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Appendix D.2 - 2D Numerical Model Results Discussion

To:	Office of Chehalis Basin (OCB)
From:	Moffatt & Nichol (MN)
Date:	6/10/2025
Subject:	2D Hydraulic Modeling to Conceptual Design
M&N Job No.:	232215

Background

Two Dimensional (2D) numerical modeling was conducted to inform the conceptual design of the flood protection features, analyze downstream impacts, quantify changes in water level, and qualitatively identify potential areas of morphological risk from numerical model velocity results. This document summarizes the conceptual level modeling that was conducted to help refine the project features.

Objective & Approach

Screening level modeling was conducted to refine the alternative alignments and assess the relative effectiveness of the different project components. Following the screening process, detailed 2D hydraulic modeling was conducted using the RiverFLOW2D model (as developed in OCB, 2024). RiverFLOW2D is a two-dimensional combined finite volume hydraulic model that simulates riverine and floodplain interactions, 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 model tributaries were forced with the design event flowrates, corresponding to the 100yr + 26% event. The results of the model were used to perform the following analyses:

- Evaluate water level changes from the without project condition, including downstream areas and along key transportation routes.

- Qualitatively evaluate potential morphological risk areas from the without project condition using the modeled velocities,
- Determine the required height of each section of levee, floodwall, or road raise assuming 3-feet of freeboard. The results of this analysis are used as inputs into the cost model. See Appendix C for the results of the costing analysis.
- Determine the required residential or commercial structure floodproofing, raising, or relocations assuming 1-foot of freeboard (based on finished floor levels in Anchor, 2024). The results of this analysis are used as inputs into the cost model. See Appendix C for the results of the costing analysis.

Model Results

The following subsections provide high level takeaways from the numerical model analyses. See Annex A for plots showing model results including timeseries extracted from the model. The peak modeled water depth and velocity in the project area are shown below in Figure 1.

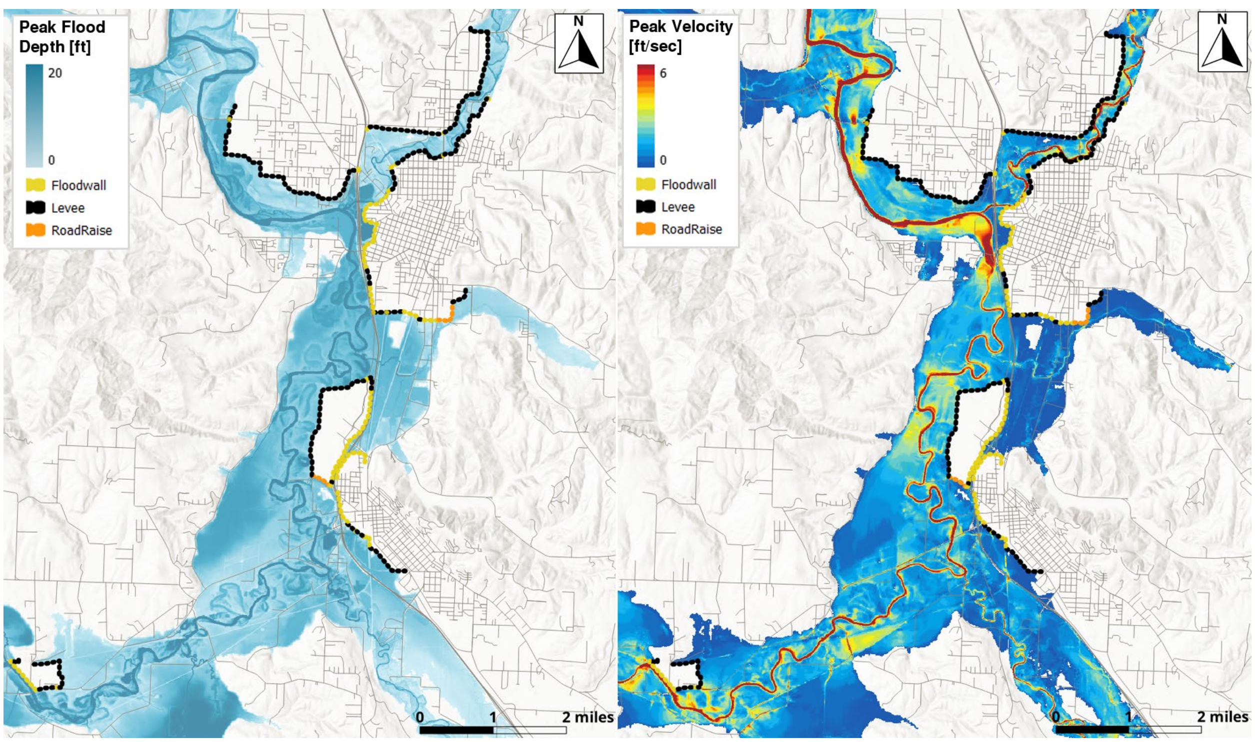

Figure 1. Peak water depth (left) and velocity (right) for the with-project (LAND) 100yr+26% numerical model results.

Water Level Changes

Modeled water level changes were analyzed in the project area and downstream of the project area to identify areas of change and potential impact. The water level changes from the without project condition in the project area are shown below in Figure 2. Similarly, the downstream water level changes from the without project condition are shown in Figure 3.

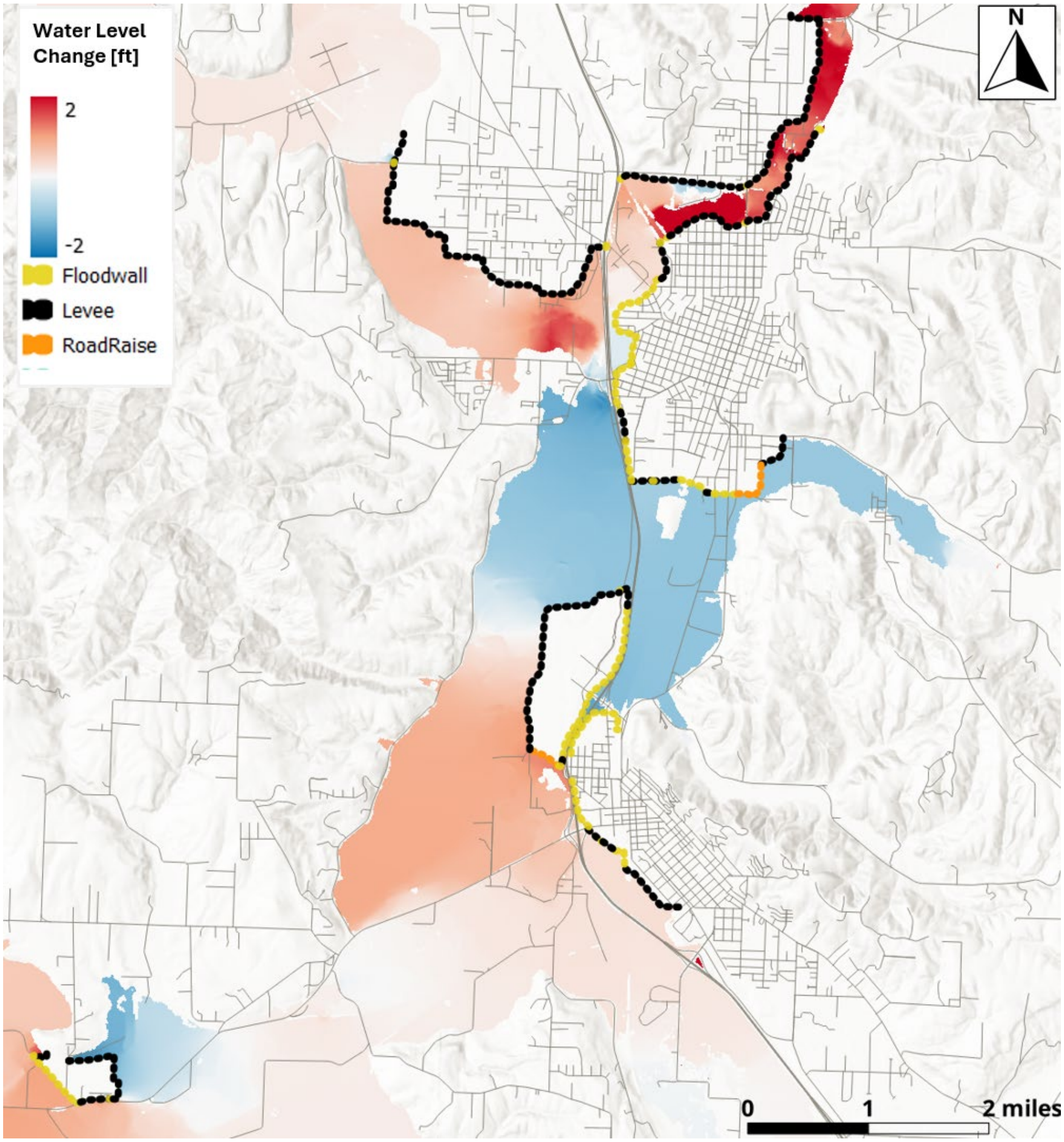

Figure 2. Water level changes from the without project condition. Blue areas represent areas of water level decrease, red areas represent areas of water level increase.

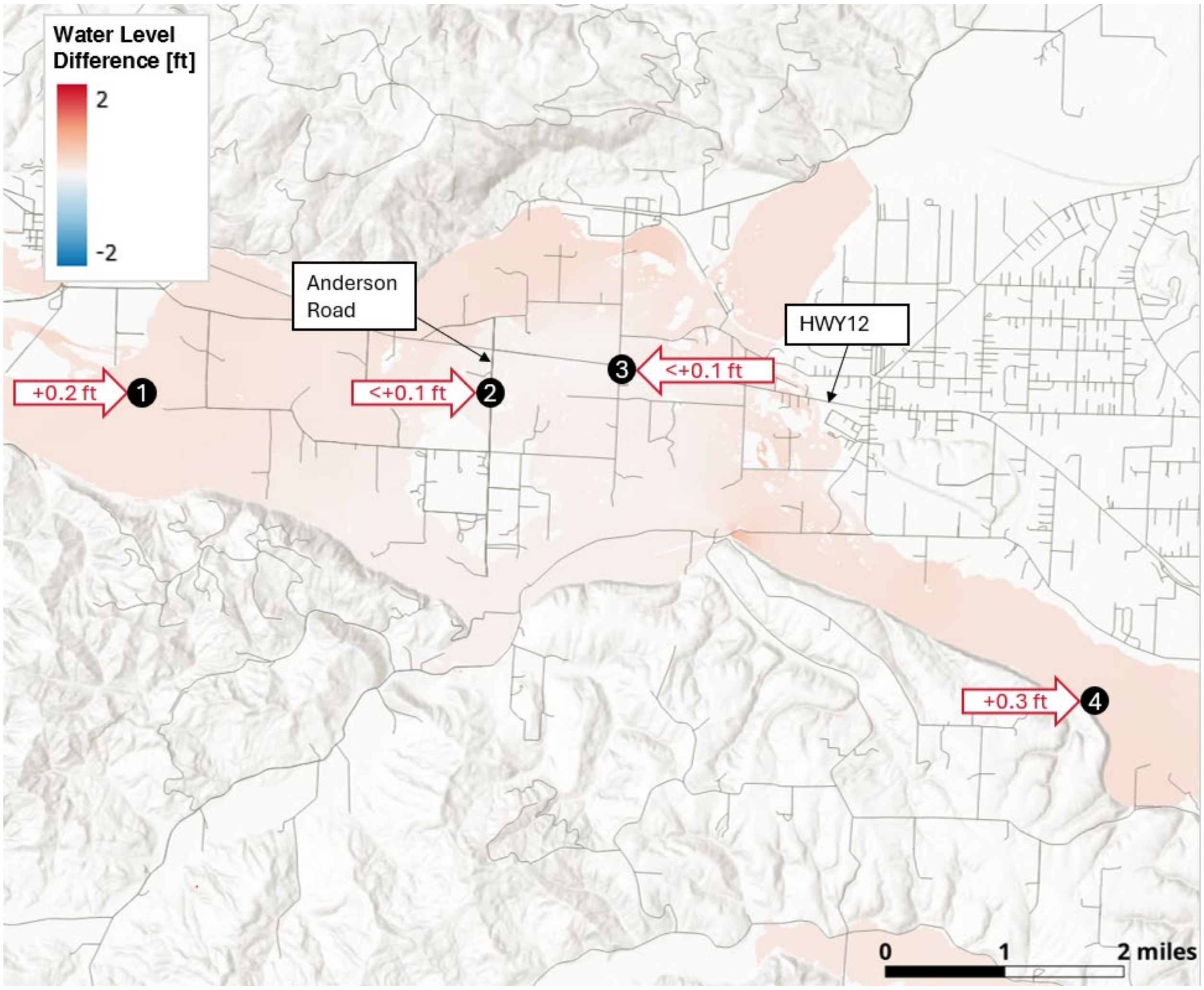

Figure 3. Water level changes from the without project condition downstream of the project area. Blue areas represent areas of water level decrease; red areas represent areas of water level increase. Numbered callouts show change at key areas including: (1) Black River Confluence, (2) Anderson Road, (3) HWY 12, and (4) Main stem of the Chehalis River.

Key notes from the water level change analysis are as follows:

- **Downstream Changes**: Downstream changes in water level for the design condition are generally low, less than 0.3 ft increase form the without project condition. Further downstream than the area shown in Figure 3, water levels are generally similar and/or slightly less than those shown in Figure 3.
- **Project Area Changes**: The most significant water level increases occur between the North and South Skookumchuck levees, which is expected due to the levees' proximity 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.

- **Incorporation into Cost Model**: The modeled peak water levels with LAND in place were used to determine the structure heights (with 3' freeboard) and residential/commercial building improvements (with 1' freeboard). See Appendix B and Appendix C for additional information on the cost model inputs and results.

- **Note on Model Inputs**: The model used the 100yr +26% conditions. Note that one scenario was modeled and different rainfall distribution patterns and resulting flowrates could result in different peak water levels than those shown in this Appendix. Additionally, more frequent, lower return period flowrates were not investigated. Similarly, changes to the Skookumchuck Dam operations were not incorporated. Therefore, additional modeling is recommended in future phases to analyze the project impacts under storm events that were not included in this phases analysis.

Qualitative Morphological Risk

Modeled changes in peak velocity were analyzed in the project area and downstream of the project area to identify areas of change and potential impact. The velocity changes from the without project condition in the project area are shown below in Figure 4.

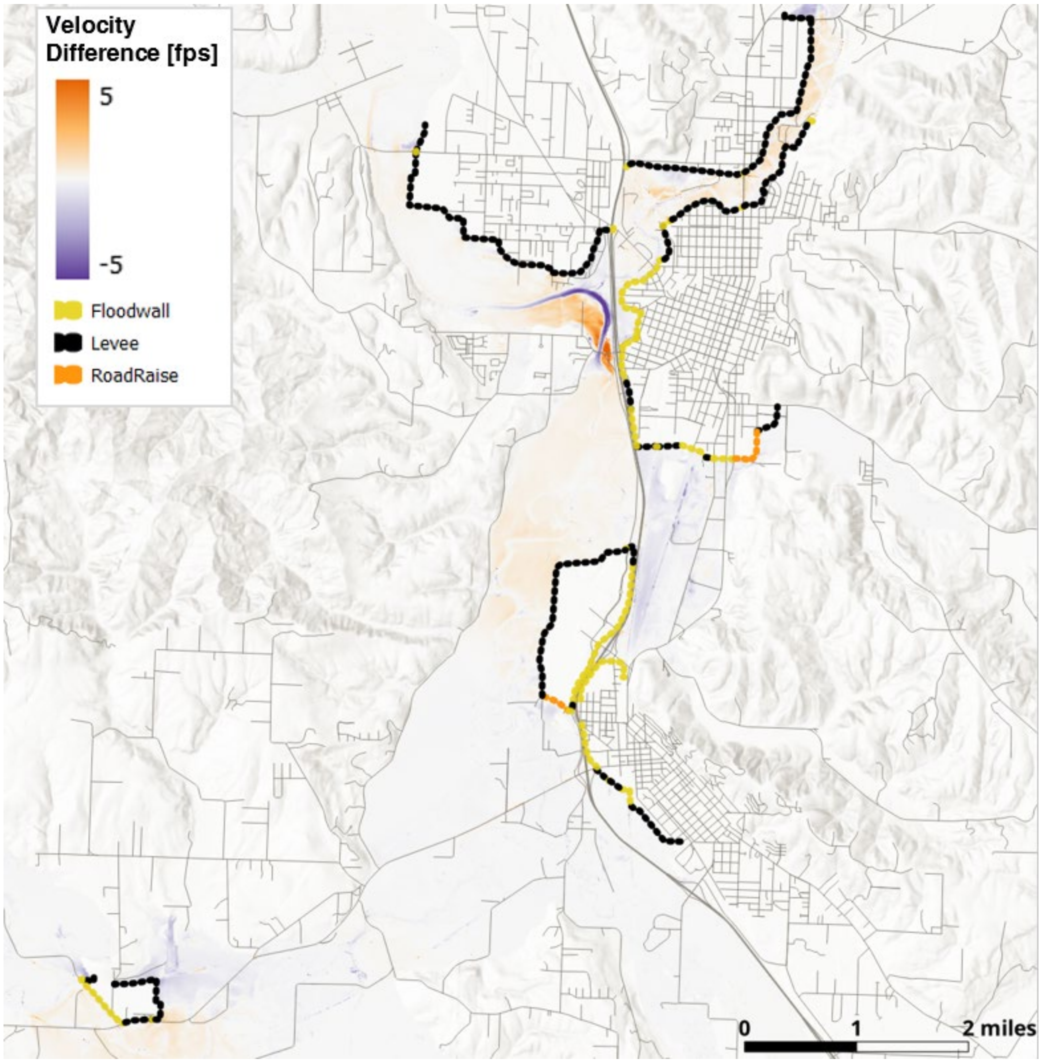

Figure 4*.* Change in velocity from the without project condition.

The modeled velocity change results were used to qualitatively assess the potential change in morphology of the area. Areas were grouped into Low, Medium, and High-risk areas based on the change in velocity with LAND to the without project condition. The resulting morphological risk analysis results in the project area are shown below in Figure 5.

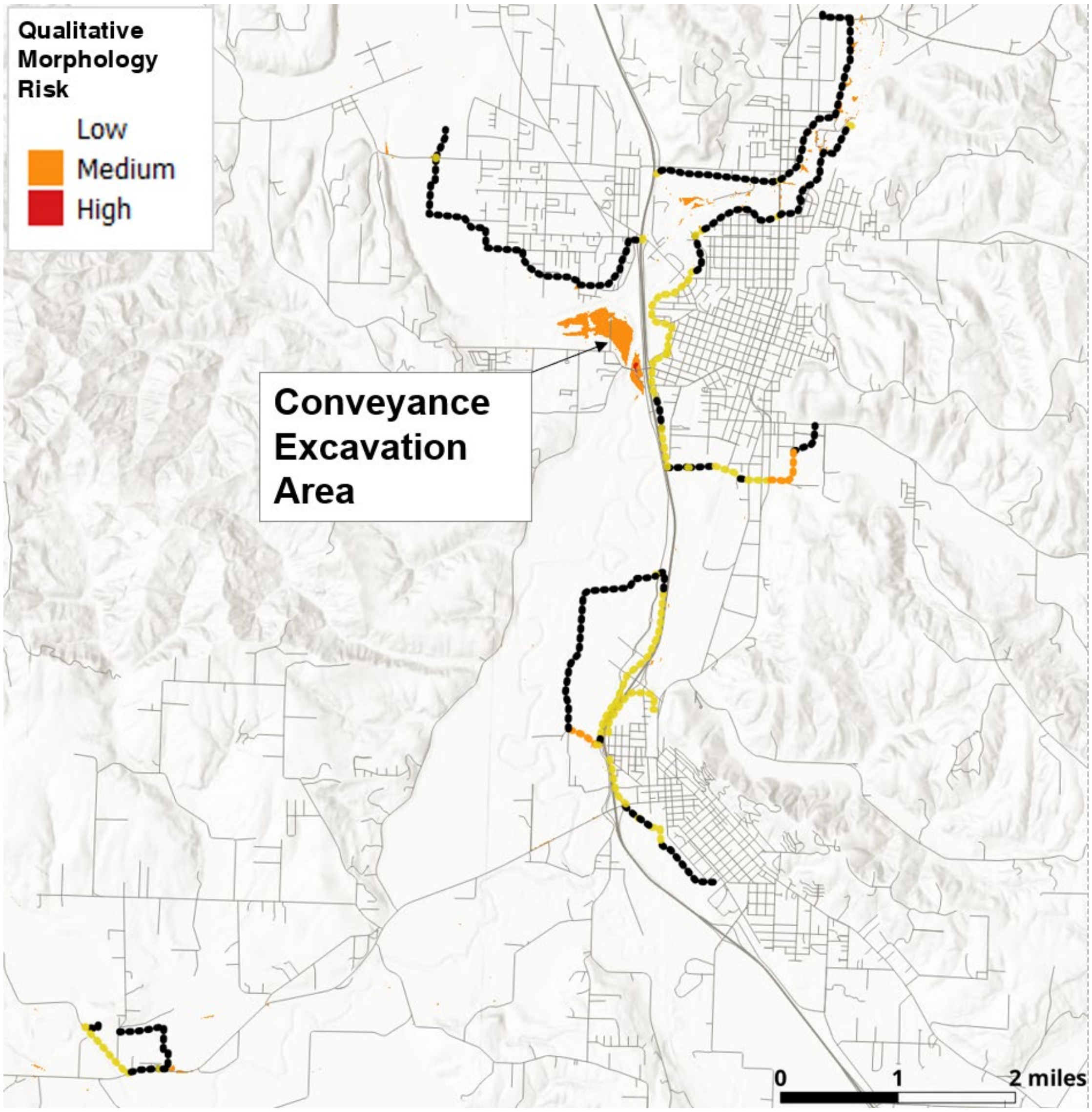

Figure 5*.* Qualitative morphological risk analysis in the project area.

Key notes from the qualitative morphological risk analysis are as follows:

- Conveyance Area: The largest increases in velocity from the without-project conditions occur within the conveyance excavation area. This outcome is expected, as the increased conveyance capacity allows water to flow more rapidly downstream in this section. The associated risks in this area are considered medium and should be thoroughly evaluated in future phases. If the increased velocities necessitate stabilization measures, nature-based shoreline stabilization techniques such as vegetative plantings, engineered log jams, or other eco-based solutions could be explored. These techniques offer can help mitigate erosion while enhancing habitat quality.

- Skookumchuck Area: The area between the Skookumchuck levees show isolated areas where the morphological risk is categorized as medium. This is likely due to the closer proximity of the levees to the existing river in this area when compared to other areas in the project. In general, levees were set-back from the river, but the proximity of existing infrastructure in this area required the levees to be closer to the river than other areas. Similar stabilization measures to those discussed in the conveyance area section could be employed if needed in future phases.

- Note on Morphology: The model used the 100yr +26% conditions. As noted in the water level change section, variations in rainfall distribution and resulting flow rates could produce peak velocities that differ from those presented in this appendix. Additionally, lower return period events, which occur more frequently, can significantly influence river morphology. To account for these effects, a quantitative morphological analysis considering lower return period events should be undertaken in future phases.

References

Anchor QEA, 2024. *Structure Database and Finished Floor Elevations – 2024*. Prepared for Office of Chehalis Basin. *et Sound LiDAR Consortium (PSLC) Topographic LiDAR: Chehalis River Watershed Area, Washington*. Accessed 5/29/2024.

Office of Chehalis Basin (OCB), 2024. *Chehalis Basin LAND: Local Actions Non-Dam Alternative*.

Annex A – 2D Model Results: Maps & Timeseries