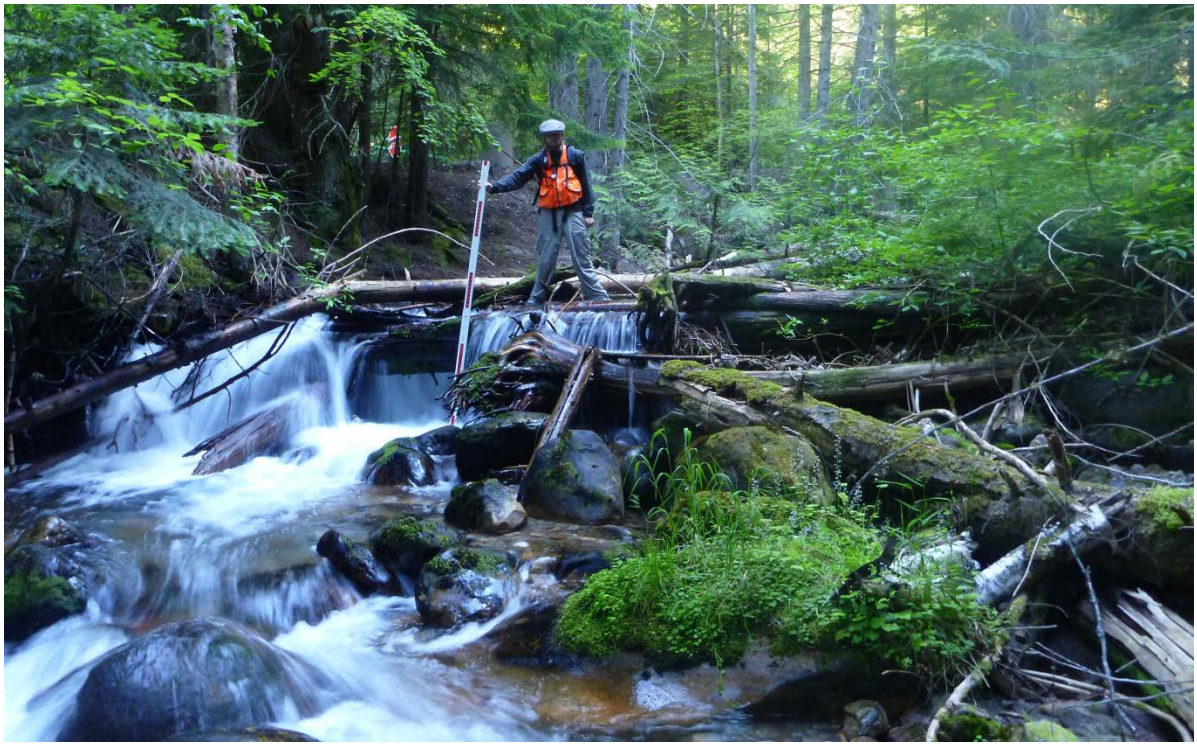
Sullivan Creek Habitat and Geomorphic Assessment

August, 2013



Prepared for:

City of Seattle
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nhc
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Ms. Kathy Dubé of Watershed Geodynamics, a subconsultant to NHC, provided excellent guidance and leadership in planning and directing field data collection, as well as in assisting with data interpretation. Her contribution to the success of the study is greatly appreciated.

Executive Summary

Sullivan Creek is the largest tributary (142 square miles) draining to Boundary Reservoir on the Pend Oreille River. The creek supports genetically pure, native westslope cutthroat populations and may offer the best available opportunity for the recovery of bull trout in northeast Washington. Past human activity, including road and dam construction, forest practices, and dispersed recreation site development, have diminished habitat access, quality, and function for native salmonids.

Northwest Hydraulic Consultants (NHC) was contracted by Seattle City Light to assess the existing geomorphic and physical habitat conditions in Sullivan Creek in order to provide a foundation for goal setting, siting, selection, and design of restoration measures. To do this, physical habitat and geomorphic conditions along 20.0 miles of Sullivan Creek and 4.4 miles of 15 separate tributary streams were field-assessed and mapped in detail. Information was collected regarding channel habitat units, LWD size and abundance, substrate conditions, canopy cover, channel cross-sectional form, bank conditions and major sediment sources. These field data were entered into high accuracy (typically 1-10 m) GPS data loggers. Additionally, LiDAR, a USGS 10 m DEM, and aerial photos were used to define thalweg and side channel flow paths, channel gradient, low-flow and bankfull channel areas, floodprone valley areas, and upstream basin area. Additionally, a one-dimensional steady state hydraulic model (HEC-RAS) of the main stem of Sullivan Creek was developed from field survey and LiDAR data. All data were then aggregated into ~200 m long subreaches and reaches of variable length but consistent character for subsequent analysis.

Data Summarization and Mapping

Two map sets and one set of charts graphically display the field data. The more detailed of the maps sets (Plates A1-A29) shows positions of individual features including pools, large wood jams, large wood pieces, patches of spawning gravel-sized material, areas of eroding and/or armored banks, and landslides on an aerial photo base map. The reach-scale map set (Plates B1-B23) shows polygons of habitat units, locations of LWD jams, bank erosion, bank armor, and landslides on a topographic base map. The series of charts (Plates C1-C6) provide a compact and high-level summary of key physical habitat and geomorphic data and provide a convenient visual complement to the text of this summary and the report as a whole.

Sullivan Creek is a steep generally cobble- and boulder-bedded mountain stream draining the west slope of the Selkirk Range of the Rocky Mountains. The hydrologic regime is dominated by spring and early summer snowmelt floods. Minimum flow occurs in the winter months due to frozen conditions. The climax riparian forest type for the study area has been identified by Andonaegui (2003) as "hemlock/wild ginger." Most of the land within the project area has been logged within the past 80 years; however, so second growth Douglas fir and western larch occur on drier slopes; and mixed western red-cedar/western hemlock stands occur in shaded and moist areas (FERC, 2011). The average stream slope in the study area is 2.5 percent, and slopes of individual reaches range from one percent to six percent. Typical main stem bankfull widths increase from 30 to 40 feet at the confluence of the Sullivan Creek headwater reach with Deemer Creek to between 50 and 100 feet at the mouth of Sullivan Creek; and typical bankfull depths increase from one to two feet upstream to three to five feet downstream. The basin area of the main stem creek increases from 15 square miles at the Sullivan-Deemer confluence to 142 square miles at the mouth of Sullivan Creek.

NHC inventoried a total of 1,949 individual morphologic habitat units under low-flow conditions within the study area and classified 48 percent of the creek area as riffle, 22 percent pool, 15 percent glide, 9 percent pocket water, and 6 percent cascade (see Plate C1). Pools are distributed throughout the creek,

but the highest concentrations were found in reaches with abundant log jams and reaches with colluvial or bedrock substrate. Steep headwater reaches (S17, S18, and many tributaries) are dominated by pocket water. Lower gradient reaches are dominated by riffles (plane bed morphology) and, where influenced by log jams, forced pool-riffle channel morphology. The canyon between Mill Pond Dam and Boundary Reservoir includes significant areas of boulder cascades interspersed with pools.

Both reach and subreach units were classified according to the Rosgen Level II approach. Entrenched streams (types A and F) occur in reaches between Mill Pond (RM 4.2) and the Highway 31 Bridge (RM 0.6). In the study area, these stream types have the least wood, almost no side channel habitat, and very little spawning area. Pools in these areas are formed by boulders and bedrock features and tend to be substantially deeper than in subreaches of other stream types.

Between Gypsy Creek (RM 15.3) and Thunder Creek (Rm17.7), the stream is a very steep, boulder-dominated, moderately-entrenched step-pool channel. This reach of Sullivan Creek is naturally steep and confined. Here, the channel has abundant pools and pocket water formed by boulder structures.

Throughout the study area, there are moderate gradient, moderately entrenched, riffle-dominated channels. These often occur in areas where the floodplain has been confined by road fill. Subreaches of this character have the most infrequent pools and low overall influence of log jams and large woody debris.

In unconfined, low-gradient areas the stream often has a meandering, alluvial pool-riffle channel with broad floodplains. In these areas, the stream generally has abundant pools, strong influence of large wood and log jams, relatively abundant side channel habitat, and good floodplain connectivity. When large wood and large wood jams are present, subreaches of this character contain some of the best habitat; but they are very sensitive to a lack of large wood and have very few pools in subreaches without log jams.

In low-gradient and lower energy headwater areas with a wide alluvial valley and dense coniferous riparian vegetation, an anastomosing channel network can form. For example, these conditions are found in Gypsy Meadows, Sullivan Creek Headwaters, and Deemer Creek. These areas have the most abundant pools, exhibit the greatest influence of log jams and large wood, and provide the most abundant spawning area of all surveyed subreaches.

Large wood pieces are recruited to the stream through tree fall caused by wind throw or bank erosion and through landslides. Large wood jams contain the majority (over 60%) of individual large wood pieces. They are concentrated in areas of low slope upstream of valley grade control features (typically tributary alluvial fans, landslides, and bedrock), where transported wood accumulates, and at the toe of and just downstream of landslides, which deliver a large charge of wood locally to the stream. Seventy percent of all log jam key pieces are greater than 35 feet long, and less than 10 percent are less than 25 feet long.

The majority of pools in the study area are formed by large wood and large wood jams (56 percent of pools), while 38 percent of pools are formed by bedrock and boulders. Five percent of pools are free-form in natural pool-riffle sequences, and the remaining pools are formed by other features, including beaver dams. The stream is typically steep and entrenched in the canyon reach (RM 0.6-2.6), a bedrock-confined reach above Mill Pond (RM 6.4-7.3), and between Gypsy Creek and Gypsy Meadows (RM 15.3-18.9) where the majority of pools (90 percent) are formed by bedrock and boulders. Elsewhere, the majority of pools (75 percent) are formed by large wood. Pool frequency is positively correlated with log jam frequency.

Roads within the Sullivan Creek valley systematically encroach on the floodplain and channel migration zone of the creek. With the exception of RM 15.3-17.7, where road encroachment probably did not significantly change geomorphic characteristics of the already confined stream, areas of road encroachment and bank revetment correspond to locales that lack wood and pools - especially where the floodprone area is narrow.

Analysis and Discussion

A limiting factors analysis was conducted to elucidate relative differences in habitat quality and key habitat deficiencies in the project area. Three separate limiting factors matrices were completed: a reach-scale matrix using regional reference criteria (Andonaegui, 2003 and Tetra Tech, 2009), and reach and subreach matrices using criteria revised to allow more robust comparison between reaches and subreaches of Sullivan Creek based on the detailed data collected in this study.

Based on this analysis, the most prevalent limiting factors in the study area include structures that limit fish passage, large woody debris abundance, log jam abundance, pool frequency, pool quality, off channel habitat, and non-indigenous fish species. Of these, the most significant problems appear to be fish passage, road encroachment, off channel habitat, log jam abundance, and pool frequency. Lowered abundance and size of wood and especially log jams appear to be the principal causes of a shift from forced pool-riffle to plane bed morphology. Additionally road encroachment has caused habitat problems by directly cutting off side channel habitat, reducing wood recruitment, and suppressing channel migration and associated wood recruitment over a larger area.

The best habitat conditions occur in tributary streams and low-gradient reaches high in the system that have wide floodprone areas (RM 12.8-15.3 —between Rainy and Gypsy creeks, and RM 18.9-19.5 —the Gypsy Meadows area). The poorest habitat quality occurs in locally steep and confined alluvial reaches (S10, S8, S13, and S14). Steep colluvial or bedrock reaches (e.g. the lower canyon or area between Gypsy Creek and Gypsy Meadows) and partially confined alluvial reaches are typically of intermediate habitat quality. Poor habitat conditions in locally steep and confined reaches and other low gradient reaches result from the sensitivity of these reaches to reduction of the size and abundance of LWD. The dominant channel types for slopes in the range of 1.5 percent to three percent are plane bed and forced pool-riffle (Montgomery and Buffington, 1997). Plane bed reaches characteristically lack pools. Pools in forced pool-riffle reaches depend on the direct influence of channel-spanning log jams, which reduce local channel gradients, and smaller jams or large pieces of well-anchored wood, which cause local hydraulic complexity that drives pool-forming scour and deposition (i.e. bar formation). In natural channels, bar formation occurs only up to slopes of about two percent (Ikeda, 1977; Florsheim, 1985). The reaches in the study area in the slope range between 1.5 and 2.5 percent are; therefore, especially sensitive to a lack of large wood and will tend to transition from forced pool-riffle morphology to plane bed morphology if the supply of wood is not sufficient.

The principal human activities that have reduced habitat quality on Sullivan Creek are historical harvesting of riparian forests, road construction in the riparian corridor and maintenance of those roads, direct channel modification including straightening and placement of log weirs, and construction of Mill Pond Dam. Most of the riparian area has mature (40+ year), but not yet old-growth, forest. The consequence of this is that the largest pieces of wood that are recruited are smaller and less stable in the stream than may have occurred prior to forest harvest in the riparian zone. Roads disconnect riparian areas from the stream and create fish passage barriers at some culverts. Disconnection of the riparian area results in reduced wood recruitment and side channel formation. Additionally, roads create a migration trap for the channel by concentrating hydraulic energy in the channel where it is constricted by riprap and/or road fill. These migration traps can halt channel migration even though

nothing on the opposite bank restricts migration. Reaches with constructed weirs have simplified channel forms: in long profile, they are typified by glides punctuated by steps at weirs (sometimes with small scour pools below steps), and in cross-section, they are typified by rectangular or trapezoidal channel forms lacking lateral variation in depth. Mill Pond Dam interrupts downstream sediment and wood conveyance, resulting in upstream aggradation and downstream bed coarsening, degradation and channel simplification.

Recommendations

The project team identified a suite of projects and actions that could be applied along Sullivan Creek to improve habitat conditions based on observed limiting factors and disrupted geomorphic processes in the study area. Typical recommended actions include construction of channel spanning LWD jams, log spurs, small log jams and/or key pieces, riparian restoration, bioengineering/LWD for bank stability (and rehabilitation of revetted banks), floodplain reconnection, and infrastructure modification or abandonment.

Specific subreaches where these general measures would be beneficial were identified utilizing the data visualization products and limiting factors analysis described above to evaluate local habitat problems, constraints, and opportunities. For each location, appropriate restoration action(s) were identified, emphasizing, where possible, those that would address root causes and promote re-establishment of natural processes. Table 22 summarizes the local habitat problems, causes of those problems, and potential solutions for each subreach in the study area.

Potential restoration actions were prioritized by a schema that evaluated the project type and magnitude of habitat affect. Specifically, the following hierarchy for *categories* of restoration action was used (listed in descending order of priority):

1. Reconnection of isolated habitat fragments (e.g., replacement of a fish passage barrier culvert)
2. Stimulation of natural habitat forming (geomorphic) processes (e.g., construction of a channel-spanning log jam to shift a reach from plane bed to forced riffle-pool morphology)
3. Direct construction of stream habitat or enhancement (e.g. installation of a single piece of wood for the primary purpose of providing cover for fish).

In addition to the project category, the magnitude of habitat benefit was also considered based on a judgment of whether the restoration benefit would be small, medium, or large in impact or spatial extent. The results of this prioritization are also summarized in Table 22.

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Appendix C WRIA 62 Pend Oreille 2496 TAG Bull Trout Rating Criteria

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Appendix F Sullivan Creek Habitat Inventory Geodatabase (digital)

Appendix G Sullivan Creek HEC-RAS Model (digital)

1 Introduction

Sullivan Creek, located in the northeastern corner of Washington, is the largest tributary (142 square miles) draining to Boundary Reservoir (Figure 1). It supports genetically pure, native westslope cutthroat populations and may offer the best available opportunity for the recovery of bull trout in northeast Washington. Past human activity, including road and dam construction, forest practices, and dispersed recreation site development, have diminished habitat access, quality, and function for native salmonids.

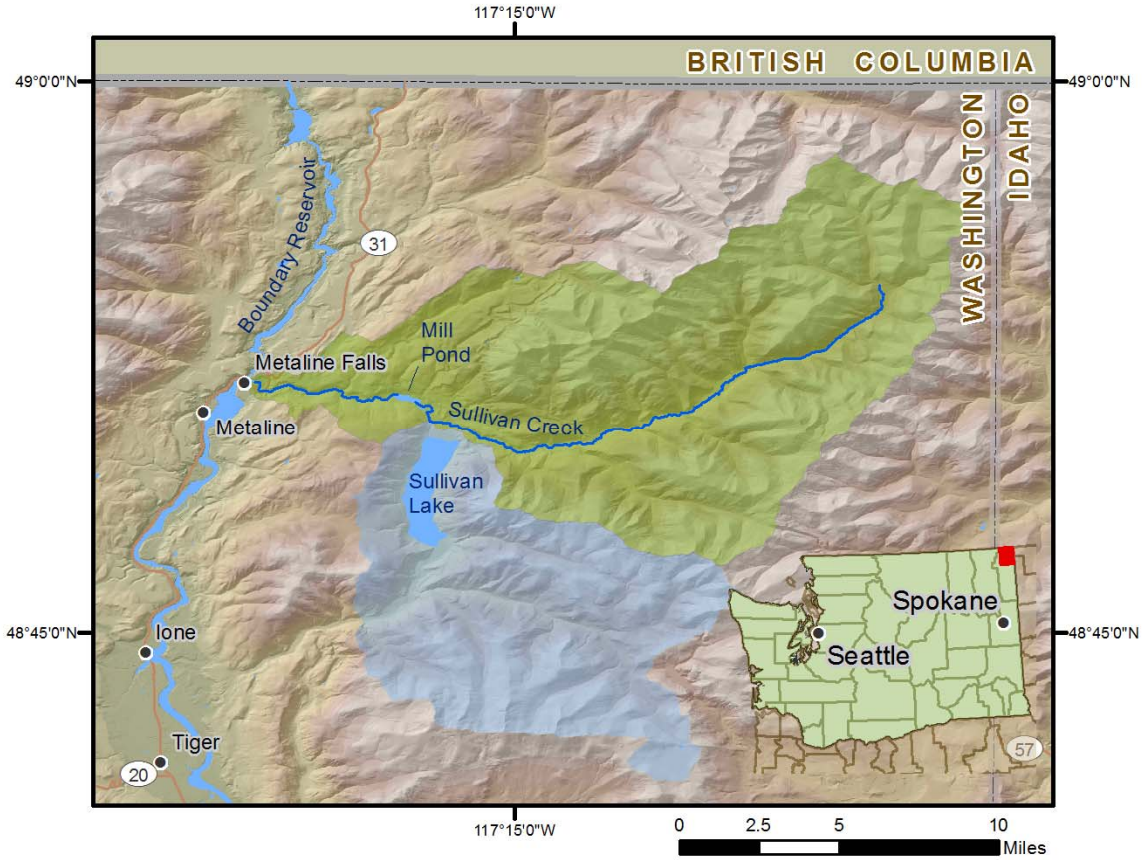


Figure 1. Sullivan Creek location map

The Settlement Agreement for relicensing of Boundary Dam on the Pend Oreille River identifies numerous measures to improve habitat conditions for native salmonids in Sullivan Creek. These include removal of Mill Pond Dam, placement of large woody debris (LWD), rehabilitation of streambanks, replacement of culverts restricting fish passage, and closure of dispersed recreational sites.

Northwest Hydraulic Consultants (NHC) was contracted by Seattle City Light to establish the geomorphic and aquatic habitat context for Sullivan Creek to inform goal setting, siting, and design for proposed restoration measures.

1.1 Study Area

The Sullivan Creek study includes the mainstem of the creek from its mouth at Boundary Reservoir to its confluence with Deemer Creek at approximately river mile (RM) 19.5the lower 800 m of North Fork Sullivan , Outlet, and Gypsy Creeks, the lower 600 m of Deemer Creek and Sullivan Creek Headwaters

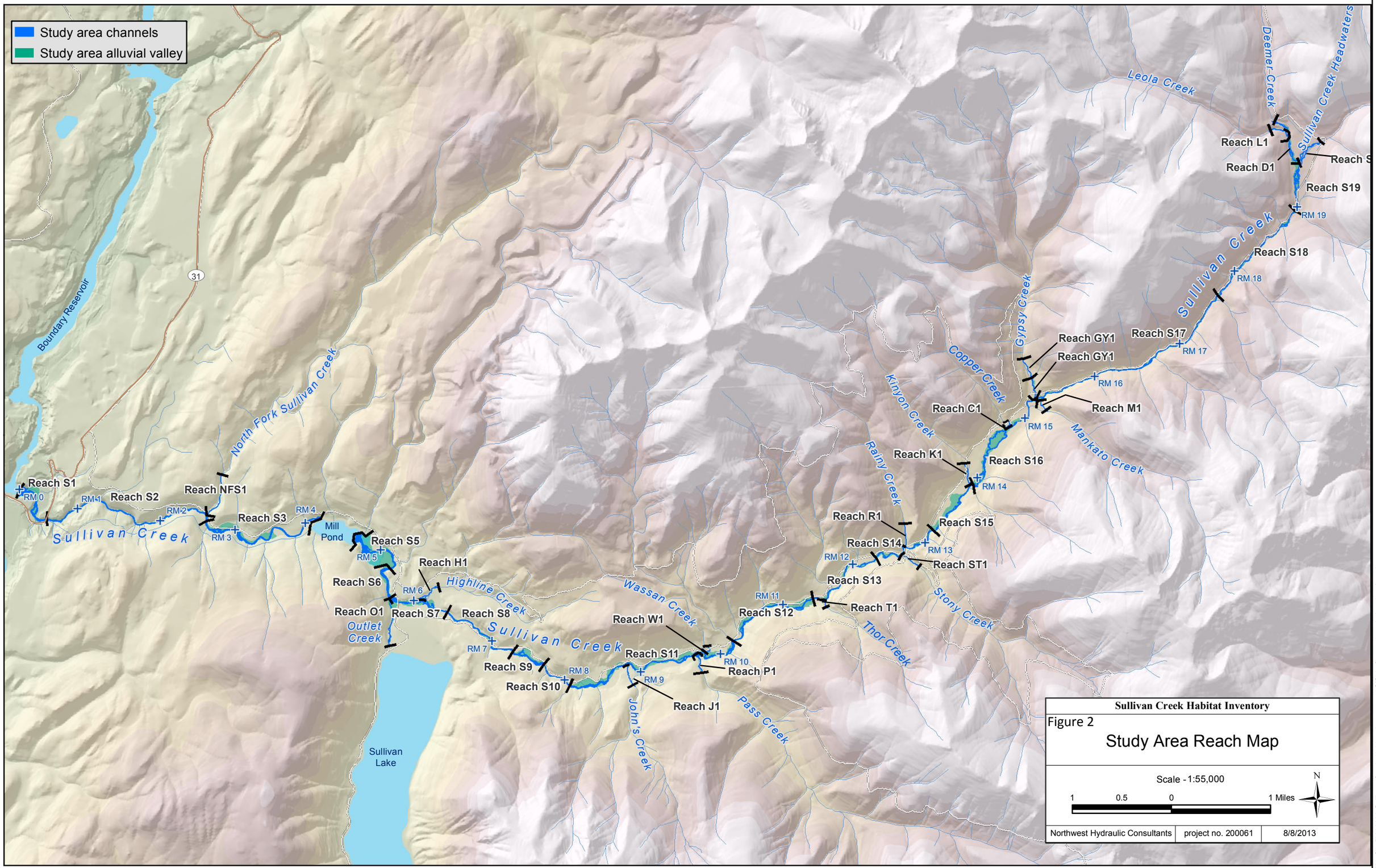
(above the Confluence of Sullivan and Deemer Creeks), the lower 400 m of Highline, John, Pass, Stony, Rainy, and Kinyon creeks, and the lower 200 meters of Wassan, Thor, Copper, and Mankato Creeks (Figure 2).

Sullivan Creek is a generally steep cobble- and boulder-bedded mountain stream, with local unconfined alluvial reaches. It drains the west slope of the Selkirk Range of the Rocky Mountains. The hydrologic regime is dominated by spring and early summer snowmelt floods. Minimum flow occurs in the winter months due to frozen conditions. The climax riparian forest type for the study area has been identified by Andonaegui (2003) as "hemlock/wild ginger." Most of the land within the project area has been logged within the past 80 years, however, so second growth Douglass fir and western larch occur on drier slopes; and mixed western red-cedar / western hemlock stands occur in shaded and moist areas. Additionally, on point bars and in other naturally dynamic areas, thin leaf alder is common (Andonaegui 2003). The average channel slope in the study area is 2.5 percent, and local slopes typically range from one percent to six percent. Typical bankfull widths increase from 30 to 40 feet at the upstream end of the study area to 50 to 100 feet at the mouth of Sullivan Creek; and typical bankfull depths increase from one to two feet upstream to three to five feet downstream. The basin area increases from 15 square miles upstream to 142 square miles downstream.

The study area was broken down into 19 mainstem reaches and 14 tributary reaches (Figure 2). The mainstem reach breaks were defined at significant landmarks (e.g. Mill Pond Dam, upstream end of Mill Pond), at select tributaries (e.g. Outlet Creek, Gypsy Creek), and at distinct morphologic breaks characterized by significant changes in slope and/or valley confinement. Table 1summarizes some general properties of mainstem reaches. Additional description of the mainstem reaches is provided in Section 3.3.

Table 1. Sullivan Creek reach properties

Reach	Length (mi)	Average Slope (%)
S1	0.4	1.3
S2	2.0	3.2
S3	2.0	1.2
S4	Mill Pond	0
S5	0.7	0.4
S6	0.4	0.8
S7	0.6	1.5
S8	0.9	1.5
S9	0.4	1.7
S10	0.4	1.2
S11	2.2	1.5
S12	1.1	1.7
S13	0.9	1.7
S14	0.9	1.6
S15	0.7	1.2
S16	1.6	1.2
S17	2.4	4.8
S18	1.3	2.8
S19	0.5	1.5
Reach S4 corresponds to Mill Pond; no data collected.		



Sullivan Creek Habitat Inventory

Figure 2

Study Area Reach Map

Scale - 1:55,000

1 0.5 0 1 Miles

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2 Methods

2.1 Field Data Collection

Habitat and geomorphic conditions along the entire length of Sullivan Creek from the mouth at Boundary Reservoir to the confluence of Sullivan and Deemer Creeks, as well as the lower 600 meters of Deemer Creek and 200 meters of Pass, Gypsy, and Leola Creeks, were surveyed during low-flow conditions in August and September 2012. The lower parts of other tributaries and Gypsy Creek form 400-800 m were surveyed during low-flow in July 2013. Table 2 shows the dates during which different parts of the study area were surveyed.

Table 2. Sullivan Creek habitat inventory survey dates

Location	Survey Dates
Below Mill Pond (RM 0-4.2)	Sept 18 to Sept 25, 2012
Mill Pond to RM 9.4	Aug 24 to Aug 30, 2012
RM 9.4 to RM 12.75 (upper of "two bridges")	Sept 25 to Sept 28, 2012
RM 12.75 to RM 16.3	Aug 25 to Aug 30, 2012
RM 16.3 to confluence of Sullivan and Deemer (RM 19.5)	Sept 18 to Sept 25, 2012
Pass Creek, Gypsy (Lower 400 m), Leola, and Deemer Creeks	Sept 26-28, 2012
North Fork Sullivan, Outlet, Highline, Johns, Wassan, Thor, Stony, Rainy, Kinyon, Copper, Gypsy (upper part), Mankato, and Sullivan Creek Headwaters	July 15-19, 2013

The survey protocol was collaboratively developed by Seattle City Light (SCL), NHC, and Watershed GeoDynamics staff prior to the commencement of field work. . It is quantitative and consistent with methodologies outlined in other published protocols applied regionally (i.e., EMAP, USFS) with a greater emphasis placed on collecting geospatial data. Once the protocol was established, an organizational framework for data collection was developed. This framework consisted of a data dictionary that was loaded into GPS data loggers used for survey data collection (Trimble GeoExplorer 6000 series, model GeoXH with GLONASS). A detailed description of the survey protocol can be found in Appendix A. This survey protocol was followed over the majority of the study reach; however, a slightly modified protocol was implemented in the lower "canyon" reach, between RM 0.5 and RM 2.5. The two primary modifications made for this reach consisted of performing the survey in the downstream direction and using a laser rangefinder to measure habitat unit lengths instead of using the hip-chain/string box to determine stationing and unit lengths. It should be noted that survey was also conducted in the downstream direction from the end of the canyon to the mouth of Sullivan Creek at RM 0.

Surveys were conducted by two 2-person teams. Team leaders were present for the entirety of both survey periods, and were responsible for entering data into the GPS data loggers, identifying dominant and subdominant channel substrate and spawning gravel area within habitat units, measuring stream stationing with the hip-chain, and photographic documentation. Other team members were responsible for tallying individual and log jam pieces and measuring habitat unit dimensions. Shared responsibilities included pebble counts, identification of bank instabilities and sediment sources, and cross-section surveys at transects.

On the first day of the survey, both teams (accompanied by the SCL project manager) surveyed the same approximately 600-meter reach of Sullivan Creek upstream of the confluence with Outlet Creek. This exercise was intended to acquaint the teams with the surroundings, review survey protocols, and compare observations. Additionally, supporting team members periodically switched which team they worked with in order to maintain consistency in survey methods between teams. For the remainder of

the 2012 survey period, Team A surveyed the uppermost reach of Sullivan Creek (upstream of approximately RM 12) as well as Deemer, Leola, Gypsy, and Pass Creeks. Team B surveyed the lower portion of Sullivan Creek from the confluence with the Boundary Reservoir up to RM 12.

2.1.1 Safety Procedures

Safety procedures for the Sullivan Creek Habitat Assessment followed those outlined in the NHC Fieldwork Safe Practices Manual. Specific safety procedures implemented for this survey included distribution of emergency and non-emergency contact numbers and locations to all team members, paired survey teams, and daily check-in times and locations. In addition, each team was outfitted with first-aid kits and satellite phones. In more hazardous terrain (i.e. the canyon reach), team members wore personal floatation devices (PFDs) and helmets and carried emergency throw-bags.

2.1.2 Data Management

Immediately following each day's survey, collected data, including the raw GPS data files and photographs, were downloaded to an external hard drive on a laptop computer. Original files were also kept on the individual GPS data loggers and cameras during the survey period. Downloaded data were grouped by day and team, and at the end of each survey period, a duplicate of all collected data was made for transport back to the office.

2.1.3 Flow Measurements

Flow measurements were made at the beginning of both the August and September survey periods to estimate discharge at four locations along the lower 15 miles of Sullivan Creek. An additional flow measurement was made on Outlet Creek at the beginning of the September survey. Measurements were made using a USGS Pygmy Meter and digitally recorded using an AquaCalc Pro data logger. Table 3 summarizes the measured discharges during both the August and September periods.

Table 3. Sullivan Creek flow measurements

	Measured Discharge (cfs)		
Location	August 23-25	September 17-18	Basin Area (mi ^{2})
RM 0.5 (near USGS 12398000)	101.2	66.8	142.4
RM 5.0 (d/s of Outlet Creek)	68.0	58.0	122.1
Outlet Creek (near mouth)	-	18.5	52.31
RM 10.5 (d/s of Thor Creek)	34.0	19.6	46.4
RM 14.5 (u/s of Gypsy Creek)	9.4	9.5	22.42

Stream stage was monitored daily to detect fluctuations in discharge. Daily checks were made from the footing of the abandoned powerhouse at the SR 31 bridge near RM 0.5 prior to initiating survey work for the day. Measure-downs (measures of the height difference between the water surface and a stable reference point) were made from the northwest corner of the footing where it directly abuts the stream. Within each survey period, stream level fluctuated very little, but a noticeable change did occur between August and September. In the month of August, measure-downs ranged from 1.50 to 1.55 feet, while in September measure-downs ranged from 1.70 to 1.76 feet, indicating a drop in water level of approximately 0.2 feet between the two survey periods. NHC verified that the change in stage and discharge were consistent with each other at RM 0.5 with a Manning's equation computation using cross-section data (channel geometry and slope) collected near the gage site.

2.2 Field Data Post-processing

2.2.1 Quality Control

Each evening following survey work, the field-team leads screened data for missing or erroneous records. These records were noted in a spreadsheet log and later corrected using aerial photos, LiDAR terrain data, field photos, and written field notes.

GLONASS-capable GPS data loggers were employed to maximize accuracy for collection and mapping of habitat features. Trimble GPS Pathfinder Office software was used to perform differential correction on field GPS data and to produce GIS files of the GPS-collected points. During the correction process, the positional accuracy for each point is estimated based on a variety of parameters, including the root mean square error of individual position measurements and comparison to positional drift of the base stations. The following base stations were used for the differential correction: UNAVCO, Bonners Ferry, ID; UNAVCO, Republic, WA; and UNAVCO, Wilbur, WA. This set of stations provides reasonably strong spatial distribution around the study area, with the study area on an edge of the triangle formed by the base stations. The distribution of estimated accuracies for all 7,261 field-determined positions is highly positively skewed (Figure 3), with a median value of 1.5 meters, a mean of 3.2 meters, and a standard deviation of 13.9 m; 95 percent and 99 percent of points are estimated to be accurate within 10 meters and 20 meters, respectively. The worst positional accuracies occurred in areas where tree canopy cover was thick and the left bank (south) valley wall steep, blocking signals from many satellites.

The positions of all habitat units, large wood, log jam, and transect location points with estimated accuracy of greater than 10 meters and with positions outside of the bankfull channel were manually corrected using field-recorded station information and aerial and field photos.

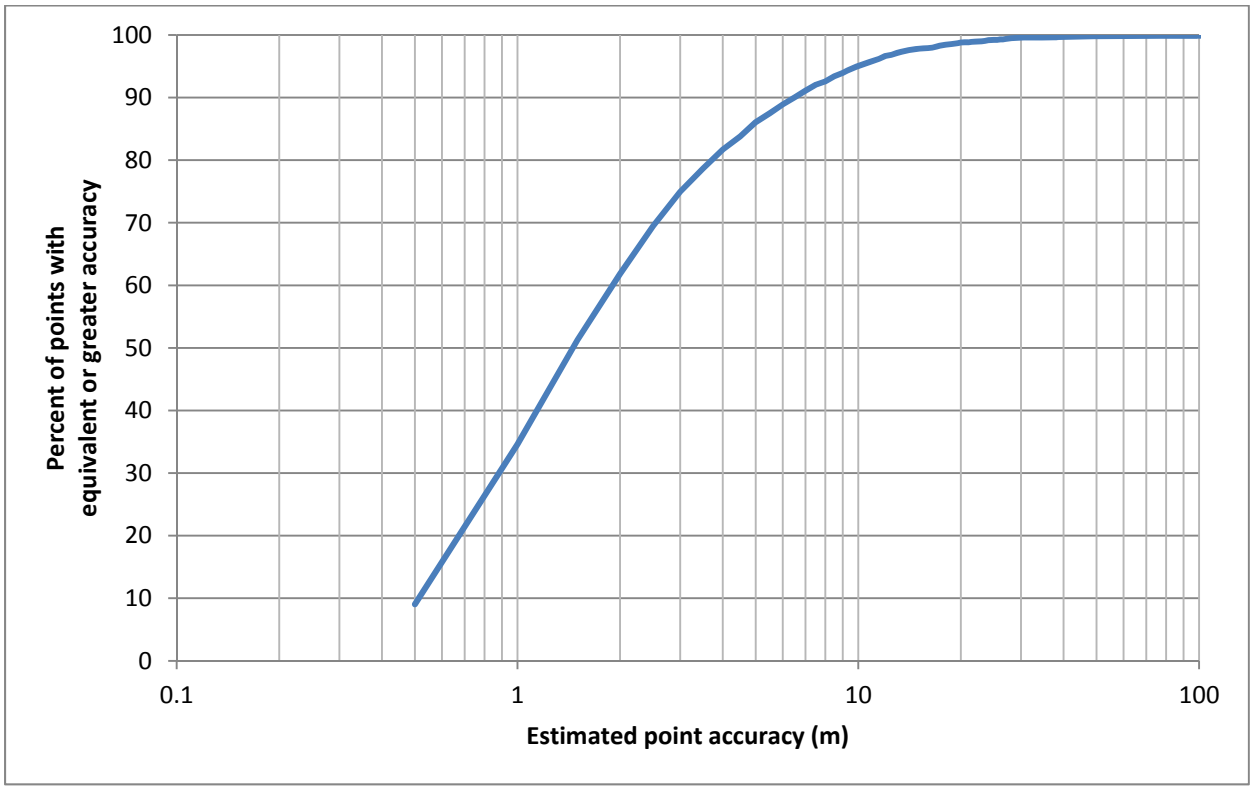


Figure 3. Cumulative distribution of estimated accuracies for all GPS-determined positions

2.2.2 Spatial Attribution

In order to simplify some elements of the data analysis, a linear referencing system was defined along Sullivan Creek. This was done using a combination of preliminary thalweg and side channel flow paths and hip-chain derived station information for individual points determined in the field. Preliminary flow paths were constructed from interpretation of one-foot resolution 2009 (USGS) and 2012 (SCL) ortho-rectified aerial photos, and, where small channels were obscured by canopy cover, from the positions of GPS points. The hip-chain derived stations were merged and referenced to a single origin (rather than many local origins at daily start locations, places the chain broke, etc.) at the stream's mouth and stretched to fit the flow path lines. Length/stationing adjustments were typically in the range of zero to ten percent.

The field data were aggregated into subreaches bounded by transect locations, which were evenly spaced at intervals of approximately 660 feet (200 m). Along most of the stream (i.e. outside of the canyon), where stationing for each point was determined using a hip chain, points were matched to subreaches by their stations (i.e. if a point had a station between those of the bounding transects it was assigned the subreach for that stretch of stream). Within the canyon, points were assigned to subreaches by their timestamps (i.e. if a point had a timestamp between those of the bounding transects it was assigned the subreach for that stretch of stream).

2.3 Terrain Data Analysis

2.3.1 Remote Sensing Datasets

2.3.1.1 Aerial photos

Two complementary high-resolution ortho-rectified aerial photo images were used in GIS analysis and mapping. They were flown during different flow conditions and at different times of day and so different areas of the stream bed are exposed and are visible outside of shadowed regions. Both had horizontal resolution of approximately one foot. The aerial photos covering most of Sullivan Creek in the USGS (2009) dataset were flown mid-afternoon in summer 2009, during low-flow conditions. The aerial photos covering Sullivan Creek in the SCL (2012) dataset were flown early in the morning during the late spring or early summer when flows were slightly below bankfull.

2.3.1.2 LiDAR

A LiDAR dataset flown on October 8 and 9, 2012 by MT LiDAR LLC provided high-resolution elevation data that were used to extract geomorphic features, to delineate final flow paths, and to define overbank topography for cross sections in the HEC-RAS model. This dataset has a grid cell size (horizontal resolution) of five feet with average vertical deviation from known control points ranging from -0.37 to +0.36 feet with a standard deviation of ±0.19 feet.

2.3.2 Flow Paths and Stream Profile

The preliminary flow paths defined from aerial photos and field GPS data were manually refined to follow local elevation minima and channel centerlines using the LiDAR elevation data and a derived hillshade image. The elevations of points along the thalweg were sampled from the LiDAR dataset at 50-foot spacing and used to develop stream profiles. These profiles were used for graphical display and to calculate subreach-average slopes. Final flow paths were defined after completion of terrain analysis (see below).

2.3.3 Terrain Metrics

A Height Above Water Surface (HAWS) grid is a useful way to display relative elevation differences across a valley bottom by eliminating the along-valley elevation trend (Jones, 2006). Patterns in the HAWS surface show geomorphic features such as active and relict channel locations, terraces, and tributary alluvial fans and the grid served as the basis for automated extraction of the low-flow and bankfull channel and floodprone area boundaries. The relative elevation above the creek was determined by creating a valley-spanning surface of the creek water surface elevation (at the time the LiDAR was flown) and subtracting this from the ground surface elevation.

In addition to the HAWS grid, grids of local slope and slope concavity (first derivative of slope) were defined from the LiDAR elevation grid. These parameters were defined for a five-foot grid size using the slope tool in the ArcGIS Spatial Analyst extension (ESRI, 2012).

2.4 Derived Spatial Products

2.4.1 Channels and Floodprone Area

Polygons bounding the low-flow channel, bankfull channel, and floodprone area were mapped using LiDAR terrain analysis and field observations. The low-flow channel was defined by an automated analysis of the terrain data. This analysis selected areas of low relative elevation (less than one-foot HAWS) and low slope (less than three percent for the mainstem, less than six percent for tributaries). This resulted in a set of discontinuous polygons along the low flow channel. A buffer of half of the observed local wetted channel width around the channel flowpath line was then added to connect these discontinuous polygons. Finally, the resulting polygon was smoothed. It should be noted that the resulting polygon includes bar tops that were not wetted during the field survey, and thus is often wider than the actual wetted width at that flow. These polygons are used for visualization of habitat conditions, but were not used in calculation of metrics such as the area of individual habitat units. These parameters were calculated directly from field measures of low-flow wetted habitat unit width and length. This procedure was modified for tributary streams surveyed in 2013 because LiDAR data was not systematically available for those streams and the scale of those streams was often such that the channel would not be resolved in a LiDAR derived topographic surface. For these streams, the low flow channel was constructed by establishing a buffer of half of the observed local wetted channel width around the channel flowpath line.

The bankfull channel polygon was also extracted from the terrain data on the basis of the HAWS grid. The field-observed difference between the water surface and bankfull elevations was mapped at each surveyed cross section and interpolated along the valley between cross sections. The area along the channel at HAWS elevations below the interpolated elevation differences defined the preliminary bankfull channel. This feature was then compared to slope and convexity maps, aerial photos, and the hillshade image and manually revised. Only areas with surface hydraulic connection to the main channel were included.

The floodprone width was defined according to Rosgen's (1996) criteria as the wetted width at twice the bankfull depth. The difference between the elevation minimum (surveyed thalweg) and bankfull elevation, i.e. the bankfull depth, was determined for each surveyed cross section and interpolated between surveyed cross sections. This depth was added to the bankfull HAWS elevation, and areas with HAWS values less than this sum value were mapped as floodprone. The outside boundary of this area was manually smoothed using landform and vegetation patterns to determine whether areas not indicated by the automated process as hydraulically connected to the main channel should be included. Along Sullivan Creek, the *floodprone area* defined in this manner is often slightly narrower than the

more generally defined *geomorphic floodplain* (as defined by Leopold et al., 1964) and occasionally excludes significant valley-bottom wetland areas.

2.4.2 Habitat Unit Polygons

Polygons representing the approximate distribution of habitat units along the streams were constructed from the geometric relationship of the habitat unit points (which are located at the downstream end of each habitat unit) and the low-flow channel polygon, without reference to the field-measured length or width of the feature. These features are useful for reach-scale cartographic display, but their area should not be used to calculate metrics of habitat unit coverage, because higher precision, field-collected data are available for this purpose. The procedure used to construct these polygons was as follows (Figure 4):

1. The habitat unit points were first sorted as to whether they belong on the main channel or a side channel.
2. Points were then snapped to the nearest location on the appropriate type of flowpath line.
3. Lines intersecting these points and perpendicular to the flowpath were constructed and used to form the habitat unit boundaries.

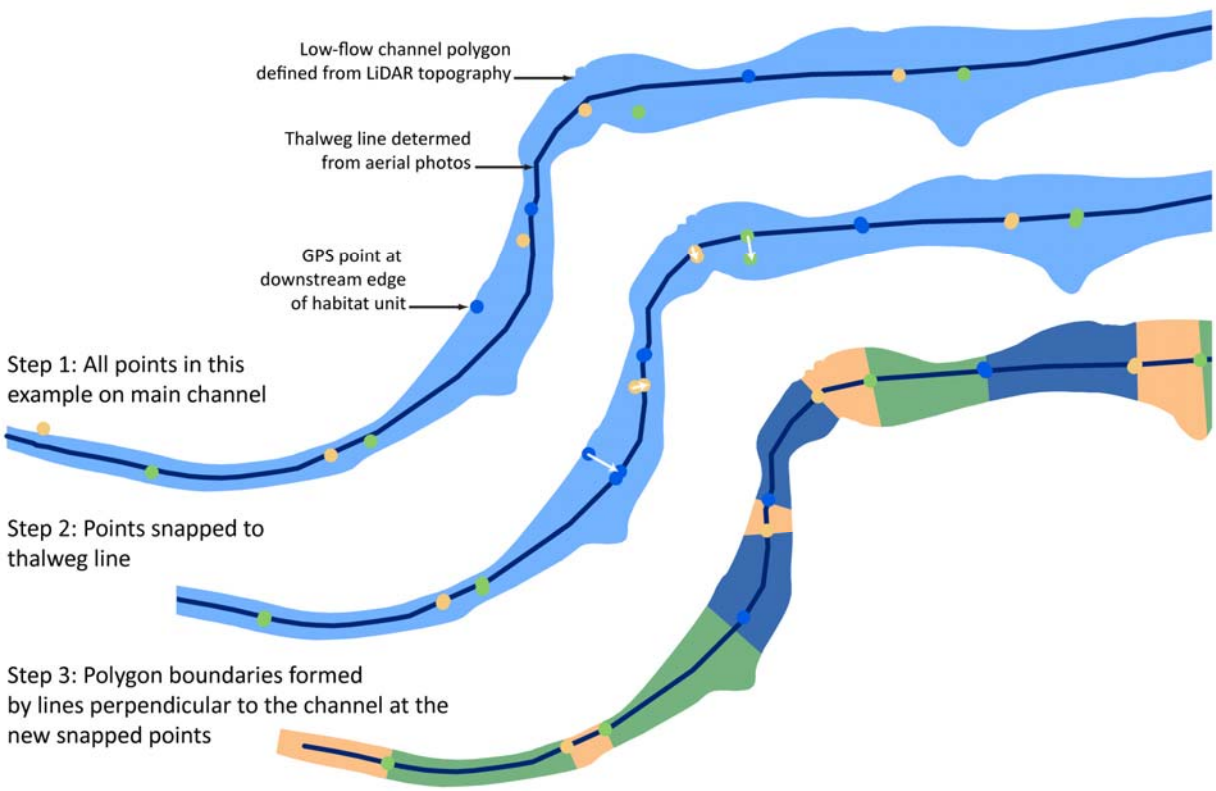


Figure 4. Habitat unit polygon creation

Embedded pools (pools deemed important by the field survey crew but that occupied less than ½ the channel width) were excluded from the above processing steps and inserted later. Points representing embedded pool locations were snapped (arbitrarily) to one of the two bank lines. Lines the length of the

unit width measured in the field were then drawn perpendicular to the bank line to form the ends of the habitat unit and connected with a line parallel to the bank to form the inside edge of the unit.

2.4.3 Subreach Drainage Area

The drainage area for each subreach was calculated using the Hydrology toolset in the ArcGIS Spatial Analyst extension (ESRI, 2012) and a 10-meter USGS DEM of the watershed. Downstream of Outlet Creek, drainage area includes the Sullivan Lake/Harvey Creek watershed.

2.4.4 Bank Conditions Lines

Bank condition lines were defined using the bank condition point features (Bank_Con in Appendix D) collected in the field and the lines along the edge of the bankfull channel polygon. The bank condition point features included attributes for the side of the channel and length of feature. These points were snapped to the appropriate side of the channel, and lines equivalent to the feature length as determined in the field were drawn along the edge of the bankfull channel polygon.

2.4.5 Landslide Polygons

Polygons representing the extent of landslides that interact with the stream were delineated at locations where sediment sources were noted in the field (Major_Se in Appendix D). The boundaries of the polygon were drawn from aerial photo and topographic interpretation informed by the field-recorded length and height dimensions.

2.5 Computation of Reach- and Subreach-scale Metrics

Because of the high spatial resolution at which field data were collected, it was possible to efficiently compute metrics describing the stream geomorphology and habitat quality at both the reach (variable lengths from 0.2 to 2.4 miles) and subreach (uniform lengths of 0.12 mile) spatial scales. Field-collected point data were placed in subreaches on the basis of the relation of the point station and/or timestamp to the corresponding attribute of the bounding transect locations. To extract information from the derived spatial products, polygons encompassing the whole valley bottom were constructed for each subreach. These subreach polygons were intersected with the various derived polygon features (e.g. bankfull channel and floodprone area) to cut the features at the subreach scale and facilitate direct comparison with the field data at that scale. Definitions of the reach and subreach attributes included in the project geodatabase are tabulated in Appendix B, Table B1 and Table B2, respectively.

2.6 Rosgen Classification

Both reach and subreach units were classified according to the Rosgen Level II approach (Rosgen, 1996). Methods for computing each of the definitive criteria (entrenchment ratio, width to depth ratio, sinuosity, slope, and channel material) are described in Table B2. (Sub) reaches with a braid index (ratio of side channel length to main channel length) greater than 1.0 were classified as having multiple channels. Following the classification key (Figure 5-3 of Rosgen, 1996), entrenchment ratio was the first classification level, followed in order by width to depth ratio, sinuosity, and slope. The reach-scale Rosgen stream type was consistently the same as the modal subreach Rosgen stream type.

2.7 Hydraulic Model

A one-dimensional, steady state hydraulic model of the main stem of Sullivan Creek was developed using the U.S. Army Corps of Engineers' HEC-RAS software package (Version 4.1.0; HEC, 2010). The

model contains the entire mainstem of Sullivan Creek, extending approximately 19.5 miles from the mouth upstream to the confluence with Deemer Creek. A large side channel, located between Kinyon and Mankato Creeks at approximately river mile 14.3, was modeled as a split reach because it was observed as a still active but topographically separate flow pathway from the main channel. The model also includes Mill Pond, with estimated spillway geometry and lake bathymetry, as well as seven bridge structures that were surveyed by NHC during the field data collection.

A total of 190 cross-sections representing the Sullivan Creek channel and overbank geometry are included in the model. Channel geometry at 138 of these cross-sections was obtained from survey data collected at transects during the field data collection, at predetermined uniform intervals of 0.12 mile, or 200 m (i.e. subreach spatial scale). Overbank elevations were extracted directly from the LiDAR data. The remaining 52 model cross sections were added to enhance model resolution with geometry extracted entirely from LiDAR data. These provide good coverage of overbank areas, but underestimate the elevation of wetted parts of the channel by the depth of the water at the time the LiDAR was flown, this error is probably typically on the order of one-foot or less.

It should be noted that both cross-section and bridge surveys were not tied into a vertical datum at the time of survey. Survey point elevations at cross sections were estimated by correlating surveyed water surface elevations with those captured in the LiDAR data at transects. Similarly, bridge deck elevations were estimated from adjacent road elevations determined from the LiDAR. Manning's roughness coefficients were initially estimated from the relation of Jarrett (1984) and later adjusted on a reach-averaged basis so that computed flow depths at the 1.5- to 2-year discharges agreed with bankfull depths estimated in the field. Final estimated values of channel Manning's roughness varied from 0.045 to 0.15, which fall within a range measured in steep mountain streams (Marcus et al, 1992). For simplicity, a single Manning's roughness coefficient of 0.10 was selected for overbank areas.

2.7.1 Estimation of Discharges for HEC-RAS Hydraulic Modeling

To provide flow inputs for the Sullivan Creek HEC-RAS model, we conducted a preliminary hydrologic analysis using USGS gage data and spatial correlation to establish flood frequency discharges at six locations along Sullivan Creek. The USGS formerly operated two gages on the mainstem of Sullivan Creek, one near the mouth of Sullivan Creek where it empties into the Pend Oreille River and another upstream of the confluence with Outlet Creek. The USGS continues to operate a gage on Outlet Creek; however, it was not used in this analysis because peak flows did not coincide with mainstem Sullivan Creek peak flows as a result of upstream regulation at the outlet of Sullivan Lake. Table 4 summarizes information for each of the USGS gage sites used in this analysis. Both gages on Sullivan Creek have 27 years of annual peak flow data available, with which flood frequency curves were computed using the U.S. Army Corps of Engineers' HEC-SSP software (Version 2.0).

Table 4. USGS gages on Sullivan Creek

Station Number	Station Name	Years of Peak Record (Water Years)	Contributing Basin Area (mi^2)
12396900	Sullivan Creek above Outlet Creek near Metaline Falls, Wash.	1958-74, 1994-2003	70.2
12398000	Sullivan Creek at Metaline Falls, Wash.	1954-68, 1970, 1994-2005	142

Flood frequency discharges were computed at four additional ungaged sites along Sullivan Creek, one located downstream of Mill Pond at the confluence with North Fork Sullivan Creek and three upstream of Outlet Creek at the confluences with Pass, Stony, and Gypsy Creeks. These sites are locations where relatively distinct and sizable increases in contributing basin area occur. Two scaling methods were used

to estimate flood frequency discharges at the ungaged sites, both of which require a flood frequency curve at a gaged location. For this analysis, the flood frequency curve computed from USGS gage data upstream of Outlet Creek was used because it represents unregulated conditions.

The first scaling method was the gaged-to-ungaged translation equation described in Sumioka et al. (1998). This relation assumes discharges at gaged and ungaged locations are proportional to their respective contributing basin areas raised to a power, which in the vicinity of Sullivan Creek (Washington Region 8) has been defined as 0.69. The Sumioka et al. (1998) equation was used to estimate flood frequency discharges on Sullivan Creek at the Pass, Stony, and Gypsy Creek confluences. Although Sumioka et al. (1998) indicate that this procedure may not be applicable when the difference in basin area between gaged and ungaged locations exceeds ± 50 percent; it was still used at Gypsy Creek. Despite draining less than 50 percent of the gaged area, results of the gaged-to-ungaged translation equation were more consistent with estimates using regional regression equations developed for nearby Idaho streams (Berenbrock, 2002) than were the Washington regression equations or alternative basin area scaling approaches.

To estimate the flow change at the confluence of the mainstem of Sullivan Creek with the North Fork, it was first necessary to estimate the flood frequency discharges for the North Fork itself. Similar to Gypsy Creek, the North Fork has a contributing basin area (10 square miles) that is less than 50 percent of the unregulated gage location. However, the Sumioka et al. equation produces results that would suggest zero, or near zero, inflow from Outlet Creek up through the 2-year event, which is not reasonable. Thus, an alternative method was employed to estimate North Fork flood frequency discharges. Here a simple linear proportionality between contributing basin areas was assumed, i.e. a power of one in the area-based translation equation. Flood frequency discharges estimated for the North Fork were then subtracted from respective values computed at the USGS gage located downstream near the mouth. Subtracting estimated North Fork discharges determined from this alternative methodology from the downstream USGS gage accounts for impacts of upstream regulation while also considering the addition of a significant unregulated tributary.

Table 5 provides the computed flood frequency discharges at gaged and ungaged locations on Sullivan Creek.

Table 5. Flood frequency discharges on Sullivan Creek

Site	HEC-RAS Reach (RM)	Drainage Area (mi^2)	Flood Frequency Discharge (cfs) Recurrence Interval (Years)						
			1.5	2	5	10	25	50	100
USGS Gage 12398000[1]	Mouth to North Fork (0-2.5)	142.6	1,054	1,322	2,095	2,692	3,544	4,250	5,019
North Fork Confluence[2]	North Fork to Outlet Ck (2.5-5.8)	130.2	924	1,172	1,899	2,465	3,279	3,957	4,698
USGS Gage 12396900[1]	Outlet Ck to Pass Ck (5.8-9.6)	69.8	909	1,042	1,365	1,577	1,843	2,040	2,237
Pass Ck Confluence[3]	Pass Ck to Stony Ck (9.6-12.6)	53.3	755	865	1,134	1,310	1,530	1,694	1,858
Stony Ck Confluence[3]	Stony Ck to Gypsy (12.6-15.2)	38.6	604	692	907	1,047	1,224	1,355	1,486
Gypsy Ck Confluence[3]	U/S Gypsy Ck (15.2-19.5)	22.5	416	477	625	721	843	933	1,023

[1]Flood Frequency Analysis, [2]Linear Scaling, [3]Gaged-to-Ungaged Translation

2.8 Limiting Factors Analysis

Three separate limiting factors matrices were completed to facilitate assessment of salmonid habitat limiting factors along Sullivan Creek—a reach-scale matrix using regional reference criteria, a reach matrix using revised criteria, and a subreach matrix using revised criteria. The regional matrix followed the template used in two previous regional studies of limiting factors for salmonid habitat (Andonaegui, 2003 and Tetra Tech, 2009), referred to henceforth as the WRIA 62 criteria. The WRIA 62 criteria were used in order to facilitate comparison of conditions along Sullivan Creek with other regional streams. The reach and subreach matrices made modifications to the WRIA 62 criteria to allow more robust comparison between reaches and subreaches of Sullivan Creek based on the detailed data collected in this study.

2.8.1 Reach-to-Regional Comparison Matrix

The WRIA 62 Pend Oreille 2496 TAG Bull Trout rating criteria (Appendix C) developed by Andonaegui (2003) were used as the basis for completion of the Sullivan Creek reach-to-regional limiting factors matrix. The following interpretations were used for ambiguous or not directly applicable criteria.

Riparian Condition. This criterion was rated as good if the riparian corridor was forested and poor if not forested. Areas with only understory disturbance (typically dispersed recreation sites) were considered to be in "good" condition because it was not possible to delineate the impact footprint from remotely-sensed data. The riparian area was defined as the larger of the floodprone area of the valley or the area within 100 feet of the bankfull channel.

Channel Substrate. The channel substrate parameter presented in the WRIA 62 could not be directly evaluated from the field inventory data collected in this study. The field data only characterized embeddedness of spawning gravel, while the WRIA 62 criteria consider the embeddedness in rearing habitat and the percent fines (as determined by sieve analysis) for spawning areas. We applied the embeddedness thresholds defined for rearing habitat to area-weighted averages of spawning gravel embeddedness: areas with average spawning gravel embeddedness less than 20 percent were rated as good, areas with 20 to 30 percent embeddedness were rated as fair, and areas with greater than 30 percent embeddedness were rated as poor. We note that embeddedness of the channel substrate along all areas of Sullivan Creek was typically very low, less than five percent.

2.8.2 Inter-reach Comparison Matrix

The inter-reach comparison limiting factors matrix was constructed based on the WRIA 62 criteria, with revisions to facilitate more nuanced evaluation of differences between reaches along Sullivan Creek. The WRIA 62 criteria, as described above, were applied to parameters retained from that matrix, except as noted in Table 6. In addition, parameters for road encroachment, streambank revetment, spawning area, dominant/subdominant substrate, log jam frequency, and pool quality were added. The criteria used to evaluate each of these metrics are presented in Table 6.

Table 6. Limiting factors criteria for inter-reach comparison matrix

Factor	Definition Criteria
Artificial structures	Same as WRIA 62 template
Riparian condition	Same as WRIA 62 template
Road encroachment	% of estimated pre-road flood prone area filled by and/or cut off by the road: <5% = G, 5-30% = F, >30% = P
Streambank instability	% of bank length stable: >90% = G, 80-90% = F, <80% = P (revised criteria from WRIA 62 template)
Streambank revetment	% of bank revetted: <3% = G, , 3-6% = F, >6% = P
Floodplain connectivity	Same as WRIA 62 template
Channel stability	Professional judgment of significant departure from either a graded condition or typical long term rate (+ indicates aggrading, - indicates degrading).
Spawning area	% of wetted area at time of survey: >5% = G, 2-5%= F, <2% = P.
Dominant/subdominant substrate	Revised criteria from NMFS (1996): G = dominant substrate is boulder, gravel or cobble (interstitial spaces clear), or embeddedness <20%; F = gravel and cobble is subdominant, or if dominant, embeddedness 20-30%; P = bedrock, sand, silt, or small gravel dominant, embeddedness >30%
Spawning gravel embeddedness	% area weighted average embeddedness of spawning gravel: <20% =G, 20-30% = F, >30% = P.
LWD	Revised WRIA 62 to include pieces ≥ channel width in addition to pieces >35 feet
Log jam frequency	Jams/mi: >9 = G, 4-9 = F, <4=poor
Pool frequency	Same as WRIA 62 template
Pool quality	Cover and/or depth. G if >50% of individual pools have >25% cover or are >1 m deep, F if >25% of individual pools have >25% cover or are >1 m deep or >50% of pools are >10% cover or less than 1 m deep, otherwise P.
Off-channel habitat	Same as WRIA 62 template
Water temperature	Same as WRIA 62 template
Change in flow regime	Same as WRIA 62 template
Non-indigenous fish species	Same as WRIA 62 template

2.8.3 Subreach Matrix

A subreach limiting factors matrix was constructed to evaluate more local conditions, as the cumulative reach-level analysis obscures important local variability in habitat conditions. Criteria were the same as those used for the inter-reach comparison limiting factors matrix, except for the off-channel habitat parameter. This parameter was evaluated using the calculated braid index (the ratio of side channel length to main channel length) for the subreach, with a value of zero being poor, zero to 0.2 fair, and greater than 0.2 good.

3 Data Summarization and Mapping

3.1 Data Summarization

More than 100 individual attributes (listed in Appendix B) were collected and/or computed for each subreach, then aggregated to the reach scale. A complete list of attributes is included in Appendix B, and selected attributes important for further analysis and discussion are summarized in Table 7 (by reach) and Table 8 (by subreach). The Sullivan Creek geodatabase (digital Appendix F) includes the complete attribute tables for each reach and subreach, as well as field-collected data and photographs.

Table 7. Summary of key attributes by reach

Reach	Rosgen channel type	Slope (LiDAR derived, ft/ft)	Pools/ mi	Large wood pieces[†]/mi	Log jams/ mi	Entrench-ment ratio	Width / depth ratio	Low flow wetted side channel (% of area)
S1	C3	0.013	8	10	9	2.24	28	3.4
S2	A2	0.030	14	6	4	1.29	11	0.3
S3	C3	0.012	3	10	6	2.30	21	0.0
S4	Mill Pond							
S5	C3-C4	0.005	7	113	9	5.35	31	4.0
S6	B3c	0.008	4	91	2	1.92	20	3.8
S7	C3	0.015	5	43	5	2.98	21	5.7
S8	B3c-B2c	0.015	6	65	2	1.71	13	0.0
S9	C4	0.017	15	135	12	3.24	24	24.8
S10	B3c	0.013	3	23	0	1.49	15	0.0
S11	C3	0.015	9	54	18	3.40	19	4.8
S12	C3-C2	0.016	16	157	25	3.27	17	8.3
S13	C3-C2	0.017	5	66	12	2.26	15	0.8
S14	C3-C2	0.015	6	22	5	2.53	13	0.8
S15	C3	0.012	8	110	16	4.01	19	0.3
S16	C3	0.015	23	89	24	3.12	21	20.3
S17	B2a	0.048	17	49	8	1.75	13	0.8
S18	B3-B2	0.028	17	143	14	2.00	18	11.9
S19	DA3c	0.02	32	380	17	4.11	31	20.3
NFS 1	B2a+	0.06	48	343	46	2.0	7.7	4
O1	C3	0.05	26	38	26	2.9	8.0	5
H1	D6a	0.14	60	24	4	15.1	3.7	58
J1	B2a+	0.11	38	8	0	2.9	3.0	1
P1	C3b	0.04	50	1176	47	2.93	15	23.3
W1	A4a+	0.11	61	27	7	1.3	1.3	0
T1	C4a+	0.10	9	43	0	4.2	1.2	25
ST1	E3a	0.10	88	88	28	2.6	6.1	0
R1	B2a+	0.10	43	55	0	2.1	1.9	0

Reach	Rosgen channel type	Slope (LiDAR derived, ft/ft)	Pools/ mi	Large wood pieces[†]/mi	Log jams/ mi	Entrench-ment ratio	Width / depth ratio	Low flow wetted side channel (% of area)
K1	A3+	0.01	61	52	8	1.3	3.0	0
C1	B4	0.10	75	55	7	2.0	2.5	18
GY1	B3b	0.06	31	684	16	2.95	15	0.6
GY2	B4a	0.09	92	116	32	3.1	5.7	3
M1	B2a+	0.13	74	314	58	1.7	3.7	2
SH1	D4a	0.11	207	556	97	13.9	9.0	38
D1	C3b	0.03	30	298	32	3.08	30	6.6
L1	B3b	0.06	40	785	24	2.23	18	10.8

[†]Defined here as pieces greater than 35 ft long if bankfull width is greater than 25 feet and pieces greater than 25 feet long if bankfull width is less than 25 feet.

3.2 Data Visualization

Two sets of maps and a series of charts were produced to visualize the habitat inventory and geomorphic data collected in this study and to facilitate evaluation of spatial relationships of habitat and geomorphic features. These maps and charts show the data at various scales and levels of generalization. Detailed Habitat Features maps show positions of key habitat features as determined from the field survey, Reach-Scale maps show generalized habitat units and floodplain topography at a broader scale, and the charts show synoptic plots of along-stream variability of many different habitat and geomorphic features.

The most detailed set of maps (1:3000-scale Habitat Features maps, Plates A1-A29) show positions of pools, large wood jams, large wood pieces, patches of spawning gravel-sized material, areas of eroding and/or armored banks, and landslides on an aerial photo base map (Pend Oreille County, 2012). In addition, they show pie charts of the dominant substrate distribution for each subreach. These maps are useful for detailed evaluation of local factors producing channel complexity and habitat value.

The Reach-Scale maps (Plates B1-B23) are plotted at a 1:6000-scale appropriate for visualizing variability over the defined study reaches. They show polygons representing individual habitat units; locations of large wood jams, bank erosion, bank armor, and landslides; bankfull channel and floodprone area; and tables summarizing key habitat metrics for each reach and subreach.

The series of charts (Plates C1-C6) area compact graphical summary of the principal geomorphic, hydraulic, and habitat feature data collected in this study. Along with the maps described above, they provide a valuable reference tool and are the basis for much of the subsequent analysis in this report. All of the charts have the same horizontal scale, so they can be stacked on top of each other to evaluate spatial correlation of different variables. Each page of charts includes the stream profile and slope plot as well as reach boundaries for reference. Other plotted parameters include dominant habitat type, relative habitat quality, spawning gravel area and embeddedness, LWD abundance, road encroachment and bank armor, side channel to main channel length ratio (i.e. braid index), distribution of dominant substrate material, size distribution of representative transported material based on Wolman pebble counts, low flow channel width, bankfull channel width and depth, and flood prone width. Summary results of the hydraulic model including the width of the 100-year floodplain, shear stress, and modeled flow velocity are similarly plotted.

Table 8. Summary of key attributes for mainstem Sullivan Creek by subreach (see appendix B for tributary data)

Sub-reach	log jams / mi	pools / mi	width / depth ratio
S1-1	6	6	56
S1-2	0	8	18
S1-3	21	41	27
S1-4	0	7	14
S2-1	0	32	12
S2-2	20	80	9
S2-3	15	60	9
S2-4	0	15	12
S2-5	0	13	13
S2-6	7	22	11
S2-7	0	36	10
S2-8	0	54	8
S2-9	0	33	8
S2-10	0	34	10
S2-11	0	42	13
S2-12	0	15	13
S3-1	7	7	17
S3-2	21	14	42
S3-3	6	0	25
S3-4	0	0	30
S3-5	0	7	21
S3-6	8	23	19
S3-7	15	7	24
S3-8	0	0	19
S3-9	22	22	16
S3-10	6	17	14
S3-11	0	28	4
S5-1	0	8	38
S5-2	8	0	48
S5-3	8	15	19
S5-4	20	20	30
S5-5	7	15	21
S6-1	0	15	24
S6-2	8	0	20
S6-3	0	13	17
S7-1	0	7	25
S7-2	8	15	20
S7-3	0	0	23
S7-4	8	16	25
S7-5	8	23	11
S8-1	0	7	14
S8-2	0	8	12
S8-3	0	38	13
S8-4	0	7	14
S8-5	8	24	13
S8-6	0	7	11
S8-7	9	17	11
S9-1	7	36	27
S9-2	0	34	20
S9-3	26	45	24
S10-1	0	0	12
S10-2	0	16	15
S10-3	0	8	19
S11-1	15	23	21
S11-2	39	54	25
S11-3	27	27	19
S11-4	8	8	16
S11-5	0	8	13
S11-6	26	32	15
S11-7	5	0	17
S11-8	8	8	15
S11-9	0	21	16
S11-10	13	44	25
S11-11	8	16	20
S11-12	14	14	17
S11-13	23	23	21
S11-14	30	30	18
S11-15	44	22	27
S12-1	8	25	15
S12-2	37	95	18
S12-3	32	59	23
S12-4	37	52	20
S12-5	8	16	13
S12-6	8	0	12
S12-7	49	49	20
S12-8	17	17	16
S13-1	0	7	16
S13-2	28	7	15
S13-3	7	15	13
S13-4	7	21	12
S13-5	0	0	13
S13-6	30	38	21
S13-7	8	0	17
S14-1	12	12	16
S14-2	0	0	12
S14-3	5	37	10
S14-4	7	22	12
S14-5	0	8	13
S14-6	0	8	15
S15-1	15	29	22
S15-2	7	15	26
S15-3	34	34	15
S15-4	27	27	18
S15-5	0	0	15
S16-1	16	64	22
S16-2	35	111	40
S16-3	34	43	26
S16-4	25	66	20
S16-5	6	23	17
S16-6	15	37	17
S16-6SC	8	70	NA
S16-7	14	29	19
S16-8	8	34	22
S16-9	0	41	21
S16-10	7	7	14
S16-11	15	77	15
S17-1	0	45	21
S17-2	9	35	15
S17-3	6	58	15
S17-4	0	50	13
S17-5	0	34	13
S17-6	0	30	10
S17-7	8	53	9
S17-8	0	30	10
S17-9	21	49	12
S17-10	7	66	17
S17-11	15	73	18
S17-12	7	40	11
S17-13	14	14	11
S17-14	14	42	10
S17-15	14	42	12
S17-16	0	46	14
S17-17	7	44	9
S17-18	8	39	9
S18-1	7	28	11
S18-2	32	80	14
S18-3	15	44	22
S18-4	0	21	14
S18-5	8	8	12
S18-6	0	38	18
S18-7	0	8	16
S18-8	33	0	14
S18-9	25	98	28
S18-10	8	109	25
S19-1	17	58	32
S19-2	8	137	21
S19-3	25	75	35
S19-4	16	86	51
S19-5	150	43	16

3.3 Geomorphic Setting

Within the study area, we inventoried a total of 1,949 individual morphologic habitat units under low-flow conditions. We found 48 percent of the creek area was riffle, 22 percent pool, 15 percent glide, 9 percent pocket water, and 6 percent cascade (see Plate C1). Pools are distributed along the stream, with highest concentration in reaches with abundant log jams and reaches with colluvial or bedrock substrate.

Steep headwater reaches (S17, S18, and tributaries) are dominated by pocket water. Lower gradient reaches are dominated by riffles and, where influenced by log jams, forced pool-riffle-glide sequences. The canyon between Mill Pond Dam and Boundary Reservoir includes significant areas of cascade interspersed with pools. The following paragraphs describe changes in conditions along Sullivan Creek (and tributary Deemer Creek) from downstream to upstream.

Reaches S1 through S3 are situated below Mill Pond Dam. Reach S1 (Plates A1 and B1) extends from the Sullivan Creek delta into Boundary Reservoir (Photo 1) across an alluvial fan through the Pend Oreille River valley (Photo 2) to the state highway crossing. The riparian area has been extensively modified in this reach, exemplified by the industrial wastewater treatment facility along the right bank, and there is limited remaining riparian forest. Sediment is deposited because the slope decreases in reaches S1&S2 resulting in aggradation in these reaches.

Reach S2 (Plates A1-A4 and B1-B2)—the canyon—flows through a narrow, steep bedrock canyon at the edge of the Pend Oreille River valley. It is characterized by cascades interspersed with deep bedrock pools (Photo 3).

Photo 1. The Sullivan Creek Delta into Boundary Reservoir. Note significant unstable bars of fine sediment.

Photo 2. Cobble-dominated riffle and cleared riparian area at boundary of subreaches S1-3 and S1-4.

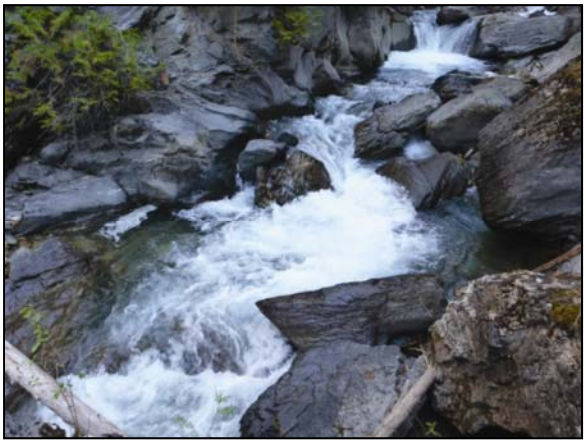


Photo 3. Boulder formed pools and cascades in canyon reach S2.

Photo 4. Riffle-dominated plane bed reach starved of fine sediment and wood in subreach S3-4.

Photo 5. Landslide between Sullivan Creek and Sullivan Lake Road in subreach S5-4

Photo 6. Decommissioned road and failed log cribwall on left bank in subreach S6-3. Revetment associated with the decommissioned road may contribute to reduced channel migration and channel simplification downstream.

Photo 7. Wood accumulation and bar growth associated with aggradation in reach S7-4 create good habitat.

Photo 8. In unconfined parts of reach S11, accumulations of large wood in log jams produce very complex channels with high-quality pools.

Photo 9. Reach S8 flows through a bedrock-confined but alluvium-filled canyon.

In reach S3 (Plates A5-A6 and B3), immediately downstream of Mill Pond Dam, the stream is starved of LWD and bedload and is dominated by long riffles (Photo 4). Bedload starvation has driven degradation that has resulted in the channel becoming disconnected from the floodplain in much of this reach. For all subreaches of reach S3, the proportion of the bed with dominant bedrock or boulder substrate (34% ± 30%) is significantly greater ($t=62$, $df=44$, $p< 0.01$) than for subreaches in other parts of the stream with comparable slope, and there is little to no gravel or smaller material.

In reaches S5 through S7 (Plates A7-A9 and B4-B5), the stream's slope increases from 0.2 percent to two percent as it moves upstream from the delta it has built into Mill Pond. The stream deposits its entire bedload and transported large woody debris in these reaches before entering Mill Pond, resulting in substantial aggradation in these reaches. The stream has initiated two large landslides in subreaches S5-4 and S5-5 (Photo 5), but typically has very simple trapezoidal cross section geometry and interacts with some local revetment (Photo 6). Outlet Creek, which conveys regulated flows from the 70-square mile Sullivan Lake watershed, enters Sullivan Creek at the boundary between reaches S6 and S7. Accumulation of large wood in jams and bars in subreach S7-4 creates high-quality habitat locally (Photo 7).

Photo 10: Road confinement in reach S10 and associated plane bed channel.

Photo 11: Sequence of channel spanning weirs and bridge crossing in subreach S11-9.

Photo 12. Pool and side channel forming log jam in subreach S16-2.

In reaches S8 through S14 (Plates A9-A17 and B6-B12), the stream is mostly unconfined with a gentle gradient (approximately 1.5 percent) (Photo 8), interspersed with short confined segments and short steeper segments (gradients up to 2.5 percent) (Photo 9). In these reaches, local steps in the channel profile are caused by bedrock control, alluvial fans, and channel-spanning log jams that cause upstream sediment accumulation and downstream degradation[1].

The floodplain in significant portions of this group of reaches has been disconnected from the stream by Sullivan Creek Road, which is commonly protected from stream erosion by riprap revetment (Photo 10). These revetments often coincide with long riffle reaches that have little habitat complexity. They also block the stream from interacting with the valley wall and recruiting wood and sediment; in these reaches, 10 of 12 significant landslides that contribute sediment and large woody debris to the stream are on the bank opposite the road.

Additionally, several sub-reaches of the stream in these reaches have been modified by channel-spanning weirs, which appear to hold the stream in a straight, uniform channel with reduced cross-channel variability in depth (Photo 11). In one subreach (S11-7), modified K-weirs[2] have caused a doubling of the channel's width and the formation of a long riffle (Plate A13).

Reaches S15 and S16 (Plates A18-A21 and B13-B15) lie in an unconfined valley. The slope increases upstream from 0.8 percent at the bottom of reach S15 to 3 percent at the head of reach S16. The stream meanders between large log jams, which induce pool-forming scour and locally split the flow into side channels (Photo 12), which typically have abundant large wood and gravel substrate (Photo 13).

Photo 13. High quality habitat in 0.3 mile long side channel (subreach S16-6SC/S16-5 to S16-7).

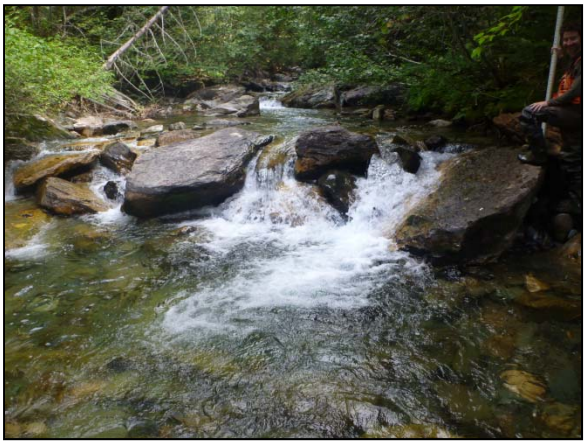


Photo 14: Boulder-formed pools in subreach S17-7

Photo 15: Pool and pocket water habitat formed by boulder and cobble roughness in subreach S17-14.

[1] Details of the pattern of aggradation and degradation are shown in Table 17 and Appendix D.
[2] That is, weirs on either side of the channel pointing obliquely downstream with a gap in-between.

Upstream of this valley, Sullivan Creek descends a steep, narrow gorge (reaches S17 and S18, Plates A22-A27 and B15-B17) where the slope ranges from three to six percent. The stream in this area is dominated by boulders that form step-pool sequences (Photo 14) and pocket water habitat (Photo 15). Finally, reach S19 and most of the surveyed part of Deemer Creek (reach D1) anastomose across a wide valley bottom (Plates A28-A29 and B18-B19). Log jams split the channel into many smaller threads that surround stable wooded islands (Photo 16 and 17).

The surveyed parts of other tributaries exhibit widely varying channel morphology and are discussed in sequence from downstream to upstream below.

North Fork Sullivan Creek joins Sullivan Creek on the right bank, below Mill Pond. It flows through a moderately sloped valley (2-4%) before dropping into a steep series of cascades and waterfalls (with up to 8 foot drop heights, Photo 19) as it approaches the main stem of Sullivan Creek. In addition to the natural fish passage barrier formed by these waterfalls, the culvert beneath Sullivan Lake Road and a water diversion structure create artificial passage barriers. The lower 800 m of this channel was surveyed. Here the dominant substrate is boulders and the channel morphology is dominated by steep cascades with some wood-forced step-pool sequences. At the upstream end of the survey, the gradient was much less steep and the channel had typical riffle-pool morphology.

Outlet Creek (left bank) joins Sullivan Creek just above Mill Pond. This creek forms the outlet to Sullivan Lake. It is low gradient, wood rich above the lowest subreach, and has abundant spawning-sized gravel (Photo 18).

The morphology of Highline Creek (right bank) is dominated by beaver dams and a human built crib wall structure, which acts as a fish passage barrier. These features form large ponds and wetlands and a very low gradient channel.

Photo 16. Part of anastomosing channel system with very high density of stable large wood in subreach S19-4.

Photo 17: Abundant Old-Growth Cedar in the Sullivan Headwaters reach.

Photo 18: Abundant large wood splits the flow of Outlet Creek around vegetated bars.

John's Creek (left bank) is steep (consistently ~10%) and is characterized by boulder-formed step-pool morphology (Photo 20). It has limited LWD and pools, with relatively young riparian forest and limited wind-throw into the creek.

Pass creek (Photo 21) in contrast, is wood rich and is dominated by wood-forced step-pool morphology.

Wassan Creek (right bank) transitions from a very steep (>20%) cascade and step-pool dominated channel above Sullivan Creek Road to a low-gradient riffle-pool and forced step-pool channel below Sullivan Creek Road. Anthropogenic features on the creek include constructed log weirs and the Sullivan Creek Road culvert. The culvert acts as a passage barrier, while the weirs create substantial pools and spawning gravel patches (Photo 22), but may also limit some fish passage.

Thor Creek (left bank) enters Sullivan Creek through a series of fish-impassable cascades. Above these, the creek flows through many, very-shallow channels due to a recent avulsion at the head of the alluvial fan.

Stony Creek (left bank) crosses under Sullivan Creek Road through a relatively new pipe-arch culvert that appears to be fish-passable. It has typical step-pool morphology forced by both boulder and wood steps and cobble-dominated substrate.

Rainy Creek (right bank) is steep (13%), has boulder-formed step pool morphology and cobble and boulder dominated substrate. Although Rainy Creek is not wood-rich, the riparian area along the creek consist of very large timber and that appears undisturbed, so modern conditions on Rainy Creek are most likely similar to pristine conditions.

Photo 19: Waterfall on North Fork Sullivan Creek with two 8-foot steps.

Photo 20: Boulder-formed step pool sequence on John's Creek.

The surveyed part of Kinyon Creek (right bank) flows across a very large and relatively low gradient alluvial fan (the channel slope is approximately 5% on the distal part of the fan). The channel has wood-forced pool-riffle and step-pool morphology with areas of cascades and long riffles where wood is lacking. The culvert where Kinyon Creek flows under Sullivan Creek Road is a fish passage barrier.

The lower part of Copper Creek (right bank) flows through an abandoned side channel of Sullivan Creek that has been dammed by the Copper Creek alluvial fan. The lower part of the creek includes large pool and wetland areas formed by beaver dams. The upper part of the creek is much steeper and exhibits boulder formed step-pool morphology. Currently, the creek is aggrading on the alluvial fan and appears poised to avulse to a new position on the fan in the near future.

Mankato Creek (left bank) is extremely steep (15% slope) with cascade and wood-forced step pool morphology (Photo 23).

Gypsy Creek (right bank) is consistently steep (~6% slope), with step-pool and cascade morphology. The lower part of the creek has recently downcut, likely due to removal of wood form the channel by recreational users.

Leola creek is steep (~6% slope), and has extremely abundant large wood that creates wood-forced step pool morphology.

Photo 21. Log-forced step pool sequence on Pass Creek.

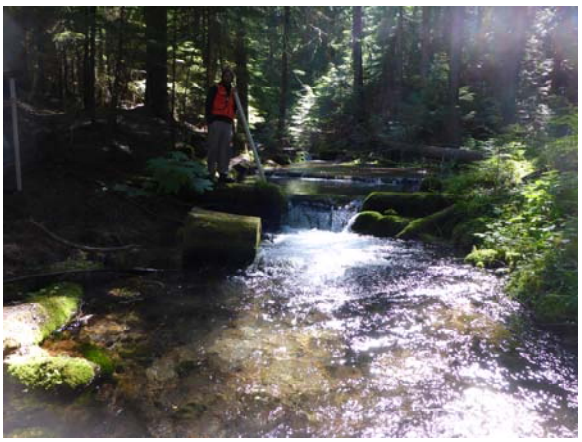


Photo 22: Constructed weirs on Wassan Creek form large pools.

Photo 23: Steep wood-rich cascade on Mankato Creek.

3.4 Relationships between Geomorphic and Habitat Conditions

3.4.1 Rosgen Stream Type

The Rosgen Level II stream type (Rosgen, 1996) was determined for each subreach. Rosgen's approach delineates stream types based on entrenchment, width to depth ratio, sinuosity, slope, and bed material (Figure 5). Stream types A (5 percent of subreaches), B (38 percent), C (47 percent), D (4 percent), E (1 percent), and F (5 percent) are represented in the study area. Rosgen type A streams are steep, entrenched, deep channels with low sinuosity; type B streams are moderately steep, moderately entrenched channels; type C are slightly entrenched, wide, and sinuous channels on lower gradients; type D are anastomosing "braided" channels; type E are slightly entrenched, deep, and sinuous, and type F are entrenched, moderate to shallow channels with moderate to low slopes.

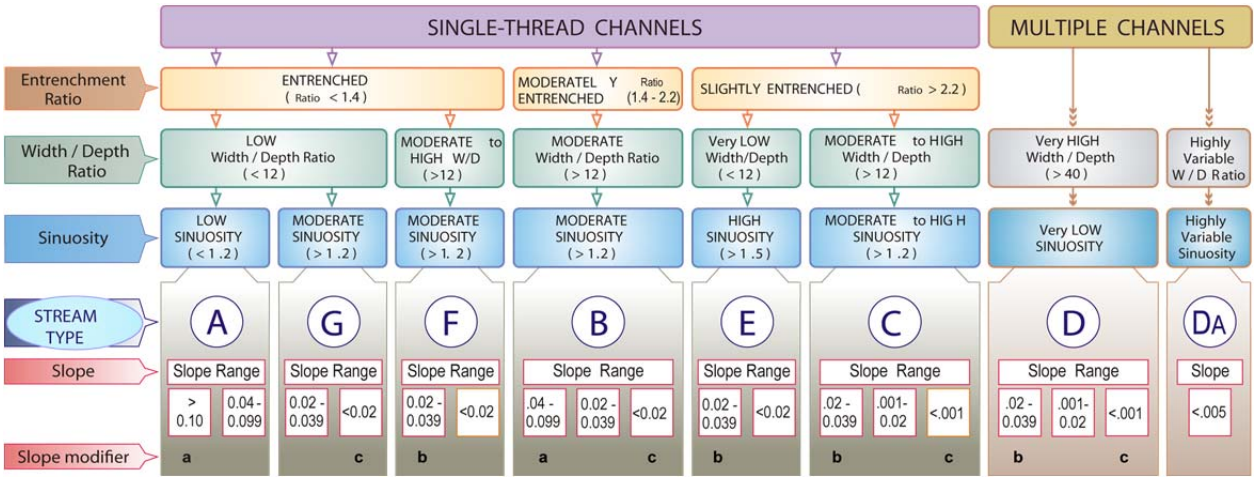


Figure 5. Key to Rosgen Classification of Natural Rivers, adapted from Rosgen (1996). Substrate number modifiers are not shown. Numbers 1-6 indicate substrate in the sequence bedrock, boulder, cobble, gravel sand, and silt/clay, respectively.

There were very few subreaches of types A, F, and E, so entrenched stream types (A and F) and slightly entrenched stream types (C and E) were grouped for purposes of this analysis. Table 9 shows the Rosgen stream types present in each reach. Because all type B2a channels were located in reach S17, which is a colluvial reach with distinct morphology and habitat characteristics, Rosgen type B2a was separated from other Rosgen type B2 streams; otherwise channel material and slope sub-classifications were not considered in this analysis. Table 10 shows some key habitat parameters summarized for these grouped Rosgen stream types.

Entrenched streams (types A and F) occur in reaches S2 and S3 in the canyon below Mill Pond. Type A streams are steep, entrenched, cascading, step-pool channels, and type F streams are entrenched, low-gradient streams with high width to depth ratio. In the study area, these stream types have the least wood, almost no side channel habitat, and very little spawning area. However, pools in these areas are formed by boulders and bedrock features and tend to be substantially deeper than in subreaches of other stream types.

Moderately entrenched streams of Rosgen B-type, excluding B2a, are moderate-gradient, riffle-dominated channels. Subreaches of this stream type occur throughout the study area, often in areas where the floodplain has been confined by road fill. In the study area, they have the most infrequent

pools and low overall influence of log jams and large woody debris. In the uncommon instances where significant log jams are present, pools form nearly as commonly as for type C streams (Table 11). The type B subreaches have few side channels and poor off-channel habitat.

Rosgen type B2a streams are very steep, boulder-dominated, moderately-entrenched step-pool channels that border on type A streams. In the study area, they occur only in reach S17, which is naturally steep and confined. The streambed is colluvial, meaning that it is dominated by boulders from adjacent hill slopes that the stream cannot move. As with other Rosgen B-type subreaches, these subreaches show limited influence of large wood. However, in contrast to the other Rosgen B-type subreaches, B2a subreaches have abundant pools and pocket water formed by boulder dams and scattered boulders in the channel.

Table 9. Subreach distribution of Rosgen Level II types by reach

	Rosgen Type																							Total Subreaches
	Entrenched						Moderately Entrenched								Slightly Entrenched						Multiple			
W/D Sub-Category	A	A	A	F	F	F	B	B	B	B	B	B	B	B	C	C	C	C	C	C	E	D	D	D	
Dominant Channel Material	1	2	3	2	2	3	2	2	2	3	3	3	3	4	2	2	3	3	4	6	3	3	3	4	
Slope Modifier					b		a		c		a	b	c	c		b		b			a		b		
S1													2				1					1			4
S2	1	5		1	3	1			1																12
S3	1			1		1							4		2		2								11
S4	Mill Pond																								0
S5																	3		2						5
S6													3												3
S7										1							4								5
S8			1						1				4				1								7
S9													1				1			1					3
S10													3												3
S11													1		1		8		4			1			15
S12													1	1		2	3	1							8
S13									2				1		1		3								7
S14								1					1			1	3								6
S15													1				4								5
S16								1									8	1						1	11
S17							13			1	2					1		1							18
S18								2		3	1		1				1	2							10
S19																	3					2			5
P1																		1			1				2
GY1												1									1				2
L1										1								3					1		5
D1											1							1							2
All	2	5	1	2	3	2	13	4	4	6	4	1	23	1	4	4	45	10	6	1	2	4	1	1	149

Rosgen type C streams are low-gradient, meandering, alluvial pool-riffle channels with broad floodplains, and type E streams are low-gradient, meandering, deep, pool-riffle channels. These slightly entrenched reaches have abundant pools, strong influence of large wood and log jams, and relatively abundant side channel habitat and good floodplain connectivity. They generally occur in unconfined, low-gradient areas. When large wood and large wood jams are present, Rosgen type C subreaches contain some of the best habitat; but they are very sensitive to a lack of large wood and have very few pools in subreaches without log jams (Table 11).

Rosgen type D streams have anastomosing channels with highly vegetated and generally stable banks. In the study area, they have the most abundant pools, greatest influence of log jams and large wood, and most abundant spawning area of the observed stream types. They occur mostly in low-gradient and lower energy headwater areas with wide alluvial valley areas and dense coniferous riparian vegetation.

Table 10. Key habitat parameters by Rosgen type

Rosgen Type(s)	Pools (pools/mi)‡	Average Residual Depth (ft)‡	Armored Bank (%)	Large Wood (pieces/mi)	Log Jams (jams/mi)	Braid Index†	Area of spawning-size gravel* (ft^2/mi)
A&F	35 ± 18	3.0 ± 1.1	1.3	82	6	0.01	800
B	24 ± 27	1.8 ± 0.6	3.2	163	8	0.1	3,000
B2a	47 ± 13	1.7 ± 0.2	0	141	8	0.07	3,000
C&E	36 ± 39	1.8 ± 0.6	1.8	198	17	0.3	5,000
D	70 ± 27	1.4 ± 0.2	3.5	232	26	1.5	11,000

†Side channel length divided by main channel length
* See appendix A for definition
‡Ranges represent ±1 standard deviation

Table 11. Average pool frequency by log jam frequency classes for different Rosgen types

Rosgen Type(s)	Average Pool Frequency by Log Jam Frequency Class (pools/mi)		
	> 10 jams/mi	4-10 jams/mi	<4 jams/mi
A&F	54	20	33
B	48	22	13
B2a	51	50	35
C&E	52	22	17
D	70	n/a	n/a

Note that positive correlation of pool and log jam frequency is stronger for type B and C&E type and less so for types B2a and A&F. Type D streams only occur where log jams are very abundant.

3.4.2 Large Wood and Log Jams

Plate C2 shows the distribution of large wood along Sullivan Creek compared to slope and longitudinal profile plots. Individual pieces of large wood (defined as logs greater than 25 feet long with diameter at breast height (dbh) greater than 12 inches or logs greater than 10 feet long with root wads 3 feet in diameter or larger) are spread more evenly through the system than large wood jams. Individual pieces of large wood are recruited to the stream through tree fall caused by windthrow or bank erosion and

through landslides. Large wood jams contain the majority (over 60%) of individual large wood pieces. They are concentrated in areas of low slope upstream of valley grade control features (typically tributary alluvial fans, landslides, and bedrock), where transported wood accumulates, and at the toe of and just downstream of landslides, which deliver a large charge of wood locally to the stream.

Dimensional characteristics of key pieces that form log jams along Sullivan Creek are shown in Table 12. Length is the most important factor: 70 percent of all key pieces are greater than 35 feet long, and less than 10 percent are less than 25 feet long. Key pieces are rarely less than 12 inches in diameter, but for pieces greater than 12 inches, there is no positive relationship between diameter and key piece status, e.g., a 30-foot log with diameter of 30 inches is not more likely to act as a key piece than a 30-foot log with diameter of 20 inches. Additionally, 70 percent of log jam key pieces have root wads. Not surprisingly, the proportion of log jam key pieces that are longer than 35 feet increases with bankfull channel width. In reaches with average bankfull width greater than 60 feet, the proportion of key pieces greater than 35 feet long ranges from 30 to 100 percent; in reaches with average bankfull width between 60 and 90 feet, the proportion of log jams with key pieces greater than 35 feet ranges from 50 to 100 percent; and in reaches wider than 90 feet (with the exception of reach S1 near the mouth), the proportion of log jams with key pieces greater than 35 feet long ranges from 90 to 100 percent.

Table 12. Percentages of log jam key pieces in length and diameter classes

		Diameter at Breast Height				
		4-12 in	12-24 in	24-36 in	>36 in	all
Length	> 35 ft	2	37	26	5	70
	25-35 ft	1	13	5	1	20
	3-25 ft	0	5	3	2	10
	all	4	55	34	7	100

3.4.3 Pools

The majority of pools in the study area are formed by large wood and large wood jams (56 percent of pools), while 38 percent of pools are formed by bedrock and boulders. Five percent of pools are free-form in natural pool-riffle sequences, and the remaining pools are formed by other features, including beaver dams. In reaches S2, S3, S8, and S17, which are typically steep and entrenched, the majority of pools (90 percent) are formed by bedrock and boulders. Elsewhere, the majority of pools (75 percent) are formed by large wood. Pool frequency is positively correlated with log jam frequency.

3.4.4 Road Encroachment and Revetment

Plate C3 shows the pattern of road encroachment and revetment in the study area. With the exception of reach S17, where the effect of road encroachment probably did not significantly change geomorphic characteristics of the already confined stream, areas of road encroachment and bank revetment, especially where the floodprone area is narrow, correspond to areas locally lacking wood and pools.

3.5 Hydraulic Modeling

The channel roughness (Manning's n) values were adjusted in the HEC-RAS model so that computed depths for the 1.5-year recurrence flow approximately matched observed bankfull depths at the surveyed cross sections. The HEC-RAS model was then run for a range of flows from the estimated 1.5-year to 100-year peaks. Table 13 provides a summary of reach averaged hydraulic parameters computed

at the 1.5-year recurrence interval. Results for higher flows are included in the digital HEC-RAS model files in Appendix G.

Table 13. Reach-averaged hydraulic parameters for 1.5-year peak flow

Reach	Discharge (cfs)	Max Channel Depth (ft)	Active Channel Top Width (ft)	Channel Velocity (ft/s)	Friction Slope (ft/ft)	Channel Shear (lb/sf)	Manning's n	D50 (mm)
S1	1054	4.5	57	6.2	0.012	2.8	0.058	96
S2	1043	5.0	63	5.6	0.029	6.8	0.098	119
S3	924	3.7	69	5.1	0.012	2.4	0.065	106
S4	— Mill Pond							
S5	924	4.0	76	4.6	0.006	1.4	0.055	66
S6	924	4.4	53	4.5	0.007	1.6	0.065	91
S7	911	4.1	47	5.6	0.013	2.9	0.068	61
S8	909	4.3	51	6.0	0.013	3.0	0.063	98
S9	909	3.7	68	6.1	0.017	2.9	0.059	-
S10	909	3.6	57	5.9	0.012	1.9	0.051	85
S11	868	3.9	56	5.7	0.013	2.9	0.064	102
S12	755	3.7	59	4.9	0.017	3.4	0.080	142
S13	755	3.9	39	7.0	0.016	2.9	0.053	-
S14	642	4.2	35	6.3	0.017	2.9	0.059	68
S15	604	3.3	32	7.0	0.012	2.1	0.045	73
S16	584	3.0	39	6.5	0.014	2.1	0.047	73
S17	293	3.0	34	4.7	0.047	7.7	0.118	120
S18	293	2.4	30	5.7	0.025	3.0	0.060	108
S19	293	2.5	35	4.9	0.013	1.3	0.047	69

The existing HEC-RAS model was developed using cross section data collected at relatively coarse spatial scales to provide approximate hydraulic parameters for conditions along Sullivan Creek. Cross section locations were determined based on the protocols established for the habitat surveys, i.e. at uniform subreach intervals of approximately 0.12 mile or 200 meters. This interval is wider than would typically be used in systems as steep as Sullivan Creek. The current model is not a robust means of evaluating local to subreach scale hydraulic controls (such as boulders, LWD, or log jams) and so it will generally not simulate local water surface elevations accurately, particularly at lower flows. In a number of locations the model defaults to critical depth. At these locations an alternative normal depth computation methodology indicates the potential error in computed flow depths and velocities may be on the order of 25 to 50 percent.

In its current form, the HEC-RAS model is best-suited as a screening-level tool to check whether flooding of road crossings may be aggravated as a result of implementing a suite of recommended actions. For design level computations, e.g. in areas targeted for restoration, additional cross-section data will be necessary to improve geometric resolution and accuracy of computed hydraulic parameters, particularly in those areas defaulting to critical depth in the existing model. Furthermore, the one-dimensional model will only provide a gross approximation of complex cross sectional variations in conveyance or velocity due to turbulent flow, abrupt transitions, or local flow obstructions (e.g. log jams and boulders). In such cases a two-dimensional model may be warranted.

4 Analysis and Discussion

The following sections provide interpretation and discussion of the data presented in previous sections. Our intention is to provide a context within which to understand observed habitat conditions, to describe variability in habitat conditions along Sullivan Creek and perceived causes of this variability, and to identify the best and poorest habitat conditions in the study area.

4.1 Limiting Factors Analysis

4.1.1 Habitat Conditions Relative to Regional Performance Criteria

The relationship of habitat conditions on Sullivan Creek to regional performance criteria was evaluated by applying WRIA 62 Pend Oreille 2496 TAG Bull Trout rating criteria (Appendix C; Andonaegui, 2003) to the habitat data collected along Sullivan Creek in this study. Details of the specific interpretation of these criteria are described in the Methods section of this report (Section 2.8.1).

Table 14 summarizes the results of this analysis. Artificial structures other than Mill Pond Dam do not limit fish passage in the study area. Riparian condition was typically rated good, except in a few reaches where the road consistently runs parallel and in close proximity to the stream. Streambank condition was exclusively rated good. Floodplain connectivity was rated good, except in reach S3, where a large floodplain area is cut off by Sullivan Lake Road.

Channel stability was rated good in 18 of 23 reaches in the study area and fair in the remaining five. These five reaches are locations where the relationship between the Rosgen (1996) width to depth and entrenchment ratios indicates significant degradation or aggradation is occurring that might result in a shift in channel type. The ratios are all within, but near the edge of, expected values. Overall, channel stability is not judged to be a significant problem on Sullivan Creek.

Channel substrate received eight poor ratings and four fair ratings, making it one of the most poorly-rated criteria. As noted in Section 2.8.1, the channel substrate data collected as a part of this study do not fit particularly well with the WRIA 62 criteria. In this study, embeddedness data were collected only for patches of “spawning gravel” sized material (uninterrupted patches of 6- to 64-mm material). The WRIA 62 criteria consider the embeddedness of both spawning and rearing habitat and/or the percent fines in spawning habitat. Because we only recorded embeddedness of spawning gravel patches, which occur almost exclusively in hydraulically sheltered areas in the study area, our sample is biased toward including embedded areas. Furthermore, our definition of spawning area was likely too restrictive for bull trout, which use both gravel and cobble substrate (e.g. USFWS, 1999 and citations therein). We observe that the majority of the Sullivan Creek channel has cobble substrate (Plate C4) with very low embeddedness and suspect that channel substrate conditions are not actually a limiting factor for bull trout. If the NMFS (1996) criteria (see the “Dominant/Subdominant” criterion in Table 6) are used, then all reaches of Sullivan Creak would be rated good with respect to channel substrate.

Large woody debris was found to be lacking in all reaches downstream of Mill Pond Dam and adequate in all reaches upstream of the dam except reaches 10 and 14, with good potential for future recruitment. We note that the WRIA 62 criterion for LWD abundance does not scale the definition of large wood to stream size. However, the areas lacking in large wood in the study area are the farthest downstream and have relatively high bankfull withstand so the WRIA 62 criterion is most appropriate for those reaches. Because of this, we believe the poor rating for large wood in these reaches is appropriate.

Table 14. Habitat limiting factors along Sullivan Creek using WRIA 62 rating criteria

Reach	Artificial Structures	Riparian Condition†	Streambank Condition (WRIA 62 definition)	Floodplain Connectivity	Channel Stability	Channel Substrate‡	LWD (WRIA 62 definition)††	Pool Frequency and Quality	Pool Depth	Off-channel Habitat‡‡	Water Temperature	Change in Flow Regime	Non-indigenous fish species
S1	G	G	G	G	G	G	P	G	G	F	F	F	P
S2	G	G	G	G	G	G	P	G	G	NA	F	F	P
S3	P	G	G	P	G	G	P	G	G	F	F	F	P
S4	Mill Pond												
S5	P	G	G	G	G	P	G	G	G	G	G	G	P
S6	G	G	G	G	G	F	G	G	F	F	G	G	P
S7	G	G	G	G	G	P	G	F	F	G	G	G	P
S8	G	G	G	G	F	P	G	G	G	P	G	G	P
S9	G	G	G	G	G	F	G	G	G	G	G	G	P
S10	G	P	G	G	F	P	P	P	G	P	G	G	P
S11	G	G	G	G	G	G	G	G	G	G	G	G	P
S12	G	G	G	G	G	P	G	G	F	G	G	G	P
S13	G	G	G	G	G	P	G	F	F	F	G	G	P
S14	G	G	G	G	F	P	P	P	G	F	G	G	P
S15	G	G	G	G	G	P	G	P	G	G	G	G	P
S16	G	G	G	G	G	F	G	G	G	G	G	G	P
S17	G	P	G	G	F	G	G	G	F	NA	G	G	P
S18	G	F	G	G	G	G	G	G	F	NA	G	G	P
S19	G	G	G	G	G	G	G	G	P	G	G	G	P
NFS1	P	F	G	G	G	F	G	F	F	NA	G	G	uk†††
O1	P	G	G	G	G	G	G	G	F	G	G	F	P
H1	P	G	G	G	F+	F	P	G	P	NA	G	G	P
ST1	P	P	G	G	G	G	G	G	P	NA	G	G	F
J1	P	G	G	G	G	G	P	F	P	NA	G	G	P
P1	G	G	G	G	G	G	G	G	P	G	G	G	P
W1	P	F	G	G	G	G	G	F	P	NA	G	G	P
T1	G	G	G	G	G	F	G	P	P	NA	G	G	F
R1	G	G	G	G	G	G	G	F	P	NA	G	G	G
K1	P	G	G	G	G	G	G	F	P	NA	G	G	P
C1	P	G	G	G	G	G	G	G	P	G	G	G	P
GY1	G	G	G	G	F	G	G	G	P	NA	G	G	P
GY2	G	G	G	G	G	G	G	G	F	NA	G	G	P
M1	G	G	G	G	G	G	G	G	P	NA	G	G	P
D1	G	G	G	G	G	G	G	G	P	G	G	G	P
L1	G	G	G	G	G	F	G	G	P	NA	G	G	P
SH1	G	G	G	G	G	P	G	G	P	NA	G	G	F

†Assumed "good" composition of riparian species if forested. Riparian area defined as areas within floodprone area of valley or within 100 ft of the bankfull channel.

‡Calculated by applying the criterion: <20% area-weighted average embeddedness of spawning gravel=good, 20-30%=fair, >30%=poor.

††This parameter does not consider either the site potential forest structure or channel width.

‡‡In reach S3, one large significant wetland area may be connected to the stream by a fish-passable culvert or may be isolated from the stream.

††† No recent survey to detect presence of Brook Trout. Steep channel and non-passable culvert at confluence with Sullivan Creek suggest no access.

The pool frequency and quality and pool depth criteria both have relatively few good ratings in the study area, indicating that high-quality pool habitat is likely a significant limiting factor on Sullivan Creek. Pool frequency is rated as fair or good in reaches S7, S10, and S13 through S15. With the exception of reach S7, these are all areas where the road significantly encroaches on the creek's alluvial corridor (see Plate C3). Most pools along Sullivan Creek occur in high gradient, step-pool reaches (which are typically dominated by pocket water habitat units) or are associated with large wood obstructions or forced pool-riffle morphology caused by log jams. In areas of moderate slope (1.5 to 2.5 percent) where stable pieces of large wood and/or log jams are lacking, a plane bed morphology lacking in pools forms. It should be noted that the pool depth criterion in the WRIA 62 matrix is not scaled to channel size. On headwater reaches of Sullivan Creek and the surveyed tributaries, a lack of sufficiently deep pools results in a poor rating for depth, even if deep pools would not be expected to form given the channel size.

Off-channel habitat also has a relatively high number of fair and poor ratings. Channel straightening, elimination of potential migration areas through road fill, and reduced abundance of LWD likely have reduced the amount of off-channel habitat available in the system.

Other limiting factors attributes in the WRIA 62 limiting factors matrix are water temperature, change in flow regime, and non-indigenous fish species. Collection of data with which to make judgments on these criteria was beyond the scope of this study. We rated change in flow regime, non-indigenous fish species, and water temperature criteria based on qualitative descriptions provided by Seattle City Light.

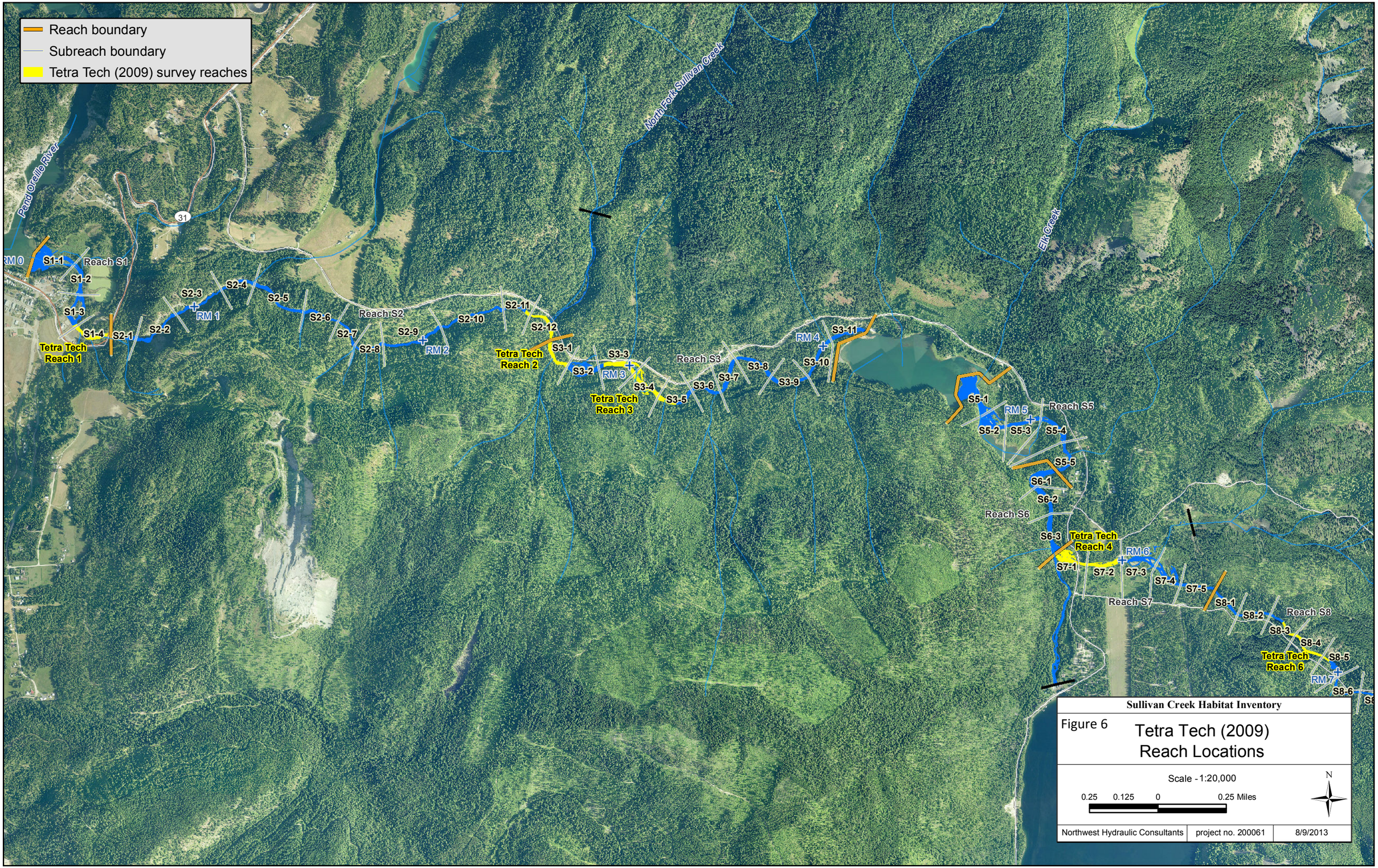
4.1.1.1 Comparison with past studies

The WRIA 62 bull trout habitat limiting factors assessment (Andonaegui, 2003) provides significant documentation of habitat conditions along Sullivan Creek, with some summary of information from other documents (USFS, 1996; R2, 1998; Entrix, 2002). Additionally, Tetra Tech (2009) surveyed five reaches of Sullivan Creek to describe geomorphic and habitat conditions. The locations of these reaches relative to the subreaches delineated in the present study are shown in Table 15 and Figure 6.

Table 15. Relationship of Tetra Tech (2009) reaches to subreaches in the present study

Tetra Tech (2009) reach	Present study subreaches
1	S1-4 through S2-1
2	S2-11 through S3-1
3	S3-3 through S3-5
4	S7-1 thorough S7-2
5	n/a (Outlet Creek)
6	S8-3 through S8-4

This comparison follows the organization of both Tetra Tech (2009) and Andonaegui (2003), which is based on elements of the limiting factors table. These descriptions evaluate barriers to fish passage, riparian condition, streambank condition, floodplain connectivity, channel stability, channel substrate, large woody debris, pool frequency and quality, pool depth, off channel habitat, and other parameters not in the scope of the present investigation.



Air photo: Pend Oreille County 2012

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Andonaegui (2003) noted two possible natural barriers to fish passage (boulder-controlled steps) in reach S2. These features were observed to still be present during fieldwork in late summer 2012. Mill Pond Dam, which is a complete barrier to fish passage, also remains in place.

Both Tetra Tech (2009) and Andonaegui (2003) describe riparian conditions along Sullivan Creek that are mostly recovering from historical timber harvest, with greater than 50 percent species composition equivalent to what would be expected under natural conditions but with not yet fully mature timber stands in much of the riparian area. Sullivan Lake Road and Sullivan Creek Road impinge on the creek's riparian corridor in many places. These descriptions are consistent with conditions observed in the present investigation. R2 (1998) determined mean canopy cover of 10 percent for a set of unspecified surveyed habitat units. In the present study, the mean canopy cover on Sullivan Creek was determined to be 42 ± 23 percent (± 1 standard deviation). Reach-average values range from a minimum of 3.1 percent in Reach 1 to a maximum of 71 percent in Reach 17, with a significant linear correlation to bankfull width(R^2=0.84, F=85, P<0.001), with canopy cover increasing as bankfull width decreases moving upstream. The value reported by R2 falls within the range of values observed in the present study.

Both Tetra Tech (2009) and Andonaegui (2003) describe both the channel and streambank as generally stable with landslides, debris torrents below Mill Pond Dam, and bank erosion contributing sediment to the system. Our observations are consistent with this description, although no recent debris torrents were noted. Our observations support the inference of Andonaegui (2003) that riprap was placed to protect Sullivan Creek Road from small rotational slides initiated by toe erosion by Sullivan Creek. One significant landslide was noted by USFS (1996) near the mouth of Clark Creek (the tributary that joins Sullivan Creek at the boundary of S5-4 and S5-5); we observed two distinct active landslides in that vicinity. Areas immediately upstream of Mill Pond dam are aggrading and areas immediately downstream are degrading.

Descriptions of floodplain connectivity in previous reports are qualitative and typically suggest that there is little floodplain connectivity because Sullivan Creek is entrenched. We have documented significant areas with good floodplain connectivity but believe that this difference is due to different areas of investigation rather than changed conditions.

Tetra Tech (2009) reports D_{50} of channel substrate for their surveyed reaches but does not describe in detail the morphologic location that was sampled. These values can be compared to our Wolman pebble counts (conducted on bar heads away from the local influence of large wood) and to field descriptions of dominant substrate (Table 16). Pebble counts from the present study typically determined a D_{50} smaller than that described by Tetra Tech (2009), but qualitative descriptions of the dominant substrate of the wetted channel are comparable. The discrepancy in measured D_{50} values most likely results from sampling of different morphologic units in the two studies and not changes in conditions through time; the present study only sampled bar-heads, which represents relatively fine material that has been actively transported, while the Tetra Tec may have sampled the wetted channel, which would typically be coarser than bars.

Table 16. Comparison of bed material descriptions from Tetra Tech (2009) and the present study

2008 Location (Tetra Tech reach number)	2008 D_{50} (mm)	2012 subreach	2012 D_{50} (mm) at bar heads	2012 dominant substrate of wetted channel
1	77	S1-4	148	cobble
2	140	S2-11	140	boulder
3	180	S3-10	105	cobble-boulder
4 downstream	130	S7-1	54	cobble
4 upstream	150	S7-2	64	cobble-boulder
6	110	S8-3	86	boulder-cobble

Andonaegui (2003) reports that 47 percent of surveyed reaches of Sullivan Creek had less than 20 pieces of large wood per mile and that 56 percent of the reaches lacking wood were below Mill Pond Dam. We found that 21 percent of surveyed subreaches of Sullivan Creek had less than 20 pieces of large wood per mile, with 50 percent of these subreaches below Mill Pond Dam. Without knowing the locations and extents of the reach surveys reported in Andonaegui (2003), it is not possible to conclusively determine whether the apparent increase in large wood is a real change in the condition of the stream or a result of sampling different areas.

Tetra Tech (2009) reported a log jam in their "Reach 3." We observe a jam that, based on similarity of photographs, appears to be the same jam in subreach S3-3. At this same location, Tetra Tech (2009) reported a one-foot wide right bank side channel, which is also still present. Tetra Tech (2009) also reported a log jam upstream of their "Reach 6." We believe this to be the same as a jam observed in subreach S8-5. This jam remains in place, as do gravel deposits upstream of the jam.

Generally, our observations of pool frequency are consistent with those of Andonaegui (2003) and Tetra Tech (2009), with one notable exception. Tetra Tech (2009) reported only one pool present in their Reach 6. We observed several pools in subreach S8-3, just upstream of a landslide. It is possible that hydraulic changes caused by this landslide have resulted in pool formation.

Overall, there is no evidence to suggest significant change in geomorphic or habitat conditions on Sullivan Creek in the areas of overlapping inventory between the present study and previous studies (USFS, 1996; R2, 1998; Entrix, 2002; Andonaegui, 2003; and Tetra Tech, 2009). The only exceptions to this general statement are in large wood abundance and the number of pools in one subreach.

4.1.2 Variability of Habitat Quality Along Sullivan Creek

Two additional habitat quality/limiting factors matrices were developed in addition to the WRIA 62 limiting factors analysis in order to better understand variability in habitat conditions within the study area. One uses data at the reach-scale (Table 17) and the second uses data at subreach-scale (Appendix D, Table D1). Assessment elements and delineation criteria were developed to incorporate additional elements and/or thresholds observed to be related to habitat conditions on Sullivan Creek and to better show variability between (sub)reaches. (Specific delineation criteria used in these analyses are described in the Methods section (see Table 6) of this report.)

Table 17. Reach-scale revised limiting factors analysis

Reach	Artificial Structures	Riparian Condition	Road Encroachment	Streambank Instability	Streambank Revetment	Floodplain Connectivity	Channel Stability†	Spawning Area	Dominant/subdom. substrate	Spawning Gravel Embeddedness	LWD	Jams	Pool Frequency	Pool Depth	Pool Quality	Off-channel Habitat	Water Temperature	Change in Flow Regime	Non-indigenous fish species
S1	G	G	G	F	P	G	G+	F	G	G	P	F	G	G	F	F	F	F	P
S2	G	G	G	G	G	G	G -	P	G	G	P	P	G	G	G	NA	F	F	P
S3	P	G	P	G	G	P	P-	P	G	G	P	F	G	G	G	F‡	F	F	P
S4	Mill Pond																		
S5	P	G	G	F	G	G	P+	G	G	P	G	F	G	G	G	G	G	G	P
S6	G	G	G	G	G	G	F+	P	G	F	G	P	G	F	P	F	G	G	P
S7	G	G	F	G	G	G	F+	P	G	P	G	F	F	F	F	G	G	G	P
S8	G	G	F	G	F	G	F-	P	G	P	G	P	G	G	G	P	G	G	P
S9	G	G	F	G	F	G	G	P	G	F	G	G	G	G	F	G	G	G	P
S10	G	P	P	G	P	G	F-	P	G	P	G	P	P	G	G	P	G	G	P
S11	G	G	F	G	G	G	G+	F	G	G	G	G	G	G	F	G	G	G	P
S12	G	G	F	G	G	G	G+	P	G	P	G	G	G	F	F	G	G	G	P
S13	G	G	F	G	G	G	G-	P	G	P	G	G	F	F	P	F	G	G	P
S14	G	G	P	G	P	G	F-	P	G	P	G	F	P	G	F	F	G	G	P
S15	G	G	G	G	G	G	G	F	G	P	G	G	P	G	F	G	G	G	P
S16	G	G	G	G	G	G	G+	G	G	F	G	G	G	G	P	G	G	G	P
S17	G	P	P	G	G	G	F-	F	G	G	G	F	G	F	P	NA	G	G	P
S18	G	F	P	G	G	G	G	G	G	G	G	G	G	F	F	NA	G	G	P
S19	G	G	P	G	G	G	G+	G	G	G	G	G	G	P	P	G	G	G	P
NFS1	P	F	F	G	G	G	G	F	G	F	G	G	F	G	F	NA	G	G	uk
O1	P	G	G	G	G	G	G	G	G	G	G	G	G	G	F	G	G	F	P
H1	P	G	G	G	G	G	F+	F	P	F	G	F	G	P	G	NA	G	G	P
J1	P	G	G	G	G	G	G	P	G	G	P	P	F	P	F	NA	G	G	F
P1	G	G	G	G	F	G	G	G	G	G	G	G	G	P	P	G	G	G	P
W1	P	F	F	G	G	G	G	G	G	G	G	F	F	P	P	NA	G	G	P
T1	G	G	G	G	G	G	G	G	G	F	G	P	P	P	G	NA	G	G	F
ST1	P	P	P	G	G	G	G	F	G	G	G	G	G	P	F	NA	G	G	F
R1	G	G	G	G	G	G	G	G	G	G	G	P	F	P	F	NA	G	G	G
K1	P	G	G	G	G	G	G	G	G	G	G	F	F	P	F	NA	G	G	P
C1	P	G	G	G	G	G	G	G	G	G	G	F	G	P	F	G	G	G	P
GY1	G	G	G	G	G	G	F-	F	G	G	G	G	G	P	P	NA	G	G	P
GY2	G	G	G	G	G	G	G	F	G	G	G	G	G	F	F	NA	G	G	P
M1	G	G	G	G	G	G	G	G	G	G	G	G	G	P	F	NA	G	G	P
D1	G	G	G	G	G	G	G	G	G	G	G	G	G	P	F	G	G	G	P
L1	G	G	G	G	G	G	G	G	G	F	G	G	G	P	F	NA	G	G	P
SH1	G	G	G	G	G	G	G	G	G	P	G	G	G	P	G	NA	G	G	F

† + indicates aggrading, - indicates degrading; ‡ In reach S3, one large significant wetland area may be connected to the stream by a fish-passable culvert or may be isolated from the stream.

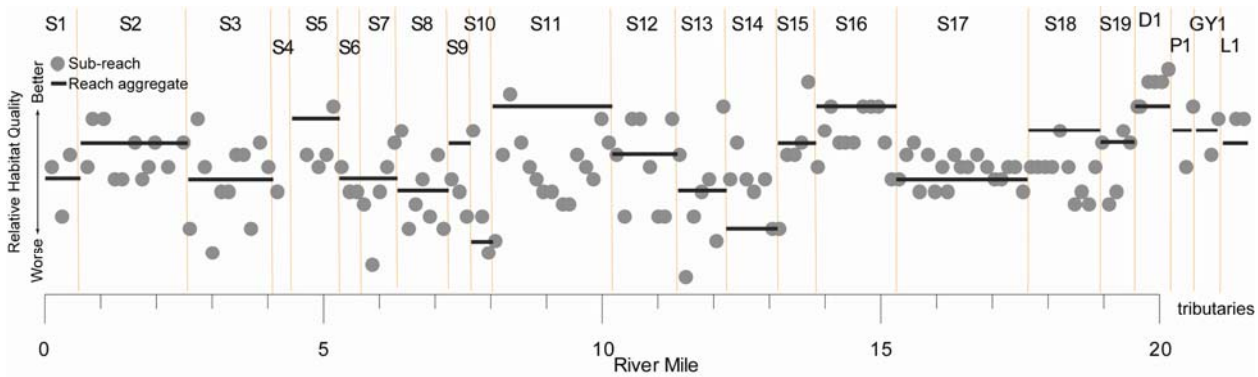

Figure 7. Relative habitat quality rankings at reach and subreach scale

4.1.2.1 Relative habitat quality by reach and subreach

In order to facilitate comparison of overall habitat conditions between and among reaches and subreaches, an aggregate habitat quality score was calculated for each reach and subreach. This was done by assigning each good rating a score of two, each fair rating a score of one, and each poor rating a score of zero, summing the values for all attributes for each (sub)reach, and scaling the resulting totals between 0 and 100. Scores were calculated for common attributes of the reach and subreach scale tables, excluding artificial structures, water temperature, change in flow regime, and non-indigenous fish species (which were not assessed at the subreach scale and are outside the primary focus of this study).

Figure 7 graphically shows the results of this analysis for both reaches and subreaches, and Table 18 ranks reaches by relative habitat quality. The top four ranking reaches are tributary streams. The next three (ranks 5 through 7) are low-gradient reaches high in the system that have wide floodprone areas. The most poorly ranked three reaches are locally steep and confined alluvial reaches.

Table 18. Habitat quality ranking of reaches surveyed in 2012 at both reach and subreach scales.

Reach	Subreach average rank	Reach aggregate rank	Reach	Subreach average rank	Reach aggregate rank
D1	1	1	S18	12	9
L1	2	6	S9	13	13
P1	3	2	S17	14	14
GY1	4	3	S3	15	17
S16	5	4	S7	16	15
S15	6	10	S14	17	21
S19	7	7	S1	18	18
S5	8	8	S6	19	16
S2	9	11	S13	20	19
S11	10	5	S8	21	20
S12	11	12	S10	22	22

Notably, the reach ranking often does not fall in the middle of the cluster of its component subreach rankings. The reach-scale rankings are consistently higher than the average of subreach-scale rankings (Figure 8). For example, in reach S11 most subreach points fall below the reach ranking. This is caused by the uneven distribution of habitat features within reach S11. Large amounts of LWD, jams, and spawning area are concentrated in just a few subreaches that, when aggregated to reach-scale, result in

good ratings. This illustrates how interpretation and ranking of habitat quality along a stream using tools such as limiting factors analysis can be highly scale-dependent.

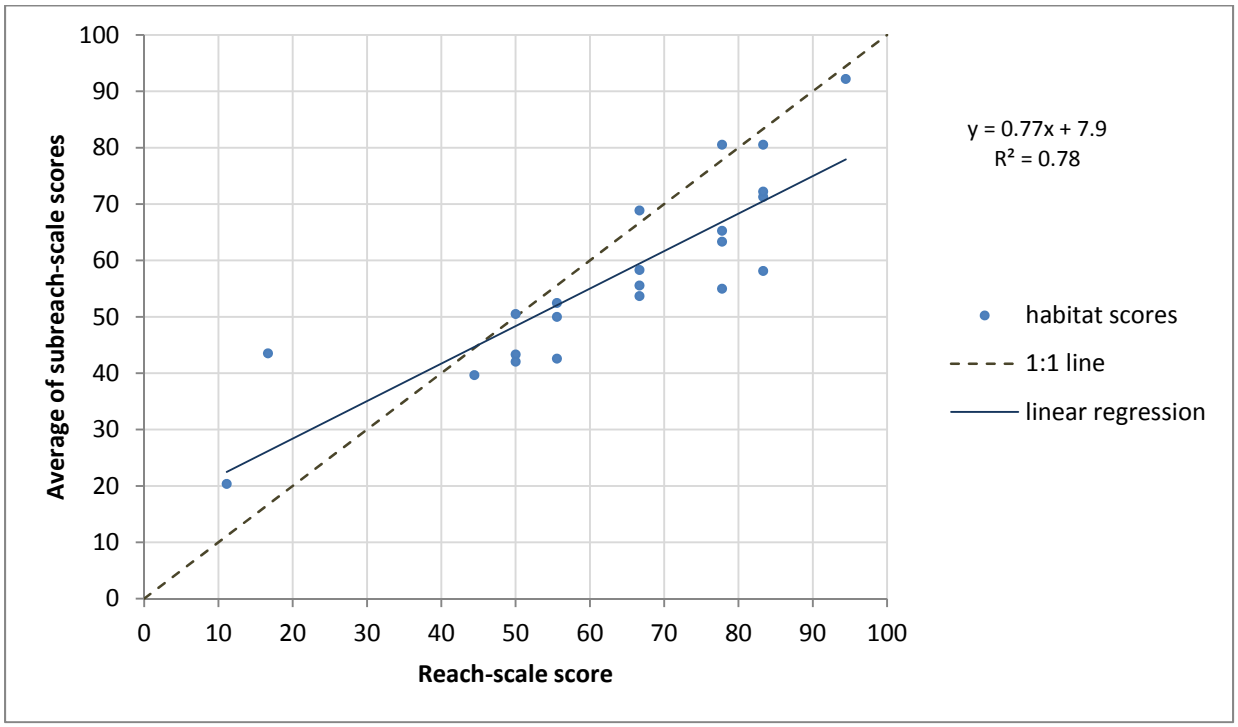

Figure 8. Relation of reach-scale habitat score to average of subreach scale scores for each reach.

Because the reach-scale ranking of habitat quality masks important intra-reach variability in many instances (Figure 7), we also report habitat quality ranking at the subreach scale (Table 19). The distribution of habitat scores closely approximated a normal distribution and descriptive rankings were defined so that the boundaries between qualitative categories (best and very good, very good and above average, etc.) approximately correspond to the mean plus or minus 1 or 2 standard deviations of the data prior to collection of data on tributary streams in summer 2013. These subreach ratings are also depicted in Figure 9, using the same color scheme for relative quality categories as shown in the table. The subreach rankings are helpful in targeting habitat deficiencies (and hence potential project locations) as will be discussed further in the Recommendations section. The rankings may also provide some basis for prioritization of locations for habitat enhancement measures.

Table 19. Ranking of subreaches by habitat quality score

Subreach	Rank	Subreach	Rank	Subreach	Rank	Subreach	Rank
D1-4	Best	S11-10	above average	S7-3	average	S17-17	below average
NFS1-4		S12-3		S8-5		S18-8	
S15-4		S16-1		S11-4		S19-1	
D1-1		S18-9		S11-6		S19-2	
D1-2		P1-2		S12-4		S6-3	
D1-3		O1-1		S12-8		S11-5	
M1-1		O1-2		S13-3		S11-9	
SH1-1		R1-1		S15-5		S13-4	
S11-2		T1-1		S16-11		S14-3	
S19-4		S2-6		S17-3		S14-5	
C1-1		S2-9		S17-5		S1-2	Poor
K1-2		S2-11		S17-8		S8-4	
O1-4		S3-9		S17-9		S9-2	
SH1-1.5		S7-4		S17-11		S12-1	
SH1-2		S11-3		S17-14		S13-2	
S5-4	Very Good	S11-14		S17-15		S18-7	
S11-13		S15-2		S18-2		S2-12	
S13-6		S15-3		S18-4		S3-8	
S16-2		S16-3		S18-6		S8-6	
S16-6		S16-4		J1-1	below average	S11-8	
S16-6SC		S16-5		S2-4		S12-5	
S16-7		S16-9		S2-5		S14-6	
S16-8		S18-3		S2-7		S8-1	
L1-2		GY1-1		S8-3		S10-1	
K1-1		S1-3		S9-1		S10-3	
NFS1-2		S3-6		S11-11		S13-5	
O1-3		S3-7		S11-12		S3-3	Worst
ST1-1		S5-1		S14-4		S10-2	
ST1-2		S5-3		S16-10		S7-1	
S2-2		S11-15		S17-2		S1-4	
S2-3		S13-7		S17-12		S13-1	
S3-1		S14-1		S17-13		S13-1	
S12-2		S15-1		S17-18			
S12-7		S17-1		S18-5			
S19-5		S17-7		NFS1-3			
P1-1		S17-10		S3-4			
GY1-2		S18-1		S3-5			
D1-5		S18-10		S3-11			
L1-1		S19-3		S6-1			
GY2-3		H1-1		S6-2			
GY2-4		NFS1-1		S7-2			
H1-2		S1-1	average	S8-2			
J1-2		S2-1		S8-7			
R1-2		S2-8		S11-7			
SH1-3		S2-10		S12-6			
W1-1		S3-2		S14-2			
S7-5		S3-10		S17-4			
S9-3		S5-2		S17-6			
S11-1		S5-5		S17-16			

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Table 20 is a matrix showing correlation of habitat attribute ratings with each other and with overall habitat score. Habitat attribute ratings that are significantly ($\alpha<0.05$) correlated with the overall habitat score are, in order of strength of association: log jams, road encroachment, riparian condition, LWD, off-channel habitat, pool frequency, spawning area, and streambank revetment. Note that in the ratings approach, good conditions for negative influences were given high scores (i.e. no road encroachment has a high score, not a low score), and so the correlations shown are all positive and in the expected direction. Habitat attribute ratings that are correlated with each other include road encroachment and riparian condition, off-channel habitat and spawning area, and jams and off-channel habitat.

Table 20. Significant habitat attribute correlations

	Riparian Condition	Road Encroachment	Streambank Instability	Streambank Revetment	Floodplain Connectivity	Channel Stability	Spawning Area	Dominant/Subdominant Substrate	Spawning Gravel Embeddedness	LWD	Jams	Pool Frequency	Pool Quality	Off Channel Habitat	Total Score
Riparian Condition	1														
Road Encroachment	0.79	1													
Streambank Instability	-	-	1												
Streambank Revetment	-	-	-	1											
Floodplain Connectivity	-	-	-	-	1										
Channel Stability	-	-	-	-	-	1									
Spawning Area	-	-	-	-	-	-	1								
Dominant/Subdominant Substrate	-	-	-	-	-	-	-	1							
Spawning Gravel Embeddedness	-	-	-	-	-	-	-	-	1						
LWD	-	-	-	-	-	-	-	-	-	1					
Jams	-	-	-	-	-	-	-	-	-	0.55	1				
Pool Frequency	-	-	-	-	-	-	-	-	-	-	-	1			
Pool Quality	-	-	-	-	-	-	-	-	-	-	-	-	1		
Off Channel Habitat	-	-	-	-	-	-	0.39	-	-	-	0.34	-	-	1	
Total Score	0.52	0.60	-	0.32	-	-	0.40	-	-	0.49	0.62	0.46	-	0.48	1

- indicates non-significant relations

4.2 Habitat Limiting Factors, Geomorphic Processes, and Anthropogenic Impacts

The limiting factors analyses were used both to determine key habitat-limiting factors and to map relative habitat quality in the study area. The above limiting factors analyses include both causal factors (e.g. road encroachment) and those that are ultimately consequential from a biological perspective (e.g. pool frequency). They do not, however, provide explicit differentiation of causal and consequential attributes or serve as a robust tool to evaluate the ultimate causes of habitat problems. Here, we integrate previous descriptions of stream morphology, human impacts, and limiting factors to determine which of the identified limiting factors are actually problems resulting from human activity that habitat enhancement measures may address.

4.2.1 Geomorphic Influences

The limiting factors analysis identified limited pool frequency and quality and limited off-channel habitat as the two most important habitat deficiencies in the study area. Sullivan Creek is a steep, mountain stream. As shown in Figure 10, the steepest reaches (those on the tributaries and in reaches S2 and S17) typically have good or above-average habitat quality ratings, while most of the below-average and poor reaches occur in areas with moderate slope (1.5 to 2.5 percent). This is likely because human activities such as such as road building and forest practices have had less impact on habitat-forming processes in steeper areas in the study area. The following discussion describes geomorphic habitat-creating processes in areas of different slope.

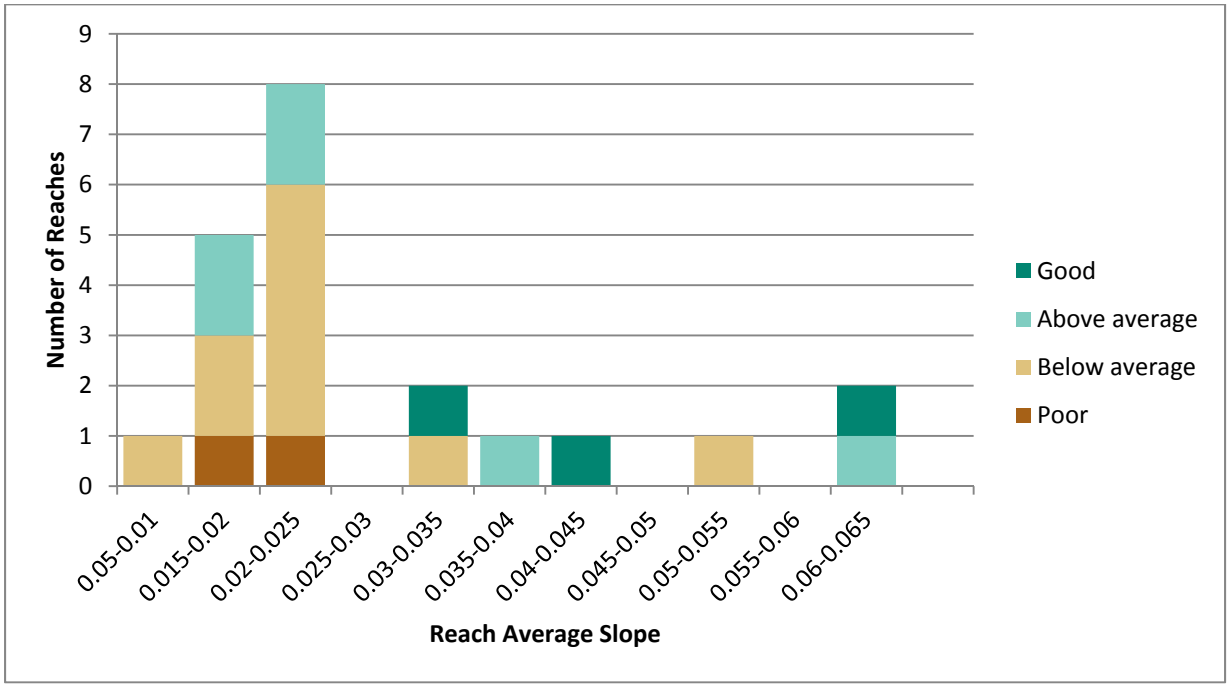

Figure 10. Reach habitat quality ratings by reach-average slope

Montgomery and Buffington (1997) provide a useful framework for describing channel morphology at the "reach-scale" (as defined more generically than our typical use in this report) that allows evaluation of alluvial geomorphic processes and their links to hillslope processes and external forcing by confinement, riparian vegetation, woody debris, and valley gradient. Viewing the Sullivan Creek data through this lens allows us to use a process-based framework to evaluate patterns observed for different Rosgen types (see Section 3.4) and to evaluate potential for channel response to anthropogenic disturbance and potential restoration activities.

The dominant channel types for slopes in the range of 1.5 percent to three percent are plane bed and forced pool-riffle (Montgomery and Buffington, 1997). Plane bed reaches characteristically lack pools. Pools in forced pool-riffle reaches depend on the direct influence of channel-spanning log jams, which reduce local channel gradients, and smaller jams or large pieces of well-anchored wood, which cause local hydraulic complexity that drives pool-forming scour and deposition (i.e. bar formation). In natural channels, bar formation occurs only up to slopes of about two percent (Ikeda, 1977; Florsheim, 1985). The reaches in the study area in the slope range between 1.5 and 2.5 percent are therefore especially sensitive to a lack of large wood and will tend to transition from forced pool-riffle morphology to plane

bed morphology if wood is removed. This corresponds closely to the observed sensitivity of channel complexity in Rosgen type B and C channels to reduced log jam frequency.

Steeper (slope greater than three percent) reaches in the study area typically have step-pool, forced step-pool, cascade, or bedrock channel types (Montgomery and Buffington 1997). In these channel types, pools are formed by bedrock, boulders, or large wood obstructions in the channel and are not as sensitive to large wood abundance or channel constriction—as can be seen in the reduced sensitivity of pool frequency relative to log jam frequency in Rosgen type A, F and B2a channels (Table 11). The limiting factors analyses appear to be somewhat misleading in the steeper areas because these alternate pool-forming mechanisms are not well accounted for. We found that, in some of these reaches, the limiting factors classified habitat as relatively mediocre because several of the causal factors rated as poor, despite consequential habitat factors being good. For example, in reach S17, pool frequency is consistently rated as good, even though jams, riparian condition, and road encroachment are consistently rated as poor. Large wood in this reach is largely immobile, and therefore is not transported to form jams, and boulders and individual pieces of immobile large wood block the channel to form pools.

Because of the factors described above, reach S17 has a slightly below average habitat quality rating. The only other steep reach with a habitat quality rating lower than above average was reach S18. For most subreaches in S18, conditions are similar to those in reach S17. The upstream two subreaches are lower gradient (less than two percent slope), and road encroachment has impacted the stream in ways typical for lower gradient reaches downstream (as described below). On the whole, steeper reaches contain some of the least impacted habitat, which has been formed through distinctly different mechanisms than good habitat in lower gradient areas.

4.2.2 Anthropogenic Impacts

The principal human activities that have reduced habitat quality on Sullivan Creek are historical harvesting of riparian forests, road construction in the riparian corridor and maintenance of those roads, direct channel modification including straightening and placement of log weirs, and construction of Mill Pond Dam (see Andonaegui, 2003 and citations therein, especially Bamote, 1996 and USFS, 1996). Disturbances to the system from these activities have operated together to reduce local recruitment and retention of large wood, making log jams along the stream less frequent. Areas lacking in log jams have collapsed from forced pool-riffle morphology to plane bed morphology, which does not support frequent or high-quality pools. Furthermore, the loss of log jams has resulted in elimination of off-channel habitat that is formed through both avulsion around log jams and formation of stable islands in the lee of log jams.

The effects of historical timber harvesting in the Sullivan Creek riparian area are today quite limited. Most of the riparian area has mature (40+ year), but not yet old-growth, forest. The consequence of this is that the largest pieces of wood that are recruited are smaller than may have occurred prior to forest harvest in the riparian zone. Therefore, individual pieces of large wood that are introduced to the stream may be less stable and more likely to be transported away from their site of introduction to the stream (where they could otherwise act as log jam key pieces), resulting in the formation of less frequent but larger log jams.

Roads in the riparian area have three principal effects that lead to a reduction of habitat quality in the study area. The most obvious effect is disconnection of riparian areas from the stream and creation of fish passage barriers at some culverts. In wide alluvial areas, this disconnection restricts the channel migration zone, reducing local wood recruitment and the potential for side channels, which tend to support high-quality habitat and provide critical high-flow refuge. In all areas, it keeps the stream from

initiating landslides from the valley walls that would deliver large wood and sediment. Tributary streams with fish passage barriers at road culverts include North Fork Sullivan, Highline, John's, Wassan, Kinyon, and Copper creeks. Additionally, in some places erosion of road surfaces results in addition of fine sediment to the stream network.

The second effect of roads in the riparian corridor is a concentration of hydraulic energy in the channel where it is constricted by riprap and/or road fill. Because of this concentration of hydraulic energy, there is significantly reduced local retention of both sediment and large wood. Large wood and sediment retained in bars both act to deflect flow, and so a lack of local recruitment and/or retention of wood and local retention of sediment (and bar formation) results in much-reduced channel migration. On revetted banks, this is further exacerbated by a lack of recruitment of large wood, which, if available, could deflect flow away from the revetment. The net result of these effects is the formation of a "migration trap" for the channel where, although nothing on the opposite bank restricts migration, the revetted bank holds the channel in place.

Two styles of constructed log weirs were observed in Sullivan Creek, both of which have contributed to local channel simplification. The most common style is a sequence of straight log weir drop structures (for example, see NRCS, 1999) along a straight channel. Stream segments controlled by these weirs have simplified channel forms: in long profile, they are typified by glides punctuated by steps at weirs (sometimes with small scour pools below steps), and in cross section, they are typified by rectangular or trapezoidal channel forms lacking lateral variation in depth. The weir drop structures dissipate hydraulic energy, so the stream does not have available energy to erode banks, recruit large wood, and reestablish channel complexity. The segment controlled by modified K-weirs (structures with pairs of logs pointing downstream at approximately a 45° angle from each bank with a gap between) has double the expected channel width, reduced depth, and simplified trapezoidal cross section geometry.

As has been already documented in other work (e.g. McMillen, 2010), Mill Pond Dam interrupts downstream sediment and wood conveyance. This results in upstream aggradation and reduction in slope and downstream degradation and channel simplification. Reaches downstream of Mill Pond Dam are lacking in large wood, have very coarse channel substrate, and appear to have reduced rates of channel migration. In addition, areas of floodplain and off-channel habitat have been disconnected from the stream because of channel degradation.

4.3 Habitat Conditions Summary

We have found that the most important habitat limiting factors in the study area (both above and below Mill Pond Dam) are limited pool frequency and quality and limited off-channel habitat. The areas of worst habitat conditions occur in naturally and artificially confined alluvial reaches (S8, S10, and S13), while the best habitat conditions occur on tributary streams and low-gradient parts of Sullivan Creek in Reach S15 and above. The principal process that has driven habitat quality degradation in the study area is reduction in large wood size and abundance (and especially a decrease in log jam abundance), which has resulted in local collapse of channel morphology from forced pool-riffle to plane bed. The reductions in large wood and log jam abundance are largely a consequence of road encroachment, which—in addition to directly cutting off side channel habitat—both reduces local wood recruitment and forms migration traps that reduce wood recruitment over a larger area.

5 Recommendations

5.1 General Strategy

This study has identified many areas of high quality habitat along Sullivan Creek, as well as a number of local and systematic deficiencies and areas of disconnected potential habitat. The most obvious physical manifestation of human impact on Sullivan Creek habitat conditions is Mill Pond Dam, which interrupts downstream sediment and large wood connectivity and blocks potential fish passage. Along the creek, disconnection of habitat has also occurred through placement of road embankments and channel degradation resulting from suppressed recruitment and reduced size of large wood in the channel, as well as reduced bedload below Mill Pond Dam.

For the most part, watershed processes along Sullivan Creek are intact or recovering from historical disturbances, which include construction of a road network and timber harvest, especially harvest of riparian areas. Our analysis has identified historical harvesting of riparian forests, road construction in the riparian corridor and maintenance of those roads, direct channel modification including straightening and placement of log weirs, and construction of Mill Pond Dam as the principal anthropogenic disruptions of natural alluvial processes in the watershed. Restriction of channel migration caused by protection of roads in the riparian area, reduced maximum size of large wood recruited to the stream, and reduced total volume of large wood recruited to the stream are the three most important ongoing disrupted watershed processes with impacts on Sullivan Creek habitat.

These disruptions have, through a set of interrelated and cascading responses, reduced log jam frequency and disconnected riparian areas, with ultimate in-stream consequences of reduced pool frequency and quality and off-channel habitat.

It is generally accepted that habitat restoration activities should focus primarily on restoring natural processes that create and maintain high-quality habitat rather than on direct manipulation of instream habitat. Roni et al. have recommended a hierarchical strategy for prioritizing stream restoration based on their evaluation of the success of many stream restoration projects, both locally and globally (Roni et al., 2002 and 2008, respectively). They recommend prioritizing first protection of high quality habitat; second, reconnection of isolated fragments of habitat; third, restoration of watershed processes; and finally, direct channel modification to improve local conditions.

As applied to Sullivan Creek, the Roni hierarchy suggests that the greatest habitat benefits would be achieved by measures that protect existing high-quality habitat areas, remove fish passage barriers and reconnect and/or create off-channel habitat areas, restore riparian areas, and construct side channels and high quality pools. As we currently see no significant threats to the remaining high-quality habitat in the study area, the emphasis shifts to mitigation and enhancement in areas with habitat deficiencies. The following sections a) outline specific measures that have been identified in this study that may protect and/or enhance habitat along Sullivan Creek, b) evaluate locations where one or more of these measures may improve habitat conditions, and c) provide an initial assessment of the relative potential habitat benefit of the identified measures.

5.2 Identification of Potential Restoration Actions

5.2.1 Conceptual Measures

The project team identified a suite of measures that could be applied along Sullivan Creek to protect and/or enhance habitat conditions. Brief descriptions of the purpose and conceptual design of each

measure are provided in Table 21. Appendix E shows sample conceptual design sketches for examples of each category.

Table 21. Conceptual habitat restoration actions for Sullivan Creek

Measure	Purpose	Effect on Compromised Watershed Processes†	Design Considerations
Channel Spanning Log Jam	Trap sediment upstream, reduce local slope upstream, create forced pool-riffle morphology, and increase floodplain connectivity.	Restoration, Mitigation	Construct a core of three to ten or more logs with length approximately the same as the local bankfull channel width. Tie jam into both banks of the stream. Anchor logs by wedging between mature riparian trees, burial in bank, or if possible boulder ballast. Drive piles to provide shear resistance.
Log Spur	Redirect channel to protect banks, encourage channel migration, and recruit additional wood.	Mitigation, Restoration	Construct a core of three to ten or more logs with length approximately the same as the local bankfull channel width. Tie jam into one bank at an angle to the thalweg. Anchor logs by wedging between mature riparian trees, burial in bank, or if possible boulder ballast. Drive piles to provide shear resistance.
Small Log Jam/ Key Log	Install features to trap woody debris, encourage local scour and pool formation, provide cover in pools, and add to general complexity.	Mitigation	Should not be placed at sites with local slope >0.02. Place one to three pieces of wood (at least one with rootwad) in channel. Place so that jam will interact with thalweg and produce local scour. In some cases, boulders or piles can be used as key structures to rack transported wood.
Riparian Restoration	Restore riparian corridor to provide long-term source of recruitable wood, shade, and terrestrial enhancements.	Restoration	Choose species appropriate for local site conditions. Faster growing, larger species (e.g. cottonwood) will have the most immediate impact on channel conditions, while long-term establishment of conifers is very valuable.
Bioengineering/ LWD for Bank Stability	Protect infrastructure or other areas where bank erosion and channel instability need to be minimized. Enhance hard armoring with more habitat friendly bank treatments that maintain or improve protection, eliminate migration traps, and create channel complexity with pools, cover, etc.	Mitigation (also prevents further compromise)	Remove and replace or build over top of existing riprap revetment using local site-appropriate techniques, likely including engineered log jams, roughness trees, and log toes, and possibly including groins and barbs. See Cramer et al. (2003) for further design considerations.

Measure	Purpose	Effect on Compromised Watershed Processes†	Design Considerations
Floodplain Reconnection/ Enhancement	Widen floodplain to disperse flood flows to lower channel velocity, reduce channel armoring, improve spawning gravel retention, and reconnect floodplain features such as wetlands and sides channels.	Mitigation, Restoration	Methods include channel-spanning log jams to raise water levels, excavation to lower adjacent floodplain (and utilize LWD for enhancement), construction of alcoves and side channels, and breaching of road embankments with culverts or bridges. Breaching of embankments and side channel construction are generally appropriate in areas where disconnected floodplain is near or below the bankfull elevation. Flood bench excavation, construction of alcoves, and channel-spanning log jams are appropriate where the floodplain elevation is above the bankfull elevation. Consider general fish passage design, fish stranding, and the frequency, timing, and duration of hydraulic connection to the main channel.
Infrastructure Modifications/ Abandonment	Restore natural channel hydraulics and allow channel migration. Encourage bank erosion to recruit LWD and streambed gravels.	Restoration	Methods include relocating road and removing manmade features that are no longer needed such as decommissioned bridges, culverts, and weirs. Most appropriate in areas where erodible floodplain or low terraces have been disconnected from the stream. Remove any bank-protection features. Pair with log spurs or channel-spanning log jam, flood bench excavation, and/or construction of side channels to hasten geomorphic recovery.

† Restoration indicates that the processes restores compromised watershed process, Mitigation indicates that the action mitigates for loss of a watershed process. Where both are listed, order indicates relative importance of effects.

5.2.2 Locations of Potential Restoration Actions

Habitat enhancement recommendations were developed at the subreach scale following a process of habitat problem identification, evaluation of constraints and opportunities for local habitat enhancement, and identification of appropriate restoration actions for specific locations.

To identify problems, we reviewed the subreach-scale limiting factors analysis (Appendix D, table D1), summary charts (Plates C1-C6), Reach Scale maps and valley topography (Plates B1-B23), and Habitat Features maps (Plates A1-A29). The review of limiting factors emphasized a few parameters found to be most descriptive of local habitat conditions: LWD jam frequency, road encroachment, pool frequency,

and off-channel habitat. The review of the summarized habitat and geomorphic data focused on trends along the reach and spatial correlations among key factors that may explain habitat deficiencies and on upstream or downstream factors that affect local subreach conditions. The review of Reach Scale maps determined active channel width, floodplain connectivity, the distribution of habitat units, and locations of bank armoring. Finally, the Habitat Features maps were used to identify habitat limiting and enhancing mechanisms, including the relationship of individual LWD and jam locations to floodplain width, gradient, and side channels; road encroachment and armoring constraints; and riparian condition.

From this information, we identified solution opportunities and locations for habitat restoration or enhancement. These included places with encroaching road segments with unstable banks, areas where the stream could be connected to the floodplain and side channels, and areas lacking complexity within the main channel (principally areas lacking LWD jams and with low pool frequency). For each location, we identified appropriate restoration action(s) (Table 21), emphasizing, where possible, those that would address root causes and promote re-establishment of natural processes. These were prioritized following the schema shown in ###, which is described in more detail in the following section. Table 23 summarizes the local habitat problems, causes of those problems, and potential solutions for each subreach in the study area.

5.3 Relative Habitat Benefits of Potential Restoration Actions

Application of an *analytical solution* or *quantitative decision support system* to prioritize application of identified restoration actions is beyond the scope of this study, but it is possible to use the results of this study to apply a *project-type* (e.g. Roni et al., 2002 and 2008) rating, which ranks projects by where they fall in a general strategy that emphasizes process restoration over direct manipulation of instream habitat (see Beechie, 2008 for detailed description of italicized terms). It is also possible to use the understanding of geomorphic processes operating along Sullivan Creek to target areas where restoration activities have the maximum probability of providing high habitat benefit.

The Roni et al. (2002 and 2008) prioritization schema suggests that high-quality habitat should be protected first. Along Sullivan Creek, there are few threats to remaining high-quality habitat. Study area reaches with functioning natural processes and high-quality habitat include all reaches upstream of and including S15 (except a small segment at the upper part of S18 and lower part of S19), and surveyed tributaries (except Gypsy Creek at and below the Sullivan Creek Road crossing). In these areas, protection from any future threat should be prioritized and instream work is not recommended.

Roni et al. recommend that reconnection of isolated fragments of habitat be given second priority. Plans already exist to remove Mill Pond Dam, which is the only anthropogenic fish-passage barrier along the creek. Fish passage through culverts on tributary streams was formally evaluated as a part of this study, but many culverts on tributary streams appear to block fish passage; these should be replaced. Along Sullivan Creek, it will likely be important to consider the sequencing of habitat reconnection relative to control of non-native fish species and/or reintroduction of native species.

The third priority is restoring watershed processes. In the Sullivan Creek watershed, the key impairments to watershed processes are impacts to the riparian area. Measures that restore area to the channel migration zone or reconnect riparian area are therefore expected to have some of the highest benefit of the identified measures. Additionally, measures that re-establish natural channel migration patterns (such as construction of flow-deflecting or channel-spanning jams or softening of bank armor) should also provide relatively high benefit.

Direct channel modifications to improve local conditions have the lowest priority in Roni et al.'s schema. However, because most habitat-forming processes in the Sullivan Creek watershed are functioning properly and comprehensive restoration of some impaired processes (e.g. road removal) is not likely, some direct channel modification along Sullivan Creek would be beneficial. Our results suggest that the areas of the stream most sensitive to the changed watershed processes are low-gradient (slope less than three percent) segments, especially those categorized as Rosgen type C or B. When the number of log jams in these areas is reduced beyond a critical threshold (probably about 10 jams per mile), local slopes increase and the channel morphology collapses from forced pool-riffle to plane bed, resulting in a loss of pool habitat. The highest potential benefit for direct in-stream restoration is thus in Rosgen type C subreaches with slope less than two percent (and that are not rapidly aggrading) that currently have poor habitat conditions. Moderate relative benefit is likely for Rosgen type B or C (slightly to moderately entrenched, moderate to high width-to-depth ratio, moderate to high sinuosity) segments where placement of channel-spanning jams or channel migration and meander formation would reduce local slopes to less than two percent.

One further condition warrants special prioritization, and that is where restoration activities would have the dual benefit of habitat enhancement and protection of roads. In these places, there is the possibility to directly mitigate some of the effects of bank armoring while protecting the road (and thereby limiting future impact of armoring).

The general strategy outlined above was followed to prioritize specific habitat restoration actions proposed in Table 23. Specifically *categories* of restoration action were prioritized in the following order:

1. Reconnection of isolated habitat fragments (e.g., replacement of a fish passage barrier culvert)
2. Stimulation of natural habitat forming (geomorphic) processes (e.g., construction of a channel-spanning log jam to shift a reach from plane bed to forced riffle-pool morphology)
3. Direct construction of stream habitat or enhancement (e.g. installation of a single piece of wood for the primary purpose of providing cover for fish).

In addition to which category a restoration action falls under, the magnitude of habitat benefit was also considered based on a judgment of whether its restoration benefit would be spatially or qualitatively small, medium, or large. Table 22 shows how this schema was specifically applied to potential restoration actions listed in Table 23. Actions that would have the dual benefit of habitat enhancement and protection of roads are flagged with an asterisk after the priority rating in Table 23.

Table 22: Prioritization schema for potential restoration actions.

Restoration Action Type	Magnitude of Impact on Habitat (quantity X quality of habitat improved)		
	Large	Moderate	Small
Habitat Reconnection	Very High	High	Low (Medium)
Geomorphic Process Restoration	High (Very High)	High	Low
Direct Modification	Medium	Medium	No Action (Low)
Addresses both habitat problem and threatened infrastructure.	Medium	Medium	Low

Table 23. Potential restoration actions for each subreach of Sullivan Creek

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
S1	1-1	Lacking pools, wood, and jams	Aggradation upstream of reservoir, limited wood supply from upstream	LWD for fish cover	M				
	1-2	Lacking pools, wood, and jams	Aggradation upstream of reservoir, limited wood supply from upstream	WD for fish cover, Install small log jams/key pieces to capture wood, increase complexity	M			3	15
	1-3	Reduced channel complexity	Bank revetment limits habitat formation and maintenance.	Improve failing revetment with bioengineering/LWD	M	Yes, see comment.	Should be completed prior to dam removal.		65
	1-4	Lacking jams, low pool quality, cleared riparian area	Limited local wood recruitment, bank revetment limits habitat formation and maintenance.	Riparian vegetation. Large wood placement and/or jam construction	H	Yes, see comment.	Downstream of Mill Pond Dam. Recommend waiting for adjustment/ equilibration following dam removal before doing in-channel work other than needed bank protection.	2	10
		Reduced channel complexity	Bank revetment limits habitat formation and maintenance.	Improve or replace revetment with bioengineering /LWD	M				65
S2		Lacking wood, jams, and gravel	Limited upstream input of LWD and gravel, restricted migration and limited riparian area because of natural confinement	No action			Canyon reach where natural geomorphic structure is intact and access is limited.		
S3	3-1	Lacking wood, jams, and gravel	Restricted supply of LWD and gravel because of Mill Pond Dam has resulted in reduced channel migration, reduced local LWD accumulation, and disconnection of the channel from the floodplain.	No action until after dam removal or plan action to operate in concert with dam removal. At that time it is likely that small jams or key pieces would be beneficial.	M	Yes, see comment.	Re-equilibration of sediment and large wood supply will occur post-dam removal, and it is difficult to predict at this time what action may be beneficial, given those changed conditions.		
	3-2	Lacking pools, jams, gravel, and off-channel habitat	Restricted supply of LWD and gravel because of Mill Pond Dam has resulted in reduced channel migration, reduced local LWD accumulation, and disconnection of the channel from the floodplain.	No action until after dam removal or plan action to operate in concert with dam removal. At that time it is likely that small jams or key pieces would be beneficial.	M	Yes, see comment.			
		Floodplain disconnection	Road has cut off large floodplain area	Add/retrofit culverts to re-connect floodplain area north of road	VH				
	3-3	Floodplain disconnection	Road has cut off large floodplain area	Add/retrofit culverts to re-connect floodplain area north of road	VH				
		Lacking pools jams, and gravel	Restricted supply of LWD and gravel because of Mill Pond Dam	Bioengineering/LWD for bank protection in anticipation of instability upon dam removal	M	Should be completed prior to dam removal.			120
		Reduced channel complexity	Bank revetment limits habitat formation and maintenance.						
	3-4	Lacking pools, jams, off-channel habitat, and gravel	Restricted supply of LWD and gravel because of Mill Pond Dam	Possibly construct channel-spanning log jams, log spurs, or key pieces.	H	Install prior to dam removal to trap sediment.	May pose risk to recreational users.		
	3-5								

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
	3-6	Lacking jams and gravel, downcutting, floodplain connectivity (less severe than in subreaches 3-5)	Restricted supply of LWD and gravel because of Mill Pond Dam						
	3-7	Lacking jams and gravel, downcutting, floodplain connectivity	Restricted supply of LWD and gravel because of Mill Pond Dam	No action until after dam removal or plan action to operate in concert with dam removal. At that time it is liklely that small jams or key pieces would be beneficial.	H	Yes, see comment.	Re-equilibration of sediment and large wood supply will occur post-dam removal and it is difficult to predict at this time what action may be beneficial.		
		Road embankment erosion	Colluvial slide on road embankment	Bioengineering/LWD for bank protection or flow deflection structure at base of landslide	M*	Should be completed prior to dam removal.		2	12
	3-8 3-9 3-10 3-11	Lacking jams and gravel, downcutting, floodplain connectivity	Restricted supply of LWD and gravel because of Mill Pond Dam	No action until after dam removal or plan action to operate in concert with dam removal. At that time it is likely that small jams or key pieces would be beneficial.	M	Yes, see comment.	Re-equilibration of sediment and large wood supply will occur post-dam removal and it is difficult to predict at this time what action may be beneficial.		
S4				Mill Pond					
S5	5-1 5-2	Instability, aggradation, lacking jams, lacking canopy cover	Backwater above Mill Pond, delta deposits and wide braided channel	Riparian restoration and LWD placement after dam removal, if indicated by conditions at that time.	H	Yes, see comment.	No action until after dam removal. Channel will downcut and change from braided to single thread form after dam is removed.		
	5-3	Lacking jams, low pool quality, off-channel habitat	Transient downcutting caused by channel migration downstream	Small log jams/key pieces to encourage local scour	M		Channel will downcut after dam is removed. Recommend waiting for adjustment/ equilibration to dam removal before doing in-channel work.	4	20
		Riparian condition	High water table, braided channel	Riparian restoration	H				
	5-4 5-5	Road threatened by landslides	Landslides triggered by toe erosion caused by natural channel migration and water saturation over geologic materials with low permeability.	Stabilize slides with appropriate geotechnical measures and redirect flow away from roadside bank using log spurs or other bioengineering/LWD for bank stability	L*		Generally good habitat; may be affected by a headcut associated with downcutting in subreaches 5-1 through 5-3. Consider waiting for adjustment/equilibration to dam removal before doing in-channel work.	4	24
S6	6-1	Lacking wood, esp. jams, channel lacking complexity	Lack of channel migration to recruit wood from banks. Wood transported by the stream is trapped in upstream jams.	Channel-spanning log jam or large log spur to drive channel migration. Plant riparian vegetation in reach S7.	H			2	12
	6-2	Lacking pools, channel complexity	Lack of channel migration to recruit wood from banks and uniform erosion resistance in bank materials.	Add key pieces to functioning jams to encourage side channel formation. Floodplain reconnection/enhancement.	M		Several functioning log jams, not clear why pool habitat is absent.	15.3	44.2
	6-3	Lacking pools and wood, esp. jams	Lack of channel migration to recruit wood from banks and uniform erosion resistance in bank materials, upstream wood supply limited.	Channel-spanning log jam or large log spur to drive channel migration. Plant riparian vegetation in reach S7. Floodplain reconnection/enhancement.	H				

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
S7	7-1	Lacking pools, wood	Limited local wood recruitment, no jams	Bioengineering/LWD for bank stability at bridge; small log jam (bar-apex) or key pieces	L		Careful consideration to LWD at bridge and immediately upstream. Some concern downstream related to increased flood levels from LWD introduction.		
		Floodplain disconnection, lacking off-channel habitat	Road embankment cuts across floodplain, blocks conveyance	Culvert through embankment, pilot side channel	M		Enhance off-channel habitat; could use HEC-RAS model to assess/design solution		
	7-2	Lacking pools, wood	Limited local wood recruitment, no significant jams	Riparian restoration. Consider log spur structures (not channel-spanning).	M		LWD structures need to be designed to minimize risk to the bridge downstream.		
	7-3	Lacking pools, wood	Limited local wood recruitment, no significant jams, wood being captured in jam upstream		M				
	7-4	No significant problems	n/a	No action			Bank erosion due to LWD and jams, which are creating pool habitat		
	7-5	No significant problems	n/a	Opportunity to add key pieces	L		Good habitat; any action would be low priority.	1	5
S8	8-1	Lacking pools and jams	Narrow confined channel, lack of jams and complexity.	Small log jams/key pieces.	L		Careful consideration of high-flow channel hydraulics. Risk of blowout due to channel confinement.		
	8-2								
	8-3								
	8-4	Lacking pools, spawning area, and wood, esp. jams	Jam in upstream sub-reach limits LWD and steepens this reach	Small log jams/key pieces or channel-spanning log jams.	L		Consider creating side channel or floodplain benches and using LWD for enhancement in other areas. Careful consideration of LWD impacts to road.	2	10
	8-5	No significant problems	n/a	No action			Existing large jam provides complexity.		
	8-6	Lacking pools and jams	Lack of channel complexity, wood recruitment limited by road	Log spurs to engage floodplain.	M		Careful consideration of LWD impacts to road.	2	12
		Bank revetment limits habitat formation and maintenance.	Road encroachment						
	8-7	Lacking complexity below jam	Wood recruitment limited by upstream jam, road	Log spurs to engage floodplain.	M		Careful consideration of LWD impacts to road.	2	12
		Bank revetment limits habitat formation and maintenance.	Road encroachment						
S9	9-1	No significant problems	n/a	No action					
	9-2	Lacking jams, off-channel habitat	Limited retention of large wood, limited channel migration reduces local input of large wood.	Log spurs or channel-spanning log jams to redirect flow into overbanks; reconnect side channel on right	M		Road encroachment minimal. Slug of sediment in channel from large landslide.	10.8	31.2
	9-3	Bank revetment limits habitat formation and maintenance.	Road immediately adjacent to right bank at upper end of subreach	Modify revetment with bioengineering/ LWD for bank stability	M*		Overall good habitat; natural bank instability is good – may open more overbank area. There is a slug of sediment in channel from large landslide.		19.5

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
S10	10-1	Bank revetment limits habitat formation and maintenance.	Road immediately adjacent to right bank at lower end of subreach	Modify revetment with bioengineering/ LWD to redirect flow and create pools	M*		Lowest-scoring reach in Limiting Factors Analysis		32.5
		Lacking pools and jams	Limited local LWD supply, uniform channel	Small log jams/key pieces or log spurs along road embankment to redirect flow, create channel complexity	M			4	24
	10-2	Bank revetment limits habitat formation and maintenance.	Naturally confined reach further confined by road	Modify revetment with bioengineering/ LWD for bank stability to redirect flow and create pools	M				44
		Lacking pools and wood, esp. jams	Limited local LWD supply, uniform channel with limited floodplain access due to downcutting	Small log jams/key pieces or log spurs along road embankment to redirect flow, create channel complexity	M			3	18
	10-3	Bank revetment limits habitat formation and maintenance.	Naturally confined reach further confined by road	Modify revetment with bioengineering/ LWD for bank stability to redirect flow and create pools	M				32
		Lacking pools and wood, esp. jams	Limited local LWD supply, uniform channel with limited floodplain access due to downcutting	Small log jams/key pieces or log spurs along road embankment to redirect flow, create channel complexity	M			5	25
S11	11-1	No significant problems	n/a	No action			Sedimentation zone in low-slope area upstream of a local bedrock grade control. Lots of wood accumulation and many high-quality pools.		
	11-2								
	11-3	Road embankment erosion	Road encroachment, extensive log jam complex downstream	Log spurs or bioengineering/LWD for bank protection and pool formation	M*		Road at risk	2	51
	11-4	Lacking pools, jams, off-channel habitat	Limited wood transport from upstream	Opportunity to reactivate two side channels with log spurs or channel-spanning jams and/or excavation	VH			2	12
	11-5	Lacking jams	Road encroachment, channel-spanning weirs restrict channel migration	Remove and/or modify channel-spanning weirs	VH			3	15
		Bank revetment limits habitat formation and maintenance.	Road encroachment	Modify revetment with bioengineering/ LWD and/or redirect flow away from road with log spurs at downstream end	M				45
		Floodplain disconnection, lacking off-channel habitat	Road cuts across historic floodplain area	Relocate road to restore riparian connectivity	H		Cost may be high relative to benefit.		
	11-6	No significant problems	n/a	Opportunity to activate right bank side channel at upstream end of subreach					

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
	11-7	Lacking pools, channel variability	Downstream-pointing V-shaped weirs (not the typical channel-spanning weirs) have caused channel widening and distributed the flow leading to the formation of a large riffle.	Small log jams/key pieces to constrain the flow and encourage scour. Remove half of the weirs on alternating sides of the channel and repurpose logs into jams.	VH		Good access, high potential to improve habitat, and currently very poor quality habitat.	3	15
		Bank revetment limits habitat formation and maintenance.	Road encroachment	Modify revetment with bioengineering/ LWD or direct flow away from the bank with log spurs.	H				56
	11-8	Low quality pools, lacking off-channel habitat	Channel-spanning weirs restrict channel migration	Remove and/or modify channel-spanning weirs. Channel-spanning log jam to encourage aggradation, channel splitting, and floodplain reconnection	H		Good access, moderate potential to improve habitat	2	10
		Floodplain disconnection, lacking off-channel habitat	Road cuts across historic floodplain area	Relocate road to restore riparian connectivity	H		Cost may be high relative to benefit.		
	11-9	Lacking channel variability, low quality pools	Channel-spanning weirs restrict channel migration	Remove and/or modify channel-spanning weirs	VH		Good access, moderate potential to improve habitat	3	15
		Off-channel habitat access	Hydraulic constriction at bridge	Widen bridge to allow floodplain reconnection	L				
	11-10	Riparian vegetation	Side channel has formed in dispersed rec site where understory has been killed by recreational use.	Riparian restoration at closed site.	H		Assumes no desire to reopen rec site. Initially channel-spanning weirs in this subreach have been flanked by channel migration and are no longer adversely affecting habitat quality.		
	11-11			Opportunity to increase side channel habitat by opening up head of small side channel cutting through former rec site to increase flow in this channel.					
	11-12	Lacking pools	Slug of sediment from upstream landslide	Modify revetment with bioengineering/ LWD and/or construct log spur or channel-spanning jam to activate a left bank side channel and create pools	VH		Existing bank revetment is failing. Good access and significant opportunity to improve habitat and protect road.		
		Bank revetment limits habitat formation and maintenance.	Road encroachment						
	11-13	No significant problems	n/a	No action			Generally good habitat		
	11-14	Side channel disconnection	Left-bank side channel spanning 11-14 and 11-15 blocked by landslide	Opportunity to reconnect side channel now that erosion has removed toe of slide	L		Landslide appears to be related to decommissioned road. Explore road drainage to determine if slide could be stabilized by reducing amount of water to the slope.		
	11-15	Bank instability, aggradation	Aggradation upstream of landslide (transient grade control)	Bioengineering/LWD features to divert flow from road bank.	M*		Careful consideration of impacts to road and side channel flow distribution		36.4

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
S12	12-1	Lacking jams, low pool quality, off-channel habitat	Reach confined between terrace and valley wall; road encroachment at downstream end	Modify revetment with bioengineering/ LWD, small jams to encourage local scour	M				10
	12-2	No significant problems	n/a	Possible opportunity to reactivate large abandoned side channel.					
	12-3								
	12-4	No significant problems	n/a	No action			Subreach in disequilibrium		
	12-5	Lacking pools, jams, off-channel habitat	Road encroachment has straightened and steepened channel	Key pieces or small jams to encourage local scour	M			2	10
	12-6								
	12-7	Floodplain disconnection	Road has cut off large relict channel	Relocate road to edge of valley.	L		Generally good habitat; low priority for action. Disconnected part of floodplain is far from the current channel and there is adequate area for channel migration. Cost may be high relative to benefit.		
	12-8	Lacking pools	Downcutting likely caused by failure of a historical very large jam downstream.	Monitor erosion around jam and construct bioengineering/LWD for bank protection if road is threatened.	L*		Pools limited but pocket water present. Road potentially threatened by erosion around log jam.		20.8
S13	13-1	Lacking pools, spawning gravel, log jams	Road encroachment, channel confinement, wood transport from upstream reduced	Log Spurs to drive lateral channel migration. Small jams/key pieces; flood benches or off-channel habitat/side channels	H		Increased channel migration would be beneficial to recruitment of gravel and LWD and to create more diverse velocities and channel complexity.	3	18
	13-2	Lacking pools, spawning gravel, log jams	Road encroachment, wood transport from upstream reduced	Log Spurs to drive lateral channel migration; flood benches or off-channel habitat/side channels.	H			3	18
	13-3	Lacking pools, spawning gravel, log jams	Narrow channel, little floodplain connection, wood transport from upstream reduced	Construct Small Jams, Flood benches or off-channel habitat/side channels.	M		Erosion might be bringing in spawning gravel.	2	10
	13-4	Channel downcutting	Hydraulic constriction at bridge	Remove abandoned bridge and abutments.	H		Bridge and road are abandoned.		
		Lacking pools, spawning gravel, log jams	Wood transport limited by road crossing	Small jams/key pieces	M		Side channel establishment could encourage wood recruitment downstream.	2	10
		Lacking off-channel habitat	Disconnection from floodplain due to bed downcutting	Channel-spanning log jam to stabilize and raise bed level and reconnect floodplain	M			9.9	28.6
	13-5	Lacking pools, spawning gravel, log jams	Wood supply limited by road, upstream jams	Modify revetment with bioengineering/ LWD or log spur; flood benches or off-channel habitat/side channels.	M		Increased channel migration would be beneficial to recruitment of gravel and LWD and to create more diverse velocities and channel complexity.		
		Bank revetment limits habitat formation and maintenance.	Road encroachment and armoring						
	13-6	No significant problems	n/a	No action			Channel migration and log jams are maintaining high quality habitat in this subreach.		
	13-7	Lacking pools, spawning gravel, log jams	Locally steep and confined channel	Channel-spanning log jam; flood benches or off-channel habitat/side channels.	H		Increased channel migration would be beneficial to recruitment of gravel and LWD and to create more diverse velocities and channel complexity.	8.1	23.4

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
S14	14-1	Lacking pools, wood	Relatively steep, downcutting reach; wood supply limited by road and upstream bridges	Small log jams/key pieces; flood benches or off-channel habitat/side channels.	M			2	10
	14-2	Lacking pools, spawning gravel, and wood, esp. jams	Relatively steep, degrading reach; wood recruitment limited by road and upstream bridges.	Key pieces/log jam to create pools, encourage off-channel habitat formation	M			2	10
		Bank erosion	Road encroachment	Bioengineering/LWD for bank protection at erosion site next to road	L*				29.9
	14-3	Road encroachment	Two road crossings in reach	No action. Channel is very confined and there is little opportunity to improve conditions. Possible site for boulder placement.	L		Complicated reach with 2 road crossings and 2 tribs. Habitat is reasonably good – probably best to leave it alone.		
	14-4	Lower end lacks pools, jams	Convex channel profile so wood and sediment do not accumulate locally.	Possible site for boulder placement.	L		Limited opportunity; need to consider potential impacts of any actions on downstream bridges		
	14-5	Lacking pools and jams	Convex channel profile so wood and sediment do not accumulate locally, wood trapped in upstream jam	Small jams/key pieces or log spurs to encourage channel complexity	H		Potential risk to downstream bridges needs to be considered.	3	15
	14-6	Lacking pools and wood, esp. jams	Convex channel profile so wood and sediment do not accumulate locally, wood trapped in upstream jam	Small jams/key pieces or log spurs to encourage channel complexity	M		Consider LWD impacts to road and risk to downstream bridges.	2	10
S15	15-1	No significant problems	n/a	Opportunity to create additional side channel habitat			Overall very good habitat. Action could create undesirable disturbance in a relatively pristine area.		
	15-2								
	15-3								
	15-4								
	15-5	Lacking pools, jams	Locally confined reach with uniform channel, large jam upstream limits wood	Could add small jams/key pieces (possible site for boulders) to encourage local channel complexity	L		Limited access and good habitat upstream and downstream – low priority for action.	2	10
S16	16-1	No significant problems	n/a	No action			Processes and conditions in this reach might be representative of maximum functioning condition for reaches S3, S5-S7, and S11. Natural aggradation caused by downstream grade control and convex slope limits pool depth.		
	16-2								
	16-3								
	16-4								
	16-5								
	16-6								
	16-7								
	16-8								
	16-9								
	16-10	Lacking pools, jams	Downcutting, probably natural (perhaps related to episodic sediment delivery from upstream and local tributaries), has caused the stream to become armored and detached from the floodplain	Channel-spanning log jam	H		Good access and high potential to improve conditions	8.1	23.4
	16-11								

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
	17-1	No significant problems, road reduces wood recruitment	n/a	No action			Good habitat; low wood but boulders serve function of providing habitat complexity. Road is consistently near stream but does not cause poor-quality habitat, though may reduce wood recruitment.		
	17-2								
	17-3								
	17-4								
	17-5								
	17-6								
	17-7								
	17-8								
	17-9								
	17-10								
	17-11								
	17-12								
	17-13			opportunity for wood placement	L			1	5
	17-14			No action					
	17-15								
	17-16								
	17-17								
	17-18								
S18	18-1	No significant problems, road reduces wood recruitment	Road is consistently near stream but does not cause poor quality habitat.	No action			Good habitat; low wood but boulders serve function of providing habitat complexity. Road is consistently near stream but does not cause poor-quality habitat, though may reduce wood recruitment.		
	18-2								
	18-3								
	18-4	Lacking pools, wood in lower part of subreach	Road may limit wood recruitment	Log spurs and small jams/key pieces or other bioengineering along road embankment, encourage side-channel development on other side	H		Lower gradient and abundance of boulders than reaches below, so reduction in wood has had important habitat consequences and wood placement would have habitat benefit.	3	18
	18-5	No significant problems	n/a	Potential opportunity for LWD enhancement at lower end of subreach but low priority			Locally steep reach with lots of pocket water.		
	18-6	No significant problems	n/a	No action					
	18-7	Lacking pools, log jams	Wood supply limited by road, upstream jams	Modify revetment with bioengineering/ LWD, log spurs to push flow away from road and add channel complexity	M				34
		Bank revetment limits habitat formation and maintenance.	Road encroachment						
	18-8	Lacking pools, wood	Lower part of reach is steeper, confined. Wood supply limited by road, upstream jams.	Modify revetment with bioengineering/ LWD	M				20

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
		Bank revetment limits habitat formation and maintenance.	Road encroachment						
	18-9	No significant problems	n/a	No action			Extensive log jams, side channels, spawning gravel		
	18-10	Bank revetment limits habitat formation and maintenance.	Road encroachment	Modify revetment with bioengineering/ LWD; excavate flood benches or off-channel habitat/side channels.	M		Wider floodplain, possible opportunity to enhance off-channel habitat		52
S19	19-1	Erosion upstream and downcutting downstream of bridge	Hydraulic constriction at bridge	Channel-spanning log jam downstream of crossing	VH		Raise bed level and create habitat features	10.8	31.2
	19-2	Floodplain disconnection	Road embankment blocks portion of historic floodplain	Culvert through embankment and other floodplain reconnection measures	H		May need pilot channel from side channel complex through culvert to reestablish flow paths		
	19-3 19-4 19-5	No significant problems	n/a	No action			Abundant wood, side channels, spawning gravel		
North Fork Sullivan Creek	1-1	Fine sediment recruitment	Erosion of surface of diversion dam access road.	Re-grading and drainage control on road.	VH				
		Fish passage (but natural passage barriers exist in NFS 1-2)	Sullivan Lake Road culvert	Culvert replacement	L		Low priority because of close proximity to natural fish passage barriers and very steep cascade-dominated channel between culvert and fish passage barriers. Wood loading is currently high.		
	1-2	Riparian Condition	Proximity of diversion dam access road.	Little possible apart from road decommissioning.	VH				
	1-3	Fish passage (but natural passage barriers exist in NFS 1-2)	Water Diversion Dam	Remove Diversion Structure	L		Diversion structure creates a large pool with significant fish utilization. Barrier removal low priority because of proximity to natural fish passage barriers.		
	1-4	No significant problems	n/a	No action			Above diversion dam, high quality habitat.		
Outlet Creek	1-1	Lacking pools, channel complexity, jams	Limited recruitment of LWD from upstream and riparian area	Small log jams/key pieces to encourage local scour	M			3	15
	1-2 & 1-3	No significant problems	n/a	No action			Many log jams, stable braided channel		
	1-4	Fish passage	Sullivan Lake Dam	Fish passage structure	VH		Large and costly project outside of the scope of the licensing agreement. Potential high benefit.		

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
Highline Creek	1-1	No significant problems	n/a	No action			Large influence of Beaver Activity		
	1-2	Fish passage	historical dam/crib wall blocks fish passage	remove structure and restore channel in vicinity of structure	VH	Yes, see comment.	Consider implications for invasive species and timing relative to fish suppression/eradication.		
John's Creek	1-1	Laking wood	Relatively young riparian forest, little recent wind-throw.	Key pieces/log jam to create pools	M			5	25
	1-2	Fish passage	Culvert on decommissioned road	Remove culvert	VH	Yes, see comment.	Consider implications for invasive species and timing relative to fish suppression/eradication.		
Pass Creek	1-1 & 1-2	Low pool depth and quality	Naturally smaller stream. Historical forest practices may have changed LWD distribution.	No action			Habitat in very good condition. Low pool depth and quality based on limiting factors thresholds.		
Wassan Creek	All	Fish passage	Culvert through Sullivan Creek Road	Replace culvert.	M	Yes, see comment.	Consider implications for invasive species and timing relative to fish suppression/eradication.		
		Fish passage and fine sediment	Constructed weirs and cascade at confluence with Sullivan Ck..	Formally evaluate fish passage at weirs and correct any problems, reduce channel width with LWD placement.	VH		Weirs create pools and spawning patches in this reach. Consider implications for invasive species and timing relative to fish suppression/eradication.	2	10
Thor Creek	All	Natural fish passage barriers	Primitive channel due to recent avulsion.	No action					
Stony Creek	All	No significant problems	n/a	No action					
Rainy Creek	All	No significant problems, potential fish passage barrier at mouth of creek.	Natural scour by Sullivan Creek	Grade control to correct fish passage barrier.	L		Evaluate fish passage conditions and habitat cost/benefit of disturbing the system to correct a natural passage barrier.		
Kinyon Creek	1-1	Lacking Jams, Functional LWD	Possibly historic timber harvest.	Key pieces/log jam to create pools	M		Habitat conditions are generally acceptable. Many significant fallen LWD pieces span the bankfull channel and could be cut to cause them to drop into the wetted channel.	3	15
	1-2	Fish passage	Sullivan Creek Road culvert	Replace culvert.	VH	Yes, see comment.	Consider implications for invasive species and timing relative to fish suppression/eradication.		
Copper Creek	All	Fish passage	Sullivan Creek Road culvert	Replace culvert.	VH	Yes, see comment.	Consider implications for invasive species and timing relative to fish suppression/eradication.		

Reach	Subreach	Problem	Cause	Restoration Opportunity	Priority	Sequence Dependency	Comment	total number large pieces (pieces > 12" and 35' long)	total number medium pieces (pieces >12" and 10' long)
Gypsy Creek	1-1	Low pool quality, downcutting, off-channel habitat, revetment	Recreational impacts; perhaps a recent natural flood or debris flow.	Small log jams/key pieces or channel-spanning log jams	H		High recreational use area – potential for continued disturbance.	10.8	31.2
	1-2	No significant problems	n/a	No action					
	1-3								
	1-4								
Mankato Creek	All	No significant problems	n/a	No action			Extremely steep, likely not fish habitat		
Sullivan Headwaters	1-1	Riparian Condition, bank erosion	Disturbance associated with use of Gypsy Meadows campsite.	Riparian planting, bank stabilization with bioengineering/LWD.	L		Habitat generally in very good condition.		10.4
	1-1.5	No significant problems	n/a	No action			Habitat in very good condition.		
	1-2								
	1-3								
Deemer Creek	All	Low pool depth and quality	Naturally smaller stream.	No action			Habitat in very good condition. Low pool depth and quality based on limiting factors thresholds.		
Leola Creek	All	Low pool depth and quality, spawning gravel embeddedness	Naturally smaller and steeper stream.	No action			Habitat in very good condition. Low pool depth and quality based on limiting factors thresholds.		

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Plates A1-A32 Habitat Features Maps

Sullivan Creek Habitat Inventory

Habitat Features

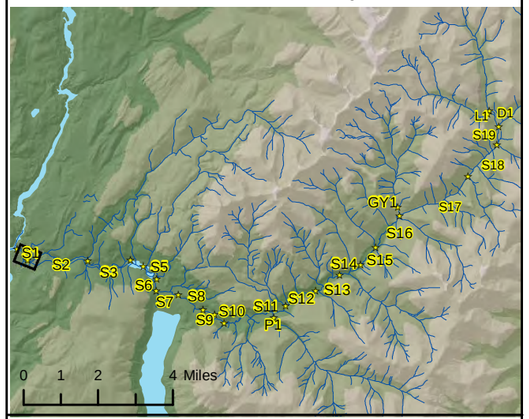
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

< 2,500 ft³

2,500 - 10,000 ft³

10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft, 1-2 ft, > 2 ft

500 ft²

2,500 ft²

10,000 ft²

Large Wood

> 25 ft long, no rootwad

> 25 ft long, with rootwad

< 25 ft long, with rootwad

Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft²

500 ft²

1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

Reach

Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

Active

Part Stable

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Sullivan Creek Habitat Inventory

Habitat Features

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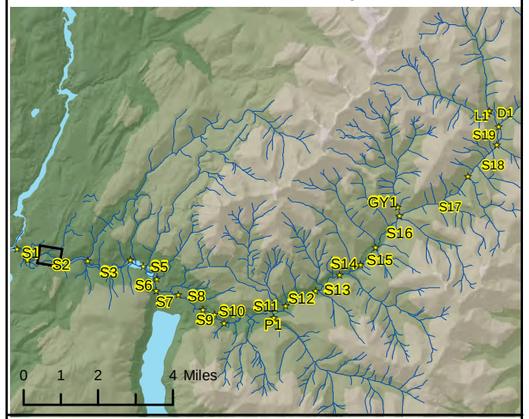

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Dominant Substrate

(proportion of area)

Boulder
Cobble
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Gravel
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Subreach

Bank Condition

Armored Natural

Eroding
Part stable
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Landslides

Active
Part Stable

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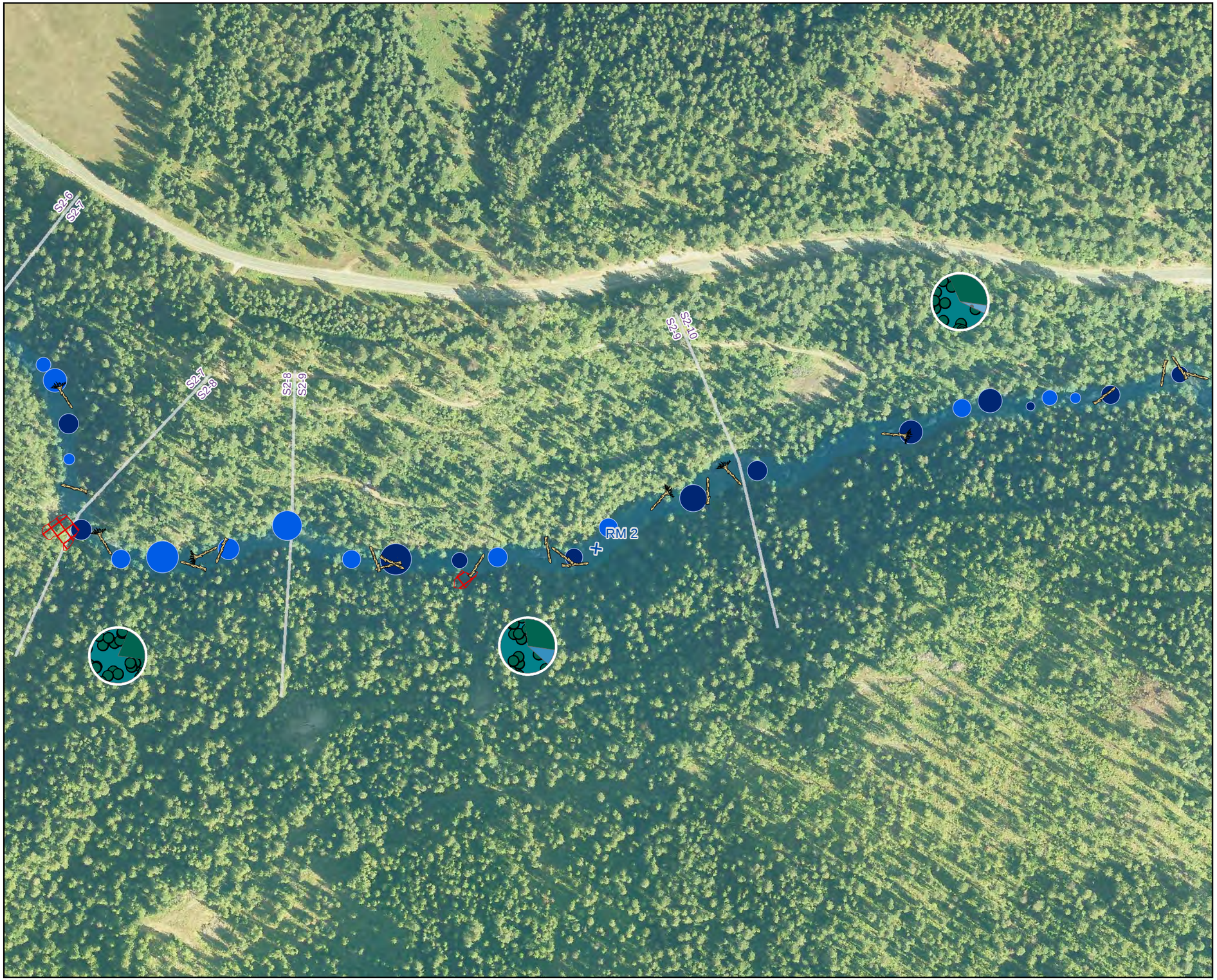

Sullivan Creek Habitat Inventory

Habitat Features

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Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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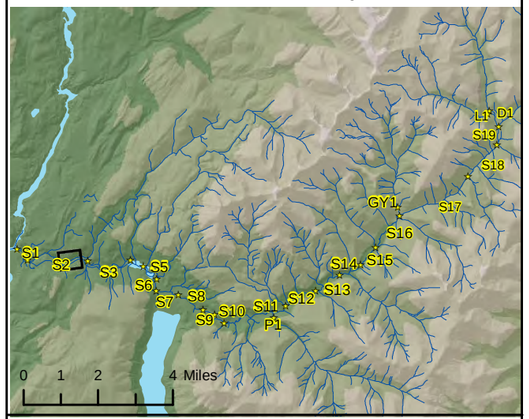

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Spawning Gravel

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≤ 100 ft², 500 ft², 1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

Bank Condition

Armored, Natural

- Eroding
- Part stable
- Stable

Landslides

- Active
- Part Stable

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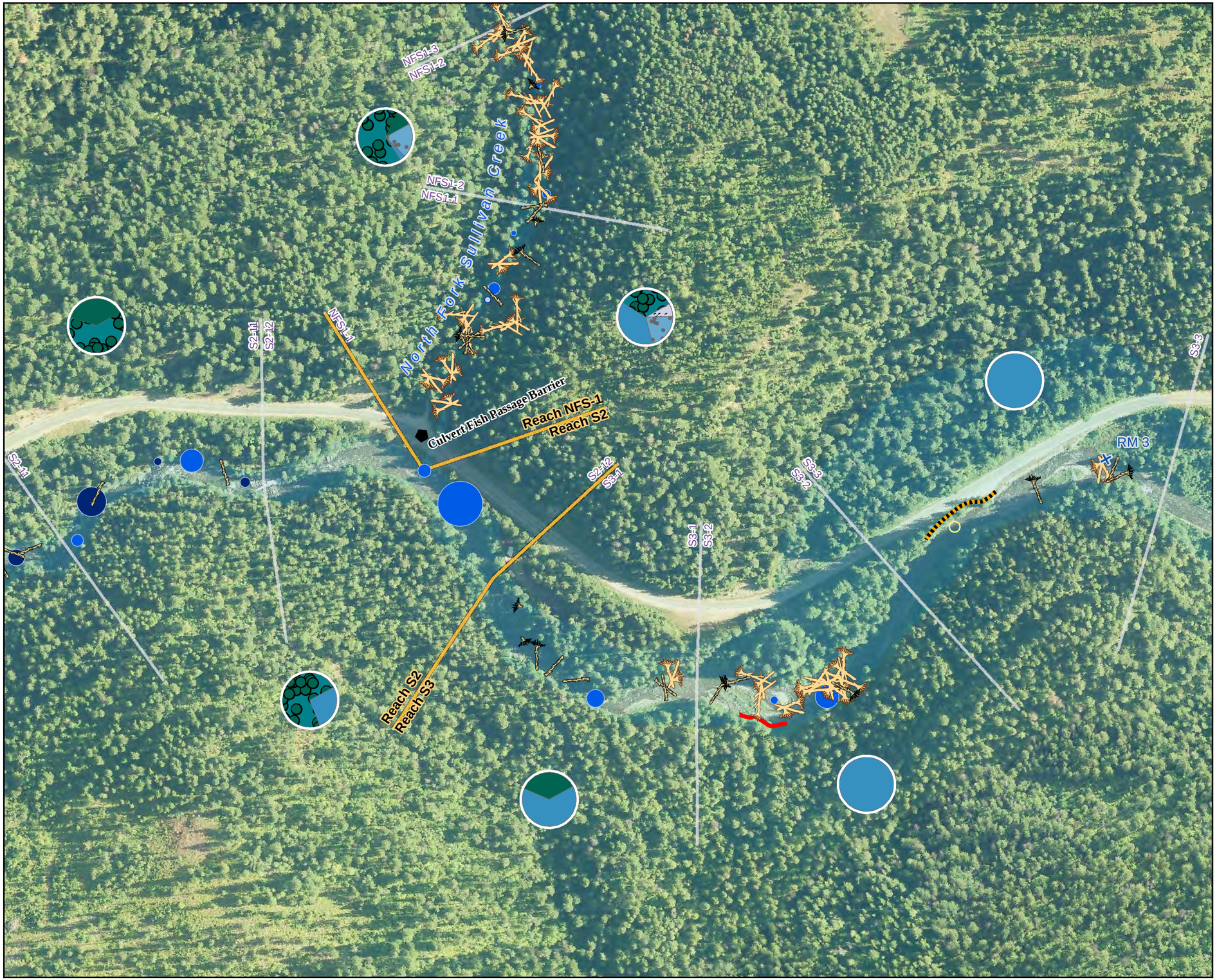


Sullivan Creek Habitat Inventory

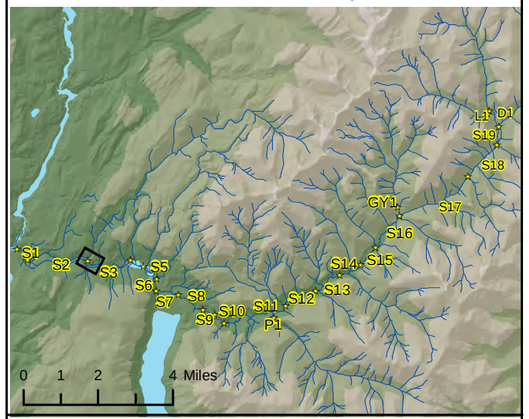
Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



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Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

- Active
- Part Stable

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Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

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Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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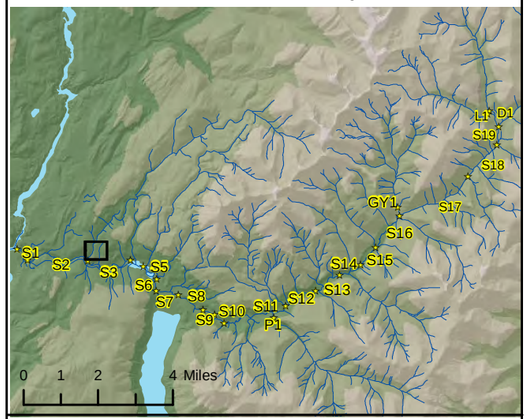

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Reach

Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

Active

Part Stable

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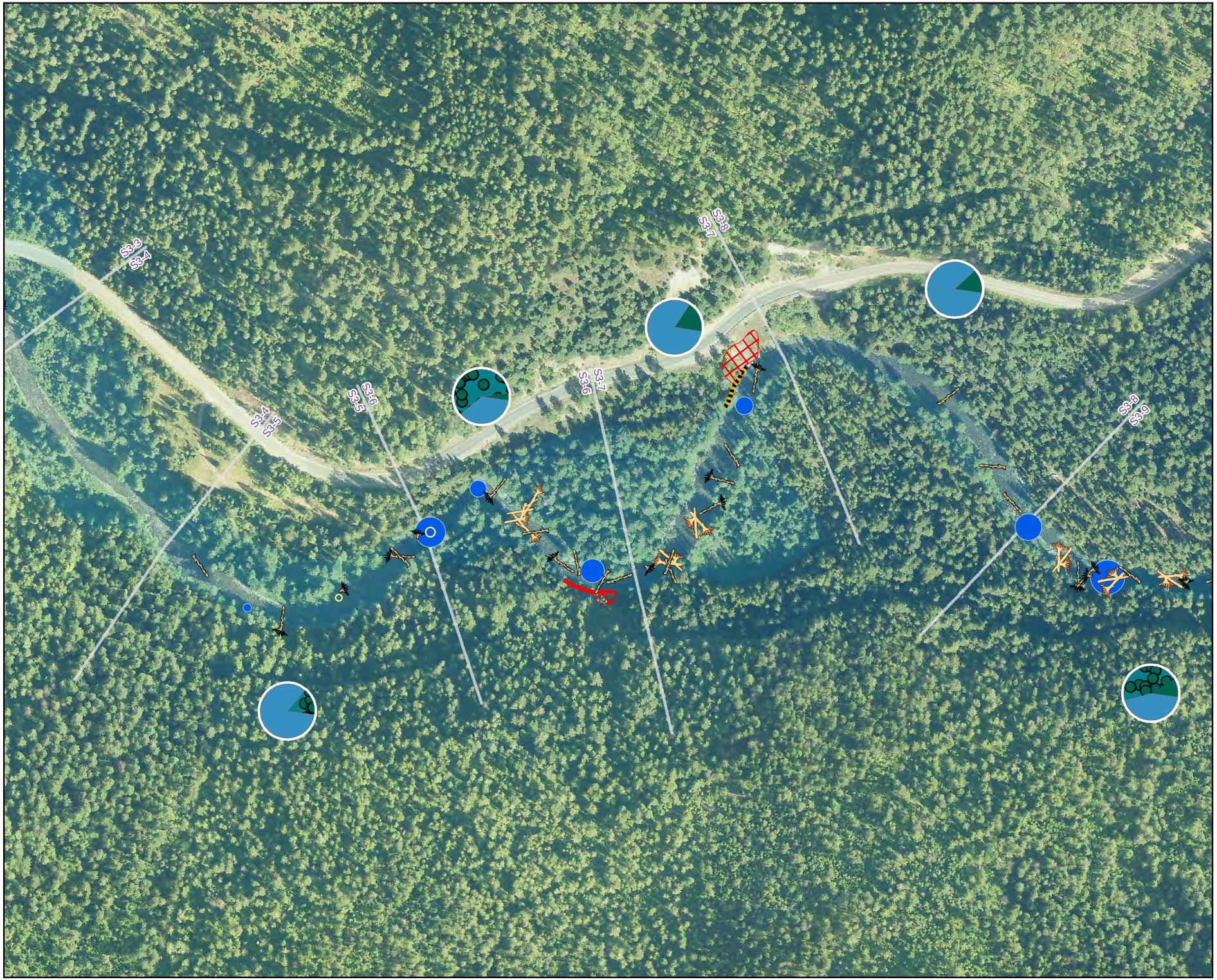

Sullivan Creek Habitat Inventory

Habitat Features

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100 50 0 100 200 Feet

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Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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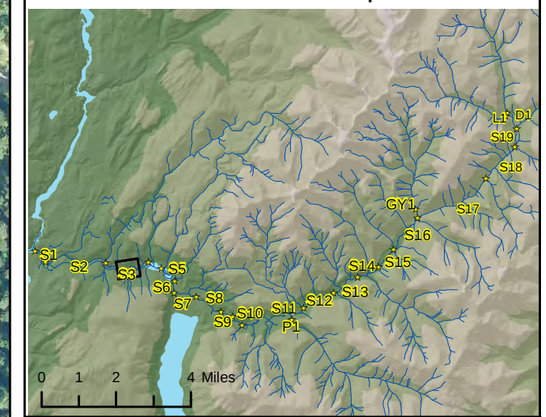

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Analysis Unit Boundary

Reach

Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

Active

Part Stable

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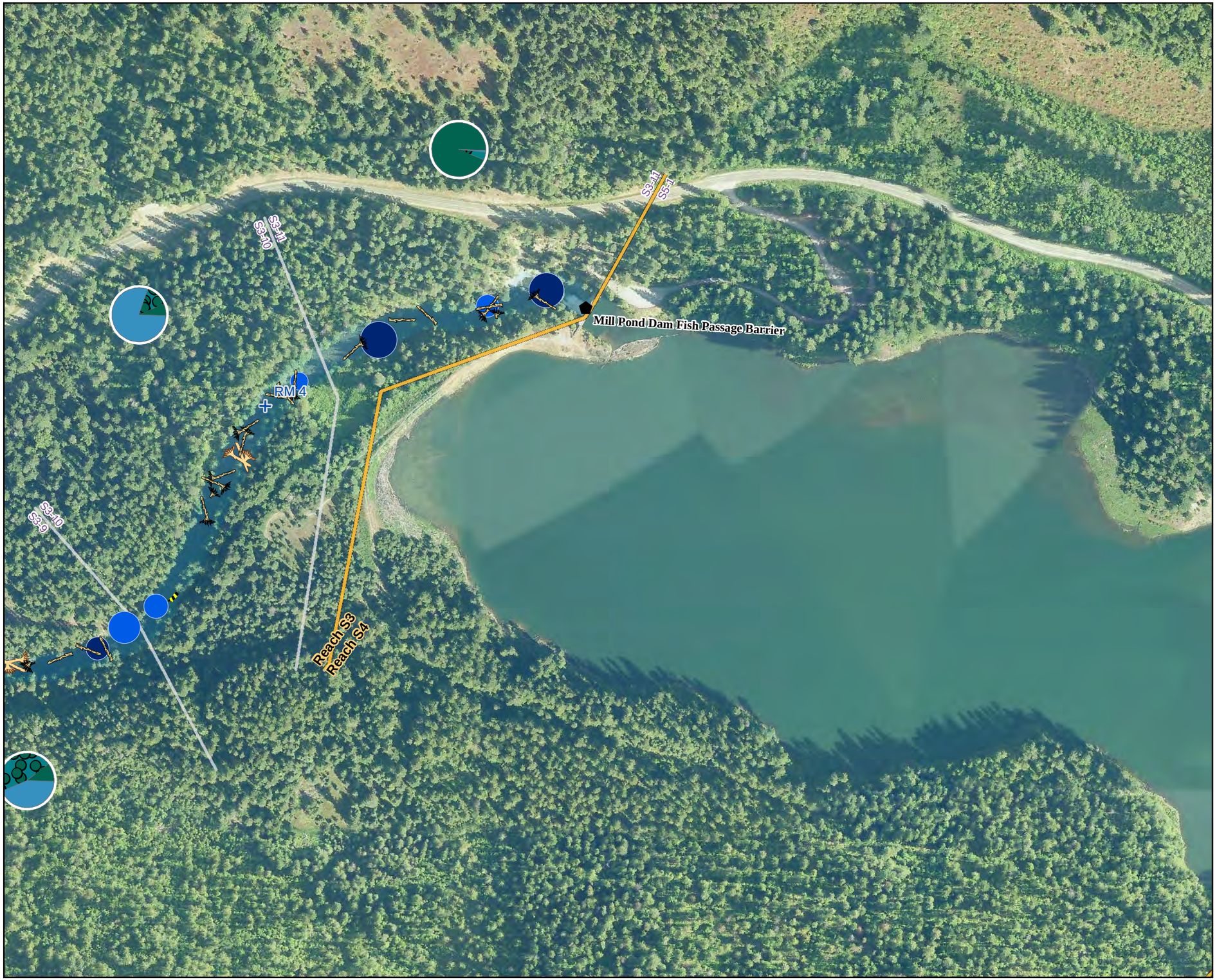

Sullivan Creek Habitat Inventory

Habitat Features

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100 50 0 100 200 Feet

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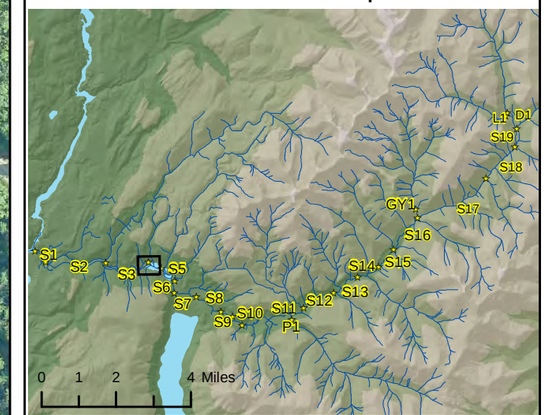

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Subreach

Bank Condition

Armored, Natural

Eroding

Part stable

Stable

Landslides

Active

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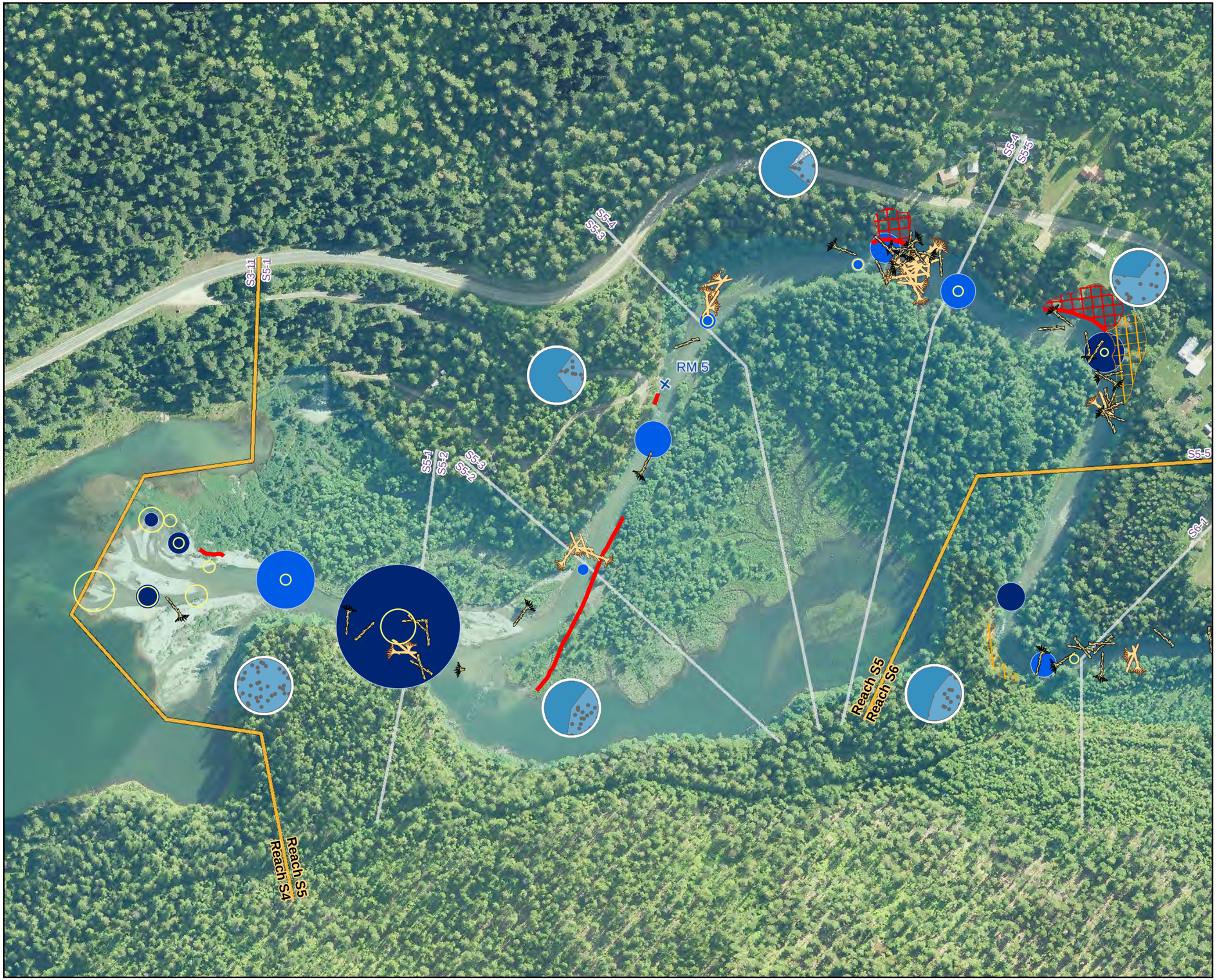

Sullivan Creek Habitat Inventory

Habitat Features

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100 50 0 100 200 Feet

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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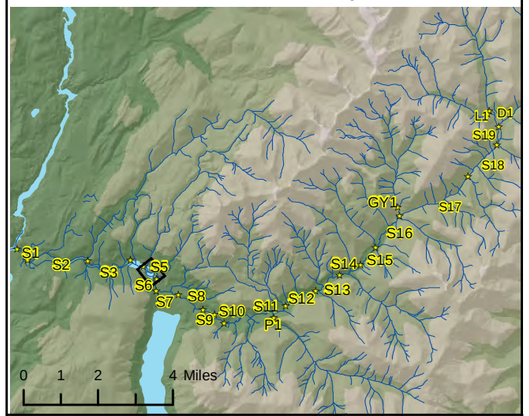

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Sullivan Creek Habitat Inventory

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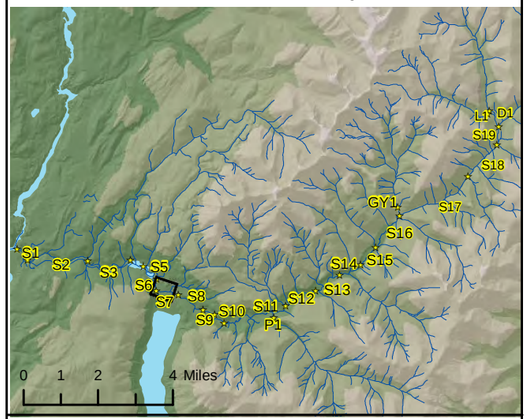

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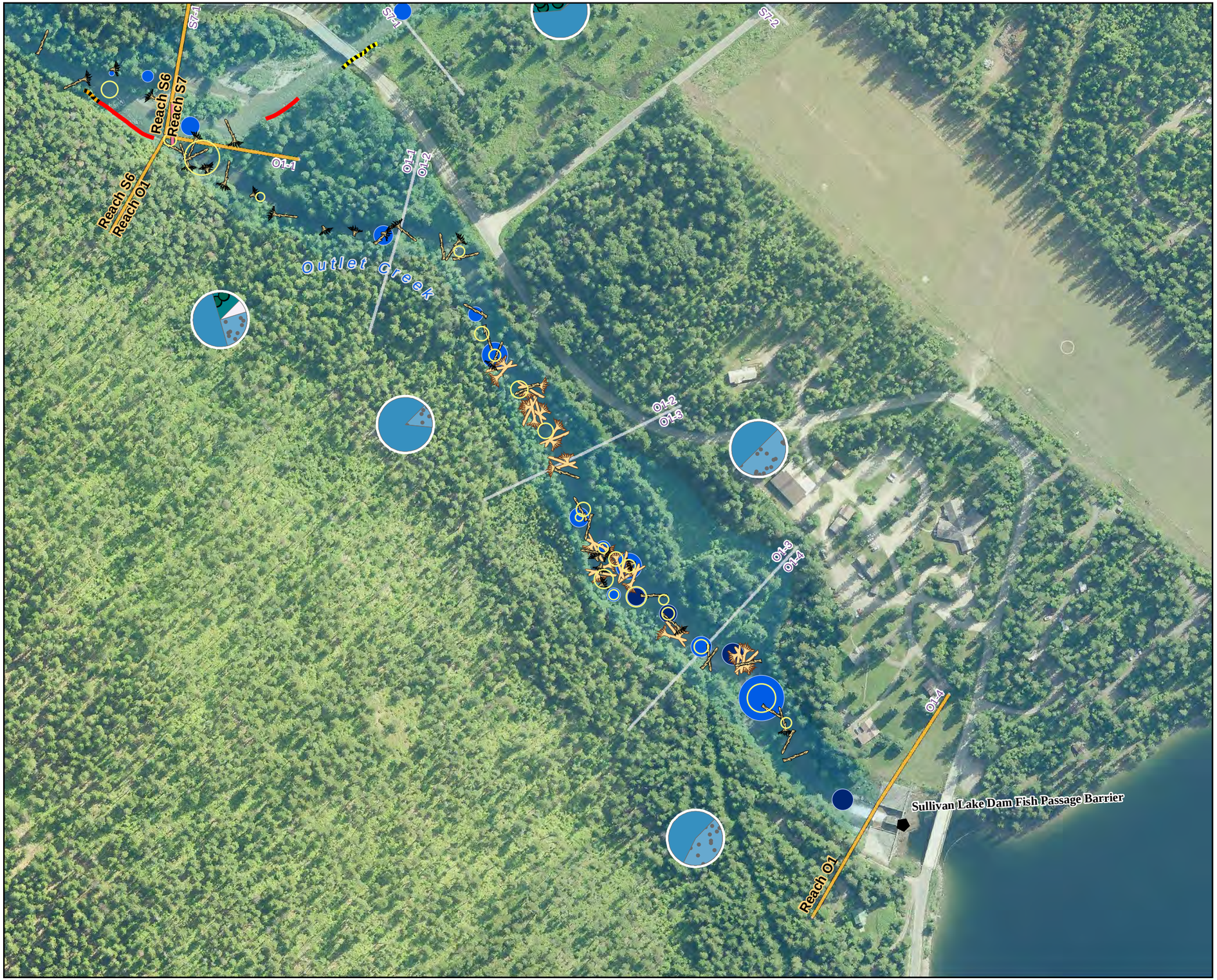

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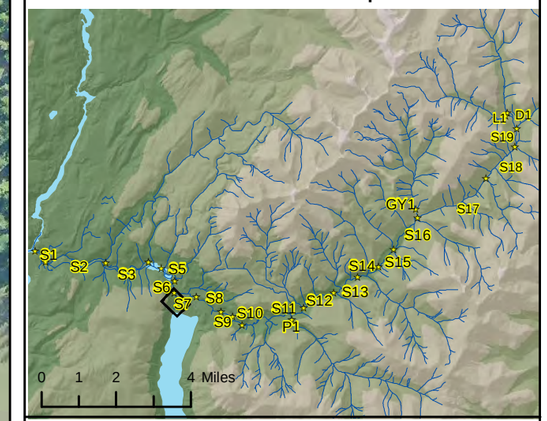

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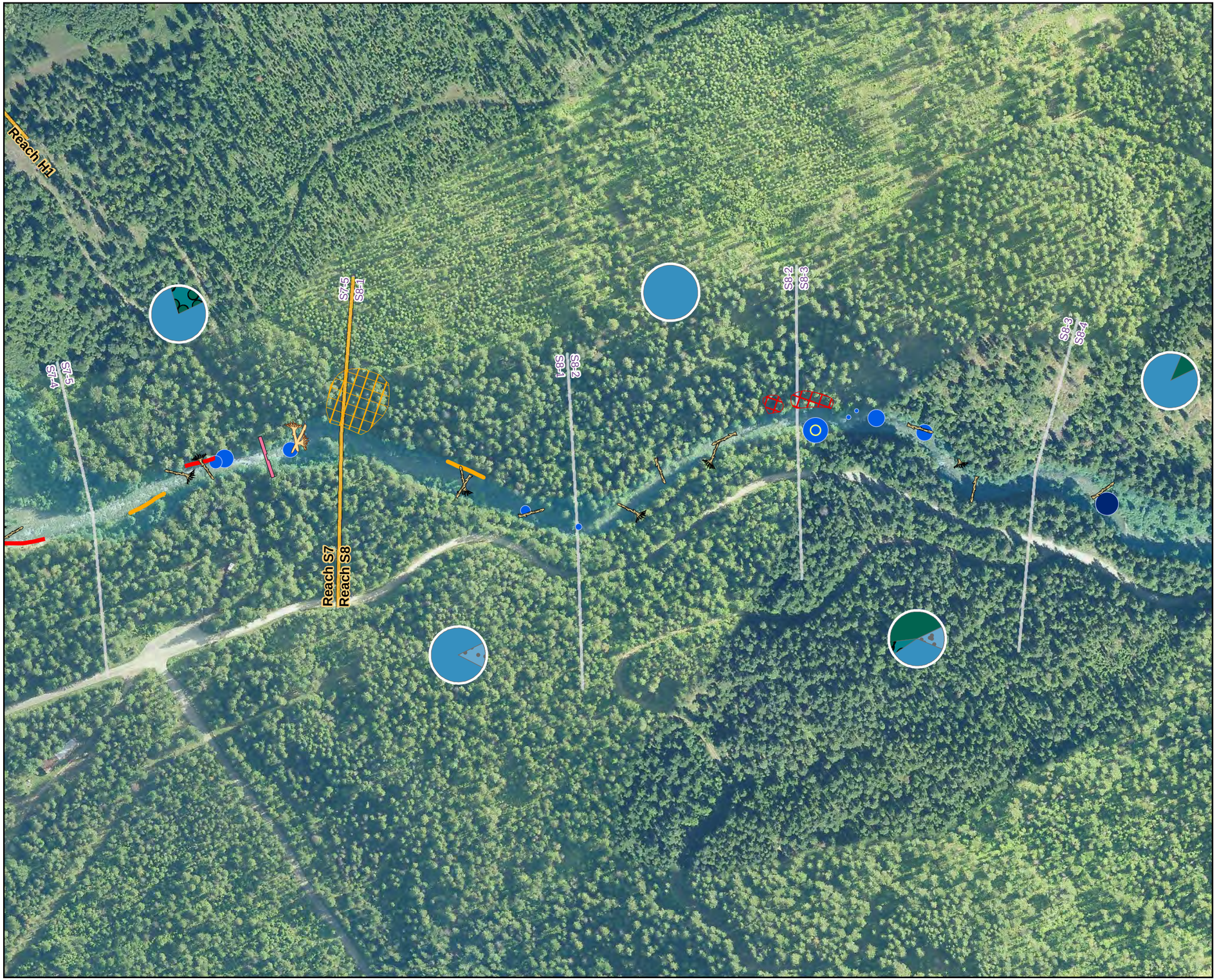

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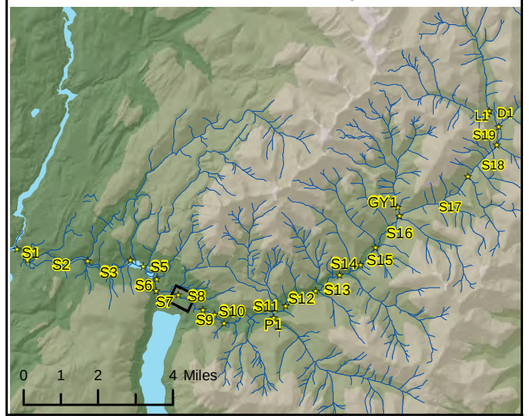

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Landslides

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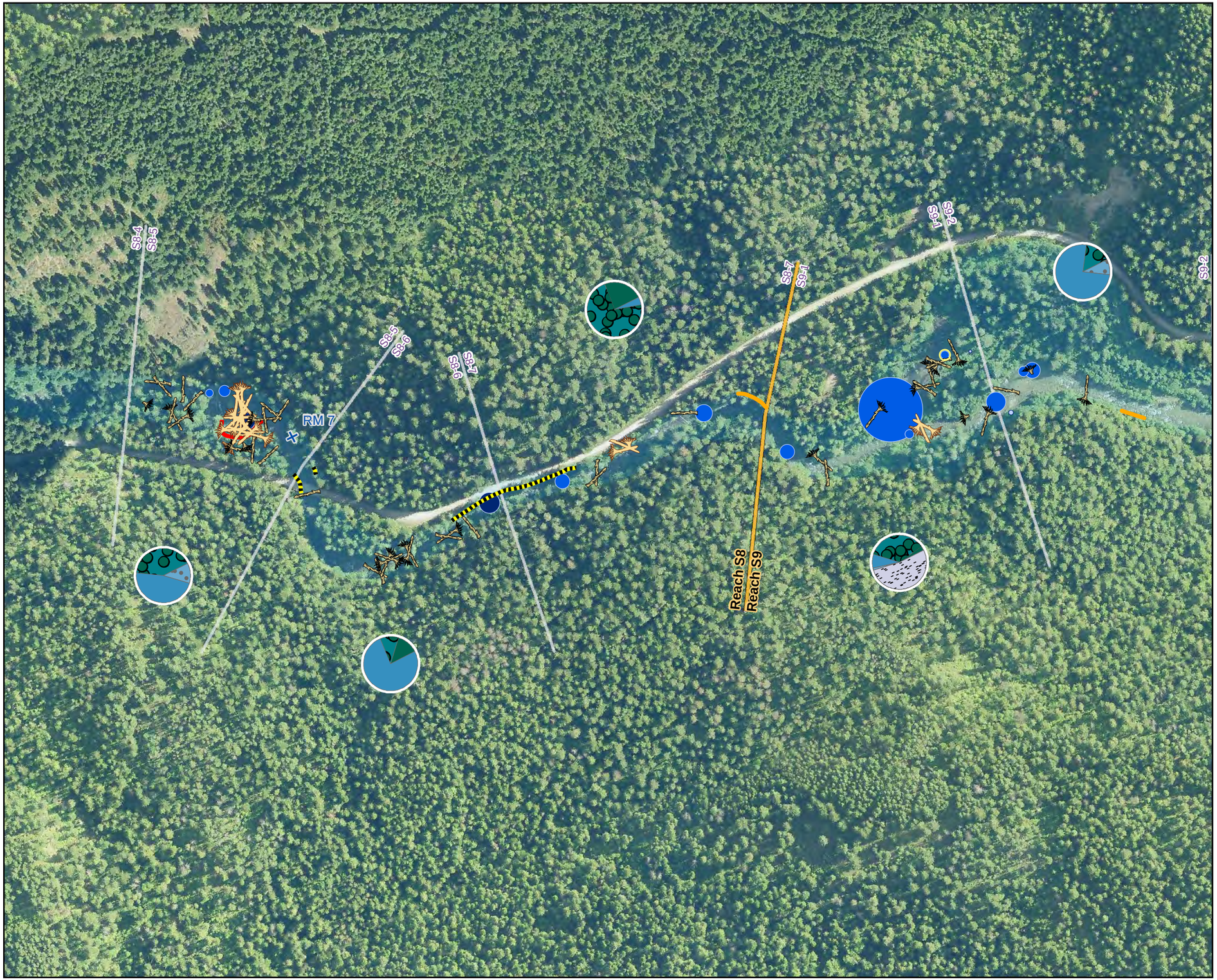
- Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd



Sullivan Creek Habitat Inventory

Habitat Features

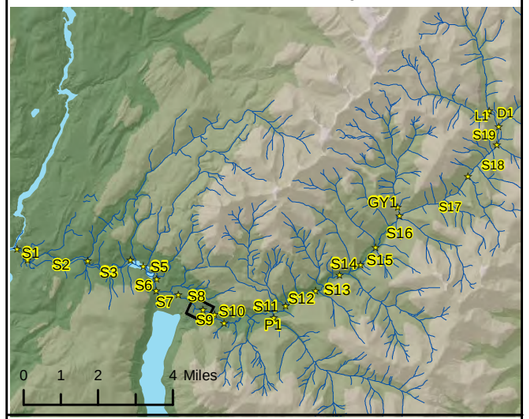
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

< 2,500 ft³

2,500 - 10,000 ft³

10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft
1-2 ft
> 2 ft

500 ft²
2,500 ft²
10,000 ft²

Large Wood

> 25 ft long, no rootwad

> 25 ft long, with rootwad

< 25 ft long, with rootwad

Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft²
500 ft²
1,000 ft²

Dominant Substrate

(proportion of area)

Boulder
Cobble
Bedrock
Gravel
Organic
Sand
Silt and Clay

Analysis Unit Boundary

Reach
Subreach

Bank Condition

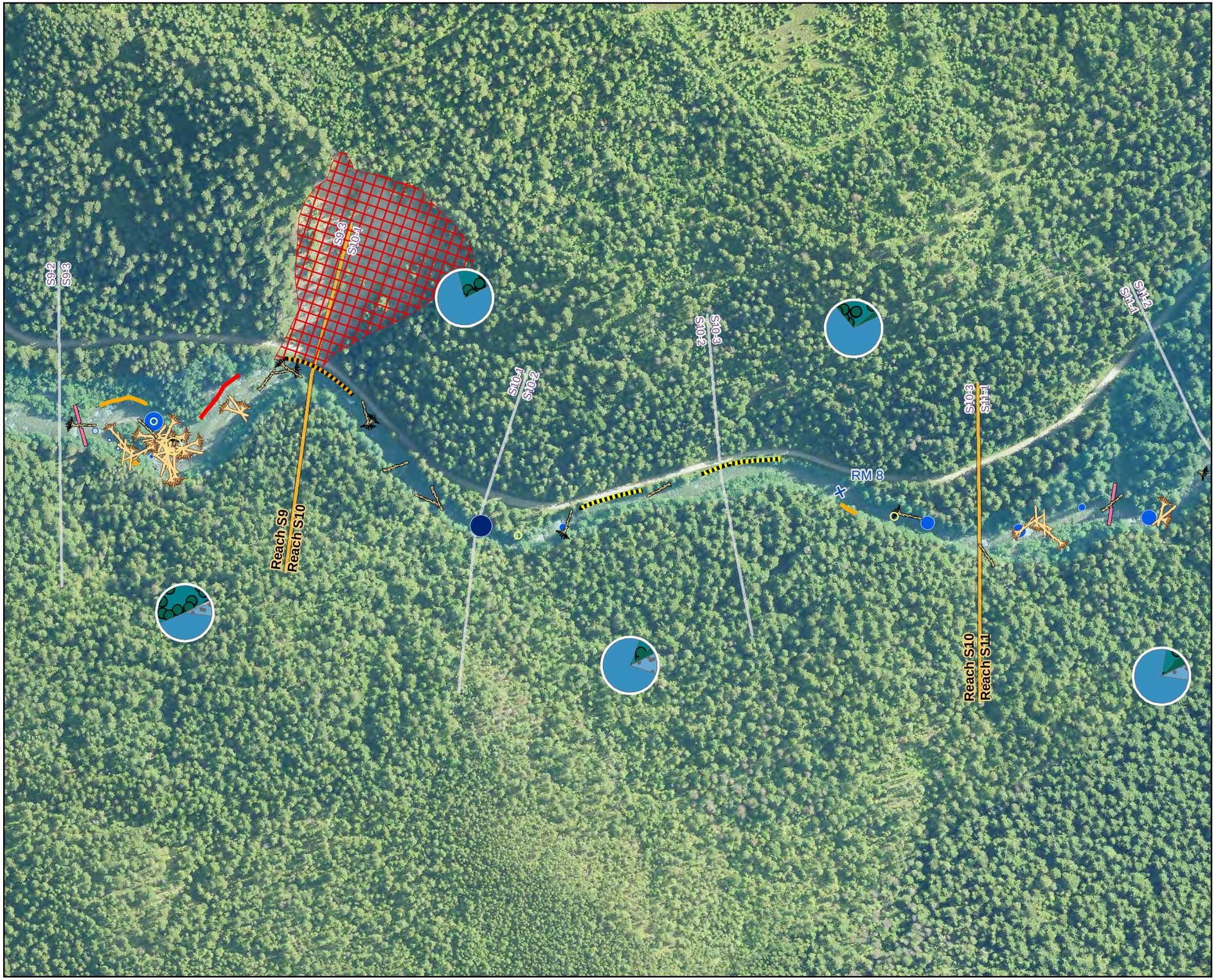
Armored Natural

Eroding
Part stable
Stable

Landslides

Active
Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd



Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

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Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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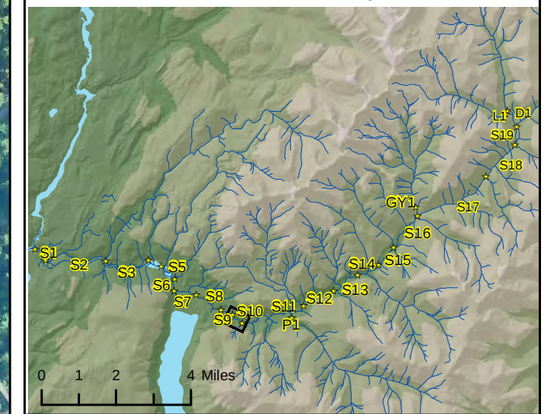

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Spawning Gravel

circle size is proportional to area

≤ 100 ft², 500 ft², 1,000 ft²

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(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

Bank Condition

Armored, Natural

- Eroding
- Part stable
- Stable

Landslides

- Active
- Part Stable

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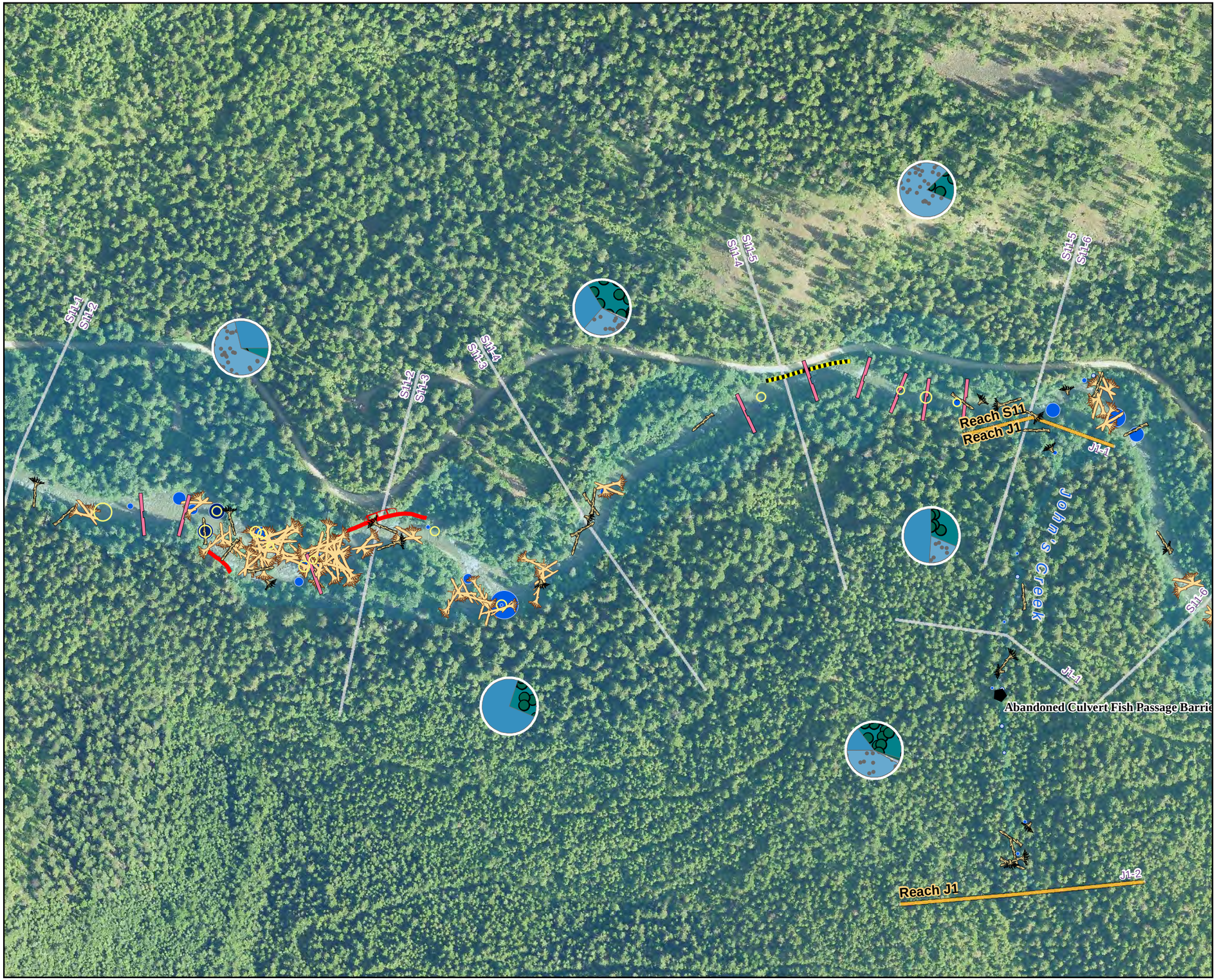

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

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Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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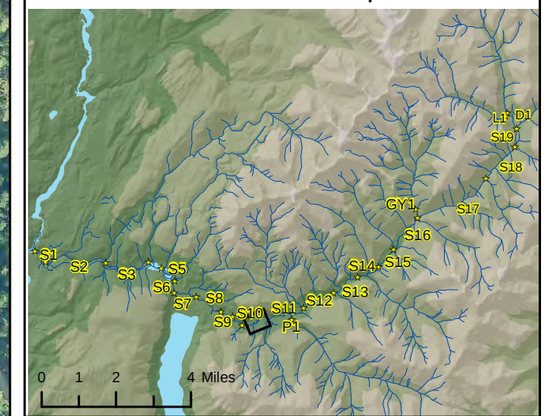

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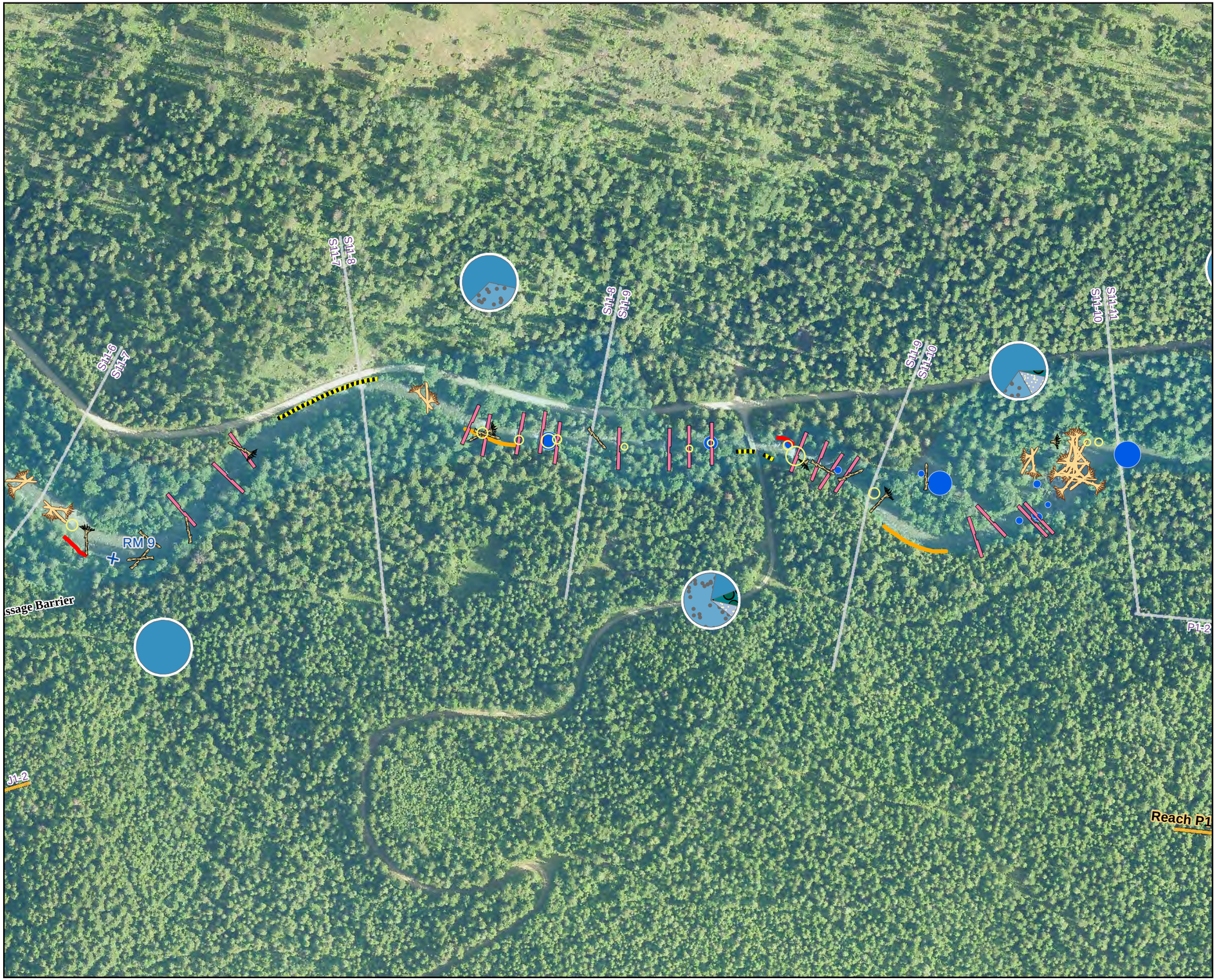

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

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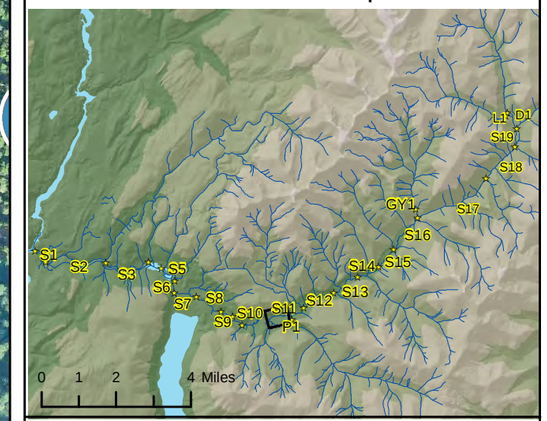

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(proportion of area)

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Landslides

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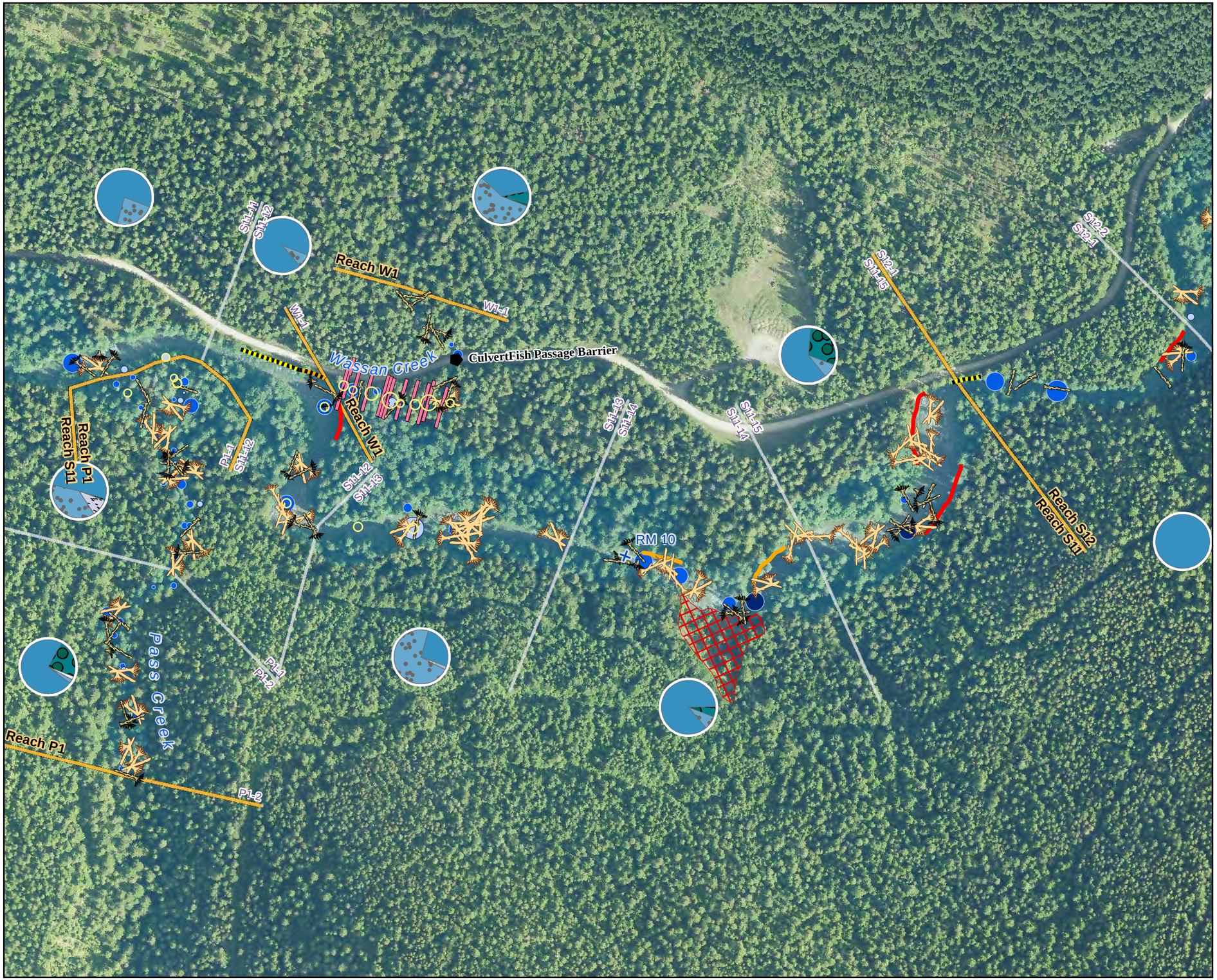

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

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Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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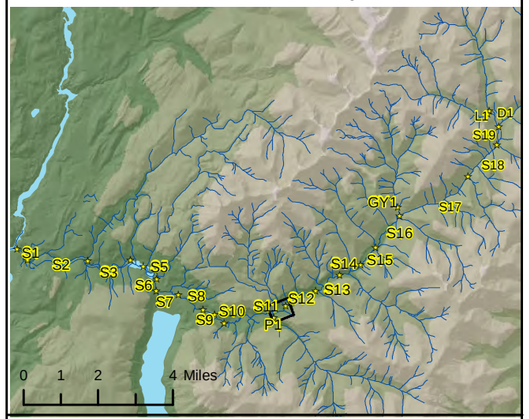

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(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

- Active
- Part Stable

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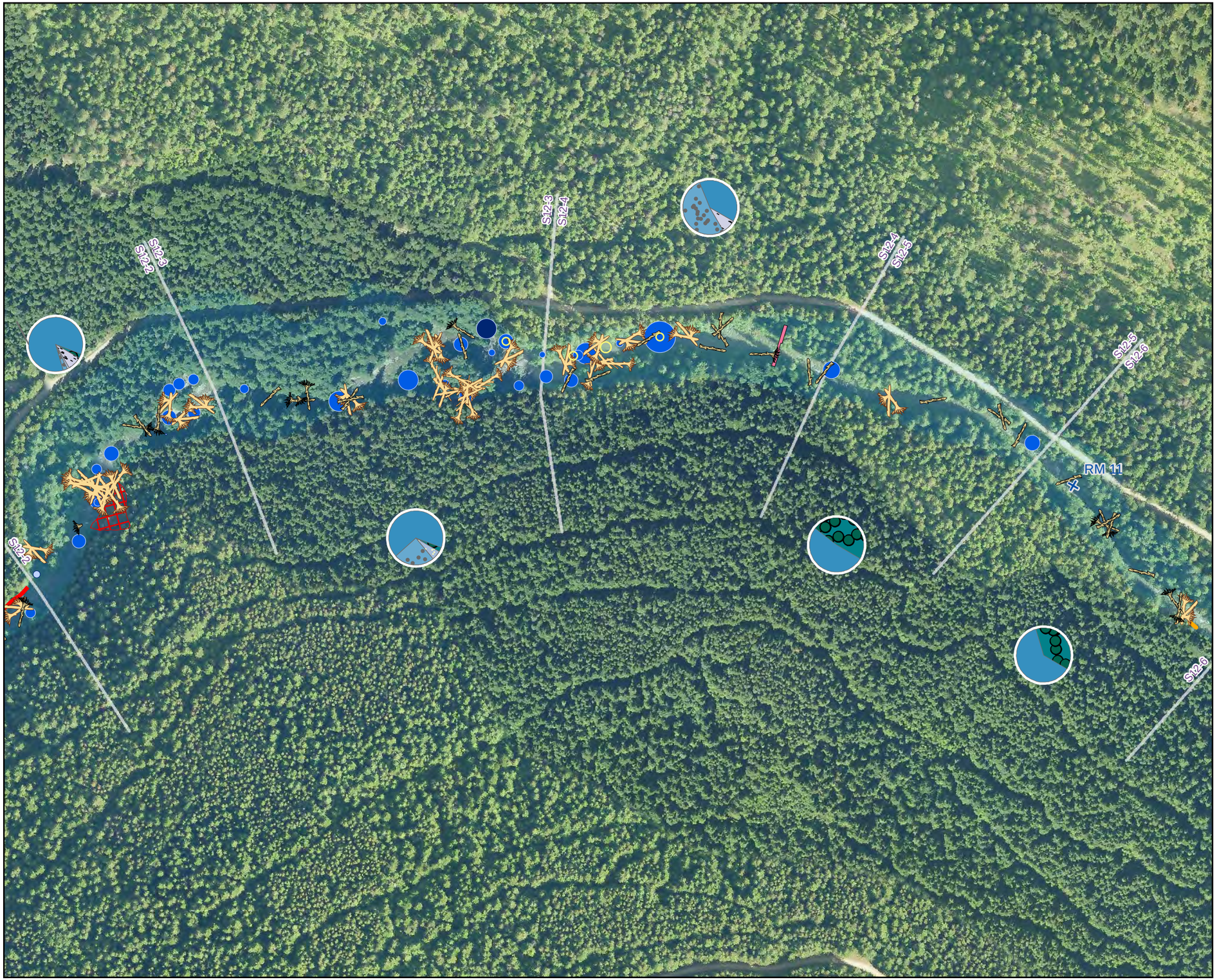

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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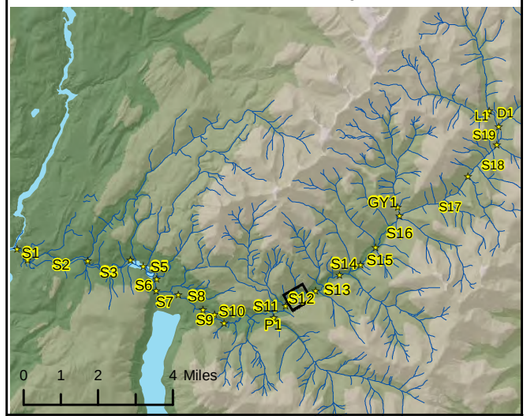

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Spawning Gravel

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500 ft²
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(proportion of area)

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Cobble
Bedrock
Gravel
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Reach
Subreach

Bank Condition

Armored Natural

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Part stable
Stable

Landslides

Active
Part Stable

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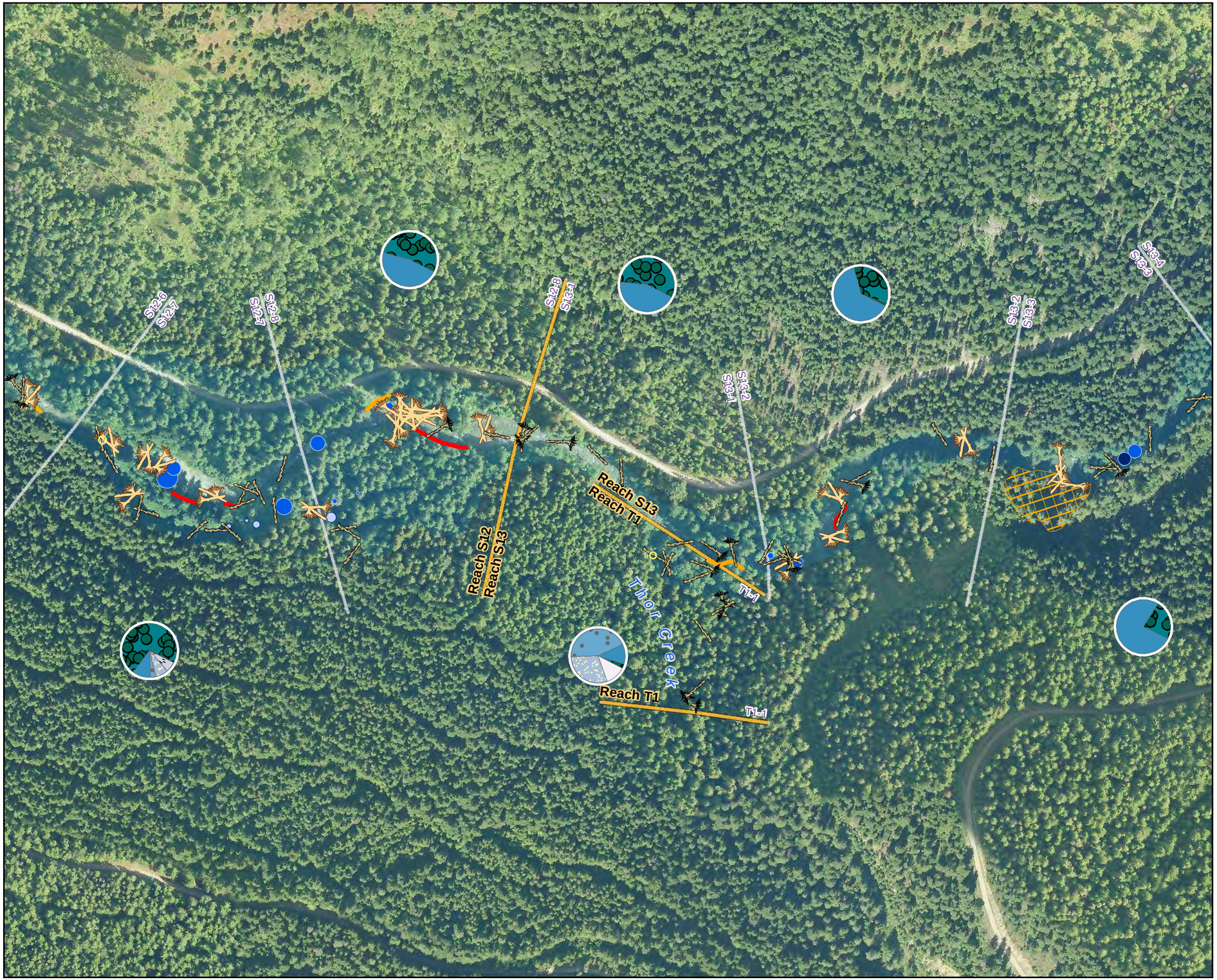

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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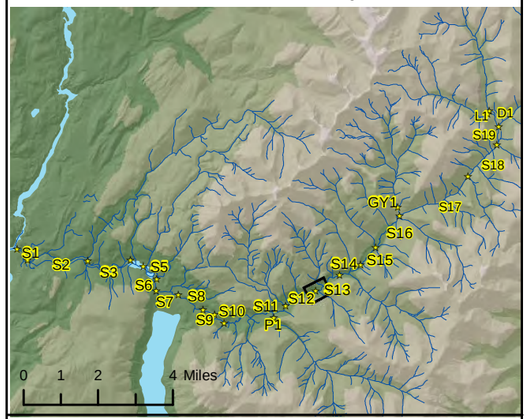

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Spawning Gravel

circle size is proportional to area

≤ 100 ft², 500 ft², 1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

- Active
- Part Stable

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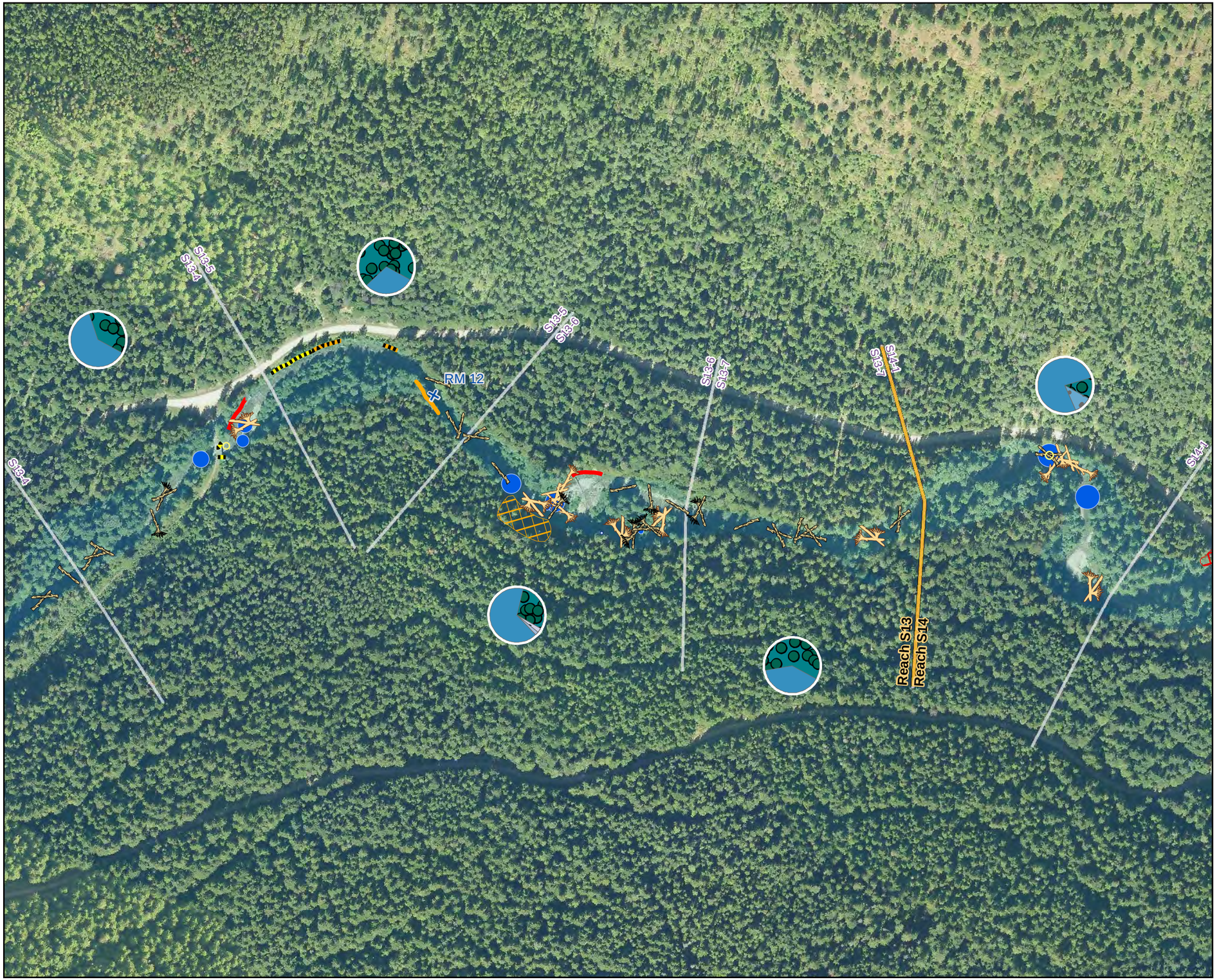

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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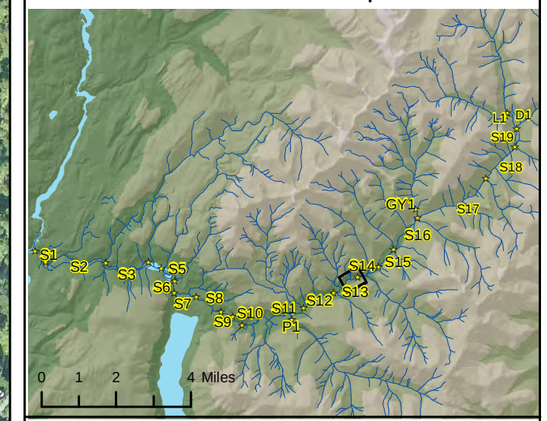

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2,500 ft²

10,000 ft²

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< 25 ft long, with rootwad

Log Weir

Spawning Gravel

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≤ 100 ft²

500 ft²

1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

Reach

Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

Active

Part Stable

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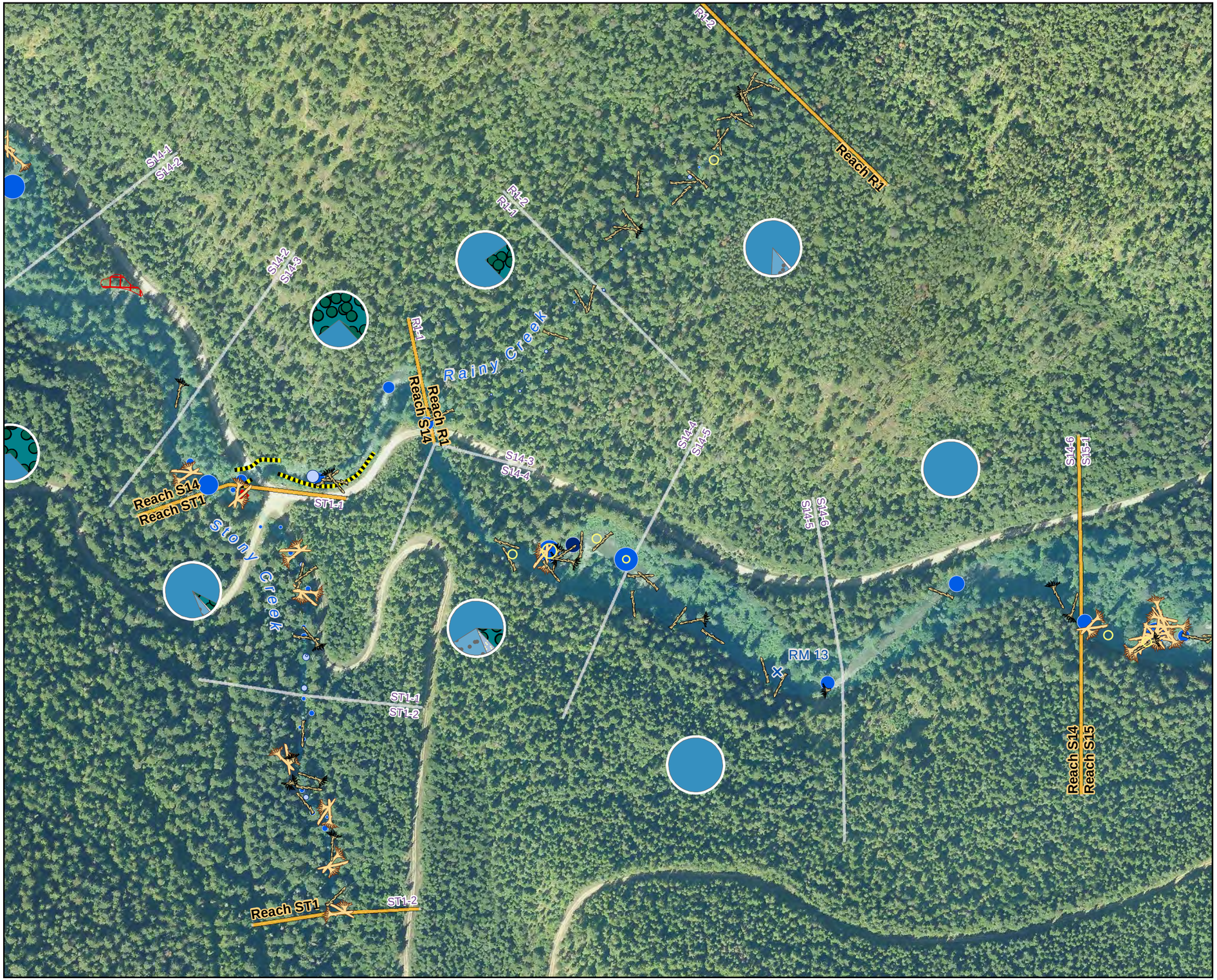

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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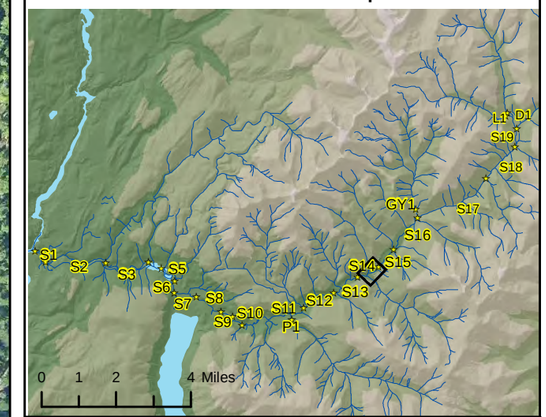

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Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

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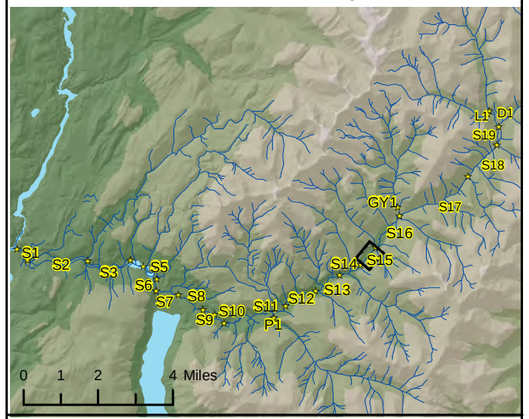

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Sullivan Creek Habitat Inventory

Habitat Features

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100 50 0 100 200 Feet

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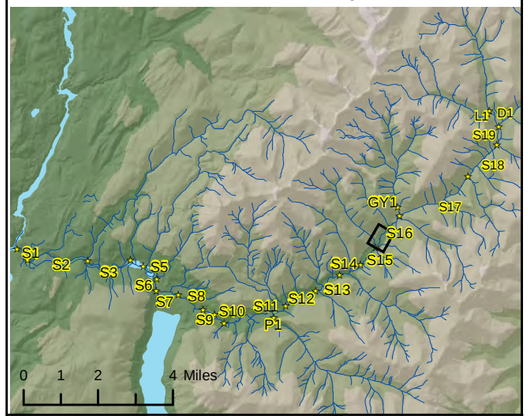

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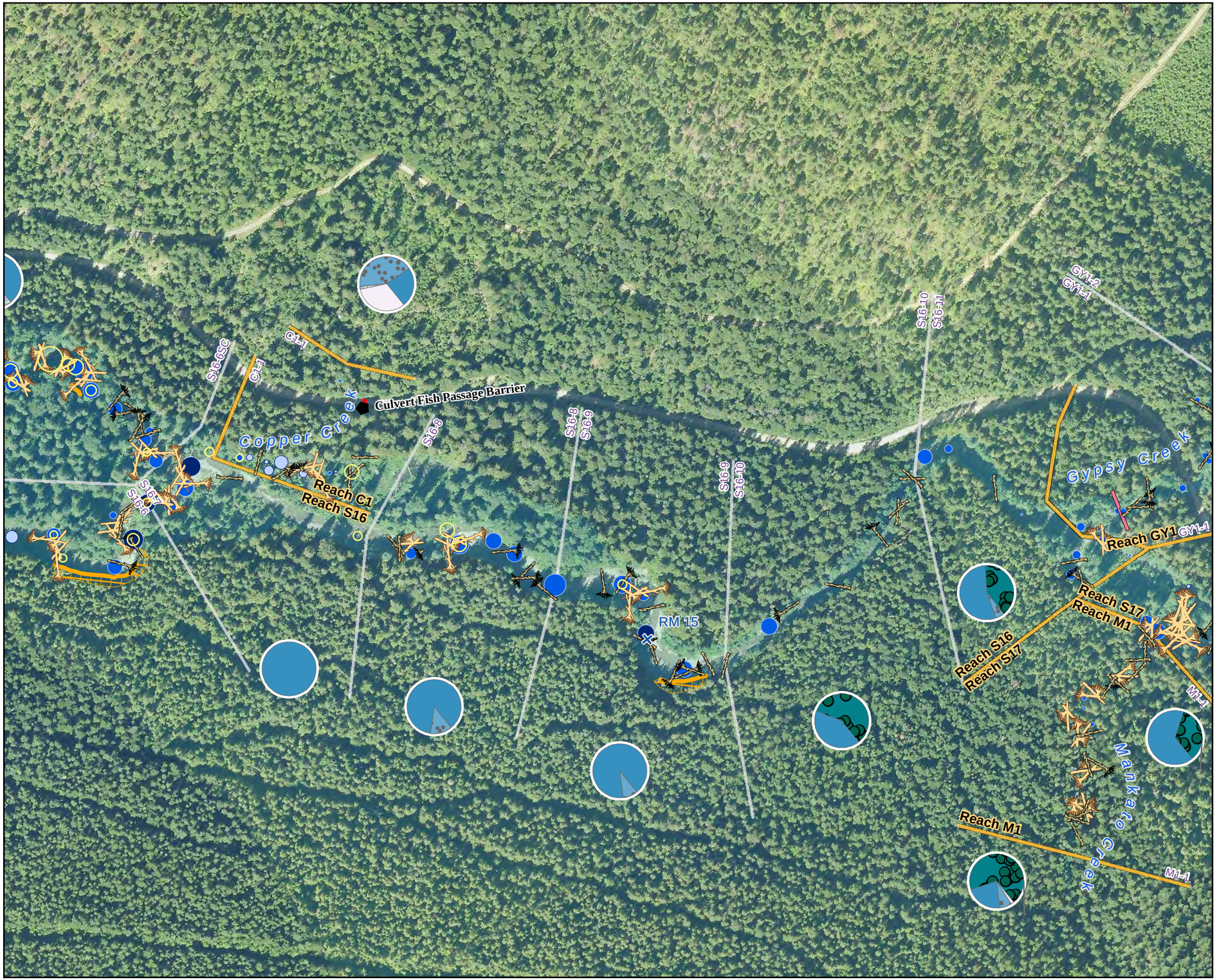

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Habitat Features

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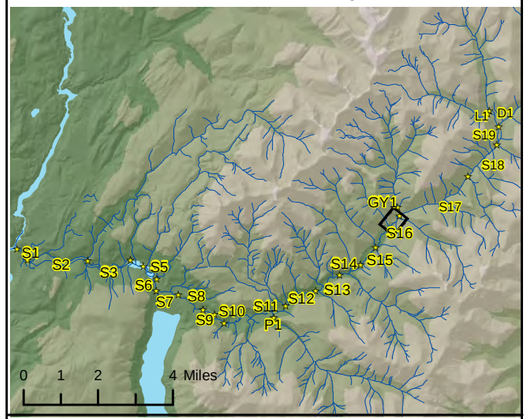

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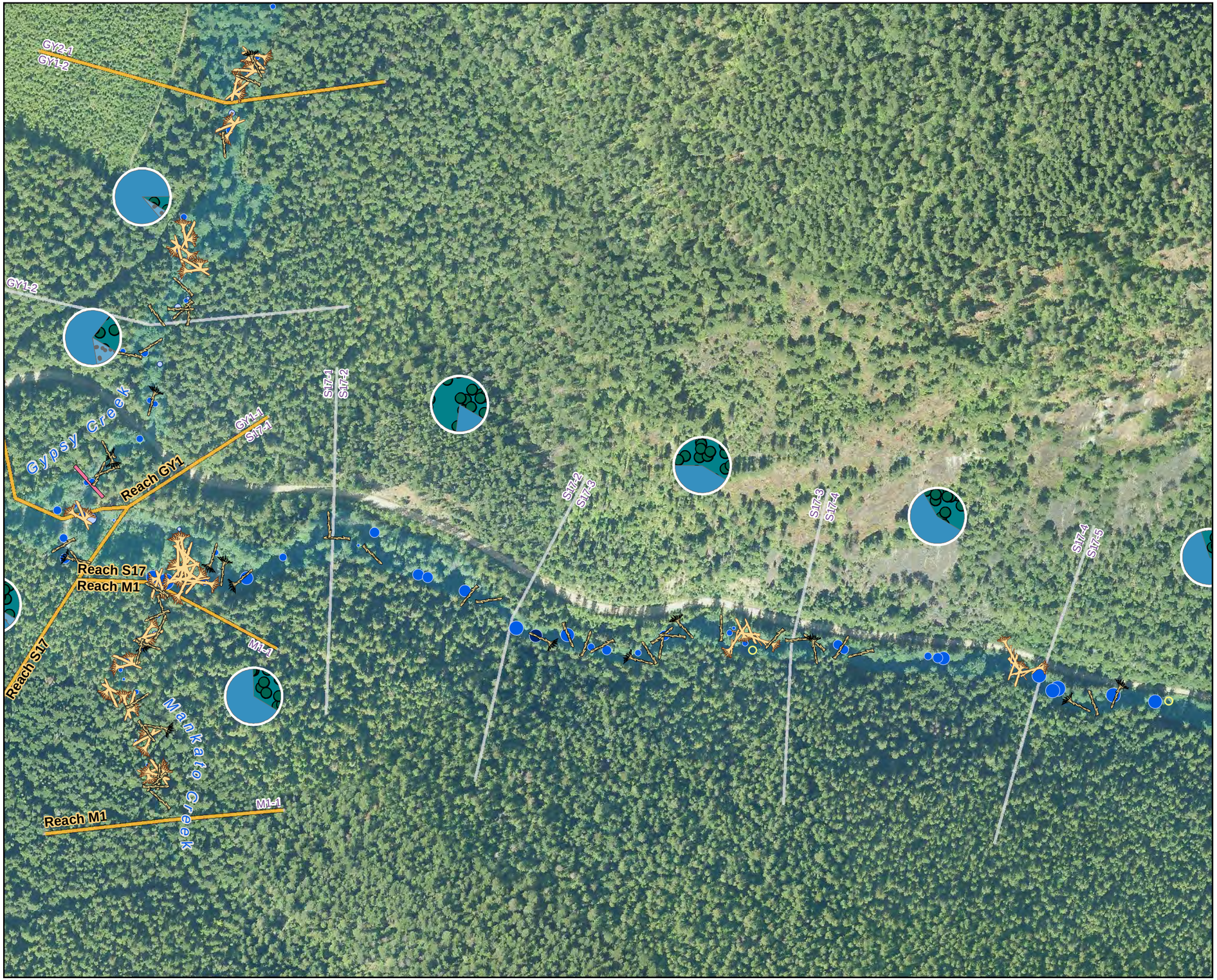

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

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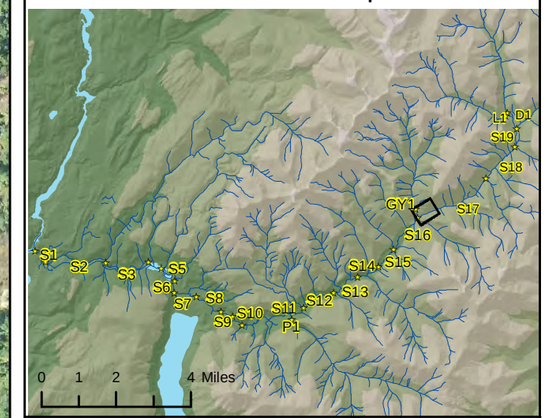

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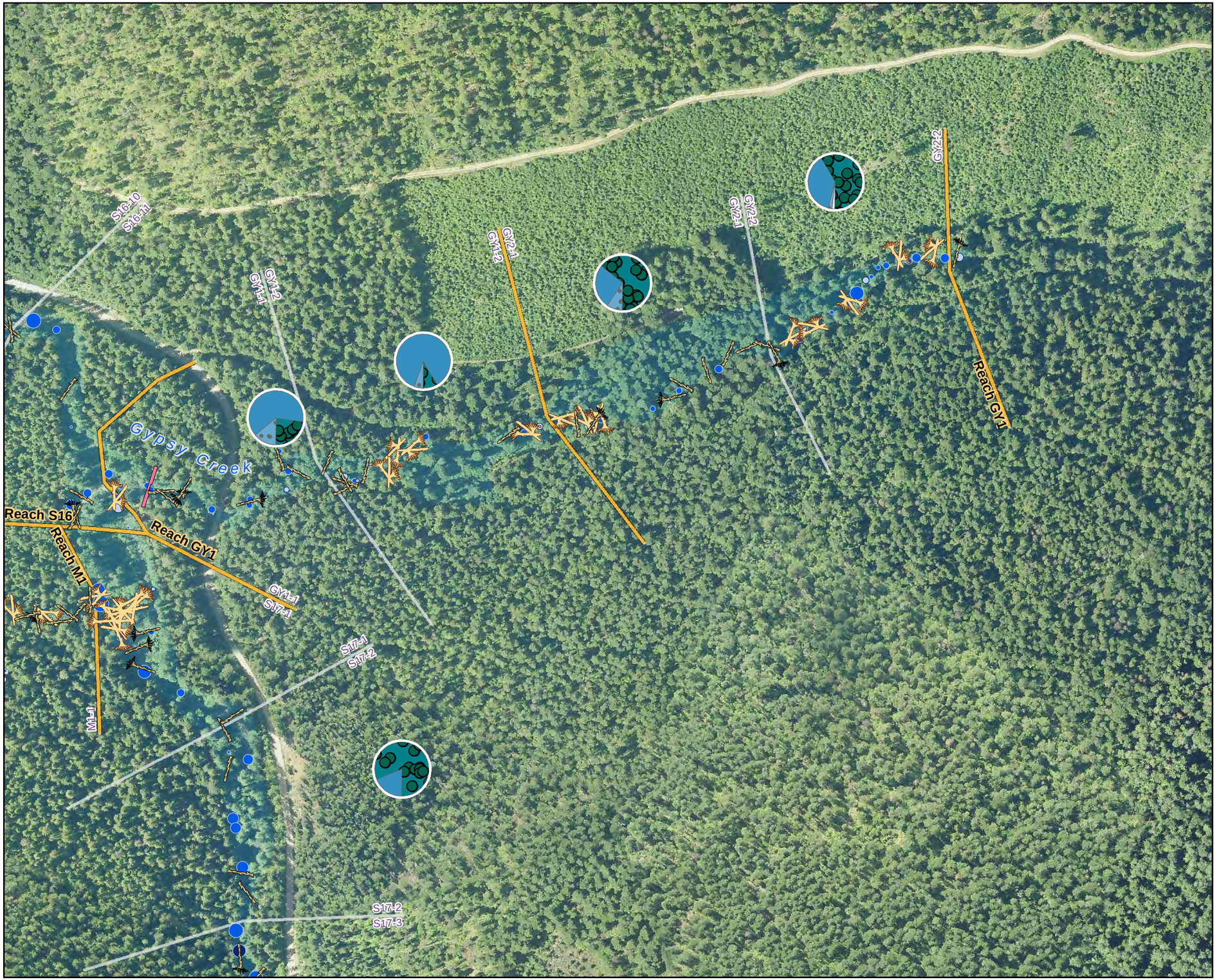

Sullivan Creek Habitat Inventory

Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

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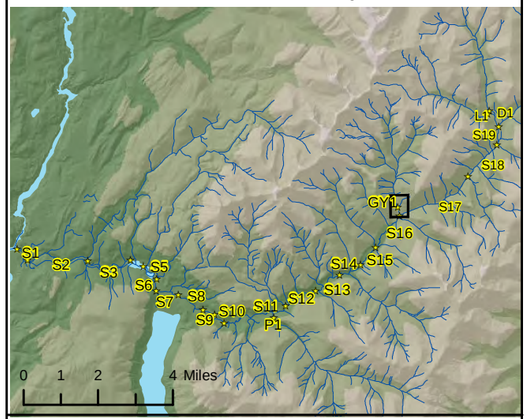
Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

< 2,500 ft³

2,500 - 10,000 ft³

10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft
1-2 ft
> 2 ft

500 ft²
2,500 ft²
10,000 ft²

Large Wood

> 25 ft long, no rootwad

> 25 ft long, with rootwad

< 25 ft long, with rootwad

Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft²
500 ft²
1,000 ft²

Dominant Substrate

(proportion of area)

Boulder
Cobble
Bedrock
Gravel
Organic
Sand
Silt and Clay

Analysis Unit Boundary

Reach
Subreach

Bank Condition

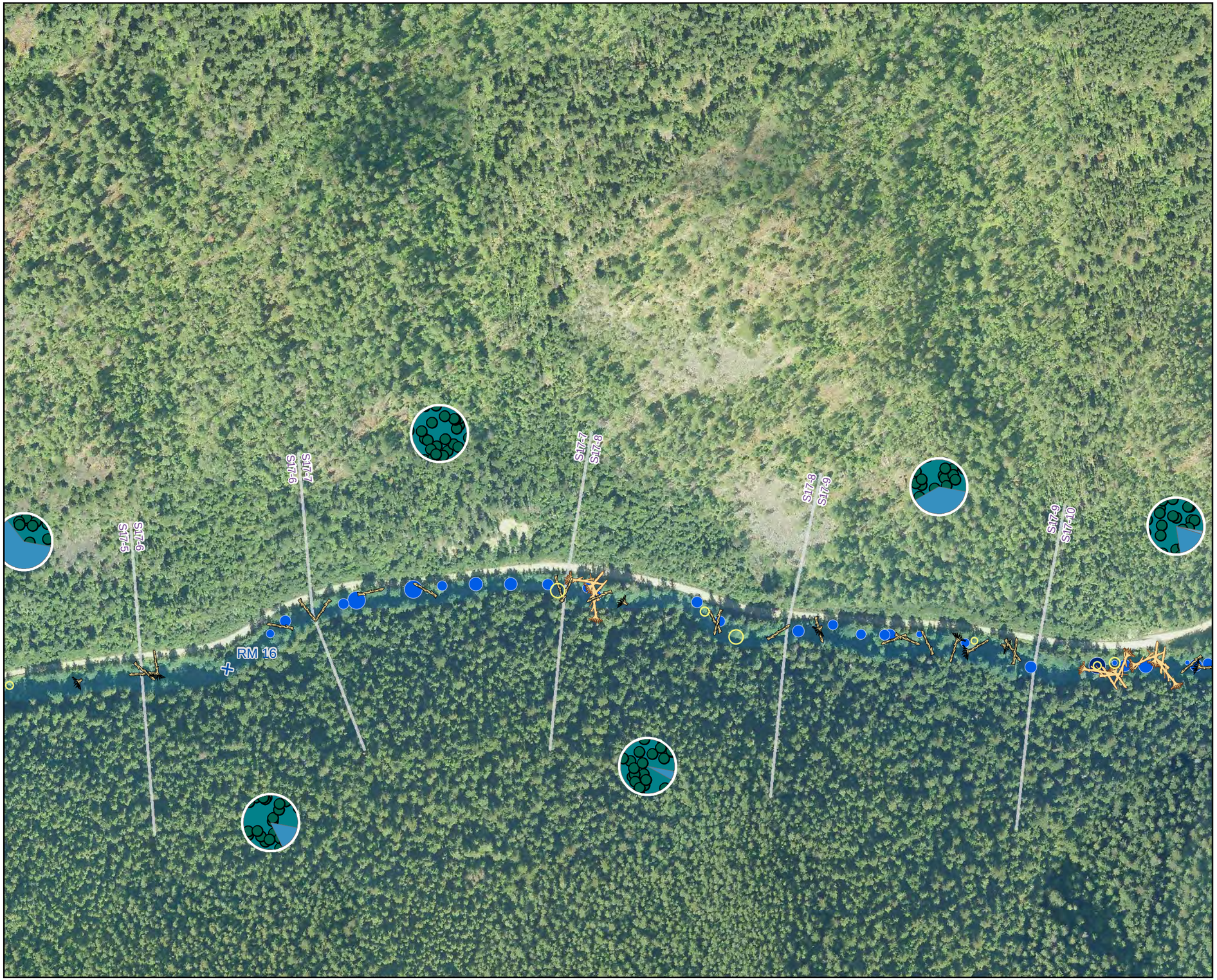
Armored Natural

Eroding
Part stable
Stable

Landslides

Active
Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd



Sullivan Creek Habitat Inventory

Habitat Features

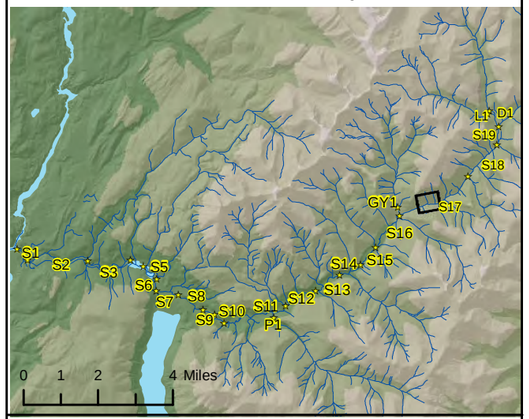
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

- < 2,500 ft³
- 2,500 - 10,000 ft³
- 10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft, 1-2 ft, > 2 ft

500 ft², 2,500 ft², 10,000 ft²

Large Wood

- > 25 ft long, no rootwad
- > 25 ft long, with rootwad
- < 25 ft long, with rootwad
- Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft², 500 ft², 1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

- Active
- Part Stable

ADN_Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd

Sullivan Creek Habitat Inventory

Habitat Features

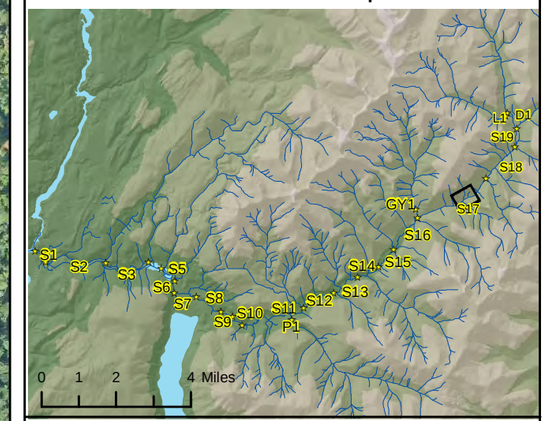
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

- < 2,500 ft³
- 2,500 - 10,000 ft³
- 10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft, 1-2 ft, > 2 ft

500 ft², 2,500 ft², 10,000 ft²

Large Wood

- > 25 ft long, no rootwad
- > 25 ft long, with rootwad
- < 25 ft long, with rootwad
- Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft², 500 ft², 1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

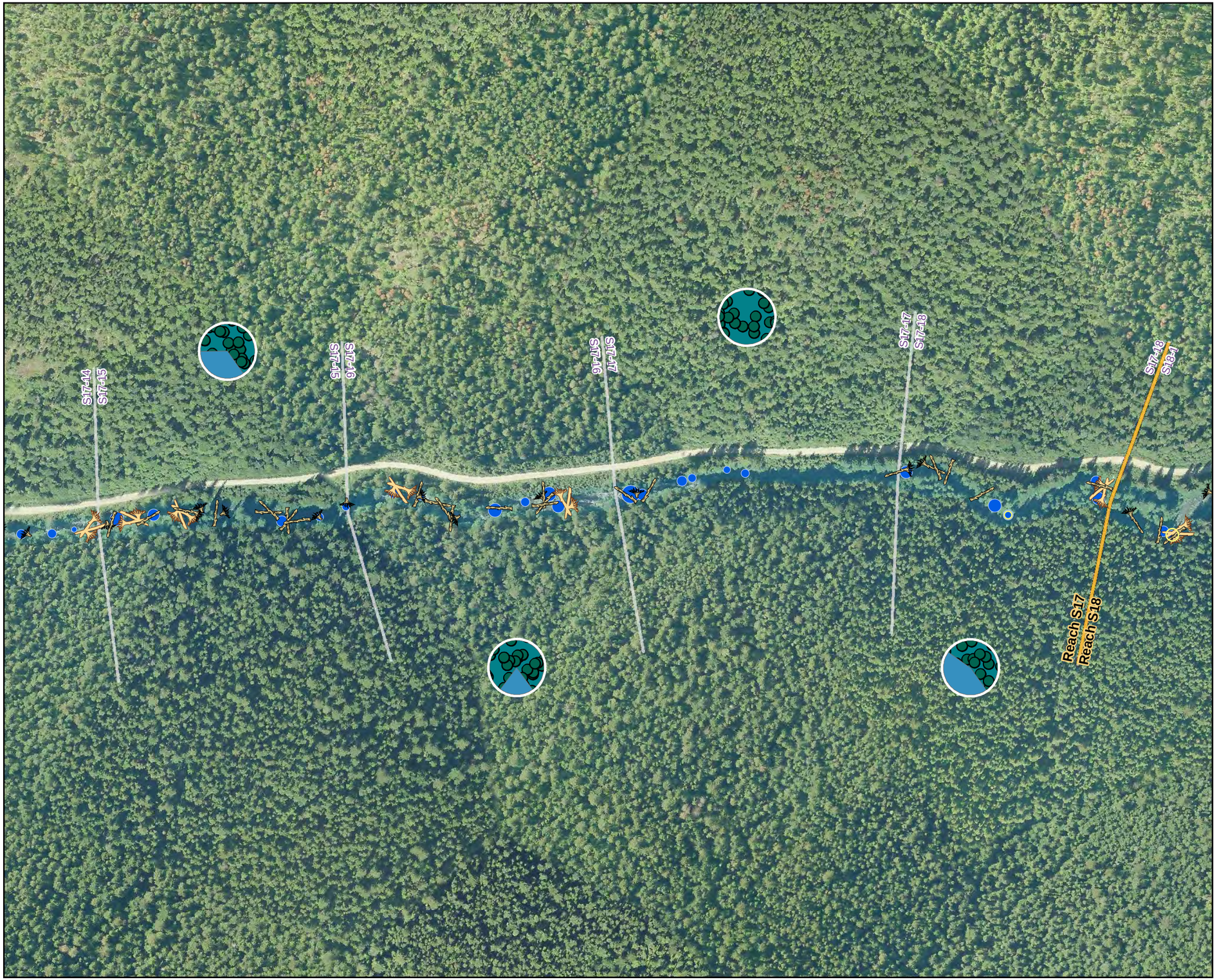
Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

- Active
- Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd



Sullivan Creek Habitat Inventory

Habitat Features

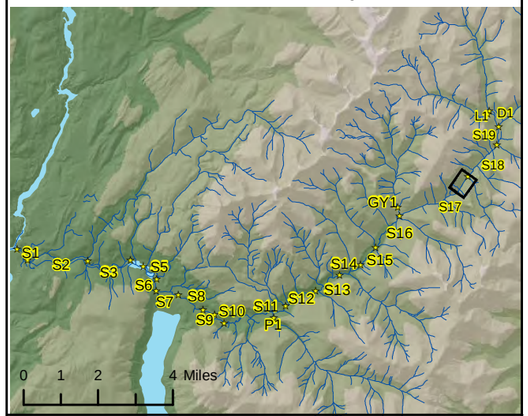
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

< 2,500 ft³

2,500 - 10,000 ft³

10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft, 1-2 ft, > 2 ft

500 ft²

2,500 ft²

10,000 ft²

Large Wood

> 25 ft long, no rootwad

> 25 ft long, with rootwad

< 25 ft long, with rootwad

Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft²

500 ft²

1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

Reach

Subreach

Bank Condition

Armored Natural

Eroding

Part stable

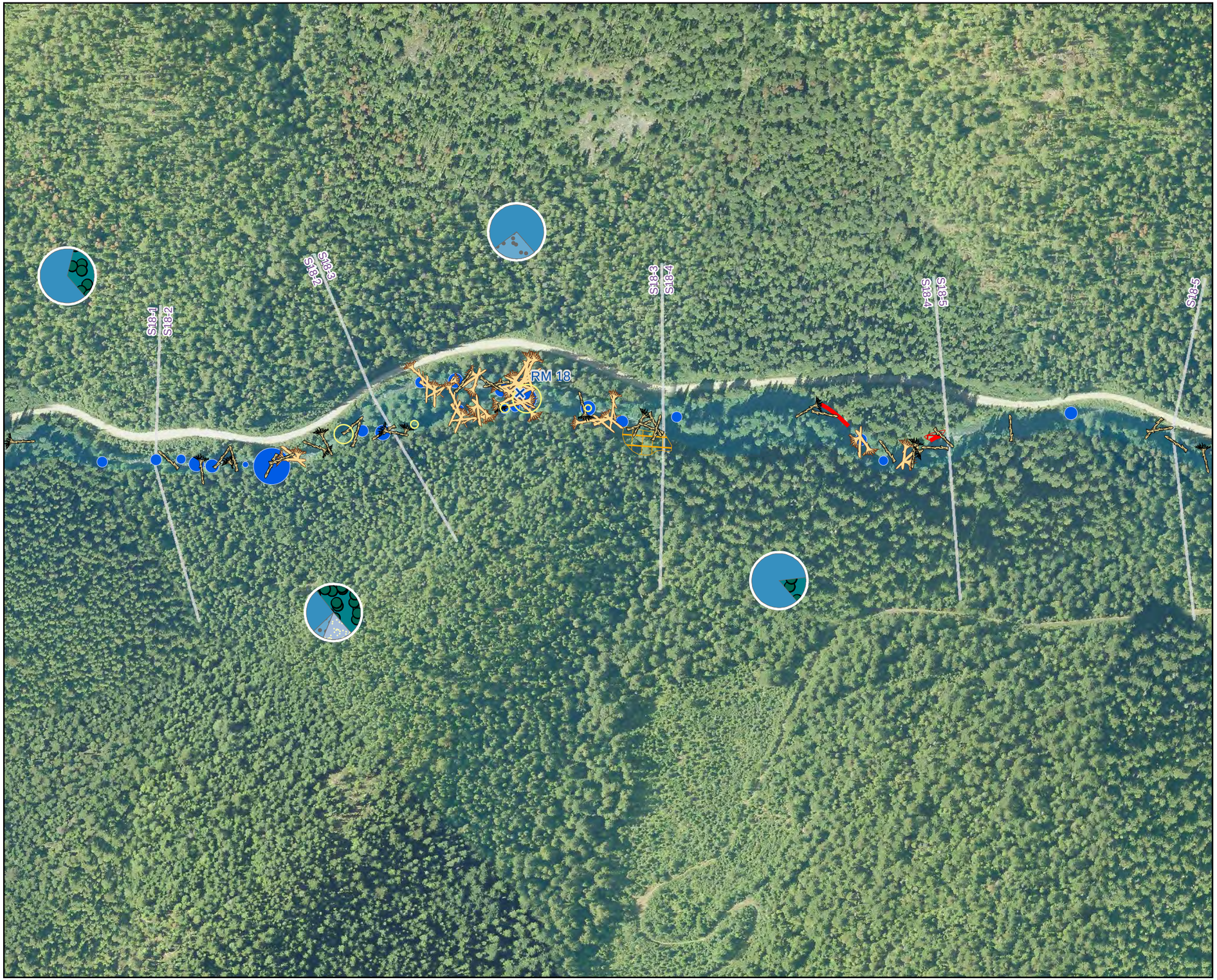
Stable

Landslides

Active

Part Stable

ADN_Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd



Sullivan Creek Habitat Inventory

Habitat Features

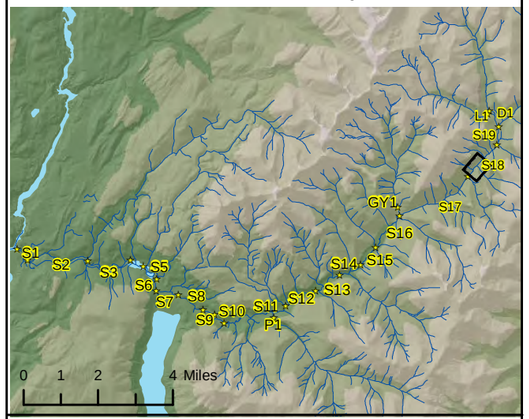
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

< 2,500 ft³

2,500 - 10,000 ft³

10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft, 1-2 ft, > 2 ft

500 ft²
2,500 ft²
10,000 ft²

Large Wood

> 25 ft long, no rootwad

> 25 ft long, with rootwad

< 25 ft long, with rootwad

Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft²
500 ft²
1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

Reach

Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

Landslides

Active

Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd

Sullivan Creek Habitat Inventory

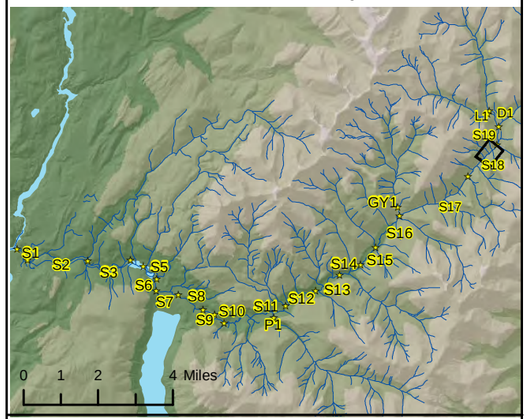
Habitat Features

Scale - 1:3,000

100 50 0 100 200 Feet

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

< 2,500 ft³

2,500 - 10,000 ft³

10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft, 1-2 ft, > 2 ft

500 ft²
2,500 ft²
10,000 ft²

Large Wood

> 25 ft long, no rootwad

> 25 ft long, with rootwad

< 25 ft long, with rootwad

Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft²
500 ft²
1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

Reach

Subreach

Bank Condition

Armored, Natural

Eroding

Part stable

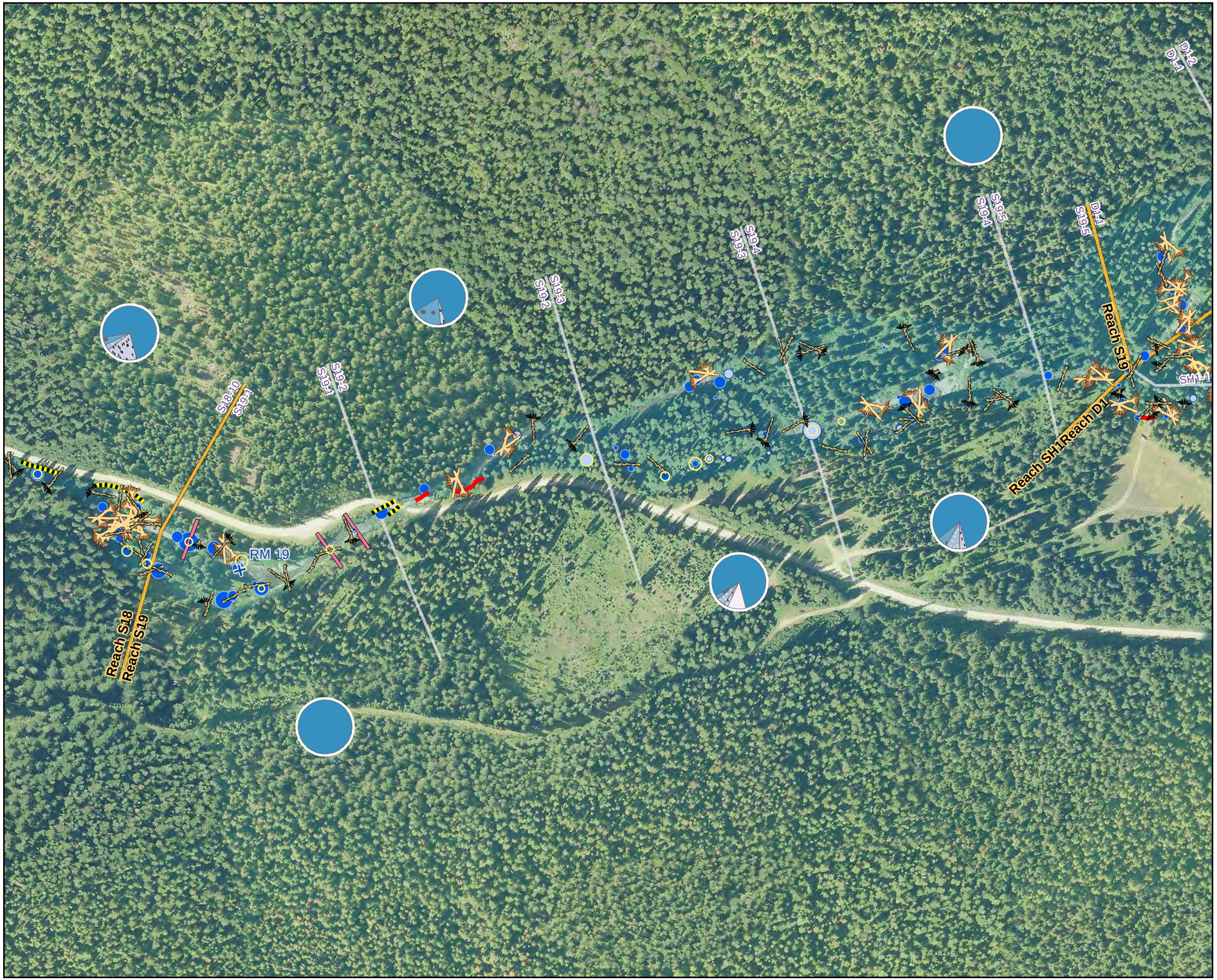
Stable

Landslides

Active

Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd



Sullivan Creek Habitat Inventory

Habitat Features

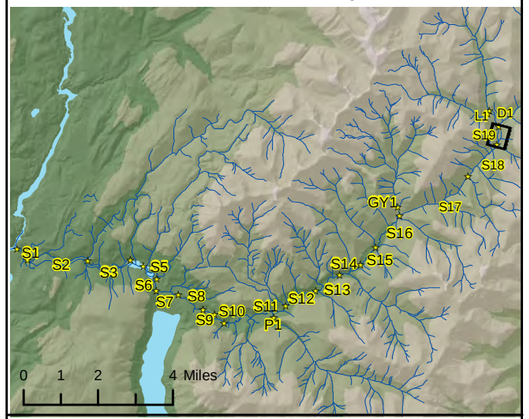
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

< 2,500 ft³

2,500 - 10,000 ft³

10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft
1-2 ft
> 2 ft

500 ft²
2,500 ft²
10,000 ft²

Large Wood

> 25 ft long, no rootwad

> 25 ft long, with rootwad

< 25 ft long, with rootwad

Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft²
500 ft²
1,000 ft²

Dominant Substrate

(proportion of area)

Boulder
Cobble
Bedrock
Gravel
Organic
Sand
Silt and Clay

Analysis Unit Boundary

Reach

Subreach

Bank Condition

Armored Natural

Eroding

Part stable

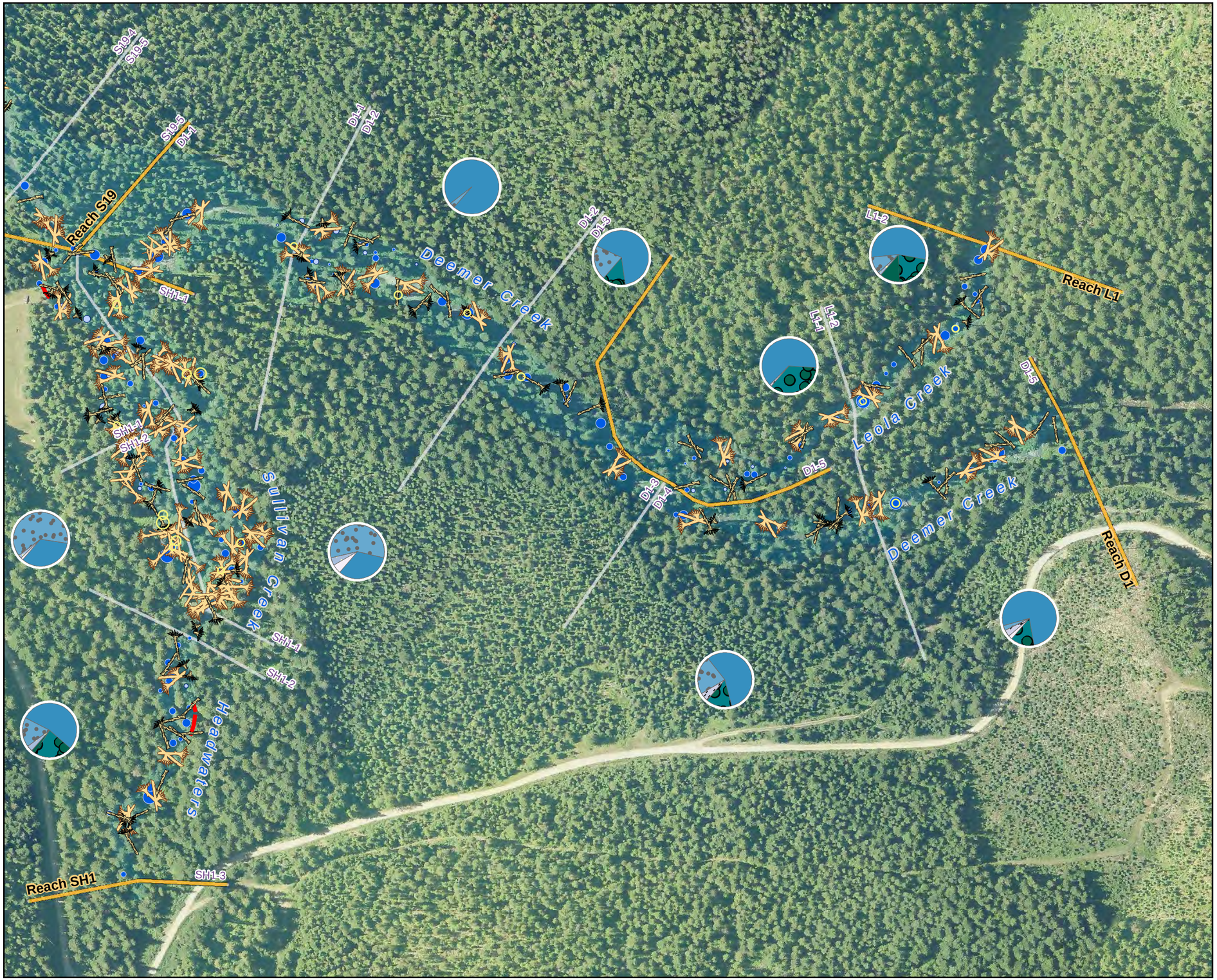
Stable

Landslides

Active

Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd



Sullivan Creek Habitat Inventory

Habitat Features

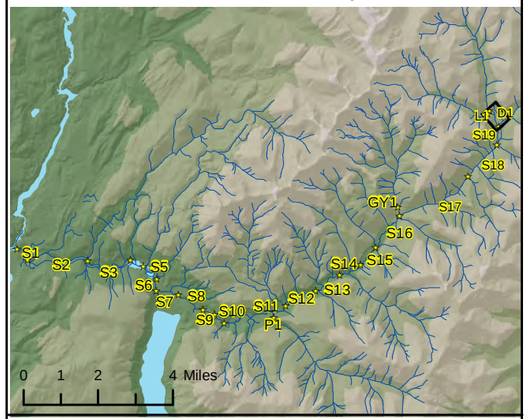
Scale - 1:3,000

100 50 0 100 200 Feet

N

Northwest Hydraulic Consultants	project no. 200061	8/9/2013

Reference Map



Large Wood Jams

- < 2,500 ft³
- 2,500 - 10,000 ft³
- 10,000 - 75,000 ft³

Pools

Circle size is proportional to area. Shade indicates residual depth.

< 1 ft, 1-2 ft, > 2 ft

500 ft², 2,500 ft², 10,000 ft²

Large Wood

- > 25 ft long, no rootwad
- > 25 ft long, with rootwad
- < 25 ft long, with rootwad
- Log Weir

Spawning Gravel

circle size is proportional to area

≤ 100 ft², 500 ft², 1,000 ft²

Dominant Substrate

(proportion of area)

Boulder, Cobble, Bedrock, Gravel, Organic, Sand, Silt and Clay

Analysis Unit Boundary

- Reach
- Subreach

Bank Condition

Armored, Natural, Eroding, Part stable, Stable

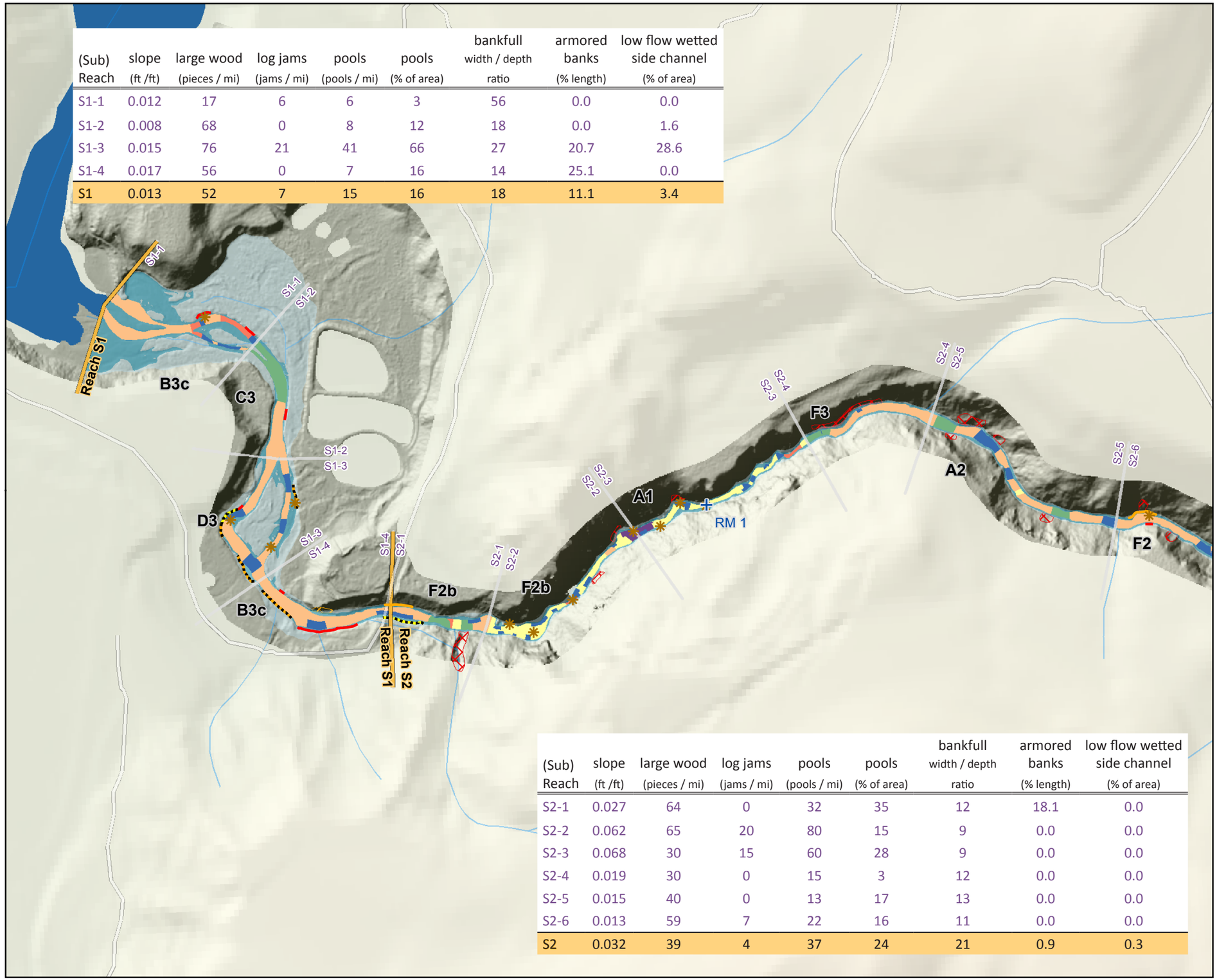
Landslides

- Active
- Part Stable

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_cartographic2_10.1_2.mxd

Plates B1-B19 Reach Maps

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S1-1	0.012	17	6	6	3	56	0.0	0.0
S1-2	0.008	68	0	8	12	18	0.0	1.6
S1-3	0.015	76	21	41	66	27	20.7	28.6
S1-4	0.017	56	0	7	16	14	25.1	0.0
S1	0.013	52	7	15	16	18	11.1	3.4



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S2-1	0.027	64	0	32	35	12	18.1	0.0
S2-2	0.062	65	20	80	15	9	0.0	0.0
S2-3	0.068	30	15	60	28	9	0.0	0.0
S2-4	0.019	30	0	15	3	12	0.0	0.0
S2-5	0.015	40	0	13	17	13	0.0	0.0
S2-6	0.013	59	7	22	16	11	0.0	0.0
S2	0.032	39	4	37	24	21	0.9	0.3

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

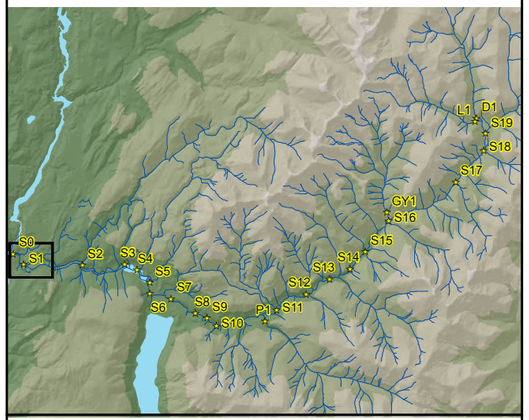
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

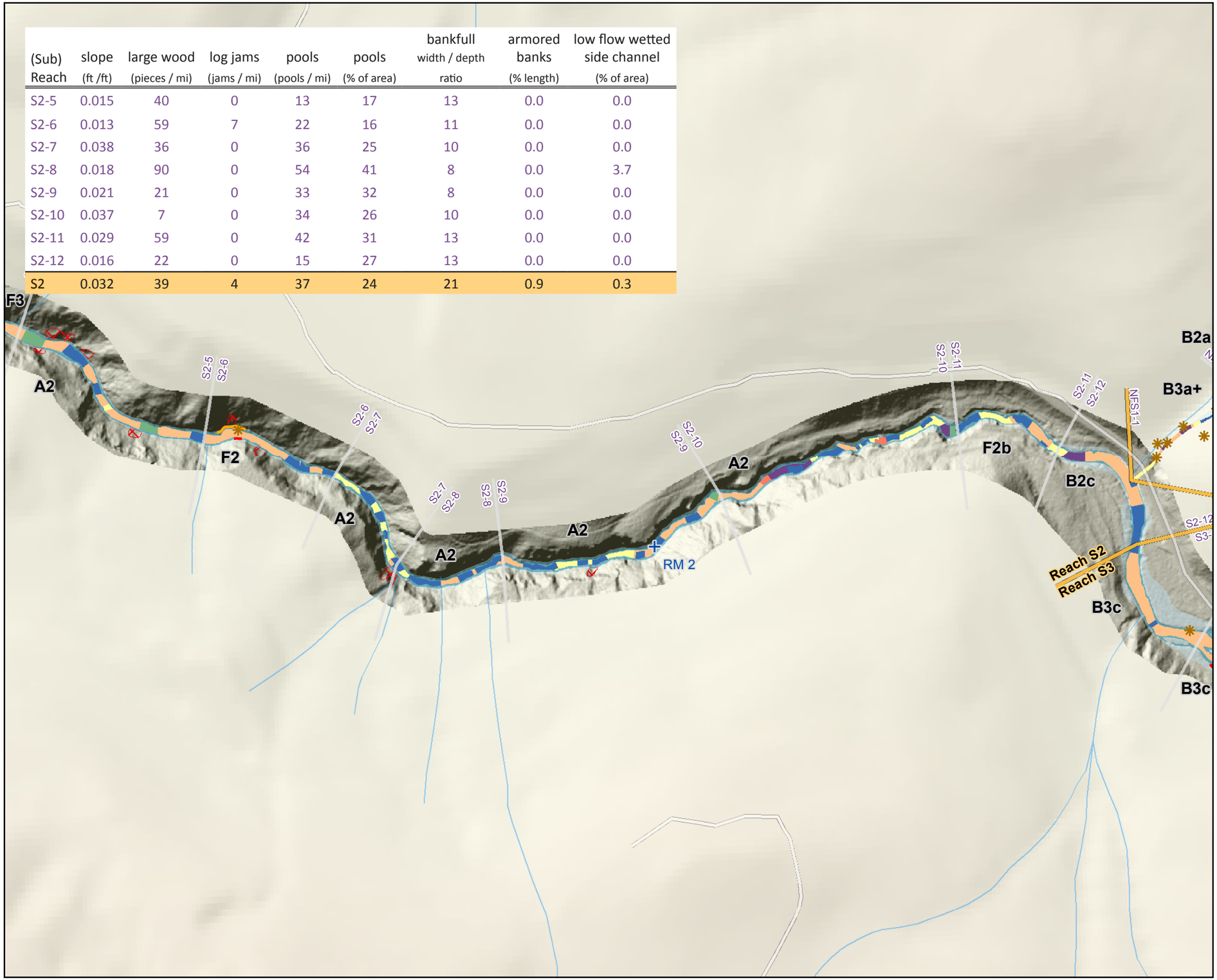
Analysis Unit Boundary
- Reach
- Subreach
- A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B1: Reach(es) Sullivan 1-2A

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S2-5	0.015	40	0	13	17	13	0.0	0.0
S2-6	0.013	59	7	22	16	11	0.0	0.0
S2-7	0.038	36	0	36	25	10	0.0	0.0
S2-8	0.018	90	0	54	41	8	0.0	3.7
S2-9	0.021	21	0	33	32	8	0.0	0.0
S2-10	0.037	7	0	34	26	10	0.0	0.0
S2-11	0.029	59	0	42	31	13	0.0	0.0
S2-12	0.016	22	0	15	27	13	0.0	0.0
S2	0.032	39	4	37	24	21	0.9	0.3



Sullivan Creek Habitat Inventory

DRAFT

Reach Map

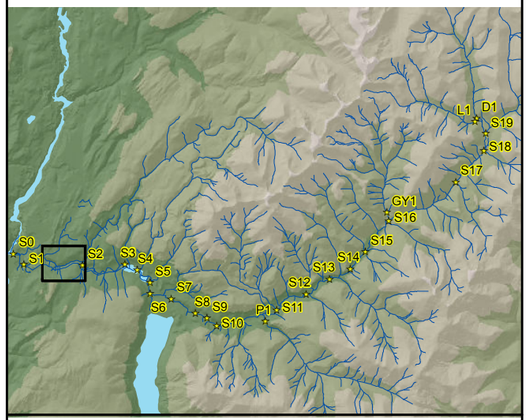
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants	project no. 200061	9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition

Armored Natural
- Eroding
- Part stable
- Stable

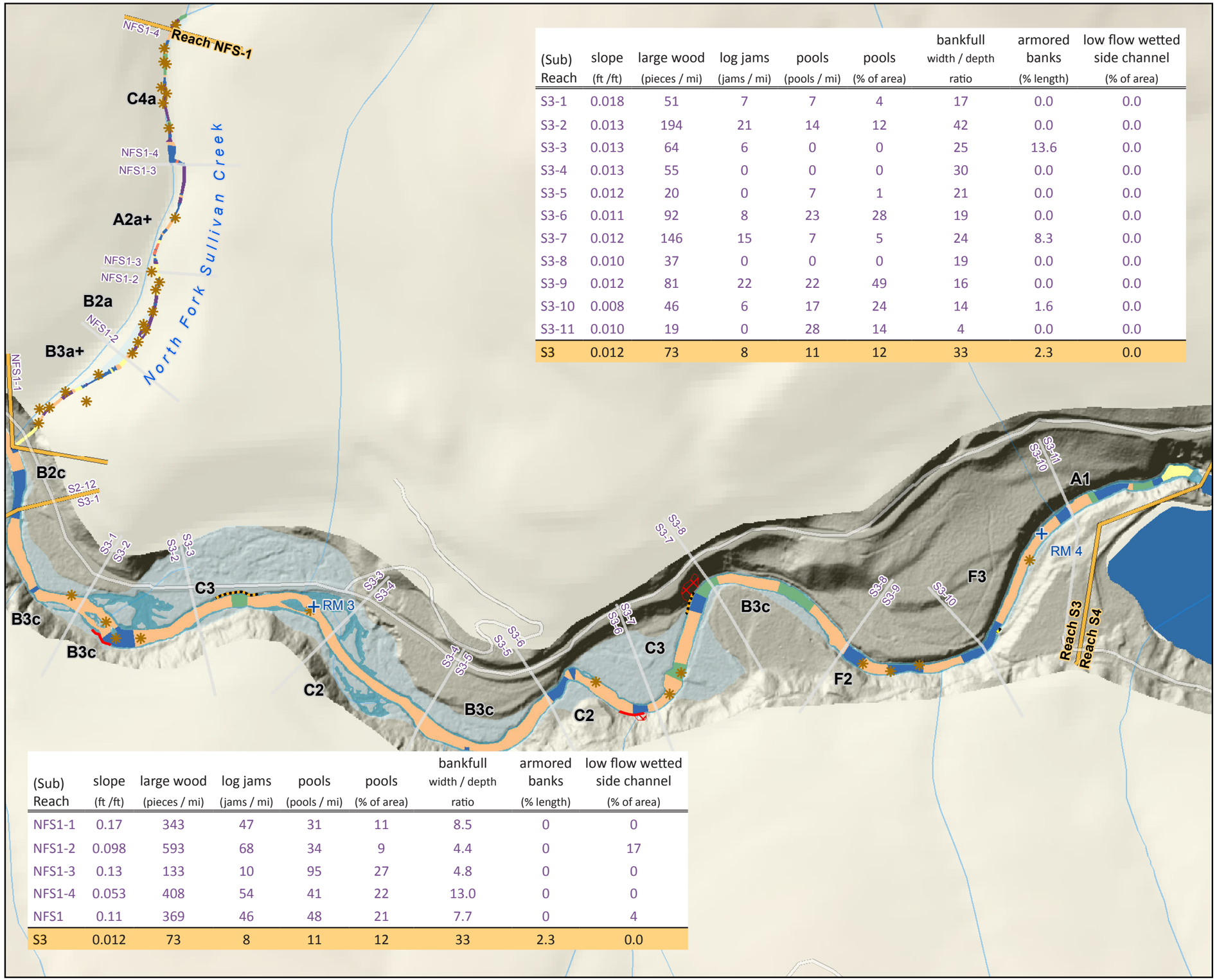
Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\20062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S3-1	0.018	51	7	7	4	17	0.0	0.0
S3-2	0.013	194	21	14	12	42	0.0	0.0
S3-3	0.013	64	6	0	0	25	13.6	0.0
S3-4	0.013	55	0	0	0	30	0.0	0.0
S3-5	0.012	20	0	7	1	21	0.0	0.0
S3-6	0.011	92	8	23	28	19	0.0	0.0
S3-7	0.012	146	15	7	5	24	8.3	0.0
S3-8	0.010	37	0	0	0	19	0.0	0.0
S3-9	0.012	81	22	22	49	16	0.0	0.0
S3-10	0.008	46	6	17	24	14	1.6	0.0
S3-11	0.010	19	0	28	14	4	0.0	0.0
S3	0.012	73	8	11	12	33	2.3	0.0

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
NFS1-1	0.17	343	47	31	11	8.5	0	0
NFS1-2	0.098	593	68	34	9	4.4	0	17
NFS1-3	0.13	133	10	95	27	4.8	0	0
NFS1-4	0.053	408	54	41	22	13.0	0	0
NFS1	0.11	369	46	48	21	7.7	0	4
S3	0.012	73	8	11	12	33	2.3	0.0

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

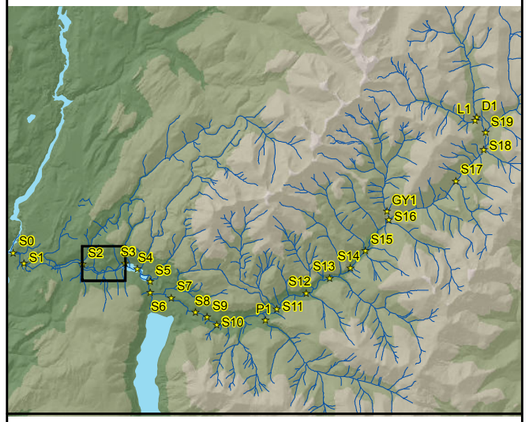
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B3: Reach(es) Sullivan 3 & North Fork Sullivan 1

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S5-1	0.003	17	0	8	81	38	0.0	7.3
S5-2	0.003	122	8	0	0	48	0.0	0.0
S5-3	0.005	98	8	15	32	19	0.0	0.0
S5-4	0.008	461	20	20	25	30	0.0	0.0
S5-5	0.007	51	7	15	43	21	0.0	0.0
S5	0.004	99	5	10	58	40	0.0	4.0

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S6-1	0.008	22	0	15	25	24	0.0	0.0
S6-2	0.008	97	8	0	0	20	0.0	0.0
S6-3	0.007	73	0	13	3	17	3.2	10.1
S6	0.008	64	2	10	10	8	1.2	3.8

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

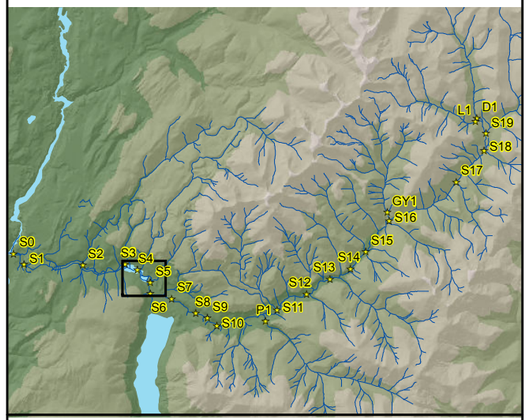
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units
in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

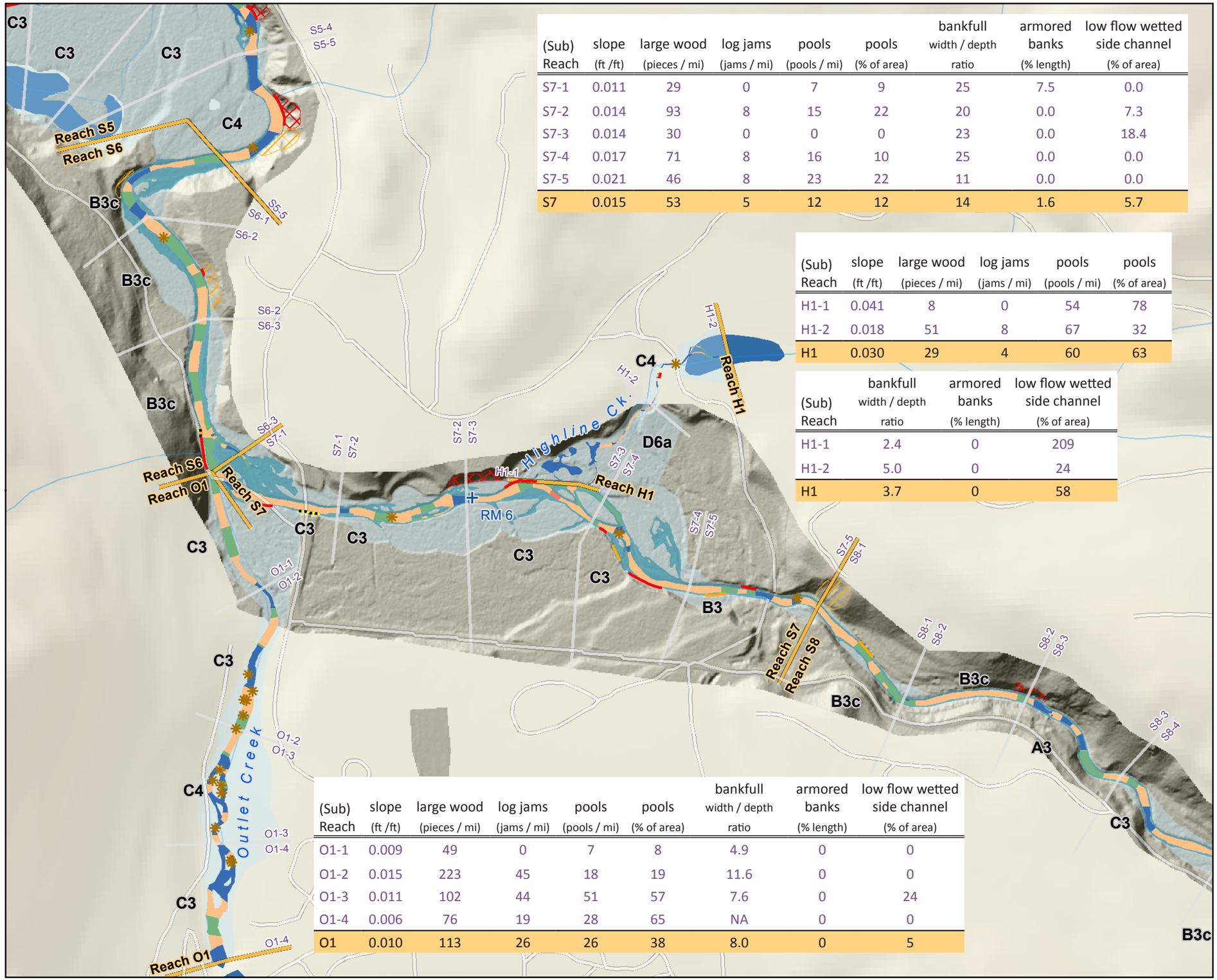
Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_frib_annotation_10.1.mxd



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S7-1	0.011	29	0	7	9	25	7.5	0.0
S7-2	0.014	93	8	15	22	20	0.0	7.3
S7-3	0.014	30	0	0	0	23	0.0	18.4
S7-4	0.017	71	8	16	10	25	0.0	0.0
S7-5	0.021	46	8	23	22	11	0.0	0.0
S7	0.015	53	5	12	12	14	1.6	5.7

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)
H1-1	0.041	8	0	54	78
H1-2	0.018	51	8	67	32
H1	0.030	29	4	60	63

(Sub) Reach	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
H1-1	2.4	0	209
H1-2	5.0	0	24
H1	3.7	0	58

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
O1-1	0.009	49	0	7	8	4.9	0	0
O1-2	0.015	223	45	18	19	11.6	0	0
O1-3	0.011	102	44	51	57	7.6	0	24
O1-4	0.006	76	19	28	65	NA	0	0
O1	0.010	113	26	26	38	8.0	0	5

Sullivan Creek Habitat Inventory

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Reach Map

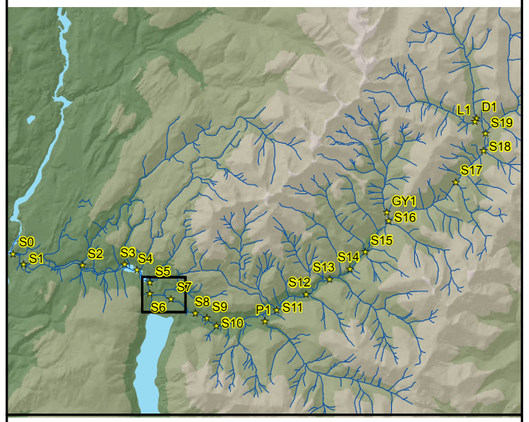
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants	project no. 200061	9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

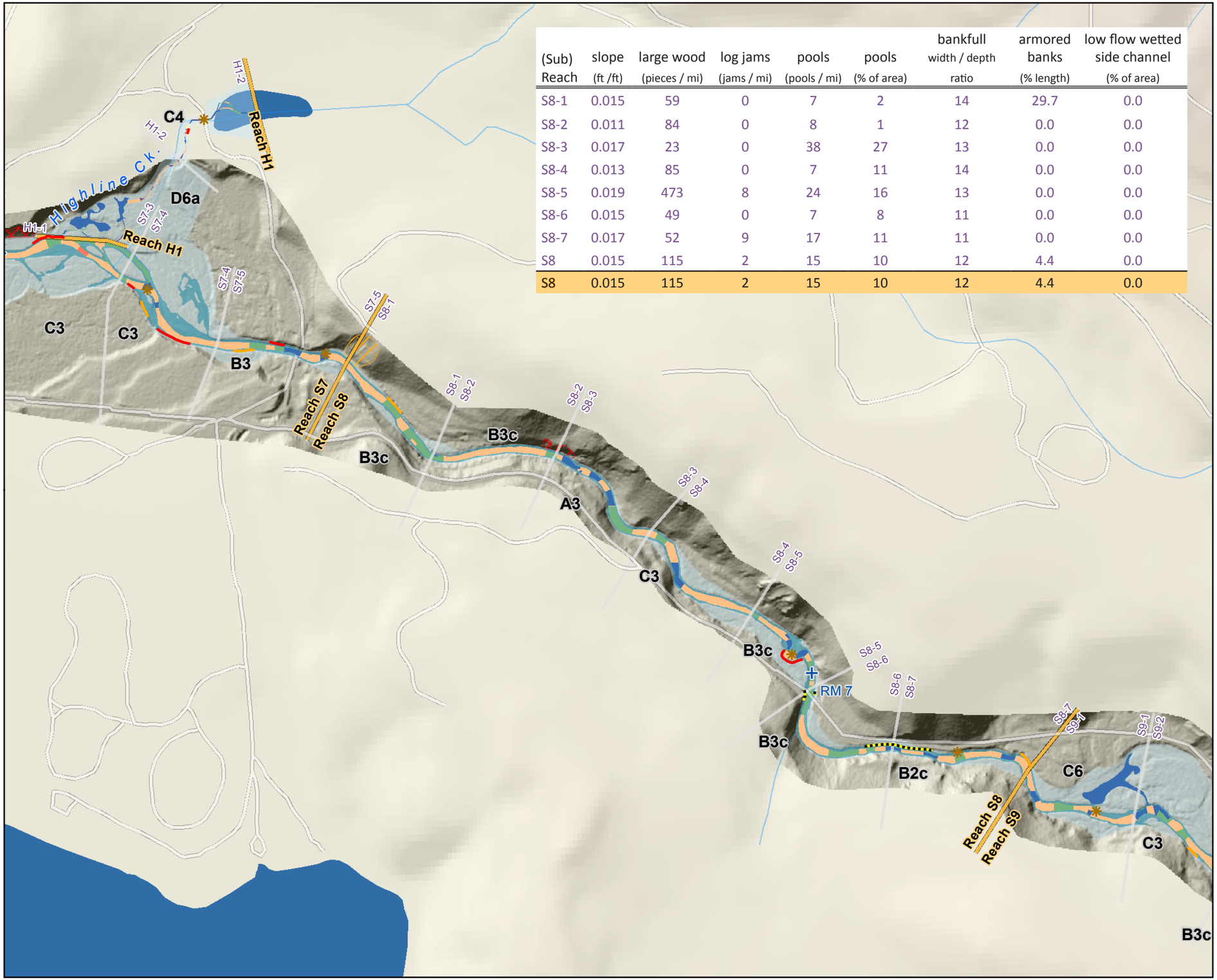
Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach
- A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B5: Reach(es) Sullivan 7, Outlet 1 & Highline 1



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S8-1	0.015	59	0	7	2	14	29.7	0.0
S8-2	0.011	84	0	8	1	12	0.0	0.0
S8-3	0.017	23	0	38	27	13	0.0	0.0
S8-4	0.013	85	0	7	11	14	0.0	0.0
S8-5	0.019	473	8	24	16	13	0.0	0.0
S8-6	0.015	49	0	7	8	11	0.0	0.0
S8-7	0.017	52	9	17	11	11	0.0	0.0
S8	0.015	115	2	15	10	12	4.4	0.0
S8	0.015	115	2	15	10	12	4.4	0.0

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

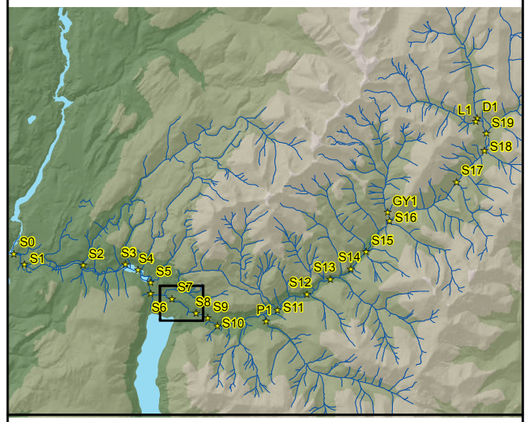
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

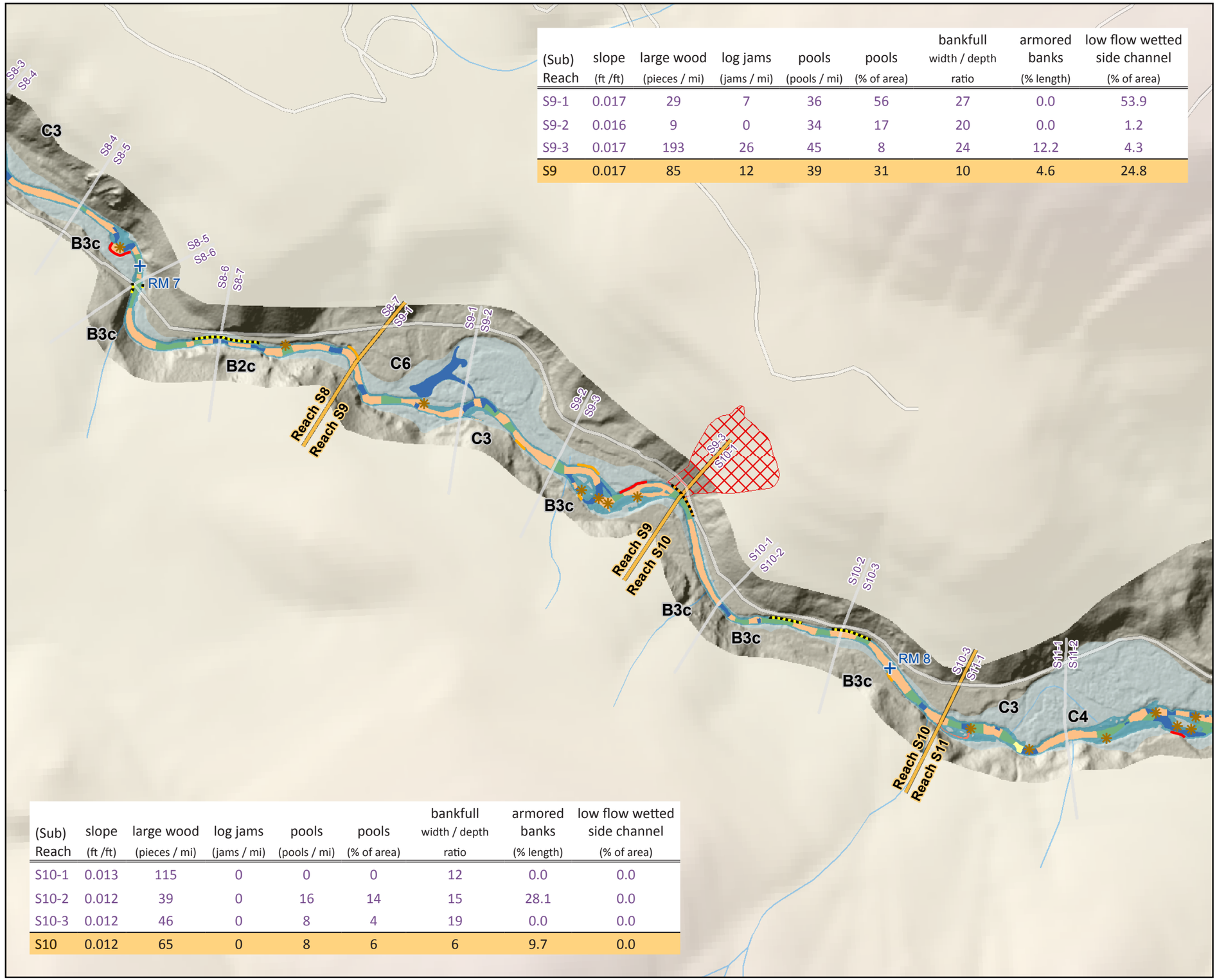
Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S9-1	0.017	29	7	36	56	27	0.0	53.9
S9-2	0.016	9	0	34	17	20	0.0	1.2
S9-3	0.017	193	26	45	8	24	12.2	4.3
S9	0.017	85	12	39	31	10	4.6	24.8



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S10-1	0.013	115	0	0	0	12	0.0	0.0
S10-2	0.012	39	0	16	14	15	28.1	0.0
S10-3	0.012	46	0	8	4	19	0.0	0.0
S10	0.012	65	0	8	6	6	9.7	0.0

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

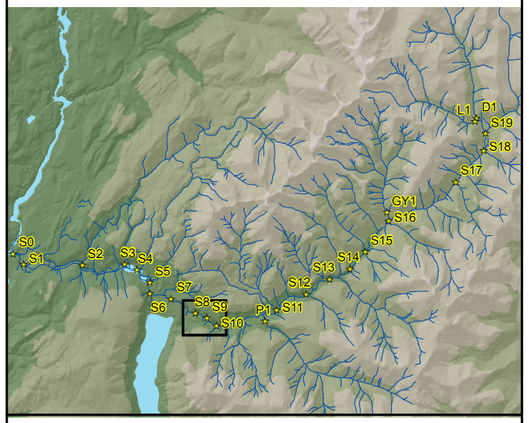
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants	project no. 200061	9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

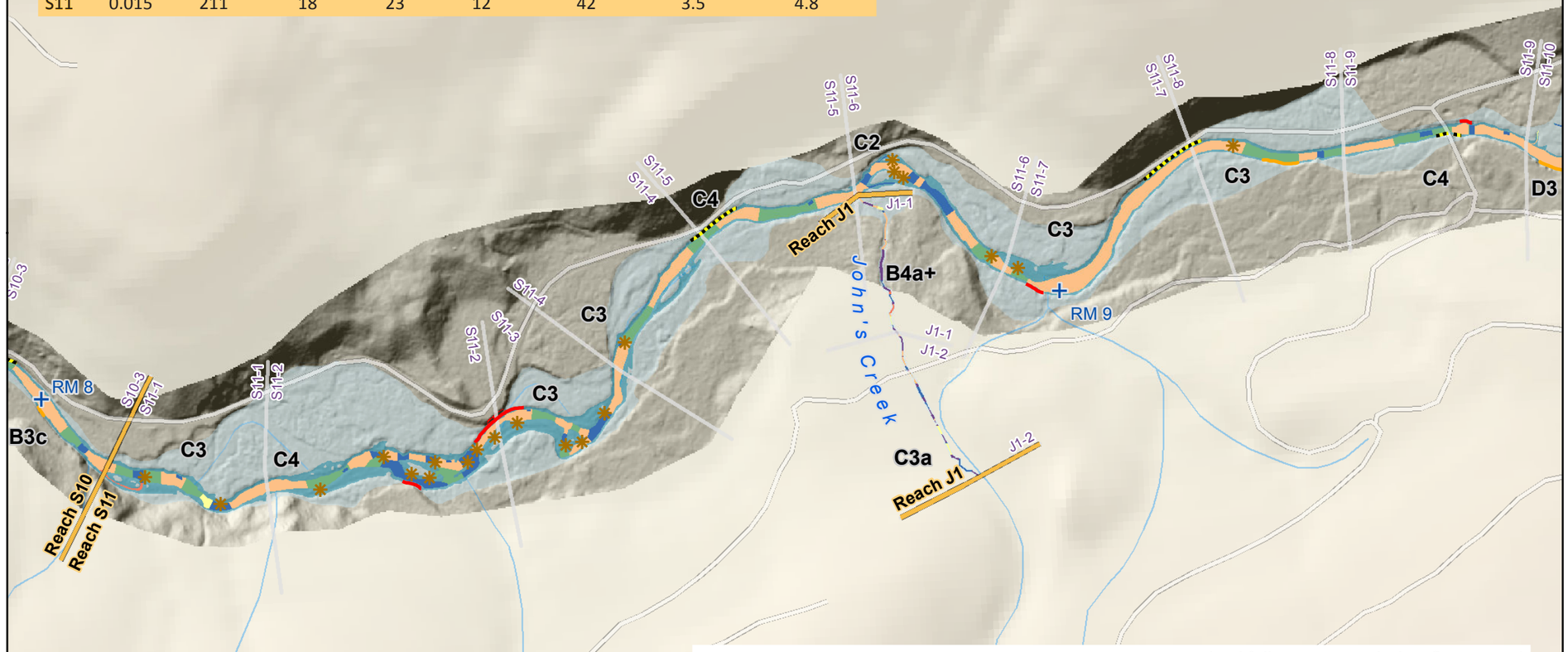
Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S11-1	0.017	253	15	23	10	21	0.0	2.0
S11-2	0.017	485	39	54	25	25	0.0	9.8
S11-3	0.014	243	27	27	24	19	0.0	14.5
S11-4	0.012	157	8	8	1	16	17.2	0.0
S11-5	0.016	163	0	8	1	13	0.0	0.0
S11-6	0.015	173	26	32	16	15	0.0	16.7
S11-7	0.012	31	5	0	0	17	13.8	0.0
S11-8	0.014	92	8	8	9	15	0.0	0.0
S11-9	0.014	7	0	21	7	16	5.2	0.0
S11	0.015	211	18	23	12	42	3.5	4.8



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
J1-1	0.10	16	0	32	7	2.3	0	0
J1-2	0.094	36	0	43	12	3.8	0	2
J1	0.099	26	0	38	10	3.0	0	1

Sullivan Creek Habitat Inventory

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Reach Map

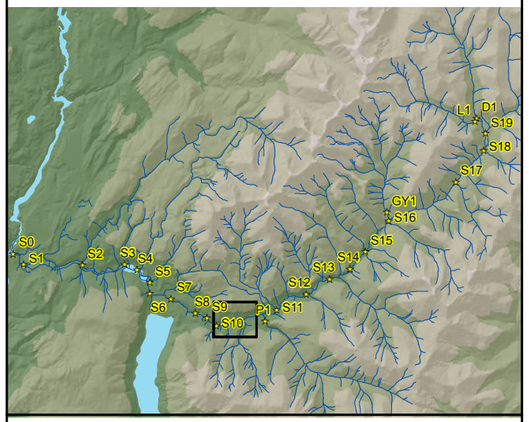
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants	project no. 200061	9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach

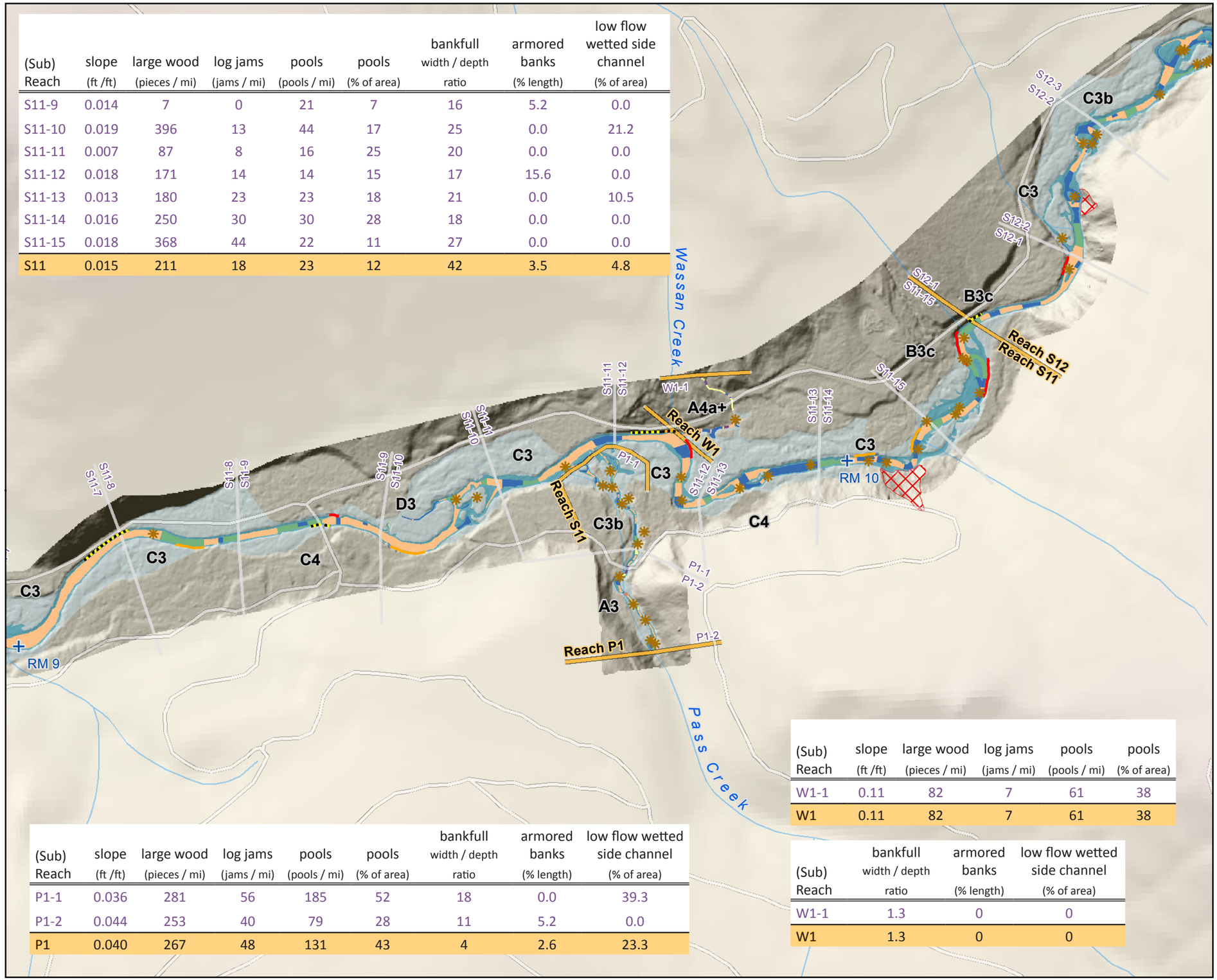
A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B8: Reach(es) Sullivan 11A & John's Creek 1

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S11-9	0.014	7	0	21	7	16	5.2	0.0
S11-10	0.019	396	13	44	17	25	0.0	21.2
S11-11	0.007	87	8	16	25	20	0.0	0.0
S11-12	0.018	171	14	14	15	17	15.6	0.0
S11-13	0.013	180	23	23	18	21	0.0	10.5
S11-14	0.016	250	30	30	28	18	0.0	0.0
S11-15	0.018	368	44	22	11	27	0.0	0.0
S11	0.015	211	18	23	12	42	3.5	4.8



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)
W1-1	0.11	82	7	61	38
W1	0.11	82	7	61	38

(Sub) Reach	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
W1-1	1.3	0	0
W1	1.3	0	0

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
P1-1	0.036	281	56	185	52	18	0.0	39.3
P1-2	0.044	253	40	79	28	11	5.2	0.0
P1	0.040	267	48	131	43	4	2.6	23.3

Sullivan Creek Habitat Inventory

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Reach Map

Scale - 1:6,000

200 100 0 200 400 600 Feet

N

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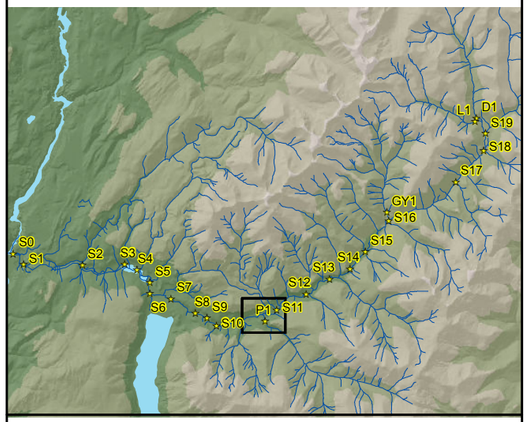
Reference Map



Habitat Units
in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

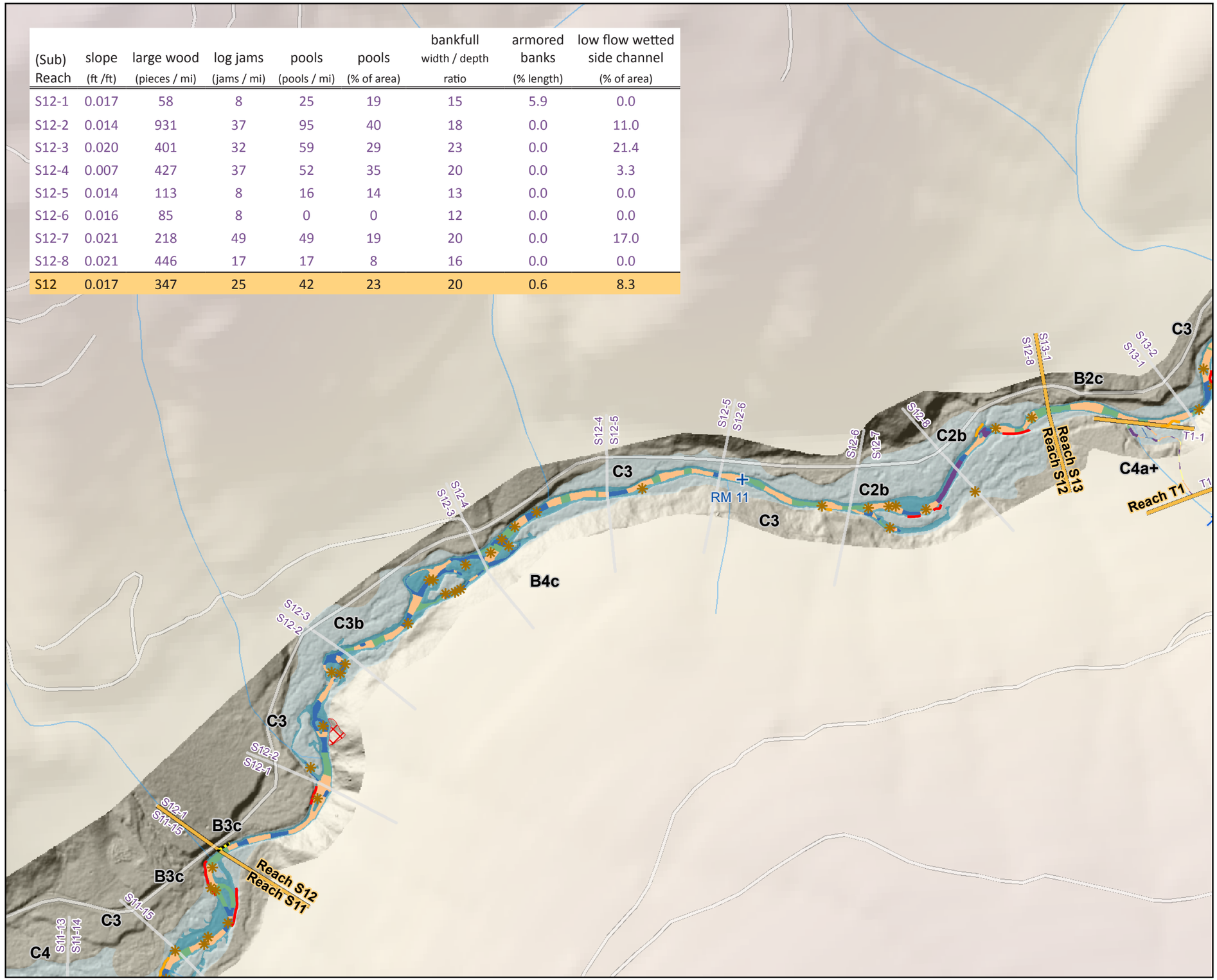
Analysis Unit Boundary
- Reach
- Subreach
- A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final\2013_reach_scale_trib_annotation_10.1.mxd

Plate B9: Reach(es) Sullivan 11B, Pass 1, & Wassan 1

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S12-1	0.017	58	8	25	19	15	5.9	0.0
S12-2	0.014	931	37	95	40	18	0.0	11.0
S12-3	0.020	401	32	59	29	23	0.0	21.4
S12-4	0.007	427	37	52	35	20	0.0	3.3
S12-5	0.014	113	8	16	14	13	0.0	0.0
S12-6	0.016	85	8	0	0	12	0.0	0.0
S12-7	0.021	218	49	49	19	20	0.0	17.0
S12-8	0.021	446	17	17	8	16	0.0	0.0
S12	0.017	347	25	42	23	20	0.6	8.3



Sullivan Creek Habitat Inventory

DRAFT

Reach Map

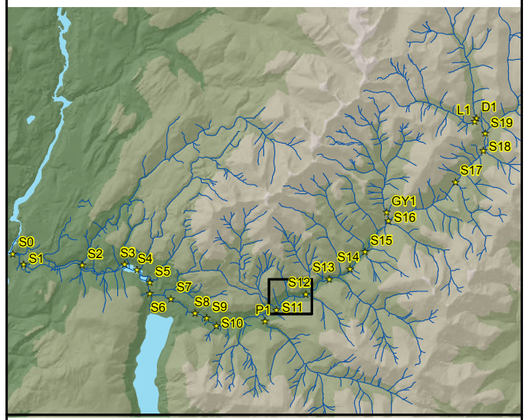
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants	project no. 200061	9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

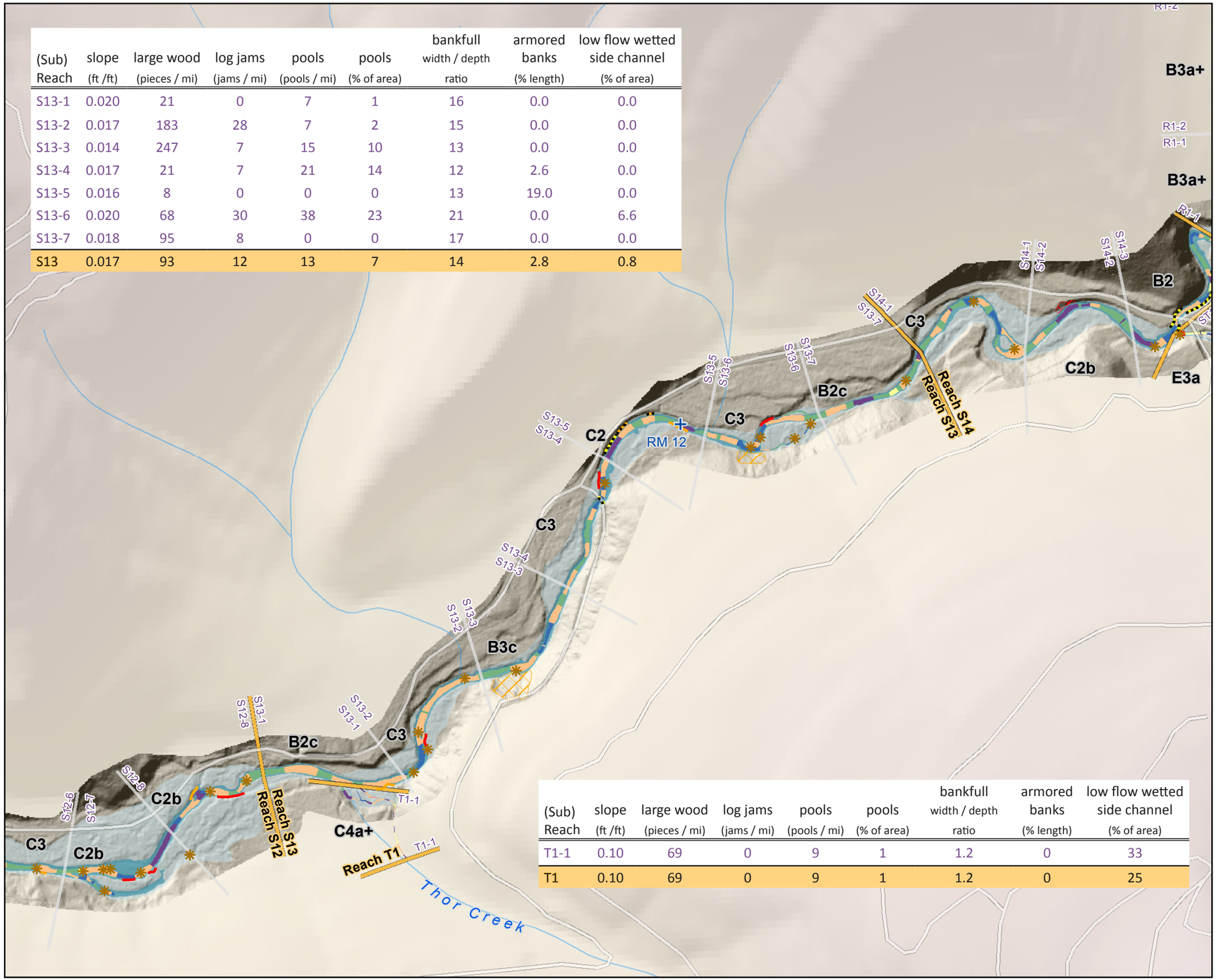
Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach
- A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S13-1	0.020	21	0	7	1	16	0.0	0.0
S13-2	0.017	183	28	7	2	15	0.0	0.0
S13-3	0.014	247	7	15	10	13	0.0	0.0
S13-4	0.017	21	7	21	14	12	2.6	0.0
S13-5	0.016	8	0	0	0	13	19.0	0.0
S13-6	0.020	68	30	38	23	21	0.0	6.6
S13-7	0.018	95	8	0	0	17	0.0	0.0
S13	0.017	93	12	13	7	14	2.8	0.8



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
T1-1	0.10	69	0	9	1	1.2	0	33
T1	0.10	69	0	9	1	1.2	0	25

Sullivan Creek Habitat Inventory

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Reach Map

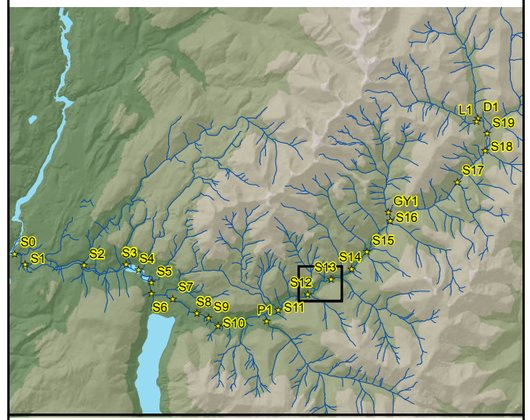
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

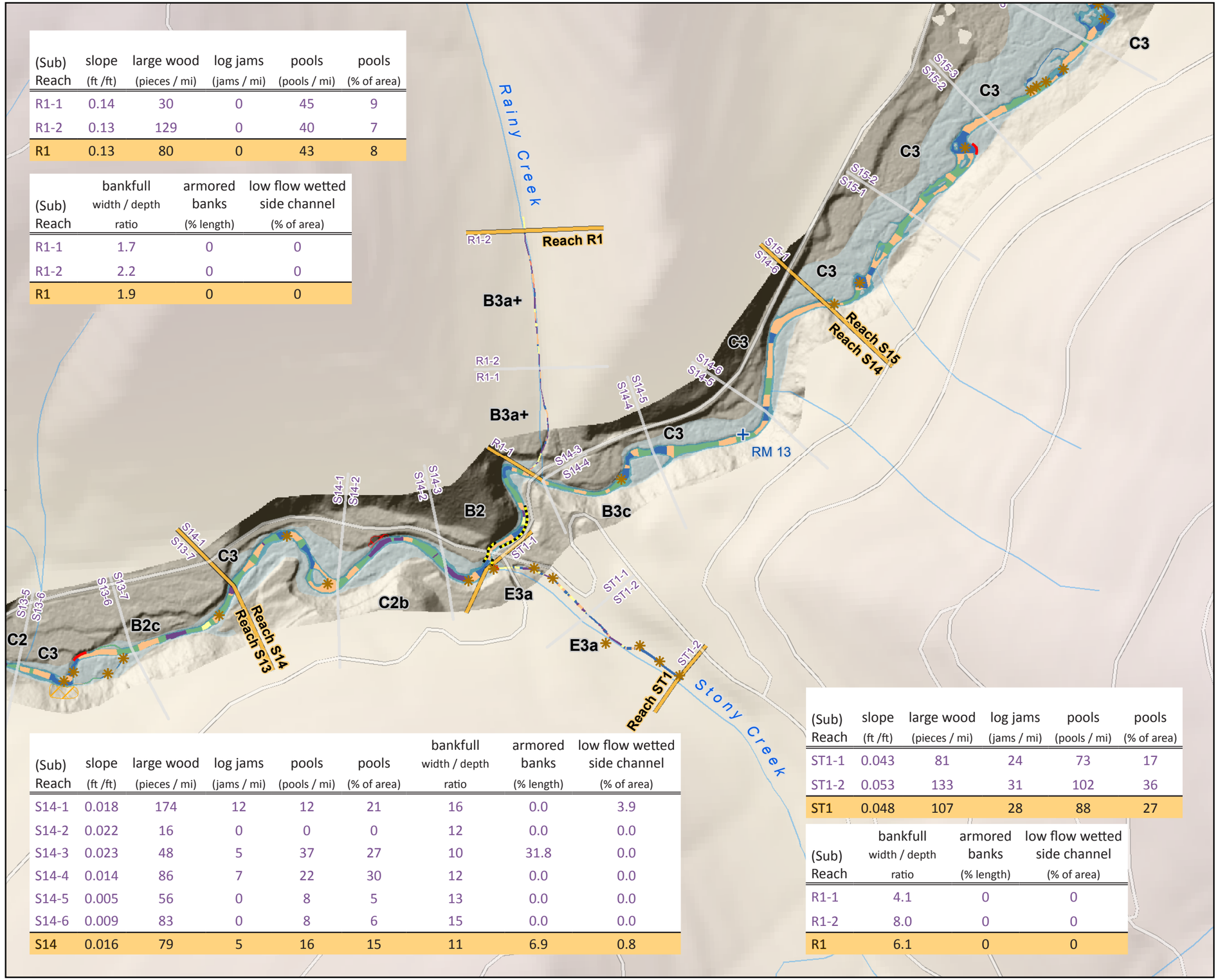
Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B11: Reach(es) Sullivan 13 & Thor 1



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)
R1-1	0.14	30	0	45	9
R1-2	0.13	129	0	40	7
R1	0.13	80	0	43	8

(Sub) Reach	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
R1-1	1.7	0	0
R1-2	2.2	0	0
R1	1.9	0	0

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S14-1	0.018	174	12	12	21	16	0.0	3.9
S14-2	0.022	16	0	0	0	12	0.0	0.0
S14-3	0.023	48	5	37	27	10	31.8	0.0
S14-4	0.014	86	7	22	30	12	0.0	0.0
S14-5	0.005	56	0	8	5	13	0.0	0.0
S14-6	0.009	83	0	8	6	15	0.0	0.0
S14	0.016	79	5	16	15	11	6.9	0.8

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)
ST1-1	0.043	81	24	73	17
ST1-2	0.053	133	31	102	36
ST1	0.048	107	28	88	27

(Sub) Reach	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
R1-1	4.1	0	0
R1-2	8.0	0	0
R1	6.1	0	0

Sullivan Creek Habitat Inventory

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Reach Map

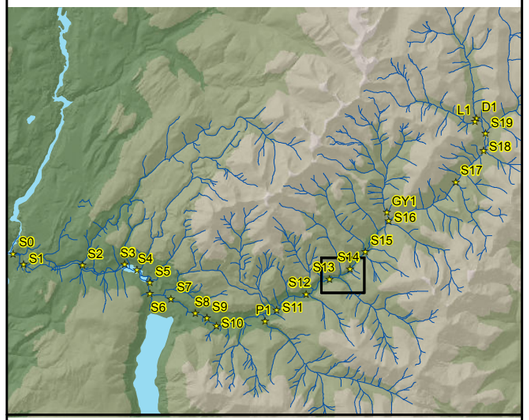
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Bankfull Channel

Floodprone Area

Selected Channel Features
- Large Wood Jam
- Log Weir

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

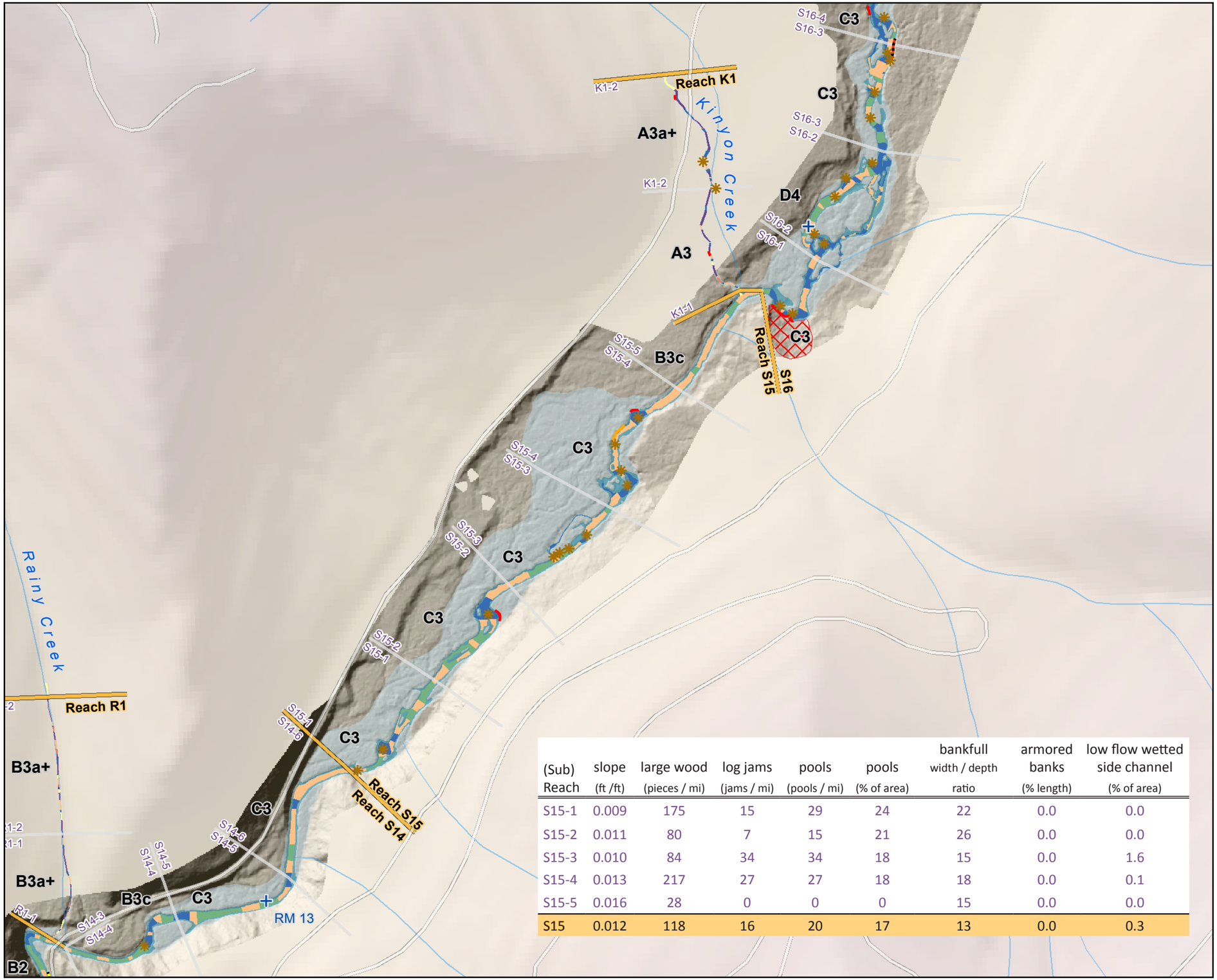
Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach
- A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B12: Reach(es) Sullivan 14, Stony 1 & Rainy 1



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S15-1	0.009	175	15	29	24	22	0.0	0.0
S15-2	0.011	80	7	15	21	26	0.0	0.0
S15-3	0.010	84	34	34	18	15	0.0	1.6
S15-4	0.013	217	27	27	18	18	0.0	0.1
S15-5	0.016	28	0	0	0	15	0.0	0.0
S15	0.012	118	16	20	17	13	0.0	0.3

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

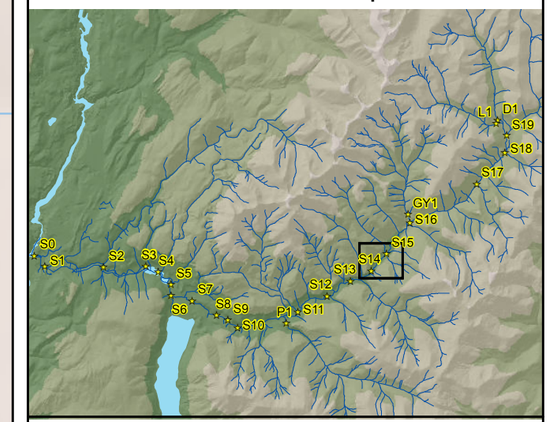
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants	project no. 200061	9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach
- A1 Subreach Rosgen Stream Type

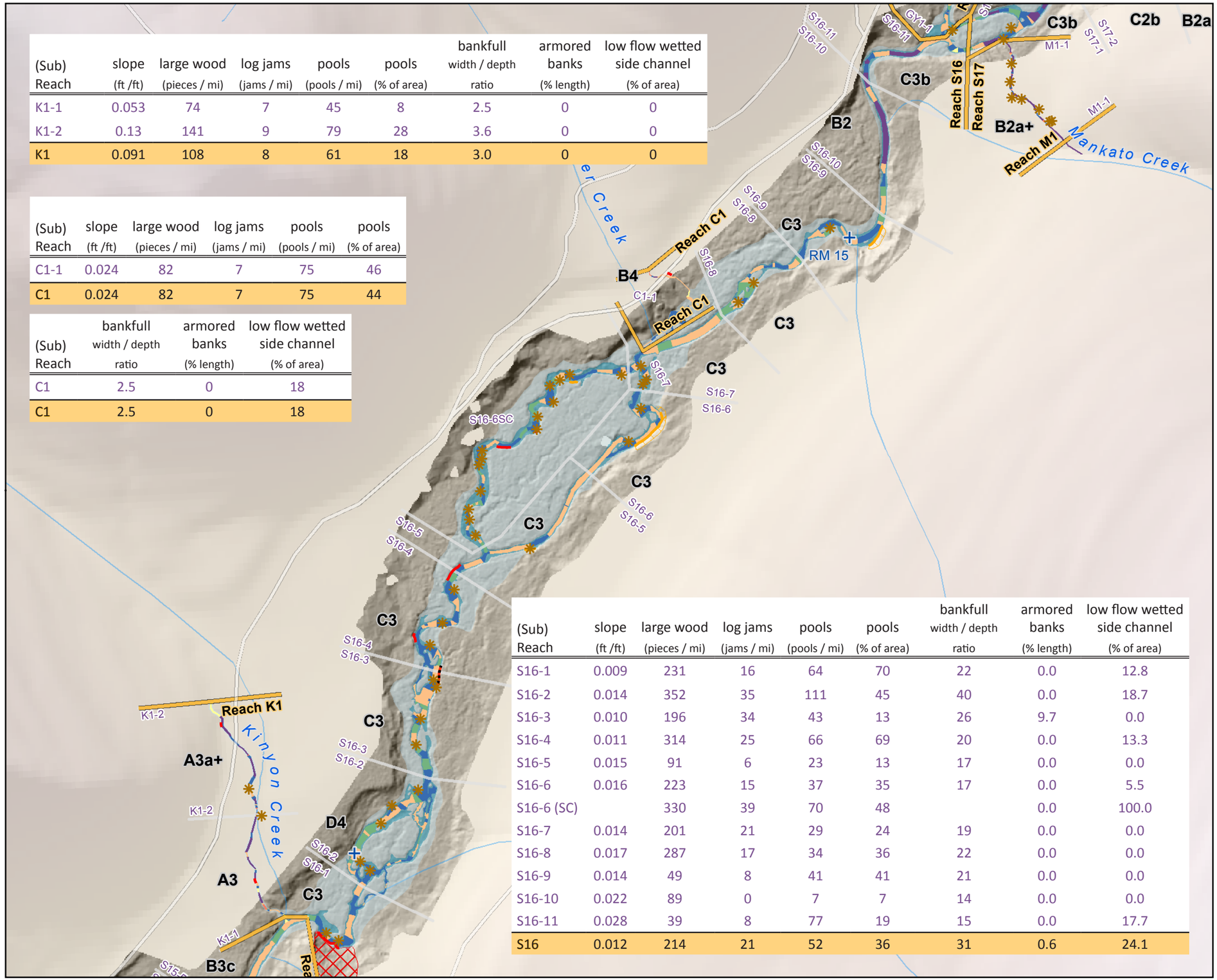
Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_frib_annotation_10.1.mxd

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
K1-1	0.053	74	7	45	8	2.5	0	0
K1-2	0.13	141	9	79	28	3.6	0	0
K1	0.091	108	8	61	18	3.0	0	0

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)
C1-1	0.024	82	7	75	46
C1	0.024	82	7	75	44

(Sub) Reach	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
C1	2.5	0	18
C1	2.5	0	18



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S16-1	0.009	231	16	64	70	22	0.0	12.8
S16-2	0.014	352	35	111	45	40	0.0	18.7
S16-3	0.010	196	34	43	13	26	9.7	0.0
S16-4	0.011	314	25	66	69	20	0.0	13.3
S16-5	0.015	91	6	23	13	17	0.0	0.0
S16-6	0.016	223	15	37	35	17	0.0	5.5
S16-6 (SC)		330	39	70	48		0.0	100.0
S16-7	0.014	201	21	29	24	19	0.0	0.0
S16-8	0.017	287	17	34	36	22	0.0	0.0
S16-9	0.014	49	8	41	41	21	0.0	0.0
S16-10	0.022	89	0	7	7	14	0.0	0.0
S16-11	0.028	39	8	77	19	15	0.0	17.7
S16	0.012	214	21	52	36	31	0.6	24.1

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

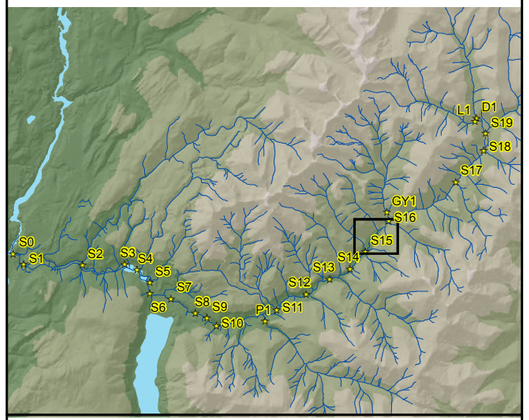
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants	project no. 200061	9/19/2013

Reference Map



Habitat Units in low flow channel

- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features

- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition

Armored Natural

- Eroding
- Part stable
- Stable

Landslides

- Active
- Part Stable

Analysis Unit Boundary

- Reach
- Subreach

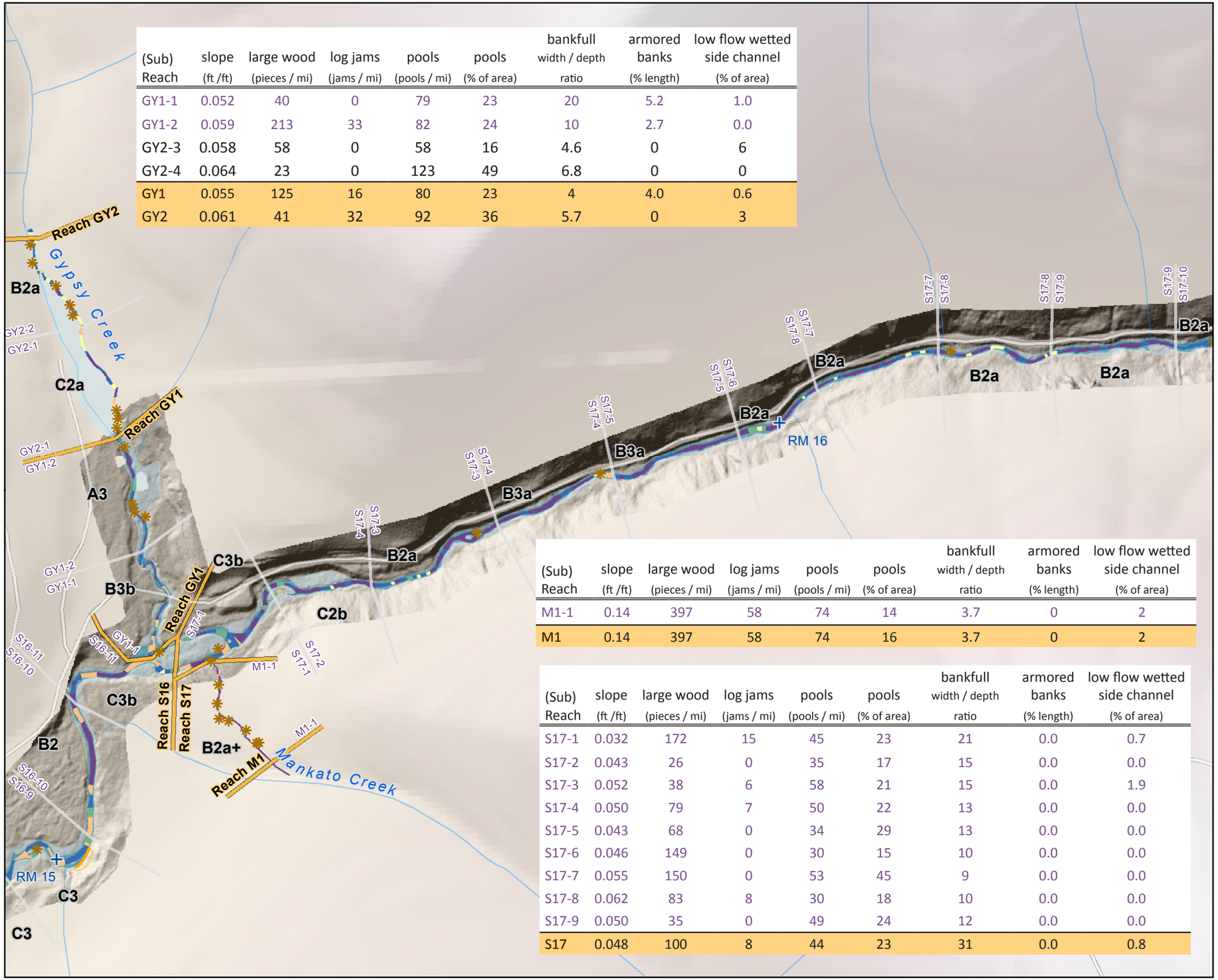
A1 Subreach Rosgen Stream Type

Other Features

- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B14: Reach(es) Sullivan 16, Kinyon, & Copper Creek



(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
GY1-1	0.052	40	0	79	23	20	5.2	1.0
GY1-2	0.059	213	33	82	24	10	2.7	0.0
GY2-3	0.058	58	0	58	16	4.6	0	6
GY2-4	0.064	23	0	123	49	6.8	0	0
GY1	0.055	125	16	80	23	4	4.0	0.6
GY2	0.061	41	32	92	36	5.7	0	3

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
M1-1	0.14	397	58	74	14	3.7	0	2
M1	0.14	397	58	74	16	3.7	0	2

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S17-1	0.032	172	15	45	23	21	0.0	0.7
S17-2	0.043	26	0	35	17	15	0.0	0.0
S17-3	0.052	38	6	58	21	15	0.0	1.9
S17-4	0.050	79	7	50	22	13	0.0	0.0
S17-5	0.043	68	0	34	29	13	0.0	0.0
S17-6	0.046	149	0	30	15	10	0.0	0.0
S17-7	0.055	150	0	53	45	9	0.0	0.0
S17-8	0.062	83	8	30	18	10	0.0	0.0
S17-9	0.050	35	0	49	24	12	0.0	0.0
S17	0.048	100	8	44	23	31	0.0	0.8

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

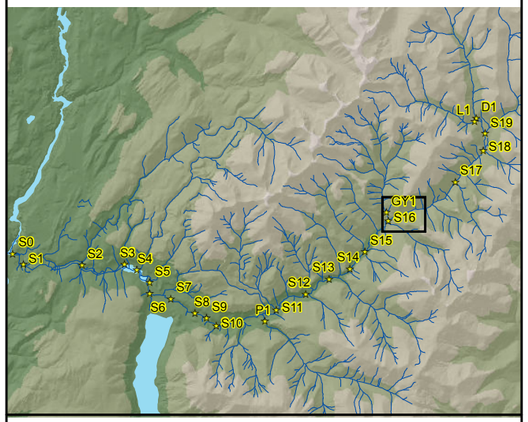
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units
in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

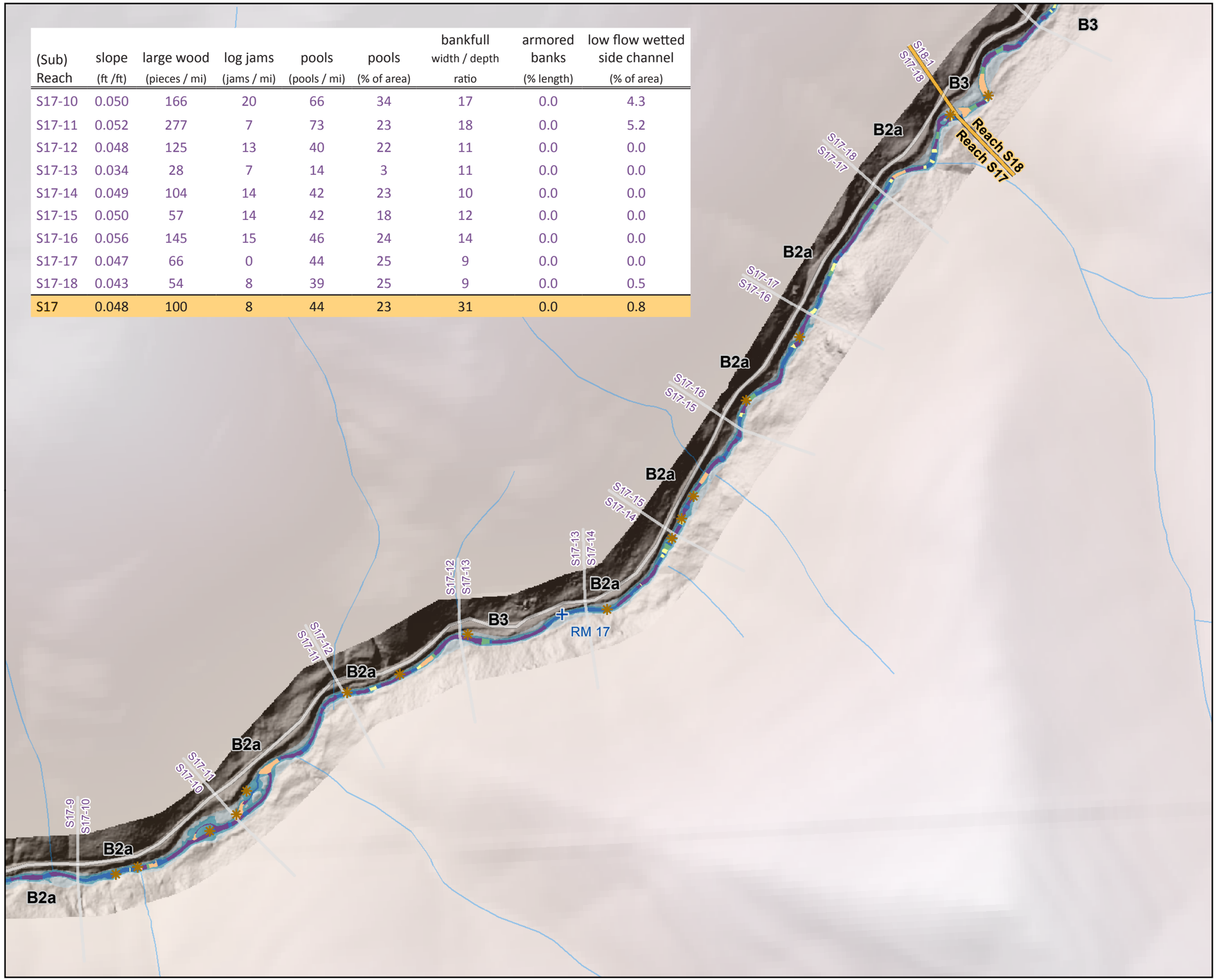
Analysis Unit Boundary
- Reach
- Subreach
- A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B15: Reach(es) Sullivan 17 A, Gypsy 1, Gypsy 2, & Mankato 1

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S17-10	0.050	166	20	66	34	17	0.0	4.3
S17-11	0.052	277	7	73	23	18	0.0	5.2
S17-12	0.048	125	13	40	22	11	0.0	0.0
S17-13	0.034	28	7	14	3	11	0.0	0.0
S17-14	0.049	104	14	42	23	10	0.0	0.0
S17-15	0.050	57	14	42	18	12	0.0	0.0
S17-16	0.056	145	15	46	24	14	0.0	0.0
S17-17	0.047	66	0	44	25	9	0.0	0.0
S17-18	0.043	54	8	39	25	9	0.0	0.5
S17	0.048	100	8	44	23	31	0.0	0.8



Sullivan Creek Habitat Inventory

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Reach Map

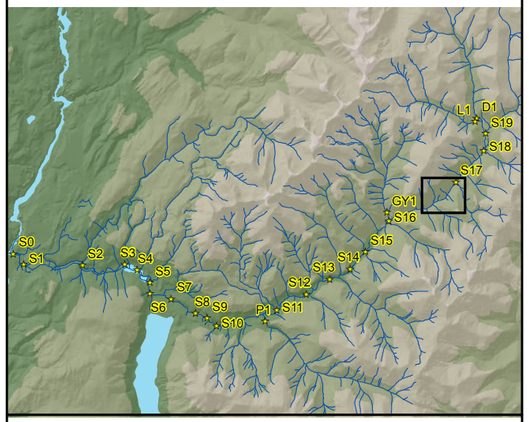
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units
in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\20062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S18-1	0.036	43	7	28	14	11	0.0	0.0
S18-2	0.037	72	8	80	63	14	0.0	32.4
S18-3	0.024	219	29	44	49	22	0.0	0.0
S18-4	0.027	62	14	21	11	14	0.0	0.0
S18-5	0.033	209	0	8	7	12	0.0	0.0
S18-6	0.043	159	8	38	16	18	0.0	5.5
S18-7	0.024	107	0	8	2	16	10.8	0.7
S18-8	0.025	41	0	0	0	14	7.1	0.0
S18-9	0.017	139	33	98	34	28	1.9	21.1
S18-10	0.016	195	23	109	41	25	19.6	40.2
S18	0.028	124	12	43	26	23	3.9	11.9

Sullivan Creek Habitat Inventory

DRAFT

Reach Map

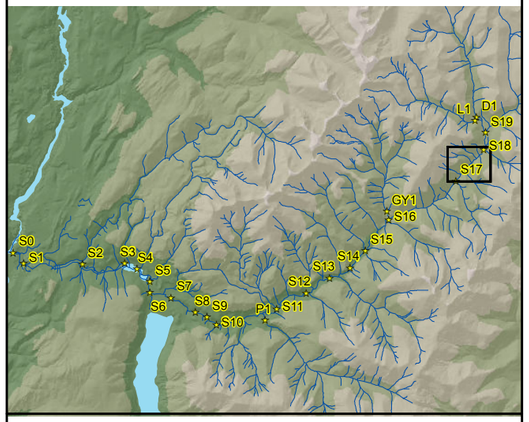
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units
in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

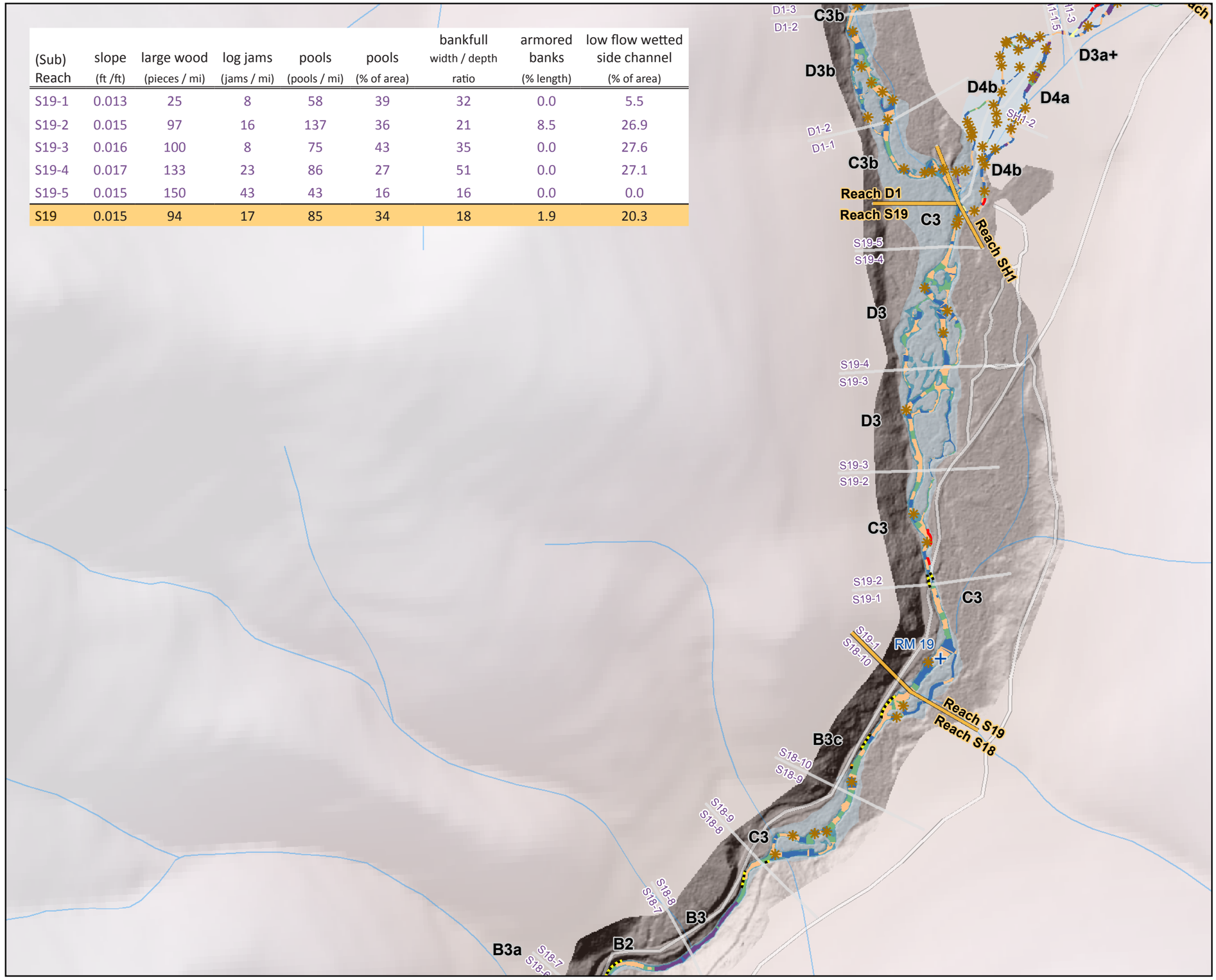
Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
S19-1	0.013	25	8	58	39	32	0.0	5.5
S19-2	0.015	97	16	137	36	21	8.5	26.9
S19-3	0.016	100	8	75	43	35	0.0	27.6
S19-4	0.017	133	23	86	27	51	0.0	27.1
S19-5	0.015	150	43	43	16	16	0.0	0.0
S19	0.015	94	17	85	34	18	1.9	20.3



Sullivan Creek Habitat Inventory

DRAFT

Reach Map

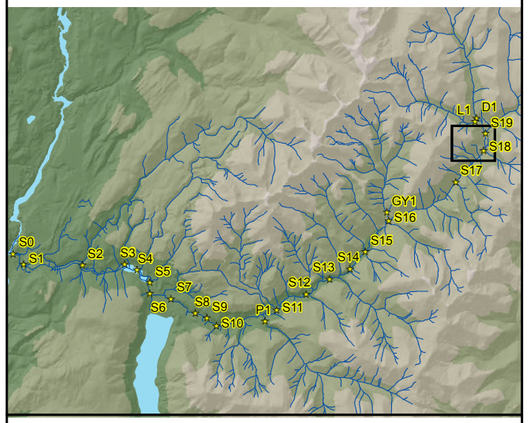
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

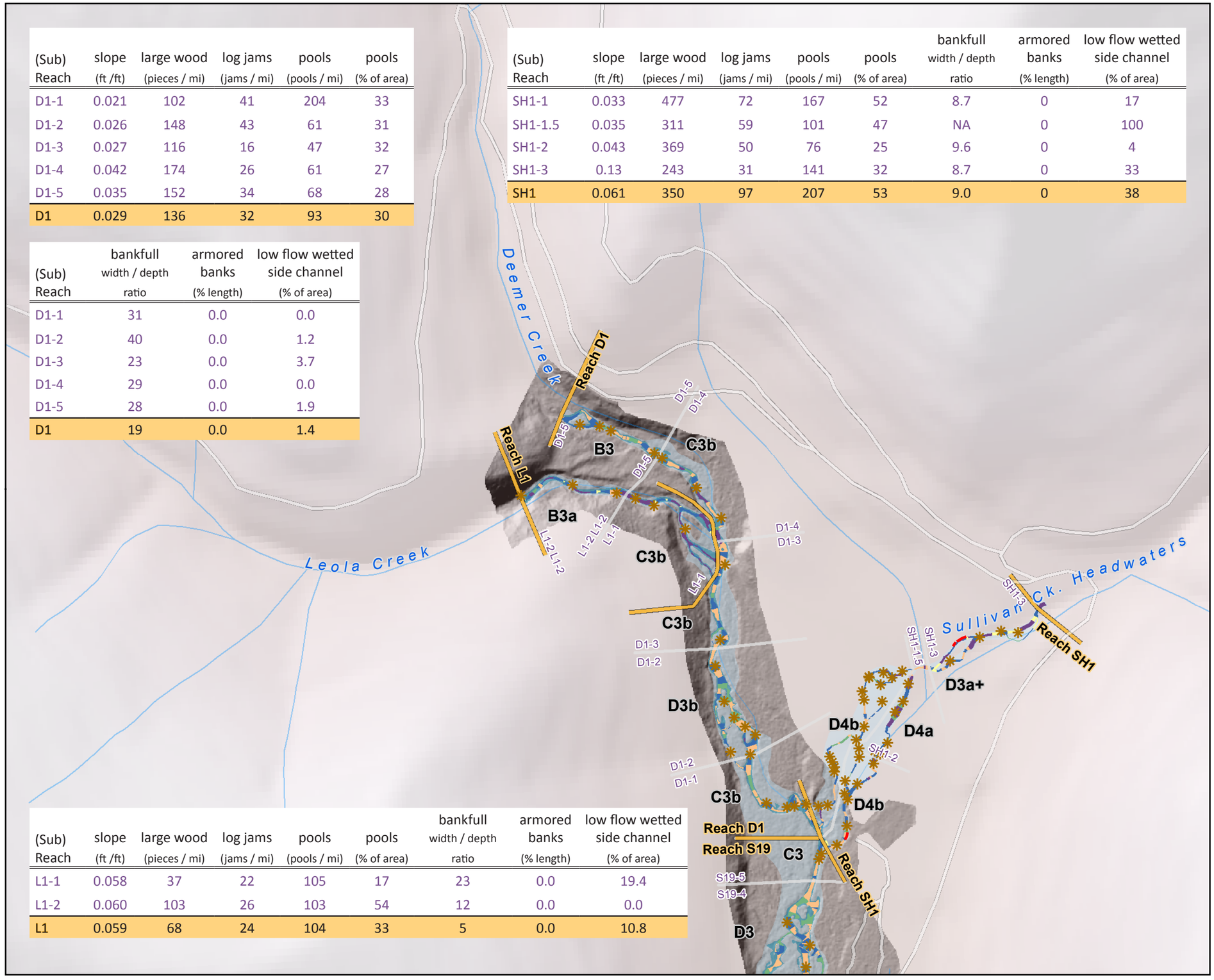
ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)
D1-1	0.021	102	41	204	33
D1-2	0.026	148	43	61	31
D1-3	0.027	116	16	47	32
D1-4	0.042	174	26	61	27
D1-5	0.035	152	34	68	28
D1	0.029	136	32	93	30

(Sub) Reach	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
D1-1	31	0.0	0.0
D1-2	40	0.0	1.2
D1-3	23	0.0	3.7
D1-4	29	0.0	0.0
D1-5	28	0.0	1.9
D1	19	0.0	1.4

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
SH1-1	0.033	477	72	167	52	8.7	0	17
SH1-1.5	0.035	311	59	101	47	NA	0	100
SH1-2	0.043	369	50	76	25	9.6	0	4
SH1-3	0.13	243	31	141	32	8.7	0	33
SH1	0.061	350	97	207	53	9.0	0	38

(Sub) Reach	slope (ft /ft)	large wood (pieces / mi)	log jams (jams / mi)	pools (pools / mi)	pools (% of area)	bankfull width / depth ratio	armored banks (% length)	low flow wetted side channel (% of area)
L1-1	0.058	37	22	105	17	23	0.0	19.4
L1-2	0.060	103	26	103	54	12	0.0	0.0
L1	0.059	68	24	104	33	5	0.0	10.8



Sullivan Creek Habitat Inventory

DRAFT

Reach Map

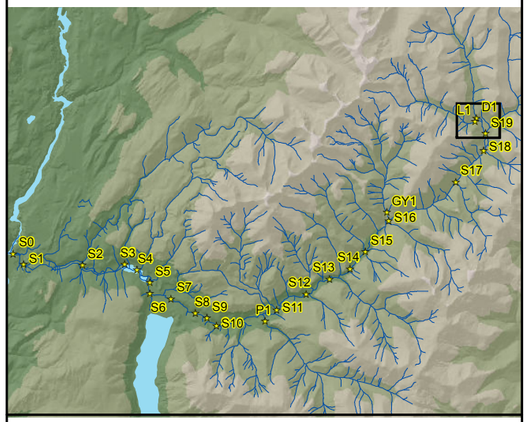
Scale - 1:6,000

200 100 0 200 400 600 Feet

N

Northwest Hydraulic Consultants | project no. 200061 | 9/19/2013

Reference Map



Habitat Units in low flow channel
- Other
- Cascade
- Riffle
- Glide
- Pocket Water
- Pool

Selected Channel Features
- Large Wood Jam
- Log Weir

Bankfull Channel

Floodprone Area

Bank Condition
Armored Natural
- Eroding
- Part stable
- Stable

Landslides
- Active
- Part Stable

Analysis Unit Boundary
- Reach
- Subreach

A1 Subreach Rosgen Stream Type

Other Features
- Tributary Stream
- Road (some decomissioned)
- 200 foot contour

ADN, Q:_B\200062-Sullivan_Creek_Habitat_Assessment\GIS\draft_maps\final2013_reach_scale_trib_annotation_10.1.mxd

Plate B19: Reach(es) Sullivan Headwaters 1, Deemer 1, & Leola 1

Plates C1-C6 Geomorphic, Hydraulic, and Habitat Features Charts

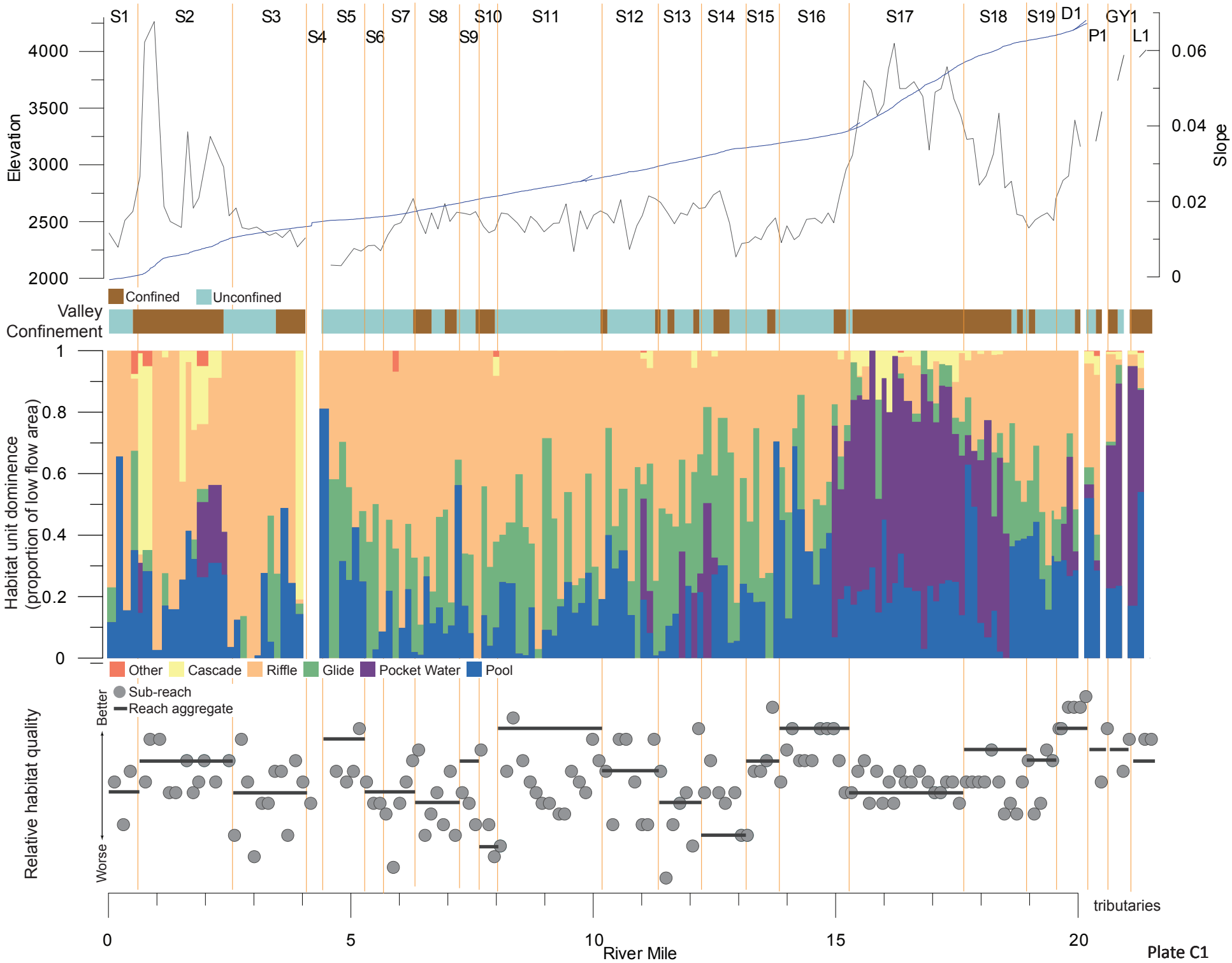

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
D1
P1
GY1
L1
Elevation
4000
3500
3000
2500
2000
Slope
0.06
0.04
0.02
0
Confined
Unconfined
Valley Confinement
Habitat unit dominence (proportion of low flow area)
1
0.8
0.6
0.4
0.2
0
Other
Cascade
Riffle
Glide
Pocket Water
Pool
Relative habitat quality
Better
Worse
Sub-reach
Reach aggregate
tributaries
0
5
10
15
20
River Mile

Plate C1

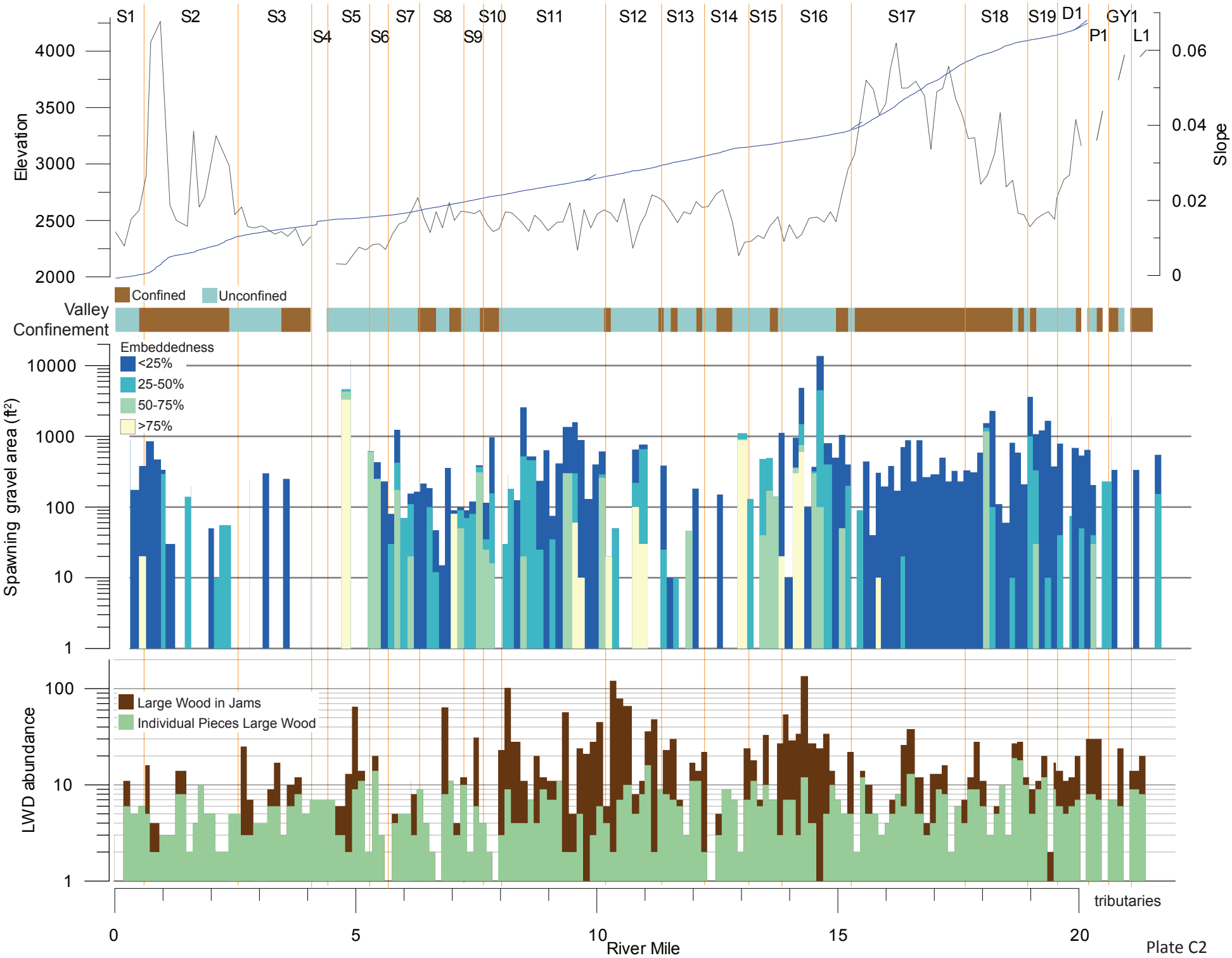

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
D1
P1
GY1
L1
Elevation
4000
3500
3000
2500
2000
Slope
0.06
0.04
0.02
0
Confined
Unconfined
Valley Confinement
Embeddedness
<25%
25-50%
50-75%
>75%
Spawning gravel area (ft²)
10000
1000
100
10
1
Large Wood in Jams
Individual Pieces Large Wood
LWD abundance
100
10
1
tributaries
0
5
10
15
20
River Mile

Plate C2

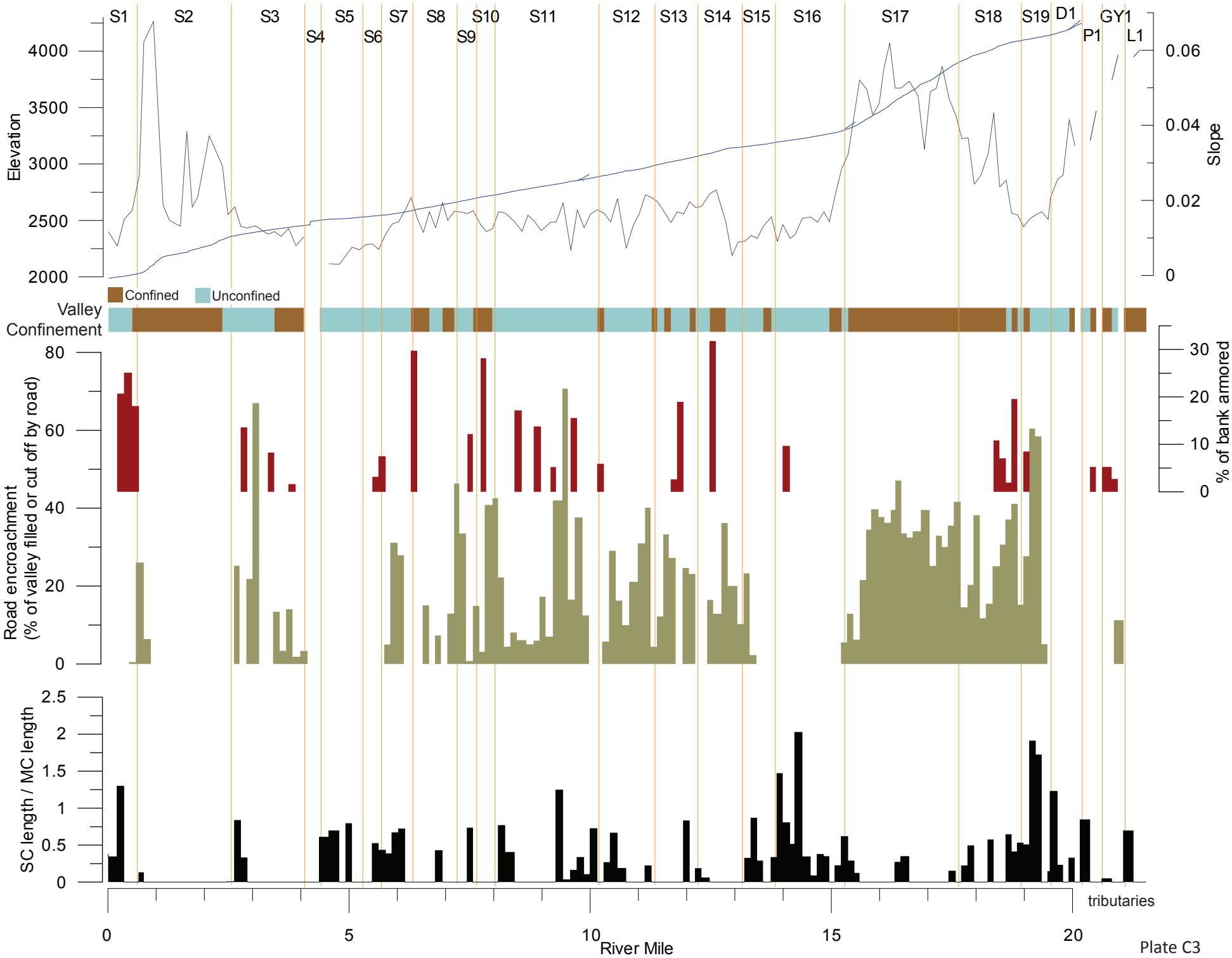

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
D1
P1
GY1
L1
Elevation
4000
3500
3000
2500
2000
Slope
0.06
0.04
0.02
0
Confined
Unconfined
Valley Confinement
Road encroachment (% of valley filled or cut off by road)
80
60
40
20
0
% of bank armored
30
20
10
0
SC length / MC length
2.5
2
1.5
1
0.5
0
tributaries
0
5
10
15
20
River Mile

Plate C3

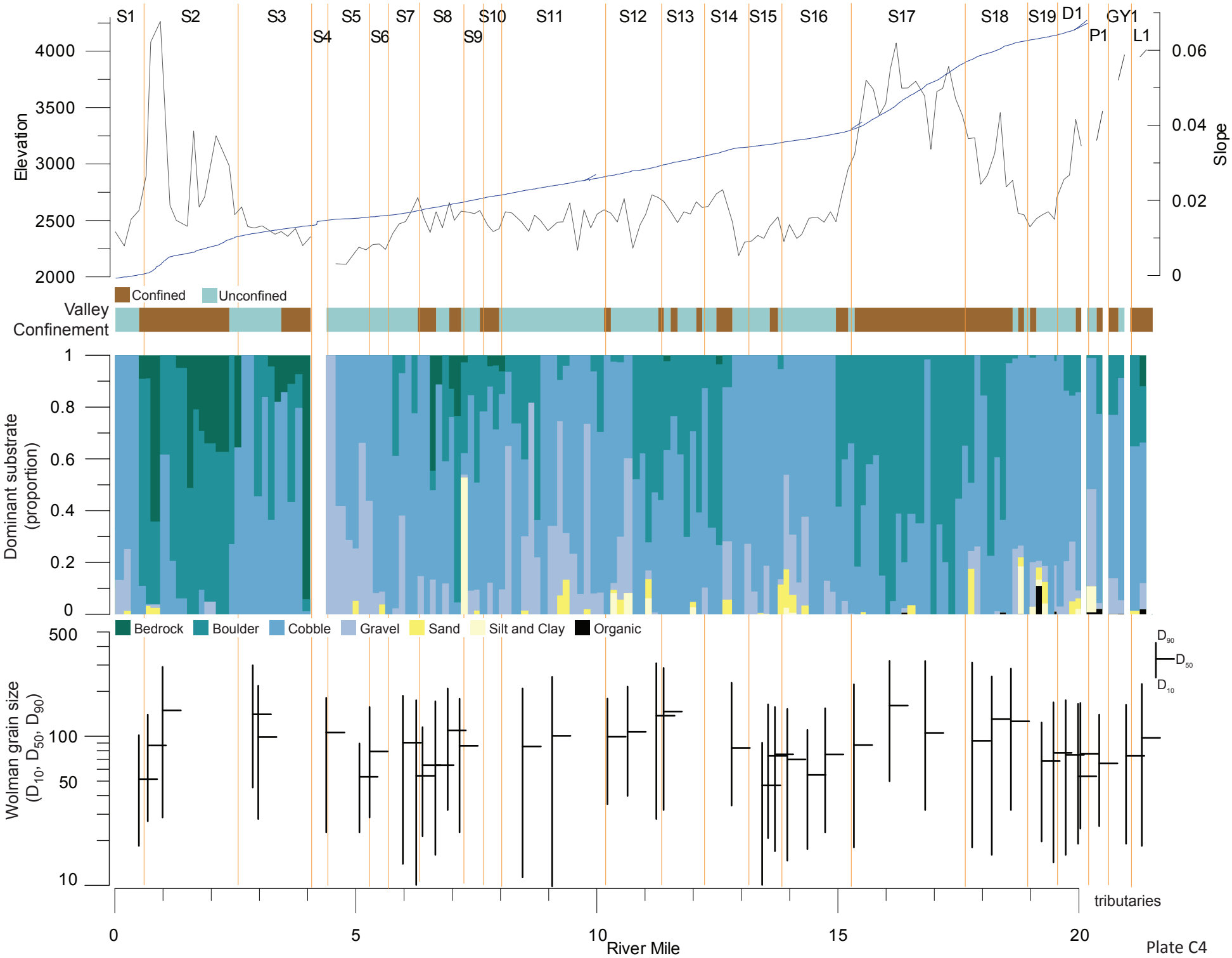

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
D1
P1
GY1
L1
Elevation
4000
3500
3000
2500
2000
Slope
0.06
0.04
0.02
0
Confined
Unconfined
Valley Confinement
Dominant substrate (proportion)
1
0.8
0.6
0.4
0.2
0
Bedrock
Boulder
Cobble
Gravel
Sand
Silt and Clay
Organic
Wolman grain size (D_{10}, D_{50}, D_{90})
500
100
50
10
D_{90}
D_{50}
D_{10}
tributaries
0
5
10
15
20
River Mile

Plate C4

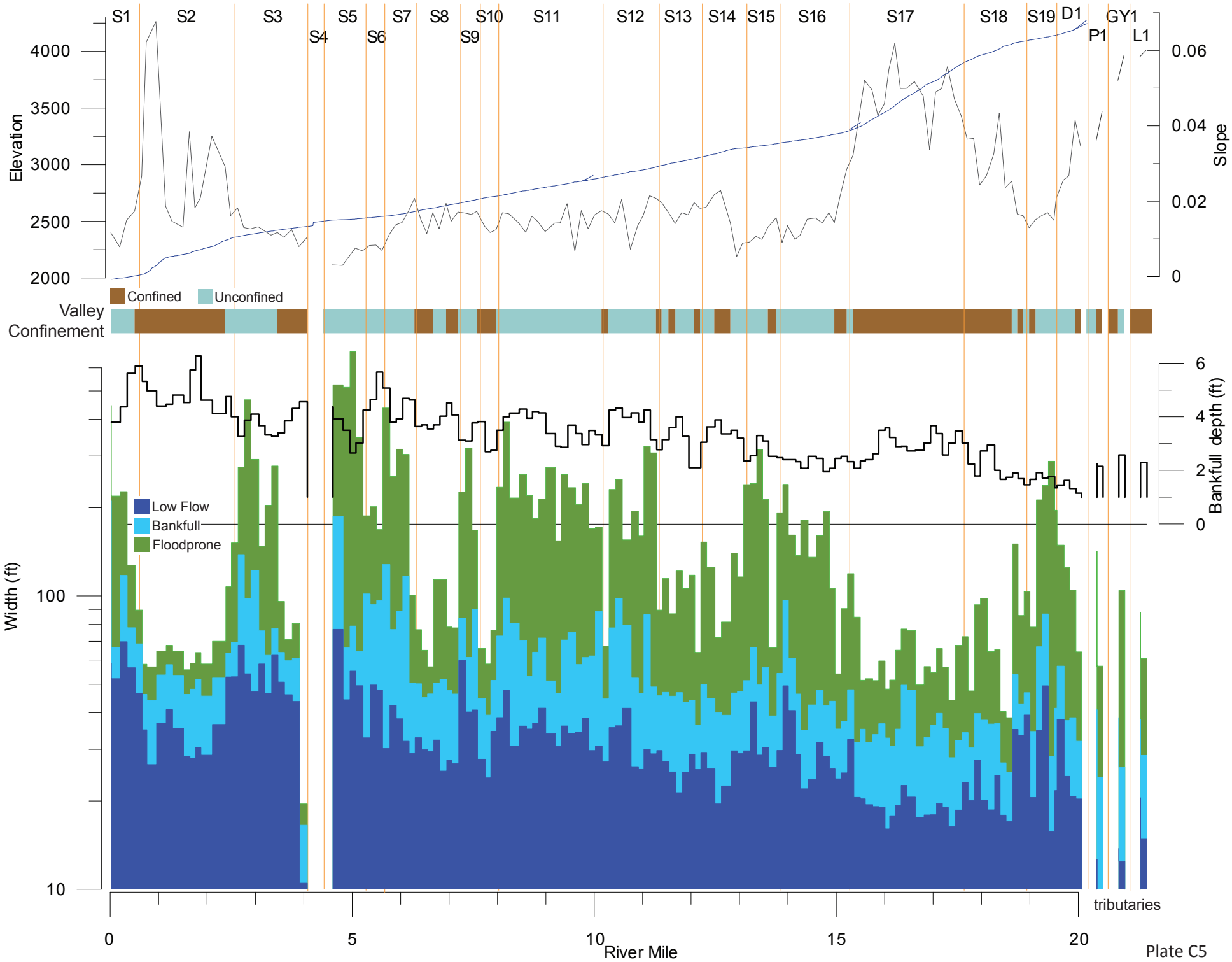

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
D1
GY1
P1
L1
Elevation
4000
3500
3000
2500
2000
Slope
0.06
0.04
0.02
0
Confined
Unconfined
Valley Confinement
Bankfull depth (ft)
6
4
2
0
Low Flow
Bankfull
Floodprone
Width (ft)
100
10
tributaries
0
5
10
15
20
River Mile

Plate C5

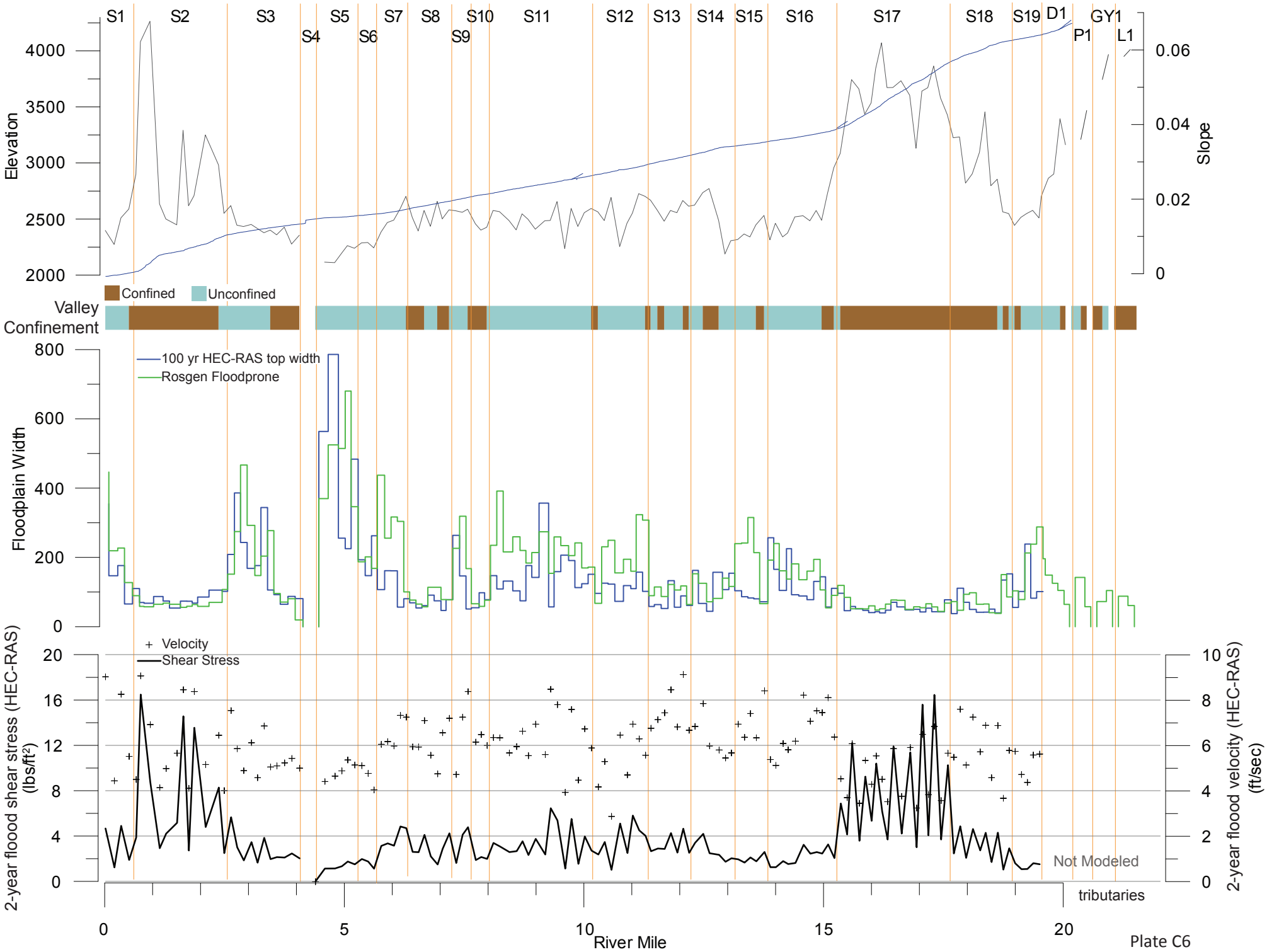

S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
D1
P1
GY1
L1
Elevation
Slope
Confined
Unconfined
Valley Confinement
100 yr HEC-RAS top width
Rosgen Floodprone
Floodplain Width
Velocity
Shear Stress
2-year floood shear stress (HEC-RAS) (lbs/ft²)
2-year floood velocity (HEC-RAS) (ft/sec)
Not Modeled
tributaries
River Mile

Plate C6

Appendix A

Sullivan Creek Habitat Survey Protocol

Sullivan Creek Habitat Survey Protocol

August 18, 2012

Introduction

This protocol is an internal document of Seattle City Light that has been modified by Andrew Haas from the following documents to meet the objectives of this project.

> Rustay, M.D., Leonetti, F.E., Haas, A.D., Purser, M.D. and B. Gaddis. 2008. Snohomish County wadeable stream habitat survey protocol for status and trend monitoring. Snohomish County, Public Works, Surface Water Management, Everett, WA.
>
> Washington Department of Fish and Wildlife, Kalispel Tribe of Indians, Spokane Tribe of Indians, and Confederated Colville Tribes. 2002. Fish Population and Habitat Assessment Methodologies for Tributary Stream, Lakes and Reservoirs. Joint Stock Assessment Project.

The protocol outlines a quantitative, GPS-based approach to data collection in wadable streams. Data are collected continuously and at regularly spaced transects and recorded in a data dictionary using a Trimble GPS unit. The protocol is designed to be repeatable and relatively rapid. Final adjustments to the protocol will be made in consultation with the selected consultant. The habitat survey should be completed during the summer low flow period between late June and early October.

Field Equipment

Trimble GeoXH GPS units (Geo Explorer 6000 series with GLONASS)
Stadia rod (metric)
Laser range finder
Hip chain (metric)
Convex spherical densiometer
Hand level rod
Hand level - pea gun
Clinometer
Thermometer
Caliper or ruler (metric)
Flagging tape/ indelible pen
Two way radios (optional)
Manual tally counter

GPS units and File Management

Survey data are entered into a data dictionary file contained on a Trimble GPS field computer running the Windows™ operating system. A Trimble GeoXH GPS unit (Geo Explorer 6000 series with GLONASS) is necessary to maximize satellite coverage. Because wadeable stream channels (especially those with dense vegetative cover or in deep valleys) are notorious for having poor satellite coverage, this survey method requires surveyors to collect as many GPS positions as possible, but does not require them for each stream feature to complete the survey. Attributes entered into the data dictionary without collecting

discrete GPS locations are post-processed in the office and exported as *.dbf tables with the ability to link to spatial data by file/reach identifier. GPS locations are recorded at the start and end of the reach and at as many transects as possible along the length of the reach. In the worst case scenario, a reach start point and end point can be digitized in the field over recent ortho-photos stored as background files in the field computer.

“Not-in-feature” position points (GPS breadcrumbs) are also collected throughout the reach at intervals of 5 meters or whenever the unit receives sufficient satellite signals (>5 m). Each one of these points carries a time stamp that can be related to time stamps from survey data entries and their corresponding hip chain station values. This allows the approximate placement (mapping) of each feature collected along a routed stream centerline in ArcGIS.

Quality assurance and control measures are applied to ensure that data collection and management minimize bias, uncertainty, and errors (entry or transcription) and maximize accuracy and precision. During data collection, a lead surveyor is designated to coordinate the survey so that measurements are not overlooked. Data are directly entered into the field computer to avoid transcription errors with data entry from field forms. Completed reach files are transferred to a PC after each day of survey work. Data are reviewed after computer upload by a member of the survey team to screen for errors, and any changes to the data are documented. Any potential recording errors are noted and communicated to the data manager.

Data Management and Output for Analysis

All stream data across survey reaches are appended by feature classes and individually uploaded to a relational database. All survey and habitat tables are organized based on the survey reach identifier. For each survey, key survey information such as total survey length is used to generate intermediate queries of channel metrics useful for estimating habitat frequencies, spacing, loading, or aerial composition.

Field Procedure

Survey Strategy

Survey teams generally consist of two to three surveyors. The lead surveyor is responsible for data entry into the field computer and survey coordination. Data recording is often a time bottleneck, and it is important for the survey lead to coordinate the survey so that measurements are not overlooked.

At the start of each day, surveyors tie off and zero the hip chain and proceed with the survey in an upstream direction. They record a station number from the hip chain for each piece of information gathered during the day. The station designation provides an organizational record for data entry into an extensive computer database. Where survey measurements are made in the main channel, MC is entered in the Channel Type field within the database. SC is entered if survey measurements are made in side channel habitat. All side channel data are organized based on only using the main channel station number where the side channel starts.

Protocol for Dry or Intermittent Channels

Channels (or side-channels) that are dry at the time of the survey are surveyed for bankfull width and depth. Major dry side channels (seen on aerials, pre-select prior to field work) are also surveyed for wood, bank condition, and transect metrics. If these channels have standing water in pools that meet the survey criteria, the pools are recorded. In streams with intermittent flow (some surface/ some sub-surface flow), stream units with no surface flow are entered as riffles. Record the length of each unit of dry channel and record a wetted width of zero. This ensures total length is recorded and preserved and that habitat area is only estimated based on wetted units.

Day Start

At the beginning of each day, take a GPS point, record date, initials of survey team, air temperature, and water temperature. Take a photo of the site linked to a GPS point.

Data entry for reach overview:
Required Values: Survey Team Members, Date, Air Temperature, Water Temperature, Photo.

Stream Flow

Because flows are variable, discharge measurement are helpful for interpreting data, particularly from year to year.

Procedure:
At the four standardized locations in the watershed, estimate stream discharge. String a tape between stakes. Break the cross-section into a minimum of 10 cells. Record the station at wetted margins and at changes in velocity or depth. Record the depth and velocity at 60% from the water surface within each cell. Follow the USGS standard methodology.

Data entry for streamflow:
Required Values: Location, description, staff gage reading, photo, surveyors. Station, depth, velocity recorded on field form.

Transect Characterization

Transect spacing is set at 200 meters. Beginning at transect 1 (station 0), data are collected from 6 transects) per kilometer as survey teams move upstream (one transect every 200 meters). A GPS location is recorded at each transect (thalweg) and transect information is recorded in the data dictionary as attributes of the transect feature class in the data dictionary. At each transect , the dominant feature (pool, riffle, other) across a majority of the stream width is identified and recorded. Teams collect data on stream gradient, bankfull width and depth (through surveyed points on cross section), canopy cover and substrate size (as a separate Wolman pebble count on a representative bar) as described below. Small wood tallied since previous transect are also entered. Take a photo of the channel at each transect linked to a GPS point.

Stream Gradient

Purpose: Stream gradient is a strong determinant of channel morphology and habitat. Gradient is measured to verify Rosgen reach determinations.

Definition: Stream gradient is the change in the vertical elevation per unit of horizontal distance of the water surface of a flowing stream.

Procedure: Stream gradients are measured with a hand level and stadia rod. The hand level rests on a pre-fabricated pole of known height. One field worker moves as far downstream as possible and places the survey rod at the edge of the wetted channel (water surface). The relative height of the downstream water surface elevation is measured by aiming the level at the survey rod and viewing the value on the rod. The distance to the downstream location is measured with the rangefinder. Measure stream distance, not valley distance if there is a major bend at the gradient location. The field worker with the stadia rod then moves a reasonable distance upstream and the relative height and distance are measured by the worker with the level. The upstream and downstream distance and relative rod elevation (foresight) are recorded in the data dictionary.

Canopy Cover

Purpose: To assess vegetative cover indicating the amount of shade provided for stream cooling or cover on stream banks as well as potential inputs of organic matter. Canopy cover also gives an indication of locations that are potentially accessible for LWD placement using a helicopter.

Definition: Canopy cover is the amount of tree cover providing shade to the stream channel.

Procedure: At each transect, a total of four cover measurements are made using a convex spherical densiometer modified as described in (California Department of Pesticide Regulation SOP FSOP.02.01) where the number of grid points are limited to 24. While holding the densiometer level at 30 cm above the water surface, one observer counts the number of cells covered by leaves, branches, etc. and records the values (0-24) in the data dictionary, where 0 corresponds to no cover (open sky) and 24 corresponds to total cover. Four readings are taken from the center of the channel facing toward the right bank, upstream, the left bank and downstream.

Entrenchment

Purpose: Entrenchment ratio is a defining characteristic of channel type that is needed to complete a Rosgen Level II assessment.

Definition: Entrenchment ratio is the flood prone width divided by the bankfull channel width. Flood prone width is defined as the width at twice the maximum depth of the channel.

Procedure: Entrenchment and flood prone width will be measured in the office using the LiDAR data and bankfull data collected during the cross section survey.

Data entry for transect:
Required Values: Transect Number, Station, Stream Gradient data (US, DS distance and rod reading), Habitat Unit Type, Canopy Cover (4 values) Photo.

Cross Section Survey at Transects

At each transect location, a quick survey of the channel cross section will be made using a tape, survey rod, and hand level (on monopod) to define the channel geometry for use in the hydraulic model. The minimum surveyed points will include top of each bank, bankfull on each bank, waters' edge on each bank, and thalweg. Intermediate points will be taken as necessary to define high flow channel (e.g., top of bars, breaks in slope)

Bankfull Width and Depth

Purpose: Bankfull width and depth are the primary measure of channel size and are used to calculate a width-to-depth ratio.

Definition: Bankfull width is the width of a stream channel at the point where over-bank flow begins during a 1.5-2 year flood event. Straight, low-gradient riffles with uniform banks, few or no obstructions (such as jams), and no side-channels are the best locations for measuring bankfull width. Bankfull width is located using any of the following indicators: the top of deposited bedload (gravel bars), stain lines, the lower limit of perennial vegetation, moss or lichen, a change in slope or particle size on the stream bank, and undercut banks (USFS 1999). Bankfull depth is defined as the vertical distance between bankfull stage and the thalweg of a riffle (Rosgen 1996).

Procedure: The location of bankfull on each side of the channel is measured as part of the surveyed cross section.

Data entry for each survey point:
Required Values: Transect Number, channel type, location across channel, distance, foresight.

Pebble Counts

Substrate Size

Purpose: To characterize size of the substrate moving as bedload.

Procedure: A standard random walk Wolman pebble count (100 grains) is taken at a representative gravel bar location (upstream end of unobstructed point bar, or mid-channel bar) if one exists within each 200 meter transect spacing. The first substrate particle touched in front of the surveyor's boot toe is picked up. Using a caliper or ruler, the intermediate axis of the particle is measured and recorded (in millimeters). The actual measurement is stored, and as part of data transformation, each particle is classified into one of the size classes listed below. Retaining the actual measurement allows for more accurate calculation of substrate size metrics (i.e., geometric mean or cumulative size distribution).

Data entry for each pebble count:
Required Values: Station, channel type, location, 100 grain sizes, Photo.

Continuous Habitat Parameters

Habitat parameters measured continuously along the reach include stream bank condition, habitat units, LWD and side-channels. Teams collect data on stream bank condition, side-channel habitat, and woody debris as described below.

Stream Bank Condition

Purpose: To inventory bank modifications and assess bank stability. Bank condition is assessed upslope from bankfull height. Banks are considered natural and stable unless noted and recorded as a feature. If rip rap is noted that is set back from main flow channel, but it is visible from the channel include it in the inventory. See "Major Sediment Sources" for major erosion areas not directly adjacent to bankfull channel.

Definitions:

Bank Stability: Banks are stable unless they show indications of any of the following features (Bauer and Burton 1993):

Breakdown: Obvious blocks of bank have broken away and are lying adjacent to the bank breakage.
Slumping or False bank: The bank has obviously slipped down, but cracks may or may not be obvious.
Fracture: A crack is visibly obvious on the bank indicating that the block of bank is about to slump or move into the stream.
Vertical and Eroding: The bank angle is steeper than 80° from the horizontal *and* the bank is mostly uncovered as defined by at least one of the following:

- ≤ 50% of ground cover is perennial vegetation
- ≤ 50% of the bank is covered by roots.
- ≤ 50% of the bank is protected by rocks of cobble size or larger.
- ≤ 50% of the bank surfaces are protected by wood ≥10-cm in diameter.

Modified Bank: Banks that have been altered by riprap, rubble, concrete, or other anthropogenic structures.

Procedure: Stream bank conditions are monitored continuously along both banks. When a portion of unstable or modified bank is encountered, the bank feature class in the data dictionary is selected, the hip chain station is recorded, and the right or left bank (facing downstream) is indicated. The length of the unstable or modified feature is measured with a rangefinder, stadia rod or hip chain. The dominant grain size of the eroding portion of the bank is visually assessed (fines, fine/coarse mix, coarse). Take a photo of major areas of channel migration linked to a GPS point.

Data entry for stream bank instability:
Required Values: Station, Channel Type, River Bank, Stability, Dominant grain size, Modification Type, Length

Major Sediment Sources

Purpose: To inventory major sediment sources (e.g. hillside mass wasting, major

sediment deposits at tributary confluences) that are not captured in the Stream Bank Condition features because they are not in contact with the bankfull channel. Take a photo linked to GPS point.

Data entry for Major Sediment Sources:
Required Values: Station, Channel Type, River Bank, Stability, Dominant Grain Size, Length, Height

Woody Debris

Purpose: To measure the characteristics and quantity of instream wood providing habitat complexity, cover and hydraulic roughness.

Definitions:

Large Woody Debris - The minimum size for a qualifying piece of wood is 1.0 meter (m) in length and 10 centimeters (cm) in diameter along the qualifying length of the piece. Small pieces deposited onto of bars are excluded if they don't appear to be reasonably stable and capable of creating habitat. For pieces that are less than 7.6 m long, the average diameter over the length of the piece is recorded. For pieces that are greater than 7.6 m long, the diameter is measured at 7.6 m from the large end. Only downed wood that intercepts the bankfull flow is counted. Wood above bankfull elevation is recorded only if it is part of a jam that contains wood below the bankfull level. Trees standing vertically, wholly or partially, within the bankfull area with their weight supported by attached roots are not counted.

Jams – Log jams are defined as three or more touching pieces of wood that are >7.6 m in length and >30 cm in diameter (USFS 1999).

Rootwads - Rootwads create habitat and stabilize large woody debris. To qualify in this survey, they are defined as having an average diameter of 1 meter or greater.

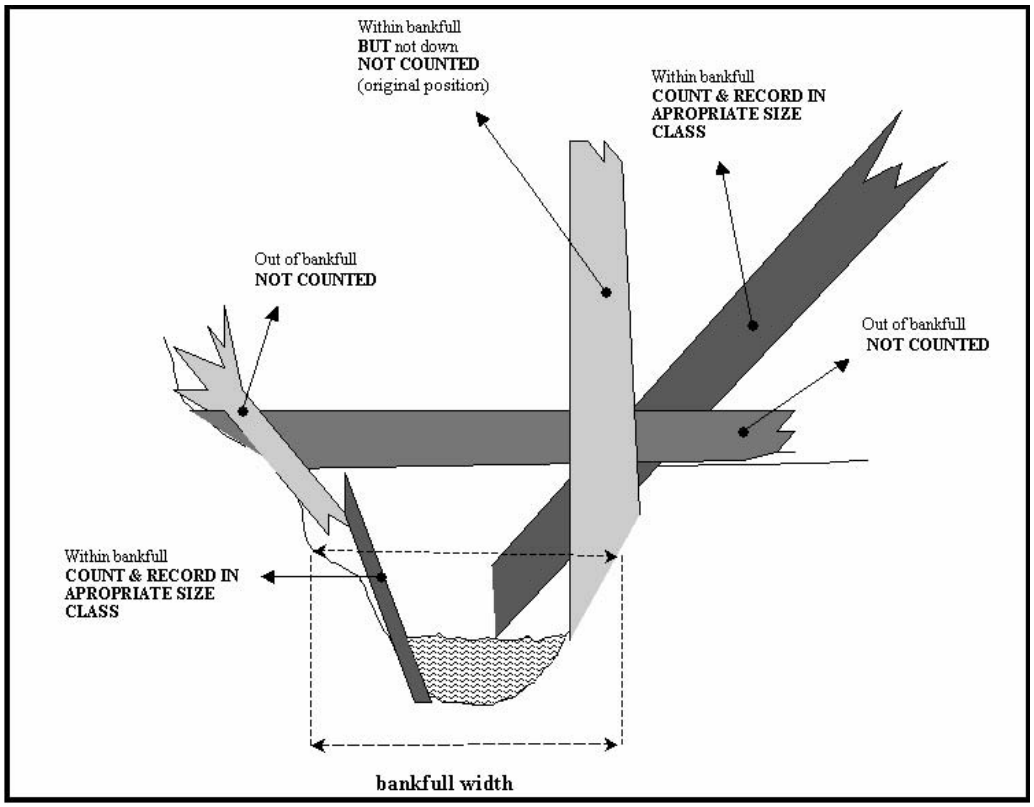
Key Pieces – The piece or pieces of wood that appear to have formed the jam.

Procedure: Small wood that is 10-30 cm in diameter and 7.6 m in length is tallied and not assigned a hip chain station. Tallies for small wood are entered for the entire length of stream inventoried between transects (entered in next transect feature upstream). Hip chain stations are recorded for individual pieces of wood greater >30 cm in diameter and/or >7.6 m in length. Measure wood with a stadia rod or rangefinder. Select and record the appropriate length (7.6-15 m, >15 m) and diameter classes (30-60 cm, 60-90 cm, >90 cm) within the data dictionary. Record whether or not each piece has a qualifying rootwad attached, if it is in contact with low flow, and if it is part of a jam. If the wood appears to have been placed as part of a past restoration project, note it in the comment field.

When a log jam is encountered, the Jam feature class in the data dictionary is utilized. The station number is entered and a GPS point is logged. Wood in jams is surveyed using the same size classes as single pieces. Each qualifying piece of wood in a jam is assessed and marked on a paper tally sheet based on length and size (see below). Key pieces are circled on the tally sheet and entered into the GPS

separately from other pieces. The number of qualifying root wads – over 1 meter in diameter (not including key pieces) are also counted and marked on the tally sheet. The total volume of the jam is estimated. All wood in jams is recorded in the Jam feature and is not recorded or tallied separately for the reach.

Sullivan Creek Log Jam Tally Sheet			
Date		Surveyors	
Location			circle key pices
	Length		
Diam	3-25 feet	25-35 feet	>35 feet
4-12 inches	1	5	9
12-24 inches	2	6	10
24-36 inches	3	7	11
>36 inches	4	8	12
Root Wads			



Data Entry for wood:
Wood (single pieces)
Required Values: Station, Channel Type, Length Class, Diameter Class, Rootwad (Yes/No), Wet (Yes/No), USFS Weir (Yes/No). Add final tallies for main channel and side channel wood in the next transect upstream.

Jams
Required Values: Station, Channel Type, Wet (Yes/No), Key piece Length Class (3), Key piece Diameter Class (3), Key piece Rootwad (Yes/No, 3), number of pieces in each of the 12 size/length classes, number of root wads, Photo.

Pool Habitat

Purpose: To measure habitat area available for holding and rearing.

Definitions:

Pool – A pool is a section of stream channel where water is impounded within a closed topographical depression (Abbe and Montgomery, 1996).

Pool Type – Primary pools (which are generally greater in length than the channel width) are located in line with the thalweg while backwater pools (also know as alcove pools) are separated from the main flow (Lazorchak *et al.*, 1998). Backwater pools and pools in side-channels are separated out from primary pools because they provide prime winter rearing habitat.
If a part of a habitat unit meets the pool width/depth criteria but the pool is in a separate channel (e.g. a braided reach), the start station is recorded and the total pool length is measured with a rangefinder and entered into the optional "length" field (length on non-secondary habitat units will be calculated based on hip chain station, but secondary habitat units are embedded within the primary habitat units so the beginning hip chain for the habitat unit may not correspond to end of secondary habitat unit).

Pool Forming Feature – The feature or process that leads to the formation of a pool is described by one of the following:

- **Rip Rap or Modification** – formed by scour along a hardened bank or other instream modification; such as a bridge pier or structural bulkhead
- **Bedrock** – formed by scour along bedrock material (does not include compact till)
- **Wood** – formed by scour around naturally occurring or placed wood or by being impounded by wood (a dammed pool) or plunging over wood
- **Beaver** – formed behind beaver dam or scoured from other beaver activity
- **Free Form** – formed in ways other than above, such as from flow convergence or lateral bank resistance

Pool Cover – Surface area of the pool with wood or undercut banks that provide cover for fish.

Spawning Habitat – Locations with suitable conditions for spawning by native salmonids. Spawning habitat often occurs in pool tailouts. It is characterized by three basic components:

- The proper gravel size for resident fish ranges from 0.6-6.4 cm; optimum size will range from 1.3-3.8 cm (Espinosa 1988).

- Located within close proximity to cover and resting pools. Desirable spawning habitat will include a pool area of sufficient depth (> 0.6 m) and cover (undercut banks, logs, boulders) to provide shelter and rest within 30.5 m up or downstream of the spawning gravels (Espinosa 1988).

- Current velocities of 0.2 - 0.6 m (0.5 - 2.0 ft) per second are considered optimum and desirable for spawning activity and incubation requirements.

- Since velocity and depth at spawning times is not known, any areas of gravel of suitable size with a patch size of over 10 square feet within the wetted channel will be counted.

Embeddedness - the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud of the stream bottom. Visually assessed and averaged over spawning gravel areas

Sample Embededness Photos:

0%

0-25%

25-50%

25-50%

50-75%

75-100%

100%

Dominant/sub-dominant Substrate – Dominant and sub-dominant substrate size within the wetted channel is recorded for each habitat unit (see chart below).

Size Class	Size Range (mm)
Organics	Organic matter (LWD, small organic matter)
Fines	< 0.06
Sand	> 0.06 to 2
Gravel (fine)	> 2 to 16
Gravel (course)	> 16 to 64
Cobble	> 64 to 250
Boulder	> 250 to 4000
Hardpan or bedrock	bedrock

Procedure: For a habitat unit to qualify as a pool in this survey, it must meet the minimum wetted area and depth requirements, consistent with Pleus et al. (1999).

Bankfull Width (m)	Wetted Area (m^2)	Residual Pool Depth (m)
0 – 2.49	0.5	0.10
2.5 – 4.9	1.0	0.20
5.0 – 9.9	2.0	0.25
10.0 – 14.9	3.0	0.30
15.0 – 19.9	4.0	0.35
>20	5.0	0.40

When a potential pool is encountered, the tailout depth and maximum depth are measured using a stadia rod in order to calculate the residual pool depth (maximum depth - tailout depth). If the residual depth is greater than the minimum required for the established bankfull width, the mean wetted width and wetted length of the pool are measured. If the wetted area (length * width) does not meet the minimum depth requirements, the habitat area is not recorded as a pool. In this case, the habitat unit area is lumped with an adjacent unit or recorded separately as glide or pocket water habitat.

Pool tailouts often provide the best salmonid spawning habitat. Observe and record the area of any patches that meet depth and substrate size criteria. Visually estimate the percent embeddedness (<25%, 25-50%, 50-75%, >75%). Also visually estimate the percent pool cover.

Data Entry for pools meeting minimum size criteria:
Required Values: Station, Channel Type, Pool Type, Pool Forming Feature, Pool Cover, Tailout Depth, Maximum Depth, Wetted Width, Spawning area, Embeddedness, Dominant and sub-dominant substrate, Photo.

Riffle Run, Glide and Pocket Water Habitat

Purpose: To quantify the prevalence of various habitat types. These measurements are also necessary to assess total wetted area.

Definitions:

Riffle – A section of stream with shallow, turbulent, higher velocity flow. The water surface may be generally unbroken, rippled, or have small waves. The wetted width boundary of riffles is the point at which substrate particles are no longer surrounded by free water (Lazorchak *et al.*, 1998).

Run – A transitional zone, intermediate between pools and riffles in physical profile. An area of swiftly flowing water, without surface agitation or waves, which approximates uniform flow and in which the slope of the water surface is roughly parallel to the overall gradient of the stream reach.

Glide – A slow-moving, relatively shallow type of run. Calm water flowing smoothly and gently, with moderately low velocities (0.1 to 0.2 m/sec), and little to no surface turbulence.

Pocket Water – A series of small pools surrounded by more swiftly flowing water, usually caused by eddies behind boulders, rubble or logs.

Cascade – A very steep, often boulder-dominated section of channel. Often has whitewater. Slope between 8 and 30 percent (Montgomery and Buffington)

Waterfall – enter jump height in the comment field for waterfall features.

Procedure: The station number of the most downstream point of the habitat unit is recorded. The average wetted width is measured to determine the most accurate representation of the area. Spawnable area is estimated in square meters for all habitat units and spawning embeddedness is visually assessed.

Data Entry for Riffles and Other:
Required Values: Station, Channel Type, Habitat Unit Type, Wetted Width, Spawnable Area, Embeddedness, Dominant and sub-dominant substrate

Side Channel Habitat

Purpose: To quantify habitat in side channels.

Definition:

Side channels – Side channels are defined as channels that are separated from the main channel by a stable island and contain the smaller portion of the total flow. A stable island in a forested stream is defined by USFS (1999) as supporting woody vegetation (excluding willow) that is estimated to be at least 5 years old and covers at least 50% of the island surface at or above bankfull elevation.

Procedure: Surveyors identify whether or not a potential side channel feature is separated from the main channel by a stable island. If the feature is not separated by a stable island, include it with the main channel measurements.

Side channel conditions are recorded in the Side Channel feature class in the data dictionary. The station number of the downstream side channel outlet is recorded and a GPS point is logged. Wetted side channel features are surveyed following the same method used for continuous survey of mainstem channels, Habitat units, unstable banks, modified banks and woody debris are recorded as separate feature classes. Each feature found within the side channel is recorded with the same initial station number in order to identify every side channel feature with each specific side

channel.

Dry side channels – minor dry side channels are not fully inventoried; if found, the upstream and downstream ends are marked and bankfull is visually estimated. Major dry side channels (clearly seen on aerial photographs) are inventoried for wood and bank condition.

Side channel total length (wet and dry units) and mean total width are recorded in the Side Channel feature class. Total wetted length and mean wetted width are estimated from wetted habitat units within the side channel as part of habitat analysis.

Data Entry for side channel measurements:
Required Values: Station, Wetted Length, Total Length, Wetted Width, Bankfull Width.

Day End

End each day with a transect if possible, or note day end station and/or length of final habitat unit. Close GPS file and flag location in field to start the next day.

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Appendix B

Summarized Habitat and Geomorphic Attributes & Definitions

Table B1. Description/definition of reach-aggregate metrics.

	ATTRIBUTE	DESCRIPTION
Geomorphic and basic descriptive attributes (B3)		
	Reach	Reach Identifier. Code formed by a letter representing the creek name and number representing the reach, ascending from downstream to upstream. S=Sullivan Creek, P=Pass Creek, GY=Gypsy Creek, D=Deemer Creek, L=Leola Creek.
	basin area (mi^2)	Basin accumulation area calculated from topography using USGS 10m DEM
	field measured main channel length	Sum of field measured lengths of non-embedded pool habitat units along main channel (ft)
	field measured side channel length	Sum of field measured lengths of non-embedded pool habitat units alongside channel(s) (ft).
	field measured total low flow area	Total area of wetted habitat units calculated as field measured length x field measured width.
	field measured side channel low flow area	Area of wetted habitat units calculated as field measured length x field measured width in side channels.
	Rosgen channel type	Level II Rosgen (1996) channel type as defined by entrenchment ratio, width/depth ratio, slope, sinuosity, and number of channels.
	Slope	Reach average slope determined from LiDAR.
	braid index	Side channel flow path length/main channel flow path length.
	entrenchment ratio	As defined by Rosgen (1996). The ratio of the floodprone area to the bankfull channel area.
	width/depth ratio	As defined by Rosgen (1996). The ratio of the bankfull channel width to bankfull channel depth.
	sinuosity	Main channel flow path length/valley length.
	average field measured slope	The average of the slope measured in the field over approximately 150 feet at transect locations within the reach. (ft/ft)
	average field measured percent canopy cover	The average canopy cover measured in the field at transect locations within the reach. (%)
Habitat unit attributes (B4)		
Main Channel	Other	Proportion of the main channel wetted area during field survey that is not in one of the other categories; mostly cascade, waterfalls and shallow backwater areas
	Pocket Water	Proportion of the main channel wetted area during field survey that is pocket water
	Pool	Proportion of the main channel wetted area during field survey that is pools
	Riffle	Proportion of the main channel wetted area during field survey that is riffles
	Run/Glide	Proportion of the main channel wetted area during field survey that is run or glide
	Pool/riffle ratio	Ratio of main channel pool area to main channel riffle area

Side Channel	Other	Proportion of the side channel wetted area during field survey that is not in one of the other categories; mostly waterfalls and shallow backwater areas
	Pocket Water	Proportion of the side channel wetted area during field survey that is pocket water
	Pool	Proportion of the side channel wetted area during field survey that is pools
	Riffle	Proportion of the side channel wetted area during field survey that is riffles
	Run/Glide	Proportion of the side channel wetted area during field survey that is run or glide
	Pool / riffle ratio	Ratio of side channel pool area to side channel riffle area
Pool attributes (B5)		
	dominant pool forming feature	The modal category determined to be the pool forming feature
	subdominant pool forming feature	The second most common category of pool forming features
	pools/mi	Number of pools normalized to field-measured channel length
	wetted widths/pool	Average spacing between pools normalized to wetted width of the channel
	average pool area	Average surface area of pools
	standard deviation of pool area	Standard deviation of pool surface area
	average pool residual depth	Average residual depth. Residual depth is calculated as maximum pool depth-pool tailout depth.
	standard deviation of pool residual depth	Standard deviation of pool residual depth. Residual depth is calculated as maximum pool depth-pool tailout depth.
	number of pools >1m deep	Total number of pools in reach with maximum depth greater than 1 m.
	average pool cover	Average (unweighted) pool percent cover.
	standard deviation of pool cover	Standard deviation of percent pool cover.
Substrate attributes (B6)		
	Average of D_{10}	Average of D_{10} of bar-head Wolman Pebble Counts in reach (10 percent of the particles are smaller than the D_{10}).
	Average of D_{50}	Average of D_{50} of bar-head Wolman Pebble Counts in reach (D_{50} is the median grain diameter).
	Average of D_{90}	Average of D_{90} of bar-head Wolman Pebble Counts in reach (90 percent of the particles are smaller than the D_{90}).
	spawn area	Total area (ft^2) of 10-square foot or greater patches of bed composed of gravel between 6-64 mm uninterrupted by cobbles.
	< 25 embeddedness	Proportion of spawning gravel area with embeddedness of 0-25%
	25-50 embeddedness	Proportion of spawning gravel area with embeddedness of 25-50%
	50-75 embeddedness	Proportion of spawning gravel area with embeddedness of 50-75%
	>75 embeddedness	Proportion of spawning gravel area with embeddedness of 75-100%

Dominant substrate	Bedrock	Proportion of the wetted channel area within the reach with dominant bedrock bed material
	Boulder	Proportion of the wetted channel area within the reach with dominant boulder sized bed material (Wentworth 1922 definitions of size classes)
	Cobble	Proportion of the wetted channel area within the reach with dominant cobble sized bed material (Wentworth 1922 definitions of size classes)
	Gravel	Proportion of the wetted channel area within the reach with dominant gravel sized bed material (Wentworth 1922 definitions of size classes)
	Organic	Proportion of the wetted channel area within the reach with dominant organic bed material (Wentworth 1922 definitions of size classes)
	Sand	Proportion of the wetted channel area within the reach with dominant sand sized bed material (Wentworth 1922 definitions of size classes)
	Silt/Clay	Proportion of the wetted channel area within the reach with dominant silt or smaller bed material (Wentworth 1922 definitions of size classes)
Subdominant substrate	Bedrock	Proportion of the wetted channel area within the reach with subdominant bedrock bed material
	Boulder	Proportion of the wetted channel area within the reach with subdominant boulder sized bed material (Wentworth 1922 definitions of size classes)
	Cobble	Proportion of the wetted channel area within the reach with subdominant cobble sized bed material (Wentworth 1922 definitions of size classes)
	Gravel	Proportion of the wetted channel area within the reach with subdominant gravel sized bed material (Wentworth 1922 definitions of size classes)
	Organic	Proportion of the wetted channel area within the reach with subdominant organic bed material (Wentworth 1922 definitions of size classes)
	Sand	Proportion of the wetted channel area within the reach with subdominant sand sized bed material (Wentworth 1922 definitions of size classes)
	Silt/Clay	Proportion of the wetted channel area within the reach with subdominant silt or smaller bed material (Wentworth 1922 definitions of size classes)
Large wood summary attributes (B7)		
Total pieces including jams	WRIA 62 LWD definition	Large wood defined as >35' long
	Scaled to bankfull width	Large wood defined as >35' long if bankfull width exceeds 25', >25' long for bankfull channel width <25'
	Field protocol definition	Large wood defined as pieces >25' long and 12" diameter or with rootwad >3' diameter. Brush wood is defined as pieces < 25' long with diameter >4”.
Individual pieces only	Main channel brush wood count	Brush wood is defined as pieces < 25’ long with diameter >4”.
	Side channel brush wood count	Brush wood is defined as pieces < 25’ long with diameter >4”.
	Main channel individual large wood count	Large wood defined as pieces >25' long and 12" diameter or with rootwad >3' diameter.
	Side channel individual large wood count	Large wood defined as pieces >25' long and 12" diameter or with rootwad >3' diameter.

Large wood detailed attributes (B8)		
Sum of wetted wood	Total	
	Main Channel	
	Side Channel	
Sum of rootwads	Total	
	Main Channel	
	Side Channel	
Sum of 25-35 ft, 12-24"	Total	
	Main Channel	
	Side Channel	
Sum of 25-35 ft, >24"	Total	
	Main Channel	
	Side Channel	
Sum of >35 ft, 12-24"	Total	
	Main Channel	
	Side Channel	
Sum of >35 ft, >24"	Total	
	Main Channel	
	Side Channel	
Log weir attributes		
	Sum of functioning FS weir	Total number of log weirs present in the reach that are both in their constructed position and retaining sediment upstream.
	Sum of non-functioning FS weir	Total number of log weirs present in the reach that are either (a) in their constructed position but not retaining sediment upstream or (b) transported away from their constructed position.
Bank conditions attributes (B9)		
	length of bank armored	Total length of bank in reach armored by riprap, concrete bridge abutments, and/or log crib walls
	length of bank with active instability	Total length of bank in reach where field indications show active migration

	length of bank with partially stabilized instability	Total length of bank in reach where field indications show active migration has slowed
	proportion armored	Length of bank armored normalized to the length of channel edge (defined as 2x the thalweg length)
	proportion unstable	Length of bank with active + partially stable instability normalized to the length of channel edge (defined as 2x the thalweg length)
Log jam summary attributes (B10)		
	Number jams	Total number of log jams in reach.
	Number jams/mi	Number of jams divided by reach length.
	Average log jam volume (ft^3)	Average volume of all log jams in reach.
	Standard deviation of log jam volume (ft^3)	Standard deviation of volume of all log jams in reach.
	Average number of log jam wood pieces (all classes)	Average of the total number of all log jam wood pieces (both large and brush wood).
	Standard deviation of number of log jam wood pieces	Standard deviation of the total number of all log jam wood pieces (both large and brush wood).
	sum of large wood pieces in log jams	Total number of large wood pieces in log jams in reach. Large wood is defined as pieces >25' long and 12" diameter or with rootwad >3' diameter.
	proportion of large wood in log jams	Proportion of all large wood pieces in reach that are in log jams.
Log jam key piece attributes (B11)		
	25-35ft long	Proportion of log jam key pieces 25-35 ft long.
	3-25ft long	Proportion of log jam key pieces 3-25 ft long.
	>36in diam	Proportion of log jam key pieces with diameter >36 in
	12-24in diam	Proportion of log jam key pieces with diameter 12-24 in
	24-36in diam	Proportion of log jam key pieces with diameter 24-36 in
	4-12in diam	Proportion of log jam key pieces with diameter 4-12 in
	With rootwad	Proportion of log jam key pieces with rootwad

Table B2. Description/definition of subreach-aggregate metrics.

	ATTRIBUTE	DESCRIPTION
Geomorphic and basic descriptive attributes (B12)		
	Subreach	Subreach identifier coded as [ReachID-subreach no] with numerical values increasing in the upstream direction.
	Drainage area (mi^2)	Cumulative drainage area calculated from topography using USGS 10m DEM
	Upstream river station (miles)	Station of the upstream subreach boundary measured as miles upstream from the stream's mouth along the main channel flow path line
	field measured main channel length	Length of the main channel subreach calculated as the sum of field measured habitat unit lengths (excluding embedded pools)
	field measured side channel length	Length of wetted side channel in the subreach calculated as the sum of field measured habitat unit lengths (excluding embedded pools)
	field measured main channel low flow area	Total main channel wetted area in subreach calculated as the sum of habitat unit length x habitat unit width
	field measured side channel low flow area	Total side channel wetted area in subreach calculated as the sum of habitat unit length x habitat unit width
	Rosgen channel type	Level II Rosgen (1996) channel type as defined by entrenchment ratio, width/depth ratio, slope, sinuosity, and number of channels.
	main channel slope (LiDAR derived)	Average slope of main channel flowpath as calculated from LiDAR topography
	braid index	Side channel flow path length/ main channel flow path length
	entrenchment ratio	As defined by Rosgen (1996). The ratio of the floodprone area to the bankfull channel area.
	width / depth ratio	As defined by Rosgen (1996). The ratio of the bankfull channel width to bankfull channel depth.
	sinuosity	Main channel flow path length/valley length.
	field measured slope (at upstream transect)	The slope measured in the field over approximately 150 feet the transect bounding the upstream side of the subreach.
	field measured percent canopy cover (at upstream transect)	Percent of the sky blocked by vegetation at the channel center at the transect bounding the upstream side of the subreach.
	bankfull depth	Average of the difference between bankfull elevation and minimum elevation in bounding transect cross sections
	low flow channel width	Average width of the low flow channel polygon in subreach
	bankfull channel width	Average width of the bankfull channel polygon in subreach
	floodprone area width	Average width of the floodprone area polygon in subreach
Habitat unit attributes (B13)		
Main channel	Cascade	Proportion of the main channel wetted area during field survey that is cascade
	Other	Proportion of the main channel wetted area during field survey that is not in one of the other categories; mostly waterfalls and shallow backwater areas
	Pocket Water	Proportion of the main channel wetted area during field survey that is pocket water

	Pool	Proportion of the main channel wetted area during field survey that is pools
	Riffle	Proportion of the main channel wetted area during field survey that is riffles
	Run/Glide	Proportion of the main channel wetted area during field survey that is run or glide
Side Channel	Cascade	Proportion of the side channel wetted area during field survey that is cascade
	Other	Proportion of the side channel wetted area during field survey that is not in one of the other categories; mostly waterfalls and shallow backwater areas
	Pocket Water	Proportion of the side channel wetted area during field survey that is pocket water
	Pool	Proportion of the side channel wetted area during field survey that is pools
	Riffle	Proportion of the side channel wetted area during field survey that is riffles
	Run/Glide	Proportion of the side channel wetted area during field survey that is run or glide
Pool attributes (B14)		
	number of pools	Number of pools normalized to field-measured channel length
	pools/mi	Average spacing between pools normalized to wetted width of the channel
	average pool area (ft^2)	Average surface area of pools
	average pool residual depth (ft)	Average residual depth. Residual depth is calculated as maximum pool depth-pool tailout depth.
	number of pools with >1m residual depth	Total number of pools in reach with maximum depth greater than 1 m.
	Proportion pools high quality	Proportion of pools with >25% cover or that are >1 m deep
	Proportion pools fair or high quality	Proportion of high quality pools (above) plus proportion of pools with 10-25% cover that are <1m deep.
Substrate attributes (B15)		
Dominant substrate	Bedrock	Proportion of the wetted channel area with dominant bedrock bed material
	Boulder	Proportion of the wetted channel area with dominant boulder sized bed material (Wentworth 1922 definitions of size classes)
	Cobble	Proportion of the wetted channel area with dominant cobble sized bed material (Wentworth 1922 definitions of size classes)
	Gravel	Proportion of the wetted channel area with dominant gravel sized bed material (Wentworth 1922 definitions of size classes)
	Sand	Proportion of the wetted channel area with dominant sand sized bed material (Wentworth 1922 definitions of size classes)
	Silt/Clay	Proportion of the wetted channel area with dominant silt or smaller bed material (Wentworth 1922 definitions of size classes)
	Organic	Proportion of the wetted channel area with dominant organic bed material
	spawning area (ft^2)	Total area (ft^2) of 10-square foot or greater patches of bed composed of gravel between 6-64 mm uninterrupted by cobbles.

Large wood summary attributes (B16)		
Large wood is defined as pieces >25' long and 12" diameter or with rootwad >3' diameter. Brush wood is defined as pieces < 25' long with diameter >4". These attributes are for the total number of pieces not in jams present in either the main channel or a side channel counted in the reach.		
Including jams	Pieces >35 ft/mi	Number of pieces of wood >35 ft long, including wood in jams
	Pieces > 25 ft/mi	Number of pieces of wood >25 ft long, including wood in jams
Individual pieces	Pieces >35 ft/mi	Number of individual pieces of wood (not in jams) > 35 ft long
	Pieces > 25 ft/mi	Number of individual pieces of wood (not in jams) > 25 ft long
	log weir count	Number of log weirs
Bank conditions attributes (B 17)		
	Sum of length hardened (ft)	Total length of bank in reach armored by riprap, concrete bridge abutments, and/or log crib walls
	Sum of length natural, active (ft)	Total length of bank in reach where field indications show active migration
	Sum of length natural, part stabilized (ft)	Total length of bank in reach where field indications show active migration has slowed
	% armored	Length of bank armored normalized to the length of channel edge (defined as 2x the flow path length)
	% unstable	Length of bank with active + partially stable instability normalized to the length of channel edge (defined as 2x the flow path length)
	% riparian area connected to stream	% of area in the union of the floodprone area and a 100 foot buffer around the bankfull channel with no road or other structure blocking channel migration and/or wood recruitment
Log jam summary attributes (B18)		
	log jam count	Total number of log jams in subreach.
	log jams/mi	Number of jams divided by channel length.
	Average log jam volume (ft^3)	Average volume of all log jams in reach.
	Standard deviation of log jam volume (ft^3)	Standard deviation of volume of all log jams in reach.
	Large wood >25 ft in log jams	Total number of large wood pieces > 25 ft long in log jams
	Large wood >35 ft in log jams	Total number of large wood pieces > 35 ft long in log jams
	Brush wood in log jams	Total number of brush wood pieces in log jams

Table B3. Geomorphic and basic descriptive attributes by reach

Reach	Geomorphic and basic descriptive attributes												
	basin area (mi^2)	field measured main channel length (ft)	field measured side channel length (ft)	field measured total low flow area (ft^2)	field measured side channel low flow area (ft^2)	Rosgen channel type	Slope (LiDAR derived, ft/ft)	braid index	entrenchment ratio	width / depth ratio	sinuosity	average field measured slope	average field measured percent canopy cover
S1	143	2,326	558	108,403	3,698	C3	0.013	0.51	2.24	28	1.14	0.013	2
S2	142	10,829	45	512,460	1,575	A2	0.030	0.01	1.29	11	1.05	0.022	40
S3	130	10,722	0	470,815	0	C3	0.012	0.11	2.30	21	1.15	0.015	27
S4	**—Mill Pond**												
S5	124	3,653	335	233,411	9,425	C3-C4	0.005	0.42	5.35	31	1.25	0.005	9
S6	122	2,211	332	89,803	3,432	B3c	0.008	0.17	1.92	20	1.10	0.008	20
S7	70	3,436	770	120,356	6,909	C3	0.015	0.44	2.98	21	1.06	0.009	23
S8	68	5,000	0	174,576	0	B3c-B2c	0.015	0.06	1.71	13	1.08	0.011	45
S9	67	2,128	919	99,348	24,663	C4	0.017	0.24	3.24	24	1.13	0.013	17
S10	67	1,919	0	65,721	0	B3c	0.013	0.00	1.49	15	1.01	0.004	38
S11	67	11,405	1,861	428,089	20,541	C3	0.015	0.25	3.40	19	1.13	0.013	39
S12	49	5,923	1,656	200,943	16,610	C3-C2	0.016	0.17	3.27	17	1.08	0.021	37
S13	46	4,910	295	163,211	1,297	C3-C2	0.017	0.12	2.26	15	1.05	0.018	44
S14	44	4,655	55	145,290	1,100	C3-C2	0.015	0.04	2.53	13	1.11	0.013	54
S15	37	3,593	57	107,859	276	C3	0.012	0.30	4.01	19	1.05	0.009	55
S16	35	8,243	3,618	292,832	59,301	C3	0.015	0.41	3.12	21	1.28	0.012	41
S17	22	12,821	534	299,056	2,431	B2a	0.048	0.10	1.75	13	1.03	0.050	71
S18	18	6,872	1,726	167,717	19,939	B3-B2	0.028	0.23	2.00	18	1.05	0.023	58
S19	15	2,839	1,972	63,341	12,829	DA3c	0.02	0.93	4.11	31	1.10	0.015	51
P1	10	1,342	539	20,262	4,728	C3b	0.04	0.42	2.93	15	1.09	0.045	94
GY1	6.4	1,293	20	16,758	100	B3b	0.06	0.02	2.95	15	1.04	0.033	95
D1	10	3,350	659	47,719	3,130	C3b	0.03	0.39	3.08	30	1.13	0.026	64
L1	4.3	1,306	199	17,782	1,923	B3b	0.06	0.35	2.23	18	1.06	0.059	49
C1	1	771	110	6,289	1,135	B4	0.024	0.14	2.00	2	NA	0.081	100
GY2	6	1,323	45	19,019	540	B4a	0.061	0.03	3.10	6	NA	0.047	92
H1	2	1,317	678	21,990	12,645	D6a	0.030	0.51	15.09	4	NA	0.028	66
J1	3	1,395	40	9,498	80	B2a+	0.099	0.03	2.89	3	NA	0.083	92
K1	2	1,309	0	12,419	0	A3+	0.091	0.00	1.32	3	NA	0.090	85
M1	2	638	35	5,614	105	B2a+	0.137	0.05	1.67	4	NA	0.123	96
NFS1	10	2,631	80	43,100	1,760	B2a+	0.112	0.03	1.97	8	NA	0.073	80
O1	52	2,624	171	99,729	4,808	C3	0.010	0.07	2.92	8	NA	0.007	22
R1	2	1,350	0	8,329	0	B2a+	0.134	0.00	2.11	2	NA	0.115	98
SH1	4	1,966	2,304	49,161	18,706	D4a	0.06	1.17	13.90	9	NA	0.075	67
ST1	5	1,325	0	14,528	0	E3a	0.05	0.00	2.57	6	NA	0.057	89
T1	1.1	612	228	4,794	1,191	C4a+	0.10	0.37	4.20	1	NA	0.202	96
W1	1	775	0	7,821	0	A4a+	0.11	0.00	1.30	1	NA	0.139	100

Table B4. Habitat unit attributes by reach

Reach	Habitat unit attributes (proportion of low flow wetted area)											
	Main Channel						Side Channel					
	Other (mostly Cascade)	Pocket Water	Pool	Riffle	Run/Glide	pool / riffle ratio	Other (mostly Cascade)	Pocket Water	Pool	Riffle	Run/Glide	pool / riffle ratio
S1	0.03	0.00	0.15	0.77	0.05	0.20	0.00	0.00	0.01	0.02	0.00	0.59
S2	0.23	0.08	0.25	0.41	0.04	0.60	0.00	0.00	0.00	0.00	0.00	100.00
S3	0.20	0.00	0.12	0.61	0.07	0.19	0.00	0.00	0.00	0.00	0.00	100.00
S4	**—Mill Pond**											
S5	0.00	0.00	0.59	0.29	0.12	2.03	0.00	0.00	0.01	0.03	0.00	0.50
S6	0.00	0.00	0.09	0.54	0.37	0.16	0.00	0.00	0.01	0.02	0.01	0.62
S7	0.02	0.00	0.13	0.72	0.13	0.18	0.00	0.00	0.00	0.02	0.04	0.00
S8	0.00	0.00	0.10	0.70	0.19	0.15	0.00	0.00	0.00	0.00	0.00	100.00
S9	0.00	0.00	0.10	0.69	0.21	0.15	0.00	0.00	0.31	0.02	0.00	16.00
S10	0.00	0.00	0.06	0.70	0.24	0.09	0.00	0.00	0.00	0.00	0.00	100.00
S11	0.00	0.00	0.11	0.67	0.22	0.16	0.00	0.00	0.02	0.02	0.01	1.25
S12	0.01	0.05	0.20	0.53	0.20	0.38	0.00	0.00	0.05	0.02	0.03	2.90
S13	0.01	0.07	0.07	0.53	0.33	0.12	0.00	0.00	0.00	0.00	0.00	5.13
S14	0.00	0.10	0.15	0.38	0.36	0.40	0.00	0.00	0.00	0.01	0.00	0.00
S15	0.00	0.00	0.17	0.56	0.27	0.31	0.00	0.00	0.00	0.00	0.00	100.00
S16	0.00	0.09	0.29	0.45	0.17	0.64	0.00	0.00	0.16	0.04	0.05	4.04
S17	0.05	0.62	0.23	0.05	0.05	4.28	0.00	0.00	0.00	0.00	0.00	0.99
S18	0.01	0.36	0.20	0.28	0.15	0.70	0.00	0.00	0.10	0.02	0.01	4.23
S19	0.00	0.00	0.33	0.53	0.14	0.63	0.00	0.00	0.10	0.08	0.07	1.20
P1	0.07	0.02	0.37	0.47	0.07	0.79	0.01	0.04	0.18	0.06	0.02	3.01
GY1	0.02	0.55	0.23	0.17	0.03	1.38	0.00	0.00	0.00	0.01	0.00	0.00
D1	0.00	0.11	0.30	0.48	0.11	0.63	0.00	0.01	0.04	0.02	0.01	1.95
L1	0.03	0.57	0.34	0.06	0.00	6.01	0.00	0.08	0.04	0.00	0.00	100.00
C1	0.14	0.12	0.34	0.37	0.02	0.92	0.00	0.00	0.97	0.03	0.00	31.43
GY2	0.30	0.24	0.34	0.12	0.00	2.87	0.00	1.00	0.00	0.00	0.00	NA
H1	0.01	0.20	0.41	0.31	0.07	1.31	0.00	0.00	0.88	0.03	0.08	31.03
J1	0.06	0.63	0.09	0.21	0.00	0.44	0.00	1.00	0.00	0.00	0.00	NA
K1	0.12	0.56	0.18	0.15	0.00	1.21	NA	NA	NA	NA	NA	NA
M1	0.10	0.72	0.14	0.03	0.01	4.52	0.00	0.00	0.00	1.00	0.00	0.00
NFS1	0.17	0.41	0.17	0.20	0.05	0.88	0.00	1.00	0.00	0.00	0.00	NA
O1	0.00	0.00	0.35	0.39	0.26	0.91	0.00	0.00	0.65	0.02	0.33	30.70
R1	0.21	0.57	0.08	0.14	0.00	0.56	NA	NA	NA	NA	NA	NA
SH1	0.05	0.34	0.36	0.17	0.08	2.09	0.02	0.17	0.43	0.28	0.10	1.52
ST1	0.27	0.24	0.27	0.22	0.00	1.27	NA	NA	NA	NA	NA	NA
T1	0.17	0.53	0.01	0.19	0.09	0.04	0.02	0.73	0.00	0.25	0.00	0.00
W1	0.25	0.07	0.38	0.30	0.00	1.25	NA	NA	NA	NA	NA	NA

Table B5. Pool attributes by reach

Reach	Pool attributes										
	pools/mi	wetted widths / pool	dominant pool forming feature	subdominant pool forming feature	total number of pools >1m deep	average pool area (ft^2)	standard deviation of pool area (ft^2)	average pool residual depth (ft)	standard deviation of pool residual depth (ft)	average pool percent cover	standard deviation of pool percent cover
S1	8	5.7	wood	none	3	1942	2312	1.42	1.85	5.7	13.7
S2	14	3.1	bedrock	boulder	60	1717	1720	3.04	1.37	0.9	4.0
S3	3	14.4	bedrock	boulder	12	3291	2074	2.71	2.38	1.1	3.6
S4	**—Mill Pond**										
S5	7	5.0	free form	wood	8	11229	22191	2.87	1.04	5.9	15.1
S6	4	14.1	wood	none	1	2170	1995	2.31	1.30	0.4	1.4
S7	5	13.0	wood	none	3	1842	1197	1.79	0.57	1.8	6.8
S8	6	10.2	bedrock	wood	8	1289	1025	2.19	1.02	2.1	9.0
S9	15	3.8	wood	free form	4	1921	5370	1.49	0.79	6.2	14.2
S10	3	18.7	bedrock	none	2	1331	1172	2.50	1.42	0.3	1.3
S11	9	6.4	wood	boulder	13	1031	945	1.84	0.95	5.4	12.4
S12	16	4.1	wood	boulder	1	996	949	1.56	0.50	8.2	17.9
S13	5	12.4	wood	boulder	1	929	688	1.63	0.71	2.9	9.2
S14	6	10.7	wood	boulder	5	1569	968	1.74	1.12	1.5	7.6
S15	8	8.6	wood	none	4	1342	1536	1.90	1.10	4.7	10.4
S16	23	3.1	wood	free form	14	1107	785	1.83	0.82	5.7	9.0
S17	17	5.1	boulder	wood	5	641	351	1.63	0.56	3.1	6.3
S18	17	5.7	wood	boulder	3	781	957	1.45	0.57	6.6	14.6
S19	32	3.5	wood	none	0	475	434	1.27	0.46	7.9	16.2
P1	50	3.5	wood	none	0	262	219	1.24	0.37	7.7	11.9
GY1	31	5.0	wood	boulder	0	193	88	1.29	0.42	6.3	8.8
D1	30	5.0	wood	boulder	0	303	222	1.29	0.42	9.7	17.8
L1	40	4.1	boulder	wood	0	228	216	1.33	0.44	5.6	9.6
C1	75	8.6	Wood	Free Form	0	261	290	0.96	0.37	11.4	5.5
GY2	92	4.0	Wood	Boulder	1	274	190	1.41	0.47	15.0	11.5
H1	60	5.3	Beaver	Free Form	0	1000	1930	1.11	0.70	37.0	26.1
J1	38	20.5	Boulder	Wood	0	89	24	1.08	0.39	11.0	9.1
K1	61	9.2	Boulder	Other	0	147	116	1.03	0.35	16.3	11.9
M1	74	8.1	Wood	NA	0	88	24	1.27	0.32	23.1	11.1
NFS1	48	6.7	Wood	Bedrock	2	298	379	1.71	0.84	16.9	12.9
O1	26	5.3	Wood	NA	4	2812	2574	3.59	4.39	15.0	15.5
R1	43	19.9	Wood	Boulder	0	61	26	0.79	0.29	15.5	10.8
SH1	207	1.0	Wood	Boulder	0	245	191	1.28	0.42	30.3	20.9
ST1	88	5.5	Wood	Boulder	0	181	85	1.14	0.29	24.5	19.3
T1	9	78.1	Wood	NA	0	25	NA	0.60	NA	30.0	NA
W1	61	8.5	Wood	NA	0	326	302	1.46	0.58	10.6	8.8

Table B6a. Substrate attributes by reach

Reach	Substrate Attributes										
	Wolman Pebble Count Data			spawning	dominant substrate (proportion of low flow wetted area)						
	Average D_{10} (mm)	Average D_{50} (mm)	Average D_{90} (mm)	field measured area (ft^2)	Bedrock	Boulder	Cobble	Gravel	Organic	Sand	Silt/Clay
S1	25	96	178	2305	0.00	0.00	0.85	0.12	0.00	0.01	0.02
S2	37	119	258	1406	0.21	0.69	0.09	0.01	0.00	0.01	0.00
S3	23	106	181	690	0.31	0.13	0.57	0.00	0.00	0.00	0.00
S4	**—Mill Pond**										
S5	26	66	123	13100	0.00	0.00	0.26	0.74	0.00	0.01	0.00
S6	14	91	187	1549	0.00	0.00	0.79	0.19	0.00	0.01	0.00
S7	16	61	154	790	0.00	0.14	0.77	0.09	0.00	0.00	0.00
S8	27	98	194	819	0.14	0.18	0.63	0.05	0.00	0.00	0.00
S9				1475	0.01	0.35	0.36	0.05	0.00	0.00	0.23
S10	11	85	209	466	0.03	0.18	0.75	0.04	0.00	0.00	0.00
S11	28	102	215	9621	0.00	0.12	0.58	0.28	0.00	0.01	0.00
S12	30	142	298	2001	0.00	0.22	0.59	0.14	0.00	0.02	0.03
S13				248	0.00	0.44	0.55	0.00	0.00	0.00	0.00
S14	22	68	161	1390	0.01	0.26	0.67	0.05	0.00	0.01	0.00
S15	16	73	155	2240	0.00	0.00	0.88	0.12	0.00	0.00	0.00
S16	19	73	162	22860	0.00	0.07	0.71	0.18	0.00	0.04	0.00
S17	33	120	317	6705	0.00	0.64	0.35	0.00	0.00	0.00	0.00
S18	23	108	220	10885	0.00	0.29	0.59	0.07	0.00	0.03	0.02
S19	16	69	169	4035	0.00	0.00	0.86	0.07	0.02	0.03	0.02
P1	19	74	163	2210	0.00	0.10	0.60	0.23	0.01	0.00	0.06
GY1	18	98	224	570	0.00	0.17	0.72	0.10	0.00	0.00	0.00
D1	24	71	153	2785	0.00	0.08	0.75	0.15	0.00	0.01	0.00
L1	24	77	164	653	0.05	0.29	0.59	0.04	0.01	0.01	0.00
C1	NA	NA	NA	1580	0.00	0.00	0.24	0.42	0.32	0.02	0.00
GY2	5	54	164	655	0.00	0.61	0.32	0.06	0.01	0.00	0.00
H1	7	27	71	1195	0.00	0.00	0.01	0.25	0.39	0.13	0.22
J1	18	63	215	175	0.01	0.36	0.32	0.31	0.00	0.01	0.00
K1	10	57	171	810	0.00	0.07	0.80	0.13	0.00	0.00	0.00
M1	20	99	239	295	0.00	0.69	0.22	0.07	0.02	0.00	0.00
NFS1	23	103	239	1967	0.07	0.39	0.15	0.34	0.00	0.04	0.02
O1	19	85	203	14010	0.00	0.04	0.60	0.33	0.02	0.00	0.00
R1	10	45	128	780	0.00	0.11	0.82	0.06	0.01	0.00	0.00
SH1	24	83	232	4502	0.01	0.07	0.36	0.52	0.02	0.03	0.00
ST1	9	40	133	665	0.00	0.09	0.70	0.21	0.00	0.00	0.00
T1	9	41	94	350	0.00	0.03	0.12	0.43	0.12	0.30	0.00
W1	9	20	42	2910	0.02	0.07	0.35	0.56	0.00	0.00	0.00

Table B6b. Substrate attributes by reach (continued)

Reach	Substrate Attributes continued										
	subdominant substrate (proportion of low flow wetted area)							embeddedness of spawning gravel (proportion in class			
	Bedrock	Boulder	Cobble	Gravel	Organic	Sand	Silt/Clay	< 25 %	25-50 %	50-75 %	>75%
S1	0.00	0.64	0.12	0.25	0.00	0.00	0.00	0.87	0.01	0.12	0.00
S2	0.20	0.27	0.51	0.02	0.00	0.00	0.00	0.89	0.00	0.11	0.00
S3	0.06	0.60	0.14	0.20	0.00	0.00	0.00	1.00	0.00	0.00	0.00
S4	**—Mill Pond**										
S5	0.00	0.05	0.20	0.26	0.00	0.41	0.08	0.18	0.63	0.12	0.08
S6	0.00	0.20	0.14	0.65	0.00	0.01	0.00	0.71	0.00	0.28	0.02
S7	0.02	0.43	0.35	0.11	0.00	0.07	0.01	0.67	0.00	0.24	0.09
S8	0.00	0.32	0.28	0.32	0.00	0.01	0.06	0.58	0.04	0.37	0.01
S9	0.00	0.04	0.39	0.28	0.00	0.30	0.00	0.80	0.00	0.17	0.04
S10	0.02	0.33	0.24	0.41	0.00	0.00	0.00	0.54	0.00	0.46	0.00
S11	0.01	0.22	0.37	0.39	0.00	0.01	0.00	0.85	0.04	0.08	0.03
S12	0.00	0.50	0.35	0.09	0.01	0.04	0.00	0.58	0.05	0.37	0.00
S13	0.00	0.54	0.45	0.01	0.00	0.00	0.00	0.51	0.00	0.34	0.15
S14	0.01	0.26	0.28	0.38	0.00	0.06	0.00	0.09	0.30	0.48	0.13
S15	0.00	0.16	0.10	0.73	0.00	0.01	0.00	0.17	0.05	0.36	0.42
S16	0.00	0.05	0.18	0.65	0.00	0.09	0.02	0.69	0.04	0.20	0.07
S17	0.00	0.32	0.60	0.08	0.00	0.00	0.00	0.99	0.00	0.01	0.00
S18	0.00	0.40	0.32	0.23	0.02	0.03	0.00	0.92	0.00	0.04	0.04
S19	0.01	0.27	0.07	0.60	0.01	0.01	0.02	0.96	0.00	0.04	0.00
P1	0.00	0.07	0.18	0.58	0.06	0.10	0.00	0.93	0.00	0.07	0.00
GY1	0.00	0.53	0.10	0.36	0.00	0.01	0.00	1.00	0.00	0.00	0.00
D1	0.02	0.25	0.11	0.53	0.01	0.08	0.00	0.95	0.00	0.04	0.01
L1	0.02	0.52	0.16	0.19	0.04	0.07	0.00	0.79	0.00	0.21	0.00
C1	0.00	0.00	0.00	0.53	0.13	0.02	0.32	0.99	0.00	0.00	0.00
GY2	0.00	0.10	0.37	0.52	0.01	0.00	0.00	0.95	0.05	0.00	0.00
H1	0.00	0.00	0.12	0.11	0.24	0.12	0.40	0.57	0.38	0.05	0.00
J1	0.01	0.15	0.50	0.34	0.00	0.00	0.00	1.00	0.00	0.00	0.00
K1	0.00	0.14	0.16	0.69	0.00	0.00	0.00	1.00	0.00	0.00	0.00
M1	0.00	0.07	0.51	0.40	0.02	0.00	0.00	1.00	0.00	0.00	0.00
NFS1	0.01	0.31	0.52	0.06	0.02	0.08	0.00	0.35	0.51	0.12	0.00
O1	0.02	0.00	0.35	0.57	0.00	0.04	0.02	1.00	0.00	0.00	0.00
R1	0.01	0.05	0.18	0.75	0.01	0.00	0.00	0.90	0.00	0.00	0.00
SH1	0.01	0.10	0.31	0.32	0.07	0.19	0.00	0.33	0.55	0.11	0.01
ST1	0.00	0.28	0.29	0.43	0.00	0.00	0.00	0.94	0.00	0.06	0.00
T1	0.00	0.00	0.14	0.42	0.06	0.38	0.00	0.43	0.51	0.06	0.00
W1	0.02	0.01	0.18	0.59	0.13	0.07	0.00	0.97	0.03	0.00	0.00

Table B7. Large wood summary attributes by reach

Reach	Large wood summary attributes						
	Total large wood in jams and individu			Total individual wood pieces (not in jams)			
	(WRIA 62 definition)	Scaled to Bankfull width (>35', or if bf channel <25' > 25')	(field protocol definition)	Main channel brush wood count	Side channel brush wood count	Main channel individual large wood count	Side channel individual large wood count
S1	5	5	82	99	32	3	26
S2	13	13	47	487	0	0	78
S3	20	20	74	354	0	0	99
S4	**—Mill Pond**						
S5	78	78	189	409	10	3	55
S6	38	38	93	175	0	0	33
S7	28	28	78	145	14	3	36
S8	61	61	140	113	0	7	69
S9	55	55	186	37	30	8	40
S10	603	603	36	59	0	0	13
S11	105	105	245	579	57	10	192
S12	42	42	362	503	201	8	77
S13	23	23	141	262	32	3	80
S14	42	42	71	225	22	2	39
S15	298	298	187	218	47	12	67
S16	57	57	301	592	358	23	121
S17	34	118	118	549	25	7	180
S18	35	186	186	454	215	24	161
S19	67	205	205	213	231	21	72
P1	79	299	299	181	65	1	30
GY1	98	167	167	141	3	0	23
D1	27	189	189	258	112	11	68
L1	12	194	194	102	55	5	26
C1	41	55	55	54	7	5	0
GY2	48	116	116	47	3	9	1
H1	4	24	24	53	18	2	0
J1	8	8	8	104	0	7	0
K1	52	52	52	135	0	20	0
M1	141	314	314	67	2	13	0
NFS1	289	343	343	237	5	22	2
O1	38	38	72	66	4	24	0
R1	55	55	55	59	0	20	0
SH1	462	556	556	194	56	20	16
ST1	60	88	88	78	0	10	0
T1	43	43	43	25	5	8	1
W1	27	27	27	43	0	8	0

Table B8a. Large wood detailed attributes by reach

Reach	Detailed individual piece attributes											
	Wetted			With rootwad			Sum of 25-35 ft, 12-24"			Sum of 25-35 ft, >24"		
	Total	Main Channel	Side Channel	Total	Main Channel	Side Channel	Total	Main Channel	Side Channel	Total	Main Channel	Side Channel
S1	9	8	1	4	4	0	10	8	2	1	1	0
S2	22	22		6	6		35	35		0	0	
S3	40	40		10	10		28	28		5	5	
S4	**—Mill Pond**											
S5	19	17	2	4	3	1	16	16	0	0	0	0
S6	13	13		1	1		8	8		0	0	
S7	12	11	1	9	9	0	4	2	2	0	0	0
S8	28	28	0	3	1	2	16	13	3	0	0	0
S9	18	10	8	4	3	1	7	5	2	2	2	0
S10	5	5		1	1		4	4		0	0	
S11	64	59	5	23	22	1	41	37	4	2	1	1
S12	22	20	2	4	4	0	43	36	7	2	2	0
S13	23	23	0	2	2	0	38	35	3	2	2	0
S14	14	14	0	1	1	0	13	12	1	0	0	0
S15	23	21	2	3	2	1	14	8	6	2	2	0
S16	42	30	12	13	8	5	26	23	3	1	1	0
S17	44	43	1	31	30	1	45	43	2	6	5	1
S18	56	37	19	13	7	6	45	31	14	7	7	0
S19	28	13	15	4	4	0	19	7	12	4	1	3
P1	12	11	1	3	3	0	7	6	1	1	1	0
GY1	8	8		1	1		7	7		0	0	
D1	26	20	6	9	6	3	22	17	5	0	0	0
L1	8	6	2	1	1	0	14	10	4	0	0	0
C1	7	6	1	2	1	1	3	3	0	1	1	0
GY2	6	6	0	4	4	0	5	5	0	0	0	0
H1	3	3	0	1	1	0	1	1	0	0	0	0
J1	4	4	0	2	2	0	5	5	0	0	0	0
K1	11	11	0	7	7	0	10	10	0	1	1	0
M1	5	5	0	2	2	0	8	8	0	2	2	0
NFS1	18	17	1	6	6	0	18	17	1	0	0	0
O1	30	29	1	16	15	1	13	13	0	1	1	0
R1	13	13	0	2	2	0	6	6	0	0	0	0
SH1	36	22	14	17	12	5	16	8	8	3	3	0
ST1	9	9	0	3	3	0	5	5	0	0	0	0
T1	9	9	0	2	2	0	4	4	0	0	0	0
W1	21	21	0	5	5	0	5	5	0	0	0	0

Table B8b. Large wood detailed attributes by reach (continued)

Reach	Detailed individual piece attributes continued						Forest Service Weirs	
	Sum of >35 ft, 12-24"			Sum of >35 ft, >24"				
	Total	Main Channel	Side Channel	Total	Main Channel	Side Channel	Sum of functioning FS Weir	Sum of non-functioning FS weir
S1	2	1	1	0	0	0	0	0
S2	13	13		2	2		0	0
S3	14	14		2	2		0	0
S4	—Mill Pond							
S5	14	12	2	2	2	0	0	0
S6	11	11		0	0		0	0
S7	8	7	1	1	1	0	1	1
S8	20	18	2	2	2	0	0	0
S9	9	4	5	0	0	0	0	0
S10	3	3		0	0		0	0
S11	30	27	3	4	3	1	20	8
S12	5	4	1	0	0	0	1	0
S13	13	13	0	2	2	0	0	0
S14	9	8	1	2	2	0	0	0
S15	22	19	3	3	1	2	0	0
S16	32	22	10	7	2	5	0	0
S17	47	44	3	7	7	0	0	0
S18	33	30	3	4	3	1	3	0
S19	11	7	4	3	1	2	2	1
P1	7	7	0	0	0	0	0	0
GY1	5	5		1	1		1	0
D1	9	7	2	2	1	1	0	0
L1	1	1	0	2	1	1	0	0
C1	0	0	0	1	1	0	0	0
GY2	4	3	1	1	1	0	0	0
H1	0	0	0	1	1	0	0	0
J1	2	2	0	0	0	0	0	0
K1	5	5	0	4	4	0	0	0
M1	2	2	0	1	1	0	0	0
NFS1	4	4	0	2	1	1	0	0
O1	10	10	0	0	0	0	0	0
R1	12	12	0	2	2	0	0	0
SH1	7	4	3	10	5	5	0	0
ST1	3	3	0	2	2	0	0	0
T1	1	1	0	4	3	1	0	0
W1	3	3	0	0	0	0	12	0

Table B9. Bank condition attributes by reach

Reach	Bank Condition				
	length of bank armored	length of bank with active instability	length of bank with partially stabalized instability	proportion armored	proportion unstable
S1	698	588	0	0.15	0.13
S2	180	40	270	0.01	0.00
S3	375	252	0	0.02	0.01
S4	**—Mill Pond**				
S5		765	0	0.00	0.10
S6	50	195	0	0.01	0.04
S7	110	590	180	0.02	0.09
S8	424	150	175	0.04	0.02
S9	200	153	205	0.05	0.04
S10	380	0	40	0.10	0.00
S11	588	921	535	0.03	0.04
S12	75	385	95	0.01	0.03
S13	280	230	185	0.03	0.02
S14	635	0	0	0.07	0.00
S15		105	90	0.00	0.01
S16	120	410	435	0.01	0.02
S17	530	122	0	0.02	0.00
S18	111	147	0	0.01	0.01
S19	70	0	0	0.01	0.00
P1	105	26	0	0.04	0.01
GY1	0	0	0	0.00	0.00
D1	0	0	0	0.00	0.00
L1	0	0	0	0.00	0.00
C1	0	25	0	0.00	0.02
GY2	0	0	0	0.00	0.00
H1	0	30	0	0.00	0.01
J1	0	0	0	0.00	0.00
K1	0	51	0	0.00	0.02
M1	0	0	0	0.00	0.00
NFS1	0	0	0	0.00	0.00
O1	0	0	0	0.00	0.00
R1	0	0	0	0.00	0.00
SH1	0	120	0	0.00	0.03
ST1	0	50	0	0.00	0.02
T1	0	0	0	0.00	0.00
W1	0	0	0	0.00	0.00

Table B10. Log jam summary attributes by reach

Reach	Log jam attributes							
	Summary attributes							
	number jams (count)	number jams / mi	Average log jam volume (ft^3)	Standard deviation of log jam volume (ft^3)	Average number of log jam wood pieces (all classes)	Standard deviation of number of log jam wood pieces	sum of large wood (WRIA 62 def) pieces in log jams	proportion of large wood (WRIA 62 def) in log jams
S1	4	9	1415	690	28	18	7	0.21
S2	8	4	4113	1962	37	17	19	0.20
S3	12	6	2897	5291	28	24	52	0.34
S4	**—Mill Pond**							
S5	6	9	9767	19801	33	28	73	0.57
S6	1	2	1250	0	18	0	6	0.15
S7	3	5	3393	4286	15	8	12	0.25
S8	2	2	32200	44972	102	136	57	0.45
S9	5	12	6158	10585	31	37	27	0.40
S10	0	0	NA	NA	NA	NA	NA	0.00
S11	39	18	6074	12403	26	35	328	0.63
S12	28	25	2666	4489	35	52	321	0.81
S13	11	12	2023	2222	15	13	48	0.38
S14	4	5	2450	3073	19	17	22	0.36
S15	11	16	11588	15640	34	23	48	0.42
S16	38	24	4389	4940	30	15	326	0.73
S17	19	8	4586	8520	29	29	100	0.36
S18	18	14	4486	5148	28	23	57	0.26
S19	9	17	1218	599	16	8	17	0.19
P1	12	47	754	373	17	9	45	0.60
GY1	4	16	1438	774	23	9	18	0.44
D1	20	32	1006	919	18	9	41	0.38
L1	6	24	1017	528	23	8	17	0.40
C1	1	7	3000.00	NA	15.00	NA	5.00	0.12
GY2	8	32	390	241	18	11	7	0.15
H1	1	4	1050	NA	31	NA	0	0.00
J1	0	0	NA	NA	NA	NA	NA	NA
K1	2	8	875	177	10	0	4	0.08
M1	7	58	1179	515	12	6	14	0.10
NFS1	23	46	3087	1736	20	8	138	0.48
O1	13	26	728	793	18	10	9	0.24
R1	0	0	NA	NA	NA	NA	NA	NA
SH1	36	97	2150	2663	14	6	155	0.34
ST1	7	28	368	94	13	5	10	0.17
T1	0	0	NA	NA	NA	NA	NA	NA
W1	1	7	600	NA	4	NA	1	0.04

Table B11. Log jam key piece attributes by reach

Reach	Log jam attributes continued						
	Key piece attributes (proportion of key pieces in class)						
	25-35ft	3-25ft	>36in	12-24in	24-36in	4-12in	with rootwad
S1	0.56	0.44	0.00	1.00	0.00	0.00	0.89
S2	0.31	0.23	0.00	0.85	0.15	0.00	0.38
S3	0.29	0.14	0.10	0.62	0.29	0.00	0.67
S4	**—Mill Pond**						
S5	0.09	0.00	0.18	0.27	0.36	0.18	0.45
S6	0.00	0.00	0.00	0.00	1.00	0.00	1.00
S7	0.33	0.00	0.00	0.22	0.78	0.00	0.44
S8	0.40	0.00	0.00	0.80	0.20	0.00	1.00
S9	0.00	0.36	0.00	0.73	0.27	0.00	1.00
S10	NA	NA	NA	NA	NA	NA	NA
S11	0.09	0.05	0.05	0.48	0.45	0.02	0.75
S12	0.21	0.05	0.16	0.55	0.21	0.08	0.74
S13	0.31	0.00	0.13	0.44	0.31	0.13	0.63
S14	0.00	0.00	0.00	0.57	0.29	0.14	0.57
S15	0.31	0.12	0.04	0.62	0.31	0.04	0.77
S16	0.07	0.07	0.14	0.21	0.63	0.02	0.86
S17	0.40	0.10	0.03	0.73	0.20	0.03	0.53
S18	0.31	0.11	0.09	0.71	0.17	0.03	0.69
S19	0.00	0.00	0.00	0.62	0.38	0.00	1.00
P1	0.29	0.07	0.00	0.86	0.00	0.14	0.57
GY1	0.00	0.00	0.20	0.60	0.20	0.00	0.60
D1	0.13	0.07	0.03	0.67	0.30	0.00	0.67
L1	0.30	0.40	0.10	0.40	0.50	0.00	0.50
C1	1.00	0.00	0.00	1.00	0.00	0.00	0.00
GY2	0.40	0.60	0.07	0.73	0.20	0.00	0.33
H1	1.00	0.00	0.00	0.50	0.50	0.00	0.00
J1	NA	NA	NA	NA	NA	NA	NA
K1	0.67	0.33	0.00	0.33	0.33	0.33	1.00
M1	1.00	0.00	0.00	1.00	0.00	0.00	0.11
NFS1	1.00	0.00	0.00	0.68	0.32	0.00	0.79
O1	0.40	0.60	0.04	0.40	0.40	0.16	0.44
R1	NA	NA	NA	NA	NA	NA	NA
SH1	1.00	0.00	0.07	0.42	0.51	0.00	0.51
ST1	0.40	0.60	0.00	0.80	0.20	0.00	0.40
T1	NA	NA	NA	NA	NA	NA	NA
W1	0.00	1.00	0.00	1.00	0.00	0.00	1.00

Table B12a. Geomorphic and basic descriptive attributes by subreach

Subreach	Geomorphic and basic descriptive attributes								
	river station at upstream boundary (miles)	cumulative drainage area (mi^2)	field measured main channel length (ft)	field measured side channel length (ft)	field measured main channel low flow area (ft)	field measured side channel low flow area (ft)	Rosgen channel type	slope (LiDAR derived)	braid index
S1-1	0.18	142.6	757	0	21,007	0	B3c	0.012	0.38
S1-2	0.33	142.6	1,099	150	46,541	750	C3	0.008	0.34
S1-3	0.49	142.6	46	408	7,357	2,948	D3	0.015	1.30
S1-4	0.64	142.6	424	0	29,800	0	B3c	0.017	0.00
S2-1	0.73	142.4	483	0	17,823	0	F2b	0.027	0.00
S2-2	0.93	142.4	1,383	0	65,989	0	F2b	0.062	0.13
S2-3	1.13	142.3	1,217	0	38,890	0	A1	0.068	0.00
S2-4	1.26	142.1	531	0	20,201	0	F3	0.019	0.00
S2-5	1.49	141.9	1,289	0	70,686	0	A2	0.015	0.00
S2-6	1.62	140.7	780	0	39,016	0	F2	0.013	0.00
S2-7	1.74	140.7	621	0	28,019	0	A2	0.038	0.00
S2-8	1.85	140.5	713	45	41,118	1,575	A2	0.018	0.00
S2-9	2.09	140.4	1,123	0	56,351	0	A2	0.021	0.00
S2-10	2.36	140.3	1,316	0	60,498	0	A2	0.037	0.00
S2-11	2.48	140.3	575	0	29,268	0	F2b	0.029	0.00
S2-12	2.62	130.2	798	0	43,026	0	B2c	0.016	0.00
S3-1	2.75	129.8	909	0	47,408	0	B3c	0.018	0.01
S3-2	2.88	129.7	702	0	26,642	0	B3c	0.013	0.83
S3-3	3.04	129.5	925	0	38,040	0	C3	0.013	0.33
S3-4	3.17	129.4	444	0	18,433	0	C2	0.013	0.00
S3-5	3.31	129.3	775	0	48,020	0	B3c	0.012	0.00
S3-6	3.44	128.7	831	0	33,278	0	C2	0.011	0.00
S3-7	3.57	128.7	570	0	32,558	0	C3	0.012	0.00
S3-8	3.74	128.6	856	0	42,975	0	B3c	0.010	0.00
S3-9	3.89	128.5	693	0	26,411	0	F2	0.012	0.00
S3-10	4.05	128.2	1,029	0	42,106	0	F3	0.008	0.00
S3-11	4.38	128.2	2,988	0	114,944	0	A1	0.010	0.00
S5-1	4.79	123.7	1,115	335	119,496	9,425	C4	0.003	0.61
S5-2	4.93	123.6	352	0	15,592	0	C3	0.003	0.69
S5-3	5.05	123.6	668	0	25,166	0	C3	0.005	0.00
S5-4	5.20	123.4	800	0	28,482	0	C3	0.008	0.79
S5-5	5.35	122.3	718	0	35,250	0	C4	0.007	0.00
S6-1	5.48	122.2	863	0	31,077	0	B3c	0.008	0.00
S6-2	5.60	122.2	540	0	24,895	0	B3c	0.008	0.00
S6-3	5.75	122.1	808	332	30,399	3,432	B3c	0.007	0.52
S7-1	5.89	69.8	684	0	22,044	0	C3	0.011	0.43
S7-2	6.02	69.8	701	274	26,904	2,121	C3	0.014	0.38
S7-3	6.15	67.7	732	496	21,171	4,788	C3	0.014	0.67
S7-4	6.27	67.7	806	0	25,555	0	C3	0.017	0.72
S7-5	6.41	67.7	513	0	17,773	0	B3	0.021	0.00
S8-1	6.53	67.7	764	0	28,397	0	B3c	0.015	0.00
S8-2	6.65	67.7	656	0	24,668	0	B3c	0.011	0.00
S8-3	6.79	67.6	731	0	25,256	0	A3	0.017	0.00
S8-4	6.93	67.6	693	0	25,305	0	C3	0.013	0.00
S8-5	7.03	67.5	659	0	15,596	0	B3c	0.019	0.43
S8-6	7.17	67.5	811	0	28,571	0	B3c	0.015	0.00
S8-7	7.32	67.4	686	0	26,783	0	B2c	0.017	0.00

Table B12a. Geomorphic and basic descriptive attributes by subreach

Subreach	Geomorphic and basic descriptive attributes								
	river station at upstream boundary (miles)	cumulative drainage area (mi^2)	field measured main channel length (ft)	field measured side channel length (ft)	field measured main channel low flow area (ft)	field measured side channel low flow area (ft)	Rosgen channel type	slope (LiDAR derived)	braid index
S9-1	7.45	67.3	606	580	19,647	22,990	C6	0.017	0.00
S9-2	7.56	67.3	609	100	24,112	300	C3	0.016	0.00
S9-3	7.72	67.2	913	239	30,926	1,373	B3c	0.017	0.73
S10-1	7.84	67.2	506	0	18,864	0	B3c	0.013	0.00
S10-2	7.96	67.1	738	0	21,492	0	B3c	0.012	0.00
S10-3	8.09	67.0	675	0	25,365	0	B3c	0.012	0.00
S11-1	8.22	66.8	819	170	25,308	510	C3	0.017	0.00
S11-2	8.42	66.5	1,058	205	34,816	3,800	C4	0.017	0.77
S11-3	8.57	66.5	751	135	17,983	3,060	C3	0.014	0.40
S11-4	8.70	66.3	588	0	20,968	0	C3	0.012	0.00
S11-5	8.82	66.3	657	0	30,802	0	C4	0.016	0.00
S11-6	8.97	66.1	767	540	22,996	4,612	C2	0.015	0.00
S11-7	9.17	63.1	1,188	0	83,627	0	C3	0.012	0.00
S11-8	9.29	63.1	511	0	20,236	0	C3	0.014	0.00
S11-9	9.43	63.0	680	0	24,552	0	C4	0.014	0.00
S11-10	9.59	63.0	852	530	22,972	6,183	D3	0.019	1.25
S11-11	9.72	53.3	684	0	23,199	0	C3	0.007	0.03
S11-12	9.86	52.5	741	0	18,339	0	C3	0.018	0.16
S11-13	10.00	52.5	672	281	20,210	2,376	C4	0.013	0.34
S11-14	10.14	52.2	764	0	22,404	0	C3	0.016	0.10
S11-15	10.28	52.1	673	0	19,136	0	B3c	0.018	0.72
S12-1	10.41	48.6	651	0	24,897	0	B3c	0.017	0.00
S12-2	10.55	48.5	723	288	20,278	2,504	C3	0.014	0.27
S12-3	10.73	48.3	1,144	670	33,722	9,200	C3b	0.020	0.66
S12-4	10.89	47.9	706	130	30,110	1,040	B4c	0.007	0.19
S12-5	11.00	47.8	717	0	20,454	0	C3	0.014	0.00
S12-6	11.13	47.8	667	0	19,740	0	C3	0.016	0.00
S12-7	11.26	47.6	635	568	18,938	3,866	C2b	0.021	0.00
S12-8	11.38	47.5	680	0	16,194	0	C2b	0.021	0.22
S13-1	11.52	46.4	657	0	24,930	0	B2c	0.020	0.00
S13-2	11.66	44.6	884	0	32,813	0	C3	0.017	0.00
S13-3	11.79	44.5	584	0	19,102	0	B3c	0.014	0.00
S13-4	11.93	44.5	798	0	25,072	0	C3	0.017	0.00
S13-5	12.05	44.3	675	0	22,343	0	C2	0.016	0.00
S13-6	12.17	44.2	643	295	18,294	1,297	C3	0.020	0.83
S13-7	12.30	44.2	669	0	19,360	0	B2c	0.018	0.00
S14-1	12.47	44.1	875	55	27,110	1,100	C3	0.018	0.19
S14-2	12.60	44.1	719	0	22,050	0	C2b	0.022	0.06
S14-3	12.80	38.6	921	0	24,345	0	B2	0.023	0.00
S14-4	12.93	36.9	823	0	22,412	0	B3c	0.014	0.00
S14-5	13.05	36.8	621	0	22,859	0	C3	0.005	0.00
S14-6	13.20	36.7	696	0	25,414	0	C3	0.009	0.00
S15-1	13.33	36.6	769	0	21,017	0	C3	0.009	0.00
S15-2	13.45	36.6	765	0	30,498	0	C3	0.011	0.32
S15-3	13.57	36.5	517	45	14,619	240	C3	0.010	0.87
S15-4	13.75	36.4	872	12	24,819	36	C3	0.013	0.29
S15-5	13.87	35.5	670	0	16,630	0	B3c	0.016	0.00

Table B12a. Geomorphic and basic descriptive attributes by subreach

Subreach	Geomorphic and basic descriptive attributes								
	river station at upstream boundary (miles)	cumulative drainage area (mi^2)	field measured main channel length (ft)	field measured side channel length (ft)	field measured main channel low flow area (ft)	field measured side channel low flow area (ft)	Rosgen channel type	slope (LiDAR derived)	braid index
S16-1	13.98	35.2	652	369	18,300	2,695	C3	0.009	0.33
S16-2	14.13	35.1	792	759	23,928	5,521	D4	0.014	1.47
S16-3	14.24	33.0	609	0	15,848	0	C3	0.010	0.80
S16-4	14.39	32.9	674	130	16,904	2,600	C3	0.011	0.51
S16-5	14.56	32.7	1,076	0	33,575	0	C3	0.015	0.04
S16-6	14.70	32.5	493	72	14,985	864	C3	0.016	0.34
S16-6SC	14.83	32.5	824	1,873	25,916	44,087	C4		
S16-7	14.95	31.4	555	0	14,785	0	C3	0.014	0.09
S16-8	15.07	31.4	643	0	20,143	0	C3	0.017	0.38
S16-9	15.20	31.4	738	0	21,509	0	C3	0.014	0.35
S16-10	15.34	28.9	652	0	16,415	0	B2	0.022	0.00
S16-11	15.47	22.5	709	415	17,071	3,534	C3b	0.028	0.22
S17-1	15.57	22.4	650	75	15,801	120	C3b	0.032	0.62
S17-2	15.72	22.4	875	0	22,229	0	C2b	0.043	0.29
S17-3	15.85	22.3	608	78	14,894	432	B2a	0.052	0.12
S17-4	15.98	22.3	846	0	19,041	0	B3a	0.050	0.00
S17-5	16.07	22.2	381	0	7,371	0	B3a	0.043	0.00
S17-6	16.20	22.1	659	0	16,214	0	B2a	0.046	0.00
S17-7	16.31	22.0	645	0	13,668	0	B2a	0.055	0.00
S17-8	16.43	21.9	759	0	16,732	0	B2a	0.062	0.00
S17-9	16.61	21.8	811	0	19,133	0	B2a	0.050	0.00
S17-10	16.79	21.5	719	150	17,085	865	B2a	0.050	0.27
S17-11	16.92	20.4	876	161	18,816	944	B2a	0.052	0.35
S17-12	17.04	20.3	836	0	20,630	0	B2a	0.048	0.00
S17-13	17.16	20.0	594	0	12,227	0	B3	0.034	0.00
S17-14	17.29	19.9	750	0	17,061	0	B2a	0.049	0.00
S17-15	17.43	19.9	677	0	17,356	0	B2a	0.050	0.00
S17-16	17.57	19.8	777	0	15,905	0	B2a	0.056	0.00
S17-17	17.69	19.7	649	0	15,391	0	B2a	0.047	0.00
S17-18	17.83	18.1	747	70	17,378	70	B2a	0.043	0.15
S18-1	17.95	18.0	629	0	14,822	0	B3	0.036	0.00
S18-2	18.09	17.9	754	463	14,684	7,112	B3	0.037	0.22
S18-3	18.24	16.9	811	0	17,108	0	C3b	0.024	0.49
S18-4	18.36	16.8	698	0	14,273	0	C3b	0.027	0.00
S18-5	18.48	16.7	645	0	15,713	0	B2	0.033	0.00
S18-6	18.61	16.7	793	167	17,931	910	B3a	0.043	0.57
S18-7	18.73	16.2	449	24	9,896	120	B2	0.024	0.00
S18-8	18.85	15.9	688	0	13,970	0	B3	0.025	0.00
S18-9	18.97	15.8	658	356	12,003	3,735	C3	0.017	0.64
S18-10	19.11	15.0	615	716	14,561	8,062	B3c	0.016	0.41
S19-1	19.23	14.9	855	71	12,215	852	C3	0.013	0.53
S19-2	19.35	14.7	533	723	8,005	4,490	C3	0.015	0.51
S19-3	19.48	14.6	637	704	11,972	3,046	D3	0.016	1.91
S19-4	19.53	14.5	199	474	3,759	4,441	D3	0.017	1.72
S19-5	658	14.5	672	0	7,293	0	C3	0.015	0.00
NFS1-1	0.12	10.0	677	0	10,604	0	B3a+	0.166	0.00
NFS1-2	0.24	9.9	623	80	10,113	1,760	B2a	0.098	0.13

Table B12a. Geomorphic and basic descriptive attributes by subreach

Subreach	Geomorphic and basic descriptive attributes								
	river station at upstream boundary (miles)	cumulative drainage area (mi^2)	field measured main channel length (ft)	field measured side channel length (ft)	field measured main channel low flow area (ft)	field measured side channel low flow area (ft)	Rosgen channel type	slope (LiDAR derived)	braid index
NFS1-3	0.35	9.9	555	0	8,562	0	A2a+	0.131	0.00
NFS1-4	0.50	9.9	776	0	12,061	0	C4a	0.053	0.00
O1-1	0.12	52.0	751	0	25,405	0	C3	0.009	0.00
O1-2	0.25	52.0	591	0	25,574	0	C3	0.015	0.00
O1-3	0.38	51.9	723	171	19,719	4,808	C4	0.011	0.24
O1-4	0.50	51.8	559	0	24,223	0	C3	0.006	0.00
H1-1	0.12	2.0	690	505	5,637	11,755	D6a	0.041	0.73
H1-2	0.25	2.0	627	173	3,708	890	C4	0.018	0.28
J1-1	0.12	2.8	658	0	4,738	0	B4a+	0.104	0.00
J1-2	0.25	2.8	737	40	4,680	80	C3a	0.094	0.05
P1-1	1325	9.6	670	539	8,241	4,728	C3b	0.036	0.84
P1-2	668	9.5	748	0	9,811	0	E3a	0.044	0.00
W1-1	0.12	0.8	775	0	7,821	0	A4a+	0.108	0.00
T1-1	0.12	1.1	612	228	3,603	1,191	C4a+	0.105	0.37
ST1-1	0.12	5.4	650	0	6,905	0	E3a	0.043	0.00
ST1-2	0.25	5.4	675	0	7,623	0	E3a	0.053	0.00
R1-1	0.13	1.7	697	0	3,930	0	B3a+	0.140	0.00
R1-2	0.25	1.6	653	0	4,399	0	B3a+	0.129	0.00
K1-1	0.13	2.0	710	0	6,457	0	A3	0.053	0.00
K1-2	0.25	2.0	599	0	5,962	0	A3a+	0.130	0.00
C1-1	0.14	1.1	771	110	5,154	1,135	B4	0.024	0.14
GY1-1	1312	6.4	545	20	6,847	100	B3b	0.052	0.05
GY1-2	777	6.3	806	0	10,441	0	E3a	0.059	0.00
GY2-3	0.12	6.2	634	45	8,604	540	C2a	0.058	0.07
GY2-4	0.25	6.2	689	0	9,875	0	B2a	0.064	0.00
M1-1	0.12	2.3	638	35	5,509	105	B2a+	0.137	0.05
D1-1	1385	10.4	632	411	8,240		C3b	0.021	0.14
D1-2	2066	10.3	699	140	10,241	100	D3b	0.026	1.23
D1-3	2674	10.3	694	63	8,976	390	C3b	0.027	0.23
D1-4	3299	5.8	519		6,081		C3b	0.042	0.00
D1-5	707	5.8	727	45	7,985	120	B3	0.035	0.33
L1-1	1323	4.3	579	199	7,874	1,923	C3b	0.058	0.70
L1-2	967	4.3	535	0	11,223	0	B3a	0.060	0.00
SH1-1	0.13	4.1	664	317	8,955	1,508	D4b	0.033	1.62
SH1-1.5	0.24	4.0	0	1,513	0	13,303	D4b	0.035	NA
SH1-2	0.24	4.0	629	85	10,987	405	D4a	0.043	1.34
SH1-3	0.37	4.0	673	389	10,513	3,490	D3a+	0.132	0.58

Table B12b. Geomorphic and basic descriptive attributes by subreach (continued)

Subreach	Geomorphic and basic descriptive attributes continued								
							topography based width		
	entrench-ment ratio	width / depth ratio	sinuosity	field measured slope (at upstream transect)	field measured percent canopy cover (at upstream transect)	bankfull depth (ft)	low flow channel	bankfull channel	floodprone area
S1-1	2.1	56	1.13	0.006	0	3.8	59	211	446
S1-2	3.3	18	1.15	0.008	5.2	3.8	52	67	219
S1-3	1.9	27	1.28	0.009	7.28	4.4	70	118	227
S1-4	1.6	14	0.99	0.031	0	5.6	57	78	127
S2-1	1.3	12	1.02	0.038	28.08	5.9	47	69	90
S2-2	1.3	9	1.22	0.023	47.84	5.3	35	46	59
S2-3	1.3	9	1.06	0.029	44.72	5.0	27	44	57
S2-4	1.2	12	1.04	0.011	27.04	4.4	37	54	65
S2-5	1.2	13	1.01	0.010	40.56	4.5	41	58	68
S2-6	1.2	11	1.03	0.012	59.28	4.8	35	54	65
S2-7	1.2	10	1.00	0.026	41.6	4.5	28	46	56
S2-8	1.2	8	1.02	0.036	41.6	5.8	28	48	59
S2-9	1.2	8	1.04	0.018	48.88	6.3	30	52	64
S2-10	1.3	10	1.10	0.033	53.04	4.6	29	46	59
S2-11	1.3	13	1.06	NA	NA	4.1	36	53	70
S2-12	1.7	13	1.02	0.010	47.84	4.8	53	64	107
S3-1	2.2	17	1.12	0.014	19.76	4.0	53	70	152
S3-2	2.0	42	1.11	0.012	24.96	3.3	68	138	275
S3-3	4.8	25	1.04	0.017	17.68	3.9	54	98	467
S3-4	2.4	30	1.00	0.015	21.84	4.1	47	123	292
S3-5	1.9	21	1.15	0.008	35.36	3.7	59	76	148
S3-6	3.2	19	1.37	0.011	35.36	3.3	47	63	204
S3-7	3.6	24	1.26	0.016	16.64	3.3	63	77	277
S3-8	1.5	19	1.54	0.016	29.12	3.4	51	64	96
S3-9	1.2	16	1.01	0.001	59.28	3.9	46	60	71
S3-10	1.3	14	1.02	0.010	20.8	4.3	44	61	81
S3-11	1.2	4	1.00	0.042	18.72	4.6	10	17	20
S5-1	2.2	38	1.24	0.001	5.2	4.4	50	165	370
S5-2	2.8	48	1.38	0.002	2.08	3.9	77	187	525
S5-3	7.7	19	1.05	0.008	5.2	3.5	44	67	514
S5-4	8.6	30	1.21	0.010	13.52	2.7	55	79	680
S5-5	5.4	21	1.38	0.004	18.72	3.0	49	65	346
S6-1	1.8	24	1.26	0.011	16.64	4.3	33	102	187
S6-2	2.2	20	0.98	0.006	26	4.7	50	93	202
S6-3	1.7	17	1.05	0.008	16.64	5.7	48	97	168
S7-1	3.4	25	1.07	0.011	19.76	5.1	30	128	437
S7-2	3.3	20	1.03	0.003	10.4	3.8	42	77	256
S7-3	3.6	23	1.15	0.008	12.48	3.9	38	89	317
S7-4	2.6	25	1.05	0.016	26	4.7	32	117	304
S7-5	2.0	11	1.01	0.009	44.72	4.6	29	50	101
S8-1	1.5	14	1.03	0.010	43.68	3.6	33	50	77
S8-2	1.4	12	1.04	0.008	28.08	3.7	30	45	65
S8-3	1.2	13	1.01	0.023	21.84	3.6	30	46	57
S8-4	2.3	14	1.02	0.003	71.76	3.7	32	50	114
S8-5	2.2	13	1.18	0.010	36.4	4.0	25	52	114
S8-6	1.6	11	1.24	0.006	59.28	4.5	28	48	78
S8-7	1.7	11	1.03	0.020	50.96	4.1	27	46	78

Table B12b. Geomorphic and basic descriptive attributes by subreach (continued)

Subreach	Geomorphic and basic descriptive attributes continued								
							topography based width		
	entrench-ment ratio	width / depth ratio	sinuosity	field measured slope (at upstream transect)	field measured percent canopy cover (at upstream transect)	bankfull depth (ft)	low flow channel	bankfull channel	floodprone area
S9-1	2.7	27	1.12	0.020	19.76	3.1	60	84	226
S9-2	5.2	20	1.07	0.011	7.28	3.1	40	62	319
S9-3	1.9	24	1.22	0.008	23.92	3.8	41	90	168
S10-1	1.5	12	1.01	0.007	55.12	3.8	28	45	66
S10-2	1.5	15	1.02	-0.012	20.8	2.7	24	39	59
S10-3	1.5	19	1.01	0.016	37.44	2.8	35	52	76
S11-1	3.2	21	1.07	0.017	40.56	3.5	38	73	235
S11-2	4.0	25	1.04	0.013	38.48	4.0	48	98	392
S11-3	2.7	19	1.24	0.017	19.76	4.1	31	81	216
S11-4	3.7	16	1.01	0.005	11.44	4.3	36	70	259
S11-5	4.1	13	1.01	0.014	38.48	4.0	35	53	220
S11-6	2.9	15	1.08	0.014	45.76	4.2	37	64	184
S11-7	3.0	17	1.21	0.014	13.52	4.2	41	72	214
S11-8	5.3	15	1.05	0.000	64.48	3.4	34	51	274
S11-9	3.3	16	1.00	0.013	50.96	2.9	31	47	154
S11-10	3.7	25	1.14	0.005	38.48	2.9	36	71	259
S11-11	3.1	20	1.02	0.009	59.28	3.7	34	75	234
S11-12	3.5	17	1.43	0.020	41.6	3.4	34	58	205
S11-13	3.9	21	1.33	0.010	58.24	3.0	38	62	242
S11-14	2.7	18	1.09	0.017	30.16	3.5	30	62	169
S11-15	1.9	27	1.19	0.021	30.16	3.3	31	89	172
S12-1	1.5	15	1.18	0.022	44.72	2.9	27	45	68
S12-2	3.0	18	1.14	0.029	43.68	4.3	36	78	231
S12-3	2.5	23	1.10	0.011	3.12	4.3	36	98	249
S12-4	2.0	20	1.04	0.011	50.96	4.0	41	80	155
S12-5	3.7	13	1.02	0.024	50.96	4.2	26	53	195
S12-6	3.4	12	1.00	0.007	45.76	3.8	26	47	160
S12-7	3.7	20	1.06	0.052	48.88	4.3	30	86	323
S12-8	6.3	16	1.10	0.014	6.24	3.2	29	49	308
S13-1	2.0	16	1.02	0.013	53.04	2.8	30	46	90
S13-2	2.4	15	1.11	0.016	57.2	3.2	27	47	115
S13-3	1.9	13	1.00	0.016	74.88	3.6	25	46	87
S13-4	2.6	12	1.04	0.021	15.6	4.0	21	47	122
S13-5	2.4	13	1.03	0.021	41.6	3.3	25	44	106
S13-6	2.7	21	1.07	0.013	15.6	2.1	29	44	118
S13-7	1.8	17	1.04	0.025	46.8	2.1	26	36	64
S14-1	3.1	16	1.28	0.010	37.44	3.1	29	50	153
S14-2	2.8	12	1.15	0.023	73.84	3.6	26	45	125
S14-3	1.8	10	1.04	0.000	42.64	3.9	20	40	72
S14-4	2.1	12	1.06	0.006	17.68	3.4	23	39	82
S14-5	3.0	13	1.10	0.010	82.16	3.5	30	47	140
S14-6	2.5	15	1.03	0.013	71.76	3.2	29	47	116
S15-1	4.7	22	1.05	0.009	37.44	2.4	30	51	240
S15-2	3.6	26	1.06	0.007	59.28	2.6	44	67	242
S15-3	6.3	15	1.04	0.009	41.6	3.3	29	50	315
S15-4	3.7	18	1.11	0.010	55.12	3.1	30	57	214
S15-5	1.7	15	1.00	0.011	82.16	2.5	26	39	67

Table B12b. Geomorphic and basic descriptive attributes by subreach (continued)

Subreach	Geomorphic and basic descriptive attributes continued								
							topography based width		
	entrench-ment ratio	width / depth ratio	sinuosity	field measured slope (at upstream transect)	field measured percent canopy cover (at upstream transect)	bankfull depth (ft)	low flow channel	bankfull channel	floodprone area
S16-1	3.5	22	1.61	0.009	39.52	2.5	30	54	192
S16-2	2.5	40	1.22	0.003	36.4	2.4	49	97	240
S16-3	2.6	26	1.08	0.020	5.2	2.4	41	61	161
S16-4	3.0	20	1.49	0.008	8.32	2.3	29	46	138
S16-5	5.2	17	1.24	0.013	45.76	2.1	22	35	181
S16-6	3.2	17	1.56	0.010	42.64	2.5	24	43	136
S16-6SC				0.011	55.12				
S16-7	3.4	19	1.18	0.008	34.32	2.5	32	48	160
S16-8	4.6	22	1.14	0.010	45.76	2.0	28	42	194
S16-9	2.4	21	1.40	0.005	34.32	2.1	26	44	106
S16-10	1.5	14	1.08	0.027	68.64	2.5	24	35	54
S16-11	2.4	15	1.06	0.017	72.8	2.5	25	37	91
S17-1	2.5	21	1.16	0.045	68.64	2.3	32	48	119
S17-2	2.7	15	1.10	0.046	91.52	2.1	21	32	85
S17-3	1.5	15	1.05	0.038	95.68	2.4	20	35	52
S17-4	1.7	13	1.01	0.044	58.24	2.4	19	32	52
S17-5	1.5	13	1.01	0.049	52	2.6	19	34	51
S17-6	1.6	10	1.00	0.061	63.44	3.5	19	37	60
S17-7	1.5	9	1.00	0.078	40.56	3.6	16	33	48
S17-8	1.7	10	1.03	0.068	72.8	3.2	18	31	52
S17-9	1.9	12	1.00	0.033	71.76	2.9	19	35	65
S17-10	1.6	17	1.01	0.029	78	2.9	23	50	77
S17-11	1.6	18	1.05	0.056	86.32	2.7	21	48	76
S17-12	1.6	11	1.01	0.049	78	2.8	18	31	50
S17-13	1.7	11	1.01	0.038	76.96	3.0	18	33	57
S17-14	1.5	10	1.00	0.069	67.6	3.7	18	36	55
S17-15	1.7	12	1.02	0.056	69.68	3.4	20	40	66
S17-16	1.6	14	1.03	0.074	60.32	2.6	19	35	57
S17-17	1.6	9	1.01	0.050	86.32	3.0	16	28	44
S17-18	2.1	9	1.11	0.022	63.44	3.5	19	32	68
S18-1	2.1	11	1.09	0.037	56.16	3.0	23	34	73
S18-2	1.6	14	1.02	0.020	57.2	2.2	20	30	47
S18-3	2.3	22	1.05	0.023	72.8	1.8	28	40	93
S18-4	2.6	14	1.09	0.032	60.32	2.7	20	38	98
S18-5	1.8	12	0.97	0.037	55.12	3.0	19	37	65
S18-6	1.8	18	1.07	0.010	37.44	2.0	24	37	66
S18-7	1.5	16	0.99	0.034	67.6	1.7	18	27	40
S18-8	1.5	14	1.01	0.009	34.32	1.7	17	25	38
S18-9	2.8	28	1.12	0.006	46.8	1.9	35	54	150
S18-10	2.0	25	1.06	0.019	52	1.7	34	43	86
S19-1	2.2	32	1.07	0.010	24.96	1.5	39	47	104
S19-2	2.3	21	1.08	0.015	55.12	1.7	21	35	78
S19-3	3.2	35	1.18	0.018	37.44	1.9	35	67	213
S19-4	2.7	51	1.15	0.019	45.76	1.7	49	87	238
S19-5	10.2	16	1.01	0.014	93.6	1.8	16	28	288
NFS1-1	2.1	9	NA	0.076	85.416667	3.4	NA	NA	NA
NFS1-2	2.1	4	NA	0.096	96.875	6.6	NA	NA	NA

Table B12b. Geomorphic and basic descriptive attributes by subreach (continued)

Subreach	Geomorphic and basic descriptive attributes continued								
							topography based width		
	entrench-ment ratio	width / depth ratio	sinuosity	field measured slope (at upstream transect)	field measured percent canopy cover (at upstream transect)	bankfull depth (ft)	low flow channel	bankfull channel	floodprone area
NFS1-3	1.4	5	NA	0.065	53.125	2.9	NA	NA	NA
NFS1-4	0.0	13	NA	0.055	83.333333	2.0	NA	NA	NA
O1-1	4.2	5	NA	0.009	50	6.3	NA	NA	NA
O1-2	1.6	12	NA	0.006	27.083333	6.8	NA	NA	NA
O1-3	2.9	8	NA	0.006	12.5	5.4	NA	NA	NA
O1-4	NA	NA	NA	NA	NA	NA	NA	NA	NA
H1-1	11.4	2	NA	0.053	70.833333	3.0	NA	NA	NA
H1-2	18.8	5	NA	0.003	61.458333	1.6	NA	NA	NA
J1-1	2.4	2	NA	0.072	95.833333	4.0	NA	NA	NA
J1-2	3.3	4	NA	0.094	88.541667	2.4	NA	NA	NA
P1-1	3.5	18	1.10	0.042	92.56	2.2	13	41	142
P1-2	2.4	11	1.08	0.047	94.64	2.2	10	24	58
W1-1	1.3	1	NA	0.139	100	3.9	NA	NA	NA
T1-1	4.2	1	NA	0.202	95.833333	4.2	NA	NA	NA
ST1-1	2.5	4	NA	0.066	83.333333	3.9	NA	NA	NA
ST1-2	2.6	8	NA	0.048	93.75	2.1	NA	NA	NA
R1-1	2.2	2	NA	0.114	97.916667	5.4	NA	NA	NA
R1-2	2.0	2	NA	0.117	97.916667	4.6	NA	NA	NA
K1-1	1.3	2	NA	0.070	77.083333	6.1	NA	NA	NA
K1-2	1.3	4	NA	0.111	92.708333	2.8	NA	NA	NA
C1-1	2.0	2	NA	0.081	100	2.4	NA	NA	NA
GY1-1	1.9	20	1.07	0.032	96.72	1.9	14	38	73
GY1-2	4.0	10	1.01	0.033	92.56	2.6	12	26	104
GY2-3	4.0	5	NA	0.035	100	3.3	NA	NA	NA
GY2-4	2.2	7	NA	0.059	84.375	3.6	NA	NA	NA
M1-1	1.7	4	NA	0.123	95.833333	4.1	NA	NA	NA
D1-1	4.7	31	1.44	0.029	60.32	1.4	22	41	196
D1-2	2.6	40	1.05	0.010	52	1.5	38	58	149
D1-3	3.3	23	1.08	0.030	67.6	1.6	24	38	125
D1-4	2.7	29	1.09	0.037	88.4	1.3	21	38	105
D1-5	2.0	28	1.00	0.025	52	1.1	20	32	64
L1-1	2.3	23	1.08	0.050	52	1.6	20	38	88
L1-2	2.1	12	1.04	0.069	45.76	2.3	15	29	61
SH1-1	35.7	9	NA	0.053	76.041667	3.2	NA	NA	NA
SH1-1.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
SH1-2	1.2	10	NA	0.049	94.791667	2.7	NA	NA	NA
SH1-3	4.8	9	NA	0.122	95.833333	2.4	NA	NA	NA

Table B13. Habitat unit attributes by subreach

Subreach	Habitat unit attributes (proportion of low flow wetted area)											
	Main Channel						Side Channel					
	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide
S1-1	0.00	0.13	0.00	0.03	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S1-2	0.00	0.00	0.00	0.12	0.77	0.12	0.00	0.00	0.00	0.00	1.00	0.00
S1-3	0.00	0.00	0.00	0.73	0.27	0.00	0.00	0.00	0.00	0.46	0.54	0.00
S1-4	0.00	0.00	0.00	0.16	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S2-1	0.02	0.08	0.00	0.35	0.23	0.32	0.00	0.00	0.00	0.00	0.00	0.00
S2-2	0.65	0.01	0.16	0.15	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S2-3	0.60	0.05	0.00	0.28	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
S2-4	0.00	0.00	0.00	0.03	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S2-5	0.02	0.00	0.00	0.17	0.70	0.11	0.00	0.00	0.00	0.00	0.00	0.00
S2-6	0.00	0.00	0.00	0.16	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S2-7	0.43	0.00	0.00	0.25	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S2-8	0.00	0.00	0.00	0.43	0.57	0.00	1.00	0.00	0.00	0.00	0.00	0.00
S2-9	0.26	0.00	0.00	0.32	0.36	0.06	0.00	0.00	0.00	0.00	0.00	0.00
S2-10	0.19	0.05	0.24	0.26	0.21	0.04	0.00	0.00	0.00	0.00	0.00	0.00
S2-11	0.09	0.00	0.25	0.31	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S2-12	0.00	0.00	0.14	0.27	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-1	0.00	0.00	0.00	0.04	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-2	0.00	0.00	0.00	0.12	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-3	0.00	0.00	0.00	0.00	0.86	0.14	0.00	0.00	0.00	0.00	0.00	0.00
S3-4	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-5	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-6	0.00	0.00	0.00	0.28	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-7	0.00	0.00	0.00	0.05	0.54	0.41	0.00	0.00	0.00	0.00	0.00	0.00
S3-8	0.00	0.00	0.00	0.00	0.73	0.27	0.00	0.00	0.00	0.00	0.00	0.00
S3-9	0.00	0.00	0.00	0.49	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-10	0.00	0.00	0.00	0.24	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S3-11	0.81	0.00	0.00	0.14	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00
S5-1	0.00	0.00	0.00	0.85	0.15	0.00	0.00	0.00	0.00	0.33	0.67	0.00
S5-2	0.00	0.00	0.00	0.00	0.42	0.58	0.00	0.00	0.00	0.00	0.00	0.00
S5-3	0.00	0.00	0.00	0.32	0.30	0.39	0.00	0.00	0.00	0.00	0.00	0.00
S5-4	0.00	0.00	0.00	0.25	0.44	0.30	0.00	0.00	0.00	0.00	0.00	0.00
S5-5	0.00	0.00	0.00	0.43	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S6-1	0.00	0.00	0.00	0.25	0.52	0.23	0.00	0.00	0.00	0.00	0.00	0.00
S6-2	0.00	0.00	0.00	0.00	0.62	0.38	0.00	0.00	0.00	0.00	0.00	0.00
S6-3	0.00	0.00	0.00	0.00	0.51	0.49	0.00	0.00	0.00	0.28	0.44	0.28
S7-1	0.00	0.00	0.00	0.09	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S7-2	0.00	0.00	0.00	0.24	0.53	0.23	0.00	0.00	0.00	0.00	0.79	0.21
S7-3	0.00	0.08	0.00	0.00	0.68	0.23	0.00	0.00	0.00	0.00	0.09	0.91
S7-4	0.00	0.00	0.00	0.10	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S7-5	0.00	0.00	0.00	0.22	0.56	0.21	0.00	0.00	0.00	0.00	0.00	0.00
S8-1	0.00	0.00	0.00	0.02	0.67	0.31	0.00	0.00	0.00	0.00	0.00	0.00
S8-2	0.00	0.00	0.00	0.01	0.89	0.10	0.00	0.00	0.00	0.00	0.00	0.00
S8-3	0.00	0.00	0.00	0.27	0.67	0.06	0.00	0.00	0.00	0.00	0.00	0.00
S8-4	0.00	0.00	0.00	0.11	0.78	0.10	0.00	0.00	0.00	0.00	0.00	0.00
S8-5	0.00	0.00	0.00	0.16	0.54	0.29	0.00	0.00	0.00	0.00	0.00	0.00
S8-6	0.00	0.00	0.00	0.08	0.52	0.40	0.00	0.00	0.00	0.00	0.00	0.00
S8-7	0.00	0.00	0.00	0.11	0.82	0.08	0.00	0.00	0.00	0.00	0.00	0.00

Table B13. Habitat unit attributes by subreach

Subreach	Habitat unit attributes (proportion of low flow wetted area)											
	Main Channel						Side Channel					
	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide
S9-1	0.00	0.00	0.00	0.08	0.74	0.18	0.00	0.00	0.00	0.97	0.03	0.00
S9-2	0.00	0.00	0.00	0.17	0.66	0.17	0.00	0.00	0.00	0.47	0.53	0.00
S9-3	0.00	0.00	0.00	0.06	0.67	0.27	0.00	0.00	0.00	0.52	0.48	0.00
S10-1	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S10-2	0.00	0.00	0.00	0.14	0.44	0.42	0.00	0.00	0.00	0.00	0.00	0.00
S10-3	0.00	0.00	0.00	0.04	0.70	0.26	0.00	0.00	0.00	0.00	0.00	0.00
S11-1	0.06	0.00	0.00	0.10	0.55	0.28	0.00	1.00	0.00	0.00	0.00	0.00
S11-2	0.00	0.00	0.00	0.20	0.66	0.13	0.00	0.00	0.00	0.63	0.00	0.37
S11-3	0.00	0.00	0.00	0.28	0.53	0.18	0.00	0.00	0.00	0.00	0.71	0.29
S11-4	0.00	0.00	0.00	0.01	0.40	0.58	0.00	0.00	0.00	0.00	0.00	0.00
S11-5	0.00	0.00	0.00	0.01	0.57	0.42	0.00	0.00	0.00	0.00	0.00	0.00
S11-6	0.00	0.00	0.00	0.19	0.69	0.12	0.00	0.00	0.00	0.06	0.29	0.65
S11-7	0.00	0.00	0.00	0.00	0.97	0.03	0.00	0.00	0.00	0.00	0.00	0.00
S11-8	0.00	0.00	0.00	0.09	0.28	0.62	0.00	0.00	0.00	0.00	0.00	0.00
S11-9	0.00	0.00	0.00	0.07	0.55	0.38	0.00	0.00	0.00	0.00	0.00	0.00
S11-10	0.00	0.00	0.00	0.00	0.98	0.02	0.00	0.00	0.00	0.79	0.15	0.05
S11-11	0.00	0.00	0.00	0.25	0.46	0.29	0.00	0.00	0.00	0.00	0.00	0.00
S11-12	0.00	0.00	0.00	0.15	0.76	0.09	0.00	0.00	0.00	0.00	0.00	0.00
S11-13	0.00	0.00	0.00	0.18	0.73	0.09	0.00	0.00	0.00	0.19	0.81	0.00
S11-14	0.00	0.00	0.00	0.28	0.40	0.32	0.00	0.00	0.00	0.00	0.00	0.00
S11-15	0.00	0.00	0.00	0.11	0.70	0.19	0.00	0.00	0.00	0.00	0.00	0.00
S12-1	0.00	0.00	0.00	0.19	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S12-2	0.00	0.00	0.00	0.36	0.26	0.38	0.00	0.00	0.00	0.76	0.18	0.06
S12-3	0.00	0.00	0.00	0.26	0.68	0.07	0.00	0.00	0.00	0.41	0.19	0.40
S12-4	0.00	0.00	0.00	0.33	0.46	0.21	0.00	0.00	0.00	1.00	0.00	0.00
S12-5	0.00	0.00	0.00	0.14	0.75	0.11	0.00	0.00	0.00	0.00	0.00	0.00
S12-6	0.00	0.00	0.00	0.00	0.38	0.62	0.00	0.00	0.00	0.00	0.00	0.00
S12-7	0.02	0.00	0.40	0.13	0.45	0.00	0.00	0.04	0.00	0.48	0.21	0.28
S12-8	0.06	0.00	0.14	0.08	0.31	0.41	0.00	0.00	0.00	0.00	0.00	0.00
S13-1	0.00	0.00	0.00	0.01	0.75	0.24	0.00	0.00	0.00	0.00	0.00	0.00
S13-2	0.00	0.00	0.00	0.02	0.51	0.46	0.00	0.00	0.00	0.00	0.00	0.00
S13-3	0.00	0.00	0.00	0.10	0.53	0.36	0.00	0.00	0.00	0.00	0.00	0.00
S13-4	0.00	0.00	0.00	0.14	0.57	0.28	0.00	0.00	0.00	0.00	0.00	0.00
S13-5	0.00	0.00	0.35	0.00	0.35	0.30	0.00	0.00	0.00	0.00	0.00	0.00
S13-6	0.00	0.00	0.00	0.22	0.60	0.18	0.00	0.00	0.00	0.41	0.08	0.51
S13-7	0.06	0.00	0.21	0.00	0.34	0.39	0.00	0.00	0.00	0.00	0.00	0.00
S14-1	0.00	0.00	0.06	0.22	0.31	0.40	0.00	0.00	0.00	0.00	1.00	0.00
S14-2	0.00	0.00	0.50	0.00	0.18	0.31	0.00	0.00	0.00	0.00	0.00	0.00
S14-3	0.02	0.00	0.05	0.27	0.39	0.27	0.00	0.00	0.00	0.00	0.00	0.00
S14-4	0.00	0.00	0.00	0.30	0.22	0.48	0.00	0.00	0.00	0.00	0.00	0.00
S14-5	0.00	0.00	0.00	0.05	0.33	0.62	0.00	0.00	0.00	0.00	0.00	0.00
S14-6	0.00	0.00	0.00	0.06	0.82	0.12	0.00	0.00	0.00	0.00	0.00	0.00
S15-1	0.00	0.00	0.00	0.24	0.41	0.34	0.00	0.00	0.00	0.00	0.00	0.00
S15-2	0.00	0.00	0.00	0.21	0.56	0.23	0.00	0.00	0.00	0.00	0.00	0.00
S15-3	0.00	0.00	0.00	0.17	0.26	0.58	0.00	0.00	0.00	1.00	0.00	0.00
S15-4	0.00	0.00	0.00	0.18	0.74	0.08	0.00	0.00	0.00	1.00	0.00	0.00
S15-5	0.00	0.00	0.00	0.00	0.72	0.28	0.00	0.00	0.00	0.00	0.00	0.00

Table B13. Habitat unit attributes by subreach

Subreach	Habitat unit attributes (proportion of low flow wetted area)											
	Main Channel						Side Channel					
	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide
S16-1	0.00	0.00	0.00	0.68	0.32	0.00	0.00	0.00	0.00	0.90	0.10	0.00
S16-2	0.00	0.00	0.00	0.39	0.44	0.17	0.00	0.00	0.00	0.70	0.10	0.19
S16-3	0.00	0.00	0.00	0.13	0.53	0.35	0.00	0.00	0.00	0.00	0.00	0.00
S16-4	0.00	0.00	0.00	0.64	0.29	0.07	0.00	0.00	0.00	1.00	0.00	0.00
S16-5	0.00	0.00	0.00	0.13	0.81	0.06	0.00	0.00	0.00	0.00	0.00	0.00
S16-6	0.00	0.00	0.00	0.31	0.69	0.00	0.00	0.00	0.00	1.00	0.00	0.00
S16-6SC	0.00	0.00	0.00	0.02	0.00	0.98	0.00	0.00	0.00	0.60	0.18	0.22
S16-7	0.00	0.00	0.00	0.24	0.48	0.28	0.00	0.00	0.00	0.00	0.00	0.00
S16-8	0.00	0.00	0.00	0.36	0.50	0.14	0.00	0.00	0.00	0.00	0.00	0.00
S16-9	0.00	0.00	0.00	0.41	0.43	0.17	0.00	0.00	0.00	0.00	0.00	0.00
S16-10	0.00	0.00	0.69	0.07	0.17	0.07	0.00	0.00	0.00	0.00	0.00	0.00
S16-11	0.03	0.00	0.40	0.15	0.35	0.06	0.00	0.00	0.14	0.39	0.15	0.32
S17-1	0.00	0.00	0.48	0.23	0.24	0.05	0.00	0.00	0.00	0.50	0.33	0.17
S17-2	0.04	0.00	0.67	0.17	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
S17-3	0.08	0.00	0.65	0.21	0.00	0.06	0.00	0.00	0.23	0.61	0.16	0.00
S17-4	0.05	0.00	0.62	0.22	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S17-5	0.00	0.00	0.71	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S17-6	0.16	0.00	0.37	0.15	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
S17-7	0.09	0.00	0.46	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S17-8	0.20	0.00	0.62	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S17-9	0.02	0.00	0.74	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S17-10	0.01	0.01	0.56	0.36	0.05	0.02	0.00	0.00	0.80	0.00	0.20	0.00
S17-11	0.02	0.00	0.62	0.23	0.14	0.00	0.00	0.00	0.44	0.25	0.30	0.00
S17-12	0.05	0.00	0.55	0.22	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00
S17-13	0.00	0.00	0.89	0.03	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
S17-14	0.06	0.00	0.60	0.23	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
S17-15	0.03	0.00	0.58	0.18	0.14	0.06	0.00	0.00	0.00	0.00	0.00	0.00
S17-16	0.04	0.00	0.64	0.24	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
S17-17	0.05	0.00	0.63	0.25	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
S17-18	0.10	0.00	0.48	0.25	0.12	0.05	0.00	0.00	1.00	0.00	0.00	0.00
S18-1	0.01	0.00	0.52	0.14	0.22	0.11	0.00	0.00	0.00	0.00	0.00	0.00
S18-2	0.05	0.00	0.14	0.68	0.06	0.07	0.00	0.00	0.00	0.53	0.25	0.23
S18-3	0.00	0.00	0.18	0.49	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S18-4	0.01	0.00	0.53	0.11	0.28	0.07	0.00	0.00	0.00	0.00	0.00	0.00
S18-5	0.00	0.00	0.71	0.07	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S18-6	0.01	0.00	0.32	0.14	0.32	0.21	0.01	0.00	0.10	0.46	0.31	0.11
S18-7	0.00	0.00	0.64	0.02	0.26	0.08	1.00	0.00	0.00	0.00	0.00	0.00
S18-8	0.00	0.00	0.41	0.00	0.36	0.23	0.00	0.00	0.00	0.00	0.00	0.00
S18-9	0.00	0.00	0.00	0.18	0.30	0.52	0.00	0.00	0.00	0.94	0.04	0.02
S18-10	0.00	0.00	0.00	0.13	0.57	0.30	0.00	0.00	0.00	0.83	0.15	0.01
S19-1	0.00	0.00	0.00	0.41	0.46	0.13	0.00	0.00	0.00	0.00	1.00	0.00
S19-2	0.00	0.00	0.00	0.24	0.61	0.15	0.00	0.00	0.00	0.68	0.08	0.24
S19-3	0.00	0.00	0.00	0.47	0.30	0.23	0.00	0.00	0.00	0.34	0.35	0.31
S19-4	0.00	0.00	0.00	0.29	0.62	0.09	0.00	0.00	0.00	0.23	0.44	0.33
S19-5	0.00	0.00	0.00	0.16	0.70	0.14	0.00	0.00	0.00	0.00	0.00	0.00
NFS1-1	0.27	0.01	0.26	0.11	0.35	0.00	NA	NA	NA	NA	NA	NA
NFS1-2	0.25	0.00	0.61	0.10	0.04	0.00	0.00	0.00	1.00	0.00	0.00	0.00

Table B13. Habitat unit attributes by subreach

Subreach	Habitat unit attributes (proportion of low flow wetted area)											
	Main Channel						Side Channel					
	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide	Cascade	Other	Pocket Water	Pool	Riffle	Run / Glide
NFS1-3	0.06	0.07	0.41	0.27	0.18	0.00	NA	NA	NA	NA	NA	NA
NFS1-4	0.00	0.02	0.37	0.22	0.20	0.19	NA	NA	NA	NA	NA	NA
O1-1	0.00	0.00	0.00	0.08	0.42	0.50	NA	NA	NA	NA	NA	NA
O1-2	0.00	0.00	0.00	0.19	0.55	0.26	NA	NA	NA	NA	NA	NA
O1-3	0.00	0.00	0.00	0.54	0.35	0.11	0.00	0.00	0.00	0.65	0.02	0.33
O1-4	0.00	0.00	0.00	0.65	0.20	0.14	NA	NA	NA	NA	NA	NA
H1-1	0.00	0.00	0.19	0.42	0.38	0.00	0.00	0.00	0.00	0.95	0.01	0.04
H1-2	0.03	0.00	0.20	0.39	0.21	0.16	0.00	0.00	0.00	0.00	0.34	0.66
J1-1	0.06	0.02	0.57	0.07	0.28	0.00	NA	NA	NA	NA	NA	NA
J1-2	0.05	0.00	0.69	0.12	0.15	0.00	0.00	0.00	1.00	0.00	0.00	0.00
P1-1	0.05	0.00	0.00	0.48	0.42	0.05	0.02	0.00	0.12	0.60	0.20	0.06
P1-2	0.06	0.02	0.03	0.28	0.52	0.08	0.00	0.00	0.00	0.00	0.00	0.00
W1-1	0.25	0.00	0.07	0.38	0.30	0.00	NA	NA	NA	NA	NA	NA
T1-1	0.17	0.00	0.53	0.01	0.19	0.09	0.00	0.02	0.73	0.00	0.25	0.00
ST1-1	0.50	0.01	0.23	0.17	0.08	0.00	NA	NA	NA	NA	NA	NA
ST1-2	0.06	0.00	0.24	0.36	0.34	0.00	NA	NA	NA	NA	NA	NA
R1-1	0.18	0.00	0.63	0.09	0.10	0.00	NA	NA	NA	NA	NA	NA
R1-2	0.21	0.02	0.52	0.07	0.18	0.00	NA	NA	NA	NA	NA	NA
K1-1	0.07	0.01	0.61	0.08	0.23	0.01	NA	NA	NA	NA	NA	NA
K1-2	0.15	0.00	0.50	0.28	0.06	0.00	NA	NA	NA	NA	NA	NA
C1-1	0.14	0.00	0.12	0.34	0.37	0.02	0.00	0.00	0.00	0.97	0.03	0.00
GY1-1	0.01	0.00	0.47	0.23	0.27	0.01	0.00	0.00	0.00	0.00	1.00	0.00
GY1-2	0.03	0.00	0.66	0.24	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00
GY2-3	0.34	0.00	0.34	0.17	0.15	0.00	0.00	0.00	1.00	0.00	0.00	0.00
GY2-4	0.25	0.01	0.16	0.49	0.10	0.00	NA	NA	NA	NA	NA	NA
M1-1	0.08	0.02	0.72	0.14	0.03	0.01	0.00	0.00	0.00	0.00	1.00	0.00
D1-1	0.00	0.00	0.00	0.33	0.52	0.15	0.00	0.00	0.00	0.57	0.31	0.12
D1-2	0.00	0.00	0.00	0.31	0.55	0.14	0.00	0.00	0.13	0.58	0.29	0.00
D1-3	0.00	0.00	0.12	0.30	0.52	0.05	0.00	0.00	0.00	0.76	0.14	0.10
D1-4	0.00	0.00	0.39	0.27	0.27	0.08	0.00	0.00				
D1-5	0.00	0.00	0.05	0.29	0.52	0.14	0.00	0.00	1.00	0.00	0.00	0.00
L1-1	0.01	0.00	0.80	0.14	0.05	0.00	0.02	0.00	0.69	0.29	0.00	0.00
L1-2	0.05	0.01	0.33	0.54	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00
SH1-1	0.03	0.00	0.10	0.54	0.29	0.04	0.00	0.00	0.05	0.39	0.45	0.12
SH1-1.5	NA	NA	NA	NA	NA	NA	0.00	0.00	0.09	0.47	0.33	0.11
SH1-2	0.00	0.00	0.41	0.23	0.18	0.18	0.00	0.00	0.00	0.67	0.33	0.00
SH1-3	0.12	0.00	0.47	0.34	0.07	0.00	0.12	0.00	0.55	0.26	0.03	0.05

Table B14. Pool attributes by subreach

Subreach	Pool Attributes						
	number of pools	pools /mi	average pool area (ft^2)	average pool residual depth (ft)	number of pools with >1m residual depth	proprotion pools high quality	proportion pools fair or high quality
S1-1	1	6	600	2.2	1	1.00	1.00
S1-2	1	8	5,508	1.3	0	0.00	0.00
S1-3	6	41	1,126	1.2	2	0.50	0.67
S1-4	1	7	4,620	2.0	0	0.00	1.00
S2-1	3	32	2,083	3.9	3	1.00	1.00
S2-2	16	80	606	2.4	10	0.63	0.63
S2-3	12	60	915	3.4	11	0.92	0.92
S2-4	2	15	265	2.0	1	0.50	0.50
S2-5	3	13	4,020	3.0	3	1.00	1.00
S2-6	3	22	2,065	2.5	3	1.00	1.00
S2-7	4	36	1,784	2.3	2	0.50	0.50
S2-8	6	54	2,947	2.7	6	1.00	1.00
S2-9	8	33	2,273	2.8	7	1.00	1.00
S2-10	9	34	1,769	4.3	9	1.00	1.00
S2-11	5	42	1,812	3.8	4	0.80	0.80
S2-12	2	15	5,838	2.0	1	0.50	0.50
S3-1	1	7	1,677	2.2	1	1.00	1.00
S3-2	2	14	1,656	1.7	1	0.50	1.00
S3-3		0			0	NA	NA
S3-4		0			0	NA	NA
S3-5	1	7	400	1.6	0	0.00	0.00
S3-6	3	23	3,072	2.1	2	0.67	0.67
S3-7	1	7	1,728	1.8	1	1.00	1.00
S3-8		0			0	NA	NA
S3-9	3	22	4,298	2.6	3	1.00	1.00
S3-10	3	17	3,426	1.7	1	0.33	0.33
S3-11	3	28	5,478	6.0	3	1.00	1.00
S5-1	5	8	20,919	3.4	5	1.00	1.00
S5-2		0			0	NA	NA
S5-3	2	15	3,965	1.6	0	0.00	0.50
S5-4	3	20	2,413	2.3	1	1.00	1.00
S5-5	2	15	7,493	3.5	2	1.00	1.00
S6-1	2	15	3,866	3.1	1	0.50	0.50
S6-2		0			0	NA	NA
S6-3	2	13	474	1.5	0	0.00	0.00
S7-1	1	7	1,900	1.6	0	0.00	0.00
S7-2	2	15	3,176	1.7	0	0.00	0.00
S7-3		0			0	NA	NA
S7-4	2	16	1,253	2.2	1	0.50	0.50
S7-5	3	23	1,326	1.7	2	0.67	0.67
S8-1	1	7	560	1.8	0	0.00	0.00
S8-2	1	8	250	1.6	0	0.00	0.00
S8-3	5	38	1,341	1.7	3	0.60	0.60
S8-4	1	7	2,856	3.7	1	1.00	1.00
S8-5	3	24	857	2.5	1	0.67	1.00
S8-6	1	7	2,275	3.6	1	1.00	1.00
S8-7	2	17	1,416	2.2	2	1.00	1.00

Table B14. Pool attributes by subreach

Subreach	Pool Attributes						
	number of pools	pools /mi	average pool area (ft^2)	average pool residual depth (ft)	number of pools with >1m residual depth	proprotion pools high quality	proportion pools fair or high quality
S9-1	5	36	4,797	1.8	2	0.60	0.80
S9-2	4	34	1,036	1.5	1	0.25	0.50
S9-3	7	45	373	1.2	1	0.29	0.57
S10-1		0			0	NA	NA
S10-2	2	16	1,496	2.7	1	0.50	0.50
S10-3	1	8	1,000	2.0	1	1.00	1.00
S11-1	3	23	855	1.8	1	0.33	0.67
S11-2	11	54	868	2.0	4	0.45	0.45
S11-3	4	27	1,280	1.5	0	0.25	0.50
S11-4	1	8	300	1.3	0	1.00	1.00
S11-5	1	8	280	1.3	0	0.00	0.00
S11-6	5	32	911	1.6	1	0.20	0.20
S11-7		0			0	NA	NA
S11-8	1	8	1,848	2.0	0	0.00	0.00
S11-9	3	21	593	1.8	1	0.33	0.33
S11-10	7	44	699	1.6	0	0.14	0.29
S11-11	2	16	2,863	2.1	0	0.00	0.00
S11-12	2	14	1,348	2.3	1	0.50	0.50
S11-13	3	23	1,347	0.7	1	0.67	0.67
S11-14	4	30	1,554	2.3	2	0.75	0.75
S11-15	3	22	671	3.1	2	0.67	1.00
S12-1	3	25	1,594	1.5	0	0.00	0.33
S12-2	13	95	701	1.5	0	0.46	0.46
S12-3	13	59	961	1.8	1	0.54	0.69
S12-4	7	52	1,558	1.7	0	0.29	0.43
S12-5	2	16	1,430	1.5	0	0.00	0.00
S12-6		0			0	NA	NA
S12-7	6	49	721	1.0	0	0.00	0.33
S12-8	2	17	660	1.7	0	0.50	0.50
S13-1	1	7	200	1.2	0	0.00	0.00
S13-2	1	7	738	1.4	0	0.00	0.00
S13-3	2	15	1,000	2.1	1	0.50	0.50
S13-4	3	21	1,207	1.9	0	0.00	0.00
S13-5		0			0	NA	NA
S13-6	5	38	919	1.4	0	0.40	0.80
S13-7		0			0	NA	NA
S14-1	2	12	3,023	2.7	2	1.00	1.00
S14-2		0			0	NA	NA
S14-3	7	37	947	1.1	1	0.14	0.29
S14-4	3	22	2,253	2.6	2	0.67	0.67
S14-5	1	8	1,125	1.8	0	0.00	0.00
S14-6	1	8	1,410	1.5	0	0.00	0.00
S15-1	4	29	1,269	1.8	0	0.00	0.25
S15-2	2	15	3,230	2.2	1	0.50	0.50
S15-3	4	34	676	1.2	0	0.00	0.25
S15-4	4	27	1,136	2.6	3	1.00	1.00
S15-5		0			0	NA	NA

Table B14. Pool attributes by subreach

Subreach	Pool Attributes						
	number of pools	pools /mi	average pool area (ft^2)	average pool residual depth (ft)	number of pools with >1m residual depth	proprotion pools high quality	proportion pools fair or high quality
S16-1	8	64	1,849	1.9	2	0.25	0.25
S16-2	16	111	826	1.7	2	0.19	0.38
S16-3	5	43	407	1.5	0	0.20	0.20
S16-4	8	66	1,679	2.1	1	0.13	0.13
S16-5	4	23	1,126	1.7	0	0.00	0.00
S16-6	5	37	1,098	2.1	2	0.40	0.40
S16-6SC	25	70	1,070	1.7	2	0.20	0.56
S16-7	4	29	1,545	2.5	2	0.50	1.00
S16-8	4	34	1,316	1.9	0	0.25	0.50
S16-9	5	41	1,637	2.8	3	0.60	0.60
S16-10	1	7	1,456	1.8	0	0.00	0.00
S16-11	10	77	385	1.2	0	0.00	0.30
S17-1	6	45	670	1.5	0	0.17	0.33
S17-2	4	35	686	1.6	0	0.00	0.00
S17-3	9	58	537	1.8	2	0.22	0.22
S17-4	7	50	473	1.6	0	0.00	0.14
S17-5	5	34	1,123	1.5	0	0.00	0.20
S17-6	2	30	548	1.8	0	0.00	0.00
S17-7	7	53	1,043	1.9	1	0.14	0.14
S17-8	4	30	614	1.9	0	0.00	0.00
S17-9	7	49	582	1.7	0	0.00	0.00
S17-10	10	66	683	1.8	1	0.10	0.10
S17-11	10	73	413	1.5	0	0.00	0.00
S17-12	6	40	684	1.8	1	0.17	0.33
S17-13	2	14	305	1.2	0	0.00	0.00
S17-14	6	42	479	1.4	0	0.00	0.17
S17-15	6	42	525	1.4	0	0.00	0.00
S17-16	6	46	701	1.5	0	0.00	0.17
S17-17	6	44	672	1.4	0	0.00	0.00
S17-18	5	39	766	1.9	0	0.00	0.00
S18-1	4	28	606	1.6	1	0.25	0.25
S18-2	10	80	1,380	1.4	0	0.20	0.30
S18-3	6	44	1,205	1.7	0	0.17	0.33
S18-4	3	21	651	1.3	0	0.33	0.33
S18-5	1	8	960	1.2	0	0.00	0.00
S18-6	5	38	518	2.0	2	0.40	0.40
S18-7	1	8	378	1.1	0	0.00	0.00
S18-8		0			0	NA	NA
S18-9	12	98	506	1.3	0	0.42	0.67
S18-10	14	109	593	1.3	0	0.43	0.57
S19-1	7	58	863	1.3	0	0.00	0.29
S19-2	17	137	351	1.2	0	0.24	0.59
S19-3	9	75	532	1.1	0	0.22	0.44
S19-4	11	86	405	1.4	0	0.36	0.64
S19-5	2	43	295	1.8	0	0.00	0.00
NFS1-1	4	31	301	1.8	0	0.00	1.00
NFS1-2	4	34	259	1.8	1	0.25	1.00

Table B14. Pool attributes by subreach

Subreach	Pool Attributes						
	number of pools	pools /mi	average pool area (ft^2)	average pool residual depth (ft)	number of pools with >1m residual depth	proprotion pools high quality	proportion pools fair or high quality
NFS1-3	10	95	230	1.5	1	0.00	0.70
NFS1-4	6	41	435	2.0	0	0.83	1.00
O1-1	1	7	2,010	1.2	0	0.00	1.00
O1-2	2	18	2,411	1.9	0	0.50	1.00
O1-3	7	51	1,980	4.4	2	0.43	0.57
O1-4	3	28	5,288	3.7	2	0.67	0.67
H1-1	7	54	1,934	1.4	0	0.86	1.00
H1-2	8	67	182	0.9	0	0.25	1.00
J1-1	4	32	82	1.1	0	0.00	0.75
J1-2	6	43	93	1.1	0	0.17	0.67
P1-1	23	185	274	1.2	0	0.13	0.35
P1-2	10	79	235	1.3	0	0.40	0.70
W1-1	9	61	326	1.5	0	0.11	0.44
T1-1	1	9	25	0.6	0	1.00	1.00
ST1-1	9	73	134	1.2	0	0.22	0.78
ST1-2	13	102	214	1.1	0	0.46	1.00
R1-1	6	45	59	0.9	0	0.17	0.67
R1-2	5	40	63	0.7	0	0.00	0.80
K1-1	6	45	84	0.9	0	0.17	0.83
K1-2	9	79	189	1.1	0	0.00	0.78
C1-1	11	75	261	1.0	0	0.00	0.73
GY1-1	10	79	226	1.3	0	0.10	0.10
GY1-2	10	82	161	1.3	0	0.10	0.40
GY2-3	7	58	204	1.5	0	0.14	0.86
GY2-4	16	123	305	1.4	1	0.19	0.75
M1-1	9	74	88	1.3	0	0.33	0.89
D1-1	30	204	274	1.2	0	0.41	0.53
D1-2	7	61	393	1.3	0	0.36	0.55
D1-3	6	47	399	1.5	0	0.33	0.44
D1-4	7	61	257	1.4	0	0.67	0.83
D1-5	8	68	406	1.4	0	0.00	0.43
L1-1	14	105	120	1.1	0	0.14	0.29
L1-2	12	103	355	1.5	0	0.17	0.42
SH1-1	21	167	257	1.2	0	0.57	0.95
SH1-1.5	29	101	215	1.2	0	0.59	0.97
SH1-2	9	76	311	1.5	0	0.89	1.00
SH1-3	18	141	247	1.3	0	0.11	0.67

Table B15. Substrate attributes by subreach

Subreach	Substrate Attributes							
	dominant substrate (proportion of low flow wetted area)							spawning
	Bedrock	Boulder	Cobble	Gravel	Sand	Silt/Clay	Organic	field measured area (ft^2)
S1-1	0.00	0.00	0.67	0.19	0.03	0.10	0.00	900
S1-2	0.00	0.00	0.87	0.13	0.00	0.00	0.00	175
S1-3	0.00	0.00	0.75	0.24	0.01	0.00	0.00	380
S1-4	0.00	0.00	1.00	0.00	0.00	0.00	0.00	850
S2-1	0.09	0.80	0.11	0.00	0.00	0.00	0.00	470
S2-2	0.09	0.87	0.00	0.00	0.03	0.00	0.00	336
S2-3	0.64	0.32	0.00	0.01	0.03	0.00	0.00	30
S2-4	0.00	0.38	0.62	0.00	0.00	0.00	0.00	0
S2-5	0.00	0.79	0.21	0.00	0.00	0.00	0.00	200
S2-6	0.05	0.89	0.06	0.00	0.00	0.00	0.00	0
S2-7	0.51	0.49	0.00	0.00	0.00	0.00	0.00	10
S2-8	0.21	0.79	0.00	0.00	0.00	0.00	0.00	50
S2-9	0.29	0.61	0.09	0.00	0.00	0.00	0.00	10
S2-10	0.34	0.61	0.00	0.05	0.00	0.00	0.00	55
S2-11	0.37	0.63	0.00	0.00	0.00	0.00	0.00	0
S2-12	0.00	0.73	0.27	0.00	0.00	0.00	0.00	245
S3-1	0.36	0.00	0.64	0.00	0.00	0.00	0.00	0
S3-2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	10
S3-3	0.00	0.00	1.00	0.00	0.00	0.00	0.00	300
S3-4	0.00	0.54	0.46	0.00	0.00	0.00	0.00	0
S3-5	0.00	0.16	0.84	0.00	0.00	0.00	0.00	120
S3-6	0.04	0.59	0.36	0.00	0.00	0.00	0.00	250
S3-7	0.18	0.00	0.82	0.00	0.00	0.00	0.00	0
S3-8	0.14	0.00	0.86	0.00	0.00	0.00	0.00	0
S3-9	0.11	0.46	0.43	0.00	0.00	0.00	0.00	10
S3-10	0.07	0.13	0.80	0.00	0.00	0.00	0.00	0
S3-11	0.94	0.05	0.01	0.00	0.00	0.00	0.00	0
S5-1	0.00	0.00	0.00	1.00	0.00	0.00	0.00	12050
S5-2	0.00	0.00	0.58	0.42	0.00	0.00	0.00	0
S5-3	0.00	0.00	0.71	0.29	0.00	0.00	0.00	0
S5-4	0.00	0.00	0.75	0.20	0.05	0.00	0.00	620
S5-5	0.00	0.00	0.34	0.66	0.00	0.00	0.00	430
S6-1	0.00	0.00	0.56	0.44	0.00	0.00	0.00	230
S6-2	0.00	0.00	0.92	0.08	0.00	0.00	0.00	80
S6-3	0.00	0.00	0.91	0.05	0.04	0.00	0.00	1239
S7-1	0.00	0.00	1.00	0.00	0.00	0.00	0.00	70
S7-2	0.00	0.39	0.59	0.02	0.00	0.00	0.00	155
S7-3	0.00	0.07	0.55	0.38	0.00	0.00	0.00	165
S7-4	0.00	0.00	1.00	0.00	0.00	0.00	0.00	215
S7-5	0.00	0.22	0.78	0.00	0.00	0.00	0.00	185
S8-1	0.00	0.00	0.85	0.15	0.00	0.00	0.00	47
S8-2	0.00	0.00	1.00	0.00	0.00	0.00	0.00	15
S8-3	0.45	0.08	0.34	0.13	0.00	0.00	0.00	357
S8-4	0.11	0.00	0.89	0.00	0.00	0.00	0.00	90
S8-5	0.00	0.41	0.47	0.12	0.00	0.00	0.00	100
S8-6	0.13	0.11	0.76	0.00	0.00	0.00	0.00	90
S8-7	0.23	0.72	0.05	0.00	0.00	0.00	0.00	120

Table B15. Substrate attributes by subreach

Subreach	Substrate Attributes							
	dominant substrate (proportion of low flow wetted area)							spawning
	Bedrock	Boulder	Cobble	Gravel	Sand	Silt/Clay	Organic	field measured area (ft^2)
S9-1	0.03	0.35	0.08	0.01	0.00	0.53	0.00	390
S9-2	0.00	0.15	0.75	0.09	0.00	0.00	0.00	115
S9-3	0.00	0.49	0.41	0.08	0.01	0.00	0.00	970
S10-1	0.00	0.22	0.78	0.00	0.00	0.00	0.00	0
S10-2	0.04	0.08	0.76	0.12	0.00	0.00	0.00	285
S10-3	0.04	0.25	0.71	0.00	0.00	0.00	0.00	181
S11-1	0.06	0.09	0.75	0.10	0.00	0.00	0.00	125
S11-2	0.00	0.06	0.29	0.65	0.00	0.00	0.00	2575
S11-3	0.00	0.26	0.74	0.00	0.00	0.00	0.00	520
S11-4	0.00	0.40	0.30	0.29	0.01	0.00	0.00	235
S11-5	0.00	0.18	0.00	0.82	0.00	0.00	0.00	635
S11-6	0.00	0.64	0.14	0.22	0.00	0.00	0.00	75
S11-7	0.00	0.00	1.00	0.00	0.00	0.00	0.00	415
S11-8	0.00	0.00	0.66	0.34	0.00	0.00	0.00	1360
S11-9	0.00	0.10	0.16	0.67	0.07	0.00	0.00	1585
S11-10	0.00	0.04	0.65	0.18	0.13	0.00	0.00	886
S11-11	0.00	0.00	0.77	0.23	0.00	0.00	0.00	130
S11-12	0.00	0.00	0.92	0.08	0.00	0.00	0.00	400
S11-13	0.00	0.00	0.27	0.72	0.02	0.00	0.00	610
S11-14	0.00	0.06	0.86	0.08	0.00	0.00	0.00	20
S11-15	0.00	0.30	0.62	0.08	0.00	0.00	0.00	50
S12-1	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0
S12-2	0.00	0.03	0.85	0.03	0.01	0.08	0.00	170
S12-3	0.00	0.03	0.67	0.24	0.06	0.00	0.00	650
S12-4	0.00	0.00	0.40	0.52	0.00	0.08	0.00	765
S12-5	0.00	0.48	0.52	0.00	0.00	0.00	0.00	0
S12-6	0.00	0.38	0.62	0.00	0.00	0.00	0.00	20
S12-7	0.00	0.72	0.11	0.03	0.07	0.06	0.00	386
S12-8	0.00	0.53	0.46	0.01	0.00	0.00	0.00	10
S13-1	0.00	0.56	0.44	0.00	0.00	0.00	0.00	10
S13-2	0.02	0.34	0.63	0.00	0.00	0.00	0.00	0
S13-3	0.00	0.23	0.77	0.00	0.00	0.00	0.00	46
S13-4	0.00	0.38	0.62	0.00	0.00	0.00	0.00	182
S13-5	0.00	0.70	0.30	0.00	0.00	0.00	0.00	0
S13-6	0.00	0.29	0.66	0.00	0.02	0.03	0.00	0
S13-7	0.00	0.61	0.39	0.00	0.00	0.00	0.00	10
S14-1	0.00	0.13	0.77	0.10	0.00	0.00	0.00	150
S14-2	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0
S14-3	0.03	0.70	0.27	0.00	0.00	0.00	0.00	0
S14-4	0.00	0.12	0.59	0.23	0.06	0.00	0.00	1110
S14-5	0.00	0.00	1.00	0.00	0.00	0.00	0.00	130
S14-6	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0
S15-1	0.00	0.00	0.73	0.27	0.00	0.00	0.00	480
S15-2	0.00	0.00	0.91	0.09	0.00	0.00	0.00	490
S15-3	0.00	0.00	0.99	0.00	0.00	0.00	0.00	140
S15-4	0.00	0.00	0.81	0.19	0.00	0.00	0.00	1120
S15-5	0.00	0.00	1.00	0.00	0.00	0.00	0.00	10

Table B15. Substrate attributes by subreach

Subreach	Substrate Attributes							
	dominant substrate (proportion of low flow wetted area)							spawning
	Bedrock	Boulder	Cobble	Gravel	Sand	Silt/Clay	Organic	field measured area (ft^2)
S16-1	0.00	0.05	0.81	0.02	0.12	0.00	0.00	955
S16-2	0.00	0.00	0.46	0.37	0.15	0.03	0.00	4850
S16-3	0.00	0.00	0.69	0.23	0.07	0.01	0.00	100
S16-4	0.00	0.00	0.88	0.12	0.00	0.00	0.00	370
S16-5	0.00	0.00	0.92	0.06	0.02	0.00	0.00	460
S16-6	0.00	0.00	1.00	0.00	0.00	0.00	0.00	800
S16-6SC	0.00	0.00	0.44	0.52	0.04	0.00	0.00	13255
S16-7	0.00	0.00	1.00	0.00	0.00	0.00	0.00	500
S16-8	0.00	0.00	0.87	0.13	0.00	0.00	0.00	1050
S16-9	0.00	0.00	0.91	0.09	0.00	0.00	0.00	400
S16-10	0.00	0.58	0.42	0.00	0.00	0.00	0.00	0
S16-11	0.00	0.40	0.55	0.05	0.00	0.00	0.00	120
S17-1	0.00	0.34	0.66	0.00	0.00	0.00	0.00	440
S17-2	0.00	0.82	0.18	0.00	0.00	0.00	0.00	40
S17-3	0.00	0.58	0.41	0.00	0.01	0.00	0.00	305
S17-4	0.00	0.42	0.58	0.00	0.00	0.00	0.00	195
S17-5	0.00	0.39	0.61	0.00	0.00	0.00	0.00	380
S17-6	0.00	0.85	0.15	0.00	0.00	0.00	0.00	170
S17-7	0.00	1.00	0.00	0.00	0.00	0.00	0.00	705
S17-8	0.00	0.95	0.05	0.00	0.00	0.00	0.00	880
S17-9	0.00	0.61	0.39	0.00	0.00	0.00	0.00	230
S17-10	0.00	0.80	0.18	0.02	0.00	0.00	0.01	880
S17-11	0.00	0.61	0.35	0.00	0.03	0.00	0.00	265
S17-12	0.00	0.65	0.35	0.00	0.00	0.00	0.00	290
S17-13	0.00	0.02	0.98	0.00	0.00	0.00	0.00	500
S17-14	0.00	1.00	0.00	0.00	0.00	0.00	0.00	230
S17-15	0.00	0.65	0.35	0.00	0.00	0.00	0.00	325
S17-16	0.00	0.80	0.20	0.00	0.00	0.00	0.00	230
S17-17	0.00	1.00	0.00	0.00	0.00	0.00	0.00	330
S17-18	0.00	0.55	0.45	0.00	0.00	0.00	0.00	310
S18-1	0.00	0.35	0.65	0.00	0.00	0.00	0.00	590
S18-2	0.00	0.49	0.26	0.07	0.18	0.00	0.00	1535
S18-3	0.00	0.00	0.74	0.26	0.00	0.00	0.00	2290
S18-4	0.00	0.15	0.85	0.00	0.00	0.00	0.00	110
S18-5	0.00	0.77	0.23	0.00	0.00	0.00	0.00	60
S18-6	0.00	0.39	0.59	0.01	0.00	0.00	0.00	810
S18-7	0.00	0.64	0.36	0.00	0.00	0.00	0.01	590
S18-8	0.00	0.03	0.97	0.00	0.00	0.00	0.00	210
S18-9	0.00	0.01	0.73	0.25	0.00	0.00	0.00	3615
S18-10	0.00	0.00	0.73	0.05	0.03	0.18	0.00	1075
S19-1	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1210
S19-2	0.00	0.01	0.79	0.17	0.00	0.03	0.00	1660
S19-3	0.00	0.00	0.79	0.03	0.05	0.02	0.11	375
S19-4	0.00	0.00	0.81	0.06	0.08	0.04	0.00	790
S19-5	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0
NFS1-1	0.00	0.33	0.38	0.22	0.00	0.08	0.00	150
NFS1-2	0.10	0.67	0.03	0.20	0.00	0.00	0.00	35

Table B15. Substrate attributes by subreach

Subreach	Substrate Attributes							
	dominant substrate (proportion of low flow wetted area)							spawning
	Bedrock	Boulder	Cobble	Gravel	Sand	Silt/Clay	Organic	field measured area (ft^2)
NFS1-3	0.19	0.43	0.18	0.20	0.00	0.00	0.00	187
NFS1-4	0.02	0.13	0.03	0.66	0.15	0.00	0.00	1595
O1-1	0.00	0.17	0.50	0.25	0.00	0.00	0.08	3650
O1-2	0.00	0.00	0.86	0.14	0.00	0.00	0.00	2640
O1-3	0.00	0.00	0.50	0.50	0.00	0.00	0.00	5225
O1-4	0.00	0.00	0.55	0.45	0.00	0.00	0.00	2495
H1-1	0.00	0.00	0.00	0.18	0.04	0.28	0.50	820
H1-2	0.00	0.00	0.04	0.50	0.46	0.00	0.00	375
J1-1	0.00	0.32	0.49	0.20	0.00	0.00	0.00	65
J1-2	0.01	0.40	0.15	0.42	0.02	0.00	0.00	110
P1-1	0.00	0.01	0.51	0.38	0.00	0.10	0.01	1875
P1-2	0.00	0.23	0.73	0.02	0.00	0.00	0.02	335
W1-1	0.02	0.07	0.35	0.56	0.00	0.00	0.00	2910
T1-1	0.00	0.03	0.12	0.43	0.30	0.00	0.12	350
ST1-1	0.00	0.05	0.89	0.05	0.00	0.00	0.01	340
ST1-2	0.00	0.12	0.53	0.35	0.00	0.00	0.00	325
R1-1	0.00	0.23	0.77	0.00	0.00	0.00	0.00	330
R1-2	0.00	0.00	0.87	0.11	0.00	0.00	0.02	450
K1-1	0.00	0.00	0.92	0.07	0.00	0.00	0.00	270
K1-2	0.00	0.14	0.66	0.20	0.00	0.00	0.00	540
C1-1	0.00	0.00	0.24	0.42	0.02	0.00	0.32	1580
GY1-1	0.00	0.23	0.63	0.14	0.00	0.00	0.00	235
GY1-2	0.00	0.09	0.86	0.05	0.00	0.00	0.00	335
GY2-3	0.00	0.65	0.26	0.09	0.00	0.00	0.00	235
GY2-4	0.00	0.59	0.38	0.02	0.00	0.00	0.01	420
M1-1	0.00	0.69	0.22	0.07	0.00	0.00	0.02	295
D1-1	0.00	0.02	0.79	0.18	0.00	0.00	0.01	715
D1-2	0.00	0.00	0.97	0.03	0.00	0.00	0.00	685
D1-3	0.00	0.14	0.66	0.20	0.00	0.00	0.00	535
D1-4	0.00	0.16	0.56	0.23	0.05	0.00	0.00	645
D1-5	0.00	0.14	0.77	0.03	0.04	0.02	0.00	205
L1-1	0.00	0.35	0.64	0.00	0.01	0.00	0.00	105
L1-2	0.12	0.22	0.54	0.10	0.00	0.00	0.02	548
SH1-1	0.02	0.00	0.18	0.79	0.00	0.00	0.01	1062
SH1-1.5	0.00	0.01	0.33	0.57	0.05	0.00	0.05	1810
SH1-2	0.00	0.00	0.34	0.63	0.02	0.00	0.01	1065
SH1-3	0.02	0.23	0.54	0.18	0.03	0.00	0.00	565

Table B16. Large wood summary attributes by subreach

Subreach	Large wood summary attributes (main channel and side channel wood aggregated)				
	total large wood (jams included)		individual large wood (jams excluded)		forest service weirs
	number pieces >35 ft/mile	number pieces >25 ft/mile	number pieces >35 ft	number pieces >25 ft	count
S1-1	0	17	0	1	0
S1-2	0	8	0	1	0
S1-3	7	76	1	6	0
S1-4	7	35	1	5	0
S2-1	32	64	3	6	0
S2-2	25	80	0	5	0
S2-3	5	20	0	2	0
S2-4	0	23	0	3	0
S2-5	4	13	1	3	0
S2-6	59	103	2	8	0
S2-7	9	18	1	2	0
S2-8	18	36	2	4	0
S2-9	21	41	5	10	0
S2-10	4	19	1	5	0
S2-11	0	17	0	2	0
S2-12	0	0	0	0	0
S3-1	22	66	1	5	0
S3-2	111	173	1	3	0
S3-3	19	45	2	3	0
S3-4	0	0	0	0	0
S3-5	7	26	1	4	0
S3-6	23	69	3	6	0
S3-7	58	124	2	6	0
S3-8	12	19	2	3	0
S3-9	22	73	3	6	0
S3-10	6	68	1	8	0
S3-11	0	47	0	5	0
S5-1	6	11	4	7	0
S5-2	24	49	0	3	0
S5-3	38	98	1	2	0
S5-4	237	428	7	9	0
S5-5	44	103	4	11	0
S6-1	15	15	2	2	1
S6-2	97	161	7	14	0
S6-3	13	20	2	3	0
S7-1	7	7	1	1	1
S7-2	8	39	1	4	0
S7-3	0	0	0	0	0
S7-4	79	87	5	5	0
S7-5	46	61	2	3	0
S8-1	30	67	4	9	0
S8-2	30	30	4	4	0
S8-3	15	15	2	2	0
S8-4	0	7	0	1	0
S8-5	312	513	3	8	0
S8-6	42	77	6	11	0
S8-7	26	35	3	3	0

Table B16. Large wood summary attributes by subreach

Subreach	Large wood summary attributes (main channel and side channel wood aggregated)				
	total large wood (jams included)		individual large wood (jams excluded)		forest service weirs
	number pieces >35 ft/mile	number pieces >25 ft/mile	number pieces >35 ft	number pieces >25 ft	count
S9-1	50	86	6	10	0
S9-2	9	17	1	2	0
S9-3	90	199	2	6	1
S10-1	9	35	1	4	3
S10-2	8	16	1	2	0
S10-3	8	8	1	1	1
S11-1	122	176	2	3	5
S11-2	348	500	3	9	0
S11-3	149	189	0	4	3
S11-4	49	91	1	4	5
S11-5	33	57	4	7	8
S11-6	90	128	2	4	4
S11-7	21	63	3	9	0
S11-8	67	92	5	7	0
S11-9	28	76	4	11	0
S11-10	163	358	1	2	0
S11-11	0	40	0	2	0
S11-12	107	171	2	5	0
S11-13	83	158	1	1	0
S11-14	144	212	3	3	0
S11-15	221	331	3	6	1
S12-1	0	50	0	4	0
S12-2	528	887	0	2	0
S12-3	191	360	0	7	0
S12-4	243	486	1	10	0
S12-5	40	64	2	5	0
S12-6	15	85	0	8	0
S12-7	137	291	3	16	0
S12-8	240	411	0	2	0
S13-1	14	63	2	9	0
S13-2	120	162	2	8	0
S13-3	167	218	1	7	0
S13-4	21	48	2	6	0
S13-5	8	25	1	3	0
S13-6	60	128	5	11	0
S13-7	24	111	2	11	0
S14-1	37	136	0	2	0
S14-2	0	8	0	1	0
S14-3	5	26	1	3	0
S14-4	36	65	5	9	0
S14-5	32	56	4	7	0
S14-6	8	15	1	2	0
S15-1	102	175	4	7	0
S15-2	80	131	10	11	0
S15-3	42	59	5	6	0
S15-4	115	224	2	10	0
S15-5	28	49	4	7	0

Table B16. Large wood summary attributes by subreach

Subreach	Large wood summary attributes (main channel and side channel wood aggregated)				
	total large wood (jams included)		individual large wood (jams excluded)		forest service weirs
	number pieces >35 ft/mile	number pieces >25 ft/mile	number pieces >35 ft	number pieces >25 ft	count
S16-1	143	215	2	3	0
S16-2	194	373	5	7	0
S16-3	119	247	7	7	0
S16-4	182	281	2	3	0
S16-5	34	57	2	4	0
S16-6	104	201	3	4	0
S16-6SC	200	352	2	8	0
S16-7	107	172	0	1	0
S16-8	101	287	1	5	0
S16-9	49	115	4	10	0
S16-10	15	52	2	7	0
S16-11	23	39	3	5	0
S17-1	89	164	3	5	0
S17-2	18	18	2	2	0
S17-3	45	90	5	12	0
S17-4	43	72	3	5	0
S17-5	27	34	4	5	0
S17-6	15	45	1	3	0
S17-7	15	30	2	4	0
S17-8	23	53	1	5	0
S17-9	28	56	4	8	0
S17-10	86	172	3	6	0
S17-11	175	277	11	13	0
S17-12	20	79	2	5	0
S17-13	14	28	2	3	0
S17-14	35	90	1	4	0
S17-15	50	92	5	9	0
S17-16	61	122	4	8	0
S17-17	0	15	0	2	0
S17-18	8	47	1	6	0
S18-1	14	50	2	4	0
S18-2	56	96	5	9	0
S18-3	88	204	3	9	0
S18-4	55	76	4	6	3
S18-5	8	25	1	3	0
S18-6	15	46	2	5	3
S18-7	31	76	4	10	0
S18-8	8	25	1	3	0
S18-9	123	221	8	19	0
S18-10	70	218	6	18	0
S19-1	41	99	5	10	0
S19-2	24	73	1	5	0
S19-3	33	92	4	9	1
S19-4	62	156	3	12	0
S19-5	43	43	1	1	0
NFS1-1	273	343	1	5	0
NFS1-2	475	593	2	5	0

Table B16. Large wood summary attributes by subreach

Subreach	Large wood summary attributes (main channel and side channel wood aggregated)				
	total large wood (jams included)		individual large wood (jams excluded)		forest service weirs
	number pieces >35 ft/mile	number pieces >25 ft/mile	number pieces >35 ft	number pieces >25 ft	count
NFS1-3	38	133	1	8	0
NFS1-4	327	408	1	5	0
O1-1	21	49	3	7	0
O1-2	98	223	4	8	0
O1-3	29	102	2	6	0
O1-4	28	76	3	7	0
H1-1	8	8	1	1	0
H1-2	0	51	0	1	0
J1-1	8	16	1	2	0
J1-2	7	36	1	5	0
P1-1	88	241	2	8	0
P1-2	142	237	5	7	0
W1-1	41	82	5	11	12
T1-1	35	69	4	8	0
ST1-1	49	81	2	4	0
ST1-2	70	133	3	6	0
R1-1	15	30	2	4	0
R1-2	97	129	12	16	0
K1-1	37	74	3	8	0
K1-2	88	141	8	14	0
C1-1	41	82	1	5	0
GY1-1	24	55	3	7	0
GY1-2	131	197	3	6	0
GY2-3	42	58	5	7	0
GY2-4	0	23	0	3	0
M1-1	141	397	3	13	0
D1-1	41	116	3	9	0
D1-2	35	122	1	6	0
D1-3	23	85	1	5	0
D1-4	52	104	4	6	0
D1-5	84	169	2	7	0
L1-1	4,332	605	1	9	0
L1-2	4,603	2,709	2	8	0
SH1-1	366	477	4	9	0
SH1-1.5	262	311	3	8	0
SH1-2	285	369	3	5	0
SH1-3	118	243	5	12	0

Table B17. Bank condition attributes by subreach

Subreach	Bank Condition					
	Sum of length hardened (ft)	Sum of length natural, active (ft)	Sum of length natural, part stabalized (ft)	% armored	% unstable	% riparian area connected to stream
S1-1	0	80	0	0	4	100
S1-2	0	124	0	0	9	100
S1-3	318	32	0	21	2	80
S1-4	380	352	0	25	23	58
S2-1	180	0	140	18	14	79
S2-2	0	0	0	0	0	100
S2-3	0	0	0	0	0	100
S2-4	0	0	0	0	0	100
S2-5	0	0	0	0	0	100
S2-6	0	40	130	0	12	100
S2-7	0	0	0	0	0	100
S2-8	0	0	0	0	0	100
S2-9	0	0	0	0	0	100
S2-10	0	0	0	0	0	100
S2-11	0	0	0	0	0	100
S2-12	0	0	0	0	0	63
S3-1	0	0	0	0	0	100
S3-2	0	120	0	0	8	70
S3-3	225	0	0	14	0	26
S3-4	0	0	0	0	0	99
S3-5	0	0	0	0	0	100
S3-6	0	132	0	0	10	90
S3-7	120	0	0	8	0	91
S3-8	0	0	0	0	0	82
S3-9	0	0	0	0	0	93
S3-10	30	0	0	2	0	93
S3-11	0	0	0	0	0	100
S5-1	0	60	0	0	1	100
S5-2	0	410	0	0	32	100
S5-3	0	30	0	0	2	98
S5-4	0	90	0	0	6	100
S5-5	0	175	0	0	12	100
S6-1	0	0	0	0	0	100
S6-2	0	25	0	0	2	100
S6-3	50	170	0	3	11	71
S7-1	110	100	0	7	7	90
S7-2	0	175	0	0	13	100
S7-3	0	0	0	0	0	100
S7-4	0	235	80	0	24	100
S7-5	0	80	100	0	13	100
S8-1	424	0	100	30	7	74
S8-2	0	0	0	0	0	94
S8-3	0	0	0	0	0	86
S8-4	0	0	0	0	0	88
S8-5	0	150	0	0	11	80
S8-6	0	0	0	0	0	72
S8-7	0	0	75	0	6	61

Table B17. Bank condition attributes by subreach

Subreach	Bank Condition					
	Sum of length hardened (ft)	Sum of length natural, active (ft)	Sum of length natural, part stabalized (ft)	% armored	% unstable	% riparian area connected to stream
S9-1	0	0	0	0	0	97
S9-2	0	0	60	0	5	100
S9-3	200	153	145	12	18	85
S10-1	0	0	0	0	0	52
S10-2	380	0	0	28	0	54
S10-3	0	0	40	0	3	61
S11-1	0	0	0	0	0	98
S11-2	0	80	0	0	4	90
S11-3	0	250	0	0	16	96
S11-4	220	0	0	17	0	89
S11-5	0	0	0	0	0	55
S11-6	0	0	0	0	0	83
S11-7	278	80	0	14	4	82
S11-8	0	0	140	0	11	53
S11-9	80	50	0	5	3	53
S11-10	0	0	175	0	10	96
S11-11	0	0	0	0	0	77
S11-12	230	86	0	16	6	74
S11-13	0	0	0	0	0	100
S11-14	0	0	220	0	16	100
S11-15	0	375	0	0	26	90
S12-1	75	100	0	6	8	87
S12-2	0	0	0	0	0	96
S12-3	0	0	0	0	0	78
S12-4	0	0	70	0	5	73
S12-5	0	0	0	0	0	69
S12-6	0	0	25	0	2	87
S12-7	0	120	0	0	9	85
S12-8	0	165	0	0	13	77
S13-1	0	0	85	0	6	65
S13-2	0	70	0	0	5	64
S13-3	0	0	0	0	0	100
S13-4	40	90	0	3	6	47
S13-5	240	0	100	19	8	57
S13-6	0	70	0	0	5	100
S13-7	0	0	0	0	0	100
S14-1	0	0	0	0	0	73
S14-2	0	0	0	0	0	72
S14-3	635	0	0	32	0	59
S14-4	0	0	0	0	0	80
S14-5	0	0	0	0	0	95
S14-6	0	0	0	0	0	76
S15-1	0	0	0	0	0	100
S15-2	0	60	0	0	4	100
S15-3	0	0	0	0	0	100
S15-4	0	45	90	0	9	100
S15-5	0	0	0	0	0	100

Table B17. Bank condition attributes by subreach

Subreach	Bank Condition					
	Sum of length hardened (ft)	Sum of length natural, active (ft)	Sum of length natural, part stabalized (ft)	% armored	% unstable	% riparian area connected to stream
S16-1	0	150	0	0	11	100
S16-2	0	0	0	0	0	100
S16-3	120	0	0	10	0	100
S16-4	0	160	0	0	13	100
S16-5	0	100	85	0	3	100
S16-6	0	0	230	0	16	100
S16-6SC						100
S16-7	0	0	0	0	0	100
S16-8	0	0	0	0	0	100
S16-9	0	0	120	0	9	100
S16-10	0	0	0	0	0	94
S16-11	0	0	0	0	0	80
S17-1	0	0	0	0	0	76
S17-2	0	0	0	0	0	65
S17-3	0	0	0	0	0	54
S17-4	0	0	0	0	0	53
S17-5	0	0	0	0	0	54
S17-6	0	0	0	0	0	55
S17-7	0	0	0	0	0	51
S17-8	0	0	0	0	0	55
S17-9	0	0	0	0	0	55
S17-10	0	0	0	0	0	60
S17-11	0	0	0	0	0	56
S17-12	0	0	0	0	0	51
S17-13	0	0	0	0	0	57
S17-14	0	0	0	0	0	59
S17-15	0	0	0	0	0	55
S17-16	0	0	0	0	0	54
S17-17	0	0	0	0	0	53
S17-18	0	0	0	0	0	56
S18-1	0	0	0	0	0	62
S18-2	0	0	0	0	0	56
S18-3	0	0	0	0	0	62
S18-4	0	122	0	0	8	73
S18-5	0	0	0	0	0	61
S18-6	0	0	0	0	0	56
S18-7	150	0	0	11	0	50
S18-8	90	0	0	7	0	54
S18-9	25	0	0	2	0	78
S18-10	265	0	0	20	0	58
S19-1	0	0	0	0	0	66
S19-2	111	122	0	8	9	62
S19-3	0	0	0	0	0	90
S19-4	0	0	0	0	0	100
S19-5	0	25	0	0	5	100
NFS1-1	0	0	0	0	0	100
NFS1-2	0	0	0	0	0	100

Table B17. Bank condition attributes by subreach

Subreach	Bank Condition					
	Sum of length hardened (ft)	Sum of length natural, active (ft)	Sum of length natural, part stabalized (ft)	% armored	% unstable	% riparian area connected to stream
NFS1-3	0	0	0	0	0	100
NFS1-4	0	0	0	0	0	100
O1-1	0	0	0	0	0	100
O1-2	0	0	0	0	0	100
O1-3	0	0	0	0	0	100
O1-4	0	0	0	0	0	100
H1-1	0	30	0	0	2	100
H1-2	0	0	0	0	0	100
J1-1	0	0	0	0	0	100
J1-2	0	0	0	0	0	100
P1-1	0	0	0	0	0	100
P1-2	70	0	0	5	0	100
W1-1	0	0	0	0	0	100
T1-1	0	0	0	0	0	100
ST1-1	0	50	0	0	4	100
ST1-2	0	0	0	0	0	100
R1-1	0	0	0	0	0	100
R1-2	0	0	0	0	0	100
K1-1	0	26	0	0	2	100
K1-2	0	25	0	0	2	100
C1-1	0	25	0	0	2	100
GY1-1	70	26	0	5	2	90
GY1-2	35	0	0	3	0	100
GY2-3	0	0	0	0	0	100
GY2-4	0	0	0	0	0	100
M1-1	0	0	0	0	0	100
D1-1	0	0	0	0	0	100
D1-2	0	0	0	0	0	100
D1-3	0	0	0	0	0	100
D1-4	0	0	0	0	0	100
D1-5	0	0	0	0	0	100
L1-1	0	0	0	0	0	100
L1-2	0	0	0	0	0	100
SH1-1	0	40	0	0	3	100
SH1-1.5	0	0	0	0	0	100
SH1-2	0	0	0	0	0	100
SH1-3	0	80	0	0	6	100

Table B18. Log jam attributes by subreach

Subreach	Log jam attributes						
	log jam count	log jams/mi	average log jam volume (ft^3)	standard deviation of log jam volume (ft3)	large wood >25 ft in log jams count	large wood >35 ft in log jams count	brush wood in log jams count
S1-1	1	6	2,160	N/A	2	0	45
S1-2	0	0				0	
S1-3	3	21	1,167	586	5	0	59
S1-4	0	0				0	
S2-1	0	0				0	
S2-2	4	20	3,275	1,473	11	5	151
S2-3	3	15	3,933	1,102	2	1	112
S2-4	0	0				0	
S2-5	0	0				0	
S2-6	1	7	8,000	N/A	6	6	15
S2-7	0	0				0	
S2-8	0	0				0	
S2-9	0	0				0	
S2-10	0	0				0	
S2-11	0	0				0	
S2-12	0	0				0	
S3-1	1	7	1,050	N/A	4	2	3
S3-2	3	21	7,873	10,113	22	15	130
S3-3	1	6	1,735	N/A	4	1	51
S3-4	0	0				0	
S3-5	0	0				0	
S3-6	1	8	2,560	N/A	3	0	13
S3-7	2	15	1,623	343	11	6	32
S3-8	0	0				0	
S3-9	3	22	452	140	4	0	34
S3-10	1	6	1,200	N/A	4	0	16
S3-11	0	0				0	
S5-1	0	0				0	
S5-2	1	8	1,200	N/A	3	3	20
S5-3	1	8	5,400	N/A	11	4	8
S5-4	3	20	17,333	28,291	56	29	89
S5-5	1	7	0	N/A	3	2	5
S6-1	0	0				0	
S6-2	1	8	1,250	N/A	6	5	12
S6-3	0	0				0	
S7-1	0	0				0	
S7-2	1	8	380	N/A	1	0	8
S7-3	0	0				0	
S7-4	1	8	8,300	N/A	6	5	18
S7-5	1	8	1,500	N/A	5	4	8
S8-1	0	0				0	
S8-2	0	0				0	
S8-3	0	0				0	
S8-4	0	0				0	
S8-5	1	8	64,000	N/A	56	36	142
S8-6	0	0				0	
S8-7	1	9	400	N/A	1	0	5

Table B18. Log jam attributes by subreach

Subreach	Log jam attributes						
	log jam count	log jams/mi	average log jam volume (ft^3)	standard deviation of log jam volume (ft3)	large wood >25 ft in log jams count	large wood >35 ft in log jams count	brush wood in log jams count
S9-1	1	7	800	N/A	2	1	10
S9-2	0	0				0	
S9-3	4	26	7,498	11,723	25	12	119
S10-1	0	0				0	
S10-2	0	0				0	
S10-3	0	0				0	
S11-1	2	15	3,175	3,995	20	14	19
S11-2	8	39	8,563	8,064	93	68	168
S11-3	4	27	3,500	2,273	24	22	29
S11-4	1	8	1,000	N/A	7	5	6
S11-5	0	0				0	
S11-6	4	26	950	1,038	16	12	28
S11-7	1	5	500	N/A	3	1	3
S11-8	1	8	500	N/A	4	3	10
S11-9	0	0				0	
S11-10	2	13	38,375	51,796	55	25	200
S11-11	1	8	750	N/A	3	0	4
S11-12	2	14	4,625	5,480	19	13	29
S11-13	3	23	4,583	6,866	20	10	61
S11-14	4	30	4,250	4,031	25	16	78
S11-15	6	44	4,125	3,224	39	27	49
S12-1	1	8	500	N/A	2	0	11
S12-2	5	37	4,840	8,505	119	72	176
S12-3	7	32	2,714	2,346	72	42	237
S12-4	5	37	1,650	1,084	56	32	99
S12-5	1	8	300	N/A	3	3	2
S12-6	1	8	800	N/A	3	2	2
S12-7	6	49	767	264	20	14	35
S12-8	2	17	8,500	9,192	46	28	95
S13-1	0	0				0	
S13-2	4	28	1,000	354	15	15	33
S13-3	1	7	5,000	N/A	23	22	28
S13-4	1	7	1,400	N/A	1	1	13
S13-5	0	0				0	
S13-6	4	30	2,850	3,180	6	3	46
S13-7	1	8	450	N/A	3	1	2
S14-1	2	12	4,000	4,243	20	6	42
S14-2	0	0				0	
S14-3	1	5	300	N/A	2	0	6
S14-4	1	7	1,500	N/A	0	0	6
S14-5	0	0				0	
S14-6	0	0				0	
S15-1	2	15	23,440	31,905	17	10	70
S15-2	1	7	36,000	N/A	7	1	36
S15-3	4	34	1,321	967	1	0	82
S15-4	4	27	9,825	6,174	23	15	141
S15-5	0	0				0	

Table B18. Log jam attributes by subreach

Subreach	Log jam attributes						
	log jam count	log jams/mi	average log jam volume (ft^3)	standard deviation of log jam volume (ft3)	large wood >25 ft in log jams count	large wood >35 ft in log jams count	brush wood in log jams count
S16-1	2	16	9,750	3,182	24	16	84
S16-2	5	35	7,900	7,394	47	23	126
S16-3	4	34	925	435	22	7	36
S16-4	3	25	2,000	500	31	20	56
S16-5	1	6	1,000	N/A	6	4	12
S16-6	2	15	8,750	1,768	23	11	46
S16-6SC	3	8	4,000	5,269	117	69	43
S16-7	2	14	2,250	2,385	23	15	49
S16-8	1	8	5,500	6,364	29	11	23
S16-9	0	0	3,600	N/A	4	2	
S16-10	1	7				0	20
S16-11	2	15	2,250	N/A	0	0	98
S17-1	0	0	18,700	23,052	17	9	
S17-2	1	9				0	16
S17-3	1	6	2,700	N/A	2	2	29
S17-4	0	0	3,000	N/A	5	3	
S17-5	0	0				0	
S17-6	0	0				0	
S17-7	1	8				0	43
S17-8	0	0	9,850	N/A	2	2	
S17-9	3	21				0	60
S17-10	1	7	3,780	1,736	20	10	80
S17-11	2	15	20,000	N/A	25	13	36
S17-12	1	7	1,025	1,025	7	1	12
S17-13	2	14	420	N/A	1	0	25
S17-14	2	14	510	127	9	4	27
S17-15	2	14	378	209	4	2	24
S17-16	0	0	825	106	8	4	
S17-17	1	7				0	28
S17-18	1	8	534	N/A	0	0	16
S18-1	1	7	875	N/A	3	0	4
S18-2	4	32	640	N/A	3	2	141
S18-3	2	15	7,500	7,767	19	9	25
S18-4	0	0	1,025	389	5	4	
S18-5	1	8				0	29
S18-6	0	0	3,700	N/A	1	0	
S18-7	0	0				0	
S18-8	4	33				0	92
S18-9	3	25	5,996	5,310	8	7	114
S18-10	1	8	5,133	5,968	10	3	26
S19-1	2	17	1,400	N/A	2	0	26
S19-2	1	8	1,400	283	4	2	12
S19-3	3	25	1,200	N/A	2	0	49
S19-4	2	16	1,467	881	8	5	10
S19-5	7	150	580	368	1	1	86
NFS1-1	6	47	3,083	1,656	39	34	90
NFS1-2	8	68	3,188	2,359	65	54	78

Table B18. Log jam attributes by subreach

Subreach	Log jam attributes						
	log jam count	log jams/mi	average log jam volume (ft^3)	standard deviation of log jam volume (ft3)	large wood >25 ft in log jams count	large wood >35 ft in log jams count	brush wood in log jams count
NFS1-3	1	10	1,500	NA	6	3	25
NFS1-4	8	54	3,188	1,252	55	47	104
O1-1	0	0	NA	NA	0	0	0
O1-2	5	45	914	917	17	7	87
O1-3	6	44	725	847	8	2	103
O1-4	2	19	270	64	1	0	16
H1-1	0	0	NA	NA	0	0	0
H1-2	1	8	1,050	NA	5	0	26
J1-1	0	0	NA	NA	0	0	0
J1-2	0	0	NA	NA	0	0	0
P1-1	5	40	686	354	22	9	72
P1-2	0	0	850	418	23	13	
W1-1	1	7	600	NA	1	1	3
T1-1	0	0	NA	NA	0	0	0
ST1-1	3	24	325	109	6	4	31
ST1-2	4	31	400	82	11	6	43
R1-1	0	0	NA	NA	0	0	0
R1-2	0	0	NA	NA	0	0	0
K1-1	1	7	1,000	NA	2	2	8
K1-2	1	9	750	NA	2	2	8
C1-1	1	7	3,000	NA	7	5	8
GY1-1	4	32				0	74
GY1-2	6	49	1,438	774	18	13	98
GY2-3	0	0	NA	32	0	0	0
GY2-4	0	0	NA	310	0	0	0
M1-1	7	58	1,179	515	35	14	50
D1-1	5	34	1,269	1,558	8	3	79
D1-2	2	17	1,026	713	8	3	29
D1-3	3	23	1,250	212	6	2	26
D1-4	4	35	708	347	6	2	96
D1-5	3	25	689	352	13	8	48
L1-1	3	22	767	293	5	48	72
L1-2	14	120	1,267	650	12	72	308
SH1-1	9	72	1,639	782	51	42	69
SH1-1.5	17	59	2,162	3,405	81	72	139
SH1-2	6	50	3,833	2,463	39	31	68
SH1-3	4	31	725	166	19	10	36

Appendix C

WRIA 62 Pend Oreille 2496 TAG Bull Trout Rating Criteria

Table 27: WRIA 62 Pend Oreille 2496 TAG Bull Trout Habitat Rating Criteria

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Access to Spawning and Rearing Habitat						
Artificial Structures (i.e. culverts, dams, dikes)	Man-made physical barriers (address subsurface flows or dewatering where they impede fish passage under water quality attributes)	All	Man-made barriers present in reaches do not allow upstream and /or downstream fish passage at a range of flows.	Man-made barriers present in the reach do not allow upstream and/or downstream fish passage at base/low flows.	Man-made barriers present in the reach allow upstream and downstream fish passage at all flows.	USFWS Guidelines
Riparian Condition						
Riparian Condition	Riparian Habitat Conservation Areas (RHCAs): Riparian corridors, wetlands, intermittent headwater streams, and other areas where proper ecological functioning is crucial to maintenance of the stream's water, sediment, woody debris and nutrient delivery systems (definition taken from INFISH)	All – Eastside	riparian areas are fragmented, poorly connected, or provide inadequate protection of habitats for sensitive aquatic species (<70% intact, refugia does not occur), and adequately buffer impacts on rangelands; percent similarity of riparian vegetation to the potential natural community/composition is <25%.	moderate loss of connectivity or function (shade, LWD recruitment, etc.) of riparian areas, or incomplete protection of habitats and refugia for sensitive aquatic species (≈ 70-80% intact) and adequately buffers impacts on rangelands: percent similarity of riparian vegetation to the potential natural community/composition is 25-50% or better.	the riparian areas provide adequate shade, LWD recruitment, and habitat protection and connectivity in subwatersheds, and buffers or includes known refugia for sensitive aquatic species (>80% intact) and adequately buffers impacts on rangelands: percent similarity of riparian vegetation to the potential natural community/composition is >50%.	USFWS Guidelines

Table 27. WRIA 62 Pend Oreille 2496 TAG Bull Trout Habitat Rating Criteria (Continued)

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Channel Conditions/Dynamics						
Streambank Condition	% of stream reach in stable condition	All - Eastside	<50% of any stream reach has ≥90% stability	50–80% of any stream reach has ≥90% stability	>80% of any stream reach has ≥90% stability	USFWS Guidelines
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	All - Eastside	Severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetlands extent drastically reduced and riparian vegetation/succession altered significantly.	Reduced linkage of wetland, floodplains and riparian areas to main channel; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of wetland function and riparian vegetation/succession.	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.	USFWS Guidelines
Channel Stability		All	W/D or Entrenchment ratio is inappropriate for geo-morphologically correct Rosgen stream type	W/D or Entrenchment ratio is increasing/decreasing beyond range of acceptable for geo-morphologically correct Rosgen stream type	W/D and Entrenchment ratio is appropriate for geo-morphologically correct Rosgen stream type	TAG 2002 and Rosgen 1996

Table 27. WRIA 62 Pend Oreille 2496 TAG Bull Trout Habitat Rating Criteria (Continued)

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Habitat Elements						
Channel Substrate	Substrate condition as it relates to rearing habitat and spawning and incubation habitat, including but not limited to, the degree of substrate embeddedness, substrate mobility, and percent fines.	All – Eastside	>30% embeddedness (rearing) or >17% fines <0.85mm (spawning/incubation)	20 – 30% embeddedness (rearing) or 12 - 17% fines <0.85mm (spawning/incubation)	<20% embeddedness (rearing) or <12% fines <0.85mm (spawning/incubation)	USFWS Guidelines
Large Woody Debris	Pieces/mile that are >12" in diameter and >35 ft. in length with at least one end of piece within the OHWL (Ordinary High Water Line); also adequate sources of woody debris are available for both long and short-term recruitment	All – Eastside	Current levels are not at those desired values for "Good/Properly Functioning", and potential sources of woody debris for short and /or long term recruitment are lacking	Current values are being maintained at minimum levels desired for "Good/Functioning Appropriately", but potential sources for long-term woody debris recruitment are lacking to maintain these minimum values	Current values are being maintained at greater than >20 pieces/mile, >12" in diameter and >35" ft. in length.	USFWS Guidelines

Table 27. WRIA 62 Pend Oreille 2496 TAG Bull Trout Habitat Rating Criteria (Continued)

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Habitat Elements (continued)						
Pool Frequency and Quality	% wetted channel surface area comprising pools	All	Pool frequency is considerably lower than values desired for "good/properly functioning"; also cover/temperature is inadequate, and there has been a major reduction of pool volume by fine sediment.	Pool frequency is similar to values in "good/ properly functioning" but pools have inadequate cover/temperature and /or there has been a moderate reduction of pool volume by fine sediment.	Pool frequency in a reach closely approximates: Wetted Width (ft) — # Pools/ mile 0–5 — 39 5-10 — 60 10-15 — 48 15-20 — 39 20-30 — 23 30-35 — 18 35-40 — 10 40-65 — 9 65-100 — 4 (can use formula: pools/ mile = 5,280/ wetted channel width ÷ # channel widths per pool	USFWS Guidelines
Pool Depth	Pools >1 meter deep	Streams >3m in wetted width	No pools	few pools	many pools present	USFWS Guidelines

Table 27. WRIA 62 Pend Oreille 2496 TAG Bull Trout Habitat Rating Criteria (Continued)

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Habitat Elements (continued)						
Off-channel Habitat	Area within the channel migration zone which is also accessible during peak flow events.	Reaches with average gradient <2%	Reach has no ponds, oxbows, backwaters, or other off-channel areas	Reach has some ponds, oxbows, backwaters, and other off-channel areas with cover; but side-channel areas are generally high energy areas	Reach has many ponds, oxbows, backwaters, and other off-channel areas with cover; and side-channels are low energy areas	USFWS Guidelines

Table 27. WRIA 62 Pend Oreille 2496 TAG Bull Trout Habitat Rating Criteria (Continued)

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Water Quality						
Temperature	degrees Celsius/ degrees Fahrenheit	All	7-day average maximum temperature in a reach during the following life history stages: • >15°C/ >59°F (rearing) • <4°C or >10°C/ <39°F or >50°F (spawning) • <1°C or >6°C/ <34°F or >43ºF (incubation) also temperatures in areas used by adults during migration regularly exceed 15ºC/59ºF (thermal barriers present)	7-day average maximum temperature in a reach during the following life history stages: • <4°C or 13-15ºC/ <39°F or 55º-59ºF (rearing) • <4°C or 10°C/ <39°F or 50°F (spawning) • <2°C or 6°C/ <36°F or 43ºF (incubation) also temperatures in areas used by adults during migration sometimes exceed 15ºC/59ºF	7-day average maximum temperature in a reach during the following life history stages: • 4°-12ºC/ 39°-54ºF (rearing) • 4° - 9ºC/ 39°-48°F (spawning) • 2°-5°C/ 36°-41ºF (incubation) also temperatures do not exceed 15ºC/59ºF in areas used by adults during migration (no thermal barriers)	USFWS Guidelines

Table 27. WRIA 62 Pend Oreille 2496 TAG Bull Trout Habitat Rating Criteria (Continued)

Habitat Factor	Parameter/Unit	Channel Type	Poor (Not Properly Functioning)	Fair (At Risk)	Good (Properly Functioning)	Source
Water Quantity						
Change in Flow Regime	Change in Peak/Base Flows	All	pronounced changes in peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	some evidence of altered peak flow, base flow and/or flow timing relative to an undisturbed watershed of similar size, geology and geography	watershed hydrograph indicates peak flow, base flow and flow timing characteristics comparable to an undisturbed watershed of similar size, geology and geography	USFWS Guidelines
Species Competition						
Non-indigenous fish species	Presence/ Absence	All	Present in the drainage	Present in an adjacent drainage and have access to the drainage	Absent in the drainage and there is not opportunity for access to the drainage	TAG 2002

Appendix D

Subreach-Scale Limiting Factors Matrix

Table D1: Subreach scale limiting factors analysis.

Subreach	Artificial Structures	Riparian Condition **	Road Encrochment	Streambank Instability	Streambank Revetment	Floodplain Connectivity	Channel Stability (+=aggrading, -=degrading)	Spawning Area	dominent / subdominent substrat	Spawning Gravel Embeddedness	LWD	Jams	Pool Frequency	Pool Quality	Off Channel Habitat (braid index 0=p,0.01-0.2=f, >0.2=g	Water Tempurature	Change in Flow Regime	Non-indigenous fish species
S1-1	G	G	G	G	G	G	G+	F	G	P	P	F	P	G	G			
S1-2	G	G	G	G	G	P	G+	P	G	G	P	P	P	P	G			
S1-3	G	P	G	G	P	P	G+	G	G	G	G	G	G	F	G			
S1-4	G	P	P	P	P	P	G	F	G	G	P	P	G	F	P			
S2-1	G	F	F	F	P	G	G-	F	G	G	G	P	G	G	NA			
S2-2	G	G	G	G	G	G	G-	P	G	P	G	G	G	G	NA			
S2-3	G	G	G	G	G	G	G-	P	P	G	G	G	G	G	NA			
S2-4	G	G	G	G	G	G	G-	P	G	NA	P	P	G	F	P			
S2-5	G	G	G	G	G	G	G-	P	G	F	P	P	G	G	P			
S2-6	G	G	G	F	G	G	G-	P	G	NA	G	F	G	G	P			
S2-7	G	G	G	G	G	G	G-	P	P	G	P	P	G	F	NA			
S2-8	G	G	G	G	G	G	G-	P	G	G	P	P	G	G	P			
S2-9	G	G	G	G	G	G	G-	P	G	P	G	P	G	G	NA			
S2-10	G	G	G	G	G	G	G-	P	G	P	P	P	G	G	NA			
S2-11	G	G	G	G	G	G	G-	P	G	NA	P	P	G	G	NA			
S2-12	G	P	P	G	G	G	G-	P	G	G	P	P	G	F	P			
S3-1	G	G	G	G	G	G	F-	P	G	NA	G	F	G	G	F			
S3-2	G	F	P	G	G	P	F-	P	G	G	G	G	G	F	G			
S3-3	G	P	P	G	P	P	F-	P	G	G	P	F	P	G	G			
S3-4	G	G	G	G	G	G	F-	P	G	NA	P	P	P	G	P			
S3-5	G	G	G	G	G	G	F-	P	G	G	P	P	G	P	P			
S3-6	G	G	F	G	G	F	F-	P	G	G	G	F	G	G	P			
S3-7	G	G	G	G	P	F	P-	P	G	NA	G	G	G	G	P			
S3-8	G	G	F	G	G	P	P-	P	G	NA	P	P	P	G	P			
S3-9	G	G	G	G	G	P	P-	P	G	G	G	G	G	G	P			
S3-10	G	G	G	G	G	G	P-	P	G	NA	P	F	G	F	P			
S3-11	P	G	G	G	G	G	P-	P	P	NA	P	P	G	G	P			
S5-1	G	F	G	G	G	G	F+	G	G	P	P	P	G	G	G			
S5-2	G	F	G	P	G	G	F+	P	G	NA	G	F	P	G	G			
S5-3	G	F	G	G	G	G	F+	P	G	NA	G	F	G	P	F			
S5-4	G	G	G	G	G	G	F+	F	G	P	G	G	G	G	G			
S5-5	G	G	G	F	G	G	G+	P	G	P	G	F	G	G	P			
S6-1	G	F	G	G	G	G	G+	P	G	G	P	P	G	F	P			
S6-2	G	F	G	G	G	F	G+	P	G	F	G	F	P	G	P			
S6-3	G	F	G	F	F	G	G+	F	G	F	G	P	P	P	G			
S7-1	G	G	P	G	P	G	G+	P	G	P	P	P	P	P	G			
S7-2	G	G	P	F	G	G	G+	P	G	P	G	F	G	P	G			
S7-3	G	G	G	G	G	G	G+	P	G	G	P	P	P	G	G			
S7-4	G	G	G	P	G	G	G+	P	G	G	G	F	G	F	G			
S7-5	G	G	G	F	G	G	F-	P	G	F	G	F	G	G	NA			
S8-1	G	F	F	G	P	G	G-	P	G	G	G	P	P	P	P			

† + indicates aggrading, - indicates degrading)
‡ In this table defined by braid index: 0=p,0.01-0.2=f, >0.2=g.

Table D1: Subreach scale limiting factors analysis.

Subreach	Artificial Structures	Riparian Condition **	Road Encrochment	Streambank Instability	Streambank Revetment	Floodplain Connectivity	Channel Stability (+=aggrading, -=degrading)	Spawning Area	dominent / subdominent substrat	Spawning Gravel Embeddedness	LWD	Jams	Pool Frequency	Pool Quality	Off Channel Habitat (braid index 0=p,0.01-0.2=f, >0.2=g	Water Tempurature	Change in Flow Regime	Non-indigenous fish species
S8-2	G	G	G	G	G	G	F-	P	G	G	G	P	P	P	P			
S8-3	G	G	F	G	G	G	G-	P	G	G	P	P	G	G	P			
S8-4	G	G	G	G	G	G	F-	P	G	P	P	P	P	G	P			
S8-5	G	F	F	F	G	G	G+	P	G	P	G	F	G	G	G			
S8-6	G	F	P	G	G	G	G+	P	G	P	G	P	P	G	P			
S8-7	G	P	P	G	G	G	P-	P	G	F	G	F	G	G	P			
S9-1	G	G	G	G	G	G	G	P	P	P	G	F	G	G	P			
S9-2	G	G	F	G	G	G	G	P	G	F	P	P	G	P	P			
S9-3	G	G	G	F	P	G	G	F	G	G	G	G	G	F	G			
S10-1	G	P	P	G	G	G	P-	P	G	NA	P	P	P	G	P			
S10-2	G	P	P	G	P	G	P-	P	G	G	P	P	G	F	P			
S10-3	G	P	P	G	G	G	P-	P	G	P	P	P	G	G	P			
S11-1	G	G	G	G	G	G	G	P	G	G	G	G	G	F	P			
S11-2	G	G	F	G	G	G	G	G	G	G	G	G	G	F	G			
S11-3	G	G	F	F	G	G	G	F	G	F	G	G	G	P	G			
S11-4	G	G	F	G	P	G	G	P	G	G	G	F	G	G	P			
S11-5	G	P	F	G	G	F	G	F	G	G	G	P	G	P	P			
S11-6	G	G	F	G	G	G	G	P	G	F	G	G	G	P	P			
S11-7	G	G	F	G	P	G	G	P	G	G	G	F	P	G	P			
S11-8	G	P	P	F	G	P	G	G	G	F	G	F	G	P	P			
S11-9	G	P	P	G	F	F	G	G	G	G	G	P	G	F	P			
S11-10	G	G	F	F	G	G	G	F	G	G	G	G	G	P	G			
S11-11	G	F	P	G	G	G	G	P	G	G	G	F	G	P	F			
S11-12	G	F	F	G	P	G	G	F	G	G	G	G	P	F	F			
S11-13	G	G	G	G	G	G	G	F	G	P	G	G	G	G	G			
S11-14	G	G	G	F	G	G	P+	P	G	P	G	G	G	G	F			
S11-15	G	G	F	P	G	G	P+	P	G	P	G	G	G	G	G			
S12-1	G	G	P	G	F	G	F-	P	G	NA	P	F	G	P	P			
S12-2	G	G	F	G	G	G	G	P	G	G	G	G	G	F	G			
S12-3	G	F	F	G	G	G	G	P	G	F	G	G	G	G	NA			
S12-4	G	F	P	G	G	G	G+	F	G	P	G	G	G	F	F			
S12-5	G	P	P	G	G	G	G-	P	G	NA	G	F	P	P	P			
S12-6	G	G	P	G	G	F	G-	P	G	G	G	F	P	G	P			
S12-7	G	G	G	G	G	F	F-	F	G	G	G	G	G	P	NA			
S12-8	G	F	F	F	G	G	F-	P	G	G	G	G	P	F	NA			
S13-1	G	P	P	G	G	G	F-	P	G	P	P	P	P	P	P			
S13-2	G	P	P	G	G	G	F-	P	G	NA	G	G	P	P	P			
S13-3	G	G	G	G	G	G	F-	P	G	P	G	F	G	F	P			
S13-4	G	P	P	G	G	G	F-	P	G	G	G	F	G	P	P			
S13-5	G	P	P	G	P	G	F-	P	G	NA	G	P	P	G	P			
S13-6	G	G	G	G	G	G	F-	P	G	NA	G	G	G	F	G			

† + indicates aggrading, - indicates degrading)
‡ In this table defined by braid index: 0=p,0.01-0.2=f, >0.2=g.

Table D1: Subreach scale limiting factors analysis.

Subreach	Artificial Structures	Riparian Condition **	Road Encrochment	Streambank Instability	Streambank Revetment	Floodplain Connectivity	Channel Stability (+=aggrading, -=degrading)	Spawning Area	dominent / subdominent substrat	Spawning Gravel Embeddedness	LWD	Jams	Pool Frequency	Pool Quality	Off Channel Habitat (braid index 0=p,0.01-0.2=f, >0.2=g	Water Tempurature	Change in Flow Regime	Non-indigenous fish species
S13-7	G	G	G	G	G	G	F-	P	G	G	G	F	P	G	P			
S14-1	G	F	F	G	G	G	F-	P	G	G	G	G	P	G	F			
S14-2	G	F	F	G	G	G	F-	P	G	NA	P	P	P	G	NA			
S14-3	G	P	P	G	P	G	F-	P	G	NA	G	F	G	P	NA			
S14-4	G	F	P	G	G	G	F-	F	G	P	G	F	G	G	P			
S14-5	G	G	F	G	G	G	G	P	G	P	G	P	G	P	P			
S14-6	G	F	P	G	G	G	G	P	G	NA	P	P	G	P	P			
S15-1	G	G	G	G	G	G	G	F	G	P	G	G	G	P	P			
S15-2	G	G	G	G	G	G	G	P	G	P	G	F	G	F	G			
S15-3	G	G	G	G	G	G	G	P	G	P	G	G	G	P	G			
S15-4	G	G	G	G	G	G	G	F	G	G	G	G	G	G	G			
S15-5	G	G	G	G	G	G	G	P	G	G	G	P	P	G	P			
S16-1	G	G	G	F	G	G	G+	G	G	P	G	G	G	P	G			
S16-2	G	G	G	G	G	G	G+	G	G	F	G	G	G	P	G			
S16-3	G	G	G	G	P	G	G+	P	G	G	G	G	G	P	G			
S16-4	G	G	G	F	G	G	G+	F	G	P	G	G	G	P	G			
S16-5	G	G	G	G	G	G	G+	P	G	G	G	F	G	P	F			
S16-6	G	G	G	F	G	G	G+	G	G	F	G	G	G	F	G			
S16-6SC	G	G	G	G	G	G	G+	G	G	F	G	F	G	F	G			
S16-7	G	G	G	G	G	G	G+	F	G	G	G	G	G	F	F			
S16-8	G	G	G	G	G	G	G+	G	G	G	G	F	G	P	G			
S16-9	G	G	G	G	G	F	G+	P	G	F	G	P	G	G	G			
S16-10	G	G	F	G	G	F	F-	P	G	NA	G	F	P	P	NA			
S16-11	G	G	F	G	G	F	F-	P	G	P	G	G	G	P	NA			
S17-1	G	F	F	G	G	G	F-	F	G	G	G	P	G	P	NA			
S17-2	G	F	F	G	G	G	G+	P	G	G	P	F	G	P	NA			
S17-3	G	P	P	G	G	G	G+	F	G	G	G	F	G	P	NA			
S17-4	G	P	P	G	G	G	G-	P	G	G	G	P	G	P	NA			
S17-5	G	P	P	G	G	G	G-	G	G	G	G	P	G	P	NA			
S17-6	G	P	P	G	G	G	G-	P	G	G	G	P	G	P	NA			
S17-7	G	P	P	G	G	G	G-	G	G	G	G	F	G	P	NA			
S17-8	G	P	P	G	G	G	G-	G	G	G	G	P	G	P	NA			
S17-9	G	P	P	G	G	G	G-	P	G	G	G	G	G	P	NA			
S17-10	G	P	P	G	G	G	G	G	G	G	G	F	G	P	NA			
S17-11	G	P	P	G	G	G	G	P	G	G	G	G	G	P	NA			
S17-12	G	P	P	G	G	G	G-	P	G	G	G	F	G	P	NA			
S17-13	G	P	P	G	G	G	G-	F	G	G	G	G	P	P	NA			
S17-14	G	P	P	G	G	G	G-	P	G	G	G	G	G	P	NA			
S17-15	G	P	P	G	G	G	G-	P	G	G	G	G	G	P	NA			
S17-16	G	P	P	G	G	G	G-	P	G	G	G	P	G	P	NA			
S17-17	G	P	P	G	G	G	G-	F	G	G	P	F	G	P	NA			

† + indicates aggrading, - indicates degrading)
‡ In this table defined by braid index: 0=p,0.01-0.2=f, >0.2=g.

Table D1: Subreach scale limiting factors analysis.

Subreach	Artificial Structures	Riparian Condition **	Road Encrochment	Streambank Instability	Streambank Revetment	Floodplain Connectivity	Channel Stability (+=aggrading, -=degrading)	Spawning Area	dominent / subdominent substrat	Spawning Gravel Embeddedness	LWD	Jams	Pool Frequency	Pool Quality	Off Channel Habitat (braid index 0=p,0.01-0.2=f, >0.2=g	Water Tempurature	Change in Flow Regime	Non-indigenous fish species
S17-18	G	P	P	G	G	G	G-	P	G	G	G	F	G	P	NA			
S18-1	G	P	F	G	G	G	G	F	G	G	G	F	G	P	NA			
S18-2	G	P	P	G	G	G	G	G	G	P	G	G	G	P	NA			
S18-3	G	P	P	G	G	G	G+	G	G	G	G	G	G	P	NA			
S18-4	G	P	F	G	G	G	G+	P	G	G	G	P	G	F	NA			
S18-5	G	F	F	G	G	G	G	P	G	G	G	F	P	P	NA			
S18-6	G	P	P	G	G	G	G	F	G	G	G	P	G	F	NA			
S18-7	G	P	P	G	P	G	G	G	G	G	G	P	P	P	NA			
S18-8	G	P	P	G	P	G	G	P	G	G	G	G	P	G	NA			
S18-9	G	P	P	G	G	G	G+	G	G	G	G	G	G	F	NA			
S18-10	G	F	F	G	P	G	F-	G	G	F	G	F	G	F	G			
S19-1	G	P	P	G	G	P	P	G	G	G	G	G	G	P	G			
S19-2	G	P	P	G	P	P	P-	G	G	G	G	F	G	F	G			
S19-3	G	P	P	G	G	G	G+	F	G	G	G	G	G	P	G			
S19-4	G	G	F	G	G	G	G+	G	G	G	G	G	G	F	G			
S19-5	G	G	G	G	G	G	G+	P	G	NA	G	G	G	P	G			
P1-1	G	G	G	G	G	G	G+	G	G	G	G	G	G	P	P			
P1-2	G	G	G	G	F	G	G-	F	G	G	G	P	G	F	NA			
GY1-1	G	G	G	G	F	P	P-	F	G	G	G	G	G	P	NA			
GY1-2	G	G	F	G	G	G	F-	F	G	G	G	G	G	P	NA			
D1-1	G	G	G	G	G	G	G+	G	G	G	G	G	G	F	NA			
D1-2	G	G	G	G	G	G	G+	G	G	G	G	G	G	F	NA			
D1-3	G	G	G	G	G	G	G	G	G	G	G	G	G	F	NA			
D1-4	G	G	G	G	G	G	G	G	G	G	G	G	G	G	NA			
D1-5	G	G	G	G	G	G	G	F	G	F	G	G	G	P	NA			
L1-1	G	G	G	G	G	G	G+	P	G	G	G	G	G	P	NA			
L1-2	G	G	G	G	G	G	G-	F	G	G	G	G	G	P	NA			
C1-1	P	G	G	G	G	G	G+/-	G	G	G	G	F	G	F	G			
GY2-3	G	G	G	G	G	G	G	F	G	G	G	P	G	F	NA			
GY2-4	G	G	G	G	G	G	G	F	G	G	G	P	G	F	NA			
H1-1	G	G	G	G	G	G	G+	F	P	G	P	P	G	G	NA			
H1-2	P	G	G	G	G	G	G+	G	G	P	G	F	G	F	NA			
J1-1	G	G	G	G	G	G	G	P	G	G	P	P	F	F	G			
J1-2	P	G	G	G	G	G	G	F	G	G	G	P	G	F	NA			
K1-1	G	G	G	G	G	G	G-	F	G	G	G	F	G	F	NA			
K1-2	P	G	G	G	G	G	G-	G	G	G	G	F	G	F	NA			
M1-1	G	G	G	G	G	G	G	G	G	G	G	G	G	F	NA			
NFS1-1	P	F	G	G	G	G	G-	P	G	P	G	G	F	F	NA			
NFS1-2	G	G	G	G	G	G	G-	P	G	G	G	G	G	F	NA			
NFS1-3	P	P	P	G	G	G	G-	F	G	P	G	F	G	F	NA			
NFS1-4	G	G	G	G	G	G	G	G	G	G	G	G	G	G	NA			

† + indicates aggrading, - indicates degrading)
‡ In this table defined by braid index: 0=p,0.01-0.2=f, >0.2=g.

Table D1: Subreach scale limiting factors analysis.

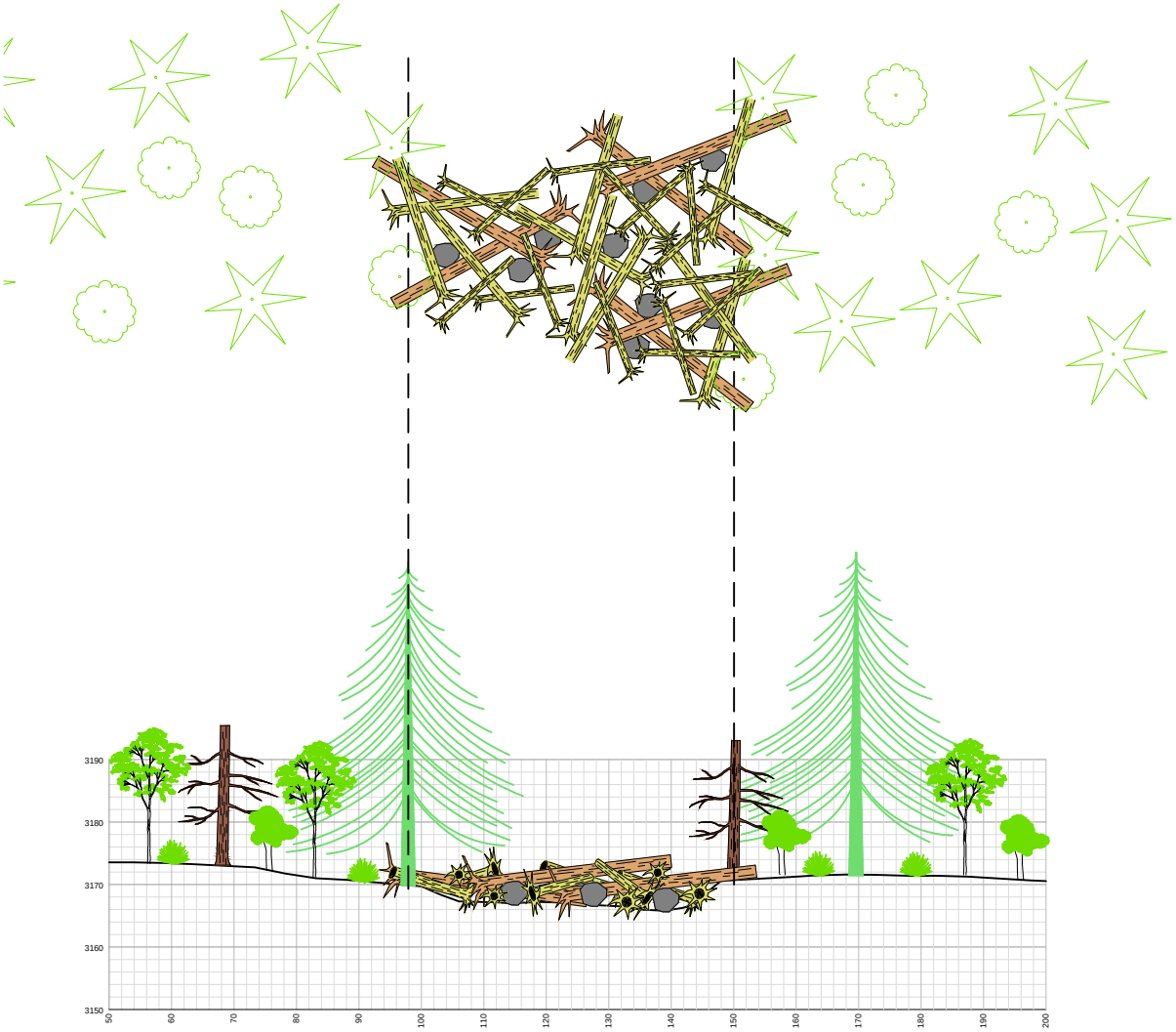
Subreach	Artificial Structures	Riparian Condition **	Road Encrochment	Streambank Instability	Streambank Revetment	Floodplain Connectivity	Channel Stability (+=aggrading, -=degrading)	Spawning Area	dominent / subdominent substrat	Spawning Gravel Embeddedness	LWD	Jams	Pool Frequency	Pool Quality	Off Channel Habitat (braid index 0=p,0.01-0.2=f, >0.2=g	Water Tempurature	Change in Flow Regime	Non-indigenous fish species
O1-1	G	G	G	G	G	G	G	G	G	G	G	P	P	F	NA			
O1-2	G	G	G	G	G	G	G	G	G	G	P	G	G	F	P			
O1-3	G	G	G	G	G	G	G	G	G	G	G	G	G	F	P			
O1-4	P	G	G	G	G	G	G	G	G	G	P	G	G	G	G			
R1-1	G	G	G	G	G	G	G-	G	G	G	G	P	G	F	P			
R1-2	G	G	G	G	G	G	G-	G	G	G	G	P	F	F	NA			
SH1-1	G	G	G	G	G	G	G	G	G	F	G	G	G	G	NA			
SH1-1.5	G	G	G	G	G	G	G+	G	G	P	G	G	G	G	NA			
SH1-2	G	G	G	G	G	G	G+/-	G	G	P	G	G	G	G	NA			
SH1-3	G	G	G	G	G	G	G	F	G	P	G	G	G	F	NA			
ST1-1	G	F	G	G	G	G	G	F	G	G	G	G	G	F	NA			
ST1-2	G	F	G	G	G	G	G	F	G	G	G	G	G	F	NA			
T1-1	G	G	G	G	G	G	G-	G	G	F	G	P	P	G	NA			
W1-1	P	F	G	G	G	G	G	G	G	G	G	F	G	P	NA			

† + indicates aggrading, - indicates degrading)
‡ In this table defined by braid index: 0=p,0.01-0.2=f, >0.2=g.

Appendix E

Sample Conceptual Designs for Restoration Actions

Channel Spanning Log Jam
Large Logs: 9
Small Logs: 26
Boulders: 9
Note: Sized for 50' channel. Scale LWD and boulder count for larger or smaller channels.



15 0 15 30 feet

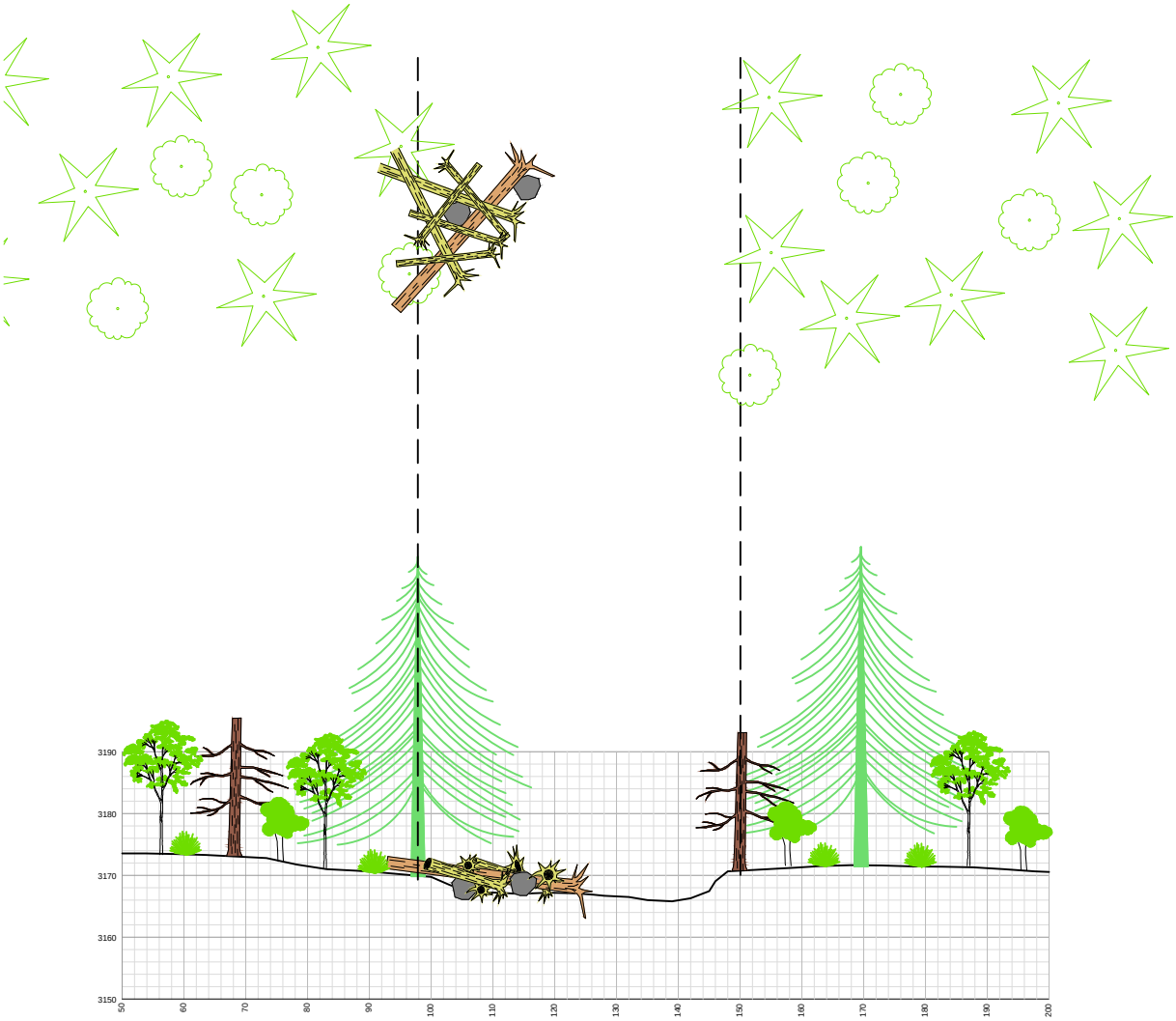
Channel Spanning Log Jam

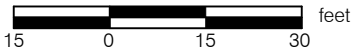
Sullivan Creek
Habitat Measures

1

nhc
August 19, 2013

Log Spur
Large Logs: 1
Small Logs: 6
Boulders: 2
Note: Sized for 50' channel. Keep LWD and boulder count the same for channels between 30' tp 100'. Scale outside of this range.





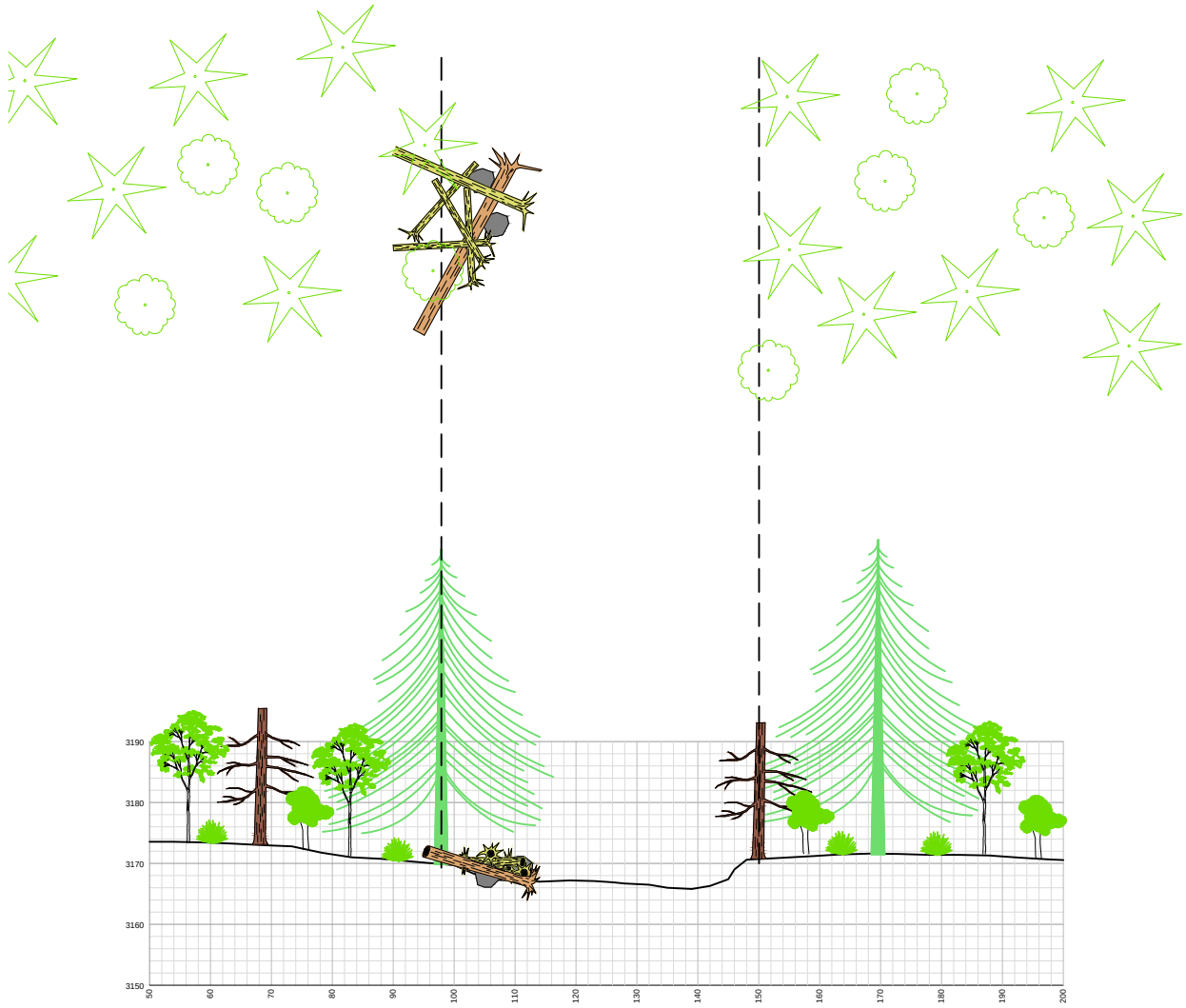
Log Spur

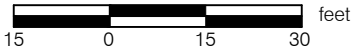
Sullivan Creek
Habitat Measures

2

nhc
August 19, 2013

Small Log Jam with Key Log – Alt 1
Large Logs: 1
Small Logs: 5
Boulders: 2
Note: Sized for 50' channel. Keep LWD and boulder count the same all channels.





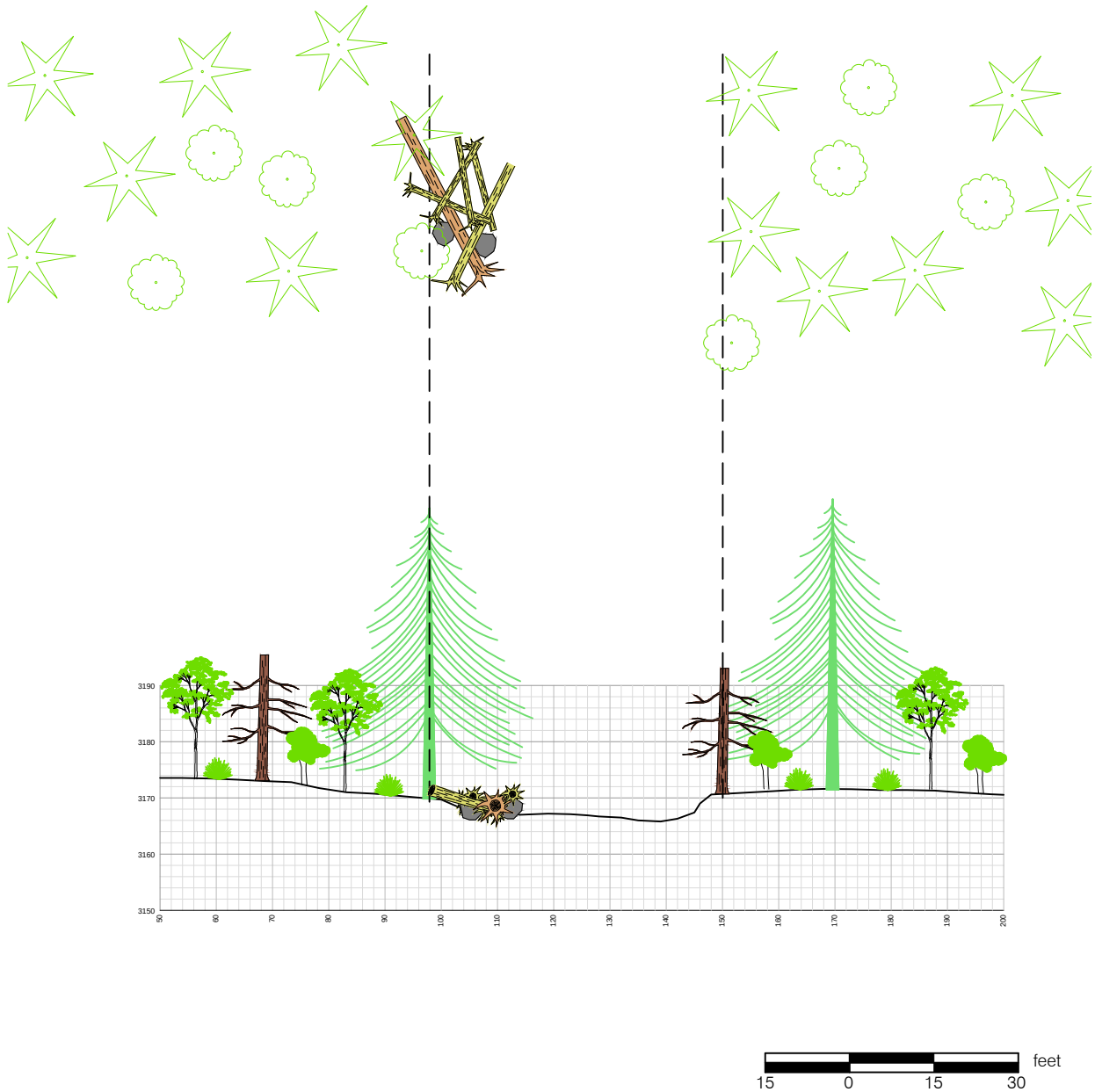
Small Jam / Key Log - Alt 1

Sullivan Creek
Habitat Measures

3

nhc
August 19, 2013

Small Log Jam with Key Log – Alt 2
Large Logs: 1
Small Logs: 5
Boulders: 2
Note: Sized for 50' channel. Keep LWD and boulder count the same all channels.



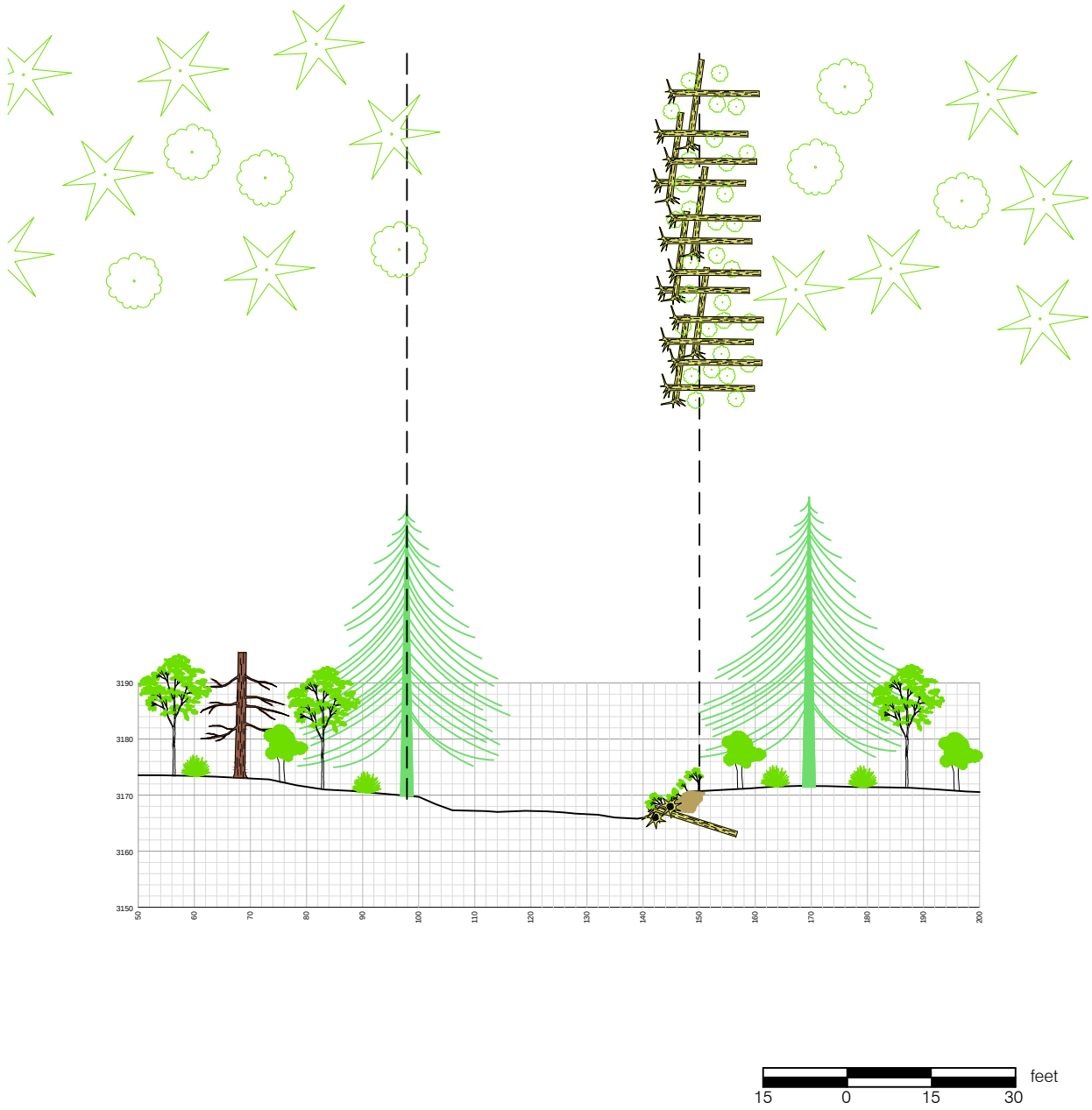
Small Jam / Key Log - Alt 2

Sullivan Creek
Habitat Measures

4

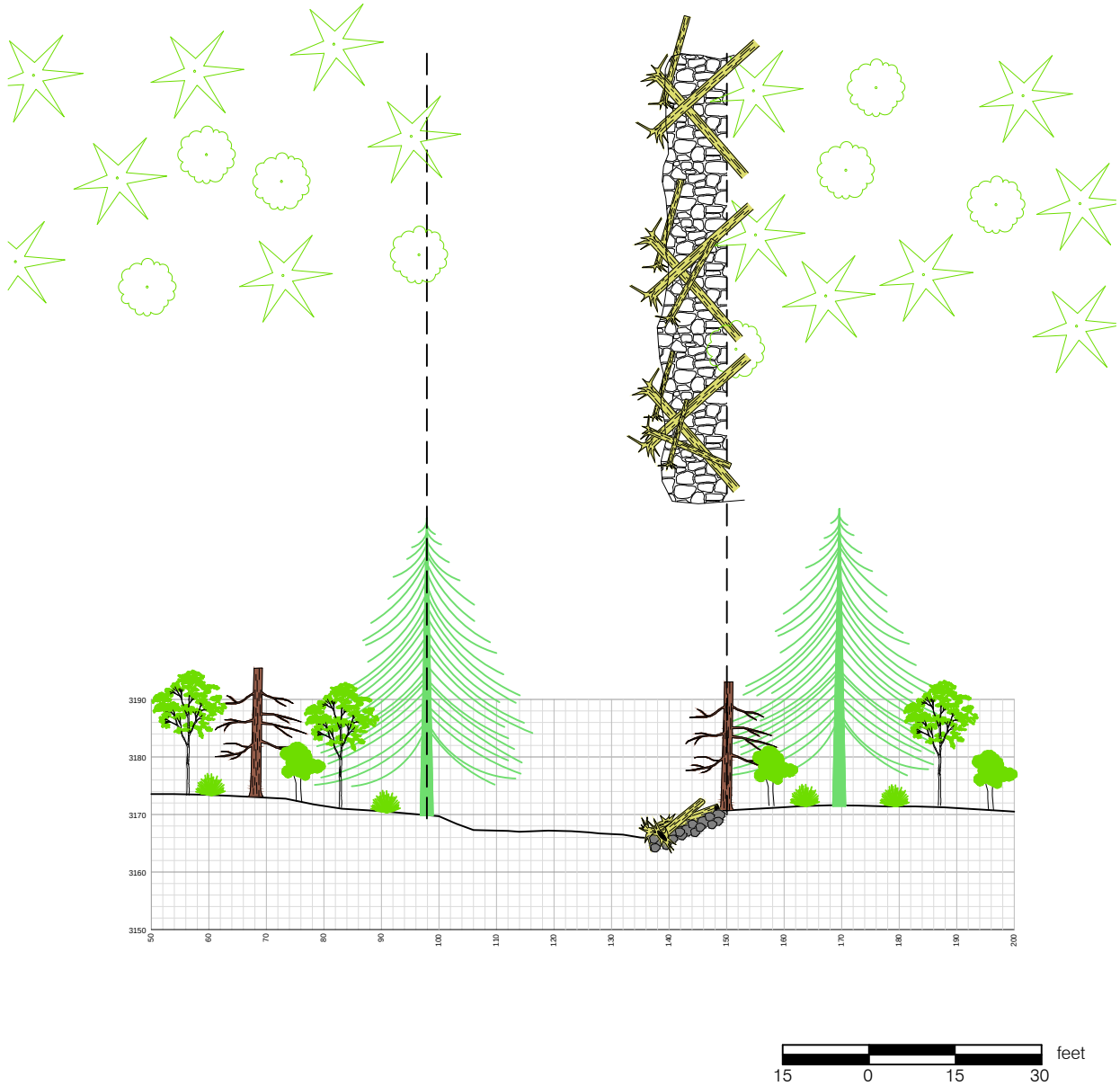
nhc
August 19, 2013

Bioengineered bank with LWD
Large Logs: 0
Small Logs: 4 to 6 along every 20 feet bio-engineered bank.



Bioengineering with LWD

LWD for bank stability on riprap
Large Logs: 0
Small Logs: 3 to 5 along every 30 feet of riprap revetment



Bioengineering - Soften Riprap

Sullivan Creek
Habitat Measures

1

nhc
August 19, 2013

Appendix F

Sullivan Creek Habitat Inventory Geodatabase [Digital Files]

Appendix G

Sullivan Creek HEC-RAS Model [Digital Files]