Chehalis River Basin Flood Control Zone District

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RE: CHEHALIS RIVER BASIN WATER RETENTION FACILITY AND LEVEE IMPROVEMENTS - PROJECT NEED, PURPOSE, AND DESCRIPTION

PROJECT NEED

Flooding has become more frequent in the Chehalis-Centralia area. The three most recent floods in 1996, 2007, and 2009 were the largest on record and caused extensive physical, emotional, and economic damage. The 2007 and 2009 floods occurred only 13 months apart, affording the community a short window of opportunity to restore the area between floods. These extreme floods caused the loss of homes, farms, and businesses. Floodwater inundation resulted in the closure of Interstate 5 (I-5) for several days. These floods also caused damage to and closure of the Chehalis-Centralia Airport. Most of the flood damage occurred in the cities of Chehalis and Centralia, where there is more intensive development in the floodplain. Peak flows from the 1996, 2007, and 2009 floods rank in the top five at stream gages at the Chehalis River near Grand Mound, the Newaukum River near Chehalis, and the South Fork Chehalis River. Peak flows from these events as measured at the Grand Mound gage on the Chehalis River mainstem are shown in Table 1. As shown, historic flooding on the order of major and catastrophic flooding have occurred relatively recently.

Table 1
Historic Flooding Levels in the Chehalis Basin in Comparison to Reference Flood-Years

HISTORIC FLOOD	REFERENCE FLOOD YEAR	AS MEASURED AT GRAND MOUND STREAM GAGE LOCATION (USGS 12027500)
--	7-year or major flood	38,800 cfs
--	100-year or catastrophic flood	75,100 cfs
1996	--	74,800 cfs
2007	--	79,100 cfs
2009	--	50,700 cfs

Notes:
cfs: cubic feet per second
USGS: U.S. Geological Survey

Flooding of this level can affect structures, such as homes, businesses, and critical public facilities; infrastructure, including transportation corridors; and access to public services. Significant flooding can also cause unsafe conditions for people and animals, including livestock.

Under existing conditions, approximately 2,500 structures of value[1] are located in the upper part of the 100-year floodplain upstream of Grand Mound (Anchor QEA and WSE 2014, 2017). Underlying land uses within the 100-year floodplain in the Chehalis-Centralia area are shown in Figures 1A and 1B. Although not all structures would be lost, depending on the extent of the flooding, significant damage to structures and dangerous conditions for people and animals can occur. The 2007 flood was by far the largest on record, with monetary damages exceeding $900 million (Ruckelshaus 2012).

The Chehalis-Centralia Airport; schools, including Centralia Christian School and Centralia High School; the Southwest Washington Fairgrounds; the Chehalis Wastewater Treatment Plant; and multiple churches and other places of worship would also be inundated in a 100-year event (Figures 1A and 1B). During major floods in the Chehalis Basin, access to these facilities would also be limited. Affected transportation corridors include I-5, State Route (SR) 6 and SR 12 and portions of the BNSF Railway, Port of Chehalis Rail Line, and Tacoma Rail Mountain Division Line.

Under current conditions, I-5 is predicted to be closed for 5 days during a 100-year flood in the Chehalis-Centralia area. A closure of this length would result in prolonged adverse impacts on public health and safety and interstate commerce. This is because prolonged closure blocks access to critical medical facilities and prevents travel to and from areas outside of Chehalis-Centralia. The estimated value of travel disruptions directly associated with I-5 for a 100-year flood without any flood-protection work is approximately $11.9 million to $20.6 million per event (Hallenbeck et al. 2014). This estimate describes only costs directly related to travel that would have occurred were it not for flooding closures. Figures 2A, 2B, and 2C show the portions of I-5 that would be inundated during such an event without the proposed project.

Agricultural land covers approximately 41% of the Chehalis River floodplain. Agricultural uses in the Chehalis Basin consists mainly of livestock grazing, crop farming, and commercial dairy operations (CBP 2004). Flooding has caused erosion that has damaged vast areas of agricultural land. Silt and wood debris transported by the flood in 2007 was estimated to have affected 4,776 acres of agricultural land, with cleanup costs of over $2.3 million. Agricultural lands have also been affected by flooding when livestock are injured and killed, and fences and farm equipment are damaged. Approximately 1,600 commercial livestock, including 400 dairy cows, were lost in the 2007 flood in Lewis County (Ruckelshaus 2012).

[1] Structures of value include schools, residences, or other structures that would have a relatively high cost associated with restoration from flood damage. Structures of value exclude garages, sheds, park shelters, carports, and similar structures with a relatively low cost of restoration.

PROJECT PURPOSE

The Chehalis River Basin Flood Control Zone District (Applicant) is proposing to construct a flood retention facility near the town of Pe Ell and airport levee improvements at the Chehalis-Centralia Airport, in Lewis County, Washington (proposed project; Figure 3). The proposed project would reduce flooding originating in the Willapa Hills and improve levee integrity at the Chehalis-Centralia Airport to reduce flood damage in the Chehalis-Centralia area as defined in Figure 4. Reduced flood damage would be measured by the following metrics:

1. Removing about 635 structures of value from flooding risk during a 100-year flood
2. Reducing the disruption of access via main transportation routes, specifically ensuring access along State Route (SR) 6 and Interstate 5 (I-5) is open within 24 hours of a 100-year flood
3. Minimizing flood-related impacts (e.g., closure) at the Chehalis-Centralia Airport

To achieve the proposed project purpose, the Applicant is proposing the following objectives:

1. Locate the proposed project within a geographic scope extending from the Pe Ell area to the Chehalis-Centralia area. More specifically, the Applicant is proposing to locate a flood retention facility near Pe Ell and implement levee improvements at the Chehalis-Centralia Airport.
2. Reduce flood elevations during a 100-year flood at the following locations:
   A. 10 feet at the Doty gage (U.S. Geological Survey [USGS] 12020000)
   B. 1 foot at the Mellen Street gage (USGS 12025500)
3. Do not extend the boundaries of the existing 100-year floodplain.
4. Provide future leaders in the Chehalis Basin the flexibility to address additional increases in peak flood levels through an adaptable design approach.

Beyond the 635 properties referenced in metric 1, many additional properties within the target area shown on Figure 4 will benefit with a reduced flood risk. Properties that remain within the 100 year flood boundary will experience lower 100 year flood levels and shorter flooding duration. Quantifying the amount of this benefit in a consistent manner would be difficult and site specific due to individual property's location, elevation, and interaction with the river, which is why it has not been included as a specific metric in the project purpose and need. Regardless, this benefit is demonstrable based on past flood damage assessments and is of critical importance to the Applicant.

The proposed project will also lead to positive results in the area outside the defined target area shown in Figure 4. The area on the Chehalis River extending upstream of the Adna area to the proposed flood facility location will also experience a reduction in 100 year flood levels and duration. This would have a positive impact and be of benefit to properties and infrastructure adjacent to the river including reducing the risk of bridge damage during a major flood. The facility is proposed to be located upstream of Pe Ell and therefore those communities immediately downstream are considered to be valuable partners with the District for the success of this project.

PROPOSED PROJECT DESCRIPTION

Location

The flood retention facility would be located on Weyerhaeuser and Panesko Tree Farm property, south of SR 6 in Lewis County, on the mainstem Chehalis River at approximately River Mile (RM) 108, about 1 mile south of (upstream of) Pe Ell. The legal description of the property is: Section 3, Township 12N, Range 5W, and the parcel number is 016392004000. The watershed area upstream of the flood retention facility is 68.9 square miles. Property acquisition within the flood retention facility and reservoir footprint would be required, and the land would no longer be managed as commercial forestland.

The Applicant is also proposing to raise the existing airport levee and part of NW Louisiana Avenue (Figure 5). The property is located in Section 30, Township 14N, Range 2W, and the parcel number is 005605080001. This construction would take place concurrently with flood retention facility construction but could be completed within 1 construction year.

Flood Retention Facility

The proposed flood retention facility, referred to as a flood retention expandable (FRE) facility, would store floodwater during major or larger floods. Except during these events, the river would flow through the facility unimpeded. Flood levels are defined in Table 2. The FRE facility would reduce the severity and duration of major floods triggered by rainfall in the Willapa Hills. It would neither protect communities from all flooding, nor would it be designed to stop regular annual flooding from the Chehalis River. The FRE facility would be located on private property that is actively managed timberland and is not intended to result in any residential or community development at or around the reservoir.

Table 2
Flood Level Terminology

QUALITATIVE TERM	ANNUAL CHANCE OF OCCURRENCE[1]	FLOOD-YEAR[2]	FLOW AT GRAND MOUND STREAM GAGE LOCATION (USGS 12027500)
Major flooding	15%	7-year	38,800 cfs
Catastrophic flooding	1%	100-year	75,100 cfs
---	0.2%	500-year	107,184 cfs

Notes:
1. Percent chance a flood of this size would occur in any given year
2. Average number of years between a flood of this magnitude

cfs: cubic feet per second
USGS: U.S. Geological Survey

FRE Facility Design and Construction Details

During a major flood, the proposed FRE facility is designed to reduce flood damage from Pe Ell to Centralia by storing up to 65,000 acre-feet of water in a temporary reservoir (Figure 6) and releasing it slowly over time. The maximum upstream extent of the temporary reservoir would be 6.2 miles upstream (based on the 2007 flood level). For major floods, the reservoir would extend an average of 5.3 miles. When it is safe to do so, retained floodwater water would be released slowly back to the river over time (up to 32 days). Most of the time, however, the Chehalis River would flow through conduits in the facility at the river's normal rate of flow and volume, allowing fish to pass without obstruction upstream and downstream (Figures 7 and 8).

The proposed FRE facility is considered to be expandable because it would be built with a foundation and hydraulic structure capable of supporting the future construction of a larger structure and reservoir that could expand the water storage from 65,000 acre-feet up to 130,000 acre-feet. This expansion may or may not occur. If pursued, it would be subject to a separate environmental review and permitting process.

Permanent Structure

The FRE would be a roller compacted concrete (RCC) gravity dam, which is a concrete structure designed to retain water primarily by using the weight of the dam to resist the pressure of water pushing against it. The top of the proposed FRE would be 1,550 feet long and up to 270 feet high (including 3 to 5 feet of freeboard for safety and a 200-foot-wide emergency spillway; HDR 2018). The emergency spillway would discharge over a concrete lined chute to a flip bucket terminal structure. The spillway is expected to be used very rarely, and for events of very short duration. The flip bucket would launch the spillway flow a safe distance downstream of the FRE facility and would dissipate the energy in the river channel (Figure 8). The dam non-overflow top of parapet elevation (654 feet) would be above the maximum estimated reservoir flood pool elevation for a catastrophic flood.

The facility would have five outlet conduits (low-level outlets [LLOs]) for the Chehalis River to pass through: one that is 12 feet wide by 20 feet high and four that are 10 feet wide by 16 feet high. The LLOs would allow the river to pass through the dam structure unimpeded outside of flood events. The LLOs would typically be open, but could be closed for an anticipated flood event using radial control gates (Figure 9). A majority of sediment and most small debris would pass through the LLOs. The LLOs would discharge to a 230-foot-long stilling basin, a concrete structure designed to slow down the flow and minimize downstream channel erosion, before re-entering the natural river channel downstream of the FRE.

Table 3 lists details on temporary reservoir conditions. The *Chehalis River Basin Flood Control: FRE Dam Alternative Combined Dam and Fish Passage Supplemental Design Report* (HDR 2018) provides additional details on the FRE facility design.

Table 3
FRE Temporary Reservoir Conditions

ELEMENT	MAJOR FLOOD CONDITIONS	MAXIMUM RESERVOIR CONDITIONS[3]
Duration of reservoir inundation upstream of the FRE	Up to 32 days	Up to 32 days
Inundation extent	5.3 miles, on average	6.2 miles
Inundated area	188 acres (median)	778 acres
Reservoir elevation[4]	513 feet (median)	620 feet
Reservoir depth	88 feet	195 feet
Maximum design reservoir elevation (invert elevation of spillway)	Not applicable	628 feet
Maximum design reservoir depth	Not applicable	208 feet
Capacity[5]	65,000 acre-feet	

Notes:

3. The FRE facility maximum capacity would be designed to account for a flood similar to the 2007 flood.
4. Elevation of the river bed at the proposed FRE facility site is 420 feet.
5. Capacity is defined as from the base of the FRE facility to the invert elevation of the spillway.

Permanent Infrastructure

Construction and operation activities would necessitate constructing a detour or bypass road for Forest Road (FR) 1000, which is a main access road for Weyerhaeuser forestry operations. The FR 1000 bypass or detour would also provide access to the reservoir area on a permanent basis when the FRE facility is in operation and FR 1000 is inundated. There may be occurrences when the bypass is also temporarily inundated during flood operations. Up to 6 miles of the existing FR 1000 would be inundated and unavailable during major peak flood retention, at which time a detour would be used, consisting of FR A-line, FR F-line, and FR 2000, to rejoin FR 1000 upstream of the reservoir. Specific locations and the extent of improvements to the bypass road for FR 1000 would be defined during the detailed design phase, in conjunction with permitting.

A new power line would be constructed to operate the facility's pumps, gates, instruments, and other controls. The new power lines for the fish passage facility and gate operations would connect to existing local transmission lines, and the new power lines would be located along existing road alignments and areas cleared for FRE facility construction.

Construction

If permitted, the Applicant expects construction would occur between 2025 and 2030 and would last approximately 3.5 years. Prior to construction, final design would take approximately 1.5 to 2 years to complete an additional 1-year permitting allowance, and contract bidding and awarding would take from 4 to 6 months. Altogether, the total contract length would be between approximately 6 and 7 years.

FRE facility construction would require developing a quarry to provide aggregate for the FRE facility structure. This would also include constructing or upgrading roads to the quarry, identifying material storage and processing sites, and constructing areas for offices and storing equipment.

Concrete aggregate could be mined within the FRE facility site or nearby, depending on aggregate availability. The proposed quarry sites are the North Quarry, South Quarry, and Huckleberry Ridge (Figure 10). The North Quarry option would require widening 1.9 miles of FR 1000. The 1000G Road would also require widening, surfacing, and moderate improvements to the subgrade. The South Quarry option would require the same as the North Quarry option with additional upgrades and widening of FR 1000 and FR 1020. The Huckleberry Ridge Quarry option would include 3.01 miles of simple improvements, 2.93 miles of moderate improvements and excavation, and 0.81 mile of complex improvements, including heavy excavation, drilling and blasting. For additional information, refer to the *Chehalis Dam Feasibility Study–Road Improvement Requirements for Dam Construction* (PFR 2019).

A concrete production facility would also be located near the FRE facility and would include both roller-compacted concrete (RCC) and conventional concrete production. The site would include the following:

- RCC batch plant
- Conventional concrete batch plant
- Aggregate crushing and screening
- Aggregate storage
- Fly ash storage
- Cement storage

Construction equipment would include the following, which would be refined as the project progresses into the permitting phase:

- A range of mid- to large-size bulldozers, track excavators, front-end loaders, off-road fixed-wheel and articulated haul trucks, integrated tool carriers, and rollers
- A range of cranes up to 250 tons or larger, such as boom trucks, hydraulic trucks, and rough terrain and track-mounted cranes
- Quarry and material processing equipment, including the following:
  - Track drills (pneumatic and hydraulic)
  - Blasting product storage and transfer
  - Crushing plants, including feeders, primary (jaw), secondary (cone) and tertiary crushers, utility and potentially overland conveyors, screen decks, potentially wash plants, large generators, and electrical control and parts vans
- Concrete production and delivery equipment, such as generators, compressors, mobile to semi-mobile concrete plants, feeders, water chillers, ice plants, nitrogen systems, cement storage silos or trailers, conveyors, overland conveyors, and specialty fabricated equipment
- Support equipment, including the following:

- Trucks (vacuum trucks, water, mechanic, fuel and lube, booms, and flatbeds)
- Storage (vans, CONEX boxes, and temporary buildings)
- Other (generators, welders, compressors, pumps, and office trailers)

Excavation and earthwork operations, or soil movement, would involve soil disturbance as well as varying degrees of foundation rock excavation. Blasting equipment would include hydraulic and air track drills, explosive equipment handling and storage equipment. Production rates for earthwork operations would vary considerably based on the specific operation but would not exceed 5,000 cubic yards per day. In-water work means work completed within the existing river channel below the ordinary high water mark (OHWM).

Work in the river would begin with the isolation and installation of upstream and downstream diversion tunnel portals. This work is expected to occur over the course of a few days during low flow times. The temporary upstream fish passage (Collection, Handling, Transport, and Release [CHTR] or trap-and-haul) would be installed before the diversion tunnel. Temporary upstream and downstream berms across the river channel would then be constructed. A temporary upstream cofferdam is assumed to be constructed with RCC behind the temporary berm to an assumed height of 665 feet mean sea level (MSL). A smaller downstream cofferdam would be constructed to protect the construction area on the downstream side to a height assumed to be El. 635 feet MSL. This work is expected to last between 2 to 4 weeks.

Once the diversion tunnel is completed and is ready for use, river water would be diverted into the prepared diversion channel and tunnel by removing the material that isolates the tunnels. Once the river is diverted, it would flow uninhibited through the diversion tunnel during construction of the FRE. With an RCC cofferdam, seepage would be minimized, but precipitation within the dam construction site runoff area and minor seepage through the cofferdam and foundation would be pumped to appropriate containment for treatment prior to being returned to the river. The duration of diversion through the bypass tunnel is likely to be on the order of 24 months.

After completion of construction (including the permanent fish passage facilities), the process would be reversed with preparation of the water passage features within the FRE facility, removal of the upstream and downstream cofferdams, and diversion of the river back to the original channel. A berm would be constructed to isolate the upstream and downstream tunnel portals so they may be plugged.

Water for construction use is likely to be drawn or predominantly drawn upstream of the cofferdam from the diversion tunnel forebay area. Water use is likely to be between 75 and 150 million gallons, with as much as 80% of the draw occurring in a 10- to 20-month window. A plan for where water would be drawn, or how much would be used, would need to be developed. If sand or aggregates are washed on site, water use would be on the high side of this range. However, it is not anticipated that conventional concrete sand or other aggregates would be washed on site.

Access to the construction site is anticipated via Muller Road and FR 1000. Trips to and from the project site have not been evaluated, but would include labor and project support, all permanent materials and consumable materials, and construction equipment. A rough range for two-axle truck off-site round trips would be between 100,000 and 180,000 loads and three-axle or larger offsite truck round trips would be between 16,000 and 26,000 loads. On-site hauling of earthwork and quarried aggregates would use site-developed roads dedicated for construction use. These estimates would be refined in future phases of design development in conjunction with and in preparation for permitting.

For additional information, refer to the *Combined Dam and Fish Passage Design Conceptual Report* (HDR 2017) and *Chehalis River Basin Flood Control: FRE Dam Alternative Combined Dam and Fish Passage Supplemental Design Report* (HDR 2018).

Fish Passage During Construction

Downstream fish passage would be provided during construction by the river bypass tunnel, which would include a 20-foot diameter, 1,630-foot long, modified horseshoe-shaped, unlit tunnel to carry water past the construction site. An upstream cofferdam would direct upstream water into the bypass tunnel. A much smaller downstream cofferdam would be constructed to protect the construction area for the stilling basin and fish collection channel. The temporary diversion tunnel would accommodate downstream fish passage consistent with NOAA Fisheries and Washington State Department of Fish and Wildlife criteria during construction of the dam.

Upstream fish passage would be provided during construction by a temporary fish trap-and-haul facility, which would include a fish passage barrier downstream of the tunnel outlet to direct the fish passing upstream into the fish trap. The fish trap would be designed to collect adult target species (species that are listed as endangered, threatened, or species of concern by the National Marine Fisheries Services [NMFS] and the Washington State Department of Fish and Wildlife [WDFW]), resident fish, and lamprey. Once in the trap, fish would be transferred to tanks specially designed for their transportation. Personnel would drive the tanks upstream to pre-determined release sites selected by fisheries biologists. The fish would then be released back into the river to continue their migration upstream

FRE Facility Operations

During non-flood conditions, the reservoir would be empty and the Chehalis River would flow through the reservoir footprint and through the LLOs. Operations are proposed to begin in 2030.

The stages of FRE facility operation are as follows:

- Threshold for operations
- Operations prior to and during floods
- Initial drawdown after floods
- Debris management
- Drawdown after debris management

- Operations outside of flood storage periods

Additional details are included in the *Chehalis Basin Strategy Operations Plan for Flood Retention Facilities* (Anchor QEA 2017) in the sections referring to the Flood Retention Only (FRO) facility.

Threshold for Operations

The FRE facility would retain river flows temporarily, only during floods that are predicted to have a flow rate exceeding 38,800 cubic feet per second (cfs) at the Grand Mound gage (USGS 12027500). A flow rate of 38,800 cfs is equivalent to about a 7-year recurrence interval event at that gage (15% chance of occurrence in any year). When the prediction exceeds 38,800 cfs, water retention would begin within 48 hours of the forecasted flood peak. A 48-hour period gives a reasonable amount of time to predict flows with confidence while also providing enough time to reduce flow rates to designated minimum release rates before major flood flows occur.

Grand Mound is approximately 48 miles downstream from the FRE facility site, so the operators of the FRE facility would rely on flooding predictions up to 4 days in advance. The source of the forecast for major flooding would be the Northwest River Forecast Center, operated by the National Oceanic and Atmospheric Administration (NOAA). The Northwest River Forecast Center uses the NWS Community Hydrologic Prediction System to simulate soil, snow, and stream channel and reservoir conditions. Daily forecasts are made using observations of temperature and precipitation. Forecast of meteorological parameters are included in the river forecast model (NOAA 2016).

Operations Prior to and During Floods

Once flood operations are triggered, flow retention would begin by partially closing the reservoir outlet gates. FRE facility outflow would be reduced at a rate of 200 cfs per hour 2 days prior to when major flooding is predicted to occur. A maximum rate of change in reservoir outflow of 200 cfs per hour was selected for this period to minimize the potential for fish stranding downstream of the reservoir. The 200 cfs per hour rate was determined by applying a 2-inch-per-hour decline in river stage downstream of the dam (to reduce the potential for fish stranding) using the HEC-RAS model developed for the Chehalis Basin Strategy (WSE 2014). The flow rate used for that calculation was 1,000 cfs, the median flow for November to March during which most floods occur. That rate of change would be adjustable and can be adaptively managed during operations.

FRE facility outflows would decrease at 200 cfs per hour until reaching 300 cfs, the minimum outflow during flood operations. A 300-cfs flow is a naturally occurring winter low flow on the Chehalis River. The 300-cfs outflow would exist for only a short distance downstream of the FRE facility where tributary streams enter the Chehalis River and increase flows. The 300-cfs outflow would continue until the peak of the flood passes Grand Mound, which would typically take 48 to 72 hours.

Initial Drawdown after Floods

In order to evacuate the reservoir, the reservoir gates would open and increase outflow by 1,000 cfs per hour to a maximum outflow of 5,000 to 6,500 cfs, causing a drawdown of the reservoir from its peak

water surface elevation. Drawdown rates would be limited to 10 feet per day (5 inches per hour) due to risks of landslides, which would limit the duration of the flow increases to about 5 hours. A maximum outflow rate would be reached in that time period and would decrease as the reservoir is drawn down. This is because there is less storage volume per foot of drawdown as the reservoir level drops. The inflow to the reservoir during drawdown could also affect the discharge, because the greater the inflow, the greater the discharge from the reservoir. The maximum duration of reservoir inundation upstream of the FRE would be up to 32 days for a catastrophic flood as described in Table 1.

Debris Management

When major floods and reservoir operations occur, debris from surrounding tributaries and hillsides would be transported into the reservoir. The concern is that large woody material (LWM) could affect the operations of the FRE facility by obstructing the LLOs. Debris up to 3 feet in diameter and 15 feet in length can pass through the LLOs , but large accumulations are expected during flood operations.

Upstream of the FRE facility, an anchored log boom would help contain LWM. At the FRE facility, steel bar racks would protect the river opening entrances from LWM that could not pass through the LLOs downstream.

Debris management procedures would use a boat to move large debris entering the reservoir during a flood to a to an existing log sorting yard previously operated by Weyerhaeuser. The log sorting yard is located on the west bank of the Chehalis River between RM 109.6 and RM 109.9 (Figure 11). It was selected because of its relatively flat topography, ground elevation, and proximity to existing roadways. Debris would be transported away from the log sorting yard by truck.

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

Drawdown After Debris Management

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

Operations Outside of Flood Storage Periods

FRE facility operations would be triggered by the prediction of 38,800 cfs water flow at the Grand Mound gage. Outside of the flood storage period, the inflow to the reservoir would be discharged through the FRE facility LLOs with gates normally open. The LLOs are designed to simulate the natural river channel condition through the dam reach to the extent possible. Flows up to approximately 8,000 cfs are expected to pass freely through the LLOs. Water is expected to be near the top (crown) of the tunnel's opening with all LLOs operating at full open gate condition. A flow of 8,000 cfs has a recurrence interval of 3 years at the FRE facility site. For flows between 8,000 cfs and 12,500 cfs, the flow would transition from a free-flowing condition to a ponding condition at the tunnel entrance. For flows greater than 12,500 cfs, water ponding would occur at the entrance to the tunnels. The ponding level rises as the flow increases because greater water depth is needed to pass the flow through the tunnels. This is expected to provide small attenuation of the event peak flow.

Fish Passage Design Details

Fish passage facilities at the FRE facility would allow fish to pass both upstream and downstream during normal flows and during major or larger floods, as described in the following sections. For more information on construction and permanent fish passage design, refer to the *Draft Technical Memorandum: Simple Description of Fish Passage Operation* (HDR 2019) and the *Chehalis Basin Strategy: Fish Passage CHTR Preliminary Design* (Anchor QEA and HDR 2018).

Fish Passage During Normal Flows

The FRE facility would allow fish to pass upstream and downstream freely in conditions that mimic the existing natural rock canyon at that location. During normal flows, fish would pass through the five unlit LLOs that would remain open during normal conditions and smaller floods. The LLOs would be 310 feet in length and are anticipated to replicate the natural stream flow and velocity exhibited by the natural channel up through river discharges of 4,000 cfs. The LLOs would discharge into a 230-foot-long stilling basin. Most of the year, when no impoundment is occurring, aquatic species passing upstream would be able to move from the river, into the stilling basin, through the LLOs, and back into the river upstream of the FRE facility. Aquatic species passing downstream would follow the same path in the opposite direction.

Fish Passage During Reservoir Impoundments

A trap-and-haul facility would be used to provide upstream fish passage during major or larger floods when the structure's LLOs are closed and a reservoir has formed. The trap-and-haul facility would consist of an attraction water supply to draw fish into the facility, fish ladders, and a lamprey ramp to guide them to the fish traps, trap and holding facilities, a fish sorting building, fish transport tanks and trucks, and ancillary support structures (Figure 12). The CHTR is intended to collect migrating adult salmon and steelhead, juvenile salmon and steelhead, resident fish, and lamprey moving upstream, and safely transport them upstream of the FRE.

Operation of the CHTR facility would begin attracting and trapping fish immediately prior to the closure of the radial gates. Operation of the CHTR facility would continue through impoundment of water behind the FRE facility as the reservoir is evacuated, as release from the reservoir is slowed for debris management, and as the last remaining water in the reservoir is released. Fish would be released into the river at pre-selected release sites upstream of the FRE facility determined by fisheries biologists. Downstream fish passage would not be provided during major floods when the LLOs are closed, a period of up to 32 days.

Vegetation Management

In addition to removing vegetation for the FRE facility, tree clearing, and vegetation removal would occur within the reservoir area before construction and during operations. Vegetation management would include an integrated harvest and replanting program to help minimize temperature impacts on the river.

Pre-Construction Vegetation Management Plan

A pre-construction vegetation management plan would be implemented during the construction phase of the FRE facility. Table 4 shows the elevation of each inundation zone, the proposed pre-construction management actions that would be implemented in each zone, and the expected vegetation community type and vegetation that would be present in each zone after facility construction and operation. Figure 13 shows the expected extent of each vegetation community type.

The inundation zones are as follows:

- 10% chance of being flooded in a year (10-year flood); will be under water for 25 days per year when flooded
- 5% chance of being flooded in a year (20-year flood); will be under water for 4 days per year when flooded
- 1% chance of being flooded in a year (100-year flood); will be under water for 1 day per year when flooded
- Less than 1% chance of being flooded in a year (greater than a 100-year flood)

Prior to construction, woody vegetation would be completely cleared from the FRE facility site and from any areas where temporary construction access would be required. All non-flood-tolerant tree species would be removed from the zone where the inundation duration is expected to last 25 days or more when the reservoir is storing water (Table 4). Non-flood-tolerant tree species are defined as those species that are unable to withstand more than a few days of flooding during the growing season without significant mortality (Whitlow and Harris 1979).

Common non-flood-tolerant tree species identified in this document for the Pacific Northwest include Douglas fir (*Pseudotsuga menziesii*), big leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and bitter cherry (*Prunus emarginata*). Douglas fir will not survive flooding that lasts more than a few days.

Table 4

Expected Vegetation Community Types by Inundation Zone in the Flood Retention Only Reservoir[5]

INUNDATION ZONE	ELEVATION RANGE (FEET)[1]	PRE-CONSTRUCTION MANAGEMENT ACTIONS[2]	AREA (ACRES)[3]	EXPECTED POST-CONSTRUCTION VEGETATION COMMUNITY TYPE AND TYPICAL VEGETATION
10% chance of being flooded in a year	424 to 567	Selectively harvested to remove non-flood-tolerant species[4]	405	**Deciduous Riparian Shrubland** – various willows, red-osier dogwood, potential emergent/scrub-shrub wetlands
5% chance of being flooded in a year	567 to 584	No harvest	80	**Deciduous Riparian Forest with some Conifers** – red alder, western red cedar, Oregon ash, black cottonwood, willows, elderberry, snowberry
1% chance of being flooded in a year	584 to 612	No harvest	136	**Mixed Coniferous/Deciduous Transitional Forest** – Douglas fir (young), red alder, big leaf maple
Less than 1% chance of being flooded in a year	612 to 627	No harvest	90	**Coniferous Forest** – Douglas fir

Notes:

1. North American Vertical Datum of 1988 (NAVD88)
2. These management actions may be either periodically repeated on a regular management cycle (e.g., every 20 years) or as needed.
3. Vegetated area extents are only those areas that are currently vegetated and do not include roads or non-vegetated land (e.g., stream channels).
4. It is assumed that the Washington Department of Natural Resources would allow the removal of non-flood-tolerant trees from the RMZ in this portion of the reservoir footprint.
5. FRE and FRO facilities have the same general operations, but the FRE facility would have higher flow capacity (five gates rather than three), which would reduce the chance of inundation in a year.

The pre-construction management actions would meet Washington Department of Natural Resources (WDNR) regulations. Proposed management actions would potentially include the removal of commercial timber from existing WDNR-defined riparian management zones (RMZs) along sections of the Chehalis River and tributaries in the reservoir footprint. This approach would primarily target all Douglas fir in the RMZ, because this species would not be expected to survive in this inundation zone. For the remaining zones where the inundation duration would range from 1 to 4 days when flooded, no harvesting would occur. Depending on inundation timing and duration, some of the remnant non-flood-tolerant trees may eventually die and go on to provide wildlife habitat as snags or downed woody material. The uppermost inundation zone of the reservoir footprint would be left as a predominantly coniferous forest.

Vegetation Management During Operation of the FRE Facility

Existing conifers located farther from the river that may provide shade while the replacement species are growing could remain in place. These trees may need to be removed if the facility reaches its maximum use and the longest holding and release period. Routine reservoir limit clearing activities are expected to be confined to the removal of trees larger than approximately 6 inches diameter at breast

height and below the catastrophic flood level (i.e., 100-year flood stage, per the Applicant), should they regrow. A periodic clearing activity would occur about every 7 to 10 years, in which trees larger than that diameter would be felled and either left to decay or salvaged for biomass.

Adaptive management activities would focus primarily on controlling temperature effects on aquatic resources, reducing potential woody debris accumulation at the LLOs, and encouraging vegetation that provides slope stability. In addition, the adaptive management program would focus on maintenance of flood-tolerant vegetation that does not produce LWM or experience large-scale die-off in response to extended submergence during the flood season or growing season. Natural species selection would also be monitored over time to determine which native species persist in this changing environment and to encourage the growth of these species.

Airport Levee Improvements

1.1.1.1 Airport Levee Design

Airport levee improvements including raising the existing airport levee and part of NW Louisiana Avenue is also proposed (Figure 5). The project would result in up to 11,211 lineal feet of protective levee and includes the following elements:

- Add 4 to 7 feet to the height of the existing 9,511-foot-long levee with earthen materials or floodwalls
- Raise 810 feet of NW Louisiana Avenue along the southern extent of the airport
- Relocate the northwest corner of the levee to avoid interfering with the runway glide path
- Replace utility infrastructure
- Terminate the West Street over-cross approach
- Widen portions of the existing levee base in locations where there are retaining walls and remove the retaining walls

1.1.1.2 Construction

Construction activities would occur under the following general sequence:

- Mobilization
- Erosion control, clearing, and grubbing
- Removal of structures or obstructions
- Material placement and compaction
- Trimming, cleanup, and sod placement

Construction equipment would include the following, which would be refined as the project progresses into the permitting phase:

- A range of equipment sizes (trending on mid- to large-size) of bulldozers, track excavators, front-end loaders, off-road fixed-wheel and articulated haul trucks, integrated tool carriers, and rollers

- Support equipment, including the following:
  - Trucks (various dump trucks, water, mechanic, fuel and lube, and flatbeds)
  - Storage (vans, CONEX boxes, and temporary buildings)
  - Other (generators, compressors, pumps, and office trailers)

Excavation and earthwork operations would include removal of existing temporary retaining walls, removal of the crushed top course that is currently on top of the levee, and any excavation needed to place hydraulic structures such as culverts. No new quarries or borrow pits would be developed. Only existing sources would be evaluated for acceptable fill material, which would be brought in from off site. Typically, soil would only be displaced in areas where benching may occur or in areas of culvert placement.

Haul routes (Figure 14) would include Airport Road, and the top of the levee would be used for site access. Louisiana Avenue to the south is the preferred off-site route to avoid the congested traffic area east of the airport.

Attachments and Additional Resource Documents

The following list of attachments and resource documents contain additional information about the proposed project and can be used to supplement information in this project description.

Additional resource documents:

- *Draft Technical Memorandum: Simple Description of Fish Passage Operation* (HDR 2019)
- *Chehalis Dam Feasibility Study–Road Improvement Requirements for Dam Construction* (PFR 2019)
- *Chehalis River Basin Flood Control: FRE Dam Alternative Combined Dam and Fish Passage Supplemental Design Report* (HDR 2018): http://chehalisbasinstrategy.com/wp-content/uploads/2018/09/FRE-Alternative-Supplemental-Report-2018-09-27-reduced.pdf
- *Chehalis Basin Strategy: Fish Passage CHTR Preliminary Design Report* (Anchor QEA and HDR 2018): http://chehalisbasinstrategy.com/wp-content/uploads/2018/03/Chehalis-CHTR-Prelim-Design-Report_FINAL_2018-02-19reduced.pdf
- *Chehalis Basin Strategy Operations Plan for Flood Retention Facilities* (Anchor QEA 2017): http://chehalisbasinstrategy.com/wp-content/uploads/2017/07/Final-Operations-Plan-for-Flood-Retention-Facilities-1.pdf
- *Chehalis Basin Strategy Technical Memorandum: Proposed Flood Retention Facility Pre-construction Vegetation Management Plan* (Anchor QEA 2016): http://chehalisbasinstrategy.com/wp-content/uploads/2017/07/Chehalis-Basin-Strategy-FRO-FRFA-PreCon-Veg-Mgmt-Memo.pdf

Applicant-provided Information:

- *Chehalis River Basin Water Retention Facility - Project Purpose, Need and Objectives*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Evan Carnes (U.S. Army Corps of Engineers). November 9, 2017.
- *Chehalis River Basin Flood Damage Reduction Project Description*. Chehalis River Basin Flood Control Zone District. 2018.
- *Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). November 30, 2018.
- *Chehalis River Basin Water Retention Facility - Project Purpose and Need Clarification.* Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). January 11, 2019.
- *Chehalis River Basin Flood Control Zone District Project Description Clarification*. Letter from Betsy Dillin (Chehalis River Basin Flood Control Zone District) to Diane Butorac (Washington Department of Ecology) and Janelle Leeson (U.S. Army Corps of Engineers). January 14, 2019.

- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). February 12, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 1, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 7, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 15, 2019.
- *Chehalis River Basin Water Retention Facility - Project Alternatives History and Alternative Selection*. Letter from Erik Martin, PE, (Chehalis River Basin Flood Control Zone District) to Bob Thomas and Janelle Leeson (U.S. Army Corps of Engineers). March 19, 2019.