Technical Memorandum

Date:	March 10, 2021
Project:	Chehalis River Basin Flood Damage Reduction Project
To:	Chehalis Basin Flood Control Zone District
From:	HDR
Subject:	Avoidance and Minimization of Rainbow Falls/Fisk Falls Lamprey Fishery Impacts and Related Cultural Effects

1.0 Introduction and Purpose

As part of a strategy to reduce flood damage to life and property along the Chehalis River, the Chehalis River Basin Flood Control Zone District (District) proposes to construct a flood retention facility near the town of Pe Ell on the mainstem of the Chehalis River. The Draft Environmental Impact Statements (EISs) prepared by the Washington Department of Ecology (Ecology) (pursuant to the State Environmental Policy Act [SEPA]) and the United States Army Corps of Engineers (pursuant to the National Environmental Policy Act [NEPA]) evaluate anticipated impacts on abiotic and biologic resources associated with construction and operation of the proposed flood retention expandable (FRE) facility (i.e., the Chehalis River Basin Flood Damage Reduction Project [proposed project]). The SEPA EIS identified potential impacts to sites that are culturally significant to Native American Tribes who currently and historically harvested fish, including lamprey, in the Chehalis River Basin. Cultural impacts may be driven by the temporary loss of access to traditional fishing areas during flood retention operations, potential physical modifications to those traditional fishing sites during and following operations, and the proposed project's operational effects on lamprey populations that are harvested at traditional fishing sites. In response to the potential impacts on culturally significant fishing areas and associated tribal fish harvest identified in the EISs, the District herein considers possible operational measures to avoid and/or minimize impacts on these resources.

The purpose of this Technical Memorandum (TM) is to describe and summarize potential FRE operational impacts on two tribal fishing locations and the associated lamprey fishery in the upper Chehalis River Basin, and to identify possible methods to minimize these impacts during FRE operations. Two specific sites, Rainbow Falls and Fisk Falls (Figure 1-1), are evaluated in this TM because Native American tribal entities have identified their importance for lamprey harvest and cultural significance. Neither site provides suitable spawning or rearing habitat for lamprey, rather these sites are traditional tribal fishing locations. Although concerns about other fisheries (e.g., salmonids) exist, the scope for this TM focuses on lamprey. Impacts on salmonids, and potential methods to avoid, minimize and mitigate for project-related effects, are currently being considered as part of mitigation being prepared for the project.

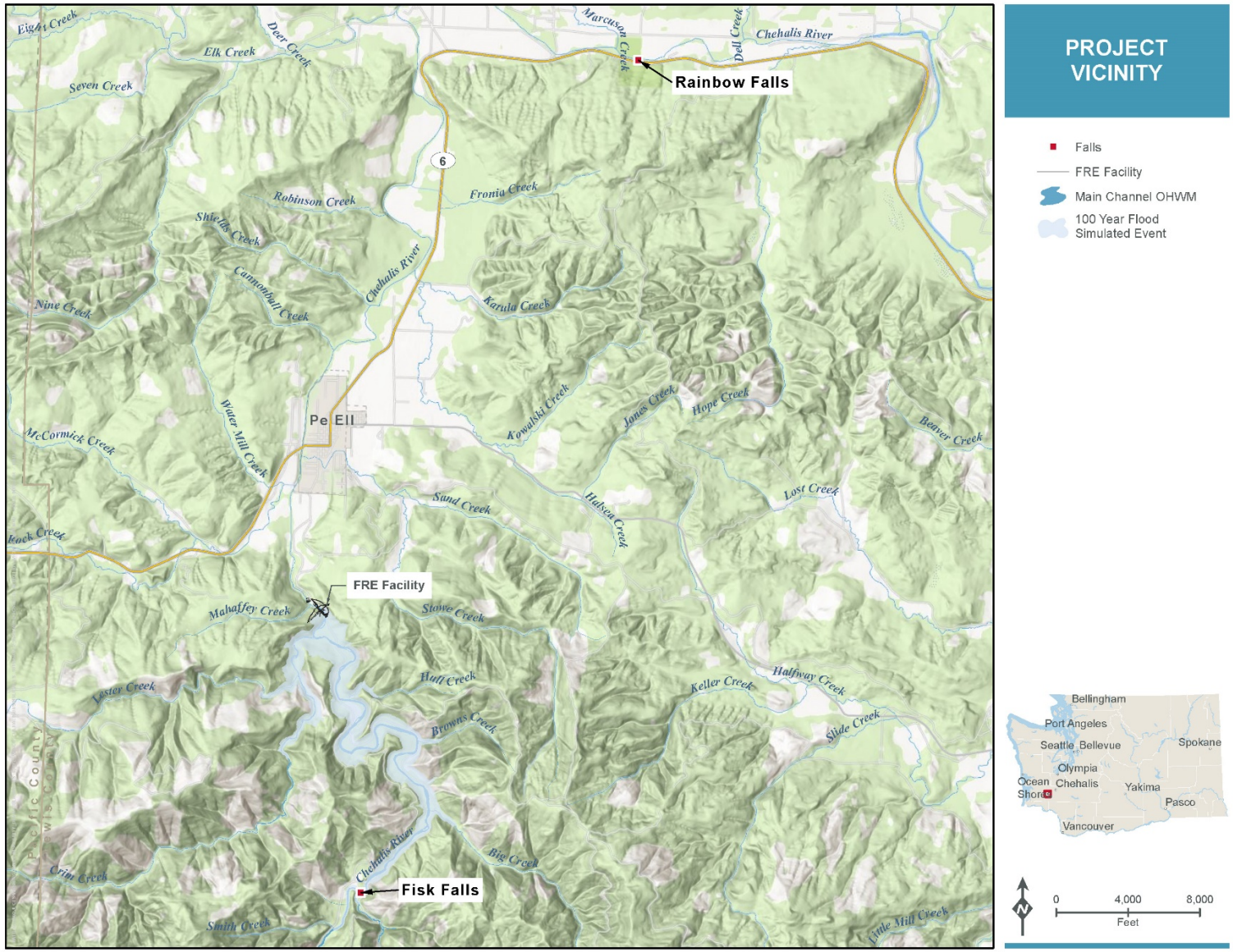

Figure 1-1. FRE Facility Vicinity Map, Depicting Locations of Fisk Falls and Rainbow Falls
Source: HDR 2020

2.0 Resource Descriptions

2.1 Chehalis River, Fisk Falls, Rainbow Falls

The headwaters of the Chehalis River begin in the Willapa Hills. The East and West forks flow from their headwaters to form the upper Chehalis River mainstem at the proposed location of the FRE facility, at approximately river mile (RM) 108. This reach is relatively high gradient and confined by a steep-sided valley with numerous bedrock outcrops (USACE 2020a). Upstream of the proposed FRE site, several tributaries enter the Chehalis River, including Roger Creek, which enters the Chehalis at approximately RM 114 (USACE 2020a). Downstream of the proposed FRE facility, the Chehalis River varies between confined, incised areas and unconfined areas where it flows through a wider valley (USACE 2020a). Several bedrock outcrops and grade controls occur along the mainstem, including Rainbow Falls at RM 98. The gradient in the reach of the Chehalis River near Rainbow Falls is less than that exhibited in the reaches upstream of the proposed FRE facility.

The Chehalis River has been identified as a resource-gathering location of importance, primarily as a fishery (Shannon et al. 2019 as cited in Ecology 2020a). Some Native American Tribes consider some resource-gathering locations to be spiritually significant, and ceremonies may accompany the first fish caught (Shannon et al. 2019 as cited in Ecology 2020a). In the past, the harvest of fish, primarily salmon, was done using weirs, traps, nets, gaffs, spears, and arrows, while other fish such as lamprey were also seasonally available and were caught with fish traps on smaller streams and tributaries.

2.1.1 Fisk Falls

Fisk Falls is an approximately 15-foot bedrock waterfall (Table 1) located near the confluence of Roger Creek and the mainstem Chehalis River. It is upstream of the proposed FRE facility location at RM 108 (Figure 1-1). The falls plunge through a series of step pools into the mainstem Chehalis River. Roger Creek is one of nine sub-basins that make up the upper Chehalis River above the proposed FRE facility and is known to contain anadromous fish that could be impacted by the proposed project (USACE 2020b). Upstream of the proposed FRE facility, a historic trail existed along the Chehalis River (U.S. Surveyor General 1891) continuing upstream to Fisk Falls, passing the mouths of Browns Creek, and crossing the Chehalis River upstream to pass Big, Smith, Alder, Thrash, and Rogers creeks (Ecology 2020a). Access to the falls is provided from forest roads located on Weyerhaeuser lands. These roads are accessible to the public only with a recreation permit from the company.

Table 1: Fisk Falls Details

Coordinates	46.502005, -123.28732
Total Height	15 feet
Pitch	90 degrees

Run	5 feet
Form	Plunge
Watershed	Chehalis River
Stream	Roger Creek

Source: Northwest Waterfall Survey

2.1.2 Rainbow Falls

Rainbow Falls is a small cascading waterfall along the Chehalis River at approximately RM 98 (Figure 1-1) that interrupts what is otherwise a flat-water (glide) section of the river. The falls tumble approximately 5 feet over a broad, rounded ledge of basalt which becomes submerged during periods of flooding (Table 2). Access to Rainbow Falls is provided via Rainbow Falls State Park, a 129-acre camping park with 3,400 feet of freshwater shoreline on the main stem of the Chehalis River.

Table 2: Rainbow Falls Details

Coordinates	46.63052, -123.2323
Total Height	5 feet
Pitch	20 degrees
Run	50 feet
Form	Gradual cascade
Watershed	Chehalis River
Stream	Chehalis River

Source: Northwest Waterfall Survey

Rainbow Falls is a culturally significant site that has been documented in ethnographic studies and oral traditional stories (Shannon 2019 as cited in Ecology 2020a). The area is associated with several meanings and uses, including use as a setting for a traditional story, a Salish place name, and a residential site, and it is connected to the harvest of lamprey and traditional economy (Shannon et al. 2019 as cited in Ecology 2020a). Shannon et al. (2019, as cited in Ecology 2020a) note that Rainbow Falls is still used as a traditional fishing location by the Chehalis Tribe.

2.2 Pacific Lamprey

Pacific Lamprey (*Entosphenus tridentatus)* and several other lamprey species occur in the Chehalis River Basin and have been traditionally harvested by local Native American Tribes. Although some lamprey species are residents, Pacific Lamprey are anadromous and exhibit a complex life history that involves larval, migratory, marine juvenile, and adult freshwater phases (Clemens 2019). Larval lamprey of all species display a patchy distribution in freshwater

habitats, but appear closely associated with fine sediments, which provide important nursery habitat (Dawson et al. 2015). Larval Pacific Lamprey live for several years burrow in sediments, where they filter feed on detritus and organic matter (Harris et al. 2020). Reports of optimal habitat by others (Stone and Barndt 2005; Merced Irrigation District 2011) indicate that rearing lamprey prefer very low velocity reaches in relatively shallow water over fine substrates. In Western Washington streams, Stone and Barndt (2005) observed optimal water depths of 70 centimeters (cm) and current velocities of 0 to 10 cm/second. Such conditions are common along slower stream margins. Stone and Barndt (2005) found that conductivity, dissolved oxygen, and gradient influenced larval lamprey distribution at the large scale (across 50-meter reaches), whereas wetted width, percent fines, canopy density, and velocity influenced distribution at the small scale (1-square meter [m^2] quadrants).

Following larval rearing and maturation in freshwater, migratory juvenile Pacific Lamprey outmigrate to the Pacific Ocean for several years of oceanic rearing prior to returning to freshwater for spawning. Adult Pacific Lamprey return to the Chehalis River Basin from March through October and spawn the following spring, from March through June (Allegro pers. comm. 2017; Ecology 2020b). Adult lamprey cue into spawning streams using olfactory cues and pheromones given off from larval lamprey that are rearing in the system (Yun et al. 2011). In this way, the adults recognize that a waterbody is suitable for spawning and rearing because larvae are already present there.

Lamprey species are important fish of cultural and ecological significance (Close et al. 2002; Dawson et al. 2015). Native American Tribes of the Pacific Northwest have harvested Pacific Lamprey for subsistence, ceremonial, and medicinal purposes (Close et al. 1995). Pacific Lamprey are important ecologically throughout their lives in terms of nutrient cycling, both as predator and prey. As juveniles, lampreys are filter feeders of detritus and algae, and a food source for fish and birds (Close et al 2002). Adult Pacific Lamprey are a prey item for marine mammals such as sea lions and likely attract predation away from adult salmon (Close et al. 2002). Decomposing Pacific Lamprey carcasses provide marine-derived nutrients to riverine systems.

Pacific Lamprey are widespread throughout the Chehalis River Basin, including the main sub-basins below the proposed FRE facility (Jolley et al. 2016), as well as the upper Chehalis River above the proposed FRE facility (USFWS 2011; Ecology 2020b). Winkowski et al. (2016) surveyed 59 reaches encompassing mainstem and tributary habitats near the proposed FRE facility site and within the modeled temporary inundation area. During the surveys, they found that larval lamprey occupied 49 percent of surveyed reaches near the proposed FRE site and temporary reservoir area, and larvae are also numerous downstream of the FRE site to Rainbow Falls.

3.0 FRE Facility Operations

During non-flood conditions, the FRE facility would convey the full flow of the upper Chehalis River through its conduits and accommodate upstream and downstream fish passage. During major floods that trigger FRE operations, the conduit gates would be mostly closed to regulate

river flows and reduce downstream flooding. During these periods of operation, floodwaters other than those continually released downstream (300 cubic feet per second [cfs]) would be temporarily stored upstream of the FRE facility. Following flood events, stored water would be released downstream over a period of several weeks.

3.1 Flood Flow Levels

The FRE facility would impound water when the river is forecasted to rise above 38,800 cfs within 48 hours at the downstream river monitoring gage at Grand Mound, Washington. When flows are forecasted to rise above 38,800 cfs at Grand Mound, FRE conduit gates would be closed and outflow would be reduced at a rate of 200 cfs per hour beginning 2 days prior to the predicted start of major flooding. The 200 cfs per hour rate was determined by applying a 2-inch per hour (in/hr.) decline in river stage downstream of the FRE facility (to reduce the potential for fish stranding) using a HEC-RAS model (WSE 2014; Anchor QEA 2017a). The flow rate used for that calculation was 1,000 cfs, the median flow for November to March, during which most floods occur. That rate of change would be adjustable and could be adaptively managed during operations.

FRE facility outflows would decrease at 200 cfs per hour until reaching 300 cfs (through a single FRE conduit), the minimum outflow during flood retention operations. The minimum flow (300 cfs) was selected by the Chehalis Basin Strategy Water Retention Technical Committee (Garello and Ferguson 2016; HDR 2017) to reduce downstream fish-stranding potential. This selected flow reflects base flows (260 cfs) established for the upper Chehalis River mainstem from the confluence with Elk Creek (RM 101.8) to the headwaters per Washington Administrative Code 173-522-020.

3.2 Inundation Levels

The amount of flow retention for each qualifying flood would vary based on inflow at the temporary inundation area. For all FRE operation flood events, temporary inundation pool release rates would be maintained at 300 cfs until the peak of the flood passes Grand Mound (Anchor QEA 2017b). HDR (2020) modeled three stages of temporary reservoir drawdown after a major flood event. These stages include:

1. **Initial Reservoir Evacuation (Maximum Pool to Water Surface Elevation [WSEL] 28 feet):** To evacuate the temporary reservoir after a major flood event, the partially closed reservoir outlet gates would open and increase outflow by 1,000 cfs per hour, beginning at 300 cfs (minimum outflow during flood operations). This would cause drawdown of the temporary reservoir from its peak WSEL at the maximum pool, which would be limited to 10 feet per day (5 in/hr.) to reduce risk of landslides and the risk of fish stranding. The 10-feet-per-day drawdown rate would continue until the storage pool elevation reaches 528 feet. Once the storage pool elevation reaches 528 feet, debris management operations would begin.
2. **Debris Management Evacuation (WSEL 528–500 feet):** Debris management procedures would be used to ensure that large woody debris would not impact dam operations or cause damage to the FRE facility. During all major flood events, debris management would begin once the pool elevation reaches 528 feet. At this time,

drawdown rates would be slowed to 2 feet per day (1 in/hr.) for a 14-day period. Once the storage pool elevation reaches 500 feet, debris management operations would conclude.

3. **Final Reservoir Evacuation (WSEL 500–425 feet):** Once the temporary reservoir reaches WSEL of 500 feet, drawdown rates would increase to 10 feet per day (5 in/hr.). Drawdown would continue at this rate until the storage pool has emptied and inflow of the Chehalis River equals the outflow through the conduits. At this time, the reservoir would no longer be impounding water, and the Chehalis River would return to a free-flowing state.

3.3 Temporary Inundation Area and Duration

HDR (2020) modeled the geographic extent and approximate duration of the temporary inundation area for specific events, including the 10-year and 100-year floods (Table 3) at Grand Mound.

Table 3: Inundation area and duration of modeled flood events

Modeled Event	Initial Reservoir Evacuation (WSEL >528 feet)			
	Area of Inundation above WSEL 528 feet	Duration of Inundation above WSEL 528 feet	Total Reservoir Area	Maximum WSEL
10-year event	238 acres	Up to 5.9 days	519 acres	568 feet
100-year event	426 acres	Up to 10.7 days	707 acres	604 feet

Source: HDR 2020

4.0 FRE Operations: Impacts on Key Resources

The following section briefly summarizes potential impacts of proposed FRE facility operations on conditions at Fisk and Rainbow falls as related to subsistence fishing access and success, as well as the potential effects on Pacific Lamprey and their habitat both upstream and downstream of the FRE site. Because Pacific Lamprey are anadromous and adults are highly mobile, impacts on lamprey habitat and abundance throughout the Chehalis River Basin may influence harvest opportunities at culturally important sites like Fisk Falls and Rainbow Falls.

4.1 Access to Fisk Falls and Rainbow Falls

Flood retention and subsequent formation of the temporary reservoir would submerge roads that are currently used to access Fisk Falls. Depending on the magnitude and duration of the flood event, access may be restricted or unavailable. During flood events up to the 10-year flood, access to Fisk Falls via Road 100 should be available. However, for flood events greater than the 10-year event, access to Fisk Falls via Road 100 likely would be restricted or temporarily blocked, as the road would be inundated during the Initial Reservoir Evacuation

period. The duration of restricted access would depend on the resources available to provide access road repairs and maintenance following a flood event.

An assessment of the condition of access roads in the vicinity of the inundation area has not been completed, and future use of the current road system is unknown at this time. It should be noted that, in the absence of the project, flood events currently may limit access and fish harvest opportunities at Roger Creek.

Because Rainbow Falls is downstream of the FRE facility, flood retention should not affect access. Rather, improved access could be available during major flood events because the FRE Facility would retain flood flows upstream of the site.

4.2 Hydrologic and Geomorphologic Considerations: Fisk Falls and Rainbow Falls

FRE operations have the potential to impact hydrologic and geomorphologic conditions at both Fisk Falls and Rainbow Falls as discussed below.

4.2.1 Fisk Falls

Fisk Falls is located upstream of the FRE facility near RM 114. Based on modeling completed by HDR (2020), Fisk Falls is located just outside the reservoir area modeled for the 10-year flood, but is within the inundation area modeled for the 100-year flood (Figure 4-1). For the 100-year flood event, Fisk Falls would be located within the Initial Evacuation Area (Figure 4-1) and would be subject to inundation for approximately 10.7 days (Table 3) once every 100 years, on average. For floods greater than the 10-year event, the falls would be temporarily inundated to various levels and durations depending on the specific flood event.

Geomorphological modeling of Fisk Falls has not been conducted to determine if FRE operations have the potential to alter the condition of the falls (e.g., possible sediment deposition or erosion). However, during flood events exceeding the 10-year event, during which Fisk Falls would be inundated, sediment from inflowing water from Roger Creek may be deposited at the falls and in the tributary delta of the reservoir pool area (Ecology 2020c). Reservoir drawdown may result in cobble, gravel, and coarse sand deposited at the falls. Such sediment deposition, depending on the nature and quantity, could temporarily alter the character of the falls until flushing flows are sufficient to evacuate the accumulated sediment.

4.2.2 Rainbow Falls

During impoundment events, FRE operations would reduce downstream flood flows during the initial flood retention period, and therefore temporarily reduce flows at Rainbow Falls (RM 98). Although a minimum of 300 cfs would always be released downstream of the FRE during the early stages of flood retention, a hydraulic analysis has not been completed for Rainbow Falls to determine the impact of flow reduction on the character and fish passage potential at the falls. If flows are reduced, passage would resemble typical winter low river flow and should not affect fishing opportunities.

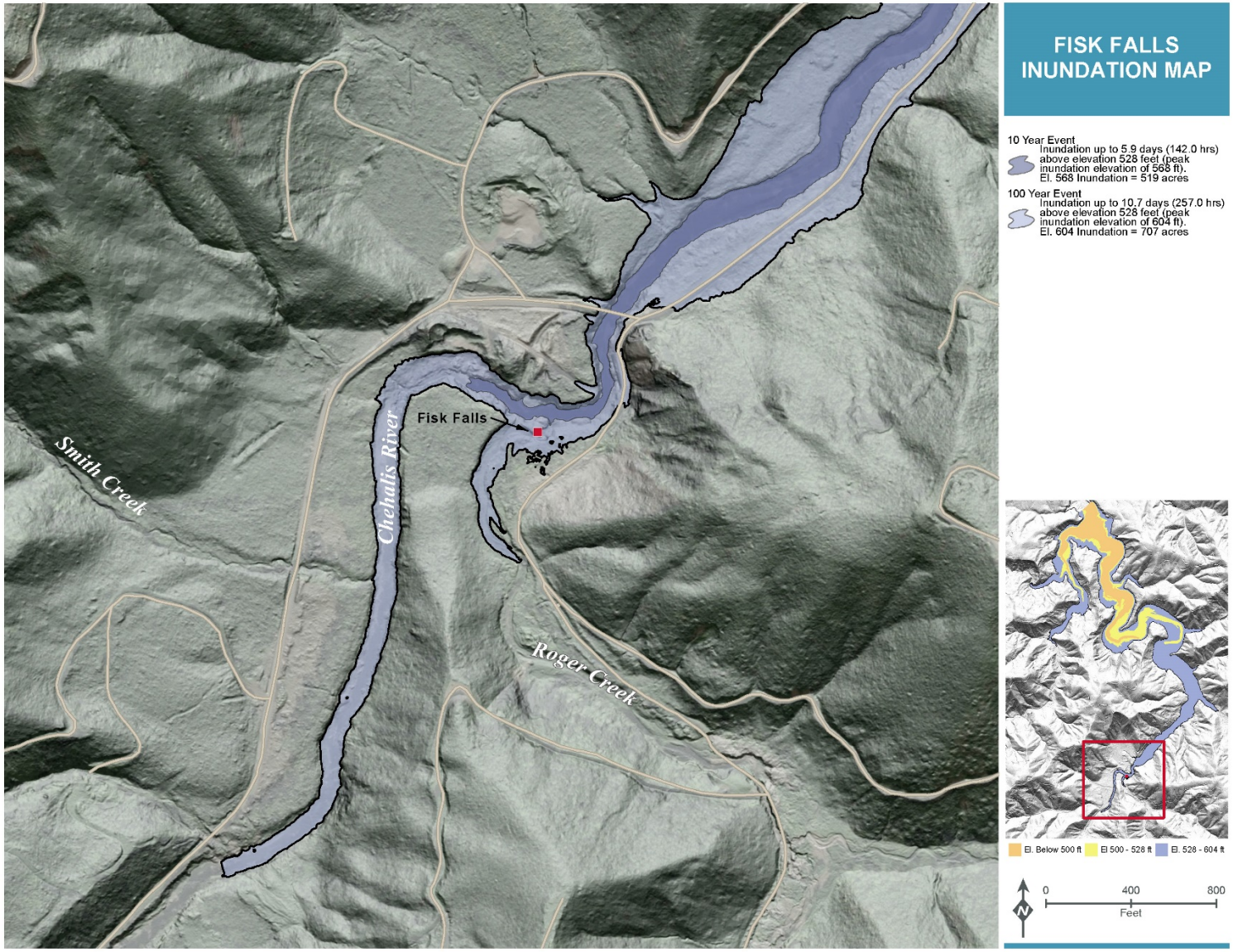

Figure 4-1. Fisk Falls Location in Relation to Inundation Area Modeled for 10-Year and 100-Year Flood Events
Source: HDR 2020

4.3 Pacific Lamprey Considerations

During FRE operations, outflows to the Chehalis River would be reduced to a minimum of 300 cfs (a typical winter low flow) for a few days, until the peak flood passes at Grand Mound (RM 59.9). Although Chehalis River flows would be greater than 300 cfs starting a relatively short distance downstream due to contributing flows from tributaries, any reduction in flow may contribute to alterations in hydraulic and geomorphologic processes that may dewater low-velocity, shallow stream margins that may be suitable for rearing larval lamprey. Reaches of the mainstem Chehalis River that are likely to be geomorphologically affected by FRE operations extend to just downstream of the confluence with the South Fork Chehalis River (RM 88) (PSU 2017; Ecology 2020c). Sediment modeling (Ecology 2020c) predicted little change in stored sediment within the mainstem Chehalis River downstream of RM 88.

Upstream of the FRE facility, depending on the flood event, mainstem and tributary reaches within the temporary inundation area would become temporarily flooded for up to 35 days, followed by ramped drawdown and the return of flow to the Chehalis River. These actions may affect Pacific Lamprey in a variety of ways, as discussed below. Considering the timing of lamprey spawning (i.e., March–June, see Section 2.2) and the fact that larval lamprey can rear in fine substrates for up to 7 years during their freshwater rearing phase, larval lamprey have a greater potential to be affected by FRE operations than spawning and incubating life histories. Therefore, larval lamprey are the primary subject of this evaluation.

4.3.1 Downstream Habitat

During flood retention operations, the minimum volume of water to be released downstream through the FRE conduits would be 300 cfs. If 300 cfs is insufficient to maintain wetted conditions along shallow stream margins that contain fine sediments occupied by larvae, operations have the potential to strand larvae if they are unable to move to wetted areas before they become exhausted, desiccated, or preyed upon. Although mark-recapture studies have demonstrated that larvae readily mobile, their rate of movement is relatively slow (Moser et al. 2007). For example, Quintella et al. (2004) found that larvae traveled both upstream and downstream, and traveled up to 27 meters during a 7-week period. Therefore, if the rate of outflow is reduced too quickly, and rearing habitats become dewatered, stranding may occur.

At Mud Mountain Dam, a flood reduction facility similar to the proposed FRE facility, fish stranding events have been documented downstream of the dam when White River flows are reduced below minimum instream flows. Fish recovery efforts, including those for larval lamprey, were conducted in the early 1990s and again in 2012 to return stranded fish to suitable habitat before mortality (USACE 2013, 2015). Although the proposed 300-cfs outflow from the FRE facility would exceed minimum instream flows established for the winter (260 cfs, WAC 173-522-020), downstream flow reduction during FRE operations could dewater stream margins. This may result in stranding and mortality if suitable fine sediment rearing habitat is present in downstream affected reaches. The reach directly downstream of the proposed FRE

facility site (approximately RM 108) is a steep, bedrock channel with some step pools and minimal sediment deposition. Therefore, impacts may be low and localized.

4.3.2 Upstream Habitat

The quantity of suitable lamprey rearing habitat and larvae abundance levels within the reservoir footprint have not been estimated. However, larval lamprey were found in 49 percent of surveyed reaches within the proposed FRE site and temporary reservoir area (Winkowski et al. 2016). During flood retention operations, mainstem and tributary reaches upstream of the FRE facility and within the temporary reservoir would be subject to filling and drawdown as discussed in Section 3.0. Sediment deposited during reservoir evacuation could smother larval lamprey in the river substrates (Ecology 2020a) or strand juvenile salmonids, larval Pacific Lamprey, and other small fishes (Anchor QEA 2017a). In Oregon's Leaburg Reservoir, reservoir dewatering at a rate of 1.8 in/hr. resulted in the emergence of nearly 50 percent of lamprey larvae (Skalicky et al. 2019). Estimated average density decreased from 10.8 larvae/m^2 before dewatering to 2.3 larvae/m^2 after refilling, suggesting that abundance declined by 79 percent. Emergence rates were similar in the laboratory (Harris et al. 2020; Liedtke et al. 2020), though abundance declines were slightly less. Abundance declines in the field were attributed to mortality (e.g., desiccation, predation) or relocation to adjacent watered habitat.

Reservoir drawdown rates (2 to 5 in/hr.) for the FRE facility were developed to reduce salmonid stranding by maintaining dewatering rates less than the 7 to 16 in/hr. as recommended by Bell et al. (2008). However, based on the studies discussed above, the proposed dewatering rates developed for salmonid stranding reduction far exceed those required to prevent larval lamprey stranding. Depending on the level of lamprey loss from stranding, smothering, or mortality from other factors, future adult homing to the FRE reservoir reach could be reduced because lesser larvae would be present to provide olfactory cues for adult migration. This could reduce lamprey fishing opportunities at Fisk Falls.

It is unknown if lamprey spawn and rear upstream of the reservoir footprint, in areas that would not be affected by inundation. If they do, some level of olfactory cue for adult migration would likely remain, but the amount is unknown. Adult Pacific Lamprey may colonize habitats where no larvae are present; however, other lamprey species be present that trigger their migration into spawning areas (Jolley et al. 2018).

4.3.3 Upstream Lamprey Passage During FRE Operations

During FRE operations, the Collection, Handling, Transfer, and Release (CHTR) facility would be operated to pass upstream adult Pacific Lamprey that enter the CHTR. Individuals that enter the facility would be subject to handling stress and reduced passage efficiency compared to non-flood conditions.

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, recently published studies, and interviews with researchers who specialize in the understanding of lamprey behavior and navigation capabilities were used to inform lamprey passage facility requirements and anticipated performance.

5.0 Potential Impact Avoidance and Minimization Measures

As discussed in Section 4.0, flood retention operations have the potential to impact hydrologic, geomorphologic, and biological stream functions both upstream and downstream of the proposed FRE facility. Operations may restrict or temporarily block access to Fisk Falls, inundate and deposit sediment in lamprey rearing habitat within the temporary reservoir, and strand larval lamprey. Operations may alter geomorphologic processes in or near culturally important areas including Fisk Falls and Rainbow Falls. The following section presents several possible measures to avoid, minimize, or mitigate operational impacts on these resources.

5.1 Fisk Falls and Rainbow Falls – Access, Hydrologic, and Geomorphologic Impact Minimization

To assess whether FRE operations may measurably alter the physical character or geomorphologic processes at either Fisk Falls or Rainbow Falls, the following measures may be considered for possible implementation for each location:

- Pre-construction consultation with affected Native American Tribes to understand potential concerns from a traditional, cultural perspective, including periods of use and access concerns. This may include pre-project monitoring and evaluation of adult returns/harvest timing at Fisk Falls and Rainbow Falls to establish baseline information for abundance and timing of harvest. This measure would be relatively straight-forward to address, but would require long-term coordination and several years of data to inform the baseline.

- Establishment of pre-construction photo points at each set of falls, using a fixed survey location. This measure would be cost-effective and relatively simple to address.

- Cross-sectional survey of each set of falls to establish contours and develop a map of existing topography and riparian conditions at each site. This measure would require a survey crew and follow-up report of existing conditions.

- Using drones, collect channel data in the form of a Digital Elevation Model (DEM). The analysis of the data collected for DEM would enable review of the channel response during the monitoring period. Overlays of successive DEM data would allow for identification of changes within the channel and at each set of falls. Gather DEM data using topography mapping technology such as Terrestrial Laser Scanning, Aerial Structure from Motion, or Aerial Laser Scanning, or a combination of these techniques. These technologies would create a high-resolution three-dimensional terrain model of the channel surfaces and water surface. The proposed methods for gathering this data are expected to utilize advanced survey equipment, such as laser scanning total stations and unmanned aerial drones equipped with photogrammetry or laser scanning equipment. This measure would require contracting through a company capable of developing such data, and would inform baseline conditions for several disciplines.

- During FRE operations and reservoir drawdown, drones may be used to assess channel conditions at each site, to compare to pre-construction conditions and evaluate the need

for potential mitigative measures for both the physical condition of the falls, and access to each location. Such measures, if approved by the affected Native American Tribes, might include sediment removal or the preparation of long-term monitoring and adaptive management plans to maintain the character and traditional use of each site, including alternative access roads to Fisk Falls that may be impacted by FRE operations during culturally important fishing and use periods.

5.2 Pacific Lamprey Impact Minimization

FRE operations that influence hydrologic, geomorphologic, and biologic stream functions have the potential to negatively affect Pacific Lamprey in occupied reaches affected by the Project. As reported in Section 2.2, larval lamprey were found in 49 percent of surveyed reaches near the proposed FRE site and temporary reservoir area; however, abundance data is lacking. If lamprey are impacted by FRE operations in quantities that reduce local population levels, such reductions could, in turn, impact traditional harvest opportunities at Fisk Falls or Rainbow Falls. To assess potential impacts on lamprey from FRE operations, the following measures may be considered prior to or during operations.

5.2.1 Downstream Stranding Minimization Measures

As reported in Section 4.3, FRE-induced impacts on geomorphology may be measurable downstream to RM 88. To gather baseline data to inform the potential for larval lamprey stranding during FRE operations, the District could conduct presence/absence surveys and baseline habitat surveys in reaches downstream to RM 88. Surveys could inform presence and abundance in affected reaches and could be accomplished with backpack electroshocking. Presence surveys could also be conducted by analysis of environmental DNA (eDNA), a rapidly developing technology that captures species presence/absence, estimated abundance, and distribution at a specific point in time in a river reach. Such techniques are cost- and resource-effective and may be implemented for developing baseline understanding and long-term monitoring of lamprey species in the upper Chehalis River Basin.

Based on the findings of habitat suitability or presence/absence surveys, the District could monitor suitable rearing habitats during initial flood retention and adaptively manage the outflow if dewatering is observed. For example, if an FRE outflow of 500 cfs measurably increases wetted widths and decreases dewatering and stranding potential compared to the proposed 300 cfs outflow, operational changes may be considered for resource protection.

Lamprey spawning areas are similar to those for anadromous salmonids. However, given the peak November–March timing of historic major flood events, and because lamprey typically spawn in the spring (March–June), the operational impacts on lamprey spawning are expected to be lesser in frequency and magnitude compared to impacts on larval lamprey rearing habitat.

5.2.2 Upstream Stranding Minimization Measures

As described in Section 4.3.2, rearing larval lamprey in reaches of the Chehalis River and tributaries within the footprint of the temporary inundation area may suffer mortality from

stranding or habitat changes (e.g., sediment smothering; loss of adequate oxygen in reservoir substrates). Potential methods to minimize these effects may include:

- Establishing a baseline upon which to implement minimization measures, by conducting:
    - Baseline surveys to determine habitat suitability for spawning and rearing, and surveys of presence/absence of lamprey species within the temporary inundation footprint using an electroshocker and/or eDNA.
    - Instream flow studies to identify areas of potential spawning and rearing habitat within the extent of the temporary reservoir to focus stranding and salvage efforts during reservoir evacuation.
- Development of a monitoring and adaptive management plan to monitor potential stranding during reservoir evacuation in coordination with Washington Department of Fish and Wildlife and affected Native American Tribes.
- If reservoir drawdown monitoring identifies significant larval stranding, particularly during Initial and Final Reservoir Evacuation, reduction of drawdown dewatering rates to levels that allow larvae to more effectively move to adjacent watered areas and minimize stranding. Note that if the drawdown rate for the temporary reservoir is reduced, the duration of inundation and duration of CHTR operations would increase. Therefore, discussions with resource agencies are recommended to balance impacts and benefits across multiple species.

Although the studies discussed in Section 4.2 did not identify an “optimal” dewatering rate and any rate of dewatering appears to result in some level of larval mortality, all studies confirm that slower dewatering rates are more protective of larval lamprey than faster rates. This information may be used to inform monitoring of habitats within the temporary inundation area that are suitable for larval rearing to determine the effect of dewatering in terms of larval densities, shoreline slope, sediment type, and how long habitat may be dewatered. Liedtke et al. (2020) concluded that slower dewatering rates offered some opportunity for larval lamprey to escape stranding. The best outcome was for the slowest dewatering rate (1 in/h). Although a dewatering rate of 1 in/hr. left about 77 percent of the larvae stranded in areas without surface water during studies (Liedtke et al. 2020), a slow dewatering rate used in a field setting could allow some fish to return to watered areas and prevent the 100-percent mortality that might occur with faster dewatering rates.

5.2.3 Adult Lamprey Passage

Pacific Lamprey migrate up and down the Chehalis River. Their migration may be affected by flood flows and the release of stored flood water from the FRE facility. To determine if such effects occur, and to respond to those effects, the following may be considered.

<u>Passage at Rainbow and Fisk Falls</u>

Adult Pacific Lamprey could be present in the vicinity of both Rainbow and Fisk falls during FRE operations, typically from November through March. As stated in Section 2.2, adult Pacific Lamprey return to the Chehalis River Basin from March through October, where they remain

until they spawn the following spring (March through June). Monitoring of Rainbow Falls is recommended during flood events that trigger FRE operations to determine if operations and proposed outflows of 300 cfs to downstream reaches are sufficient to allow adult Pacific Lamprey passage at the falls. Such monitoring could be conducted through photo documentation and cross-sectional surveys across the falls. Alternatively, drone monitoring could be conducted during initial flood retention (when outflows are lowered to 300 cfs) to inform channel conditions and estimate passage conditions.

Because adult lamprey could be present anytime of the year based on migration and holding periods, if drone monitoring determines that the 300 cfs outflows are insufficient to provide passage pathways for adult Pacific Lamprey at Rainbow Falls, operators could increase outflows during initial FRE operations. Because outflows of 300 cfs would only occur for a few days during initial flood retention, the impact of FRE operations on lamprey passage at Rainbow Falls is expected to be low.

Fisk Falls is located upstream of the temporary reservoir modeled for floods at or below the 10-year flood event. Therefore, FRE operations during such events would not affect lamprey passage. At higher flood events when the falls are inundated by temporary floodflow retention in the reservoir, drones could be used to monitor the condition of the falls to inform both passage and geomorphologic conditions at the site.

Passage at CHTR

During FRE operations, the CHTR facility would be operated to pass upstream adult Pacific Lamprey that enter the CHTR. An operations and maintenance plan has not yet been developed for the CHTR; however, preliminary designs for the CHTR have been prepared in coordination with the multi-agency Fish Passage Technical Subcommittee (HDR 2018). The subcommittee could consider coordination with the Lamprey Technical Working Group within the Lamprey Conservation Agreement (USFWS 2012) to more accurately consider Pacific Lamprey passage needs at the CHTR and during flood operations. The District is committed to continuing to work with resource agencies to consider the passage of all species under their jurisdiction, including lamprey. By adhering to these future passage requirements, adverse effects on adult lamprey passage would be minimized.

5.2.4 Long-Term Population Monitoring

Long-term monitoring can assess the effectiveness of measures implemented to avoid, minimize, and mitigate impacts on lamprey and associated traditional harvesting sites at Fisk Falls and Rainbow Falls. A Pacific Lamprey monitoring program may be implemented to monitor trends in abundance and distribution of the species within the upper Chehalis River Basin. Collection of baseline information on distribution and life history of the species in the upper Chehalis River Basin, in addition to testing and refining monitoring methodologies, are important for designing and implementing a monitoring program.

In the Columbia Basin, long-term monitoring using electrofishing surveys, eDNA collection, and tagging and telemetry surveys have been utilized to understand presence/absence, abundance, and distribution of Pacific Lamprey throughout basin and tributaries. These methodologies have

been implemented to understand Pacific Lamprey passage at hydroelectric facilities, adult migration patterns upstream and juvenile migrations downstream, and population responses to translocation programs to specific basins and tributaries. Similar monitoring methodologies may be available for use in a long-term monitoring program in the Chehalis River Basin. These may include:

- Population surveys of larvae in the mainstem Chehalis River and tributaries using electrofishing techniques. These surveys provide presence/absence information at a specific point in time for various life forms.
- Opportunistic tagging of adults using Passive Integrated Transponder (PIT) Tags during CHTR operations. Using radio telemetry tagging methods during inundation events would provide important information on adult lamprey upstream migration patterns, movements following release upstream of the temporary inundation area, and potential for tracking spawning locations in tributaries/upper basin.
- Use of eDNA for monitoring of lamprey species in specific locations above and below the FRE facility. Environmental DNA is cost- and resource-effective and may be implemented for developing baseline understanding and long-term monitoring of lamprey species in the upper Chehalis River Basin.
- Use of a juvenile trapping system, such as a weir or a rotary screw trap, in tributaries in the inundation area to capture and monitor outmigrating juveniles. This monitoring method allows for the assessment of annual fluctuations in the run timing and abundance of downstream migrating lampreys as well as the genus/species and life stage composition. Such a trap system, or similar device, may be considered for use on Roger Creek to evaluate lamprey use of the creek and migration patterns through Fisk Falls.
- Using fish collected in the juvenile traps, researches can insert 8-millimeter PIT tags to learn additional information about the migration patterns of juvenile lamprey downstream through the Chehalis River. PIT tag monitoring would require the use of existing PIT tag arrays (if present and permitted) or the use of new monitoring equipment installed in downstream reaches.
- Over the long term, collection of genetic samples from captured lampreys could be used to improve the understanding of intraspecific genetic diversity within the Chehalis River Basin.

5.2.5 Measures to Address Reduced Abundance in Upper Chehalis River Sub-basin

If monitoring of affected lamprey spawning and rearing habitat suggests that FRE operations may be impacting Pacific Lamprey (or other lamprey) abundance in the upper Chehalis River sub-basin, supplementation may be considered. One recovery strategy for Pacific Lamprey is the translocation of pre-spawn adults from downstream locations and supplementation with hatchery-spawned larvae into suitable habitat.

Pacific Lamprey do not home to specific natal sites and instead rely on environmental or other cues for locating spawning reaches (Cummings et al. 2008), including pheromones released by

larvae (Fine et al. 2004; Yun et al. 2011). Since the late 1990s and 2006, the Umatilla, Yakama, and Nez Perce tribes, respectively, have been implementing Pacific Lamprey translocation programs as a conservation measure to maintain some level of lamprey production in target spawning streams. These Native American Tribes have successfully translocated lamprey and seeded non- or under-occupied systems in cooperation with state and federal entities (BPA et al. 2019). Future returning adult lamprey key into these areas because they contain rearing larvae, and this may therefore be considered in underutilized, suitable habitat upstream of the temporary reservoir, or other areas in the basin.

6.0 Conclusions

This TM summarizes potential FRE operational impacts on two tribal fishing locations, Rainbow Falls and Fisk Falls, including possible impacts on access to these sites. In addition, this TM identifies possible impacts on lamprey populations upstream and downstream of the proposed FRE facility, which could affect tribal lamprey fishing opportunities at traditional harvest sites. This TM identifies possible methods to minimize impacts through potential changes in how the FRE facility is operated.

As discussed in this memo, FRE facility operations have the potential to:

- Temporarily impact geomorphology and hydrology at Rainbow and Fisk falls, two culturally significant sites for traditional harvesting of Pacific Lamprey by the Chehalis Tribe;
- Modify the physical character of Fisk Falls if sedimentation is deposited during flood retention and drawdown;
- Restrict access to tribal fishers and other users of Fisk Falls during flood retention and the resulting formation of the temporary reservoir, which would block Road 100 and possibly damage the road. Access would be restricted until the road were repaired, or alternative access routes are identified. Access to Rainbow Falls would not be negatively affected by FRE operations.
- Smother or strand larval lamprey in the temporary reservoir during reservoir evacuation, if suitable rearing habitat is present and occupied within the inundation zone;
- Strand larvae along suitable stream margins downstream of the FRE facility during outflow reductions during initial flood retention.

Possible operational strategies that may be considered to reduce geomorphological or hydrologic impacts on Rainbow or Fisk Falls, or reduce potential loss of lamprey from smothering or stranding during operations include:

- Monitoring of Rainbow and Fisk falls, via drones or other remote devices, during FRE operations and after reservoir evacuation to determine if any changes in hydrology or geomorphologic condition have occurred.

    - If footage during operations indicates that sufficient flow is not present to provide lamprey passage during initial outflow reduction at the FRE at the beginning of a flood, outflow could be adaptively managed to increase flow.
    - If post-operation monitoring determines that geomorphologic changes have occurred, the District could consult with the affected tribes to determine an appropriate course of correction to return the features to pre-operational condition.

- Regarding access, the District could consult with Weyerhaeuser and affected tribes to determine alternate access routes to Fisk Falls during and after FRE operations. Following operations, the District could visually inspect and clear existing access roads to determine if improvements are required to allow continued access to these locations.
- Regarding lamprey populations, the District could conduct habitat suitability surveys to identify potential lamprey rearing habitat in the inundation area, and in areas downstream to RM 88. These surveys would inform baseline conditions for larval use and abundance in affected reaches. Based on these evaluations, the District may better estimate larval lamprey losses from operations, and make decisions on methods by which to minimize or mitigate these effects including:
    - Adaptively managing drawdown rates during reservoir evacuation to reduce stranding.
    - Supplementation if population-level impacts on lamprey are observed over time, which may impact tribal fishing opportunities. The District could consider translocating adults or larvae to locations upstream of the maximum FRE inundation area that contain suitable spawning or rearing habitat.

It is recommended that the resources discussed in this TM (Fisk Falls, Rainbow Falls, and lamprey) be considered in development of an operational adaptive management framework, to balance resource protection during flood management. Future considerations for impact minimization and mitigation actions may be considered as part of the ongoing development of Mitigation Program actions, in coordination with agencies and Native American Tribes. Because potential options for operational measures to reduce effects on Rainbow and Fisk falls and the lamprey fishery include changes to inundation levels, inundation durations, and flood flow levels, additional evaluation of these elements would be required for any options advanced for further consideration.

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8.0 Abbreviations List

Chehalis Tribe	Confederated Tribes of the Chehalis Reservation

CHTR	Collection, Handling, Transfer, and Release
cm	centimeters
District	Chehalis River Basin Flood Control Zone District
Ecology	Washington Department of Ecology
eDNA	environmental DNA
EIS	environmental impact statement
FRE	flood retention expandable
HDR	HDR Engineering, Inc.
in/hr.	inches per hour
NEPA	National Environmental Policy Act
PIT	Passive Integrated Transponder
proposed project	proposed Chehalis River Basin Flood Damage Reduction Project
RM	River Mile
SEPA	State Environmental Policy Act
TM	technical memorandum
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WSEL	water surface elevation