 2019

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Janelle Leeson
PO Box 3755, Seattle, WA 98124-3755

RE: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection

Ms. Leeson:
This letter is a follow up to the Corps letter dated March 1, 2019, providing additional information on several questions. The following numbered items correspond to the previous letter.

1. **What improvements are proposed for the bypass road for Forest Road (FR) 1000 to be used during operation (including location, dimensions, fill, maintenance needs)?**

We have uploaded a shapefile of the bypass road FR 1000 and a AutoCAD file of the potential quarry roads to our file transfer site. You will be receiving a link to that site in your email. We have also attached a pdf map of the roads to this letter.

1.f. Describe adaptive management approaches.

Our answer to this question referred to 'regular' inundation. We would like to clarify that we are not planning to inundate the reservoir area on a planned or scheduled basis. The planned operation is for a 7-year recurrence interval storm, but the operation is better described as a 14% probability storm, which may happen more than once in a given year or may not occur for many years.

4. **Would there be lighting in the tunnels of the outlet works and construction diversion tunnel to facilitate fish passage?**

The applicability of the lighting design guidelines through the fish passage tunnels was discussed by the technical subcommittee during the early stages of FRO development. The topic did not come up again in a Fish Passage Subcommittee Meeting forum when the idea of the FRE was introduced. The underlying fact that fish mainly travel at night implies that it did not merit separate consideration regarding the influence of longer tunnel length, and was not further discussed.

9. Provide detailed information related to flood retention facility construction:

c. When and for how long would in-water work occur?

In-water work could be considered as under-water work, barge-staged work, or work within the active river channel. The project does not plan for any underwater or barge-staged work, with the exception of a limited number days of mechanical equipment (gate) inspection or adjustment well after initial filling. Active-river channel work would be limited to a few periods of a few days through the course of the project. The initial work in the river will begin after the bypass tunnel is completed to pass water around the construction site. An upstream and downstream cofferdam will be installed during low flow times to divert flow into the bypass tunnel, which is expected to take 2-4 weeks, however the majority of the water will be flowing through tunnels within a couple of days. Once the flow is diverted into the bypass tunnel, the construction work is no longer in the active channel. Final river routing through the completed works and cofferdam removal will have similar time line. More specific planning for in water work will occur in future phases of design development in conjunction with and in preparation for permitting.

Regarding water draws for construction use: 1) water is likely to be drawn or predominantly drawn upstream of the cofferdam from the diversion tunnel forebay area; 2) the duration of diversion through the bypass tunnel is likely to be on the order of 24 months; 3) construction water use is likely to be between 75k and 150k mgals with as much as 80% of the draw occurring in a 10-20 month window. We have not developed a plan for where water will be drawn, or how much will be used. If sand or aggregates are washed on site, water use would be on the high side of this range. However, it is not anticipated that conventional concrete sand or other aggregates would be washed on site.

10. Define details of the Airport Levee Improvements:

c. Would any of the existing levee base be widened?

The widening of the levee base may need to occur in several areas that could impact the ditch located on the inside of the levee. This ditch has a discernable Ordinary High Water Mark and a defined bed and bank, which meets the current definition of Jurisdictional. In

351 NW North St
Chehalis, WA 98532-1900

Phase 1, walls were put in for these areas and those will need to be removed before the levee could be widened.
Similarly to our approach to the bump out area, we are presenting the conservative case and we are exploring exactly which levees need to be widened and to what degree, so jurisdictional drainage impacts may be avoided or minimized.

d. **What are the design specifications of raising 1,700 feet of Airport Road that may require changing the existing footprint of the roadway?**

We would like to transmit additional information regarding the tie- in to the road in the week of March 18th.

11. How would the Airport Levee Improvements be constructed?

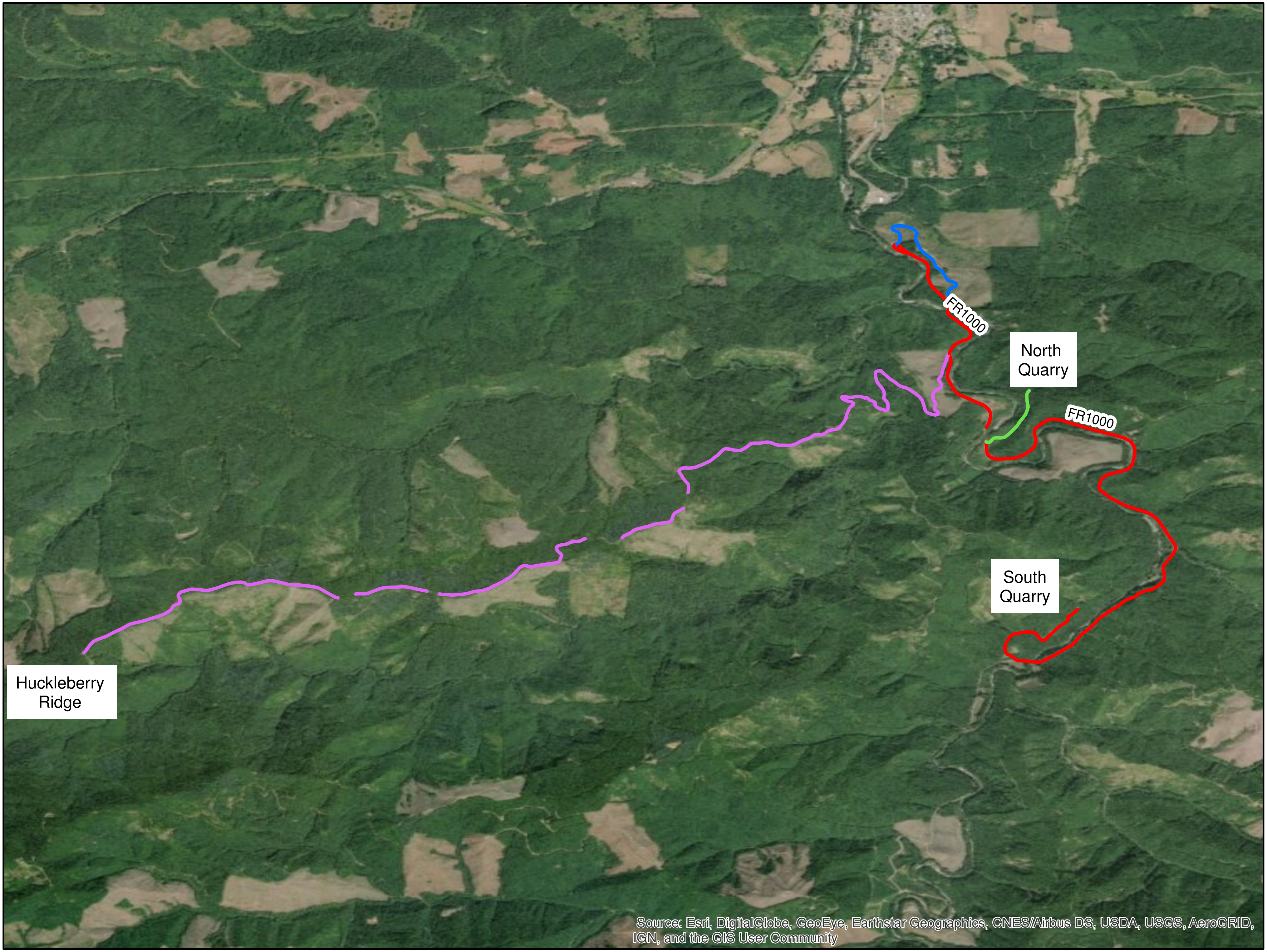
We anticipate that the years of construction for the Levee will be concurrent with the Dam construction, i.e. from starting in 2025 and ending before 2030.

If you would like any further information or clarification please do not hesitate to contact erik.martin@lewiscountywa.gov or (360) 740-2697, or Betsy Dillin at betsy.dillin@lewiscountywa.gov or (360) 740-1138.

Sincerely,

Erik Martin, PE

Cc: Diane Butorac, Department of Ecology
Board of Supervisors, Chehalis River Basin FCZD


FR1000
North Quarry
FR1000
South Quarry
Huckleberry Ridge
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

A.10. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection. March 19, 2019.

Chehalis River Basin Flood Control Zone District

2025 NE Kresky Ave
Erik P. Martin, P.E., District Administrator *Chehalis, WA 98532-1900*

March 19, 2019

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Janelle Leeson
PO Box 3755, Seattle, WA 98124-3755

RE: Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection
Ms. Leeson:

This letter is a follow up to the letter on March 1, 2019, providing additional information on several questions. The following numbered items correspond to the previous letter.

10 d. What are the design specifications of raising 1,700 feet of Airport Road that may require changing the existing footprint of the roadway?

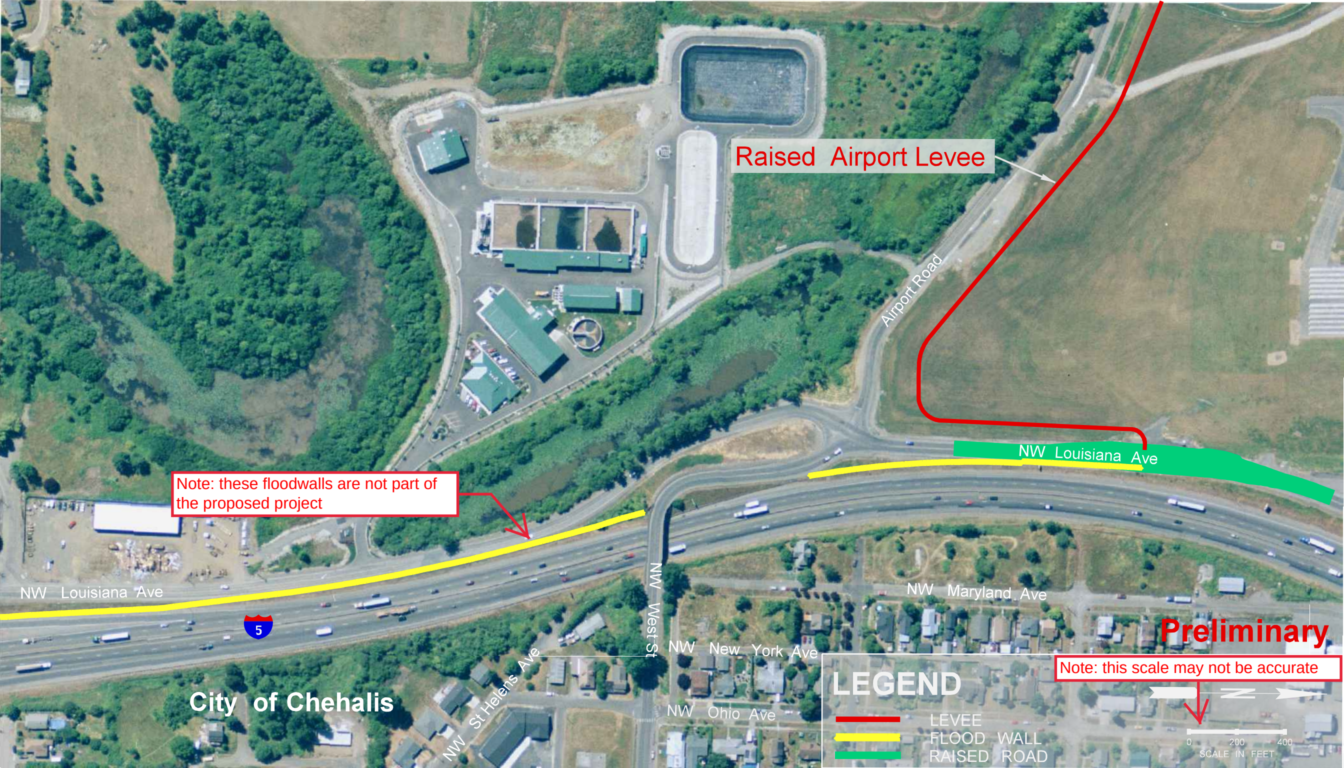
The Programmatic EIS states that 1,700 feet of Airport Road would be raised to meet the ultimate airport levee height. We would like to correct this statement; the road to be raised is NW Louisiana Avenue, and the length is about 810 feet. The location is shown as the green area on the attached figure. Please note on the figure that the floodwalls shown are not part of our proposal, also the scale shown in the lower right may not be accurate. We have also added the shapefile of the area to our Cloud site for your use. The elevation of the levee at the tie in is 186.0 ft which is shown on the attached Plan and Profile Drawings.

If you would like any further information or clarification please do not hesitate to contact erik.martin@lewiscountywa.gov or (360) 740-2697, or Betsy Dillin at betsy.dillin@lewiscountywa.gov or (360) 740-1138.

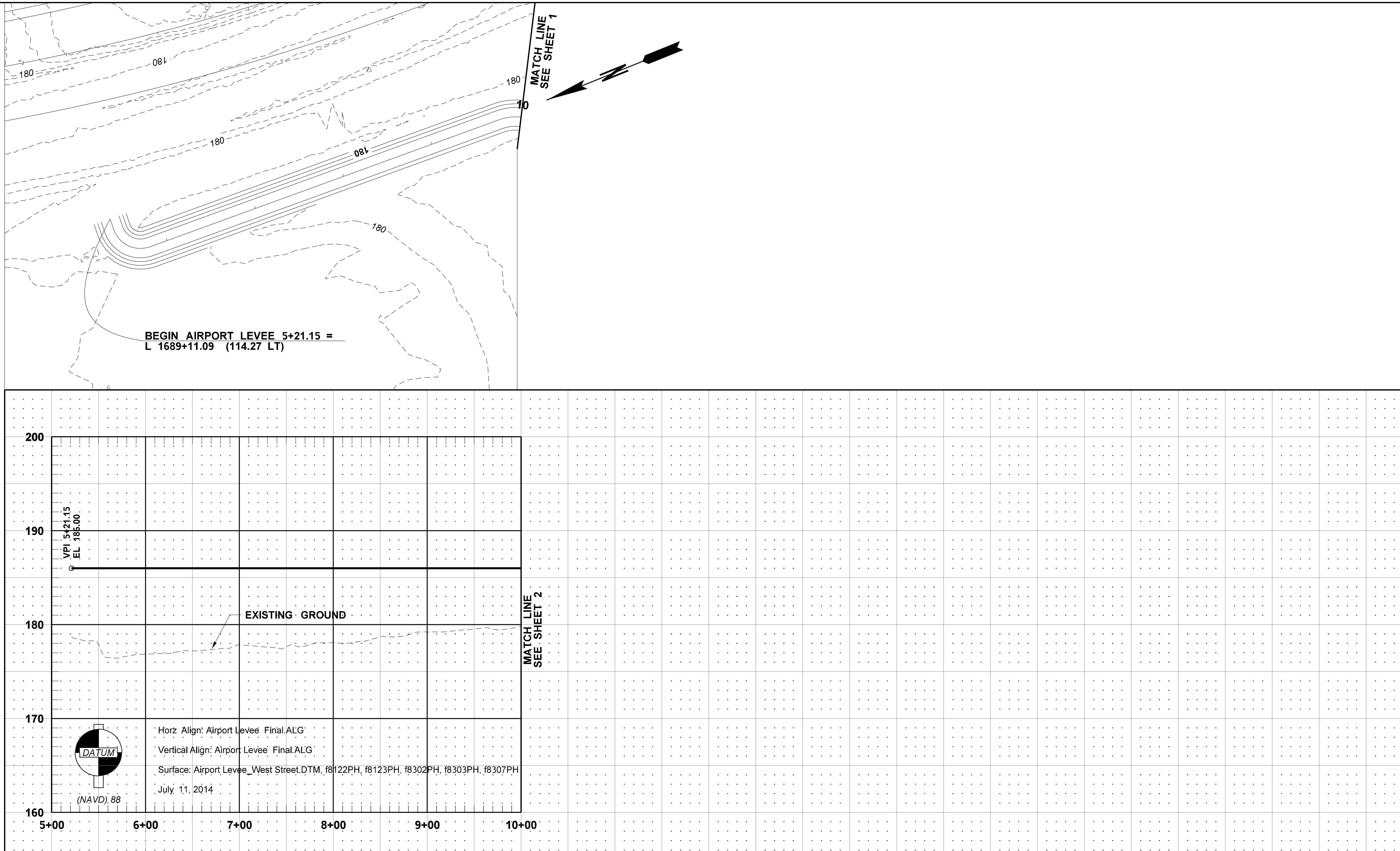
Sincerely,

Erik Martin, PE

Cc: Diane Butorac, Department of Ecology
Board of Supervisors, Chehalis River Basin FCZD



Raised Airport Levee
Airport Road
NW Louisiana Ave
Note: these floodwalls are not part of the proposed project
NW Louisiana Ave
5
NW Maryland Ave
NW West St
NW New York Ave
NW Ohio Ave
NW St Helens Ave
City of Chehalis
Preliminary
Note: this scale may not be accurate
LEGEND
LEVEE
FLOOD WALL
RAISED ROAD
N
0
200
400
SCALE IN FEET



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DESIGNED BY	V. LIAMBILA
ENTERED BY	S. LUKATAH
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PROJ. ENGR.	K. MILLER
REGIONAL ADM.	D. WAGNER

REVISION | DATE | BY

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JOB NUMBER: MS7119

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Department of Transportation

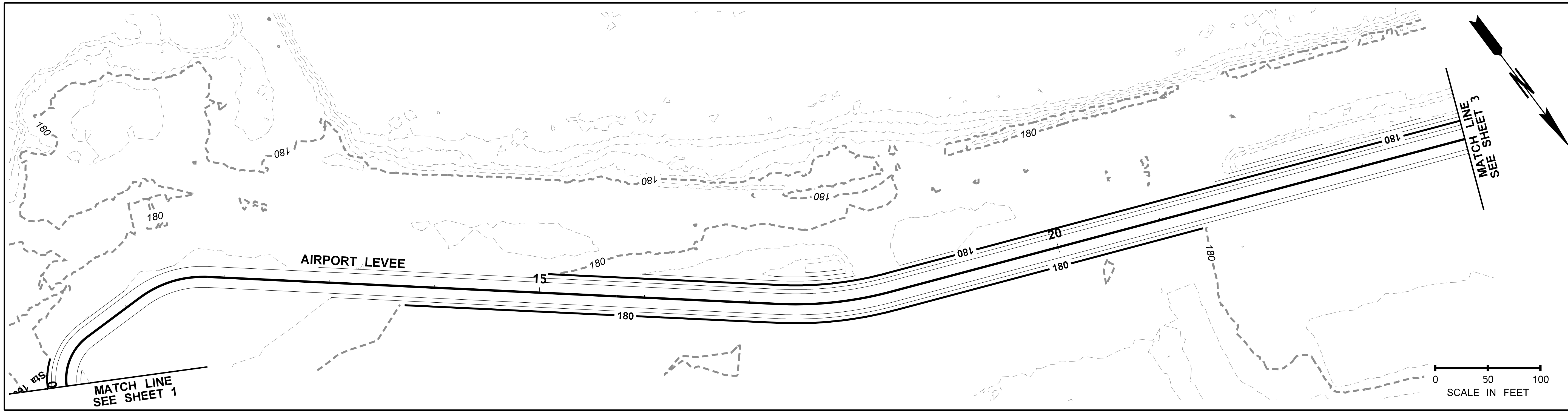
I-5
LEWIS COUNTY
FLOOD PROTECTION

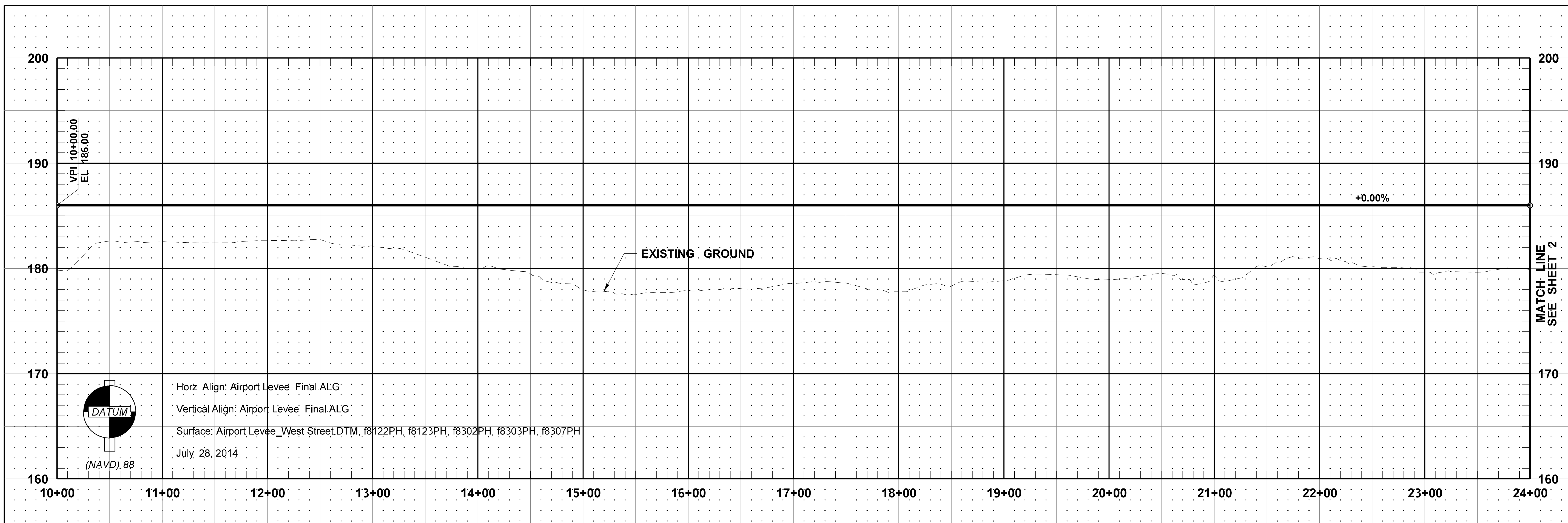
AIRPORT LEVEE

Plot 1

PLAN REF. NO. PS&PR

SHEET 1 OF 11 SHEETS





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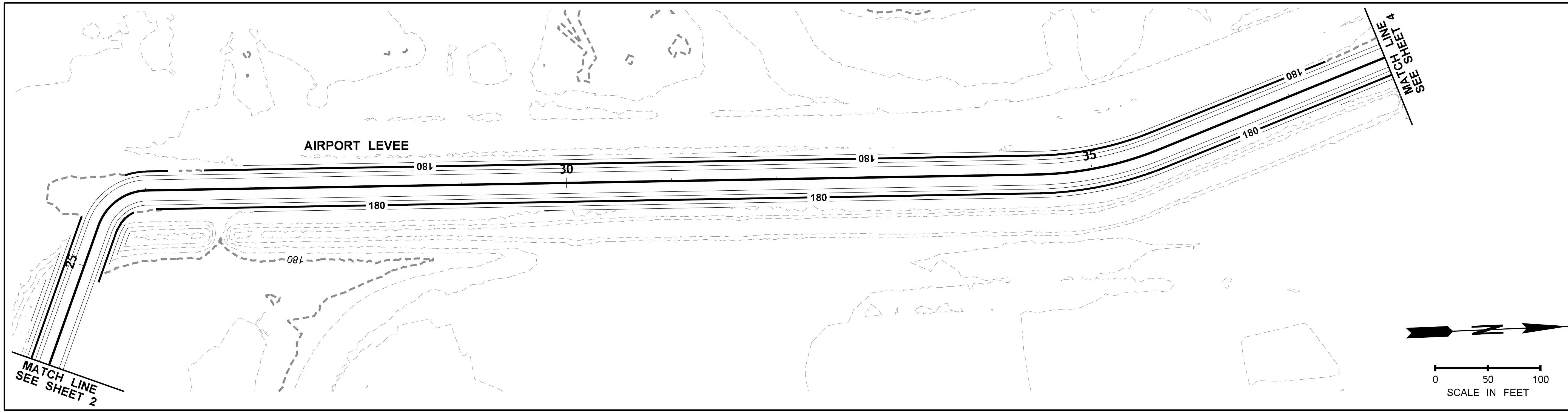
I-5
LEWIS COUNTY
FLOOD PROTECTION

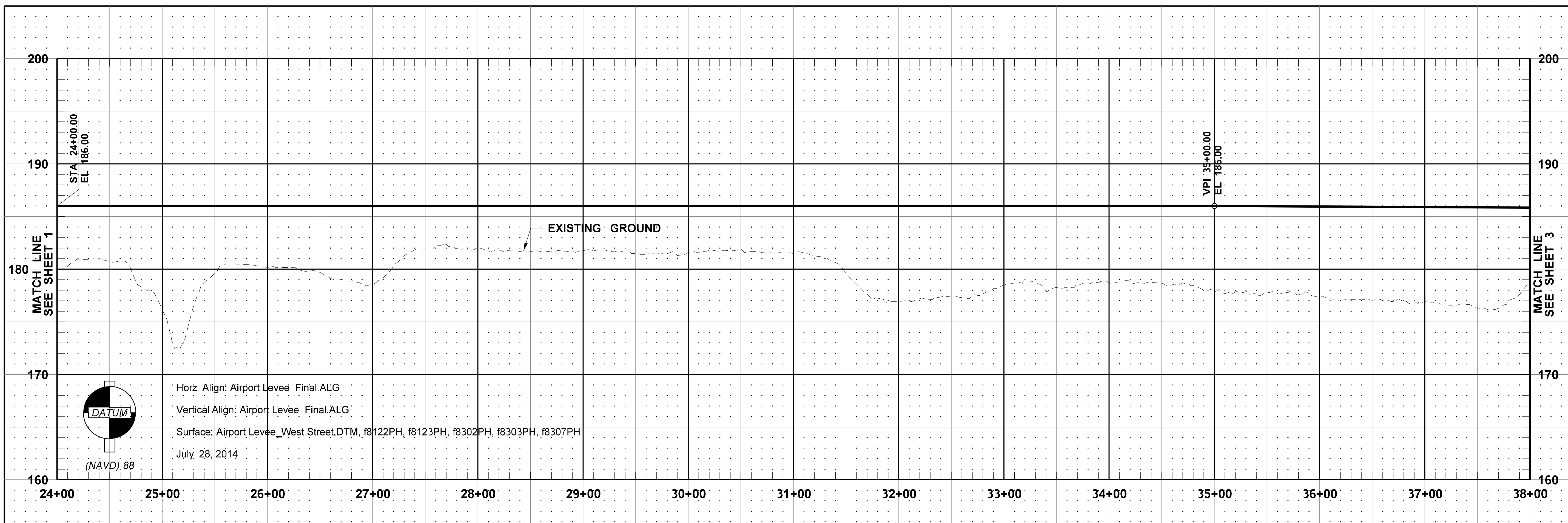
AIRPORT LEVEE

Plot 2

PLAN REF. NO. PS&PR

SHEET 2 OF 11 SHEETS





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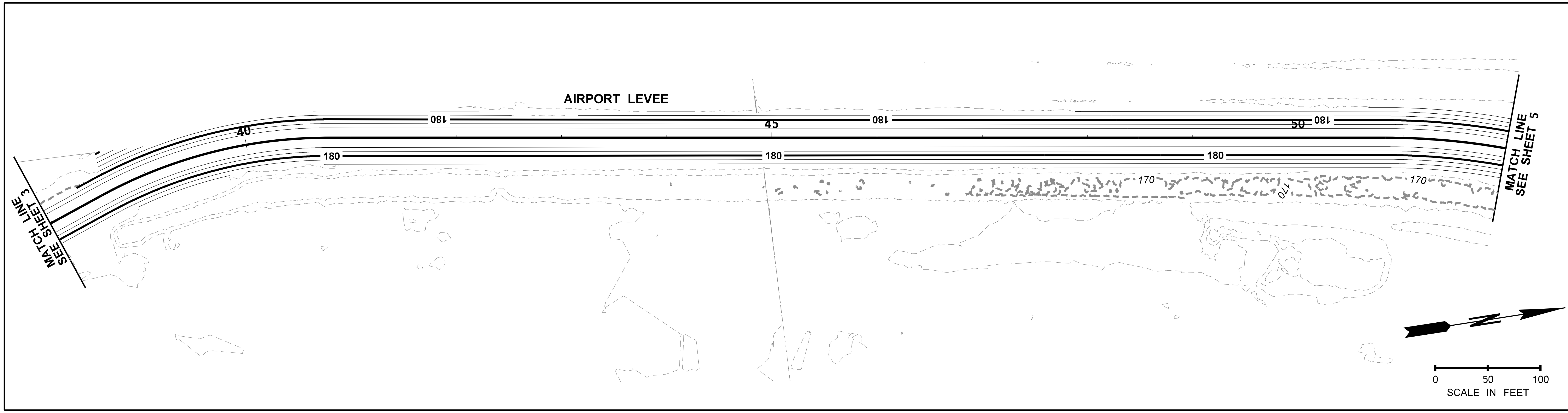
I-5
LEWIS COUNTY
FLOOD PROTECTION

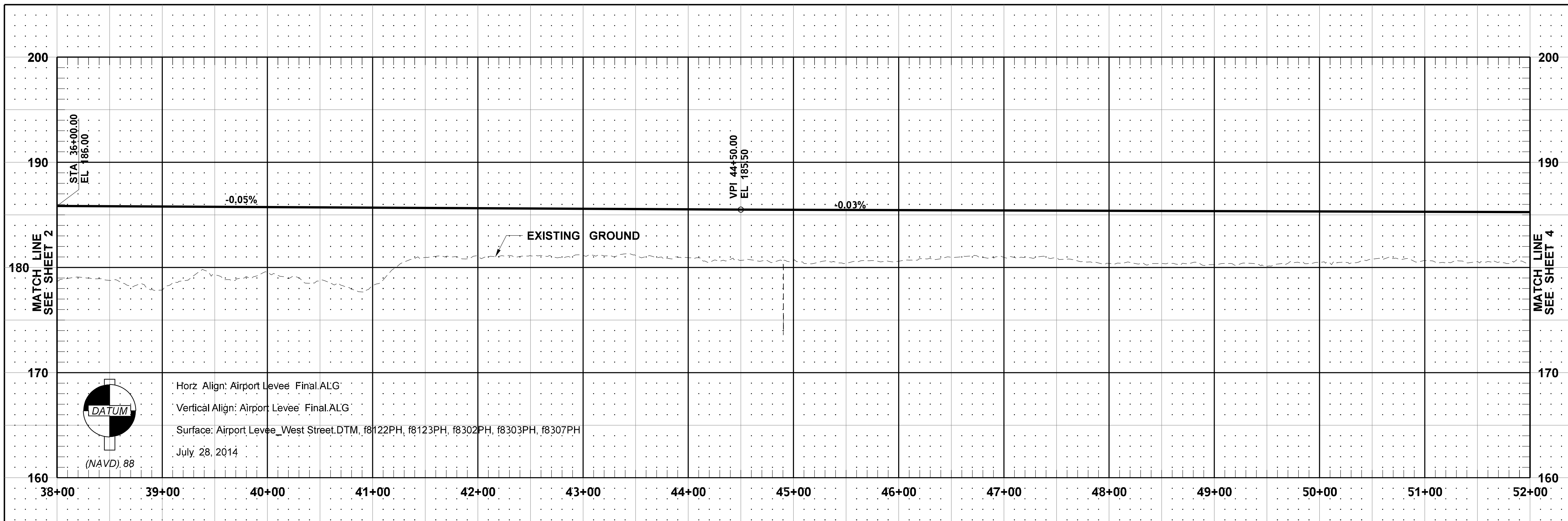
AIRPORT LEVEE

Plot 3

PLAN REF. NO. PS&PR

SHEET 3 OF 11 SHEETS





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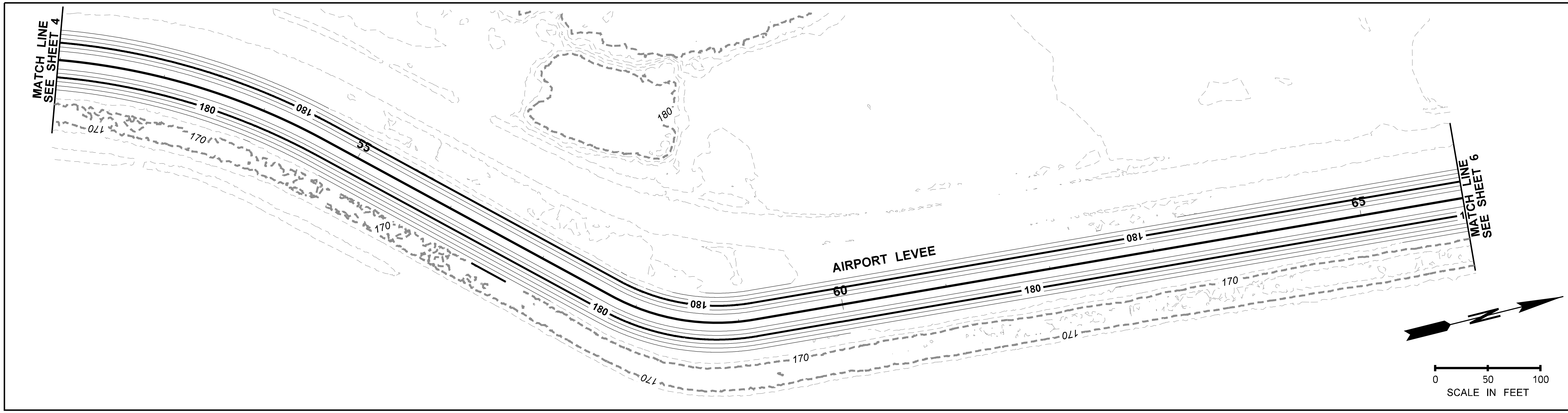
I-5
LEWIS COUNTY
FLOOD PROTECTION

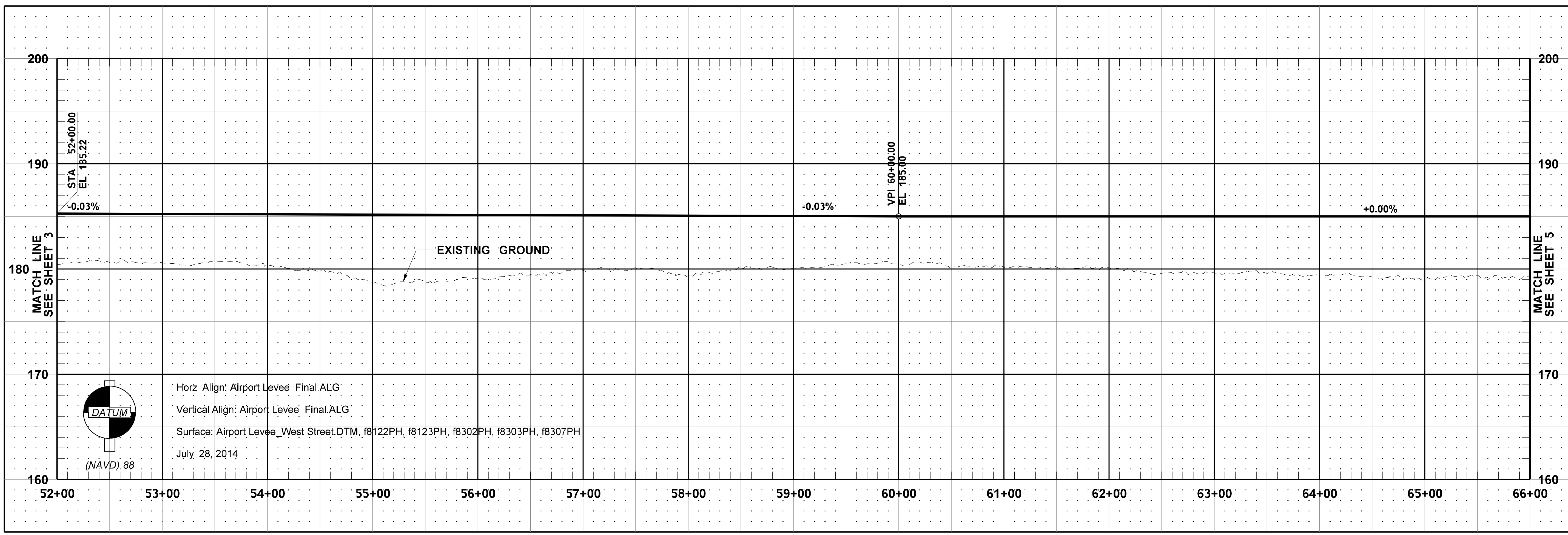
AIRPORT LEVEE

Plot 4

PLAN REF. NO. PS&PR

SHEET 4 OF 11 SHEETS





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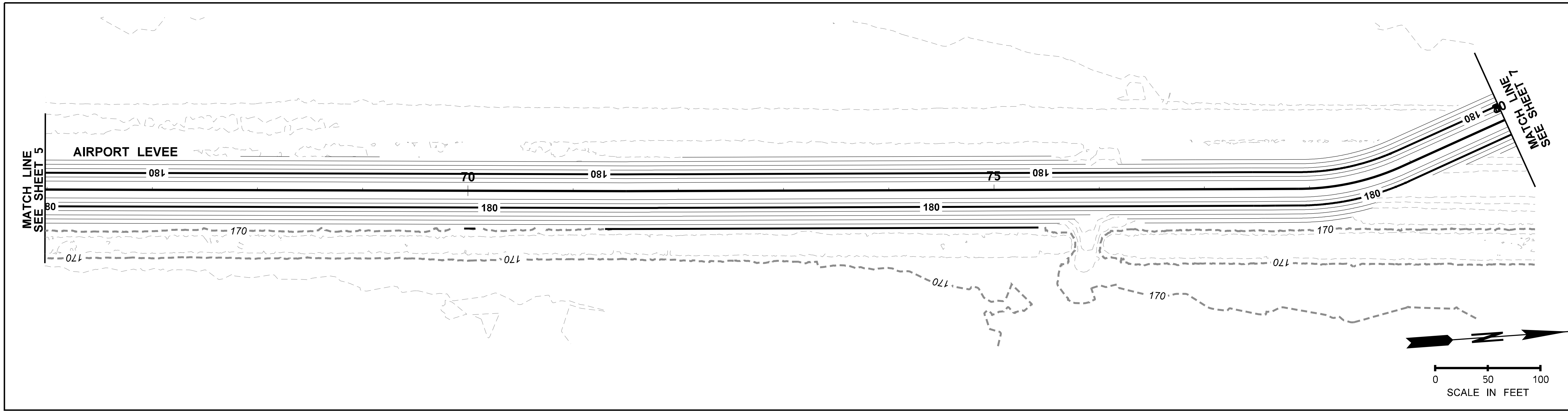
I-5
LEWIS COUNTY
FLOOD PROTECTION

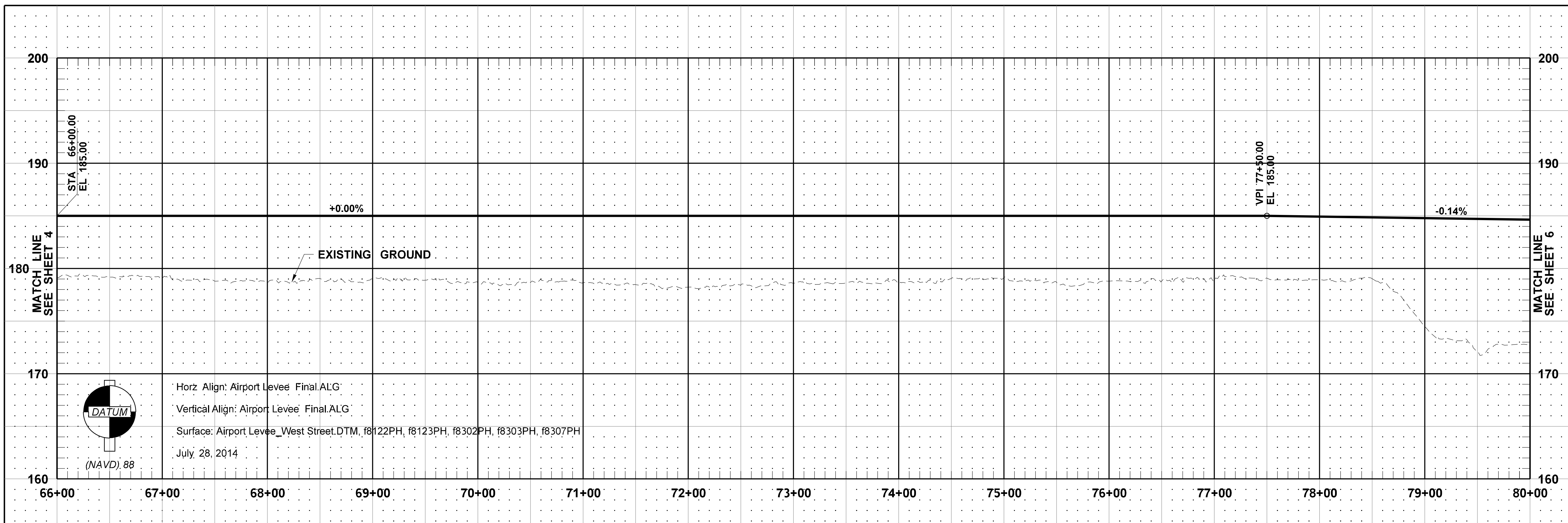
AIRPORT LEVEE

Plot 5

PLAN REF. NO. PS&PR

SHEET 5 OF 11 SHEETS





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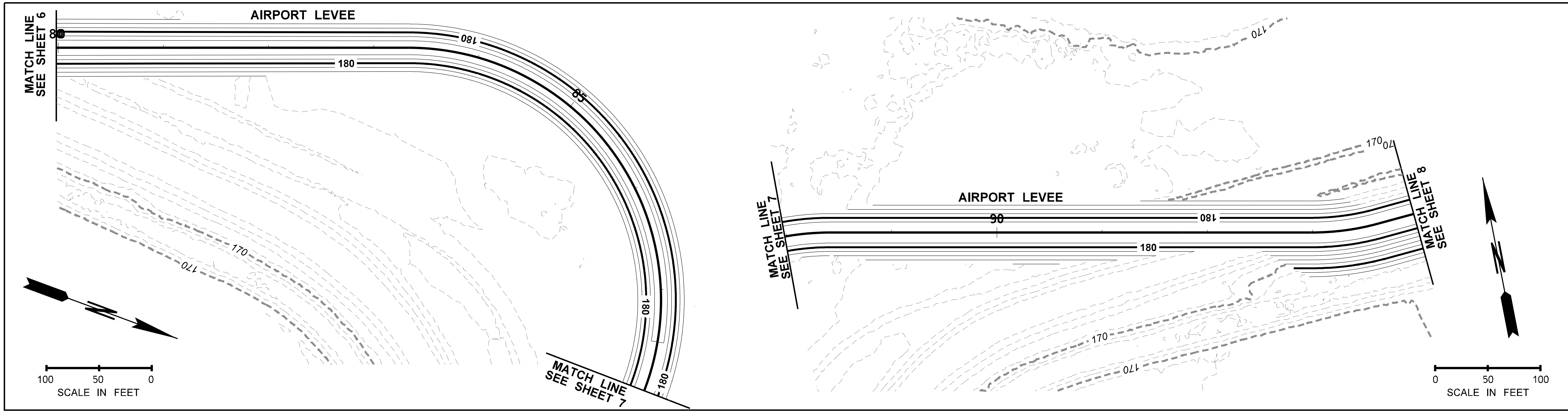
I-5
LEWIS COUNTY
FLOOD PROTECTION

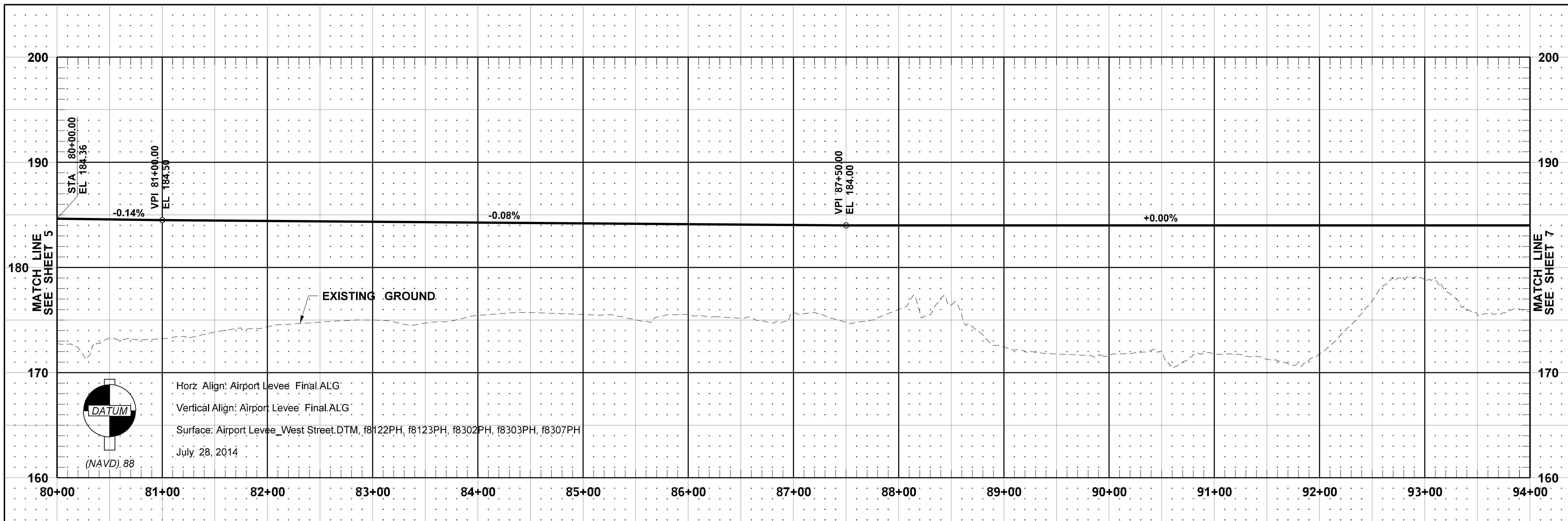
AIRPORT LEVEE

Plot 6

PLAN REF. NO. PS&PR

SHEET 6 OF 11 SHEETS





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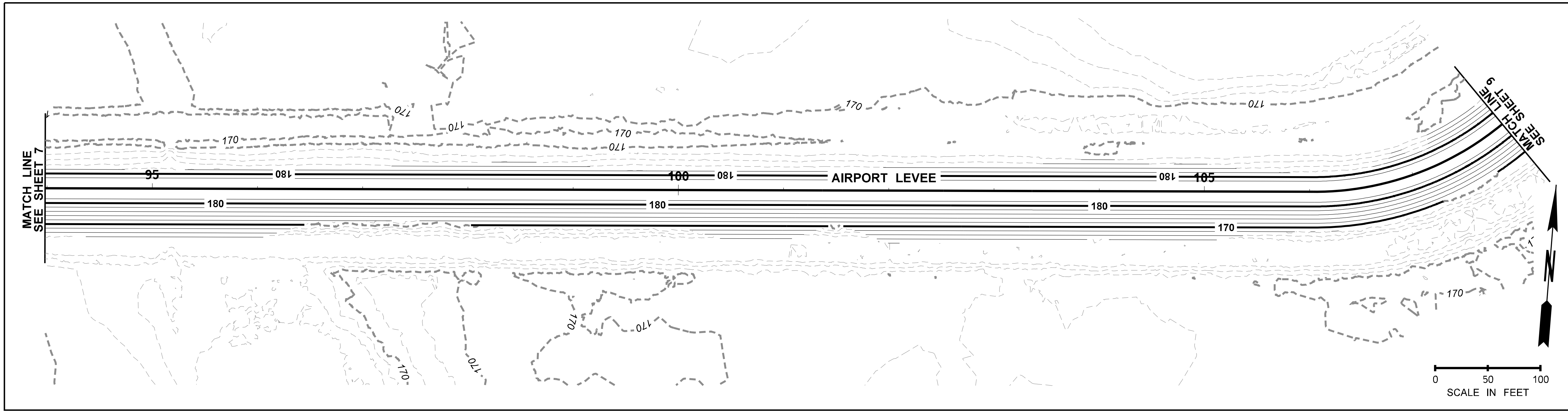
LEWIS COUNTY
FLOOD PROTECTION

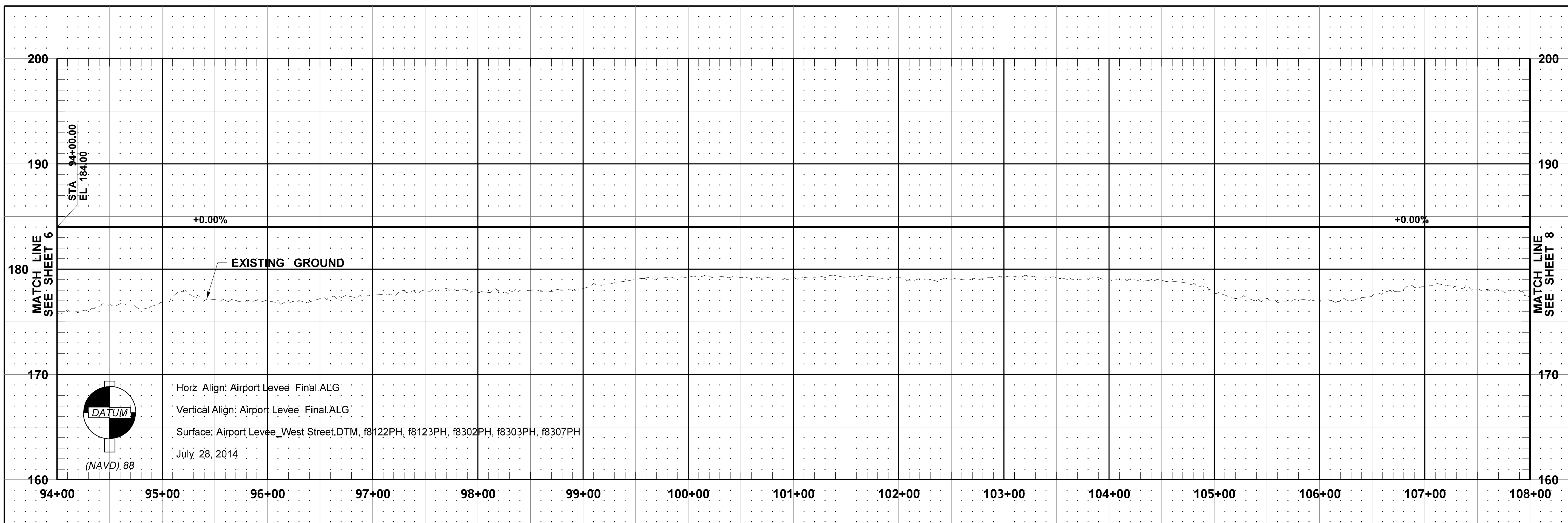
AIRPORT LEVEE

Plot 7

PLAN REF. NO. PS&PR

SHEET 7 OF 11 SHEETS





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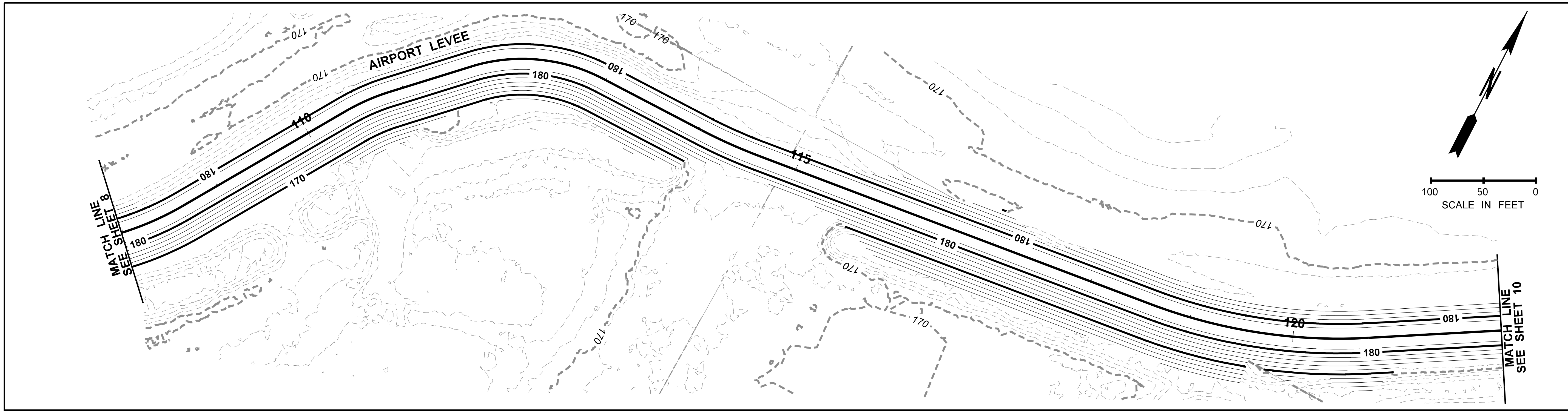
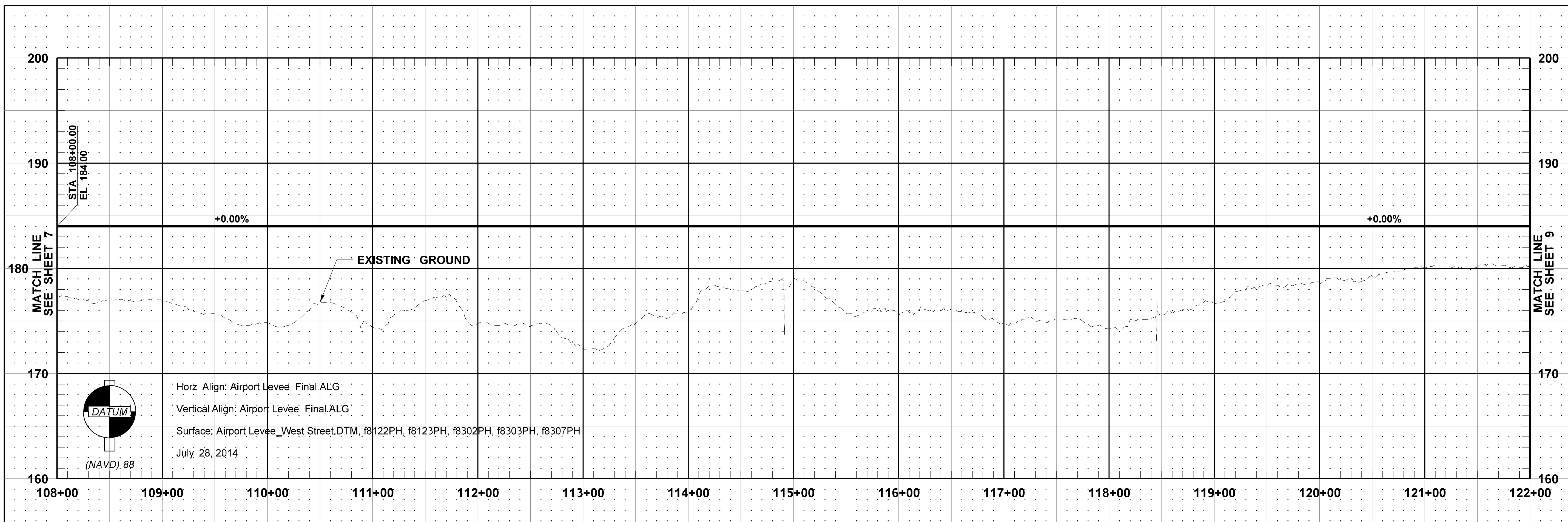
LEWIS COUNTY
FLOOD PROTECTION

AIRPORT LEVEE

Plot 8
PLAN REF. NO. PS&PR
SHEET 8 OF 11 SHEETS





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LEWIS COUNTY
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AIRPORT LEVEE

Plot 9
PLAN REF. NO.
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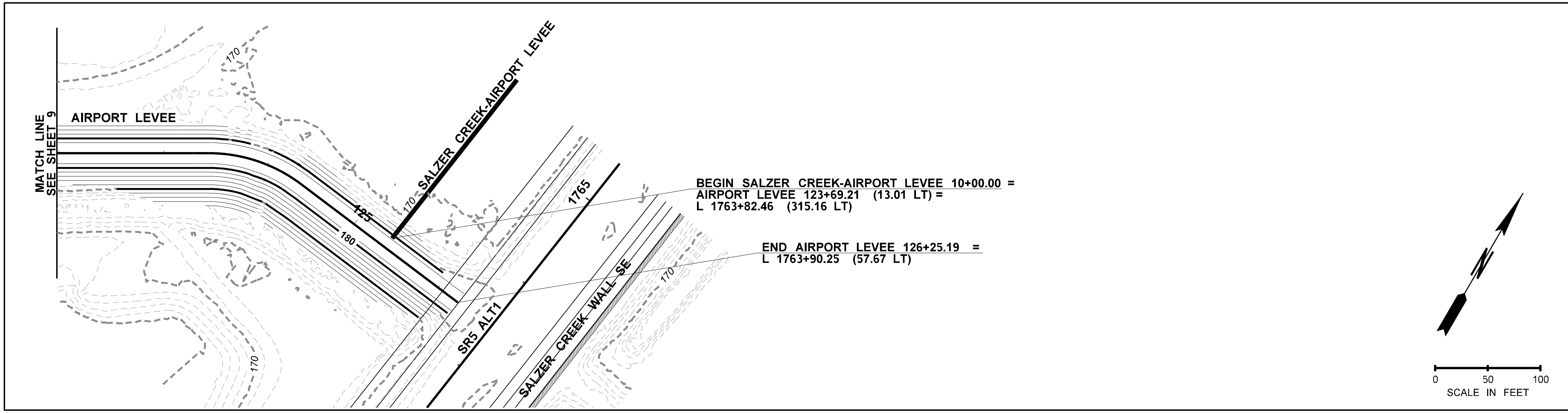
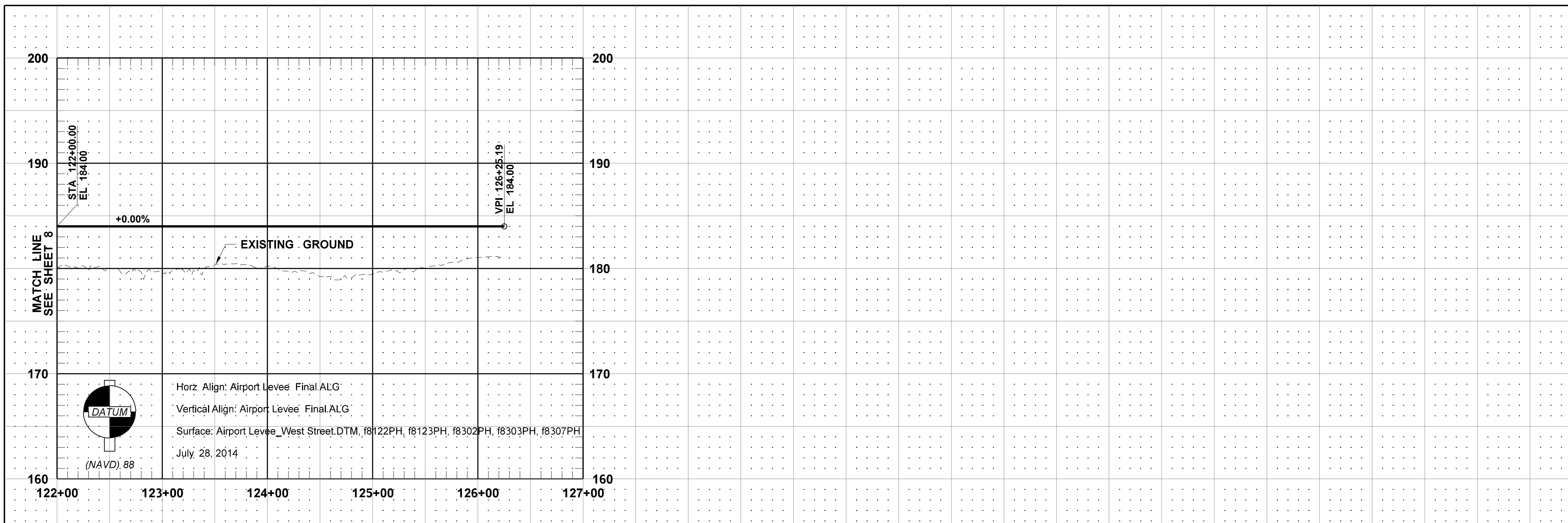
SHEET 9 OF 11 SHEETS





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Washington State Department of Transportation

I-5
LEWIS COUNTY
FLOOD PROTECTION

AIRPORT LEVEE VICINITY MAP

Plot 10

PLAN REF. NO. PS&PR

SHEET 10 OF 11 SHEETS

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Washington State
Department of Transportation

I-5
LEWIS COUNTY
FLOOD PROTECTION

AIRPORT LEVEE

Plot 11
PLAN REF NO
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A.11. Email from Betsy Dillin to Diane Butorac (Washington Department of Ecology) and Janelle Leeson (U.S. Army Corps of Engineers). Regarding: Additional Construction information for the Dam and Levee. April 16, 2019.

From: Betsy Dillin <Betsy.Dillin@lewiscountywa.gov>
Sent: Tuesday, April 16, 2019 4:52 PM
To: Butorac, Diane (ECY) <dbut461@ECY.WA.GOV>; 'Leeson, Janelle D CIV USARMY (US)' <Janelle.D.Leeson@usace.army.mil>
Cc: Erik Martin <Erik.Martin@lewiscountywa.gov>; Jim Waldo <jwaldo@gth-law.com>
Subject: Additional Construction Information for the Dam and Levee

Diane and Janelle,

Below is some additional information about the dam and levee construction schedules and expected in water work.

1. **Construction schedule for Levees**

The actual construction for the levees can be done in a single construction season. There is opportunity to stage the construction work to meet environmental or seasonal restrictions, but at this time we are planning for one year construction.

2. **Construction schedule for Dam**

There are many potential variables associated with contracting strategy and construction approach that influence the construction timeline. These are discussed in the FRO/FRFA report (HDR June 2017). As a simplifying assumption for EIS planning, an assumption of a single construction contract may be an appropriate approach.

The following is from Table 14-2 (HDR June 2017) for FRO Single Construction Contract.

Final Design – (after completing preliminary design and site characterization)	1.5 – 2 yr
Additional permitting allowance	1 yr
Bid/Award	4 – 6 months
Construction	2.5 – 3.5 yr
Total	5.5 – 7yr

The FRE construction schedule will be very similar to the FRO option. The FRE option will be closer to 3.5 years of construction since there is more foundation work, which would lead to an assumption of construction for the EIS from summer 2026 to the end of 2030. The construction period will be better defined in design development.

3. **In-Water Work /Construction Info**

A summary of the conceptual level detail regarding the construction plan, in-water work, dewatering, etc. that has already been completed is provided below. Much of the detail that has been developed is provided in Sections 10 and 14 of the FRO/FRFA report (HDR June 2017).

The construction work is planned to minimize disturbance of the river. This is achieved by starting work in low flow times and isolating the upstream and downstream diversion tunnel portals. Temporary upstream fish passage CHTR (trap and haul) will be installed before the diversion. Once the diversion tunnel is completed and are ready for use, the water is diverted from the existing streambed into the prepared diversion channel and tunnel by removing the material that isolates the tunnels and building temporary upstream and downstream berms across the river channel during low flow times. A temporary upstream cofferdam is assumed to be constructed with RCC behind the temporary berm to an assumed height of El. 665 ft msl. A smaller downstream cofferdam would be constructed to protect the construction area on the downstream side to a height assumed to be El. 635 ft msl. Once the river is diverted, it will flow uninhibited through the diversion tunnel during dam construction. With an RCC cofferdam, seepage will be minimized, but precipitation within the dam construction site runoff area and minor seepage through the cofferdam and foundation will be pumped to appropriate containment for treatment prior to being returned to the river.

After completion of construction (including the permanent fish passage facilities), the process is reversed with preparation of the water passage features of dam for use, removal of the upstream and downstream cofferdams and diversion of the river back to the original channel by constructing a berm to isolate the upstream and downstream tunnel portals. The diversion tunnel is then plugged in the dry. There is more information on the construction sequence in Table 14-1 (HDR June 2017) which is copied below.

Table 14-1

Preliminary Construction Sequence

WORK BREAKDOWN	SEQUENCE CONSIDERATIONS
TUNNEL CONSTRUCTION & INITIAL DIVERSION	
• Isolate portal areas from river flow	Low-flow limitation
• Slowly dewater and “fish” portal areas	Manually and safely remove fish from the areas to be dewatered and return them to the active river system
• Construct tunnel portals	Low-flow limitation
• Build the diversion tunnel by advancing from the downstream side portal to the upstream side portal	Low-flow limitation during completion of tunnel at upstream end.
• Build temporary berm to divert low flows through tunnel	River diverted – low flow
CONSTRUCT COFFERDAMS	
• Prepare flow diversion cofferdam foundation	Low-flow limitation
• Construct cofferdams, RCC upstream	Diversion ready for capacity flows; probable low-flow limitation; start flood risk
• Slowly dewater and “fish” areas behind cofferdams	Manually and safely remove fish from the areas to be dewatered and return them to the active river system
FOUNDATION PREPARATION	
• Excavate abutments & bottom	Emphasize right side to allow structure starts
• Prepare river outlet foundation	Start primary flood risk. Consider grout curtain continuity, avoid undercut
• Perform curtain grout	Include consolidation grouting, if required
• Foundation treatments & dental concrete	Prudent to allow some schedule contingency
LOWER-LEVEL HYDRAULIC STRUCTURES	
• Construct lower-level river outlet works (ROW)	Precedes RCC, through encasement. Includes flood control conduit/passage, ROW piping
• Construct initial energy dissipation, stilling basin	
• Construct lower-level fish passage	
RCC AND DAM	
• Place RCC – bottom to top of ROW encasement	Preceded by quarry development, initial aggregate processing, plant and delivery setup, trial section

• Place RCC – top of ROW to spillway break, include flip bucket mass block	RCC concurrent activities; aggregate processing, instrumentation, gallery construction, face and drain system construction, abutment preparation, ongoing ROW, stilling basin, fish passage construction. Primary flood risk complete
• Place RCC – right wing	
• Place RCC – right side to crest	
• Place RCC – left side to crest	
RIVER OUTLET WORKS	
• Complete intake, gate & service shaft, control structures	Gate & service shaft likely to precede RCC, but formed void could be considered
• Install flood regulating gate	
• Install river outlet gates	
• Install river outlet trash racks & metals	
• Complete ROW & flood regulating mechanical & controls	
• Complete control structure – electrical, mechanical & building trades	ROW ready for re-divert & tunnel plug
SPILLWAY	
• Complete stilling basin & energy dissipation structures	
• Complete plunge pool preparation	Spillway ready for re-divert & tunnel plug
• Construct spillway training walls	
• Construct spillway chute and flip	
• Construct spillway ogee	
• Construct spillway piers & bridge	
FISH PASSAGE	
• Complete downstream fish passage and mechanical	Fish passage ready for re-divert and tunnel plug
• Complete upstream fish passage	
• Complete fish passage conveyance	
• Complete fish passage mechanical & controls, building trades	
COMMISSIONING & RESTORATION	
• Complete electrical & mechanical commissioning	
• Final ROW access & grading construction	
• Breech cofferdams & re-divert river	Final flood risk complete
• Construct plug tunnel	
• Dam backfill, downstream and abutment grading	
• Complete quarry, access, & staging restoration	Preceded by reservoir clearing
• Project schedule contingency	

Thank you,

Betsy Dillin, PE
Senior Utilities and Surface Water Engineer

Lewis County Public Works
2025 NE Kresky Ave
Chehalis, WA 98532
Phone: (360) 740-1138

Betsy.Dillin@lewiscountywa.gov

A.12. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Evan Carnes (U.S. Army Corps of Engineers). Regarding: Chehalis River Basin Water Retention Facility and Levee Improvements - Project Need, Purpose, and Description. May 7, 2019.

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

351 NW North St
Chehalis, WA 98532-1900

May 7, 2019

United States Army Corps of Engineers, Seattle District Regulatory Branch
Attn: Bob Thomas and Evan Carnes
PO Box 3755, Seattle, WA 98124-3755

RE: CHEHALIS RIVER BASIN WATER RETENTION FACILITY AND LEVEE IMPROVEMENTS - PROJECT NEED, PURPOSE, AND DESCRIPTION

PROJECT NEED

Flooding has become more frequent in the Chehalis-Centralia area. The three most recent floods in 1996, 2007, and 2009 were the largest on record and caused extensive physical, emotional, and economic damage. The 2007 and 2009 floods occurred only 13 months apart, affording the community a short window of opportunity to restore the area between floods. These extreme floods caused the loss of homes, farms, and businesses. Floodwater inundation resulted in the closure of Interstate 5 (I-5) for several days. These floods also caused damage to and closure of the Chehalis-Centralia Airport. Most of the flood damage occurred in the cities of Chehalis and Centralia, where there is more intensive development in the floodplain. Peak flows from the 1996, 2007, and 2009 floods rank in the top five at stream gages at the Chehalis River near Grand Mound, the Newaukum River near Chehalis, and the South Fork Chehalis River. Peak flows from these events as measured at the Grand Mound gage on the Chehalis River mainstem are shown in Table 1. As shown, historic flooding on the order of major and catastrophic flooding have occurred relatively recently.

Table 1
Historic Flooding Levels in the Chehalis Basin in Comparison to Reference Flood-Years

HISTORIC FLOOD	REFERENCE FLOOD YEAR	AS MEASURED AT GRAND MOUND STREAM GAGE LOCATION (USGS 12027500)
--	7-year or major flood	38,800 cfs
--	100-year or catastrophic flood	75,100 cfs
1996	--	74,800 cfs
2007	--	79,100 cfs
2009	--	50,700 cfs

Notes:
cfs: cubic feet per second
USGS: U.S. Geological Survey

Flooding of this level can affect structures, such as homes, businesses, and critical public facilities; infrastructure, including transportation corridors; and access to public services. Significant flooding can also cause unsafe conditions for people and animals, including livestock.

Under existing conditions, approximately 2,500 structures of value[1] are located in the upper part of the 100-year floodplain upstream of Grand Mound (Anchor QEA and WSE 2014, 2017). Underlying land uses within the 100-year floodplain in the Chehalis-Centralia area are shown in Figures 1A and 1B. Although not all structures would be lost, depending on the extent of the flooding, significant damage to structures and dangerous conditions for people and animals can occur. The 2007 flood was by far the largest on record, with monetary damages exceeding $900 million (Ruckelshaus 2012).

The Chehalis-Centralia Airport; schools, including Centralia Christian School and Centralia High School; the Southwest Washington Fairgrounds; the Chehalis Wastewater Treatment Plant; and multiple churches and other places of worship would also be inundated in a 100-year event (Figures 1A and 1B). During major floods in the Chehalis Basin, access to these facilities would also be limited. Affected transportation corridors include I-5, State Route (SR) 6 and SR 12 and portions of the BNSF Railway, Port of Chehalis Rail Line, and Tacoma Rail Mountain Division Line.

Under current conditions, I-5 is predicted to be closed for 5 days during a 100-year flood in the Chehalis-Centralia area. A closure of this length would result in prolonged adverse impacts on public health and safety and interstate commerce. This is because prolonged closure blocks access to critical medical facilities and prevents travel to and from areas outside of Chehalis-Centralia. The estimated value of travel disruptions directly associated with I-5 for a 100-year flood without any flood-protection work is approximately $11.9 million to $20.6 million per event (Hallenbeck et al. 2014). This estimate describes only costs directly related to travel that would have occurred were it not for flooding closures. Figures 2A, 2B, and 2C show the portions of I-5 that would be inundated during such an event without the proposed project.

Agricultural land covers approximately 41% of the Chehalis River floodplain. Agricultural uses in the Chehalis Basin consists mainly of livestock grazing, crop farming, and commercial dairy operations (CBP 2004). Flooding has caused erosion that has damaged vast areas of agricultural land. Silt and wood debris transported by the flood in 2007 was estimated to have affected 4,776 acres of agricultural land, with cleanup costs of over $2.3 million. Agricultural lands have also been affected by flooding when livestock are injured and killed, and fences and farm equipment are damaged. Approximately 1,600 commercial livestock, including 400 dairy cows, were lost in the 2007 flood in Lewis County (Ruckelshaus 2012).

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[1] Structures of value include schools, residences, or other structures that would have a relatively high cost associated with restoration from flood damage. Structures of value exclude garages, sheds, park shelters, carports, and similar structures with a relatively low cost of restoration.

PROJECT PURPOSE

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing to construct a flood retention facility near the town of Pe Ell and airport levee improvements at the Chehalis-Centralia Airport, in Lewis County, Washington (proposed project; Figure 3). The proposed project would reduce flooding originating in the Willapa Hills and improve levee integrity at the Chehalis-Centralia Airport to reduce flood damage in the Chehalis-Centralia area as defined in Figure 4. Reduced flood damage would be measured by the following metrics:

1. Removing about 635 structures of value from flooding risk during a 100-year flood
2. Reducing the disruption of access via main transportation routes, specifically ensuring access along State Route (SR) 6 and Interstate 5 (I-5) is open within 24 hours of a 100-year flood
3. Minimizing flood-related impacts (e.g., closure) at the Chehalis-Centralia Airport

To achieve the proposed project purpose, the Applicant is proposing the following objectives:

1. Locate the proposed project within a geographic scope extending from the Pe Ell area to the Chehalis-Centralia area. More specifically, the Applicant is proposing to locate a flood retention facility near Pe Ell and implement levee improvements at the Chehalis-Centralia Airport.
2. Reduce flood elevations during a 100-year flood at the following locations:
   A. 10 feet at the Doty gage (U.S. Geological Survey [USGS] 12020000)
   B. 1 foot at the Mellen Street gage (USGS 12025500)
3. Do not extend the boundaries of the existing 100-year floodplain.
4. Provide future leaders in the Chehalis Basin the flexibility to address additional increases in peak flood levels through an adaptable design approach.

Beyond the 635 properties referenced in metric 1, many additional properties within the target area shown on Figure 4 will benefit with a reduced flood risk. Properties that remain within the 100 year flood boundary will experience lower 100 year flood levels and shorter flooding duration. Quantifying the amount of this benefit in a consistent manner would be difficult and site specific due to individual property's location, elevation, and interaction with the river, which is why it has not been included as a specific metric in the project purpose and need. Regardless, this benefit is demonstrable based on past flood damage assessments and is of critical importance to the Applicant.

The proposed project will also lead to positive results in the area outside the defined target area shown in Figure 4. The area on the Chehalis River extending upstream of the Adna area to the proposed flood facility location will also experience a reduction in 100 year flood levels and duration. This would have a positive impact and be of benefit to properties and infrastructure adjacent to the river including reducing the risk of bridge damage during a major flood. The facility is proposed to be located upstream of Pe Ell and therefore those communities immediately downstream are considered to be valuable partners with the District for the success of this project.

PROPOSED PROJECT DESCRIPTION

Location

The flood retention facility would be located on Weyerhaeuser and Panesko Tree Farm property, south of SR 6 in Lewis County, on the mainstem Chehalis River at approximately River Mile (RM) 108, about 1 mile south of (upstream of) Pe Ell. The legal description of the property is: Section 3, Township 12N, Range 5W, and the parcel number is 016392004000. The watershed area upstream of the flood retention facility is 68.9 square miles. Property acquisition within the flood retention facility and reservoir footprint would be required, and the land would no longer be managed as commercial forestland.

The Applicant is also proposing to raise the existing airport levee and part of NW Louisiana Avenue (Figure 5). The property is located in Section 30, Township 14N, Range 2W, and the parcel number is 005605080001. This construction would take place concurrently with flood retention facility construction but could be completed within 1 construction year.

Flood Retention Facility

The proposed flood retention facility, referred to as a flood retention expandable (FRE) facility, would store floodwater during major or larger floods. Except during these events, the river would flow through the facility unimpeded. Flood levels are defined in Table 2. The FRE facility would reduce the severity and duration of major floods triggered by rainfall in the Willapa Hills. It would neither protect communities from all flooding, nor would it be designed to stop regular annual flooding from the Chehalis River. The FRE facility would be located on private property that is actively managed timberland and is not intended to result in any residential or community development at or around the reservoir.

Table 2
Flood Level Terminology

QUALITATIVE TERM	ANNUAL CHANCE OF OCCURRENCE[1]	FLOOD-YEAR[2]	FLOW AT GRAND MOUND STREAM GAGE LOCATION (USGS 12027500)
Major flooding	15%	7-year	38,800 cfs
Catastrophic flooding	1%	100-year	75,100 cfs
---	0.2%	500-year	107,184 cfs

Notes:
1. Percent chance a flood of this size would occur in any given year
2. Average number of years between a flood of this magnitude

cfs: cubic feet per second
USGS: U.S. Geological Survey

FRE Facility Design and Construction Details

During a major flood, the proposed FRE facility is designed to reduce flood damage from Pe Ell to Centralia by storing up to 65,000 acre-feet of water in a temporary reservoir (Figure 6) and releasing it slowly over time. The maximum upstream extent of the temporary reservoir would be 6.2 miles upstream (based on the 2007 flood level). For major floods, the reservoir would extend an average of 5.3 miles. When it is safe to do so, retained floodwater water would be released slowly back to the river over time (up to 32 days). Most of the time, however, the Chehalis River would flow through conduits in the facility at the river's normal rate of flow and volume, allowing fish to pass without obstruction upstream and downstream (Figures 7 and 8).

The proposed FRE facility is considered to be expandable because it would be built with a foundation and hydraulic structure capable of supporting the future construction of a larger structure and reservoir that could expand the water storage from 65,000 acre-feet up to 130,000 acre-feet. This expansion may or may not occur. If pursued, it would be subject to a separate environmental review and permitting process.

Permanent Structure

The FRE would be a roller compacted concrete (RCC) gravity dam, which is a concrete structure designed to retain water primarily by using the weight of the dam to resist the pressure of water pushing against it. The top of the proposed FRE would be 1,550 feet long and up to 270 feet high (including 3 to 5 feet of freeboard for safety and a 200-foot-wide emergency spillway; HDR 2018). The emergency spillway would discharge over a concrete lined chute to a flip bucket terminal structure. The spillway is expected to be used very rarely, and for events of very short duration. The flip bucket would launch the spillway flow a safe distance downstream of the FRE facility and would dissipate the energy in the river channel (Figure 8). The dam non-overflow top of parapet elevation (654 feet) would be above the maximum estimated reservoir flood pool elevation for a catastrophic flood.

The facility would have five outlet conduits (low-level outlets [LLOs]) for the Chehalis River to pass through: one that is 12 feet wide by 20 feet high and four that are 10 feet wide by 16 feet high. The LLOs would allow the river to pass through the dam structure unimpeded outside of flood events. The LLOs would typically be open, but could be closed for an anticipated flood event using radial control gates (Figure 9). A majority of sediment and most small debris would pass through the LLOs. The LLOs would discharge to a 230-foot-long stilling basin, a concrete structure designed to slow down the flow and minimize downstream channel erosion, before re-entering the natural river channel downstream of the FRE.

Table 3 lists details on temporary reservoir conditions. The *Chehalis River Basin Flood Control: FRE Dam Alternative Combined Dam and Fish Passage Supplemental Design Report* (HDR 2018) provides additional details on the FRE facility design.

Table 3
FRE Temporary Reservoir Conditions

ELEMENT	MAJOR FLOOD CONDITIONS	MAXIMUM RESERVOIR CONDITIONS[3]
Duration of reservoir inundation upstream of the FRE	Up to 32 days	Up to 32 days
Inundation extent	5.3 miles, on average	6.2 miles
Inundated area	188 acres (median)	778 acres
Reservoir elevation[4]	513 feet (median)	620 feet
Reservoir depth	88 feet	195 feet
Maximum design reservoir elevation (invert elevation of spillway)	Not applicable	628 feet
Maximum design reservoir depth	Not applicable	208 feet
Capacity[5]	65,000 acre-feet	

Notes:
3. The FRE facility maximum capacity would be designed to account for a flood similar to the 2007 flood.
4. Elevation of the river bed at the proposed FRE facility site is 420 feet.
5. Capacity is defined as from the base of the FRE facility to the invert elevation of the spillway.

Permanent Infrastructure

Construction and operation activities would necessitate constructing a detour or bypass road for Forest Road (FR) 1000, which is a main access road for Weyerhaeuser forestry operations. The FR 1000 bypass or detour would also provide access to the reservoir area on a permanent basis when the FRE facility is in operation and FR 1000 is inundated. There may be occurrences when the bypass is also temporarily inundated during flood operations. Up to 6 miles of the existing FR 1000 would be inundated and unavailable during major peak flood retention, at which time a detour would be used, consisting of FR A-line, FR F-line, and FR 2000, to rejoin FR 1000 upstream of the reservoir. Specific locations and the extent of improvements to the bypass road for FR 1000 would be defined during the detailed design phase, in conjunction with permitting.

A new power line would be constructed to operate the facility's pumps, gates, instruments, and other controls. The new power lines for the fish passage facility and gate operations would connect to existing local transmission lines, and the new power lines would be located along existing road alignments and areas cleared for FRE facility construction.

Construction

If permitted, the Applicant expects construction would occur between 2025 and 2030 and would last approximately 3.5 years. Prior to construction, final design would take approximately 1.5 to 2 years to complete an additional 1-year permitting allowance, and contract bidding and awarding would take from 4 to 6 months. Altogether, the total contract length would be between approximately 6 and 7 years.

FRE facility construction would require developing a quarry to provide aggregate for the FRE facility structure. This would also include constructing or upgrading roads to the quarry, identifying material storage and processing sites, and constructing areas for offices and storing equipment.

Concrete aggregate could be mined within the FRE facility site or nearby, depending on aggregate availability. The proposed quarry sites are the North Quarry, South Quarry, and Huckleberry Ridge (Figure 10). The North Quarry option would require widening 1.9 miles of FR 1000. The 1000G Road would also require widening, surfacing, and moderate improvements to the subgrade. The South Quarry option would require the same as the North Quarry option with additional upgrades and widening of FR 1000 and FR 1020. The Huckleberry Ridge Quarry option would include 3.01 miles of simple improvements, 2.93 miles of moderate improvements and excavation, and 0.81 mile of complex improvements, including heavy excavation, drilling and blasting. For additional information, refer to the *Chehalis Dam Feasibility Study–Road Improvement Requirements for Dam Construction* (PFR 2019).

A concrete production facility would also be located near the FRE facility and would include both roller-compacted concrete (RCC) and conventional concrete production. The site would include the following:

- RCC batch plant
- Conventional concrete batch plant
- Aggregate crushing and screening
- Aggregate storage
- Fly ash storage
- Cement storage

Construction equipment would include the following, which would be refined as the project progresses into the permitting phase:

- A range of mid- to large-size bulldozers, track excavators, front-end loaders, off-road fixed-wheel and articulated haul trucks, integrated tool carriers, and rollers
- A range of cranes up to 250 tons or larger, such as boom trucks, hydraulic trucks, and rough terrain and track-mounted cranes
- Quarry and material processing equipment, including the following:
  - Track drills (pneumatic and hydraulic)
  - Blasting product storage and transfer
  - Crushing plants, including feeders, primary (jaw), secondary (cone) and tertiary crushers, utility and potentially overland conveyors, screen decks, potentially wash plants, large generators, and electrical control and parts vans
- Concrete production and delivery equipment, such as generators, compressors, mobile to semi-mobile concrete plants, feeders, water chillers, ice plants, nitrogen systems, cement storage silos or trailers, conveyors, overland conveyors, and specialty fabricated equipment
- Support equipment, including the following:

- Trucks (vacuum trucks, water, mechanic, fuel and lube, booms, and flatbeds)
- Storage (vans, CONEX boxes, and temporary buildings)
- Other (generators, welders, compressors, pumps, and office trailers)

Excavation and earthwork operations, or soil movement, would involve soil disturbance as well as varying degrees of foundation rock excavation. Blasting equipment would include hydraulic and air track drills, explosive equipment handling and storage equipment. Production rates for earthwork operations would vary considerably based on the specific operation but would not exceed 5,000 cubic yards per day. In-water work means work completed within the existing river channel below the ordinary high water mark (OHWM).

Work in the river would begin with the isolation and installation of upstream and downstream diversion tunnel portals. This work is expected to occur over the course of a few days during low flow times. The temporary upstream fish passage (Collection, Handling, Transport, and Release [CHTR] or trap-and-haul) would be installed before the diversion tunnel. Temporary upstream and downstream berms across the river channel would then be constructed. A temporary upstream cofferdam is assumed to be constructed with RCC behind the temporary berm to an assumed height of 665 feet mean sea level (MSL). A smaller downstream cofferdam would be constructed to protect the construction area on the downstream side to a height assumed to be El. 635 feet MSL. This work is expected to last between 2 to 4 weeks.

Once the diversion tunnel is completed and is ready for use, river water would be diverted into the prepared diversion channel and tunnel by removing the material that isolates the tunnels. Once the river is diverted, it would flow uninhibited through the diversion tunnel during construction of the FRE. With an RCC cofferdam, seepage would be minimized, but precipitation within the dam construction site runoff area and minor seepage through the cofferdam and foundation would be pumped to appropriate containment for treatment prior to being returned to the river. The duration of diversion through the bypass tunnel is likely to be on the order of 24 months.

After completion of construction (including the permanent fish passage facilities), the process would be reversed with preparation of the water passage features within the FRE facility, removal of the upstream and downstream cofferdams, and diversion of the river back to the original channel. A berm would be constructed to isolate the upstream and downstream tunnel portals so they may be plugged.

Water for construction use is likely to be drawn or predominantly drawn upstream of the cofferdam from the diversion tunnel forebay area. Water use is likely to be between 75,000 and 150,000 million gallons, with as much as 80% of the draw occurring in a 10- to 20-month window. A plan for where water would be drawn, or how much would be used, would need to be developed. If sand or aggregates are washed on site, water use would be on the high side of this range. However, it is not anticipated that conventional concrete sand or other aggregates would be washed on site.

Access to the construction site is anticipated via Muller Road and FR 1000. Trips to and from the project site have not been evaluated, but would include labor and project support, all permanent materials and consumable materials, and construction equipment. A rough range for two-axle truck off-site round trips would be between 100,000 and 180,000 loads and three-axle or larger offsite truck round trips would be between 16,000 and 26,000 loads. On-site hauling of earthwork and quarried aggregates would use site-developed roads dedicated for construction use. These estimates would be refined in future phases of design development in conjunction with and in preparation for permitting.

For additional information, refer to the *Combined Dam and Fish Passage Design Conceptual Report* (HDR 2017) and *Chehalis River Basin Flood Control: FRE Dam Alternative Combined Dam and Fish Passage Supplemental Design Report* (HDR 2018).

Fish Passage During Construction

Downstream fish passage would be provided during construction by the river bypass tunnel, which would include a 20-foot diameter, 1,630-foot long, modified horseshoe-shaped, unlit tunnel to carry water past the construction site. An upstream cofferdam would direct upstream water into the bypass tunnel. A much smaller downstream cofferdam would be constructed to protect the construction area for the stilling basin and fish collection channel. The temporary diversion tunnel would accommodate downstream fish passage consistent with NOAA Fisheries and Washington State Department of Fish and Wildlife criteria during construction of the dam.

Upstream fish passage would be provided during construction by a temporary fish trap-and-haul facility, which would include a fish passage barrier downstream of the tunnel outlet to direct the fish passing upstream into the fish trap. The fish trap would be designed to collect adult target species (species that are listed as endangered, threatened, or species of concern by the National Marine Fisheries Services [NMFS] and the Washington State Department of Fish and Wildlife [WDFW]), resident fish, and lamprey. Once in the trap, fish would be transferred to tanks specially designed for their transportation. Personnel would drive the tanks upstream to pre-determined release sites selected by fisheries biologists. The fish would then be released back into the river to continue their migration upstream

FRE Facility Operations

During non-flood conditions, the reservoir would be empty and the Chehalis River would flow through the reservoir footprint and through the LLOs. Operations are proposed to begin in 2030.

The stages of FRE facility operation are as follows:

- Threshold for operations
- Operations prior to and during floods
- Initial drawdown after floods
- Debris management
- Drawdown after debris management

- Operations outside of flood storage periods

Additional details are included in the *Chehalis Basin Strategy Operations Plan for Flood Retention Facilities* (Anchor QEA 2017) in the sections referring to the Flood Retention Only (FRO) facility.

Threshold for Operations

The FRE facility would retain river flows temporarily, only during floods that are predicted to have a flow rate exceeding 38,800 cubic feet per second (cfs) at the Grand Mound gage (USGS 12027500). A flow rate of 38,800 cfs is equivalent to about a 7-year recurrence interval event at that gage (15% chance of occurrence in any year). When the prediction exceeds 38,800 cfs, water retention would begin within 48 hours of the forecasted flood peak. A 48-hour period gives a reasonable amount of time to predict flows with confidence while also providing enough time to reduce flow rates to designated minimum release rates before major flood flows occur.

Grand Mound is approximately 48 miles downstream from the FRE facility site, so the operators of the FRE facility would rely on flooding predictions up to 4 days in advance. The source of the forecast for major flooding would be the Northwest River Forecast Center, operated by the National Oceanic and Atmospheric Administration (NOAA). The Northwest River Forecast Center uses the NWS Community Hydrologic Prediction System to simulate soil, snow, and stream channel and reservoir conditions. Daily forecasts are made using observations of temperature and precipitation. Forecast of meteorological parameters are included in the river forecast model (NOAA 2016).

Operations Prior to and During Floods

Once flood operations are triggered, flow retention would begin by partially closing the reservoir outlet gates. FRE facility outflow would be reduced at a rate of 200 cfs per hour 2 days prior to when major flooding is predicted to occur. A maximum rate of change in reservoir outflow of 200 cfs per hour was selected for this period to minimize the potential for fish stranding downstream of the reservoir. The 200 cfs per hour rate was determined by applying a 2-inch-per-hour decline in river stage downstream of the dam (to reduce the potential for fish stranding) using the HEC-RAS model developed for the Chehalis Basin Strategy (WSE 2014). The flow rate used for that calculation was 1,000 cfs, the median flow for November to March during which most floods occur. That rate of change would be adjustable and can be adaptively managed during operations.

FRE facility outflows would decrease at 200 cfs per hour until reaching 300 cfs, the minimum outflow during flood operations. A 300-cfs flow is a naturally occurring winter low flow on the Chehalis River. The 300-cfs outflow would exist for only a short distance downstream of the FRE facility where tributary streams enter the Chehalis River and increase flows. The 300-cfs outflow would continue until the peak of the flood passes Grand Mound, which would typically take 48 to 72 hours.

Initial Drawdown after Floods

In order to evacuate the reservoir, the reservoir gates would open and increase outflow by 1,000 cfs per hour to a maximum outflow of 5,000 to 6,500 cfs, causing a drawdown of the reservoir from its peak water surface elevation. Drawdown rates would be limited to 10 feet per day (5 inches per hour) due to risks of landslides, which would limit the duration of the flow increases to about 5 hours. A maximum outflow rate would be reached in that time period and would decrease as the reservoir is drawn down. This is because there is less storage volume per foot of drawdown as the reservoir level drops. The inflow to the reservoir during drawdown could also affect the discharge, because the greater the inflow, the greater the discharge from the reservoir. The maximum duration of reservoir inundation upstream of the FRE would be up to 32 days for a catastrophic flood as described in Table 1.

Debris Management

When major floods and reservoir operations occur, debris from surrounding tributaries and hillsides would be transported into the reservoir. The concern is that large woody material (LWM) could affect the operations of the FRE facility by obstructing the LLOs. Debris up to 3 feet in diameter and 15 feet in length can pass through the LLOs , but large accumulations are expected during flood operations.

Upstream of the FRE facility, an anchored log boom would help contain LWM. At the FRE facility, steel bar racks would protect the river opening entrances from LWM that could not pass through the LLOs downstream.

Debris management procedures would use a boat to move large debris entering the reservoir during a flood to a to an existing log sorting yard previously operated by Weyerhaeuser. The log sorting yard is located on the west bank of the Chehalis River between RM 109.6 and RM 109.9 (Figure 11). It was selected because of its relatively flat topography, ground elevation, and proximity to existing roadways. Debris would be transported away from the log sorting yard by truck.

To give boats time to move logs to the sorting yard location, drawdown rates would be slowed to 2 feet per day (1 inch per hour) for a 2-week period. The decrease in drawdown rate would occur when the storage pool elevation reaches approximately 528 feet. At a storage pool elevation of 528 feet, debris could be readily moved to the designated sorting yard. After corralling the debris onto the sorting yard location, drawdown would continue, and the sorting yard would no longer be inundated. Debris would be either cut up and disposed of, or wood suitable for habitat projects in the Chehalis Basin would be sorted and trucked out of the reservoir area. The removal of the wood debris would occur after the reservoir is drained and once the ground dries out enough to allow heavy equipment onto the sorting yard. The operation of the reservoir (length of time water is retained) to manage debris accumulations would be adaptive and depend on the amount of wood accumulated and the ability of operations personnel to move wood to the sorting yard location.

Drawdown After Debris Management

Drawdown rates would increase to 10 feet per day (5 inches per hour) when debris management operations have concluded and the storage pool elevation reaches 500 feet. Drawdown rates would continue at this rate until the storage pool is emptied (pool elevation of 425 feet). At this point, the reservoir would no longer be impounding water and the Chehalis River would return to a free-flowing state.

Operations Outside of Flood Storage Periods

FRE facility operations would be triggered by the prediction of 38,800 cfs water flow at the Grand Mound gage. Outside of the flood storage period, the inflow to the reservoir would be discharged through the FRE facility LLOs with gates normally open. The LLOs are designed to simulate the natural river channel condition through the dam reach to the extent possible. Flows up to approximately 8,000 cfs are expected to pass freely through the LLOs. Water is expected to be near the top (crown) of the tunnel's opening with all LLOs operating at full open gate condition. A flow of 8,000 cfs has a recurrence interval of 3 years at the FRE facility site. For flows between 8,000 cfs and 12,500 cfs, the flow would transition from a free-flowing condition to a ponding condition at the tunnel entrance. For flows greater than 12,500 cfs, water ponding would occur at the entrance to the tunnels. The ponding level rises as the flow increases because greater water depth is needed to pass the flow through the tunnels. This is expected to provide small attenuation of the event peak flow.

Fish Passage Design Details

Fish passage facilities at the FRE facility would allow fish to pass both upstream and downstream during normal flows and during major or larger floods, as described in the following sections. For more information on construction and permanent fish passage design, refer to the *Draft Technical Memorandum: Simple Description of Fish Passage Operation* (HDR 2019) and the *Chehalis Basin Strategy: Fish Passage CHTR Preliminary Design* (Anchor QEA and HDR 2018).

Fish Passage During Normal Flows

The FRE facility would allow fish to pass upstream and downstream freely in conditions that mimic the existing natural rock canyon at that location. During normal flows, fish would pass through the five unlit LLOs that would remain open during normal conditions and smaller floods. The LLOs would be 310 feet in length and are anticipated to replicate the natural stream flow and velocity exhibited by the natural channel up through river discharges of 4,000 cfs. The LLOs would discharge into a 230-foot-long stilling basin. Most of the year, when no impoundment is occurring, aquatic species passing upstream would be able to move from the river, into the stilling basin, through the LLOs, and back into the river upstream of the FRE facility. Aquatic species passing downstream would follow the same path in the opposite direction.

Fish Passage During Reservoir Impoundments

A trap-and-haul facility would be used to provide upstream fish passage during major or larger floods when the structure's LLOs are closed and a reservoir has formed. The trap-and-haul facility would consist of an attraction water supply to draw fish into the facility, fish ladders, and a lamprey ramp to guide them to the fish traps, trap and holding facilities, a fish sorting building, fish transport tanks and trucks, and ancillary support structures (Figure 12). The CHTR is intended to collect migrating adult salmon and steelhead, juvenile salmon and steelhead, resident fish, and lamprey moving upstream, and safely transport them upstream of the FRE.

Operation of the CHTR facility would begin attracting and trapping fish immediately prior to the closure of the radial gates. Operation of the CHTR facility would continue through impoundment of water behind the FRE facility as the reservoir is evacuated, as release from the reservoir is slowed for debris management, and as the last remaining water in the reservoir is released. Fish would be released into the river at pre-selected release sites upstream of the FRE facility determined by fisheries biologists. Downstream fish passage would not be provided during major floods when the LLOs are closed, a period of up to 32 days.

Vegetation Management

In addition to removing vegetation for the FRE facility, tree clearing, and vegetation removal would occur within the reservoir area before construction and during operations. Vegetation management would include an integrated harvest and replanting program to help minimize temperature impacts on the river.

Pre-Construction Vegetation Management Plan

A pre-construction vegetation management plan would be implemented during the construction phase of the FRE facility. Table 4 shows the elevation of each inundation zone, the proposed pre-construction management actions that would be implemented in each zone, and the expected vegetation community type and vegetation that would be present in each zone after facility construction and operation. Figure 13 shows the expected extent of each vegetation community type.

The inundation zones are as follows:

- 10% chance of being flooded in a year (10-year flood); will be under water for 25 days per year when flooded
- 5% chance of being flooded in a year (20-year flood); will be under water for 4 days per year when flooded
- 1% chance of being flooded in a year (100-year flood); will be under water for 1 day per year when flooded
- Less than 1% chance of being flooded in a year (greater than a 100-year flood)

Prior to construction, woody vegetation would be completely cleared from the FRE facility site and from any areas where temporary construction access would be required. All non-flood-tolerant tree species would be removed from the zone where the inundation duration is expected to last 25 days or more when the reservoir is storing water (Table 4). Non-flood-tolerant tree species are defined as those species that are unable to withstand more than a few days of flooding during the growing season without significant mortality (Whitlow and Harris 1979).

Common non-flood-tolerant tree species identified in this document for the Pacific Northwest include Douglas fir (*Pseudotsuga menziesii*), big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and bitter cherry (*Prunus emarginata*). Douglas fir will not survive flooding that lasts more than a few days.

Table 4
Expected Vegetation Community Types by Inundation Zone in the Flood Retention Only Reservoir[5]

INUNDATION ZONE	ELEVATION RANGE (FEET)[1]	PRE-CONSTRUCTION MANAGEMENT ACTIONS[2]	AREA (ACRES)[3]	EXPECTED POST-CONSTRUCTION VEGETATION COMMUNITY TYPE AND TYPICAL VEGETATION
10% chance of being flooded in a year	424 to 567	Selectively harvested to remove non-flood-tolerant species[4]	405	**Deciduous Riparian Shrubland** – various willows, red-osier dogwood, potential emergent/scrub-shrub wetlands
5% chance of being flooded in a year	567 to 584	No harvest	80	**Deciduous Riparian Forest with some Conifers** – red alder, western red cedar, Oregon ash, black cottonwood, willows, elderberry, snowberry
1% chance of being flooded in a year	584 to 612	No harvest	136	**Mixed Coniferous/Deciduous Transitional Forest** – Douglas fir (young), red alder, big leaf maple
Less than 1% chance of being flooded in a year	612 to 627	No harvest	90	**Coniferous Forest** – Douglas fir

Notes:
1. North American Vertical Datum of 1988 (NAVD88)
2. These management actions may be either periodically repeated on a regular management cycle (e.g., every 20 years) or as needed.
3. Vegetated area extents are only those areas that are currently vegetated and do not include roads or non-vegetated land (e.g., stream channels).
4. It is assumed that the Washington Department of Natural Resources would allow the removal of non-flood-tolerant trees from the RMZ in this portion of the reservoir footprint.
5. FRE and FRO facilities have the same general operations, but the FRE facility would have higher flow capacity (five gates rather than three), which would reduce the chance of inundation in a year.

The pre-construction management actions would meet Washington Department of Natural Resources (WDNR) regulations. Proposed management actions would potentially include the removal of commercial timber from existing WDNR-defined riparian management zones (RMZs) along sections of the Chehalis River and tributaries in the reservoir footprint. This approach would primarily target all Douglas fir in the RMZ, because this species would not be expected to survive in this inundation zone. For the remaining zones where the inundation duration would range from 1 to 4 days when flooded, no harvesting would occur. Depending on inundation timing and duration, some of the remnant non-flood-tolerant trees may eventually die and go on to provide wildlife habitat as snags or downed woody material. The uppermost inundation zone of the reservoir footprint would be left as a predominantly coniferous forest.

Vegetation Management During Operation of the FRE Facility

Existing conifers located farther from the river that may provide shade while the replacement species are growing could remain in place. These trees may need to be removed if the facility reaches its maximum use and the longest holding and release period. Routine reservoir limit clearing activities are expected to be confined to the removal of trees larger than approximately 6 inches diameter at breast height and below the catastrophic flood level (i.e., 100-year flood stage, per the Applicant), should they regrow. A periodic clearing activity would occur about every 7 to 10 years, in which trees larger than that diameter would be felled and either left to decay or salvaged for biomass.

Adaptive management activities would focus primarily on controlling temperature effects on aquatic resources, reducing potential woody debris accumulation at the LLOs, and encouraging vegetation that provides slope stability. In addition, the adaptive management program would focus on maintenance of flood-tolerant vegetation that does not produce LWM or experience large-scale die-off in response to extended submergence during the flood season or growing season. Natural species selection would also be monitored over time to determine which native species persist in this changing environment and to encourage the growth of these species.

Airport Levee Improvements

1.1.1.1 Airport Levee Design

Airport levee improvements including raising the existing airport levee and part of NW Louisiana Avenue is also proposed (Figure 5). The project would result in up to 11,211 lineal feet of protective levee and includes the following elements:

- Add 4 to 7 feet to the height of the existing 9,511-foot-long levee with earthen materials or floodwalls
- Raise 810 feet of NW Louisiana Avenue along the southern extent of the airport
- Relocate the northwest corner of the levee to avoid interfering with the runway glide path
- Replace utility infrastructure
- Terminate the West Street over-cross approach
- Widen portions of the existing levee base in locations where there are retaining walls and remove the retaining walls

1.1.1.2 Construction

Construction activities would occur under the following general sequence:

- Mobilization
- Erosion control, clearing, and grubbing
- Removal of structures or obstructions
- Material placement and compaction
- Trimming, cleanup, and sod placement

Construction equipment would include the following, which would be refined as the project progresses into the permitting phase:

- A range of equipment sizes (trending on mid- to large-size) of bulldozers, track excavators, front-end loaders, off-road fixed-wheel and articulated haul trucks, integrated tool carriers, and rollers

- Support equipment, including the following:
  - Trucks (various dump trucks, water, mechanic, fuel and lube, and flatbeds)
  - Storage (vans, CONEX boxes, and temporary buildings)
  - Other (generators, compressors, pumps, and office trailers)

Excavation and earthwork operations would include removal of existing temporary retaining walls, removal of the crushed top course that is currently on top of the levee, and any excavation needed to place hydraulic structures such as culverts. No new quarries or borrow pits would be developed. Only existing sources would be evaluated for acceptable fill material, which would be brought in from off site. Typically, soil would only be displaced in areas where benching may occur or in areas of culvert placement.

Haul routes (Figure 14) would include Airport Road, and the top of the levee would be used for site access. Louisiana Avenue to the south is the preferred off-site route to avoid the congested traffic area east of the airport.

Attachments and Additional Resource Documents

The following list of attachments and resource documents contain additional information about the proposed project and can be used to supplement information in this project description.

Additional resource documents:

- *Draft Technical Memorandum: Simple Description of Fish Passage Operation* (HDR 2019)
- *Chehalis Dam Feasibility Study–Road Improvement Requirements for Dam Construction* (PFR 2019)
- *Chehalis River Basin Flood Control: FRE Dam Alternative Combined Dam and Fish Passage Supplemental Design Report* (HDR 2018): http://chehalisbasinstrategy.com/wp-content/uploads/2018/09/FRE-Alternative-Supplemental-Report-2018-09-27-reduced.pdf
- *Chehalis Basin Strategy: Fish Passage CHTR Preliminary Design Report* (Anchor QEA and HDR 2018): http://chehalisbasinstrategy.com/wp-content/uploads/2018/03/Chehalis-CHTR-Prelim-Design-Report_FINAL_2018-02-19reduced.pdf
- *Chehalis Basin Strategy Operations Plan for Flood Retention Facilities* (Anchor QEA 2017): http://chehalisbasinstrategy.com/wp-content/uploads/2017/07/Final-Operations-Plan-for-Flood-Retention-Facilities-1.pdf
- *Chehalis Basin Strategy Technical Memorandum: Proposed Flood Retention Facility Pre-construction Vegetation Management Plan* (Anchor QEA 2016): http://chehalisbasinstrategy.com/wp-content/uploads/2017/07/Chehalis-Basin-Strategy-FRO-FRFA-PreCon-Veg-Mgmt-Memo.pdf

Applicant-provided Information:

- *Chehalis River Basin Water Retention Facility - Project Purpose, Need and Objectives*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Evan Carnes (U.S. Army Corps of Engineers). November 9, 2017.
- *Chehalis River Basin Flood Damage Reduction Project Description*. Chehalis River Basin Flood Control Zone District. 2018.
- *Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). November 30, 2018.
- *Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification.* Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). January 11, 2019.
- *Chehalis River Basin Flood Control Zone District Project Description Clarification*. Letter from Betsy Dillin (Chehalis River Basin Flood Control Zone District) to Diane Butorac (Washington Department of Ecology) and Janelle Leeson (U.S. Army Corps of Engineers). January 14, 2019.

- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). February 12, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 1, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 7, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 15, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 19, 2019.

FIGURES

Figure 1A
Land Use – 100-Year Floodplain

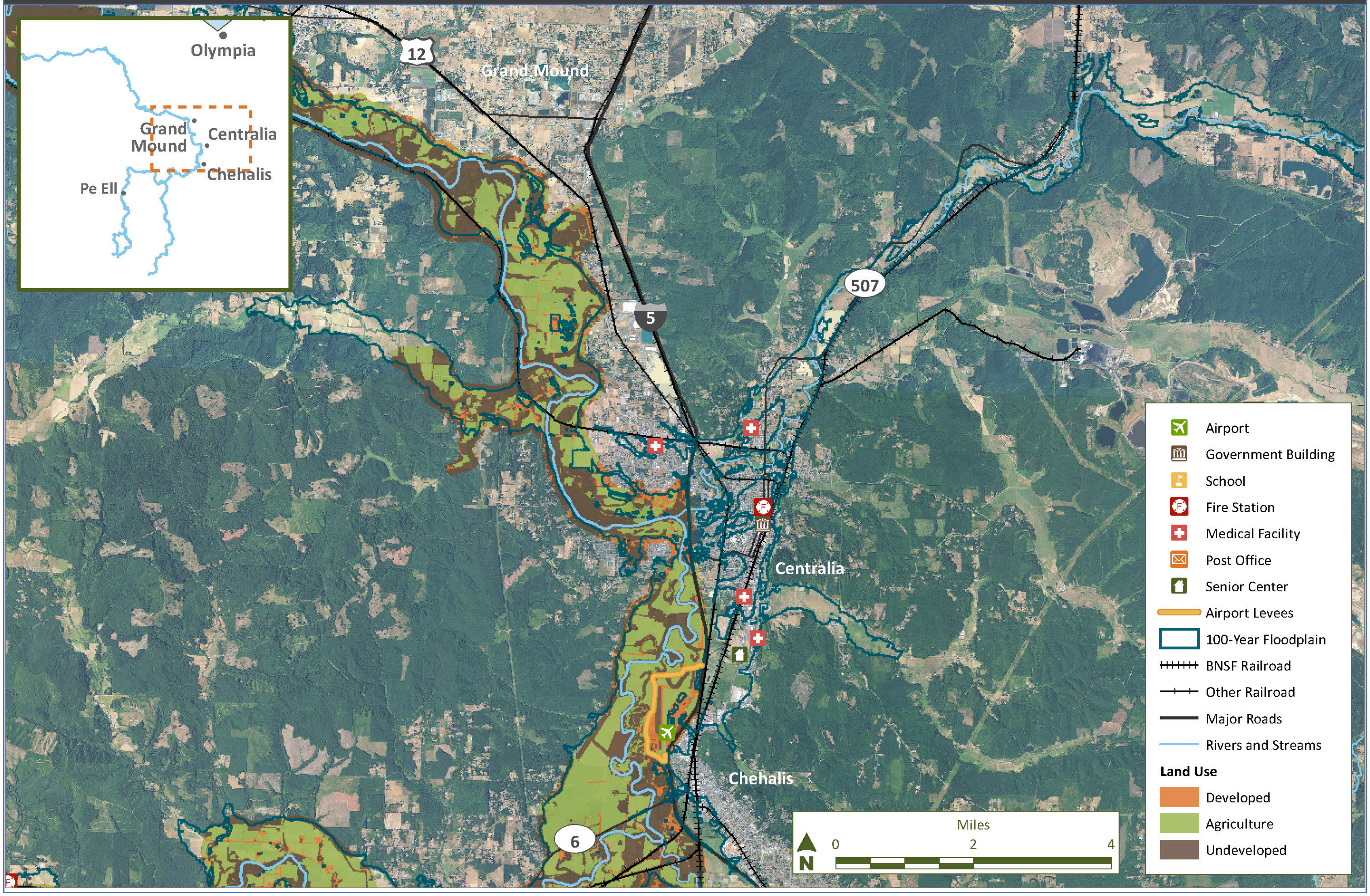


Figure 1B

Land Use – 100-Year Floodplain

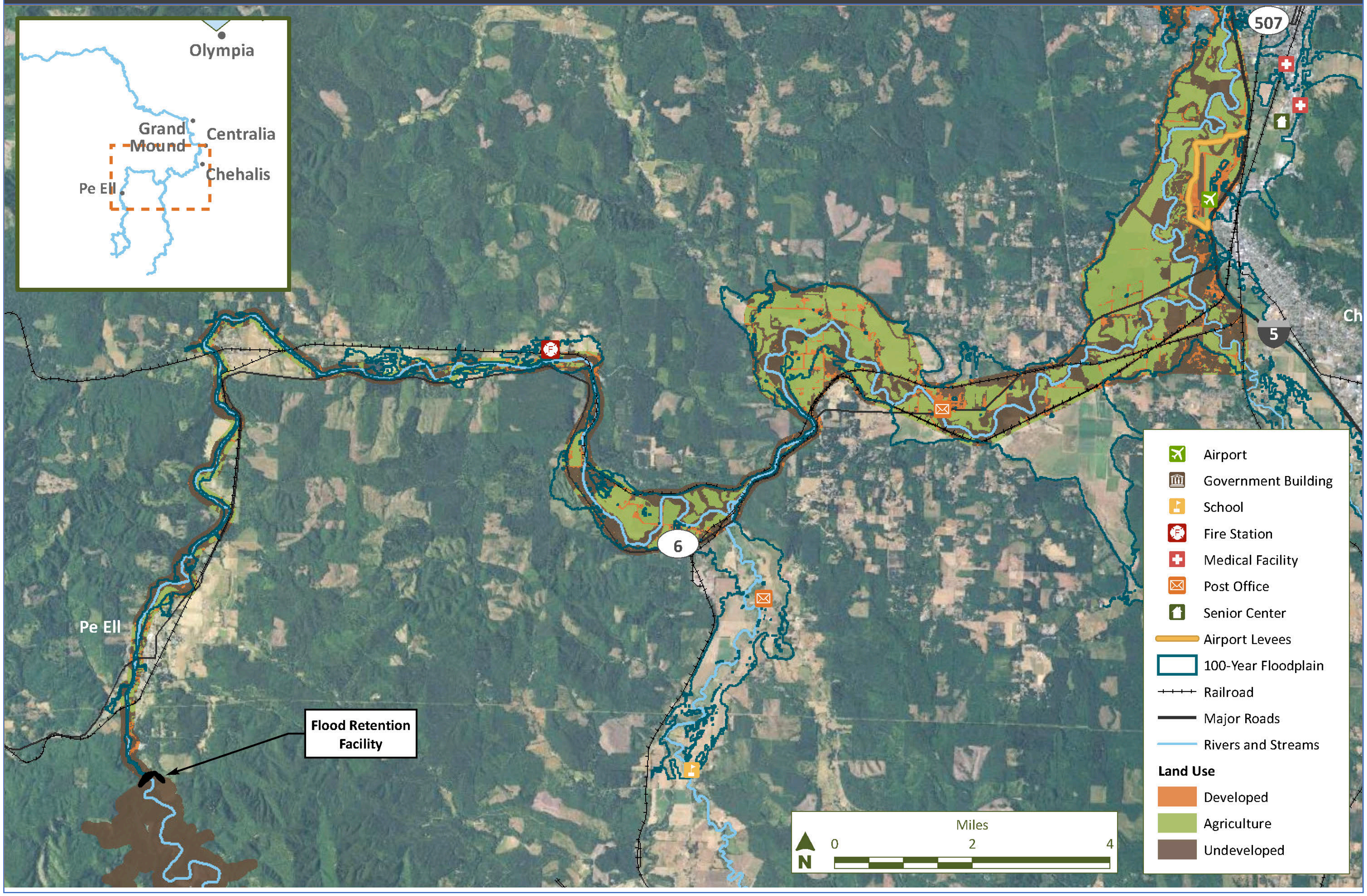


Figure 2A
I-5 Inundation

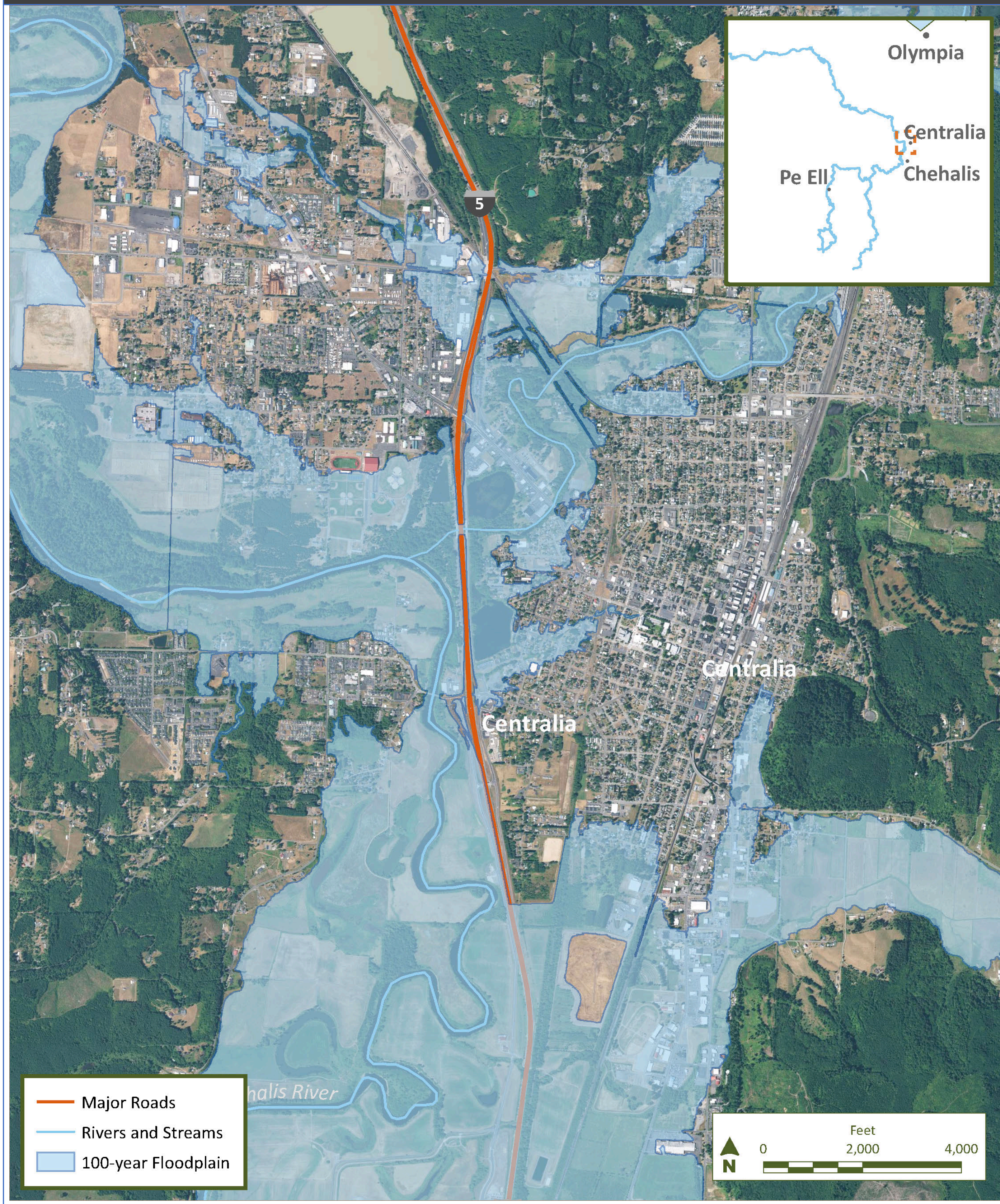


Figure 2B

I-5 Inundation

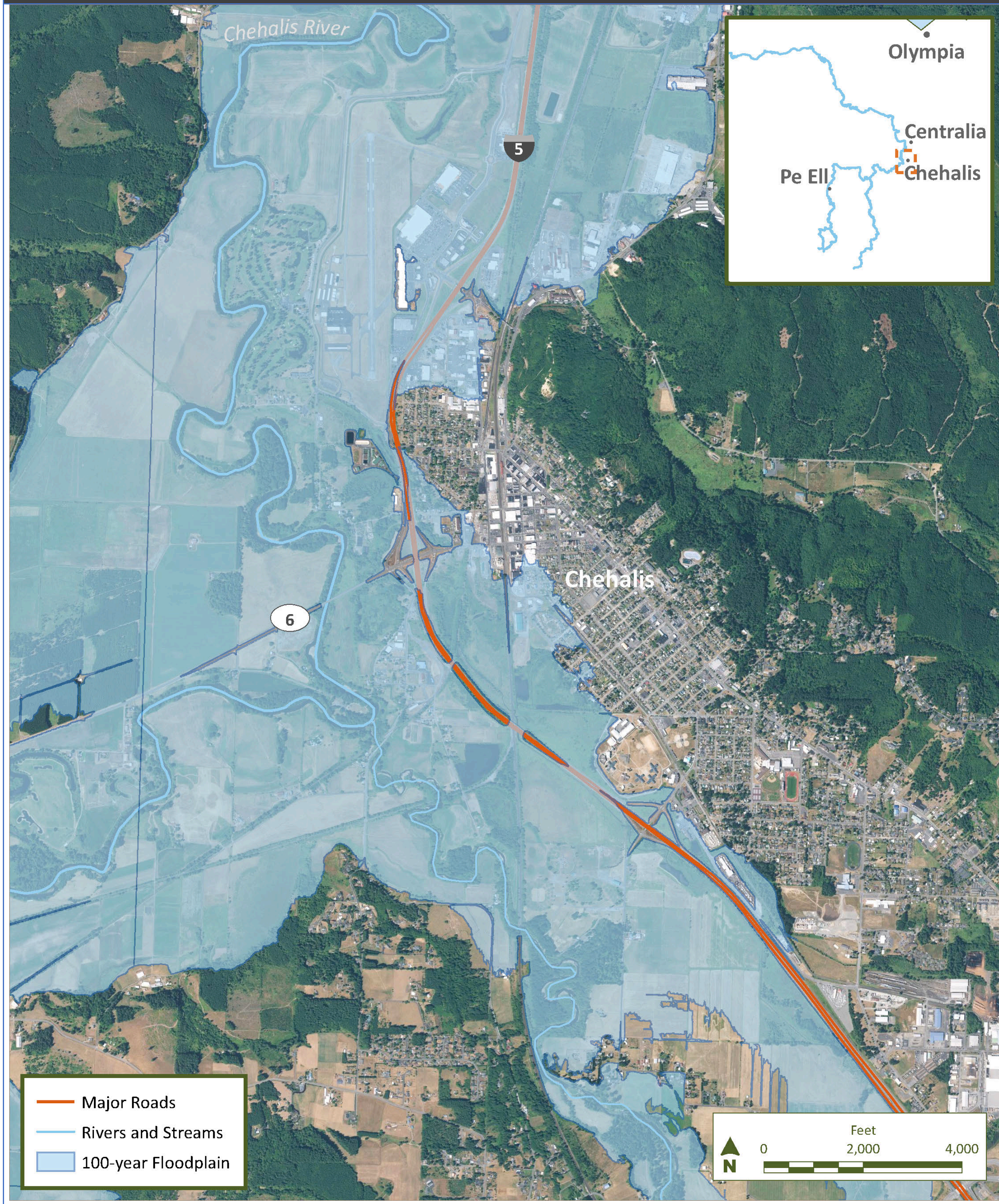


Figure 2C

I-5 Inundation

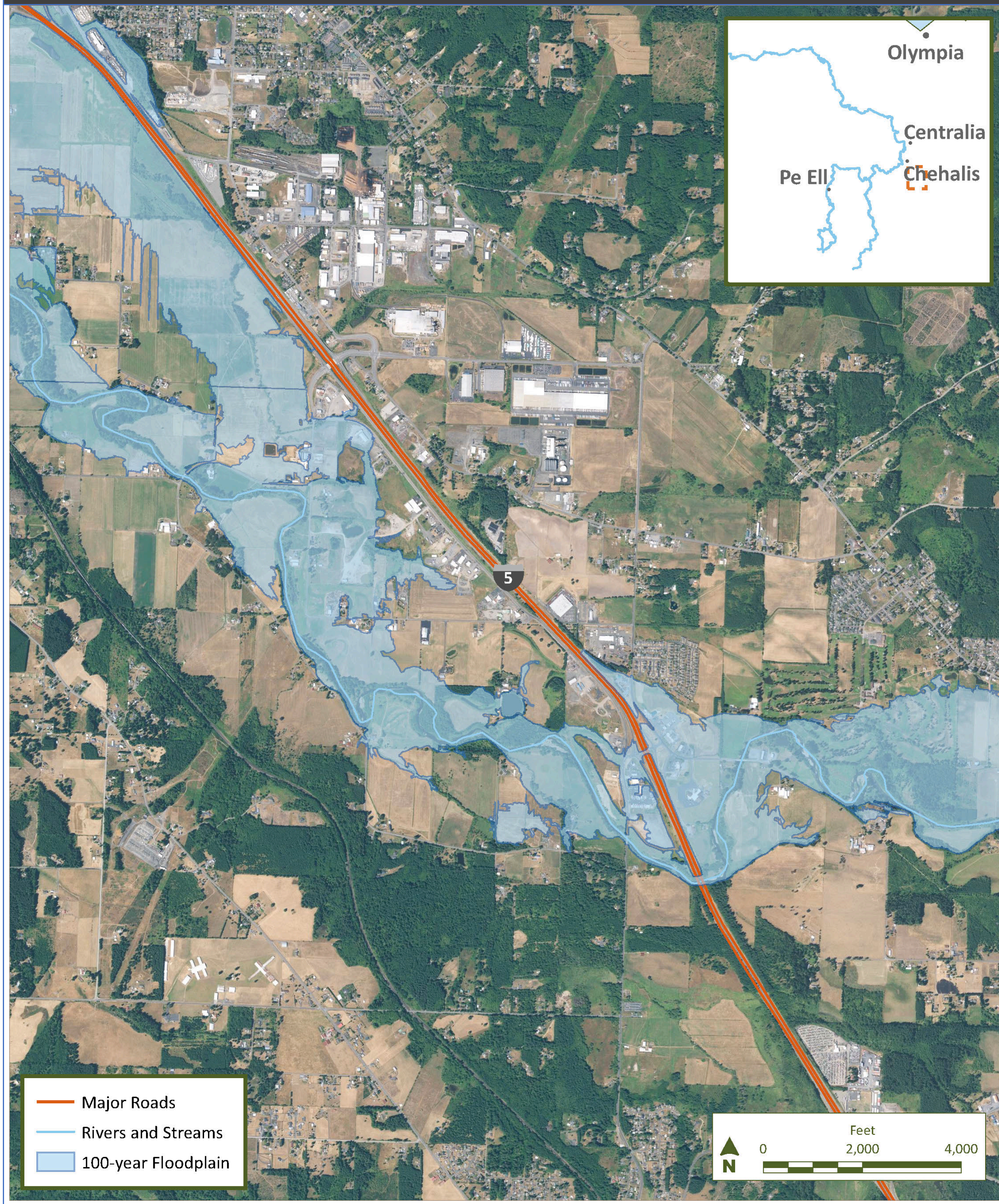


Figure 3
Vicinity Map

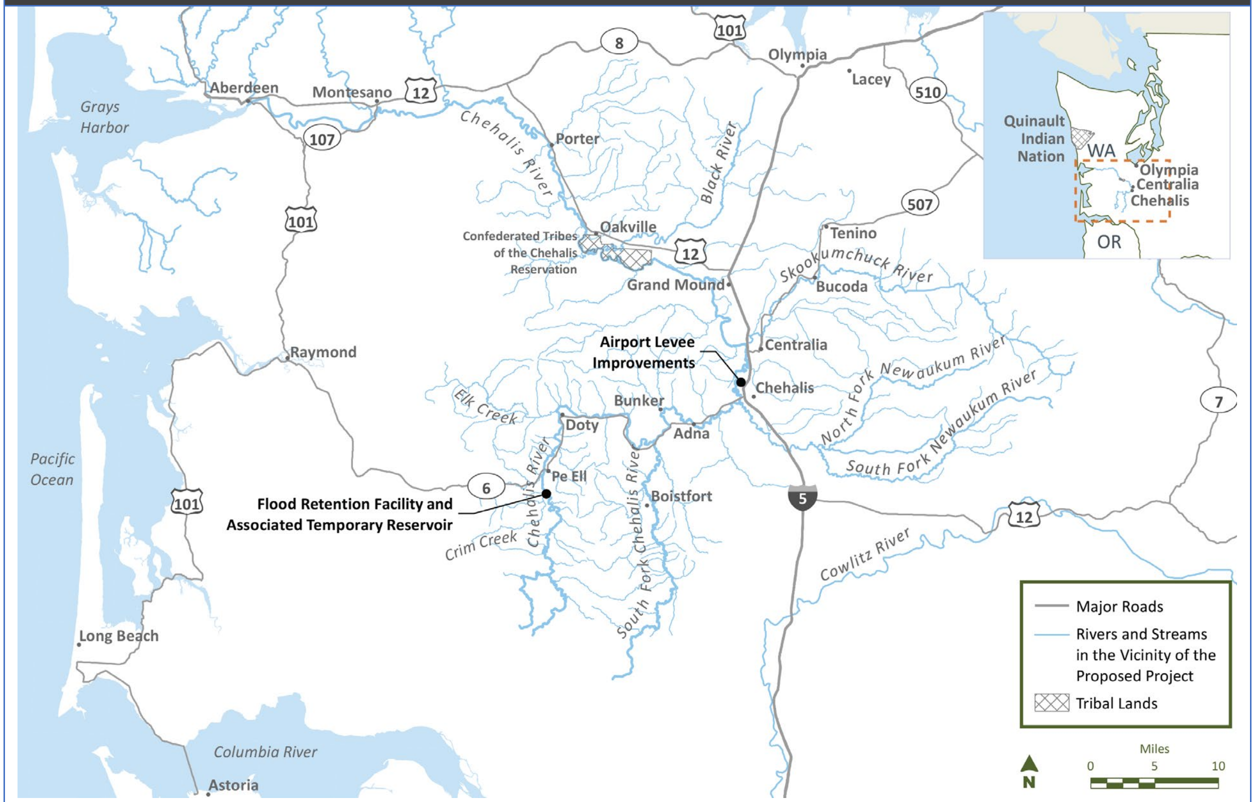


Figure 4
Flood Damage Reduction Target Area

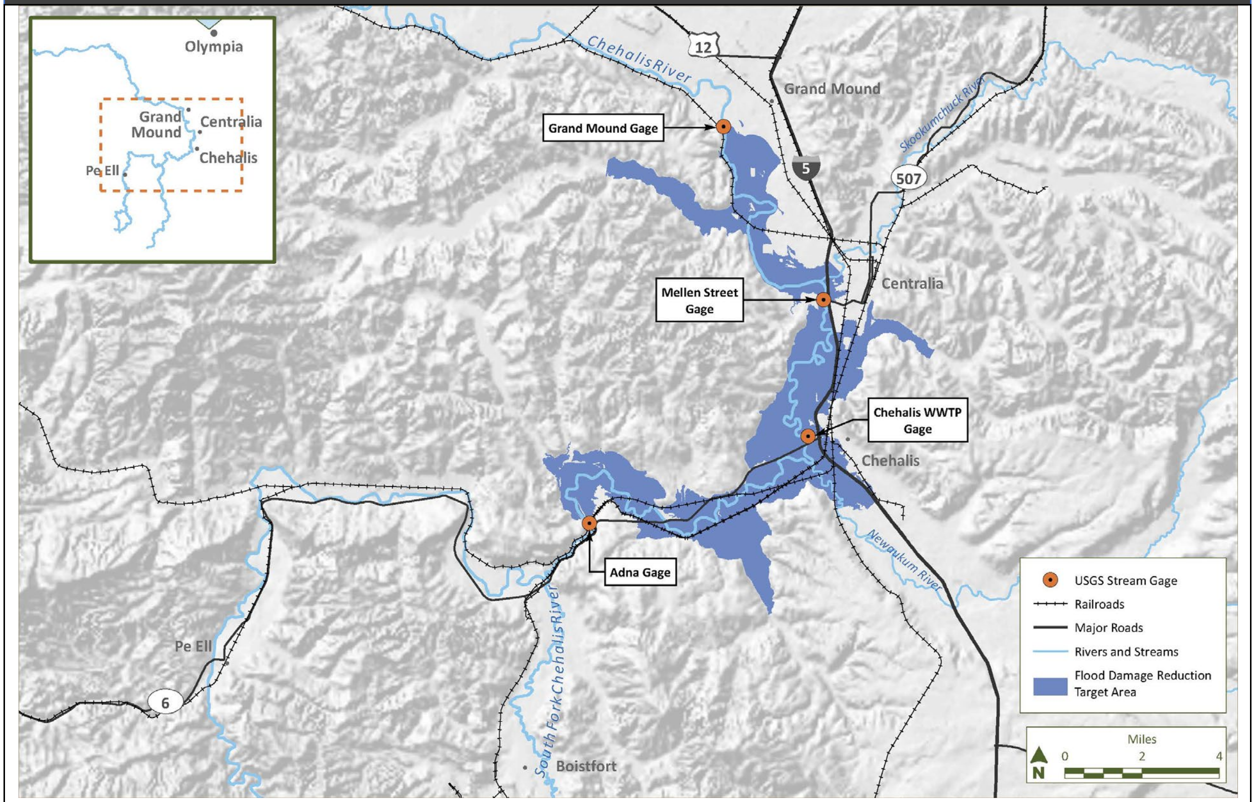


Figure 5
Airport Levee Improvements (DRAFT)

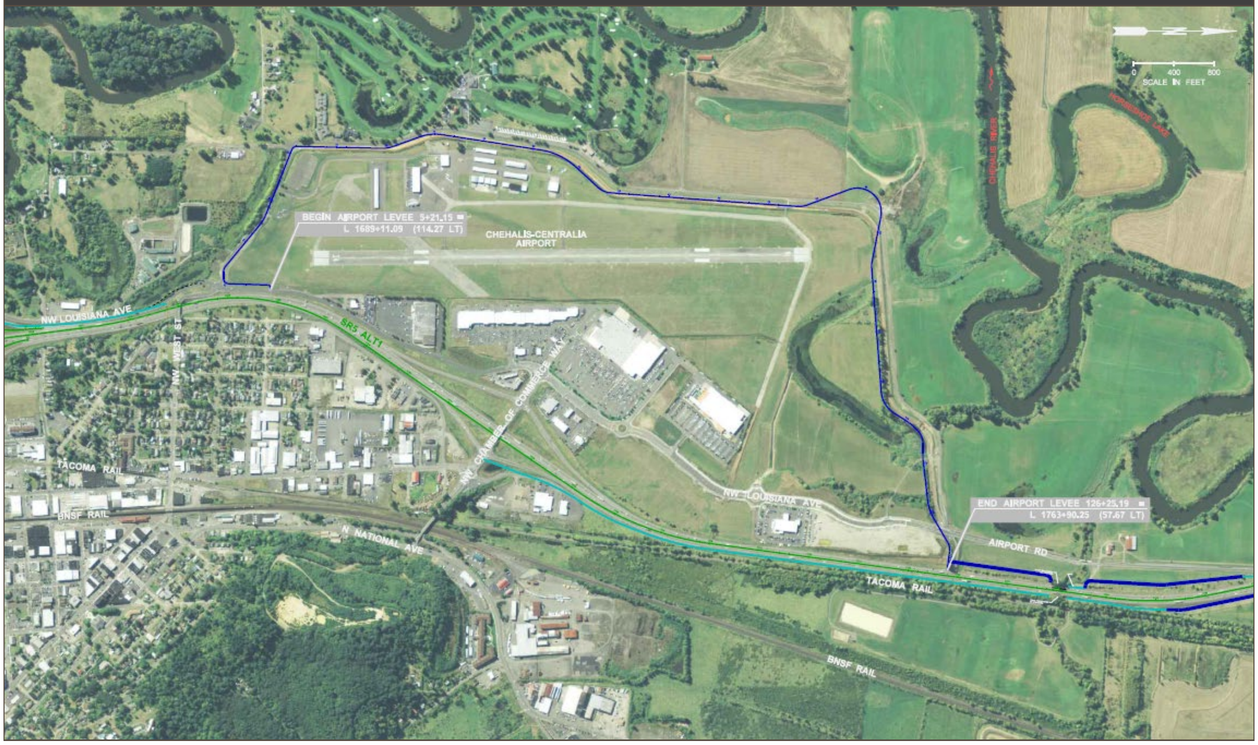


Figure 6

Maximum Reservoir Extent (DRAFT)

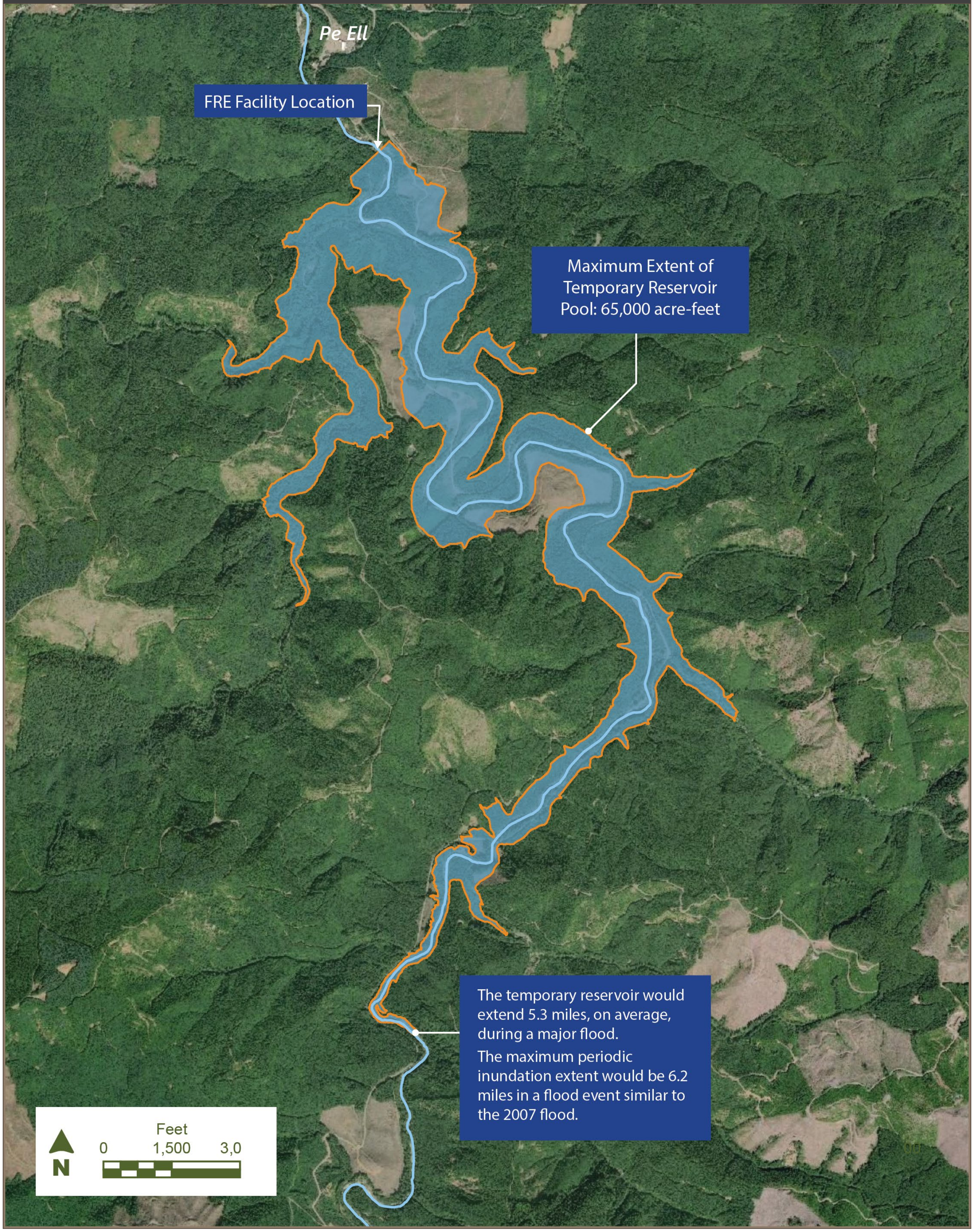


Figure 7
FRE Plan View (DRAFT)

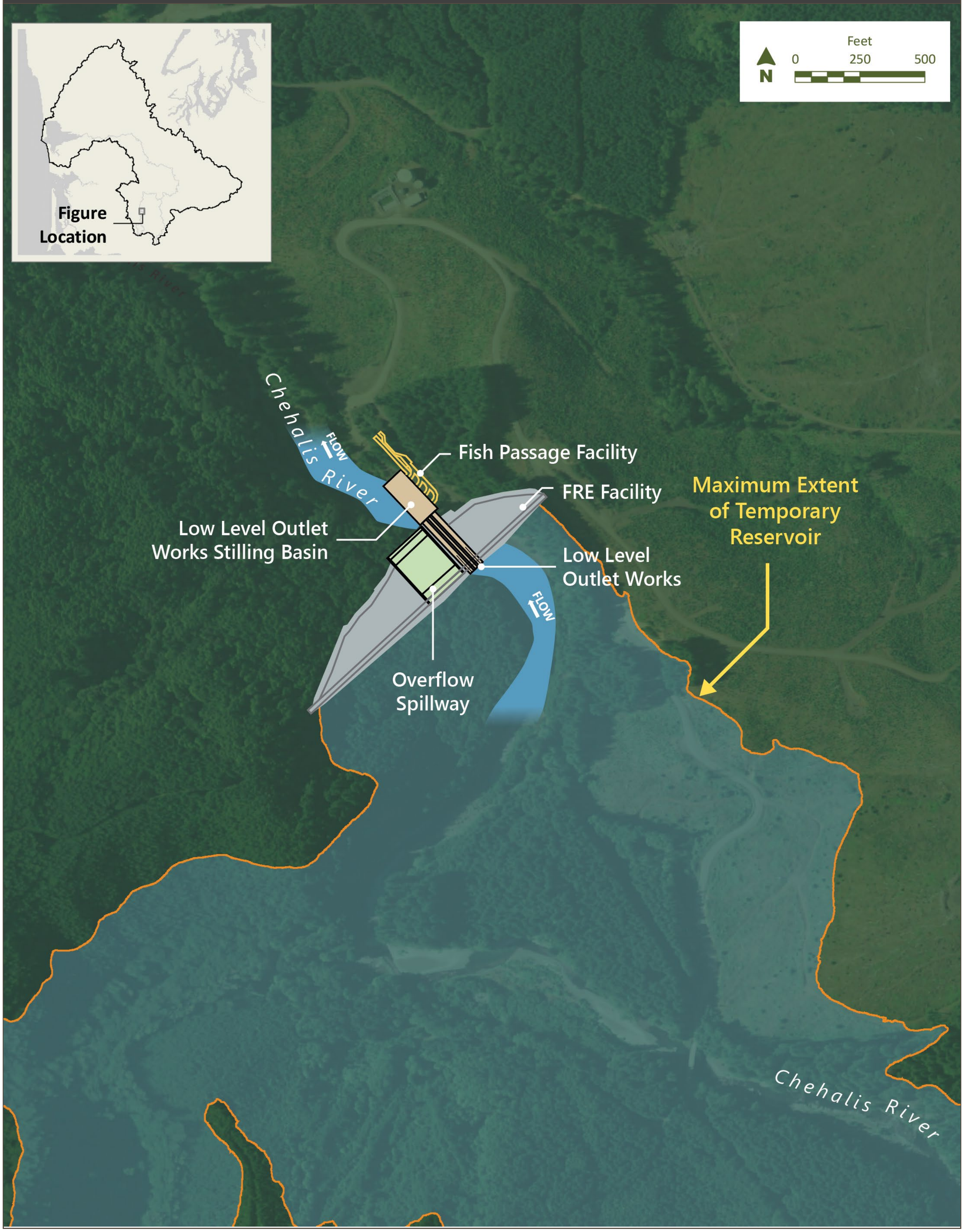


Figure 8
FRE Schematic Facing Upstream (DRAFT)

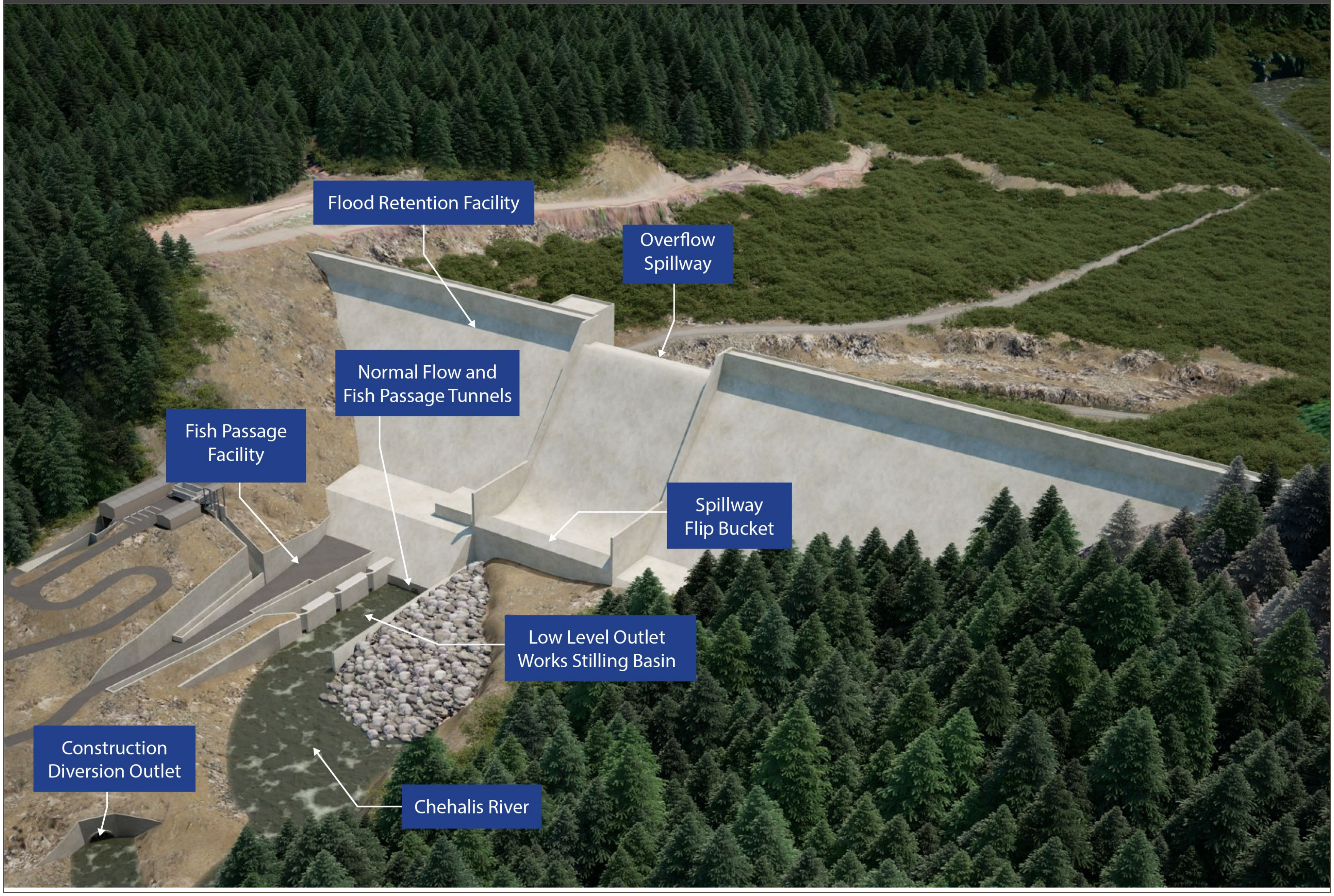


Figure 9

FRE Facility Section Showing Flow During Normal Conditions (DRAFT)

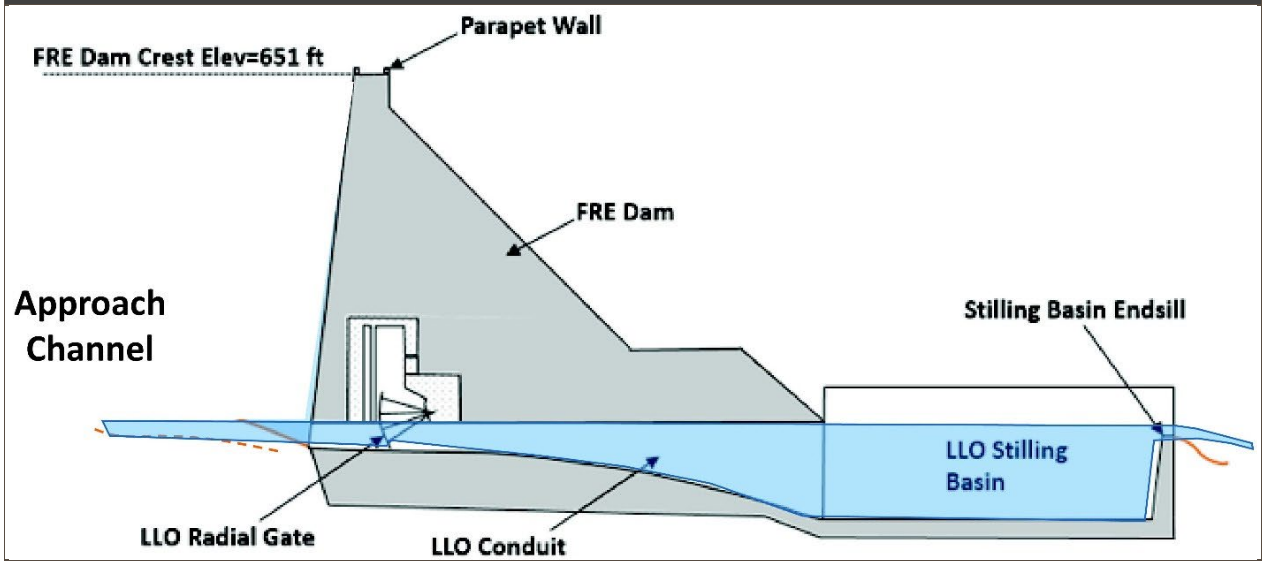


Figure 10
Proposed Quarry Sites (DRAFT)

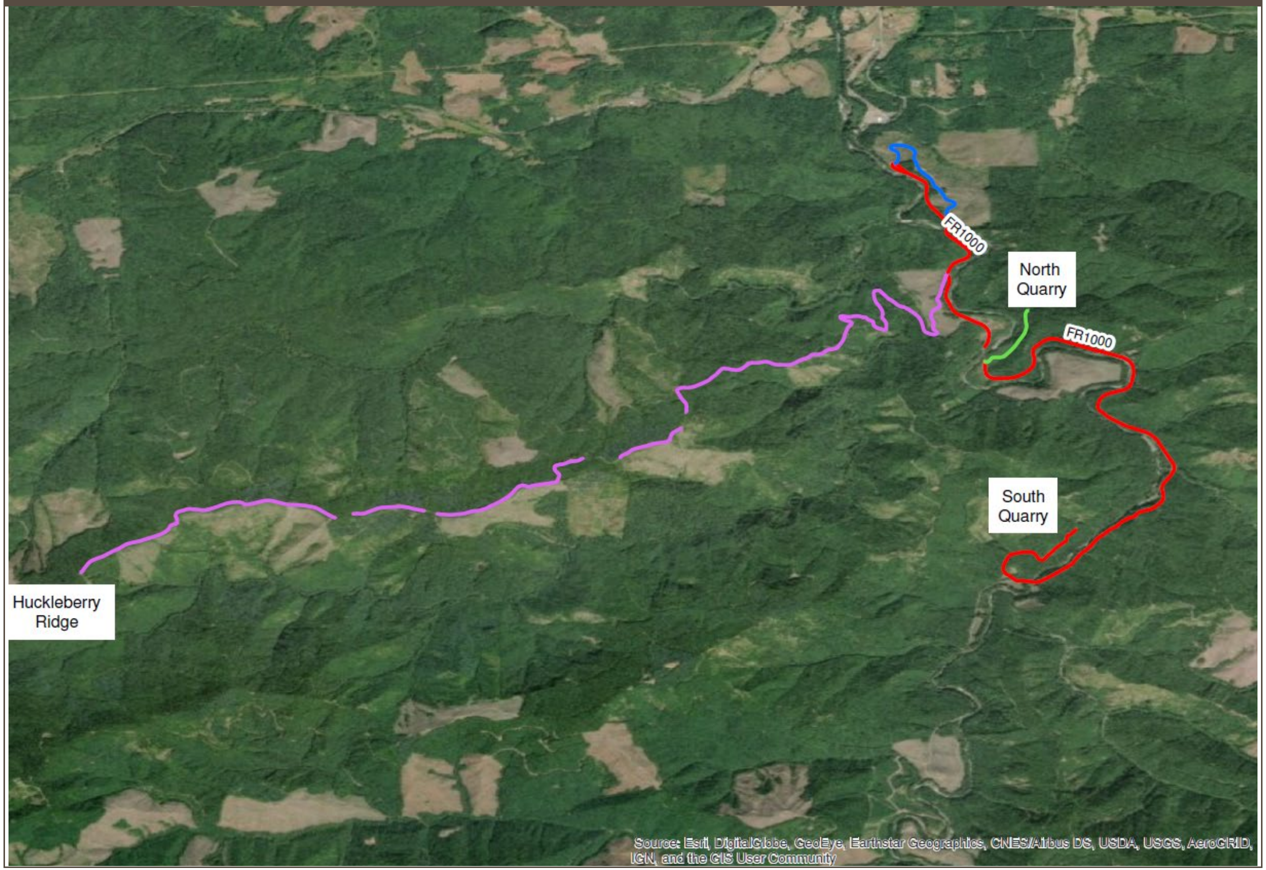


Figure 11

Sorting Yard Location (DRAFT)

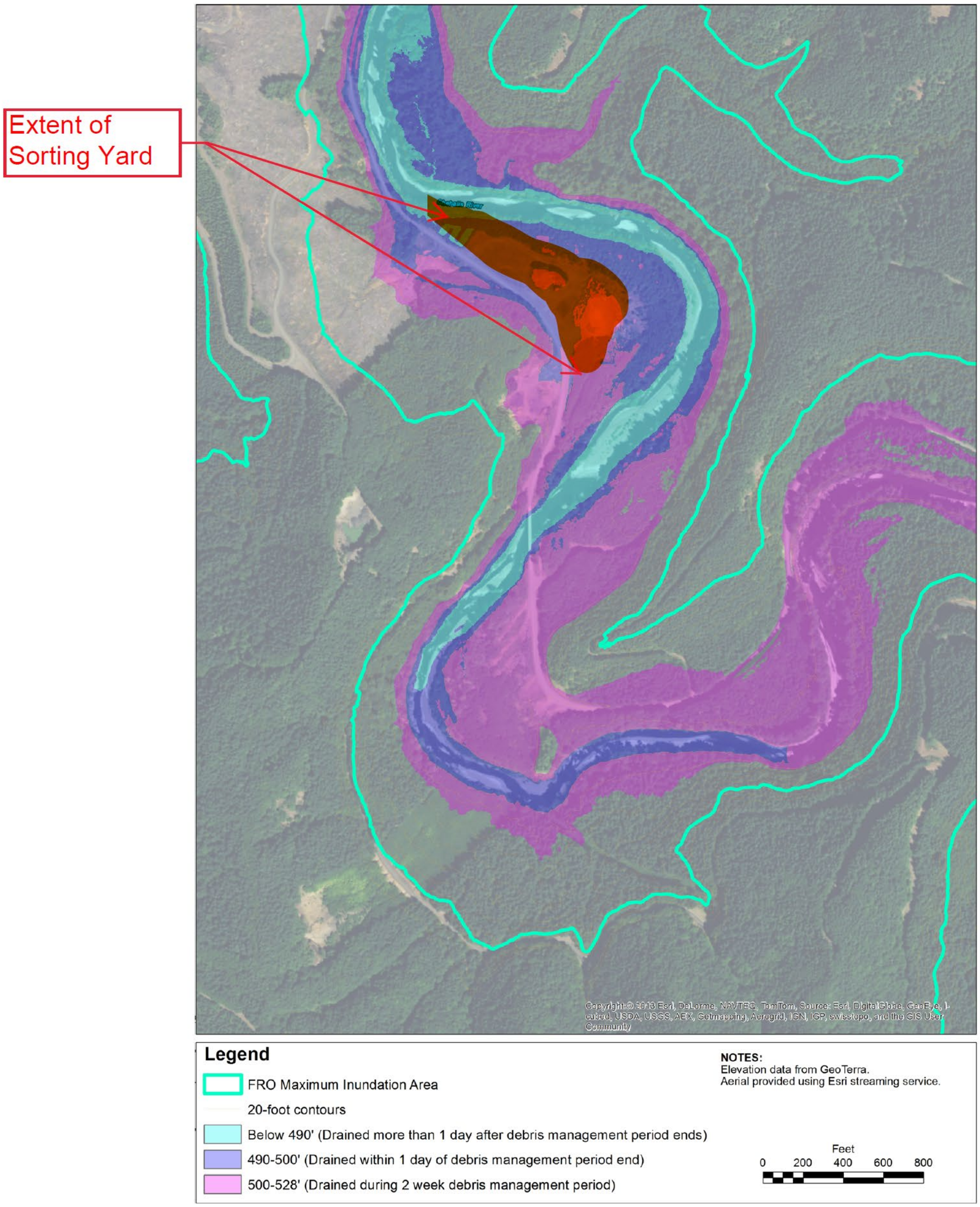


Figure 12
Isometric View of the CHTR Fish Passage Facility (DRAFT)

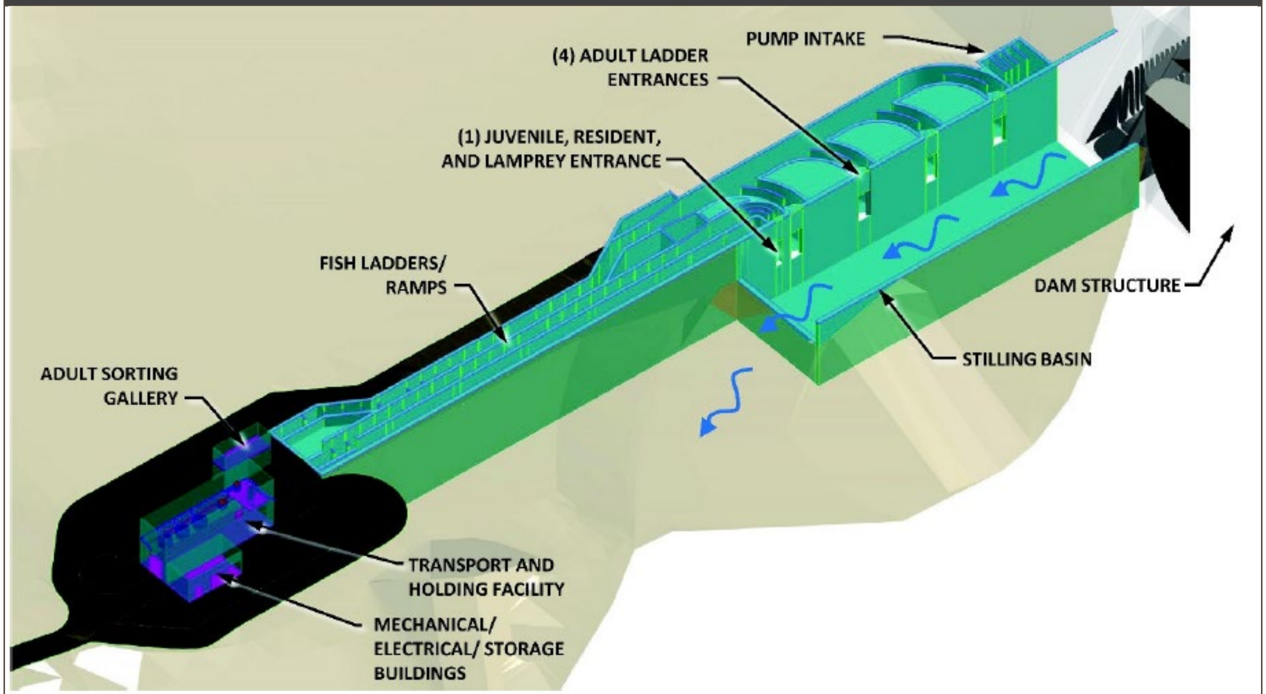
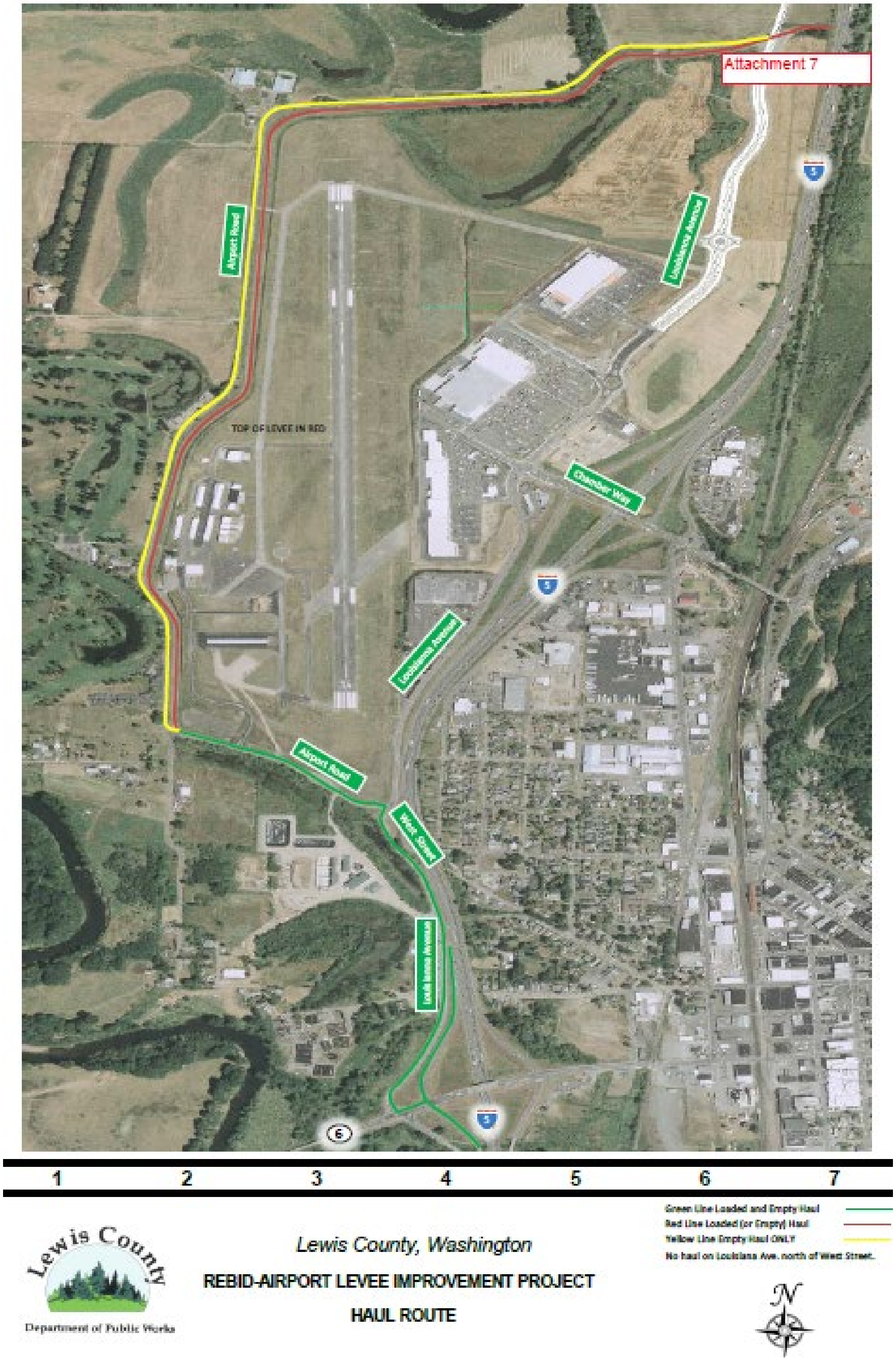


Figure 13
Expected Vegetation Community Type in the Flood Retention Only Reservoir

Figure 14
Airport Levee Improvements Proposed Haul Routes (DRAFT)



A.13. Email from Betsy Dillin to Diane Butorac (Washington Department of Ecology) and James R. Thomas (U.S. Army Corps of Engineers). Regarding: Access Road Clarification. June 24, 2019.

From: Betsy Dillin <Betsy.Dillin@lewiscountywa.gov>
Sent: Wednesday, July 24, 2019 3:31 PM
To: Butorac, Diane (ECY) <dbut461@ECY.WA.GOV>; 'James.R.Thomas@usace.army.mil' <James.R.Thomas@usace.army.mil>
Cc: Erik Martin <Erik.Martin@lewiscountywa.gov>; 'John Robinson' <crossings43@gmail.com>; Jim Waldo <jwaldo@gth-law.com>
Subject: Access Road Clarification

Hi Diane,
This email is to follow up on our phone discussion on 7/23/2019 regarding access roads around the Water Retention Facility (WRF) site.

All access roads are planned to be on existing roads, no new roads are being proposed for access, haul, or detour. The County owned road ends about 2,500 ft before the WRF site, however there is a private road that connects the County Road to the site. Within the site and proposed reservoir area there are private roads that are currently being used by Weyerhauser. There will be some smaller temporary construction roads within the active construction site and quarry that will be removed and the site restored after construction is complete.

Bypass roads for use by others during construction are also planned to be improvements to existing roads that bypass the construction site. These have not yet been specifically identified to date, but alternative access is known to exist. We will have ongoing coordination with Weyerhaeuser to determine what roads would be used for their timber operations.

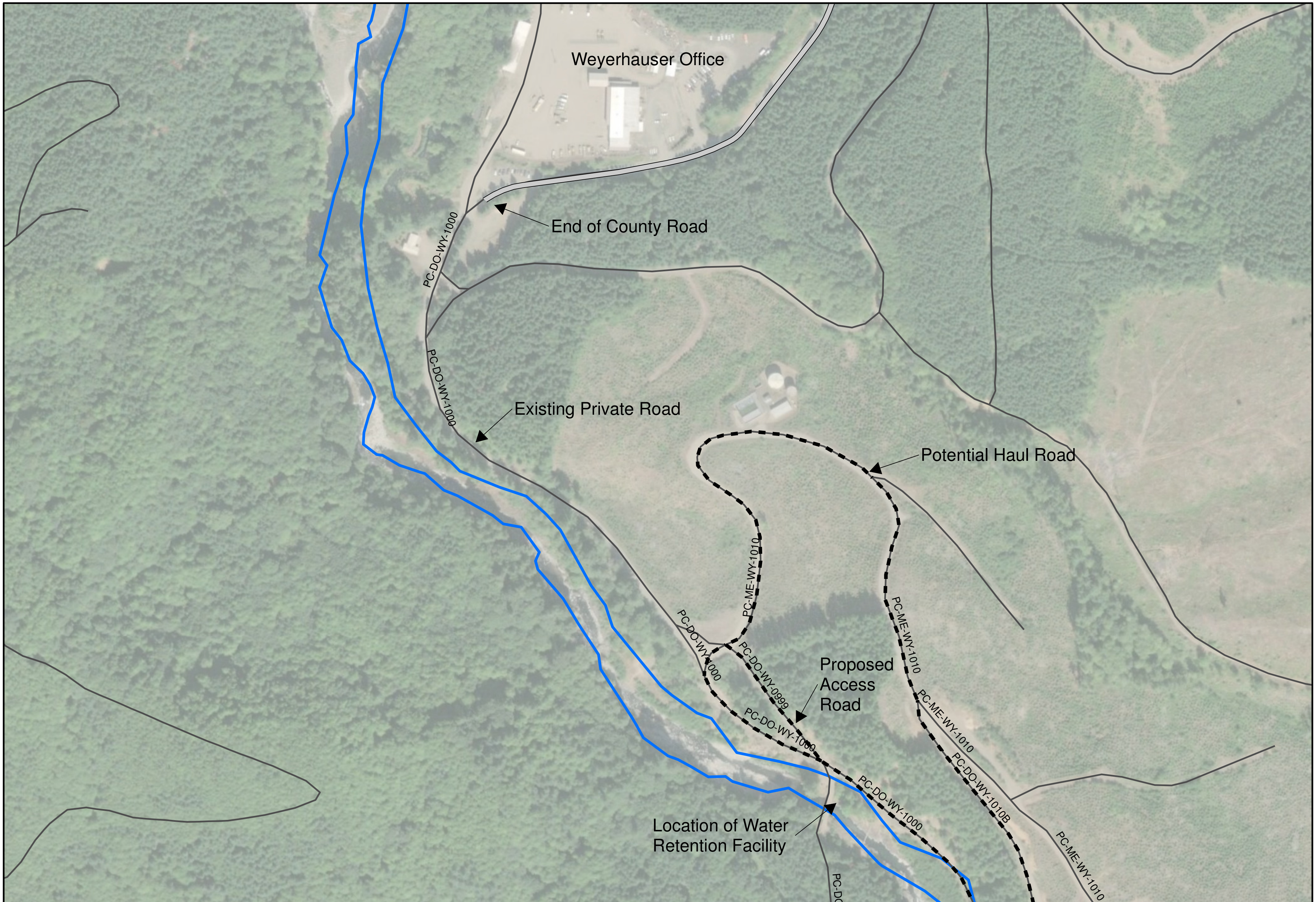
The attached maps shows the existing roads in the WRF area and what has been envisioned for construction access. I have also posted the GIS shapefile of the access and bypass roads onto our Cloud site, the link is attached to this email.

Thank you,

Betsy Dillin, PE
Senior Utilities and Surface Water Engineer

Lewis County Public Works
2025 NE Kresky Ave
Chehalis, WA 98532
Phone: (360) 740-1138

Betsy.Dillin@lewiscountywa.gov



351 NE North St.
Chehalis WA 98532

Water Retention Facilty Site Access

0 0.025 0.05 0.1 Miles

N

Laura Arendall

From: IT Services <it.services@lewiscountywa.gov>
Sent: Wednesday, July 24, 2019 3:28 PM
To: Betsy Dillin
Subject: BPDillin shared »Roads« with you

Hey there,

just letting you know that BPDillin shared **Roads** with you.
View it!

The share will expire on December 31, 2019.

Cheers!

--
Lewis County ownCloud - Share and sync Lewis County files.
http://lewiscountywa.gov

A.14. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Diane Butorac (Washington Department of Ecology) and Bob Thomas and Brandon Clinton (U.S. Army Corps of Engineers). Regarding: Construction Schedule Supplemental Information. September 18, 2019.

Chehalis River Basin Flood Control Zone District

Erik P. Martin, P.E., District Administrator

351 NW North St
Chehalis, WA 98532-1900

September 18, 2019

Washington State Department of Ecology
Attn: Diane Butorac
PO Box 47600
Olympia, WA 98504-7600

AND

United States Army Corps of Engineers
Seattle District Regulatory Branch
Attn: Bob Thomas and Brandon Clinton
PO Box 3755, Seattle, WA 98124-3755

RE: Construction Schedule Supplemental Information

Ms. Butorac and Mr. Clinton,

In response to your request at our meeting on May 28, 2019 we submit the enclosed information which supplements existing information regarding the estimated construction schedule for the proposed Chehalis Flood Reduction Project that has been previously developed and published in the reports listed therein. Some of the information from those reports has been reproduced for convenience; none of the supplemental information changes the intent or conclusions of the previous reports.

The activities, schedule, and assumptions are conceptual in nature and are subject to refinement based on information that will be developed as the proposed project design is finalized and permit conditions are established by regulatory agencies.

If you have any questions please do not hesitate to contact erik.martin@lewiscountywa.gov or (360) 740-2697, or Betsy Dillin at betsy.dillin@lewiscountywa.gov or (360)740-1138.

Sincerely,

Erik Martin, PE
District Administrator

Cc: Board of Supervisors, Chehalis River Basin FCZD

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Proposed Flood Retention Dam Construction Schedule Supplemental Information

Submitted to the Washington Department of Ecology and the United States Army Corps of Engineers

Submitted by the Chehalis River Basin Flood Control Zone District

September 2019

Preface

This document provides clarifying information to the Washington Department of Ecology and the United States Army Corps of Engineers regarding the proposed construction schedule for the Flood Reduction Dam proposed by the Chehalis Flood Control Zone District on the Chehalis River near Pe Ell, Washington. This information was requested by Ecology and the Corps of Engineers to support their preparation of Environmental Impact Statements for the proposed project. This information supplements information found in the reports entitled *Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Combined Dam and Fish Passage Conceptual Design Report* and *Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Combined Dam and Fish Passage Supplemental Design Report, FRE Dam Alternative,* previously submitted by the District to Ecology and the Corps of Engineers.

Contents

Tables

Figures

Appendices

PROPOSED FLOOD RETENTION DAM CONSTRUCTION SCHEDULE SUPPLEMENTAL INFORMATION

Introduction

This document has been prepared to provide clarification and supplemental information to the Washington State Department of Ecology (Ecology) and the United States Army Corps of Engineers (USACE) in support of their preparation of Draft Environmental Impact Statement (EIS) documents for the Proposed Chehalis River Basin Flood Damage Reduction Project, under the State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA) respectively. This document references existing documentation where appropriate and introduces supplemental information to provide additional detail on the proposed construction schedule and construction work sequencing. The supplemental information also clarifies potential design elements and better defines work conducted in-water and anticipated environmental mitigation during construction. The information provided in this document reflects development of the design to a level of detail sufficient to inform the agencies preparing the Draft EIS documents. Following completion of the environmental review process and initial state and federal approval to construct the project the design will be further developed in greater detail to support project permitting and construction contracting.

The supplemental information in this document is organized following the proposed sequence of construction activities. As natural resource protection activities apply throughout the construction process, information regarding natural resource protection precedes the construction sequencing in this document. Additional detail regarding start-up of the Flood Retention Expandable (FRE) dam and how it will be operated following construction is provided following construction sequence related information. Plates containing scaled drawings of information provided are included in Appendix A, and Appendix B at the end of this document.

Sections of this document reference the corresponding sections in the following previously published documents:

- HDR, Inc. 2017. *Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Combined Dam and Fish Passage Conceptual Design Report.* Prepared for the Washington State Recreation and Conservation Office and Chehalis Basin Work Group. ***(Conceptual Report)***
- HDR, Inc. 2018. *Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Combined Dam and Fish Passage Supplemental Design Report, FRE Dam Alternative*. Prepared for the Washington State Recreation and Conservation Office and Chehalis Basin Work Group. ***(FRE Report)***

- HDR, Inc. 2018. *Chehalis Basin Strategy – Fish Passage: CHTR Preliminary Design Report.* Prepared for the Washington State Recreation and Conservation Office and Chehalis Basin Work Group. ***(CHTR Report)***
- Anchor QEA, LLC. 2017. *Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Operations Plan for Flood Retention Facilities*. Prepared for the Washington State Recreation and Conservation Office and Chehalis Basin Work Group. ***(Operations Plan)***
- Shannon & Wilson. 2019. *Chehalis Basin Strategy, Rock Quarry Characterization, Potential RCC Aggregate Sources for Chehalis Dam*. Prepared for the Office of Chehalis Basin. ***(Quarry Report)***

Schedule and Construction Considerations

The following factors were considered in developing the construction schedule.

Construction Notice to Proceed

The Notice to Proceed (NTP) occurs when the contractor is released to proceed with construction by the entity that is letting the contract. The timing of the NTP will influence the schedule and the overall construction period. The timing for the NTP needs to provide adequate time to prepare for the first period of in-water work.[1] Too little time in advance of the first period of in-water work could lead to inefficient preparatory construction activities that could lead to missing some or all low flow time, resulting in a significant project delay. The schedule presented here has conservatively assumed an NTP in January.

Seasonal Hydrology Considerations

Understanding the seasonal hydrology provides important insights to construction constraints and the timing of in-water work. Table 1 summarizes the monthly exceedance flows at the dam site. The values in the table are based on data taken from U.S. Geological Survey (USGS) gage station 12020000 on the Chehalis River near Doty, Washington (Doty gage). Mean annual flows and exceedance flows for each month were calculated using the period of record from 1939 to mid-2019 for flows at the Doty gage. The mean annual flows and exceedance flows at the Doty gage were then multiplied by an area weighted scaling factor to estimate the mean annual and exceedance flows at the dam site. The distribution of flow by month indicates that July through September have the lowest flows for the year. These low flow months are selected for in-water work as the low flows minimize the footprint of dewatering facilities, minimize the impact to the river, and reduce the risk of flooding dewatered areas. Accordingly, the in-water work periods are planned to occur July through September in the construction schedule.

[1] In-water work includes construction related activities that occur below the ordinary high water line of the flowing river. Work that occurs within the portion of natural channel that no longer passes the flowing river when the river is diverted outside its natural course is not included in the definition of in-water work for the purposes of this document. The river will be diverted around the dam construction site during a significant portion of the construction time period.

Table 1: Chehalis River Mean Annual and Monthly Exceedance Flows at the Proposed Dam Site in Cubic Feet per Second (cfs).

PERCENT OF TIME EXCEEDED	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
99	110	93	96	93	54	30	18	13	12	13	21	83
95	145	144	145	126	66	38	21	14	14	15	56	138
90	181	191	180	147	75	43	24	16	15	18	81	182
80	243	250	236	180	91	51	28	18	18	24	136	260
50	509	478	419	278	138	74	38	24	24	72	361	540
25	1,007	849	744	454	210	105	52	31	40	197	790	1,026
15	1,448	1,197	987	591	270	135	63	37	68	329	1,152	1,421
10	1,836	1,525	1,203	717	328	165	72	42	100	467	1,480	1,756
5	2,461	2,111	1,625	974	430	220	88	53	170	763	2,079	2,467
2	3,375	3,290	2,253	1,322	595	306	115	99	274	1,266	2,994	3,569
1	4,155	4,034	2,948	1,717	750	387	157	144	354	1,740	3,823	4,264
Annual Mean Flow	812	725	601	384	180	95	45	29	51	188	629	830

Approved Agency Standard In-Water Work Window

The Washington Department of Fish and Wildlife (WDFW) approved in-water work window for the Chehalis Basin upstream of the South Fork is August 1 – August 31,[2] and the USACE approved in-water work window for the same river reach is July 1 – August 31.[3] To minimize impacts during construction by making use of the optimal hydrologic conditions as described above, and to avoid impacts from continuous construction over a longer period of time, an extension of the in-water work window from July 1 to September 30 will be requested from WDFW and USACE.

Construction Vibration

Construction processes such as blasting (tunnel excavation, foundation excavation and quarry development), construction truck operation, foundation drilling/grouting, material processing, roller compacted concrete (RCC) placement, and compaction, may cause vibrations. Of these activities, blasting is the most likely to create potentially harmful vibrations on nearshore, aquatic, and terrestrial environments. The majority of the construction work will have sufficient buffer distance to minimize vibration transmitted to the river. Buffer distances will be used to determine when vibration attenuation measures must be employed. Buffer distances will be in compliance with jurisdictional requirements. If buffer distances are not defined by the governing jurisdictions, buffer distances identified in industry standards and by other government entities will be considered and employed. Special considerations for blasting activities are included below.

[2] WDFW. 2018. Times when spawning or incubating salmonids are least likely to be within Washington State freshwater. June 1 2018.
[3] USACE. 2008. Approved work windows for fish protection for all freshwaters excluding waters within National Park boundaries, Columbia River, Snake River, and Lakes by county and specific watercourse.

Rock Excavation: Blasting

Blasting is the controlled excavation of rock through the use of explosives. Blasting will be required for preparation of the dam foundation, diversion tunnel construction, and quarry rock excavation for aggregate production at selected quarry sites. Blasting for the dam foundation and diversion tunnel construction will occur as often as one to four times per week during development of these project elements. Blasting as part of the dam foundation excavations would occur over a limited time frame of approximately 12 months. Blasting for tunnel construction would occur once or twice per day over a period of approximately 9 months with almost all blasting occurring in the interior of the tunnel. Quarry aggregate blasting is expected to continue for up to 3 years of the total construction period and would occur one to four times per week during active development of the quarries. Final quarry development and timing will be coordinated to comply with site restrictions described below if Endangered Species Act (ESA)-listed species are found to influence the construction sequencing.

Blast timing restrictions are anticipated if nests/breeding occurrences are documented in proximity to blasting locations for bald eagles, marbled murrelet, or northern spotted owls. Blast timing restrictions for ESA-listed species, including marbled murrelet and northern spotted owls, will be determined during the ESA Section 7 consultation to be completed for this project. Blast timing restrictions for bald eagles will similarly be determined during permitting consultations, as required under the Bald and Golden Eagle Protection Act. Construction will comply with the requirements of permits and/or consultation terms and conditions.

No blasting will occur within the active river channel (with water flowing). Water transmits shock waves more effectively than air, so isolating blasts from water is an effective means of reducing blasting effects. Blasting for the dam foundation excavation will occur with the river diverted to the diversion tunnel and remain “in the dry” with a minimum 25-foot-wide dry working space buffer between the blast site and the cofferdam that isolates the in-water work area from active river flow.

To reduce or eliminate effects to fish or to keep fish out of regions where blasting pressure waves are harmful, the selected contractor will be required to attenuate vibration transference when blasting close to the active flow in the Chehalis River or its tributaries. Attenuation may include maintaining a dry in-water work area within this zone, through the use of sheetpiling as cofferdams. Additional attenuation measures such as the use of bubble curtains directly waterward of blast locations may be considered if deemed effective in minimizing shock waves from blasting. Shock waves from blasting may also be reduced by selecting the minimum sized charge and type of explosives necessary to accomplish the excavation. Buffer distances between blasting charges and the actively flowing river will be used to determine when vibration attenuation measures must be employed. As previously noted, buffer distances will be in compliance with jurisdictional requirements. If buffer distances are not defined by the governing jurisdictions, buffer distances identified in industry standards and by other government entities will be considered and employed, such as the Alaska Department of Fish and Game’s Blasting

Standards for the Protection of Fish (1991) which recommends at 50-foot buffer distance for use of 1-2 pound explosive charges typically used for trenching excavation. Larger buffer distances may be required for larger explosive charges.

Prior to rock blasting the contractor will be required to provide a rock blasting plan for review. In addition to the requirements above, the contractor will be required to follow local, state, federal, and industry standards for safety and environmental protection during blasting, including:

- Safety procedures that minimize the potential for human presence in the blasting area and flyrock zone (the area in which blast induced rock fall could occur) during the blasting period,
- Compliance with codes and permit requirements governing noise levels,
- Compliance with codes and permit requirements governing the times and locations of blasting, and avoidance of blasting during identified blast timing restrictions for wildlife protection to the extent possible,
- Use of blast curtains and other debris containment practices to control debris produced by blasting activities,
- Monitoring of blast activities and limiting peak particle velocities induced by blasting operations,
- Use of water spray or other best management practices to control the dust produced from blasting activities, and
- Implementation of other vibration mitigation measures when blasting within a prescribed distance of water bodies where fish are present, such as sheet pile walls and bubble curtains. The distance from water bodies will be determined in coordination with the consulting agencies.

Construction Schedule

A preliminary construction sequence and generalized project schedule were provided in Section 14 of the Conceptual Report and Section 10 of the FRE Report, respectively (these are reproduced and included in Appendix C for reference).

The total anticipated time to construct the Project is 4.5 years. A possible 6-month contingency may be considered to account for project delays due to weather, unexpected conditions, delays associated with equipment or material delivery, or other factors as described above. Figure 1 which is an expansion of the project schedule from the Conceptual Report provides a more detailed overview of the planning level construction schedule and shows the three in-water work periods and the period of the river diversion. Table 2 summarizes the construction activities and general construction assumptions for each stage of construction including each of the in-water work periods. It also provides references to associated Plates (included in Appendix A and Appendix B at the end of this document) that define the general extent or each construction activity as appropriate. A more detail description of each construction phase is included following Table 2.

Figure 1. Simplified Construction Schedule.

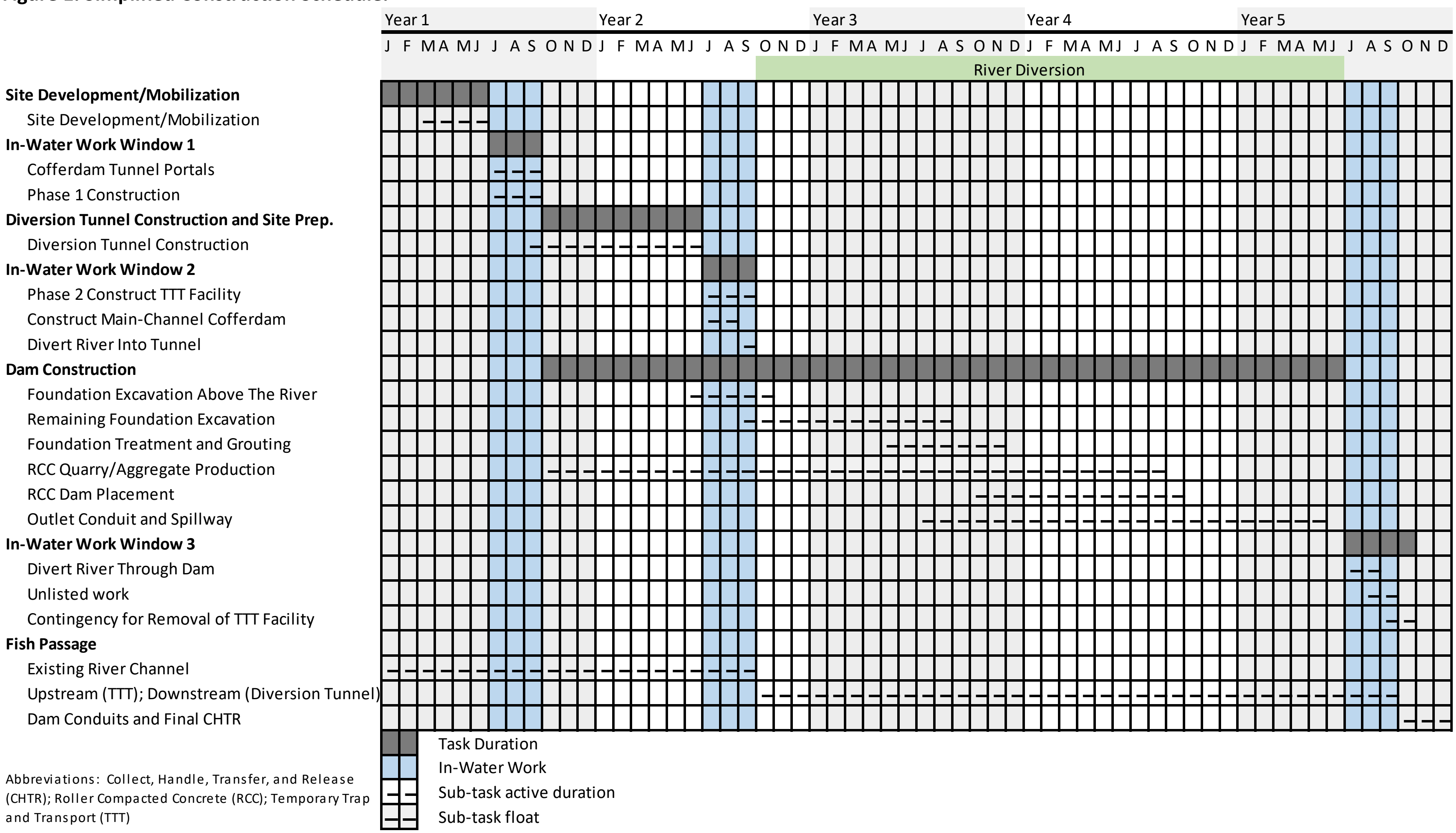

Table 2. DRAFT Preliminary Feasible Construction Schedule.

PERIOD	YEAR (Y)	TIME FRAME (MN)	ANTICIPATED ACTIVITIES[1]	FIGURE CROSS REFERENCE	CONSTRUCTION INFORMATION
Site Development/ Mobilization	Y1	6 MN	• Site survey • Resource protection & Best management practices (BMPs) during construction • Erosion and sediment control • Construction bypass and access roads • Distribution line for construction power • Staging laydown areas and construction offices • Preparation and initial development of quarries • Material processing equipment installation	Plate A-1, (based on G-4 Site Plan)	Work Schedule: 10 hours/day, 5 days/week Water usage: (minimal; dust control, truck wash, etc.) up to 100 gal/min Vibration Considerations: Construction Trucks and Site Clearing Construction Equipment away from the river as well as quarry development.
Initial In-water Work Window 1: Construction of Temporary Trap & Transport Facility and Diversion Tunnel Cofferdams	Y1	2.5 - 3 MN(July-Sept.)	• Protect the upstream and downstream diversion tunnel portals using cofferdams • Stage 1 of construction of "in water" temporary fish passage facilities **From Table 14.1** • *Isolate portal areas from river flow* • *Slowly dewater and "fish" portal areas*	Plate A-2 (based on FRE S1); Plates B-1 and B-2	Work Schedule: Work 10 hours/day, 5 days/week Water usage: (minimal; dust control, truck wash, etc.) up to 150 gal/min Vibration Considerations: Construction Trucks and Site Clearing Construction Equipment away from the river. Fish removal: Includes salmonids, shellfish, and resident fish.

PERIOD	YEAR (Y)	TIME FRAME (MN)	ANTICIPATED ACTIVITIES[1]	FIGURE CROSS REFERENCE	CONSTRUCTION INFORMATION
Diversion Tunnel Construction and Site Preparation	Y1-Y2	10 MN [Sept. (Y1)-June (Y2)]	• Diversion tunnel construction • Process aggregate material for RCC • Prepare RCC test fill • Excavate channel for flow through diversion tunnel **From Table 14.1** • *Construct tunnel portals* *Build the diversion tunnel by advancing from downstream side portal to upstream side portal*	Plate A-4, (based on FRE S-1-B, Diversion Tunnel and Temporary Trap and Transport Facility)	Work Schedule: 10 hours/day, 7 days/week Water usage: (minimal; dust control, truck wash, etc.) 200-750 gal/min Vibration Considerations: Tunnel drilling will include controlled blasting for preparation of the tunnel portals and tunneling. There will also be construction truck activity.
In-Water Work Window 2: Initiate River Diversion	Y2	2.5 – 3 MN (July – Sept.)	• Upstream and downstream RCC cofferdam construction • Stage 2 complete temporary trap & transport fish passage facility construction & begin operation • Initiate river diversion **From Table 14.1** • *Prepare flow diversion cofferdam foundation Construction of the RCC cofferdam* • *Slowly dewater and "fish" areas behind cofferdams* • *Manually and safely remove fish from the areas to be dewatered and return them to the active river system*	Plate A-4, (based on FRE S-1); Plates B-1, B-3, and B-4	Work Schedule: 10 hours/day, 7 days/week Water usage: (low; dust control, truck wash, material processing, RCC test, etc.) up to 250 gal/min Vibration Considerations: There will also be vibratory rollers used for RCC placement of the coffer dam and construction truck activity.
Dam Construction	Y2-Y4	Approx. 32 MN [(Sept. (Y2)-June (Y5)]	• Dam, spillway and outlet conduit construction activities • Construction flood risk management **From Table 14.1** • *Excavate abutments & bottom* • *Prepare river outlet foundation* • *Perform curtain grouting* • *Foundation treatments & dental concrete*	Plate A-5, (based on FRE S-1); Plate B-5	Work Schedule: 10 hours/day, 7 days/week (RCC operations 20 hours/day, 7 days/week) Water usage: Approx. 4.5M gal total Approx. 200-400 gal/min (during Aggregate and RCC production)

PERIOD	YEAR (Y)	TIME FRAME (MN)	ANTICIPATED ACTIVITIES[1]	FIGURE CROSS REFERENCE	CONSTRUCTION INFORMATION
			• *Construct lower-level river outlet works (ROW)* • Construct initial energy dissipation, stilling basin • Construct lower-level fish passage • *Place RCC – bottom to top of ROW encasement* • *Place RCC – top of ROW to spillway break, include flip bucket mass block* • *Place RCC – right wing* • *Place RCC right side to crest* • *Place RCC left side to crest* • *Complete intake, gate & service shaft, control structures* • *Install flood regulating gates* • *Install river outlet gates* • *Install river outlet trash racks & metals* • *Complete ROW & flood regulating mechanical & controls* • *Complete control structure – electrical, mechanical & building trades* • *Complete stilling basin & energy dissipation structures* • *Complete plunge pool preparation* • *Construct spillway training walls* • *Construct spillway chute and flip* • *Construct spillway ogee* • *Construct spillway piers & bridge* • *Complete downstream fish passage and mechanical* • *Complete upstream fish passage* • *Complete fish passage conveyance* • *Complete fish passage mechanical & controls, building trades*		Vibration Considerations: Quarry development and dam foundation excavation will include controlled blasting. There will also be construction truck activity and vibratory rollers for RCC placement.

PERIOD	YEAR (Y)	TIME FRAME (MN)	ANTICIPATED ACTIVITIES[1]	FIGURE CROSS REFERENCE	CONSTRUCTION INFORMATION
In-water Work Window 3: Project Completion and Initial Operation	Y	2.5 -3 MN (July-Sept.)	• Remove RCC cofferdams • Channel Restoration, rewatering through new conduits, and diversion tunnel closure • Complete/commission permanent CHTR fish passage facility • Remove construction of temporary trap and transport facility **From Table 14.1** • *Complete electrical & mechanical commissioning* • *Final ROW access & grading construction* • *Breech cofferdams & redivert river* • *Construct plug tunnel* • *Dam backfill, downstream and abutment grading* • *Complete quarry, access, & staging restoration* • *Project schedule contingency*	Plate A-6, (based on FRE S-3); Plates B-6 and B-7	Work Schedule: 10 hours/day, 7 days/week Water usage: (minimal; dust control, truck wash, etc.) up to 100 gal/min Vibration Considerations: Construction truck activity will be the main source of construction related vibrations.

Notes:

[1] Adapted from Table 14.1 in the Conceptual Report.

CHTR = collect, handle, transfer, and release; FRE = Flood Retention Expandable; FRFA = Flood Retention Flow Augmentation; M = million; MN = month; RCC = roller compacted concrete; ROW = right-of-way; Y = year

Site Development/Mobilization

The site development and mobilization activities are summarized on Plate A-1. Plate A-1 is based on Figure G-4 of Appendix A of the Conceptual Report. This plate shows the overall site and areas identified as potential staging areas and material spoil areas (areas where material excavated from the dam footprint and abutments is permanently relocated, stabilized and re-vegetated). The activities remain as described in the Purpose and Need and Project Description submitted to Ecology and USACE on May 7, 2019, and in the reports referenced in the introduction of this document.

The items described below will be completed during the initial construction work period as indicated in Section 10 of the Conceptual Report and Section 6 and Appendix J of the FRE Report.

Site Surveys

Locations for the upland portions of the construction site will be surveyed in advance of site clearing and preparation to allow preparation of resource protection and best management practices (BMPs) installation.

Resource Protection and BMPs during Construction

Protection of natural resources from erosion, sedimentation, excess clearing, pollutant discharge, and other harms that have the potential to occur is a necessary part of construction and will be an important element of the site control requirements of the project specifications. Erosion and sediment control during construction is addressed in the next section. Construction will comply with the National Pollutant Discharge Elimination System (NPDES) permit, Washington Administrative Code (WAC) 173-201A: Water Quality Standards for Surface Waters of the State of Washington, and other federal, state, and local codes and regulations. BMPs will be implemented in accordance with the Washington State Department of Ecology *Stormwater Management Manual for Western Washington*, current WSDOT Standard Specifications for Road, Bridge, and Municipal Construction and Standard Plans, and Lewis County standards. BMPs and other resource protection actions may include items such as:

- High visibility fence
- Stabilized construction entrance
- Spill Prevention Control and Countermeasures (SPCC) Plan for temporary fuel tanks, construction equipment and diesel generator on site
- Dust control, including water trucks
- Stabilized construction access roads and parking areas
- Adaptive management for stormwater control during construction
- Measurement of identified pollutants such as turbidity and pH throughout construction at identified compliance points in compliance with permit requirements

Erosion and Sediment Control

Temporary Erosion and Sediment Control (TESC) measures will be implemented to help minimize stormwater impacts, such as significant storm flow runoff, soil erosion, waterborne sediment from exposed soils, and degradation of water quality from on-site pollutant sources. TESC BMPs will be implemented per the Washington State Department of Ecology Construction Stormwater General Permit and in accordance with the Washington State Department of Ecology *Stormwater Management Manual for Western Washington*. Supplemental BMP specifications will be obtained from the current version of WSDOT Standard Specifications for Road, Bridge, and Municipal Construction and Lewis County standards. BMPs may include items such as:

- Silt fence
- Vegetated strips
- Brush barriers
- Erosion control at culvert ends such as compost berms, sand bags, silt fence, and geotextile
- Compost socks
- Straw bales
- Check dams
- Catch basin and inlet protection
- Wheel wash stations
- Water quality and quantity BMPs, including
  - Baker tanks
  - Sediment traps
  - Flow control structures
  - Oil-water separators
  - Interceptor dikes and swales
  - Ditches
  - Level spreaders
- Temporary stockpile and slope stabilization and coverings such as mulch, nets and blankets, plastic coverings, temporary seeding and sodding, and compost blankets

Construction Bypass and Access Roads

The current approach for access road construction is to minimize disturbance including sedimentation impacts by using existing roads to provide permanent access around the flood inundation area and to provide temporary access to and around the construction site, and to construct some smaller, new temporary roads within the active construction site and quarry for construction access. Temporary roads within the active construction site will be removed and restored after construction is complete. The temporary roads provide access for various planned work activities, equipment and material storage, and construction administration (including parking for work personnel and visitors), as well as from the quarry to material processing and production areas. Existing roads will be improved to provide safe temporary access to and around the construction site. Existing roads will also be improved to allow others to bypass the construction site. Existing roads are planned for bypass around the site however have not yet been specifically identified. Alternative access around the site is known to exist, and discussions with Weyerhaeuser regarding routes for bypass around the site and improvements to existing roads will be conducted. Other stakeholders may also have opinions on whether existing or new roads should be used for timber related operations. All road construction activity will include use of appropriate BMPs for resource protection. The access road approach will be further developed in future phases of project design. See discussion in Section 10.5, Construction Access, of the Conceptual Report.

Distribution Lines for Construction Power

The proposed FRE dam will require an electrical supply during construction and for operations of the gates and other dam equipment. Construction power requirements may be provided either with on-site diesel powered generators or through a distribution power line interconnection with the existing electrical grid, or a combination of both. Electrical power for operations will be provided by installation of a distribution power line to the electrical grid. The location of interconnection and route of the interconnecting distribution line will be determined by the local power supply utility. Overhead lines would be installed along existing roads within the first six months of year one of the construction schedule. Section 13.3.5, Transmission Lines Substation Equipment, (if applicable) of the Conceptual Report describes some considerations for planning of power supply strategies/options. No electrical generation is planned as part of the dam configuration or operations.

Staging Laydown Areas and Construction Offices

Staging and construction laydown areas will be prepared with appropriate site grading, surfacing, and drainage provisions that allow for construction equipment and materials to be stored, secured and utilized. These areas will be located near the construction site and will include construction offices, areas for material processing and storage, as well as parking for construction vehicles. BMPs will be utilized at these sites.

Preparation and Initial Development of Quarries

Three potential quarry locations were identified and described in the Conceptual Report (Section 9.1, Aggregate Sourcing). In 2018, site investigations identified an additional quarry source and eliminated one of the three originally identified sites (Quarry Report). The three sites still under consideration are the North, South, and Huckleberry Ridge sites. The North and South quarries are preferred as they are located the shortest distance to the construction staging and dam site locations (Figure 2). All quarry development will include implementation of BMPs prior to ground disturbance.

Initial development will include access to the quarry, access and work area development, excavation to expose the rock to be quarried followed by controlled rock blasting to produce material suitable for processing into construction materials.

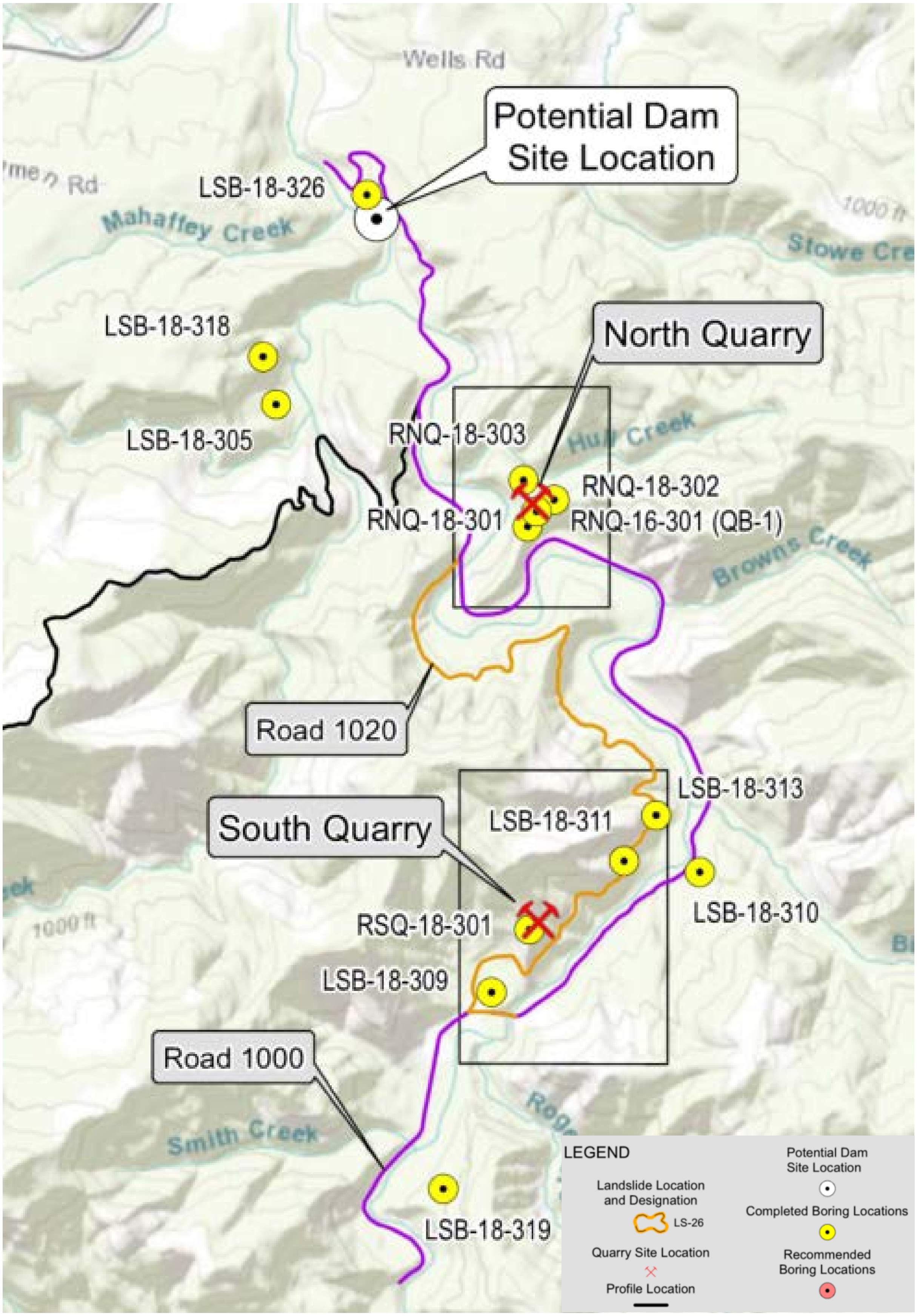

Figure 2. North and South Quarry Sites (Quarry Report, Fig. 1).

Material Processing Equipment Installation

Material processing equipment will be used to produce aggregates suitable for RCC and conventional concrete from materials excavated from the quarries and concrete mixing plants. This will include rock crushers and processing plants, stockpiles, conveyors, and potential washing equipment, to produce different size sand, gravel, and rock required for construction. Imported materials such as Portland cement and concrete add mixtures will be stored at the concrete mixing plant location.

Both conveyors and trucks are anticipated to transport the materials within the process plant to storage piles and to transport material between aggregate processing area (part of area S2 on Plate A-1) to the concrete plants and from the concrete plants to the dam site.

Initial In-Water Work Window 1: Temporary Trap and Transport and Diversion Tunnel Cofferdams

Upstream and Downstream Diversion Tunnel Portals Protection

Construction of the diversion tunnel is broken into three work periods. The first period of work during the initial in-water work window involves installation of cofferdams using sheet piles, earthen berms, or other protection features to isolate the diversion tunnel portals from the river (Plate B-2). This protection allows the second work period (described below) to be completed in the dry. The third period of work involves diversion of water into the diversion tunnel (described in the In-Water Work Window 2 Section below; see Plate B-4). Some of the activities required to install the protection features will require in-water work. Protection of the diversion tunnel is described in the Conceptual Report. This activity will provide a dry work area away from the river for construction of the diversion tunnel.

Temporary Trap and Transport Fish Passage Facility Construction

Assumed Fish Passage Options during Construction

The FRE Report identified three potential options for fish passage during construction of the dam but did not identify a preferred option. An alternatives evaluation leading to selection of a preferred option will be conducted during future phases of project design. However, some assumptions may be made for the purposes of informing the SEPA/NEPA process at this early stage of project development:

- Upstream Fish Passage during the Dam Construction Period: The FRE Report identified the use of the permanent facility to collect, handle, transfer, and release (CHTR) fish passing upstream during construction as infeasible (FRE Report, Alternative 2). Alternative 1 from the FRE Report, use of the diversion tunnel, would require substantial modifications to the diversion tunnel to make it conform to National Marine Fisheries Service (NMFS) guidelines for upstream fish passage. As such, Alternative 1 from the FRE Report is no longer being considered. Alternative 3 from the FRE Report involves the construction of a temporary trap and transport facility downstream of the diversion tunnel outlet. This is the most likely alternative to be selected for upstream fish passage during construction.

- Downstream Fish Passage during the Construction Period: The FRE Report identified use of the diversion tunnel as the single option for downstream fish passage. The diversion tunnel presented in the Conceptual Report and FRE Report requires minor modifications to accommodate downstream fish passage in accordance with NMFS passage criteria. Specifically, the flow depth in the diversion tunnel would be two inches at the 95 percent exceedance flow (16 cfs). It is anticipated the diversion tunnel can be modified to provide a depth of 6 to 12 inches with minor changes to the tunnel invert geometry. The water depth in the tunnel for the 95 percent exceedance flow will be developed in consultation with the fisheries agencies during final design.

The selected temporary trap and transport facility would operate during the period in which the river is conveyed through the diversion tunnel. At this time, for upstream passage at the temporary fish passage facility, the District proposes passage of the same adult anadromous salmonid species identified for passage at the permanent CHTR facility. These include adult spring and fall Chinook salmon, Coho salmon, winter steelhead, and coastal cutthroat trout. Juvenile salmonids, resident fish, and lamprey that are captured and collected will be considered incidental to the collection of adult target salmonid species. Species and life stages that are incidentally captured will be transported upstream of the construction area and released back to the Chehalis River. Downstream passage would be available to most species for the duration of the FRE construction period through the diversion bypass tunnel. Upstream and downstream passage of juvenile salmonids, resident fish, and lamprey during operation of the temporary passage facility will continue to be discussed with WDFW as the project progresses.

Stage 1 Temporary Trap and Transport Fish Passage Facility Construction

The temporary trap and transport facility as described in Section 7.2.3 of the FRE Report will require work within the river channel and below the ordinary high water mark to construct the passage barrier, fish ladder entrance, and attraction water intake. The fish ladder is described as being located on the left bank in Alternative 3: Temporary Trap and Transport Facility of the FRE Report. However, to clarify, the fish ladder for the temporary trap and transport facility will be located on the right bank when looking downstream. The intake for the temporary trap and transport facility will conform to the most current revision of the NMFS and WDFW fish passage and screening design guidelines and criteria.

An order of magnitude estimate (consistent with the current conceptual state of design) for the duration of in-water work required to construct facilities of this size and complexity is approximately 3 to 6 months. The sample construction schedule provided in this document assumes construction of the temporary trap and transport fish passage facility will occur in two separate in-water work periods of 2.5 months each (Period 1 and 2 shown in Table 2). This is similar to durations at other projects in the basin, including the Ceres Hill Long-Term Bank Stabilization and Habitat Mitigation Project (HPA permit number 2015-5-72+01) and the Mid 3000 (bridge) Repair (HPA permit number 2015-5-34+01). It is assumed the fish passage facility will be constructed in the right half of the river and on the right bank during the first in-water work season. The in-water work will occur behind a cofferdam in the dry while the river continues to flow through the left portion of the channel, as shown in Plate B-2. Following completion of the facility on the right half of the river, the cofferdams will be removed. The left half of the facility will be constructed during the second in-water work window (see In-Water Work Window 2 below).

Diversion Tunnel Construction and Site Preparation

Diversion Tunnel Construction

A description of the flow diversion from the current river channel to the temporary diversion is included in the Conceptual Report, Section 10.2, Temporary Flow Diversion.

Once the tunnel is constructed, diversion of the river is assumed to continue for a 3-year uninterrupted time period to accommodate construction of the dam. An example of a project that utilized a similar diversion time is the Mirabel project in Sonoma County, California. The Mirabel project diverted the Russian River around 400 feet of the natural river channel for over 2 years. During that period, fish passed upstream and downstream via a roughened channel around the work area. Following completion of construction and restoration of the river to its natural channel, no adverse effects to fish passage due to construction were observed. The FRE dam project would divert the river into the tunnel for approximately 32 months, over a distance of 1,630 feet (Conceptual Report, Appendix A, Figure G-5). Fish moving downstream are able to pass volitionally through the tunnel during this period. Movement downstream will be dependent on flow and light conditions, with downstream movement increasing during freshets (periods of greater flow) and at night and periods of low light. Similar to the Mirabel project, it is anticipated that flow diversion during construction will result in low or no adverse effects to downstream fish passage. As previously discussed upstream fish passage of adult salmonids would be provided via the temporary trap and transport facility, as shown on Plate B-4.

Process Aggregate for RCC

The period during tunnel construction can also be used to refine the material processing equipment and develop stock piles for roller compacted concrete (RCC) and concrete placement. Aggregate stockpiles will provide some flexibility for potential restrictions for quarry operations.

RCC Test Fill

An RCC test fill will be completed during this period to confirm the RCC design mix. This includes the proposed concrete materials and aggregate processed from the on-site quarry, as well as the adequacy of the contractor’s selected construction equipment, and the contractor’s means and methods. The test fill provides the opportunity to revise the assumed mix design to achieve design goals. The test fill can either be incorporated into the cofferdam construction or made separately in a designated construction laydown area.

Construct Diversion Tunnel

The diversion tunnel will be driven starting from the downstream portal and working upstream (see Plate A-2). Blasting is anticipated to break up the rock for tunnel construction. As described above, BMPs will be utilized to minimize energy transfer to water from blasting.

In-water Work Window 2: Initiate River Diversion

During in-water work window 2, coffer dams and other work elements necessary to begin operation of the temporary trap and transport facility and divert the river through the diversion tunnel will be completed.

Stage 2 Complete Temporary Trap and Transport Fish Passage Facility Construction and Begin Operation

The temporary trap and transport facility as described in the FRE Report will require work within the river channel and below the ordinary high water mark to complete the passage barrier, fish ladder entrance, and attraction water intake, as described above. During the second in-water work window it is assumed the left half of the facility, looking downstream, will be constructed. As shown in Plate B-3, the in-water work will occur behind a cofferdam in the dry while the river continues to flow through the fish passage barrier in the right portion of the channel constructed during the previous in-water work window. Cofferdams will be removed from the channel following completion of the left portion temporary trap and transport facility. The facility will undergo testing during this period, prior to beginning operation. The temporary trap and transport facility will be fully operational prior to initiating river diversion.

Initiate River Diversion

River diversion is a critical element of the Project as it allows for the dam foundation, dam, and related features in the river channel to be constructed. Plate A-3 shows flow through river channel and the diversion tunnel to illustrate the transition of the river flow into the diversion tunnel.

The Chehalis River will flow through the proposed dam site in its natural channel until the temporary trap and transport facility is constructed and operating. After the facility is operating successfully, the Chehalis River will be diverted through the diversion tunnel (See Plate B-4). As described in Table 14-1 of the Conceptual Report and in Table 2 above, as water is diverted into the tunnel, the area between the upstream and downstream cofferdams will be dewatered. This area will be slowly dewatered to facilitate safe and timely removal of fish. Flows will be maintained in the Chehalis River downstream of the project site to avoid impacts to fish and other natural resources downstream during dewatering, fish removal, and river diversion. All persons participating in the capture and removal of fish from the area to be dewatered will have training, knowledge, and skills in the safe handling of fish. All captured and collected fish will be returned to the Chehalis River at locations identified in consultation with the governing fisheries agencies. Fish will be returned to the river at locations sufficient for the fish to recover and reorient themselves to the river environment.

RCC Cofferdam Construction

The upstream and downstream RCC cofferdams required to isolate the dam foundation area from the active river will be constructed in a manner that considers both safe operation during the construction period plus the need for removal and stream restoration after construction is complete. The sequencing for construction of the RCC cofferdams is illustrated on Plate B-4.

Dam Construction

Dam and Dam Conduit Construction Activities

Dam construction includes multiple activities described in detail in the Conceptual Report, FRE Report, and CHTR Report. Environmental and natural resource protections will be implemented during this portion of the work. Many of these have been described in the Resource Protection and BMPs during Construction section above. Project-specific erosion and sediment control plans as well as spill prevention plans will be prepared and accompanied by monitoring and inspection practices to document compliance.

Plate A-4 shows the river flow diverted through the diversion tunnel in preparation for dam construction and Plate A-5 shows the completed FRE dam water conduit and permanent fish passage facilities. During this period, fish moving downstream would be able to pass volitionally through the tunnel while upstream fish passage of adult salmonids would be provided via the temporary trap and transport facility, as shown on Plate B-5.

Construction Flood Risk Preparation

The approach to addressing construction flood risks is outlined in the Conceptual Report, Section 10.1, Construction Phase Flood Risks; Section 10.2, Temporary Flow Diversion; and Section 10.3, Diversion Sequence.

A pre-flood preparation plan will be prepared to mitigate against potential floods that could result in cofferdam overtopping during construction. Cofferdams will be built to protect against 3-year return flood events. In the event of a greater then 3-year return flood event is predicted, the pre-flood preparation plan will implemented and will include preparation measures to avoid unwanted material from entering the river in the event of cofferdam overtopping. Flood preparation measures may include moving equipment, cleaning the site, and avoiding concrete pours. In addition, fish will be removed from the site when present during these events. The RCC cofferdams will not be damaged by overtopping flows.

In-water Work Window 3: Project Completion and Initial Operation

Remove RCC cofferdams

Prior to diverting the river into the permanent water conduit through the dam, the RCC cofferdams will need to be removed and the river channel restored. The cofferdam designs will consider the temporary nature of the structure and the need for removal and restoration prior to diverting the river into the river channel. The same process used during initial river diversion can be used in reverse to facilitate removal of the RCC cofferdams. Fish passage during this period is illustrated on Plate B-6 and B-7.

Channel Restoration, Rewatering Through New Conduits, and Diversion Tunnel Closure

The river channel and surrounding area between the upstream and downstream cofferdams will be restored prior to removal of the cofferdams and rewatering of the Chehalis River through the new outlet conduits.

Dewatering of the diversion tunnel, rewatering of the natural river channel and conduits, and removal of fish from the diversion tunnel will occur simultaneously until all fish are removed from the tunnel and the Chehalis River is returned to its natural channel through the project site and the outlet conduits. As shown on Plates B-5 and B-6, closure of the diversion tunnel will occur after the channel restoration work is completed and the diversion capacity is no longer needed. Once flow is restored to the natural Chehalis River channel and through the dam conduits, the fish barrier associated with the temporary trap and transport facility must be removed or cease to operate before the natural channel and dam conduits will be volitionally passable upstream and downstream by aquatic species.

Complete/Commission Permanent CHTR Fish Passage Facility

The dam conduit gates and permanent CHTR fish passage facility described in the CHTR Report will be commissioned and operational as described in the Operations Plan prior to removal of the temporary trap and transport fish passage facility to ensure fish passage remains uninterrupted. Commissioning of the dam conduit gates and CHTR facility must occur after the Chehalis River has been restored to its natural channel through the project site and the dam conduits because both facilities require an actively flowing river to demonstrate they are operating properly. Given the limited time available for in-water work, the timing of commissioning of the dam conduit gates and permanent CHTR fish passage facility will be critical to meeting the proposed schedule to allow removal of the temporary trap and transport facility.

Removal of Temporary Trap and Transport Fish Passage Facility

The FRE Report indicated that the temporary trap and transport facility will be operated for the full construction period. Once flows are established through the conduits, the river channel is restored, and the CHTR is commissioned and operational, the temporary trap and transport facility will not be hydraulically necessary for the successful and timely passage of fish through the project site. As such, the temporary trap and transport facility may be fully removed and river restored, or the facility may be partially removed to allow natural, volitional passage in the river channel but retain some of the temporary trap and transport infrastructure. Plate B-7 illustrates this sequence and fish passage routes available during this period. There may be benefits to the fisheries resources associated with keeping some of the infrastructure of the temporary facility in place after the river is restored to its natural channel. For example, if a picket weir fish barrier is used as part of the temporary facility, the pickets may be removed but the concrete foundations may be left in place to allow the picket barrier to be easily installed again if need arises in the future. A decision to keep some of the infrastructure in place would be determined in consultation with the governing fisheries agencies. Removal of part or all of the temporary facility would be subject to in-water work window requirements. An order of magnitude estimate for the duration of in-water work required to remove the facility and restore the river channel is approximately 2.5 months. Plate B-8 illustrates upstream and downstream fish passage routes (via the river channel and dam conduits) during normal operation of the project following completion of construction.

Construction Schedule Refinement

The construction sequence description and associated construction schedule described in this document are consistent with the level of project design that has been developed to support the environmental review process under SEPA and NEPA. As the project progresses from conceptual to preliminary design, additional design detail will become available and additional site specific data will be gathered. This will allow further refinement of the construction schedule. A final construction schedule will be established in response to construction permit requirements set by regulatory agencies (including mitigation) with the jurisdiction, project sponsored mitigation, and the construction contractors bid.

APPENDICES

Appendix A: Construction Sequencing Plates

Appendix B: Fish Passage Sequencing During Construction Plates

Appendix C: Preliminary Construction Sequence Provided in Section 14 of Conceptual Report and Section 10 of the FRE Report

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Appendix A: Construction Sequencing Plates

Plate A-1: Site Plan
Plate A-2: Diversion Tunnel and Temporary Trap and Transport Facility
Plate A-3: River Diversion and Super Sack Cofferdam
Plate A-4: Foundation Treatment
Plate A-5: Channel Restoration & Rewatering Through New Conduits
Plate A-6: Completed Dam and Fish Passage Facility

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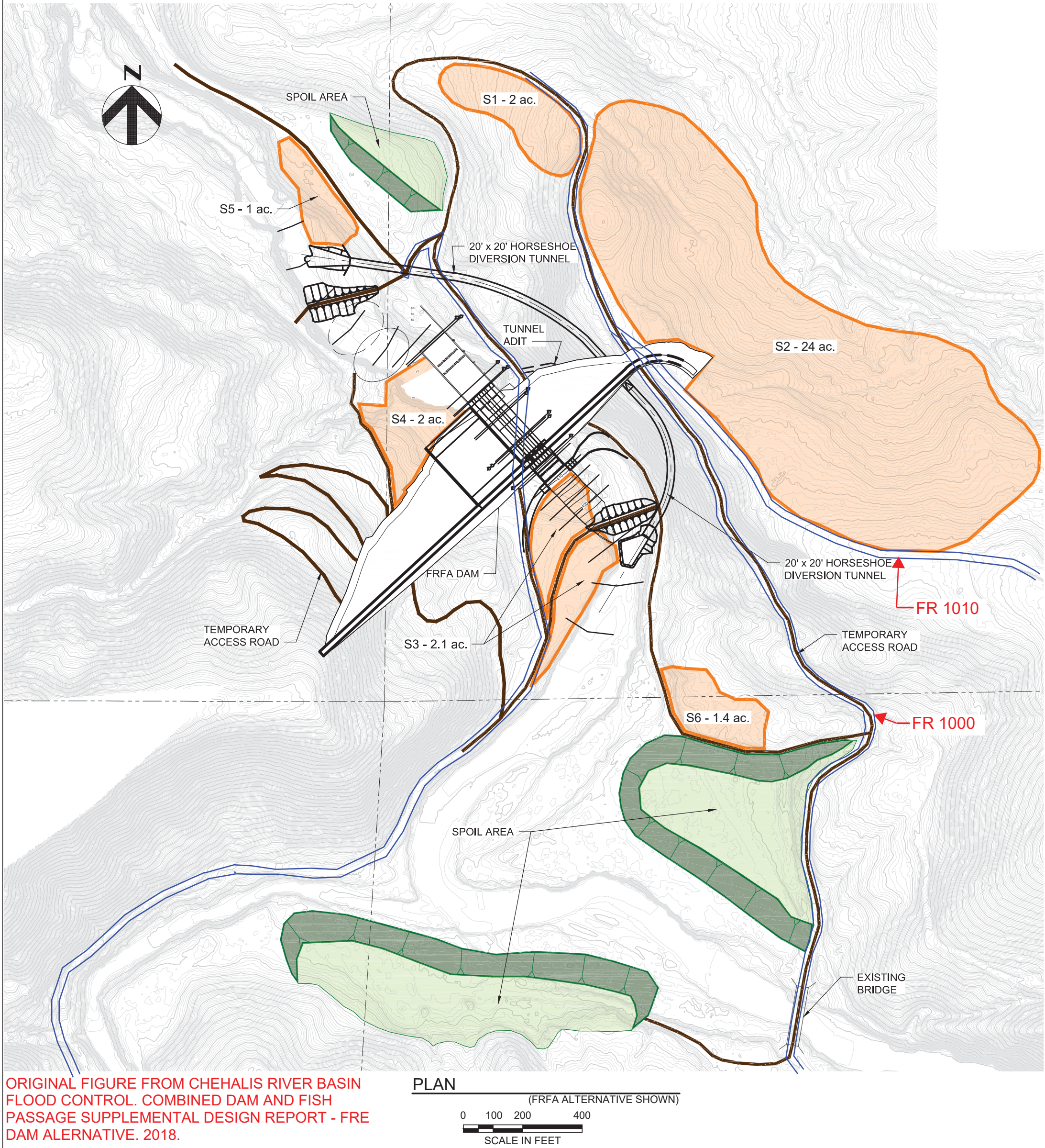

ORIGINAL FIGURE FROM CHEHALIS RIVER BASIN FLOOD CONTROL. COMBINED DAM AND FISH PASSAGE SUPPLEMENTAL DESIGN REPORT - FRE DAM ALERNATIVE. 2018.

Plate	Title	Description
A-1	Site Plan	Conceptual site plan layout including staging, access roads, facilities, cofferdams, diversion tunnels, and final constructed dam facility.
A-2	Diversion Tunnel and Temporary Trap and Transport Facility	Conceptual construction staging of temporary trap and transport facility and diversion tunnel excavation showing isolation of tunnel inlet and exit portals.
A-3	River Diversion and Super Sack Cofferdam	Conceptual construction staging of super sack cofferdams as well as operation and initial river flow through diversion tunnel.
A-4	River Diversion During Construction	Diversion of water through the diversion tunnel during the construction period.
A-5	Channel Restoration and Rewatering Through New Conduits	Conceptual channel restoration and rewatering through new conduits following construction of the dam, removal of cofferdams, and closure of the diversion tunnel.
A-6	Completed Dam and Fish Passage Facility	Final conceptual Project layout showing completed dam and fish passage facility.

PLAN LEGEND:

- S1 - OFFICES, RECEIVING, SECURITY.
- S2 - 1) RCC PLANT, CONVENTIONAL CONCRETE PLANT, COOLING SYSTEMS, CEMENT & FLY ASH STORAGE, SUPPLEMENTARY AGGREGATE STOCKPILES.
  2) FABRICATION & MAINTENANCE.
  3) GATES & MECHANICAL STAGING.
- S3 - STRUCTURE & DAM STAGING
- S4 - (S2 - S3) SUPPLEMENTAL STRUCTURE & DAM STAGING.
- S5 - DOWNSTREAM PORTAL STAGING.
- S6 - UPSTREAM PORTAL STAGING.
- SPOIL AREA
- TEMPORARY ACCESS ROAD
- EXISTING ROAD

PLATE A-1
SITE PLAN

HDR

SITE PLAN

CHEHALIS BASIN DAM

DATE
September 2019

PLATE
A-1

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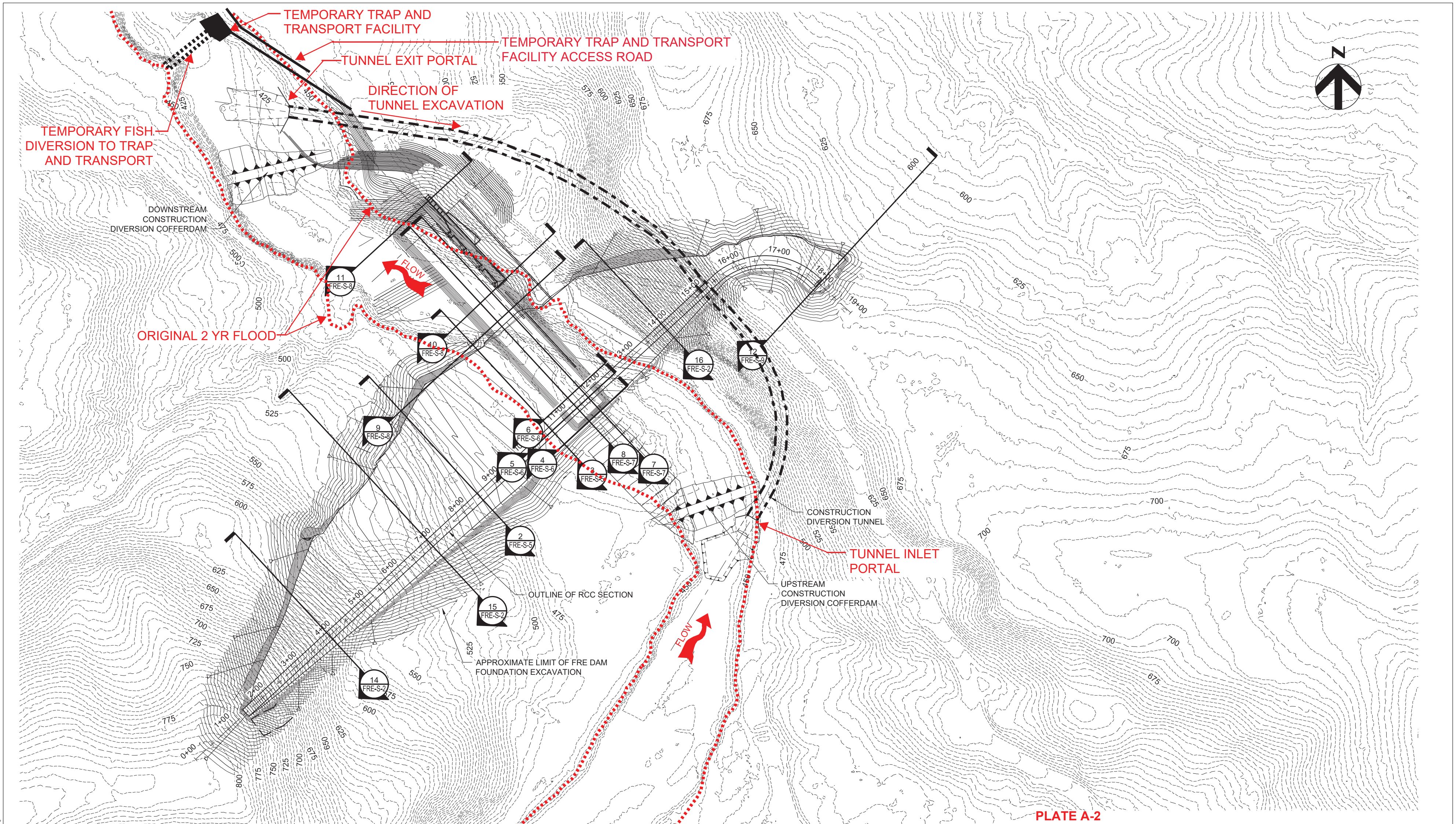

ORIGINAL FIGURE FROM CHEHALIS RIVER BASIN FLOOD CONTROL. COMBINED DAM AND FISH PASSAGE SUPPLEMENTAL DESIGN REPORT - FRE DAM ALERNATIVE. 2018.

DAM EXCAVATION PLAN

0 50 100 200
SCALE IN FEET

PLATE A-2
DIVERSION TUNNEL AND TEMPORARY TRAP AND TRANSPORT FACILITY

HDR	DIVERSION TUNNEL AND TEMPORARY TRAP AND TRANSPORT FACILITY CHEHALIS BASIN DAM	DATE September 2019 PLATE A-2

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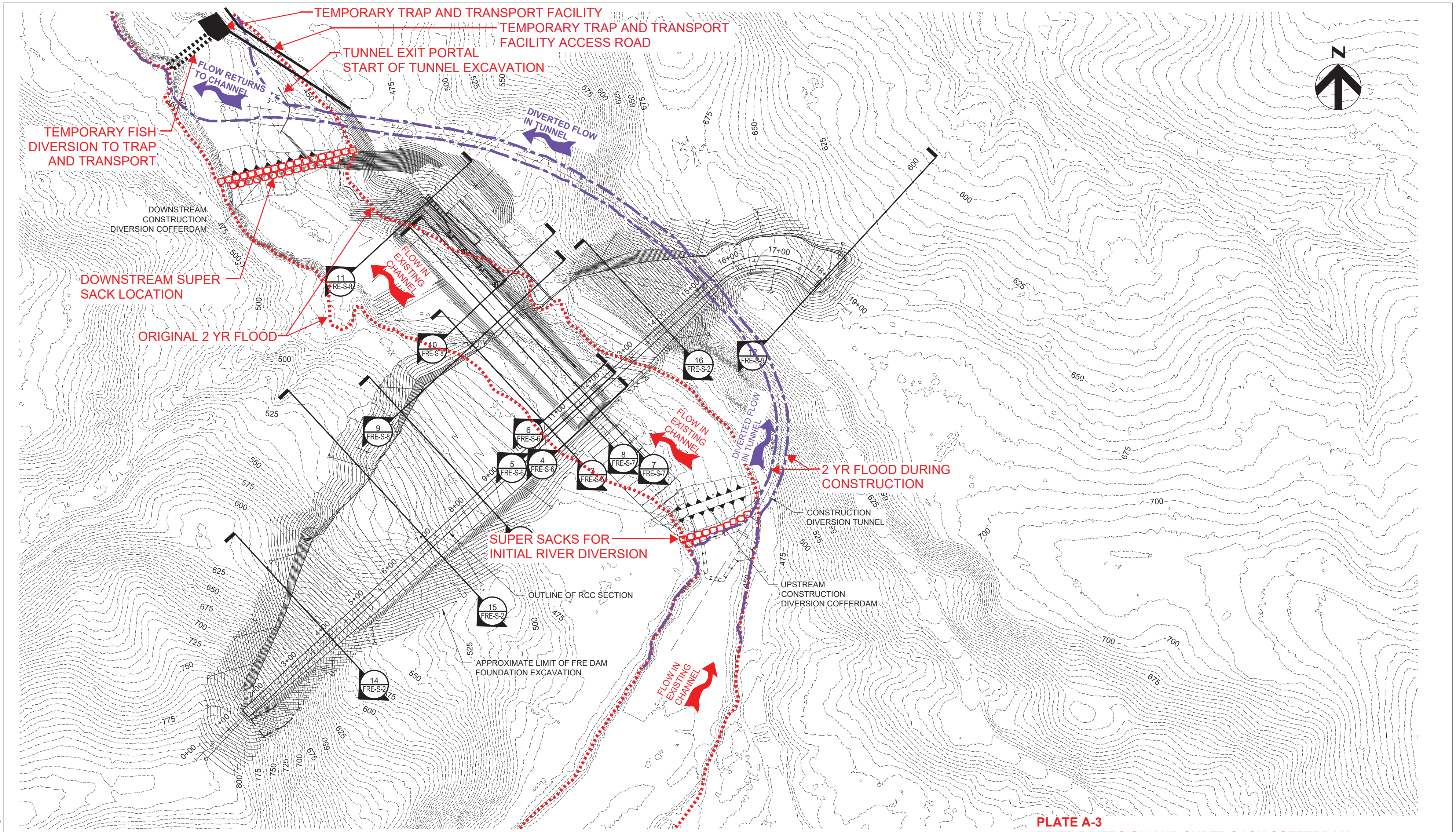


PLATE A-3
RIVER DIVERSION AND SUPER SACK COFFERDAM

ORIGINAL FIGURE FROM CHEHALIS RIVER BASIN FLOOD CONTROL. COMBINED DAM AND FISH PASSAGE SUPPLEMENTAL DESIGN REPORT - FRE DAM ALERNATIVE. 2018.

DAM EXCAVATION PLAN

0 50 100 200
SCALE IN FEET

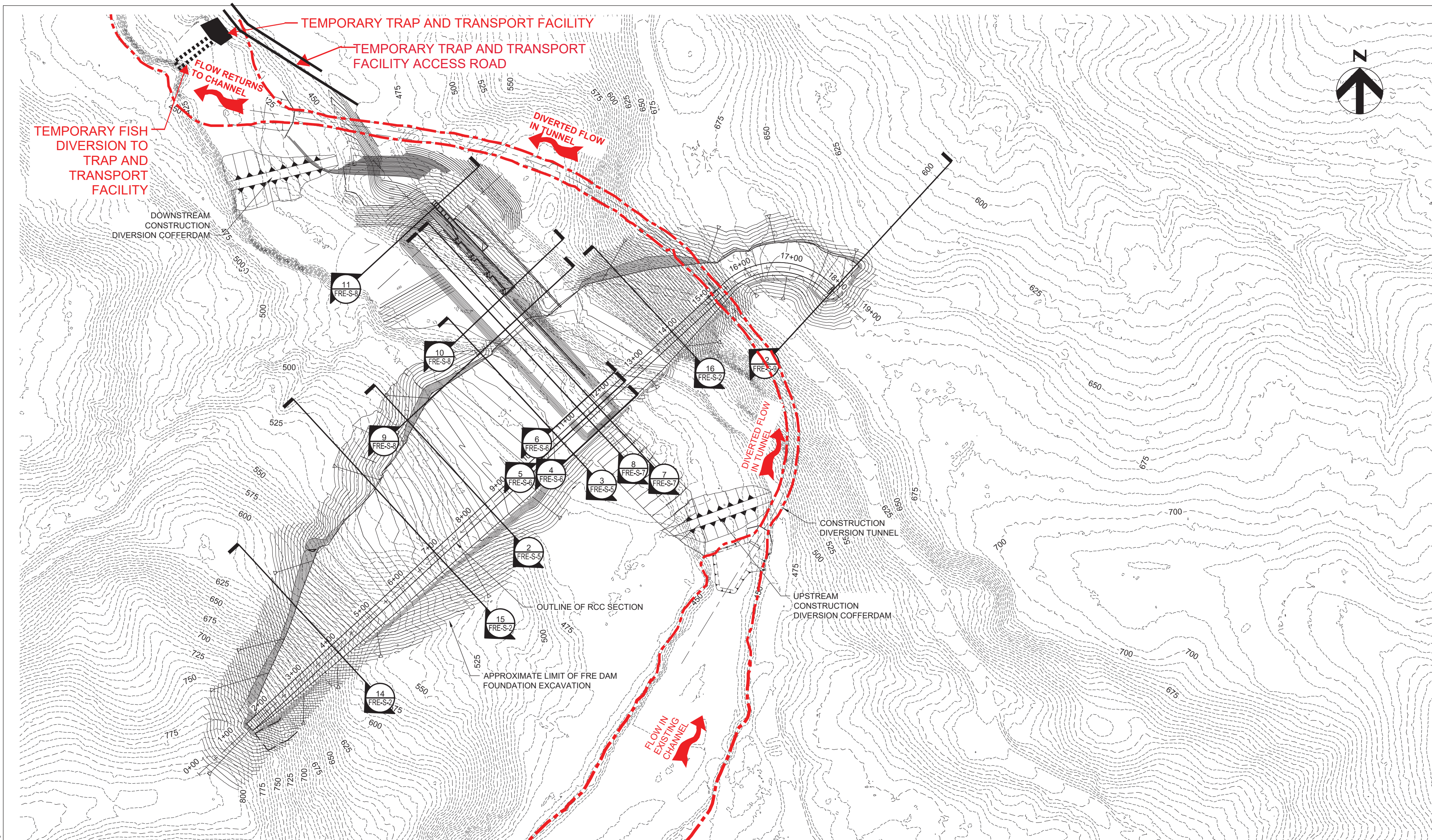
HDR

DIVERSION TUNNEL AND TEMPORARY TRAP AND TRANSPORT FACILITY

CHEHALIS BASIN DAM

DATE
September 2019

PLATE
A-3



ORIGINAL FIGURE FROM CHEHALIS RIVER BASIN FLOOD CONTROL. COMBINED DAM AND FISH PASSAGE SUPPLEMENTAL DESIGN REPORT - FRE DAM ALERNATIVE. 2018.

DAM EXCAVATION PLAN

0 50 100 200
SCALE IN FEET

PLATE A-4
FOUNDATION TREATMENT

HDR	RIVER DIVERSION DURING CONSTRUCTION CHEHALIS BASIN DAM	DATE September 2019 PLATE A-4

C:\pwworking\sea\d1810432\FRE-S-1 - REPORT.dwg, S-01, 7/12/2019 11:25:59 AM, PKOWALKE

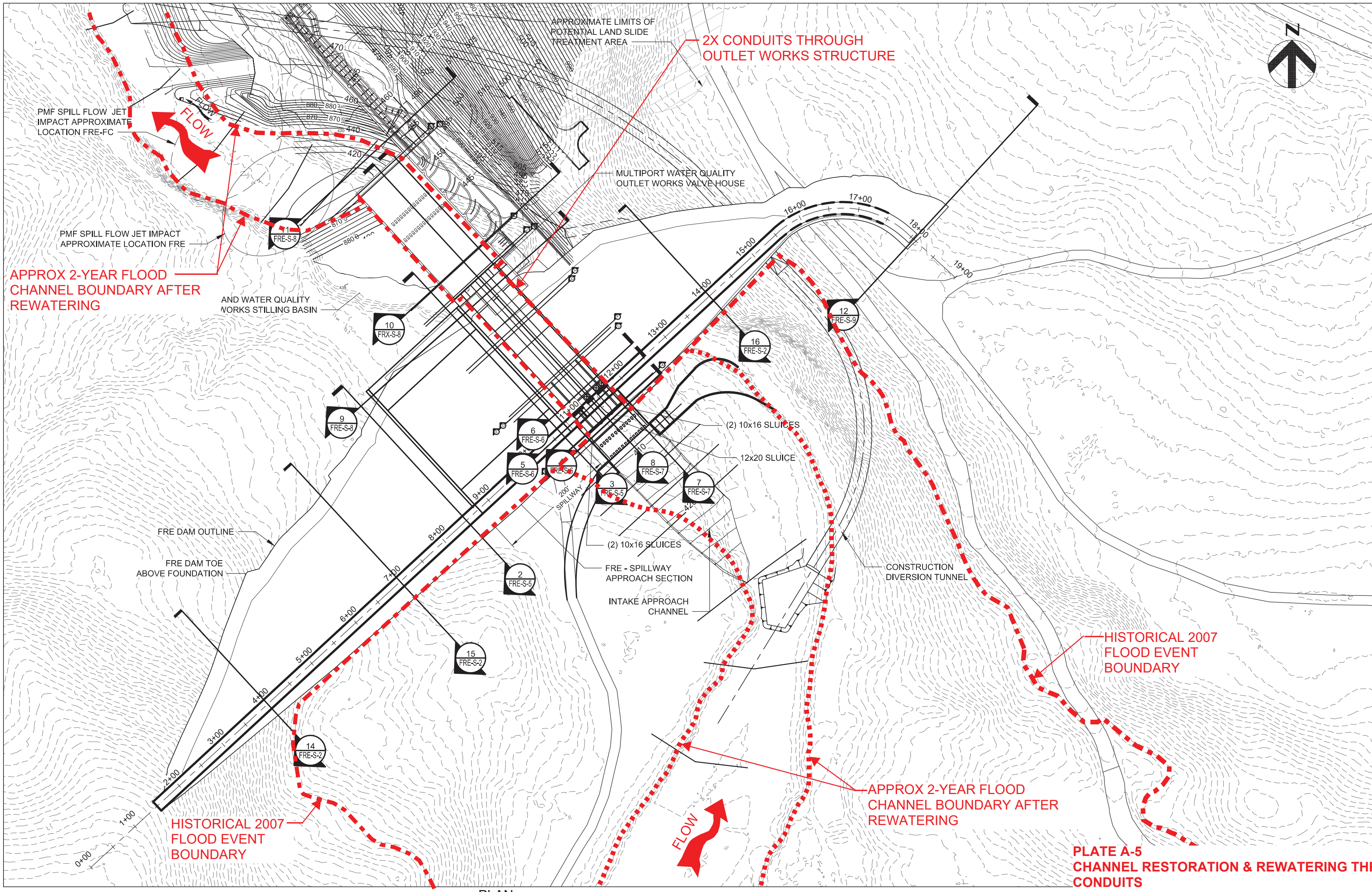


PLATE A-5
CHANNEL RESTORATION & REWATERING THROUGH NEW CONDUITS

ORIGINAL FIGURE FROM CHEHALIS RIVER BASIN FLOOD CONTROL. COMBINED DAM AND FISH PASSAGE SUPPLEMENTAL DESIGN REPORT - FRE DAM ALERNATIVE. 2018.

PLAN

0 40 80 160
SCALE IN FEET

HDR

CHANNEL RESTORATION AND REWATERING THROUGH NEW CONDUITS

CHEHALIS BASIN DAM

DATE
September 2019

PLATE
A-5

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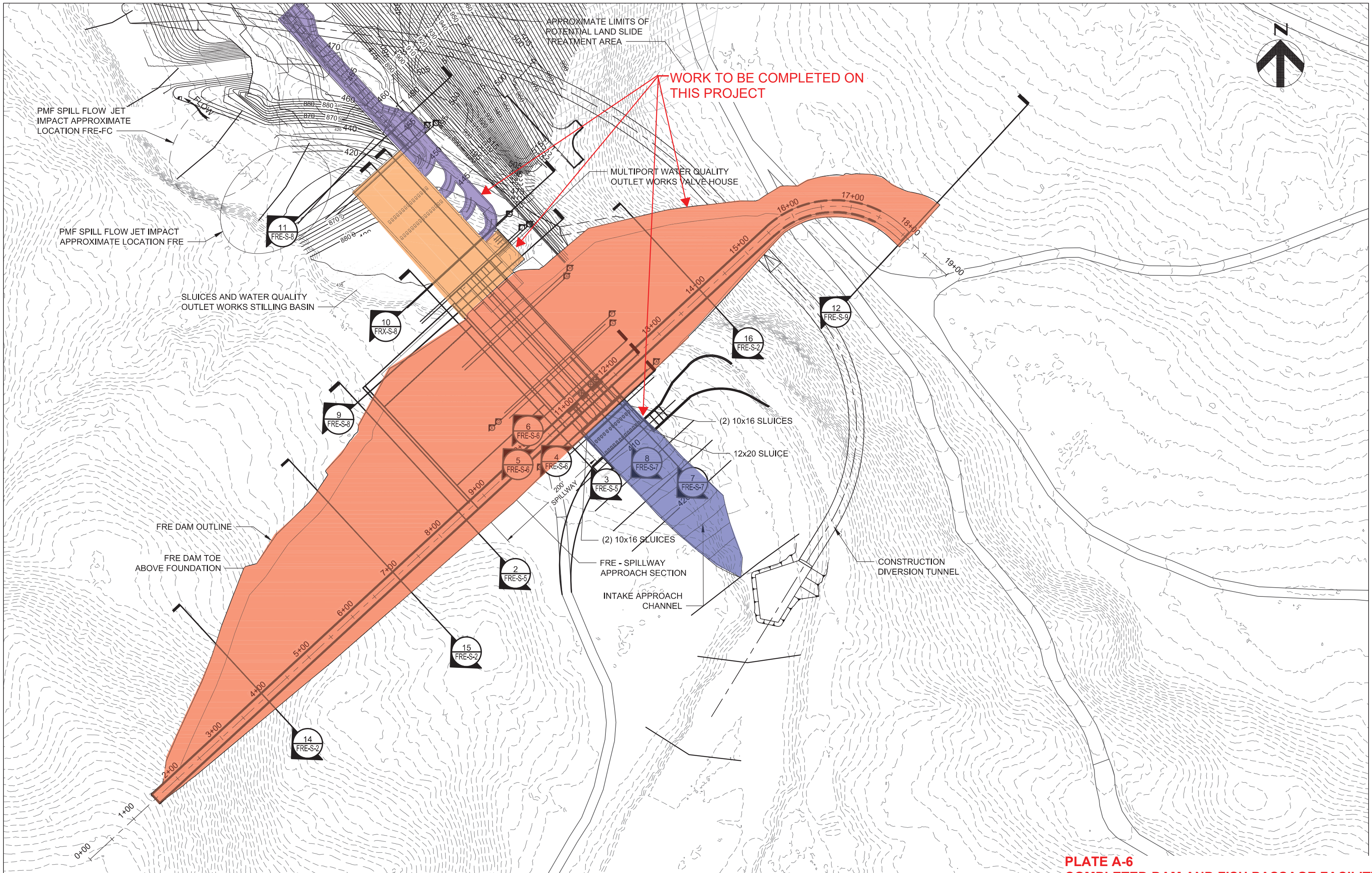

PLATE A-6
COMPLETED DAM AND FISH PASSAGE FACILITY

ORIGINAL FIGURE FROM CHEHALIS RIVER BASIN FLOOD CONTROL. COMBINED DAM AND FISH PASSAGE SUPPLEMENTAL DESIGN REPORT - FRE DAM ALERNATIVE. 2018.

PLAN

0 40 80 160
SCALE IN FEET

HDR

CHANNEL RESTORATION AND REWATERING THROUGH NEW CONDUITS

CHEHALIS BASIN DAM

DATE
September 2019

PLATE
A-6

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Appendix B: Fish Passage Sequencing During Construction Plates

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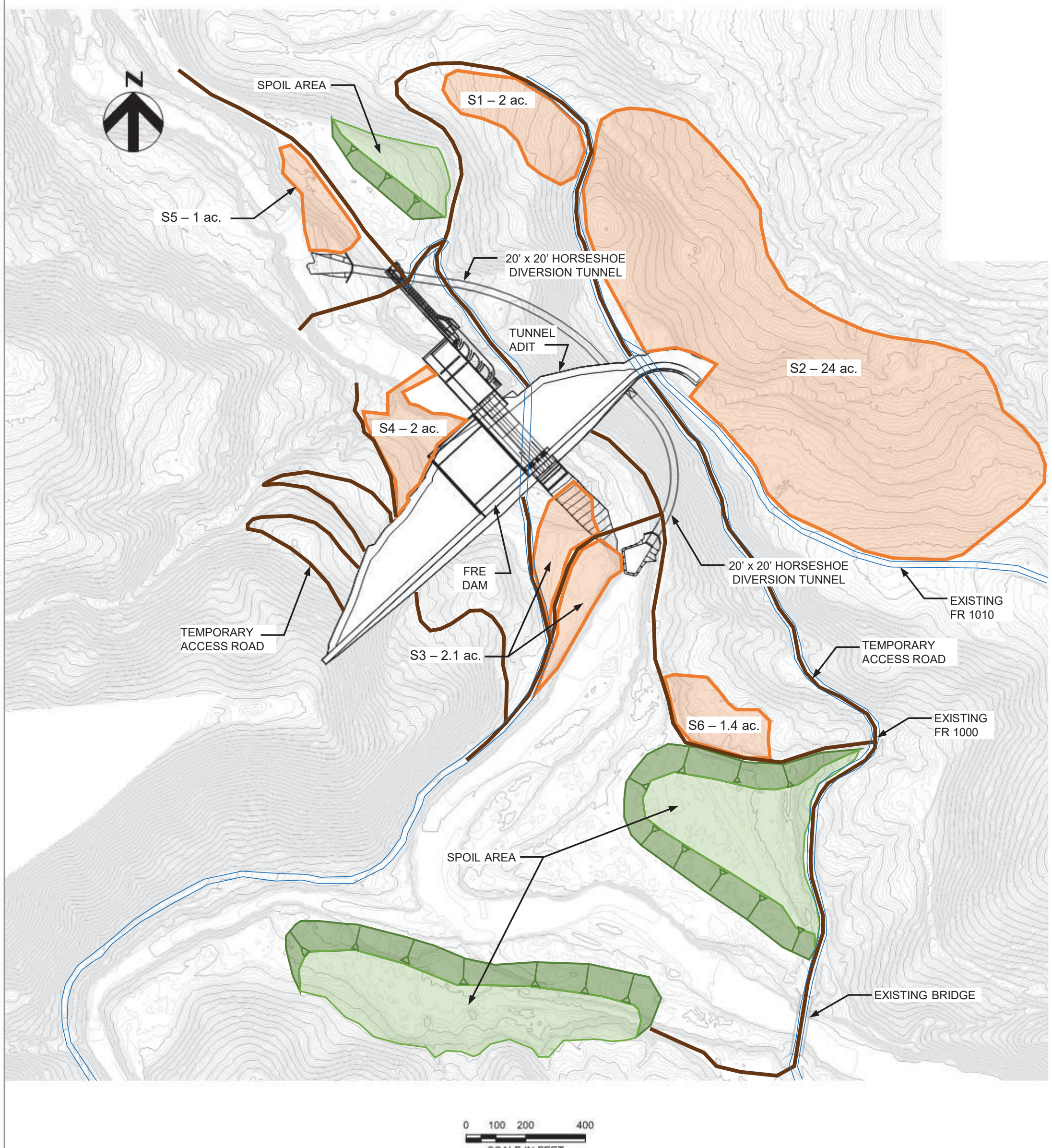


Plate	In-Water Work Window	Time Frame	Fish Passage Strategy
B-2	Work Window 1	Y1, July - Sept	Fish will pass through the construction area via the river channel.
B-3	Work Window 2 - Phase 1	Y2, July - Sept	Fish will pass through the construction area via the river channel.
B-4	Work Window 2 - Phase 2	Y2, July - Sept	Following completion of the work shown on Plate B-3, the river will be diverted through the Diversion Tunnel, at which time, fish will pass downstream via the Diversion Tunnel and upstream via the Temporary Trap and Transport Facility.
B-5	Chehalis River Bypassed through Diversion Tunnel, All Work In Dry	Y2, Sept - Y5, June	Fish will pass downstream via the Diversion Tunnel and upstream via the Temporary Trap and Transport Facility.
B-6	Work Window 3 - Phase 1	Y5, July - Sept	Fish will pass downstream via the Diversion Tunnel and upstream via the Temporary Trap and Transport Facility.
B-7	Work Window 3 - Phase 2	Y5, July - Sept	Fish will pass downstream via the river channel and dam conduits and upstream via the Temporary Trap and Transport Facility until the dam conduits and permanent fish passage facility (Collect, Handle, Transfer, and Release [CHTR] facility) has been commissioned. Following completion and commissioning of the dam and CHTR facility, the temporary trap and transport facility will be removed or decommissioned and upstream river passage restored.
B-8	n/a	after Y5, Sept	Post-Construction Normal Operation: Fish will pass upstream and downstream via the river channel and dam conduits.

PLAN LEGEND:

- S1 – OFFICES, RECEIVING, SECURITY.
- S2 – 1) RCC PLANT, CONVENTIONAL CONCRETE PLANT, COOLING SYSTEMS, CEMENT & FLY ASH STORAGE, SUPPLEMENTARY AGGREGATE STOCKPILES
  2) FABRICATION & MAINTENANCE
  3) GATES & MECHANICAL STAGING
- S3 – STRUCTURE & DAM STAGING
- S4 – (S2 – S3) SUPPLEMENTAL STRUCTURE & DAM STAGING.
- S5 – DOWNSTREAM PORTAL STAGING.
- S6 – UPSTREAM PORTAL STAGING.
- SPOIL AREA
- TEMPORARY ACCESS ROAD
- EXISTING ACCESS ROAD

~ CONCEPTUAL ~

FISH PASSAGE DURING CONSTRUCTION

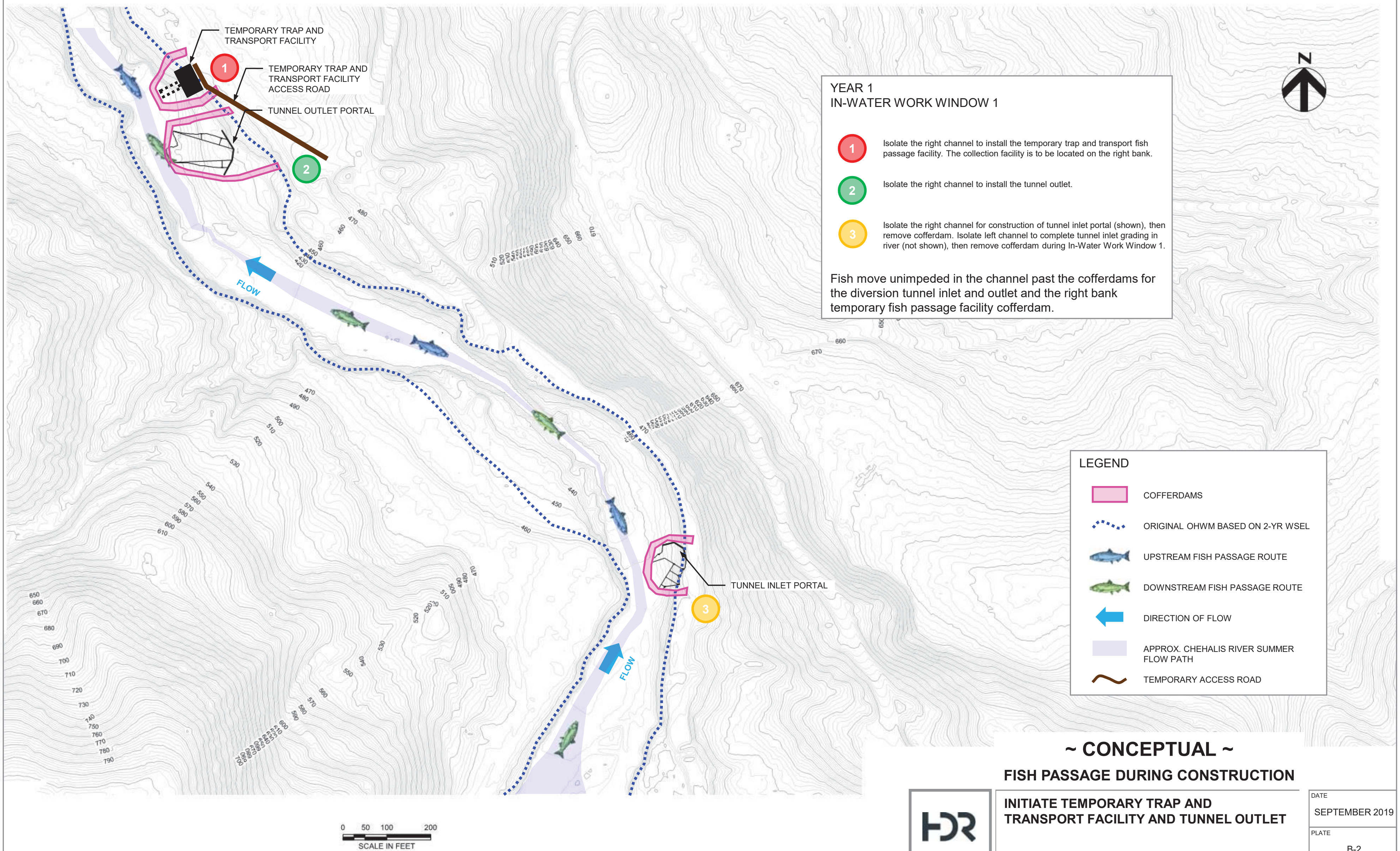
HDR

SITE PLAN

CHEHALIS BASIN DAM

DATE: SEPTEMBER 2019

PLATE: B-1



~ CONCEPTUAL ~

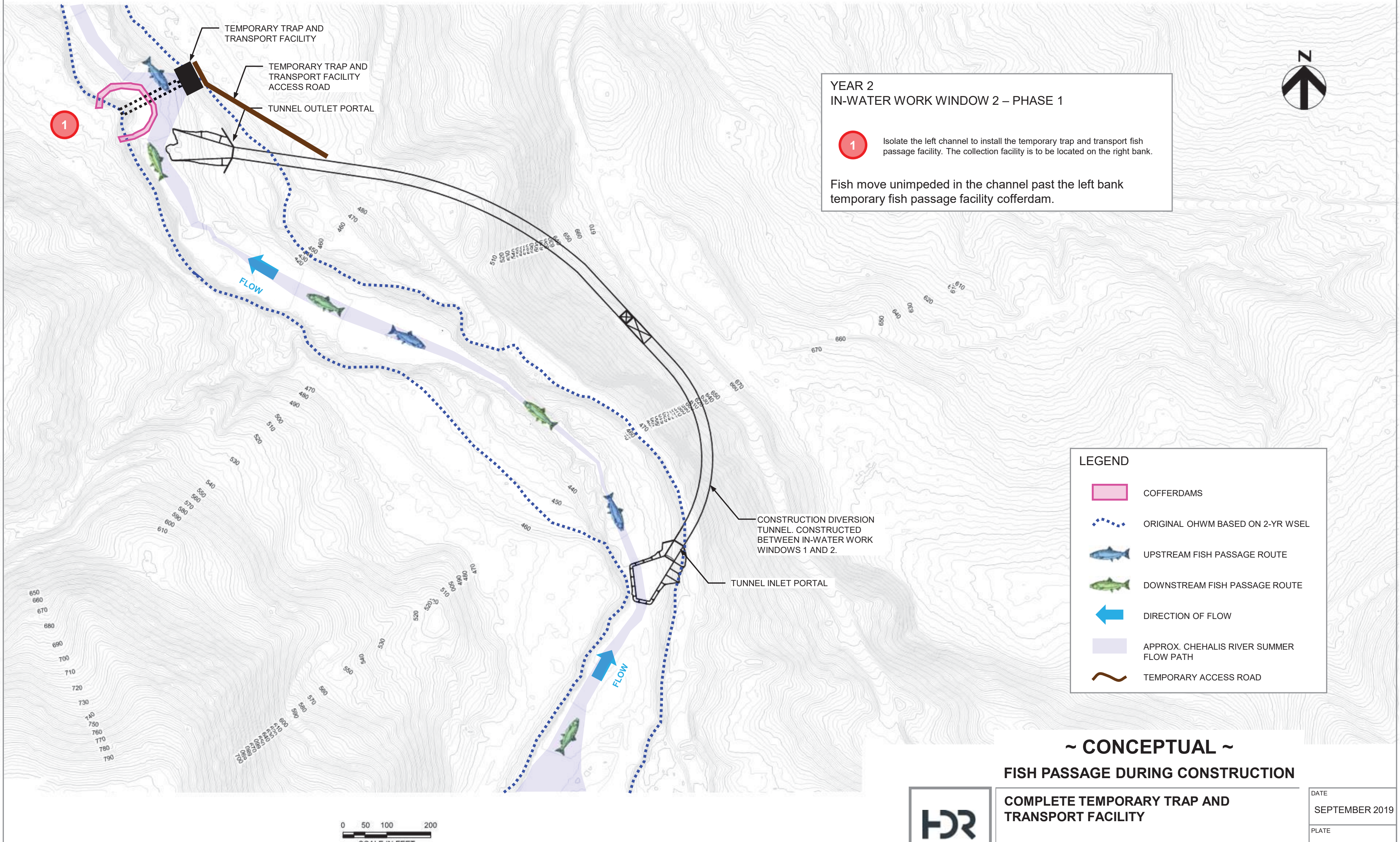
FISH PASSAGE DURING CONSTRUCTION

INITIATE TEMPORARY TRAP AND TRANSPORT FACILITY AND TUNNEL OUTLET

CHEHALIS BASIN DAM

DATE SEPTEMBER 2019

PLATE B-2



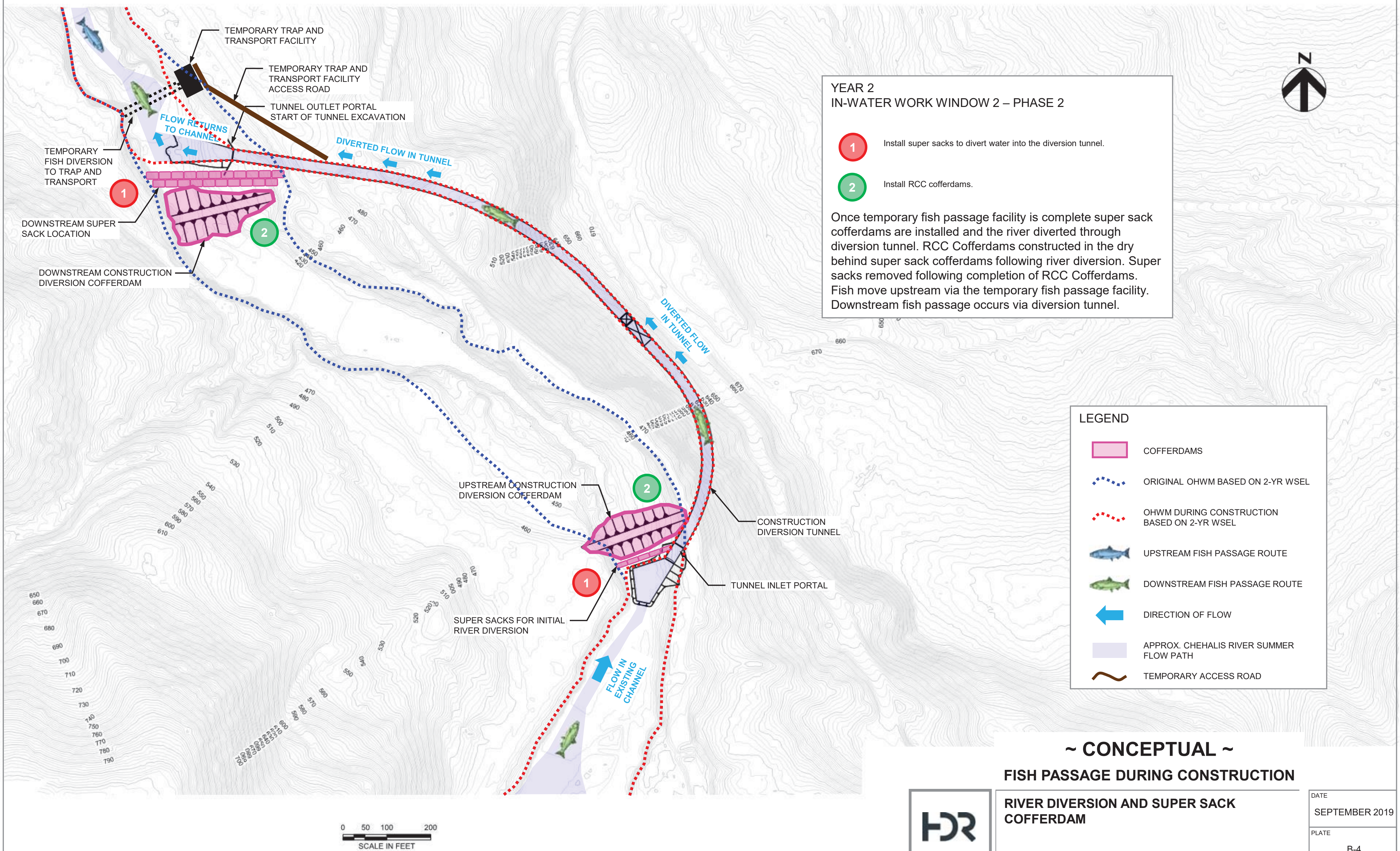
~ CONCEPTUAL ~

FISH PASSAGE DURING CONSTRUCTION

COMPLETE TEMPORARY TRAP AND TRANSPORT FACILITY

CHEHALIS BASIN DAM

DATE	SEPTEMBER 2019
PLATE	B-3



~ CONCEPTUAL ~

FISH PASSAGE DURING CONSTRUCTION

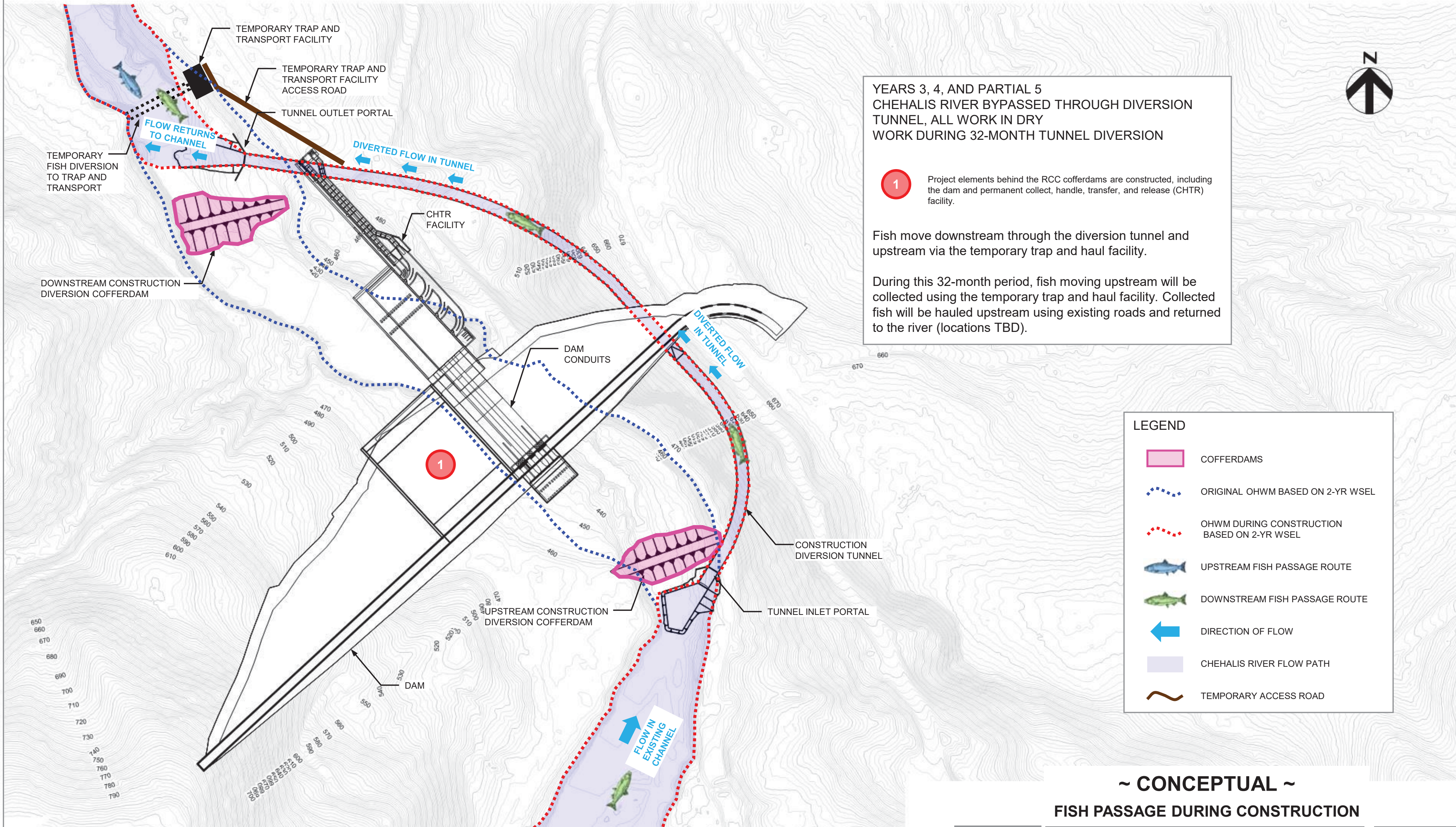
HDR

RIVER DIVERSION AND SUPER SACK COFFERDAM

CHEHALIS BASIN DAM

DATE
SEPTEMBER 2019

PLATE
B-4



YEARS 3, 4, AND PARTIAL 5
CHEHALIS RIVER BYPASSED THROUGH DIVERSION TUNNEL, ALL WORK IN DRY
WORK DURING 32-MONTH TUNNEL DIVERSION

1 Project elements behind the RCC cofferdams are constructed, including the dam and permanent collect, handle, transfer, and release (CHTR) facility.

Fish move downstream through the diversion tunnel and upstream via the temporary trap and haul facility.

During this 32-month period, fish moving upstream will be collected using the temporary trap and haul facility. Collected fish will be hauled upstream using existing roads and returned to the river (locations TBD).

~ CONCEPTUAL ~

FISH PASSAGE DURING CONSTRUCTION

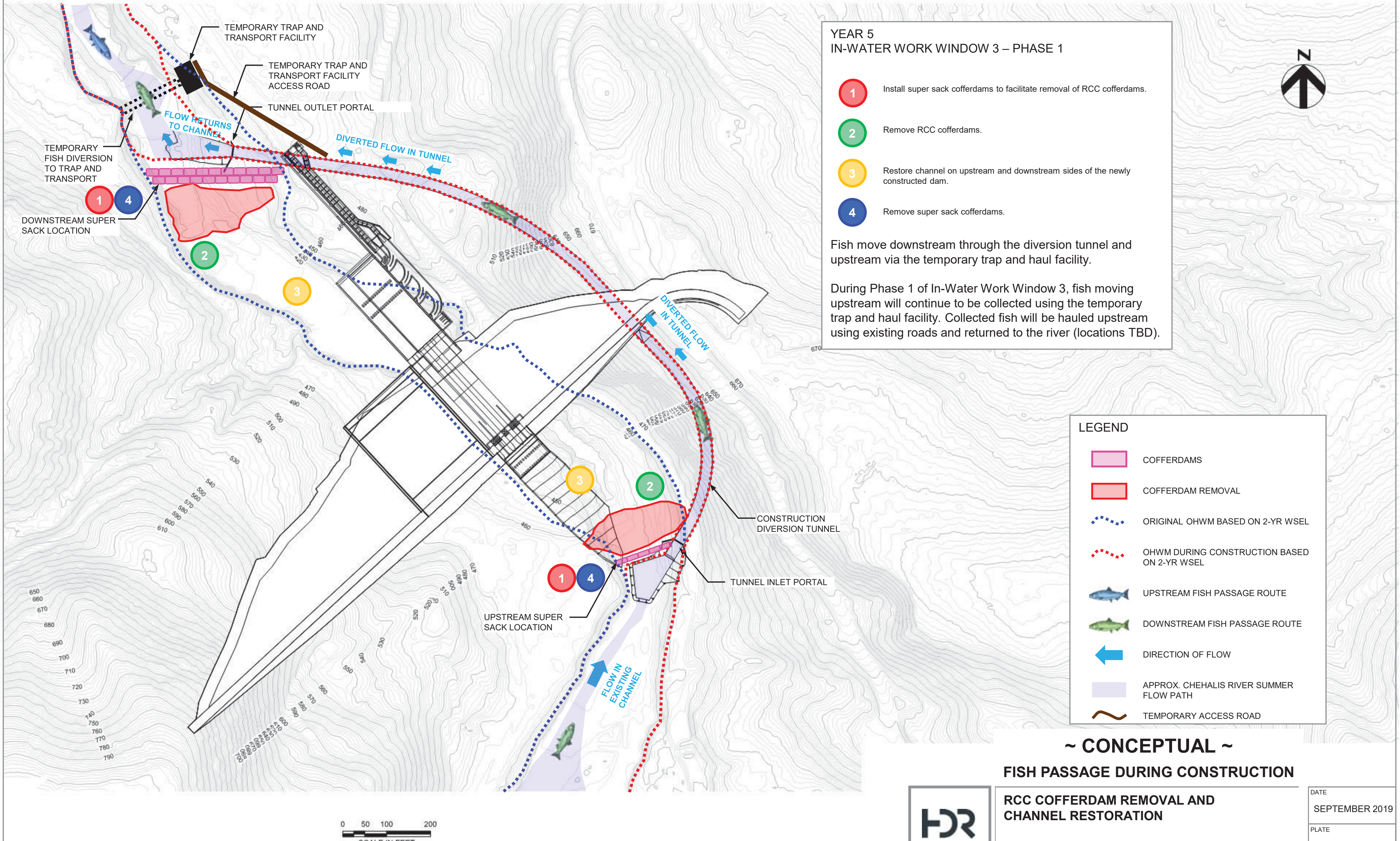
HDR

FRE AND CHTR CONSTRUCTION

CHEHALIS BASIN DAM

DATE
SEPTEMBER 2019

PLATE
B-5



~ CONCEPTUAL ~

FISH PASSAGE DURING CONSTRUCTION

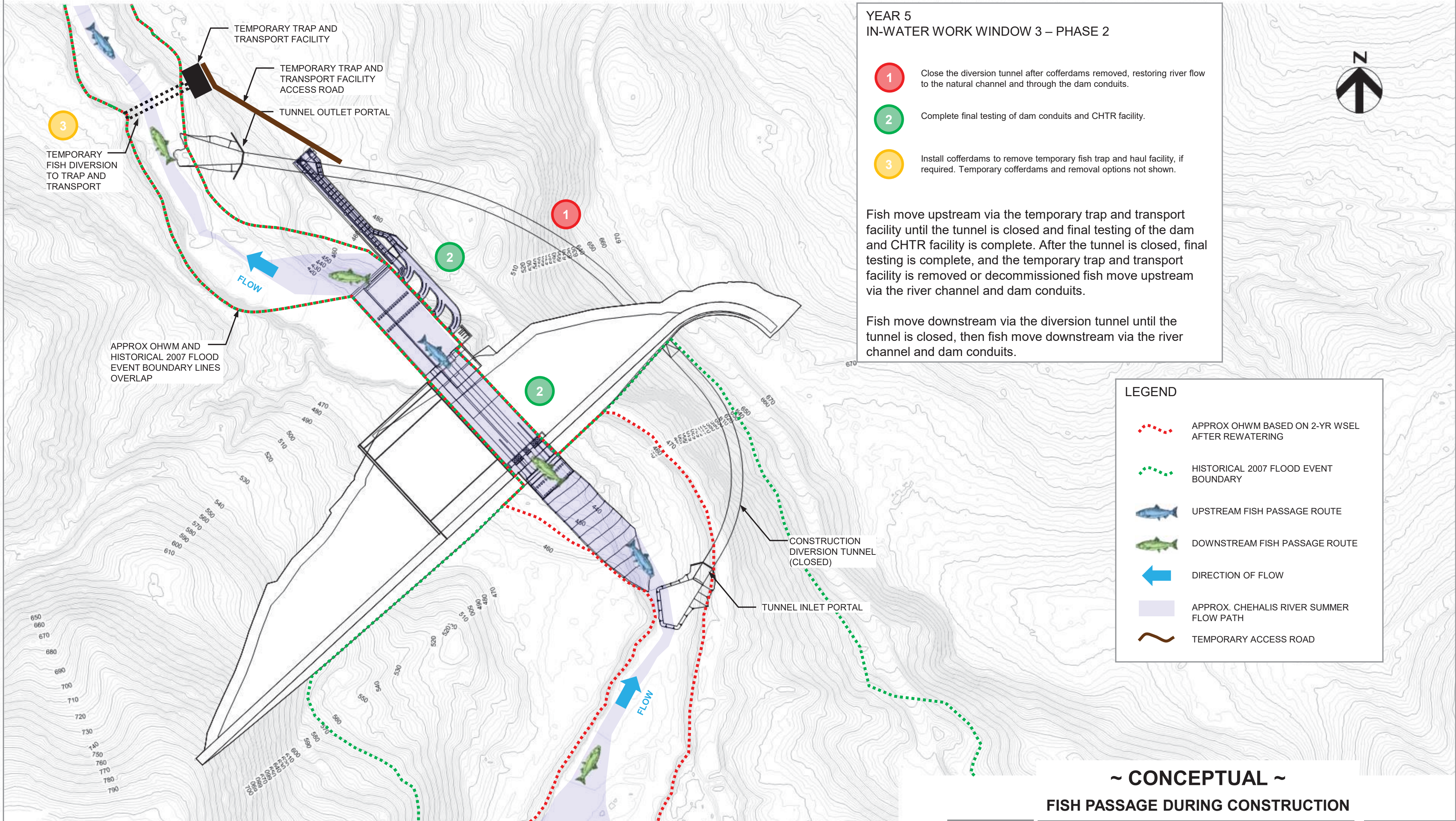
HDR

RCC COFFERDAM REMOVAL AND CHANNEL RESTORATION

CHEHALIS BASIN DAM

DATE: SEPTEMBER 2019

PLATE: B-6



YEAR 5
IN-WATER WORK WINDOW 3 – PHASE 2

1. Close the diversion tunnel after cofferdams removed, restoring river flow to the natural channel and through the dam conduits.
2. Complete final testing of dam conduits and CHTR facility.
3. Install cofferdams to remove temporary fish trap and haul facility, if required. Temporary cofferdams and removal options not shown.

Fish move upstream via the temporary trap and transport facility until the tunnel is closed and final testing of the dam and CHTR facility is complete. After the tunnel is closed, final testing is complete, and the temporary trap and transport facility is removed or decommissioned fish move upstream via the river channel and dam conduits.

Fish move downstream via the diversion tunnel until the tunnel is closed, then fish move downstream via the river channel and dam conduits.

LEGEND

- APPROX OHWM BASED ON 2-YR WSEL AFTER REWATERING
- HISTORICAL 2007 FLOOD EVENT BOUNDARY
- UPSTREAM FISH PASSAGE ROUTE
- DOWNSTREAM FISH PASSAGE ROUTE
- DIRECTION OF FLOW
- APPROX. CHEHALIS RIVER SUMMER FLOW PATH
- TEMPORARY ACCESS ROAD

~ CONCEPTUAL ~

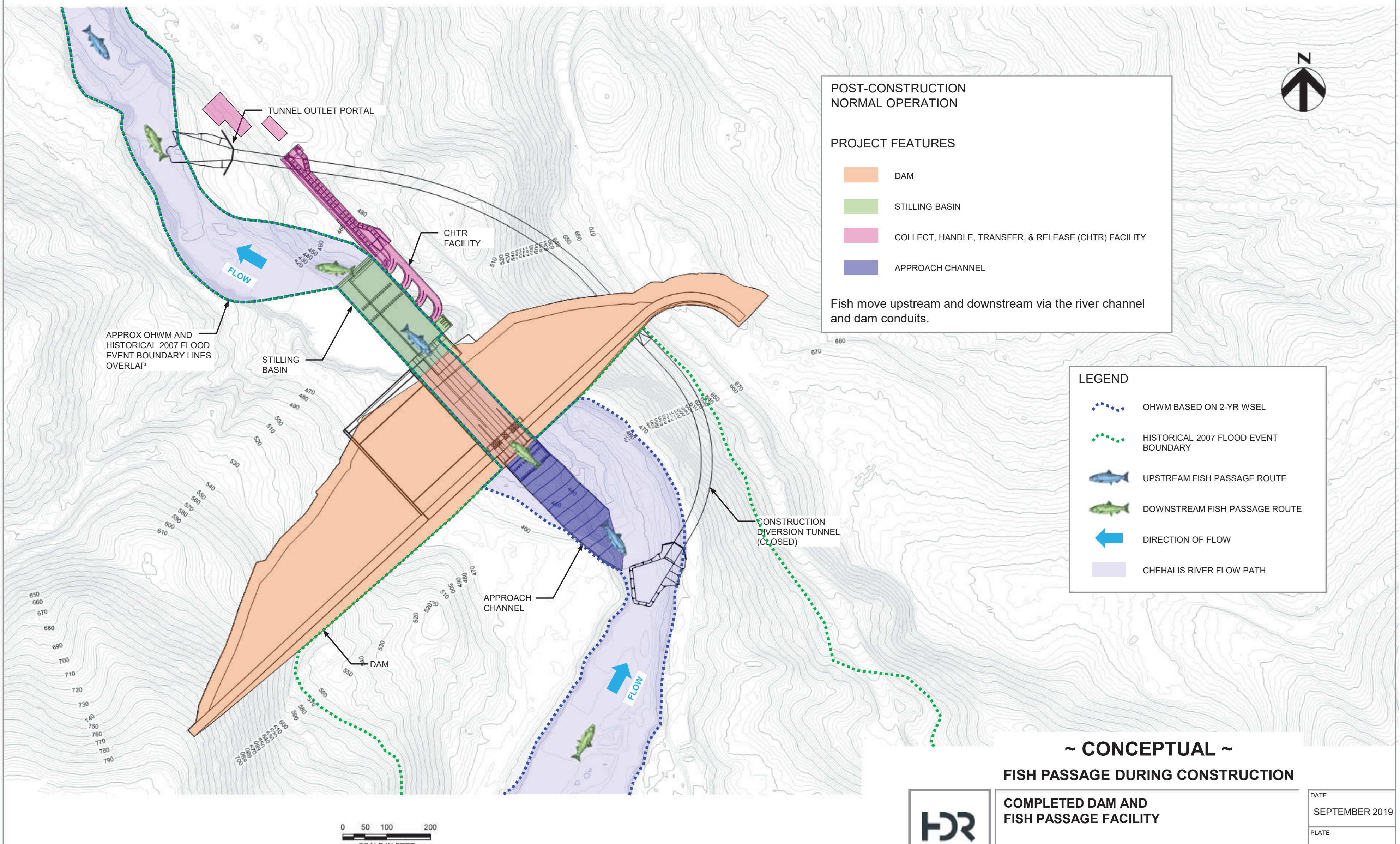
FISH PASSAGE DURING CONSTRUCTION

BYPASS TUNNEL CLOSURE AND CHANNEL REWATERING THROUGH NEW CONDUITS

CHEHALIS BASIN DAM

DATE
SEPTEMBER 2019

PLATE
B-7



~ CONCEPTUAL ~

FISH PASSAGE DURING CONSTRUCTION

COMPLETED DAM AND FISH PASSAGE FACILITY

CHEHALIS BASIN DAM

HDR

DATE
SEPTEMBER 2019

PLATE
B-8

Appendix C: Preliminary Construction Sequence Provided in Section 14 of Conceptual Report and Section 10 of the FRE Report

Section 14 pages from the Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Combined Dam and Fish Passage Conceptual Design Report

Section 10 pages from the Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species, Combined Dam and Fish Passage Supplemental Design Report, FRE Dam Alternative

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14 CONSTRUCTION SCHEDULE

14.1 Construction Sequence

A conceptual sequence for construction is described in Table 14-1. As illustrated by the sequence, construction schedule could be significantly influenced by flow conditions, and there are numerous schedule dependencies that would influence the completion date for the project.

Table 14-1
Preliminary Construction Sequence

WORK BREAKDOWN	SEQUENCE CONSIDERATIONS
TUNNEL CONSTRUCTION & INITIAL DIVERSION	
• Isolate portal areas from river flow	Low-flow limitation
• Slowly dewater and "fish" portal areas	Manually and safely remove fish from the areas to be dewatered and return them to the active river system
• Construct tunnel portals	Low-flow limitation
• Build the diversion tunnel by advancing from the downstream side portal to the upstream side portal	Low-flow limitation during completion of tunnel at upstream end.
• Build temporary berm to divert low flows through tunnel	River diverted – low flow
CONSTRUCT COFFERDAMS	
• Prepare flow diversion cofferdam foundation	Low-flow limitation
• Construct cofferdams, RCC upstream	Diversion ready for capacity flows; probable low-flow limitation; start flood risk
• Slowly dewater and "fish" areas behind cofferdams	Manually and safely remove fish from the areas to be dewatered and return them to the active river system
FOUNDATION PREPARATION	
• Excavate abutments & bottom	Emphasize right side to allow structure starts
• Prepare river outlet foundation	Start primary flood risk. Consider grout curtain continuity, avoid undercut
• Perform curtain grout	Include consolidation grouting, if required
• Foundation treatments & dental concrete	Prudent to allow some schedule contingency
LOWER-LEVEL HYDRAULIC STRUCTURES	
• Construct lower-level river outlet works (ROW)	Precedes RCC, through encasement. Includes flood control conduit/passage, ROW piping
• Construct initial energy dissipation, stilling basin	
• Construct lower-level fish passage	
RCC AND DAM	
• Place RCC – bottom to top of ROW encasement	Preceded by quarry development, initial aggregate processing, plant and delivery setup, trial section

WORK BREAKDOWN	SEQUENCE CONSIDERATIONS
• Place RCC – top of ROW to spillway break, include flip bucket mass block	RCC concurrent activities; aggregate processing, instrumentation, gallery construction, face and drain system construction, abutment preparation, ongoing ROW, stilling basin, fish passage construction. Primary flood risk complete
• Place RCC – right wing	
• Place RCC – right side to crest	
• Place RCC – left side to crest	
RIVER OUTLET WORKS	
• Complete intake, gate & service shaft, control structures	Gate & service shaft likely to precede RCC, but formed void could be considered
• Install flood regulating gate	
• Install river outlet gates	
• Install river outlet trash racks & metals	
• Complete ROW & flood regulating mechanical & controls	
• Complete control structure – electrical, mechanical & building trades	ROW ready for re-divert & tunnel plug
SPILLWAY	
• Complete stilling basin & energy dissipation structures	
• Complete plunge pool preparation	Spillway ready for re-divert & tunnel plug
• Construct spillway training walls	
• Construct spillway chute and flip	
• Construct spillway ogee	
• Construct spillway piers & bridge	
FISH PASSAGE	
• Complete downstream fish passage and mechanical	Fish passage ready for re-divert and tunnel plug
• Complete upstream fish passage	
• Complete fish passage conveyance	
• Complete fish passage mechanical & controls, building trades	
COMMISSIONING & RESTORATION	
• Complete electrical & mechanical commissioning	
• Final ROW access & grading construction	
• Breech cofferdams & re-divert river	Final flood risk complete
• Construct plug tunnel	
• Dam backfill, downstream and abutment grading	
• Complete quarry, access, & staging restoration	Preceded by reservoir clearing
• Project schedule contingency	

14.2 Contract Approach and Duration

The project duration, and ultimately the completed project delivery date, will depend upon permitting, design schedule, contract delivery approach, and contract execution. Concept-level planning should consider at least 8 years for engineering and construction. If final design were to begin in the beginning of 2017, this would lead to completion at the end of 2024. A shorter time frame could be realized if an accelerated project delivery became a driving project goal.

As discussed in the previous study (HDR, 2014), there could be advantages in building the project using two separate construction contracts. One contract could be used for construction of the river diversion, while the other contract could be used for construction of the main dam and associated fisheries facilities. The creation of two separate contracts would influence assignment of responsibility for construction and schedule risk, and could influence project cost.

Advantages of establishing separate contracts could include:

- By creating separate contracts, the owner could potentially maintain greater control over schedule risks by having greater control over diversion capacity and work sequence.
- Separate contracts could allow an earlier start to construction, which could allow early completion of diversion work and a reduced project duration.
- Separate contracts could make it possible to advance the project without having funding in place for the entire project.
- RCC construction and tunneling are specialized work. Separation of work into multiple contracts would allow specialists to competitively bid on separate portions of work, potentially resulting in lower bid costs.
- Depending on the timing of the separate contracts, use of a separate contract for tunnel diversion work could help isolate the construction of the dam from the schedule risk associated with the diversion contract.

Advantages of having a single contract could include:

- One contract assigns all responsibility of risk to one contractor, which could reduce the complexity of determining liability in the event there are requests for change orders or schedule modifications during construction.
- One contract provides the most flexibility to the dam contractor in determining how to conduct and schedule work. A contractor's tolerance for risk and approaches for mitigating those risks could lead to lower project costs.
- One contract could encourage innovation.
- A single contract would likely result in a dam contractor assuming liability and costs associated with managing the work of tunneling subcontractor. Under the dual contract configuration, the

State would assume the costs of managing two contracts rather than one. Likewise, the State would assume the risk of overlapping contracts or contract interference.

- Under a single contract, the quality of the diversion work is the responsibility of the same party that is at risk in the event of the failure of the diversion, which could result in higher quality work and lower failure risk.

The selection of contracting approach would influence the project schedule. Table 14-2 provides an estimate of project timelines for each contracting approach for each dam option. As shown in the table, it is anticipated that the duration for the contract would be reduced by using separate contracts. A thorough review of contract structure will need to be considered during design. No consideration is shown for starting the first of a two-contract approach before final design is complete.

Table 14-2
Comparison of Schedule for Alternatives

	FRFA		FRO	
	1 CONTRACT	**2 CONTRACTS**	**1 CONTRACT**	**2 CONTRACTS**
Final Design – (after completing preliminary design and site characterization)	2 - 2.5 yr	2 - 2.5 yr	1.5 - 2 yr	1.5 - 2 yr
Additional permitting allowance	1.5 yr	1.5 yr	1 yr	1 yr
Procurement – Phase 1 bid/award	6 months	6 months	4 - 6 months	4 - 6 months
Phase 1 Construction		1 - 1.5 yr		1 - 1.5 yr
Procurement – Phase 2 bid/award		6 months[1]		4 - 6 months[1]
Phase 2 Construction		3 - 3.5 yr		2 -3 yr
Single Contract Construction	3 - 4 yr		2.5 - 3.5 yr	
Total	**7 - 8.5 yr**	**8 - 10 yr**	**5.5 - 7 yr**	**6.5 - 8 yr**

Note:
1. Concurrent with Phase 1 construction

10 CONSTRUCTION SCHEDULE

10.1 Construction Sequence

It is anticipated that the FRE project would have a very similar duration to the FRO and potentially the FRFA which have been considered at 6 and 7 years of design and construction, respectively. While shorter schedules for each are plausible, the important reality is that the access development, tunnel and diversion systems, aggregate development, foundation features, early hydraulic structures, and the dam are all very similar between the FRO, FRFA, and FRE. It is unlikely a schedule difference greater than 1 year could be generated between the options. Regarding the FRE-FC, which would benefit from the earlier access and staging development, earlier quarry development, and foundation completion, its construction could reasonably be completed in two years, perhaps less. Due to similarities in scheduling requirements, new construction schedules have not been developed specifically for either the FRE or FRE-FC designs.

A.15. Email from Betsy Dillin to Diane Butorac (Washington Department of Ecology). Regarding: Levee Trail and Pe Ell Roads. October 29, 2019.

From: Betsy Dillin <Betsy.Dillin@lewiscountywa.gov>
Sent: Tuesday, October 29, 2019 8:25 AM
To: Butorac, Diane (ECY) <dbut461@ECY.WA.GOV>
Cc: Erik Martin <Erik.Martin@lewiscountywa.gov>; Lara McRea <Lara.McRea@lewiscountywa.gov>
Subject: Levee Trail and Pe Ell Roads

Hi Diane,
As a follow up to our conversation yesterday, I am writing this email to confirm that 1) the project will replace the recreational trail that is located on the top of the airport levee, and 2) the FCZD does not have a current plan for routes through Pe Ell that will serve for site access.
In addition, we would like to request that DOE consider the possibility of holding an open house in Pe Ell for EIS comments, or otherwise doing some additional outreach in that area.

Thank you,

Betsy Dillin, PE
Senior Utilities and Surface Water Engineer

Lewis County Public Works
2025 NE Kresky Ave
Chehalis, WA 98532
Phone: (360) 740-1138

Betsy.Dillin@lewiscountywa.gov

A.16. Letter from Erik Martin, PE (Chehalis River Basin Flood Control Zone District) to Diane Butorac (Washington Department of Ecology) and Brandon Clinton (U.S. Army Corps of Engineers). Regarding: Airport Levee Design Update. November 22, 2019.

November 22, 2019

United States Army Corps of Engineers
Seattle District Regulatory Branch
Attn: Bob Thomas and Brandon Clinton
PO Box 3755, Seattle, WA 98124-3755

And

Washington State Department of Ecology
Attn: Diane Butorac
PO Box 47600
Olympia, WA 98504-7600

RE: Airport Levee Design Update

Ms. Butorac and Mr. Clinton,

One element of the Flood Control Zone District's (FCZD) proposed project is modification of the flood control levee adjacent to the Chehalis-Centralia airport. This levee is located between the Chehalis River channel and the west side of the airport. The project proposal is to increase the height of the existing levee along most of its current alignment to provide 100-year flood protection to the airport and prevent inundation of the airport as has happened in the past. At the northwest corner of the airport, the levee is proposed to be relocated to move it farther away from the airport. It has become evident through a preliminary Cultural Resources investigation and mapping local wetlands, that the relocated portion of the levee would occur in an area that is rich in cultural resources and would extend into jurisdictional wetlands.

The FCZD takes the responsibility to avoid, minimize, or mitigate project impacts very seriously and we recognize that avoidance is the best mitigation method possible. Upon further review of the levee configuration we have determined that relocating the portion of the levee that would impact cultural resources and wetlands can be avoided and that the entire levee project can occur within its existing alignment.

The attached figure shows the proposed updated alignment, which is within the existing footprint of the levee. We will update the engineering design accordingly, should this project move farther.

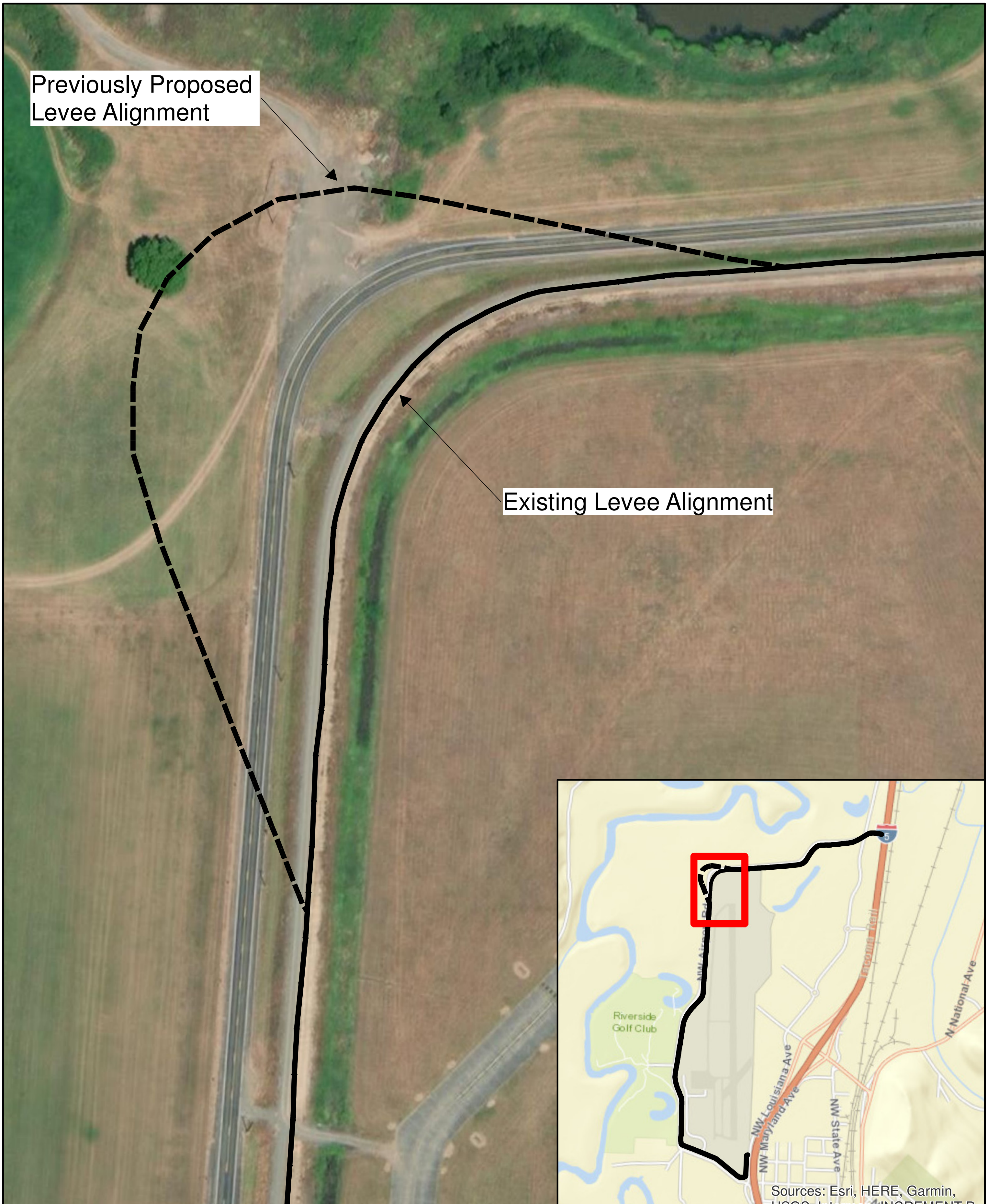
We consider this design change to be fairly minor from a project standpoint; it does not change the purpose, need, or overall project description. The construction methods will remain as described previously in the Project Description, except no construction or disturbance activity will occur within the cultural resource sites or wetland areas. We expect that this change will result in fewer environmental and cultural impacts. Due to the proximity to the airport, either alignment would be subject to FAA review of the final proposed height.

If you have any questions please do not hesitate to contact erik.martin@lewiscountywa.gov or (360) 740-2697, or Betsy Dillin at betsy.dillin@lewiscountywa.gov or (360)740-1138.

Sincerely,

Erik Martin, PE
District Administrator

Cc: Board of Supervisors, Chehalis River Basin FCZD



Chehalis River Basin
Flood Control Zone District

November 21, 2019

Airport Levee (Northwest Corner)
Alignment to Avoid Cultural Resources and Wetlands

A.17. Email from Betsy Dillin to Diane Butorac (Washington Department of Ecology). Regarding: Minor clarifications of Project Description in SEPA EIS. January 27, 2020.

From: Betsy Dillin <Betsy.Dillin@lewiscountywa.gov>
Sent: Monday, January 27, 2020 8:29 AM
To: Butorac, Diane (ECY) <dbut461@ECY.WA.GOV>
Cc: Erik Martin <Erik.Martin@lewiscountywa.gov>
Subject: RE: Chehalis EIS Project Description Sections for Review by Jan 23

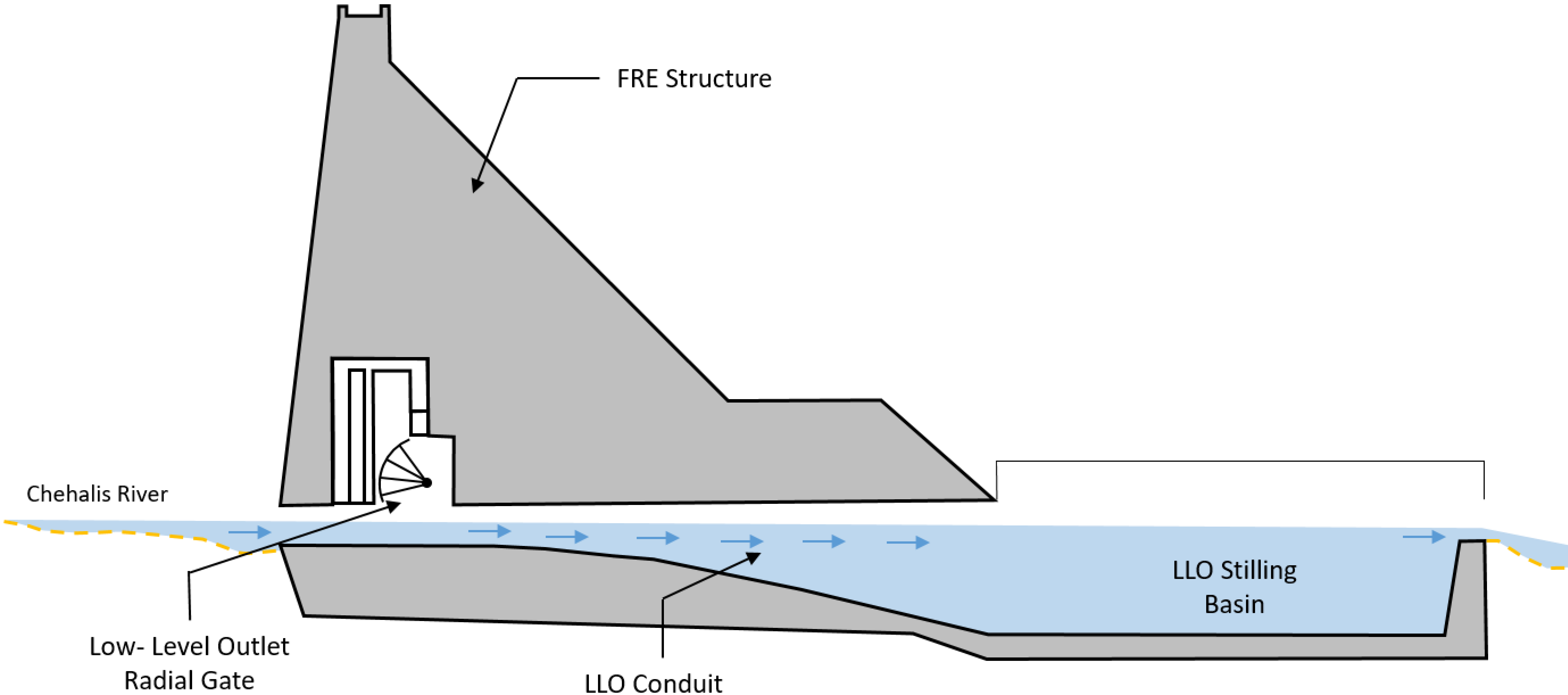
THIS EMAIL ORIGINATED FROM OUTSIDE THE WASHINGTON STATE EMAIL SYSTEM - Take caution not to open attachments or links unless you know the sender AND were expecting the attachment or the link

Hi Diane,
Yes we have a few comments, see attached. I have also attached a revised figure to replace Exhibit 2-2. Most of our comments are minor in nature except for the comment in Section 1.3.5.1. The project description states that the FCZD is planning on terminating the West St over-cross approach – this is not the case, and this may have an impact on your analysis. Please give me a call if you need more clarification or to discuss.

Betsy Dillin, PE
Senior Surface Water Engineer

Chehalis River Basin Flood Control Zone District
2025 NE Kresky Ave
Chehalis, WA 98532
Phone: (360) 740-1138

Betsy.Dillin@lewiscountywa.gov


FRE Structure
Chehalis River
LLO Stilling
Basin
Low- Level Outlet
Radial Gate
LLO Conduit