February 2020

Proposed Chehalis River Basin Flood Damage Reduction Project

SEPA Draft Environmental Impact Statement

Appendix N
Water Discipline Report

Publication No.: 20-06-002

DEPARTMENT OF ECOLOGY
State of Washington

About this Document

This discipline report has been prepared as part of the Washington Department of Ecology's (Ecology's) State Environmental Policy Act (SEPA) Environmental Impact Statement (EIS) to evaluate a proposal from the Chehalis River Basin Flood Control Zone District (Applicant).

Proposed Action

The Applicant seeks to construct a new flood retention facility and temporary reservoir near Pe Ell, Washington, and make changes to the Chehalis-Centralia Airport levee in Chehalis, Washington. The purpose of the Applicant's proposal is to 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.

Time Frames for Evaluation

If permitted, the Applicant expects Flood Retention Expandable (FRE) facility construction would begin in 2025 and operations in 2030, and the Airport Levee Changes construction would occur over a 1-year period between 2025 and 2030. The EIS analyzes probable impacts from the Proposed Action and alternatives for construction during the years 2025 to 2030 and for operations from 2030 to 2080. For purposes of analysis, the term "mid-century" applies to the operational period from approximately 2030 to 2060. The term "late-century" applies to the operational period from approximately 2060 to 2080.

Scenarios Evaluated in the Discipline Report

This report analyzes probable significant environmental impacts from the Proposed Action, the Local Actions Alternative, and the No Action Alternative under the following three flooding scenarios (flow rate is measured at the Grand Mound gage):

- **Major flood:** Water flow rate of 38,800 cubic feet per second (cfs) or greater
- **Catastrophic flood:** Water flow rate of 75,100 cfs
- **Recurring flood:** A major flood or greater that occurs in each of 3 consecutive years

The general area of analysis includes the area in the vicinity of the FRE facility and temporary reservoir; the area in the vicinity of the Airport Levee Changes; and downstream areas of the Chehalis River to approximately river mile 9, just west of Montesano.

Local Actions Alternative

The Local Actions Alternative represents a local and nonstructural approach to reduce flood damage in the Chehalis-Centralia area. It considers a variety of local-scale actions that approximate the Applicant's purpose through improving floodplain function, land use management actions, buying out at-risk properties or structures, improving flood emergency response actions, and increasing water storage from Pe Ell to Centralia. No flood retention facility or Airport Levee Changes would be constructed.

No Action

Under the No Action Alternative, no flood retention facility or Airport Levee Changes would be constructed. Basin-wide large and small scale efforts would continue as part of the Chehalis Basin Strategy work, and local flood damage reduction efforts would continue based on local planning and regulatory actions.

SUMMARY

The discussion in this *Water Discipline Report* describes existing conditions and probable impacts resulting from the Proposed Action and alternatives on surface waters and groundwater, regarding water quantity, water quality, and water uses and rights. The study area for the water analysis is in the Chehalis River Basin. It encompasses the modeled limits of late-century catastrophic flooding for over 100 miles of the Chehalis River, extending from the upstream extent of the temporary reservoir (river mile [RM] 116) of the proposed Flood Retention Expandable (FRE) facility near Pe Ell downstream to about RM 9, just west of Montesano. It also includes the lower portions of major Chehalis River tributaries including the South Fork Chehalis, Newaukum, Skookumchuck, and Black rivers as well as smaller tributary streams.

The following water issues were analyzed:

- Short-term impacts on surface water and groundwater resulting from construction activities and elements, including heavy equipment operation, stream diversions, temporary construction access routes, equipment and material staging areas, and quarries developed for FRE facility construction
- Long-term water quality impacts within the temporary reservoir and downstream in the Chehalis River and its floodplain as a result of FRE facility operation
- Impacts to surface water quantity from surface water inundation changes in the Chehalis River as a result of the operation of the FRE facility and completion of Airport Levee Changes
- Impacts from changes in groundwater levels and flows from FRE facility operation and Airport Levee Changes
- Impacts on water uses and rights upstream of the FRE facility, within or near the temporary reservoir footprint, and near the airport levee

A summary of anticipated impacts on water is included in Tables N-1 and N-2.

Table N-1
Summary of Water Impacts from the Proposed Action

IMPACT	IMPACT FINDING	MITIGATION PROPOSED (SUMMARIZED, SEE SECTION 3.2.4)	SIGNIFICANT AND UNAVOIDABLE ADVERSE IMPACT
PROPOSED ACTION (FRE FACILITY AND AIRPORT LEVEE CHANGES) – CONSTRUCTION			
Increases in water temperature of 2°C to 3°C in summer for Chehalis River and decreased dissolved oxygen from removal of vegetation in the upland and riparian areas of the FRE facility and temporary reservoir.	**Significant**	**FISH-1:** Develop and implement a Fish and Aquatic Species and Habitat Plan. **WATER-1**: Develop and implement a Surface Water Quality Mitigation Plan. **WET-2:** Develop and implement a Stream and Stream Buffer Mitigation Plan. **WILDLIFE-1:** Develop and implement a Vegetation Management Plan. **WILDLIFE-3**: Develop and implement a Riparian Habitat Mitigation Plan.	**Yes, unless mitigation is feasible**
A water supply line for the Town of Pe Ell's water system would be affected by the Flood Retention Facility (FRE) construction and temporary reservoir inundation, and the line could require relocation or improvement, resulting in impacts to the Town of Pe Ell's water rights and water service.	**Significant**	**PSU-1:** The Applicant will conduct a study with the Town of Pe Ell to determine if the Pe Ell water line at Lester Creek needs to be designed to ensure that the water line can withstand inundation within the temporary reservoir or needs to be relocated, and, if so, will develop a cost estimate and provide funding for this work.	No
Increases in stream turbidity and pollutant discharges from construction.	Moderate to Minor	Same as above	No
Changes to groundwater quantity from Airport Levee Changes.	Moderate to Minor	No	No
Potential for FRE facility construction impacts on water uses and rights, such as need for construction-related water withdrawals.	Moderate to Minor	No	No
Impacts to water quality from construction of quarries	Moderate to minor	No	No
Changes to groundwater quantity from construction of the FRE facility.	Minor	No	No

IMPACT	IMPACT FINDING	MITIGATION PROPOSED (SUMMARIZED, SEE SECTION 3.2.4)	SIGNIFICANT AND UNAVOIDABLE ADVERSE IMPACT
Potential for introduction of pollutants to groundwater from construction activities.	Minor	No	No
Changes to surface water quantity and upstream and downstream flooding resulting from bypass tunnel and from stormwater runoff during construction of the FRE facility.	Minor	No	No
Impacts to surface water quality and quantity from construction of the Airport Levee Changes.	Minor	No	No
PROPOSED ACTION (FRE FACILITY AND AIRPORT LEVEE CHANGES) – OPERATIONS			
Increased temperatures of 2°C to 3°C in summer for Chehalis River and decreased dissolved oxygen exceeding water quality criteria in the Chehalis River in the temporary reservoir footprint and downstream when the FRE facility is not storing water, due to loss of riparian cover and stream shading. Exceedances of turbidity water quality criteria after major floods or larger events when the temporary reservoir is inundated and water released, and during subsequent storms or high flows when sediment may be resuspended.	**Significant**	**FISH-1:** Develop and implement a Fish and Aquatic Species and Habitat Plan. **WATER-1**: Develop and implement a Surface Water Quality Mitigation Plan. **WET-2:** Develop and implement a Stream and Stream Buffer Mitigation Plan. **WILDLIFE-1:** Develop and implement a Vegetation Management Plan. **WILDLIFE-3**: Develop and implement a Riparian Habitat Mitigation Plan.	**Yes, unless mitigation is feasible**
A water supply line for the Town of Pe Ell's water system would be affected by the Flood Retention Facility (FRE) construction and temporary reservoir inundation, and the line could require relocation or improvement, resulting in impacts to the Town of Pe Ell's water rights and water service.	**Significant**	**PSU-1:** The Applicant will conduct a study with the Town of Pe Ell to determine if the Pe Ell water line at Lester Creek needs to be designed to ensure that the water line can withstand inundation within the temporary reservoir or needs to be relocated, and, if so, will develop a cost estimate and provide funding for this work.	No
Surface water quantity impacts upstream of the temporary reservoir when water held (up to 35 days, every 4 to 5 years).	Moderate	No	No

IMPACT	IMPACT FINDING	MITIGATION PROPOSED (SUMMARIZED, SEE SECTION 3.2.4)	SIGNIFICANT AND UNAVOIDABLE ADVERSE IMPACT
Changes to groundwater quantity from FRE facility operation and from the subsurface placement of fill material and/or structures associated with the Airport Levee Changes.	Moderate to Minor	No	No
Water use impact to the Town of Pe Ell from FRE facility operations. A water diversion point on Crim Creek is not currently used but could be in the future.	Moderate	No	No
If the Airport Levee Changes are completed before the FRE facility is operational and a catastrophic flood occurs, there is the potential for increased flood elevations immediately upstream and downstream of the levee.	Moderate	**LAND-3**: Make Airport Levee Changes during the last part of the FRE construction period.	No
Pollutant mobilization during floods could affect water quality.	Minor	No	No
No impact to groundwater quality from FRE facility or levee operations.	No impact	No	No
Changes to groundwater quantity in the temporary reservoir area from operation of the FRE facility.	No impact	No	No
No impact to surface water quantity downstream of the FRE facility.	No impact	No	No
No impact to water uses and rights downstream of the FRE facility or from the levee from operations.	No impact	No	No
No impact to surface water quantity from levee operations.	No impact	No	No

Table N-2
Summary of Water Impacts from Alternatives

IMPACT	IMPACT FINDING
LOCAL ACTIONS ALTERNATIVE	
Increases in stream turbidity and pollutant discharges from construction activities.	Moderate to Minor
In the long term, flooding would not be significantly reduced at a large scale; water resources throughout the study area would continue to be vulnerable to impacts during both major and catastrophic floods.	**Continuing substantial flood risk**
Subsurface placement of fill material and/or structures for floodproofing actions could locally modify shallow groundwater flows.	Moderate
NO ACTION ALTERNATIVE	
Impacts on water resources from the construction or operation of the No Action Alternative would not occur.	No impacts
In the long term, flooding would not be significantly reduced at a large scale; water resources throughout the study area would continue to be vulnerable to impacts during both major and catastrophic floods.	**Continuing substantial flood risk**

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1 INTRODUCTION

1.1 Resource Description

In this discipline report, the term "water" refers to surface water, including the Chehalis River and its tributaries, and groundwater. Water quality, water quantity (flows and levels), and water uses and rights are key features of both surface water and groundwater. The study area for water is described in Section 2.1.

1.2 Regulatory Context

Table N-3 identifies the primary federal, state, and local regulations that relate to surface waters and groundwater in the study area. Section 3.2.3 identifies and describes the expected water-related permits needed to implement the Proposed Action.

Table N-3
Regulations, Statutes, and Guidelines for Water

REGULATION, STATUTE, GUIDELINE	DESCRIPTION
FEDERAL	
Clean Water Act (33 U.S. Code 1251 et seq.)	The Federal Water Pollution Control Act of 1948 was the first major U.S. federal law to address water pollution. The law was amended in 1972 and became commonly known as the Clean Water Act. The Clean Water Act establishes the basic structure for regulating pollutant discharges into waters of the U.S. and makes it unlawful to discharge any pollutant from a point source into those waters without a permit. The following rows identify key sections of the Clean Water Act relevant to permitting facilities for which construction or operation would result in a discharge into waters of the U.S.
Clean Water Act Section 401 (Certification)	• Provides states the authority to ensure that federal agencies do not issue permits or licenses that violate state water quality standards or other protections of the Clean Water Act. • An applicant for a federal permit must obtain a Section 401 Water Quality Certification from the state in which the activity would occur. • The Washington Department of Ecology (Ecology) administers Section 401 certifications in Washington.

REGULATION, STATUTE, GUIDELINE	DESCRIPTION
Clean Water Act Section 402 (National Pollutant Discharge Elimination System; NPDES)	• Establishes the NPDES program, requiring pollutant discharges to surface waters be authorized by a permit. • NPDES permit requirements initially applied to point source discharges, but the program was expanded in 1987 to explicitly include stormwater discharges. • Ecology administers the NPDES permitting program in Washington. • Ecology's Construction Stormwater General NPDES Permit and its Sand and Gravel General NPDES Permit reference Ecology's Stormwater Management Manual for Western Washington.
Clean Water Act Section 404 (Permits for Dredged or Fill Material)	• Establishes a program to regulate the discharge of dredged or fill material into waters of the U.S., including wetlands. • The U.S. Army Corps of Engineers issues Section 404 permit decisions.
Clean Water Act Section 303(d) (Impaired Waters and Total Maximum Daily Loads)	• Establishes a process to identify and clean up polluted waters.
Coastal Zone Management Act (CZMA)	• Provides for the management of coastal resources. • Gives states the primary role in managing their coastal zone.
STATE	
Coastal Zone Management Program (CZMP)	The federal CZMA authorizes Washington State to review projects which require a federal permit in a state's coastal zone. Generally, federal consistency requires that federal actions within and outside the coastal zone, which have reasonably foreseeable effects on any coastal use (land or water) or natural resource of the coastal zone be consistent with the enforceable policies of a state's federally approved CZMP. Under Washington's CZMP, activities which could affect the coastal zone must comply with Washington State's Shoreline Management Act, Water Pollution Control Act, Clean Air Act, and Ocean Resources Management Act.
Growth Management Act (Revised Code of Washington [RCW] Title 36)	• Chapter 36.70A contains Washington's Growth Management Act, which requires local governments to manage growth by identifying and protecting critical areas and natural resource lands, among other measures.
Flood Control (RCW Title 86)	• Covers laws relating to floodplain management, flood control by counties, flood control by state in cooperation with federal agencies, and flood control zone districts.
Floodplain Management (Washington Administrative Code [WAC] 173-158)	• Implements RCW Title 86 law (Chapter 86.16–Floodplain Management), establishing regulations for floodplain management to ensure local government compliance with the National Flood Insurance Program.
Shoreline Master Program Approval/Amendment Procedures and Master Program Guidelines (WAC 173-26)	• Implements the requirements of the Shoreline Management Act (RCW 90.58), directing local governments to develop and administer local shoreline management programs for regulation of land uses on shorelines of the state.

REGULATION, STATUTE, GUIDELINE	DESCRIPTION
Water Quality Standards for Surface Water (WAC 173-201A)	• Establishes water quality standards for surface waters, implementing RCW Title 90 law (Chapter 90.48 - Water Pollution Control Act). • Freshwater designated uses and associated criteria are specifically identified in WAC 173-201A-200.
Water Quality Standards for Groundwater (WAC 173-200)	• Establishes water quality standards for groundwaters, implementing RCW Title 90 laws including Chapters 90.48 (Water Pollution Control Act) and 90.54 (Water Resources Act of 1971).
Water Resources Program in the Chehalis River Basin, Water Resource Inventory Area (WRIA) 22 and 23 (WAC 173-522)	• Implements RCW Title 90 law (Chapter 90.54–Water Resources Act of 1971) and establishes regulations for Ecology's water resources program in the Chehalis River Basin (WRIAs 22 and 23), including minimum instream flows, allocation and prioritization of surface water for beneficial uses, and streams closed to further consumptive appropriations.
Water Rights (WAC 173-152)	• Establishes the framework for Ecology's performance of basin assessments and processing of water rights applications, implementing Title 90 laws including RCW 90.03 (Water Code) and RCW 90.82 (Watershed Planning).
Water Rights–Environment (RCW Title 90)	• Contains many laws covering subjects including water rights registration, minimum streamflows, water pollution control, shoreline management, and aquatic resources mitigation.
WAC Title 508 (Ecology, Water Resources) Administration of Surface and Groundwater Codes (WAC 508-12)	• Establish regulations for Ecology's administration of surface and groundwater codes, including regulation of water right diversions, surface water and groundwater appropriation procedures, and reservoir permits.
LOCAL	
Chehalis Municipal Code Chapter 17.18 (Shoreline Substantial Development Permit)	• Adopts by reference the standards for the regulation of shorelines contained in the City's Shoreline Master Program (Resolution 19-81). • Implements Washington's Shoreline Management Act of 1971 (RCW 90.58) and applies protections to certain rivers, streams, wetlands, reservoirs, and adjacent lands.
Chehalis Municipal Code Chapter 17.22 (Frequently Flooded Areas-Flood Hazard Zone)	• Establishes regulations to promote public safety and minimize losses due to flood conditions. • Regulates development in areas subject to a base flood and/or designated as an area of special flood hazard as identified in the Flood Insurance Study for Chehalis and the accompanying Flood Insurance Rate Maps (FIRMs; 2006). • Empowers the City of Chehalis to create special flood hazard zones based on best available information including elevation data, topographic information, and flood-of-record data.
Chehalis Municipal Code Chapter 17.26 (Critical Aquifer Recharge Areas)	• Regulates development and the use of land in critical aquifer recharge areas to ensure long-term protection of the water supply resources under the City's jurisdiction. • Implements Washington's Growth Management Act (RCW 36.70A).
Chehalis Municipal Code Chapter 15.30 (Storm Water and Storm Water Runoff)	• Provides requirements for including adequate stormwater quantity and quality controls for construction and development activities, and outlines the associated City review/permitting procedures.

REGULATION, STATUTE, GUIDELINE	DESCRIPTION
Lewis County Code Chapter 17.25 (Shoreline Management)	• Adopts, by reference, the standards for the regulation of shorelines in Lewis County contained in the Lewis County Shoreline Master Program (adopted October 16, 2017, or as amended). • Implements Washington's Shoreline Management Act of 1971 (RCW 90.58) and applies protections to certain rivers, streams, wetlands, reservoirs, and adjacent lands.
Lewis County Code Chapter 17.35 (Critical Areas)	• Represents the Lewis County Critical Areas Ordinance and establishes regulations for the protection of ecological functions and values of critical areas, the preservation of human health and safety, and the preservation and enhancement of anadromous fisheries. • Implements Washington's Growth Management Act (RCW 36.70A) and applies protections to critical areas and buffers including wetlands, fish and wildlife habitat areas, and critical aquifer recharge areas.
Lewis County Code Chapter 15.35 (Flood Damage Prevention)	• Establishes regulations to promote public safety and minimize losses due to flood conditions. • Regulates development in areas subject to a base flood and/or designated as an area of special flood hazard as identified in the Flood Insurance Study for Lewis County and the accompanying FIRMs (1981, and as amended).
Lewis County Code Chapter 15.45 (Stormwater Management)	• Provides requirements for including adequate stormwater quantity and quality controls for construction and development activities, and outlines associated County review/permitting procedures. • Ecology's Stormwater Management Manual is referenced in this chapter, for use as a guide in selecting appropriate stormwater best management practices.

2 METHODOLOGY

2.1 Study Area

The study area for water encompasses surface waters and groundwater with the potential to be affected by construction or operation of the Proposed Action, including the following:

- Short-term impacts on surface water and groundwater resulting from construction activities and elements, including heavy equipment operation, stream diversions, temporary construction access routes, equipment and material staging areas, and quarries developed for FRE facility construction
- Long-term water quality impacts within the temporary reservoir and downstream in the Chehalis River and its floodplain as a result of FRE facility operation
- Impacts to surface water levels in the Chehalis River as a result of the operation of the FRE facility and completion of Airport Levee Changes
- Impacts from changes in groundwater levels and flows from FRE facility operation and Airport Levee Changes
- Impacts on water uses and rights upstream of the FRE facility, within or near the temporary reservoir footprint, and near the airport levee

The study area is within the Chehalis River Basin. It includes portions of the Upper Chehalis River Basin (Water Resource Inventory Area [WRIA] 23) which extends from headwaters in the Willapa Hills and Cascade Range foothills, and the Lower Chehalis River Basin (WRIA 22) (Figure N-1). It encompasses the modeled limits of late-century catastrophic flooding for over 100 miles of the Chehalis River, extending from the upstream extent of the temporary reservoir (river mile [RM] 116) of the proposed FRE facility near Pe Ell to downstream to about RM 9, just west of Montesano (Figure N-2). It also includes the lower portions of major Chehalis River tributaries including the South Fork Chehalis, Newaukum, Skookumchuck, and Black rivers as well as smaller tributary streams.

The study area was determined based on the results of water hydraulic models, which were used to identify the estimated limits of flooding along the mainstem Chehalis River as described in Section 2.4. The maximum extents of the flooding were modeled based on a catastrophic flood in the late-century from a storm originating in the Willapa Hills, accounting for climate change estimates. For the Skookumchuck River, South Fork Newaukum River, and South Fork Chehalis River, the study area extends an additional 1,500 feet upstream of the modeled limits (Figure N-2). The downstream limit of the study area at RM 9 is where the tidal influence is larger than the river influence.

2.2 Existing Conditions

2.2.1 Precipitation

Precipitation in the upper Chehalis Basin is dominated by rain that falls primarily during the fall and winter. Mean annual precipitation was 72.6 inches between October 2001 and September 2015, ranging from less than 50 inches in the north (around Centralia) to more than 140 inches at the higher elevations (DAYMET precipitation data from Thornton et al. 2017, from USGS 2018). Elevations range from approximately 25 feet at Porter to approximately 3,825 feet in the Cascade Range foothills.

Peak precipitation events in the Chehalis Basin typically occur between November and February. Heavy rainfall is often associated with "atmospheric river" weather systems. Atmospheric rivers, or "pineapple express" systems, carry bands of concentrated warm, low-level moisture from the tropics, producing heavy rain when they encounter the mountain ranges and cooler air of the western U.S. Rainfall from such systems has led to major flooding in the Chehalis Basin (Ruckelshaus Center 2012) as described in Section 2.2.2.2, and the heaviest precipitation in the basin typically falls in the Willapa Hills, Cascade Range foothills (to the east of the study area), and Black Hills (Figure N-3).

Figure N-1
Water Resource Inventory Area 23 and Lower Mainstem Chehalis River Subbasin

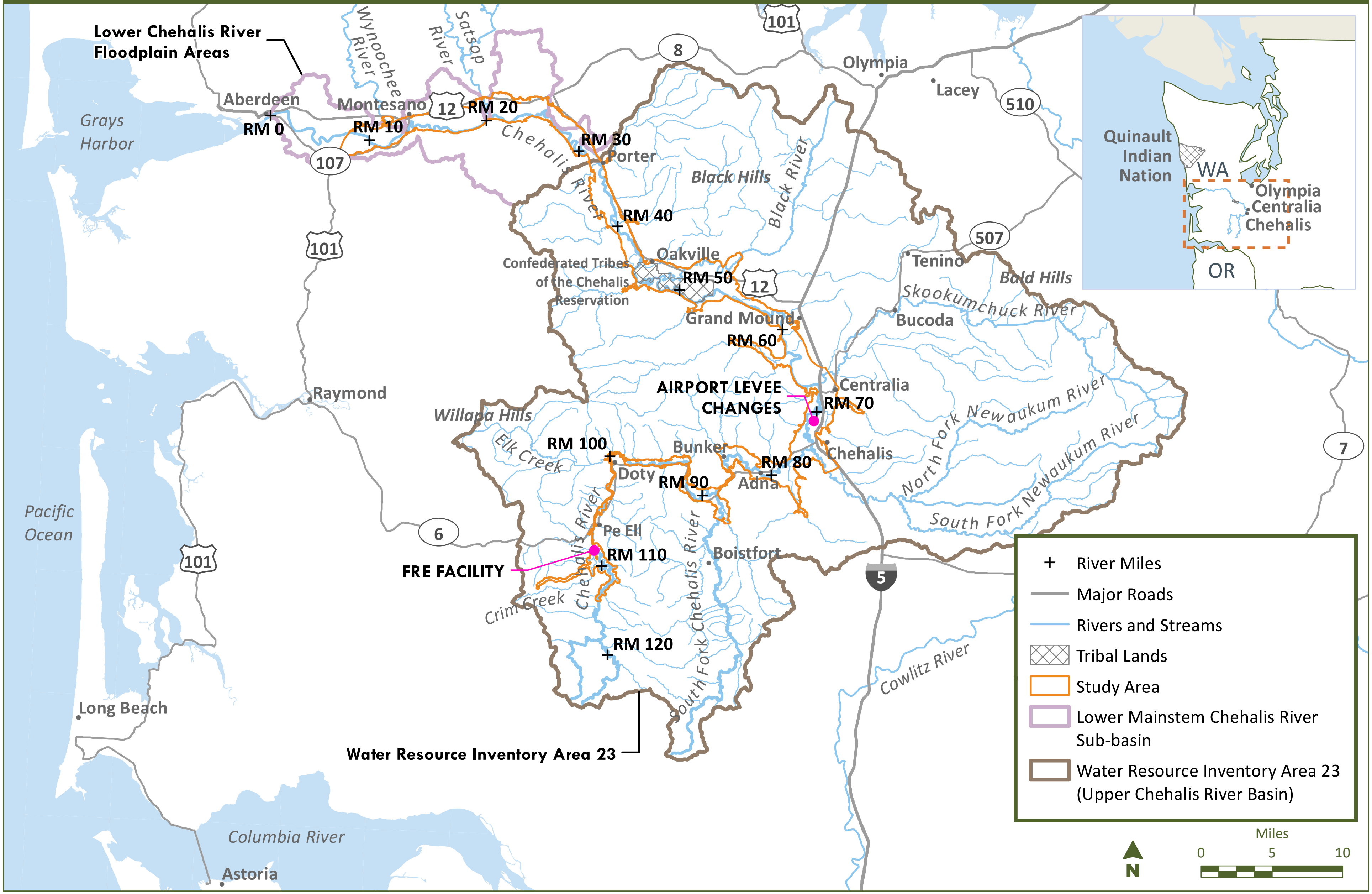


Figure N-2
Water Study Area

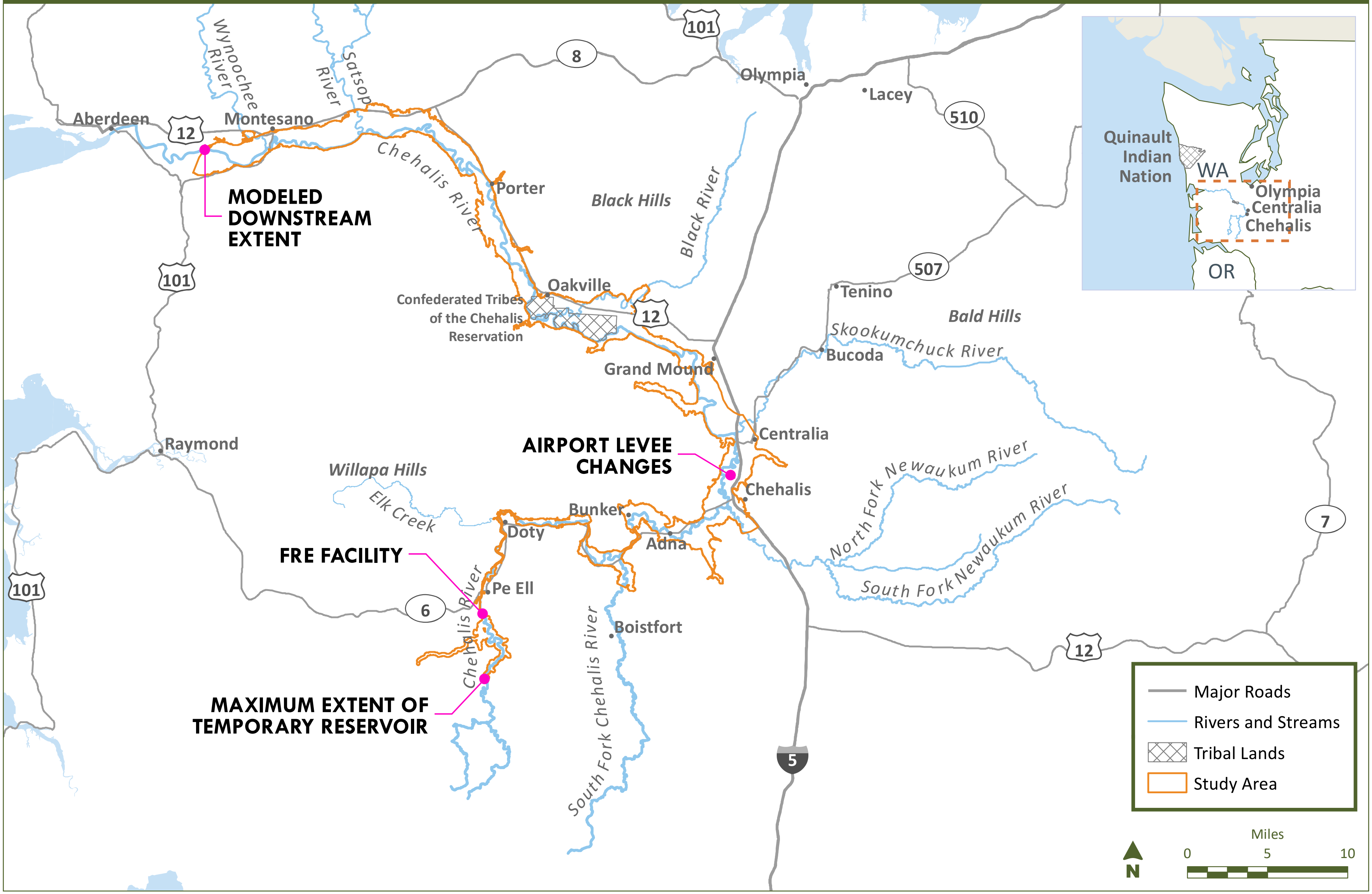
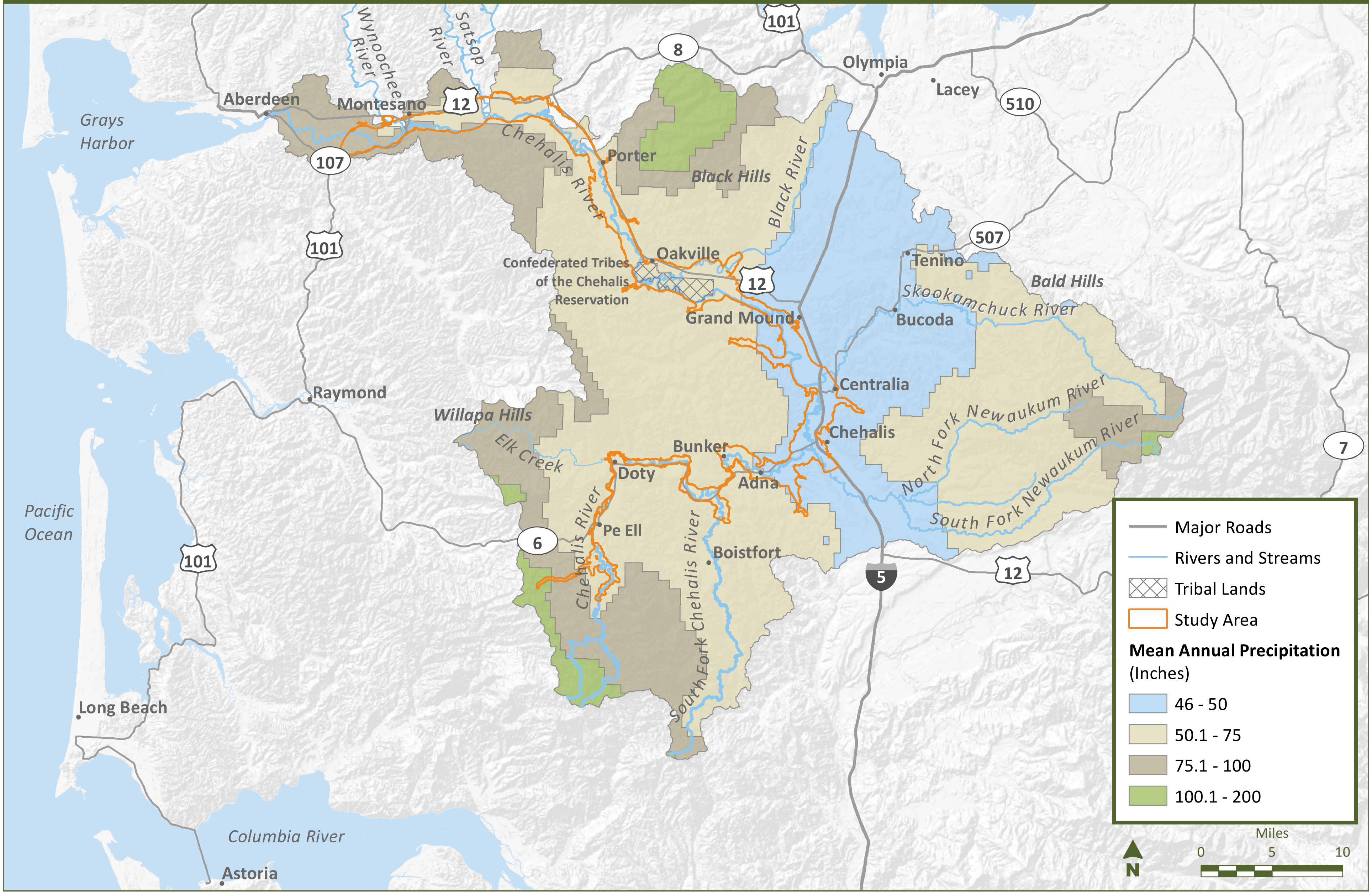


Figure N-3
Mean Annual Precipitation



2.2.2 Surface Water

The Chehalis Basin in Southwestern Washington encompasses the state-designated WRIAs 22 and 23. The Basin drains approximately 2,660 square miles of land in Lewis, Thurston, Grays Harbor, Pacific, Wahkiakum, Mason, Jefferson, and Cowlitz counties to Grays Harbor at the Pacific Ocean near Aberdeen.

In the upper Chehalis Basin (WRIA 23), the mainstem Chehalis River and the South Fork Chehalis River drain areas south and west of Chehalis and Centralia, including the Willapa Hills of the Coast Range. Major tributaries in the upper Chehalis Basin include the Newaukum and Skookumchuck rivers, which have headwaters in the Cascade Range foothills and enter the Chehalis River near Chehalis and Centralia, respectively. Another major tributary, the Black River, originates from Black Lake and enters the Chehalis River between Grand Mound (RM 60) and Porter (RM 33).

The Chehalis River is the primary surface water feature in the study area and flows over 125 miles from its headwaters in the Willapa Hills to Grays Harbor. The proposed FRE facility is on the Chehalis River at RM 108, about 1 mile upstream of (south of) Pe Ell. The proposed Airport Levee Changes are located in Chehalis at approximately RM 67 (Figure N-1).

Several tributary streams enter the Chehalis River between RM 108 and RM 116, in the proposed temporary reservoir footprint, including the following: Crim Creek, Hull Creek, Browns Creek, Big Creek, Roger Creek, Smith Creek, and Alder Creek. Additionally, Lester Creek flows into Crim Creek within the temporary reservoir footprint. Mahaffey Creek flows into the Chehalis River immediately downstream of the proposed FRE facility at RM 108 (Figure N-4).

2.2.2.1 Streamflow

The U.S. Geological Survey (USGS) maintains nine active gages on the Chehalis River that record information on streamflows and/or water levels. Additional USGS and Washington Department of Ecology (Ecology) gages in the Chehalis Basin provide streamflow and water level information for tributaries. Figure N-5 depicts the active stream gages in the Chehalis Basin. The primary USGS gages near Doty, Grand Mound, and Porter are used to define Chehalis River flows in the study area (Table N-4).

Table N-4
Primary USGS Chehalis River Streamflow Gages

GAGE NAME	GAGE NUMBER	RM	PERIOD OF RECORD
Chehalis River near Doty	12020000	102	1939 to present
Chehalis River near Grand Mound	12027500	60	1928 to present
Chehalis River at Porter	12031000	33	1952 to present

Figure N-4
Tributaries in the Vicinity of the Temporary Reservoir

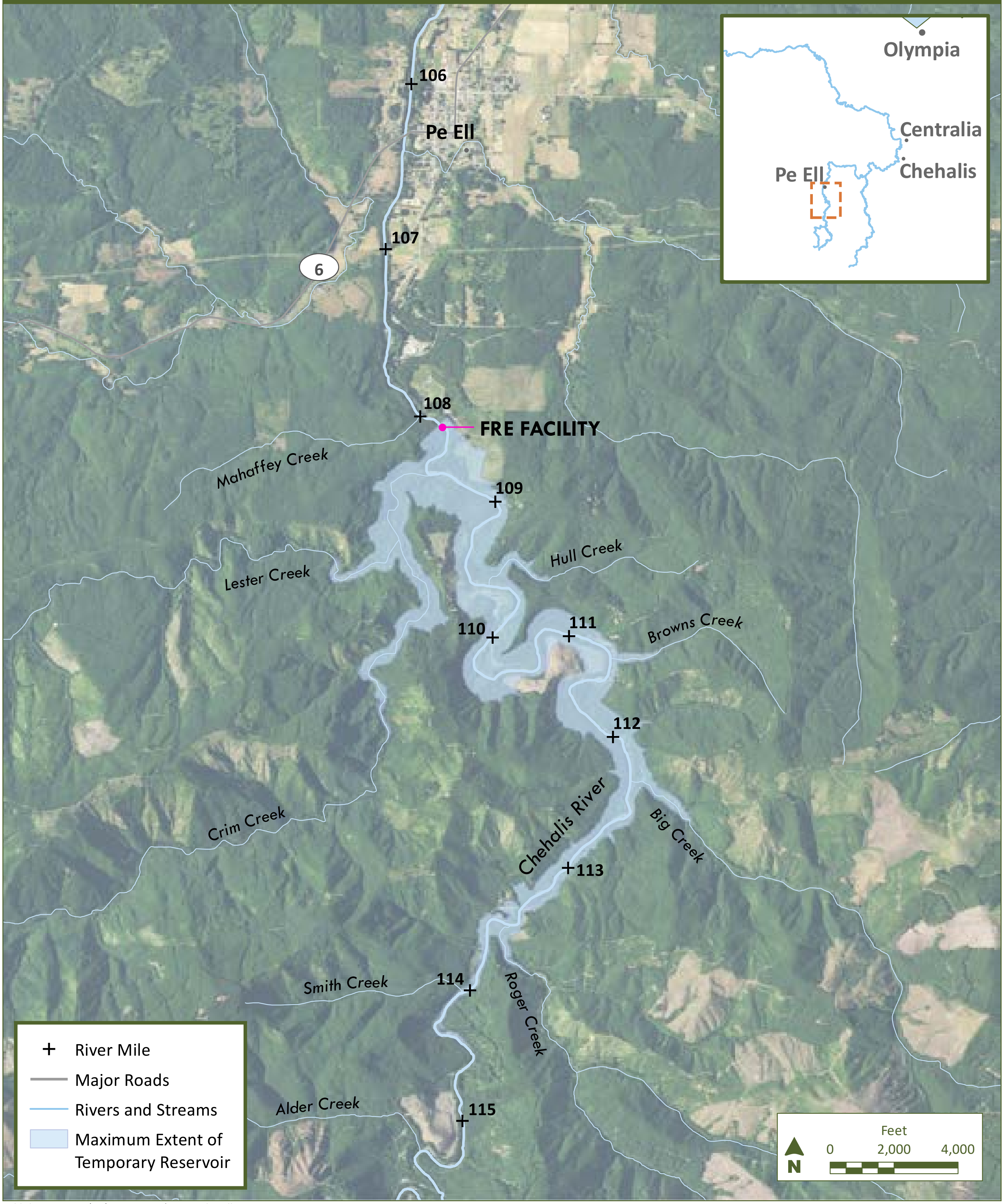


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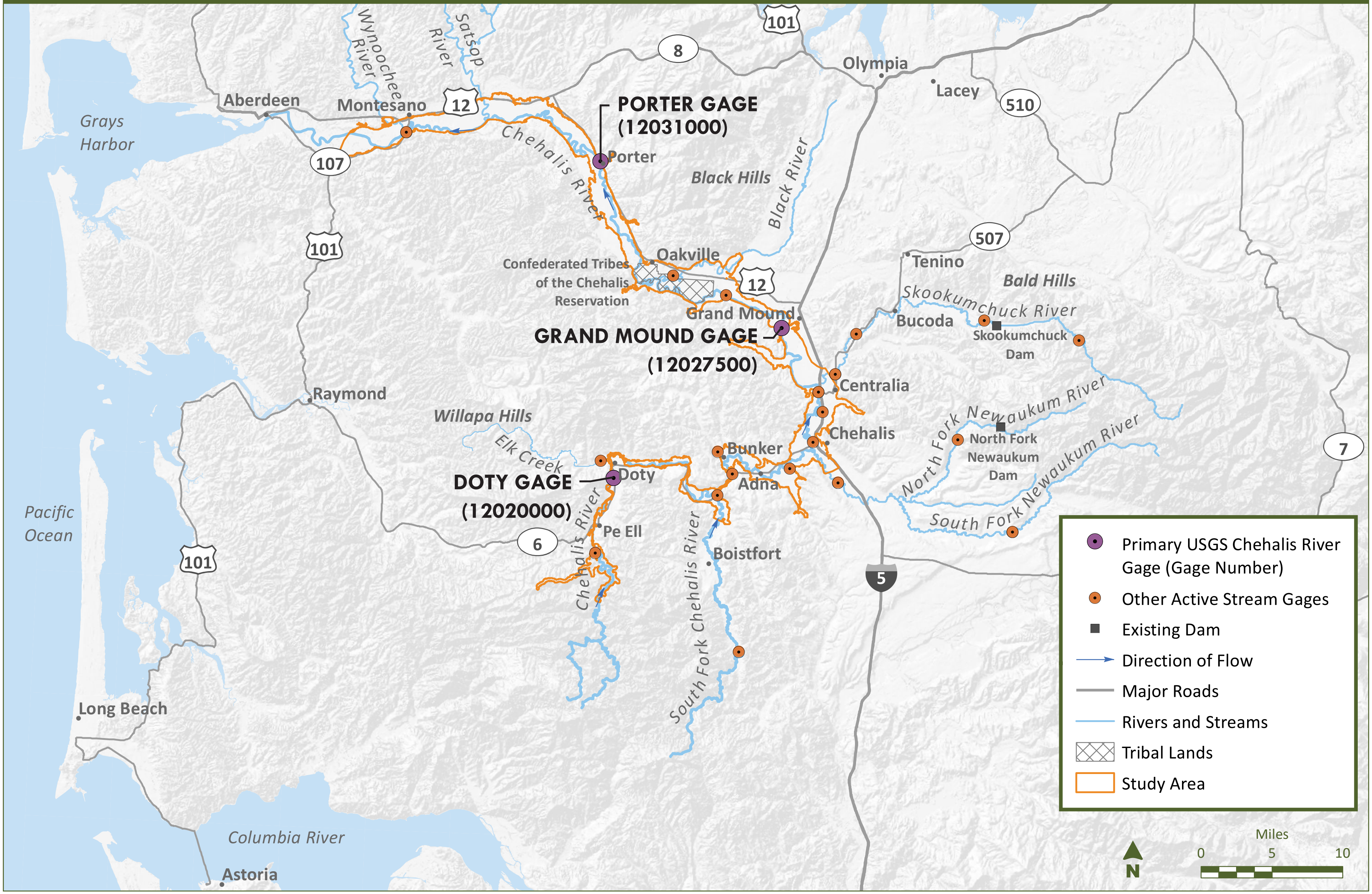
Figure N-5
Streamflow Monitoring Sites



Hydrographs showing median weekly flows and ranges of weekly flows at the Doty, Grand Mound, and Porter gages for a 30-year period (October 1988 to September 2018) are presented in Figure N-6. The gage data show Chehalis River flows are typically highest from November to February, and lowest from July to September. Median weekly flows from November to February range from 400 to 1,000 cubic feet per second (cfs) at Doty, to 1,500 to 5,500 cfs at Grand Mound, to 2,300 to 7,700 cfs at Porter. Median weekly flows from July to September range from 30 to 65 cfs at Doty, to 210 to 430 cfs at Grand Mound, to 390 to 630 cfs at Porter.

2.2.2.2 Flooding and Floodplains

Terminology to describe floods varies by the organization, and flood levels vary by location. Flood terms like "100-year flood" are based on statistics and historical records, but the frequency can vary as flood records change so this terminology can be confusing when discussing future events. For purposes of this environmental impact statement (EIS), the terms used for the analysis are "major" and "catastrophic" floods. These are referenced based on cfs as measured at the USGS stream gage on the Chehalis River at Grand Mound.

For the purposes of the EIS analysis, the following apply:

- A **major flood** is when 38,800 cfs is measured at the Grand Mound gage
- A **catastrophic flood** is when 75,100 cfs is measured at the Grand Mound gage
- A **recurring flood** scenario is when a major flood or greater occurs in each of 3 consecutive years

This approach provides consistency in the studies when describing past floods and potential future floods. Table N-5 provides a cross-reference of flooding terms used in other plans and guidance.

Table N-5
Flood Level Terminology

QUALITATIVE TERM USED IN THE EIS	CHANCE OF OCCURRENCE[1] IN 1 YEAR	ASSOCIATED FLOOD-YEAR TERM	FLOW[2]	SIMILARITY TO OTHER FLOOD PLAN TERMINOLOGY	SIMILAR PAST FLOODS FOR REFERENCE
Major flood	Current: 14% Mid-century: 20% Late-century: 25%	Current: 7-year Mid-century: 5-year Late-Century: 4-year	38,800 cfs at Grand Mound[2]	N/A	2009 flood
Catastrophic flood	Current: 1% Mid-century: 2% Late-century: 4%	Current: 100-year Mid-century: 44-year Late-Century: 27-year	75,100 cfs at Grand Mound[2]	• Comprehensive Flood Hazard Management Plans • Base flood level used by National Flood Insurance Program • High risk Federal Emergency Management Agency (FEMA) flood zones • Special Flood Hazard Area on FEMA maps • Base flood level used by Lewis County floodplain development regulations	1996 flood

Notes:
1. Percent chance a flood of this size would occur in any given year
2. USGS Gage 12027500 at Grand Mound
3. USGS Gage 12020000 at Doty

2.2.2.2.1 *Flooding History and Patterns*

Flooding is historically a common occurrence in the Chehalis Basin. According to accounts dating back to the 1930s, minor flooding generally occurred every 2 to 5 years, and major flooding took place roughly every 10 years (Ruckelshaus Center 2012). In the past 50 years, major floods occurred in 1972, 1975, 1986, 1990, 1996, 2007, and 2009. The 1996, 2007, and 2009 floods are the three largest floods on record, and the 2007 and 2009 floods occurred only 14 months apart. Most of the damage from the recent major floods occurred in Chehalis and Centralia, where there has been more development in the floodplain than in other areas of the Basin. The 1996, 2007, and 2009 floods all resulted in the loss of homes, farms, and businesses and multi-day closures of Interstate 5.

The 2007 flood event was an atmospheric river ("pineapple express") event with extremely high rainfall concentrated in the Willapa Hills. This event affected the Chehalis River mainstem and South Fork, and there was far less rainfall to the east in the Skookumchuck River Basin. The USGS gage for Grand Mound read 79,100 cfs for the 2007 flood; however, peak flows at the Doty gage were estimated at 52,600 cfs, almost double the next highest flood in the 74-year record. This flood is a 500-year flood with a 0.2% chance of occurring in a year.

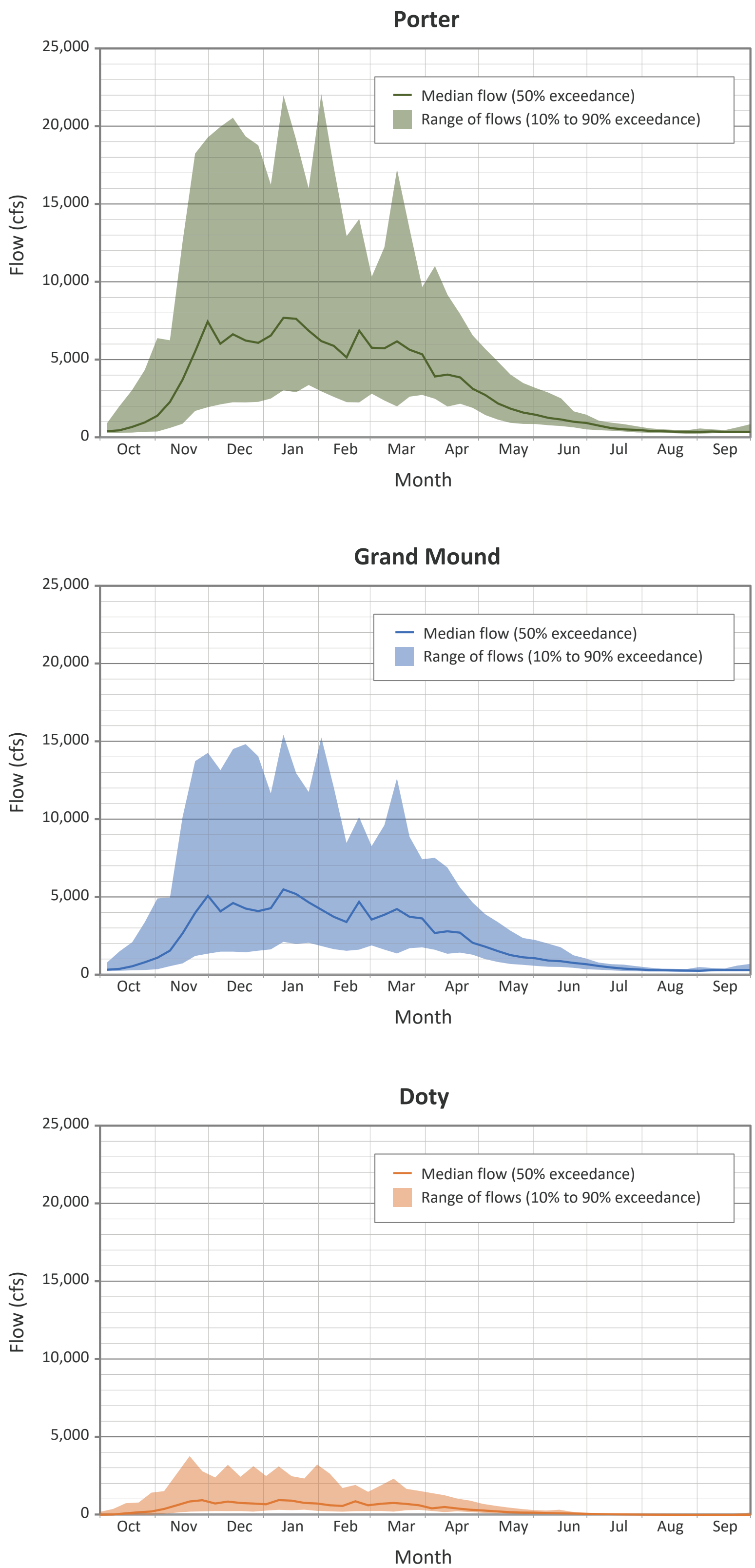
For the late-century catastrophic flood scenario in the EIS, rainfall and runoff projections are modeled statistically throughout the Chehalis Basin, with peak flows distributed in all areas in the basin, and not focused on a particular area. Because rain for the 2007 flood event was focused in one area, the estimated peak flows in 2007 are higher at Doty than peak flows under the late-century catastrophic flood scenario, but lower at Grand Mound. Thus, while the numbers at the Grand Mound gage are similar, the 2007 flood was much larger than the catastrophic flood modeled for this EIS.

Peak flood levels have been rising in the Chehalis Basin over the last 30 years and are likely to continue to rise due to climate change (CBWG 2014). The five highest annual peak flows recorded since 1928 at the Grand Mound gage on the Chehalis River, all of which exceeded 50,000 cfs, occurred since 1986 (Figure N-7).

Flooding in the Chehalis Basin typically occurs in fall and early winter, with recent major flooding between November and March. Atmospheric river weather systems are almost always the cause of major floods in Western Washington (Neiman et al. 2011). During the largest Chehalis River flood on record (2007), exceptionally heavy rainfall in the Willapa Hills headwaters approached 20 inches in one gaged location over the 4-day period from December 1 to December 4 (Mote et al. 2008). While snow is not a primary driver of major flooding in the Chehalis Basin, rain-on-snow events do occur and can contribute to flooding, as observed in January 2009 when rain fell on snow that had accumulated down to sea level (Perry et al. 2016).

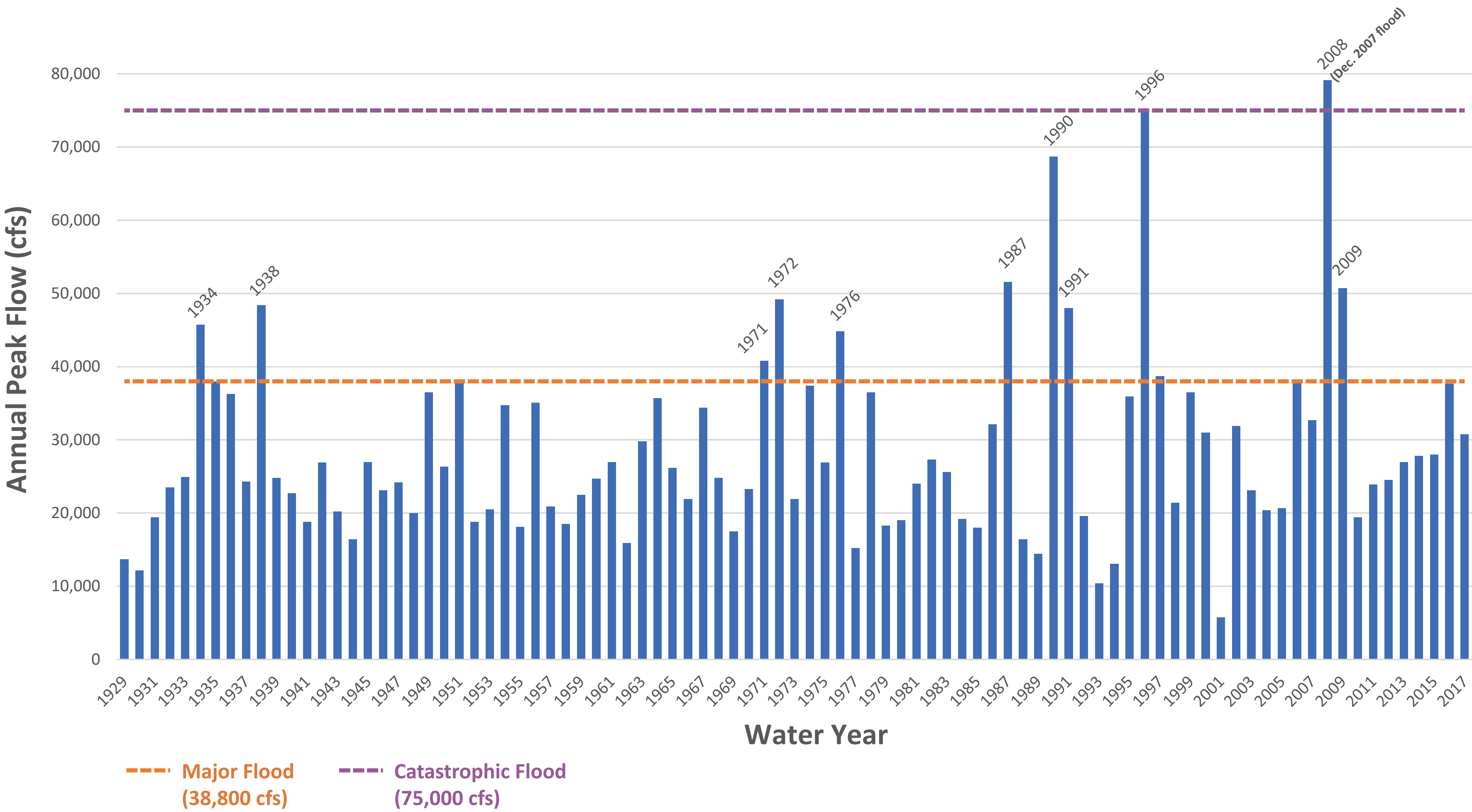
Flooding in the Chehalis Basin may result from heavy rains in the Willapa Hills, Cascade Range foothills, and Black Hills. Flooding tends to be more widespread when heavy precipitation is widespread. Storms centered on the Willapa Hills frequently cause flooding in the upper Chehalis Basin and downstream throughout the Basin. Storms centered over the Black Hills and Cascade Range foothills can cause flooding in the Skookumchuck, Newaukum, and Chehalis rivers in the Centralia/Chehalis area, but generally do not cause major flooding downstream in the Chehalis River (Ruckelshaus Center 2012).

Figure N-6
Chehalis River Streamflow History



Note: Weekly averages are depicted for the 30-year period of October 1988 to September 2018.

Figure N-7
Peak Flow History at Grand Mound



Notes:
1. A single peak flow is shown for each year, although some years experienced additional floods that would exceed the major flood or catastrophic flood levels:
   - Water Year 1933 had three major flood events
   - Water Year 1990 had two major flood events
   - Water Year 1991 had two major flood events
2. Prior to water year 1988, instantaneous peak flows for additional events within each year were not available.

Reviews of USGS gage data show high Chehalis River flows at Grand Mound are closely associated with high Chehalis River headwater flows at Doty. Watershed Science & Engineering (WSE) analyzed data from the ten highest annual peak flows at the Grand Mound gage on the Chehalis River, along with upstream USGS gages including: Chehalis River at Doty, South Fork Chehalis River, Newaukum River, and Skookumchuck River (WSE and WEST Consultants 2012). That analysis supports the following key observations:

- A large flow on the Chehalis River at Grand Mound has never been observed without a correspondingly large flow upstream on the Chehalis River at Doty.
- A large flow at Doty is a reliable indicator of a large flow downstream at Grand Mound.
- A large flow on the Chehalis River at Grand Mound can occur with or without a large flow contribution from the Skookumchuck River upstream.
- A large flow on the Skookumchuck River is not a reliable indicator of large flows downstream at Grand Mound.
- Peak flows on the Newaukum River and South Fork Chehalis River are similarly correlated to the downstream flows at Grand Mound; less so than the Doty flows but more so than the Skookumchuck flows.

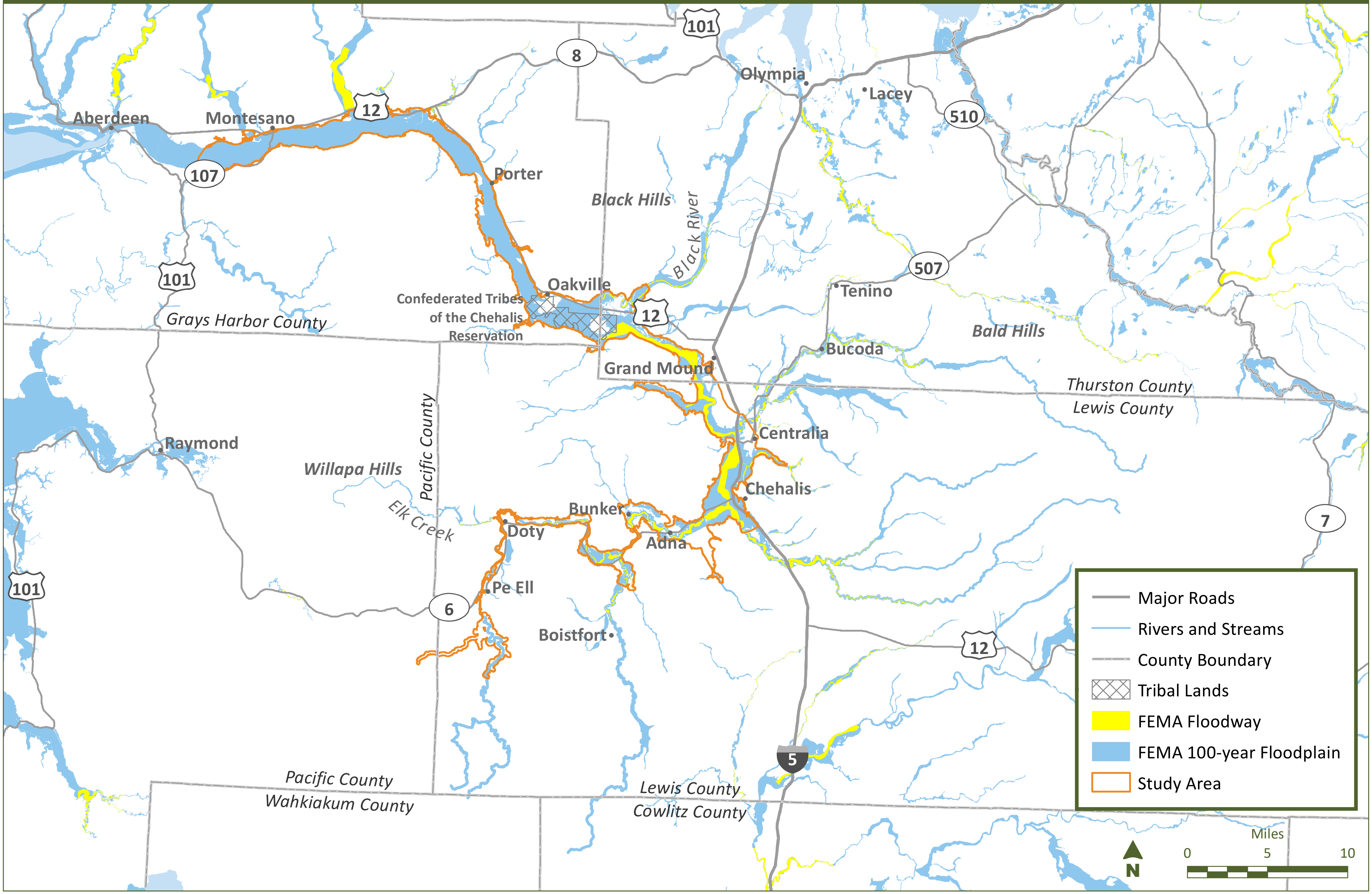
On average, approximately two-thirds of the Chehalis River flow observed at Grand Mound during the top ten floods can be attributed to flows from the upper Chehalis and South Fork Chehalis rivers, while approximately one-third can be attributed to Newaukum and Skookumchuck river flows (CBS 2016; WSE 2012).

2.2.2.2.2 Floodplain Mapping and Modeling

In the Chehalis Basin, communities that participate in the National Flood Insurance Program include: Bucoda, Centralia, Chehalis, Grays Harbor County, Lewis County, Oakville, Napavine, Pe Ell, and Thurston County. The Federal Emergency Management Agency (FEMA) has produced Flood Insurance Rate Maps for each participating community that identifies the Special Flood Hazard Area, or 100-year floodplain (Figure N-8). The FEMA floodplain maps and data provide a foundation for each community's regulation of floodplain development.

A recent assessment of floodplain management programs in the Chehalis Basin noted that maps for several communities are based on out-of-date or incomplete data and show regulatory floodplains that do not match observed historical flooding (French & Associates 2015). The FEMA floodplain maps for Centralia, for example, have been in place since June 1, 1982, while the estimate for a statistical 100-year flood has increased 33% in the last 30 years (CBWG 2014).

Figure N-8
FEMA Floodplains and Floodways



WSE developed a two-dimensional (2D) hydraulic computer model of the Chehalis River and its floodplain (WSE 2019b). The Riverflow 2D model extends from the proposed FRE facility, about 1.5 miles upstream of Pe Ell, downstream approximately 100 miles to a point west of Montesano in Grays Harbor County. It includes the sections of the Chehalis River extending through Centralia and Chehalis and encompasses portions of major tributaries including the South Fork Chehalis, Newaukum, Skookumchuck, and Black rivers and many smaller tributaries.

The model incorporates Light Detection and Ranging (LiDAR) topographic data and surveyed river channel cross-sections. It was calibrated to high water marks and observed data and stream gages for the January 2009 and December 2007 floods, and later validated using data from the February 1996 flood (WSE 2019b). The updated hydraulic model was used to determine the extent of the catastrophic flood analyzed in this EIS, and to map and analyze other flood scenarios.

A table of ground surface elevations and modeled water surface elevations for 25 key locations distributed throughout the study area, for various current and future conditions scenarios, is included in Attachment N-1. The 25 locations are primarily along the mainstem Chehalis River but also include points along the South Fork Chehalis River and Newaukum River. The 25 locations shown in Attachment N-1 are consistent with the locations reported for previous HEC-RAS modeling efforts in the basin (WSE 2019b; Ruckelshaus Center 2012).

2.2.2.3 Minimum Instream Flows

Ecology has established minimum instream flows for the Chehalis Basin (lower and upper) to provide for the preservation of wildlife, fish, scenic, aesthetic and other environmental and navigational values (Washington Administrative Code [WAC] 173-522). The minimum instream flows specify the amount of water needed in a particular place for a defined time, typically following seasonal variations, to protect and preserve instream resources and uses. They effectively serve as a water right for the stream and the resources that depend on it.

WAC 173-522 establishes minimum instream flows (base flows) for 31 stream management units in the Chehalis Basin, each of which has an associated control station designated for flow monitoring. Five of the 31 stream management units are on the mainstem Chehalis River, as shown in Table N-6. The remainder are on tributaries of the Chehalis River, including Elk Creek, South Fork Chehalis River, Newaukum River and its North and South forks, Salzer Creek, Skookumchuck River, Black River, Cedar Creek, Porter Creek, and several additional tributaries downstream of Porter.

Table N-6
Chehalis River Stream Management Units, Control Stations, and Minimum Instream Flows

CONTROL STATION NO./ STREAM MGMT UNIT	RM	AFFECTED STREAM REACH	RANGE OF BASE FLOWS (CFS)
12.0200.00/Chehalis River confluence with Elk Creek	101.8	From confluence with Elk Creek to headwaters, excluding Elk Creek	31 (Aug./Sep.) to 260 (Dec.-Apr.)
12.0235.00/Chehalis River	77.6	From confluence with Newaukum River to confluence with Elk Creek, excluding Elk Creek/ Newaukum River	75 (Aug./Sep.) to 700 (Dec.-Apr.)
12.0275.00/Chehalis River at Grand Mound	59.9	From confluence with Newaukum River to confluence with Prairie Creek	165 (Aug./Sep.) to 1,300 (Dec.-Apr.)
12.0310.00/Chehalis River at Porter	33.3	From confluence with Prairie Creek near Grand Mound to confluence with Porter Creek, including Prairie Creek	260 (Aug./Sep.) to 2,500 (Dec.-Apr.)
12.0350.02/Chehalis River below Satsop River confluence	20.0	From confluence with Porter Creek to just below confluence with Satsop River	550 (Aug./Sep.) to 3,800 (Dec./Apr.)

Flow monitoring data collected from the USGS gage at Grand Mound (No. 12027500), which under the Proposed Action serves as the reference gage for determining when to begin flood operations at the FRE facility and store flows in the temporary reservoir, indicate minimum instream flows are commonly not met at that location. Instream flows at Grand Mound were below the minimum for an average of 63 days per year (17%) for the 1929 to 2015 water years and are least likely to be met from May through August (Hill 2016). Instream flows at Grand Mound are generally met from January through March. For the 2018 water year at the Doty gage, instream flows were below the 31-cfs minimum established for the nearby Elk Creek control station, for most of the August 15 to September 15 period, with recorded low flows of 24 cfs.

During periods of water shortage (when minimum instream flows are not met), junior water rights (issued after March 10, 1976) may be required to stop withdrawing water. Uses of junior water rights during periods of water shortage are subject to a priority of use, with rights for domestic use having priority over all other uses and earlier-dated rights having priority over later-dated rights (WAC 173-522-040). In May 2019, Ecology curtailed access to surface water for irrigation for junior water right holders in the Chehalis River basin for the Chehalis, Newaukum, Satsop, and Wynoochee rivers and tributaries (Ecology Blogspot 2019).

2.2.2.4 Water Quality

Water quality in the Chehalis Basin has been studied by Ecology and others including Anchor QEA, LLC, and Portland State University (PSU). Ecology maintains long-term water quality monitoring stations on the mainstem Chehalis River at Dryad (RM 97.8) and Porter (RM 33), and instantaneous water quality data have been collected from additional locations on the Chehalis River and its tributaries as part of various studies. This description of existing water quality conditions focuses on the Chehalis River and the lower reaches of its primary tributaries in the upper Chehalis Basin (upstream of Porter at RM 33), where the potential for impacts from the Proposed Action is greatest.

Ecology has assessed approximately 780 miles (of 9,257 miles) of streams in the upper Chehalis Basin and determined that approximately 30% of those waters are meeting water quality standards while 70% are not (Collyard 2017). The most common water quality issues observed in the upper Chehalis Basin are high water temperature, low dissolved oxygen (DO), and fecal coliform bacteria standard exceedances. Excessive turbidity and pH values outside of the water quality standard range have also been documented in water samples, and elevated concentrations of dioxins and polychlorinated biphenyls (PCBs) have been found in fish tissue.

Ecology's current (2016) U.S. Environmental Protection Agency (EPA)-approved 303(d) list identifies segments of the upper Chehalis River as water quality limited (Category 5 waters) for turbidity, DO, dioxin, and PCBs. Total Maximum Daily Loads (TMDLs) are in place for the Chehalis Basin for temperature, DO, and fecal coliform bacteria. For the temperature TMDL, the load allocations are based on two assumptions: 1) riparian vegetation will be protected and re-established as the result of management action; and 2) water quality will not be degraded further by other influences. The major causes of water quality impairment in the upper Chehalis Basin include degraded riparian conditions, failing septic systems, and stormwater runoff from urban areas, agricultural lands, and commercial forestlands.

2.2.2.4.1 Water Quality Index Scores

Ecology assigns Water Quality Index (WQI) scores for the data collected at its long-term monitoring stations on the Chehalis River at Dryad (RM 97.8, Station 23A160) and Porter (RM 33, Station 23A070). Data are provided in Table N-7. The WQI summarizes and presents water quality data as a number ranging from 1 to 100, with a higher number indicating better water quality. WQI scores of 80 and above indicate that water quality is good and of lowest concern; scores between 40 and 80 indicate water quality is of moderate concern; and scores below 40 indicate poor water quality of the highest concern (Ecology 2019a).

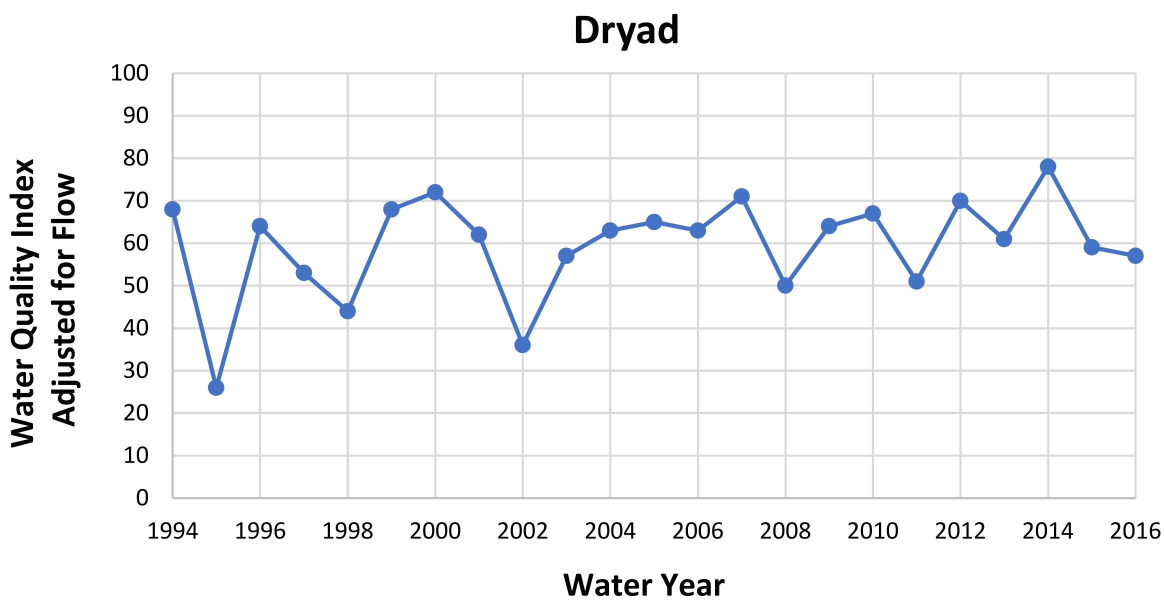
Table N-7
Water Quality Index Scores for Water Year 2016 at Dryad and Porter Monitoring Stations

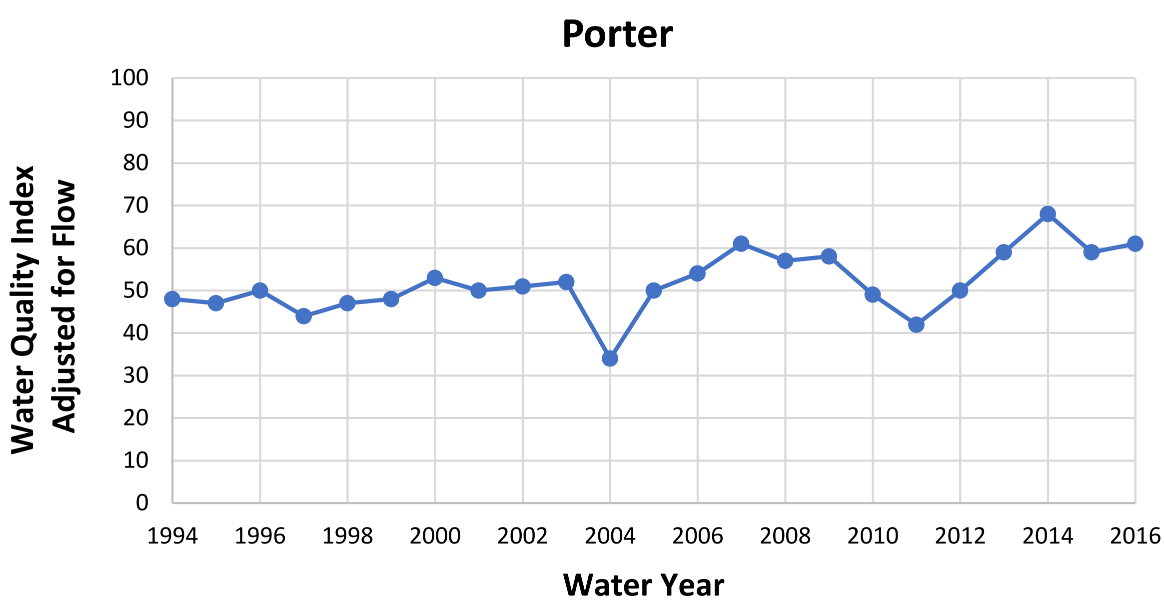
CONSTITUENT	DRYAD WQI SCORE	PORTER WQI SCORE
Fecal coliform bacteria	83	80
Oxygen	70	91
pH	94	89
Suspended solids	56	57
Temperature	67	63
Total persulfate nitrogen	47	42
Total phosphorus	54	45
Turbidity	60	60

As seen in Figure N-9, annualized WQI scores based on water year 2016 water quality data from the Dryad station showed good conditions for pH and fecal coliform bacteria and moderate conditions for DO, suspended solids, turbidity, temperature, nitrogen, and phosphorus. The 2016 data for the Porter station showed good conditions for fecal coliform bacteria, DO, and pH, and moderate conditions for suspended solids, turbidity, temperature, nitrogen, and phosphorus. The 2016 annual scores for both Dryad and Porter did not identify poor WQI scores for any parameter.

While annual WQI scores for the Dryad and Porter stations have generally trended higher in recent years and have been in the moderate to good range (Figure N-9), monitoring data from Ecology and Anchor QEA have shown poor water quality conditions for several parameters in the Chehalis Basin during at least some portions of the year. Additional information for specific parameters is provided in the following subsections.

Figure N-9
Water Quality Index Scores





2.2.2.4.2 Temperature

Monitoring data collected by Ecology and others show that summer water temperatures regularly exceed criteria for designated aquatic life uses in the Chehalis River and its tributaries. The applicable criteria for select stream segments in the study area are summarized in Table N-8 and in the text following the table.

Table N-8
Designated Aquatic Life Uses and Temperature Criteria for Select Chehalis Basin Streams (WAC 173-201A-200)

STREAM SEGMENT	DESIGNATED AQUATIC LIFE USES	CRITERIA (7-DADMax)
Chehalis River upstream of RM 90.2	Core summer salmonid habitat	16°C*
	Supplemental spawning and incubation (Sept 15 to July 1)	13°C
Chehalis River downstream of RM 90.2	Spawning, rearing, and migration	17.5°C*
	Supplemental spawning and incubation (Oct. 1 to May 15)	13°C
Elk Creek	Core summer salmonid habitat	16°C *
	Supplemental spawning and incubation (Sept. 15 to July 1)	13°C
South Fork Chehalis River mouth to 0.4 mile upstream	Spawning, rearing, and migration	17.5°C *
	Supplemental spawning and incubation (Sept. 15 to July 1)	13°C
Newaukum River	Core summer salmonid habitat	16°C*
	Supplemental spawning and incubation (Sept. 15 to July 1)	13°C
Skookumchuck River mouth to Hanaford Creek	Core summer salmonid habitat	16°C*
	Supplemental spawning and incubation (Sept. 15 to July 1)	13°C
Lincoln Creek	Spawning, rearing, and migration	17.5°C*
	Supplemental spawning and incubation (Sept. 15 to July 1)	13°C
Black River	Spawning, rearing, and migration	17.5°C**

Notes:
7-DADMax: 7-day average of daily maximum temperature
* Applies year-round except when superseded by supplemental spawning and incubation criteria
** Applies year-round

In addition to the numeric temperature criteria shown in Table N-8, Ecology's surface water quality standards contain other narrative criteria and guidelines relating to temperature, including the following:

- Moderately acclimated (16°C to 20°C) adult and juvenile salmonids will generally be protected from acute lethality by discrete human actions maintaining the 7-day average of daily maximum (7-DADMax) temperature at or below 22°C and the 1-day maximum (1-DMax) temperature at or below 23°C (WAC 173-201A-200(1)(c)(vii)(A)).

- When a waterbody's temperature is warmer than the criteria (or within 0.3°C of the criteria) and that condition is due to natural causes, then human actions considered cumulatively may not cause the 7-DADMax temperature of that waterbody to increase more than 0.3°C (WAC 173-201A-200).

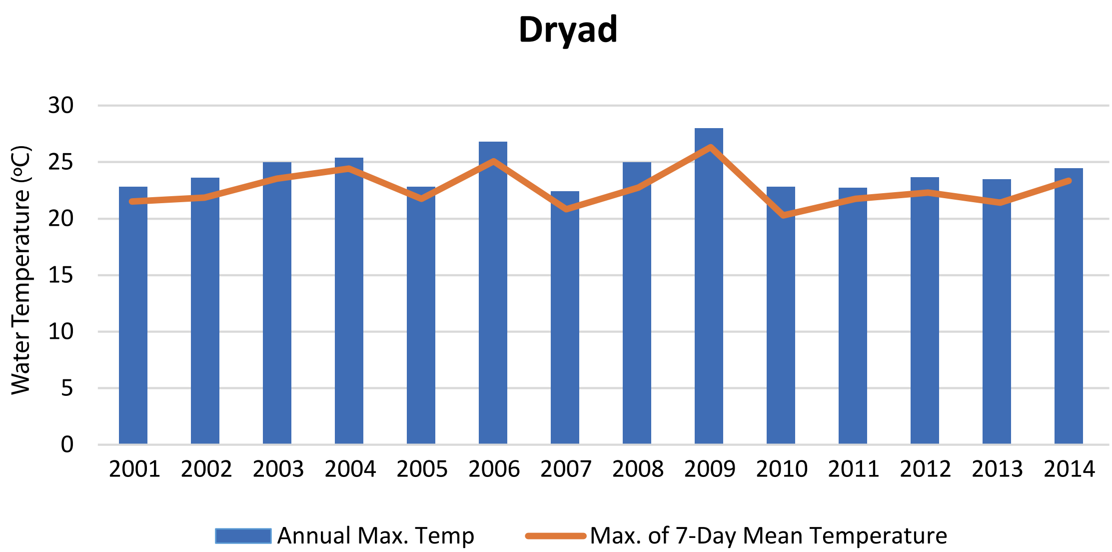
Ecology's long-term monitoring stations on the mainstem Chehalis River at Dryad (RM 97.8) and Porter (RM 33) show that from 2001 to 2016, annual maximum temperatures and 7-DADMax temperatures for nearly all years were above 20°C and some years were above 25°C (Figure N-10; Ecology 2019a, 2019b). 20°C exceeds criteria for core summer habitat (16°) and spawning, rearing, and migration habitat (17.5°C), and 25°C exceeds the Washington state narrative acute lethality guidelines for moderately acclimated juveniles and adult salmonids.

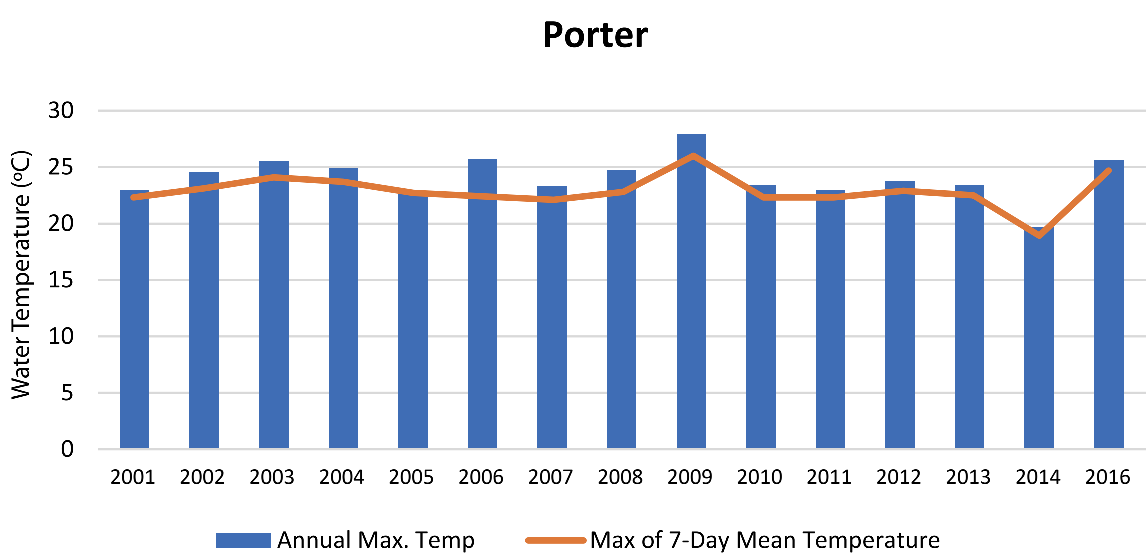
Anchor QEA conducted continuous temperature monitoring in 2013 and 2014, to characterize baseline conditions in the upper Chehalis Basin (Anchor QEA 2014). Automated temperature data were collected from 12 Chehalis River sites, from upstream of Pe Ell (RM 107), downstream to near Oakville (RM 42), and from tributaries including Elk and Lincoln creeks, and the Newaukum, Skookumchuck, and Black rivers. The approximately 1-year temperature monitoring period extended from late July 2013 through July 2014.

In general, the 2013 to 2014 monitoring showed that all stations in stream reaches designated as core summer salmonid habitat exceeded the criterion (16°C) in August and September 2013 and July 2014. Stations in stream reaches with supplemental spawning/incubation criteria applied in the September 15 to July 1 range showed exceedances of the 13°C criteria in late September and again from late May through June. The data for the station on the Chehalis River above Pe Ell (RM 107) show that the 7-DADmax was approximately 21°C in August 2013 and 23°C in July 2014. The July 2014 data show acute impairment that exceeds Washington's lethality guidelines.

The highest stream temperatures typically occur in July and August. Solar heating is the primary driver of water temperatures, and elevated stream temperatures are primarily attributed to a lack of stream shading, including that provided by mature riparian vegetation. Human activities, including urban and residential development, agriculture, and forest harvesting, have contributed to degraded riparian vegetation in the Chehalis Basin (Ecology 2001). Ecology's temperature TMDL study report for the upper Chehalis River and its tributaries notes that over 30% of riparian vegetation has been lost or reduced (Ecology 2001).

Figure N-10
Chehalis River Maximum Water Temperatures





2.2.2.4.3 Dissolved Oxygen

DO is an important water quality parameter because many aquatic species, including fish, need it to survive. Water's capacity to hold DO decreases with increasing temperature, and DO levels are generally lower in summer when flows are lower and temperatures and biological activity are higher. The upper Chehalis River is identified on Ecology's most recent 303(d) list as water quality limited for DO, based on criteria exceedances from 2004 to 2009 monitoring data from Ecology's Dryad station (Ecology 2016a).

Similar to temperature, Washington's water quality criteria for DO are based on designated aquatic life uses. The criterion for core summer salmonid habitat is a 1-day minimum of 9.5 milligrams per liter (mg/L); this applies to the mainstem Chehalis River upstream of the South Fork confluence, as well as Elk Creek, Newaukum River, and Skookumchuck River. The criterion for salmonid spawning, rearing, and migration habitat is 8.0 mg/L; this includes the mainstem Chehalis River downstream of the South Fork confluence, the South Fork Chehalis River, Lincoln Creek, and Black River.

When a waterbody's DO levels are lower than the criteria, and that condition is due to natural causes, then human actions considered cumulatively may not cause the DO level of that waterbody to decrease more than 0.2 mg/L (WAC 173-201A-200).

Monthly sampling data collected by Ecology from the Dryad station on the Chehalis River (RM 97.8) show exceedances of the daily minimum DO criterion of 9.5 mg/L during the summer. Between 2010 and 2016, the lowest monthly DO sampling result from Dryad was 8.5 mg/L (Ecology 2019b). At the long-term monitoring station at Porter (RM 33), monthly sampling data show that the daily minimum DO criterion of 8.0 mg/L is typically met, with one exceedance (at 7.9 mg/L) since 2001 (Ecology 2019c).

Monthly sampling by Ecology in 2016, 2017, and 2018 identified DO levels in samples collected from the Chehalis River above Pe Ell to be below the 9.5 mg/L criteria on August 31, 2016 (8.9 mg/L) and August 15, 2018 (8.9 mg/L). DO monitoring data collected by Anchor QEA showed DO below 9.5 mg/L downstream of Pe Ell in August and September 2013 and in July 2014 (Anchor QEA 2014).

2.2.2.4.4 Turbidity

Turbidity is a measure of water clarity that is largely influenced by suspended sediments, with higher total suspended solids (TSS) levels generally associated with higher turbidity levels. Algae can also contribute to elevated turbidity levels. Excessive instream turbidity and suspended sediment can adversely affect fish and aquatic habitat in several ways, including by reducing the amount of light available for aquatic plants, interfering with fish feeding behavior, clogging gills, and silting in spawning gravels.

The aquatic life turbidity criteria for Chehalis Basin streams state turbidity shall not exceed 5 nephelometric turbidity units (NTUs) over background when the background is 50 NTUs or less; or a 10% increase in turbidity when the background is more than 50 NTUs. The upper Chehalis River is identified on Ecology's most recent 303(d) list as water quality limited for turbidity, based on measured turbidity differences between the Dryad station (upstream) and Cloquato station (downstream) in 1992 to 2001 (Ecology 2016a).

Instream turbidity levels are naturally highly variable, depending on conditions. They are typically highest in winter months during periods of heavy precipitation and high flows, and lowest in summer when precipitation and flows are low. For example, turbidity measured on the Chehalis River at the proposed FRE facility site was 610 NTUs on February 9, 2017, during high flows, and 12.2 NTUs on March 29, 2017, during moderate flows (Anchor QEA 2017c). Data from Ecology's long-term monitoring sites at Dryad and Porter show that summer turbidity is often in the range of 2 NTUs or less (Ecology 2019b, 2019c).

2.2.2.4.5 Fecal Coliform

Fecal coliform bacteria originate in the intestines of humans and other animals. Fecal coliform contamination is introduced to the upper Chehalis River system almost entirely from non-point sources including failing sewage septic systems, livestock operations, dairy farms, hobby farms, stormwater, and wildlife (Ecology 2004). Washington's water contact recreation bacteria criteria currently state that fecal coliform or E. coli may be used for compliance purposes until December 31, 2020. Fecal coliform levels must not exceed a geometric mean value of 100 colony forming units (CFUs) or most probable number (MPN) per 100 milliliters (mL), with not more than 10% of samples exceeding 200 CFU or MPN per 100 mL (WAC 173-201A-200). *E. coli* levels must not exceed a geometric mean value of 100 CFUs or MPN per 100 mL, with not more than 10% of samples exceeding 320 CFU or MPN per 100 mL (WAC 173-201A-200).

A fecal coliform bacteria TMDL for the upper Chehalis River was implemented in 2004 based on standard exceedances, and instream levels have generally been decreasing over time. Monitoring data from Ecology's long-term monitoring station at Dryad show only one monthly sample exceedance of the fecal coliform standard since 2004. Farther downstream, the monitoring station at Porter shows four exceedances of the water quality standard since 2004 (Ecology 2019b and 2019c). The upper Chehalis River is still listed in Ecology's Water Quality Assessment as a water of concern (Category 2) for fecal coliform bacteria (Ecology 2016a).

2.2.2.4.6 pH

Water pH is a measure of acidity or basicity, with lower pH values (below 7 Standard Units [SUs]) more acidic and higher pH values more basic. In rivers and streams, pH is influenced by chemical interactions between water and sediments as well as photosynthesis by aquatic plants and algae. Pollutant discharges that change water chemistry and aquatic biological functions can lead to excessively low or high instream pH, which can be harmful to aquatic organisms that require a limited pH range to survive.

Washington's water quality criteria state that freshwater pH should be within the range of 6.5 to 8.5 SUs. Allowable human-caused variation to the standard is limited to 0.2 SUs in core summer salmonid habitat and 0.5 SUs in salmonid spawning, rearing, and migration habitat.

Ecology's Water Quality Assessment identifies the upper Chehalis River as a water of concern (Category 2) for pH, based on limited exceedances in monitoring data from Ecology's long-term monitoring station at Dryad (RM 97.8). However, there have been no recorded exceedances of pH criteria in the monthly sampling data at Dryad since 2005 or at Porter (RM 33) since 1996 (Ecology 2019b, 2019c). Recent sampling by Anchor QEA showed pH to be within the water quality standard range at all sampling locations over multiple sampling dates in 2013 to 2014 and 2017, with the exception of pH values above the high end of the standard (between 8.5 and 9.0) in the Chehalis River downstream of Pe Ell in September 2013 (Anchor QEA 2014; Opdyke et al. 2017).

2.2.3 Groundwater

Groundwater is the water found underground in the spaces of saturated soil and rock. A saturated soil or rock layer with spaces that allow water to move through it is called an aquifer. Aquifers may be confined or unconfined. A confined aquifer is bound by impermeable layers (e.g., rock or clay) above and below it and is usually under pressure. Unconfined aquifers have no upper confining layer; the top of the aquifer is the water table that is in equilibrium with atmospheric pressure and rises and falls in response to recharge or discharge.

In general, groundwater flow is influenced by topography and moves toward surface water drainages and marine waterbodies. The area of sediment beneath and adjacent to a waterbody where surface water and groundwater interact is known as the hyporheic zone. Groundwater in the shallow aquifers of the Chehalis Basin is closely connected with the Chehalis River and its tributaries (Ecology 2005), and that connection means affecting the quantity or quality of one can affect the quantity or quality of the other.

The following subsections address existing groundwater conditions in the Chehalis Basin, which have been studied for various purposes by the USGS, Ecology, and others.

2.2.3.1 Hydrogeologic Units

Both unconfined and confined aquifers provide significant sources of groundwater in the Chehalis Basin, with the primary aquifers comprised of Pleistocene glacial outwash and Holocene alluvium deposited along the valleys of the Chehalis River and its major tributaries (USGS 2011). As part of a study of the hydrogeologic framework and groundwater/surface water interactions in the basin, USGS (2011) identified and characterized five hydrogeologic units above a low-permeability basal bedrock unit. The five hydrogeologic units and the underlying basalt bedrock, all of which are present in the Chehalis Basin, are summarized here and shown in Figure N-11.

A Aquifer

The A aquifer extends throughout the major river valleys and lowland prairies of the Chehalis River. It is the most extensive surficial aquifer in the Chehalis River Basin and comprises most of the floodplain areas with the potential to be affected by the Proposed Action.

The A aquifer interacts closely with surface water features, generally receiving recharge from the rivers during the winter when river levels are high and discharging to rivers in the summer when levels are low. This unit contains silt, sand, gravel, and coarser alluvial sediments of glacial and non-glacial origin. The youngest sediments are coarse-grained channel and fine-grained overbank deposits distributed across the floodplain of the Chehalis River and its tributaries. These sediments overly and are hydrologically connected to older glacial deposits below. South of Centralia, the aquifer is mostly composed of older, poorly sorted, fine-grained material, weathered from alpine glacial outwash forming terraces in the Newaukum and Chehalis river valleys.

B Confining Unit

The B confining unit is composed of unsorted and unstratified clay- to boulder-sized material that occurs in the north part of the Chehalis Basin. Although some local deposits of sand and gravel contain small amounts of groundwater, the B confining unit mainly consists of fine-grained sediments that act as a confining unit. This material was deposited during the last glacial advance.

C Aquifer

The C aquifer is mainly composed of well-sorted sand, gravel, and cobble-sized sediment deposited as glacial outwash. This aquifer is confined by the B confining unit in the north part of the Chehalis Basin.

D Undifferentiated Aquifers and Confining Units

The D unit is composed of glacial tills and outwash sequences deposited in the north part of the Chehalis Basin (north of Centralia). Groundwater aquifers in the unit are confined and within coarse-grained outwash sequences that are separated from higher aquifers (A and C) by thin till layers. Multiple aquifers and confining units within the D unit may exist where they have not been eroded and have not been differentiated because they are not laterally continuous.

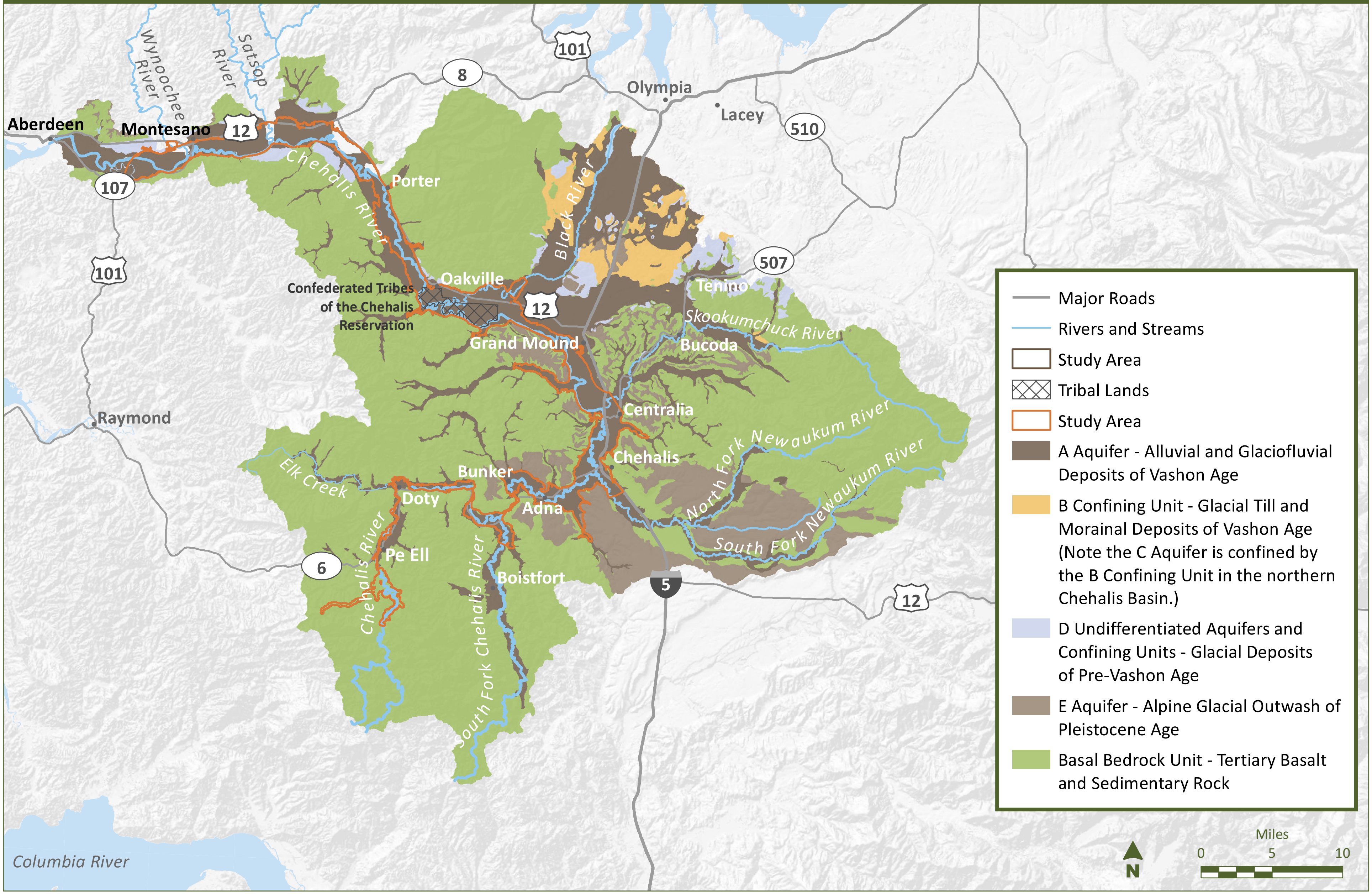
E Aquifer

The E aquifer is situated on the bedrock uplands of the Chehalis Basin and is composed of alpine glacial outwash originating from the Cascade Range and Olympic Mountains. Deposits in this unit consist of volcanic and sedimentary rocks, including siltstones, sandstones, and conglomerates. The top portions of these deposits have been weathered into clay, confining groundwater where saturated.

Basal Bedrock Unit

Tertiary bedrock forms the base confining unit of the groundwater-flow system in the Chehalis Basin. It is relatively impervious, consisting of marine and non-marine siltstones, sandstones, and conglomerates, as well as intrusive and extrusive volcanic rocks. Groundwater is present in bedrock fractures in some locations at quantities sufficient for domestic use. In the south part of the Chehalis Basin, groundwater is contained within sandstone interbeds of the inferred non-marine Miocene Wilkes Formation.

Figure N-11
Groundwater Aquifers



2.2.3.2 Groundwater Movement and Fluctuation

USGS (2011) studied groundwater/surface water interactions and groundwater movement and fluctuations in the Chehalis Basin, using information from streamflow gaging and well monitoring stations. In general, horizontal groundwater flow generally follows the contours of the surface water drainage of the Chehalis River and its tributaries, flowing from the headwaters toward Grays Harbor. Hydraulic gradients are relatively steep in the tributary valleys such as the Newaukum Valley (about 23 feet per mile) and flatter in the alluvial valley of the central Chehalis River (about 6 feet per mile).

In the Chehalis Basin, groundwater levels fluctuate seasonally, and over shorter periods, in response to storms and river stages. In general, groundwater levels rise in fall and winter when precipitation is highest and water use is lowest, and levels fall in summer when precipitation is lower and water use increases. In the USGS study (2011), water levels measured from 14 wells in the surficial aquifer fluctuated between 4.8 feet and 16.8 feet during the 2010 water year, with the largest fluctuation observed in a well farthest from a river and within a confined D-unit aquifer. Rivers and other surface waters may attenuate water level fluctuations in wells close to these waters because they can provide aquifer recharge when aquifer levels are low and receive aquifer discharge when levels are high (USGS 2011).

The uppermost unconfined aquifer (A unit) exchanges water with the Chehalis River and its tributaries. Groundwater levels in wells very near the Chehalis River (less than 0.1 mile) have been observed to fluctuate directly with river stage, while water levels in wells at greater distances from the river have more muted responses to fluctuations in river stage (USGS 2011; Ecology 2005).

2.2.3.3 Groundwater Quality

Ecology completed extensive groundwater quality monitoring as part of a 2003 to 2005 hydrogeologic assessment of the Centralia-Chehalis area surficial aquifer (Ecology 2005). The study area encompassing approximately 32 square miles of the floodplain and bottomland surrounding the confluences of the Chehalis, Newaukum, and Skookumchuck rivers.

The Ecology study found that overall, groundwater quality in the study area was good (Ecology 2005). All of the water supply wells sampled were below the public drinking water maximum contaminant level (MCL) for nitrate of 10 mg/L, although several wells in the north portion of the study area (vicinity of Fords Prairie) had elevated values between 5 mg/L and 10 mg/L. Approximately one-third of the wells tested exceeded the secondary (aesthetic) drinking water standards for iron or manganese, which is a common non-health related water quality condition in Western Washington. Approximately 20% of wells tested exceeded the secondary standard for sodium. There were no standard exceedances for chloride, total dissolved solids, sulfate, or lead, and volatile organic compounds were not detected at significant concentrations in any wells. Arsenic exceeded the public drinking water MCL of 10 micrograms per liter (µg/L) in a single well and the (much lower) state groundwater standard of

0.05 µg/L in most of the wells tested, although arsenic concentrations up to 1 ug/L are expected to represent natural conditions.

The Ecology study found water quality results were generally consistent between the end of the wet season in May and the end of the dry season in October. Also, the water quality measured in instream piezometers frequently matched conditions observed in upgradient wells, providing an indication of the close hydraulic and geochemical connections between area rivers and the surficial aquifer system (Ecology 2005).

An investigation of groundwater temperatures was conducted by Anchor QEA in 2014 as part of a larger water quality characterization effort for the Chehalis Basin Strategy (Anchor QEA 2014). Groundwater temperatures were measured in domestic wells in the Chehalis Basin, in river reaches previously identified by the USGS (USGS 2008) to have the greatest contribution to surface water flow. Temperatures were measured in September 2013, October 2013, and July 2014.

The results of the Anchor QEA study showed that in September 2013 and July 2014, groundwater temperatures were significantly cooler than surface water (by up to 6°C), while in October 2013 the groundwater temperatures were slightly warmer. In summer, the groundwater temperature in the upper reaches (above Elk Creek at RM 104) and immediately downstream of the South Fork Chehalis River confluence (RM 87) were warmer than at other locations, but still cooler in summer and warmer in October than surface water at both locations. At each of two locations where two wells were sampled, one deep and one shallow, temperature differences between the shallow and deeper wells were generally not significant (within 2°C of each other).

2.2.4 Water Use and Water Rights

2.2.4.1 Water Use

Most residential, industrial, and agricultural development and demand for water in the Chehalis Basin are within the valleys of the Chehalis River and its primary tributaries, the Newaukum and Skookumchuck rivers (USGS 2011). Centralia and Chehalis are served by municipal public water supply systems, while most rural water users are self-supplied (e.g., domestic and irrigation wells) or served by smaller public water systems (USGS 2018).

The largest public water supply withdrawals in the study area (more than 100 million gallons per year) are from municipal groundwater wells for the City of Centralia and surface water intakes on the North Fork Newaukum River and Chehalis River for the City of Chehalis. The next largest public water withdrawal in the study area is Pe Ell's municipal water supply, which is approved for up to 510 connections and has an annual consumption of more than 50 million gallons (Lewis County 2010). A 2015 Town of Pe Ell Water System Master Plan identified 373 connections at that time, consisting of 343 residential, 12 business, 1 public school, 1 industrial, and 16 standby connections (Gray & Osborne 2015).

The Town of Pe Ell's primary water intake is on Lester Creek, which flows into Crim Creek just upstream of its confluence with the Chehalis River, approximately 3 miles upstream of Pe Ell. The Lester Creek intake site impounds streamflows with a concrete dam with wooden weir boards. Raw water flows are transmitted from the intake by gravity flow to a water treatment facility on the east side of the Chehalis River (Gray & Osborne 2015). Pe Ell also has a secondary (backup) intake on the Chehalis River, from which river flows can be pumped to the water treatment facility (Figure N-12).

2.2.4.2 Water Rights

There are approximately 1,740 water right permits and certificates, and an additional 5,300 water right claims, in the Chehalis Basin (Ecology 2018). These cover both consumptive and non-consumptive uses of water. Consumptive water uses cause diminishment of the source at the point of appropriation; examples include common uses for domestic and irrigation purposes. Non-consumptive uses do not diminish the source; for example, fish hatcheries for which the outflow is returned to the point of diversion.

Irrigation and domestic use are the primary purposes for the largest number of water rights in the upper Basin. Irrigation and power generation are the primary purposes for the rights with the highest total instantaneous withdrawal rates, with the largest of these being 140 cfs and 80 cfs rights issued to Pacific Power & Light Co. (now Pacific Power) for withdrawals from the Skookumchuck River at the Skookumchuck Dam. Irrigation, fish propagation, and power generation represent the primary purposes for rights with the highest annual volume limit (CBP 2004).

Pe Ell holds a water right for municipal surface water withdrawals from Lester Creek and the Chehalis River under Water Right No. CS2-SWC1060, which has a priority date of November 22, 1934 (Figure N-12). This water right authorizes up to a 2-cfs withdrawal from Lester Creek and a 0.78-cfs withdrawal from the Chehalis River. The combined withdrawal from both sources must not exceed 250.27 acre-feet per year and must be used for municipal supply purposes.

Pe Ell holds two other water rights for diversion of surface water from Crim Creek (S2-00818C) and Mahaffey Creek (S2-0836C), each for 0.67 cfs and 206 acre-feet per year (Figure N-12). Those rights have a priority date of August 5, 1971. The diversions and conveyance systems from those points have been removed and water is not currently being withdrawn from those locations; however, Pe Ell could use them at some point in the future (Gray & Osborne 2015).

Types of Water Rights

A water right is the legal authorization to use a certain amount of public water for a designated purpose. The water must be put to a beneficial use. There are three types of water rights:

- **Claim:** A "claim" that water was used prior to the 1917 Surface Water Law or 1945 Ground Water Law
- **Permit:** Permission by the state to develop a water right, but not a final water right; must be perfected to be certificated
- **Certificate:** Issued as a legal record of the water right and recorded with the county once all permit conditions are met; a water right certificate is considered a property right

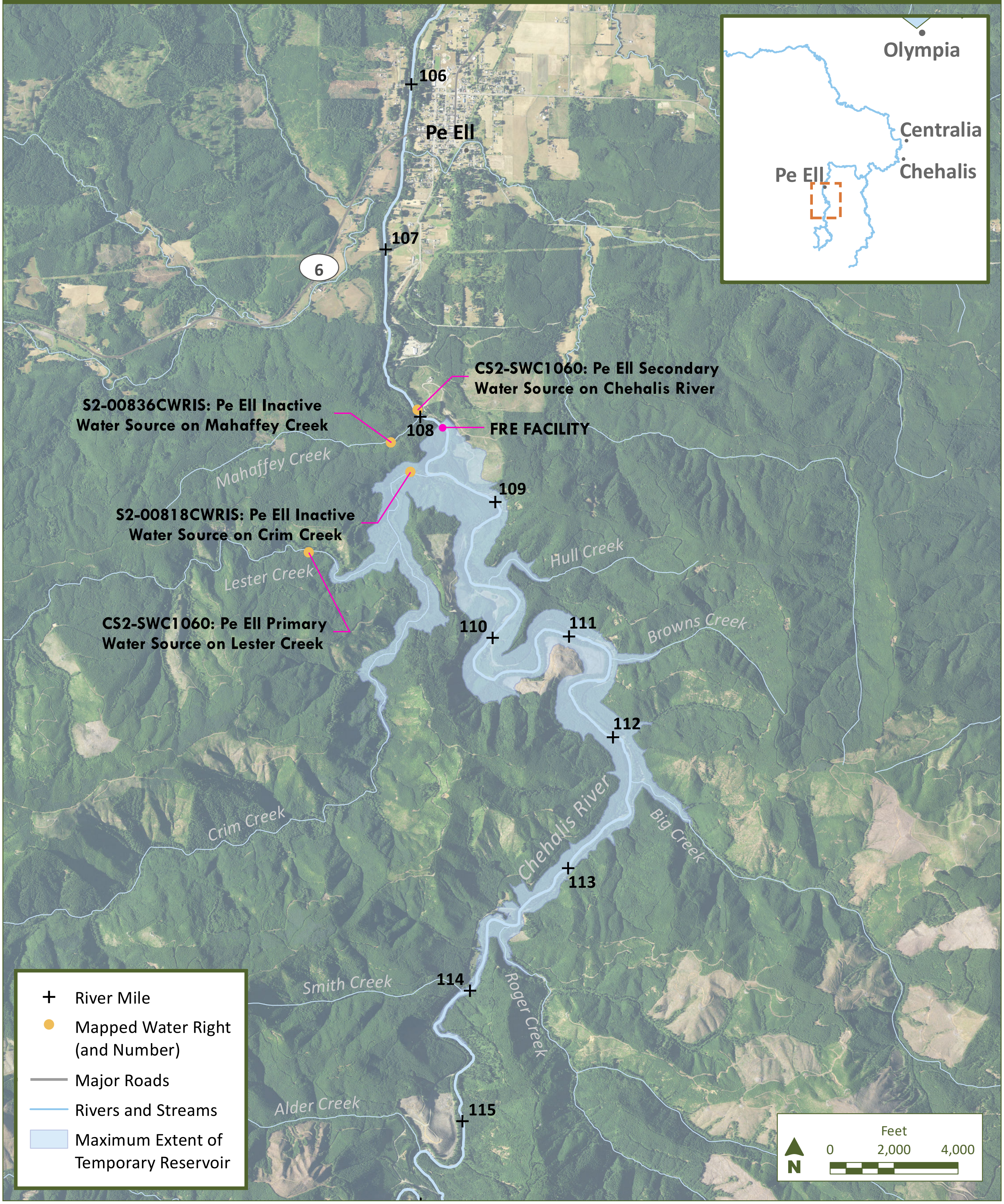
In an evaluation conducted in support of the 2004 *Chehalis Basin Watershed Management Plan*, estimates of allocated water rights were found to exceed actual water use, and the sum of instream flow requirements and allocated water rights was found to exceed Chehalis River flows at Porter for portions of the year (CBP 2004). As described in Section 2.2.2.3, minimum instream flows required under WAC 173-522 are commonly not met in the Chehalis Basin, and Ecology recognizes there is limited water available for new uses (Ecology 2016b).

Holders of junior water rights—those that were issued after the March 10, 1976 effective date of the state's instream flow regulation for the Chehalis Basin (WAC 173-522)—are subject to curtailment orders when minimum instream flows are not met. On May 30, 2019, Ecology issued curtailment orders to 93 junior water right holders in the Chehalis Basin to stop diverting water from the Chehalis, Newaukum, Satsop, and Wynoochee rivers for irrigation purposes. Such actions are not uncommon, as 2019 was the fifth consecutive year that Ecology issued curtailment orders to junior water rights holders in the Basin as a result of instream flows not being met (Ecology Blogspot 2019).

A 2003 evaluation of water quantity in support of the *Chehalis Basin Watershed Management Plan* estimated that, in addition to water rights, there are more than 5,000 permit-exempt wells in the Chehalis Basin (Tetra Tech/KCM 2003). Washington's Groundwater Code (Chapter 90.44 Revised Code of Washington [RCW]) allows small withdrawals of groundwater from such wells for domestic and industrial uses (less than 5,000 gallons per day), irrigation of lawns or non-commercial gardens (0.5 acre in size or less), and livestock watering. Although permit-exempt wells do not require a water right permit, they establish a right that is equal to a permitted right and may not be impaired by a junior water right user.

In January 2018, RCW 90.94 was signed into law in response to the Hirst decision. Hirst was a 2016 Washington State Supreme Court decision that changed how some counties issued building permits. In general, the decision limited a landowner's ability to get a building permit for a new home when the proposed source of water was a permit-exempt well. RCW 90.94 addresses the court's decision by allowing landowners to obtain a building permit for a new home relying on a permit-exempt well. The law also directs local planning groups to develop streamflow restoration plans that address the potentially negative impacts from new development.

Figure N-12
Surface Waters and Water Rights Near FRE Facility



2.3 Studies and Reports Referenced/Used

The following studies and reports were used to inform an understanding of the existing water conditions described in this discipline report:

- *Chehalis Basin Strategy Programmatic Environmental Impact Statement* (Ecology 2017)
- Ecology's Water Quality Assessment and 303(d) list (Ecology 2016a)
- *Upper Chehalis River Watershed Multi-Parameter TMDL* (Ecology 2010a)
- *Upper Chehalis River Fecal Coliform TMDL* Recommendations (Ecology 2004a)
- *Upper Chehalis River Basin Temperature Total Maximum Daily Load* (Ecology 2001)
- *The Chehalis/Grays Harbor Watershed Dissolved Oxygen, Temperature, and Fecal Coliform Bacteria TMDL – Detailed Implementation (Cleanup) Plan* (Ecology 2004b)
- *Revised Upper Chehalis River Basin Dissolved Oxygen TMDL – Submittal Report* (Ecology 2000)
- *Black River Dry Season Dissolved Oxygen and Phosphorus TMDL* (Ecology 1994)
- *Chehalis Basin Watershed Assessment* (Ecology 2010b)
- *Chehalis Basin Watershed Management Plan* (CBP 2004) and related assessment reports
- *Quinault Indian Nation State of the Watersheds Report* (Quinault Indian Nation 2016)
- *Hydrology and Quality of Groundwater in the Centralia-Chehalis Area Surficial Aquifer* (Ecology 2005)
- *Chehalis Basin Ecosystem Restoration General Investigation Study Baseline Hydrology and Hydraulics Modeling* (WEST Consultants 2014)
- USGS stream gage data
- Ecology water quality monitoring data
- *Water Quality Studies Final Report* (Anchor QEA 2014)
- Summary of water quality data collected on February 9 and March 29, 2017 (Anchor QEA 2017c)
- *Hydrogeologic Framework and Groundwater/Surface-Water Interactions of the Chehalis River Basin, Southwestern Washington* (USGS 2011)
- *Seepage Investigation for Selected River Reaches in the Chehalis River Basin, Washington* (USGS 2008)
- *Chehalis River Watershed Surficial Aquifer Characterization* (Ecology 1998)
- *Water Budget of the Upper Chehalis River Basin, Southwestern Washington* (USGS 2018)
- *Comprehensive Flood Hazard Management Plan for the Confederated Tribes of the Chehalis Reservation* (GeoEngineers and Herrera 2009)

Additionally, the following studies and reports were used to analyze the effects of the alternatives on water:

- *Operations Plan for Flood Retention Facilities* (Anchor QEA 2017a)
- Memorandum on Development and Calibration of Hydraulic Model (WSE 2014)
- Memorandum on Chehalis River Existing Conditions Riverflow 2D Model Development and Calibration (WSE 2019b)

- Memorandum on Chehalis River Basin Hydrologic Modeling (WSE 2019a)
- *Chehalis Water Quality and Hydrodynamic Modeling Model Setup, Calibration, and Scenario Analysis* (PSU 2017)
- *Reservoir Water Quality Model Report* (Anchor QEA 2017b)
- *Reservoir Water Quality Report* (Anchor QEA 2019a)
- *Draft Potential Groundwater Level Effects Analysis* (Anchor QEA 2019b)
- *Geomorphology and Sediment Transport* (Watershed GeoDynamics 2019)

2.4 Technical Approach

To evaluate the potential effects on water, existing data and information from previous studies were used to characterize existing conditions for surface waters and groundwater in the study area. Recent project-related technical studies and modeling were then used to qualitatively and/or quantitatively evaluate impacts on water from the Proposed Action and the alternatives for future conditions in mid- and late century. Future conditions modeling accounted for anticipated changes to hydrological and meteorological conditions associated with climate change.

A 2D hydraulic model, RiverFlow2D, was used to identify the area of study and impacts. It includes the sections of the Chehalis River extending through Centralia and Chehalis and encompasses portions of major tributaries including the South Fork Chehalis, Newaukum, Skookumchuck, and Black rivers and many smaller tributaries. The model incorporates LiDAR topographic data collected in 2012 and 2017 and surveyed river channel cross-sections from multiple sources (WSE 2019b). It was calibrated to high water marks and observed data and stream gages for the January 2009 and December 2007 floods, and later validated using data from the February 1996 flood (WSE 2019b). Ordinary high water levels for surface waters in the study area are described in detail in the *Wetlands Discipline Report* (Anchor QEA 2020a).

The RiverFlow2D hydraulic model incorporated hydrologic inputs that account for climate change in future conditions scenarios. The factors applied to increasing peak flows due to climate change were informed by the use of Distributed Hydrologic Soil Vegetation Model software that was used to configure a hydrologic model, providing an integrated representation of watershed processes. Meteorological inputs for the hydrologic model were provided by the University of Washington's Climate Impacts Group and included a historical data set spanning January 1981 through December 2015, as well as two long-term historical/future data sets based on Global Climate Model predictions. USGS gage flow records were used in conjunction with the model to estimate flows for future climate change conditions (Anchor QEA and WSE 2019).

Water quality models were used to assess the effects on temperature and other water quality parameters in the temporary reservoir when storing water, in the temporary reservoir footprint when not storing water, and downstream of the FRE facility under storage and non-storage conditions.

CE-QUAL-W2 models were used based on their suitability and history of use for rivers and reservoirs. The reservoir model evaluated effects along the mainstem Chehalis River from the proposed FRE facility (RM 108) upstream to approximately RM 115. It also extended approximately 2.5 miles into the lower section of Crim Creek, including portions of Lester Creek. The downstream model extended from the FRE facility downstream to Porter at RM 33, which represents the downstream extent of the upper Chehalis Basin (WRIA 23), where the proposed FRE facility is located and water quality impacts are probable.

Impacts on geomorphology are discussed in detail in the *Earth Discipline Report* (Shannon & Wilson and Watershed GeoDynamics 2020). A combination of CE-QUAL-W2, HEC-RAS, and Water Erosion Prediction Project (WEPP) models were used to evaluate the different deposition and resuspension mechanisms for major and catastrophic floods; model details are documented in the *Reservoir Water Quality Report* (Anchor QEA 2019a). To represent the range of solids sizes entering the FRE facility, TSS is split into three size classes: sand, silt, and clay. The initial deposition of sediments during impoundment and the resulting effect on TSS and turbidity in outflowing water as the temporary reservoir drains was simulated in CE-QUAL-W2. The HEC-RAS model was used to evaluate deposition and resuspension of sediments within the active river channel as the temporary reservoir empties. The following two approaches were used to estimate erosion and transport of sediments from the upland (i.e., valley wall) portions of the temporary reservoir footprint:

- The possibility of wave erosion was estimated by assuming all fines (i.e., silts and clays) resuspend as the temporary reservoir elevation drops.
- The possibility of erosion and transport of sand-sized particles from the valley walls into streams within the temporary reservoir footprint triggered by rainfall events after the temporary reservoir drained was estimated using WEPP.

The impacts analysis considered construction- and operation-related effects on water quality, water quantity, and water uses and rights for both surface water and groundwater. The Proposed Action and alternatives were analyzed to determine if they would have a significant or moderate impact on water. In general, impacts for water are identified based on their potential to conflict with regulatory requirements or otherwise change ambient conditions in an adverse way.

3 TECHNICAL ANALYSIS AND RESULTS

3.1 Overview

This section describes the probable water impacts from the Proposed Action (Section 3.2), Local Actions Alternative (Section 3.3), and No Action Alternative (Section 3.4). This section also evaluates required permit conditions and planning document requirements that could address the impacts identified (Section 3.2.3). When probable significant adverse environmental impacts remain after considering these, the report identifies mitigation measures that could avoid, minimize, or reduce the identified impact below the level of significance (Section 3.2.4).

3.2 Proposed Action

3.2.1 Impacts from Construction

This section describes the impacts from construction of a flood retention facility (referred to as the FRE facility) and associated activities including heavy equipment operation, constructing and operating a bypass tunnel, equipment and material staging areas, road upgrades, and quarries developed for FRE facility construction. It also describes the impacts from construction activities associated with changes to the airport levee. The potential impacts of the FRE facility and changes to the airport levee on surface water, groundwater, and water uses and rights are addressed in the following subsections. The Chehalis River Basin Flood Control Zone District (Applicant) plans to construct the FRE facility from 2025 to 2030, if permitted. The airport levee construction would occur over 1 year during this period.

3.2.1.1 Flood Retention Expandable Facility

3.2.1.1.1 Surface Water

3.2.1.1.1.1 Surface Water Quantity

Construction of the FRE facility would affect surface water quantity (streamflows and water levels) by diverting Chehalis River flows from the existing channel through a bypass tunnel, around areas of active construction. Construction of the bypass system, which would include installation of upstream and downstream bypass tunnel portals, the tunnel, and temporary berms and cofferdams across the river channel, is planned by the Applicant to take 10 months with in-water work occurring in July through September. Once the diversion system is operational, the river would flow through the 20-foot diameter, 1,630-foot-long bypass tunnel unimpeded while the FRE facility is constructed. The Applicant's construction schedule plans for the flow diversion through the bypass tunnel to be used for 32 months.

The Proposed Action would use, divert, obstruct, and change the natural flow and bed of freshwaters of the state and therefore would require a Hydraulic Project Approval (HPA) from the Washington Department of Fish and Wildlife under the state's hydraulic code rules (220-660 WAC). The HPA would include conditions intended to minimize impacts on instream and riparian habitat and functions.

Construction of the FRE facility and the stream diversion system would also be done under the regulation of a U.S. Army Corps of Engineers (Corps) Section 404 (Clean Water Act) permit, due to the need for work below the ordinary high water level of the Chehalis River. The proposed diversion system would be reviewed by the Corps as part of the Section 404 permitting process, and the permit would include conditions requiring the permittee to construct the system to withstand high flows and manage the system in a way that would avoid and minimize impeding the passage of normal or high flows. An appropriately designed, permitted, and constructed bypass system is not expected to contribute to increased flooding upstream or downstream of the FRE facility, and the temporary adverse impacts to surface water quantity resulting from operation of the diversion would be **minor**.

Vegetation clearing, earthwork, and the installation of temporary construction access roads and staging areas would likely reduce interception and infiltration of precipitation falling on the site, alter stormwater runoff and drainage patterns, and may increase the rate of runoff reaching the Chehalis River and tributaries in the construction footprint. Construction would include removing non-flood tolerant trees (mature conifers) from approximately 485 acres of the temporary reservoir footprint, soil disturbance at the FRE facility site, and improving approximately 13.5 miles of unpaved access roads for quarry and construction access.

Construction activities would be done under the regulation of an Ecology National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Permit and local land use and development permits issued by Lewis County. The NPDES Construction Stormwater Permit includes conditions requiring the permittee to control flow rates to protect waterways downstream, as required by the local plan approval authority. The NPDES permit requires that, when needed to protect downstream waterways and properties, for example, stormwater detention facilities be constructed as one of the first steps in grading, and to ensure that such facilities are functioning properly before constructing site improvements. With the appropriate flow control measures in place as required by permits, changes in stormwater runoff resulting from construction-related ground disturbance are not expected to contribute to increased flooding upstream or downstream of the FRE facility and would represent a **minor** adverse impact on surface water quantity.

Withdrawals of water from the Chehalis River for concrete production could temporarily reduce Chehalis River flows downstream of the FRE facility. Water would likely be withdrawn upstream of the cofferdam from the bypass tunnel forebay area. Construction-related water withdrawals would likely total between 75 and 150 million gallons, with up to 80% of that total withdrawn in a 10- to 20-month period. The impacts resulting from the withdrawal of Chehalis River water for construction uses are described in Water Use and Rights, Section 3.2.1.1.3.

3.2.1.1.1.2 Surface Water Quality

In-Water Construction of the FRE Structure

Construction of the FRE structure could affect surface water quality through in-water work activities in the Chehalis River, which would include the installation and later removal of temporary river crossings and stream diversion and work area isolation measures, including cofferdams and a bypass tunnel to route flows around the construction site. Related disturbance of sediments would likely result in short-term increases in turbidity and temperature, and short-term decreases in DO, in and downstream of the in-water construction activities. Additionally, the operation of heavy equipment in the stream channel presents the potential for pollutants such as diesel fuel, gasoline, oil and grease, and hydraulic fluid to enter surface waters. The Applicant's plan shows the installation of the diversion system would take 2.5 months during the in-water work window of July through September.

In-water work activities would be performed under the regulation of WDFW's HPA and a Corps Section 404 permit, which would include conditions requiring erosion, sediment, and pollution control measures to be implemented during and after in-water construction. Additionally, the work would be performed under the regulation of a Section 401 (Clean Water Act) Water Quality Certification from Ecology. The Section 401 Certification would include additional conditions related to water quality protection, and would include requirements for monitoring turbidity during in-water work to ensure that water quality standards are met and work is stopped if permitted thresholds are exceeded, until problems are addressed. The isolation of the in-water work area and bypassing of flows around the work area would be the most important best management practices (BMPs) for in-water work. The noted permits would restrict timing of in-water work activities to low-flow periods during agency-recognized in-water work windows. For the upper basin Chehalis River, the designated in-water work window is August 1 through 31. The Applicant intends to request an extension of the work window to 2.5 months from July through September.

With appropriate control measures and monitoring programs in place and as required by permits, construction-related short-term increases in stream turbidity, temperature, and pollutant discharges must meet water quality standards and are expected to be within anthropogenic allowance, and therefore would represent **moderate to minor** adverse impacts on water quality.

Temporary Reservoir Area

Vegetation clearing, excavation, and fill placement in riparian and upland areas for FRE facility construction would expose soils and increase the potential for their mobilization and transport to surface waters from stormwater runoff. Additionally, the creation and use of temporary construction access roads and equipment/material staging areas would increase the potential for sediment entry into surface waters and could increase turbidity in surface waters. The introduction of construction vehicles, equipment, and materials would also increase the potential for pollutants (e.g., oil and grease, hydraulic fluids, metals) to enter surface waters through stormwater runoff. This includes aboveground tanks to store petroleum products to fuel equipment and a diesel generator.

Vegetation clearing would include removal of non-flood-tolerant trees and all trees over 6 inches diameter at breast height within 600 acres of the temporary reservoir footprint, including in the riparian zone. In addition to vegetation clearing for the temporary reservoir, approximately 13.5 miles of unpaved access roads would be widened for quarry and construction access, resulting in up to about 21 acres of clearing to widen roads. Road surface erosion would result from the heavy truck use. As described in the *Transportation Discipline Report* (ESA 2020b), an approximate range for two-axle truck off-site round trips would be between 100,000 and 180,000, and three-axle or larger off-site truck round trips would be between 16,000 and 26,000. The estimated erosion from the construction access road surfaces alone is estimated to be approximately 100 tons per year, as detailed in the *Earth Discipline Report* (Shannon & Wilson and Watershed GeoDynamics 2020). Construction is expected to occur over an approximately 5-year period estimated to last from 2025 to 2030.

The removal of trees during construction would increase water temperatures in the reservoir footprint due to the decrease in shading. Modeling showed that daily maximum temperatures of the Chehalis River could increase by up to 2°C to 3°C in mid- to late-summer in the temporary reservoir footprint relative to the No Action Alternative, exceeding temperature water quality criteria (PSU 2017). Additionally, modeling for Crim Creek in the temporary reservoir footprint showed that loss of riparian cover and stream shading associated with the FRE facility is predicted to result in temperature increases of between 2°C and 5°C relative to the No Action Alternative, exceeding water quality criteria (Anchor QEA 2017b). The increased water temperatures would exceed water quality standards and be a **significant adverse** impact to surface water quality and designated uses of the Chehalis River and Crim Creek for salmonid habitat.

The load allocations developed for the upper Chehalis River Basin temperature TMDL (Ecology 2001) are based on two assumptions: 1) riparian vegetation will be protected and re-established as the result of management actions; and 2) water quality will be degraded no further by other influences. The proposed FRE facility would reduce shade on the Chehalis River and tributaries in the temporary reservoir footprint through the removal of mature and non-flood-tolerant trees. The predicted increases in summer stream temperatures as a result of the FRE facility, as noted previously, would further degrade water quality. FRE facility construction and operation is therefore not consistent with the goals of the TMDL or the assumptions used to develop the load allocations stated in the TMDL.

Warmer water holds less DO than cooler water and can also increase demand for DO by stimulating biological activity; therefore, the river temperature increase resulting from FRE facility operation decreases DO. The footprint water quality modeling predicted differences in DO levels between the Proposed Project and the No Action Alternative at the FRE facility site, with the differences due mostly to lower saturation concentrations resulting from warmer temperatures. The modeling showed small (less than 0.2 mg/L) differences for much of the year with larger differences (up to approximately 0.3 to 0.4 mg/L) in summer months (PSU 2017, Figures 203 and 204). This would be a **significant adverse impact** to surface water quality.

Previously described permits including the Corps Section 404 Permit, the Ecology 401 Water Quality Certification, and Ecology's NPDES Construction Stormwater Permit would require the permittee to develop, implement, monitor, and maintain a number of BMPs for construction activities to comply with water quality standards. Permit-required measures related to water quality during construction including the following:

- Implementation of Erosion and Sediment Control Plans to limit sediment inputs to receiving waters during and after construction, which would include revegetating temporary disturbance areas after construction to stabilize soils
- Implementation of Spill Prevention and Response Plans to limit the potential for spills of fuels or other hazardous materials and to facilitate containment in the event a spill occurs, to minimize the potential for pollutant releases to surface water and groundwater
- Managing water pumped from excavations for construction dewatering in a way that allows it to infiltrate on site and/or ensure it is contained and treated prior to discharge to surface waters
- Treating and monitoring construction discharge water for pH, turbidity, and other pollutants as appropriate prior to discharging to surface waters
- Implementation of construction and post-construction Stormwater Pollution Prevention Plans in accordance with Ecology Stormwater Management Manual guidance and requirements
- Implementation of a monitoring program during construction to ensure that erosion, sediment, and pollution control measures are regularly inspected and maintained, and records are kept
- Implementation of a monitoring program after construction to ensure that site stabilization measures and revegetated areas remain functional over time and after each inundation event

The increased water temperatures and decreased DO levels would exceed water quality standards and be **significant** impacts to surface water quality and designated uses of the Chehalis River and Crim Creek for salmonid habitat. Mitigation is proposed for the Applicant to develop and implement a Surface Water Quality Mitigation Plan to address these impacts; however, there is uncertainty if the implementation of a plan is technically feasible and economically practicable. Therefore, the Proposed Action would have **significant and unavoidable** adverse environmental impacts on surface water quality, unless the Applicant develops a Surface Water Quality Mitigation Plan which meets regulatory requirements and for which implementation is feasible. The plan must be approved by Ecology and other applicable agencies as part of the Section 401 and NPDES permit applications. The plan must provide reasonable assurance that water quality standards and designated in-water uses will be met.

Quarries and Concrete Production

Quarry construction and operation for the mining of rock for concrete aggregate, along with the establishment and operation of concrete production facilities for the FRE structure, would increase the potential for sediment and pollutant entry into surface waters through stormwater runoff and process wastewater discharges. Stormwater and wastewater that have had contact with cement used in concrete production present a potential for introducing high-pH discharges to surface waters, thereby elevating instream pH levels.

The mining of concrete aggregate and concrete production would be performed under the regulation of an NPDES Sand and Gravel Permit issued by Ecology. The Sand and Gravel Permit includes conditions requiring the permittee to implement BMPs to control pollutants from process water, mine dewatering water, and stormwater. The permit includes effluent limits and monitoring requirements for process water and mine dewatering discharges for parameters including pH, turbidity, TSS, oil, and total dissolved solids (TDS). Permittees are required to implement erosion and sediment control plans, stormwater pollution prevention plans, spill control plans, and monitoring plans, and to submit discharge monitoring reports to Ecology.

With appropriate control measures, BMPs, and monitoring programs in place and as required by permits, construction-related short-term increases in stream turbidity, temperature, and pollutant discharges must meet water quality standards and are expected to be within anthropogenic allowance, and therefore would represent **moderate to minor** adverse impacts on water quality.

Downstream of the FRE Facility

With construction of the FRE facility, summer temperatures immediately downstream could be up to 2°C to 3°C warmer than with no FRE facility, exceeding temperature water quality criteria and therefore representing a **significant** adverse impact on water quality. The modeling showed the Chehalis River temperature impacts to decrease moving downstream, becoming negligible below about the confluence with the South Fork Chehalis River at RM 88 (PSU 2017).

DO impacts are predicted to decrease moving downstream. Downstream modeling showed little (less than 0.2 mg/L) difference in DO levels between the Proposed Project and the No Action Alternative in the Chehalis River at downstream locations, including the confluence with the South Fork Chehalis River and the confluence with the Skookumchuck River (PSU 2017). This would be a **moderate** adverse impact on water quality downstream of the FRE facility site.

The increased water temperatures would exceed water quality standards and result in **significant** impacts to surface water quality and designated uses of the Chehalis River for salmonid habitat. Mitigation is proposed for the Applicant to develop and implement a Surface Water Quality Mitigation Plan to address these impacts; however, there is uncertainty if the implementation of a plan is technically feasible and economically practicable. Therefore, the Proposed Action would have **significant and unavoidable** adverse environmental impacts on surface water quality, unless the Applicant develops a Surface Water Quality Mitigation Plan that meets regulatory requirements and for which implementation is feasible. The plan must be approved by Ecology and other applicable agencies as part of the Section 401 and NPDES permit applications. The plan must provide reasonable assurance that water quality standards and designated in-water uses will be met.

3.2.1.1.2 Groundwater

Shallow groundwater levels and flows could be locally affected by the temporary (approximately 32-month) diversion of the Chehalis River through a bypass tunnel during FRE facility construction. Dewatering of the stream channel and excavations in upland areas may also be needed and could temporarily affect shallow groundwater levels and flows. Additionally, construction activities involving vegetation clearing, soil compaction, and the installation of temporary access routes, staging areas, and rock quarries could affect infiltration of precipitation and groundwater recharge rates in those areas.

The FRE facility would be constructed in a narrow valley with bedrock at or near the ground surface. Layers of alluvial material on the valley bottom and soils on nearby hillsides are thin, limiting the potential for groundwater in areas of construction. The hyporheic zone at the FRE facility site is absent due to bedrock and lack of sediment along the streambed and banks at that location, and no construction-related impacts on hyporheic zone connectivity are anticipated. Construction-related adverse impacts on groundwater quantity would therefore be **minor**.

Direct discharges of construction-related stormwater or wastewater to groundwater (e.g., through underground injection wells) are not proposed. Ecology's NPDES Construction Stormwater Permit includes requirements for controlling pollutants that would reduce the potential for incidental releases to groundwater. For example, the NPDES permit requires spill prevention and control measures including cover and containment for all chemicals, liquids, and petroleum products that have the potential to pose a threat to human health or the environment. The implementation of such permit-required pollution-control measures, coupled with the limited groundwater resources in the study area, would limit the potential for the introduction of pollutants to groundwater from construction activities. Construction-related adverse impacts on groundwater quality would therefore also be **minor**.

3.2.1.1.3 Water Use and Water Rights

Construction of the FRE facility would involve withdrawals of surface water from the Chehalis River for activities including concrete production. Water would likely be withdrawn upstream of the cofferdam from the bypass tunnel forebay area. An estimated 75 to 150 million gallons would be withdrawn for construction use over the construction period, with as much as 80% of the withdrawal in a 10- to 20-month window.

Construction-related withdrawals of water from the Chehalis River would represent a small but measurable proportion of Chehalis River flows at that location. The significance of the withdrawals would vary through the year based on flow conditions and seasonal water needs of others, with periods of highest concern when minimum instream flows (per WAC-173-522) are not met and/or when water demand is highest (typically in summer, during irrigation season).

Assuming a maximum of 80% of 150 million gallons, or 120 million gallons, is withdrawn over a minimum 10-month period, the average withdrawal rate from the Chehalis River would be approximately 400,000 gallons per day, or about 0.6 cfs. Maximum daily demand may be higher than the average withdrawal rate.

For municipal systems, the Washington Department of Health Water System Design Manual considers a peaking factor of 2.0 to be adequately conservative for estimating maximum daily demand based on average daily demand (DOH 2019). Applying a peaking factor of 2.0 to the withdrawals for FRE facility construction would result in a maximum daily demand of about 800,000 gallons per day, or about 1.2 cfs. Withdrawals at that rate would represent approximately 4% of Chehalis River flows at Doty during typical summer low-flow conditions, when the lowest flows are often around or below 30 cfs. The minimum instream flow established by WAC-173-522 for the Chehalis River in the vicinity of the FRE facility is 31 cfs between August 15 and September 15.

A short-term water use permit from Ecology would be needed to withdraw water from the Chehalis River for construction of the FRE facility. A plan would be developed to specify the withdrawal location, timing, and how much water would be used. With the considerations for instream flow requirements and withdrawal amounts and timing, and in compliance with an Ecology permit, the adverse impact of FRE facility construction on water uses and rights would be **moderate to minor**.

Based on their location in relation to anticipated construction areas, Pe Ell's water treatment facility and intake at Lester Creek would not be affected by construction. A water line for the water treatment facility from Lester Creek may need to be improved or relocated because of conflicts with construction activities of the FRE facility, and to ensure that the water line can withstand inundation during operations (ESA 2020a). If the water line requires improvement or relocation, this would be a **significant** adverse impact to Pe Ell's water service. The *Public Services and Utilities Discipline Report* includes a mitigation measure for the Applicant to conduct a study to determine if the water line needs to be improved or relocated and, if so, to develop a cost estimate and ensure that funding is provided for this work.

3.2.1.2 Airport Levee Changes

3.2.1.2.1 Surface Water

Construction of the Airport Levee Changes would be completed within an approximately 1-year period, concurrent with FRE facility construction in the 2025 to 2030 timeframe. Construction of the Airport Levee Changes would not involve work within or immediately adjacent to the Chehalis River. Construction-related ground disturbance including excavation and fill would temporarily increase the erosion potential of the site and the potential for sediment to enter surface waters through stormwater runoff, which could temporarily elevate turbidity in receiving waters. Approximately 114,500 cubic yards of fill would be deposited at the airport levee construction site. Fine-grained sediment (sand, silt, clay) in the fill would be subject to erosion during rainfall if not adequately covered or stabilized.

Ecology's NPDES Construction Stormwater Permit requires the establishment, monitoring, and maintenance of erosion and sediment control measures to minimize impacts on receiving waters.

Required measures generally include preservation of vegetation and marking of clearing limits; establishing designated construction access; controlling flow rates; installing sediment controls; stabilizing slopes, channels, and outlets; controlling pollutants; and maintaining BMPs throughout construction until the site is stabilized.

Adverse impacts on water quality and water quantity are expected to be **minor** with the appropriate erosion, sediment, and pollution control measures in place, in accordance with permit requirements.

3.2.1.2.2 Groundwater

Subsurface excavations, fill placement, and potential dewatering in areas of levee widening or existing structure (retaining wall) removal could result in **moderate to minor** adverse impacts on groundwater quantity by locally affecting shallow groundwater flows. Construction-related adverse impacts on groundwater quality would be **minor** with the appropriate pollution control measures in place, as required by permits.

3.2.1.2.3 Water Use and Water Rights

Construction of the Airport Levee Changes would not introduce a new water use or interfere with existing water uses or rights, and there would be **no** construction-related adverse impacts on water uses or rights.

3.2.2 Impacts from Operation

3.2.2.1 Flood Retention Expandable Facility

Flows would be unimpeded when the FRE outlets are open, thereby maintaining unmodified flushing and channel-maintenance flows. The FRE facility would temporarily retain Chehalis River flows, through closure of the FRE outlet gates, when flows are forecasted to be above 38,800 cfs at Grand Mound within a 2-day time window. Because the Grand Mound gage measures flow from the Chehalis River, the Newaukum River, and the Skookumchuck River, the reading of 38,800 cfs would include water from all three rivers. Based on the historical record, when the Grand Mound gage reads 38,800 cfs, the flow at the FRE facility site has ranged from 10,000 to 15,000 cfs.

Modeling showed that in the future, on average, such flows would occur about once every 5 years (i.e., about a 20% chance of occurring in any given year) in the mid-century, and once every 4 years in the late-century (25% chance of occurring in any given year), most commonly between October and March. Modeling showed catastrophic floods, when the Grand Mound gage is 75,100 cfs, would occur about once every 44 years (approximately a 2% chance of occurring in any given year) in the mid-century and once every 27 years (approximately a 4% chance of occurring in any given year) in the late-century.

After the flood peaks, the temporary reservoir would empty at a maximum drawdown rate of 10 feet per day over the course of up to 35 days for a catastrophic flood. The FRE facility is intended to hold up to 65,810 acre-feet of water from a catastrophic flood. Flows exceeding the temporary reservoir's capacity to store and pass through the outlet structure would discharge through an emergency spillway at the top of the structure. The emergency spillway is expected to be used very rarely and for very short duration, such as for 200- and 500-year floods if the water flows exceed the capacity of the temporary reservoir. In non-flood conditions, the river would flow unimpeded through the temporary reservoir footprint. Additional operational details of the facility are contained in the *Operations Plan for Flood Retention Facilities* (Anchor QEA 2017a).

Operation of the FRE facility would change sediment transport and channel forming processes by eliminating large peak flows at the FRE location during major or greater flood events. For example, the estimated peak flow at the FRE facility site during the 2007 flood event was 34,700 cfs and if the FRE had been in place the outlet gates would have been closed. Flows of this magnitude would be reduced to the levels described below for the closed and drawdown periods.

Estimates of the maximum flow through the FRE outlets would vary under different conditions. These are based on the historical record and are estimates for the late-century catastrophic flood scenario.

- When FRE gates are open: Up to 18,520 cfs. The FRE gates would be closed when the water level at the Grand Mound gage is predicted to be 38,800 cfs. However, if the prediction is less than 38,800, the flow through the outlet could be up to 18,520 cfs, based on the historical record.
- When FRE gates are being closed: 300 to 6,000 cfs
- When FRE gates are closed: 300 cfs
- During FRE drawdown periods: 4,320 to 10,600 cfs

Future conditions modeling includes predicted changes to hydrological and meteorological conditions associated with climate change. Modeling showed that surface temperatures accounting for climate change would be warmer than under current conditions, with an increase in water temperatures proportional to the increase in air temperatures. Summer water temperatures in the Chehalis River in the temporary reservoir vicinity, for example, are predicted to become approximately 3°C to 4°C warmer under future baseline conditions accounting for climate change (Anchor QEA 2017b). Floods are predicted to occur more frequently in the future, and peak flows are predicted to increase by 12% by mid-century and by 26% by late-century (WSE 2019a).

Operation of the FRE facility would affect water through inundation upstream of the FRE facility and changes in peak flows and flood extents downstream. The potential impacts of FRE facility operation on surface water, groundwater, and water uses and rights are addressed in the following subsections.

3.2.2.1.1 Surface Water

3.2.2.1.1.1 Surface Water Quantity

Upstream of FRE Facility and the Temporary Reservoir

Operation of the FRE facility for a major flood or larger would turn a free-flowing section of the Chehalis River into a temporary reservoir, inundating a maximum area of approximately 847 acres of the existing river channel, its floodplain, tributaries, and nearby hillsides. The temporary reservoir would extend approximately 5.3 miles upstream of the FRE facility on average during a major flood, and would extend up to 6.4 miles upstream during greater floods. The temporary reservoir would hold 65,810 acre-feet of water at full capacity and have a maximum depth of 202 feet. A water right from Ecology would be needed to retain flood flows in the temporary reservoir. The water right would define conditions of allowable water storage, including amounts and timing.

The *Wetlands Discipline Report* (Anchor QEA 2020a) identifies approximately 113 acres of regulatory waterbodies in the full temporary reservoir footprint and identifies **moderate** adverse impacts on surface water bodies from inundation, due to the potential for periodic changes to waterbody channel morphology from repeated reservoir filling and drawdown. The *Wildlife Species and Habitats Discipline Report* (Anchor QEA 2020c) and *Wetlands Discipline Report* also identify that stream buffer vegetation would die during an inundation event and would be permanently maintained in an early successional emergent or shrub/sapling condition, thus reducing shade, detrital input, and cover functions for the waterbodies.

The inundation of surface waters upstream of the FRE facility and the associated impacts on riverine functions described above would represent a **moderate** adverse impact on surface water quantity, based on the above factors and on the periodic and temporary nature of the inundation (for up to 35 days, about once every 4 to 5 years, on average). When the FRE facility is not operational, the Chehalis River and its tributaries in the temporary reservoir footprint would flow unimpeded.

Downstream of FRE Facility

When the FRE facility is storing water, outflows to the Chehalis River would be reduced to a minimum of 300 cfs (a typical winter low flow) for 2 to 3 days, until the peak flood passes at Grand Mound. However, Chehalis River flows would be greater than 300 cfs starting a relatively short distance downstream, due to contributing flows from tributaries. After the peak flows contributed from the rest of the basin have passed, the FRE facility outlet gates would be opened in a controlled manner and facility outflows would increase to approximately 4,320 to 10,600 cfs, to allow the temporary reservoir to drain. The maximum drawdown rate would be 10 feet per day over the course of up to 35 days.

Operation of the FRE facility would reduce downstream Chehalis River flows and water levels during major and greater floods. The degree of reduction in flood inundation would vary by location and elevation, and would also depend on the magnitude of flows. A table of ground surface elevations and modeled water surface elevations for 25 select locations in the study area, for various future conditions scenarios, is provided in Attachment N-1. The modeling evaluated major and catastrophic floods specifically, which the FRE facility is intended to address. While the FRE facility would provide some peak flow attenuation for floods greater than catastrophic (e.g., the 500-year flood), it was not designed to target peak flow reduction for flows of that magnitude and would discharge flows exceeding its capacity to store/transmit over its emergency spillway.

As described in Section 2.2.2.2, WSE developed a hydraulic model of the Chehalis River and its floodplain that can be used to predict water levels downstream of the FRE facility for various flow conditions. The model covers the approximately 100-mile stretch of the Chehalis River from the FRE facility site (RM 108) downstream to a point just west of Montesano (RM 9). It includes the sections of the Chehalis River extending through Centralia and Chehalis and encompasses portions of major tributaries including the South Fork Chehalis, Newaukum, Skookumchuck, and Black rivers as well as many smaller tributaries. The modeling for future conditions (mid- and late-century) for the both the Proposed Action and No Action Alternative accounted for projected changes in hydrology due to climate change (Anchor QEA and WSE 2019).

Figure N-13 illustrates comparisons of the inundation modeling results for the FRE facility, and Figures N-14 and N-15 show inundation modeling results for the Airport Levee Changes. The table in Attachment N-1 presents modeled water surface elevations for 25 select locations for various conditions. More detailed maps presented in Attachment N-1 show side-by-side comparisons of predicted flood depths for the No Action Alternative and Proposed Action across the entire modeled area for both mid-century and late-century timeframes.

Figure N-13
Temporary Reservoir Inundation Area at Mid-Century and Late-Century

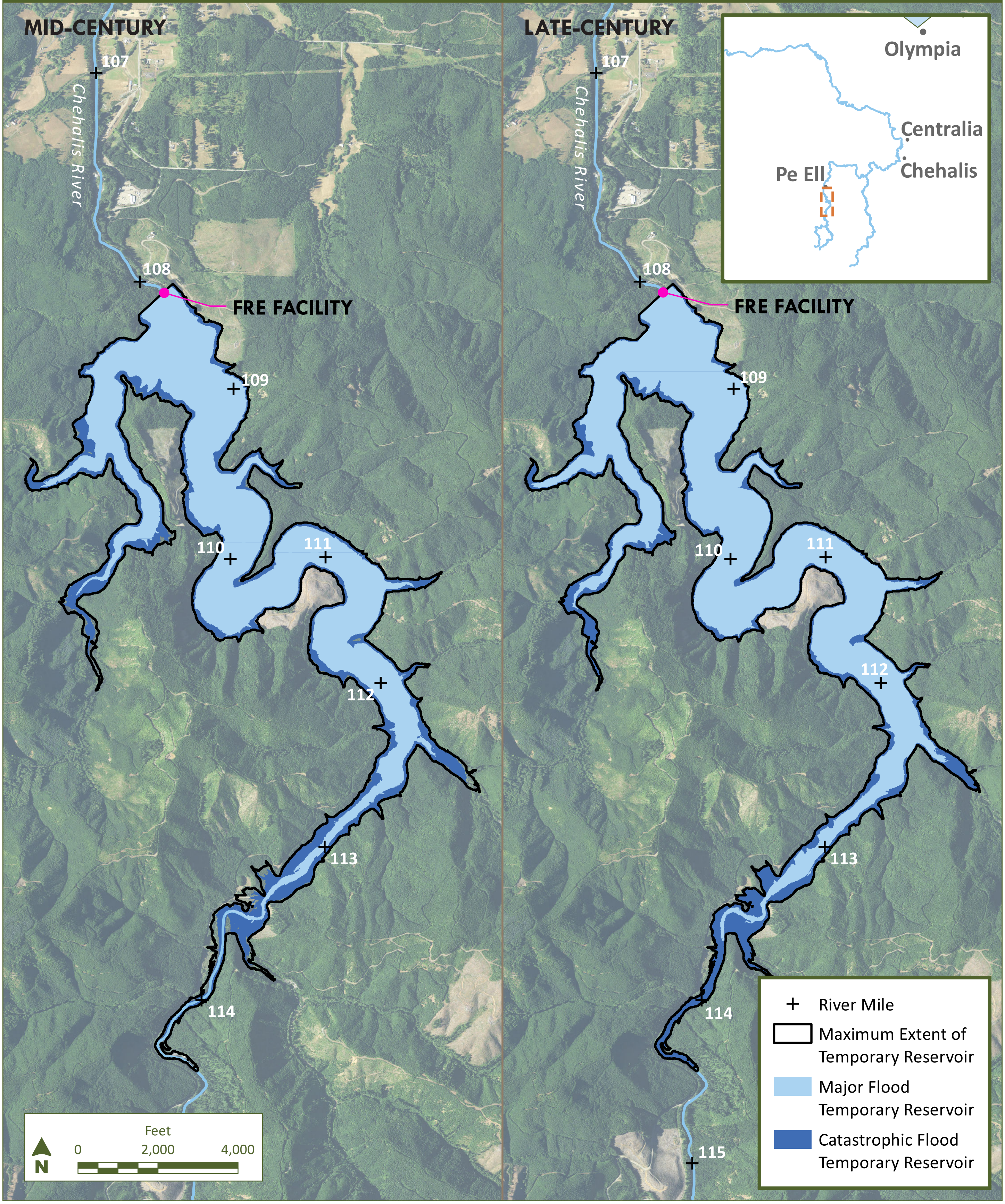


Figure N-14
Predicted Changes in Inundation Depths Near Airport Levee at Mid-Century

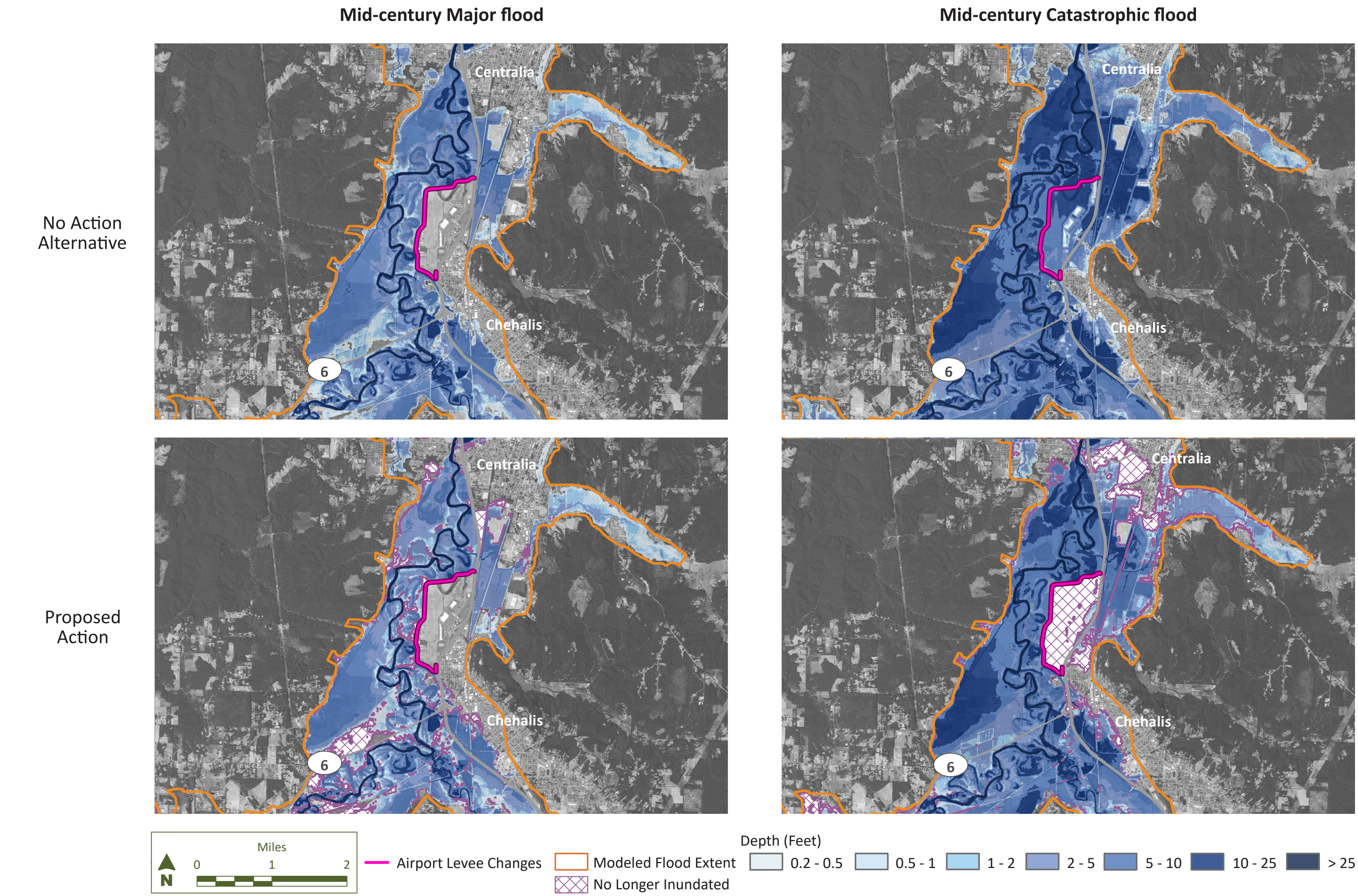
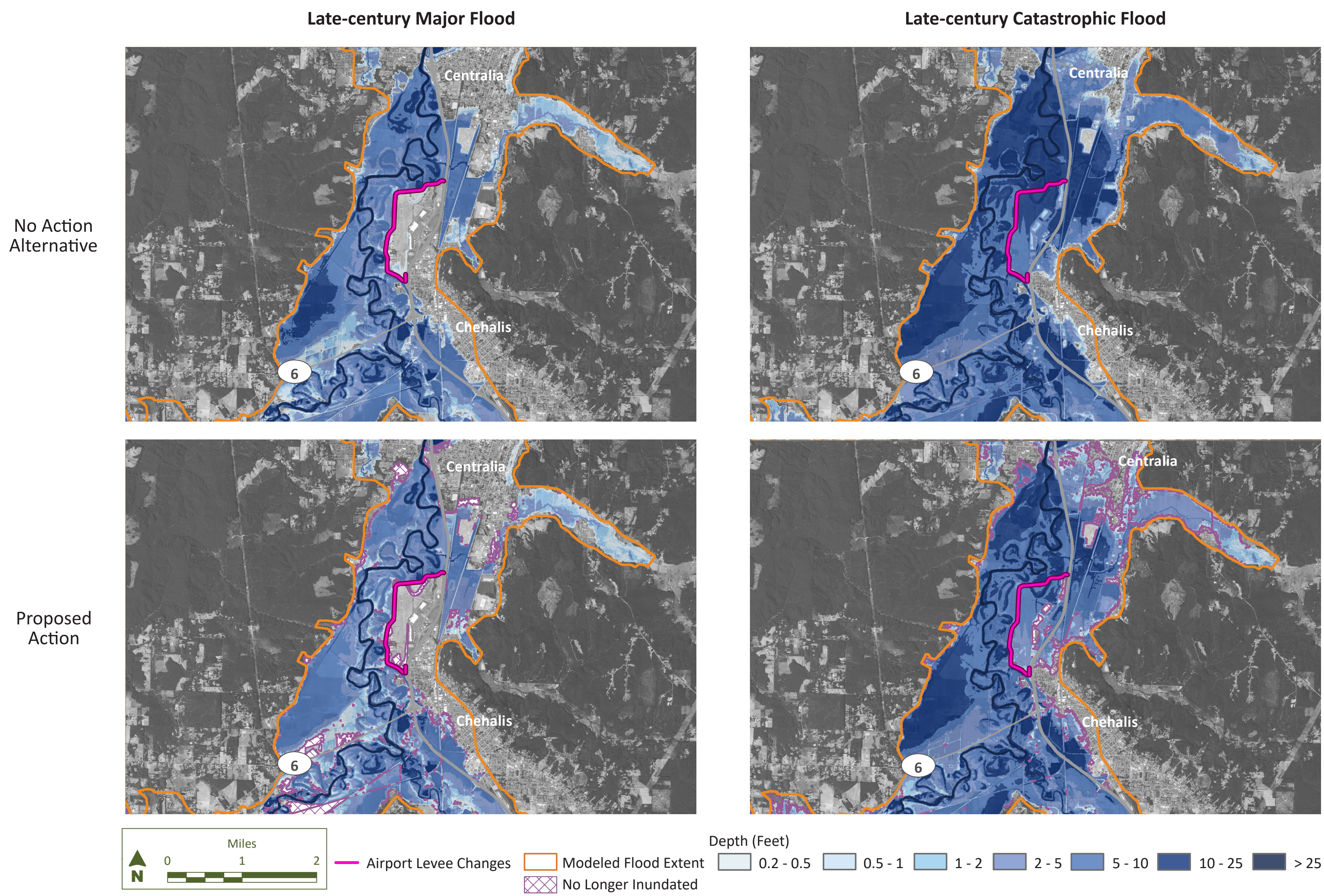


Figure N-15
Predicted Changes in Inundation Depths Near Airport Levee at Late-Century



A subset of the model results from the table in Attachment N-1 is presented in Tables N-9 and N-11 to highlight predicted changes in water surface elevations for select locations/communities. Tables N-10 and N-12 show predicted changes in inundation depths for those same locations. These tables provide examples of the range of predicted differences in water levels at select locations for the Proposed Action and No Action alternatives; Attachment N-1 includes these and additional locations.

Table N-9
Modeled Water Surface Elevations for a Major Flood (in feet)

LOCATION	RM LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY			LATE-CENTURY		
			NO ACTION	PROPOSED ACTION	DIFFERENCE	NO ACTION	PROPOSED ACTION	DIFFERENCE
Near Doty	101.0	293.8	312.9	303.5	-9.4	314.3	304.4	-9.8
Near Adna	80.2	160.6	195.8	193.4	-2.5	196.4	194.6	-1.8
Newaukum Confluence (near Chehalis)	75.2	152.6	183.3	182.1	-1.2	183.8	182.8	-1.0
Skookumchuck Confluence (near Centralia)	66.9	143.0	171.0	169.5	-1.6	172.3	170.6	-1.7
Grand Mound (Prather Rd Bridge)	59.9	117.5	144.5	143.9	-0.6	145.0	144.3	-0.6
Near Rochester	54.5	105.0	121.9	121.1	-0.7	122.5	121.7	-0.8
Black River Confluence	46.9	70.7	91.6	90.9	-0.7	92.3	91.5	-0.8
Porter (Porter Creek Rd Bridge)	33.6	22.1	51.7	50.9	-0.8	52.5	51.7	-0.9
Satsop Confluence	19.9	8.8	30.0	29.6	-0.4	30.4	30.1	-0.3
Montesano Bridge	12.5	-26.9	17.0	16.5	-0.6	18.2	17.7	-0.6
Cosmopolis	1.99	-52.8	9.4	9.3	-0.1	10.3	10.2	-0.1

Table N-10

Modeled Inundation Depths for a Major Flood (in feet)

LOCATION	RM LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY			LATE-CENTURY		
			NO ACTION	PROPOSED ACTION	DIFFERENCE	NO ACTION	PROPOSED ACTION	DIFFERENCE
Near Doty	101.0	293.8	19.1	9.7	-9.4	20.5	10.6	-9.8
Near Adna	80.2	160.6	35.2	32.8	-2.5	35.8	34.0	-1.8
Newaukum Confluence (near Chehalis)	75.2	152.6	30.7	29.5	-1.2	31.2	30.2	-1.0
Skookumchuck Confluence (near Centralia)	66.9	143.0	28.0	26.5	-1.6	29.3	27.6	-1.7
Grand Mound (Prather Rd Bridge)	59.9	117.5	27.0	26.4	-0.6	27.5	26.8	-0.6
Near Rochester	54.5	105.0	16.9	16.1	-0.7	17.5	16.7	-0.8
Black River Confluence	46.9	70.7	20.9	20.2	-0.7	21.6	20.8	-0.8
Porter (Porter Creek Rd Bridge)	33.6	22.0	29.2	28.7	-0.5	29.8	29.2	-0.6
Satsop Confluence	19.9	8.8	21.2	20.8	-0.4	21.6	21.3	-0.3
Montesano Bridge	12.5	-26.9	43.9	43.4	-0.5	45.1	44.6	-0.5
Cosmopolis	1.99	-52.8	62.2	62.1	-0.1	63.1	63.0	-0.1

Table N-11
Modeled Water Surface Elevations for a Catastrophic Flood (in feet)

LOCATION	RM LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY			LATE-CENTURY		
			NO ACTION	PROPOSED ACTION	DIFFERENCE	NO ACTION	PROPOSED ACTION	DIFFERENCE
Near Doty	101.0	293.8	321.1	309.6	-11.5	323.0	310.9	-12.1
Near Adna	80.2	160.6	198.5	197.3	-1.2	198.9	197.8	-1.1
Newaukum Confluence (near Chehalis)	75.2	152.6	186.4	185.2	-1.2	186.9	185.9	-1.0
Skookumchuck Confluence (near Centralia)	66.9	143.0	176.3	174.3	-2.0	177.6	175.2	-2.3
Grand Mound (Prather Rd Bridge)	59.9	117.5	147.1	146.0	-1.0	147.9	146.6	-1.3
Near Rochester	54.5	105.0	124.8	123.0	-1.0	125.7	124.4	-1.3
Black River Confluence	46.9	70.7	95.2	93.9	-1.3	96.2	94.8	-1.4
Porter (Porter Creek Rd Bridge)	33.6	22.0	55.9	54.6	-1.3	57.2	55.6	-1.5
Satsop Confluence	19.9	8.8	31.9	31.4	-0.6	32.7	32.0	-0.7
Montesano Bridge	12.5	-26.9	20.8	19.8	-1.0	22.3	21.2	-1.2
Cosmopolis	1.99	-52.8	10.1	9.9	-0.2	11.2	10.9	-0.3

Table N-12

Modeled Inundation Depths for a Catastrophic Flood (in feet)

LOCATION	RM LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY			LATE-CENTURY		
			NO ACTION	PROPOSED ACTION	DIFFERENCE	NO ACTION	PROPOSED ACTION	DIFFERENCE
Near Doty	101.0	293.8	27.3	15.8	-11.5	29.2	17.1	-12.1
Near Adna	80.2	160.6	37.9	36.7	-1.2	38.3	37.2	-1.1
Newaukum Confluence (near Chehalis)	75.2	152.6	33.8	32.6	-1.2	34.3	33.3	-1.0
Skookumchuck Confluence (near Centralia)	66.9	143.0	33.3	31.3	-2.0	34.6	32.2	-2.3
Grand Mound (Prather Rd Bridge)	59.9	117.5	29.6	28.5	-1.0	30.4	19.1	-1.3
Near Rochester	54.5	105.0	19.8	18.8	-1.0	20.7	19.4	-1.3
Black River Confluence	46.9	70.7	24.5	23.2	-1.3	25.5	24.1	-1.4
Porter (Porter Creek Rd Bridge)	33.6	22.0	32.2	31.2	-1.1	33.3	32.0	-1.2
Satsop Confluence	19.9	8.8	23.1	22.6	-0.5	23.9	23.2	-0.7
Montesano Bridge	12.5	-26.9	47.7	46.7	-1.0	49.2	48.1	-1.1
Cosmopolis	1.99	-52.8	62.9	62.7	-0.2	64.0	63.7	-0.3

For reference, the peak flow measured at Grand Mound during the December 2007 flood—the largest on record—was 79,100 cfs. Note that the modeled results for the Proposed Action account for the completion of the Airport Levee Changes in addition to FRE facility operation.

Based on the modeling, reductions in flood inundation would generally be greater closer to the FRE facility and smaller farther downstream. Near Doty, for example, the Proposed Action would reduce flood levels by approximately 9 to 10 feet for a major flood and 11 to 12 feet for a catastrophic flood for the mid- and late-century scenarios. Downstream, near Chehalis and Centralia, flood reductions would generally be on the order of 1 to 2.5 feet, with the exception that greater flood reductions would be expected landward of the raised airport levee (see Section 3.2.2.2). At Porter, flood reductions ranging on the order of 0.8 foot for a mid-century major flood up to 1.5 feet for a late-century catastrophic flood are predicted. At the downstream end of the modeled reach of the Chehalis River, predicted flood reductions near Montesano range from approximately 0.6 foot for a mid-century major flood to about 1.2 feet for a late-century catastrophic flood.

Figures N.2-a through N.5-j in Attachment N-1 identify the modeled depth of flooding in the study area for the No Action Alternative and Proposed Action for each of the flood scenarios considered. Figures N.7-a through N.10-h in Attachment N-1 include focus maps showing depth of flooding in Pe Ell, Chehalis, and Centralia. The figures in Attachment N-1 highlight the areas that would no longer be inundated under the Proposed Action.

The Proposed Action reduces flood levels as described above and as shown in Attachment N-1; however, it does not reduce the water levels to zero for all locations. Attachment N-1 figures also provide information on the remaining flood level depths with the Proposed Action.

The *Land Use Discipline Report* (Anchor QEA 2020b) discusses in detail the impact of reduced flood elevations on land uses and structures. Table N-13 summarizes reductions in total inundated area as a result of the Proposed Action for the various flood scenarios considered.

Table N-13
Acres No Longer Inundated with the Proposed Action

	FLOOD SCENARIO			
	MID-CENTURY MAJOR	LATE-CENTURY MAJOR	MID-CENTURY CATASTROPHIC	LATE-CENTURY CATASTROPHIC
Acres No Longer Inundated	3,625	3,514	4,679	3,795

Under the modeled late-century major flood, approximately 3,514 acres of land inundated under the No Action Alternative would not be inundated under the Proposed Action. Under the modeled late-century catastrophic flood, approximately 3,795 acres of land inundated under the No Action Alternative would not be inundated under the Proposed Action. This includes rural and agricultural lands downstream of

Pe Ell and through the communities of Doty, Bunker, and Adna. It also includes wetlands, described in the *Wetlands Discipline Report*. Most portions of Chehalis that would be inundated under a late-century catastrophic flood under the No Action Alternative would also be inundated under the Proposed Action, with some areas experiencing more than 10 feet of inundation. The modeling shows more substantial flood area reduction in Centralia under the Proposed Action, with some residential areas on the east side of the Chehalis River protected under the late-century catastrophic flood scenario. Smaller reductions in inundated flood areas are predicted for the communities of Grand Mound and Oakville, with little change in inundated area downstream of Oakville to Porter and Montesano.

There is no predicted increase in downstream inundated area during major or larger floods as a result of the FRE facility operation, and therefore FRE facility operation would result in **no** adverse impacts on surface water quantity downstream.

3.2.2.1.1.2 Surface Water Quality

Surface water quality impacts from the operation of a flood retention facility were analyzed and modeled by PSU and Anchor QEA. The CE-QUAL-W2 model was selected to evaluate temperature and other water quality parameters based on its suitability and history of use for rivers and reservoirs. The following water quality models were developed:

- **Reservoir:** A model of the reservoir to simulate conditions in the temporary reservoir for scenarios when the temporary reservoir would be temporarily holding water
- **Footprint**: A model of the Chehalis River in the inundation area to simulate current and future baseline conditions, and changes in summer with the FRE facility in place
- **Downstream:** A model of the Chehalis River downstream of the FRE facility to simulate current and future baseline conditions, and changes resulting from flood retention scenarios

The impacts on water quality parameters summarized in the following subsections are described in the following primary studies and reports:

- *Reservoir Water Quality Model* (Anchor QEA 2017b)
- *Reservoir Water Quality Report* (Anchor QEA 2019a)
- *Chehalis Water Quality and Hydrodynamic Modeling: Model Setup, Calibration, and Scenario Analysis* (PSU 2017)
- *Geomorphology and Sediment Transport* (Watershed Geodynamics 2019)
- *Earth Discipline Report* (Shannon & Wilson and Watershed GeoDynamics 2020)

Temperature

Reservoir Model

The reservoir model was applied to the 2013 to 2015 period to evaluate changes in temperature conditions during the wet period (October through March), when the temporary reservoir could be storing water to reduce downstream flooding. In general, floods that occur earlier in the wet period

(October) could be subject to greater solar heating than floods later in the wet period (spring), creating the potential for temporary reservoir and outflow temperatures to exceed the Supplemental Spawning and Incubation Criteria (SSIC) of 13°C that is in effect from September 15 through July 1. Thermal stratification is predicted to be relatively minor for storage during most of the wet period, with stronger stratification predicted for early wet period (October) storage (Anchor QEA 2017b).

Future conditions modeling for the temporary reservoir area accounted for predicted changes to hydrological and meteorological conditions associated with climate change. Modeling showed that surface temperatures accounting for climate change would be warmer than under current conditions, with an increase in water temperatures proportional to the increase in air temperatures. Floods are predicted to occur more frequently in the future and peak flows are predicted to increase by 12% by mid-century and by 26% by late-century (WSE 2019a). Any expansion of the FRE facility would require separate and new environmental reviews.

Modeling shows that for floods similar to the 2009 flood, water temperature near the surface would exceed the SSIC of 13°C in fall, but would generally be cooler (less than 10°C) in spring conditions (Anchor QEA 2017b). Stratification would increase slightly along with the increasing temperatures in future conditions, while water temperatures near the bottom of the temporary reservoir and in outflows are predicted to be largely comparable between existing and future conditions. Similar to existing conditions, temperatures in the outflow during early wet period floods under future conditions could exceed the 13°C criterion in effect after September 15 (Anchor QEA 2017b).

Since there is no temporary reservoir at the site currently, there is no baseline from which to evaluate proposed FRE facility operations on reservoir temperatures, in terms of temperature increases relative to state water quality standards. The impacts of FRE facility operation on Chehalis River (and tributary) temperatures in the temporary reservoir footprint and downstream are discussed in the following section describing the results of the footprint and downstream models.

Footprint and Downstream Models

When the FRE facility is not storing water and the Chehalis River passes through the facility outlets, daily maximum temperatures of the Chehalis River could increase by up to 2°C to 3°C in mid- to late-summer in the temporary reservoir footprint relative to the No Action Alternative, exceeding temperature water quality criteria (PSU 2017). The increase in water temperatures would result from the loss of tree cover and shading. Additionally, modeling for Crim Creek in the temporary reservoir footprint showed that loss of riparian cover and stream shading associated with the FRE facility is predicted to result in temperature increases of between 2°C and 5°C relative to the No Action Alternative, exceeding water quality criteria (Anchor QEA 2017b). Therefore, the operation of the FRE facility would result in a **significant** adverse impact on water quality.

With the FRE facility, summer temperatures immediately downstream could be up to 2° to 3°C warmer than with no FRE facility, exceeding temperature water quality criteria and therefore representing a **significant** adverse impact on water quality. The modeling showed the Chehalis River temperature impacts to decrease moving downstream, becoming negligible below about the confluence with the South Fork Chehalis River at RM 88 (PSU 2017).

The increased water temperatures would exceed water quality standards and be **significant** impacts to surface water quality and designated uses of the Chehalis River and Crim Creek for salmonid habitat. Mitigation is proposed (WATER-1) for the Applicant to develop and implement a Surface Water Quality Mitigation Plan to address these impacts, but at this time it is not certain the plan is feasible. The plan must meet regulatory requirements and be approved by Ecology and other applicable agencies as part of the Section 401 and NPDES permit applications. The plan must provide reasonable assurance that water quality standards and designated in-water uses will be met.

The load allocations developed for the upper Chehalis River Basin temperature TMDL (Ecology 2001) are based on two assumptions: 1) riparian vegetation will be protected and re-established as the result of management actions; and 2) water quality will be degraded no further by other influences. The proposed FRE facility would reduce shade on the Chehalis River and tributaries in the temporary reservoir footprint through the removal of mature and non-flood-tolerant trees. The predicted increases in summer stream temperatures as a result of the FRE facility, as noted previously, would further degrade water quality. FRE facility operation is therefore not consistent with the goals of the TMDL or the assumptions used to develop the load allocations stated in the TMDL.

Modeling showed that water released from the temporary reservoir could reduce downstream river temperatures in spring and fall, due to the fact that outflows from the reservoir bottom are expected to be cooler than downstream river temperatures under future conditions (Anchor QEA 2017b). The modeling showed that releases from the temporary reservoir in fall could reduce downstream river temperatures by approximately 3°C to 4°C, between the FRE facility at RM 108 and Porter at RM 33. The same 3°C to 4°C reduction is predicted immediately downstream of the FRE facility for spring flows, but the effect would be dampened moving downstream, with a reduction of about 1°C predicted at Porter (RM 33) and further diminishing temperature reductions expected downstream of Porter. The benefit of this reduction in downstream temperatures during reservoir release periods would be greatest in fall, when river temperatures are more likely to exceed water quality criteria.

Dissolved Oxygen

Warmer water holds less DO than cooler water and can also increase demand for DO by stimulating biological activity; therefore, the river temperature increase resulting from FRE facility operation decreases DO.

The footprint water quality modeling predicted differences in DO levels between the Proposed Project and the No Action Alternative at the FRE facility site, with the differences due mostly to lower saturation concentrations resulting from warmer temperatures. The modeling showed small (less than 0.2 mg/L) differences for much of the year with larger differences (up to approximately 0.3 to 0.4 mg/L) in summer months (PSU 2017, Figures 203 and 204). These differences would likely result in DO criteria exceedances, and therefore would constitute a **significant** adverse impact on water quality.

DO impacts are predicted to decrease moving downstream. Downstream modeling showed little (less than 0.2 mg/L) difference in DO levels between the Proposed Project and the No Action Alternative in the Chehalis River at downstream locations, including the confluence with the South Fork Chehalis River and the confluence with the Skookumchuck River (PSU 2017). This would be a **moderate** adverse impact on water quality downstream of the FRE facility site.

Turbidity

FRE facility operations would potentially increase turbidity in the Chehalis River during certain periods and reduce turbidity during others. Turbidity impacts would be influenced by several factors relating to both surface runoff and in-water processes.

Flood flows typically carry relatively high levels of suspended sediments as a result of high water velocities and associated mobilization of bed and bank material (scour). When high-velocity, high-turbidity flows enter the temporary reservoir (when the FRE facility is impounding water), velocities would slow and some suspended sediments would settle out. When the FRE facility gates are closed and the temporary reservoir is impounding water, some water would still flow through the FRE facility at a minimum of 300 cfs, but the inflows would exceed outflows and peak turbidity in water leaving the temporary reservoir would be lower than peak turbidity in water entering the temporary reservoir. In such conditions, FRE facility operations would not increase downstream turbidity levels.

Resuspension of deposited sediments while the temporary reservoir is draining, or during subsequent storms or high flows when the temporary reservoir is not storing water, could lead to temporary increases in turbidity. Resuspension of sediments may be caused by several factors, such as erosion in the active river channel during and after impoundment, erosion on the valley walls along the shoreline due to wave action as the temporary reservoir drains, and hillslope erosion due to rainfall events after the temporary reservoir is drained (Shannon & Wilson and Watershed GeoDynamics 2020; Anchor QEA 2019a).

The *Earth Discipline Report* (Shannon & Wilson and Watershed GeoDynamics 2020) documents a detailed review of the various erosion mechanisms noted above and associated sediment inputs and transport. Various models including the CE-QUAL-W2 water quality and hydrodynamic model and the WEPP model were used to evaluate erosion. A HEC-RAS model was used to determine long-term changes to substrate, channel profiles, and sediment transport. Hydrology inputs for the HEC-RAS model were based on a 30-year flow record of historical flows in the Chehalis Basin (1988 to 2018) and modified to incorporate future mid- and late-century climate change scenarios.

The *Earth Discipline Report* documents that the net effect of these erosion mechanisms during FRE facility operation would be to decrease sediment input to the mainstem Chehalis River downstream of the FRE facility during impoundment events and increase fine sediment input in the mainstem Chehalis River as the temporary reservoir drains and during one or two intense rainstorms after the temporary reservoir is drained. Overall, the HEC-RAS modeling predicts significant adverse impacts to sediment transport and substrate characteristics within the temporary reservoir fluctuation zone. This could be a **significant** impact to water quality during the latter parts of the temporary reservoir draining period if incoming turbidity levels are low because eroded sediment could exceed 10% of the background input. The HEC-RAS modeling predicted that over the long term, there would be a net accumulation of sediment within the temporary reservoir, a decrease in sediment storage in the confined bedrock canyon for 0.5 mile downstream of the FRE facility, and then alternating areas of more or less sediment storage to approximately RM 85, with little change in sediment storage downstream of RM 85 (Shannon & Wilson and Watershed GeoDynamics 2020).

In the *Reservoir Water Quality Report* for the FRE facility, Anchor QEA (2019a) documented an evaluation of the deposition and resuspension of sediments and associated impacts on turbidity. A combination of CE-QUAL-W2, HEC-RAS, and WEPP models were used to evaluate the different mechanisms. In these reviews, changes in TSS and turbidity in outflow water were compared to background TSS in inflow water and described relative to turbidity water quality criteria. Two floods were simulated in the report: the December 2007 flood, which represents a catastrophic flood; and the January 2009 flood, which represents a major flood.

The modeling for impoundment conditions predicted that the FRE facility would reduce *peak* outflow turbidity concentrations by more than 50% for both major and catastrophic floods when the FRE facility gates are closed (Anchor QEA 2019a). The modeling also showed that during major flood or larger events, the FRE facility may cause an exceedance of turbidity water quality criteria when the temporary reservoir is draining and turbidity in temporary reservoir outflows exceeds turbidity in temporary reservoir inflows. Using conservative “worst-case” assumptions during modeling based on data from past flood events, water quality criteria exceedances were predicted to occur for 18 days for a modeled catastrophic flood and 28 days for a modeled major flood. Since turbidity water quality criteria are based on increases relative to background levels, exceedances of turbidity criteria are highly dependent on the turbidity of Chehalis River flows entering the temporary reservoir following the flood. The modeling predicted more days of exceedances for the major flood than the catastrophic flood because inflowing turbidity remained elevated longer for the catastrophic flood and returned to lower levels more quickly for the major flood, so outflow turbidity remained at least 10% higher than inflow turbidity for a longer time for the major flood.

Modeling for non-impounding conditions showed that deposited sediments from previous inundations could later be eroded during a storm, leading to an exceedance of turbidity criteria, particularly when the background turbidity is relatively low. Increases in turbidity from rainfall-induced erosion would generally be limited to the period of the rain event. Such erosion may occur during intense rain events for 1 to 2 years following an impoundment event, but the planned vegetation re-establishment would likely reduce erosion risk in the following years (Anchor QEA 2019a).

The predicted periodic exceedances of turbidity water quality criteria would violate water quality standards because the reservoir outflow turbidity would be more than 10% higher than the reservoir inflow turbidity and represent a **significant** adverse impact on water quality resulting from operation of the FRE facility.

Summary of Surface Water Quality Impacts from FRE Facility Operations

The increased water temperatures, decreased DO and exceedances of turbidity would exceed water quality standards and be **significant** impacts to surface water quality and designated uses of the Chehalis River for salmonid habitat. Mitigation is proposed for the Applicant to develop and implement a Surface Water Quality Mitigation Plan to address these impacts; however, there is uncertainty if the implementation of a plan is technically feasible and economically practicable. Therefore, the Proposed Action would have **significant and unavoidable** adverse environmental impacts on surface water quality, unless the Applicant develops a Surface Water Quality Mitigation Plan which meets regulatory requirements and for which implementation is feasible. The plan must be approved by Ecology and other applicable agencies as part of the Section 401 and NPDES permit applications. The plan must provide reasonable assurance that water quality standards and designated in-water uses will be met.

Other Surface Water Quality Considerations

Lakes and reservoirs that hold water for long periods of time can, in some cases, trigger various additional water quality concerns. Studies evaluated the potential for the operation of the FRE facility to result in impacts related to the following:

- **Mercury and Methylmercury**: Mercury is widespread in the environment and occurs naturally in coal and other fossil fuels. It is released to the air when fossil fuels are burned, and coal-fired power plants represent the largest source of mercury emissions nationally (EPA 2019). Airborne mercury can enter surface waters through rainfall and air deposition on land and water surfaces. Methylmercury is the most common mercury compound in the environment and is often created by bacteria in anaerobic sediments, which can underlie permanent pools of water such as lakes and permanent reservoirs. Methylmercury is of concern because it is toxic to aquatic life and it bioaccumulates, and natural lakes and reservoirs in Washington with permanent pools of water have shown elevated levels of mercury and methylmercury in fish (Maupin and Pickett 2017, as cited in Anchor 2019a).
- **Harmful Algal Blooms (such as cyanobacteria)**: Cyanobacteria are also known as blue-green algae and are common in surface waters including rivers, lakes, and reservoirs. They can

produce toxins when present at high concentrations and are a concern in several waterbodies in Western Washington. Cyanobacteria often form "blooms" in favorable conditions, which generally include calm, stable waters with high temperatures and high concentrations of phosphorus, nitrogen, and ferrous iron (Anchor QEA 2019a).

- **Fecal Coliform Bacteria**: As described in Section 2.2.2.4, fecal coliform bacteria originate in the intestines of humans and other animals. Fecal coliform contamination can represent a health risk to humans, and it is introduced to the Chehalis Basin almost entirely from non-point sources including failing sewage septic systems, livestock operations, dairy farms, hobby farms, stormwater, and wildlife (Ecology 2004a). Lakes and reservoirs present a potential for attracting wildlife including geese, which represent a potential source of fecal coliform bacteria to surface waters.

The evaluation of these parameters is documented in the *Reservoir Water Quality Report* (Anchor QEA 2019a), which found the FRE facility would have several characteristics that would make it unlikely to generate or promote significant methylmercury or cyanobacteria problems, including the following:

- Infrequent Inundation: The temporary reservoir would not hold floodwater most of the time, and when it is not retaining water, the river would flow naturally through the FRE facility.
- Short Inundation Periods: The temporary reservoir would store water for limited periods of up to about 1 month.
- Relatively Low Temperatures: Flood flows high enough to trigger temporary reservoir storage would typically occur between October and March, when air and river temperatures are typically relatively low.
- Hydraulic Properties: Flood flows into and through the temporary reservoir would tend to be highly turbulent.

Additionally, the FRE facility would be **unlikely** to exacerbate fecal coliform bacteria concerns because it is unlikely to affect any human-generated sources of fecal coliform bacteria and would have no direct impact on agriculture or livestock wastes. Additionally, the temporary reservoir setting (forested canyon with steep side slopes) would not provide ideal open-grazing habitat for geese or other waterfowl, even during periods of inundation (Anchor QEA 2019b). Even with the removal/loss of mature trees in the temporary reservoir footprint, the anticipated vegetation at the lowest elevations of the temporary reservoir side slopes is expected to be dominated by shrubs, transitioning to deciduous and mixed coniferous forest at higher (and less frequently inundated) elevations.

Major floods create a potential for mobilizing pollutants from normally dry portions of the floodplain and introducing them to surface waters. In general, the reduction in inundation area could reduce the amount of pollutants entering surface waters from sources such as agricultural fields, roads and parking lots, and commercial and industrial properties.

3.2.2.1.2 Groundwater

By altering Chehalis River flows during major floods, the operation of the FRE facility has the potential to alter groundwater levels and flows in the temporary reservoir footprint and downstream in the Chehalis River floodplain.

Temporary Reservoir Footprint

When the FRE facility is impounding flows for major or larger floods, soils and sediments in the temporary reservoir footprint would become saturated and groundwater recharge could occur (where groundwater is present). Following the flood, groundwater conditions would return to normal as the temporary reservoir drains and surface water levels drop.

The proposed FRE facility is in a narrow valley with bedrock at or near the ground surface. Limited groundwater is present in the temporary reservoir footprint because layers of alluvial material on the valley bottom and the soils on the adjacent steep hillsides are thin and have little capacity to hold water. The localized, infrequent, and short-duration changes to groundwater conditions in the temporary reservoir footprint would **not** adversely affect groundwater conditions.

Downstream

When the FRE facility is storing water, outflows to the Chehalis River would be reduced to a minimum of 300 cfs (a typical winter low flow) for 2 to 3 days, until the peak flood passes at Grand Mound. However, Chehalis River flows would be greater than 300 cfs starting a relatively short distance downstream, due to contributing flows from tributaries. After the peak flows have passed, the FRE facility outflows would increase to approximately 4,320 to 10,600 cfs, to allow the temporary reservoir to drain.

Some reduction in groundwater recharge could occur due to the reduction in Chehalis River flows and floodplain area that is inundated during major floods, when the FRE facility is storing water. Anchor QEA analyzed the potential effects of FRE facility operation on groundwater levels in the surficial aquifer (A aquifer) downstream of the facility. That analysis is documented in the technical memorandum titled *Potential Groundwater Effects Analysis* (Anchor QEA 2019b). Key points from that analysis are summarized here.

Groundwater levels would rise temporarily in areas inundated by a major flood, but would return to pre-flood levels within an estimated 1 to 2 weeks. It is predicted that peak flood flows at Grand Mound would be reduced by 15% to 27% from FRE facility operation during a major flood of 38,800 cfs. Floods of this magnitude do not occur frequently enough to be a significant source of groundwater recharge. A flood of this magnitude or greater has about a 20% chance of occurring in any given year, or would occur on average about once every 5 years.

Additionally, overbank flood recharge is a relatively minor contributor to total groundwater recharge in the Chehalis River floodplain, in part because recharge rates in the floodplain are fairly low during a major flood. The floodplain in the Chehalis Basin contains mostly Hydrologic Soil Group B soils with small areas of Group A soils. The estimated maximum recharge rate is 0.6 inches/day for Group B soils and 2 inches per day for Group A soils.

The depth and duration of flooding varies depending on location and characteristics of the flood, but generally lasts for a period of 1 to 3 days during a major flood. During that period of inundation, recharge to the shallow groundwater aquifer could be in the range of 0.6 to 6 inches based on the maximum recharge rates of the Group A and B soils. A major flood with an average recurrence interval of 5 years could provide average annual recharge in the range of 0.1 to 0.8 inch. By comparison, the estimated average annual recharge from precipitation in the Chehalis Basin is 22 inches per year (USGS 2018).

The potential for groundwater recharge from the Chehalis River along its banks may increase slightly after the initial 48 to 72 hours when the FRE facility gates are closed. As the temporary reservoir drains and outflows exceed inflows, the Chehalis River downstream of the FRE facility would see slightly higher water surface elevations for up to about 1 month, until the temporary reservoir is emptied. This presents the potential for slight increases in bank recharge to the A aquifer along the entire length of the river.

In summary, groundwater levels in the A aquifer would not be substantially affected when the FRE facility is in operation for major or larger floods because of the following:

- Chehalis River flows would be substantially reduced for a short period of time (2 to 3 days) during a major flood, but then would be increased by the outflow from the temporary reservoir for up to 35 days while the temporary reservoir drains, potentially increasing bank recharge.
- Reduction in overbank flooding inundation occurrence and duration during major floods would not substantially affect groundwater recharge because recharge from overbank flooding is a minor contributor (a few percent) to groundwater recharge, and the reduction in recharge would occur only in areas where flood inundation no longer occurs or is reduced in duration.

Overall, adverse impacts on groundwater quantity from FRE facility operation are expected to be **moderate to minor**.

No adverse impacts on groundwater quality are anticipated.

3.2.2.1.3 Water Use and Water Rights

FRE facility operation has the potential to affect water uses and rights upstream of the facility, within or near the temporary reservoir footprint. The only permitted water uses and rights in or near the proposed temporary reservoir footprint are related to the Town of Pe Ell's municipal supply (Ecology Water Resources Explorer 2019). There are no water wells mapped within the temporary reservoir footprint or within 0.5-mile of the temporary reservoir footprint (Ecology Well Report Viewer 2019).

As described in Section 2.2.4, the Town of Pe Ell holds a water right for municipal surface water withdrawals from Lester Creek under Water Right No. CS2-SWC1060. The lower portion of Lester Creek would be inundated when the FRE facility is storing water. The intake on Lester Creek serves as the town's primary withdrawal point, and the water right authorizes up to 2 cfs to be withdrawn from this location. At approximately 640 feet in elevation, the Lester Creek withdrawal point is located above and outside of the maximum pool elevation of the temporary reservoir, which is 628 feet. Additionally, the water treatment facility and pump station are outside of the area of modeled inundation, and are therefore not anticipated to be affected by the Proposed Action. However, an 8,000-foot-long portion of the water line is located within the area of modeled inundation of the temporary reservoir and may need to be improved or relocated because of conflicts with construction activities. If the water line requires improvement or relocation, and the Applicant does not improve the water line to withstand inundation, relocate the line, or provide funding for this work, this would be a **significant adverse impact** on the Town of Pe Ell's water right.

A mitigation measure is included (PSU-1) for the Applicant to conduct a study to determine if the water line needs to be improved or relocated and, if so, to develop a cost estimate and ensure that funding is provided for this work. With this mitigation measure, there would be **no adverse impact** on Pe Ell's water supply. For more information, see the *Public Services and Utilities Discipline Report* (ESA 2020a).

The Town of Pe Ell also holds a surface water right for withdrawals of up to 0.67 cfs from Crim Creek (S2-00818C), within the temporary reservoir footprint. The authorized point of diversion on Crim Creek would be inundated when the FRE facility is operating. The diversion and conveyance system from Crim Creek have been removed, and water is not currently withdrawn from that location. However, the Town of Pe Ell may desire to exercise this water right in the future. Since the authorized diversion point is within the area of temporary reservoir inundation, the FRE facility would affect that ability of the Town of Pe Ell to use water from this location in the future, representing a **moderate** adverse impact on water use and rights in the FRE facility vicinity.

The Town of Pe Ell's backup municipal water intake on the Chehalis River (under Water Right CS2-SWC1060) is downstream of the proposed FRE facility. Mahaffey Creek, on which the Town of Pe Ell holds an additional but unused water right (S2-0836C), enters the Chehalis River downstream of the FRE facility.

FRE facility operation would **not** directly adversely affect water uses and rights downstream of the facility, based on the fact that it would only store water for relatively short periods (up to 35 days) during major floods, when water supply exceeds demand. Additionally, downstream water uses and rights would **not** be indirectly adversely affected by geomorphology impacts, based on the findings in the *Earth Discipline Report*. As described in detail in the *Earth Discipline Report*, the FRE facility operation is predicted to result in: slight reductions in downstream bank erosion and channel migration rates in select places and little change in others; minor coarsening of bed material in places below the FRE facility to about RM 102 and little change in grain size downstream of RM 102; and no major change in long-term channel incision in the mainstem Chehalis River or its tributaries (Shannon & Wilson and Watershed GeoDynamics 2020).

3.2.2.2 Airport Levee Changes

The Airport Levee Changes would include the following:

- Adding 4 to 7 feet to the height of the existing 9,511-foot-long levee with earthen materials or floodwalls
- Raising about 1,700 feet of Airport Road along the southern extent of the airport
- Replacing utility infrastructure and terminating the West Street over-cross approach

The potential impacts of the Airport Levee Changes on surface water, groundwater, and water uses and rights are addressed in the following subsections.

3.2.2.2.1 Surface Water

Water Quantity

The existing airport levee provides protection during a major flood but is overtopped by a catastrophic flood. Raising the existing levee by 4 to 7 feet would reduce or eliminate flooding behind the levee during a catastrophic flood.

As discussed in Section 3.2.2.1, hydraulic modeling results for the Proposed Action for selected locations are presented in the table in Attachment N-1. A subset of the model results is presented in Tables N-14 through N-17 to highlight the effect of the predicted changes in water surface elevations and inundation depths at select locations near the airport levee.

Figures N.2-a through N.5-j in Attachment N-1 identify the modeled depth of flooding in the study area for the No Action and Proposed Action alternatives for each of the flood scenarios considered. Figures N.7-a through N.10-h in Attachment N-1 include focus maps showing depth of flooding within the communities of Pe Ell, Chehalis, and Centralia. The figures in Attachment N-1 highlight the areas that would no longer be inundated under the Proposed Action.

As shown in Tables N-14 and N-15, the area inside of the existing airport levee is predicted not to be inundated by a mid-century or late-century major flood with or without the Proposed Action.

Substantial reductions in flood depths are predicted for a catastrophic flood, however, as shown in Tables N-16 and N-17. Areas inside of the levee that are predicted to be inundated as much as 18 feet (north end of levee) in a mid-century catastrophic flood would remain dry as a result of the Proposed Action. Areas inside of the levee are predicted to be inundated by a late-century catastrophic flood with or without the Proposed Action. Flood depths would be reduced between approximately 3 and 5 feet for the late-century catastrophic flood as a result of the Proposed Action, with inundation depths ranging from less than 3 feet inside the south end of the levee to nearly 16 feet inside the north end of the levee.

Table N-14

Modeled Water Surface Elevations at Airport Levee for a Major Flood (in feet)

LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY (2050)			LATE-CENTURY (2090)		
		NO ACTION	PROPOSED ACTION	DIFFERENCE	NO ACTION	PROPOSED ACTION	DIFFERENCE
South End of Airport, Riverward of Levee	177.2	178.5	177.2	-1.3	179.3	178.0	-1.3
South End of Airport, Landward of Levee	176.0	Dry	Dry	N/A	Dry	Dry	N/A
North End of Airport, Riverward of Levee	171.4	175.3	173.9	-1.4	176.4	174.8	-1.5
North End of Airport, Landward of Levee	162.9	Dry	Dry	N/A	162.9	Dry	N/A

Table N-15

Modeled Inundation Depths at Airport Levee for a Major Flood (in feet)

LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY		LATE-CENTURY	
		NO ACTION	PROPOSED ACTION	NO ACTION	PROPOSED ACTION
South End of Airport, Riverward of Levee	177.2	1.3	0	2.1	0.8
South End of Airport, Landward of Levee	176.0	0	0	0	0
North End of Airport, Riverward of Levee	171.4	3.9	2.5	5.0	3.4
North End of Airport, Landward of Levee	162.9	0	0	0	0

Table N-16

Modeled Water Surface Elevations at Airport Levee for a Catastrophic Flood (in feet)

LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY (2050)			LATE-CENTURY (2090)		
		NO ACTION	PROPOSED ACTION	DIFFERENCE	NO ACTION	PROPOSED ACTION	DIFFERENCE
South End of Airport, Riverward of Levee	177.2	182.5	181.3	-1.2	183.4	182.5	-0.9
South End of Airport, Landward of Levee	176.0	181.6	Dry	N/A	183.2	178.7	-4.5
North End of Airport, Riverward of Levee	171.4	180.9	178.5	-2.4	182.3	179.7	-2.6
North End of Airport, Landward of Levee	162.9	181.0	Dry	N/A	182.4	178.7	-3.6

Table N-17

Modeled Inundation Depths at Airport Levee for a Catastrophic Flood (in feet)

LOCATION	GROUND ELEVATION (FEET)	MID-CENTURY		LATE-CENTURY	
		NO ACTION	PROPOSED ACTION	NO ACTION	PROPOSED ACTION
South End of Airport, Riverward of Levee	177.2	5.3	4.1	6.2	5.3
South End of Airport, Landward of Levee	176.0	5.6	0	6.2	2.7
North End of Airport, Riverward of Levee	171.4	9.5	7.1	10.9	8.3
North End of Airport, Landward of Levee	162.9	18.1	0	19.5	15.8

The effect of the Airport Levee Changes on water surface elevations was not analyzed separately from the effect of the FRE facility in the 2019 Riverflow 2-D hydraulic modeling performed by WSE. Since both elements are part of the same proposed action, modeling accounted for the combined effect of both. Previous HEC-RAS hydraulic modeling performed by WSE for showed that, considered alone, the Airport Levee Changes could increase floodwater elevations immediately upstream and downstream of the levee during a 100-year flood, due to backwater effects and/or the displacement of floodwater that would otherwise have flooded the airport. The modeling showed increases of up to 0.9 foot upstream and 0.2 foot downstream of the levee (Ecology 2017).

The Airport Levee Changes and FRE facility are proposed for construction during the same general 2025 to 2030 timeframe, although the FRE facility construction would take longer and it likely would not be operational until 2030. If the Airport Levee Changes are completed before the FRE facility is operational and a catastrophic flood occurs, there is the potential for **moderate** adverse impacts from increased flood elevations immediately upstream and downstream of the levee. Once the FRE facility is operational, there would be only reductions in flood elevations in the vicinity of the airport levee relative to current conditions. Mitigation is proposed for the Applicant to develop a schedule in which the levee is built during the last part of the FRE facility construction period to eliminate the risk of additional flooding from a catastrophic flood if the Airport Levee Changes were completed before the FRE facility is constructed.

Water Quality

The Airport Levee Changes are not expected to adversely affect surface water quality. By reducing the area of inundation during catastrophic floods, the Airport Levee Changes could benefit water quality by reducing surface water exposure to pollutants from airport and nearby surrounding area surfaces and sources.

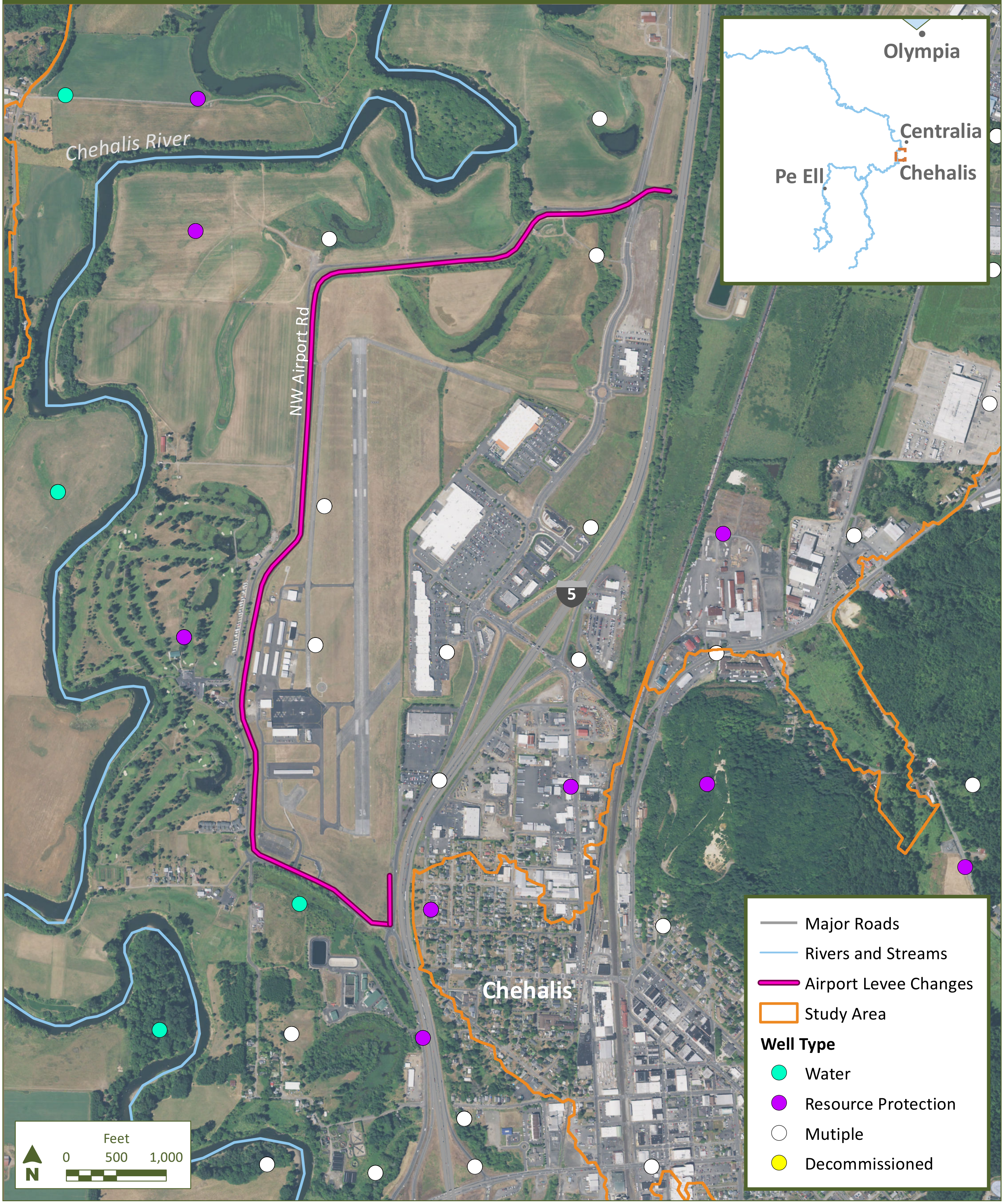
3.2.2.2.2 Groundwater

Subsurface placement of fill material and/or structures (e.g., floodwalls) for the Airport Levee Changes could locally modify shallow groundwater flows, representing a **moderate** adverse impact on groundwater quantity.

3.2.2.2.3 Water Use and Water Rights

The Airport Levee Changes would not displace or otherwise interfere with any existing water uses or rights. Ecology's Well Report Viewer (2019) identifies one water well located riverward and near the proposed Airport Levee Changes, on the south side of Airport Road (Well Report ID No. 313759; see Figure N-16). The precise location of this water well is unknown, but its general location is in an area that would be inundated under mid- and late-century, major and catastrophic floods for both the Proposed Action and No Action Alternative (see Figures N-14 and N-15). Reductions in floodwater surface elevations resulting from the Proposed Action, or temporary small increases in floodwater surface elevations that could result if the Airport Levee Changes are completed before the FRE facility is operational, are unlikely to substantially affect the well since it would likely be inundated to some degree by the evaluated flood scenarios regardless. **No adverse impacts** are anticipated.

Figure N-16
Water Well Located Near Airport Levee Changes



Source: Ecology Well Construction Map (https://fortress.wa.gov/ecy/wellconstructionmap)

3.2.3 Required Permits

The following water-related permits are expected to be required for the Proposed Action:

- **Clean Water Action Section 404 Permit (Corps)**: Section 404 requires discharges of dredged/fill material to waters of the U.S. be done only under the authorization of a permit. Because construction of the FRE facility would involve the excavation and fill placement in the Chehalis River, and construction of the Airport Levee Changes may involve fill placement in wetlands, the Proposed Action would require a Section 404 permit from the Corps.
- **Clean Water Act Section 401 Water Quality Certification (Ecology)**: Because a federal (Corps Section 404) permit would be needed to construct the Proposed Action, a Section 401 Water Quality Certification from Ecology would be needed to document the state's review of the project and its concurrence that the Applicant has demonstrated that the Proposed Action will meet state water quality standards.
- **Coastal Zone Management Program Consistency (Ecology):** Construction and operation of the FRE facility may be subject to the federal consistency provision of the Coastal Zone Management Act and the state's Coastal Zone Management Program.
- **Dam Safety Construction Permit (Ecology)**: Because the FRE facility would be capable of storing more than 10 acre-feet of water and would impound water at depths in excess of 10 feet, permits from Ecology would be needed to construct and operate the FRE facility.
- **Hydraulic Project Approval (Washington Department of Fish and Wildlife)**: The Proposed Action would use, divert, obstruct, and change the natural flow and bed of freshwaters of the state and therefore would require a Hydraulic Project Approval (HPA) from the Washington Department of Fish and Wildlife under the state's hydraulic code rules (220-660 WAC). The HPA would include conditions intended to minimize impacts on instream and riparian habitat and functions.
- **Local Land Use and Development Permits (Lewis County and City of Chehalis)**: The Proposed Action would affect water-related resources regulated by Lewis County (FRE facility) and the City of Chehalis (Airport Levee Changes) under Shoreline Management Programs, Critical Areas Ordinances, and floodplain and stormwater management codes. Permits from both local governments would be needed in accordance with their local development codes.
- **NPDES Construction Stormwater General Permit (Ecology)**: Construction of the Proposed Action would result in more than 1 acre of ground disturbance and involve stormwater discharges to surface waters. Therefore, coverage under an Ecology Construction Stormwater Permit would be required. The NPDES permit would include conditions requiring the permittee to prepare a Stormwater Pollution Prevention Plan (SWPPP) and implement appropriate erosion, sediment, and pollution control measures for the duration of construction.
- **NPDES Sand and Gravel Permit (Ecology):** FRE facility construction would require quarry development to provide aggregate for the FRE facility. Mining of concrete aggregate and concrete production would require coverage under Ecology's Sand and Gravel General Permit, which is an NPDES and State Waste Discharge Permit. The Sand and Gravel Permit includes

conditions requiring the permittee to prepare a SWPPP and implement BMPs to control pollutants from process water, mine dewatering water, and stormwater. The permit includes effluent limits and monitoring requirements for process water and mine dewatering discharges for parameters including pH, turbidity, TSS, oil, and TDS.

- **Water Rights Permits (Ecology)**: The Proposed Action would involve temporary withdrawals of water from the Chehalis River for the construction of the FRE facility and would involve storage of Chehalis River flows during major floods as part of FRE facility operations. Water rights permits from Ecology would be needed for the surface water withdrawals and storage.

3.2.4 Proposed Mitigation Measures

This section describes the mitigation measures proposed for the Applicant to implement that would reduce impacts on water from construction and operation of the Proposed Action. These mitigation measures would be implemented in addition to project design measures, BMPs, and compliance with permits, plans, and authorizations. The Applicant will implement the following measure to mitigate impacts on water use:

- **WATER-1**: To reduce probable impacts to surface water quality and designated aquatic life uses of the Chehalis River and Crim Creek from construction and operation of the Proposed Action, mitigation is proposed for the Applicant to develop and implement a Surface Water Quality Mitigation Plan. The plan must be approved by Ecology and other applicable local, state, and federal agencies and be provided as part of the Section 401 and NPDES permit applications. The plan must provide reasonable assurance that water quality standards and designated in-water uses will be met. The mitigation must be done within the Chehalis River Basin. The plan may include a range of options for mitigation. The plan will include, but is not limited to, the following:
  - Mitigation for the increase in daily maximum temperature of up to 2°C to 3°C (3.6°F to 5.4°F) in the Chehalis River in the temporary reservoir footprint and to about 20 miles downstream of the FRE facility, and of up to 5°C (9°F) in the lower portion of Crim Creek, below its confluence with Lester Creek.
  - Mitigation for the decrease in daily minimum DO by up to 0.4 mg/L in the Chehalis River within the temporary reservoir.
  - Measures to minimize the exceedances of turbidity water quality criteria to the downstream Chehalis River when the temporary reservoir is draining and outflow turbidity exceeds inflow turbidity by more than 10% or by more than 5 nephelometric turbidity units (NTU) if inflows are less than 50 NTU.
  - Measures to minimize the exceedances of turbidity water quality criteria in the reservoir area from shallow landslides.
  - This plan will be developed in conjunction with management and mitigation plans for vegetation, wetlands and wetland buffers, streams and stream buffers, fish and aquatic species and habitat, wildlife species and habitat, riparian habitat, and large woody material.

Other Related Mitigation Measures

- **FISH-1 (Fish and Aquatic Species and Habitat Plan):** To mitigate the impacts to fish and aquatic species and habitats associated with construction and operation of the Proposed Action, mitigation is proposed for the Applicant to develop and implement a Fish and Aquatic Species and Habitat Plan (for details, see *Fish Species and Habitats Discipline Report*; Anchor QEA 2020d).
- **WET-2 (Stream and Stream Buffer Mitigation Plan):** To mitigate the impacts to streams and stream buffers from construction and operation of the Proposed Action, mitigation is proposed for the Applicant to develop and implement a Stream and Stream Buffer Mitigation Plan (for details, see *Wetlands Discipline Report)*.
- **WILDLIFE-1 (Vegetation Management Plan):** To mitigate the impacts to habitat from construction and operation of the FRE and temporary reservoir, mitigation is proposed for the Applicant to develop and implement a Vegetation Management Plan (for details, see *Wildlife Species and Habitats Discipline Report)*.
- **WILDLIFE-3 (Riparian Habitat Mitigation Plan):** To mitigate the impacts to riparian habitat from construction and operation of the Proposed Action, mitigation is proposed for the Applicant to develop and implement a Riparian Habitat Mitigation Plan (for details, see *Wildlife Species and Habitats Discipline Report)*.
- **PSU-1:** To reduce potential impacts on Pe Ell's water supply system, mitigation is proposed for the Applicant to work with the Town of Pe Ell to conduct a study to determine if the Pe Ell water line at Lester Creek needs to be relocated or redesigned to ensure that it can withstand inundation within the temporary reservoir. If relocation or redesign is required, the Applicant will develop a cost estimate and provide funding for this work.
- **LAND-3:** The Applicant will develop a schedule in which the levee is built during the last part of the FRE facility construction period to eliminate the risk of additional flooding from a catastrophic flood if the Airport Levee Changes are completed before the FRE facility is constructed.

3.2.5 Significant and Unavoidable Adverse Impacts

There is uncertainty if mitigation is technically feasible or economically practicable; therefore, the Proposed Action would have **significant and unavoidable** adverse environmental impacts on surface water quality as follows:

- Daily maximum temperatures in the Chehalis River within the temporary reservoir footprint and immediately downstream of the FRE facility increasing by up to 2°C to 3°C by late-century in mid- to late-summer as a result of FRE facility operation.
- Temperature impacts would decrease moving downstream, becoming negligible approximately 20 miles downstream of the FRE facility, below the confluence with the South Fork Chehalis River.

- Temperature impacts to tributaries within the temporary reservoir footprint could be up to a 5°C increase predicted in the lower portion of Crim Creek, below its confluence with Lester Creek.
- Decrease in minimum DO in the Chehalis River within the temporary reservoir footprint by up to 0.4 mg/L by late-century in middle to late summer.
- Exceedances of turbidity water quality criteria when the temporary reservoir is draining and outflow turbidity exceeds inflow turbidity by more than 10% or by more than 5 NTU if inflows are less than 50 NTU.

The Applicant may provide a Surface Water Quality Mitigation Plan as described above. If Ecology determines the plan meets the requirements of the Clean Water Act, RCW 90.48, and WAC 173-201A and implementation is feasible, then the impacts would be addressed as part of the permitting processes.

3.3 Local Actions Alternative

The Local Actions Alternative considers various local-scale actions to reduce flood damage in the Chehalis Basin. Elements of this alternative could be supported by the Applicant through funding or technical assistance and could include the following:

- Land use management
- Floodproofing existing structures
- Buy-out of at-risk properties or structures
- Floodplain storage improvements including riparian restoration, afforestation, floodplain reconnection, and water flow abatement
- Channel migration protection
- Early flood warning systems

3.3.1 Impacts from Construction

Of the six measures identified under this alternative, three could result in the need for construction activities: floodproofing existing structures, floodplain storage improvements, and channel migration protection.

Construction activities in the floodplain could adversely affect surface water quality by disturbing soils and increasing their potential to reach receiving waters in runoff, leading to increases in stream turbidity. Additionally, the introduction of construction equipment and materials increases the potential for associated pollutants (e.g., oil and grease, fuel, hydraulic fluids) to enter surface waters through stormwater runoff or groundwater through infiltration. Additionally, shallow groundwater levels/flows could be temporarily altered by subsurface excavation/dewatering. Construction activities that could affect water quality would be required to have an NPDES permit.

The construction-related impacts for the Local Actions Alternative would be periodic, temporary, and localized in nature, and would therefore represent a **moderate to minor** adverse impact on surface water quality.

3.3.2 Impacts from Operation

Local actions that would protect existing pollutant-generating impervious surfaces or areas of hazardous materials storage from inundation during floods, or that would remove such development from the floodplain, would benefit surface water quality by reducing pollutant contact with surface waters. Associated benefits to shallow groundwater quality may also result in connection with the reduced pollutant exposure. Subsurface placement of fill material and/or structures for floodproofing actions could locally modify shallow groundwater flows, representing a **moderate** adverse impact on groundwater quantity.

Most of the local-scale actions considered under this alternative would primarily seek to manage flood risk and minimize property damages, rather than reduce floodwater levels. Of the six local action measures identified, only the floodplain storage improvements provide some potential for reducing floodwater surface elevations. The types of flood storage improvements considered with this alternative include placing wood in rivers and streams to increase roughness and water levels, causing floodwaters to more fully occupy undeveloped floodplain areas. They also include restoring riparian areas and revegetating or reforesting floodplain areas to support improved floodplain function and increase floodplain storage.

Floodplain restoration activities that improve vegetation conditions and floodplain functions could benefit surface water quality through reduced erosion and increased pollutant filtration and infiltration. Floodplain enhancement activities that increase floodplain storage and retention in desired areas could also benefit water quantity by locally reducing flood levels and velocities.

While localized reductions in floodwater levels may result from local floodplain storage improvement projects, these projects likely would not achieve significant reductions in Chehalis River peak flows during major or catastrophic floods. For comparison, the maximum volume of water storage provided by the FRE facility would be 65,810 acre-feet, or over 100 million cubic yards, and it is predicted to generally reduce floodwater elevations in the Chehalis-Centralia area by approximately 1 to 2.5 feet for mid- to late-century, major to catastrophic floods. For context, the calculated volumes of flow passing Grand Mound for the 100-year flood (catastrophic flood) are approximately: 127,000 acre-feet over 1 day; 277,000 acre-feet over 3 days; 447,000 acre-feet over 7 days; and 681,700 acre-feet over 15 days (West Consultants 2014).

Achieving comparable (or close to comparable) reductions in peak flows by increasing floodplain roughness through revegetation or large wood additions, or by excavating sufficient additional floodplain storage through local projects, is likely not realistic due to characteristics and availability of lands for restoration and floodplain storage and the results of studies showing the effectiveness of restoration in achieving flood reduction on a large scale.

Natural Systems Design recently completed a feasibility evaluation for a restorative flood protection approach that built upon previous work in the upper Chehalis Basin and involved additional detailed work in the Newaukum Basin (NSD 2018). That analysis found that floodplain restoration can increase flood storage and help attenuate flows, but that the effectiveness of restoration measures on peak flow reduction decreases with flood magnitude and with the slope of the stream. The study reported that, specific to the Newaukum and upper Chehalis basins, hydraulic modeling showed that potential Chehalis River flood peak reductions (at Grand Mound) from a restoration approach in the Newaukum Basin are well below those predicted for a large impoundment on the upper Chehalis, due largely to the steepness of the valley slopes in the Newaukum Basin. The study concluded that floodplain restoration does show significant attenuation benefits when applied in low-gradient valleys, however, and that a floodplain restoration approach at a smaller scale is likely to be an effective element of a flood attenuation strategy (NSD 2018).

3.3.3 Flood Conditions and Impacts

The modeling done for the No Action Alternative would be similar for the Local Actions Alternative. As shown in the table of water surface elevations in Attachment N-1, water levels for major and catastrophic floods are expected to continue to increase across the study area over time. Floods would continue to inundate rivers, streams, habitat, and properties. Water quality and use throughout the study area would experience **continuing substantial flood** risk during both major and catastrophic floods under the Local Actions Alternative.

3.4 No Action Alternative

The No Action Alternative represents the most likely future in the absence of implementing the Proposed Action. Under the No Action Alternative, the FRE facility and Airport Levee Changes would not be constructed, and local flood damage reduction efforts would likely continue based on local planning and regulatory actions. The No Action Alternative would include programs and projects that have been constructed, are underway, or are funded and permitted, including local floodproofing efforts, projects led by the Chehalis Basin Flood Authority, and Washington State Department of Transportation programs.

3.4.1 Flood Conditions and Impacts

The No Action Alternative would provide mostly localized (site-scale) benefits for flood damage reduction and is not be expected to result in large-scale, basin-wide reductions in flood levels or extents during a major or catastrophic flood.

As discussed in Section 3.2 of this report, modeling for future conditions (mid- and late-century) was conducted for both the No Action Alternative and Proposed Action, and it accounted for projected changes in hydrology due to climate change. The table in Attachment N-1 presents modeled future conditions water surface elevations for 25 select locations throughout the study area for both the No Action Alternative and Proposed Action. Maps presented in Attachment N-1 show side-by-side comparisons of predicted flood depths for the No Action Alternative and Proposed Action across the entire modeled area for both mid-century and late-century timeframes. The maps in Attachment N-1 highlight areas that would be inundated under the No Action Alternative but would not be inundated under the Proposed Action.

As shown in the table and maps of Attachment N-1, water levels for major and catastrophic floods are expected to continue to increase across the study area over time under the No Action Alternative, and the predicted flood depths and flood area extents are greater for the No Action Alternative than the Proposed Action. Under the modeled late-century catastrophic flood, for example, approximately 3,795 acres more land would be inundated under the No Action Alternative than under the Proposed Action, including rural and agricultural lands as well as residential neighborhoods in Centralia (Anchor QEA 2020b).

Predicted differences in water surface elevations between the No Action and Proposed Action alternatives would be greater closer to the FRE facility and smaller farther downstream. Near Doty, for example, water surface elevations are predicted to be 12.1 feet higher under the No Action Alternative than the Proposed Action for a late-century catastrophic flood, while the difference in water levels between No Action and Proposed Action at the Porter Creek Road Bridge is 1.5 feet for a late-century catastrophic flood. Further downstream at Montesano, modeling predicts there would be a 1.2-foot difference between the No Action and Proposed Action alternatives for the late-century catastrophic flood. The modeling shows no areas downstream of the FRE facility where the No Action Alternative would result in lower water surface elevations than the Proposed Action for major or catastrophic floods.

Predicted inundation depths under the No Action Alternative vary widely across the floodplain, from river channel bottom (deep) to the edge of the floodplain (near zero). Predicted flood inundation depths for the No Action Alternative are identified for select locations/communities in Tables N-10 and N-12 of this report, and Tables N-15 and N-17 present that information for select locations inside and outside of the levee at the Chehalis-Centralia Airport. Flood inundation depths for the No Action Alternative for the selected locations in Tables N-10 and N-12, for example, range from 19.1 feet near Doty for a mid-century major flood to 38.3 feet near Adna for a late-century catastrophic flood. Areas inside (landward) of the Airport levee would not be inundated during a mid-century or late-century major flood under the No Action Alternative, but those areas would be inundated during mid-century and late-century catastrophic floods, with up to 19.5 feet of inundation predicted at the north end of the Airport during the late-century catastrophic flood.

Water quality and use throughout the study area would continue to experience **substantial flood risk** during both major and catastrophic floods under the No Action Alternative.

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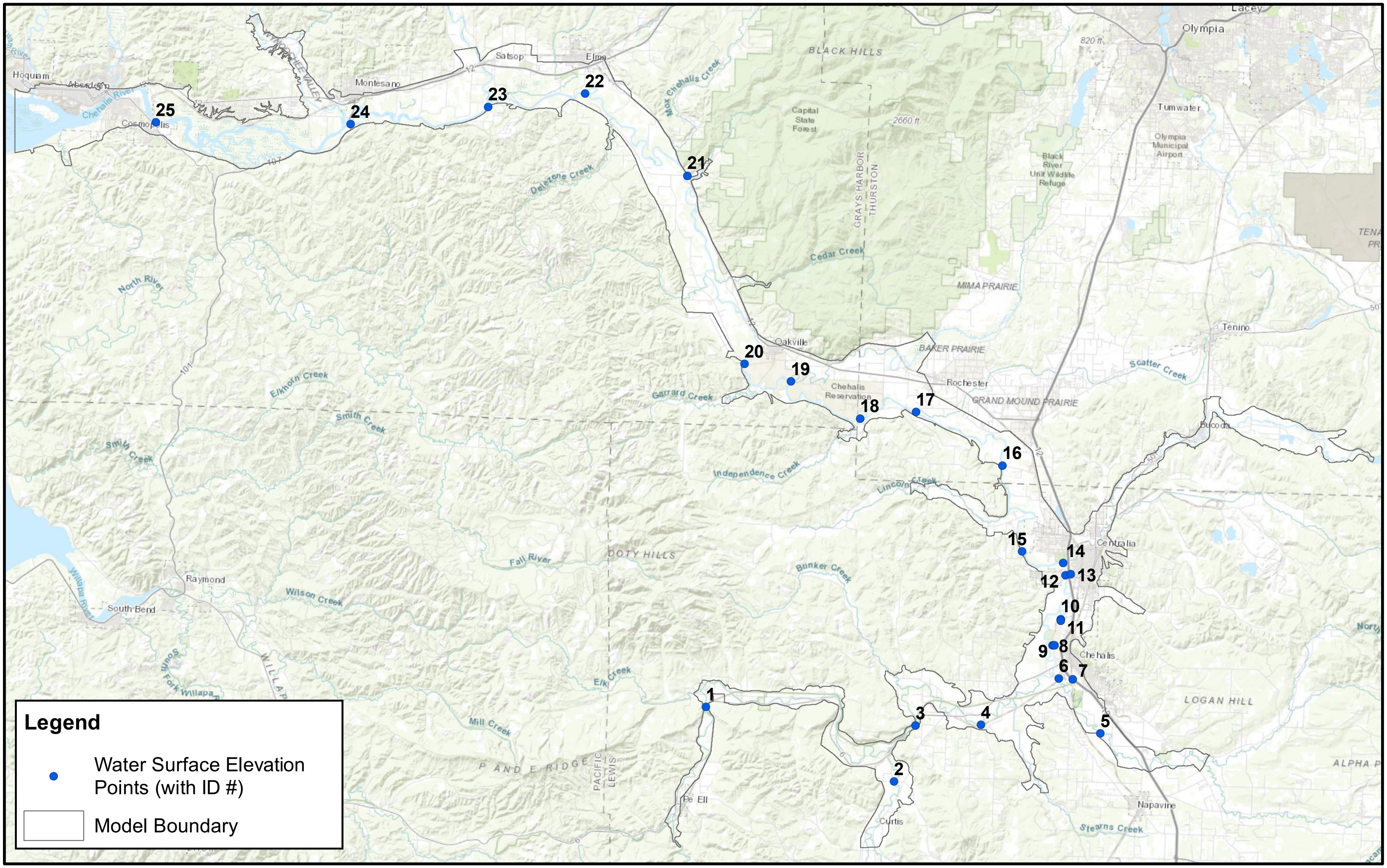
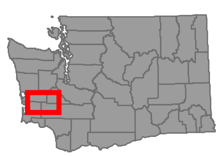
Attachment N-1
Water Surface Elevation Model Results

N-1.1
Hydraulic Modeling Water Surface Elevation Results – Key Locations

Hydraulic Modeling Water Surface Elevation Results (feet)

ID	Location	Ground Elevation (feet)	Dec. 2007 Max. WSEL (ft)	Current Conditions (Construction Period)		Major Flood						Catastrophic Flood					
						Mid-Century			Late-Century			Mid-Century			Late-Century		
				Major Flood	Catastrophic Flood	No Action	Propoosed Action	Difference from No Action	No Action	Proposed Action	Difference from No Action	No Action	Proposed Action	Difference from No Action	No Action	Proposed Action	Difference from No Action
1	Near Doty	293.8	325.6	311.9	319.5	312.9	303.5	-9.4	314.3	304.4	-9.8	321.1	309.6	-11.5	323.0	310.9	-12.1
2	Curtis Store (on South Fork Chehalis River)	208.7	237.7	229.5	231.9	229.9	229.8	-0.1	230.3	230.2	-0.1	233.0	231.6	-1.4	234.4	232.1	-2.4
3	Downstream of South Fork	186.5	225.5	214.3	220.1	215.3	212.1	-3.1	216.3	213.1	-3.2	221.3	217.5	-3.9	222.7	218.7	-4.0
4	Near Adna	160.6	199.2	195.3	198.1	195.8	193.4	-2.5	196.4	194.6	-1.8	198.5	197.3	-1.2	198.9	197.8	-1.1
5	Labree Road Bridge (on Newaukum River)	189.4	206.1	205.5	206.2	205.7	205.7	0.0	205.9	205.9	0.0	206.3	206.3	0.0	206.5	206.5	0.0
6	Newaukum Confluence	152.6	186.9	182.8	185.9	183.3	182.1	-1.2	183.8	182.8	-1.0	186.4	185.2	-1.2	186.9	185.9	-1.0
7	Dillenbaugh Creek at I-5	175.5	187.0	181.6	186.0	182.5	181.7	-0.8	183.5	182.8	-0.7	186.6	185.4	-1.2	187.1	186.1	-0.9
8	South End of Airport Riverward of Levee	177.2	183.2	177.9	181.8	178.5	177.2	-1.3	179.3	178.0	-1.3	182.5	181.3	-1.2	183.4	182.5	-0.9
9	South End of Airport Landward of Levee	176.0	182.9	Dry	179.9	Dry	Dry	N/A	Dry	Dry	N/A	181.6	Dry	N/A	183.2	178.7	-4.5
10	North End of Airport Riverward of Levee	171.4	181.9	174.5	179.4	175.3	173.9	-1.4	176.4	174.8	-1.5	180.9	178.5	-2.4	182.3	179.7	-2.6
11	North End of Airport Landward of Levee	162.9	182.0	Dry	179.5	Dry	Dry	N/A	162.9	Dry	N/A	181.0	Dry	N/A	182.4	178.7	-3.6
12	Mellen Street Bridge	134.0	178.4	171.5	176.7	172.6	170.8	-1.8	173.9	172.0	-1.9	177.8	176.0	-1.8	178.9	176.9	-2.0
13	Mellen Street just east of I-5	168.6	178.1	171.9	176.1	173.0	171.2	-1.8	173.8	172.6	-1.2	177.5	176.1	-1.5	179.3	177.2	-2.0
14	Skookumchuck Confluence	143.0	176.6	170.0	174.9	171.0	169.5	-1.6	172.3	170.6	-1.7	176.3	174.3	-2.0	177.6	175.2	-2.3
15	Upstream of Galvin Road	144.0	168.9	163.2	167.2	163.9	162.7	-1.3	164.9	163.6	-1.3	168.5	166.6	-2.0	169.7	167.5	-2.2
16	Grand Mound (Prather Road Bridge)	117.5	147.0	144.1	146.3	144.5	143.9	-0.6	145.0	144.3	-0.6	147.1	146.0	-1.0	147.9	146.6	-1.3
17	Near Rochester	105.0	124.6	121.3	124.1	121.9	121.1	-0.7	122.5	121.7	-0.8	124.8	123.8	-1.0	125.7	124.4	-1.3
18	Anderson Road	91.3	110.8	108.5	110.6	108.9	108.4	-0.5	109.4	108.8	-0.6	111.1	110.4	-0.7	111.7	110.9	-0.8
19	Black River Confluence	70.7	94.5	91.0	94.2	91.6	90.9	-0.7	92.3	91.5	-0.8	95.2	93.9	-1.3	96.2	94.8	-1.4
20	Sickman Ford Bridge	47.1	82.6	79.2	82.5	79.8	79.0	-0.7	80.5	79.7	-0.8	83.5	82.2	-1.3	84.6	83.2	-1.4
21	Porter Creek Road Bridge	22.1	54.9	51.0	54.8	51.7	50.9	-0.8	52.5	51.7	-0.9	55.9	54.6	-1.3	57.2	55.6	-1.5
22	Wakefield Road Bridge	14.0	40.3	37.7	40.6	38.4	37.7	-0.7	39.1	38.5	-0.6	41.2	40.5	-0.6	42.0	41.0	-1.0
23	Satsop Confluence	8.8	30.8	29.5	31.3	30.0	29.6	-0.3	30.4	30.1	-0.3	31.9	31.4	-0.6	32.7	32.0	-0.7
24	Montesano Bridge	-26.9	17.9	15.9	19.5	17.0	16.5	-0.6	18.2	17.7	-0.6	20.8	19.8	-1.0	22.3	21.2	-1.2
25	Cosmopolis	-52.8	11.0	9.0	9.5	9.4	9.3	-0.1	10.3	10.2	-0.1	10.1	9.9	-0.2	11.2	10.9	-0.3





Chehalis River 2D Hydraulic Model
Water Surface Elevation Locations

0 1 2 3 4 5 Miles

N

NAD 1983 HARN
StatePlane Washington
South FIPS 4602 Feet

23 Dec 2019

WATERSHED
SCIENCE & ENGINEERING

N-1.2
Hydraulic Model Map Set

Mid-Century and Late-Century Mapping for Major and Catastrophic
Flood Conditions for the Proposed Action and No Action Alternative

Figure N.1
Key to Extents in Mapbook

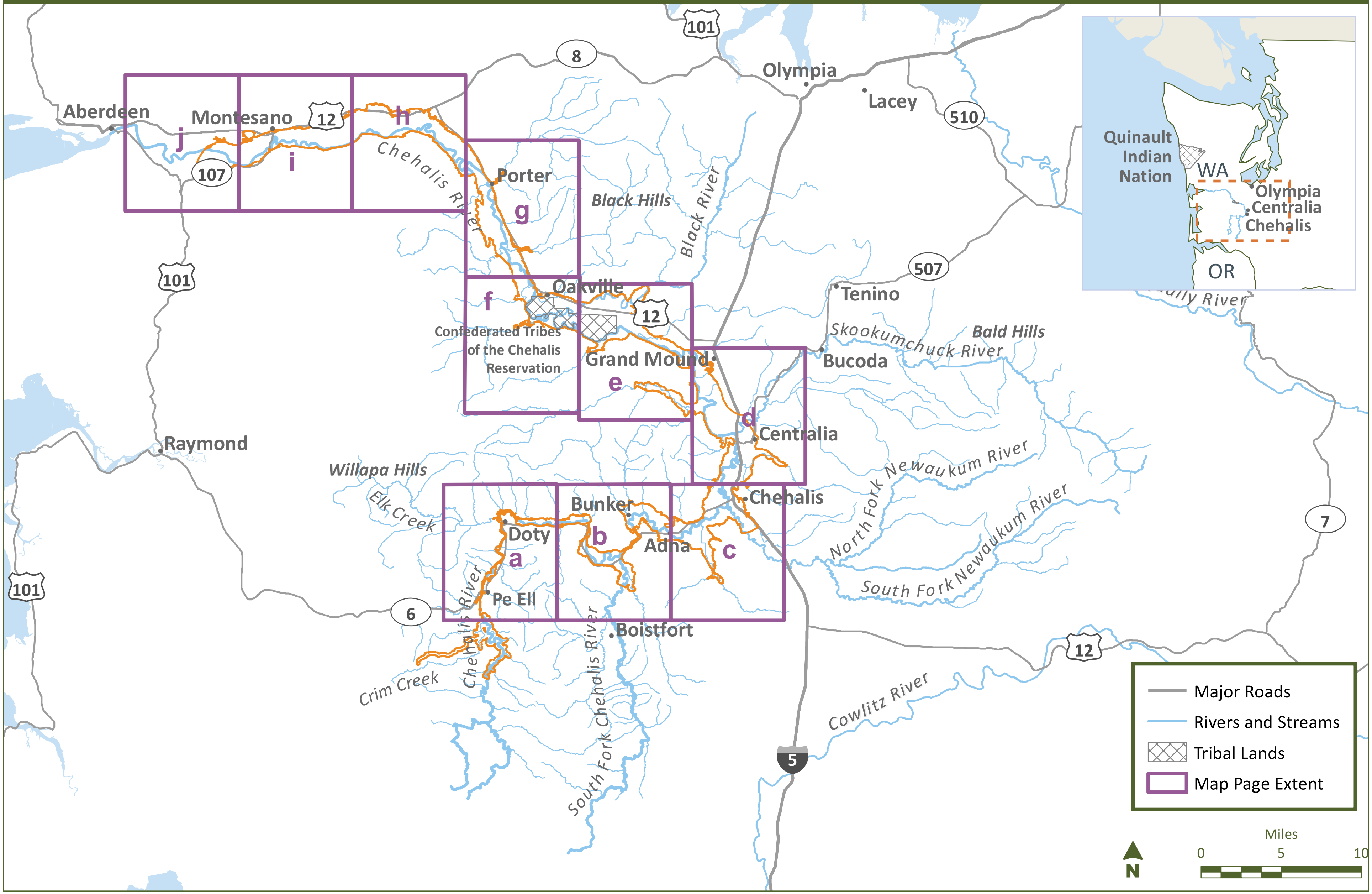
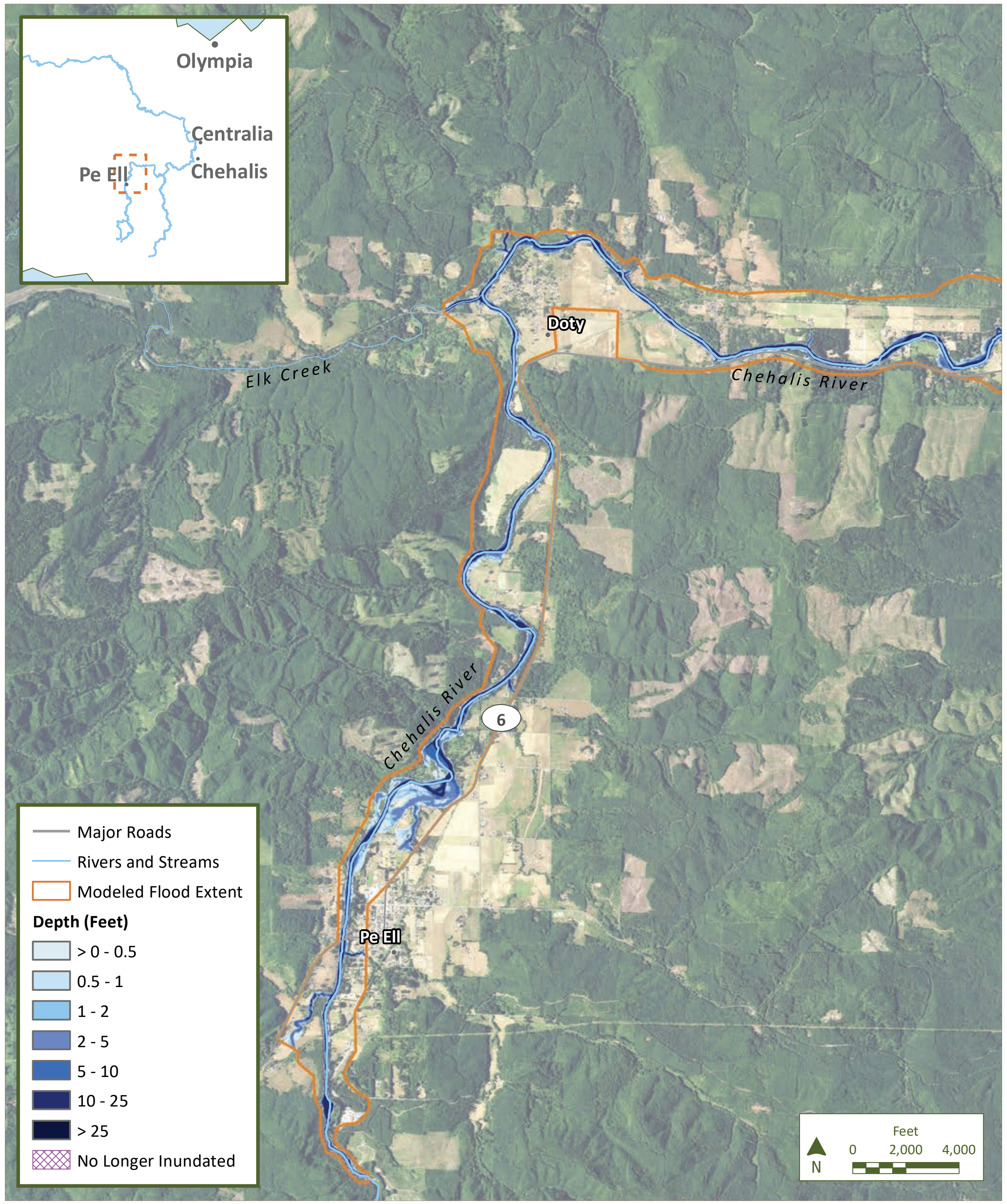


Figure N.2-a
Mid-Century Major Flood

No Action



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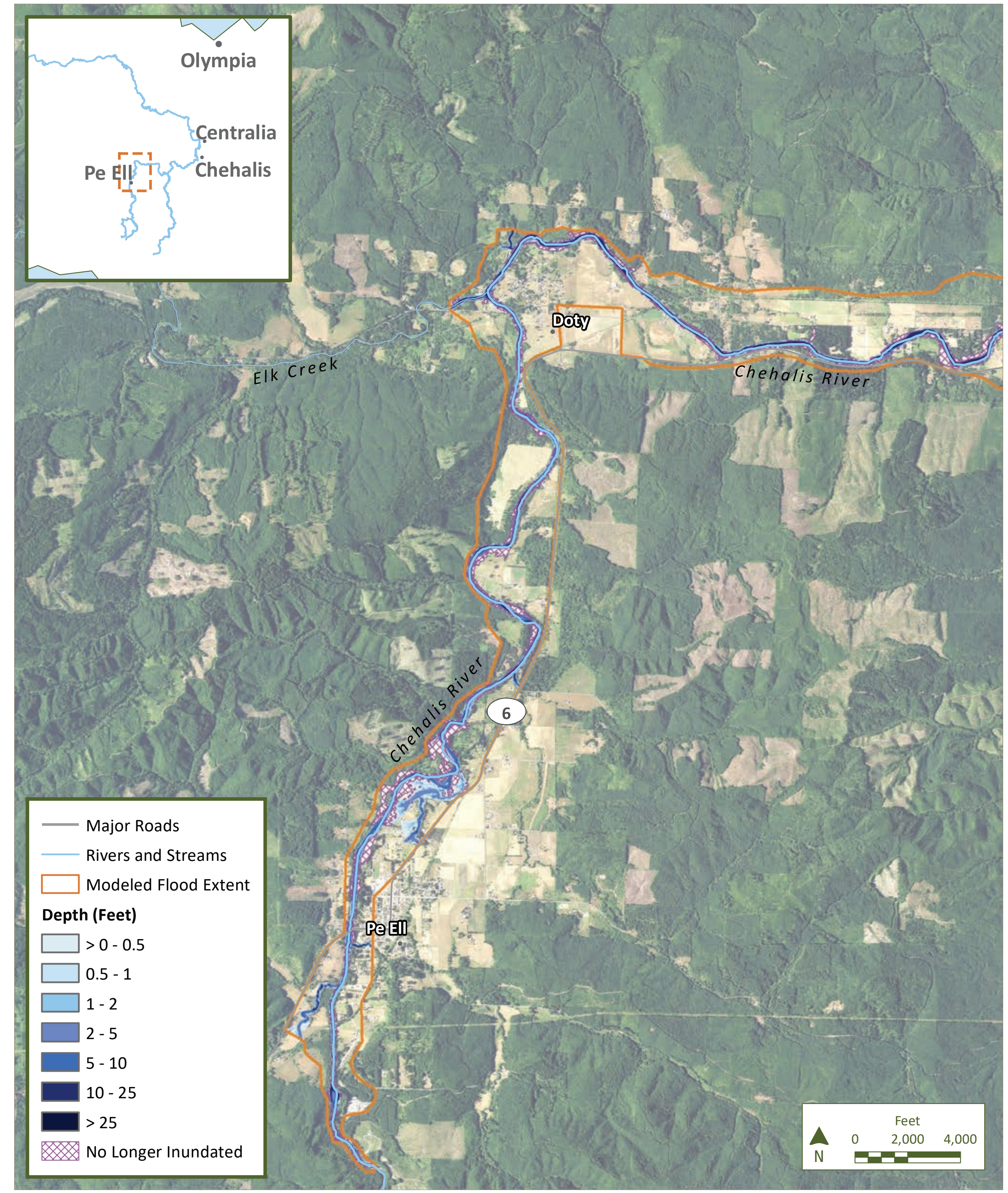

Figure N.2-b
Mid-Century Major Flood

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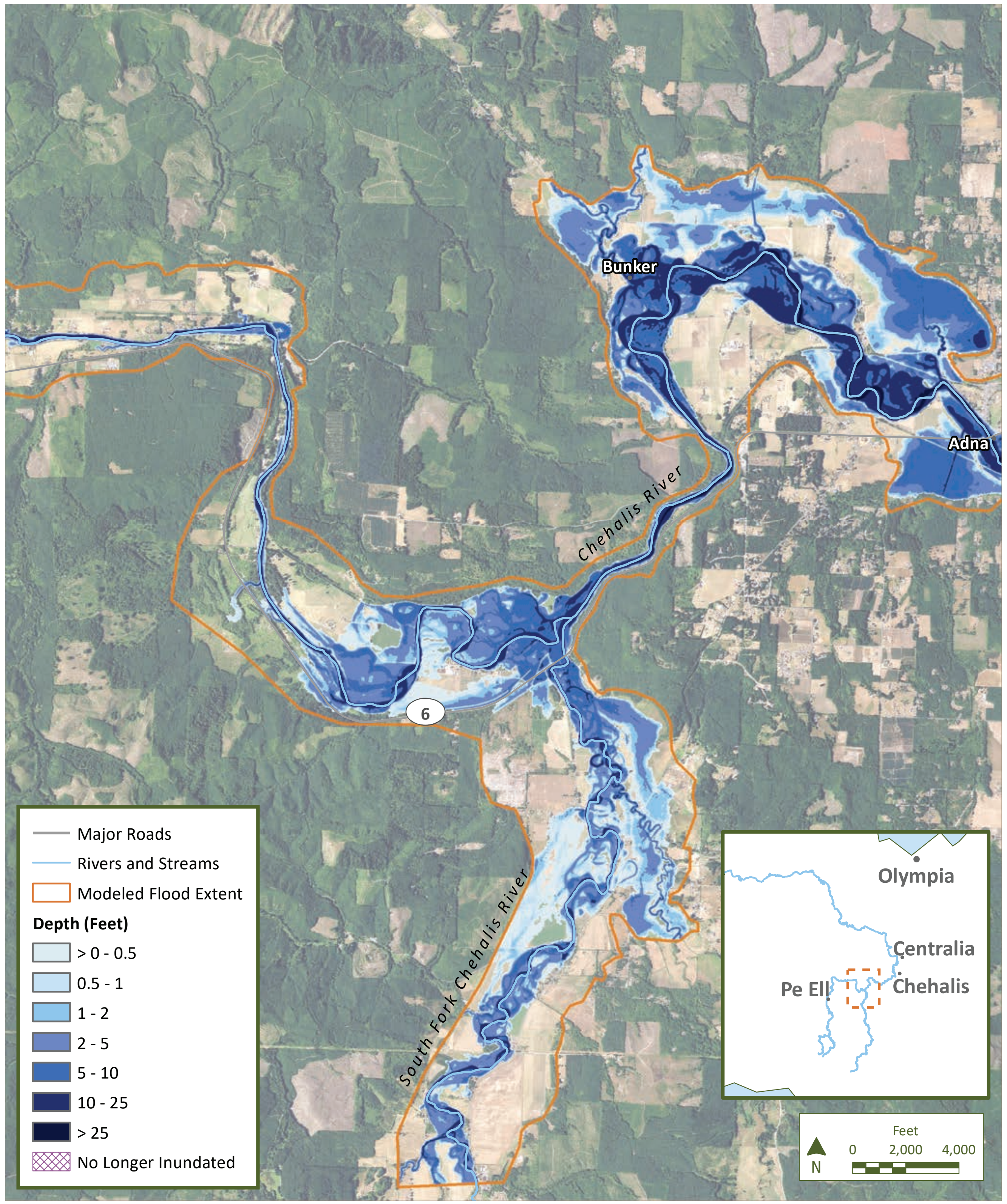

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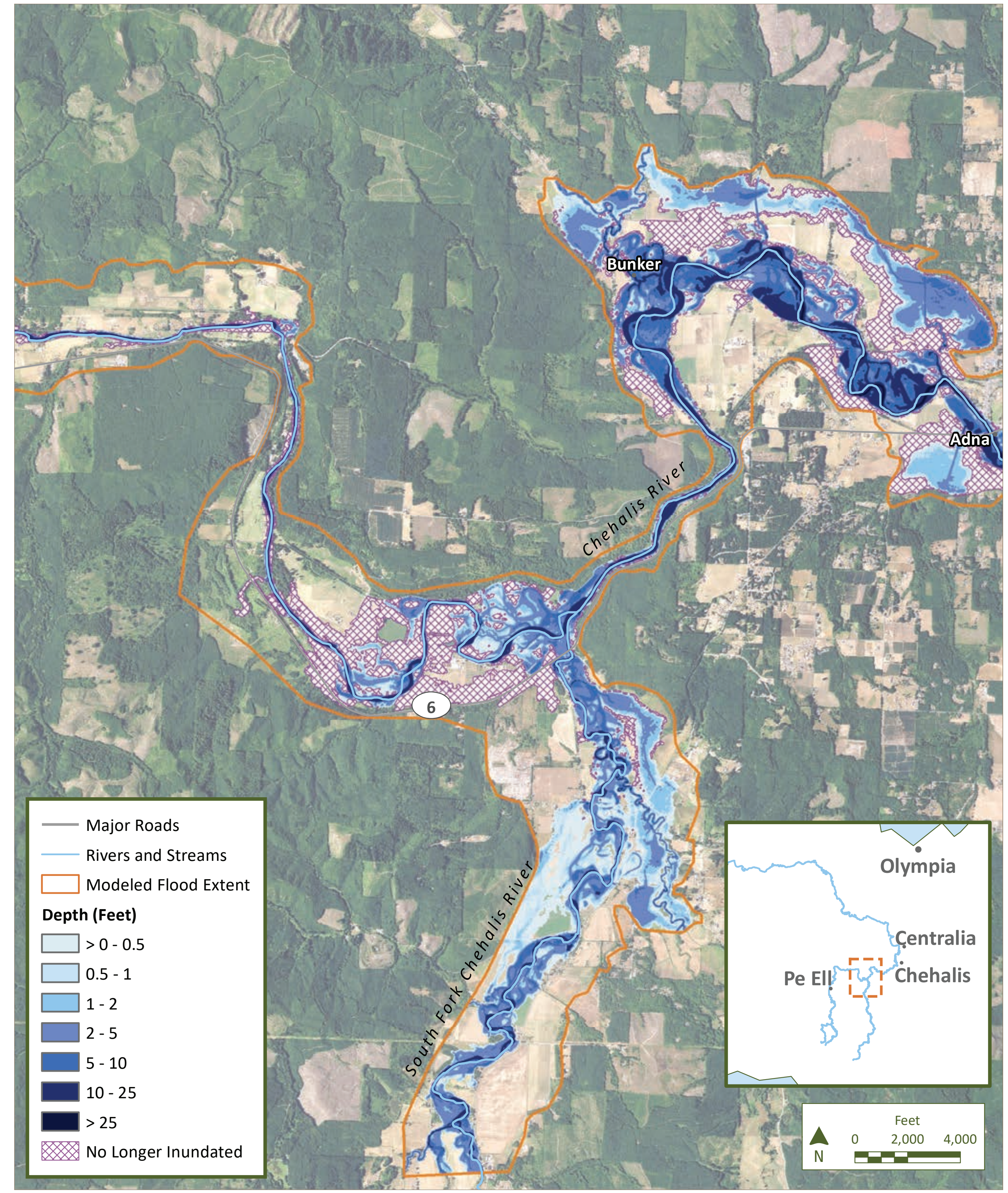
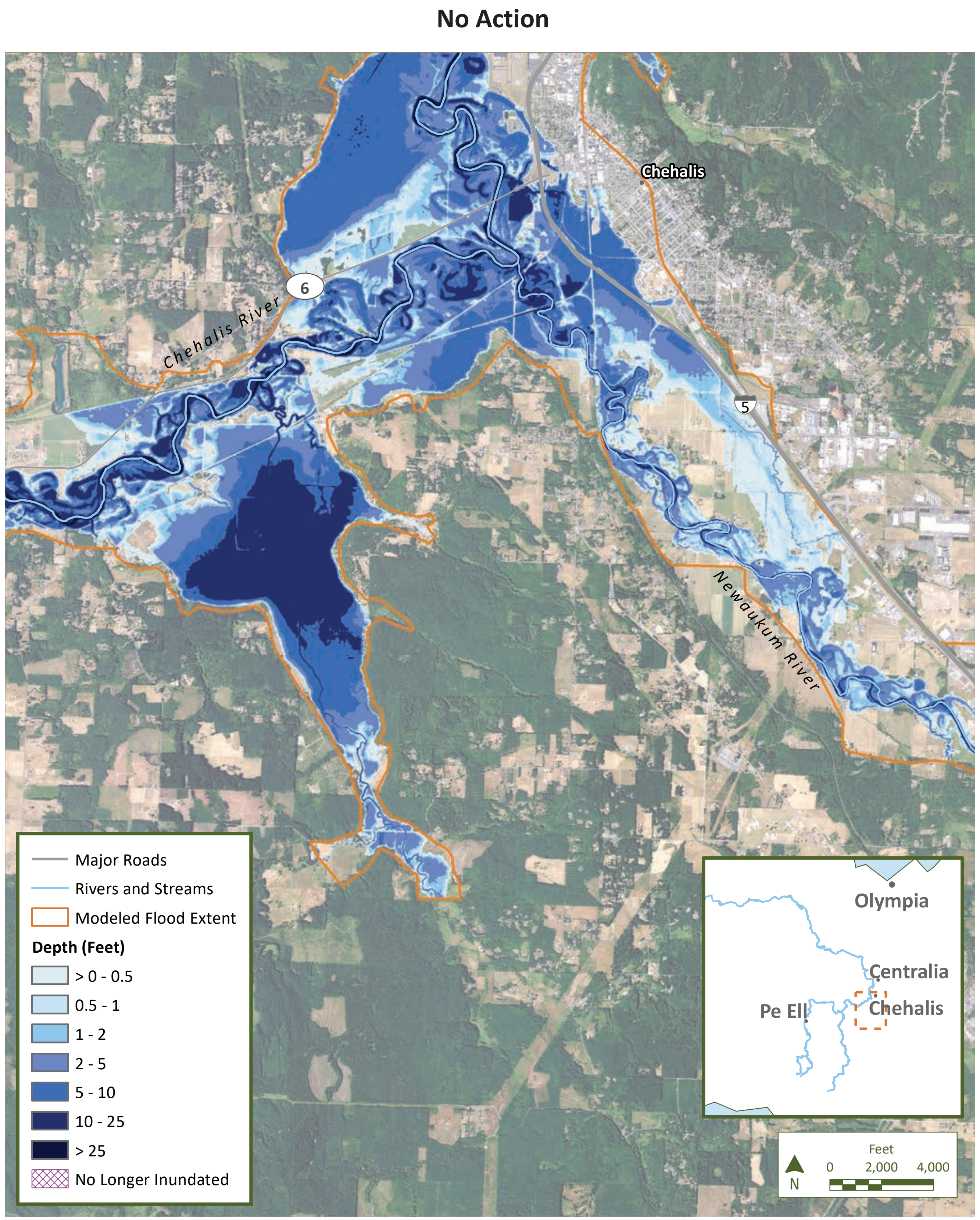


Figure N.2-c
Mid-Century Major Flood



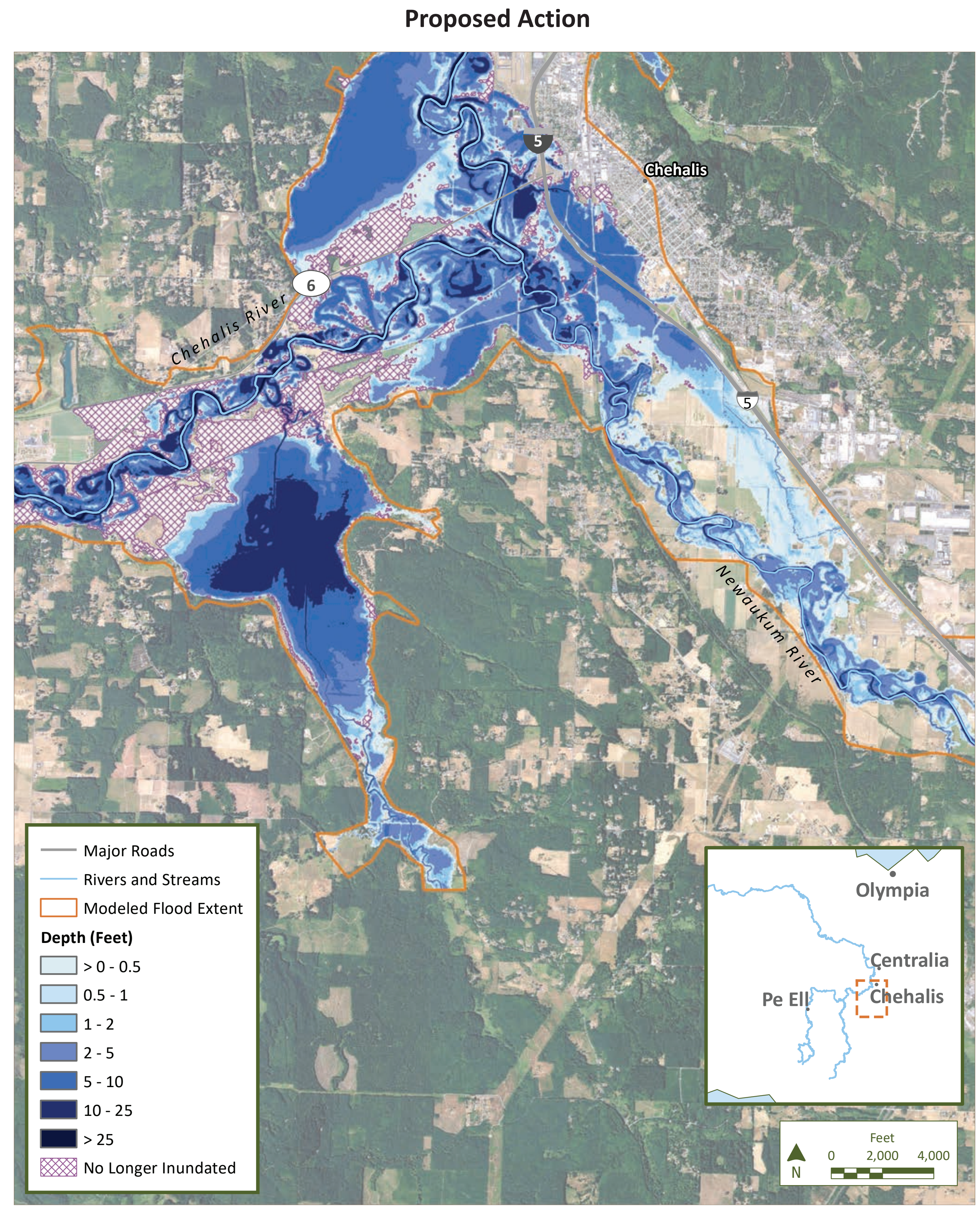


Figure N.2-d
Mid-Century Major Flood

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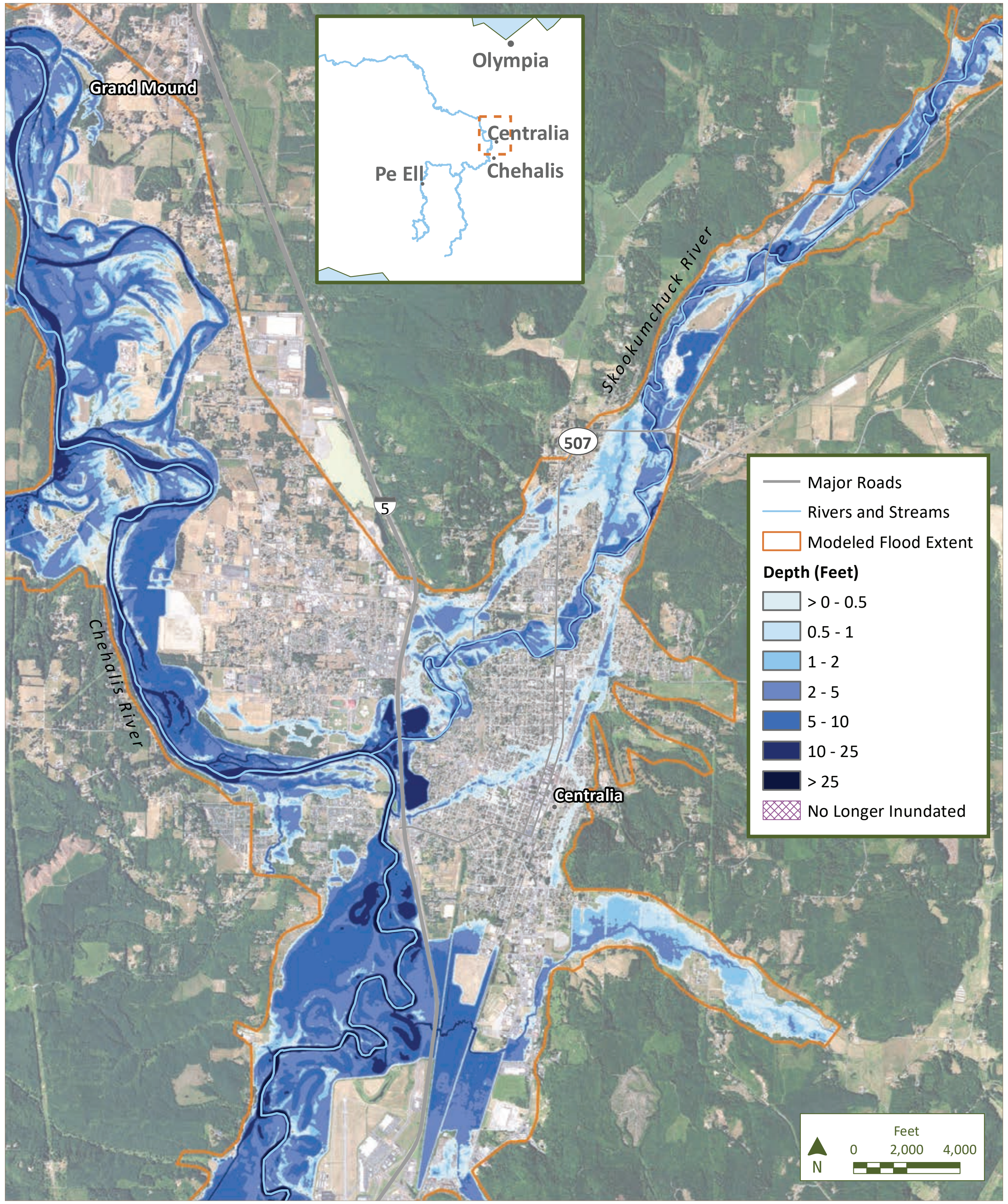

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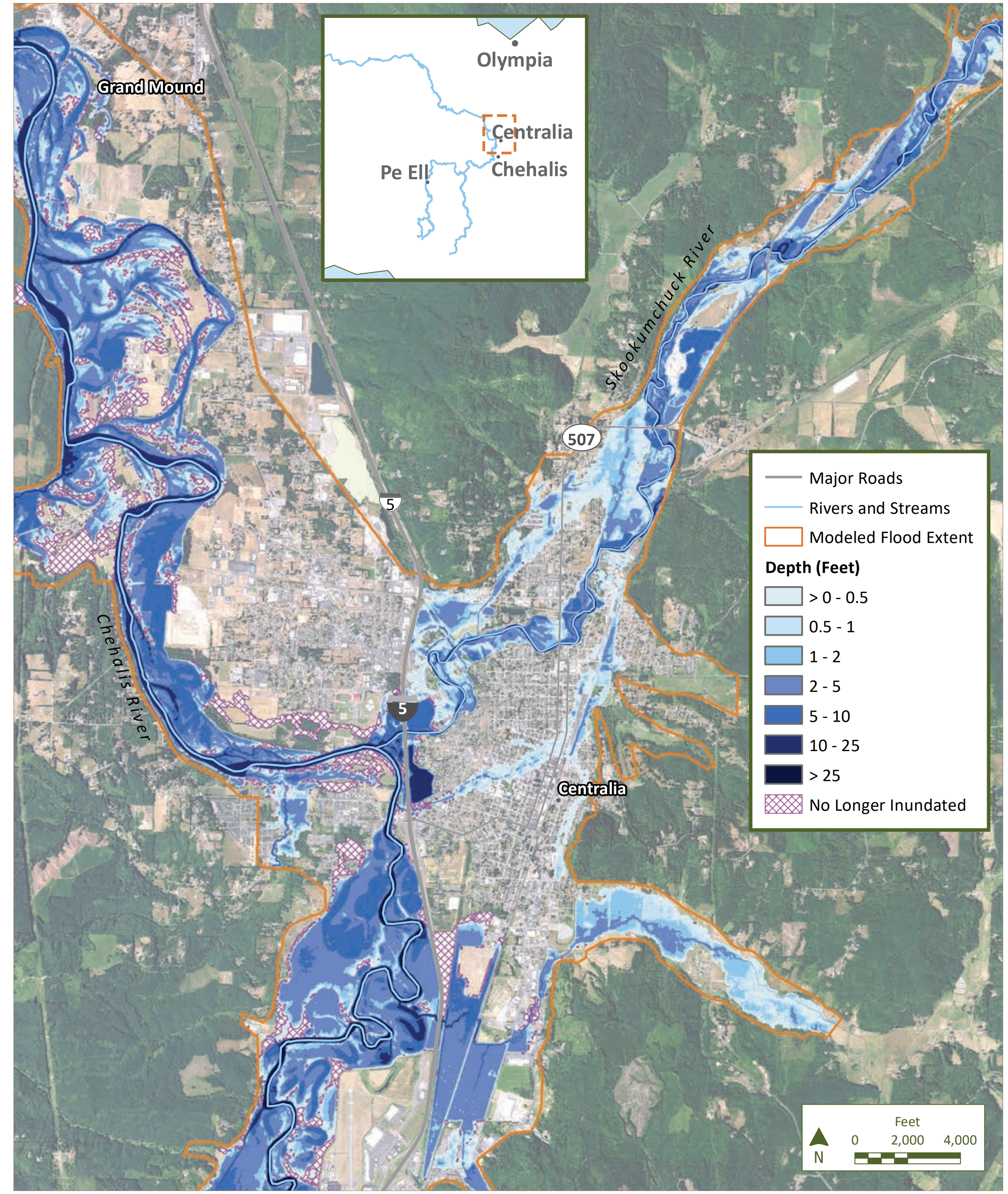
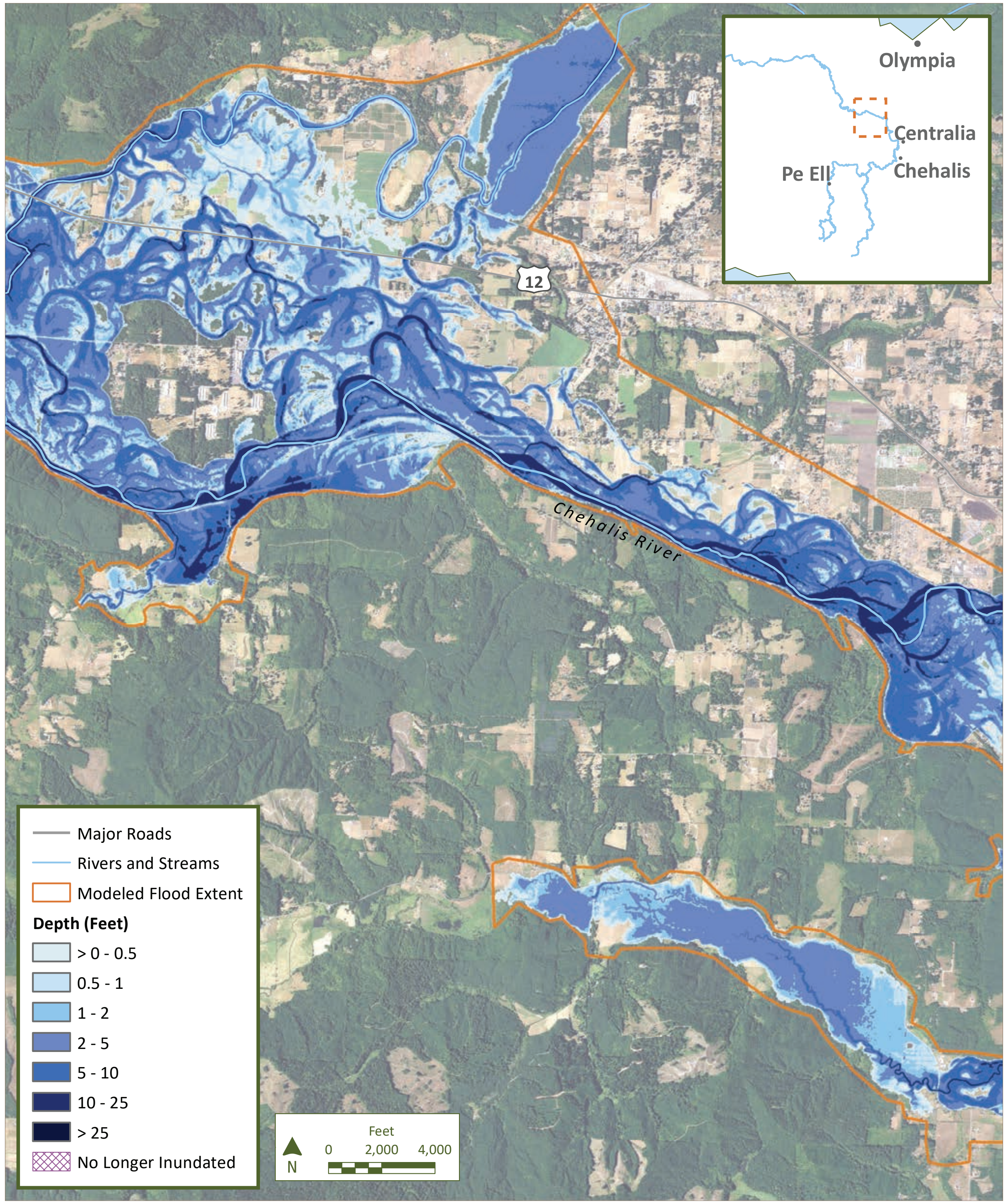


Figure N.2-e
Mid-Century Major Flood

No Action



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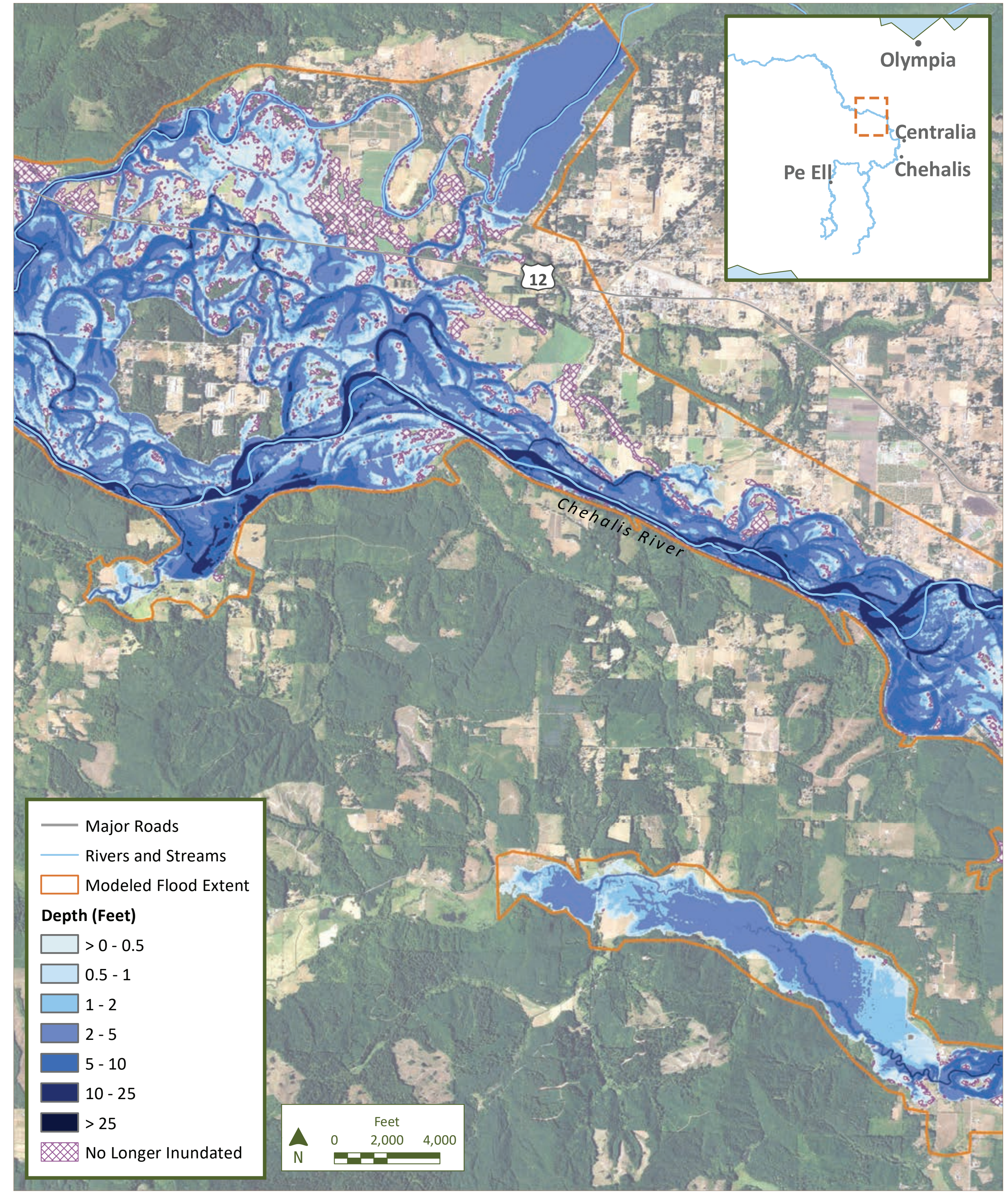


Figure N.2-f
Mid-Century Major Flood

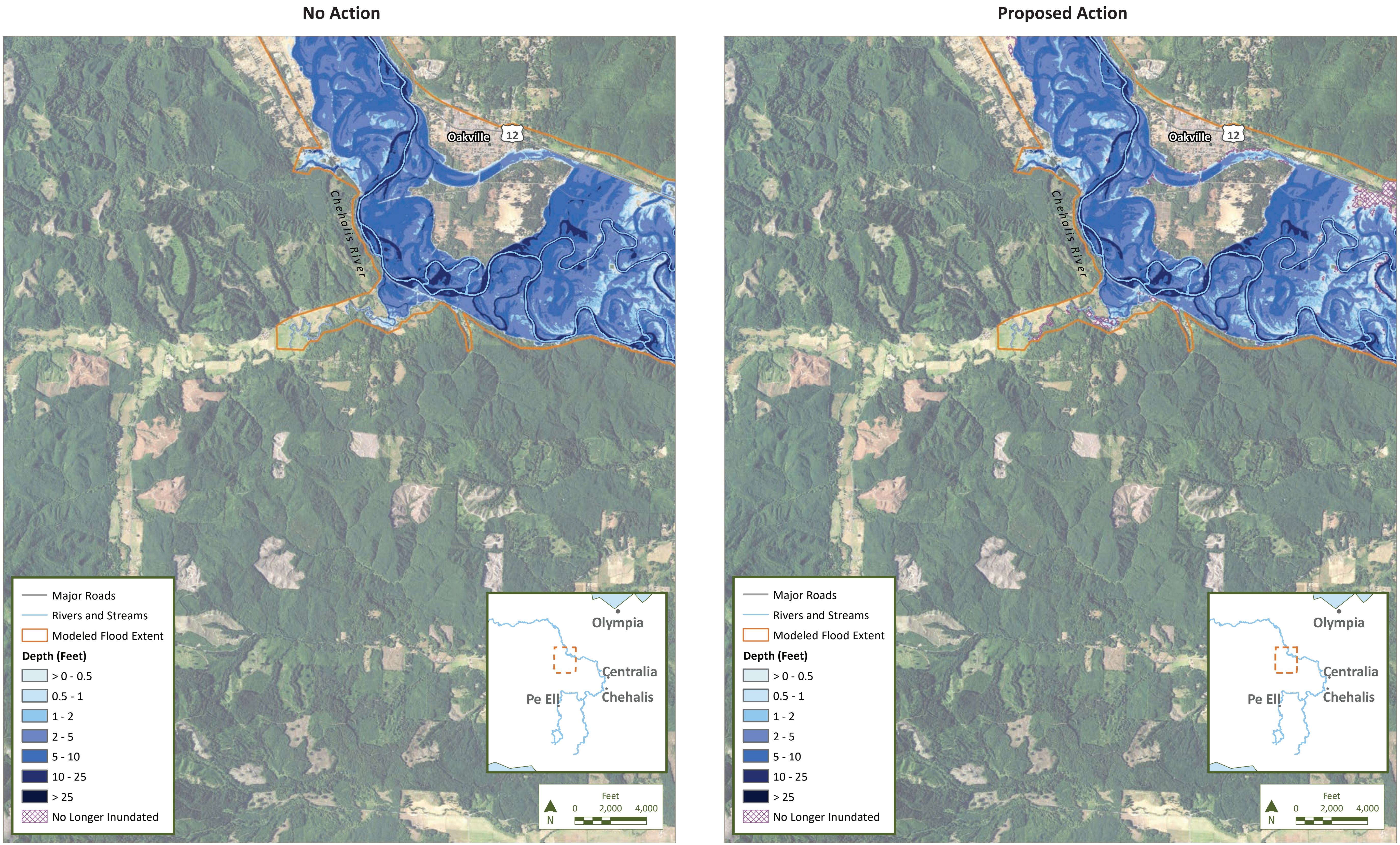
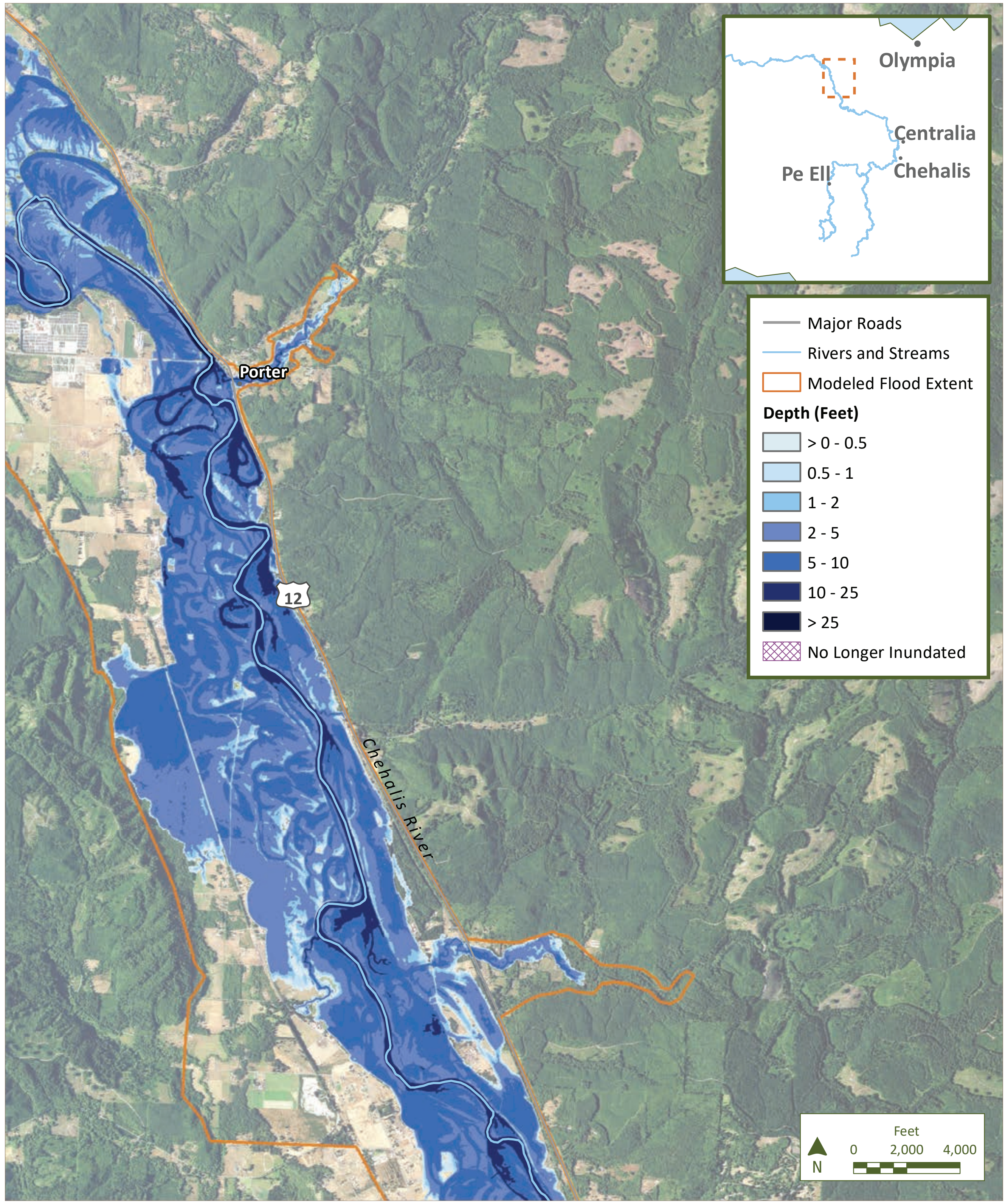


Figure N.2-g
Mid-Century Major Flood

No Action



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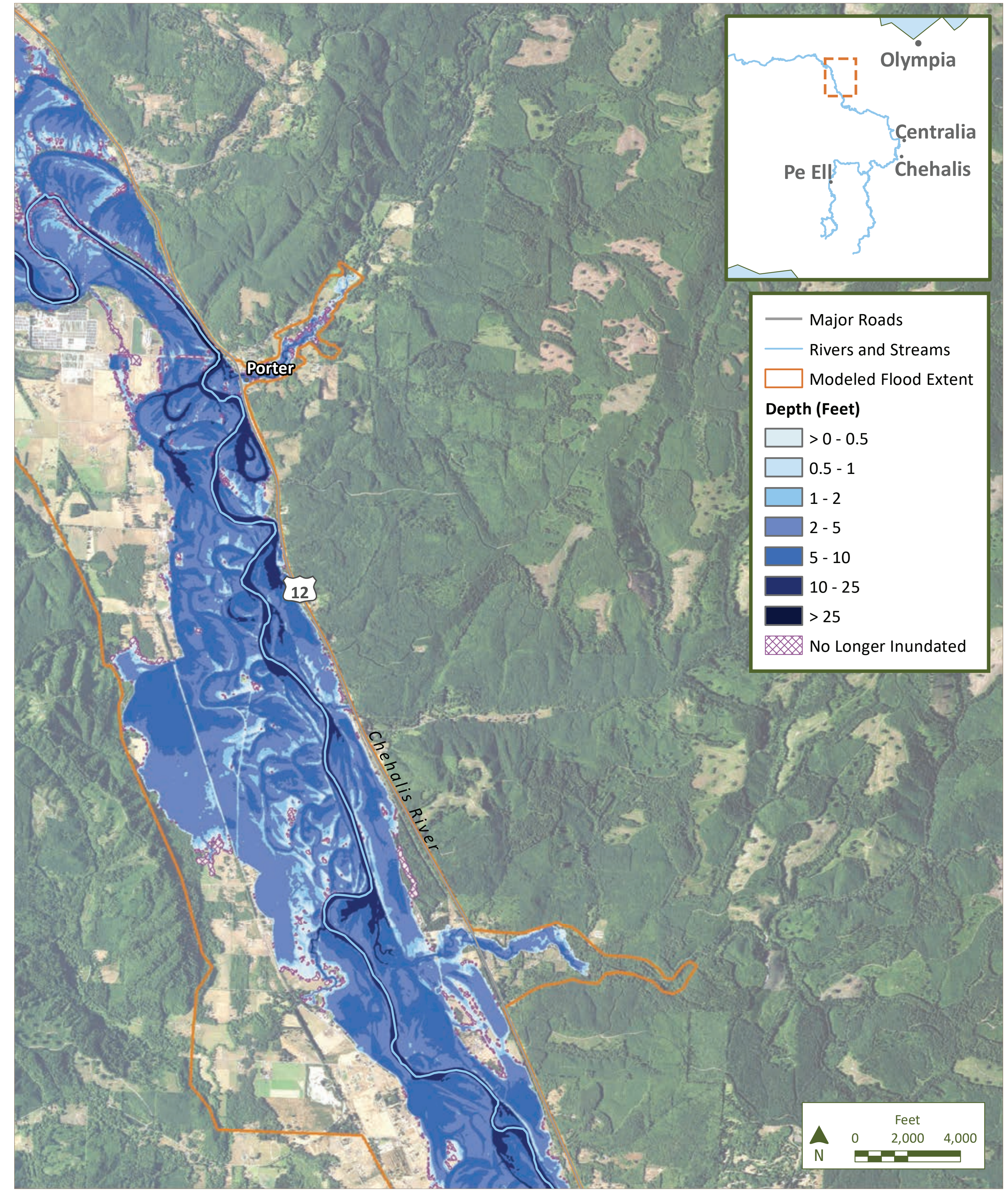
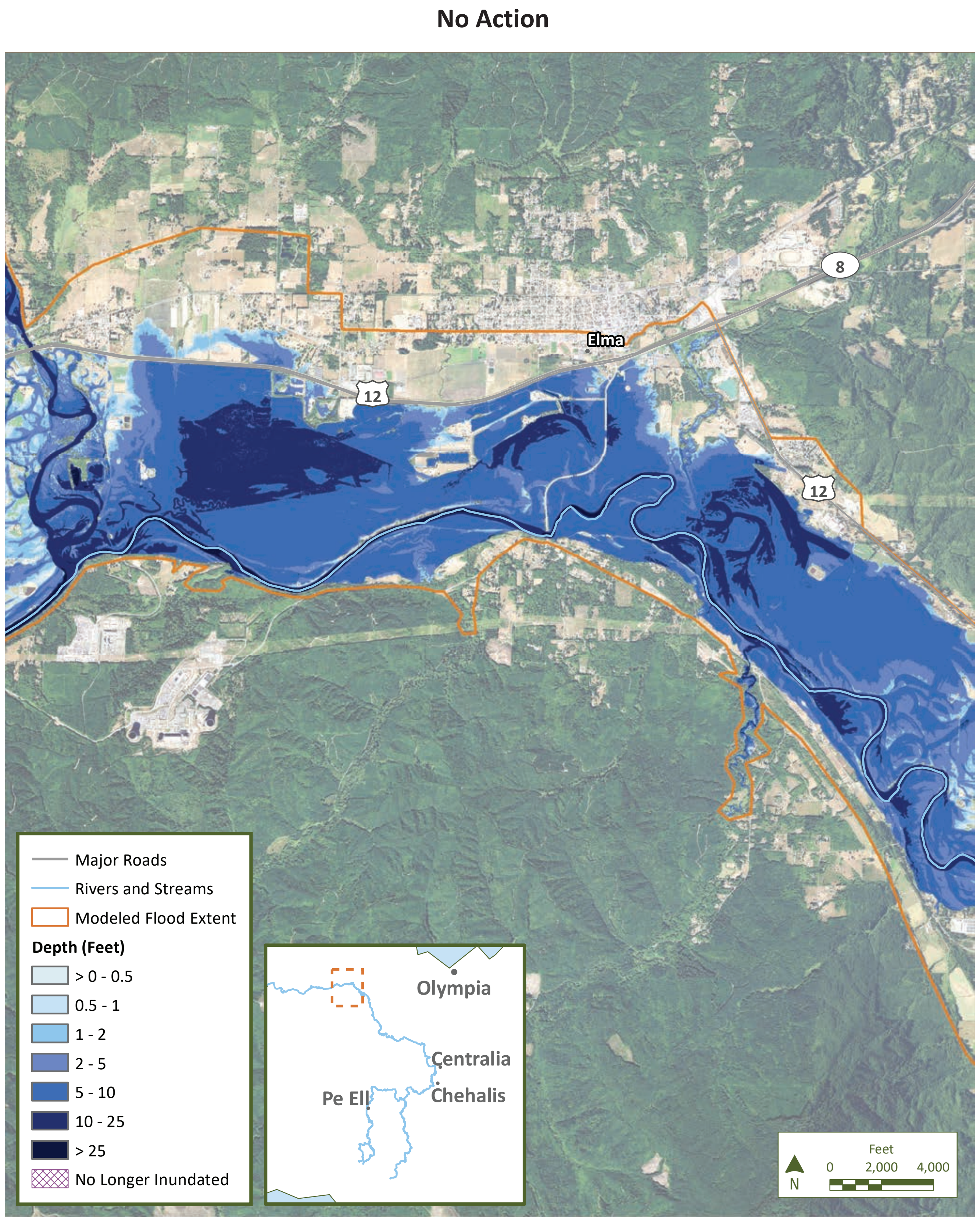


Figure N.2-h
Mid-Century Major Flood



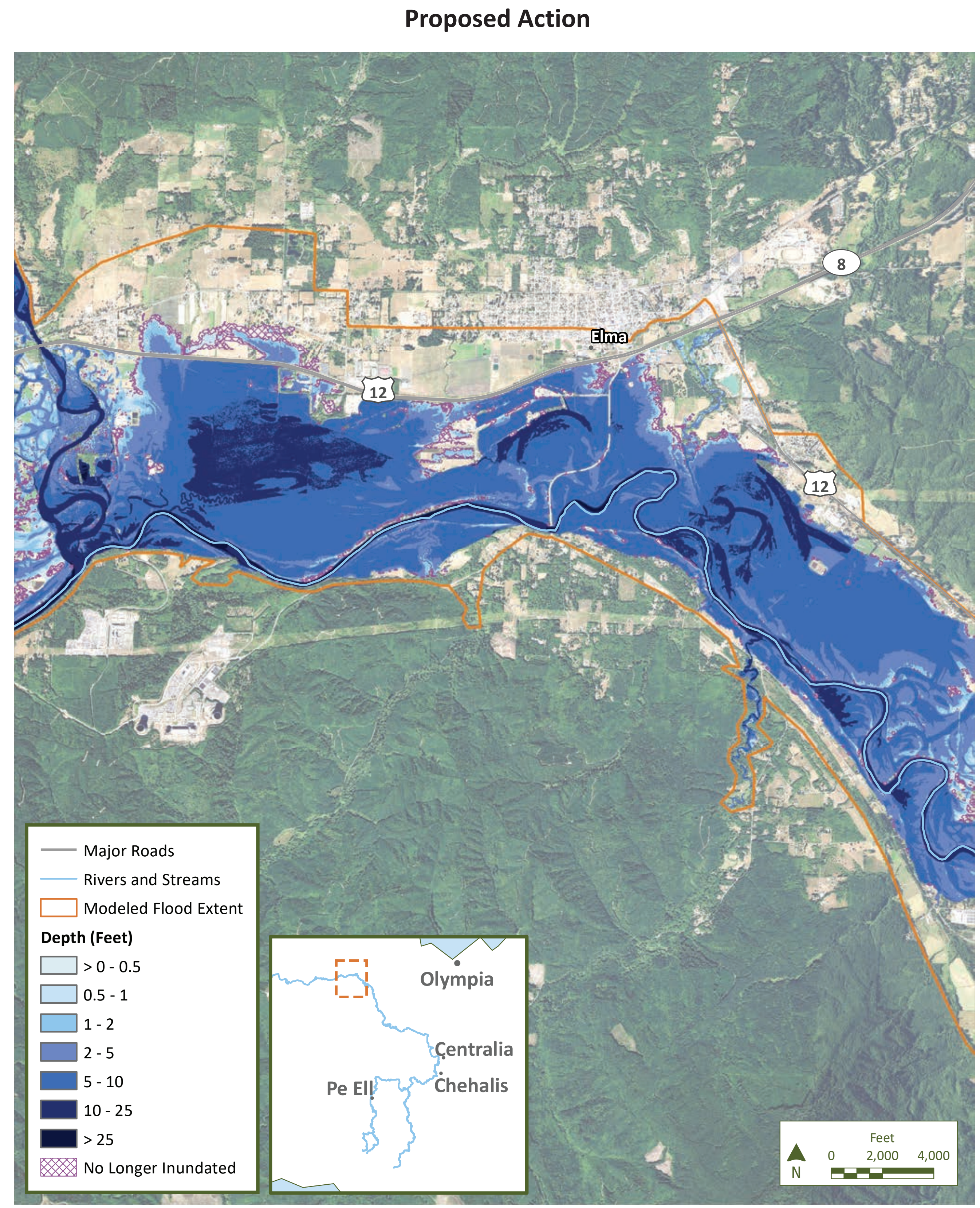
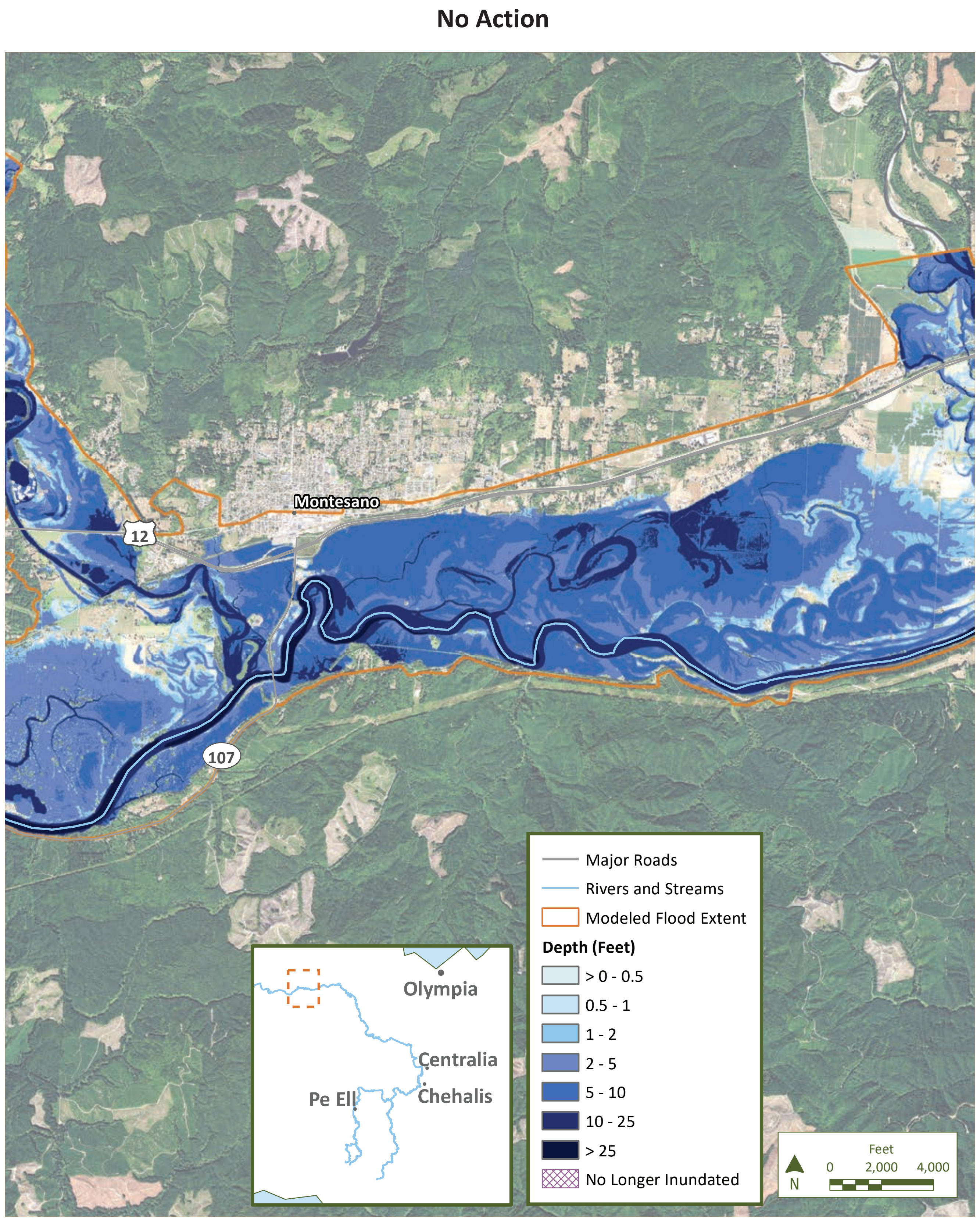


Figure N.2-i
Mid-Century Major Flood



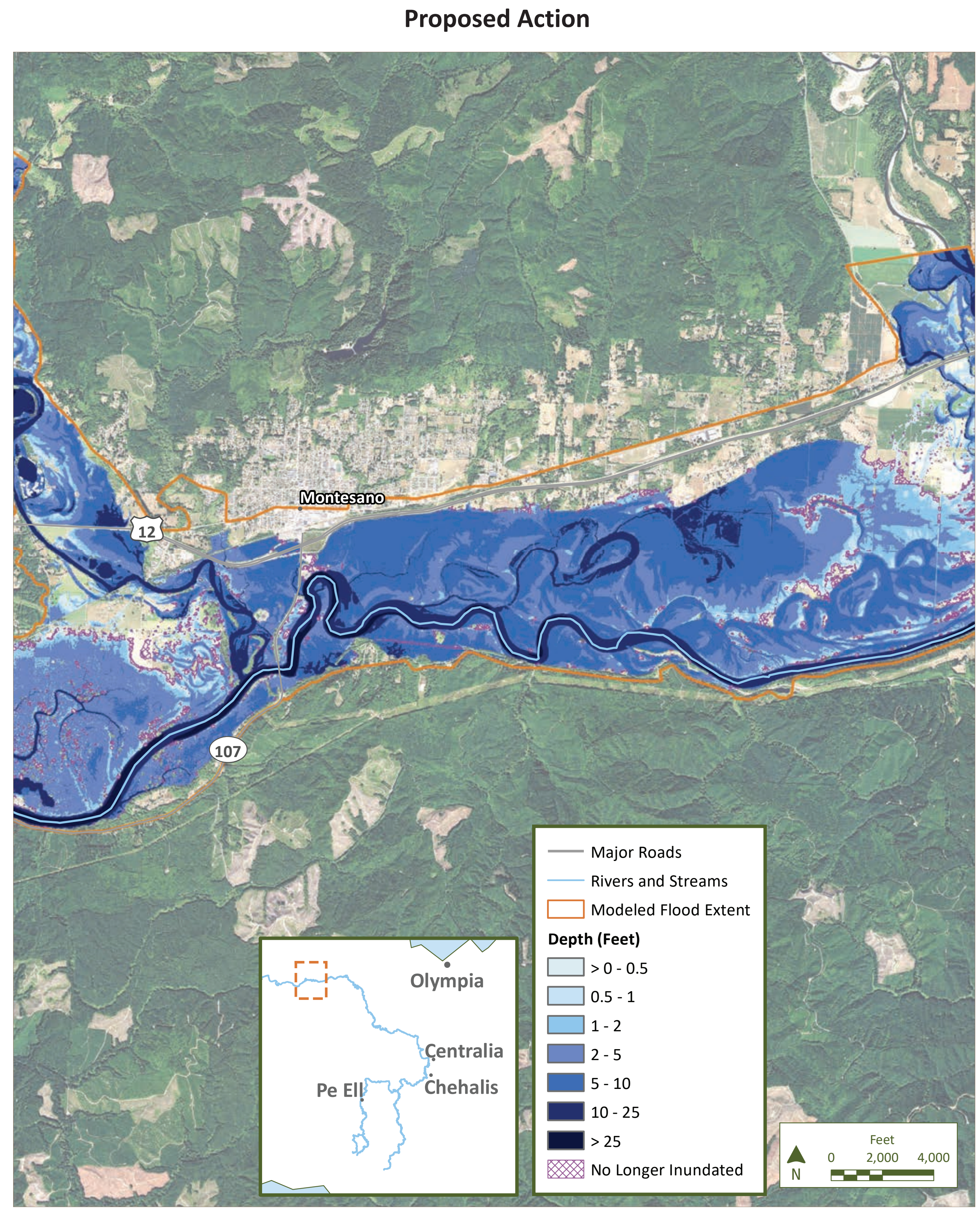
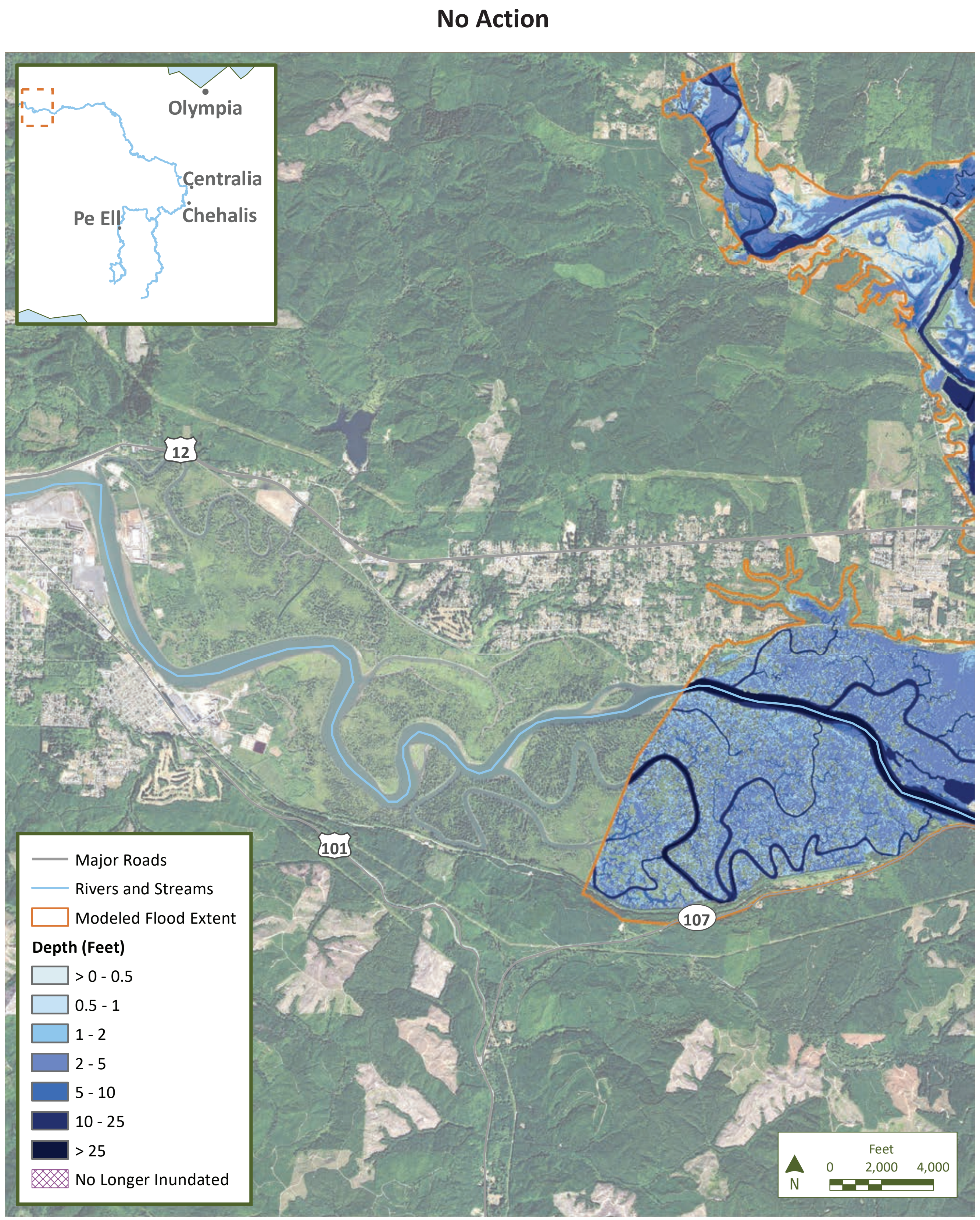


Figure N.2-j
Mid-Century Major Flood



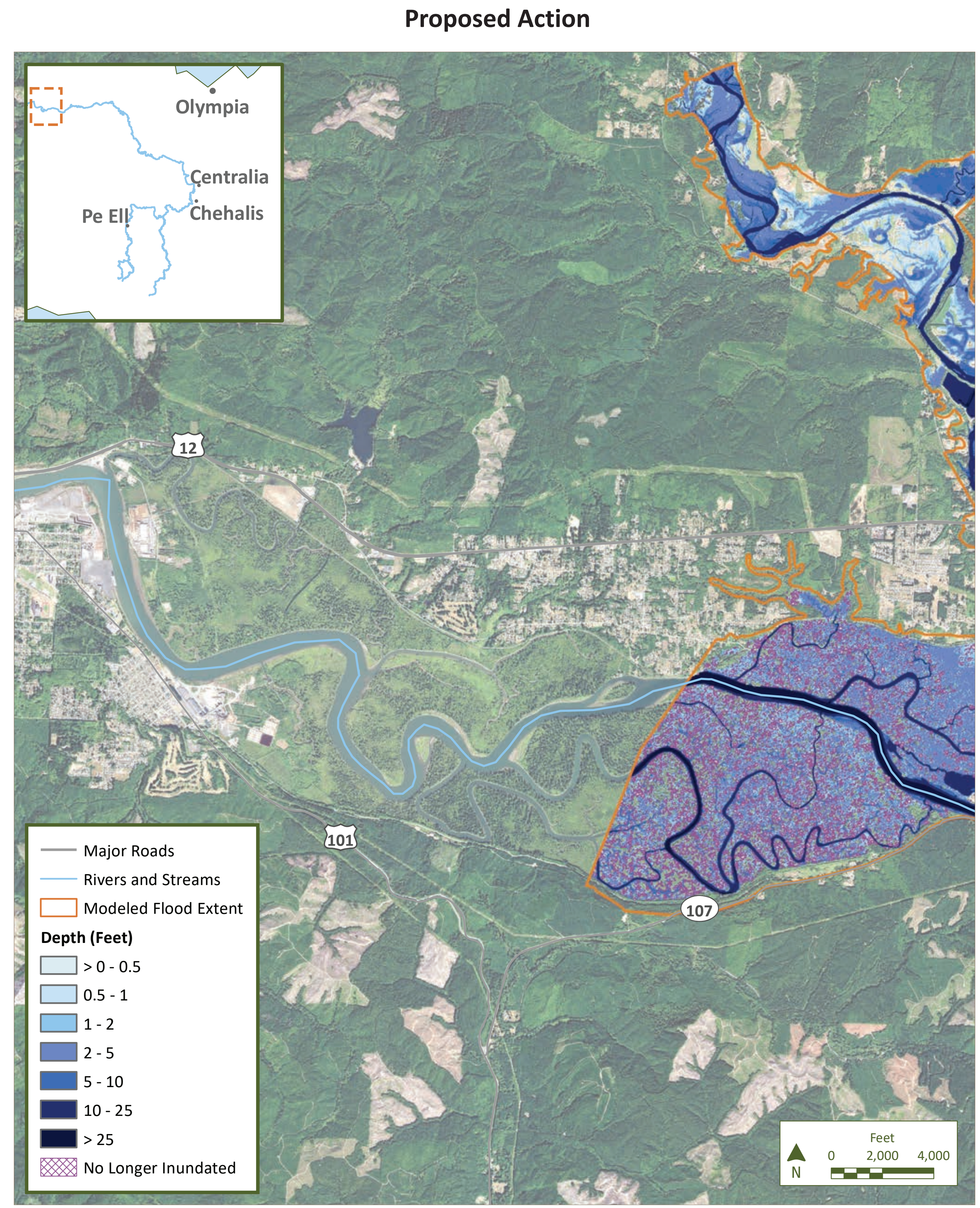
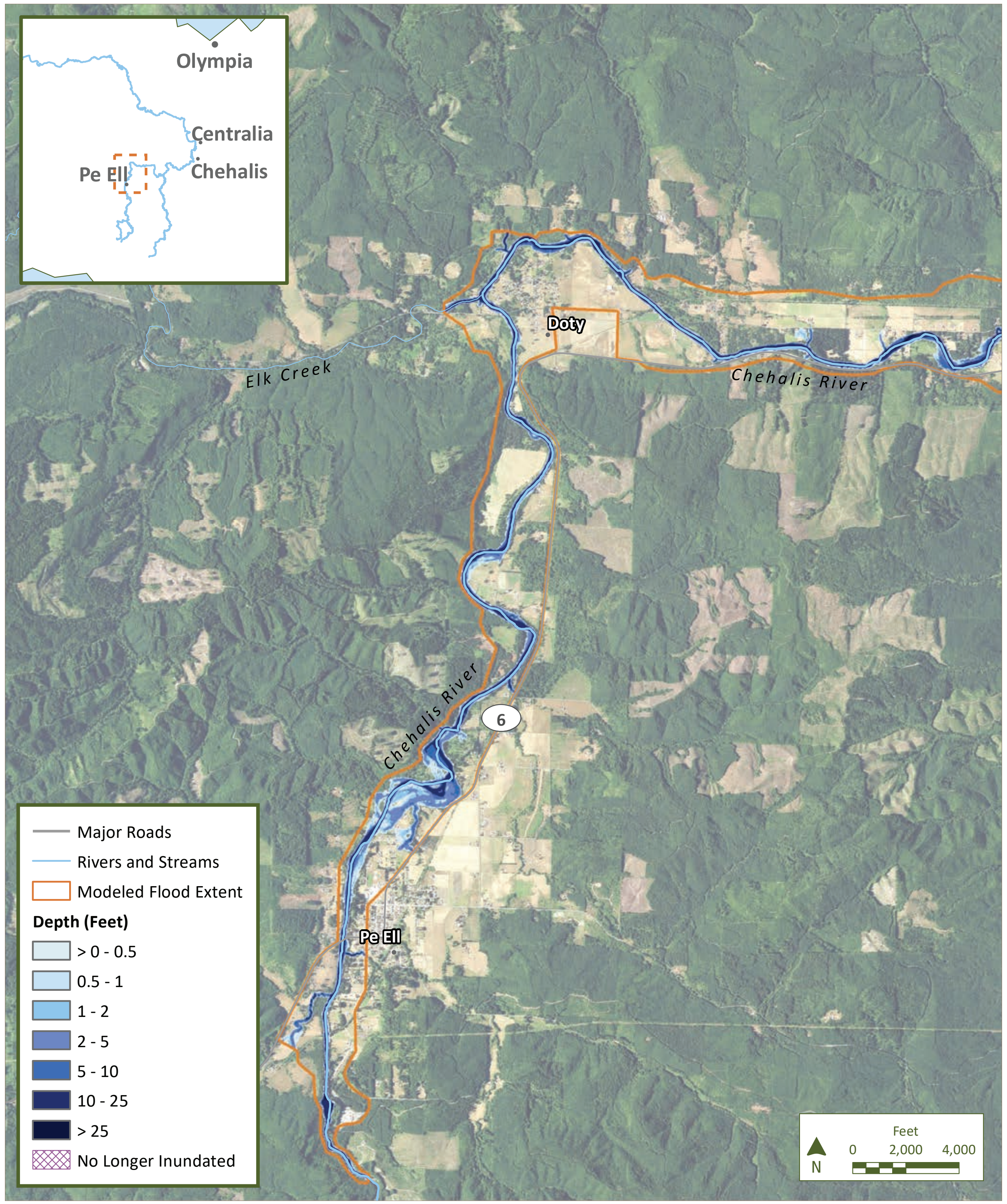


Figure N.3-a
Late-Century Major Flood

No Action



Proposed Action

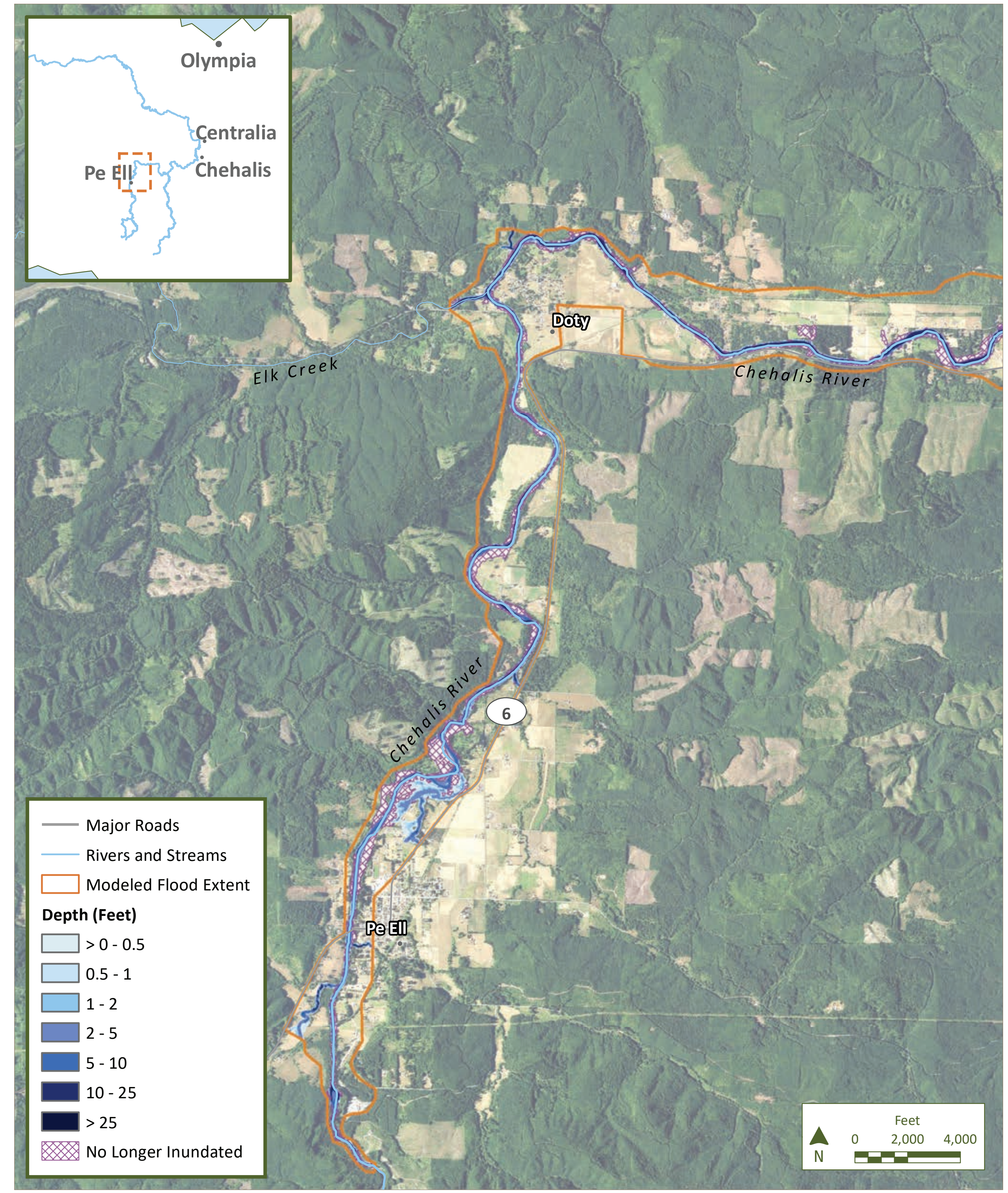
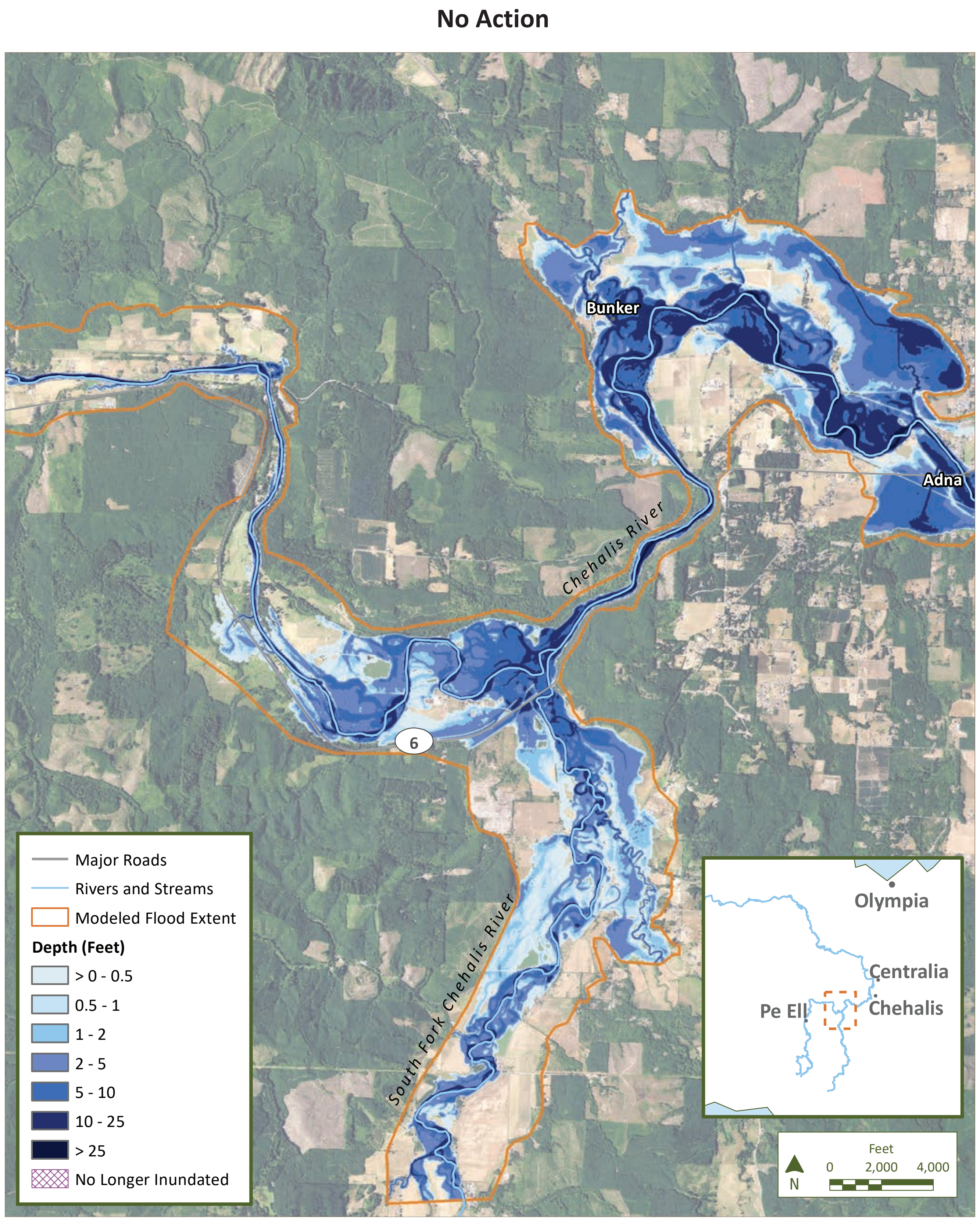


Figure N.3-b
Late-Century Major Flood



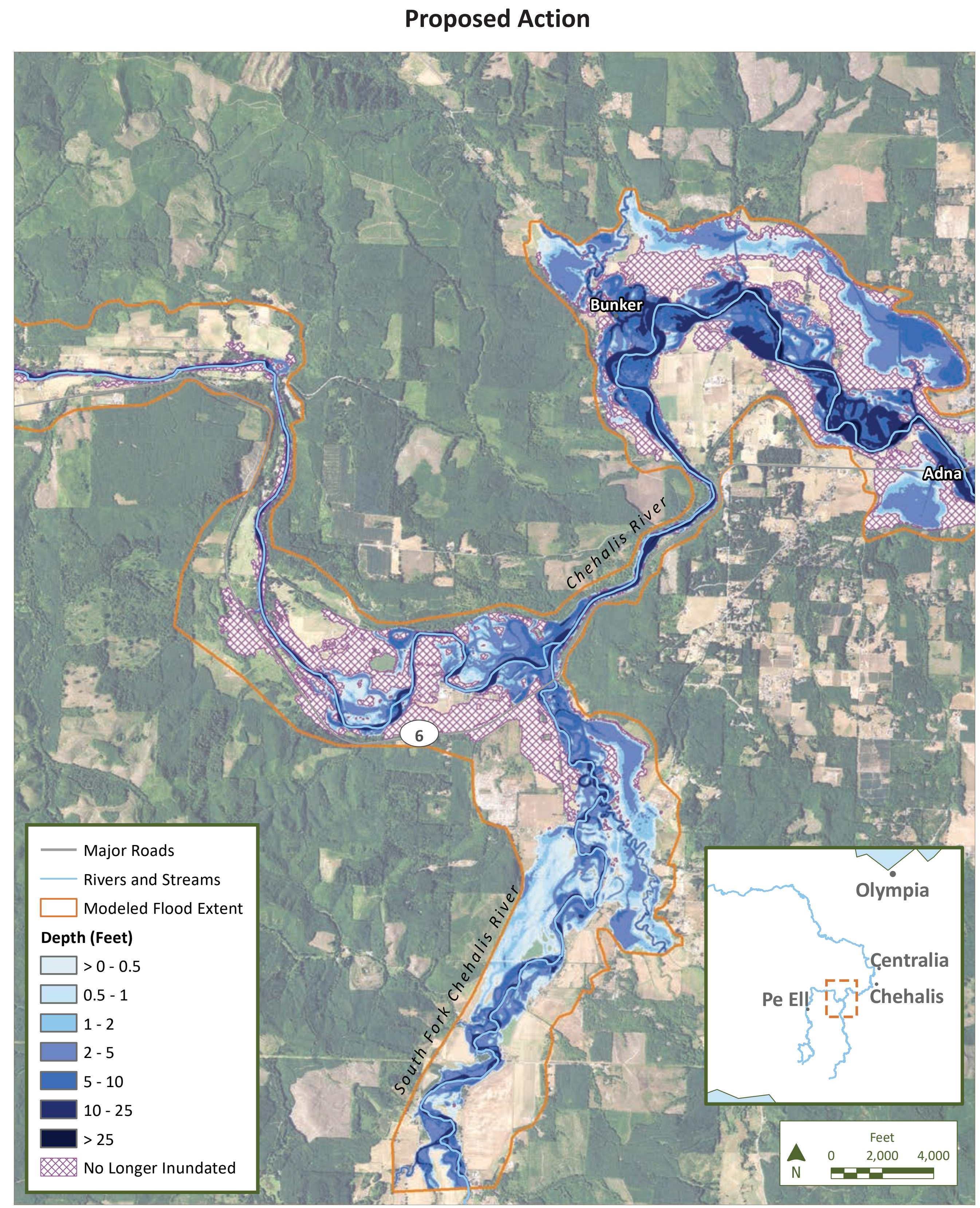


Figure N.3-c
Late-Century Major Flood

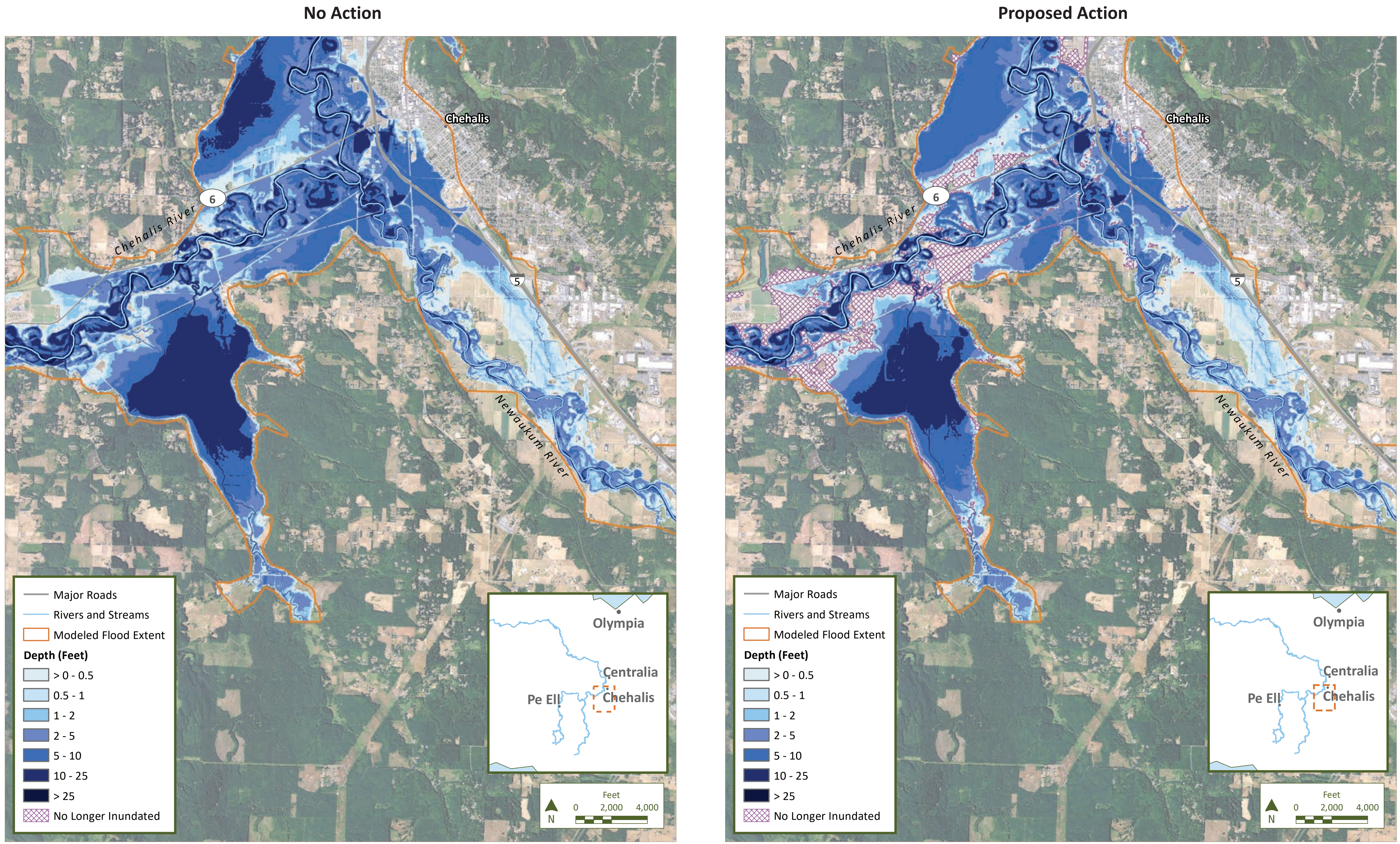
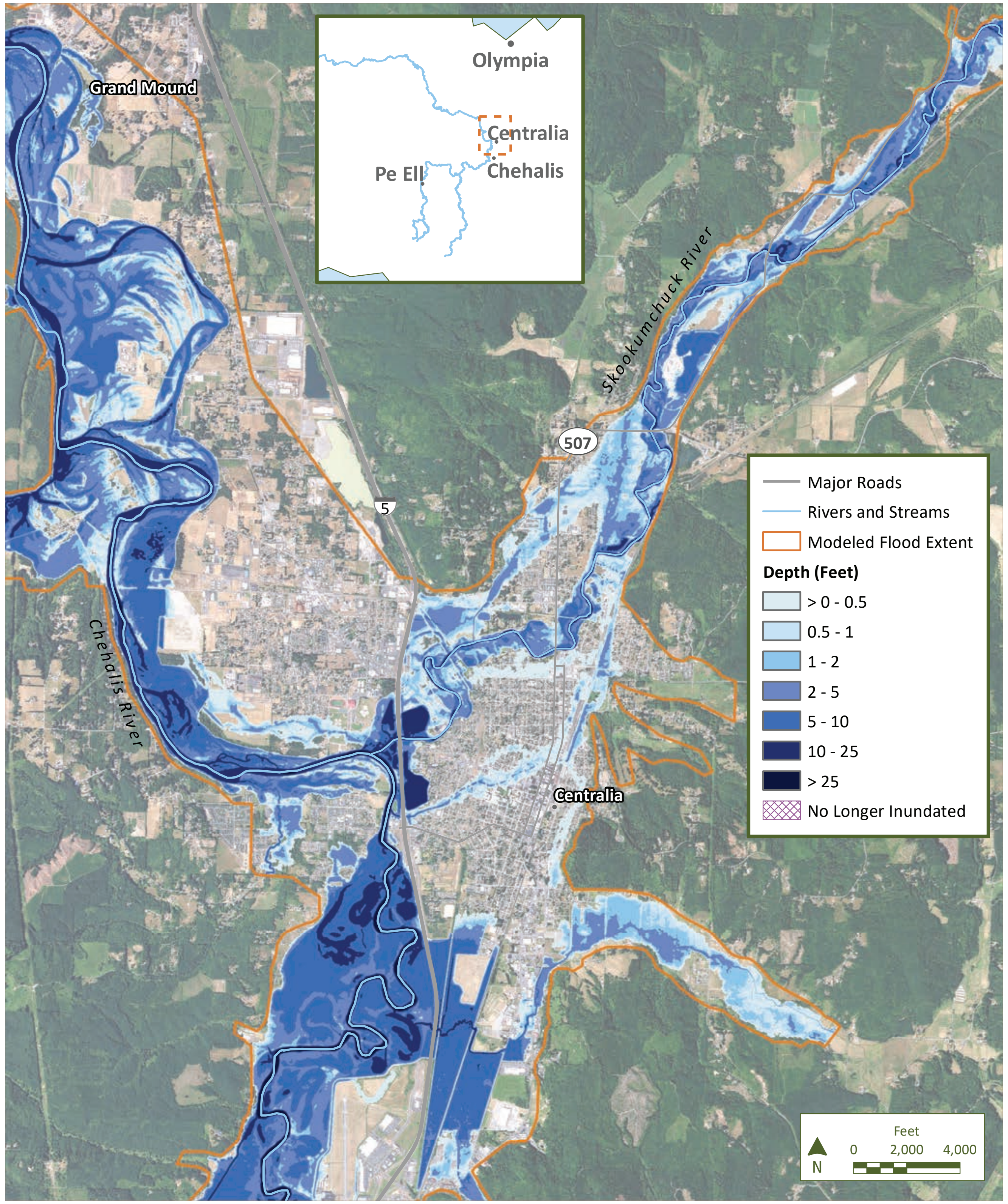


Figure N.3-d
Late-Century Major Flood

No Action



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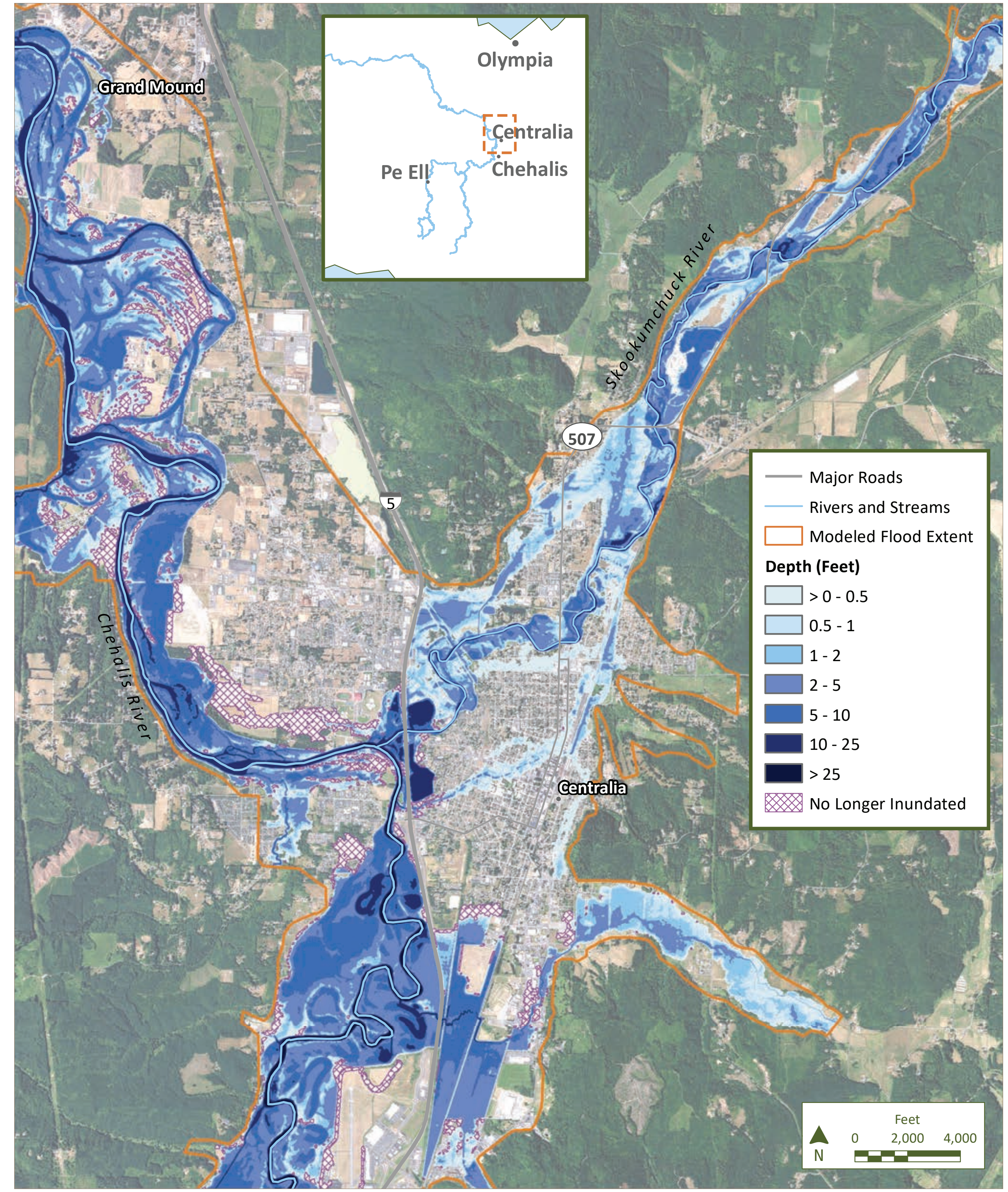
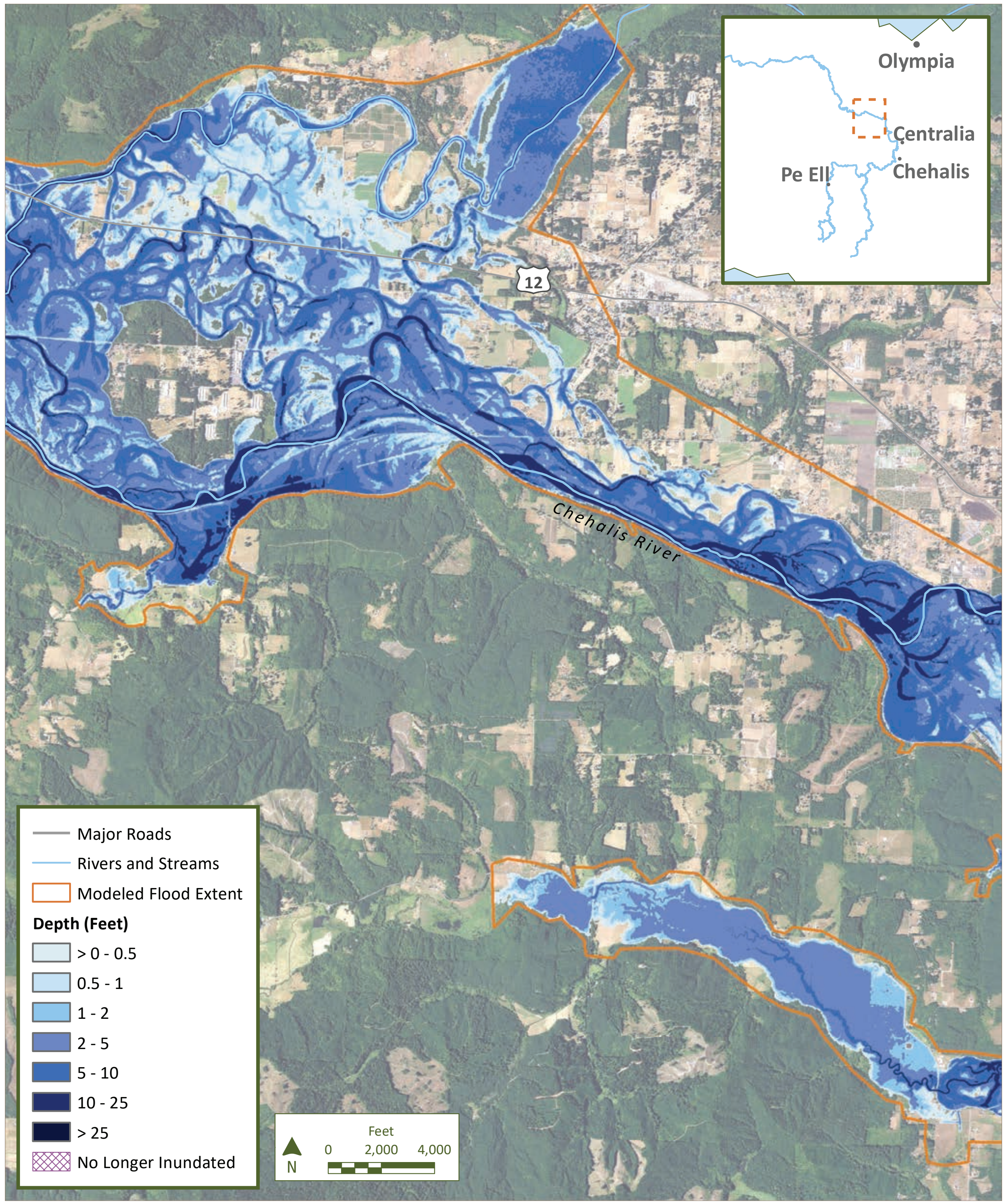


Figure N.3-e
Late-Century Major Flood

No Action



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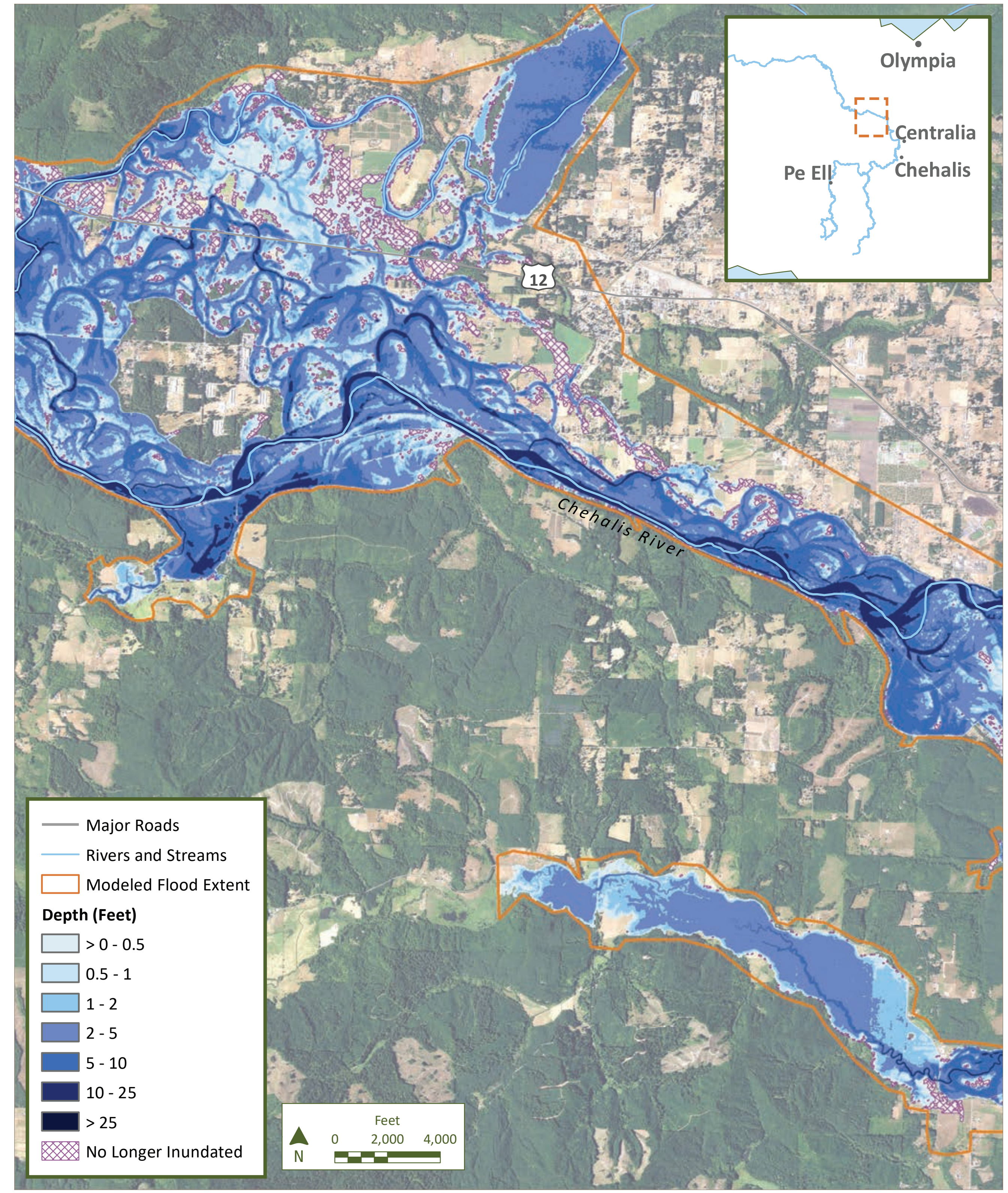

Figure N.3-f
Late-Century Major Flood

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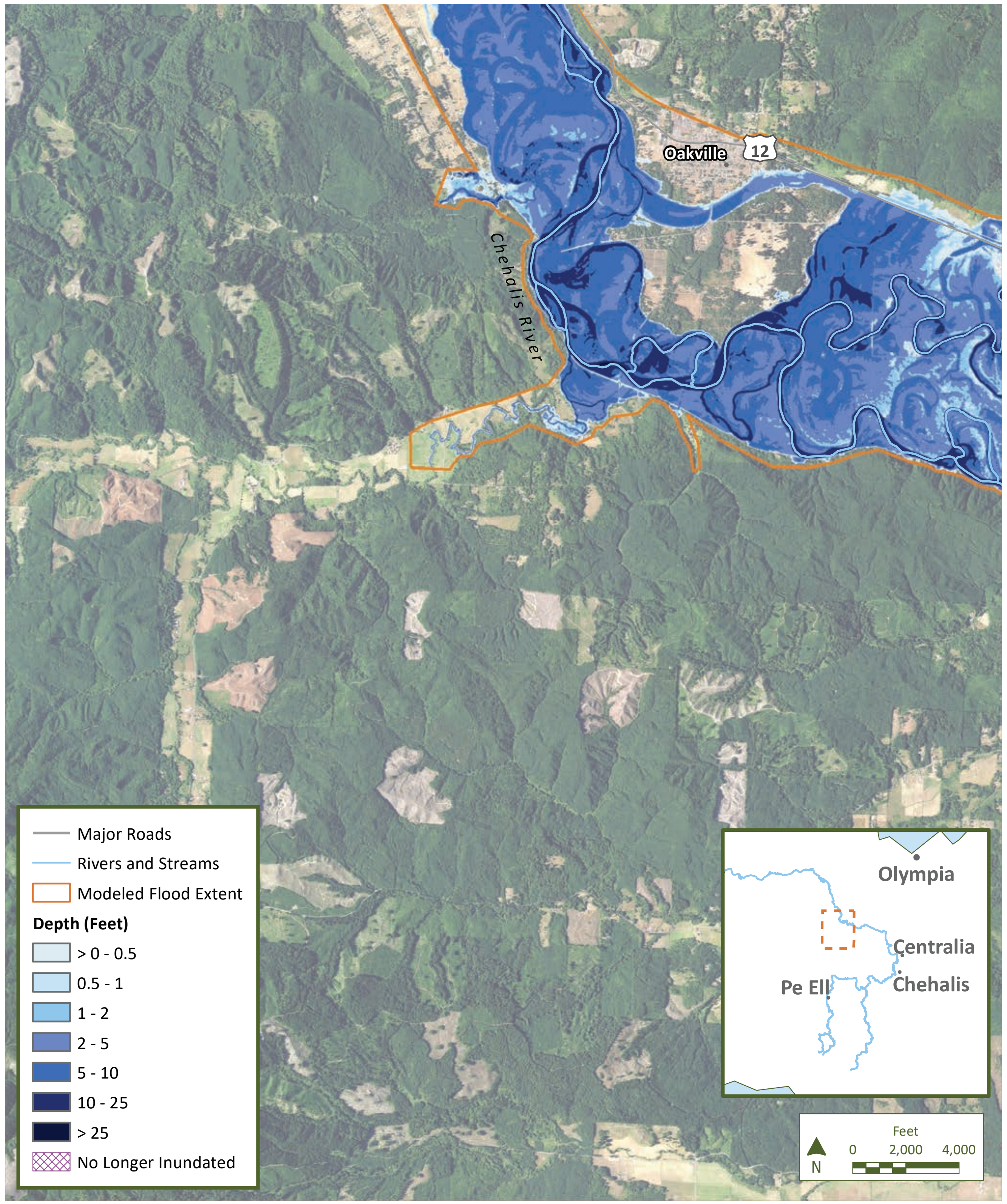

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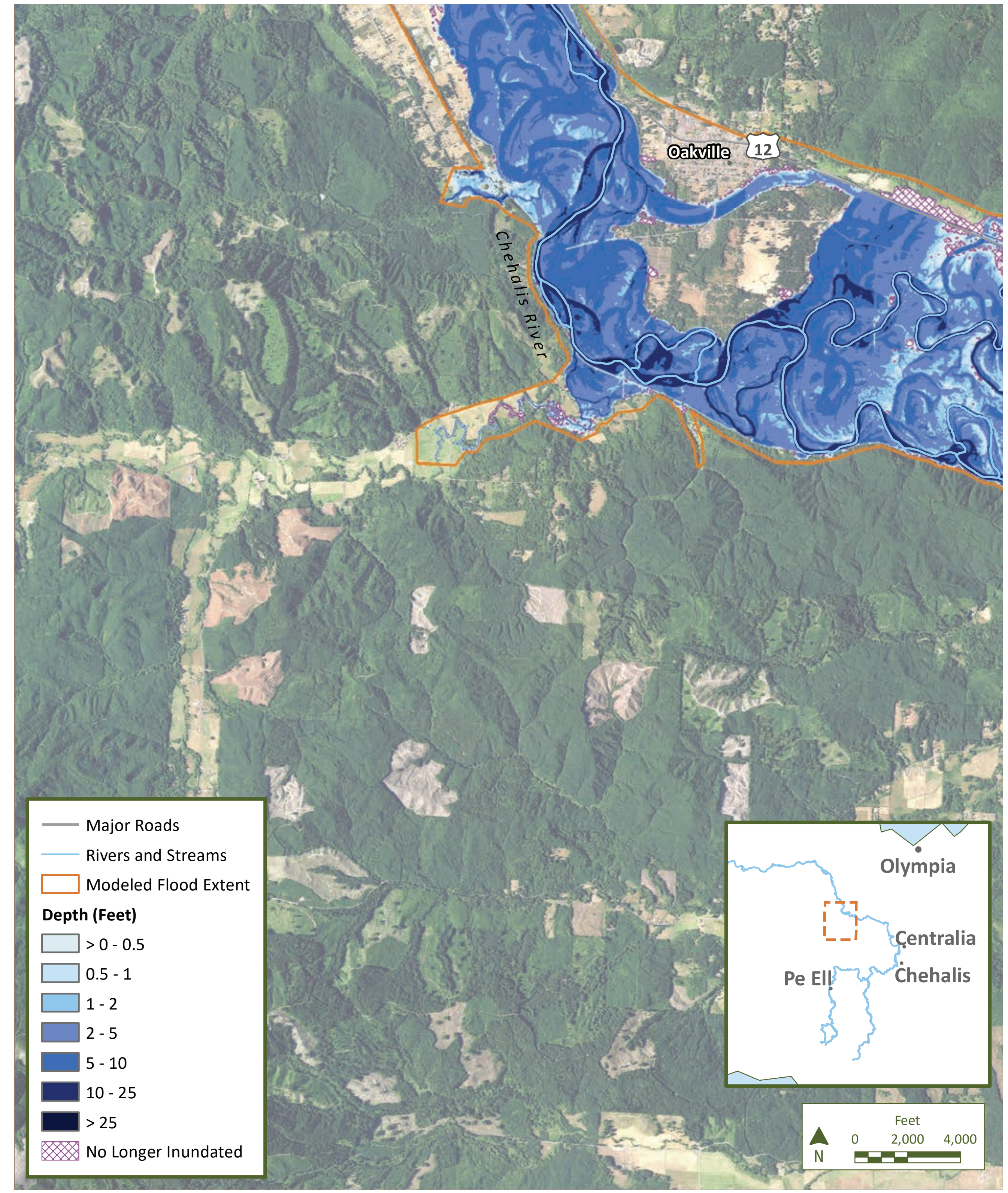

Figure N.3-g
Late-Century Major Flood

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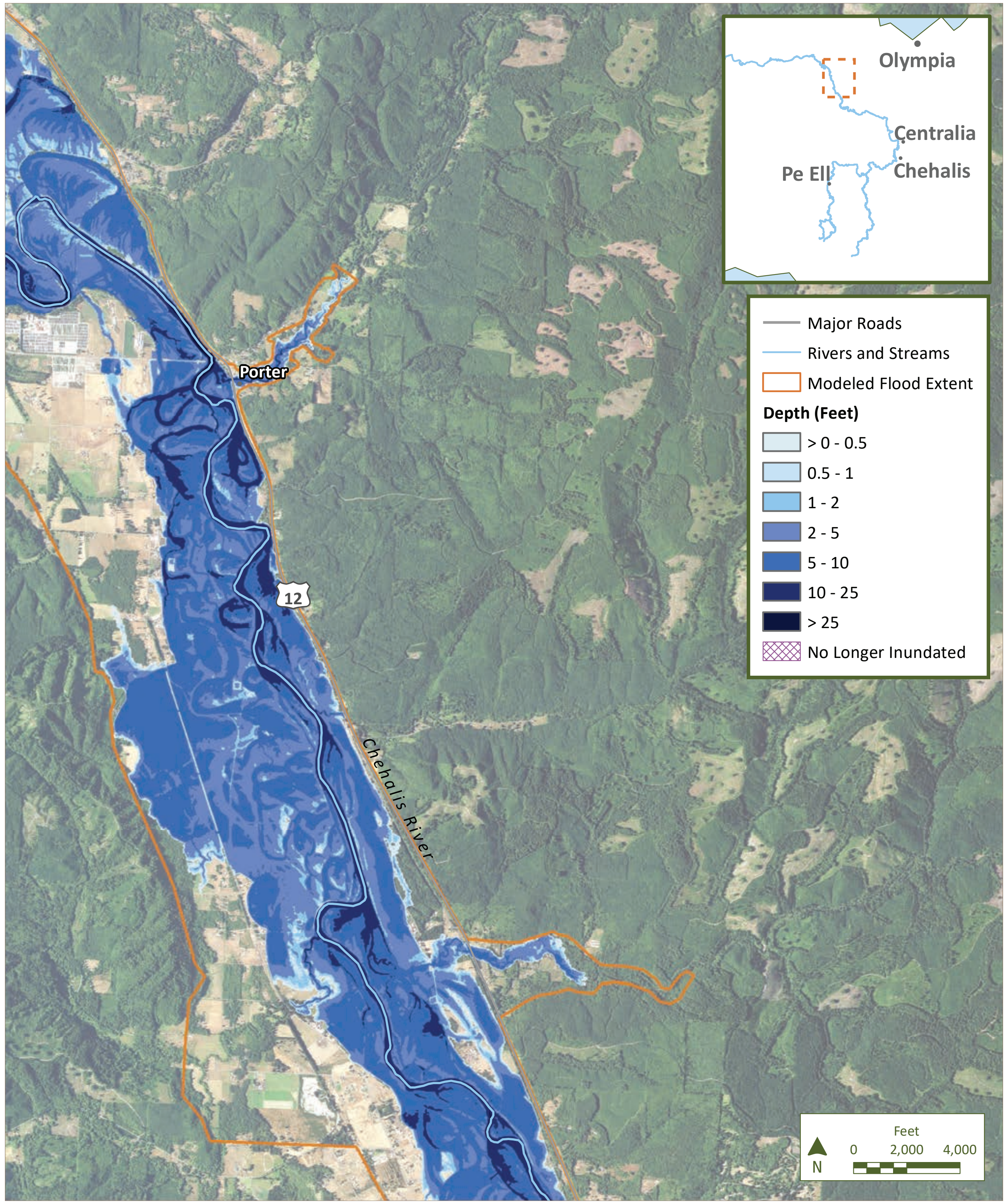

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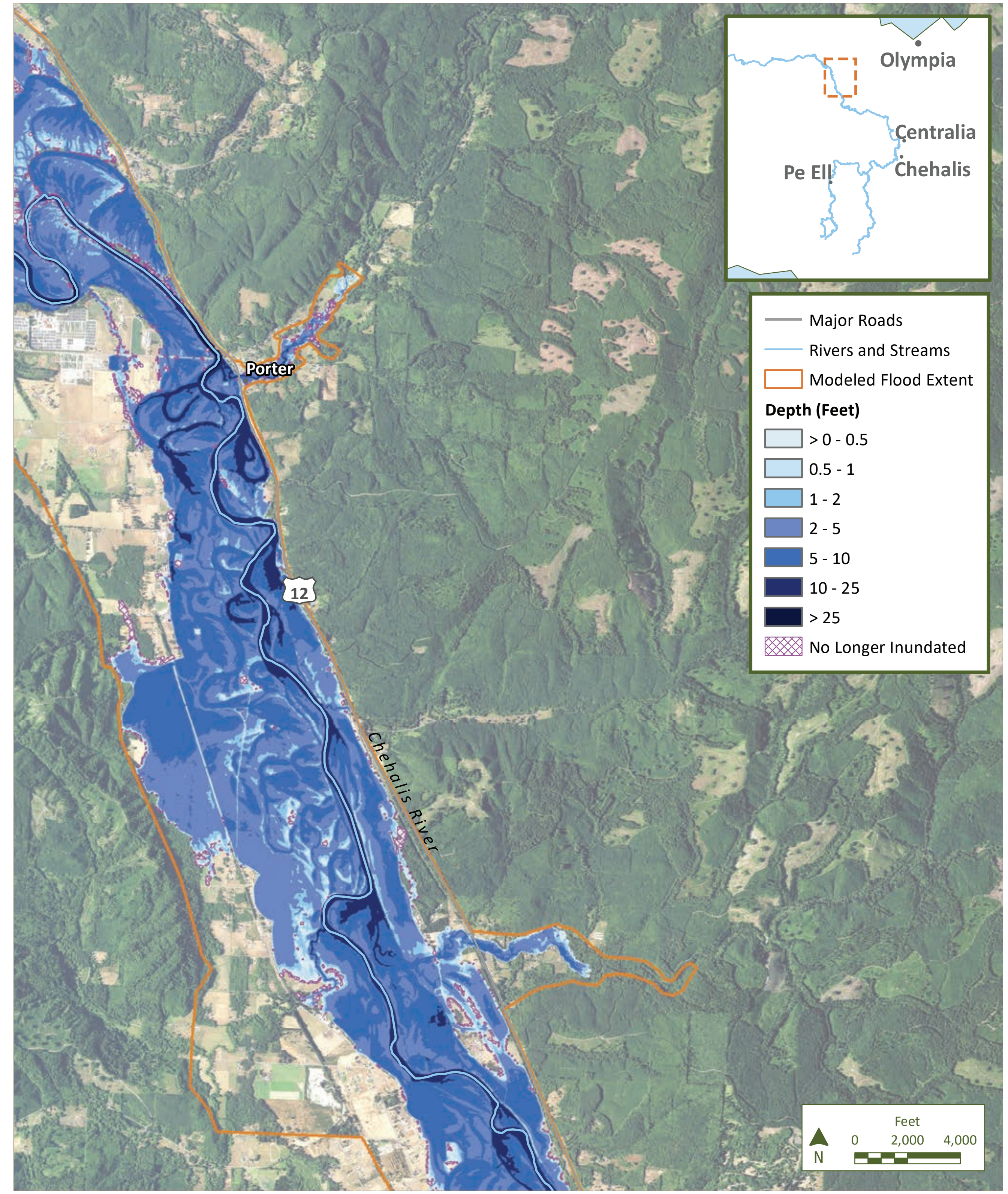

Figure N.3-h
Late-Century Major Flood

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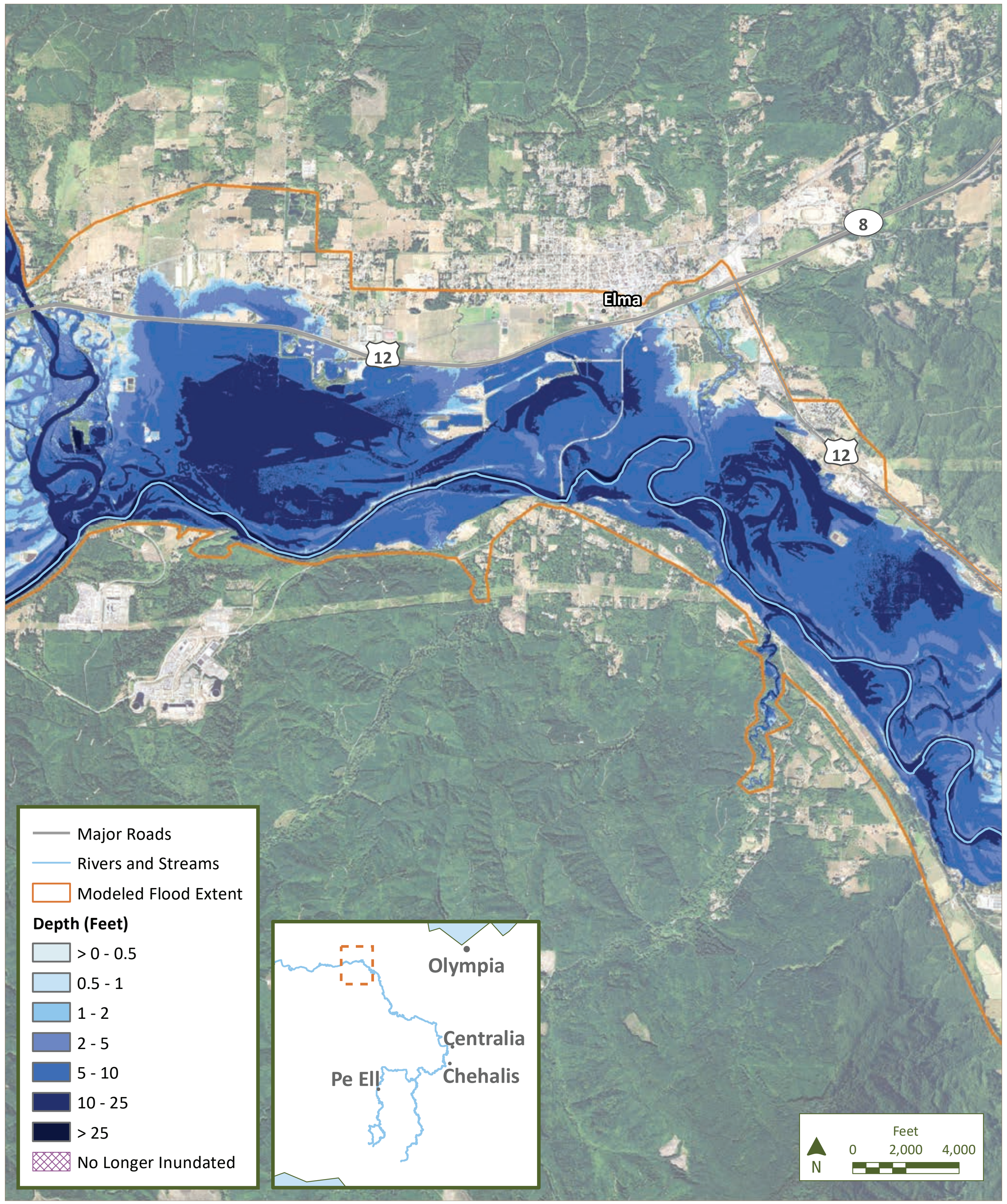

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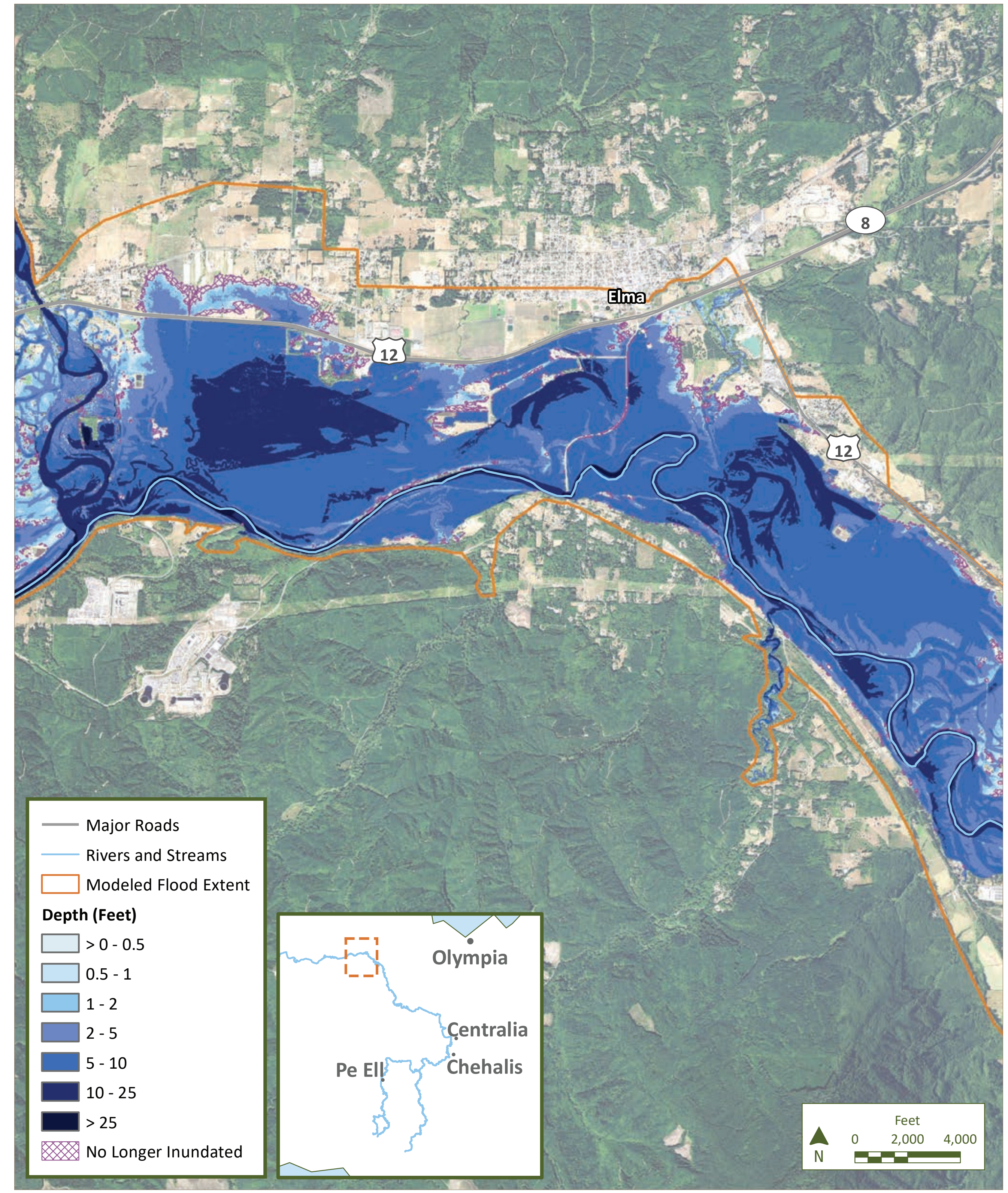
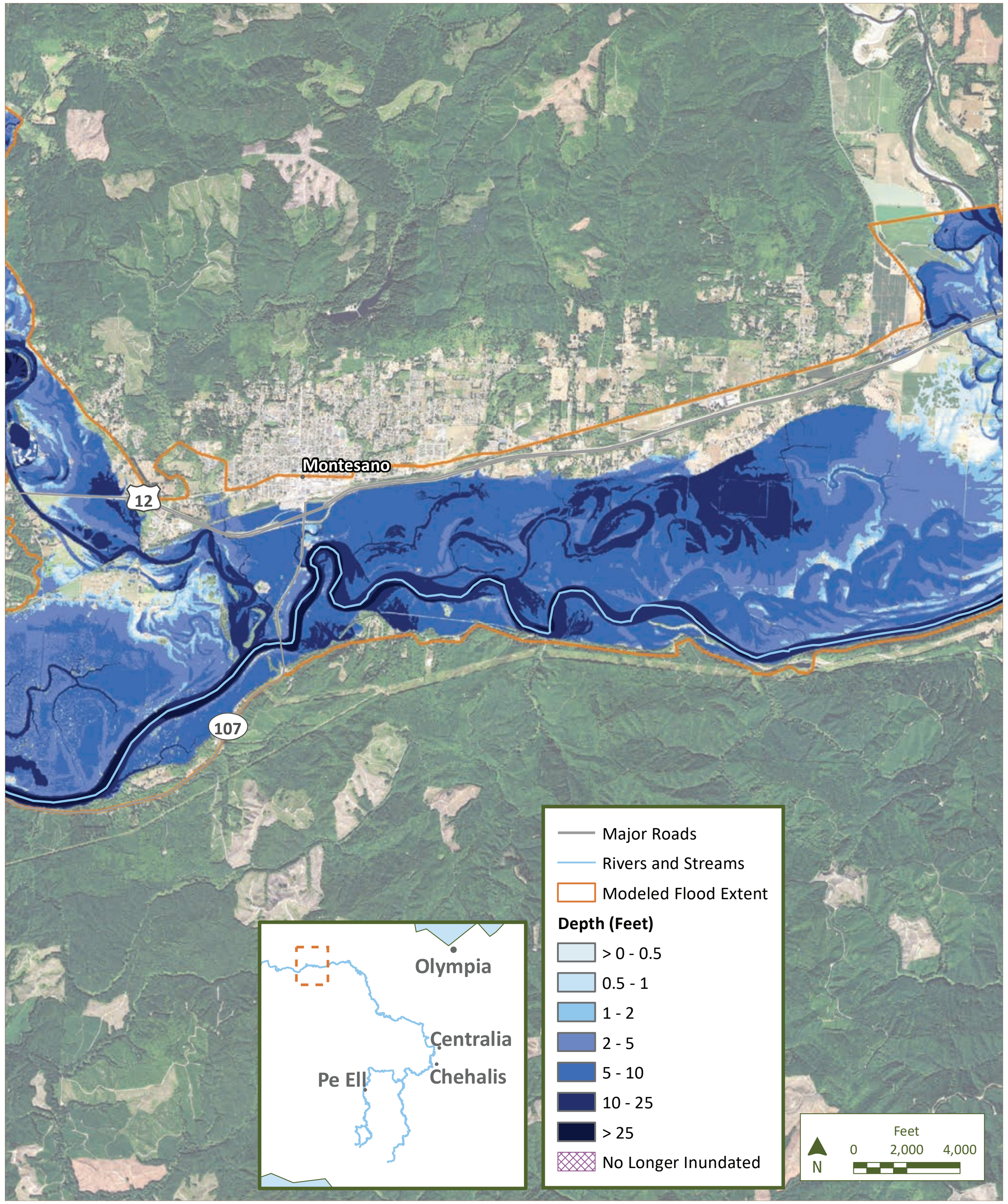


Figure N.3-i
Late-Century Major Flood

No Action



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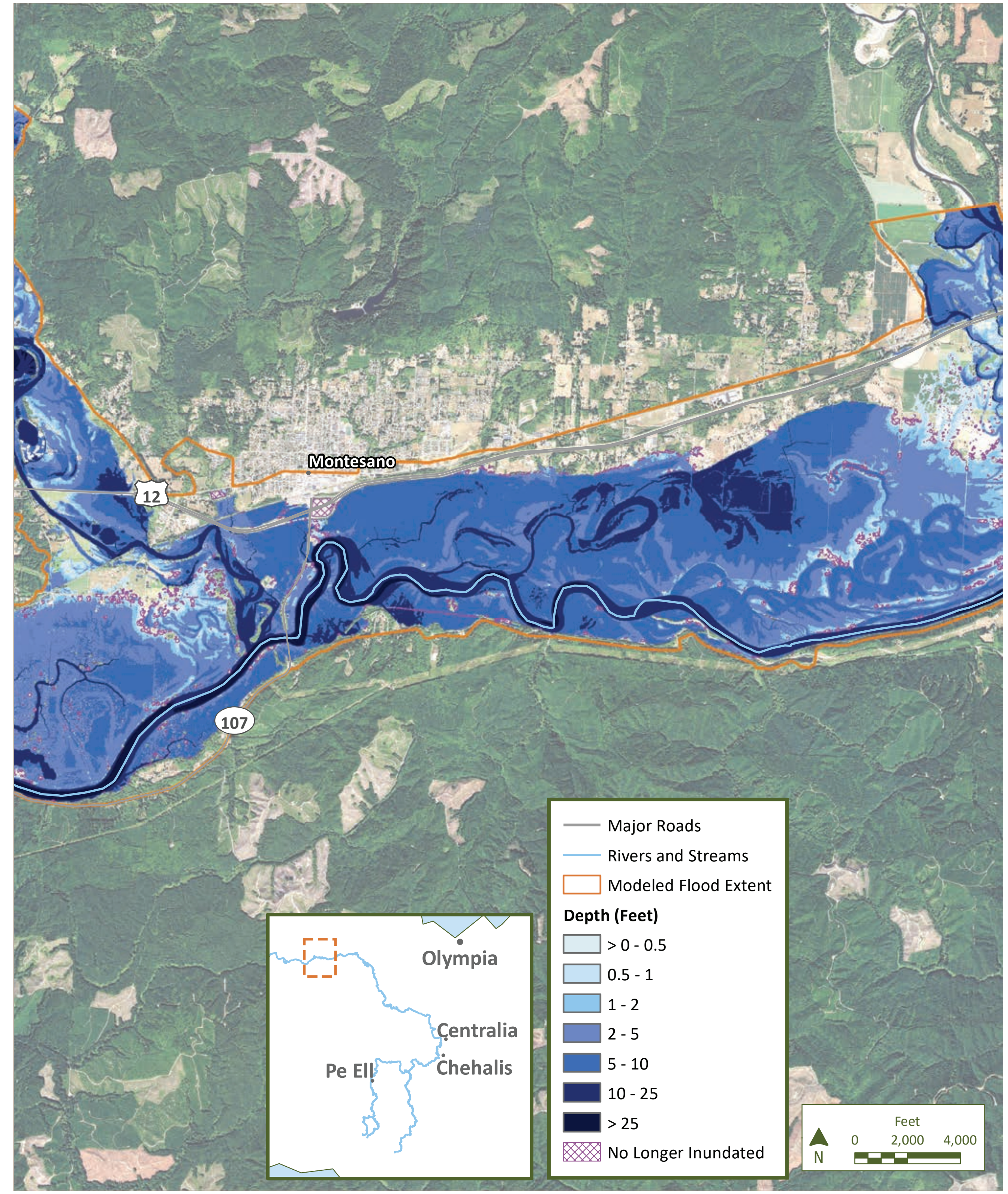
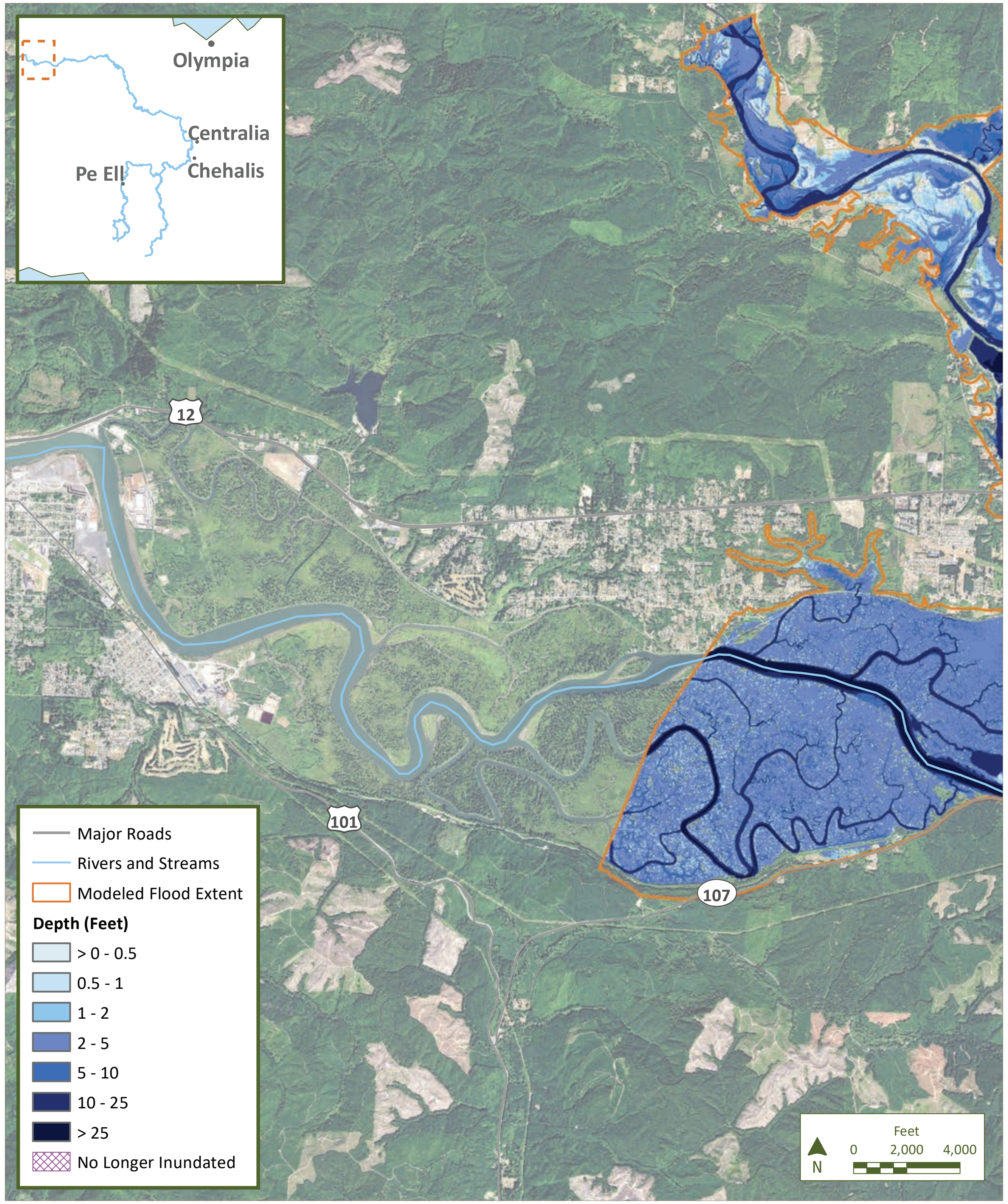


Figure N.3-j
Late-Century Major Flood

No Action



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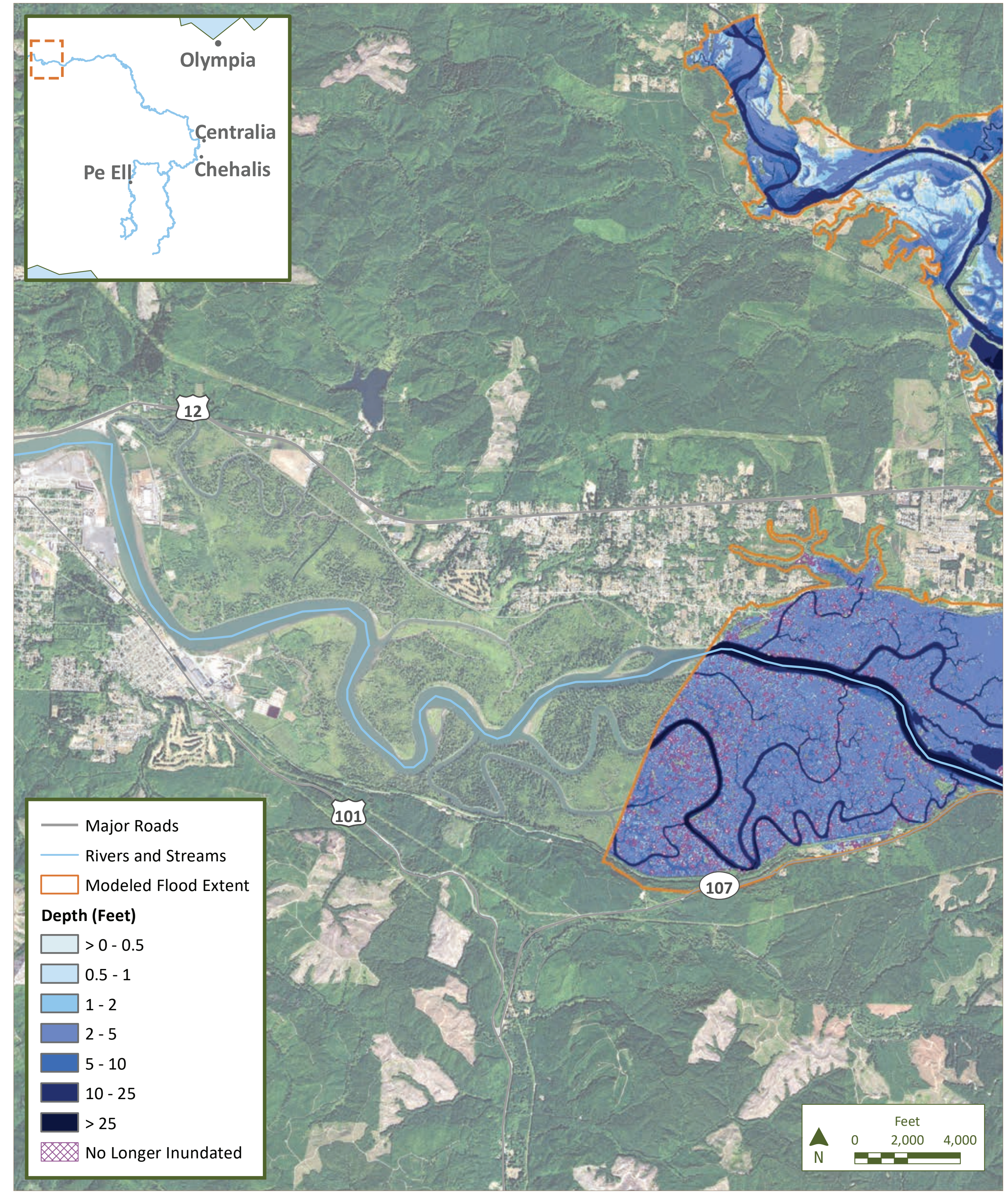
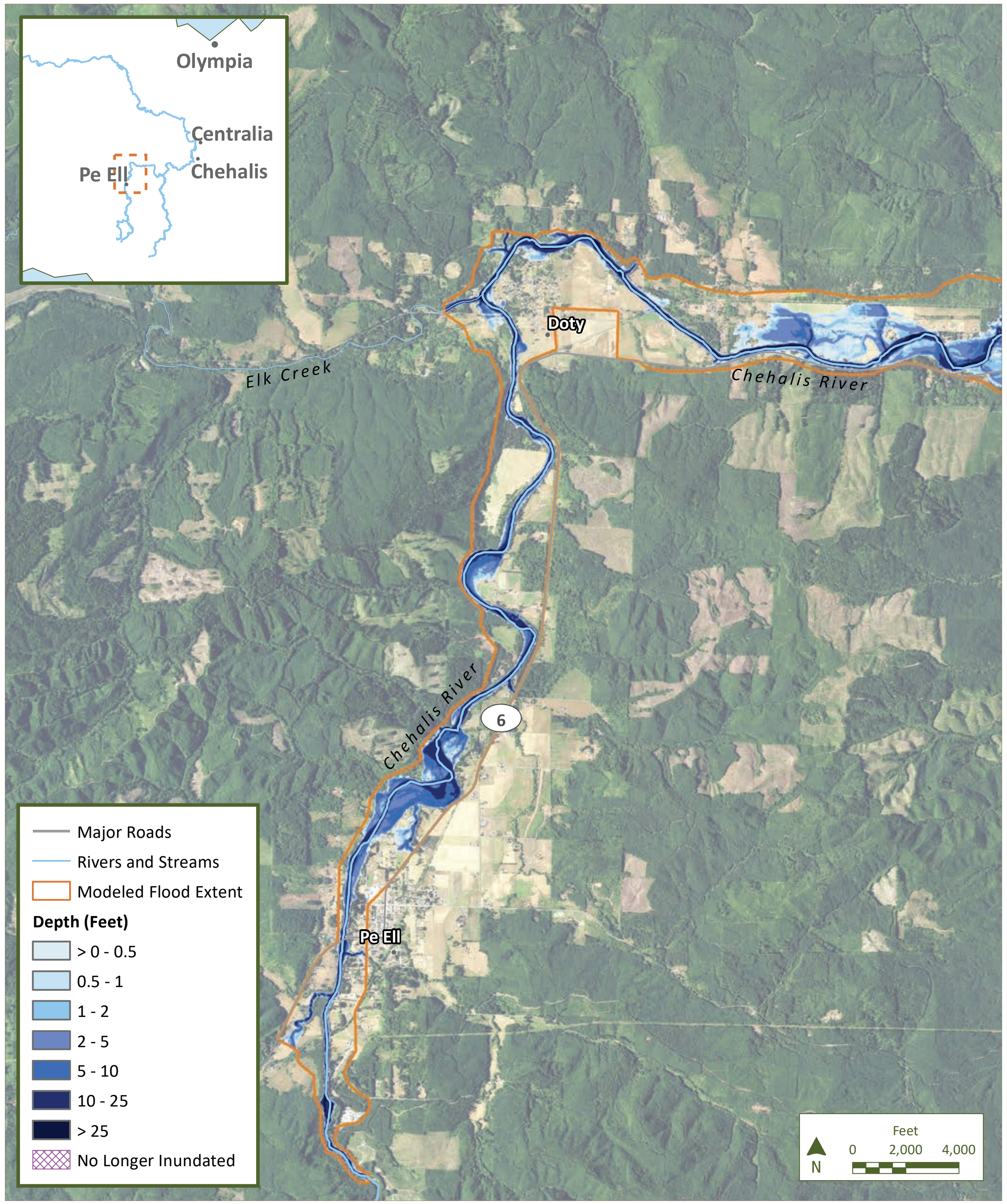


Figure N.4-a
Mid-Century Catastrophic Flood

No Action



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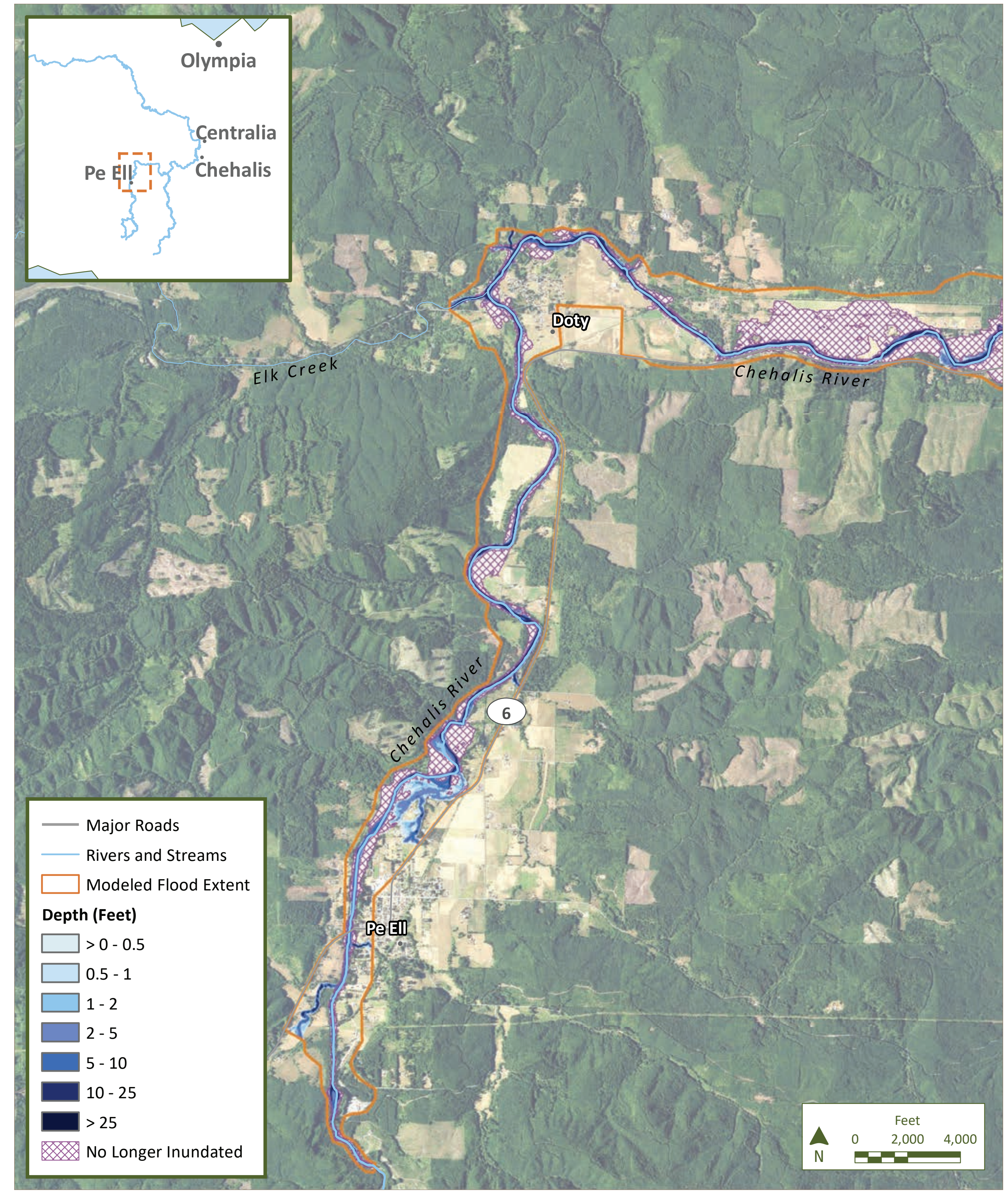

Figure N.4-b
Mid-Century Catastrophic Flood

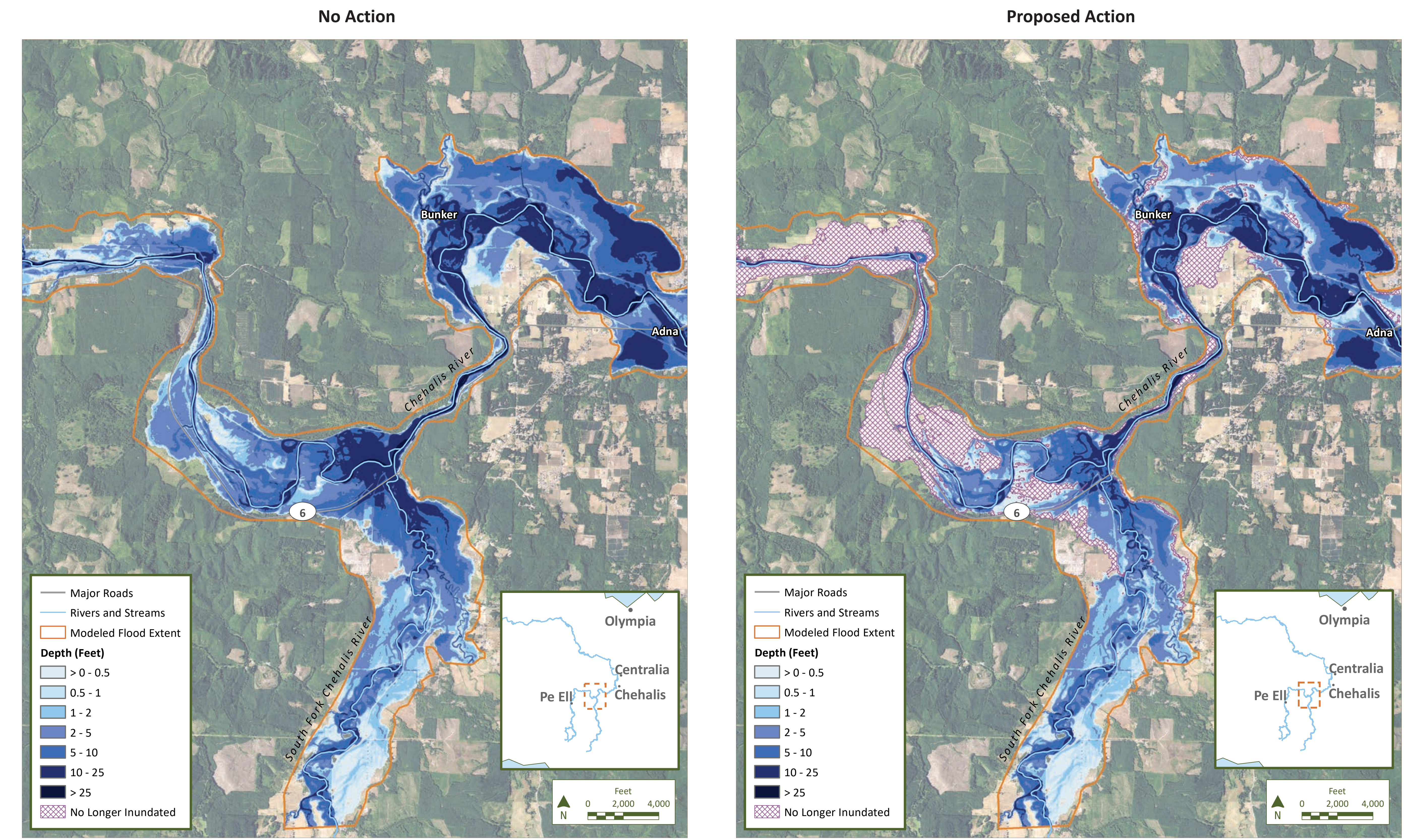

Figure N.4-c
Mid-Century Catastrophic Flood

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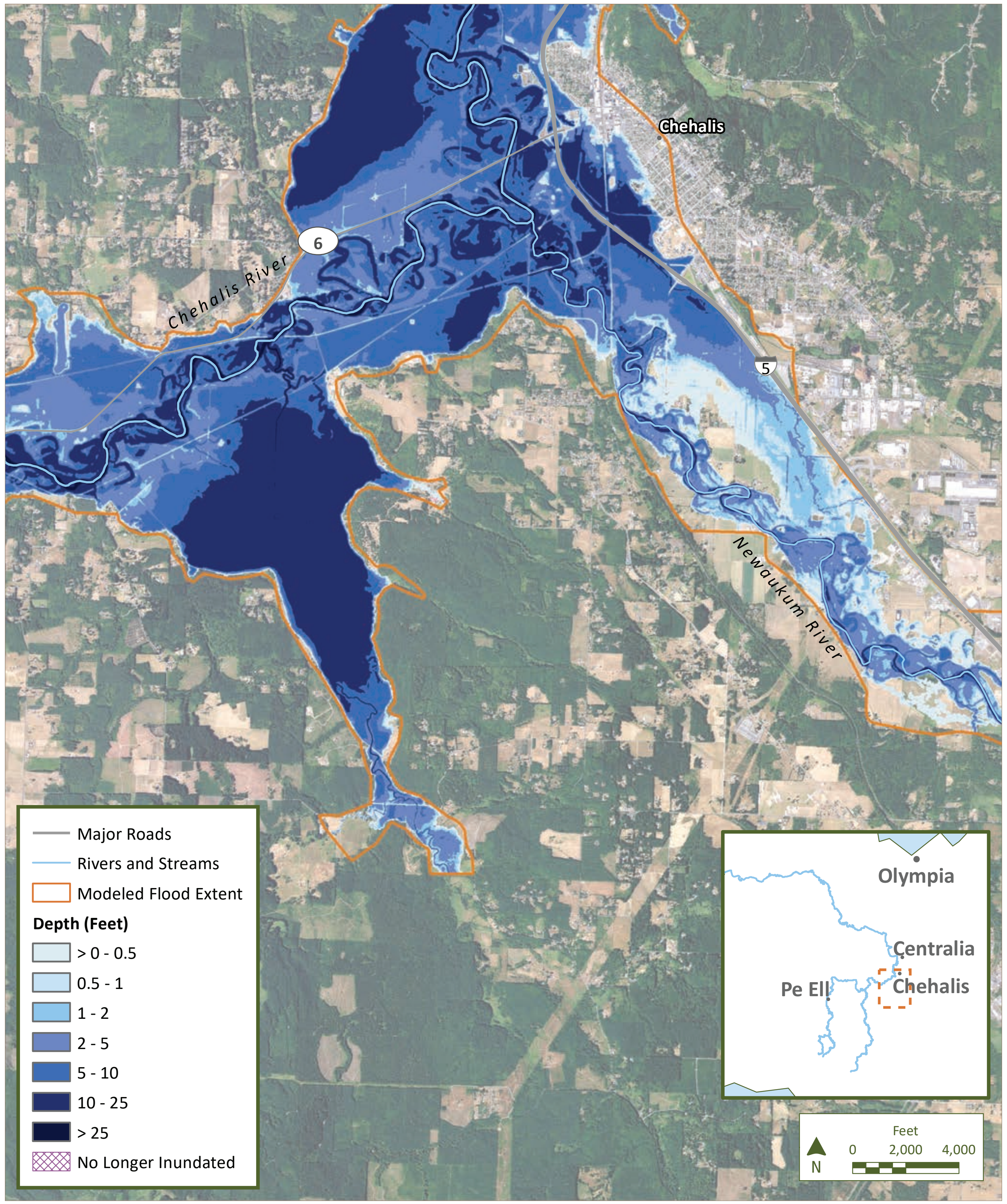

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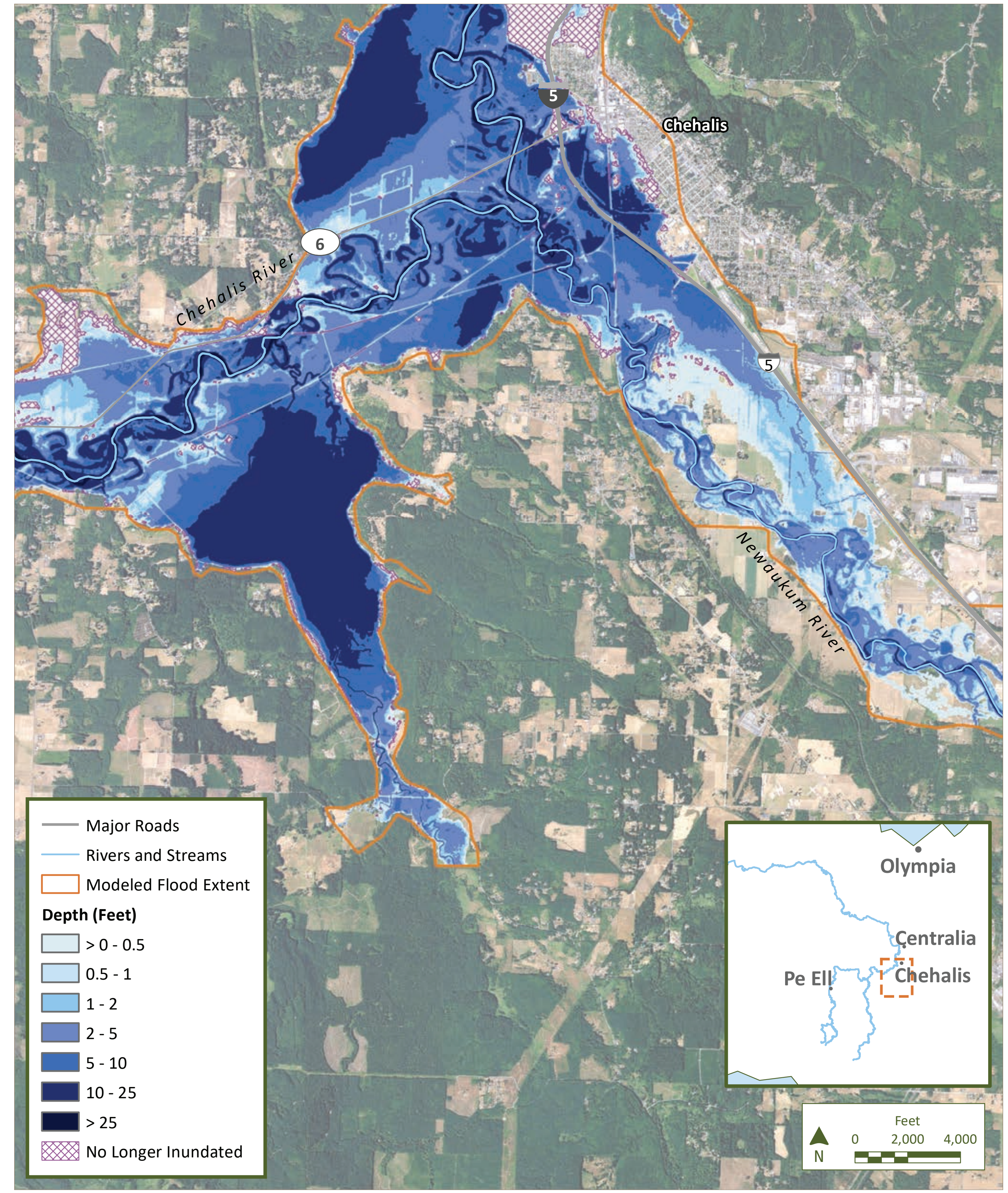

Figure N.4-d
Mid-Century Catastrophic Flood

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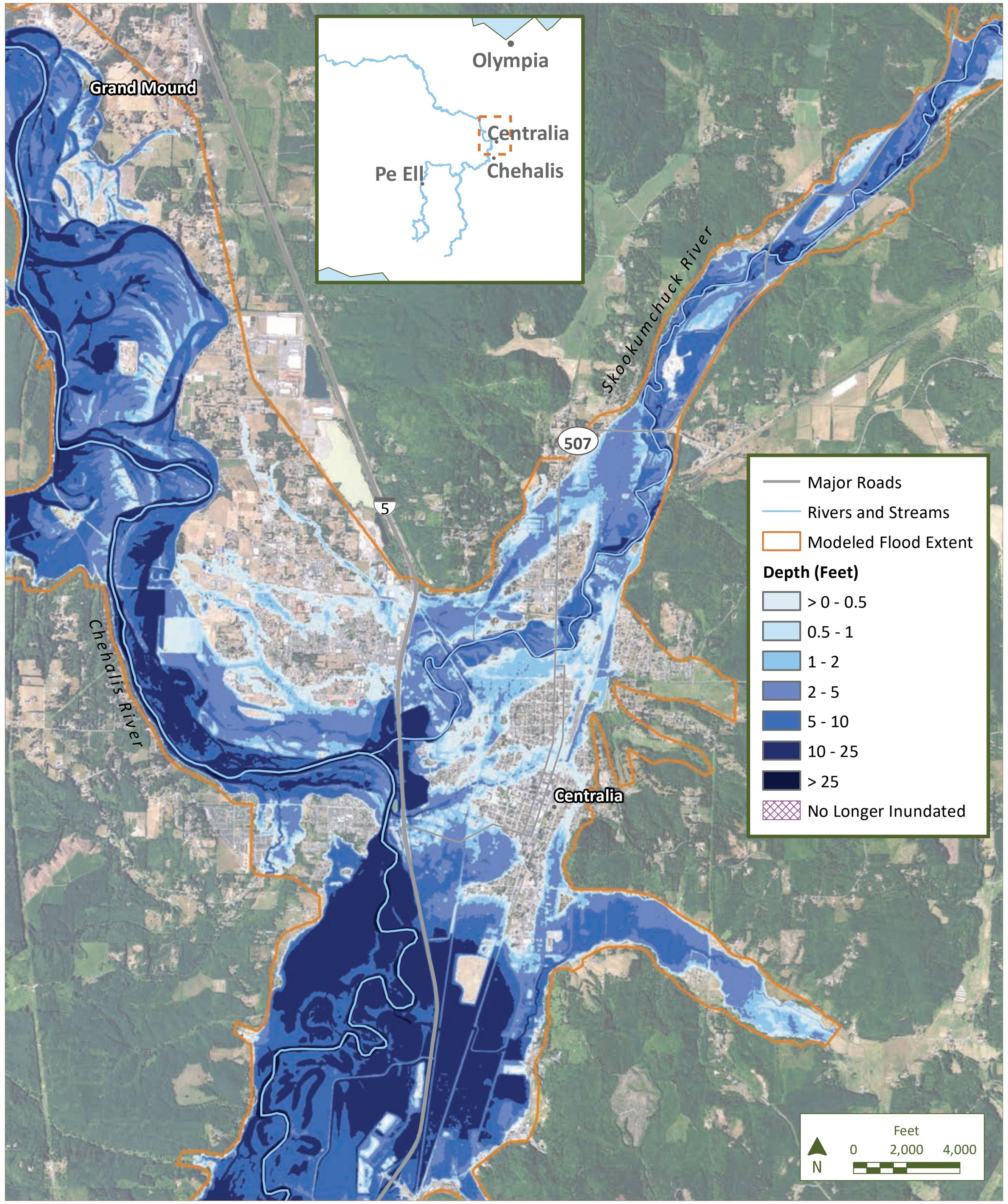

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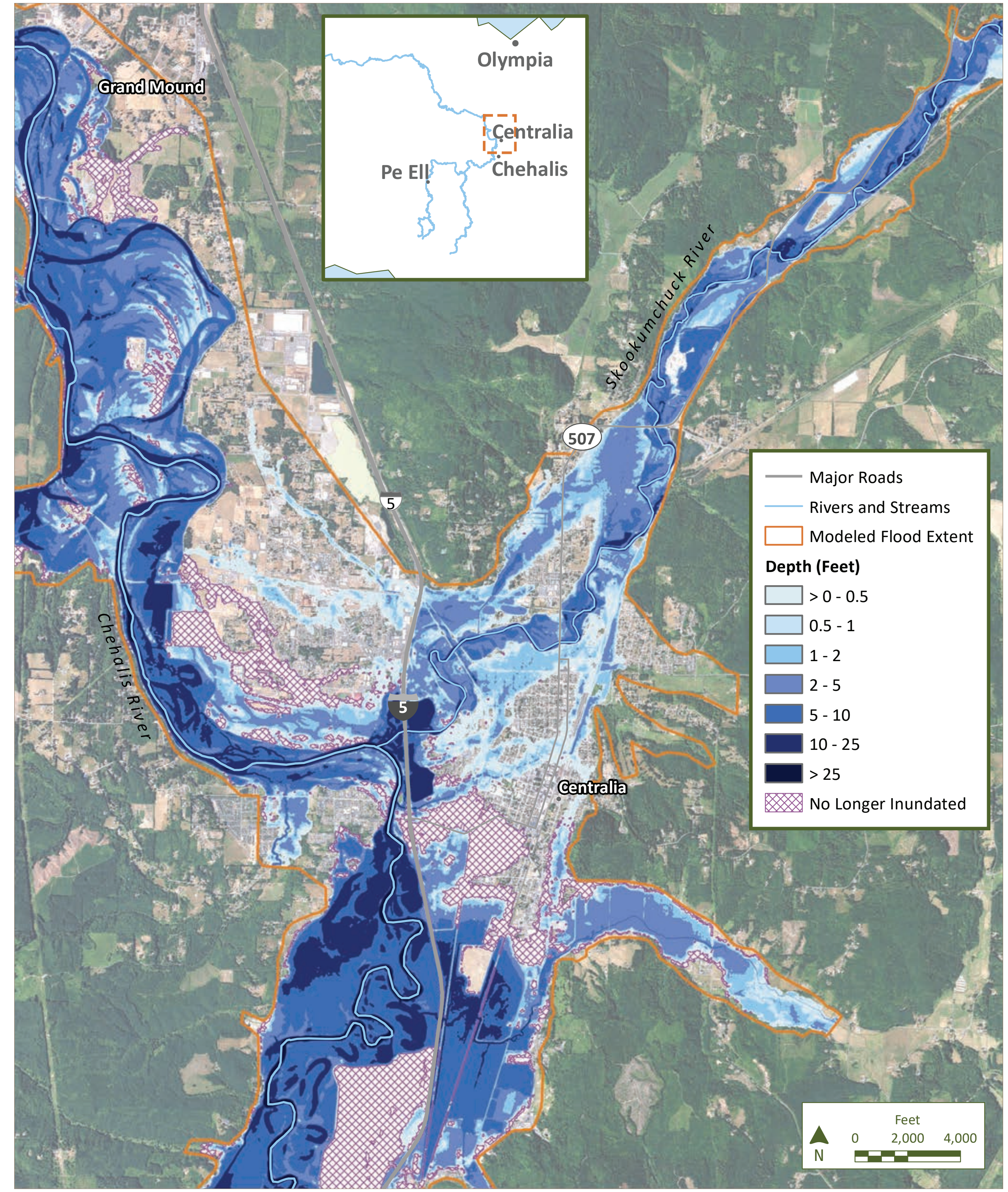
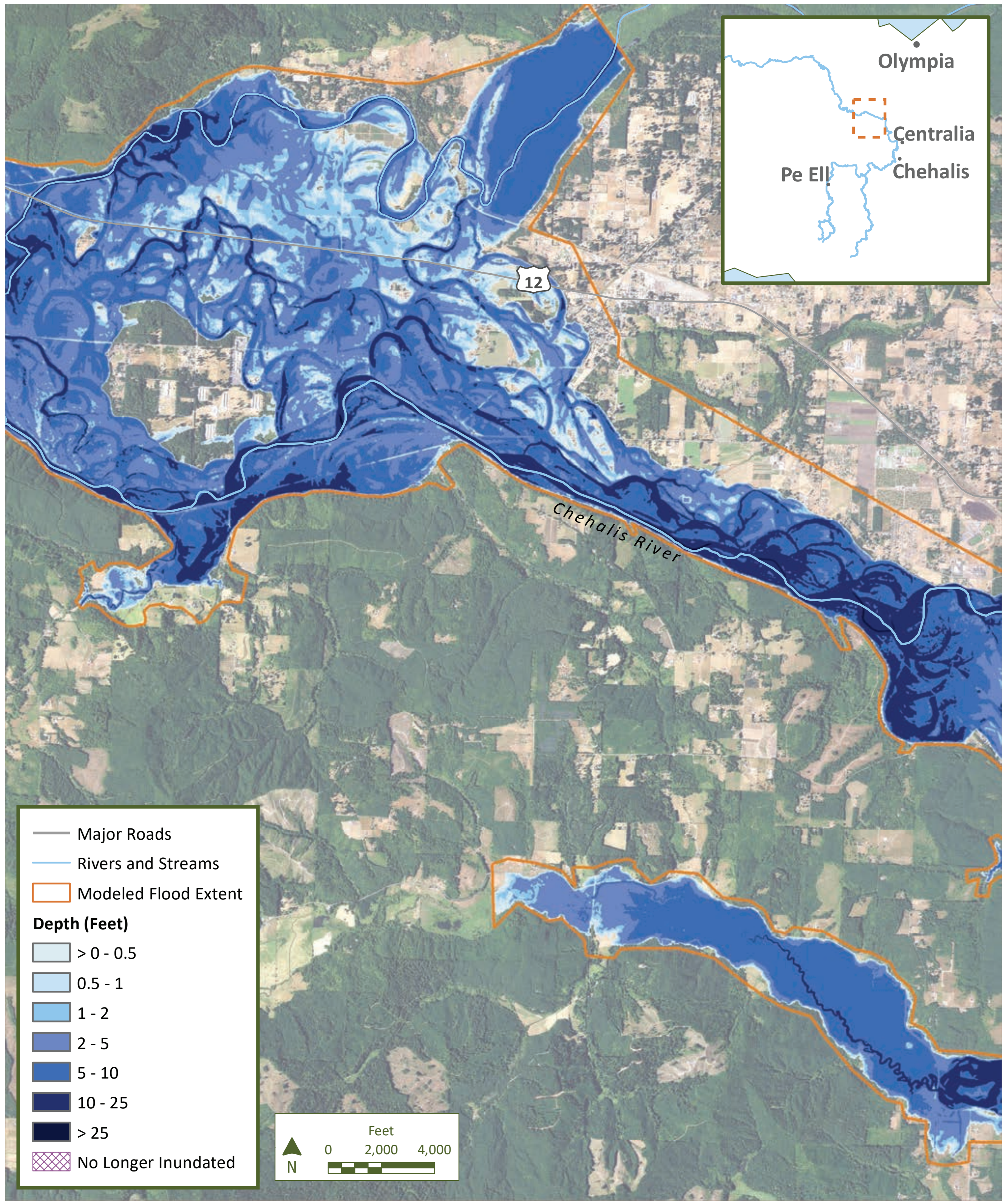


Figure N.4-e
Mid-Century Catastrophic Flood

No Action



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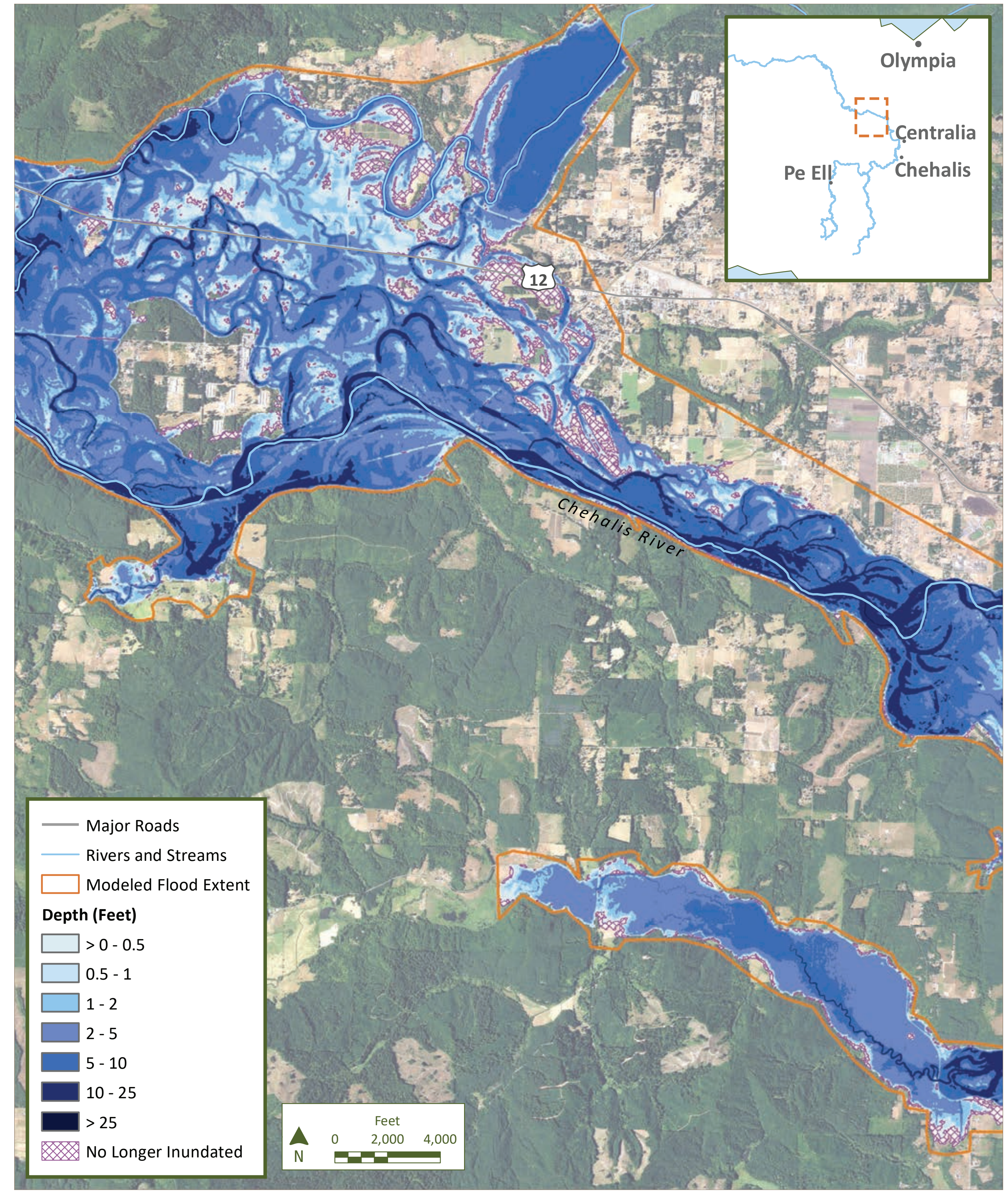

Figure N.4-f
Mid-Century Catastrophic Flood

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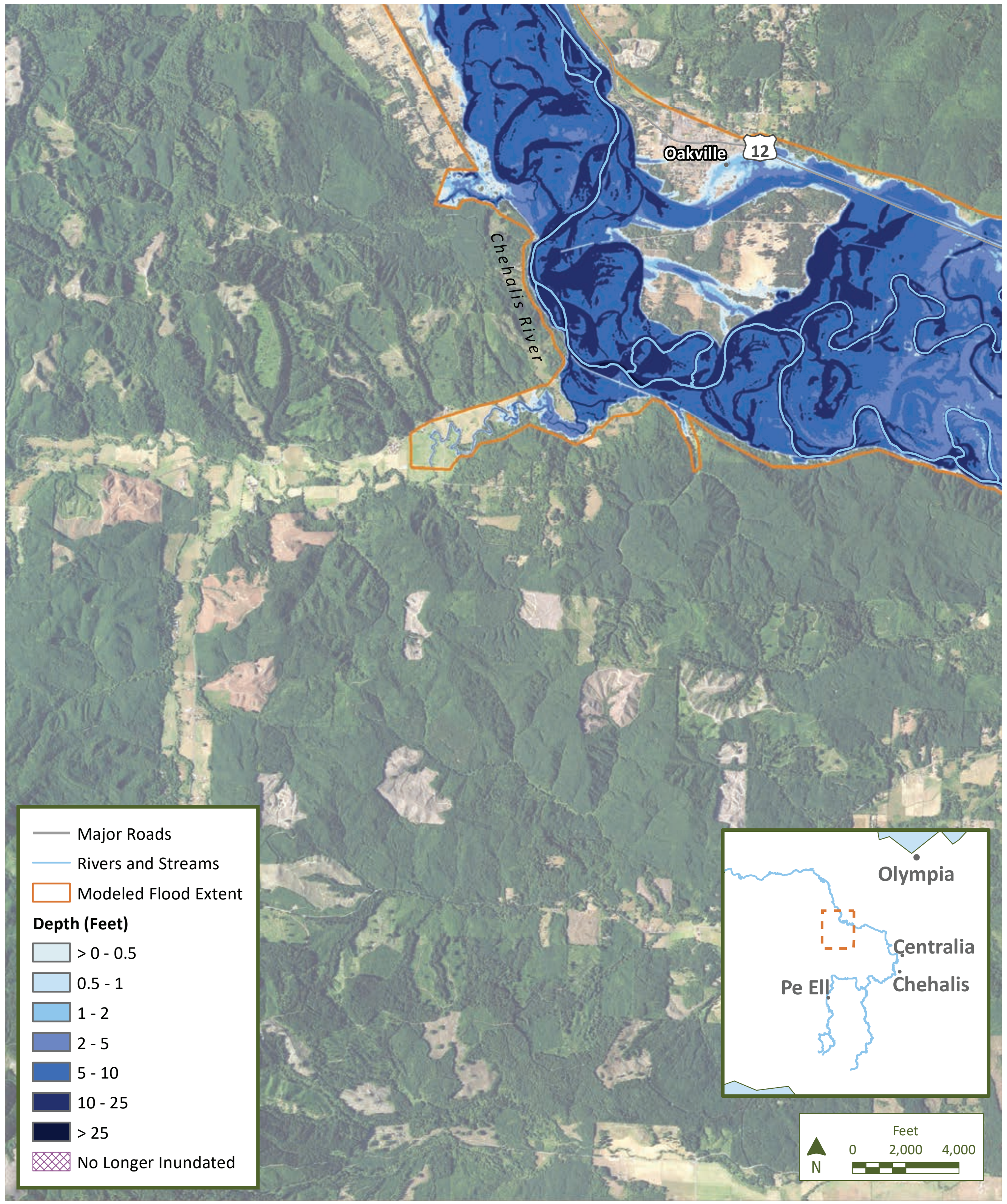

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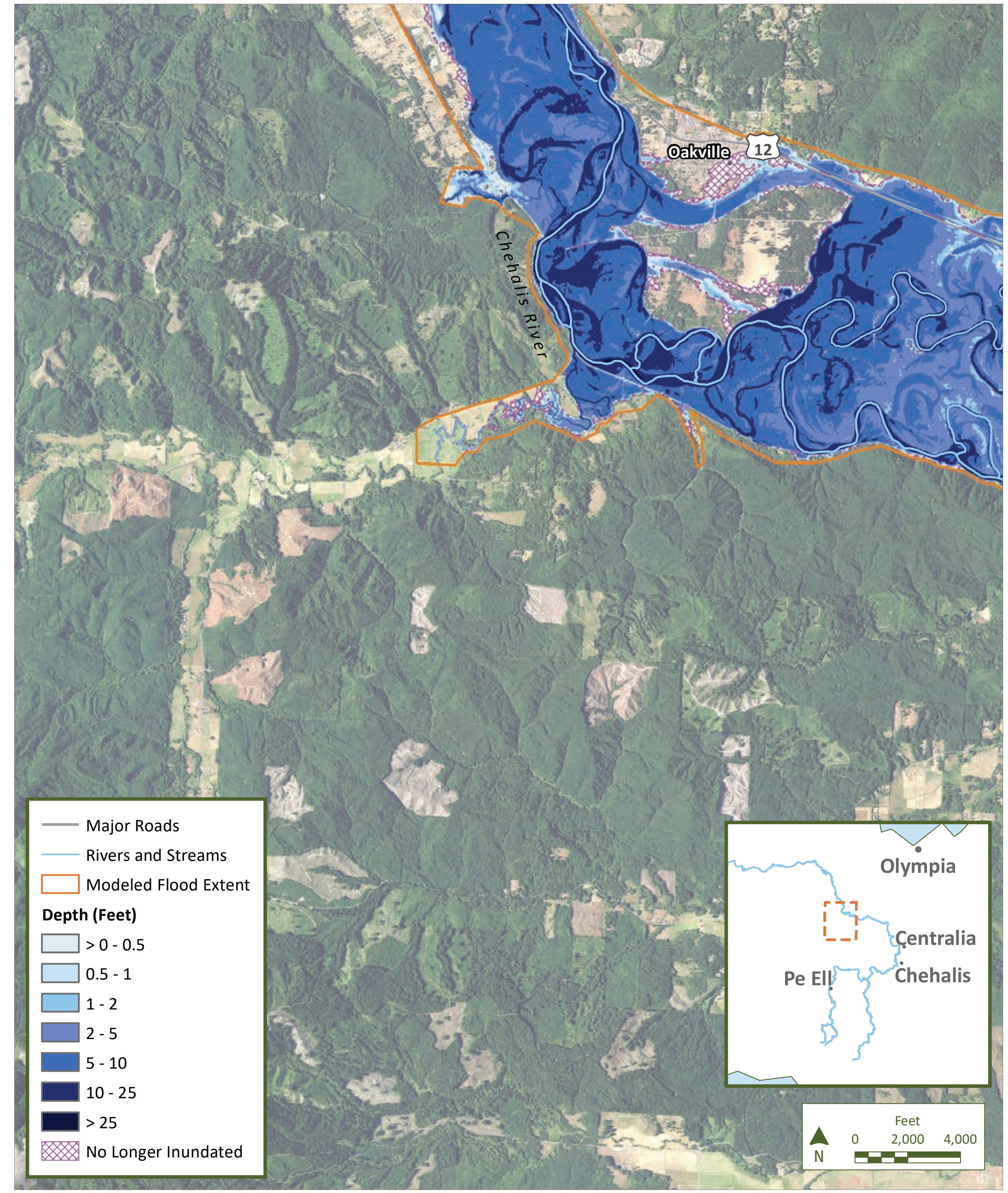

Figure N.4-g
Mid-Century Catastrophic Flood

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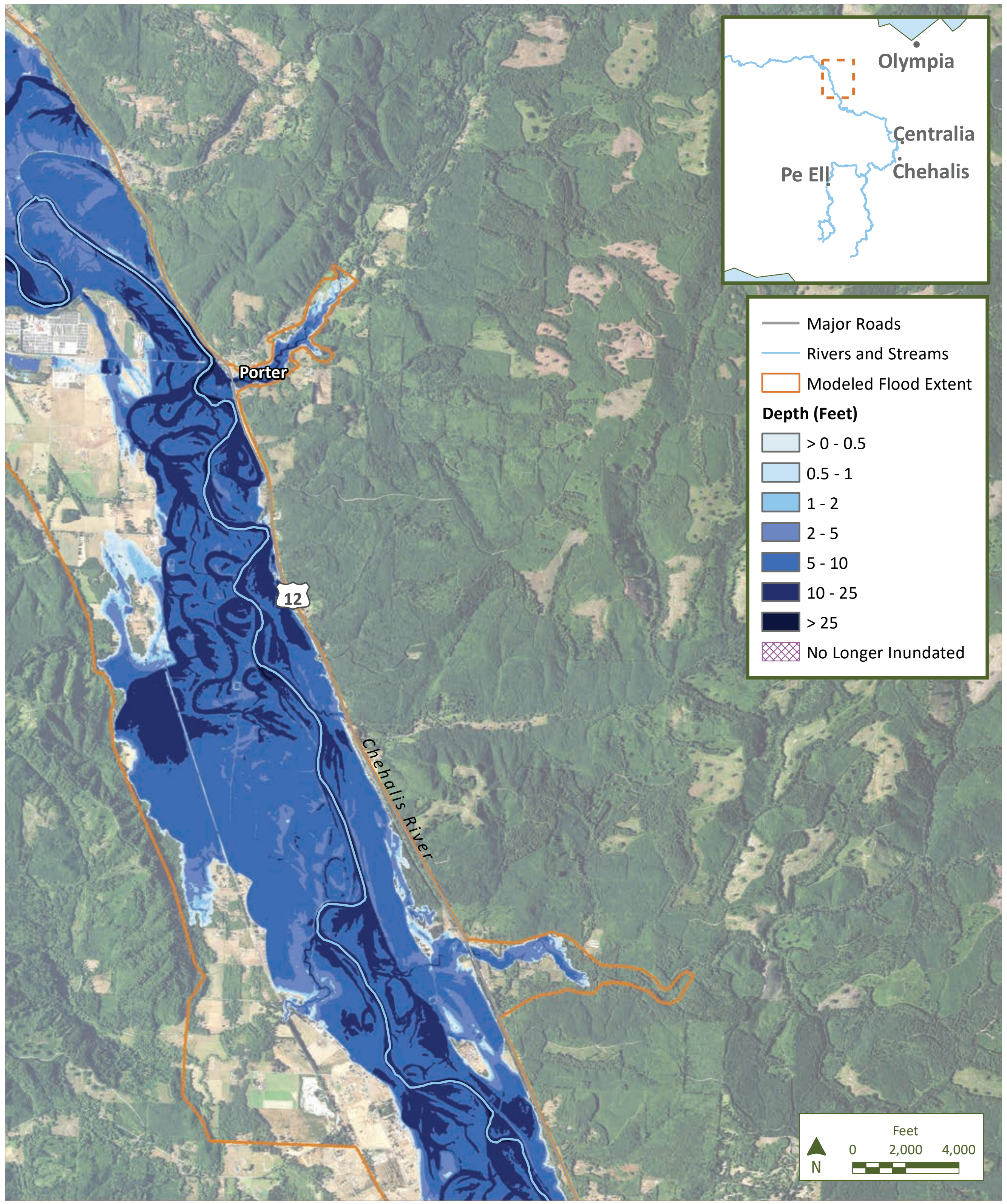

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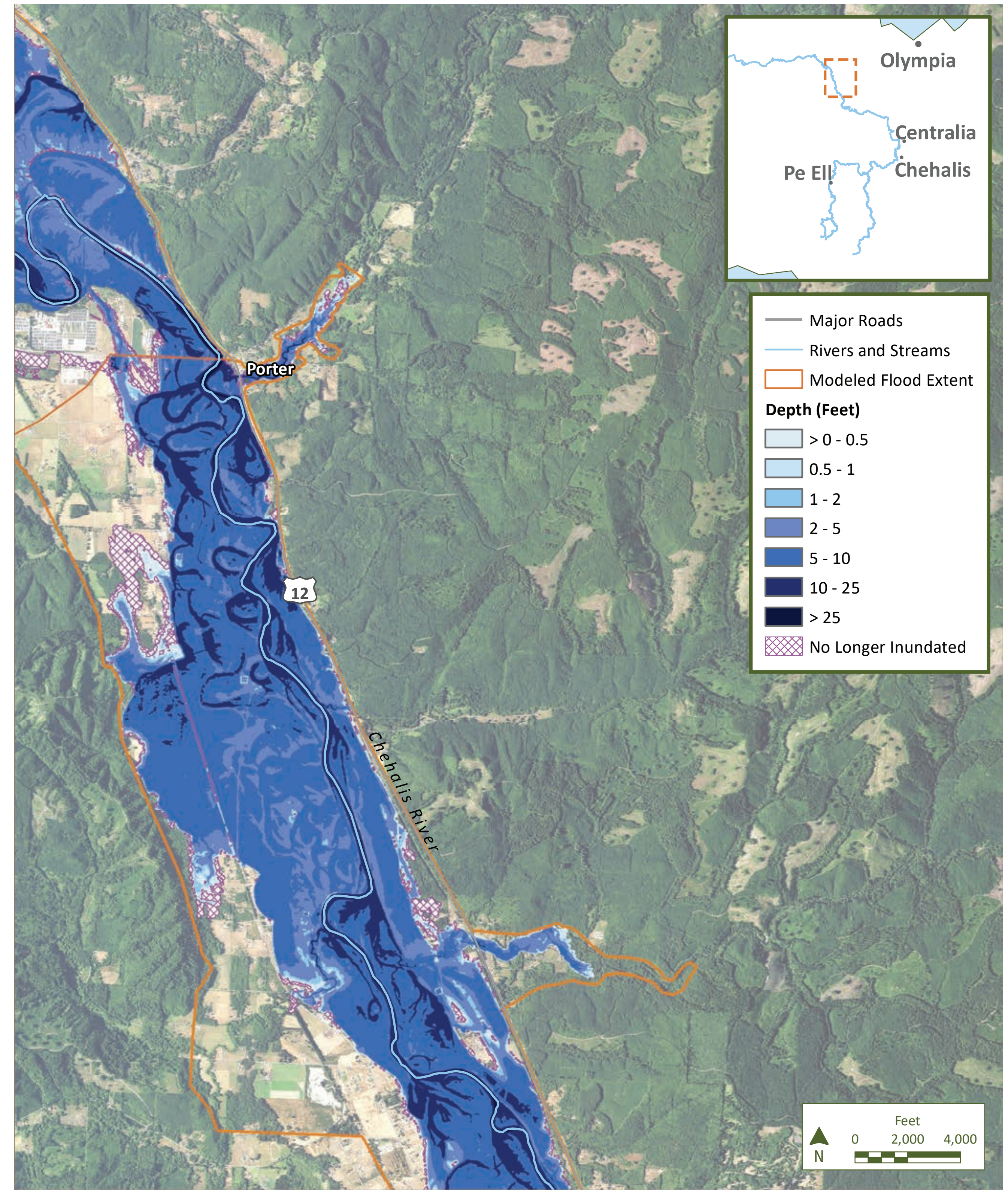

Figure N.4-h
Mid-Century Catastrophic Flood

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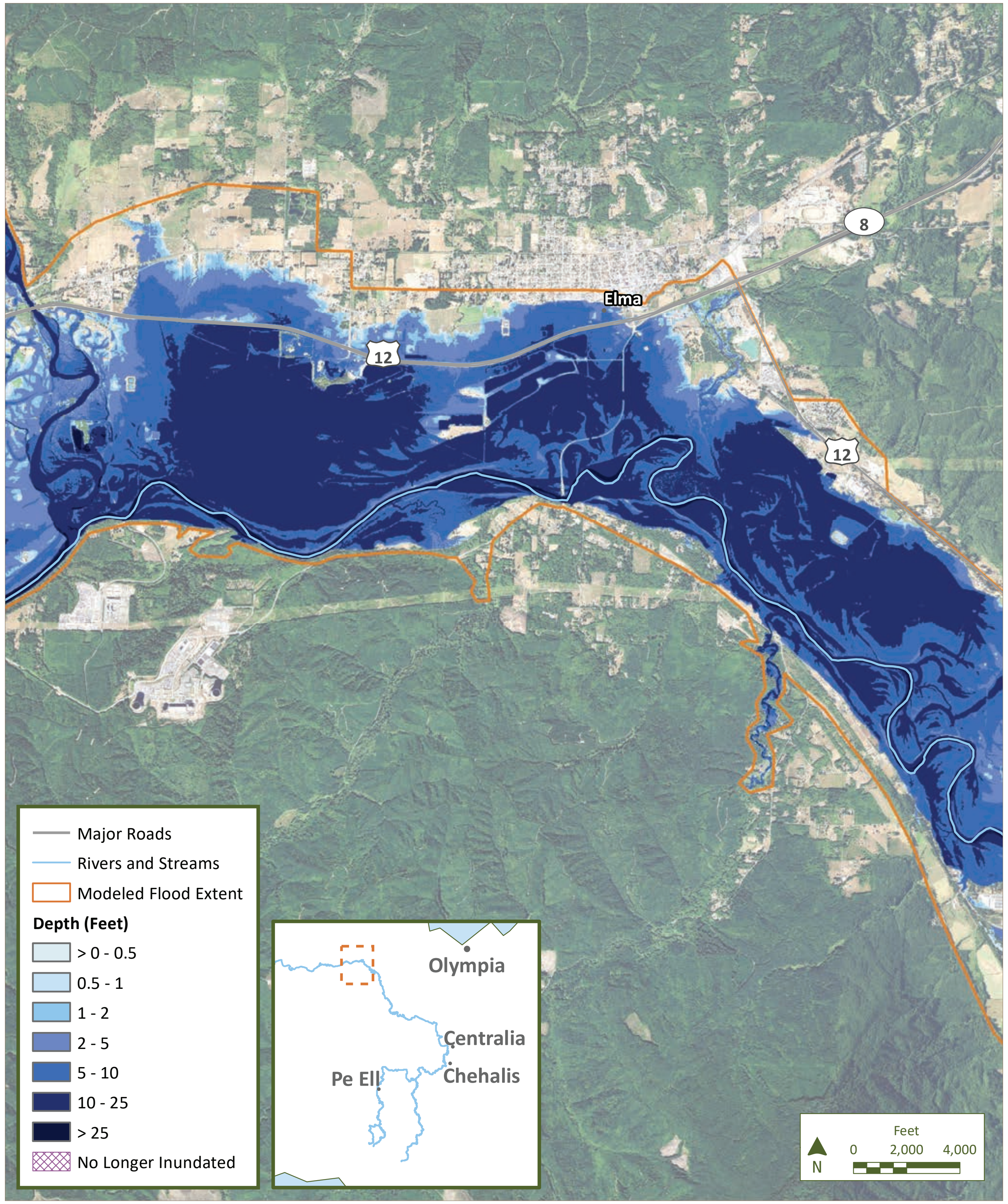

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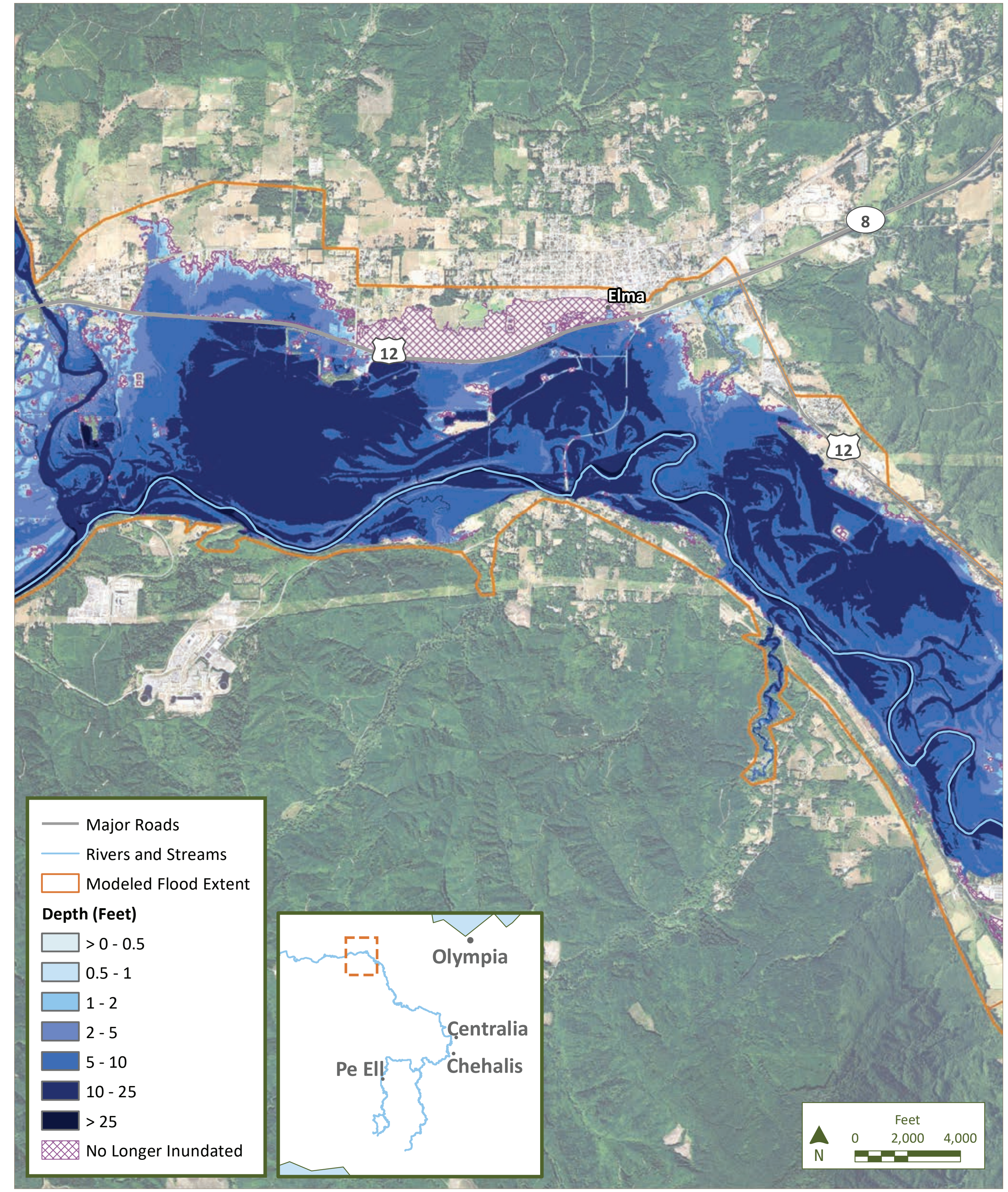

Figure N.4-i
Mid-Century Catastrophic Flood

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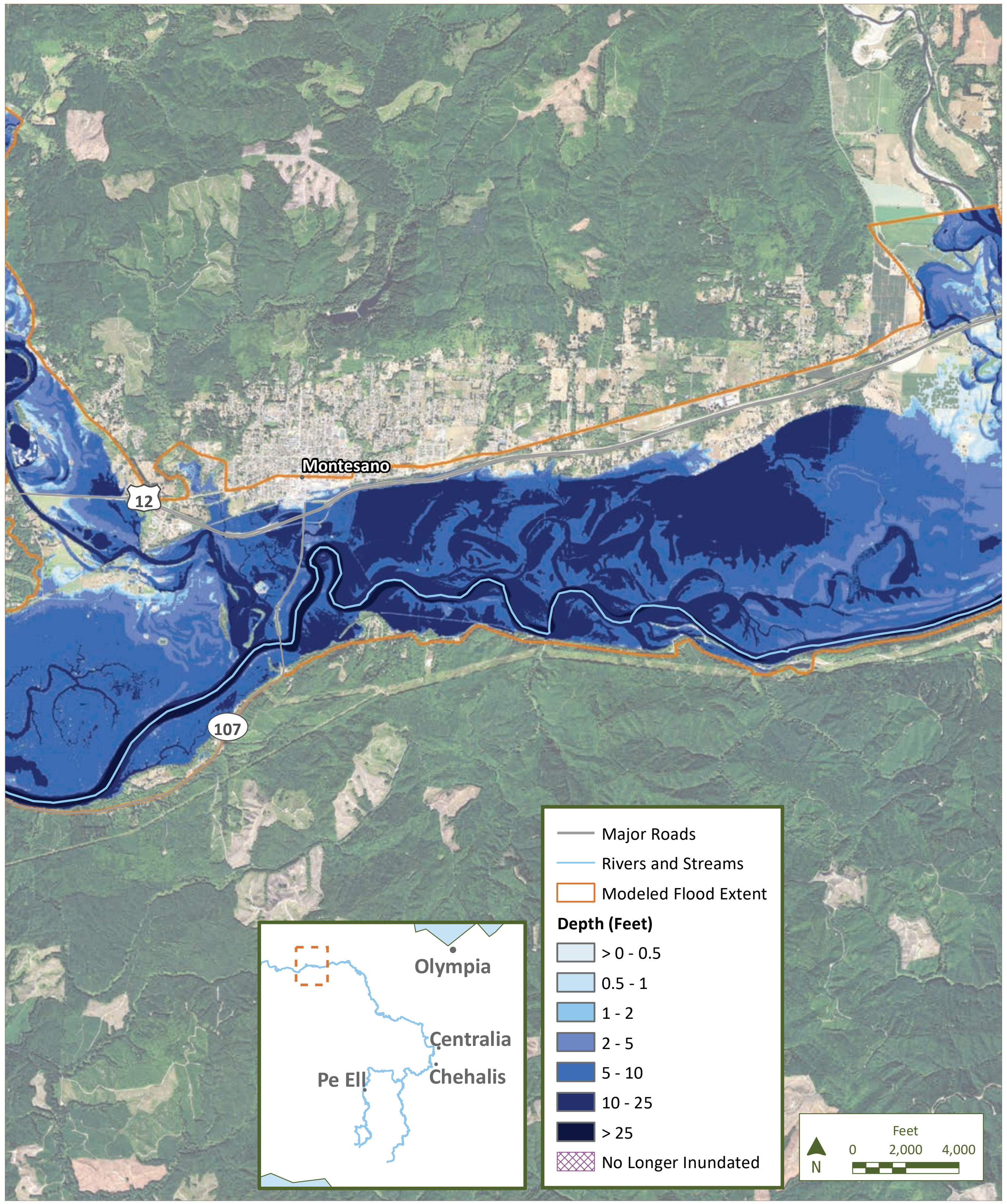

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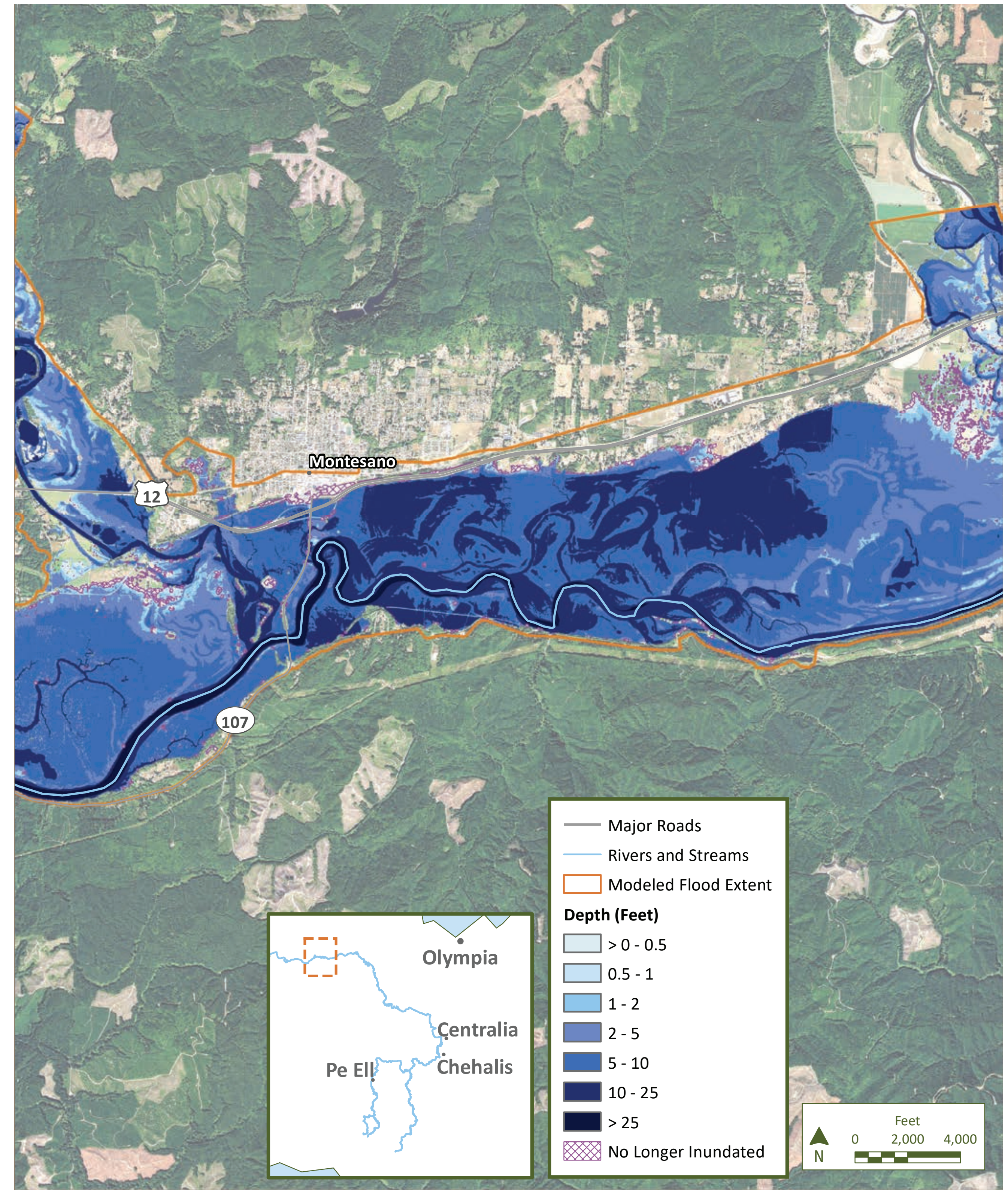

Figure N.4-j
Mid-Century Catastrophic Flood

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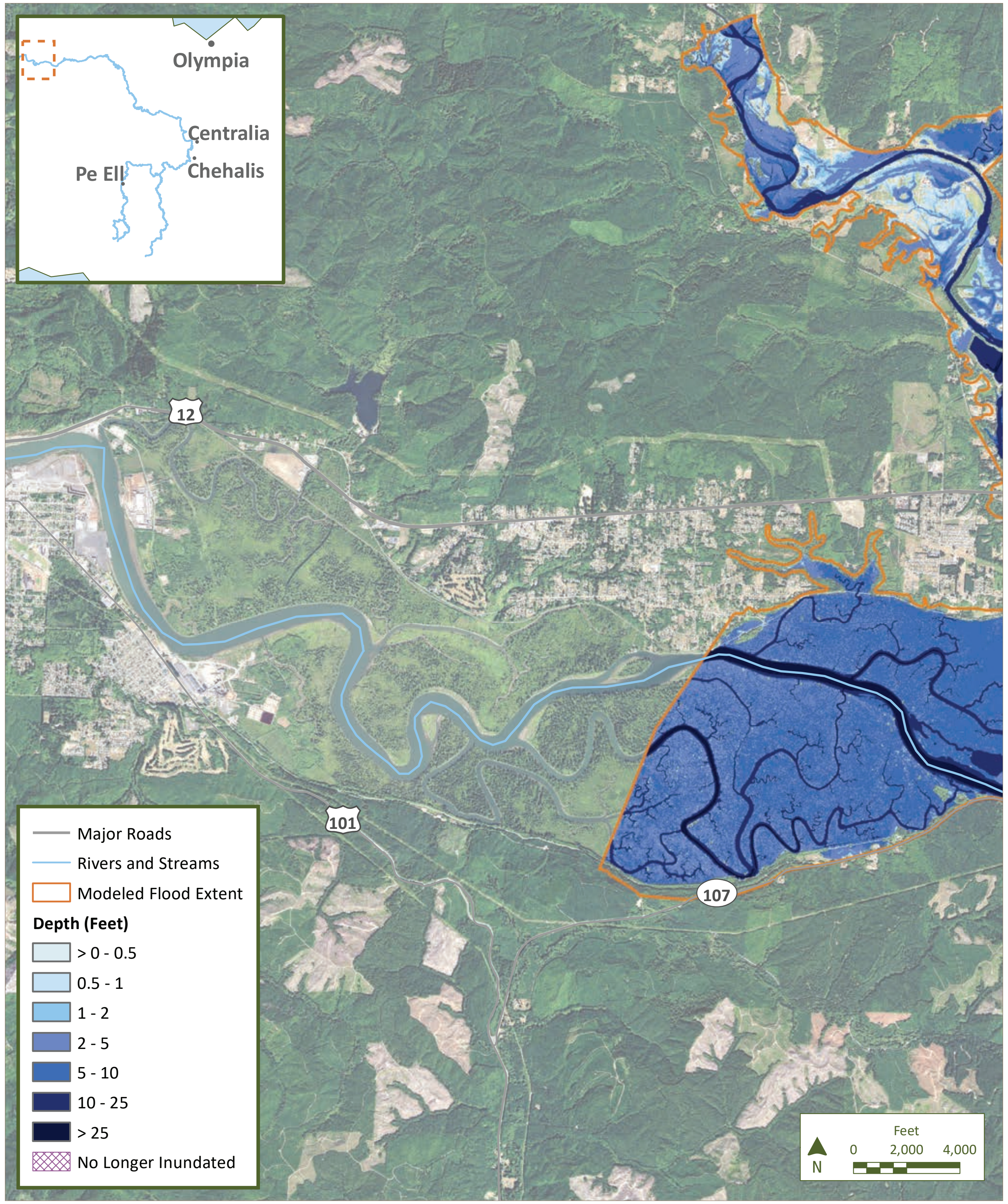

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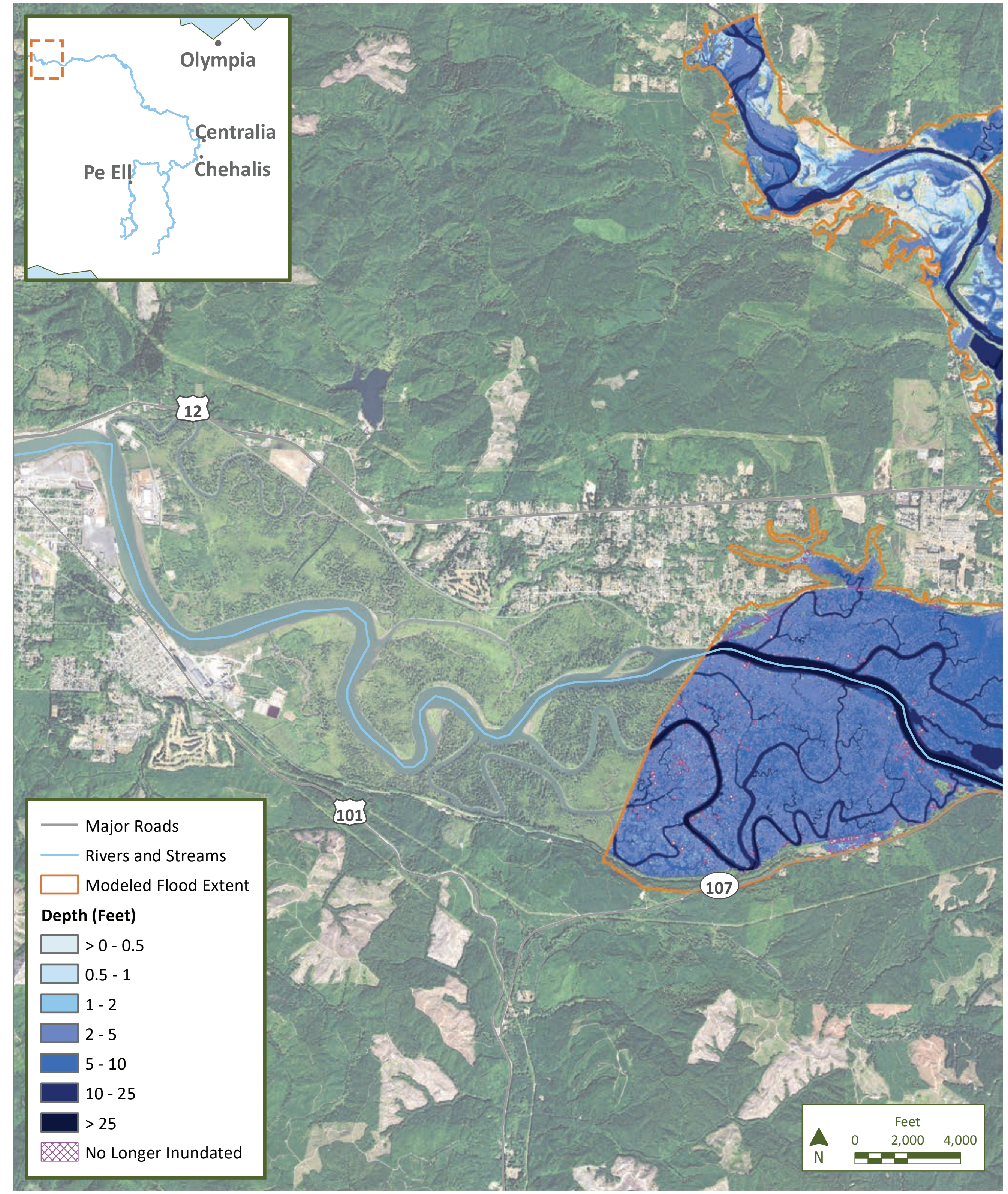

Figure N.5-a
Late-Century Catastrophic Flood

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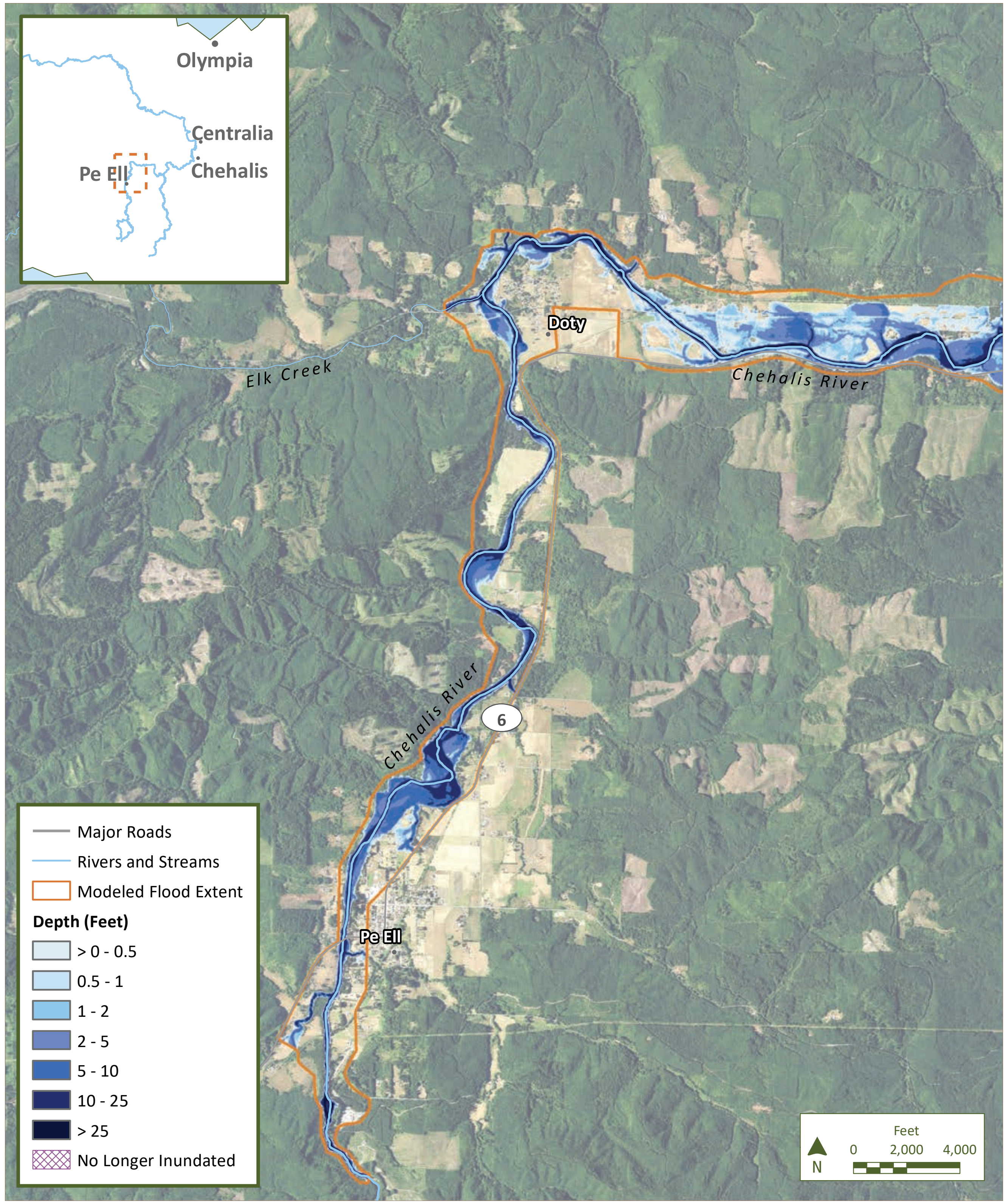

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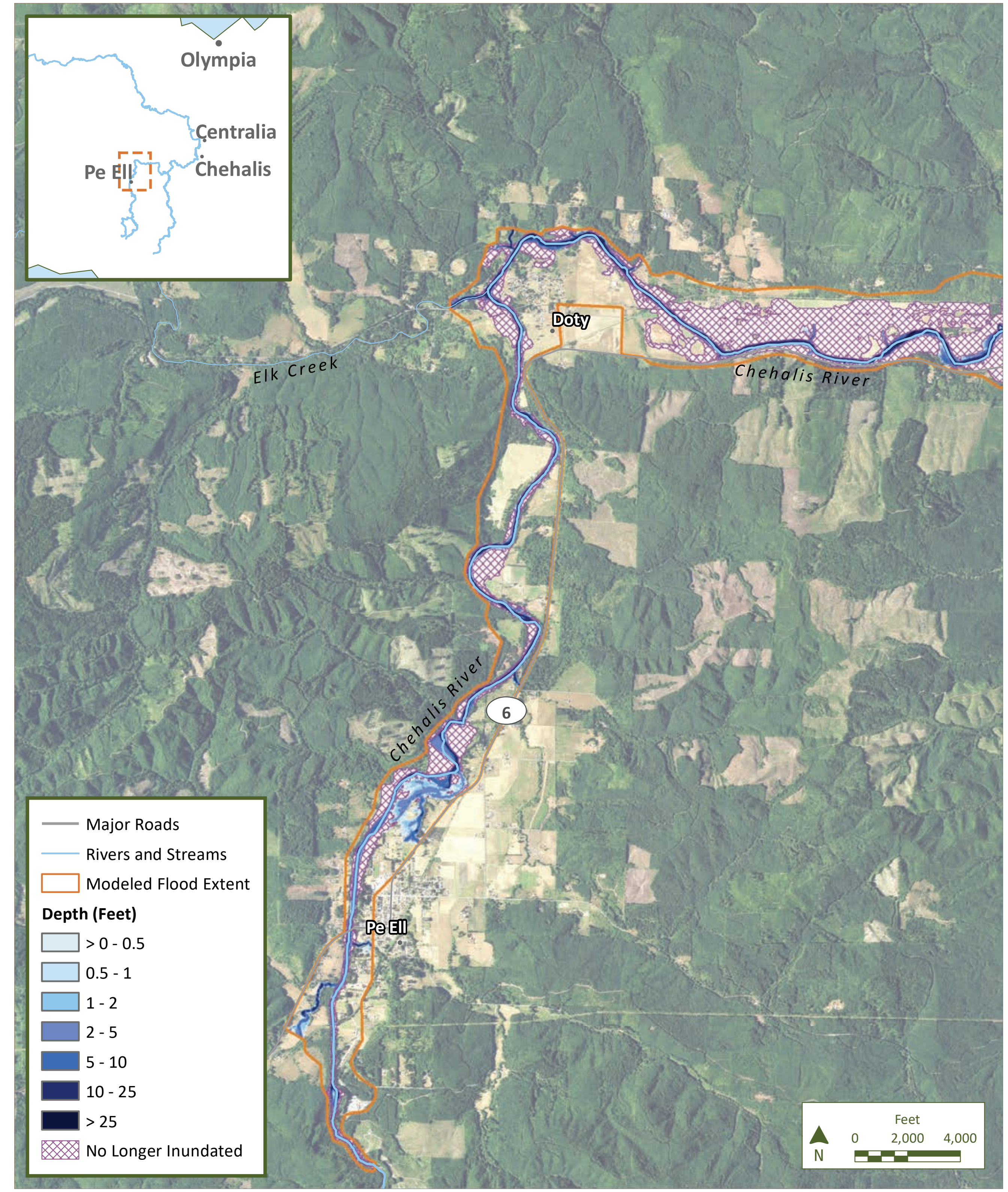

Figure N.5-b
Late-Century Catastrophic Flood

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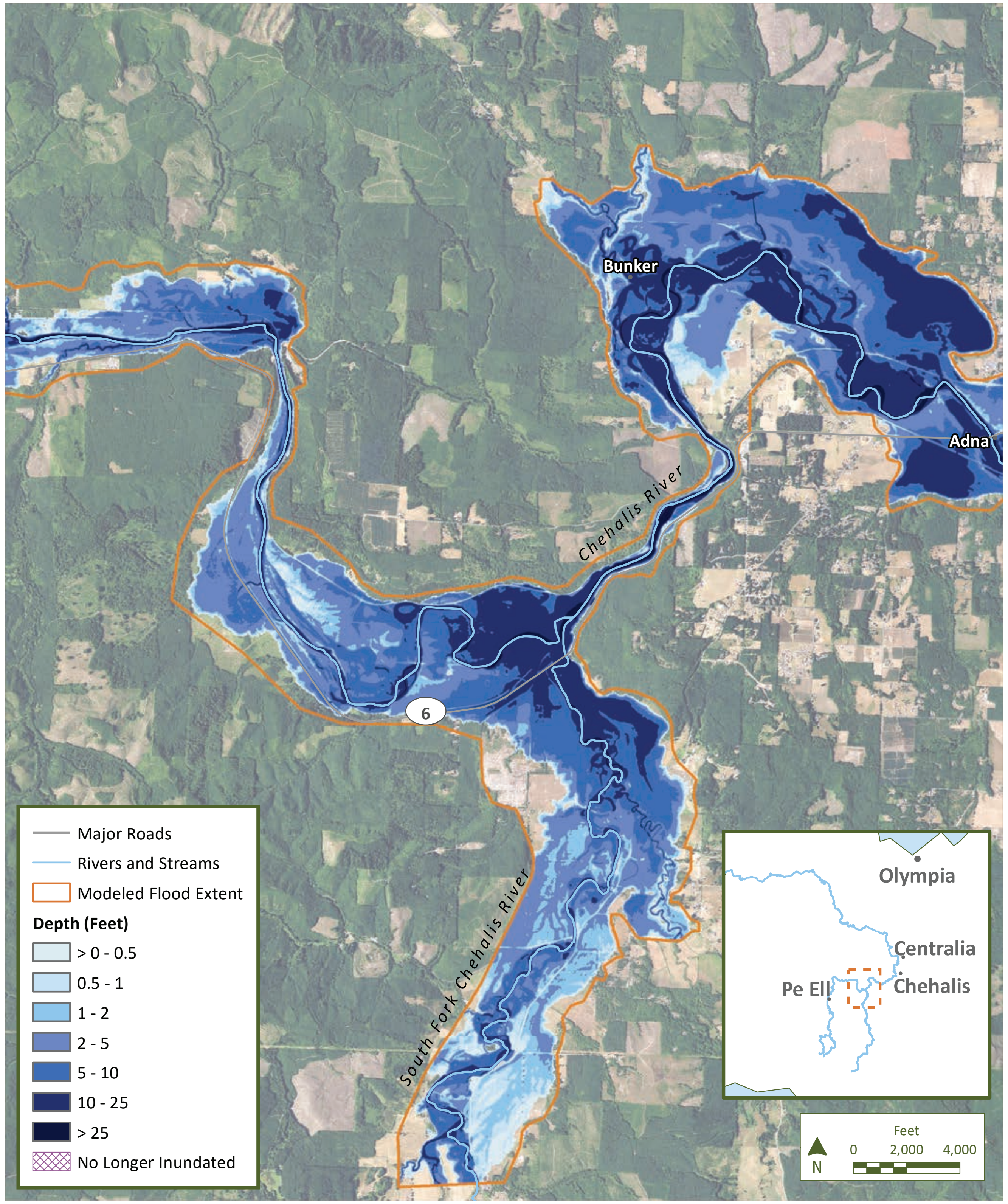

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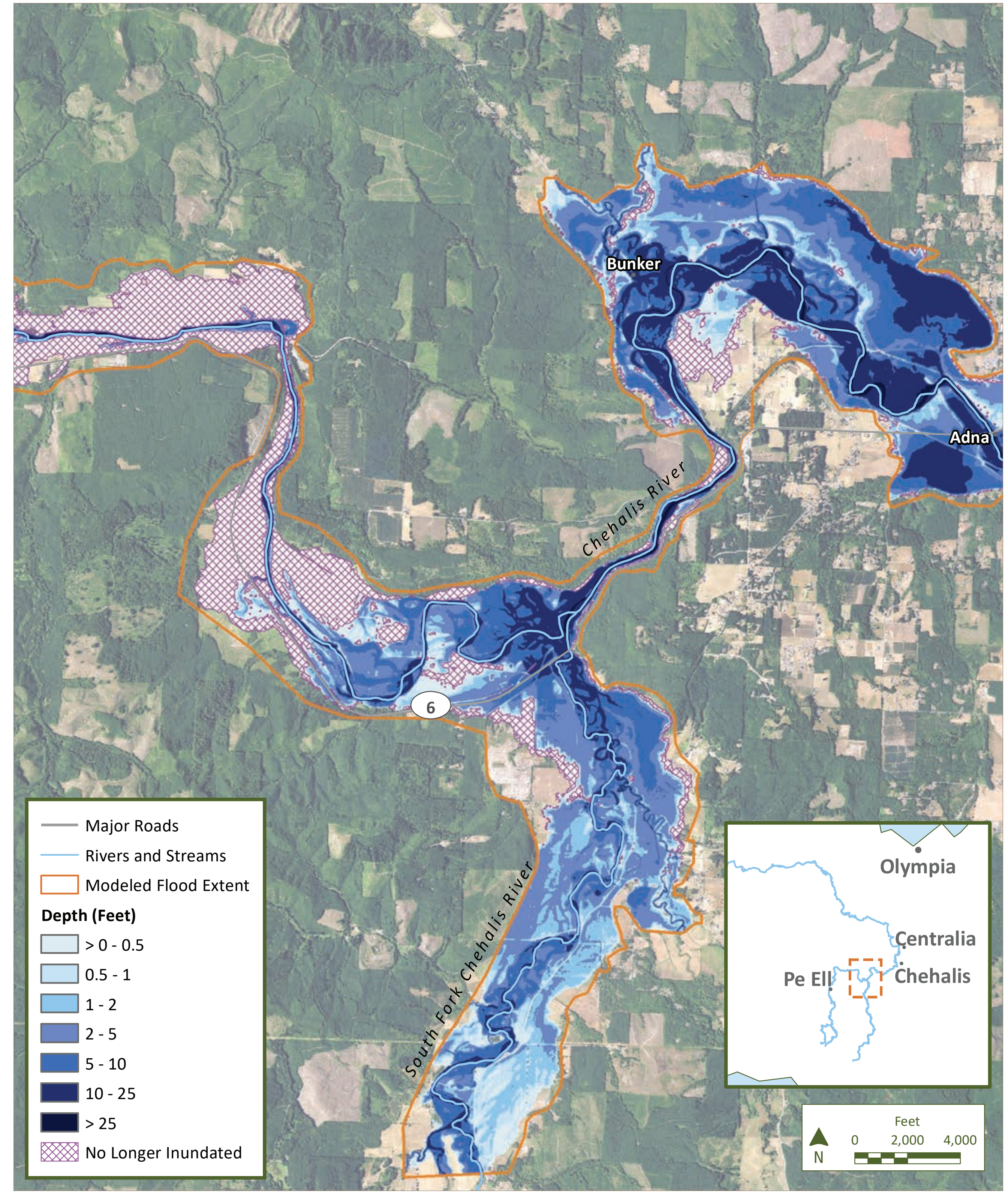

Figure N.5-c
Late-Century Catastrophic Flood

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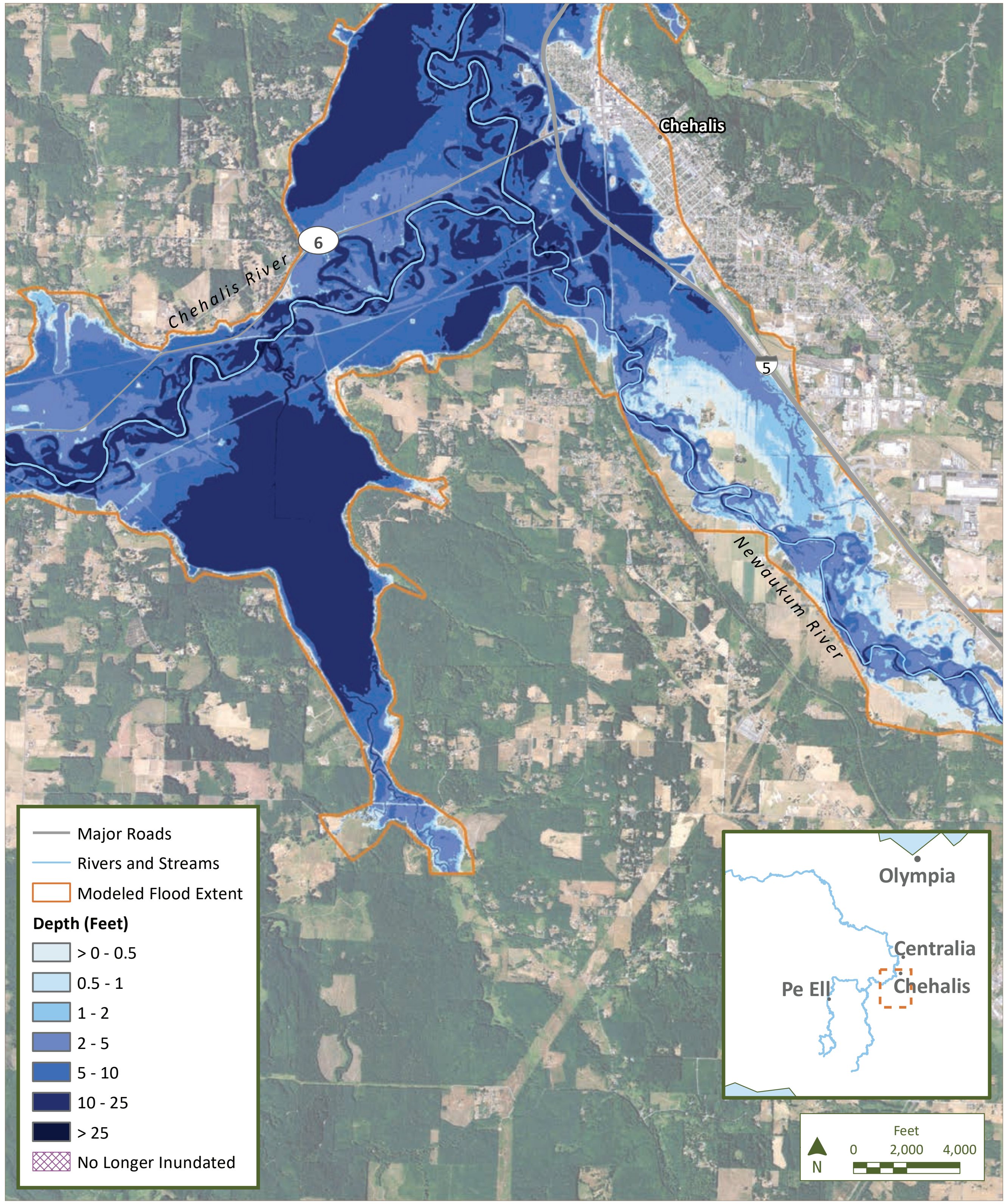

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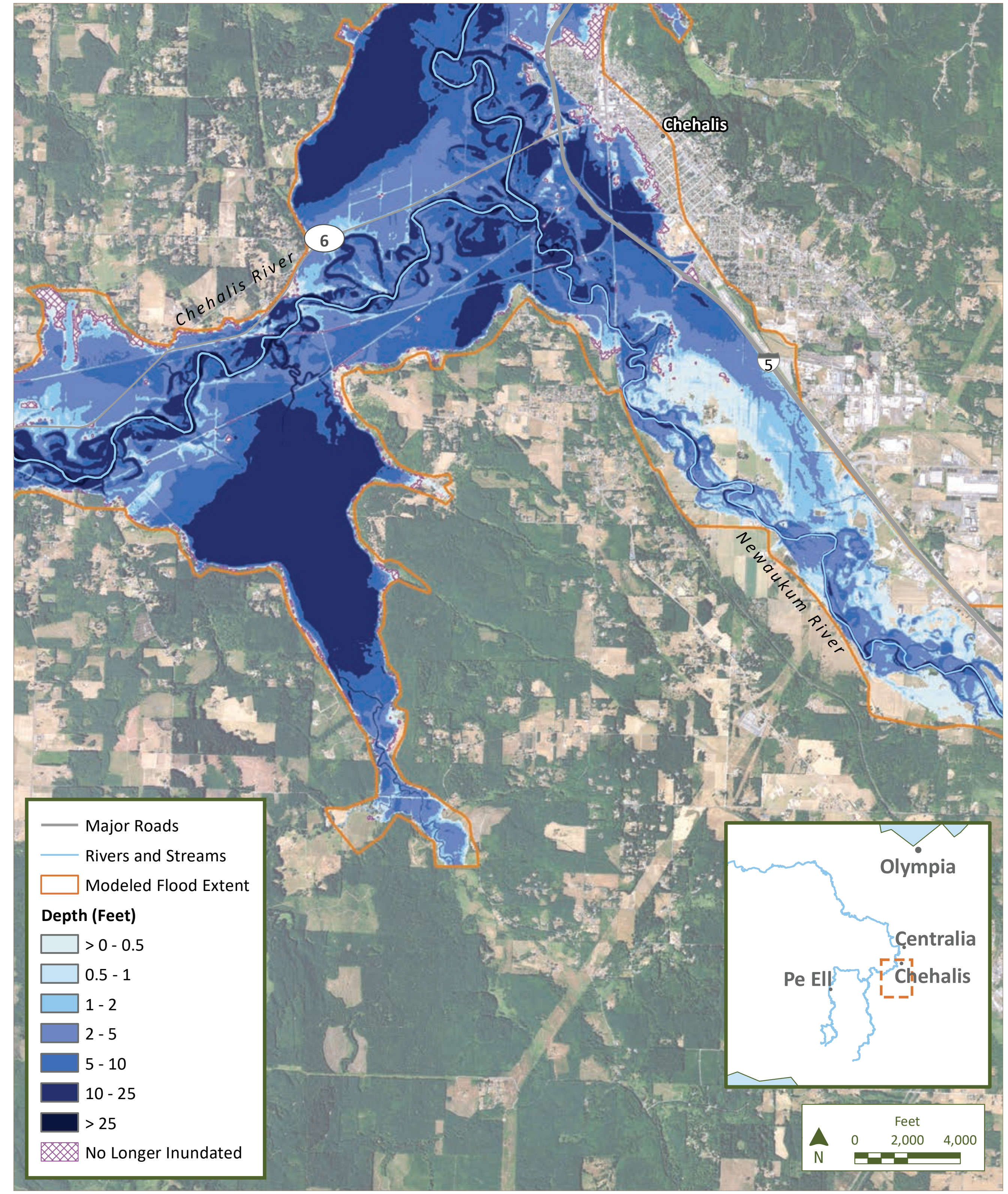
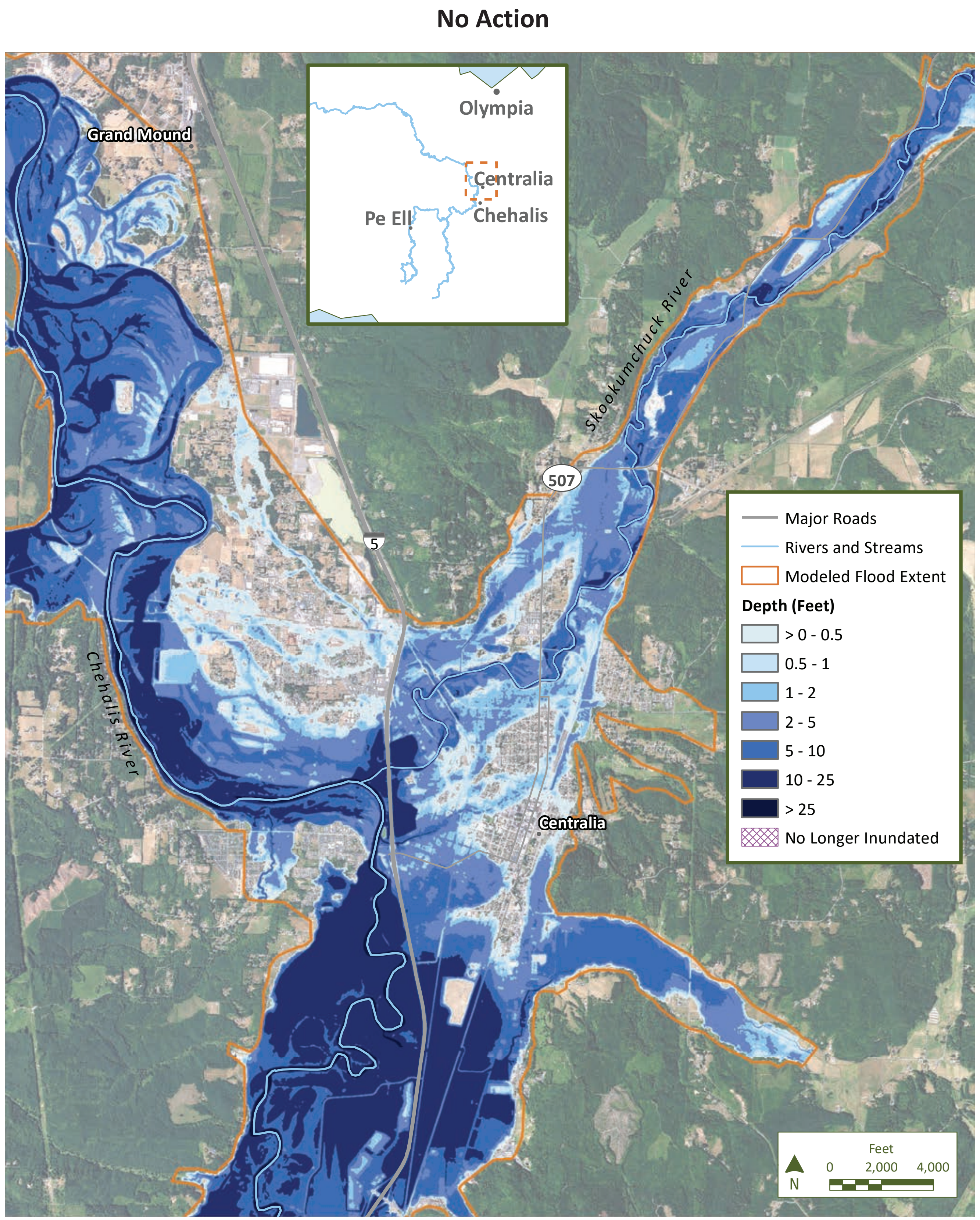


Figure N.5-d
Late-Century Catastrophic Flood



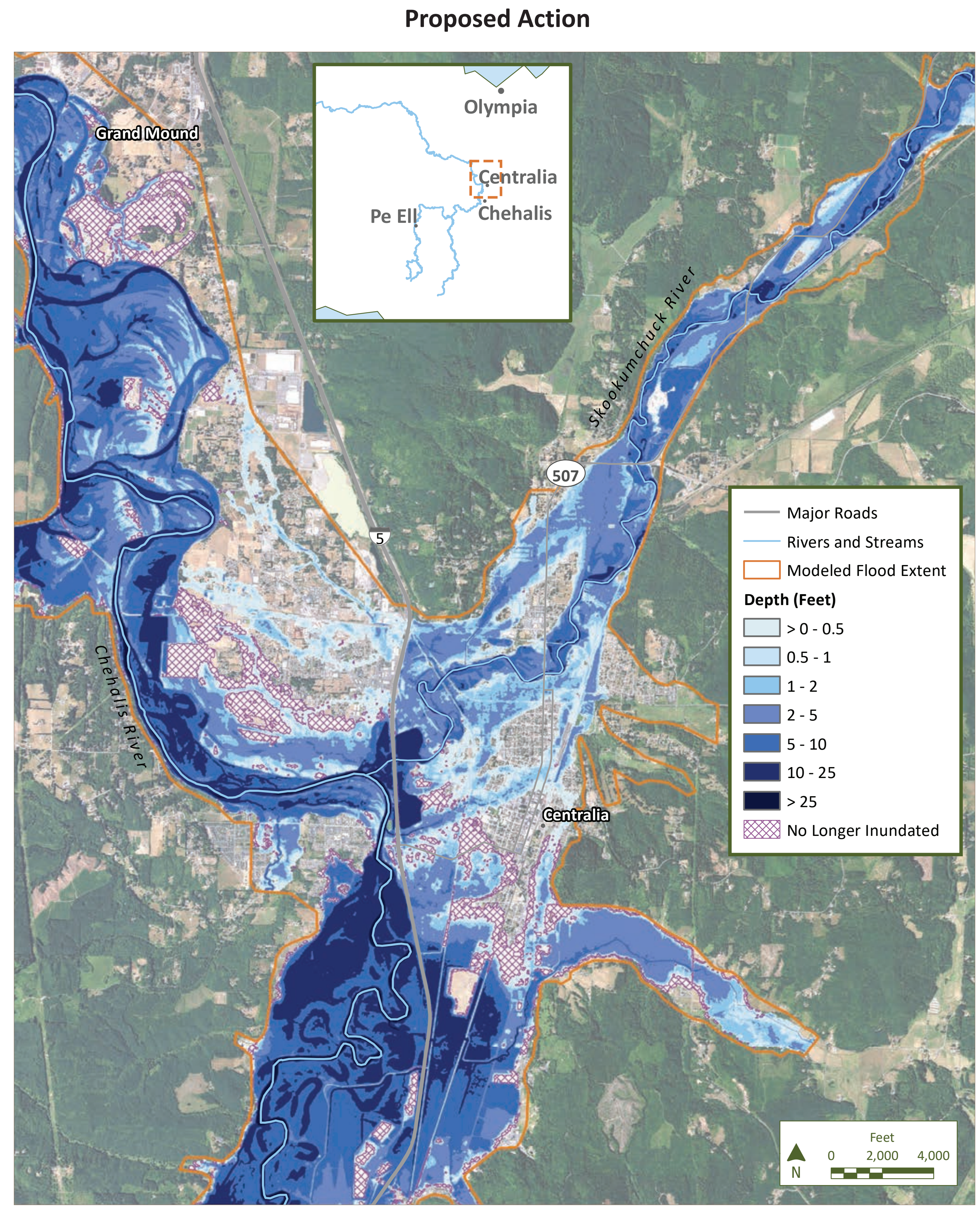
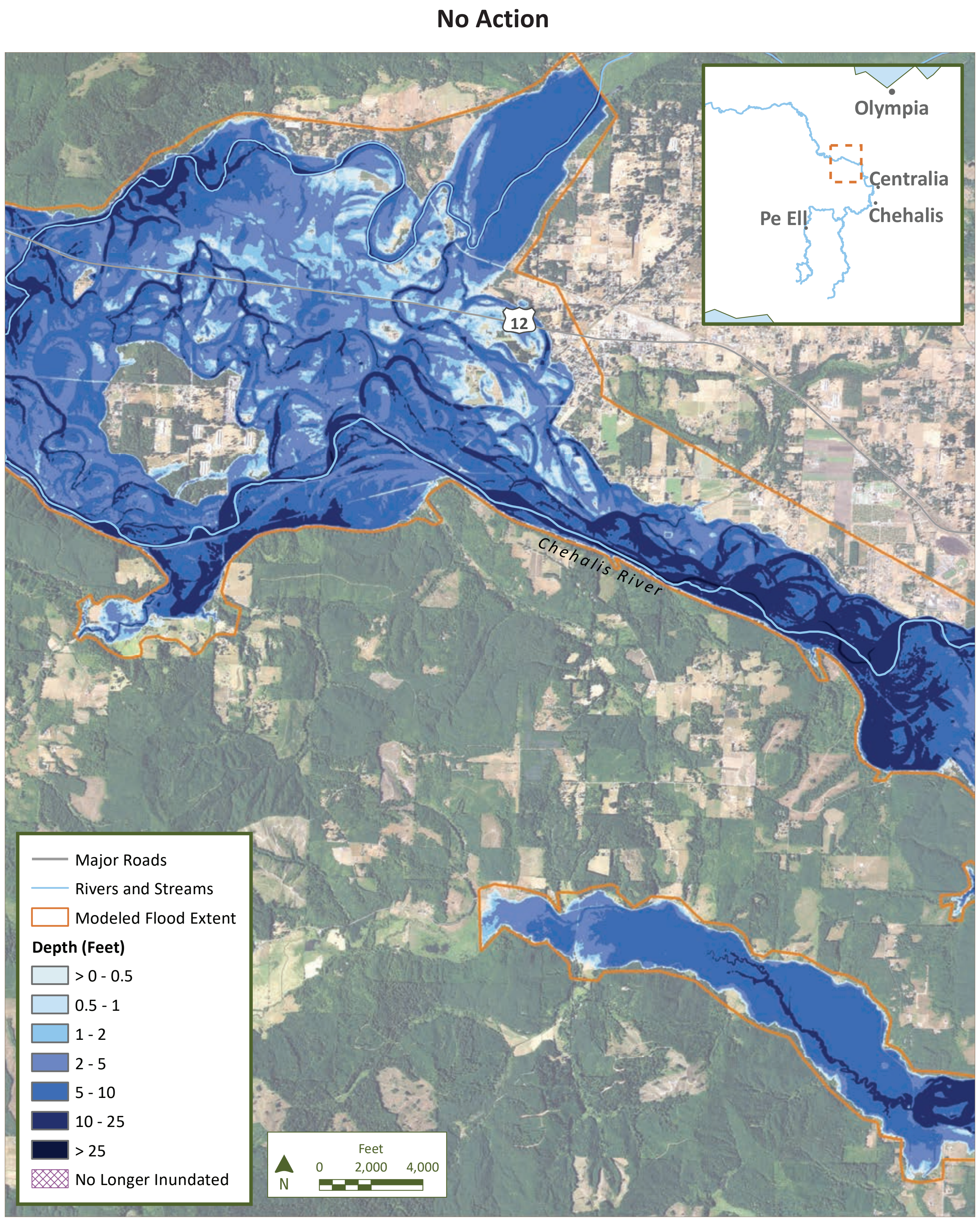


Figure N.5-e
Late-Century Catastrophic Flood



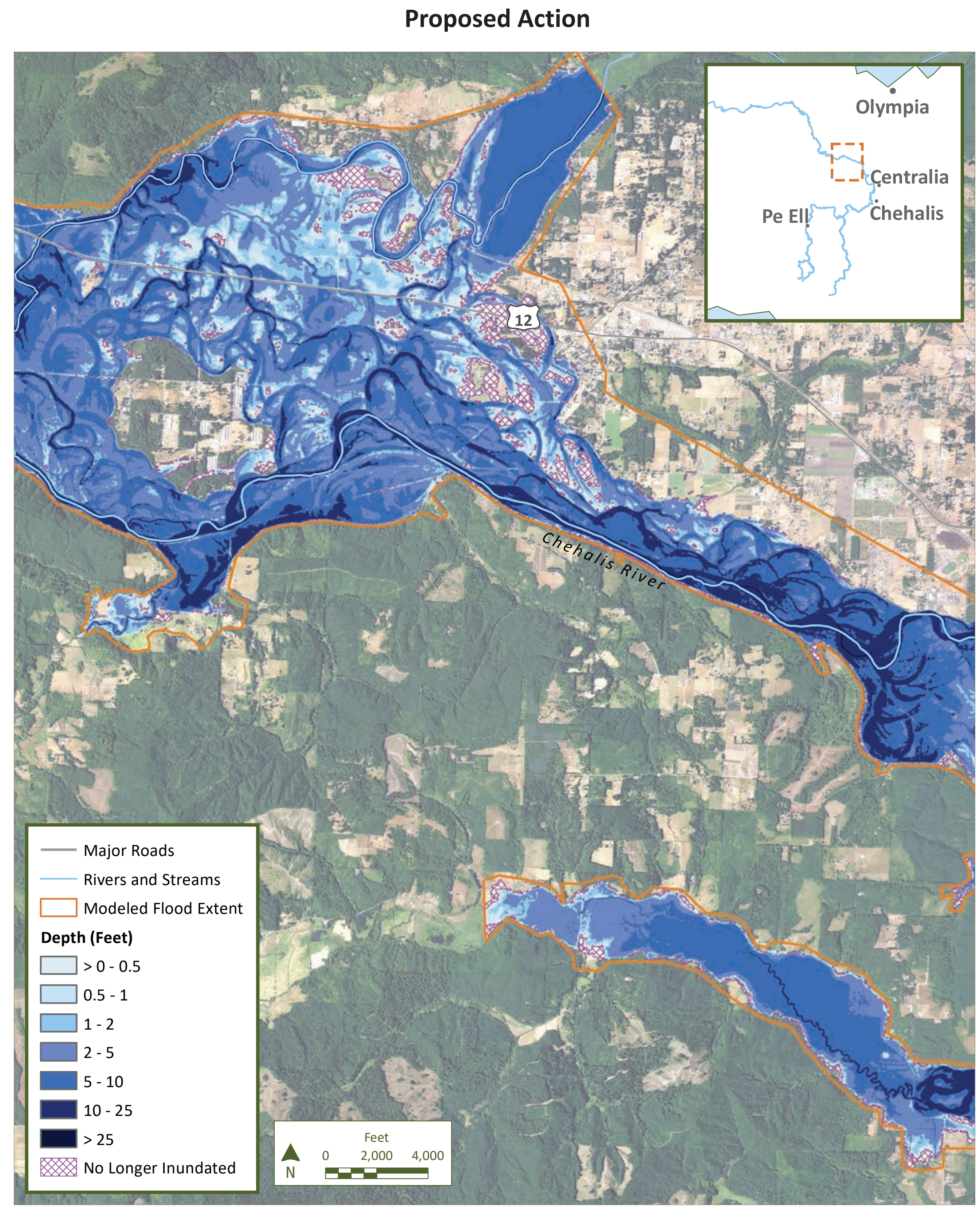


Figure N.5-f
Late-Century Catastrophic Flood

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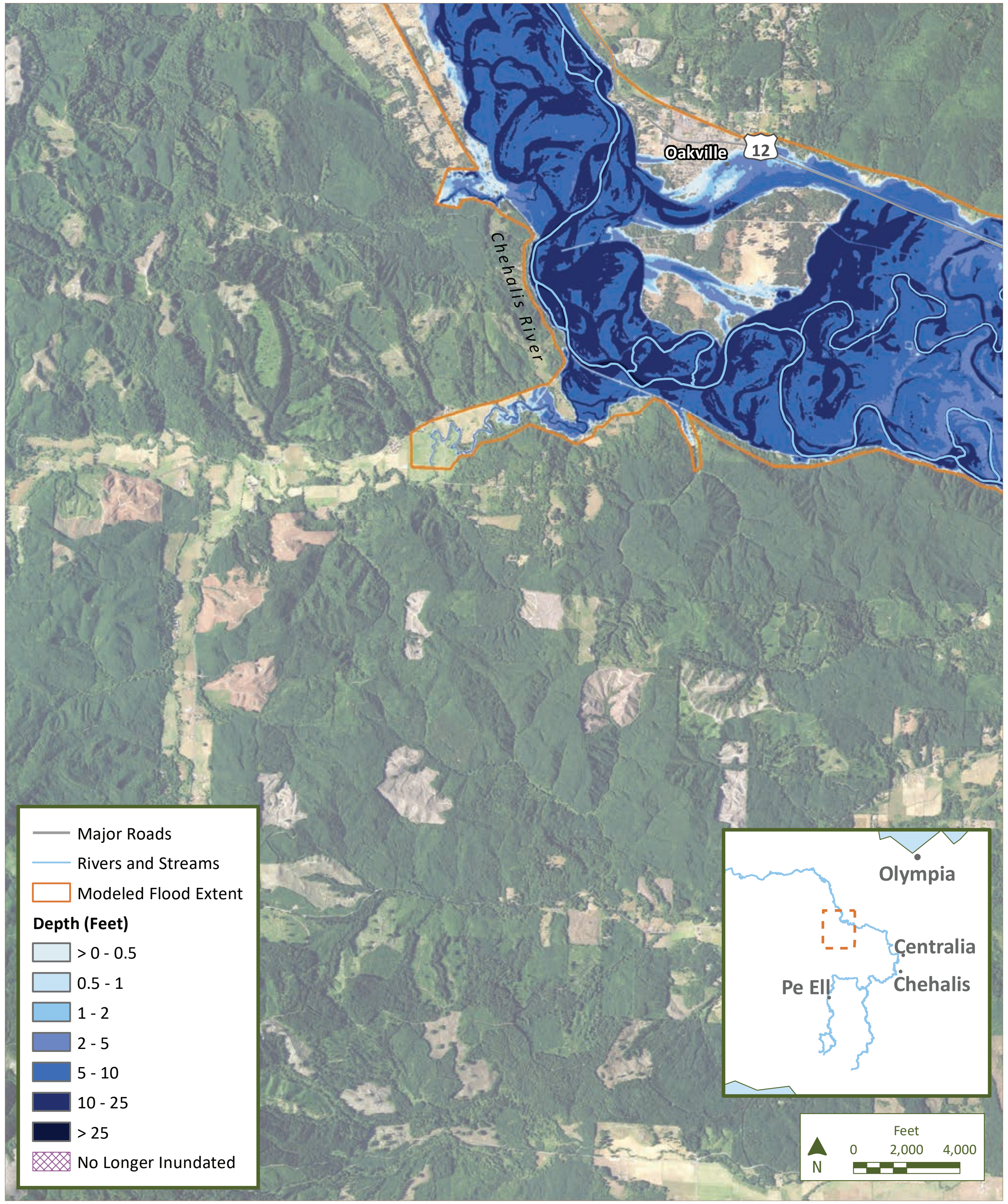

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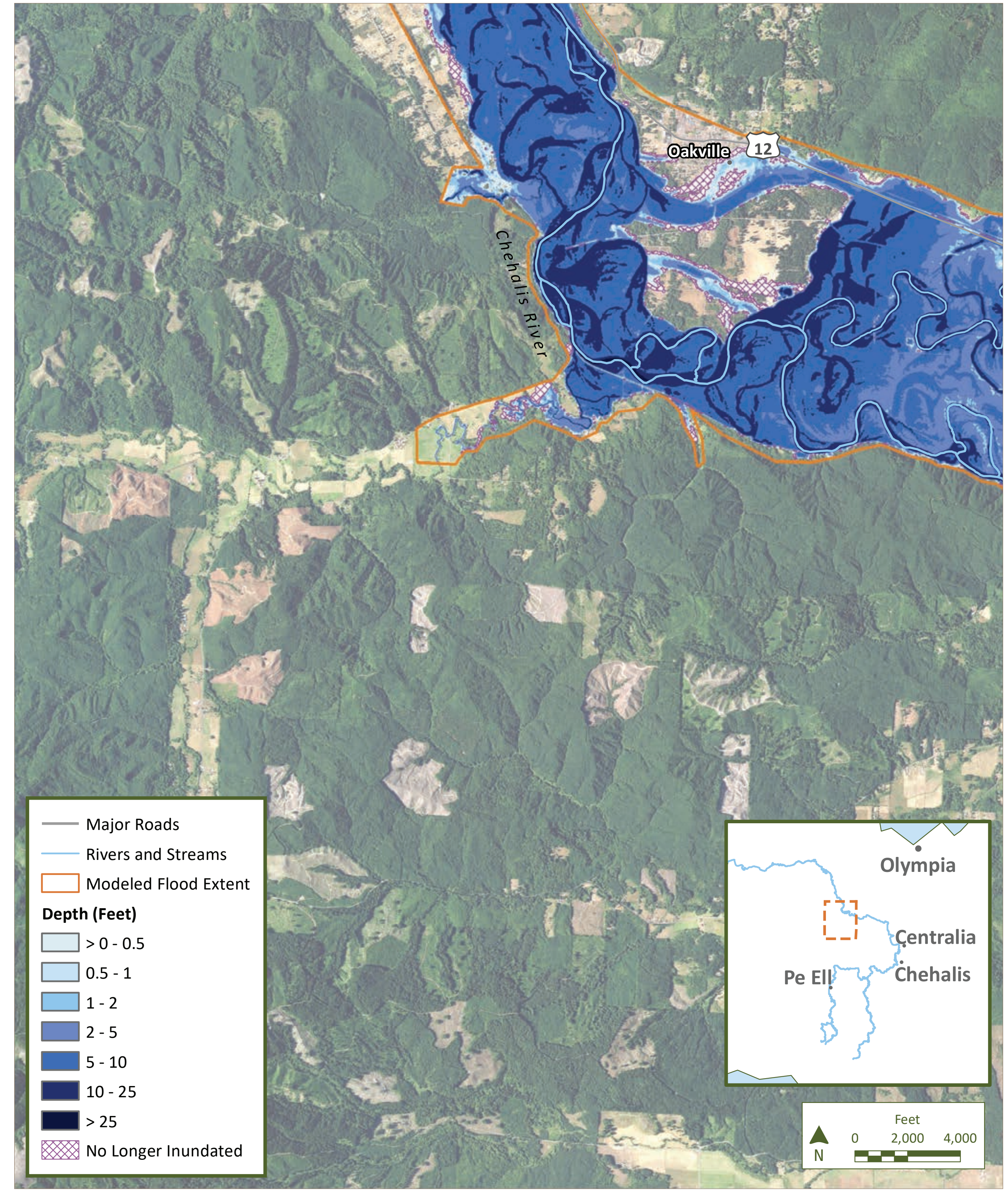

Figure N.5-g
Late-Century Catastrophic Flood

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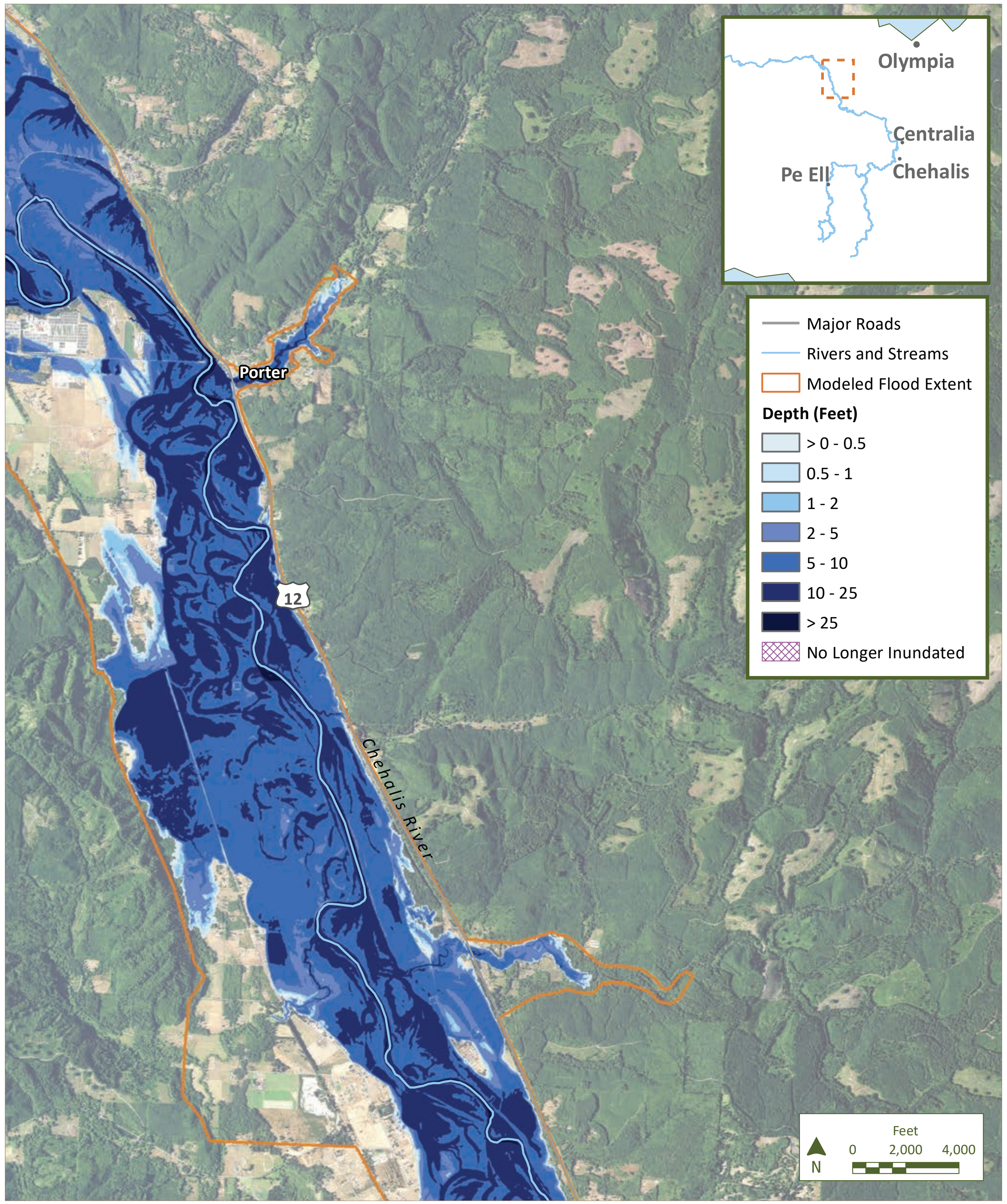

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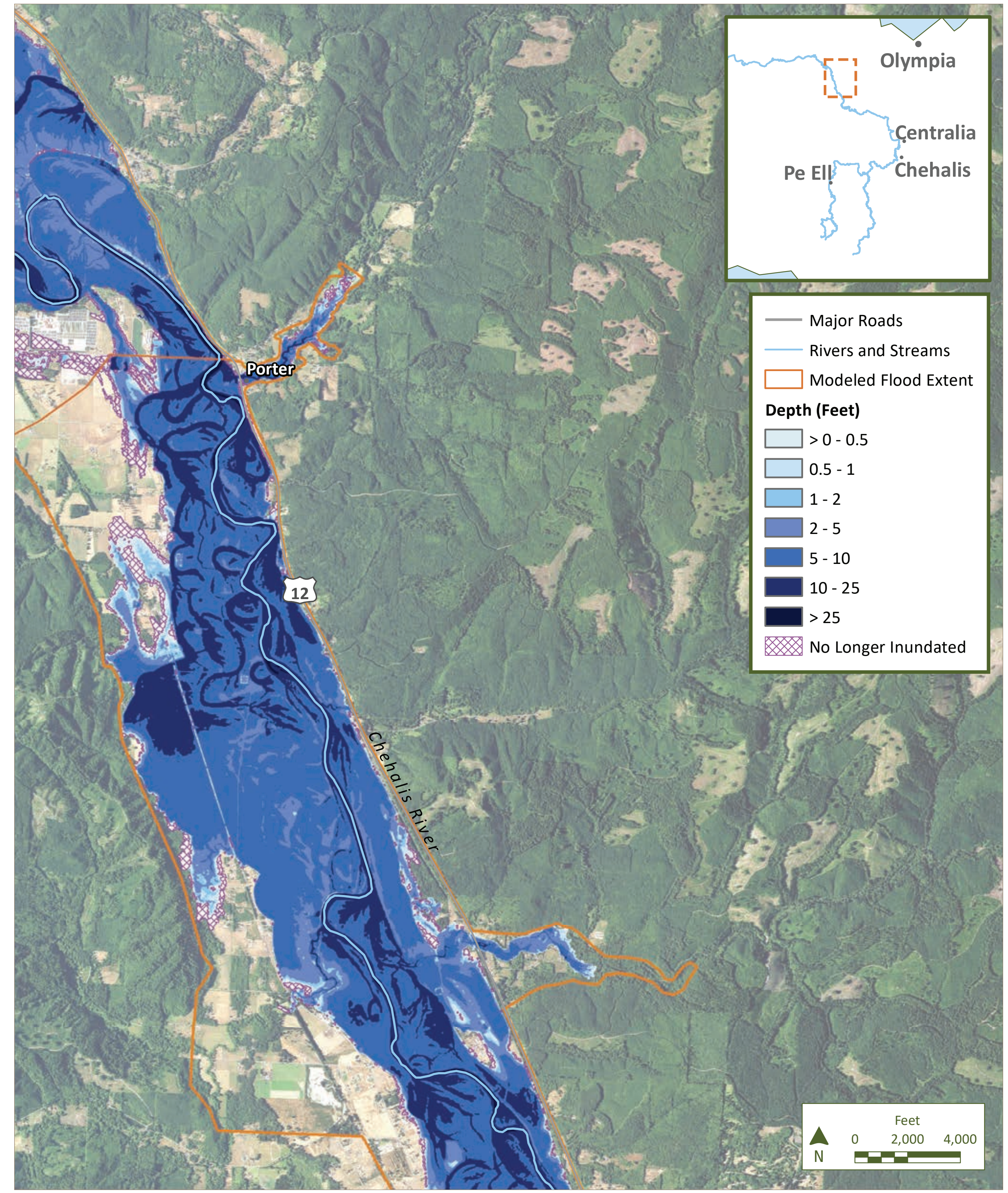

Figure N.5-h
Late-Century Catastrophic Flood

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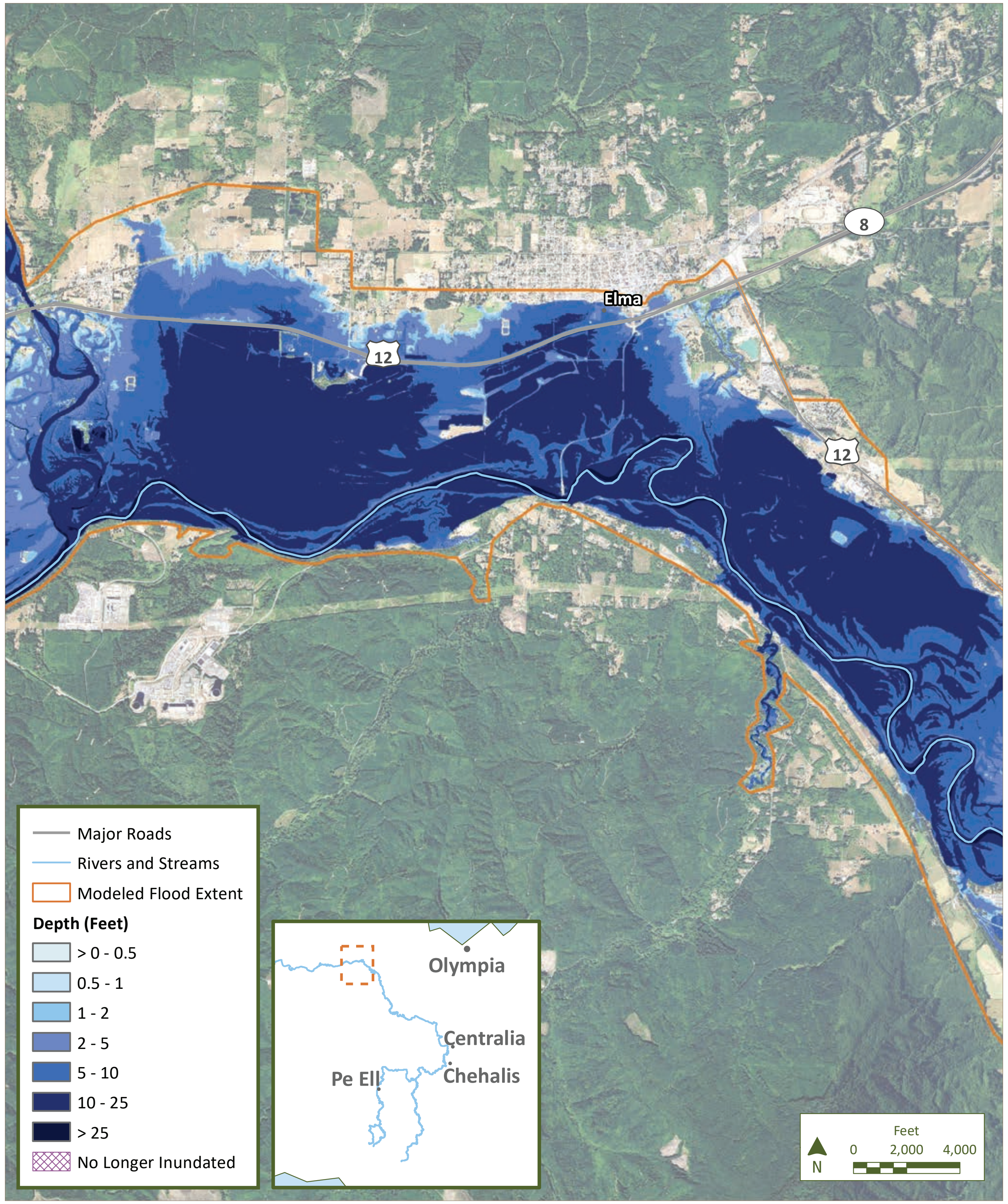

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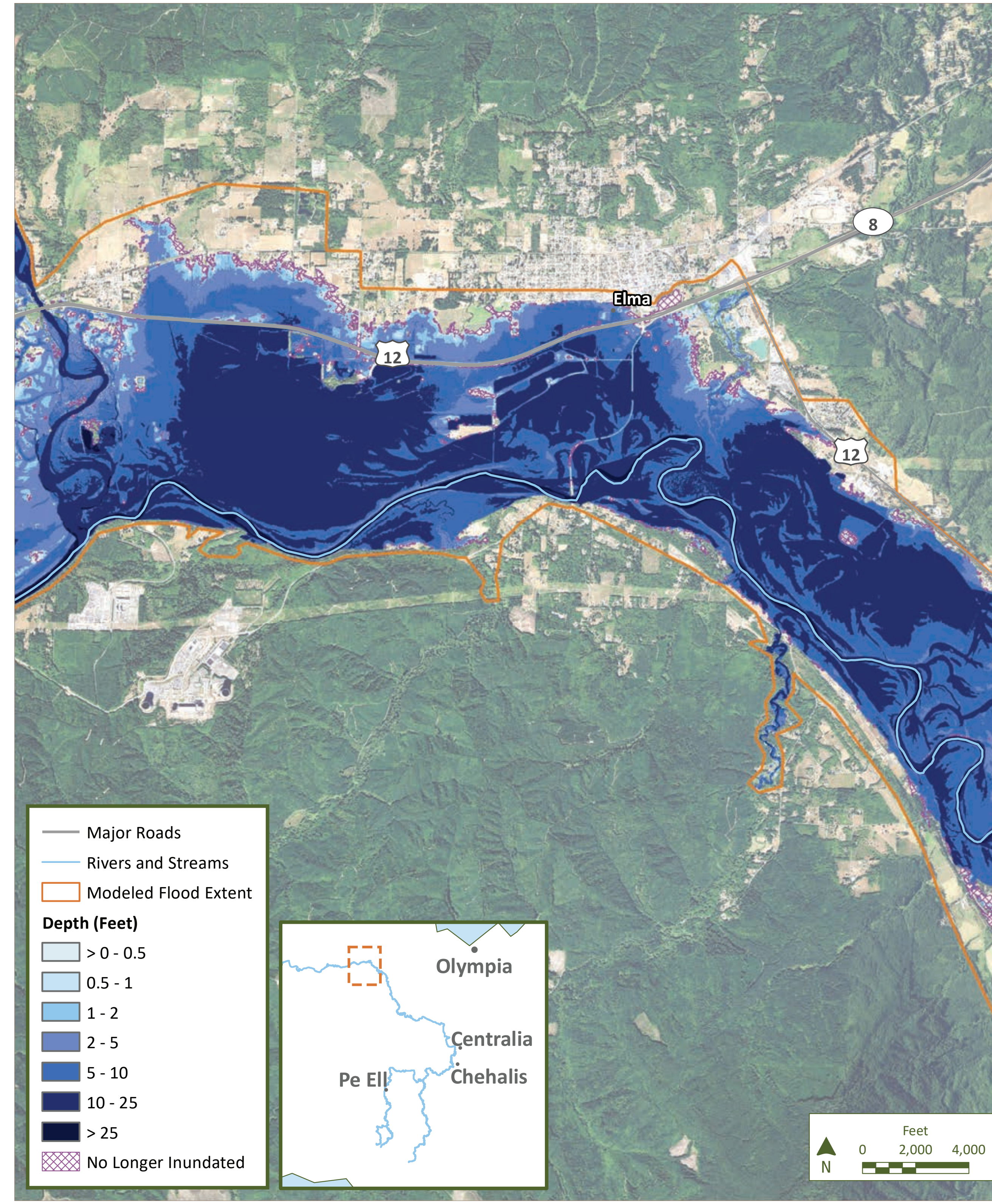
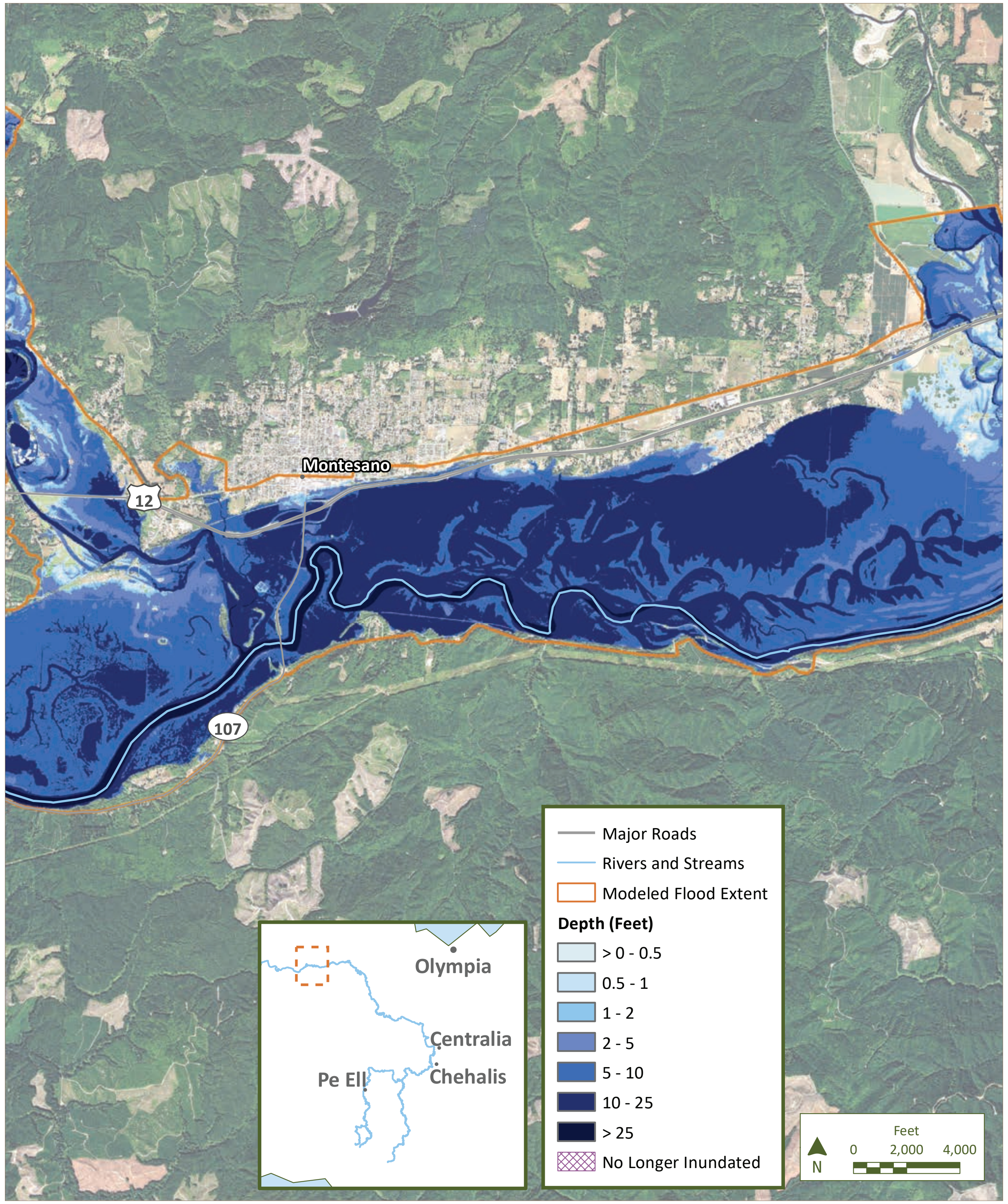


Figure N.5-i
Late-Century Catastrophic Flood

No Action



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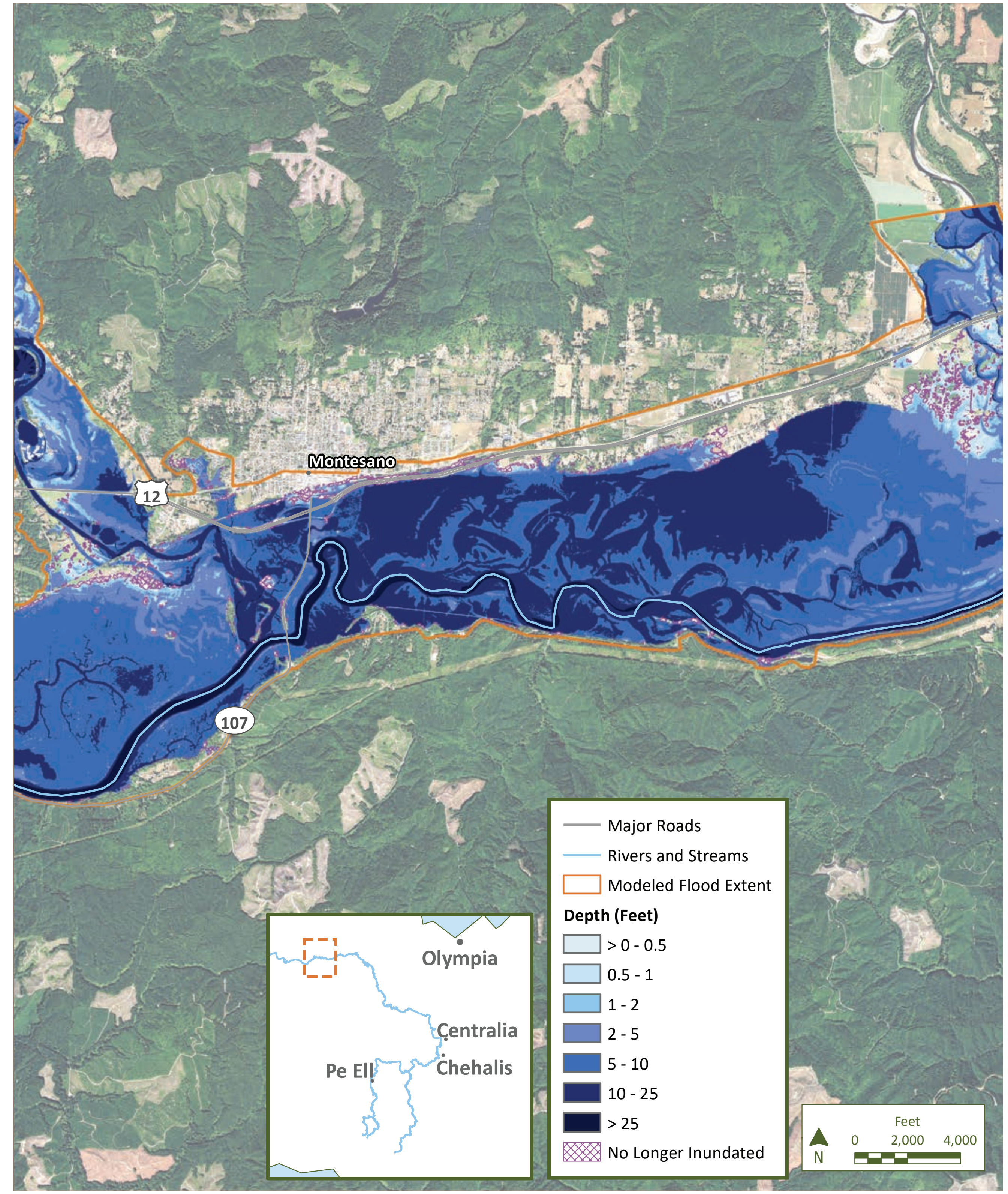

Figure N.5-j
Late-Century Catastrophic Flood

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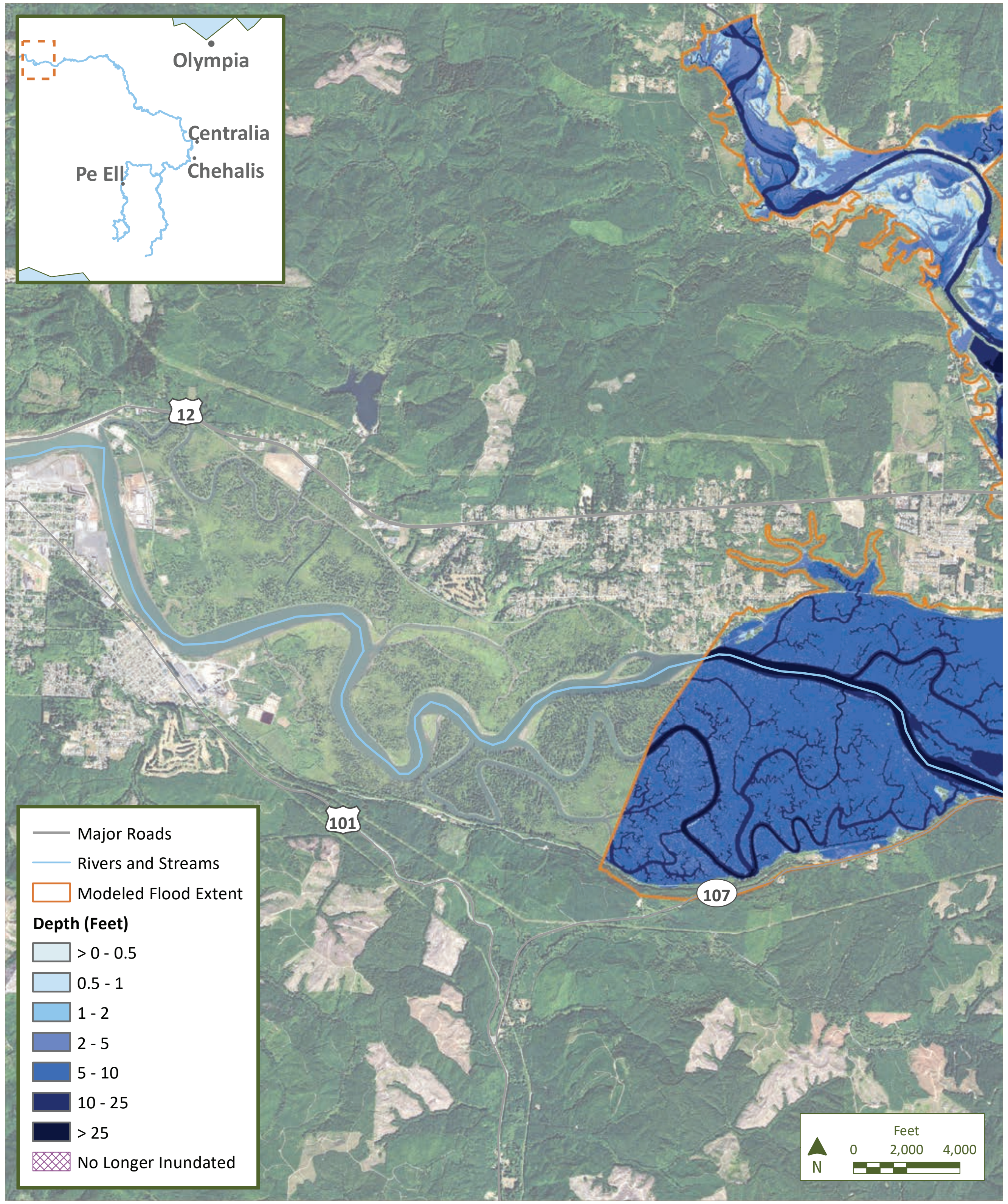

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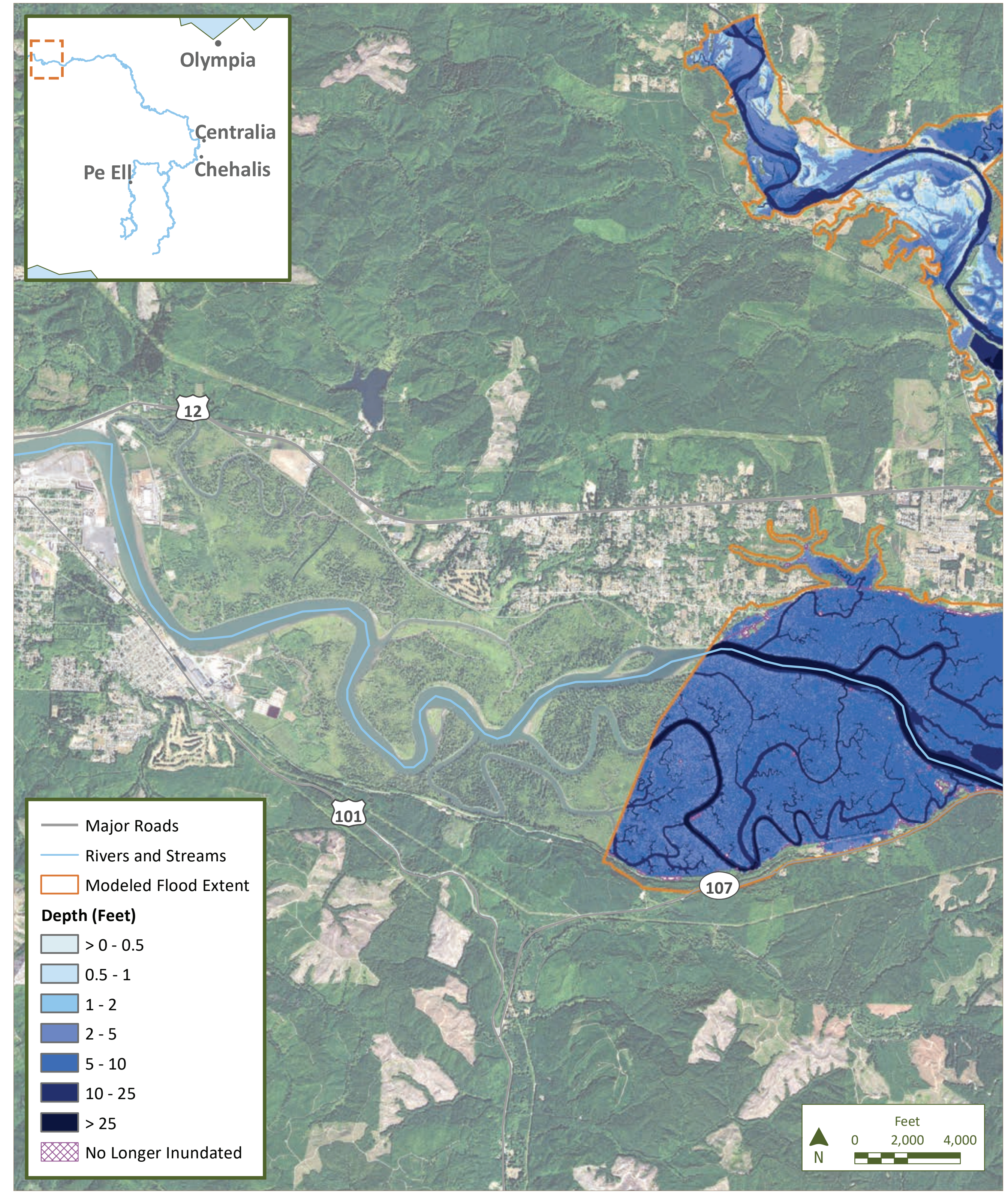


Figure N.6
Key to Extents in City-Focused Maps

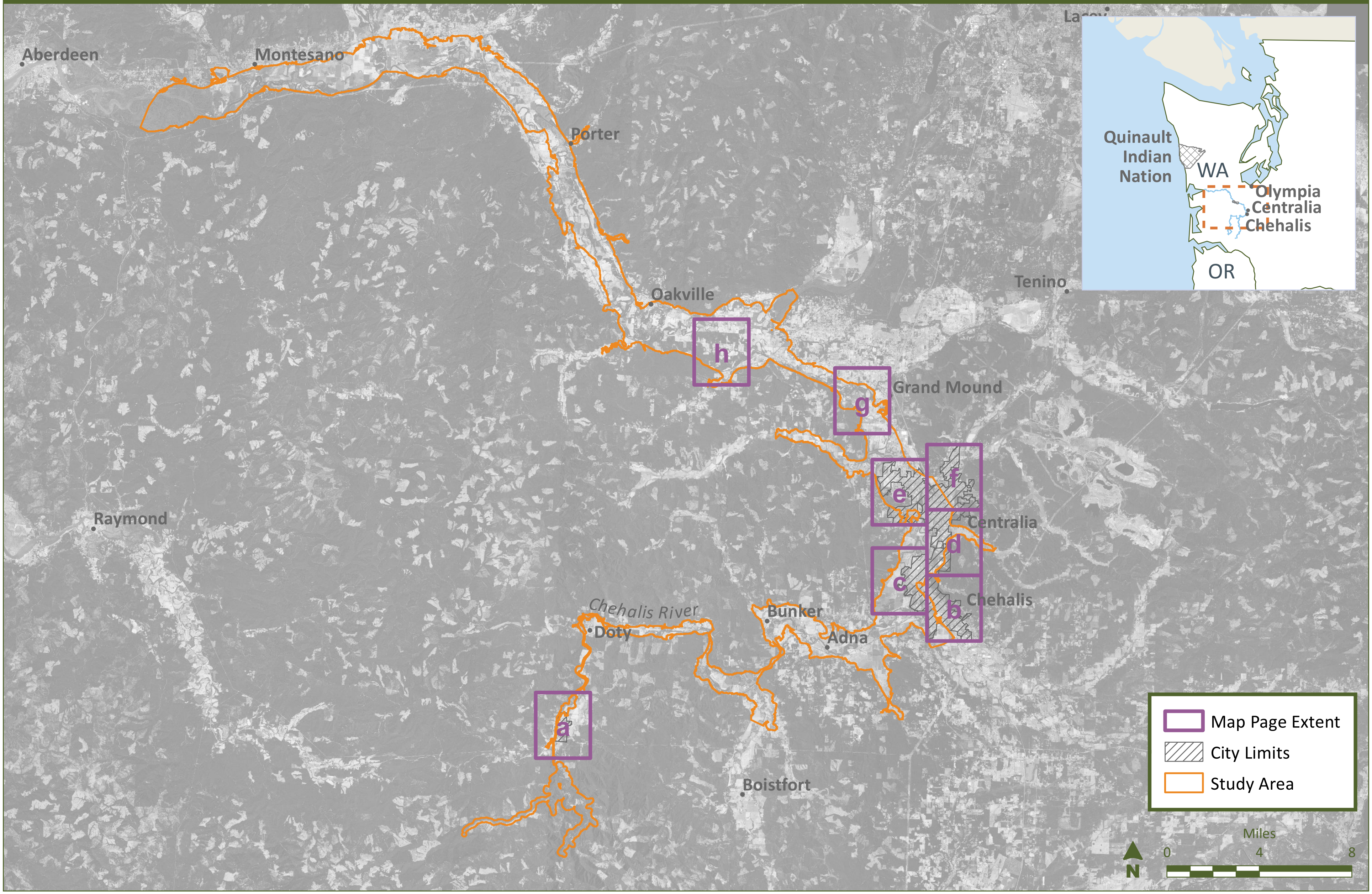
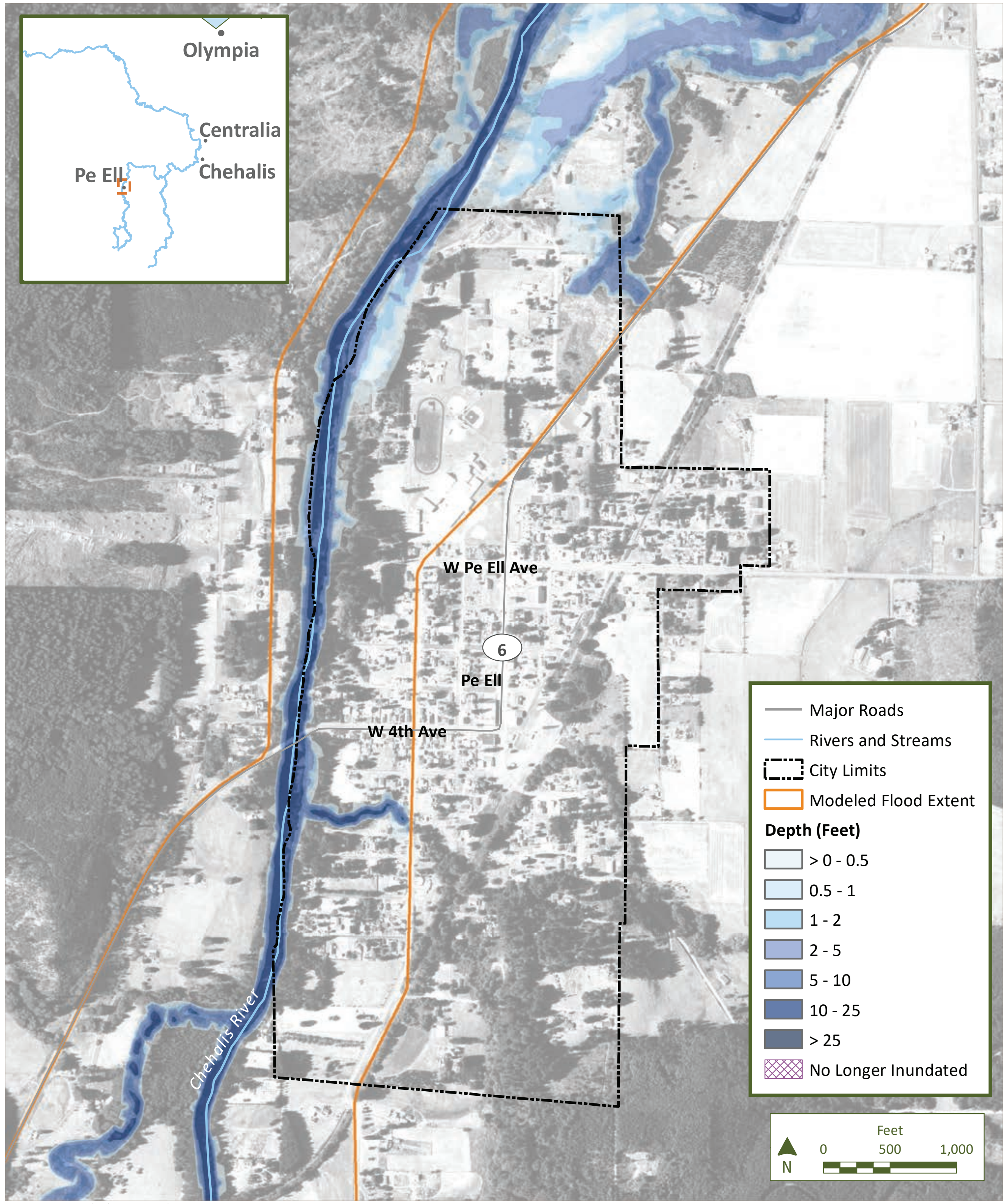


Figure N.7-a
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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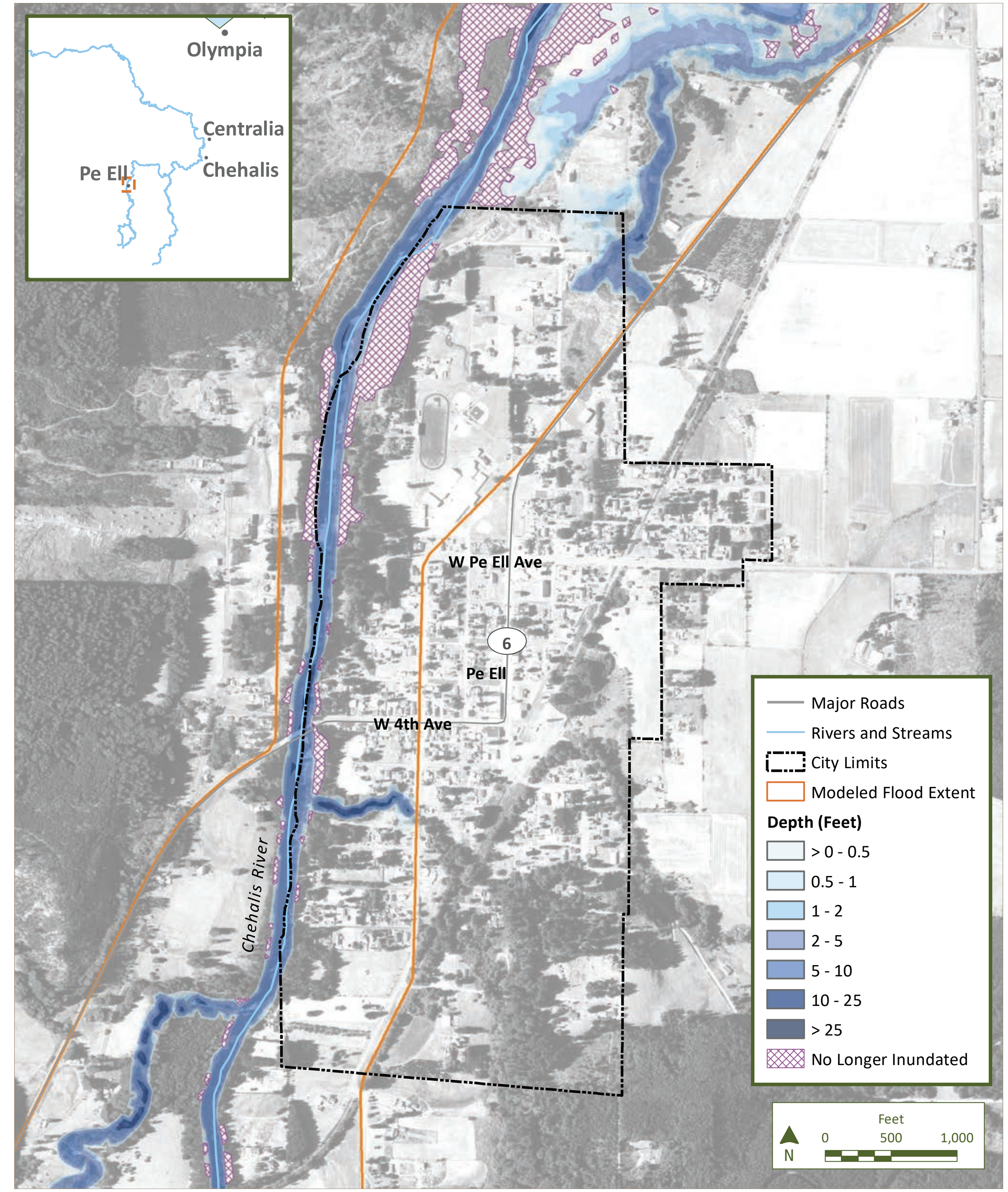

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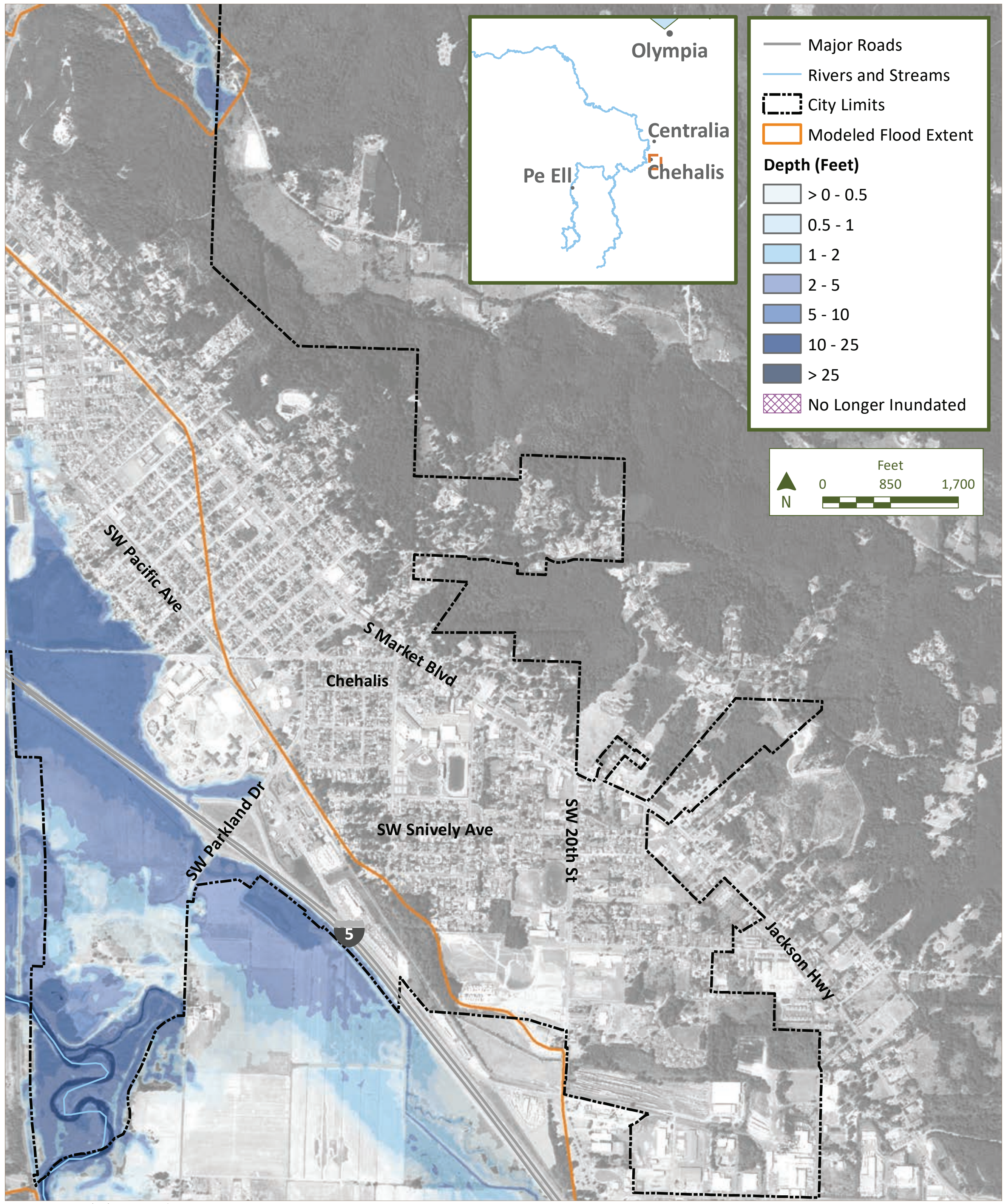
Figure N.7-b
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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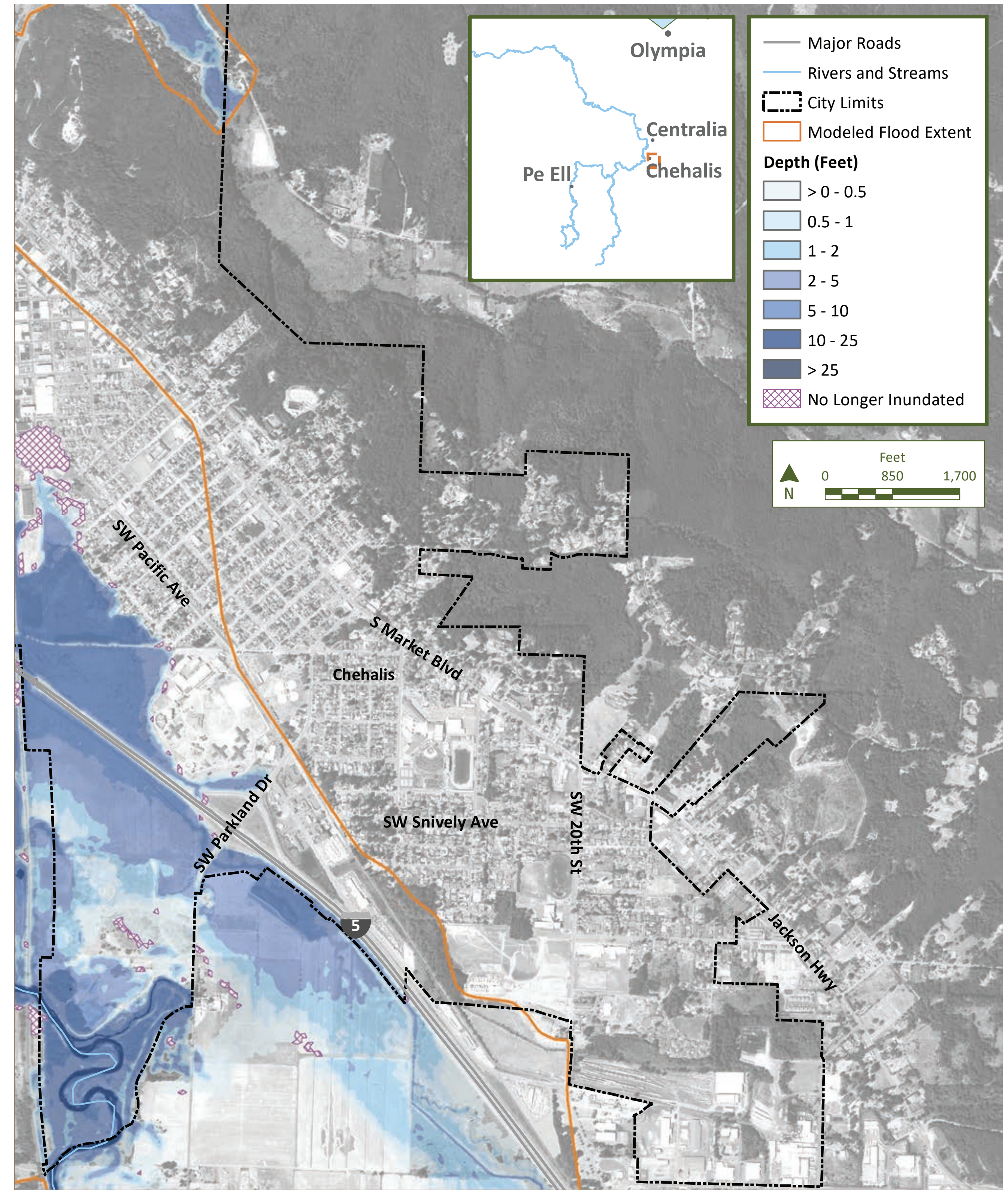

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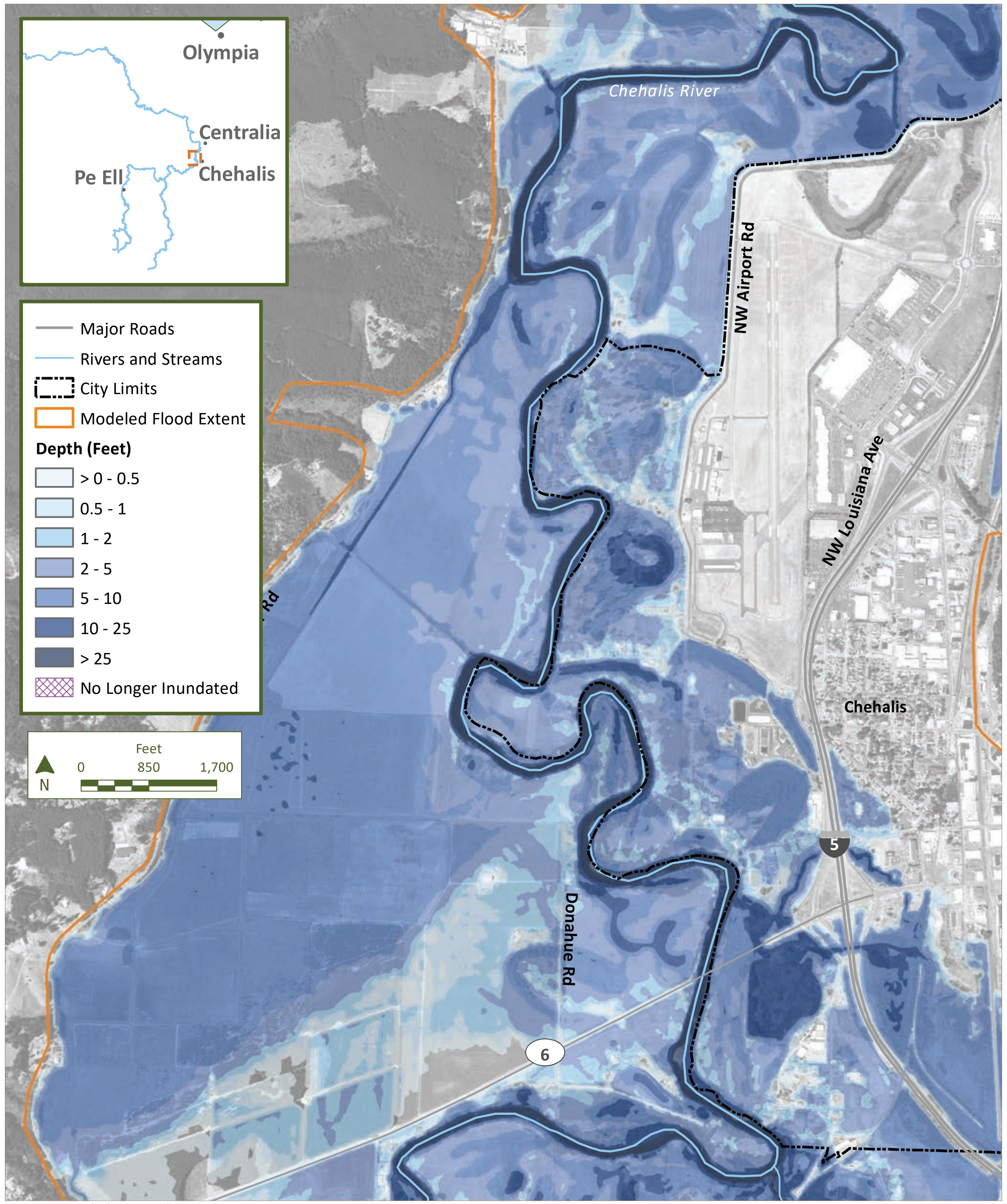
Figure N.7-c
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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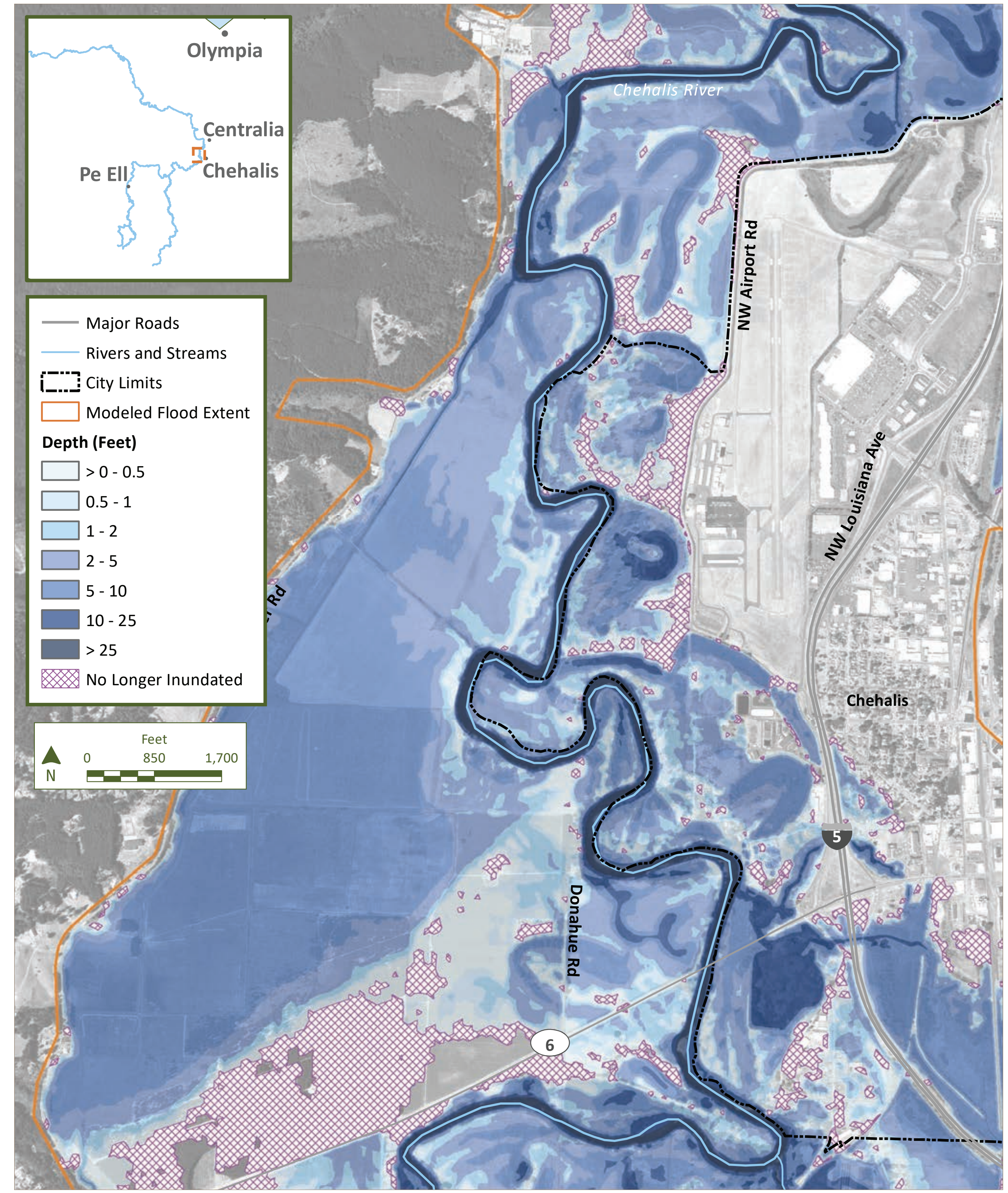

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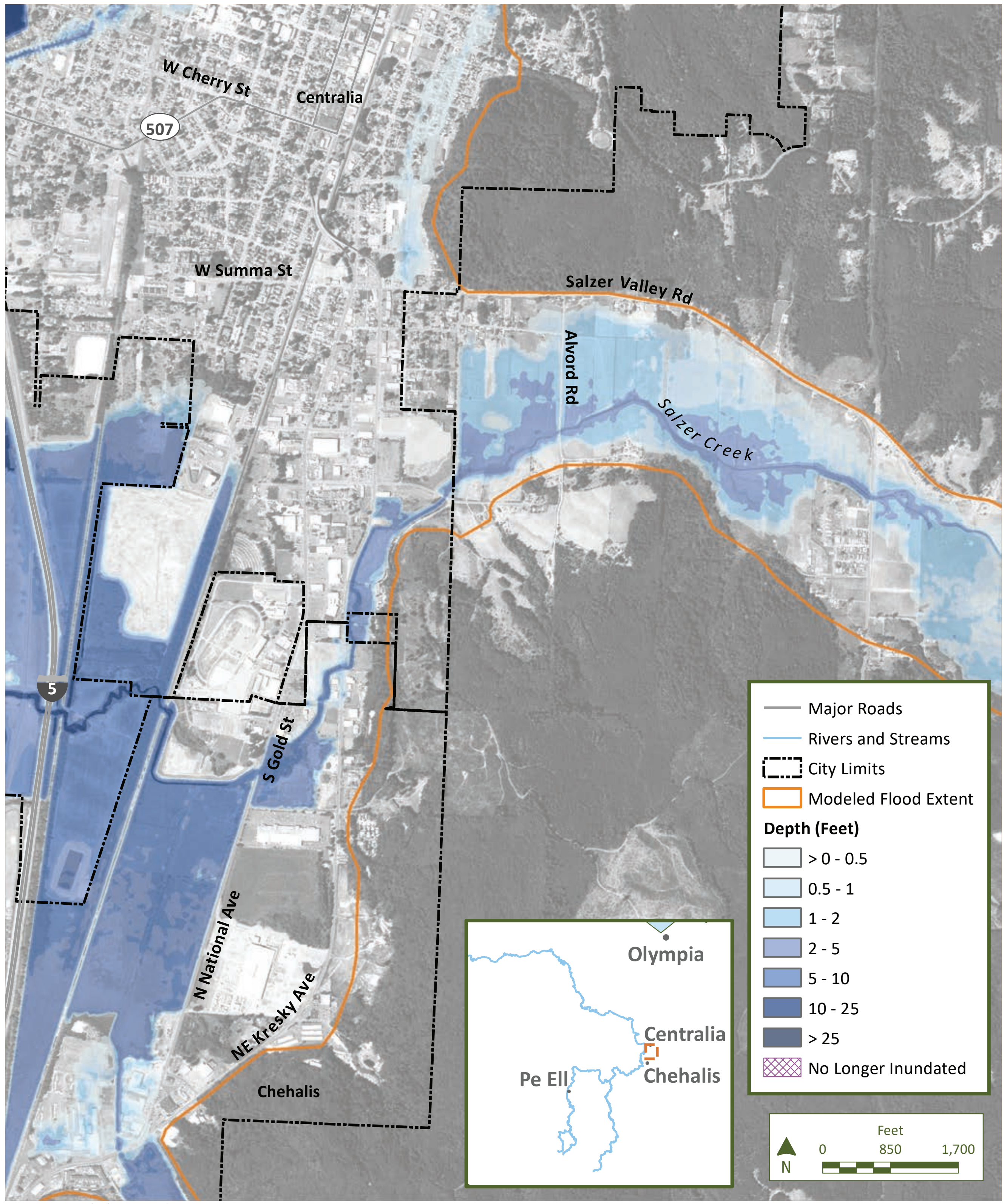
Figure N.7-d
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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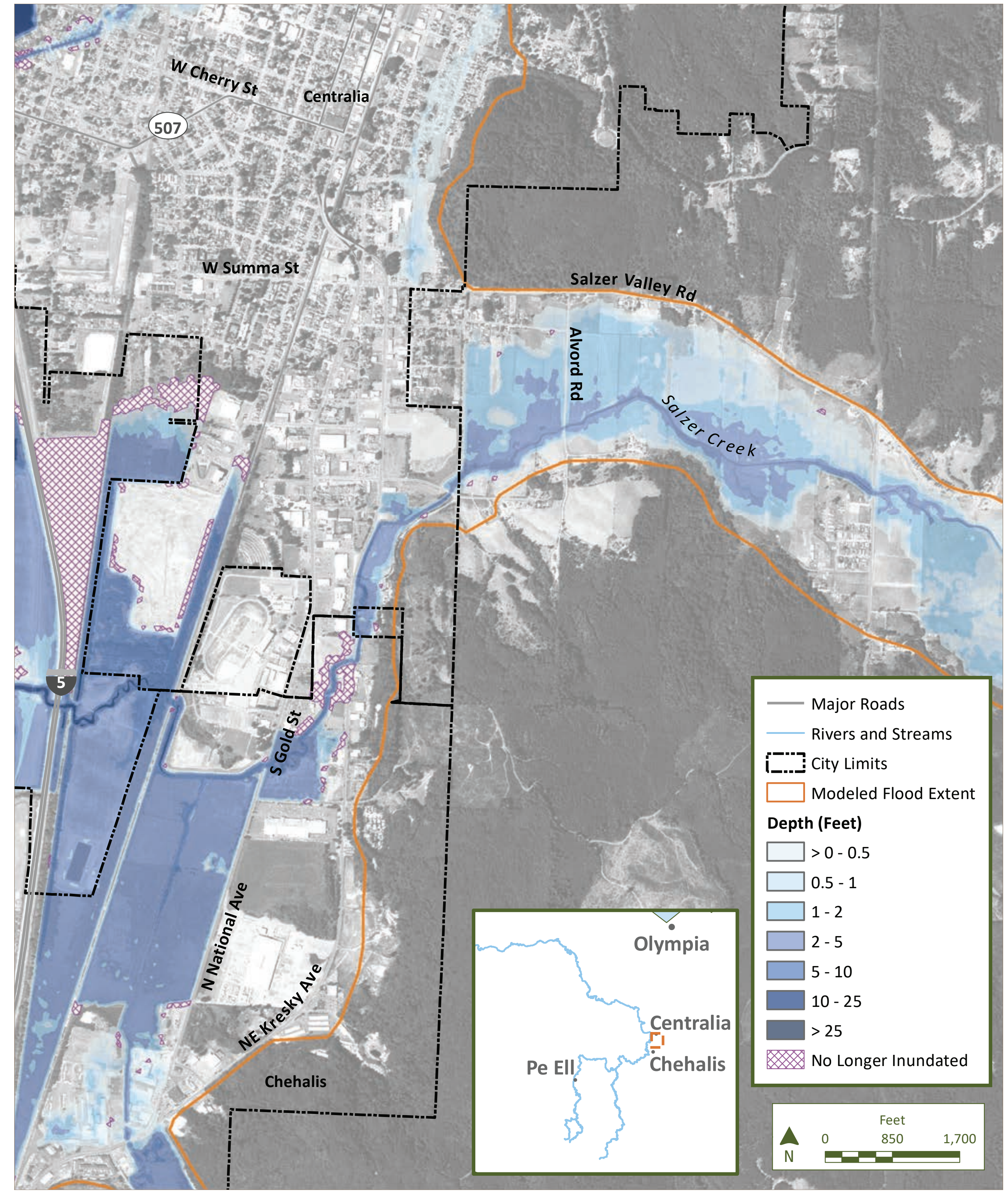

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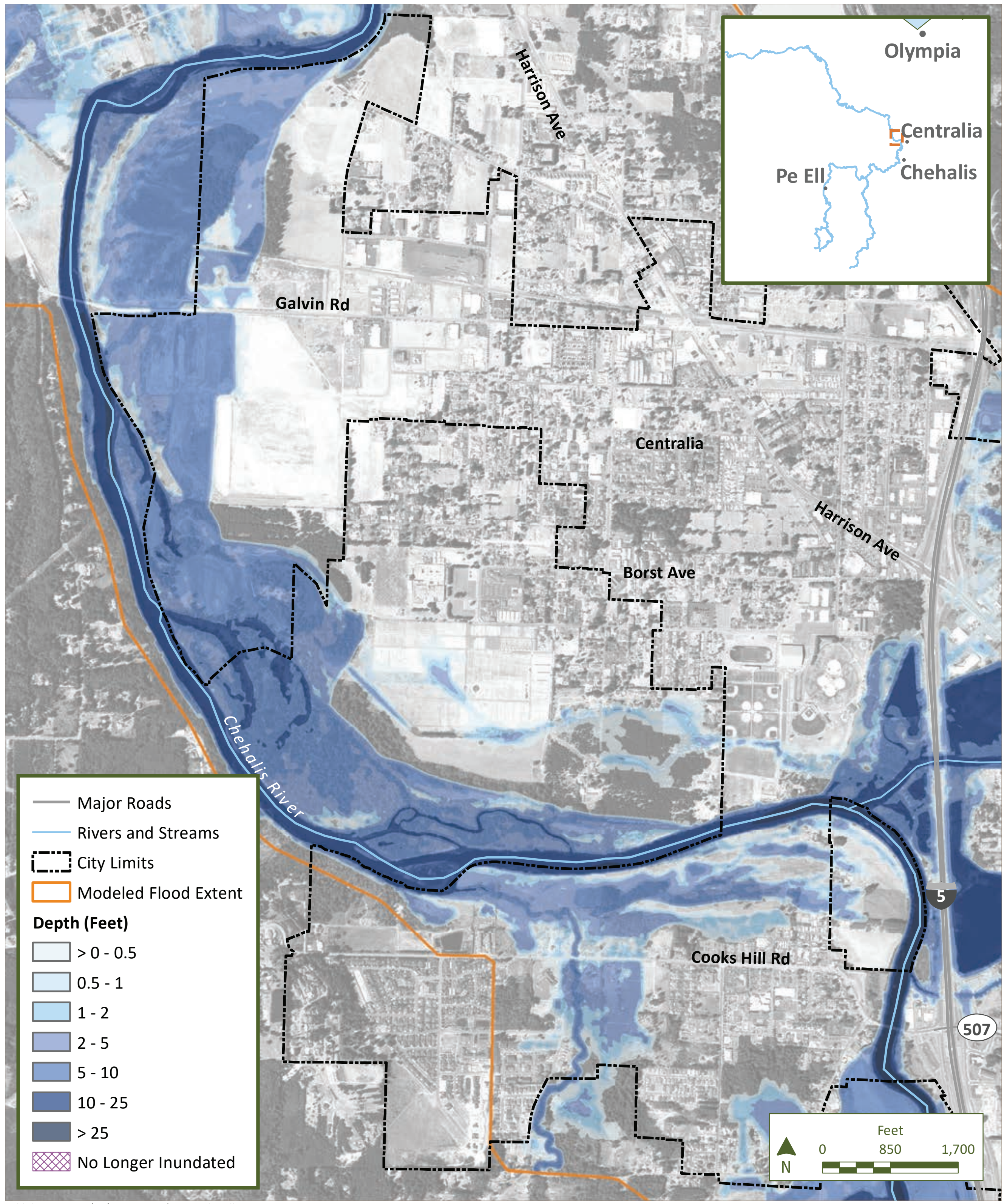
Figure N.7-e
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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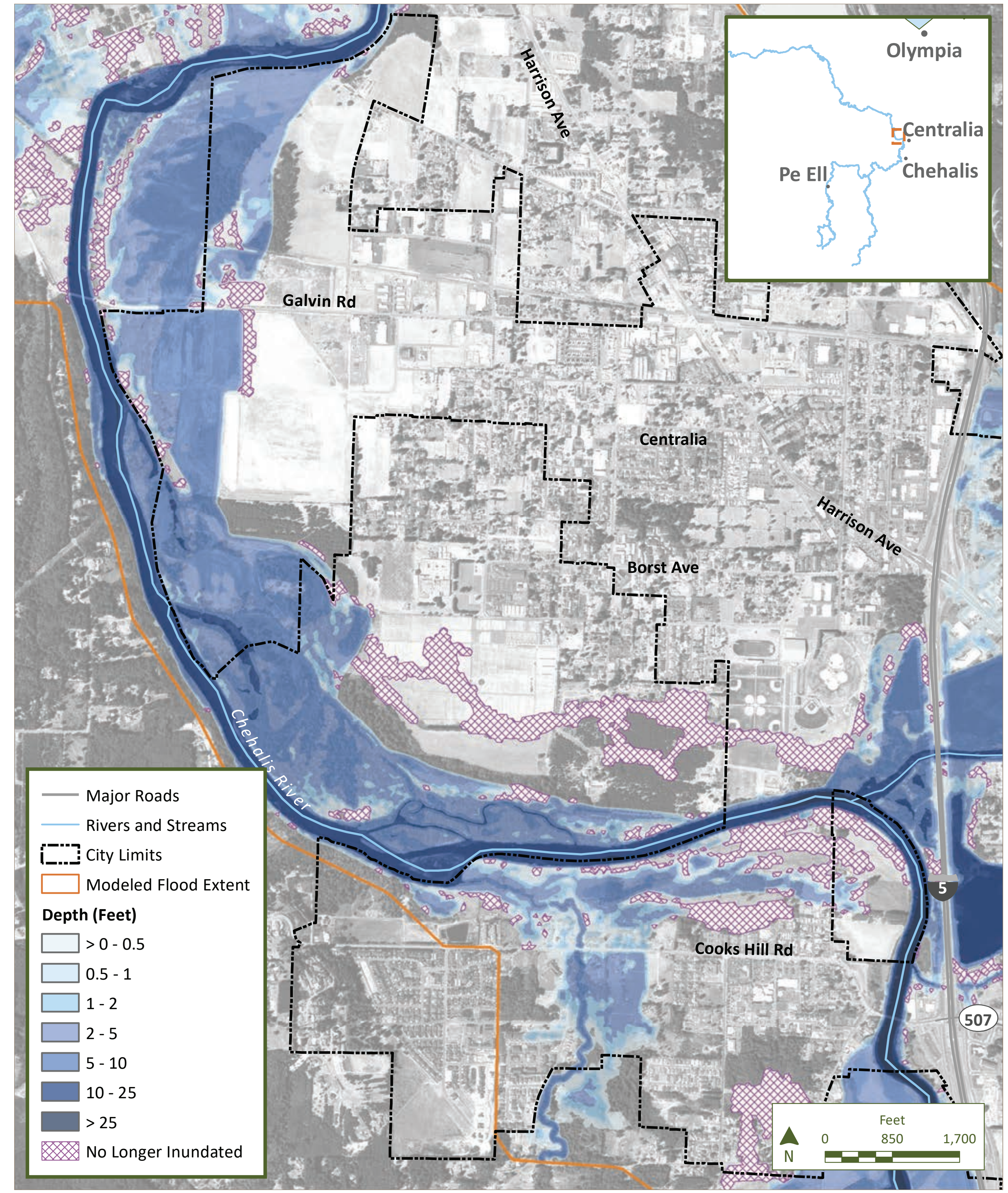

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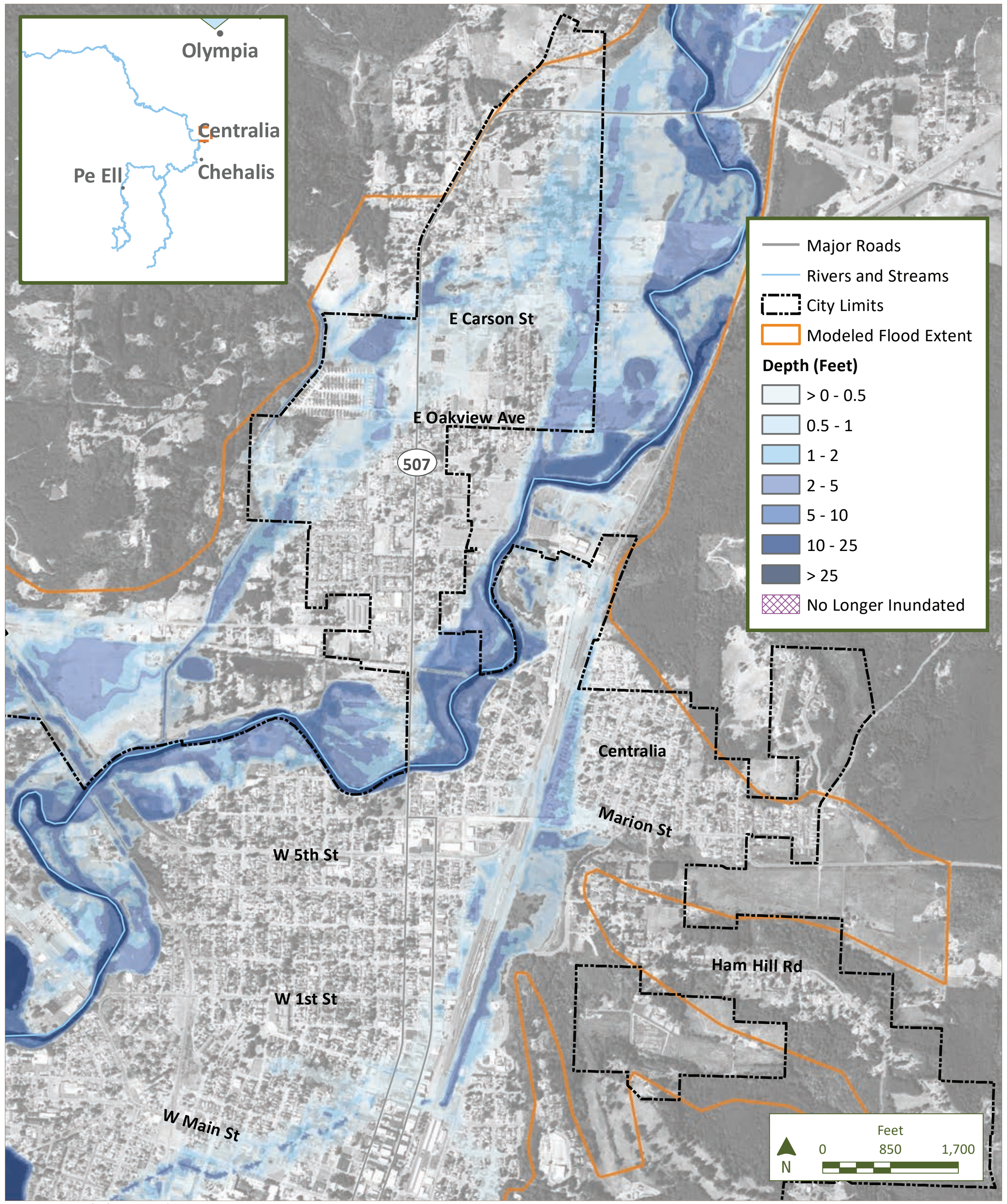
Figure N.7-f
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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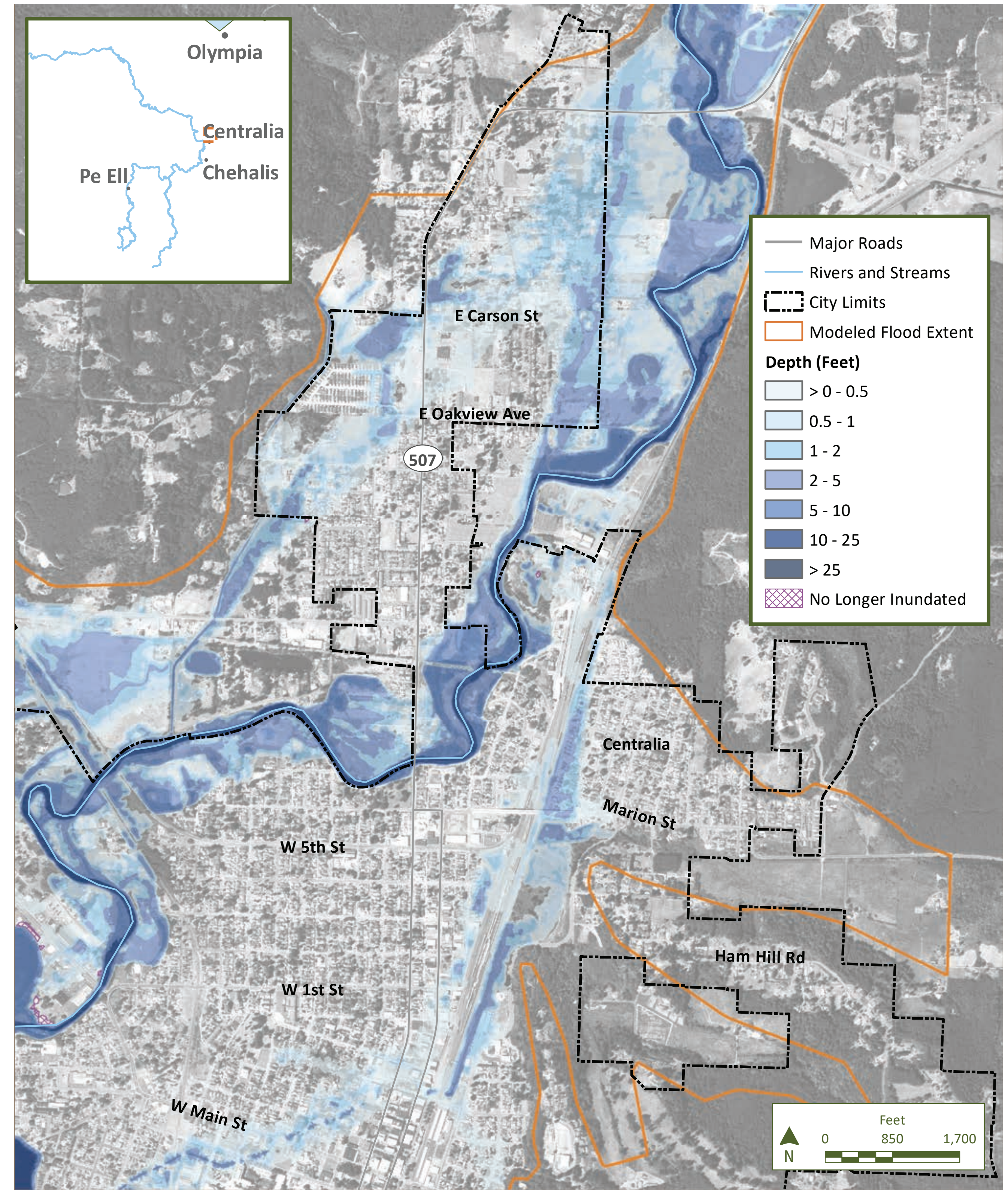

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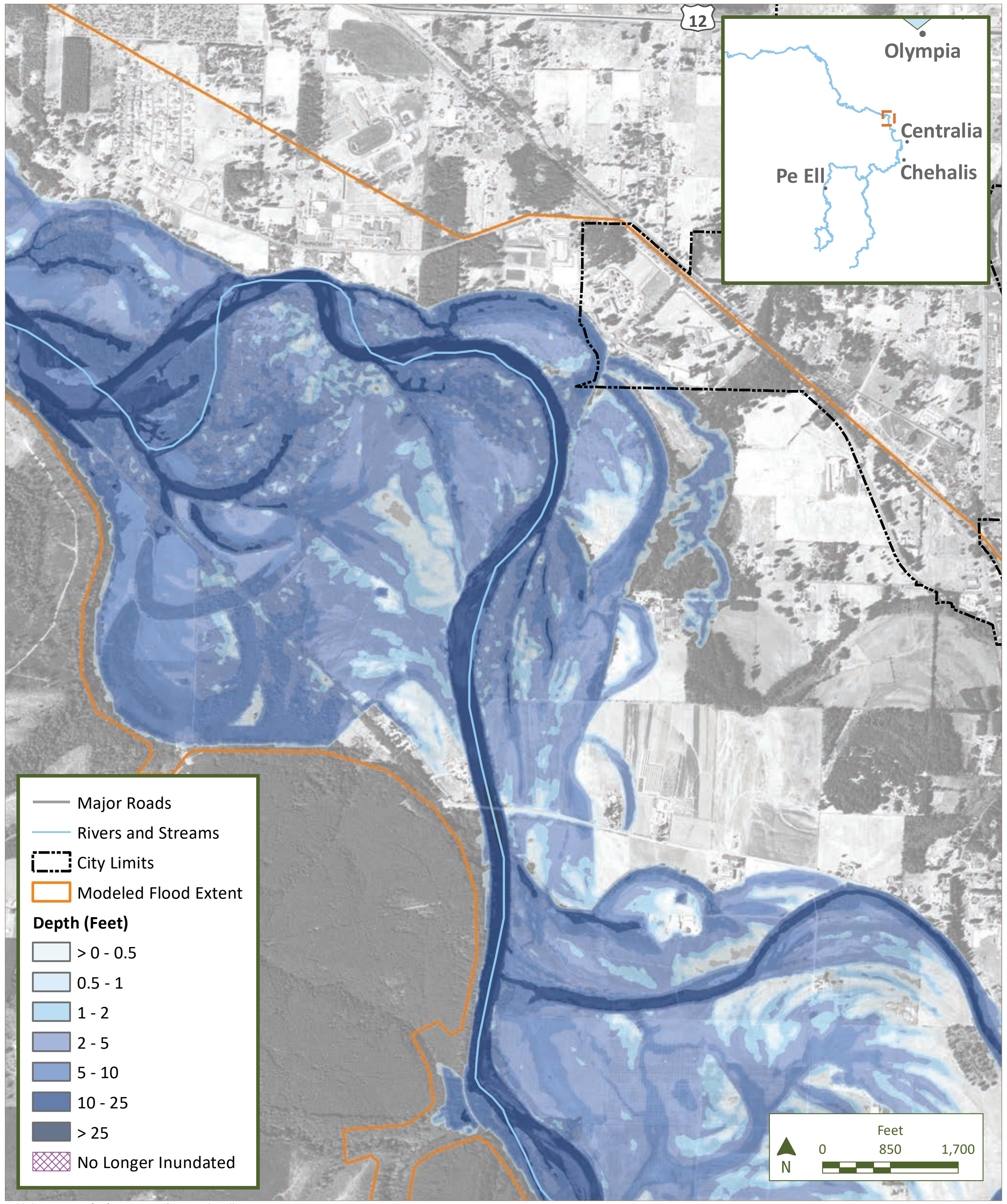
Figure N.7-g
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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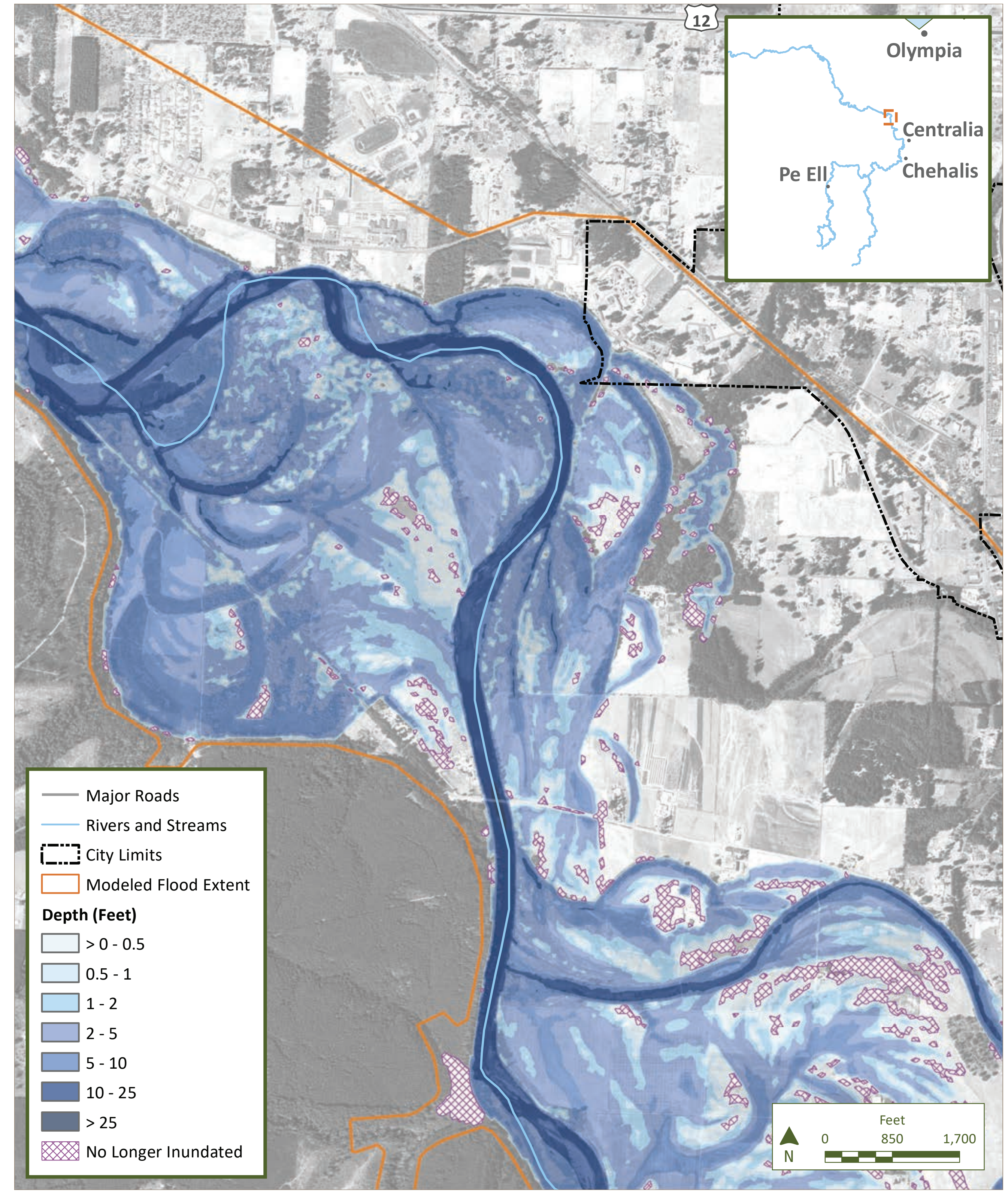

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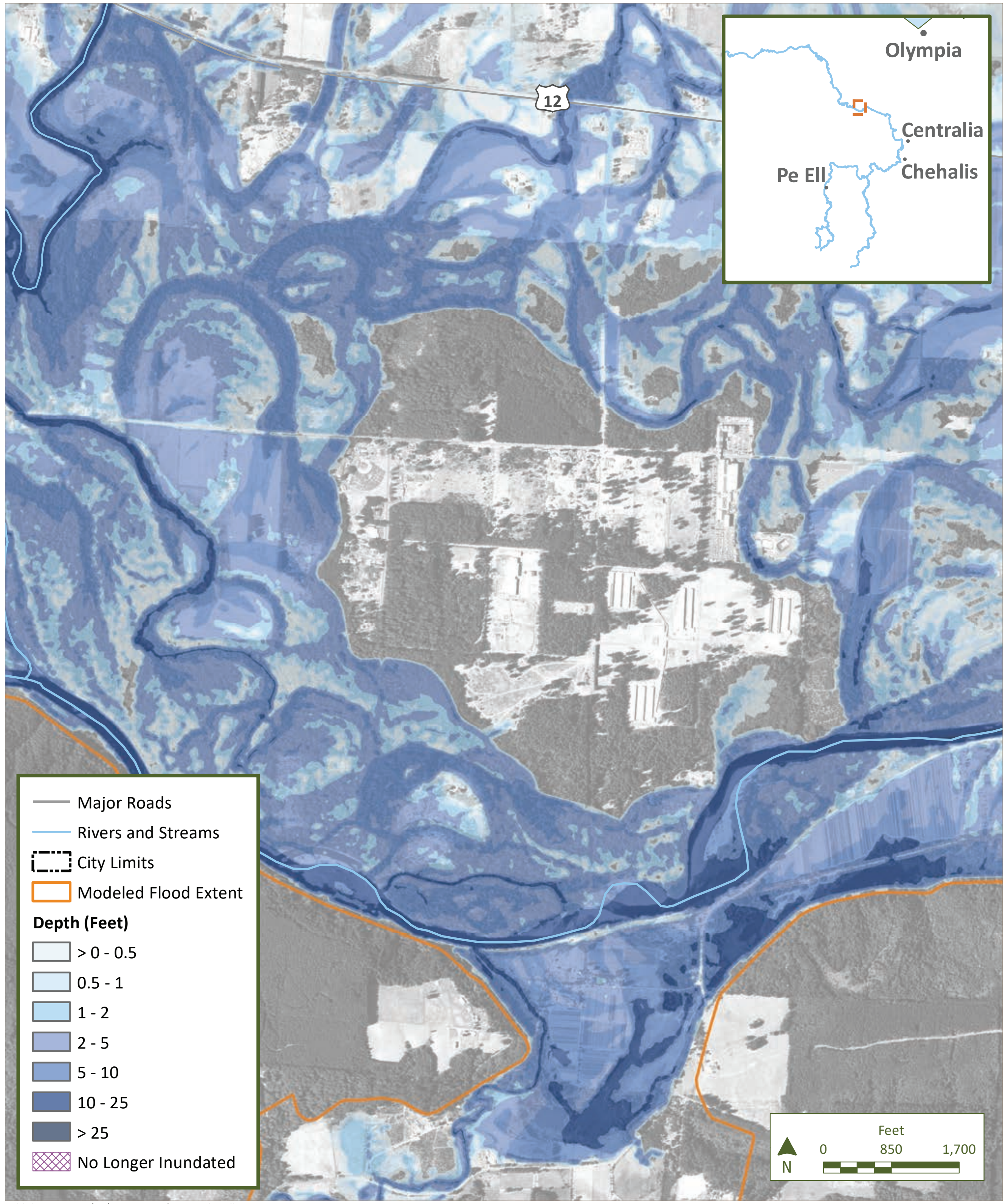
Figure N.7-h
Mid-Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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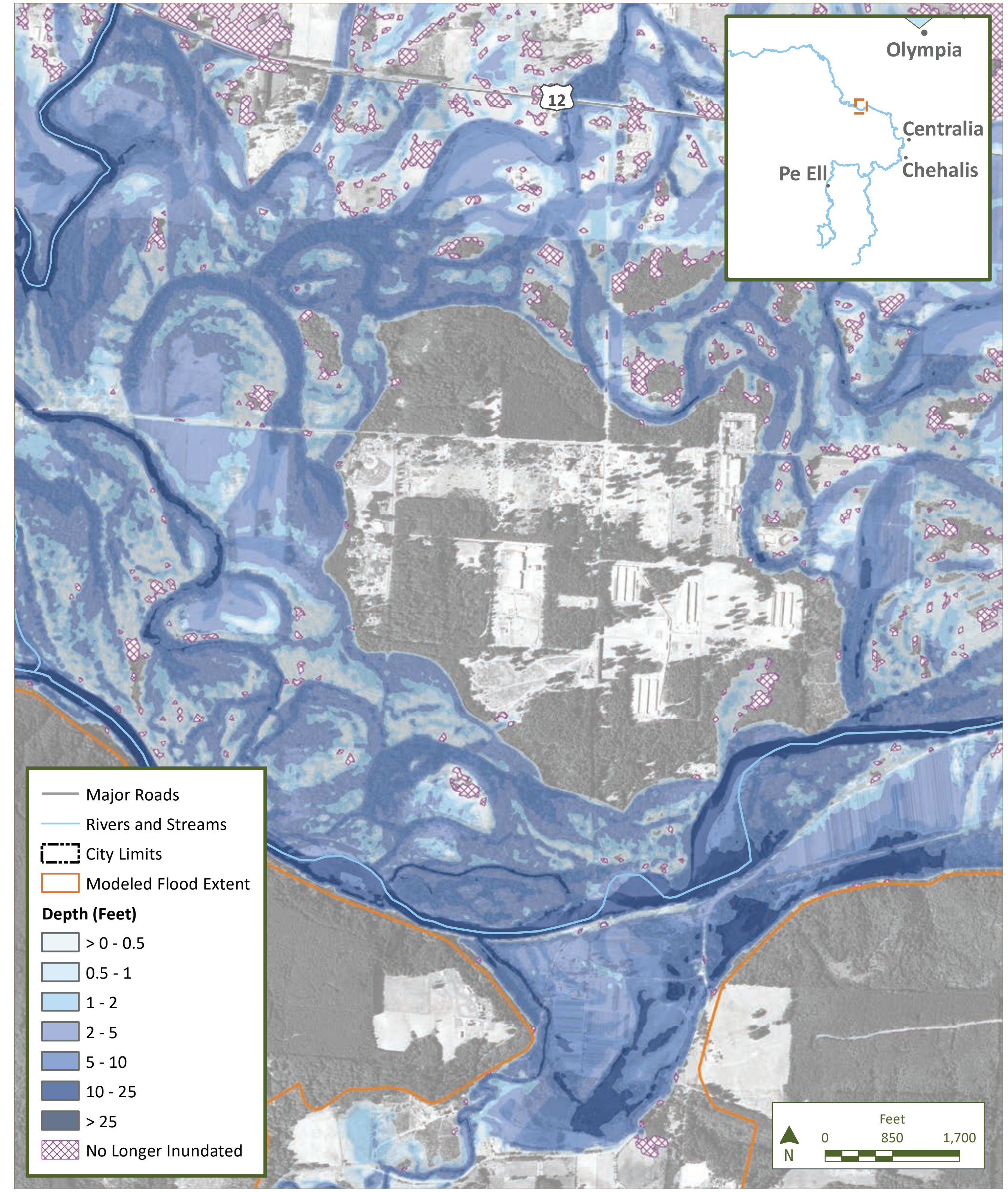

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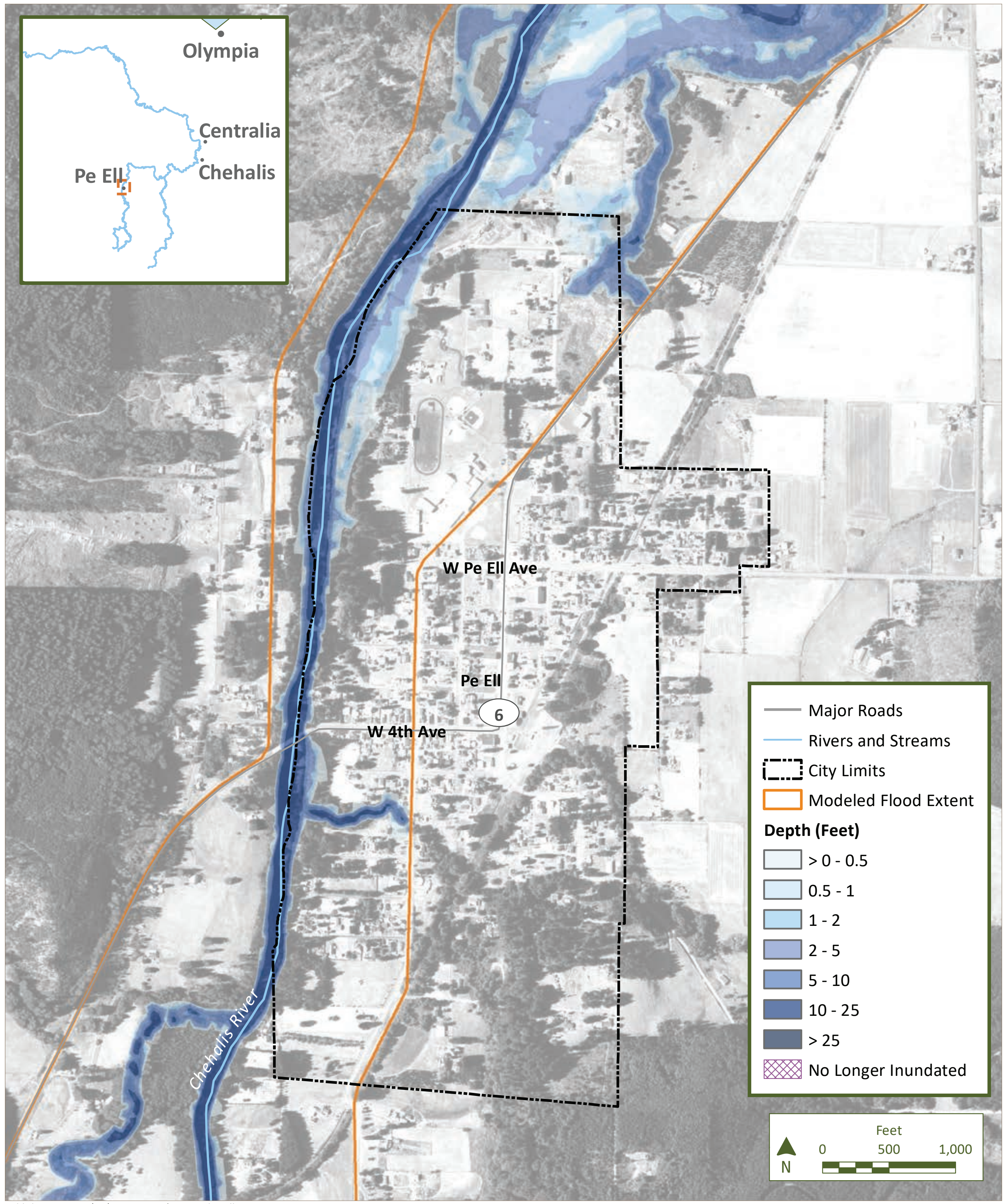
Figure N.8-a
Late Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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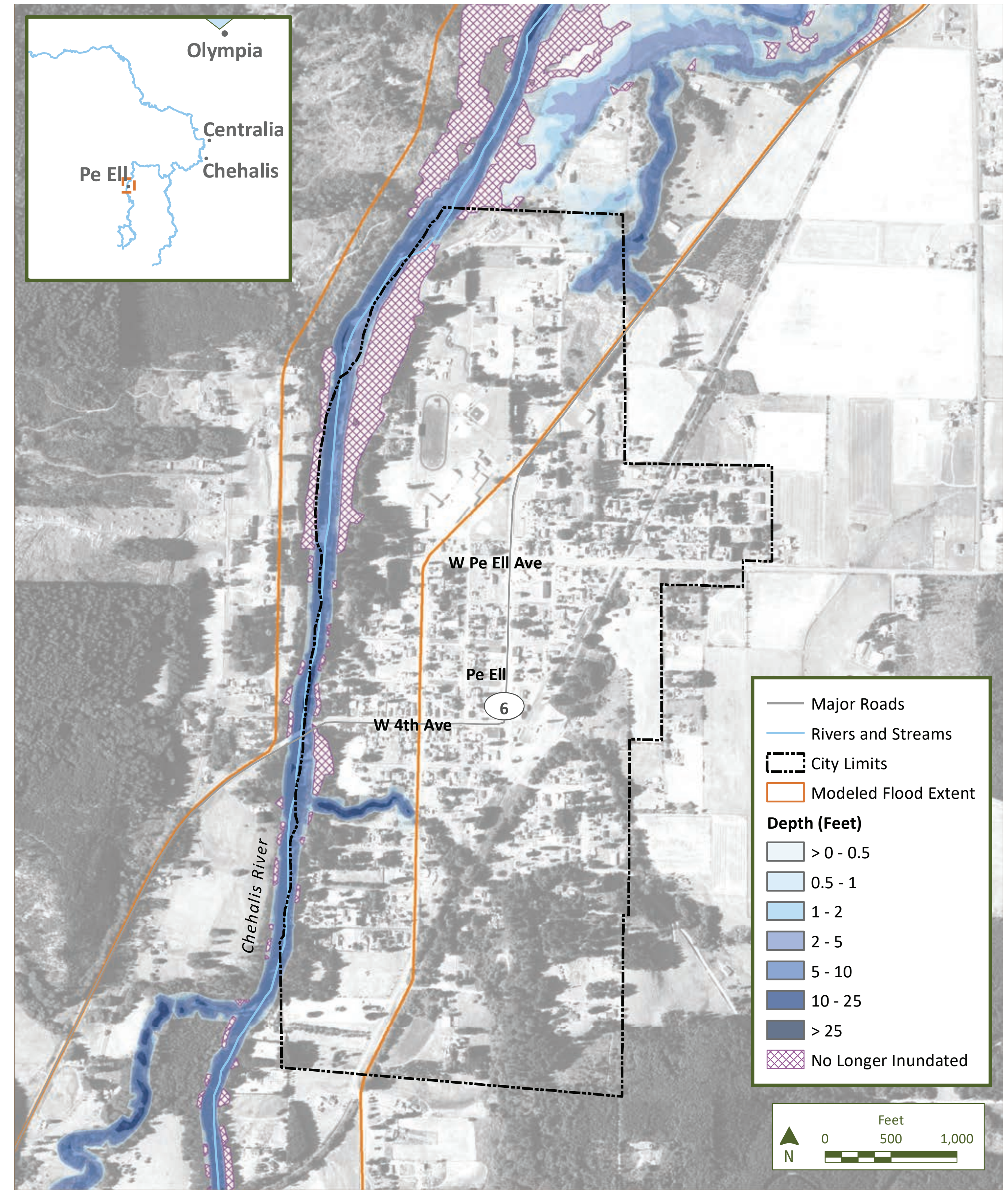

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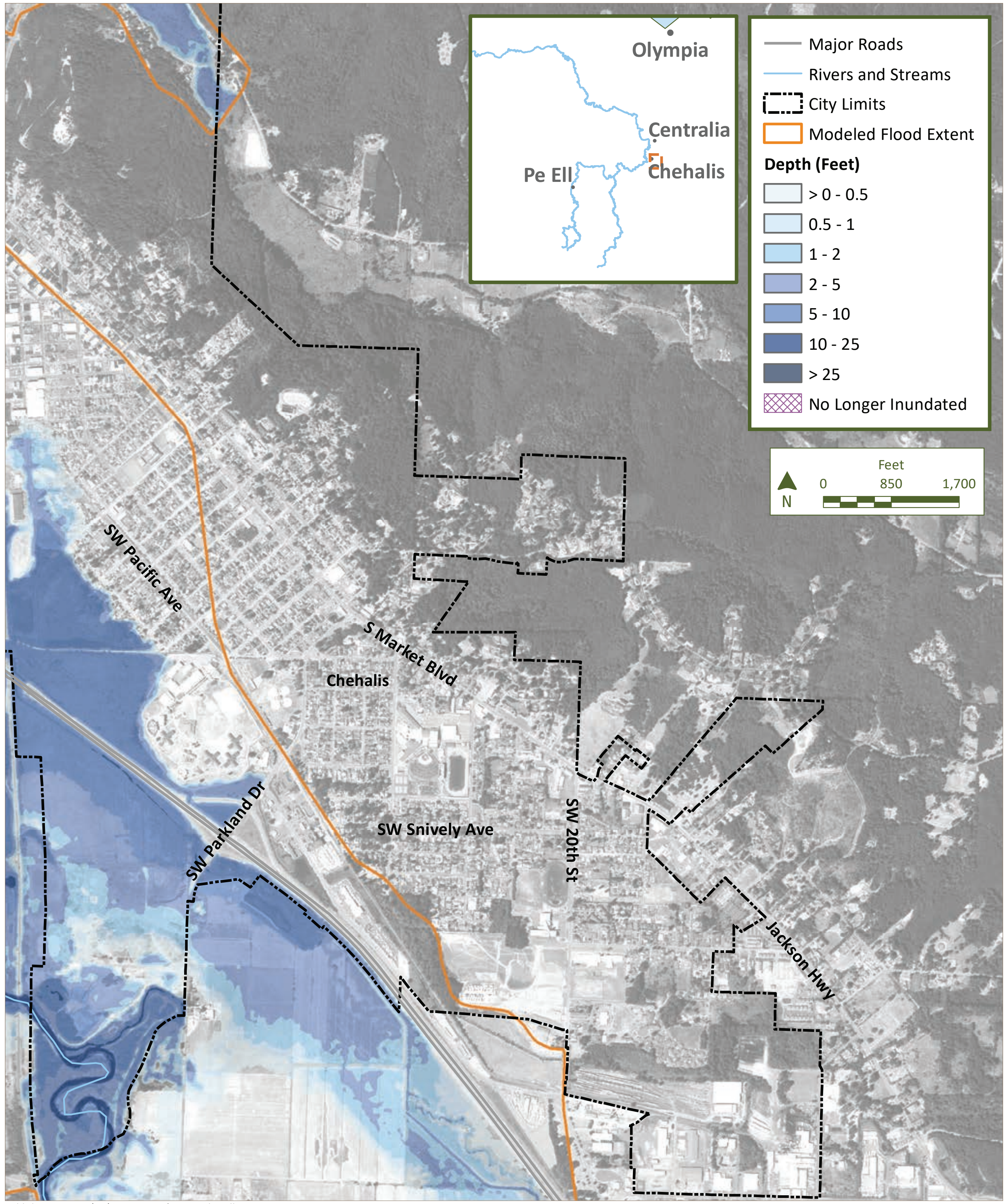
Figure N.8-b
Late Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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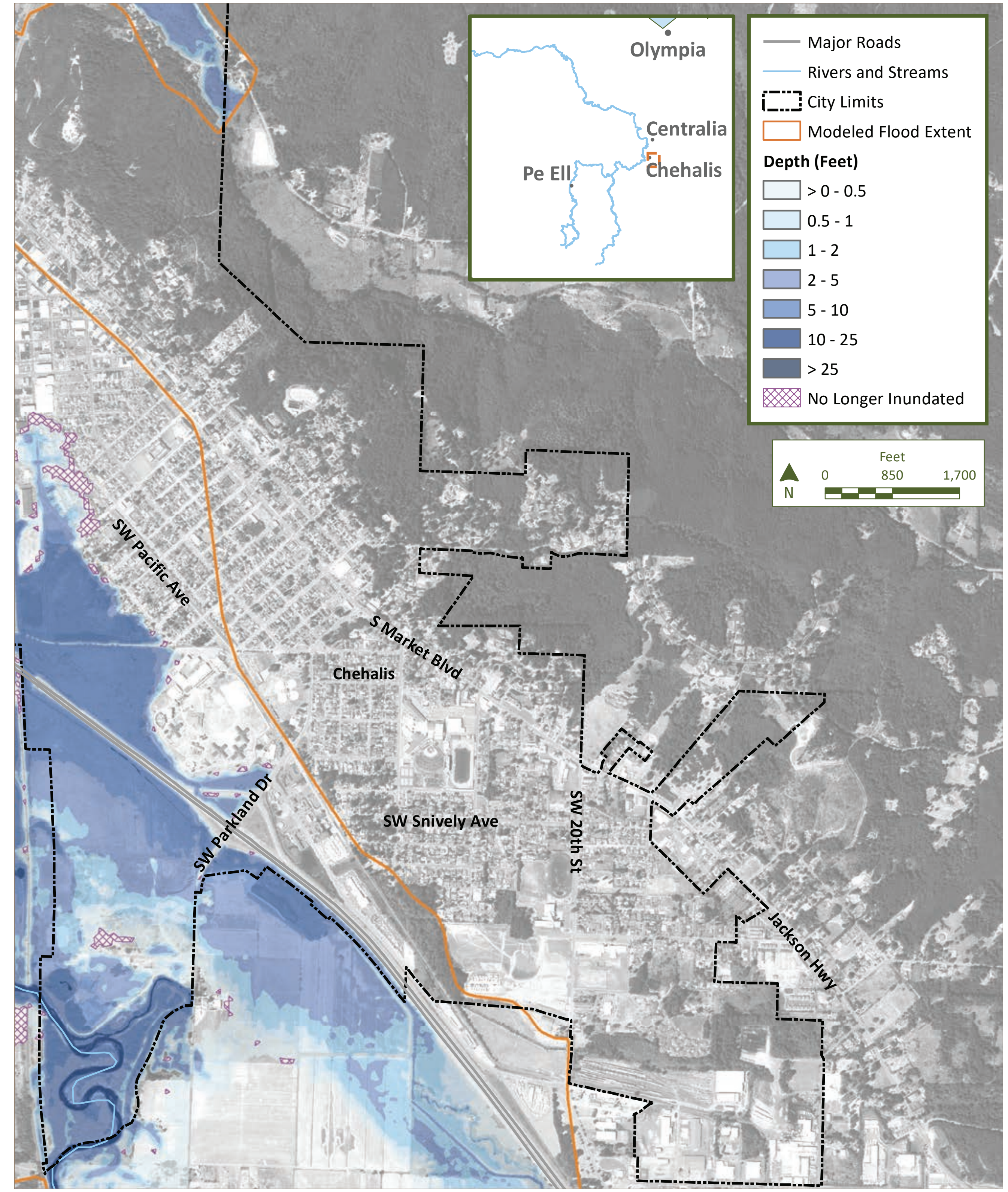

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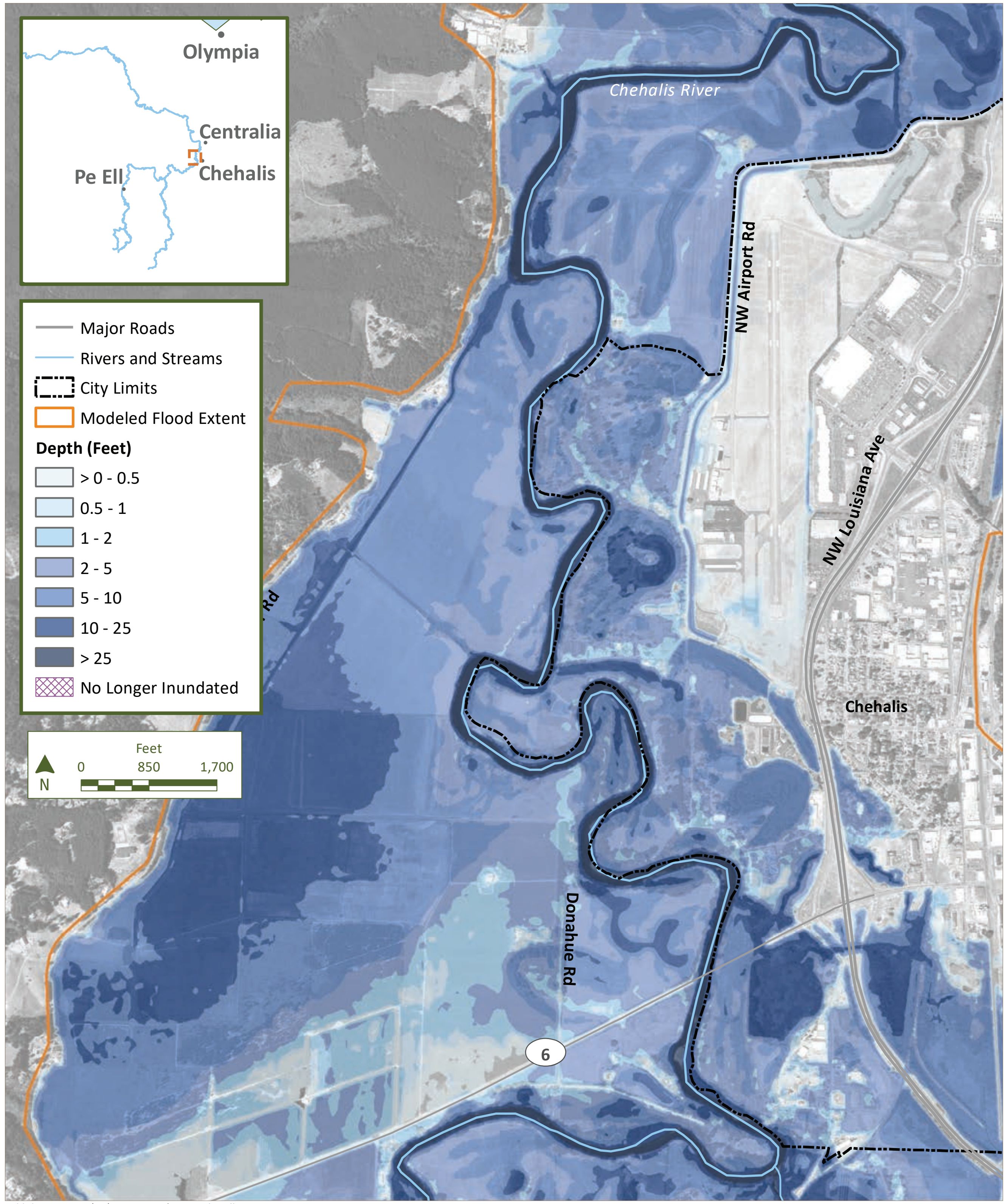
Figure N.8-c
Late Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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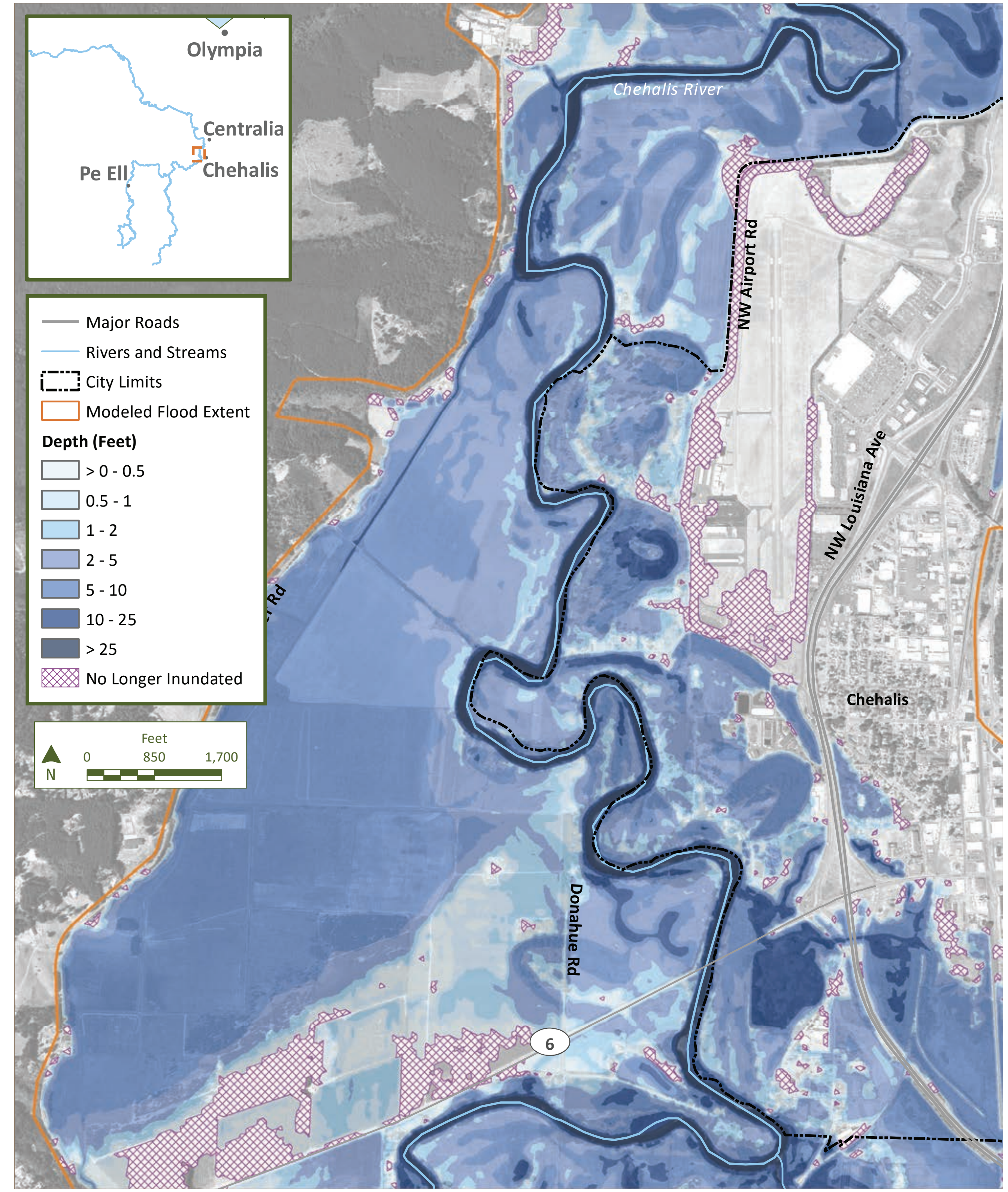
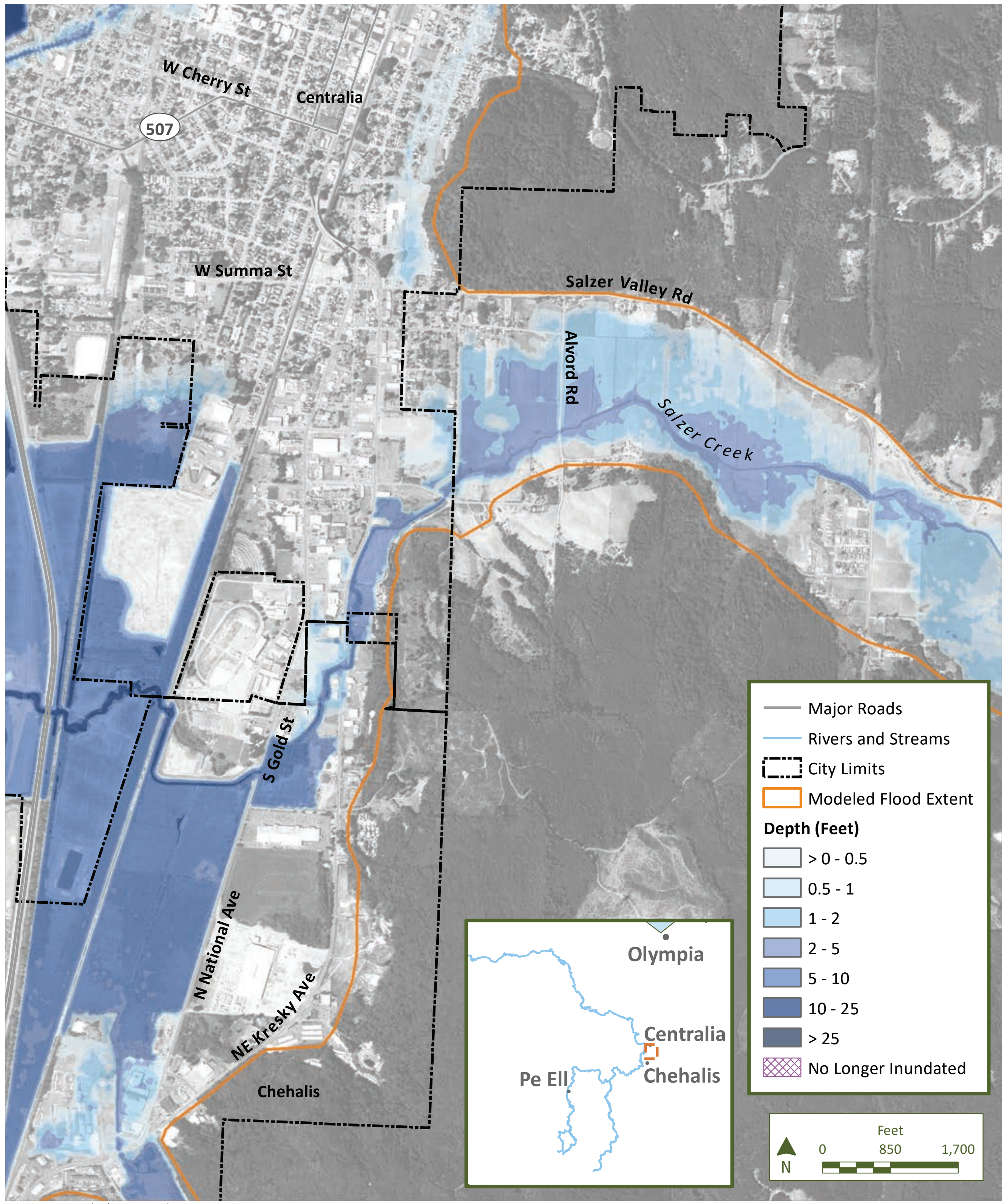


Figure N.8-d
Late Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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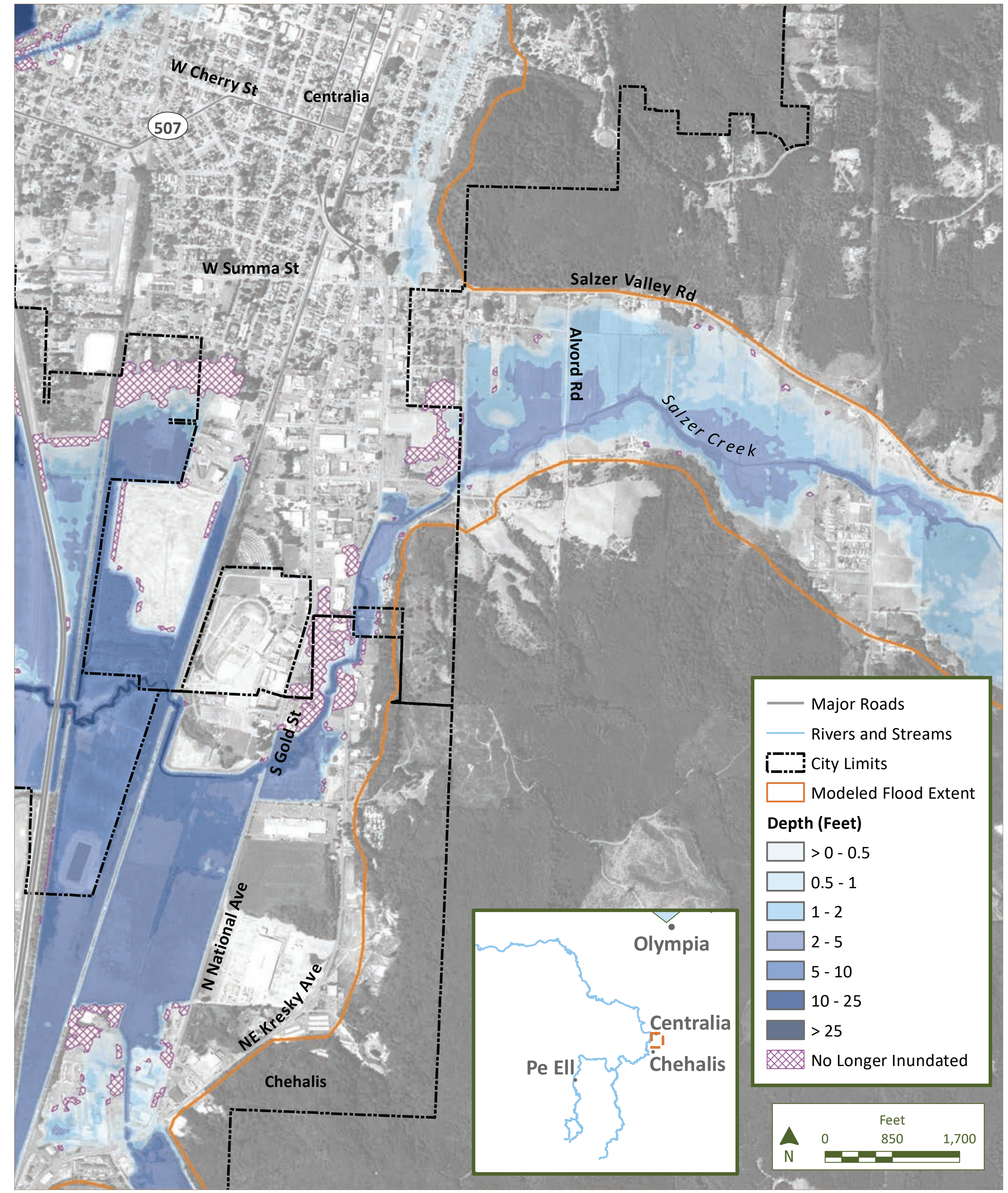

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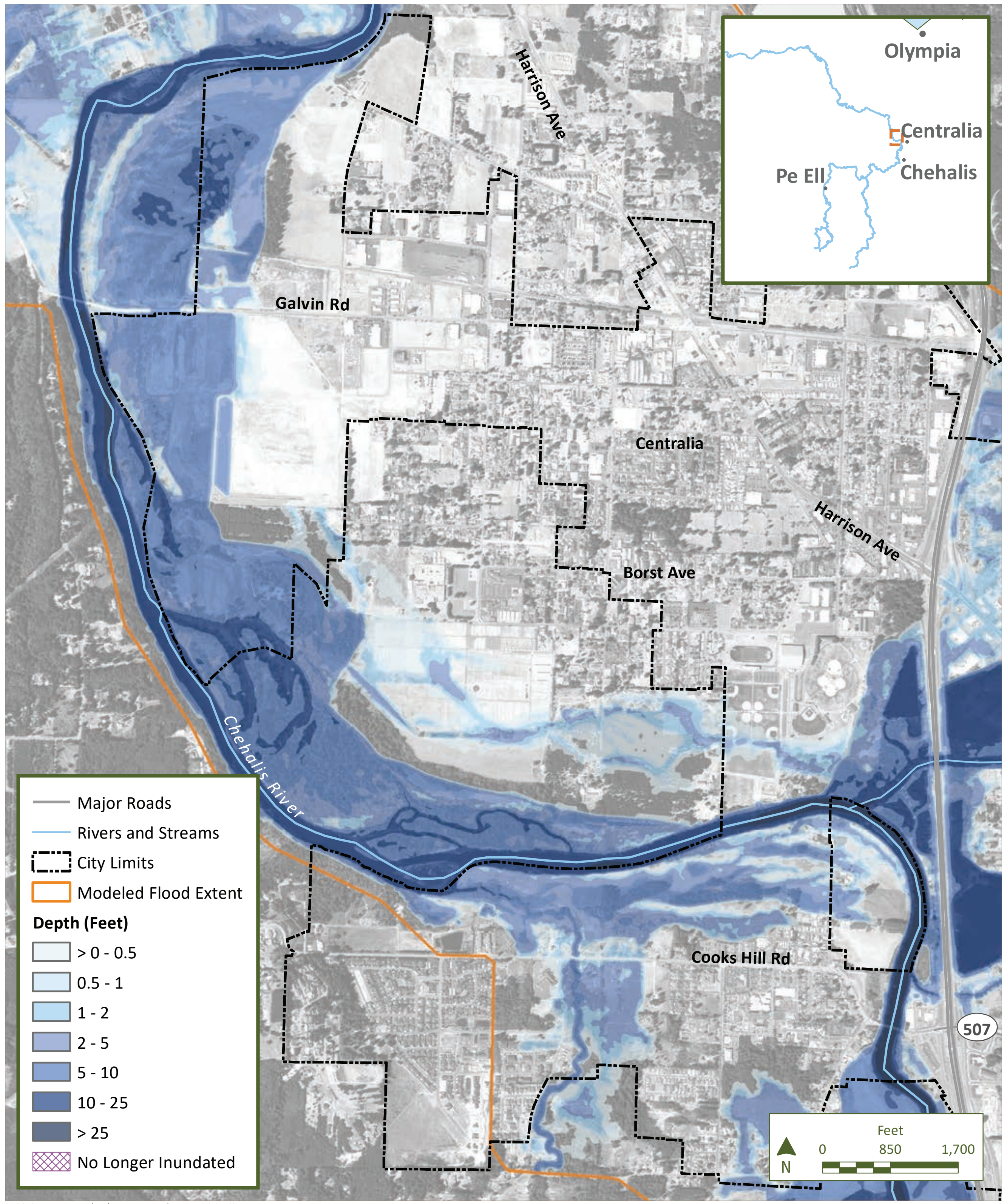
Figure N.8-e
Late Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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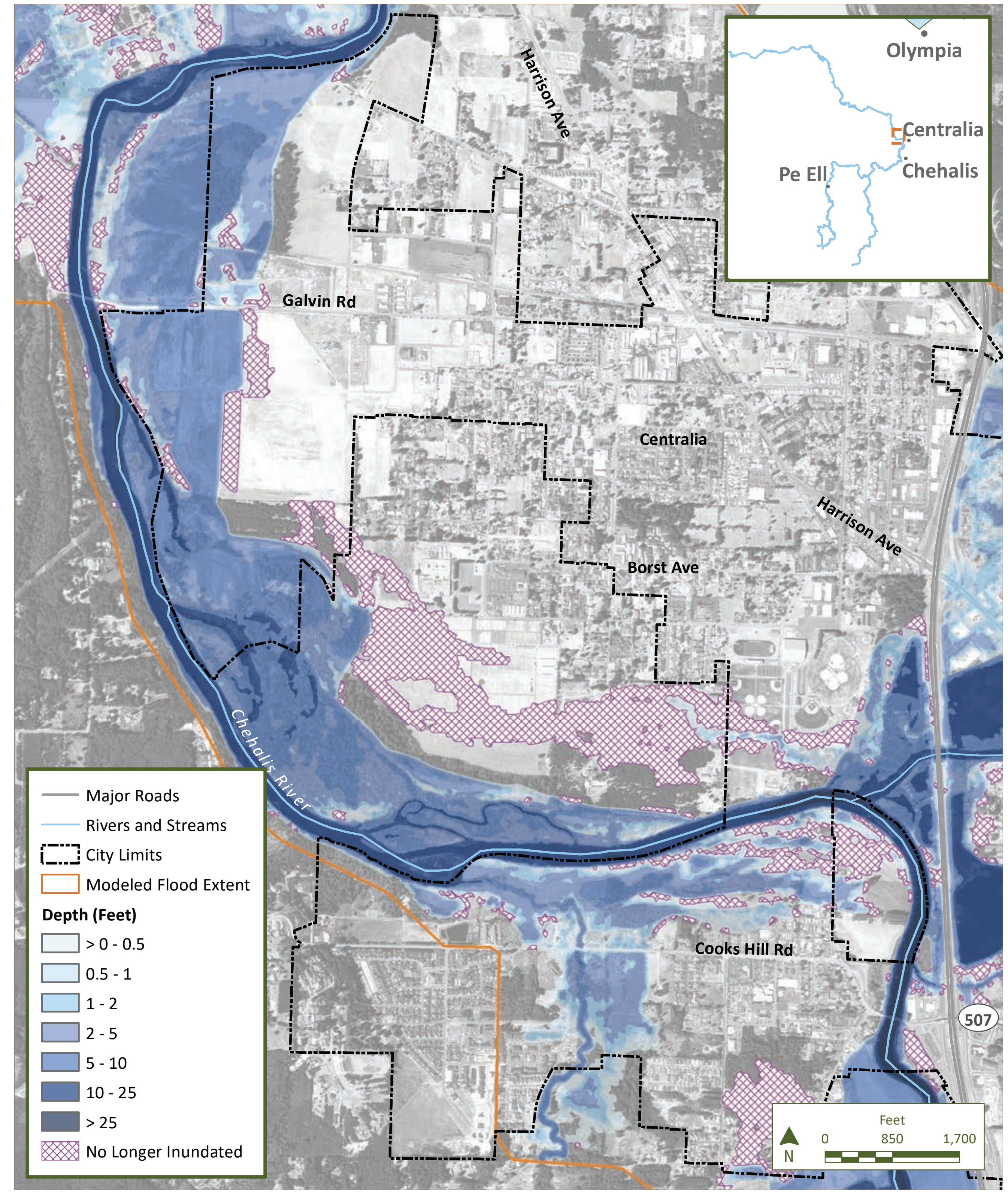

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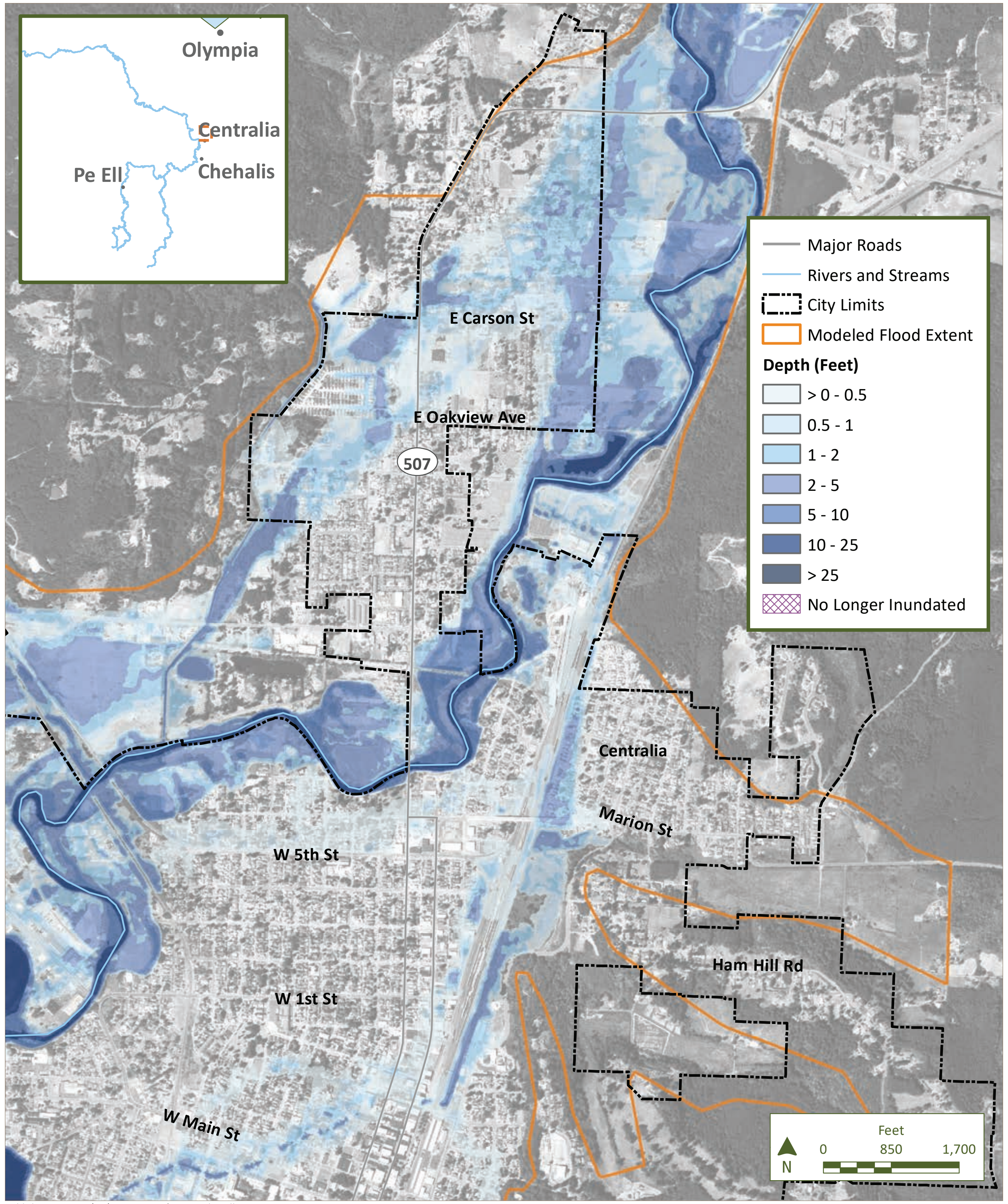
Figure N.8-f
Late Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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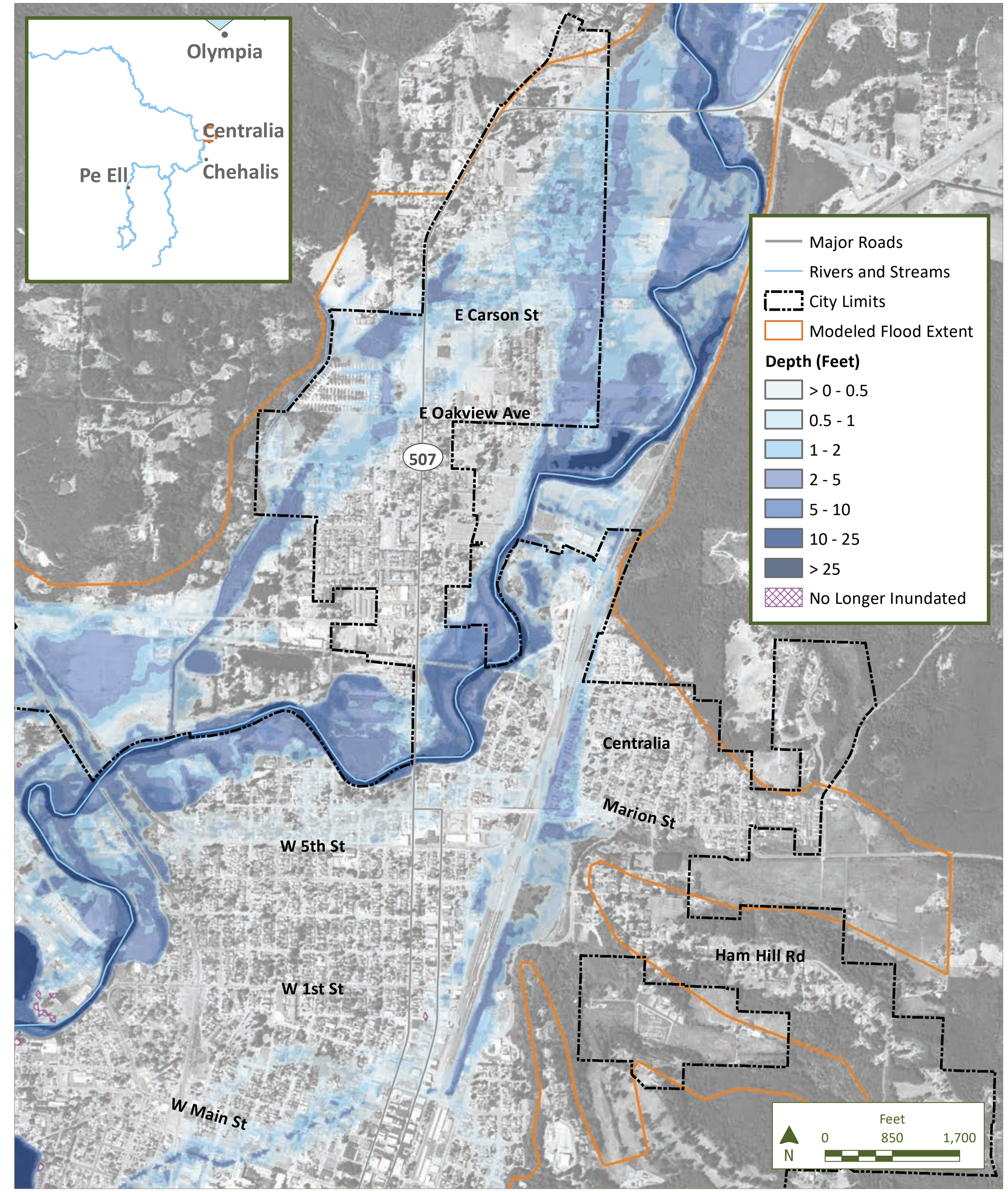

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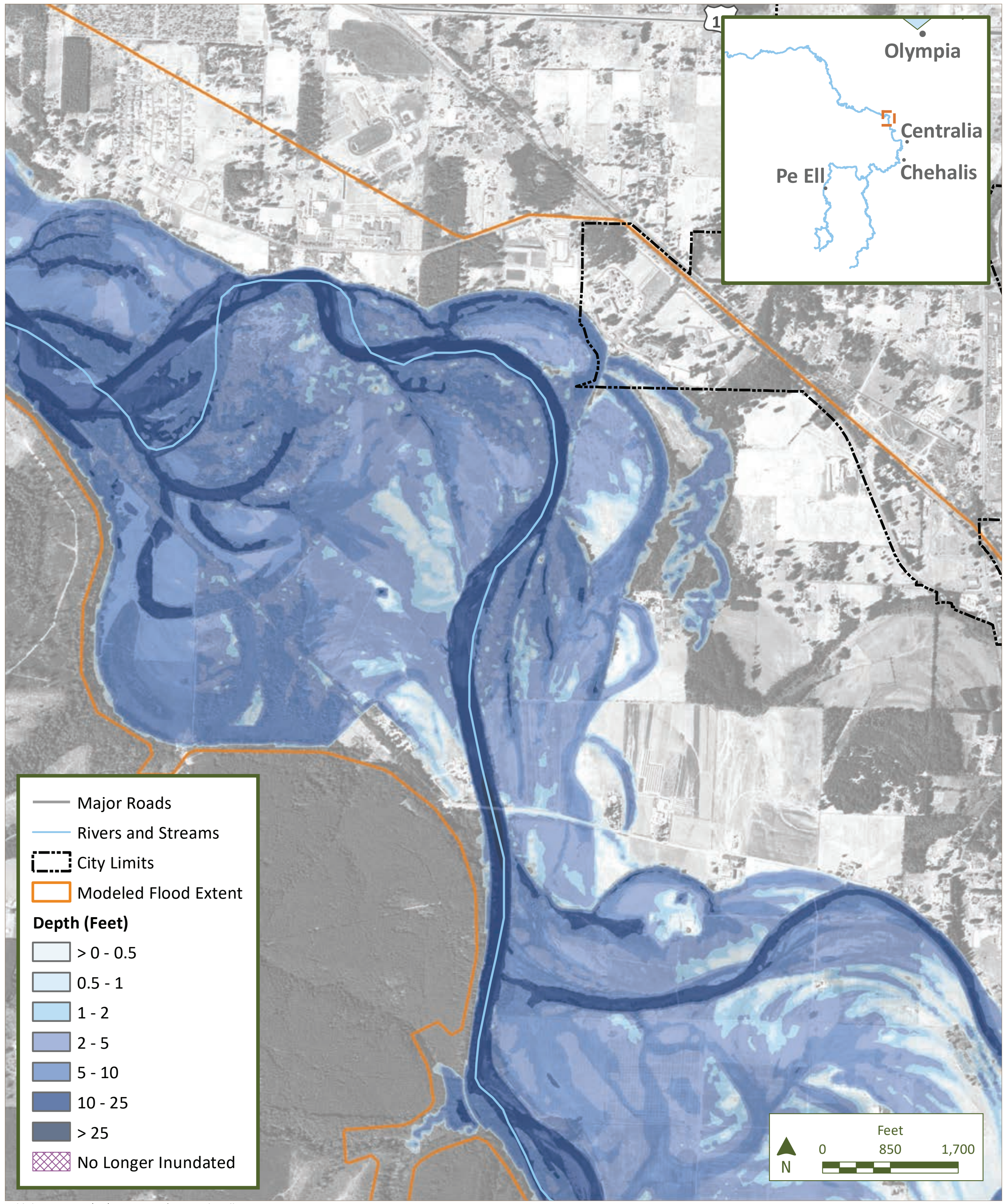
Figure N.8-g
Late Century Major Flood in Pe Ell, Chehalis, and Centralia

No Action



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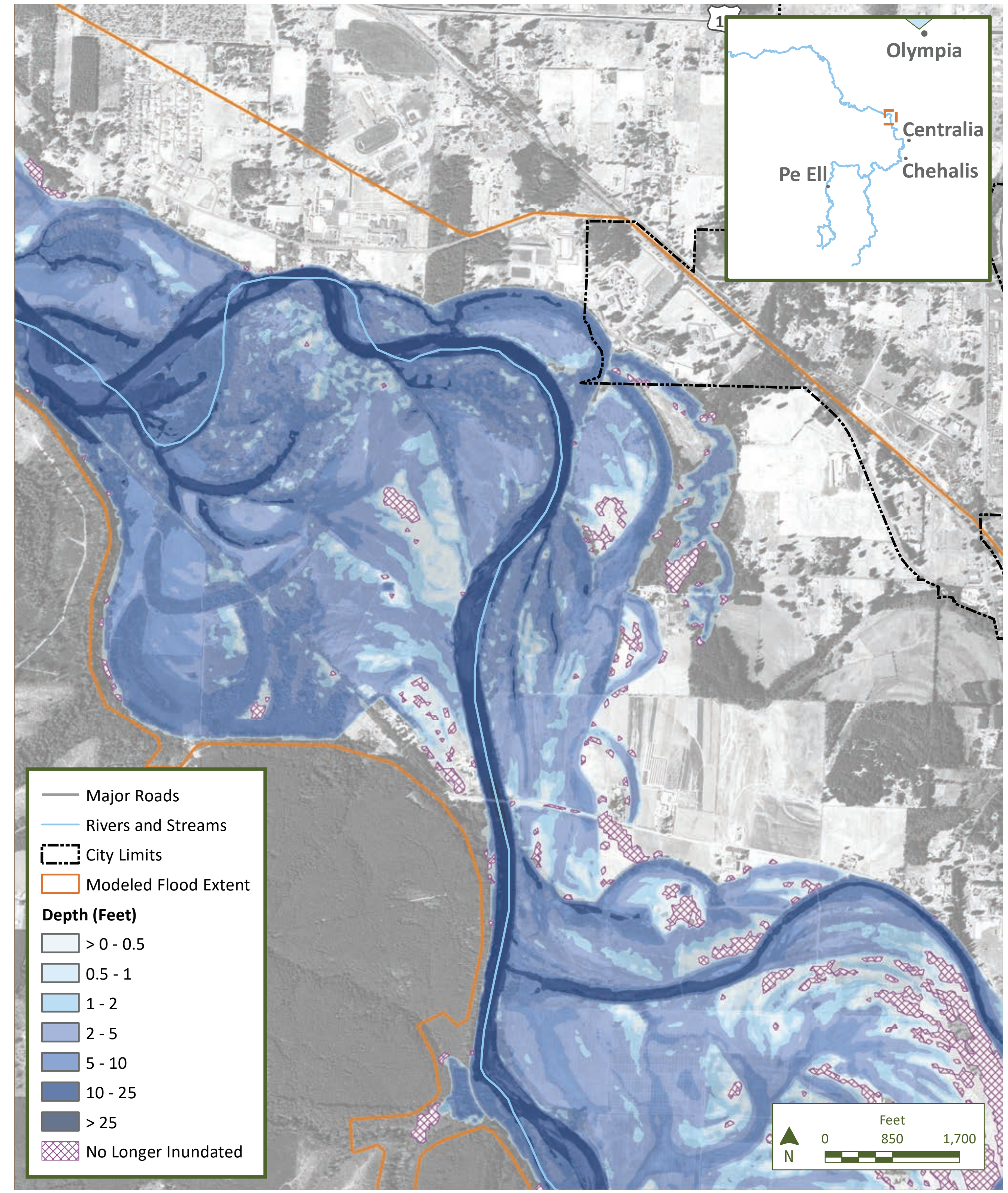

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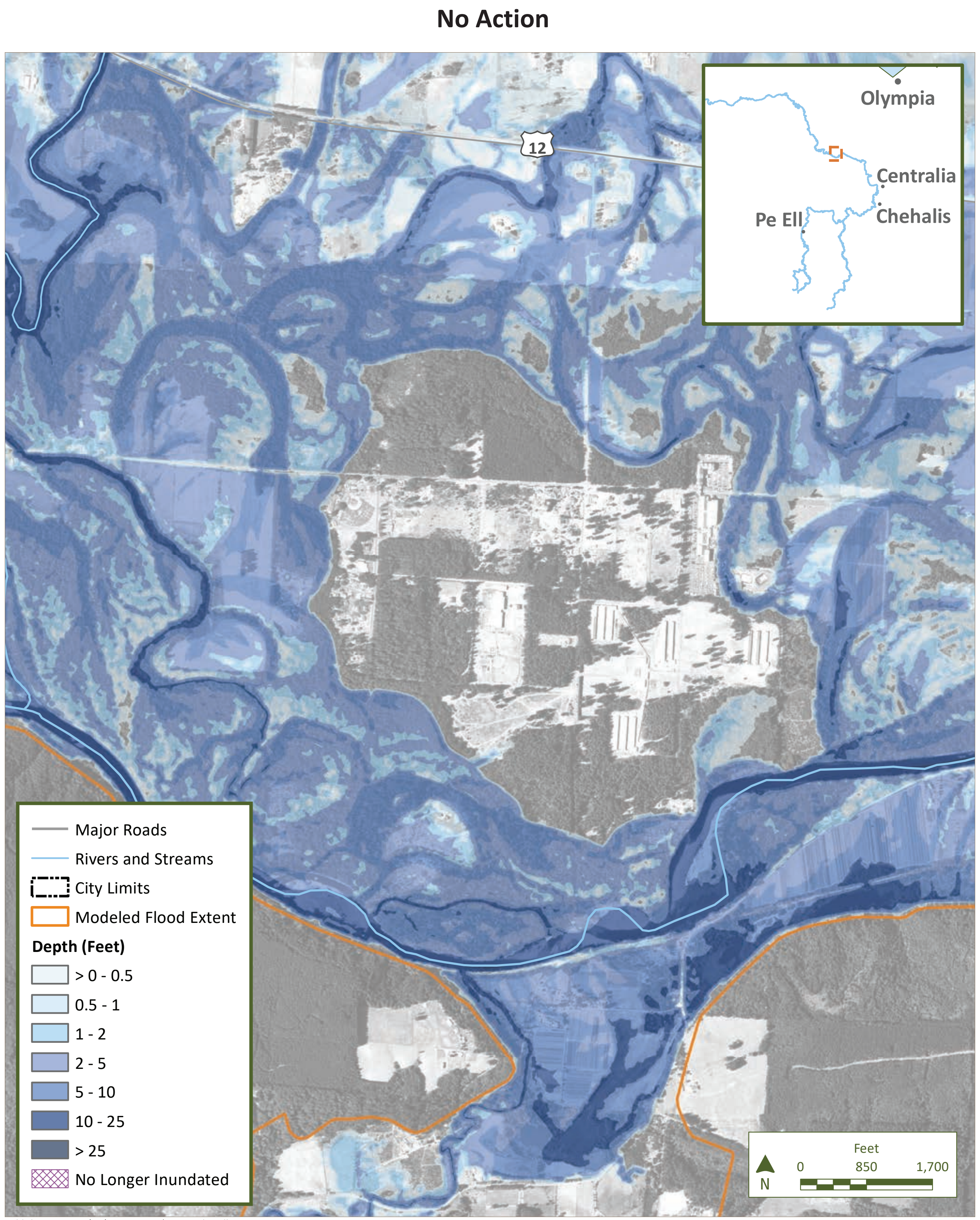
Figure N.8-h
Late Century Major Flood in Pe Ell, Chehalis, and Centralia



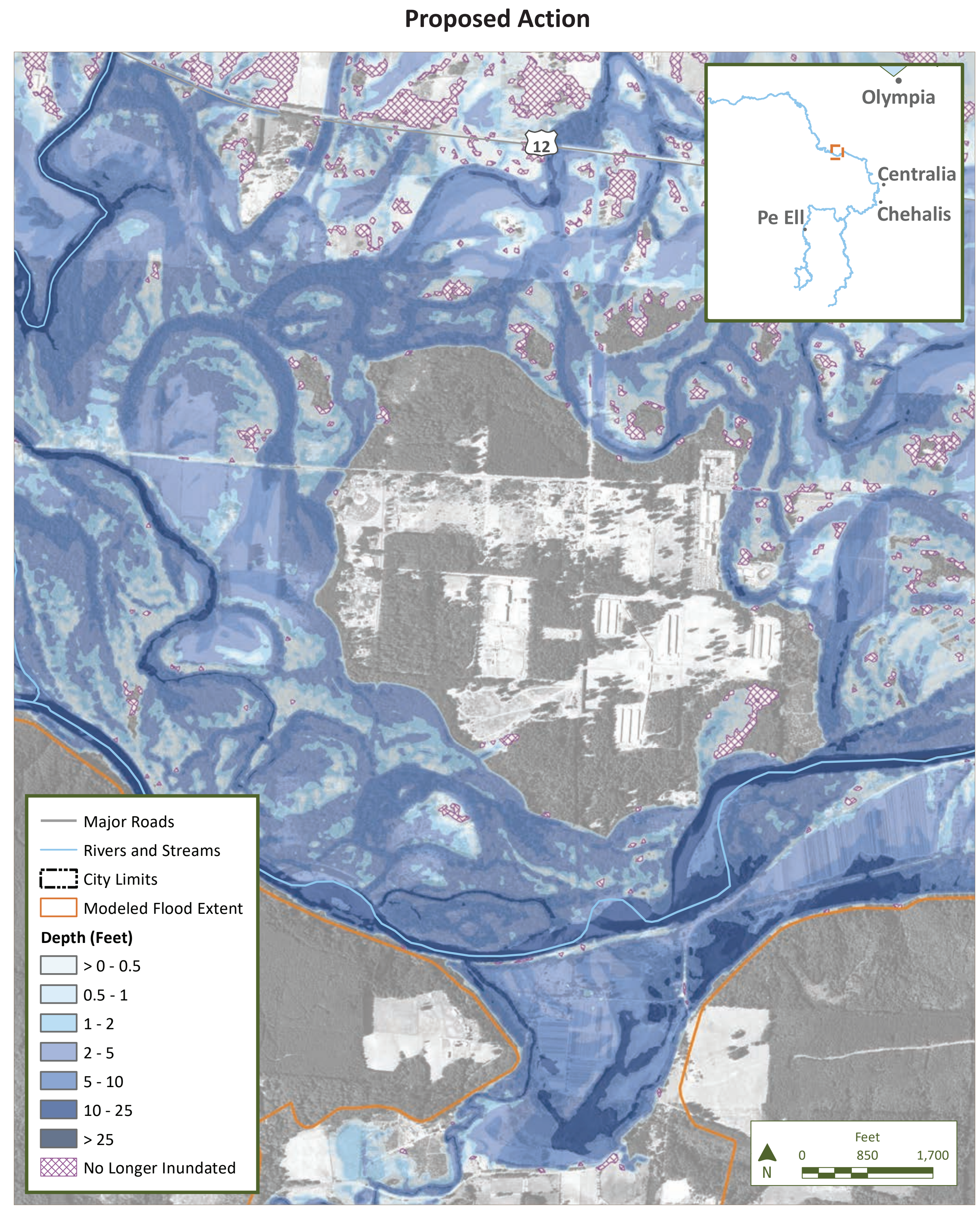


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Figure N.9-a
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

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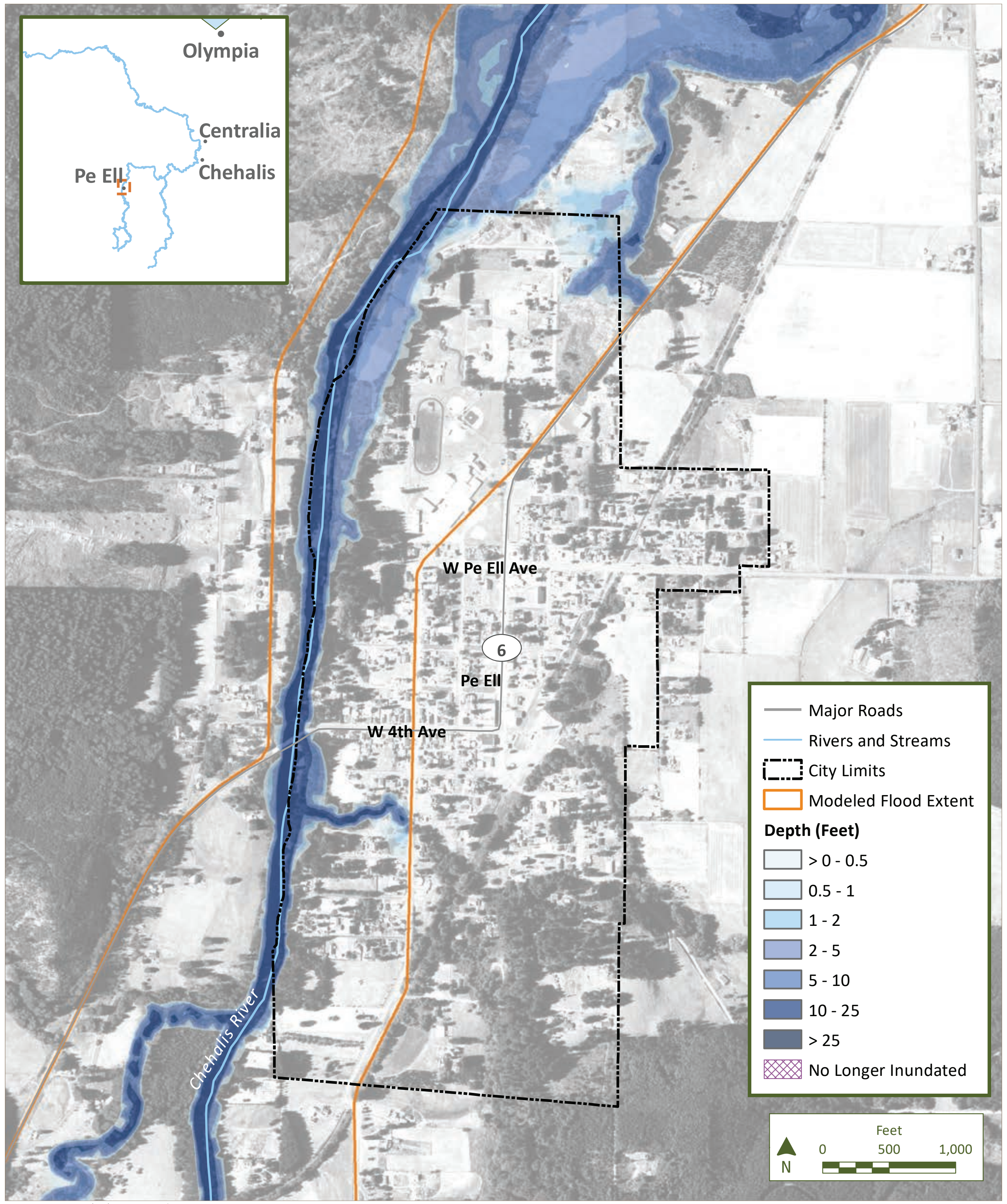

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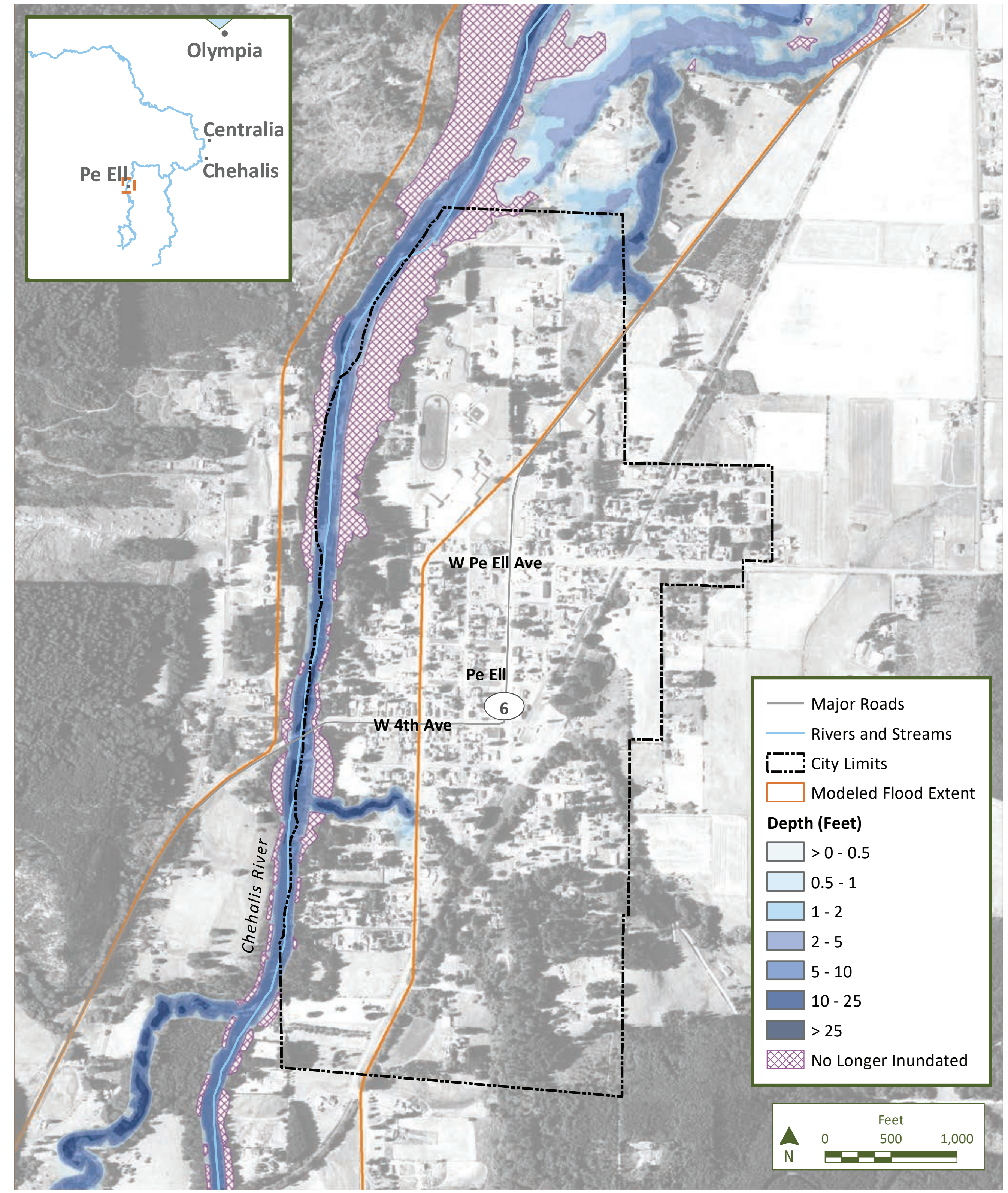

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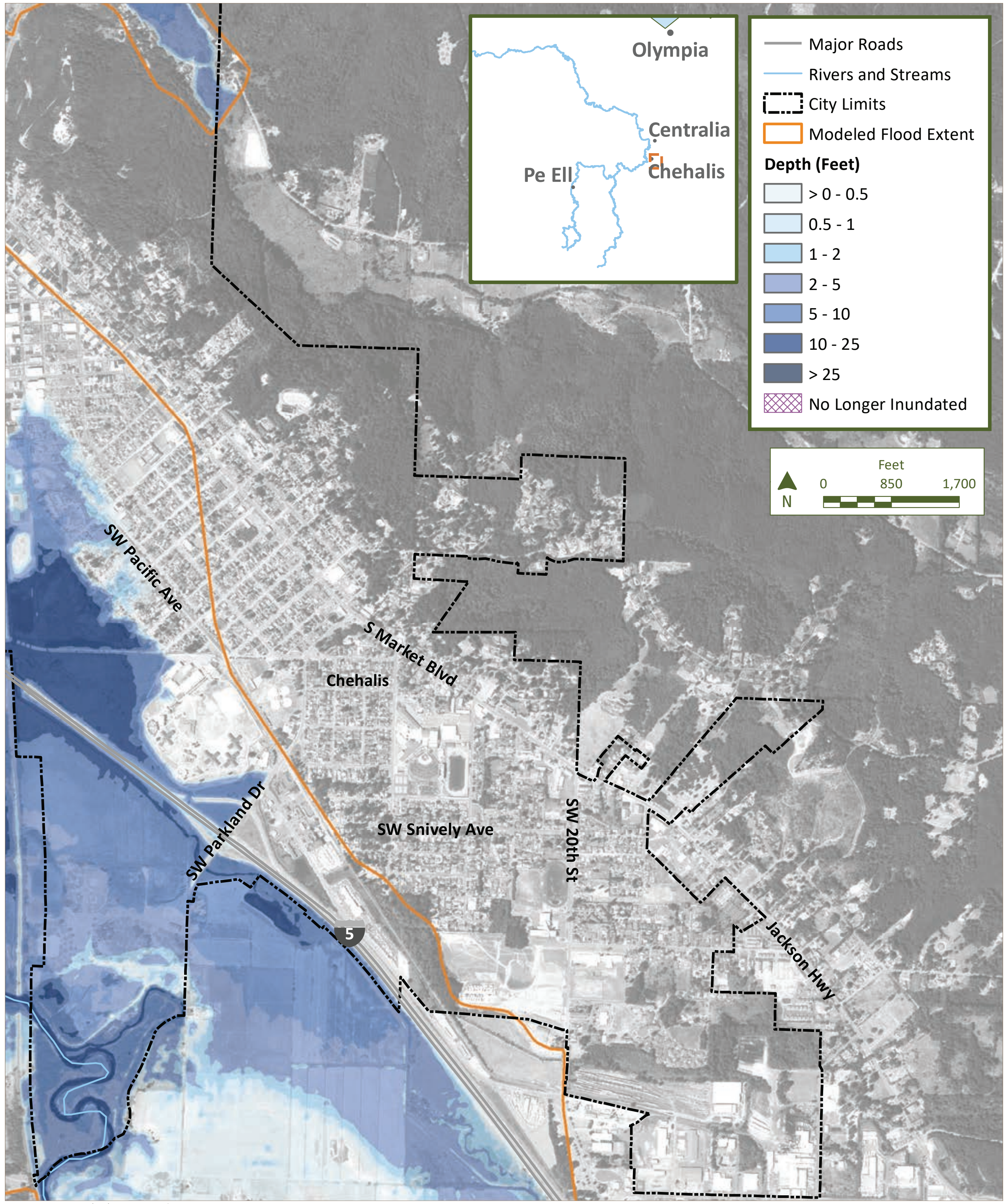
Figure N.9-b
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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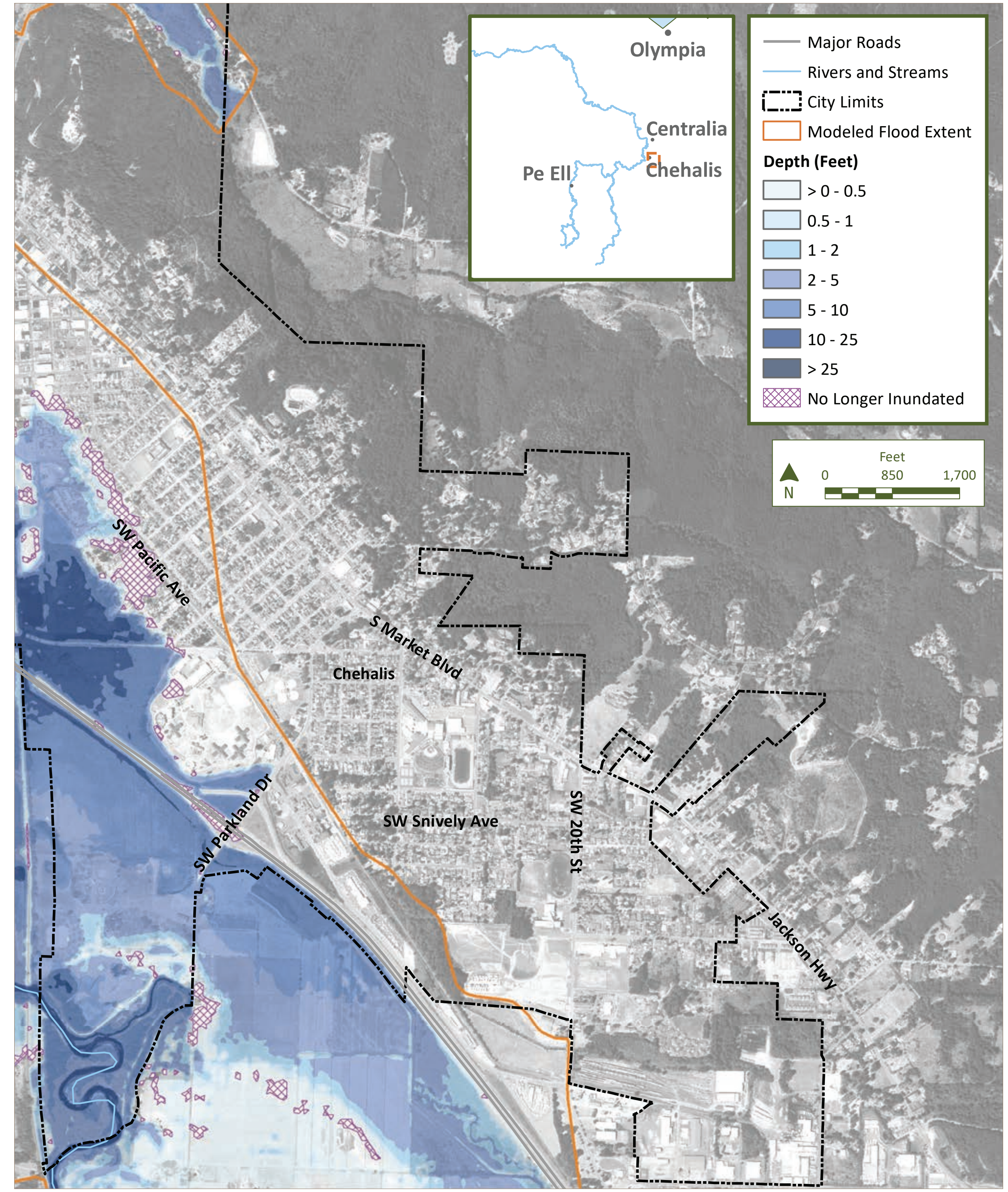
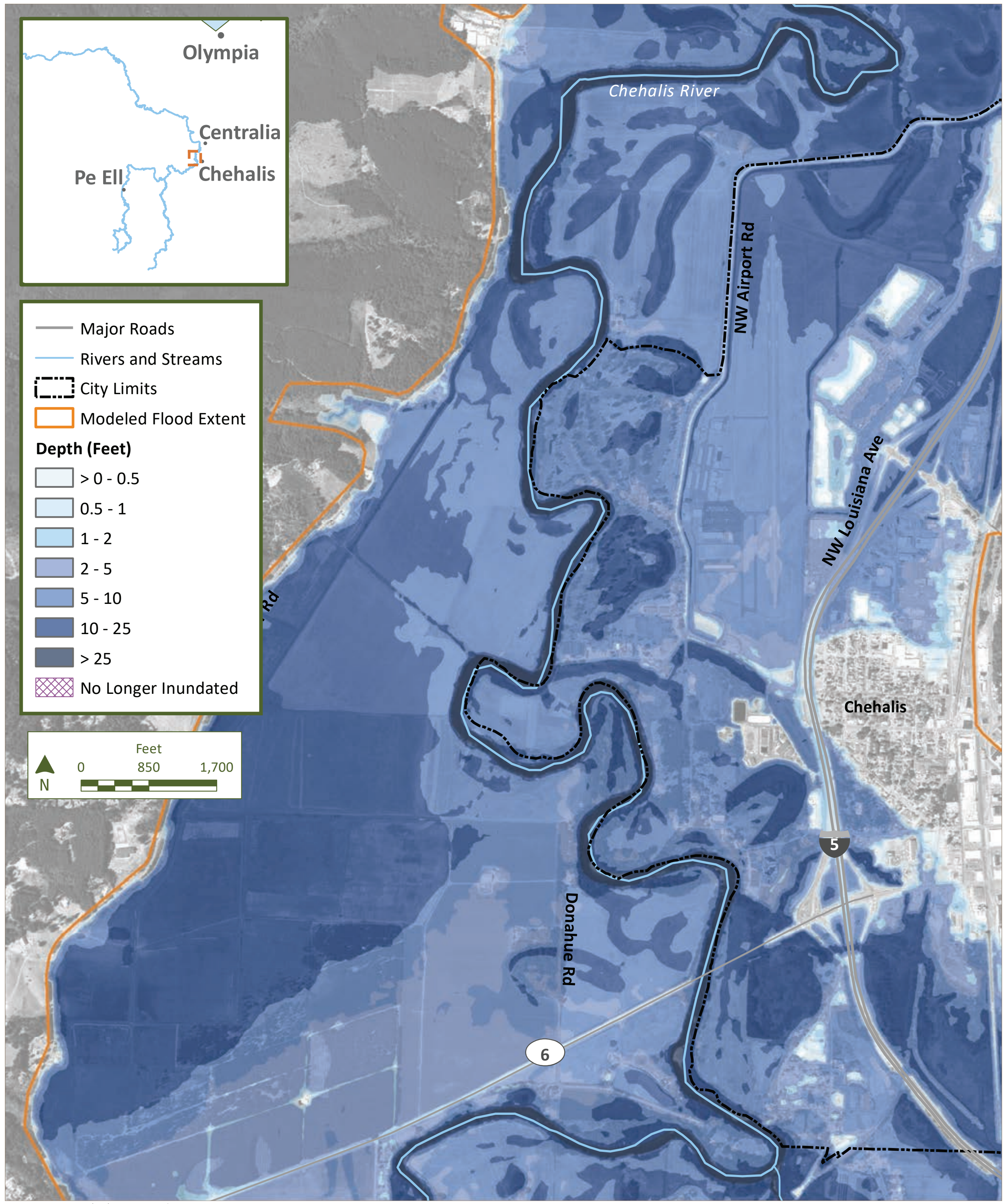


Figure N.9-c
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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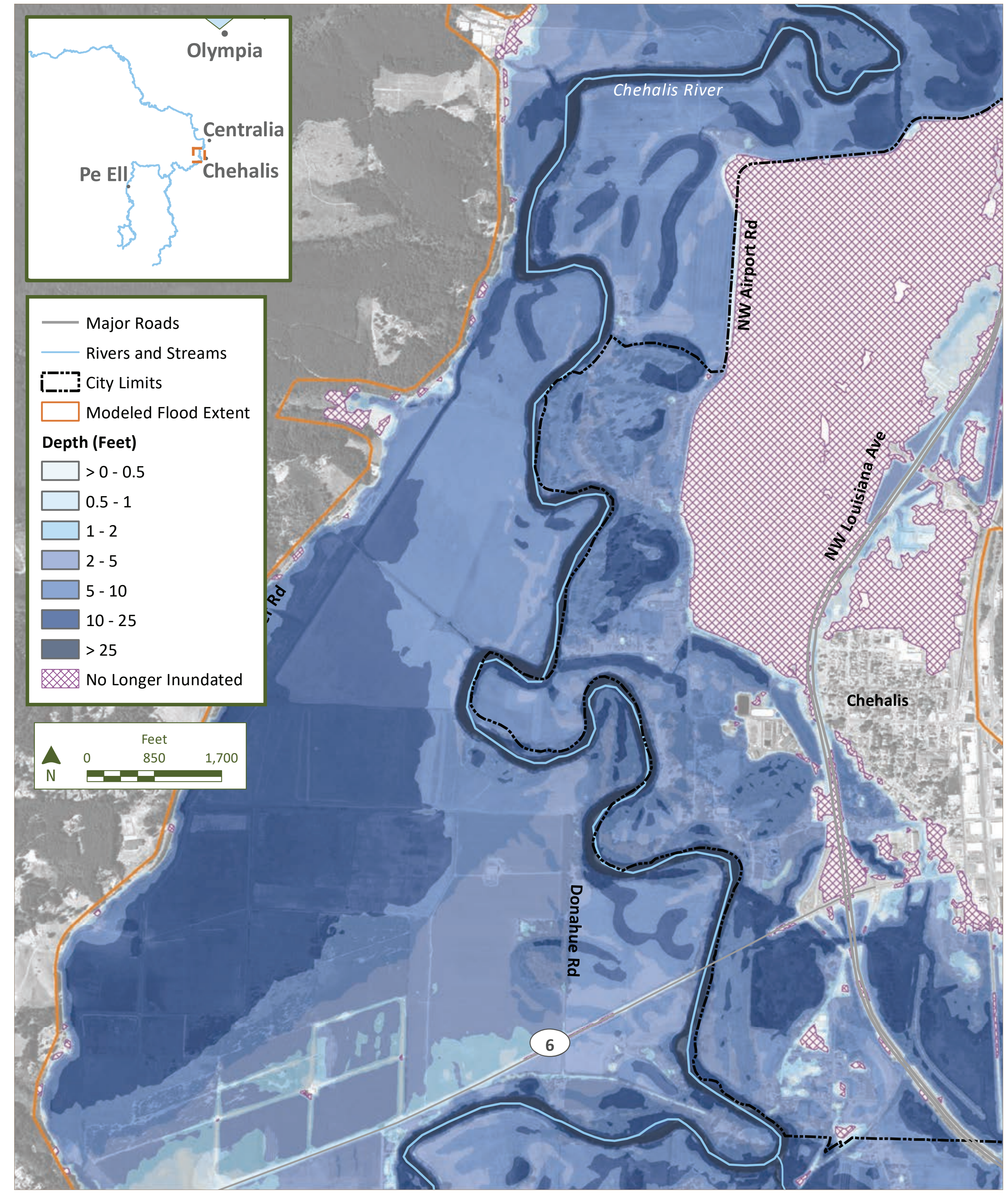

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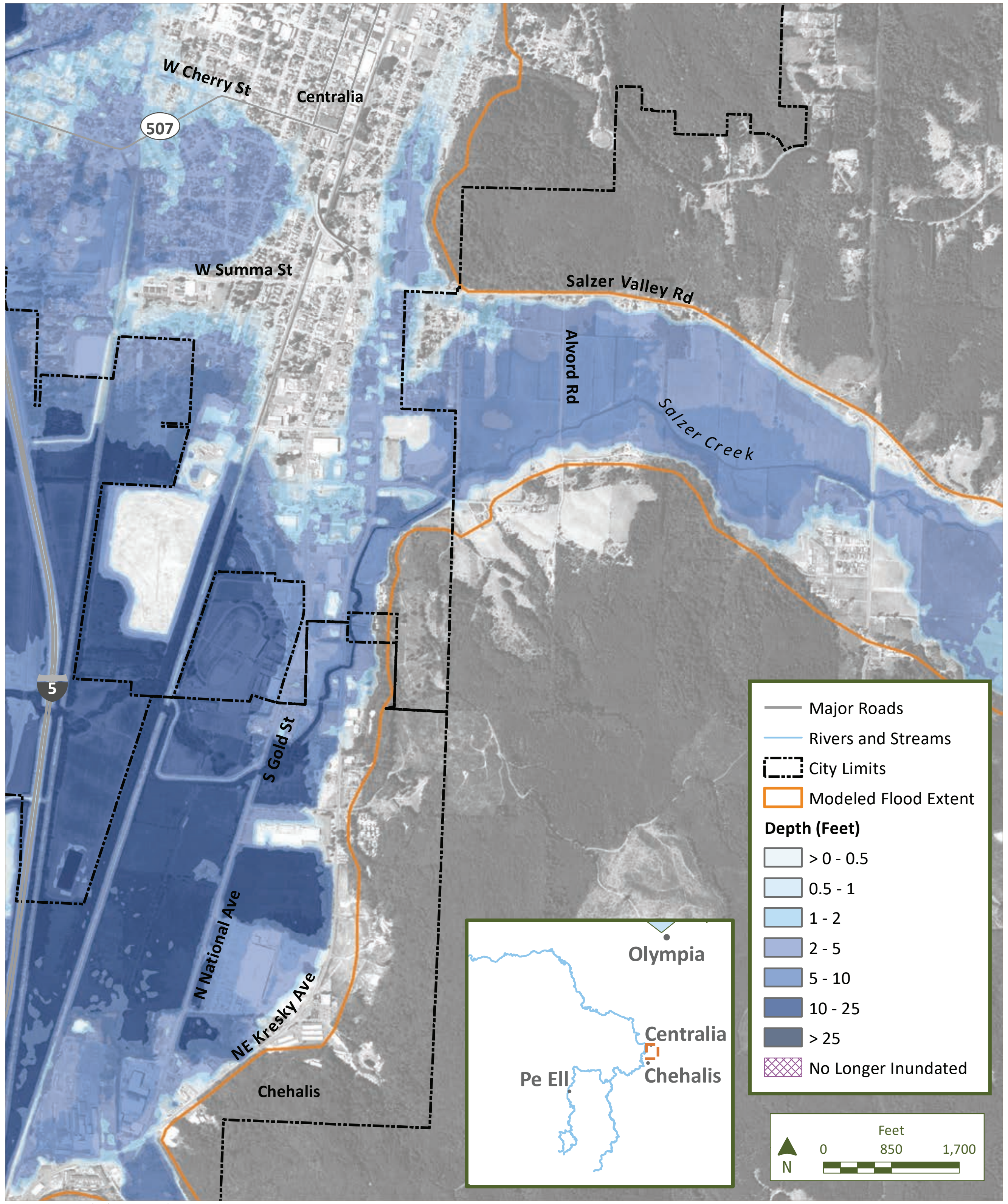
Figure N.9-d
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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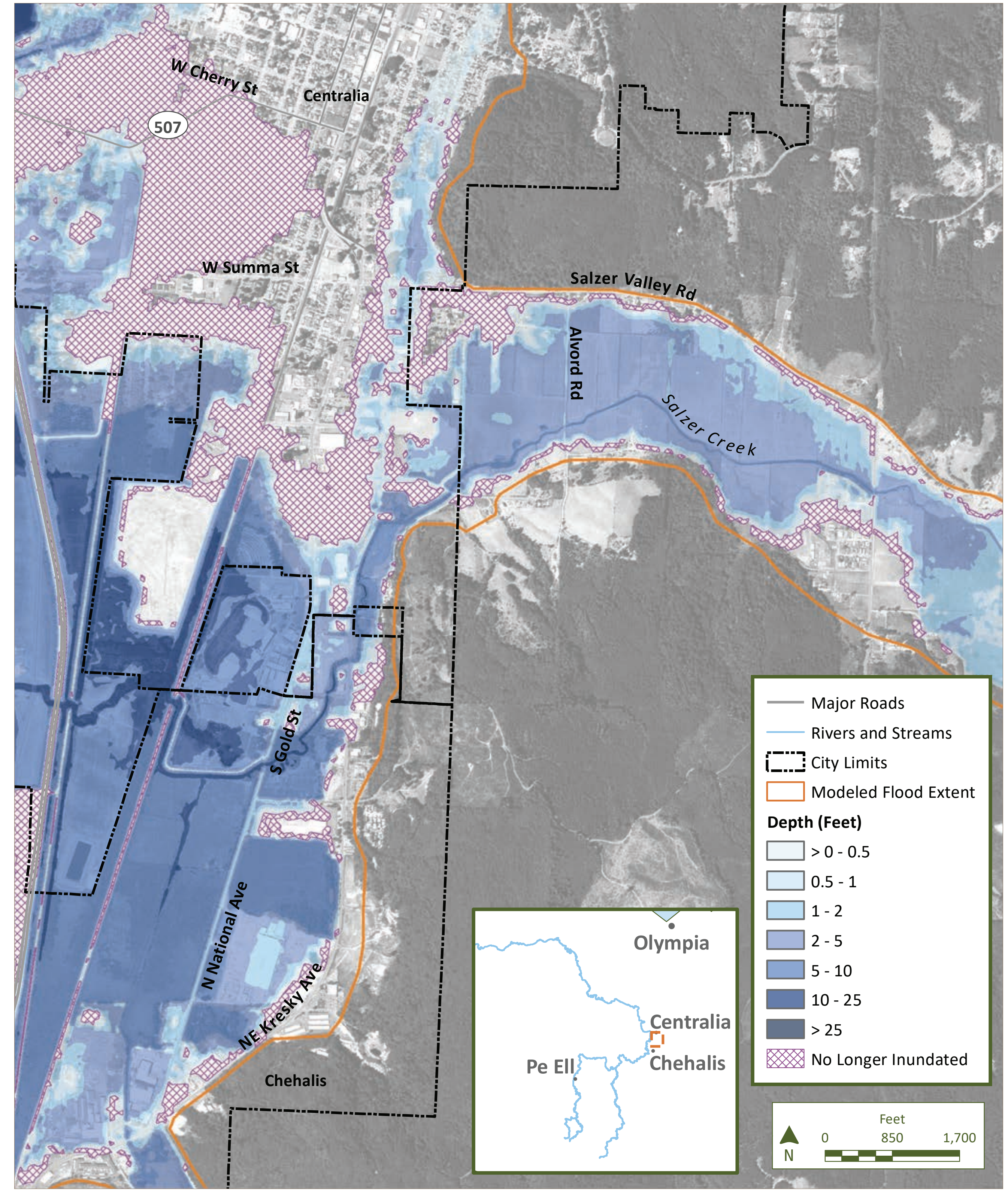

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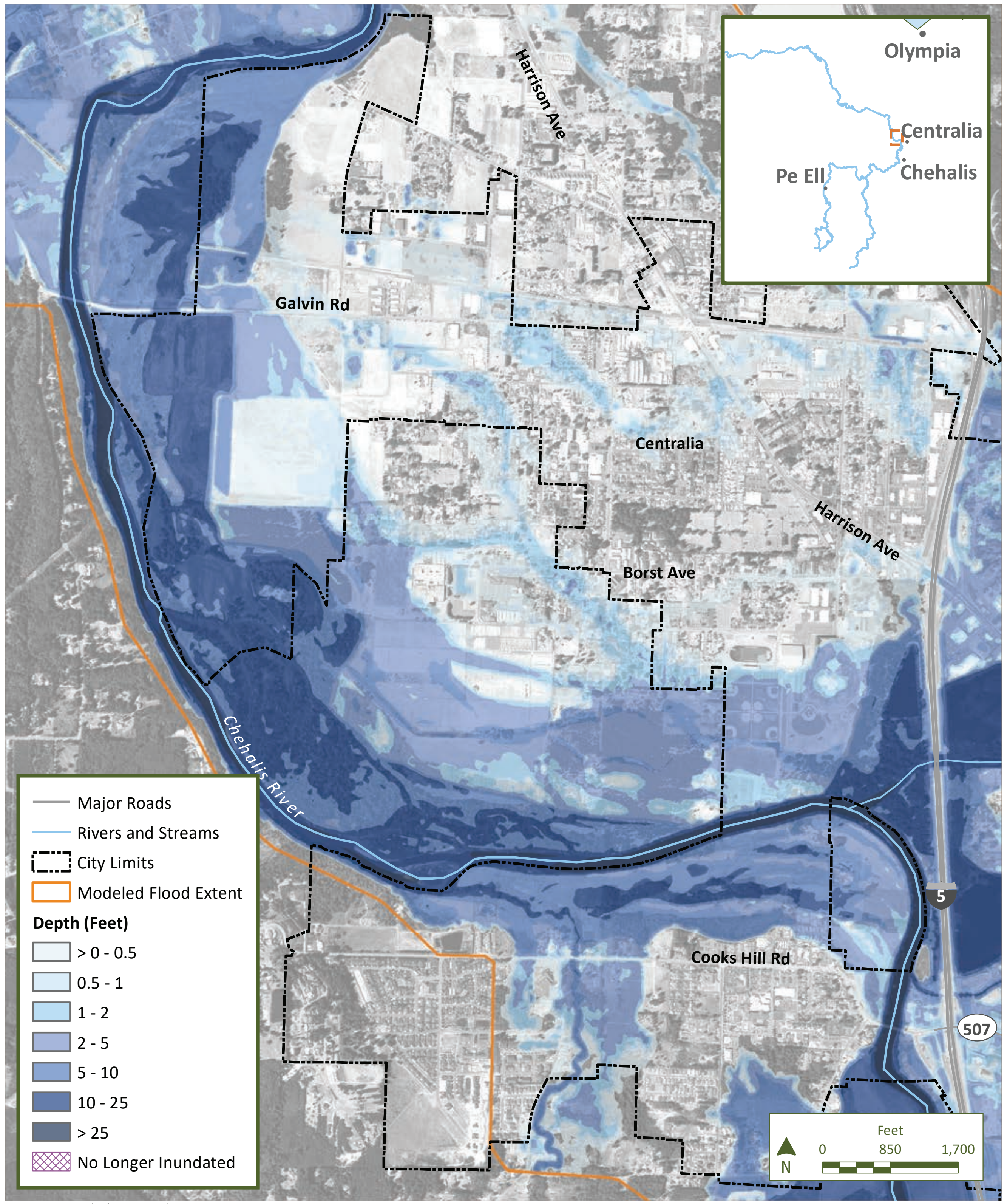
Figure N.9-e
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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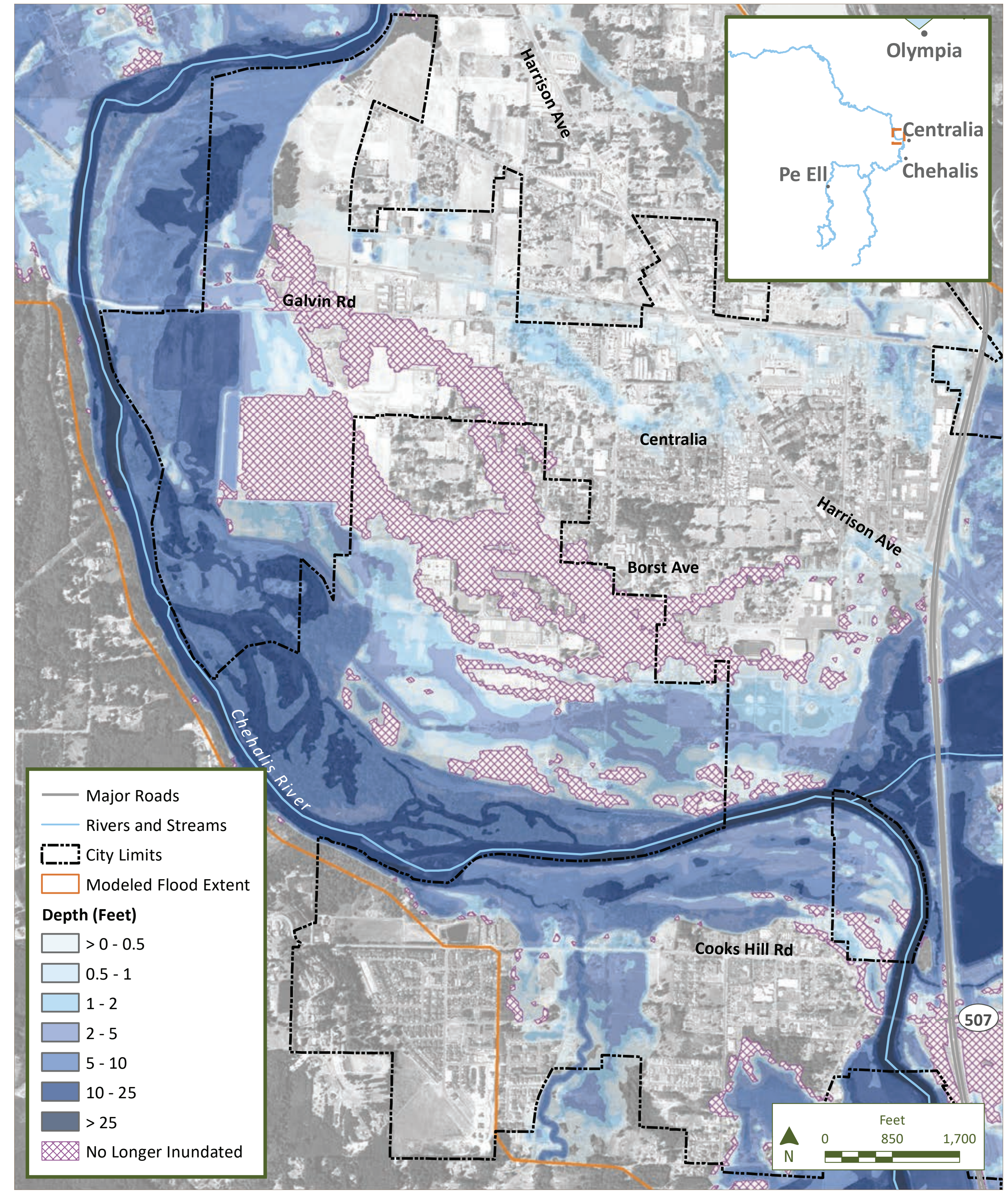

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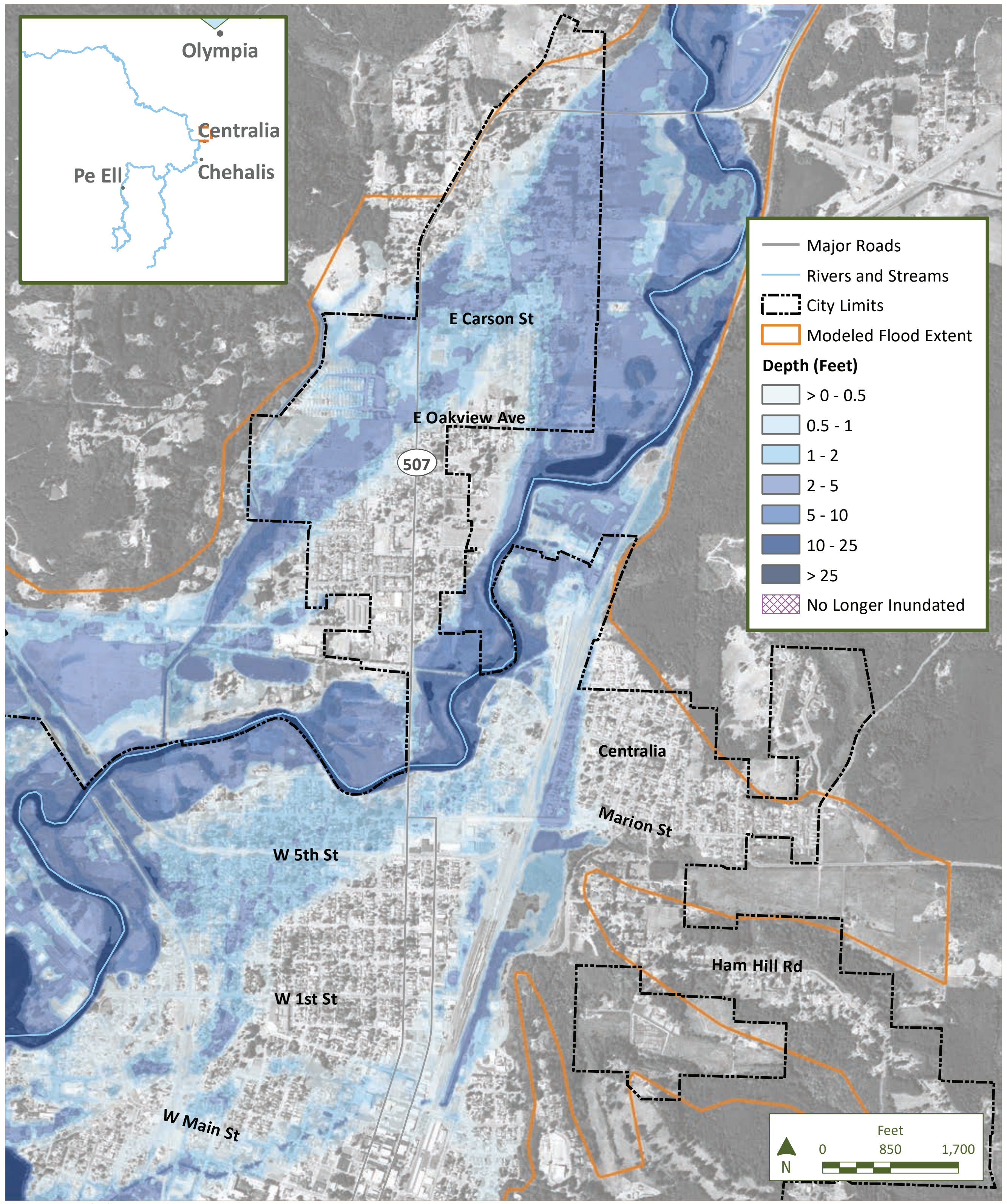
Figure N.9-f
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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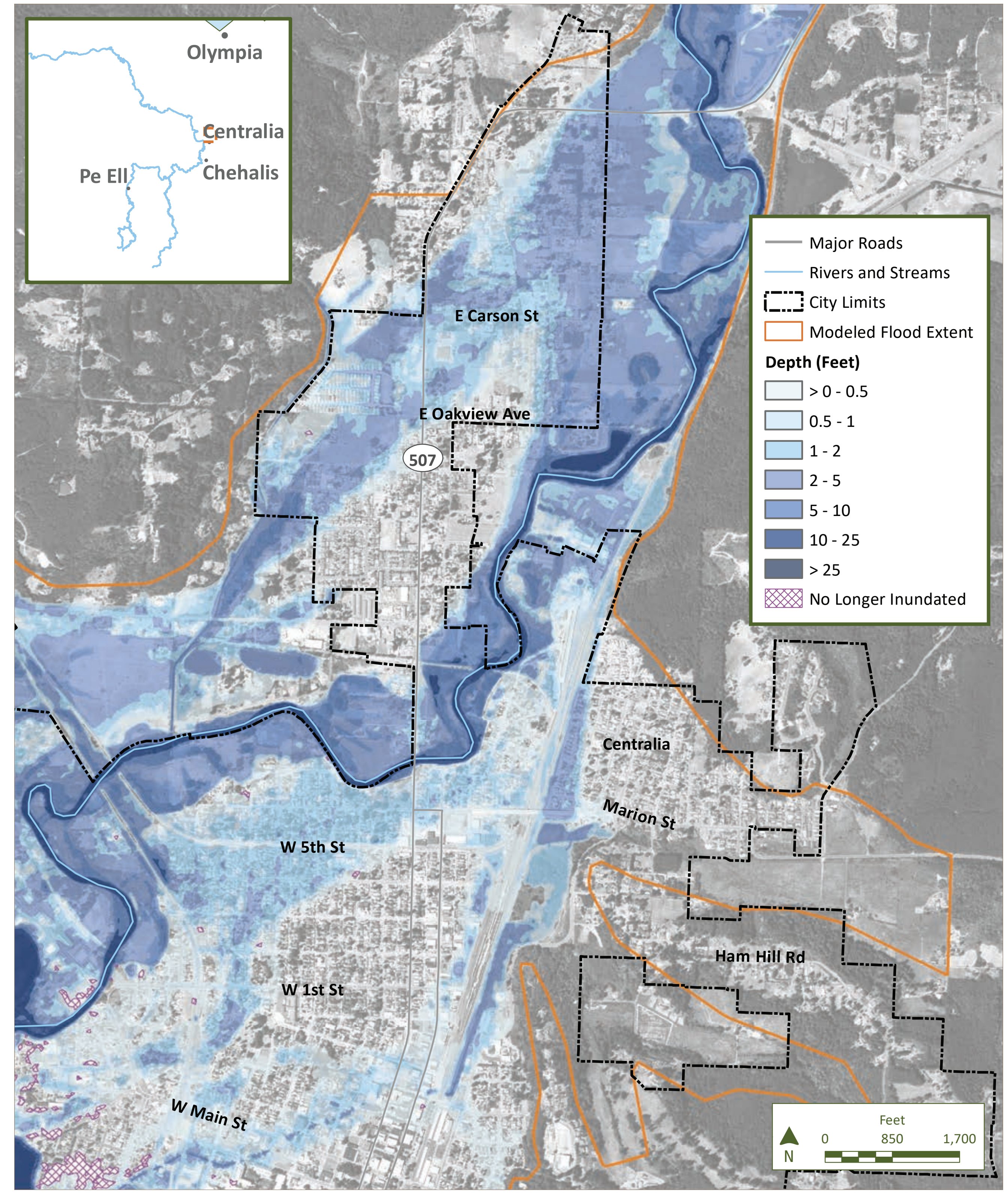

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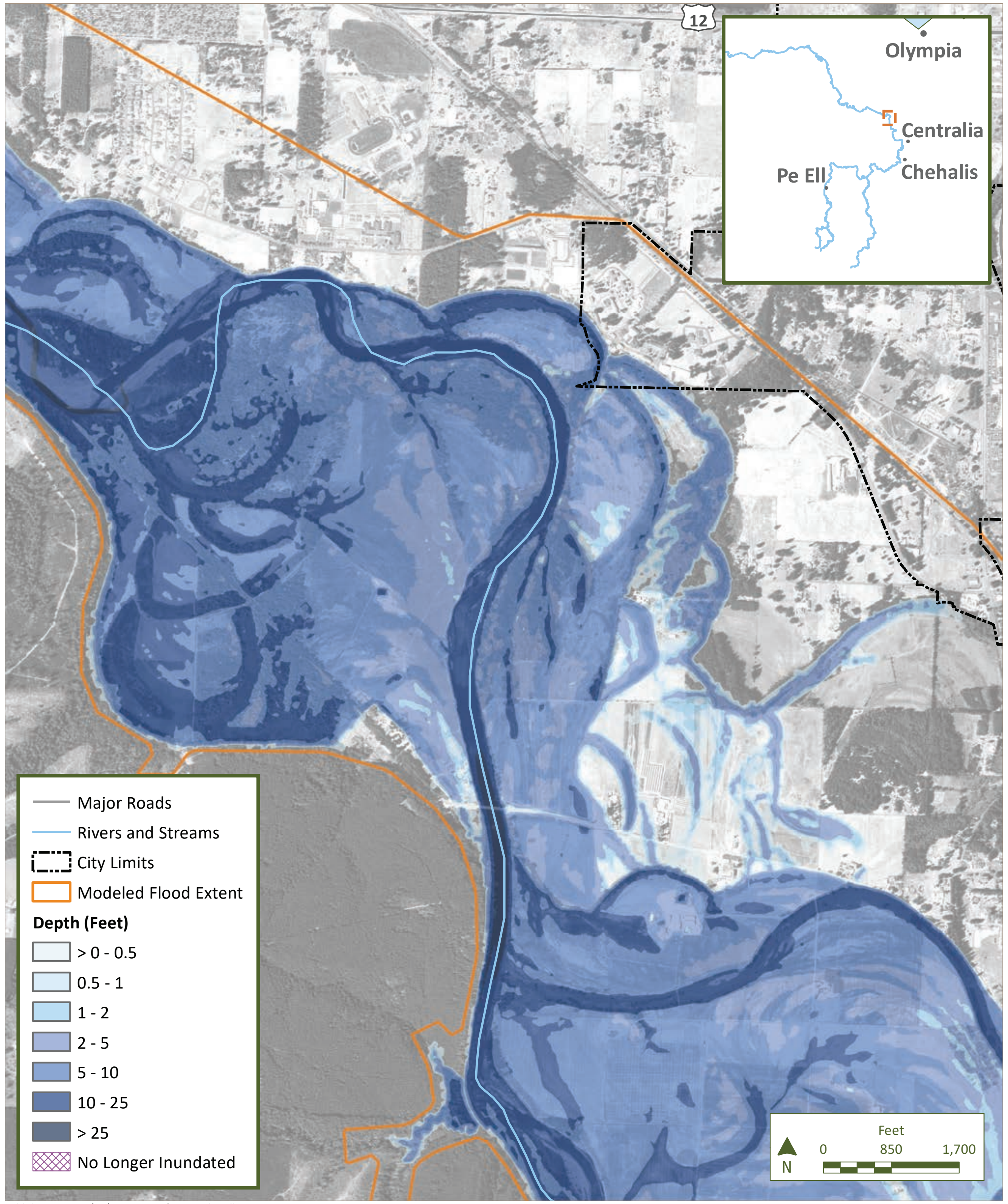
Figure N.9-g
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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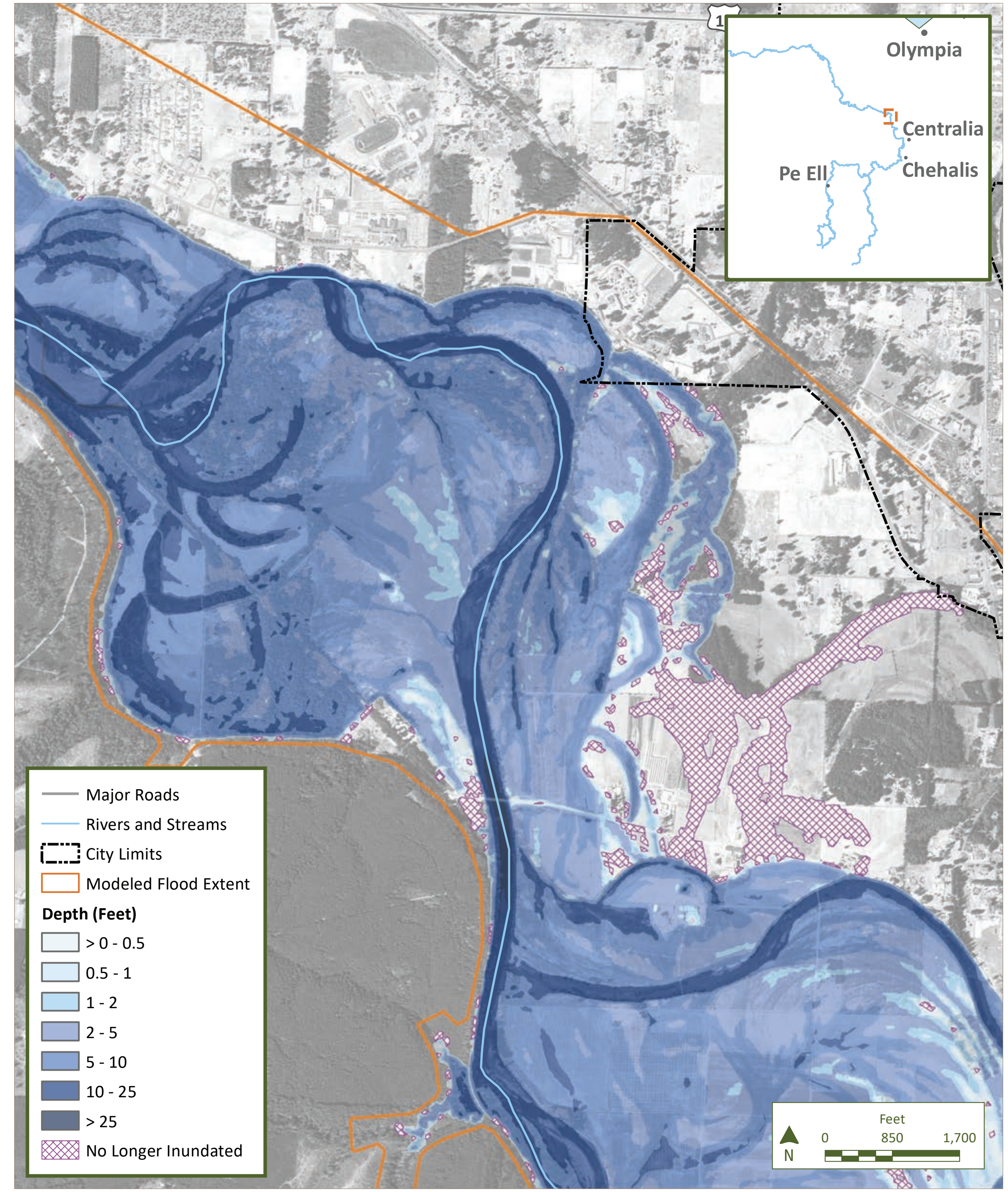

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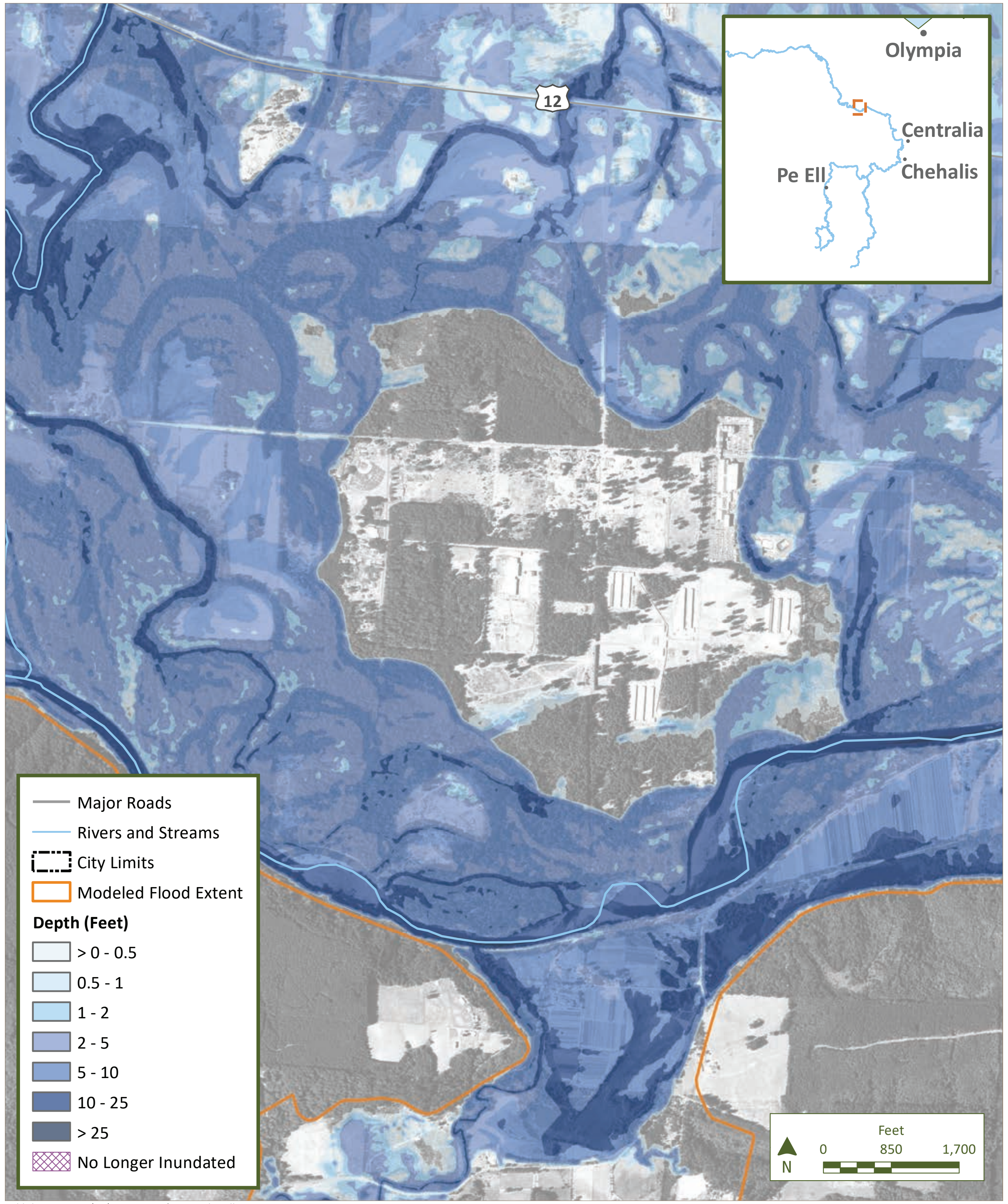
Figure N.9-h
Mid-Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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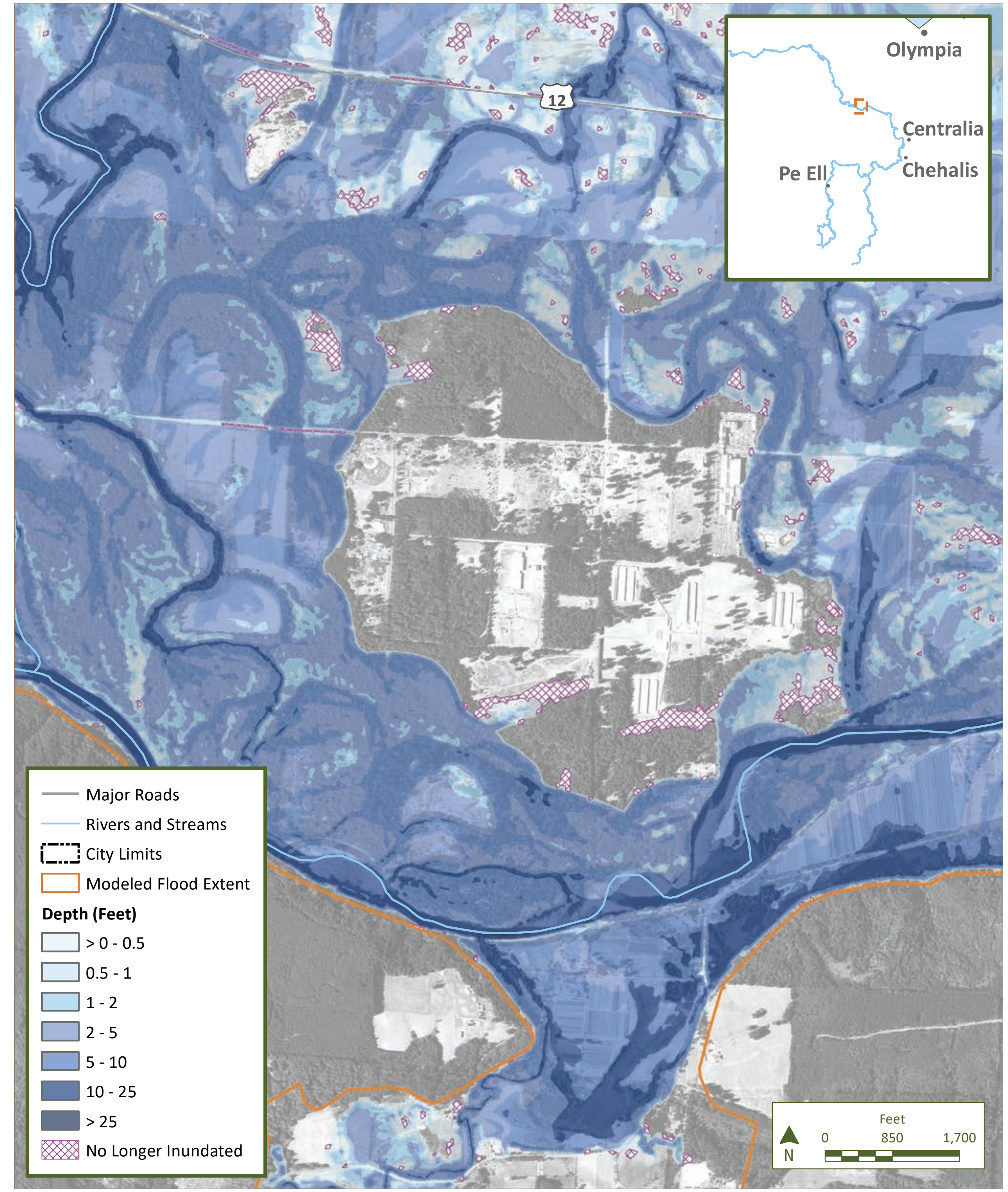

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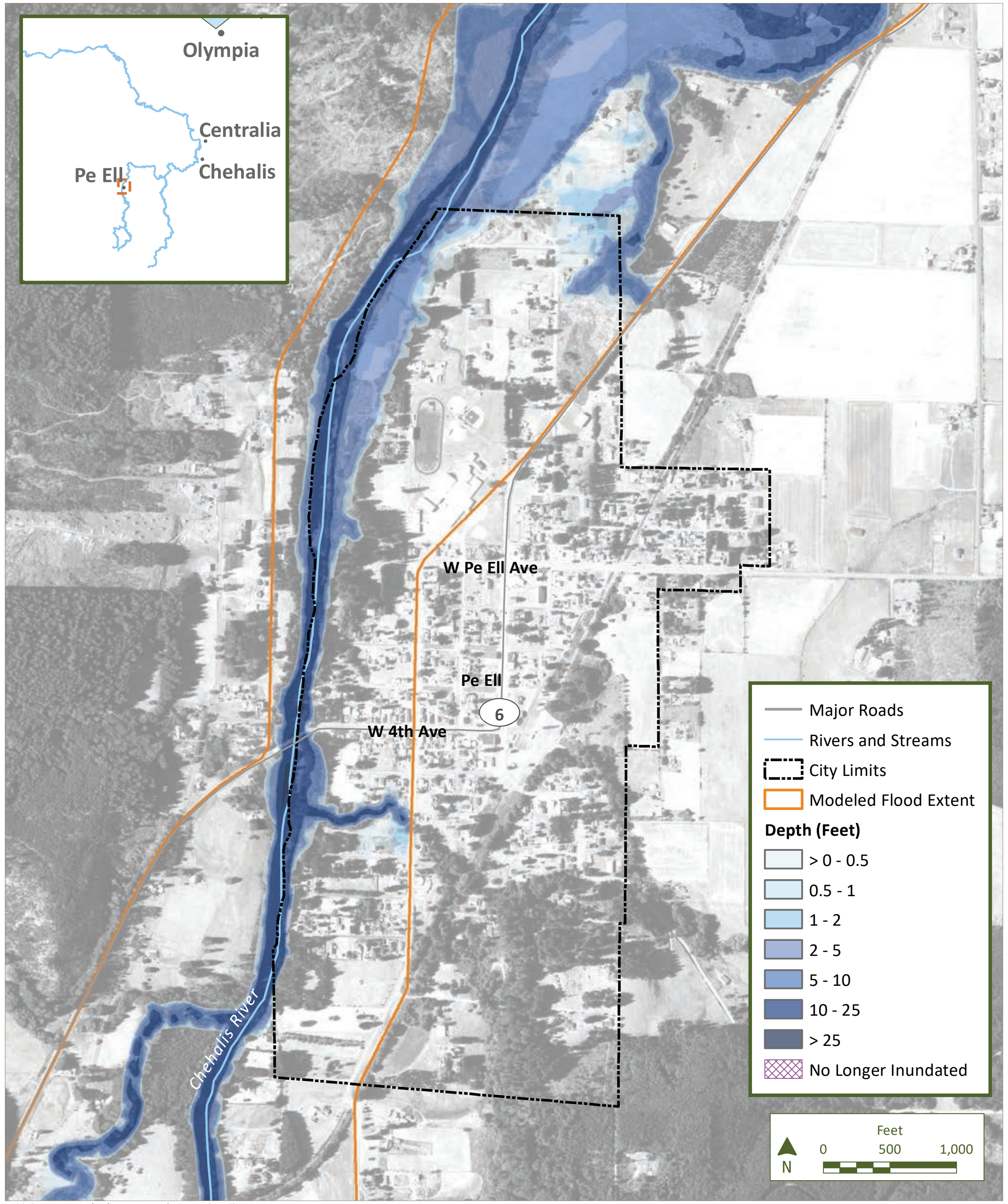
Figure N.10-a
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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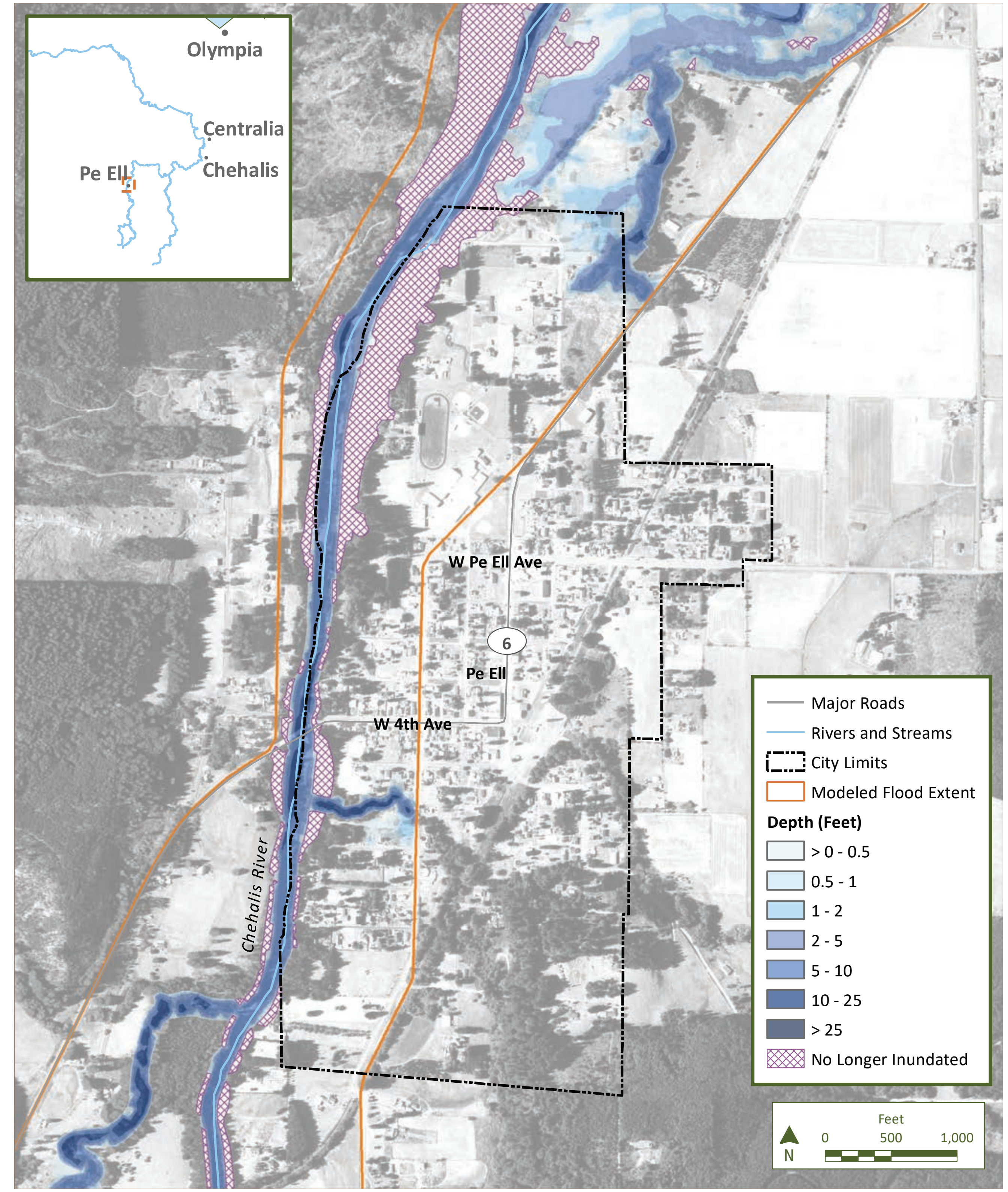

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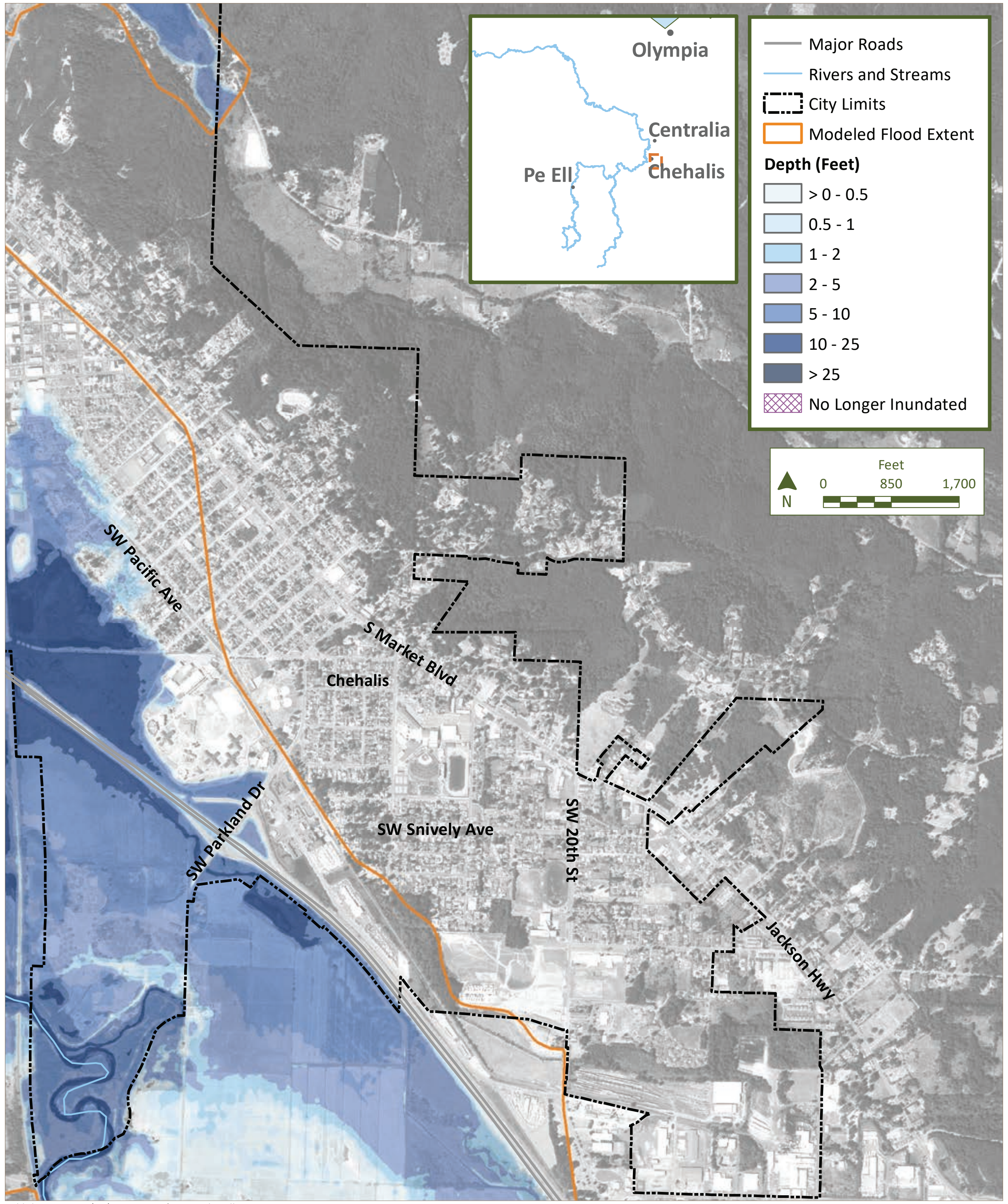
Figure N.10-b
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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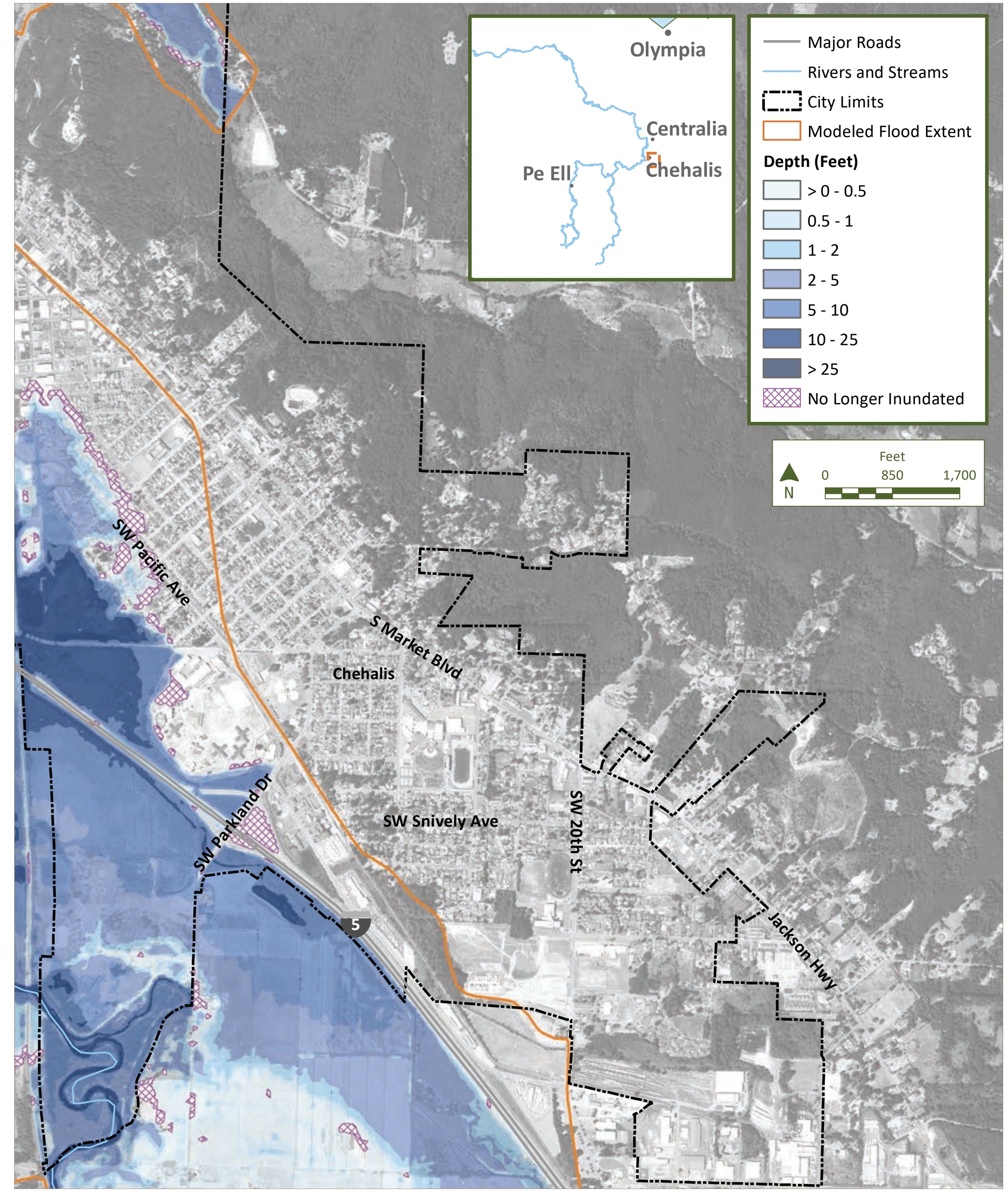

Figure N.10-c
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

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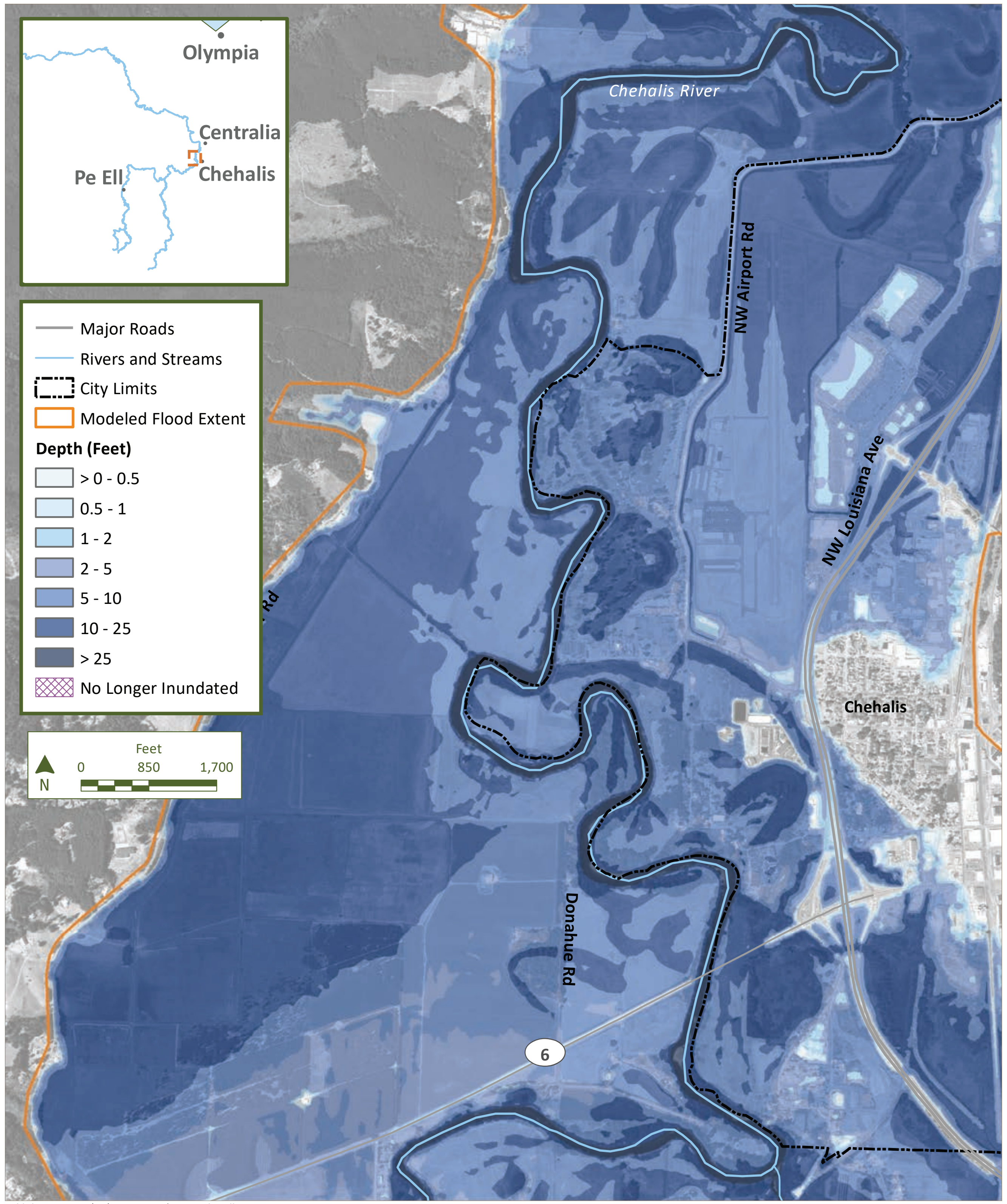

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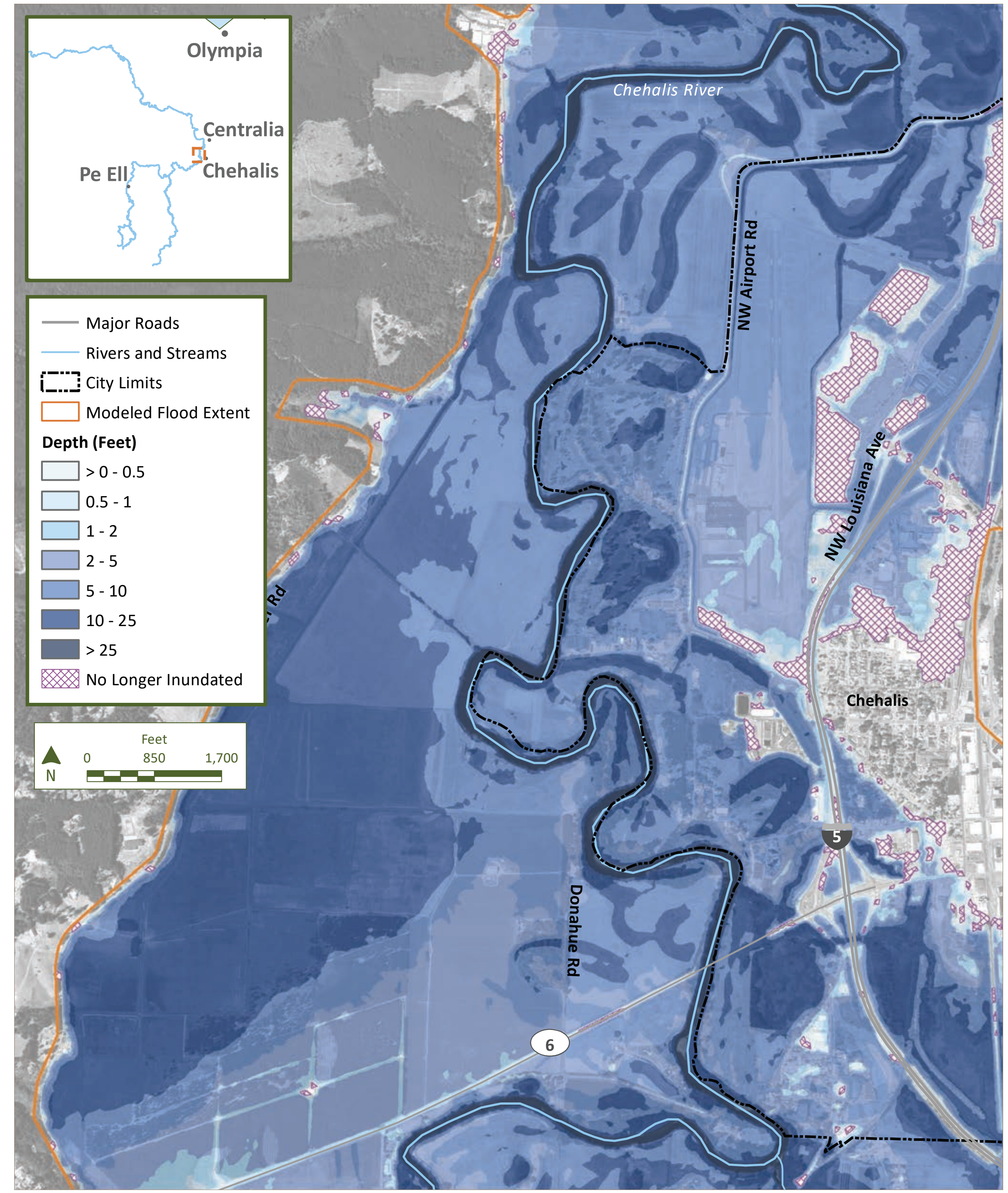

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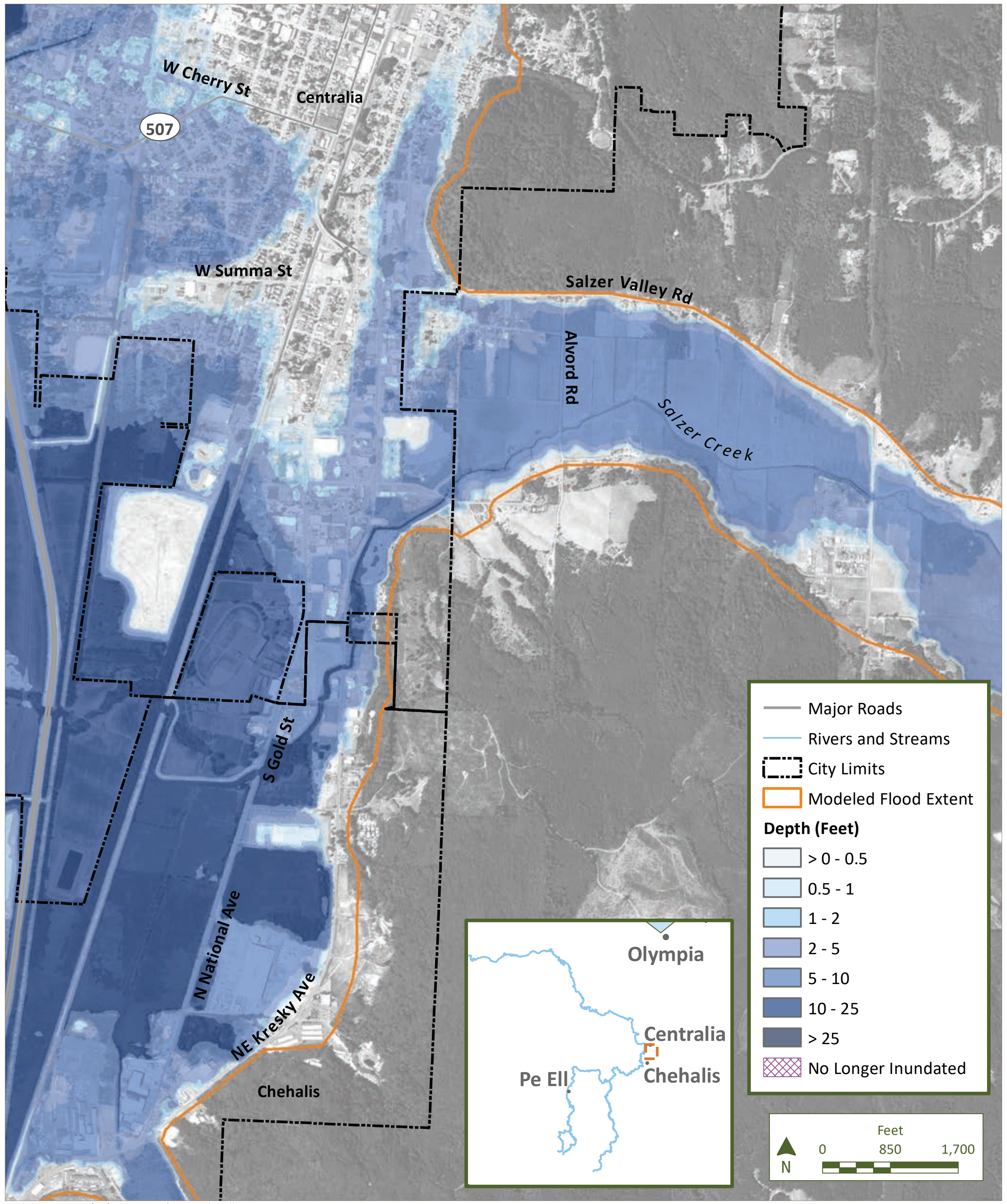
Figure N.10-d
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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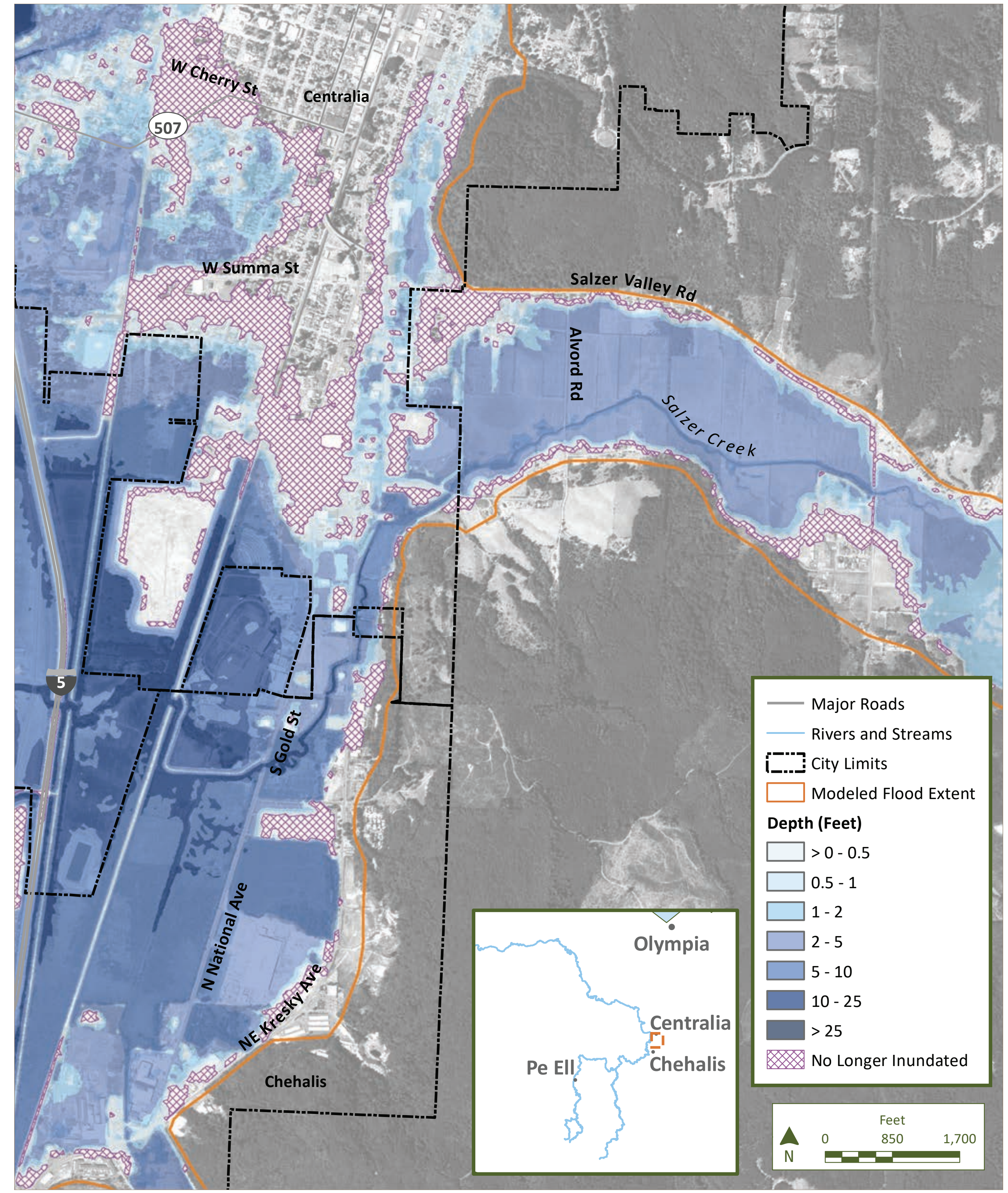

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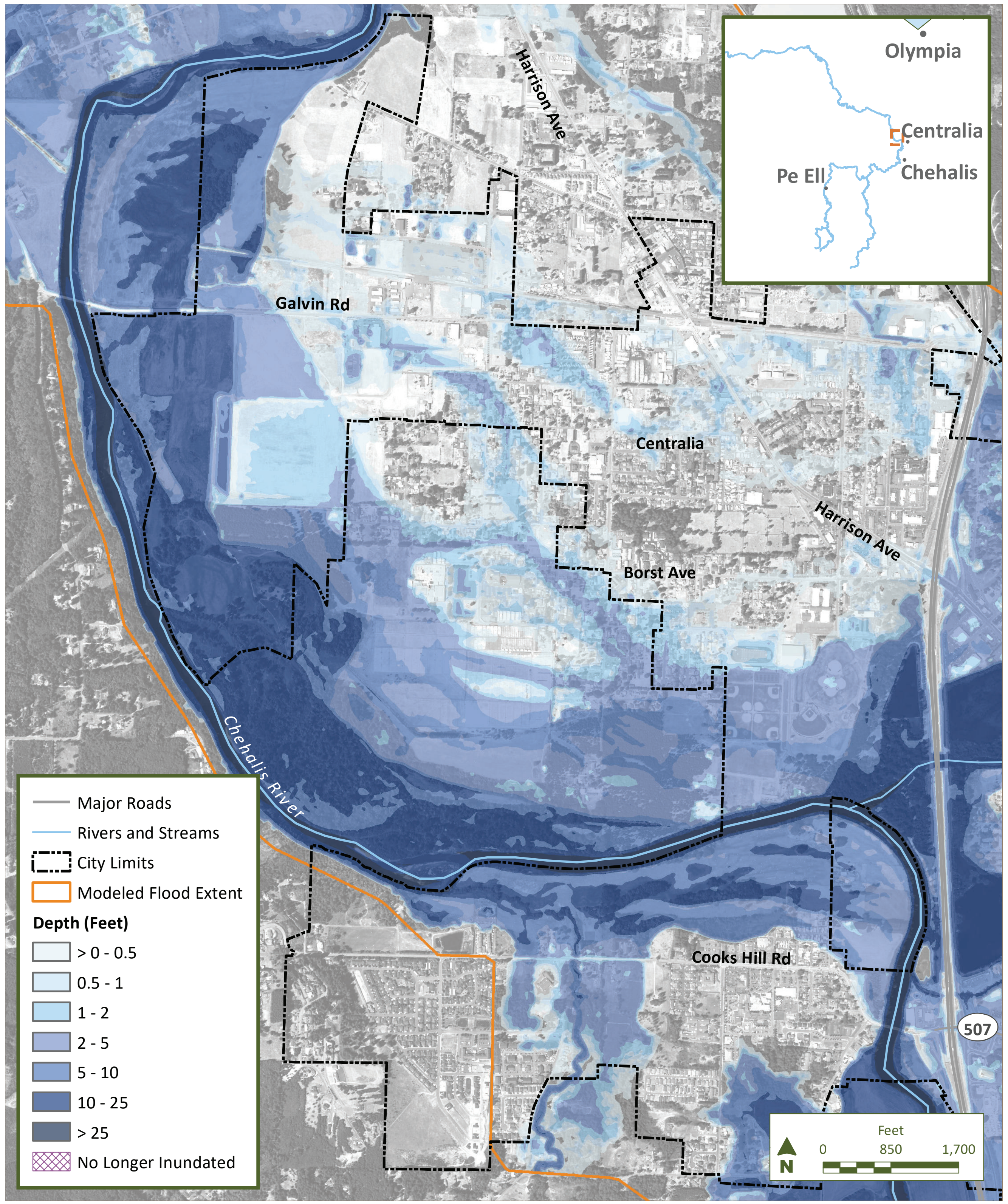
Figure N.10-e
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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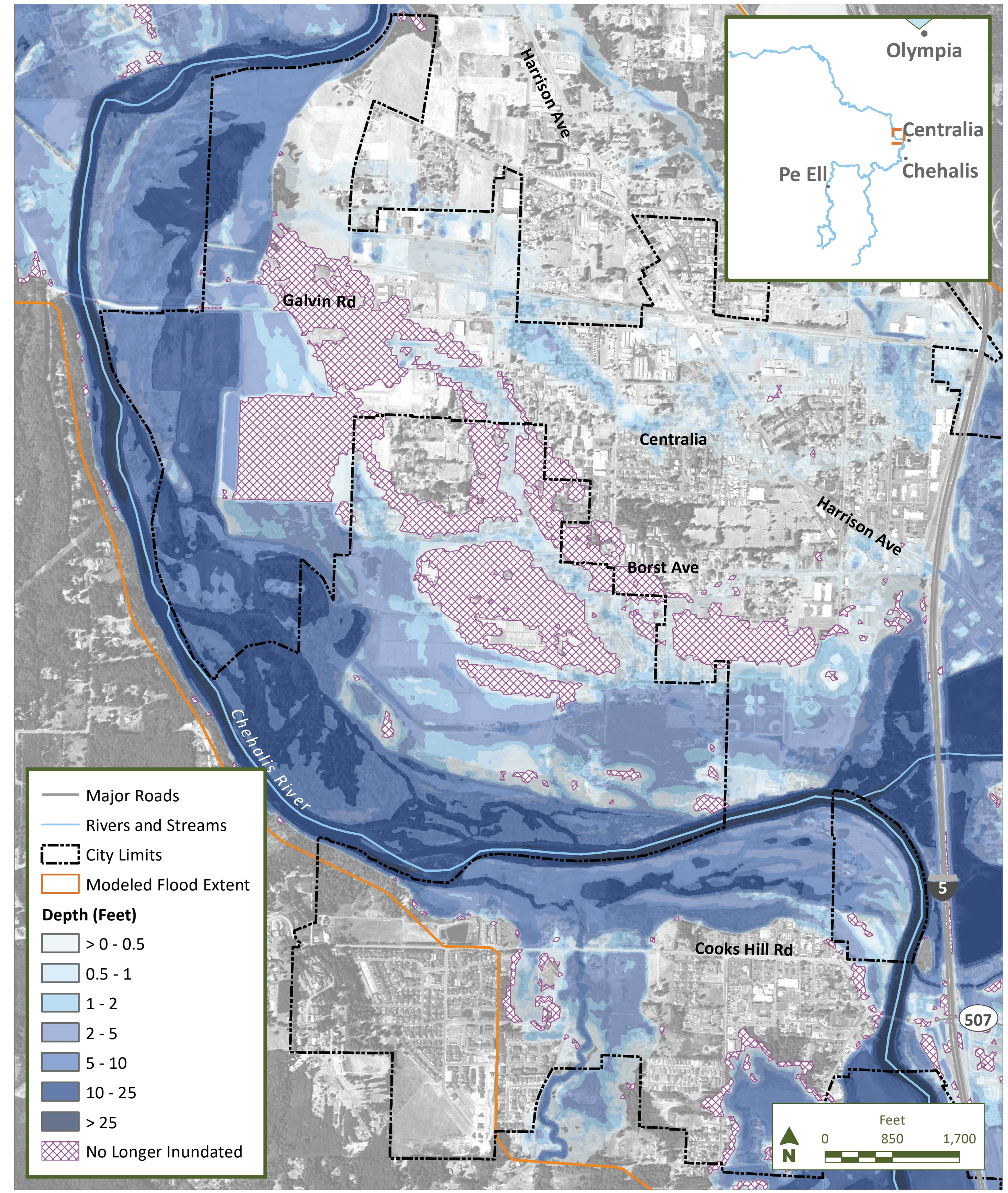
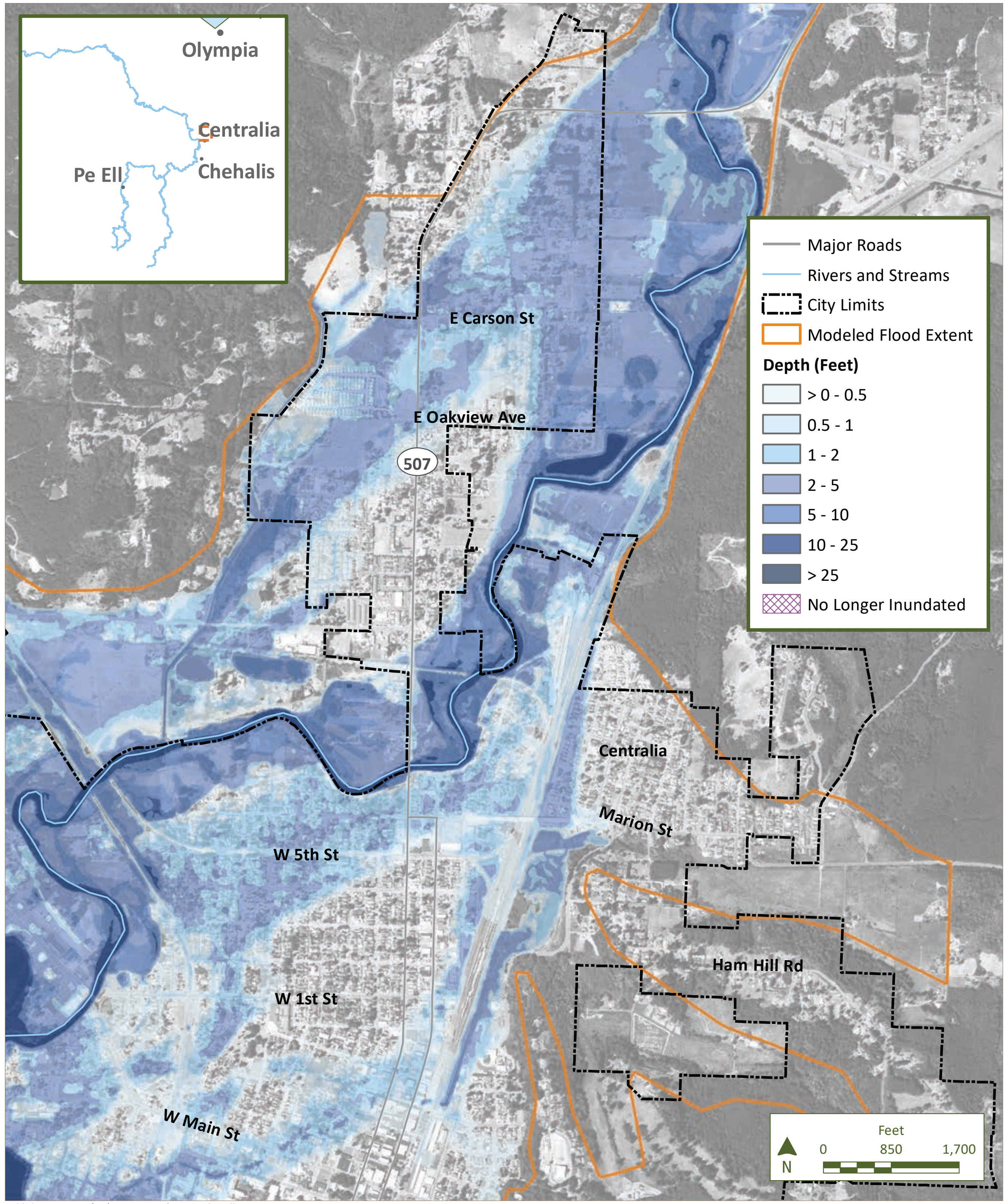


Figure N.10-f
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

No Action



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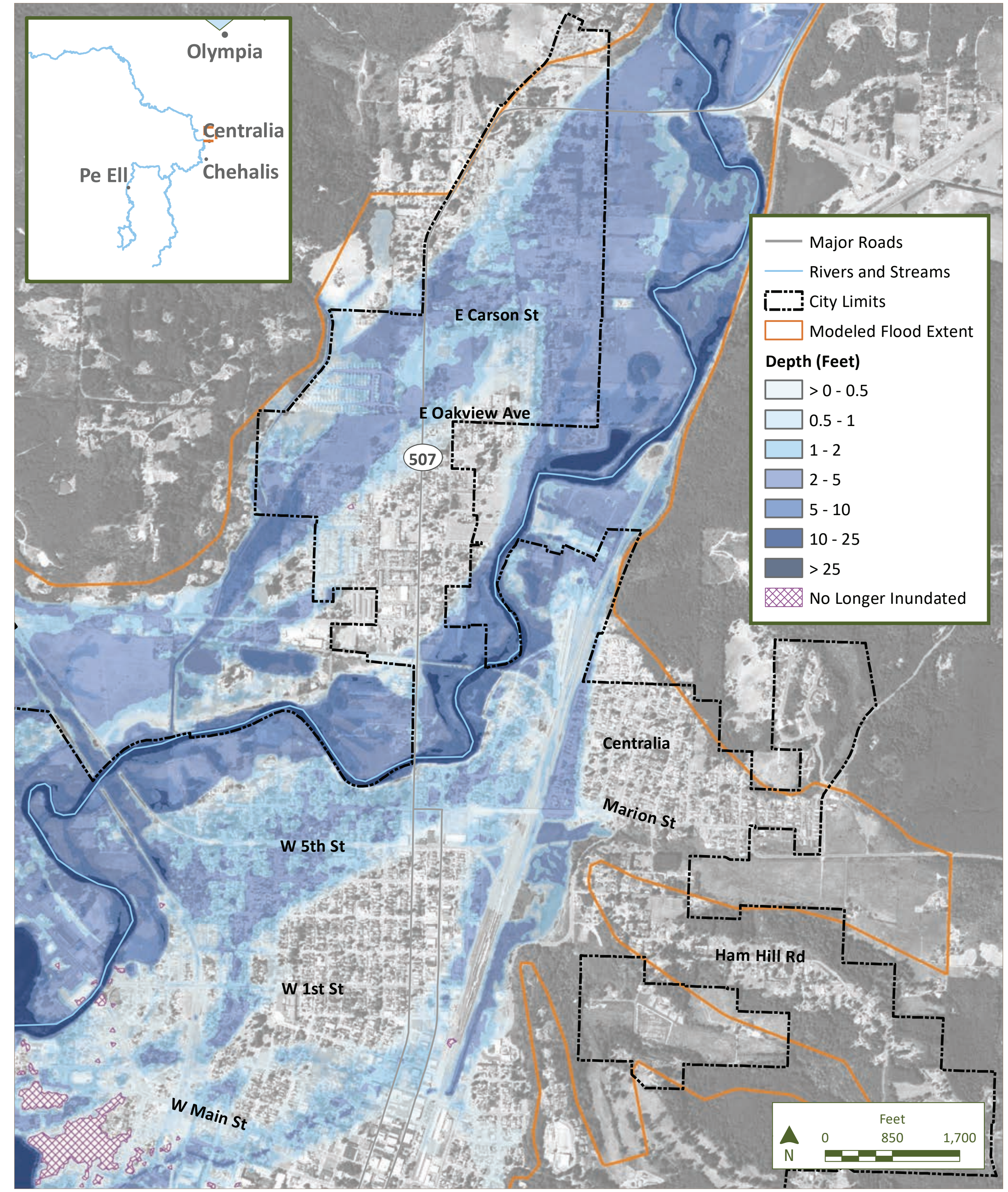

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Figure N.10-g
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

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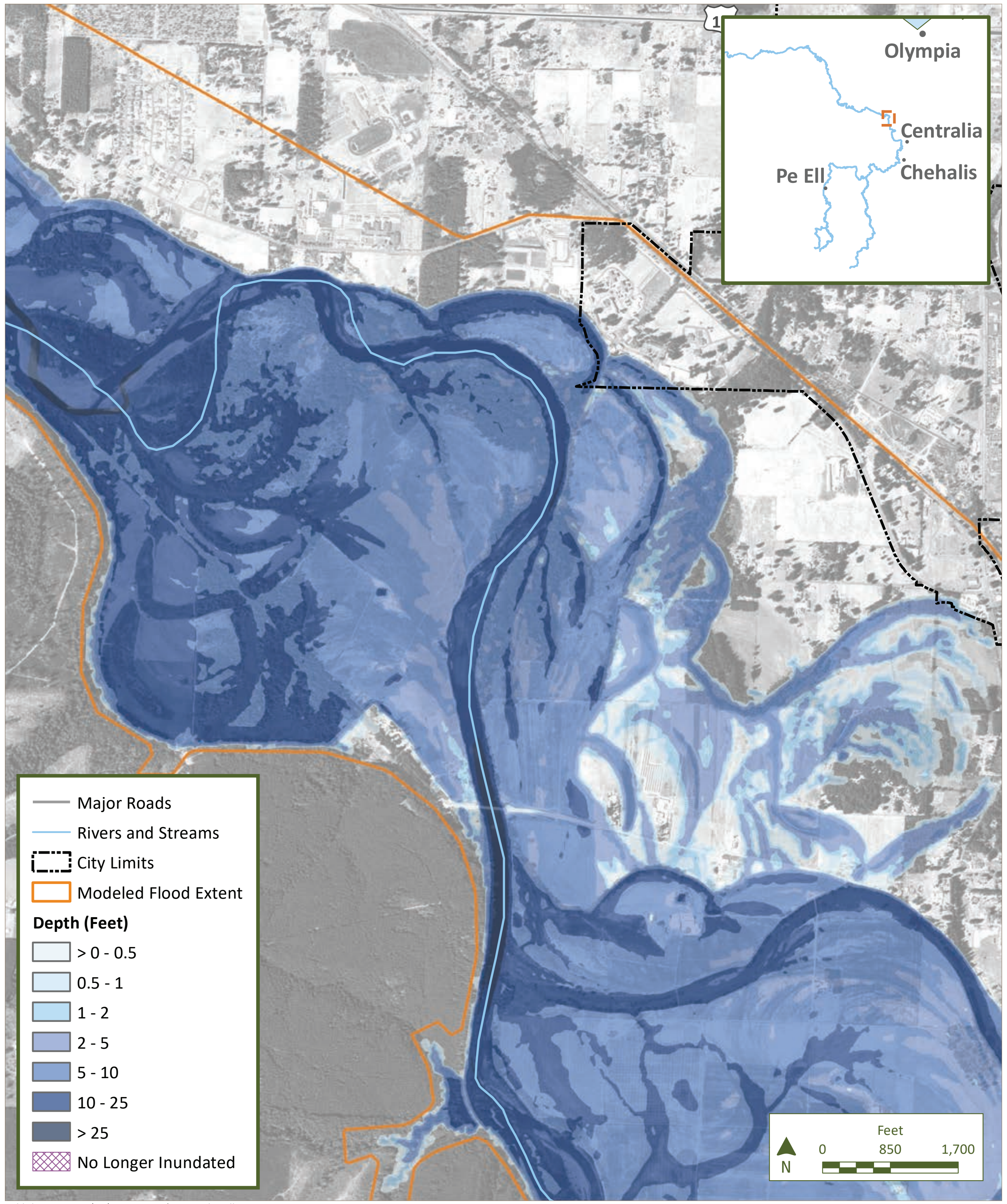

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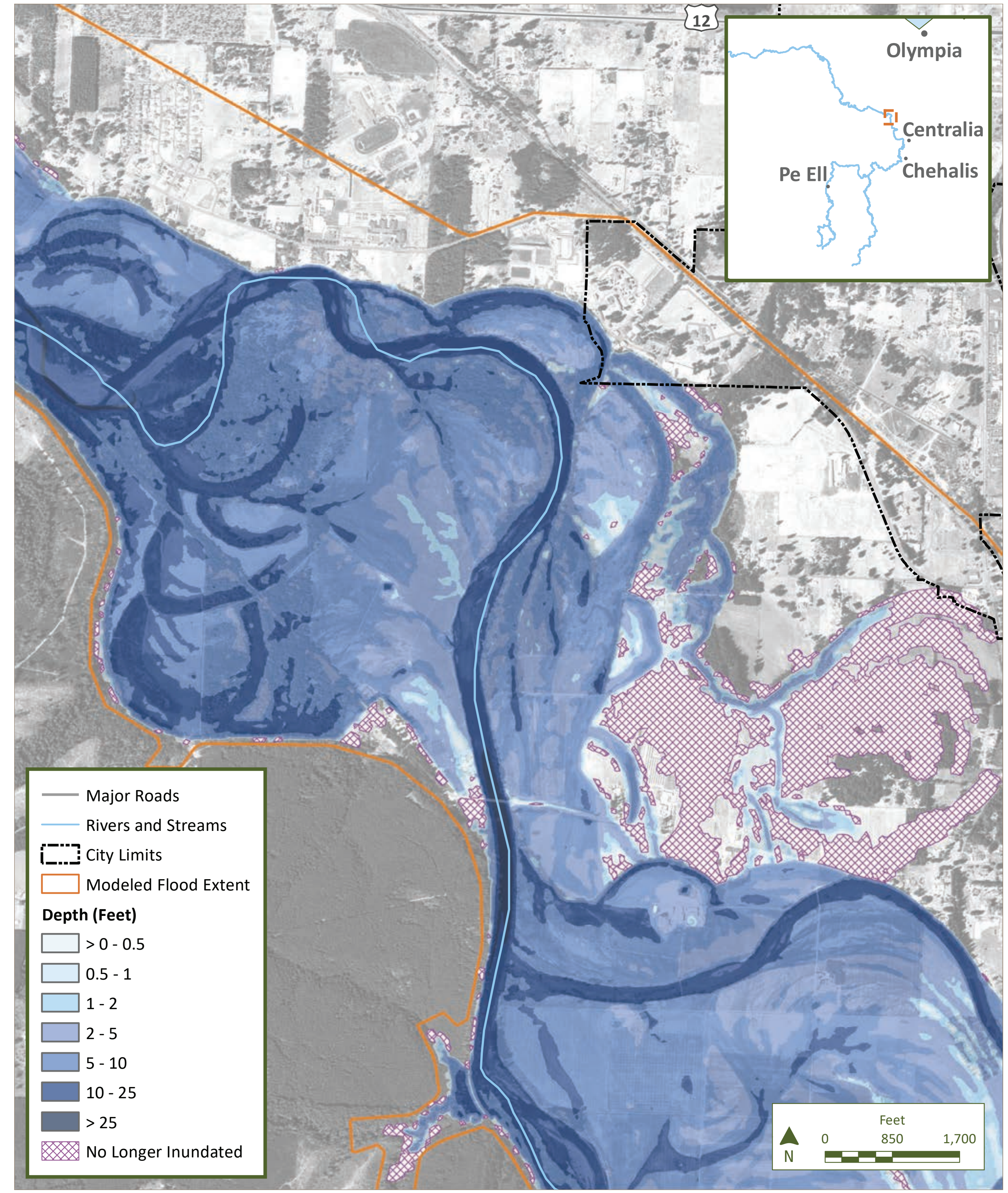

Figure N.10-h
Late Century Catastrophic Flood in Pe Ell, Chehalis, and Centralia

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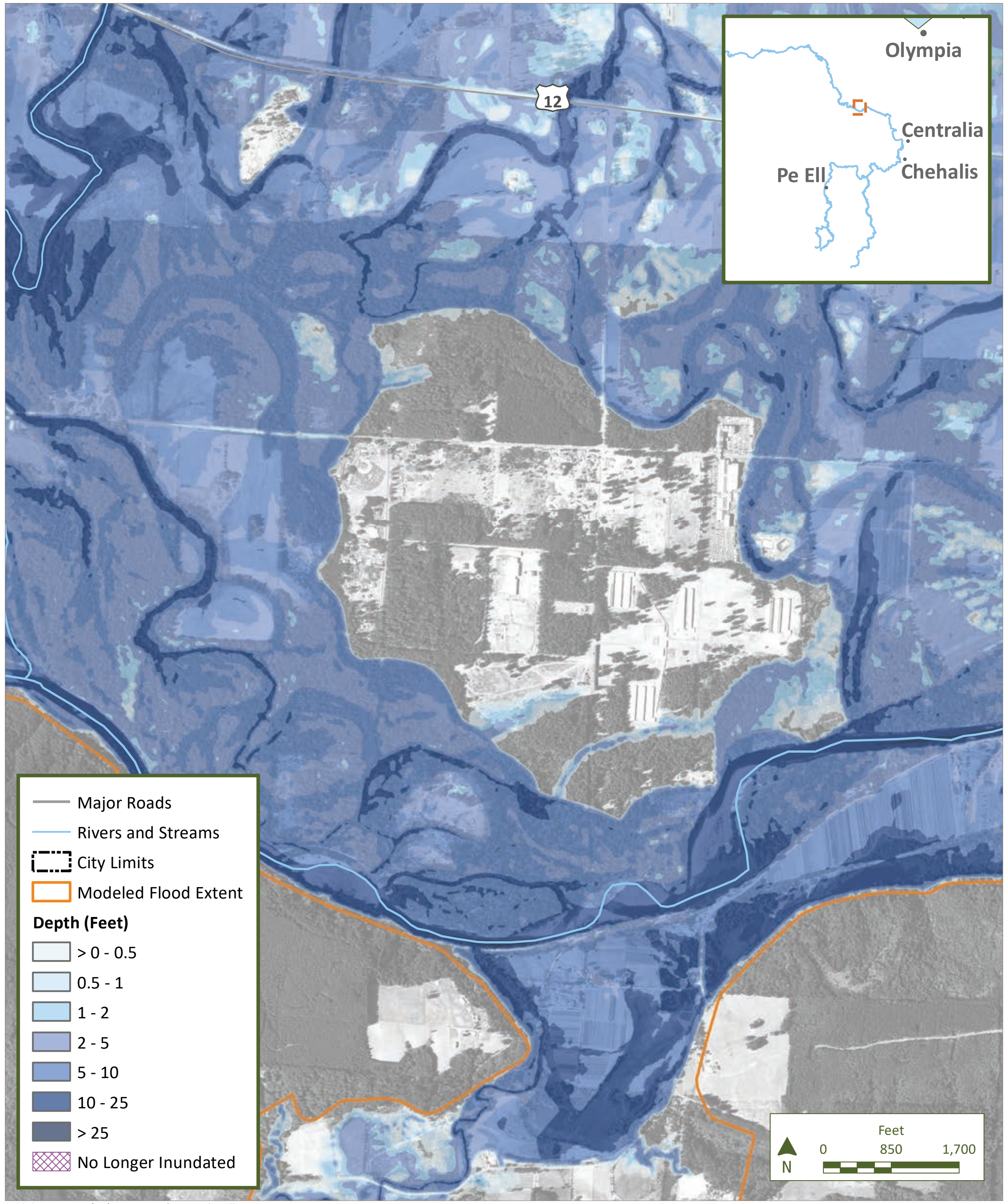

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Proposed Action