

EFFECTIVENESS MONITORING OF
SOUTH FORK NOOKSACK INSTREAM HABITAT PROJECTS,

SUMMER 2011

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For more information on the *WRIA 1 Salmonid Recovery Plan* and the salmon recovery program in Water Resource Inventory Area (WRIA) 1, the Nooksack Basin, please visit salmon.wria1.org.

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INTRODUCTION

Efforts to recover Nooksack salmon populations began in the mid-1980s in response to declines in wild salmon runs, especially native spring chinook. Early salmon recovery efforts included curtailment of fisheries and initiation of studies to determine factors limiting salmon production. Through the 1990s, hundreds of riparian, sediment reduction, fish passage, and instream projects were implemented throughout the watersheds of the Nooksack River and independent coastal tributaries in WRIA 1. Since 1999, when Puget Sound Chinook and Coastal/Puget Sound Bull Trout were listed under the federal Endangered Species Act and the Washington State Salmon Recovery Funding Board formed, salmon recovery funding has been targeted locally to projects that maximize benefit to our two local native chinook populations: North Fork/Middle Fork Nooksack early chinook and South Fork Nooksack early chinook.

The *WRIA 1 Salmonid Recovery Plan* (WRIA 1 Salmon Recovery Board 2005) identified priority geographic areas, limiting factors, and general restoration strategies for Nooksack early chinook. More detailed reach assessments and restoration plans have been or are being developed for the following priority areas:

- South Fork Nooksack River (Maudlin et al. 2002; Soicher et al. 2006; Brown and Maudlin 2007)
- Middle Fork Nooksack River (Lummi Nation 2011)
- North Fork Nooksack River (Hyatt 2007)
- Nooksack River Estuary (Brown et al. 2005)

The *WRIA 1 Salmonid Recovery Plan* and associated implementation guidance prioritize projects based on magnitude, immediacy, and lifespan of benefit to native chinook, as well as certainty of project success. Both Nooksack early chinook populations are considered essential for Puget Sound Chinook salmon ESU recovery, but current abundances of Nooksack natural-origin spawners are critically low. While hatchery programs are in place to ensure persistence of both populations, recovery will require substantial improvement in habitat conditions over the near term. Construction of log jams to restore habitats and habitat-forming processes is a cornerstone of restoration efforts throughout the Forks due to the relative immediacy of benefit delivered. Since 2001, 20 log jam projects have been implemented, including 6 in the North Fork, 3 in the Middle Fork, and 11 in the South Fork. While some individual projects have been monitored sporadically over the past decade, the need to develop a comprehensive program to systematically monitor project effectiveness is clear.

Consistent with NOAA and Puget Sound Partnership guidance, the WRIA 1 Salmon Recovery Board is working to develop a *WRIA 1 Salmonid Recovery Plan: Monitoring and Adaptive Management Plan* that will document the approach and methodology to monitoring the following:

1. Status and Trends
 - a. Nooksack early chinook populations
 - b. Early chinook habitat
2. Implementation/Compliance
 - a. Habitat projects

- b. Land use regulations
 - c. Hatchery programs
 - d. Harvest programs
3. Effectiveness of Salmon Recovery Actions
- a. Habitat projects
 - b. Land use regulations
 - c. Hatchery programs
 - d. Harvest programs

There has been considerable interest recently in evaluating project effectiveness (element 3a), especially instream habitat projects, given the substantial investment of local SRFB and PSAR funding in such projects. To that end, we began systematic structure-scale effectiveness monitoring in summer 2011 for South Fork instream habitat projects; we plan to expand that work (adapting the methods as appropriate) to monitor North Fork and Middle Fork projects later this year or early next year. We anticipate repeating such monitoring over time at intervals of 1-5 years. This structure-scale monitoring, together with planned reach-scale monitoring (channel, meso-habitat and floodplain forest mapping) and temperature monitoring, constitutes the approach to evaluating the effectiveness of log jam projects in the Nooksack River watershed.

This report presents the results of structure-scale effectiveness monitoring for the eleven instream habitat restoration projects implemented in the South Fork Nooksack River from 2001 through 2010. These projects, comprised of 83 total log jams and representing a \$5.83M investment, were developed by a variety of agencies, designed by a variety of consulting firms, and constructed by a variety of contractors over the course of ten years. Project objectives varied somewhat, but each project included pool formation and increase in woody cover as objectives. The target established for pools in the South Fork Nooksack is 18 wood-formed pools per mile. The structure-scale effectiveness monitoring focused on subjective assessment of structure stability and quantification of pool formation and woody cover associated with each log jam structure, the two log jam functions considered to be the most limiting to chinook salmon in the South Fork Nooksack (WRIA 1 Salmon Recovery Board 2005). Evidence of other geomorphic functions was also recorded by structure. Other habitat functions of log jams, such as formation of flood and temperature refugia, while also important, were not evaluated in this study.

STUDY AREA

All instream habitat projects implemented in the South Fork Nooksack River from 2001 through 2010 were monitored. The projects are located between river mile (RM) 1 and 30 of the South Fork Nooksack River (Figure 1). The eleven projects consisted of 83 individual structures that were assessed (Table 1). Site plans, and where applicable as-built photos, are presented in Appendix 1.

METHODS

Each structure completed as a part of an instream restoration project was visited between August 5 and September 6, 2011; South Fork discharge (Saxon Rd. gage) ranged from 172 cfs to 485 cfs during

surveys. For each structure, the type of pool formed (primary, secondary, isolated or none) was determined, and its maximum depth, tail-out depth and surface area were measured. A primary pool covered the majority of the South Fork channel width, a secondary pool either occurred in a side channel or covered less than half of the channel width, and an isolated pool was disconnected from the flow of the South Fork Nooksack at the time of the survey. Depth was recorded using a stadia rod, and distance was measured using a laser range finder or stadia rod. Depth is presented either as the maximum depth from the water surface, or as the residual depth (maximum depth minus the tail-out depth). Area was estimated from a maximum length and an average width measurement.

Length and average width of woody cover were measured using the laser rangefinder for all portions of the structure that were interacting with wetted channel, including isolated pools. The cover length and an average width were measured and multiplied for an estimate of the cover area.

Evidence of other geomorphic functions were noted when they were present. These included splitting the low flow (SLF), splitting bank-full flow (as represented by the unvegetated channel area; SBF), sediment deposition (SED), low or high flow channel deflection (DFC), and channel avulsion (CAV). Structures that served to protect banks were also noted (BANK). Any notes on the general stability of the structures were included.

Since frequency and magnitude of channel-forming flows are important to consider in evaluating project effectiveness, discharge data for the lower South Fork Nooksack River were examined for the period since log jam construction began in 2001. Peak streamflow¹ and instantaneous discharge data² were obtained for the following:

- *SF Nooksack River near Wickersham, WA* gage (Site 12209000; RM 14.8; WY³ 2002-2008)
- *SF Nooksack River at Saxon Bridge, WA* gage (Site 12210000; RM 12.9; WY 2009-2011).

For each water year evaluated, the number and duration of bankfull discharge events were determined. Bankfull discharge was selected as a reference point due to data availability and because it commonly corresponds to the effective discharge⁴ in magnitude (Andrews 1980, as cited in Ziemer and Lisle 1998).

¹ <http://nwis.waterdata.usgs.gov/wa/nwis/peak/>

² <http://ida.water.usgs.gov/ida/> (through WY2007; http://nwis.waterdata.usgs.gov/nwis/uv/?referred_module=sw WY 2008+).

³ "Water year" (WY) is defined as the 12-month period from October 1 through September 30 of the following year. The water year is designated by the year in which it ends, i.e. the year ending 9/30/1999 is WY 1999.

⁴ Effective discharge is the flow magnitude that, on average, transports the most sediment or does the most work in forming the channel (Wolman and Miller 1960, as cited in Ziemer and Lisle 1998). It requires estimates of the sediment transport rate.

FIGURE 1: LOGJAM LOCATIONS IN THE SOUTH FORK NOOKSACK WATERSHED

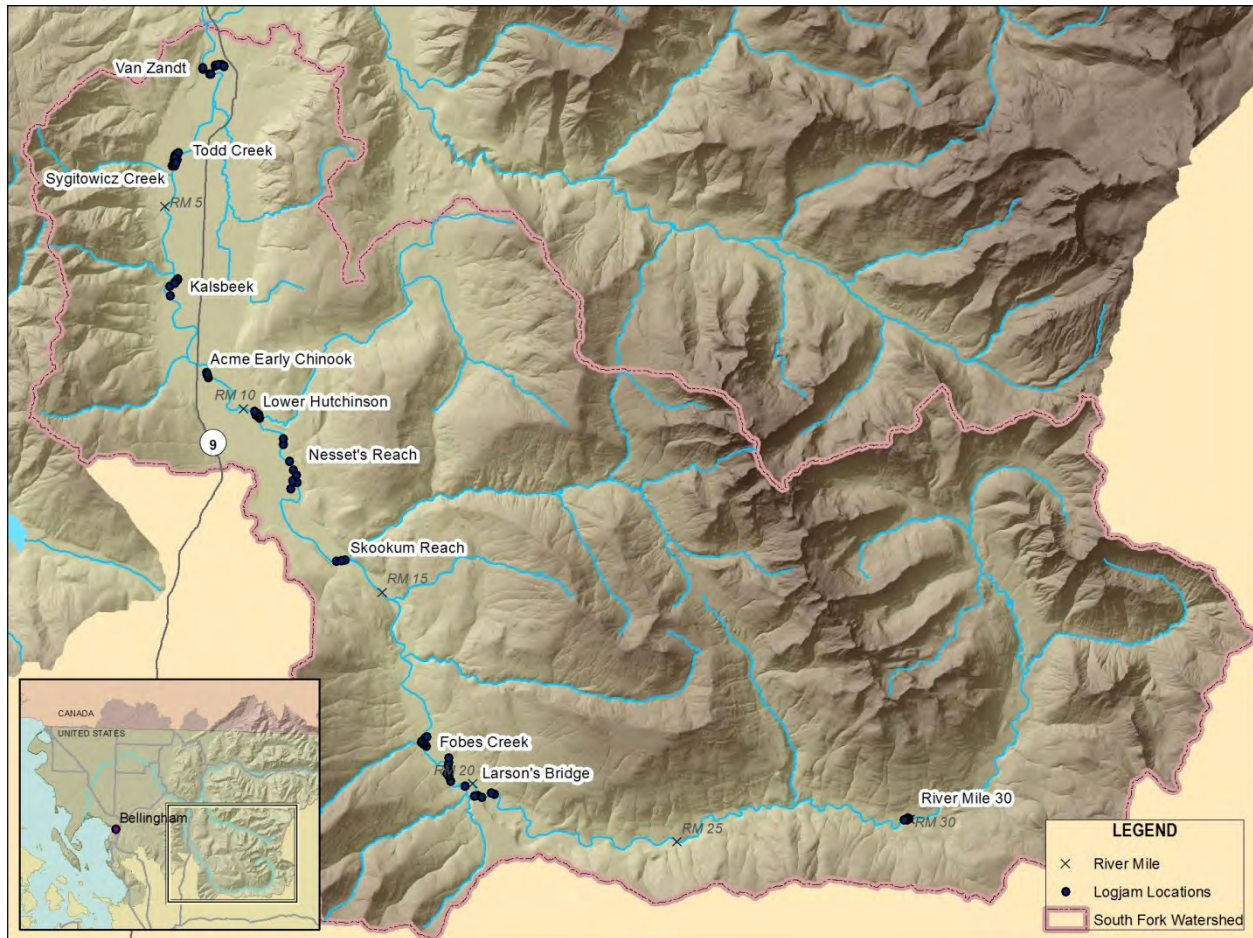


TABLE 1: LOGJAM PROJECT LOCATION, NUMBER OF STRUCTURES, SPONSOR AND YEAR COMPLETED.

Project Name	RCO Project #	South Fork Location (River Mile)	Structures Monitored	Lead Sponsor	Year Completed
Van Zandt	07-1800	1.1	15	Nooksack Tribe	2010
Todd	06-2247	3.5	8	Nooksack Tribe	2008
Sygitowicz	10-1442	4.0	7	Nooksack Tribe	2010
Kalsbeek	05-1569	6.7	7	Nooksack Tribe	2007
Acme	07-1790	9.0	5	Whatcom County	2010
Lower Hutchinson	01-1329	10.5	6	Lummi Nation	2006
Nessel	07-1794	11.5	8	Lummi Nation	2008
Skookum	07-1803; 09-1687	14.3	3	Lummi Nation	2010
Fobes	09-1686	18.5	14	Lummi Nation	2010
Larson's Bridge	99-1708; 00-1136	20.0	6	Lummi Nation	2001
River Mile 30	N/A	30.0	4	Lummi Nation	2007

RESULTS

The results of the summer 2011 effectiveness monitoring are presented for each project below, beginning with the most upstream project and proceeding downstream, followed by a summary of relative project effectiveness.

INDIVIDUAL PROJECTS

RM 30 PROJECT

Constructed in 2007, this project included the removal of a failing bridge across the South Fork, pull-back of artificial bridge approach fill in the floodplain and channel, abandonment of approximately 2000 feet of forest road, and installation of four engineered logjams (Figure 2). The design was developed by Tracy Drury of Anchor Environmental. The logjam structures consisted of logs cabled together into an open-box-shape and then filled with rock ballast. The structures were designed to settle into the bed of the channel as local scour undercut them. The habitat objectives of the project included isolating the channel from a stream-adjacent landslide, creating scour pools, and sorting gravel to provide areas for spawning. The RM 30 Project was assessed on August 5, 2011, when the mean flow at Saxon Bridge (RM 13) was 485 cfs. The bank-full flow at the gage is 9520 cfs. Since the gage has only been in place for a few years, the mean daily flow is subject to a lot of variance, but the mean monthly flow for August is 208 cfs, which compares well with the 70 years of record at the nearby, but discontinued, Wickersham gage (210 cfs).

FIGURE 2: RM 30 PROJECT LOGJAM LOCATIONS AND STRUCTURE NUMBERS (PHOTO: 2009 NAIP IMAGE).



Of the four structures built, one (#1) formed a primary pool (Table 2). This structure was placed in the middle of the active channel with the intent of splitting the majority of the flow away from the landslide now protected by Structure #2, which was being actively undermined by the channel at the time of construction, and toward Structure #4. The logjam has formed one of the deeper pools (maximum depth= 2.8m) of all of the projects in the South Fork, in spite of the large boulder-dominated substrate. The structure is deeply undercut and provides nearly 78m² of woody cover. The scour has led to the settling of the structure, and the cracking of at least one of the log pieces, although it is still cabled into the structure. The logjam has lost some gravel ballast that has been washed through the structure during high flow. Very little wood debris has racked onto the structure. The logjam has sorted sediment, and has developed a bar of suitable spawning sized gravel (~2-10 cm) in the lee that could provide spawning, although it was exposed at the time of the survey.

Logjam #2 was designed to protect the toe of an unstable slope from erosion by the river, and form a pool with complex wood cover. The hillslope immediately above the structure was revegetating with young alder trees, although the landslide is continuing to fail around the logjam. The logjam itself is beginning to be buried by the slide material. At the time of the survey, a small side channel led around Logjam #1 to #2. A secondary pool was formed in the side channel and the structure was providing a small amount of cover. The structure has no racked material aside from the small amount that has been contributed by the landslide.

Logjam #3 showed signs of local scour as the thalweg of the channel flowed along the side of the structure. The structure was slightly undercut and providing slower water habitat than the adjacent rapid. With the flow along the structure, it is likely that the structure will form a pool over time just as the others have done. The jam has a small amount of wood racked on the upstream side and has formed a bar in the lee of the structure.

Logjam #4 was forming a secondary pool in a side-channel riffle. The structure was undercut and providing woody cover for the mainstem South Fork, as well as a small tributary that enters the channel at the logjam. A small amount of material was racked on the upstream side of the logjam.

TABLE 2: HABITAT FUNCTIONS OF THE RM 30 LOGJAMS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Primary	2.8	0.7	2.1	599.0	77.6	1	1	1	0	0	0
2	Secondary	1.1	0.05	1.05	110.6	18.5	0	0	0	0	0	1
3	None	N/A	N/A	N/A	N/A	35.8	0	0	1	0	0	0
4	Secondary	1.2	0.4	0.8	111.7	36.0	0	0	0	0	0	0

LARSON'S BRIDGE PROJECT

Constructed in 2001, the Larson's Bridge project included the construction of 6 engineered logjams, one of which was a 130m woody revetment (Logjam #5) around the toe of a deep-seated landslide (Figure 3). The logjams were constructed by excavating below the expected scour depth and stacking and interweaving the logs up to a height where the wood and back-filled gravel was providing adequate ballast. This project was the first major instream project in the Nooksack Watershed and one of the first engineered logjam projects built in the region. The project was designed by Tim Abbe and Tracy Drury, while at the University of Washington, with final engineering design by Tracy Drury while with GeoEngineers. Regular monitoring of the site has occurred since its construction, and the site has continued to change over the ten years of informal monitoring. The project objectives included stabilizing a large deep-seated landslide, pool formation, increased woody cover, increased side channel length, and gravel sorting for improved spawning. The Larson's Bridge project was monitored on August 5, 2011 when the mean flow at Saxon Bridge was 485 cfs. The Saxon Bridge gage has a mean monthly flow for August of 208 cfs and a bank-full discharge of 9520 cfs.

FIGURE 3: LARSON'S BRIDGE PROJECT STRUCTURE NUMBERS AND LOCATION (PHOTO: 2009 NAIP IMAGE).



The objective of the first structure was to form a pool, provide cover, and split flow toward the north into an existing low-flow side channel and toward Logjam #2, which was to split flow into a floodplain channel. As the primary pool developed along the southern side of the logjam, the changed bed elevation likely contributed to deposition in the mouth of the side channel and abandonment of this

habitat (Table 3). Currently the structure splits bank-full flow into the side channel. The structure does not appear to have racked much woody debris beyond what was originally placed as a part of construction. Some of the ballast has eroded away, exposing several of the key pieces at the front of the log jam.

Logjam #2 is located on a former low flow side-channel of the South Fork Nooksack that was no longer connected at the time of the survey. Vegetation has encroached on the channel and it appears to only be connected at higher flows. This is likely due to changes in the channel occurring upstream at Logjam #1. The structure was originally designed to pass flow through it and into a floodplain channel behind the structure. The structure is now completely overgrown and isolated by sediment deposition except during high flow. There is currently no connectivity between the side channel and floodplain channel through the logjam and no habitat functions were observed at the site.

Logjam #3 was designed to scour a pool, provide cover and protect a streamside slope failure. This structure has scoured the deepest pool (maximum depth = 4.2m) of any structure in the South Fork Nooksack. The pool is scoured through the shallow alluvium and into the underlying glacio-lacustrine deposits. It is possible that the glacial deposit limits scour depth, or slows the development of the pool, but observed depth indicates that it does not form a significant barrier to pool development. The upslope area has not continued to fail and help bury the structure as anticipated. The pool formed by the structure has resulted in a broad gravel tail-out that appears suitable for spawning. The logjam is deeply undercut for over half of its width and has lost most of its gravel ballast. The structure appears to have lost several of its key pieces, but appears to still be stable, with young alders growing on the remaining ballast. The structure has not racked much more material beyond what was originally placed.

TABLE 3: LARSON'S BRIDGE PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Primary	2.4	0.8	1.6	624.8	47.6	0	1	0	0	0	0
2	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	0
3	Primary	4.2	0.8	3.4	850.8	107.3	0	0	1	0	0	1
4	Primary	3.2	0.8	2.4	582.2	84.1	0	1	0	0	0	0
5	Primary	3.2	0.5	2.7	1960.9	386.0	0	0	1	0	0	1
6	Secondary	1.8	0.25	1.55	286.0	30.0	0	1	0	0	0	0

Logjam #4 has also formed a deep primary pool (maximum depth = 3.2m) with woody cover, as it was designed to do. The structure was also intended to split low flow into an existing floodplain channel, which was the main channel of the South Fork prior to a mid-1990's avulsion, but it appears that channel incision has isolated the floodplain channel except during high flow. The structure has lost the

gravel ballast on the riverward 1/3 of the logjam and the rest is revegetating with alders. There hasn't been a noticeable change in the amount of wood racked on the logjam, and it appears to still be stable.

Logjam #5 was built as a long revetment to provide an area for a large landslide to fail to a stable angle of repose without impacting the water quality of the river. In addition to forming a deep pool (max= 3.2m) with woody cover, the structure was intended to create a large bar in its lee to better connect two tributaries (Deer and Roaring creeks) that enter the river just downstream of the logjam. Historically, these creeks came together on the South Fork River floodplain and flowed downstream through a relict channel for nearly a quarter of a mile. The mid-1990s avulsion captured this channel and shortened and steepened these two creeks creating a partial passage barrier. The structure has lost most of its ballast on the upstream side and the key pieces are all deeply undercut by the river, providing by far the greatest extent of woody cover of any structure in the South Fork. Much of the racking that was placed during construction has been lost, although natural accumulation has replaced some of this at the upstream end. The landslide has completely filled the basin behind the structure and it is now revegetating with deciduous trees. This has likely improved the stability as it has provided additional ballast. A large bar has formed downstream of the structure and both of the tributaries have increased their low gradient length.

Logjam #6 forms a pool in a secondary channel. The main channel has recently moved to the south leaving a smaller braid interacting with the logjam. The structure is covered in young alders and appears stable in spite of the loss of a portion of the gravel ballast. The structure may split bank-full flow, although the bar to the north of the logjam is revegetating- indicating that it is not frequently inundated. The structure has added a small amount of racked material.

FOBES REACH PROJECT

The Fobes project was constructed in 2010 and consisted of 14 engineered logjams to provide improved holding habitat (deep pools with wood cover) in the core spawning area for South Fork Nooksack early chinook (Figure 4). The project also intended to provide local scour and woody cover in the cool water influence area of Fobes Creek. The project design was developed by Gus Kays of Herrera Environmental Associates. The structures were built of large pieces placed around piles driven by excavator and tied together with manila rope. The Fobes Project was monitored on August 11, 2011. The mean flow of the South Fork Nooksack at Saxon Bridge was 333 cfs, which was still above the mean flow of 208 cfs for August.

FIGURE 4: FOBES PROJECT STRUTURE NUMBERS AND LOCATION (PHOTO: 2009 NAIP IMAGE).



Logjam #1 and #2 are located on a lateral bar where they had scoured small secondary pools at the edge of the low flow channel. The upstream structure (#1) had racked ~4m of wood on the upstream side. Both of these structures appear to be splitting the high flow channel and #2 showed signs of sediment sorting on the upstream side (Table 4).

Logjam #3 is located at the upstream end of a forested island with a low flow channel split. The structure has formed a medial bar, and is providing cover in a riffle in the left bank channel and a secondary backwater pool in the right bank channel.

Logjam #4 was designed to scour a pool and provide cover at the confluence with Fobes Creek, a cool water tributary to the South Fork Nooksack. The structure only includes a few large pieces of wood between piles and does not look as large as the structure shown in the design plans. Sediment deposition from the creek has isolated the structure from the low flow channel and no habitat functions were identified.

TABLE 4: FOBES STRUCTURE HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Secondary	0.4	0.05	0.35	38.9	22.6	0	1	0	0	0	0
2	Secondary	0.45	0.35	0.1	14.7	2.7	0	1	1	0	0	0
3	Secondary	0.4	0.15	0.25	24.5	5.9	1	1	1	0	0	0
4	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	0
5	Isolated	0.35	N/A	N/A	24.8	1.0	0	1	0	0	0	0
6	Isolated	0.35	N/A	N/A	7.0	1.2	0	1	0	0	0	0
7	Secondary	0.6	0.01	0.59	43.2	11.0	0	0	0	0	1	0
8	Isolated	0.2	N/A	N/A	6.0	6.0	0	1	0	0	0	0
9	Secondary	0.28	0.17	0.11	4.0	2.7	0	1	0	0	0	0
	Isolated	0.7	N/A	N/A	6.6							
10	Isolated	0.25	N/A	N/A	13.0	0.5	0	1	0	0	0	0
11	Secondary	0.4	0.01	0.39	24.2	19.5	0	1	1	0	0	0
12	Secondary	0.65	0.05	0.6	103.5	3.6	0	1	0	0	1	0
13	Secondary	0.4	0.25	0.15	21.0	4.0	0	1	0	0	0	0
14	Secondary	0.5	0.03	0.47	56.6	7.0	0	1	0	0	0	0

Logjams #5 and #6 are located on a lateral bar and both were isolated from the low flow channel, although racked wood and local scour indicated that the structures were interacting with high flow. The pools appear to have been excavated as a part of the construction.

Logjam #7 is located at the upstream end of the same lateral bar that #5 and #6 are built on. This structure has formed a small secondary pool at the margin of the main channel and has racked wood over 10m laterally on the upstream end of the structure. An additional deposit of wood that is 10m long is loosely associated with the structure. This deposit is racked across a high flow channel and appears to be deflecting high flow toward the left bank.

Logjams #8 and #9 are located on a high lateral bar. The structures were identified as splitting bank-full because the bar was largely unvegetated, although the bar was high relative to the channel and recent wood deposition appeared to be related to local backwatering in front of logjam #8, rather than flow across the bar. The pools associated with the structures were likely left from construction, although logjam #9 had formed a small secondary pool at the edge of the main channel.

Logjam #10 is isolated from the main channel, with a pool that appears to be left from the construction of the structure. Large piles of gravel were also left on the bar from the construction and these may inhibit flow across the bar.

Logjams #11 and #12 are also located on the same lateral bar as #10. Both of these structures have formed small secondary pools. The pool associated with logjam #12 was the deepest observed in the project (0.65m). Logjam #11 has ~2.5m of freshly racked wood and has formed an arcuate bar upstream of the structure. Logjam #12 has racked ~9m of material on the upstream side. The racked material has grown upstream along the outside of a bend and is currently deflecting the high flow channel toward the right bank. Logjam #12 also splits high flow into disconnected side channel area that appears to be connected through the majority of the year.

Logjams #13 and #14 are both located on a lateral bar and both have small secondary backwater pools at the margin of the main channel. Both appear to split the high flow channel.

SKOOKUM PROJECT

The Skookum Project was constructed in 2010 and included the setback of ~850m of stream-adjacent road, the installation of 3 engineered logjams along a terrace of the South Fork Nooksack, and revegetation of the old road grade (Figure 5). The goal of the project was to take advantage of the cool water influence of Skookum Creek and the hatchery outfall to provide thermal refuge for migrating and holding chinook salmon and to provide cover near the hatchery outfall for returning salmon to reduce potential for poaching. The structures were intended to scour deep pools with woody cover in the plumes of these two cool water sources. The project was designed by Gus Kays, with Herrera Environmental Consultants. The structures were built around excavated piles and set into the bank to provide ballast and reduce local increases in flood height. The larger pieces were attached to the piles using manila rope. The Skookum Project reach was monitored on August 31, 2011, when the mean daily flow at the Saxon Bridge was 216 cfs, which was approximately the mean flow for the month (208 cfs).

Logjam #1 is located on the margin of a long flat-water (run) section of the mainstem South Fork. The structure has scoured a small secondary pool (max depth= 0.85m) along the edge of the cool and clear plume of Skookum Creek. The structure is set into the bank and provides bank resistance to the slowly eroding terrace (Table 5).

Logjams #2 and #3 lie in a side channel that runs along the base of the terrace. Logjam #2 is forming a small secondary pool with wood cover in the side channel immediately downstream of the outfall from the Skookum Hatchery. Logjam #3 also lies in a run along the same side channel. The structure is providing a small amount of cover, but has no local scour associated with it. Both structures are set into the bank, providing increased bank resistance to the slowly eroding terrace. None of the structures have resulted in a deep scour pool as intended, likely due to being set deeply into the terrace. Continued erosion of the terrace may expose more of the structures to the flow of the river and lead to deeper local scour, although the erosion rate has historically been slow due in part to the location near the point of inflection on the inside of a bend in the South Fork.

FIGURE 5: SKOOKUM PROJECT SHOWING LOGJAM LOCATIONS AND STRUCTURE NUMBERS. THE ROAD SETBACK CORRIDOR IS VISIBLE TO THE WEST OF THE SKOOKUM HATCHERY (PHOTO: 2009 NAIP IMAGE).



TABLE 5: HABITAT FUNCTIONS ASSOCIATED WITH THE SKOOKUM REACH LOGJAMS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Secondary	0.85	0.3	0.55	34.5	1.9	0	0	0	0	0	1
2	Secondary	0.6	0.2	0.4	11.0	3.3	0	0	0	0	0	1
3	None	N/A	N/A	N/A	N/A	2.3	0	0	0	0	0	1

NESSET'S REACH PROJECT

Constructed in the summer of 2008, the Nessel's Reach Project consisted of stabilizing eight existing woody debris piles in the South Fork Nooksack between RM 10.5 and 11.5. The goal of the project was to create deep scour pools with cover. The sites were stabilized using piles driven with an excavator, and several pieces of wood were placed with existing large wood to help ballast the structure. The project had no engineering design, instead opting for a "safe-fail" design that would minimize any downstream impacts of the added pieces of wood, by sizing them similarly to the large wood that was already

present in the channel. Of the eight sites stabilized in 2008, three (#2, #3, and #8) have subsequently washed-out (Figure 6). The Nesset's Reach Project was monitored on August 31, 2011, when the mean daily flow at the Saxon Bridge (upstream at RM 13) was 216 cfs.

FIGURE 6: NESSET'S PROJECT REACH SHOWING STABILIZATION SITE LOCATIONS AND NUMBER (PHOTO: 2009 NAIP IMAGE).



Logjam #1 is located at the edge of the active channel area, where an ephemeral side channel enters the mainstem of the South Fork Nooksack. This structure forms a pool in the side channel, which was isolated from the main channel at the time of the survey (Table 6).

Sites #2 and #3 were both washed-out at the time of the survey. In both cases, downstream migration of a meander undermined the sites and washed the large placed wood and pilings away.

Site #4 formed an isolated pool on a lateral bar. The structure was previously splitting low flow, but down-valley migration of the upstream meanders has isolated the site. Several juvenile salmonids were present in the pool, indicating a recent connection with the wetted channel. A small amount of wood has racked on the upstream side of the structure, and it currently splits the bank-full flow.

Site #5 now lies on a lateral bar to the right of the main channel; the channel has migrated downstream past the structure. A small channel initiates at the secondary pool under the structure and connects to the main flow of the river. The logjam has racked ~3m of material on the upstream side and it splits the high flow channel.

Site #6 is now located on a right lateral bar due to down-valley migration of the channel. The structure has lost several of its pilings, but is still holding the logjam in place. Currently, the only habitat function is splitting the high flow. Similarly, Site #7, which is located at the head of a forested island, is isolated from the low-flow channel and only splitting the high flow.

Site #8 has washed-out. The low flow channel has migrated through the structure and left only one piling.

TABLE 6: NESSET'S REACH PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Isolated	0.2	N/A	N/A	80.3	2.3	0	0	0	0	0	0
2	Washed-out											
3	Washed-out											
4	Isolated	0.7	N/A	N/A	46.1	10.9	0	1	0	0	0	0
5	Secondary	0.2	0.05	0.15	6.0	0.1	0	1	0	0	0	0
6	None	N/A	N/A	N/A	N/A	None	0	1	0	0	0	0
7	None	N/A	N/A	N/A	N/A	None	0	1	0	0	0	0
8	Washed-out											

LOWER HUTCHINSON PROJECT

The Lower Hutchinson Project was completed in 2006 and was the second engineered logjam project in the Nooksack Watershed. The project included setting back ~150m of levee and construction of six engineered logjams. The project was originally designed by Tim Abbe then with Herrera Environmental Consultants, although subsequent community input lead to substantial design changes, including the construction of three of the logjams (#4-6) as a setback behind the structures along the river (Figure 7). The purpose of the setback was to both reassure the community regarding concerns for potential flooding or avulsion to the north and to encourage side channel formation between the river adjacent and setback jams roughly in the pre-project location of lower Hutchinson Creek. The structures were constructed by excavating below scour depth and driving piles. The key pieces were placed between piles and built up to above the 100-year flood elevation. The structures were then back-filled with gravel for ballast. The project objectives included pool formation, improved wood cover, and reconnection of Hutchinson Creek to provide a cool water refuge. The Lower Hutchinson Project was assessed on August 10, 2011, when the mean daily flow at Saxon Bridge was 364 cfs. This was higher than the 208 cfs historical mean for the month.

Logjam #1 is located in a riffle in a braided channel of the South Fork Nooksack. The logjam has loosely racked material for a length of ~10m along the bank upstream, although this appears to be temporary. Some of this material appears racked on submerged rock left over from the eroding remnant of levee

upstream of the logjam. The logjam has no local scour associated with it, although it is providing cover and slowing the velocity in the riffle (Table 7: Lower Hutchinson Project habitat functions (1= function observed, 0=not observed)). The remnant of riprap upstream of Logjam #1 is likely slowing migration of the channel toward the north and limiting the engagement of the logjam with the channel.

FIGURE 7: LOWER HUTCHINSON PROJECT SHOWING THE STRUCTURE LOCATIONS AND NUMBERS.



Logjam #2 is located at the confluence with Hutchinson Creek. The structure forms a primary pool (max= 2.9m) and is deeply undercut providing complex wood cover. Hutchinson Creek flows into the scour pool to provide a cool water source to the channel. The structure has accumulated several meters of material on upstream side of the structure. Wood and sediment deposition on the right bank side of the structure has obstructed the old channel of Hutchinson Creek that was associated with the back side of the removed levee. The structure still appears to split the bank-full flow of the river.

Logjam #3 forms a secondary pool in a flat water section of the South Fork Nooksack. There is some evidence that the structure split high flow (sand deposition around the structure), although the area is thoroughly vegetated. The logjam has not accumulated any additional wood since construction.

Logjams #4, #5 and #6 all lie on the floodplain behind the first three structures. These were intended to obstruct the South Fork if it moved between the structures in the first row and to encourage secondary channel formation in the former lower reach of Hutchinson Creek. There is some evidence of high flow

scour around #4, but it is likely that this occurs only during the larger floods. There were no other habitat functions described for these structures.

TABLE 7: LOWER HUTCHINSON PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	None	N/A	N/A	N/A	N/A	88.4	0	0	1	0	0	0
2	Primary	2.9	0.8	2.1	1007.0	39.0	0	1	0	0	0	0
3	Secondary	1.6	0.75	0.85	162.4	35.0	0	1	0	0	0	0
4	None	N/A	N/A	N/A	N/A	None	0	1	0	0	0	0
5	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	0
6	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	0

ACME PROJECT

The Acme Project was built over two years and included five groups of structures in the South Fork Nooksack and several smaller habitat structures in the Landingstrip Creek side channel (Figure 8). In 2009 Structures #4 and #5 in the mainstem were completed. The fourth structure was augmented in 2010 and the other three structures were added downstream, along with small structures on the left bank of the former channel of Landingstrip Creek downstream of #3. The logjams consist of pilings driven along the bank with wood and rock ballast cabled together along the surface. The Acme Project was designed to integrate flood management and salmon habitat and included increasing bank resistance to erosion as a project objective, along with pool scour and increased wood cover at a range of flow elevations along with enhanced flow into the Landingstrip Creek side channel (former channel location). The project was designed by Erik Rowland and Derek Ray of Northwest Hydraulic Consultants. The Acme Project site was monitored on August 12, 2011, when the mean daily flow was 328 cfs upstream at the Saxon Bridge (RM 13). This was higher than the historical mean flow for August.

Logjam #1 is composed of approximately 60' of woody bank treatment. Additional wood was added to supplement the structure in early 2011. The jam is constructed of interlocking triangles of large woody debris that are anchored with short cables to rock ballast to address buoyancy and to pilings to provide lateral strength to the structure. The structures were placed on the bank and bed with no excavation but are designed to settle as scour occurs. The structure is forming a secondary pool in a run unit and providing complex woody cover for the edge habitat. The logjam has not racked any additional material and is providing bank resistance to the floodplain where it was formerly eroding.

Logjam #2 is also an approximately 60' long woody bank treatment that projects further into the channel than either #1 or #3 and was constructed similarly to #1. This structure also forms a deep

secondary pool (maximum depth= 2.05m) in mainstem run habitat. The pool is scoured under the logjam providing substantial woody cover. As with the other structures, this logjam protects a formerly eroding bank.

Logjam #3 lies at the divergence of a side channel that was historically separated from the South Fork by a high bank and which contained the flow of Landingstrip Creek. Recent migration by the South Fork reclaimed the side channel and captured Landingstrip Creek which now enters the South Fork at jam #4. Logjam #3 was constructed by excavation to place footer logs with subsequent log layers being interlaced with and cabled to driven pilings and rock ballast. This structure forms a secondary pool in the mainstem run that is connected to the pool formed by Logjam #2, with only a slight tail-out separating the two. The apex structure splits moderate to high flow into the Landingstrip side channel. This structure also protects the upstream end of the island separating the side channel from the main flow of the river.

FIGURE 8: ACME PROJECT STRUCTURE LOCATIONS AND NUMBERS (PHOTO: 2009 NAIP IMAGE).



TABLE 8: ACME PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Secondary	1.2	0.5	0.7	72.7	14.4	0	0	0	0	0	1
2	Secondary	2.05	0.75	1.3	137.5	65.1	0	0	0	0	0	1
3	Secondary	1.19	0.95	0.24	39.0	43.2	0	1	0	0	0	1
4	Primary	3.9	0.7	3.2	2386.2	127.5	0	0	0	0	1	1
5	Secondary	1.4	0.7	0.7	73.2	79.9	0	0	0	0	0	1
	Secondary	1.9	1	0.9	124.3							
	Secondary	1.44	1.17	0.27	174.0							

Logjam #4 was constructed in 2009 and enhanced a pre-existing log jam at the confluence of Landingstrip Creek with the South Fork Nooksack. Additional wood was added in 2010. The structure forms the second deepest pool (max= 3.9m) of the 83 structures monitored throughout the South Fork. The logjam has accumulated ~3m of racked material, including a piece from one of the eroded structures in the Nesset's Reach. The racked wood contributes to the logjam providing the second largest area of woody cover of all South Fork structures monitored. The structure deflects the low flow channel toward the right bank and protects the entrance of the Landingstrip side channel, which is in the lee of the structure.

Logjam #5 is an approximately 200' long bank treatment of the confluence with Landingstrip Creek. The bank treatment was constructed in 2009 as a series of interlocking structures which function as a unit. Three secondary pools were mapped along the edge of the main channel run habitat. The pools were generally associated with individual logs that projected farther into the channel, some of which are remnants of an historic logjam at this site and which remain embedded in the channel bed. Some small woody debris has racked onto this jam. As with the other structures, this one provides bank protection for the eroding floodplain.

The Landingstrip creek side channel structures were not evaluated and no flow was present in the side channel at the time of survey.

KALSBECK PROJECT

The Kalsbeek Project was completed in 2007 and includes three logjams, six bank structures, and a series of small habitat structures placed in a side channel of the South Fork Nooksack (Figure 9). The original design called for additional upstream structures on the opposite bank to encourage flow toward the side channel, but these were dropped due to a lack of landowner cooperation. The logjams and bank structures consist of pilings and interwoven logs stacked-up from below the scour depth to above the 100-year flood elevation. The bank structures are built into the margin of the floodplain surface, while the logjams are designed to function with flow around them. Two of the logjams (#2 and #3) were built

into the floodplain margin, essentially limiting the potential for flow to move around them. The habitat objectives of the project were to reconnect a side channel and create deep scour pools with complex woody cover. The Kalsbeek Project was designed by Tim Abbe and Gus Kays with Herrera Environmental Consultants. The Kalsbeek Project site was monitored on September 8, 2011, and the mean daily flow at Saxon Bridge was 172 cfs, which is representative of the low flow period of the South Fork Nooksack.

Logjam #1 was located at the upstream end of the side channel, with the objective of splitting the low flow into the side channel and scouring a pool. The logjam currently forms a secondary pool in the main channel riffle (Table 9). The logjam has racked wood on the upstream side for a length of approximately 20m that has grown across the inlet of the side channel. A narrow opening to the side channel is still present upstream of the racked material and the channel maintains enough flow to remain unvegetated, although it was dry at the time of the survey. At the time of construction, the natural logjam at the ELJ #1 site had material racked upstream across the mouth of the side channel, which was removed during construction. The logjam does deflect the high flow of the channel away from the side channel, creating a protected flood refuge. Sediment sorting was also observed upstream of the structure.

Logjams #2 and #3 were both isolated from the channel at the time of the survey. Logjam #2 was on the downstream end of the dewatered side channel and was providing no habitat functions. Logjam #3 has a piece of wood cabled in front of it that has formed a sandbar. The sandbar has isolated the logjam from the flow. It is likely that both of these structures are engaged with the wetted channel and providing cover when the mainstem flow is slightly higher than it was when it was surveyed.

The two upstream-most bank structures (#4 and #5) each form a secondary pool in a long flat water section of the South Fork. Bank structures #6 and #7 were located close enough together that they were essentially the same structure and were associated with the same pool. The same was true for structures #8 and #9, which were tied together into one structure with placed logs. None of these bank structures has accumulated any woody material. All of these structures provide protection from erosion to the adjacent floodplain.

FIGURE 9: KALSBECK PROJECT SHOWING STRUCTURE NUMBERS AND LOCATIONS (PHOTO: 2010 PICTOMETRY IMAGE).



TABLE 9: KALSBECK PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Secondary	1.2	0.4	0.8	198.3	15.7	0	0	1	0	1	0
2	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
3	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
Bank 4	Secondary	1.6	0.8	0.8	129.9	31.8	0	0	0	0	0	1
Bank 5	Secondary	1.1	0.8	0.3	40.7	13.9	0	0	0	0	0	1
Bank 6&7	Secondary	1.8	0.5	1.3	238.8	58.9	0	0	0	0	0	1
Bank 8&9	Secondary	1.5	0.4	1.1	125.1	43.5	0	0	0	0	0	1

SYGITOWICZ PROJECT

The Sygitowicz Project, built in 2010 and 2011, consists of seven engineered logjam structures and the removal of ~150m of riprap bank protection. The project area is contiguous with the downstream Todd

Project, which was built in 2008 (Figure 10). The objectives of the project were to create deep, thermally stratified pools with cover and to encourage flow toward the left bank structures build as a part of the Todd Project. The design included 5 logjams built into the high bank of the Sygitowicz Creek and Todd Creek alluvial fans (#1-5) and two structures build to split flow around them (#6 and #7). Similar to the Skookum Project, the Sygitowicz design compensated for potential flooding issues by setting the bank structures deeply into the bank. After 2010, it was evident that the bank excavation for the structures left the logjams sitting in a backwater and not likely to form the pools that were a project objective. Additional large pieces of wood were added to three of the bank structures (#3, #4 and #5) in 2011, so that they now project further into the wetted channel. The project design was completed by Gus Kays with Herrera Environmental Consultants. The Sygitowicz Project was surveyed on August 31, 2011. The South Fork Nooksack mean daily flow was 216 cfs, which represents the historical mean for the month of August.

FIGURE 10: THE SYGITOWICZ PROJECT SHOWING THE LOGJAM LOCATION (DARK CIRCLES) AND MONITORING NUMBER (PHOTO: 2010).



Logjams #1 and #2 are located along a high bank on a lateral bar. These two structures are intended to encourage the main channel flow across the bar and reestablish a low flow channel along the bank, although they are currently only functioning during high flow. Logjam #3 is also located in the bank at the upstream extent of this bar and it is also only functioning at high flow. A small high flow channel

runs along the bank from Logjam #3 to the downstream Todd Project. None of these structures are currently providing any other habitat functions aside from protecting the bank from erosion (Table 10).

Logjam #4 forms a secondary pool in a long run habitat unit in the South Fork. The pool is being formed by the log that was added to the structure in 2011, and this was the only part of the structure that was providing cover. The log had accumulated some small brush, but the rest of the structure was isolated from the channel and providing no functions aside from protecting the bank. Logjam #5 also lies along the edge of the same run habitat in the South Fork. The additional log added to this structure is providing some woody cover, but no pool scour was observed at the site. Pool scour may have been limited in the first year by remnant riprap boulders in the channel, but subsequent removal may improve conditions.

TABLE 10: SYGITOWICZ PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
2	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
3	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
4	Secondary	1.4	0.6	0.8	18.0	10.1	0	0	0	0	0	1
5	None	N/A	N/A	N/A	N/A	4.0	0	0	0	0	0	1
6	Secondary	0.2	0.05	0.15	22.8	0.0	0	0	0	0	0	0
7	Secondary	0.8	0.3	0.5	131.8	33.2	0	1	1	0	0	0

Logjam #6 was built into the floodplain along the edge of a shallow riffle in the South Fork. The structure has scoured a shallow secondary pool that was backwatered at the time of the survey. The logjam was above the water column, so the wood was not providing any instream cover- only overhead cover.

Logjam #7 is also located at the edge of the shallow riffle- downstream of Logjam #6. This structure consists of open pilings with buried wood that has accumulated approximately 2 meters of racked wood. The racked material is undercut and forming secondary pool. The structure has also accumulated a small arcuate bar upstream of the pool. This logjam splits the high flow, and it appears that the floodplain channel to the right of the structure is showing signs of erosion and enlarging from increased flow.

TODD PROJECT

The Todd Project was designed by Gus Kays with Herrera Environmental Consultants and constructed in 2008. The project includes six bank logjams, one bar-apex logjam (#7), and the stabilization of an existing debris pile (#8) (Figure 11). The goal of the project was to create deep, thermally stratified pools with complex wood y cover for migrating and holding habitat. The structures were built around piles driven to below the scour depth. Logs were then stacked and interwoven between the pilings to form the structures. The existing accumulation was stabilized with pilings driven through it and the wood

placed around the piling. The Todd Project was monitored on September 6, 2011, when the mean daily flow at Saxon Bridge (RM 13) was 175 cfs.

FIGURE 11: TODD PROJECT LOGJAM LOCATIONS (DARK CIRCLES) AND STRUCTURE NUMBERS (PHOTO: 2010).



Logjam #1 was built into the Todd Creek alluvial fan, which is above the modeled 100-year flood surface. The structure forms a deep pool in a disconnected side channel (Table 11). It appears that the side channel is connected at the downstream end for most of the year, and at the upstream end during high flow events. This side channel bar area was the main channel when the project was constructed, but the main channel moved to the east of Logjam #7, leaving this area as a high flow channel. The structure is providing some woody cover for the abundant juveniles present in the isolated pool. Logjam #2 is also built into the alluvial fan deposit upstream of Logjam #1 and forms another isolated pool. There is a subtle tail-out between this pool and the pool associated with Logjam #1, but they are essentially the same feature. The pool has filled substantially in the last year, with fresh gravel bars narrowing the backwater area. As with Logjam #1, this structure protects the bank from erosion.

Logjams #3 and #4 are also built into the high bank of the alluvial fan deposit. Both of these logjams form isolated pools in the side channel. The maximum depth at Logjam #3 is 2.1m, making it one of the deeper pools created for the South Fork projects. There is a subtle tail-out between the two isolated pools, but they are both the same feature. These two structures have each accumulated ~1m of woody material since they were constructed. These structures also protect the high bank from erosion.

Logjams #5 and #6 each form an isolated pool on the lateral bar upstream of the discontinuous side channel. During higher flow, these logjams protect the high bank from erosion, and provide cover for the channel along the bank. These structures have not accumulated any additional material.

Logjam #7 is located on a lateral bar at the edge of the low flow channel. When constructed, this logjam was located on the opposite bank, but the channel subsequently avulsed to the right of the structure. The logjam is currently forming a secondary pool in a riffle. This pool is approaching half of the channel width and is nearly a primary pool. The logjam has accumulated approximately 4 meters of wood on the upstream end (including a piece from the wash-out Nessel's Project), which has encouraged the pool formation. The structure splits the high flow, although the recent pool scour in the main channel may be contributing to the disconnection and sediment deposition in the former main channel to the left of the structure has the bed elevation is lowered in the main channel to the right.

Logjam #8 is a natural logjam that has been stabilized with piles driven through it and augmented with several large logs. This site is currently forming a secondary backwater pool at the edge of a riffle. The structure also appears to split the high flow into a channel to the east of the logjam.

TABLE 11: TODD PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	Isolated	1.7	N/A	N/A	184.8	11.9	0	0	0	0	0	1
2	Isolated	1.1	0.9	0.2	27.3	2.9	0	0	0	0	0	1
3	Isolated	2.1	0.1	2.0	292.0	28.4	0	0	0	0	0	1
4	Isolated	1.6	0.95	0.65	168.0	19.5	0	0	0	0	0	1
5	Isolated	0.8	N/A	N/A	43.7	1.6	0	0	0	0	0	1
6	Isolated	0.55	N/A	N/A	25.6	17.8	0	0	0	0	0	1
7	Secondary	1.7	0.7	1.0	389.9	58.0	0	1	0	0	0	0
8	Secondary	0.5	0.15	0.35	55.9	8.1	0	1	0	0	0	0

VAN ZANDT PROJECT

The Van Zandt Project was constructed in 2010 and includes 14 engineered logjams and the stabilization of a large cottonwood tree (#15) that is keying a natural logjam (Figure 12). The goal of the Van Zandt Project was to scour deep, thermally stratified pools with complex wood cover for migrating and holding habitat. The project also protects an old landfill that was built on an ancient landslide deposit from channel migration and avulsion. The project was designed by Gus Kays with Herrera Environmental Consultants. The Van Zandt Project was monitored on September 6, 2011, when the mean daily flow for the South Fork Nooksack at Saxon Bridge was 175 cfs.

The upstream-most logjams (#1 and #2) currently lie in a backwater depositional area of the channel. Neither was interacting with the low flow channel at the time of the survey (Table 12). Both of these structures show evidence of splitting the flood flow when the stage is high enough to top the bank to the north. Both of these logjams protect the low floodplain from bank erosion.

FIGURE 12: VAN ZANDT PROJECT LOGJAM LOCATIONS AND NUMBERS (PHOTO: 2010).



Logjams #3, #4, and #5 are all located along the high bank of landslide material at the outside of the meander bend. Logjam #3 forms a secondary pool with a subtle tail-out leading into the primary pool associated with Logjam #4. Since construction, the bank has retreated between the logjams and exposed more of the structures to the force of the river and resulted in some wood accumulation on them. The primary pool formed at Logjam #4 is aided by additional scour from a large rock that has eroded from the landslide deposit. Logjam #5 is located in the tail-out of the pool formed by Logjam #4. All three of these structures locally protect the floodplain and are tall enough to split the flood flow when it crests the bank to the north.

Logjam #6 forms a primary pool that is one of the deepest (max = 3.1m) found during the surveys. The pool is formed in the clay, silt and fine sand that makes up the deposit of a large deep-seated landslide and begins immediately downstream of the tail-out from the pool formed near Logjams #3, #4, and #5. The structure locally protects the bank, although erosion between the structures has exposed more of the logjams to flow and encouraged deep pool formation. As with the other structures, Logjam #6 splits the flow when it is high enough to top the bank.

Logjam #7 lies behind an existing debris pile and was not interacting with the low flow channel. During high flow this structure likely provides protection for the bank.

Logjams #8 and #9 form a primary pool, with only a subtle tail-out between the two structures. The maximum depth is one of the deeper (max = 2.8m) found in the monitoring effort. The structures are built along a resistant bank, which is also contributing to the pool formation. The structures are both providing bank protection.

TABLE 12: VAN ZANDT PROJECT HABITAT FUNCTIONS (1= FUNCTION OBSERVED, 0=NOT OBSERVED).

Structure Number	Habitat Functions											
	PFF					COV	Other Functions					
	Pool Type	Max Depth (m)	Tailout Depth (m)	Residual Depth (m)	Pool Area (m ²)	Logjam Cover Area (m ²)	SLF	SBF	SED	CAV	DFC	BANK
1	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
2	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
3	Secondary	1.6	1.3	0.3	263.6	2.0	0	0	0	0	0	1
4	Primary	1.8	1.1	0.7	434.2	3.7	0	0	0	0	0	1
5	None	N/A	N/A	N/A	N/A	8.0	0	0	0	0	0	1
6	Primary	3.1	0.5	2.6	643.0	18.0	0	0	0	0	0	1
7	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
8	Secondary	2.8	2.1	0.7	288.4	64.5	0	0	0	0	0	1
9	Primary	2.5	1.0	1.5	664.0	33.2	0	0	0	0	0	1
10	None	N/A	N/A	N/A	N/A	None	0	0	0	0	0	1
11	Secondary	2.7	1.0	1.7	249.5	32.4	0	0	0	0	0	1
12	Secondary	0.7	0.4	0.3	10.3	12.8	0	0	0	0	0	1
13	Secondary	1.4	0.4	1.0	72.0	41.6	0	0	0	0	0	1
14	None	N/A	N/A	N/A	N/A	18.1	0	0	0	0	0	1
15	Secondary	1.5	0.5	1.0	166.6	104.7	0	0	1	0	1	0

Logjams #10 and #11 are both located on a small patch of low floodplain at the foot of a higher floodplain surface. At the time of construction, both of these logjams were isolated from the channel, but subsequent channel migration has exposed Logjam #11. This structure forms the deepest secondary pool found (max depth = 2.1m) in the surveys in a flat water section of the South Fork. The logjam is deeply undercut and providing excellent cover. Both of these structures are providing protection to the higher floodplain surface behind them.

Logjams #12, #13 and #14 are all located along a riprap-armored bank. The riprap has been removed in the footprint where the structures were constructed. Both Logjams #12 and #13 are forming secondary pools in a mainstem run habitat unit. Logjam #13 has racked material on the upstream side of the structure for a length of ~3m, which is largely responsible for the pool scour. Logjam #14 is located at the downstream end of the riprap revetment and is providing cover for the riprap-formed scour pool.

While this pool was approximately 1.5m deep, it was not attributed to the logjam. All three of these logjams are providing bank protection to the narrow strip of floodplain behind them.

Logjam #15 is racked on a large cottonwood tree that was stabilized with pilings. The log has racked woody material upstream along the bank of the river for a length of approximately 40 meters, which is forming a secondary pool in the mainstem run habitat. The stability of the racked material is questionable, but any lost will likely be replaced by new recruitment. A deeper pool is associated with a natural logjam just upstream of the racked material, and it is possible that continued growth of the logjam could join these two accumulations together. Logjam #15 deflects the low flow channel and has a sand bar deposited in the lee of structure- between the logjam and high bank behind it. This accumulation has contributed to the isolation Logjams #1 and #2.

SOUTH FORK DISCHARGE

Annual South Fork Nooksack River peak discharges between completion of the first log jam project and when monitoring occurred has varied interannually, with peak discharges substantially exceeding bankfull discharge (8000 cfs: SF@Wickersham gage⁵, 9500 cfs: SF@Saxon Bridge⁶) about every 2 years (Figure 13; Table 13). Annual peak discharges have ranged from 5,230 to 18,500 cfs for water years 2002-2008 (SF@Wickersham) and from 11,500 to 20,500 cfs for water years 2009-2011 (SF@Saxon). All projects experienced the highest discharge on record for the lower South Fork during the period – the 20,500 cfs peak recorded at the Saxon Bridge gage on 12/12/2010. However, scaling that discharge by watershed area to facilitate comparison with the SF@Wickersham gage, suggests the event was smaller (estimated 16,370 cfs at SF@Wickersham) than the 18,500 cfs event recorded at the SF@Wickersham gage on 10/17/03 (Figure 13).

Clearly, the older the project, the greater number of bankfull, presumably channel-forming⁷ events that project has experienced. South Fork log jam projects were subject to the following frequency and duration of bankfull events (Table 13) between project construction and when project effectiveness was monitored:

- 23 bankfull events (235 total hours) for the project built in 2001 (Larson's)
- 12 bankfull events (120 total hours) for the project built in 2006 (Lower Hutchinson)
- 8 bankfull events (94 total hours) for the projects built in 2007 and 2008 (Todd, Kalsbeek, Nasset, RM 30)
- 2 bankfull events (34 total hours) for the projects built in 2010 (Van Zandt, Sygitowicz, Acme, Skookum, Fobes).

⁵ GeoEngineers 2002, as cited in Maudlin et al. 2002

⁶ <http://www.nwrfc.noaa.gov/river/station/ratplot/ratplot.cgi?NSSW1>.

⁷ As described in Methods, bankfull discharge was selected as a reference point because it commonly corresponds to the effective discharge, the dominant channel-forming discharge, in magnitude (Andrews 1980, as cited in Ziemer and Lisle 1998).

FIGURE 13. SOUTH FORK PEAK DISCHARGES BY WATER YEAR RELATIVE TO LOG JAM PROJECT IMPLEMENTATION DATES.

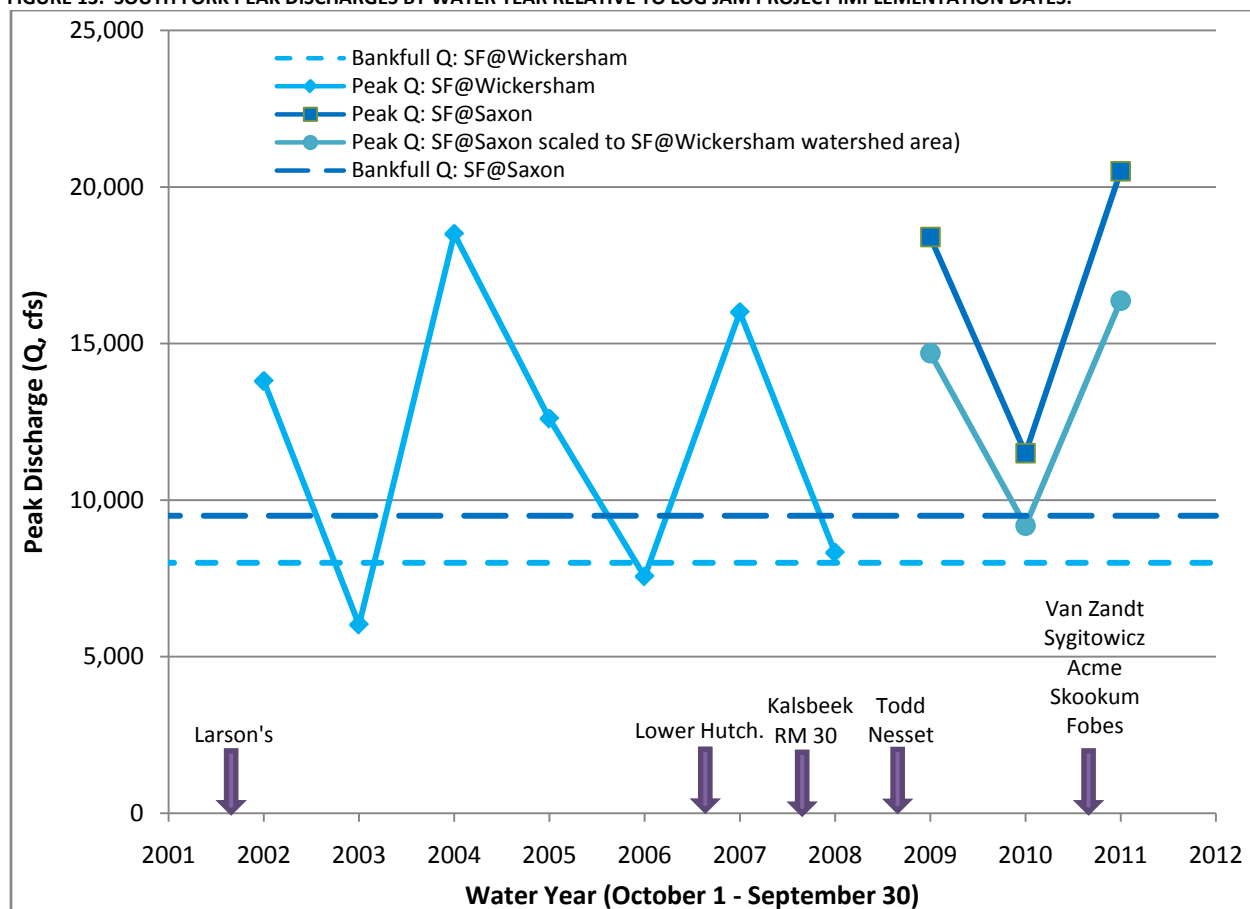


TABLE 13. FREQUENCY AND DURATION OF BANKFULL EVENTS IN THE SOUTH FORK NOOKSACK BY WATER YEAR (WY2001-2011).

Water Year	Number of bankfull events	Total duration (hours) above bankfull
2002	2	35.5
2003	0	0.0
2004	4	44.3
2005	5	35.5
2006	0	0.0
2007	4	25.7
2008	0	0.0
2009	2	45.5
2010	4	14.5
2011	2	34.0

RELATIVE PROJECT EFFECTIVENESS

The 2011 effectiveness monitoring effort focused on quantification of pool formation and woody cover, two of the main limiting factors in the South Fork Nooksack. All of the projects developed in the South Fork included pool formation as a primary habitat objective. While it is not expected that all structures will be forming pools at the same time due to channel migration, it is expected that the structures will provide enough deep (>1 m) pools in the project reach to meet the habitat recovery goal of 18 wood-formed pools per mile. Relative effectiveness of projects at addressing these two primary habitat objectives is shown in Table 14.

The three projects that yielded the greatest area of wood-formed pools and cover were the Larson's Bridge, Acme and Van Zandt projects (Figure 14; Table 14). For the Larson's Bridge and Acme projects, this was accomplished by a few (5 to 6) structures forming very large pools. In the case of the Acme Project, one pool was approximately 2385m² in area, accounting for nearly 80% of the pool area in the project reach, and 16% of the total South Fork project-formed pool area (Table 15). This was also the case in the Larson's Reach where one pool accounted for 1960m², which represented 45% of the reach area and 13% of the total project-formed pool area.

While pool area and cover area are related at the project reach scale, at the individual structure level they are not (Figure 15). Structures that create larger pools do not provide the most instream cover area. This could imply that these should be separated as objectives at the structure level, and the engineering designs should be directed toward the individual objectives as necessary. At the reach scale, the three most effective projects at creating pools and cover were the Larson's Bridge, Acme and Van Zandt projects, while the four least effective were Skookum, Nasset, Sygitowicz, and Fobes (Figure 14; Table 14).

FIGURE 14: CUMULATIVE NUMBER OF STRUCTURES, POOL AREA AND COVER AREA FOR EACH PROJECT

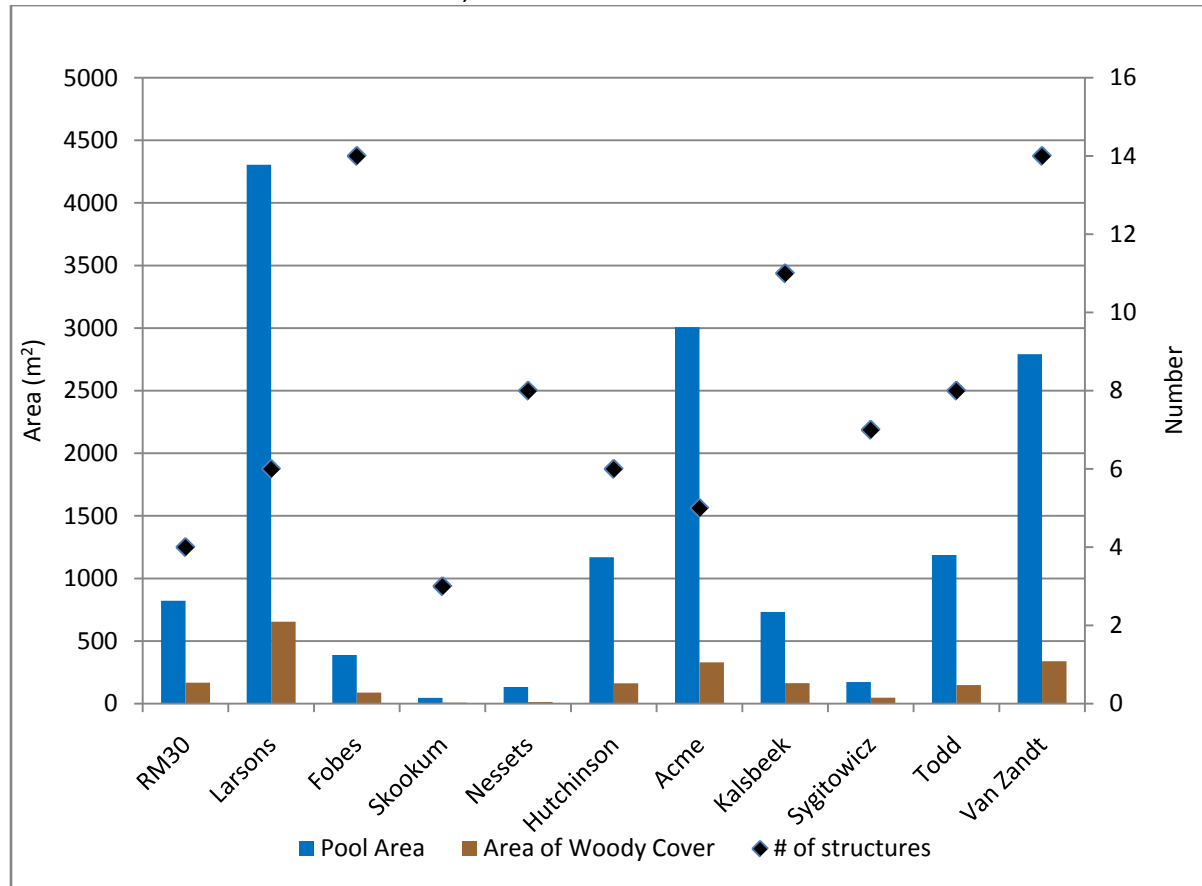


TABLE 14: RELATIVE PROJECT EFFECTIVENESS.

Project	Number of structures	SF Discharge at Saxon at time of survey (cfs)	Primary Pools Formed			Secondary Pools Formed			Total Low-Flow Pools ¹		Total Low-Flow Woody Cover ¹		Bankfull Discharge Events	
			Total #	Mean Residual Depth (m)	% of structures forming 1° Pools	Total #	Mean Residual Depth (m)	% of structures forming 2° Pools	Total Pool Area	Mean pool area per Structure	Total Woody Cover Area	Mean woody cover area per Structure	Number	Total Duration (hours)
River Mile 30	4	485	1	2.1	25%	2	0.9	50%	821.3	205.3	167.9	42.0	8	94
Larson	6	485	4	2.5	67%	1	1.6	17%	4304.7	717.5	655.0	109.2	23	235
Fobes	14	333	0	n/a	0%	9	0.3	64%	330.6	23.6	79.0	5.6	2	34
Skookum	3	216	0	n/a	0%	2	0.5	67%	45.5	15.2	7.5	2.5	2	34
Nesset	8	216	0	n/a	0%	1	0.2	13%	6.0	0.8	0.1	0.0	8	94
Lower Hutchinson	6	364	1	2.1	17%	1	0.9	17%	1169.4	194.9	162.4	27.1	12	120
Acme	5	328	1	3.2	20%	6	0.7	80%	3006.9	601.4	330.1	66.0	2	34
Kalsbeek	7	172	0	n/a	0%	5	0.9	71%	732.8	104.7	163.8	23.4	8	94
Sygitowicz	7	216	0	n/a	0%	3	0.5	43%	172.6	24.7	47.3	6.8	2	34
Todd	8	175	0	n/a	0%	2	0.7	25%	445.8	55.7	66.1	8.3	8	94
Van Zandt	15	175	3	1.6	20%	6	0.8	40%	2791.6	186.1	339.1	22.6	2	34

¹ Note: Isolated pools and cover are excluded from this indicator.

FIGURE 15: COVER AREA RELATED TO POOL AREA AT THE PROJECT (CUMULATIVE) LEVEL AND INDIVIDUAL STRUCTURE LEVEL.

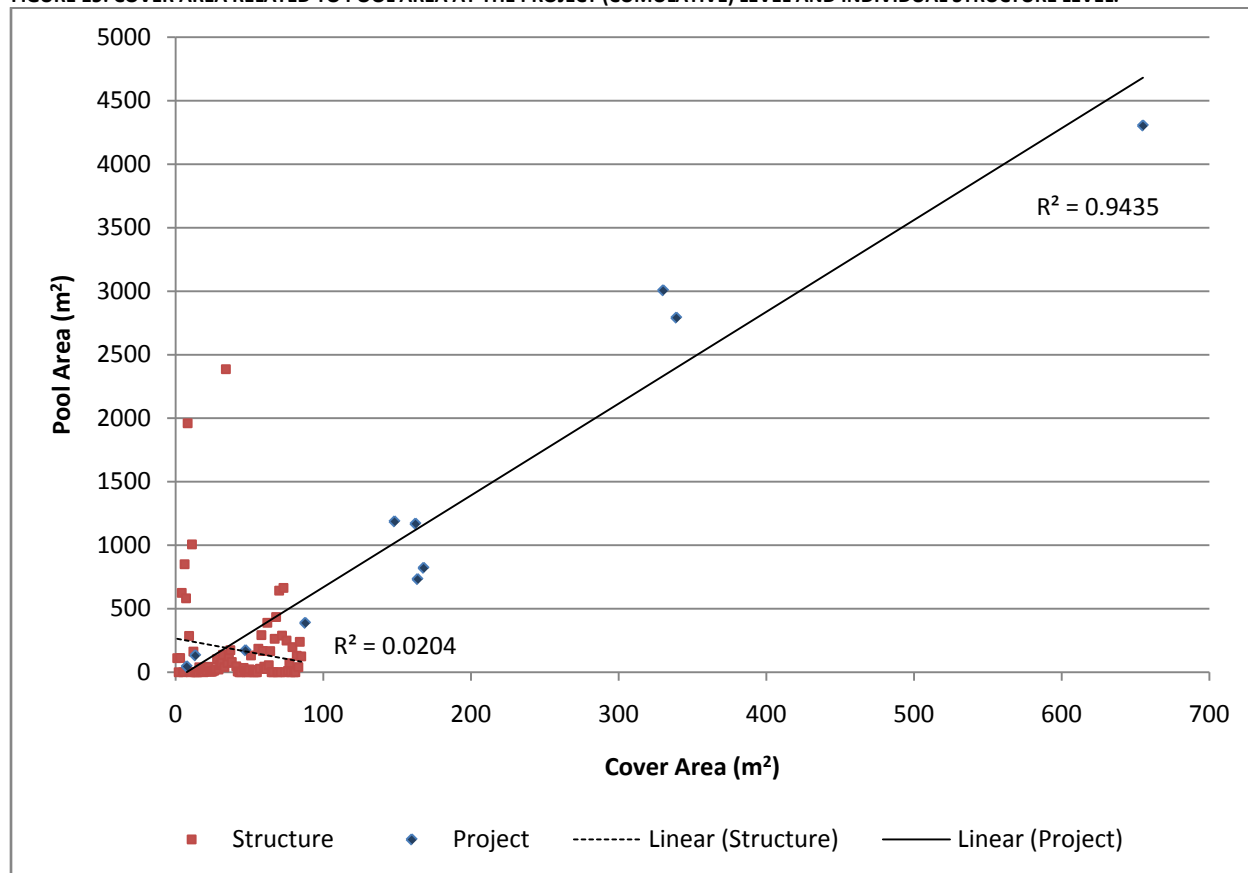


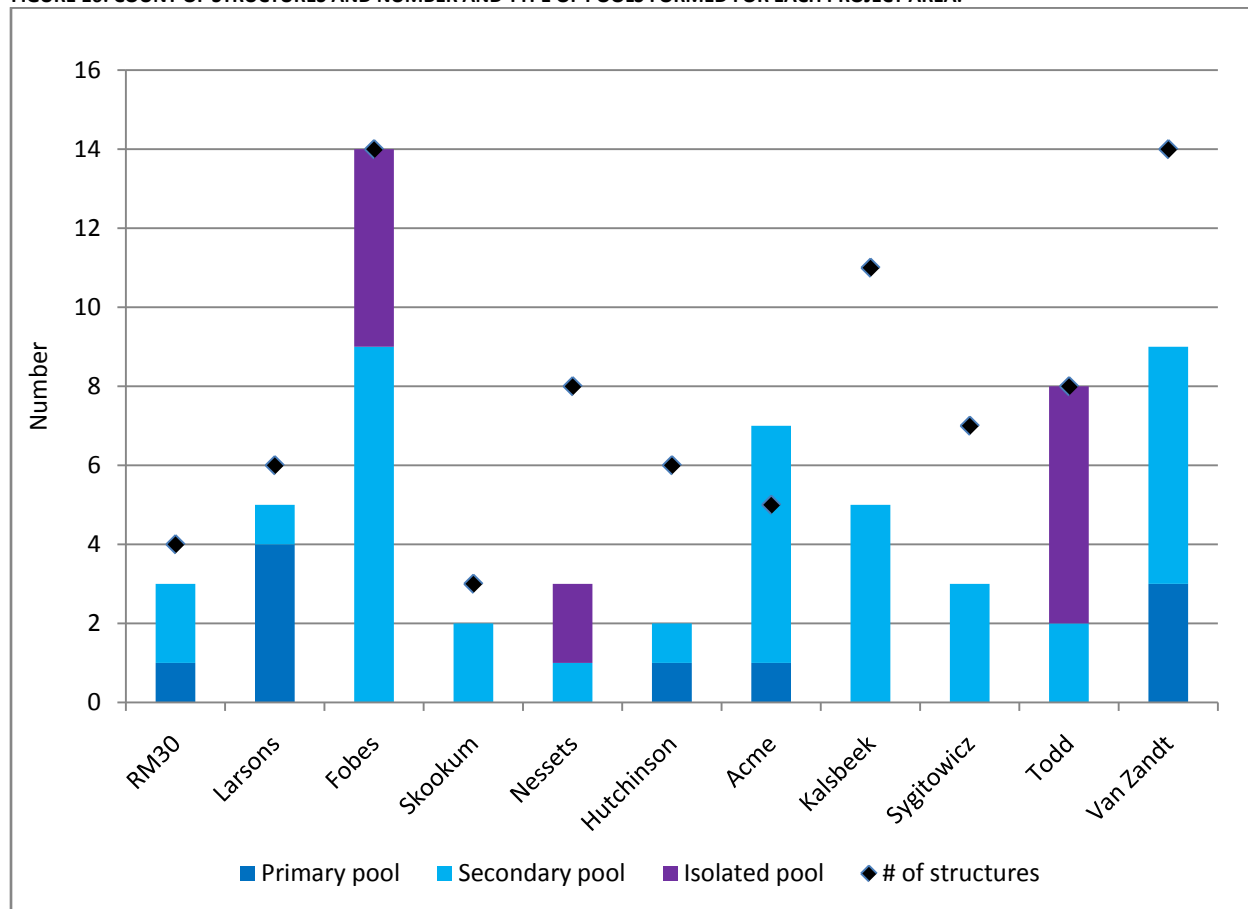
TABLE 15: POOL AREA FOR ALL POOLS GREATER THAN 500M².

Project	Structure	Pool Area (m ²)	% of SF Total Project-formed Pools
Acme	#4	2386	16.2
Larson's Bridge	#5	1961	13.3
Lower Hutchinson	#2	1007	6.8
Larson's Bridge	#3	851	5.8
Van Zandt	#9	664	4.5
Van Zandt	#6	643	4.4
Larson's Bridge	#1	625	4.2
RM 30	#1	599	4.1
Larson's Bridge	#4	582	3.9

The different projects also created different types of pools: primary (comprising greater than half of the channel width), secondary (comprising less than half of the channel width), and isolated (not interacting with the flow at the time of the survey) (Figure 16). Because primary pools are large (average area = 975 m²) and deep (average= 2.2 m residual depth), they provide the highest quality holding and rearing habitat and were the focus for restoration projects in the South Fork. However, only ten of the eighty-

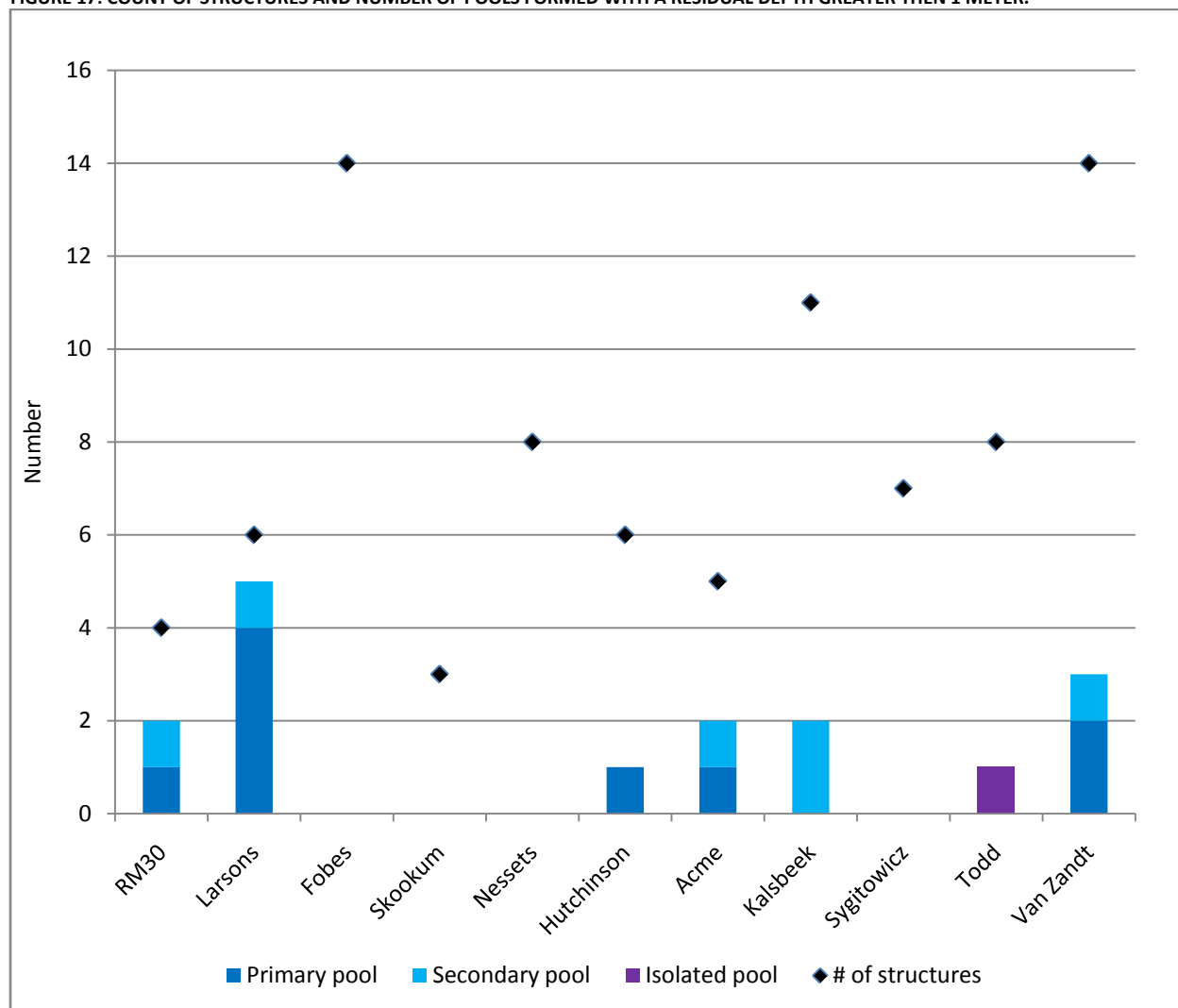
three structures formed primary pools (Table 14). These ten structures were distributed among five projects, with the Larson's Bridge Project accounting for four of the ten and the Van Zandt Project accounting for three of the ten pools. Since over half (44 of 83) of the structures were completed in 2010 and have seen only two events that have exceeded the bank-full stage (December 12, 2010 and January 17, 2011), it is likely that more primary pools will be formed through time.

FIGURE 16: COUNT OF STRUCTURES AND NUMBER AND TYPE OF POOLS FORMED FOR EACH PROJECT AREA.



The logjams have been more effective at creating secondary scour pools, with nearly half (38) of the structures providing local scour in the South Fork Nooksack channel. These pools are generally small and shallow, averaging 107m² in area and 0.6 m in residual depth, relative to primary pools. Cumulatively, these 38 secondary pools represent 4075 m² of pool area, less than half of the 9750 m² created by the 10 primary pools. There are nine secondary pools with a 1m or greater residual depth (Figure 17). There are also 13 isolated pools that are associated with the logjam structures. These pools would be connected during high flow, either when the South Fork was inundating lateral bars, or when higher flow channels were connected to the South Fork. These 13 pools accounted for an additional 925 m² of pool area. Four isolated pools, all in the Todd Project, had a maximum depth greater than 1 m.

FIGURE 17: COUNT OF STRUCTURES AND NUMBER OF POOLS FORMED WITH A RESIDUAL DEPTH GREATER THEN 1 METER.

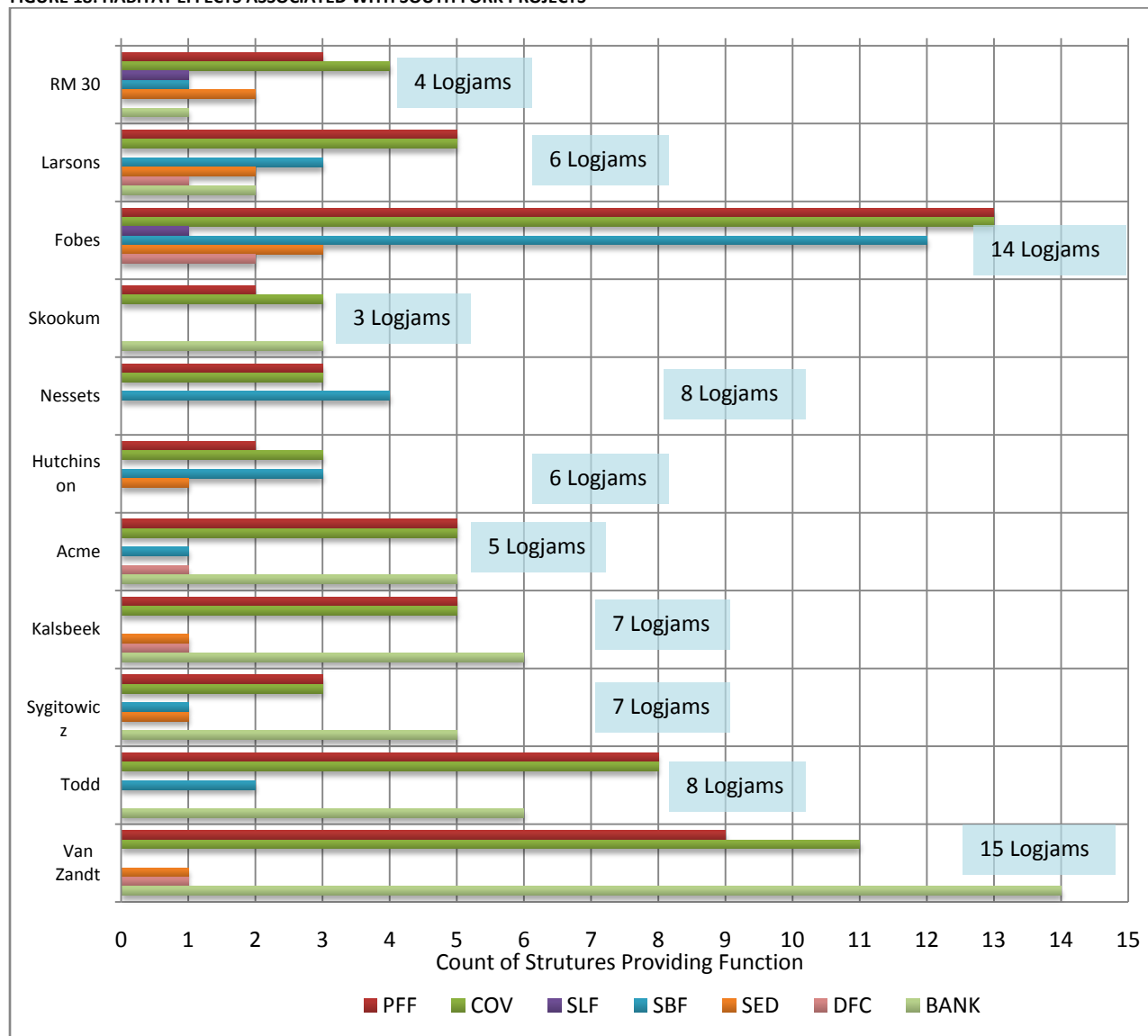


In addition to measuring pool and cover area and pool depth, several other habitat effects were noted when present. These included splitting the low or bank-full flow, sediment sorting, causing channel avulsion, deflecting the channel, or protecting a stream bank. While all projects shared the goal of creating deep pools with cover, other habitat effects varied based on the channel type and engineering design of the project (Figure 18). In reaches where the South Fork Nooksack is more incised and confined by terraces and high floodplain, many of the structures are built into the bank. This is the case in the Van Zandt, Todd, Sygitowicz, Kalsbeek, Acme and Skookum projects. In two instances, the River Mile 30 and Larson's Bridge projects, the structures were designed to protect the bank at the toe of an active landslide. In less confined reaches, the structures are situated on bars and are splitting the bank-full channel. Examples of these project reaches include the Hutchinson, Nessel and Fobes projects.

Projects were generally more effective at producing site-scale effects, such as pool formation and bank protection, rather than reach-scale effects, such as channel deflection or flow splitting. While only three projects had a stated objective of protecting a bank, nearly all projects included structures that would

slow channel migration. Only two projects, Fobes and RM 30, have resulted in the formation of a secondary low flow channel and neither of these projects specifically identified side channel formation as a goal. For the two projects, Larson's Bridge and Kalsbeek, that did include low flow side channel formation as an objective, no logjam-induced side channel formation was observed.

FIGURE 18: HABITAT EFFECTS ASSOCIATED WITH SOUTH FORK PROJECTS

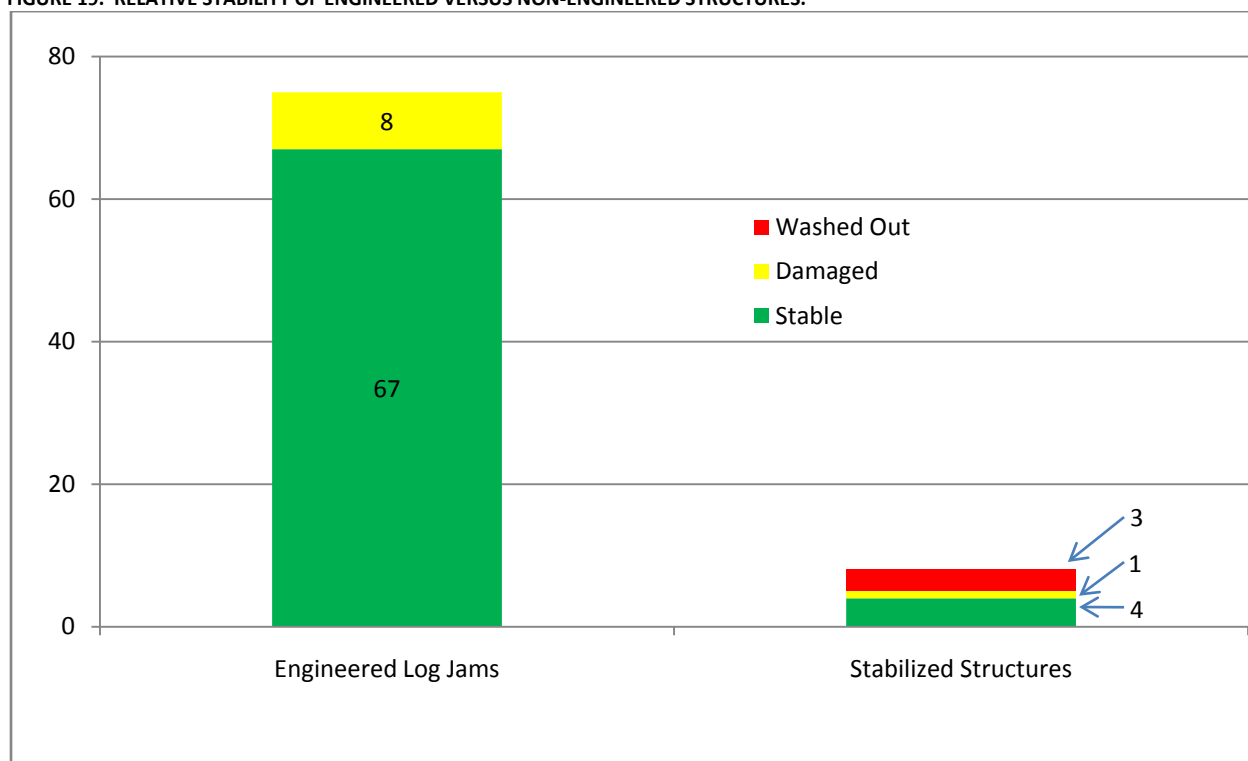


Conclusions

STRUCTURE STABILITY

In terms of contribution to the working habitat target of 30 stable log jams/mile (WRIA 1 SRB 2005), constructing new engineered log jams has proven to be more effective than stabilizing existing structures (i.e. without engineering design). Almost all of the projects (10 of 11) implemented engineered designs, and most (89%) engineered structures have been stable since construction. Of the 75 engineered structures built, 8 have sustained minor damage (primarily loss of ballast; one structure lost key pieces; Figure 19). For the project that involved stabilization of existing structures (Nesset), 3 of 8 structures stabilized have washed out and an additional structure has lost pilings. Of the 4 remaining, 2 have not interacted with the channel so evaluation of stability is premature.

FIGURE 19. RELATIVE STABILITY OF ENGINEERED VERSUS NON-ENGINEERED STRUCTURES.



HABITAT FORMATION

The cumulative results of the eleven logjam projects show that the structures have been most effective at scouring pools, providing woody cover and protecting banks from erosion (Figure 20). Out of the 83 structures, only 10 formed primary pools (Table 14). These were located in 5 of the 11 projects, with the Larson's Bridge and Van Zandt Projects accounting for 7 of the 11 pools. Jam-formed secondary (38 structures) and isolated pools (13 structures) were common; secondary pools provide a limited amount of habitat at low flow, while pools that are isolated at low flow can actually be sources of mortality for juvenile salmonids that get trapped therein due to dewatering, high temperatures, and high rates of predation. Deep pools were uncommon, with only fifteen pools in the low-flow channel (i.e. excluding

isolated pools) greater than 1m residual depth and eight pools greater than 2m residual depth. Normalizing for the number of structures, Larson and Acme projects had the greatest effect on area of low-flow pools formed (717.5 and 601.4 m²/structure, respectively), followed by River Mile 30 (205.3 m²), Lower Hutchinson (194.9 m²), and Van Zandt (186.1 m²; Table 14). Nasset (0.8 m²/structure), followed by Skookum (15.2 m²), Fobes (23.6), and Sygitowicz (24.7 m²) projects were associated with the lowest area of low-flow pools formed.

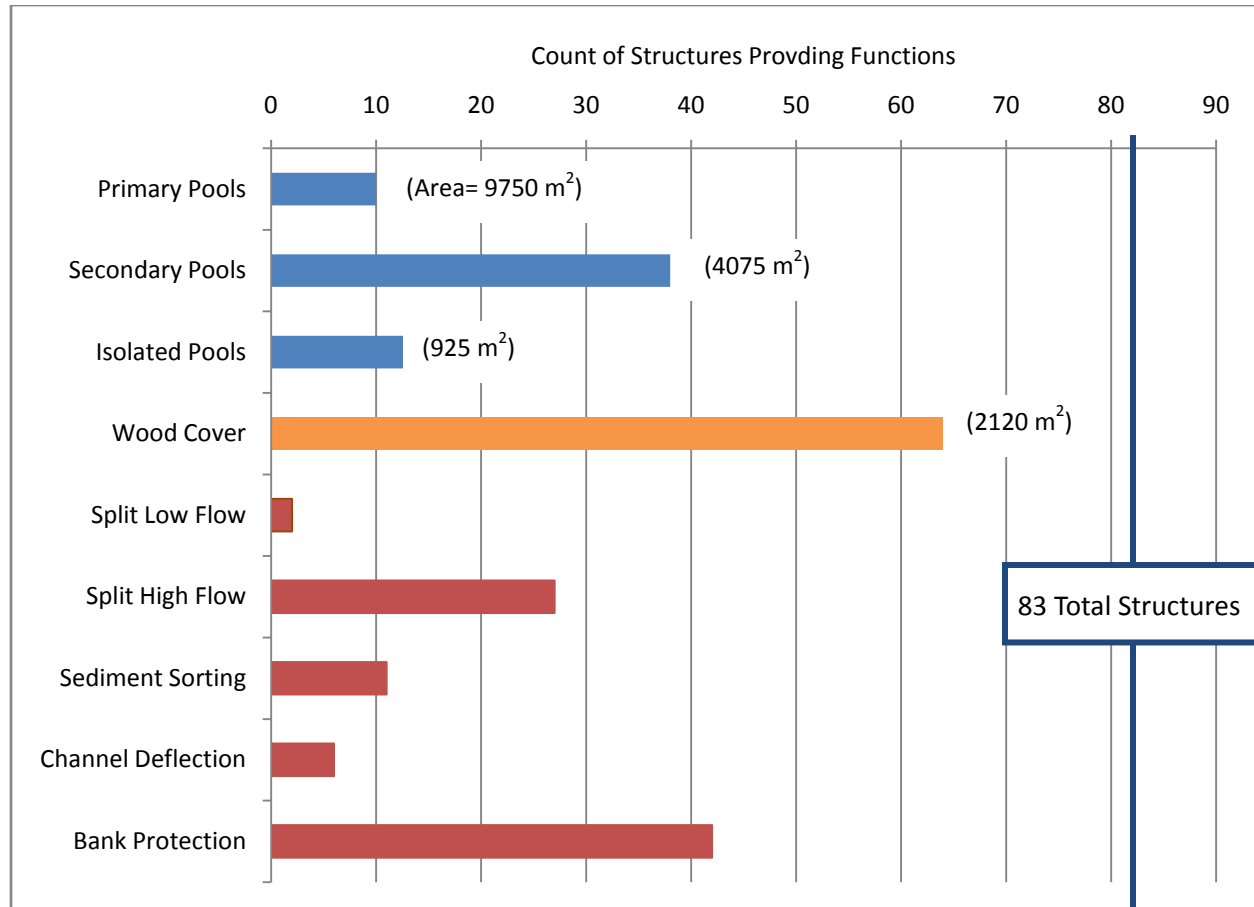
Channel position also likely played a role the effectiveness of pool formation. Of the structures built, the majority (51) were built along, or into, a high bank that did not allow flow around the structure. Twenty-four were built on lateral bars adjacent to the channel, three were built on the floodplain and two were built on mid-channel bars. The effectiveness of the bank structures was largely related to how far the structure projected into the active channel area and whether the channel was adjacent to the bank where the structure was located. Twenty-seven (52%) of the bank structures had formed a pool with seven (14%) of the structures forming primary pools. Of the projects that included structures that were deeply set into the bank to meet flood constraints (Skookum, Sygitowicz, Van Zandt), only those at the Van Zandt site that had been subsequently exposed by channel migration created primary pools.

Wood cover was commonly associated with the logjam structures. Sixty-four (77%) of the logjams were providing some woody cover, although the average cover amount was only 33 m² per logjam providing cover. Only fifty-three (64%) of the jams provided cover in the low-flow channel. Approximately 30% of the total woody cover area (655 m²) was being provided by the Larson's Project (385 m² by one structure), which had several large, deeply undercut logjams. Normalizing for the number of structures, Larson contributed the greatest area of woody cover (109.2m²/structure), followed by Acme (66.0 m²) and River Mile 30 (42.0 m²), while Nasset (<0.1m²), Skookum (2.5), Fobes (5.6), Sygitowicz (6.8), and Todd (8.3) provided the least (Table 13).

Flow splitting was most commonly found in the unconfined reaches of the river, where logjams were built on lateral bars. The Fobes Project accounted for nearly half (44%) of the 27 structures that split high flow. Low flow splitting was uncommon, with only 2 structures associated with a low flow split. In both cases, the flow split existed prior to construction of the project, but the structure was influencing the split with bar development.

Sediment sorting was a project objective of both the Larson's Bridge and RM 30 projects, where limited spawning was occurring due to a lack of suitable spawning gravel. In both of these instances, sediment deposition and bar formation was associated with structures. Sediment sorting was more common in projects in the unconfined reaches of the upper watershed (Larson's Bridge, Fobes and RM 30) than in the lower watershed. These three projects accounted for 7 of the 11 structures that were associated with sediment sorting.

FIGURE 20: CUMULATIVE HABITAT FUNCTIONS OF SOUTH FORK LOGJAMS.



Channel deflection and channel avulsion were uncommon habitat effects associated with the projects. No structures were associated with causing a channel avulsion, and only six were deflecting the channel. This was largely the result of wood accumulation racked on the structures.

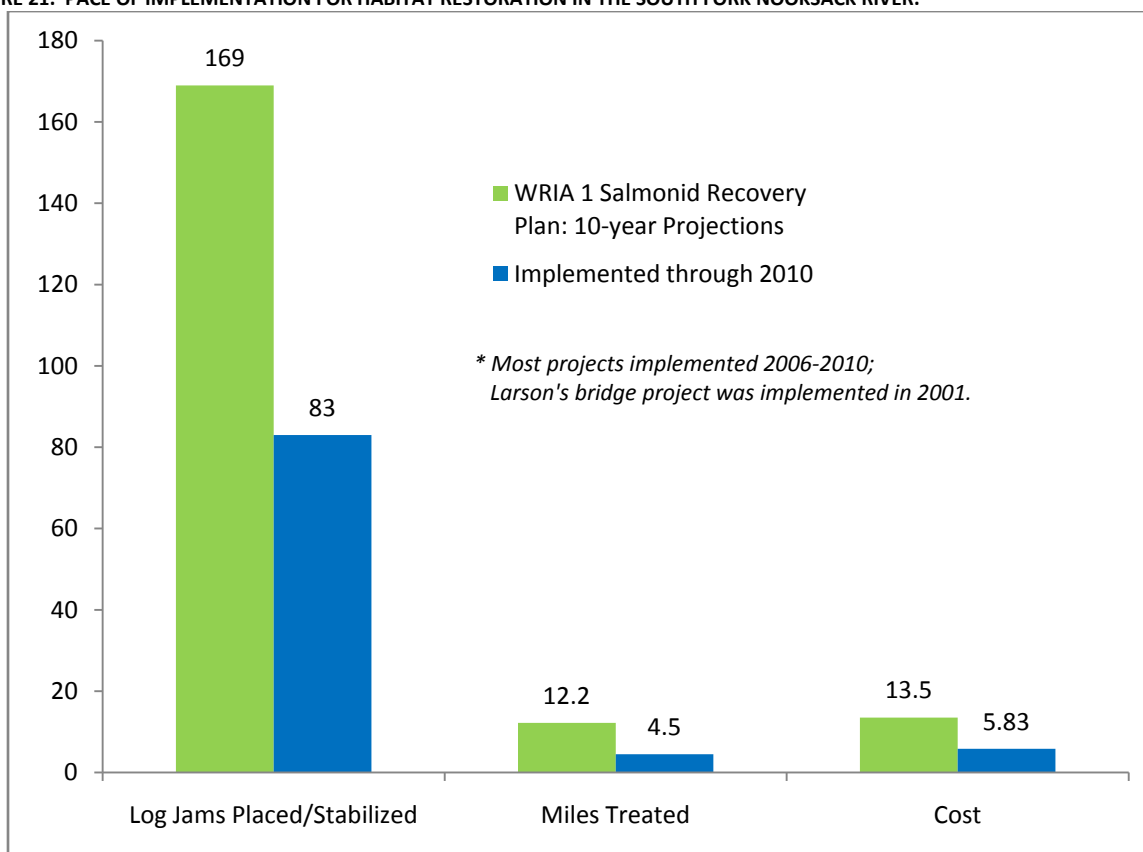
Bank protection was a common habitat effect observed. In two cases, the project objective was to stabilize an existing landslide to reduce fine sediment impacts on the river. Further downstream, logjams were commonly built into the high floodplain or terrace. In the case of the Sygitowicz, Todd, Acme and Van Zandt Projects, rock bank armoring was removed and replaced with logjams. For some projects, such as Skookum and Sygitowicz, concerns about increased flood elevations led to setting structures deeply into the bank. This ultimately led to a reduction in the habitat functions associated with these logjams.

PACE OF IMPLEMENTATION

The *WRIA 1 Salmonid Recovery Plan* estimated that habitat restoration in the South Fork Nooksack River over a 10-year time frame would entail placement of 169 log jams, with 12.2 miles treated at a total estimated cost of \$13.5M (\$80,000/log jam). Five years into plan implementation, – all but Larson’s were implemented from 2006-2010 – substantial progress has been made toward this interim target

(Figure 21), with almost half (49%) of the projected number of log jams built/stabilized, 37% of miles treated, and 43% of projected cost spent, for an average log jam cost of \$70,233.

FIGURE 21. PACE OF IMPLEMENTATION FOR HABITAT RESTORATION IN THE SOUTH FORK NOOKSACK RIVER.



Factors influencing pace of implementation include grant cycle scheduling, funding availability, and permitting constraints. The primary sources of salmon recovery funding in WRIA 1 are Salmon Recovery Funding Board (SRFB) and Puget Sound Acquisition and Restoration (PSAR) funding, both of which are administered through the Washington State Recreation and Conservation Office (RCO). The grant process has increased in length and complexity in recent years as additional review steps have been added, including by the Puget Sound Partnership and Recovery Implementation Technical Team, such that the time lag between concept development and funding award is almost a year. Additions to 3-year work programs are solicited during winter, initial proposals developed in spring, and proposals vetted, ranked, and finalized through the local process (with involvement by WRIA 1 Salmon Recovery Staff Team, Combined Review Team, and WRIA 1 Management Team) through summer. The Salmon Recovery Funding Board awards funding in December of that same year, and project grant agreements are typically approved in the first few months of the year following initial proposal submission. When local salmon recovery partners began implementing log jam projects, projects were framed as design-build projects, such that projects proposed for funding in one grant round could be designed and constructed the following year. In recent years, habitat restoration projects in WRIA 1 have been separated into phases to increase certainty of cost and benefit (e.g. reach-scale design, followed by phase 1 implementation, then phase 2 implementation, etc.). Depending on project reach length and

complexity, the design process can extend in length from several months to over a year. Thus, while it is possible to proceed to phase 1 construction within 2 years of design proposal submission, the more likely scenario is for a 3-year lag between design proposal submission and phase 1 construction (year 0: design proposal submitted; year 1: design funding awarded; year 1-2: design developed; year 2: phase 1 construction proposal submitted, year 3: phase 1 construction funding awarded, phase 1 project implemented). Obviously, such a scenario assumes timely funding of project phases, which depends on the availability of funding. The declines in both SRFB and PSAR funding allocations that have been observed over time thus jeopardize the pace of implementation.

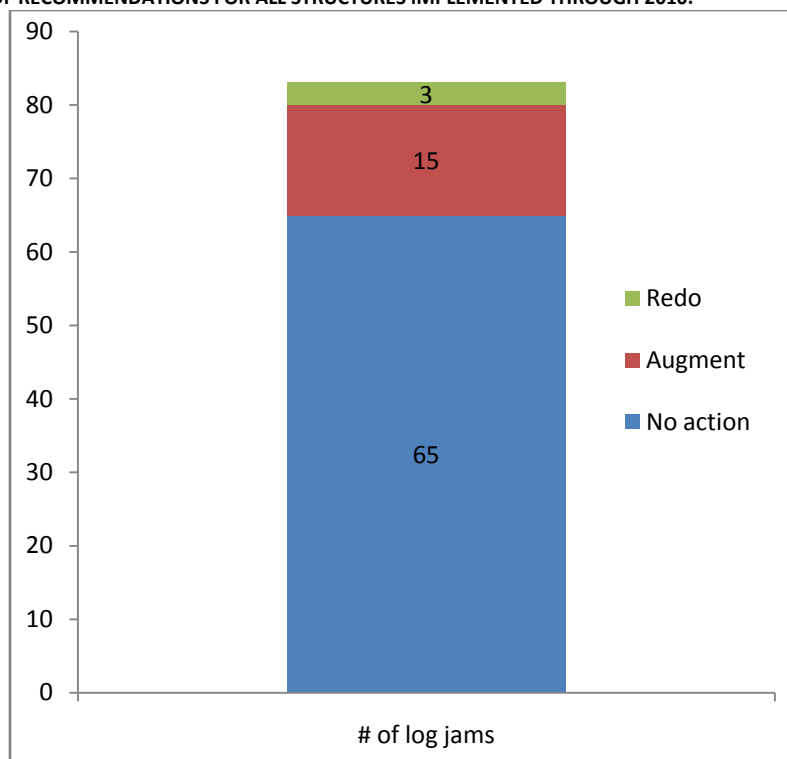
The permitting burden of log jam projects has also increased, similarly challenging the pace of implementation efforts. Until recently, river log jam projects were eligible as fish habitat enhancement projects for the streamlined Hydraulic Project Approval (HPA) process, which exempts projects from SEPA and local permits. In 2010, project sponsors began securing County floodplain development permits because, although it is a *local* permit, it is the mechanism for implementing the *federal* National Flood Insurance Program and, thus, ineligible for the exemption. The floodplain development permit requires that projects meet FEMA no-rise requirements and provide log jam monitoring and maintenance plans; if a project is unable to meet no-rise requirements, it must go through the lengthy LOMR (letter of map revision) process. Additionally, in response to a ruling at the Pollution Control Hearings Board that found that the streamlined process should only apply to “small” and “simple” projects, river log jam projects have since 2011 been deemed by WDFW to be ineligible for streamlined permitting. Finally, DNR, which issues Aquatic Use permits, is increasingly scrutinizing log jam projects for public safety concerns, now requiring completion of a public safety checklist and placement of signage at put-ins, upstream of and on log jams. There is also discussion of transitioning to Aquatic Leases as the mechanism for restoration on Aquatic Lands, which would further increase the costs, permitting time, and liability associating with log jam projects.

RECOMMENDATIONS

PROJECT RECOMMENDATIONS

Based on the surveys, there were opportunities in most of the project reaches to improve the effectiveness of the project (Table 16). However, for the vast majority of log jams (76%), no action is recommended (Figure 22), since habitat improvements will continue to develop as the channel responds over time. Augmentation of structures to increase interaction with the low-flow channel is recommended for about 18% of the jams, especially those limited by no-rise requirements. The only project recommended for redo was the Nessel’s Reach Project, which has lost several of its structures and now likely will not meet the habitat recovery goals identified for the South Fork Nooksack. In this case, it is recommended that a new design be developed for the Nessel’s Reach that will persist longer and better meet habitat objectives.

FIGURE 22. SUMMARY OF RECOMMENDATIONS FOR ALL STRUCTURES IMPLEMENTED THROUGH 2010.



Specific project level recommendations are summarized below.

RIVER MILE 30 PROJECT

This project appears to be functioning well. There are no recommendations for improvement.

LARSON'S BRIDGE PROJECT

This project also appears to be functioning well. Five of the structures show signs of damage (lost ballast), but all continue to function. Adding ballast to several of the structures could be explored. The original design for this reach included additional structures, and continuing with another phase (particularly upstream of the bridge) could be warranted here. Additional structures downstream of logjam #6 should also be considered to improve in-stream cover in proximity to spawning and to encourage stabilization and riparian re-colonization of large mid-channel and lateral bars.

FOBES PROJECT

This project has only been in the water for one season and has yet to strongly influence the channel. It is likely that the habitat will improve as the channel migrates and interacts more with the structures. The structure at the mouth of Fobes Creek, which was intended to create a scour pool and cover in the cool water influence area of the creek, doesn't appear to be providing those functions. The structure doesn't look like the design typical drawing, so potentially enhancing this logjam could help meet the cool water refuge objective. The jam placements on the lateral bars should also be monitored to evaluate whether

channel process objectives are being met or if the structures need modification or other action if channel responses are neutral or negative.

SKOOKUM PROJECT

This project is not providing the intended habitat benefits. The structures are set deeply into the banks, requiring substantial channel widening before the structures will be exhumed and begin to scour a pool in the cool water influence area of the river. Since channel migration and bank retreat has been historically slow at this site, extending some key-sized wood pieces further into the channel would improve the near-term habitat. It also looks like there is an opportunity to add structures upstream of the existing logjams to create a scour pool in the plume of Skookum Creek and develop pools where channel hydraulics are more favorable to pool formation.

NESSET'S REACH PROJECT

Three of the eight structures in this project reach have been washed-out by the river and one structure has lost several of its pilings. The remaining structures have provided habitat when the channel was interacting with them, but at the time of the surveys none of the remaining five structures were creating primary pools. Given the length of the reach and the few stable structures, it is unlikely that the remaining structures will provide adequate habitat to meet the recovery objectives. We recommend development and implementation of a new reach-scale design that will have high certainty of achieving habitat targets within the reach.

LOWER HUTCHINSON PROJECT

This project is currently functioning well. A remnant of riprap upstream of Logjam #1 is likely slowing migration of the channel into that structure and limiting the near-term habitat function. Removing the riprap and levee could improve the habitat formation for this structure, and may also lead to increased flow between the downstream structures by allowing increased migration toward the logjams. Addition of key piece wood to jam #3 that extends slightly more into the channel may also encourage local hydraulics necessary to fix the thalweg against this structure and enhance primary pool formation.

ACME

This project appears to be functioning well. Recent repair on the downstream structures shows no additional signs of instability. An existing concrete box culvert on the Landingstrip side channel may be functioning as a local grade control that limits side channel bed adjustments necessary to induce perennial flow through the side channel. Removal of the box culvert should be considered.

KALSBECK

The bank structures associated with this project could provide improved pool formation if they interacted more with the channel. With changes in landownership, it may be possible to construct the upstream logjams that were dropped from the original design. Constructing additional structures along the bank structures that project into the flow could encourage more pool scour. The bank structures were recently repaired and showed no additional signs of instability.

SYGITOWICZ

The recent addition of key-sized pieces to the left bank logjams appears to be increasing pool scour along these structures. Right bank structures could potentially benefit from a similar approach.

TODD

The channel has avulsed away from the majority of these structures, leaving them in a backwater that was not connected at the time of the survey. It is anticipated that the channel will eventually reoccupy this area. There are no recommendations for improvement.

VAN ZANDT

This project is functioning well. No recommendations for improvement. A recently repaired structure showed no additional signs of instability.

TABLE 16: PROJECT EFFECTIVENESS SUMMARY AND RECOMMENDATIONS

Project	Years Post Construction	Project Reach Length (mi)	Structures/ mile	Stability Issues	Total Number of Deep Pools	Deep pools/ mile	Factors Limiting Effectiveness	Recommendations for improvement
Larson's	10	0.60	10	Loss of backfilled ballast (5 jams) and key pieces (1 jam), and racking (1 jam)	5	8	None.	Explore implementation of additional phases of this design.
Lower Hutchinson	5	0.16	38	None.	1	6	Failing riprap inhibits flow around ELJ #1.	Remove riprap bank upstream of logjam #1.
River Mile 30	4	0.10	63	Some loss of ballast (1 jam)	2	21	None.	None.
Kalsbeek	4	0.59	10	None (repaired loss of wood).	2	3	Bank structures don't project into the channel. Landowner willingness.	Augment bank structures with logjams projecting further into low flow channel. Contact new upstream landowner about constructing logjams dropped from the original design.
Nesset's	3	0.96	6	Wash-out (3 jams).	0	0	Lack of longer-term stability of the design.	Develop a new design for the reach.
Todd	3	0.13	46	Some loss of backfilled ballast on apex logjam.	0	0	Channel movement away from structures.	None.

Project	Years Post Construction	Project Reach Length (mi)	Structures/ mile	Stability Issues	Total Number of Deep Pools	Deep pools/ mile	Factors Limiting Effectiveness	Recommendations for improvement
Fobes	1	1.10	5	None.	0	0	Logjams built on bars adjacent to channel- requires more migration to engage. Logjam #4 is not interacting with refuge.	Enhance structure #4 at Fobes to take advantage of cool water influence. Not built to scale shown in design.
Skookum	1	0.17	35	None.	0	0	Structures are not projecting into the channel.	Augment structures with key pieces to extend into low-flow. Construct additional structure near confluence with Skookum Creek. Consider additional phases for more effective pool scour.
Acme	1	0.09	64	None.	2	21	None.	Consider box culvert removal from side channel.
Sygitowicz	1	0.14	43	None.	0	0	Right bank structures not projecting into the channel.	Augment right bank structures so that they project into the channel.
Van Zandt	1	0.47	13	None (repaired loss of ballast)	3	6	None.	None.

GENERAL RECOMMENDATIONS

In addition to the project-specific recommendations provided above, we offer the following general recommendations:

- *Quantitative project objectives should be clearly articulated in designs and/or design reports.* Lacking quantitative project objectives, the projects included in this monitoring effort were evaluated for relative contribution to important limiting factors in the South Fork: lack of pools and lack of woody cover. However, evaluation of project effectiveness is best accomplished by comparison of expected versus actual outcomes.
- *Work to reduce institutional barriers to implementation.* Permitting, grant cycle delays, and funding availability all limit the pace of implementation. Lack of funding to advance projects is the single greatest constraint; on an annual basis, work should focus on securing sufficient funding to advance specific projects ready for implementation, rather than maintaining an arbitrary allocation. Any work to reduce permitting burden (no-rise, HPA, DNR) and compress the grant cycle will also reduce implementation time and costs.
- *Incorporate engineering into designs and implement methods with higher likelihood of success at maintaining structure stability in large river environments, such as excavation to and placement of key members at scour depths, vertically-driven piles, or use of ballast.* The design process needs to reflect the challenges of the project environment. Stabilizing existing natural jams in riverine settings, while lower in cost, is less cost-effective overall if structures wash out when the channel engages them.
- *Maintain focus on achieving salmon habitat objectives through design and construction.* Accommodating other objectives, like protecting banks and minimizing flooding, may be necessary to implement a project at a specific location, but if such objectives compromise the likelihood of achieving salmon habitat objectives, it may not be worth the investment of limited salmon recovery funding to implement the project.
- *Increase opportunity for restoration in the lower South Fork Nooksack River.* Clearly, project effectiveness in the lower South Fork is limited by lack of landowner willingness to allow channel migration, flooding, and/or riparian forest development. Actions that might decrease this significant barrier to implementation include: general education and outreach, targeted outreach to river-adjacent landowners, acquisition (fee-simple purchase, flood easements, conservation easements), and/or development of incentives that improve stewardship. To the extent possible, restoration needs should also be integrated into comprehensive flood-hazard management planning to facilitate projects with mutual benefit to flood management and salmon (i.e. levee setback).
- *Incorporate lessons learned into designs for future projects.* Clearly, this report is most directly applicable to the South Fork Nooksack River, especially the project reaches evaluated. Extrapolating the results to other areas should consider the comparability of geomorphic settings, log jam designs, and other factors that influenced effectiveness of the projects evaluated herein. However, the first four general recommendations provided above are more broadly applicable.

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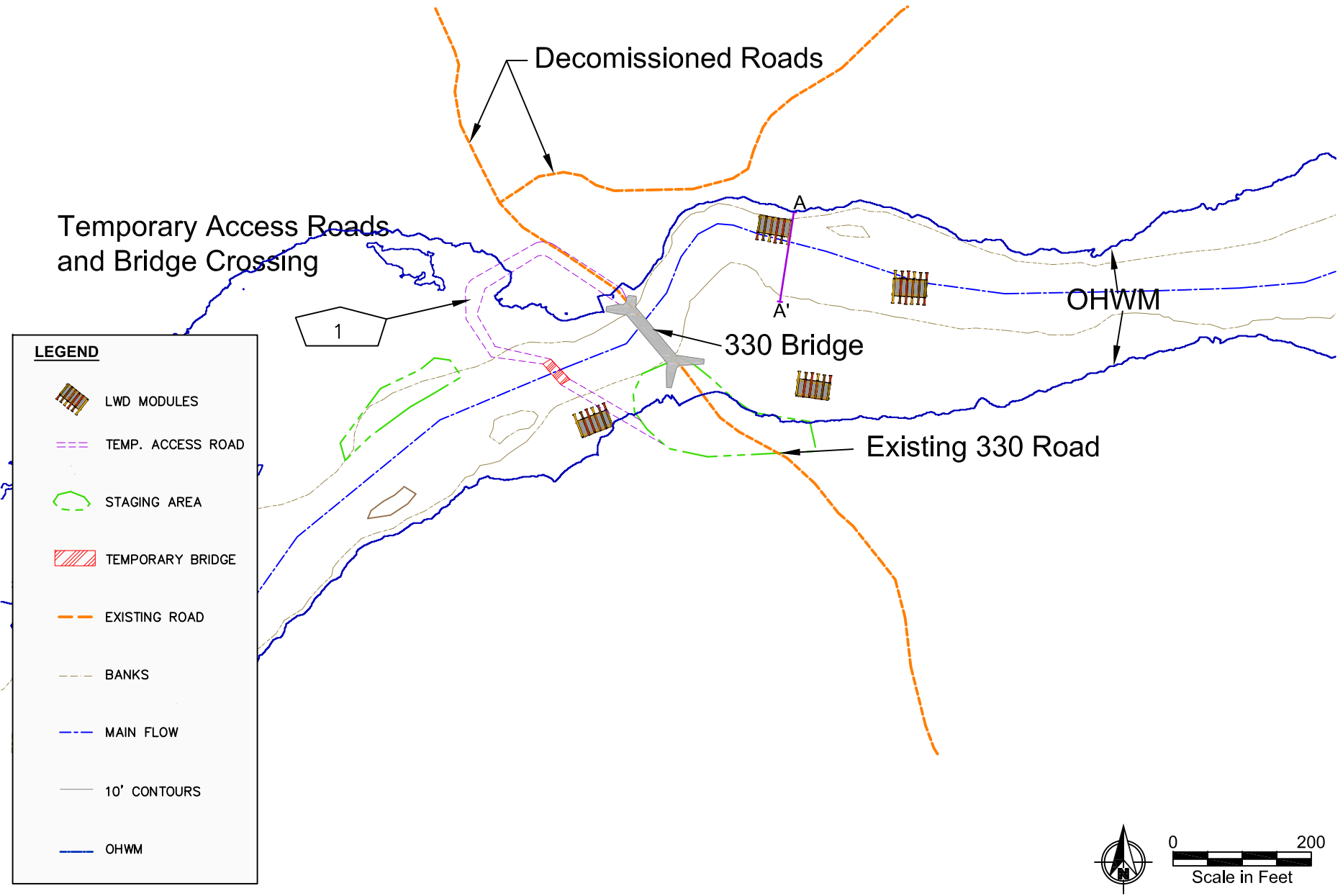
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APPENDIX A: PROJECT DESIGN SITE PLANS

TABLE A-1. LIST OF PROJECT SITE PLANS.

Project Name	PRISM Attachment #	Name	Document Date
River Mile 30	N/A	<i>South Fork Nooksack River Mile 30 Instream Project, Lummi Natural Resources: Figure 2 Site Plan</i>	July 18, 2007
	N/A	<i>River Mile 30 Project As-Built Design</i>	July 9, 2012
Larson's Bridge	00-1136-10	<i>South Fork Nooksack at Larson's Bridge: Phase 1 planset (page 1 inset excerpt)</i>	Not dated
Fobes	09-1686-10	<i>Fobes Creek: South Fork Nooksack River Fobes Creek Reach Habitat Restoration Project: Proposed Site Plan 1 (C-1)</i>	March 2010
		<i>Fobes Creek: South Fork Nooksack River Fobes Creek Reach Habitat Restoration Project: Proposed Site Plan 2 (C-2)</i>	
Skookum	07-1803-35	<i>South Fork Nooksack River Skookum Creek Habitat Restoration Project: Proposed Site Plan (C-1)</i>	June 2010
Nesset	07-1794-10	<i>General Site Plan 06-2008</i>	June 2008
	07-1794-30	<i>Nesset's Reach Project As-Built Design</i>	July 11, 2012
Lower Hutchinson	01-1329-25	<i>South Fork Nooksack Lower Hutchinson Creek Restoration Project: General Site Plan (C-2)</i>	March 2006
Acme	N/A	<i>South Fork Nooksack at Acme, WA: Habitat Restoration and Bank Protection Phase 2 – As Built</i>	January 12, 2011
Kalsbeek	05-1569-22	<i>South Fork Nooksack River Mile 6.5 Restoration Project: Site Access Plan and Proposed Work (G-3)</i>	July 2007
Sygitowicz	09-1684-15	<i>Sygitowicz Creek South Fork Nooksack River Restoration Project River Mile 4.0: Site Plan and Proposed Work (G-3)</i>	August 2010
Todd	06-2247-23	<i>Todd Creek South Fork Nooksack River Restoration Project River Mile 3.8: Site Plan and Proposed Work (G-3)</i>	April 2008
Van Zandt	07-1800-12	<i>Van Zandt Reach South Fork Nooksack River Restoration Project River Mile 1.0: Site Plan (G-3)</i>	July 2010

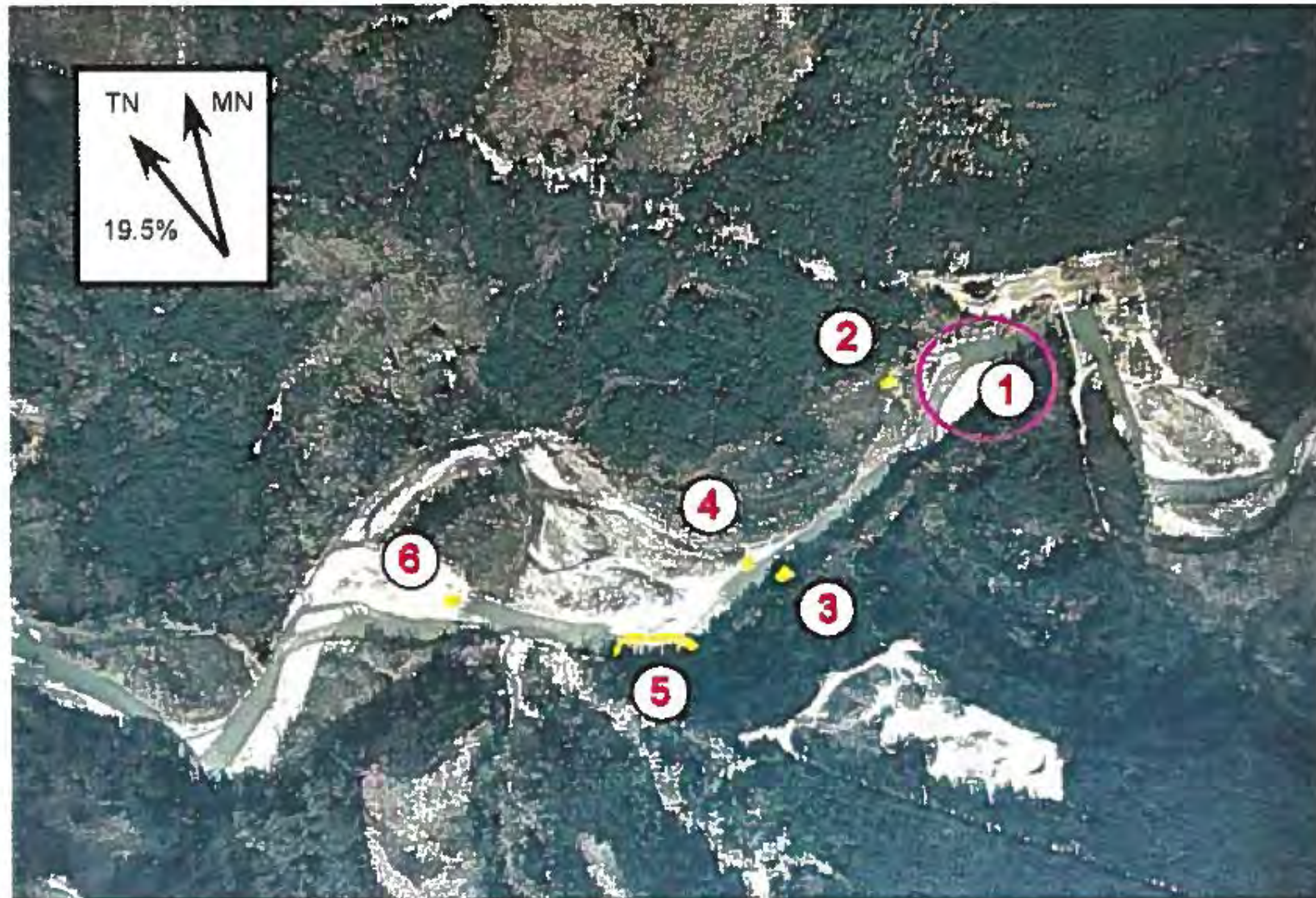




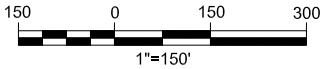
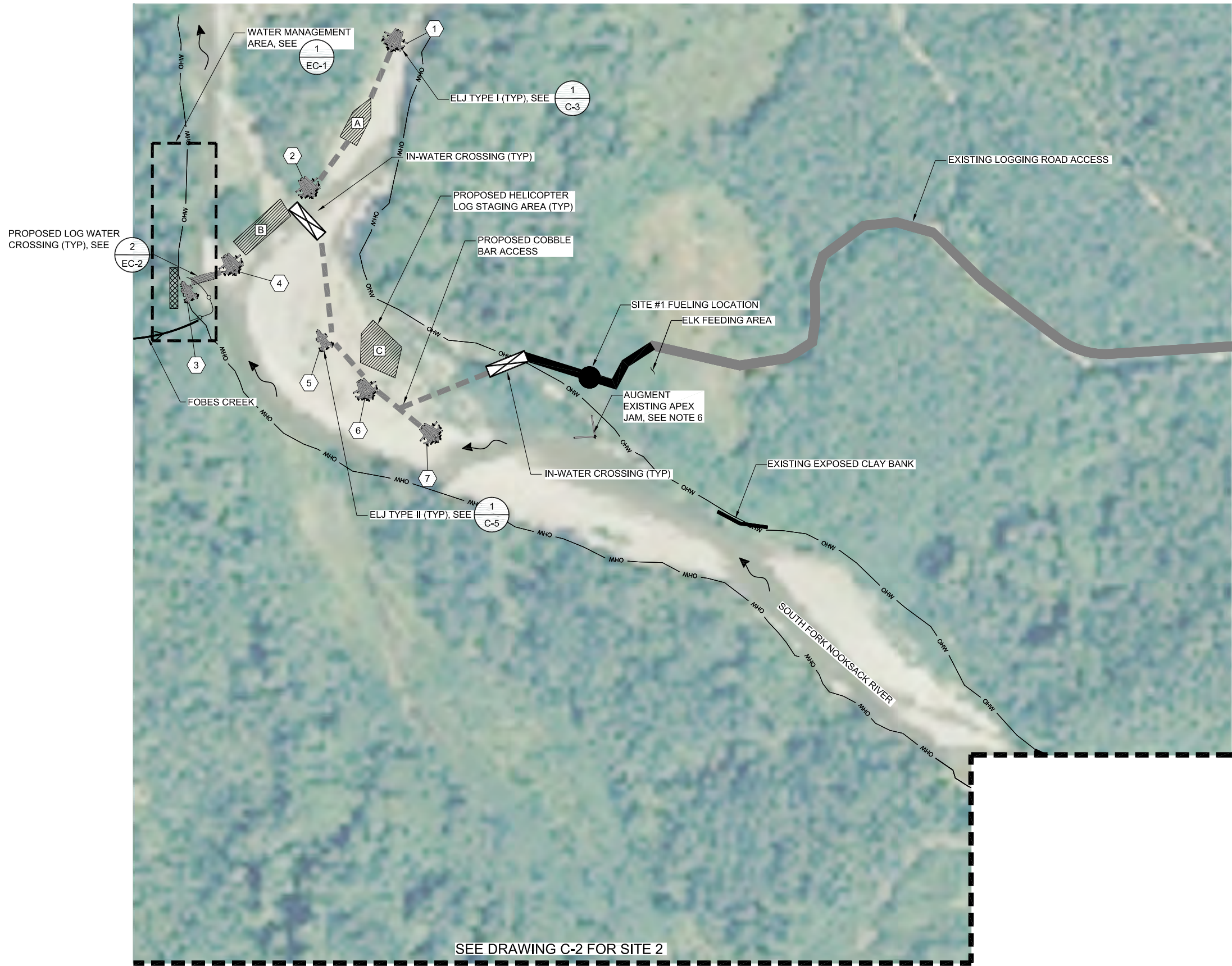
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River Mile 30 Project As-Built Design

Two of the structures were relocated based on site conditions at the time of construction. The third structure was moved closer to the channel near the road crossing to increase the interaction with the expected channel location and reduce the disturbance associated with construction. The fourth (and farthest downstream) structure was relocated to the opposite side of the channel. This was also done to reduce the disturbance from construction and improve the connectivity of the floodplain channels.



ENGINEERED LOG JAM #1
SOUTH FORK NOOKSACK AT LARSON'S BRIDGE
SUMMARY OF DESIGN VIEWS



LEGEND:

	EXISTING FOBES CREEK
	EXISTING LOGGING ROAD ACCESS
	NEW CONSTRUCTION ACCESS
	EXISTING EXPOSED CLAY
	ORDINARY HIGH WATER
	PROPOSED COBBLE BAR ACCESS
	SITE 1 AND 2 EXTENTS
	SILT BOOM
	FUELING LOCATION
	ELJ NUMBER
	LOG STAGING AREA IDENTIFICATION (TYP), SEE 2 G-2
	FLOW ARROW
	ELJ TYPE I
	ELJ TYPE II
	LOG WATER CROSSING
	IN-WATER CROSSING
	PROPOSED HELICOPTER LOG STAGING AREA
	UPLAND EQUIPMENT WORK AREA

NOTES:

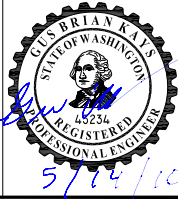
1. ALL HELICOPTER STAGING AREAS SHALL HAVE A MINIMUM 50' HORIZONTAL CLEAR ZONE.
2. NO REFUELING OF EQUIPMENT SHALL OCCUR WITHIN 100' OF THE UNVEGETATED CHANNEL WIDTH OR OUTSIDE DESIGNATED FUELING AREAS DESIGNATED ON PLANS WITHOUT PERMISSION OF ENGINEER AND PERMITTING AGENCIES.
3. WATER CROSSINGS SHALL BE LOCATED BY LUMMI NATION BIOLOGIST TO AVOID SPAWNING HABITAT. CROSSINGS SHALL BE ORIENTATED PERPENDICULAR TO FLOW DIRECTION TO MINIMIZE WETTED CHANNEL CROSSINGS DISTANCE. WATER CROSSINGS SHALL BE LIMITED TO THE MINIMUM NUMBER OF EQUIPMENT TRIPS NECESSARY TO ACCESS THE ELJ LOCATIONS. ADDITIONAL CROSSINGS WILL BE REQUIRED FOR EQUIPMENT FUELINGS.
4. ALL ELJS (EXCEPT ELJS 3) SHALL BE CONSTRUCTED ON COBBLE BARS AND SHALL BE LOCATED TO AVOID IN WATER WORK OTHER THAN WATER CROSSINGS FOR ACCESS. EXCLUDING ELJ #3.
5. PROJECT SITE ACCESS FROM HWY 20 / SIERRA PACIFIC LOGGING ROAD. ACCESS TO BE COORDINATED BY LUMMI NATION. SEE VICINITY MAP ON G-1.
6. PLACE 3 LOGS (40+ FEET LONG, 30+ INCHES DBH WITH ROOTWADS) ON EXISTING APEX JAM DEBRIS. LOGS SHALL BE ARRANGED BY EXCAVATOR FOLLOWING PLACEMENT ONLY IF A DRY GRAVEL BAR ACCESS IS AVAILABLE OR WET CROSSINGS ARE PERMITTED. LOGS SHALL BE STAGED AT ELK AREA.
7. A PLAN AND SCHEDULE FOR STAGING LOGS AT DESIGNATED STAGING AREA IS LISTED IN A TABLE ON DRAWING G-2.

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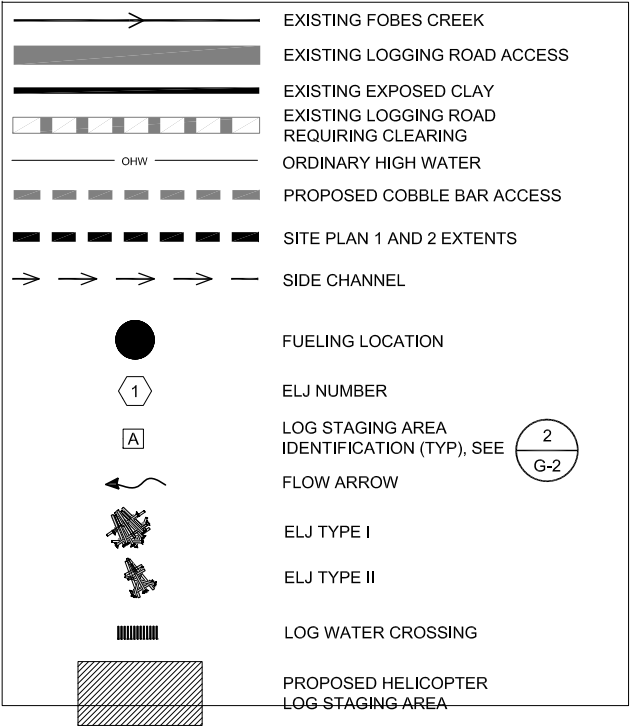
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DESIGNED: M. STRAZER	DRAWN: -
DESIGNED: -	CHECKED: J. GOLDSMITH
SCALE: AS NOTED	APPROVED: M. SPILLANE

FOBES CREEK
SOUTH FORK NOOKSACK RIVER
FOBES CREEK REACH
HABITAT RESTORATION PROJECT
PROPOSED SITE PLAN 1

DATE:	
MARCH 2010	
PROJECT NO:	
08-03983-001	
DRAWING NO:	
C-1	
SHEET NO:	OF
4	11



LEGEND:



NOTES:

- 1. ALL HELICOPTER STAGING AREAS SHALL HAVE A MINIMUM 50' HORIZONTAL CLEAR ZONE.
- 2. NO REFUELING OF EQUIPMENT SHALL OCCUR WITHIN 100' OF THE UNVEGETATED CHANNEL WIDTH OR OUTSIDE DESIGNATED FUELING AREAS DESIGNATED ON PLANS WITHOUT PERMISSION OF ENGINEER AND PERMITTING AGENCIES.
- 3. WATER CROSSINGS SHALL BE LOCATED BY LUMMI NATION BIOLOGIST TO AVOID SPAWNING HABITAT. CROSSINGS SHALL BE ORIENTATED PERPENDICULAR TO FLOW DIRECTION TO MINIMIZE WETTED CHANNEL CROSSINGS DISTANCE. WATER CROSSINGS SHALL BE LIMITED TO THE MINIMUM NUMBER OF EQUIPMENT TRIPS NECESSARY TO ACCESS THE ELJ LOCATIONS. ADDITIONAL CROSSINGS WILL BE REQUIRED FOR EQUIPMENT FUELINGS.
- 4. ACCESS SHALL BE USED BASED ON CHANNEL LOCATION AT TIME OF CONSTRUCTION. MINIMAL CLEARING REQUIRED FOR SITE AND ACCESS IMPROVEMENTS TO EXISTING ABANDONED ROAD ALIGNMENT. REPLANTING TO BE COORDINATED BY LUMNI NATION.
- 5. ALL ELJS (EXCEPT ELJS 3) SHALL BE CONSTRUCTED ON COBBLE BARS AND SHALL BE LOCATED TO AVOID IN WATER WORK OTHER THAN WATER CROSSINGS FOR ACCESS.
- 6. A PLAN AND SCHEDULE FOR STAGING LOGS AT DESIGNATED STAGING AREA IS LISTED IN A TABLE ON DRAWING G-2.
- 7. CONTRACTOR SHALL REMOVE AND INCORPORATE EXISTING WOODY DEBRIS WITHIN ELJ 12 FOOTPRINT AS RACKING MATERIAL ON ELJ UPSTREAM FACE

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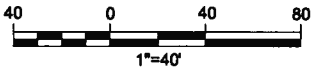
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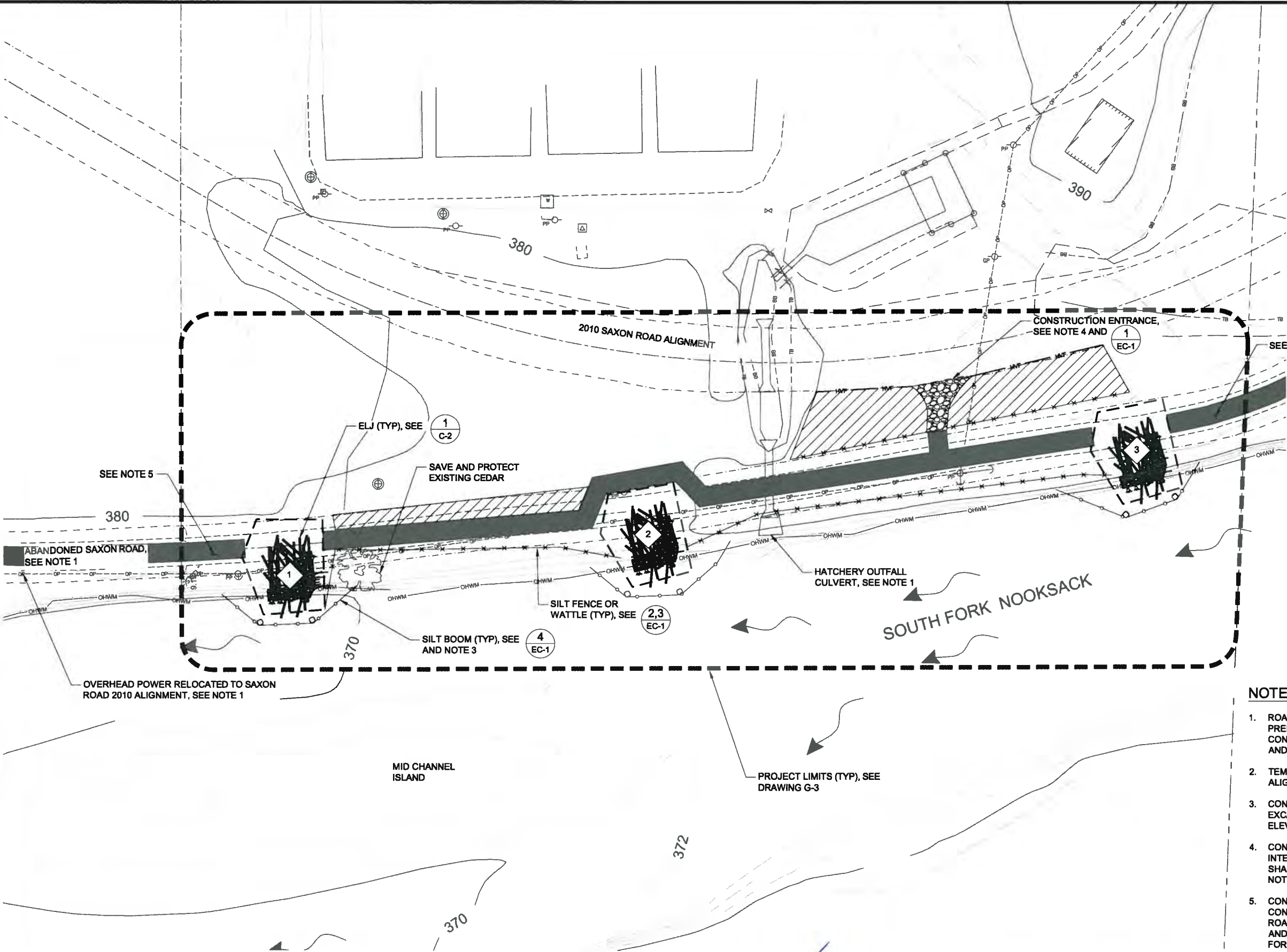
FOBES CREEK
SOUTH FORK NOOKSACK RIVER
FOBES CREEK REACH
HABITAT RESTORATION PROJECT
PROPOSED SITE PLAN 2

DATE:	
MARCH 2010	
PROJECT NO:	
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C-2	
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5	11



LEGEND:

- PROJECT LIMITS
- EXISTING CONTOURS
- ORDINARY HIGH WATER MARK
- RIGHT OF WAY
- EDGE OF PAVEMENT
- 2010 SAXON ROAD CENTERLINE
- SILT FENCE OR WATTLE
- SILT BOOM
- HIGH VISIBILITY FENCE
- PROPOSED TOPSOIL/ EXCAVATION EXTENTS
- TEMPORARY ACCESS ROAD
- BULK BAG SILT BOOM ANCHOR
- STAGING AREAS
- FLOW ARROW
- TYPICAL ELJ STRUCTURE
- ELJ NUMBER
- EXISTING CULVERT, SEE NOTE 1



NOTES:

- ROAD REMOVAL BEYOND ELJ STRUCTURE EXCAVATION TO BE PERFORMED BY OTHERS. CONSTRUCTION ANTICIPATED FOR POST ELJ CONSTRUCTION. CONTRACTOR SHALL VERIFY ROAD, CULVERT, UTILITY, AND OUTFALL LOCATIONS PRIOR TO CONSTRUCTION.
- TEMPORARY ACCESS ROAD TO FOLLOW ABANDONED SAXON ROAD ALIGNMENT.
- CONTRACTOR SHALL EXTEND SILT BOOM AROUND STRUCTURE DURING EXCAVATION AND CONSTRUCTION ACTIVITIES TO A MIN OF OHWM ELEVATION.
- CONTRACTOR MAY HAVE TEMPORARY ACCESS TO SITE BY INTERSECTION OF ABANDONED AND NEW SAXON ROAD. CONTRACTOR SHALL CONSTRUCT BMPS AS NECESSARY TO ENSURE SEDIMENT DOES NOT LEAVE THE SITE IF THESE ACCESS POINTS ARE USED.
- CONTRACTOR MAY USE ABANDONED SAXON ROAD AS ALTERNATE CONSTRUCTION ACCESS. CONTRACTOR SHALL SECURE SITE AND ROAD AT ALL TIMES. CONTRACTOR SHALL PROVIDE TRAFFIC SIGNAGE AND RELOCATE ECOLOGY BLOCKS AT ROAD EXTENTS AS NECESSARY FOR PUBLIC SAFETY.

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DESIGNED: -	CHECKED: J. GOLDSMITH, A. BEHNKE
SCALE: AS NOTED	APPROVED: M. SPILLANE

SOUTH FORK NOOKSACK RIVER
SKOOKUM CREEK
HABITAT RESTORATION PROJECT

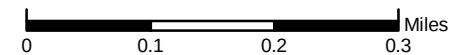
PROPOSED SITE PLAN

DATE: JUNE 2010
PROJECT NO: 08-03983-000
DRAWING NO: C-1
SHEET NO: 4 OF 7



Site Access

- County Road
- State Route 9
- ===== Farm Road
- + + + Burlington Northern RR
-  Stabilization Site
-  Ordinary High Water



Lummi Natural Resources Department
2616 Kwina Road
Bellingham, WA 98225



0 25 50 100 150 200 Meters

Nesset's Reach Project As-Built Design

Two of the planned structures were dropped based on site conditions at the time of construction. Both structures were dropped because the debris piles were too small and the pieces decayed for stabilization. The materials (logs and piles) for the two sites were incorporated into structures #3 and #6.

NOTES:

- 1. SHADED AREAS INDICATED ARE UPLAND AREAS OUTSIDE OF DELINEATED WETLAND BOUNDARIES. INFORMATION PROVIDED FROM WETLAND DELINEATION BY LIBC, MARCH 29, 2005
- 2. WETTED CHANNEL AREA SHOWN IS APPROXIMATE. CHANNEL EDGE, EXTENT OF WATER AND WATER ELEVATIONS, SHOULD BE EXPECTED TO VARY.
- 3. STRUCTURE LOCATIONS SHALL BE POSITIONED BY PILE COORDINATES. SEE SHEETS C6 AND C9.
- 4. LOG CLUSTER LOCATIONS SHOWN ARE APPROXIMATE. ENGINEER WILL FIELD LOCATE CLUSTER LOCATIONS. SPECIFY ORIENTATIONS WITHIN THE FLOODPLAIN.
- 5. ALL HABITAT LOG LOCATIONS ARE NOT SHOWN. ENGINEER WILL LOCATE FIFTY (50) LOG LOCATIONS THROUGH THE PROJECT SITE. SEE SPECIFICATIONS FOR TYPE AND INSTALLATION REQUIREMENTS.
- 6. LOWER HUTCHINSON CREEK SHALL BE DIVERTED INTO S.F. NOOKSACK OF ELJ-1 THROUGH A TEMPORARY BREACH IN THE HUTCHINSON LEVEE BY PASSING MOST OF THE WORK AREA DURING CONSTRUCTION OF ELJS 1-3.
- 7. MATERIALS REMOVED FROM LEVEE BREACH SHALL BE STORED ADJACENT TO THE BREACH LOCATION.

LEGEND:

EXISTING LEVEE TO BE REMOVED AND REPLACED AFTER CONSTRUCTION OF ELJS 1-3

EXISTING LEVEE

EXISTING LEVEE TO BE REMOVED

TEMPORARY FLOODPLAIN ACCESS ROAD

TEMPORARY BRIDGE

BANK PROTECTION

ELJ STRUCTURES 1 THRU 6
SEE DETAIL 1/C7, TYP

ORDINARY HIGH WATER

LOG CLUSTERS, SEE NOTE 4

APPROXIMATE LOCATION OF WETTED CHANNEL (2002)

UPLAND AREAS FROM MARCH 2005 WETLAND DELINEATION, SEE NOTE 1

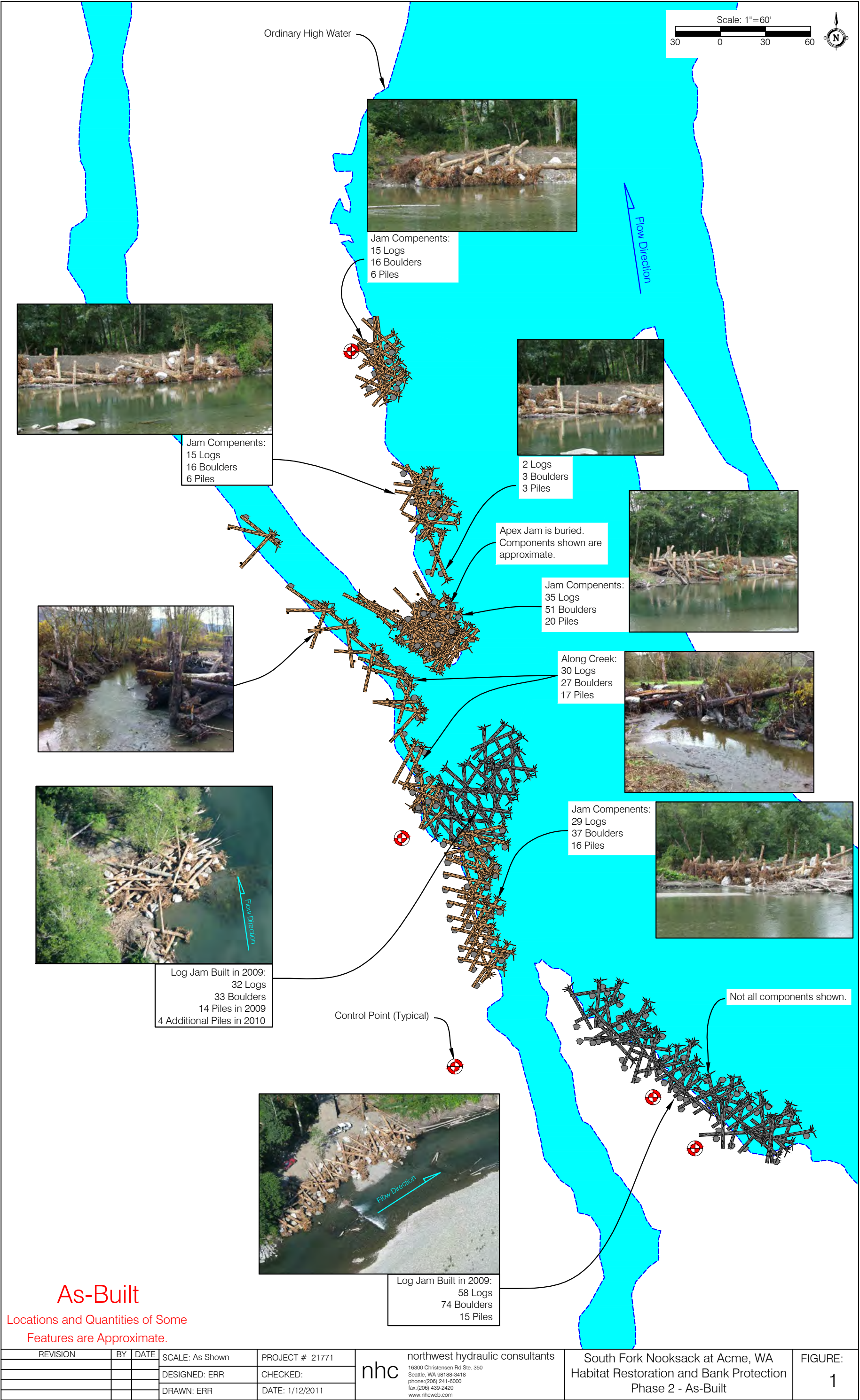
HABITAT LOGS, SEE NOTE 5

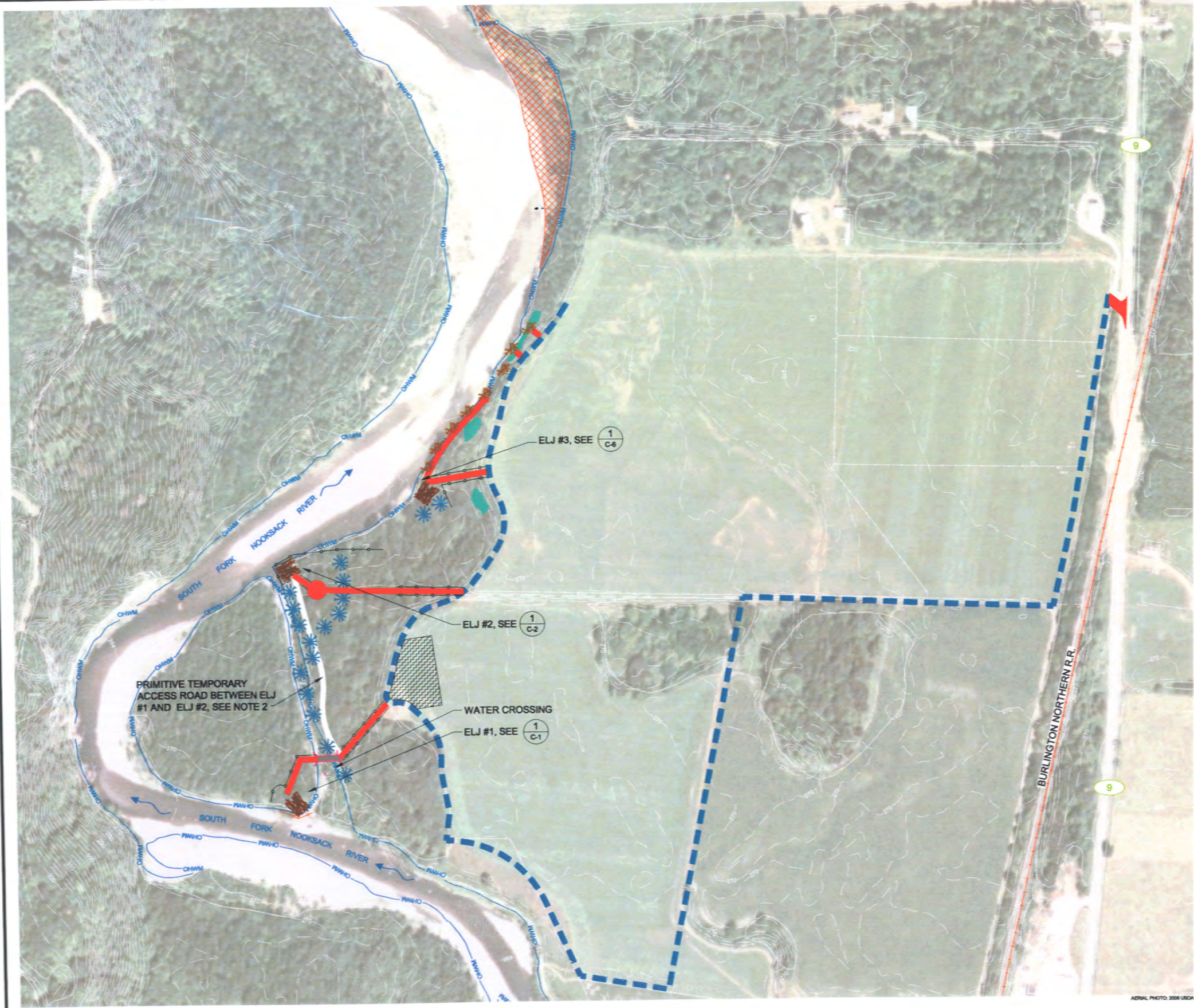
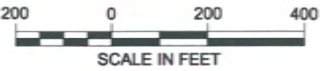
WETLAND

WORK LIMITS

CONSTRUCTION SET

HERRERA ENVIRONMENTAL CONSULTANTS 2200 Sixth Avenue Suite 1100 Seattle, Washington 98121-1820 206-441-9080 206-441-9108 FAX http://www.herrerainc.com				Nooksack Tribe of Indians NATURAL RESOURCES LUMMI NATION TREATY OF 1855 MICHAEL M. SPILLANE STATE OF WASHINGTON REGISTERED PROFESSIONAL ENGINEER 30780 EXPIRES: 4/5/2007	<table><tr><td>DESIGNED:</td><td>M. SPILLANE</td><td>DRAWN:</td><td>T. PRESCOTT</td></tr><tr><td>DESIGNED:</td><td>M. RUEBEL</td><td>SCALE:</td><td>-</td></tr><tr><td>DESIGNED:</td><td>T. ABBE</td><td>CHECKED:</td><td>J. GOLDSMITH</td></tr><tr><td>RECOMMENDED:</td><td>-</td><td>APPROVED:</td><td>M. SPILLANE</td></tr></table>	DESIGNED:	M. SPILLANE	DRAWN:	T. PRESCOTT	DESIGNED:	M. RUEBEL	SCALE:	-	DESIGNED:	T. ABBE	CHECKED:	J. GOLDSMITH	RECOMMENDED:	-	APPROVED:	M. SPILLANE	SOUTH FORK NOOKSACK LOWER HUTCHINSON CREEK RESTORATION PROJECT GENERAL SITE PLAN	<table><tr><td>DATE:</td><td>MARCH 2006</td></tr><tr><td>PROJECT NO:</td><td>04-02945-001</td></tr><tr><td>DRAWING NO:</td><td>C-2</td></tr><tr><td>SHEET NO:</td><td>4 OF 12</td></tr></table>	DATE:	MARCH 2006	PROJECT NO:	04-02945-001	DRAWING NO:	C-2	SHEET NO:	4 OF 12
DESIGNED:	M. SPILLANE	DRAWN:	T. PRESCOTT																												
DESIGNED:	M. RUEBEL	SCALE:	-																												
DESIGNED:	T. ABBE	CHECKED:	J. GOLDSMITH																												
RECOMMENDED:	-	APPROVED:	M. SPILLANE																												
DATE:	MARCH 2006																														
PROJECT NO:	04-02945-001																														
DRAWING NO:	C-2																														
SHEET NO:	4 OF 12																														





NOTES:

- 1. TEMPORARY ACCESS ROAD ALIGNMENTS SHALL BE ROUTED TO MINIMIZE DISTURBANCE OF EXISTING VEGETATION.
- 2. CONTRACTOR SHALL USE EXISTING CLEARED CORRIDOR FOR ACCESS. NO GRADING TO OCCUR. CONTRACTOR SHALL LIMIT ACTIVITIES TO MINIMIZE DISTURBANCE. ACCESS TO BE USED ONLY FOR CONSTRUCTION AND PLACEMENT OF LWD CLUSTERS.

LEGEND:

	ORDINARY HIGH WATER MARK (OHWM)
	EXISTING ACCESS ROAD
	WETLAND
	ERODED BANK
	BURLINGTON NORTHERN RAILROAD
	TEMPORARY ACCESS ROAD
	PRIMITIVE TEMPORARY ACCESS ROAD
	WATER CROSSING, SEE WM-1
	SILT FENCE, SEE WM-1
	SILT BOOM, SEE WM-1
	STABILIZED CONSTRUCTION ENTRANCE
	CONSTRUCTION STAGING AREA
	ELJ STRUCTURE
	LWD CLUSTER (SEE DWG C-11)
	LWD ROUGHNESS (SEE DWG C-9)

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Cad User: Todd Prescott
Plot Style Table: Herrera-Color.ctb

No.	REVISION	BY	APPD	DATE

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NOOKSACK TRIBE OF INDIANS
NATURAL RESOURCES

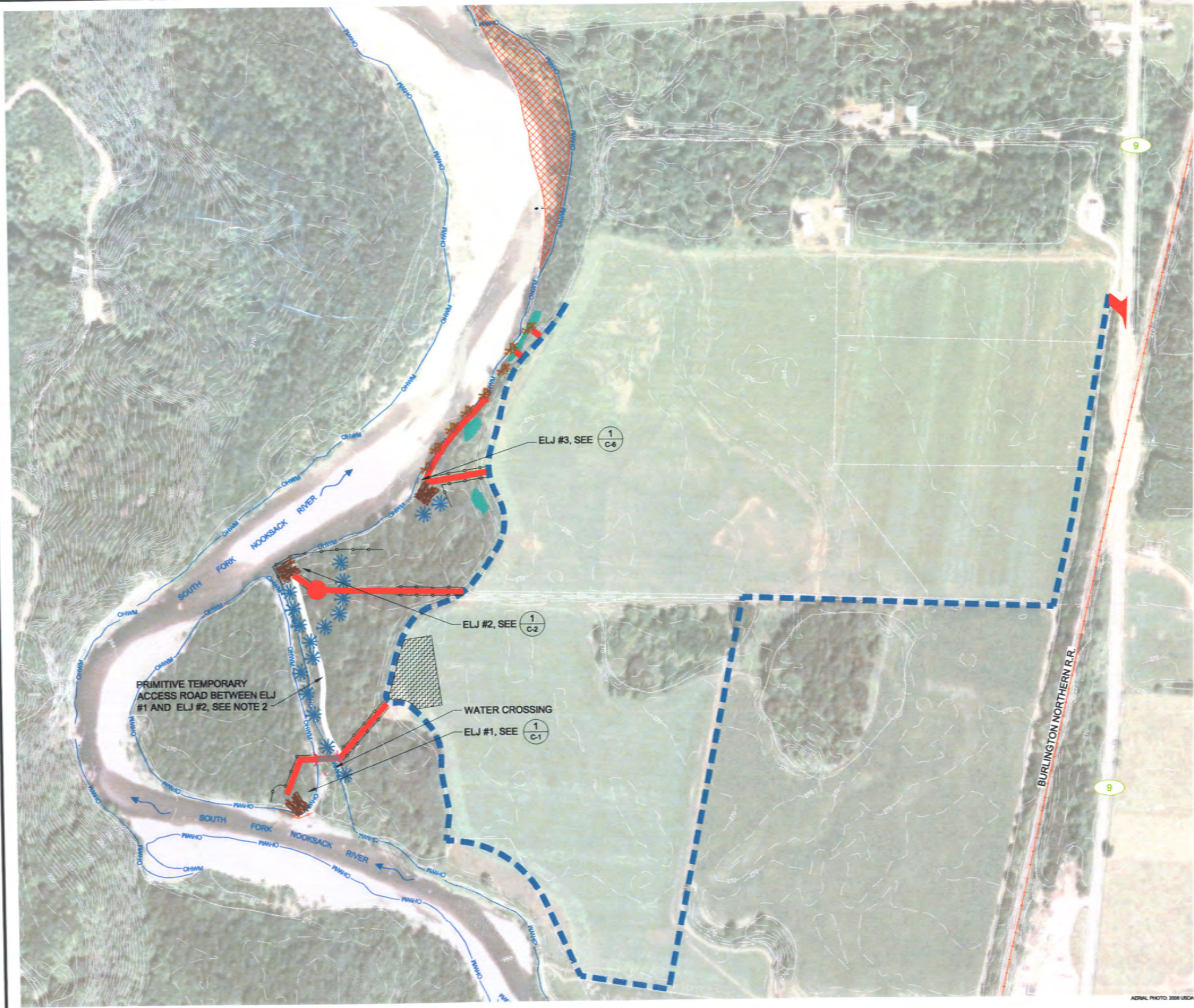
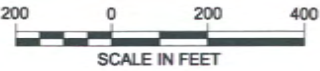
MICHAEL M. SPILLANE
REGISTERED PROFESSIONAL ENGINEER
30780
EXPIRES: 4/5/2009

DESIGNED:	DRAWN:
G. KAYS	T. PRESCOTT
DESIGNED:	DRAWN:
C. AVOLIO	T. GRIGA
DESIGNED:	CHECKED:
-	J. GOLDSMITH
SCALE:	APPROVED:
AS NOTED	M. SPILLANE

SOUTH FORK NOOKSACK
RIVER MILE 6.5
RESTORATION PROJECT

SITE ACCESS PLAN AND PROPOSED WORK

DATE:	JULY 2007
PROJECT NO:	05-03256-000
DRAWING NO:	G-3
SHEET NO:	3 OF 18



NOTES:

- 1. TEMPORARY ACCESS ROAD ALIGNMENTS SHALL BE ROUTED TO MINIMIZE DISTURBANCE OF EXISTING VEGETATION.
- 2. CONTRACTOR SHALL USE EXISTING CLEARED CORRIDOR FOR ACCESS. NO GRADING TO OCCUR. CONTRACTOR SHALL LIMIT ACTIVITIES TO MINIMIZE DISTURBANCE. ACCESS TO BE USED ONLY FOR CONSTRUCTION AND PLACEMENT OF LWD CLUSTERS.

LEGEND:

	ORDINARY HIGH WATER MARK (OHWM)
	EXISTING ACCESS ROAD
	WETLAND
	ERODED BANK
	BURLINGTON NORTHERN RAILROAD
	TEMPORARY ACCESS ROAD
	PRIMITIVE TEMPORARY ACCESS ROAD
	WATER CROSSING, SEE WM-1
	SILT FENCE, SEE WM-1
	SILT BOOM, SEE WM-1
	STABILIZED CONSTRUCTION ENTRANCE
	CONSTRUCTION STAGING AREA
	ELJ STRUCTURE
	LWD CLUSTER (SEE DWG C-11)
	LWD ROUGHNESS (SEE DWG C-9)

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User: Todd Prescott
Cad User: Todd Prescott
Plot Style Table: Herrera-Color.ctb

No.	REVISION	BY	APPD	DATE

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NOOKSACK TRIBE OF INDIANS
1855
NATURAL RESOURCES

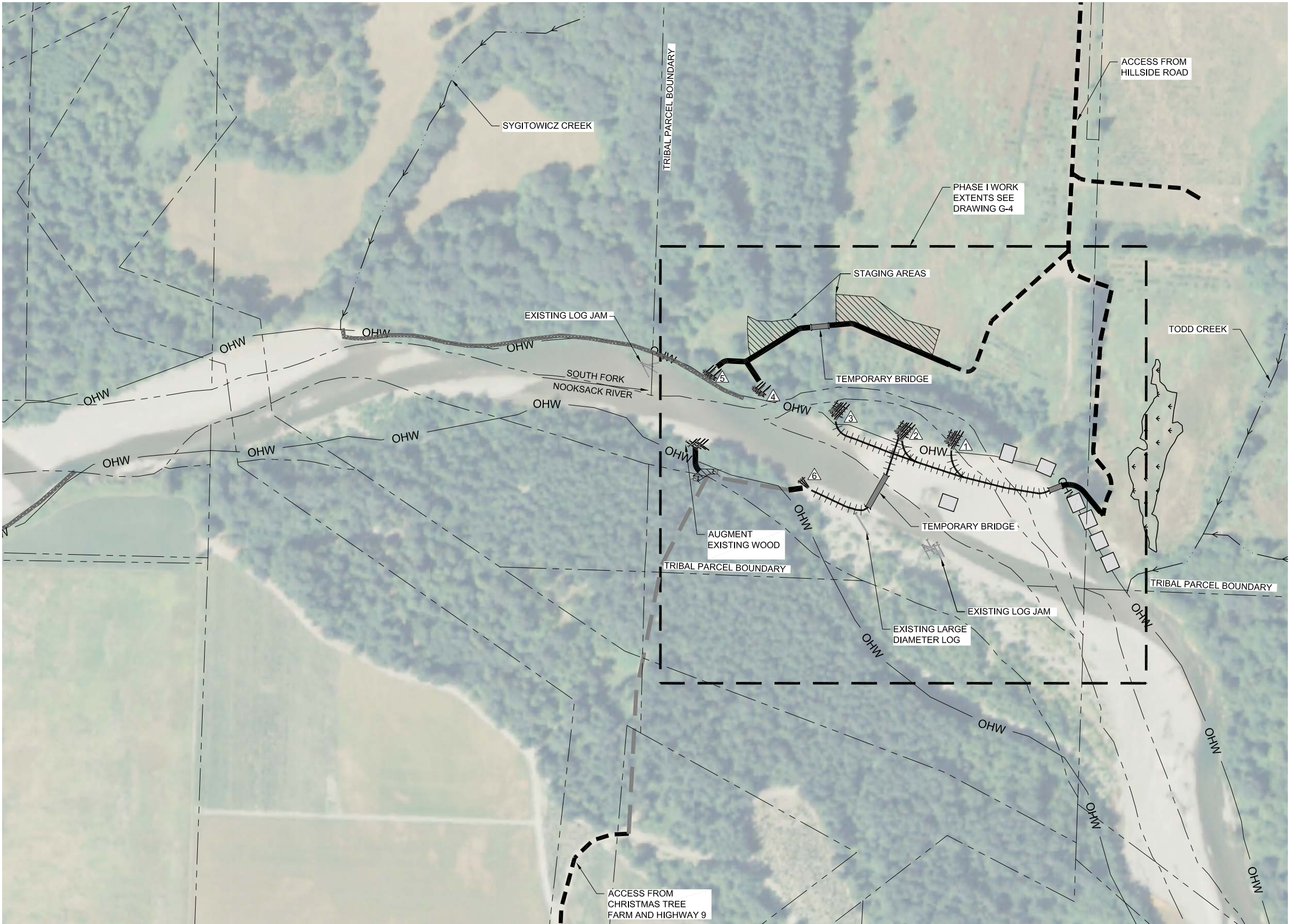
MICHAEL M. SPILLANE
REGISTERED PROFESSIONAL ENGINEER
30780
7/13/07
EXPIRES: 7/5/2009

DESIGNED:	DRAWN:
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SCALE:	APPROVED:
AS NOTED	M. SPILLANE

SOUTH FORK NOOKSACK
RIVER MILE 6.5
RESTORATION PROJECT

SITE ACCESS PLAN AND PROPOSED WORK

DATE:	JULY 2007
PROJECT NO:	05-03256-000
DRAWING NO:	G-3
SHEET NO:	3 OF 18



LEGEND:

	OHW	ORDINARY HIGH WATER MARK (OHWM)
	CREEK	
	EXISTING ACCESS ROAD	
	WETLAND	
	EXISTING PRIMITIVE ACCESS ROAD	
	EXISTING ACCESS ROAD	
	PARCEL BOUNDARY	
	EXISTING RIPRAP ARMORING	
	PROJECT LIMITS	
	TEMPORARY COBBLE BAR ACCESS	
	FLOOD PLAIN ROUGHENING LOGS	
	EXISTING ENGINEERED LOG JAM	
	TYPE 1 ELJ	
	TYPE 2 ELJ	
	TYPE 3 ELJ	
	ENGINEERED LOG JAM NUMBER	
	STAGING AREAS	

NOTES:

1. AERIAL PHOTO TAKEN IN 2009 (USDA). CURRENT CONDITIONS SHOULD BE VERIFIED
2. WETLANDS, EXISTING RIPRAP, OHWM DELINEATED BY NOOKSACK TRIBE
3. PARCEL BOUNDARIES PROVIDED BY NOOKSACK TRIBE.

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No.	REVISION	BY	APP'D	DATE



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DESIGNED: H. MACHEL	DRAWN: -
DESIGNED: -	CHECKED: A. BEHNKE
SCALE: AS NOTED	APPROVED: M. SPILLANE

SYGITOWICZ CREEK
SOUTH FORK NOOKSACK RIVER
RESTORATION PROJECT
RIVER MILE 4.0
SITE PLAN AND PROPOSED WORK

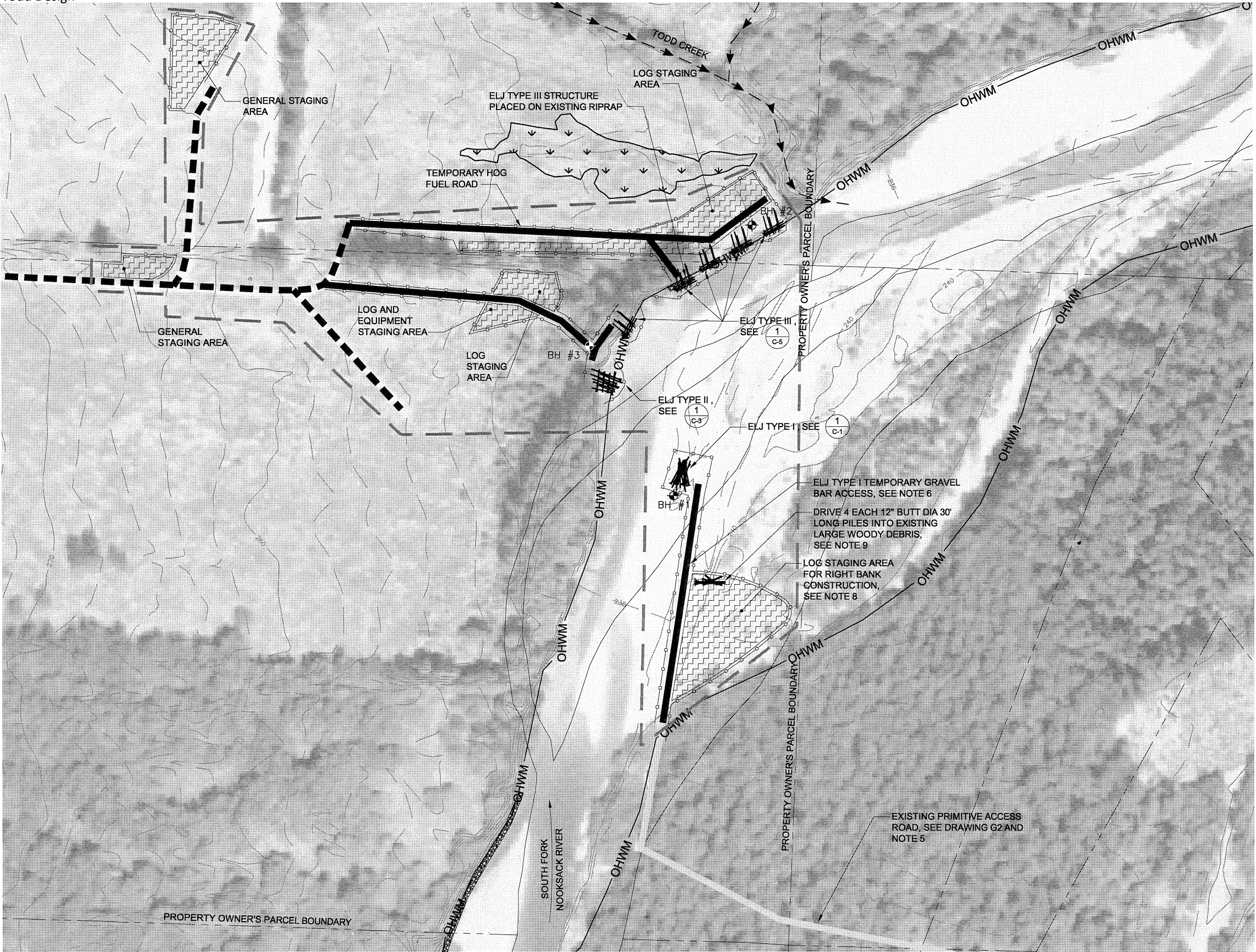
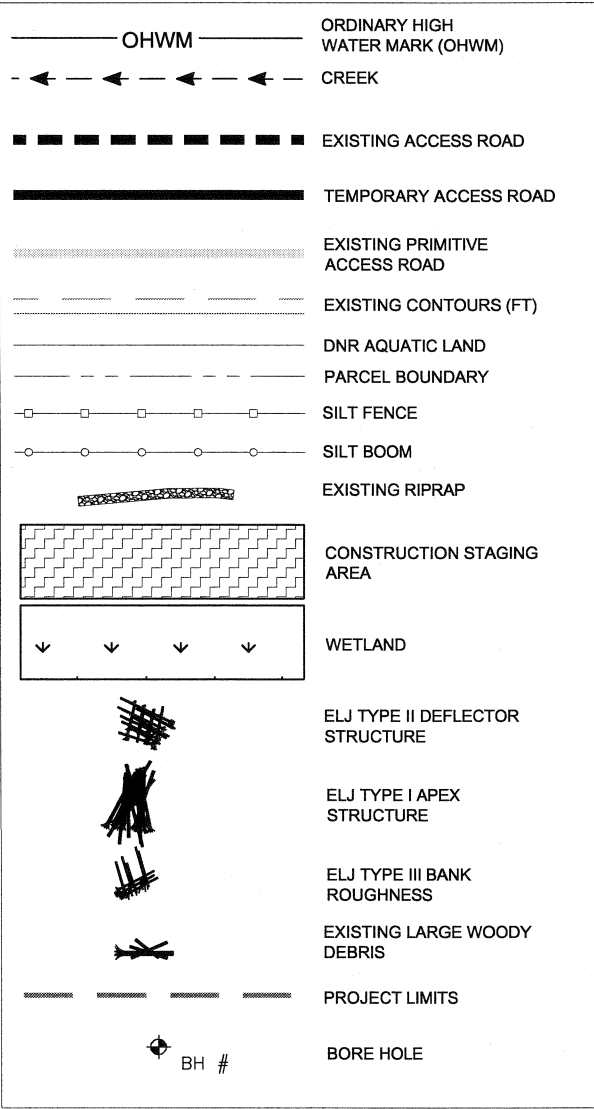
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PROJECT NO: 10-04639-000
DRAWING NO: G-3
SHEET NO: 3
OF 13



NOTES:

- 1. AERIAL PHOTO TAKEN IN 2006. CURRENT CONDITIONS SHOULD BE VERIFIED.
- 2. WETLANDS, EXISTING RIPRAP, AND OHWM DELINEATED BY NOOKSACK TRIBE.
- 3. PARCEL BOUNDARIES PROVIDED BY NOOKSACK TRIBE.
- 4. TEMPORARY HOG FUEL ACCESS ROAD ALIGNMENTS SHALL BE ROUTED TO MINIMIZE DISTURBANCE OF EXISTING VEGETATION.
- 5. CONTRACTOR SHALL USE EXISTING CLEARED CORRIDOR FOR ACCESS TO ELJ TYPE 1 ON GRAVEL BAR. NO GRADING TO OCCUR. CONTRACTOR SHALL LIMIT ACTIVITIES TO MINIMIZE DISTURBANCE.
- 6. NO HOG FUEL SHALL BE PLACED ON TEMPORARY GRAVEL BAR ACCESS ROAD.
- 7. TOPOGRAPHIC SURVEY FROM WALKER AND ASSOCIATES 2004 PHOTOGRAMETRY (HORIZONTAL STATE PLANE NORTH NAD83/91 VERTICAL NGVD 29).
- 8. RIGHT BANK STAGING AREA SHALL BE FOR LOG STORAGE ONLY. EQUIPMENT SHALL BE STAGED ALONG THE EXISTING PRIMITIVE ACCESS ROAD ABOVE THE OHWM.
- 9. PILE LOCATION TO BE STAKED BY SITE ENGINEER. PILES DRIVEN 25' BELOW EXISTING GRADE.

LEGEND:

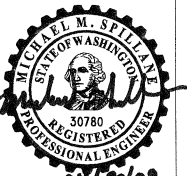


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User: Laura Turnidge
Printer: herra.ctb

No.	REVISION	BY	APP'D	DATE



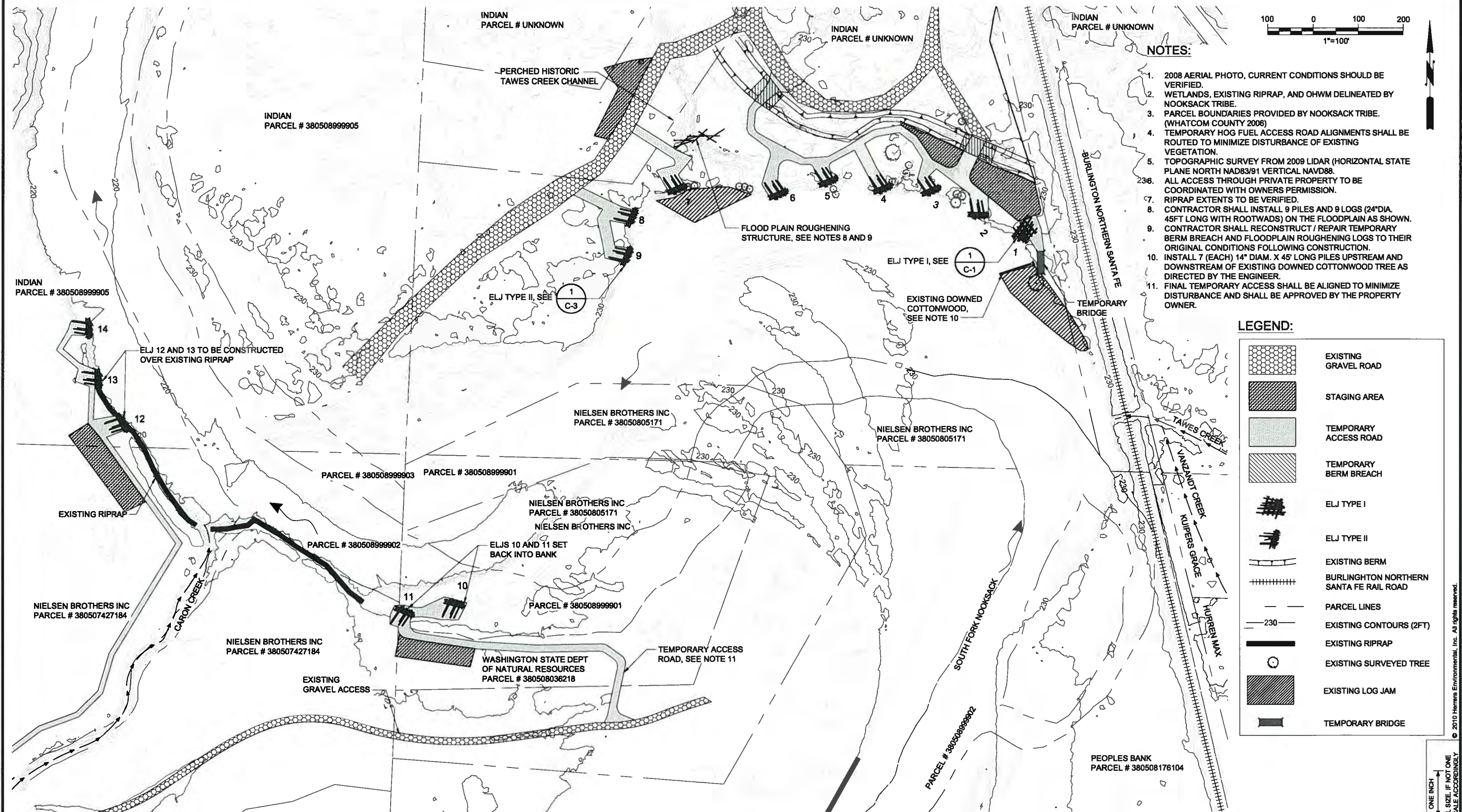
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DESIGNED: -	CHECKED: J. GOLDSMITH
SCALE: AS NOTED	APPROVED: M. SPILLANE

TODD CREEK
SOUTH FORK NOOKSACK RIVER
RESTORATION PROJECT
RIVER MILE 3.8
SITE PLAN AND PROPOSED WORK

DATE: APRIL 2008
PROJECT NO: 07-03818-000
DRAWING NO: G-3
SHEET NO: 3 OF 12



No.	REVISION	BY	APPD	DATE



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DESIGNED:	DRAWN:
H. MACHEL	-
DESIGNED:	CHECKED:
-	C. BRUMMER
SCALE:	APPROVED:
AS NOTED	M. SPILLANE

**VANZANDT REACH
SOUTH FORK NOOKSACK RIVER
RESTORATION PROJECT
RIVER MILE 1.0
SITE PLAN**

DATE:	JULY 2010	
PROJECT NO:	09-04252-000	
DRAWING NO:	G-3	
SHEET NO:	3	OF 10