NORTH FORK NOOKSACK FARMHOUSE REACH

FEASIBILITY AND ALTERNATIVES ANALYSIS

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INTRODUCTION

The North Fork Nooksack Farmhouse Reach (RM 46.8 to 49.4) was identified as a priority for habitat restoration in *Lower North Fork Nooksack River: Reach Assessment and Restoration Recommendations* (Hyatt 2007). This report assessed habitat changes in the North Fork Nooksack River (RM 37-58) through time and identified key limiting factors to salmon production in the river (Figure 1). The primary limiting factor identified was a lack of channel stability during the winter incubation and early rearing period. The lack of stability was attributed to changes in wood recruitment to the channel and more frequent large floods. These landscape-scale changes due to timber harvest and floodplain encroachment have resulted in a reduction in the number of large trees that can be recruited to the channel during floods, and therefore fewer logjams to form and stabilize forested channel islands and floodplain areas, leading to more transient river bars and smaller suitable areas for vegetation to become established (Hyatt 2007). The goal of restoration in the North fork Nooksack is to restore the channel stability and improve incubation success, through the placement of wood structures that will improve flow impedance and bank resistance to allow stable floodplain and island formation.

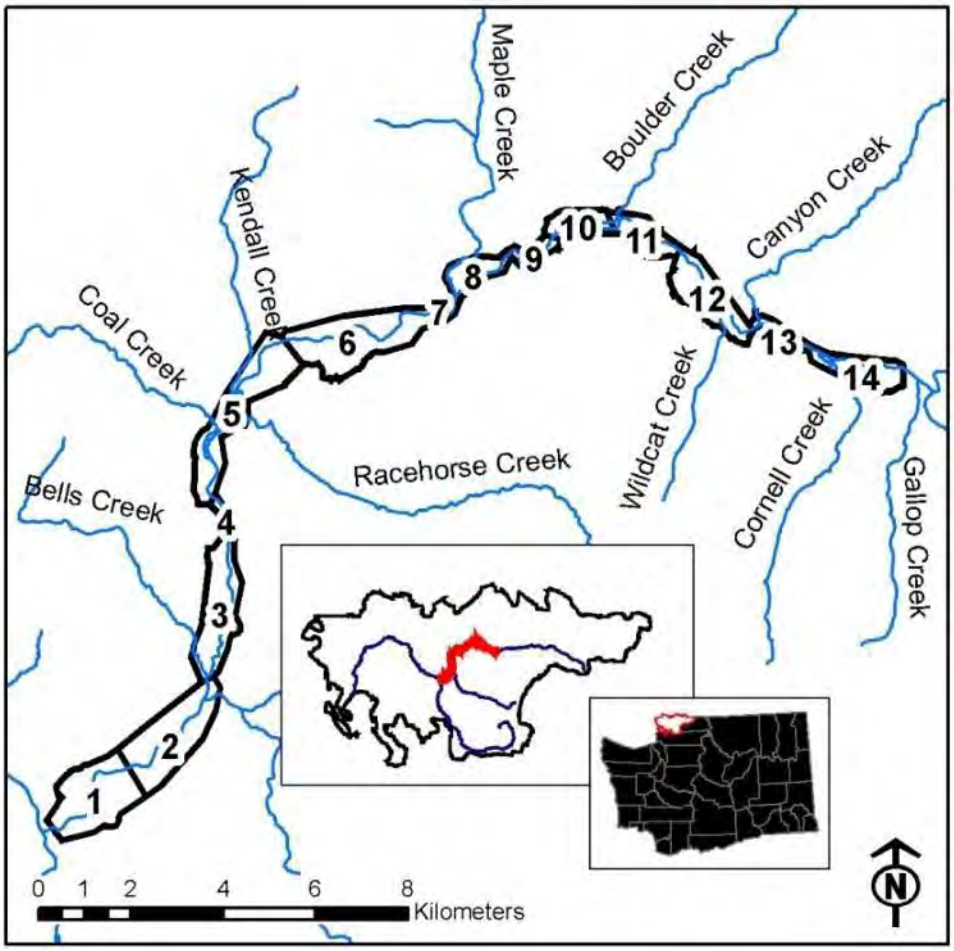
The Feasibility and Alternatives Analysis will focus on refining the limiting factors identified in the 2007 *Reach Assessment* and developing a suite of project alternatives for analysis relative to reach-specific restoration objectives and targets. The preferred alternative will be selected and any design iterations due to hydraulic modeling and geomorphic response will be documented.

BACKGROUND

NORTH FORK NOOKSACK RIVER

The headwaters of the North Fork Nooksack River lie on the eastern flank of Mt. Shuksan. From there it flows westerly for approximately 30 miles, then bends to the south and joins the Middle Fork Nooksack about 4 miles east of Deming, WA. The river drains 290 square miles of mountainous terrain, including the glaciated slopes of Mount Baker and Mount Shuksan. The watershed ranges from less than 300 feet in elevation to over 10,000 feet at the summit of Mount Baker. The gradient of the North Fork channel ranges from 0.001 to 0.01 (Hyatt 2007). The average annual precipitation of the North Fork watershed is approximately 100 inches/ year and the average annual discharge is approximately 780 cubic feet per second (cfs) (USGS gage #12205000). The highest average monthly discharge occurs in June and the lowest flow occurs in March. The highest recorded peak flow over a 37-year record occurred in October 2003 and reached 15,200 cfs. Peak flow for the period of record for the North Fork Nooksack gage (12205000) has shown an increase in flows greater than the 10-year flood in the last two decades (Figure 2).

FIGURE 1: NORTH FORK NOOKSACK RIVER SHOWING THE 14 ANALYSIS REACHES DELINEATED BY HYATT (2007).
Note: THE FARMHOUSE PROJECT REACH IS #6 IN THE FIGURE.

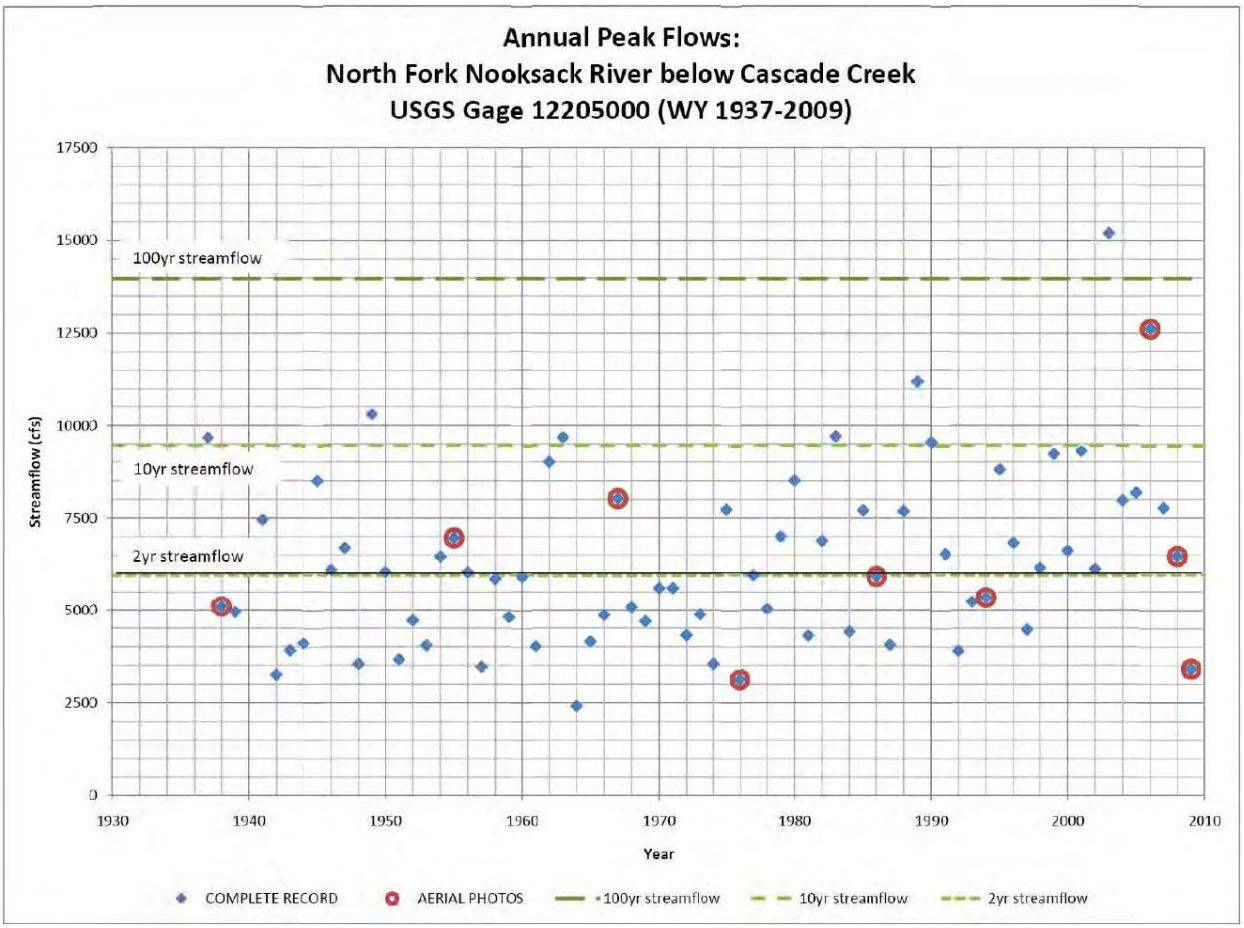


The North Fork Nooksack is home to seven anadromous salmonid species: fall and spring chinook, chum, coho, sockeye, steelhead, cutthroat, and bull trout. The Nooksack stocks of chinook, steelhead and bulltrout are all listed as "Threatened" under the Endangered Species Act, and the Nooksack chinook stocks are considered essential to the recovery of the Puget Sound population (Puget Sound Technical Review Team 2002). The North Fork Nooksack provides more than 30 miles of mainstem spawning and rearing habitat, which is more than doubled by the length of side channels and braids present along its length (Hyatt 2007). The river is characterized by high sediment load, high average summer flow and cool summer water temperature- all a result of the glaciers present in the headwaters of the system (Hyatt 2007).

Using the Ecosystem Diagnosis and Treatment (EDT) model, limiting habitat factors for chinook salmon were determined and prioritized for the Nooksack watershed. Modeling indicated that channel instability was the highest impact to early chinook in the lower North Fork (downstream of the Glacier Creek confluence at RM 57.6), and that the cause was likely related to degraded riparian conditions in the watershed (WRIA 1 Salmon Recovery Plan 2005). Other limiting factors that were identified include elevated fine sediment, and a lack of key habitat for rearing, holding and spawning chinook, indicating that the habitat types most

limiting in the reach are primary pool, backwater pools, complex edge habitats, side channels, and pool tail-outs (WRIA 1 Salmon Recovery Plan 2005).

FIGURE 2: ANNUAL PEAK FLOW FOR THE NORTH FORK NOOKSACK (USGS GAGE 12205000).
Source: GeoEngineers 2012.

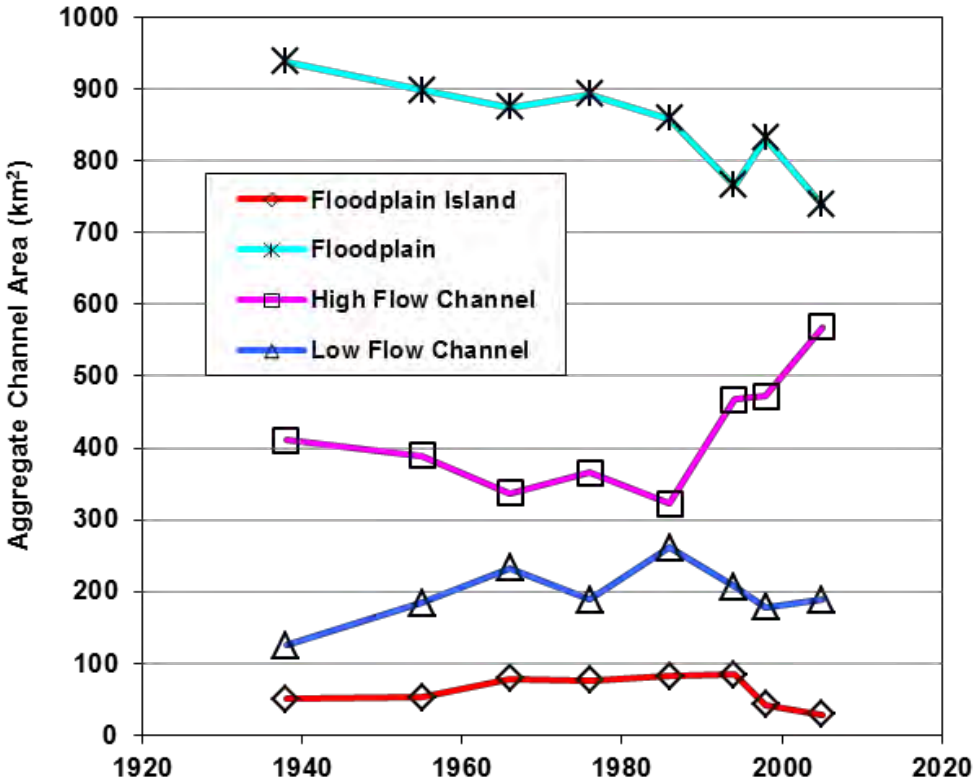


The current and historic habitat and channel characteristics of the North Fork Nooksack watershed were characterized by Hyatt (2007). The key finding was that the aggregate channel island area in the lower North Fork is approximately one-third of the average aggregate island area between 1938 and 1994. Accompanying the loss of stable island area, the high flow channel area (unvegetated bars) of the North Fork increased by more than 75% between 1986 and 2005 (Figure 3). Wood surveys through the river also showed a generally low count of key-sized pieces and stable logjams, although the Farmhouse Reach had a relatively high volume (Lummi Natural Resources Department 2007). Given the losses in channel island area and lack of large wood in the channel, Hyatt (2007) proposed that the loss of accumulations of large wood that can be important for forming and stabilizing forested islands has led to more rapid destruction of islands and the protected side channel areas that accompany them.

In a related study, Hyatt and Rabang (2003) identified the importance of protected side channels for incubation success in the North Fork, as a part of a spawning and incubation assessment of the Nooksack watershed. Mainstem and braided channels had a disproportionate tendency toward redd failure;

while scour chains in tributaries, sloughs and back-channels showed a tendency toward redd survival (redd failure was defined as >20cm scour, complete dewatering, or 50 cm overburden at emergence). Habitat mapping in the North Fork has also shown that secondary channels have a much greater habitat diversity (habitat units/mile) and a much closer pool spacing (pools/channel width) than mainstem and braided habitats (Nooksack Natural Resources data, Nooksack Salmon Enhancement Association 2010). This indicates that the loss of forested islands through time and the protected side channels that are associated with them may have a profound impact on spawning, incubation and rearing success. This has led to a general restoration strategy in the North Fork directed at maintaining and restoring floodplain forest patches.

FIGURE 3: NORTH FORK NOOKSACK (RM 37-58) FLOODPLAIN LAND TYPE CHANGES OVER TIME.
Source: Hyatt 2007.



FARMHOUSE PROJECT REACH

The Farmhouse Project Reach is approximately 2.6 miles long, extending from the lower end of a short canyon below Maple Creek downstream to rural property upstream of Kendall Creek (Figure 4). Zoning in the reach is a mix of commercial forestry, rural forestry, rural residential, and rural land uses (Figure 5). The channel area is managed by the State of Washington's Aquatic Lands Division.

FIGURE 4: NORTH FORK NOOKSACK FARMHOUSE REACH (RM 46.8-49.4).

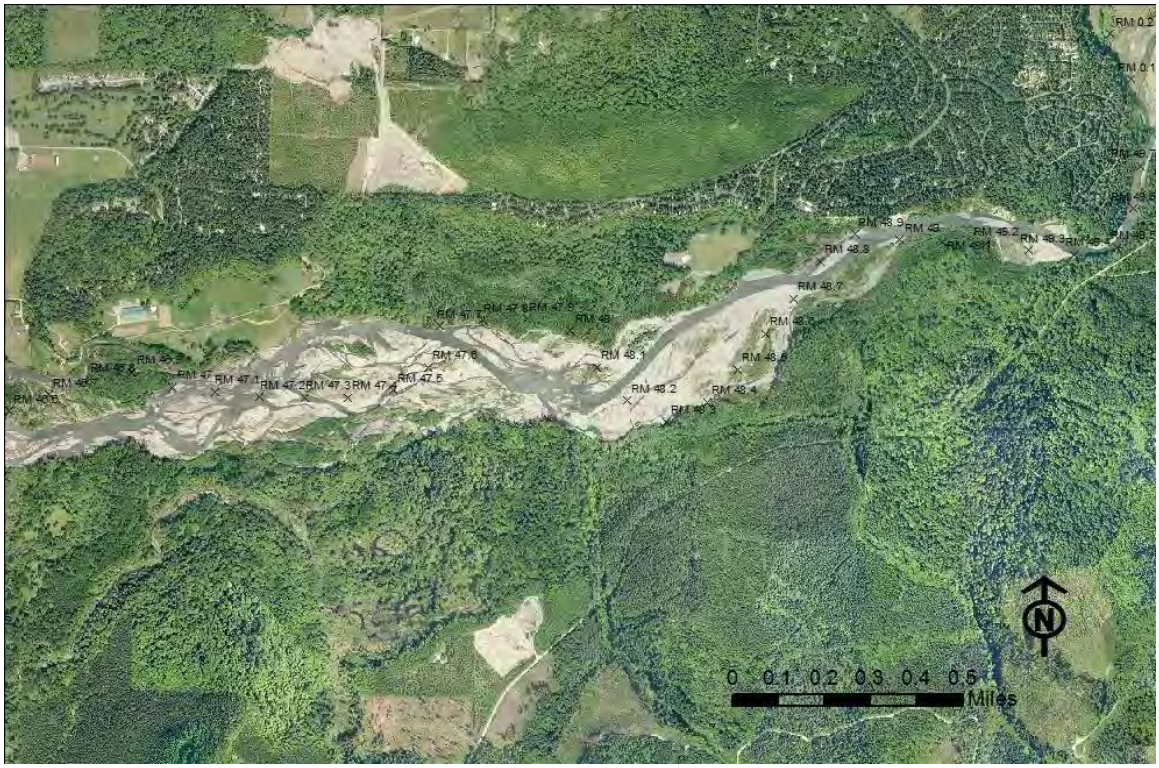
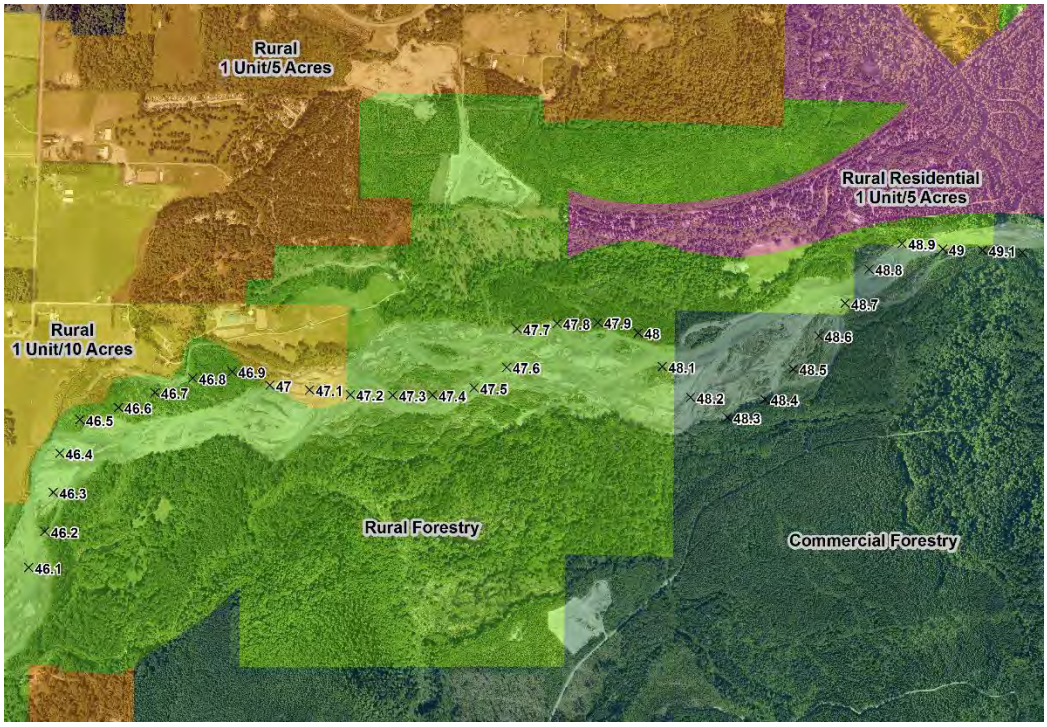
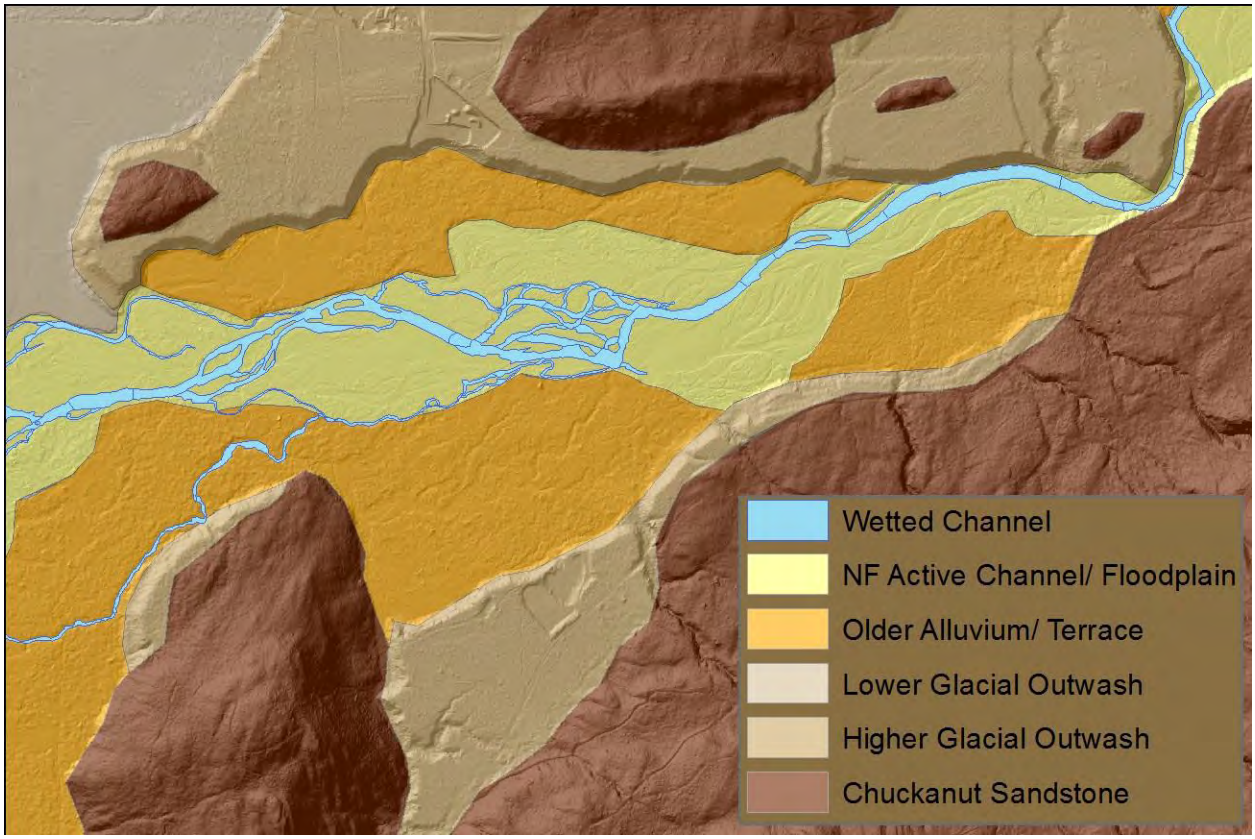


FIGURE 5: ZONING IN THE FARMHOUSE REACH.



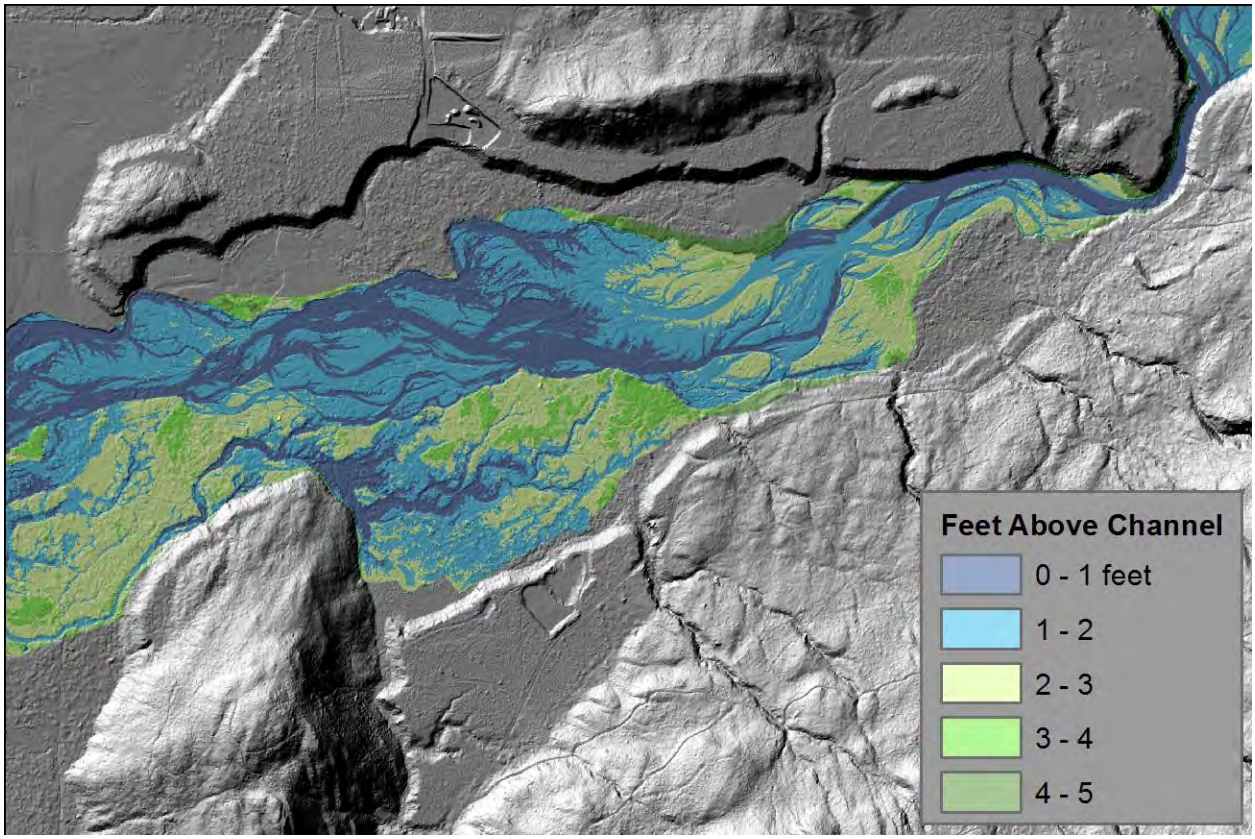
The mainstem channel exits the bedrock constriction of Maple Canyon and flows along the base of a high bluff composed of unconsolidated glacial deposits (Figure 6). This bluff borders both sides of the floodplain of the North Fork River through the length of the reach, although only a narrow remnant of the glacial deposit is present along much of the southern side. The floodplain and alluvial valley widen steadily downstream of the canyon as the river has eroded into the higher glacial bluff, until approximately RM 47, where a sandstone hill on the south side abruptly confines the North Fork floodplain from approximately 4570 feet to 2680 feet, or narrowing to approximately 60% of the maximum width.

FIGURE 6: PHYSIOGRAPHY AND SURFICIAL GEOLOGY OF THE FARMHOUSE REACH.



The historic migration zone is represented by the low alluvial surface (floodplain), inset into the older alluvium. Older alluvial areas outside of the historic channel area are often several feet higher than the floodplain (Figure 7). Many of these floodplain patches of older alluvium are separated by floodplain channels, which may have potential for enhancement and improved connectivity. Higher areas within the active channel area could become future forest islands, if they remain isolated form the river long enough to revegetate.

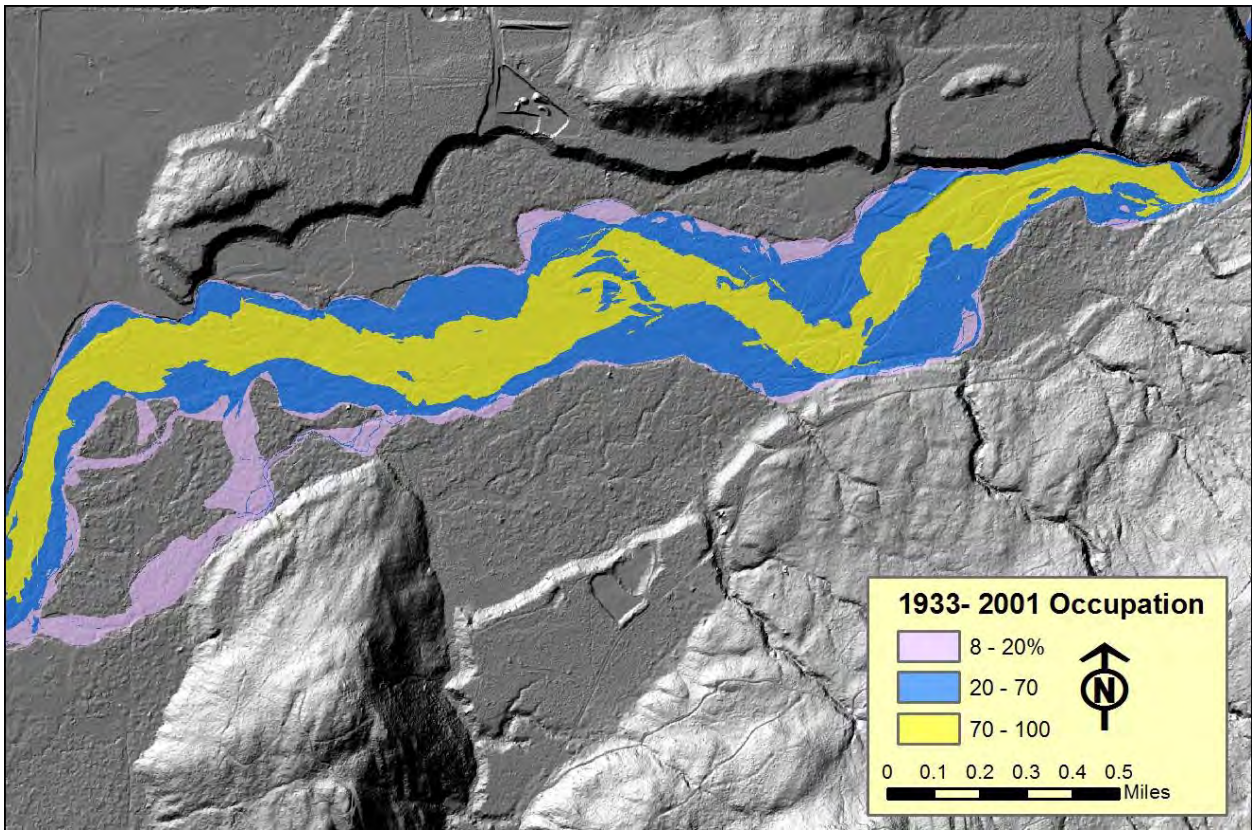
FIGURE 7: HEIGHT ABOVE THE LOW-FLOW CHANNEL IN THE FARMHOUSE REACH.



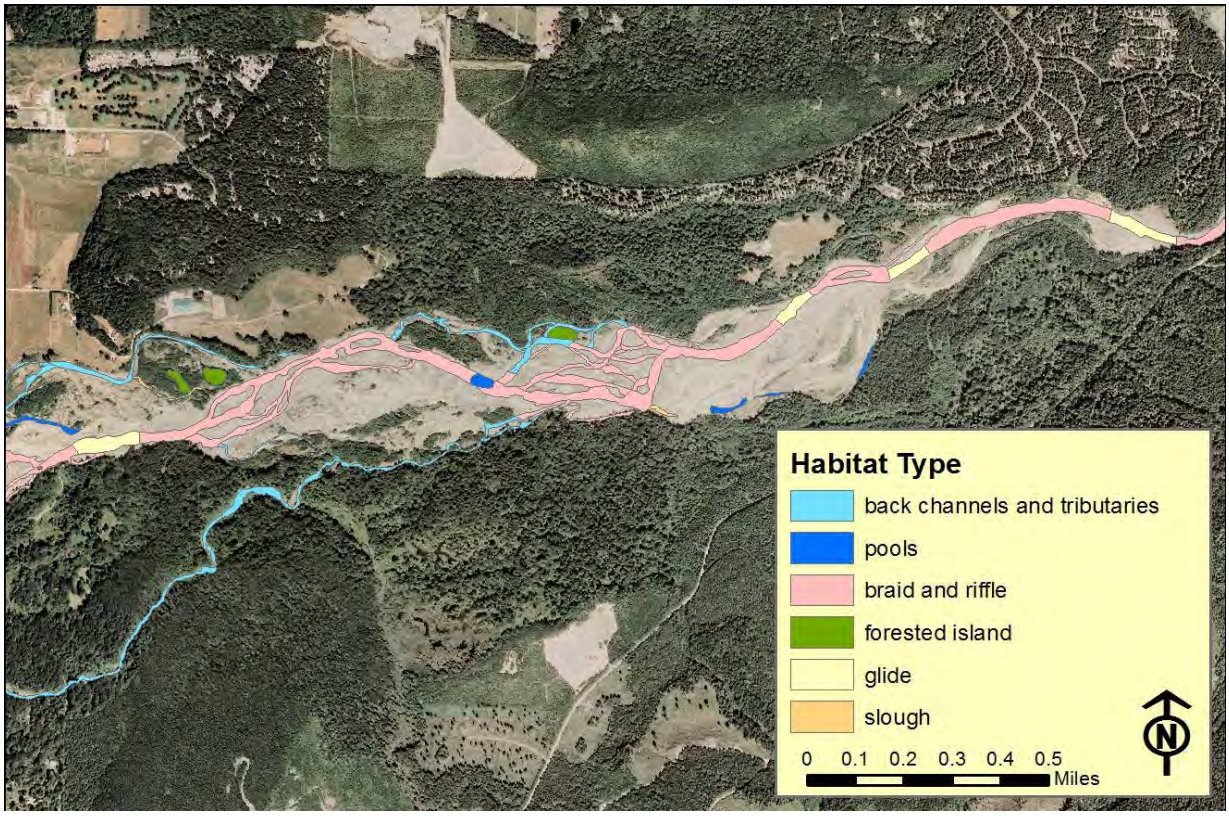
Immediately downstream of the eroding glacial outwash bluff at the mouth of the canyon, two deflection levees were built in the mid-1980s to protect eroding property owned by The Glen. The upstream levee was built within the historic migration area of the channel- reducing the width from 1350 feet to 940 feet- a loss of 30% of the width. Since construction of the levees, a portion of the low flow channel has been consistently adjacent to the upstream levee. The downstream levee lies at the boundary of the historic migration area and only periodically interacts with the low flow channel.

The Farmhouse reach is one of the widest on the North Fork (above the Middle Fork), averaging 278 m over the entire reach and varying between 135 m at the upstream end near the Maple Canyon and more than 300 m downstream near the Bennett-Woodland farm (Hyatt 2007). Overall gradient is 0.006, steeper than any of the reaches downstream, and varies locally (by 100 m segments) up to 0.02 but with most segments less than 0.01. Channel migration rates in the reach downstream of the Glen average 17 m/year and ranges between 11.7 and 29.0 m/year (Hyatt 2007). The percentage occupation grid shows a clear band of 100% occupation down the middle of the reach, with several zones of low (<20%) occupation having recently been occupied by the channel, in particular after the 2003 and 2004 floods (Figure 8, Hyatt 2007).

FIGURE 8: CHANNEL OCCUPATION IN THE FARMHOUSE REACH BETWEEN 1933 AND 2001.
Source: Collins & Sheikh 2004.



The Farmhouse Reach is among the most active and volatile reaches in the North Fork, with a broad alluvial plain carved by shallow braids and shift multiple times in a given year. Mainstem habitat in the Farmhouse reach was predominantly riffle (56%), followed by braid (15%), glide (6%), and pools (<1%) when it was mapped in 2005 (Hyatt 2007) (



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The one large convergence pool in 2005 occurred where three channel braids were joined, but had disappeared the following year. The lack of main channel pools was typical of the North Fork Nooksack River, which averaged 1.1 pools per mile over the 20.9 miles surveyed, although the reach near RM 41 (just upstream of Mosquito Lake Road) had 5 pools per mile (Figure 10). Off-channel habitat, primarily in the form of back channels, made up 21% of the wetted habitat in the reach. In the braided section, the channels shift inter-annually, with little in the way of channel islands or logjams to anchor the channel (Hyatt 2007). In 2005, the lower half of the reach included two significant back-channels, particularly the upstream half of the Bear Creek slough to the southwest, which included significant channel island area. An increase in habitat diversity and key habitat quantity associated with the increase in secondary channel types appears critical to addressing the limiting factors identified for North Fork early Chinook.

FIGURE 9: HABITAT MAPPING IN THE FARMHOUSE REACH.
Source: NNR 2005, on 2009 NAIP Aerial photo.

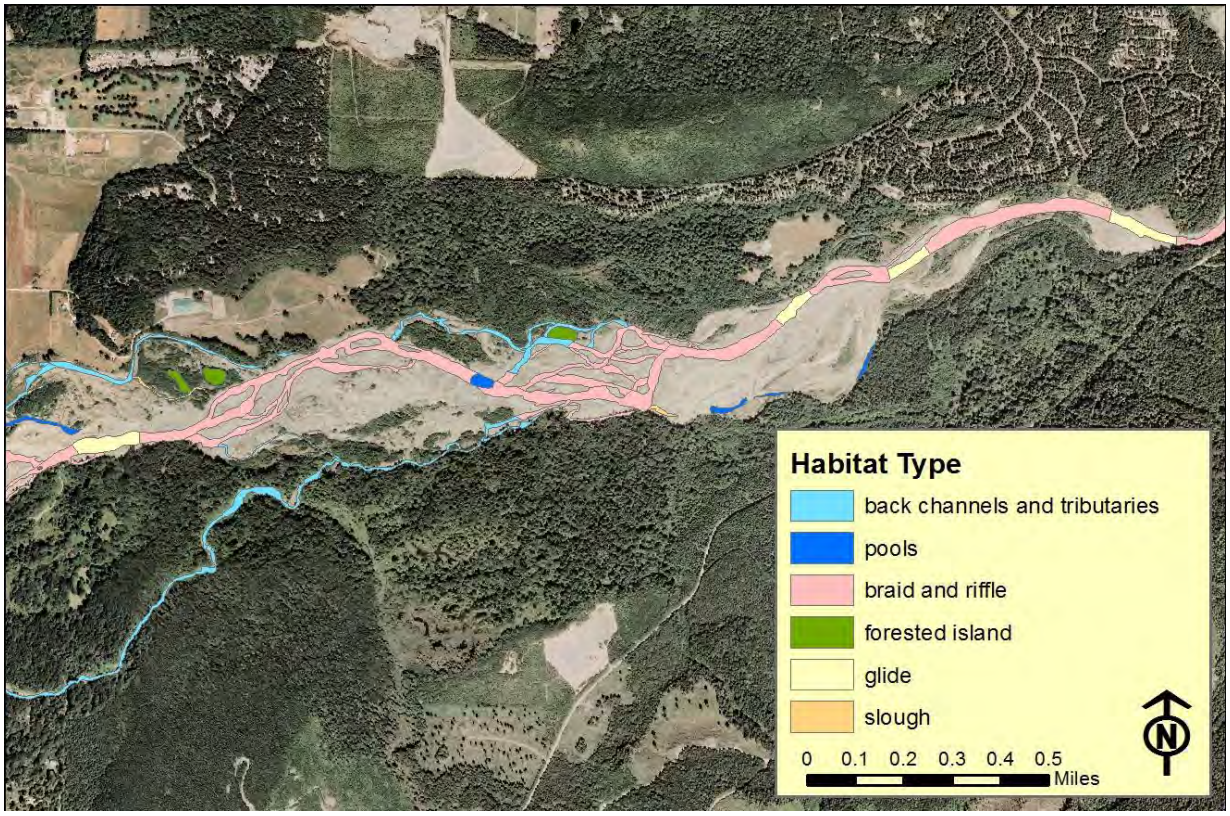
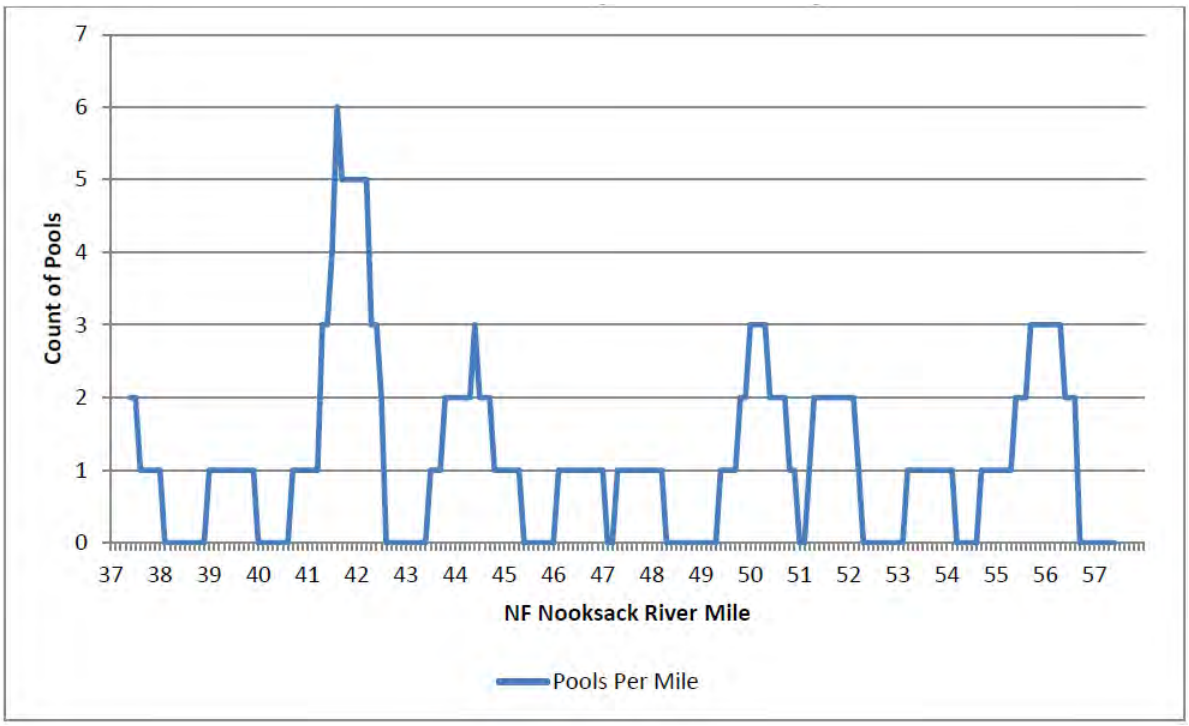
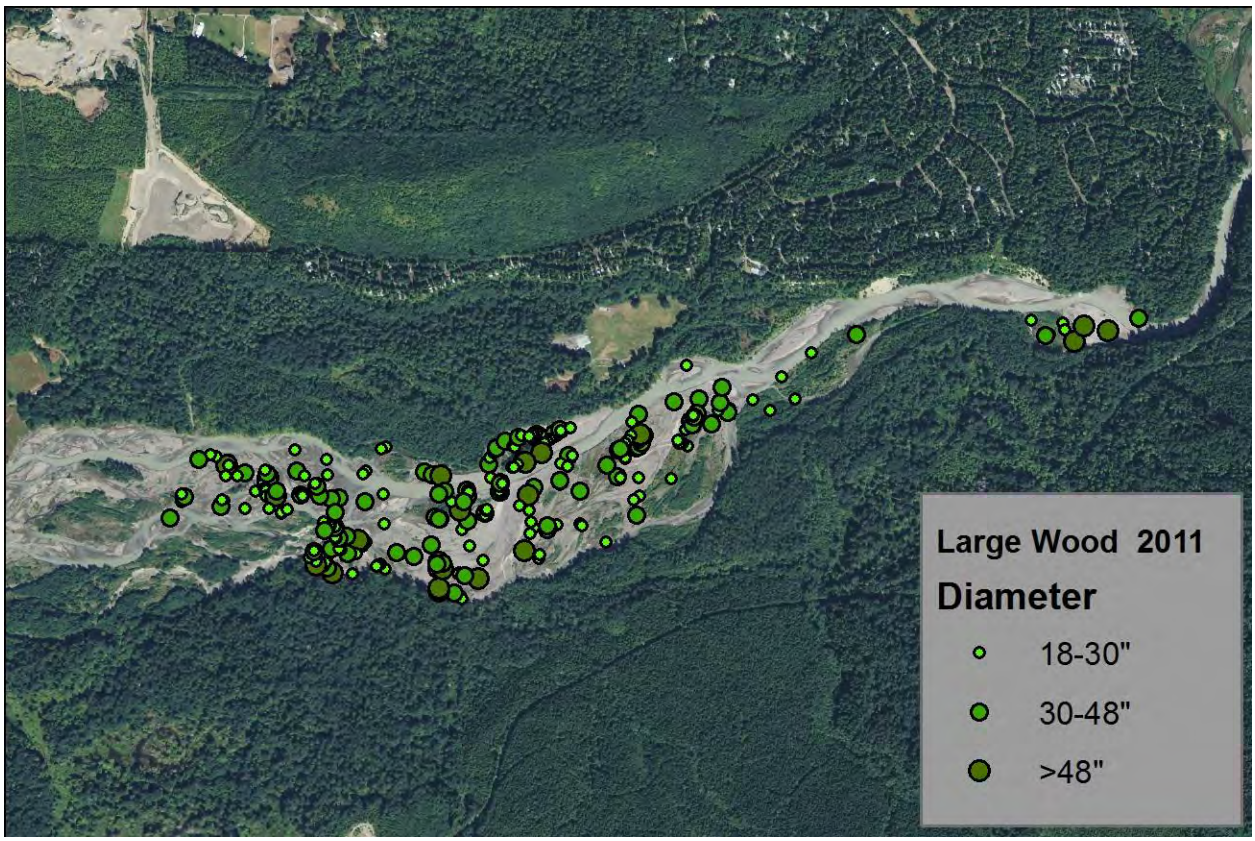


FIGURE 10: ROLLING POOLS-PER-MILE IN THE NORTH FORK NOOKSACK RIVER.
Source: Hyatt 2007.



The low pool counts in the mainstem likely reflect the reduced availability through time of pool-forming large wood. The Farmhouse Reach had one of the lowest concentrations of LWD in the North Fork when it was mapped in 2004, due in part to the large active channel area. For each 100m of mainstem channel, the 2004 LWD surveys (LNR 2007) counted 0.08 key pieces and 0.71 m^3 of LWD, compared to North Fork averages of 0.30 pieces and 2.73 m^3, respectively (cited from Hyatt 2007). More recent wood mapping in the upstream-most 1.4 miles found 283 pieces of wood greater than 18" in diameter and more than 30' long, most of which was located in the more unconfined portion of the channel (Figure 11). Of these 283 pieces, 172 were between 18" and 30", 90 were between 30" and 48", and 21 were larger than 48" in diameter (Nooksack Natural Resources data). Assuming that the larger pieces are roughly equivalent with the key-sized pieces mapped in 2004, this represents a large increase in LWD count to 0.87 pieces per 100m. This change in LWD through the reach reflects the dynamic nature of the channel and the ephemeral nature of the wood that is present.

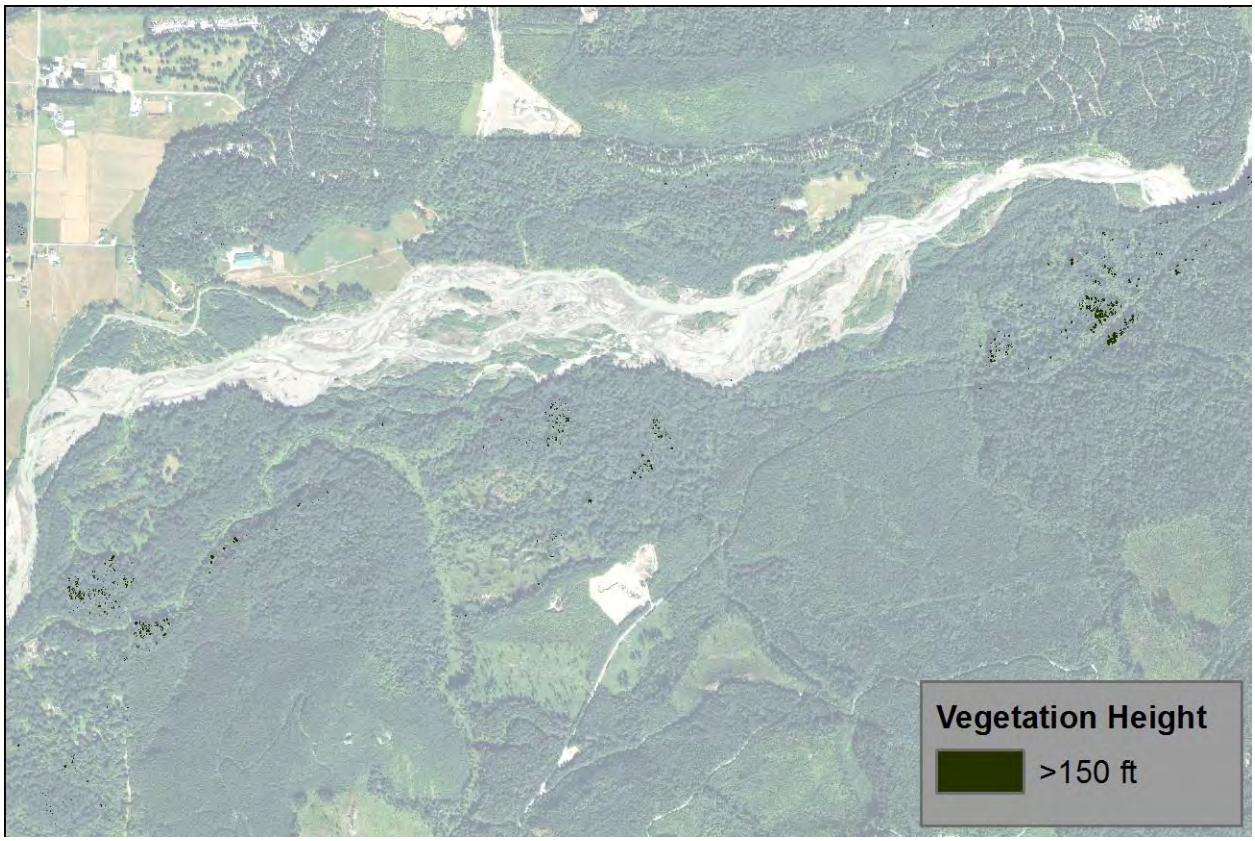
FIGURE 11: LARGE WOOD MAPPED IN THE UPPERMOST 1.4-MILES OF THE FARMHOUSE REACH.
Source: NNR unpublished data, 2011.



Future local wood recruitment is also limited by the riparian conditions. Less than 1% of the floodplain has timber >40 m in height (Hyatt 2007). The majority of the floodplain is bare cobble or vegetation less than 3 m tall. The few stands of mature conifers in the reach are located on the older alluvial terraces, the closest of which is more than 80 meters from the edge of the active channel area (Figure 12). Considering the average historic migration rate of 17m/ year, these stands could be accessed by the channel in the near future, although the historic channel occupancy shows a relatively narrow, sinuous band where the channel has

tended to stay. Since wood is often rapidly depleted from the system (Hyatt 2007), the local sources of recruitment and means of retention are critical to maintain the functions of LWD in the channel. With diminished sources of wood to the channel for the foreseeable future, restoring these functions through LWD placement will likely be the means of meeting our habitat objectives in the reach.

FIGURE 12: RIPARIAN STAND CONDITIONS IN THE FARMHOUSE REACH: TREE HEIGHT BASED ON 2005 LIDAR..



Habitat mapping from aerial photos and historic maps by Collins and Sheikh (2004) found an increase in active channel area (low flow and unvegetated gravel bars) through time in the Farmhouse Reach (Table 1). This trend mirrors the overall trend for the North Fork identified by Hyatt (2007). The widening of the active channel area comes at the expense of forest floodplain at the margins of the channel, rather than from a significant loss of forested islands in this reach (Figure 13). While the overall area of forested islands has declined through time, the island area appears more driven by changes in the number of small islands rather than the coalition and destruction of larger islands, as seen by the relatively small average area for most years (Table 2). The exception was 1976, where three large areas of emergent forest formed along the margin of the active channel area.

TABLE 1: HISTORIC HABITAT TYPE AREA (COLLINS ANS SHEIKH 2004).

Year	Habitat Type (acres)			
	Low Flow	High Flow	Total Channel Area	Forested Island
1891	N/A	N/A	103.8	37.0
1918	69.9	130.9	200.8	24.3
1938	44.3	159.4	203.7	4.1
1955	64.8	154.5	219.3	10.2
1966	91.9	147.5	239.4	13.5
1976	65.1	164.4	229.5	56.6
1986	107.3	173.2	280.5	24.8
1994	65.3	227.9	293.2	9.4
1998	55.7	178.2	233.9	2.4

FIGURE 13: CHANGE IN AREA (ACRES) OF HABITAT TYPES THROUGH TIME (1891-1998).

Source: Collins and Sheikh (2004)

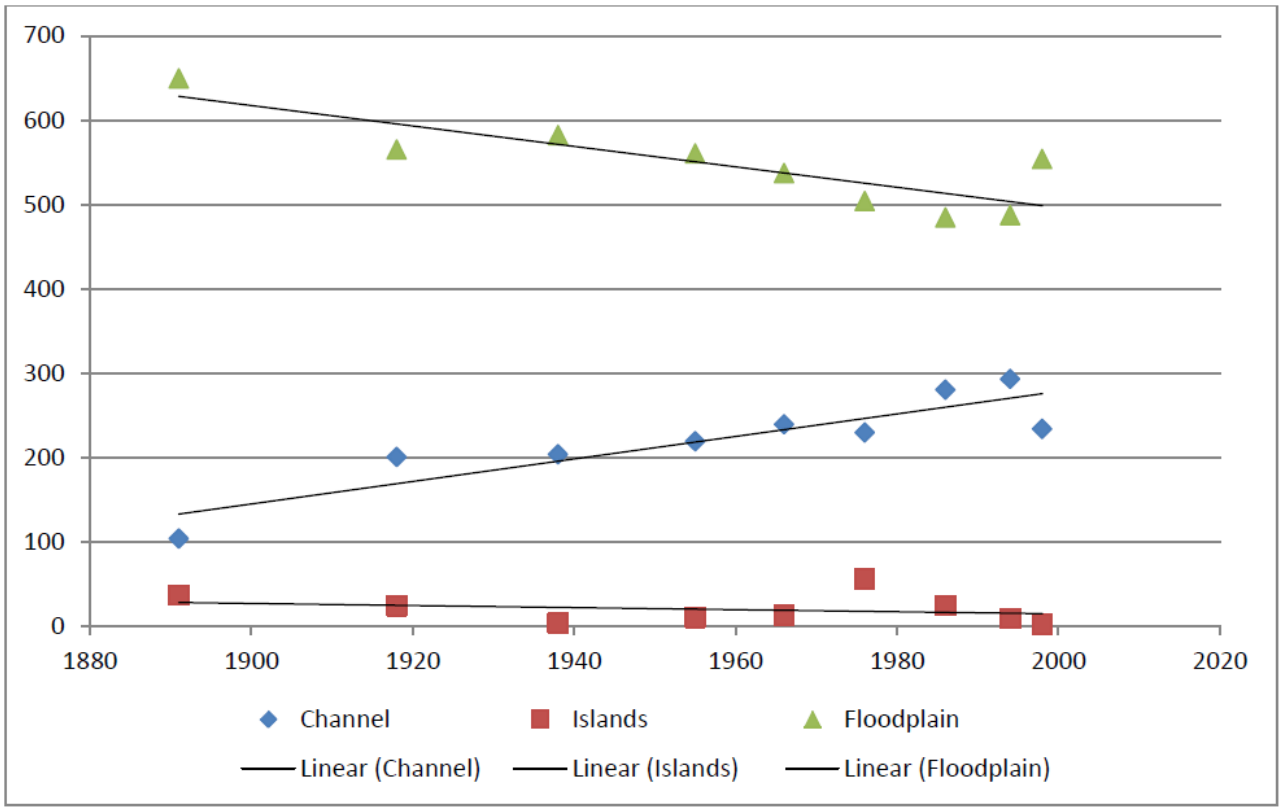


TABLE 2: TOTAL FORESTED ISLAND AREA, COUNT AND AVERAGE AREA THROUGH TIME (COLLINS AND SHEIKH 2004, NNR 2005 DATA).

Photo Year	Total Island Area (acres)	Count	Average Island Area (acres)	Maximum Single Area (acres)
1938	4.1	6	0.7	1.5
1955	10.2	6	1.7	4.8
1966	13.5	9	1.5	3.8
1976	56.6	7	8.1	26.6
1986	24.8	16	1.6	5.4
1994	9.4	7	1.3	3.0

1998	2.4	1	2.4	2.4
2005	2.1	3	0.7	0.8

Looking at the fate of forest patches that initiated as islands in the Farmhouse Reach shows the rapid growth and destruction of forest islands (Table 3). An exception is where these islands are along the margin of the channel and become incorporated into the floodplain forest. This accounts for the difference in total area between Table 2 and Table 3. The river has undergone periods where island formation has outpaced island destruction, as it did from 1938-1976, and periods where islands have been eroded faster than new islands have formed 1976-1998. The period between 1966 and 1976 is the greatest for new forest establishment in the active channel of the river. During this time, 46.3 acres of new forested island formed, with only 7 acres lost to erosion. Much of this occurred as three large islands on the margins of the active channel that were subsequently incorporated into the floodplain forest. In the twelve years between 1998 and 1986, there was only 5.2 acres of new forest formed in the Farmhouse Reach, while losing approximately 20 acres during that time.

TABLE 3: PERSISTENCE OF FLOODPLAIN FOREST PATCHES THAT INTITATE AS ISLANDS (1933-1998) (ALL VALUES IN ACRES).

Year	Total Area	Area persisting from all previous photo years							Area change since the previous photo year		
		1933	1938	1955	1966	1976	1986	1994	New Forest	Lost Forest	Persisting forest
1933	16.9	-	-	-	-	-	-	-	-	-	-
1938	5.0	4.4	-	-	-	-	-	-	0.6	12.5	4.4
1955	10.6	0.5	0.5	-	-	-	-	-	10.1	4.5	0.5
1966	18.1	0.1	0.1	4.5	-	-	-	-	13.6	6.1	4.5
1976	57.4	0.1	0.1	2.7	11.1	-	-	-	46.3	7.0	11.1
1986	43.4	0.1	0.1	0.6	7.4	27.2	-	-	16.2	30.2	27.2
1994	31.6	0	0	0	6.2	22.5	26.9	-	4.7	16.5	26.9
1998	28.2	0	0	0	6.2	22.1	24.1	27.7	0.5	3.9	27.7

The age of forested islands visible in the 1998 show that even during the period of island erosion, a small portion of the floodplain forest has been able to persist for more than 30 years. Over six acres (22%) of the 28.2 acres of forest seen in the 1998 photo dates from the 1966 aerial photo, 15.9 acres (56%) from the 1976 photo, 2 acres (7%) and 3.6 acres (12%) from the 1994 photo. This indicates the importance of protecting the existing forest patches to increase their persistence, since floodplain forest is not being formed as rapidly as it is being eroded. No patches seen in the photo record have been able to persist long enough to provide large wood recruitment to the channel.

Along with the change in forested islands, GeoEngineers (2012) also characterized the active channel changes in the Farmhouse Reach (Table 4). The average width increased considerably in the 1986 and 1994 photo years, which corresponds to the period where forest patches were being eroded faster than they were being created. This was also a period that saw three floods that exceeded the 10-year recurrence interval. This increase in width likely reflects periods of rapid channel migration in the reach, often associated with floods and sediment deposition (GeoEngineers 2012). The annual channel migration rate for the reach averaged nearly 17 meters (~55 feet) per year from 1933-2005, although this has occurred in a relatively narrow portion of the floodplain (Hyatt 2007).

TABLE 4: HISTORIC CHANNEL WIDTH IN THE FARMHOUSE REACH (GEOENGINEERS 2012).

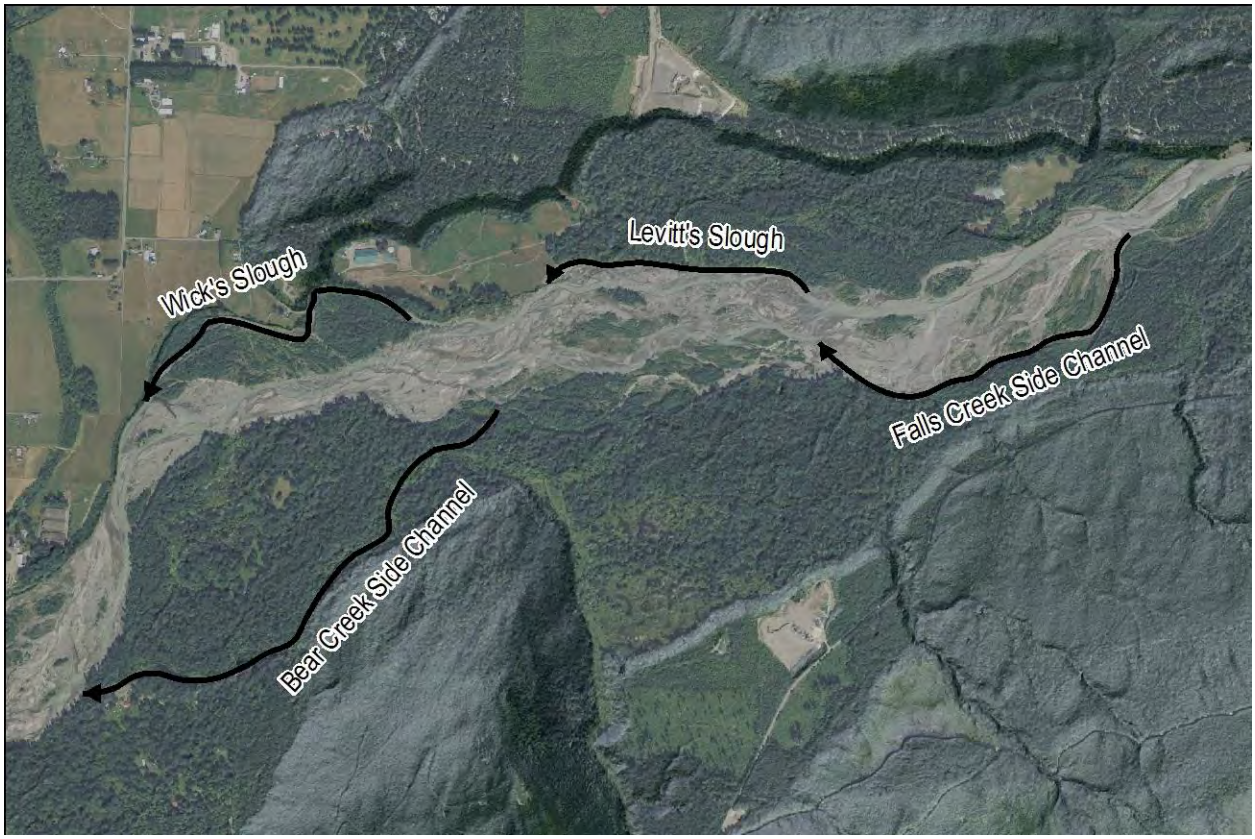
Photo Year	Active Channel Area		
	Average width (ft.)	Change in Width Relative to Historic Average (ft.)	Percent Change from Previous Record
1938	720	-120	-
1955	760	-80	6%
1976	740	-100	-3%
1986	1010	+170	36%
1994	1060	+220	5%
1998	780	-60	-26%
2005	770	-70	-1%
2010	850	+10	10%

Spawning in the reach is tied strongly the edge of the historic migration area. In places where secondary channels are present along the edge of the higher terrace, spawning by all anadromous species is prevalent (Julie Klacan, Tasha Geiger, WDFW, pers. comm. Jan 2012). Areas such as Wicks Slough, Levitt's Slough, the Falls Creek Side-channel, and Bear Creek Slough all see high levels of use by all of the anadromous species present in the reach when secondary channels are present. This may be related to the stability of these channels relative to the braided active channel area, or to groundwater and tributary discharge from the older alluvium. All of these areas lie at the foot of the terrace that borders the recent channel migration area (Figure 14). When side channels are formed with in the active channel area, away from the margins, they are less heavily used, although chum salmon still key in on the prevalent groundwater emergence areas within the braids (J. Klacan/ T. Geiger, WDFW, pers. comm. Jan 2012).

Recent spawning surveys have found little spawning use in the upper-most section of the reach that borders the two revetments along the Glen at Maple Falls, although a few steelhead redds have been seen in the reach. The Falls Creek Side Channel is heavily used by steelhead and chinook. Chinook mostly use the lower portion of the side channel because of better flow during spawning season due to the influence of Falls Creek. Steelhead, which will spawn later when flows are higher, will use the portion of the side channel upstream of the tributary. The Wick's Slough area is the most heavily used spawning area in the project reach. The side channel area can be limited by low flows, and an obstruction at the upstream end has reduced the flow into the side channel. This obstruction may be associated with a previous habitat restoration project in the reach, which should be evaluated to ensure that the side channel flow can be maintained.

Bear Creek Slough is also heavily used for spawning by all species. The upstream head of this channel has been obstructed the last several years, and only high flow accesses the channel. Downstream entrance to the channel can be difficult during low flow do to the shallow water depth over gravel bars in the channel, which the upstream obstruction likely exacerbates. When the slough has acted as a NF side channel, the mainstem has tended to be on the southern side of the of the active channel area, with side channels flowing among the forest patches at the edge of the active channel area. Encouraging more flow into these heavily used and flow dependent habitats could provide the stable spawning areas that are limiting to the North Fork Nooksack chinook population.

FIGURE 14: SIDE CHANNEL AREAS WITH HIGH LEVELS OF SPAWNING USE IN THE FARMHOUSE REACH.



RESTORATION DESIGN DEVELOPMENT

FARMHOUSE PROJECT GOALS, OBJECTIVES, AND HABITAT TARGETS

The rapid changes in channel location within the active channel area, associated loss of patches of mature floodplain vegetation, and lack of persistent accumulations of wood has led to a loss of key habitat (pools and complex edge habitat), reduced habitat diversity, and increased channel instability in the Farmhouse Reach. The general approach to restoration in the Farmhouse reach is to address limiting factors by placing log jams to catalyze a shift from the current braided planform to the anastomosing/anabranching planform historically evident. Specific goals of restoration are to: (1) slow lateral migration to allow transient river bars and incipient forest islands along the margins of the historic migration area to stabilize and immature floodplain vegetation to reach a size (50-years) where it can produce functional wood to the channel; (2) increase pool habitat throughout the reach; (3) improve low flow connectivity of existing side channels; and (4) Increase stable spawning habitat of the reach, especially in side channel areas.

Based on these restoration goals, specific project measurable objectives for the Farmhouse Reach were developed and include:

1. Increase key habitat quantity (defined as primary and backwater pools, complex edges and tail-outs), especially in side channel areas *by placing LWD structures that cause local scour and provide complex edge habitat.*
2. Improve low flow connectivity of key marginal side channel areas- Bear Creek Slough, Wicks Slough, Levitt's Slough and Falls Creek Side Channel by *separating and encouraging flow toward marginal channel areas*.
3. Narrow the active channel area *by encouraging vegetation establishment and succession on existing exposed gravel bars*.
4. Increase longevity of forest islands for riparian habitat *by increasing the bank resistance along existing and emerging forest islands*.

These specific habitat objectives were used to evaluate the expected benefit of different restoration alternatives. While these objectives do not necessarily reflect restored habitat conditions, they provides a metric for evaluating the different alternatives. Once a preferred restoration alternative was selected, a project concept was developed for the reach. The concept was then evaluated and refined using a two-dimensional hydraulic model and the expected channel response assessed. For evaluating the project alternatives, the following targets were used:

1. 30 pools in the reach, including mainstem and side channel, but with an emphasis on side channels where more stable spawning habitat exists.
2. 11,000 feet of low flow side channel, which represents having the majority of the length of three of the four target areas connected.
3. Less than 200 acres of high flow channel area, which represents the equivalent of the 1918 active channel area outside of the forest areas.
4. Conifer dominated patches within the forest islands and a mosaic of forest stands across the floodplain.

Restoration Alternatives

General restoration alternatives were developed based on differing degrees of passive and active restoration in the reach. All alternatives included placement of engineered log jams as the main component of restoration. In the Nooksack Watershed, we have experimented with a wide variety of lower-cost, non-engineered log jam designs over the last 14 years, including the USFS 4-mile Flats, LNR Nessets, NSEA NF Nooksack Channel Island LWD Augmentation, and NSEA Middle Fork LWD Placement and Middle Fork Porter Reach projects. Effectiveness monitoring of these projects in the North and Middle Forks (i.e. in similar channels with similar project objectives to the Farmhouse project) in 2013 showed that, of 99 non-engineered structures, 25 showed signs of structural failure (including 12 severely damaged within 5 years of construction), 11 formed pools, 17 provided wood cover, and 1 was associated with a low-flow channel split. Based on these and similar results from the South Fork, we have recommended that restoration in the Nooksack River Forks incorporate engineering into designs and implement methods with higher likelihood of success at maintaining structure stability and reaching habitat targets (Maudlin and Coe 2012).

The three restoration alternatives developed for the Farmhouse Reach were: (1) constructing fewer (66) engineered logjams around small island patches and allow these to coalesce into target islands and allow side channel habitat to develop through local wood recruitment, (2) construction of more frequent (149) engineered logjams to protected larger island patches and allow these to coalesce into target islands and provide habitat structures in the expected side channel areas, and (3) construction of more frequent (159) engineered logjams to immediately reach target island size, and provide habitat structures in the expected side channel areas. These approaches were evaluated, along with a no action alternative, to determine how well they would meet our habitat objectives for the reach.

Approach 1: Small forest islands

The small forest island approach relies on limited active near-term restoration and the longer-term expectation that natural habitat-forming processes will allow the project to meet our habitat targets for the reach. The approach focuses on the establishment of small islands that lie between the expected side channel and mainstem channel locations (Figure 15). It is expected that these small islands will provide the nucleus for larger islands to form around and eventually reach the target area of forested island/ active channel area during periods of vegetation encroachment. The small persistent patches immediately associated with the structures should eventually become conifer dominated, with a varying amount of deciduous and mixed conifer forest surrounding the patches. While the reach has undergone periods of floodplain development, island patch size has generally been small likely requiring a long time before isolated patches coalesce and significantly narrow the active channel area (Table 2). The small patches associated with the structures should form flow splits and create side channels when the mainstem channel is adjacent to the head of the patch. Because the patches are generally small, with many opportunities for the channels to divide and rejoin, it is unlikely that long side channel areas (such as the target areas) will persist in the reach. Meeting side channel habitat targets will require local wood recruitment from the forested floodplain to scour pools and provide cover. Since side channels migrate and widen more slowly than the mainstem active channel area, it is expected that the wood recruitment rate will be fairly slow and require a long time to meet the target pool levels. Riparian conditions along the margins of the channel are also generally

immature, so the size and nature of the wood recruited to the channel will likely be less stable and less likely to form pools (Figure 12). The 66 structures should increase the pool count in the mainstem channel area.

Approach 2: Construct medium-sized island patches and improve side channel habitat

This approach calls for providing larger forested island patches that will be expected to coalesce into larger islands that will reduce the active channel area through the reach and also provides structures in side channel areas to create habitat in the near-term while the riparian conditions recover (Figure 16). Since the area of the channel that is isolated from erosion by the structures is larger, it is expected that the project will be more effective at narrowing the active channel area. The project still relies on islands to grow around the stabilized patches to reach the target, but the size and density of the patches should allow this to happen over time. The frequent openings between the patches will likely mean that the vegetation outside of the patch area remains as younger deciduous forest as the river migrates between the stabilized islands. Because the patches are larger than the patches in Approach 1, this approach limits the number of side channel connections and lengthens each of the potential side-channels compared to the small island restoration approach. The approach will lead still lead to more pathways left open for side channels could lead to shorter, more frequent side channels than the large island approach described below. The project includes placement of structures in the target side channel areas, which should allow the project to quickly meet the goal of 30 pools in the reach. The 149 structures should also improve the pool counts in the mainstem channel area.

Approach 3: Construct large island patches and improve side channel habitat.

This approach (Figure 17) was informed by our understanding of historic conditions in the North Fork Nooksack River, and the Farmhouse Reach in particular. The target island patch size, side channel length and active channel area are all based on historic values for the reach and allow for the channel to respond to changes in flow, wood and sediment through time. The large islands isolated from the river by the structures should lead to a substantial increase in the area of conifer-dominated forest in the floodplain and active channel area. It is possible that these areas could grow modestly and coalesce together, which may inhibit side channel development. Since the forested patch size is much larger in Approach 3, there are fewer potential points of connection between the side channels and mainstem channel. The approach should lead to longer, higher quality side channels when they are connected to mainstem, but limits the opportunities for connection. The narrower active channel area should force more interaction between the mainstem channel and the side channel areas. The project includes placement of structures in the target side channel areas, which should allow the project to quickly meet the goal of 30 pools in the reach. The 159 structures should also improve the pool counts in the mainstem channel area.

Approach 4: No Action.

The No Action approach relies entirely on natural recovery in the watershed to meet our reach-scale habitat targets. Since the current forest island area is relatively low when compared to the historic mean, it is expected that the reach will see periods of significant island development and vegetation encroachment in the future. These changes will likely lead to an improvement in habitat conditions in the reach. It is expected that the active channel area will narrow, side channel length will increase, and pool count will increase, although none of these would likely meet our habitat targets. Based on the historic persistence of forest patches in Table 3, it is not expected that conifer-dominated patches will persist.

FIGURE 15: SMALL FOREST ISLAND ALTERNATIVE.

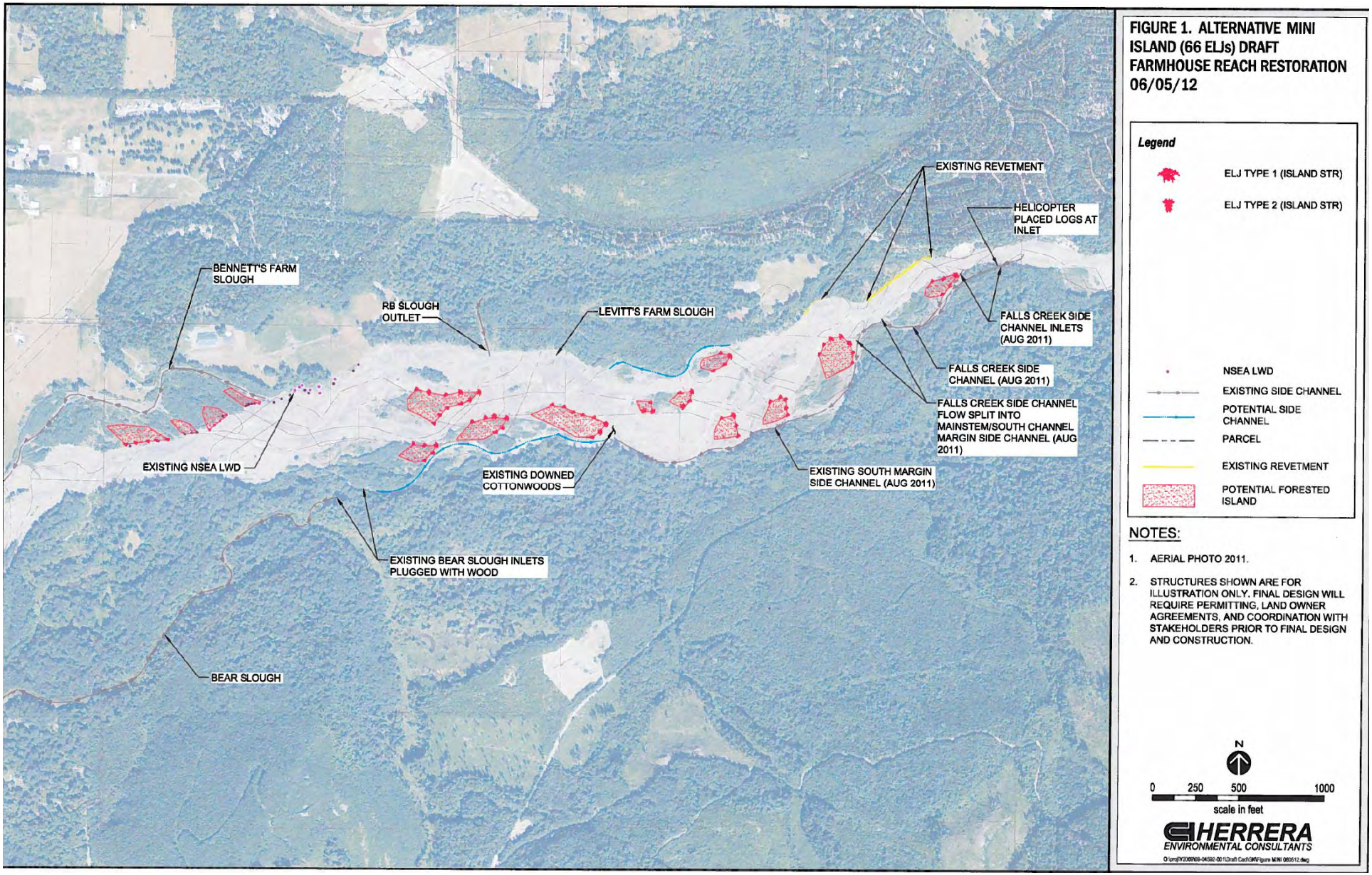


FIGURE 16: MEDIUM-SIZED ISLAND ALTERNATIVE.

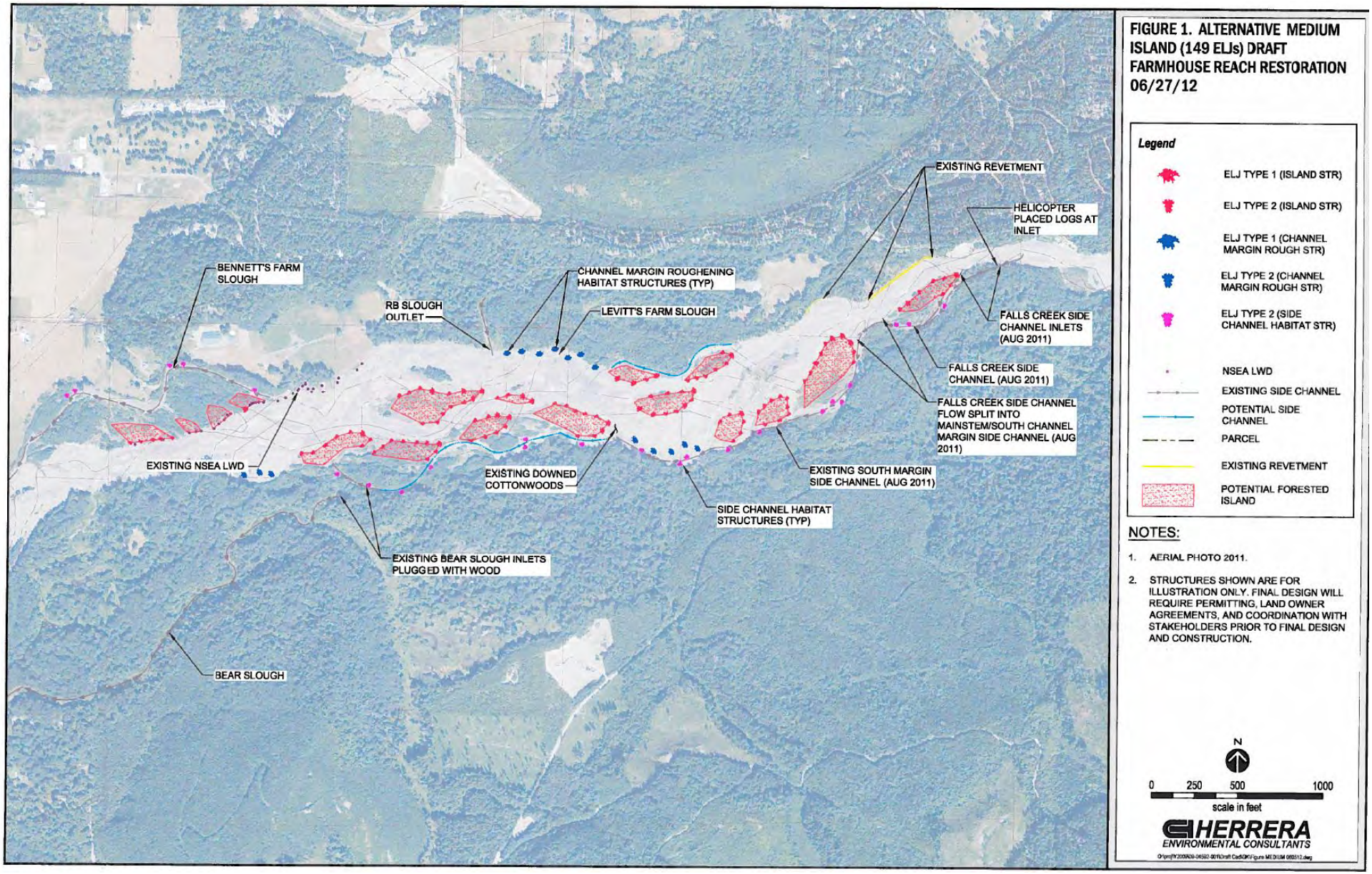
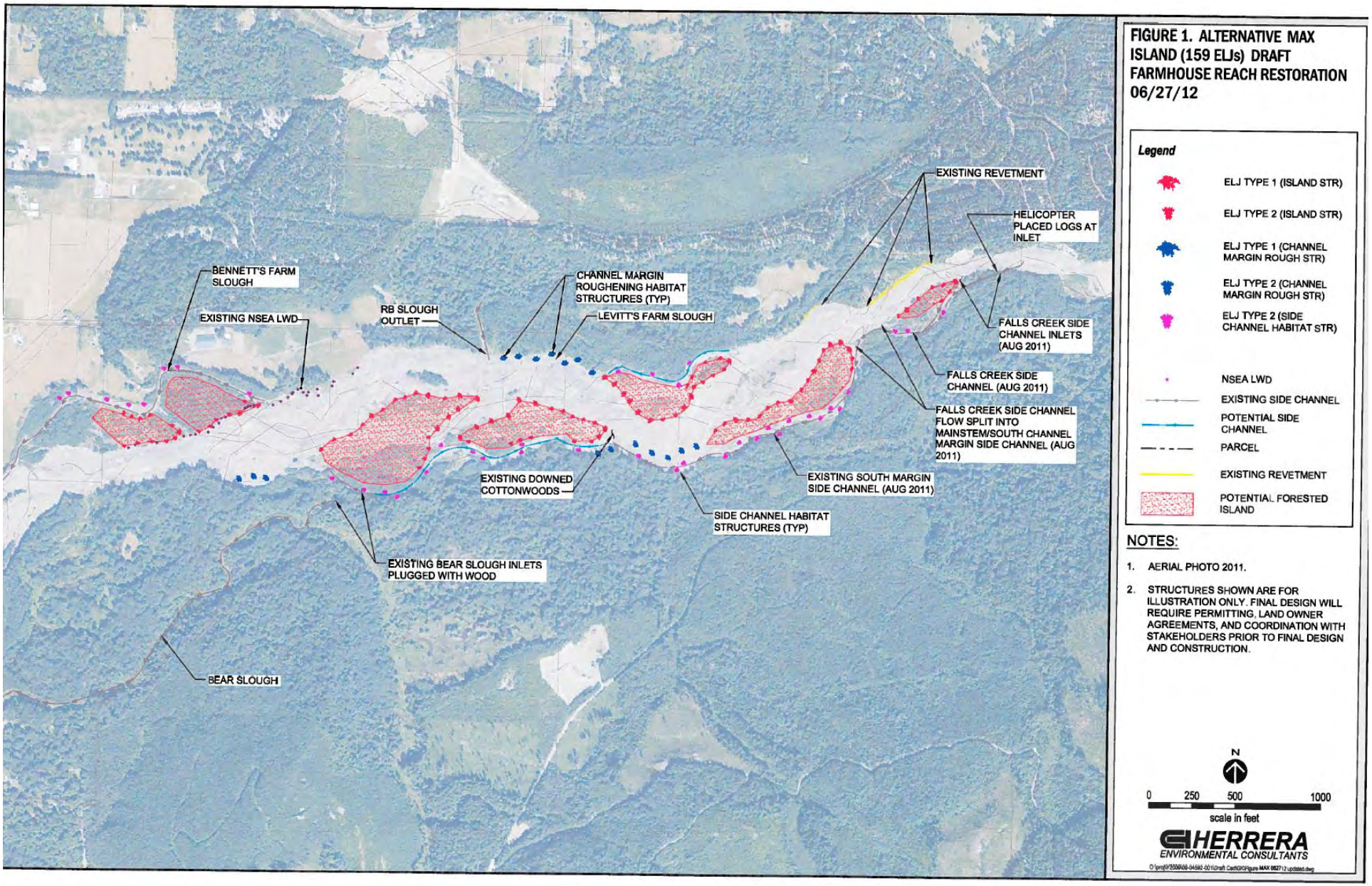


FIGURE 17: LARGE ISLAND ALTERNATIVE.



Alternatives Analysis

The project concepts have been evaluated according to their ability to address the habitat objectives in the reach. These objectives tie back to the major limiting factors affecting spring Chinook in the reach: lack of channel stability during the incubation period, and lack of key habitat in the channel. The relative degree of impact will be summarized from the descriptions above.

TABLE 5 displays the relative degree of impact: "++" indicates approach is expected to meet habitat objective; "+" indicates approach is expected to improve condition, but likely will not lead to meeting target; and "0" indicates approach likely has no effect.

Based on the relative evaluation, Approach 3 appears to have the greatest potential for meeting our habitat objectives. Any potential for increased risk of flooding and bank erosion with this approach will need to be evaluated during the design, hydraulic modeling and geomorphic assessment of the project.

TABLE 5: RELATIVE IMPACTS OF RESTORATION ALTERNATIVES ON HABITAT OBJECTIVES.

Restoration Approach	Near-term Change Relative to Current Conditions			
	Increase in Count of Pools	Increase Perennial Side-channel Length and Persistence	Increase Forest Islands and Conifer-dominated Patches	Narrow Active Channel Area
1: Small Island	+	+	+	+
2:Medium Island	++	+	+	++
3: Large Island	++	++	++	++
4: No Action	+	+	0	+

Preferred Alternative

Based on the expected near-term benefit, the Large Island approach (Figure 17) was selected for further refinement. It is expected that all of the alternatives could reach the same desired future conditions, but there was a greater lag time and greater uncertainty for the small and medium island alternatives.

The preferred concept was first assessed using a hydraulic model to determine whether there were any unanticipated flood or erosion hazards. The initial modeling found an increase in velocity along the riprap that protects the Glen at Maple Falls property that could increase the likelihood of bank erosion on the property, a slowing of velocity in the Bear Slough island area that could lead to sediment deposition and disconnection of the side channel, increased water depth on the Bennett Farm property and a general pushing of flow from the south to the north of the active channel area. Based on this modeling, the June 2012 conceptual design was refined in December 2012 to address these potential issues (Figure 18):

- Logjams were added in front of the riprap levee to slow velocity
- Logjams on the islands south of the active channel area were moved south to reduce the pushing of flow to the north

- Widened the spacing on the logjams protecting the islands upstream of Bear Slough to allow more flow into the side channel areas.
- Added logjams on the north bank downstream of Leavitt's Slough to slow velocity along the bank and not increase flow through a floodplain swale on the Bennett Farm property.

The December 2012 concept was remodeled with the changes and the results evaluated. The results showed that the revision had improved the issues identified in the original modeling results, but that the risks were still present at those locations. Several design iterations were developed and modeled to address these risks. The preliminary reach-scale design was finalized in March 2013 (Figure 19) and included the following refinements to the December 2012 version:

- Side channel structure placements were adjusted to avoid plugging Bear Creek Slough.
- Logjams were adjusted around Wicks Slough inlet to improve connectivity and to reduce flooding effects at God's Eagle Habitat.
- Added logjams on the north bank downstream of Leavitt's Slough to continue to slow velocity and not increase flood levels at Bennett Farm.

Expected hydraulic response (change in 100-year flow depth, change in 100-year flow velocity with proposed restoration) to the March 2013 design are shown in Figure 20 and Figure 21.

Since the project reach is long (2.6 miles) with a wide active channel area, the project is designed to be implemented in several phases. This will also allow for adaptive management of subsequent phases depending on the channel response to the earlier phases. Since project implementation will be phased, the project team identified priorities for restoration and project constraints to guide the phasing. Project priorities are:

1. Improve low flow connectivity and habitat diversity in the Falls Creek side channel area and create forested island separating side channel from the main channel and narrow active channel width.
2. Improve low flow connectivity and habitat diversity in the Wicks Slough side channel area and protect the forest island separating the side channel from the mainstem and narrow active channel width.
3. Improve low flow connectivity and habitat diversity in the Bear Slough island area. Encourage flow toward the inlet of Bear Slough. Protect and encourage coalescing of forest islands to narrow active channel width.
4. Create separation from the mainstem and increase habitat diversity for Leavitt's Slough. Encourage narrowing of active channel area.
5. Increase mainstem habitat diversity and key habitat quantity.

The project reach also has constraints that may affect the phasing of the project, or make a phase contingent on the previous construction in another section of the reach. These include no increase in flooding and no increase in channel velocity along on adjacent private property owned by the Glen at Maple Falls and by the Bennett Farm. From the priorities and constraints a phasing approach was developed for the project reach (Figure 22).

FIGURE 18: FARMHOUSE PREFERRED ALTERNATIVE: DECEMBER 12, 2012, REVISION

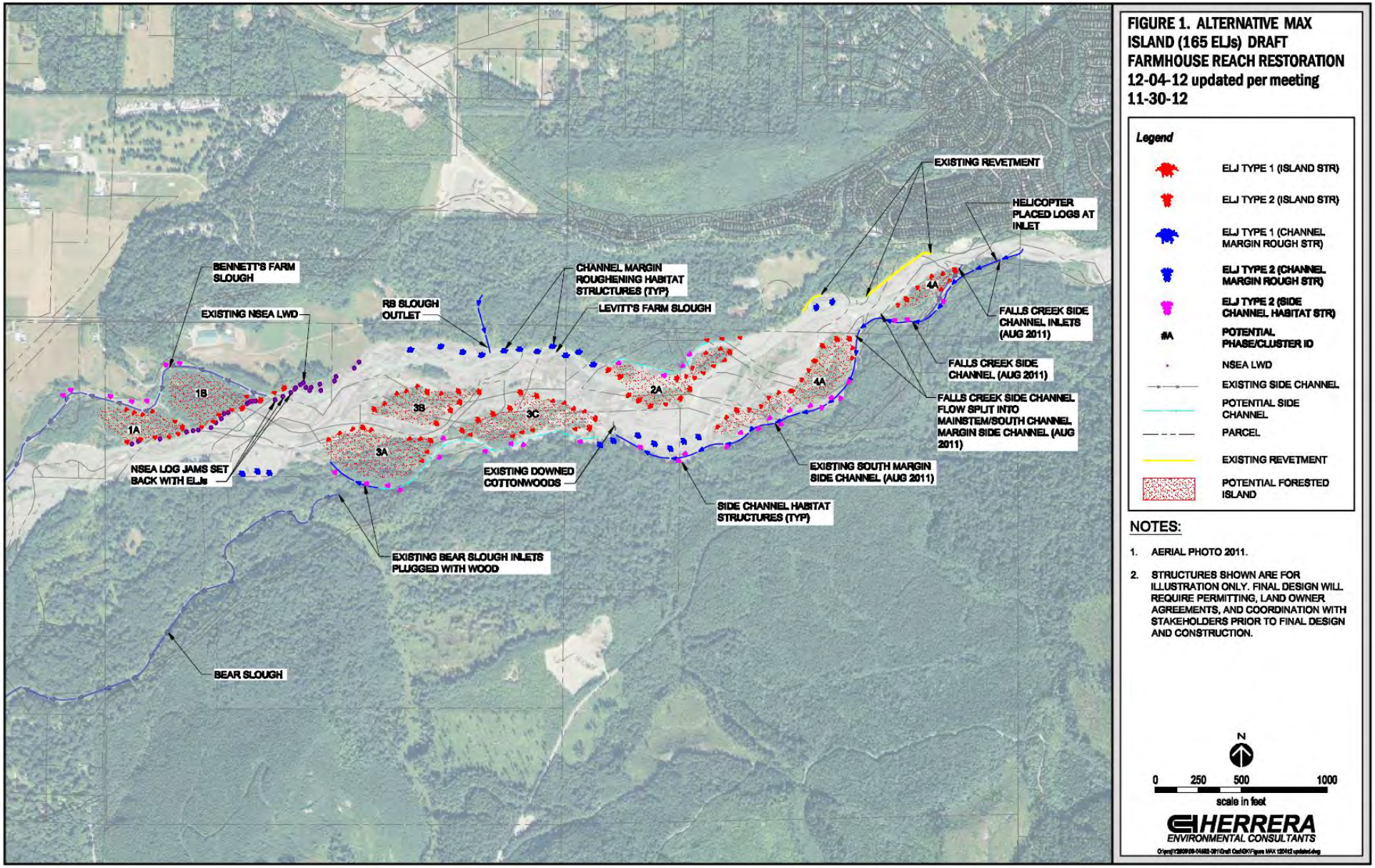


FIGURE 19: FARMHOUSE PREFERRED ALTERNATIVE: MARCH 8, 2013, REVISION.

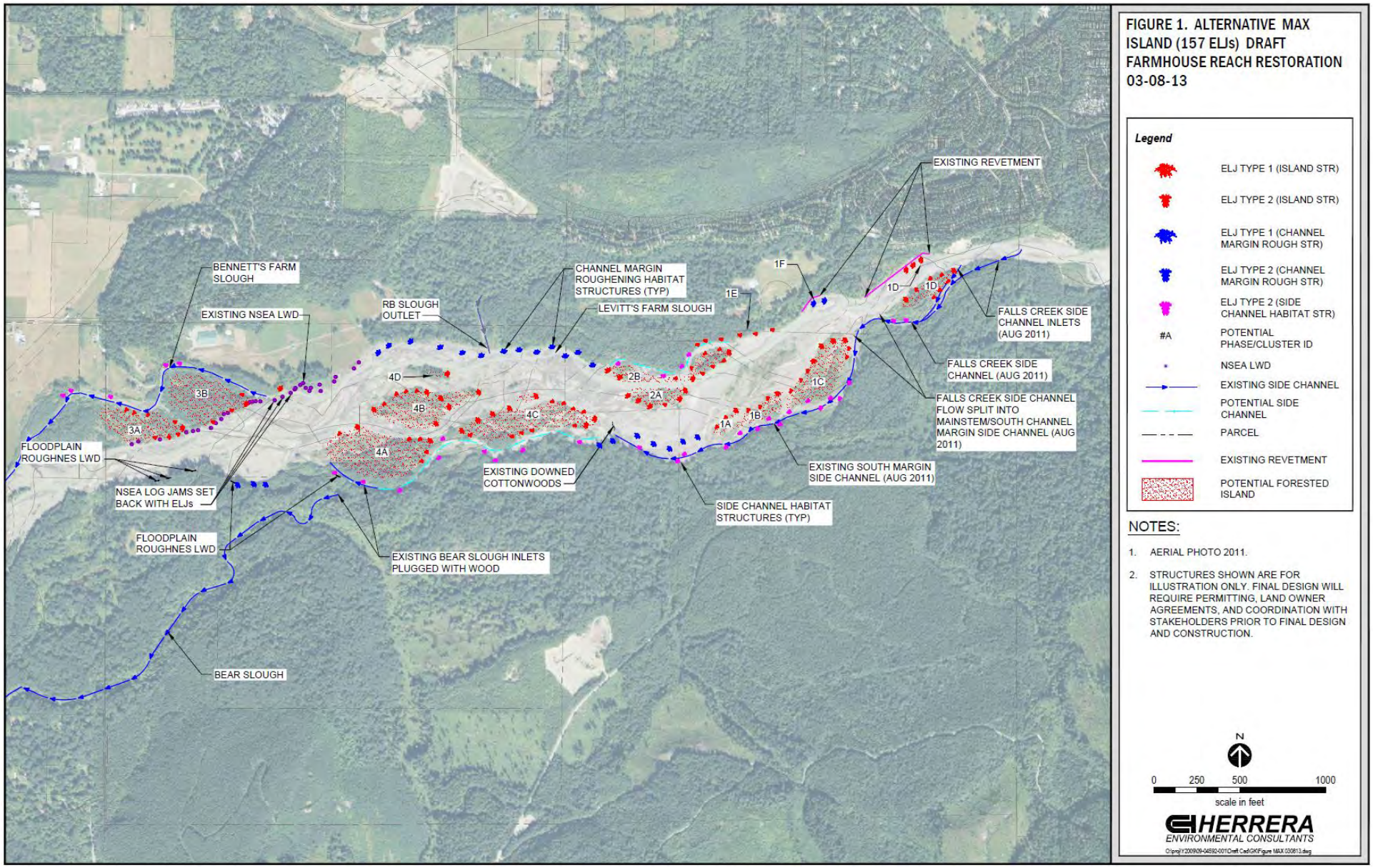


FIGURE 20: CHANGE IN 100-YEAR FLOW DEPTH: PRELIMINARY REACH-SCALE DESIGN.

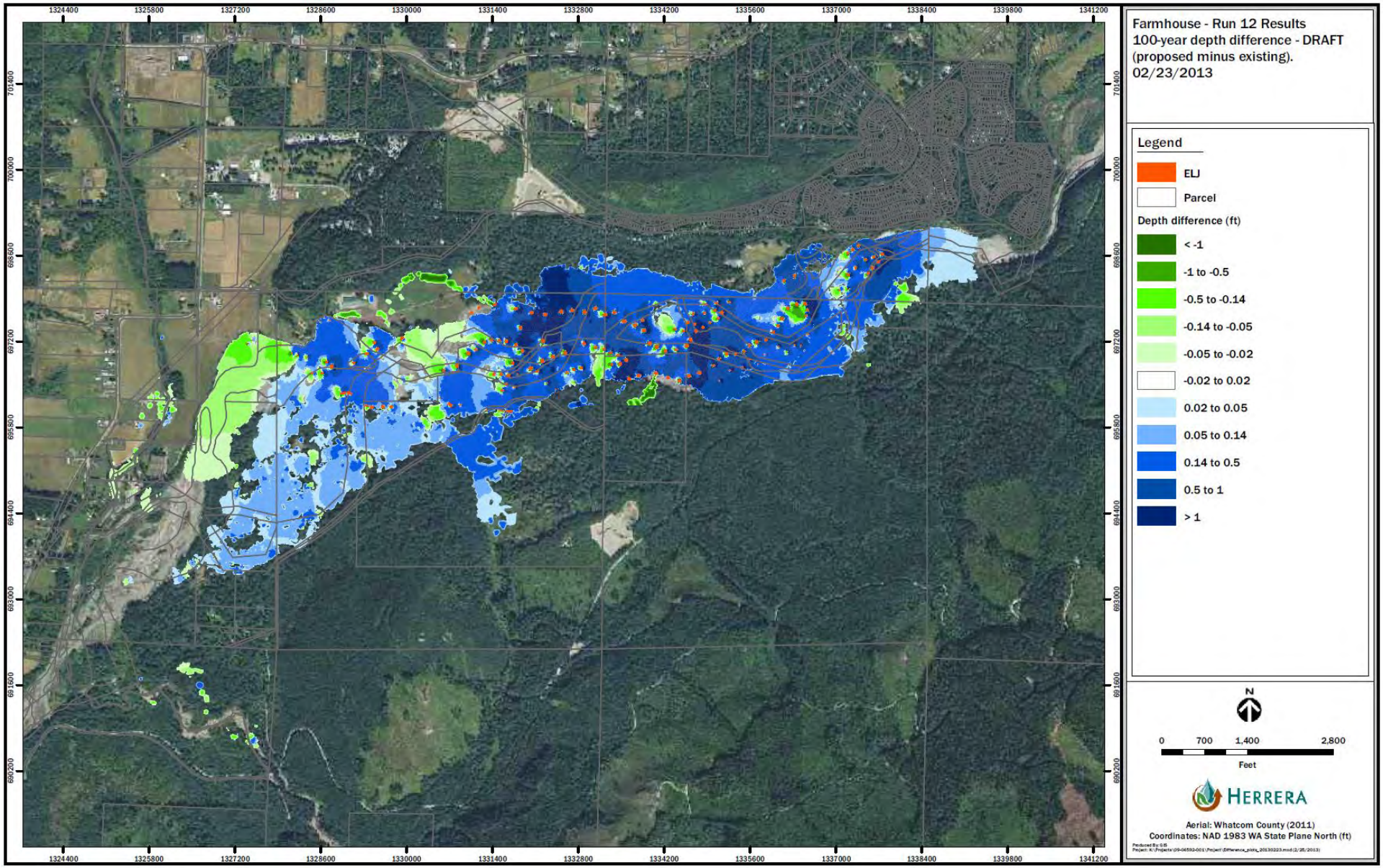
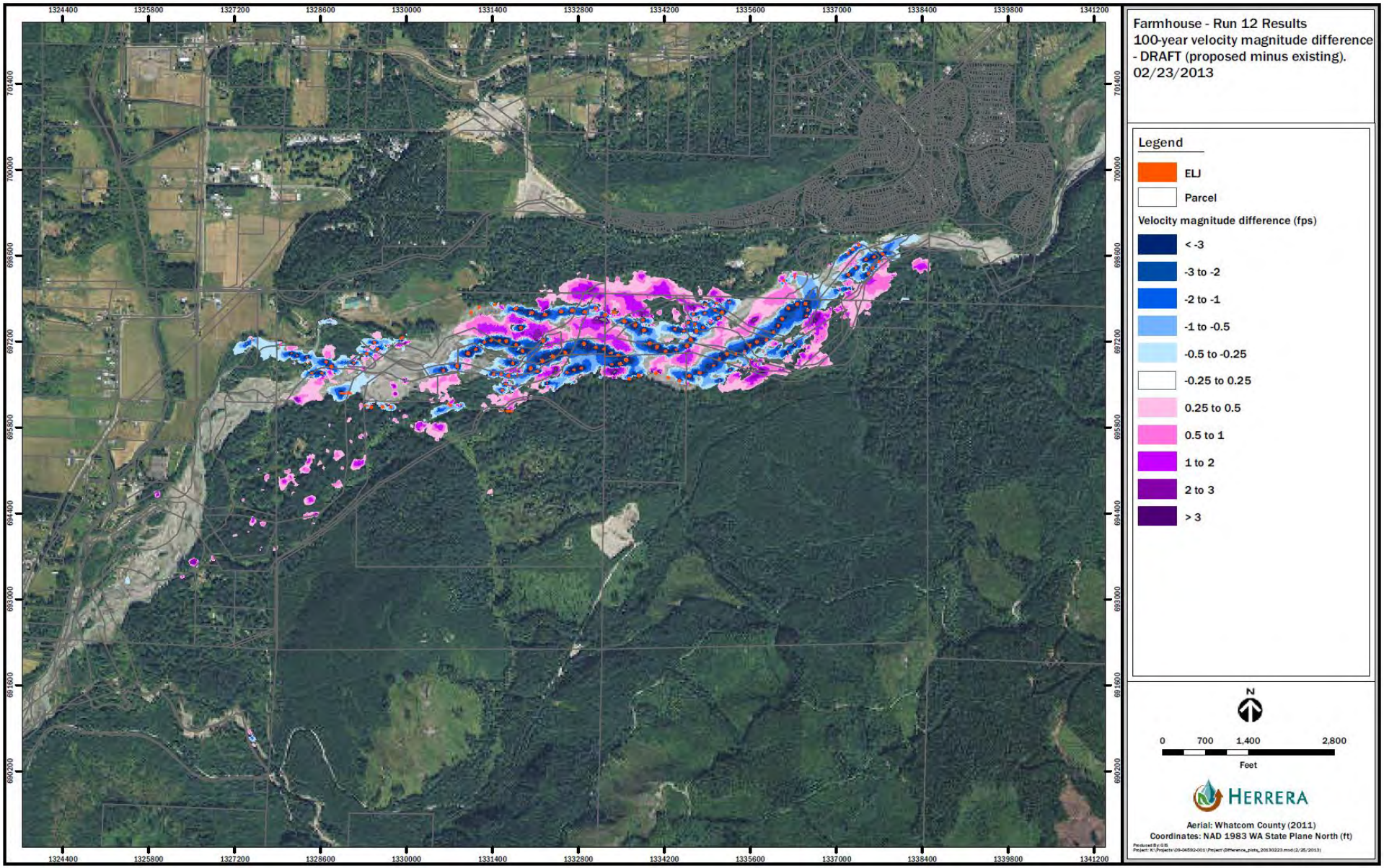


FIGURE 21: CHANGE IN 100-YEAR FLOW VELOCITY: PRELIMINARY REACH-SCALE DESIGN.



Phase 1 Design

Phase 1 focuses on the highest priority side channel area: Falls Creek side channel. Due to concern that constructing the logjams across the river from the Glen would encourage flow toward their property, structures that were originally part of the Leavitt Slough island area (north side of the channel) were included as part of Phase 1.

The Phase 1 component of the reach-scale design (Figure 19) was assessed and refined with hydraulic modeling. The design continued to show increased flow along the Glen property downstream of the lower bank armoring. Additional structures were placed along the bank at this location to reduce the flow along the northern bank. Hydraulic modeling of the May 2013 design revision (Figure 23) showed that all of the issues identified in the previous modeling efforts had been resolved (Figure 24, Figure 25). This updated Phase 1 60% design was evaluated for potential unanticipated geomorphic impacts (GeoEngineers 2012). It was determined that the project would likely meet its habitat objectives without causing negative impacts, such as bank erosion or flooding, to adjacent property owners.

A Salmon Recovery Funding Board proposal (#13-1276) was developed based on the Phase 1 60% design (44 structures). As the budget was updated during preparation of the final grant proposal based on more current cost estimates, the scope was scaled back to 38 structures to fit the available funding (Figure 26). Phase 1 designs and hydraulic modeling were finalized in May 2014 (Herrera 2014a, 2014b), and final products address input (described below) from landowners, stakeholders and permitting agencies.

FIGURE 22: FARMHOUSE REACH 60% DESIGN AND CONSTRUCTION PHASING (MAY 2013).

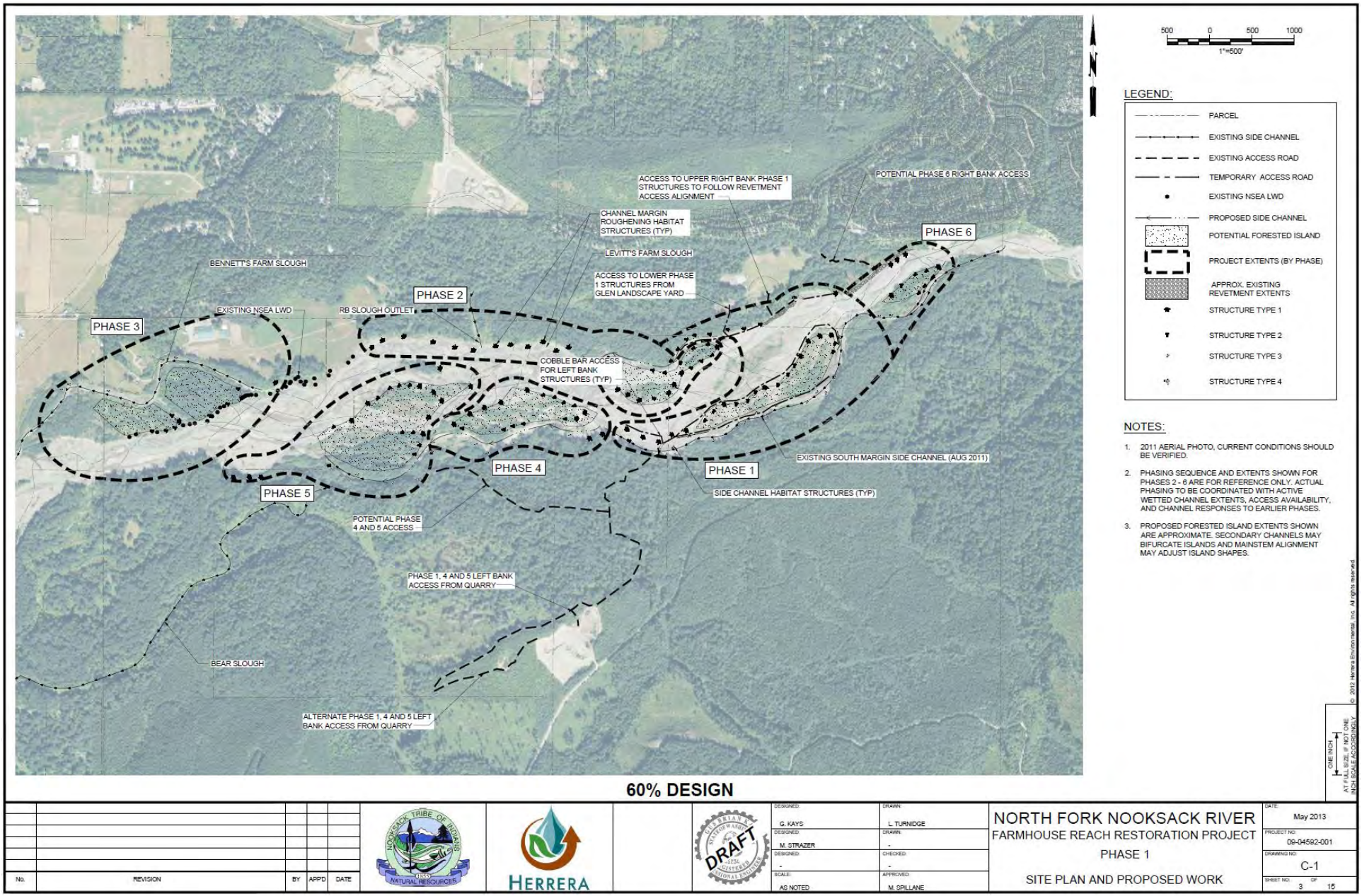


FIGURE 23: PHASE 1 60% DESIGN SITE PLAN.

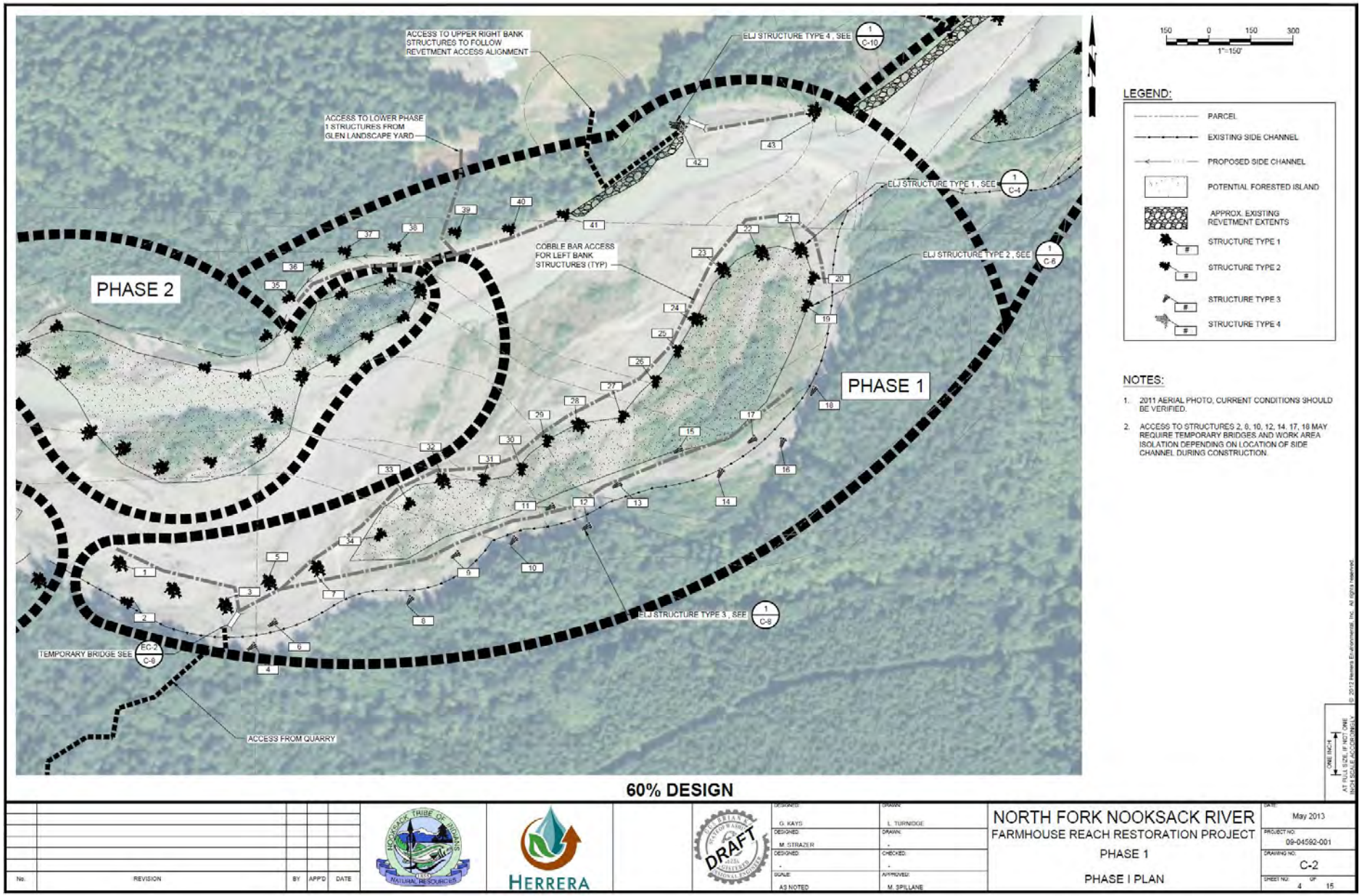


FIGURE 24: CHANGE IN 100-YEAR FLOW DEPTH: PHASE 1 60% DESIGN.

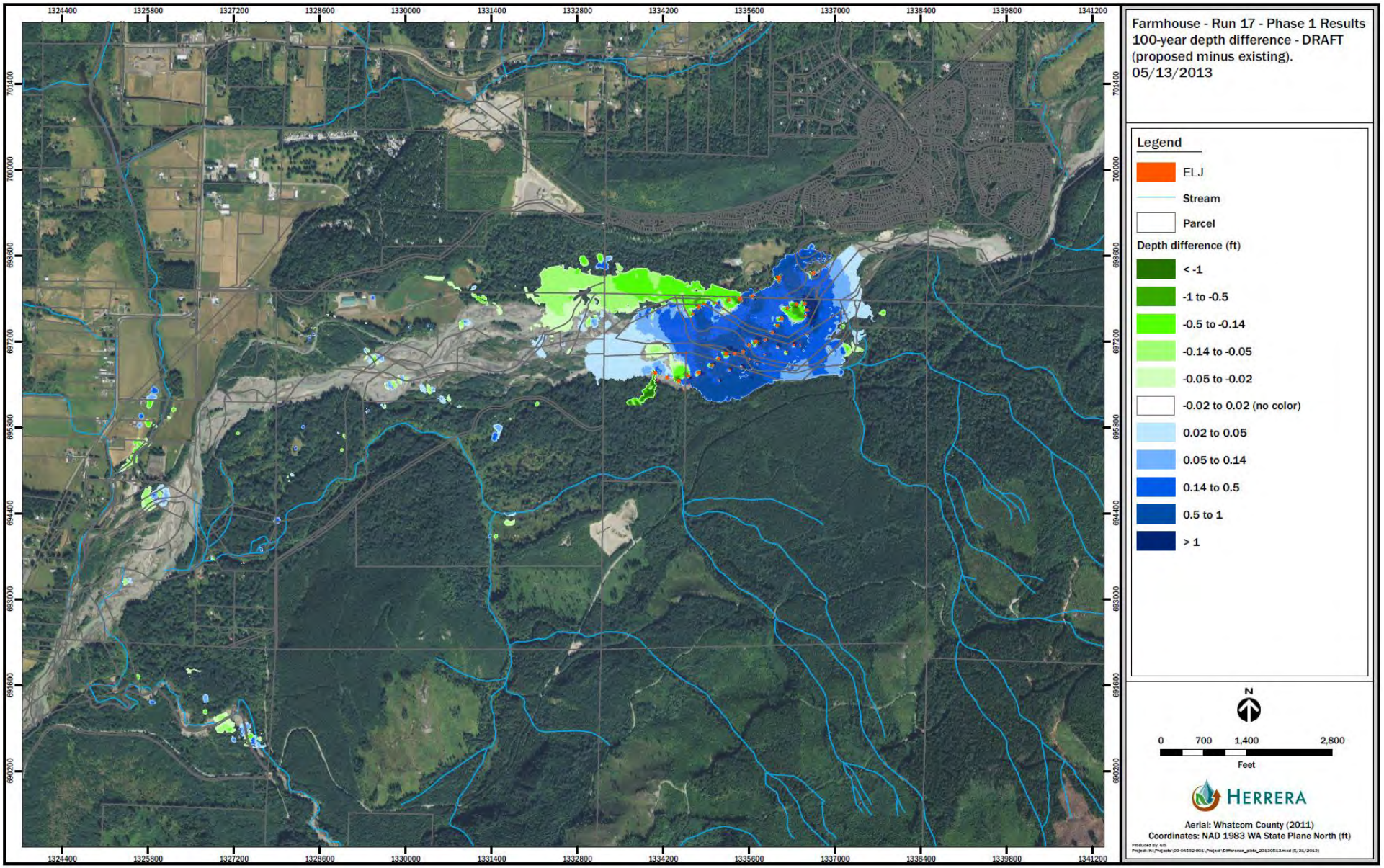


FIGURE 25: CHANGE IN 100-YEAR FLOW VELOCITY: PHASE 1 60% DESIGN.

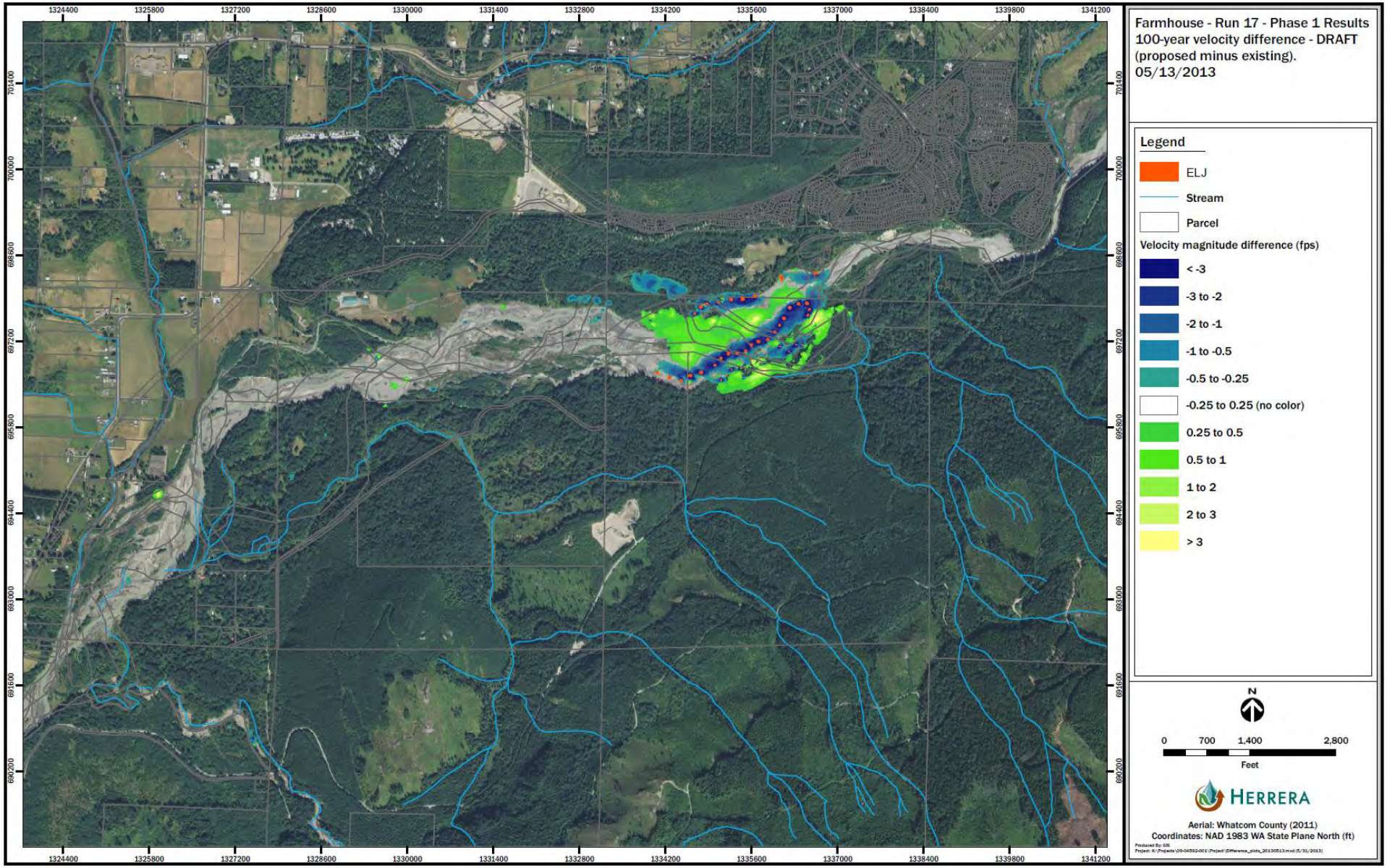
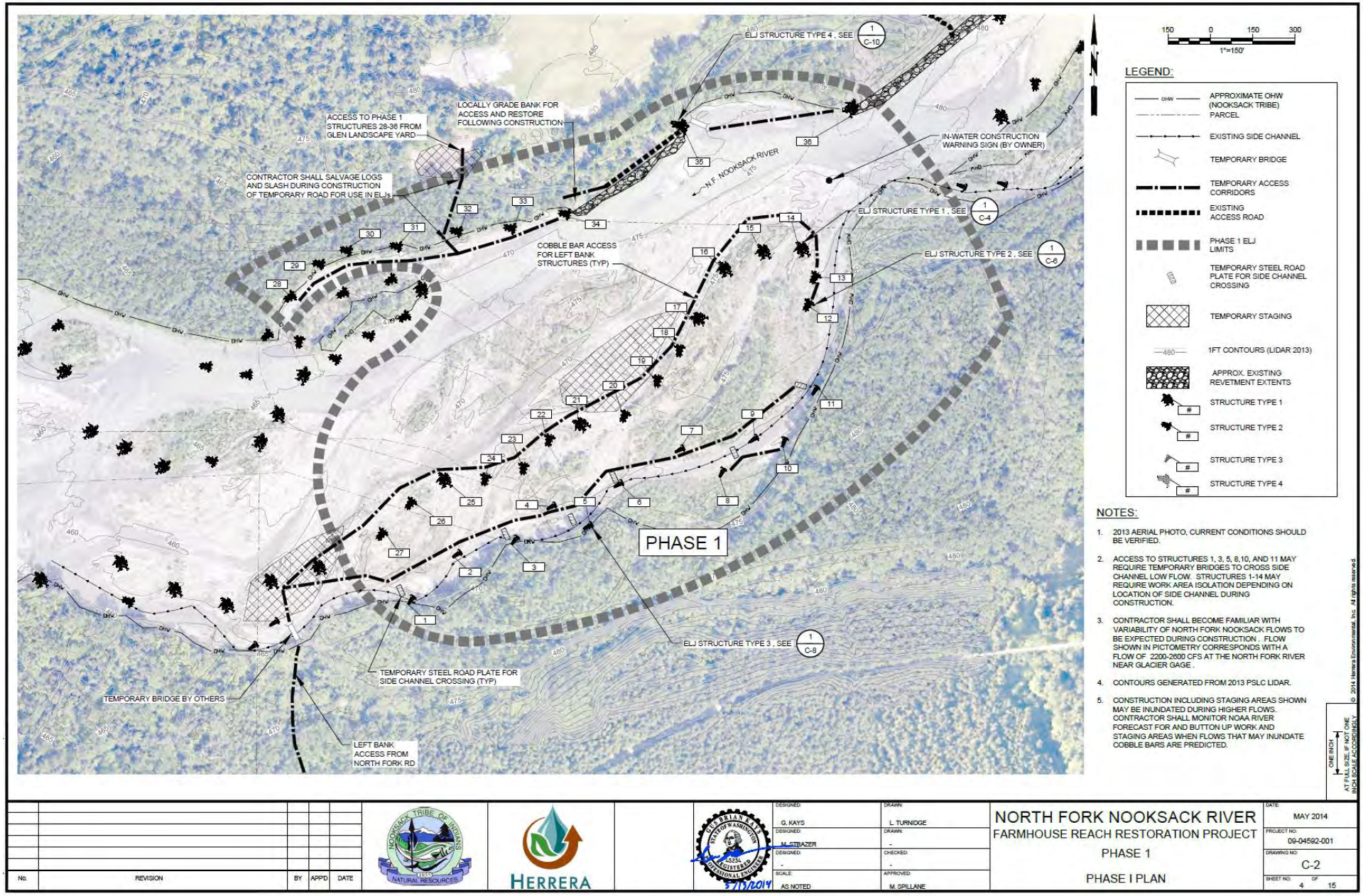


FIGURE 26: PHASE 1 FINAL DESIGN SITE PLAN.



STAKEHOLDER OUTREACH

LANDOWNERS

The Farmhouse Reach is comprised of 8 main stakeholders, including both public and private landowners, on both sides of the NF Nooksack River (Figure 27). A majority of the landownership along the left bank consists of Washington State Department of Natural Resources (DNR) parcels, including both State lands (upland) and Aquatic lands. A large parcel surrounded by the DNR land is owned by the Washington State Forest Board but is managed by DNR. Land ownership along the right bank consists almost entirely of private stakeholders with the exception of DNR Aquatic lands. The Glen at Maple Falls Community Association (The Glen) is the primary right bank landowner in the upper portion of the Farmhouse Reach, and Roger McMunn/Kalypso Farms is the primary right bank landowner in the lower portion. Stakeholder outreach is summarized by landowner below:

- **DNR State Lands (includes WA State Forest Board parcel**). The Tribe began landowner outreach with DNR State lands staff regarding access to the left-bank side of the NF Nooksack River for Farmhouse Phase 1 in May, 2013. The DNR and their staff have been supportive of the Tribe's restoration efforts, although no permitting flexibility was afforded to the Tribe. The Tribe was subject to the same access and permitting requirements as other users, including avoidance of marbled murrelet impacts and payment for cut trees and hauling. In addition, concern was expressed about liability. A final Road Use Permit agreement between the Tribe and DNR required a limited waiver of sovereign immunity; it was finalized on June 24th, 2014 with a termination date of July 1st, 2015. Please see also ***Permitting*** section below.
- **DNR Aquatic Lands.** The Tribe began landowner outreach with DNR Aquatics staff for the Farmhouse Phase 1 project in May 2013. The DNR Aquatics Department has been supportive of the Farmhouse Project, provided the Tribe supply DNR staff with the required documentation such as the Public Safety Checklist. DNR Aquatics staff also visited the Farmhouse Reach with Tribal staff on March 26th, 2014 to discuss Phase 1 design, construction, and any concerns DNR may have with the project proposal. Concerns focus on public safety and liability, given the scale and complexity of the reach-scale project. A final Right of Entry Agreement between the Tribe and DNR Aquatic lands included a limited waiver of tribal sovereign immunity; it was finalized in June 2014 for a term beginning July 1st, 2014 until June 30th, 2019. DNR Aquatics has also provided signed Landowner Acknowledgement forms for both the Farmhouse Reach Restoration and Farmhouse Phase 3 Design. Please see also ***Permitting*** section below.
- **The Glen at Maple Falls Community Association.** The Glen is a private recreational residential development. The Glen has a full-time Manager who serves as the contact and a 9-member Board of Directors that has final decision-making authority. Tribal staff initiated outreach to the Glen's previous manager, Art Cates, in May 2013 , with phone calls, emails and a site visit on May 23rd, 2013, to discuss the Farmhouse Phase 1 project. Tribal staff, along with Herrera Environmental engineer Gus Kays, presented the Farmhouse Project to the Board of Directors on two separate occasions: June 8th, 2013 and November 9th, 2013. The Glen Board and Manager are generally supportive of the Farmhouse Reach project. Their key concerns are erosion along their two revetments, large vehicle traffic during construction and damages to the road by trucks and equipment near the staging area, and affects on recreational use of the property during construction. The Tribe was able to address The Glen's concerns by requesting an extended WDFW fish-window to allow construction to occur on their property after Labor Day; the Tribe also agreed to pay in advance for repair of damage along a specified portion of the access road. The Landowner Agreement for the Farmhouse Phase 1 construction was signed on April 28th, 2014. A Landowner Acknowledgement form was signed by The Glen for the NF Nooksack Farmhouse Reach Restoration project as well on July 28th, 2014. Although The Glen has been generally supportive of our project, they are eager for Phase 2 to be completed in 2015 to limit impacts to their residents.
- **Roger McMunn (Kalypso Bay Farm/Kate Shadow).** Formerly owned and operated as Bennett Woodland Farms, the parcel now owned by Roger McMunn is operated by Kate Shadow as Kalypso Bay Farm, an equine stable and breeding center for gypsy vanner horses. The Tribe met with Kate Shadow of Kalypso Bay Farm first

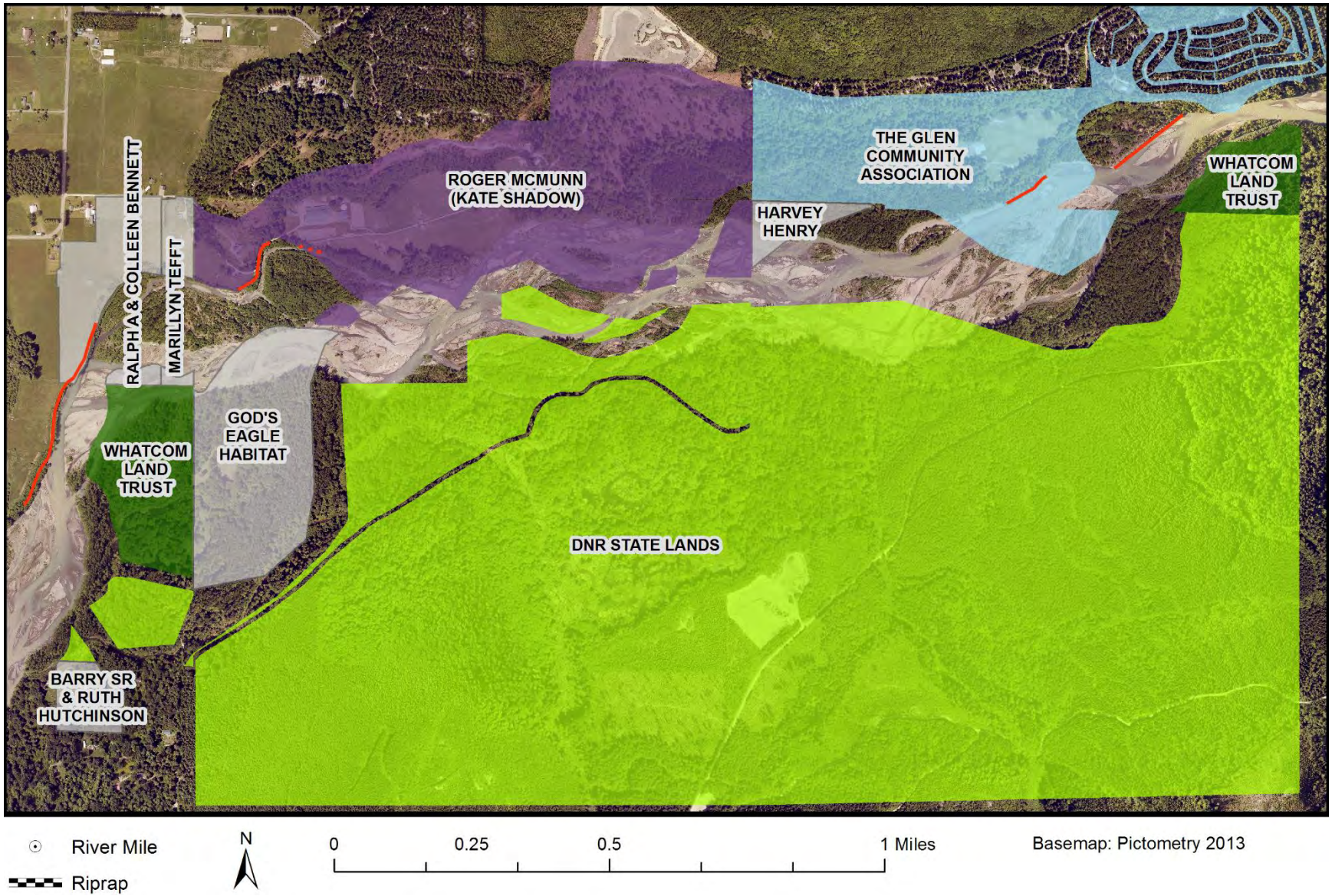
on March 4th, 2013 and again on July 22nd, 2014 to introduce and discuss the Farmhouse Reach project. Kate indicated that Roger McMunn is a silent partner who lives in Costa Rica and that she has full authority on all property matters. Kate expressed support for the Farmhouse Reach project, including allowing access for construction. A Landowner Acknowledgement was signed by Kate Shadow on July 22nd, 2014, for the NF Nooksack Farmhouse Reach Restoration project.

- **Whatcom Land Trust.** The Whatcom Land Trust (WLT) owns two parcels in the Reach for habitat conservation and restoration purposes: one at the upstream reaches of the project area and another at the downstream end along the left bank. WLT is generally very supportive of our restoration efforts and have been very cooperative with our past projects regarding access, flooding and channel migrations on their property, although they do require limited waivers of Tribal sovereign immunity in landowner agreements. The Tribe received a signed Landowner Acknowledgement form from WLT for the Farmhouse Reach project on July 24th, 2014.
- **God's Eagle Habitat**. The Tribe mailed a landowner outreach letter and relevant figures to the mailing address listed on the Whatcom County Assessor's database for God's Eagle Habitat on September 26th, 2014. We have not yet received a response from this landowner, but we shall continue to reach out to them.
- **Ralph and Colleen Bennett.** Tribe staff met with Colleen and Ralph Bennett on October 7th, 2014, to introduce and discuss the Farmhouse Reach project. As former owners of the Bennett Woodland farm (currently Roger McMunn/Kalypso Bay Farms) as well as their current property, they have been concerned in the past with erosion and channel migration on their property, as well as flooding. Their concerns have been somewhat mitigated by ballasted wood structures placed along their current property line; these structures are designed to fall in and protect the bank from further erosion should the bank line retreat further. The Bennetts expressed their support for restoration work in the reach that benefits salmon and the environment. Colleen was given the Landowner Acknowledgment form and said she would mail it to the Tribe soon. Staff informed them that we would engage them in design review and expected channel response as we proceeded. It should be noted that the Bennett property is currently up for sale, and outreach with new landowners should be anticipated in the future.
- **Marilyn Tefft.** Tribal staff had a brief phone conversation with Marilyn Tefft on August 15th, 2014. She was eager to hear more about the project and was open to scheduling a time to meet with the Tribe. Tribal staff plan to continue outreaching to Marilyn regarding the project.
- **Harvey Henry.** The Tribe mailed Harvey Henry a landowner outreach letter on September 26th, 2014, and spoke with him via phone on October 9th, 2014. Harvey considers his parcel on the right-bank within the Farmhouse Reach to be somewhat "obsolete", since he does not have access to the site and isn't certain where the property boundaries are. He was grateful for the landowner map included with the letter as it was helpful for him to see the adjacent landowners. After a brief introduction to the Farmhouse Reach project, Harvey was very supportive and willing to sign the Landowner Acknowledgement form. He would like to have a site visit on his property eventually, mostly so he can become more familiar with the land and hear more about the project. The Tribe plans to mail Harvey the Landowner Acknowledgement form as soon as the Farmhouse Phase 2 Design is updated by the end of October 2014.
- **Barry and Ruth Hutchinson.** No work is yet proposed on this property, although the Tribe plans outreach in late 2014 to gain potential access and discuss potential project impacts.

Other Stakeholders

Comments on the preliminary reach-scale design were solicited from the WRIA 1 Combined Review Team and WRIA 1 Salmon Recovery Staff Team in February 2013 (Appendix 1). Only John Thompson, Whatcom County, provided comments and questions; his comments were addressed by Tribal staff in May 2013 (Appendix 2). John's comments did not affect the design, but did help identify areas of this report and the Geomorphic Assessment report that could be improved.

FIGURE 27: LAND OWNERSHIP IN THE FARMHOUSE REACH.



PERMITTING

Permits were acquired, and minor design adjustments made as appropriate, as described below.

- **US Army Corps of Engineers.** Nationwide 27: USACE review of the project is triggered by submitting a Joint Aquatic Resources Application (JARPA). The USACE reviewed the Farmhouse Phase 1 to determine if the project is authorized under the Nationwide Permit (NWP) 27 Aquatic Habitat Restoration, Establishment and Enhancement Activities. The USACE determined that the Farmhouse Phase 1 Project was authorized under the NWP 27 on June 3, 2014.
- **US Fish and Wildlife Services.** Project was evaluated as to whether it met the requirements of the Endangered Species Act 2008 Fish Passage and Restoration Programmatic Consultation: The requirement is triggered during the USACE Nationwide 27 review process. The Tribe submitted a Specific Project Information Form describing the Farmhouse Phase 1 project on March 12, 2014 to meet the requirements of the Endangered Species Act 2008 Fish Passage and Restoration Programmatic Consultation. USFWS issued an Electronic Approval for Use of the Programmatic to the USACE.
- **Washington State Department of Fish and Wildlife Hydraulic Permit Approval (HPA)**: HPA is obtained from WDFW by submitting a Joint Aquatics Resources Application (JARPA). The Tribe consulted with WDFW and had a site walk through with WDFW staff prior to submitting the JARPA application. During our site visit, the WDFW biologist had the opportunity to see the proposed engineered log jam structure locations and the overall conditions of the reach. We discussed potential crossing locations and techniques and discussed timing of the construction of the project. The WDFW biologist requested the Tribe include any potential stream crossing locations in the design plans and requested photos of each potential crossing location. WDFW provided a site map showing in-water work windows for specific structures to work around landowner requests and incorporated the Tribe's timing requests into the final HPA. No major design changes were made due to the HPA or WDFW consultation.
- **Washington State Department of Natural Resources (DNR)**
    - **Forest Practices Permit (FPA)**: In the past, the Tribe has not needed to obtain an FPA because access for our past projects has been through parcels owned by Whatcom Land Trust or private landowners. A majority of the land along the left bank side of the Farmhouse Reach is in the Washington State Forest Board ownership which is managed by DNR. Originally the Tribe proposed to access the left-bank side of Farmhouse via an existing abandoned road grade on the DNR Statelands. However, the road grade traversed through Marbled Murrelet habitat and the DNR area biologist described the stand as "of exceptional quality"; use of the road was not authorized by DNR. As a result, the Tribe proposed an alternate access with east of the existing road grade which required felling DNR-owned timber. In order to clear the access road, the Tribe was required to obtain an FPA and a DNR Road Use Permit on the uplands portion of the DNR Statelands.
    - **Aquatic Use Authorization /Aquatic Right of Entry:** The Tribe obtained the Aquatic Right of Entry (ROE) through an Aquatic Lands Conservation License Agreement. The DNR Aquatic Use Authorization process is triggered with the JARPA application by submitting Attachment E of the JARPA Form. The Tribe had a site visit with DNR staff to discuss the project and review potential Public Safety concerns. DNR requested the use of chain rather than cable for lashing rocks and lashing logs together. Due to the higher cost of chain not being incorporated to our original budget, we were able to negotiate with DNR to use chain for the rocks but to still use cable to tie the log lashings for Phase 1.
    - **Road Use Permit**: The Road Use Permit (RUP) was required by DNR in order to build the new road on Stateland parcels. A Right-of-Way application was submitted to the DNR in March to begin the RUP approval process. As part of the RUP the Tribe was required to pay for the timber to be cut on Statelands and pay for the RUP fee cost which is based on the amount of material being hauled on DNR roads. The RUP was finalized in mid-June after a lengthy agreement and negotiation process between DNR and The Tribe. The RUP permit requirements did not affect the design of the project, however it did add to the cost.
- **Whatcom County**

- **SEPA Determination:** Submitting a SEPA for this project was required through both the Shoreline Exemption Permit and the DNR Road Use Permit process. A Determination of Non-Significance was issued by Whatcom County on May 2, 2014 and no comments were received during the 14-day comment period.
- **Shoreline Exemption:** In order for the project to be exempt from obtaining a Substantial Development Permit required by the Whatcom County Shoreline Management Program, the Tribe submitted a Shoreline Exemption application in March. The Shoreline Exemption Determination cannot be issued until the SEPA Determination and the HPA have been issued and a Project Approval letter from WDFW is submitted to Whatcom County. The HPA was issued on June 16, 2014 and the Shoreline Exemption Determination was later issued on June 17, 2014.
- **Flood Development Permit:** The Flood Development Permit is triggered during the flood review of the Shoreline Exemption through Whatcom County. Whatcom County is required to review the project for flood risk through the National Flood Insurance Program administered by the Federal Emergency Management Agency. In order to receive a Flood Development Permit, the project does not "adversely affect the flood-carrying capacity of the area of special flood hazard". In order to ensure there are no adverse flood affects as a result of the project, the Tribe worked closely with our engineer, Herrera, to design the project so that the project will not increase the water surface elevation of the base flood more than one foot at any point. This requires running multiple flood models and design changes to ensure the placement of the engineered log jams meet the Flood Development Permit requirements. The Flood Development Permit was issued on July 11, 2014.

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GeoEngineers (2012). Geomorphic characterization and response assessment- Farmhouse Reach Restoration. Final memorandum to Herrera Environmental Consultants. October 22, 2012.

Herrera Environmental Consultants (2014a). North Fork Nooksack River Farmhouse Reach Restoration Project Phase 1, Final Stamped Planset: Project #09-04592-001. May 2014.

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Hyatt, T. (2007). Lower North Fork Nooksack River: Reach Assessment and Restoration Recommendations. June 29, 2007. Nooksack Indian Tribe, Natural Resources Department, Deming, WA.

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WRIA Salmonid Recovery Board (2005). WRIA 1 Salmonid Recovery Plan. April 30, 2005.

APPENDIX 1. SOLICITATION OF STAKEHOLDER COMMENTS.

Memo

To: WRIA 1 Combined Review Team; WRIA 1 Salmon Recovery Staff Team

From: Treva Coe

CC: Becky Peterson

Date: 2/22/13

Re: RCO #09-1680, NF Nooksack Farmhouse Reach Feasibility and Design: review of reach-scale restoration design

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At last summer's ranking meeting, the Combined Review Team requested that members have the opportunity to review and provide comments on discrete design deliverables of funded projects. The preliminary (30%) design (site plan only) for the North Fork Farmhouse reach-scale preferred alternative can be downloaded at**:** http://dl.dropbox.com/u/93966524/Farmhouse-Figure%20MAX%202-20-2013.pdf **Please submit comments on this design to me or Becky Peterson by 3/5/13.** Thanks!

To review, the Farmhouse reach of the North Fork Nooksack River (RM 46.8-49.4) is a priority reach for restoration in the North Fork Nooksack River. Rapid channel shifting, associated loss of mature floodplain vegetation, and lack of persistent accumulations of wood have led to increased redd scour and a loss of stable side channels, pools, and complex edge habitat. The objectives of restoration in the reach are to: (1) increase key habitat quantity (primary and backwater pools, complex edges and tailouts), especially in side channel areas *by placing large wood structures that cause local scour and provide complex edge habitat*; (2) improve low-flow connectivity of key marginal side channel areas – Bear Creek Slough, Wicks Slough, Levitt's Slough and Falls Creek Side Channel *by separating and encouraging flow toward marginal channel areas*; (3) narrow the active channel *by encouraging vegetation establishment and succession on existing exposed gravel bars*; and (4) increase the longevity of forest islands for riparian habitat *by increasing the bank resistance along existing and emerging forest islands*.

The design project funded by SRFB/PSAR includes three components: (1) feasibility study, including refinement of limiting factors and reach-specific objectives, identification and evaluation of various alternatives, landowner outreach, and selection and staging of the preferred alternative; (2) preliminary (30%) design for the reach-scale preferred alternative, including flood risk assessment, design report, and cost estimates; and (3) final design and permits for the 1st project phase. The feasibility study and preliminary reach-scale design are complete, and final Phase 1 design is in progress. The specific habitat targets that were developed for the reach are: (1) 30 pools, including in the mainstem and side channels; (2) 11,000 feet of low-flow side channel (i.e. the majority of the length of three of the four target areas connected; (3) less than 200 acres of high flow channel area, which represents the equivalent of the 1918 active channel area outside of the forest areas; and (4) conifer-dominated patches within the forest islands and a mosaic of forest stands across the

floodplain. The reach-scale alternative was selected because it was determined to have the greatest certainty of meeting these habitat targets.

We are hereby soliciting input on the preliminary design for the reach-scale preferred alternative. Structure types and architecture will be similar to that constructed in the North Fork Wildcat Reach. Salient figures from the draft feasibility report are included herein to facilitate design review.

Figure 1. Physiography and surficial geology of the Farmhouse Project Reach.

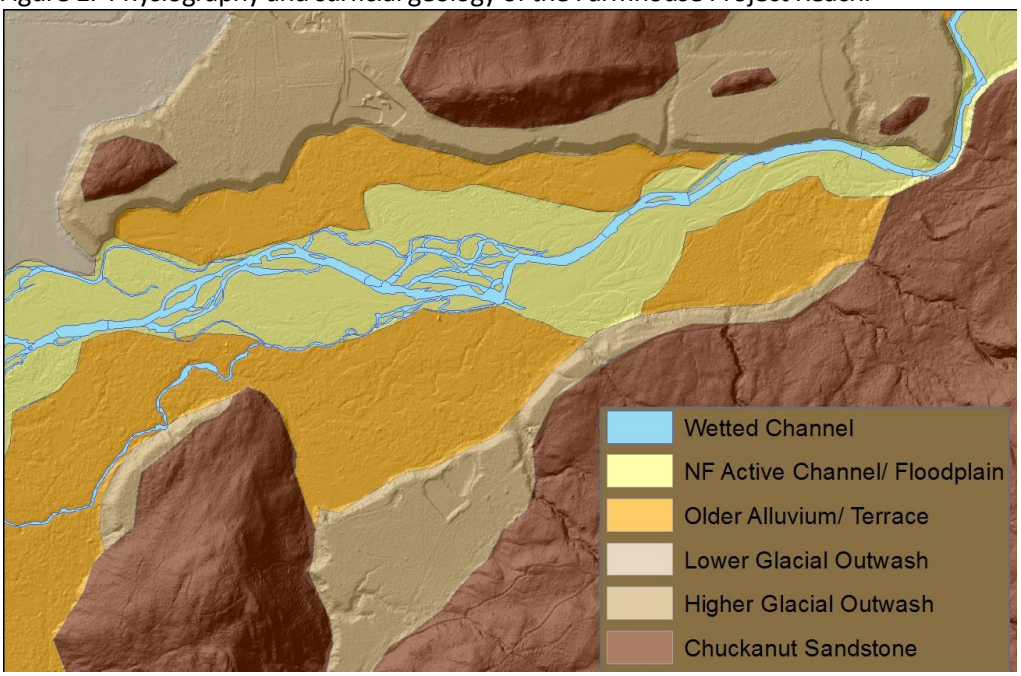


Figure 2. Height above the low-flow channel in the Farmhouse reach.

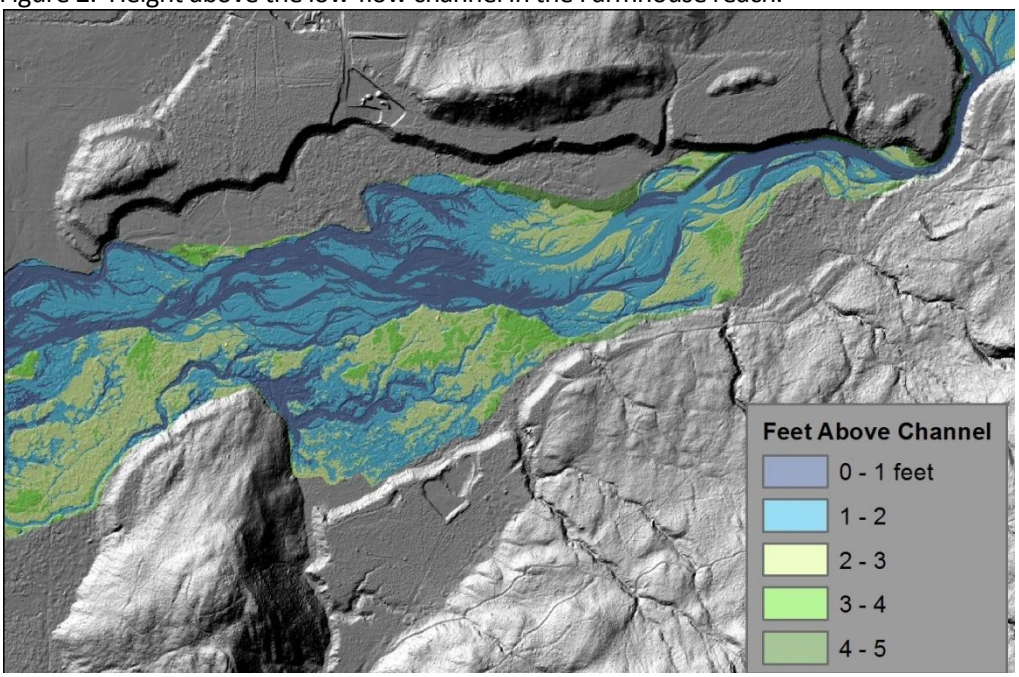


Figure 3. Channel occupation in the Farmhouse reach between 1933 and 2001 (Collins and Sheikh 2004).

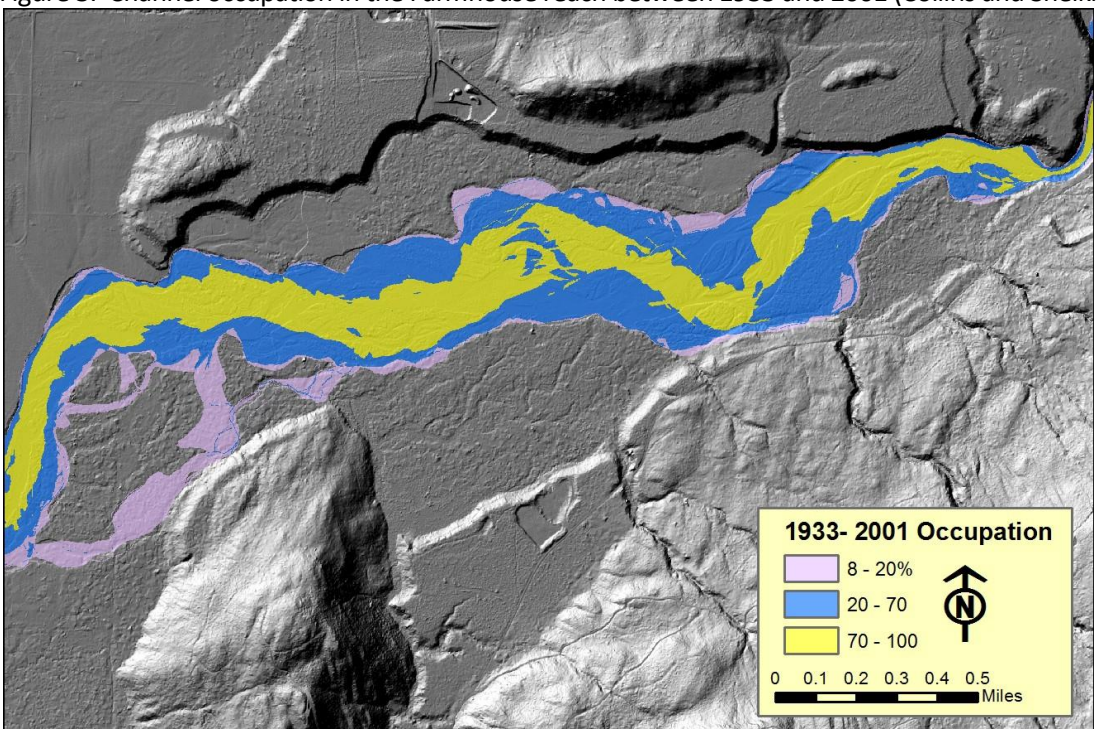


Figure 4. Habitat mapping in the Farmhouse reach (NNR 2005, on 2009 NAIP aerial photo).

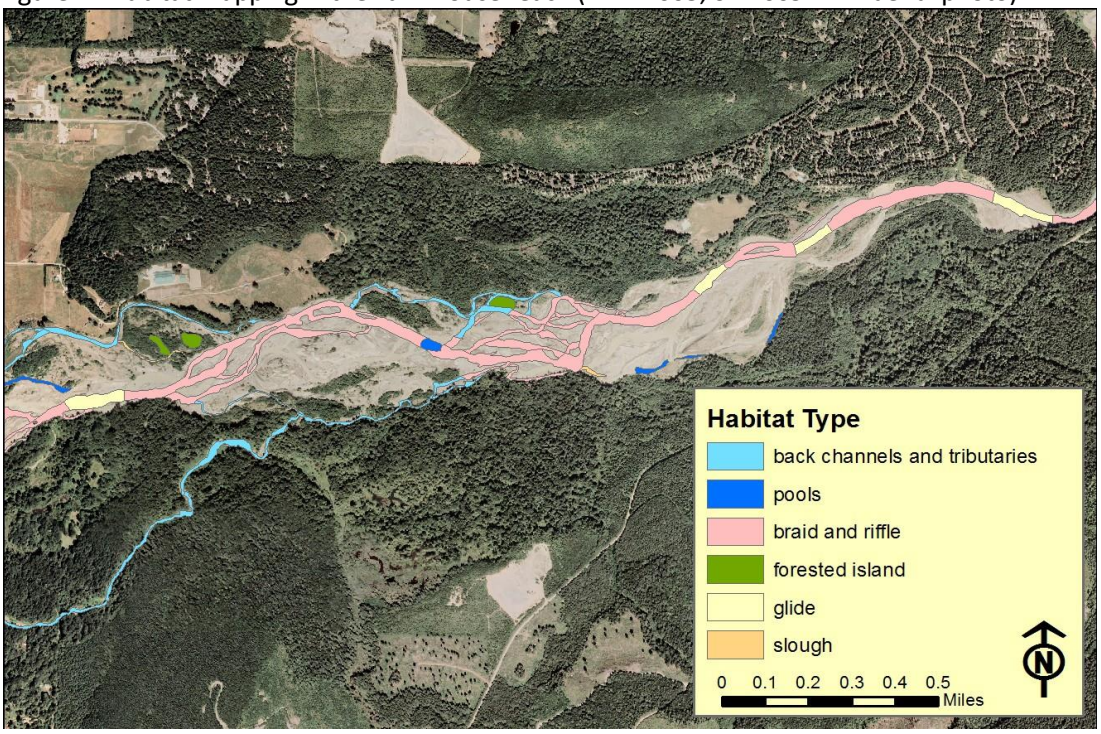


Figure 5. Change in area (acres) of habitat types through time (1891-1998) (Collins & Sheikh 2004).

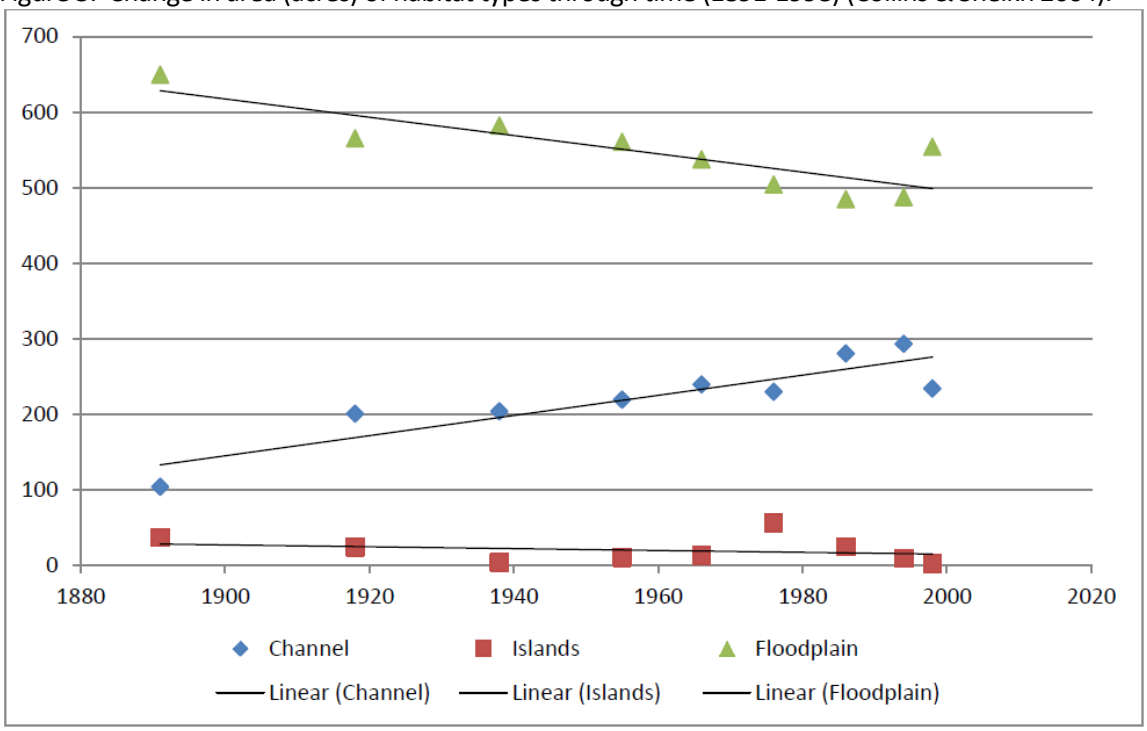
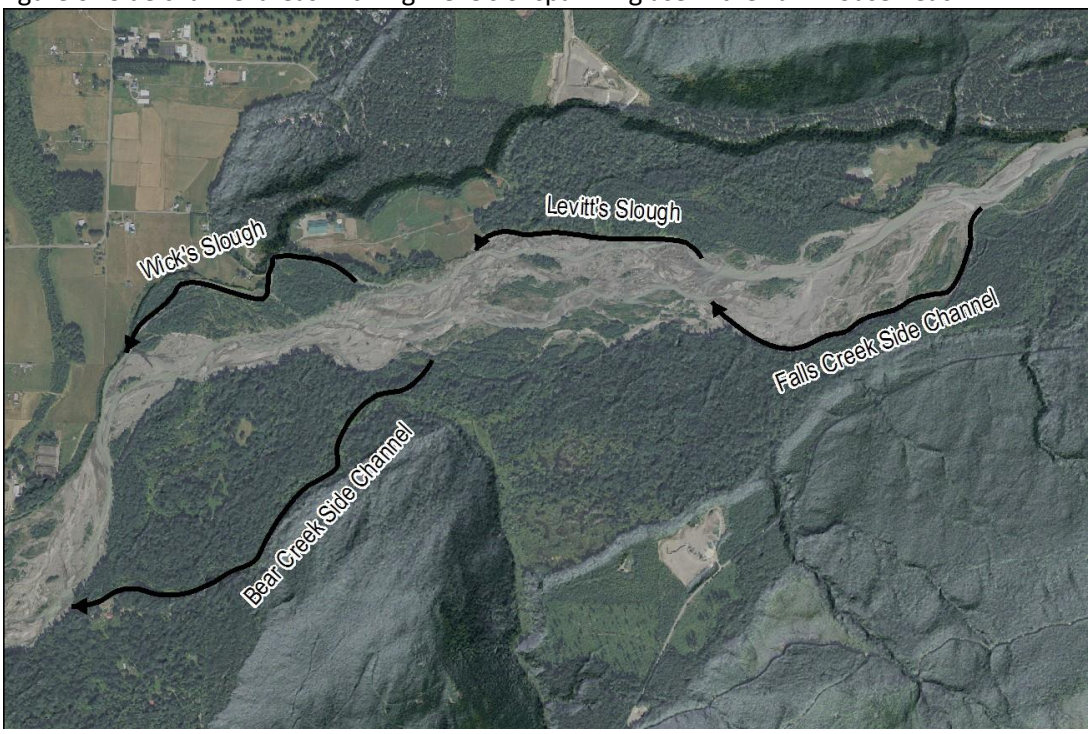


Figure 6. Side channel areas with high levels of spawning use in the Farmhouse Reach.



APPENDIX 2. RESPONSE TO STAKEHOLDER COMMENTS.

Memo

To: File

From: Treva Coe

Date: May 2013

Re: Comments on NF Nooksack Farmhouse Reach Feasibility and Design

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In response to our solicitation of comments on the preliminary Farmhouse Reach Preliminary Design, John Thompson (Whatcom County, WRIA 1 Salmon Recovery Staff Team) provided the comments and questions below (numbered below) on February 28, 2013. Our responses to those comments are provided below in italics.

1. Does geomorphic analysis indicate anything about relative importance of factors leading to reach braiding (loss of bank cohesion, lwd, sediment, other)? Any insights into trends in reach-scale sediment input, export, and storage? Will project address causative factors? This may help understand potential effectiveness in getting forested islands to persist. Is a net increase and/or duration in sediment storage (gross or by size fraction) that is expected or, with channel narrowing and incision, will there be a net export to downstream reaches where channel widening could be exacerbated? Any targets for net changes in cross-sectional channel area or average bed elevation? Note: these comments are geared more towards setting clear measureable geomorphic objectives for the project as a base for future monitoring and effectiveness evaluation.

Tim Hyatt's work hypothesizes that the rapid depletion of LWD once it enters the channel, combined with the loss of recruitable large trees to replace the depleted LWD has led to a decrease in forested islands and increased active channel width. Tim also indicated that erosion due to recent high flow events has led to active channel widening, which GeoEngineers also concluded.

The project will address causative factors by increasing bank resistance to slow migration and allow trees in the riparian zone to reach a functional size.

There was no assessment of sediment transport, but there was a subtraction of several topographic data sets to show where there was a trend in sediment storage. The results surprisingly showed no change (-.5 ft average over the project area) in bar elevation between 1994 and 2004.

Changes in sediment size were observed in the reach. The uppermost, more single thread section was coarser than the braided reach downstream, indicating a loss of transport in the lower reaches. There is the potential that the braided section will become more similar to the single thread sinuous reach upstream and that sediment transport could become more uniform though the reach as a result of the project. It is expected that the increase in flow obstruction and the availability of secondary channels will largely offset this. It is unclear if increasing sediment transport in this reach will significantly affect channel migration in downstream reaches.

2. You have developed specific habitat targets. Maybe we should also be thinking in terms of setting geomorphic targets as a way to quantify desired changes in channel/habitat forming process not just channel/habitat structure.

Habitat targets are considered to be derivative (i.e. will develop in response to) the geomorphic conditions and processes we are trying to restore.

3. Links with background documents would be helpful for reviewers and for SRST to better understand technical basis.

Request noted and incorporated into future drafts.

4. Typicals of structures would be beneficial to see relative height, size, etc.

Request noted. Typicals will be available as the design is developed; early design iterations focus on structure type and location (i.e. site plan).

5. 3-4 floodplain cross-sections showing relative elevations of geomorphic surfaces and relative elevation of base and top of ELJ's would be helpful.

Request noted. Relative elevations will be shown in typicals in future design iterations.

6. Would floodplain portion of Falls Creek and length of Bear Slough also benefit from placement of side channel habitat structures if it could be done by helicopter to minimize ground disturbance?

Falls Creek definitely would. Bear Creek probably would as well.

7. Would the Glen be open to replacement of the downstream revetment with multiple jams? This could replace the bank protection while providing habitat diversity including cover near the spawning channel. Yeah, I know it would mostly benefit chum, but they're food for somebody……

The Glen is not open to removing the downstream revetment and replacing it with multiple jams.

8. Is there an opportunity to improve connectivity to the sloughs west of the Glen's pool area and north of Leavitt's (proper spelling) Slough? Those areas had some potential for improved connectivity in the past and have good groundwater feed and beaver activity. Enhance or best to leave alone?

The modeling shows increased flow through those areas, but we are not expecting side channel development.

9. What is potential for changes average channel elevation post-project (up or down) and what effect does this have on flood conveyance?

The changes are expected to be flood neutral over a longer timeframe. We don't want to keep the channel from responding to changes in sediment delivery to the reach. We expect periods of aggradation and periods of incision through time, with the long-term trend being an equilibrium.

10. We currently lack trend data on sediment inputs to this reach. What are likely responses to the channel to increased inputs should glacial retreat produce that response and does the design provide some robustness to vertical changes (up or down) that will both hold up and persist?

Do we expect the changes from glacial retreat to exceed the impact from land clearing in the watershed? We have seen the response to fairly extreme changes in the sediment delivery (local riparian harvest, large-scale flooding, etc) and those changes were used to inform the design of the project. The lifespan of an engineered logjam is ~50 years- do we expect extreme changes in sediment delivery over that time frame, especially considering the length of time that the glaciers have already been retreating?

11. Project is very ambitious. The SRST should be thinking about allocation of resources and the ability to sequentially and surely implement projects of this scale while not neglecting other priorities or areas. To channel Alan, will we see a measurable fish benefit commensurate with the expense and on what timeframe do we expect to see those results? I mention this not to be critical, just that we should expect questions and we should have some good answers.

Yes, we will. The North Fork strategy is longer-term than the South Fork. We expect near-term benefits to habitat, such as pool-formation and increased wood cover, that will increase as the vegetation encroaches on the channel and habitat-forming processes recover. The project is addressing the dominant limiting factor in the North Fork- channel stability. How long until the fish come back- can anyone can answer that?