



Chehalis Basin Local Actions Non-Dam (LAND) Alternative

Conceptual Alternatives Analysis Report

By

Moffatt & Nichol

For the

Office of Chehalis Basin

Washington State Department of Ecology
Olympia, Washington

November 2025, Publication 25-13-015

Publication Information

This document is available on the Department of Ecology's website at:

<https://apps.ecology.wa.gov/publications/summarypages/2513015.html>

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DEPARTMENT OF
ECOLOGY
State of Washington

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Acknowledgements

The authors of this report thank the following people for their contributions to this study:

Voting Chehalis Basin Board Members:

- Vickie Raines, Chair, Chehalis River Basin Flood Authority
- Jay Gordon, Chehalis River Basin Flood Authority
- Scott Brummer, Chehalis River Basin Flood Authority
- Tyson Johnston, Quinault Indian Nation
- Dustin Klatush, Confederated Tribes of the Chehalis Reservation
- Glen Connelly, Alternate for Confederated Tribes of the Chehalis Reservation
- J. Vander Stoep, Office of the Governor
- Steve Malloch, Office of the Governor
- Edna Fund, Former Board Member

Ex Officio Chehalis Basin Board Members:

- Michael Garrity, Department of Fish and Wildlife
- Katie Rose Allen, Department of Natural Resources
- Mark Gaines, Department of Transportation
- Josh Giuntoli, Washington State Conservation Commission
- Jennifer Hennessey, Department of Ecology

LAND Phase 1 Working Group Members:

- Norm Chapman
- Todd Chaput
- Jessica Helsley
- Dan Maughan
- Brandon Parsons

- Brian Stewart

Washington State Department of Ecology Staff:

- Jeff Zenk
- Nat Kale

Consultants:

- Moffatt & Nichol
- Biohabitats
- GeoEngineers
- MIG, Inc.
- Northwest Hydraulic Consultants
- Willamette Cultural Resources Associates

Abstract

This study was completed by the Office of Chehalis Basin (OCB), housed within the Washington State Department of Ecology, and includes Phase 2 conceptual design work completed as part of the Chehalis Basin Local Actions Non-Dam (LAND) Alternatives Analysis. This study aims to reduce flood damage to communities across the Chehalis Basin by building upon the Phase 1 LAND work completed in 2024 by OCB.

Phase 2 of the LAND study focused on refining conceptual designs for structural flood protection features, including levees, floodwalls, and conveyance improvements. The analysis was conducted in two phases – first a concept-level screening analysis and stakeholder coordination effort was conducted to refine the features from Phase 1 of LAND. The concept-level screening removed the diversion component of the project due to cost, environmental, and stakeholder concerns. The screening process also included analysis of different levee and floodwall alignments and developed potential phased construction scenarios.

Following the concept screening analysis, two-dimensional hydraulic modeling (RiverFLOW2D) was conducted to assess potential water level and velocity changes resulting from construction of the conceptual flood protection features. The model results showed relatively minimal downstream increases in water level and identified isolated areas of morphological risk for further analysis in future phases of the study. The estimated project costs range from \$850 million to \$1.5 billion (2025 dollars), including a 55 percent contingency.

Future phases of LAND should advance the conceptual designs identified herein through conducting geotechnical investigations, refining hydraulic models, integrating the LAND components with other studies in the basin, and including other recommendations noted in the main report.

Executive Summary

The Chehalis Basin, the second largest river drainage in Washington State, is a regional hub for both economic and recreational opportunities. The area is highly susceptible to riverine flooding, with smaller flood events occurring every 2-5 years and major floods occurring roughly every decade (OCB, 2024). The Local Actions Non-Dam (LAND) Alternative is an effort to develop an approach to reduce long-term flood damage across the Chehalis Basin as an alternative and/or in addition to the proposed flood retention facility (FRE) and Chehalis Airport levee improvement projects sponsored by the Chehalis River Basin Flood Control District.

The objectives of this phase of the LAND Alternative development are to:

- Provide flood damage reduction while considering impacts to local wildlife, residents and businesses, and cost by developing conceptual designs for:
 - Structural interventions (new/expanded levees, floodwalls, pump stations, etc.)
 - Improved Chehalis River conveyance
- Protect community lifelines, enhance resiliency during flood events, and inform future local floodplain planning efforts.
- Develop tangible results during an alternatives analysis that will be used to further support the Chehalis Basin Board’s decision-making process on a long-term integrated strategy for the basin.

Guiding principles

A list of guiding principles to support the alternatives assessment process was developed, as shown in Figure 1. The guiding principles were developed in conjunction with OCB and project stakeholders to ensure the alternatives developed met the specific needs of the region. The guiding principles were used in conjunction with industry standard engineering guidelines to develop the flood protection features.

Figure 1: Guiding principles for the alternatives analysis



Key design criteria

Study requirements, including the design criteria for infrastructure improvements and corresponding flood damage reduction, were documented in a Basis of Analysis (BOA) document that was updated throughout the duration of the study. Throughout the study, the design criteria were coordinated with OCB to gain alignment on objectives and critical points of focus. Key design criteria are summarized below, with a full description of the design criteria included in the BOA Appendix to the main report. These design criteria were used to develop and assess the LAND project features.

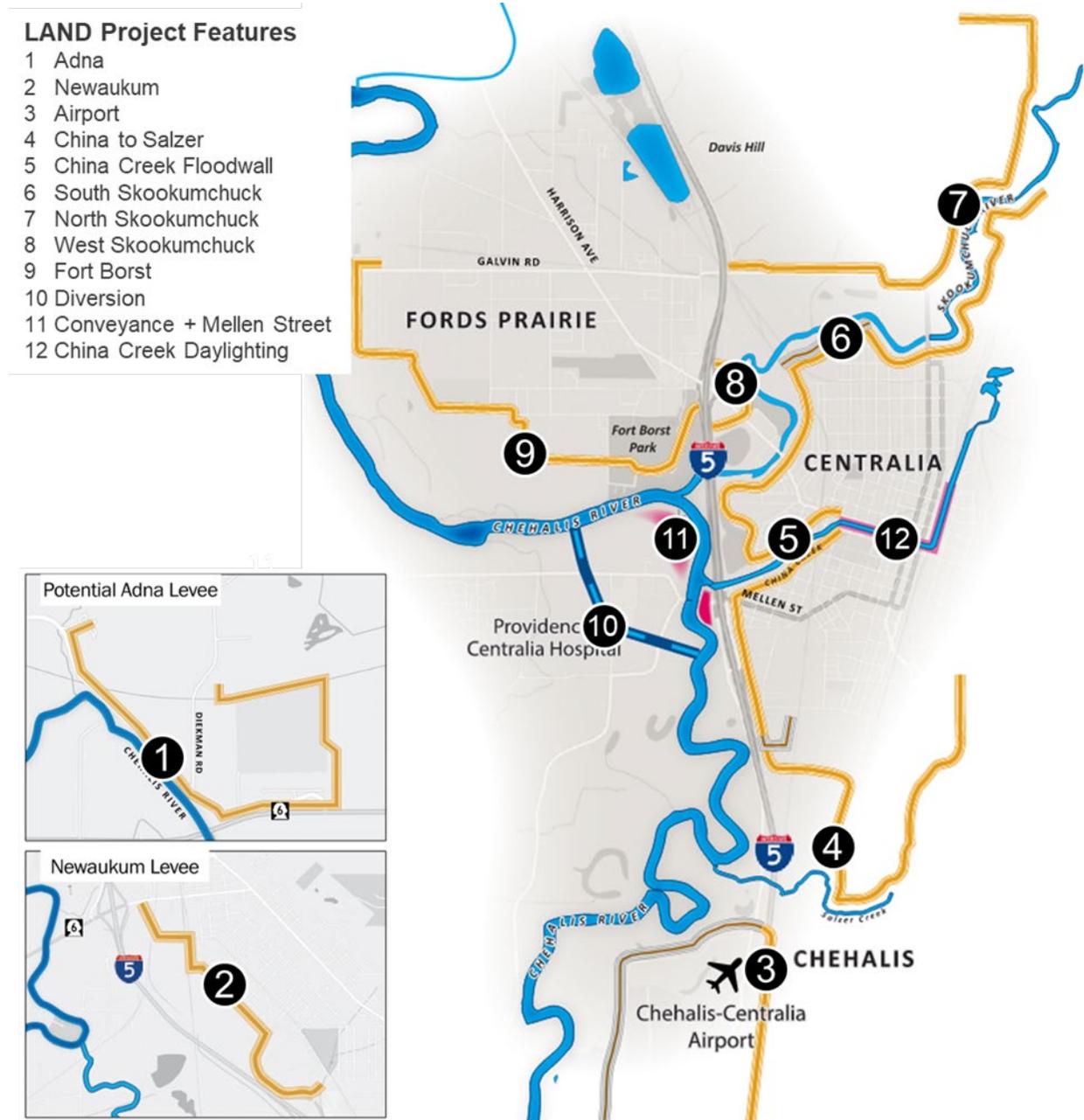
- **Design Flow Event:** 100-year return period plus 26 percent flow event.
- **Required Freeboard for Flood Protection Structures:** 3 feet above design flood level.
- **Required Freeboard for Structure Retrofits and Raises:** 1 foot above the design flood level.

Local Actions Non Dam (LAND) Analysis Summary

The Chehalis LAND Alternative is a comprehensive, community-driven approach developed to address increasing flood risks in the Chehalis Basin without constructing a flood retention dam. Phase 1 of the LAND Alternative was previously developed through technical analysis and Partner engagement and completed with a summary report issued in summer of 2024 (OCB, 2024). The Phase 1 work, and alignments of the different project features were the starting

point for this phase of LAND. The advancement of the conceptual design work conducted during the Phase 2 work is described in the following sections. The feasibility-level analysis resulted in the development of twelve structural project features that are the focus of the Phase 2 work conducted in this study, as shown in Figure 2 (per OCB, 2024). Note that the numbers within the black circles shown in Figure 2 associated with each project feature are used throughout the document.

Figure 2: Project features resulting from Phase 1 LAND analysis, adapted from OCB, 2024

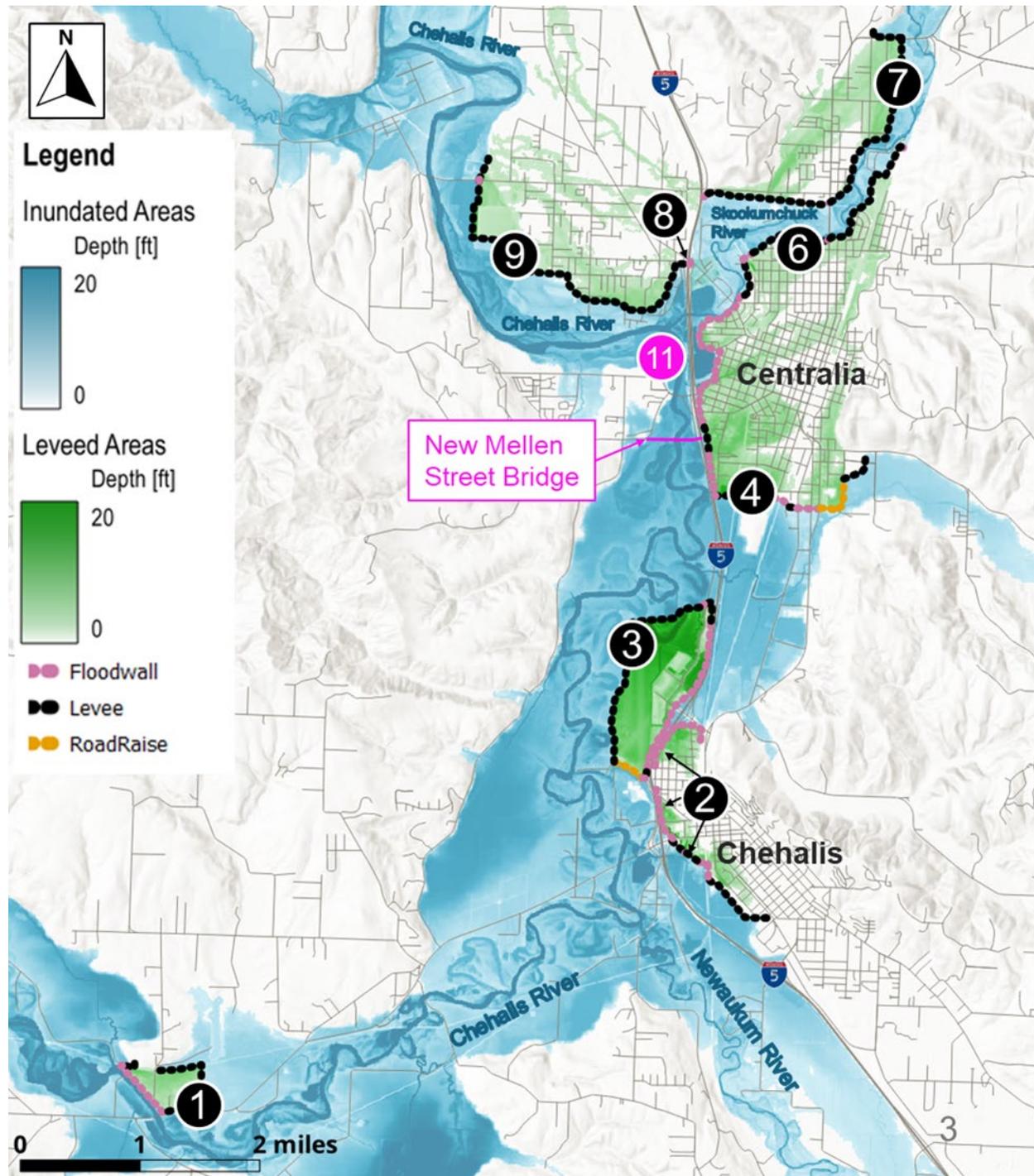


Conceptual design of project features

The LAND analysis and refinement conducted during this study included two steps:

- **Screening:** A concept-level screening analysis was conducted to refine and advance the LAND levee and floodwall alignments developed during the previous phase of the project (OCB, 2024). The concept-level screening assessment was conducted to compare different alignments, investigate phasing feasibility, and review effectiveness of the different project components at reducing flood hazards within the Chehalis Basin. The screening analysis helped refine and coordinate project features prior to a more detailed conceptual design effort. Key findings from the screening process include:
 - *Diversion:* After conducting a concept-level cost-benefit analysis, considering stakeholder input, and assessing environmental impacts, the diversion project component was deemed nonviable and removed from the conceptual design.
 - *Alignments:* The levee and floodwall alignments were refined from the previous phase based on guiding principles, stakeholder engagement, and cost considerations.
 - *Phasing:* Potential phasing scenarios were evaluated, and the analysis indicated that phased construction of the LAND levees and floodwalls is feasible. The main report provides a summary of one possible phased construction scenario. Further analysis of phased construction approaches is recommended for future studies.
- **Conceptual Design:** After the initial screening phase, more detailed hydraulic analyses, cost estimates, and other analyses were conducted to refine and inform the conceptual design of the project features. The results of the concept design process (approximate 10 percent level) are shown in Figure 3 and were used to develop conceptual project costs.

Figure 3: Summary of the LAND alignments resulting from the screening analysis



During the conceptual design process, detailed two-dimensional hydraulic modeling was conducted using the RiverFLOW2D model. RiverFlow2D, a two-dimensional combined finite volume hydraulic model that simulates riverine and floodplain interactions, was used to analyze the hydraulic changes resulting from implementation of the levee, floodwall, and conveyance systems. The project features shown in Figure 3 were built into the two-dimensional model

domain. The model tributaries were forced with the design event flowrates. Key findings from the numerical modeling analysis are described below, and the changes in water level from the No-Action condition, as well as morphological risk assessments, are shown in the main report.

- **Water Level Changes:** The most significant water level increases occur between the North and South Skookumchuck levees, which is expected due to the proximity of the levees to the river in this area. The majority of structures in this region will be protected by the levees; for those not, the project cost includes provisions for raising homes to address these increases. Overall, changes in downstream water levels are low, generally less than 0.3 feet.
- **Velocity Changes and Morphological Risk:** Changes in modeled peak flow velocity when the LAND features were in place was used to qualitatively assess the potential for morphological changes. The results indicate that risk areas for such changes are largely isolated, primarily concentrated in the conveyance excavation area and the Skookumchuck River. Further investigation of these areas is recommended in future modeling studies.

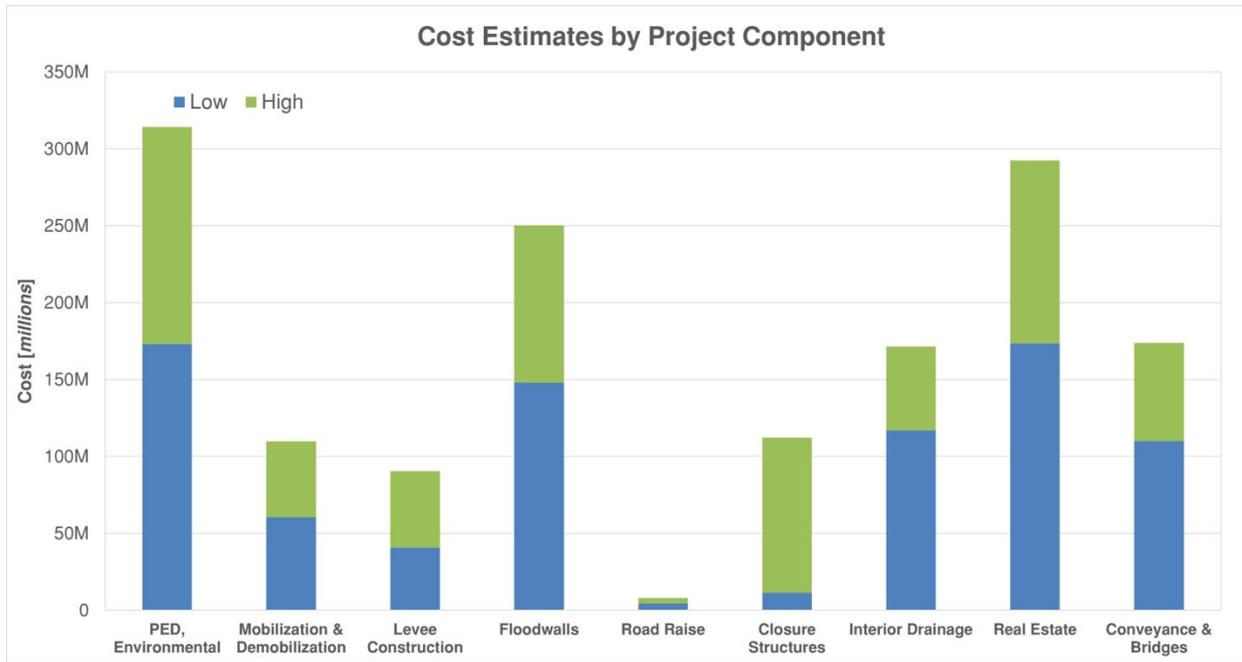
Cost analysis

Class V level project cost estimates were developed for the conceptual design. The estimates include 55 percent contingency (per NLSP, 2023 recommendations) and are in 2025 dollars with no escalation applied. Please see the main report and associated appendices for additional information. The cost estimate categories include the following items, please see the main report for additional detail on the components included in each cost category:

- (1) Pre-Construction Engineering and Design and Environmental
- (2) Mobilization and Demobilization
- (3) Levees
- (4) Floodwalls
- (5) Road Raises
- (6) Closure Structures
- (7) Interior Drainage
- (8) Real Estate
- (9) Conveyance and Bridges

The resulting project costs are shown below in Figure 4, assuming all project features and phases are constructed at once. Summaries of the estimated project costs of the individual components are included in the main report, including potential options to construct LAND in different phases.

Figure 4: Estimated project cost (Class 5) for all project components, including all project features, including 55% contingency for low and high estimates. The estimated total cost ranges from approximately \$850 million to \$1.5 billion



Introduction

Local Actions Non-Dam (LAND) Project History

The Chehalis Basin is a critical area in Washington State that is the second largest river drainage basin and a local hub for both economic and recreational opportunities in the region. The area is highly susceptible to riverine flooding, with smaller flood events occurring every 2-5 years and major floods occurring roughly every decade (OCB, 2024). Following catastrophic flooding in the mid-late 2000s (Figure 5), which included closure of Interstate-5 (I-5) due to elevated flood levels, state and local Partners began exploring strategies to mitigate damage and enhance resilience across the basin. An initial workgroup came together in 2012, which led to the formation of the Office of Chehalis Basin (OCB) and Chehalis Basin Board in 2016 to provide long-term oversight and implementation of a Chehalis Basin Strategy to investigate flood risk reduction measures within the basin.

Figure 5: Flooding near the City of Centralia.



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² Source: fortress.wa.gov/ecy/gisresources

In 2017, a Programmatic Environmental Impact Statement (PEIS) evaluated potential programs and projects to mitigate flooding in the region. The development of the PEIS led to the start of the State Environmental Policy Act (SEPA) and National Environmental Policy Act (NEPA) analyses of a proposed flood retention facility-expandable (FRE) near Pe Ell, Washington, as well as improvements to the existing Chehalis-Centralia Airport (CLS) levees. The draft Environmental Impact Statement (EIS) for the FRE structure was released in 2020 by the Washington State Department of Ecology. Following extensive community input on the FRE proposal, it became evident that there were differing perspectives across the Chehalis Basin regarding how to address flood risk and determine a path forward. In response, Governor Jay Inslee called for a pause and the exploration of alternative approaches.

The governor formally directed the development of an alternative approach to the proposed FRE documented in the EIS. This resulted in the development of a LAND approach as a long-term flood risk reduction measure as an alternative and/or addition to the proposed FRE and Chehalis, Washington, airport levee improvement projects. The LAND Alternative was developed to reflect the diverse needs of the Chehalis Basin by gathering input from Tribes, agriculture business owners, community members, technical experts, and local governments. To succeed, it must demonstrate that it can reduce flood risk at a level comparable to the FRE proposal.

The objectives of the LAND Alternative are to provide flood damage reduction while considering impacts on local wildlife, residents and businesses, and cost. The LAND Alternative seeks to reduce flood damage while preserving the Chehalis Basin's ecological, cultural, and community values and minimizing any impacts to downstream communities and habitats. It emphasizes sustainability, safety, and economic vitality through equitable solutions developed in collaboration with tribal nations, conservationists, and local governments. This phase of the project builds upon previously conducted work (Phase 1); see OCB, 2024, as summarized in the following sections to advance the conceptual design of the LAND project features.

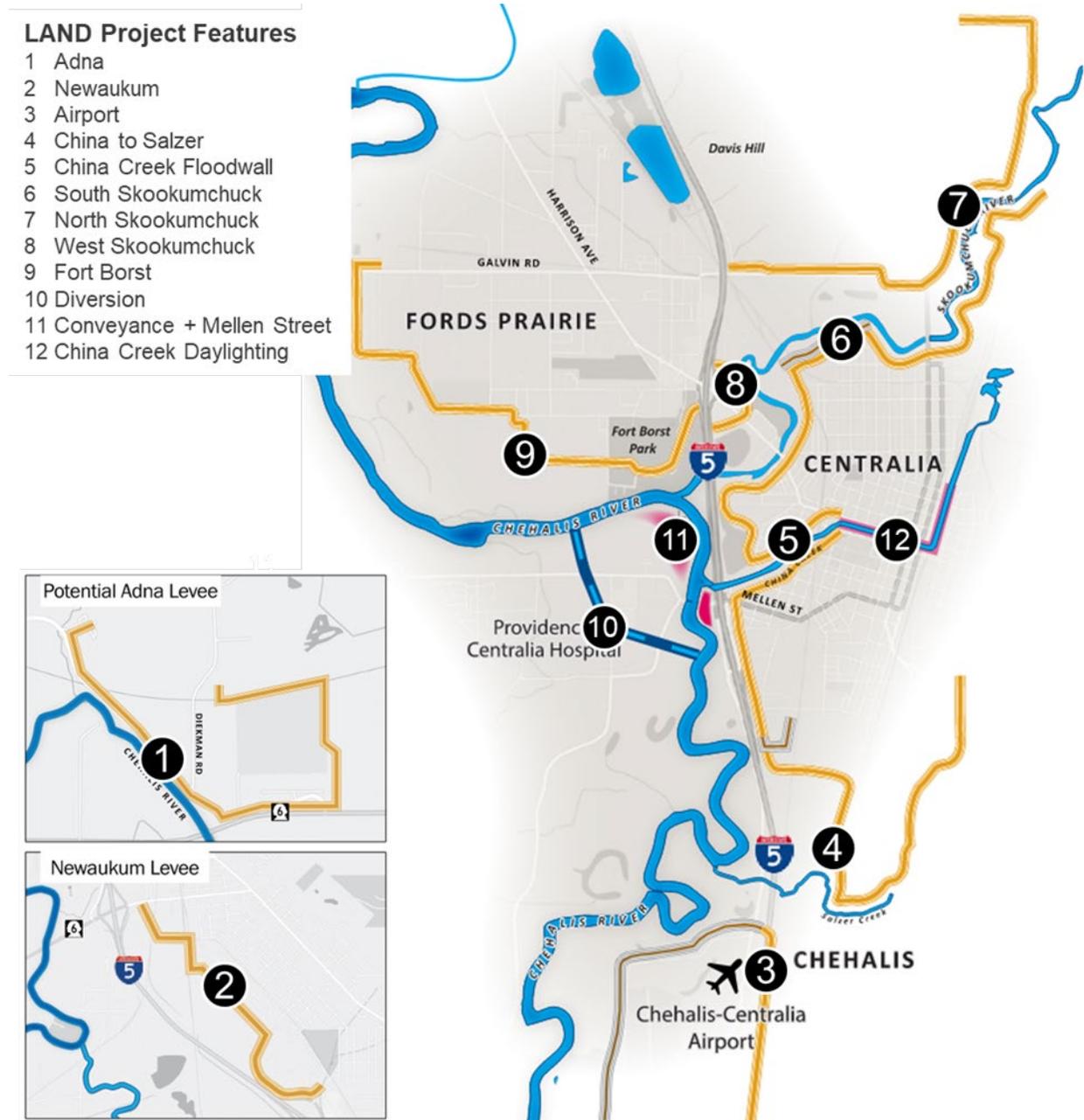
Phase 1 LAND overview (previous work)

The Chehalis LAND Alternative is a comprehensive, community-driven approach developed to address increasing flood risks in the Chehalis Basin without constructing a FRE. Phase 1 of the LAND Alternative was developed through technical analysis and Partner engagement and previously completed with a summary report issued in summer of 2024 (OCB, 2024). Phase 1 of LAND was developed in response to the region's history of frequent and severe flooding by proposing a suite of integrated solutions that prioritizes public safety, environmental health, economic resilience, and respect for Tribal sovereignty. The result of the Phase 1 work was a high-level set of flood risk reduction alternatives that can be analyzed in more detail during the current Phase 2 work.

The LAND Alternative outlines a set of infrastructure projects and programs including new and expanded levees, diversion and conveyance modifications, structure retrofitting and relocation, and floodplain restoration. Central to the plan is the Safe Structures Program, which offers tiered mitigation strategies for at-risk buildings. The alternative also emphasizes community

resiliency through emergency access improvements and resilience hubs. The feasibility-level analysis resulted in the development of twelve structural project features that are the focus of the Phase 2 work conducted in this study, as shown in Figure 6 (per OCB, 2024). Note that the numbers within the black circles shown in Figure 6 associated with each project feature are used throughout the document.

Figure 6: Project features resulting from Phase 1 LAND analysis, adapted from OCB, 2024



Phase 2 project background

OCB initiated this phase of the LAND study to evaluate the feasibility and concept-level costs of constructing levees, floodwalls, and other structural interventions to provide flood protection for the cities of Centralia and Chehalis, and surrounding areas of the Chehalis Basin. This planning project advances technical studies on interrelated structural components of the Chehalis Basin LAND Alternative. This includes advancing the design of the proposed levees and diversion/conveyance improvements developed during Phase 1 of the LAND study. The major tasks conducted during this phase (Phase 2) of the study include:

- Conduct an alternative analysis to refine the locations for new or expanded levees from the preliminary alignments developed during Phase 1 of the LAND study. The levees will be designed to protect against the late-century (2080) 100-year flood within urbanized areas in the upper Chehalis Basin. The late century (2080) flood includes the 100-year flowrates, increased by 26 percent to account for future climate impacts (OCB, 2024). Previous phases of the project developed highly conceptual potential alignments for the levees, flow diversion, and conveyance improvements; this phase aims to analyze and refine these project components, including the alignments, to develop feasible flood protection features.
- Develop conceptual designs and cost estimates for the refined alternatives. The conceptual design analysis includes evaluating hydraulics, geological conditions, cultural resources, biological resources, flood plains, and transportation elements.
- Coordinate throughout the project with project Partners, including local municipalities, government agencies, Tribes, and the Chehalis Basin Board and Subgroup.

At the direction of the OCB Board, this study did not attempt to investigate any improvements, changes, or alterations to the elevation and design of I-5 to reduce flooding. These potential are not included in the project scope and were therefore not assessed; however, the study did attempt to avoid making flooding worse on I-5 as shown later in the project's guiding principles. Future assessments should coordinate with the Washington Department of Transportation to investigate how flood-related impacts to I-5 and associated flood damage can be minimized. The goal of the study is to develop a feasible flood protection alternative in consultation with OCB, Tribes, and key project Partners. The key goals and objectives considered when developing the conceptual alternative project features include:

- Reduce flood damage risks to structures via:
 - Structural interventions (new/expanded levees, floodwalls, pump stations, etc.)
 - Improved Chehalis River conveyance
 - Diversion of the river through new flow pathways

- Protect community lifelines and enhance resiliency during flood events
- Inform future local floodplain planning

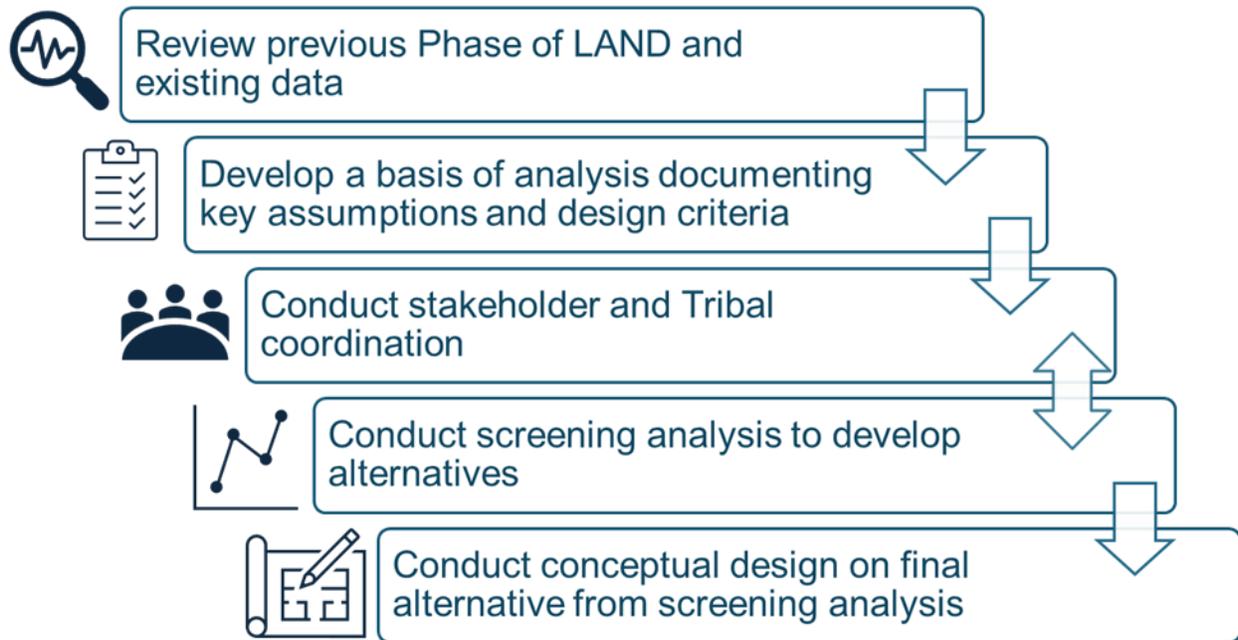
There are many ways to meet these project goals via different combinations of structural interventions. Therefore, a set of guiding principles was developed to guide the alternatives development and ensure the key values of the project are met. These guiding principles are described in the Guiding Principles Used to Advance LAND Conceptual Design section.

Phase 2 LAND scope, goals, and objectives

The primary goal of Phase 2 of LAND is to advance technical studies and conceptual designs for the flood damage reduction infrastructure—such as levees, conveyance improvements, and a diversion channel—as a continuation of Phase 1 of the study. The work produced during this Phase 1s intended to support the Chehalis Basin Board’s decision-making process by providing feasibility analyses, conceptual engineering, and cost estimates for major structural interventions (as shown in Figure 4). The analysis included two steps. The first is a screening analysis to coordinate potential improvements with project Partners, including Tribal governments, and ensure that all work aligns with the Chehalis Basin Strategy’s environmental and community objectives. The screening step investigated different structure alignments and project features to arrive at a combination of structural interventions that were analyzed in more detail during the second step of the process. The second step involved conceptual design, numerical modeling, and more detailed analysis of the flood damage reduction infrastructure identified in the screening process. Throughout the process, the Chehalis Basin Board and Subgroup were engaged to ensure alignment on the LAND Alternative conceptual design.

The analysis evaluated the feasibility of proposed levee alignments, diversion and conveyance improvements, and bridge modifications, while also assessing environmental, social, and land use impacts. The study emphasized the use of peer-reviewed science, equity considerations, and coordination to ensure that flood mitigation efforts are both technically sound and community centered. A flowchart of the general process used to conduct the Phase 2 analysis is shown below in Figure 7.

Figure 7: Flowchart showing the process used to develop the conceptual design for the flood protection features shown in this report



Guiding principles used to advance LAND conceptual design

During concept-level screening and assessment of different levee and floodwall alignments, there are often competing objectives that result in difficult, conflicting decisions. Therefore, a group of guiding principles were developed in coordination with OCB to help guide the screening and conceptual design process. These guiding principles are shown in Figure 8. The guiding principles developed during Phase 1 of the study (OCB, 2024) were also considered during the alternative development. Although it is difficult to fully satisfy every guiding principle due to the competing objectives of structural interventions, the principles shown in Figure 8 were frequently referenced throughout the project to guide the development and screening of structure alignments and footprints.

Figure 8: Summary of the guiding principles used during the alternative screening and conceptual design development



Minimize any impact on downstream water levels



Minimize any impact on downstream geomorphological processes



Minimize any impact to Interstate 5 (I-5)



Design alternatives with the ability to implement fully or incrementally over time



Maintain community lifelines: protect critical facilities and emergency route access



Preserve cultural resources and habitat

The guiding principles detailed in Figure 8 were not the only criteria used to develop, screen, and assess alternative alignments. Local project Partner coordination, cost comparisons, OCB Board coordination, and existing structure locations were considered when screening and assessing alternatives. However, often during the screening analysis, different alignments, structure types, and structure heights had similar performance. Therefore, it was key for the project team to consistently refer back to these guiding principles to ensure the alternative alignments developed during the screening process met the project goals.

Introduction to flood risk reduction features

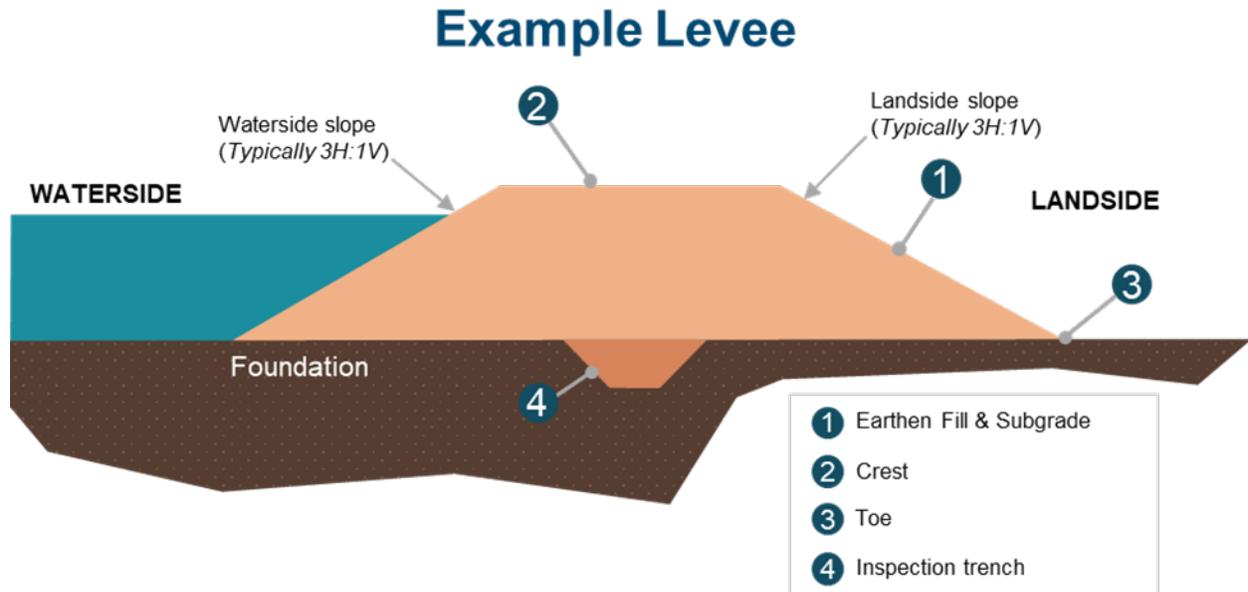
The communities in the Chehalis Basin study area—such as Chehalis, Centralia, Adna, and nearby areas—are prone to flooding from rainfall and subsequent elevated water levels in the Chehalis River and surrounding tributaries. As part of the LAND project, structural interventions are included to reduce flood risk to existing structures and key pieces of infrastructure. Levees, floodwalls, closure structures, new bridges, and conveyance improvements are some of the key project components, which when combined reduce the risk of flooding to areas within the protected area. This section is meant to introduce these features, so a collective understanding of the feature purpose and general definition of the different project components is established.

Levees

Levees are earthen structures made to reduce the risk of flooding on the protected side of the levee. They are typically constructed adjacent to a river or other waterway. The levees typically

tie into high ground that is above the design flood event of the levee on either end. Sometimes levees form a ring where there is no high ground near the protected area. As part of the levee, there can be other features such as trails on the levee crest, pedestrian access points along the levee, gates, or pump stations. In general, the levees will be set as far back from the river as possible while still protecting key infrastructure, to create setback levees rather than traditional levees that are immediately adjacent to the main river channel, constricting flow.

Figure 9: Example levee schematic



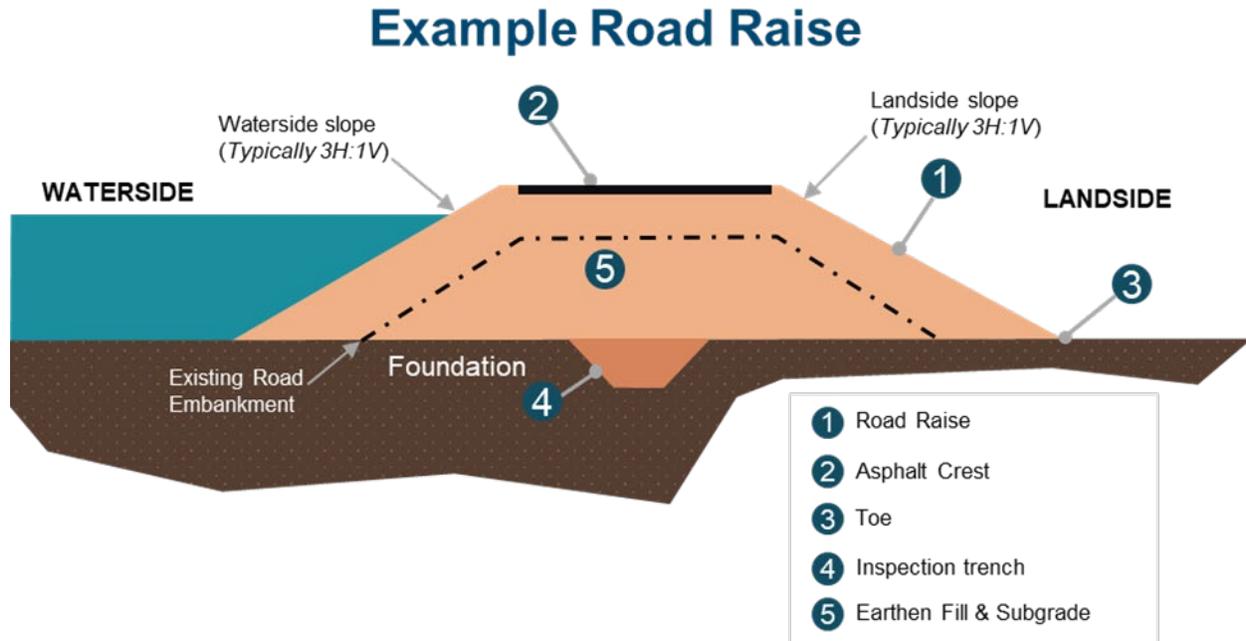
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Road raises

Road raises may be used selectively to raise existing roads and function similarly to earthen levees to reduce the risk of flooding on the protected side of the levee. The major difference is using asphalt along the crest and appropriate road subgrade, such as gravel base and top course, as part of the levee. Depending on the height of the levee, earthen fill could be used as part of the road subgrade. Inspection trenches may or may not be needed depending on the existing conditions. Similarly, studies need to be done to ensure that seepage through the road subgrade material is not a concern.

³ Graphic adapted from National Levee Safety Guidelines, 2024. Note some areas adjacent to rivers may require riprap (stone) scour protection along the levee slope.

Figure 10: Example road raise schematic



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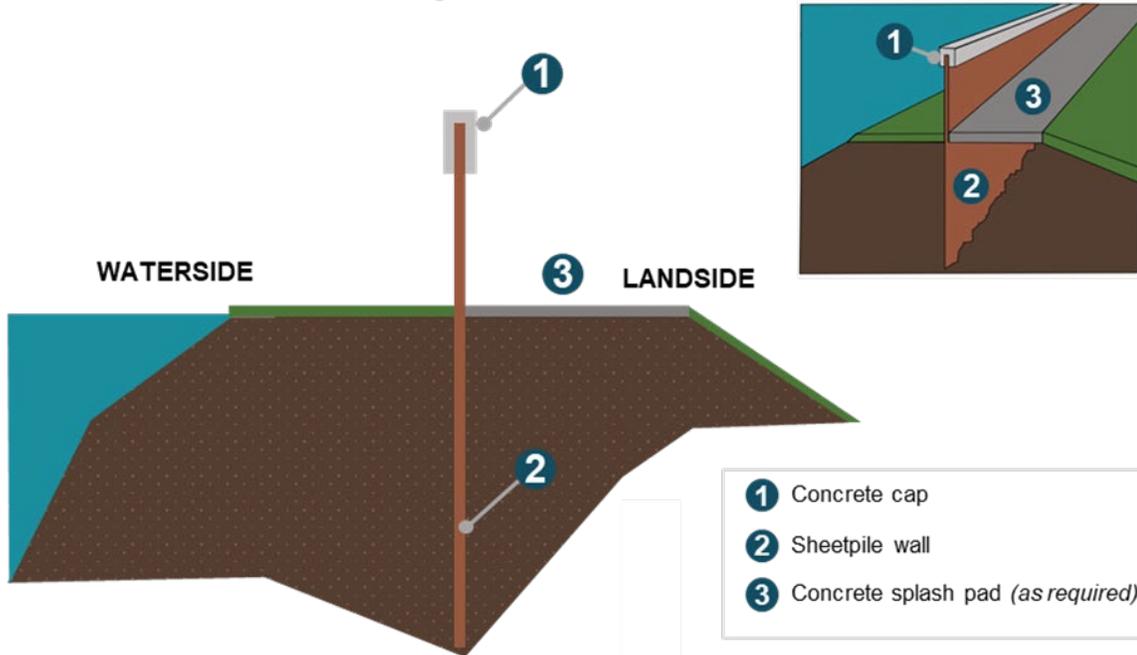
Floodwalls

Floodwalls are included in the LAND alignments where levees are impractical, often due to space constraints in urban areas or when alignments cross existing roads or railroads and a closure structure is required. Floodwalls have a smaller spatial footprint than levees but are typically more expensive to construct. There are different types of floodwalls that are discussed further in subsequent sections; however, they are generally constructed of either steel or concrete. For the LAND study, two types of floodwalls were considered: steel sheetpile I-walls where shorter structures are required, and concrete T-walls where taller structures are required due to floodwater depth. For both floodwall types, a portion is buried to provide stability against loading from floodwaters.

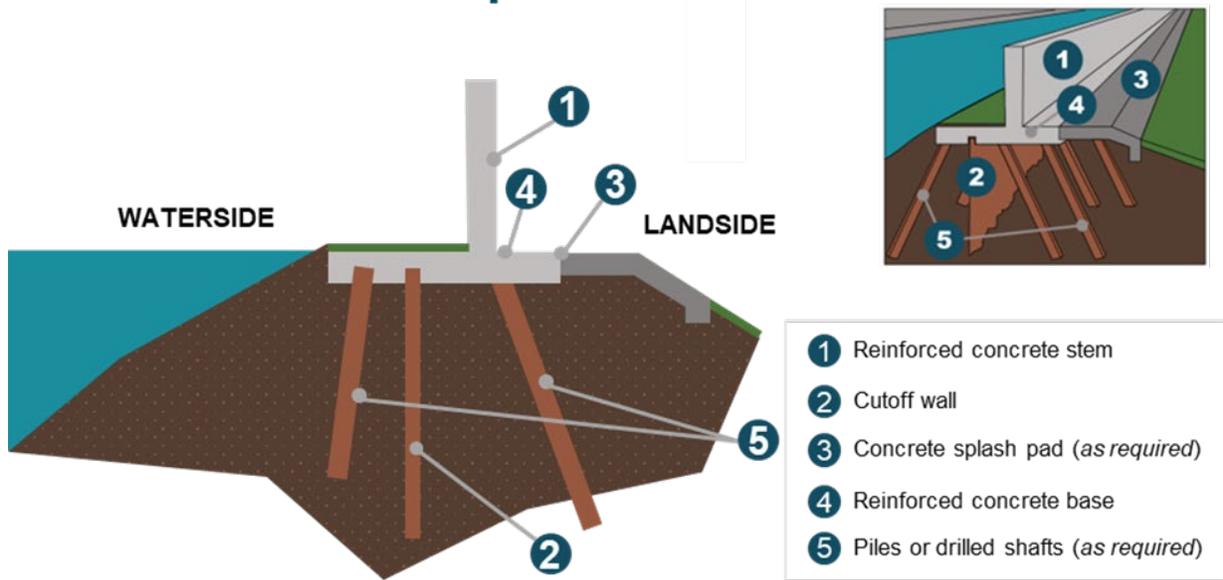
⁴ Graphic adapted from National Levee Safety Guidelines, 2024. Note some areas adjacent to rivers may require riprap (stone) scour protection along the road slope, and that the trenching is sometimes done on top of the existing road embankment.

Figure 11: Example I-wall (top) and T-wall (bottom) schematics

Example I-Wall



Example T-Wall



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⁵ The example waterside water level is shown at a lower flood level; at higher flood events, the water will be closer to the top of the wall. Graphic adapted from National Levee Safety Guidelines, 2024.

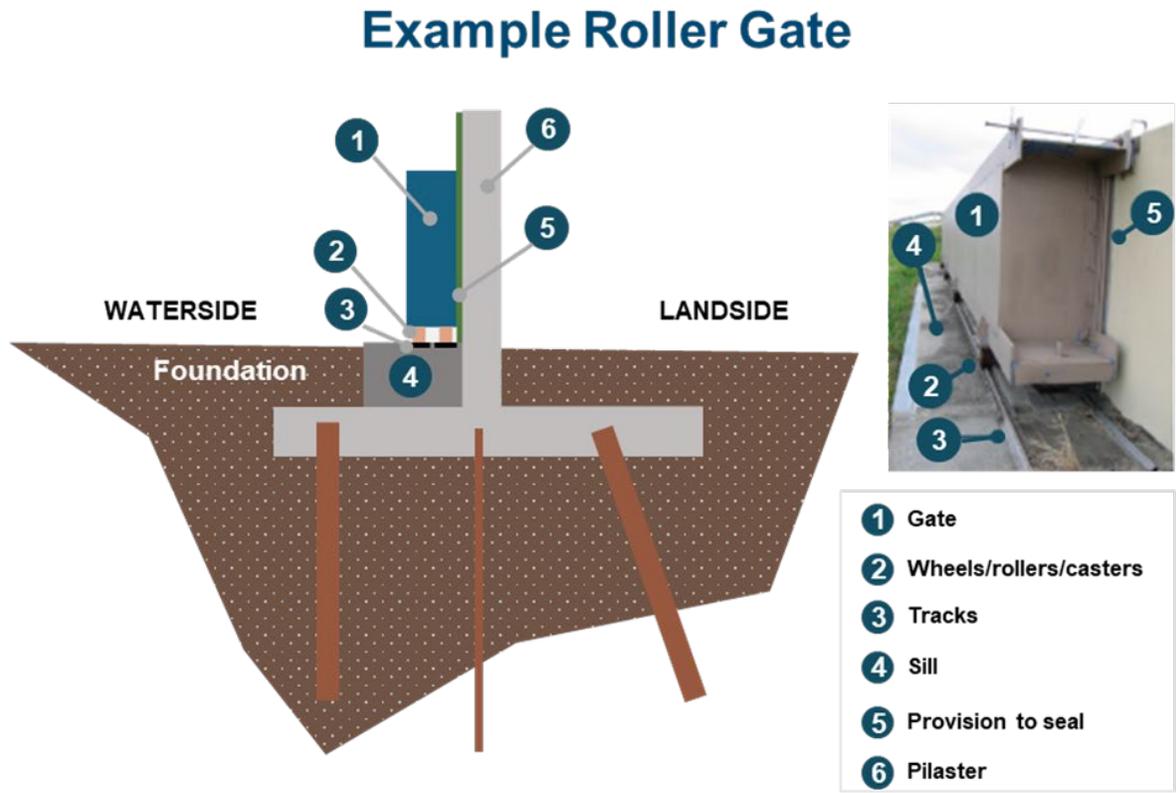
Closure structures

Closure structures are included in the project where a levee or floodwall alignment crosses an existing road or railway. In general, the closure structures remain open most of the time. In advance of a forecasted flood event, the structures are temporarily closed to prevent flooding on the interior of a floodwall and/or levee system. There are numerous types of closure structures that can be implemented in a flood protection system. For the conceptual-level design of the LAND project, the following closure structures have been focused on.

Roller gates

Roller gate closure structures are movable gates that slide along tracks on their foundation, often using a mechanical system for deployment, and are designed to seal effectively when in place. For the LAND study, roller gates are assumed at all places where floodwalls or levees cross railroad tracks. As discussed later in the main document, there are an estimated eight roller gates included in the LAND alternative. This assumption should be investigated on a closure structure by closure structure basis in future phases of design.

Figure 12: Example roller gate schematic (top) and photo showing transitions from roller gate to floodwall to levee (bottom)



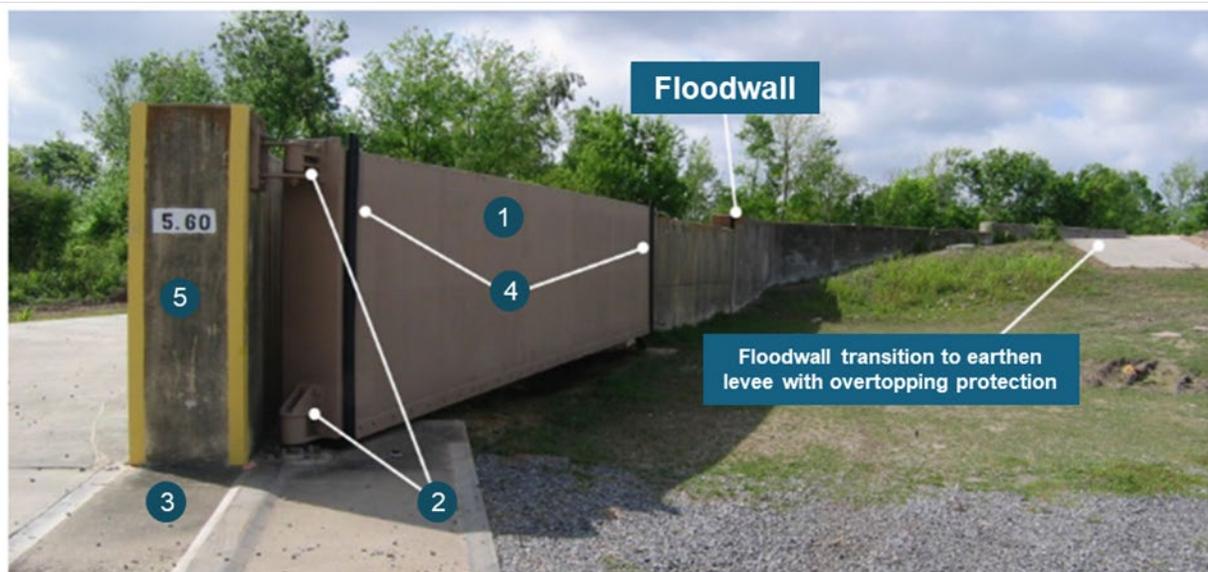
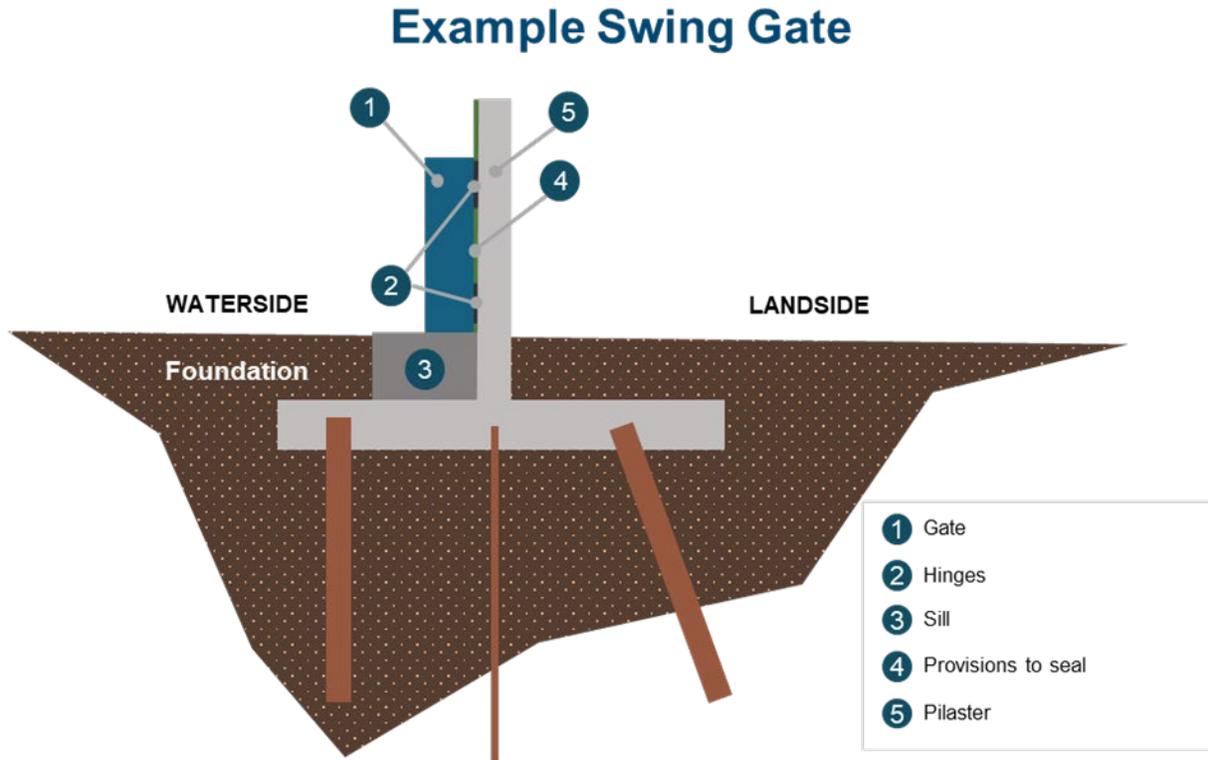
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⁶ Graphic from National Levee Safety Guidelines, 2024

Swing gates

Swing gate closures are steel gates hinged to a concrete floodwall, designed to swing into place and latch securely in either an open or closed position. Wider openings require two gate leaves with a center support, while smaller openings use a single gate leaf, making them easy to deploy. For the LAND study, swing gates are assumed at all places where floodwalls or levees cross existing roads. As discussed later in the main document, there are an estimated 18 swing gates included in the LAND alternative. This assumption should be investigated on a closure structure by closure structure basis in future phases of design.

Figure 13: Example swing gate schematic (top) and photo showing transitions from swing gate to floodwall to levee (bottom)



7

⁷ Graphic from National Levee Safety Guidelines, 2024

An alternative option at intersections of flood protection systems and roads is to raise sections of the road, often referred to as road ramps. This approach is especially useful where emergency bypass routes cross levees or floodwalls. By raising the road, access and egress could be maintained during flood events, and a closure structure would not be required. Additional information about these locations is provided in the Transportation Assessment section. For this study's cost analysis, closure gates were assumed at all such intersections. However, raising road sections in these areas could reduce costs, though it would require additional engineering studies including evaluating existing utility systems. Future project phases should further investigate the feasibility of road raises, particularly in the emergency bypass areas highlighted in the Transportation Assessment section.

Conveyance improvements and diversion

Mellen Street Bridge conveyance improvements

Currently the existing Mellen Street Bridge, originally constructed in 1911, is along a narrow section in the Chehalis River Floodplain. The floodplain is naturally very narrow in this area and, when combined with the Mellen Street Bridge abutment, can cause restricted flow and elevated water levels upstream of the bridge. The general area investigated for the conveyance improvements is shown later in Figure 14. The conveyance improvements investigated at and adjacent to the Mellen Street Bridge include:

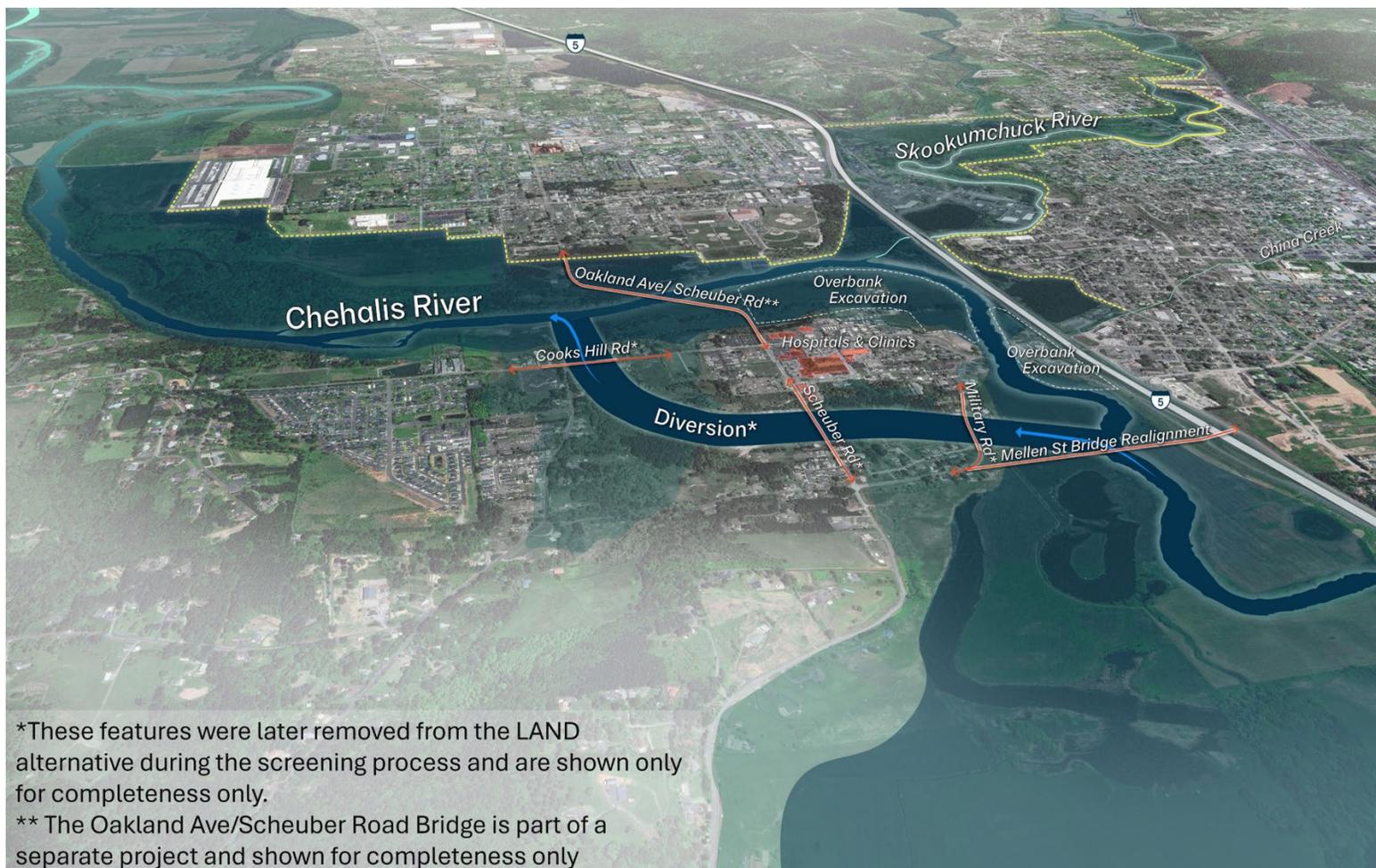
- **Relocation of the existing Mellen Street Bridge:** Remove the existing Mellen Street Bridge and relocate it approximately 1,900 feet upriver (south). The eastern abutment of the new bridge would connect to the existing Airport Road overpass, and the western approach would connect to Military Road. Sections of Military Road may need to be elevated if emergency access is needed during flood events.
- **Excavation:** Once the existing Mellen Street Bridge is demolished and relocated south, remove approximately 800,000 cubic yards of material adjacent to the Chehalis River via excavation near the existing Mellen Street Bridge to improve conveyance. The excavation template extends approximately 800 feet upriver (south) and 2,300 feet downriver (north) of the existing Mellen Street Bridge. The bottom of the excavation cut is set to the approximate 2-year water level, meaning that the conveyance area will be dry the vast majority of the time and only activated with floodwater during large flow events to improve conveyance.

Diversion

The diversion is similar to the conveyance improvements, in that it would provide flow relief during peak flood elevations by providing a path for floodwaters around the existing Mellen Street Bridge restriction. The diversion could be constructed alone or in addition to the conveyance improvements. The 700-foot-wide channel diversion would require approximately 1.3 million cubic yards of excavated material and have three bridges or concrete fords to facilitate road and pedestrian traffic across the diversion. To facilitate traffic across the

diversion cut, three bridges (Cooks Hill Road, Military Road, and Scheuber Road in Figure 14) would need to be constructed. Like the conveyance improvements, the bottom of the excavation cut is set to the approximate 2-year water level, with the diversion dry the majority of the time. A rendering of the diversion is included below in Figure 14. Note that, as later described in the Concept Screening Analysis section, the diversion was removed from consideration as part of the project during the concept screening analysis and is only shown in this Section for completeness.

Figure 14: Area investigated for diversion and associated bridges and conveyance (labeled overbank excavation) and Mellen Street Bridge realignment



⁸ Note that the diversion, Cooks Hill Road, Scheuber Road, and Military Road elements shown in this figure were later removed from the project as part of the screening process. The “Oakland Avenue/Scheuber Road” is shown for clarity only and is part of a separate study

Data Collection and Design Criteria

The data collection effort was completed in sequential steps, starting with a review of existing information, compilation of a GIS Project database that included data collected in the previous phase of the LAND study, and additional data collected as described below and in further detail in Appendix B. Following collection and review of existing data, the basis of analysis was developed to document key assumptions in the design process. A Partner outreach effort was conducted to acquire input on the study criteria development and help guide the screening process. Screening criteria were developed to help guide the screening process and ensure Partner input was incorporated as much as possible into the assessment prior to conducting the conceptual design.

Existing data review

A review of available data, reports, and previous studies was conducted throughout the study duration. Data collection efforts included obtaining data from internet databases, from previous phases of the LAND study, from local and state databases, in coordination with project Partners, and in coordination with other consultant teams working within the basin. The following provides a high-level summary of the types of data that were compiled to conduct the study:

- Structural database summarizing finished floor elevations of structures in and near the floodplain within the basin (Anchor QEA, 2024)
- LiDAR and topographic elevations (USGS, 2012 and NV5, 2024)
- Community lifelines and emergency service routes (Lewis County, 2024a)
- Parcel data (Lewis County, 2024b)
- Desktop soil characteristics and geological data (USGS, 2011)
- Environmental data including wetland locations and contaminated sites (See Appendix F)
- Cultural resources data and Tribal database coordination
- Hydraulic model results from the previous phase of the LAND study (OCB, 2024)

For a detailed summary of these data sources, please see the referenced appendices and associated bibliography of sources contained within each Appendix as referenced above.

Basis of analysis and key assumptions

Key design criteria were developed in coordination with OCB and key project Partners. The design criteria, as summarized below, were used to develop, analyze, and assess the proposed flood protection structures. In general, design criteria were selected considering local and national engineering guidelines and to maintain consistency with the Phase 1 LAND alternatives assessment. The design criteria were coordinated early on with OCB and project Partners to gain alignment. The selection of criteria during this phase was done to allow flexibility in future phases regarding federal (FEMA or USACE) accreditation of the flood protection structures. See Appendix A for a detailed summary of the design criteria and considerations.

- **Design Flow Event:** 100-year return period plus 26 percent flow event. This flow event was selected in the previous phase of LAND (OCB, 2024) to generally align with a projected future climate scenario similar to that being used in the SEPA analysis for the FRE.
- **Required Freeboard for Flood Protection Structures:** 3 feet above design flood level.
- **Required Freeboard for Structure Retrofits and Raises:** 1 foot above the design flood level.
- **Key Levee Design Criteria:**
 - *Type:* Earthen core levees
 - *Crest Width:* 12 feet
 - *Sideslopes:* 3H:1V
 - *Crest Elevation:* 3 feet above design flood level
- **Key Floodwall Design Criteria:**
 - *Type:* Sheetpile floodwalls (less than 12 feet in height) and concrete T-walls (greater than 12 feet in height).
 - The 12-foot maximum sheetpile floodwall height assumes 3 feet of freeboard and is based on USACE, 2011 guidance, which recommends a maximum water depth of 9 feet for sheetpile walls in sandy soils. This assumption is based on general guidance from USACE, 2011 and should be validated with a deformation analysis once additional subsurface data becomes available.
 - Floodwalls in areas with poor geotechnical characteristics, i.e., soft soils, may require pile-supported concrete T-walls or similar structures even at floodwall heights less than 12 feet. In future phases, floodwalls less than 12 feet in height may require concrete T-walls depending on site-specific

geotechnical characteristics. Specific selection of either concrete T-walls or sheetpile structures should be assessed further in future phases of the project once additional geotechnical data is collected, design criteria are refined, and surface constraints are better understood.

- *Top of Floodwall Elevation:* 3 feet above design flood level. Sheetpile floodwalls assumed to be one-third above ground, two-thirds embedded into in-situ soils.
- **Key Structure Retrofit Design Criteria:**
 - *Residential Structure Retrofit Categories:*
 - 0-1 feet of inundation: Floodproof existing structure.
 - 1-5 feet of inundation: Raise existing structure.
 - Greater than 5 feet of inundation: Buyout and/or relocate existing structure.
 - *Commercial Structure Retrofit Categories:* Assumed floodproofing for commercial structures.
 - *Structures Included in Project Cost:* The residential and commercial structures included in the project cost are broken down into two categories:
 - **Structures Where Inundation Levels are Increased Under Design Event:** Outside of the levee boundaries, any residential or commercial property that is deemed valuable in the Anchor 2024 database and is adversely affected by the alternative (i.e. water level is raised at the property due to the LAND alternative) will be assessed for structural raises and floodproofing. The LAND project cost analysis assumes that the difference in cost between the without-project and with-project conditions will be included in the overall project cost estimates for these structures.
 - **Structures Adjacent to Levees/Floodwalls:** Additionally, structures in close proximity (assumed to be approximately 0.5 miles from the levee or floodwall for this study) to the levee and floodwall alignments, but not within the protected area, will be included in the structural raise costs. It is assumed that structures outside of these two categories will be addressed by other projects and/or initiatives within the basin.
- **Right of Way (ROW)/Access Corridor:** Assumed 15-foot access corridor on either side of the levee or floodwall for maintenance and equipment access. For some flood protection structures adjacent to rivers, ROW may be smaller on the riverward side of

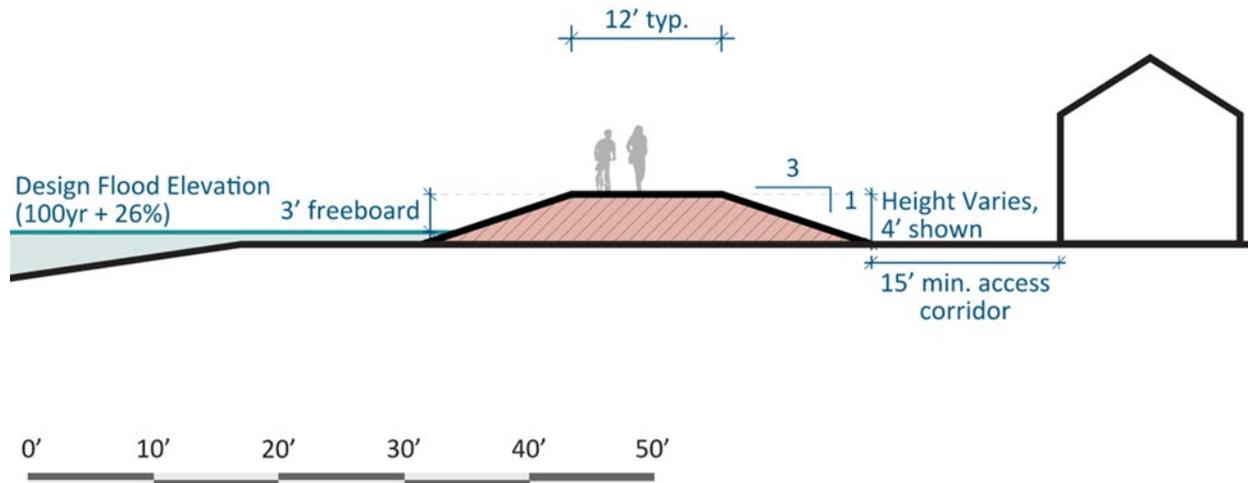
the structure. Preliminary estimates of structures within the ROW that require relocation are included in the project analysis and costs.

- **Key Bridge Design Criteria:**
 - *Type:* Concrete girder bridge.
 - *Width:* 45 feet total width (2 travel lanes, shoulders, sidewalks, and structure).
 - *Freeboard:* Bottom chord of bridge a minimum of 3 feet above the design event.
- **Room for the River:** The "Room for the River" design criteria prioritize setting back levees and positioning levees outside of the current designated FEMA floodway to preserve natural floodplains, reduce flood risk, and enhance ecological function.

The design criteria above were used to develop conceptual-level sketches of the different levees, floodwalls, and other flood protection components. Figure 15 depicts the small and medium categories of earthen levees. Conceptual cross sections for large earthen levees (greater than or equal to 12 feet) follow the same design criteria.

Figure 15: Conceptual levee cross sections showing small (0-6 feet, top) and medium (6-12 feet, bottom) categories of earthen levees

Typical Levee (Small 0-6 ft)



Typical Levee (Medium 6-12 ft)

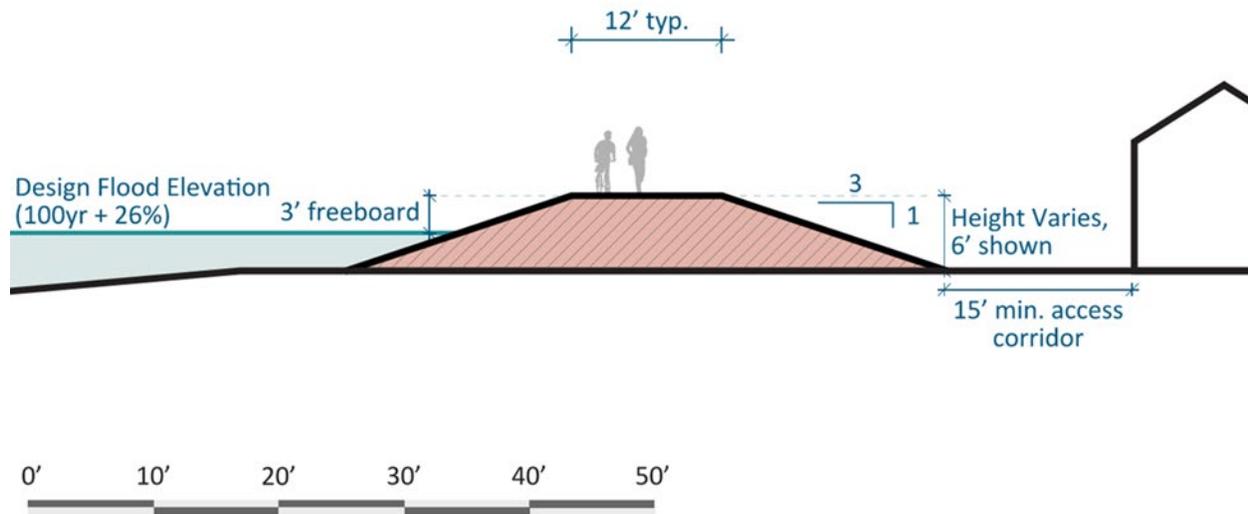
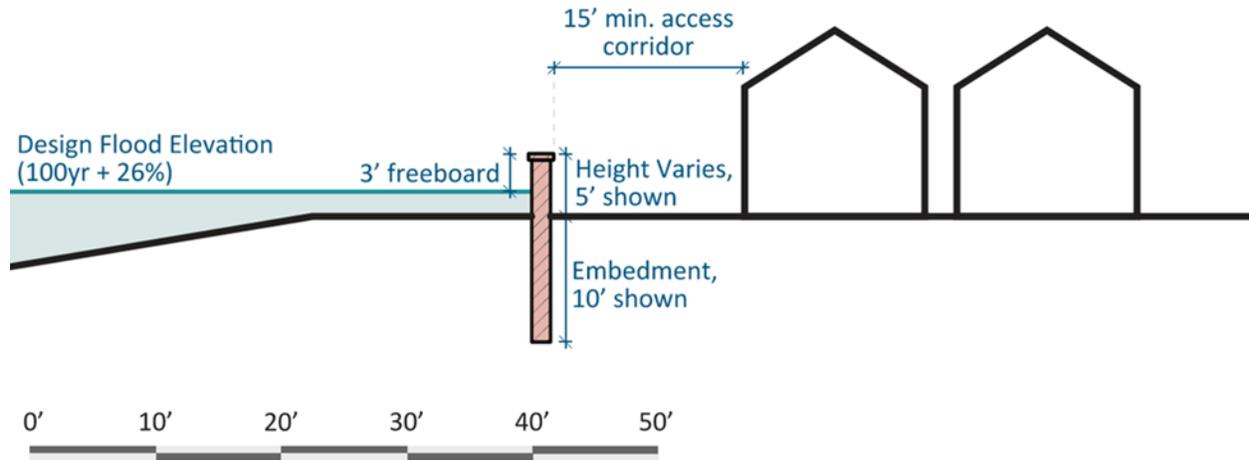


Figure 16 below depicts conceptual-level sketches of the small and medium (sheetpile) and large floodwalls (concrete T-wall). As previously noted, floodwalls in areas with poor geotechnical characteristics, i.e., soft soil, may require concrete T-walls or similar structures at heights less than 12 feet and should be assessed in future design phases.

Figure 16: Conceptual floodwall cross sections showing small and medium sheetpile floodwalls (0-12 feet top) and large concrete T-walls (greater than 12 feet, bottom)

Small/Medium Floodwall (Sheetpile I-Wall, 0-12 ft)



Large Floodwall (Concrete T-Wall, 12+ ft)

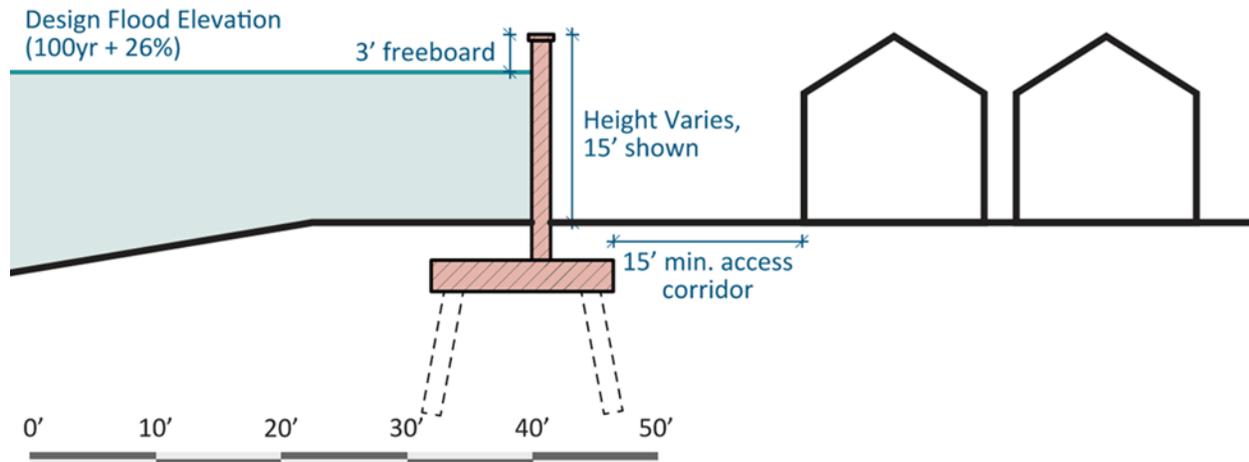
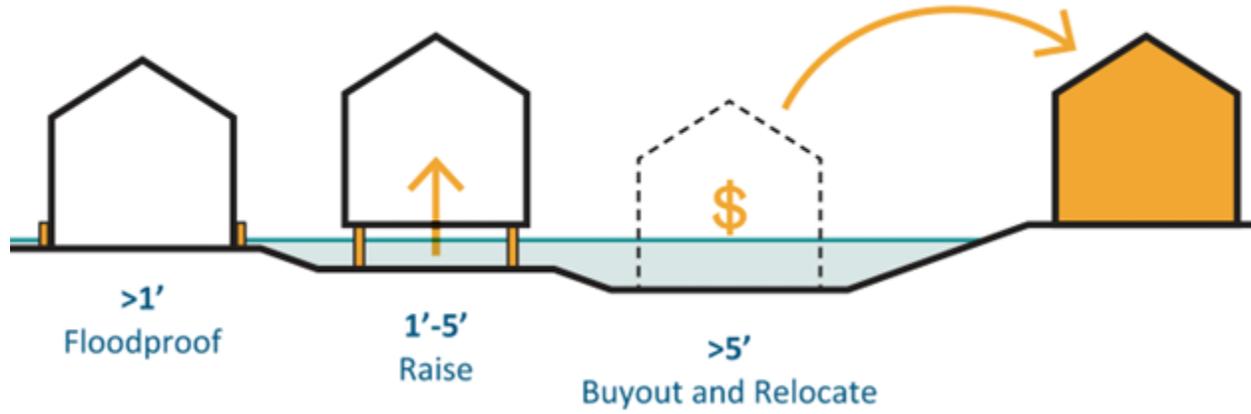


Figure 17 depicts conceptual-level sketches of the different structural retrofit categories. Note that these adaptation strategies match the proposed approach in the previous phase of LAND (OCB, 2024) and are in addition to the strategies proposed by the Safe Structures Program. See Appendix B for further details on how the structural retrofits will be applied to properties impacted by the LAND project.

Figure 17: Adaptation strategies for residential properties that are inundated with LAND in place and within the floodplain

Adapting Houses in the Floodplain



Coordination Efforts and Screening Analysis

Project partner and Tribal coordination

Project Partner coordination meetings were conducted with officials from the cities of Chehalis and Centralia, Lewis County, and the Washington State Department of Transportation (WSDOT). Tribal coordination meetings were also conducted with the Quinault Indian Nation and the Chehalis Tribe. The primary objective of this outreach was to ensure that the proposed project alternatives were consistent with the planning priorities of these local jurisdictions. Note that cultural resources coordination was conducted separately from these efforts with local Tribes. The Partner engagement resulted in valuable feedback on the orientation, alignment, and approach used to develop the screening-level LAND features, as well as key items that should be incorporated into the screening criteria. The initial Partner engagement efforts provided valuable insights that shaped the guiding principles outlined in earlier sections and informed the early screening analysis. The key feedback from these initial discussions that influenced the development of the guiding principles includes:

- **Community Lifelines:** Discussions highlighted the need to protect essential services, including hospitals, homeless shelters, and emergency facilities like police and fire stations, from floodwater within areas safeguarded by levees and floodwalls.
- **Emergency Connectivity and Commercial Traffic:** Potential routes to connect communities to key community lifelines during flood events were discussed with Partners. In addition, commerce and truck traffic routes during previous flood events that caused accessibility issues because of diverted truck traffic were discussed. While the development of new emergency connectivity and bypass routes needs further study, it was imperative to gather input from Partners to ensure that the potential levee and floodwall alignments did not preclude necessary updates to emergency routes within the basin.
- **Downstream Water Level Impacts:** Partners and Tribes stressed the need to consider downstream water level, including impacts to transportation and access at the Chehalis Reservation, when developing and assessing the levee and floodwall alignments.
- **Morphological Changes:** Consider the potential changes to river channel morphology resulting from implementation of the LAND Alternative. Given that only one flow scenario is modeled in this phase, it was noted that a qualitative assessment would be performed using numerical model data and future investigations should be conducted in future phases.
- **Room for the River:** Partners and Tribes noted the "Room for the River" design criteria concept. This prioritizes setting back levees and positions levees outside of the current designated FEMA floodway to preserve natural floodplains, reduce flood risk, and

enhance ecological function. Consider nature-based solutions and engineering with nature when possible.

After the initial outreach, the screening analysis was conducted. Subsequently, additional meetings were held to gather Partner feedback on the proposed screening alignments and alternatives. Key insights from these discussions include:

- **Future Development Plans:** After a high-level review of the screening-level alignments, Partners were able to provide input on potential future development areas relative to potential levee and floodwall configurations. Additionally, previous and future developments along China Creek, including potential plans for daylighting were discussed relative to the LAND Alternative.
- **Alternative Alignments:** Partners and Tribes provided insight into potential adjustments to the alignments, including protecting key infrastructure and community hubs like the Fort Borst Park ball fields. Partner comments relative to the initial round of revised LAND alternatives were incorporated as much as possible into the concept-level alignments.
- **Airport Levee Realignment:** Through Partner engagement, the Chehalis LAND project evaluated potential additional flood storage through incorporating the historic oxbow, Airport Lake, as part of increasing flood capacity in the vicinity of the Chehalis-Centralia Airport (Airport). The proposed levee alteration would extend the flood storage area onto existing Airport property adjacent to the north end of the Airport runway. Note that this alteration would encroach onto Airport property and would bring the flood storage area to within approximately 500 feet of the main Airport runway. Due to the volume of flood water associated with the design event, small alterations and oxbow engagement are unlikely to significantly alter or improve flooding conditions in the area. Therefore, it is recommended that oxbow engagement, floodplain restoration, and other measures to reduce flooding inundation during smaller, less intense flow events be investigated in future phases.
- **Regulatory Floodway:** Improvements in the regulatory floodway would need to meet the minimum National Flood Insurance Program requirements. Additional analysis and permitting work would be required if local communities apply for conditional FIRM and floodway revisions. The proposed alignments were compared to the regulatory floodway, as designated in the Lewis County FEMA maps (Lewis County, 2025). The alignments generally avoid the regulatory floodway. However, the Lewis County maps are very old, and errors in digitization can occur. It is recommended that the levee alignments be compared to revised FEMA maps if/when they are issued.

- **FEMA Accreditation:** Meetings with Tribes and Partners noted that potential future FEMA accreditation of the levees should be considered. Accreditation is not pursued as part of this phase of the study but could later be investigated. The assumptions made in this phase of the study generally align with FEMA principles; however, a detailed study is needed to ensure the proposed levees and floodwalls meet all FEMA accreditation requirements. This must be done in future phases of the study.
- **Adaptive Design:** Tribes requested a scenario planning for future development and climate shifts. This could include adaptive design strategies and “what-if” modeling to address future uncertainties. The current phase only considers the 100-year plus 26 percent design event, however future phases could review different planning scenarios to develop potential adaptive design plans.
- **Equity Considerations:** Consider lower income areas and environmental justice when aligning levees to ensure that they are not excluded from the protected area, as much as possible.

Concept screening analysis

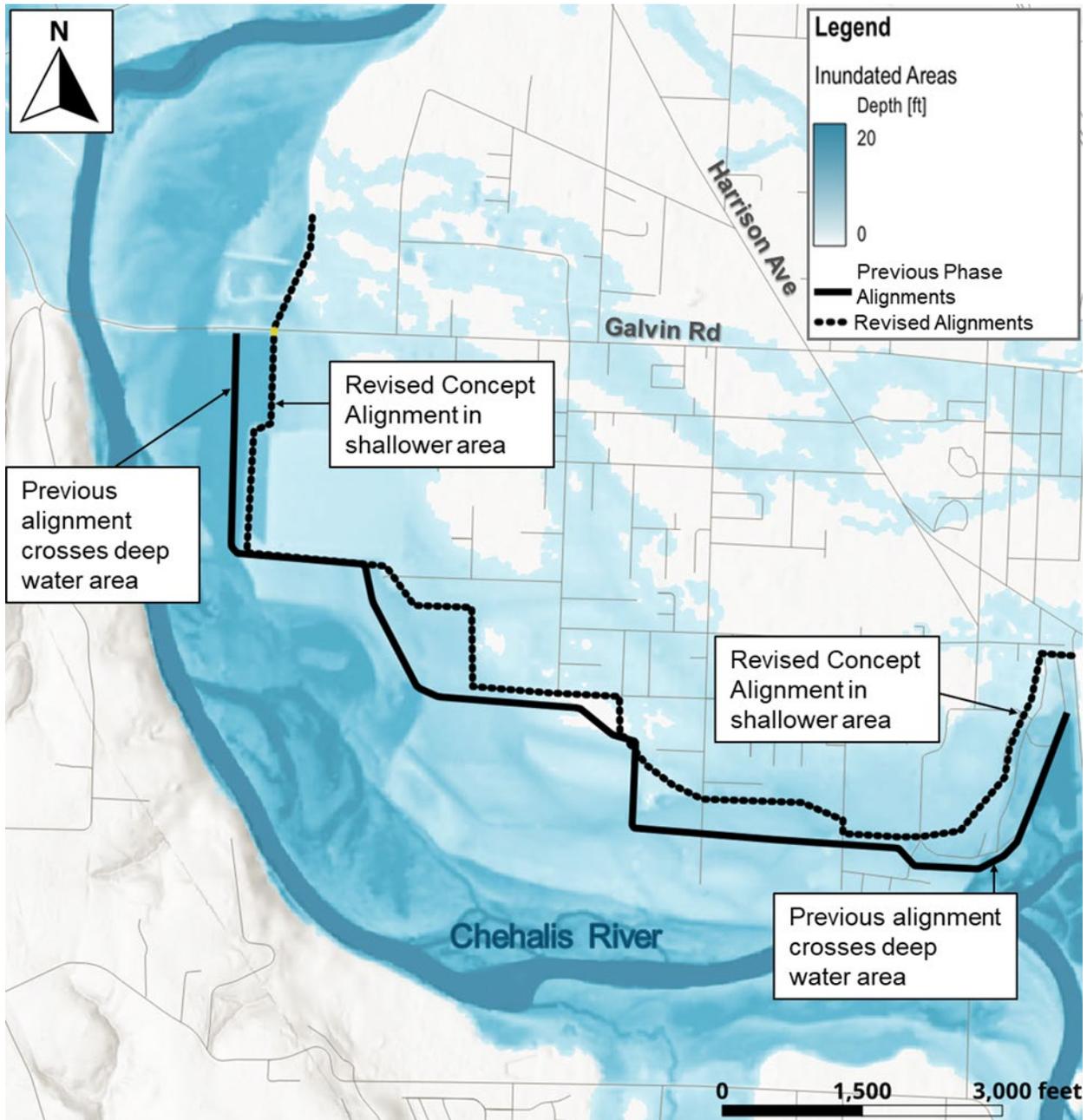
A concept-level screening analysis was conducted to evaluate and refine the LAND levee and floodwall alignments developed during the previous phase (Phase 1). The goal of the concept screening analysis was to review different structure alignments and combinations of structures to land on a set of structural interventions that would be assessed in more detail during the conceptual design step of this process (see Conceptual Design section for more detail on the conceptual design approach). During the screening analysis, the potential alignments and structure types were reviewed with OCB and key Partners and Tribes during a series of in-person and virtual meetings. Key outcomes and evaluation criteria discussed in the review meetings and summarized in the previous section were incorporated as metrics into the conceptual screening analysis.

The conceptual screening analysis was conducted using a two-step approach that first reviewed existing data and hydrodynamic model results and coordinated project goals and objectives with key Partners and Tribes. The following is a summary of the first phase of the conceptual screening analysis approach:

- **Review Existing Data:** An assessment of existing data, including finished floor elevations of structures within the project area, Light Detection and Ranging (LiDAR) elevation data, parcel ownership data, desktop-level geotechnical data, existing trail systems, environmental data including aquatic and riparian habitat, fish and wildlife species, and cultural resources data, was conducted. The existing data was used to inform the screening process and help refine the alignments developed in Phase 1 of the LAND study (OCB, 2024).

- **Review Existing Model Results:** Numerical modeling was conducted in the previous phase of the LAND study (OCB, 2024) that showed inundation depths, water surface elevations, and velocities under the same design flow event used during this study (100-year greater than or equal to 26 percent). The highly conceptual LAND alignments developed in the previous phase were then overlaid with the previous phases model results to identify opportunities to reduce project cost by following natural highpoints in the topography. This results in shorter, less costly structures. An example of this approach of following natural highpoints in the topography is shown in Figure 18. This approach also involved moving levees further away from the river where possible to keep as much of the floodplain intact, thereby creating setback levees while balancing protection of existing structures.

Figure 18: Example of the screening-level refinements at the Fort Borst area



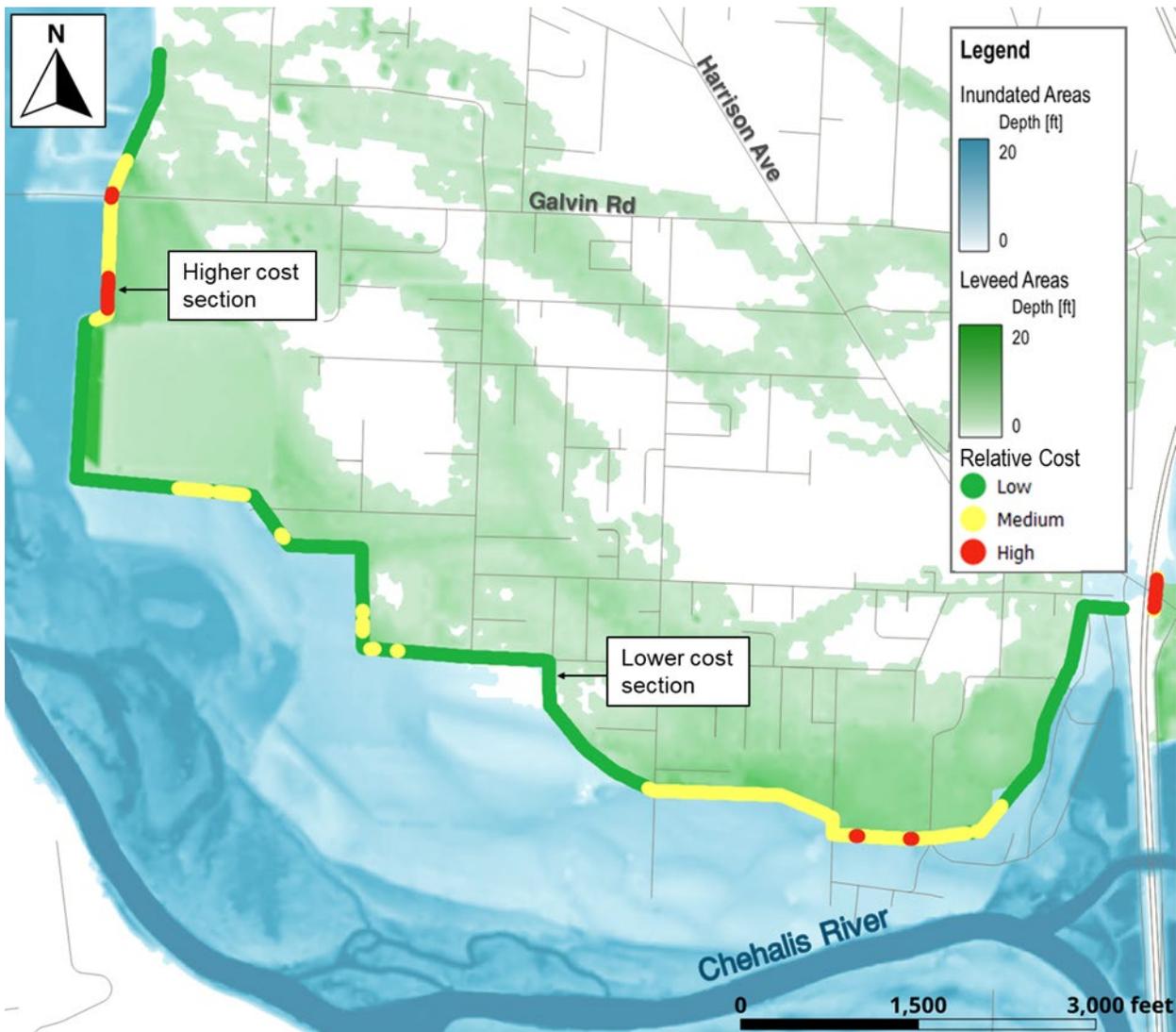
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- Develop a Cost Model to Refine Alternative Alignments:** The without-project hydraulic model results from the previous phase were used to initially refine the location of the levees and floodwalls. The height of the levees and floodwalls, considering the 3 feet of

⁹ The previous phase alignment crossed deepwater areas that required higher structures to protect against the design flood event. The revised concept alignment aims to avoid these areas, thereby reducing the required structure height and overall project costs while maintaining protection.

required freeboard, was then calculated, and screening-level costs were developed based on the height of the structure. Note that site-specific geotechnical considerations may vary along the alignment and were not available due to lack of data. Future phases should conduct more detailed geotechnical investigations as recommended in the Conclusion and Recommendations sections. The screening-level cost model outputs (low, medium, high) were used to assess different alignments and help refine the screened alignments. An example of the screening-level cost model outputs at the Fort Borst area is shown below in Figure 19.

Figure 19: Example relative cost along screening-level alignment of the Fort Borst Levee



- **Structural Database Analysis:** Similarly, the without-project hydraulic model results from the previous phase were used in combination with the structural database, developed by Anchor QEA, 2024, to determine the level of inundation above the

finished floor elevations during the design event. This allowed the alignments to be refined to prioritize areas where a large number of structures were inundated.

- **Environmental Justice Considerations:** The screening level alignments were planned with consideration for environmental justice and lower-income areas. The alignments were adjusted actively working to include environmental justice and lower-income areas within the protected zone where possible. An environmental justice mapping analysis was conducted, the results of which are included in Appendix A.
- **Alignment with Partner and Tribal Engagement Outcomes:** The screening-level alignments were developed to reflect the key outcomes of the Partner and Tribal engagement as noted in the Introduction section. A secondary set of meetings were conducted with the entities to present the revised alignments to the Partners and Tribes. Additional revisions to the screening alignments were conducted after the second set of meetings.

Following the initial concept-level screening analysis and Partner outreach, screening-level hydraulic modeling was conducted to refine the levee and floodwall alignments, diversion footprint, and conveyance improvements. A series of conceptual model runs using 1D HEC RAS (Hydrologic Engineering Centers River Analysis System) were conducted. 1D HEC-RAS is a computational tool used to simulate water flow and predict flooding extents in rivers and channels. The model runs use the same 100-year plus 26 percent flow rates as in the previous phase of LAND and in the 2D model runs conducted during the conceptual design phase of the project. The 1D HEC-RAS tool was used to quickly assess different levee alignments and a combination of flood protection systems, and to analyze the effectiveness of the diversion and conveyance features. The screening-level model simulations are grouped into the following categories:

- **Diversion and Conveyance Refinement:** Investigating the effectiveness of a smaller diversion and the diversion in combination with and/or without conveyance features.
- **Lighter Touch Options:** Evaluating the effectiveness of a smaller array of levees and conveyance improvements.
- **Project Phasing:** Investigating hydraulics and qualitative impacts of constructing the project features in different phases.

More detailed 2D modeling was conducted during the conceptual design phase to refine the project features, as described in the following section. The general categories of the screening level model runs are described below, as well as key outcomes and takeaways. See Appendix D for additional details on the screening-level modeling setup, results, and outcomes.

- **Diversions Size:** 200-foot and 700-foot bottom width diversions were assessed with the 1D model. Of the two, the 700-foot bottom width provided more relative benefits, including reductions in upstream peak water level, proving more cost effective than the 200-foot bottom width scenario. Therefore, the 700-foot bottom width diversion was used in the next set of screening-level model runs as described below.
- **Diversions Effectiveness:** A set of screening-level model runs was conducted to analyze the relative effectiveness of the 700-foot diversion and conveyance improvements. Based on these numerical model results, the diversion was shown to be less cost effective than the conveyance improvements. In addition, other factors such as Partner input and potential environmental, real estate, and social impacts favored the conveyance improvements. Therefore, in coordination with the Chehalis Basin Board, the diversion was removed from consideration as part of the project.
- **Project Phasing:** One of the guiding principles is the requirement for the LAND Alternative to be designed with the ability to implement fully or incrementally over time. Therefore, it is important to analyze potential phasing scenarios early in the screening process so the different project features can be constructed in distinct stages. One potential scenario was modeled, where the northernmost project components were constructed first, followed by the conveyance feature, followed by the Fort Borst and West Skookumchuck levees, and finally the southernmost project components (see Appendix D for a more detailed review of the model results). The analysis revealed that the conveyance feature is critical for preventing upstream water level increases and avoiding induced flooding of structures. As a result, it is recommended that conveyance improvements be prioritized early in the project timeline. Additionally, excavated material from the conveyance improvements could potentially be repurposed for levee construction, provided geotechnical analyses confirm the material meets the necessary soil property requirements. The resulting phasing scenario is described below. Further analysis of phased construction approaches is recommended for future studies.
 - *Phase 1:* (4) China to Salzer, (6) South Skookumchuck, (7) North Skookumchuck, (11) Conveyance and Bridges
 - *Phase 2:* (8) West Skookumchuck, (9) Fort Borst
 - *Phase 3:* (3) Airport, (2) Newaukum, (1) Adna

The screening-level analysis described in this section linked the Phase 1 work, which included previous alignments and the diversion, with the Phase 2 project features. The screening analysis produced a set of project features and alignments that formed the basis of the LAND project plan. Following this step, the refined alignments and project features were evaluated in greater

detail through conceptual design and cost estimating. The key decisions made during the screening process are as follows:

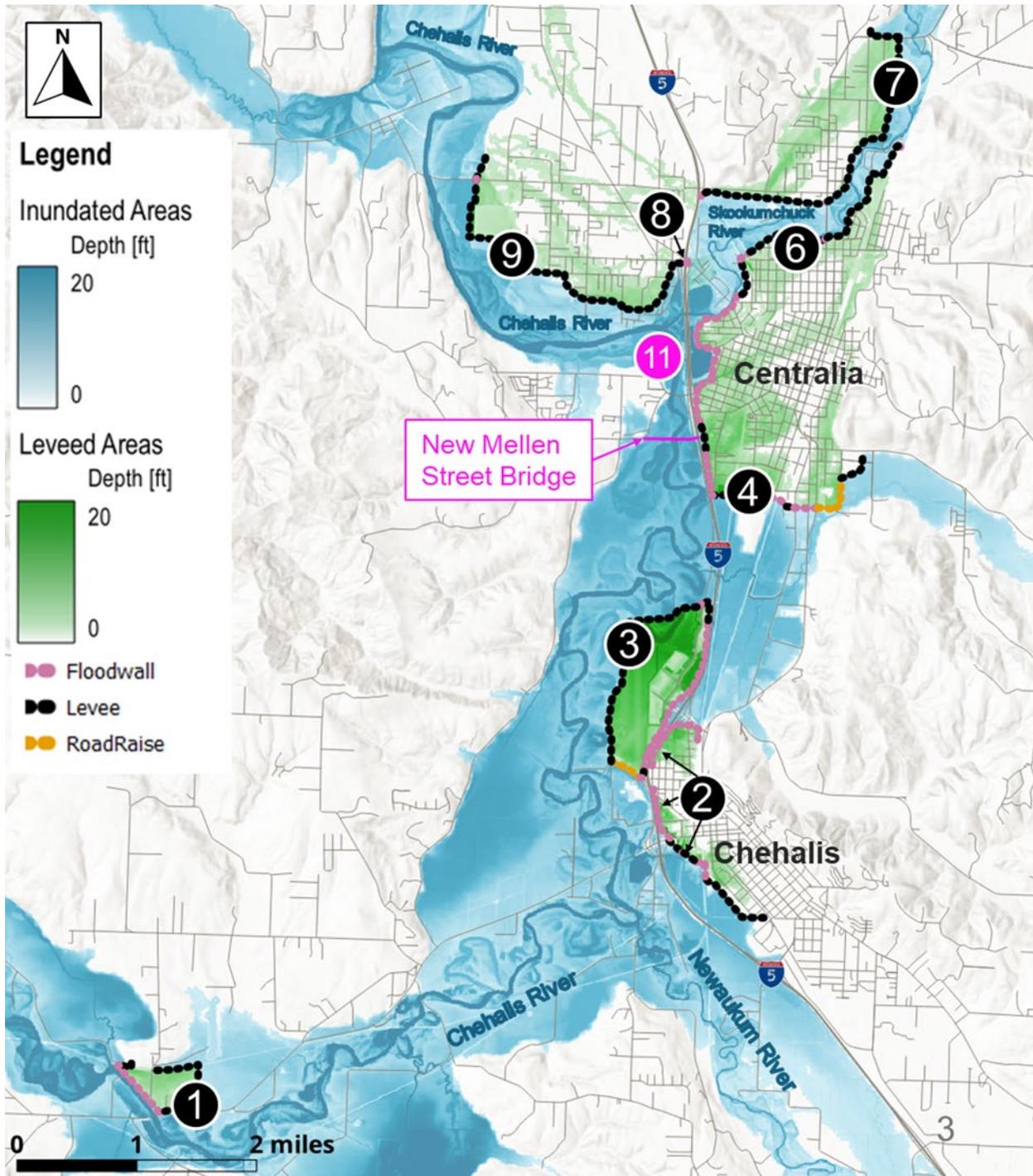
- Removal of the diversion from the project due to high cost, lower effectiveness, and Partner and Tribal input.
- Refinement of the levee and floodwall alignments to reduce overall project cost while maintaining high levels of protection of existing structures and reducing downstream impacts. The refined levee and floodwall alignments resulting from the screening process were carried forward for conceptual design.
- The conveyance improvements, including the Mellen Street Bridge relocation, were carried forward for conceptual design.
- The conceptual-level numerical modeling showed that the project could potentially be built in phases, as described above.

The resulting alignments, structure types, and project components from the screening analysis are shown below in Figure 20. These project features, as shown in Figure 20, were analyzed in more detail using 2D numerical modeling as described in the Conceptual Design section. The resulting project features from the screening analysis include:

- (1) Adna
- (2) Newaukum
- (3) Airport
- (4) China to Salzer
- (6) South Skookumchuck
- (7) North Skookumchuck
- (8) West Skookumchuck
- (9) Fort Borst
- (11) Mellen Street Bridge Relocation and Conveyance Improvements
- Note: (12) China Creek Daylighting is recommended for further investigation in future phases. Potential feasibility-level concepts for daylighting and additional discussions are shown in Appendix I. Costs for these improvements are not included in the overall project costs.

The conceptual design, analysis, and project components are described in more detail in the following section. Note that there are some sections of existing levees, particularly along the South Skookumchuck levee alignment and expansion of the existing Airport levees, where existing levees would need to be raised and incorporated in the alternative improvements.

Figure 20: Summary of the LAND alignments resulting from the screening analysis



Conceptual Design

After the initial screening phase to assess different LAND alignments and project components through preliminary hydraulic analyses and Partner and Tribal coordination, more detailed hydraulic analyses were conducted to develop conceptual designs of the project features. To advance the alternatives evaluation and concept-level design of the levees, floodwalls, road raises, and conveyance, the hydraulic model developed in the previous phase of the project was modified to include the proposed features. The hydraulic model results were used to evaluate the resulting effects of implementing the project on existing structures, infrastructure such as I 5 and key state routes, and downstream communities. The evaluation compared modeled water levels and velocities during the design event with and without the LAND project features in place. The following sections describe key findings from the conceptual design process and describe the conceptual designs for the project features.

Conceptual design process and high-level findings

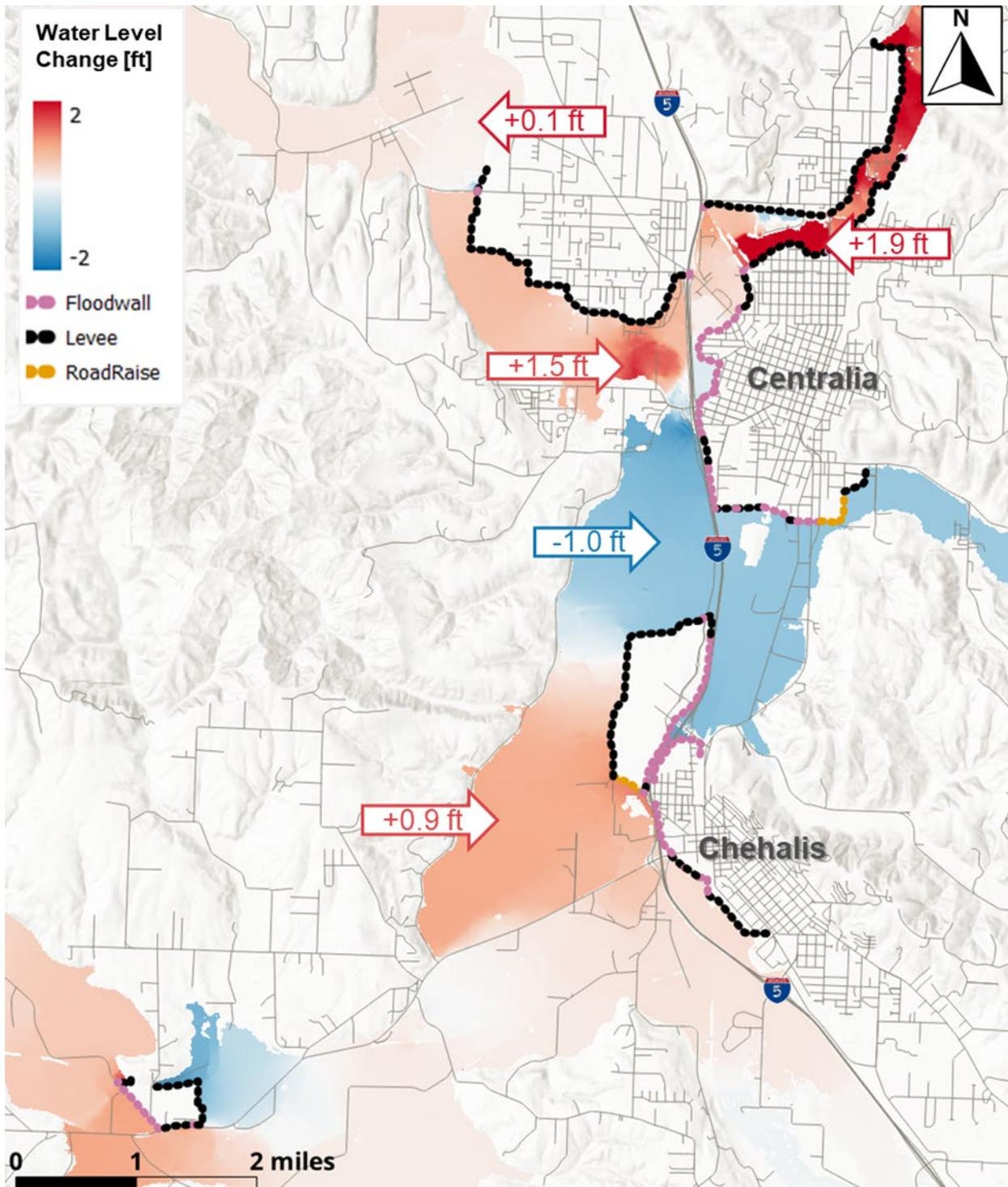
The screening analysis, as described in the previous section, resulted in the conceptual floodwall, levee, and road raise alignments shown in Figure 20. Conceptual-level design of the project features was conducted using the stepwise process described in the following subsections.

Evaluate hydraulic model results for the 100-year plus 26 percent design event

Detailed 2D hydraulic modeling was conducted using the RiverFLOW2D model. RiverFlow2D, a two-dimensional combined finite volume hydraulic model that simulates riverine and floodplain interactions, was used to analyze the hydraulic changes resulting from construction of the levee, floodwall, road raise, and conveyance features. These project features were built into the 2D model domain. The base RiverFlow2D model was developed by Watershed Science and Engineering (WSE) (WSE, 2019). The model tributaries were forced with the design event flowrates, corresponding to the 100-year plus 26 percent event. Future phases of the study will refine the design event flowrate and investigate different return period events to analyze the resiliency of the proposed flood protection measures.

Modeled water surface elevations and current velocities were extracted to analyze changes from the without-project condition. In addition, the modeled water levels were compared to the levee and floodwall heights to ensure that the structures met the 3-foot freeboard requirement. The resulting water level change from the without-project scenario, under the 100-year plus 26 percent design event, is shown below in Figure 21. Warmer colors represent increases in peak water level compared to the without-project condition, and cooler colors represent reductions in peak water level. Additional discussion regarding modeled water level and velocity changes from the without-project condition are included in Appendix D.

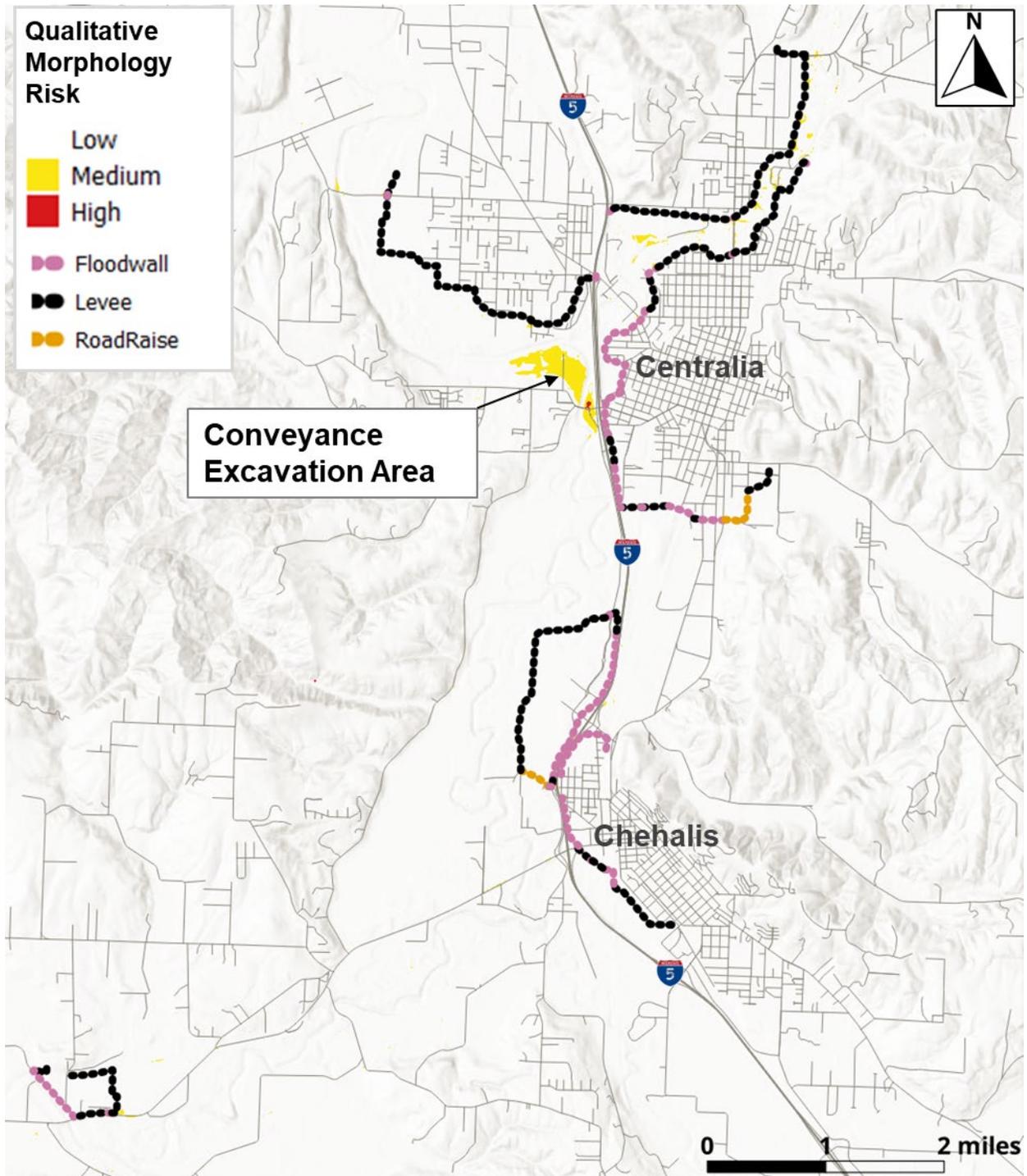
Figure 21: Water level changes for the without -project condition for the design flow event.



Modeled velocities for the with- and without-project conditions were also compared. The results were used to assess the risk of morphological changes due to increased peak velocity by quantifying low- to high-risk areas by the increase in peak velocity. In general, the risk areas were classified as low, with some moderate-risk areas noted in the conveyance excavation

footprint and in the area between the North and South Skookumchuck Flood protection features. The results of the risk assessment are shown in Figure 22. Therefore, this qualitative morphological risk assessment is intended to show areas of potential risk that should be assessed further in future studies.

Figure 22: Morphological risk assessment results.



Key findings from the water surface elevation and velocity comparisons are as follows, with additional discussion in Appendix D:

- **Water Level Changes:** The most significant water level increases occur between the North and South Skookumchuck levees, which is expected due to the proximity of the levees to the river in this area. The majority of structures in this region will be protected by the levees; for those not, the project cost includes provisions for raising homes to address these increases in water level. The next-greatest water level increase is in the conveyance excavation area. This is again expected due to the increased volume of water flowing through this area due to the deeper water depths. Overall, changes in downstream water levels are low, generally less than 0.3 feet. Water level changes along I-5 are discussed in more detail in the Major Transportation Route Impacts Assessment Section later in this document. Additionally, see Appendix D for additional discussion of the model results.
- **Velocity Changes and Morphological Risk:** Modeled peak flow velocities were used to qualitatively assess the potential for morphological changes. The results indicate that risk areas for such changes are largely isolated, primarily concentrated in the conveyance excavation area and the Skookumchuck River. Further investigation of these areas is recommended in future modeling studies, as morphological change in riverine systems is a complex process that is caused by many different flow regimes and storm events. See Appendix D for additional discussion of the model results.

Transportation assessment

A feasibility-level assessment of impacts to traffic and transportation, neighborhood connectivity, and other emergency services was conducted. The assessment identified changes in inundation on major roads, including I-5, as a result of the project, potential projects needed to maintain emergency access during flood events that require further study in future phases, and the ability to maintain emergency access from facilities in Chehalis and Centralia.

Emergency access

A conceptual-level transportation assessment was conducted by comparing numerical model results to potential emergency access transportation routes. Two types of emergency access transportation routes were assessed:

- **Emergency Bypass Routes:** Emergency bypass routes were investigated to maintain access to designated emergency facilities and community lifelines such as hospitals, homeless shelters, and fire stations during major flooding events. These potential bypass routes were identified by comparing existing roadway infrastructure to the levee alignments and identifying key potential updates to the roadway infrastructure that would be required to maintain access during flood events. The analysis also identified where these key emergency bypass routes intersect levee or floodwall alignments. For

this feasibility level study, these intersections were assumed to include closure structures. However, future phases should individually assess these locations to determine which sections of road along the emergency bypass routes should be raised to maintain transit during flood events.

- **Evacuation Routes:** Evacuation routes were developed as part of the 2016 Lewis County Multi-Jurisdictional Hazard Mitigation Plan (Lewis County, 2016). These existing routes were evaluated as part of the transportation assessment, and project recommendations were developed to maintain these routes where appropriate. Potential impacts to existing emergency evacuation routes and suggested future studies are discussed further in Appendix G.

The two major emergency bypass routes identified were the “Eastside Bypass” and “Westside Bypass” as shown in Figure 23.

The Westside Bypass maintains north to south access along the western side of the Chehalis Valley. The potential bypass route would rely on the new Chehalis River Bridge along Scheuber Road, currently being designed by the City of Centralia and Lewis County. To maintain access along this route, the project team has identified projects that would need to be constructed to connect Chehalis to the hospital and complete an emergency bypass route. These projects are summarized below; see Appendix G for additional descriptions and locations of the projects.

- **Construct the Scheuber Road Bridge (West Connector Bridge):** Integrate the currently planned Scheuber Road Bridge with the proposed levee systems, considering integration with the proposed Fort Borst Levee system.
- **South Scheuber Road and Graf Road/Military Road:** To maintain access to the hospital during large flood events, Raise South Scheuber Road from near the Graf Road/Military Road intersection to approximately 700 feet north of the intersection.
- **South Scheuber Road Spot Improvements:** Raise sections of South Scheuber Road between State Route 6 and the Graf Road/Military Road intersection.
- **State Route 6 (South Scheuber Road to I-5):** Replace the existing bridge over the Chehalis River, constructed in 1939, and elevate sections of SR-6 to improve floodplain connections and minimize upstream raised water surface elevation.

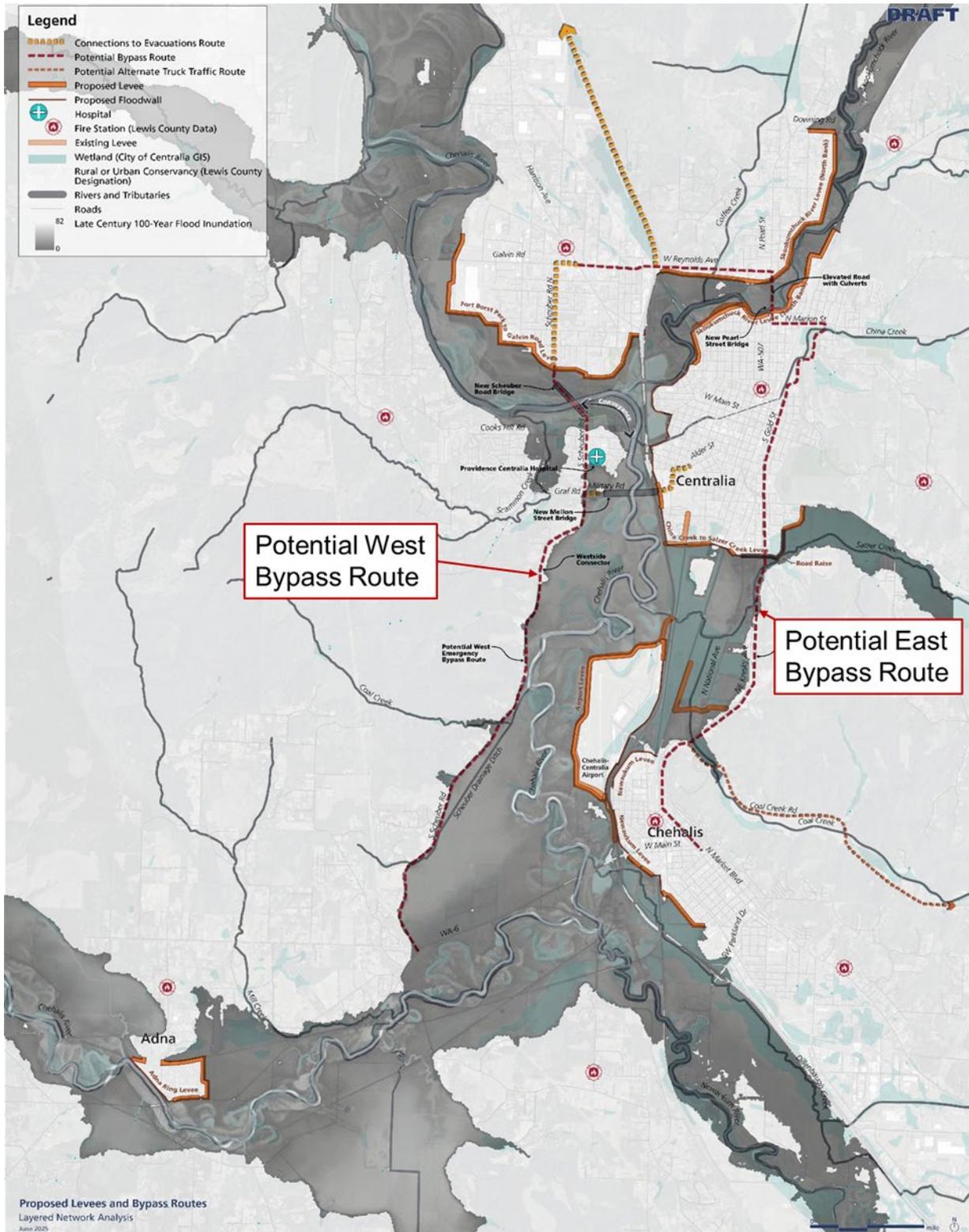
The intersection of the Scheuber Road Bridge (first item above) and Fort Borst Levee should be analyzed to ensure access is maintained during flood events. This would involve raising Scheuber Road and/or the Scheuber Road Bridge above the levee in this area, which is estimated to be approximately 8-9 feet high. Additional analyses are required to identify if other improvements are needed in excess of the four mentioned above.

The Eastside Bypass would connect Chehalis and Centralia, allowing access to the hospital facility from both cities during a major flood event and provide a potential bypass route for I 5. The project team has identified projects that would need to be conducted to complete this emergency bypass route, assuming the levee and floodwall projects are constructed. The projects are summarized below; see Appendix G for additional descriptions and locations of the projects.

- **North National to Kresky Avenue:** This project includes improvements along the North National to Kresky Avenue section of the eastside bypass. The project would require elevating the road above the proposed China to Salzer Levee (8-10 feet in height) to maintain access during flood events. Additionally, selected sections of roadway/bridges may need to be elevated to maintain access during flood events and should be studied in future phases.
- **Pearl Street and Pearl Street Bridge (SR 507):** Pearl Street (SR 507) crosses both the South and North Skookumchuck levee systems. To maintain access during floods, the existing bridge must be replaced and the adjacent roadway elevated above the levees. WSDOT plans to replace the aging bridge in the coming years, and the design should account for the estimated 5-foot levee height. Extending the bridge as a causeway or elevated roadway over the North Skookumchuck levee (3-4 feet high), with culverts for flood flow, should also be considered to ensure connectivity across Centralia during major flood events. Coordination with WSDOT is recommended in future planning phases.

During project Partner meetings in the screening phase of the project, it was noted that, when I 5 is closed due to flooding, truck traffic can back up in the City of Chehalis as trucks attempt to bypass closed sections of I-5. Damages to roadways not designed for truck traffic have occurred. During the meetings, an alternate route along Coal Creek Road was identified to potentially alleviate truck traffic backup and allow bypass when I-5 is closed due to flooding. The potential alternate truck traffic route is also delineated in Figure 23. Note that Coal Creek Road is a narrow two-lane road and should be evaluated in future studies for the potential to use this as an alternative truck route if I-5 is closed and to identify if additional projects are needed to upgrade the road for truck traffic.

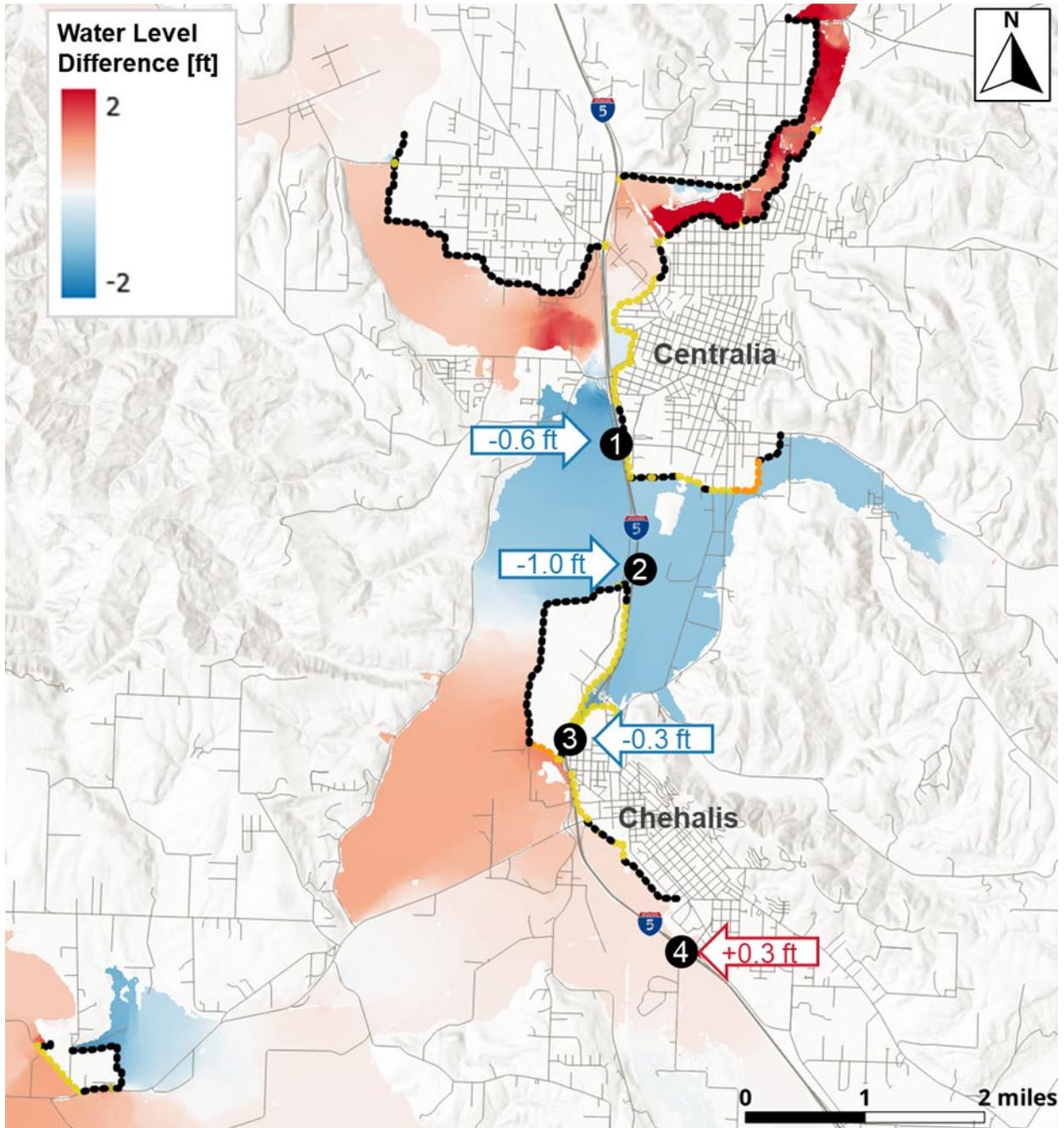
Figure 23: LAND structure alignments selected key facilities including hospitals and fire stations, emergency potential bypass routes, and existing evacuation routes per Lewis County, 2016



Major transportation route impacts assessment

As discussed in the Phase 1 LAND Overview (Previous Work) section, LAND does not assess potential improvements to I-5 that could to reduce flooding potential within the basin. Additionally, LAND was not specifically designed to reduce potential flooding impacts to I-5 but was developed with the goal of minimizing any impacts along the I-5 corridor and adjacent major transportation routes. This section assesses how the refined LAND Alternative affects I 5 and other major transportation routes in terms of severity of flooding. Figure 24 shows the difference in peak water surface elevation for the design flood event between the with- and without-project numerical model results, with callouts at four selected points along I-5.

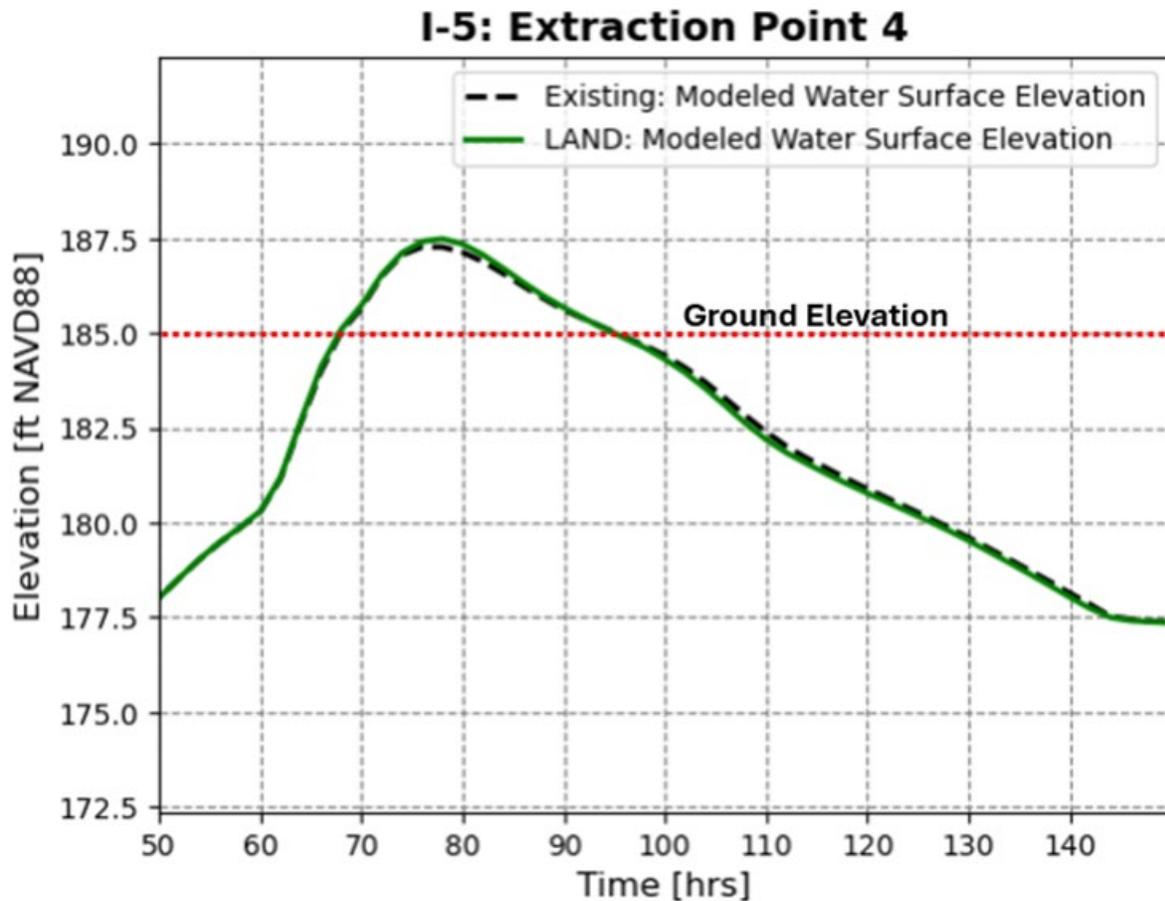
Figure 24: Changes in peak water level during design storm event at four points along I-5 (with LAND minus without LAND)



in addition to the change in peak water levels, it is important to consider the change in the duration of flooding along key transportation routes. Figure 25 shows the modeled water surface elevation during the design flood event for the with- (green) and without-project (black) conditions at I-5 Extraction Point 4, as shown in Figure 24. The time of inundation (i.e., above the existing ground elevation which is labeled by the red line) for with and without LAND is very

similar. Please see Appendix D for additional information and inundation comparison plots for other extraction points.

Figure 25: Modeled water surface elevation during design storm event



In addition to the high-level transportation impacts assessment, conceptual-level designs for the new Mellen Street Bridge were developed. The bridge would tie into the existing I 5 overpass on the west side and Military Road on the east side. Selected sections of Military Road may need to be raised to maintain access during flood events. See the Conveyance Improvements section and Appendix G for additional information on the proposed Mellen Street Bridge relocation.

Geotechnical findings and risks

A geotechnical risk assessment was conducted using publicly available surficial geology data. High-level findings and risks are summarized below. See Appendix E for additional information on the geotechnical risk assessment.

- Seismic risk may be significant due to the number of faults identified in the Centralia region (WGS, 2018). A closer look at the intersection of actual faults and proposed and

existing structures is warranted. USACE guidance allows consideration of maintenance and repair of earthquake-damaged reaches prior to the next flood event rather than seismic structural resilience.

- Upper layers of alluvium materials are expected to be fine grained and therefore will be moisture sensitive. Excavation of conveyance improvements will need to be staged and coordinated with considerations for beneficial use as fill.
- Embankment levees constructed on alluvium will likely experience some settlement. Preloading phased construction or overbuilding can be effective ways of minimizing or mitigating for settlement after construction.
- Relatively soft upper soil layers provide little lateral support for I-walls. Structure foundation design would require deeper embedment for stability and should be assessed in more detail in future phases.

Identify environmental, land use, and cultural resources

Environmental impacts and ecosystems approach

Environmental impacts, including impacts on fish and other natural resources, construction related impacts for the alternatives, and construction-related fill/excavation activities were identified on a concept level. Ecological considerations, including identifying ways to minimize impacts on key ecological functions within the project area, were also assessed. Screening-level analysis criteria were developed to characterize and evaluate the ecosystem services impacted by each individual levee system. A high-level summary of the potential impacts by LAND project component is shown in Table 1. See Appendix F for additional information.

Table 1: High-level summary of potential impacts by LAND component

Category	Category Description	Considerations for Ranking	Adna	Newaukum	Skookum-chuck (N/S/W)	Fort Borst Park	China Creek to Salzer	Airport	Conveyance
Site context	Land use adjacent to flood protection feature	None	Rural/residential	Urban/ag.	Urban/residential/ag.	Urban/ag.	Urban	Urban	Urban/rural/ag.
Geo-morphic	Riverine and floodplain processes	Floodplain function, potential incision/bank erosion, etc. (Mod.)	Mod.	Minor	Mod.	Mod.	Mod.	Mod.	Minor
Aquatic and riparian	Alteration of stream corridor	Distance from river/channel length (Major)	Major	Minor	Major	Minor	Minor	Minor	Minor
Aquatic and riparian	Riparian/floodplain habitat	Extent and condition of riparian and wetland vegetation (Mod.)	Mod.	Minor	Mod.	Minor	Mod.	Minor	Mod.
Aquatic and riparian	Existing/historic refugia for fish spawning and/or rearing	Existing off-channel habitat, pools, substrate conditions (Mod.)	Mod.	Minor	Mod.	Mod.	Minor	Minor	Minor
Fish and wildlife species	Fish life history characteristic	Migration, spawning, rearing of target fish species (salmonids, lampreys) (Minor)	Minor	Minor	Mod.	Mod.	Minor	Minor	Minor
Fish and wildlife species	Wildlife species that occupy floodplain habitats	Amphibians, migratory birds, wetlands, open water (Minor)	Minor	Minor	Mod.	Mod.	Minor	Mod.	Mod.

Note: Blue denotes minor impacts. Yellow denotes moderate (mod.) impacts. Gray denotes major impacts. Agricultural is denoted by ag.

Additional details and high-level findings from the impacts assessment and ecosystem approach are summarized below for the alternatives that are carried into conceptual design.

- **Adna:** Site assessment area is a mix of rural residential and agricultural land use. Agricultural land with historical side channels may provide major opportunities for restoration/ecological lift.
 - *Geomorphic:* Moderate overall impacts due to potential channel incisions, bank erosion, and altered flow conveyance.
 - *Aquatic and Riparian Habitat:* Moderate impacts to a narrow, continuous strip of riparian area between levee and river. Minor risk of floodplain habitat impacts.
 - *Fish and Wildlife:* Native fish species could be impacted because of loss of access to off-channel rearing habitats. Minor wildlife impacts likely due to some loss of riparian vegetation habitat and potentially reduced connectivity.

- **Newaukum:** Site is a mix of urban and agricultural land use. Temperate freshwater emergent marsh and lowland riparian forest and shrubland take up approximately half of the assessment area.
 - *Geomorphic:* Minor impacts due to confinement of flows in Dillenbaugh Creek, and minor risk of reduction in floodplain capacity and storage.
 - *Aquatic and Riparian Habitat:* Minor impacts to streambank and existing refugia that can be conducive for fish spawning and/or rearing. Opportunities exist to create uplift for native fish species by establishing riparian buffer and increasing habitat for juvenile fish rearing.
 - *Fish and Wildlife:* Minor impacts expected since levee is set back.

- **Skookumchuck (North, South, West):** Site is a mix of urban, residential, agricultural, and industrial uses. Most of the areas are low-intensity urban development with some areas of high intensity.
 - *Geomorphic:* Moderate overall impacts due to potential impacts to existing floodplain areas, and potential increased rates of channel incision and bank erosion.
 - *Aquatic and Riparian Habitat:* Moderate potential impacts include direct alternation of the streambank and large areas of wetlands within the assessment area. Moderate potential impacts to spawning and rearing habitat of the Skookumchuck River which provides core habitat for spring Chinook salmon and coho salmon.

- *Fish and Wildlife Species*: Moderate impacts to wildlife species that occupy and use the floodplain habitats. However, the area is already mostly urban and industrial land uses, so presence and abundance of wildlife is expected to be already degraded.
- **Fort Borst**: Site is primarily agricultural and undeveloped land use.
 - *Geomorphic*: Moderate impacts due to narrowing of floodplain in localized areas.
 - *Aquatic and Riparian Habitat*: Minor impacts due to the levee locations set back from the Chehalis River.
 - *Fish and Wildlife*: Moderate impacts in areas where floodplain narrowing could reduce habitat connectivity.
- **China to Salzer**: Site land uses are agricultural, rural residential, and urban residential.
 - *Geomorphological*: Localized areas of moderate impacts to the proximity to Salzer Creek and constraining hillslope to the south/southeast.
 - *Aquatic and Riparian Habitat*: Minor potential impacts because only a small section of the levee is along the streambank. Riparian habitat is fragmented to non-existent leading to limitations on spawning and rearing habitat.
 - *Fish and Wildlife*: Minor impacts due to little change to existing habitat connectivity.
- **Airport**: Land uses of the assessment area include cultivated cropland and agriculture, and commercial development in the vicinity of the airport.
 - *Geomorphic*: Localized areas of moderate impacts due to narrowing of floodplain and disconnection of side channels.
 - *Aquatic and Riparian Habitat*: Minor risk of impacts to existing refugia for spawning and/or fish rearing. Adult fish migrate through the assessment area on their way to higher quality spawning habitat upstream.
 - *Fish and Wildlife Species*: Moderate impact to wildlife could occur due to fragmentation of portions of floodplain habitat.
- **Conveyance Improvements**: Existing land use of the conveyance improvements along the Chehalis River is mainly agricultural and undeveloped.
 - *Geomorphic*: Minor impacts to geomorphologic processes are expected.

- *Aquatic and Riparian Habitat*: Minor impacts to aquatic and riparian habitat.
- *Fish and Wildlife Species*: Moderate impacts may result to wildlife from removal of soil and vegetation. Connectivity will be impacted in the near term but should eventually recover.

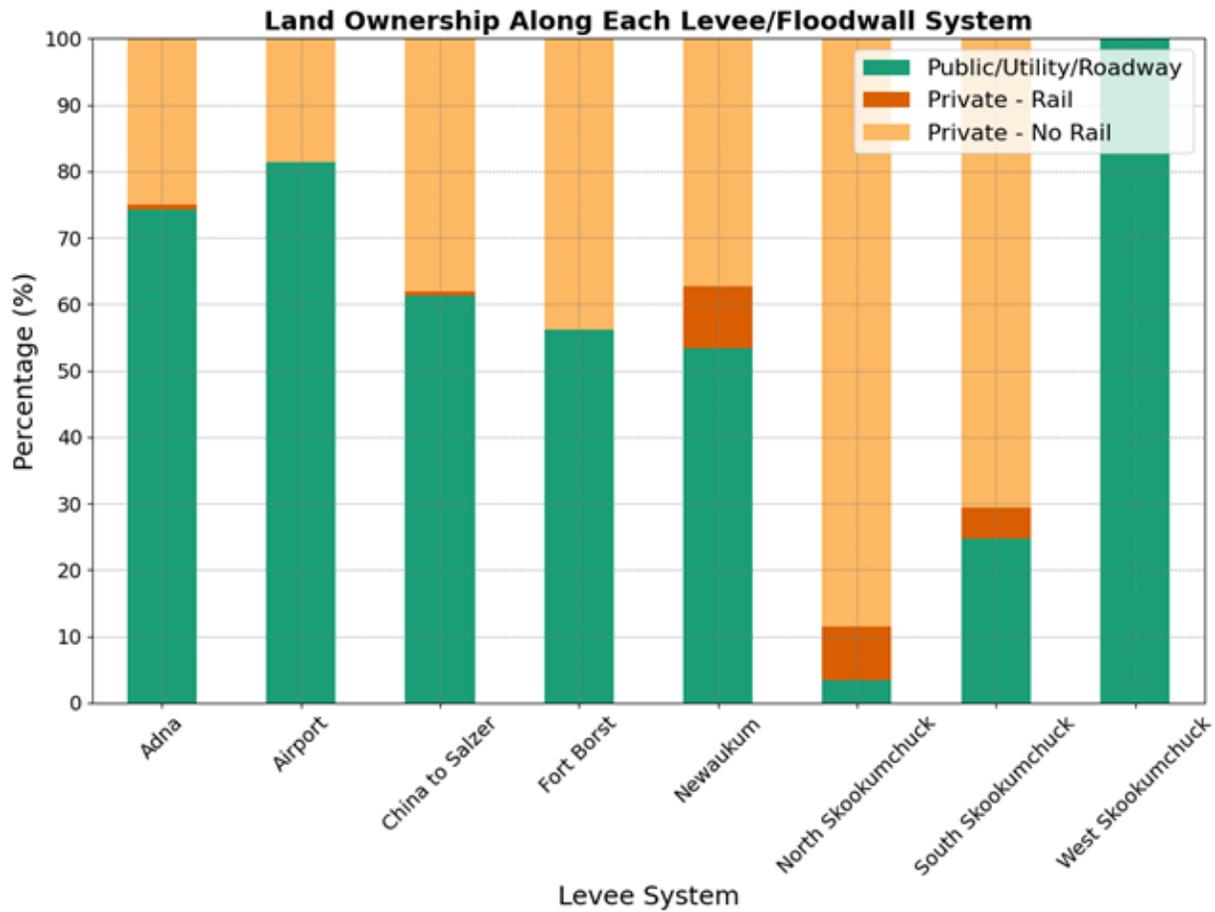
Mitigation opportunities include creating ecological uplift for native fish species through enhancement of conditions at tributary confluences in the area. Opportunities are consistent with concepts identified in the ASRP for the Middle Chehalis Basin. The addition of large complex wood structures at confluence areas can be considered to provide hold areas for adult fish as they prepare for upstream migration. Floodplain side channels could be improved to increase connectivity to the river with a wider range of flows.

Low-integrity riparian and wetland systems (e.g., China Creek, Skookumchuck) may offer restoration potential, including ecological uplift, floodplain reconnection, and native species reintroduction and resilience.

Land ownership

Understanding whether land along the proposed levee and floodwall alignments is publicly or privately owned helps identify potential legal, financial, and logistical challenges early in the planning process. This land use assessment was conducted to identify which levee and floodwall alignments will require more coordination with private landowners and project Partners. Note that costs to acquire the private land are included in the overall project costs and that efforts were made to minimize impacts to existing structures. Relocations of structures within the levee/floodwall ROW are also included in the project overall costs as described further in the LAND Project History section. The resulting percentage of the total length of each levee that is along public (roads, parks, utility right of ways, etc.) versus private (commercial, residential, railroads, etc.) land is shown below in Figure 26.

Figure 26: Percent public vs private along the total feature length for each system



Note: Private lands are separated into those on railway ROW (dark orange) and any other private land (light orange)

Cultural resources

After the screening-level project alignments and features were developed, cultural resources coordination was conducted with local Tribal partners including Confederated Tribes of the Chehalis Reservation, Cowlitz Indian Tribe, Nisqually Indian Tribe, and Quinault Indian Nation. In addition, a desktop review, focusing on archaeological and historic built environment resources (HBE), relative to the potential levee, floodwall, bridge, and conveyance footprints identified areas with cultural resources concerns. The results are preliminary and for planning purposes only. A high-level summary of the findings is as follows:

- Archaeological Sensitivity:** The study identified 51 previously recorded archaeological sites that overlap or buffer the Study Area. Approximately 70 percent of the Study Area has not undergone subsurface archaeological survey, and of the surveyed areas, about 24 percent of the buffered levee and floodwall alignment intersect with known sites or buffer zones from known sites. This suggests a high likelihood of encountering

previously unidentified archaeological resources, and need for further investigation at existing sites.

- **Tribal Input Highlights Cultural Importance:** Tribal outreach conducted during this phase confirmed that the Study Area has long-standing cultural significance as a travel corridor, habitation zone, and resource area. Tribes emphasized the need for continued consultation, protection of cultural and natural resources, and recognition of Treaty rights throughout the project lifecycle.
- **Need for Further Cultural Resource Work:** Given the potential for both archaeological and HBE impacts, the LAND alternative will require HBE surveys, additional archaeological investigations, and formal consultation with Tribes and regulatory agencies. Future schedules should incorporate adequate time for investigations and consultation.

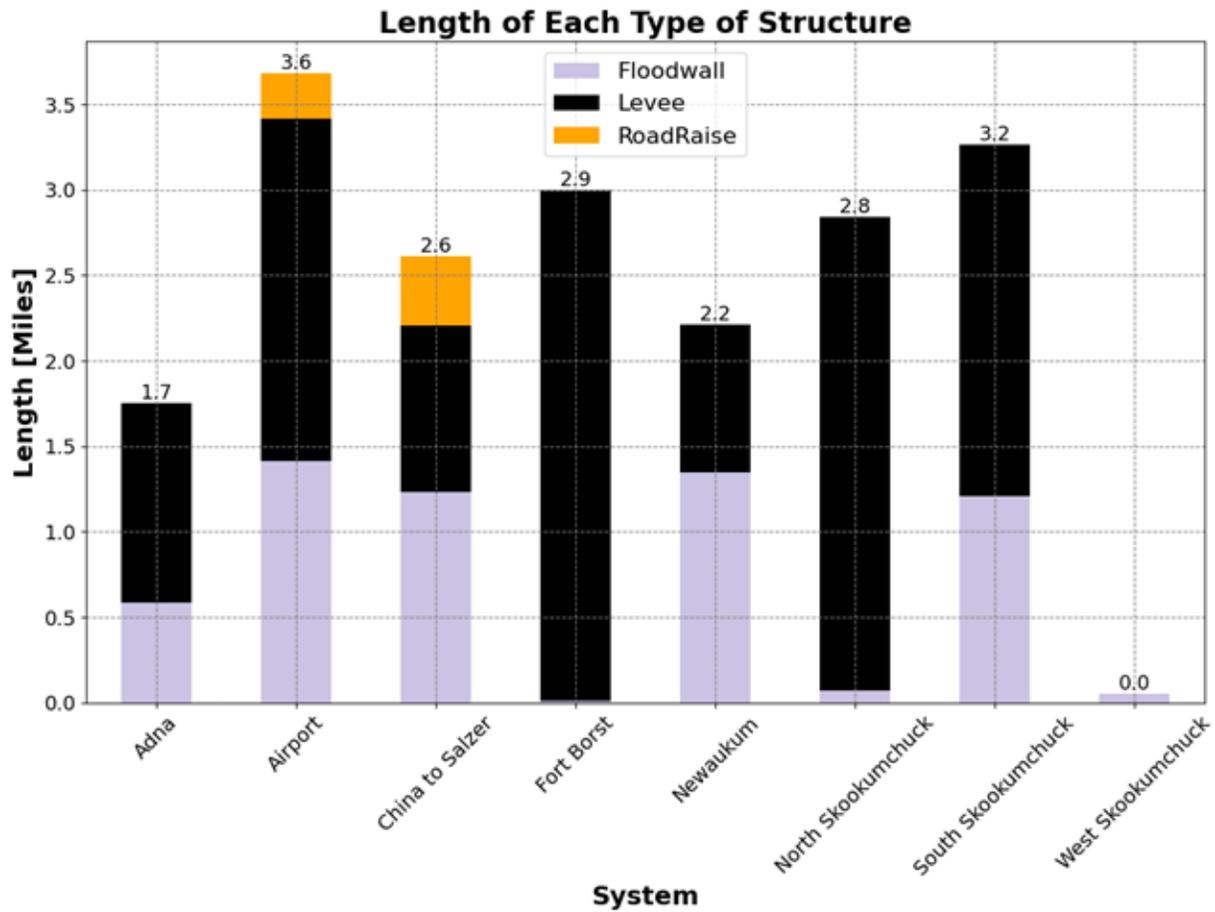
Conceptual designs for project features

The following sections provide a summary of key information for each set of levees and floodwalls, including the estimated project cost range.

Structure type

The length of levee, floodwalls, and road raises along each project component is shown below in Figure 27. The overall length of structures is approximately 19-20 miles. The alignments include approximately 5.9 miles of floodwall, 12.8 miles of levee, and 0.7 miles of road raises. In general, levees were selected in more open, rural areas and are typically lower cost than floodwalls. More urban areas require floodwalls or road raises, which typically cost more than levees.

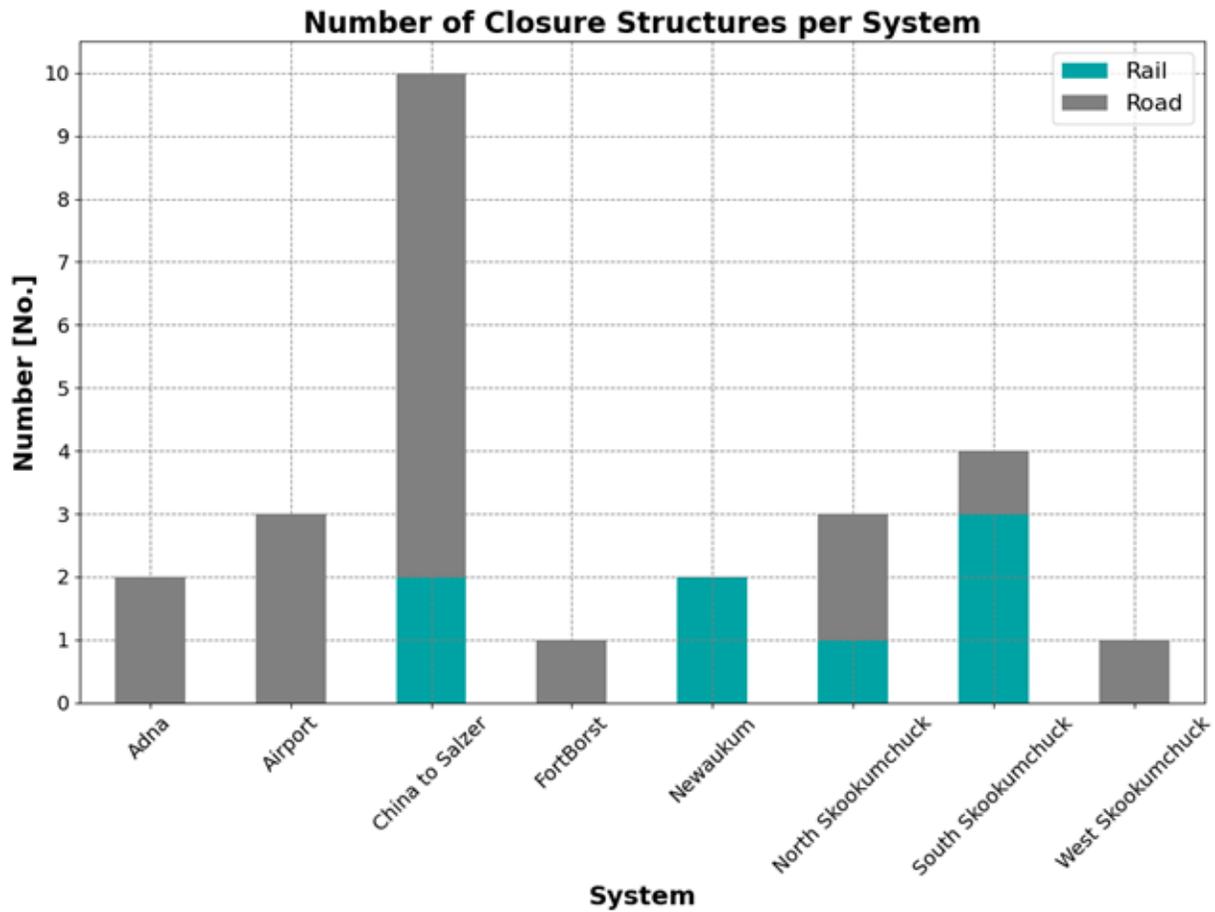
Figure 27: Breakdown of structure type by levee/floodwall system



Closure structures

Closure structures are critical components in the LAND levee and floodwall systems designed to provide temporary barriers across openings for roadways and railways during flood events. Roller gates are assumed to be constructed across railroads and move horizontally to seal off the track opening and prevent flooding during storm events. Swing gates are assumed at all road crossings, operate on a hinge, and pivot closed to seal off the roadway opening. Ahead of forecasted flood events, these gates would be closed by trained city, county, or local personnel. Personnel would also test, operate, and close the gate systems. As part of future phases of the project, pre-storm operational plans and checklists should be developed to ensure protocol is developed and followed prior to and during flood events. Additionally, some areas may require alternative gate types and/or road raises rather than closure structures to facilitate emergency access and should be investigated further. The number of gates for each levee system is shown below in Figure 28. In total, there are an estimated 8 railroad gates and 18 roadway gates.

Figure 28: Breakdown of number of closure structures (Rail vs Road) by project component



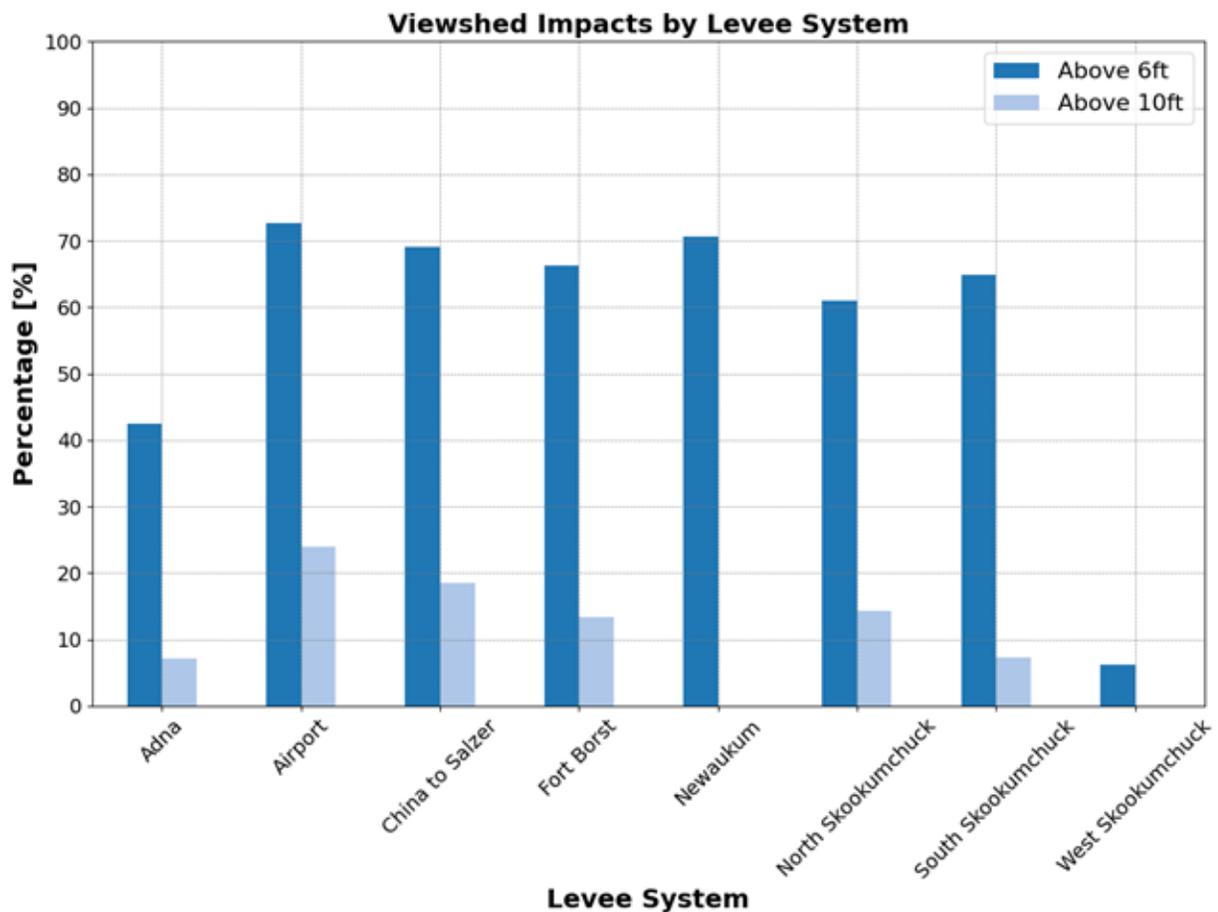
For the planning-level design and cost analysis conducted in this phase of LAND, closure structure gates have been assumed at all locations where a levee or floodwall crosses a road. However, as discussed earlier in the Transportation Assessment section, there are opportunities to integrate emergency bypass routes to maintain connectivity between communities and emergency facilities during large flood events. Gates at specific locations could be replaced by roads raised over the levee system to maintain connectivity as discussed in the Transportation Assessment section. This includes the proposed WSDOT replacement of the existing Pearl Street Bridge, which could be integrated into the potential Eastside Connector emergency bypass route. Therefore, it is recommended that the LAND team coordinate planned improvements with private railway owners and operators and other government agencies such as WSDOT and local municipalities to help improve connectivity during storm events within the basin.

Visual impacts considerations

In general, higher levees and floodwalls have greater impacts on the viewsheds in an area. As mentioned in the Concept Screening Analysis section, the alignments were refined to try and follow highpoints in the natural topography to reduce impacts to cost and viewshed.

Additionally, whenever feasible, earthen embankment levees were selected rather than floodwalls to reduce visual impacts on the landscape. These levees would be planted with grass to protect esthetic values as possible. In general, deep-rooted vegetation such as trees and shrubs are not allowed on levees to maintain levee stability. Opportunities for parks, recreation, and other public amenities were considered, included pathways along the levee crest to tie into existing and proposed trails (refer to Appendix H for discussion). Viewshed impacts depend on setback of the levees and floodwalls from sightlines, so high-level assumptions were made to consider viewshed impacts. The general principle followed is that viewshed impacts are considered when the height of a levee or floodwall exceeds eye level for most observers. This can vary based on the site, vantage points, viewer height, and adjacency to existing infrastructure. For the purposes of this feasibility-level assessment, it was assumed that levees or floodwalls greater than 6 feet could cause viewshed impacts, and those above 10 feet could cause significant visual barriers in the landscape. The following figure shows the percent of each levee system that is above each threshold level. See Appendix A for additional figures showing the height of the levee and floodwall systems. As described earlier in the report, the height was determined by adding 3 feet of freeboard above the modeled water depth for the design storm event (100 year return period plus 26 percent).

Figure 29: Visual impacts assessment by levee system



Interior drainage

A screening-level interior drainage analysis was conducted to determine the potential need for pump stations. The interior drainage analysis used LiDAR (USGS, 2012 and NV5 Geospatial, 2024) to approximate the required pump station capacities to mitigate interior drainage. Siting of the facilities was not conducted, as full-scale interior drainage assessments including consideration of weirs, detention ponds, land use, existing interior drainage systems, and other potential drainage improvements should be included in future phases. However, the cost to mitigate the peak interior drainage flow for all levee and floodwall systems is included in the overall project costs shown in the cost appendix. These costs and analyses are conceptual in nature, and future studies must be conducted to refine these estimates.

Two creeks cross the proposed levee and floodwall alignments—China Creek at the China to Salzer flood protection system, and Coffee Creek at the North Skookumchuck flood protection system. Pump stations are included to mitigate storm flow during these events, extracted from the design storm hydraulic modeling. Descriptions of the potential pump station facilities at China Creek and Coffee Creek are shown below.

China Creek is a small urban waterway that runs through downtown Centralia, connecting with the Chehalis River through a series of culverts under I-5. Portions of China Creek are currently underground through a series of culverts and tunnels. These underground sections are primarily downtown, where the underground creek emerges intermittently in small channels. The proposed South Skookumchuck Levee and Floodwall intersects China Creek east of I 5. Coffee Creek is a fish-bearing stream that intersects the proposed North Skookumchuck Levee and Floodwall. The China and Coffee Creek intersections assume the following:

- At the creek and floodwall intersection, a flow gate would be placed that allows normal flows to pass unobstructed into the main stem of the Chehalis River (China Creek) and Skookumchuck River (Coffee Creek).
- The gate would close when the main stem of the river floodwaters rise, preventing backwater from entering Coffee Creek or China Creek and the surrounding neighborhoods during storm events.
- When the gate is closed, a pump station would engage to pass the peak flow for the design event, with additional facilities included to allow fish passage during high flow events.

Recommended next steps to advance the China Creek and Coffee Creek interior drainage analysis in future phases are as follows:

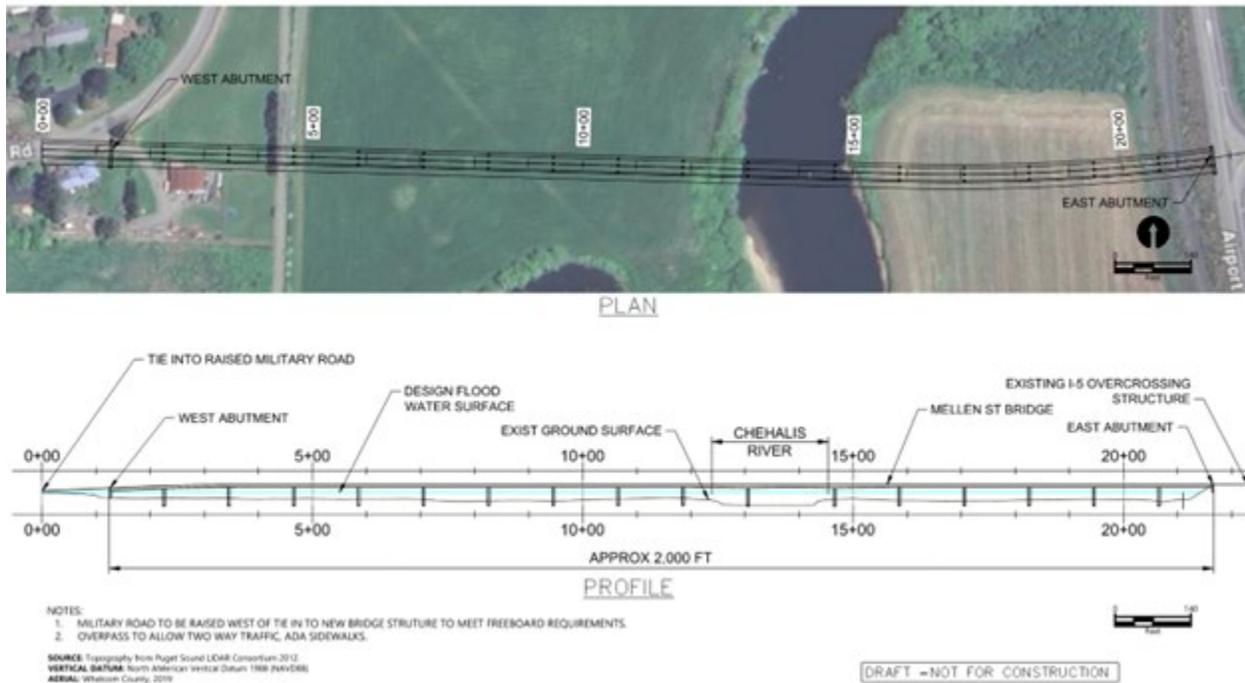
- Interior routing of water to the pump station and/or upstream mitigation of flows to reduce peak flows along China Creek have not been designed as part of this study. Future studies should investigate upstream watershed improvements including:

- Investigate upstream gate structures to utilize the natural floodplain for additional storage during storm events. Automated gates would control and regulate downstream releases through the closed system. This storage can mitigate high flow during the extreme of other events for flood protection. Similarly, detention ponds to increase upstream storage should be investigated.
- Investigate internal routing of flows from China Creek to the Chehalis or Skookumchuck River. Flows could be directly routed to the potential pump station locations or utilize existing interior drainage infrastructure.
- Additional studies should be conducted to route interior drainage flows. For this study, it was assumed that all flows would be routed to pump stations, and subsequent pump station costs were included. See Appendix C for the estimated pump capacities. In future studies, interior drainage analyses, including tying into existing drainage systems, should be investigated.
- Potential China Creek daylighting options have been preliminarily investigated as part of this study (see Appendix I). Daylighting should be investigated further and considered as part of the project design.
- Full scale interior drainage assessments for other levee systems, including consideration of weirs, detention ponds, land use, existing interior drainage systems, routing of flows and pump stations, and other potential drainage improvements, should be included in future phases.

Conveyance improvements

The conveyance improvements included as part of LAND have been studied in numerous previous efforts, including OCB (2024), USACE (2003), and others. The extents of the conveyance excavation footprint have been refined since Phase 1 of LAND to increase conveyance while avoiding existing properties to the extent possible. In general, the conveyance improvement design includes demolition and relocation of the existing Mellen Street Bridge and excavation of approximately 800,000 cubic yards of material to improve conveyance of the Chehalis River during storm events. The proposed relocation of the Mellen Street Bridge is shown below in Figure 30.

Figure 30: New Mellen Street Bridge alignment



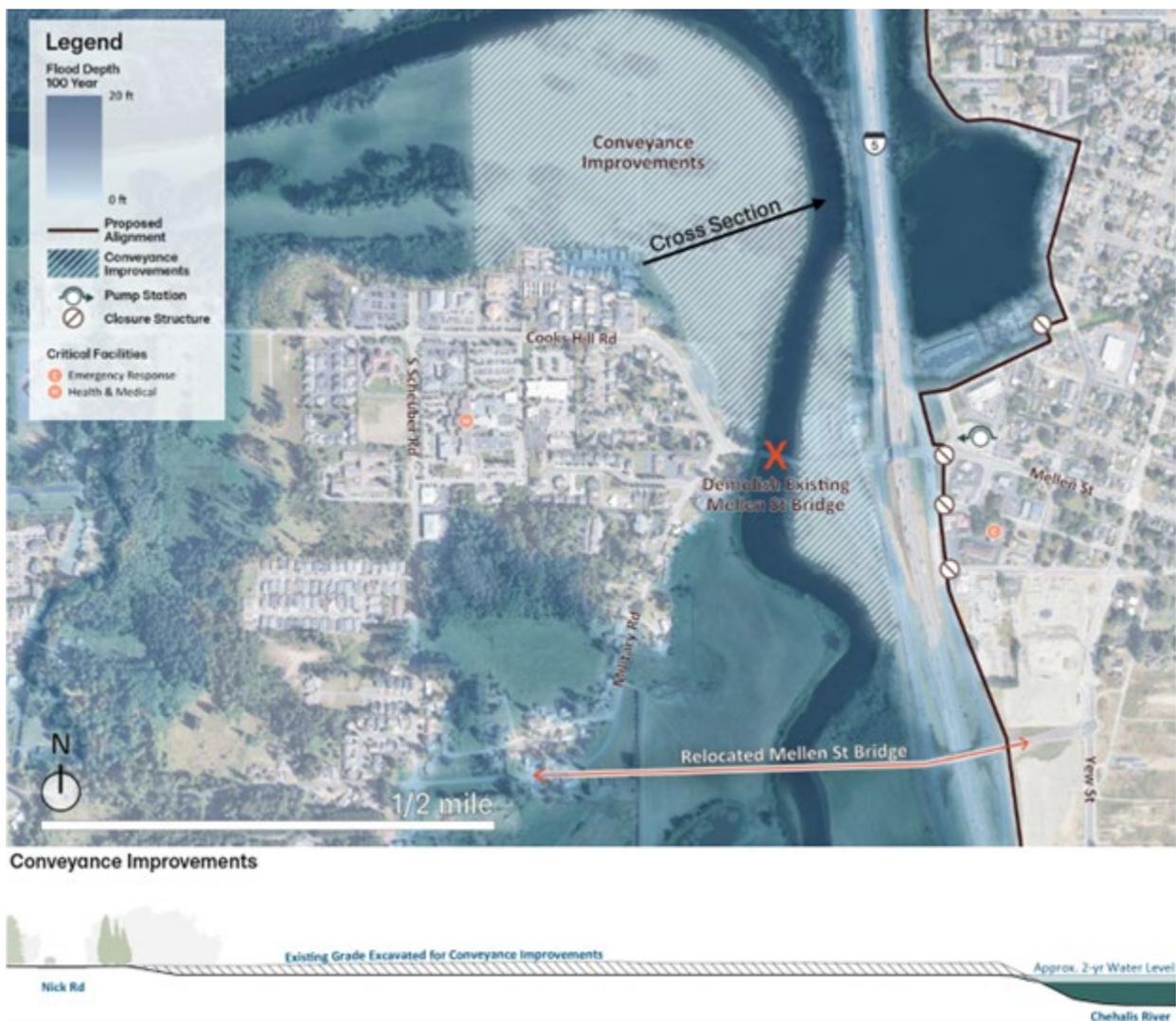
Key notes on the Mellen Street Bridge relocation are as follows:

- The new bridge is assumed to be 45 feet wide with two 12-foot lanes, a 3-foot buffer strip, a 6-foot shoulder, and a 12-foot shared use bike path. As shown in Figure 30, the bridge is approximately 2,150 feet long.
- The west end of the bridge will tie into Military Road. If this route is selected to be part of an emergency bypass route as described in the Transportation Assessment section, Military Road should be raised by approximately 3-4 feet if it is to remain dry during the design flood event.
- The east end of the new bridge will tie into the existing I-5 overpass structure along Art Lehman Drive. The existing structure is currently one way. Preliminary conversations with WSDOT indicate the bridge could be converted to two-way traffic; however, follow up coordination with WSDOT and more detailed design should be conducted in future phases of the project.
- Note that the recent Art Lehman Drive elevation and the new I-5 overpass structures are not included in the numerical model. Based on preliminary investigations of the new overpass, it appears that Art Lehman Drive is above the design flood elevation and would allow connectivity between Centralia and the new Mellen Street Bridge during flood events. This should be investigated further in future traffic and emergency routing studies as part of the project.

The conveyance excavation removes approximately 800,000 cubic yards of material. The potential conveyance excavation footprint and an example cross section are shown in Figure 31. Key notes on the conveyance excavation are included below:

- The conveyance excavation footprint was adjusted during project Partner coordination meetings with the City of Centralia to avoid the existing sewer main just west of I-5. The top edge of conveyance excavation was adjusted to be riverward of the sewer main.
- The conveyance excavation intersects approximately 15 existing valuable structures per Anchor, 2024. The costs for relocating these structures are included in the project capital cost estimate.

Figure 31: Approximate conveyance improvement excavation bounds, existing Mellen Street Bridge demolition, and relocated Mellen Street Bridge (top) and example cross section of conveyance excavation (bottom)

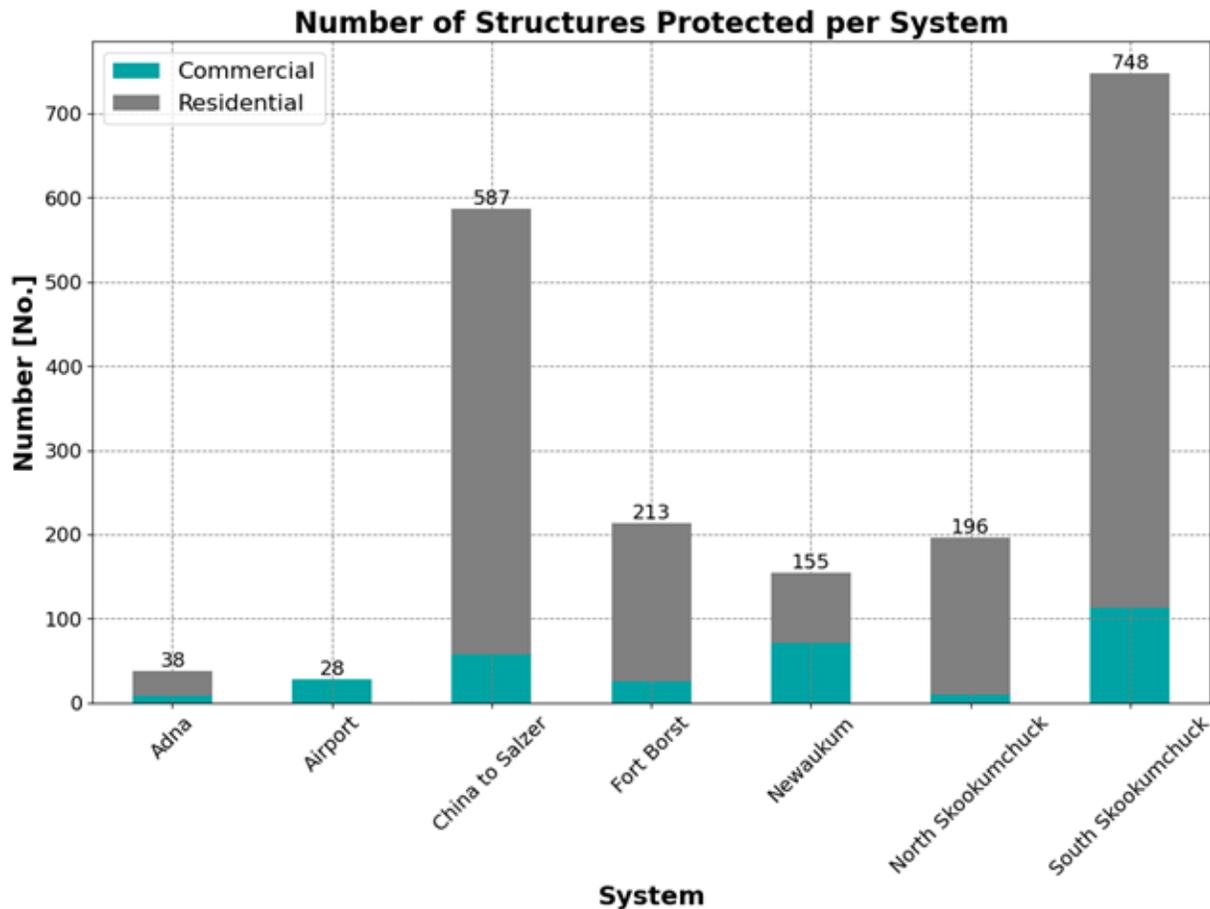


Structures protected and structural retrofits

Structures within the levee and floodwall boundaries are protected from floodwater during the design event. A structures database (Anchor QEA, 2024) was used to assess inundation depths at structures both with and without the LAND project. The number of structures that are inundated without LAND and are no longer inundated with LAND in place are summarized below. Note that the Fort Borst and West Skookumchuck levees serve to protect the same area, with Fort Borst protecting from floodwaters entering from the south and west, and the West Skookumchuck levee protecting from floodwaters entering through Harrison Avenue under I 5. Therefore, the total number of structures protected by both is in the “Fort Borst” column.

Figure 32: Breakdown of the number of structures that were previously inundated that are no longer flooded with LAND in place, summarized by system.

Numbers show total number of structures, blue (commercial) and gray (residential) show the breakdown of structure type. West Skookumchuck is included in the Fort Borst totals for this chart.



Structure retrofits include raises, floodproofing, and relocations for residential structures and floodproofing for commercial or agricultural structures. Note that retrofits only apply to structures that are inundated under the design storm with LAND in place. The LAND project groups structural retrofits into two categories as described below. It is assumed that inundated

structures outside of these categories will be addressed by other projects and/or initiatives within the basin.

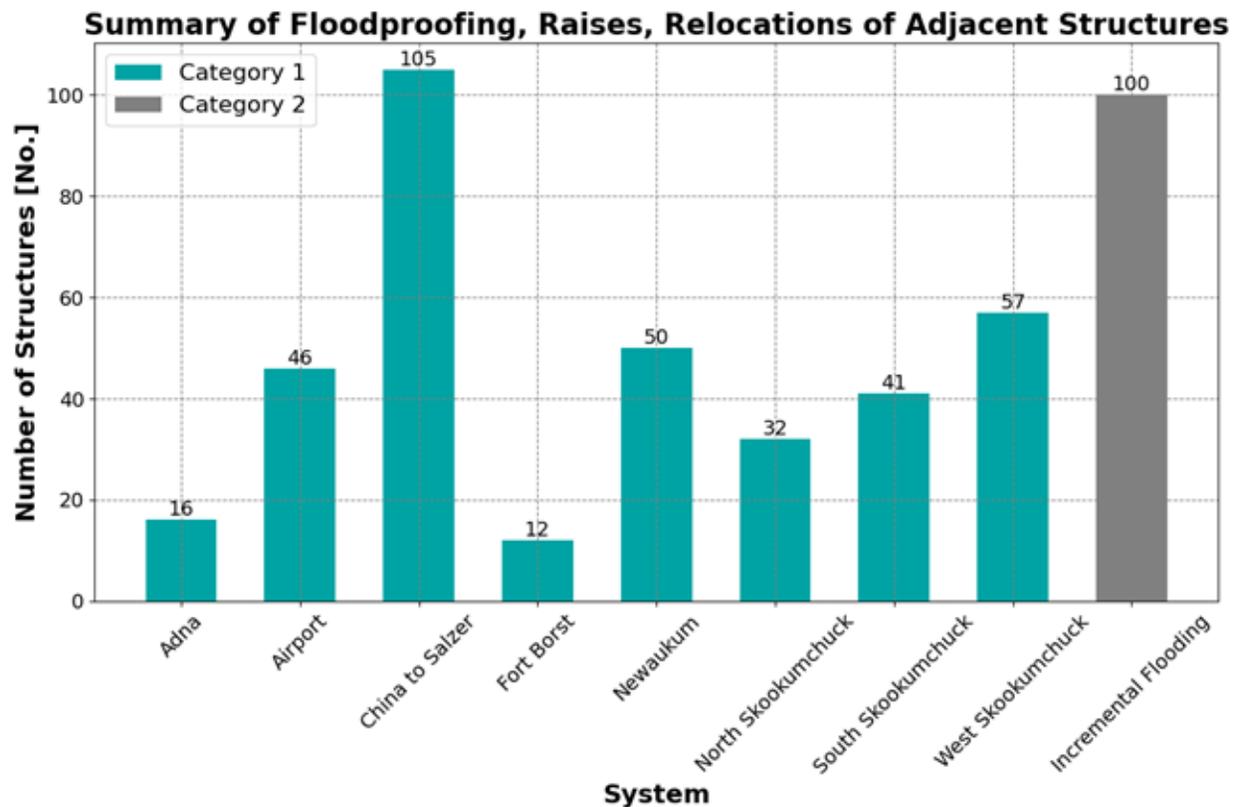
- **(1) Floodproof, Raise, Relocate Adjacent Structures:** Costs to raise, floodproof, or relocate residents within all structures that are inundated with LAND in place and nearby (assumed to be approximately 0.5 miles for this study) the levee and floodwall alignments are included in the project costs. Note that this includes all structures within this radius, even those that are inundated without the project in place or in areas where water levels are decreased.
- **(2) Incremental Impacts to Structures Outside of Levee Systems:** There are areas outside of the levees where peak water levels during the design event are larger with LAND in place than without. The incremental impact needs to residential and commercial structures in these areas is considered in the project costs. For example, if a structure does not flood without the project under the design event but is inundated with floodwaters 1 foot above the finished floor elevation with LAND in place, the cost to floodproof that structure is included in the overall cost. Therefore, the LAND project structural retrofit analysis assumes that the incremental difference in costs between the without-LAND and with-LAND conditions are included in the overall project costs.

A summary of the number of structures assumed to be raised, retrofit, and floodproofed immediately adjacent (within Category 1 above) to each system is shown in Figure 33. The incremental impacts to structures outside of the levee systems (within Category 2 above) include an estimated 100 structures as shown in the last bar of Figure 33. Note that this considers only the design storm, and future studies should consider impacts during other storm events; see Appendix C for more detail on the costs.

Figure 33: A summary of the number of structures assumed to be raised, retrofit, and floodproofed that are outside the protected levee and floodwall area as part of the LAND project.

Category 1 (teal): Summary of the number of valuable structures within 0.5 miles if each flood protection system that are to be raised, floodproofed, or relocated as part of the project.

Category 2 (gray): Total number of structures falling under Category 2, incremental impacts to structures outside of the levee system



Recreational trails and park features

A review of existing parks, recreation, and open space plans from Lewis County, Centralia, and Chehalis was conducted to identify proposed projects or plans that could be included as part of the levee and conveyance recommendations currently under evaluation. Preliminary results included:

- Identification of any policy direction that informs connections to water through parks and trails.
- Identification and mapping of existing trails, recreation paths, and bicycle networks (including rail trails) within Lewis County, Centralia, Chehalis, and surrounding communities (as applicable).

Trails

The following projects could be included as part of the levee and conveyance recommendations. Many of these projects are built from planned projects identified within City and County Public Recreation and Open Space (PROS) plans. Project descriptions are the same as identified in local plans.

Nature trails within the City of Centralia

- **Chehalis River Trail:** The Chehalis River Trail is also referred to as Nature Trail A in the City's PROS plan. This trail interfaces with the Fort Borst Park to Galvin Road Levee. Possible opportunity for integration with Chehalis LAND infrastructure improvements: re-route a section of the Chehalis River Trail along the top of the levee to provide views and integrate the levee into the recreation infrastructure.
- **Old Sewer Treatment Trail:** The Old Sewer Treatment Trail is also referred to as Nature Trail B in the City's PROS plan. This trail runs within 1/4 mile of the China Creek Floodwall and new Mellon Street Bridge. Possible opportunity for integration with Chehalis LAND infrastructure improvements: study trail connection to and across the Mellon Street Bridge.
- **Hayes Lake Trail:** The Hayes Lake Trail is also referred to as Nature Trail C in the City's PROS plan. This trail runs within 1/4 mile of the Skookumchuck River levee (south bank). Possible opportunity for integration with Chehalis LAND infrastructure improvements: study whether multi-use trail circulation can be tied into possible Skookumchuck River levee trail to the south.
- **Skookumchuck River Trail:** The Skookumchuck River Trail is also referred to as Nature Trail D in the City's PROS plan. This trail interfaces with the Skookumchuck River levee (south bank and north bank). Possible opportunity for integration with Chehalis LAND infrastructure improvements: re-route sections of the Skookumchuck River Trail along the top of the proposed levees to provide views and integrate the levees into the recreation infrastructure.
- **China Creek Trail:** The China Creek Trail is also referred to as Nature Trail E in the City's PROS plan. This trail interfaces with the floodwall at China Creek. Possible opportunity for integration with Chehalis LAND infrastructure improvements: re-route the China Creek Trail along the daylighted portions of China Creek through Downtown Chehalis.

Urban trails in the City of Centralia

- **Harrison/Reynolds Urban Trail:** The Harrison/Reynolds Urban Trail is also referred to as Urban Trail G in the City's PROS plan. This trail interfaces with the Skookumchuck River levee (north bank). Possible opportunity for integration with Chehalis LAND infrastructure improvements: re-route a section of the Harrison/Reynolds Trail along the Skookumchuck River levee (north bank).

- **Westside Connector Urban Trail:** The Westside Connector Urban Trail is also referred to as Urban Trail H in the City’s PROS plan. This trail interfaces with the Skookumchuck River levee (north bank). Possible opportunity for integration with Chehalis LAND infrastructure improvements: connect to a portion of the Chehalis River Trail where it can be re-routed along the top of the Fort Borst Park to Galvin Road levee.
- **First Street Urban Trail:** The First Street Urban Trail is also referred to as Urban Trail X in the City’s PROS plan. This trail interfaces with the Skookumchuck River levee (south bank). Possible opportunity for integration with Chehalis LAND infrastructure improvements: connect to Skookumchuck River Trail where it may be re-routed along the proposed levee to the east of the West 1st Street and Harrison Avenue intersection.
- **Old Tacoma Trail Line – Rail to Trail:** This proposed trail runs through the City of Centralia and City of Chehalis and interfaces with the Newaukum Levee. Possible opportunity for integration with Chehalis LAND infrastructure improvements: form connections to the top of the Newaukum Levee for views into the surrounding wetland and Chehalis River.

Figure 34: Proposed levees connections to PROS Plan projects - North

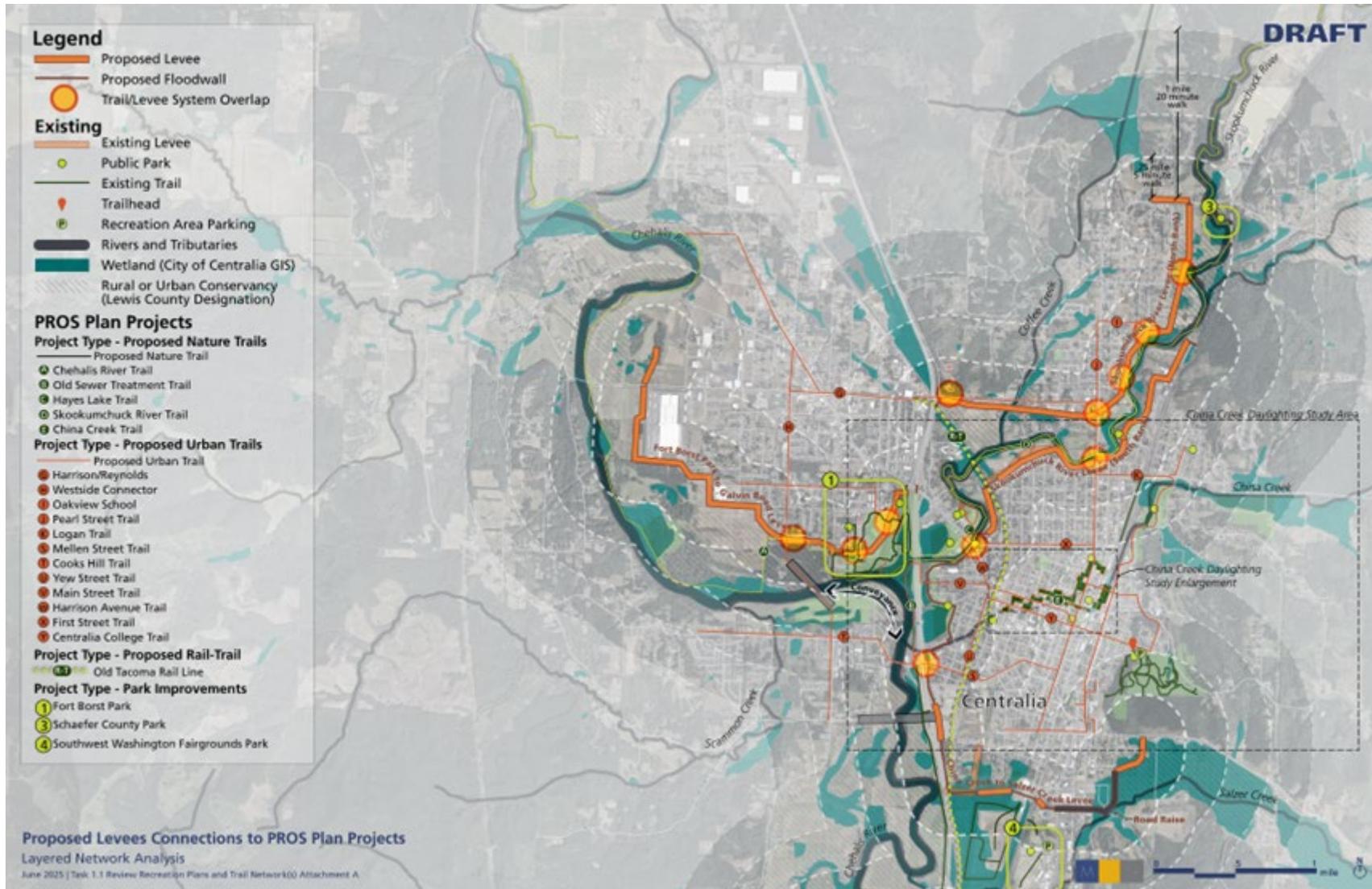
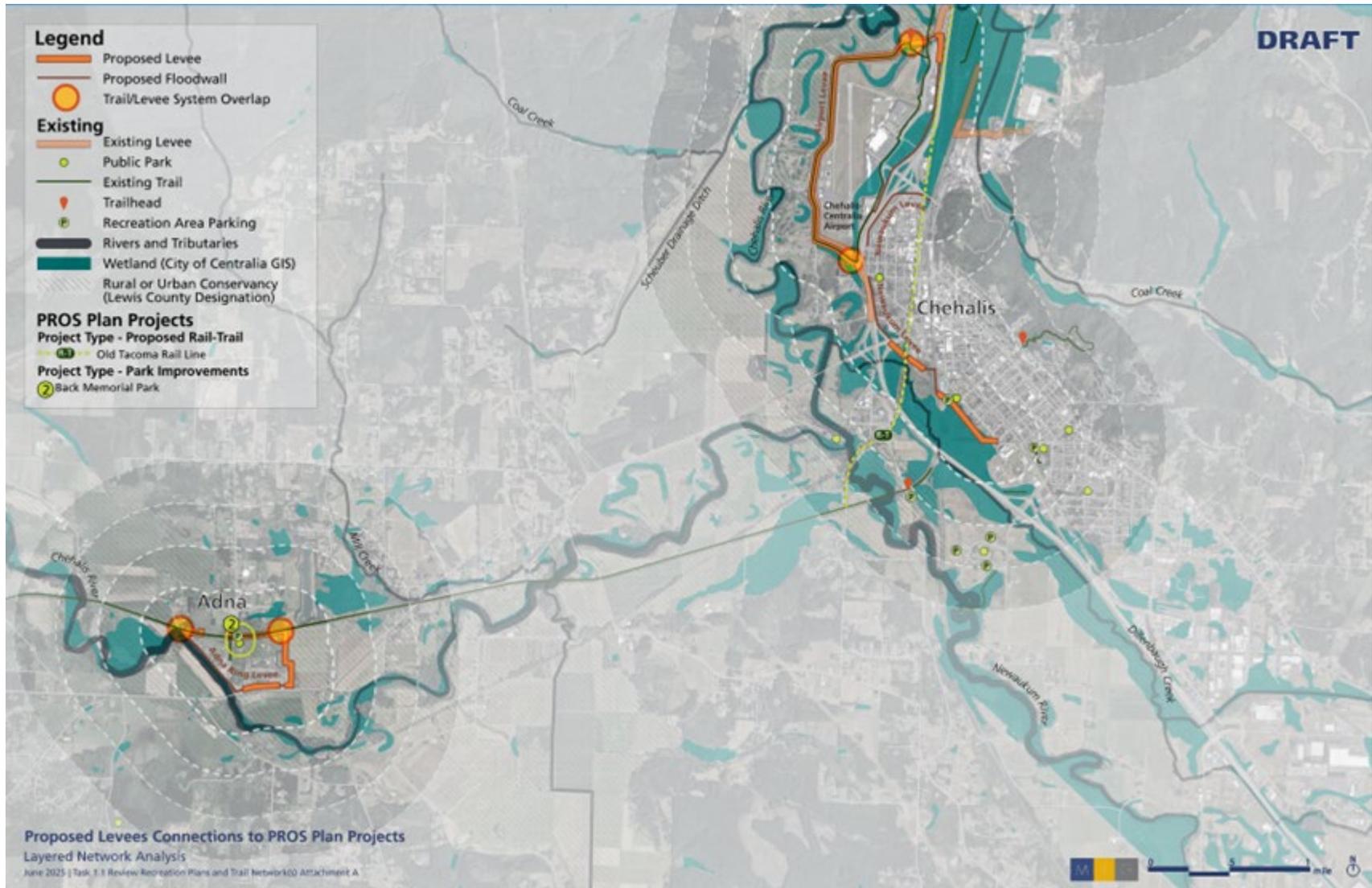


Figure 35: Proposed levees connections to PROS Plan projects - South



Potential park projects

Existing projects or plans that could be incorporated as part of the levee and conveyance recommendations are listed below.

- **Fort Borst Park:** Fort Borst Park is located north of the Chehalis River in the City of Centralia and is bisected by the Fort Borst Park to Galvin Road Levee. Possible opportunity for integration with Chehalis LAND infrastructure improvements: use levees to create an elevated trail system through Fort Borst Park. Terraced seating and spectator opportunities can be integrated into levee walls adjacent to sport courts.
- **Back Memorial Park:** Back Memorial Park is located next to the sport fields of Adna Middle/High School and adjacent to Washington State’s Willapa Hills Trail in the unincorporated community of Adna, Lewis County. Back Memorial Park is located within 1/4 mile of the Adna Levee. Possible opportunity for integration with Chehalis LAND infrastructure improvements: connect to Willapa Hills Trail along proposed levee route. Terraced seating and spectator opportunities can be integrated into levee walls adjacent to sport courts.
- **Schaefer County Park:** Schaefer County Park is located on Bucoda Highway/SR-507 one mile north of the City of Centralia on the Skookumchuck River. The City of Centralia and Lewis County both own adjacent lands, making it a good opportunity for multi-jurisdictional investment and collaboration. The Schaefer County Park is located within 1/4 mile of the Skookumchuck River levee (north bank). Possible opportunity for integration with Chehalis LAND infrastructure improvements: extend trail along SR-507 to connect to possible levee trail along the top of the Skookumchuck River levee (north bank).
- **Southwest Washington Fairgrounds Park:** Southwest Washington Fairgrounds Park is made up of five parcels consisting of 78.2 acres. It is located on Gold Street/National Avenue between Centralia and Chehalis and is within 0.5 miles of the proposed Airport and Salazer Creek Levees. Possible opportunity for integration with LAND infrastructure improvements: will depend on final China to Salzer levee alignment as determined in future phases.

Additional parks and recreation project opportunities

In addition to the projects outlined in the PROS plans that interface with the proposed infrastructure improvements, there are other opportunities for parks and recreation integration with the proposed levees.

- **River Walk Trail – 2022 Values Planning:** This trail opportunity came out of the public outreach undertaken as a part of the earlier work on Chehalis LAND alternatives in 2022.

The proposed trail would start at Borst Park and run north/south along the west side of the Chehalis River to the Newaukum River with a possible connection to the Willapa Hills Rail Trail.

- **Newaukum Levee Trail – Connecting Millet Field to Recreation Park:** The levee along the Newaukum River provides a unique opportunity for an elevated trail along the existing wetland. The trail could connect Millet Field, the Chehalis Avenue Apartments, and other nearby destinations to Recreation Park. Both ends of the levee meet existing grade, making this an ideal opportunity for an end-to-end trail connection.

Impacts on existing parks and recreation

The following existing trails will be impacted by the proposed levee alignment, and consideration should be given to maintain water access and recreation opportunities.

- **Willapa Hills Rail Trail – at the proposed Adna Levee:** The proposed Adna Levee runs along the existing Willapa Hills Nature Trail north of Adna, on either side of Dieckman Road. Possible opportunity for integration with LAND infrastructure improvements: the height of the elevated levee trail can provide an additional opportunity for views from the Rail Trail. Additionally, improvements to the Willapa Hills Trail could make use of the levee height to explore opportunities for a separated connection over Bunker Creek Road, similar to the Willapa Hills Trail bridge crossing State Route 6 to the east.
- **Airport Levee Trail – at the proposed Airport Levee Improvements:** The proposed Airport Levee runs along the existing Airport Levee Trail north, west, and south of the airport. Possible opportunity for integration with LAND infrastructure improvements: the height of the elevated levee trail can provide an additional opportunity for views from the trail. Levee construction should consider opportunities for improvements at the trailhead. Improvements could include ramps and stairs to reach the increased height of the new levee.

China Creek daylighting alternatives

China Creek currently runs through Downtown Centralia in a pipe, including under City Hall and several other buildings. Regular flooding has been a significant issue for the City of Centralia for many years along this waterway, prompting the City to develop a phased flood reduction plan upstream of Downtown. This project aligns with the phased projects the City has currently or will undertake in the future on China Creek and focuses on areas downstream of those projects to address continued flood issues along the stream.

In addition to flood damage reduction, daylighting China Creek also encourages adjacent water oriented development opportunities on vacant and underdeveloped properties. This project has the potential to create economic development opportunities both from recreation- and natural-based systems approaches.

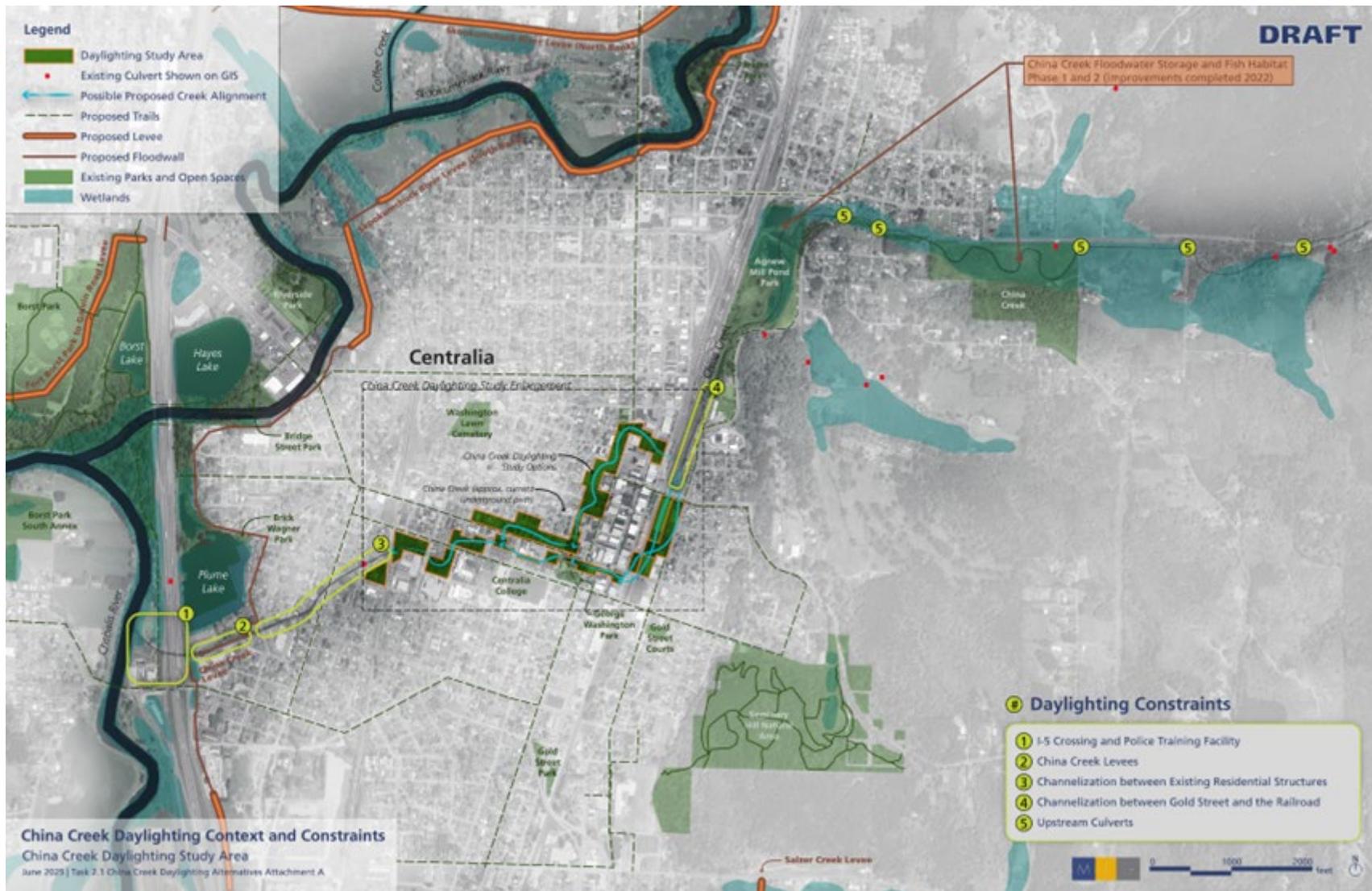
Note that the daylighting alternatives shown herein are conceptual and nature and will need additional analyses, numerical modeling, and cost analysis in future phases. Costs for daylighting are not included in the overall project costs herein. Refer to Appendix I for additional maps and information regarding the daylighting alternatives.

China Creek daylighting alternatives and outcomes

The daylighting alternatives address the length of China Creek generally between Agnew Mill Pond Park and the railroad tracks where China Creek is underground or daylighted and flows under or near buildings. These alternatives are broken into sections, which can be combined based on future property availability and community priorities.

Alternatives consider projects identified in the Centralia Parks Recreation and Open Spaces Plan to identify possible connections to existing and proposed recreation in the vicinity of China Creek. For all alternatives, mid-block crossings were prioritized to simplify the creation of road underpass construction and minimize utility disturbance. Additional studies would be required to identify the extent of areas needed to reduce flooding in adjacent areas.

Figure 36: China Creek daylighting context and constraints



Opportunities and issues

The China Creek daylighting concept would present several opportunities for Downtown Centralia. The project could also support flood mitigation and create educational and economic development opportunities. Considerations include land use, historic structures, trees, trails and recreation, and street-level access.

Estimated Project Cost Summary

Conceptual Class V level (AACE, 2020) costs were developed for the project components to aid OCB in future package development and expenditure planning related to construction of each component of the LAND Alternative. The cost estimate analysis was conducted using the unit costs and assumptions detailed in Appendix B and Appendix C. Capital, as well as operational and maintenance costs, were developed. Given the conceptual level of the alternatives analysis, low-, medium-, and high-level estimates were developed for each unit price item in the cost analysis. The major cost items considered include the following items:

- **(1) Planning Engineering Design (PED) and Environmental:** Includes estimated labor to conduct investigations, additional engineering and design, engineering management during planning, and construction management services. Environmental costs include environmental mitigation and regulatory and permitting efforts. These costs are based on historical USACE levee projects and feasibility-level guidance provided by NLSP, 2023 and by flood protection projects conducted on the west coast of the United States (USACE, 2014 and Parsons Brinkerhoff, 2011). A full cost estimate of future planning, engineering, and environmental analyses should be conducted in future phases to refine these costs.
- **(2) Mobilization and Demobilization:** Includes efforts by the construction contractor to conduct preparatory activities to transport equipment, personnel, and materials to the project site including setting up temporary facilities. Demobilization generally includes removal of equipment, personnel, site restoration, punch-list items, and final documentation.
- **(3) Levees:** Levee costs include the labor, material, and equipment for the capital construction of the levees. The per cubic yard unit costs are based on similar earthwork projects in the area. Quantity estimates were developed based on the required height of each levee segment, given 3 feet of freeboard. Additional refinement of the construction unit costs should be conducted in future phases, including investigating value engineering opportunities such as reuse of the excavated conveyance material.
- **(4) Floodwalls:** Floodwall costs include all labor, material, and equipment for capital construction of the floodwalls. The per linear foot unit costs are based on sheetpile projects in the project area and guidance provided by NLSP, 2023. As discussed in the Basis of Analysis and Key Assumptions section, small- and medium-sized floodwalls (0-12 feet) are assumed to be sheetpile I-walls with a concrete cap, and larger floodwalls (greater than 12 feet) are assumed to be concrete T-walls. As noted earlier, this assumption should be refined in future phases once more site-specific geotechnical data is available.

- **(5) Road Raise:** Selected road raises are included as part of the project. Unit costs per linear foot of road raise were developed using WSDOT unit bid prices. The design assumes use of asphalt, with base and top course and subgrade fill.
- **(6) Closure Structures:** The cost of closure structures will vary based on the assumed 3 feet of freeboard above the design flood event, the number of locations at railroad and roadway crossings where they are deemed necessary, geotechnical conditions, and the type of structure selected (swing gates or rolling gates). The high end of the potential unit costs is for areas of poor geotechnical conditions, and additional geotechnical analysis and surveys should be conducted in future phases to refine these costs.
- **(7) Interior Drainage:** Includes the number and capacity of pump stations needed, determined by a screening-level interior drainage analysis using analytical equations and existing data. The assessment conducted during this phase assumes the pump stations will cover the full peak flow volume of the interior watersheds and does not include existing drainage infrastructure, re-routing of interior drainage, upriver improvements, or other measures to reduce the peak runoff. As mentioned previously, routing interior drainage and/or daylighting of China Creek is not included in these costs. Instead, the pump station costs include pumping the peak flowrate of China Creek and interior drainage to Centralia. Combinations of upstream storage and other flow routing would reduce overall pump costs assumed herein. Future phases should conduct additional internal drainage analyses and numerical modeling that incorporates the existing drainage infrastructure within the levees to site the pump stations. Additionally, upriver improvements like weirs and detention ponds should be investigated and included in the analysis to reduce the potential size of the pump stations.
- **(8) Real Estate:** Real estate costs include the following:
 - *ROW Real Estate Compensation (Levee, Floodwall, Road Raise):* Estimated cost for compensating landowners for the ROW acreage needed to construct the levees, floodwalls, and road raises. Note that this is for land compensation only, and that relocations are addressed separately for structures within the ROW that need to be relocated, summarized in the bullet below.
 - *Relocations (within Levee, Floodwall, Road Raise ROW):* Estimated cost for compensating landowners for structures that fall within the levees, floodwalls, and road raises ROW footprint and require relocation. Unit costs are based on the assessed value of the individual properties plus escalation.
 - *Adjacent Structures – Floodproofing, Raises, Relocations:* Estimated cost for raising, floodproofing, or buying out and relocating residents for all structures that are outside of the protected area of the LAND Alternative and are inundated under the

design storm event. This category considers structures within approximately 0.5 miles of the levee centerline (See Figure 33 for a breakdown of adjacent structures).

- *Incremental Impacts to Structures Outside Levees:* Estimated cost for raising, floodproofing, or buying out and relocating residents for all structures that are impacted by increased water levels due to the project. Outside of the levee boundaries, any residential or commercial property that is deemed valuable in the Anchor 2024 database and is adversely affected by the alternative (i.e., water level is raised at the property due to the LAND Alternative) will be assessed for the incremental cost of structural raises and floodproofing. The LAND project cost analysis assumes that the incremental difference in cost between the without project and with-project conditions will be included in the overall project cost estimates.
- *Utility Relocation:* Estimated cost for activities related to the relocation of existing utilities (gas, water, sewer, etc.) within the levee project. Project-specific relocation costs were not calculated for this project, and an estimated cost of 4 percent of the total construction cost was considered, based on historical USACE levee projects and feasibility-level guidance provided by NLSP, 2023. Project-specific utility relocations using local county and city data should be investigated in future phases to refine these estimates.
- **(9) Conveyance Improvements:** The conveyance improvements include excavating for the conveyance footprint and acquiring the necessary real estate within the footprint. They also include estimated costs for demolishing the existing Mellen Street Bridge and constructing a new concrete girder Mellen Street Bridge.
- **(10) Operations and Maintenance (O&M):** Assumed yearly rolled-up O&M costs for flood protection features are primarily based on a percentage of the project capital construction costs, varying by component, with specific activities like levee inspections or floodwall maintenance included. General O&M, covering staffing and overhead, is calculated as a percentage of the capital cost for levees, floodwalls, and closure structures, while pump station O&M has a separate capital cost percentage assumption. Environmental O&M for habitat monitoring and mitigation areas is assumed as a percentage of capital environmental construction costs, with specifics determined by permitting. See Appendix B and Appendix C for a summary of the estimated O&M costs.

A key guiding principle is the ability to implement the LAND project all at once or in phases. As discussed earlier in the Concept Screening Analysis section, a phasing scenario was investigated using preliminary hydraulic modeling to assess feasibility. The modeling showed that phasing of the LAND elements was feasible. The potential phasing that was investigated is shown in Table

2. It should be noted that different phasing scenarios could be implemented depending on community preferences, analysis conducted in future phases, or other considerations.

The estimated capital construction cost ranges for the individual project elements are shown below in Table 2. The total phase costs and number of structures protected by each phase are shown in Table 3. For additional details on quantities, unit costs, and other assumptions used in the cost estimate development see Appendix B and Appendix C. Note that these costs do not include costs associated with mitigating incremental impacts on structures outside levees. If the full LAND (i.e., all three phases) is constructed, this should be included in Phase 1. See Appendix C for additional costs associated with mitigating the incremental structure impacts outside of the levees.

Table 2: Range of estimated costs for project elements, including contingency, compared with number of structures protected. Estimated cost ranges for each project component include mobilization and demobilization, PED and environmental, and utility relocation

Potential Phase	Project Component	Estimated Cost Range [Low-High, \$M]	Number of Inundated Structures Protected	Percent Public Land [%]
Phase 1	(4) China to Salzer	\$130M-\$260M	587	60%
Phase 1	(6) South Skookumchuck	\$110M-\$180M	748	28%
Phase 1	(7) North Skookumchuck	\$50M-\$100M	196	10%
Phase 1	(11) Conveyance and Bridges	\$150-\$240M	--	7%
Phase 2	(8) West Skookumchuck	\$20M-\$50M	N/A	100%
Phase 2	(9) Fort Borst	\$40M-\$80M	213	50%
Phase 3	(3) Airport	\$180M-\$320M	28	80%
Phase 3	(2) Newaukum	\$100M-\$190M	155	60%
Phase 3	(1) Adna	\$30M-\$60M	38	75%

Table 3: Summary of the estimated range of estimated costs for each potential project phase, as well as the total number of previously inundated structures protected by phase

Potential Phase	Potential Phase Cost [Low-High, \$M]	Number of Inundated Structures Protected by Phase
Phase 1	\$440M-\$770M	1,531
Phase 2	\$60M-\$130M	213
Phase 3	\$310M-\$570M	221

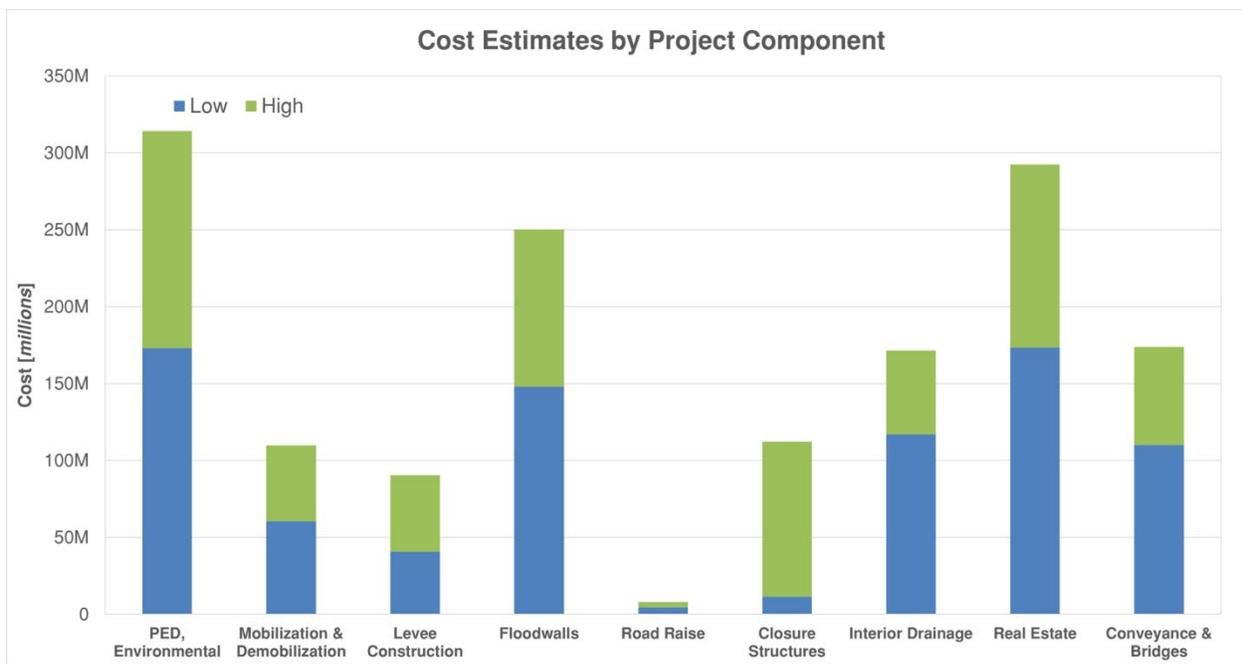
The cost estimate ranges provided in Table 2 indicate the high and low total costs including contingency, rounded to nearest \$10 million. Note that, given the preliminary nature of the

project designs, changes to these estimated costs may occur as additional data is available and the designs are progressed.

The total estimated capital construction costs, including all project components, are summarized in Figure 37. The total estimated project cost, broken down by major cost items, includes contingency. Note that this figure assumes all project components are constructed at the same time. The blue bar represents the low end of the cost estimate, while the green shows the high end of the cost estimate. The total estimated range of capital construction costs, rounded to the nearest \$50 million, is between \$850 million to \$1.5 billion.

Figure 37: Total estimated project cost, broken down by major cost items.

Blue shows the low end of cost estimate (\$850M). Green shows the high end of cost estimate (\$1.5B)



Conclusions

This section summarizes key findings and conclusions from the LAND alternatives analysis. The key findings are separated into technical observations, based on the engineering analysis performed, and into qualitative findings and recommendations based on Partner, Tribal, and OCB coordination.

Technical findings

- **Overall:** The LAND Alternative provides substantial flood hazard reduction for the Chehalis Basin that are in alignment with the guiding principles outlined in this study.
- **Diversion:** After evaluating cost-benefit analysis, Partner input, and environmental impact, the diversion option was deemed nonviable and removed from the conceptual design.
- **Phasing:** The phasing of the LAND alternatives appears to be feasible and will play a critical role in shaping implementation strategies. Further analysis of various phasing scenarios is necessary in future phases, but preliminary phased modeling has revealed the following key insights:
 - The conveyance should be constructed concurrently with the North and South Skookumchuck and China to Salzer systems to meet the guiding principles. Other flood protection systems may be constructed as future analyses and Partner coordination dictate.
 - Similarly, early construction of the conveyance may allow for the excavated material to be reused in construction of the levees, pending future geotechnical investigations.
 - The project features can be phased to align with funding, permitting, and community readiness.
- **Downstream Changes:** The hydrodynamic changes downstream are relatively low. Although the extent, size, and magnitude of the flood protection improvements make it challenging to show no changes in water levels and hydrodynamics, it has been demonstrated that such changes can be small and effectively minimized.

Qualitative findings based on Partner, Tribal, and OCB coordination

- **Community Lifelines and Emergency Bypass:** Emergency vehicle bypasses could be implemented with the LAND Alternative to improve flood resiliency and connectivity to

community lifelines, such as hospitals or other emergency services, during flood events. See the main report for more information on the community lifeline analysis.

- **Partner and Tribal Coordination:** Continued coordination and collaboration with Partners, Tribes, and government agencies on a more refined basis during the next phase of implementation to advance the LAND project design is critical.
- **Recreation:** Flood protection infrastructure could align well with planned City parks and recreation trail programs and provide opportunities for integration and multifunctional use of the proposed levees included in this phase of the LAND plan.
- **Infrastructure Planning:** This phase of LAND showed the importance of connected thinking for infrastructure improvements and a need to coordinate planned improvements with other government agencies such as WSDOT and local municipalities to help in connectivity of various efforts within the basin.
- **Floodplain Management:** Without coordinated land use and development coordination, the LAND flood protection systems could become less effective, especially if development continually occurs outside of the protected areas of the LAND project elements. Sound floodplain management policy will help align infrastructure investments such as LAND with long-term resilience in the basin. This illustrates the importance of floodplain management policy on the feasibility of the LAND Alternative to meet the guiding principles and corresponding costs for implementation.
- **Room for the River Design Philosophy:** Flood protection strategies must balance the principles of "room for the river" and hydraulic efficiency with the need to safeguard homes and commercial structures. A best-value approach should integrate both concepts to ensure effective and sustainable implementation of LAND alternatives.

Recommendations

Recommended next steps to refine the conceptual-level LAND Alternative and progress towards final design and construction are identified in this section. The Chehalis Basin Board is currently deliberating between several long-term options for reducing flood damage in the Chehalis Basin. All of these recommendations assume the Board will support continuing with the LAND, which may or may not be the outcome of their deliberation. The next steps were identified by the project team, incorporating input from OCB and project Partners. Next steps necessary to refine the feasibility-level alternatives developed here and progress towards final design and construction are identified as follows:

- **Overall Long-Term Goal:** Progress LAND towards a final design package in coordination with Partners, Tribes, OCB Board members, and the community. The advancement of the design should include a formal risk register and contingency analysis, schedule and construction duration analysis, additional engineering analysis using refined numerical models, and geotechnical investigations.
- **Community and Partner Engagement:** Continue Partner and community outreach to refine the plan. Coordinate with WSDOT and BNSF on planned improvements to gather further input to aid in the design refinement. Additionally, coordination of planned improvements should be conducted to integrate LAND with other jurisdictions planned improvements (such as Pearl Street Bridge, Railroad Crossings, any China Creek Improvements, etc.).
- **Geotechnical Investigations:** Conduct Geotechnical Investigations as part of the next step of design to inform design, cost, reuse of material. Geotechnical investigations will also help refine the design and type of flood protection features, including further refinement of applicable elevation limits for the different floodwall types.
- **Connect Strategies in the Basin:** Connectivity of the LAND with FRE and other basin projects including the ASRP, to aid in the development of coordinated and integrated strategies. The LAND Alternative should be aligned and coordinated with the ASRP already developed by OCB (OCB, 2019).
- **Skookumchuck Dam:** Modifications to Skookumchuck Dam flow regime could have a change in the size of the flood protection infrastructure requirements in Centralia to meet the guiding principles and project criteria. Potential modifications to the Skookumchuck Dam operations relative to the LAND Alternative should be coordinated with future phases of the LAND study.
- **Refine Numerical Modeling:** Numerical modeling should be refined to incorporate the latest science, topography, and flowrates in the project area to align with other studies

in the basin and progress the project design. Additionally, interior drainage modeling should be conducted to further refine the feasibility-level assumptions in this study, analyzing individual sub-basins and developing upstream flood reduction strategies for China Creek and Coffee Creek. Finally, modeling and investigation of the project performance under lower return period, more frequent events should be conducted.

- **Investigate Floodplain Restoration:** The large flows of the design event reduce the effectiveness of floodplain restoration at reducing flows during such large extremal events. However, as part of future phases of the LAND study, it is recommended to investigate opportunities for off channel storage and floodplain restoration to reduce impacts during lower return period events such as oxbow engagement, etc.
- **Adaptation:** Further investigation and future studies are required to evaluate how the alternatives can adapt to potential future changes in floodwater levels due to climate change or other causes of increased water levels. Adaptation measures should be assessed both at the specific project site level and from a basin-wide perspective. Future evaluations should also consider phased implementation of the solutions themselves, accounting for changes in flood risk over time. In particular, evaluations should investigate project performance under larger, less frequent storms such as the 500-year flood event. Project elements could be designed with adaptability in mind, allowing for modifications in response to evolving conditions. While this approach may involve additional upfront costs, it would provide greater flexibility and resilience for future needs.

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Glossary, Acronyms, and Abbreviations

Glossary

Riparian: Relating to the banks along a natural course of water

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, and playfields, and from gravel roads and parking lots.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Acronyms and abbreviations

ASRP	Aquatic Species Restoration Plan
BOA	Basis of Analysis
CLS	Chehalis-Centralia Airport
EIS	Environmental Impact Statement
FRE	Flood Retention Facility Expandable
HBE	Historic Built Environment
HEC-RAS	Hydrologic Engineering Centers River Analysis System
I-5	Interstate 5
LAND	Local Actions Non-Dam
LiDAR	Light Detection and Ranging
NEPA	National Environmental Policy Act
O&M	Operations and Maintenance
OCB	Office of Chehalis Basin
PEIS	Programmatic Environmental Impact Statement
PROS	Public Recreation and Open Space
SEPA	State Environmental Policy Act
SR-507	Pearl Street
USGS	United States Geological Survey
WSDOT	Washington State Department of Transportation
WSE	Watershed Science and Engineering

Units of Measurement

CY – Cubic Yards

FT – Feet

Appendices

Appendix A – Maps Packet and Supplementary Analysis Results

Appendix B – Basis of Analysis Results

Appendix C – Cost Tables

Appendix D – Numerical Modeling Summary

Appendix D.1.1 – Screening Level Model Results

Appendix D.1.2 – 1D Modeling

Appendix D.2.1 – 2D Numerical Modeling Results

Appendix D.2.2 – Annex A Maps and Timeseries

Appendix E – Geotechnical Report

Appendix E.1 – Geotechnical Appendices

Appendix F – Environmental Analysis Memo

Appendix G – Transportation Impacts and Opportunities

Appendix H – Trails and Parks

Appendix H.1 – Trails and Parks Appendices

Appendix I – China Creek Daylighting

Appendix I.1 – China Creek Daylighting Appendices