Technical Memorandum

Date:	April 24, 2024
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR Engineering, Inc.
Subject:	**Fish Passage Design**

1.0 Introduction

As a part of recommended measures to reduce damage to communities of the Chehalis River Basin during major flood events, identified as part of the Chehalis River Basin Flood Damage Reduction Project, the Chehalis Basin Flood Control Zone District (District) is proposing a Flood Retention Expandable (FRE) structure located on the Chehalis River, south of the town of Pe Ell.

The FRE structure includes the following fish passage components, designed to provide passage for a range of species and life stages:

- Flood Fish Passage Facility (FFPF)
- Fish Passage Conduits
- Temporary channels
- Permanent channels

The fish passage design documented in this technical memorandum includes updates of the design criteria to comply with current standards, update of previous concept- level design development, performance assessment for a newly proposed bypass channel, and development of a plan and timeline to advance the fish passage design to a level necessary to inform the final Biological Assessment. These activities were performed in collaboration with Washington Department of Fish and Wildlife (WDFW) and National Oceanic and Atmospheric Administration (NOAA) Fisheries and in concert with numerous other physical, biological, and engineering studies and analyses being performed by others to refine the FRE Proposed Project design, evaluate potential flood damage reduction, and minimize and avoid environmental impact. The newly formed Fish Passage Technical Working Group (TWG) also provided input to these activities through periodic design update meetings.

2.0 Purpose and Intent

The integration of fish passage systems is a central component of the flood damage reduction structure design. Fish passage is required by the State of Washington's regulatory authority defined in Revised Code of Washington 77.57.030, Fishways required in dams, obstructions – penalties, remedies for failure. This statute requires that dam owners provide safe and timely fish passage for all fish species and fish life stages present in an affected area. Although no aquatic species are federally listed as endangered or threatened on this part of the Chehalis River, the integration of fish passage systems is also required by Section 7 of the federal Endangered Species Act, as spring and fall Chinook salmon are prey items for the endangered Southern Resident Killer Whale. Fish passage facility design has occurred simultaneously with dam design efforts throughout the development of the Revised Project Description Report (RPDR). The purpose of this technical memorandum is to summarize the results and conclusions of fish passage concept development performed in previous documents and in 2023 for this RPDR and identify a "roadmap" for fish passage design development supporting the final Biological Assessment. This information is intended to be used by the Washington Department of Ecology (WDOE) in development of the State Environmental Policy Act (SEPA) Environmental Impact Statement (EIS), the U.S. Army Corps of Engineers (USACE) in development of the National Environmental Policy Act (NEPA) EIS, and by WDFW, NOAA Fisheries, and the Technical Working Group (TWG) to inform decisions regarding the integration and performance of potential fish passage technologies with the FRE structure being developed by the design team.

3.0 Design Criteria

This section describes design criteria used for the conceptual design of fish passage components at the Proposed Project. Previous design development identified design criteria based on contemporary design guidance, collaboration with regulatory agencies and non-regulatory entities, and contemporary science. Some, but not all, of the previously developed design criteria have been updated to reflect current design guidance, science, and collaboration. Both design criteria that have been updated since previous documentation was published and design criteria that remain unchanged and are utilized in the current design are documented in this technical memorandum. Some of the design criteria in this technical memorandum were developed using design guidance that that has since been superseded. Design criteria based on superseded guidance that are not identified as updated in this section are utilized and incorporated in the current design. Future design development will utilize current design guidelines, such as NOAA (2022a) instead of NOAA 2011, and the design criteria and design will be updated accordingly. Refer to Section 6.0 for additional information regarding potential design criteria revision.

This section notes criteria that have been confirmed, added to, removed from, or revised from design criteria in previously published documents.

3.1 Collaboration with Technical Committees

From 2016 to 2017, the fish passage design team and members of the Chehalis Basin Strategy Flood Damage Reduction Technical Committee coordinated and held several Fish Passage Subcommittee (Subcommittee) meetings. During development of the RPDR in 2023 and 2024, the Fish Passage Technical Working Group (TWG) was formed to continue coordination with members of the Subcommittee. Two TWG meetings were held during development of this study.

The TWG meetings were forums for information transfer, detailed discussion, and decision making relative to biological and technical aspects of fish passage facility alternative development. Of primary importance were the discussion, interpretation, and formulation of design criteria. Participants attending these meetings included representatives from the following organizations:

- WDFW (Subcommittee and TWG participant)
- U.S. Fish and Wildlife Service (USFWS) (Subcommittee and TWG participant)
- USACE (Subcommittee and TWG participant)
- NOAA Fisheries (Subcommittee and TWG participant)
- WDOE (Subcommittee and TWG participant)
- Quinault Indian Nation (Subcommittee participant; invited to participate in the TWG)
- Cowlitz Indian Tribe (TWG participant)
- State of Washington Consultant Study Team (Subcommittee and TWG participant)

In addition to the Subcommittee and TWG meetings, the design team met separately with WDFW and NOAA Fisheries to discuss specific aspects of the design.

The Quinault Indian Nation and the Confederated Tribes of the Chehalis Reservation have been invited to participate in the TWG but at the time this document was written have not attended or participated in these meetings.

Meeting dates, agenda, and notes resulting from both the 2016-2017 Subcommittee meetings and the 2023-2024 TWG meetings are included in Attachment 1 and form a basis for criteria refinement and identification of key assumptions necessary to continue engineering development of potential fish passage facilities.

3.2 Biological Design Criteria

In 2016, the Washington state legislature created the Chehalis Basin Strategy, tasking participants with “designing and implementing on-the-ground projects to restore aquatic habitats and protect residents from flood damage”. As part of the Chehalis Basin Strategy, WDFW has led an extensive field sampling program to collect data and better understand the phenology, abundance, habitat requirements, distribution, and migration patterns of fish present within the

Chehalis River, and more specifically, in the potentially affected areas of the FRE structure and reservoir inundation limits. Using new and historically available data, WDFW assisted the Subcommittee with biological criteria development in collaboration with other participating Subcommittee members. The three primary types of biological design criteria that have the most influence on facility type, size, and configuration relate to the following:

- **Selected Species and Migration Timing:** Informs the selection of species and life stages targeted for fish passage design as well as their seasonality, anticipated hydrologic conditions, and duration of periods where these target fish species may be expected to migrate upstream and/or downstream of the dam location.
- **Species Abundance:** Informs the annual number of fish that require passage as well as the peak daily rate of migration that influences facility size and operation requirements.
- **Trapping and Holding Criteria:** Informs the requirements for fish trapping and holding, including, but not limited to, holding volume, duration, temperature, and water supply.

Biological design criteria, including target species and migration timing, species abundance, and trapping and holding criteria for the Proposed Project are discussed in the following subsections.

3.2.1 General Biological Design Criteria

General biological design criteria apply to all project components where fish passage must be maintained (i.e., fish passage conduits, FFPF, permanent Chehalis River and Crim Creek channels, and Chehalis River and Crim Creek construction bypass channels), unless stated otherwise.

3.2.1.1 Selected Species Migration and Timing

The selection of fish species and life stages for fish passage design was derived from field-specific data obtained by WDFW in 2015 and 2016 in addition to readily available historical documentation developed for the Chehalis Basin. In general, Washington State interprets its regulatory authority (Revised Code of Washington 77.57.030, *Fishways required in dams, obstructions penalties, remedies for failure*) to require provisions for passage of all fish and fish life stages believed to be present in the system. For development of the general fish passage criteria, anadromous and resident species known to occur within the influence of the FRE structure, in the inundation area of the associated reservoir, and upstream of the reservoir were selected for both upstream and downstream passage. These primary species and their known swimming and leaping abilities were used to influence development of specific technical design criteria. Species known to occur downstream of the dam site were selected for consideration but did not directly influence the development of specific technical design criteria.

The life histories and specific life stages of each target species were also considered relative to their known occurrence, distribution, and movement through the dam site. Life stages of specific species were selected if they have been observed moving or are believed to move through the dam site (either upstream or downstream).

Table 1 presents the target fish species and their respective life stages that were selected for the purposes of design development in this study.

Table 1. Target Fish Species and Life Stages Selected for Design Development

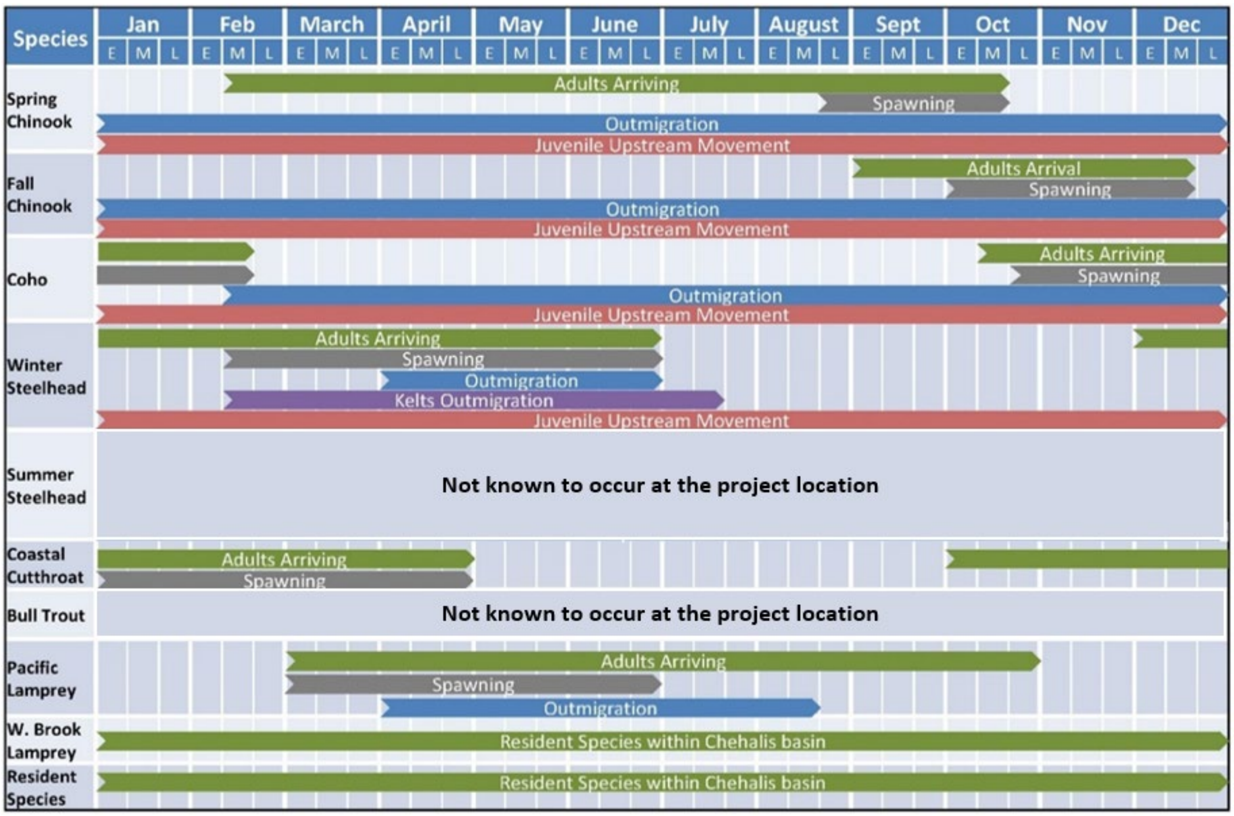
Species	Upstream	Downstream
Spring-run Chinook salmon	Adult, juvenile	Juvenile
Fall-run Chinook salmon	Adult, juvenile	Juvenile
Coho salmon	Adult, juvenile	Juvenile
Winter-run Steelhead	Adult, juvenile	Adult, juvenile
Coastal cutthroat trout	Adult, juvenile	Adult, juvenile
Pacific lamprey	Adult	Ammocoetes, Macropthalmia
Western brook lamprey	Adult	Ammocoetes, Macropthalmia
Resident fish, including: river lamprey, largescale sucker, Salish sucker, torrent sculpin, reticulate sculpin, riffle sculpin, prickly sculpin, speckled dace, longnose dace, peamouth, northern pikeminnow, redside shiner, rainbow trout, mountain whitefish	Adult	Adult

Bull trout are believed to occur only downstream of the proposed dam location, so were removed by the Subcommittee/TWG as a target species. Of the species and life stages targeted for upstream passage, juvenile salmonids, resident fishes, and lamprey exhibit the most variable life history, are the weakest swimmers, and represent the most challenging species and life stages requiring passage. Therefore, technical design criteria used to target the passage requirements of these species and life stages are believed to also accommodate the requirements of bull trout.

Passage technologies for lamprey are relatively new, and few facilities exist in the western United States that target lamprey for passage or collection and transport above dams. Where applicable, readily available best practices, lessons learned from experimental facilities on the Columbia River, and interviews with researchers who specialize in understanding lamprey behavior and navigational capabilities were used to inform lamprey passage facility requirements and anticipated performance. In addition to salmonids and the anadromous Pacific lamprey, multiple resident fish species and two species of resident lamprey (western brook and river) are believed to inhabit and transit the proposed dam area (Table 1). Therefore, these resident species are also included as target species.

Many of the target species are known to have unique migration behaviors and believed to pass upstream or downstream through the dam site at specific times of the year. Fish species migration timing and duration influence the design and operation of proposed fish passage facilities by defining the physical, operational, and environmental conditions expected to occur while passage is required. The migration timing and duration for each selected fish species and life stage were discussed at Subcommittee/TWG meetings as new information was collected in the field and from literature sources. The resulting conclusions were used in fish passage design development (Figure 1).

Figure 1. Anticipated Migration Periods of the Targeted Species and Life Stages (Periodicity)



The selected values provide a summary of upstream migration, spawning, and outmigration periods suitable to inform robust fish passage designs. The periods shown in Figure 1 incorporate anecdotal data of species presence at the extreme ends of known movement periods and thereby are potentially broader than what may actually be found in the river. Aquatic target species' actual migration and spawning periods are far more complicated and nuanced.

3.2.1.2 Species Abundance

Fish abundance was evaluated by WDFW and discussed during Subcommittee meetings. Abundance was described in terms of peak annual and peak daily rates of migration. The peak daily rate of migration for both upstream and downstream migrating fish influences the size of many fish passage component alternatives. The following subsections summarize the conclusions from two references developed by WDFW (2016a and 2016b). These results were consulted for the purposes of design development during this study.

Upstream Migration

Upstream migration rates were estimated based on two factors: 1) historic data relative to adult spawner survey results and escapement records, and 2) proposed annual peak goals after project implementation and potential habitat restoration. Table Table 2 provides the peak rate of annual migration for adult salmonids moving upstream.

Table 2. Peak Number of Annual Upstream-Migrating Fish

Species	Peak Annual Migration
Spring-run Chinook salmon	1,350
Fall-run Chinook salmon	3,900
Coho salmon	12,900
Winter-run Steelhead	5,630

Numbers for adult upstream migrating Pacific lamprey, cutthroat trout, resident fish, and juvenile salmonids have not been estimated. Although these species are an important influence on the overall design of each fish passage alternative, their peak rate of migration is currently unknown and not anticipated to significantly influence facility size to the extent of adult salmonids.

The peak daily counts of salmon and Steelhead migrating upstream were estimated as 10 percent of the maximum annual run (WDFW 1992), and peak hourly counts were estimated as 20 percent of the peak daily count based on Bell (1991) and as cited in NOAA Fisheries (2011). Applying both criteria results in the peak hourly count being 2 percent of the annual run for each species. Using this methodology and based on the run timing information in the periodicity chart (Figure 1), a combined peak daily count of roughly 2,000 adult salmonids and a peak hourly count of 400 adult salmonids was used for design purposes.

Downstream Migration

Table 3 summarizes the total abundance numbers recommended for use in design of downstream fish passage for juvenile salmon and Steelhead. These values represent sub-adult fish migrating downstream to the location selected for the dam.

Table 3. Predicted Abundance of Juvenile Salmon and Steelhead that will Migrate Downstream from Freshwater Habitat above River Mile 108 of the Chehalis River

Species	Life Stage	Migration Period	Maximum Abundance
Coho salmon	Fall parr	September - December	340,000
	Spring smolt	March - June	17,000
Steelhead trout	Fall parr	September - December	97,000
	Spring smolt	March - June	14,500

Species	Life Stage	Migration Period	Maximum Abundance
Chinook salmon	Subyearling (fry)	January - April	229,000
	Subyearling (parr/smolt)	May - August	114,500
	Yearling	March - June	11,000
Other species	Data unavailable to support conclusions regarding downstream migration.		

For spring smolts, freshwater capacity and migration timing were used to predict total daily arrivals between January and August using two example migration curves originating from other river systems. Timing curve 1 represented a free-flowing river (Coweeman River), whereas timing curve 2 represented a dammed river where smolts rear in cooler stream temperatures and navigate a reservoir during their downstream migration (Cowlitz River). The expected daily numbers (mean and maximum values) of downstream migrants were similar between the two migration timing curves when all species were included. However, when only Coho salmon and Steelhead trout were included, mean and maximum values were higher under timing curve 1 than timing curve 2. The difference between the two scenarios results from the smolts of Coho salmon and Steelhead trout having a more protracted migration timing under timing curve 2 than timing curve 1.

For fall migrants, timing curves were not available, and daily numbers were approximated based on available information (WDFW 2016a and 2016b). Estimates of daily numbers of fall migrants were based on the maximum daily values derived for spring smolts of Coho salmon and Steelhead trout increased by a multiplier of 17.0. The resulting maximum daily abundance selected for design purposes is therefore 55,505 smolt as indicated in Table 4.

Table 4. Predicted Daily Numbers of Juvenile Salmon and Steelhead Originating from Freshwater Habitat Upstream of River Mile 108 in the Chehalis River

Daily Metric	Spring Smolts (Jan Aug)		Spring Smolts (Jan Aug) Coho and Steelhead Only		Fall Smolts (Sep Dec) Coho and Steelhead Only	
	Daily Abundance		Daily Abundance		Daily Abundance	
	Timing 1	Timing 2	Timing 1	Timing 2	Timing 1	Timing 2
Mean	1,919	1,882	203	82	3,451	1,394
Maximum	11,013	10,935	3,265	668	**55,505**	11,356

3.2.1.3 Resident Fish

Guidelines have been established by NOAA Fisheries (2011) and WDFW (2000a, 2000b) for salmonid passage facility design, but little data exists regarding the passage of lamprey and resident fish species through fish passage facilities. The Subcommittee, with support from the team's USFWS representative, assembled relevant biological data for the target resident species, lamprey, and salmonids. The Subcommittee was not able to find data on all target resident species. A summary of the data compiled for each species is provided in Table 5. Through continued collaboration with the TWG, all fish passage is being designed to accommodate these resident species listed in Table 5 to the extent possible, and without adversely affecting facility performance for listed priority species (salmonids and lamprey).

Table 5. Locomotive and Biological Data Availability

Species		Data Collected*	
Life Stage	Common Name	Swim Speed	Jump Height
Adult	Spring-run Chinook salmon	●	●
Adult	Fall-run Chinook salmon	●	●
Adult	Coho salmon	●	●
Adult	Winter-run Steelhead	●	●
Adult	Summer-run Steelhead	●	●
Juvenile	Spring-run Chinook salmon	●	●
Juvenile	Fall-run Chinook salmon	●	●
Juvenile	Coho salmon	●	●
Juvenile	Winter-run Steelhead	●	●
Juvenile	Summer-run Steelhead	●	●
Adult	Coastal cutthroat trout	●	●
Adult	Bull trout	●	●
Adult	Pacific lamprey	●	Not applicable
Adult	Western brook lamprey	●	Not applicable
Adult	River lamprey	●	Not applicable
Adult	Largescale sucker	●	
Adult	Salish sucker	●	
Adult	Torrent sculpin	Not applicable	
Adult	Reticulate sculpin	Not applicable	
Adult	Riffle sculpin	Not applicable	
Adult	Prickly sculpin	Not applicable	

Species		Data Collected*	
Life Stage	Common Name	Swim Speed	Jump Height
Adult	Speckled dace	●	
Adult	Longnose dace	●	
Adult	Peamouth	●	
Adult	Northern pikeminnow	●	
Adult	Redside shiner	●	
Adult	Rainbow trout	●	
Adult	Mountain whitefish	●	

● = Indicates a data source was identified

3.2.2 FFPF-Specific Biological Design Criteria

Biological criteria for the FFPF which differ from the general fish passage criteria discussed in Section 3.2.1 are identified in the following subsections.

3.2.2.1 Selected Species Migration and Timing

For development of the FFPF, anadromous and resident 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. Refer to Table 1 for specific species and life stages selected for design. Fish species migration timing and duration used for design of the FFPF follows the criteria discussed in Section 3.2.1.1 and shown in Figure 1.

3.2.2.2 Species Abundance

Upstream migration rates used for FFPF design follow the general biological fish passage criteria discussed in Section 3.2.1.2. Facilities for downstream migration are not proposed for the FFPF design.

Downstream passage of juvenile salmon and Steelhead is provided via the fish passage conduits when they are open. Downstream passage of outmigrating fish will be delayed during impoundment events coincident with flood retention activities. Because the primary flood control gates are almost closed and water is retained upstream of the dam, outmigrating fish entering the impoundment at this time would also be temporarily retained.

Upstream passage of juvenile salmon and Steelhead is provided via the fish passage conduits when they are open. Upstream migration of juvenile species through trap and transport facilities has been documented and is expected to occur at some level during FFPF operations. Although the FFPF is not proposed to be specifically designed for upstream passage of juveniles, juveniles may pass through the facility and their collections is expected to occur to some degree. The same holding, sorting, and transport facilities for adults will also be used for juveniles (HDR 2017, RPDR Appendix G).

3.2.2.3 Resident Fish

FFPF design criteria for resident fish do not differ from the general biological fish passage criteria discussed in Section 3.2.1.3; however, through collaboration with the Subcommittee and continued collaboration with the TWG, the FFPF is being designed to accommodate trap and transport of resident species to the extent possible, and without adversely affecting facility performance for priority species (salmonids, cutthroat trout, and lamprey).

Trap and transport of resident species will be accommodated through incorporation of a separate low volume, low velocity entrance, fish ladder, hopper, and transport tank. Based on known swim speeds for resident species, the species will be able to enter the low volume, low velocity entrance and continue migrating upstream in the juvenile fish ladder via orifices. Because the design team was unable to locate data to inform how many resident or juvenile fish may enter the low volume, low velocity entrance and ascend the fish ladder, it was decided that the hopper and transport tank for the juvenile/resident fish ladder will be sized to match the hopper for adult salmonids. Similarly, because there is little data available regarding trap and holding requirements for the target resident fish species, the juvenile and resident fish hopper and transport tank were sized using adult salmonid criteria.

3.2.2.4 Trapping and Holding Criteria

The criteria for fish trapping and holding are specific to the FFPF and are provided in Table 6 Table and Table 7.

Table 6. Trapping and Holding Criteria

Criteria	Value	Reference
Holding duration holding gallery	• 24 hours, maximum	NMFS (2011)
Holding duration hopper and transport tank	• 24 hours, maximum • 1/2 hour, maximum during peak run rates	NMFS (2011)
Temperature	• 50°F	NMFS (2011)
Dissolved oxygen	• 6 to 7 parts per million	NMFS (2011)
Water supply, holding, fry	• 0.0075 gallons per minute (gpm) per fish	Piper et al. 1982
Water supply, holding, smolts	• 0.13 gpm per fish	Piper et al. 1982
Water supply, holding, adults	• 0.67 gpm per fish	NMFS (2011)

Criteria	Value	Reference
Adult jump provisions	• Required	NMFS (2011)
Segregation of fish	• Capability required	Not applicable
General	Decrease poundage of fish held by 5% for every degree over 50ºF	

NMFS = NOAA National Marine Fisheries Service, or NOAA Fisheries

Table 7. Fish Size, Holding Volume, and Long-Term Holding Flow Criteria

Species	Average Assumed Weight/Fish (pounds)	Long-Term Holding: Flow/Fish (gpm)	Holding Volume (cubic feet/pound)
Spring-run Chinook salmon	23	1	0.25
Fall-run Chinook salmon	23	1	0.25
Coho salmon	9.5	0.5	0.25
Winter-run Steelhead	9	2.0	0.25
Summer-run Steelhead	8	2.0	0.25
Coastal cutthroat trout	1	Unknown	0.25
Lamprey	Unknown		
Resident species	Unknown		

Holding volume and long-term holding flow requirements per NOAA Fisheries (NMFS 2011)
Long-term flow requirements are for emergency situations where fish must be held for more than 72 hours
Adult fish sizes per Bell (1991).

Fish holding volume requirements do not change based on the amount of time held. However, flow requirements are contingent upon holding time, and fish held longer than 72 hours require more flow than fish held less than 72 hours. The Subcommittee did not address fish holding periods during emergencies (e.g., a situation where washed-out roads prevent fish transportation activities). Fish holding during emergency situations where holding may be required for more than 72 hours will be addressed during the next phase of design development. Flow requirements for long-term holding are provided in Table 7 for reference.

Volume and flow needed for the holding gallery, fish hoppers, and transport tanks were determined using the trapping and holding criteria presented in Table 6 and the peak daily and hourly number of fish as determined in the general biological fish passage criteria discussed in Section 3.2.1.2. The number of fish used to size these design elements is as follows:

- Holding gallery
  - Flow: Peak daily number of fish
  - Volume: Peak daily number of fish

- Hopper
  - Flow: Half the peak hourly number of fish
  - Volume: Half the peak hourly number of fish
- Transport tank
  - Flow: Not applicable
  - Volume: Half the peak hourly number of fish

To limit their size, the hoppers hold half the peak hourly count of fish. Fish hoppers will be emptied frequently during peak short-term runs (e.g., every 20 minutes). However, during most of the trapping period, it is expected that low numbers of fish will enter the low volume, low velocity entrance each day, and as such the hopper will be emptied less frequently (e.g., every few hours). While the hopper may hold fish for up to 24 hours, it will be operated such that no more than half the estimated peak hourly fish rate of migration is held at a time. Receptacles for life support systems will be provided on the outside wall of the hopper vessel (e.g., oxygen tanks). Use of such equipment will be evaluated based on need during the commissioning and demonstration period.

Calculations determining the adult holding gallery, and hopper and transport tank sizes are provided in Table 8 and Table 9, respectively.

Table 8. Adult Holding Gallery Sizing

Criteria	No. of Fish	Pounds of Fish	Cubic Feet Required	Flow (gpm)
Spring-run Chinook salmon	135	3,105	776.25	
Coho salmon	1,290	12,255	3,063.75	
Winter-run Steelhead	563	5,067	1,266.75	
Subtotal	1,988	20,427	5,107	
Factor of Safety (20%)	-	-	1,022	
Total	**1,988**	**20,427**	**6,130**	**1,332**

Holding gallery sized for 1 day of peak-day run.
Factor of safety only applied to cubic feet required.

Table 9. Hopper and Transport Tank Sizing

Criteria	No. of Fish	Pounds of Fish	Cubic Feet Required	Flow (gpm)
Adult hopper and transport tank	200	2,043	511	134
Juvenile/resident hopper and transport tank	Same as adult hopper and transport tank			

Juvenile/resident hopper and transport tank sized to match adult hopper and transport tank.

3.3 Technical Design Criteria

This section identifies technical design criteria, sources, and guidance relevant to the development of fish passage designs. Technical fish facility design criteria typically fall into two categories: criteria and guidelines. Criteria are specific standards for fish passage design that require an approved variance from the governing state or federal agency before a design can deviate from the established criteria. Deviating from an agency-established criterion requires establishing a site-specific, biological- or physical-based rationale for the deviation. In contrast, guidelines provide a range of values, or in some instances, specific values that the designer should seek to achieve, but that can be adjusted in light of project-specific conditions, if needed, to achieve the overall fish passage objectives by supporting better performance or solving site-specific issues. Adjustments to a design may be requested by the governing agencies during development of the design.

The technical design criteria used in the RPD were primarily developed in previous design phases and documented in previous design documents. The technical design criteria for the constructed channels (Section 3.3.1.4) is the only technical design criteria that utilize current design guidance. The technical design criteria will be updated in future design development in accordance with current design guidelines, such as NMFS (2022a) instead of NMFS (2011), and the design criteria will be updated accordingly. If two or more agencies provide differing guidance on a design criterion, the most conservative guidance for fish passage and protection will be followed. The following documents provide the guidelines that were used during previous conceptual design:

- Anadromous Salmonid Passage Facility Design (NMFS 2011)
- Best Management Practices to Minimize Adverse Effects to Pacific Lamprey (USFWS 2010)
- Draft Fishway Guidelines for Washington State (WDFW 2000a)
- Draft Fish Protection Screen Guidelines for Washington State (WDFW 2000b)
- Water Crossing Design Guidelines (WDFW 2013)

3.3.1 General Technical Design Criteria

Technical design criteria for each fish passage component of the Proposed Project are discussed in the following subsections. General fish passage criteria apply to all project components where fish passage must be maintained (i.e., conduits, FFPF, and construction bypass), unless shown otherwise.

3.3.1.1 Fish Passage Conduits

The fish passage conduits are intended to provide year-round, safe, volitional upstream and downstream passage for migrating adult salmon and Steelhead, resident fish, and lamprey for the full range of fish passage flow conditions as required by NOAA Fisheries criteria. During a 2014 study (HDR 2014a through 2014e), the criteria for the fish passage conduits were based on WDFW (2013). The WDFW document suggests that a minimum hydraulic design target of 0.8 feet of water depth and maximum flow velocity of 2 ft/s be used for water crossing structures with lengths of approximately 200 feet. However, in consultation with members of the Fish Passage Technical Subcommittee in 2015 and 2016, it was determined that the natural flow characteristics in this reach of the river were more restrictive to passage than WDFW's guidelines. It was agreed that the hydraulic conditions in the natural channel upstream and downstream of the passage tunnels (fish passage conduits) would negate the passage benefit of designing the tunnels to WDFW's guidelines. Therefore, the Subcommittee concluded that the proposed flow velocity and depth through the conduits mimic the flow velocity and depth occurring naturally through the existing river reach at the dam. This premise influenced the overall approach towards designing and evaluating performance of upstream and downstream passage through the conduits.

This design approach was revisited and presented to WDFW, NOAA Fisheries, and the TWG during the course of this study. No objections were voiced as of the publication of this document. The location of the existing rock-incised channel is shown in the slides attached to the January 17, 2024 TWG meeting notes provided in Attachment 1.

3.3.1.2 Lamprey Passage

As requested by participating resource agencies and Indian Tribes, incorporation of the best available science relating to the passage of lamprey was considered throughout the design. As mentioned previously in Section 3.2.1.1 best practices, lessons learned from experimental facilities on the Columbia River, and interviews with researchers who specialize in understanding lamprey behavior and navigational capabilities were used to inform lamprey passage facility requirements. Key facility requirements related to the passage of lamprey are summarized in Table 10. The following resources outline a number of experimental facilities and best practices focusing on passing lamprey upstream which were used to form a basis of design for lamprey passage technologies and measures:

- Best Management Practices to Minimize Adverse Effects to Pacific Lamprey (USFWS 2010)
- Adult Pacific Lamprey Passage: Data Synthesis and Fishway Improvement Prioritization Tools (Keefer et al. 2012)
- Pacific Lamprey and NRCS [Natural Resources Conservation Service]: Conservation, Management and Guidelines for Instream and Riparian Activities (USDA 2011).
- Pacific Lamprey Protection Guidelines (USDA 2010)
- Lamprey Passage in the Willamette Basin: Considerations, Challenges, and Examples (USFWS 2011)
- Adult Pacific Lamprey: Known passage challenges and opportunities for improvement (Keefer et al. 2014)

- Evaluation of Adult Pacific Lamprey Fish Passage at Snake River Dams (Stevens et al. 2015)

Table 10. Lamprey Upstream Passage Criteria

Criterion	Value	Reference
Flow Velocity (max.)	4 to 6 ft/s	USDA 2010
Wall Finish	Smooth	USDA 2010
Corner Geometry	Rounded	USDA 2010

3.3.1.3 Trashracks

Trashracks are commonly used at fishway exits and entrances to exclude large debris from entering fish passage facilities. Trashracks are also used at the fish passage conduits. Table 11 lists the design criteria for trashracks.

Table 11. Trashrack Criteria

Criterion	Value	Reference
Velocity	1.5 ft/s, maximum	NMFS 2011
Water depth	Equal to fish ladder exit pool depth	NMFS 2011
Bar spacing	10 inches, minimum	NMFS 2011
Support bar spacing	24 inches, minimum	NMFS 2011
Slope	1 horizontal 5 vertical	NMFS 2011

3.3.1.4 Constructed Channels

A reference reach design approach (WDFW 2013, NMFS 2022a) is utilized for the permanent Chehalis River approach and discharge channels and Crim Creek as well as for the construction phase Chehalis River and Crim Creek bypass channels. This approach was presented to WDFW, NOAA Fisheries, and the TWG during the course of this study. No objections were voiced as of the publication of this document. The locations of the reference reaches are shown in the slides attached to the January 17, 2024 TWG meeting notes provided in Attachment 1.

3.3.2 FFPF-Specific Technical Design Criteria

Technical design criteria for the FFPF that differ from the general technical fish passage criteria discussed in Section 3.3.1 are identified in the following subsections.

3.3.2.1 Fish Passage Conduits

Fish passage conduit design criteria is not applicable to the design of the FFPF as the fish passage conduits are not an available passage pathway when the FFPF is operating.

3.3.2.2 Fishway Criteria

Upstream fish passage designs at dams use widely recognized fishway design guidelines and references and are traditionally designed for the adult fish life stage. There are three major components to a fishway: fishway entrance, fish ladder, and fishway exit. Table 12, Table 13, and Table 14 list the criteria for each of these components.

Table 12. Fishway Entrance Criteria

Criterion	Value	Reference
Location	Easily located by fish	NMFS 2011, WDFW 2009
Width	4 feet, minimum	NMFS 2011
Depth	6 feet, minimum	NMFS 2011
Head differential, adults	1 - 1.5 feet	NMFS 2011, WDFW 2009
Head differential, juveniles	0.13 inches	NMFS 2011
Attraction flow	5% 10% of the maximum of the 5% exceedance flows for the migration period of each species	NMFS 2011
AWS energy dissipation factor	16 ft-lbs/sec/ft^3	NMFS 2011
AWS diffuser velocity, vertical	1 ft/s, maximum	NMFS 2011
AWS diffuser velocity, horizontal	0.5 ft/s, maximum	NMFS 2011
AWS diffuser bar Spacing	1.75 millimeters, maximum (juvenile criterion)	NMFS 2011
Fish burst speed	27 ft/s, maximum	Bell 1991, pg. 6.3 (Steelhead)
Fish burst duration	10 seconds, maximum	Bell 1991, pg. 6.2
Depth required for jumping	2 feet, minimum	USDA Forest Service Handbook 2090.21, 22.6 – Exhibit 01 Adult Salmonid Migration Blockage Table (adapted 2001)

AWS – auxiliary water supply; ft-lbs/sec/ft^3 = foot-pounds per second per cubic foot

Table 13. Fish Ladder Criteria

Criterion	Value	Reference
Head differential, juveniles	0.7 feet, maximum	NMFS 2011
Head differential, adults	1.0 feet	NMFS 2011
Energy dissipation factor	2 ft-lbs/sec/ft^3 (juvenile criterion)	NMFS 2011
Turning pool	Radius corners	NMFS 2011, WDFW 2009
Pool width	6 feet, minimum	NMFS 2011
Pool length	8 feet, minimum	NMFS 2011
Pool depth	5 feet, minimum	NMFS 2011
Baffle orifice dimensions	18 inches high x 15 inches wide	WDFW 2009
Freeboard	3 feet, minimum	NMFS 2011, WDFW 2009

Table 14. Fishway Exit Criteria

Criterion	Value	Reference
Head differential	0.25 to 1.0 feet	NMFS 2011
Length	2x fish ladder pool length	NMFS 2011
Location	Along the shoreline Downstream current < 4 ft/s Minimize fallback	NMFS 2011, WDFW 2009
Coarse trashrack velocity	1.5 ft/s, maximum	NMFS 2011
Coarse trashrack water depth	Equal to fish ladder exit pool depth	NMFS 2011
Coarse trashrack bar spacing	10 inches, minimum	NMFS 2011
Coarse trashrack support bar spacing	24 inches, minimum	NMFS 2011
Coarse trashrack slope	1H:5V	NMFS 2011

The Fish Passage Technical Subcommittee identified two types of fish ladders that were expected to provide the best performance for target and resident species: half-Ice Harbor fish ladder and vertical slot fish ladder. Hydraulic analysis of half-Ice Harbor and vertical slot-type fish ladders resulted in calculated orifice and slot velocities of 4.1 ft/s and 4.8 to 5.0 ft/s, respectively for passage of juvenile and resident fish. Data collected on the swimming speeds of target and resident fish indicate burst swimming speeds as low as 3.5 ft/s. Given that the half-Ice Harbor-type ladder is believed to provide lower through-orifice velocities and therefore better passage performance than the vertical slot-type fish ladder, it was selected as the preferred type of fish ladder.

3.3.2.3 Lamprey Passage

Lamprey passage design criteria used for design of the FFPF follow the general technical fish passage criteria discussed in Section 3.3.1.2. Additional design criteria were identified for conceptual design of the FFPF lamprey passage components (Table 15). These design criteria are based on the same resources identified in the general fish passage criteria for lamprey passage.

Table 15. Lamprey Passage Design Criteria

Criteria	Value	Reference
Flow velocity	6 ft/s, maximum	USDA (2010)
Ramp width	1.0 foot minimum	USACE (2015)
Distance between resting pools	20 feet maximum	USACE (2015)
Water depth in ramp	3 inches, minimum	USACE (2015)
Wetted surface finish	Smooth	USACE (2015)

3.3.2.4 Trashracks

Trashrack design criteria used for FFPF design follow the general technical fish passage criteria discussed in Section 3.3.1.3.

3.3.2.5 Fish Screen and Bypass

A downstream passage system consists of five major components:

- Fish screens (Table 16) to protect juvenile fish from entrainment or impingement.
- A bypass channel (Table 17). The bypass channel conveys the fish and is often located adjacent to the fish screens.
- A bypass entrance (Table 18) located at the end of the fish screens.
- A bypass conduit (Table 19), which conveys fish from the bypass entrance to a point of release downstream (bypass exit).
- A bypass exit (Table 20) located at the end of the bypass conduit.

Table 16. Fish Screen Criteria

Criterion	Value	Reference
Approach velocity, Va	0.4 ft/s	NMFS 2011
Sweeping velocity, Vs	Vs > Va and ∆Vs ≥ 0	NMFS 2011, WDFW 2009
Screen orientation (river)	Parallel to flow	NMFS 2011, WDFW 2009
Screen orientation (reservoir)	As required to maximize fish attraction	NMFS 2011, WDFW 2009
Screen type	Wedgewire or profile bar	n/a
Screen opening	1.75mm	NMFS 2011
Screen open area	27% minimum	NMFS 2011, WDFW 2009
Screen cleaning	Automatic	n/a
Head differential to start automated screen cleaning	0.1 feet	NMFS 2011

Table 17. Bypass Channel Criteria

Criterion	Value	Reference
Acceleration, Ac	0.2 ft/s/ft > Ac > 0	NMFS 2011
Bypass entrance Location	At downstream end of screens	NMFS 2011
Capture Velocity, Vc	Vc ≥ 8 ft/s	Stakeholder input

Table 18. Bypass Entrance Criteria

Criterion	Value	Reference
Flow control	Independent & at bypass entrance	NMFS 2011
Velocity, Ve	Ve > 110% of bypass channel velocity	NMFS 2011, WDFW 2009
Capture velocity, Vc	Vc ≥ 8 ft/s	Stakeholder input
Width	18 inches, minimum	NMFS 2011, WDFW 2009
Depth of water over weir	1 foot min	NMFS 2011

Table 19. Bypass Conduit Criteria

Criterion	Value	Reference
Flow	Approx. 5% of screened flow	NMFS 2011
Flow type	Open channel	NMFS 2011, WDFW 2009
Water depth	40% of channel diameter or width and 9 inches minimum	NMFS 2011 and WDFW 2009, respectively
Velocity, goal	6 ft/s to 12 ft/s	NMFS 2011
Velocity, minimum	2 ft/s	NMFS 2011
Velocity, maximum	30 ft/s	WDFW 2009
Material	Smooth interior surfaces, walls, joints	NMFS 2011, WDFW 2009
Closure valves	None allowed within conduit	NMFS 2011, WDFW 2009
Hydraulic jumps	None allowed within conduit	NMFS 2011, WDFW 2009

Table 20. Bypass Exit Criteria

Criteria	value	reference
Velocity	25 ft/s, maximum	NMFS 2011, WDFW 2009
Location	• Strong downstream current • Sufficient depth to avoid fish injury • Minimize adult attraction	NMFS 2011, WDFW 2009

The FFPF conceptual design includes the use of pumped flow from the dam stilling basin to supply flows to multiple FFPF components. The intake for the pump station is designed in accordance with the Hydraulic Institute's (2012) pump intake design guidelines and NOAA Fisheries salmonid passage facility design guidelines (NMFS 2011). The intake to the pump station will be screened according to NOAA Fisheries (NMFS 2011) guidelines, which include the values shown in Table 21.

Table 21. Intake Screen Design Criteria

Criteria	Value
Screen bar spacing	1.75 millimeter
Approach velocity	0.40 ft/s, maximum
Screen cleaning	Active

3.3.2.6 Freeboard

The elevation of the finished ground at the sorting facility and the exterior walls of the fish ladder and the pump station will have a top elevation no less than 6 feet of freeboard above the 100-year flood elevation.

3.3.2.7 General Operating Criteria

Operating criteria used for FFPF design follow the general technical fish passage criteria discussed in Section 3.3.1. Additional operating criteria specific to FFPF design are discussed below.

The FFPF is intended to collect migrating adult salmonids, juvenile salmonids, resident fish, and lamprey moving upstream during an impoundment event and safely transport them upstream of the FRE structure. While adult salmon and Steelhead only pass upstream during certain periods of the year, the FFPF must be capable of operating at any time of year to accommodate Cutthroat trout, resident fish, lamprey, and juvenile salmonids that currently traverse this reach of the Chehalis River and may wish to move upstream.

Operational trigger, operating rules, and operational frequency for impoundment events is described in RPDR Appendix J. It is worth noting that water will also be impounded in the reservoir when the natural flow of the river is greater than the capacity of the fish passage conduits, but not large enough at Grand Mound to trigger an impoundment event. Such situations are estimated to occur approximately once per year and last an average of 1 day. During these water retention events, the fish passage conduit gates would not be operated and remain fully open, and operation of the FFPF would not be required. Impoundment events in this TM refer to flood operations triggered by high flows at Grand Mound and do not include events where some water is retained in the reservoir due to high flows at the dam but not at Grand Mound.

Downstream passage of outmigrating fish will be delayed during impoundment events coincident with flood retention activities. Because the primary flood control gates are almost closed and water is retained upstream of the dam, outmigrating fish entering the impoundment at this time would also be temporarily retained. The passage of fish downstream would occur as the flood operations cease and the reservoir is drained. Downstream passage would resume as normal operations of the dam structure resume.

In addition, the FFPF fish passage facility will have to be maintained throughout its dormant periods to ensure that it is ready to operate with less than 48 hours’ notice. The following operating criteria define how design elements of the FFPF will operate, what components of the facility must be maintained, and how often maintenance will be required.

Operation Schedule

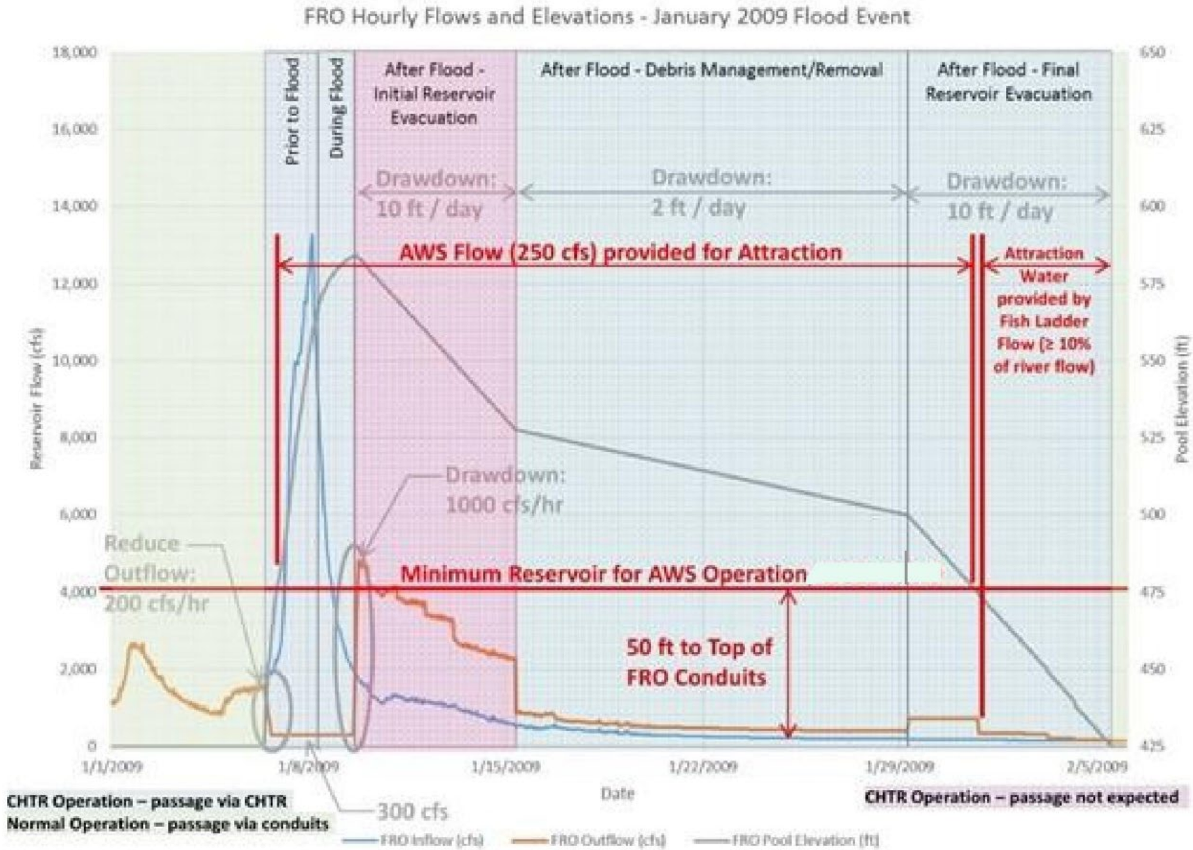
The FRE structure is operated as a flow-through dam for flood control. Fish passage past the FRE structure takes place under normal operating conditions via fish passage conduits through the dam that are placed at river grade. The dam will impound water during anticipated floods at

Grand Mound, Washington (impoundment events). Upstream fish passage is continuously provided during impoundment events by opening and operating the FFPF. Upstream fish passage via the FFPF will be designed to operate for 24 hours a day, 7 days a week for the full duration of each impoundment event.

Auxiliary Water Supply

Fish ladder flow is supplemented by an AWS to meet the fish ladder entrance attraction guidelines provided by NOAA Fisheries guidelines (NMFS 2011). The Fish Passage Technical Subcommittee agreed that the auxiliary flow should be sufficient to meet the 300 cubic feet per second (cfs) attraction flow requirement described in Section 4.1.2.3 (HDR 2018b). The Subcommittee further agreed auxiliary water could be provided solely via gravity from the impoundment pool when the impoundment pool depth exceeded 50 feet above the crown of the highest operating outlet. However, this would result in periods during FFPF operation when additional attraction water (i.e., AWS) would not be provided because the depth in the reservoir was too low (e.g., about half of January 6, 2009 and approximately January 31, 2009 through February 5, 2009 in Figure 2). Despite this, the attraction water requirements (10 percent of river flow) are still met during most of the time the AWS is not operating (e.g., approximately February 1, 2009 through February 5, 2009 in Figure 2) because the fish ladder flow alone provides attraction flow greater than 10 percent of the river flow. The periods where AWS flow is not provided were also accepted by the Fish Passage Technical Subcommittee (Attachment 1). Figure 2 shows when attraction water guidelines are met and when auxiliary water may be supplied via gravity (without the use of pumped flow) for a sample impoundment period. In the event that gravity flow cannot be provided and flow from the fish ladder does not meet NOAA Fisheries criteria for attraction, auxiliary water is provided via a pump station.

Figure 2. Attraction Water and Auxiliary Water Supply Durations during a Sample Impoundment Event



4.0 Fish Passage Design

This section summarizes the fish passage facility design, including the fish passage conduits, FFPF, permanent river channels, and construction bypass channels.

It should be noted that the FFPF design has not substantially changed from the original conceptual design. Elements of the FFPF that are site-specific, including the fish ladder entrances, the FFPF water supply, and the physical location of the individual FFPF components (i.e., sorting building, fish ladder) were relocated to the current Proposed Project site. Other elements of the FFPF (i.e., the internal components of the FFPF) function the same as the original design, were not advanced during the course of this study, and remain valid.

4.1 Design Flows

Flows used for fish passage design at the project site are summarized in the following subsections.

4.1.1 Fish Passage Conduits and Permanent River Channels

The design flows used for the RPD for the fish passage conduits and constructed river channels – 3,400 cfs to 14 cfs – were determined using *NOAA Fisheries West Coast Region Guidance to Improve the Resilience of Fish Passage Facilities to Climate Change* (NMFS 2022b). The fish passage conduits have a life expectancy greater than 10 years so determination of the fish passage design flows for the fish passage conduits must follow the process for long-term projects defined in Section 2.3 of the guidance. This process is underway and collaboration with NOAA Fisheries is on-going at the time of publication of this report. Since development of fish passage design flows incorporating climate change following NOAA Fisheries guidance is not complete, interim fish passage design flows incorporating climate change have been adopted for use in the design in collaboration with NOAA Fisheries.

Climate change information is incorporated into the fish passage design flows using peak flow scalars that were derived from the 12 global climate models produced by WDOE's consultants for the SEPA EIS (WSE 2023). The late-century ensemble average maximum scalar (+55 percent) is applied to the historic high fish passage flow. The historic high fish passage flow is 2,200 cfs, corresponding to 5 percent exceedance (HDR 2017). The mid-century average minimum scalar (-14 percent) is applied to the historic low fish passage flow. The historic low fish passage flow is 16 cfs, corresponding to the 95 percent exceedance (HDR 2017). The high and low fish passage design flows used in the design of the fish passage conduits documented in this report are 3,400 cfs and 14 cfs, respectively. These climate change scalars are conservative. This approach to approximating fish passage design flows incorporating climate change conditions is conservative and consistent with a conceptual level of design development. See Section 6.0 for future development of fish passage design flows in accordance with current NOAA Fisheries climate change guidelines (NMFS 2022b).

4.1.2 Flood Fish Passage Facility

Flows used in the design of the FFPF were documented in previously published documents and remain unchanged. The design flows for the FFPF have not been revisited as part of the fish passage design documented in this report. These design flows are incorporated as part of current fish passage design. These previously established design flows for the FFPF will be updated in future design development to be consistent with current NOAA Fisheries design guidance, including the incorporation of climate change (NMFS 2022b). See Section 6.1 for additional information.

4.1.2.1 FFPF Design Flows

Fish passage design flow criteria influence several factors associated with fish passage facility size and complexity. NOAA Fisheries and WDFW provide guidelines for the selection of high and low flows to be used in the design of fish passage facilities. Guidelines presented by NOAA Fisheries and WDFW are based on exceedance calculations of mean daily flows but can be modified to suit site-specific requirements. The exceedance flows statistically represent the flow equaled or exceeded during certain percentages of the time when migrating fish may be present. The established guidelines are used to set instream flow depths, flow velocities, debris and bedload conditions, fish attraction requirements, tailwater fluctuations, and numerous other factors that a facility might experience while target fish species are migrating.

NOAA Fisheries (NMFS 2011) requires the high fish passage design flow to be the mean daily stream flow that is exceeded 5 percent of the time during periods when target fish species are migrating. WDFW (2000b) suggests a 10 percent exceedance flow be used as a high design flow. NOAA Fisheries (NMFS 2011) requires a low fish passage design flow equal to the mean daily stream flow that is exceeded 95 percent of the time during periods when migrating fish are typically present. WDFW recommends that a low flow be established based upon site-specific conditions. A flow range between the 95 percent and 5 percent exceedance flows provides the widest range of flows for which facilities should be capable of passing fish, therefore, this flow range is set as the design criterion for the proposed facilities.

Mean daily flows at the proposed dam site were estimated by WSE (2014). WSE used a precipitation-weighted basin area ratio to relate the effective watershed area occurring above the proposed dam site to the effective watershed area occurring upstream of the USGS gage 12020000 near Doty. Mean daily flows from USGS gage 12020000 near Doty were reduced using this ratio in order to estimate mean daily flows at the proposed dam site for water years 1940 through 2012. An exceedance analysis was then performed on the estimated flows at the proposed dam site. Annual flow exceedance flows are summarized in Table 22.

The 5 and 95 percent exceedance flows at the dam site were developed based on the mean daily flows for water years 1940 through 2012 from USGS gage 12020000 near Doty and then listed for each adult species using their respective upstream migration timing. The lowest 95 percent exceedance flow and the largest 5 percent exceedance determined the fish passage design flow range that both FRE upstream fish passage facilities will be designed for. The lowest 95 percent exceedance flow is 16 cfs, which occurs during the Fall Chinook migration period. The highest 5 percent exceedance flow is 2,197 cfs, which occurs during the Coho migration period. Therefore, fish passage facilities were designed to operate from a low fish passage flow of 16 cfs to 2,200 cfs.

Table 22. Annual Flow Exceedance at the Proposed Dam Site

Percent of Time Exceeded	Flow (cfs)
99%	15
95%	19
90%	24
80%	37
75%	48
50%	171
25%	437
10%	960
5%	1,447
1%	2,957

Table 23. Flow Exceedance during Fish Migration Periods at the Proposed Dam Site

Fish Species and migration	95 Percent Exceedance (cfs; min design flow)	5 Percent Exceedance (cfs; max design flow)
Spring Chinook	18	882
Fall Chinook	**16**	1,592
Coho	36	**2,197**
Winter Steelhead	63	1,724
Coastal Cutthroat	34	1,908
Pacific Lamprey	17	737
Western Brook Lamprey	19	1,447

4.1.2.2 Tailwater and Reservoir Fluctuation Ranges

Anticipated tailwater fluctuations for the FRE structure are significant factors in determining the type, size, and complexity of the FFPF fish passage facility. The fish ladder and fish ladder entrance of the FFPF facility must provide a continuous hydraulic connection throughout the anticipated range of tailwater elevations. In addition, the pump station supplying water for the

FFPF facility that draws water from the tailwater pool must also accommodate the fluctuation in tailwater elevation without adversely affecting the water supply or endangering the facilities. As tailwater fluctuations become larger, the facilities become larger and more complex. In some cases, certain fish passage and water supply technologies can be dismissed because they are unable to accommodate large tailwater fluctuations.

Historical river flows were used to calibrate the HEC-HMS simulation model to estimate the flood flows (WSE 2019). HDR had performed hydraulic modeling of the stilling basin previously to develop a tailwater rating curve that associates the tailwater elevations in the stilling basin with flows passing through the stilling basin (HDR 2018a). The design fish passage flows and select floods associated with their respective tailwater elevations in the stilling basins are provided in Table 24.

Table 24. Tailwater Elevations for Fish Passage Design Flows and Select Floods

Flow Event	Flow (cfs)	Tailwater Elevation (feet)
Low fish passage design flow	16	417.0
High fish passage design flow	2,200	419.3

The FRE reservoir will only hold a pool during impoundment events. The WSEL in the reservoir will vary corresponding to the dam operations plan (Anchor QEA 2016). Operation of the reservoir during an impoundment event is presented in RPDR Appendix K. Flow past the dam is controlled by the conduits and AWS system for the FFPF during impoundment events until water in the reservoir reaches the spillway crest elevation of 628.0. Water above the spillway crest elevation will pass uncontrolled over the spillway and downstream of the dam. More detailed information describing the potential flood storage and spill operations for the structural alternatives is presented in the dam operations plan (Anchor QEA 2016).

4.1.2.3 Water Supply

Multiple design elements of the FFPF require water to operate. The design flows for each element are provided in Table 25. The basis for these design flows is provided in the following subsections.

Table 25. Water Supply Flows for FFPF Facility Elements

Design Element	Flow (cfs)
Adult AWS	200
Juvenile AWS	50
Adult fish ladder	25
Juvenile fish ladder	25

Design Element	Flow (cfs)
Lamprey ramp	4
Sorting facility	10
Intake backwash system	6

Auxiliary Water Supply

NOAA Fisheries (NMFS 2011) states that attraction flows from the entrance of the fish ladder should be greater than 10 percent of the high fish passage design flow. The minimum attraction flow for the FFPF facility should then be at least 220 cfs. However, the Subcommittee decided in its March 22, 2017, meeting that, because the minimum outflow during the early portion of the impoundment period was 300 cfs, as defined in the operations plan (Anchor QEA 2016), the attraction water flow for the FFPF should be increased to 300 cfs. It was agreed that providing a single source of attraction water from the ladder entrances into the stilling basin will improve the fish passage performance of the facility given that it represents the only navigable pathway for fish to ascend upstream. This is commonly observed at other facilities in operation where attraction water from the ladder is the primary source of flow that fish experience as they navigate upstream.

Gravity and Pumped Water Supply

Water is supplied to the FFPF facility via gravity throughout most of the FFPF operating period. When water levels in the reservoir are too low to supply water via gravity, water supply to the AWS is suspended and water supply to the adult fish ladder, juvenile fish ladder, lamprey ramp, and sorting facility is provided via pumping. The sorting facility consists of the sorting building, holding gallery, and surrounding area. A pump station draws water from the tailwater pool. The adult fish ladder, juvenile fish ladder, and lamprey ramp are supplied by a single pump or a set of pumps, depending on the amount of pumped flow required. A single backup pump will remain available for use if needed. A single pump will be provided to supply water to the backwash screen cleaning system for the pump station intake screens.

4.1.3 Construction Bypass

Since development of fish passage design flows following NOAA Fisheries (NMFS 2011) guidance is not complete and updated hydrology, including revised exceedance and flood flows, were in development and not available at the time of hydraulic modeling of these channels the fish passage design flows used in HDR (2017) have been adopted for use in the design documented in this report. The historic high fish passage design flow is 2,200 cfs, corresponding to 5 percent exceedance. The historic low fish passage flow is 16 cfs, corresponding to the 95 percent exceedance.

4.2 Flood Fish Passage Facility Upstream Release Sites

The locations of potential upstream fish release sites used as part of FFPF operation have not yet been identified. This is consistent with a conceptual level of design development. Potential specific locations will be developed in consultation with state and federal agencies based on existing redd data and review quality of each habitat and accessibility as part of WDFW Hydraulic Project Approval development.

Factors influencing the identification and selection of upstream fish release sites will be considered in selecting fish release locations, including the species, maturity, life history, time of year, preferred spawning habitat, potential for fallback and delay, and flow depth, velocity, and temperature of the receiving waters. Spawning studies conducted by WDFW identifying spawning locations in the project area, including in and upstream of the reservoir area, (WDFW 2017; WDFW 2018) will also be referenced early in discussions with state and federal agencies regarding potential upstream release locations. Selection of release locations will be consistent with state and federal fish passage guidelines (NMFS 2022a), such as releasing fish:

- a sufficient distance upstream of the dam and spillway so as to minimize potential for fallback;
- along the shoreline with sufficient flow to guide the fish to move upstream, acceptable velocities are generally less than 4 ft/sec;
- with a drop from the transport vehicle that is less than six vertical feet, with an impact velocity less than 25 feet per second; and
- into receiving waters that are greater than 3 feet deep.

Multiple modes of transportation are available to FFPF operators in transporting fish to upstream release sites. Access roads around and upstream of the FRE reservoir are identified in the RPDR. The access roads presented in this document are developed to a conceptual level. Minor changes to the access roads presented in this document may be made to provide access to upstream fish release locations when they are identified in collaboration with state and federal agencies. Access to upstream release locations may also be achieved by other means, such as boat, helicopter, or off-road vehicle.

4.3 Fish Passage Hydraulic Modeling Results

Hydraulic model results for fish passage conduits and permanent and construction bypass channels demonstrate depths and velocities at the high and low fish passage design flows similar to their analogous and reference reaches. Model results are provided in RPDR Appendix D and were presented to the fish passage TWG on January 17, 2024 (Attachment 1). The design of the conduits and channels was developed to a conceptual level of detail. This is reflecting in hydraulic modeling that utilizes uniform roughness for conduit and channel surfaces and does not incorporate large roughness elements. Nonetheless the velocity results indicate slower velocities along the margins of the channel, indicating that inclusion of roughness elements, velocity refugia, and variations in the channel cross section are likely to be successful in creating passage routes for weaker swimmers.

4.4 Flood Fish Passage Facility Fish Ladder Entrance and Stilling Basin Design

The entrances to the FFPF are located as far upstream in the river as possible (immediately downstream of the fish passage conduits) to improve the performance of the FFPF by minimizing the potential for false attraction. Multiple entrances are located within the stilling basin to prevent fall back. Juvenile and resident fish are the weakest swimmers of the target species (e.g., lower burst speeds, less energetic) therefore the juvenile/resident/lamprey entrance is located closest to the stilling basin endsill. All the water entering the river during portions of the FFPF operation comes out of the fish ladder entrances and passes over the stilling basin endsill. During the remaining periods of FFPF operation all the water entering the river downstream of the FRE structure comes from the fish ladder entrances and from the evacuation conduit. At all times during FFPF operation attraction water from the fish ladder entrances meets or exceeds NOAA Fisheries requirements (NMFS 2022a), reducing the potential for false attraction.

The amount of downstream flow over the stilling basin endsill is managed during FFPF operation by the auxiliary water system. The minimum outflow during the early portion of the impoundment period is approximately 300 cfs. All water from the impoundment during this period is routed through the fish ladders, lamprey ramp, and auxiliary water system. By providing a single source of attraction water from the fish ladder entrances into the stilling basin the fish passage performance of the facility is improved as it the only navigable pathway for fish to move upstream.

Uniform flow passes over the full width of the stilling basin endsill providing hydraulic conditions, such as lower velocities and less turbulence, that are favorable to fish passage. During FFPF operation the minimum depth over the endsill will be one foot. The channel downstream of the end sill is designed without a hydraulic drop, hydraulic jump, or excessive velocity that could create an impediment to fish access to the stilling basin and the fish ladder entrances. Detailed design of the end sill to accommodate the low fish passage design flow will occur in future phases of design development. At low flow the endsill must provide depths and velocities conducive to fish passage.

4.5 Lighting of Fish Passage Conduits

Lighting of the fish passage conduits was not examined as part of the design documented in this report. Concern regarding fish delay or holding due to the length of the fish passage conduits if they remain unlit was shared during the January 17, 2024 fish passage TWG meeting (Attachment 1). It was noted in the meeting that the Lower Granite Dam on the Snake River has a fish passage tunnel under eight spill bays (approximately 200-300 ft total) that is artificially lit to encourage passage. TWG members shared that studies show no fish passage delay through the tunnel. At a minimum, artificially lighting the fish passage conduits will be included in preliminary and final design. Other opportunities such as eliminating the ceiling of the fish passage conduits beyond (downstream) of the cross section of the FRE structure and studies of fish passage performance with such design features will be examined in future design development.

5.0 Fish Passage Performance

Fishways and other fish passage technologies are designed to provide continuous volitional fish passage at the location of an in-stream barrier. Performance at fish passage facilities is generally characterized by the proportion of fish that can locate and navigate a fish passage facility without being harmed or perishing. Research on fish passage performance is largely limited to facilities that consist of structures, such as fish ladders or floating surface collectors, or facilities composed of natural materials (e.g., rocks and boulders), such as nature-like fishways and roughened channels.

The construction bypass channels and permanent approach and discharge channels are fundamentally different from traditional fish passage facilities and more analogous to restoration and channel design projects. The design methodology for these channels is to mimic the physical characteristics (i.e., slope, cross section, bed material, complexity) and thus the hydraulic conditions (i.e., depth, velocity, flow paths) within the Chehalis River and Crim Creek in the vicinity of the Proposed Project. This methodology is derived from the WDFW's stream simulation design approach, which assumes that fish present in the natural channel are not expected to be challenged by the stream simulation channel that looks and performs similarly to adjacent natural channels (WDFW 2013). Additionally, these channels will convey 100 percent of the flow in system.

Two-dimensional hydraulic modeling of the construction bypass channels and the permanent river channels (RPDR Appendix D) confirm that at the fish passage design flows, flow depth and velocity within these channels are similar to, or more favorable than, the reference reaches used to design the channels. At the current level of design, there is no evidence to suggest that fish passage performance through the channels will be negatively impacted by the channels themselves, when compared to the existing river at the Proposed Project location. Therefore, fish passage performance and survival through the proposed channels is assumed to be 100 percent.

For anticipated fish passage performance through the fish passage conduits, see Table 4-2 in Appendix G of HDR (2017).

6.0 Roadmap for Future Fish Passage Design

Future fish passage design efforts will complete the conceptual fish passage design and, prior to completion of the final Biological Assessment being prepared under the Endangered Species Act Section 10 consultation, will advance the fish passage design sufficiently to demonstrate the final design of the proposed project will meet current NOAA Fisheries and WDFW fish passage requirements.

The fish passage design will be fully integrated and compatible with the overall dam design. Future design phases will incorporate cross-discipline design development, design evaluations and analyses, coordination meetings, and configuration decisions to achieve a complete project.

6.1 Climate Change Incorporation

Fish passage design flows meeting the NOAA Fisheries guidance (NMFS 2022b) will be established in collaboration with NOAA Fisheries representatives during preliminary design.

The quantity of auxiliary water flow will be revisited and updated during the preliminary design phase to meet the NOAA Fisheries attraction water flow requirement and the fish passage design flows incorporating climate change.

6.2 Flood Fish Passage Facility

The design of the FFPF, referred to in previous documents as the CHTR facility, has not been advanced since publication of the CHTR Preliminary Design Report (HDR 2018b). The design will be advanced during the preliminary design phase to be consistent with the current FRE structure and location. Using revised fish passage design flows meeting NOAA Fisheries (NMFS 2022b) and current WDFW and NOAA Fisheries fish passage design guidelines, the fish passage design will be updated during future phases of design development following preliminary design. Input from WDFW, NOAA Fisheries, and the TWG will be incorporated throughout future phases of design development, including preliminary design.

6.3 Fish Passage Conduits

The fish passage conduit design will be refined during preliminary design. Concepts identified at this time for refinement include, but are not limited to, staggered invert elevations, roughness elements, conduit size, length and spacing, and artificial lighting. Additional analyses include identifying low-velocity fish passage pathways, sediment transport analysis, and 2D hydraulic modeling. Further fish passage conduit design refinement will be required following preliminary design, including 3D hydraulic modeling, sediment transport modeling, additional roughness elements, artificial lighting, and staggered invert elevations. Input from WDFW, NOAA Fisheries, and the TWG will be incorporated throughout future phases of design development, including preliminary design.

6.4 Permanent and Construction Bypass Channels

The permanent and bypass channel designs in both the mainstem Chehalis River and Crim Creek will be refined in preliminary design. Concepts identified at this time for refinement include, but are not limited to, channel roughness, slope, alignment, and velocity refugia. Additional analyses include identifying low-velocity fish passage pathways and 2D hydraulic modeling. Further refinement of the permanent and bypass channel design will be required following preliminary design, including additional hydraulic modeling, sediment transport modeling, additional roughness elements, artificial lighting, and staggered invert elevations. Three-dimensional hydraulic modeling of the permanent and bypass channels may also be required. Input from WDFW, NOAA Fisheries, and the TWG will be incorporated throughout future phases of design development, including preliminary design.

Future design development of the channels will also include design of the channel to resist erosion and to avoid subsurface flow, especially at low river flows, so that a minimum depth for fish passage is maintained in the channels. Stable elements such as large rock will be used to set a stable cross-section in the channels, including downstream of the fish passage conduit stilling basin endsill, to meet hydraulic and fish passage design requirements.

7.0 References

Anchor QEA, LLC

2016 Reservoir Operations HEC-ResSim Model

Bell, M.

1991 Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

HDR Engineering, Inc. (HDR)

2014a Combined Dam and Fish Passage Alternatives Technical Memorandum. Bellevue, Washington.

2014b Draft Dam Design Technical Memorandum. Bellevue, Washington.

2014c Fish Passage Briefing, Interim Report. Bellevue, Washington.

2014d Fish Passage Design Technical Memorandum. Bellevue, Washington.

2014e Combined Dam and Fish Passage Alternatives Technical Memorandum. Bellevue, Washington.

2017 Combined Dam and Fish Passage Conceptual Design Report. June 2017.

2018a Combined Dam and Fish Passage Supplemental Design Report FRE Dam Alternative Report. September 2018.

2018b Fish Passage: CHTR Preliminary Design Report. February 2018.

Hydraulic Institute

2012 ANSI/HI 9.8-2012, Rotodynamic Pumps for Pump Intake Design. Prepared for the American National Standards Institute. 2012.

Keefer, Matthew, Christopher Caudill, and Mary Moser

2012 Adult Pacific Lamprey Passage: Data Synthesis and Fishway Improvement Prioritization Tools.

2014 Adult Pacific Lamprey: Known passage challenges and opportunities for improvement. 2014.

National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS)

2011 National Oceanic and Atmospheric Administration - National Marine Fisheries Service Northwest Region, Anadromous Salmonid Passage Facility Design.

2022a NOAA Fisheries Guidelines for Salmonid Stream Crossings in WA, OR, and ID. 2022.

2022b NOAA Fisheries WCR Guidance to Improve the Resilience of Fish Passage Facilities to Climate Change.

Piper, Robert G., Ivan B. McElwain, Leo E. Orme, Joseph P. McCraren, Laurie G. Fowler, and John R. Leonard

1982 Fish Hatchery Management. Prepared for the U.S. Fish and Wildlife Service. 1982.

Stevens, Peter, Ian Courter, Christopher C. Caudill, and Chris Peery

2015 Evaluation of Adult Pacific Lamprey Passage at Lower Snake River Dams. Prepared under contract W912EF-14-P-5061 for the U.S. Army Corps of Engineers.

U.S. Army Corps of Engineers (USACE) and U.S. Bureau of Reclamation (Reclamation)

2015 Design Guidelines for Pacific Lamprey Passage Structures

U.S. Fish and Wildlife Service (USFWS)

2010 Best Management Practices to Minimize Adverse Effects to Pacific Lamprey. 2010.

2011 Lamprey Passage in the Willamette Basin: Considerations, Challenges, and Examples. 2011.

U.S. Department of Agriculture (USDA)

2001 Forest Service Handbook 2090.21, 22.6 – Exhibit 01 Adult Salmonid Migration Blockage Table (adapted 2001).

2010 Pacific Lamprey Protection Guidelines for USDA Natural Resources Conservation Service Instream and Riparian Activities.

2011 Biological Technical Note No. 51: Pacific Lamprey and NRCS: Conservation, Management and Guidelines for Instream and Riparian Activities. Prepared March 2011.

Washington Department of Fish and Wildlife (WDFW)

1992 Washington State Salmon and Steelhead Stock Inventory. 1992.

2000a Draft Fishway Guidelines for Washington State

2000b Draft Fish Protection Screen Guidelines for Washington State

2009 Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual

2013 Water Crossing Design Guidelines

2016a Juvenile salmon and Steelhead projected for the Upper Chehalis River FRFA dam alternative. Memo from Mara Zimmerman to Justin Allegro and Erik Neatherlin dated June 27, 2016.

2016b Memo to fish passage sub-committee to support design of downstream passage systems on the Chehalis River under the FRFA dam alternative. Prepared by Mara Zimmerman. Dated August 19, 2016.

2017 Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2013-2017.

2018 Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2017-2018.

Watershed Science & Engineering (WSE)

2014 Re-evaluation of Statistical Hydrology and Design Storm Selection for the Chehalis River Basin Technical Memorandum. Prepared for the Hydrologic and Hydraulic Technical Committee. January 31, 2014.

2019 Chehalis River Basin Hydrologic Modeling Technical Memorandum. Prepared for Anchor QEA. February 28, 2019.

2023 Simulation and Analysis of Global Climate Model Ensemble for the Chehalis Basin Memorandum. May 25, 2023.

8.0 Acronyms and Abbreviations

AWS	auxiliary water supply
cfs	cubic feet per second
District	Chehalis Basin Flood Control Zone District
EIS	Environmental Impact Statement
FFPF	Flood Fish Passage Facility
FRE	Flood Retention Expandable (FRE)
ft-lbs/sec/ft3	foot-pounds per second per cubic foot
gpm	gallons per minute
HDR	HDR Engineering, Inc.
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
RPDR	Revised Project Description Report
SEPA	State Environmental Policy Act
Subcommittee	Fish Passage Subcommittee
TWG	Technical Working Group
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology

This page intentionally left blank.

Attachment 1 - Fish Passage Collaboration Meeting Notes

This page intentionally left blank.

DRAFT - Meeting Notes

Project:	Chehalis River Basin Flood Damage Reduction Project
Subject:	Fish Passage Technical Workgroup Meeting
Date:	Monday, August 21, 2023
Location:	WebEx
Attendees:	Benjamin Cross, USFWS Celina Abercrombie, WDFW Jeff Brown, NMFS Jenae Churchill, USACE Jerry BigEagle, Cowlitz Indian Tribe John Best, WDFW John Robinson, consultant to District Marisa Litz, WDFW Matt Dillin, District Pad Smith, WDFW Rich Doenges, Ecology Matt Prociv, HDR Nick Szigeti, HDR Sandy Cody, HDR

USFWS: U.S. Fish and Wildlife Service
WDFW: Washington Department of Fish and Wildlife
USACE: U.S. Army Corps of Engineers
District: Chehalis Basin Flood Control Zone District
Ecology: WA Department of Ecology

Meeting Objectives

- To inform the Technical Working Group (TWG) members of:
  - Current status of the Modified Flood Retention Expandable (FRE) project activities
  - Attendee roles and responsibilities
  - Scope of requested input
  - Why we will be establishing goals and success factors
  - Next steps
- Establish a standing agenda and topics for future meetings
- Establish meeting frequency for this phase of the project

Discussion Topics

- **TWG meeting objectives**
  - To inform the TWG members of:
    - Current status of the Modified FRE project activities
    - Attendee roles and responsibilities
    - Scope of requested input
    - Why we will be establishing goals and success factors
    - Next Steps
  - Establish a standing agenda and topics for future meetings, as well as any additional topics the TWG would like to include in the future
  - Establish meeting frequency

- **Roles and Responsibilities**
  - District – Project proponent who is responsible for listening to TWG input, assisting in data gathering, and providing feedback as requested.

  - HDR – Consultant for the District (engineers, biologists, scientists, regulatory professionals, etc.) will be responsible for providing data and will facilitate discussion and decision-making within the TWG including items like design criteria and criteria for project success.
  - TWG Members: WA Ecology, WDFW, USFWS, NMFS, Chehalis Tribe, USACE, and Cowlitz Tribe – responsible for actively participating in TWG meetings and providing input for goals and success factors.
    - Quinault Indian Tribe was invited but has declined participation. However, the Quinault Indian Tribe will be provided meeting notes and meeting invites to keep them apprised of the project.
  - The USACE is the federal nexus for the Environmental Impact Statement (EIS).

- **Scope of Input:**
  - Design criteria (biological and technical criteria) including species and periodicity, climate change criteria, etc.
  - Design approach and methodology – Trying to mimic natural flow of the river hydraulicly – what is the appropriate methodology for design?
  - FRE water retention operating rules – Idea is to close conduit gates and retain floodwaters. How much water and when should retention occur? What are the ramping rates for the reservoir and downstream release?
  - FRE and flood fish passage facility (FFPF) operation and maintenance (O&M) – staffing, credentials, training, maintenance process. The facility will only operate occasionally; how do we ensure that the staff that runs the facility are qualified and are up to speed on training and how the facility is supposed to operate.
  - Identification of topics for discussion in future meetings and phasing of those discussions, i.e., discuss biology and species before discussing fish ladder pools.

- **TWG Goals & Success Factors (over course of project) (HDR)**
  - One main goal is dialogue between TWG members regarding what is the most appropriate science to follow for this project.
  - Identify design criteria – will review previous criteria as well as additional criteria such as resident fish criteria. Criteria may fall into two categories:
    - Can be readily adopted (e.g. target species)
    - Requires more info or discussion, such as:
      - Fish passage design flows for conduits, with climate change or annual, peak, daily, peak hourly upstream fish abundance. What is the best/most appropriate way to break down annual abundance into peak daily or peak hourly numbers for design?
  - Success factors for HDR
      - Reach consensus on design criteria where possible.
      - Develop reasonable interpretation of biological goals.
      - Provide input on the environmental process.
  - TWG members would like to see the following goals and success factors:
    - Jerry BigEagle would like information gathered previously (including by the Chehalis Tribe) to be considered, including the best location for the FRE and how it affects the Chehalis Tribe cultural sites. Jerry noted that the Chehalis Tribe is also concerned that the project may affect their traditional fishing locations. Jerry

    would like the design to consider how to mitigate these potential impacts if they occur.
    - Matt Dillin has a goal of new questions being asked/answered that weren't anticipated at the onset.

- **TWG Logistics (over course of project) – Open invite will be to USFWS, NMFS, WDFW, Ecology, USACE, Chehalis Tribe, Cowlitz Tribe, Quinault Indian Tribe, and the District.**
  - HDR to send out a recurring TWG meeting invitation
    - Every 6 weeks, three-hour duration with the goal of finishing meeting in two hours
    - Will be held via MS Teams.
    - In-person may be held twice a year. Celina noted that some interactive group work during those meetings make them more beneficial. Jerry BigEagle noted in-person may be useful for bringing in additional consulting technical experts to discuss modeling results, etc. Will take in-person meetings into account when future meeting topics come up that may benefit from in-person meetings.
    - Avoid Monday and Tuesdays for meetings.
    - Celina would like materials and ppt in advance. Would HDR team have that ability to provide materials 10 days to 2 weeks in advance? If want materials this far in advance, Matt says would likely need 6 week interval for meetings. Celina prefers two hours for the meeting but is ok with 3-hour calendar block.
  - Standing Agenda will include previous meeting recap and open discussion.
  - Lead times
    - Invite – 2 to 3 weeks (may be standing invite)
    - Agenda – 2 weeks prior
    - Meeting notes – 3 week schedule
      - Draft notes 1 week after meeting.
      - One week to review meeting notes back to HDR.
      - One week for HDR to incorporate comments and send out final meeting notes.
- **Project Update**
  - Current concept/design anatomy and arrangement – Nick presented the plan view for the current alternative, including the FRE structure, the spillway, conduits, and water diversions. The conduits would convey flows under normal conditions. Other components include fish ladder and adult FFPF, and regraded section of the river to flow into the conduits.
    - Location is approximately 1,000 feet upstream of original location considered in the alternatives analysis to minimize impacts to a traditional cultural place. Topography and geology at new proposed location differs; design changed from linear dam to a curved structure.
    - Reservoir depth is approximately 220 feet from spillway crest to conduit invert.
    - Conduits would be designed to mimic the natural flow of the river.
    - An FRE-FC Dam (not included as part of this project) is shown on the design schematic. Included to show that FRE will be designed for future expansion,

which influences foundation design of the structure. Any potential higher dam would be a completely new, separate project with separate EIS and permitting.

- Maintenance decks would be at lower levels of conduit, which would be part of debris removal and maintenance of structures.
- Significant freeboard is present from the conduit stilling basin through conduits to reduce flow velocities during use.
- At the maximum flood storage pool of approximately 62,000 acre-feet, floodwaters would crest over the spillway.
- Flip bucket may be used to dissipate energy into the Chehalis River, which is part of an alternatives analysis for the best energy dissipation technology to be used for the project.
- PMF elevation will be used for design.
- Jerry BigEagle noted that the water releases after a flood event may result in pressurized bubbles in fish because releases from the conduits aren't stilled before they enter the stilling basin. Downstream aquatic species can be affected. Jerry would like to see a model/how mixing of releases with other water will occur. High pressure water has negative effects downstream aquatic species (air embolism). Jerry would like to know if there is somebody in the group who can provide additional information. Jeff Brown noted that gassing issues in spill scenarios which would be unlikely to happen since the project would have controlled releases. Matt noted that it is difficult to estimate hydraulicly how far the jet from the conduit will go down stream during small flow releases when impounding water and how much turbulence is in the stilling basin. Water would be pressurized on upstream side but not on the downstream side. Jerry noted that he now understands how the fish ladder would be part of the system and this may not be an issue.

- Current draft proposed FRE operations
  - Triggered by forecast of 38,800 cfs at Grand Mound Gage 48 hours prior
  - Duration would vary by volume stored, with storage time up to 35 days. Radial gates would close to the conduits. Debris control/salvaging would occur and of reservoir water would be evacuated. Any time conduits are closed, the flood fish passage facility (FFPF) would be operating. The FFPF was named Collect, Handle, Transfer, and Release facility (CHTR) in previous documents.
- Construction sequence
  - Phase I would include construction of Chehalis River and Crim Creek bypass to temporary diversion channels to allow conduits, fish passage facilities, and a portion of the permanent Chehalis River channel to be constructed in the dry.
    - It is anticipated the District would request and extension of the in-water-work window to three months.
    - In-river work, including dewatering the existing channel, fish salvage, and construction of temporary cofferdams, would occur within the in-water work window.
    - Partial channel grading in the dry and the western portion (left abutment) of the FRE and fish passage facilities.
  - Phase II would include removing temporary bypass/re-route the Chehalis River and Crim Creek back to their channels. This would be followed by construction of the right abutment and restoration of diversion channels to existing conditions.

        - It is anticipated the District would request and extension of the in-water-work window to three months.
    - Development timeline
        - Currently in concept design and revised project description, which will inform the SEPA FEIS until early 2024.
        - Next step is preliminary design and ESA Analysis/Coordination – Early 2024-2025
        - The two year process of the TWG will be incorporated into the revised project description. The TWG will continue into the ESA consultation process and will inform the NEPA EIS.
        - Section 106 will also influence the design similar to the way it did during the previous work, which resulted in relocating the project approximately 1,000 feet upstream.

- **Topics/Design Methodology for Future Meeting Discussions**
    - Biological design criteria
        - Species occurrence and distribution and upstream presence, etc. using latest published information or any unpublished data/ongoing studies that the TWG could provide.
        - Species and life stages for each project element (conduits). Initial discussions in 2018 were collection of juvenile and adults.
        - Periodicity (run timing, outmigration, spawning, and juvenile movement). Currently have periodicity table from 2018. TWG may know of newer data they could provide.
        - Fish abundance (adult salmonid, juvenile salmonid, resident fish, and lamprey estimates) – WDFW completed a study in 2018/2019 regarding adult and redd distribution above the project site. Is this the latest data that should be used or is other data more available? Will also need to translate peak annual fish abundance into day and hour peak abundance for sizing of the facility.
        - John Best suggests adding timing of potential flood events (within-year timing). The current prediction is once every seven years, with the understanding that climate change may change that. Periodicity could be compared to anticipated within-year timing of flood events. Climate change analysis is currently underway.
        - Ben Cross noted that temperature criteria should be considered. There is concern of warm or cool releases affecting water temperatures. Matt noted that a vegetation management plan is being drafted including how it may affect stream temperatures. Impoundment isn’t held at a constant elevation long enough to create a temperature stratification. A mitigation plan will also address water temperatures in the basin.
    - Technical design criteria (flow rates, velocities, screening, etc.)
        - NMFS – fish passage, climate change, and stream crossings
        - USFWS – lamprey BMPs
        - WDFW – fish screens, fishways, and water crossings
        - Published papers – lamprey design
        - Any new unpublished/published studies the TWG can pass along
        - For conduit criteria:

    - Design flows
    - Design depths
    - Design velocities
    - Trashrack approach velocity, bar spacing, and slope
    - Slopes and gradients
- Permanent River and Creek Channels
  - Design flows – anything other than NMFS guidance?
  - Design depths
  - Design velocities
  - Channel roughness – some portions of the riverbed in this area is exposed bedrock so what is the appropriate design roughness and channel cross sections.
  - Slopes and gradients
- Fish screens – will have pump station pulling water from stilling basin to provide attractant flows.
  - Bar size and spacing
  - Approach and sweeping velocities
  - Open area
  - Cleaning system
  - Head differential
- Fishway
  - Fish ladder entrance
  - Fish ladder
  - Fish ladder exit
  - Lamprey upstream passage
  - Flow, depth, width, velocity, and volume
- Fish Trapping and holding
  - Holding duration
  - Holding volume
  - Fish size
  - Temperature
  - Dissolved oxygen levels
  - Flow
  - Flume flow, depth, velocity, material
- Design methodologies – use federal/state guidance or something more complex (e.g. physical model) to inform design.
  - Stream simulation for conduits, permanent river and creek channels, and temporary bypass channels. Conversations were held with WDFW regarding the appropriateness of using the stream simulation method.
  - NMFS Fishway Guidance – adult and juvenile
  - Published studies – lamprey ramp

    - Modeling that is appropriate for the varying levels of design and project elements. Currently hydraulic and sediment transport, spreadsheet concept development, 1D and 2D HEC-RAC being used for preliminary design. Is work beyond a 2D model appropriate as the project moves along (i.e., 3D computational fluid dynamics or physical modeling)? Will likely want to touch on this during the next TWG meeting.
- Impoundment operating criteria – information presented during this meeting was mainly for comparison; other factors may need to be considered to set the rules for impoundments/operations.
- FFPF operation and timing. How early should it be operated? Previous idea as several days before the gates close down and impoundment begins.
- Release rates
    - How far should jets go downstream?
    - Turbulence and oxygenation of the water
    - Celina Abercrombie noted that in operation, we should also discuss inclement weather given that the facility would operate during period of high rainfall and river flow. We want to make sure fish can be moved safely/roads will be accessible for safe transport. Matt says that specific release sites haven't been determined but said that can be included as part of the conversation.
- FRE and FFPF operation and maintenance – staffing, training, etc.
    - Conduits – exercise of gate control, maintenance of run-of-river operations, regular, long-term, and emergency maintenance
    - Debris management – collection procedures and timing, reservoir collection, trashrack debris removal, reuse of materials. Current idea is slow drawdown so boats can remove woody debris in reservoir. Debris from trashrack would also occur after reservoir is drawn down. Then must decide what should happen to collected woody debris material.
    - Operations of FFPF
- Additional discussion regarding design criteria:
    - Jerry BigEagle noted that a fish ladder could be designed to move up and down with impoundment water elevations. Matt said some of this was discussed during the alternatives analysis and can be provided to Jerry BigEagle.
    - Jerry will look for the literature regarding that. Jerry said that he has a USGS contact that could provide information regarding the flood zones in the Chehalis. Matt P. noted that flood modeling is being conducted for the basin and can provide to Jerry BigEagle.
    - Jerry also said that discussions of in-water work window has been occurring on the Columbia River that may be useful for this project.
    - Ben Cross - Downstream passage – previous approach was that impoundment of reservoir was so short that fish would hold and not move down until regular run-of-river so downstream passage wasn't originally included. Can include discussion of downstream passage and likelihood of back-to-back impoundment events.
    - Celina Abercrombie asked if the FRE will have artificial lighting at night. Curious about light related effects on fish and if that should be part of the conversation. Would like to include a discussion of lighting in the design criteria.

- John Best would like to see information on flows (turbulence, etc.) in the stilling basin during drawdown periods to make sure that the fishway is still accessible.
- John Best would like to see the effects of the permanent channels on sediment transport downstream during normal run-of-river operations. Matt noted that sediment modeling is currently being conducted. Previous model results can be provided as a baseline idea of what to expect from new model.

- **Next Steps / Action Items**
  - HDR to send out a recurring TWG meeting invitation
  - Matt will send out a Doodle Poll for the next meeting date and time.
  - HDR to provide draft meeting notes for review by TWG. Will provide final notes based on TWG review.
  - Send presentation from today's meeting.
  - Identify topics for next meeting.
  - Set up a meeting between Matt and Jerry BigEagle (and potentially others) to go over previous discussions during previous TWG meetings to get Jerry up to speed on the project and previous alternatives discussed.
  - Provide the group with flow and operation information of within year timing of flood events and how often (current assumption is approximately 7 years)
  - Provide information regarding downstream passage.
  - TWG members will Identify topics for next meeting via email.

Chehalis River Basin Flood Damage Reduction Project

Fish Passage Technical Working Group Meeting

Chehalis River Basin Flood Control Zone District

August 21, 2021

Introductions

- Name, position & organization, relationship to project
- Favorite fish species?
- What do you want to get out of these meetings?

Meeting Objectives

- To inform the TWG members of:
  - Current status of the Modified FRE project activities
  - Attendee roles and responsibilities
  - Scope of requested input
  - Why we will be establishing goals and success factors
  - Next steps
- Establish a standing agenda and topics for future meetings
- Establish meeting frequency

Agenda

- Roles and Responsibilities
- TWG Goals & Success Factors
- TWG Logistics
- *Break*
- Project Update
- Topics for Future Meetings
- Next Steps / Action Items

Roles and Responsibilities

Chehalis River Basin Flood Control Zone District

- Role
  - Project proponent
- Responsibilities
  - Listen to TWG input
  - Assist data gathering
  - Provide feedback as requested

Chehalis River Basin
Flood Control Zone District

Roles and Responsibilities

HDR

- Role
  - Consultant for the District
    - Engineers, biologists, scientists, regulatory professionals, etc.
- Responsibilities
  - Provide data
  - Facilitate discussion and decision-making

Roles and Responsibilities

TWG Participants

- Role
  - Technical Working Group
- Responsibilities
  - Actively participate in discussion
  - Provide input to TWG goals and success factors

Declined participation but on TWG distribution list & invited to provide input.

QUINAULT INDIAN NATION

COWLITZ INDIAN TRIBE
The Forever People

The Confederated Tribes of the Chehalis Reservation

Washington Department of FISH and WILDLIFE

U.S. FISH & WILDLIFE SERVICE

NOAA FISHERIES

DEPARTMENT OF ECOLOGY
State of Washington

Roles and Responsibilities

Scope of Input from the TWG

- Design Criteria
  - Biological criteria
  - Technical criteria
- Design Approach and Methodology
- FRE water retention operating rules
- FRE and Flood Fish Passage Facility (FFPF) O&M
  - E.g., staffing, credentials, training, maintenance process
- Identification of topics for discussion and future meetings

TWG Goals and Success Factors

Goal: Dialogue

- Expect a lot of questions
- Ask questions
- Initiate & participate in discussion

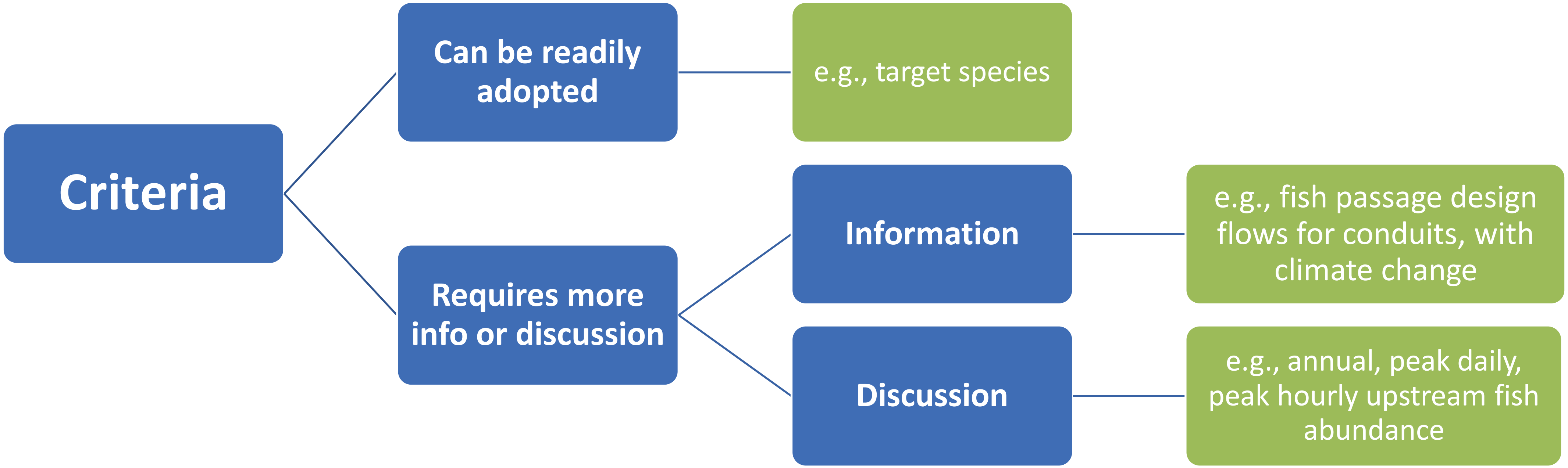
TWG Goals and Success Factors

Goal: Identify Design Criteria

- Review previous criteria
- Identify *additional* criteria
  - E.g. Resident fish criteria

TWG Goals and Success Factors

Goal: Identify Design Criteria



TWG Goals and Success Factors

Success Factors for HDR

- Reach consensus on design criteria where possible
- Develop a reasonable interpretation of biological goals
- Provide input on the environmental process

TWG Goals and Success Factors

Success Factors for TWG Members

- What goals and success factors would you like to see for the TWG meetings?

TWG Logistics

- Every 6 weeks – recurring meeting w/ flexibility
- Virtual unless TWG see a compelling need for in-person
  - MS Teams? WebEx?
- 3 hours?
- Open invite to:
  - USFWS, NMFS, WDFW, Ecology, USACE, Chehalis Tribe, Cowlitz Tribe, Quinault Nation, and District

TWG Logistics

Proposed Standing Agenda

- Icebreaker
- Previous meeting recap
  - Design & TWG process updates
- Open discussion
- Decisions
- Next steps & action items

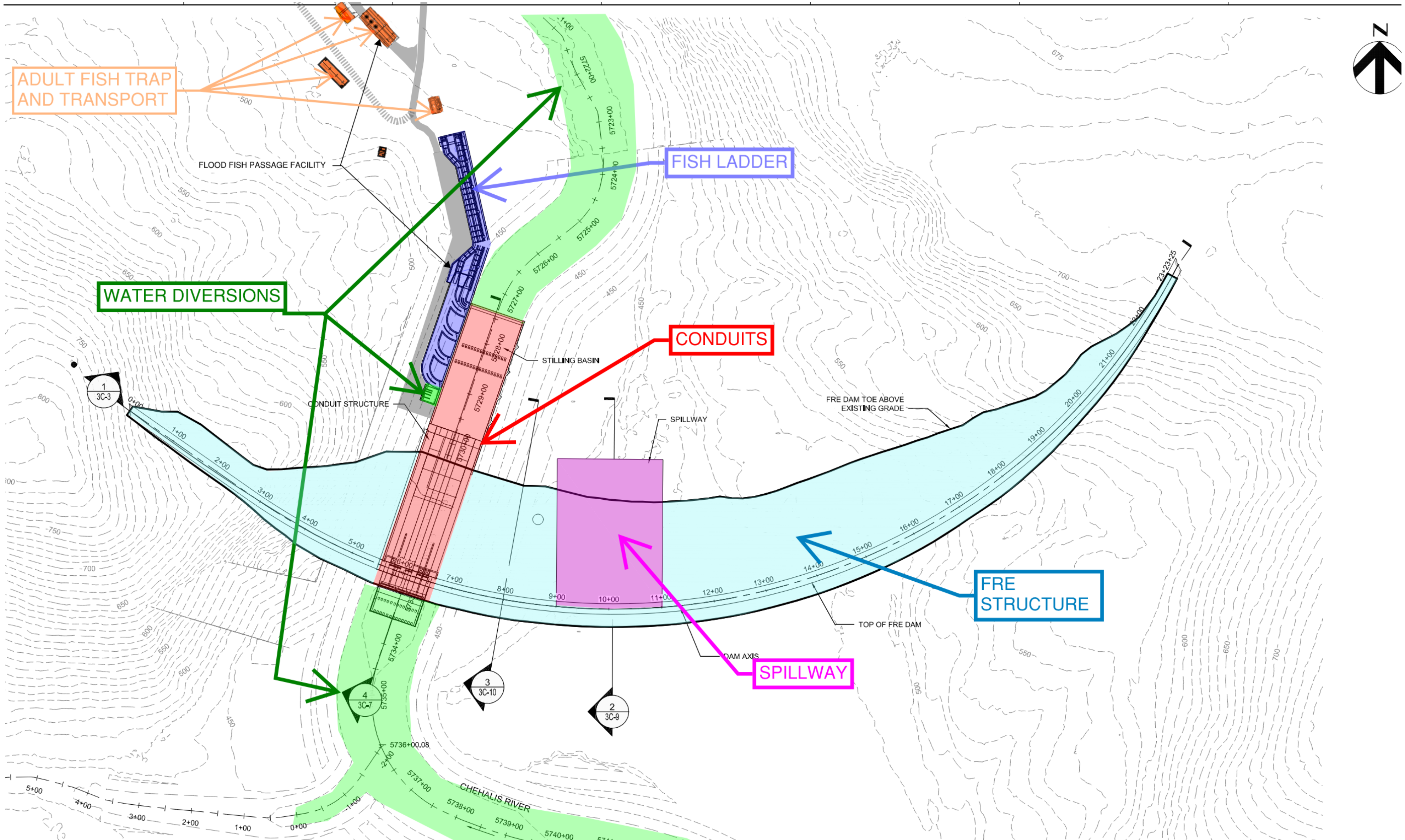
TWG Logistics

Lead Times

- Invite – 2-3 weeks prior? Standing invite?
- Agenda – 2 weeks prior?
- Meeting Notes – 3 weeks for draft to final?
  - 1 week after meeting: Draft meeting notes to TWG
  - 1 week to send input on meeting notes back to HDR
  - 1 week for HDR to incorporate comments & send out final meeting notes

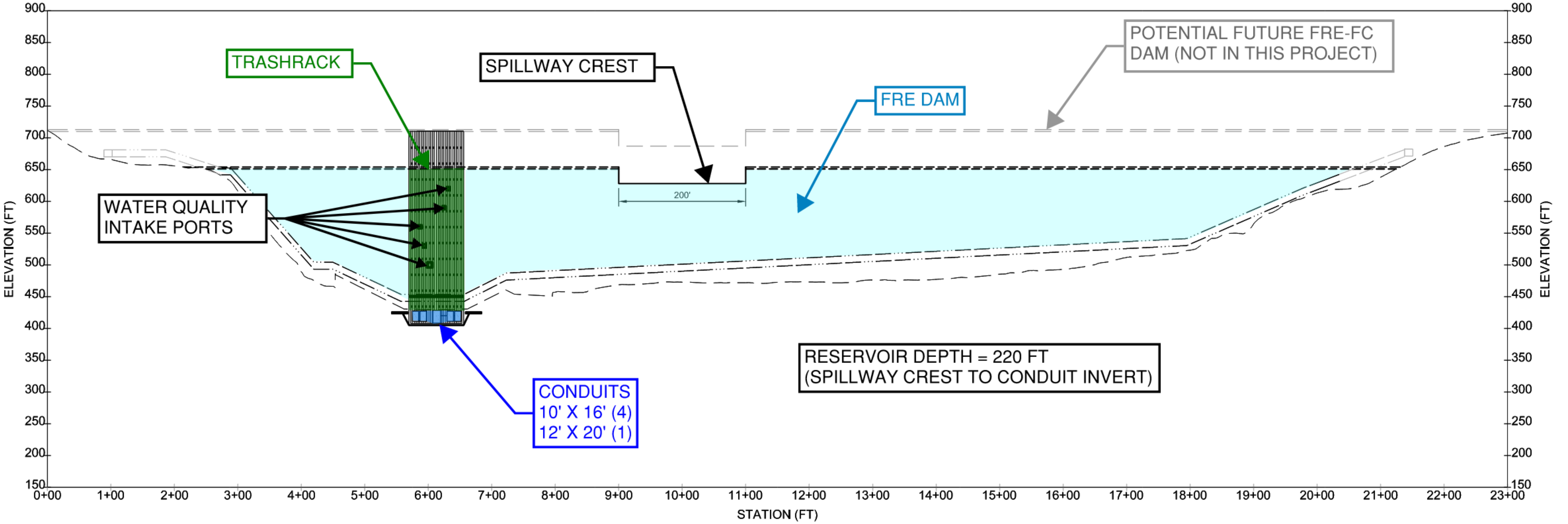
Project Update

Primary Project Elements



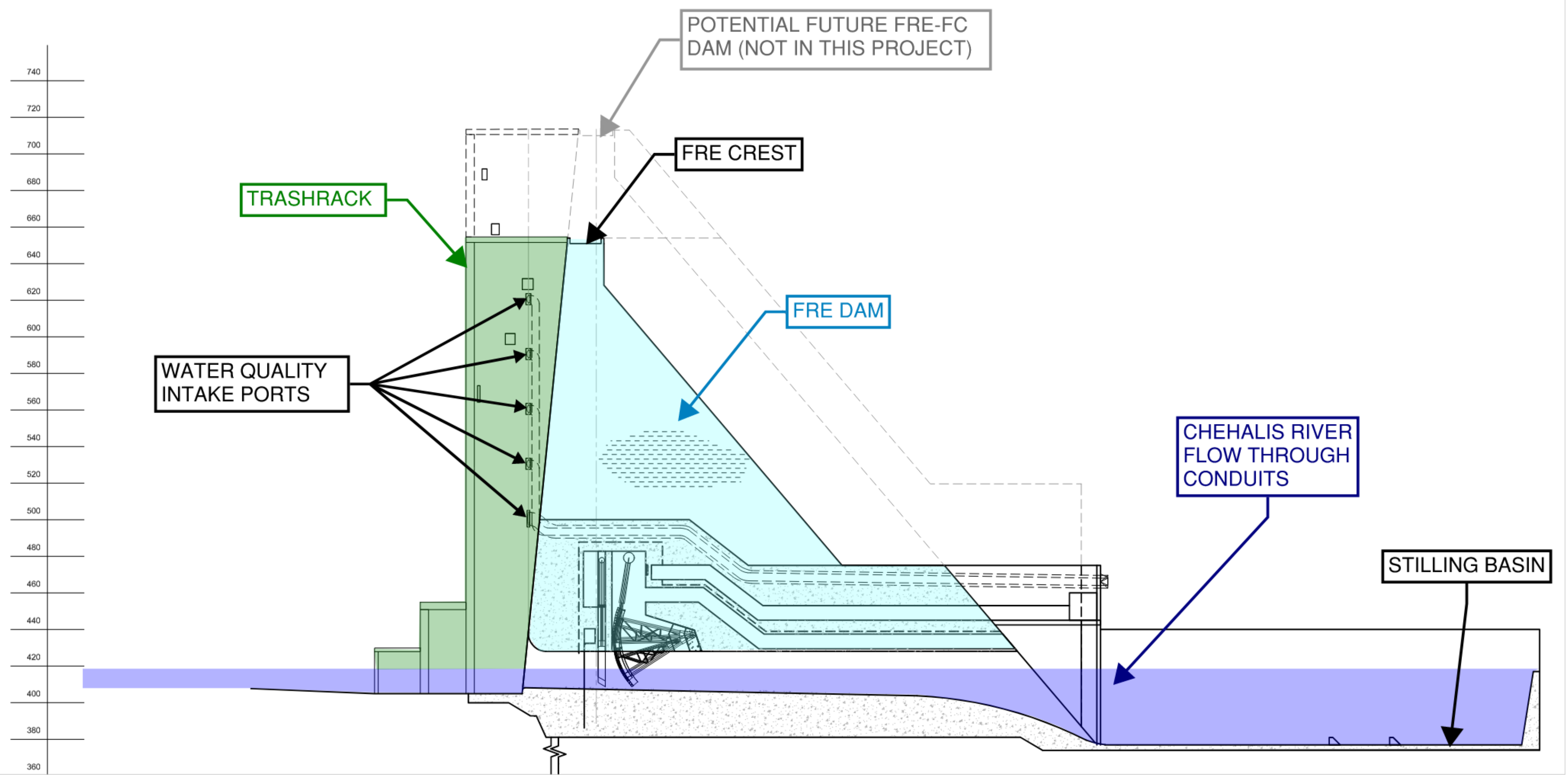
Project Update

FRE Elevation

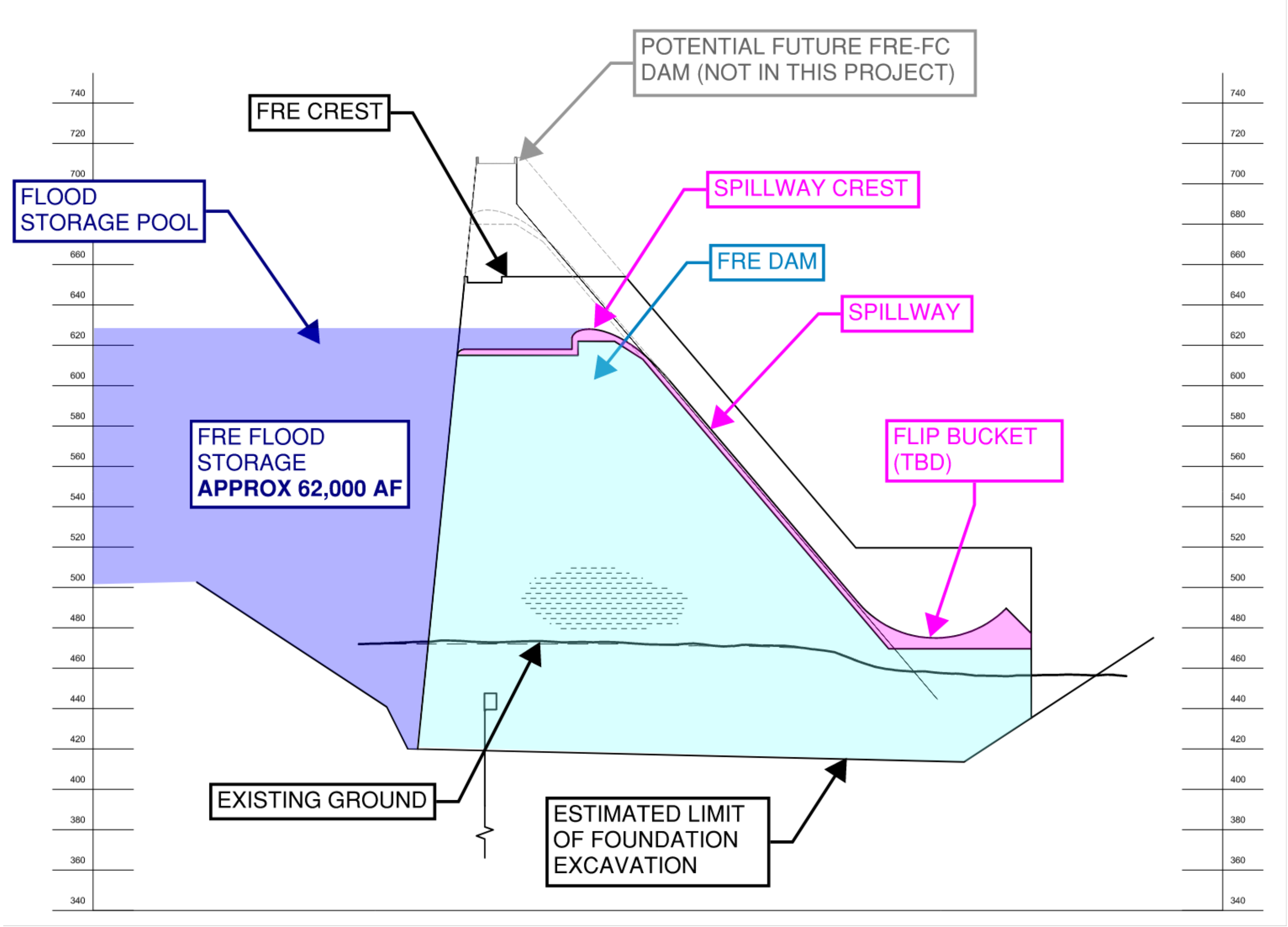


Project Update

Conduit Section

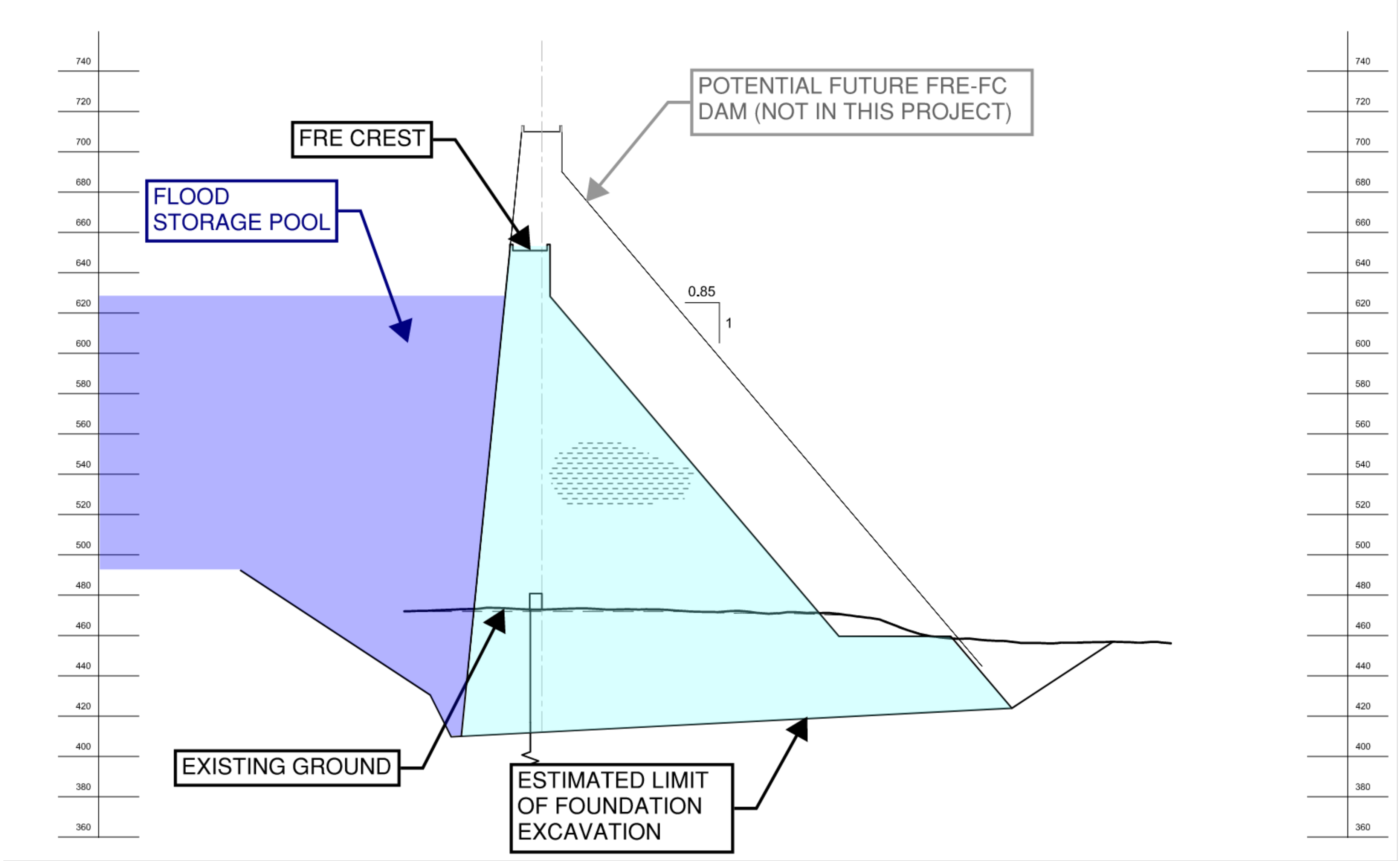


Project Update
Spillway Section



Project Update

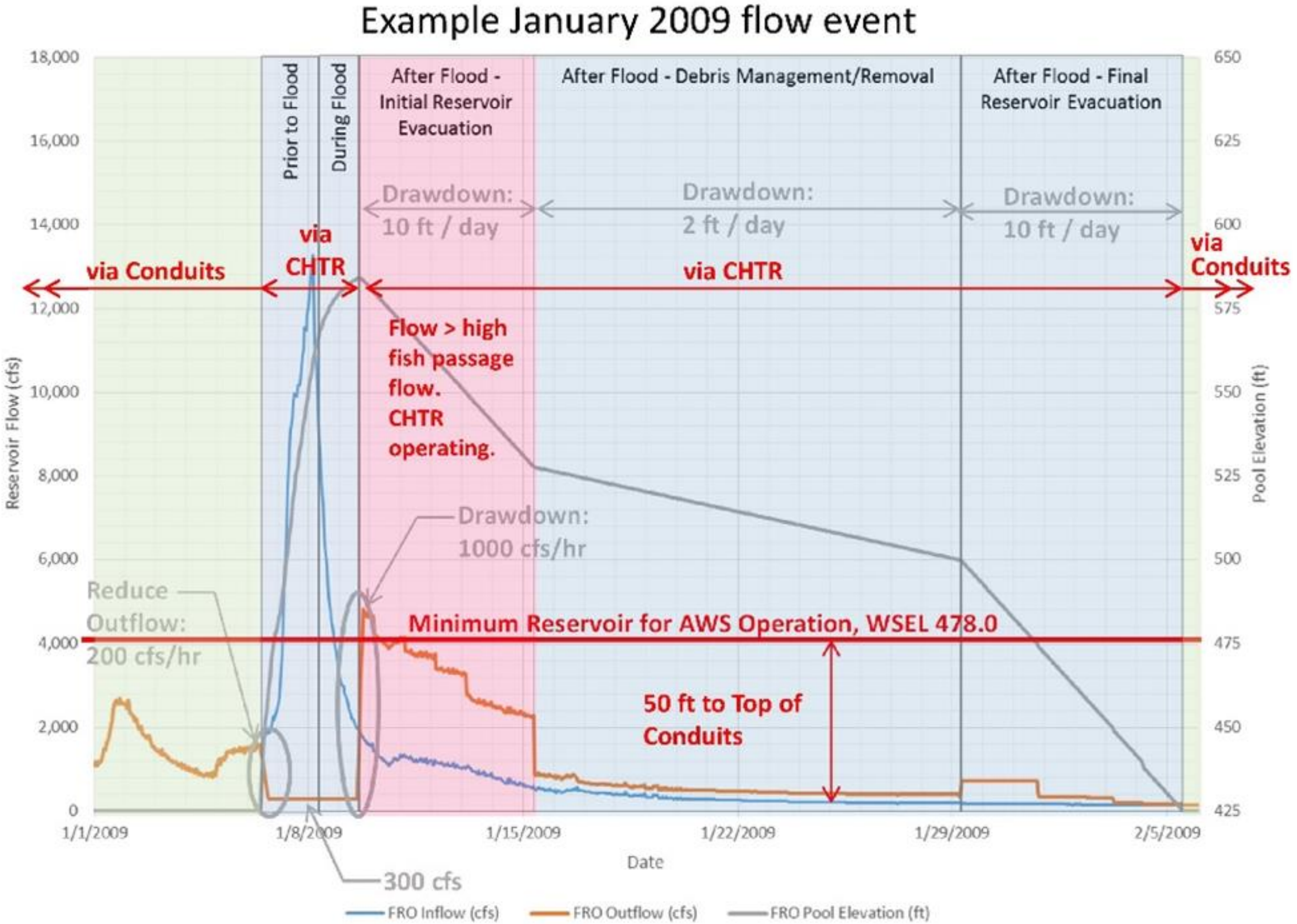
Typical FRE Dam Section



Project Update

Reservoir & FFPF Operations

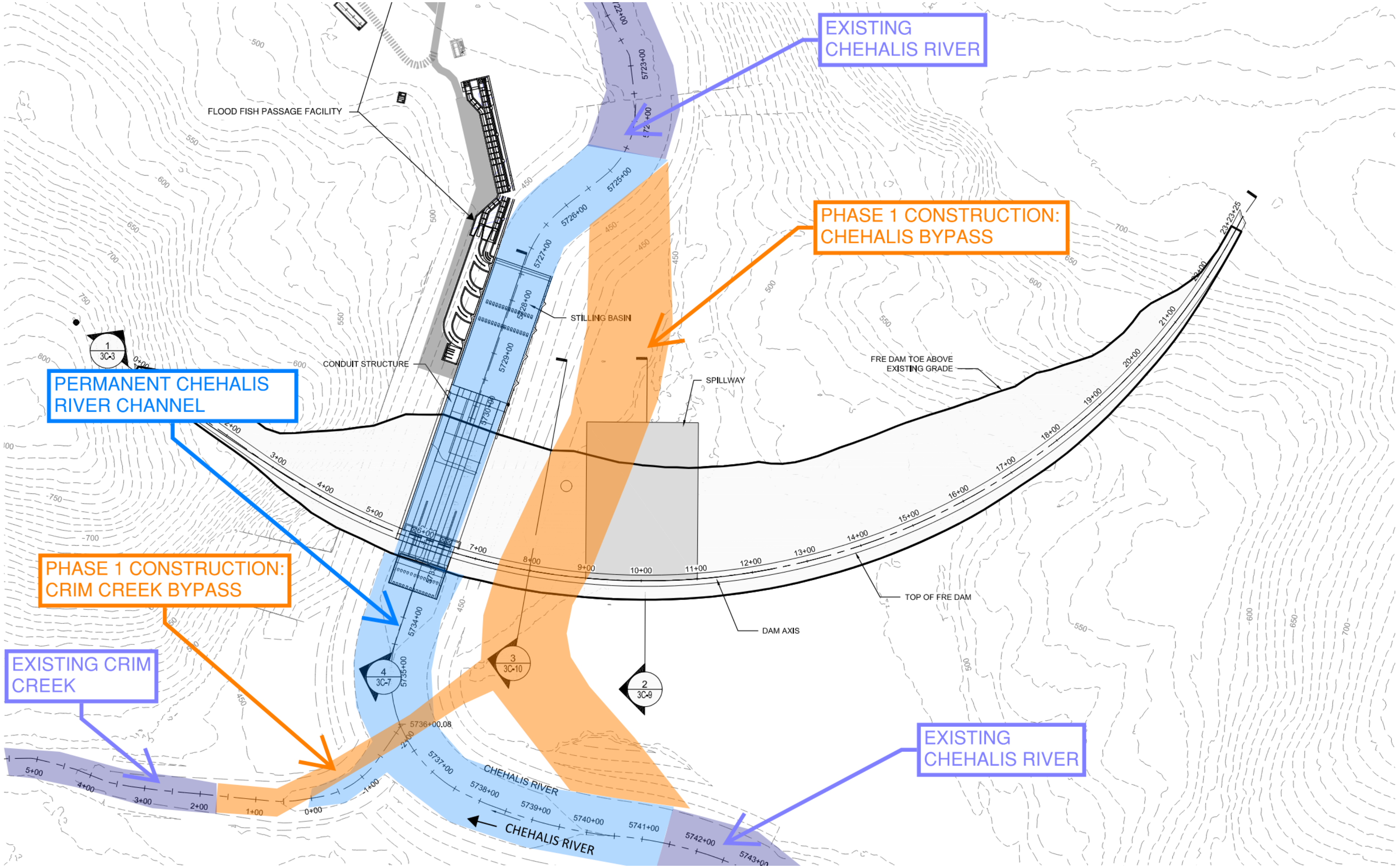
- Triggered by: forecast of 38,800 cfs at Grand Mound Gage 48 hrs prior
- Duration:
  - Varies by volume stored
  - Storage time up to ~35 days



Potential Operation Overlaid on 2009 Flow Event Hydrograph

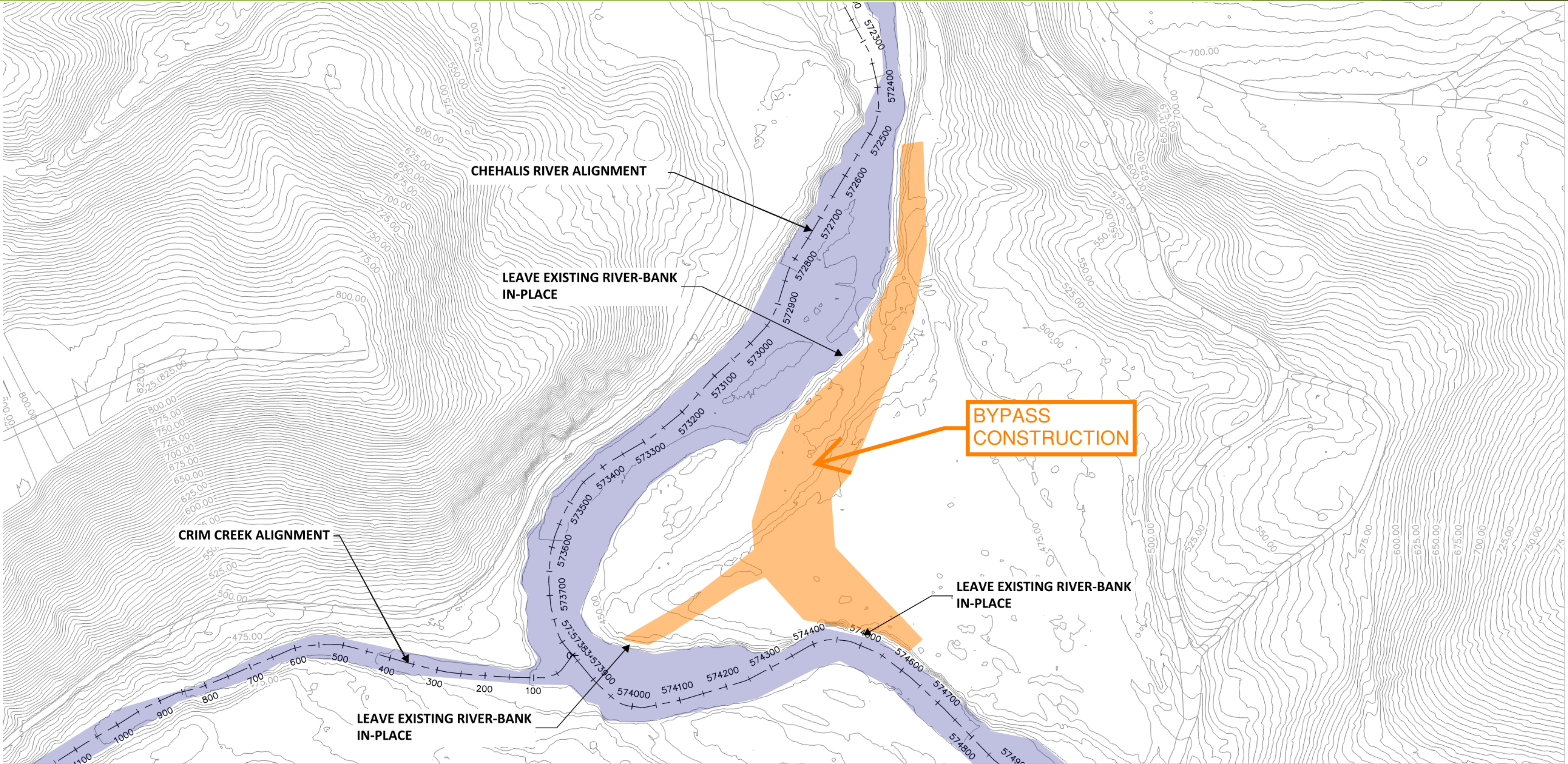
Project Update

Construction Phasing Overview



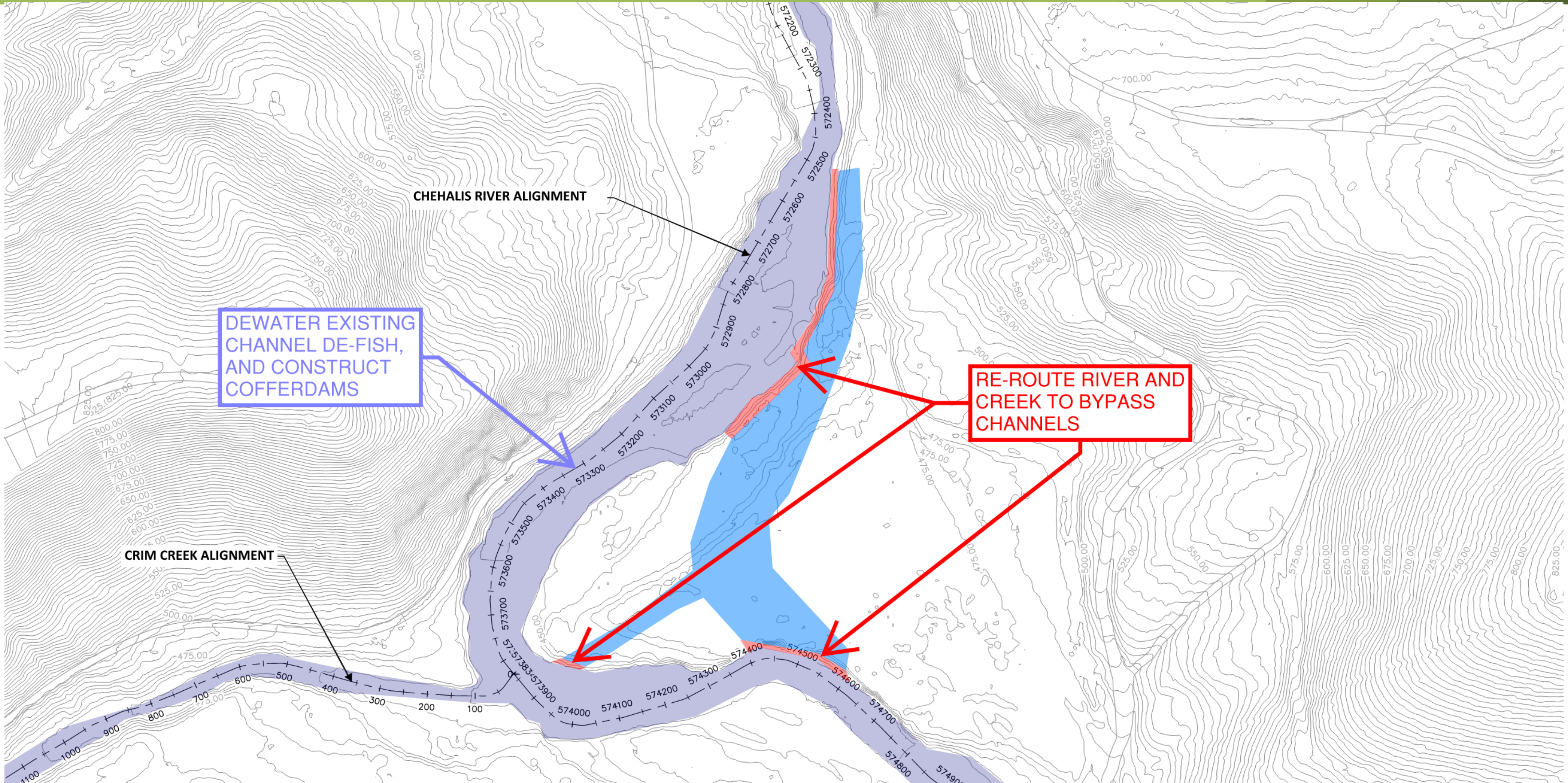
Project Update

Phase 1: Prework in the Dry



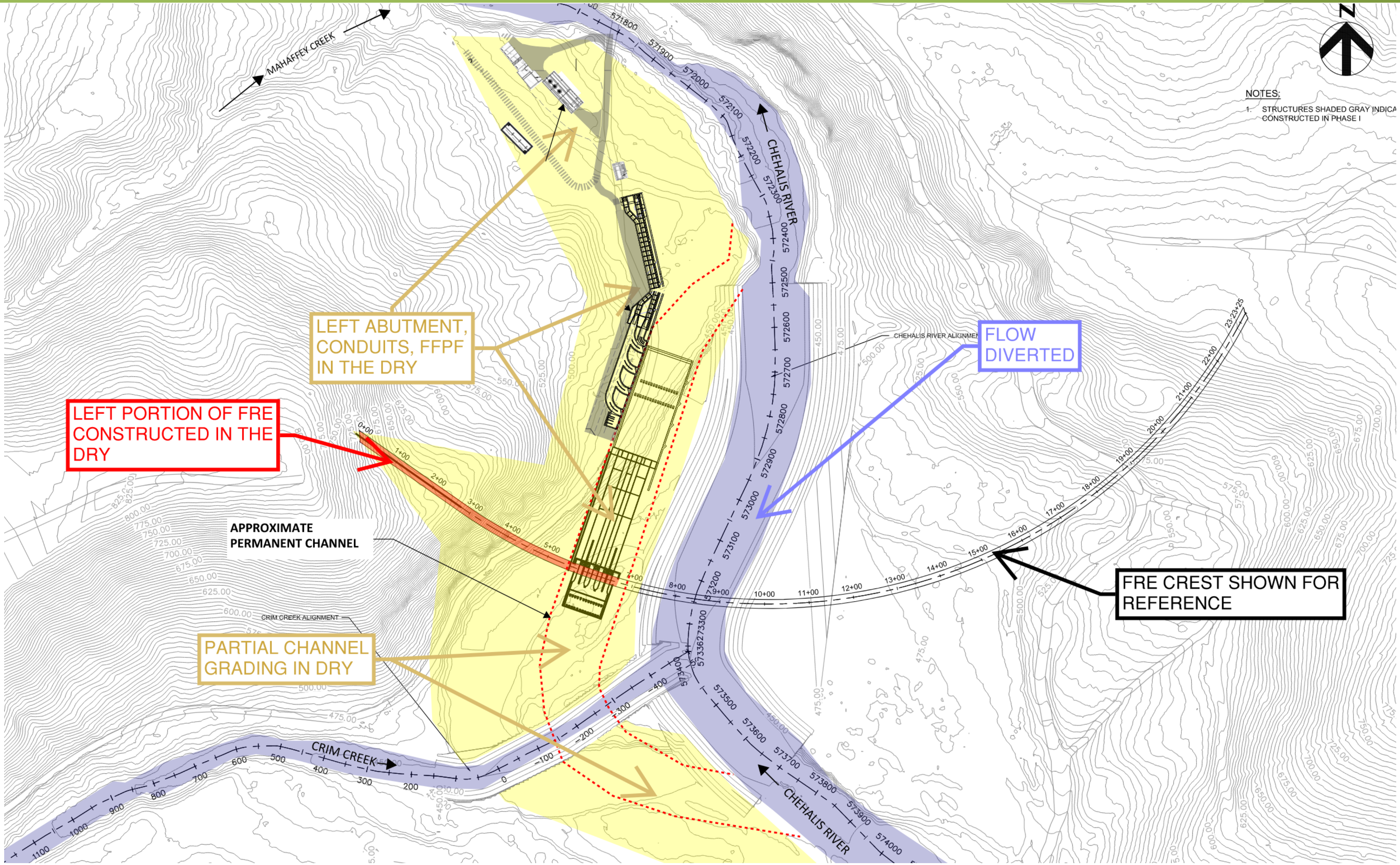
Project Update

Phase 1: River Diversion Within In-Water Work Window



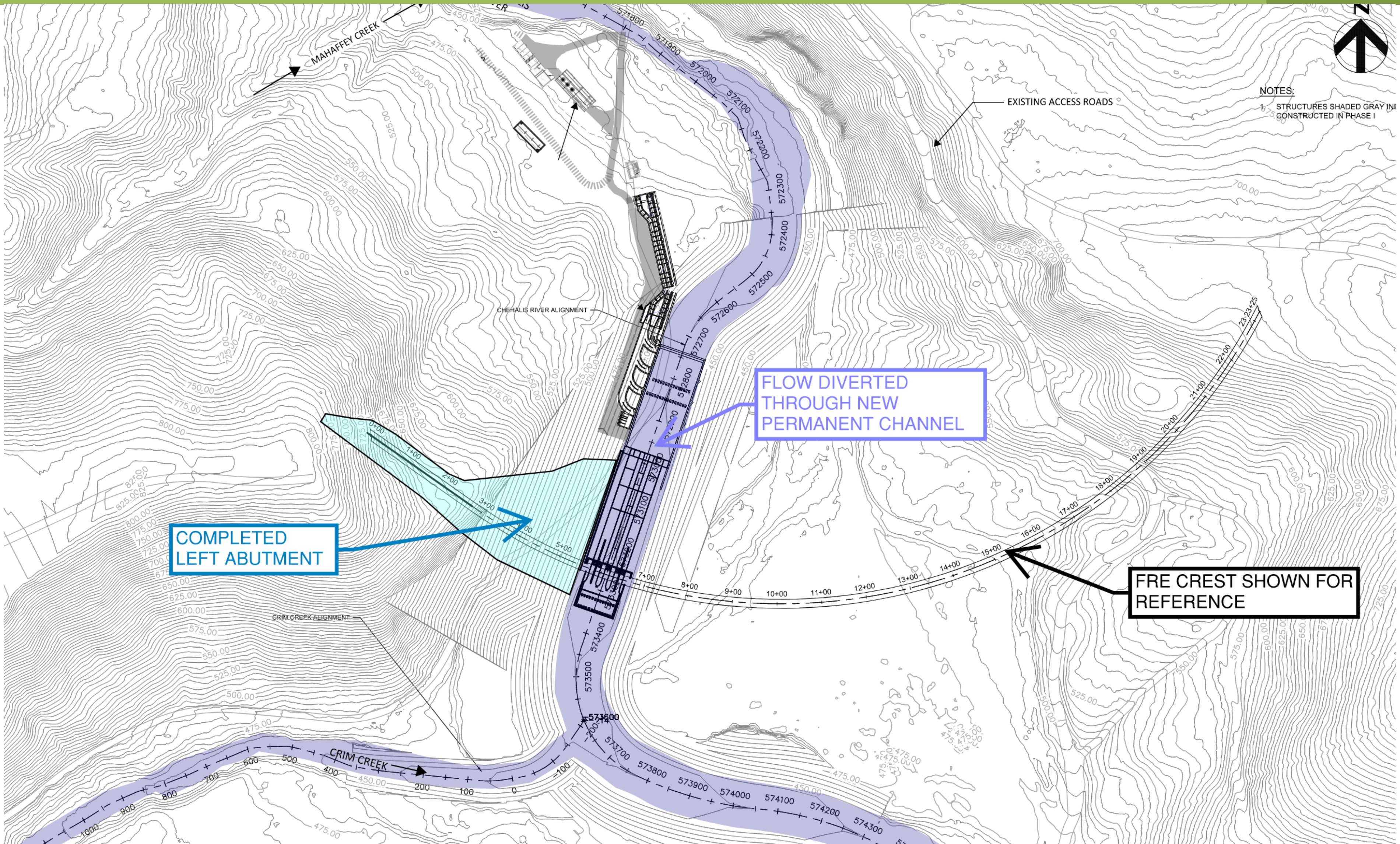
Project Update

Phase 1: Left Abutment and Structures in the Dry



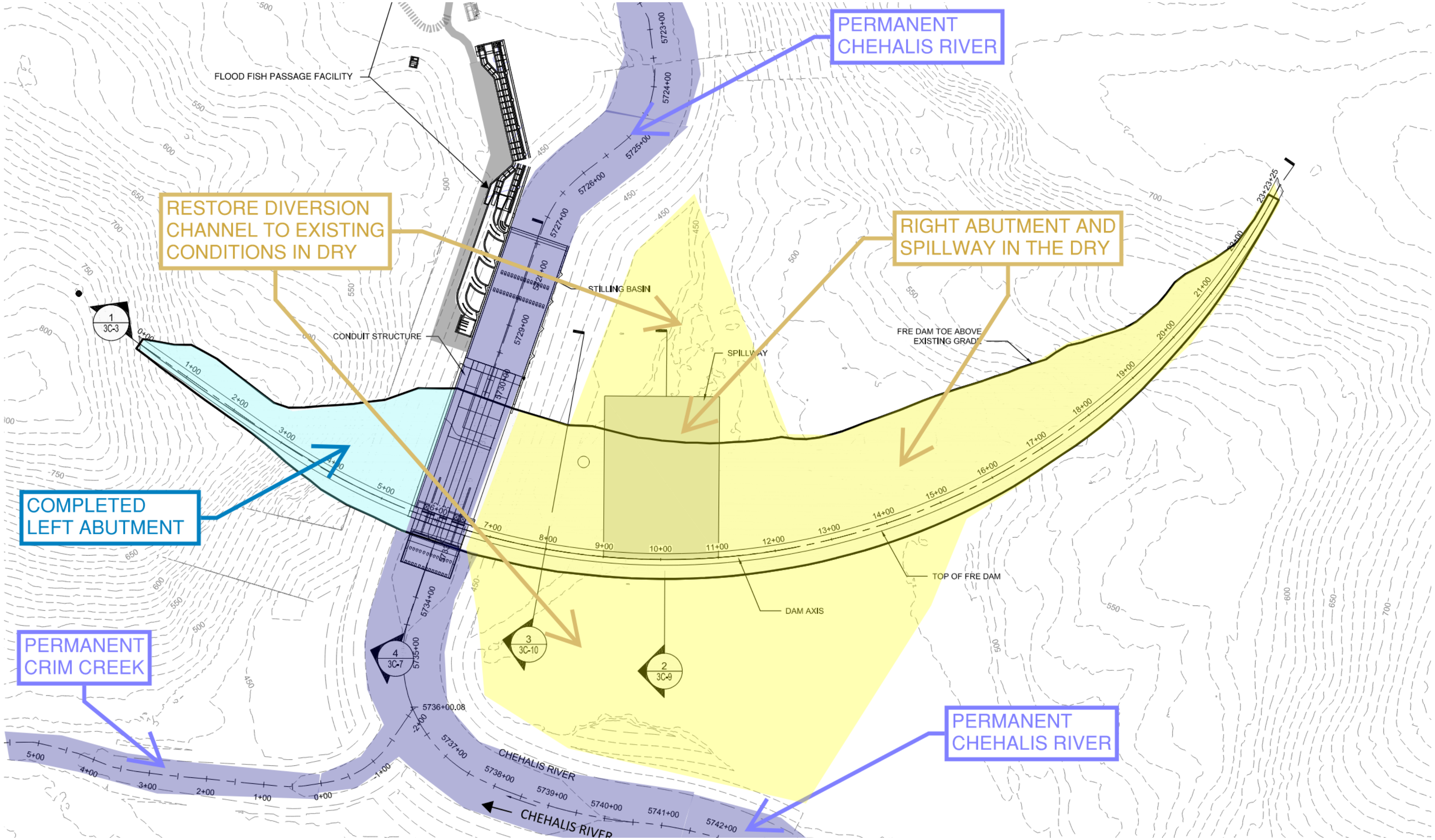
Project Update

Phase 2: Divert Flow Through Completed Channel Within In-Water Work Window



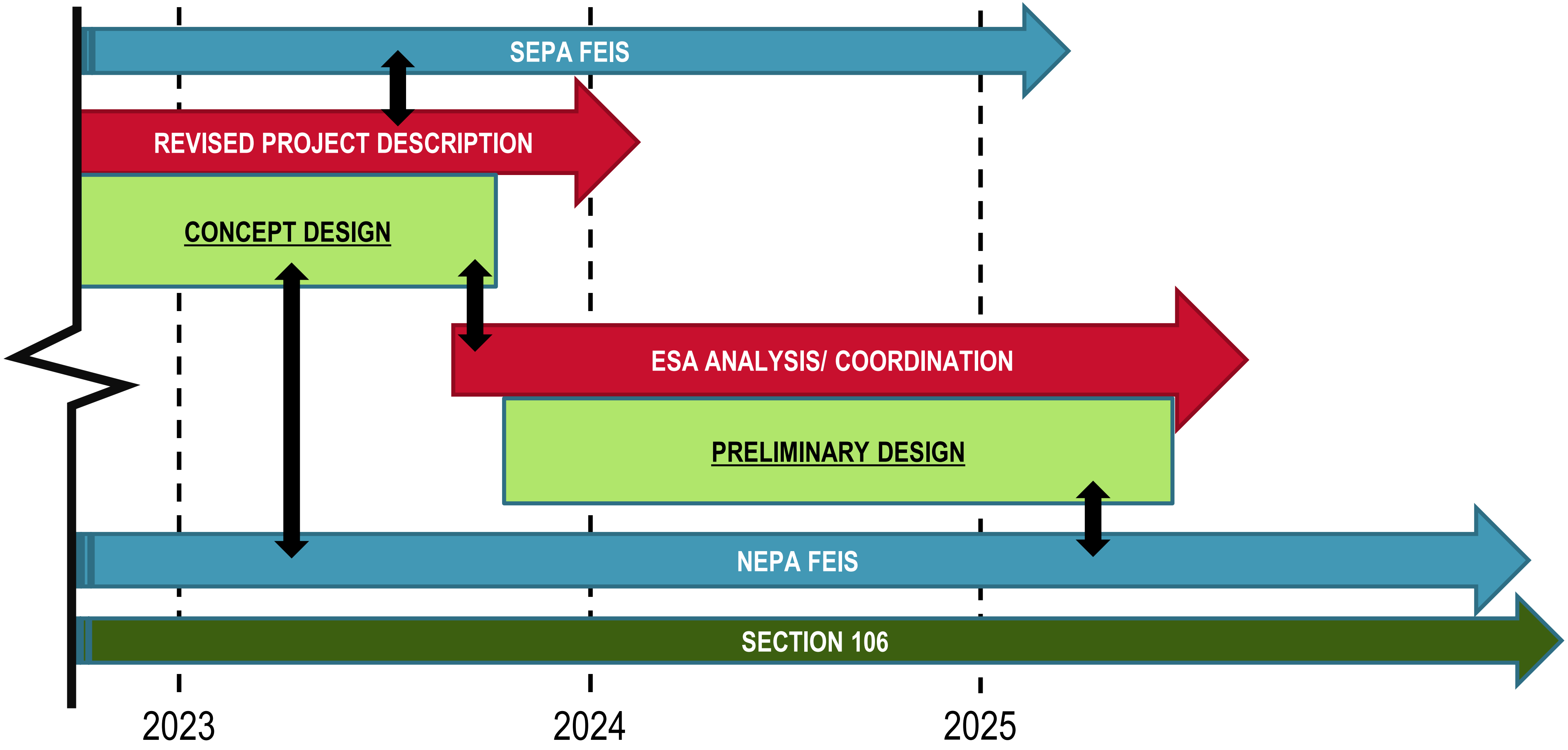
Project Update

Phase 2: Right Abutment, Spillway, and Restoration in the Dry



Project Update

Project Development Timeline



Topics for Future Meetings

- Biological Design Criteria
- Technical Design Criteria
- Design Methodologies
- Impoundment Operating Criteria
- FRE and FFPF Operation and Maintenance

Topics for Future Meetings

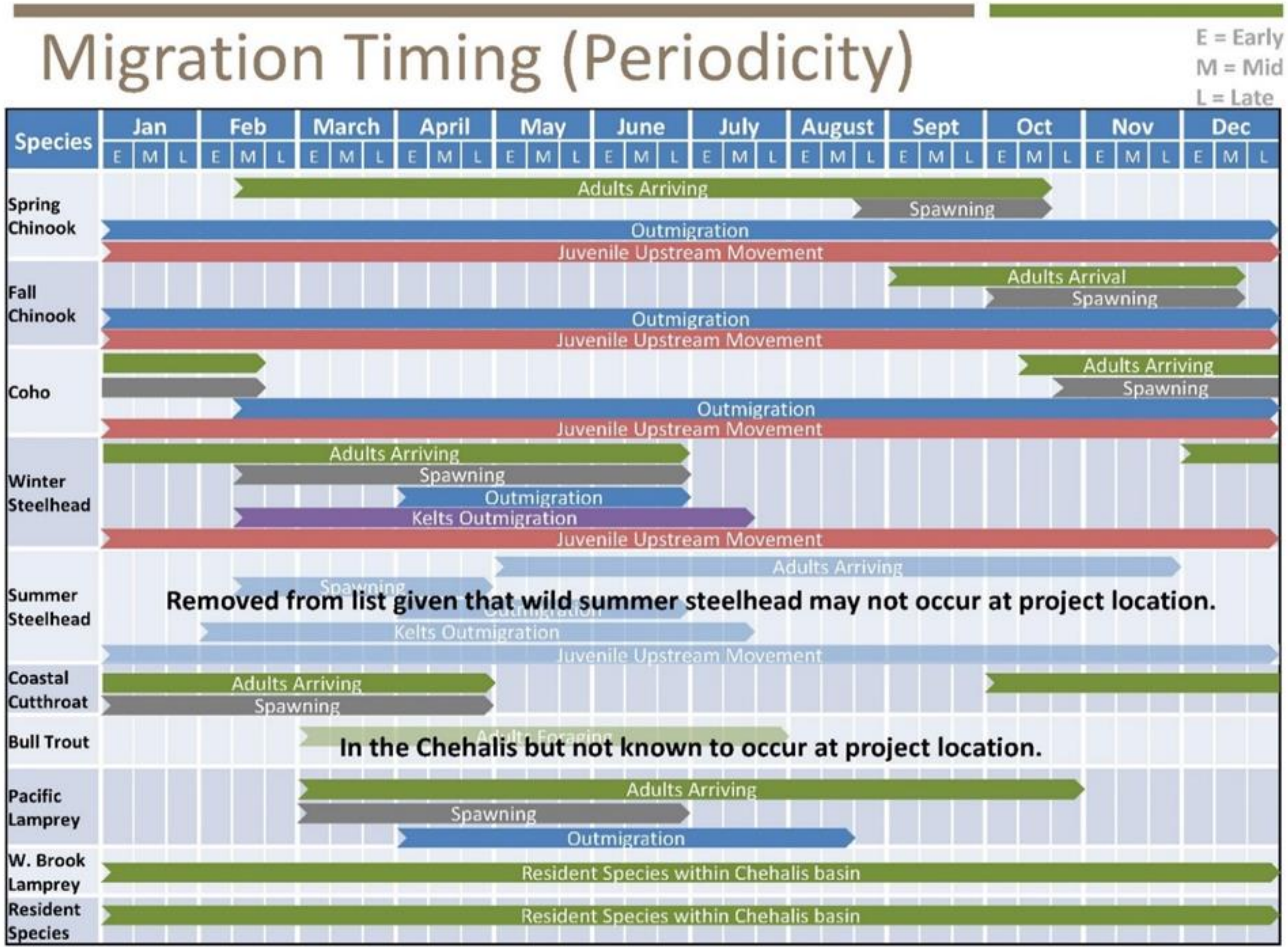
Biological Design Criteria

- Species occurrence and distribution
  - Latest published information
  - Unpublished data
  - Ongoing studies
- Species & life stages for each project element (e.g., conduits)

Topics for Future Meetings

Biological Design Criteria

- Periodicity
  - Run timing, outmigration, spawning, & juvenile movement



Topics for Future Meetings

Biological Design Criteria

- Fish abundance upstream of project site
  - Adult salmonid
  - Juvenile salmonid
  - Resident fish and lamprey estimates
  - Peak annual, day, & hour
  - Studies and model results
  - Consider run timing, operating periods, & abundance numbers to determine design parameters

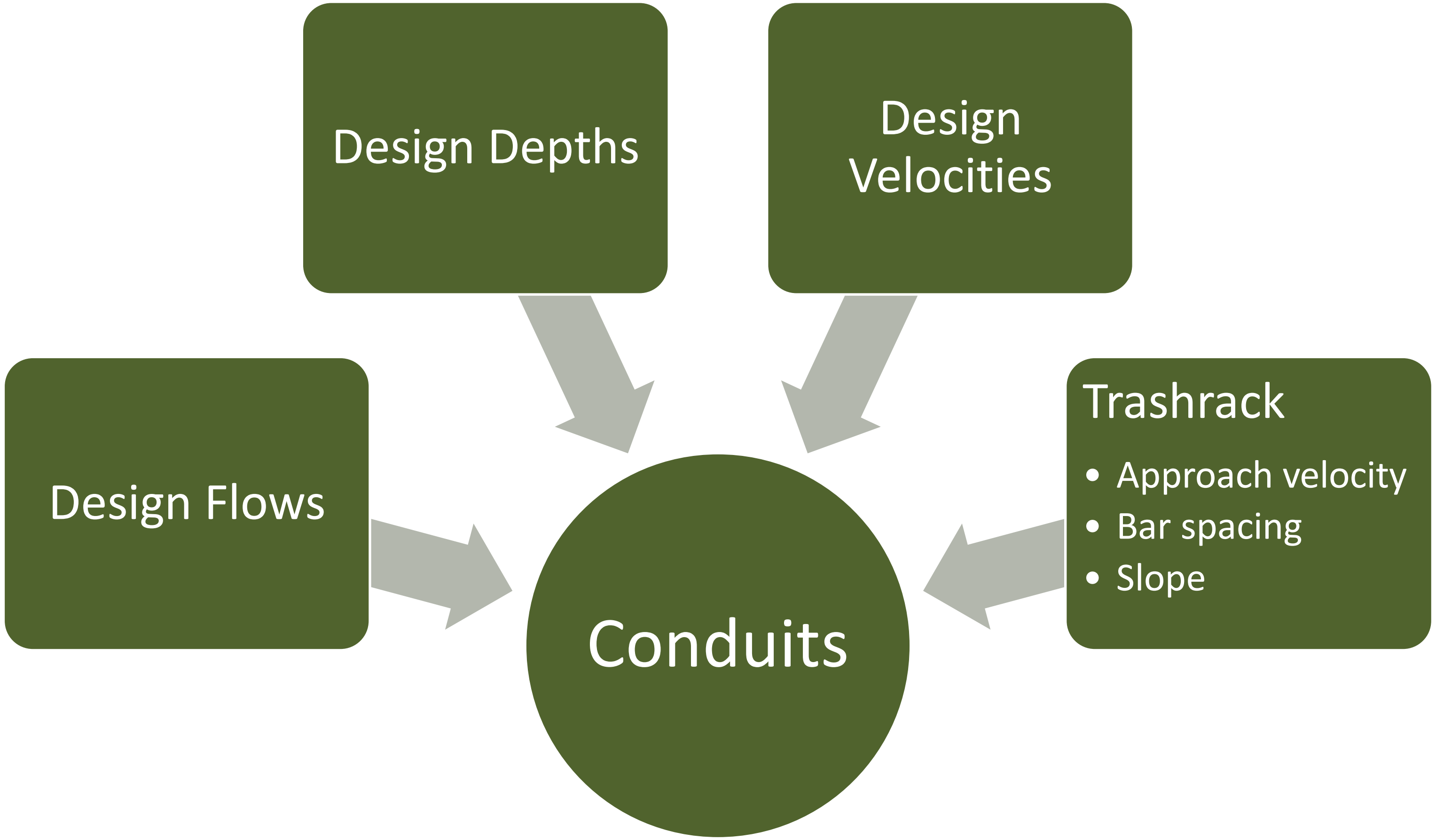
Topics for Future Meetings

Technical Design Criteria

- Guidance documents
  - NMFS – fish passage, climate change, and stream crossing
  - USFWS – Lamprey BMPs
  - WDFW – Fish screens, fishways, water crossings
  - Published papers – Lamprey design

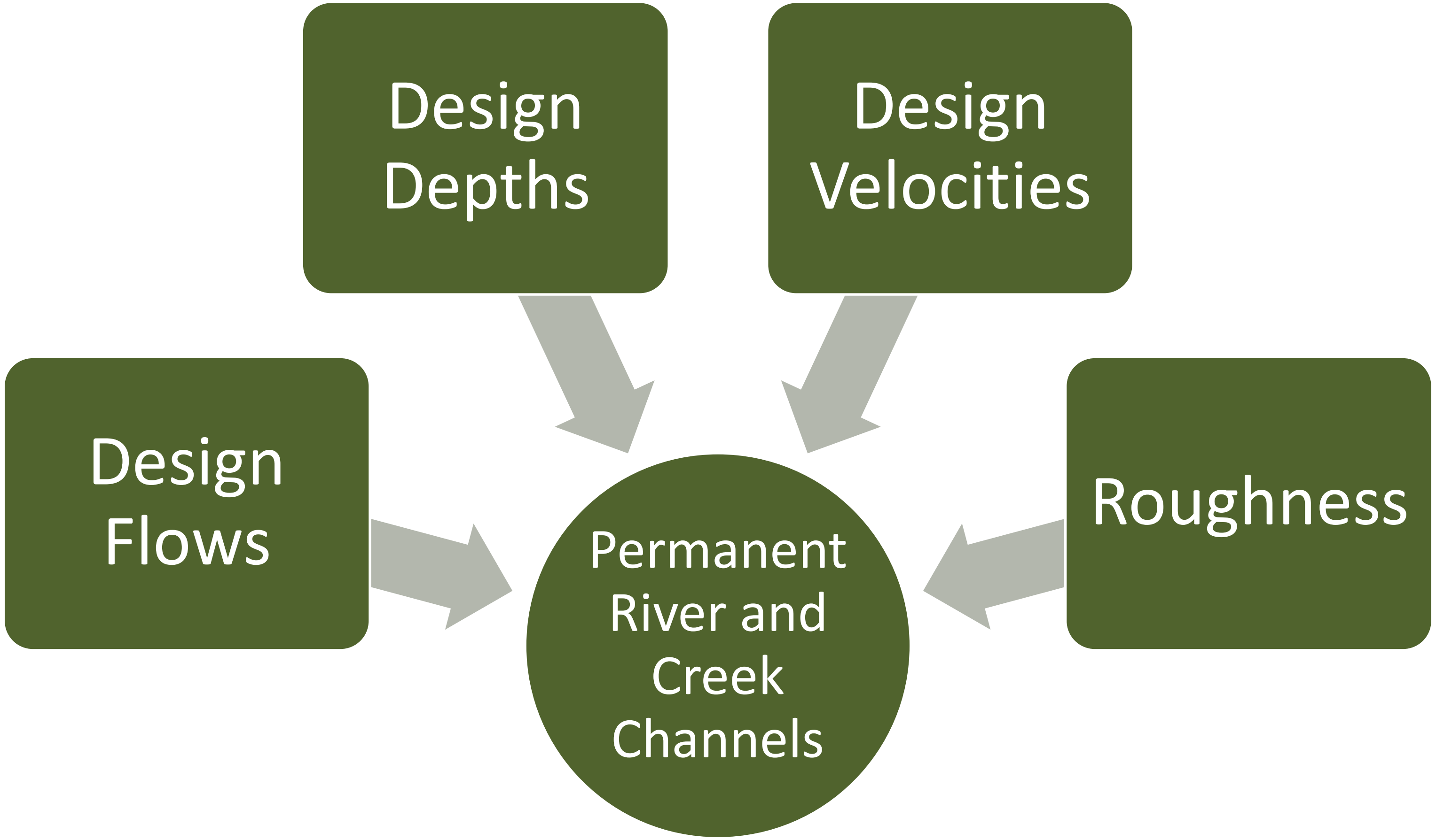
Topics for Future Meetings

Technical Design Criteria



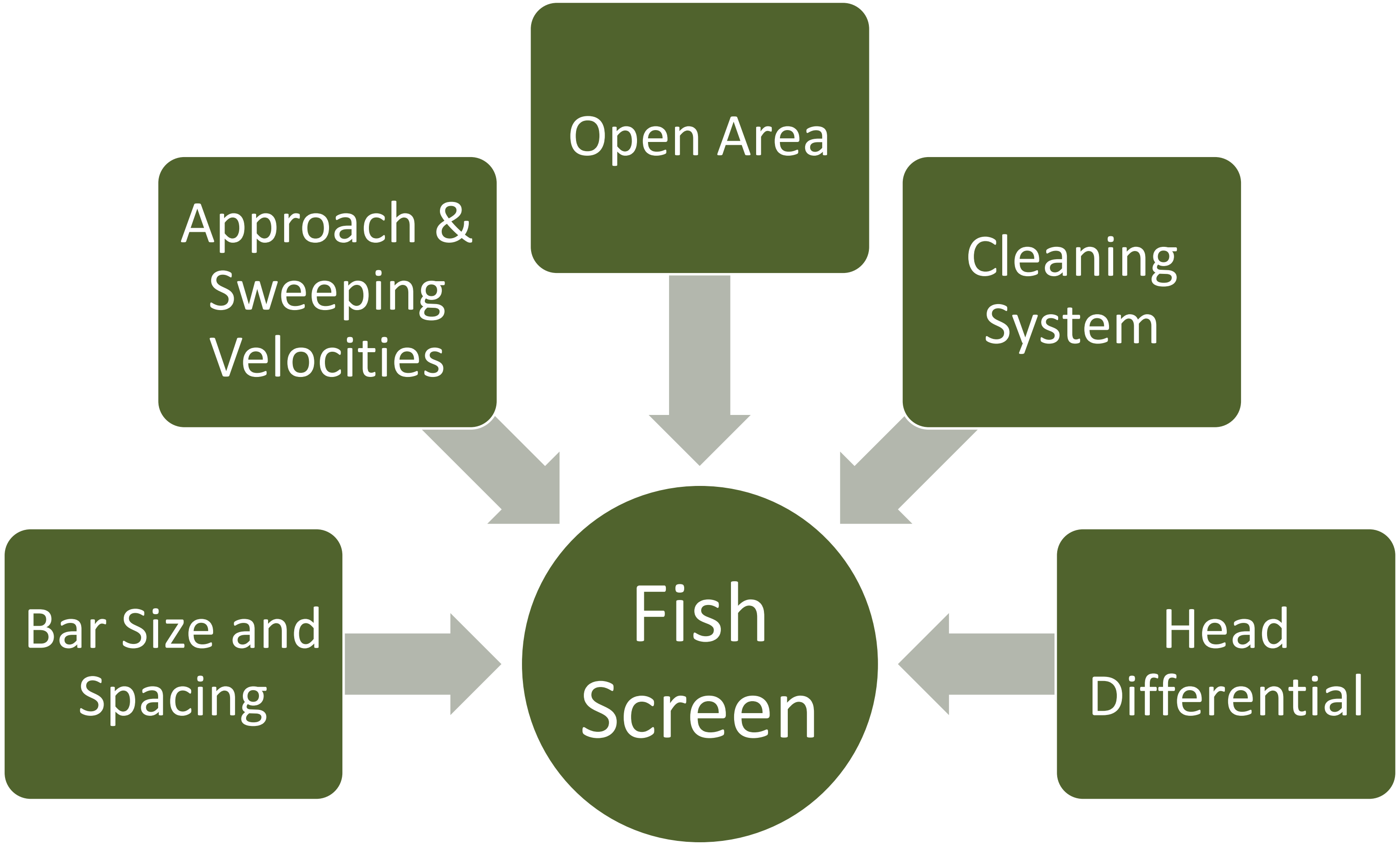
Topics for Future Meetings

Technical Design Criteria



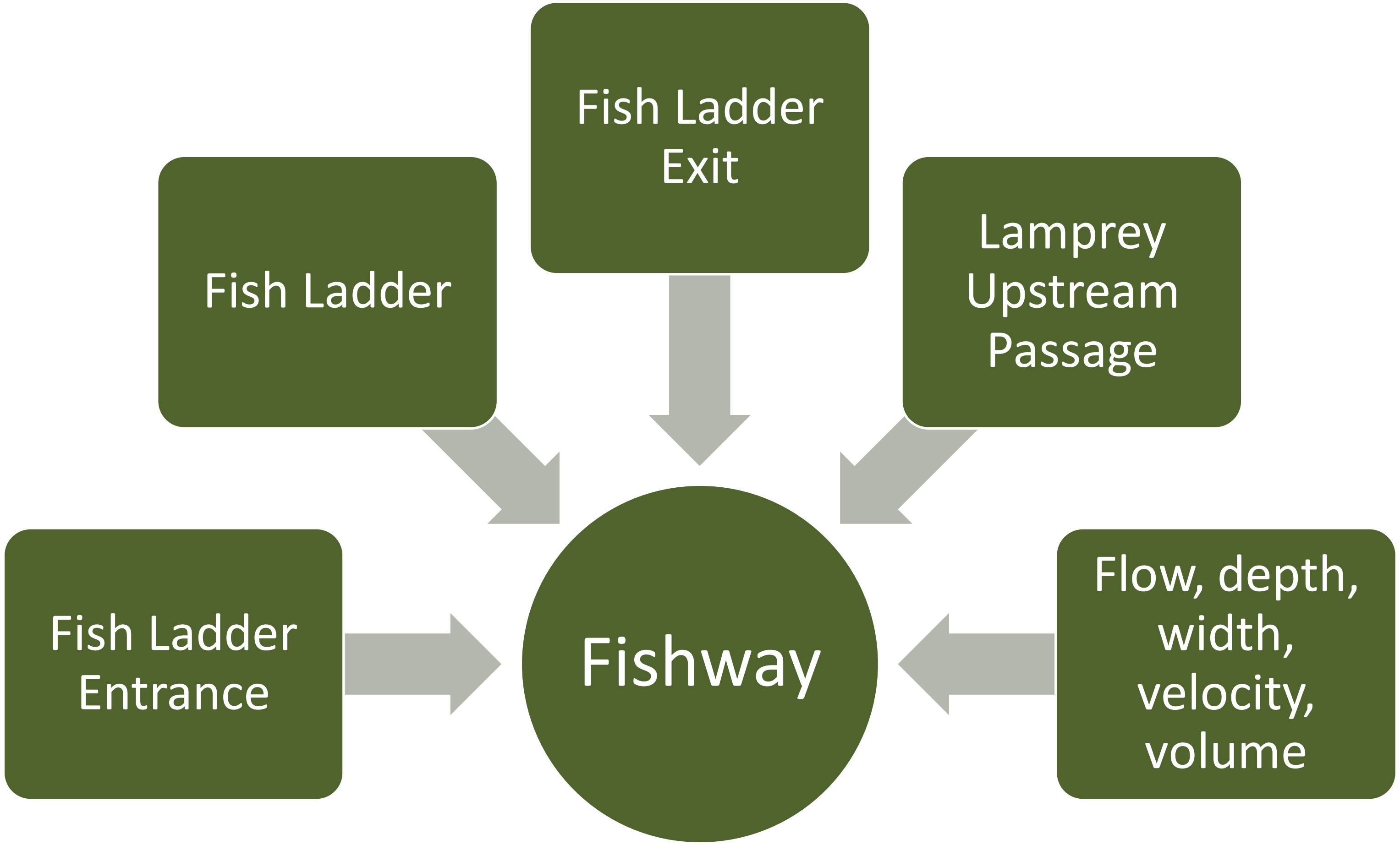
Topics for Future Meetings

Technical Design Criteria



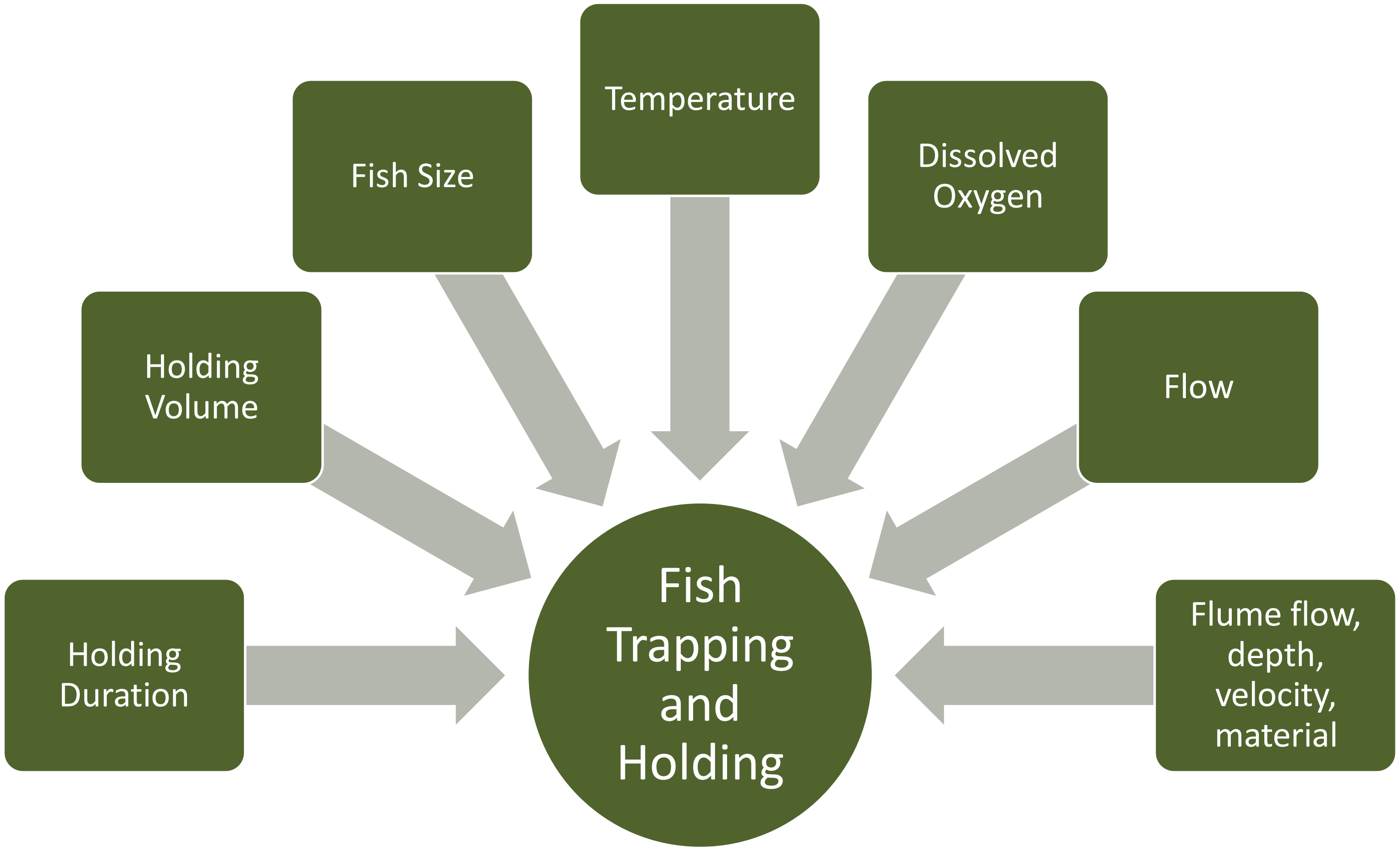
Topics for Future Meetings

Technical Design Criteria



Topics for Future Meetings

Technical Design Criteria



Topics for Future Meetings

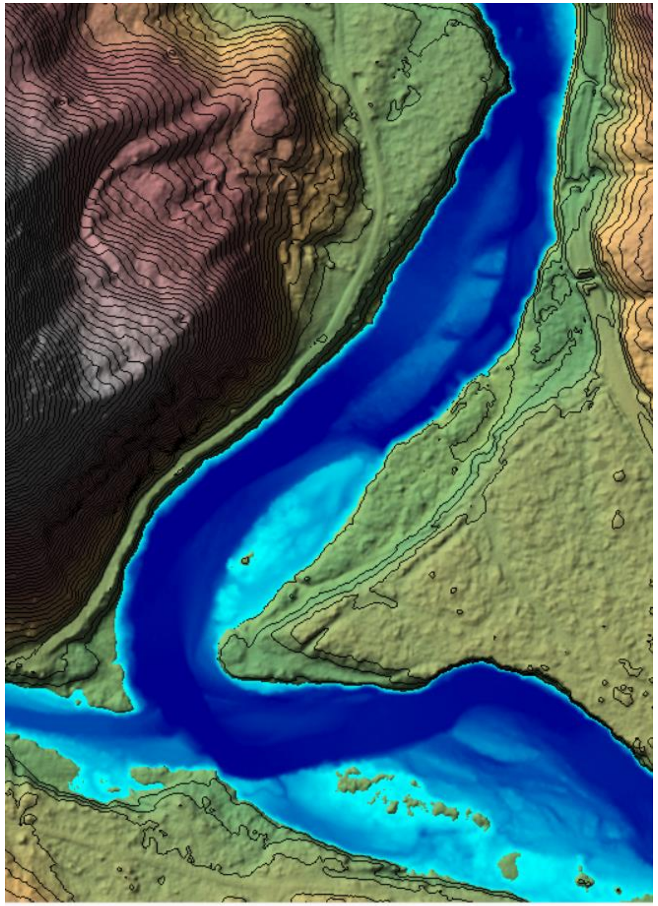
Design Methodologies

- Stream simulation – conduits, permanent river & creek channels, temporary bypass channels
- NMFS Fishway Guidance – adult & juvenile
- Published studies – lamprey ramp

Topics for Future Meetings

Design Methodologies

- Modeling
  - Hydraulic & sediment transport
  - Spreadsheet concept development
  - 1D & 2D HEC-RAS – preliminary design
  - 3D Computation Fluid Dynamics (CFD) – final design
  - Physical – final design



Topics for Future Meetings

Impoundment Operating Criteria

- Flood Fish Passage Facility operation and timing
- Release rates

Topics for Future Meetings

FRE & FFPF Operation and Maintenance

Conduits

- Exercise of conduit gates
- Maintenance during run-of-river operations
- Regular, long-term, and emergency maintenance

Debris Management

- Collection procedures and timing
  - Reservoir Collection
  - Trashrack Debris Removal
- Reuse of materials

Operation of FFPF

- Personnel experience
- Training
- Callout
- Regular, long-term, and emergency maintenance

Next Steps / Action Items

- HDR: send out recurring meeting invitation
- Develop meeting notes
  - HDR: send out draft meeting notes for input
  - **TWG**: provide input on draft meeting notes
  - HDR: send out final meeting notes
- Identify topics for next meeting

DRAFT Meeting Notes

Project:	Proposed Chehalis River Basin Flood Damage Reduction Project
Subject:	Fish Passage Technical Workgroup Meeting
Date:	Wednesday, January 17, 2024
Location:	MS Teams
Attendees:	Ann Costanza, Anchor QEA Seth Ballhorn, Ecology John Best, WDFW Meg Bommarito, Ecology Ben Cross, USFWS Daniel Didricksen, WDFW James Gordon, Cowlitz Tribe Jeff Brown, NMFS John Ferguson, Anchor QEA Marisa Litz, WDFW Matt Dillin, Chehalis Basin Flood Control Zone District (District) Matt Kuziensky, Anchor QEA Pad Smith, WDFW Jenae Churchill, USACE Matt Prociv, HDR Nick Szigeti, HDR Sandy Cody, HDR

Please Note: This project discussed in this meeting and in the notes below is proposed and is currently conceptual. Please keep in mind that all references to the project in the meeting notes and presentation are made with the acknowledgement that the project is in the proposal phase.

Meeting Objectives

- To inform the TWG members of:
  - Progress of requested project history presentation
  - Updates to the proposed FRE design since our last Technical Working Group (TWG) meeting in August
  - Incorporation of climate change into the design now and later
  - Initial hydraulic results for permanent and temporary channels
  - Next steps

Discussion Topics

- **Introductions & Background**
  - Attendees introduced themselves, discussed role on the project and what they would like to get out of today's meeting.
    - Most attendees are looking forward for updates on the project design for today's meeting, including fish passage design.
  - HDR's role is consultant for the District and provide data. TWG role is to provide feedback.
  - The focus today will be discussion of design approach and methodology and identification of topics for discussion at future meetings
- **Status of Project History Presentation**
  - Matt proposed either a future meeting or a video to go over the Project history.

- Daniel Didricksen proposed a site visit. Matt Dillin noted that the site is on Weyerhaeuser property and would require rights of entry.
- Kleinschmidt has conducted drone flights in the basin and that may become available for this group.
- Marisa said a presentation and video would be great. Would also be amenable to a site visit.
- Matt Prociv said HDR and the District would look into organizing a site visit, perhaps with an in-person presentation beforehand, but getting Weyerhaeuser permission, if provided, requires some administrative effort and will take some time.

- Update on Design – Matt Prociv noted that the project is in conceptual design. The FRE facility was moved upstream in an effort to <u>minimize</u> the impact to a traditional cultural place (TCP). A curved structure was selected in an effort to further help <u>minimize</u> potential impacts to the TCP and reduce the project footprint at the new location.
    - **CORRECTION**: During the meeting Matt Prociv had incorrectly stated that the upstream alignment is an avoidance measure. The District has received clear feedback from the Section 106 participants that the upstream alignment does not avoid impacts to the TCP and can only be considered an effort to minimization impacts. The meeting notes have been updated to reflect this correction.
- The smooth spillway with a flip bucket has been replaced with a stepped spillway with a stilling basin. Matt Prociv communicated that the proposed FRE was moved upstream to avoid potential impacts to the TCP, but the intent was to communicate that the proposed FRE was moved upstream to minimize potential impacts to the TCP.
- Flood Fish Passage Facility (FFPF) –The FFPF was originally called Collect, Handle, Transfer, and Release facility (CHTR). It is a trap and transport facility for upstream passage. the FFPF would not be operated during run-of-river. Operation of the FFPF would begin just before impoundment of water and would stop just after run-of-river flow was fully resumed.
- Fish Passage conduit structure
    - The walls used to be parallel going downstream. Since having gone to a curved FRE structure, the walls are now angled so they are perpendicular to the axis of the FRE structure. This did not change the hydraulic function of the conduits.
    - The evacuation conduit was added in 2023 and discharges via an energy dissipation valve into the spillway stilling basin. The evacuation conduit is 9 feet in diameter and would be operated at elevation (EL) 510. Above EL 510 the energy dissipation valve throttles the flow per the discharge operation rules. Below EL 510, it would be closed. The evacuation conduit would also be closed during run-of-river.

  - The evacuation conduit would be used to evacuate the reservoir and would discharge into the spillway stilling basin, but this is still conceptual and may change.
  - The evacuation conduit can be designed for a single function – to only release water to the river. This provides better operational flexibility and fine control of flow releases downstream compared to the previous design, which used the fish passage conduits to evacuate the reservoir.
  - The evacuation conduit would operate when there would be high levels of storage (i.e., high head) behind the FRE.
  - TWG shares concern that false attraction to the evacuation area during reservoir evacuation may occur when we want strong attraction to the FFPF entrances.
    - Matt Prociv shares that at the conceptual design level, we're currently not showing the water supply pipe to the fish ladder entrance. However, the design intent is that during low discharge flows, all the discharge from the reservoir would be sent to the attraction water facility, resulting in all the water in the river downstream coming out of the FFPF fish ladder entrances. During higher reservoir discharge flows, the appropriate ratio of river flow to FFPF attraction flow recommended by NMFS and WDFW would be provided.
- A trash rack would be located in front of fish passage and evacuation conduit. The trash rack has 2-foot spacing on the bars and goes the full height to accommodate the reservoir fluctuation.
- The number and size of the fish passage conduits has not changed from the previous FRE location. There are five fish passage conduits – four secondary conduits (10 feet wide) and one primary conduit (12 feet wide).
  - Separating the reservoir evacuation function from the fish passage conduits allows the design of the fish passage conduits to be focused on volitional upstream and downstream passage and sediment continuity.
  - If evacuation of water from the reservoir was through the fish passage conduits, the conduits must be dual purpose (volitional fish passage and evacuating the reservoir), which is hydraulicly difficult for a single set of wide, rectangular conduits. Evacuation through fish passage conduits would also not allow for fine control of flow release.
  - The design will include roughness elements to optimize passage.
  - The wall between adjacent secondary conduits may be extended to improve function – the design team will look at this in the future.
  - **CORRECTION**: In the meeting Matt Prociv stated that the conduits have gotten longer since the design at the previous FRE location downstream near the existing bridge - from about 250 ft long to 320 feet long. Since the meeting, HDR has verified the conduits have not changed in length since the design at the previous FRE location.

        - The primary conduit would have a tainter (radial gate). During reservoir filling and evacuation, the primary conduit would be closed above EL 510 and would throttle the flow at reservoir elevations below EL 510.
        - Secondary conduits – These conduits are a secondary flow path that are available during run-of-river when the river is high. The conduits may open one at a time as the river flow increases or they may all stay open and convey flow without intervention based on their staggered invert elevations. This is to be decided in future phases of development. During operation/impoundment, the secondary conduit gates would be closed. The secondary conduits would use bonneted slide gates.
    - Stepped Spillway
        - The configuration of the spillway has changed.
        - The spillway is now located closer to conduit structure.
        - Water only flows over the spillway in really high flood events.
        - The face has gone from smooth to stepped and it has been widened from approximately 200 to 316 feet. The steps and widening provides more energy dissipation on the face of the spillway and allows for reducing the size of the spillway stilling basin and potential impacts to the river downstream.
        - The spillway would not be activated until approximately the 100-year flood event.
    - FRE Structure
        - No downstream migration path is available during maximum impoundment, which minimizes the time the pool is held. Downstream fish passage would be available again once the primary conduit is re-opened.
  - Fill and Evacuation Operation
    - Matt Prociv shared the steps in the fill and evacuation process. See the steps provided in the meeting presentation.
- Ann Costanza has requested that changes to the design since the FRE structure was located downstream near the existing bridge be shown in a table/cross walk so TWG can see what the changes are. The District is also providing a revised project description in March and the front end of that document will summarize design changes. The upcoming interagency meeting will also have presentation that will have side by side cross sections of changes.
- **Incorporation of Climate Change**
  - HDR and the District are following NMFS new 2022 climate change design guidance.
    - There are two pathways for incorporation: for projects with more than a 10-year life expectancy and projects with less than a 10-year life expectancy.

- For this project, design of the permanent features will follow the guidance for projects with more than a 10-year life expectancy. The features proposed during construction will follow the design guidance for projects with less than a 10-year life expectancy.
- 2023-March 2024 – The Project Description will be revised to incorporate climate change guidance. The SEPA EIS climate change flow scalers from March 2023 memo were used to revise Project Description and determine fish passage design flows.
- 2024-2025 –The biological assessment will be updated, which will include analysis of data from the 12 global climate models (GCMs) provided by University of Washington Climate Impacts Group.
- The review of climate change data will allow for refinement of climate change design flows through NMFS collaboration.
- The design team will review the operational analysis for climate change and will develop avoidance and minimization of impacts.

- **Design Approach & Initial Hydraulic Results**
  - Fish passage design approach
    - Conduits will mimic existing hydraulic characteristics in this reach of the Chehalis River. This design approach was developed and selected by 2016-2017 Fish Passage Technical Subcommittee.
    - Permanent and bypass channels will follow NMFS and WDFW guidance for the reference reach design approach.
    - Long-term use (permanent) features are designed for high and low passage flows, adjusted for climate change.
    - Short-term features used during construction are designed for high and low flow passage based on the historic record.
    - The high design flow used in the current phase of work for the Revised Project Description (RPD) is 3,400 cfs (5% historic exceedance is 2,200 cfs multiplied by 55% climate change scalar).
    - The low design flow used in the current phase of work for the Revised Project Description (RPD) is 14 cfs (95% historic exceedance of 16 cfs multiplied by -14% climate change scalar).
    - Fish passage design flows used in the final design of the permanent features will be determined through the NMFS collaboration process using the NMFS 2022 climate change design guidance.
  - Hydraulic results
    - All hydraulic results assume bare conduits. Sediment analysis will be conducted in the next phase of the design.

- The velocity and depth results presented in the meeting reflect the current design but the slopes presented in the meeting did not. The slopes for the proposed permanent and temporary Chehalis River and Crim Creek channels and their corresponding reference reaches presented in the meeting reflected a previous design iteration. The presentation slides attached to these meeting notes have been updated to reflect the slopes used in the current hydraulic modeling.

- Permanent Fish Passage:

  - Fish passage conduits mimic the hydraulics of the rock incised channel at the previous FRE location. The fish passage conduits will maintain an open channel through a range of low to high fish passage design flows.

  - For the initial hydraulic modeling of the conduits with climate change, no bathymetry data is available at the existing rock-incised channel but is scheduled to occur once river flows drops. Modeled conduit depths are similar to that of the existing rock-incised channel. At high flow, velocity is approximately 4 ft/s with velocity refuge spots. The design team will look at adding roughness elements in future design development to ensure good passage options for fish. At low flow, conduit depth is similar to that of the existing rock-incised channel. At low fish passage design flow, the conduits are backwatered from the stilling basin and the velocity is less than 0.1 ft/s, which is also similar to the existing rock-incised channel. Velocity is dependent on backwater operations. John Ferguson noted that under low flow, the secondary conduits are closed, and flow would be down the middle of the structure.

  - How is backwater being controlled to get desired fish passage velocity? Backwater control is currently being shown as an end wall for the stilling basin with a fixed crest elevation. There will be some natural transition to the river downstream. These features have not been sorted in this conceptual design phase. Options for improving operational flexibility and providing fish passage will be explored in Preliminary Design.

  - What is the thinking of adult passage during low flows at the end sill? Matt Prociv agreed that the end sill will likely not be functional for adult passage as currently shown. We are still at a conceptual level. It is expected that the end sill will be notched or other changes to the design will be implemented to ensure safe and timely adult passage. Matt Prociv noted that a multi-panel Obermeyer weir or other design with similar function may be a more appropriate option. This will be a topic for refinement in next phases of design.

  - Is there advantage to shaping the cross-sectional area to keep velocities higher at low flows to keep a good signal to keep fish moving. Matt Prociv noted the stilling basin is partially a holdover from previous design. Now that reservoir evacuation is not occurring through the fish passage conduits at high EL, what is the function of the stilling basin? Matt Prociv said the stilling basin 1) provides appropriate depth and velocity in the fish passage conduits by creating backwater and 2) when operating the FFPF, it provides access to the fish passage entrances.

  - Are the entrances to the FFPF collection system in the stilling basin or downstream? The entrances are in the stilling basin. Matt Prociv reiterated the importance for end sill refinement so adults can reach the FFPF entrances at low flow.

- Permanent Channels – Chehalis River
  - The slope of the approach channel is between that of the cascade and non-cascade reference reaches. However, the approach channel will be backwatered so the channel slope has less impact on the hydraulics.
  - The permanent and bypass river and creek cross sections are designed to convey the 25-year flood with 3 feet of freeboard without overtopping. This is done to reduce the risk of flooding the project during construction. The left side of the FRE structure and FFPF would be constructed first by bypassing the Chehalis River and Crim Creek around the project site. When the left side work is complete, then the Chehalis River and Crim Creek flows will switch to the permanent river and creek channels.
  - The depth and velocity of design channels match fairly closely to reference channels during high and low design flows.
- Permanent Channel - Crim Creek
  - The permanent channel and reference channel slopes and bankfull widths are very similar and will also be designed to contain the 25-year flood plus 3 feet of freeboard.
  - Crim Creek has exposed bedrock and large cobble.
  - Velocities and flows are similar for the reference Crim Creek channel and permanent channel.
- Temporary Channel – Chehalis River Bypass
  - During construction of the left portion of the FRE structure and FFPF, the river will be moved to a bypass channel that will run through the landslide remnant.
  - The reference reach is just to the west of the channel re-alignment and located within the proposed FRE alignment.
  - The bypass channel has a low flow section and steep slide slopes, similar to the natural channel. The bankfull width would also be similar between the reference and temporary channel. Exposed bedrock is located along the left bank in the reference reach location.
  - A pebble count was conducted at point bar just upstream of the confluence of the Chehalis River with Crim Creek. This is the only reach in the vicinity of the proposed project with a viable location to perform a pebble count.
  - Depth results are close to matching between the bypass and reference reach for both low and high flows. Velocities are also similar.

        - Temporary Channel – Crim Creek Bypass
            - The Crim Creek bypass will lengthen Crim Creek to meet up with Chehalis River bypass channel.
            - The Crim Creek bypass exhibited the same hydraulic conditions as the existing reference reach. There is a slight backwater effect where it ties into the bypass. As the design develops, the design will be refined with close attention paid to the confluence of Crim Creek with the Chehalis River so that fish migration conditions up Crim Creek will remain desirable.

- **Next Steps of Fish Passage Design**
  2024-2025
    - The design team will continue to work on fish passage design flows per NMFS climate change guidance.
    - Refine the fish passage conduit design. Concepts identified at this time for refinement include, but are not limited to, staggered invert elevations, roughness elements, conduit size, length and spacing, and artificial lighting. Additional analyses include identifying low-velocity pathways, sediment transport analysis, and 2D hydraulic modeling.
    - Refine the permanent and bypass channels. Concepts identified at this time for refinement include, but are not limited to, channel roughness, slope, alignment, and velocity refugia. Additional analyses include identifying low-velocity pathways and 2D hydraulic modeling.
    - Refine reservoir drawdown rates and durations. Concepts identified at this time for refinement include, but are not limited to, operating rule adjustments based on storm center location (may get floods that would trigger operation without rain within the basin, therefore there is opportunity to refine duration of operation based on precipitation predictions) and minimization and avoidance measures, particularly for redds.

  Future phases (after 2025)
    - Fish passage conduit and channel design refinement occurring in design phases after mid-2025 would likely include 3D numerical and/or physical model.
    - Refine the FFPF. Concepts identified at this time for refinement include, but are not limited to, entrances, auxiliary water, fish ladder, holding and handling, transport, and release locations (at concept level, too early to define specific locations for release).
            - Additionally, investigate opportunities to release fish in the upper creeks during an inundation period. Transport methods may include vehicle, boating or helicopter transfer.
    - Refine operation and adaptive management plan. Concepts identified at this time for refinement include, but are not limited to, drawdown rates, inundation durations, operating rule adjustments based on storm center location, and avoidance and minimization measures.

- **Open Discussion and Questions**
  - Concerns about conduits don't have daylighting for 300 feet. Are there thoughts on daylighting these to encourage migration?
    - Matt Prociv said they will want to daylight as much as possible and may try to shorten conduits up (currently 300 feet long).
    - Conduits have not been hydraulically optimized yet. Also, there may be an opportunity to daylight the top of the conduit structure.
    - Artificial lighting may be included for portions that aren't opened.
    - The Lower Granite Dam on the Snake River has a fish passage tunnel under eight spill bays (approximately 200-300 ft total) that is artificially lit to encourage passage. Study(ies) show no fish passage delay through the tunnel. This dam would be a good example to look at for Chehalis. Matt Prociv to contact John Ferguson for reference to the specific study(ies). The study contains fish counts and other data that could be useful.
  - Trash Racks: Looking at the trash rack design and the broader shorter section and the taller, thinner section – what is the reason behind the shape? The trash rack boxes are associated with two access roads to access the trash rack. The trash racks are vertically and horizontally staggered. After a freshet or evacuation, vehicles can drive out on top of the lower trash rack structure and remove debris.
  - Ben Cross noted that temperature may be an issue – the project may flood out riparian vegetation that provides shade during operations. Solar radiation will impact water temperatures. Matt Prociv noted that a vegetation management plan (VMP) is being updated. Matt Dillin said the VMP is a minimization measure for temperature. There is also another flood facility at Mud Mountain that operates similarly to the proposed project. That reservoir had been clear cut and naturally recruited deciduous vegetation. HDR is reviewing the Mud Mountain data for information about flood tolerant species and will include this information in the VMP update. The VMP also includes planting plans to guide the intentional transition to flood tolerant species in the reservoir area. The mitigation plan also includes potential mitigation in other sections of the river where there may be opportunities to lower water temperatures. Ben requested we present the river temperature and corresponding flow data from the District's temperature modeling in a future meeting.
  - Can the previous materials and materials presented today be accessed through a SharePoint site? Matt Dillin noted that some federal agencies may have issues accessing file sharing sites. He asked the group if SharePoint would be okay or if another site that would work better for them. NMFS can only sometimes use SharePoint. If there is an existing website, that would probably be best for the federal agencies. USFWS has fewer issues accessing SharePoint. Typically, okay to download content from sites but more restriction with uploading content.
- **Topics for Future meetings**
  - Dan Didrickson would like to see a depiction of upstream and downstream migration and transitional periods, particularly when delaying downstream migration, what goes into causing delays in migration, and potential impacts from delaying downstream migration.

- Has non-salmonid passage been considerations? Matt Prociv said yes, all species and all life stages are being designed for. Will dig into this topic more during future meetings.

- **Action Items**
  - HDR: Send out recurring meeting invitation – Matt to send out a Doodle Poll.
    - Meetings will be scheduled for every 6 weeks.
    - Each meeting will be scheduled for 3 hours but will aim for limiting the meetings to 2 hours long.
  - Develop meeting notes for this meeting and our previous one
    - HDR send out draft notes for input
    - TWG: Provide input on draft meeting notes
    - HDR sends out final notes and presentation slides
  - HDR and the District would look into organizing a site visit, perhaps with an in-person presentation beforehand
  - Matt Prociv to contact John Ferguson for reference to the specific study(ies). The study contains fish counts and other data that could be useful.

Proposed Chehalis River Basin Flood Damage Reduction Project

Fish Passage Technical Working Group Meeting

Chehalis River Basin Flood Control Zone District

January 17, 2024

Introductions

- Name, position & organization, relationship to project
- Favorite season?
- What single thing would you most like to get out of today's meeting?

Meeting Objectives

- To inform the TWG members of:
  - Progress of requested project history presentation
  - Updates to the FRE Design since our last TWG meeting in August
  - Incorporation of climate change into the design now and later
  - Initial hydraulic results for permanent and temporary channels
  - Next steps

Roles and Responsibilities

- HDR:
  - Role: Consultant for the District
  - Responsibilities: Data, discussion, and decision-making
- TWG Participants:
  - Role: Active membership in the Technical Working Group
  - Responsibilities: Participation in discussion, input and feedback
  - Participants:
    - The Confederated Tribes of the Chehalis Reservation
    - Cowlitz Indian Tribe
    - Quinault Indian Nation (on distribution list – declined participation)
    - Washington Department of Ecology
    - Washington Department of Fish and Wildlife
    - U.S. Fish and Wildlife
    - NOAA Fisheries

Roles and Responsibilities
Scope of Input from the TWG

- Design Criteria
  - Biological criteria
  - Technical criteria
- **Design Approach and Methodology**
- Flood Retention Expandable (FRE) water retention operating rules
- FRE and Flood Fish Passage Facility (FFPF) O&M
  - E.g., staffing, credentials, training, maintenance process
- **Identification of topics for discussion and future meetings**

Agenda

- Introductions and Background
- Status of Project History Presentation
- Incorporation of Climate Change
- Design Update
- *Break*
- Passage Route Design Approach and Initial Hydraulic Results
- Topics for Future Meetings
- Next Steps / Action Items

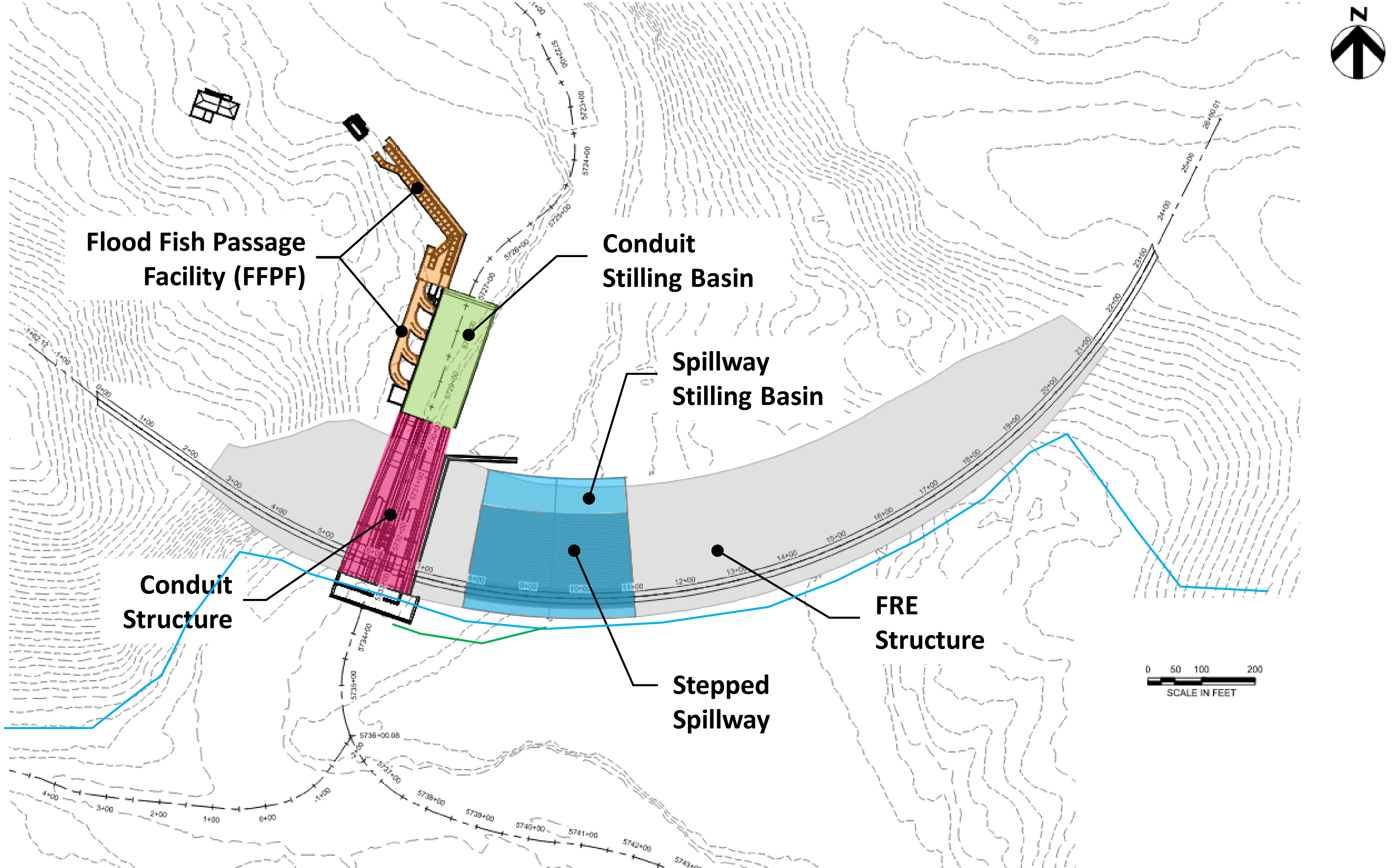
HDR

Status of Project History Presentation

- In our last TWG meeting, request for:
  - History of proposed project
  - Summary of previous fish passage subcommittee meetings
- Currently under development
- Preference for presentation or video?

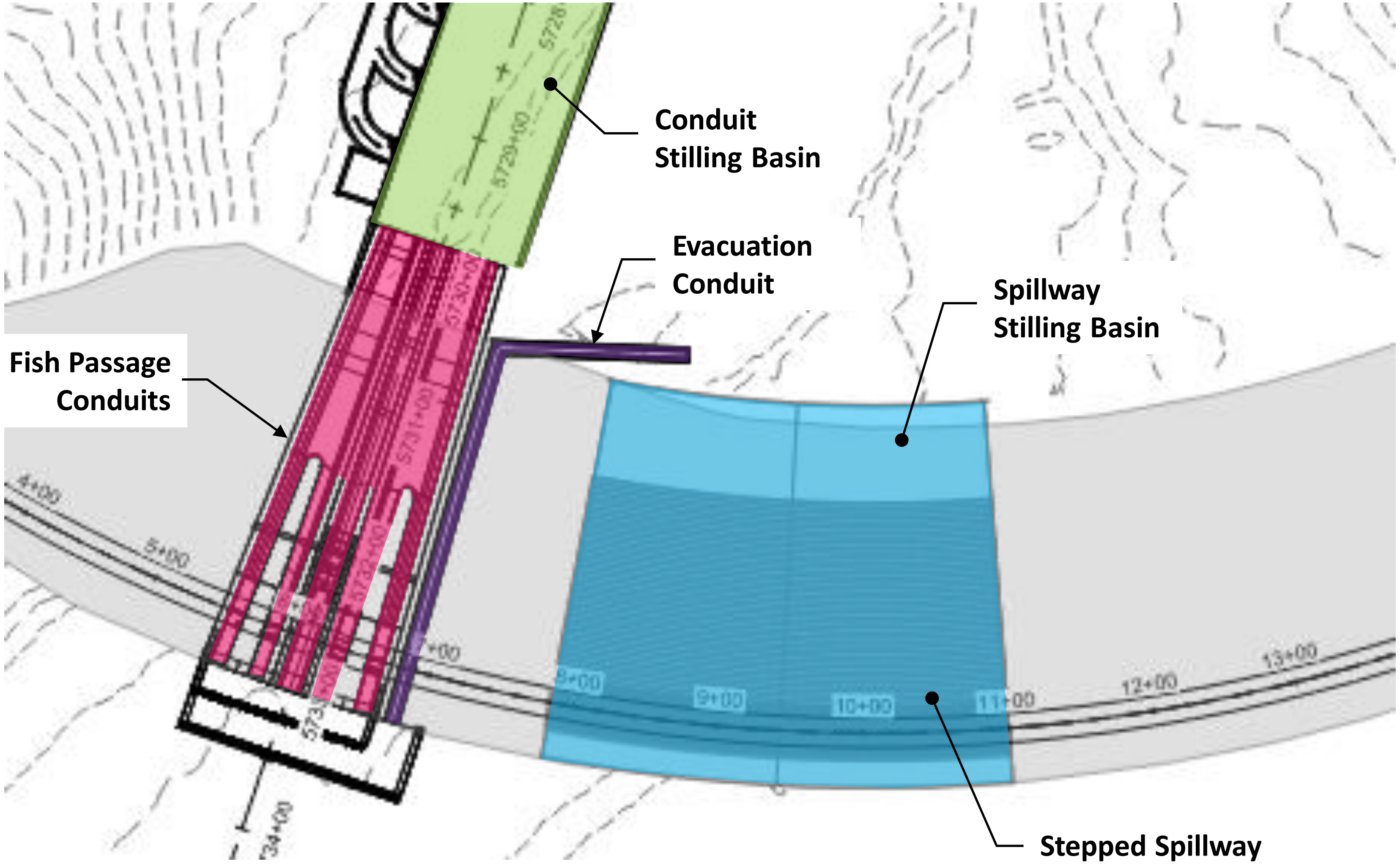
HDR

Site Plan



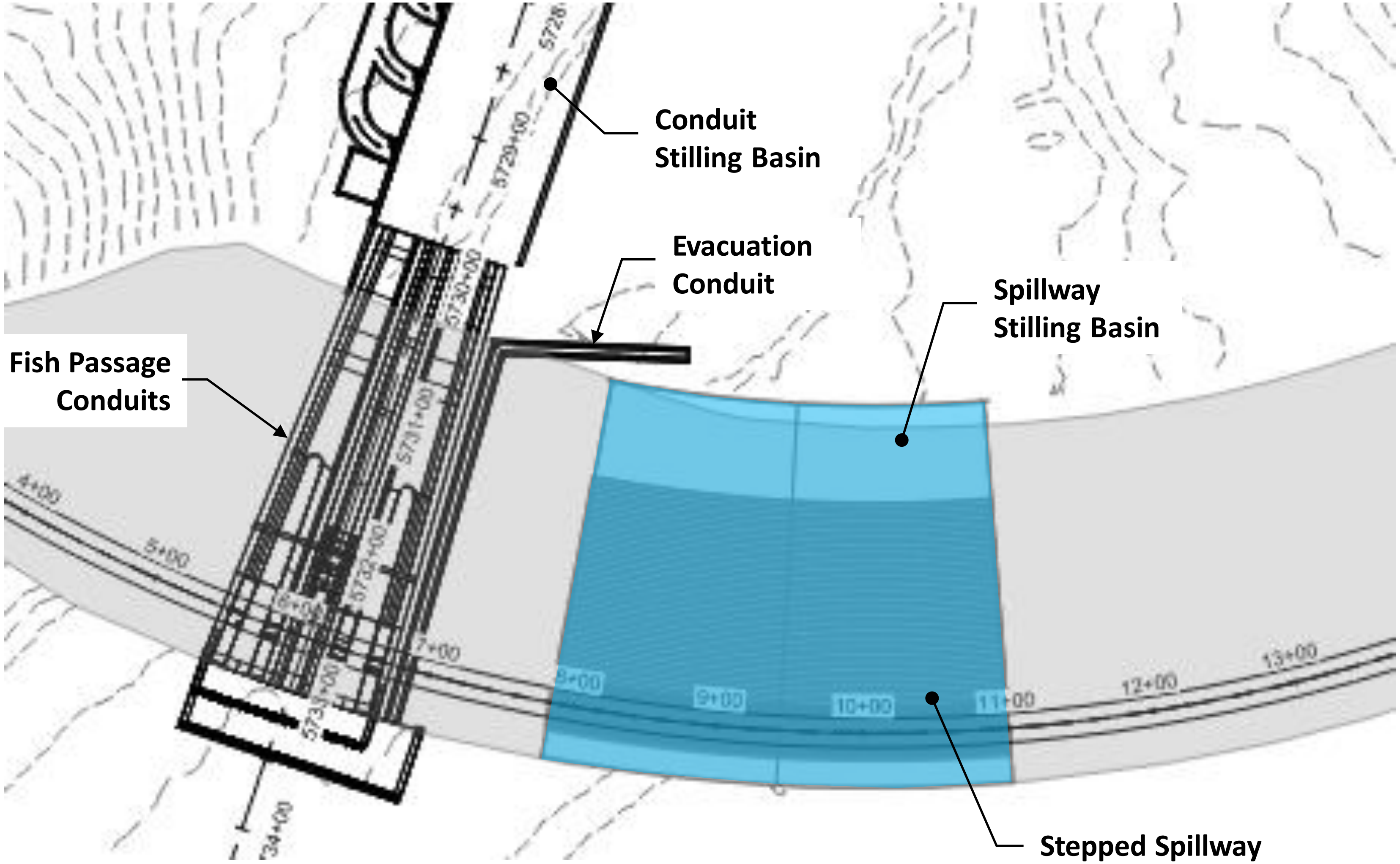
Flood Fish Passage Facility (FFPF)
Conduit Stilling Basin
Spillway Stilling Basin
Conduit Structure
FRE Structure
Stepped Spillway
SCALE IN FEET

Site Plan



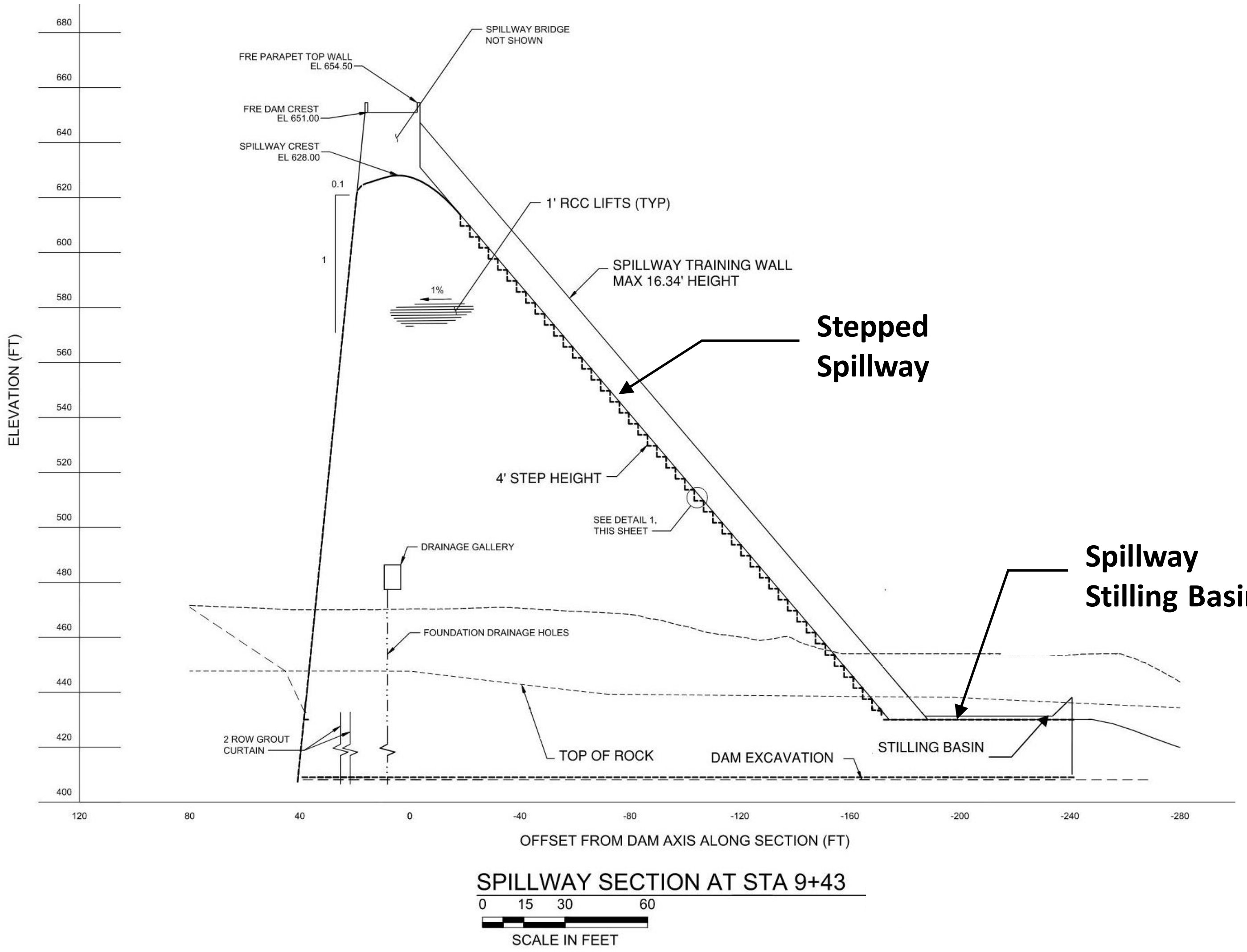
Conduit Stilling Basin
Evacuation Conduit
Spillway Stilling Basin
Fish Passage Conduits
Stepped Spillway
4+00
5+00
8+00
9+00
10+00
11+00
12+00
13+00

Spillway



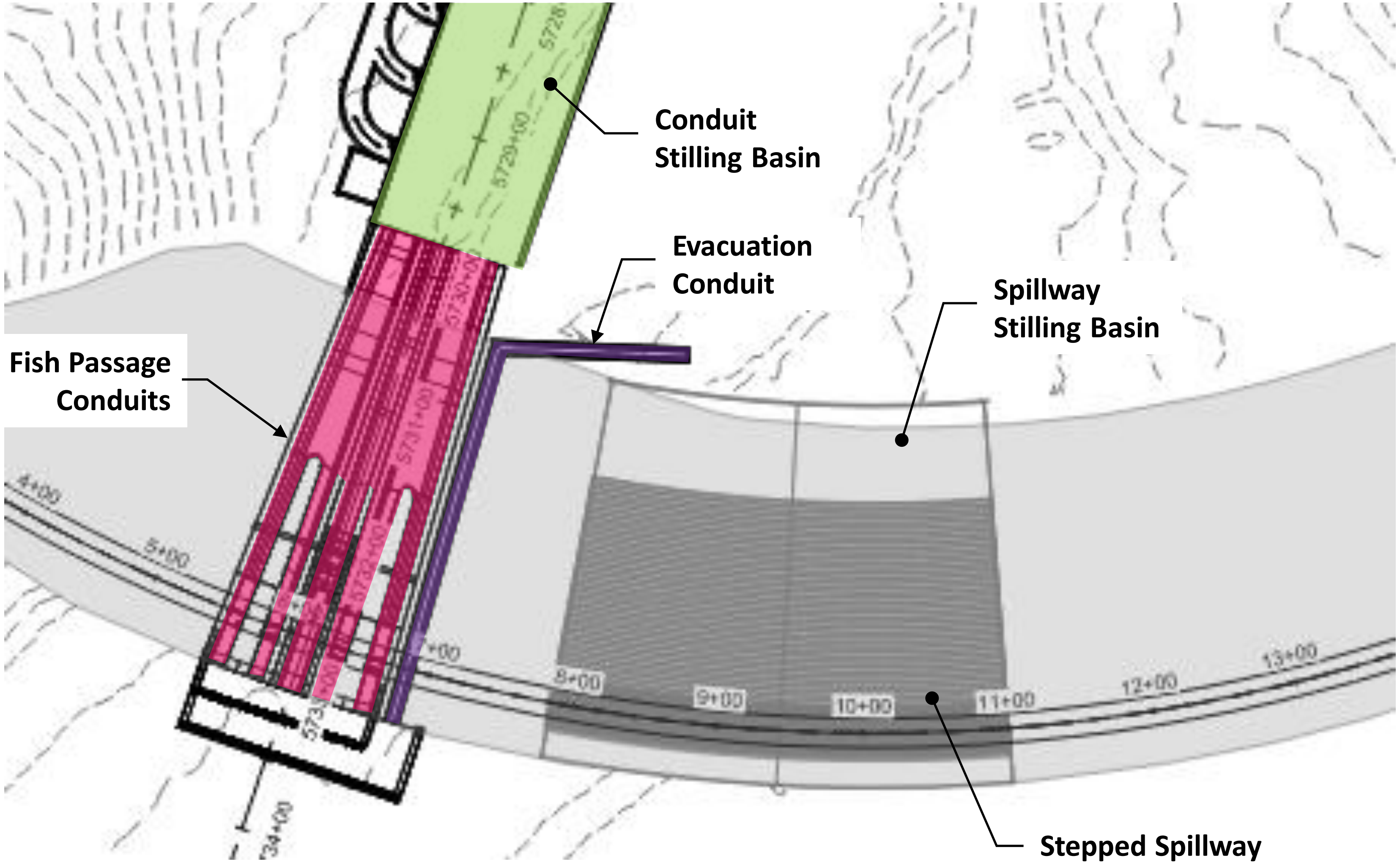
Conduit
Stilling Basin
Evacuation
Conduit
Spillway
Stilling Basin
Fish Passage
Conduits
Stepped Spillway

Spillway



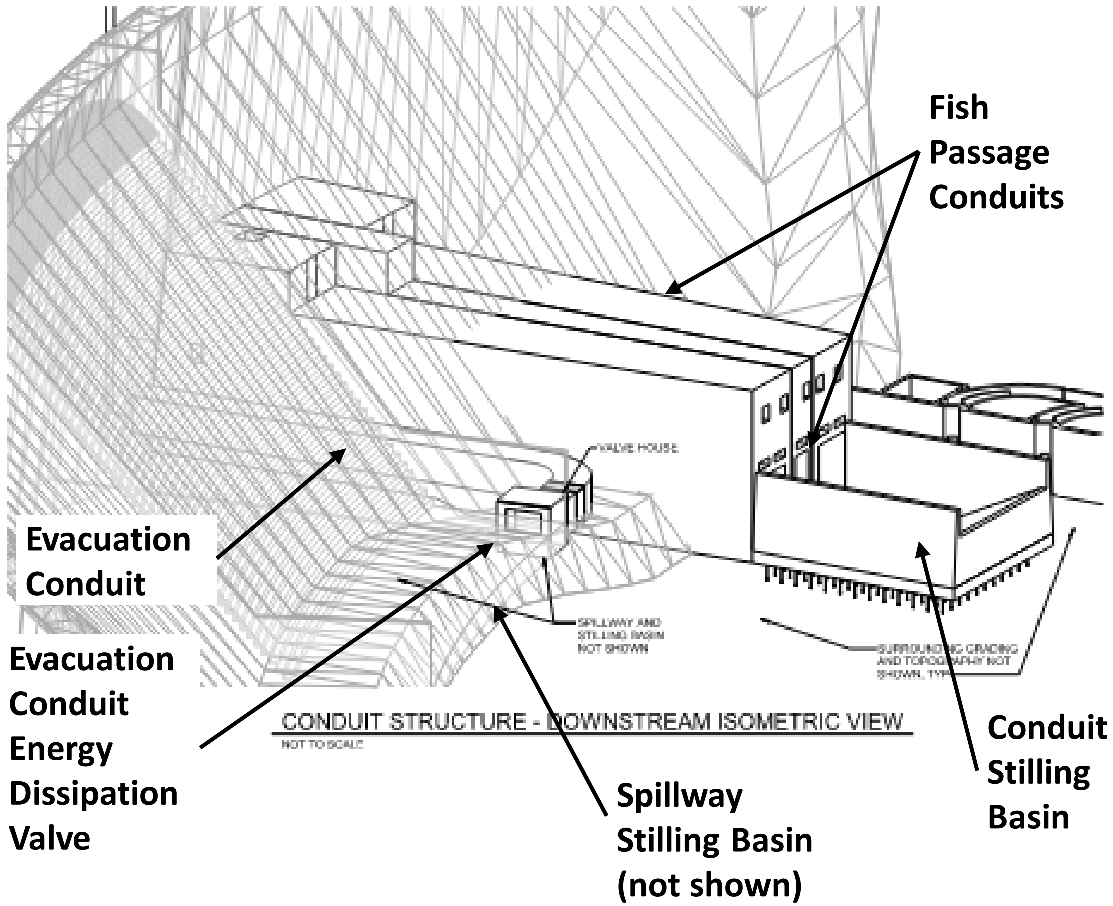
680
660
640
620
600
580
560
540
520
500
480
460
440
420
400
ELEVATION (FT)
SPILLWAY BRIDGE
NOT SHOWN
FRE PARAPET TOP WALL
EL 654.50
FRE DAM CREST
EL 651.00
SPILLWAY CREST
EL 628.00
0.1
1
1%
1' RCC LIFTS (TYP)
SPILLWAY TRAINING WALL
MAX 16.34' HEIGHT
Stepped
Spillway
4' STEP HEIGHT
SEE DETAIL 1,
THIS SHEET
DRAINAGE GALLERY
Spillway
Stilling Basin
FOUNDATION DRAINAGE HOLES
2 ROW GROUT
CURTAIN
TOP OF ROCK
DAM EXCAVATION
STILLING BASIN
120
80
40
0
-40
-80
-120
-160
-200
-240
-280
OFFSET FROM DAM AXIS ALONG SECTION (FT)
SPILLWAY SECTION AT STA 9+43
0 15 30 60
SCALE IN FEET

Conduits

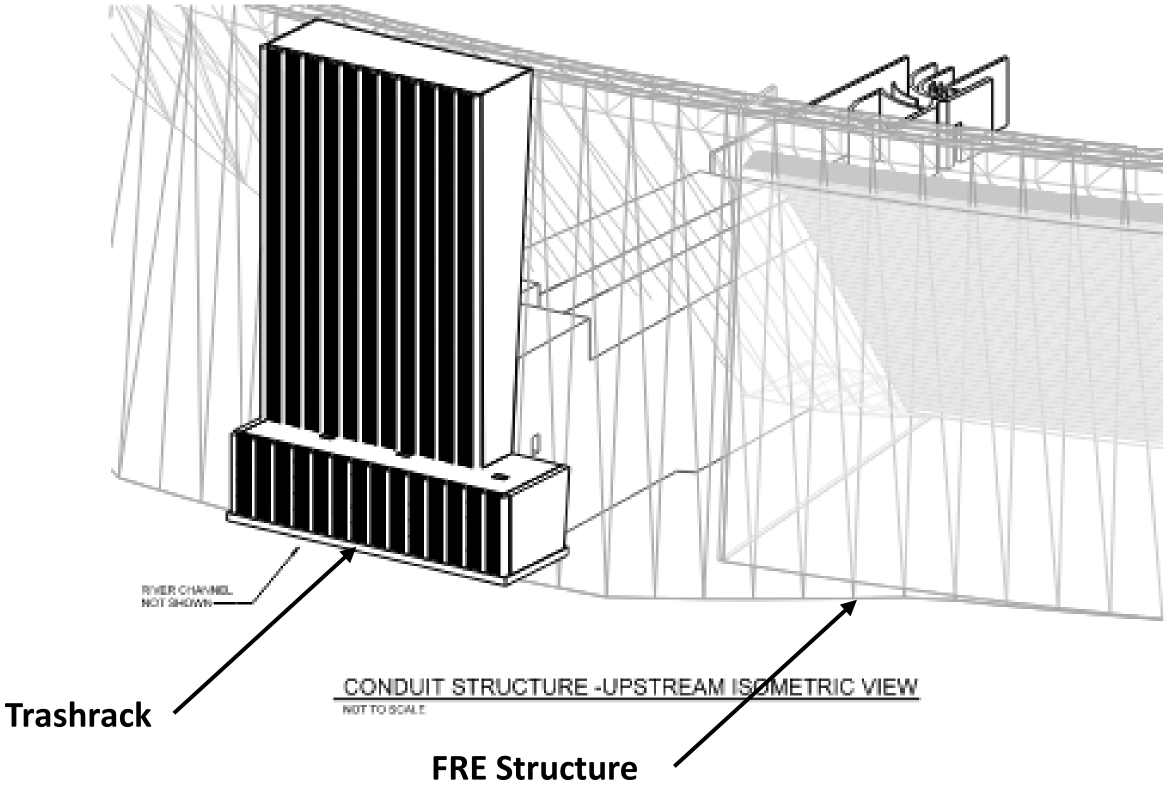


Conduit
Stilling Basin
Evacuation
Conduit
Spillway
Stilling Basin
Fish Passage
Conduits
Stepped Spillway
4+00
5+00
8+00
9+00
10+00
11+00
12+00
13+00

Conduits

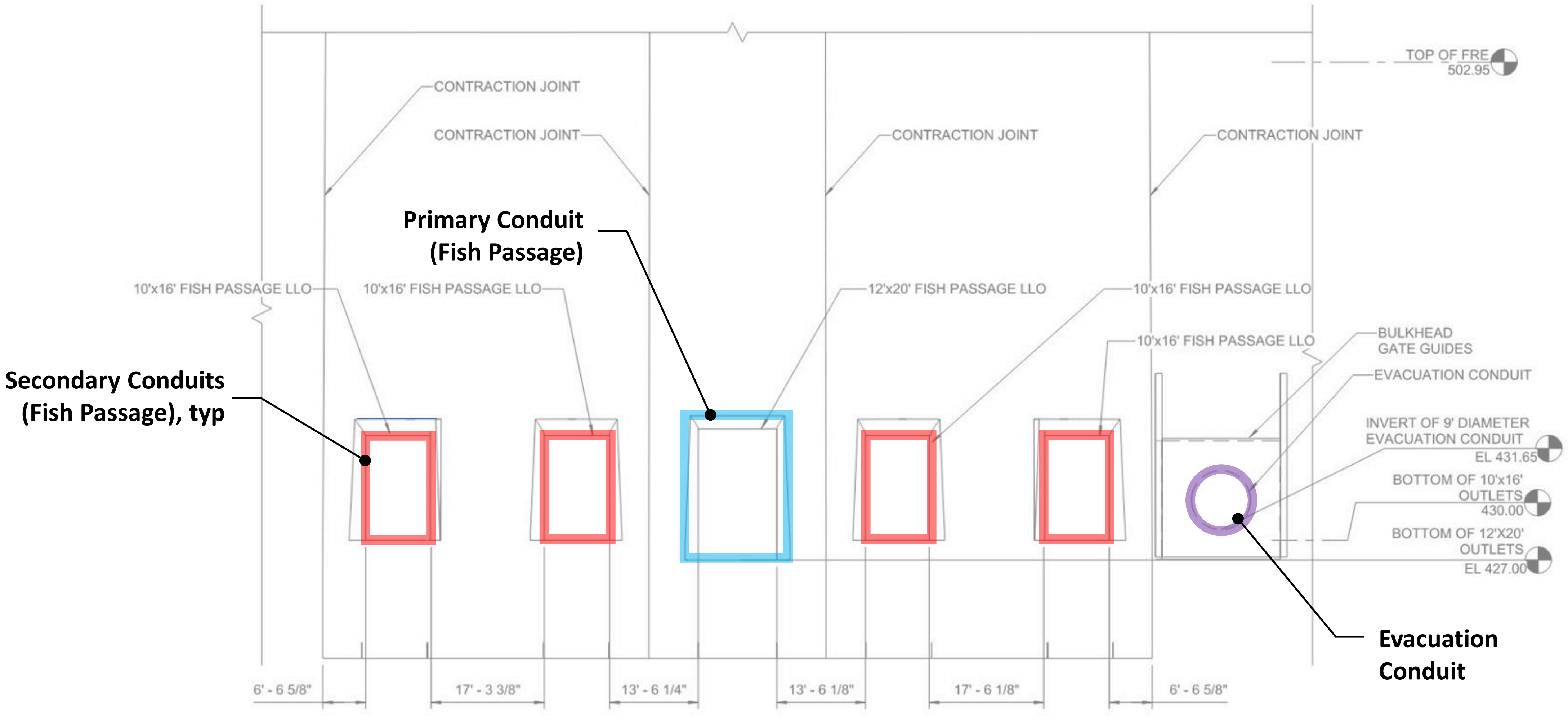


Fish Passage Conduits
VALVE HOUSE
Evacuation Conduit
Evacuation Conduit Energy Dissipation Valve
SPILLWAY AND STILLING BASIN NOT SHOWN
SURROUNDING GRADING AND TOPOGRAPHY NOT SHOWN, TYP
CONDUIT STRUCTURE - DOWNSTREAM ISOMETRIC VIEW
NOT TO SCALE
Spillway Stilling Basin (not shown)
Conduit Stilling Basin

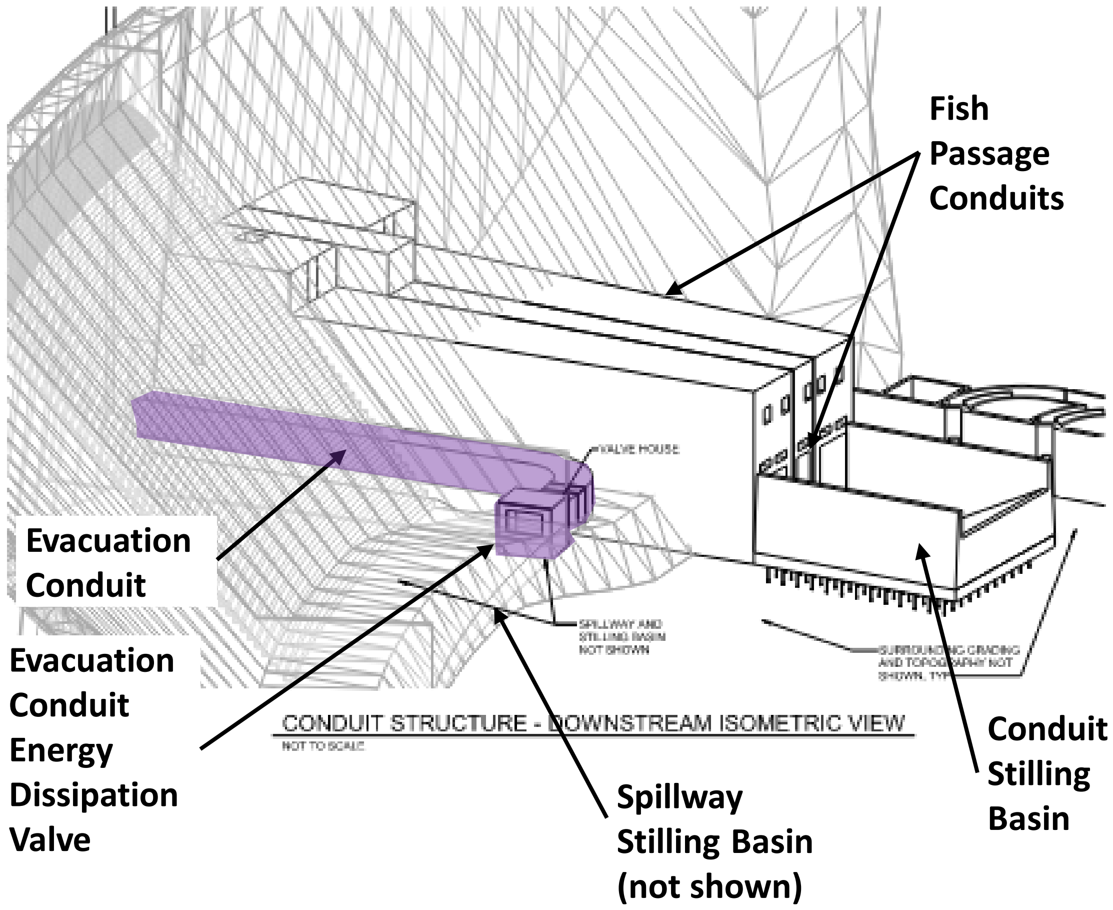


RIVER CHANNEL NOT SHOWN
Trashrack
CONDUIT STRUCTURE -UPSTREAM ISOMETRIC VIEW
NOT TO SCALE
FRE Structure

Conduit Layout



Evacuation Conduit

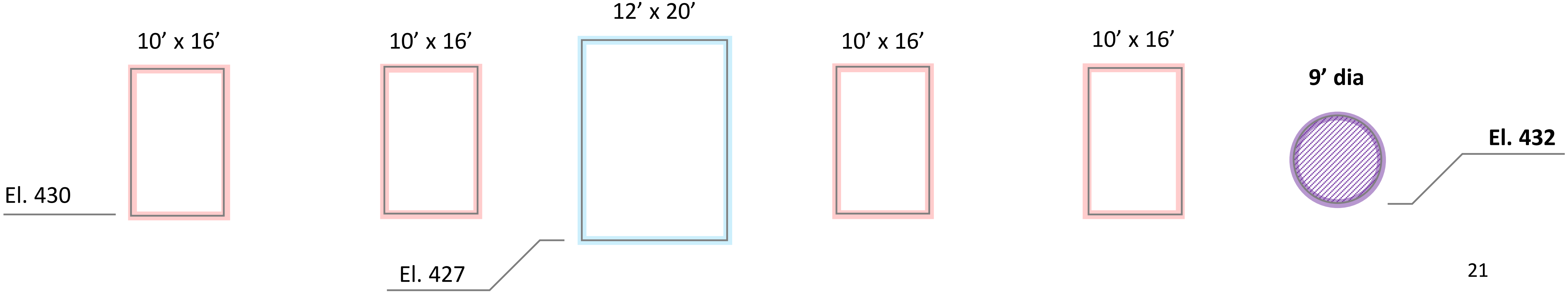


- Evacuation Conduit designed solely to release water from the reservoir.
- Benefits:
  - More flexibility in operation
  - Finer control of flow releases
  - Fish passage conduits designed primarily for volitional passage.
- Releases facilitate fish ladder entrance performance.

Evacuation Conduit

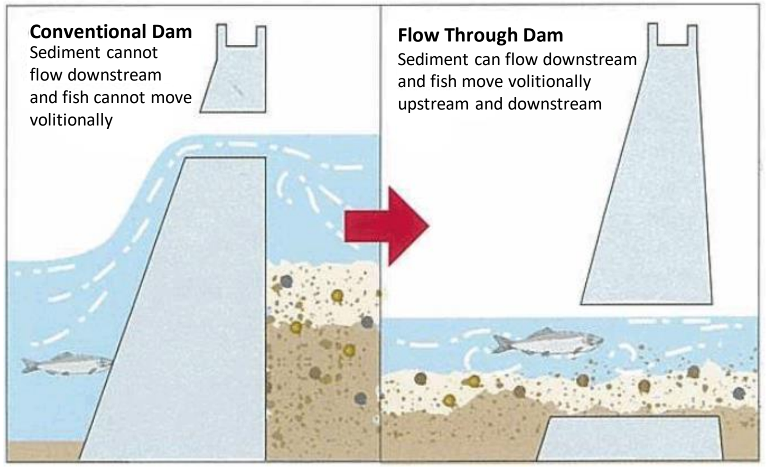
- Run-of-River Condition:
  - Closed
- During Operation:
  - Used for fill and evacuation above EL 510
  - Above EL 510 = Throttling, Below EL 510 = Closed

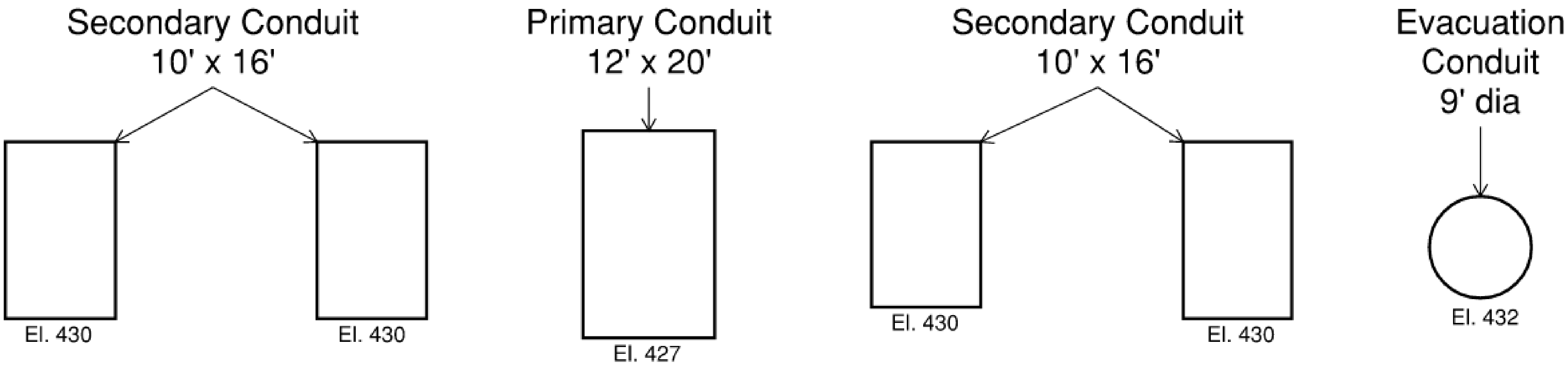
Valve type: Howell bunger valve



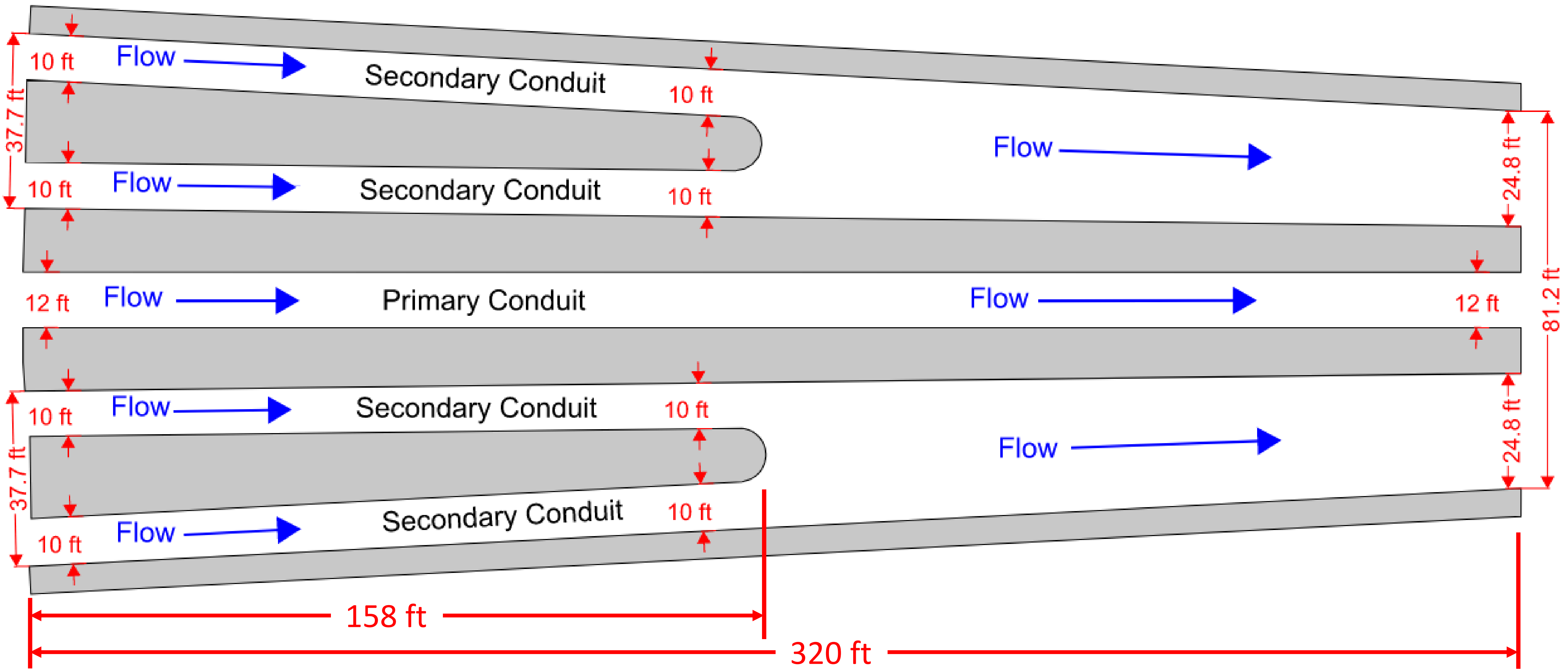
Fish Passage Conduit Design

- Fish Passage Conduits designed for flow through dam.
  - Volitional passage
  - Sediment continuity
- Low head transition to and from reservoir pool.
- Roughness elements and sediment deposition





Fish Passage Conduit Layout

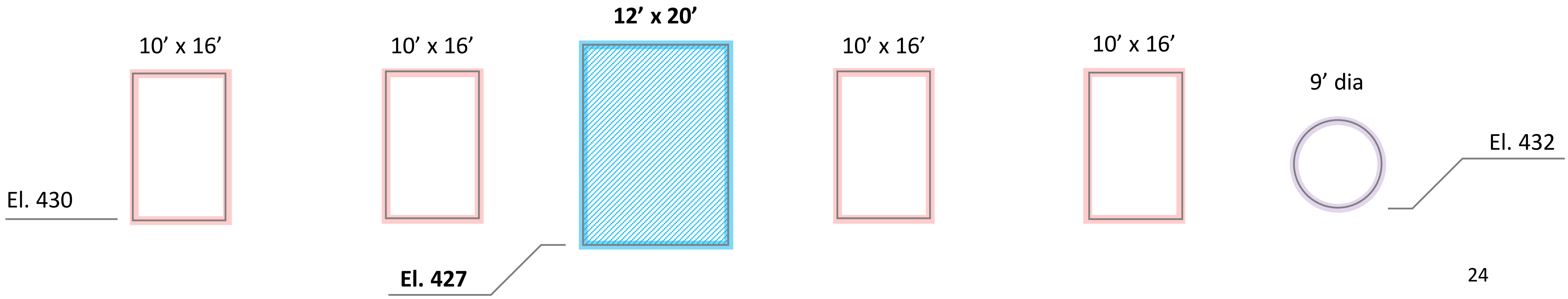


**Evacuation conduit not shown*

Primary Conduit

- Run-of-River Condition:
  - Primary flow path
  - Full open
- During Operation:
  - Used for fill and evacuation below EL 510
  - Above EL 510 = Closed, Below EL 510 = Throttling

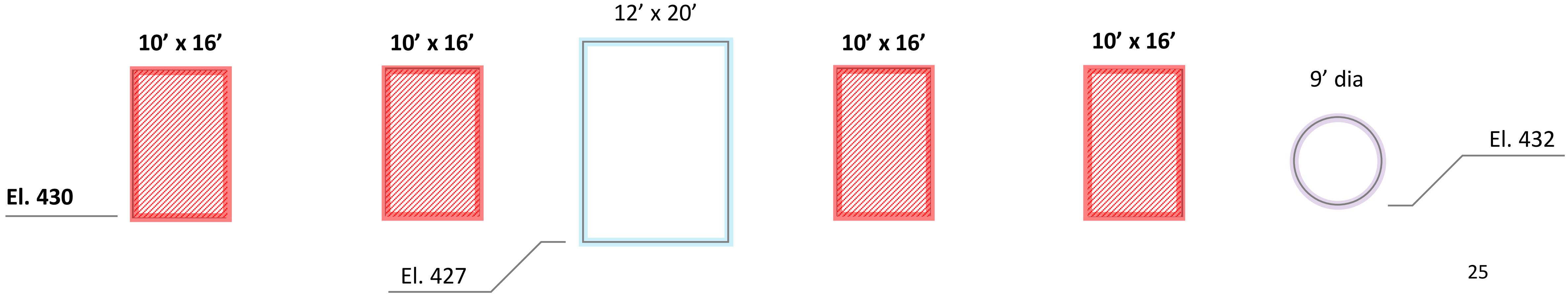
Gate type: tainter (radial) gate



Secondary Conduits

- Run-of-River Condition:
  - Secondary flow path, when river flow is high
  - TBD - closed or open with staggered elevations
- During Operation:
  - Closed

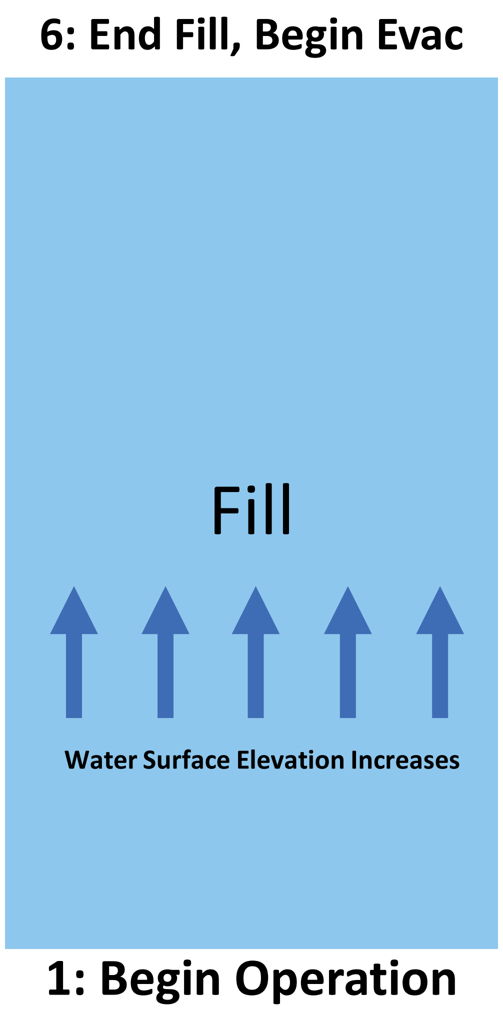
Gate type:
bonneted slide gate



Fill & Evacuation Operation

Operation:

- Step 1 – Flow projection triggers operation. Begin closing Secondary Conduits
- Step 2 – Secondary Conduits Closed
- Step 3 – Begin closing Primary Conduit
- Step 4 – Control river flow using Primary Conduit Gate
- Step 5 – at pool elevation 510 feet, begin closing Primary Conduit Gate and opening Evacuation Conduit
- Step 6 – Close Primary Conduit. Control flow using Evacuation Conduit.

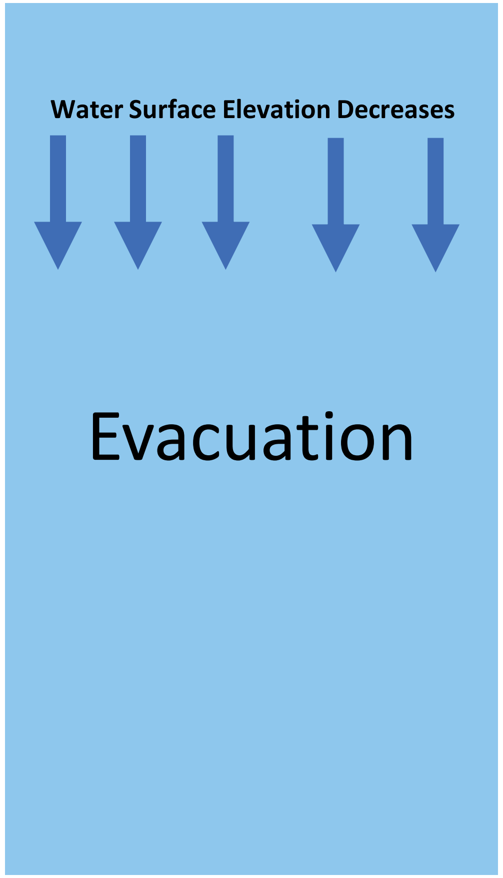


Fill & Evacuation Operation

Operation:

- Step 7 – Begin reservoir evacuation following ramping rates using Evacuation Conduit
- Step 8 – At pool elevation 510 feet, begin opening Primary Conduit Gate and start closing Evacuation Conduit
- Step 9 – Evacuation Conduit Closed. Control flow following evacuation rates using Primary Conduit Gate
- Step 10 – Evacuation complete. Fully open Primary Conduit Gate. Resume flow-through run-of-river condition. Open Secondary Flow Gate(s) as necessary.

7: Begin Evacuation



10: End Operation

NMFS Climate Change Guidance

Project Life Expectancy > 10 yr:

- Fish Passage Conduits
- Permanent Channels
- Flood Fish Passage Facility (FFPF)

***Temporary* construction phase bypass channel** uses fish passage design flows based on historic flow data, **project life expectancy < 10 yr**

Review Available Climate Projections → **Apply Climate Model Results** → **Estimate Future Hydrologic / Environmental Conditions**

Timeline: Incorporate Climate Change

- 2023-March 2024: Revised Project Description
  - NMFS collaboration underway
  - Use revised SEPA EIS climate change flow scalars
- 2024-2025: Updated Biological Assessment
  - District analysis of 12 GCMs provided by UW CIG
  - Consideration of Ecology 12 GCM analysis
  - Final climate change design flows through NMFS collaboration
  - Operational analysis for climate change
    - Avoid and minimize impacts

Fish Passage Design Approach

- Conduits:
  - Mimic existing hydraulic characteristics in the rock-incised reach of the Chehalis R.
    - Developed and selected by 2016-2017 Fish Passage Technical Subcommittee
- Permanent and Bypass Channels:
  - Reference reach approach
- Guidance and Reference Documents:
  - NOAA Fisheries West Coast Region Guidance to Improve the Resilience of Fish Passage Facilities to Climate Change (2022)
  - WDFW Water Crossing Design Guidelines (2013)
- Design Considerations
  - Approximate natural channel hydraulics
  - Approximate sediment transport capability

Passage Route Design Approach

- NMFS Climate Change Guidance:
  - Long-term use (permanent): designed for high and low fish passage flows adjusted for climate change
    - Fish Passage Conduits
    - Approach and Discharge Channels
  - Short-term use (construction): designed for high and low fish passage flows using historic record
    - Chehalis River bypass
    - Crim Creek bypass

Initial Hydraulic Results

- Current fish passage design flows are assumed
  - High design flow = 3,400 cfs
    - 5% historic exceedance (2,200 cfs) * 55% CC scalar
  - Low design flow = 14 cfs
    - 95% historic exceedance (16 cfs) * -14% CC scalar
- Final design flows anticipated to be established in 2024/2025 with NMFS with TWG input.
  - Following NOAA Fisheries West Coast Region Guidance to Improve the Resilience of Fish Passage Facilities to Climate Change (2022)

Initial Hydraulic Results

- All hydraulic data presented is assuming bare conduits and channels

- Sediment analysis will be conducted in the next phase of design

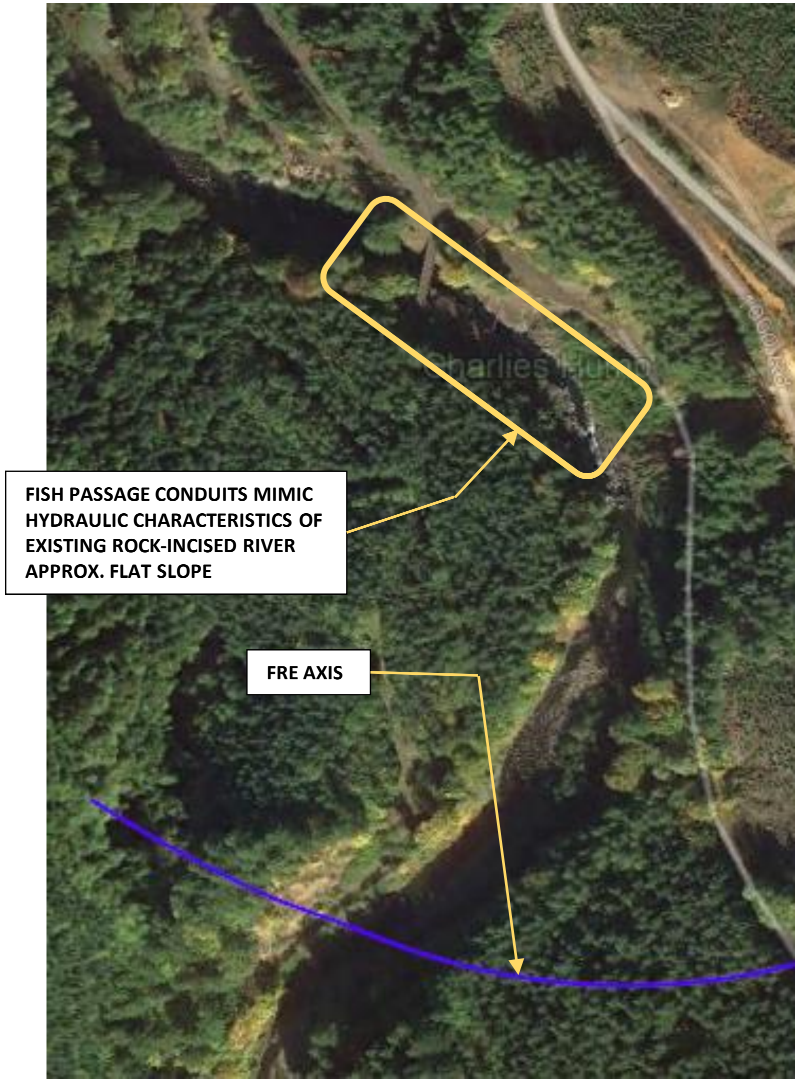
BREAK

Channel Design Approach & Hydraulic Modeling Results

- Permanent:
  - Fish Passage Conduits

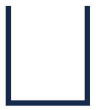
Fish Passage Conduits
Hydraulic Design Approach

- Permanent:
  - Fish Passage Conduits

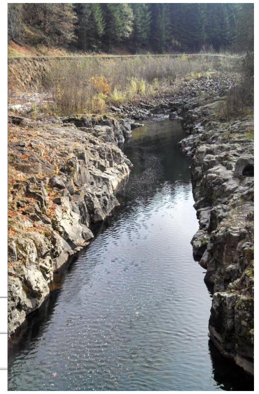


Channel Design Approach

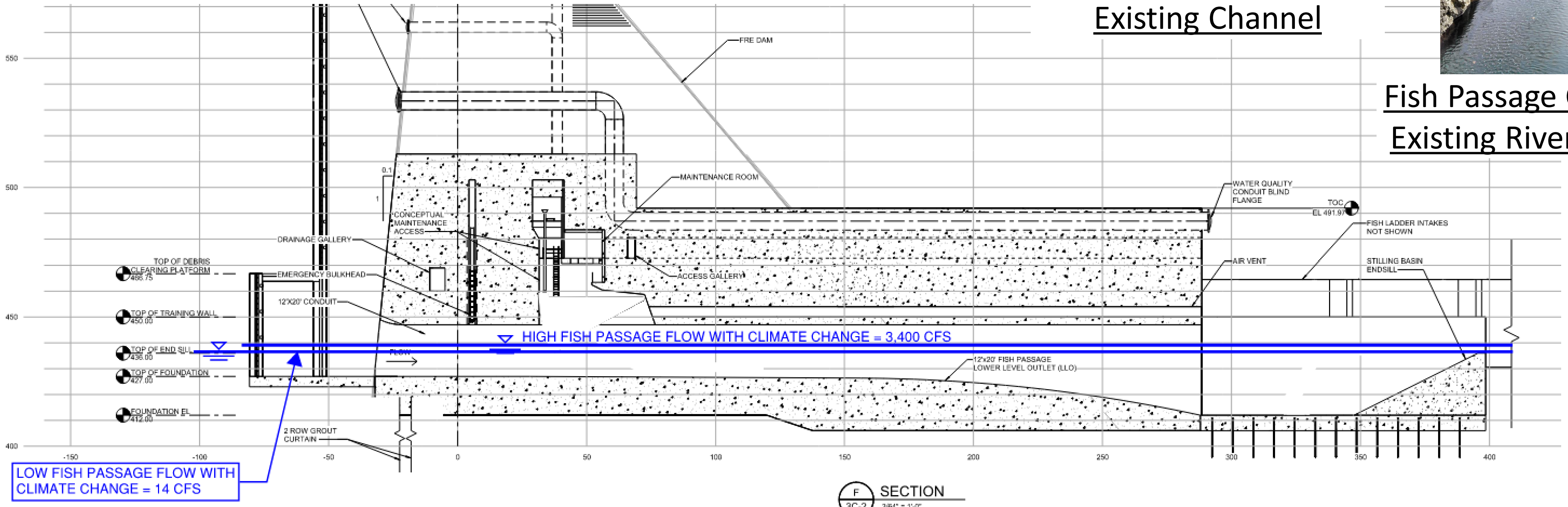
- Fish Passage Conduits - Permanent



Fish Passage Conduit General Section of Existing Channel



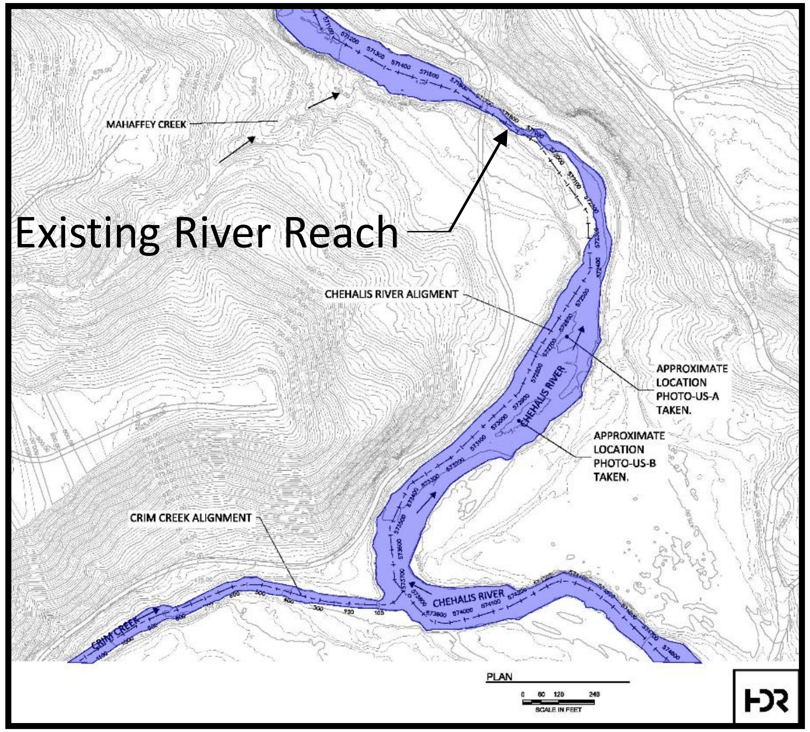
Fish Passage Conduit Existing River Reach



Fish Passage Conduit - Profile

Channel Design Approach: Substrate Material & Channel Roughness

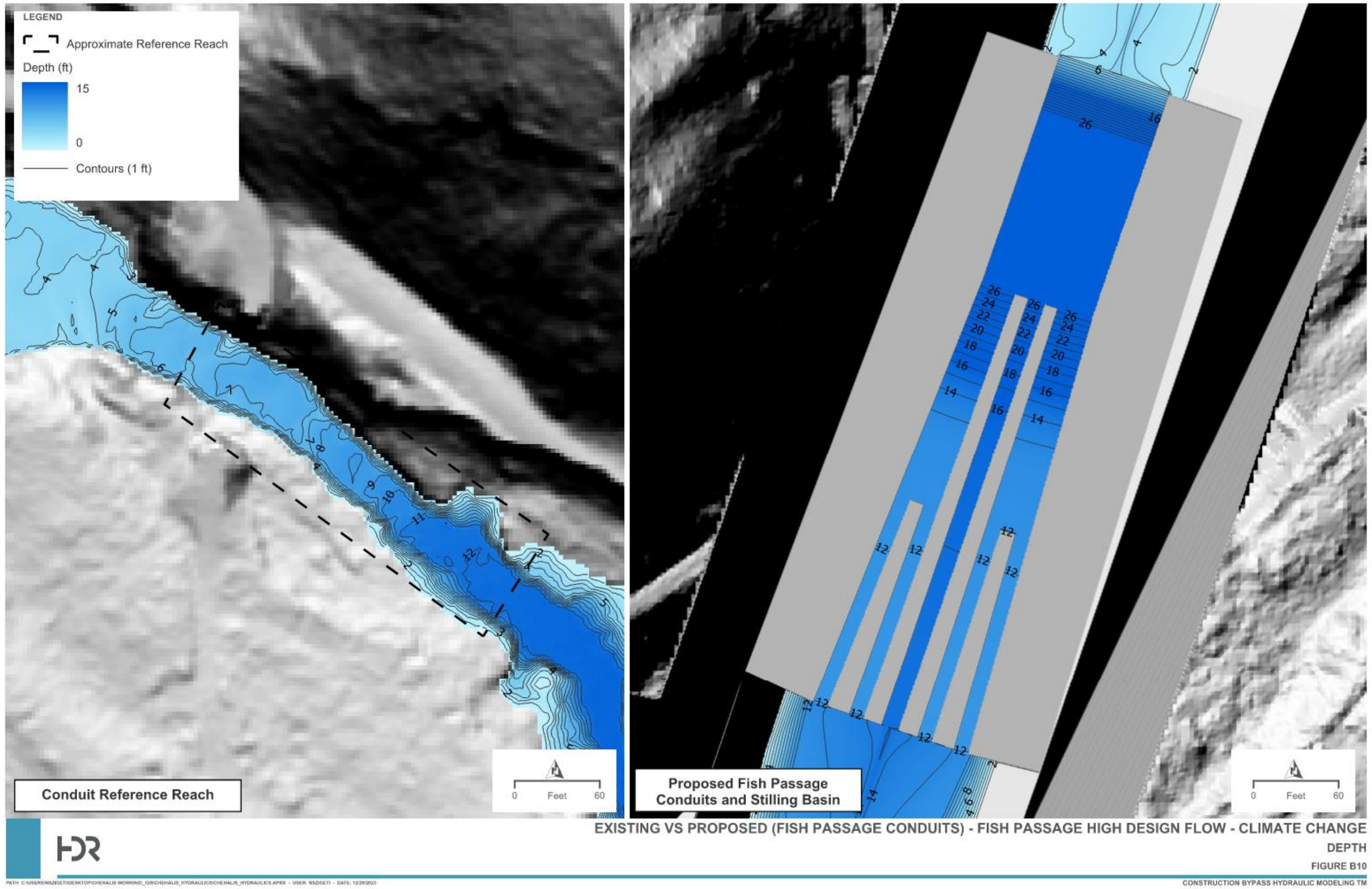
- Fish Passage Conduits - Permanent

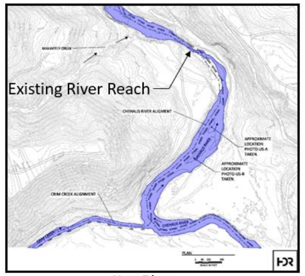


Key Plan

Existing River Reach
Approx. Flow = 150 cfs

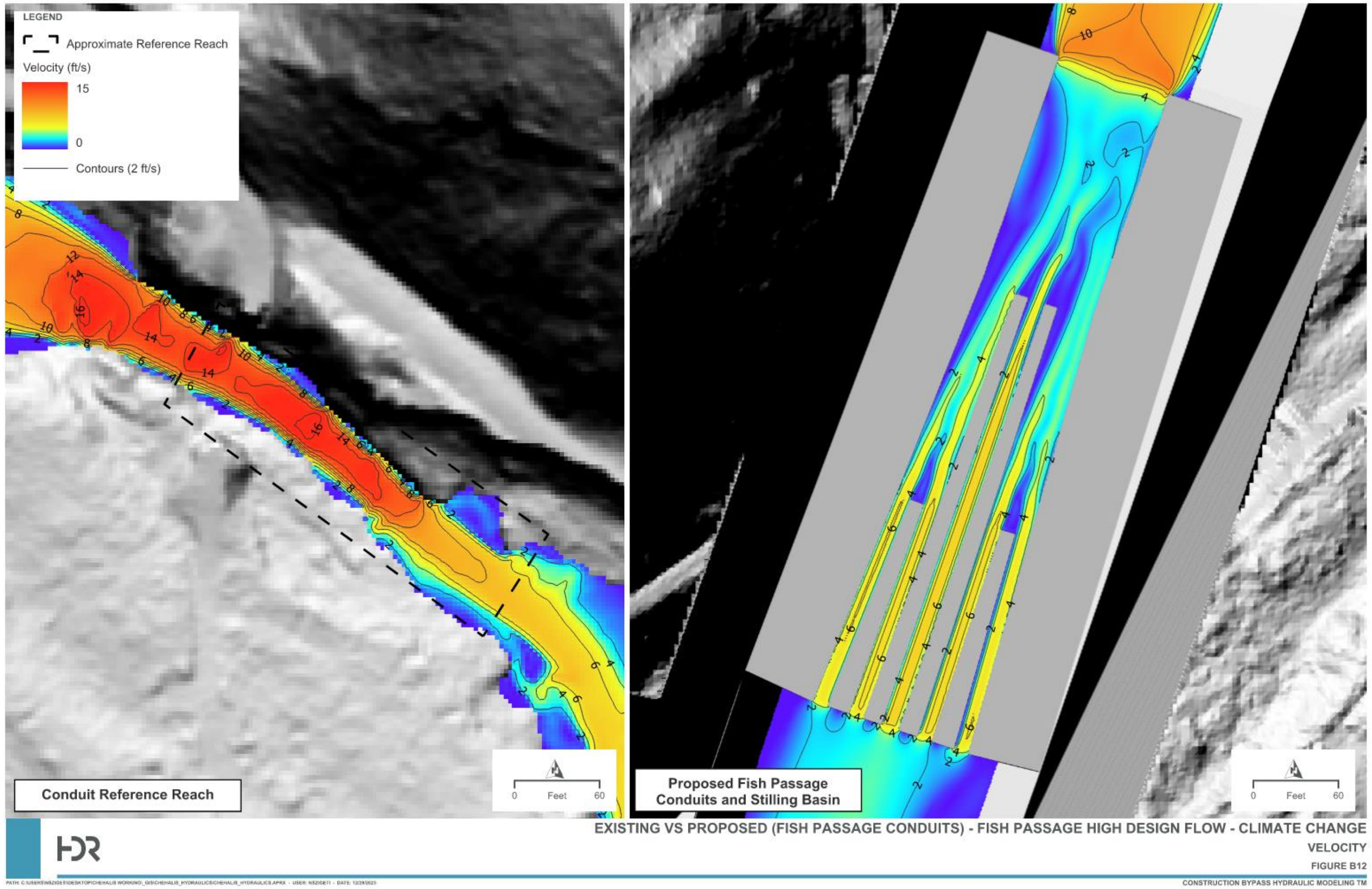
Fish Passage Conduits – Permanent High Fish Passage Flow w/ Climate Change Depth Heat Map

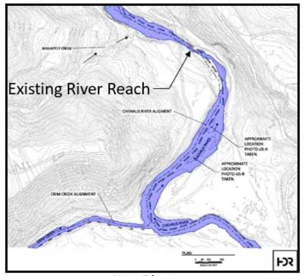




Key Plan

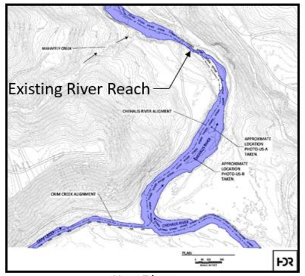
Fish Passage Conduits – Permanent High Fish Passage Flow w/ Climate Change Velocity Heat Map



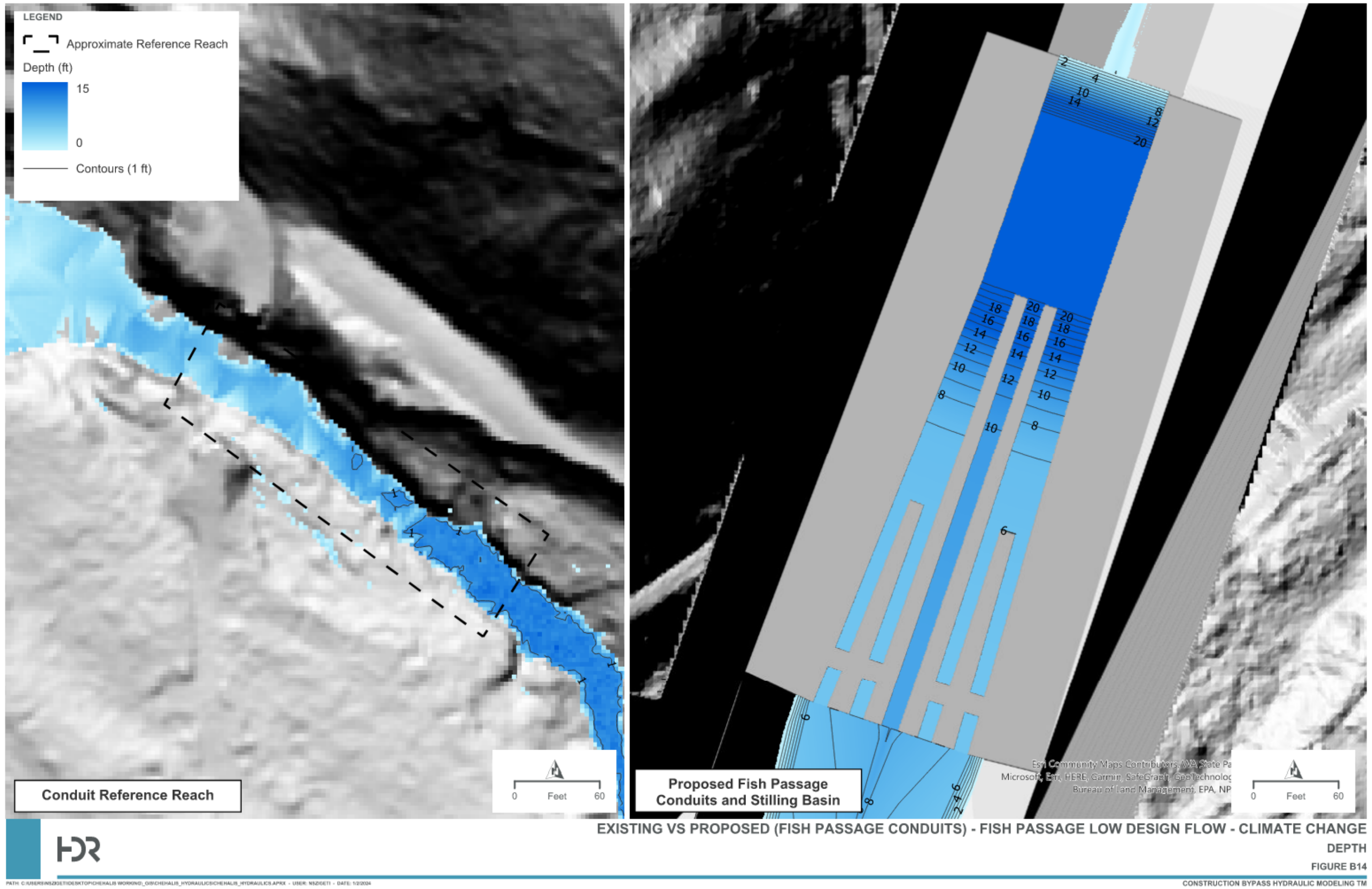


Key Plan

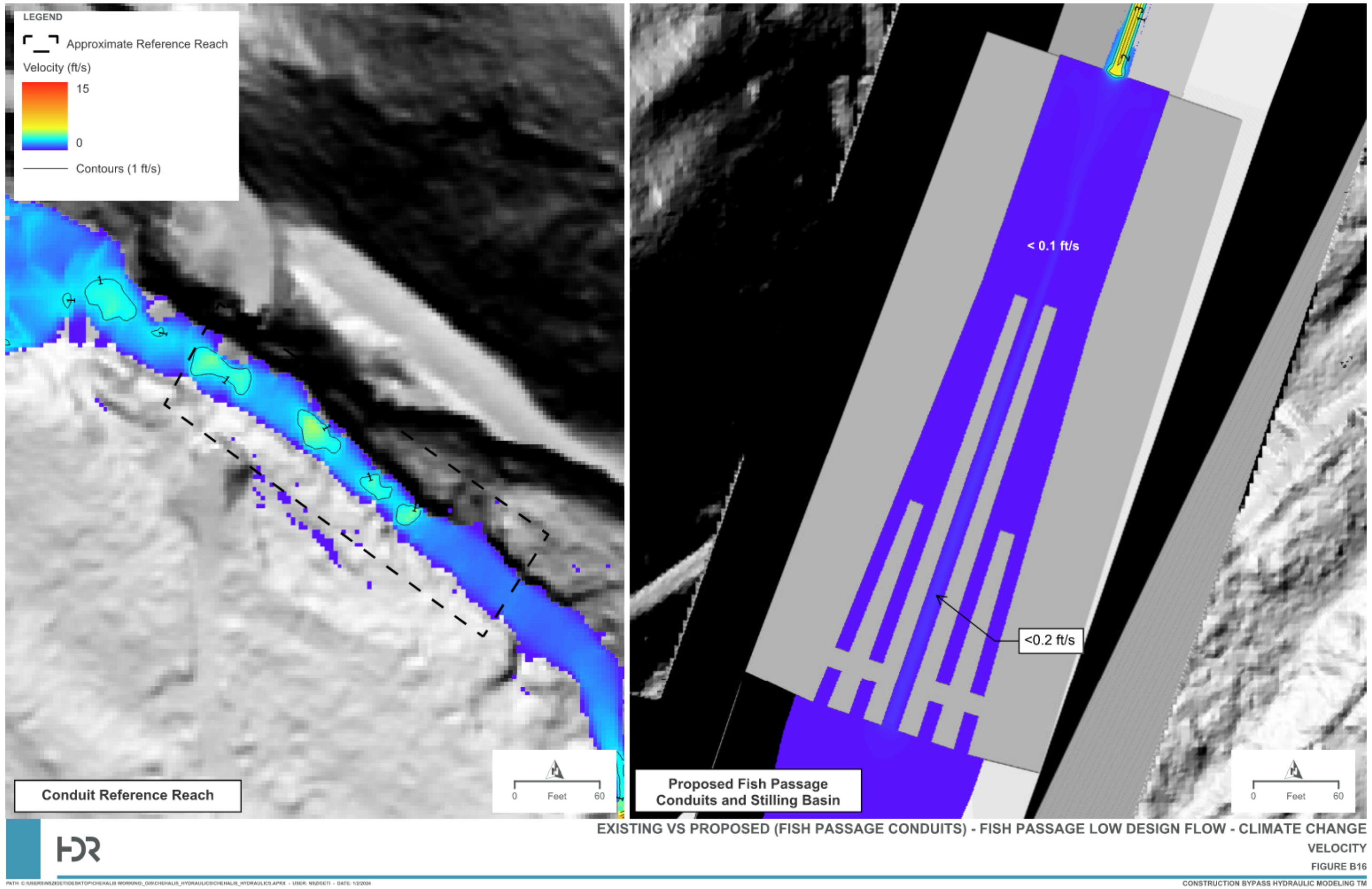
Fish Passage Conduits – Permanent Low Fish Passage Flow w/ Climate Change Depth Heat Map

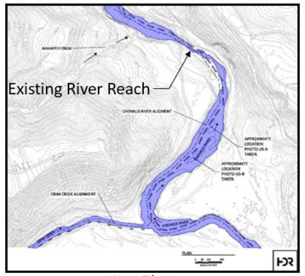


Key Plan



Fish Passage Conduits – Permanent Low Fish Passage Flow w/ Climate Change Velocity Heat Map





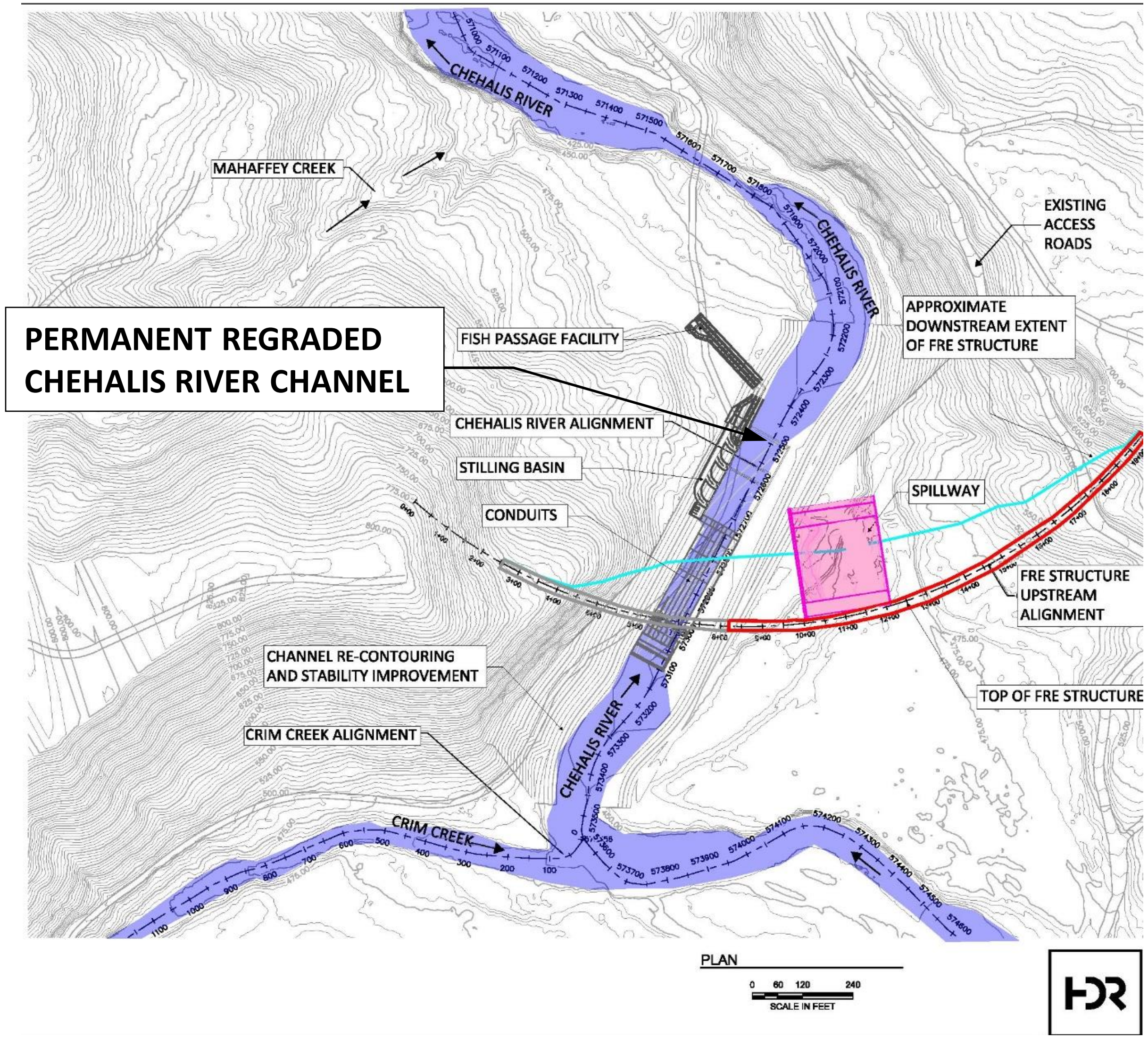
Key Plan

Channel Design Approach & Hydraulic Modeling Results

- Permanent – Chehalis River Approach and Discharge Channels and Crim Creek Channel

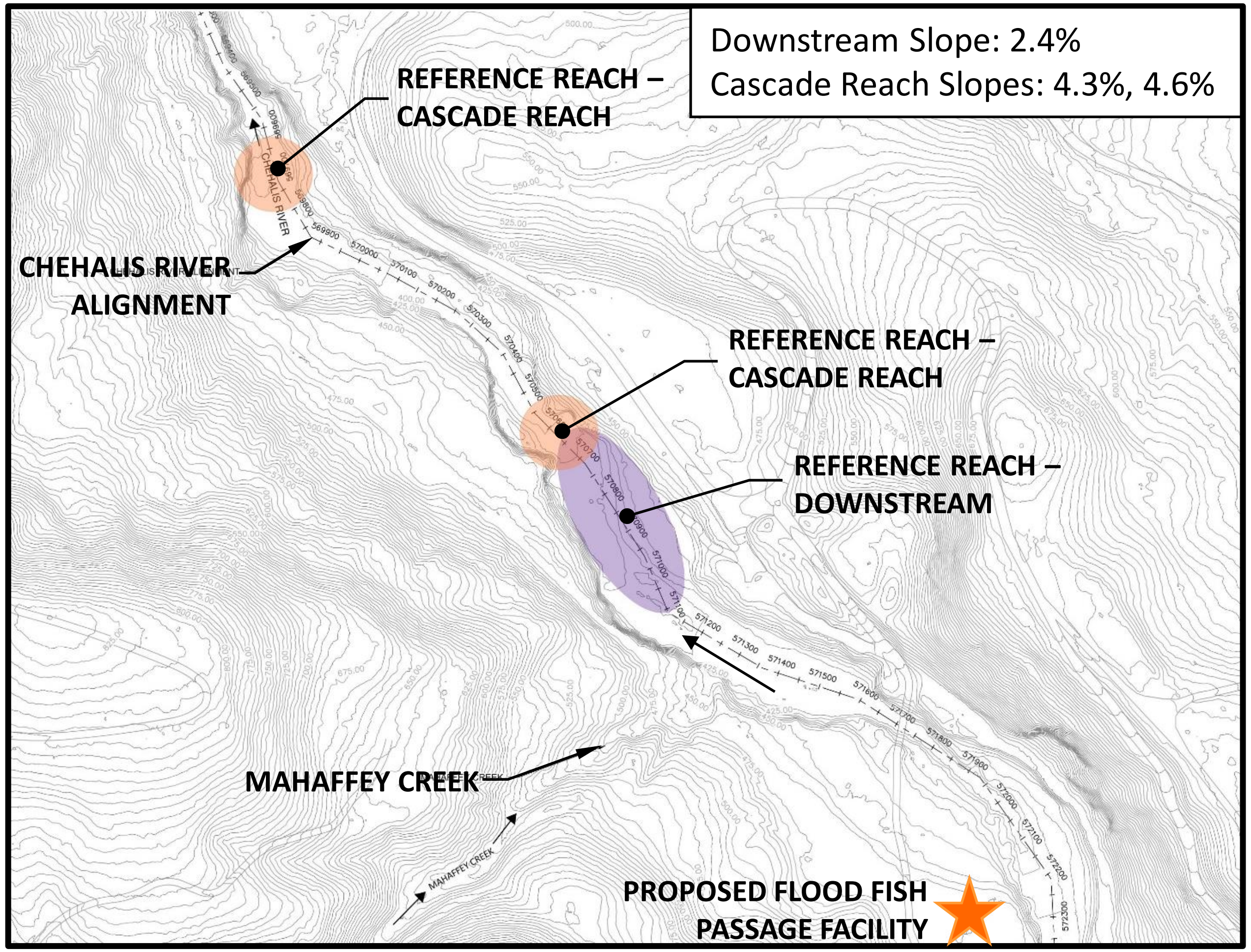
Channel Design Approach

- Permanent:
  - Chehalis River Channel

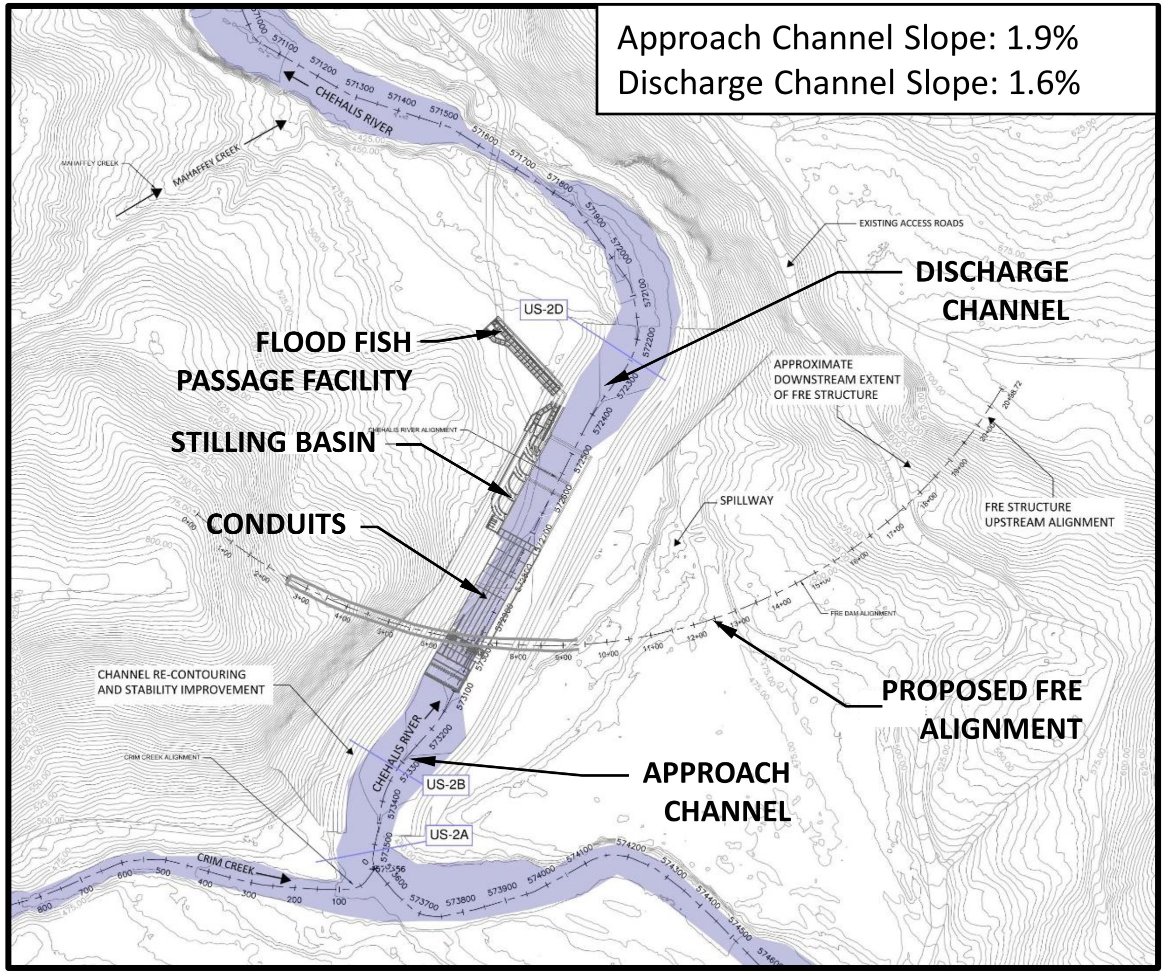


Channel Design Approach

- Permanent: Chehalis River Channel



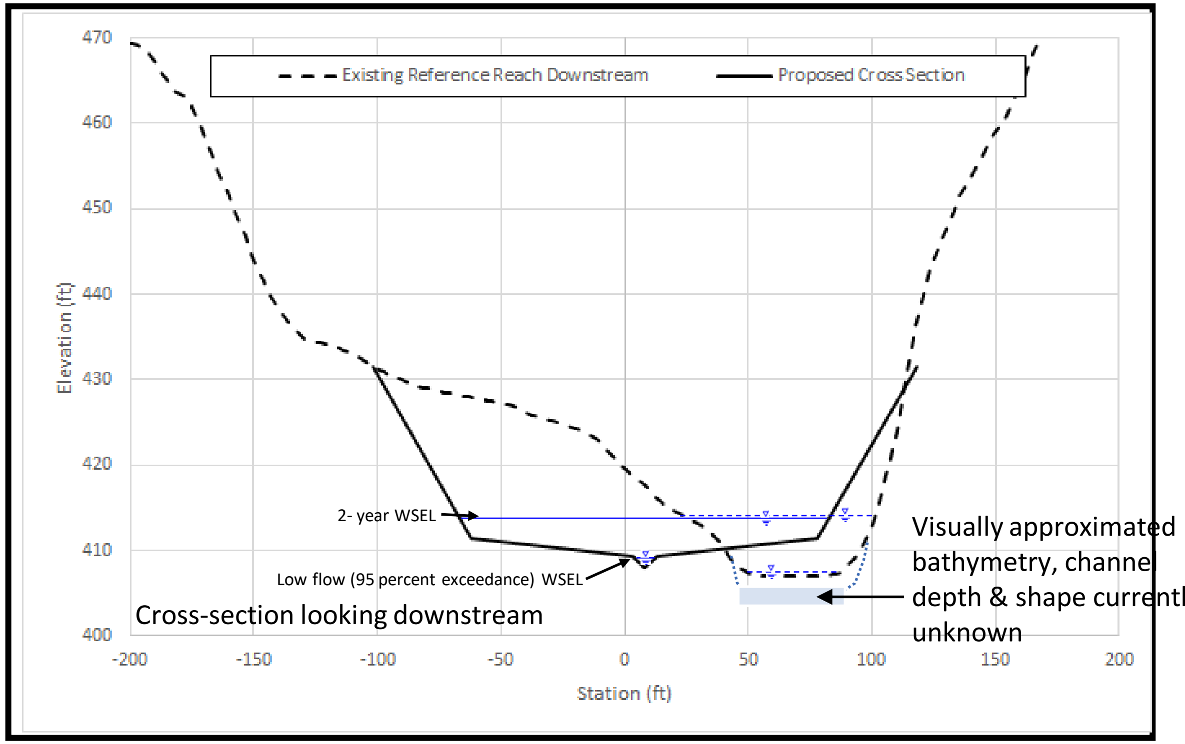
Reference Reach - Plan



Chehalis River Channel - Plan

Channel Design Approach

- Permanent: Chehalis River Channel



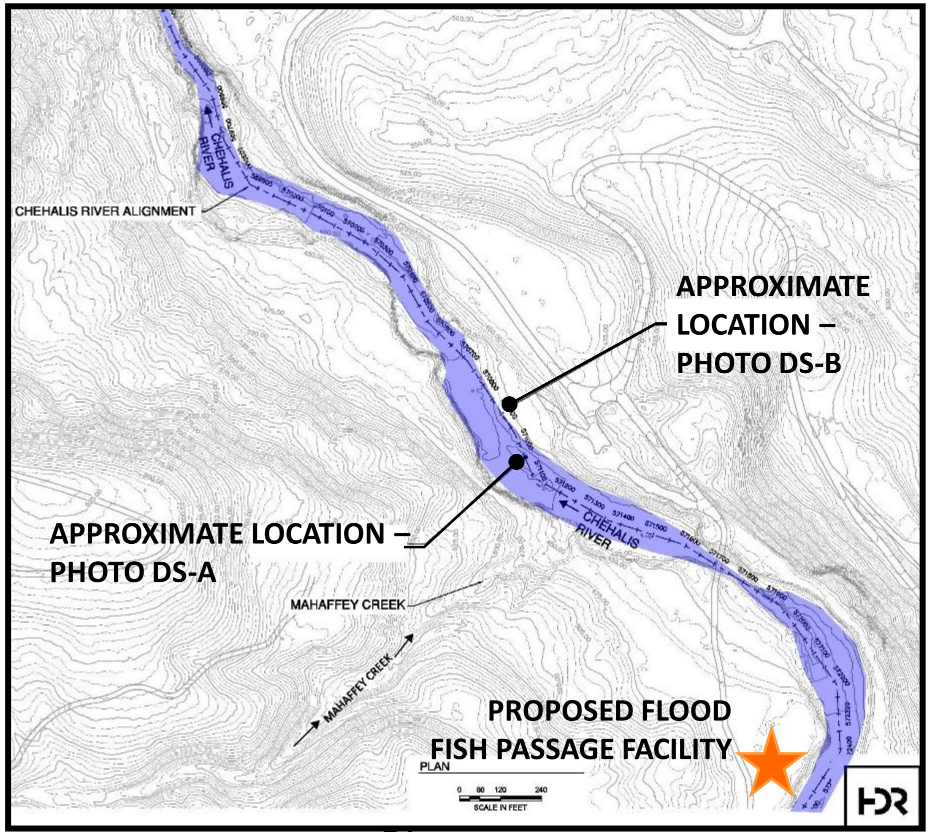
Chehalis River Channel

Reference Reach BFW (average): 113 ft
Cross Section BFW: 168 ft

Channel cross section shapes are preliminary. They will be revisited as development advances and bathymetry of the existing channel is collected and incorporated.

Channel Design Approach: Substrate Material & Channel Roughness

- Permanent: Chehalis River Channel

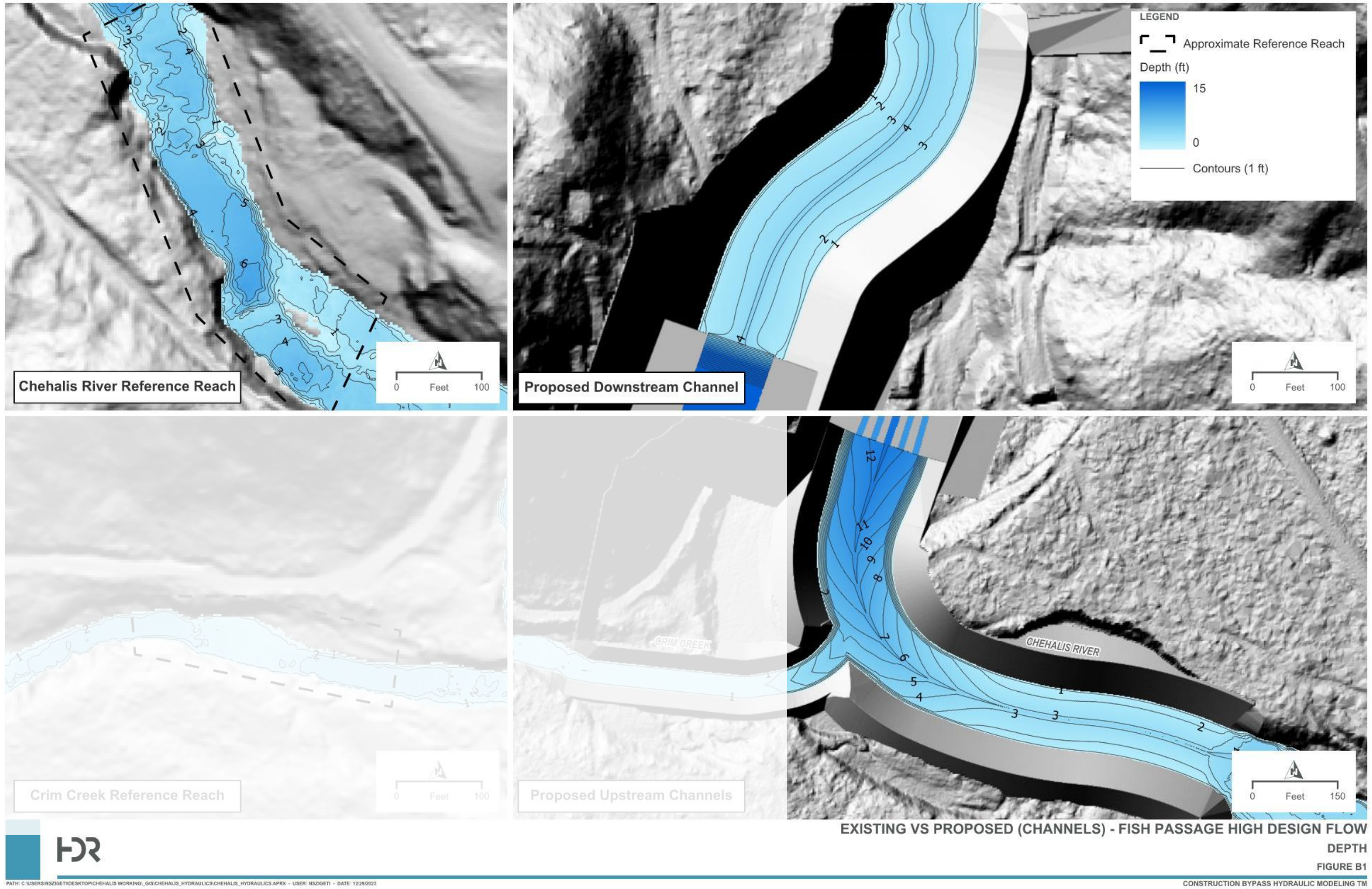


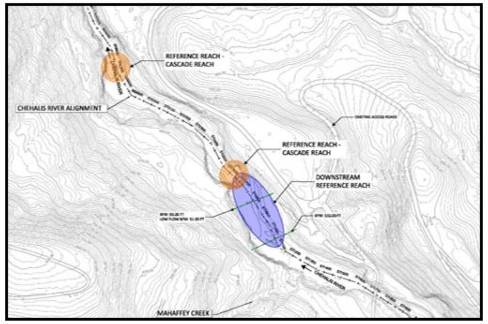
Plan

Photo-DS-A

Photo-DS-B

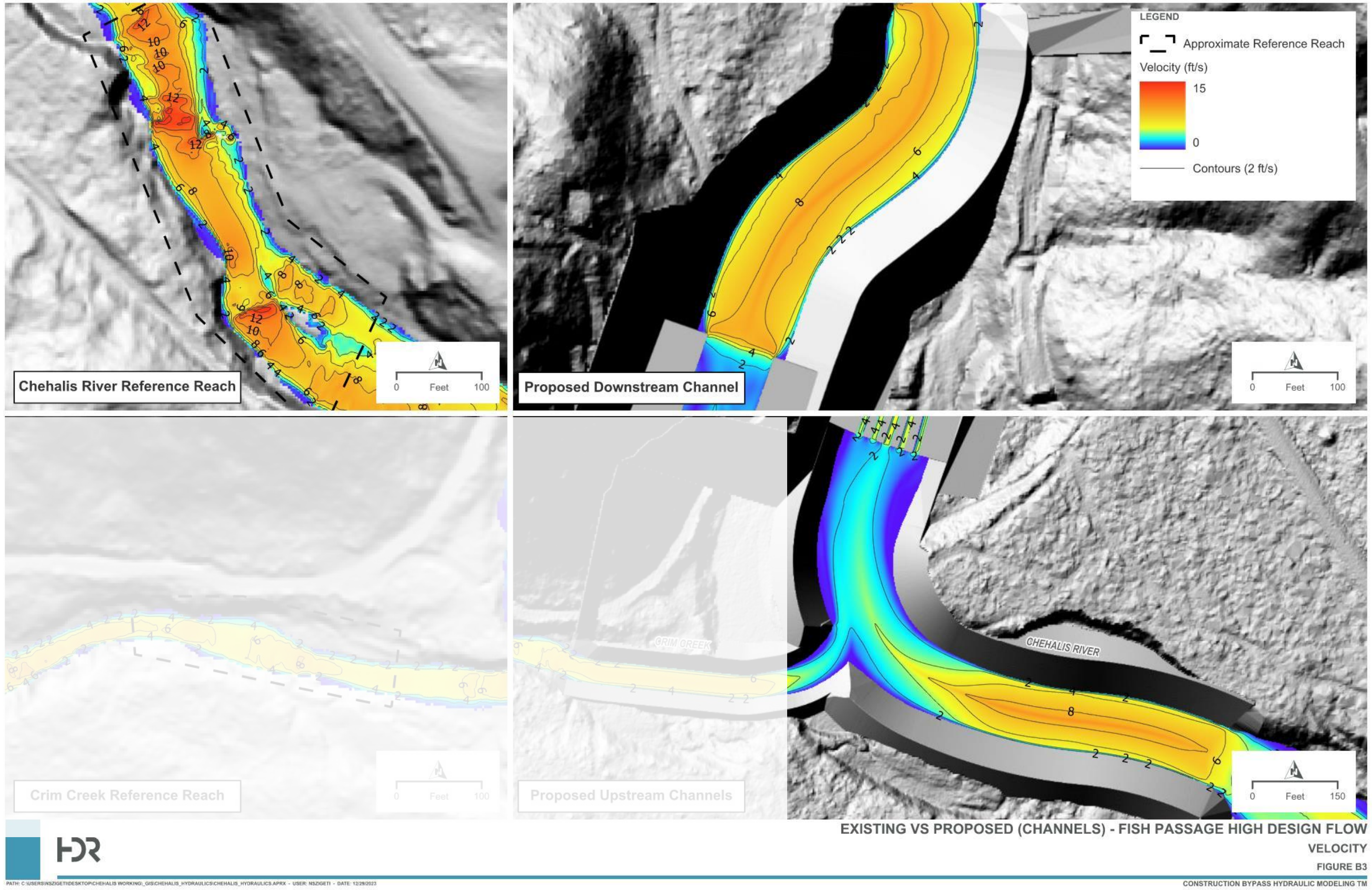
Approach & Discharge Channels – Perm. High Fish Passage Flow (5% Exceedance) Depth Results

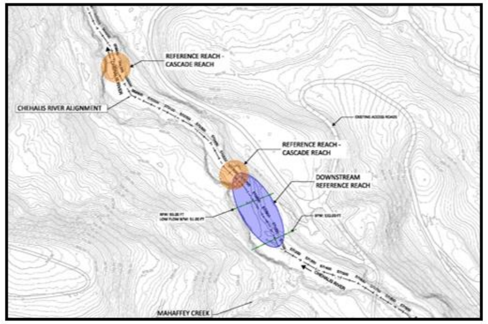




Reference Reach – Key Plan

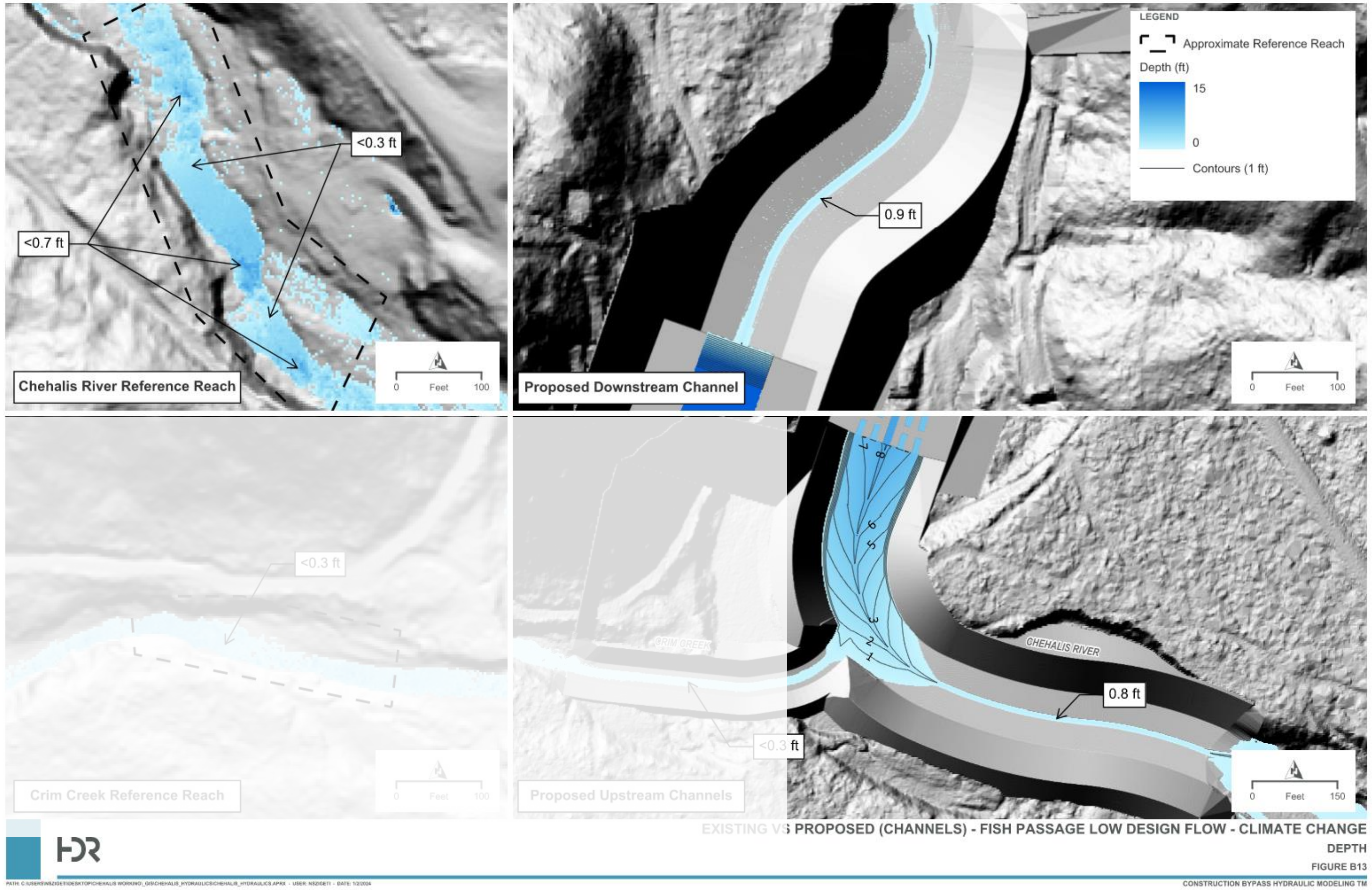
Approach & Discharge Channels – Perm. High Fish Passage Flow (5% Exceedance) Velocity Results

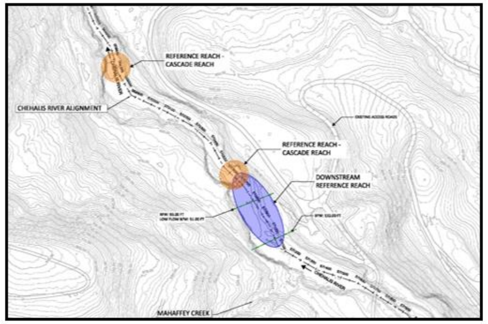




Reference Reach – Key Plan

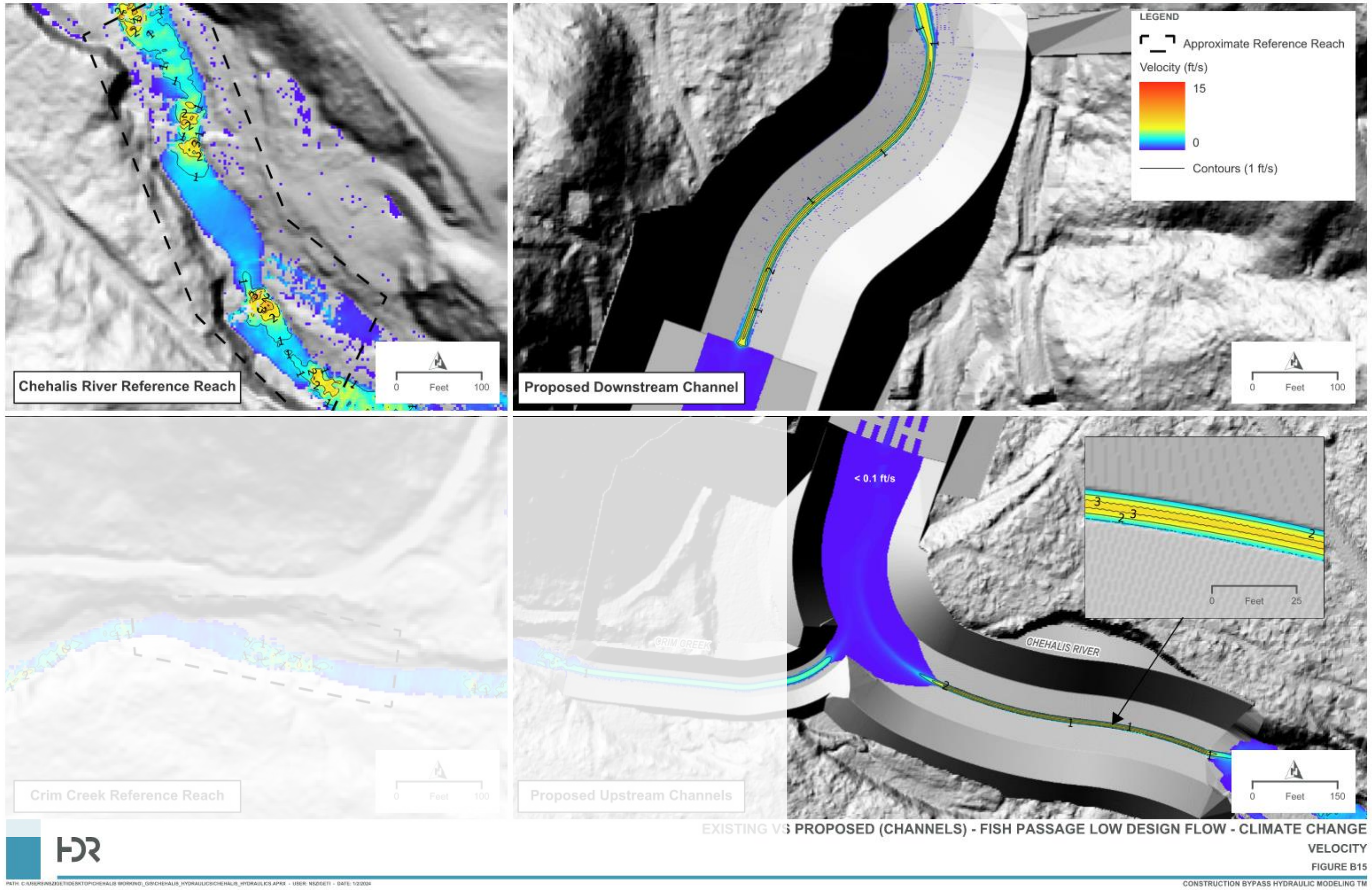
Approach & Discharge Channels – Perm. Low Fish Passage Flow (95% Exceedance) Depth Results

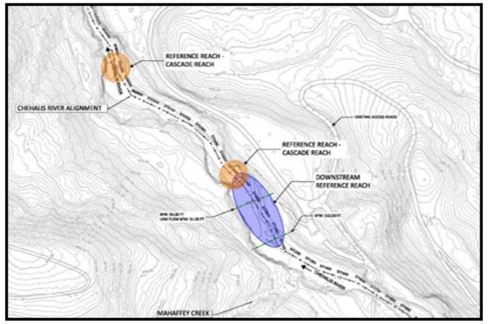




Reference Reach – Key Plan

Approach & Discharge Channels – Perm. Low Fish Passage Flow (95% Exceedance) Velocity Results

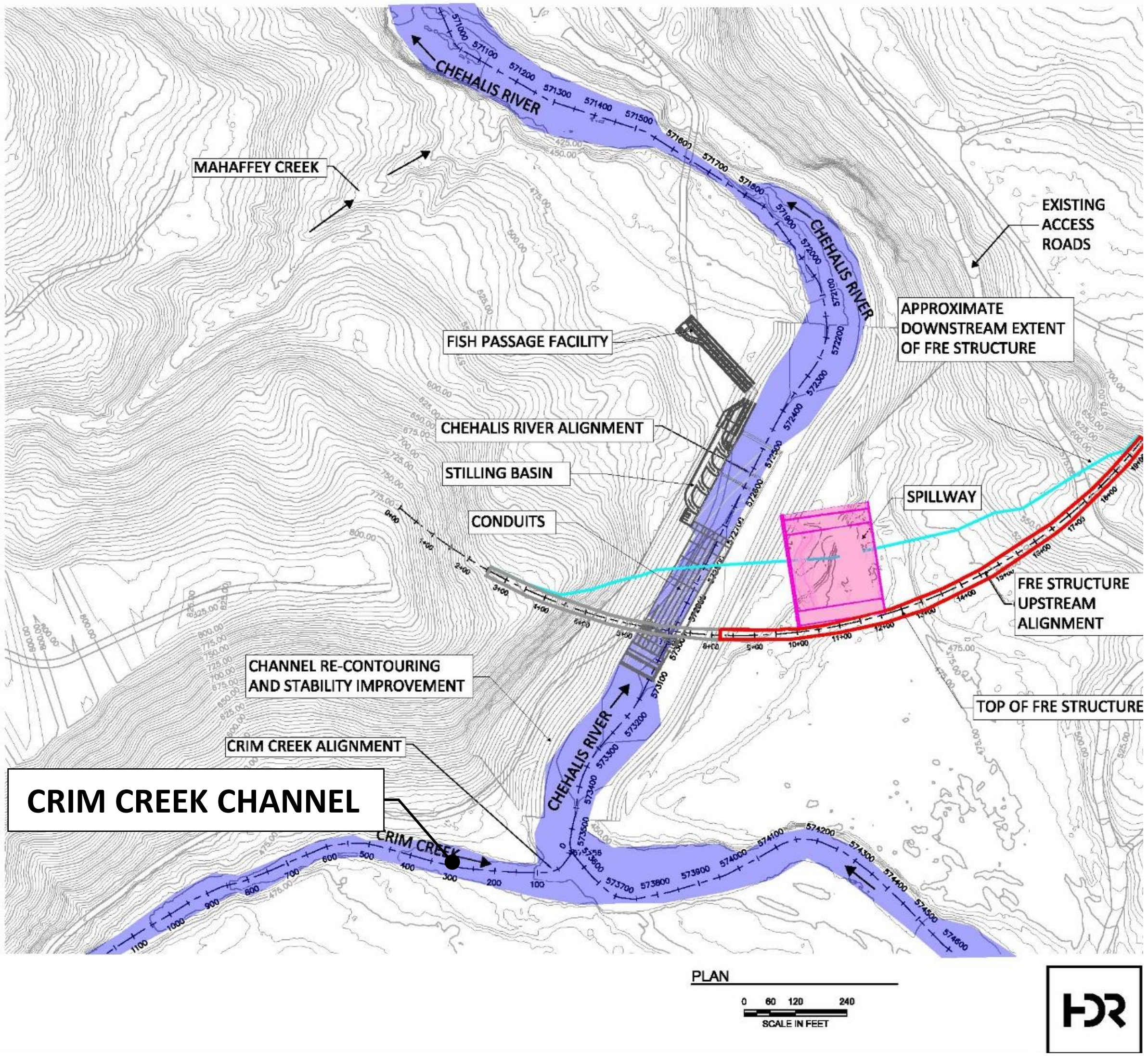




Reference Reach – Key Plan

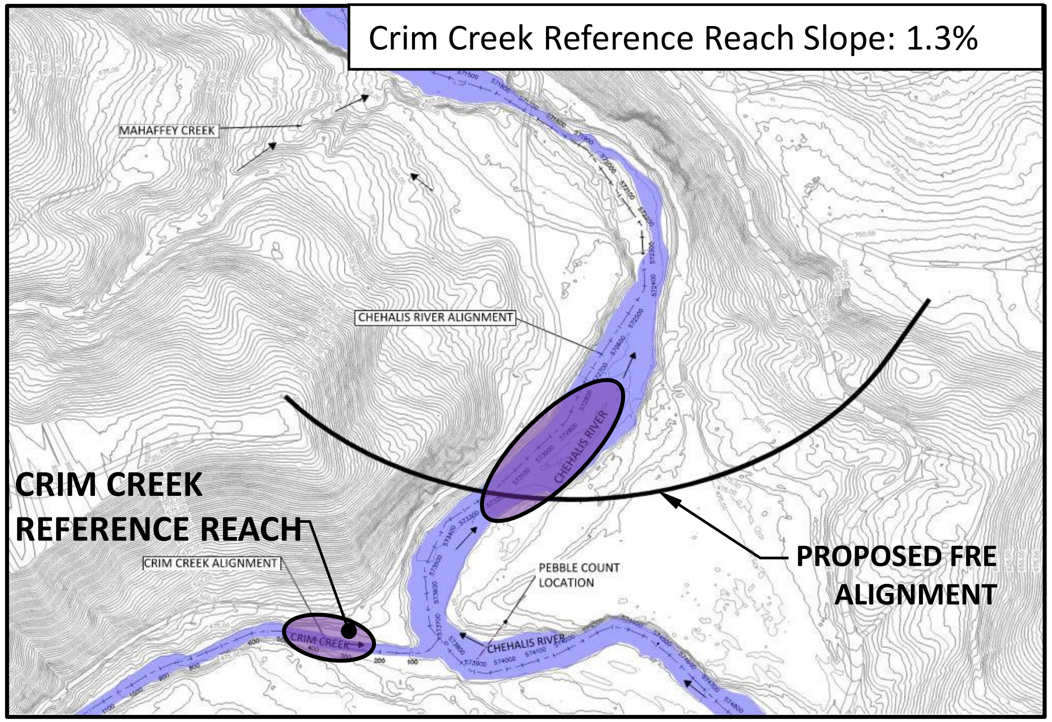
Channel Design Approach

- Permanent: Crim Creek

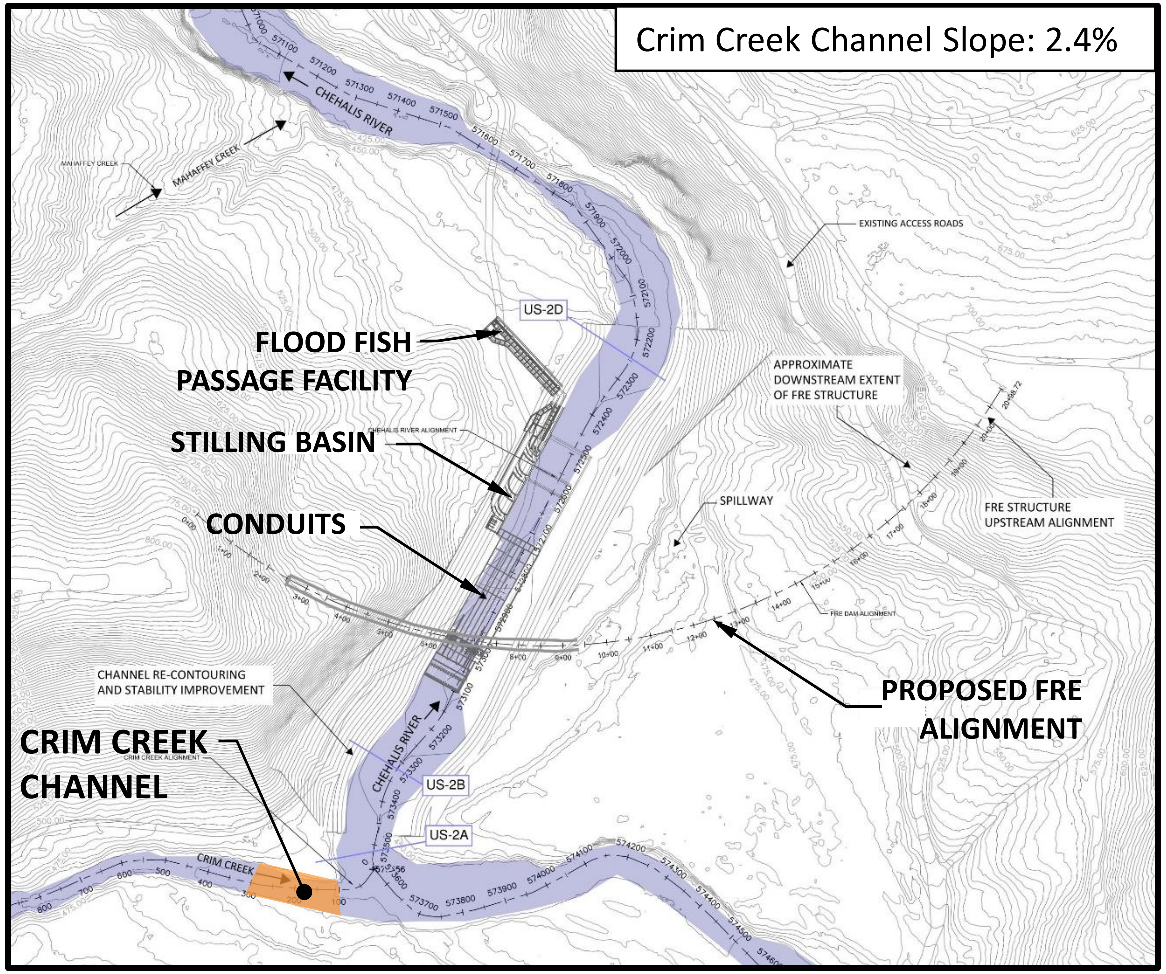


Channel Design Approach

- Permanent – Crim Creek



Reference Reach - Plan

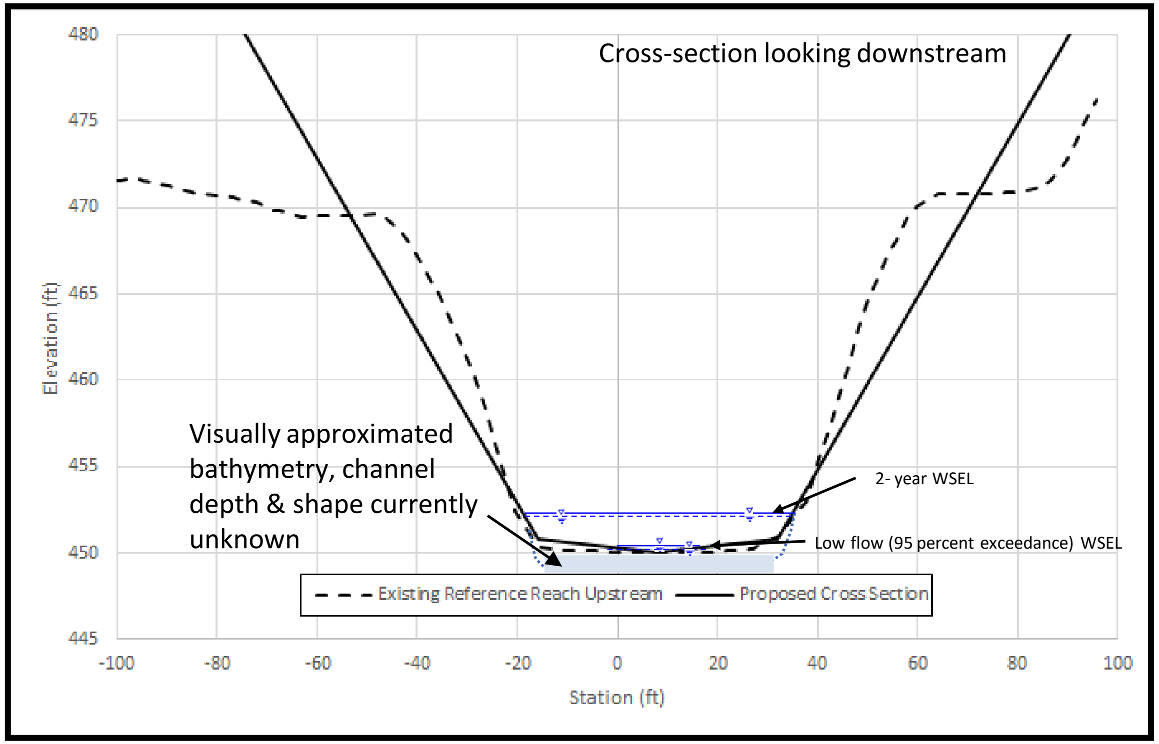


Crim Creek Channel - Plan

Channel Design Approach

- Permanent – Crim Creek

Reference Reach BFW (average): 49 ft
Cross Section BFW: 55 ft

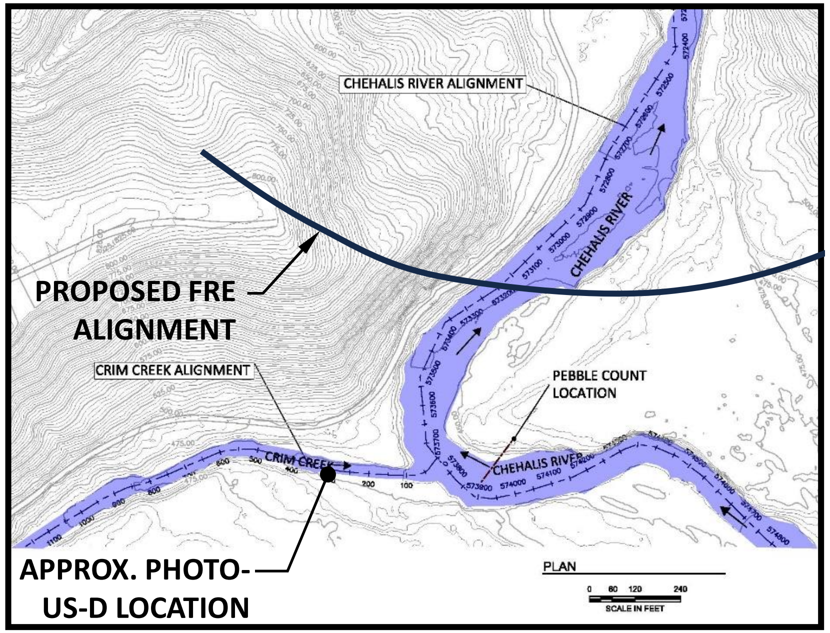


Chehalis River Channel

Channel cross section shapes are preliminary. They will be revisited as development advances and bathymetry of the existing channel is collected and incorporated.

Channel Design Approach: Substrate Material & Channel Roughness

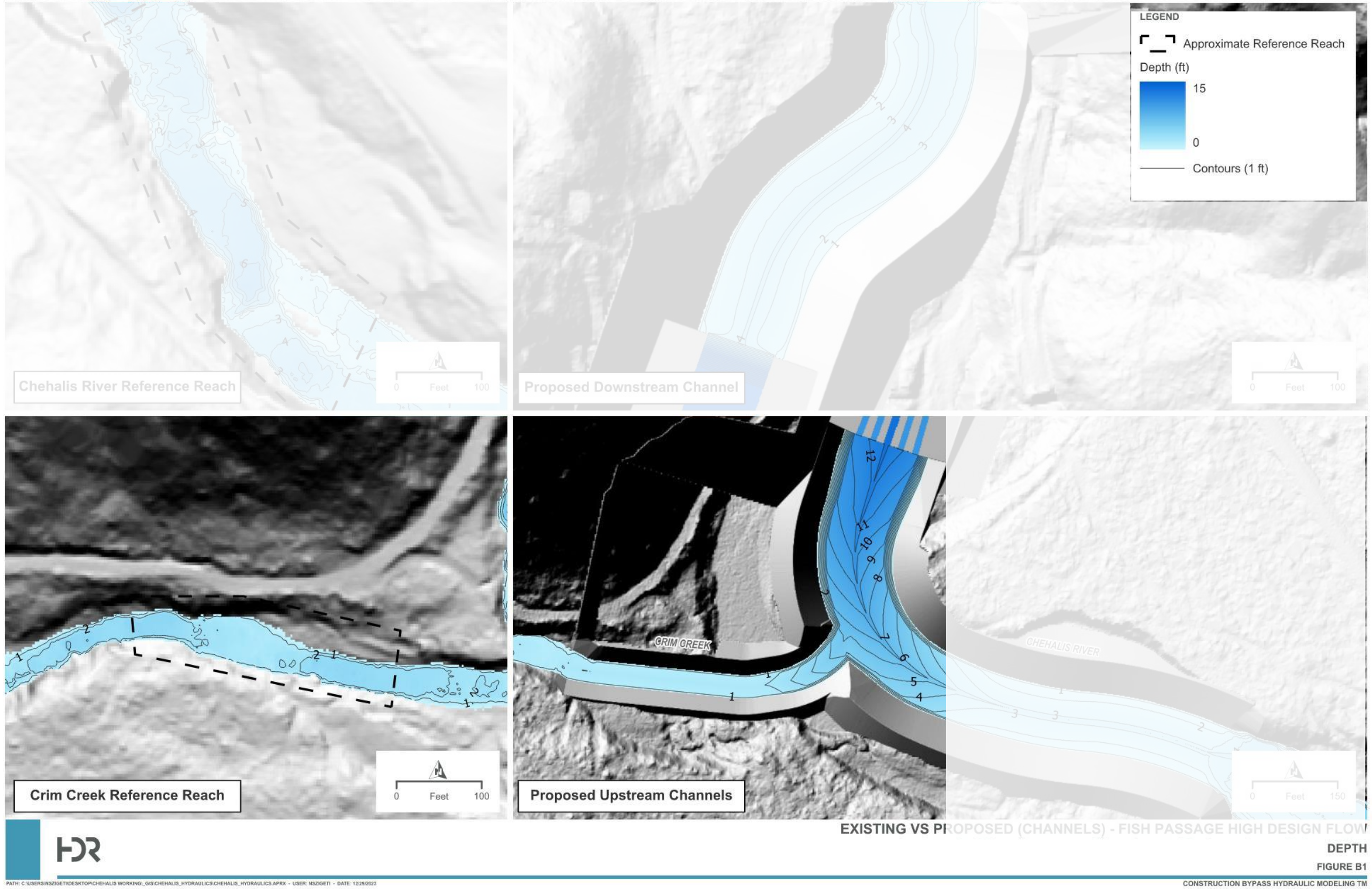
- Permanent – Crim Creek



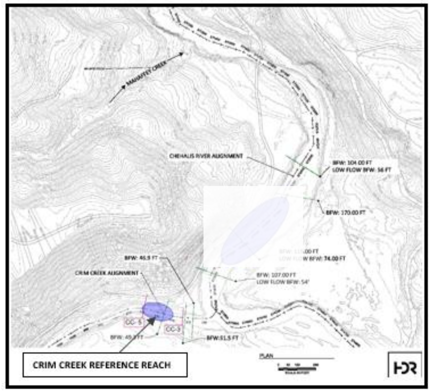
Plan

Photo-US-D: Crim Creek

Approach & Discharge Channels – Perm. High Fish Passage Flow (5% Exceedance) Depth Results

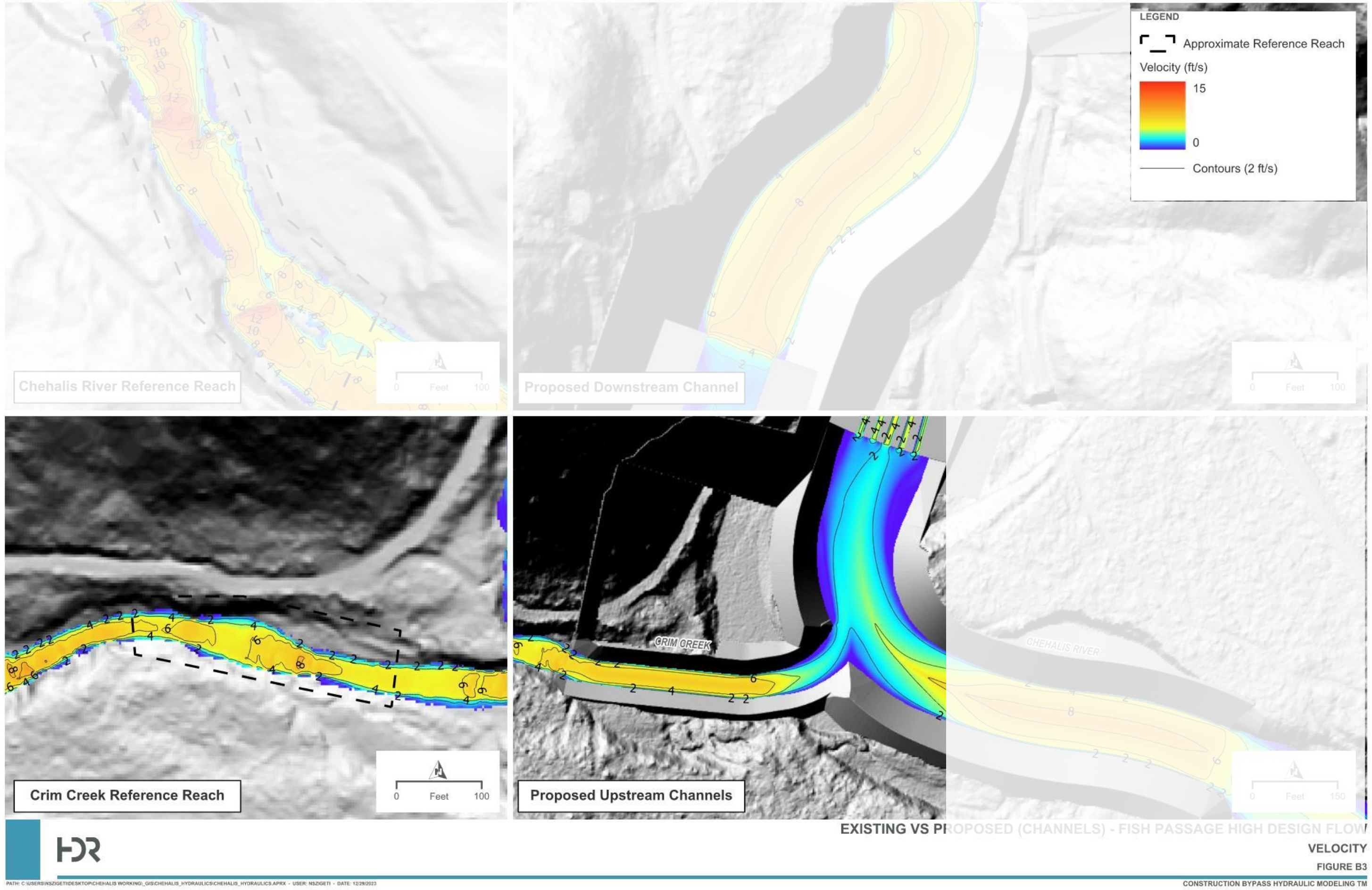


Reference Reach – Key Plan

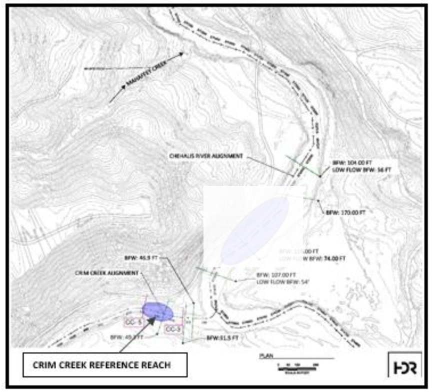


Reference Reach – Key Plan

Approach & Discharge Channels – Perm. High Fish Passage Flow (5% Exceedance) Velocity Results

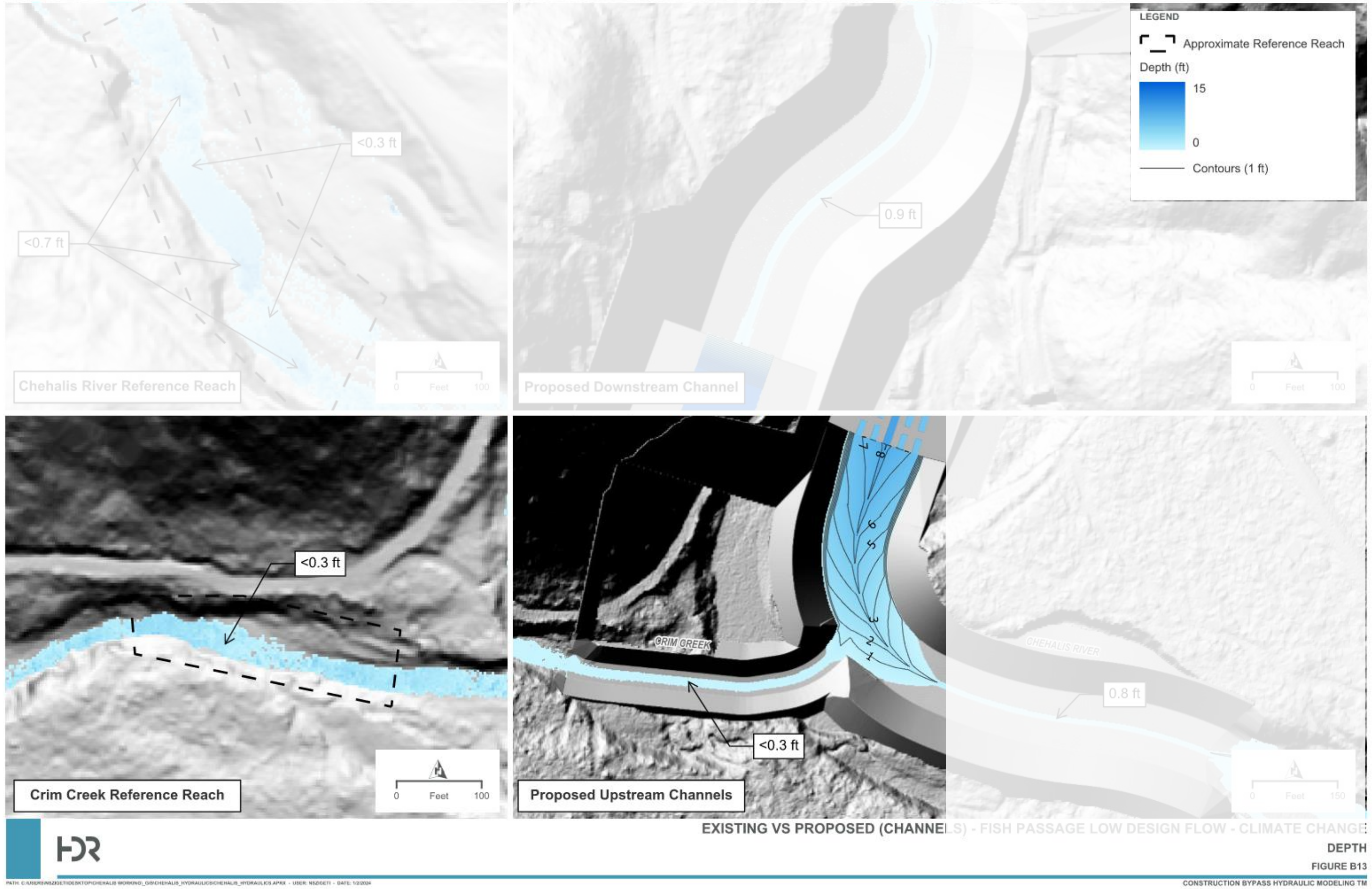


Reference Reach – Key Plan

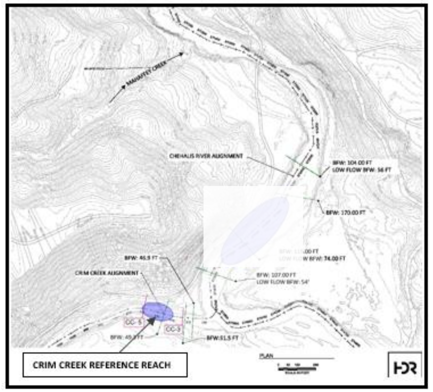


Reference Reach – Key Plan

Approach & Discharge Channels – Perm. Low Fish Passage Flow (95% Exceedance) Depth Results

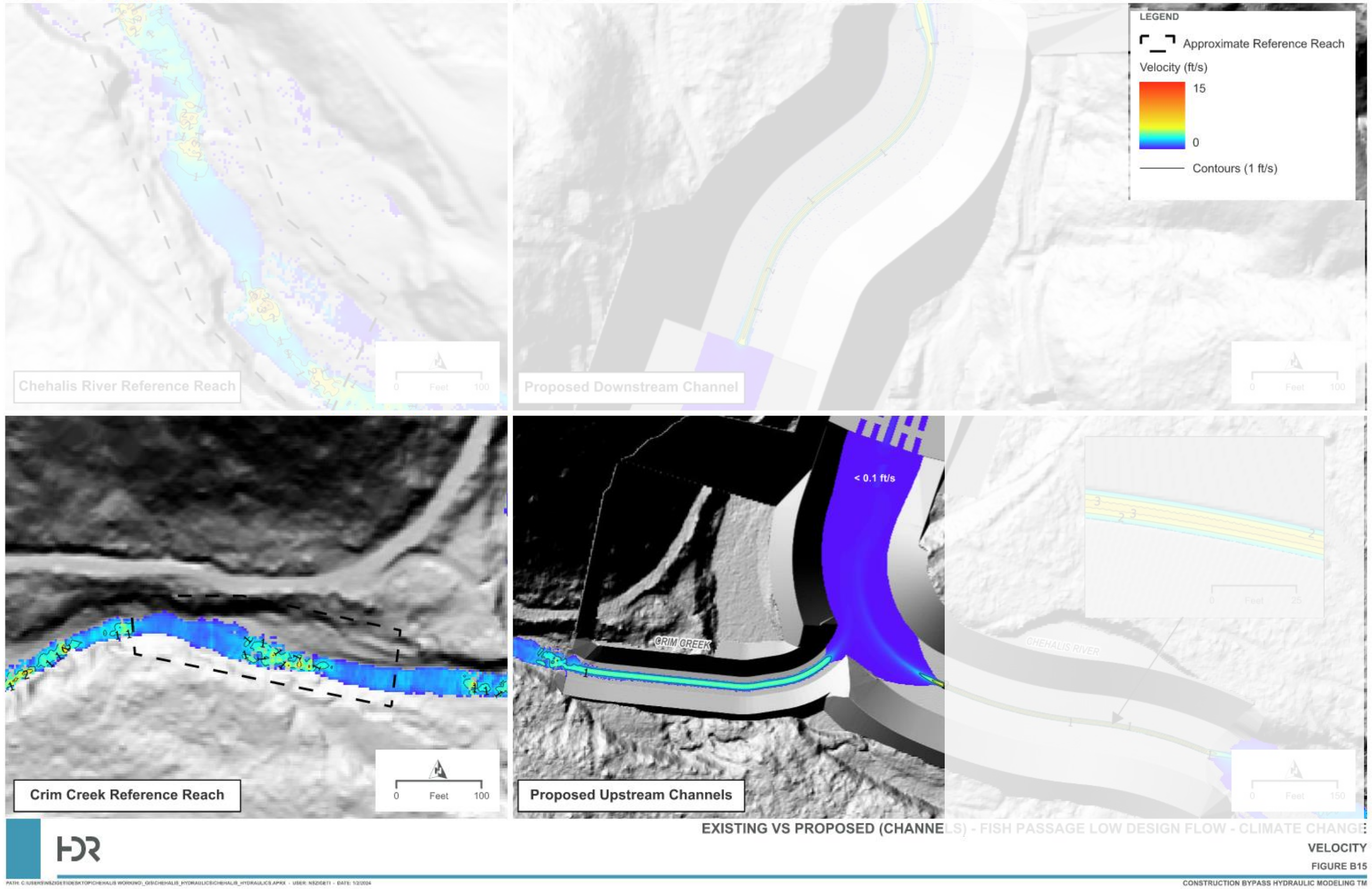


Reference Reach – Key Plan

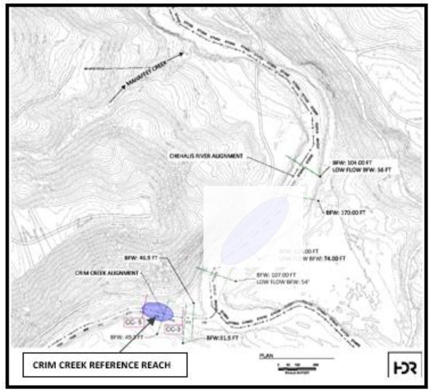


Reference Reach – Key Plan

Approach & Discharge Channels – Perm. Low Fish Passage Flow (95% Exceedance) Velocity Results



Reference Reach – Key Plan



Reference Reach – Key Plan

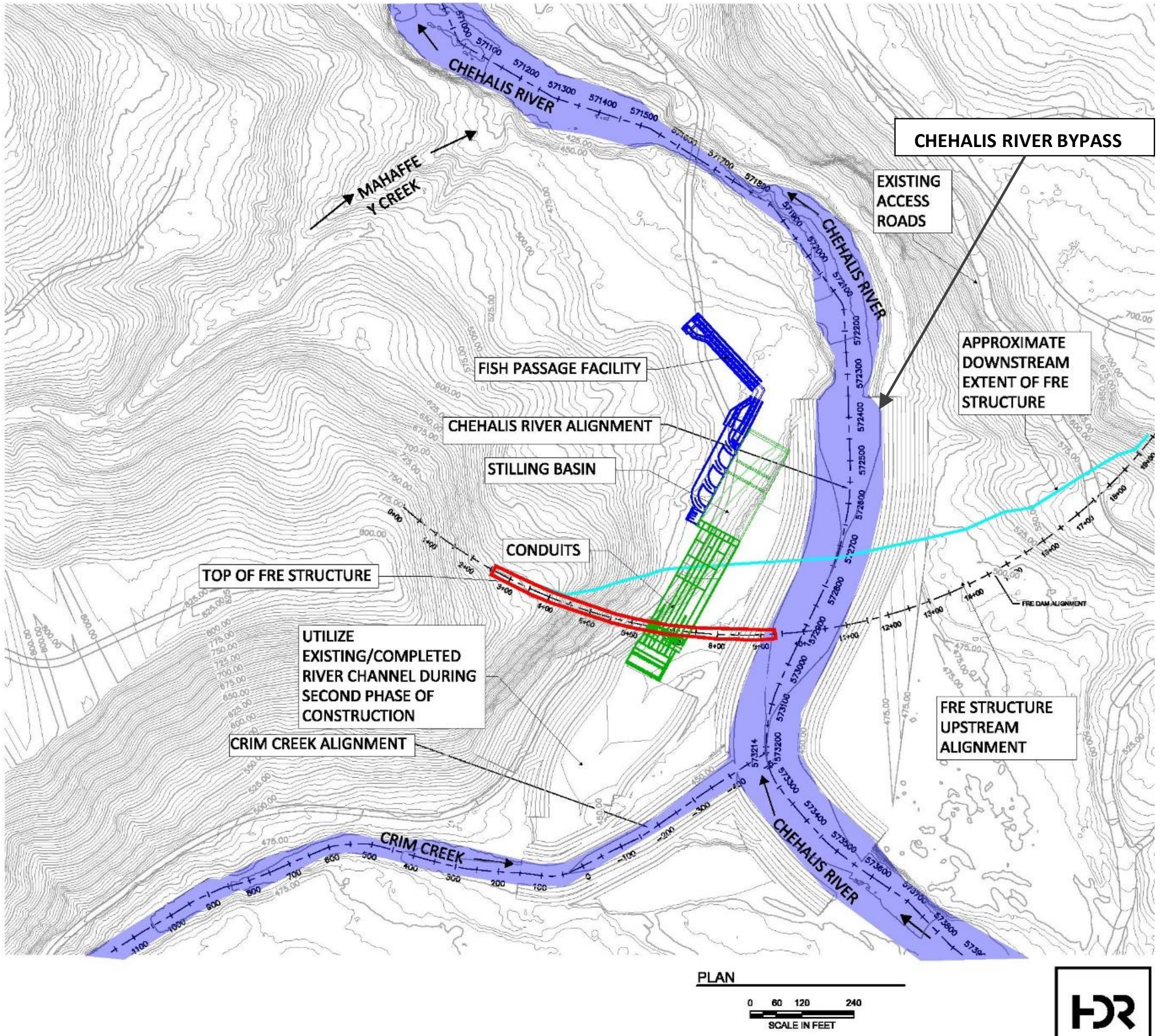
HDR

Channel Design Approach & Hydraulic Modeling Results

- Construction (temporary) –
  Chehalis River Bypass Channel

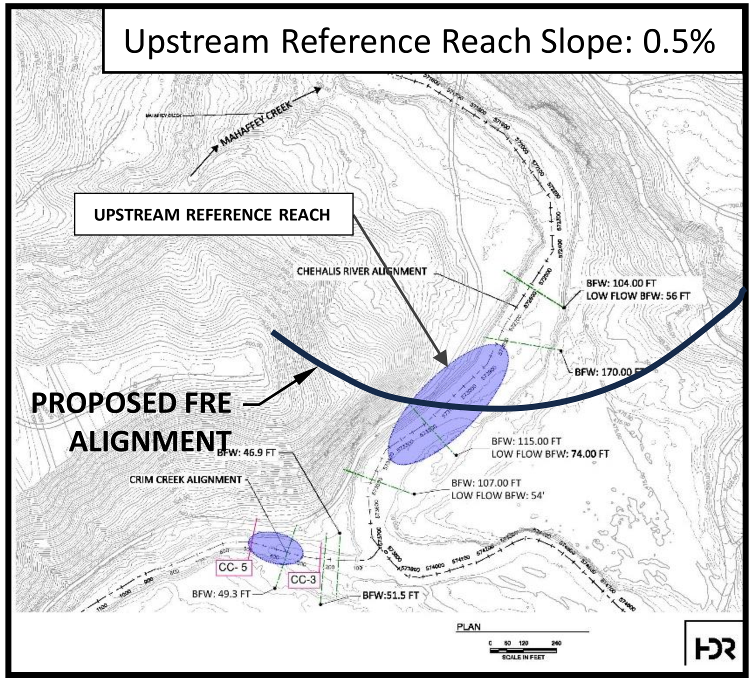
Construction Bypass Channels Hydraulic Design Approach

- Construction:
  Chehalis River Bypass

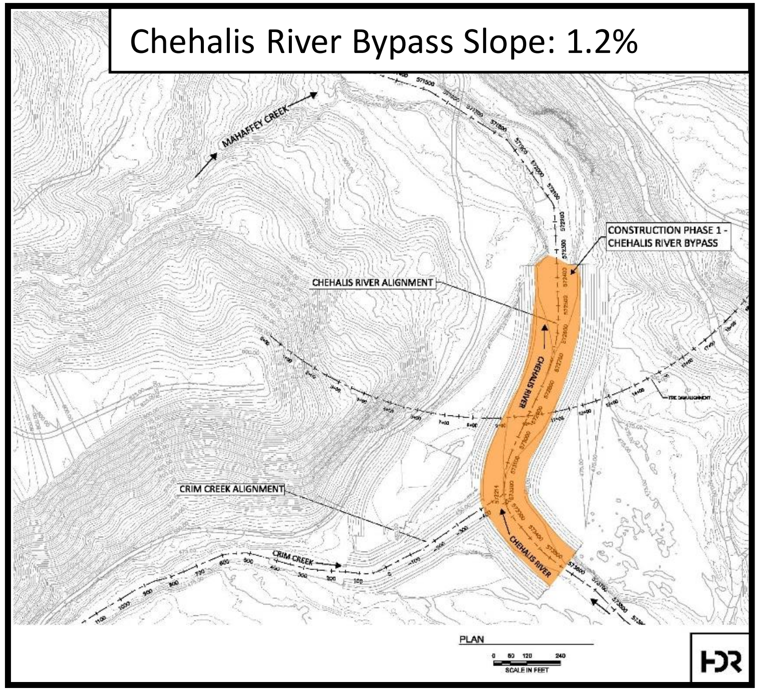


Channel Design Approach

- Construction:
  Chehalis River Bypass



Reference Reach - Plan

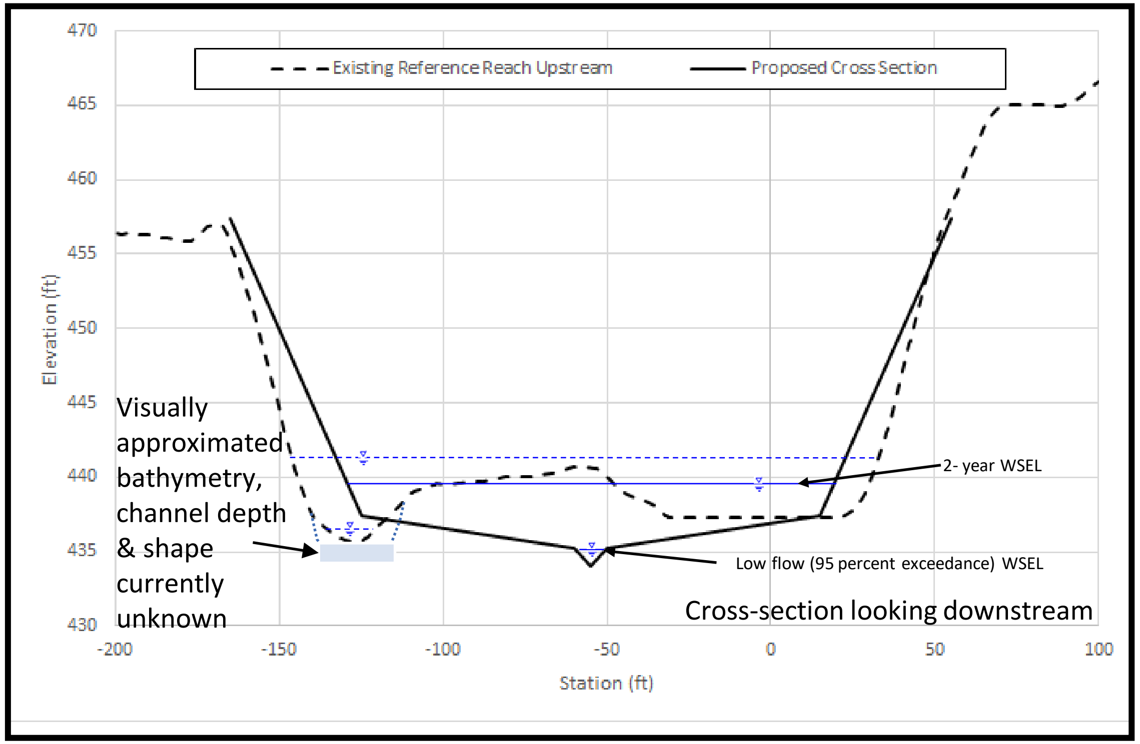


Chehalis River Bypass - Plan

Channel Design Approach

- Construction – Chehalis River Bypass

Reference Reach BFW (average): 143 ft
Cross Section BFW: 156 ft

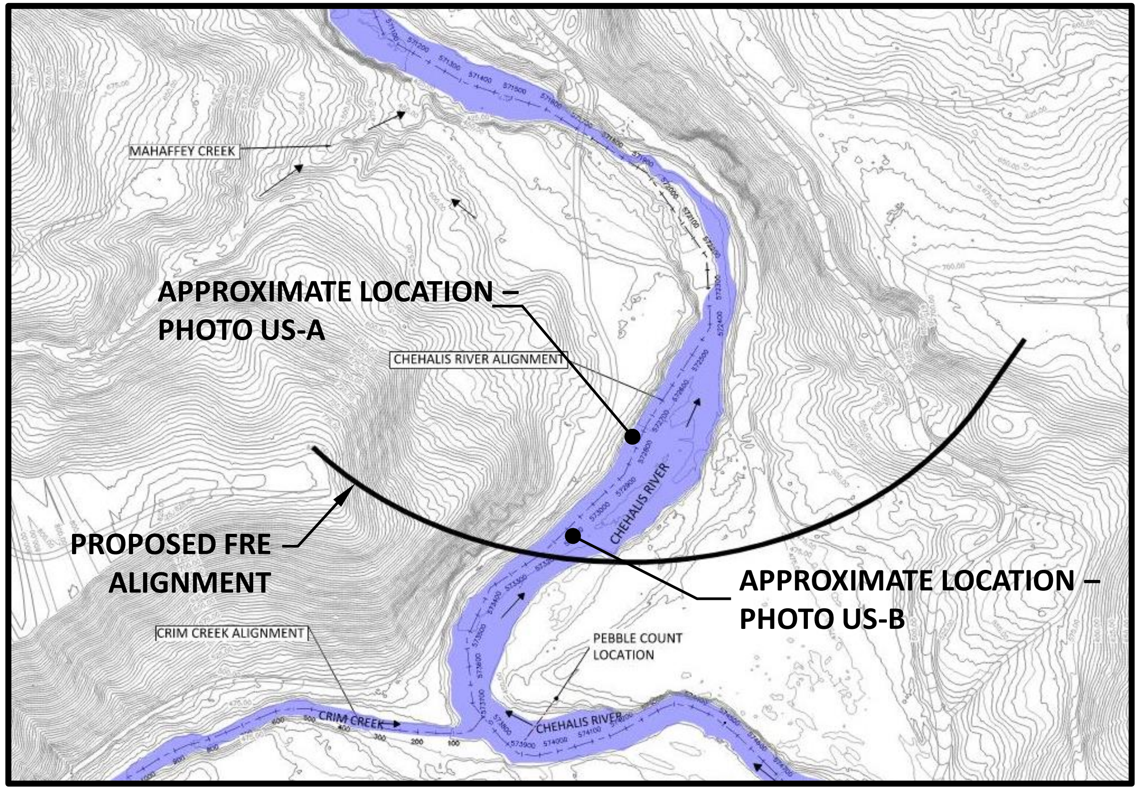


Chehalis River Channel

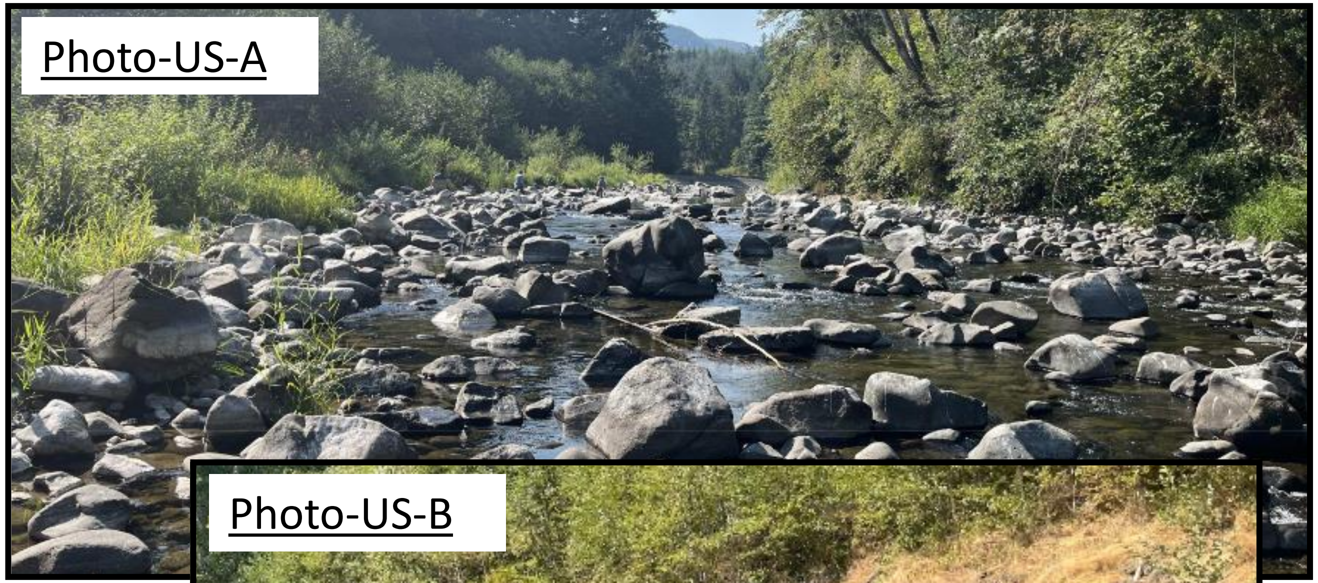
Channel cross section shapes are preliminary. They will be revisited as development advances and bathymetry of the existing channel is collected and incorporated.

Channel Design Approach: Substrate Material & Channel Roughness

- Construction:
  Chehalis River Bypass

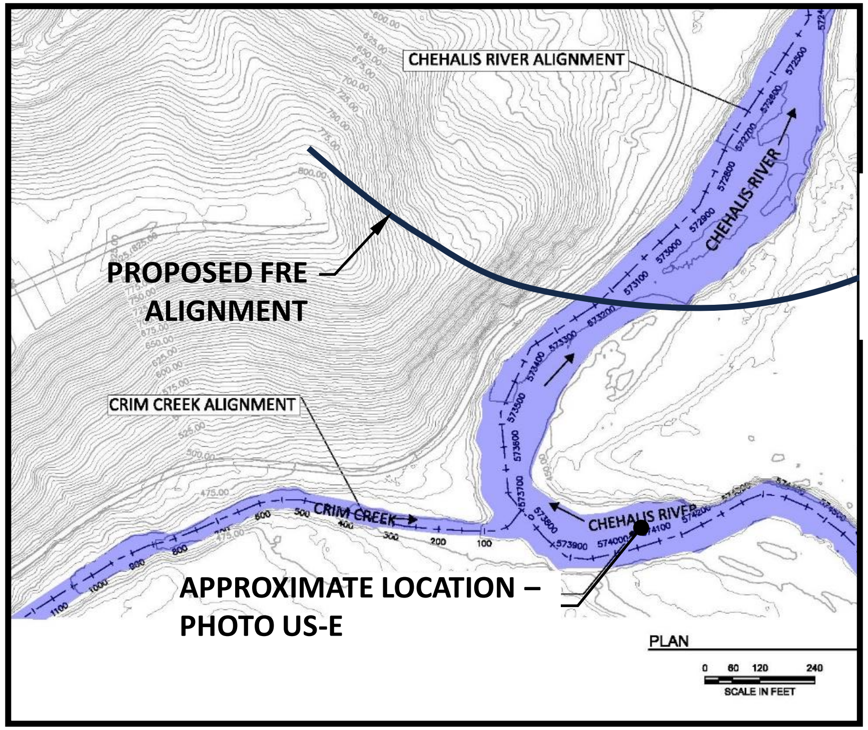


Plan



Channel Design Approach: Substrate Material & Channel Roughness

- Construction – Chehalis River Bypass

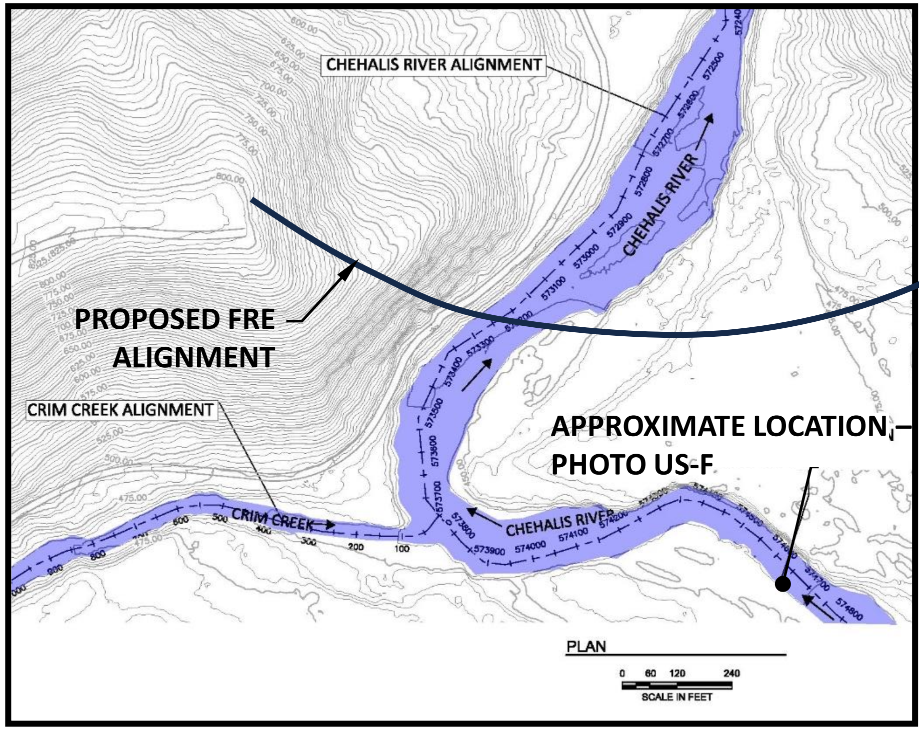


Plan

Photo-US-E: Pebble Count

Channel Design Approach: Substrate Material & Channel Roughness

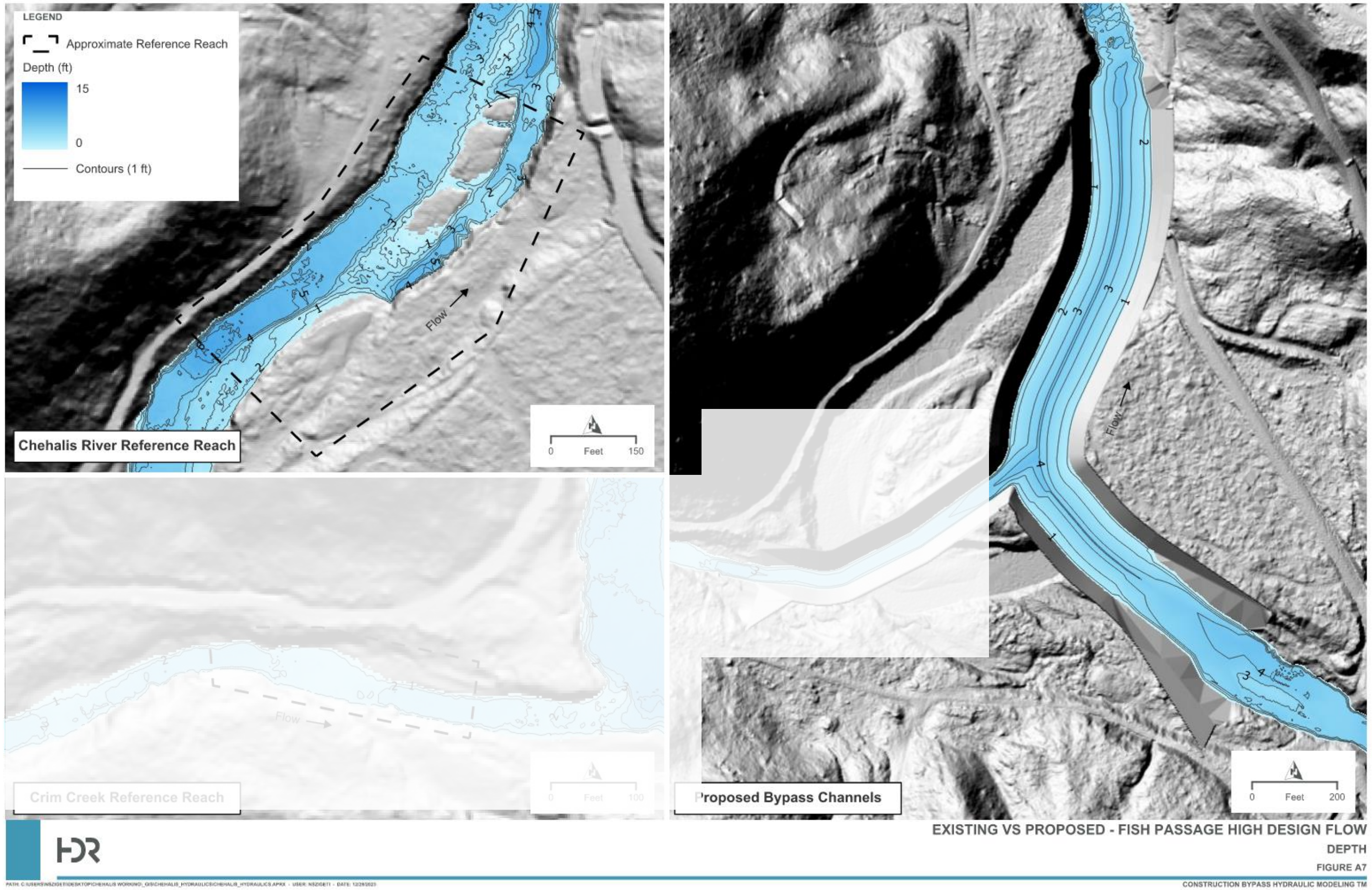
- Construction – Chehalis River Bypass

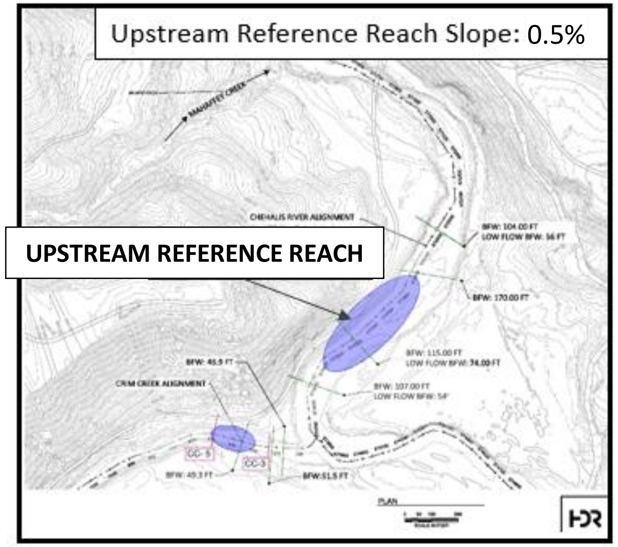


Plan

Photo-US-F: Bypass Upstream Connection to Chehalis River

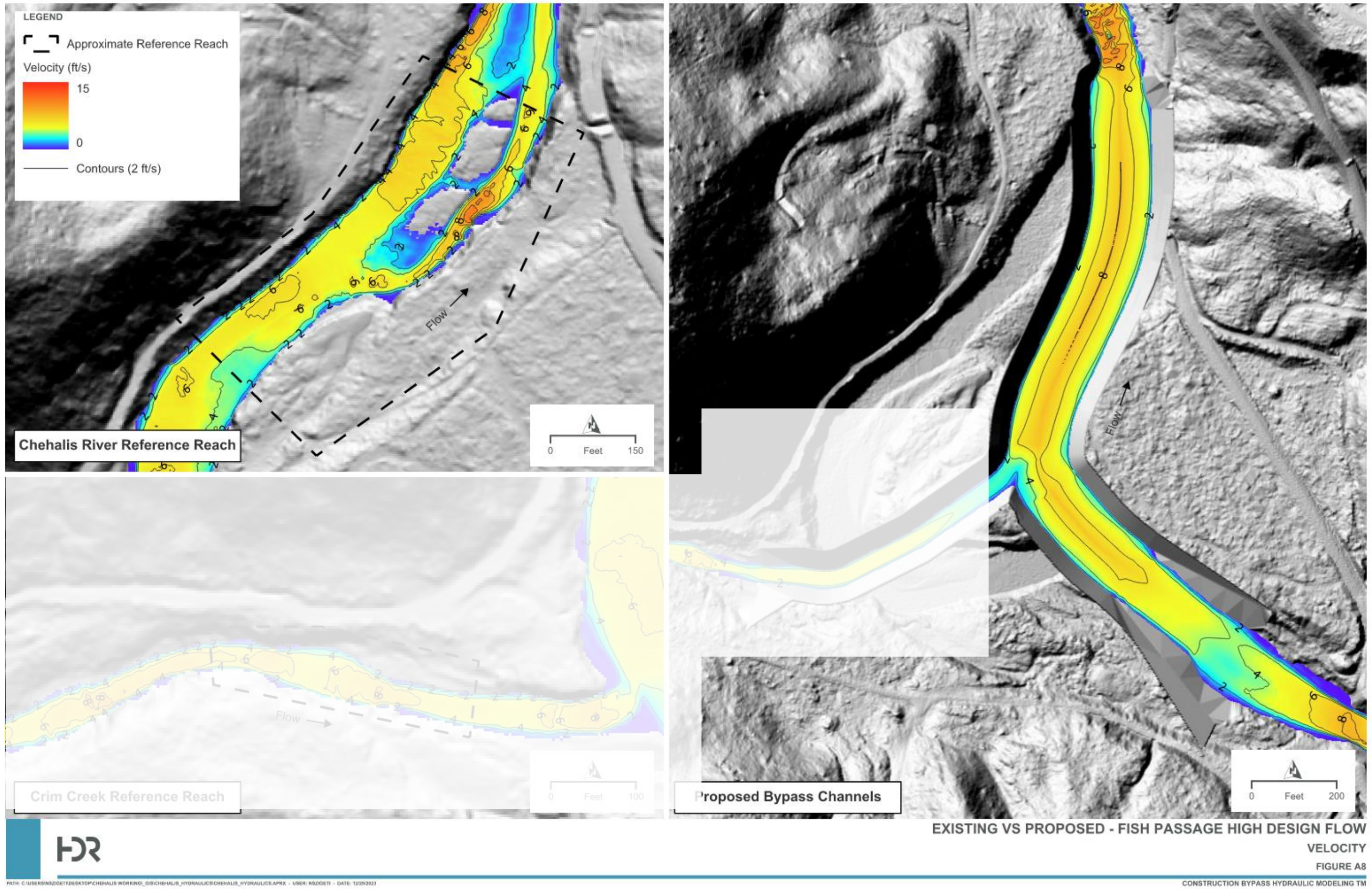
Chehalis Bypass Channel – Construction High Fish Passage Flow (5% Exceedance) Depth Results

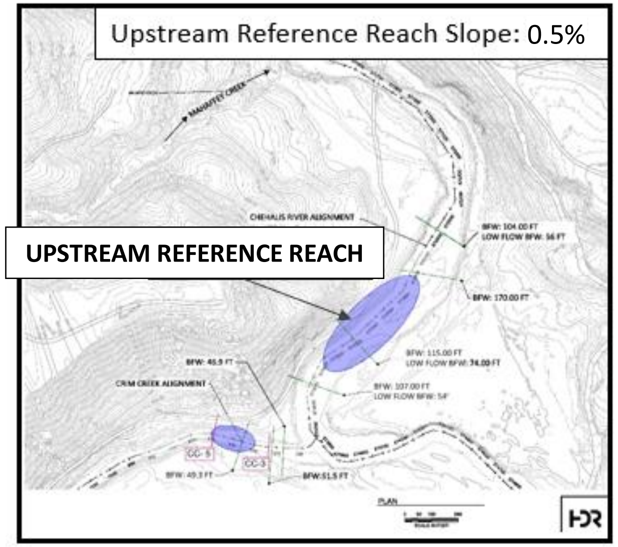




Reference Reach - Plan

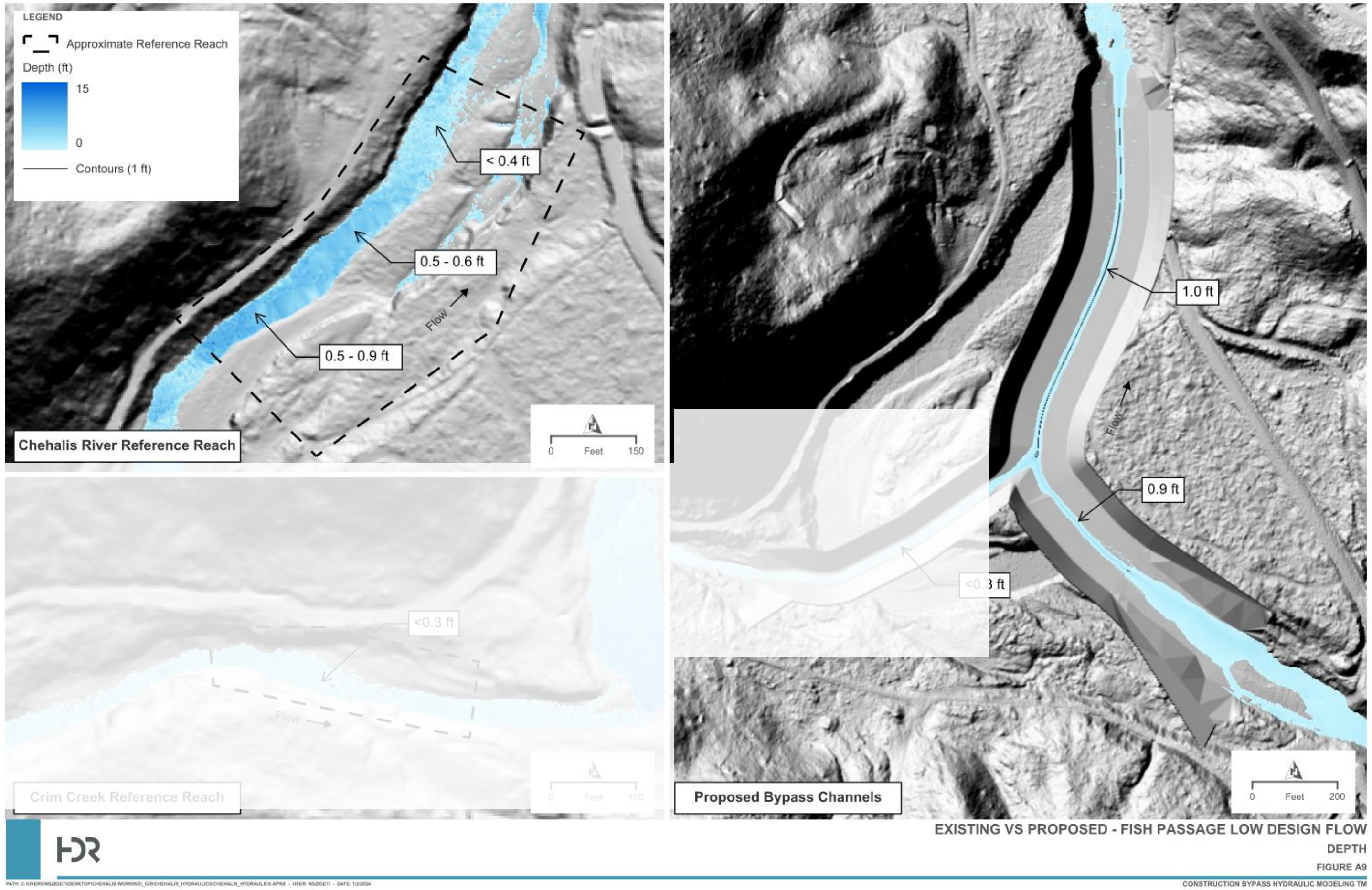
Chehalis Bypass Channel – Construction High Fish Passage Flow (5% Exceedance) Velocity Results

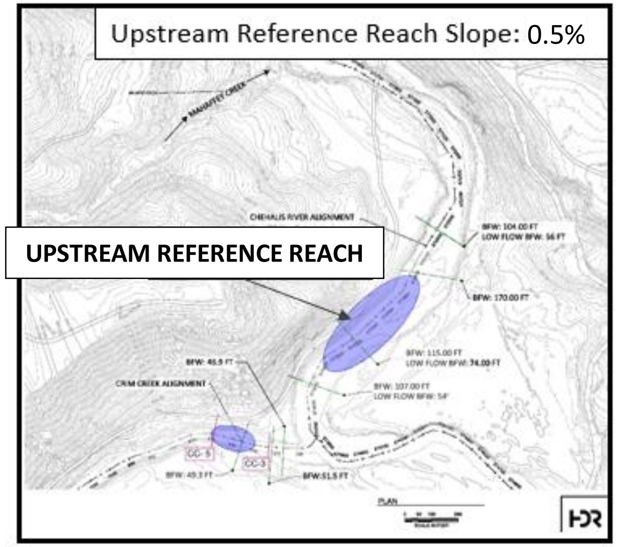




Reference Reach - Plan

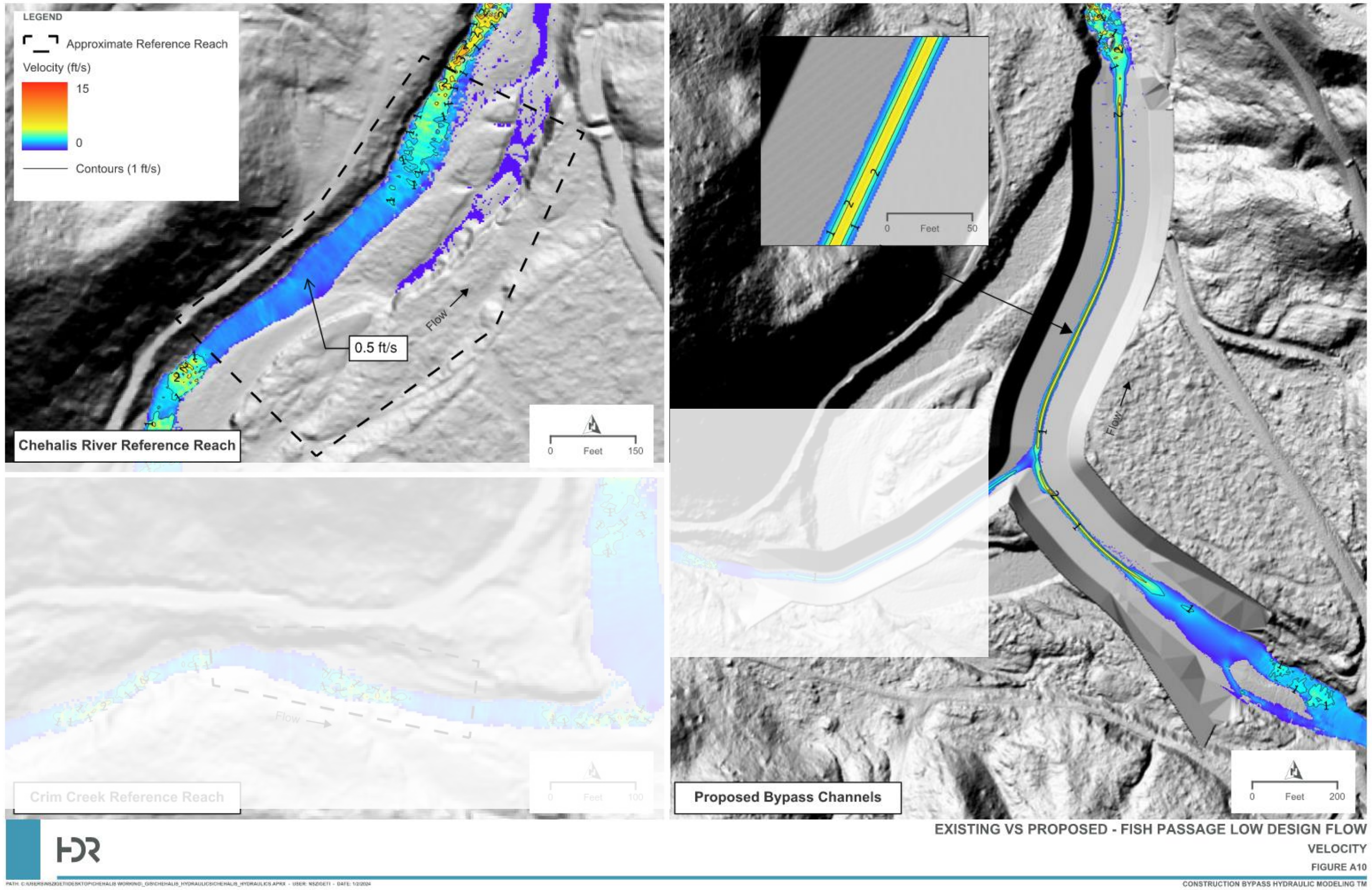
Chehalis Bypass Channel – Construction Low Fish Passage Flow (95% Exceedance) Depth Results

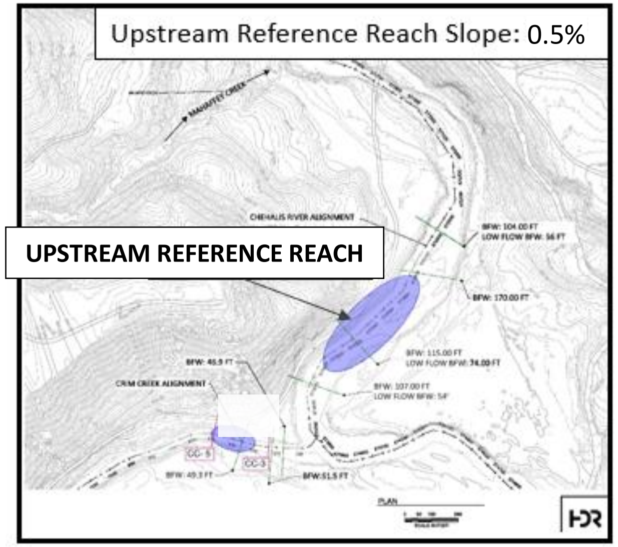




Reference Reach - Plan

Chehalis Bypass Channel – Construction Low Fish Passage Flow (95% Exceedance) Velocity Results





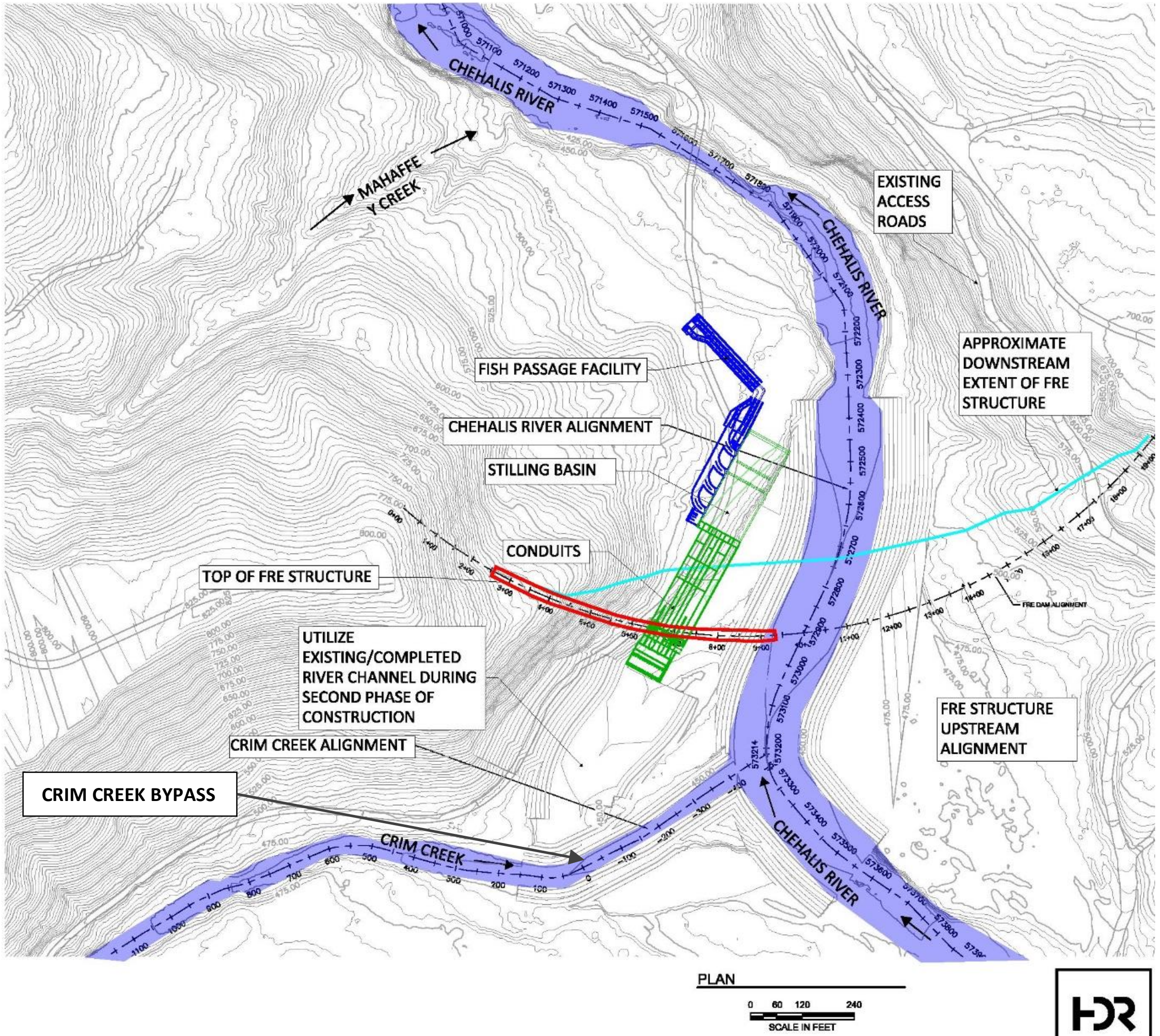
Reference Reach - Plan

Channel Design Approach & Hydraulic Modeling Results

- Construction:
  Crim Creek Bypass

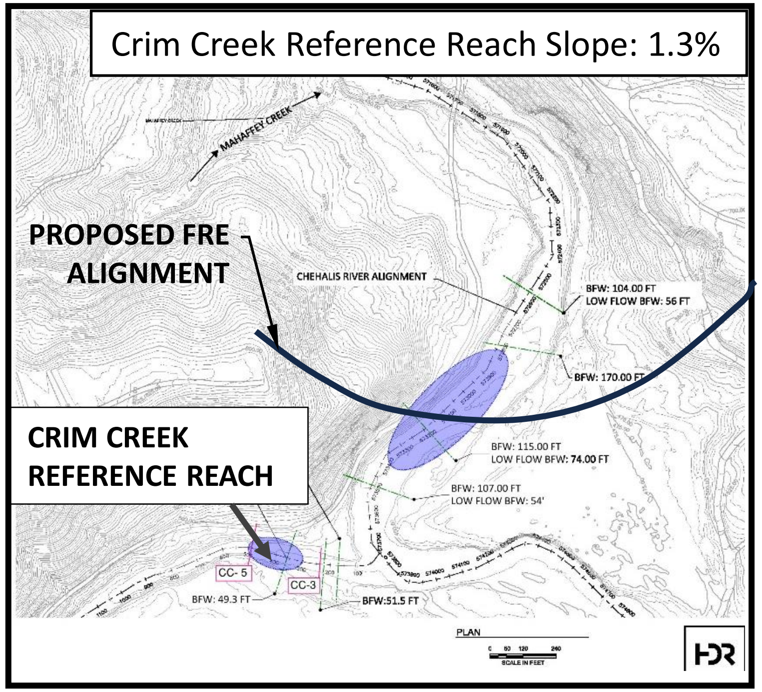
Construction Bypass Channels Hydraulic Design Approach

- Construction Phase 1:
  Crim Creek Bypass

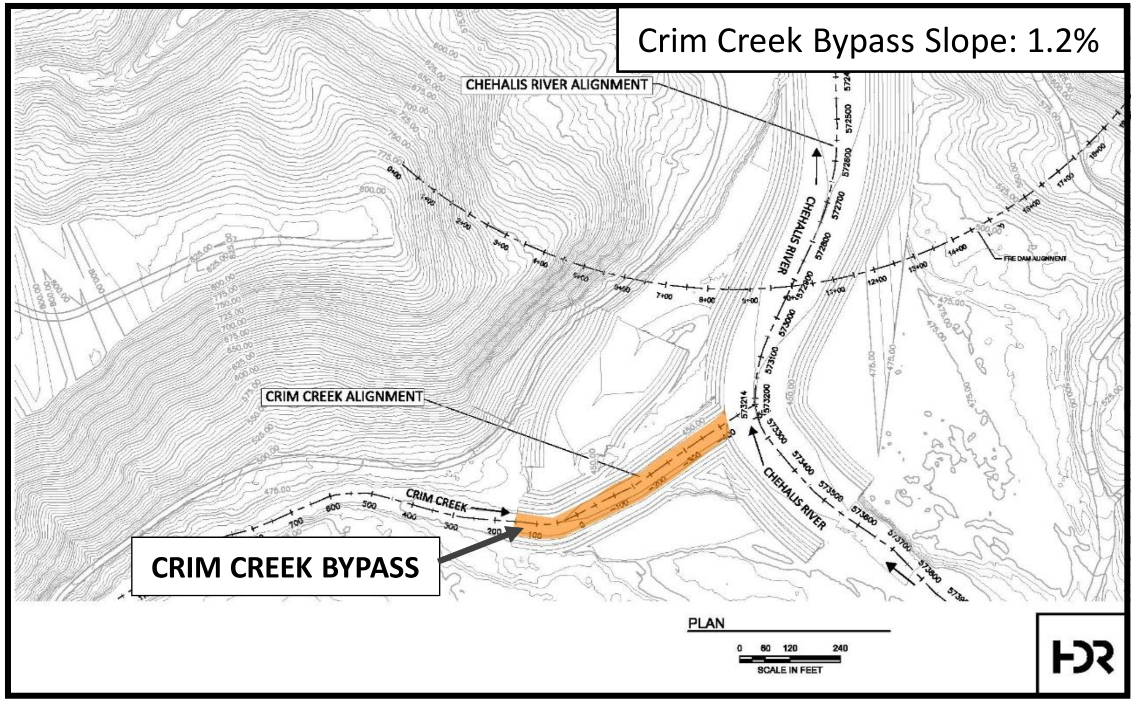


Channel Design Approach

- Construction:
  Crim Creek Bypass



Reference Reach - Plan

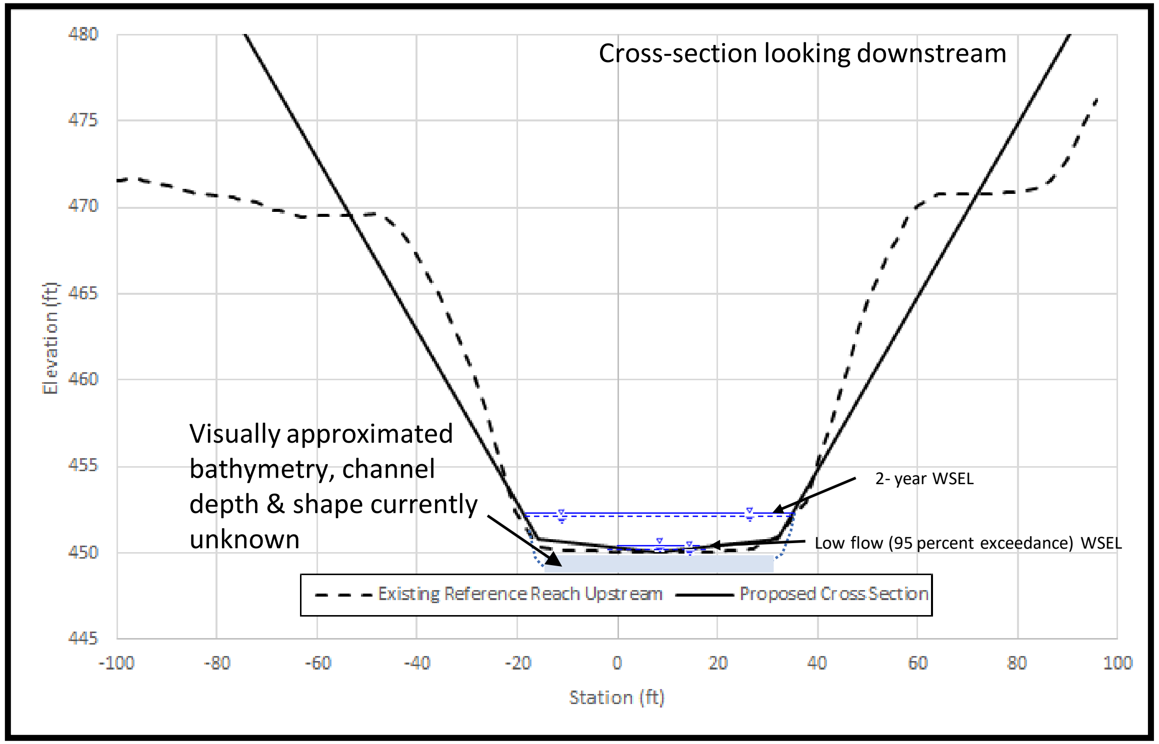


Crim Creek Bypass - Plan

Channel Design Approach

- Construction:
  Crim Creek Bypass

Reference Reach BFW (average): 49 ft
Cross Section BFW: 55 ft

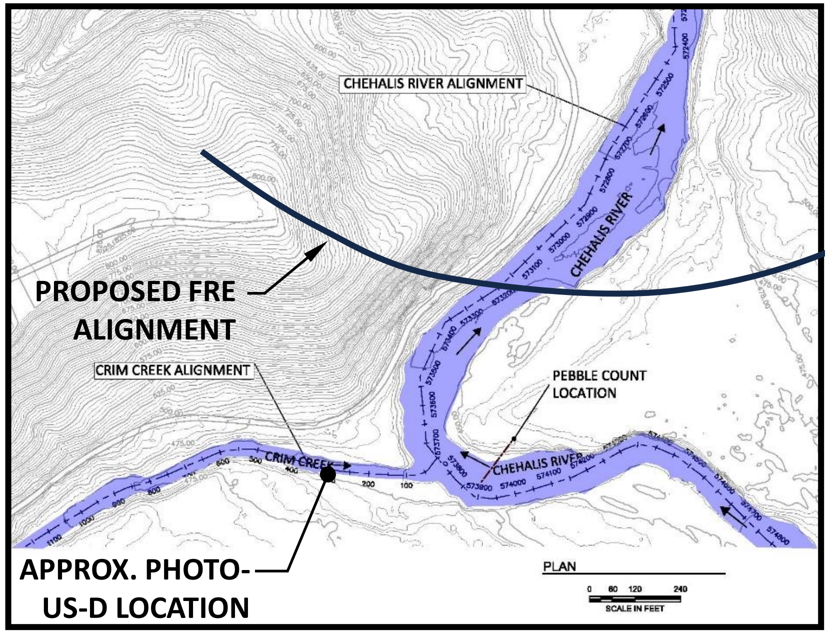


Chehalis River Channel

Channel cross section shapes are preliminary. They will be revisited as development advances and bathymetry of the existing channel is collected and incorporated.

Channel Design Approach: Substrate Material & Channel Roughness

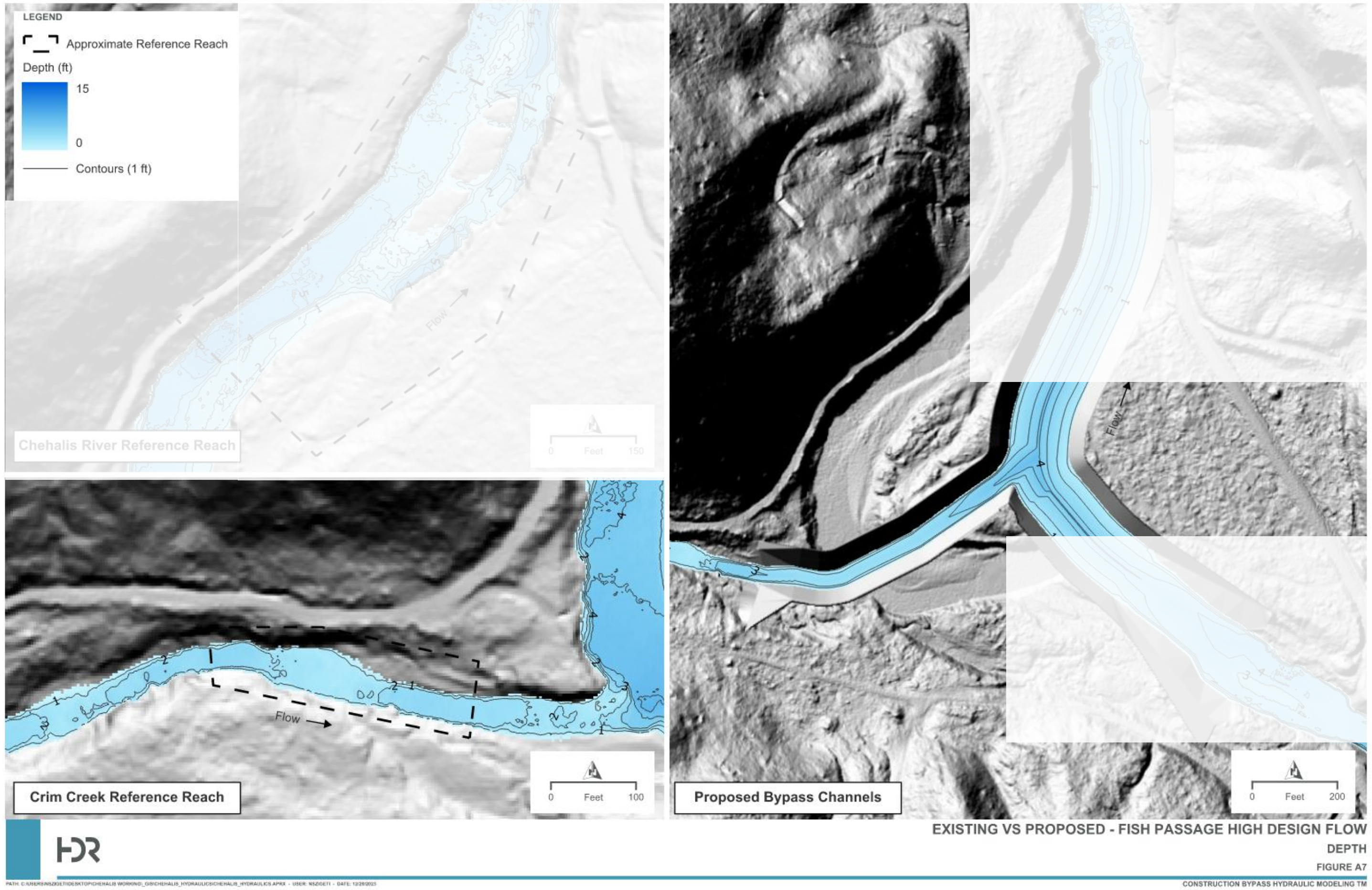
- Construction:
  Crim Creek Bypass



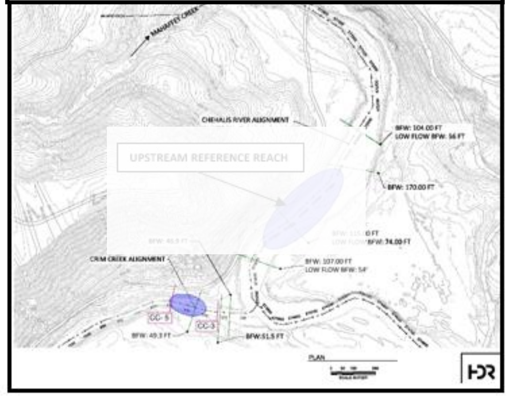
Plan

Photo-US-D: Crim Creek

Crim Cr. Bypass Channel – Construction High Fish Passage Flow (5% Exceedance) Depth Results

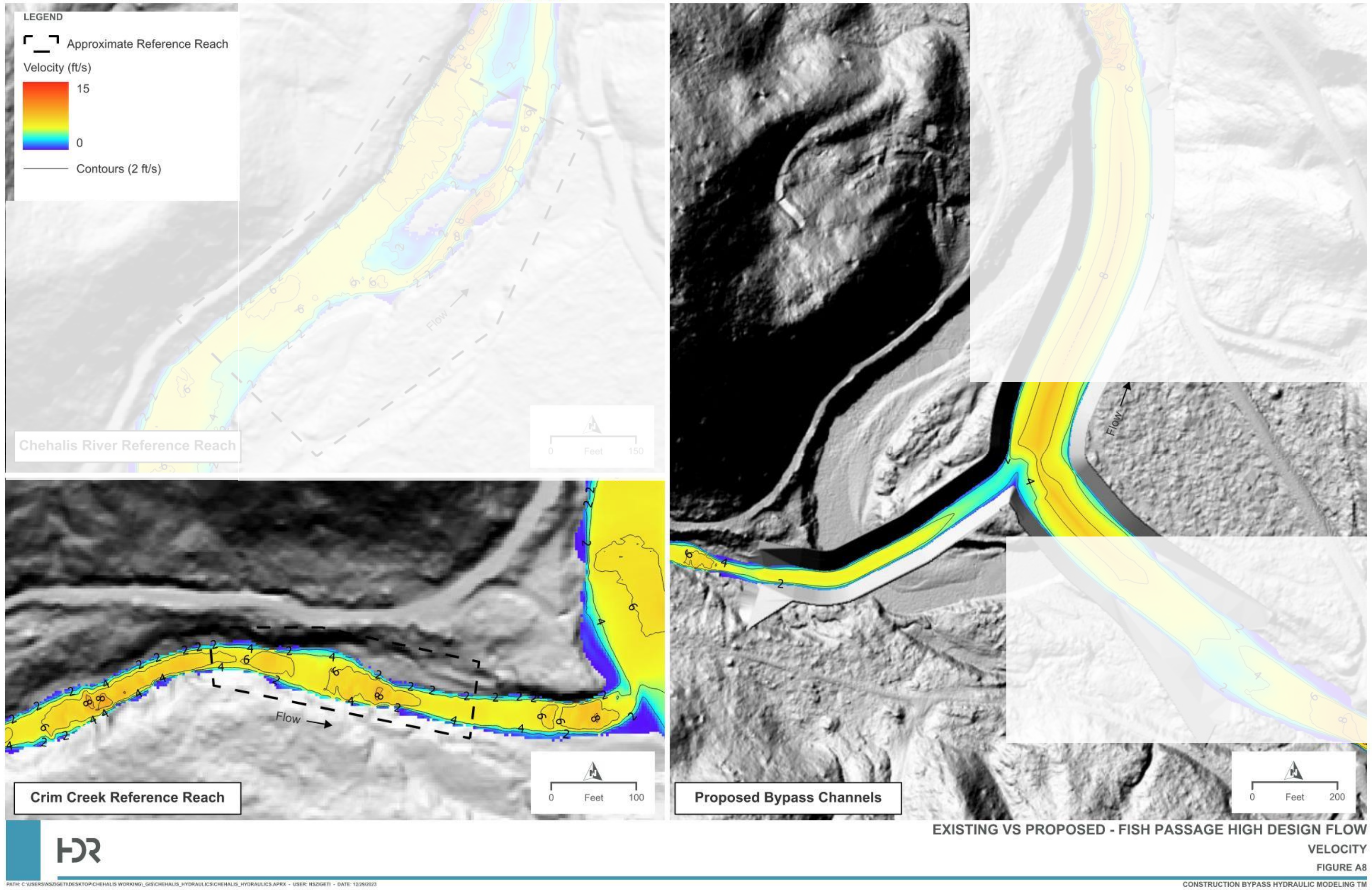


Crim Creek Reference Reach Slope: 1.3%

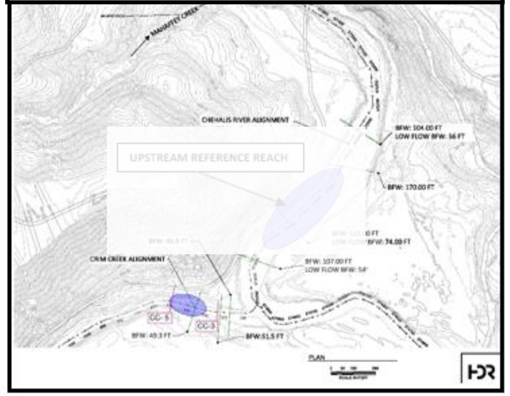


Reference Reach - Plan

Crim Cr. Bypass Channel – Construction High Fish Passage Flow (5% Exceedance) Velocity Results

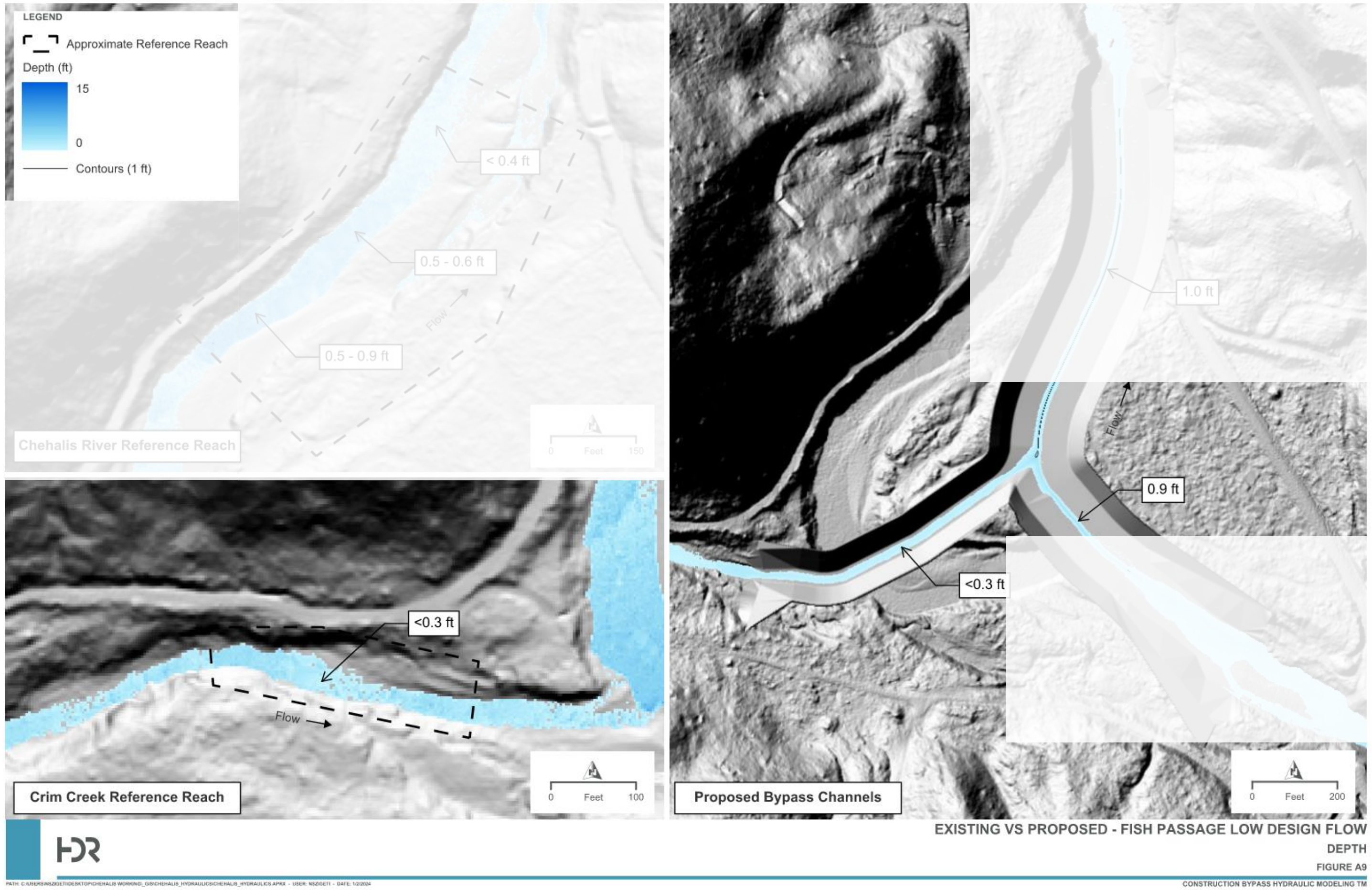


Crim Creek Reference Reach Slope: 1.3%

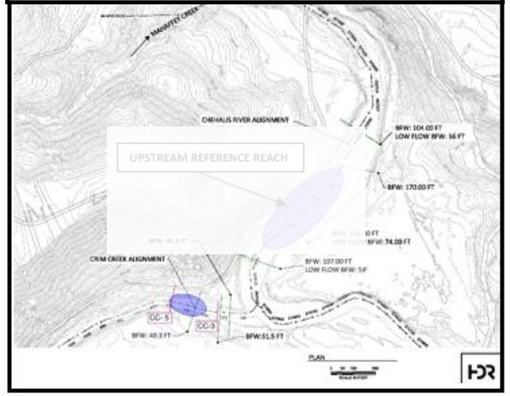


Reference Reach - Plan

Crim Cr. Bypass Channel – Construction Low Fish Passage Flow (95% Exceedance) Depth Results

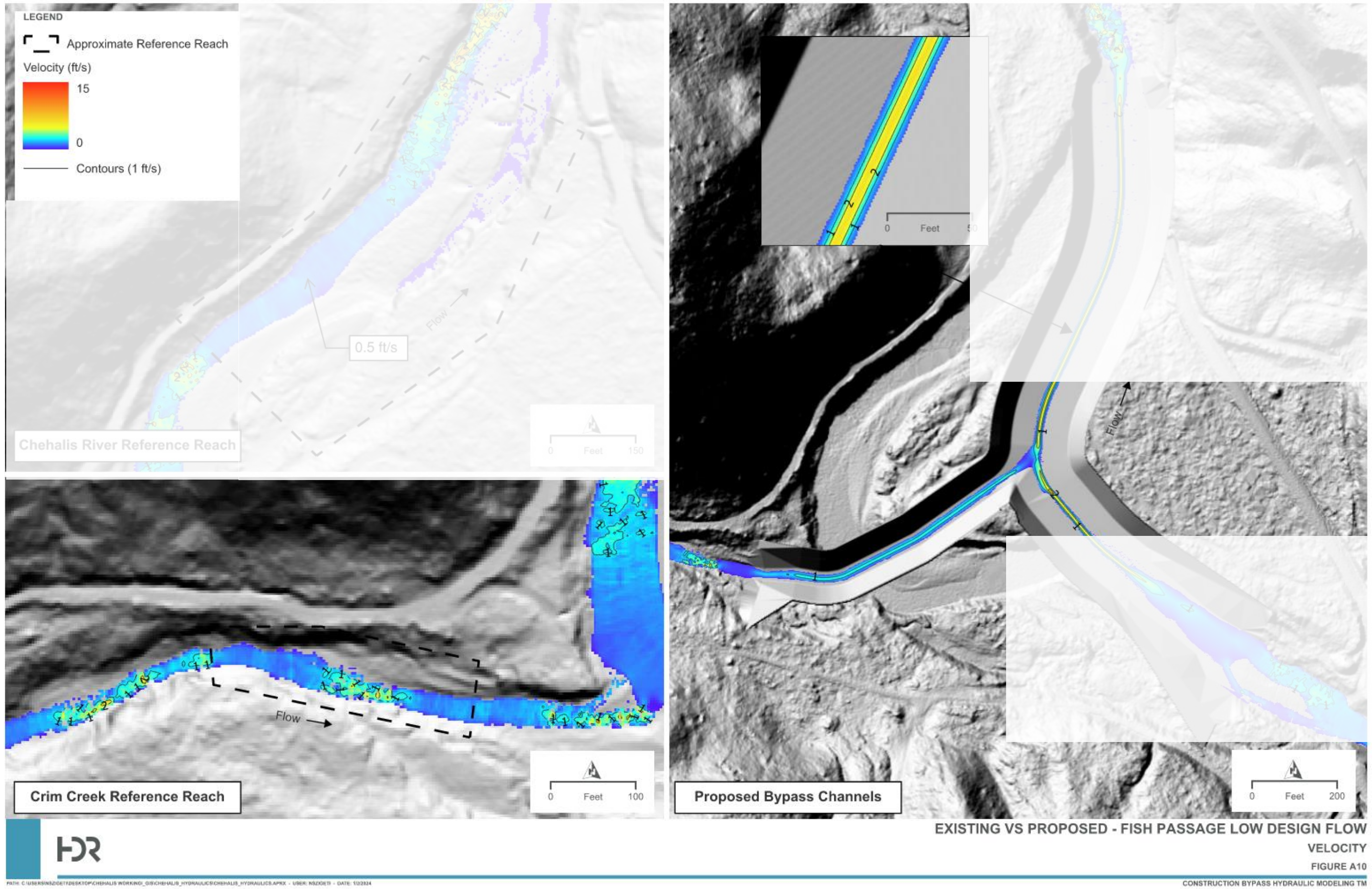


Crim Creek Reference Reach Slope: 1.3%

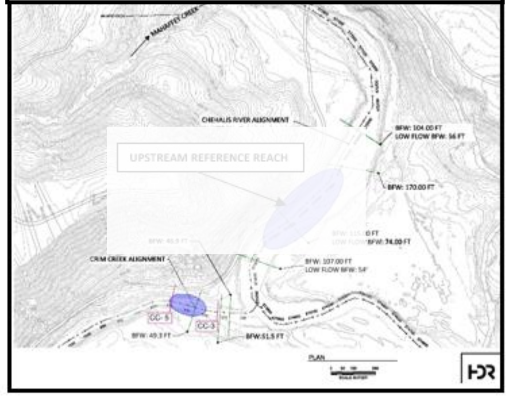


Reference Reach - Plan

Crim Cr. Bypass Channel – Construction Low Fish Passage Flow (95% Exceedance) Velocity Results



Crim Creek Reference Reach Slope: 1.3%



Reference Reach - Plan

HDR

Fish Passage Design Roadmap

Anticipated timeline:

- 2024-2025
  - Fish passage design flows per NMFS CC guidance
  - Fish passage conduit refinement
    - Stagger conduit elevations; roughness elements; size, length, number, & spacing; define low-velocity pathways
    - Sediment transport & 2D hydraulic modeling
  - Permanent & bypass channel refinement
    - Channel roughness; velocity refugia; define low-velocity pathways
    - 2D hydraulic modeling
  - Operations refinement
    - Drawdown rates & durations; operations adjusted based on storm center location
    - Minimization & avoidance

Fish Passage Design Roadmap

Anticipated timeline:

- Future phases (after 2025)
  - Fish passage conduit & channel refinement
    - 3D numerical and/or physical hydraulic modeling
    - Velocity refugia, refine roughness, low-velocity pathways, stepped conduit elevations
  - Flood Fish Passage Facility refinement
    - Entrances, aux. water, and fish ladder; holding and handling; transport; release locations
  - Operations refinement
    - Defined operation and adaptive management plan
    - Drawdown rates & durations; operations adjusted based on storm center location
    - Minimization & avoidance

Topics for Future Meetings

- Biological Design Criteria
- Technical Design Criteria
- Design Methodologies
- Impoundment Operating Criteria
- FRE and FFPF Operation and Maintenance

Next Steps / Action Items

- HDR: send out recurring meeting invitation
- Develop meeting notes for this meeting and our previous one
  - HDR: send out draft meeting notes for input
  - **TWG**: provide input on draft meeting notes
  - HDR: send out final meeting notes
- Identify topics for next meeting