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June 2, 2014

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Subject: Lower Middle Fork Nooksack River – Phase 1 Preliminary Basis of Design Report

PROJECT BACKGROUND

The Nooksack Salmon Enhancement Association (NSEA) and Lummi Natural Resources Department (LNRD) have identified the Lower Middle Fork Nooksack River (Middle Fork) near Porter Creek as a candidate location for habitat restoration. The proposed restoration reach is between river mile RM 4.9 (upstream end) and RM 4.6 (downstream end) (Figure 1). This reach was targeted by NSEA for restoration following the recommendations put forth in the WRIA I Recovery Plan (WRIA 1 2005) for the entire Middle Fork, and the geomorphic and hydraulic assessment conducted by Natural Systems Design (NSD, 2013).

RESTORATION GOALS

The specific restoration goals for the project reach include:

1. Improve long-term channel stability
2. Promote the formation and growth of forested islands and associated side channels
3. Increase key habitat quantity and quality through primary pool creation
4. Increase the frequency of stable spawning habitat
5. Stabilize naturally occurring accumulations of unstable large wood within the reach
6. Increase floodplain and side channel connectivity.
7. Project/enhance floodplain tributary habitat

Increases in these key habitat metrics will address limiting factors in the reach to ESA listed spring Chinook salmon, as well as other salmonids (pink, sockeye, fall Chinook, and coho) (WRIA 1 2005) that use the reach. Many of the project goals are anticipated to be met by increasing the number of stable accumulations of large wood debris (LWD) through the use of engineered logjams (ELJs). In addition to these improvements, higher LWD loading would increase the number of pools, provide additional hydraulic complexity leading to sorting of spawning gravels, reducing channel energy through shear stress partitioning, greater in-stream cover, and locally increased water elevations to improve side channel and floodplain connectivity.

RESTORATION RECOMMENDATIONS

Habitat conditions within the project reach are degraded in large part due to reach and watershed scale impacts to the Middle Fork watershed, including historic clearing of riparian forests, removal of in-stream wood, and a historic trend of increasing peak flows. A geomorphic assessment (NSD 2013) identified logging of the riparian corridor and removal of instream LWD as contributing to general incision and channel instability (higher channel migration rates and avulsion frequency) throughout the Middle Fork. Given the watershed and geomorphic conditions, this reach of the river is naturally susceptible to significant changes as variations in LWD loading, sediment supply and flows occur. The loss of functional and stable wood (trees greater than 4-ft in diameter and over 100-ft in length) and logjams could easily explain the historic trend in channel incision, channel instability, and lack of pools. The original forest had trees that would have obstructed the entire river channel when they fell that would easily have formed stable logjams that overtime would have created base level control and reduced the rate and magnitude of fluvial changes. With the loss of stable wood, the river has increased its streamflow energy and sediment transport capacity resulting in scour that has gradually lowered the channel and increased channel migration. When combined with shorter channel lengths resulting from on-going channel migration and avulsions, incision has been further exacerbated, creating a positive feedback loop. Numerous large stable wood placements in the form of ELJs are critical to reverse this feedback loop to slow incision and habitat degradation. Without countermeasures, incision and channel instability will continue, further simplifying and isolating habitat features. Disconnection of off-channel habitats (floodplains, floodplain side channels, and tributaries) has already been documented (NSD 2013), and would be anticipated to worsen with continued incision and channel migration. With evidence that peak flows may be increasing as a result of the warming climate (Mote 2006; Hamlet and Lettenmaier 2007; Abbe et al. 2008; Mote et al. 2008, Lee and Hamlet 2011; Neiman et al. 2011), it is even more important to aggressively reload the Middle Fork with stable wood and accelerate reforestation of riparian and floodplain areas. To ensure ELJ placements are engaged a high percentage of the time, placements should be made across the active channel width whenever possible. Observations of constructed LWD placements and persistent natural LWD accumulations within the Middle Fork suggest that stable LWD is very effective at creating flow obstructions leading to sediment deposition and channel migration away from the stable LWD locations. To combat this trend, ELJ placements that span the width of the active channel will ensure that as the low flow channel migrates across the active channel, it will be engaged with stable LWD at one or multiple locations.

The proposed restoration actions are primarily focused on increasing stable LWD in the form of ELJs within the project reach to meet the restoration objectives. Increasing stable LWD within the channel is anticipated to create geomorphic responses listed below, which in turn will address restoration goals.

Geomorphic responses induced by LWD	Restoration goals that will benefit
• Primary and secondary pool formation	3
• Sediment deposition downstream in the lee of LWD	2, 4, 5
• Increase water surface elevations	1, 2, 6
• Sediment grain size sorting	2
• Bed aggradation	1, 4, 6
• Spreading high flows into multiple channels	2, 4, 6
• Deflecting high flow energy away from existing critical habitat to improve stability	1, 2, 4, 7

The addition of stable LWD to the project reach will contribute to achieving all of the restoration goals, with habitat benefits that can be summarized as:

- Increasing channel roughness and partitioning shear stress (improving stability)
- More deep water cover refugia (pools),
- Increasing spawning gravel deposits (sediment deposition & sorting),
- Increased side channel habitat (increased water surface elevations, bed aggradation),
- Increased floodplain connection (increased water surface elevations, bed aggradation), and
- Improve stability of critical floodplain tributary habitat.

In addition to these habitat benefits from the geomorphic response, in-stream cover and edge habitat would both increase and benefit from stable LWD within the project reach. ELJs are designed to emulate the function of the large old growth snags once found throughout the river. Historically (pre-European settlement), one old growth snag would have been easily capable of obstructing the entire river channel within the project reach. Evidence of these trees was observed in the field, with numerous stumps 6-feet or more in diameter observed within the project area. Natural logjams and ELJs have been shown to be very effective in deflecting flow to create forested islands and side channels, raising river stage when they occlude much of the bankfull channel to backwater the river and aggrade the channel bed upstream (Abbe et al 2003, Montgomery and Abbe 2006).

CONCEPTUAL DESIGN DEVELOPMENT

The conceptual restoration design for the Middle Fork were developed to meet the restoration objectives and informed by the geomorphic, hydraulic and hydrologic analyses completed (NSD, 2013). Conceptual restoration plans were submitted to NSEA in December 2013. Due to the size of the reach, distinctly different geomorphic segments to the river, and the number of proposed restoration elements, the project reach was divided into 6 distinct sub-reaches. The site sequence was chosen to start with the furthest upstream site (Sub-Reach 6) and work downstream to Sub-Reach 1 at the confluence with the North Fork Nooksack River. The sequencing was chosen to begin from the upstream direction (Sub-Reach 6) and progress downstream due to recent avulsions and channel migration processes within the Middle Fork. In order to ensure the success of each site, restoration actions are recommended to begin at the upstream end of each sub-reach to minimize the possibility of avulsion through the restored sites. Due to the size of Sub-Reach 6, and the number of proposed ELJs, the sub-reach was divided into 5 phases to facilitate funding the project over several years and the in-stream construction period on the Middle Fork.

We recommend stable LWD be installed within the entire Phase 1 project reach, beginning just downstream of Mosquito Lake Road Bridge, with the intent of increasing the frequency of flow into the right bank channel. Presently, flow enters this channel at and above 1,600-cfs, however channel incision in combination with sediment deposition in the right bank channel has the potential to further disconnect the right channel from the current (left) channel. Increasing the connectivity of the right bank channel offers two primary benefits: 1. Reducing stream energies currently eroding into the Peat Bog and Bear Creek tributary channels, 2. Dramatically increasing habitat quantity and quality (a more even flow distribution between the left and right channels doubles the main channel and edge habitat within this sub-reach). Given the geomorphic conditions at the divide between the left and right channels, the channel should be expected to continue dynamic behavior in the future (varying percentage of flow down each channel flow path). ELJs placed to increase flow into the right bank channel will also provide bounds on future channel response (less likely for a full avulsion to one channel) through the formation of stable hard points. Additional ELJs placed in the left channel downstream of the flow divide at RM 4.85 will provide local habitat benefits, as well as partitioning shear stress upstream of the Bear Creek and Peat Bog Creek tributaries.

In 2013 Bear Creek and Peat Bog Creek tributaries had 90% of the observed spawning within the entire lower MFN (Lummi, 2013). In past surveys, these tributaries account for 40-80% of the annual redds count in the entire Middle Fork (Lummi, 2013). Presently, these areas are at risk of being captured by the main channel through channel migration and bank erosion. The shear stress partitioning from the proposed ELJs in Phase 1 creating a more distributed flow down the left and right channels will reduce the channel migration potential downstream at these high quality tributaries. Additional ELJs are proposed in future phases (Phase 2) adjacent to the Peat Bog and Bear Creek tributaries to further protect them from being captured by the main channel.

PROJECT COMPONENTS

To achieve the restoration objectives, conceptual designs and layouts for ELJ placements were developed within the project area (see Appendix A). ELJ structure types were developed to mimic the size, form, and function of historic stable LWD within the Middle Fork, using observations from persistent LWD accumulations observed during field reconnaissance. These ELJs are constructed with a core of structural logs partially embedded into the channel and arranged to induce a desired hydraulic and geomorphic effect. Each ELJ includes a large volume of smaller (racking) logs packed on the upstream end and flanks of the ELJs to provide complex interstitial cover for fish and invertebrates, and additional stability to the structure by forcing scour away from the core structure. Existing natural logjams within the project reach were used to size the proposed structures, as well as emulate the ecological and geomorphic function currently contributing to beneficial habitat. Based on these criteria, 3 structure architectures are proposed, each unique in the geomorphic and habitat benefits provided. The developed structure types are as follows:

- TYPE-1 ELJ – Type-1 ELJs are the largest proposed structures with a width and length of 80- and 45-feet, respectively. Type-1 ELJs will mimic the geomorphic, ecologic and hydraulic function once provided by large old growth tress that once lined the banks and were recruited into the channel of the Middle Fork. These structures are intended to force primary pool formation on the upstream end, promote stable forested island formation downstream, increase in-stream cover, sort spawning sized gravels, and with a sufficient number of structures densely spaced, will decrease basal shear stresses reach-wide to promote bed aggradation. Type-1 ELJs will be excavated into the channel bed to protect the structure from scour and will be post supported. Due to the construction cost of this ELJ type, placements were limited to high energy or severe hydraulic locations where a simpler, less robust ELJ would be less stable.
- TYPE-2 ELJ – Type-2 ELJs are a medium sized structure with a width and length of 60- and 30-feet, respectively. Type-2 ELJs will provide similar geomorphic, ecologic and hydraulic benefits as the Type-1 structures at a smaller scale, and are strategically placed to function with adjacent ELJs to increase habitat benefits while providing cost savings. Type-2 structures will be excavated into the channel bed to protect the structure from scour; are post supported, and cost less than Type-1 structures.
- TYPE-3 ELJ – Type-3 ELJs are a large structure with a width and length of 75- and 35-feet, respectively. Type-3 ELJs will provide similar geomorphic, ecologic and hydraulic benefits as the Type-1 structures at a much lower cost. The Type-3 ELJ design was partially developed to mimic the vertical members (in the form of mature second growth trees) observed in the persistent LWD accumulation at RM 4.5 in the right channel, and also on a pile array ELJ developed for the Upper Quinault River (see Figure 2). To reduce construction costs, Type-3 structures will be excavated a nominal depth into the channel, are post supported, and uses a smaller number of key pieces. To have its intended effect, the Type-3 structure relies on trapping mobile wood moving through the project reach to create a large stable wood accumulation over time. Minimizing the excavation depth and number of key pieces results in significant cost savings, but also a less robust structure in the short-term. Stability will increase over time as additional logs rack onto the structure. Type-3 structures are located in sub-reaches that are lower energy or have less severe hydraulic conditions where natural LWD would be likely to deposit and where the structure is at a lower risk of becoming unstable. Similar low cost structures have been developed and successfully implemented on the Upper Quinault River as shown in Figure 2 and offer a great opportunity to re-introduce stable LWD on a reach scale in the Middle Fork.

STAKEHOLDER CONSULTATION

Following internal discussions with the project team, the conceptual designs for the project reach were presented to WRIA1 Salmon Staff Team on December 6, 2013. Entities present at the meeting include NSEA, the Nooksack Tribe, the Lummi Tribe, Whatcom County, and Washington Department of Fish and Wildlife (WDFW). During the presentation geomorphic and hydraulic findings, restoration recommendations were discussed and input solicited. Feedback received from all entities was positive and comments received on the conceptual designs were incorporated into the preliminary design drawings for the priority sub-reach (attached).

PRELIMINARY DESIGN DEVELOPMENT

Following the conceptual design and input from project stakeholders, preliminary designs plans (Appendix A) were developed to achieve the restoration objectives, and expand upon the conceptual design recommendations. The following section provides additional descriptions for each site and structure and evaluates each proposed structure in relation to the restoration objectives.

PHASE 1 PROJECT AREA

The restoration approach for the Phase 1 project is to improve channel stability, an anabranching planform, and habitat quality and quantity through the creation of stable accumulations of LWD. These accumulations will be established by constructing ELJs that will distribute flows in the channel, forming stable forested islands downstream of the ELJ over time. The anabranching planform will reduce channel widths and increase depths compared to the current channel, and the ELJs will maintain pools as downward vortices are created as flow impinges on the structures.

Specific objectives within the Phase 1 project area are to:

1. Dissipate high streamflow energies through adding roughness, disrupting flow patterns, and partitioning flow more evenly into the left and right channels downstream of the flow divide and RM 4.85, leading to increased channel stability over time,
2. Promote the formation and growth of forested islands in the lee of proposed ELJs,
3. Create stable pool habitat with cover immediately upstream and/or adjacent to proposed ELJs,
4. Increase the frequency of stable spawning habitat by partitioning shear stress in the channel, reducing average grain size to more suitable spawning sized gravels, as well as development of depositional gravel pockets in lee of proposed ELJs,
5. Trap mobile LWD to further obstruct flow and provide additional habitat benefits, and maximize residence time of large trees within the project reach susceptible to recruitment as the channel adjusts to ELJs,
6. Increase floodplain and side channel connectivity throughout the project reach, with a focus on a more even flow distribution at RM 4.85.
7. Protect floodplain tributary habitat associated with Peat Bog and Bear Creeks.

The proposed ELJs are laid out in strategic locations to maximize their hydraulic, geomorphic, and habitat forming benefits both immediately following construction and in the long term. The ELJs function individually and as a whole to meet the project goals. Individually, the proposed ELJs will provide pool and cover habitat, locally increase water surface elevations when engaged with flow, trap mobile LWD during floods, and increase instream roughness. However, when they are considered together their function impacts a much larger area, and can begin to restore broader goals of floodplain and side channel connectivity, improved channel stability through shear stress partitioning, and maintaining stable habitat features over time. Specific descriptions for each structure placement within this site are as follows;

- ELJ 1-2-1 is a Type 2 structure that is designed to create a primary pool on the left bank side of the main stem channel, deflect flows toward the right bank toward the inlet to the right channel flow path, and promote stable vegetated island formation.
- ELJ 1-1-2 is a Type 1 structure designed to create and maintain a primary pool in the main stem channel, deflect flow toward the inlet of the right channel flow path and ELJ 1-2-3, and promote stable vegetated island formation. Local increase in water surface elevation will further contribute to flow entering the right channel flow path over a range of discharges. This structure, in combination with ELJ 1-2-1, is specifically designed to promote flow down the right channel flow path.
- ELJ 1-2-3 is a Type 3 structure designed to create a primary pool in the main stem (left) channel, deflect flows toward the right bank and into ELJ 1-1-4, and promote stable vegetated island formation. Deflecting flows to the right is expected to promote recruitment of large (greater than 50-ft tall) trees from the right bank floodplain as the channel adjusts locally to the structure.
- ELJ 1-1-4 is a Type 1 structure that is designed to create a primary pool in the main stem (left) channel, deflect flows to either side of the structure (toward ELJ 1-3-5 and ELJ 1-3-6), and promote stable vegetated island formation. Deflected flows are expected to initiate channel adjustment and recruitment of large trees (greater than 50-ft tall) from the left and right bank floodplains. This structure will also help to trap trees recruited into the channel from anticipated channel adjustments due to flow deflection at the upstream ELJ 1-2-3.
- ELJ 1-3-5 is a Type 3 structure that is designed to create a primary pool in the main stem (left) channel, deflect flows to either side of the structure (toward ELJ 1-2-8 and ELJ 1-1-9), and contribute to reach scale increases in flow depth (in combination with ELJ 1-3-6 and 1-3-7) to improve floodplain connectivity and decrease shear stress to promote bed aggradation and fining. This structure will also help to trap trees recruited into the channel from anticipated channel adjustments due to flow deflection at upstream ELJs 1-1-4 and 1-2-3.
- ELJ 1-3-6 is a Type 3 structure that is designed to create a primary pool in the main stem (left) channel, deflect flows to either side of the structure (toward ELJ 1-2-8 and ELJ 1-1-9), and contribute to reach scale increases in flow depth (in combination with ELJ 1-3-5 and 1-3-7) to improve floodplain connectivity and decrease shear stress to promote bed aggradation and fining. This structure will also help to trap trees recruited into the channel from anticipated channel adjustments due to flow deflection at upstream ELJs 1-1-4 and 1-2-3.
- ELJ 1-3-7 is a Type 3 structure that is designed to create a primary pool in the main stem (left) channel, deflect flows to either side of the structure (toward ELJ 1-2-8), and contribute to reach scale increases in flow depth (in combination with ELJ 1-3-5 and 1-3-6) to improve floodplain connectivity and decrease shear stress to promote bed aggradation and fining. This structure will also help to trap trees recruited into the channel from anticipated channel adjustments due to flow deflection at upstream ELJ 1-1-4.
- ELJ 1-2-8 is a Type 2 structure that is designed to create a secondary pool in the main stem (left) channel, deflect flows to either side of the structure, and promote stable vegetated island formation. This structure would be engaged with flows greater than base flow under the current condition, and would provide a stable hard point should the channel migrate toward the structure. This structure will also help to trap trees recruited into the channel from anticipated channel adjustments due to flow deflection at upstream ELJs 1-3-5, 1-3-6 and 1-3-7.

- ELJ 1-1-9 is a Type 1 structure that is located on the left bank of the main stem (left) channel and is designed to create a primary pool, deflect flows to the right of the structure, and promote stable vegetated island formation. This structure will also help to trap trees recruited into the channel from anticipated channel adjustments due to flow deflection at all upstream ELJs.
- ELJ 1-3-10 is a Type 3 structure that is designed to create a secondary pool in the main stem (right) channel, deflect flows to either side of the structure (toward ELJ 1-3-11), and promote stable vegetated island formation. It is anticipated that this structure would be engaged with the main stem (right) channel during future low flow conditions due to the combined effect of ELJs 1-2-2 and 1-1-3 in increasing flow into the right channel.
- ELJ 1-3-11 is a Type 3 structure that is designed to create a secondary pool in the main stem (right) channel, and deflect flows to either side of the structure. It is anticipated that this structure would be engaged with the main stem (right) channel during future low flow conditions due to the combined effect of ELJs 1-2-2 and 1-1-3 in increasing flow into the right channel.

TABLE 1 – PHASE 1 RESTORATION ELEMENT SUMARY

RESTORATION ELEMENT	TYPE	PRIMARY RESTORATION GOALS ACHIEVED*
ELJ 1-2-1	2	1, 2, 3, 4, 5
ELJ 1-1-2	2	1, 2, 3, 5, 6
ELJ 1-2-3	1	1, 2, 3, 4, 5, 6
ELJ 1-1-4	3	1, 2, 3, 4, 5, 6
ELJ 1-3-5	1	1, 2, 3, 4, 5, 6
ELJ 1-3-6	2	1, 2, 3, 4, 5, 6
ELJ 1-3-7	3	1, 2, 3, 4, 5, 6
ELJ 1-2-8	3	1, 2, 3, 5, 6
ELJ 1-1-9	1	1, 3, 4, 5, 6
ELJ 1-3-10	3	1, 2, 3, 5
ELJ 1-3-11	3	1, 2, 3, 5

** numbers correspond to list of restoration goals on pages 1 and 5*

SITE ACCESS

Several site access routes were identified that will be potentially be utilized to construct the proposed restoration elements. Temporary bridge crossings from the Mosquito Lake Road Bridge parking area will be required at the site to reach the forested islands to construct ELJs. Up to 4 temporary bridge locations are proposed, however, depending on the location of the low flow channel during construction, the number and locations of proposed temporary bridge locations may vary. It is anticipated that no more than 4 temporary bridges will be needed during construction. Access routes follow exposed unvegetated gravel bars where possible to minimize impacts to adjacent riparian vegetation and to avoid known existing LWD locations. The location of access routes will be verified prior to construction and modified to accommodate future channel migration and/or redistribution of LWD on bars.

SPAWNING IMPACTS

Spawning redd locations for endangered salmonids were considered in the placement of proposed restoration elements. Spawning redd data from 2000 to 2010 for the project area was provided by LNRD and NSEA in GIS format, with more recent redd locations (2012 and 2013) provided in graphic form. Redd locations were overlaid with proposed ELJ, access road, and temporary bridge locations to ensure these elements did not interfere with recently observed redd locations. All structures to be constructed in the wetted channel will be reviewed by a permitting agency and LNRD biologist prior to construction starting. If any redd or significant fish activity is observed in the immediate structure location, that structure will either not be constructed or relocated at the direction of the NSD engineer of record.

To further reduce impacts to the endangered salmonids, proposed ELJs will be constructed during the allowable in-stream construction window and temporary erosion control measures will be implemented in accordance with Department of Ecology Stormwater Management Regulations and Best Management Practices for Western Washington. Based upon the distance to observed redd locations, construction period, construction methods, and results from the hydraulic model, the proposed ELJ locations are not anticipated to adversely affect know spawning locations. Furthermore, the location of proposed ELJs proximal to observed redd locations are anticipated to create scour holes and adult holding habitat for spawning salmonids that will enhance these locations over time.

PROPOSED CONDITION HYDRAULICS

A proposed conditions hydraulic model was developed by modifying the existing conditions model (NSD 2013) to evaluate the hydraulic effects of proposed restoration elements. The existing conditions model was modified to be representative of proposed conditions by adjusting the elevations within the footprint of the proposed structures to the design elevations of the individual ELJs (Appendix A), and adjusting the roughness value within the footprint of the proposed ELJ. Existing logjams and NSEA structures built between 2003 and 2010 are represented as well by higher roughness values in the existing and proposed hydraulic models. All discharges modeled for existing conditions (1-, 10-, and 100-yr peak flows) were modeled for the proposed condition to evaluate the performance of specific project elements over a range of discharges. All model runs were performed in a steady state (discharge does not vary with time) and non-deformable bed (no adjustments for scour, sediment transport, erosion, and deposition). A detailed description of the hydraulic model setup, including data used in its development and parameters used, is provided in the geomorphic and hydraulic assessment (NSD 2013). Reach and site scale figures of the proposed hydraulic model outputs are provided in Appendix B for the 1- and 10-year flow simulations.

The results of the proposed conditions hydraulic modeling demonstrate how the design achieves the project goals by altering the hydraulic conditions during the 1- and 10-year flood. One of the important project goals is to more evenly distribute flow between the right and left channel flow paths at the RM 4.85 flow divide. Having a more even flow distribution will help to meet several of the project goals (1, 4, 6). Under the current condition during the 1-year flood, flow is just starting enter the right channel flow path, with only 8 cfs predicted. Under the proposed condition during the same flow, 650 cfs is deflected into the right flow path, or 26% of the total discharge (Figure 3). This increased flow in the right channel flow path results in a dramatic increase in channel length and edge habitat available, as well as reduce velocities in the left channel flow path (Figure 4). The reduction in flow velocities in the left bank channel flow path result in decreased sediment transport capacity, leading to long term aggradation and fining of the channel bed to more suitable spawning sized gravels (Figure 5). Figure 4 is also useful in predicting anticipated channel response to the proposed ELJs, where areas of increased velocity likely indicating an increased chance of channel migration, and areas of decreased velocity predictive of areas that will aggrade. The significant backwater formed by ELJ 1-1-4 slows flow down 5 ft/s for 400 ft upstream of the structure, indicating aggradation is to be expected in this area (Figure 4). Conversely, flow deflected to the left of ELJ 1-2-1 will increase flow velocities more than 3 ft/s along the left bank, indicating bank erosion is likely at this location (Figure 4).

Engagement of structures during the 1-year flow event is important to create and maintain stable pool habitat, and to trap mobile wood moving through the reach, other important goals of the project. All of the proposed ELJs are engaged with the 1-year flow extent (Figure 3), and are anticipated to create and maintain stable pool habitat with complex cover, and help increase residence time of mobile wood within the reach by trapping debris.

For the 10-year flood event, average flow depths across the project reach are increased between 0.5-1 ft, with local increases greater than 3-ft (Figure 6). These increases in flow depth demonstrate greater floodplain and side channel connectivity within the project reach, another important goal of the project. These increases in depth are accompanied by decreases in channel velocities (Figure 7) averaging 1-2 ft/s along the channel within the project reach, and up to 5 ft/s in some locations. Most of the area shown as having increased velocity is floodplain inundated area that has low velocities under both the existing and proposed condition. These results are consistent with that shown for the 1-year flood event, demonstrating that the habitat benefits realized by the project occur over a wide range of flow conditions.

SCOUR ANALYSIS

A scour analysis was performed to ensure the ELJ structures are designed and constructed to withstand the scour that may occur during severe flood events. For each ELJ type, only the ELJ experiencing the most severe hydraulic conditions (highest velocity and flow depth) was evaluated. The scour analysis was performed using empirical equations developed to predict scour and results from the 10-year proposed condition hydraulic analysis. The scour potential for all ELJs was evaluated following the procedures outlined in FHWA HEC-18, Fourth Edition (Richardson and Davis 2001), FHWA HEC-20, Third Edition (Lagasse et al., 2001), and Scientific Investigation Report 2004-5111 (Chase and Holnbeck, 2004). Scour estimates were performed for the 10-year discharge and considered long-term degradation, contraction scour, and pier scour components. Scour related to long-term degradation and contraction scour was determined to be negligible for this project. Pier scour for this project was determined using the Simplified Chinese Equation developed by Landers and Mueller, 1996. The results of the scour analysis for each structure type are shown in Table 2, below. To withstand the estimated scour, the bottom elevations of proposed ELJs will be placed below the estimated scour elevation and coarse channel material will placed in front of each structure to inhibit scour that could destabilize the ELJ. The project will directly address general scour by reducing the river's sediment transport capacity and the predicted bed aggradation induced by the project will reduce the risks associated with scour. This scour assessment conservatively assumes that no racking logs are present on the upstream face of the ELJ, and that scour would initiate directly upstream of the ELJ face. All of the proposed ELJ types will be constructed racking logs installed on the upstream face (minimum 10-ft thick) that will force scour initiation away from the ELJ core. Mobile LWD within the project reach is expected to rack onto proposed ELJ, further pushing scour away from the ELJ core. Burial depth of the Type-3 ELJ does not exceed the maximum potential scour predicted (Table 2), however the analysis does not account for abundant racking logs on the upstream face of the structure that will push scour away from the structure and prevent undermining during scouring floods.

TABLE 2 – SUMMARY OF SCOUR ANALYSIS FOR 10-YR PEAK DESIGN EVENT

STRUCTURE TYPE	MAXIMUM POTENTIAL SCOUR* (FT)	DESIGN SCOUR DEPTH (FT)**
TYPE 1 (ELJ 1-1-2)	17.0	17.0

STRUCTURE TYPE	MAXIMUM POTENTIAL SCOUR* (FT)	DESIGN SCOUR DEPTH (FT)**
TYPE 2 (ELJ 1-2-1)	13.5	16.0
TYPE 3 (ELJ 2-3-13)	15.7	11.0

** Scour depths presented are for the worst case for each structure type*

*** Design scour depth is representative of embedment depth of vertical posts below the channel bed*

STABILITY ANALYSIS

A stability analysis was performed to ensure the ELJ structures are designed and constructed to withstand the hydraulic forces that occur during severe flood events. For each ELJ type, only the ELJ experiencing the most severe hydraulic conditions (highest velocity and flow depth) was evaluated. The stability analysis was performed using force balance equations developed to predict buoyant and lateral (sliding) forces, results from the 10-year proposed condition hydraulic analysis, and material properties for the specific ELJ components. The stability for all ELJs evaluated followed the procedures outlined in D'Oust and Millar (2000), Abbe (2000), Shields et al. (2000), and Brauderick and Grant (2000). Stability estimates were performed for the 10-year recurrence discharge and considered destabilizing forces related to the buoyancy of large wood and sliding force caused by the streamflow velocities and the stabilizing forces related to alluvium ballast, and the friction between the bottom of the ELJ and the channel. The results of the stability analysis in terms of the factor of safety (resisting forces/destabilizing forces) for each structure type are shown in Table 3, below. Type 1, 2, and 3 structures were designed to withstand buoyant and lateral forces using excavated timber posts and alluvium backfill. Estimates are considered conservative since channel aggradation will result in a reduction of drag forces (by decreasing area of wood exposed to flow), an addition of surcharge (log burial), a reduction in basal shear stress (by reducing hydraulic gradients and flow depths), and a reduction in effective shear stress acting on wood by the cumulative effect of the ELJs in partitioning basal shear stress.

TABLE 3 – SUMMARY OF STABILITY ANALYSIS FOR 10-YR PEAK DESIGN EVENT

STRUCTURE TYPE	BOUYANCY FS*	LATERAL FS*
TYPE 1 (ELJ 1-1-2)	8.8	3.4
TYPE 2 (ELJ 1-2-1)	9.3	3.0
TYPE 3 (ELJ 2-3-13)	4.3	2.3

** FS presented are for the worst case for each structure type*

CONSTRUCTION COST ESTIMATES

The construction cost estimate presented for this project (Appendix C) is largely based on our professional judgment, consultation with construction contractors and recent experience with similar projects. Cost data for large wood was provided by Lummi Natural Resources Department from recent project experience within the watershed. Quantity estimates are considered approximate but are sufficiently accurate for the preliminary design phase.

Construction costs were calculated in a single Microsoft Excel workbook, using consistent unit costs for each construction element or quantity. Construction quantities for each element were multiplied by their respective unit costs, and the resulting products totaled into a construction sub-total. Additional fees for taxes, contingencies, and incidentals were accounted for as a percentage of the construction sub-total. The construction sub-total was then increased by the percentages of the additional fees to estimate the total construction cost. The construction costs do not include engineering and permitting fees.

RISK ASSESSMENT

The proposed restoration design is intended to improve channel stability and habitat quantity and quality throughout the project reach. The introduction of ELJs will also result in changes to water surface elevations that meet the goal of improving side channel and floodplain connectivity, but this change must be balanced so as not to put existing habitat, forest, and local infrastructure at risk. Thus it is critical to evaluate the hydraulic effect of the proposed ELJs to ensure they have no undesired impacts. A risk assessment was conducted to evaluate potential impacts of the proposed restoration actions and to document that no adverse effects to habitat relative to the existing condition are predicted.

Risk is a function of the probability of a hazard occurring (such as structure failure/washout, flood inundation, or boater entanglement) and the consequences of that event (e.g., habitat loss, property damage, or injury). If an event has little or no consequence then the associated risk would be relatively low, whereas a high negative consequence coupled with a high probability of occurrence results in a high risk factor. Rivers and natural systems have evolved to function within a wide range of conditions, however these processes are not always consistent with human needs and expectations. The Middle Fork is a dynamic river in its current condition and high flows pose risks to nearby infrastructure, developing riparian forest, and recreational users. The primary natural hazards for the project area are related to flood and erosion risks, including lateral bank erosion (channel migration/avulsion), sediment delivery from mass wasting events upstream, riparian woody debris recruitment, and in-stream LWD. Non-natural hazards include failure of in-stream structures, creation of boating hazards, changes in inundation/channel forming processes, the establishment of non-native vegetation, and construction impacts. Longer-term hazards such as climate change were not addressed as part of this assessment. This risk assessment establishes due diligence in evaluating the proposed design for the Phase 1 Middle Fork restoration and consists of the following elements:

- Assessment of short-term risk associated with construction activities
- Assessment of potential impacts to habitat and infrastructure
- Description of how ELJs will influence channel migration
- Assessment of potential impacts of ELJs for recreational users of the river
- Description of risks of a no-action alternative

Short-Term Risks from Construction Activities

Several hazards have been identified related to construction activities that pose potential risks to construction delays, water quality, and habitat during construction. Construction activities included in this risk assessment are:

- Earthmoving
- Re-vegetation
- Water management
- In-stream structures

Earthmoving

Primary earthmoving activities included in the design are excavation of ELJ placements and scour pits as well as backfill of excavated material into ELJs. Grading associated with staging and stockpile areas, and establishment of proposed access routes is anticipated to be minimal. Any areas that are excavated or filled during construction will clearing, and will remain exposed in the short-term as vegetation re-establishes naturally or as a result of planting. The proposed design plans incorporating re-vegetation in some areas, the risk associated with earthmoving is very low.

The risk associated with flooding inundation and erosion is very low for the project area during construction given anticipated low-flows during the proposed construction time frame. Construction areas that are within the wetted channel during construction will be isolated using temporary cofferdams where applicable to minimize inundation risk. All materials and equipment will be stored above/outside of the ordinary high water line to minimize risk from unlikely high flows during construction.

Re-Vegetation

Following construction the backfilled ELJs and any disturbed areas above the ordinary high water line (access routes, staging areas where applicable) will be planted and/or seeded to initiate establishment of native vegetation. Habitats to be formed include coniferous forest and riparian deciduous forest. The primary risk to establishment of the plantings is from flood erosion in the growth period following construction and available root water following installation. Selection of appropriate native vegetation and installation to sufficient depths will be used to mitigate any risk to the success of re-vegetation efforts.

Water Management

Some of the proposed ELJ locations will infringe on the low flow channel during construction, requiring water management techniques to isolate the work area and divert water elsewhere. Prior to the initiation of isolation and construction of each structure, the wetted channel bed will be inspected for recent fish usage, include redds. Should a recent redd be present within the area proposed to be isolated, the proposed ELJ location will be changed to avoid impacts to fish usage. If no fish usage is documented, the area will be isolated using bulk bags or other agency approved method. Water will be pumped from the isolated area and diverted from the work area prior to starting excavation for the proposed ELJ. Water diverted from the isolated work area will be diverted onto the adjacent floodplains in a location such that it infiltrates into the ground completely prior to re-entering the river. If diverted water remains as turbid surface flow as is re-enters the river, BMPs will be employed to slow the flow, filter suspended sediment, and/or otherwise keep turbidity in the river below the threshold set by permit applications. Periodic sampling for turbidity in the river downstream of the isolated work area and re-entry point of diverted waters will be conducted to ensure turbidity is maintained within levels permitted. Should turbidity remain above threshold levels, work will stop until BMPs are employed to manage turbidity below allowable levels.

In-Stream Structures

The project design includes in-stream ELJs (Appendix A). Construction of these design elements will be performed when low-flow conditions exist. The primary risk to project elements during construction is from flooding of the work area. Due to the hydrologic regime and work occurring during low-flow conditions, the risk from flooding is very low. Should inundation of the work area occur during construction, construction would be halted immediately until the water subsides.

Potential Impacts to Habitat and Infrastructure

Improving habitat quality and quantity throughout the project reach is the main goal of the proposed restoration design. By activating additional side channels and reconnecting the floodplain, habitat will be created through the engagement of habitat features more frequently by increasing water elevations and local deflection into side channel inlets. Engaging these areas is regarded as an improvement relative to existing habitat conditions, but it may also result in decreased flow depths and velocities in the current channel that could negatively impact existing habitat. However, these anticipated reductions in mainstem flow will benefit the project goals of countering channel incision and reducing avulsion potential by partitioning shear stress in the project reach, resulting in bed aggradation in the current (left) main channel, reach scale elevated water surface elevations, and thus enhanced floodplain and side channel connectivity. Distributing flows between the left and right flow paths in the project reach will also add over a mile of active channel, more than doubling the amount of edge habitat contributing to in-stream cover and complexity (Figure 3, Appendix B). Annual flood depths are expected to increase by up to 3.5 ft in the right flow path, with scour pool depths up to 6- to 8-ft (Figure 3). No existing infrastructure is at risk of being inundated in the right bank floodplain. The activation of this channel is anticipated to reduce annual flood depths and velocities in the left (mainstem) channel by up to 3 ft and 6 ft/s, respectively (Figures 3 & 4), effectively reducing stream power and sediment transport capacity. Under the modeled conditions, flow reductions are not expected to result in fish stranding or passage barriers in either flow path (Figure 3). In addition to reducing flow velocities in the existing channel, the proposed structures will create holding areas for adult fish and cover for juveniles. The risk to existing habitat associated with the proposed project work is low.

In the near-term, activation of the right channel is likely to cause increased erosion risk of the valley toe at the counterclockwise bend along the right bank near Mosquito Lake Road (Figure 1). Extensive erosion or undermining of the slope is not anticipated, and future project phases are intended to counter eastward channel migration toward the road (Appendix A). Other infrastructure in the project reach includes Mosquito Lake Road Bridge and the old steelhead hatchery acclimation ponds. Due to the backwatering effect of the most upstream ELJ (1-2-1), no net changes to flow velocities or sediment mobility are expected through the bridge crossing, thus no increased pier scour of the bridge footings is anticipated. 100-year water surface elevations are expected to increase by up to 0.3 ft under the bridge, and freeboard between the water surface and bridge will remain greater than 15 ft. The risk of damage to the bridge relative to existing conditions is low. 100-year and 10-year flood depths may rise up to 0.5 and 0.2 ft along the old steelhead hatchery access road, respectively. No inundation of the acclimation ponds is anticipated under any of the modeled conditions. Structures 1-2-5 and 1-1-9 may deflect flow to the west and increase erosion of the left bank adjacent to the ponds (Figure 4 and 7). A 160 ft forested buffer between the active channel and ponds is currently present and channel migration is not expected to breach this buffer.

ELJ Impacts on Channel Migration

Existing natural wood accumulations have effectively diverted flow when jams form, causing unchecked channel migration due to the limited amount of large, stable large wood in the Middle Fork. The quantity and distribution of the proposed ELJs is intended to encourage habitat and pool formation while reducing the potential for future channel migrations that may pose risks to forest development and available fish habitat. The project reach currently has high avulsion potential and is prone to rapid channel migrations as evidenced by recent avulsions in the past 20-years. The short-term channel response to ELJ placements is likely to include bank erosion and bed scour adjacent to the structures due to deflection of flows. The additional sediment and wood from bank erosion is expected to accumulate in the lee of ELJs, backwater areas of reduced velocity, and on downstream structures. Short term, localized changes at each structure may be amplified as the channel adjusts to the flow alignments encouraged by the ELJs and sediment and wood are redistributed. In the long term, the design collectively makes channel-forming processes more predictable by partitioning flows, lengthening the channel, and introducing roughness, reducing stream power throughout the reach. The stable hard points created will also allow for the development of forested islands in the lee of ELJs, providing shade, wildlife habitat, and vegetative bank stability. It is possible that future aggradation in the left channel could result in a partial avulsion due to changes in hydraulic head induced by increases in water surface elevations relative to the right channel alignment. Future restoration phases are intended to balance aggradation throughout both flow paths, reducing the risk of avulsion.

Potential Impacts to Recreational Users

Due to the dynamic nature of the river and mass delivery of sediment and large wood upstream of the project reach, the Lower Middle Fork is moderately dangerous under existing conditions. Frequent channel migrations and partial channel avulsions are part of the river's current geomorphic regime. The dynamic response of the river to these changes makes recreational safety and boater navigation slightly unpredictable at present. Although the proposed work includes large wood additions to the channel, these structures are not projected to become mobilized under the range of flows in the Middle Fork. Wood debris jams are considered natural features in western Washington fluvial systems. Large wood presence in the Middle Fork poses a hazard to recreational users regardless of the restoration work. The efficiency of ELJs in capturing additional wood may increase the risk for inexperienced boaters; however, the structures will increase the overall stability and predictability of the channel form relative to existing conditions. The addition of ELJ structures will enhance channel complexity, requiring boaters to be more aware of obstructions and flow patterns. Wood placements will also create areas of slow moving backwater, which may increase boater response times and the number of available pullouts.

Many recreational boaters on the Middle Fork commonly take out near the Mosquito Lake Road Bridge upstream of the project site. Public outreach regarding the proposed work should be implemented to aid boaters in understanding any changes in safety and channel form. Posting orange warning signs on each engineered wood placement may help boaters recognize and navigate around flow obstructions. Warning signs can be placed at known launch points upstream or within the project reach that indicate the river has natural and engineered wood debris that should be avoided. The same signage can also note facts about the restoration project and other conditions that may pose a hazard such as areas of constricted, fast-moving water. Correspondence and public meetings with river guides and recreational groups known to use the river can also improve safety by educating users and thus reduce risk.

Risks of a No-Action Alternative

Due to historic losses of riparian forest and the removal of large wood from the Middle Fork, the project reach is subject to frequent and sudden disturbances (NSD 2013). The proposed restoration is intended to expedite the system's recovery and reverse historic trends in channel incision, rapid channel migration, and frequent avulsions, in order to create a more stable river and higher quality habitat. Without restoration, the Middle Fork is expected to continue incising, lowering the water surface and further disconnecting floodplain and side channel habitats. As the channel becomes more entrenched in a simplified channel, stream power is expected to increase, exacerbating incision and erosional processes. In the project reach, channel instability will result in the ongoing loss of developing riparian forest as the channel continues to migrate in the absence of stable hard points and forested islands. The recruitment of young successional forest will not limit channel migration rates, or contribute to stable wood accumulations. Active channel migration at the Bear and Peat Bog Creek tributaries would be expected to continue, further reducing spawning opportunities in this high value habitat. There is also a risk of continued loss of spawning gravels, pools, and edge habitat due to the increased shear stress associated with an incised channel.

LIMITATIONS

We have prepared this report for the Nooksack Salmon Enhancement Association, their authorized agents and regulatory agencies responsible for the Middle Fork restoration project. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices for river restoration and the engineered placement of wood in this area at the time this report was prepared. The conclusions, recommendations, and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, expressed or implied, should be understood.

We appreciate this opportunity to be of service to the Nooksack Salmon Enhancement Association for this project and look forward to continuing to work with you. Please call if you have any questions regarding this report, or if you need additional information.

Sincerely,

Natural Systems Design, Inc.

R. Leif Embertson, MS, PE, CFM
Senior River Engineer

Tim Abbe, PhD, PEG, PHG
Principal Geomorphologist

Attachments:

Figure 1 – Project reach map
Figure 2 – Example Type-3 ELJ
Figure 3 – Change in flow depth during 1-yr flow
Figure 4 – Change in flow velocity during 1-yr flow
Figure 5 – Change in minimum stable particle size during 1-yr flow
Figure 6 – Change in flow depth during 10-yr flow
Figure 7 – Change in flow velocity during 10-yr flow

Appendix A - Preliminary Design Drawings
Appendix B - Proposed Hydraulic Conditions
Appendix C - Preliminary Design Cost Estimate

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FIGURES

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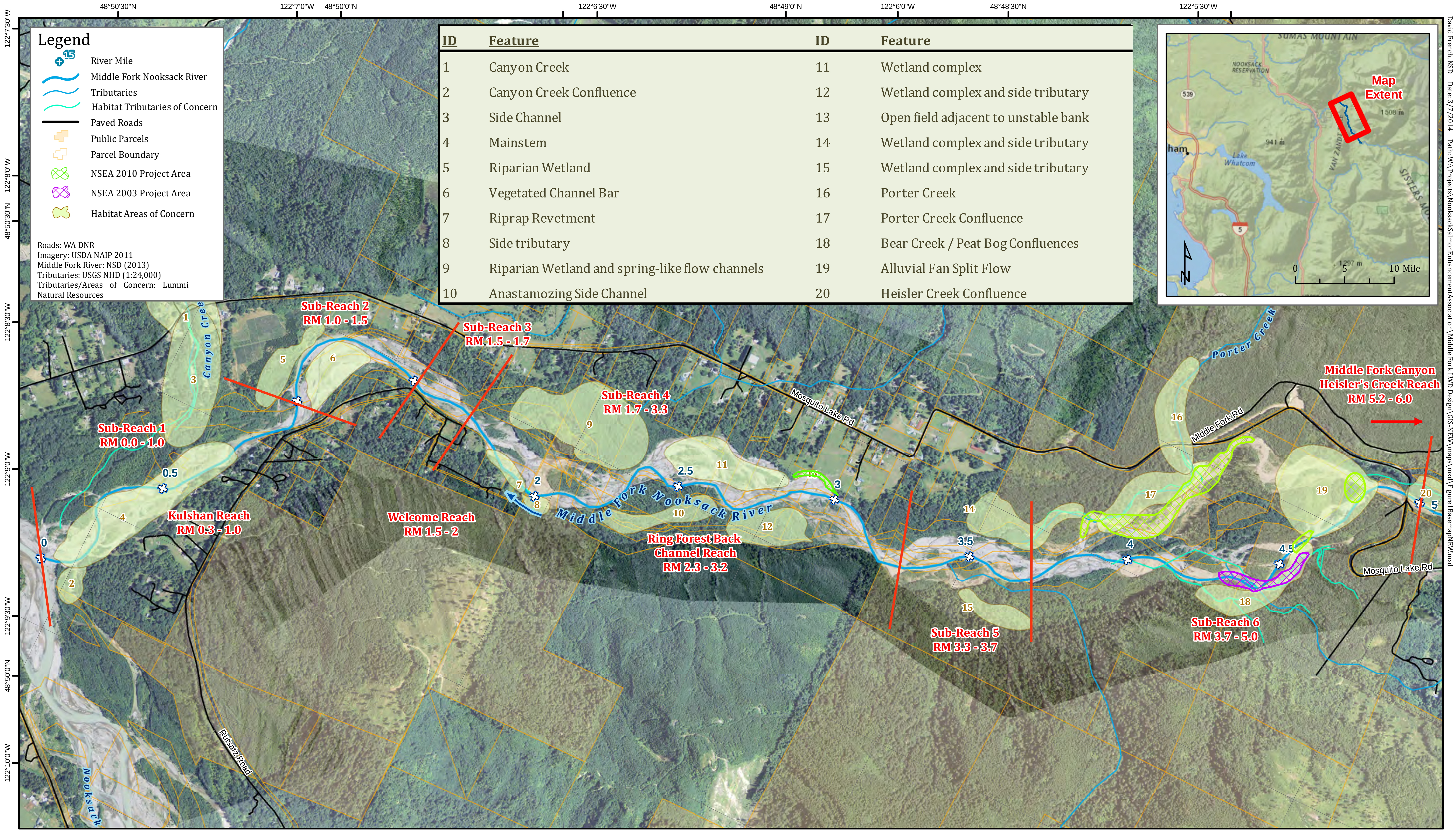

Middle Fork Nooksack River LWD Preliminary Design

Figure 1 - Project Reach Basemap

LiDAR Hillshade from : Watershed Sciences (2011) LiDAR (collected April, 22nd 2011 at 220 cfs)
Aerial Imagery from: USDA National Agriculture Imagery Program 2011
River Miles digitized by NSD based on 2011 low-flow channel
Habitat reach segments from MFN River Habitat Assessment (Lummi Nation, 2011)

0 1,000 2,000 3,000 4,000 Feet
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

FIGURE 2 – 2013 Aerial photo (GoogleEarth) of constructed pile array ELJs on the Upper Quinault River basin (Top left); Left bank pile array ELJ constructed in 2012 (Lower left); Center channel pile array ELJ constructed in 2012 with significant newly racked mobile LWD (Lower right)

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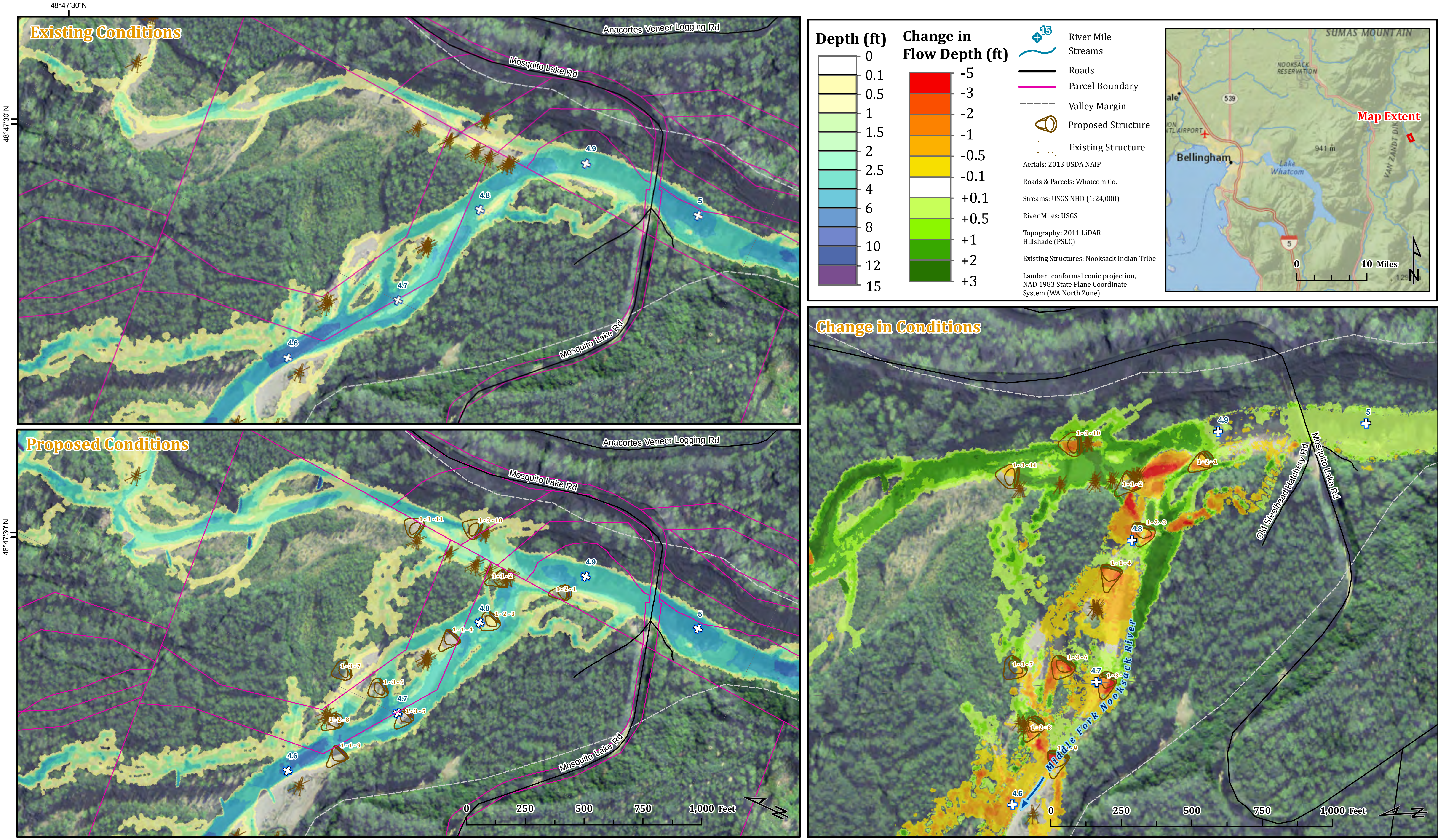
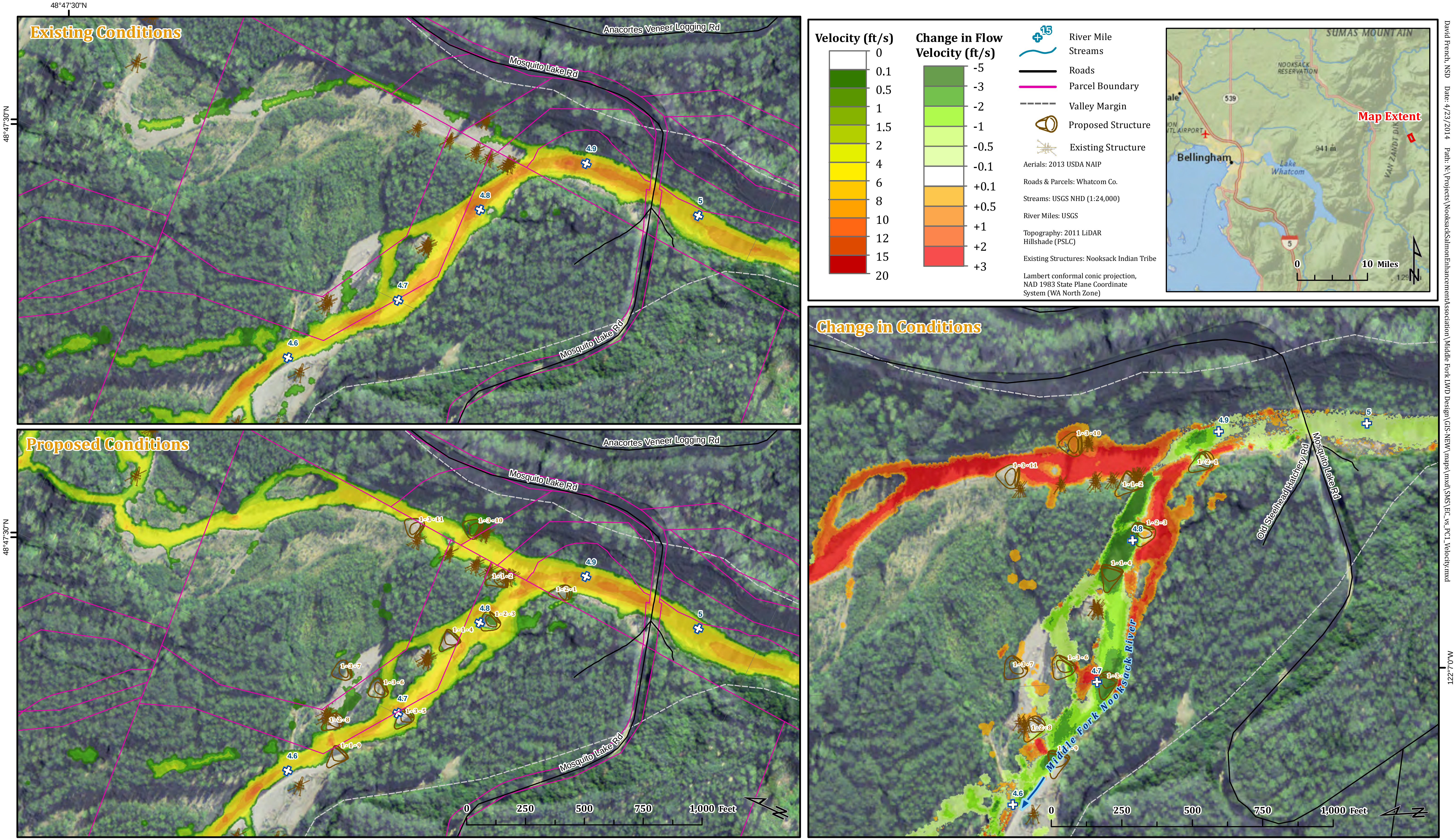


Middle Fork Nooksack River Large Wood Design

Figure 3 - Change in Depth during 1-yr Flow

Hydronia RiverFlo-2D hydraulic model results for 1 year flow event (2,480 cfs) under existing and proposed conditions. Change in conditions derived from difference between proposed and existing.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French



Middle Fork Nooksack River Large Wood Design

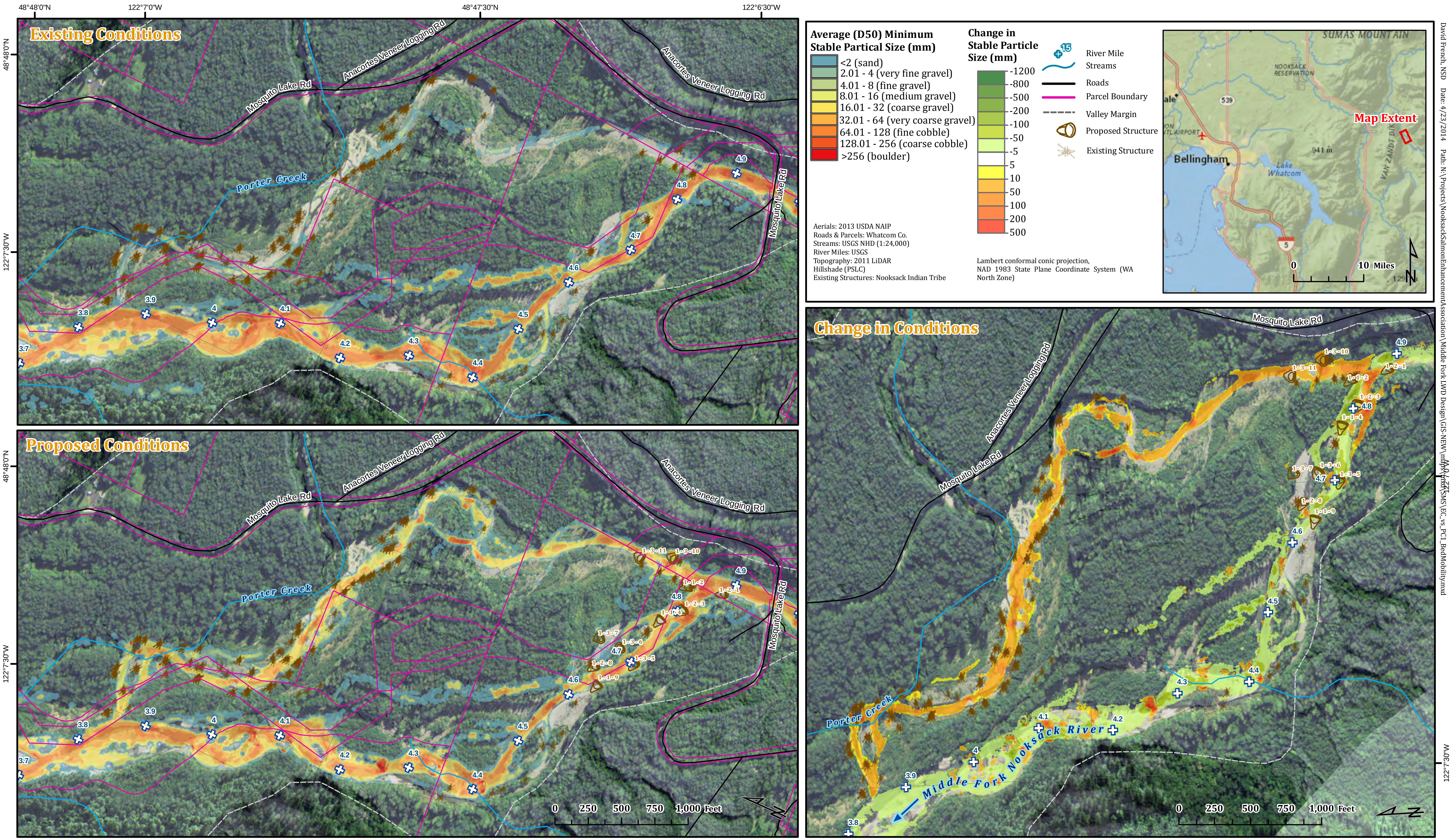
Figure 4 - Change in Velocity during 1-yr Flow

Hydronia RiverFlo-2D hydraulic model results for 1 year flow event (2,480 cfs) under existing and proposed conditions. Change in conditions derived from difference between proposed and existing.

NSD Modeling: G. Dooley, EIT; L. Embertson, P.E., M.S., C.F.M.

QA/QC for NSD Modeling: M. Ericsson, M.S. P.G.; L. Embertson, P.E., M.S., C.F.M.

Drafting: D. French



Middle Fork Nooksack River Large Wood Design

Figure 5 - Change in Minimum Stable Particle Size during 1-yr Flow

Hydronia RiverFlo-2D hydraulic model results for 1 year flow event (2,480 cfs) under existing and proposed conditions. Change in conditions derived from difference between proposed and existing.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French

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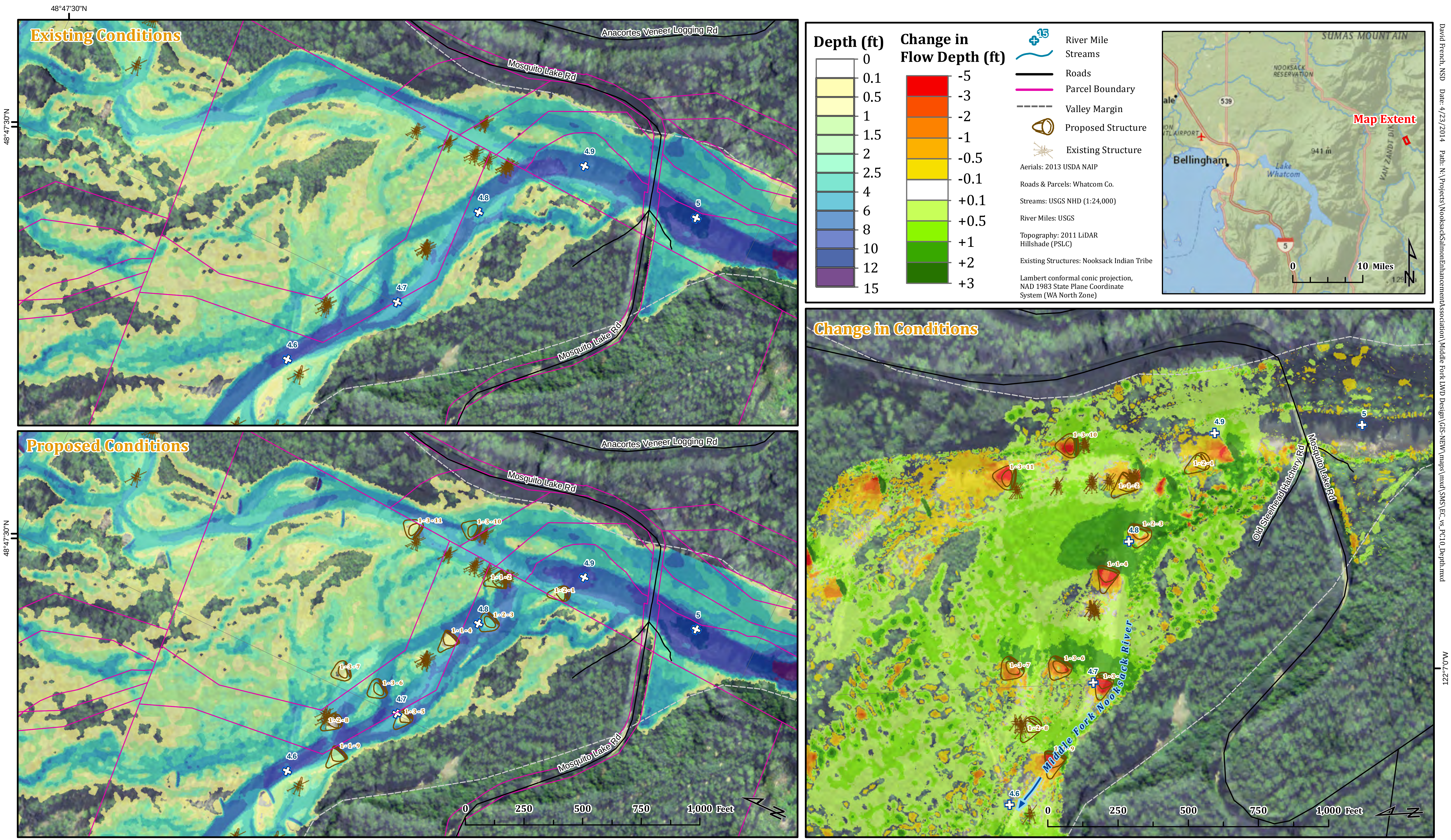
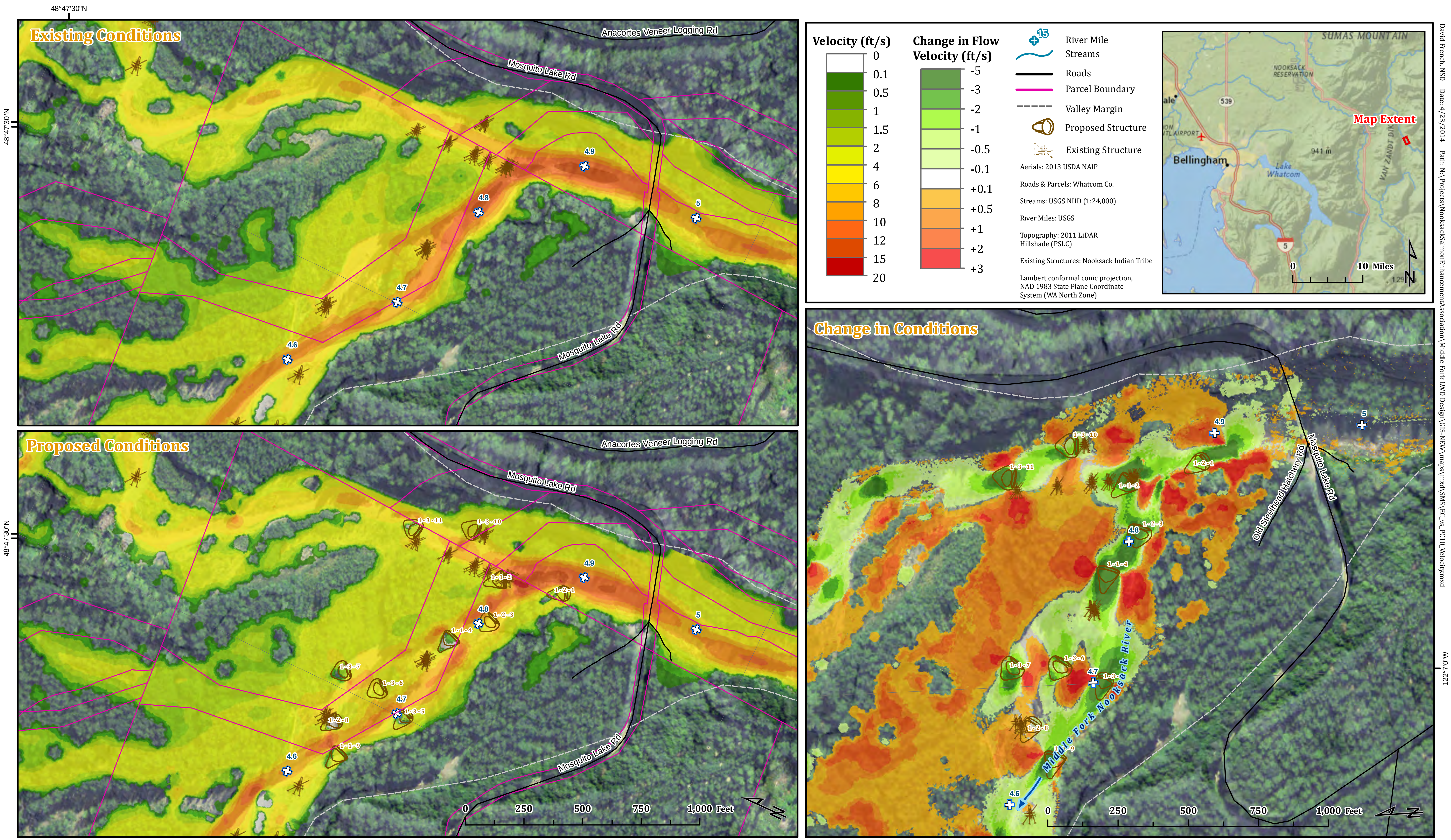


Middle Fork Nooksack River Large Wood Design

Figure 6 - Change in Depth during 10-yr Flow

Hydronia RiverFlo-2D hydraulic model results for 10 year flow event (13,680 cfs) under existing and proposed conditions. Change in conditions derived from difference between proposed and existing.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French



Middle Fork Nooksack River Large Wood Design

Figure 7 - Change in Velocity during 10-yr Flow

Hydronia RiverFlo-2D hydraulic model results for 10 year flow event (13,680 cfs) under existing and proposed conditions. Change in conditions derived from difference between proposed and existing.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French

APPENDIX A

PRELIMINARY DESIGN DRAWINGS

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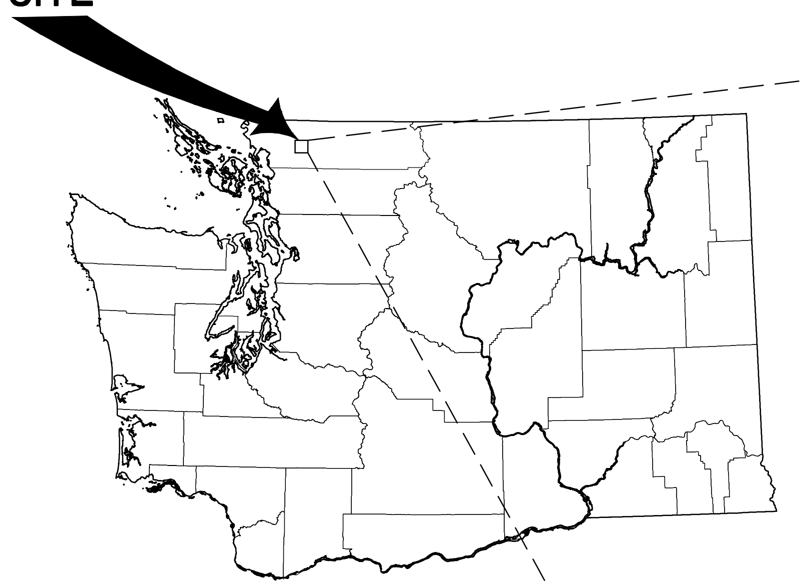
MIDDLE FORK NOOKSACK RESTORATION PHASE 1

PRELIMINARY DESIGN



WASHINGTON STATE
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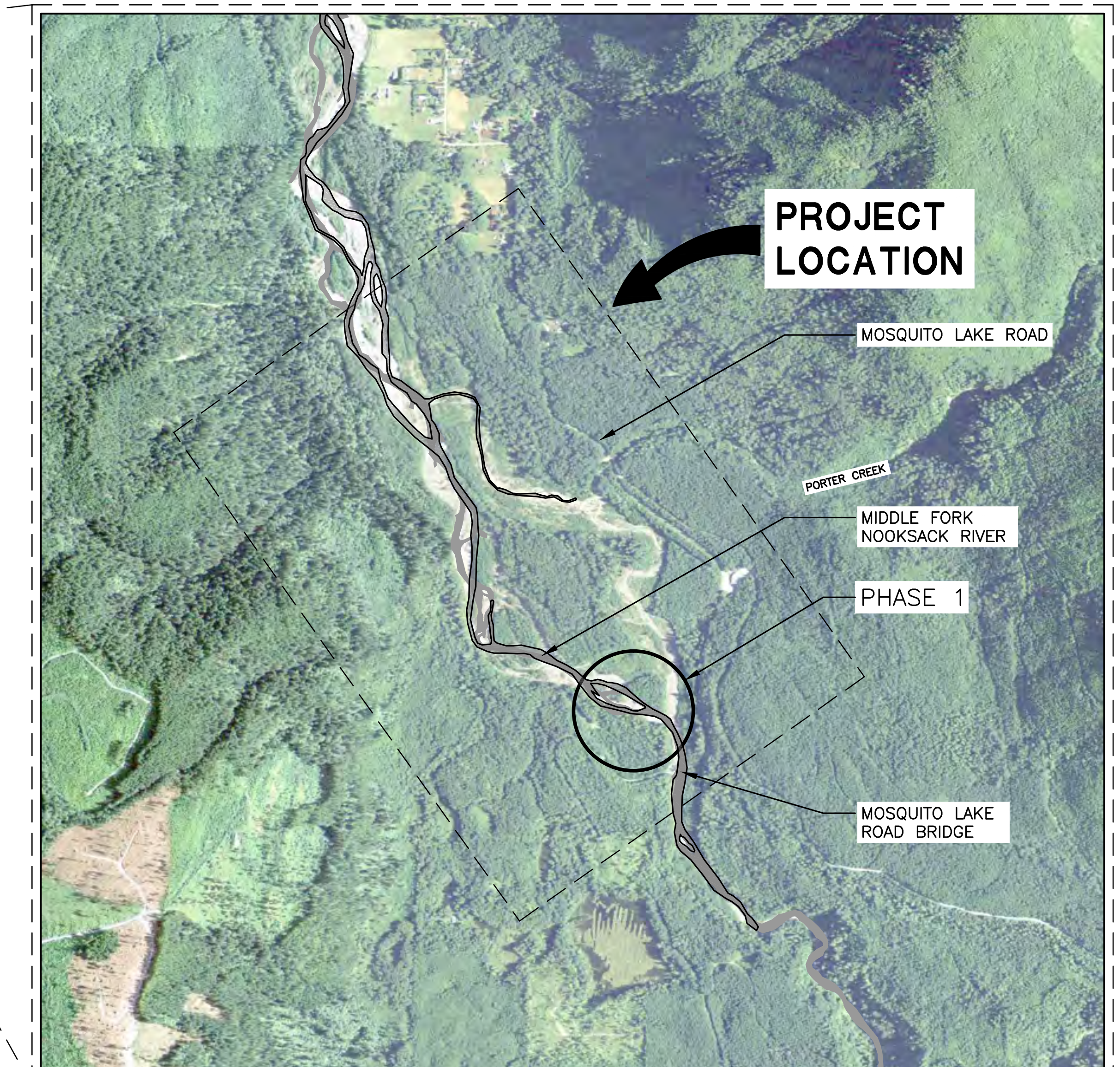

VICINITY MAP
SCALE:1" = 1000'

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SHEET LIST TABLE	
Sheet Number	Sheet Title
1	COVER SHEET
2	GENERAL NOTES
3	LEGEND
4	SITE PLAN
5	PHASE 1
6	TYPE 1 ELJ
7	TYPE 2 ELJ
8	TYPE 3 ELJ
9	RESTORATION DETAILS
10	TESC PLAN
11	TESC DETAILS

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60% PRELIMINARY DESIGN

Jun-2-2014

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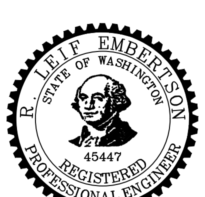

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IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NSEA
NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

NAME OR INITIALS AND DATE	
DESIGNED	RLE
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DRAWN	GD, GM, MW
CHECKED	--

GEOGRAPHIC INFORMATION	
LATITUDE	48°49'00"N
LONGITUDE	122°08'00"W
TN/SC/RG	T38N/S2/R5E
DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

COVER SHEET

1

SHEET 1 OF 11

GENERAL NOTES

1. THESE PLANS HAVE BEEN PREPARED FOR THE EXCLUSIVE USE OF NOOKSACK SALMON ENHANCEMENT ASSOCIATION, HEREAFTER REFERRED TO AS "OWNER" AND THEIR AUTHORIZED AGENTS.

2. NATURAL SYSTEMS DESIGN HEREAFTER REFERRED TO AS "ENGINEER" IS RESPONSIBLE FOR THE PREPARATION OF THESE ORIGINAL PLANS AND ASSOCIATED SPECIFICATIONS AND WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR UNATHORIZED CHANGES TO OR USES OF THESE PLANS. ANY USE WHICH INCLUDES ALTERATION, DELETION, OR EDITING OF THIS DOCUMENT WITHOUT EXPLICIT WRITTEN PERMISSION FROM THE ENGINEER, IS STRICTLY PROHIBITED. ANY OTHER UNAUTHORIZED USE OF THIS DOCUMENT IS PROHIBITED.

3. MINOR MODIFICATIONS ARE EXPECTED TO SUIT JOB SITE DIMENSIONS OR CONDITIONS. SUCH MODIFICATIONS SHALL BE INCLUDED AS PART OF THE WORK. THE OWNER, ENGINEER AND APPROPRIATE REGULATORY AGENCIES WILL BE NOTIFIED OF ANY OWNER–AUTHORIZED CHANGE RESULTING IN MORE THAN A 10% DESIGN CHANGE OF PROPOSED FOOTPRINT OR SIGNIFICANTLY AFFECTING THE INTENDED BENEFIT OR FUNCTION OF A PROJECT ELEMENT.

4. THE LOCATION OF ALL FEATURES SHOWN IS APPROXIMATE.

5. THE CONTRACTOR AGREES TO ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR JOB SITE CONDITIONS DURING THE COURSE OF CONSTRUCTION OF THIS PROJECT, INCLUDING SAFETY OF ALL PERSONS AND PROPERTY, AND FURTHER AGREES THAT THIS REQUIREMENT SHALL APPLY CONTINUOUSLY AND NOT BE LIMITED TO NORMAL WORKING HOURS IN ACCORDANCE WITH THE PROVISIONS OUTLINED BY THE PROJECT CONTRACT AND SPECIFICATIONS.

6. ALL IMPROVEMENTS SHALL BE ACCOMPLISHED UNDER THE APPROVAL, INSPECTION, AND TO THE SATISFACTION OF THE OWNER. IMPROVEMENT CONSTRUCTION SHALL COMPLY WITH THESE PLANS AND THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) STANDARD PLANS FOR CONSTRUCTION OF ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION, CURRENT EDITION UNLESS NOTED OTHERWISE. ALL REFERENCES TO THE "STANDARD SPECIFICATIONS" SHALL MEAN THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) STANDARD SPECIFICATIONS FOR CONSTRUCTION OF LOCAL STREETS AND ROADS, CURRENT EDITION. CONSTRUCTION NOT SPECIFIED ON THESE PLANS SHALL CONFORM TO THE REQUIREMENTS OF THE STANDARD SPECIFICATIONS. THE CONTRACTOR IS OBLIGATED TO BE FAMILIAR WITH APPLICABLE SECTIONS OF THE STANDARD SPECIFICATIONS NOT DISCUSSED IN THE GENERAL NOTES. THE CONTRACT SPECIAL PROVISIONS SHALL SUPERSEDE THOSE OF THE STANDARD SPECIFICATIONS WHERE DISCREPANCIES OCCUR.

7. IT IS THE RESPONSIBILITY OF THE CONTRACTOR AND HIS SUBCONTRACTOR(S) TO EXAMINE THE PROJECT SITE PRIOR TO THE OPENING OF BID PROPOSALS. THE CONTRACTOR SHALL BECOME FAMILIAR WITH THE CONDITIONS UNDER WHICH THE WORK IS TO BE PERFORMED, SUCH AS THE NATURE AND LOCATION OF THE WORK AND THE GENERAL AND LOCAL CONDITIONS, PARTICULARLY THOSE AFFECTING THE AVAILABILITY OF TRANSPORTATION, THE DISPOSAL, HANDLING, AND STORAGE OF MATERIALS, AVAILABILITY OF LABOR, WATER, ELECTRICITY, ROADS, THE UNCERTAINTIES OF WEATHER, THE CONDITIONS OF THE GROUND, SURFACE AND SUBSURFACE MATERIALS, GROUNDWATER, THE EQUIPMENT AND FACILITIES NEEDED FOR AND DURING THE PERFORMANCE OF THE WORK, AND THE COSTS THEREOF. ANY FAILURE BY THE CONTRACTOR AND SUBCONTRACTOR(S) TO ACQUAINT THEMSELVES WITH ALL THE AVAILABLE INFORMATION WILL NOT RELIEVE THE CONTRACTOR AND SUBCONTRACTOR(S) FROM RESPONSIBILITY FOR PROPERLY ESTIMATING THE DIFFICULTY AND COST OF SUCCESSFULLY PERFORMING THE WORK.

8. THE CONTRACTOR IS RESPONSIBLE FOR REVIEWING THE CONTRACT DOCUMENTS AND FOR ALL SUBMITTALS REQUIRED TO THE OWNER FOR REVIEW AND ACCEPTANCE.

PERMIT NOTES

1. EVERY REASONABLE EFFORT SHALL BE MADE TO CONDUCT THE ACTIVITIES SHOWN IN THESE PLANS, IN A MANNER THAT MINIMIZES THE ADVERSE IMPACT ON WATER QUALITY, FISH AND WILDLIFE, AND THE NATURAL ENVIRONMENT.

2. ALL WORK WILL BE IN COMPLIANCE WITH PERMIT CONDITIONS ISSUED BY VARIOUS REGULATORY AGENCIES. IT IS THE CONTRACTOR'S RESPONSIBILITY TO HAVE COPIES OF ALL PERMITS ON THE JOB SITE, UNDERSTAND AND COMPLY WITH ALL PERMIT CONDITIONS.

3. ALL WORK THAT DISTURBS THE SUBSTRATE, BANK, OR SHORE OF A WATERS OF THE STATE THAT CONTAINS FISH LIFE SHALL BE CONDUCTED ONLY DURING THE WORK PERIOD FOR THAT WATERBODY AS INDICATED IN THE MOST RECENT ALLOWABLE WORK PERIODS FOR HYDRAULIC PROJECTS IN FRESHWATER FOR THE PROJECT AREA. THOSE PORTIONS OF THE PROJECT WORK THAT OCCUR OUTSIDE OR ABOVE THE ORDINARY HIGH WATER MARK (ABOVE THE CORPS JURISDICTIONAL LINE) ARE NOT SUBJECT TO THE WORK PERIODS DESCRIBED ABOVE UNLESS SPECIFIED IN THE RELEVANT PERMITS.

4. ALL ACTIVITIES THAT INVOLVE WORK ADJACENT TO OR WITHIN THE WETTED CHANNEL SHALL, AT ALL TIMES, REMAIN CONSISTENT WITH ALL APPLICABLE WATER QUALITY STANDARDS, EFFLUENT LIMITATION AND STANDARDS OF PERFORMANCE, PROHIBITIONS, PRETREATMENT STANDARDS, AND MANAGEMENT PRACTICES ESTABLISHED PURSUANT TO THE CLEAN WATER ACT OR PURSUANT TO APPLICABLE STATE AND LOCAL LAW.

5. IF AT ANY TIME, AS A RESULT OF PROJECT ACTIVITIES, FISH ARE OBSERVED IN DISTRESS, A FISH KILL OCCURS, OR WATER QUALITY PROBLEMS DEVELOP (INCLUDING EQUIPMENT LEAKS OR SPILLS), OPERATIONS SHALL CEASE AND THE OWNER SHALL BE NOTIFIED IMMEDIATELY.

6. IF, DURING CONSTRUCTION, ARCHAEOLOGICAL REMAINS ARE ENCOUNTERED, CONSTRUCTION IN THE VICINITY SHALL BE HALTED, AND THE STATE OFFICE OF HISTORIC PRESERVATION AND THE OWNER SHALL BE NOTIFIED IMMEDIATELY.

SURVEY NOTES

1. UNLESS NOTED OTHERWISE ON THE PLANS, THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROTECTION OF ALL EXISTING SURVEY MONUMENTS AND OTHER SURVEY MARKERS DURING CONSTRUCTION.

2. THE CONTRACTOR SHALL MAINTAIN A SET OF PLANS ON THE JOB SHOWING "AS–CONSTRUCTED" CHANGES MADE TO DATE. UPON COMPLETION OF THE PROJECT, THE CONTRACTOR SHALL SUPPLY TO OWNER A SET OF PLANS, MARKED UP TO THE SATISFACTION OF THE OWNER, REFLECTING THE AS–CONSTRUCTED MODIFICATIONS.

3. ELEVATIONS SHOWN ON THE PLANS FOR PIPE INVERTS, TOPS OF BANKS, THALWEG, GRADE CONTROLS, ETC., ARE BASED UPON THE TOPOGRAPHIC INFORMATION SHOWN ON THE PLANS. THE CONTRACTOR SHALL VERIFY ALL NECESSARY SURFACE ELEVATIONS IN THE FIELD AND NOTIFY THE OWNER OF ANY DISCREPANCIES, WHICH MIGHT AFFECT PROPER OPERATION OF THE NEW FACILITIES BEFORE BREAKING GROUND AND PRIOR TO FACILITY INSTALLATION. THE OWNER SHALL BE CONTACTED IN THE EVENT ELEVATIONS ARE INCORRECT SO THAT THE PROPER ADJUSTMENTS CAN BE MADE BY ENGINEER PRIOR TO THE INSTALLATION OF THE FACILITIES, AS SET FORTH IN THE SPECIAL PROVISIONS.

4. LIDAR FOR THIS PROJECT WAS PROVIDED BY PUGET SOUND LIDAR CONSORTIUM BY WATERSHED SCIENCES, INC. AND IS REPRESENTATIVE OF 2011 CONDITIONS. THE VERTICAL DATUM IS NAVD 88 (FT) GEOID03. THE HORIZONTAL DATUM IS NAD 83 WASHINGTON STATE PLANE NORTH FIPS 4601, US SURVEY FT.

EROSION, SEDIMENT CONTROL AND WATER MANAGEMENT NOTES

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING ALL TEMPORARY EROSION CONTROL MEASURES. THE EROSION CONTROL MEASURES SHALL BE IN ACCORDANCE WITH ALL FEDERAL, STATE, AND LOCAL REQUIREMENTS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE MAINTENANCE AND PERFORMANCE OF THE TEMPORARY EROSION CONTROL MEASURES THROUGHOUT THE DURATION OF THE PROJECT.

2. A SEDIMENT AND EROSION CONTROL PLAN WILL BE DEVELOPED BY THE CONTRACTOR AND SUBMITTED FOR APPROVAL BY OWNER AND/OR THE ENGINEER BEFORE ANY CONSTRUCTION MAY BEGIN. THE SEDIMENT AND EROSION CONTROL PLAN WILL IDENTIFY BEST MANAGEMENT PRACTICES TO ENSURE THAT THE TRANSPORT OF SEDIMENT TO SURFACE WATERS, DRAINAGE SYSTEMS, AND ADJACENT PROPERTIES IS MINIMIZED.

3. ACTIVITIES SHALL BE DESIGNED AND CONSTRUCTED TO AVOID AND MINIMIZE ADVERSE IMPACTS TO WATERS OF THE UNITED STATES TO THE MAXIMUM EXTENT PRACTICAL THROUGH THE USE OF PRACTICAL ALTERNATIVES. ALTERNATIVES THAT SHALL BE CONSIDERED INCLUDE THOSE THAT MINIMIZE THE NUMBER AND EXTENT OF IN–WATER WORK AND EQUIPMENT CROSSINGS OF WETTED CHANNELS.

4. AT NO TIME SHALL SEDIMENT–LADEN WATER BE DISCHARGED OR PUMPED DIRECTLY INTO THE SUBJECT RIVER, STREAM, OR WETLAND. WATER SHALL BE DISCHARGED IN ACCORDANCE WITH REQUIREMENTS SET FORTH IN THE PROJECT PERMITS AND / OR SPECIFICATIONS.

5. IF HIGH WATER LEVEL CONDITIONS THAT CAUSE SILTATION OR EROSION ARE ENCOUNTERED DURING CONSTRUCTION, WORK SHALL STOP UNTIL THE WATER LEVEL SUBSIDES.

6. PERMIT CONDITIONS CONTAIN SPECIFIC REQUIREMENTS FOR THE CONTROL OF EROSION AND TURBIDITY FROM PROJECT OPERATIONS. TURBIDITY WILL BE MONITORED ON A FREQUENT BASIS BY THE PROJECT MANAGEMENT AND INSPECTION STAFF ON–SITE. TURBIDITY AMOUNTS IN EXCESS OF THE PERMITTED CONCENTRATIONS AND/OR DURATIONS WILL CAUSE WORK TO BE STOPPED UNTIL IMPROVED PRACTICES ARE IN EFFECT AND THE PROBLEMS CONTROLLED. THE CONTRACTOR IS COMPLETELY RESPONSIBLE FOR ANY PROJECT DELAYS THAT OCCUR BY NATURE OF THIS FAILURE TO ADEQUATELY CONTAIN SEDIMENT ON–SITE.

7. CONTRACTOR SHALL LIMIT MACHINERY MOVEMENT TO CONSTRUCTION AREAS DEFINED ON SITE PLAN OR IDENTIFIED AS ACCEPTABLE BY THE ENGINEER OR OWNER.

8. ALL EXTERNAL GREASE AND OIL SHALL BE PRESSURE–WASHED OFF THE EQUIPMENT PRIOR TO TRANSPORT TO THE SITE.

9. THE CONTRACTOR IS RESPONSIBLE TO ENSURE THAT NO PETROLEUM PRODUCTS, HYDRAULIC FLUID, SEDIMENTS, SEDIMENT–LADEN WATER, CHEMICALS, OR ANY OTHER TOXIC OR DELETERIOUS MATERIALS ARE ALLOWED TO ENTER OR LEACH INTO THE SUBJECT RIVER, STREAM, OR WETLAND.

10. THE CONTRACTOR SHALL HAVE AN EMERGENCY SPILL KIT ONSITE AT ALL TIMES.

11. NO TREES OR WETLAND VEGETATION SHALL BE REMOVED UNLESS THEY ARE SHOWN AND NOTED TO BE REMOVED ON THE PLANS OR AS DIRECTLY SPECIFIED ON–SITE BY THE PROJECT MANAGEMENT STAFF. ALL TREES CONFLICTING WITH GRADING SHALL BE REMOVED. NO GRADING SHALL TAKE PLACE WITHIN THE DRIP LINE OF TREES NOT TO BE REMOVED UNLESS OTHERWISE APPROVED.

12. FOLLOWING CONSTRUCTION, SITE RESTORATION WILL INCLUDE ESTABLISHING LONG–TERM EROSION PROTECTION MEASURES. THESE MEASURES WILL INCLUDE PLANTINGS, EROSION CONTROL FABRIC, SEED, AND MULCH. EQUIPMENT AND EXCESS SUPPLIES WILL BE REMOVED AND THE WORK AREA WILL BE CLEANED. MAINTENANCE ACTIVITIES FOR THE NEWLY CONSTRUCTED RESTORATION PROJECTS ARE ANTICIPATED TO OCCUR PERIODICALLY.

CONSTRUCTION NOTES

1. CONTRACT DOCUMENTS REFER TO THESE PLANS.

2. CONTRACTOR SHALL FURNISH ALL MATERIALS, EQUIPMENT, AND LABOR NECESSARY TO COMPLETE ALL WORK AS INDICATED IN THE CONTRACT DOCUMENTS.

3. CONSTRUCTION HOURS SHALL BE WEEKDAYS BETWEEN 7:00 A.M. AND 6:30 P.M. UNLESS PRIOR APPROVAL IS RECEIVED FROM THE OWNER.

4. ANY DISCREPANCIES ARE TO BE BROUGHT TO THE ATTENTION OF THE OWNER PRIOR TO PROCEEDING WITH THE WORK.

5. THE CONTRACTOR SHALL INSTALL ALL EQUIPMENT AND MATERIALS IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS UNLESS SPECIFICALLY INDICATED OTHERWISE BY THE OWNER OR WHERE LOCAL CODES OR REGULATIONS TAKE PRECEDENCE.

6. ALL WORK PERFORMED AND MATERIALS INSTALLED SHALL BE IN STRICT ACCORDANCE WITH ALL APPLICABLE CODES, REGULATIONS, AND ORDINANCES.

7. THE CONTRACTOR SHALL SUPERVISE AND DIRECT THE WORK USING THE BEST SKILLS AND ATTENTION. THE CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR ALL CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES, AND PROCEDURES AND FOR COORDINATING ALL PORTIONS OF THE WORK UNDER THIS CONTRACT.

8. THE CONTRACTOR SHALL MAKE ALL NECESSARY PROVISIONS TO PROTECT EXISTING IMPROVEMENTS, ROADWAY, DRAINAGE WAYS, PRIVATE BRIDGE, CULVERTS, AND VEGETATION UNTIL SUCH ITEMS ARE TO BE DISTURBED OR REMOVED AS INDICATED ON THE CONTRACT DOCUMENTS.

9. THE CONTRACTOR SHALL KEEP THE JOB SITE CLEAN AND HAZARD FREE. CONTRACTOR SHALL DISPOSE OF ALL DIRT, DEBRIS, AND RUBBISH FOR THE DURATION OF THE WORK. UPON COMPLETION OF WORK, CONTRACTOR SHALL REMOVE ALL MATERIAL AND EQUIPMENT NOT SPECIFIED AS REMAINING ON THE PROPERTY.

10. NOTES AND DETAILS ON THE PLANS SHALL TAKE PRECEDENCE OVER GENERAL NOTES HEREIN.

11. DIMENSIONS CALLOUTS SHALL TAKE PRECEDENCE OVER SCALES SHOWN ON THE PLANS.

12. THE PLANS REPRESENT THE FINISHED STRUCTURE. THEY DO NOT INDICATE THE METHOD OF ALL CONSTRUCTION. THE CONTRACTOR SHALL PROVIDE ALL MEASURES NECESSARY TO PROTECT THE STRUCTURES, WORKS, AND THE PUBLIC DURING CONSTRUCTION.

13. MATERIAL SHALL NOT BE STORED OUTSIDE OF IDENTIFIED STAGING AREAS. THE CONTRACTOR SHALL USE ONLY DESIGNATED SPECIFIC SITES FOR STORAGE OF EQUIPMENT AND MATERIALS AS SHOWN ON THESE PLANS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE SECURITY OF ALL EQUIPMENT AND MATERIALS.

Jun-2-2014 60% PRELIMINARY DESIGN

R. LEIF EMBERTSON, STATE OF WASHINGTON, 45447, REGISTERED PROFESSIONAL ENGINEER

State of Washington, Licensed Geologist, 1181, Timothy B. Abbe

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NSEA — NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

NAME OR INITIALS AND DATE		GEOGRAPHIC INFORMATION	
DESIGNED	RLE	LATITUDE	48°49'00"N
CHECKED	--	LONGITUDE	122°08'00"W
DRAWN	GD, GM, MW	TN/SC/RG	T38N/S2/R5E
CHECKED	--	DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

GENERAL NOTES

2

GENERAL LEGEND

Symbol	Description
	PROPERTY LINE
	PHASE LINE
ROW — ROW	RIGHT OF WAY LINE
	EXISTING ROAD
CL — CL	CLEARING LIMIT
GL — GL	GRADING LIMIT
-5-	EXISTING MAJOR CONTOUR
-1-	EXISTING MINOR CONTOUR
5	PROPOSED MAJOR CONTOUR
1	PROPOSED MINOR CONTOUR
	LOW FLOW CHANNEL
> > >	EXISTING FLOW
OHWM	EXISTING OHWM
OHWM	PROPOSED OHWM
MHHW	MEAN HIGHER HIGH WATER
MHW — MHW	MEAN HIGH WATER
MLLW	MEAN LOWER LOW WATER
2-YR	2-YEAR FLOOD BOUNDARY
100-YR	100-YEAR FLOOD BOUNDARY
SD — SD	EXISTING STORM SEWER
SS — SS	EXISTING SANITARY SEWER
WL — WL	EXISTING WETLAND
WL — WL	PROPOSED WETLAND
W — W — W	EXISTING WATER
W — W — W	PROPOSED WATER
	CONTROL POINT LOCATION
	VALLEY MARGIN LINE
	RACKING AND SLASH MATERIAL
	LARGE WOOD PIECE
	ENGINEERED LOGJAM TYPE 1, SEE SHEET 6 – TYPE 1 ELJ
	ENGINEERED LOGJAM TYPE 2, SEE SHEET 7 – TYPE 2 ELJ
	ENGINEERED LOGJAM TYPE 3, SEE SHEET 8 – TYPE 3 ELJ
	NATIVE ALLUVIUM
	STREAMBED GRAVEL
	RIPRAP
	BOULDER CLUSTER
	STEEL CABLE
2.8	RIVER MILE

RESTORATION LEGEND

Symbol	Description
	FILL SLOPE LINE
	EXCAVATION SLOPE LINE
	SWALE
	FLOODPLAIN MOUNDS
	FLOODPLAIN DEPRESSIONS
	TRAIL EDGE
	RIPARIAN
	FLOODPLAIN
	UPLAND UNDERPLANTING
	WETLAND UNDERPLANTING

TEMPORARY EROSION CONTROL LEGEND

Symbol	Description
SB — SB	SILT BOOM
BN — BN	BLOCK NETS
SF — SF	SILT FENCE
SW — SW	STRAW WATTLE
	PROPOSED STREAM BYPASS
	PROPOSED STAGING AREA
	BULK BAG COFFERDAM
	TEMPORARY ACCESS ROAD
	PUMP OUTLET LOCATION

DETAIL AND SECTION REFERENCING

Symbol	Description
1	NOTE REFERENCING NUMBER
4 / 6	DETAIL REFERENCE NUMBER SHEET ON WHICH DETAIL APPEARS
4 / 2	DETAIL REFERENCE NUMBER SHEET ON WHICH DETAIL APPEARS
(TYP)	SPECIFIES THAT DETAIL IS UNIFORMLY TYPICAL THROUGHOUT PROJECT EXCEPT WHERE OTHERWISE NOTED
(VAR)	SPECIFIES THAT DETAIL WAS TAKEN FROM SEVERAL SHEETS
A A32	SECTION A–A IS SHOWN ON SHEET 32
SECTION A–A 32 SCALE: NTS	SECTION A–A IS SHOWN ON SHEET 32

R. LEIF EMBERTSON, STATE OF WASHINGTON, REGISTERED PROFESSIONAL ENGINEER, 45447

State of Washington, Hydrogeologist, 1181, Licensed Geologist, Timothy B. Abbe

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DRAWN	GD, GM, MW
CHECKED	--

GEOGRAPHIC INFORMATION	
LATITUDE	48°49'00"N
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TN/SC/RG	T38N/S2/R5E
DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

LEGEND

3

SHEET 3 OF 11

Jun-2-2014 60% PRELIMINARY DESIGN

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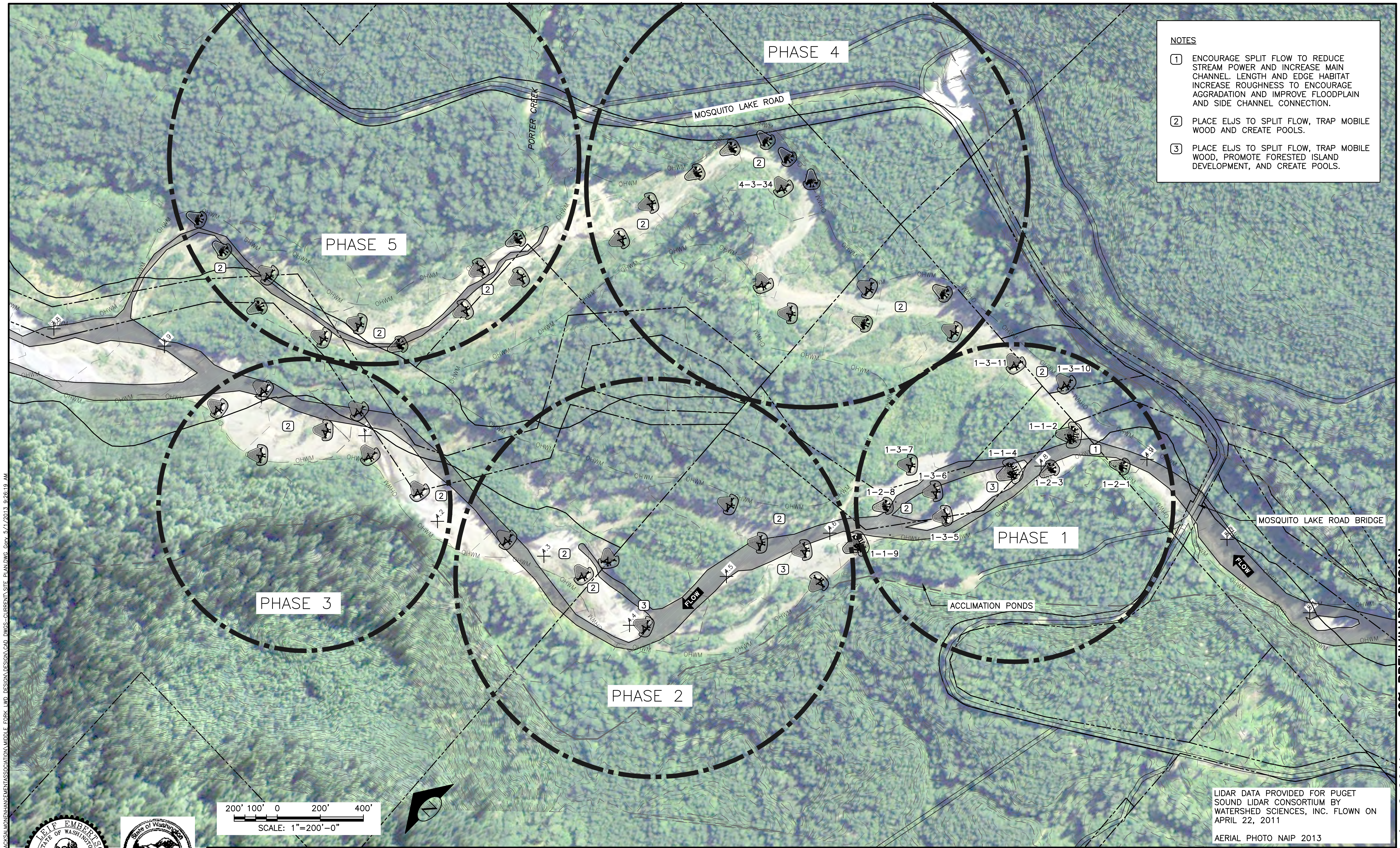

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State of Washington, Licensed Geologist, Timothy B. Abbe

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Natural Systems Design

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CHECKED	--

GEOGRAPHIC INFORMATION	
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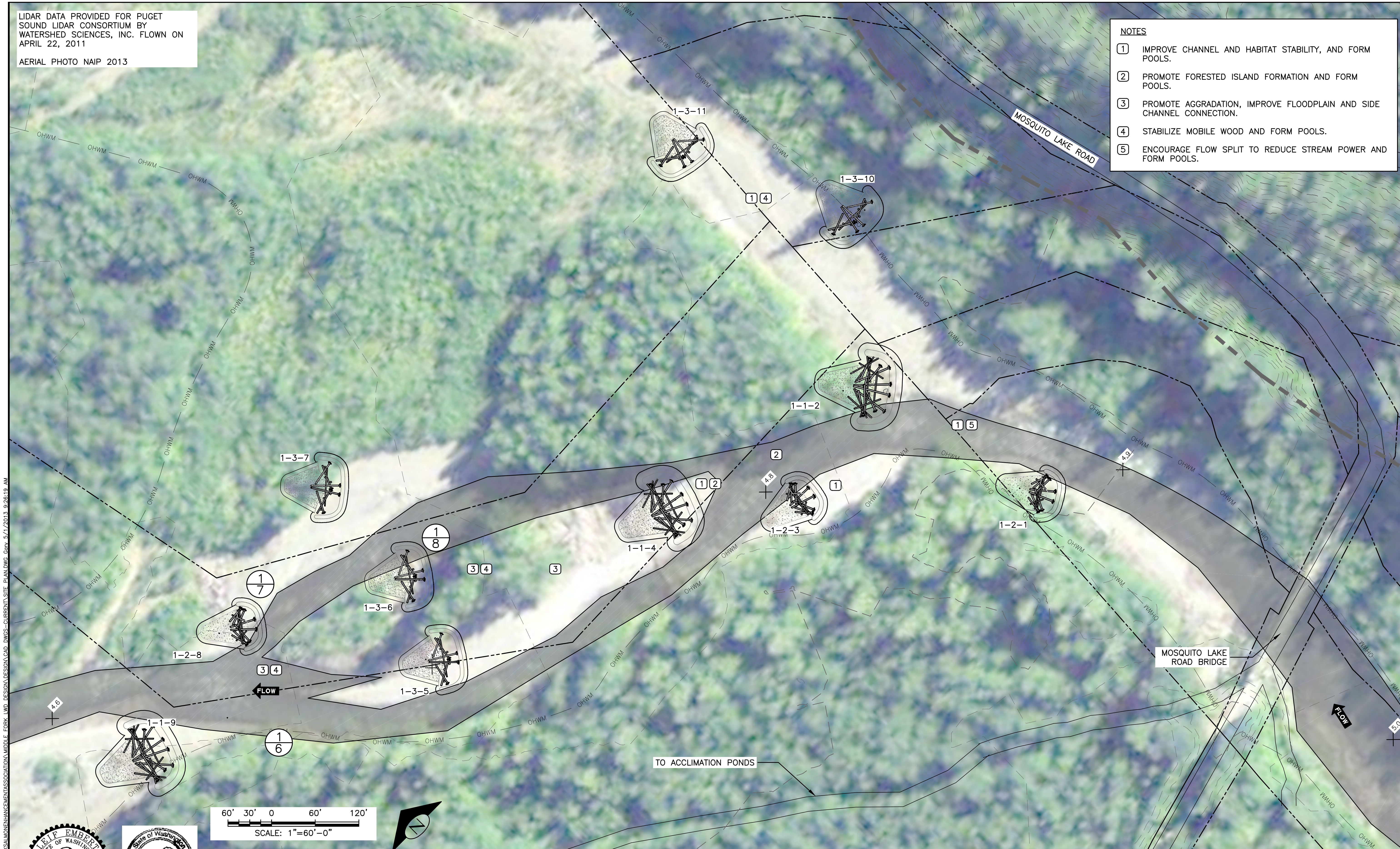
LONGITUDE	122°08'00"W
TN/SC/RG	T38N/S2/R5E
DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

SITE PLAN

4

SHEET 4 OF 11



NOTES

1. IMPROVE CHANNEL AND HABITAT STABILITY, AND FORM POOLS.
2. PROMOTE FORESTED ISLAND FORMATION AND FORM POOLS.
3. PROMOTE AGGRADATION, IMPROVE FLOODPLAIN AND SIDE CHANNEL CONNECTION.
4. STABILIZE MOBILE WOOD AND FORM POOLS.
5. ENCOURAGE FLOW SPLIT TO REDUCE STREAM POWER AND FORM POOLS.

60% PRELIMINARY DESIGN

Jun-2-2014

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State of Washington Licensed Geologist, Hydrogeologist 1161, Timothy B. Abbe

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CHECKED	--

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DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

PHASE 1

5

SHEET 5 OF 11

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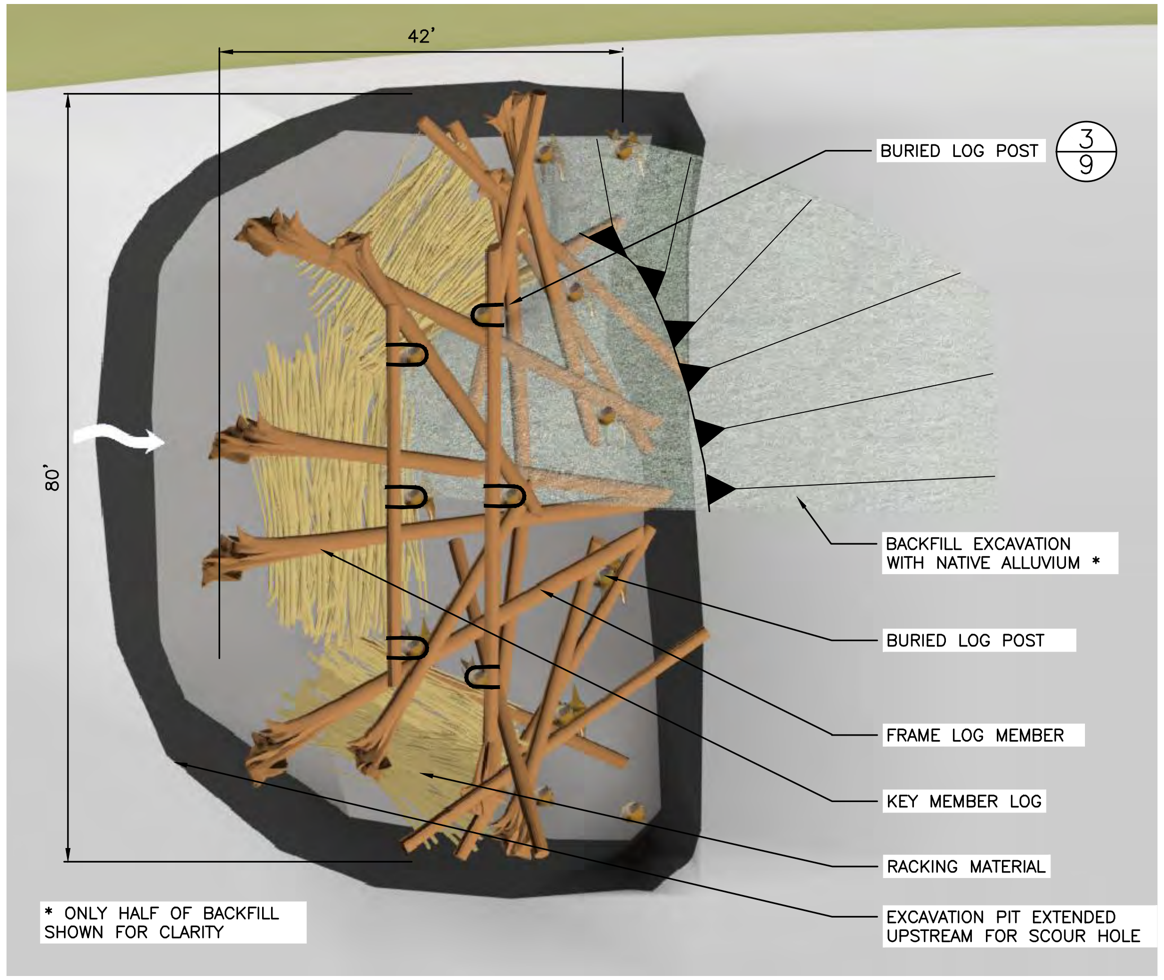


TYPE 1 ELJ PLAN

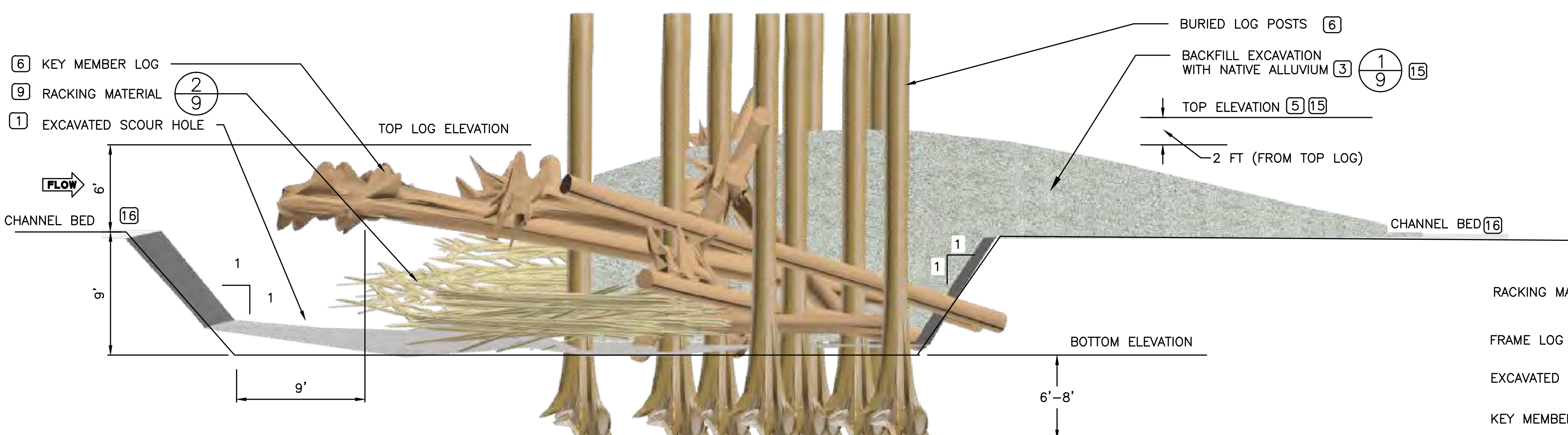
SCALE: 1"=10'

TYPE 1 ELJ STRUCTURE SCHEDULE – PHASE 1

STRUCTURE LABEL*	**	**	**	**	**	**	**	**	**
STRUCTURE LENGTH, (ft)	**	**	**	**	**	**	**	**	**
MINIMUM FRAME LOG DIAMETER, (in)	**	**	**	**	**	**	**	**	**
MINIMUM KEY LOG DIAMETER, (in)	**	**	**	**	**	**	**	**	**
TIMBER POST DIAMETER, (in)	**	**	**	**	**	**	**	**	**
GROUND ELEVATION AT STRUCTURE, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
STRUCTURE BOTTOM ELEVATION, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
TOP LOG ELEVATION, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
STRUCTURE TOP ELEVATION, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
MINIMUM PILE TIP ELEVATIONS, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
AVERAGE SEPTEMBER WATER SURFACE ELEVATION (ft-NAVD 88)	**	**	**	**	**	**	**	**	**
Label format, Phase-ELJ Type-ELJ Number									
***TBD - To be determined and verified at final design phase*									

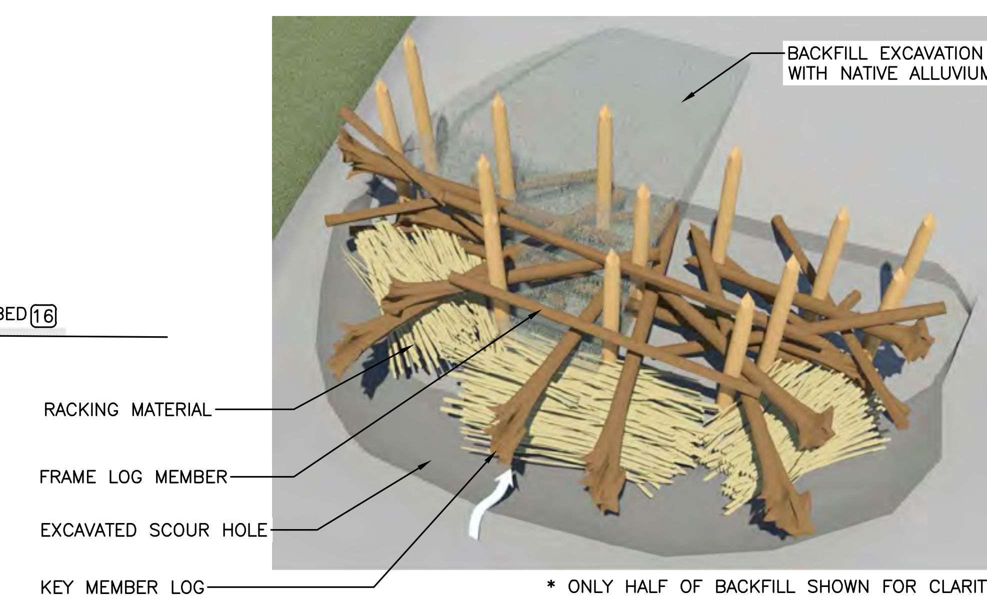
TYPE 1 ELJ STRUCTURE NOTES

1. EXCAVATE IN FRONT OF LOGJAM FOR PLACEMENT OF RACKING MATERIAL. EXCAVATION AREA SHALL NOT BE BACKFILLED WITH ALLUVIUM, BUT LEFT AS A SCOUR HOLE.
2. EXCAVATION SPOILS SHALL BE STAGED ACCORDING TO THE SWPPP. SPOILS SHALL ALSO BE STOCKPILED TO ALLOW LOG LAYER PLACEMENT AND CONSTRUCTION ACCESS.
3. BACKFILL EXTENTS MAY VARY AND TO BE CONSTRUCTED WITH NATIVE ALLUVIUM FROM EXCAVATION SPOILS.
4. BACKFILL EACH STRUCTURE LAYER WITH NATIVE ALLUVIUM FLUSH WITH THE CURRENT LAYER PRIOR TO PLACEMENT OF THE SUBSEQUENT LAYER.
5. FINAL ELJ HEIGHT TO BE ACHIEVED AS SPECIFIED REGARDLESS OF ACTUAL LOG DIAMETERS USED OR STACKING ARRANGEMENT.
6. ALL LARGE WOOD DIMENSIONS DO NOT INCLUDE BARK THICKNESS.
7. COVER TOP OF BACKFILL AREA AND BASE OF STRUCTURES 6–12 INCHES WITH LOOSE WOOD DEBRIS AND CHIPS.
8. CABLE FRAME LOG MEMBERS PER INSTRUCTIONS ON LAYERING PLAN TO VERTICAL POSTS WITH 1/2 INCH GALVANIZED STEEL CABLE AND 4 CABLE CLAMPS PER LASHING. STAPLES WILL NOT BE USED TO FASTEN CABLE ENDS TOGETHER. ALL CLAMPS AND HAND SPLICING SHALL BE PER THE MANUFACTURER SPECIFICATIONS TIGHTEN CABLE TO APPROXIMATELY 500–POUNDS TENSION.
9. RACKING MATERIAL SHALL CONSIST OF APPROXIMATELY 150 CU. YDS PER STRUCTURE WITH 6" – 12" DIA DBH AND A MINIMUM OF 5–FEET LENGTH. RACKING PLACEMENT SHALL OCCUR WITH EACH LAYER PLACEMENT TO ENSURE RACKING MATERIAL EXTENDS THROUGH STRUCTURE AND PINNED IN PLACE BY SUBSEQUENT LAYERS.
10. THE CONTRACTOR SHALL FIELD VERIFY WITH THE OWNER REPRESENTATIVE OR ENGINEER ALL STRUCTURE LOCATIONS, PILE LOCATIONS, LENGTHS, WIDTHS AND ELEVATIONS PRIOR TO EXCAVATION, ASSEMBLY AND INSTALLATION OF EACH STRUCTURE.
11. LOCATIONS FOR ALL STRUCTURE PLACEMENTS WILL BE STAKED IN FIELD BY THE ENGINEER OR OWNER REPRESENTATIVE PRIOR TO START OF CONSTRUCTION.
12. EXCAVATION LIMITS SHALL BE FIELD VERIFIED BY THE OWNER REPRESENTATIVE OR ENGINEER PRIOR TO EXCAVATION COMMENCING AND PLACEMENT OF ANY LARGE WOOD.
13. LOG TYPE IDENTIFICATION SHALL BE PAINTED ON ALL LOGS BY THE CONTRACTOR IN A PLACE VISIBLE FOR FIELD VERIFICATION PRIOR TO PLACEMENT WITH LEAD–FREE, BLAZE–ORANGE SURVEY MARKING PAINT.
14. THE WOOD LAYER PLACEMENT IN EACH LOGJAM LAYER SHALL BE FIELD VERIFIED BY ON–SITE OWNER REPRESENTATIVE PRIOR TO BACKFILLING.
15. BACKFILL NOT TO EXCEED TOP ELEVATION. EXCESS BACKFILL TO BE PLACED DOWNSTREAM OF FINISHED ELJ.
16. CHANNEL BED ELEVATION IS REPRESENTATIVE OF A LOCAL AVERAGE CHANNEL BED AT RIFFLES. CHANNEL BED ELEVATION SHOULD NOT BE TAKEN IN POOLS.



TYPE 1 ELJ PROFILE

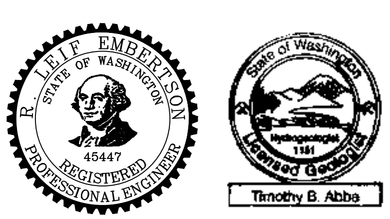
SCALE: 1"=5'



TYPE 1 ELJ PERSPECTIVE

60% PRELIMINARY DESIGN

Jun-2-2014



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NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

NAME OR INITIALS AND DATE		GEOGRAPHIC INFORMATION	
DESIGNED	RLE	LATITUDE	48°49'00"N
CHECKED	--	LONGITUDE	122°08'00"W
DRAWN	GD, GM, MW	TN/SC/RG	T38N/S2/R5E
CHECKED	--	DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

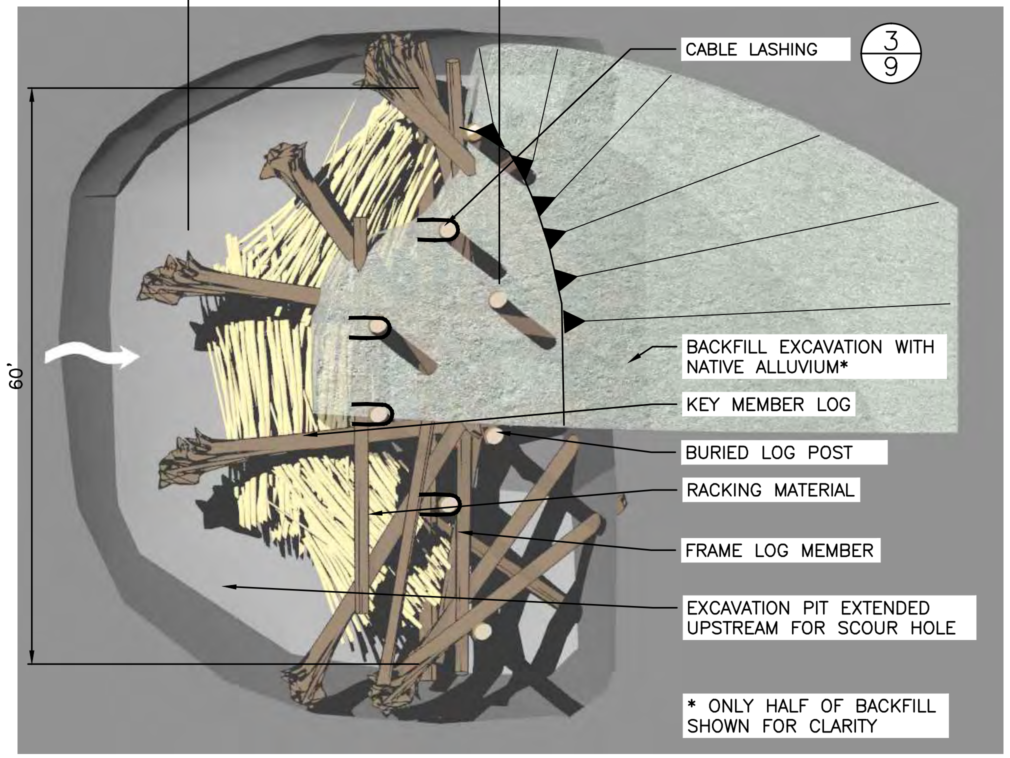
TYPE 1 ELJ

6

SHEET 6 OF 11

TYPE 2 ELJ STRUCTURE SCHEDULE – PHASE 1

STRUCTURE LABEL*	**	**	**	**	**	**	**	**	**
STRUCTURE WIDTH, (ft)	**	**	**	**	**	**	**	**	**
STRUCTURE LENGTH, (ft)	**	**	**	**	**	**	**	**	**
MINIMUM FRAME LOG DIAMETER, (in)	**	**	**	**	**	**	**	**	**
MINIMUM KEY LOG DIAMETER, (in)	**	**	**	**	**	**	**	**	**
TIMBER POST DIAMETER, (in)	**	**	**	**	**	**	**	**	**
GROUND ELEVATION AT STRUCTURE, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
STRUCTURE BOTTOM ELEVATION, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
TOP LOG ELEVATION, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
STRUCTURE TOP ELEVATION, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
MINIMUM PILE TIP ELEVATIONS, (ft-NAVD88)	**	**	**	**	**	**	**	**	**
AVERAGE SEPTEMBER WATER SURFACE ELEVATION (ft-NAVD 88)	**	**	**	**	**	**	**	**	**
** Label format, Phase-ELJ Type-ELJ Number*									
***TBD - To be determined at final design phase*									

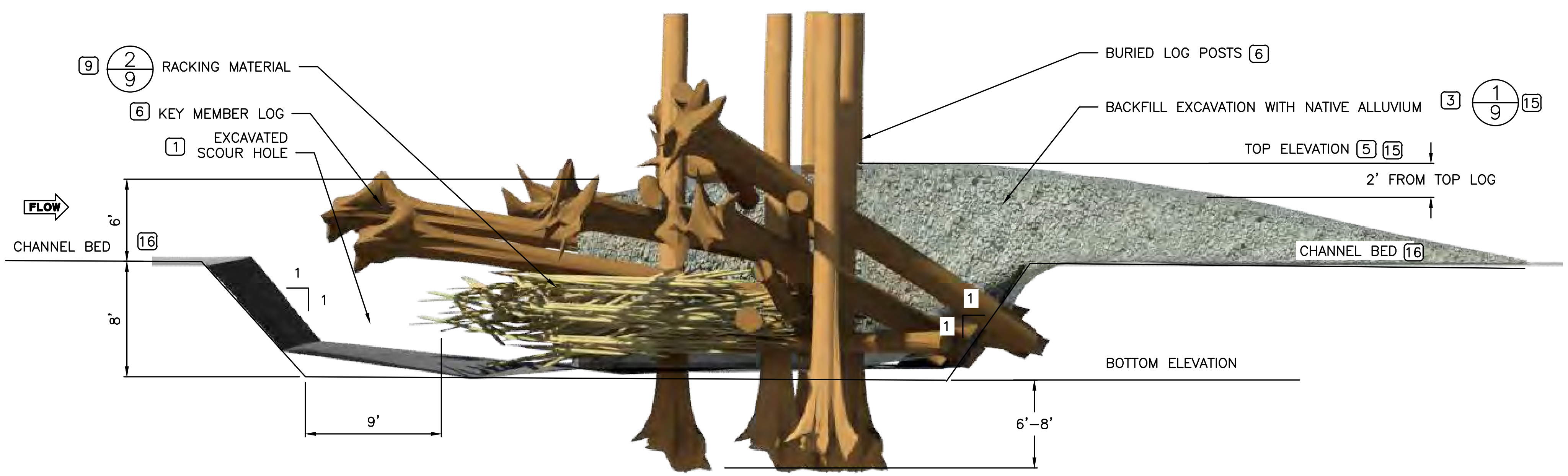


TYPE 2 ELJ PLAN

SCALE: 1" = 10'

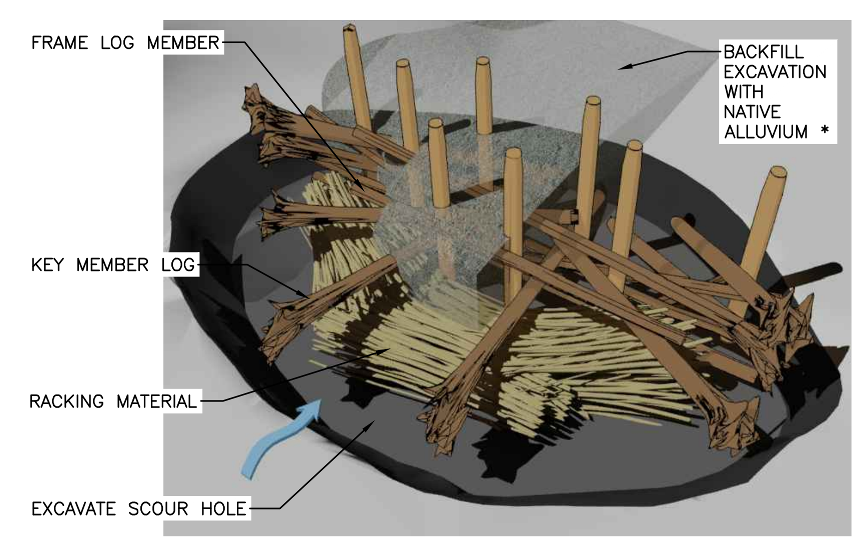
TYPE 2 ELJ STRUCTURE NOTES

1. EXCAVATE IN FRONT OF LOGJAM FOR PLACEMENT OF RACKING MATERIAL. EXCAVATION AREA SHALL NOT BE BACKFILLED WITH ALLUVIUM, BUT LEFT AS A SCOUR HOLE.
2. EXCAVATION SPOILS SHALL BE STAGED ACCORDING TO THE SWPPP. SPOILS SHALL ALSO BE STOCKPILED TO ALLOW LOG LAYER PLACEMENT AND CONSTRUCTION ACCESS.
3. BACKFILL EXTENTS MAY VARY AND TO BE CONSTRUCTED WITH NATIVE ALLUVIUM FROM EXCAVATION SPOILS.
4. BACKFILL EACH STRUCTURE LAYER WITH NATIVE ALLUVIUM FLUSH WITH THE CURRENT LAYER PRIOR TO PLACEMENT OF THE SUBSEQUENT LAYER.
5. FINAL ELJ HEIGHT TO BE ACHIEVED AS SPECIFIED REGARDLESS OF ACTUAL LOG DIAMETERS USED OR STACKING ARRANGEMENT.
6. ALL LARGE WOOD DIMENSIONS DO NOT INCLUDE BARK THICKNESS.
7. COVER TOP OF BACKFILL AREA AND BASE OF STRUCTURES 6-12 INCHES WITH LOOSE WOOD DEBRIS AND CHIPS.
8. CABLE FRAME LOG MEMBERS PER INSTRUCTIONS ON LAYERING PLAN TO VERTICAL POSTS WITH 1/2 INCH GALVANIZED STEEL CABLE AND 4 CABLE CLAMPS PER LASHING. STAPLES WILL NOT BE USED TO FASTEN CABLE ENDS TOGETHER. ALL CLAMPS AND HAND SPLICING SHALL BE PER THE MANUFACTURER SPECIFICATIONS TIGHTEN CABLE TO APPROXIMATELY 500-POUNDS TENSION.
9. RACKING MATERIAL SHALL CONSIST OF APPROXIMATELY 110 CU YARDS PER STRUCTURE WITH 6" – 12" DIA DBH AND A MINIMUM OF 5-FEET LENGTH. RACKING PLACEMENT SHALL OCCUR WITH EACH LAYER PLACEMENT TO ENSURE RACKING MATERIAL EXTENDS THROUGH STRUCTURE AND PINNED IN PLACE BY SUBSEQUENT LAYERS.
10. THE CONTRACTOR SHALL FIELD VERIFY WITH THE OWNER REPRESENTATIVE OR ENGINEER ALL STRUCTURE LOCATIONS, PILE LOCATIONS, LENGTHS, WIDTHS AND ELEVATIONS PRIOR TO EXCAVATION, ASSEMBLY AND INSTALLATION OF EACH STRUCTURE.
11. LOCATIONS FOR ALL STRUCTURE PLACEMENTS WILL BE STAKED IN FIELD BY THE ENGINEER OR OWNER REPRESENTATIVE PRIOR TO START OF CONSTRUCTION.
12. EXCAVATION LIMITS SHALL BE FIELD VERIFIED BY THE OWNER REPRESENTATIVE OR ENGINEER PRIOR TO EXCAVATION COMMENCING AND PLACEMENT OF ANY LARGE WOOD.
13. LOG TYPE IDENTIFICATION SHALL BE PAINTED ON ALL LOGS BY THE CONTRACTOR IN A PLACE VISIBLE FOR FIELD VERIFICATION PRIOR TO PLACEMENT WITH LEAD-FREE, BLAZE-ORANGE SURVEY MARKING PAINT.
14. THE WOOD LAYER PLACEMENT IN EACH LOGJAM LAYER SHALL BE FIELD VERIFIED BY ON-SITE OWNER REPRESENTATIVE PRIOR TO BACKFILLING.
15. BACKFILL NOT TO EXCEED TOP ELEVATION. EXCESS BACKFILL TO BE PLACED DOWNSTREAM OF FINISHED ELJ.
16. CHANNEL BED ELEVATION IS REPRESENTATIVE OF A LOCAL AVERAGE CHANNEL BED AT RIFFLES. CHANNEL BED ELEVATION SHOULD NOT BE TAKEN IN POOLS.



TYPE 2 ELJ PROFILE

SCALE: 1" = 5'



* ONLY HALF OF BACKFILL SHOWN FOR CLARITY

TYPE 2 ELJ PERSPECTIVE

60% PRELIMINARY DESIGN

Jun-2-2014

R. LEIF EMBERTSON, STATE OF WASHINGTON, 45447, REGISTERED PROFESSIONAL ENGINEER

State of Washington, Hydrogeologist 1181, Licensed Geologist, Timothy B. Abbe

0 Ø 1

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NSEA — NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

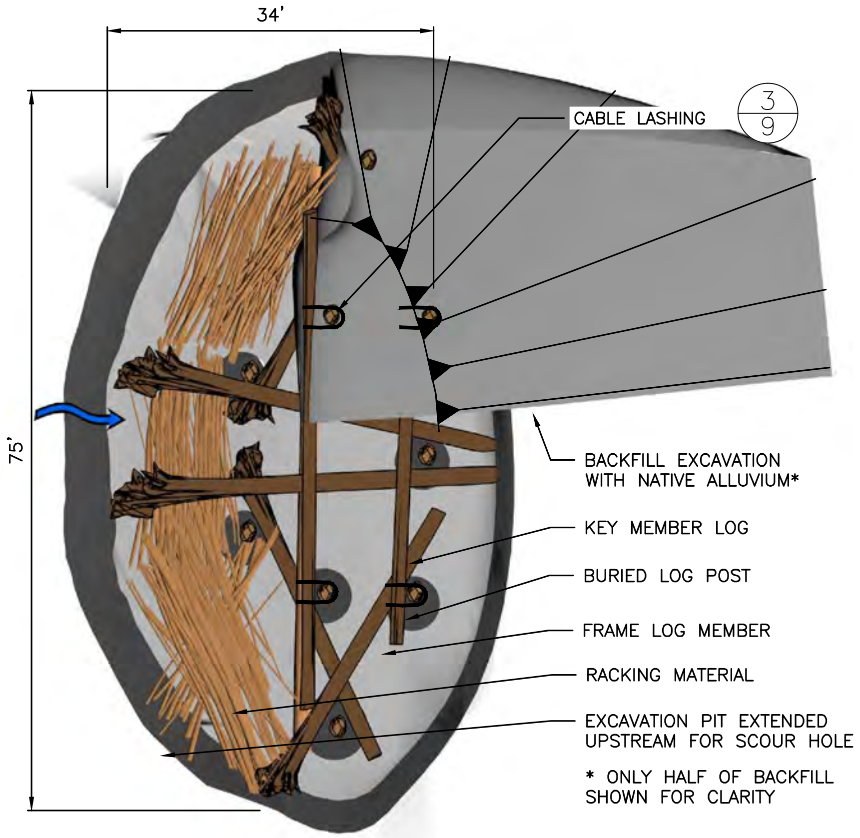
NAME OR INITIALS AND DATE		GEOGRAPHIC INFORMATION	
DESIGNED	RLE	LATITUDE	48°49'00"N
CHECKED	TA	LONGITUDE	122°08'00"W
DRAWN	GB, GM, MW	TN/SC/RG	T38N/S2/R5E
CHECKED	RLE	DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

TYPE 2 ELJ

7

SHEET 7 OF 11



TYPE 3 ELJ PLAN

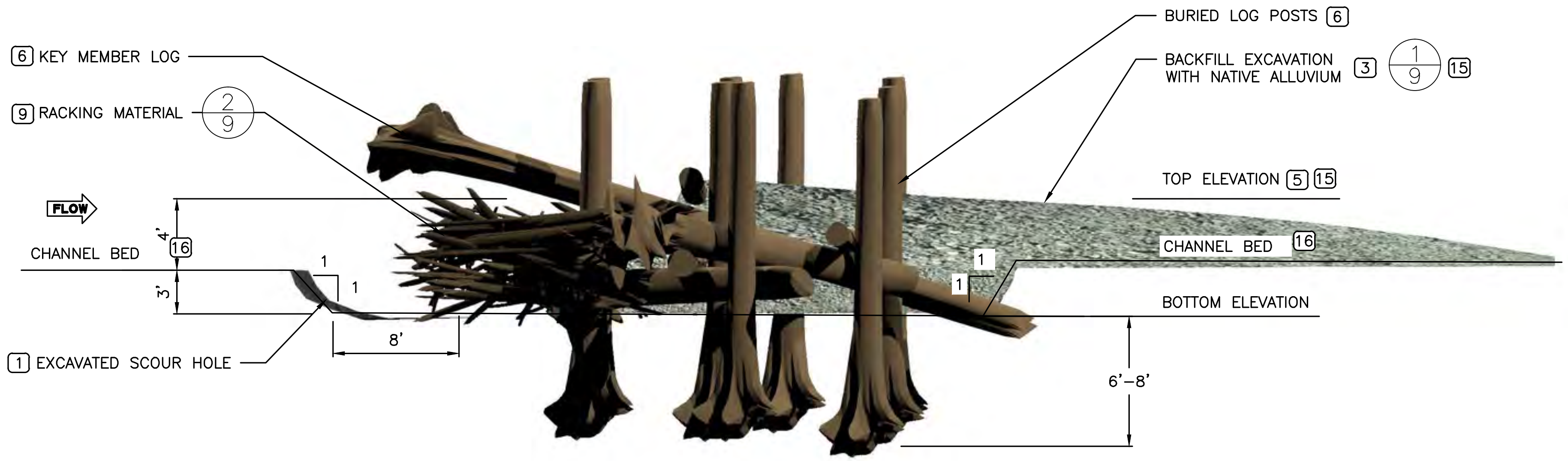
SCALE: 1"=10'

TYPE 3 ELJ STRUCTURE SCHEDULE – PHASE 1

STRUCTURE LABEL*	**	**	**	**	**	**	**	**	**
STRUCTURE WIDTH, (ft)	**	**	**	**	**	**	**	**	**
STRUCTURE LENGTH, (ft)	**	**	**	**	**	**	**	**	**
MINIMUM FRAME LOG DIAMETER, (in)	**	**	**	**	**	**	**	**	**
MINIMUM KEY LOG DIAMETER, (in)	**	**	**	**	**	**	**	**	**
TIMBER POST DIAMETER, (in)	**	**	**	**	**	**	**	**	**
GROUND ELEVATION AT STRUCTURE, (ft–NAVD88)	**	**	**	**	**	**	**	**	**
STRUCTURE BOTTOM ELEVATION, (ft–NAVD88)	**	**	**	**	**	**	**	**	**
TOP LOG ELEVATION, (ft–NAVD88)	**	**	**	**	**	**	**	**	**
STRUCTURE TOP ELEVATION, (ft–NAVD88)	**	**	**	**	**	**	**	**	**
MINIMUM PILE TIP ELEVATIONS, (ft–NAVD88)	**	**	**	**	**	**	**	**	**
AVERAGE SEPTEMBER WATER SURFACE ELEVATION (ft–NAVD 88)	**	**	**	**	**	**	**	**	**
* Label format, Phase–ELJ Type–ELJ Number									
**TBD – To be determined at final design phase									

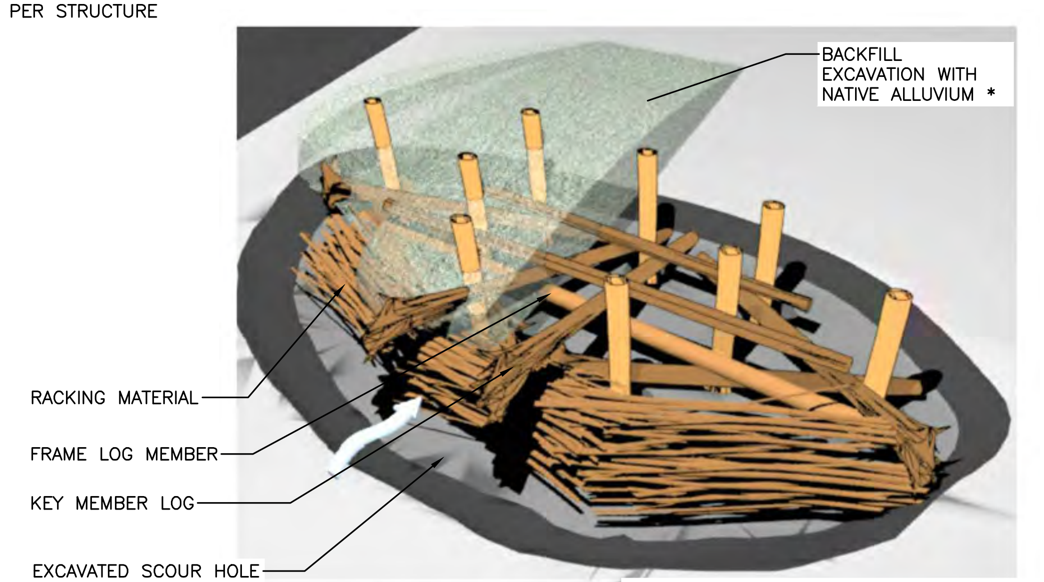
TYPE 3 ELJ STRUCTURE NOTES

1. EXCAVATE IN FRONT OF LOGJAM FOR PLACEMENT OF RACKING MATERIAL. EXCAVATION AREA SHALL NOT BE BACKFILLED WITH ALLUVIUM, BUT LEFT AS A SCOUR HOLE.
2. EXCAVATION SPOILS SHALL BE STAGED ACCORDING TO THE SWPPP. SPOILS SHALL ALSO BE STOCKPILED TO ALLOW LOG LAYER PLACEMENT AND CONSTRUCTION ACCESS.
3. BACKFILL EXTENTS MAY VARY AND TO BE CONSTRUCTED WITH NATIVE ALLUVIUM FROM EXCAVATION SPOILS.
4. BACKFILL EACH STRUCTURE LAYER WITH NATIVE ALLUVIUM FLUSH WITH THE CURRENT LAYER PRIOR TO PLACEMENT OF THE SUBSEQUENT LAYER.
5. FINAL ELJ HEIGHT TO BE ACHIEVED AS SPECIFIED REGARDLESS OF ACTUAL LOG DIAMETERS USED OR STACKING ARRANGEMENT.
6. ALL LARGE WOOD DIMENSIONS DO NOT INCLUDE BARK THICKNESS.
7. COVER TOP OF BACKFILL AREA AND BASE OF STRUCTURES 6–12 INCHES WITH LOOSE WOOD DEBRIS AND CHIPS.
8. CABLE FRAME LOG MEMBERS PER INSTRUCTIONS ON LAYERING PLAN TO VERTICAL POSTS WITH 1/2 INCH GALVANIZED STEEL CABLE AND 4 CABLE CLAMPS PER LASHING. STAPLES WILL NOT BE USED TO FASTEN CABLE ENDS TOGETHER. ALL CLAMPS AND HAND SPLICING SHALL BE PER THE MANUFACTURER SPECIFICATIONS TIGHTEN CABLE TO APPROXIMATELY 500–POUNDS TENSION.
9. RACKING MATERIAL SHALL CONSIST OF APPROXIMATELY 150 CU. YDS PER STRUCTURE WITH 6" – 12" DIA DBH AND A MINIMUM OF 5–FEET LENGTH. RACKING PLACEMENT SHALL OCCUR WITH EACH LAYER PLACEMENT TO ENSURE RACKING MATERIAL EXTENDS THROUGH STRUCTURE AND PINNED IN PLACE BY SUBSEQUENT LAYERS.
10. THE CONTRACTOR SHALL FIELD VERIFY WITH THE OWNER REPRESENTATIVE OR ENGINEER ALL STRUCTURE LOCATIONS, PILE LOCATIONS, LENGTHS, WIDTHS AND ELEVATIONS PRIOR TO EXCAVATION, ASSEMBLY AND INSTALLATION OF EACH STRUCTURE.
11. LOCATIONS FOR ALL STRUCTURE PLACEMENTS WILL BE STAKED IN FIELD BY THE ENGINEER OR OWNER REPRESENTATIVE PRIOR TO START OF CONSTRUCTION.
12. EXCAVATION LIMITS SHALL BE FIELD VERIFIED BY THE OWNER REPRESENTATIVE OR ENGINEER PRIOR TO EXCAVATION COMMENCING AND PLACEMENT OF ANY LARGE WOOD.
13. LOG TYPE IDENTIFICATION SHALL BE PAINTED ON ALL LOGS BY THE CONTRACTOR IN A PLACE VISIBLE FOR FIELD VERIFICATION PRIOR TO PLACEMENT WITH LEAD–FREE, BLAZE–ORANGE SURVEY MARKING PAINT.
14. THE WOOD LAYER PLACEMENT IN EACH LOGJAM LAYER SHALL BE FIELD VERIFIED BY ON–SITE OWNER REPRESENTATIVE PRIOR TO BACKFILLING.
15. BACKFILL NOT TO EXCEED TOP ELEVATION. EXCESS BACKFILL TO BE PLACED DOWNSTREAM OF FINISHED ELJ.
16. CHANNEL BED ELEVATION IS REPRESENTATIVE OF A LOCAL AVERAGE CHANNEL BED AT RIFFLES. CHANNEL BED ELEVATION SHOULD NOT BE TAKEN IN POOLS.



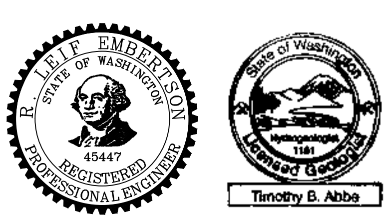
TYPE 3 ELJ PROFILE

SCALE: 1"=5'



* ONLY HALF OF BACKFILL SHOWN FOR CLARITY

TYPE 3 ELJ PERSPECTIVE



IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NSEA NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

NAME OR INITIALS AND DATE		GEOGRAPHIC INFORMATION	
DESIGNED	RLE	LATITUDE	48°49'00"N
CHECKED	TA	LONGITUDE	122°08'00"W
DRAWN	GB, GM, MW	TN/SC/RG	T38N/S2/R5E
CHECKED	RLE	DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

TYPE 3 ELJ

8

SHEET 8 OF 11

60% PRELIMINARY DESIGN

Jun-2-2014

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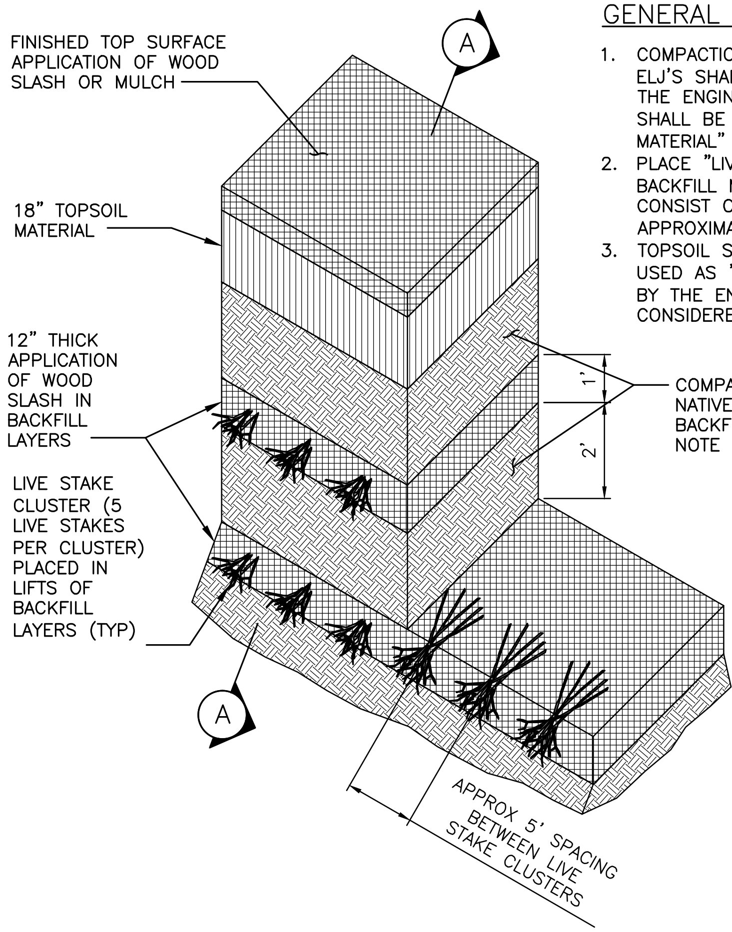
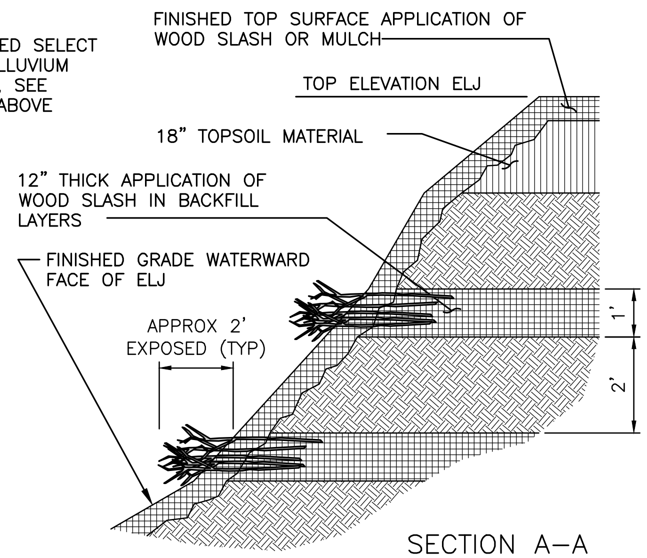
GENERAL ELJ BACKFILL LAYERING NOTES:

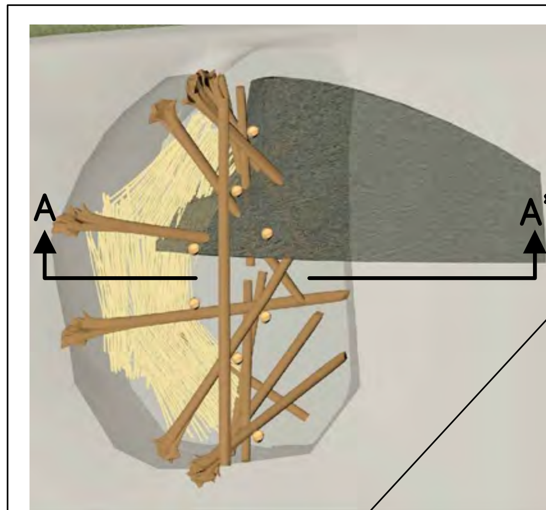
1. COMPACTION OF "SELECT NATIVE ALLUVIUM BACKFILL MATERIAL" IN ALL ELJ'S SHALL BE IN "FIRM AND UNYEILDING" LIFTS, TO THE SATISFACTION OF THE ENGINEER, USING HOE-PACK OR APPROVED EQUAL. BACKFILL MATERIAL SHALL BE TAKEN FROM STOCKPILED" SELECT NATIVE ALLUVIUM BACKFILL MATERIAL" ONLY UNLESS OTHERWISE APPROVED BY THE ENGINEER.
2. PLACE "LIVE STAKES" OVER COMPACTED " SELECT NATIVE ALLUVIUM BACKFILL MATERIAL" IN CRISS-CROSS PATTERN WHEREAS 1 CLUSTER SHALL CONSIST OF 5 LIVE STAKES. LIVE STAKE CLUSTERS SHALL BE PLACED AT APPROXIMATELY 5' O.C. ALONG EACH WOOD SLASH LAYER.
3. TOPSOIL SHALL BE GENERATED FROM SELECTED "GRUBBING AREAS AND USED AS "TOP DRESSING" WHERE SHOWN ON THE PLANS OR AS DIRECTED BY THE ENGINEER. THE TOP OF "TOPSOIL TYPE B" MATERIAL SHALL BE CONSIDERED FINISH GRADE.



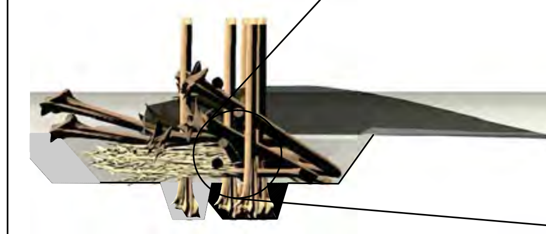


SECTION A–A

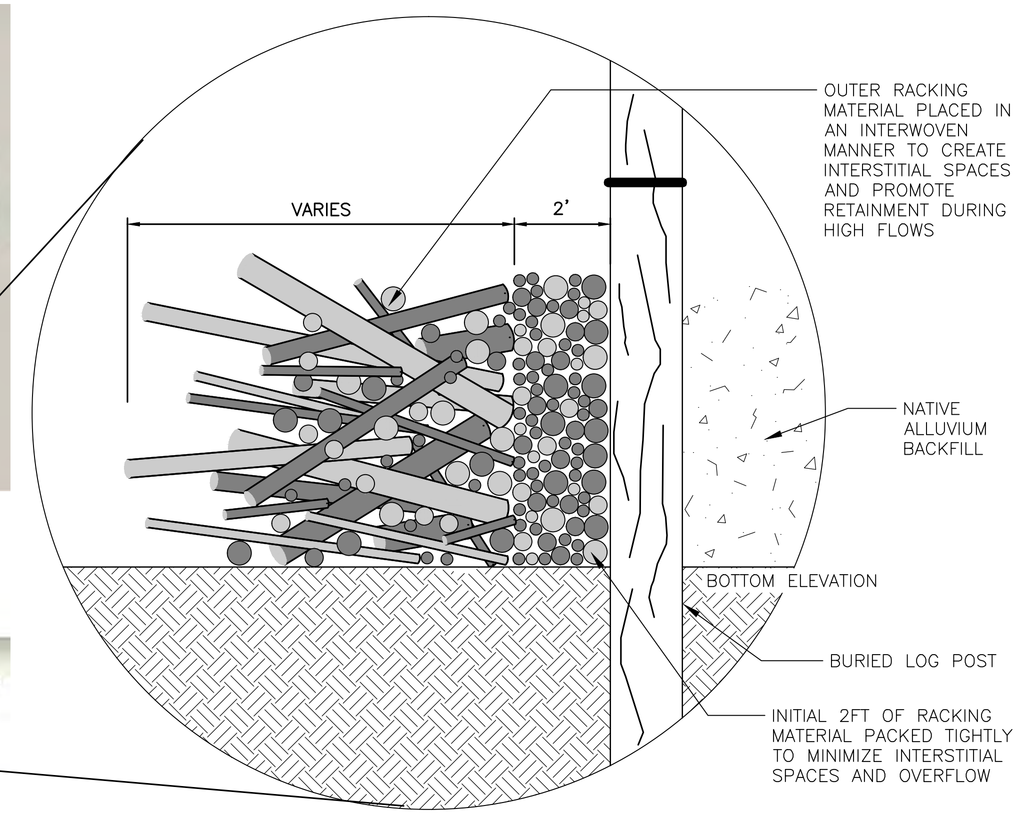
ELJ BACKFILL LAYERING DETAIL 1/9
NTS



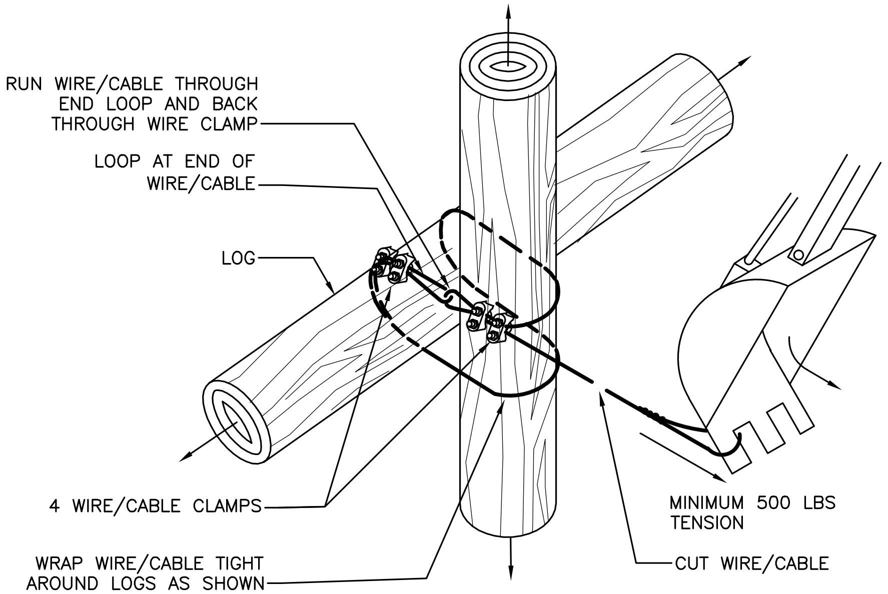
ELJ PLAN



SECTION A–A'



RACKING MATERIAL DETAIL 2/9
NTS



CABLE LASHING 3/9
NTS

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Jun-2-2014 60% PRELIMINARY DESIGN

R. LEIF EMBERTSON, STATE OF WASHINGTON, 45447, REGISTERED PROFESSIONAL ENGINEER

State of Washington, Hydrogeologist, 1181, Licensed Geologist, Timothy B. Abbe

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IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

NSEA NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

NAME OR INITIALS AND DATE	
DESIGNED	RLE
CHECKED	--
DRAWN	GB, GM, MW
CHECKED	--

GEOGRAPHIC INFORMATION	
LATITUDE	48°49'00"N
LONGITUDE	122°08'00"W
TN/SC/RG	T38N/S2/R5E
DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

RESTORATION DETAILS

60% PRELIMINARY DESIGN

Jun-2-2014

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R. LEIF EMBERTSON, STATE OF WASHINGTON, 45447, REGISTERED PROFESSIONAL ENGINEER

State of Washington, Hydrogeologist, 1181, Licensed Geologist, Timothy B. Abbe

0 Ø 1

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NSEA — NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

NAME OR INITIALS AND DATE	
DESIGNED	RLE
CHECKED	--
DRAWN	GD, GM, MW
CHECKED	--

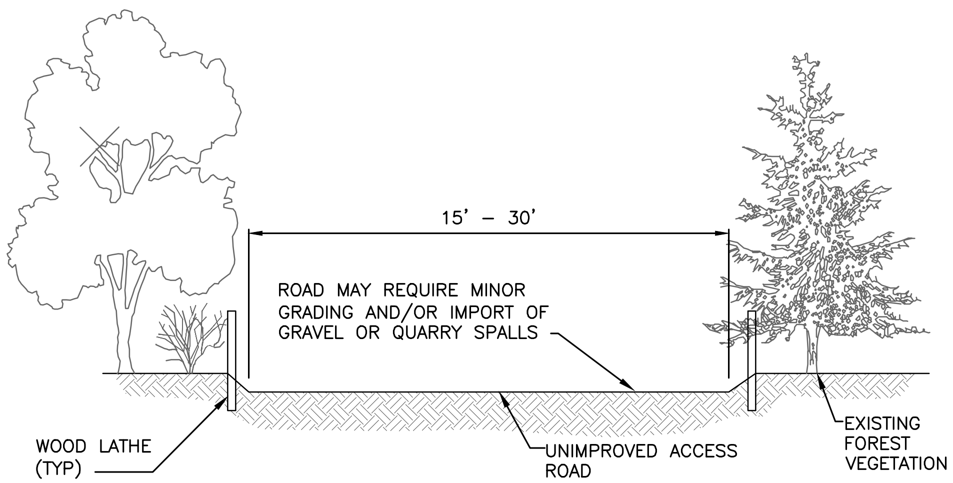
GEOGRAPHIC INFORMATION	
LATITUDE	48°49'00"N
LONGITUDE	122°08'00"W
TN/SC/RG	T38N/S2/R5E
DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

TESC PLAN

10

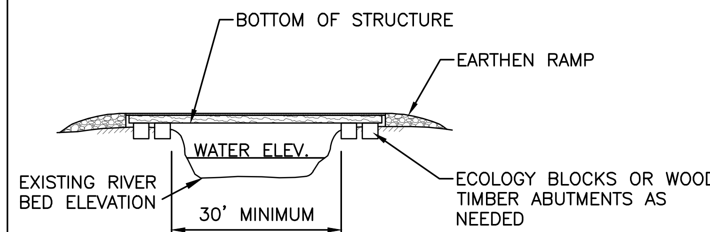
SHEET 10 OF 11



NOTES FOR TEMPORARY CLEARED ACCESS

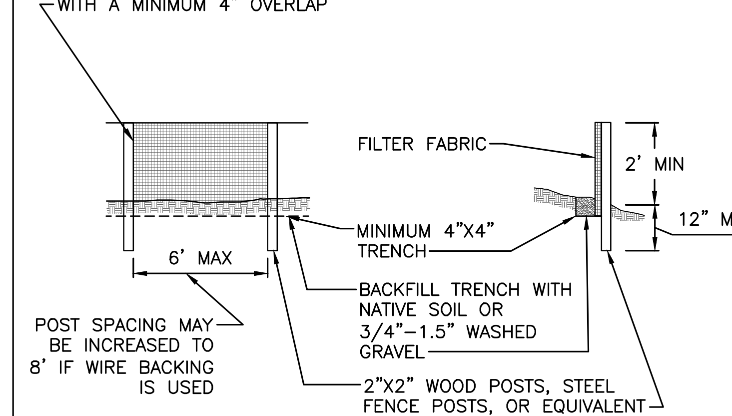
1. CLEARED ACCESS TO BE ROUTED TO MINIMIZE VEGETATION DISTURBANCE AND FOREST CLEARING.
2. CONTRACTOR SHALL MARK CLEARING LIMITS WITH FLAGGING. CLEARING LIMITS TO BE APPROVED BY ENGINEER PRIOR TO ANY CLEARING ACTIVITIES.
3. ANY TREES GREATER THAN 18" ø SHALL BE REMOVED W/ ROOTWADS INTACT AND STOCKPILED FOR USE IN LOGJAM CONSTRUCTION.
4. TREES AND SHRUBS WITH 6"–18" ø SHALL BE STOCKPILED FOR USE AS RACKING MATERIAL IN LOGJAM CONSTRUCTION.
5. REMAINDER OF VEGETATION AND ORGANIC SOIL SHALL BE GRUBBED, STOCKPILED AND BROADCASTED ON ROAD ALIGNMENT FOLLOWING TERMINATION OF WORK.
6. ACCESS SHALL BE MAINTAINED BY MINOR GRADING AND IMPORTATION OF WOOD CHIPS, GRAVEL AND/OR QUARRY SPALLS.
7. CLEARED ACCESS SHALL BE SCARIFIED AND DECONSTRUCTED TO PREVENT FUTURE ACCESS AT THE TERMINATION OF WORK.
8. REVEGETATION ROAD ALIGNMENT FOLLOWING CONSTRUCTION WILL BE PERFORMED BY CONTRACTOR.
9. ALL GRAVEL OR QUARRY SPALLS PLACED SHALL BE UNDERLAIN WITH A GEOTEXTILE AND REMOVED AT TERMINATION OF WORK IF UTILIIZED.

TEMPORARY CLEARED ACCESS 1/11
SCALE: NTS



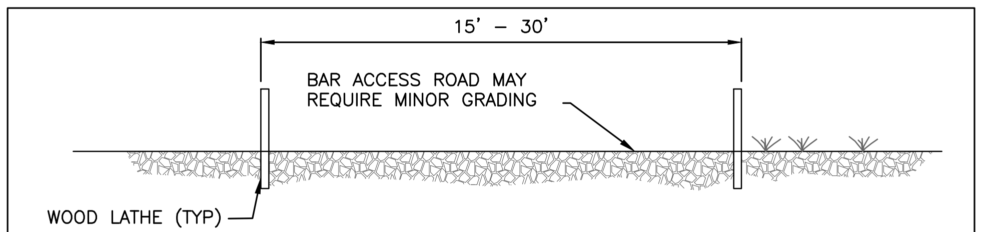
NOTES:
1. CONTRACTOR TO DESIGN TEMPORARY BRIDGE.
2. BRIDGE SHALL BE LOCATED SUCH THAT ONLY ONE SPAN IS USED TO ELIMINATE IMPACTS TO SUBSTRATE OF CHANNEL.
3. END OF BRIDGE SHALL BEAR ON HIGH BANKS WITH SUFFICIENT BEARING CAPACITY TO PREVENT SLOUGHING OR COLLAPSE OF SIDE CHANNEL BANKS.
4. CONCRETE ECOLOGY BLOCKS OR WOOD ABUTMENTS MAY BE USED TO SUPPORT ENDS OF TEMPORARY BRIDGE AS NEEDED.
5. BRIDGES MAY BE CONSTRUCTED FROM LOGS, RAIL CAR BEDS OR APPROVED EQUAL AND DECKED WITH STEEL SHEET, WOOD LAGGING OR APPROVED EQUAL.

TEMPORARY BRIDGE 2/11
SCALE: NTS



REFERENCE; WASHINGTON STATE DEPARTMENT OF ECOLOGY STORMWATER MANAGEMENT MANUAL FOR WESTERN WASHINGTON (FIGURE 4–19)

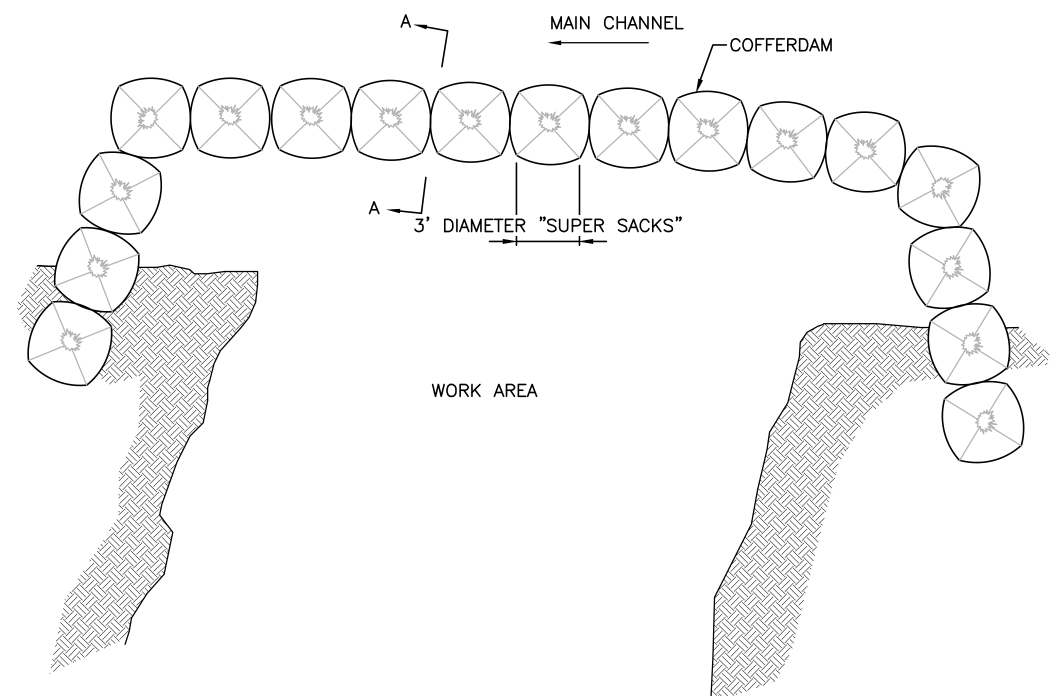
TEMPORARY SILT FENCE 3/11
SCALE: NTS

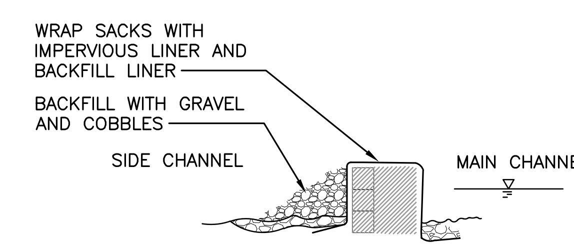


NOTES FOR TEMPORARY BAR ACCESS

1. BAR ACCESS TO BE ROUTED TO MINIMIZE VEGETATION DISTURBANCE.
2. CONTRACTOR SHALL STAKE EDGES OF PROPOSED BAR ACCESS FOR APPROVAL BY ENGINEER.
3. EQUIPMENT SHALL OPERATE ONLY WITHIN STAKED BAR ACCESS ALIGNMENT OR OTHER DEFINED PROJECT AREAS.
4. BAR ACCESS SHALL BE SCARIFIED AT TERMINATION OF WORK.

TEMPORARY BAR ACCESS 4/11
SCALE: NTS





SECTION A–A

NOTES:
1. WRAP "SUPER SACKS WITH IMPERVIOUS PLASTIC LINER TO PREVENT SEEPAGE.
2. BACKFILL THE DOWNSTREAM SIDE COFFER DAM WITH NATIVE, ADJACENT ALLUVIUM.
3. USE "SUPER SACKS" AS BUTTRESSES AS REQUIRED.

COFFERDAM 5/11
SCALE: NTS

Jun-2-2014 60% PRELIMINARY DESIGN

R. LEIF EMBERTSON, STATE OF WASHINGTON, 45447, REGISTERED PROFESSIONAL ENGINEER

State of Washington, Licensed Geologist, Timothy B. Abbe

0 Ø 1
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NSEA – NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

NAME OR INITIALS AND DATE		GEOGRAPHIC INFORMATION	
DESIGNED	RLE	LATITUDE	48°49'00"N
CHECKED	--	LONGITUDE	122°08'00"W
DRAWN	GB, GM, MW	TN/SC/RG	T38N/S2/R5E
CHECKED	--	DATE	2/28/2014

MIDDLE FORK NOOKSACK RESTORATION PHASE 1

TESC DETAILS

11

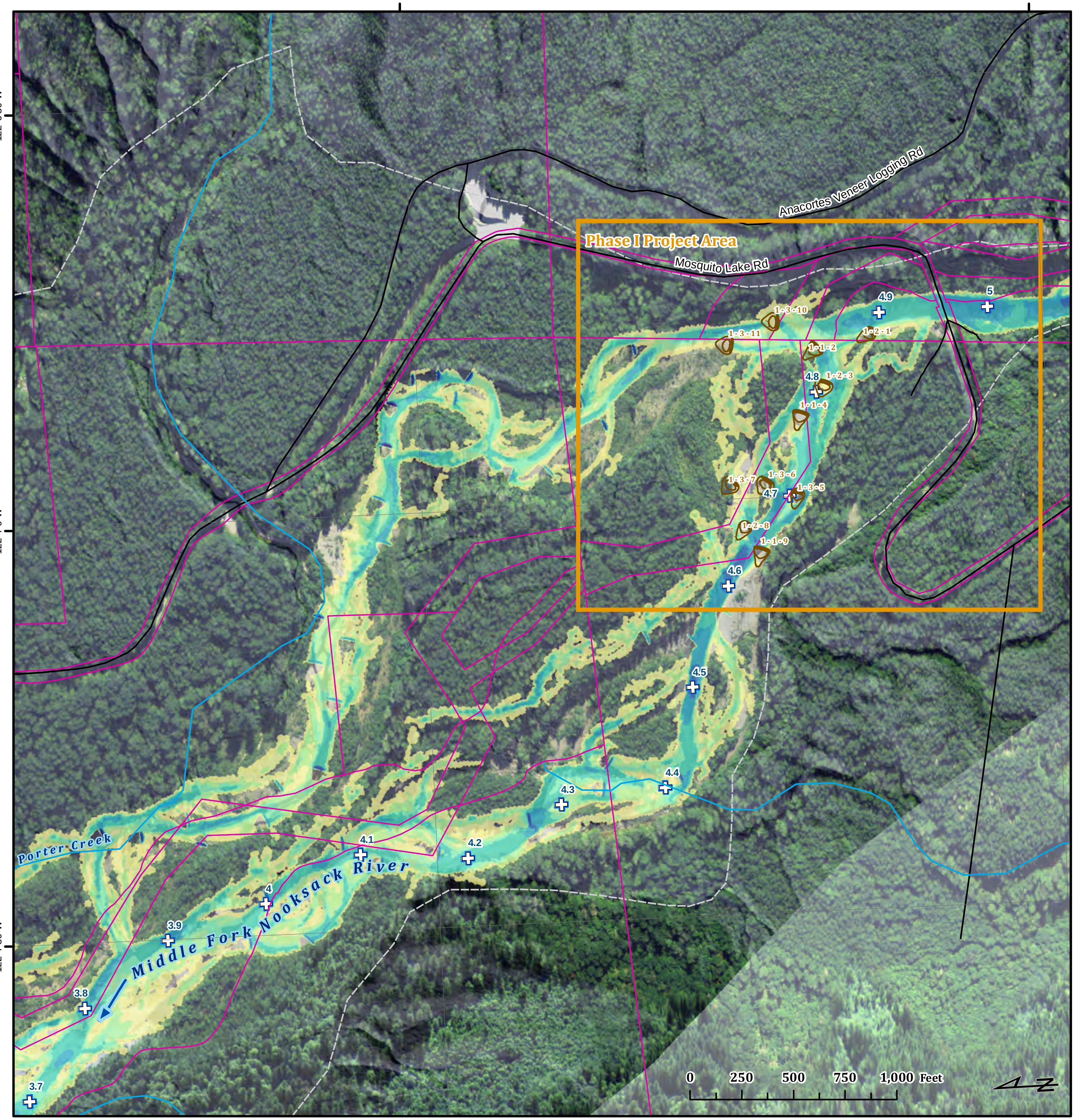
SHEET 11 OF 11

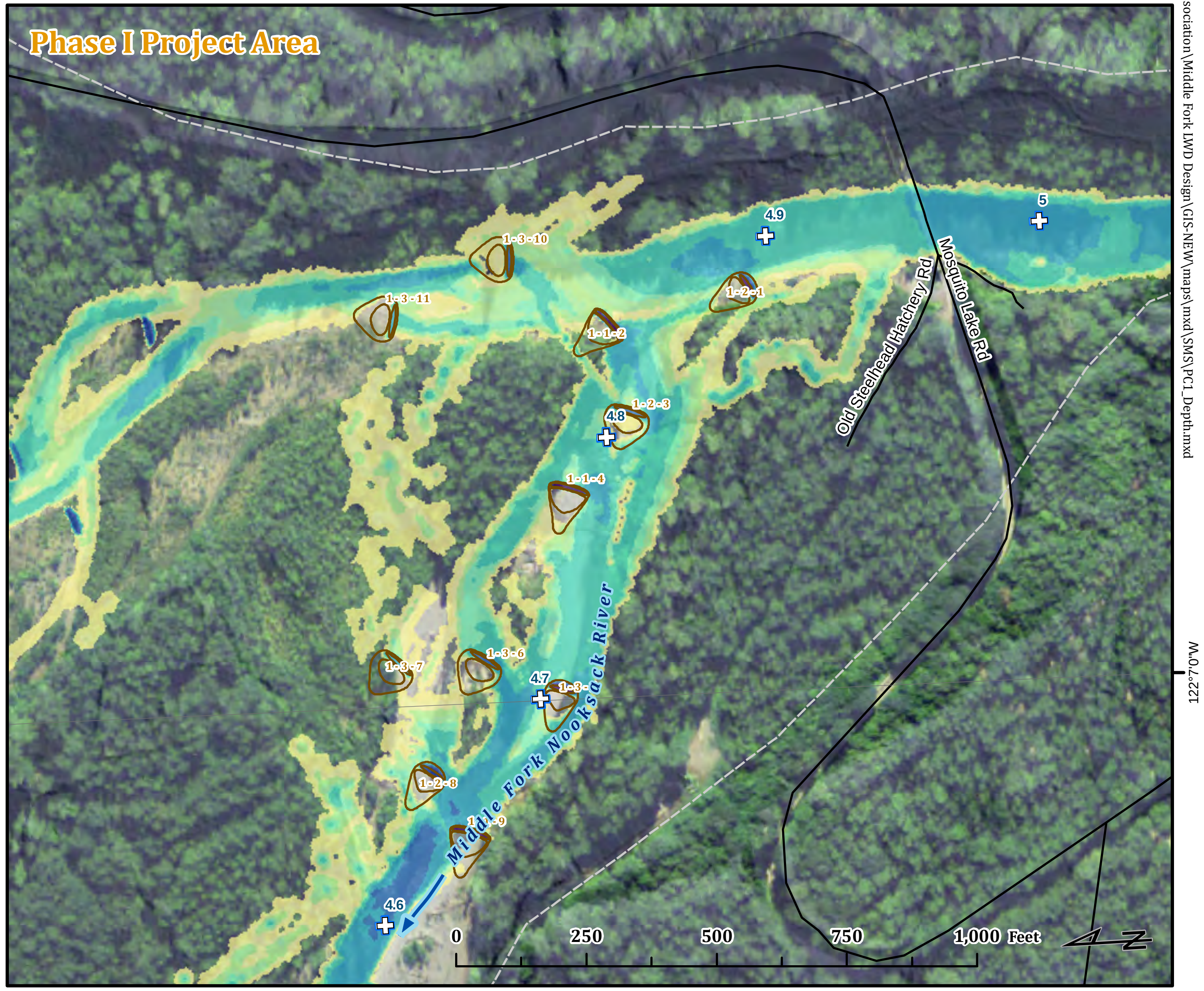
APPENDIX B

PROPOSED HYDRAULIC CONDITIONS

Natural Systems Design

P.O. Box 15609, Seattle, WA 98105 T: (206) 834-0175





Depth (ft)

0
0.1
0.5
1
1.5
2
2.5
4
6
8
10
12
15

River Mile
Streams
Roads
Parcel Boundary
Valley Margin
Proposed Structure

Aerials: 2013 USDA NAIP
Roads & Parcels: Whatcom Co.
Streams: USGS NHD (1:24,000)
River Miles: USGS
Topography: 2011 LiDAR Hillshade (PSLC)
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)

David French, NSD Date: 3/4/2014 Path: N:\Projects\NooksackSalmonEnhancementAssociation\Middle Fork LWD Design\GIS-NEW\maps\mxd\SMS\PC1_Depth.mxd

Middle Fork Nooksack River Large Wood Design

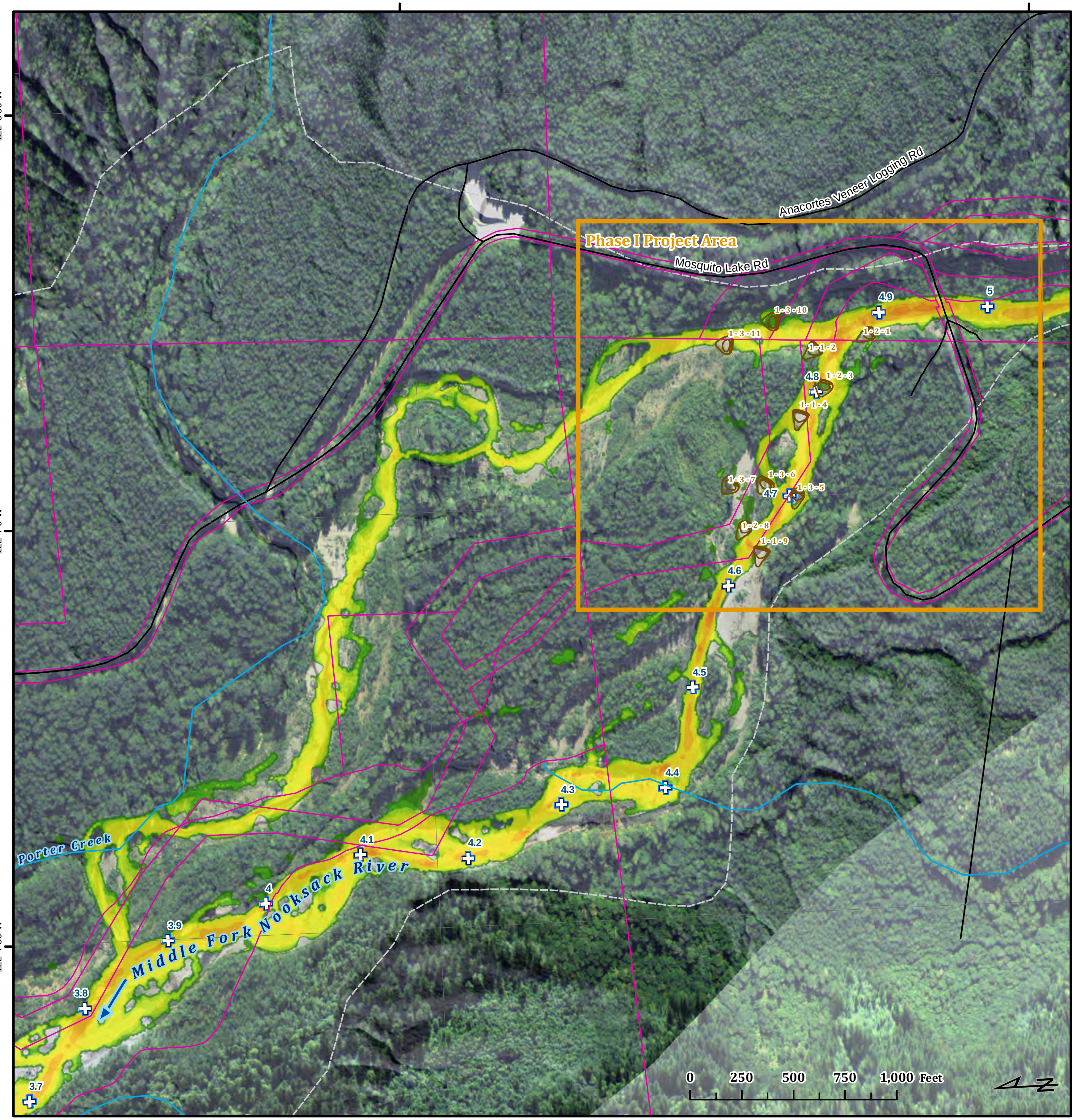
Proposed Conditions- 1 year Flow Depths

Hydronia RiverFlo-2D hydraulic model results for 1 year flow event (2,480 cfs) under proposed conditions.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French

NSEA
NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design



Velocity (ft/s)

Velocity (ft/s)
0
0.1
0.5
1
1.5
2
4
6
8
10
12
15
20

- River Mile
- Streams
- Roads
- Parcel Boundary
- Valley Margin
- Proposed Structure

Aerials: 2013 USDA NAIP

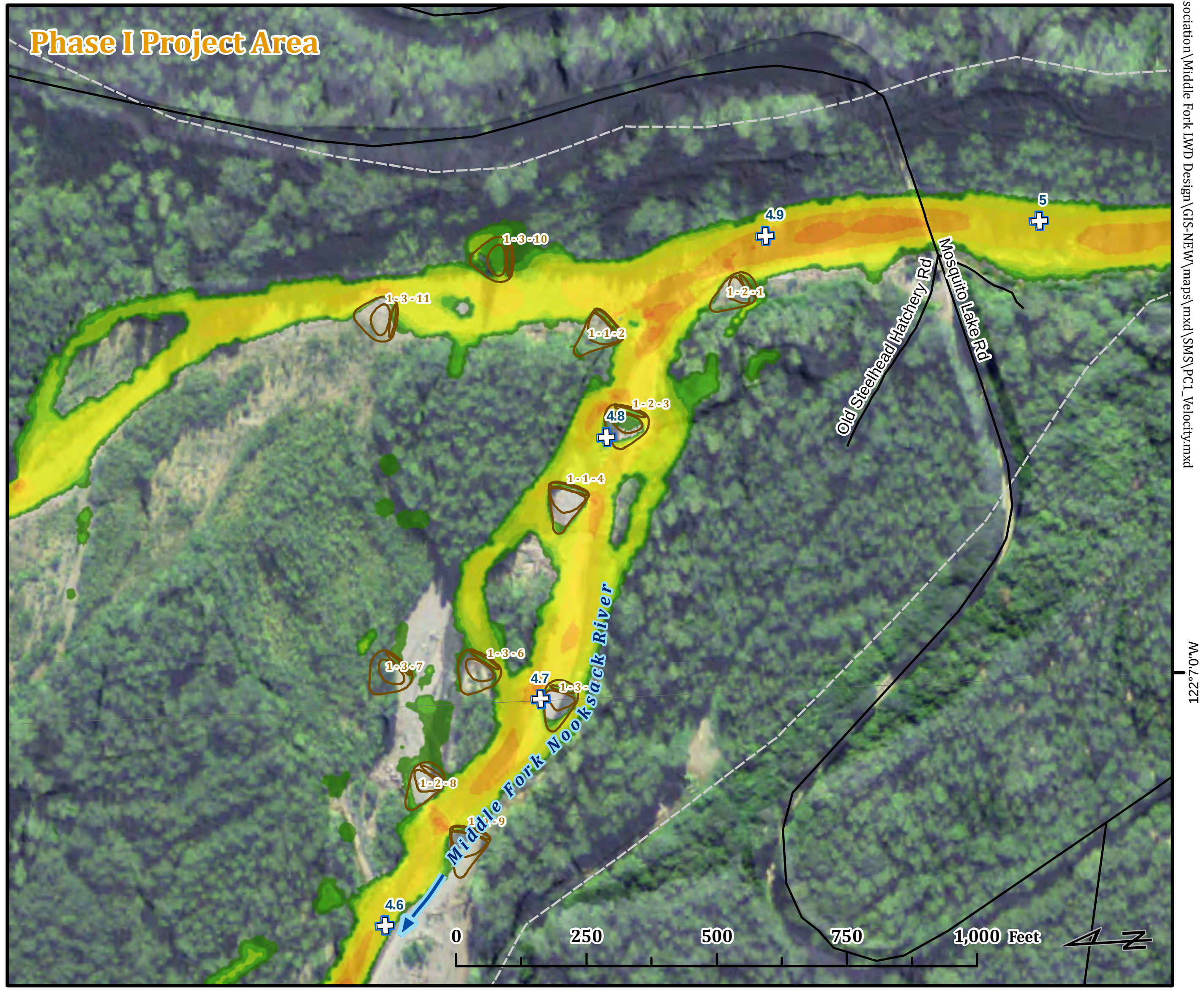
Roads & Parcels: Whatcom Co.

Streams: USGS NHD (1:24,000)

River Miles: USGS

Topography: 2011 LiDAR Hillshade (PSLC)

Lambert conformal conic projection, NAD 1983 State Plane Coordinate System (WA North Zone)



David French, NSD Date: 3/4/2014 Path: N:\Projects\NooksackSalmonEnhancementAssociation\Middle Fork LWD Design\GIS-NEW\maps\mxd\SMS\PC1_Velocity.mxd

Middle Fork Nooksack River Large Wood Design

Proposed Conditions- 1 year Flow Velocities

Hydronia RiverFlo-2D hydraulic model results for 1 year flow event (2,480 cfs) under proposed conditions.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French

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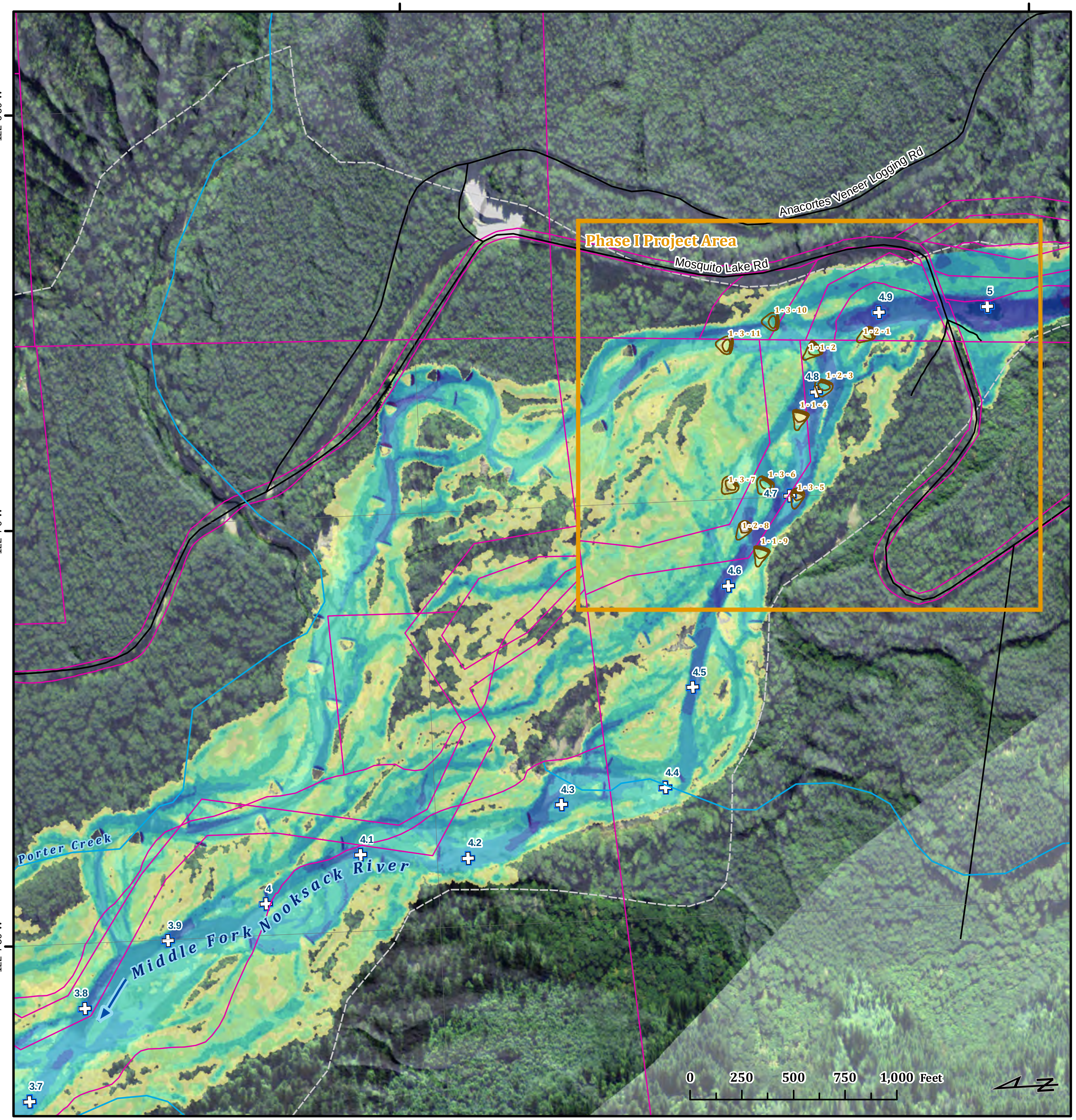
NOOKSACK SALMON ENHANCEMENT ASSOCIATION

Natural Systems Design

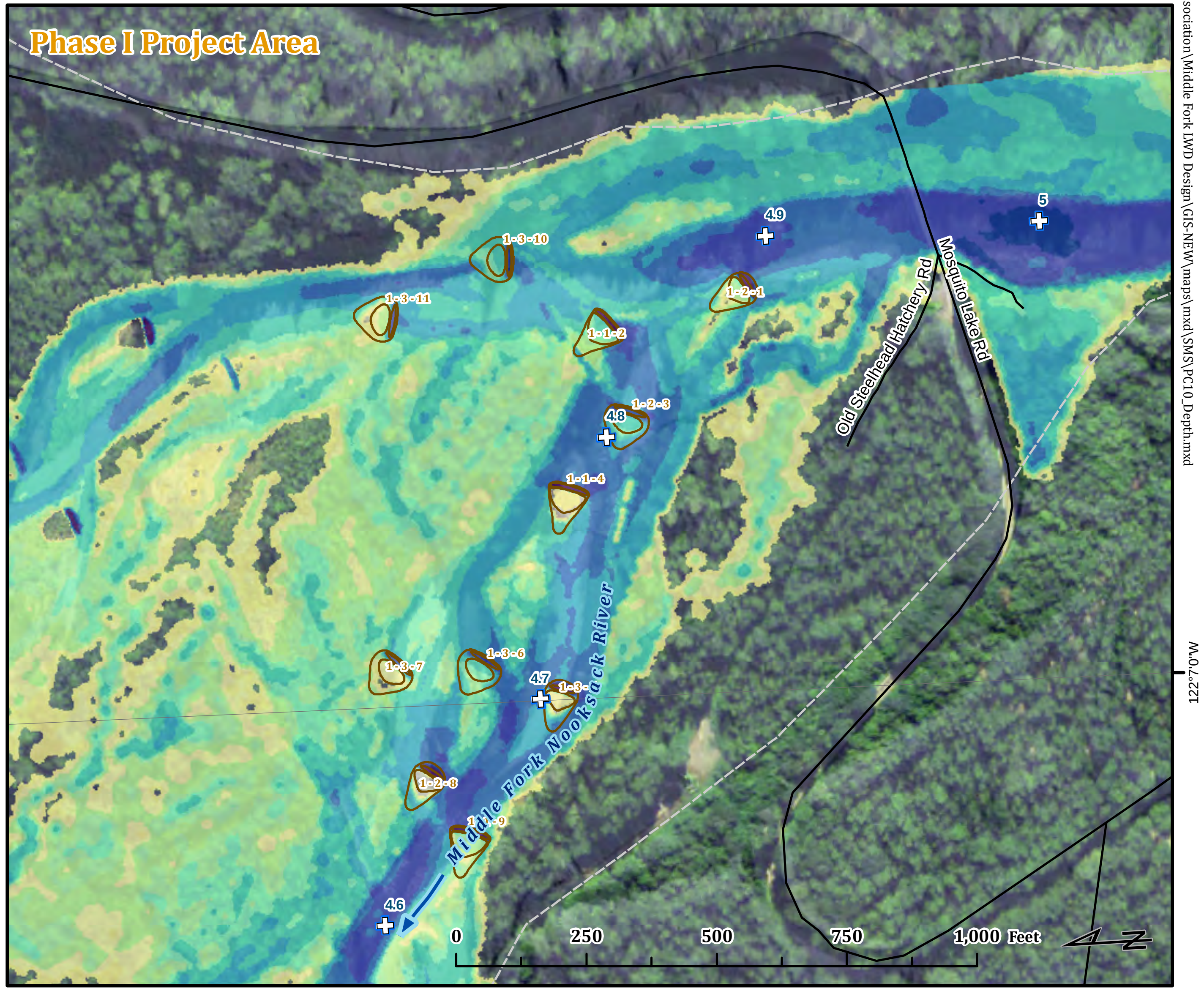


Depth (ft)

0
0.1
0.5
1
1.5
2
2.5
4
6
8
10
12
15

River Mile
Streams
Roads
Parcel Boundary
Valley Margin
Proposed Structure

Aerials: 2013 USDA NAIP
Roads & Parcels: Whatcom Co.
Streams: USGS NHD (1:24,000)
River Miles: USGS
Topography: 2011 LiDAR Hillshade (PSLC)
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)



David French, NSD Date: 3/4/2014 Path: N:\Projects\NooksackSalmonEnhancementAssociation\Middle Fork LWD Design\GIS-NEW\maps\mxd\SMS\PC10_Depth.mxd

Middle Fork Nooksack River Large Wood Design

Proposed Conditions- 10 year Flow Depths

Hydronia RiverFlo-2D hydraulic model results for 10 year flow event (13,680 cfs) under proposed conditions.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French

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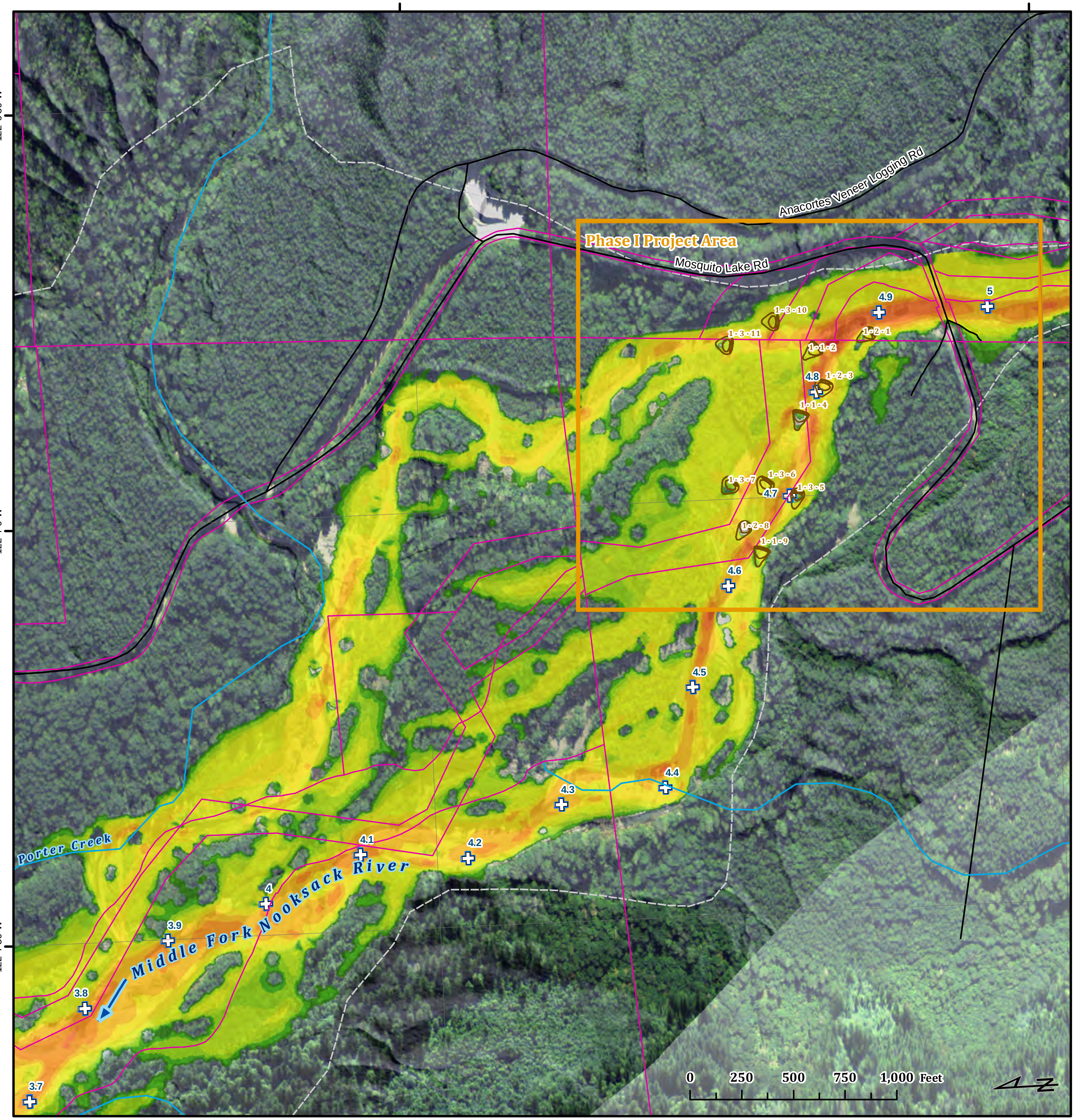
Natural Systems Design

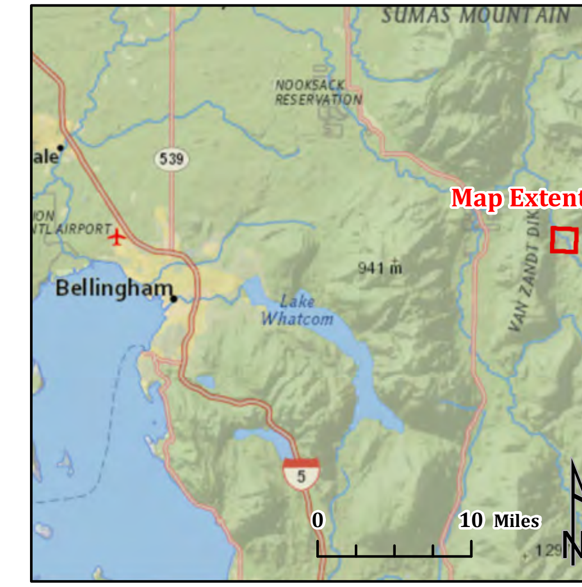


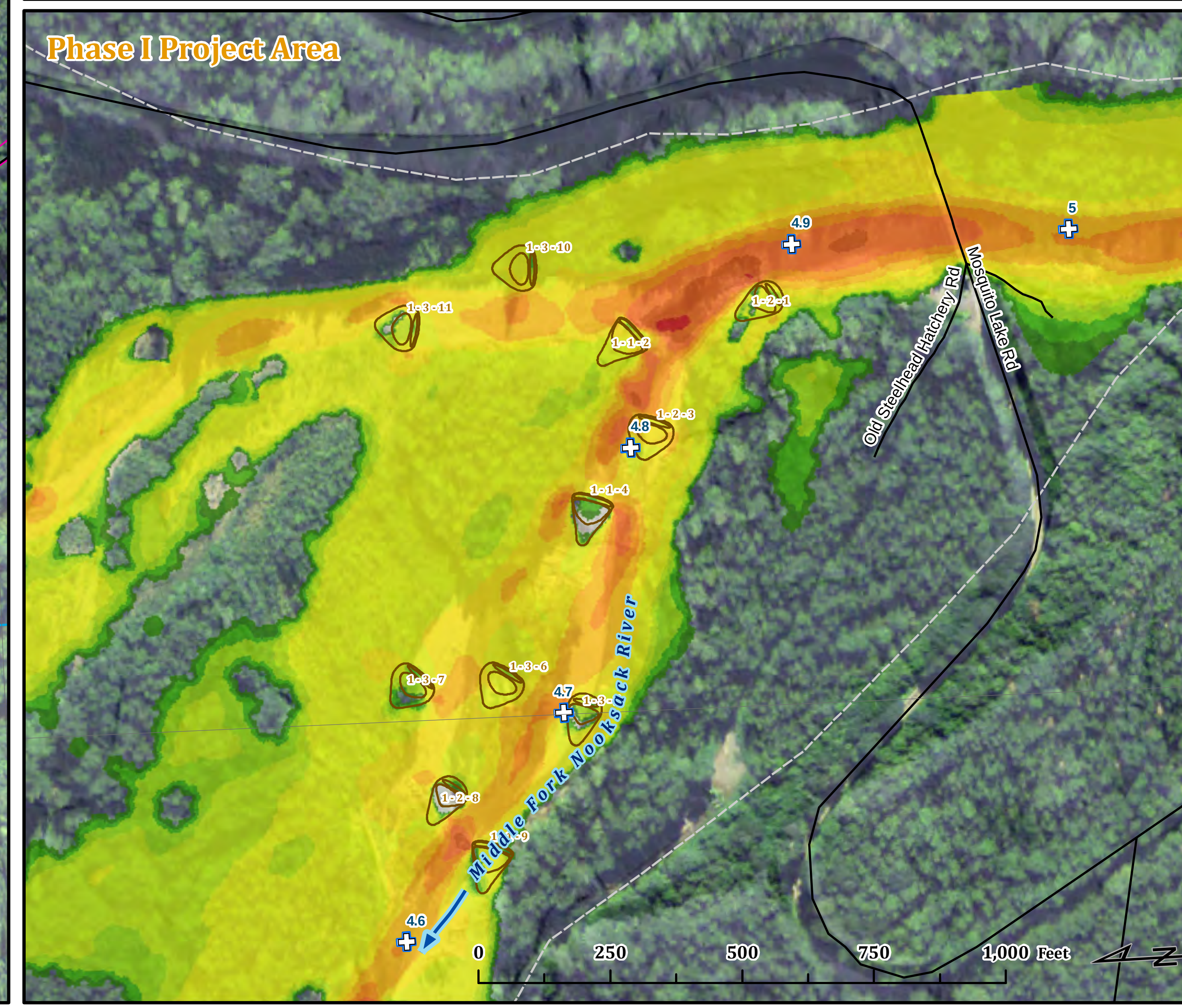
Velocity (ft/s)

Velocity (ft/s)
0
0.1
0.5
1
1.5
2
4
6
8
10
12
15
20

River Mile
Streams
Roads
Parcel Boundary
Valley Margin
Proposed Structure

Aerials: 2013 USDA NAIP
Roads & Parcels: Whatcom Co.
Streams: USGS NHD (1:24,000)
River Miles: USGS
Topography: 2011 LiDAR Hillshade (PSLC)
Lambert conformal conic projection, NAD 1983 State Plane Coordinate System (WA North Zone)





David French, NSD Date: 3/4/2014 Path: N:\Projects\NooksackSalmonEnhancementAssociation\Middle Fork LWD Design\GIS-NEW\maps\mxd\SMS\PC10_Velocity.mxd

Middle Fork Nooksack River Large Wood Design

Proposed Conditions- 10 year Flow Velocities

Hydronia RiverFlo-2D hydraulic model results for 10 year flow event (13,680 cfs) under proposed conditions.

NSD Modeling:	G. Dooley, EIT L. Embertson, P.E., M.S., C.F.M.
QA/QC for NSD Modeling:	M. Ericsson, M.S. P.G. L. Embertson, P.E., M.S., C.F.M.
Drafting:	D. French

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APPENDIX C

COST ESTIMATE

Natural Systems Design

P.O. Box 15609, Seattle, WA 98105 T: (206) 834-0175

Unit Costs

Project: MIDDLE FORK NOOKSACK LWD DESIGN PHASE 1

Analyst: G. Dooley
Latest Revision: 3/4/14
Reviewed by: L. Embertson

- This spreadsheet calculates the costs associated with site preparation. Unit costs include materials, labor, equipment, overhead and contractor profit.
- Reference used for "unit costs" include:
  (1) R.S. Means Heavy Construction Cost Data Manual, 2009 (Means)
  (2) Engineering Experience & Recent Similar Projects
  (3) Contractor or Supplier
- Inflation adjustment is a rough estimate using the Consumer Price Index average between 2009 and 2010.
- Additional adjustments are based on engineering judgment, experience and site-specific degree of difficulty.
- Blank rows are provided at the bottom for additional items. Add new items & unit costs on this sheet, if necessary. These will be used to calculate costs on subsequent sheets.
- General mark-up percentages are also provided at the bottom.

12 = Adjustment for inflation from to 2009 to 2014 (Construction) (%)

3.9 = Location Factor (Seattle, WA) (%) (Adjustment from national average)

0 = Additional Location Factor (%)

Item #	Item Description	Ref. ID	Ref. #	Page #	Units	Unit Cost ($)	Quantity per Item	Inflation & Location Adjustments (%)	Additional Adjustments (%)	Adjusted Unit Price ($)
1	MOBILIZATION	2	Cavanaugh Bids		LS	25,000				25000.0
2	TEMPORARY ACCESS ROAD	2	Cavanaugh Bids		LS	10,000				10000.0
3	TEMPORARY ACCESS BRIDGE	2			EA	5,000				5000.0
4	TESC MEASURES	2	Cavanaugh Bids		LS	5,000				5000.0
5	DEWATERING, DIVERSION	2	Cavanaugh Bids		LS	20,000				20000.0
6	TYPE 1 ELJ - 85ft WIDE POST SUPPORTED				EA					95400
a	Stream Excavation (short haul)	1	31-23-16.42-0200 31-23-16.46-2200	219 222	CY	7.0	1,175.00	15.9		8.1
b	Structure Backfill (short haul)	1	31-23-23.17-0150	226	CY	3.0	1,175.00	15.9		3.5
c	Log 1 - Vertical Posts - 20in DBH, 30ft long, rootwad	2	LNNR		EA	1,000	14.00	0		1000.0
d	Log 2 - 18in DBH, 30ft long	2	LNNR		EA	300	2.00	0		300.0
e	Log 4 - 18in DBH, 40ft long	2	LNNR		EA	400	7.00	0		400.0
f	Log 3 - 24in DBH, 50ft long	2	LNNR		EA	500	2.00	0		500.0
g	Log 5 - 18in DBH, 40-feet, with rootwad	2	LNNR		EA	1200	6.00	0		1200.0
h	Log 6 - 24in DBH, 45-feet, with rootwad	2	LNNR		EA	1200	4.00	0		1200.0
i	RACKING MATERIAL; 8-16in DBH, 25-50- feet	2	LNNR		CY	70.0	150.00	0		70.0
j	SLASH MATERIAL	2	Pierce Co Bid Tabs		CY	25.0	450.00	0		25.0
k	1/2in Steel Cabling	3	Internet supplier		LF	1.5	100.00	0		1.5
l	Crew Costs (Log Placement / ELJ Construction)	1	(see notes)		DAY	8,500.0	3.00	15.9		9852
7	TYPE 2 ELJ - 55ft WIDE POST SUPPORTED				EA					65200
a	Stream Excavation (short haul)	1	31-23-16.42-0200 31-23-16.46-2200	219 222	CY	7.0	625.00	15.9		8
b	Structure Backfill (short haul)	1	31-23-23.17-0150	226	CY	3.0	625.00	15.9		3
c	Log 1 - Vertical Posts - 20in DBH, 30ft long, rootwad	2	LNNR		EA	1,000	8.00	0		1000
d	Log 2 - 18in DBH, 30ft long	2	LNNR		EA	300	7.00	0		300
e	Log 7 - 18in DBH, 50ft long	2	LNNR		EA	500	2.00	0		500
f	Log 8 - 18in DBH, 30-feet, with rootwad	2	LNNR		EA	1000	4.00	0		1000
g	Log 10 - 24in DBH, 40-feet, with rootwad	2	LNNR		EA	1200	2.00	0		1200
h	Log 9 - 24in DBH, 50-feet, with rootwad	2	LNNR		EA	1200	2.00	0		1200
i	RACKING MATERIAL; 8-16in DBH, 25-50- feet	2	LNNR		CY	70.0	100.00	0		70
j	SLASH MATERIAL	3	Pierce Co Bid Tabs		CY	25.0	450.00	0		25
k	1/2in Steel Cabling	3	Internet supplier		LF	1.5	100.00	0		2
l	Crew Costs (Log Placement / ELJ Construction)	1	(see notes)		DAY	8,500.0	2.00	15.9		9852
8	TYPE 3 ELJ - POST ARRAY				EA					29900
a	Stream Excavation (short haul)	1	31-23-16.42-0200 31-23-16.46-2200	219 222	CY	7.0	335.00	15.9		8
b	Structure Backfill (short haul)	1	31-23-23.17-0150	226	CY	3.0	335.00	15.9		3
c	Log 12 - Vertical Posts - 18in DBH, 25ft long, rootwad	2	LNNR		EA	900	9.00	0		900
d	Log 5 - 18in DBH, 40ft long, rootwad	2	LNNR		EA	1200	2.00	0		1200
e	Log 7 - 18in DBH, 50ft long	2	LNNR		EA	500	2.00	0		500
f	Log 9 - 24in DBH, 50-feet, with rootwad	2	LNNR		EA	1200	2.00	0		1200
g	Log 4 - 18in DBH, 40ft long	2	LNNR		EA	400	1.00	0		400
h	Log 11 - 18in DBH, 45ft long	2	LNNR		EA	450	2.00	0		450
i	RACKING MATERIAL; 8-16in DBH, 25-50- feet	2	LNNR		CY	70.0	70.00	0		70
j	1/2in Steel Cabling	3	Internet supplier		LF	1.5	75.00	0		2
k	Crew Costs (Log Placement / ELJ Construction)	1	(see notes)		DAY	5,000	1.00	15.9		5795
								0		0
9										0
a								0		0
b								0		0
c								0		0
d								0		0
e								0		0
f								0		0
								0		0
								0		0
10	FISH PROTECTION	3			DAY	720		0		720
11	CONSTRUCTION OBSERVATION	3			DAY	1,800		0		1800
12	ROADSIDE CLEANUP	3			LS	5,000		0		5000
13								0		0
101	Taxes (materials and major taxes included in line items)									8.0
102	Incidentals not included in items above (as % of Construction Sub-Total)									5.0
103	Contingency (as % of Construction Sub-Total)									15.0
104	Permitting (as % of Construction Sub-Total)									2.0
105	Additional survey and design (as % of Construction Sub-Total)									5.0

Phase I Preliminary Cost Estimate

Project: MIDDLE FORK NOOKSACK LWD DESIGN PHASE 1

Analyst: G. Dooley

Latest Revision: 3/4/14

Reviewed by: L. Embertson

- This spreadsheet calculates the costs for the items noted. Item # references the Item # on the Unit Cost sheet.
- The unit costs are based upon those listed & calculated on the Unit Cost sheet.
- Blue cells represent cells that require input.

Item #	Item Description	Units	Adjusted Unit Cost	No. of Units	Cost per Item ($)
1	MOBILIZATION	LS	25000	1.0	25,000
2	TEMPORARY ACCESS ROAD	LS	10000	1.0	10,000
3	TEMPORARY ACCESS BRIDGE	EA	5000	3.0	15,000
4	TESC MEASURES	LS	5000	1.0	5,000
5	DEWATERING, DIVERSION	LS	20000	1.0	20,000
6	TYPE 1 ELJ - 85ft WIDE POST SUPPORTED	EA	95400	3.0	286,200
7	TYPE 2 ELJ - 55ft WIDE POST SUPPORTED	EA	65200	3.0	195,600
8	TYPE 3 ELJ - POST ARRAY	EA	29900	5.0	149,500
10	FISH PROTECTION	DAY	720	10.0	7,200
11	CONSTRUCTION OBSERVATION	DAY	1800	10.0	18,000
12	ROADSIDE CLEANUP	LS	5000	1.0	5,000
	Constrution Sub-Total				**740,000**
101	Taxes (materials and major taxes included in line items)			8.0%	59,200
102	Incidentals not included in items above (as % of Construction Sub-Total)			5.0%	37,000
103	Contingency (as % of Construction Sub-Total)			15.0%	111,000
104	Permitting (as % of Construction Sub-Total)			2.0%	14,800
105	Additional survey and design (as % of Construction Sub-Total)			5.0%	37,000
	Final Construction Cost				**1,000,000**