Appendix K:
Constructability Report

Chehalis River Basin Flood Damage Reduction Project

Lewis County, Washington

April 24, 2024

Chehalis River Basin Flood Control Zone District

Contents

Tables

Appendices

Acronyms and Abbreviations

CVC	conventional vibrated concrete
cy	cubic yards
F	Fahrenheit
FRE	Flood Retention Expandable
H:V	horizontal to vertical
M	million
NTP	Notice to Proceed
psi	pounds per square inch
RCC	roller-compacted concrete
RPD	Revised Project Description
RPDR	Revised Project Description Report
SCM	supplemental cementitious materials
TESC	Temporary Erosion and Sediment Control

1 Background

The Chehalis River Basin Flood Damage Reduction project objective is to develop recommendations for a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of the town of Pe Ell.

The Chehalis River Basin Flood Damage Reduction, Revised Project Description Report (RPDR) documents the relocation of and revisions to the proposed FRE facility and supporting infrastructure located within the Proposed Project area as originally documented within the Combined Dam and Fish Passage Conceptual Design Report (HDR Engineering, Inc. [HDR] 2017) and FRE Dam Alternative Report (HDR 2018).

The RPDR describes, supports, contrasts, and illustrates the revisions and enhancements to the proposed FRE in a single comprehensive document.

2 Introduction

As Appendix K to the RPDR, this report supports and offers constructability as well as cost and schedule considerations for the Chehalis River Basin Flood Damage Reduction Project RPDR, which includes an arched, roller-compacted concrete (RCC) dam alignment, constructed to FRE extents that will not impede the potential for future facility expansion. While this report touches on aggregate and quarry operations, the current RPDR Appendix E Conceptual Geotechnical Design Report provides more detailed background and aggregate and quarry needs. Considerations, recommendations, and conclusions offered in this report may be useful guiding preliminary and final design, as well as preparing for successful project and construction implementation. This report also informs permitting efforts that may depend on cost, schedule, constructability, and related construction risk understanding.

2.1 Project Scope and Scale

Considering size, function, expandability, and a gravity arch configuration, the Chehalis FRE is notably large, complex, and bears unique elements in comparison to most RCC dams designed and constructed in the United States. The FRE is about 1,450,000 cubic yards (cy) expandable to 2,250,000 cy in a gravity arch configuration, increased from 870,000 cy and 1,475,000 cy, respectively, for the original alignment. Other large, world-class, and comparable past and current projects include: San Vicente Dam Raise (0.6 million [M] cy), Olivenhain Dam (1.3 M cy), Taum Sauk Dam Replacement (3.2 M cy), Saluda Dam (1.3 M cy), and Gross Dam Raise (0.9 M cy). Site and regional geology, construction material needs, challenging river hydrology, and cultural and environmental drivers challenge thoughtful design and successful procurement and construction.

2.2 Design Basis and Status

Constructability and schedule assessments, as presented in this report, have been developed concurrently with the RPD engineering and design. Supporting documents and appendices to this report may reflect draft design figures and analysis, pending finalization of the RPDR. Key project features and design components include:

- Construction and permanent access roads
- Construction staging and site use
- Construction materials sourcing
- Excavation and foundation preparation
- River bypass and diversion
- River and flood outlet works
- RCC dam and spillway construction
- Fish ladder and passage systems

RPD design reflects understanding and judgment based on limited prior site investigation and characterization. Design will change to an unknown degree pending future site characterization and engineering evaluations targeted to support the dam's configuration and alignment and a better understanding of available construction materials.

3 Project Existing Conditions

Refer to the RPDR for a complete project existing conditions description. In context, existing conditions include site surface and sub-surface physical conditions but also client and stakeholder requirements, limitations, and understanding based on developing and prior efforts. Several site conditions listed below directly and indirectly affect cost, schedule, and constructability considerations and are discussed herein.

Project Socioeconomic Setting

- Driving need for flood control and potential water storage
- Acute environmental interest and awareness
- Cultural and related stakeholder interests as well as restrictions and limitations
- Regional prevalence and project ties to the logging and timber industry
- Uncertain project timeline

Construction Resource Setting

- Rural setting within robust regional Pacific Northwest construction infrastructure
- Labor cost and availability influenced by proximity to the Seattle metropolitan area
- Available but uncertain practicality and cost of site and commercial mineral aggregates

- Large and challenging project that will attract keen industry interest and national and international contractors

Climate and Hydrologic Setting

- Wet and seasonal Pacific Northwest and southwest Washington climate
- Flashy and challenging basin construction hydrology

3.1 Access and Site Availability

The project site and reservoir boundary are a greenfield site, with existing gravel and logging roads providing some site and river access. Appendix A provides a site use figure that shows the project in the context of existing site roads as well as preliminary site use planning. Construction access and staging that supports the FRE project key work elements.

3.2 Climate

Climate affects project cost and constructability in a few direct ways. Rain and snow will affect generally available workdays limit select work (e.g., RCC placement). Historical climatic information is summarized from https://en.climate-data.org/north-america/united-states-of-america/washington/pe-ell-15542/:

- Region is classified as warm and temperate, with winters rainier than summers
- Temperatures are favorable for construction while precipitation is less favorable
- Annual precipitation is about 67 inches per year
- Mean yearly temperature is about 49 degrees Fahrenheit (F)
- Average daily temperatures range from about 37 to 63 degrees F, while average low and high temperatures range from about 34 to 54 degrees F and 43 to 76 degrees F, respectively
- Precipitation varies from about 1 inch in July to about 10 inches in November and December
- Rainfall days vary from 4 days in July and August to 12 to 14 days from November through April

Weather impacts will be assessed when the construction schedule developed during the next phase of design. Finally, while indirect, precipitation strongly contributes to flashy hydrology which both directly and indirectly contribute to project cost, schedule, and related risks. While contractors will expect adverse weather and some impacts, it will be important for the project to define and assess contractual handling of unusual weather.

3.3 Hydrology

Table 3-1 provides annual and monthly exceedance probabilities to support diversion planning and work sequencing.

An approximate annual 25-year return period flow, or approximately 26,800 cubic feet per second was assumed for the maximum in the RDP construction flow modeling. Although project-specific, diversion capacities protecting work at a return period flow approximately five times the construction duration are commonly chosen. For example, design for a 25-year return period flow may be reasonable protection for a project with a 5-year construction exposure. The project would bear additional risk above that design threshold. Chapter 5.6 discusses preliminary diversion planning.

Table 3-1 shows comparative low flow rates for the drier months June or July through August or September. If aspects of work requiring flow bypass can be completed in a 1- to 3- or 4-month window, and that window can be favorably scheduled, bypass flow capacity as low as 250 cubic feet per second may provide adequate work protection.

Construction also could be affected by a previously approved in-water work window of July and/or August with the possibility of expanding to July through September. Work in the river would be annually allowed only within the approved in-water work window months.

Table 3-1 Annual and Monthly Flood Return Intervals

Flood Events	USACE 7/1 – 8/31	HDR 7/1 – 9/30	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1-yr	32	36	2,580	1,339	352	320	297	82	57	31	16	17	94	617	872
2-yr	94	163	9,496	4,896	2,713	2,247	1,133	395	198	80	50	93	1,221	4,256	4,756
5-yr	196	466	15,531	8,500	5,998	4,442	2,576	738	429	129	117	320	3,012	8,181	9,597
10-yr	314	920	20,175	11,550	9,188	6,311	4,297	1,036	694	172	204	720	4,800	11,405	14,126
15-yr	406	1,336	23,011	13,521	11,399	7,509	5,670	1,230	902	200	277	1,128	6,047	13,426	17,214
20-yr	485	1,730	25,098	15,022	13,148	8,413	6,858	1,378	1,079	221	342	1,540	7,034	14,932	19,637
25-yr	555	2,106	26,756	16,244	14,610	9,144	7,920	1,500	1,236	239	402	1,952	7,858	16,138	21,653
50-yr	834	3,816	32,169	20,408	19,812	11,595	12,200	1,915	1,858	300	655	4,008	10,780	20,118	28,772
100-yr	1,236	6,781	38,014	25,190	26,144	14,337	18,459	2,393	2,748	371	1,053	8,059	14,303	24,468	37,364
250-yr	2,048	14,190	46,478	32,612	36,568	18,444	31,264	3,137	4,522	485	1,941	19,818	20,014	30,816	51,416
500-yr	2,972	24,492	53,491	39,182	46,283	21,945	46,020	3,797	6,518	589	3,053	38,606	25,240	36,096	64,463

Source: HDR (2024)

3.4 Permit Development and Requirements

Permitting requirements that will guide or constrain construction are yet to be determined. Design development and permit preparation and procurement must be effectively coordinated to reasonably balance cost and schedule with compliance requirements.

3.5 Existing Conditions

The project site is generally heavily forested, steep, and rugged with the Chehalis River challenging access and site use. Few, if any, structures and utilities requiring relocation or demolition exist within the disturbance limit. Private logging and public roads will require modification, relocation, and protection, to facilitate construction access, permanent operational access, and a continued safe logging industry and public interface.

3.6 Concurrent, Competing Site Use

Other, unrelated work is not anticipated in the project area during construction. While work breakdown and contract work packaging has not been considered in the RPD, if broken into multiple work packages or contracts, competing site use interests could result, creating a need for allocating site use time and space.

4 Project Work Elements and Work Breakdown

4.1 Salient Features and Driving Work Elements

Key work elements include:

- Permanent access road relocation and construction
- Construction access and staging
- Quarry development and aggregate processing
- Work within each of four diversion work phases:
    - Foundation excavation and stabilization
    - Foundation preparation including cleaning, grouting, and drain hole drilling
    - Permanent bypass and outlet works structure construction
    - Stilling basin construction
    - RCC batching, delivery, and placement
    - Dam construction components concurrent with RCC; gallery, spillway and dam faces, dam joints, etc.

- Fish passage construction
- Spillway and dam crest structures, parapet, and training walls
- Metals, mechanical, and electrical installations; debris management, gates, valves, and instrumentation and controls
- Dam backfill
- Site reclamation and restoration

4.2 Work Stages

Work stages could be categorized in the following broad groups.

4.2.1 Site Preparation and Development

In addition to road construction, significant work will be undertaken to develop one or more quarry locations, staging and laydown areas, river crossings, and planned diversion crossings. Depending on contract delivery and permit timing, awarding an early site development work contract may benefit cost and cost-risk, while providing an opportunity to allow valuable quarry assessments. The dam construction will demand a well-developed concrete and RCC plant area with associated aggregate feed and cementitious product storage. The RPD site use figure in Appendix A shows this primary staging above the dam's right abutment. Creating this area will require significant excavation and/or fills and could be developed to incorporate much needed room for excavation spoils. Appendix A includes potential staging areas and an assessment of the primary staging area and its ability to receive spoils.

4.2.2 Dam Construction Subject to Diverted River Flow Constraints

Bypassing river flows during dam construction necessitates constructing the dam, and most importantly, its foundation in phases. Appendix A illustrates four anticipated work phases, arranged spatially to allow the foundation to be fully exposed and prepared without risk of having to be undercut when the next phase's foundation is excavated and prepared. Once exposed, each area will have a critical path sequence of foundation preparation, structure construction, RCC starting, and preparation for the next work phase. To enable the final work phases, the bypass and outlet works structure must be constructed (Phase 2) to be nearly complete, such that it can be used to route flows with no remaining ability to route flows elsewhere for final structural, metals, or mechanical works.

4.2.3 Post RCC/Dam Placement Structures and Site Reclamation

Once the RCC dam is completed, final structural, metals, mechanical, and electrical work can be performed. Additionally, final site restoration and reclamation can be performed in the quarries, and the dam and staging areas.

4.3 Temporary Works

Along with the permanent configuration design, aspects of temporary or work necessary for contractor safety and/or convenience need attention. The following work components have been identified as temporary work for consideration assessing cost, schedule, and construction risk.

- Construction utility supply and distribution: water, power, air, etc.
- Surface water controls and treatment
- Diversion sequence isolation walls, guide-walls, and tailwater cofferdams
- Diversion exceedance: avoidance, recovery
- Excavation dewatering
- Temporary excavation and aggregate stockpile areas
- Excavation slope stabilization and scaling beyond permanent design slopes
- Receiving, laydown, office, warehouse, and workshop facilities
- RCC and conventional concrete plant and batching systems
- RCC and conventional concrete delivery infrastructure during dam placement
- Form and falsework, safety, and work protection

4.3.1 Construction Utilities

Construction water will be required for dust control, aggregate processing, concrete production, embankment fill, offices, warehouses, shops, tunneling operations, and various unlisted uses. A water demand evaluation will be performed during design development.

Construction power is anticipated to be provided by mobile diesel generators. Line power for offices and laydown needs and potentially for the batch plant and concrete delivery needs should be considered if costs and benefits warrant a service be dropped near the dam’s upper right abutment staging area.

4.4 Work Breakdown Structure

A comprehensive Work Breakdown Structure will be developed after establishing the RPD and will serve multiple uses including construction schedule development, cost opinion estimation, work package and contract delivery planning, and finally work measurement and payment considerations.

5 Construction Approach and Methods

Generally, construction approach, means, and methods will be deferred to the contractor, subject to final guidance required by the design, contract provisions, plans, and specifications. The following Construction approach and concepts have been developed to preliminarily support design and planning, including cost, schedule, and risk assessment.

5.1 Site Needs and Use

5.1.1 Project Access

Permanent access to the construction site is via Muller Road to 1000 Road. Final project configuration will require construction of additional permanent roads as well as relocation and re-establishment of some existing logging and public use roads within the reservoir boundaries. Refer RPDR for permanent and construction access road needs and development.

5.1.2 Construction Site Use

Illustrations in Appendix A show preliminary site use, including a Proposed Project disturbance limit, contractor staging areas, permanent roads, construction roads. Quarry locations can be referenced in Appendix E of the RPDR. Pending further design development, including site characterization, the configuration of the temporary construction facilities can only be approximated based on the current RPD design and a conceptual construction approach. While construction access roads have been shown, related permit requirements and construction access and staging design should be limited to provide the contractor flexibility in choosing locations and extent of both staging and access.

5.1.3 Site Reclamation and Restoration

During construction, logging and public through-access will be maintained, while prohibiting public access on the construction roads. Following construction phases or completion, construction access roads and staging will be removed or reclaimed to restore suitable conditions as established by permit requirements and design.

5.1.4 Construction Staging and Laydown

Illustrations in Appendix A show staging areas capturing space and proximity for excavation spoils, equipment staging and service, storage and maintenance, fabrication facilities, offices, and concrete and RCC plant systems. A primary laydown area has been conceived near the dam's upper right abutment which could be developed to roughly receive 0.6 M to 2.5 M cy of spoils with a pad elevation somewhere between 670 and 710 feet North American Vertical Datum of 1988. Staging here and in other locations needs to be planned and account for right-of-way availability, drainage, surface water routing and control, and sedimentation controls. While some aggregate stockpiling is assumed near the plant sites, preliminary site use planning assumes primary aggregate stockpiles will be near the quarry crushing operation(s). Additional staging areas are indicated convenient to the project entrance, immediately upstream of the dam's central valley, and in the valley south of the Chehalis River. Use of the lower elevation staging areas should consider water potential during extreme flow events. Though not shown, staging will also be developed immediately downstream of the dam to support the outlet works conduit structure, fish passage structure, dam, and the spillway stilling basin.

5.1.5 Resource Protection and Best Management Practices 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 permit, Washington Administrative Code 173- 201A: Water Quality Standards for Surface Waters of the State of Washington, and other federal, state, and local codes and regulations. Best Management Practices (BMPs) will be implemented in accordance with the Washington State Department of Ecology Stormwater Management Manual for Western Washington, current Washington State Department of Transportation 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 entrances and parking areas
- Spill Prevention Control and Countermeasures Plan for temporary fuel tanks, construction equipment and diesel generator on site
- Dust control, including water trucks
- Adaptive management for stormwater control during construction
- Measurement of identified pollutants such as turbidity and pH throughout construction at identified compliance points required by permit(s)

Erosion and Sediment Control

Temporary Erosion and Sediment Control (TESC) measures will be implemented to 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 in accordance with the Washington State Department of Ecology Construction Stormwater General Permit and its Stormwater Management Manual for Western Washington. Supplemental BMP specifications will be obtained from the current version of Washington State Department of Transportation 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
- Temporary stockpile and slope stabilization and coverings such as mulch, nets and blankets, plastic coverings, temporary seeding and sodding, and compost blankets

The construction general contractor will hold the permit for erosion and sediment control and the construction contract and be responsible for developing the plan, location, and maintenance for all required BMPs. A TESC plan will be developed during final design.

Fuel Storage and Containment Areas

Primary and secondary containment will be required as part of the permit and construction contract, and all fuel storage areas will be located where they cannot be affected by a flood event. A mobile fueling truck and large stationary fuel cell likely will be used. Fuel storage area design and locations will be determined by the contractor.

5.2 Sitework

5.2.1 Clearing and Grubbing

Clearing activities to construct the FRE facility are required at the dam footprint, staging areas, quarry areas, spoil disposal areas, and debris management sorting area. A site vegetation management plan has not been developed and revegetation specifics are not addressed in this report. The debris management, dam site, and staging site areas are estimated to be 8, 25, and 75 acres respectively, totaling approximately 110 acres, without the quarry areas. While yet to be determined, grubbing will likely be required on 30 to 50 percent of the cleared areas. Grubbing is anticipated to be disposed of by burying, suitable timber salvaged, and slash and debris disposal as approved by burning, chipping, and burying. Topsoil will be stripped from excavation and most grubbed areas, stockpiled, and made available for site reclamation.

5.2.2 Reclamation and Vegetation

Topsoil will be spread on all excavation and fill slopes designated for seeding and revegetation. Seeding and revegetation design and requirements will be developed during a future design phase.

5.3 Construction Materials

This section discusses the various material types required to construct the proposed FRE. Refer to Aggregate Material Source, Section 9, and Geotechnical Design, Section 7, within the RPDR for proposed quarry development.

5.3.1 Aggregates

Aggregates for temporary and permanent roads and staging areas will be produced from site quarries. Permanent applications for road surfacing will meet Washington State Department of Transportation design standards for road base. Construction needs may be supplied from more marginal materials mined and generated during the quarry development and operations.

Conventional concrete coarse aggregate is anticipated to come from site quarries and meet ASTM C33 quality requirements. Conventional concrete fine aggregate (sand) will either be supplied commercially or from washed and potentially sized site operations, depending on contractor equipment and approach.

RCC aggregates are intended to be produced from project site quarry locations. While generally meeting ASTM C33 quality requirements, a material and mix design testing program will be developed and implemented to assess aggregate quality, determine appropriate cementitious materials and proportions, evaluate mix workability, and potentially evaluate alternative supplemental cementitious materials (SCM).

Initial qualification testing of the basalt materials targeted for aggregate production from the three quarry sites shows acceptable durability, relatively high absorption, and marginal to low specific gravities. The basalt variability suggests a relatively high percentage of unsuitable rock and quarry waste that will need to be contemplated during planning of the quarry layout and crushing operations. Conceptual-level costs should conservatively consider that up to 40 to 50 percent of the quarried rock may be unsuitable and require permanent spoil storage within the completed limits of the quarries or other identified storage location. Alternatively, more cementitious material might be needed to achieve acceptable design strength if the marginal basalt materials are to be utilized. Aggregate and trial mix design development and testing should include testing to evaluate potential use of marginal materials.

Depending on design development, project delivery, and contract work packaging, strong consideration will be given to implementing full-scale test crush of one or more of the designated quarries. Crusher testing will allow assessment of material quality, processing methods, and waste factors, and may provide the added benefit of generating early crushed base materials for early project development.

5.3.2 Cement and Supplemental Cementitious Materials

Cement and SCM will be regionally sourced. Notable changes from the prior material sourcing information include the strong likelihood of using low-carbon (Type 1L) cement rather than Type II, and the likely use of fly ash or other SCM options remain uncertain. The material sourcing update and the mix design program will evaluate available sources and target testing to determine appropriate use and expectations.

Cement, Class F fly ash, and slag supply are currently available in the region with regional and national manufacturers and distributors including CalPortland, Lafarge, Ash Grove, and Lehigh. Regional fly ash may come from TransAlta's Centralia, Washington, coal-fired power plant (which has a contract with Lafarge for use of fly ash generated from their facility). In recent years, fly ash supplies have either been consumed or greatly reduced during high regional hydropower production. Consequently, Canadian fly ash is also available, through CalPortland's Portland rail terminal, supplied by a facility in Genesee, Alberta. Further coal-fired plant generation reductions are anticipated, which will make fly ash an even tougher commodity to procure. In addition to regional cement mills, CalPortland supplies Asian cement from its parent, Tokyo-based Taiheiyo Cement Corporation.

Currently, the industry is trending toward low-carbon cements (e.g., Type 1L) and facing diminishing coal-sourced fly ash supply. Consequently, the Mix Design Program should consider both low-carbon cement as well as a range of alternative SCM materials such as slag. Concurrently, structural design should potentially consider more aggressive thermal and seepage control strategies as alternatives to high SCM percentages and consider:

- Smaller control joint spacing
- More aggressive batched RCC temperature control
- Post placement cooling
- External upstream face membranes

Coupling strong mix design and structural design understanding may be valuable if cementitious material pricing changes dramatically driven by supply trends.

5.3.3 RCC and Conventional Vibrated Concrete Mix Designs

Based on experience and precedent from similar projects as well as the structural analyses completed for the downstream FRE project configuration (HDR 2017), it is expected that the RCC mix design will be targeting a 1-year unconfined compressive strength of 2,500 to 3,000 pounds per square inch (psi). This target compressive strength should provide the needed tensile and shear strength of the RCC materials and allow for optimization of the arch configuration of the dam for the expected reservoir, flood, and earthquake loading conditions of the site.

The RCC mix likely will have a medium- to high-cementitious content ranging from 250 to 300 pounds per cubic yard of RCC. The cementitious content likely will include up to 50 percent fly ash, slag, or other SCM replacement. The aggregate gradation utilizing locally generated materials from the quarries described in Section 5.4 will have a 1- to 1½-inch maximum-size, 40 to 45 percent sand content target, and a non-plastic fines content between 5 and 10 percent. A workable mix with set retarding admixtures will be used to create a consistency favorable for grout-enriched RCC faces of the dam and lift joint cohesion. While facing systems will be selected during final design, the RPD anticipates grout-enriched RCC will be a component of the upstream seepage control strategy to help produce a durable and aesthetically acceptable downstream face.

Conventional vibrated concrete (CVC) mix designs for facing elements and other structures will be preliminarily evaluated based on RCC aggregate and trial mix testing.

5.3.4 RCC Trial Mix Program and Trial Placements

Beginning early during the next design phase, an aggregate material testing and mix design development plan will be developed. Critical to structural design as well as cost, schedule, and related construction risk, it is important to establish assumed as well as tested mix design wet and hardened properties. A mix design and trial mix program will target evaluating:

- Strength relationships to cement content, water content, sand content, fine content, and workability
- Aggregate suitability
- Effects of marginal aggregate
- Effects of low-carbon cement
- Alternative SCM materials

Mix design program results will be used to inform cost estimates and guide contractor engagement and/or contract provisions related to material and mix verification and requirements.

A strong mix design program is anticipated to verify whether site aggregates can meet design objectives, evaluate a range of cementitious content, and determine the sensitivity of fly ash reduction mitigation strategies. Adiabatic heat-rise or other thermal-specific testing may be evaluated if lessening or eliminating pozzolan from select mixes is considered. Additionally, the mix design program will provide a confident basis for cost estimating and specification development, serving to help manage procurement and construction risk.

While aggregate qualification for RCC will concurrently inform aggregate suitability for CVC, CVC applications will include higher strength mixes and concrete for hydraulic structures needing good abrasion resistance often strongly related to aggregate strength and quality. Consequently, CVC aggregate requirements will be strictly held to common ASTM C33 quality requirements. While perhaps not as extensive as RCC trial mix planning, some CVC trial mix testing during design and mix verification early in the construction contract will be prudent.

An RCC full-scale trial placement will be completed in advance of production RCC placement to confirm mix design properties and demonstrate plant operation and placement preparedness. This testing is required to confirm contractors means and methods and quality control of RCC placement prior to beginning bulk placement for the FRE facility.

5.4 Quarry and Aggregate Operations

Reference RPDR Section 9 and Appendix E for quarry locations and detailed material and quantity assessments. Quarries have not yet been investigated sufficiently to confidently assess overburden depths, anticipated quarry waste, and quarry access, benching, and stabilization needs. Three quarry locations have been advanced for consideration in the RPDR. Once more fully investigated, quarry development and sizing will rely on these developmental factors as well as product needs and aggregate processing methods. Aggregate processing is currently anticipated to occur at the quarry locations and may involve more than one quarry and more than one crushing operation. For quarry and aggregate operations, consider the following:

- Quarry overburden excavation slopes: 1.5 horizontal (H) :1 vertical (V)

- Quarry excavation slopes: 0.5H:1V with 1-foot benches not to exceed 40 feet high
- Quarry oversize, shot-pull, unsuitable zones, and processing waste combining to a quarry yield of 1.3 to 1.6 tons of stockpiled aggregate per cubic yard of quarry shot to feed the crushing operations.
- Crushing Operations:
  - RCC aggregates produced in three stockpile fractions; CVC in two coarse fractions and one sand fraction, if produced on site
  - Large primary jaw crusher (e.g., > 30-inch x 54-inch), capability to eliminate materials less than 1-inch to 1.5-inch before advancing
  - Secondary and tertiary crushing combing one or more types of cone and/or vertical shaft impact crushers
  - Large screening capacity (e.g., multiple [two to three] 8-foot by 20-foot, three-deck screens incorporated into circulating crusher circuits
  - Stacking conveyor and trucked product stockpiling
  - Tunnel reclaim conveyors/feeders after the primary crusher and potentially for discharging from final product stockpiles
  - Likely single or multiple plant capacity ~ 600 to 1,000 ton/hour throughput
  - CVC coarse aggregate is likely to be produced at the site quarries while the CVC sand may be commercially supplied
  - Washing operations using log (coarse material) washers as well as sand screw and potentially sand classifying units to control washed sand gradings
  - Crushing operations: 5 to 6 days per week; two shifts per day, 8- to 10-hour shifts
- Quarry Equipment and Operational Time
  - Quarry and aggregate processing assumptions reflect equipment and construction approaches typical of large-quantity, project-dedicated, stripping, quarrying, and quarried-rock aggregate processing. A wide variety of equipment and production approaches could be employed which the following assumptions should reasonably represent.
  - At current project stage, requirements for equipment to be used to mine the quarries and the time it takes cannot be determined, is highly dependent on a contractor means and methods, and requires a more detailed design of the project to adequately inform the required quantities of quarried material. The following list provides typical equipment required for a quarry operation:
    - Multiple large scrapers
    - Multiple large bulldozers
    - Multiple large front-end loaders
    - Multiple large rock dump trucks

    - Drilling rigs for blasting
    - Rock crushers
    - Grizzley bars
    - Multiple water trucks
    - Support pickup trucks
    - Multiple road graders
    - Multiple skid steers
    - Multiple conveyor belts
    - Fuel trucks
    - Lube trucks
- Considering the current preliminary level of design, the assumed quarry operation duration will be the full duration of the construction schedule anticipated at 5 years.

5.5 Dewater

Unwatering (i.e., removing water from a surface hole or collection) may be required during brief periods and in limited locations when diversions are made from one phase to the next. Unwatering will be slow and deliberate to facilitate safe and timely removal of any fish trapped in pools.

Foundation dewatering (i.e., removing groundwater to manage the groundwater table and groundwater discharges into work area) during excavation, foundation preparation, and subsequent RCC dam and hydraulic structures construction will last several months and generally engage clean water from shallow sumps and wells located along the excavation between the cofferdam limits. Water is likely to be pumped upstream for initial discharge into the Chehalis River if clean, or alternatively into tanks or basins for selective treatment as needed. Select temporary wells or a series of temporary wells behind the diversion channel and tailwater cofferdams may be required to catch and handle any seepage through the cofferdams or their foundations. If seepage is minimal through the cofferdams, the contractor may elect to use sump pits to handle nuisance water. The downstream portal staging area likely will be used for any water quality settling tanks or additional required treatment.

Depending on developing design requirements, a detailed dewatering and unwatering plan will be developed to outline water quantity and duration and identify quality thresholds that may require treatment. The overall dewatering plan will be up to the contractor’s means and methods required to efficiently execute the project.

5.6 Diversion and Diversion Components

5.6.1 Diversion Planning

The RPD has been designed around staged construction routing the water first through an earthen diversion channel allowing construction of a permanent bypass conduit structure that becomes the dam's outlet works system. Once complete, the river would be routed through the completed bypass conduit structure allowing construction of the dam beneath and beyond the diversion channel. Preliminary modeling has been evaluated routing up to 25-year recurrent flows through a diversion channel, which equates to about five times a presumed construction duration, which is yet to be evaluated and confirmed. Once the bypass conduit is completed, the practical diversion capacity reduces to approximately 10-year recurrent flow levels. Reference Chapter 7.8 in the RPDR and the Construction Bypass Hydraulic Modeling TM in Appendix D for flow modeling.

5.6.2 Diversion Sequencing

Appendix A, pages 3-11 illustrate a four-phase diversion scheme, summarized on the final page identifying flow locations, work performed, high-level duration estimates, and qualitative risk descriptors. Table 5-1 summarizes the risk.

Table 5-1. Risk Summary for Diversion Sequence

Phase		Work	Duration (months)	Risk
0	Preliminary	Preliminary work independent of the river	6-12	low
1	River flow	Construct diversion channel and right dam foundation	10-12	moderate
2	Channel flow	Construct bypass outlet works conduit, left dam foundation	20-24	high
3	Bypass Conduit Flow	Remove diversion channel, construct dam foundation closure	10-12	high
4	Bypass Conduit flow	Complete dam construction, and final outlet conduit configuration modifications	6-12	low

5.6.3 Diversion Implementation Considerations

While not yet determined, aspects of the diversion design are likely to be contractor responsibility. Future design will determine diversion requirements, thresholds, and the assignment of roles, responsibility, and risk. Earthwork from site excavations and staging area developments will be used to construct diversion berms. Berms may need to be structurally designed, lined, or otherwise stable and suitable for sustained flows and favorable to support dewatering needs. Some areas may not be wide enough for berms to isolate the flows from adjacent work. Consequently, in some areas isolation walls or cofferdams may involve retained fills, pile wall installations, soldier pile and lagged walls, or other structural walls founded on the excavations or cantilevered into foundation rock or the complete structure. Seepage control may require liners. Cofferdams with flow storage are not anticipated, so public or dam safety related to downstream failed diversion system surges are not considered to be a factor.

5.7 Excavation and Foundation Preparation

5.7.1 Excavation

Excavation is expected to include blasting, controlled blasting, dozers, large excavators, off-road haul trucks. Excavation near diversion staging and to facilitate diversion staging may require controlled blasting or alternative means. Structural, dental, and trim excavations will include controlled blasting, small equipment, excavator attachments as well as small tools. Blasting will be carefully guided by specification and monitoring requirements and follow state and federal guidelines. Stabilization may be required for select excavation areas dictated by design, ground conditions, or by contractor safety requirements. Stabilization measures may include bolting, netting, scaling, benching, or other designed or approved methods.

5.7.2 Foundation Preparation and Treatments

Foundation cleaning will include air and water jetting, vacuum truck cleaning, hand methods, and, in areas, craned skip support. Grouting operations will include track mounted air and/or hydraulic drills depending on grout hole drilling depth and specified drilled methods. In areas of steep or highly irregular foundations grout drilling access may require temporary rails systems, fills, and/or dental concrete placements. In schedule planning, time will be provided for required geologic mapping. Dental excavations, slush grouting, dental concrete, and leveling concrete will each be used to prepare the foundation and the area for starting RCC placements.

5.8 FRE Dam Construction

5.8.1 CVC and RCC Plant and Delivery

Future design efforts will include an RCC production plan and assessment where RCC vertical and volumetric production rates are evaluated and plant and delivery capacities can be better determined. Until then, consider:

- The dam's size, height, and volume
- A need for placement in each of three construction phases

Also consider the following factors to guide RPD understanding of the dam placement.

Plant and Delivery Capacity

- 240 feet high total (160 to 200 placement days without diversion consideration); averages 6,250 cy per lift and 7,500 to 9,500 cy per placement day
- Assume 14 production hours per day and peak at 1.5 times the nominal daily ~ 800 to 1,000 cy per hour sustained batch and delivery capacity
- Phase consideration:
    - Phase 2 RCC placement from elevation 412 feet to between 490 and 520 feet (assume 50 to 80 placement days)

  - Phase 3 RCC placement from elevation 435 feet to between 490 and 520 feet (30 to 60 placement days), continuing on
  - Phase 4 from elevation 490 to 520 feet to completion at 650 feet (100 to 140 placement days); totaling 180 to 280 placement days, or 15 to 40 percent longer than without Phases
- Consider sustainable hourly capacity to require a minimum of 650 to 800 cy per hour
- One way to mitigate high rainfall potential is having capacity to reach high production rates during good-weather times; therefore, consider target system capacity at 800 to 1,000 cy per hour.

Plant and Delivery Equipment

- Minimum two each 8 cy, batch-type, dedicated RCC plant, compulsory mixing units; gob-hoppers allowing minor discharge flexibility; conveyor or alternative discharge to truck loading flexibility.
- Dedicated CVC plant, not as complex nor as critical, assume (150 to 300 cy/hour sustainable system capacity).
- Moderate temperature control systems (e.g., 70-75 degree F, partial-year coarse aggregate cooling, mix-water ice, spot nitrogen supplemental cooling, conveyor shading).
- High-speed (Rotec) conveyor delivery from the plant area (downstream upper right abutment) to the dam's lift surface for on-lift truck receiving and delivery. Phases may dictate truck delivery for Phase 2 placements.
- Consider delivery system road crossing.

5.8.2 Dam Construction

RCC is presumed to be delivered to the lifts by conveyor, transported to final placement location by on-lift trucks. RCC placement will involve concurrent activities: spreading, compaction, curing, grout-enriched or CVC formwork and facing placements, spillway face forming and reinforcing steel, abutment grout-enriched or grout treatments, and control joint drains and bond-breaker joint installations. Intermittent, occasional, or limited duration activities during dam placement will include: foundation treatment anomalies, gallery construction, foundation drain drilling, rain protection and cold joint cleaning and recovery, spillway block out and chimney formwork transitions, delivery system reconfigurations, and equipment maintenance and breakdown recovery. Equipment and methods are likely to be similar to other large and high-production RCC dams. Large, heavy load and long reach, craning will be required to support dam construction and may be staged immediately upstream, downstream, or perhaps within the dam with tower craning embedded in the dam body.

The following preliminary assumptions guide the RPD cost and constructability planning:

- Abutment and structure interface – grout enriched RCC or 3-inch abutment CVC concrete

- Lift joints – 8 to 12 percent cold joints requiring cleaning and bedding
- Dam control joints – 50-foot spacing, upstream formed and caulked inducer, waterstop, drain, galvanized steel bond-breaking plates each lift, full width
- Foundation drains – from gallery elevation, 15-foot spacing, 200-foot rotary drilled depth
- Dam drains – from dam/spillway crest to gallery, 15-foot spacing, extruded
- Facing elements: vertical upstream grout-enriched; vertical grout-enriched chimney downstream; stepped downstream non-overflow exposed RCC or grout-enriched; spillway stepped face, reinforced CVC facing elements
- Gallery – 6 by 9 feet sloping up right abutment, transition to drain manifolds for each side's steep abutments
- Staged placements:
    - Phase 1 potential right-most dam foundation
    - Phase 2 surrounding outlet works conduit area
    - Phase 3 right-side diversion closure and full dam length
    - Phase 4 complete dam placement

5.8.3 Hydraulic and Other Concrete Structures

Bypass Outlet Works Conduit

The bypass and outlet works conduit structure will be constructed using conventional methods for accessing, forming, and placing these massive structures. Crane support may be by track cranes upstream or downstream of the dam, or potentially using tower crane(s) near the structure alignment, perhaps within the dam body. The conduit construction, when active, is likely to dominate currently active work, with RCC unlikely occurring at the same time unless right of the diversion channel. Conversely, when RCC production is active it likely will dominate work, getting first call on resources, construction, and field management efforts. The fish passage structure is likely to be integrated with and follow the outlet works conduit structure, largely being complete prior to diverting flows into the conduit for Phase 3.

Spillway

Stilling basin concrete can only be constructed once the diversion channel is no longer in use; Phase 3. Dewatering and diversion tailwater isolation will be key. Training walls and stilling basin walls are challenging and will require well developed access and significant craning.

Training walls and the ogee crest will be constructed after RCC is complete and face challenging access, form work, and concrete supply.

The spillway control section end walls are likely to be placed as facing elements during dam RCC placement.

Dam Crest

A crest slab and both upstream and downstream concrete parapet walls will be completed, likely after spillway concrete is completed.

6 Project Schedule

6.1 Schedule and Construction Considerations

The construction schedule has not been updated to reflect the RPD but will be updated when project design advances. While not fully relevant, there is important reference information regarding construction schedule in the Proposed Flood Retention Dam Construction Schedule Supplemental Information (HDR 2019). Key schedule and schedule risk drivers for the RPD include:

- Contract performance period
- Notice to Proceed (NTP) date in comparison to in-water work constraints
- In-water work restrictions
- Climate and precipitation impacts on RCC and other weather sensitive work
- Access and staging development
- Construction phase sequencing:
  - Phase 1 diversion channel construction
  - Phase 2 bypass outlet works conduit and necessary left-side work
  - Phase 3 foundation, dam, and stilling basin construction in the diversion channel closure section
  - Construction and completion of hydraulic structures following RCC
- Early quarry development and aggregate production outpacing demand
- Favorable river and flood flows during the work, avoiding exceedance events
- High-capacity RCC and concrete production and delivery systems
- A qualified and well-resourced contractor with strong project management capacity

A few of the schedule drivers are discussed in the following paragraphs.

6.1.1 Performance Period and Construction Notice to Proceed

The NTP occurs when the contractor is released to proceed with construction. NTP timing will influence the schedule and overall construction period, and optimally provide adequate time to prepare for the first in-water work period. An unfavorable NTP date may leave insufficient time to prepare for effective use of the first in-water work period. Missing an in-water work period for critical work could result in a significant project delay and should be considered in performance period determination. The contract performance period may be based on allowable workdays, allowable calendar days, or calendar dates. Prior construction schedule sensitivity analysis indicated that the construction duration, and therefore performance period, was sensitive to NTP timing in relation to in-water work. Unfavorable NTP timing led to longer project duration with critical early work waiting for an acceptable in-water work window.

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.

6.1.2 Agency Approved Standard In-Water Work Window

The Washington Department of Fish and Wildlife (WDFW 2018) approved in-water work window for the Chehalis Basin upstream of the South Fork is August 1 – August 31, and the U.S. Army Corps of Engineers (USACE 2010) approved in-water work window for the same river reach is July 1 – August 31. To allow greater flexibility during favorable low flow months and an extension of the in-water work window from July 1 to September 30 will be requested from WDFW and USACE.

6.1.3 In-Water Work

The next sections describe the work that may be practically or formally partially subject to the approved in-water window, or otherwise low-flow periods.

Phase 1 – Flow in Existing River

- Construct permanent and access road river crossings.
- Construct portions of the diversion channel or barriers that may isolate the diversion channel work from the Phase 1 river flow.
- Prepare the constructed diversion channel for flow.
- Construct select-area structure isolation cofferdams and flow walls when diversion channel is in tight proximity to the pending Phase 2 work, predominantly near the bypass outlet works conduit and fish passage discharge limits.
- Breach the riverbank and construct berm closures to divert river flow into the diversion channel.

Phase 2 – Flow in Diversion Channel

- Re-align and construct upstream and downstream flow isolation walls to keep Phase 3 flow from entering the Phase 3 excavation of the diversion channel area and spillway stilling basin.
- Prepare the conduit for Phase 3 diversion flow.

- Breach the berms and walls isolating the conduit and left-side work area and construct diversion closures to divert flows from the diversion channel back into the river channel and conduit.

Phase 3 – Bypass Outlet Conduit Flow (uncontrolled)

- Remove isolation berms and walls that had been isolating the stilling basin and dam closure section construction.

Phase 4 – Bypass Outlet Conduit Flow (controlled)

- Construct remaining upper conduit trashrack structure to the extent upstream ground access needs limit the construction to low flow periods.
- Use temporary fabrications, barriers, permanent gates, and alternating conduit closures to isolate adjacent conduits, allowing final configuration modifications if necessary.

6.1.4 Work Sequence

Appendix A, page 11 of 11 provides a table summarizing the construction sequence and work occurring during each phase and the work required to divert from one phase to the next.

6.1.5 Construction Flood Risk Preparation

Construction flood risk begins as soon as work begins to construct the diversion channel. To varying degrees, flood risk lasts until the conduit structure is complete, including all mechanical and electrical installation, and the upstream is prepared for inundation and flood storage. Table 6-1 provides the presumed protection provided during each work phase.

Table 6-1. Presumed Protection during Work Phases

Phase		Isolating Feature	Estimated Protection Requirements
1	River Flow	Existing river channel and supplemental isolation berms	25-year
2	Channel Flow	Diversion channel excavation and berm, and supplemental isolation flow walls	25-year
3	Conduit (uncontrolled)	Isolation berms and walls	10-year
4	Conduit (controlled)	Upstream gates, bulkheads; downstream temporary flow isolation walls; low flow only	Dry season only; 5-year

Contract provisions will be developed during design development but are likely to require the following provisions related to diversion risk cost and schedule:

- Basin flow forecasting and monitoring
- Diversion design, construction, and maintenance by phase submittal

- Requirements for threshold protection levels; perhaps tied to flow rate, water surface elevation, season, dates of exposure, duration of exposure, etc.
- Thresholds and pay items related to:
  - Preparation for controlling work suspension and demobilization (each)
  - Demobilization and remobilization (each)
  - Standby/delay during exceedance demobilization (calendar day)
  - Work recovery (unwatering, cleanup, restoration of work site; force account or by each occurrence)
  - Rework (reconstruction of damaged permanent or temporary works; force account)

6.2 Construction Schedule

A construction schedule has not yet been prepared. Appendix A, page 11 of 11, provides a rough project duration estimate in relation to the phased construction, which totals 52 months, and is without consideration of in-water work constraints and impacts.

HDR judges the total anticipated time to construct the project is 5 years within a probable range of between 4 and 6 years. Schedule contingency is warranted considering: a project schedule has not yet been developed, weather impacts, remaining foundation characterization, diversion exceedance potential, unexpected conditions, delays associated with equipment or material delivery, or other factors.

7 Temporary Construction Facility and Trucking Information

Appendix B, Temporary Construction Facilities and Trucking Information, of this Constructability Report provides a conceptual construction layout and facilities required to construct the proposed FRE along with a comprehensive estimate of construction truck trips.

8 Constructability Considerations and Impacts

Constructability considerations are provided throughout, but the list below captures high-level constructability considerations to inform and support permitting and design development.

8.1 General

- Maximize contractor selection and development of staging and access
- Create and preserve options for supplemental or alternative quarry development

- Consider allowing maximum seasonal and daily flexibility in project hours including deliveries
- Develop thoughtful balance of diversion requirements and contractor flexibility
- Develop detailed construction sequencing related to conduit construction and use for Phase 3 and 4 flows
- Consider value-based or early contractor involvement through CMAR [Construction Manager at Risk] or CM/GC [Construction Manager/General Contractor] project delivery

8.2 RCC/Dam Design

- Optimize dam placement temperature with regional climate and joint design
- Balance competing RCC interests: workability, facing options, cool temperatures, initial set, maximum sized aggregate
- Consider allowing sloping layer placement
- Consider allowing monolith construction
- Consider optimizing strength requirements and available cementitious product use
- Consider bid options between facing element options

8.3 Value Planning Considerations

While premature for value engineering, the following general subjects stand out as topics where optimization may lead to enhanced project value and/or lower costs.

- Intake structure design
- RCC cross-section and arch design
- Unfaced or marginally faced design
- Optimized spillway design

9 Construction Risk

The RPD is a large and complex project challenged by significant diversion requirements, intensive environmental needs, rough topography, a seasonal and wet climate, uncertain material sourcing, and limited geotechnical characterization of the revised alignment. Failing to bring adequately characterized quarries into a construction contract, risks environmental re-consideration, and potentially places great burden on a commercial supply alternative, project delay, increased cost, and cost-risk. Further, the aggregate timing and quantity demand may exceed supply capability and add environmental and safety impacts not otherwise raised in the RPD. Construction cost and schedule risk will be captured more completely in the Opinion of Probable Costs

Report when prepared. Outlined below are recognized cost and schedule construction risk drivers.

9.1 General/Site

- Undetermined environmental controls
- Extreme adverse weather potential
- Work scope and quantities pending foundation characterization
- Adequacy of staging and spoils areas
- Site excavation and slope stability
- Diversion design and risk assignment
- Diversion exceedance

9.2 Materials/RCC

- Quarry adequacy pending further quarry characterization
- Adequacy of quarry volume
- Uncertain quarry yield
- Cement cost and supply
- SCM cost and supply

9.3 Program and Project Delivery

- Project delivery and work packaging decisions
- Contractor competitive interest
- Program schedule and escalation

10 References

HDR Engineering, Inc. (HDR)

2017 Combined Dam and Fish Passage Conceptual Design Report, Prepared for Chehalis Basin Flood Control Zone District, Chehalis River Basin Flood Damage Reduction Project. June 2017.

2018 Combined Dam and Fish Passage Supplemental Design Report FRE Dam Alternative Report, Prepared for Chehalis Basin Flood Control Zone District, Chehalis River Basin Flood Damage Reduction Project. September 2018.

2019 Proposed Flood Retention Dam Construction Schedule Supplemental Information, Prepared for Chehalis Basin Flood Control Zone District, Chehalis River Basin Flood Damage Reduction Project. September 2019.

Washington Department of Fish and Wildlife (WDFW)

2018 Times when spawning or incubating salmonids are least likely to be within Washington State freshwater. June 1, 2018.

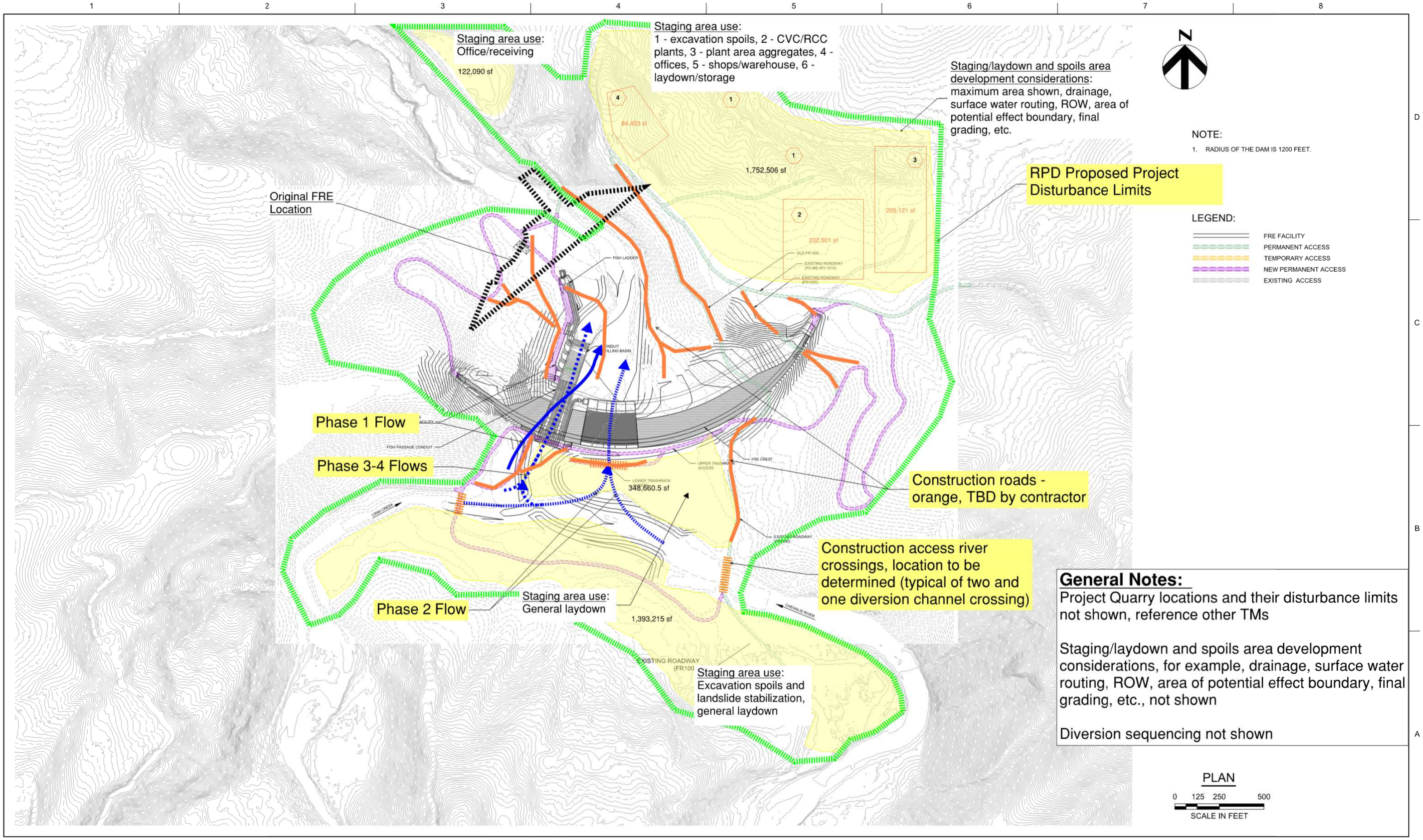
U.S. Army Corps of Engineers (USACE).

2010 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. March 9, 2010.

This page intentionally left blank.

Appendix A. Site Use, Diversion, and Sequencing Illustration

This page intentionally left blank.

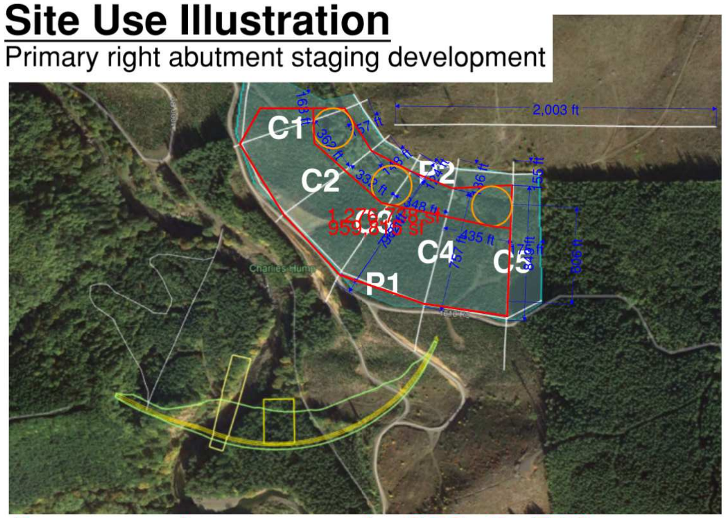


Site Use Illustration

Attachment A: Site Use, Diversion, and Sequencing Illustrations
Page 1/11

Site Use Illustration

Primary right abutment staging development

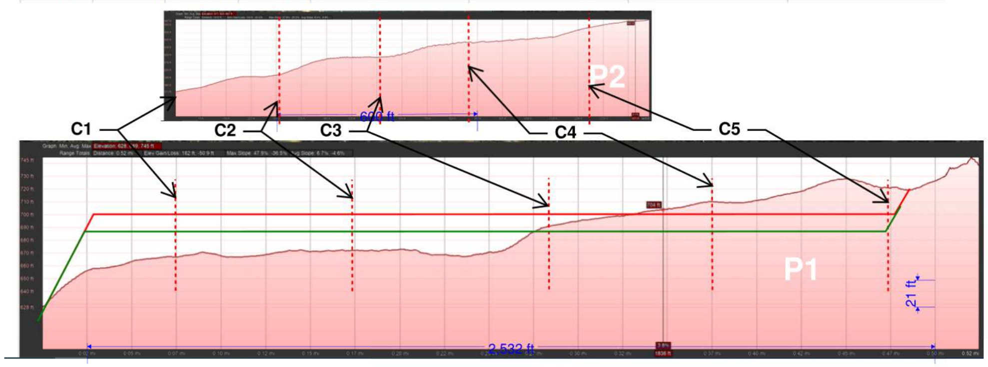


Summary to support C&C & OPC

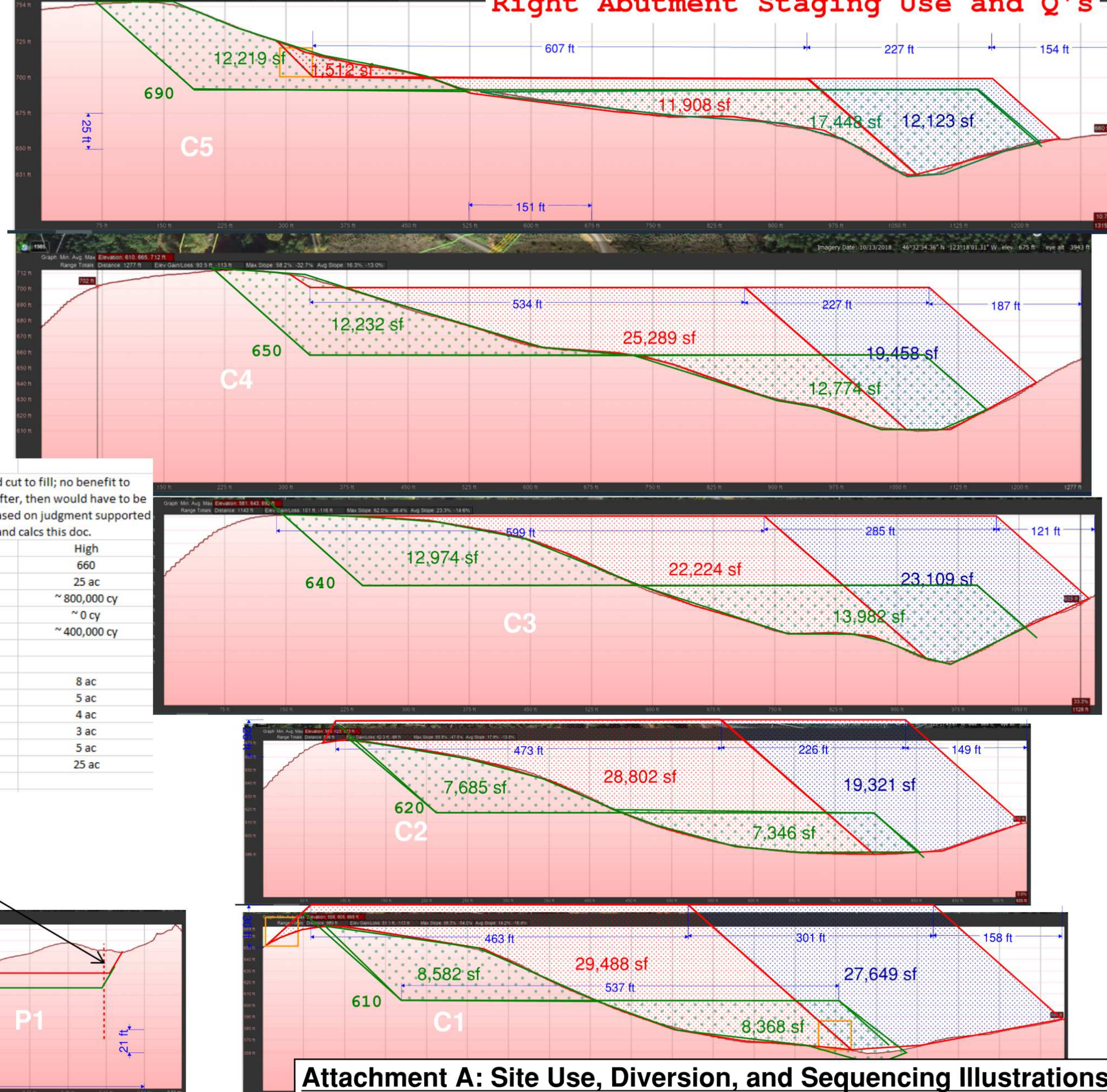
Right Abutment Staging Area Effort and Use Summary

Basis	1) Maximizing area and volume for spoils, minimizing cut to create staging area. Based on judgment supported by GE loose sections and calcs this doc.		2) Balance staging pad cut to fill; no benefit to spoils disposal until after, then would have to be above graded pad. Based on judgment supported by GE loose sections and calcs this doc.	
	Low	High	Low	High
Staging bench elevation	670	710	630	660
Staging bench area	22 ac	32 ac	15 ac	25 ac
Excavation (to fill)	~ 20,000 cy	~ 20,000 cy	~ 650,000 cy	~ 800,000 cy
Embankment (from exc or spoils)	~ 1,450,000 cy	~ 2,690,000 cy	~ 0 cy	~ 0 cy
Spoils if graded above finished staging pad	~ 200,000 cy	~ 400,000 cy	~ 200,000 cy	~ 400,000 cy
During Construction uses:				
CVC and RCC plant operations	4 ac	10 ac	4 ac	8 ac
Surface spoil storage during construction	5 ac	5 ac	0 ac	5 ac
Office/Admin/Engr	2 ac	4 ac	2 ac	4 ac
Additional short term aggregate storage	5 ac	5 ac	3 ac	3 ac
Storage/spares/laydown	6 ac	8 ac	6 ac	5 ac
	22 ac	32 ac	15 ac	25 ac

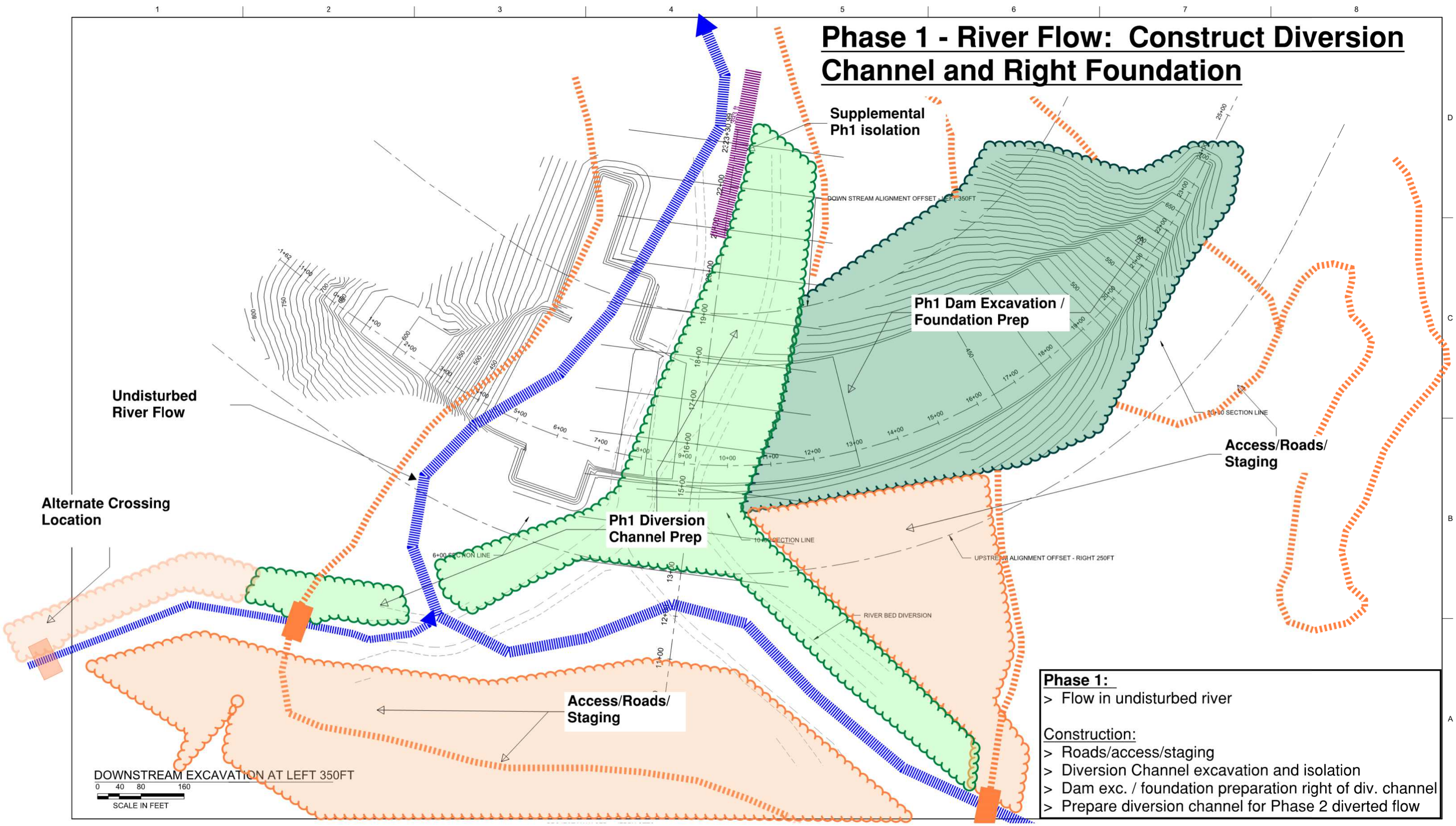
From: RA Staging concept for areas and spoils.xlsx ; Calc Support



Right Abutment Staging Use and Q's

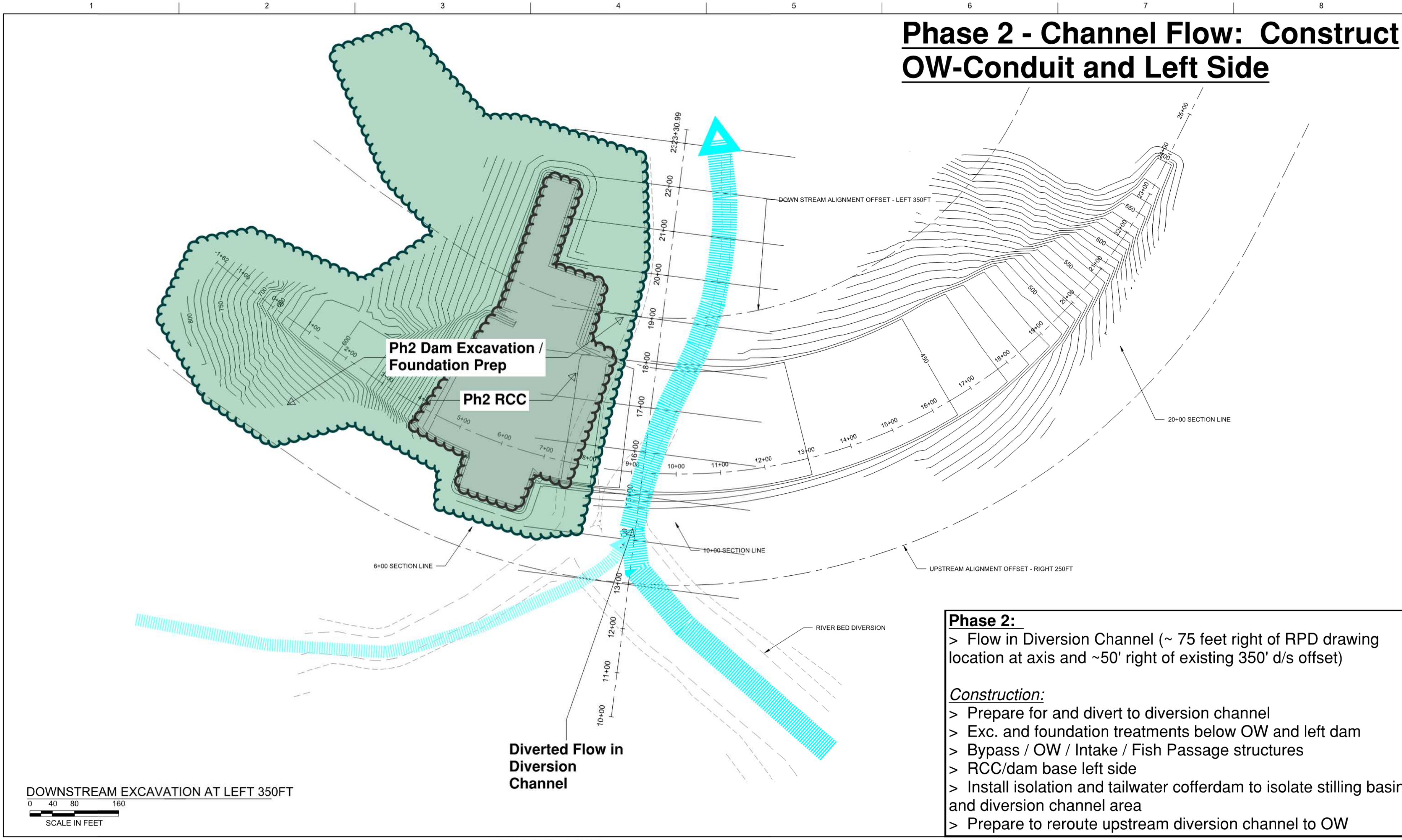


Attachment A: Site Use, Diversion, and Sequencing Illustrations



Attachment A: Site Use, Diversion, and Sequencing Illustrations
Page 3/11

Phase 2 - Channel Flow: Construct OW-Conduit and Left Side



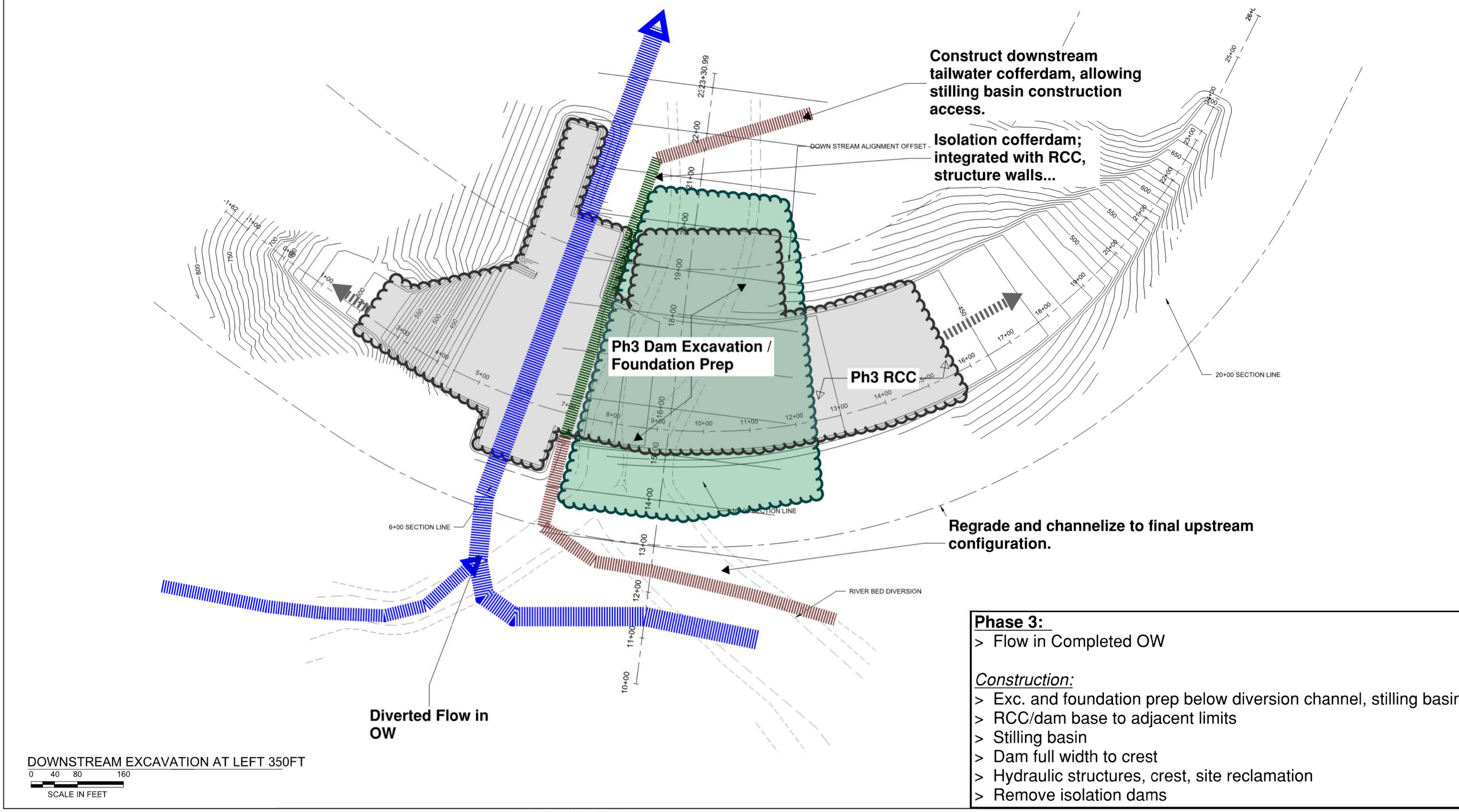
Phase 2:

\> Flow in Diversion Channel (~ 75 feet right of RPD drawing location at axis and ~50' right of existing 350' d/s offset)

Construction:

\> Prepare for and divert to diversion channel
\> Exc. and foundation treatments below OW and left dam
\> Bypass / OW / Intake / Fish Passage structures
\> RCC/dam base left side
\> Install isolation and tailwater cofferdam to isolate stilling basin and diversion channel area
\> Prepare to reroute upstream diversion channel to OW

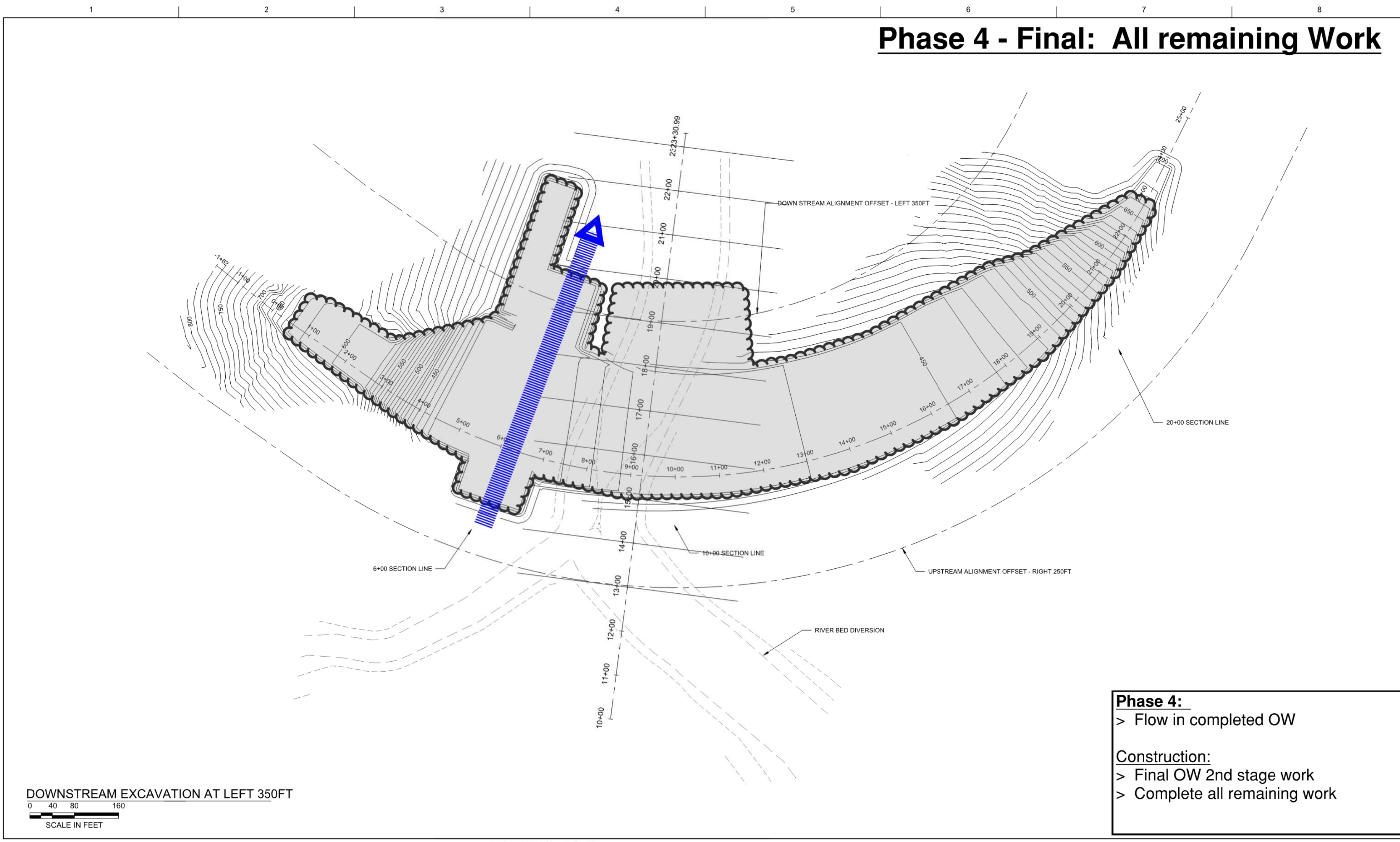
Phase 3 - OW Flow: Diversion Closure



Phase 3:
> Flow in Completed OW

Construction:
> Exc. and foundation prep below diversion channel, stilling basin
> RCC/dam base to adjacent limits
> Stilling basin
> Dam full width to crest
> Hydraulic structures, crest, site reclamation
> Remove isolation dams

Phase 4 - Final: All remaining Work



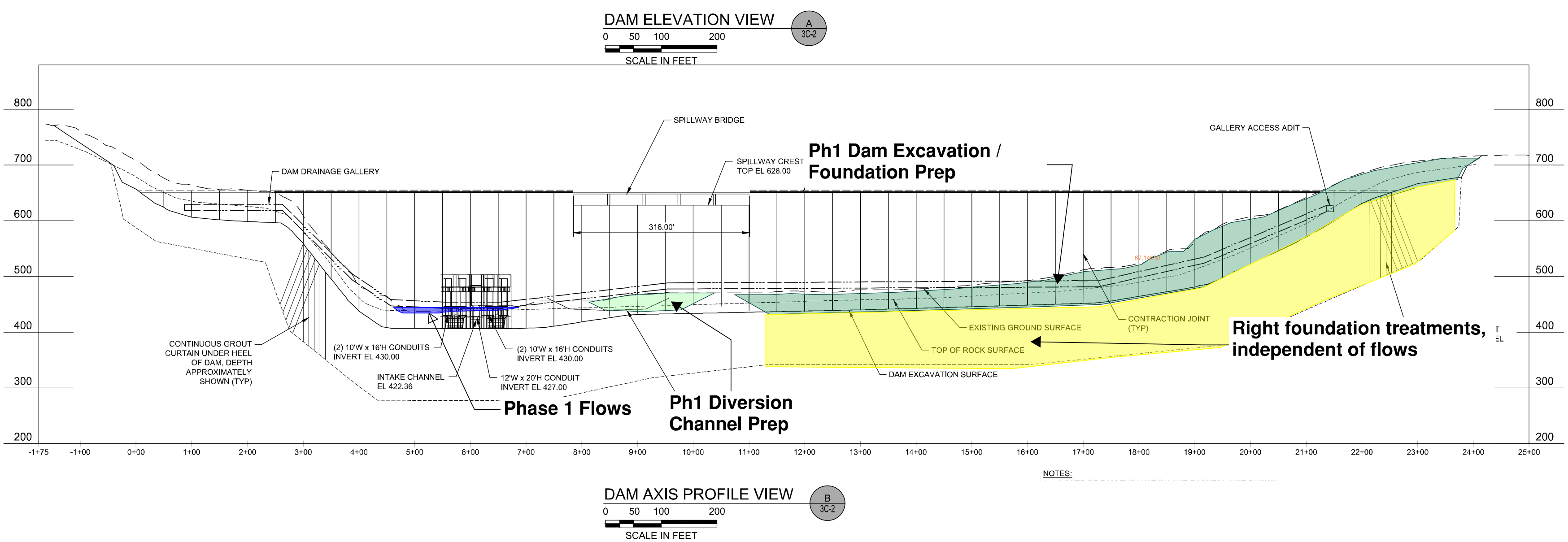
Phase 4:
> Flow in completed OW

Construction:
> Final OW 2nd stage work
> Complete all remaining work

Phase 1 - River Flow: Construct Diversion Channel and Right Foundation

Phase 1:
> Flow in undisturbed river

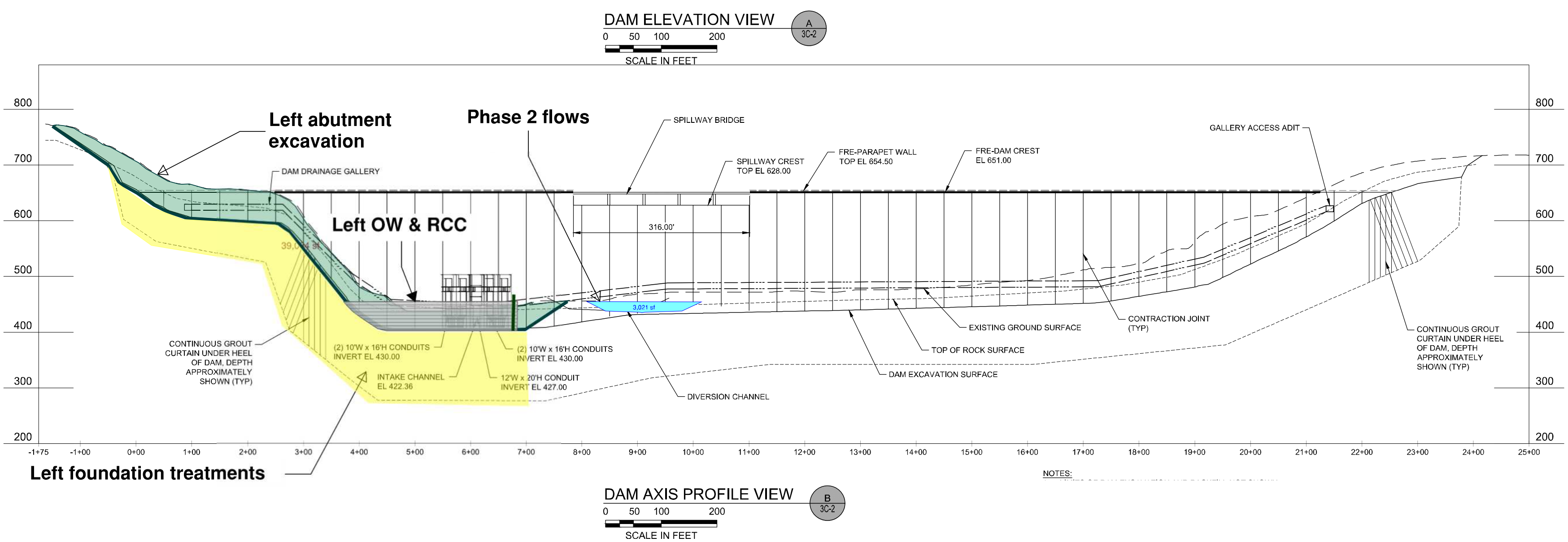
Construction:
> Roads/access/staging
> Diversion Channel excavation and isolation
> Dam exc. / foundation preparation right of div. channel
> Prepare diversion channel for Phase 2 diverted flow



Phase 2 - Channel Flow: Construct OW and Left Side

Phase 2:
> Flow in Diversion Channel (~ 75 feet right of RPD drawing location at axis and ~50' right of existing 350' d/s offset)

Construction:
> Prepare for and divert to diversion channel
> Exc. and foundation treatments below OW and left dam
> Bypass / OW / Intake / Fish Passage structures
> RCC/dam base left side
> Install isolation and tailwater cofferdam to isolate stilling basin and diversion channel area
> Prepare to reroute upstream diversion channel to OW



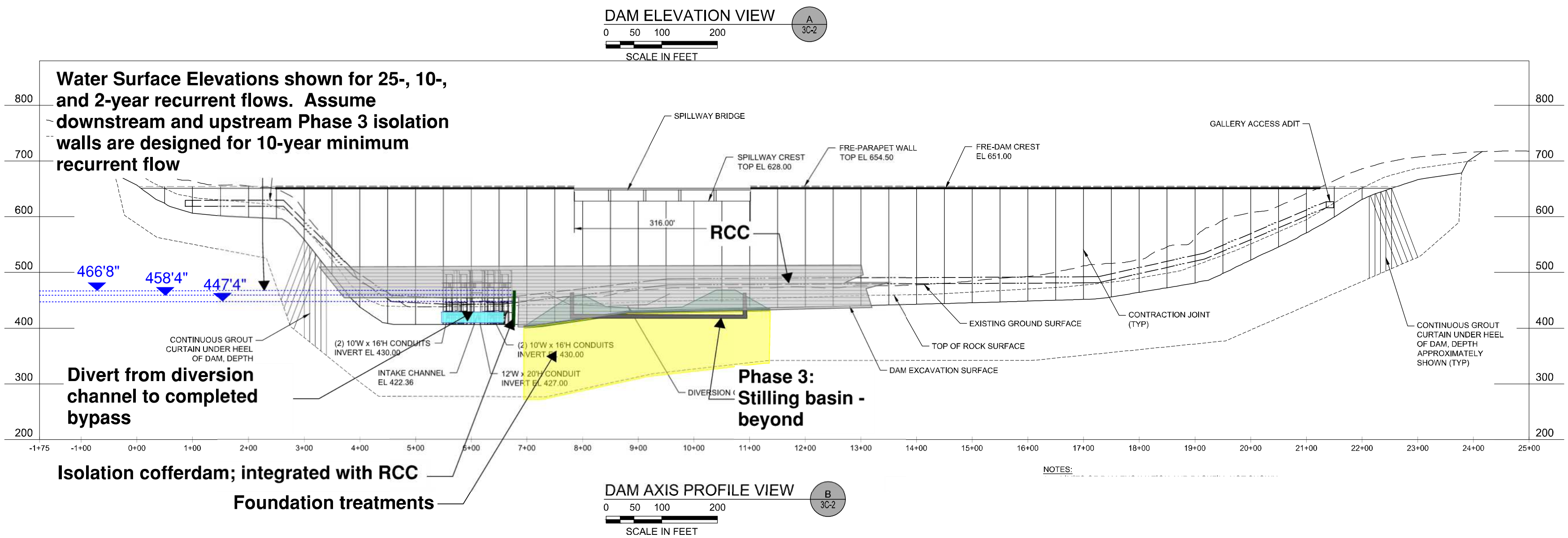
Phase 3 - OW-Conduit Flow: Diversion Closure

Phase 3:
> Flow in Completed OW

Construction:
> Exc. and foundation prep below diversion channel, stilling basin
> RCC/dam base to adjacent limits
> Stilling basin
> Dam full width to crest
> Hydraulic structures, crest, site reclamation
> Remove isolation dams

Flow when all water level elevations for when all outlet works conduit gates are installed and fully open:

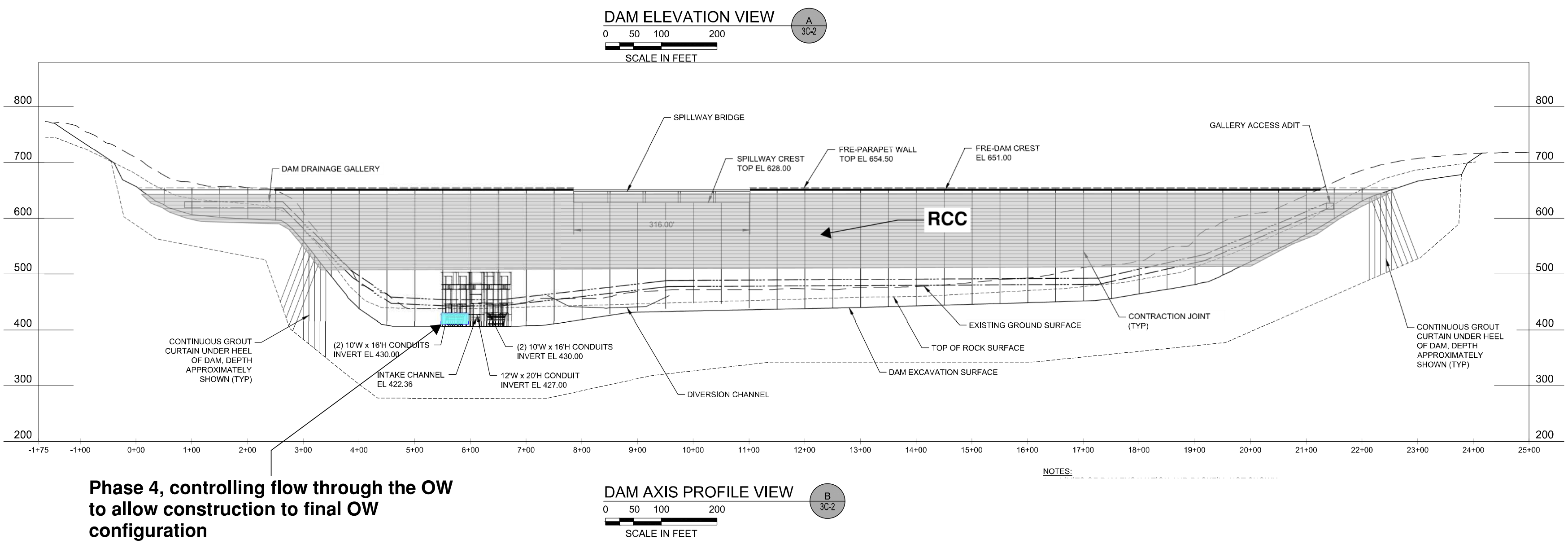
Annual Exceedance Probability (AEP)	Annual Return Interval	Flows	Water Level Elevation (NAVD88)
99%	1-yr	2,580 cfs	441.2 ft
50%	2-yrs	9,496 cfs	447.3 ft
20%	5-yrs	15,531 cfs	452.7 ft
10%	10-yrs	20,175 cfs	458.2 ft
6.7%	15-yrs	23,011 cfs	461.7 ft
5%	20-yrs	25,098 cfs	464.4 ft
4%	25-yrs	26,756 cfs	466.7 ft
2%	50-yrs	32,169 cfs	474.4 ft
1%	100-yrs	38,014 cfs	483.5 ft



Phase 4 - Final: All remaining Work

Phase 4:
> Flow in completed OW

Construction:
> Final OW 2nd stage work
> Complete all remaining work



Phase 4, controlling flow through the OW to allow construction to final OW configuration

Attachment A: Site Use, Diversion, and Sequencing Illustrations

Chehalis RPD Construction Sequence Descriptions

Phase	Phase Name	Flow	Diversion Effort and Risk	Work Description During Phase	Duration Assumptio	Risk Rating	Risk Impact
1	**River flow**	Original river channel	**Construct:** channel and berms, crossing(s). **Risk:** exeeding river flow would innundate channel exavations causing delay and rework.	Access and staging development. Construct river crossings (calendar restrictions). Excavate and construct berms/longitudinal cofferdams for diversion channel. Right abutment excavation and foundation preparation (independent of flow location)	52 wk	Moderate	Moderate
D1	**Divert 1-2**	River to Diversion Channel	**Construct:** Open constructed diversion channel to divert river flow. Monitor and stabilize. **Risk: Divert flow when ready;** not limited to a fish window. Otherwise, increases risk to wait.	Ongoing unrelated work; right abutment, staging, crushing, plants, etc.	2 wk	Low	Moderate
2	**Channel Flow**	Flow in Diversion Channel	Maintain diversion flows in diversion channel. Left abutment surface flows need to be contained and routed to discharge. **Risk:** of overtopping if > 10-year recurrent flow. Delay, recovery, reconstruction risks are substantial and exposure is quite long.	Excavate left abutment and left valley, leaving foundation unconstructed 7+00 to 11+50 approx (below channel). Construct outlet works structure, intake structure base, and fish passage foundation and lower levels. Construct foundation treatments below OW and in left valley bottom. Construct right abutment foundation preparation (independent of flow). Construct RCC base left of outlet works. Prepare completed work with isolation barriers and longitudinal cofferdams.	86 wk	High	High
D2	**Divert 2 to 3**	Diversion Channel to Outlet Works	Finalize longitudinal/isolation cofferdams - upstream, across dam structure, downstream to include tailwater protection. Divert flows from river to new OW structure. **Risk:** Divert flow when ready; not limited to fish window. Otherwise delays work.	Ongoing unrelated work; right abutment, staging, foundation treatments, crushing, RCC, etc.	8 wk	Low	Low
3	**Outlet Works Flow; Closure**	Flow in Partially Completed Outlet Works.	Maintain diverted flows. **Risk:** 25-year recurrent flow will require a Water Surface Elevation of about 467, quite high and likely impractical; leading to a reduced diversion capacity during this phase. Assume 5-, to 10-year recurrent flow design for Phase 3. If flows exceed Outlet Works capacity at berm heights, flows would route through channel area and stilling basin consturction. Delay, recovery, reconstruction risks are substantial, duration is comparatively low versus Phase 2. Risk greatly reduces once RCC is raised to adjacent limits.	Excavate and foundation treatments. Stilling basin excavation, foundation and basin construction. RCC/dam base to adjacent limits. Once RCC has started, RCC can continue throughout full extents. Once RCC is complete, continue with hydraulic structures, crest, site reclamation. Remove isolation dams and open structure to final configuration.	52 wk	High	High
4	**Final**	Outlet Works Final	Using designed outlet works controls, isolate OW components to allow final, or any second-stage modifications unable to be finished during Phase 2	Finalize OW configuration. Complete all remaining work	26 wk	Low	Low
					52 months		

This page intentionally left blank.

Appendix B. Temporary Construction Facilities and Trucking Information

This page intentionally left blank.

HDR

Chehalis River Basin
Flood Control Zone District

Technical Memorandum

Date:	April 24, 2024
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District (District)
From:	HDR– Teresa Krause, Greg Young
Subject:	**Temporary Construction Facilities and Trucking Information**

1.0 Background

The Chehalis River Basin Flood Damage Reduction project objective is to develop recommendations for a series of measures aimed at reducing damage to the communities of the Chehalis River Basin from Pe Ell to Centralia during major flood events. Among these measures is a proposed Flood Retention Expandable (FRE) structure on the Chehalis River, south of the town of Pe Ell.

The Chehalis River Basin Flood Damage Reduction, Revised Project Description Report (RPDR) documents the relocation of and revisions to the proposed FRE facility and supporting infrastructure located within the Proposed Project area as originally documented within the Combined Dam and Fish Passage Conceptual Design Report (HDR Engineering, Inc. [HDR] 2017) and FRE Dam Alternative Report (HDR 2018).

The RPDR describes, supports, contrasts, and illustrates the revisions and enhancements to the proposed FRE in a single comprehensive document.

2.0 Introduction and Purpose

This Technical Memorandum (TM) provides a revised conceptual layout for temporary construction facilities and revised trucking information for the proposed revised FRE alignment.

The configuration of the temporary construction facilities can be approximated based on a general understanding of construction processes and accompanying best management practices (BMPs) for environmental protection. The rough order of magnitude (ROM) estimates provided herein reflect the current conceptual level of design for the proposed FRE facility and assumptions regarding the requirements for the temporary construction facilities. HDR has used professional judgement to provide the recommended value for the project description to be evaluated in the EIS; however, this value can only be used as a guideline at this point in time.

3.0 Conceptual Layout of Temporary Construction Facilities

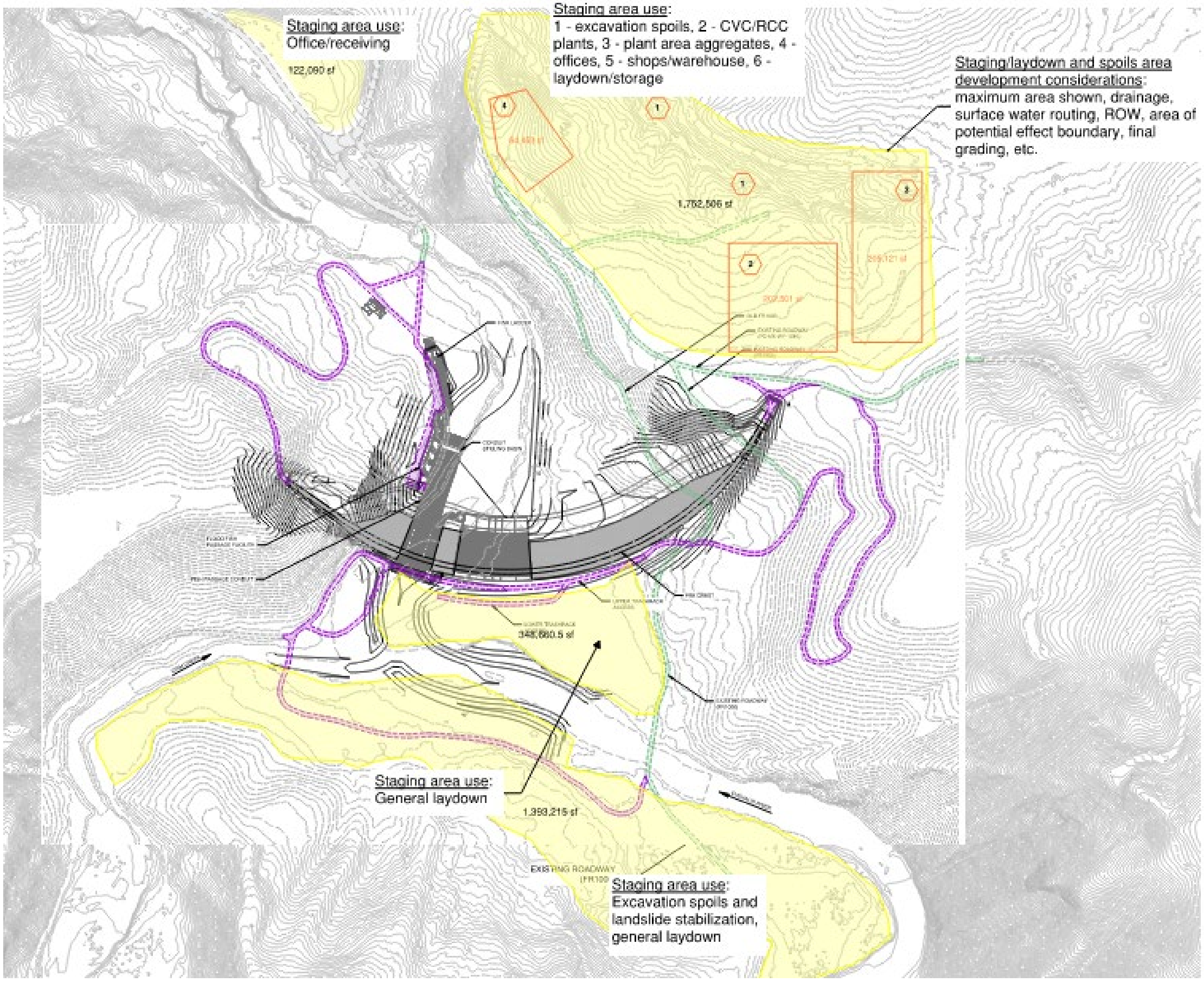
HDR has developed a preliminary project site plan showing potential contractor staging, laydown, and spoil areas. In the end, it will be the contractor's responsibility to develop temporary facilities by their own means and methods in accordance with the contract documents that will provide performance specifications and BMP details.

Staging and construction laydown areas will be prepared with appropriate site grading, surfacing, and drainage provisions that allow construction equipment and materials to be stored, secured, and utilized. These areas will be located near the construction site and include construction offices, areas for material processing and storage, and parking for construction vehicles. Figure 1 shows a conceptual layout of staging and spoil areas. Refer to the Access Road and Best Management Practices Technical Memorandum, dated March 27, 2024 for more detail on access road impacts.

Equipment used to develop staging areas may include large scrapers, large frontend loaders, large bull dozers, large excavators, dump trucks, water trucks, compactors, and road graders.

Materials from the construction of roads, FRE facility, staging area, and other construction activities that cannot be used as fill or reused, will be deposited in spoil areas. Figure 1 shows some possible spoil areas of the site. Most of the materials of the spoil areas are natural ground materials. Vegetation will eventually grow and populate these areas over time. Further design and coordination with environmental agencies will define the exact measures of the treatment of the spoil areas after construction.

Figure 1. Chehalis Conceptual Layout of Staging and Spoil Areas



4.0 Material Estimate and Vehicle Use for the Staging Areas

The ROM for material and vehicle use associated with the staging areas is estimated in Table 1. The table summarizes the estimated impacts during construction of each staging area.

Estimates are expected to be refined as a result of additional design and development and as the contractor's means and methods for construction are developed.

Table 1. Material Estimate and Vehicle Use for Staging Areas*

Staging Area	Area (acre)	Volume of Material (CY)	Weight of Material (tons)**	Truck Loads***
Offices, Receiving, Security	7.5	3,030	5,000	120
CVC/RCC Plants	4.6	1,880	3,100	70
Supplemental Structure Staging – Shops and Warehouse	1.9	780	1,300	30
Other Staging and Laydown Areas	66.1	26,670	44,000	1,050

All numbers are subject to change.
**Assumes 1.65 tons per cubic yard
***Each off-road dump truck is assumed to carry a payload of 85,000 (42 tons)

4.1 General Assumptions:

- No embankment material import to construct the staging areas is required. Only road base material import coming from offsite areas will be required for the Staging Areas. Therefore no quantification of long haul truck trips is required for embankment materials for staging areas.
- To determine the air quality impact of the quarry operations, equipment selections would need to be determined from the equipment listed in Section 2.0 and then applied to the anticipated duration of construction.
- Contractor is expected to design the staging area earthwork to balance cut and fill.

The number of trucks quantified in Table 1 are to haul material less than 0.5 miles within the footprint of the staging areas. There is no consideration for transferring embankment materials from one staging area to another, as it is assumed that each staging area can be developed with a balanced cut/fill earthwork approach.

After construction the staging areas will have to be reclaimed. Different staging areas will have different future purposes. The surface materials could be reused to repair roads and for parking areas for recreational sites. Vegetation could be planted on those sites once the ground materials is natural ground and surface materials have been removed. Detailed design and plans for the restoration or mitigation of the staging areas will be developed with further design in the future.

5.0 Environmental Control Efforts during Construction

5.1 Temporary Erosion and Sediment Control

Temporary Erosion and Sediment Control (TESC) measures will be implemented to minimize stormwater impacts such as 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 in accordance with Ecology's Construction Stormwater General Permit and Stormwater Management Manual for Western Washington. Supplemental BMP specifications will be obtained from the current version of Washington State Department of Transportation's Standard Specifications for Road, Bridge, and Municipal Construction and Lewis County standards. The BMPs which may be utilized to control and minimize storm water impacts include:

- 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 slope stabilization and coverings such as mulch, nets and blankets, plastic coverings, temporary seeding and sodding, and compost blankets

The construction general contractor will hold the permit for erosion and sediment control as well as the construction contract and be responsible for developing the plan, location, and maintenance for all required BMPs. A TESC plan will be developed during final design.

5.2 Fuel Storage and Containment Areas

Primary and secondary containment will be required as part of the permit and construction contract, and all fuel storage areas will be located where they cannot be affected by a flood event. A mobile fueling truck and large stationary fuel cell likely will be used. Fuel storage area design and locations will be based on contractor's means and methods.

5.3 Process Aggregate for Roller-Compacted Concrete

Quarry development, followed by quarry operations and aggregate production, will begin early in construction and proceed through much of the construction period. The RPDR Geotechnical Design Section addresses quarry locations and quantities.

5.4 Roller-Compacted Concrete Test Area

A roller-compacted concrete (RCC) test fill will be completed a few weeks in advance of production RCC placement to confirm mix design properties and demonstrate plant operation and placement preparedness. This testing is required to confirm contractors means and methods and quality control of RCC placement prior to beginning bulk placement for the FRE facility. After testing is complete, the testing remnants will be demolished and disposed.

5.5 Roller-Compacted Concrete Dam Construction

RCC for the main dam will be placed on the prepared, competent rock foundation and constructed in horizontal lifts. Figure 1 indicates a potential staging area for the on-site RCC batching plant. Once hauled or conveyed to the final lift placement location, the RCC is spread by bulldozer and compacted by smooth drum vibratory rollers. Each lift surface requires proper bonding with successive RCC lifts. Lifts that are not covered quickly enough by fresh RCC require a combination of cleaning and bedding concrete placement, depending on age.

Placement of the RCC is accompanied with typical stormwater management practices and concrete washout prevention practices to avoid environmental impacts.

Installation of RCC is a dynamic and multi-disciplined construction operation due concurrent operations like RCC placement, upstream and downstream dam faces, abutment preparation, dam contraction joints, drainage gallery construction, and other related tasks.

5.6 Water Use during Construction

Construction water will be required for dust control, aggregate processing, concrete production, embankment fill, offices, warehouses, shops, tunneling operations, and various unlisted uses. Dam projects require a considerable amount of water with usage varying due to concrete specifications, aggregate in-situ properties, aggregate processing specifications, embankment compaction requirements, seasonal climate, number of on-site workers/staff, and various other project requirements. Based on other project experiences, water demand requirements are estimated to be 2,000,000 gallons per day (3 cfs) during construction activities. A water demand evaluation will be performed during final design to refine the estimate. The District is committed to avoid impacts to existing water supplies and water quality for local water withdrawals such as the City of Pe Ell while using water during construction.

The demand flow rate for construction water will vary throughout the course of construction as construction activities vary. Seasonal influences will also affect water demand. For example, construction water consumption for dust control will be much reduced during rainy months. Water storage tanks will likely be utilized by the construction contractor to help buffer some of the short term peak demands and to facilitate continuous construction. Construction water will likely be obtained through surface water withdrawals from the Chehalis River. “Limited groundwater is present in (the vicinity of the project site) because the substrates are predominately bedrock with a thin layer of overlaid alluvial material” (Draft Biological Assessment and Essential Fish Habitat Assessment Chehalis River Basin Flood Damage Reduction Project. HDR, 2021). As such it is unlikely that groundwater would be employed for construction water. Fish screens meeting state and federal fish screening requirements would be employed for surface water withdrawals. The withdrawal location on the Chehalis River will likely be in the vicinity of the construction to minimize the footprint of the temporary water supply infrastructure. Temporary water supply infrastructure, including the withdrawal location, will be designed, installed, and operated in accordance with federal, state, and local laws and regulations. The proposed location of the construction water withdrawal will be identified as the design is further developed. Temporary water supply pipeline(s) will be installed to carry water to specific locations on the construction site, including water storage tanks and the concrete batch plant. All temporary water supply infrastructure such as water lines, pumps, and storage tanks will be removed upon completion of construction.

5.7 Water Rights for Construction

A feasibility study will be performed to identify water rights requirements for construction following Ecology guidelines. Water may be pulled directly from the Chehalis River, from a well drilled to obtain water or a combination of both sources. Public water supply lines within the area for project construction use are assumed to be unavailable.

5.8 Dewatering Needs

Dewatering needs are described in the RDPR, Constructability TM.

6.0 Impacts of Aggregate and Concrete Material Processing

This section provides an estimate for trucking impacts for material imports to the site. The estimate does not include any daily work force vehicular use or off-road hauling of materials from the quarry to the on-site staging areas. Load impact estimates for concrete production and construction activities are provided in Table 2. These estimates are expected to change as the design is refined and the contractor's means and methods for construction are developed.

Table 2. Impacts of Concrete Material Production and Construction Activities*

Materials	Base Weight – Quantity in Tons	Estimated Truck Loads**
Construction Mobilization	N/A	250
Concrete Sand for Conventional Concrete	301,100	12,000
Aggregate for RCC	2,253,000	90,000
Bulk Cement	155,260	6,000
Fly Ash	66,540	2,700

Materials	Base Weight – Quantity in Tons	Estimated Truck Loads**
Rebar	16,000	640
Gates	175	20
Miscellaneous Metals	1,100	44
Clearing	2,800 to 11,000	100-350

* All numbers are subject to change.
** Truck loads are assumed to be 25-ton highway trucks

RCC and conventional concrete production likely will require two on-site, central mix, concrete batch plants. Near-continuous placement requirements for dam construction contribute to the need for two concrete batch plants to produce RCC and conventional concrete separately. A central mix plant includes components for aggregate, cement, and water and admixture supply and batching; mixing equipment; and often concrete heating and cooling systems. Truck deliveries from the plant to the dam placement site are impractical and often not allowed.

Conveyor delivery from the plant to the dam's active lift surface, followed by conveyor and/or on-lift trucks to the final placement for spreading, is more common and should be assumed.

7.0 Operation Phase Truck Trips

The District anticipates that truck trips required during the operation phase of the proposed project will be limited and primarily associated with routing inspections, facility maintenance, debris management, and road and facility maintenance and fish transport. On an annual basis the number of truck trips during the operational phase will be much fewer than those during construction phase. Routine visual inspections of FRE facilities and the inundation area will be conducted monthly to observe facility conditions and identify potential maintenance requirements. This will likely be undertaken by a single vehicle. Identified maintenance requirements will require the presence of vehicles to support intermittent maintenance activities. Intermittent maintenance activities are expected to occur twice annually. Following periodic retention events, debris management will be required that are assumed to require the use of boats, 2-axle trucks, and log handling equipment for the collection and staging of woody debris at the log sorting yard (river mile 109.6 to 109.9). Debris management activities include the removal of large woody debris from the log sorting to locations in the basin used for habitat restoration and enhancement efforts as proposed in the Mitigation Plan. Limited use of 3- or 4-axle trucks may also be required. Road maintenance and maintenance of the proposed FRE and Flood Fish Passage Facilities (FFPF) will also be required during the operational phase. Trucks will be needed to haul material to maintain and repair roads. Additionally, 2-axle trucks will be used to transport fish upstream during retention events as part of the FFPF operation.

The average number of truck trips per year has not been estimated for the operational phase of the proposed project because truck trips are directly correlated to specific maintenance activities and operational procedures. This information will be developed during the final design and permitting phase of the project.

8.0 Clearing

Clearing activities to construct the FRE facility are required at the dam footprint, staging areas, quarry areas, and debris management sorting area. Refer to the Vegetation Management Plan for inundation area clearing activities within the reservoir pool. The debris management area is estimated to equal a total of 110 acres.

The tree density within these areas can vary significantly. To confidently assess timber and debris content, a detailed site analysis should be conducted. Considering a range of 25 to 100 tons per acre, a preliminary conceptual cleared timber quantity may be between 2,800 and 11,000 tons; or 100 to 350 truckloads.

9.0 Truck Trip Summary

The number of truck trips estimated for construction of the proposed FRE facility is summarized in Table 3.

The rough order of magnitude estimates summarized herein reflect the current revised conceptual level of design for the proposed FRE facility and assumptions regarding the requirements for the temporary construction facilities.

Table 3. Construction Phase Rough Order of Magnitude Truck Trip Estimates

Description of Construction Phase Activity	Number of Truck Trips
TOTAL	**207,474**
Staging Areas	
Offices, Receiving, Security	120
CVC/RCC Plants	70
Supplemental Structure Staging – Shops and Warehouse	30
Other Staging and Laydown Areas	1,050
FRE Structure and Flood Fish Passage Facility Construction	
Construction Mobilization	250
Concrete Sand for Conventional Concrete	12,000
Concrete Sand for RCC	90,000
Bulk Cement	6,000
Fly Ash	2,700

Description of Construction Phase Activity	Number of Truck Trips
Rebar	640
Gates	20
Miscellaneous Metals	44
Clearing	350
Access Road Construction	
Construction Road Upgrades and Development (21 miles, Aggregate)	14,200
Construction Road Upgrades and Development (21 miles, Earthwork)	80,000