Preliminary Design Report
PROJECT: 15-1231 RST, MASHEL EATONVILLE RESTORATION PHASE III
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Preliminary Design Alternatives
Building on the 2009 design iteration, Herrera developed two preliminary design alternatives to qualitatively assess and compare 1) their improvement on current in-channel and off-channel habitat conditions and geomorphic processes that create and sustain habitat, 2) their impact (if any) on current flooding conditions and on the existing landslide, and 3) their implementation complexity. Alternative 1 included the minimum number of baseline design elements (DEs) Herrera felt were needed to meet the project's habitat improvement objectives while not increasing the potential for bank erosion along the landslide toe nor increasing flooding of adjacent private property that is not owned by the Nisqually Land Trust (NLT). Alternative 2 included additional DEs Herrera felt were needed to maximize habitat improvements and that could be added to Alternative 1 and still meet said requirements of not increasing the risk of landslide activity or flooding of adjacent private property.

Alternatives 1 and 2 are shown collectively in the "Mashel River Reach 7 Alternative 2 Water Surface Elevation (WSE) Differences for 100-year Flood Event". Alternative 1 DEs are colored orange. Alternative 2 DEs added to Alternative 1 are colored blue so that Alternative 2 includes both the blue and orange colored DEs.

The DEs included in both alternatives include large bank engineered logjams (ELJs) built into the left and right banks of the river(s), large apex (mid-channel) ELJs, removal of bank armoring (riprap) at the Little Mashel and mainstem Mashel River confluence, pilot side channel construction, floodplain roughening of the left bank floodplain at the confluence, a flood containment berm along the Tweet-NLT property boundary, and small and medium habitat structures.

In addition to helping to deflect flows towards a particular location, the large bank and apex ELJs and smaller LWD structures will provide large scale hydraulic roughness during large flows to help slow flow velocities and promote sediment sorting and deposition of gravel, which is sorely needed in the project reach. They will provide habitat by virtue of their architectural complexity and influence on local hydraulics (e.g., scour pool formation) and they will accumulate flood borne wood debris to help replace any small wood debris that is lost over time. Pilot side channels will be 10 foot wide at the bottom with 1H:1V banks and will be graded to be active during the mean annual flow. Making them 10 feet wide will allow them to convey adequate flows initially while allowing them to adjust naturally to flow, and it will reduce construction impacts and costs. Removing the rock armoring at the confluence will allow much more flow onto the NLT, Tweet and Raymer properties during large flow events, so a flood containment berm is needed to maintain existing flood flow patterns on the Tweet and Raymer properties. Floodplain roughening (if deemed necessary based on the results of the hydraulic modeling) on the NLT property near the Tweet property boundary will discourage channel development into the Tweet property while still allowing natural channel migration into the left bank. Floodplain roughening (if needed) will include dense installation of 2 to 4 inch diameter cottonwood live-stakes (poles) and a few small LWD clusters placed on the floodplain surface and partially embedded into the soil.

Starting at the upstream end of the project reach, Alternative 1 includes the following DEs:

1. DE 1: A left bank ELJ to help deflect flows into the downstream right bank ELJ.

2. DE 2: A right bank ELJ to help deflect flows into the new left bank side channel.

3. DE 3: A left bank side channel extending to the Little Mashel River.

4. DE 16: A left bank ELJ along the Little Mashel to provide additional large scale hydraulic roughness.

5. DE 18: Removal of the bank armoring rock along the left bank at the confluence.

6. DE 14: A flood containment berm along the Tweet-NLT property boundary.

7. DE 15: Floodplain roughening in the hydraulic shadow of the left bank ELJ on the Little Mashel River.

8. DE 7: An apex ELJ in the middle of the mainstem Mashel River just downstream of the confluence to help deflect flows into the right bank floodplain and abandoned mainstem meander.

9. DE 12: A right bank ELJ at the downstream end of the right bank abandoned meander to provide additional large scale hydraulic roughness.

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Alternative 2 includes the following DEs that were added to Alternative 1:

1. DE 3: Additional inlets to the left bank side channel to accommodate additional flow.

2. DE 4: An apex ELJ on the gravel bar just downstream of the inlets to the left bank side channel (DE 3) to deflect flow into them.

3. DE 5: An apex ELJ in the channel just upstream of the confluence to provide large scale hydraulic roughness.

4. DE 6: A side channel within the abandoned right bank floodplain meander channel with multiple small habitat structures.

5. DE 17: A left bank ELJ at the confluence to deflect flows towards the apex ELJ (DE 7) and the right bank side channel (DE 6).

6. DE 9: Another left bank ELJ to provide large scale hydraulic roughness.

7. DE 8: An apex ELJ on the right bank gravel bar to provide large scale hydraulic roughness.

8. DE 10 and DE 11: Two medium sized habitat structures on the right bank gravel bar with the upstream one placed to help deflect flows into the existing left bank side channel.

Preferred Alternative

The project partners (representatives from the SPSSEG, the Nisqually Indian Tribe and the Nisqually Land Trust) met to discuss Alternatives 1 and 2, and then provided Herrera with a few general comments and several questions to obtain a better understanding of their performance, benefits and impacts. Herrera provided responses to their questions, which were followed by one additional round of comments and questions from the project partners. After reviewing Herrera's final round of responses the project partners selected Alternative 2 to commence with hydraulic modeling and then development of the preliminary design. Preliminary design would be completed after hydraulic modeling was completed for Alternative 2 so that any modifications could be made so as to not increase flooding on properties not owned by the NLT.

Alternative 2 was chosen over Alternative 1 for several reasons. Alternative 2 included many more DEs than Alternative 1 thereby maximizing the potential for improving habitat conditions and natural geomorphic processes in the project reach using a diversity means (e.g., ELJs, side channels, removal of bank constraints to allow channel migration). Herrera was confident that most, or all, of the additional DEs in Alternative 2 could be included, and modified as needed, and not increase the current risk of landslide activity due to toe erosion. The perceived short term impacts of constructing Alternative 2 are not significantly greater than those for Alternative 1, and can be justified given the significant increase in habitat conditions that would likely result from Alternative 2 compared to Alternative 1. Permitting requirements and efforts needed to secure access to the project site are the same for both alternatives. Additionally, some DEs could be removed from Alternative 2 and still result in more DEs than Alternative 1 if project budget constraints limit the scale of the project or the results of the hydraulic modeling for Alternative 2 show that some DEs need to be removed to not increase existing flood risks on property not owned by the NLT.

The Alternative 2 concept was submitted to the SRFB Review Team and they provided general approval and a "greenlight" to proceed to Preliminary Design.

Design Considerations and Preliminary Analyses

Prior to developing Alternatives 1 and 2 Herrera collaborated with the project partners to develop several design criteria that guided their development of the alternatives, which included the following:

1. ELJs will be located throughout the project reach to promote reach-wide hydraulic roughness, sediment (gravel) retention, accumulation of flood borne wood debris and scour pool formation, and to deflect flow into new side channels.

2. Side channels will be designed to be active during the mean annual flow.

3. ELJs will be located so they promote natural channel migration into the floodplain, but not allow channel migration into property not owned by the NLT or the Town of Eatonville.

4. ELJs will be located so they 1) do not direct the entire river towards the landslide toe and 2) do not cause an increase in flow velocities or water surface elevations along the landslide toe.

5. Artificial bank armoring (riprap) will be removed to allow natural bank erosion and channel migration.

Herrera completed several different analysis to support selecting Alternative 2 as the preferred alternative, to confirm the project will meet the design criteria listed above, and to support advancing Alternative 2 to the preliminary and final design stages. These analyses included the following:

1. Hydraulic modeling of existing (pre-project) and proposed project conditions.

2. A landside risk assessment.

3. A geomorphic assessment of the landslide toe.

4. A geophysical survey of subsurface conditions near the proposed ELJs and along the lower half of the landslide.

Modelling

Herrera completed two-dimensional (2D) hydraulic modeling for existing conditions to obtain baseline pre-project hydraulic conditions for the mean annual flow (228 cfs), and the 2-yr (3,214 cfs), 10-yr (4,995 cfs), and 100-yr (8,250 cfs) flows. Modeling was completed using the software RiverFLO2D, and the 2015 ground survey of the project reach completed by PGS, Inc. and the 2010 lidar were merged together to create the modeling surface. The existing model was calibrated using data included in the 2003 FEMA Flood Insurance Study for the Mashel River and FEMA's digital flood insurance rate maps (DFIRMs). After Alternative 2 was selected as the preferred alternative, Herrera completed hydraulic modeling for the proposed project conditions included in Alternative 2 for the 100-yr flow. Initial model results for Alternative 2 showed a few small, yet unacceptable, increases in flooding on property along the left (south) bank not owned by the NLT. Herrera completed several iterations of the model by making minor modifications to Alternative 2 to arrive at a final configuration that serves as the basis for the preliminary design included with this report.

Landslide and Geomorphic Assessment
Herrera's geotechnical engineer completed a landslide risk assessment. The purpose of the assessment was to develop a better understanding of historical landslide activity and the potential for future landslide activity to determine the risk to the project from current or future landslide activity, and to determine how the project could potentially influence the risk of future landslide activity. To support the landside risk assessment Herrera assessed the geomorphic conditions along the landslide toe to determine how the landslide potentially initially developed, how recent (since the 1940s) channel migration and current (2015) channel location are potentially affecting the stability of the landslide, and to what extent toe erosion would be necessary to potentially activate the landslide. A geophysical survey of the project reach using seismic refraction and ground penetrating radar was also completed to characterize the subsurface conditions and determine the presence of bedrock near ELJs and along the lower half of the landslide.

Based on the results of the geomorphic assessment, the geophysical survey results, the hydraulic model results for existing and proposed project conditions, and observations and analysis completed by Herrera's geotechnical engineer as part of the landslide risk assessment, the factors that likely contributed to past landslide activity include 1) a pre-existing weak shear zone in the highly plastic claystone that occurred during formation of the bedrock within the landslide, loading from prior glaciations, or from large seismic events; 2) high groundwater levels in the bedrock formation, and 3) river erosion at the toe of the slope after the landslide initially developed. Although there is potential for future landslide activity due to mechanisms #1 and #2 these mechanisms are not influenced by the river. The distance between the landslide toe and scarp is great enough currently that it is does not threaten to destabilize the upper scarp; ongoing slope failures there are likely driven by concentrated surface and/or groundwater drainage at the top of the landslide. Channel migration into the landslide toe has abated at the present time and toe erosion is likely to occur only during very high and infrequent floods; therefore, the likelihood of landslide activity occurring due to toe erosion is relatively low. Furthermore, the hydraulic model results for proposed conditions show flow velocities and water surface elevations decreasing along the landslide toe during flood events; therefore, the potential for toe erosion and thus potential for landslide activity due to toe erosion should decrease compared to pre-project levels.

Supporting Attachments:

- Preliminary Design
- Cost Estimate
- Model Output: "Mashel River Reach 7 Alternative 2 Water Surface Elevation (WSE) Differences for 100-year Flood Event"
- "Mashel River Reach 7 Landslide Geomorphic Assessment"
- "Seismic Refraction Survey Report" (geophysical survey of subsurface conditions near the proposed ELJs and along the lower half of the landslide.