Vegetation Management Plan

Chehalis River Basin Flood Damage Reduction Project

Submitted by the Chehalis River Basin Flood Control Zone District

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Preface

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This document contains a *Vegetation Management Plan* for the Chehalis River Basin Flood Damage Reduction Project (proposed project) proposed by the Chehalis River Basin Flood Control Zone District. The purpose of the *Vegetation Management Plan* is to expand upon the Conceptual *Vegetation Management Plan* (*Conceptual VMP*) developed by HDR Engineering, Inc. (HDR), in 2020 (HDR 2020). Similar to the *Conceptual VMP*, a primary objective of this *Vegetation Management Plan* is to minimize the extent of tree clearing and vegetation removal in the Flood Retention Expandable (FRE) facility and temporary reservoir footprint to the extent practical, while balancing the need to reduce the amount of woody material that would be generated within the area during a flood event that triggers FRE operation.

This *Vegetation Management Plan* builds upon concepts previously introduced in the *Conceptual VMP* and provides greater detail about proposed vegetation management implementation and activities within and adjacent to the proposed project area. The *Vegetation Management Plan* will be used for future stakeholder and agency coordination efforts and serve as the basis for a more detailed *Final Vegetation Management Plan* once Project permitting commences.

Acronyms and Abbreviations

Anchor QEA	Anchor QEA, LLC
BMPs	best management practices
cfs	cubic feet per second
Conceptual VMP	*Conceptual Vegetation Management Plan*
District	Chehalis River Basin Flood Control Zone District
DSM	digital surface model
DTM	digital terrain model
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FRE	Flood Retention Facility – Expandable
GIS	geographic information system
HDR	HDR Engineering, Inc.
LiDAR	light detection and ranging
LWM	large woody material
mxd	map exchange document
NEPA	National Environmental Policy Act
NRCS	Natural Resources Conservation Service
NTP	Notice to Proceed
OHWM	ordinary high water mark
proposed project	Chehalis River Basin Flood Damage Reduction Project
SEPA	State Environmental Policy Act
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WDNR	Washington Department of Natural Resources
WSEL	water surface elevation

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1.0 Introduction

1.1 Purpose of Vegetation Management Plan – Impact Avoidance and Minimization

As part of a strategy to reduce flood damage 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 U.S. Army Corps of Engineers (USACE) (pursuant to the National Environmental Policy Act [NEPA]) evaluate anticipated impacts on 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 EISs identified that among the most consequential effects of the proposed project are the potential impacts on aquatic habitat and species as they relate to the potential loss of vegetation in the temporary inundation area of the FRE facility site. In response, the District has pursued additional analytical and planning work to develop feasible methods and actions to avoid, minimize, and mitigate these potential effects.

Previously, the District proposed a *Conceptual Vegetation Management Plan* (*Conceptual VMP*) in November 2020 (HDR 2020) to describe the intended approach to vegetation management in the temporary inundation area. Following the development of the *Conceptual VMP*, the District prepared related analysis including a *Water Temperature Model Sensitivity Analysis* (HDR 2021a), which highlights the potential for vegetation in the temporary inundation area to minimize effects to stream temperature and provides a review of Mud Mountain Dam, a similar flood retention control facility in Western Washington. Additionally, a *Proposed Plant Replacement Plan* (HDR 2021b) was developed that provides further clarification concerning the expected vegetation that will viably persist within the proposed temporary inundation area. The purpose of the *Vegetation Management Plan* presented here is to clarify the proposed plan to minimize the extent of tree clearing and vegetation removal in temporary inundation area. This *Vegetation Management Plan* builds upon concepts previously introduced in the *Conceptual VMP*, *Water Temperature Model Sensitivity Analysis*, and *Proposed Plant Replacement Plan*, and provides greater detail including a construction selective tree removal plan, plant replacement strategy including a species list and planting plan, timeline of implementation, and a proposed adaptive management plan.

The *Vegetation Management Plan* is a component of the overall ecosystem effects mitigation approach for the proposed project's impacts on aquatic species and habitats. Vegetation communities in the project area, specifically streamside riparian vegetation, can help moderate local stream temperatures, intercept runoff and rainfall, and uptake nutrients that may affect downstream water quality including stream temperatures and turbidity. Vegetation also provides habitat for wildlife. Functions provided by vegetation affect a variety of natural resources that are regulated at the federal, state, and local levels.

The *Vegetation Management Plan* aims to avoid and minimize impacts on vegetation communities to the extent practical at the FRE facility and within the temporary inundation area. Further, a draft adaptive management plan is proposed in anticipation of the dynamic changes that will occur in the temporary inundation area following operations of the FRE facility and resulting effects on vegetation (see Section 7.0).

The *Vegetation Management Plan* looks at the anticipated flooding of the site through the lens of disturbance. Disturbance is the agent of change through which vegetation constantly adapts and evolves. In this case, the disturbance type (flooding) is planned and expected, but uncertainty remains surrounding the impacts. The intent of proposed vegetation management is to design for resilience in the face of disturbance.

The proposed vegetation management strategy designs for resilience by:

1. Limiting advanced conversion of the site to retain ecological function of the existing vegetation. Initial efforts instead look for opportunities to enhance and replace existing vegetation that is less tolerant of flooding.
2. Retaining legacy habitat components (e.g., snags, root wads, large woody material [LWM]).
3. Exclusively utilizing native, site-adapted species for planting, potentially with seeds or cuttings sourced from the site.
4. Planting a variety of species expected to have success at each inundation level.
5. Inclusion of test plots with potential flood-tolerant species and permanent plots for monitoring.

1.2 Project Background

The Chehalis River Basin has a history of chronic flooding and damage from large floods from the Chehalis River and its major tributaries that has become more frequent in the Chehalis-Centralia area in recent years. 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, and floodwater inundation resulted in the closure of Interstate 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 ever observed at stream gages in the Chehalis River near Grand Mound, the Newaukum River near Chehalis, and the South Fork Chehalis River.

In 2012, the Governor's Chehalis Basin Work Group was created to look at how to reduce flood damage and improve aquatic species habitat in the Chehalis Basin. The Work Group evaluated a variety of options, including both big and small projects. Following the efforts of the Work Group, the Chehalis Basin Strategy was created in 2014 to coordinate projects and efforts to reduce flood damage and improve aquatic habitat. In 2017, Ecology finalized a Programmatic EIS, which evaluated large projects that might be used for the Chehalis Basin Strategy to reduce damage from floods and restore degraded aquatic species habitat. It considered several concepts to reduce flood damage and restore aquatic habitat, including water retention facilities and levee improvements.

In 2017, the District became the project sponsor for a flood reduction project that includes the proposed FRE facility and levee improvements at the Chehalis-Centralia Airport. The proposed project will 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.

In 2020, the Draft EISs prepared by Ecology (pursuant to SEPA) and the USACE (pursuant to NEPA) were released to the public, providing a preliminary evaluation of the anticipated impacts on resources associated with construction and operation of the proposed project. Both agencies are in the process of preparing Final EISs to evaluate the anticipated impacts on resources of the Chehalis River Basin.

1.3 Project Location

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

At the Chehalis-Centralia Airport, the District is proposing to raise the existing airport levee and part of NW Louisiana Avenue. The property is located in Section 30, Township 14N, Range 2W, and the parcel number is 005605080001. This construction will take place concurrently with flood retention facility construction but could be completed within 1 construction year.

1.4 Project Description

The proposed FRE facility will temporarily store floodwater during major floods and then release retained floodwater following the flood peak. Specific flow release operations will depend on inflow and the need to hold water to relieve downstream flooding. Major floods include events with river flows forecasted to reach 38,800 cubic feet per second (cfs) or more as measured at the Chehalis River Grand Mound gage located in Thurston County. Hydrologists have estimated that, based on historical data, a flow event of this magnitude has a 15 percent probability of occurring in any 1 year. This translates to an approximate 7-year recurrence interval. Under future climate change projections, flood events that trigger the operation of the FRE facility are predicted to occur more frequently. This potential increase in frequency of flood occurrence does not affect the conclusions of the vegetation management recommendations since the *Vegetation Management Plan* predicts tree mortality and plant species survival based on a modelled event and conservative estimates using the Mud Mountain Dam for reference (HDR 2021a). That facility floods much more frequently than the proposed FRE. The replanting plan and the adaptive management plan are also intended to address the inherent unpredictability of future disturbances and provide resilience through robust monitoring and periodic adjustments to vegetation management over time.

Major floods also include those with a lower frequency of occurrence, such as 10-year, 100-year, and 500-year floods. Except during flood reduction operations, the Chehalis River will flow through the structure's low-level outlet works at its normal rate of flow and volume, and no water will be stored in the temporary reservoir. This mode of operation will allow fish to pass both upstream and downstream.

The FRE facility will operate when flood forecasts predict a major or greater flood, as measured at the Grand Mound gage (U.S. Geological Survey 12027500). The FRE facility conduit gates will begin to close and start holding water approximately 48 hours before flows at the Grand Mound gage were predicted to exceed 38,800 cfs (major flood) due to heavy rainfall in the Willapa Hills. Once conduit gates begin to close, flows through the conduit gates will be reduced until reaching a flow of 300 cfs. A 300-cfs flow is a naturally occurring winter low flow on the Chehalis River. The outflow rate will be adjusted based on observed flows and revised predictions. The FRE facility will be operated to keep river outflow at a reduced rate until the peak flood passes the Grand Mound gage.

FRE facility operation will cause the temporary reservoir to fill. The depth to which the temporary reservoir is filled and the amount of flood water temporarily stored depends on the peak of the flood flow and its duration. The temporary reservoir will have a maximum depth of 212 feet, measured at conduit invert elevation 408 feet. The extent of area flooded within the temporary reservoir will be no more than 808 acres and in some cases could be less. Peak flood flows for major or greater floods are predicted to last on the order of 2 to 3 days. Once the peak flood flow has passed, a three-stage reservoir evacuation operation will be implemented (see Section 4.0) to empty the reservoir of temporarily stored floodwaters. The duration of temporary reservoir evacuation will depend on the magnitude of the flood event and the amount of water temporarily stored. For catastrophic floods with flows on the order of 75,100 cfs as measured at Grand Mound, it is estimated that inundation will last approximately 32 days total from closing of conduit gates through final reservoir evacuation.

The proposed construction of the FRE facility will require removal of vegetation for construction, staging, and access in and around the FRE facilities footprint, as well as selective vegetation removal within the temporary reservoir area before the proposed project is commissioned and available for operation.

Operation of the FRE facility will also require ongoing routine vegetation management in the temporary reservoir footprint to ensure that the FRE facility could be safely operated. Vegetation management will involve periodic selective tree/snag removal in the temporary reservoir when monitoring recommends action. This will happen about every 7 to 10 years to keep "large" trees (greater than 6-inches-diameter at breast height trees that have the potential to harm the facility) from growing in areas that will be flooded frequently when the FRE facility is activated.

1.5 Project Construction Timeline

The FRE facility will be constructed over a period of 4.5 to 5 years. The overall construction schedule is partly dependent on the date of Notice to Proceed (NTP) since the project will require in-water construction that will be regulated by permit conditions and time-of-year river flows. The current construction schedule has conservatively assumed an NTP in January during the first year of construction, although the overall starting year is currently unknown. A 6-month contingency may be added to the overall schedule to account for project delays due to weather, unexpected conditions, delays associated with equipment or material delivery, or other factors. Implementation of the proposed *Vegetation Management Plan* is integral to the proposed construction sequencing of the FRE facility, as it relates to achieving desired vegetation height and shading. Additional information regarding the construction schedule, expected construction facilities, and anticipated access requirements during construction have been provided to Ecology and the USACE from the District in a series of technical memoranda including:

- Proposed Flood Retention Dam Construction Schedule Supplemental Information (HDR 2019).
- Temporary Construction Facilities (HDR 2021c).
- Access Road Update and Best Management Practices (HDR 2021d).

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2.0 Regulatory Considerations

2.1 NEPA Environmental Review

As a federal agency with jurisdiction over the proposed project under Section 404 of the Clean Water Act, the USACE is required to review the potential environmental impacts of the proposed project under NEPA by preparing an EIS. The USACE serves as the federal lead agency for preparation of the EIS, which may then be used by any other federal agency that may have jurisdiction.

In the Draft EIS prepared by the USACE and issued on September 28, 2020, the USACE identified potential impacts to terrestrial and aquatic resources based on a *Preliminary Conceptual Vegetation Management Plan* (Anchor QEA 2017) for the project, which was considered under an earlier Programmatic Environmental Impact Statement prepared by Ecology. The USACE requested that the District, as the project proponent, further address means to avoid, minimize, or mitigate these potential impacts to inform their preparation of the Final EIS. This *Vegetation Management Plan* is submitted in response to that request and is intended to update earlier, more conceptual plans.

2.2 SEPA Environmental Review

Ecology prepared a Draft EIS issued on February 28, 2020, using the SEPA requirements in Washington Administrative Code 197-11. The Ecology Draft EIS evaluates the probable significant adverse impacts on the environment from a proposed project and alternatives and considers the future conditions when the project is proposed to be constructed and operated. An EIS issued by Ecology does not approve or deny a proposed project. Local and state agencies will use the SEPA EIS as part of future permitting decisions related to the project.

Like the Draft EIS prepared by the USACE, the Draft EIS prepared by Ecology also based the analysis of impacts on terrestrial and aquatic resources on the *Preliminary Conceptual Vegetation Management Plan* (Anchor QEA 2017). The *Vegetation Management Plan* is submitted in response to requests for a more detailed vegetation management plan that was previously submitted and used for evaluation in the Draft EIS.

2.3 Permitting Considerations

The *Vegetation Management Plan* presented here is intended to inform the development and review of the following permits, licenses, and approvals provided in Table 1 that will be required as part of the proposed project.

Table 1. Summary of Regulatory Agencies and Permits Applicable to Project

Jurisdiction	Agency	Permits and Reports
Federal	USACE	Section 404 Clean Water Act
		NEPA EIS
	U.S. Fish and Wildlife Service (USFWS)	Endangered Species Act (ESA)
	National Marine Fisheries Service	ESA
		Magnuson-Stevens Fishery Conservation and Management Act
State	Ecology	Shoreline Conditional Use and Substantial Development Permit
		Section 401 Clean Water Act Water Quality Certification
		SEPA EIS
	Washington Department of Fish and Wildlife (WDFW)	Hydraulic Project Approval
	Washington Department of Natural Resources (WDNR)	Forest Practices Permit
	Washington State Department of Archaeology and Historic Preservation	Section 106 of the National Historic Preservation Act under NEPA
County	Lewis County	Critical Areas Review
		Shoreline Conditional Use and Shoreline Substantial Development Permit
Tribal	Interested Tribes for Consultation	Review of *Vegetation Management Plan* for government-to-government consultation

3.0 Existing Conditions

3.1 Overview and Purpose

The following assessment of existing vegetation is intended to refine earlier vegetation community and topographic mapping for the proposed FRE reservoir. Available topographic data, aerial photographs, and geographic information system (GIS) analysis were used to extrapolate site reconnaissance observations and provided detailed vegetation community characterization along elevation gradients within the proposed reservoir footprint.

A summary of existing landcover classifications is provided below.

3.2 Existing Vegetation Mapping

3.2.1 Vegetation Mapping Methods

Existing vegetation communities were documented in the FRE temporary inundation study area, which encompasses the temporary reservoir pool from water surface elevation (WSEL) 425 up to WSEL 620 feet, the maximum WSEL for the 2007 event of record. Vegetation mapping used geographic GIS data and aerial photography available from public sources. A map exchange document (mxd) was set up in GIS with an empty feature class with defined domains for each land cover community that will be digitized. The mxd was populated with the following GIS reference files from previous studies and publicly available information: digital surface models (DSMs) showing the height of tree canopy (WDNR 2020a); digital terrain models (DTMs) representing the ground elevation (WDNR 2020b); streams, wetlands, and ditches mapped by Anchor QEA, LLC (Anchor QEA 2018); and logging road data (WDNR 2020c).

Using the reference data above as well as Google Earth aerial imagery from 1990 through 2018 (Google, LLC 2019), vegetation was characterized in the study area and digitized into distinct land cover classes using the vegetation communities identified in the *Proposed Flood Retention Facility Pre-construction Vegetation Management Plan* (Anchor QEA 2016) as amended with additional land use classifications such as open water, bare ground/roads, and logged lands to accurately capture current conditions in the study area. Land cover classes were also modeled after vegetation classifications outlined by the USFWS in *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979), which classifies wetlands based on their dominant vegetation structure (e.g., forested, scrub-shrub, emergent). A reconnaissance-level site visit was conducted by District consultants in June 2020 to qualitatively ground-truth the mapping of land cover types in the digitized database.

Table 2 summarizes land cover classifications, typical vegetation within each cover classification, and distinct characteristics that were used to map identified land cover types in the study area. In the sections following Table 2, additional information is given regarding the development of data for each land cover classification.

Table 2. Summary of Land Cover Classifications

Land Cover Classification	Cover in Study Area[a]	Typical Vegetation	Distinct Characteristics
Wetlands	1%	See Anchor QEA (2018)	Wetlands delineated by Anchor QEA (2018).
Open Water/Sand Bar	10%	Unvegetated	Mapped aquatic features (Anchor QEA 2018) and associated sand bars, rock features, etc.
Terrestrial Bare Ground/Roads	4%	Unvegetated	Lack of vegetation over multiple growing seasons; often associated with wide logging roads and equipment staging areas.
Herbaceous/Grass	1%	Reed canarygrass (*Phalaris arundinacea*), colonial bentgrass (*Agrostis capillaris*), sword fern (*Polystichum munitum*), western lady fern (*Athyrium angustum*), piggyback plant (*Tolmiea menziesii*), creeping buttercup (*Ranunculus repens*)	Grasses and forbs present during growing season; often found adjacent to wetlands, riparian corridors, and recently disturbed areas.
Deciduous Riparian Shrubland	<1%	Various willows (*Salix* spp.), young red alder (*Alnus rubra*), red-osier dogwood (*Cornus alba*), vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), thimbleberry (*Rubus parviflorus*), salmonberry (*Rubus spectabilis*)	Dominated by deciduous shrub/saplings less than 6 meters (20 feet) tall (>75% cover).
Deciduous Riparian Forest with Some Conifers	17%	Red alder, Western red cedar (*Thuja plicata*), Western hemlock (*Tsuga heterophylla*), black cottonwood (*Populus balsamifera*), cascara (*Frangula purshiana*), willows, big leaf maple (*Acer macrophyllum*), red elderberry (*Sambucus racemosa*), snowberry (*Symphoricarpos albus*)	Dominated by deciduous tree species 6 meters (20 feet) tall or taller (>75% cover).
Mixed Coniferous/Deciduous Transitional Forest	29%	Douglas fir (*Pseudotsuga menziesii*), red alder, big leaf maple	Approximately equal distribution of deciduous and coniferous species (not clearly dominated by one or the other).
Coniferous Forest	28%	Douglas fir	Dominated by coniferous species (>75% cover).

Land Cover Classification	Cover in Study Area[a]	Typical Vegetation	Distinct Characteristics
Logged, replanted 0–5 years	7%	Sun-tolerant grasses and forbs, Douglas fir seedlings	Evidence of logging (i.e., clearcutting) on historic aerial imagery; replanting visible within last 5 years (2015–2020) or not replanted.
Logged, replanted 5–15+ years	3%	Douglas fir saplings	Evidence of logging on historic aerial imagery; replanting identified 5 or more years ago (prior to 2015).

[a] Cover in study area is expressed as a percentage of overall study area. Study area is approximately 863 acres in size, which encompasses the temporary reservoir pool from WSEL 425 feet up to WSEL 620 feet, the maximum WSEL for the 2007 event of record.

3.2.1.1 Wetland and Open Water/Sand Bar

Wetlands and streams mapped in the *Wetland, Water, and Ordinary High Water Mark Delineation Report* (Anchor QEA 2018) were imported into GIS to create the Wetland and Open Water/Sand Bar land cover classifications, respectively.

The ordinary high water marks (OHWMs) for Crim Creek, Roger Creek, and the Chehalis River were not delineated in their entirety during field visits conducted by Anchor QEA due to access limitations and the length of reaches within the proposed project area. Instead, Anchor QEA conducted a desktop-based GIS analysis using light detection and ranging (LiDAR)-generated topography to interpret the OHWM elevation between each point that was gathered in the field. Minor adjustments were made to GIS-based stream mapping to more accurately reflect the spatial extent of streams visible on aerial photography.

3.2.1.2 Terrestrial Bare Ground/Roads

The Terrestrial Bare Ground/Roads land cover class includes wide logging roads, equipment staging areas, and adjacent open areas lacking vegetation. Historic aerial imagery was used to identify areas lacking vegetation for multiple growing seasons that were not associated with aquatic areas. To account for the surface area of logging roads obscured by dense vegetation and not visible on aerial imagery, a 7.5-foot buffer was applied to the centerline of mapped road features.

3.2.1.3 Herbaceous/Grass

The Herbaceous/Grass class accounts for upland areas dominated by grasses and forbs that are not wetlands. Herbaceous vegetation was distinguished from bare ground by comparing multiple years of aerial imagery to confirm the presence of vegetation during the growing season. Herbaceous vegetation was also commonly associated with areas recently disturbed by logging operations and was found adjacent to areas categorized as Terrestrial Bare Ground. Species typically found in these areas include reed canarygrass (*Phalaris arundinacea*), colonial bentgrass (*Agrostis capillaris*), sword fern (*Polystichum* *munitum*), western lady fern (*Athyrium angustum*), piggyback plant (*Tolmiea menziesii*), and creeping buttercup (*Ranunculus repens*).

3.2.1.4 Deciduous Riparian Shrubland

The Deciduous Riparian Shrubland class was modeled after the Cowardin "Scrub-Shrub" class, which includes areas dominated by woody vegetation less than 6 meters (20 feet) tall, including true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions (Cowardin et al. 1979). This class was identified and mapped based on the prevalence of deciduous shrub species and proximity (generally within 200 feet) to mapped streams and aquatic areas. Species typically found in these areas include various willows (*Salix* spp.), red-osier dogwood (*Cornus alba*), vine maple (*Acer circinatum*), Indian plum (*Oemleria cerasiformis*), thimbleberry (*Rubus parviflorus*), salmonberry (*Rubus spectabilis*), and red alder (*Alnus rubra*) saplings.

3.2.1.5 Deciduous Riparian Forest with Some Conifers

The Deciduous Riparian Forest classification was established based on the Cowardin "Forested" class, which includes forested areas characterized by woody vegetation that is 6 meters (20 feet) or taller (Cowardin et al. 1979). Deciduous forest stands were differentiated from scrub-shrub communities using the DSM GIS layer to determine approximate tree height. Although the class is dominated by deciduous tree species (approximately >75 percent deciduous cover), scattered conifer trees were also commonly observed in these areas. Deciduous species were distinguished from conifers using multiple years of aerial imagery to identify seasonal differences in canopy cover. Species typically found in the Deciduous Riparian Forest class include red alder, Western red cedar (*Thuja plicata*), Western hemlock (*Tsuga heterophylla*), black cottonwood (*Populus balsamifera*), cascara (*Frangula purshiana*), willows, big leaf maple (*Acer macrophyllum*), red elderberry (*Sambucus racemosa*), and snowberry (*Symphoricarpos albus*).

3.2.1.6 Mixed Coniferous/Deciduous Transitional Forest

Mixed Coniferous/Deciduous Transitional Forest represents areas with an approximately equal distribution of coniferous and deciduous tree species. Tree heights were estimated using the DSM layer, and the distribution of coniferous and deciduous species was determined using seasonal differences in canopy cover from historic aerial imagery. Species typically found in these areas include Douglas fir (*Pseudotsuga menziesii*), red alder, and big leaf maple.

3.2.1.7 Coniferous Forest

Areas dominated by coniferous tree species (>75 percent cover) were characterized as Coniferous Forest. The Coniferous Forest class is typically dominated by Douglas fir and often includes stands of various age classes managed for logging.

3.2.1.8 Recently Logged Areas

Areas with evidence of recent logging activity (i.e., clearcutting) were identified by comparing multiple years of aerial imagery. Recently logged areas with evidence of replanting within the last 5 years (2015 to present) or no evidence of replanting were characterized as "Logged, replanted 0-5 years." Areas with evidence of replanting more than 5 years ago (prior to 2015) were characterized as "Logged, replanted 5-15+ years." The 5-year threshold represents an approximation of time required for logged lands in the Pacific Northwest to transition from an early seral stage, in which grasses and forbs are predominant, to a shrub-sapling stage in which Douglas-fir seedlings accelerate in growth (Burns and Honkala 1990; Lam and Maguire 2011; USDA Forest Service 2012).

3.2.2 Existing Vegetation Mapping Results

An existing land cover map of the study area is presented in Figure 1.

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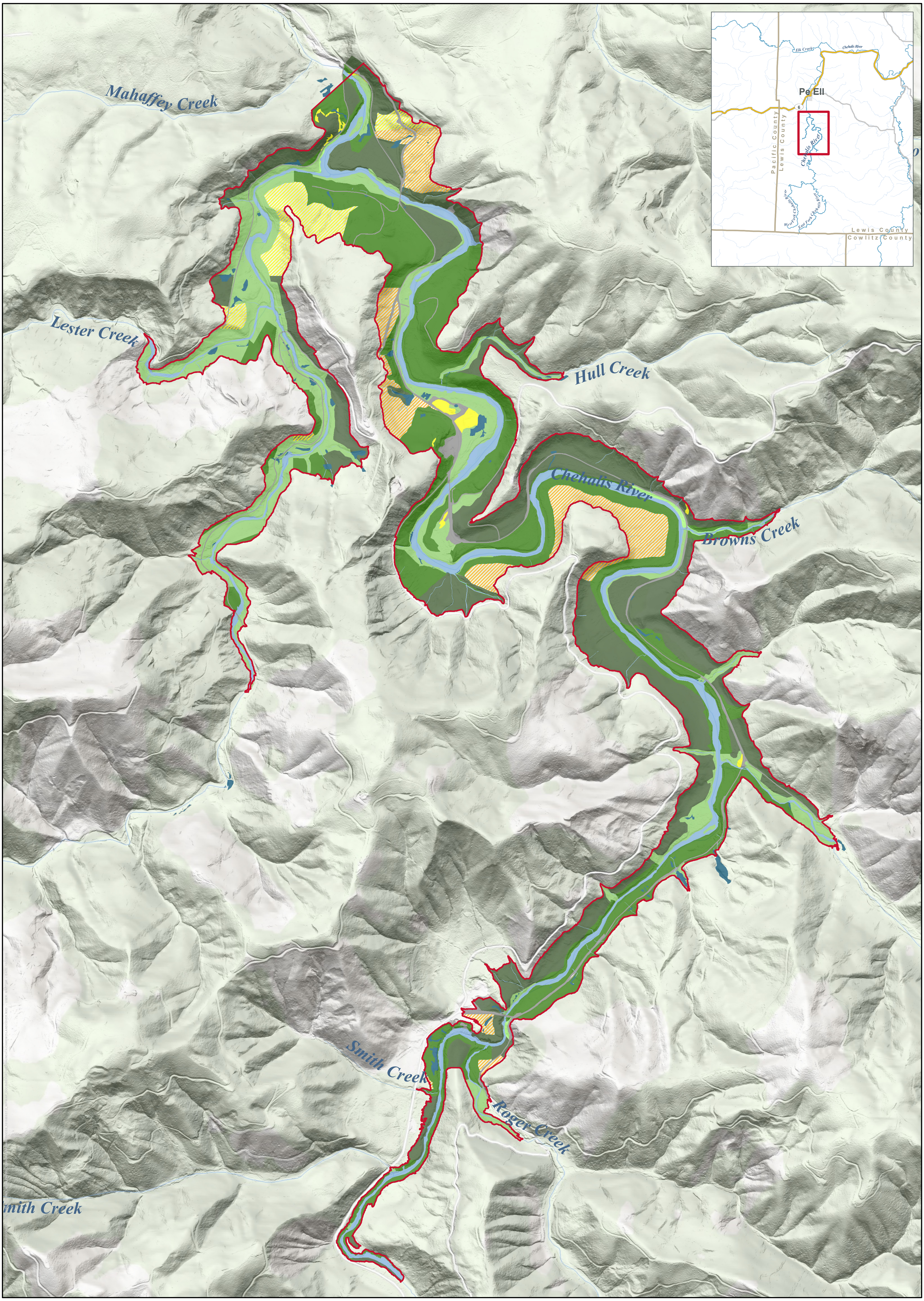

Source: Landcover, FRE Facility - HDR; Streams - DNR; Basemap - ESRI Online; Hillshade - DNR LiDAR Portal

LAND COVER CLASSIFICATION

Chehalis River Basin Flood Damage Reduction Project

Date: 10/2/2020

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4.0 FRE Temporary Reservoir Inundation Impacts

4.1 Overview and Purpose

The inundation mapping methods described below were used to generate the temporary reservoir inundation limits anticipated to occur during regulation of flood events by the proposed FRE facility. The identified inundation limits were then used to determine the extent of the vegetation study area described in Section 3.0, which encompasses WSEL 425–620 feet, the maximum WSEL for the 2007 event of record. The results of inundation mapping were also used to identify three main areas of reservoir evacuation: (1) Initial Reservoir Evacuation Area (max WSEL to WSEL 528 feet), (2) Debris Management Evacuation Area (WSEL 528–500 feet), and (3) Final Reservoir Evacuation Area (WSEL 500–425 feet). These three areas of temporary reservoir evacuation are described in greater detail below.

Identification of the limits of temporary reservoir inundation is intended to provide more granularity to the spatial analysis of potential changes in vegetation community composition. This analysis was also used to develop proposed strategies for vegetation removal and plant replacement outlined in subsequent sections of the VMP.

4.2 Inundation Mapping

4.2.1 Inundation Mapping Methods

To map the temporary reservoir inundation limits for each major flood event evaluated, topography data were obtained from public LiDAR databases. A series of DTMs provided by the WDNR LiDAR program were used to generate contour lines (datum: North American Vertical Datum of 1988). HDR Engineering, Inc. (HDR), used ArcGIS's "Mosaic to New Raster" tool to merge multiple DTMs into a single DTM that covers the entire project area. Once created, the new DTM was used to derive contours using the ArcGIS Contour tool. This tool was used to define the base contour, contour interval, and maximum vertices per contour. No unit conversion factor (Z factor) was used to generate the proposed project contours. For the purpose of modeling, contours at 5-foot intervals were created, with a base contour of zero.

The contour files were imported to AutoCAD 2018 and used to generate the inundation contour lines and show the aerial extent of these inundation limits. The following key WSEL contours were selected to illustrate the aerial (i.e., planform) extent of inundation during each of the three stages of temporary reservoir evacuation that will be implemented to evacuate the reservoir after a major flood event (i.e., events with river flows forecasted to reach 38,800 cfs or more) when the FRE facility is activated:

1. **Initial Reservoir Evacuation Area (Max. WSEL to WSEL 528 feet):** The maximum WSEL for each major flood event will vary depending on the intensity of the flood event. To evacuate the

temporary reservoir after a major flood event, the partially closed reservoir outlet gates will open and increase outflow by 1,000 cfs each hour, from 300 cfs (minimum outflow during flood operations) to a maximum outflow of 5,000 to 6,500 cfs. This will cause evacuation of the temporary reservoir from its peak WSEL at the maximum pool and will be limited to 10 feet per day (5 inches per hour) to reduce risk of landslides. During all major flood events, the 10-feet-per-day evacuation rate will continue until the pool elevation reaches 528 feet. Once the pool elevation reaches 528 feet, debris management operations will begin.

2. **Debris Management Evacuation Area (WSEL 528–500 feet):** During major flood events, debris from surrounding tributaries and hillsides may be swept into the reservoir. Debris management procedures will be used to ensure that large woody debris will not impact dam operations or cause damage to the FRE facility.

   Debris management will begin once the pool elevation falls to 528 feet. At this time, evacuation rates will be slowed to 2 feet per day (1 inch per hour) for a 14-day period. During this period, crews operating from boats will move large debris to an existing log-sorting yard within the reservoir area operated previously by Weyerhaeuser. The slowed evacuation rate will continue until the pool elevation falls to 500 feet. Once the pool elevation reaches 500 feet, debris management operations will conclude.

3. **Final Reservoir Evacuation Area (WSEL 500–425 feet):** When the pool elevation falls to WSEL 500 feet, evacuation rates will increase to 10 feet per day (5 inches per hour) once debris management operations are complete. Evacuation will continue at this rate until the pool elevation returns to 425 feet (empty reservoir). At this point, the reservoir will no longer be impounding water, and the Chehalis River will return to a free-flowing state.

The *SEPA Draft EIS: Proposed Chehalis River Basin Flood Damage Reduction Project* (Ecology 2020) analyzed three historical flood events and two theoretical events, the 10-year event and the 100-year event (see Table 3). To determine the predicted maximum reservoir pool WSELs resulting from FRE operations for each of these flood events, the regulated and unregulated flood hydrographs were obtained from the EIS and notations were added to the hydrograph plots to clarify key evacuation stages. Similar information was applied to the inundation limit map created in AutoCAD 2018. Additionally, the total inundation time above each of the three key reservoir evacuation elevations—maximum WSEL, WSEL 528 feet, and WSEL 500 feet—was determined from the time steps obtained from the flood hydrographs provided in the EIS.

4.2.2 Inundation Mapping Results

Table 3 shows the acreage and duration of inundation expected during the three stages of temporary reservoir drawdown for each major flood event evaluated. Inundation maps for historical and modeled flood events are presented in Appendix A. The figures show the Initial Reservoir Evacuation Area, Debris

Management Evacuation Area, and Final Reservoir Evacuation Area in blue, yellow, and orange, respectively. Hydrographs for each major flood event are provided in Appendix B.

The terms used in Table 3 are defined as follows:

- **Area of inundation** refers to the area (in acres) of reservoir inundated during each stage of temporary reservoir drawdown. As described above, the Debris Management Evacuation and Final Reservoir Evacuation Areas will have uniform operation during all major flood events; therefore, the acreage will be consistent during these operational milestones. The area inundated at the start of the Initial Reservoir Evacuation stage differs based on the severity of the flood event.
- **Duration of inundation** represents the maximum number of days of inundation during each stage of reservoir evacuation. The duration differs depending on the severity of the historical or modeled flood event. For the Debris Management Evacuation stage, this number includes 14 days for debris-clearing activities.
- **Maximum WSEL** gives the peak temporary reservoir pool WSEL for each flood event prior to the start of the Initial Reservoir Evacuation stage.

Table 3. Acreage and Duration of Inundation for Historical and Modeled Flood Events during Temporary Reservoir Evacuation Stages

Historical/Modeled Event	Initial Reservoir Evacuation (WSEL >528 feet)				Debris Management Evacuation (WSEL 528–500 feet)			Final Reservoir Evacuation (WSEL 500–425 feet)		
	Area of Inundation above WSEL 528 feet	Duration of Inundation above WSEL 528 feet	Total Reservoir Area[a]	Maximum WSEL[b]	Area of Inundation at WSEL 500–528 feet	Duration of Inundation at WSEL 528–500 feet[c]	Total Reservoir Area	Area of Inundation at WSEL 425–500 feet	Duration of Inundation at WSEL 500–425 feet[d]	Total Reservoir Area
10-year event	238 acres	Up to 5.9 days	519 acres	568 feet	122 acres	Up to 20.2 days	281 acres	159 acres	Up to 26.9 days	159 acres
100-year event	426 acres	Up to 10.7 days	707 acres	604 feet	122 acres	Up to 25.0 days	281 acres	159 acres	Up to 31.8 days	159 acres
1996 flood event	410 acres	Up to 9.8 days	691 acres	601 feet	122 acres	Up to 24.5 days	281 acres	159 acres	Up to 31.0 days	159 acres
2007 flood event	527 acres	Up to 11.1 days	808 acres	620 feet	122 acres	Up to 25.2 days	281 acres	159 acres	Up to 32.3 days	159 acres
2009 flood event	324 acres	Up to 7.8 days	605 acres	585 feet	122 acres	Up to 22.0 days	281 acres	159 acres	Up to 28.8 days	159 acres

[a] This value also represents the maximum area of inundation for the modelled flood event.
[b] This value also represents the maximum WSEL for the modelled flood event.
[c] Includes 14 days for debris-clearing activities starting when evacuation following flood peak falls to WSEL 528 feet.
[d] This value also represents the maximum number of days of flooding for the modelled flood event.

The results of the inundation mapping show that the maximum pool WSEL of the Initial Reservoir Evacuation Area will range between 620 and 568 feet. The acreage of inundation above 528 feet (lower limit of the Initial Reservoir Evacuation Area) will range between 238 and 527 acres, and the duration of inundation will range between 5.9 and 11.1 days. The Debris Management Evacuation Area will have 122 acres of inundation between WSEL 528 and 500 feet, and will be inundated between 20.2 and 25.2 days. The Final Reservoir Evacuation Area will have 159 acres of inundation between WSEL 500 and 425 feet. This area will be inundated at least 26 days under each flood event, and up to 32 days under the event of record (historic 2007 flood event).

Table 4 summarizes the range of acreage, inundation extent, and duration at each evacuation stage from the more frequent (10 percent chance) major flood event (10-year event) to the least frequent (<1 percent chance) major flood event (2007 event of record). Figure 2 graphically depicts each evacuation stage for each flood event plotted as acreage of inundation versus length of inundation time. The standardized three-stage evacuation operations that will be implemented when the dam is activated during all major flood events provide a more accurate depiction of the duration and extent of inundation to evaluate impacts during operation of the dam. During any major flood event, nearly half of the reservoir or more will be inundated for only 6 to 11 days. Longer periods of inundation that will have greater potential effects on vegetation will commence at the Debris Management Evacuation stage.

Table 4. Inundation Areas Based on Temporary Reservoir Evacuation Stages

Temporary Reservoir Drawdown Stage	Chance of being Flooded in a Year	Duration	WSEL Range	Total Reservoir Area
Initial Reservoir Evacuation	10%	Up to 5.9 days	568–528	238 acres
	<1%	Up to 11.1 days	620–528	527 acres
Debris Management Evacuation	10%	Up to 20.2 days	528–500	122 acres
	<1%	Up to 25.2 days	528–500	122 acres
Final Reservoir Evacuation	10%	Up to 26.9 days	500–425	159 acres
	<1%	Up to 32.3 days	500–425	159 acres

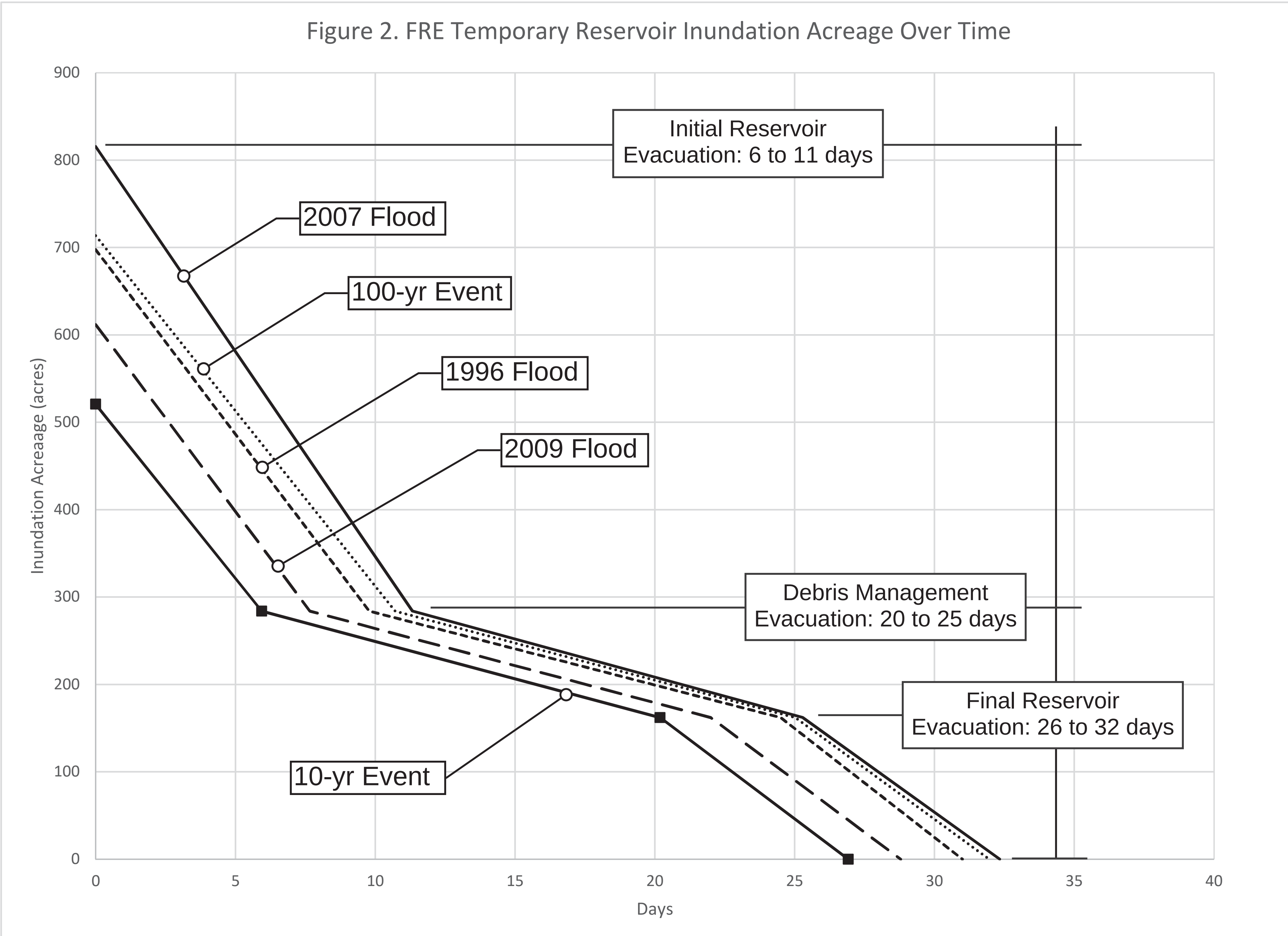
Figure 2. FRE Temporary Reservoir Inundation Acreage Over Time
Initial Reservoir Evacuation: 6 to 11 days
2007 Flood
100-yr Event
1996 Flood
2009 Flood
Debris Management Evacuation: 20 to 25 days
Final Reservoir Evacuation: 26 to 32 days
10-yr Event
Inundation Acreage (acres)
Days
0
100
200
300
400
500
600
700
800
900
0
5
10
15
20
25
30
35
40

These findings inform the expected conditions for each of the inundation areas. Plant survival and replanting recommendations reflect these estimated inundation depths and durations as well as differences in terrain that result in different planting conditions. For example, the riparian areas for the Chehalis River and its tributaries are treated separately in the planting recommendations. Since each of these inundation areas cover a range of elevations plant survival may vary within each area. This plan focuses on the riparian zone replanting in particular because this will assist in the control of stream bank erosion and help minimize loss of over water shade.

4.3 Vegetation Responses to Flooding

4.3.1 Overview and Purpose

A thorough review of scientific literature was conducted to review expected vegetation responses to flooding under a variety of site conditions. This analysis focused on the existing vegetation communities and species identified in Section 3.0 and is intended to provide a basis for determining how these species can reasonably be expected to respond following inundation events. The general considerations for flood tolerance and relative flood tolerance of identified species were also used to develop the proposed replanting strategy outlined in Section 6.0.

Although scientific literature generally reviews overall flood tolerance rather than full submergence (as will likely be experienced by vegetation in the Final Reservoir Evacuation Area during a major flood event), general flood tolerance and known survivability factors were used to extrapolate anticipated vegetation responses to inundation in the temporary reservoir footprint.

4.3.2 General Flood Tolerance Considerations

The likelihood of woody vegetation to survive a flood event is dependent on a variety of factors, including time of year, soil type, age and health of plants, frequency, duration and depth of inundation, and plant species. Flooding also causes mechanical destruction of vegetation through the direct impact of flood waters and the debris they transport, and through the erosion of substrate (Bendix 1998). It has also been noted that standing water is more harmful than moving flood water and that flood-tolerant plants are often injured by flooding in standing water (Kozlowski 1982, as cited in Kozlowski 1984).

Flooding also contributes to changes in the physical status of soil because waterlogging causes large aggregates to break into smaller particles. As flood levels recede, the small particles are rearranged into denser structure, creating smaller soil-pore diameters, higher mechanical resistance to root penetration, low oxygen concentrations, and inhibition of resource use (Engelaar et al. 1993).

The types of soils found in the inundated area and their ability to drain or retain water also influences vegetation survival. Sandy soils drain much faster than predominantly clay-based soils, which hold water and remain wet for longer periods (Jull 2008). Soils in the study area are mapped by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) as Winston loam (45.6 percent), Bunker loam (20.3 percent), Katula-Rock outcrop complex (10.9 percent), Aquic

Xerofluvents (5.0 percent), and others (USDA NRCS 2019). In their natural state, nearly all soils found in the study area are classified as "well drained," meaning that water is removed from the soil readily but not rapidly (Soil Science Division Staff 2017).

Flooding that occurs during the growing season is significantly more harmful to plant survival than flooding that occurs during the dormant season (Kozlowski 1984, 1997). The growing season for the project area was determined based on the period in which temperatures are above 28 degrees Fahrenheit in 5 out of 10 years using the long-term climatological data collected by the USDA NRCS (2020a). Using the USDA NRCS Climate Analysis for Wetlands table for the nearest station (Centralia), the growing season was approximated to be typically between March 6 and November 23, or a total of 262 days.

The depth of flooding also introduces stresses to vegetation. Partially to fully submerged plants have partial to full loss of direct contact with atmospheric oxygen, which limits the ability for gas exchange to occur in leaves. Sunlight is also greatly reduced or extinguished, hampering photosynthesis (Parolin 2009). Trees that are submerged only partially during a flood event generally have greater survivability than fully submerged trees (Siebel et al. 1998; North Dakota State University 2000).

The age and health of the plants also contribute to their ability to survive a flood event. Young seedlings have been found to be more sensitive to flooding injury than older seedlings (Kozlowski 1997). Established, healthy trees and shrubs are also more tolerant of flooding than old, stressed, or young plants of the same species (Jull 2008).

4.3.3 Flood Tolerance of Plant Species in the FRE Temporary Reservoir

Flood-tolerant plants survive in anaerobic environments using various morphological and physiological adaptations, depending on the species and environmental conditions. For example, red alder exhibits adaptations that permit flood tolerance, including the formation of adventitious roots when subject to flooding (Batzli and Dawson 1997; Harrington 2006). Other studies recorded 100 percent survival of red alder seedlings when subjected to a 20-day flood and a 20-day recovery period (Harrington 1987).

Other examples were found in a controlled flooding experiment conducted by Minore in 1968, in which winter inundation did not significantly affect the survival or growth of western hemlock, red alder, Sitka spruce, lodgepole pine, or Western red cedar, but even 1 week of winter inundation was detrimental to Douglas fir. In the same experiment, summer flooding survival rates for both Western red cedar and lodgepole pine were significantly better than those for Douglas fir after 4 weeks of summer flooding. Minore (1968) concluded that short periods of winter flooding will likely not injure western hemlock, red alder, Sitka spruce, lodgepole pine, or Western red cedar seedlings, but found that Douglas fir seedlings are very intolerant of flooding. It was also found that photosynthesis and transpiration of Douglas fir have been shown to decrease within 4 to 5 hours after flooding, indicating rapid stomatal closure (Zaerr 1983, as cited in Kozlowski and Pallardy 2002).

Based on a comprehensive literature review, existing vegetation species commonly found in the project area were sorted into four categories of anticipated flood tolerance:

- Low: 1–7 days of inundation
- Moderate: 8–14 days of inundation
- Medium-high: 6–30 days of inundation
- High: 15–30+ days of inundation

Table 5 summarizes the relative flood tolerance of common native woody plants found in the project area, based on the findings of a variety of peer-reviewed studies. Species with low anticipated flood tolerance, including Douglas fir, are likely to exhibit signs of flood stress after only a few days. Signs of flood stress in plants include yellowing or browning of leaves, curled leaves, leaf wilt and drop, reduced size of new leaves, early fall color, branch dieback, formation of sprouts along stems or trunk, and gradual decline and death (Jull 2008). Stressed trees are also more susceptible to secondary organisms such as canker fungi and insects that bore into phloem and wood (Jull 2008).

Table 5. Relative Flood Tolerance of Common Native Woody Plants in the FRE Temporary Reservoir

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
Red-osier dogwood	*Cornus alba*	High (10–30+ days)	Very tolerant (2+ growing seasons)	High tolerance	Very tolerant (>1 year)	N/A	High	N/A
Narrow leaf willow	*Salix exigua*	Medium-high (6—30 days)	Very tolerant (all willows; 2+ growing seasons)	High tolerance (all willows)	Very tolerant (>1 year)	Moderately tolerant	High	94.9 days of maximum flooding at elevations where species was most common[b]
Hooker's willow	*Salix hookeriana*	N/A	Very tolerant (all willows; 2+ growing seasons)	High tolerance (all willows)	Very tolerant (>1 year)	Moderately tolerant	High	N/A
Pacific willow	*Salix lasiandra*	Medium-high (6–30 days)	Very tolerant (all willows; 2+ growing seasons)	High tolerance (all willows)	Very tolerant (>1 year)	Moderately tolerant	High	146.3 days of maximum flooding at elevations where species was most common[b]
Lodgepole pine	*Pinus contorta*	N/A	Intermediately tolerant (1–3 months during growing season)	N/A	Tolerant (1 growing season)	Moderately tolerant	Low	100% survival of seedlings inundated 1–4 weeks in winter; 100% survival after 4 weeks in summer; 50% survival after 8 weeks in summer;[c] tolerated submergence for 14 days[d]
Black cottonwood	*Populus balsamifera ssp. Trichocarpa*	Medium (6–10 days)	Tolerant (most of 1 growing season)	High tolerance	Tolerant (1 growing season)	Moderately tolerant	Medium	100% survival but varied growth response after 20-day flooding and 20-day recovery period[e]
Red elderberry	*Sambucus racemosa*	Medium (6–10 days)	N/A	High tolerance	Tolerant (1 growing season)	N/A	N/A	N/A
Hardhack	*Spiraea douglasii*	N/A	N/A	High tolerance	Tolerant (1 growing season)	N/A	High	Suffered no obvious injury after being inundated and covered in fine layer of silt during flood event[f]

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
Western red cedar	*Thuja plicata*	N/A	Tolerant (most of 1 growing season)	High tolerance	Tolerant (1 growing season)	Weakly tolerant	N/A	100% survival of seedlings inundated 1–4 weeks in winter and 4 and 8 weeks in summer[c]
Sitka spruce	*Picea sitchensis*	N/A	Tolerant (most of 1 growing season)	N/A	Slightly tolerant (30 days)	Weakly tolerant	Low	100% survival of seedlings inundated 1–4 weeks in winter; 84% survival after 4 weeks in summer; 34% after 8 weeks in summer;[c] actively growing seedlings were alive after 22 days of root flooding[g]
Ponderosa pine	*Pinus ponderosa*	N/A	Intermediately tolerant (1–3 months during growing season)	Medium tolerance	Slightly tolerant (30 days)	Intolerant	N/A	N/A
Western hemlock	*Tsuga heterophylla*	N/A	Tolerant (most of 1 growing season)	N/A	Slightly tolerant (30 days)	Weakly tolerant	N/A	100% seedling survival after 1–4 weeks inundation in winter; 34% survival after 4 weeks in summer; 16% survival after 8 weeks in summer[c]
Big leaf maple	*Acer macrophyllum*	N/A	Intermediately tolerant (1–3 months during growing season)	Medium tolerance	Intolerant (no more than a few days)	Weakly tolerant	Medium	In repeated flood events in British Columbia, Canada, some maples succumbed, particularly if they were growing very actively[f]
Vine maple	*Acer circinatum*	N/A	Tolerant (most of 1 growing season)	Low tolerance	N/A	N/A	N/A	N/A

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
Red alder	*Alnus rubra*	Medium (6–10 days)	Very tolerant (2+ growing seasons)	High tolerance	Intolerant (no more than a few days)	Moderately tolerant	Low	Recovered after 50-day flood and 20-day recovery;[h] 100% seedling survival but varied growth response after 20-day flood and 20-day recovery;[e] 100% seedling survival after 1–4 weeks in winter; 50% survival after 4 weeks in summer; 65% survival after 8 weeks in summer;[c] static flooding killed 2-year-old saplings after 4–6 days of flooding when water was above soil surface;[i] suffered "markedly" in flooded lowland forest after inundation; died in large numbers and regarded as one of the trees most susceptible to damage by flooding[f]
White alder	*Alnus rhombifolia*	N/A	Very tolerant (2+ growing seasons)	High tolerance	N/A	N/A	Low	N/A
Indian plum	*Oemleria cerasiformis*	N/A	N/A	Low to medium tolerance	N/A	N/A	Medium	N/A
Snowberry	*Symphoricarpos albus*	Medium (6–10 days)	Intermediately tolerant (1–3 months during growing season)	Medium tolerance	N/A	N/A	N/A	N/A
Thimbleberry	*Rubus parviflorus*	N/A	N/A	Low tolerance	N/A	N/A	Low	N/A
Salmonberry	*Rubus spectabilis*	N/A	N/A	High tolerance	N/A	N/A	Medium	N/A

Common Name	Scientific Name	Tilley et al. 2012	Walters et al. 1980	Withrow-Robinson et al. 2011	Whitlow and Harris 1979	Wenger 1984	USDA PLANTS Database[a]	Miscellaneous Sources
Mock orange	*Philadelphus L.*	Unknown	N/A	Medium tolerance	Intolerant (no more than a few days)	N/A	N/A	N/A
Bitter cherry	*Prunus emarginata*	N/A	Intermediately tolerant (1–3 months during growing season)	N/A	Intolerant (no more than a few days)	N/A	N/A	N/A
Douglas fir	*Pseudotsuga menziesii*	N/A	N/A	Low tolerance	Intolerant (no more than a few days)	Intolerant	Low	Winter flooding for 1–4 weeks caused severe injury; 0% seedling survival after 4 or 8 weeks during summer;[c] tolerated submergence for 14 days[d]
Cascara	*Frangula purshiana*	N/A	N/A	Medium tolerance	Intolerant (no more than a few days)	N/A	N/A	N/A
Oregon ash	*Fraxinus latifolia*	N/A	Tolerant (most of 1 growing season)	High tolerance	N/A	Weakly tolerant	High	Static flooding killed 2-year-old saplings after 4–6 days of flooding when water was above soil surface[i]

[a]USDA NRCS 2020b.

[b]Wakefield 1966, as cited in Whitlow and Harris 1979. Looks at days of average maximum flooding at elevations where species was found to be most common.

[c]Minore 1968.

[d]McCaughey and Weaver 1991.

[e]Harrington 1987.

[f]Brink 1954.

[g]Coutts 1981, as cited in McCaughey and Weaver 1991.

[h]Batzli and Dawson 1997.

[i]Ewing 1996.

4.4 Inundation Effects in FRE Temporary Reservoir and Proposed Pre-Construction Tree Removal Rationale

The acreage of existing land cover within each of the identified evacuation areas is presented in Table 6. Based on the relative flood tolerance of various species found in the project area, the distribution of existing vegetation was used to refine predicted impacts on vegetation following inundation events. This analysis was then used to provide rationale for proposed methods of vegetation removal, which is described in greater detail below.

Table 6. Acreage of Existing Land Cover by Evacuation Area

Existing Land Cover Classification	Acres of Existing Land Cover		
	Initial Reservoir Evacuation Area (WSEL >528 feet)[a]	Debris Management Evacuation Area (WSEL 528–500 feet)	Final Reservoir Evacuation Area (WSEL 500–425 feet)
Wetlands	3.7	1.0	3.1
Open Water/Sand Bar	31.3	13.0	35.8
Terrestrial Bare Ground/Roads	13.0	7.0	7.3
Herbaceous/Grass	0.7	1.4	2.7
Deciduous Riparian Shrubland	1.2	1.0	0.5
Deciduous Riparian Forest with Some Conifers	65.3	22.8	33.1
Mixed Coniferous Forest/Deciduous Transitional Forest	115.0	50.4	45.2
Coniferous Forest	141.2	13.7	26.9
Logged, replanted 0-5 years	38.7	5.6	2.7
Logged, replanted 5-15+ years	15.9	5.6	1.9
Total:	426.0	121.5	159.2

[a] Existing land cover acreages reported for the Initial Reservoir Evacuation Area are based on expected area of inundation from 100-year event (WSEL 528–604 feet).

The Initial Reservoir Evacuation Area consists mainly of Coniferous Forest, dominated by Douglas fir, and Mixed Coniferous/Deciduous Transitional Forest, dominated by Douglas fir, red alder, and big leaf maple. The Initial Reservoir Evacuation Area will be inundated between 6 to 11 days during a flood event, and some trees could be partially submerged, depending on the severity of the flood. As such, species with low anticipated flood tolerance (e.g., Douglas fir) will likely exhibit signs of flood stress and some mortality from a single flood event. These trees will be monitored and removed if they exhibit significant injury or mortality following a flood event. Species with moderate flood tolerance are not expected to experience significant mortality in the Initial Reservoir Evacuation Area from a single event, but will be monitored for signs of flood stress over time. Potential monitoring methods are described in more detail in Section 7.2.

The Debris Management Evacuation Area consists primarily of Mixed Coniferous/Deciduous Transitional Forest, dominated by Douglas fir, red alder, and big leaf maple, and Deciduous Riparian Forest with Some Conifers, including species such as red alder, Western red cedar, Western hemlock, black cottonwood, willows, and big leaf maple. The Debris Management Evacuation Area will be inundated between 20 and 25.2 days during a flood event, and most trees throughout this area will be partially or fully submerged for the duration of this time. Submergence introduces additional novel stresses to trees, decreasing their likelihood of survival. Therefore, all tree species that are not highly tolerant of flooding (i.e., all species except for willows and black cottonwood) are expected to experience flood stress and may not survive this level of flooding. Douglas fir will likely perish; therefore, areas dominated by Douglas fir will be targeted for pre-operational in-planting of more flood tolerant species. If die-off does occur, most dead trees will be removed and replaced with trees and shrubs showing higher tolerance post-flooding. Some snags will be retained for habitat, and root wads and shrubs will not be removed.

The Final Reservoir Evacuation Area consists mainly of Deciduous Riparian Forest with Some Conifers, Mixed Coniferous/Deciduous Transitional Forest, and Open Water land cover classifications. The Final Reservoir Evacuation Area will be inundated between 26 and 32 days during a flood event, and trees in this area will be fully submerged. It is highly unlikely that any trees will be able to survive in this area after prolonged inundation and full submergence. Therefore, this area will require full conversion to more flood-tolerant plant species, and all trees in this area will need to be removed and replaced over time to minimize safety risks.

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5.0 Vegetation Management Strategy

5.1 Overview and Purpose

The vegetation management component of this *Vegetation Management Plan* is intended to build upon earlier assumptions of anticipated impacts to existing vegetation and provide a proposed approach to vegetation management following FRE construction and temporary reservoir inundation. Goals and objectives for maintaining key riparian functions in the project reach of the Chehalis River and its tributaries, as well as for ensuring safe and efficient operation of the FRE facility, are also outlined below.

Overall, the proposed vegetation management strategy is intended to design for resilience in the face of disturbance (i.e., major flood events). Although the frequency, intensity, and extent of flood events are unknown, the *Vegetation Management Plan* promotes resilience by reducing the advanced conversion of the site to retain ecological function of the existing vegetation. Instead, initial vegetation management efforts aim to enhance and replace existing vegetation that is less tolerant of flooding. Where feasible, legacy habitat components, including snags and stumps, will be retained to limit ground disturbance, promote slope stability, and provide wildlife habitat.

5.2 Vegetation Management Strategy Goals and Objectives

The District's proposed vegetation management strategy incorporates the following goals and objectives for vegetation monitoring, removal, replanting and adaptive management to avoid and to minimize impacts on environmental resources in the project area while meeting the safety and operational needs of the FRE facility.

5.2.1 Goal 1: Reduce potential for future damage to dam facilities and ensure safety of dam operations personnel.

Objective: Clear woody vegetation from near the dam site and from any areas where temporary construction and associated access and staging will be required.

Objective: Remove vegetation that could pose a hazard to dam operations personnel, especially those responsible for wood material collection and transport.

Objective: Avoid burning of all cleared vegetation.

5.2.2 Goal 2: Remove trees in areas where projected inundation depths and durations would be expected to kill tree species that do not tolerate extended flooding or submersion.

Objective: Remove dead trees following a flood event or other event. This is expected to include species that are not highly flood-tolerant in the Final Reservoir Evacuation Area and the Debris Management Evacuation Area.

Objective: Retain snags where feasible.

Objective: Avoid disturbing understory vegetation.

Objective: Remove trees while retaining stumps and minimizing ground disturbance and potential sedimentation.

Objective: Avoid burning of all removed trees.

5.2.3 Goal 3: Remove trees in a manner to avoid and minimize impacts on aquatic and riparian functions along the Chehalis River and its tributaries in the reservoir footprint.

Objective: Apply applicable best management practices (BMPs) to minimize impacts on waterbodies and riparian areas. Key BMPs include, but are not limited to:

(1) Avoid disturbing understory riparian vegetation.

(2) Avoid disturbing stumps and root systems and any logs embedded in the bank.

(3) Leave high stumps where necessary to prevent felled and bucked timber from entering the water.

(4) Leave any retained trees that display large root systems embedded in the bank.

(5) Use reasonable care during timber yarding to minimize damage to the vegetation providing shade to the stream or open water areas and to minimize disturbance to understory vegetation, stumps, and root systems.

(6) Minimize the release of sediment to waters downstream from the yarding activity.

5.2.4 Goal 4: Remove trees in a manner to avoid and minimize impacts to wetland functions in the temporary reservoir footprint to the extent practical.

Objective: Apply applicable BMPs to minimize impacts in wetlands. Key BMPs include, but are not limited to:

(1) Avoid disturbing understory wetland vegetation.

(2) Minimize the release of sediment to waters downstream from the yarding activity.

5.2.5 Goal 5: Minimize temporal loss of tree canopy in the temporary reservoir footprint.

Objective: Conduct 20 percent of the proposed pre-operational tree removal each construction year over the 5-year construction period.

Objective: Replace trees that will eventually be removed at least a 1:1 ratio with tree seedlings within the Debris Management and Initial Reservoir Evacuation Areas. Replaced trees will be planted during the planting season (October-March). Tree species selection will be based on the reservoir evacuation area where replanting is needed (Table 7).

5.2.6 Goal 6: Minimize impacts to understory vegetation during tree removal.

Objective: Conduct tree removals from existing access roads to the greatest extent feasible to avoid impacts on adjacent understory vegetation.

Objective: Use reasonable care during timber yarding to minimize disturbance to understory vegetation, stumps, and root systems.

5.3 Selective Tree Removal Plan

The proposed project will require management of vegetation within the proposed FRE facility footprint and removal of trees and shrubs to accommodate the construction access and staging areas for the new impoundment facility. Existing access roads will be maintained and used for vegetation management activities. As discussed in Section 4.4, most trees in the Debris Management Evacuation and Final Reservoir Evacuation Areas of the temporary reservoir will experience significant stress or mortality resulting from prolonged inundation during a flood event. Following a triggering flood event, the entire temporary reservoir footprint will be assessed, and trees that are deemed dead or likely to die will be targeted for removal. Large trees will be felled and yarded to equipment operating from existing roads. No new access roads are proposed for the vegetation management activities, as existing roads were designed and used for the purpose of active management.

The District commits to the avoidance of burning of trees and other cleared vegetation at the FRE facility site, along routes of new roads, and within the FRE temporary reservoir footprint. To the extent practical, removed trees will be used in the construction of mitigation measures or released downstream to resupply woody material to maintain natural aquatic habitats. Where feasible, the slash generated from tree removal will be retained on-site and used to augment habitat enhancement efforts. Any surplus material will be sold. Root wads will be left in the ground to help stabilize slopes from erosive forces unless they are needed for in-stream habitat mitigation actions.

Additional BMPs to avoid and minimize impacts on threatened and endangered species during vegetation management activities are provided in the *Biological Assessment and Essential Fish Habitat Assessment – Chehalis River Basin Flood Damage Reduction Project: Flood Retention Facility, Airport Levee Improvements, and Mitigation Actions* (HDR 2021e).

5.3.1 Final Reservoir Evacuation Area

The vegetation within the Final Reservoir Evacuation Area will be most affected by the operation of the proposed FRE facility. This area will be flooded most frequently and for a longer duration than the other inundation areas. The approach in this area is to aggressively plant the riparian portions of this area with flood-tolerant species of woody plants, mostly willow species, and monitor the area following a disturbance event and then selectively remove larger vegetation during the dry part of the year. Some of the trees that perish may be retained as downed wood or snags to enhance wildlife habitat on-site.

Monitoring may also reveal other species of plants that could be installed within this area to bolster resiliency.

One goal of the vegetation removal is to reduce the potential for debris and vegetation to damage the new facility and to reduce the safety risk for operations personnel. Full removal of large trees near the facility or trees that have been determined to pose a threat to the safe operation of the facility is recommended to achieve this primary goal. Once the large trees have been removed, appropriate vegetation can be installed. The remaining acres within the Final Reservoir Evacuation Area will be initially in-planted and converted over time to species that are more tolerant of flooding than the existing vegetation, but trees will be removed only following events that cause the trees to die. Shrub and organic material will be retained in this area to provide soil stabilization during the overstory conversion. Large woody debris removed from this area may be harvested in a manner that is conducive for reuse of the material in habitat restoration or enhancement efforts associated with the overall proposed project. For instance, some trees may be removed with their root balls attached so these may be used for engineered logjams or other instream habitat features either upstream or downstream of the facility. Instream habitat restoration actions are being developed as part of a comprehensive mitigation program in coordination with agency stakeholders.

5.3.2 Debris Management Evacuation Area

The Debris Management Evacuation Area is also expected to require logging of affected trees, but some of the existing vegetation is expected to survive and be retained. Tree species that are expected to be intolerant of flooding, such as Douglas fir, will be removed as they perish and replaced with more flood-tolerant species. In-planting trees at the start of construction and prior to logging can assist in the establishment of flood-tolerant species and those that may require some shade during establishment, such as Western red cedar. This area will also include the establishment of a Debris Management Sorting Yard that will intercept and stockpile woody debris that may be transported downstream during a flood event. The woody debris that is stockpiled may be used for habitat enhancement associated with the overall proposed project. Selective replacement of overstory near the river will help moderate the temporal impacts to stream shading and river temperature associated with tree removal in the Debris Management Evacuation Area.

5.3.3 Initial Reservoir Evacuation Area

The Initial Reservoir Evacuation Area is not slated for pre-construction logging. This portion of the reservoir will be inventoried and monitored following construction. Tree retention is proposed to help limit temporal impacts to shading and river temperature associated with the tree removal in the Initial Reservoir Evacuation Area. Monitoring will reveal the need for tree replacements and in-planting once the facility is operational. Flood-tolerant species, such as black cottonwood or Oregon ash, will be inplanted along the riparian fringe and in flatter areas that may experience sedimentation during flooding events that inundate lower portions of the reservoir. The need for additional planting will be determined following a disturbance event through monitoring.

5.4 Facility Operations Selective Tree Removal Plan

Following a flood event, trees in the temporary reservoir footprint will be monitored for significant stress and mortality. Flood stress in plants can cause yellowing or browning of leaves, curled leaves, leaf wilt and drop, reduced size of new leaves, early fall color, branch dieback, formation of sprouts along stems or trunk, and greater susceptibility to harmful organisms such as canker fungi and insects (Jull 2008). There will be uncertainty in predicting an elevation at which trees will likely be severely stressed or killed once the FRE facility is activated during major flood events. The uncertainty is due in part to the unpredictable nature of flood events and in part to the difficulty in predicting how individual trees will respond to inundation.

Trees in the FRE temporary reservoir will be monitored by a forester or other approved professional annually and after periods of prolonged inundation for signs of flood stress. Unhealthy and dead trees will be marked and removed on an as-needed basis to eliminate potential risks to dam operations personnel and facility infrastructure. Trees that will need to be removed will be either cut and removed from the site, topped and retained as a snag, cut and retained on-site as downed large woody debris, or removed and utilized as material for other mitigation actions for the project. Monitoring efforts will also evaluate the establishment of tree and shrub species in areas where planting is conducted (i.e., Debris Management Evacuation and Final Reservoir Evacuation Areas). Additional information on proposed monitoring is described in Section 7.3.

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6.0 Plant Replacement Strategy

6.1 Overview and Purpose

The plant replacement component of this *Vegetation Management Plan* is intended to further refine earlier assumptions concerning the expected vegetation that will viably persist within the proposed temporary inundation area of the FRE facility once it has been constructed. A planting schedule is also provided for each of the proposed replanting areas.

Detailed planting plans will be developed following a flood event, since the actual frequency, intensity, and extent of flood events over time will determine which areas need to be revegetated and cannot be predicted during the design phase. It is anticipated that some areas that are subject to more frequent flooding may need to be revegetated soon after the start of facility construction to allow establishment of more flood-tolerant species. Conversely, some vegetation communities will likely show slower transition over time and not need immediate or whole-scale revegetation efforts. An overall goal of the plant replacement portion of the *Vegetation Management Plan* is to maintain appropriate vegetative cover throughout the temporary reservoir to avoid and minimize impacts on terrestrial and aquatic habitats.

6.2 Plant Replacement Strategy Goals and Objectives

6.2.1 Goal 1: Maintain an appropriate level of riparian vegetation adjacent to the Chehalis River and its tributaries.

Objective: Proactively plant suitable plant species adjacent to the Chehalis River and its tributaries to allow establishment of flood-tolerant species following the start of facility construction and prior to first major flood event.

Objective: Monitor vegetation community survivorship in riparian areas following major flood events.

Objective: Revegetate riparian areas with appropriate plant species as needed in response to major flood events.

6.2.2 Goal 2: Maintain an appropriate level of deciduous riparian vegetation throughout the Debris Management Evacuation Area and Final Reservoir Evacuation Area.

Objective: Proactively plant suitable plant species in the Debris Management Evacuation Area and Final Reservoir Evacuation Area following the start of facility construction and prior to first major flood event.

Objective: Monitor vegetation community survivorship in the Debris Management Evacuation Area and Final Reservoir Evacuation Area following major flood events.

Objective: Revegetate impacted areas of the Debris Management Evacuation Area and Final Reservoir Evacuation Area with appropriate plant species as needed in response to major flood events.

6.2.3 Goal 3: Maintain an appropriate level of existing vegetation in the Initial Reservoir Evacuation Area.

Objective: Monitor vegetation community survivorship in the Initial Reservoir Evacuation Area following major flood events.

Objective: Revegetate impacted areas of the Initial Reservoir Evacuation Area with appropriate plant species as needed in response to major flood events.

6.2.4 Goal 4: Minimize loss of wetland vegetation communities throughout the FRE temporary reservoir.

Objective: Monitor vegetation community survivorship in previously delineated wetlands (Anchor QEA 2018) following major flood events.

Objective: Revegetate impacted wetlands throughout the temporary reservoir footprint with appropriate plant species as needed in response to major flood events.

6.3 Site Preparation

Site preparation will be focused mainly on preparing revegetation and replacement areas so that plantings can successfully establish with minimal maintenance, while avoiding disturbance to surrounding live vegetation. Site preparation methods will include hand cutting or mechanical removal of unhealthy or dead trees and spot treatment with herbicides, if needed prior to replanting. Existing vegetation, including low shrubs and trees, will be retained wherever feasible.

Plant material will be provided from commercial nurseries. Inspection of all woody plants will be conducted to ensure compliance with the revegetation plan specifications regarding size requirements, root ball mass, and overall health of the plant. Planting areas will be delineated per the revegetation plan, with planting conducted under the supervision of District biologists or other qualified staff. Planting is to occur from October through March, avoiding times of FRE operation.

6.4 Planting Plan

The area within the temporary reservoir will be redesignated from commercial forest land to a non-commercial status and will not continue to be regulated under the WDNR Forest Practices Act. Initial planting of the riparian zone and other portions of the temporary reservoir will commence as soon as the District has control of the land and permits are secured for construction of the facility. This is expected to occur in Year 1 of the construction timeline. Different vegetation management strategies will be initiated within each of the identified inundation areas, as duration, extent, and frequency of flooding will be the primary drivers for survival of vegetation in replanted areas. The Debris

Management Evacuation and Final Reservoir Evacuation Areas will likely experience more prolonged and deeper flooding after major flood events, and therefore will require revegetation with more flood-tolerant species. The Initial Reservoir Evacuation Area will experience shorter, shallower periods of flooding, and therefore moderately flood-tolerant species are expected to survive in this area. Currently, limited planting is proposed in the Initial Reservoir Evacuation Area. In-planting within the riparian areas is recommended to help limit erosion along the streamside and to accelerate riparian tree height development. Monitoring will reveal the need for additional tree replacements in the Initial Reservoir Evacuation Area once the facility is operational. Additionally, no planting is proposed within existing access roads or the 4.6-acre FRE Debris Management Sorting Yard, as these areas will need to be maintained to implement the *Vegetation Management Plan* and manage LWM after flood events. For more information on proposed LWM management, refer to the *Large Woody Material Downstream Passage and Placement Clarification Technical Memorandum* (HDR 2021f) prepared for the proposed project.

The replanting areas defined in this plan build upon the previously identified inundation areas and further refine proposed planting strategies based on landscape position and flooding duration expected in each area, and species survival based on data from the Mud Mountain Dam reservoir (HDR 2021a). Plant species proposed for each replanting area and approximate acreages of replanting in the temporary inundation area (following a major flood event) are listed in Table 7 and Table 8, respectively. A description of each planting area is included in Section 6.4.1 through 6.4.4 below. The locations for proposed replanting are shown on Figure 3 through Figure 6.

Table 7. Proposed Plant Schedule by Replanting Area

Replanting Area	Scientific Name	Common Name	Size	Condition	Spacing
Riparian Treatment	**Trees**				
	Salix lasiandra	Pacific willow	3 feet	Live stake	6–10 feet o.c.
	Shrubs				
	Cornus alba	Red-osier dogwood	3 feet	Bare root	3–5 feet o.c.
	Salix exigua	Narrow-leaf willow	3 feet	Live stake	3–5 feet o.c.
	Salix hookeriana	Hooker's willow	3 feet	Live stake	3–5 feet o.c.
	Salix sitchensis	Sitka willow	3 feet	Live stake	3–5 feet o.c.
	Spiraea douglasii	Hardhack	3 feet	Bare root	3–5 feet o.c.
Final Evacuation Area Treatment	**Trees**				
	Salix lasiandra	Pacific willow	3 feet	Live stake	12–15 feet o.c.
	Shrubs				
	Cornus alba	Red-osier dogwood	3 feet	Bare root	6–10 feet o.c.
	Salix exigua	Narrow-leaf willow	3 feet	Live stake	6–10 feet o.c.
	Salix hookeriana	Hooker's willow	3 feet	Live stake	6–10 feet o.c.
	Salix sitchensis	Sitka willow	3 feet	Live stake	6–10 feet o.c.
	Spiraea douglasii	Hardhack	3 feet	Bare root	6–10 feet o.c.
Debris Management Area Treatment	**Trees**				
	Fraxinus latifolia	Oregon ash	3 feet	Bare root	12–15 feet o.c.
	Populus balsamifera	Black cottonwood	3 feet	Bare root	12–15 feet o.c.
	Salix lasiandra	Pacific willow	3 feet	Live stake	12–15 feet o.c.
	Shrubs				
	Cornus alba	Red-osier dogwood	3 feet	Bare root	6–10 feet o.c.
	Lonicera involucrata	Twinberry	3 feet	Bare root	6–10 feet o.c.
	Spiraea douglasii	Hardhack	3 feet	Bare root	6–10 feet o.c.
	Rosa nutkana	Nootka rose	3 feet	Bare root	6–10 feet o.c.
	Rubus spectabilis	Salmonberry	3 feet	Bare root	6–10 feet o.c.
Wetland Mix	**Trees**				
	Alnus rubra	Red alder	3 feet	Bare root	12–15 feet o.c.
	Salix lasiandra	Pacific willow	3 feet	Live stake	12–15 feet o.c.
	Shrubs				
	Cornus alba	Red-osier dogwood	3 feet	Bare root	6–10 feet o.c.
	Rubus spectabilis	Salmonberry	3 feet	Bare root	6–10 feet o.c.
	Salix sitchensis	Sitka willow	3 feet	Live stake	6–10 feet o.c.
	Salix scouleriana	Scouler's willow	3 feet	Live stake	6-10 feet o.c.
	Salix hookeriana	Hooker's willow	3 feet	Live stake	6–10 feet o.c.

Note: o.c. = on center

Table 8. Acreages of Proposed Replanting

Replanting Area	Acres of Replanting (per Inundation Area)	
	Debris Management Evacuation Area (WSEL 528–500 feet)	Final Reservoir Evacuation Area (WSEL 500–425 feet)
Riparian Treatment	67	83
Final Evacuation Area Treatment	0	29
Debris Management Area Treatment	37	0
Wetland Mix	1	3
Total:	105	115

Note: No replanting is currently proposed in the Initial Reservoir Evacuation Area. Areas of replanting exclude existing roads and the FRE Debris Management Sorting Yard, as these areas would need to be maintained to implement the *Vegetation Management Plan* and manage LWM after flood events. Proposed replanting will occur in 86% of the overall Debris Management Evacuation Area (roughly 122 acres total) and 72% of the Final Reservoir Evacuation Area (roughly 159 acres total).

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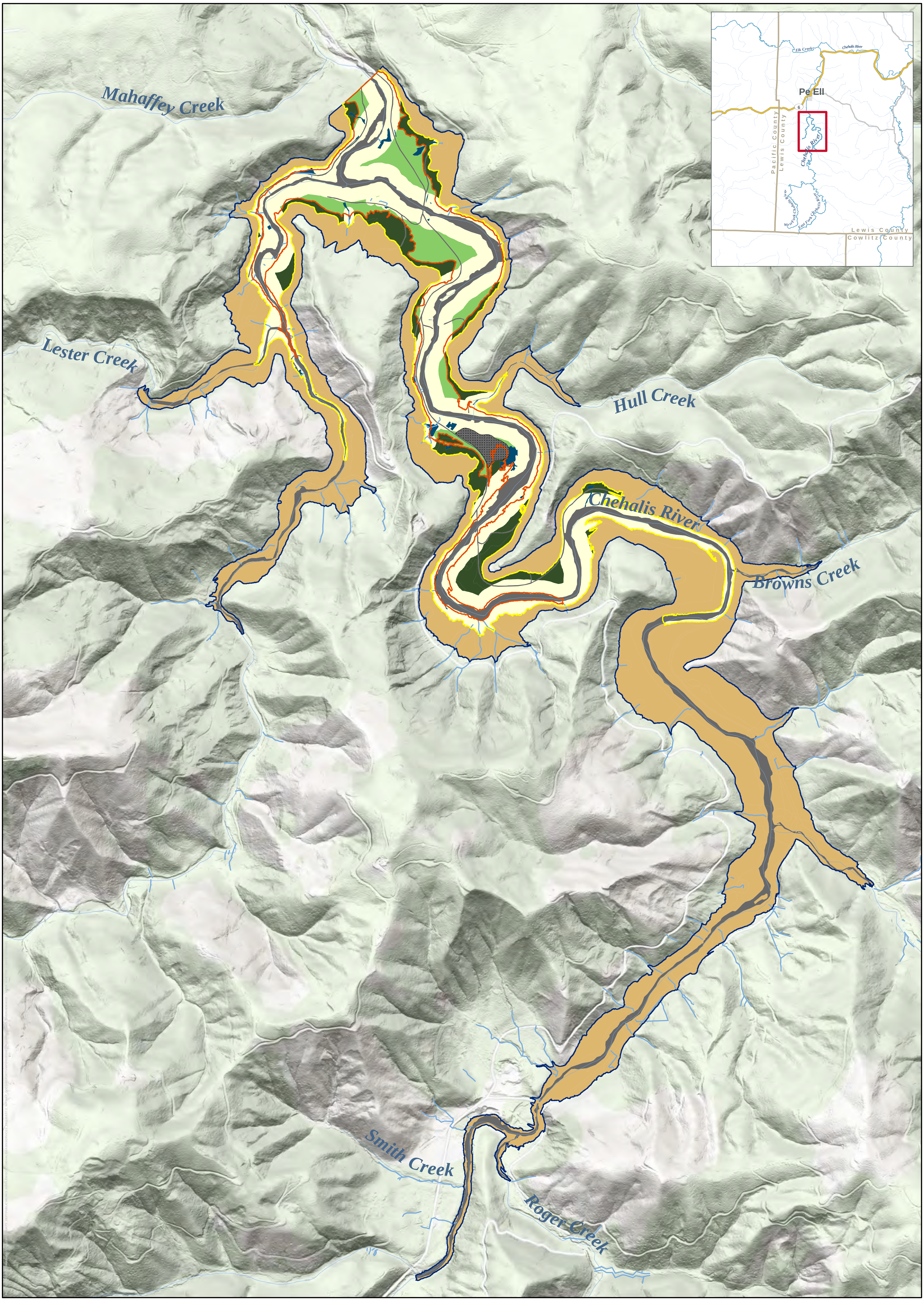

Source: Landcover, FRE Facility - HDR; Streams - DNR; Basemap - ESRI Online; Hillshade - DNR LiDAR Portal

Mapped Tributary
Debris Management Sorting Yard
Final Reservoir Evacuation Area
Debris Management Evacuation Area
Initial Reservoir Evacuation Area

Proposed Planting Area
Debris Management Area Treatment
Final Evacuation Area Treatment
Riparian Treatment
Wetland Mix
No Treatment
Initial Evacuation Area - No Treatment

N

0 1,000 2,000

Feet

FIGURE 3: PROPOSED PLANTING AREAS

Chehalis River Basin Flood Damage Reduction Project

Date: 11/30/2021

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FIGURE 4: PROPOSED PLANTING AREAS

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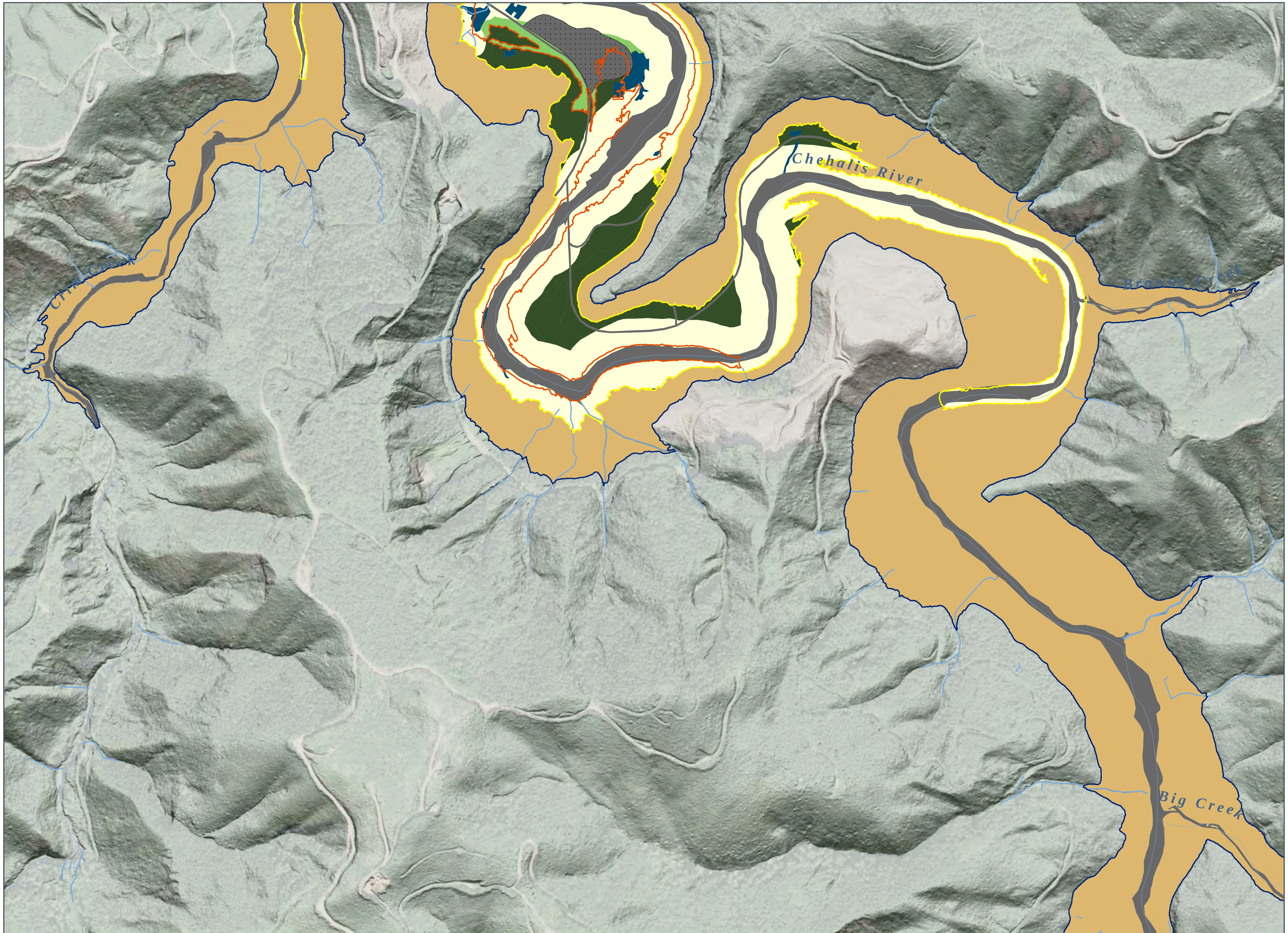

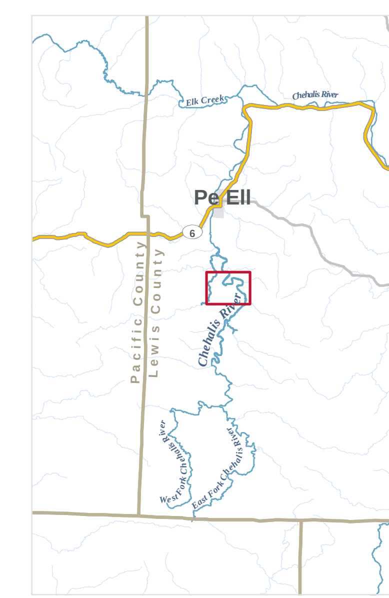

FIGURE 5: PROPOSED PLANTING AREAS

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FIGURE 6: PROPOSED PLANTING AREAS

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6.4.1 Riparian Treatment

The Riparian Treatment area includes all proposed planting that is within 200 feet of the Chehalis River or Crim Creek (Type S streams) or within 150 feet or 75 feet of smaller tributaries within the temporary inundation area, depending on their mapped WDNR stream types. Treatment widths were applied to mapped streams following the guidance of Lewis County Code buffers for Aquatic Priority Habitat Areas outlined in Lewis County Code 17.38.420, Table 17.38-6.

The species chosen for the Riparian Treatment were selected because they are generally flood-tolerant, rapidly growing species that can be reasonably expected to persist following an inundation event. Additionally, woody species in the Riparian Treatment area will be planted at greater densities than other planting areas to promote streambank stability and increase shading adjacent to streams in the temporary inundation area.

Approximately 83 acres of land suitable for planting (i.e., areas within the temporary inundation area excluding existing roads and the FRE Debris Management Sorting Yard) will receive the Riparian Treatment within the Final Reservoir Evacuation Area. Approximately 67 acres of land suitable for planting will receive the Riparian Treatment within the Debris Management Evacuation Area (Table 8).

6.4.2 Final Evacuation Area Treatment

The Final Evacuation Area Treatment includes all proposed planting areas that are within the Final Reservoir Evacuation Area but outside of the designated Riparian Treatment area (i.e., located more than 200 feet from the Chehalis River and Crim Creek and greater than 150 feet or 75 feet from smaller tributaries, depending on their mapped WDNR stream type). The species chosen for the Final Evacuation Area Treatment are identical to the species selected for the Riparian Treatment; the proposed treatments differ only in density of planting. These species are generally flood-tolerant, rapidly growing species that will contribute to the growth of woody vegetation in the Final Reservoir Evacuation Area.

Approximately 29 acres of land suitable for planting will receive the Final Evacuation Area Treatment (Table 8).

6.4.3 Debris Management Area Treatment

The Debris Management Area Treatment includes proposed planting within the Debris Management Evacuation Area that is outside of the Riparian Treatment area described above. The species chosen for the Debris Management Area Treatment were selected because they are moderately flood-tolerant species that can be reasonably expected to persist in the Debris Management Evacuation Area following an inundation event.

Approximately 37 acres of land suitable for planting will receive the Debris Management Area Treatment (Table 8).

6.4.4 Wetland Mix

Wetlands mapped in the Debris Management Evacuation Area and Final Reservoir Evacuation Area will be planted with a Wetland Mix described in Table 7. Preference will be given to flood-tolerant species that currently occur in the existing wetlands, as identified by Anchor QEA (2018), including red alder, salmonberry, and willows. Vegetation management activities occurring within or adjacent to existing wetlands will be conducted in accordance with Lewis County mitigation requirements.

Approximately 1 acre and 3 acres of existing wetlands will be planted with the Wetland Mix within the Debris Management Evacuation Area and Final Reservoir Evacuation Area, respectively (Table 8).

6.5 Planting Density and Erosion

As mentioned in Section 6.4.1, areas immediately adjacent to existing stream channel will be densely planted with species included in the Riparian Treatment area (primarily willows) to promote streambank stability adjacent to streams, including the Chehalis River, Crim Creek, Lester Creek, and other mapped tributaries. Following guidance outlined in USDA NRCS Technical Note Plant Materials No. 23 (Hoag 2007), proposed planting areas have been designed to increase in “roughness” away from the central stream channel to center high flows and slow water velocity. Roughness is defined as “resistance to flow contributed by vegetation, rough surfaces, or structures” (Hoag 2007).

Dense willow plantings in the Riparian Treatment area have been selected to provide dense thickets of shrubby vegetation that will bend with high flows and slow velocity against more erosive stream banks and terraces. Proposed planting in areas farther away from the stream channels (i.e., Debris Management Area Treatment and Final Evacuation Area Treatment) have been designed to support stiffer woody vegetation that further slows flow and reduces erosion.

6.6 Expected Tree Heights

Table 9 presents the assumptions of species height over a 50-year growth horizon after planting. A literature review was completed to determine approximate growth rates for red alder, Western red cedar, Sitka spruce, black cottonwood, Oregon ash, Pacific willow, and Sitka willow. Literature reviewed include scientific journal articles, silviculture resources, public university and governmental plant indices, and local plant society webpages. Results were found by querying the species names with “growth rate,” “height,” “site index curves,” “stand,” or “seedling.” Sources were determined to provide relevant information for the purposes of estimating growth rates based on the type of study conducted, variables measured, and location of study. For scientific research articles, heights of individuals over time were collected for the control groups, and experimental groups were excluded. For silviculture resources, multiple site index curves were reported for each species; low site indices indicate poor site conditions and correlate with slower growth rates. A low site index was selected for the literature review, as this provided a more conservative estimate of growth over time based on the proposed site conditions of the planting areas. Public university, government, and local plant society resources generally provided overall heights of mature individuals of tree species and relative growth rates (e.g., rapid, slow).

A greater amount of data was found to be available for the growth rates of red alder, Western red cedar, Sitka spruce, and black cottonwood. This is likely due to their greater economic importance for timber production and the need for knowledge of growth on varying site conditions over time. Silviculture resources and scientific journals were able to provide ample data for these species. For species with little to no timber production value—Oregon ash, Pacific willow, and Sitka willow—less data on growth rates was available, and scientific journal articles were relied on more heavily. Thus, a less-complete estimate of height over time was able to be gathered for these species from the literature. In addition, scientific journal articles more frequently studied changes in diameter at breast height over time in response to experimental variables as opposed to height over time, limiting the availability of usable data for the purposes of this literature review.

Estimations for tree heights over time were determined by averaging the available data for each species for each age interval. Age intervals for which no available data was found were estimated based on similar species, and/or extrapolation from overall mature tree heights, age to maturity, and known heights at other age intervals (as indicated in Table 9). Overall heights were calculated by averaging reported mature tree heights from available resources.

Figure 7 shows a conceptual representation of the *Vegetation Management Plan* implementation timeline in addition to expected growth of trees and shrubs planted in the temporary reservoir footprint over time. The construction phasing outlined in Figure 7 is described in more detail in *Proposed Flood Retention Dam Construction Schedule Supplemental Information* (HDR 2019).

Table 9. Expected Tree Heights Over Time

Tree Species	Source	Estimated Tree Height (feet)							
		Year 1	Year 5	Year 10	Year 20	Year 30	Year 40	Year 50	Mature Height[a]
Red alder (*Alnus rubra*)	Deal et al. 2004, Harrington et al. 1994, Mitchell and Polsson 1988, Niemiec and OSU 1995, Tilley et al. 2012	5.0[b]	26	35	43	55	59	666	90
Western red cedar (*Thuja plicata*)	Burns and Honkala 1990, Messier and Kimmins 1991, Mitchell and Polsson 1988, Negrave et al. 2007, Nigh 2000, Viereck and Little 1972	1	6	18	30	45	58	71	150
Sitka spruce (*Picea sitchensis*)	Burns and Honkala 1990, Centritto et al. 1998, Farr and Harris 1979, Meyer 1937, Mitchell and Polsson 1988, Roulund 1973, Tashe and Borges 2011, Viereck and Little 1972	1	4	8	21	31	44	64	200
Black cottonwood (*Populus balsamifera spp. Trichocarpa*)	Cline and McAllister 2012, Kennedy 1985, Murray and Harrington 1983, Niemiec and OSU 1995, Shaw and Packee 1998, Tashe and Borges 2011, Tilley et al. 2012, Viereck and Little 1972	5	25	30	46	75	68	69	100
Oregon ash (*Fraxinus latifolia*)	Burns and Honkala 1990, Viereck and Little 1972	2	9	18	35	47	58	70	70
Pacific willow (*Salix lasiandra*)	Cline and McAllister 2012, Darris and Lambert 1993, Tilley et al. 2012, Viereck and Little 1972, WNPS 2021	1	10	35	51	51	51	51	53
Sitka willow (*Salix sitchensis*)	Coville 1900, Darris and Lambert 1993, Hill 2005, Tashe and Borges 2011, Tilley et al. 2012, Viereck and Little 1972	1	1	2	7	12	17	17	23

[a] Mature heights source: USDA Plants Database https://plants.usda.gov/home

[b] Age intervals for which no available data was found and were estimated based on similar species, and/or extrapolation from overall mature tree heights, age to maturity, and known heights at other age intervals.

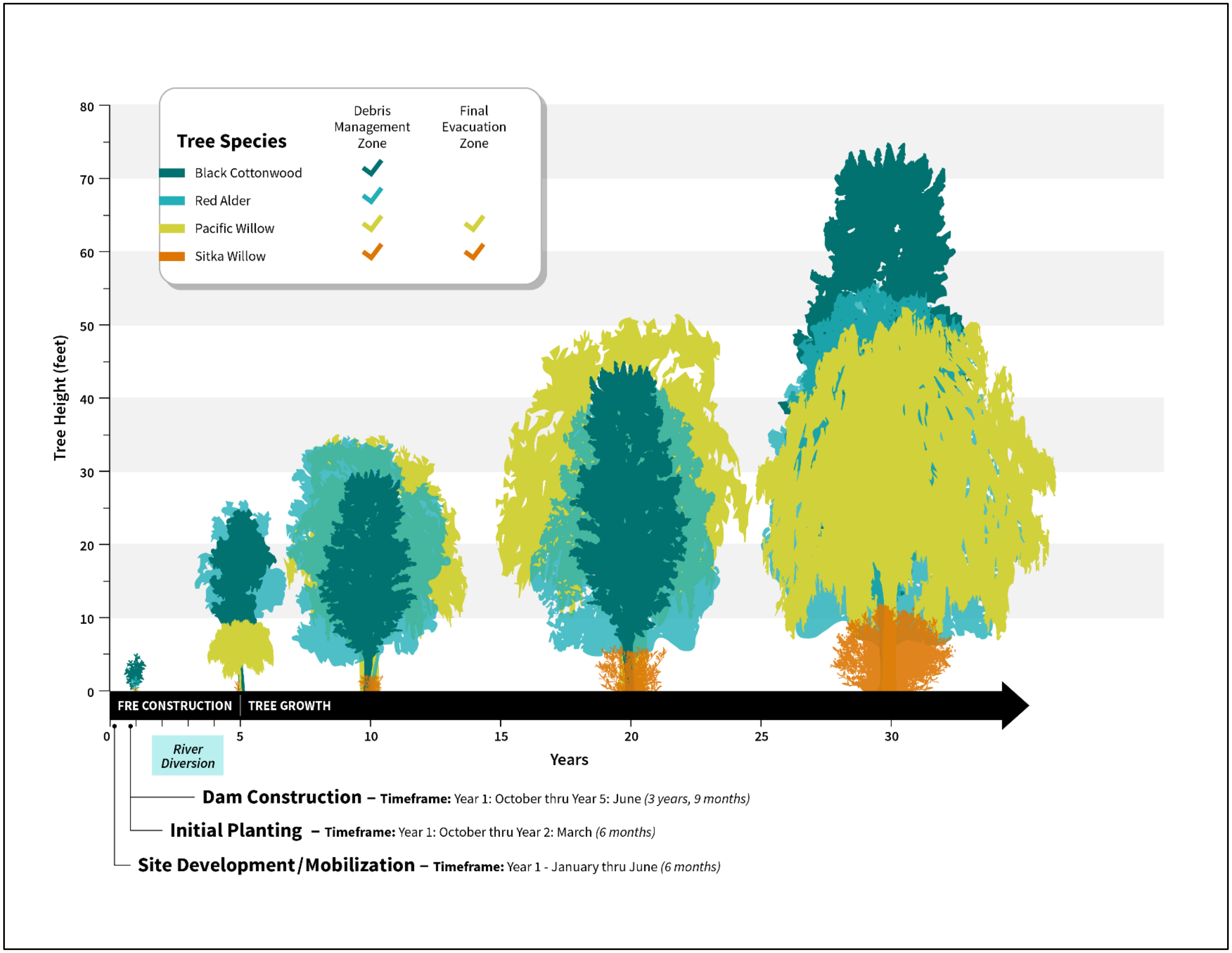

Figure 7: Conceptual VMP Implementation and Tree Growth Timeline

6.7 Expected Canopy Cover

The goal of this *Vegetation Management Plan* is to establish flood-tolerant vegetation that can be expected to persist over time after construction of the proposed project. The proposed planting scheme provided in Section 6.4 relies in part on establishing plant species that can be expected to grow rapidly in full sun and within an altered hydrologic regime. Overall, plant cover is a function of plant growth and how densely the initial plantings are spaced. To facilitate the establishment of canopy cover, especially within the riparian zone of the Chehalis River and its tributaries, dense (3 feet on center) plantings are proposed. This type of dense planting is expected to result in 80 to 100 percent cover after a period of 5 to 10 years. The existing cover that is provided by both trees and shrubs will be removed following mortality, but may still function as shade for the riparian areas while the new plantings are becoming established and before the first event activates the facility. The monitoring plan will specifically measure cover compliance over time. The dense planting over such a large area will require a large number of planting stock, and to help ensure that plants will be available for this effort, plants have been specified as “Live Stakes” wherever feasible due to both the ease of planting and the ease of propagation. Some contract growing may be required.

7.0 Draft Adaptive Management Approach

7.1 Overview

The adaptive management approach of the *Vegetation Management Plan* addresses how uncertainties regarding the frequency, duration, and intensity of future flood events and resulting impacts on vegetation will be considered in order to inform the management of vegetation in the reservoir footprint. Although impacts from future flood events are unknown, the *Vegetation Management Plan* is designed to manage for resilience in response to future disturbance.

For the purposes of this plan, “adaptive management” refers to actions taken as part of the proposed project to:

- Establish long-term ecological goals and objectives to avoid and minimize long-term impacts to riparian, wetland, and upland habitats;
- Identify uncertainties associated with future flood events and potential impacts on vegetation in the temporary reservoir footprint;
- Identify potential problems, possible solutions, and site management adjustments to rectify foreseeable issues based on results of long-term monitoring;
- Provide contingency plans if needed for proposed vegetation management; and
- Serve as part of the feedback loop between vegetation monitoring and management actions that will lead to appropriate adjustment.

Pre-construction, during construction, and during operations (pre-inundation and post-inundation) monitoring, adaptive management goals and objectives and replanting treatments will be applied based on the inundation areas identified previously in this *Vegetation Management Plan*. The draft adaptive management component of the *Vegetation Management Plan* described below presents basic plan elements that will be developed in more detail into the *Vegetation Management Plan* once permitting is underway.

7.2 Adaptive Management Goals, Objectives, and Contingencies

The following Adaptive Management Goals are established to govern the adaptive management component of the *Vegetation Management Plan*; Adaptive Management Objectives describe individual components of the adaptive management process designed to achieve the goals.

Performance standards, which identify measurable, quantifiable indicators of performance relative to the restoration goals and objectives, will be developed as part of the final *Vegetation Management Plan* once proposed goals and objectives are confirmed during permitting. Examples of minimum performance standards to be proposed for planting areas include measurable indicators of survivability (i.e., 100 percent survival of planted stock in Year 1; minimum 80 percent survival of planted stock in Year 2 through 10, etc.), woody vegetation cover (i.e. minimum 25 percent cover of planted areas in Year 1; 50 percent cover in Year 2; 60 percent cover in Year 3, etc.), and tree height (i.e., planted Pacific willow minimum 0.5 feet in Year 1; 9.5 feet in Year 5; 35 feet in Year 10, etc.).

7.2.1 Riparian Treatment

Goal 1: Maintain the minimal acceptable level of riparian function in the FRE temporary reservoir footprint compared to pre-construction conditions.

Objective: Maintain the following functions in Riparian Treatment areas at the minimal acceptable level as determined during the permitting process:

(1) Stream shading

(2) Stream bank stability

(3) Woody debris availability and recruitment

(4) Sediment filtering

(5) Nutrients and leaf litter fall

Objective: Monitor woody plant cover over time to estimate stream bank stability and monitor ability of riparian woody vegetation to prevent erosion caused by rapid drops in flow after flooding.

Objective: Monitor bank undercutting and scouring during peak flow events and flooding.

Objective: Monitor riparian treatment planting installation for survivorship of plant installation and percent plant cover through the use of belt and/or line transects. Survival of installed riparian treatment plants will be determined by a count of the number of living plants compared to the number of installed plants (percent survivability).

Objective: Monitor sediment deposition along the stream banks to determine if growth and/or survivability is adversely impacted during peak flow and flood events.

7.2.2 Final Evacuation Area Treatment

Goal 2: Minimize loss of deciduous riparian vegetation communities in the Final Reservoir Evacuation Area compared to pre-construction conditions.

Objective: Retain the net acreage of deciduous riparian vegetation identified in the Final Reservoir Evacuation Area during pre-construction monitoring as deciduous riparian habitat.

Objective: Monitor vegetation communities receiving the Final Evacuation Area Treatment through the use of belt and/or line transects to determine survivorship of plant installation and percent plant cover. Survival of installed plants will be determined by a count of the number of living plants compared to the number of installed plants (percent survivability).

7.2.3 Debris Management Area Treatment

Goal 3: Minimize loss of deciduous riparian vegetation communities in the Debris Management Evacuation Area compared to pre-construction conditions.

Objective: Retain the net acreage of deciduous riparian vegetation identified in the Debris Management Evacuation Area during pre-construction monitoring as deciduous riparian habitat.

Objective: Monitor vegetation community survivorship and percentage plant cover in areas receiving the Debris Management Area Treatment through the use of belt and/or line transects. Survival of installed plants will be determined by a count of the number of living plants compared to the number of installed plants (percent survivability).

7.2.4 Wetlands

Goal 4: Minimize loss of wetland vegetation communities in the FRE temporary reservoir compared to pre-construction conditions.

Objective: Quantify acreage of wetland vegetation communities during pre-construction monitoring and confirm no net loss of wetland communities following FRE construction.

Objective: Monitor wetland hydrology by visual inspection, excavating soil pits, and photograph documentation.

Objective: Monitor wetland vegetation with belt and/or line transects to determine survivorship and percent plant cover of wetland plant species. Survival of installed wetland mix plants will be determined by a count of the number of living plants compared to the number of installed plants (percent survivability).

7.2.5 Noxious and Invasive Weeds in all Planting Areas

Goal 5: Limit the establishment of noxious and invasive weeds throughout the planting areas in the FRE temporary reservoir. Establishment of weeds should not exceed 20 percent plant cover.

Objective: Eradicate all Class A weeds and control selected Class B weeds on Lewis County's noxious weed list (2020) if identified in the reservoir footprint.

Objective: Contain specific damaging invasive species of plants, such as Japanese knotweed, within the disturbed areas of the reservoir and aggressively manage occurrences to limit downstream effects.

Objective: Determine method for noxious and/or invasive weed removal/control based on species type, severity of infestation, and conditions of infested area (e.g., herbicide application, mowing).

7.2.6 Slope Stability in all Planting Areas

Goal 6: Minimize loss of vegetation communities as a result of landslides and slope failure throughout the planting areas in the FRE temporary reservoir.

Objective: In the event of a landslide, monitor vegetation communities survivorship and percentage plant cover through the use of belt and/or line transects.

7.2.7 Potential Remedial Actions

The inherent unpredictable nature of disturbance effects on natural systems requires the use of indicators and flexibility. A set of potential remedial actions is proposed to address ecological needs as they arise, but other actions may be revealed through monitoring and consultation with agencies or interested parties. The adaptive management plan goals, objectives, and performance standards create a baseline by which to measure whether the site is performing as proposed and whether a contingency plan is necessary. All potential remedial actions cannot be anticipated.

The contingency plan will be flexible so that modifications can be made if portions of the adaptive management process do not produce the desired results. Problems or potential problems will be evaluated by the District. Specific scientifically and economically feasible contingency actions will be developed and implemented to correct deficiencies as appropriate. Contingency actions listed are only a subset of potential actions. All contingency actions discussed below will be considered and the appropriate actions taken based on an understanding of the actual causes of poor performance.

Resource/Issue: Sites do not meet goals and objectives for respective vegetation planting areas

- Revegetate with appropriate plant species for the respective vegetation planting areas.
- Re-evaluate the suitability of the plant species for site conditions.
- Consider use of alternate species.
- Undertake additional monitoring.

Resource/Issue: Over-competition by invasive species

- Identify/Evaluate predominant invasive species in the mitigation areas.
- Initiate invasive species control protocols appropriate to species type, conditions of infestation area, and level of infestation (e.g., herbicide application, mowing).

Resource/Issue: Drought stress

- Identify areas in which installed plants are adversely affected by lack of groundwater and/or precipitation (i.e., premature senescing of herbaceous plants during the growing season, yellow or browning leaves, loss of leaves on deciduous or conifer individuals during the growing season).
- Revegetate with appropriate plant species for the respective vegetation planting areas.
- Re-evaluate the suitability of the plant species for site conditions.

Resource/Issue: Herbivory

- Identify areas in which installed plants are excessively affected by herbivory. Herbivorous species in the project area may include elk, deer, and small mammals.
- Implement herbivory deterrents to affected areas such as chemical repellants or physical barriers.
- Determine if affected plants need replacement and if planting mix for the affected area needs to be amended with species of lower herbivory susceptibility.

Resource/Issue: Excess sedimentation after landslide or inundation events

- Identify areas in which existing vegetation and/or installed plants are adversely affected by excess sediment after a landslide or inundation event.
- Revegetate with appropriate plant species for the respective vegetation planting areas.
- Re-evaluate the suitability of the plant species for site conditions.

Resource/Issue: Increased impacts to vegetation caused by more frequent and potentially longer duration operations of the FRE facility due to climate change

- Identify areas in which existing vegetation and/or installed plants are adversely affected by inundation events.
- Revegetate with appropriate plant species for the respective vegetation planting areas.
- Re-evaluate the suitability of the plant species for site conditions.
- Undertake additional vegetation monitoring.

7.3 Adaptive Management Monitoring

7.3.1 Monitoring Methods

Long-term monitoring will be conducted annually to evaluate vegetation conditions in the FRE temporary reservoir footprint, especially following periods of inundation. Monitoring efforts will focus on evaluating whether performance standards are being met. The monitoring phase of the proposed project is expected to consist of iterative and corrective measures, such as removing invasive species, and is expected to occur for the lifetime of the FRE facility operations. Performance standards will be identified in the final *Vegetation Management Plan*.

Potential monitoring methods to evaluate vegetation conditions include a combination of vegetation surveys and photo documentation in areas of replanting and various locations throughout the FRE temporary reservoir footprint following an inundation event. Vegetation conditions in the temporary reservoir could also be evaluated with the use of drones or unmanned aerial vehicles equipped with cameras, as these devices may represent a more cost-effective and efficient method for data collection in remote areas of the temporary reservoir as opposed to manual field surveys. Additionally, two common quantitative field data collection methods that are recommended to assess plant survival and areal cover are belt transect sampling and line-intercept sampling. These sampling methods generally follow the procedures described in the *Field and Laboratory Methods for General Ecology* (Brower et al. 1998).

Plant survival in each transect will be determined by establishing a 6-foot-wide belt transect centered on multiple transect lines. The species, vigor, and transect location of each plant within the belt transect will be recorded on data sheets. The areal cover of planted trees and shrubs in each transect will be estimated by line-intercept method. For each shrub or tree that falls directly under or above the transect line, the plant species and the intercept length to the nearest tenth of a foot will be recorded from the point the plant is first encountered along the transect line to the point it ends. In addition to randomized sampling locations, permanent transects will be established in multiple representative planting areas throughout the temporary reservoir footprint, in order to establish a monitoring baseline and assess relative species survival over time.

7.3.2 Monitoring Schedule

Pre-construction monitoring will be conducted once, 1 to 2 years prior to start of construction activities during the growing season, as well as during construction of the FRE facility. Post-construction monitoring will commence from the month that the planting schedule is completed to document installation of plants and establish baseline data for future monitoring reports. Additional monitoring will be conducted in perpetuity during operations of the FRE, both annually during the growing season and after flooding events once inundation has dissipated.

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Appendix A. Inundation Maps for Historic and Modeled Major Flood Events

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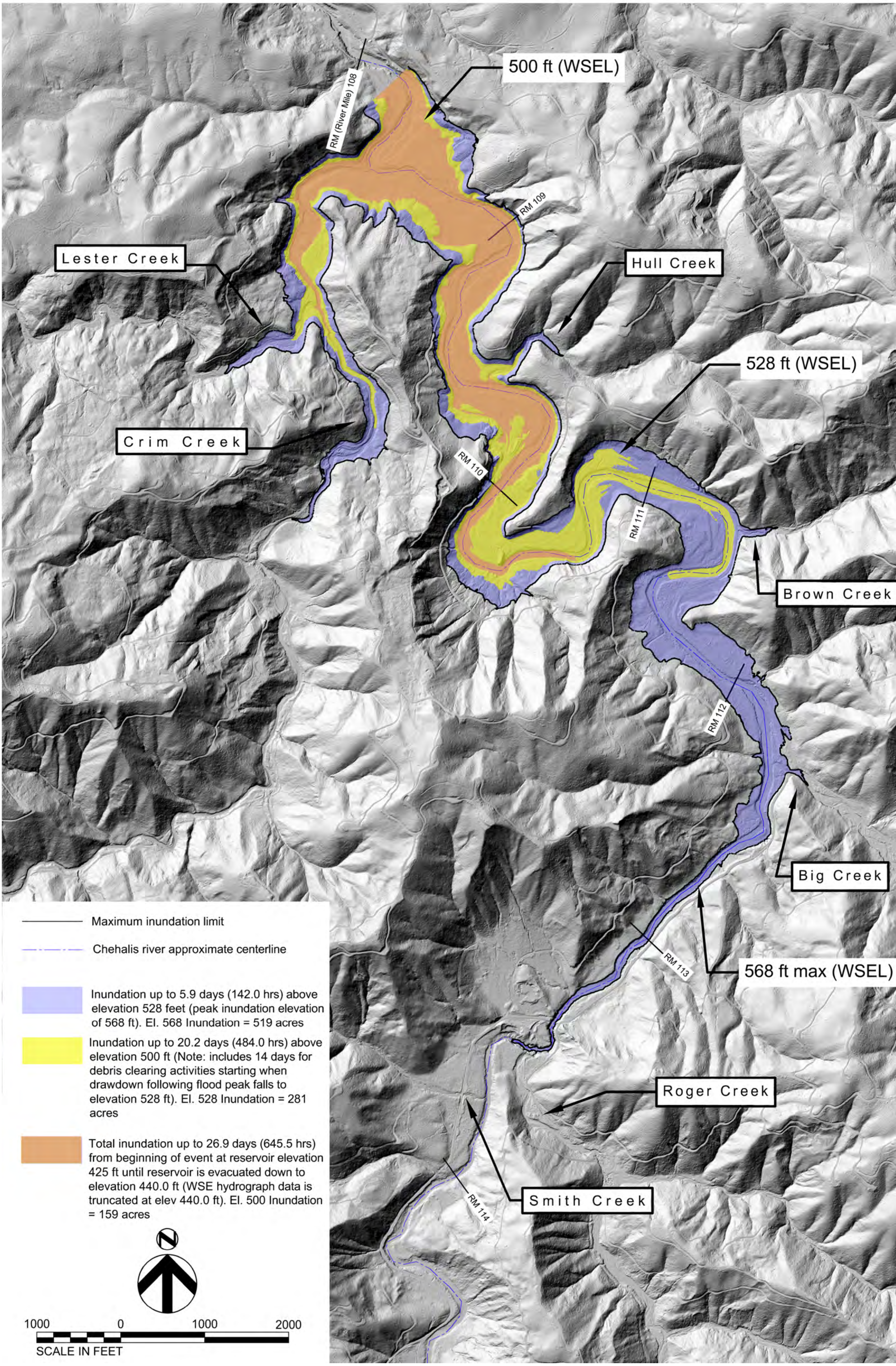
10 Year Event Inundation Map for Proposed Dam (FRE)



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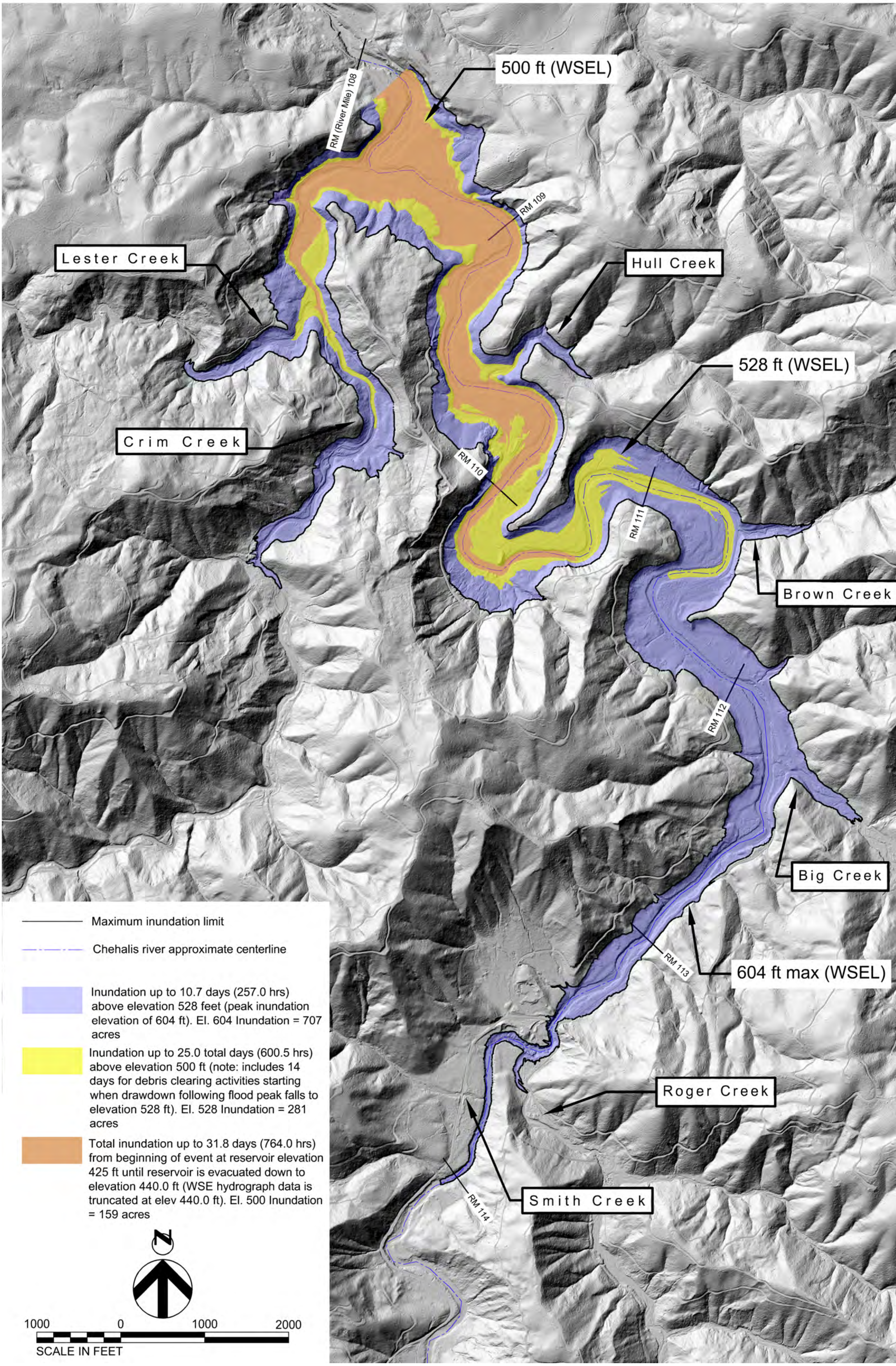
100 Year Event Inundation Map for Proposed Dam (FRE)



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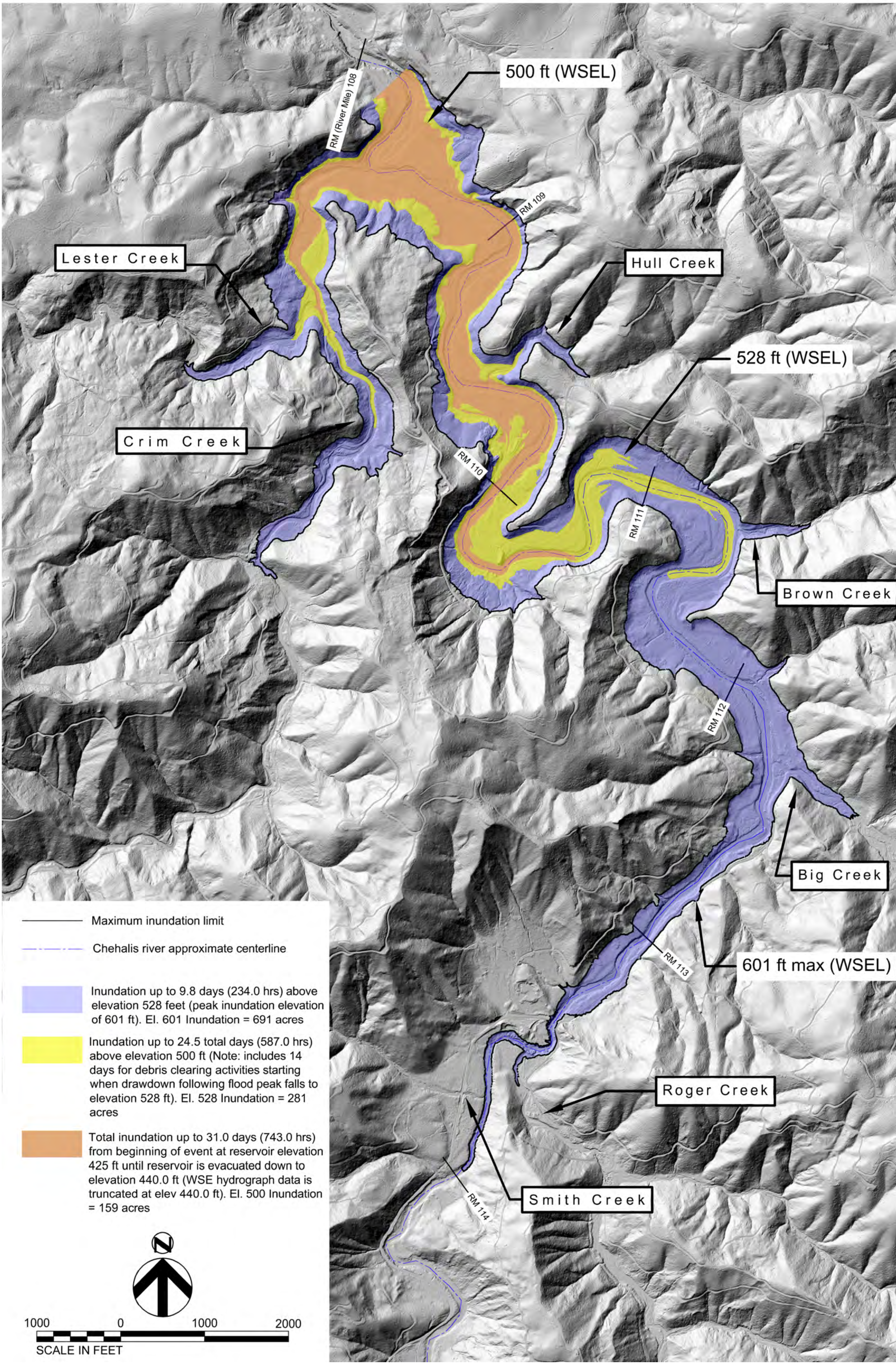
1996 Event Inundation Map for Proposed Dam (FRE)



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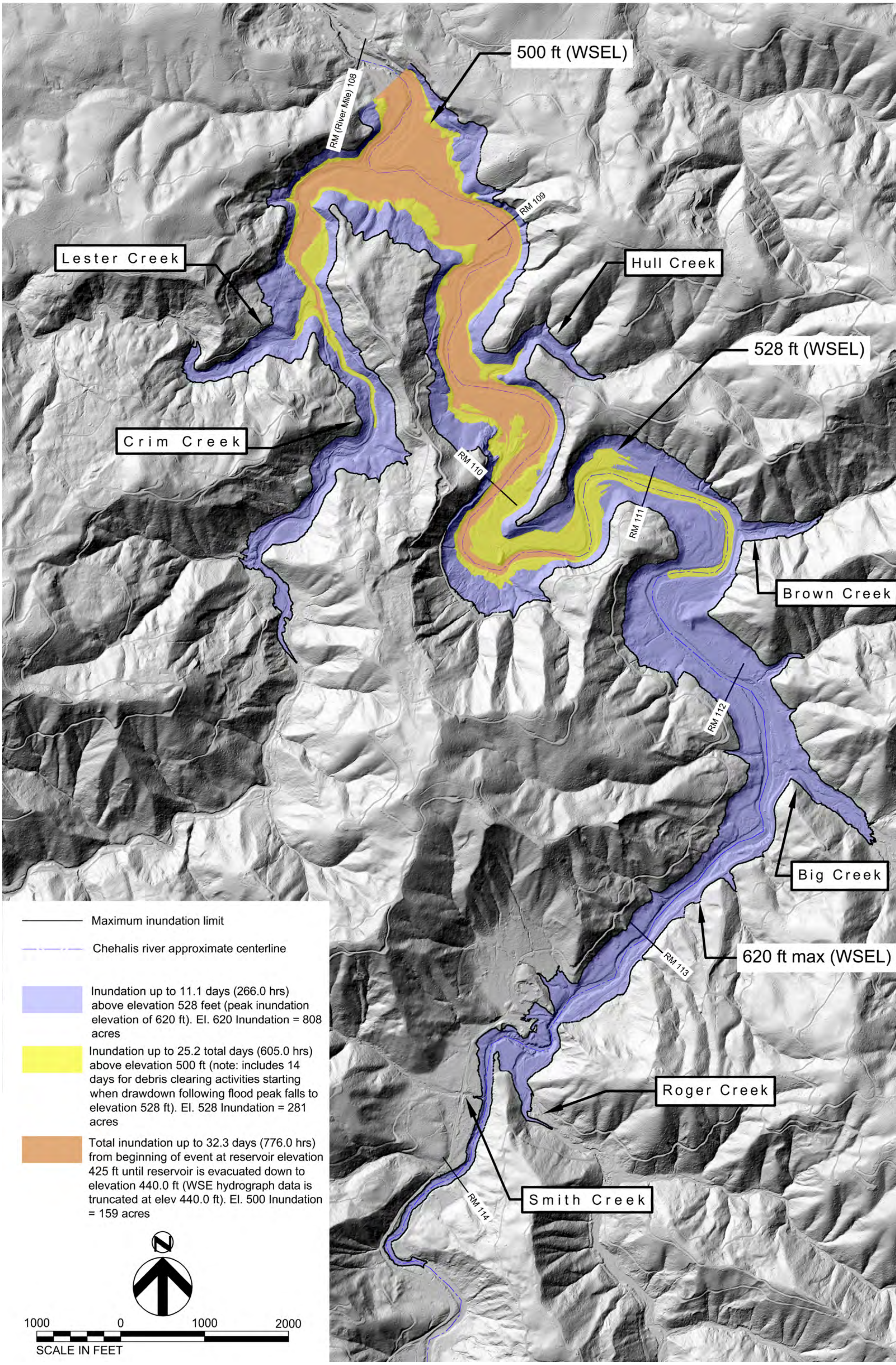
2007 Event Inundation Map for Proposed Dam (FRE)



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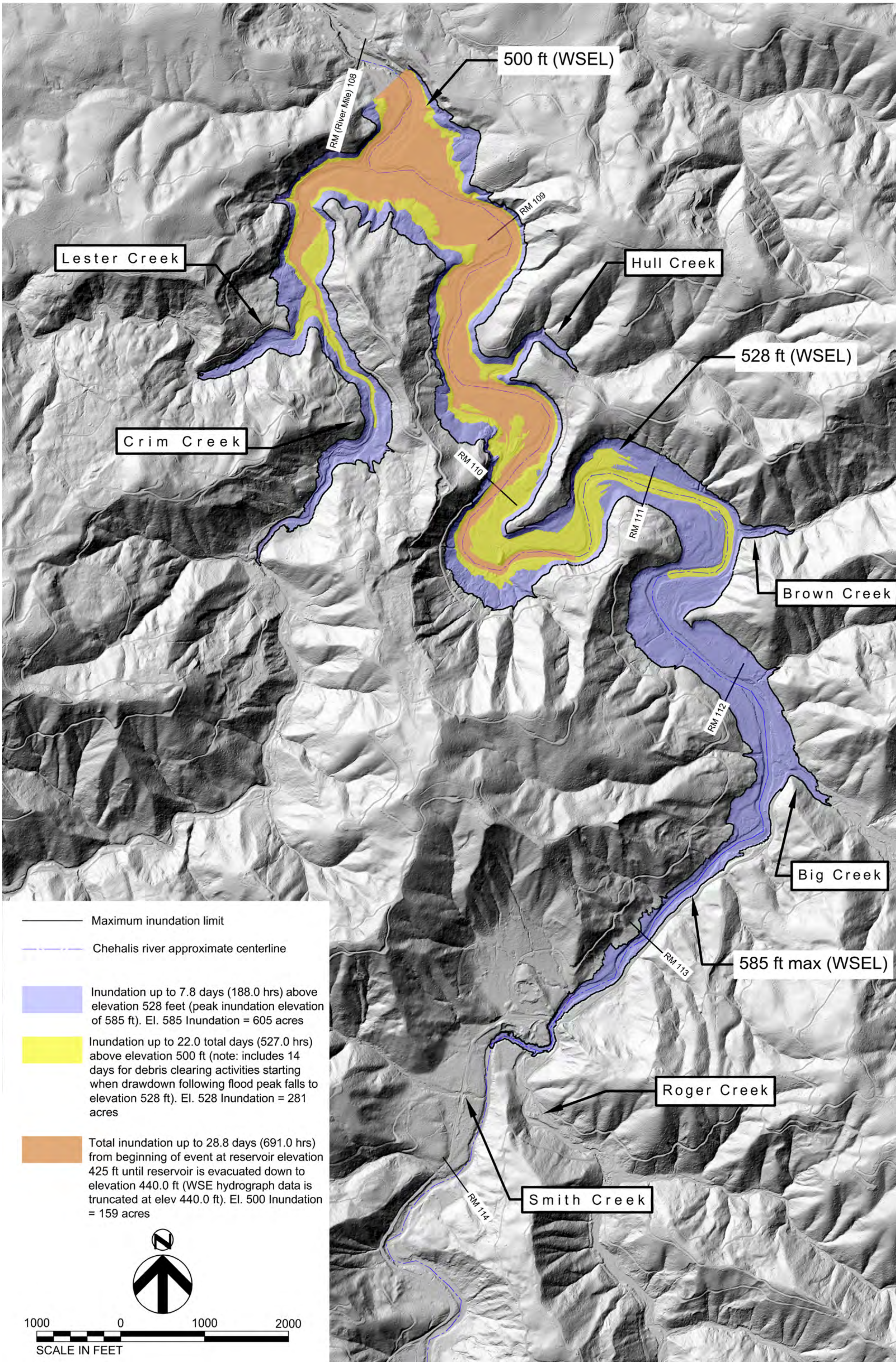
2009 Event Inundation Map for Proposed Dam (FRE)



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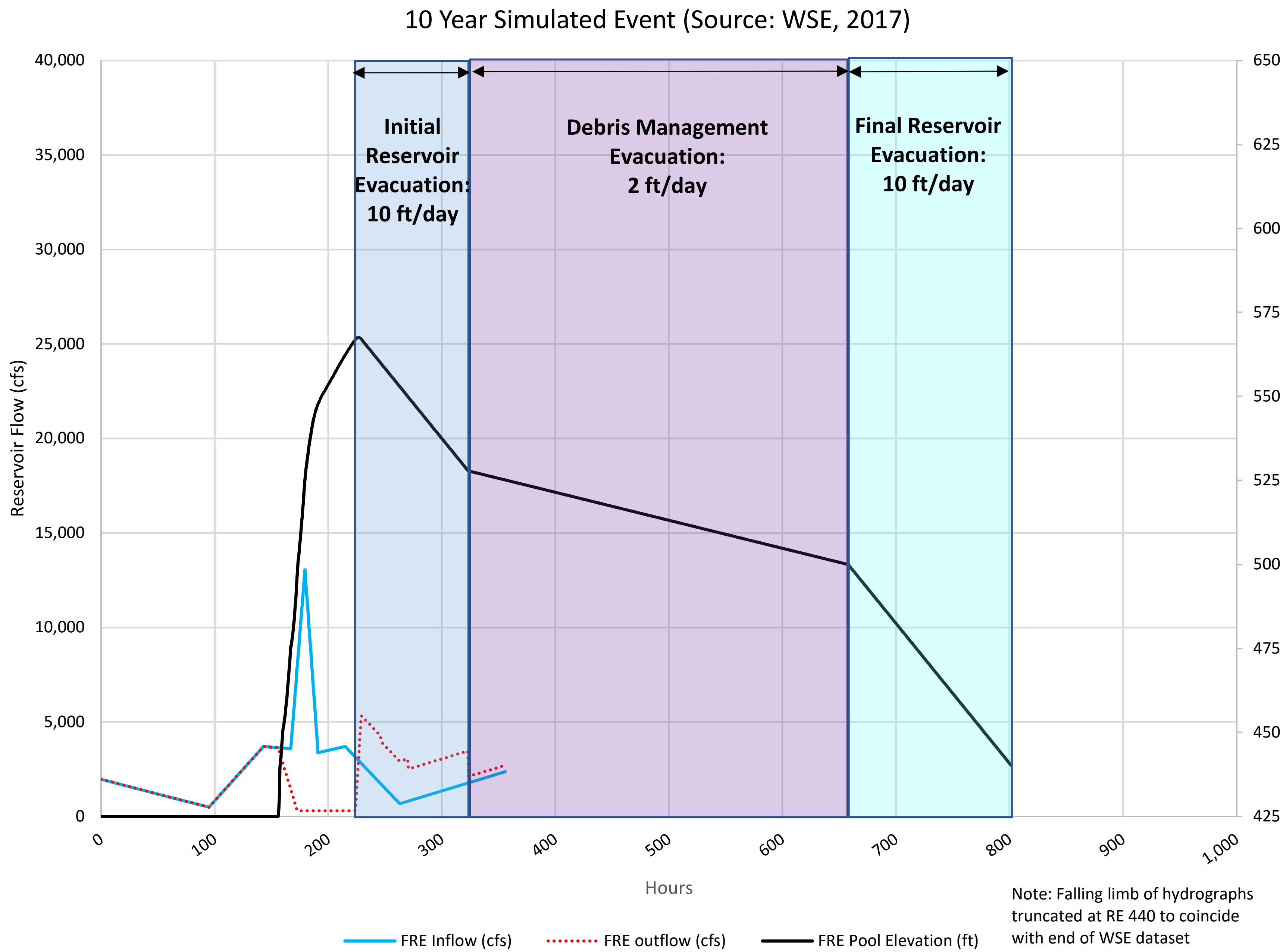
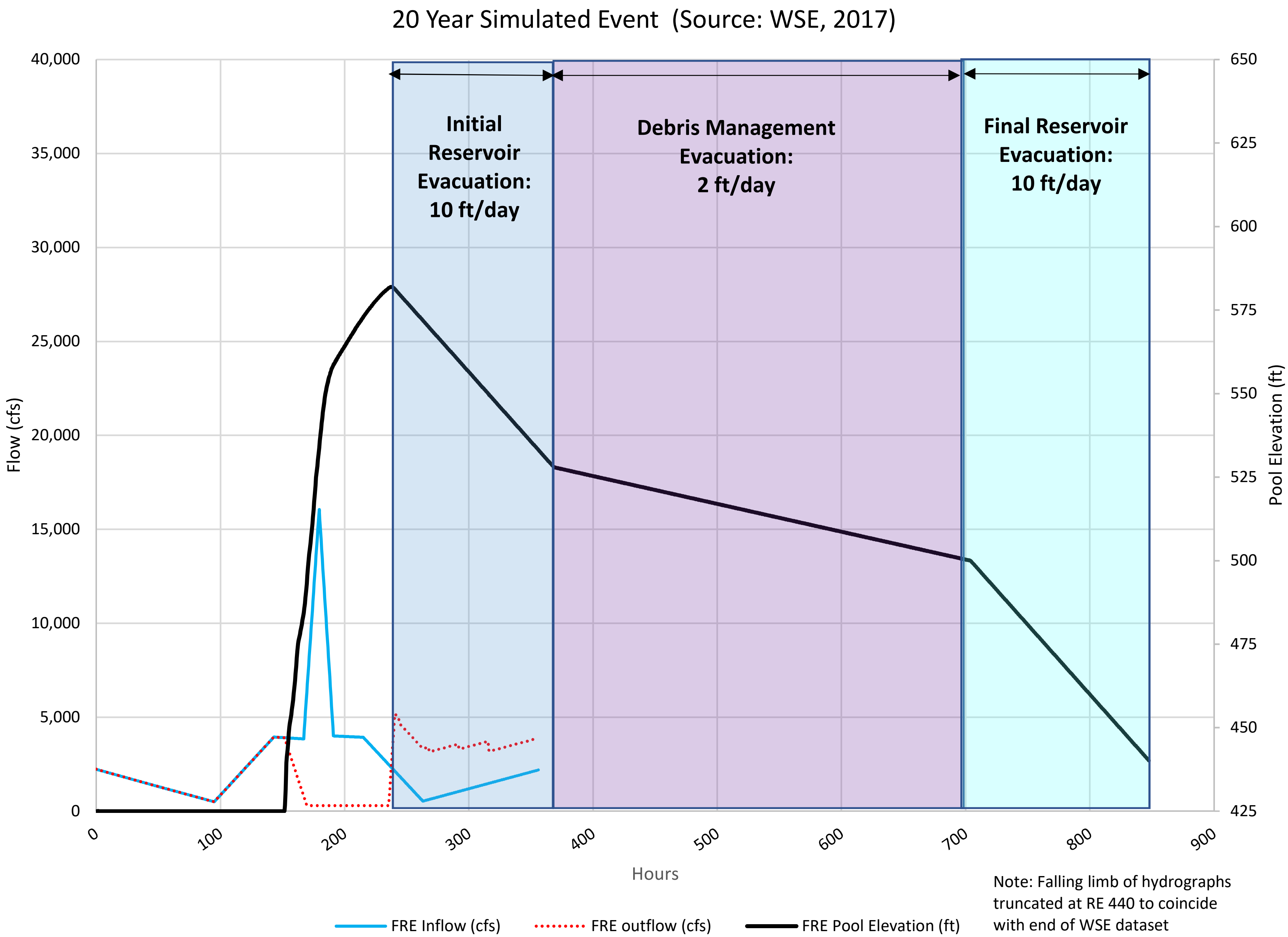
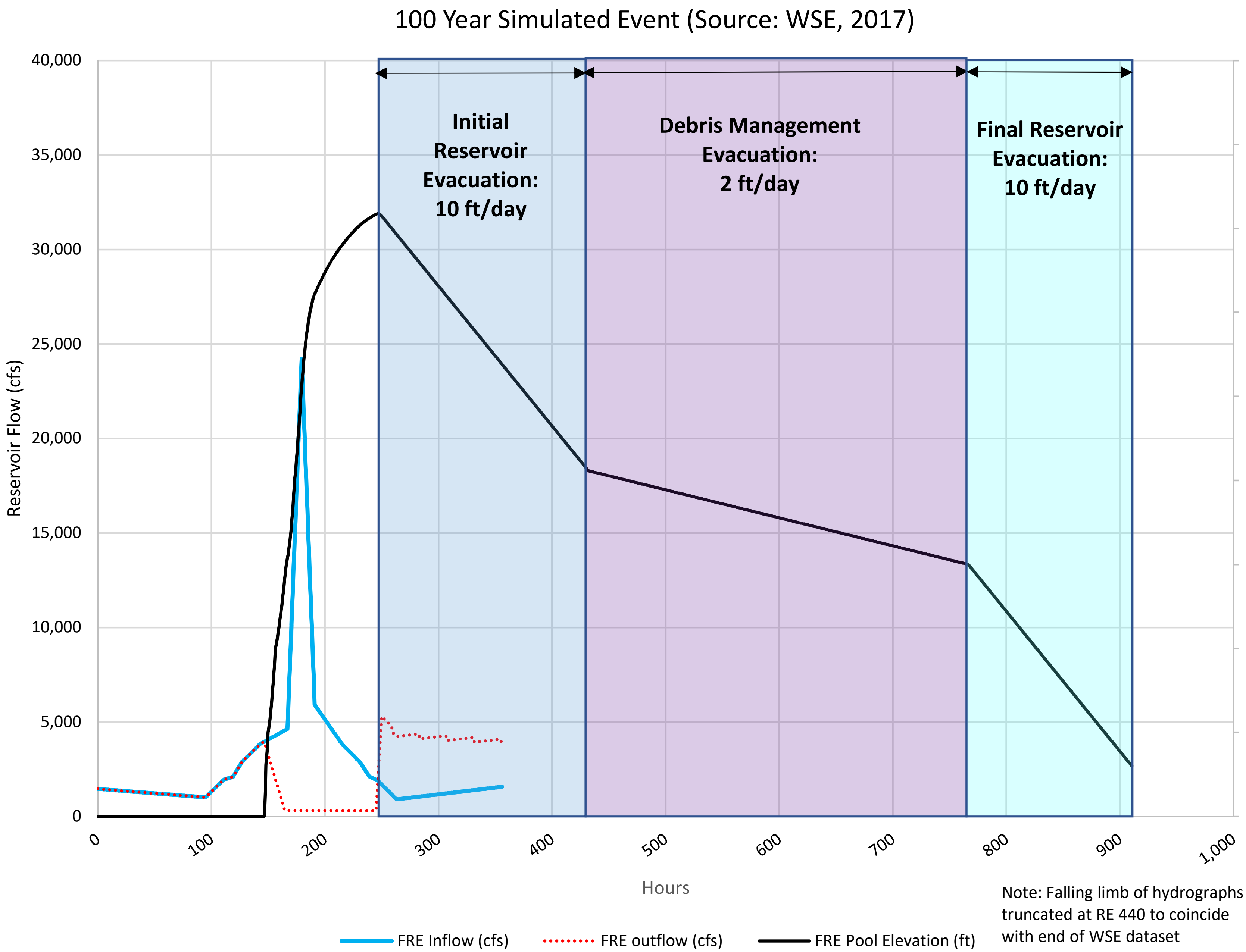
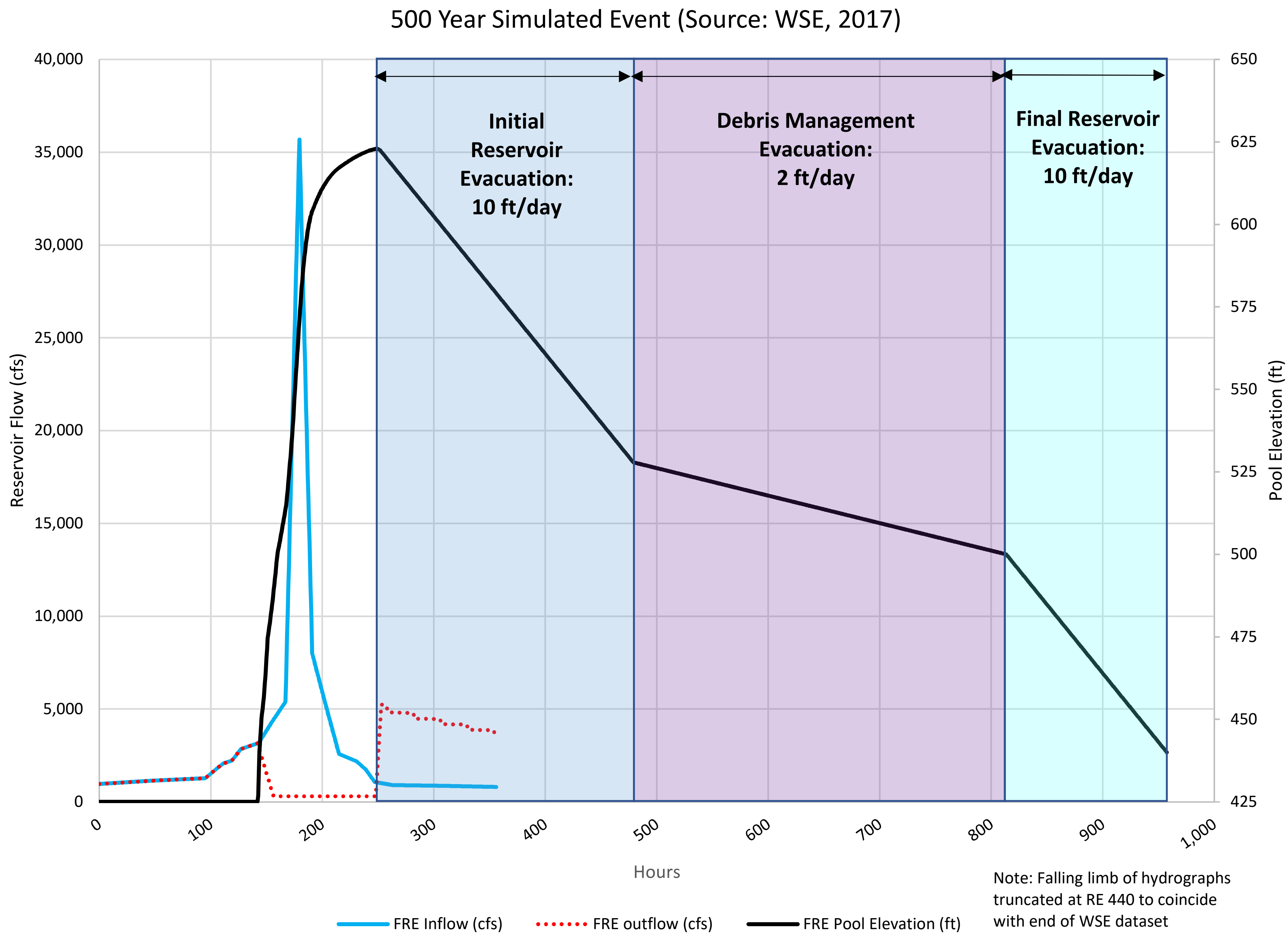
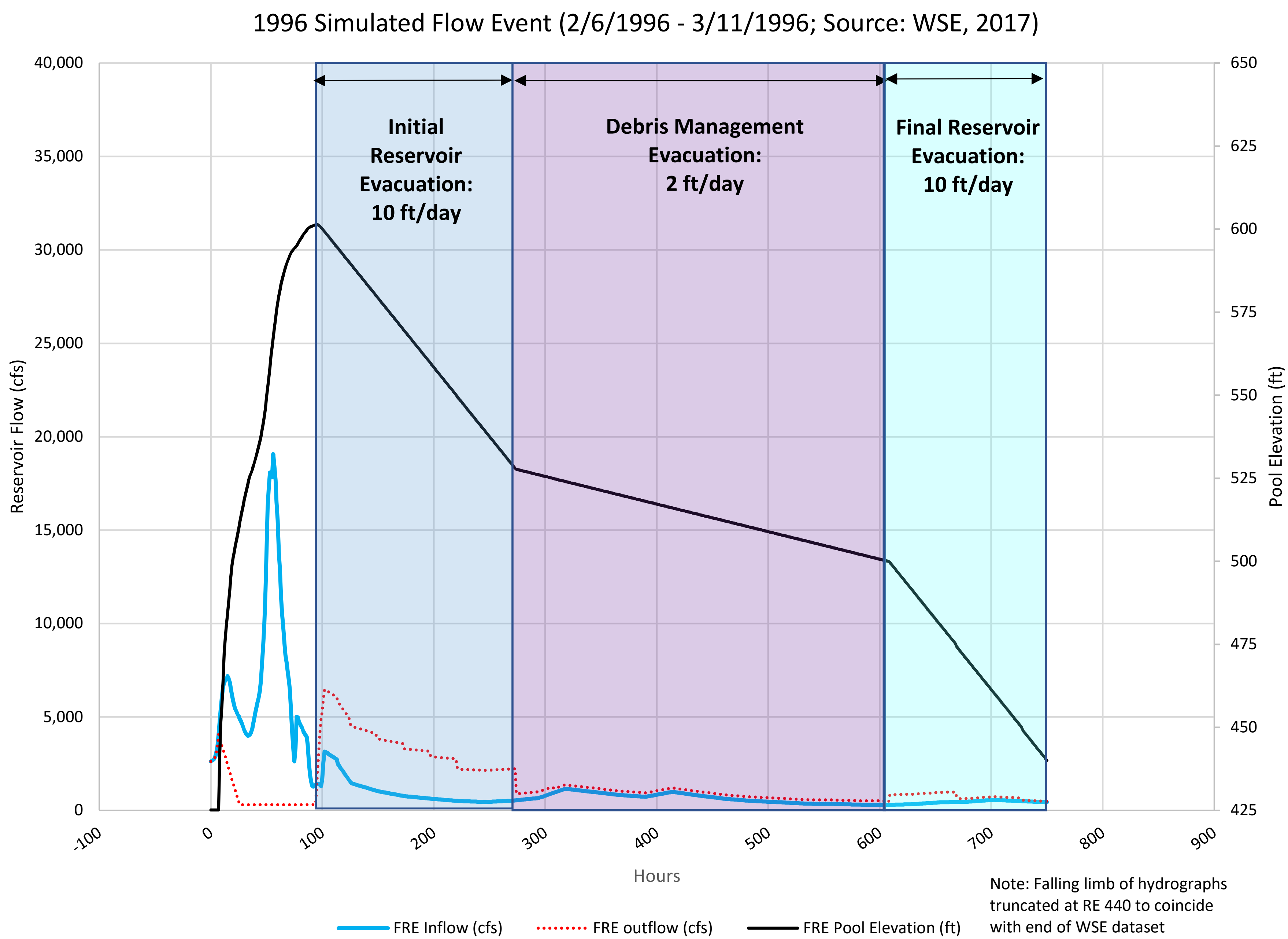
Appendix B. Hydrographs for Major Flood Events

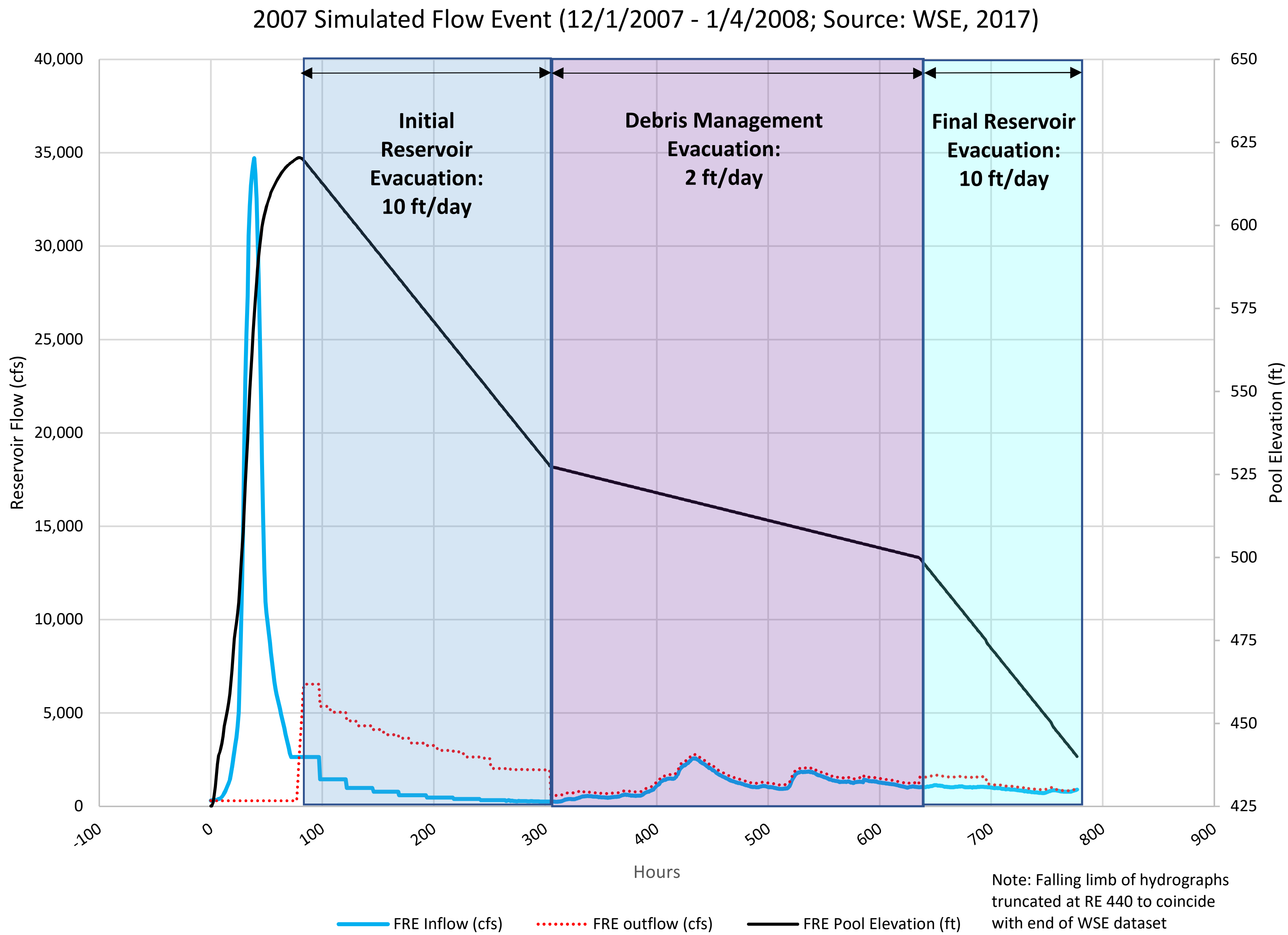

10 Year Simulated Event (Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
425
450
475
500
525
550
575
600
625
650
0
100
200
300
400
500
600
700
800
900
1,000
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset

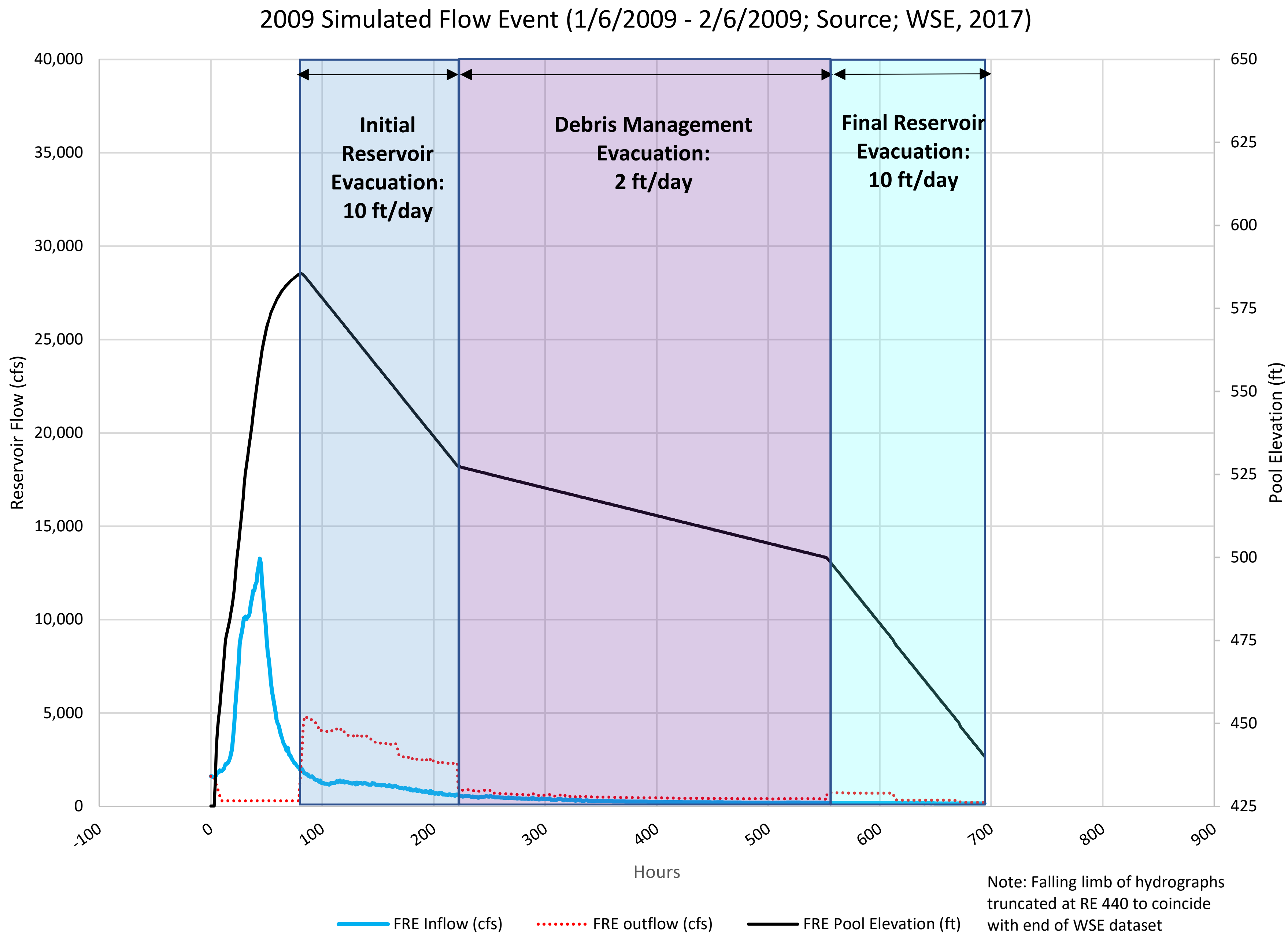

20 Year Simulated Event (Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Flow (cfs)
Pool Elevation (ft)
Hours
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
425
450
475
500
525
550
575
600
625
650
0
100
200
300
400
500
600
700
800
900
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset


100 Year Simulated Event (Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
425
450
475
500
525
550
575
600
625
650
0
100
200
300
400
500
600
700
800
900
1,000
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset


500 Year Simulated Event (Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
650
625
600
575
550
525
500
475
450
425
0
100
200
300
400
500
600
700
800
900
1,000
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)


1996 Simulated Flow Event (2/6/1996 - 3/11/1996; Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
650
625
600
575
550
525
500
475
450
425
-100
0
100
200
300
400
500
600
700
800
900
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)


2007 Simulated Flow Event (12/1/2007 - 1/4/2008; Source: WSE, 2017)
Initial Reservoir Evacuation: 10 ft/day
Debris Management Evacuation: 2 ft/day
Final Reservoir Evacuation: 10 ft/day
Reservoir Flow (cfs)
Pool Elevation (ft)
Hours
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
650
625
600
575
550
525
500
475
450
425
-100
0
100
200
300
400
500
600
700
800
900
Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset
FRE Inflow (cfs)
FRE outflow (cfs)
FRE Pool Elevation (ft)



Note: Falling limb of hydrographs truncated at RE 440 to coincide with end of WSE dataset