STOUT CREEK ASSESSMENT AND RESTORATION PLAN

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EXECUTIVE SUMMARY

Stout Creek originates in the Cascade foothills and flows through the Willamette Valley foothills and plains. Flowing in a westerly direction from its headwaters, Stout Creek drains forested and agricultural lands before joining the North Santiam River near Mehama, Oregon. Chinook salmon and steelhead are some of the native anadromous fish species that have been documented in Stout Creek. Long-term habitat changes have affected both watershed hydrology and fish populations. Changes such as timber harvesting in the upper part of the watershed, irrigation systems, agriculture, construction of road networks, and rural residential development have affected Stout Creek. Limiting factors impacting streambank stability and the native fish community include simplified habitat, high water temperatures during periods of low flow, invasive weeds, and loss of riparian forests and associated large wood that once created dynamic habitat.

The North Santiam Watershed Council (NSWC) retained River Design Group, Inc. to complete an existing conditions assessment and restoration prioritization plan for Stout Creek. This effort follows the North Santiam River Watershed Assessment (E&S Environmental Chemistry 2002) which provided an evaluation of the drainage at the watershed scale. This document serves two purposes. First, as a reach assessment, it presents information on historical and existing conditions based on field data collection, remote sensing, and existing data review. Secondly, the document serves as a stream corridor restoration plan that prioritizes aquatic habitat improvement and conservation projects in the 2.5-mile assessment reach in Lower Stout Creek. The restoration and conservation actions are specified for each of three sub-reaches. Restoration Actions are prioritized based on expected ecological benefits, costs, and risks. Conservation Actions are also presented as a means to preserve remaining floodplains, riparian vegetation, and upland forests.

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GLOSSARY

Active Floodplain: Lowlands bordering a river, which are subject to flooding on a periodic basis. Floodplains are composed of sediments carried by rivers (alluvium) and deposited on land during flooding. The active area is characterized by recently deposited river-borne debris, limited terrestrial vegetation, and recent scarring of trees by material transported by floodwaters.

Aggradation: The geologic process by which streambeds, floodplains and the bottoms of other water bodies are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of degradation.

Alluvial: Deposited by running water.

Anadromous: Fish that breed in freshwater but live their adult life in the sea. On the Pacific coast, anadromous fish include all the Pacific salmon, steelhead trout, some cutthroat trout and Dolly Varden char, lampreys and eulachons.

Avulsion: An abrupt change in the course of a stream whereby the stream leaves its old channel for a new one.

Bankfull (Stage): Water surface elevation at which a stream first overflows its natural banks, spilling water onto the floodplain.

Base Flow: Streamflow coming from sustained subsurface sources, not directly from surface runoff.

Bedload: Sediment particles transported on or near the streambed by rolling and bouncing.

Beltwidth: The distance of a stream measured from outside of channel to outside of channel.

Bifurcate: The division of a stream channel into two branches or a fork in the stream channel.

Braided Stream: Stream that forms a network of branching and recombining channels separated by islands or channel bars.

Channelization: Straightening and (or) deepening a pre-existing channel, or constructing a new channel, for the purpose of runoff control or navigation.

Degradation: Removal of materials from one place to another via erosion, causing lowering of the elevation of streambeds and floodplains over time.

Floodplain: A level, low-lying area adjacent to streams that is periodically flooded by stream water. It includes lands at the same elevation as areas with evidence of moving water, such as active or inactive flood channels, recent fluvial soils, sediment on the ground surface or in tree bark, rafted debris, and tree scarring.

Groundwater: Subsurface water in the zone of saturation below the level of the water table, where the hydrostatic pressure is equal to or greater than the atmospheric pressure.

Hydric: Sites where water is removed so slowly that the water table is at or above the soil surface all year; gleyed mineral or organic soils are present.

Hyporheic Zone: Zone beneath and adjacent to streams where water and dissolved chemicals move easily between surface and groundwater.

Large Woody Debris: Coarse woody material (conventionally greater than 10 cm in diameter and 1 m long), such as twigs, branches, logs, trees, and roots, that falls into a stream.

Manning's n-value: Empirical coefficient for computing stream bottom roughness, or the irregularity of streambed materials as they contribute to resistance to flow, which is often used to determine water velocity in stream discharge calculations.

Meander: A sinuous channel form in flatter river grades formed by the erosion on one side of the channel (pools) and deposition on the other side (point bars).

Meander Length: Distance in the general course of the meanders between corresponding points of successive meanders of the same phase. Twice the distance between successive points of inflection of the meander wave.

Off Channel: Bodies of water adjacent to the main channel that have surface water connections to the main river channel at summer discharge levels.

Riffle: A shallow section of a stream or river characterized by rapid current and a surface broken by completely or partially submerged obstructions such as gravel or boulders.

Riparian (Area): An area of land adjacent to a stream, river, lake or wetland that contains vegetation that, due to the presence of water, is distinctly different from the vegetation of adjacent upland areas. The riparian area is influenced by and influences the adjacent body of water.

Riprap: A layer of large, durable material such as coarse rock used to protect exposed surfaces and slopes susceptible to erosion such as fills and streambanks.

Salmonid: Refers to a member of the fish family *Salmonidae*, including the salmons, trouts, chars, whitefishes and grayling.

Shear Stress: Stress caused by forces operating parallel to one another but in opposite directions.

Sinuous: Characterized by a serpentine or winding form, typically referring to stream channels.

Substrate: The basic surface on which material adheres, typically mineral and (or) organic material that forms the bed of a stream.

Thalweg: Line of deepest water in a stream channel as seen from above. Normally associated with the zone of greatest velocity in the stream. If there is no stream, it is the line of lowest points of a valley.

Watershed: Also referred to as a drainage basin or catchment area. Watersheds are the natural landscape units from which hierarchical drainage networks are formed. Watershed boundaries typically are the height of land dividing two areas that are drained by different river systems.

1 INTRODUCTION

1.1. Purpose of Effort

The North Santiam Watershed Council (NSWC) retained River Design Group, Inc. (RDG) to complete the *Stout Creek Assessment and Restoration Plan* (Plan). The Plan scope of work included reviewing existing information, completing a field assessment and hydrologic analysis, and identifying potential restoration, conservation, and/or resource protection opportunities on lower Stout Creek from Fernridge Road in Mehama, Oregon, to the confluence with the North Santiam River. The assessment reach is approximately 2.5 miles in length.

The purpose of the Plan is to provide an overview of stream corridor conditions and recommendations for restoring, conserving, and protecting resources in the study area. RDG and NSWC developed the following project objectives for the Plan:

1) Evaluate existing and historical stream corridor conditions in the project reach.
2) Complete a hydrologic/hydraulic analysis to evaluate flow frequency and duration and floodplain connectivity.
3) Address existing stream corridor conditions that may affect erosion rates, streambank stability, and migratory fish species.
4) Identify potential restoration sites and provide typical treatments for improving fish habitat. Restoration strategies should focus on limiting factors in the watershed and take into account multiple native fish species and life stages.

2 METHODS

The following sections outline RDG's methods for collecting data, evaluating the existing river corridor conditions, and preparing the conceptual design plans.

RDG completed field data collection in July 2008 to characterize the stream corridor, channel habitats, sediment sources, and bank erosion sites. Field data collection methods included a reconnaissance-level stream walk-through, channel surveys, discharge measurements, and stream substrate characterization. The field surveys characterized typical channel conditions in each of the three reaches that were established.

Three project reaches were delineated according to river conditions typified by channel type, valley morphologies, and land development patterns. These reaches are listed in Table 2-1.

Table 2-1. Project reach delineation.

Reach Number	Start of Reach Station	Start of Reach Description	End of Reach Station	End of Reach Description
1	0+00	Fernridge Rd SE Bridge	38+00	Stockpile Ln SE Bridge
2	38+00	Stockpile Ln SE Bridge	93+00	Ferry Rd SE Bridge
3	93+00	Ferry Rd SE Bridge	136+00	North Santiam River

2.1. Stream Reconnaissance

RDG completed a stream reconnaissance on lower Stout Creek in July 2008. The reconnaissance began at the Fernridge Road SE bridge and continued downstream approximately 2.5 miles to the confluence with the North Santiam River. Tasks completed during the reconnaissance included the following:

- Channel habitat unit classification and mapping.
- Bank erosion site mapping.
- Invasive plant species mapping.
- Evaluation of existing impaired and reference reach conditions.
- Photographic documentation of river corridor conditions.

Data collection sheets were completed and transferred into Microsoft Excel for processing. Spatial data were plotted in ArcGIS on 2005 NAIP air photo imagery. A map of the project area is included in Appendix A, and a reach map is in Appendix B. Reconnaissance information was also used for preparing conceptual restoration, conservation, and stabilization plans.

2.1.1. Channel Habitat Unit Classification and Mapping

Channel habitat units were classified to evaluate habitat diversity in each of the three reaches. Breaks in habitat unit types were noted and stations were recorded. Habitat feature locations and extents were noted on aerial photograph base maps. Habitat units were determined based on water velocity, turbulence, channel bed profile facet slopes, and water depth.

The four primary features encountered in Stout Creek included pools, glides, runs, and riffles. Pools are deep habitat units with typically low water velocities. Although water levels were low at the time of the site surveys, pools accounted for the greatest proportion of habitat units in the assessment reach. Glides were marked by an increasing channel bed elevation, forming a transition between the pool and the subsequent run or riffle. Runs were defined as the transition from the riffle into the pool. Run features were characterized as channel sections with higher water velocities transitioning into slower water velocities marked by the upstream end of the pool. Riffles were defined as higher gradient sections of the channel exhibiting surface turbulence. Table 2-2 summarizes channel habitat unit features. A channel habitat unit map is presented in Appendix C – Stout Creek Habitat Units.

Table 2-2. Characteristics of channel habitat features.

Habitat Unit	Surface Turbulence	Water Velocity	Water Depth	Bed Facet Slope	Fish Habitat Benefits
Pool	Low	Low	High	Positive	Resting and feeding areas
Glide	Low	Low	Medium	Negative	Resting, feeding, and spawning areas
Run	Medium	High	Medium	Positive	Feeding areas
Riffle	High	Medium	Low	Positive	Food production

2.1.2. Bank Erosion Site Mapping

Prominent bank erosion sites were noted on the aerial photograph base maps and photographed. Due to the lack of sites with severe bank erosion, a GIS layer was not created for bank erosion sites in Stout Creek.

2.1.3. Impaired and Reference Conditions

Typical stream corridor conditions were noted during the reconnaissance. Typical impaired condition sections of the stream were noted by steep or eroded banks, low habitat diversity, poor riparian vegetation, infrequent large wood, and low floodplain habitat complexity. Reference sections of the river generally had dynamic channel conditions typified by abundant large wood, high habitat diversity characterized by a range of velocities and water depths, and floodplains with multi-story vegetation, floodplain channels and ponds, and large woody debris.

2.1.4. Channel Surveys

Channel surveys were completed with a total station and survey laser. Survey data collection followed U.S. Forest Service (USFS) procedures (Harrelson et al. 1994) and included channel cross-sections and profiles. Surveys were completed at one site in Reach 2 and one site in Reach 3.

Survey data included cross-sections, longitudinal channel profiles, discharge measurements, pebble counts, and ground photos. Data were collected to characterize terrace, floodplain, bankfull, water surface, and thalweg features. Channel thalweg measurements were generally collected at changes in the channel bed elevation or habitat features. Water surface measurements were collected at changes in the water surface slope and corresponding habitat features. Total station survey data were processed using AutoCAD Land Development Desktop 2007/2008 (Autodesk 2007).

Pebble counts were collected to characterize the channel bed sediment (Wolman 1954). Pebble count data were imported into RiverMorph for storage, processing, and analysis. Multiple photographs were taken at each surveyed cross-section and within each reach. Ground photographs are stored on RDG's Corvallis office network and are provided on a DVD at the end of this report.

2.2. Hydraulic Modeling

Hydraulic modeling was completed to evaluate channel hydraulics in the project reach. At-a-section modeling was completed using WinXSPro (Hardy et al. 2005). Data used in the models included the respective channel cross-sections, the low discharge and bankfull discharge water surface slopes, and channel substrate materials (D_{84} particle size). Discharge measurements were completed to assist in model calibration.

2.3. Remote Sensing

ArcGIS programs were used to develop field base maps and visualization figures. Programs included ArcGIS Version 9.1 (ESRI 2005a) and ArcGIS extensions Spatial Analyst (ESRI 2005b) and 3D Analyst (ESRI 2005c). Channel plan form measurements were based on air photo interpretation. Spatial data were acquired from multiple state and federal agency sources.

2.4. Stream Classification

The Rosgen stream classification system (Rosgen 1994) was used to characterize physical features of Stout Creek. The classification system is useful as a communication tool to convey typical channel conditions exhibited by a river. Morphological features used to classify a river include the following variables.

- Entrenchment ratio (width of flood-prone area to top width of bankfull channel)
- Width-to-depth ratio (ratio of bankfull top width to mean bankfull depth)
- Dominant channel materials (D_{50} particle size)
- Slope
- Sinuosity (ratio of stream length to valley length)

The channel bankfull slope, width, mean depth, maximum depth, flood prone width, and channel bed sediment were surveyed in the field. Channel sinuosity was measured using aerial photographs.

The Rosgen stream classification system uses these physical characteristics to delineate stream reaches into major stream types. Streams are given alpha-numeric codes with letters from A to G denoting major stream type and numbers denoting the median particle size (D_{50}) calculated from pebble counts. For example, a B4 stream type is a channel with low sinuosity, a high width/depth ratio, stable plan and profile, and gravel-dominated substrate. Stream types are typically used to label stream reaches that are either 20 bankfull widths or two meander sequences in length. Smaller sub-reaches may be labeled as stream type inclusions. The following section provides a general description of the characteristics of the major Rosgen stream types found within the Stout Creek study area.

Rosgen B Stream Type
Rosgen B streams have a medium gradient (slope 2-3.9%), are moderately entrenched (ratio of flood-prone width to bankfull width 1.4-2.2), have moderate to high width-to-depth ratios (>12), and low sinuosity values (>1.2). These channels have very stable plans and profiles, and stable banks. Type B streams typically occur in narrow, gently sloping valleys. They are riffle-dominated types with rapids and infrequently spaced pools. Natural sediment supply is usually low, as is streambank erosion potential. The Rosgen B stream type is the dominant type found in all three reaches in Stout Creek. Using the Montgomery and Buffington (1997) classification system, B stream types are defined as plane bed morphology streams.

Rosgen C Stream Type
Rosgen C streams have a low gradient (slope <2%), are slightly entrenched (ratio of flood-prone width to bankfull width >2.2), have moderate to high width-to-depth ratios (>12), moderate sinuosity values (>1.4), and are characterized by riffle/pool sequences. These channels have characteristic point bars and broad, well-defined floodplains. Vegetation influences channel stability in C stream types. When vegetation is disturbed and removed, C stream types are sensitive to both lateral (bank) and vertical (down-cutting) erosion. Natural sediment supply is moderate to high except in those areas where streambanks are well vegetated. These streams are highly sensitive to changes in sediment and stream flow (Rosgen 1996). Using the Montgomery and Buffington (1997) classification system, C stream types are defined as riffle-pool morphology streams. Rosgen C stream types are found in short sections in all three reaches of Stout Creek.

Rosgen F Stream Type
The F stream type occurs where the floodplain is restricted by topography or where the stream has a more unstable form as a result of disturbances. F type streams have low gradients (slope <2%) and are entrenched (ratio of flood-prone width to bankfull width <1.4), with most flood flows confined to the channel. This stream type tends to create a new floodplain at a lower elevation than the historical floodplain, a process which leads to high levels of bank erosion, bar development, and sediment transport. Because of the entrenchment and high width-to-depth ratio (>12), velocities can reach relatively high levels at flood flows because the floodplain is not connected enough to dissipate energies. Stream power is thus greater and may lead to increased damage to streambanks and the channel bed. Using the Montgomery and Buffington (1997) classification system, F stream types are defined as plane bed and/or riffle-pool morphology streams. Rosgen F stream types occur in Stout Creek where berms, other bank stabilization structures, or adjacent hillslopes lead to entrenchment of the channel.

Rosgen Stream Type Numerical System
Stream types are further described by the median channel bed sediment particle size, which is given a numerical value. The numbering system ranges from 1 to 6, with increasing values representing a finer median particle size. A bedrock-dominated channel is given a value of 1, while a silt bed is given a value of 6. Table 2-3 includes the numerical values and the associated particle size ranges.

Table 2-3. Rosgen stream classification system numerical values, common sediment class name, and associated particle size distribution.

Numerical Value	Sediment Class Name	Sediment Class Size Range (mm)
1	Bedrock	Bedrock
2	Boulder	256-2,048
3	Cobble	64-256
4	Gravel	2-64
5	Sand	0.062-2
6	Silt	< 0.062

Stout Creek is a gravel bed river with areas of silt/sand substrate and minor inclusions of clay hardpan in areas that have been scoured. Most of the reaches classify as Rosgen B3 stream types.

3 STOUT CREEK WATERSHED OVERVIEW

Information in the following sections is largely taken from the North Santiam Watershed Assessment (E&S Environmental Chemistry 2002). This information is provided as a summary of historical and existing conditions that are important to consider when evaluating both the current state of the stream corridor, the restoration objectives, and the potential to re-establish ecological processes.

3.1. Historical Landscapes

Stout Creek has undergone several changes and modifications through time. In general, changes to stream channels that are caused by dams, channelization, and diversions alter the physical character of streams and may adversely affect aquatic organisms and habitats. Land use activities including agriculture, timber production, and rural residential development have led to the simplification of the Stout Creek corridor. Results of the historical planform analysis for the assessment reach are presented in Section 4.1.1.

Most of the impacts to the Stout Creek channel have come from past draining of floodplains and channelization of streambanks. Land use in the 11.6 mi^2 Stout Creek watershed is 1.6% urban, 77.9% forest, 14.3% rural non-forest, 2.0% native valley vegetation, and 4.2% agriculture. Most of the forested lands are found in the upper part of the watershed. In the vicinity of the assessment reach in lower Stout Creek, primary land uses are urban, rural non-forest, and agriculture.

Changes to historical land uses have effects both on stream channel habitat and water quality. For example, agricultural uses may lead to channel modifications, changes in pool quantity and quality, large wood abundance, shade and canopy, substrate quality, and flow alterations. Corresponding effects on water quality include increased water temperature, turbidity, fine sediments, nutrients, bacteria, and pesticides, and decreased dissolved oxygen.

3.2. Hydrology

Major tributaries to Stout Creek include Shellburg Creek and Ayers Creek, both of which enter Stout Creek above the assessment reach. Tietz Creek is a tributary with intermittent flow that enters Stout Creek at approximately STA 47+00. The entire Stout Creek watershed is approximately 11.6 square miles in area. Hydrology in the watershed is largely determined by the climate and potential for rain-on-snow events in the upper watershed. The climate in the Stout Creek watershed is characterized by warm, dry summers and cool, wet winters. Mean annual average precipitation is 80 inches, and elevations range from 561 to 3,297 feet.

Stream gage data are not available for Stout Creek. This summary of the hydrological characteristics of Stout Creek is based on data from a U.S. Geological Survey and Oregon Water Resources Department regional regression model (Cooper 2005). Flows in Stout Creek vary greatly throughout the year due to seasonal precipitation and summer water withdrawals. The magnitude of annual runoff also varies between years, as rain-on-snow flood events are possible between December and February.

The regional regression model was also used to characterize peak flow return intervals. Estimated flood frequencies for Stout Creek are provided in Table 3-1. The estimated 2-year discharge for Stout Creek near the confluence with the North Santiam River is 572 cfs.

Table 3-1. Flood frequencies for Stout Creek based on watershed characteristics and regional relationships.

Return Period (years)	Peak Flow (cfs)	95% Confidence Limits	
		Lower (cfs)	Upper (cfs)
2	572	306	1,070
5	826	443	1,540
10	1,000	532	1,880
20	1,170	613	2,230
25	1,220	638	2,350
50	1,390	711	2,720
100	1,560	781	3,110
500	1,950	928	4,100

3.3. Vegetation

Stout Creek supports a varied riparian vegetation community. In the higher elevations of the watershed, vegetation is characterized by Douglas fir, western hemlock, and grand fir forest. At middle elevations, Douglas fir and Oregon white oak forest and woodlands are common. In more extensive floodplain areas in the lower part of the watershed, oak, Douglas fir, ponderosa pine, and pasture lands predominate.

Riparian vegetation classes as a percentage of the Stout Creek watershed are as follows: 69.3% Douglas fir-western hemlock-grand fir forest, 13.3% Douglas fir-Oregon white oak forest and woodland, 6.6% agricultural cropland and pasture land, 6.0% recent timber harvest areas, and 4.6% oak-Douglas fir-ponderosa pine-pasture-urban mosaic.

Areas of grass/shrub riparian conditions are associated with agricultural lands in Lower Stout Creek. Common understory shrubs in the assessment reach include willow, red-osier dogwood, and vine maple. In areas of disturbance or agricultural and rural development, non-native invasive plants such as Himalayan blackberry, Japanese knotweed, reed canary grass, scotch broom, English ivy, and black bamboo are common. Typical vegetation in the Stout Creek assessment reach is shown in Figure 3-1, and locations of invasive vegetation are shown in Appendix D – Stout Creek Invasive Weed Locations.

The 2.5-mile assessment reach in Lower Stout Creek has scattered areas of narrow riparian buffers or no buffers, creating a discontinuous riparian zone. In general, the riparian vegetation conditions in the assessment reach are in poor to fair condition due to surrounding land uses that have led to vegetation thinning and decreased width of the riparian corridor.

Historical aerial photographs indicate that much of the riparian vegetation along the Stout Creek assessment reach had already been removed by 1953. Much of the land that once supported upland vegetation was converted to for agricultural development. Remaining patches of older trees are mostly on hillslopes that are too steep for farming, and they are most extensive on the inside bend of stream channel meanders.


Figure 3-1. Examples of riparian conditions in Stout Creek. Willows and other shrubs are common riparian understory species (left). A view of the riparian forest shows blackberry in the foreground, with bigleaf maple, vine maple, and some alders and Douglas fir common in the overstory (right).

3.4. Fisheries and Habitat

The following sections describe the fish species that are known to occur in Stout Creek, habitat needs for each target species, and a description of current fish habitat conditions in the assessment reach.

3.4.1. Fish Community

The Stout Creek fish community includes both native and introduced fish species. Native salmonids include spring Chinook and coho salmon, as well as winter steelhead and cutthroat trout. Wild stocks of spring Chinook salmon and steelhead are listed as threatened under the Endangered Species Act. Planting of hatchery stocks of both species in the North Santiam watershed has been extensive, and is believed to have contributed to declines in abundance of wild stocks. Resident cutthroat trout and rainbow trout are present in the upper portion of the watershed.

Non-salmonid fish present in the watershed include Pacific lamprey, sculpins, and dace. There is a greater abundance of non-salmonid fish in the lower watershed, but some species, such as sculpins, may be found throughout the watershed. The North Santiam River also supports a small population of Oregon chub, which is an endangered species that is endemic to the Willamette Valley.

There is also a variety of non-native fish in the watershed that have been introduced to the Willamette River and tributary streams. Most of the documented use by non-native fish is in the North Santiam River where warmer water temperatures and altered habitat have provided ideal conditions for many of these fish. Fish species found in the Stout Creek and North Santiam River watersheds are included in Table 3-2.

Table 3-2. Native salmonids, native non-salmonids, and introduced fish species in Stout Creek and the North Santiam River.

Fish Species	Notes
Native Salmonid Species	
Winter steelhead, *Oncorhynchus mykiss* Chinook salmon, *Oncorhynchus tshawytscha* Coho salmon, *Oncorhynchus kisutch* Cutthroat trout, *Oncorhynchus clarkii clarkii* Rainbow trout, *Oncorhynchus mykiss*	Willamette spring Chinook salmon and winter steelhead (both anadromous species) were listed as threatened under the Federal Endangered Species Act (ESA) in 1999. Factors contributing to their decline include habitat loss, fish passage barriers, altered flow regimes, water quality, and the negative impacts of hatchery fish.
Native Non-salmonid Species	
Lamprey Pacific lamprey, *Lampetra tridentata*	Pacific lamprey are anadromous (adults reside in the ocean and return to rivers and streams to spawn). Pacific lamprey were listed as an Oregon state sensitive species in 1993 due to a serious decline in abundance.
Minnows Speckled dace, *Rhinichthys osculus* Longnose dace, *Rhinichthys cataractae* Northern pikeminnow, *Ptycheilus oregonensis* Redside shiner, *Richardsonius balteatus* Chiselmouth, *Acrocheilus alutaceus* Peamouth, *Mylocheilus caurinus* Oregon chub, *Oregonichys crameri*	Dace typically occur in the lower portions of tributaries to the North Santiam River. *Oregon chub* is a small minnow native to the Willamette River basin. Oregon chub were listed as endangered under the Federal ESA. Chub prefer low gradient tributaries and off-channel habitats such as side-channels and sloughs. Their decline has been attributed to loss of habitats, altered flow regimes, and predation.
Suckers Largescale sucker, *Catostomus macrocheilus*	Most suckers occur in the lower part of the North Santiam River.
Sculpins Mottled sculpin, *Cottus baurdi* Paiute sculpin, *Cottus beldingi* Prickley sculpin, *Cottus asper* Shorthead sculpin, *Cottus confusus* Reticulate sculpin, *Cottus perplexus* Torrent sculpin, *Cottus rhotheus*	Sculpins occupy habitat throughout the Stout Creek watershed.
Sticklebacks Three-spine stickleback, *Gasterosteus aculeatus*	
Troutperch Sand roller, *Percopsis transmontana*	
Non-Native Species (all non-salmonid)	
Largemouth bass, *Micropterus salmoides* Smallmouth bass, *Micropterus dolomieui* Brown bullhead, *Ameiurus melas* Yellow bullhead, *Ameiurus natalis* Bluegill, *Lepomis macrochirus* Pumpkinseed, *Lepomis gibbosus* Warmouth, *Lepomis gulosus* Black crappie, *Pomoxis nigromaculatus* White crappie, *Pomoxis annularis* Western mosquitofish, *Gambusia affinis*	Most of these species occur in the North Santiam River.

3.4.2. Species Habitat Needs

The following sections present the habitat needs for the three target salmonid species in the Lower Stout Creek assessment reach.

Winter steelhead

Migration and Spawning: Returning adults enter the Willamette River between December and April, with peak spawning in tributaries occurring in April and May. Spawning occurs in low to moderate gradient streams (up to 8%). Lower Stout Creek provides important steelhead spawning habitat due to its low-gradient floodplain and suitable channel size.

Figure 3-2. An example of potential juvenile steelhead and salmon rearing habitat in Stout Creek

Rearing: Juveniles may rear in Stout Creek for as long as 4 years. Juvenile steelhead prefer pools with cover, large wood (Figure 3-2), cool water temperatures (less than 64°F), and high dissolved oxygen levels.

Spring Chinook salmon

Migration and spawning: Spring Chinook enter the Stout Creek watershed in late April and May with the migration continuing into July. Spawning takes place between September and October. Before spawning, adult spring Chinook hold in pools, preferring deep pools with cool water, abundant large wood, and undercut banks for cover. Spring Chinook salmon spawning takes place in lower Stout Creek. Spring Chinook salmon die after spawning, providing a marine-derived nutrient source to Stout Creek.

Rearing: Juveniles can spend up to a year rearing in Stout Creek. Like other salmonids, juvenile spring Chinook require cold water, and deep pools for feeding and cover from predators. Access to tributary streams to find refuge from high flows in the winter is also important. Juvenile spring Chinook salmon require cool water temperatures (less than 64°F), and high dissolved oxygen levels.

Coho salmon

Migration and spawning: Coho salmon were originally introduced to the Stout Creek watershed from hatchery stocking programs that were active between 1958 and 1982. Although coho salmon are no longer stocked, a small population in Stout Creek has remained self-sustaining. Coho salmon typically spawn between November and February, and they prefer gravel-cobble substrates, abundant large wood, and deep pools for cover. Coho salmon spawn throughout the Stout Creek assessment reach.

Rearing: Juvenile coho salmon normally spend one summer and one winter in freshwater. Downstream migration to the ocean occurs in the spring, usually one year after emergence. Coho salmon juveniles require cold water (less than 64°F), deep pools and cover, and high levels of dissolved oxygen.

3.4.3. Fish Species Status

Anadromous fish spend a portion of their lives residing in the ocean and return to freshwater for spawning and juvenile rearing. Four anadromous fish species that reside in the Stout Creek watershed are Chinook salmon, coho salmon, winter steelhead, and Pacific lamprey. There is concern over decreased populations of both resident and anadromous fish that currently or historically occurred in the Stout Creek watershed. Because anadromous fish have very complex life cycles, migrating through the river network as adults on their way to spawning areas and as juveniles moving downstream to the ocean, they are vulnerable to predation and human impacts such as passage barriers, water withdrawals, fishing pressures, and changes in habitat.

Upper Willamette River spring Chinook salmon and winter steelhead are listed as threatened under the Federal Endangered Species Act. Pacific lamprey is listed as an Oregon state sensitive species. In addition to these anadromous fish, there are reduced populations of Oregon chub, a resident fish native to the Willamette River basin. Oregon chub are also listed as endangered under the Federal Endangered Species Act.

3.4.4. Fish Habitat

All other factors being equal, channels with high sinuosity often contain more features that are favorable for fish and wildlife than do channels with low sinuosity. A highly sinuous river creates a larger number of ponds, islands, alcoves, side channels, and gravel bars. These features provide special habitat niches for certain species during various life stages. Juvenile spring Chinook salmon and winter steelhead use these types of features during non-summer months.

The combination of channel gradient and channel sinuosity reflects where gravel deposition occurs in Stout Creek. Gravel deposition is greatest where channel sinuosity increases and channel gradient decreases, thereby slowing the water velocity and causing much of the gravel load to settle out rather than move further downstream (Figure 3-3). Gravel bars were much less frequent in the downstream areas of the reach that have straighter channel morphologies.

Riffle habitats with gravel bars benefit fish because they provide favorable habitat for aquatic insect prey and often create areas of sorted gravels that are the right size for spawning. Zones of cooler water are often found immediately downstream of gravel bars. As a portion of the river flows subsurface through a gravel bar, the water loses heat to the gravel and exits at the downstream end at a cooler temperature. When the river becomes too warm, fish will often retreat to these cool zones for refuge.

Alcoves, side channels, and natural ponds serve as areas of refuge for juvenile spring Chinook salmon during high flows. Although these habitat features are usually narrow and have a small overall area, their influence on the river ecosystem is greater than what their area might suggest. These features have a sizable amount of edge habitat which allows sunlight to reach the bottom and supports high productivity of algae, other aquatic plants, insects, and other aquatic species.

Figure 3-3. An example of a gravel bar at STA 42+00 in Reach 1. Gravel bars are important for aquatic invertebrate production and spawning habitat for salmon and steelhead.

Large wood historically played an important role in creating habitat diversity in Stout Creek (Figure 3-4). However, removal of riparian vegetation and large wood from the creek has reduced the prevalence of habitat-forming trees in Lower Stout Creek. As in other areas in the Willamette Valley, logs on the floodplain are often cut, either for firewood or to reduce the chance of logs damaging property or infrastructure during floods. Large wood is important for fish in streams and rivers because it creates pools, hiding areas, and gravel bars, provides a substrate for aquatic insects, and contributes to channel habitat complexity.

Figure 3-4. Large wood provides overhead cover for fish habitat and also influences channel morphology. Large wood is a vital component for maintaining fish habitat in Stout Creek. Photographs are from STA 4+50 in Reach 1 (left) and STA 66+00 in Reach 2 (right).

The current condition of fish habitat in the assessment reach is discussed in detail for each of the three sub-reaches in Chapter 4.

3.5. Land Use

Present-day land use in the Stout Creek watershed is dominated by forest lands in higher elevations and agriculture in lower elevations. Approximately three-quarters of the watershed is used for forestry and other natural vegetation (wetlands and riparian areas), and one quarter is used for rural non-forest, agriculture native valley vegetation, and urban area. Land ownership in the Stout Creek watershed is 40% private non-industrial, 27% private industrial, 23% State forest, and 9% Bureau of Land Management. In lower Stout Creek in the vicinity of the assessment reach, dominant land uses are urban, rural non-forest, and agriculture.

3.6. Limiting Factors

Several habitat conditions in lower Stout Creek may negatively impact salmon and steelhead populations. These include poor riparian vegetation, erosion, limited habitat complexity, limited large wood in the stream channel, and water quality and temperature issues.

Like many North Santiam River tributaries, Stout Creek is on the 303(d) list for water quality impaired water bodies for excessive summer water temperatures. In addition to temperature, primary limiting factors include erosion, invasive vegetation, and lack of habitat complexity due to a lack of large wood. Noxious weeds are present in several locations, resulting in a lack of shade and riparian buffer.

Long-term habitat changes in Stout Creek have affected spring Chinook salmon and winter steelhead. Bottom et al. (1995) identified factors that have affected salmon habitat in the Willamette River Valley. These include streamflow reductions, elevated temperatures, riparian habitat loss, and in-stream habitat degradation. In Stout Creek, water withdrawals for irrigation uses as well as removal of streamside vegetation contribute to reduced streamflow and high temperatures. In 1990, ODFW established in-stream water rights for the protection of anadromous and resident fish habitat in Stout Creek, but these are junior to other water rights in the watershed. The overall dewatering potential in Stout Creek is high, at 65% in August and 55% in September. Dewatering has often been cited as a primary cause of reductions in salmonid populations in the watershed. Debris removal and stream channelization of Stout Creek have also caused long-term damage to salmonid habitats.

Stout Creek has low potential for large wood recruitment. The reduced number of logs and other wood in the stream channel limit the creation of pools and hiding habitat for fish. In addition, the lack of large trees growing along some sections of the river contributes to the long-term shortage of wood in channels. The status of streamside forests and wood removal actions have cumulatively impacted the river channel and fish habitat quality, reducing the formation of pools, limiting hiding cover, and slowing the trapping of spawning gravels. A targeted approach to in-channel wood restoration and riparian area enhancement would emphasize the most responsive reaches of Stout Creek. Areas of active gravel deposition would be especially responsive to short-term actions to protect current wood in the channel and promote future activities that support enhanced riparian areas.

Water quality throughout the Stout Creek watershed influences its use by fish, wildlife, and humans. Excessive values for water temperature, suspended sediment, nitrogen, phosphorus, and pesticides can make portions of the watershed unfavorable for some species fish and wildlife, especially during the summer when these species are most stressed and water levels are low. Excessive bacteria levels in the water can make the water more difficult to treat for drinking and increase the risk of infection for those who swim and angle in the river.

Stout Creek is included in the 303(d) list as water quality limited for temperature, as a result of the river exceeding the water quality standard of 64°F in its lower reaches. The NSWC monitored water temperature in lower Stout Creek in 2000, and results indicated that maximum temperature exceeded the water quality standard.

Shade is sparser in agricultural, rural, and urban areas of Stout Creek than in the higher elevation forested areas. Shade provided by riparian trees and large woody debris structures is most critical to providing cool water refugia for fish during the summer months. Summer water temperatures in lower Stout Creek could be reduced and made more suitable for juvenile winter steelhead and Chinook and coho salmon if streamside vegetation were restored along selected reaches that are currently grazed or otherwise lacking vegetation.

There is evidence of bank slumping and erosion in the Stout Creek assessment reach, especially on the outside curve of stream meanders (Figure 3-5). In addition to being a concern for landowners, streambank failures release large inputs of fine sediments into the creek, which may be detrimental to fish species. However, controlling natural meanders on one segment of stream can cause downstream erosion, often creating problems for neighboring landowners, if localized energy dissipation is not combined with the bank stabilization. By decreasing the meandering of a river, water velocity increases, downcutting of the river bottom may occur, gravel bars become coarser, and pool habitats decrease, all of which are detrimental to fish.

Figure 3-5. Examples of bank erosion in the lower Stout Creek assessment reach. Erosion tends to occur at a faster rate in zones with no riparian vegetation than in areas with in-tact riparian vegetation and large trees that divert flows away from the bank.

3.7. Summary

In summary, Stout Creek has been impacted by several decades of development that has brought changes to the stream corridor and greater watershed. Despite both historical and contemporary alterations to the stream, lower Stout Creek offers outstanding potential for restoring and conserving ecological and physical processes necessary to improve streambank stability and habitat conditions for Chinook and coho salmon and steelhead, among other fish species. Proposed restoration and conservation actions addressing current habitat conditions are discussed in detail in Chapter 5 for each of the three sub-reaches.

4 STREAM SUB-REACH CONDITIONS

The following sections present information from the stream reconnaissance, stream surveys, and remote sensing completed by RDG.

4.1. Stream Corridor Overview

The 2.5-mile study area was delineated into three reaches based on channel morphology and clear reach breaks (see Appendix C – Stout Creek Habitat Units). Reach 1 extends from the Fernridge Road Bridge to the Stockpile Lane Bridge, where the meandering of the channel slows and the stream type changes. Reach 2 extends through the Ferry Road Bridge. Reach 3 begins at the Ferry Road Bridge and continues to the end of the assessment reach at the confluence with the North Santiam River. Table 4-1 includes summary of channel characteristics by reach.

Table 4-1. Reach dimensions and characteristics for the Stout Creek study area.

Reach	Dominant Stream Type	Channel Length (miles)	Valley Length (miles)	Channel Sinuosity	General Reach Characteristics
Reach 1	Rosgen B/C	0.65	0.61	1.06	Sinuous channel, well-developed floodplain
Reach 2	Rosgen B/F	1.01	0.94	1.07	Narrow beltwidth and valley bottom
Reach 3	Rosgen B	0.86	0.78	1.10	Very low sinuosity, narrow beltwidth
Total		2.51	2.33	1.08	

4.1.1. Historical Planform Analysis

A time series air photo analysis was completed to evaluate the channel planform geometry over time. Aerial photos were obtained for 1939, 1953, 1961, 1965, and 2005. This analysis provides insight into historical river changes, stability of the reach, river dynamics and potential for restoration. Planform metrics are presented in Table 4-2. The 1964 flood event may have affected the channel planform captured in the 1965 aerial photograph. The average radius of curvature and average meander length were lowest in 1961 and highest in 2005. The channel beltwidth was greatest in 1953 and lowest in 1965. Large channel beltwidths are typically associated with flatter channel slopes, lower water velocities and shear stress, and more diverse floodplain morphologies. Channel sinuosity has fluctuated over time, with the greatest sinuosity values observed in 1953 and 1965.

The channel metrics suggest the 1961 channel was characterized by a relatively tight planform with short radius of curvature and meander length measurements, and an intermediate beltwidth. The channel planform therefore reflected frequent, short pools. Current 2005 metrics suggest the stream planform is straighter compared to historical channel planforms, as the radius of curvature and meander lengths are large, and channel sinuosity is small relative to historical values. However, the relatively high average channel beltwidth suggests Stout Creek expanded laterally from 1965 to 2005.

A review of historical and recent channel alignments illustrates the changes in the channel planform in Stout Creek over the past 70 years. The stream lacks riparian vegetation in some areas and has been simplified and straightened over time. In general, there are few changes in the Stout Creek channel alignment that are evident from a review of historical photographs.

Table 4-2. Channel planform metrics from the historical air photo analysis for the Stout Creek assessment reach.

Year	Metric	Radius of Curvature (ft)	Meander Length (ft)	Beltwidth (ft)	Sinuosity
1939	Mean	282	381	72	1.13
	Min	84	103	25	
	Max	1,454	1,727	206	
1953	Mean	384	426	93	1.18
	Min	70	137	43	
	Max	950	1,318	287	
1961	Mean	278	366	79	1.14
	Min	46	83	33	
	Max	716	859	172	
1965	Mean	370	379	71	1.18
	Min	77	140	29	
	Max	802	832	154	
2005	Mean	655	564	91	1.14
	Min	98	194	46	
	Max	1,850	1,605	308	

4.2. Reach 1 – Upper Meandering Reach

Reach 1 begins at the Fernridge Road Bridge and continues to the Stockpile Lane Bridge. The channel has a dominant Rosgen B4 stream type, with a moderate gradient slope, moderate entrenchment, and gravel substrate. Reach 1 extends 0.72 miles to a change in the dominant stream type marking the start of Reach 2. The majority of Reach 1 is characterized by a broad step pool morphology, with low gradient riffles. Riffles typically have short runs into deep pools. Glides out of pools tend to be relatively long and broad.

The floodplain morphology in the reach is influenced by the valley bottom width and stream processes. The Stout Creek channel has a well-developed floodplain and a broad valley on the left bank, and it is constricted by the hillslope on the right bank. The channel planform is fairly stable. Riparian vegetation understory is dominated by multiple age classes of willows and red-osier dogwood, as well as invasive vegetation such as Japanese knotweed. Mature cottonwoods, alders, and big leaf maple form the overstory where the riparian corridor is wide. The hillslope on the right bank in this reach is a source of mature large wood inputs to the stream. The presence of large wood on stream banks tends to reduce erosion by deflecting flow away from banks.

Reach 1 had the largest number of habitat units (65) of the three reaches, which is an indication of greater habitat diversity. Pool habitats accounted for the greatest channel length, while run habitats were the least common. Habitat unit summary statistics for the reach are presented in Table 4-3. Appendix C presents a map of the distribution of habitat units in all three reaches.

Table 4-3. Habitat unit summary for Reach 1.

Habitat Unit	Number of Units	Channel Length (ft)	Percent of Total Length
Riffle	31	1,264	33.3%
Run	4	193	5.1%
Glide	5	705	18.6%
Pool	25	1,638	43.1%
Total	65	3,800	100.0%

Channel habitat unit diversity in the reach reflects the range of fish habitat conditions found in Reach 1. Diverse habitats, frequent large wood, and wider riparian vegetation corridors contribute to fish habitat diversity in the reach. The channel habitat units provide a good range of in-stream conditions to support food production and fish growth. In-stream large wood provides cover and varied flow paths beneficial for fish foraging and resting. Off-channel habitats provide juvenile rearing habitat during all flows, and are especially important resting areas during high water events. The multi-age riparian community provides wood and leaf litter to the stream creating habitat and the basic nutrients for the aquatic community.

4.2.1. Bank Stabilization Sites

Bank stabilization and erosion sites were noted during the field reconnaissance. Bank stabilization in Reach 1 was limited to an approximately 100-ft gabion wall along the south stream bank upstream from the Fernridge Road Bridge (Figure 4-1). A floodplain levee paralleling the southern streambank was placed to limit flooding of nearby buildings.

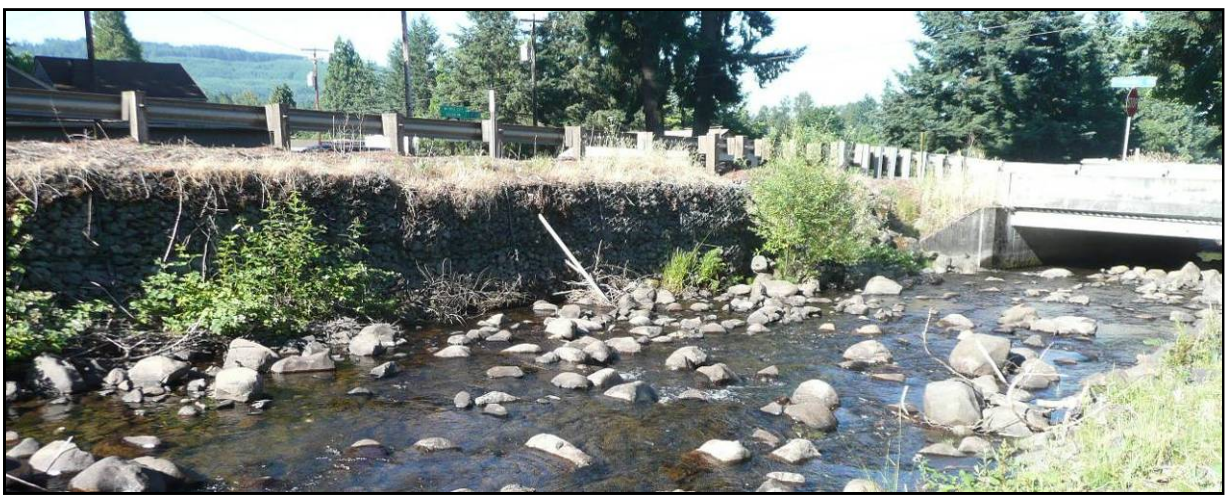


Figure 4-1. The gabion wall upstream of the Fernridge Road Bridge limits lateral channel migration and protects the road. Photograph is taken from the right bank just upstream of the bridge.

No significant erosion in Reach 1 was noted during field reconnaissance.

4.2.2. Channel Survey Results

Channel surveys were completed in Reach 1 in July 2008, and two channel cross-sections were completed in downstream reaches in November 2008. Because the stream corridor is relatively stable and in-stream habitats are functioning well in Reach 1, a channel cross-section was not completed in this reach.

4.2.3. Fish Habitat Conditions

In the Stout Creek assessment reach, Reach 1 provides a relatively high level of fish habitat diversity. The B stream type with step pool and riffle-step morphologies, and the C stream type reach with riffle-pool morphologies provide juvenile rearing habitat. Juvenile rearing habitats include backwater areas, pools with cover provided by large wood pieces, shallow channel margins in the lower third of meanders, and areas adjacent to point bars. Reach 1 also has a good supply of large wood in the channel and on the channel margins. Large trees and rootwads provide cover for fish, add channel habitat complexity, and stabilize banks.

4.2.4. Summary

In Reach 1, bank stabilization at the Fernridge Road Bridge site is functioning as intended. There is no evidence of significant streambank erosion in Reach 1. Streambank slumping, erosion, and property loss are more severe in downstream reaches. In general, riparian vegetation in Reach 1 of Stout Creek is in proper functioning condition aside from invasive weeds that were sporadically located throughout the reach.

4.3. Reach 2 – Middle Reach

Reach 2 begins at the Stockpile Lane Bridge and continues through the Ferry Road Bridge at STA 93+00, approximately 1.01 miles downstream. This reach is distinguishable from Reach 1 by a narrower riparian buffer, more common invasive weeds, and frequent bedrock channel substrate. There is slightly more streambank instability and erosion in Reach 2. The floodplain morphology in the reach is influenced by the valley bottom width and river processes. Meandering of the channel through Reach 2 is confined on the right bank by the Fern Ridge and Stout Mountain hillslopes.

Reach 2 primarily exhibits Rosgen B and F stream types. Because of constraints on channel meandering, Reach 2 has very low sinuosity and lacks habitat complexity. Various land uses in some areas of the reach have led to the removal of riparian vegetation and potential backwater areas. Water velocities in this reach may be very high at flood flows because the floodplain is not connected enough to dissipate energy. This may lead to increased erosion of streambanks and the channel bed.

The riparian understory is dominated by willows and red-osier dogwood, although invasive species such as Japanese knotweed, Himalayan blackberry, reed canarygrass, and ivy are common in this reach. Bigleaf maple, cottonwood, and alder make up the overstory. There is typically more riparian vegetation on the northern side of the channel than on the southern. Vegetation patterns reflect the agricultural practices that predominate in Reach 2. The most severe bank erosion is evident in stream reaches lacking riparian vegetation. Livestock grazing on streambanks also adversely affects riparian vegetation and streambank stability. Figure 4-2 includes some typical photographs of the riparian conditions in Reach 2.

Figure 4-2. Typical vegetation conditions in Reach 2. Willows, dogwood, and blackberry are common understory species while big leaf maple, Oregon ash, and cottonwood are common in the overstory (left). The lack of riparian vegetation on the left bank of the channel bend at STA 68+00 contributes to bank instability (right).

Reach 2 has 42 habitat units. There is a good mixture of riffle, glide, and pool habitat in this reach. Habitat unit summary statistics are presented in Table 4-4, and are mapped in Appendix C.

Table 4-4. Habitat unit summary for Reach 2.

Habitat Unit	Number of Units	Channel Length (ft)	Percent of Total Length
Riffle	20	1,246	22.7%
Run	1	150	2.7%
Glide	12	2,378	43.2%
Pool	9	1,726	31.4%
Total	30	5,500	100.0%

4.3.1. Bank Stabilization and Erosion Sites

Bank stabilization and erosion sites were limited in Reach 2. There is one area of rock fill used for bank stabilization in Reach 2 upstream of the Highway 22 Bridge. Figure 4-3 illustrates bank stabilization treatments in Reach 2.

Figure 4-3. Bank stabilization site in Reach 2. Rock fill was added to the left bank to slow erosion.

Erosion in Reach 2 is related to vegetation conditions, past land use, and bank stabilization efforts undertaken to limit channel meandering. The narrow riparian zone through much of Reach 2 results in a narrower buffer between the active channel and adjacent properties. Displacement of the native shrub layer and the presence of grasses have reduced the floodplain's resistance to lateral erosion. In Reach 2, two erosion sites are located at approximately STA 51+00 and STA 62+00.

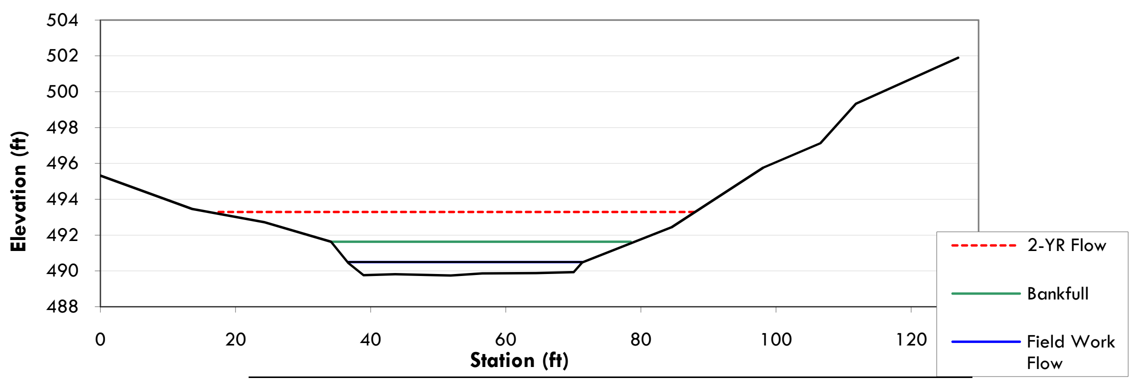
4.3.2. Channel Survey Results

A channel survey was completed in July 2008, and a cross-section was completed on November 21, 2008. A hydraulic channel cross-section was established in Reach 2 just upstream of the Phantom Lane Bridge. A summary of results from the cross-section surveys that are analyzed in this report are provided in Table 4-5.

Table 4-5. Bankfull channel cross-section summary for Stout Creek. The bankfull channel was delineated based on topographic breaks, sediment deposition, and vegetation patterns.

Reach	Station	Stream Type	Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)	Hydraulic Radius (ft)
Reach 2	71+00	B3	Glide	45.0	67.2	1.5	1.9	1.47
Reach 3	126+00	B3	Run	110.4	114.0	1.0	3.6	1.01

The survey included a cross-section and channel profile. Summary information from the survey is included in Figure 4-4. The photos capture typical river corridor conditions in the vicinity of the Phantom Lane Bridge. Himalayan blackberry is growing on the left bank. The right bank is the side of the hillslope, but medium density riparian vegetation provides some measure of stability to the bank. Beyond the riparian corridor, the left floodplain is used for rural residence. The cross-section also exhibits the relatively flat channel bottom that predominates through this bedrock section of Stout Creek.



Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)
Glide	45.0	67.16	1.49	1.88

Figure 4-4. The cross-section at STA 71+00. The photographs show the view looking upstream (left) and downstream (right) from the site of the cross-section.

Results from the pebble count at the site of the cross-section in Reach 2 are presented in Table 4-6. The channel at this site is dominated by bedrock. Of the 100 particles sampled for the pebble count, 63 were bedrock. Channel bed sediment was relatively consistent across the channel in this location. The median particle size (D_{50}), the size at which half the particles are smaller and half are larger, was small cobble.

Table 4-6. Pebble count results for Reach 2.

Particle Class	STA 71+00 Particle Size (mm)
D16	35.5
D35	53.6
D50	66.2
D65	96.9
D84	194.2
D95	262.7

4.3.3. Hydraulic Modeling Results

One at-a-section hydraulic model was completed in Reach 2 to evaluate channel hydraulics and connection to the floodplain. Pebble count and discharge data were used to calibrate the model. Modeling results are included in Table 4-7.

Table 4-7. The hydraulic modeling results for three stages on Stout Creek at STA 71+00.

Feature	Max Depth (ft)	Area (ft^2)	Width (ft)	Hydraulic Radius (ft)	Slope (ft/ft)	Mannings-n Value	Average Velocity (fps)	Discharge (cfs)	Shear Stress (lbs/ft^2)
Discharge Measurement	0.7	21.9	34.9	0.6	0.005	0.054	1.4	±31	0.19
Field Selected Bankfull Indicator	1.9	67.2	45.0	1.5	0.005	0.053	2.6	±172	0.46
Estimated 2-yr Event Hydraulics	3.5	163.6	72.1	2.2	0.005	0.052	3.5	±574	0.70

4.3.4. Fish Habitat Conditions

Channel habitat types in Reach 2 are relatively varied, with pool, riffle, and glide habitat common. While there are some parts of the channel with overhanging willows or other shrubs that provide cover to fish, riparian vegetation corridors are generally thin. As a result, features that improve habitat complexity and enhance fish habitat are limited in the reach. When the channel site survey was conducted in July 2008, livestock were seen on streambanks, which may contribute to destabilization of banks and poor water quality. Backwater refuge areas are limited in Reach 2. One small backwater area was noted near bedrock in the lower part of Reach 2, at approximately STA 82+00.

The historical air photo analysis suggests the channel has been located in a similar alignment since the 1930s. Hill slope encroachment on the channel limits natural channel migration. Development of the adjacent floodplain has reduced the potential for large wood recruitment to the channel. Finally, many of the shrubs in the riparian corridor have been displaced. Shrubs typically provide overhead cover for fish along channel margins, contribute small wood and leaf detritus to the stream that serves as a forage base for macroinvertebrates, and maintain streambank stability. Fish habitat improvement recommendations for Reach 2 focus on large wood recruitment and recovery of the riparian zone where it has been fragmented or removed.

4.3.5. Summary

The river corridor through Reach 2 is typified by a narrow riparian community, confined channel, and low sinuosity. Areas of the reach that are constrained by bank stabilization features may contribute to downstream erosion. Maintaining and enhancing the riparian community throughout the reach will improve the long-term stability of stream-side properties and also benefit aquatic habitat.

4.4. Reach 3 – Lower Reach

Reach 3 begins just downstream of the Ferry Road Bridge. Similar to the other reaches, Reach 3 of Stout Creek is relatively straight; however, the channel is not confined by hillslope encroachment or by a road. Reach 3 has the least habitat diversity of the three reaches. Reach 3 extends 0.8 miles to the end of the assessment reach, and is classified as a Rosgen B4 stream type with segments of F-type and C-type streams. A detailed channel cross-section survey and hydraulic modeling were conducted in Reach 3 near STA 126+00.

Channel habitat diversity is lowest in Reach 3. Pool habitat makes up just over half of the reach length, and there are no run habitat units. Riparian corridors in Reach 3 are narrow, especially in more agricultural parts of the reach. Lateral channel migration has been limited during the past century in order to prevent property loss in the largely agricultural floodplain. Reed canarygrass dominates the near-channel riparian community, displacing native vegetation and reducing floodplain diversity.

A review of the historical channel alignments suggests the river pattern has been fairly constant over time. Historical photographs indicate that there may have been a dam approximately at STA 120+00 through 1965.

Reach 3 had the least channel habitat diversity of all the reaches. Pools are the dominant habitat type; riffles and runs are present but less common. Habitat unit summary statistics are presented in Table 4-8, and Appendix C presents a map of the habitat unit distribution. The ratio of pools to other habitat types suggests that Reach 3 provides conditions suitable to a range of fish age classes in varying streamflows.

Table 4-8. Habitat unit summary for Reach 3.

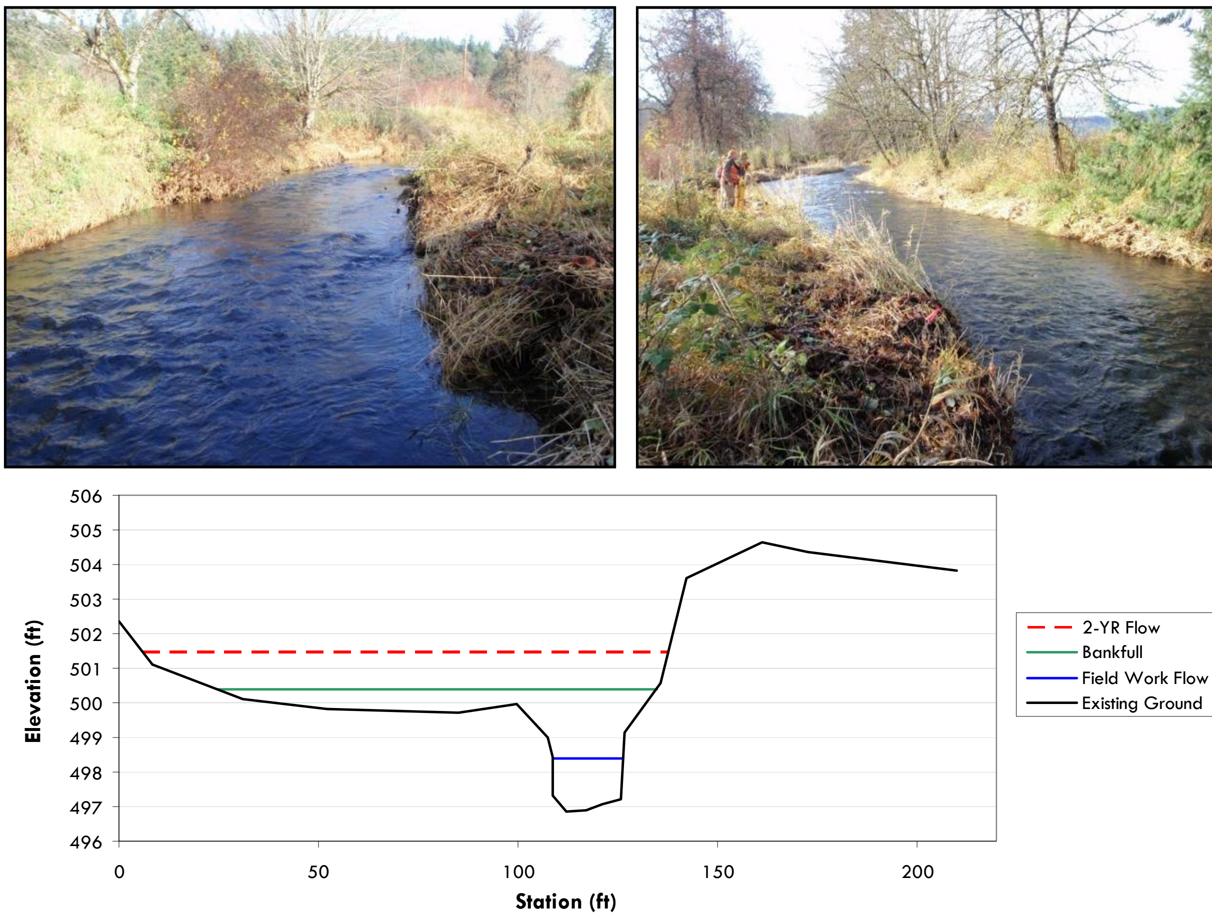
Habitat Unit	Number of Units	Channel Length (ft)	Percent of Total Length
Riffle	14	917	21.3%
Run	0	0	0.0%
Glide	8	1,184	27.5%
Pool	8	2,199	51.1%
Total	30	4,300	100.0%

4.4.1. Bank Stabilization and Erosion Sites

Bank stabilization and erosion sites were noted during field reconnaissance. Although the riparian corridor in this reach is very narrow, and invasive vegetation such as reed canarygrass is common, there was no visible evidence of bank stabilization structures or erosion in Reach 3.

4.4.2. Channel Survey Results

A hydraulic channel cross-section was established in Reach 3 downstream from the Ferry Road Bridge. A channel survey was completed on November 21, 2008. The survey included a cross-section and channel profile. Summary information from the survey is included in Figure 4-5. The photos capture typical river corridor conditions in the vicinity of cross-section. The left bank has a shallow slope that opens onto an agricultural floodplain. The right bank has a somewhat steeper bank, but the riparian vegetation present provides some measure of stability to the bank. Beyond the very narrow riparian corridor, the right floodplain is used for agriculture. The cross-section also exhibits the entrenched channel and relatively flat channel bottom that predominates through this section of Stout Creek.



Feature	Width (ft)	Area (ft^2)	Mean Depth (ft)	Maximum Depth (ft)
Run	110.4	114.0	1.03	3.60

Figure 4-5. The cross-section at STA 126+00. The photographs show the view looking upstream (left) and downstream (right) from the site of the cross-section.

Results from the pebble count at the site of the cross-section in Reach 3 are presented in Table 4-9. Channel bed sediment was relatively consistent across the channel in this location. The median particle size (D50), the size at which half the particles are smaller and half are larger, was medium cobble.

Table 4-9. Pebble count results for Reach 2.

Particle Class	STA 71+00 Particle Size (mm)
D16	46.6
D35	81.6
D50	114.7
D65	144.0
D84	180.0
D95	274.4

4.4.3. Hydraulic Modeling Results

One at-a-section hydraulic model was completed in Reach 3 to evaluate channel hydraulics and connection to the floodplain. Pebble count and discharge data were used to calibrate the model. Modeling results are included in Table 4-10.

Table 4-10. The hydraulic modeling results for three stages on Stout Creek at STA 126+00.

Feature	Max Depth (ft)	Area (ft^2)	Width (ft)	Hydraulic Radius (ft)	Slope (ft/ft)	Mannings-n Value	Average Velocity (fps)	Discharge (cfs)	Shear Stress (lbs/ft^2)
Discharge Measurement	1.6	24.0	17.7	1.2	0.0041	0.065	1.7	±40	0.32
Field Selected Bankfull Indicator	3.6	114.0	110.4	1.0	0.0041	0.062	1.5	±176	0.26
Estimated 2-yr Event Hydraulics	4.6	244.6	131.7	1.8	0.0041	0.061	2.4	±574	0.47

4.4.4. Fish Habitat Conditions

Reach 3 provides the least fish habitat diversity of the three reaches. Riparian corridors on both the left and right banks are narrow, and sources of large wood in the reach are very limited. Reach 3 lacks high quality off-channel fish habitat. The limited habitat diversity in this reach may be due in part to land use patterns in the floodplain and the lack of a wide riparian corridor. Fish habitat enhancement actions in this reach should focus on improving habitat diversity through large wood additions and riparian corridor conservation.

4.4.5. Summary

Reach 3 maintains high quality stream substrate, but lacks habitat complexity and floodplain connectivity. The stream corridor through Reach 3 has a narrow riparian community with common invasive vegetation species, a confined channel, and low sinuosity. Maintaining and enhancing the riparian community throughout the reach will benefit aquatic habitat by providing a source of large wood to the stream, improving habitat diversity, and shading the stream channel.

5 RESTORATION/CONSERVATION PRIORITIZATION PLAN

5.1. Introduction

In addition to the historical and existing conditions site assessment, RDG was tasked with developing a Restoration and Conservation Prioritization Plan for the 2.5-mile reach of Stout Creek starting near the Fernridge Road Bridge. Restoration/Conservation (R/C) goals included the following items:

- Enhance stream corridor habitat for multiple life stages and fish species inhabiting Stout Creek.
- Address stream corridor conditions that have been identified as limiting factors for Stout Creek, namely water temperature.

R/C strategies were proposed to address the aforementioned goals. The following sections outline the types of habitats and treatments that are addressed by the R/C Prioritization Plan. Proposed treatments are also provided by reach. Appendix E provides a map of the locations of proposed R/C strategies. Appendix F includes typical drawings, and Appendix G provides typical costs. Additional assessment, design, and funding will be necessary to narrow the range of proposed actions as well as to implement the strategies.

5.2. Addressing Limiting Factors

As part of the prioritization plan, RDG reviewed the North Santiam River Watershed Assessment completed by E&S Environmental Chemistry (2002) to evaluate previous work and restoration priorities. The following information was adapted from the assessments and pertains to the restoration and conservation treatments that RDG focused on during the prioritization.

Fish species that use Stout Creek include spring Chinook salmon, coho salmon, winter steelhead, and resident cutthroat trout. Production of these species is enhanced in structurally complex streams with in-stream large wood, connectivity to floodplains, beaver ponds, braided channels, marshes, and bogs.

There are several conditions that are believed to be negatively affecting the Stout Creek fish community. These limiting factors include the following issues:

- Summer water temperatures that exceed state standards,
- Dewatering of the stream,
- Lack of wetland habitat,
- Decreased channel complexity resulting from a loss of historical floodplain channels and ponds, and
- Historical and current riparian vegetation and large wood removal resulting in habitat simplification.

RDG's Restoration and Conservation Actions are intended to address some of the limiting factors, especially stream water temperature, riparian vegetation, and channel complexity. The following priorities are directed towards improving the fish community and river corridor conditions.

1. Use fencing and temporary restriction of livestock to keep domestic animals out of creeks, and thereby
    a. reduce streambank erosion,
    b. allow riparian growth for stream shading,
    c. decrease turbidity and temperature, and
    d. reduce fecal coliform bacteria inputs to the stream water.

2. Protect intact riparian areas and conserve the healthiest and most productive riparian habitat areas in Stout Creek.

3. Improve riparian vegetation and shading by planting native shrub and tree vegetation along stream corridors in watersheds supporting historic and current anadromous fish.

4. Identify instream projects, such as adding large wood or boulder structures to improve channel conditions for anadromous fish.

5.3. Stream Corridor Habitat Treatment Types

Recommended treatments in the Stout Creek assessment reach are aimed at increasing habitat diversity for the fish community and enhancing the riparian community for stream shading, woody debris sources, and reducing fine sediment loading. Treatments include instream structures and riparian buffer establishment and revegetation. The following sections provide the scientific basis for the recommended treatments.

5.3.1. Backwater, Floodplain Pond, and Side Channel Overview

Backwater habitats, floodplain ponds, and side channels provide a range of habitats favorable for juvenile fish rearing and adult fish holding. These habitats also support a range of wildlife species including birds and amphibians. These unique features are influenced by river hydraulics, sediment transport, vegetation conditions, large woody debris, and ground water-surface water interactions. Enhancing existing features, by creating new features, or re-establishing these habitats in historical channel locations, offers a range of opportunities for increasing the frequency and quality of these habitats.

A variety of factors have likely reduced the number and/or capacity of off-channel habitat in the assessment reach. Activities that have led to channel simplification and loss of unique habitats include land reclamation for agriculture, log transport and splash-damming, channel straightening and dredging, dike construction, removal of large woody debris jams, and rural residential development.

Backwater areas and floodplains often derive a major portion of their flow from either groundwater or seepage from the adjacent stream/river. The role of surface water in side channel habitats varies depending on mainstem and groundwater hydrology, channel topography, and physical features. The following paragraph is adapted from Peterson and Reid (1984) and describes floodplain ponds in more detail.

> F*loodplain ponds* are natural or constructed ponds in or above the floodplain such as abandoned gravel pits, mill ponds, ponds, and river oxbows. Floodplain ponds might be supplied by groundwater or surface water from streams or springs and have varying degrees of connectivity with the river. Habitat projects associated with floodplain ponds

may include providing fish access to ponds from the river as well as enhancing habitat within the ponds. Fish stranding in floodplain ponds may also be problematic if fish remain in the pond following drawdown of the river stage. Depending on the pond's water source and other conditions, fish remaining in floodplain ponds may not survive through inter-flood periods.

Backwater habitats form another type of floodplain habitat. During the Stout Creek reconnaissance, backwater habitats were delineated as scoured areas connected to the mainstem river channel that remain inundated by the river over all stages of the hydrograph. These habitat units typically provide important juvenile rearing habitats that also collect detritus, wood, and vegetation, the food items for aquatic macroinvertebrates. Backwaters tend to occur in the cross-over from one meander to the next and are often located in the lower third of meanders. Depending on hydraulics and sediment deposition and scour, these features may be shaped by the river on an annual basis. The persistence of a backwater area is dependent on alluvial processes.

Side channels typically form when large wood in the main channel causes a constriction and the river splits to form a small relief channel, which is active primarily during high flows. Likewise, side channels can form in relic channels resulting from lateral channel migration or abrupt channel relocations. Side channels often derive a major portion of their flow from either groundwater or seepage from the adjacent stream/river. The role of surface water in side channel habitats varies depending on mainstem and groundwater hydrology, channel topography, and physical features. The following sections are adapted from Peterson and Reid (1984) and describe three types of side channel habitats within a river floodplain: overflow channels, percolation-fed channels, and wall-based channels.

Overflow channels are flood swales, and often relict mainstem channels, that are directly connected to the main river channel during high flows. They are often very dynamic as a result of the periodic influx of water, sediment, wood, nutrients, and organic material from the main channel. Fish habitat associated with overflow channels is often unstable and typically prone to flooding and channel shifting. Periodic floods through these channels can help maintain their productivity, cleaning and redistributing spawning bed material and creating new habitat as other habitat is destroyed. Restoration of overflow channels might include reconnection of the channel to the mainstem and placement of habitat features within the channel. The level of fish utilization of overflow channels may depend on the frequency of inundation by the mainstem. Entrapment of fish can occur if the surface water connection with the river attenuates abruptly.

Percolation channels are relict river and/or flood channels and are primarily supplied by groundwater of the hyporheic zone. The hyporheic zone is the area beneath and next to a river channel where there is exchange and mixing of surface water and shallow groundwater. Frequently, percolation channels are better protected from floods than overflow channels due to their more distant proximity to the mainstem channel. Groundwater inputs result in more stable flows. Groundwater channels provide winter and summer refuge for juvenile fish, larval and adult amphibians, and a suite of invertebrates; spawning habitat for adult fish, some amphibians, and some invertebrates; and foraging habitat for many bird and mammal species. Some fish species, particularly salmonids, select spawning areas at least partially based on hyporheic discharge.

Groundwater discharge is typically cooler in the summer months and warmer in the winter relative to mainstem surface water temperatures.

Wall-based channels can be groundwater fed but are often fed from springs or surface water from an adjacent terrace. Wall-based channels are usually higher in elevation relative to percolation-fed channels. Habitat projects might include providing fish access to them and enhancing habitat within the channels. Wall-based channels were not identified during the field reconnaissance but likely exist where springs discharge to the stream corridor or where tributaries or irrigation return channels flow to the river corridor.

Off-channel Habitat Ecological Benefits
Off-channel habitats, such as backwaters, side channels, and other permanently flooded areas, are important rearing areas for juvenile salmonids (Groot and Margolis 1991) and offer a wide variety of ecological benefits to other native fish species, amphibians, and wildlife.

Artificially constructed channels have been shown to support densities of juvenile salmonids equal to or greater than levels observed in natural side channels. Off-channel habitats that are connected to shallow groundwater sources stay cooler in the summer and warmer in the winter when compared to reference side channels and mainstem reaches. In the winter, even slightly lower water temperatures cause juvenile salmonids to become more sluggish and thus more vulnerable to predation (Sandercock 1991). During the summer, warmer temperatures result in higher fish metabolic rates and a corresponding increase in food requirements (Welsh et al. 2001).

By locating off-channel habitat in areas of groundwater upwelling and providing appropriately sized gravels, constructed channels can also offer spawning habitat for *adult* salmonids (Cowan 1991). In addition, off-channel areas are likely to provide adult fish with refugia from high flows. Off-channel refugia may be especially important for migratory species engaged in strenuous spawning migrations. Although coho salmon have been the focus of many studies regarding the use of off-channel habitat, many other fish species utilize this habitat at various life stages (Lister and Finnigan 1997). Fish species inhabiting Stout Creek that would be expected to benefit from side channel enhancement include the spring Chinook salmon, coho salmon, and winter steelhead. Amphibians and pond turtles may also benefit from enhanced off-channel habitats.

Stout Creek Backwater, Floodplain Pond, and Side Channel Characteristics
Floodplain channel and pond features in the Stout Creek assessment reach include a potential backwater habitat in Reach 1. There is less potential for backwater habitat enhancement in the other reaches due to current land use. Dikes, historical channel straightening, and bank stabilization structures now limit channel migration in some areas. Enhancement of off-channel habitat in Stout Creek will require excavation and activation of floodplain channels.

In the Stout Creek assessment reach, side channel habitat is of marginal quality due to reed canarygrass infestation and channel modifications. The quality of potential side channel habitat is slightly better in the lower end of the assessment reach (STA 100+00 to STA 125+00) due to the flatter gradient and broader channel beltwidth. Enhancement of side channel habitat in Stout Creek would require substantial construction and excavation as the few existing side channels are marginal, and could not be easily reconnected.

5.3.2. Large Wood Overview

Large wood (LW) can be used to disperse streamflow energy (Buffington and Montgomery 1999), stabilize channel banks and bed forms (Bilby 1984), increase aquatic habitat (Bryant and Sedell 1995), narrow a stream and reduce the width to depth ratio (Sedell and Froggatt 1984), cause localized deposition (Keller et al. 1995), and form pools (Bilby and Ward 1989). Installation of large wood in the assessment reach is intended to serve multiple purposes. First, engineered log jams (ELJs) are recommended for protecting stream banks and promoting pool scour and sediment deposition. ELJs are placed to intercept high water flow vectors. The ELJs deflect the flow away from the streambank but also promote vertical channel scour. Scour pools typically form in front of and to the streamside of ELJs. Scoured sediments are typically transported a short distance and deposited as a tailout feature of the scoured pool. Depending on the site hydraulics, the deposited gravels may be used by spawning fish. On Stout Creek, ELJs are recommended for outside streambanks that are experiencing accelerated erosion, to augment existing bank stabilization projects that exhibit streambank erosion, or to diversify aquatic habitats in morphologically-homogenous sections of the river.

Placement of large wood is also recommended for enhancing off-channel habitats. Unlike ELJs which typically involved at least ten logs and considerable rock for structure ballast, large wood for habitat enhancement typically requires less anchoring material. Since the large wood will be placed in off-channel habitats (e.g. sidechannels, alcoves, and floodplain ponds), the wood will be subjected to lower water velocities. To maintain structure stability, logs can be partially buried, braced between standing mature trees, pinned together, or anchored with large rock placed below grade. Large wood with branches and rootwads provide the greatest range of microhabitats and also resist transport relative to limbed, cut logs.

Large Wood Ecological Benefits

Observations from intact low-gradient rivers suggest the on-going loss of wood substantially reduces biocomplexity (Gurnell et al. 2005) and alters key biophysical patterns in developed rivers. When present, logs enhance instream complexity and promote floodplain inundation (Kellerhals et al. 1976). Large logs are central to organic matter retention (Bilby 1981), to pool formation (Beechie and Sibley 1997), and to nutrient uptake (Valett et al. 2002). Remnant logs provide habitat for a variety of terrestrial organisms and facilitate conifer establishment. Most logs reside in floodplain river valleys for decades, although some fraction lasts for centuries or more (Montgomery and Abbe 2006). Those remaining stable over long periods may represent a sizeable carbon reservoir (Guyette et al. 2002) and aid in replenishing supplies of new large logs by protecting developing forests from erosion long enough for trees to grow large (Montgomery and Abbe 2006). In the absence of large wood, few structures in low-gradient rivers are suitable ecological surrogates for these functions.

Studies have documented the importance of large wood within the stream channel to slow bedload movement, deposit and sort gravel, scour pools, and increase nutrients through salmon carcass retention time (Ralph et al. 1994). Pools with large and complex accumulations of wood often show higher densities of rearing juvenile salmonids, particularly in winter, when storms routinely cause flooding. More recent studies have also shown the increase in percentage of surface area of pool habitat, pool depth, and an increase in winter sidechannel habitat following the placement of large wood in restoration activities (Johnson et al. 2005). Results from Johnson et al. (2005) indicate a higher smolt survival rate for coho salmon, steelhead, and sea run cutthroat trout following large wood treatments in two streams.

Stout Creek Large Wood Characteristics

Large wood was not formally documented during the Stout Creek reconnaissance. However, the presence, location, and orientation of stable large wood were noted during the walk-through. In reaches with a valley bottom floodplain and intact riparian zone, large wood is recruited to the river during high water when standing trees fall or transient large wood on the floodplain is mobilized. Although individual trees exert a limited influence on the channel, aggregations of large trees influence channel and habitat forming processes. Large in-stream trees focus scour, creating deeper pool habitat. Tree aggregations may become stable enough that riparian vegetation is able to colonize the fine sediment that accumulates around woody debris over time.

Stout Creek maintains a diverse riparian zone characterized by a multi-age stand structure. Cottonwoods, big leaf maple, alder, and Oregon ash comprise most of the large wood found in the project reach. How large wood influences the river corridor depends on the wood properties, location in the river corridor, and vegetation conditions. Large trees with attached rootwads are more resistant to transport and may also collect mobile wood, forming large aggregations. Aggregations are resistant to transport and also provide interstitial space for fish and wildlife. Scour against stable aggregations creates pools and often develop habitats conducive to salmonid spawning.

How wood functions also depends on its location within the river corridor. Wood in the mainstem river is typically more mobile than floodplain wood, since mainstem woody debris experiences higher velocities and shear stress. Vegetation can trap large wood and create rafts of debris. Vegetation may also colonize the fine sediments that typically deposit in the leeward direction of wood, and over time, vegetation anchors the wood. Figure 5-1 includes several examples of large wood in Stout Creek. Photos illustrate the role of wood in forming channel morphology, providing fish habitat, and influencing channel hydraulics.

Figure 5-1. Examples of large wood in Stout Creek. Large wood influences sediment deposition patterns, focuses stream flow to create scour pools or deflect flow away from streambanks, provides cover for fish and wildlife, and captures additional debris.

5.3.3. Riparian Vegetation Overview

Riparian vegetation provides numerous benefits for the river corridor. Plants maintain streambank integrity, filter runoff, maintain the water table, provide habitat and stream shading, and contribute organic debris to river systems. Each of these services is applicable to Stout Creek.

Plant roots bind soil, thereby increasing streambank integrity and resistance to scour. Deeply penetrating roots associated with hydric grasses, sedges, rushes, and forbs provide structural support for streambanks. Plant stems and leafy canopies slow floodwater, increasing fine sediment deposition. During high flows, woody shrubs flex and overlay the floodplain surface, slowing water velocities and protecting the floodplain surface. Water-tolerant or water-loving plants with deeper and stronger roots are more effective for holding streambanks in place than are plants from upland areas.

Plants retain nutrients transported into riparian areas and decompact soils, facilitating water capture and infiltration. Healthy riparian vegetation captures and filters water through the soil. Riparian areas with a diversity of plant species are most effective in slowing the flow of water and storing it for future use.

Different types of vegetation provide multiple services to hold streambank soils in place and protect them from erosion and undercutting by floodwaters, transported woody debris, or ice jams. The deep, penetrating roots of sedges, rushes, willow, grasses, and other herbaceous plants provide structural support for streambanks, while the thicker, harder roots of woody plants protect streambanks against bank scouring by floods and ice jams.

Vegetation Ecological Benefits

A healthy riparian zone provides habitat for terrestrial, aquatic, and amphibious wildlife. A diverse community supports more terrestrial species than a simplified forest with no understory complexity, or a diverse understory with no overstory canopy. From a fisheries perspective, grasses and shrubs maintain bank integrity, shrubs over-hang streams providing cover and contributing debris, and mature trees shade the stream corridor and contribute wood. Shading of the stream water surface is an extremely important ecological service of riparian vegetation in Stout Creek, where summer water temperatures frequently exceed State standards.

Stout Creek Vegetation Characteristics

Vegetation conditions in Stout Creek vary according to site conditions, historical land uses and river processes, and contemporary land uses. In general, the assessment reach is bracketed by a multi-structured riparian forest. However, brush and large wood removal, land clearing, and the introduction of non-native invasive plant species have modified native plant communities. Reed canarygrass, Japanese knotweed, and Himalayan blackberry are aggressive non-native species that are fast growing and hardy, making them capable of out-competing native vegetation. Some wildlife such as pond turtles may not be capable of completing their life history in altered vegetation communities. Invasive plants have different properties that do not appropriately substitute the services provided by native species.

The complete removal of reed canarygrass from the Stout Creek system is not recommended as a restoration goal. Such a goal would be extremely difficult to attain given the pervasiveness of this invasive weed in the system. The best means for addressing reed canarygrass in the Stout Creek assessment reach is solarization, which involves placing clear or black plastic over patches for a period of at least one year to kill weeds. This would be part of a larger revegetation plan to establish new native shrubs and trees in the area. One option is to place 3' x 3' brush mats around planted native vegetation in containers to limit reed canarygrass growth near the new plants. In addition, the establishment of wide riparian buffers would provide stream shading and limit regeneration of reed canarygrass.

5.3.4. Off-Channel Habitats, Large Wood, and Vegetation for Habitat Enhancement

Restoration and conservation treatments seek to emulate existing functioning habitats to enhance Stout Creek. Proposed activities will include augmenting existing backwater and off-channel habitats, importing and stabilizing large wood, planting riparian and upland vegetation and instituting riparian buffers. Agricultural development has led to the removal of much of the riparian zone, and the remaining floodplain forests in Stout Creek should be protected. Displacement of the dwindling riparian forest will likely result in further simplification of the river corridor, reduced large wood recruitment to the river, and more pressure from landowners to erect flood protection structures. Maintaining and expanding riparian forests is encouraged to address the limiting factors that have been identified in this report.

5.4. Reach Restoration Plans

The following sections outline the restoration and conservation prioritization plan for the assessment reach of Stout Creek.

5.4.1. Reach 1 Restoration Plan

Reach 1 offers numerous opportunities for enhancing fish habitat. In general, fisheries habitat through this reach is in good condition, with evidence of large wood and large patches of riparian and upland vegetation. However, there are some areas where improving channel complexity on the stream margins would benefit fish species. To achieve the fish habitat goals presented by the project stakeholders, proposed restoration and conservation actions are aimed at enhancing existing moderate to high quality fish habitats and expanding riparian buffers.

Restoration Actions

Four Restoration Actions were identified in Reach 1. Each of the opportunities was prioritized for implementation. High priority projects are relatively low cost, augment existing moderate to high quality habitat, are lower risk, and are expected to yield biological benefits. Medium priority projects are more costly, typically requiring a more aggressive approach to stabilize eroding streambanks and enhance habitat. Low priority projects include habitat work similar to the medium priority projects but have a lower benefit-cost ratio or are located far from high priority sites.

The proposed projects primarily focus on bank stabilization and enhancing fish habitat in the reach, with emphasis on enhancing instream cover and off-channel habitats. Off-channel areas provide juvenile rearing habitat and may provide thermal refugia. Off-channel habitats are also critical areas for fish during high water as they typically have lower velocities that allow fish to maintain their position with lower energy expenditures. The proposed projects would also increase the width of riparian and upland vegetation corridors in parts of Reach 1, which is expected to limit heating of water in the creek. Table 5-1 includes the proposed Restoration Actions in Reach 1. A more detailed description of each project is included following the table.

Table 5-1. Proposed Restoration Actions for Reach 1. Priorities are categorized as low (L), medium (M), and high (H).

Site #	Landowner	Station	River Side (R/L)	Current Stream Condition	Proposed Restoration Action	Priority
R1-1	Prine	5+00	Right	Cobble-dominated channel with limited habitat complexity	Add large wood to pool habitat for improved complexity of fish habitat.	H
R1-2	Stutzman; Prine	9+00	Right	Limited channel complexity	Construct large wood structure to encourage pool scour and improve habitat complexity.	H
R1-3	Stutzman	10+00	Right	Potential backwater	Excavate backwater area on right bank floodplain, and add large wood.	M
R1-4	Dyke	16+00	Right	Limited channel complexity	Construct a large wood structure in the stream for fish habitat complexity.	H

R1-1: Fish habitat through this reach is generally in good condition, but lacks habitat complexity created by large wood structures and connectivity with the floodplain. The proposed project would add large wood pieces to existing pool habitat to provide cover features and improve overall channel complexity.

R1-2: The channel at this site would benefit from engineered large wood structures to improve fish habitat complexity by providing cover, pool scour, and resting areas on the channel margins.

R1-3: There is a small potential backwater area on the right bank of the channel. The proposed project would extend this backwater further into the floodplain, and enhance it with large wood to provide additional cover for juvenile and adult fish.

R1-4: The channel at this site would benefit from engineered large wood structures to improve fish habitat complexity by providing cover, pool scour, and resting areas on the channel margins.

Conservation Actions

Conservation opportunities were also identified for Reach 1. Conservation Actions are more passive approaches to preserving or enhancing desirable river corridor features. Example Conservation Actions include establishing conservation easements, increasing riparian buffers, and monitoring site conditions.

The proposed Conservation Actions primarily focus on preserving existing high quality floodplain environments. Maintaining gallery forests provides fish and wildlife benefits as well as protecting upland properties from erosion. Vegetation patterns and large wood contributions to the stream enhance habitat diversity. Canopy shading of backwater habitats and floodplain channels preserves cool water refugia for fish. Expanding riparian buffers is intended to reduce agricultural runoff to the river, increase bank stability, and result in a more diverse riparian community over the long-term. Table 5-2 presents proposed Conservation Actions for Reach 1. Narrative descriptions of each action follow the table.

Table 5-2. Proposed Conservation Actions for Reach 1. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C1-1	Prine	5+00 to 6+00	Right	Remove non-native ivy from streambanks.	Improved riparian vegetation community, stream shading
C1-2	Kinberg	13+00	Left	Remove non-native Japanese knotweed from streambank.	Improved riparian vegetation community, stream shading
C1-3	Wilson	19+00 to 29+00	Left	Expand the riparian buffer to 50 feet from the top of streambank.	Stream shading, habitat, large wood recruitment

C1-1: Remove non-native invasive ivy from the streambank and riparian buffer. Plant native riparian vegetation such as willows and red-osier dogwood. Establishment of native vegetation species in the riparian corridor is expected to benefit Stout Creek through improved stream shading and, eventually, large wood recruitment.

C1-2: Currently, Japanese knotweed dominates the riparian vegetation on the left bank, while blackberries are present on the right bank. Remove these non-native species and plant native riparian vegetation such as willows and red-osier dogwood. Establishment of native vegetation species in the riparian corridor is expected to benefit Stout Creek through improved stream shading and, eventually, large wood recruitment.

C1-3: Expand the riparian buffer to 50 feet from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

5.4.2. Reach 2 Restoration Plan

Reach 2 has a slightly more confined valley bottom than Reach 1 due to the hillslope on the north bank. Nonetheless, Reach 2 offers some good opportunities for enhancing fish and wildlife habitat on Stout Creek. Restoration Actions focus on adding large wood to the mainstem channel in the form of engineered log jams. Conservation Actions focus on expanding riparian corridors to buffer developed areas from erosion as well as buffering the river from runoff.

Restoration Actions

Three Restoration Action opportunities were identified in Reach 2. Each of the opportunities was prioritized for implementation. For Reach 2, the highest priority projects include bank stabilization and shaping. Medium priority projects include the installation of stable large wood structures to promote pool scour, to deflect flow away from the bank, and to provide diverse microhabitats. The proposed projects primarily focus on enhancing fish habitat in the mainstem river and halting bank erosion. Table 5-3 includes the proposed Restoration Actions in Reach 2. A summary of each project is included following the table. Projects are presented from upstream to downstream.

Table 5-3. Proposed Restoration Actions for Reach 2. Priorities are categorized as low (L), medium (M), and high (H).

Site #	Landowner	Station	River Side (R/L)	Current Stream Condition	Proposed Restoration Action	Priority
R2-1	Riggs	51+00	Left	Streambank erosion and stream incision are a source of sediment influx	Shape bank, plant native vegetation, and install large wood structure to slow erosion and provide habitat complexity.	H
R2-2	Clugston	58+00	Left	Streambank erosion and lack of riparian vegetation	Install vegetated soil lifts, plant riparian vegetation on re-shaped bank, and increase riparian buffer width to 50 feet.	H
R2-3	Jenkins	62+00	Left	Streambank erosion and lack of riparian vegetation	Install vegetated soil lifts, plant riparian vegetation on re-shaped bank, and increase riparian buffer width to 50 feet.	H
R2-4	Schoppert	77+00	Left	Lack of channel habitat complexity	Install large wood structure to improve habitat complexity and provide juvenile and adult salmonid rearing and resting habitat.	M

R2-1: Erosion at this site is a source of sediment to Stout Creek. Increased riparian plantings and riparian buffer establishment would help stabilize the bank, shade the stream, and provide future inputs of large wood to the stream system. In addition, in-stream installation of a large wood structure and vegetated soil lifts would deflect streamflows away from the bank and provide additional habitat complexity. A very short side channel may be enhanced by excavation and removing reed canarygrass.

R2-2: The proposed project would re-shape the streambank at approximately 3:1 slope, place large wood at the bank toe, add vegetated soil lifts, and plant native shrubs and trees on the slope and upland areas to create a riparian buffer. In addition to providing improved streambank stability, this project is expected to improve stream shading to limit increases in water temperature during low flow summer months. Fish are expected to benefit from rearing habitat and cover areas provided by large wood structures.

R2-3: The channel at this site lacks complexity. An engineered log jam is proposed to provide cover features for fish in Stout Creek and deflect flows away from the bank. Riparian vegetation and natural processes of large wood additions should also be protected.

Conservation Actions

Three conservation opportunities were also identified for Reach 2. Conservation Actions are more passive approaches to preserving or enhancing desirable river corridor features. Example Conservation Actions include establishing conservation easements, livestock fencing to protect riparian buffers, expanding riparian buffers, and monitoring site conditions. Table 5-4 presents proposed Conservation Actions for Reach 2. Narrative descriptions of each action follow the table.

Table 5-4. Proposed Conservation Actions for Reach 2. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C2-1	Carpenter	48+00 to 50+00	Left	Expand the riparian buffer to 50 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-2	Bilyeu; Clugston	54+00 to 59+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-3	Blum	85+00 to 89+00	Left	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment

C2-1: Expand the existing riparian buffer to 50 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-2: Expand the existing riparian buffer to 50 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

C2-3: Expand the existing riparian buffer to 50 ft from the top of the river bank. Plant native riparian and upland vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years.

5.4.3. Reach 3 Restoration Plan

Reach 3 offers opportunities for enhancing fish and wildlife habitat on Stout Creek. In general the river lacks connection to an expansive, dynamic floodplain, and the riparian corridor is very narrow or non-existent in places. To achieve the biological goals presented by the project stakeholders, proposed Restoration and Conservation Actions are aimed towards both enhancing existing habitat and re-establishing floodplain features that have been affected by past land management activities.

Restoration Actions

Two Restoration Action opportunities were identified in Reach 3. The proposed projects primarily focus on enhancing fish habitat in the reach, with emphasis on addressing in-channel habitat that provides juvenile rearing habitat, adult spawning habitat, and thermal refugia. Adding large wood is expected to provide resident and anadromous fish with a broader range of habitats. Table 5-5 includes the proposed Restoration Actions in Reach 3. A summary of each project is included following the table.

Table 5-5. Proposed Restoration Actions for Reach 3. Benefits pertain to streambank stability, fish life stage and other attributes. Priorities are categorized as low (L), medium (M), and high (H).

Site #	Landowner	Station	River Side (R/L)	Current Stream Condition	Proposed Restoration Action	Priority
R3-1	Boedigheimer	102+00	Left	Lack of instream habitat complexity	Install large wood habitat structure. Potential side channel development.	M
R3-2	Krautmann Family Nursery	106+00	Left	Lack of instream habitat complexity	Install large wood habitat structure and increase riparian buffer to 50 feet.	M
R3-3	Krautmann Family Nursery	116+00	Right	Lack of instream habitat complexity	Install large wood habitat structure.	M
R3-4	Krautmann Family Nursery	116+00	Left	Lack of instream habitat complexity	Install large wood habitat structure and excavate a backwater habitat area.	M
R3-5	Krautmann Family Nursery	118+00	Left	Lack of instream habitat complexity	Install large wood habitat structure and increase riparian buffer to 50 feet.	M
R3-6	Krautmann Family Nursery	123+00	Right	Lack of instream habitat complexity	Install large wood habitat structure in existing backwater area.	M
R3-7	Krautmann Family Nursery	134+00	Right	Lack of instream habitat complexity	Install large wood habitat structure.	M

R3-1: Add large wood aggregates and single pieces of large wood to provide in-stream channel complexity. Adding large wood to the channel will enhance the availability of juvenile rearing habitat and improve production of salmonids in Stout Creek. Large wood additions will also provide high water refugia for adult and juvenile fish. Side channel development is a potential restoration action at this site. If pursued, this restoration action would require substantial excavation, removal of reed canarygrass, and installation of a vegetated soil lift.

R3-2: Add large wood aggregates and single pieces of large wood to provide in-stream channel complexity. In addition, expand the existing riparian buffer to 50 ft from the top of the river bank. Plant native riparian and upland vegetation.

R3-3: Add large wood aggregates and single pieces of large wood to provide in-stream channel complexity. Adding large wood to the channel will enhance the availability of juvenile rearing habitat and improve production of salmonids in Stout Creek. Large wood additions will also provide high water refugia for adult and juvenile fish.

R3-4: Excavate a backwater habitat area on the left bank channel margin. Add large wood aggregates and single pieces of large wood to provide in-stream channel complexity.

R3-5: Add large wood aggregates and single pieces of large wood to provide in-stream channel complexity. In addition, expand the existing riparian buffer to 50 ft from the top of the river bank. Plant native riparian and upland vegetation.

R3-6: Add large wood aggregates and single pieces of large wood to existing backwater area on the right bank. Adding large wood to the backwater will enhance the availability of juvenile rearing habitat and improve production of salmonids in Stout Creek. Large wood additions will also provide high water refugia for adult and juvenile fish.

R3-7: Add large wood aggregates and single pieces of large wood to provide in-stream channel complexity. Adding large wood to the channel will enhance the availability of juvenile rearing habitat and improve production of salmonids in Stout Creek. Large wood additions will also provide high water refugia for adult and juvenile fish.

Conservation Actions

One conservation opportunity was also identified for Reach 3. Conservation Actions are more passive approaches to preserving or enhancing desirable river corridor features, such as establishing conservation easements. Table 5-6 presents the proposed Conservation Action for Reach 3. Narrative descriptions of each action follow the table.

Table 5-6. Proposed Conservation Actions for Reach 3. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Station	River Side (R/L)	Proposed Restoration Action	Benefits
C3-1	Krautmann Family Nursery	125+00 to 135+00	Right	Increase riparian buffer to improve stream processes including large wood recruitment, habitat creation, and water quality.	Stream shading, habitat, large wood recruitment, water quality

C3-1: Expand the riparian buffer by planting native riparian and upland vegetation at this site. Existing vegetation conditions are inadequate due to the lack of riparian vegetation. Planted vegetation should be irrigated and maintained for a minimum of 2 years. Plant native riparian shrubs for habitat and water quality. Native riparian vegetation is better suited to providing stream shading and wood inputs to the system than non-native vegetation.

5.5. Restoration Plan Implementation

Restoration Actions and Conservation Actions were outlined for each of the three sub-reaches in the Stout Creek assessment reach. Actions were prioritized by sub-reach rather than for the whole assessment reach. As a result, an action that ranked as a high priority in one sub-reach may have only garnered a medium priority in another sub-reach depending on how many and what types of actions were identified. Future funding applications will be prepared by sub-reach to implement larger scale restoration planning rather than site-specific treatments which are usually less beneficial and more costly to implement. Both Restoration Actions and Conservation Actions aim to enhance stream and floodplain habitats, preserve landowner properties, and restore ecological processes to provide long-term river corridor improvements. The following sections outline the process for implementing restoration activities.

5.5.1. Backwater Excavation

Backwater enhancements would include adding aggregations of large wood. Work would be completed with heavy equipment including excavators, off-road dump trucks, and front-end loaders. Floodplain excavation would lower and/or expand existing habitats so that channels access groundwater or are hydraulically connected with Stout Creek at baseflows or high frequency flood events. These actions would increase the juvenile rearing habitat and flood refugia. Channel and pond shaping would replicate naturally occurring habitats that provide the range of desired habitats. Where possible, channel and pond work would be completed in forested areas of the floodplain. The floodplain forest would shade the channel, contribute organic material and woody debris, and provide stability through root structures.

Excavation would minimize disturbance to adjacent vegetation and floodplain surfaces. Excavated materials would either be shaped on the floodplain (creating topography) or hauled off-site for disposal. Construction would be completed in one pass (excavation and habitat materials placement) to speed construction and reduce the project footprint.

5.5.2. Large Wood Placement

Large wood has been removed from Stout Creek over the last 100 years to protect infrastructure. The loss of large wood has led to habitat simplification, gravel mobilization, and a less dynamic river system. Incorporating large wood in alcove habitat enhancement is proposed for creating and augmenting existing habitats. Fish use large wood for cover, with juveniles inhabiting the interstitial spaces and adult fish using the scour pools commonly associated with stable wood aggregates. Large wood would be placed as both individual pieces and in aggregate. Aggregates are more expensive to build as they require more material and time to complete, but provide more complex microhabitats than single pieces. Aggregates also tend to be more stable over time and typically collect other wood transported by the river.

Procuring large wood may be done by importing materials from outside the stream corridor and using trees that are displaced during floodplain channel and pond work. Because large wood is a limited resource in the lower Stout Creek watershed, importing large wood from outside of the project area is recommended. However, from a cost perspective, using displaced and downed trees to augment floodplain habitats is preferable.

Large wood will be installed both singularly and in aggregate to ensure channel stability, provide habitat, and to trap sediment. These structures will be smaller than ELJs and require less material (Figure 5-2). In general, each structure will include at two rootwads and several logs for ballast. Orienting wood along the channel margin will deflect flows and provide bank stability. Placing trees in the channel alignment can promote several types of habitat. For example, large wood in a pool provides overhead cover and interstitial space. Wood in a run will promote vertical scour at the head of a pool.

Figure 5-2. A large wood habitat composite and vegetated soil lift on Elk Creek in western Montana.

Large wood structures may either be anchored in the ground, ballasted with large rock, pinned together, or longer tree pieces will be placed in the riparian zone angled towards the channel. Wood should remain stable to provide the intended benefits as well as to limit downstream transport and the formation of unintended log jams. However, imported wood will be redistributed over time by large floods. Log relocation would be expected to benefit areas of Stout Creek downstream from initial placement.

5.5.3. Engineered Log Jams

Engineered log jams (ELJs) are installed for bank stabilization, flow deflection, and mainstem river habitat. ELJs will be completed on the mainstem river and will provide complex cover for juvenile and adult fish. ELJs will be constructed with approximately 10 to 15 trees including rootwads, whole trees, and tree tops (Figure 5-3). To provide structure ballast, approximately 10 yd^3 of large rock will be placed within each structure. The ELJs are also backfilled with native alluvium to reduce the potential for intra-structure piping. Rootwad sizes will average 3 ft to 4 ft in fan diameters and have minimum stem lengths of 30 ft. ELJs span from the predicted scour depth to above the bankfull channel elevation to provide a range of fish habitat and structure stability.

Figure 5-3. Example engineered log jams on streams in western Montana.

5.5.4. Vegetated Soil Lifts

A vegetated soil lift is a bioengineering technique that combines layers of dormant willow cuttings and/or containerized willows with fabric-wrapped soil to revegetate and stabilize stream banks and slopes (Figure 5-4). Vegetated soil lifts are proposed for stabilizing bank erosion sites where a new bank face will be constructed. To construct a vegetated soil lift, a coarse cobble toe is first established. The first soil lift incorporates a high density coir log backed with soil and wrapped within two layers of biodegradable coconut (coir) fiber fabric.

Dormant willow cuttings or containerized plants and a native seed mix are placed on each lift. The cuttings or plants are placed horizontally to extend into the stream channel. Cuttings should be placed so that only ¼ of the cutting is exposed. A two to three-inch layer of top soil is placed between each lift to reduce air pockets and provide rooting medium for the willow cuttings. The coir fabric holds the soil in place while vegetation becomes established in the relatively high stress land/water interface. Vegetated soil lifts will provide near-term bank protection until planted vegetation becomes established. In Stout Creek, the installation of vegetated soil lifts is recommended for Restoration Actions R2-1 and R2-2. Soil lifts may also be used for bank stability in Reach 3 if revegetation and side channel enhancement treatments are pursued.

Figure 5-4. Willows growing from a vegetated soil lift on the Jocko River during the fourth growing season.

5.5.5. Conservation Actions

Highlighted Conservation Actions are intended to preserve remaining floodplain and upland forests as well as expand these areas. Floodplain areas bordering the river have been impacted by agriculture and residential encroachment. The once expansive riparian forests have contracted in the Stout Creek drainage in a similar fashion to most of the Willamette Valley. Protecting and expanding the remaining forests is advised to preserve riverine habitats, to maintain a naturally regenerating floodplain forest, and to protect upland property owners from erosion. Working with landowners to preserve these areas is critical. Various conservation programs are also available for landowners who are willing to forego some land uses in exchange for compensation. Most programs require a time commitment from the landowner to take the land out of production. The Natural Resources Conservation Service and the Farm Service Agency offer qualifying programs. Landowners may work with the watershed council and federal agencies to evaluate programs that would meet the landowners' needs and provide resource protection.

6 SUMMARY

The Lower Reach of Stout Creek near Mehama, Oregon, retains many of the characteristics that historically supported larger populations of Chinook salmon, coho salmon, and winter steelhead. Over 100 years of land uses favoring timber harvest and log transport, agricultural production, and residential development have altered the river corridor. An assessment of the Lower Reach from the Fernridge Road Bridge downstream approximately 2.5 river miles was completed in 2008 to evaluate potential restoration, conservation, and stabilization opportunities. Proposed actions were developed and prioritized for three sections of the Lower Reach. Actions emphasize improving in-stream habitat complexity to provide more habitat for juvenile and adult fish. Critical habitats include juvenile rearing habitat, adult holding habitat, as well as cool water and flood refugia. Existing functional habitats that support juvenile and adult salmonids would be used as templates for creating and enhancing other such habitats.

Restoration Actions were prioritized based on their potential benefit, cost, and failure risk. Projects that would expand and enhance floodplain and backwater channels would be subjected to lower flood effects than mainstem projects, and were therefore given the highest priority. Mainstem projects including engineered log jams and soils lifts that would address sediment sources and land loss, were rated lower due to higher implementation costs and greater risk potential. Low priority projects included high risk projects or enhancing existing medium to high quality habitat. Landowners may also collaborate with federal agencies to address bank stabilization as well as conservation opportunities for their properties. Conservation Actions include protecting remaining floodplain and upland forests, expanding riparian forest buffers that have been narrowed by development, and installing exclusion fences for livestock.

Implementing projects on a reach scale is preferable to maximize ecological benefits and lower costs. The North Santiam Watershed Council is currently working with landowners to develop support for projects on a reach basis. Implementation of the Restoration and Conservation Actions outlined in this report will result in improved bank stability, reduced property loss, and enhanced habitat for both anadromous and resident fish species in Stout Creek.

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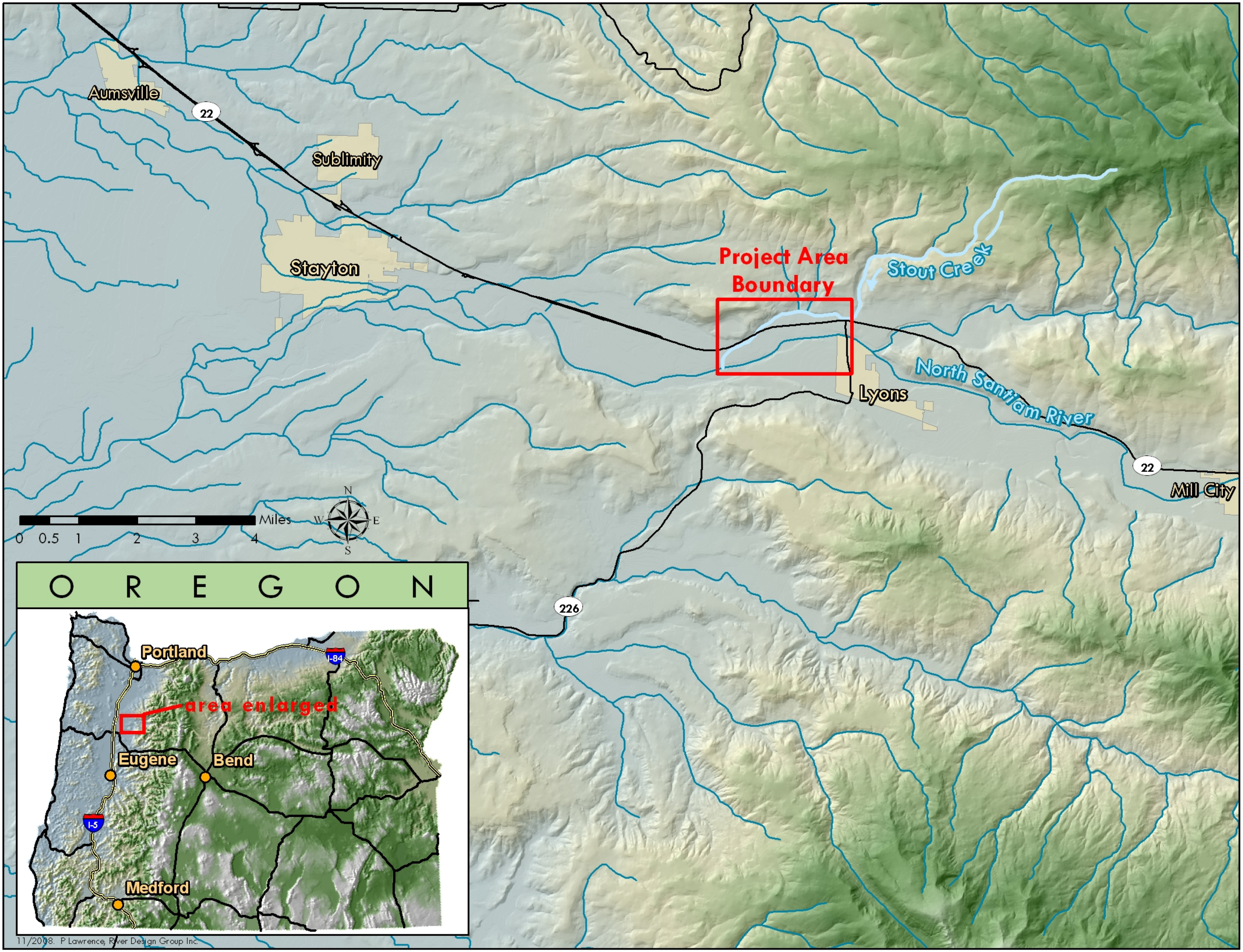
APPENDIX A
STOUT CREEK PROJECT AREA


Aumsville
22
Sublimity
Stayton
Project Area
Boundary
Stout Creek
North Santiam River
Lyons
22
Mill City
226
Miles
0 0.5 1 2 3 4
N
W
E
S
O R E G O N
Portland
I-84
area enlarged
Eugene
Bend
I-5
Medford
11/2008. P Lawrence, River Design Group Inc.

APPENDIX C
STOUT CREEK HABITAT UNITS

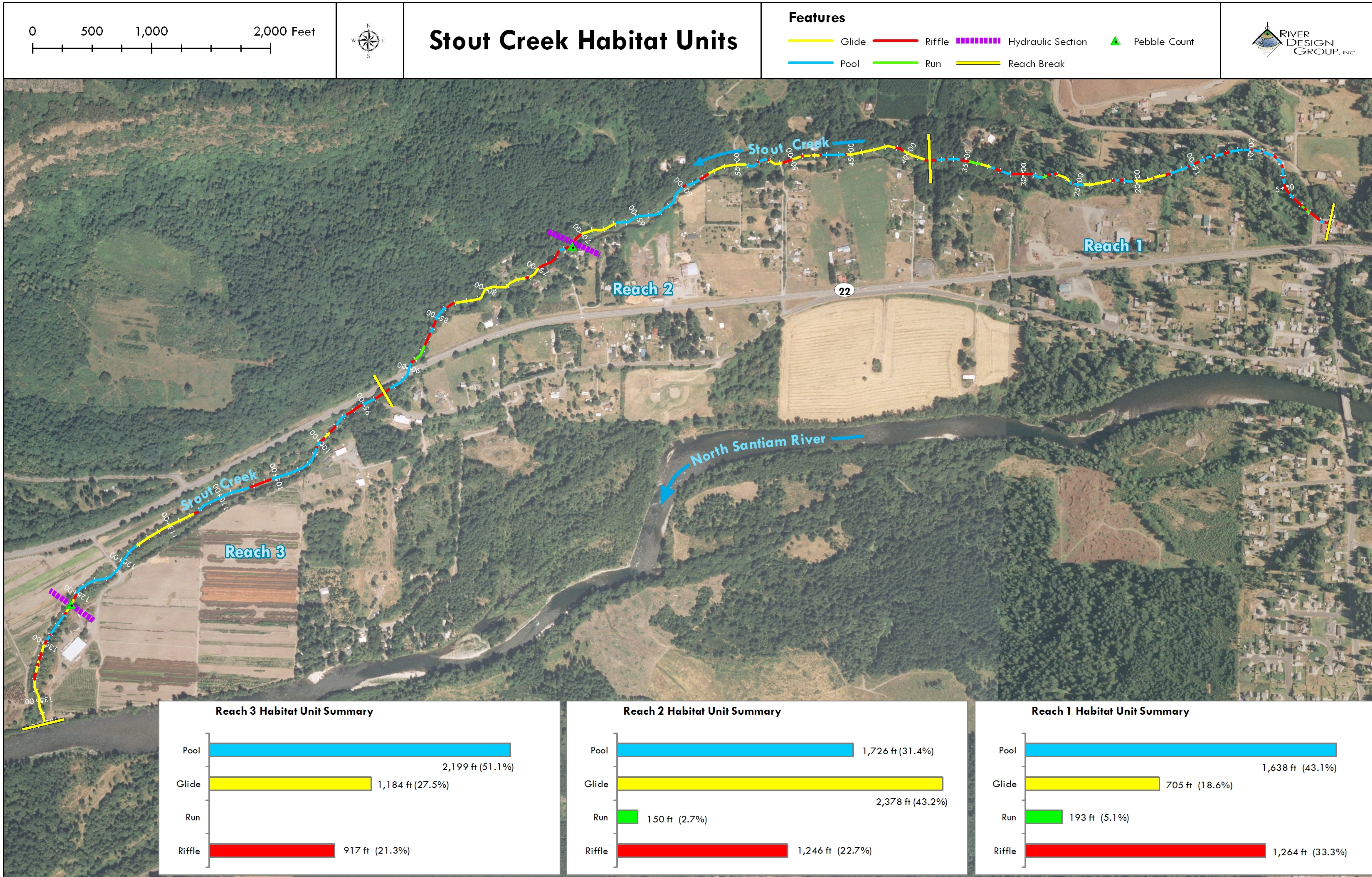
0 500 1,000 2,000 Feet

Stout Creek Reach Map

River Design Group, Inc.

APPENDIX B
STOUT CREEK REACH MAP

Stout Creek Habitat Units



APPENDIX D
STOUT CREEK INVASIVE WEED LOCATIONS

Stout Creek Invasive Weed Locations

0 500 1,000 2,000 Feet

Invasive Vegetation Type

- Ivy
- Knotweed
- Reed Canarygrass
- Reed Canarygrass and Blackberry

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APPENDIX E
RESTORATION AND CONSERVATION SITES MAPS

Stout Creek - Reach 1

Proposed Restoration and Conservation Actions

0 125 250 500 Feet

Restoration/Conservation Actions

- High Priority
- Medium Priority
- Conservation Action
- Reach Break
- Property Boundaries
- Bank Stabilization

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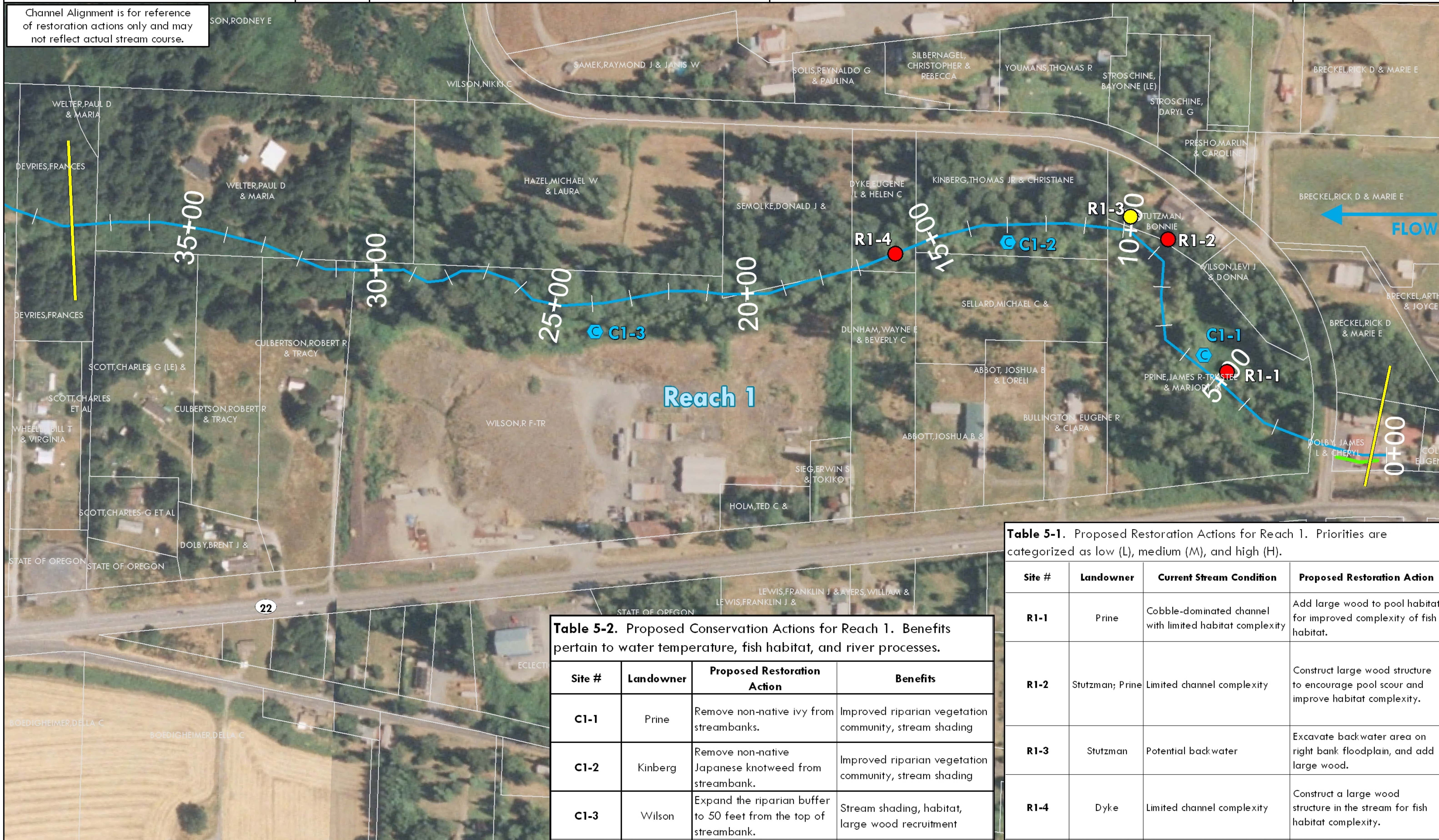

Table 5-1. Proposed Restoration Actions for Reach 1. Priorities are categorized as low (L), medium (M), and high (H).

Site #	Landowner	Current Stream Condition	Proposed Restoration Action
R1-1	Prine	Cobble-dominated channel with limited habitat complexity	Add large wood to pool habitat for improved complexity of fish habitat.
R1-2	Stutzman; Prine	Limited channel complexity	Construct large wood structure to encourage pool scour and improve habitat complexity.
R1-3	Stutzman	Potential backwater	Excavate backwater area on right bank floodplain, and add large wood.
R1-4	Dyke	Limited channel complexity	Construct a large wood structure in the stream for fish habitat complexity.

Table 5-2. Proposed Conservation Actions for Reach 1. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Proposed Restoration Action	Benefits
C1-1	Prine	Remove non-native ivy from streambanks.	Improved riparian vegetation community, stream shading
C1-2	Kinberg	Remove non-native Japanese knotweed from streambank.	Improved riparian vegetation community, stream shading
C1-3	Wilson	Expand the riparian buffer to 50 feet from the top of streambank.	Stream shading, habitat, large wood recruitment

Background: 2005 NAIP Imagery. Taxlots: Marion County GIS

Stout Creek - Reach 2

Proposed Restoration and Conservation Actions

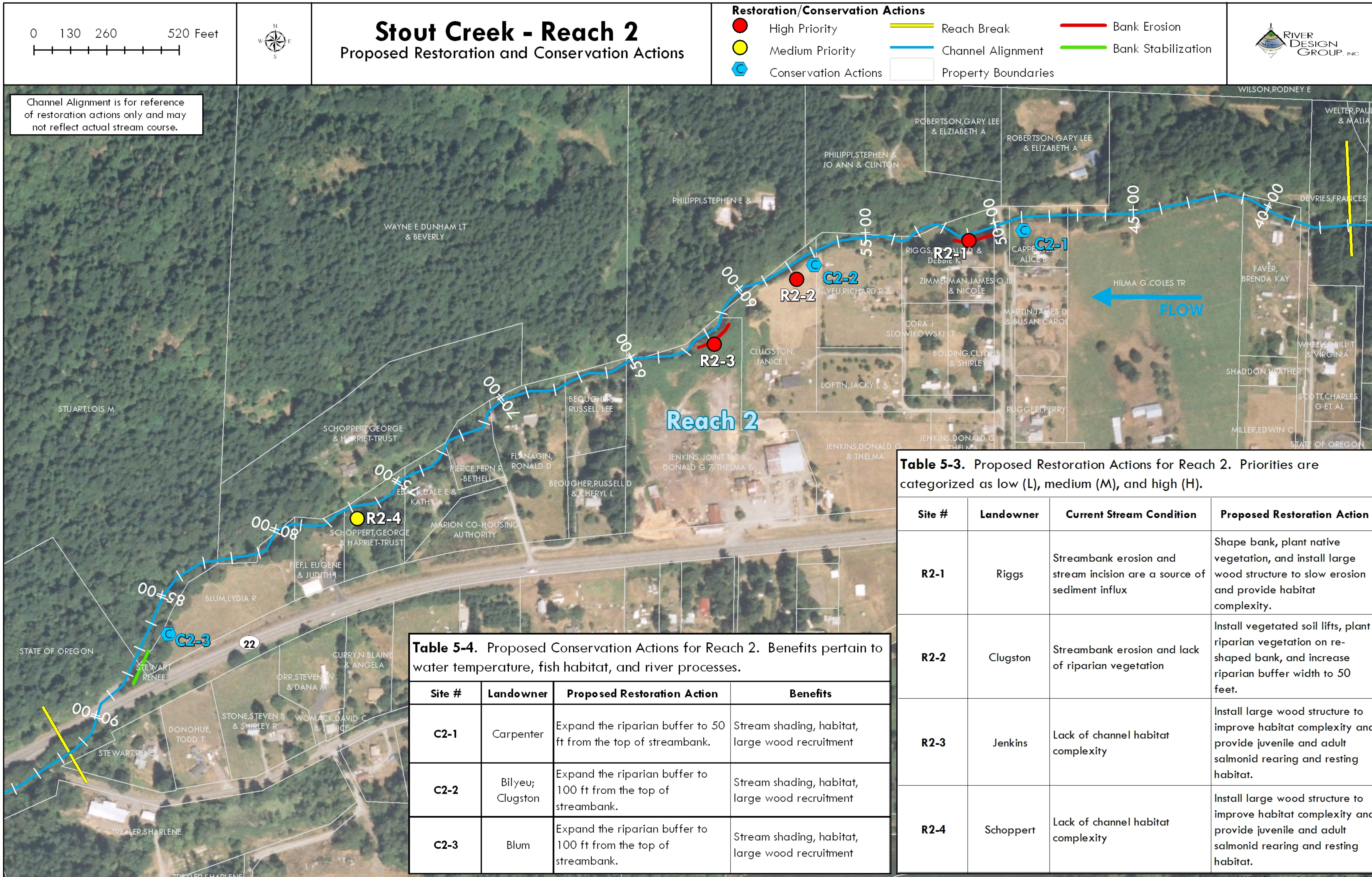

Table 5-3. Proposed Restoration Actions for Reach 2. Priorities are categorized as low (L), medium (M), and high (H).

Site #	Landowner	Current Stream Condition	Proposed Restoration Action
R2-1	Riggs	Streambank erosion and stream incision are a source of sediment influx	Shape bank, plant native vegetation, and install large wood structure to slow erosion and provide habitat complexity.
R2-2	Clugston	Streambank erosion and lack of riparian vegetation	Install vegetated soil lifts, plant riparian vegetation on re-shaped bank, and increase riparian buffer width to 50 feet.
R2-3	Jenkins	Lack of channel habitat complexity	Install large wood structure to improve habitat complexity and provide juvenile and adult salmonid rearing and resting habitat.
R2-4	Schoppert	Lack of channel habitat complexity	Install large wood structure to improve habitat complexity and provide juvenile and adult salmonid rearing and resting habitat.

Table 5-4. Proposed Conservation Actions for Reach 2. Benefits pertain to water temperature, fish habitat, and river processes.

Site #	Landowner	Proposed Restoration Action	Benefits
C2-1	Carpenter	Expand the riparian buffer to 50 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-2	Bilyeu; Clugston	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment
C2-3	Blum	Expand the riparian buffer to 100 ft from the top of streambank.	Stream shading, habitat, large wood recruitment

Stout Creek - Reach 3

Proposed Restoration and Conservation Actions

0 125 250 500 Feet

Restoration/Conservation Actions
- High Priority
- Medium Priority
- Conservation Actions
- Reach Break
- Channel Alignment
- Property Boundaries

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Channel Alignment is for reference of restoration actions only and may not reflect actual stream course.

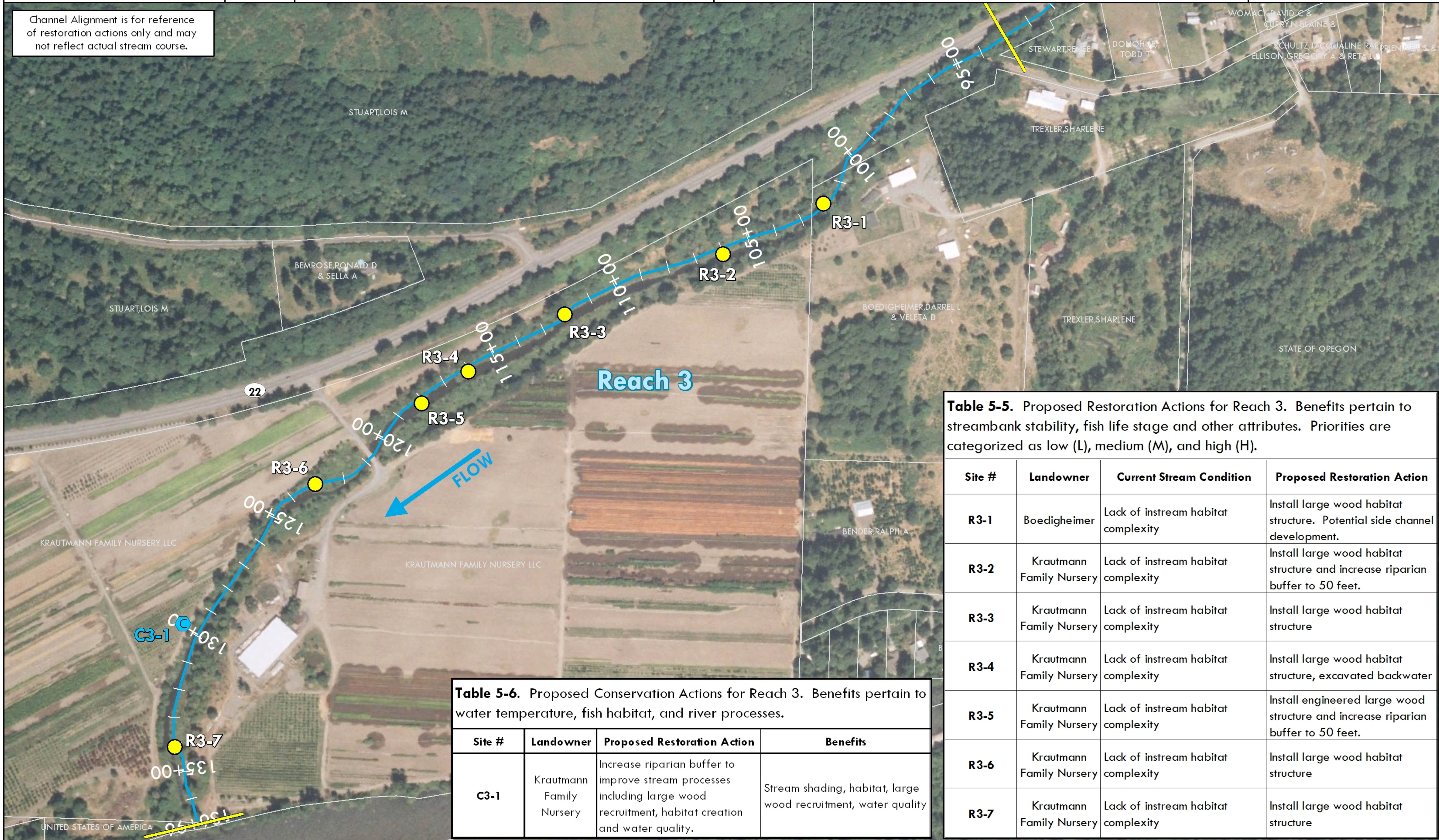


Table 5-5. Proposed Restoration Actions for Reach 3. Benefits pertain to streambank stability, fish life stage and other attributes. Priorities are categorized as low (L), medium (M), and high (H).

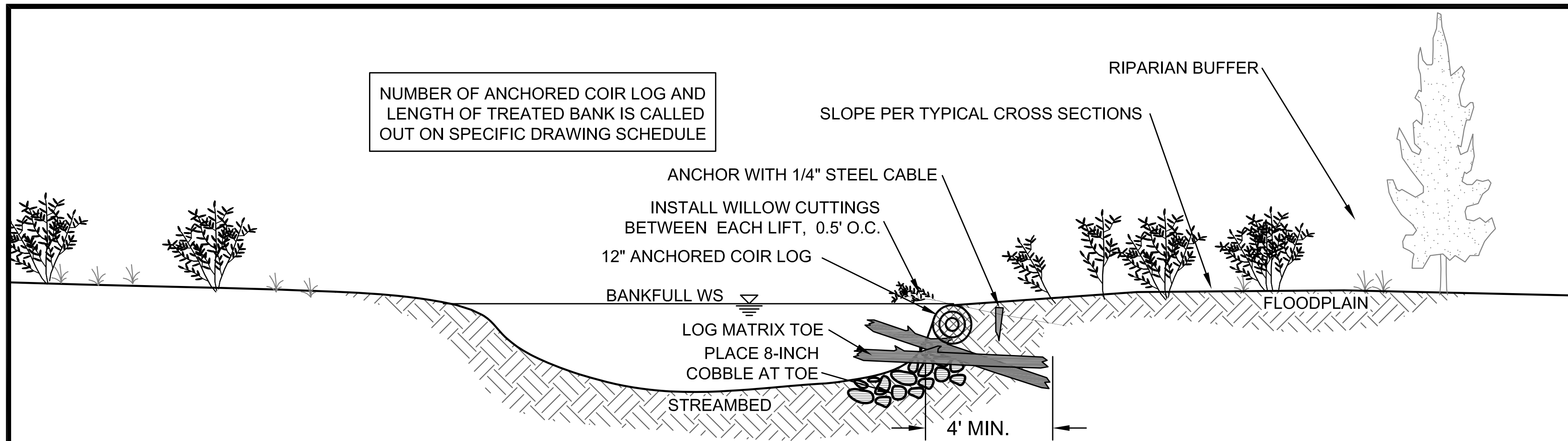
Site #	Landowner	Current Stream Condition	Proposed Restoration Action
R3-1	Boedigheimer	Lack of instream habitat complexity	Install large wood habitat structure. Potential side channel development.
R3-2	Krautmann Family Nursery	Lack of instream habitat complexity	Install large wood habitat structure and increase riparian buffer to 50 feet.
R3-3	Krautmann Family Nursery	Lack of instream habitat complexity	Install large wood habitat structure
R3-4	Krautmann Family Nursery	Lack of instream habitat complexity	Install large wood habitat structure, excavated backwater
R3-5	Krautmann Family Nursery	Lack of instream habitat complexity	Install engineered large wood structure and increase riparian buffer to 50 feet.
R3-6	Krautmann Family Nursery	Lack of instream habitat complexity	Install large wood habitat structure
R3-7	Krautmann Family Nursery	Lack of instream habitat complexity	Install large wood habitat structure

Table 5-6. Proposed Conservation Actions for Reach 3. Benefits pertain to water temperature, fish habitat, and river processes.

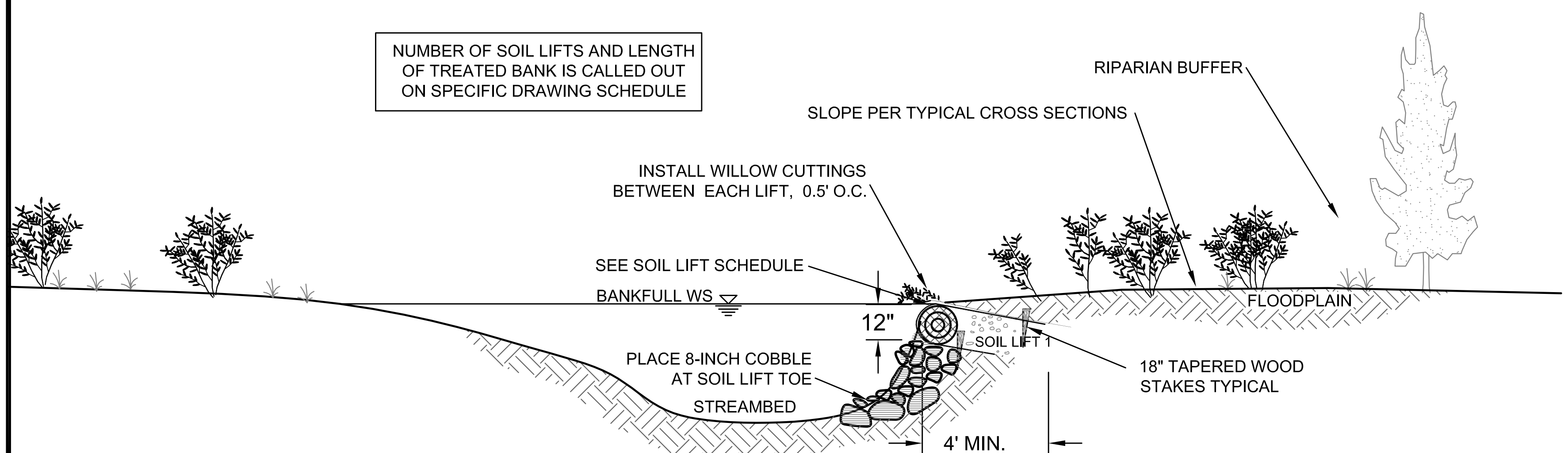
Site #	Landowner	Proposed Restoration Action	Benefits
C3-1	Krautmann Family Nursery	Increase riparian buffer to improve stream processes including large wood recruitment, habitat creation and water quality.	Stream shading, habitat, large wood recruitment, water quality

Background: 2005 NAIP Imagery. Taxlots: Marion County GIS

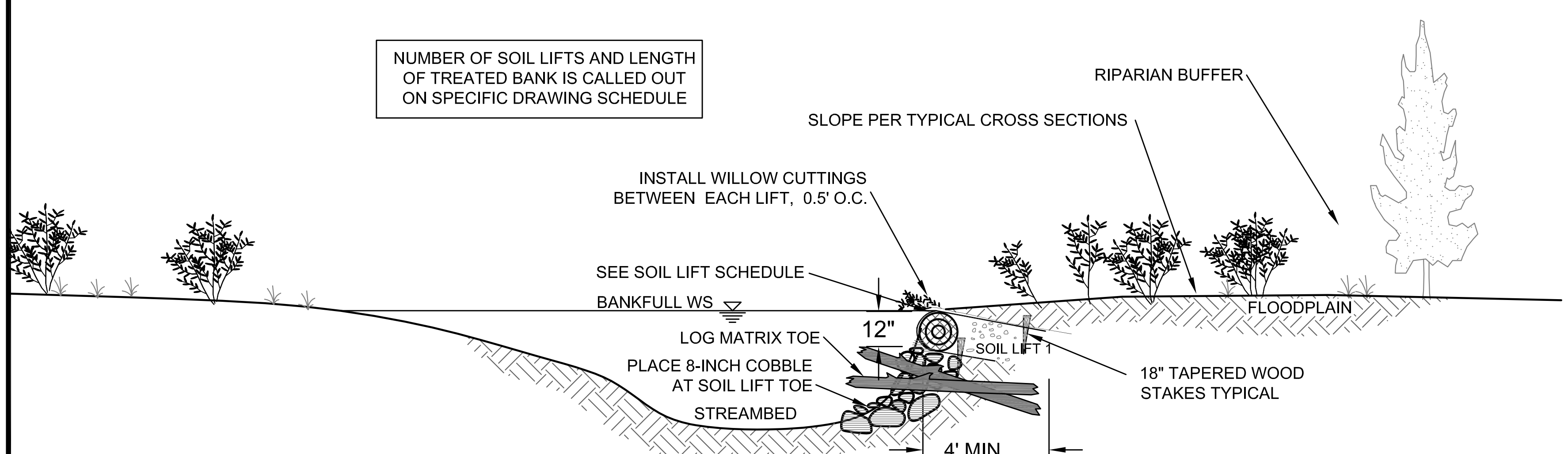
APPENDIX F
TYPICAL DRAWINGS



1 **ANCHORED COIR LOG W/ TOE WOOD**
TYPICAL CROSS SECTION NTS



2 **VEGETATED SOIL LIFT**
TYPICAL CROSS SECTION NTS



3 **VEGETATED SOIL LIFT W/ LOG TOE**
TYPICAL CROSS SECTION NTS

ANCHORED COIR LOG - CONSTRUCTION NOTES

ANCHORED COIR LOGS SHALL BE BUILT ON SUITABLE ALLUVIUM OR IMPORTED ALLUVIUM AS SPECIFIED. THE CONSTRUCTION MANAGER SHALL VIEW AND APPROVE FOUNDATION LAYER PRIOR TO CONSTRUCTING WRAPPED COIR LOGS.

CONSTRUCT A L-SHAPED TRENCH PARALLEL TO THE TOE OF THE STREAMBANK. THE SHELF SHALL BE 1.5' WIDE X 1.5' DEEP AND LOCATED AT APPROXIMATELY BANKFULL ELEVATION AND APPROXIMATELY 1' FROM THE EDGE OF THE CHANNEL.

THE COIR LOG SHALL BE SECURED USING DUCKBILL EARTH ANCHORS ATTACHED TO 3' OF ¼-INCH GALVANIZED STEEL WIRE EVERY 5' - 10' WHILE PLACED WITHIN THE CONSTRUCTED SHELF. BACKFILL SHALL BE PLACED BEHIND AND TO THE TOP OF THE COIR LOG USING SILT LOAM OR OTHER FINE TEXTURED MATERIAL AND THEN COMPACTED.

SOIL LIFT - CONSTRUCTION NOTES

SOIL LIFTS SHALL BE BUILT ON SUITABLE, STABLE NATIVE GROUND OR COMPACTED FILL AS NECESSARY, CONSTRUCTION MANAGER SHALL VIEW AND APPROVE FOUNDATION LAYER PRIOR TO CONSTRUCTING SOIL LIFTS.

TOE OF SOIL LIFT SHALL BE STABILIZED USING A MIXTURE OF THE LARGEST NATURAL GRAVELS AND COBBLES FOUND IN THE STREAM, OR COARSER MATERIAL SHOULD BE IMPORTED. TOE MATERIAL MUST EXCEED THE DESIGN SHEAR STRESS. A CROSSED SERIES OF TWO STACKED LOGS SHALL BE PLACED WITHIN THE TOE MATERIAL PROTRUDING A MINIMUM OF 4 FT. TOE SHALL BE STABILIZED DOWN TO THE MAXIMUM ANTICIPATED SCOUR DEPTH.

UPSTREAM AND DOWNSTREAM "TIE-IN" POINTS SHALL BE STABLE AREAS AND THE FABRIC SHALL BE STAKED TIGHTLY INTO THE STABILE AREA USING WOOD STAKES AT 2-FOOT O.C.

SLOPE ENGINEERED SOIL LIFTS APPROXIMATELY 10-DEGREES AS ILLUSTRATED ON THE SECTION DETAIL, OR ALLOW FOR A MINIMUM SETBACK OF 12-INCHES BETWEEN THE TOE FACE AND THE SOIL LIFT.

EMBED LIVE CUTTINGS A MINIMUM OF 4-FEET INTO SOIL LIFT, INSTALL WHILE VEGETATION IS DORMANT. MAY SUBSTITUTE CONTAINERIZED PLANTS IF PLANTED DURING THE GROWING SEASON.

THE SOIL LIFT FOUNDATION SHALL BE BUILT WITH A TAPERED SLOPE FROM THE LIFT FACE TO THE LIFT REAR TO PROMOTE MOISTURE RETENTION AND VEGETATION GROWTH.

NOTIFY CONSTRUCTION MANAGER OF ANY PROPOSED CHANGES PRIOR TO IMPLEMENTATION. THE CONSTRUCTION MANAGER RESERVES THE RIGHT TO MODIFY STRUCTURE DESIGN SPECIFICATIONS DURING CONSTRUCTION IF WARRANTED DUE TO UNFORESEEN CONDITIONS.

SOIL LIFT BACKFILL:

1. SOIL LIFTS SHALL CONTAIN A MIXTURE OF NATIVE GRAVELS AND SOIL FROM ON-SITE SOURCES.
2. LIFT SHALL CONTAIN SOILS FOR PLANTING AND THE LIFTS SHALL BE COMPACTED USING A VIBRATORY PLATE COMPACTOR OR EQUAL TO A MINIMUM OF 90% MAXIMUM RELATIVE DENSITY.
3. WILLOW STAKES SHALL BE PLACED IN A SHALLOW LAYER OF DIRT BETWEEN EACH SOIL LIFT.
4. APPLY NATIVE SEED MIX TO INSIDE OF FRONT 2-FEET OF SOIL LIFT.
5. SOIL LIFT FABRIC TO BE DRAWN TIGHT WITH NO FOLDS, ROLLS, OR GAPS.
6. INSERT STAKES AT 18" TO 24" FROM SOIL LIFT FACE SO THAT BACKFILL WILL COVER STAKES.
7. VEGETATE TOP OF SOIL LIFT PER PLANTING PLANS.

EXAMPLE OF VEGETATED SOIL LIFTS FOLLOWING CONSTRUCTION

RIVER DESIGN GROUP, INC.
Whitefish, Montana
5098 HWY 93 South
406.862.4927
Corvallis, Oregon
311 SW Jefferson
541.738.2920

STREAMBANK BIOENGINEERING
STOUT CREEK
NORTH SANTIAM WATERSHED COUNCIL - STAYTON, OREGON

Fieldwork:	XX
Date:	XX
Design:	TB
Drawn:	RB
Checked:	SW

PROJECT NUMBER
RDG-08-051

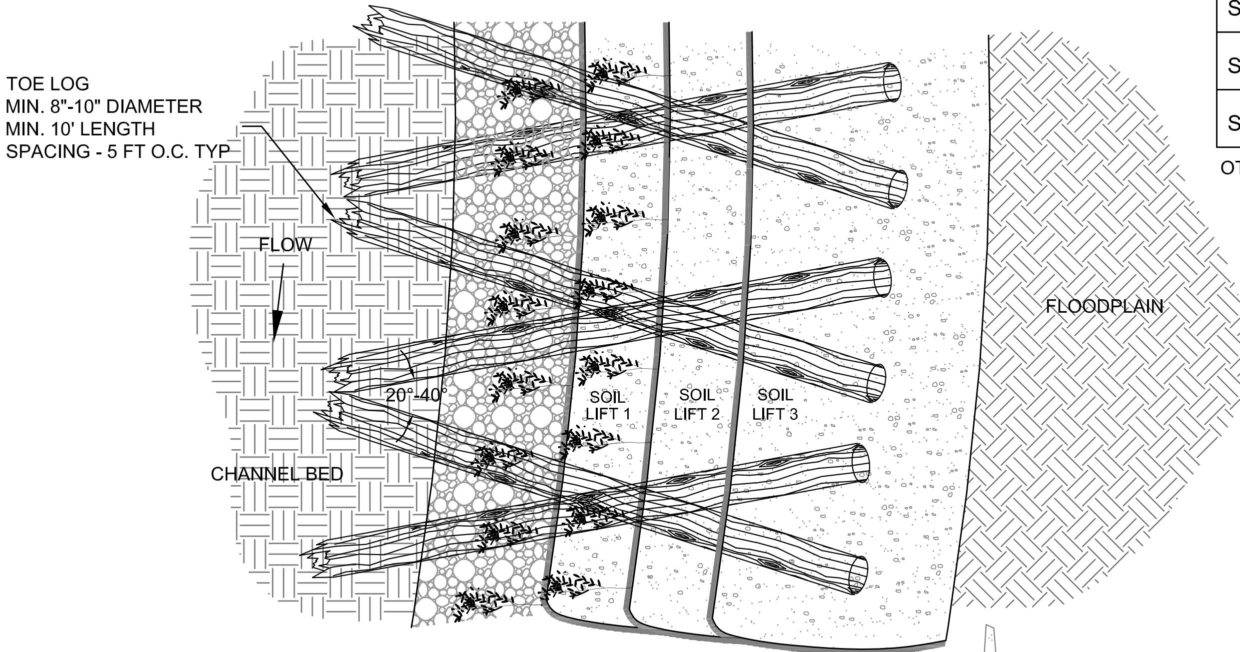
REVISION	DATE
X	XX/XX/XX

DRAWING NUMBER
1.0

VEGETATED SOIL LIFT SCHEDULE

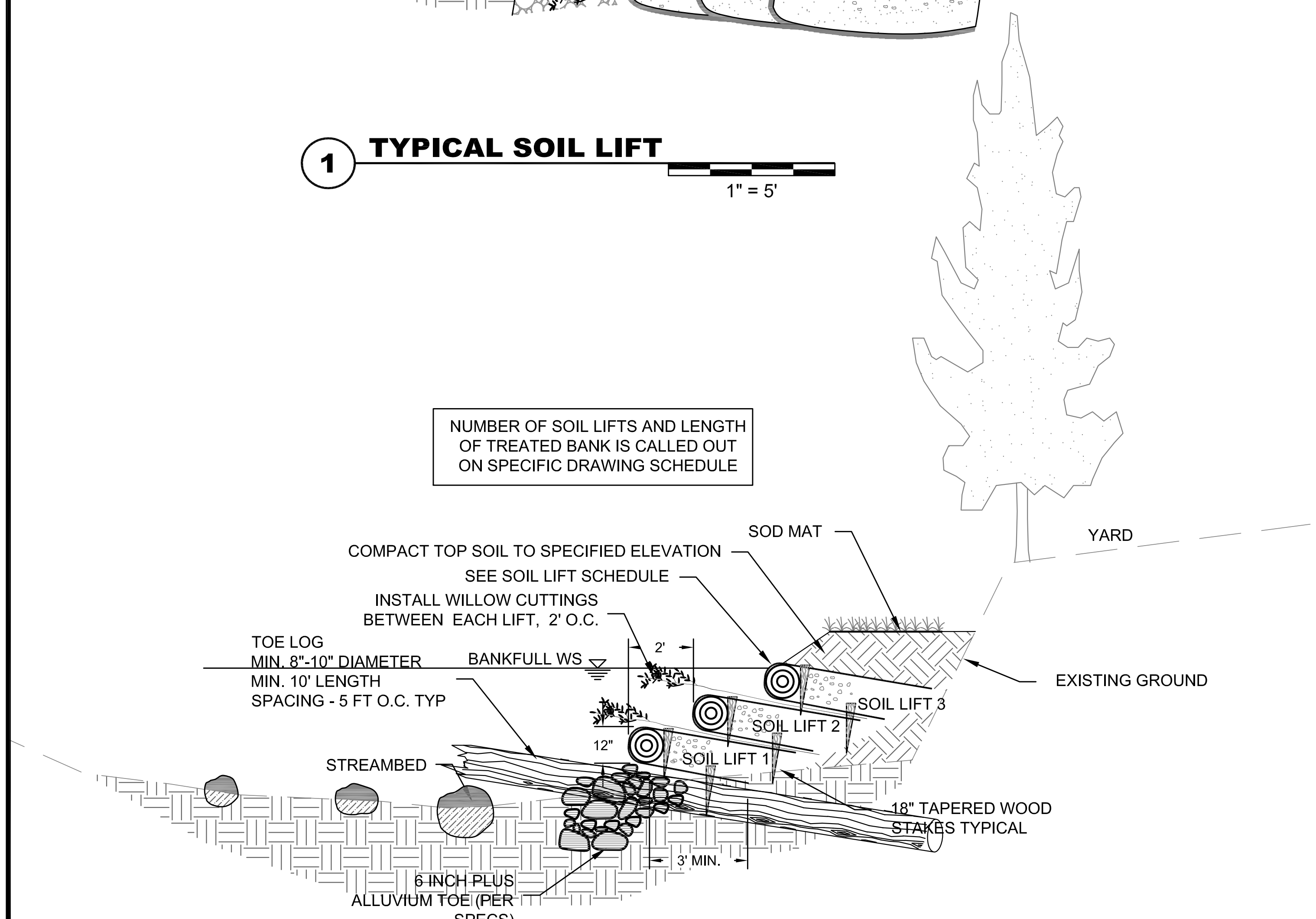
Callout	Height	Coir Log Designation	Outside Wrap	Inner Wrap	Stakes
SOIL LIFT 1	12"	Belton Ind . Coir Log, 12" Ø x 13 ft	Dekowe 700 Coir Mat, 4M x 50M	NAG C125n 2M x 30M	TAPERED 18" 2" x 4"
SOIL LIFT 2	12"	Belton Ind. Coir Log, 12" Ø x 13 ft	Dekowe 700 Coir Mat, 4M x 50M	NAG C125n 2M X 30M	TAPERED 18" 2" x 4"
SOIL LIFT 3	12"	Belton Ind. Coir Log, 12" Ø x 13 ft	Dekowe 700 Coir Mat, 4M x 50M	NAG C125n 2M X 30M	TAPERED 18" 2" x 4"

OTHER BRAND MATERIALS MAY BE SUBSTITUTED FOR SPECIFIED BRAND MATERIALS AS LONG AS SPECIFICATIONS ARE SIMILAR.



1 TYPICAL SOIL LIFT

1" = 5'



2 SOIL LIFT SECTION

1" = 5'

CONSTRUCTION NOTES

TOE OF SOIL LIFT 1 SHALL BE STABILIZED USING A MIXTURE OF THE LARGEST NATURAL GRAVELS AND COBBLES FOUND IN THE STREAM, OR COARSER MATERIAL SHOULD BE IMPORTED. TOE MATERIAL MUST EXCEED THE DESIGN SHEAR STRESS. TOE SHALL BE STABILIZED DOWN TO THE MAXIMUM ANTICIPATED SCOUR DEPTH. CONSTRUCTION MANAGER SHALL VIEW AND APPROVE FOUNDATION LAYER PRIOR TO CONSTRUCTING SOIL LIFTS.

UPSTREAM AND DOWNSTREAM "TIE-IN" POINTS SHALL BE STABLE AREAS AND THE FABRIC SHALL BE STAKED TIGHTLY INTO THE STABILE AREA USING WOOD STAKES AT 2-FOOT O.C. STABLE AREAS INCLUDE LARGE WOOD OR BOULDERS TO PROTECT FABRIC TIE IN POINTS.

SLOPE ENGINEERED SOIL LIFTS APPROXIMATELY 30-DEGREES AS ILLUSTRATED ON THE SECTION DETAIL, OR ALLOW FOR A MINIMUM SETBACK OF 12-INCHES BETWEEN THE TOE FACE AND FIRST LIFT, AND 12-18" BETWEEN SUBSEQUENT LIFTS.

EMBED LIVE CUTTINGS A MINIMUM OF 5-FEET INTO SOIL LIFT, INSTALL WHILE VEGETATION IS DORMANT. MAY SUBSTITUTE CONTAINERIZED PLANTS IF PLANTED DURING THE GROWING SEASON.

THE SOIL LIFT FOUNDATION AND SUBSEQUENT LIFTS TO BE BUILT WITH A TAPERED SLOPE (45°-60°) FROM THE LIFT FACE TO THE LIFT REAR TO PROMOTE MOISTURE RETENTION AND VEGETATION GROWTH. PLACE WILLOW CUTTINGS BUTT ENDS WITHIN ONE FOOT OF BASE FLOW WATER SURFACE ELEVATION.

NOTIFY CONSTRUCTION MANAGER OF ANY PROPOSED CHANGES PRIOR TO IMPLEMENTATION. THE CONSTRUCTION MANAGER RESERVES THE RIGHT TO MODIFY STRUCTURE DESIGN SPECIFICATIONS DURING CONSTRUCTION IF WARRANTED DUE TO UNFORESEEN CONDITIONS.

INSTALL CONTAINERIZED WILLOWS AND AT LEAST 4 FOOT WILLOW CUTTINGS SELECTED FROM LOCAL SOURCES FOR OVERBANK AND RIPARIAN BUFFER. SALVAGE AND INSTALL SHRUB AND WILLOW TRANSPLANTS AS THEY ARE AVAILABLE IN CONSTRUCTED FLOODPLAIN SURFACE.

SOIL LIFT BACKFILL:
1. SOIL LIFTS SHALL CONTAIN A MIXTURE OF NATIVE GRAVELS AND SOIL FROM ON-SITE SOURCES.
2. EACH LIFT SHALL CONTAIN SOILS FOR PLANTING AND THE LIFTS SHALL BE COMPACTED USING A VIBRATORY PLATE COMPACTOR OR EQUAL TO A MINIMUM OF 90% MAXIMUM RELATIVE DENSITY.
3. WILLOW STAKES SHALL BE PLACED IN A SHALLOW LAYER OF DIRT BETWEEN EACH SOIL LIFT.
4. APPLY NATIVE SEED MIX TO INSIDE OF FRONT 2-FEET OF SOIL LIFT.
5. SOIL LIFT FABRIC TO BE DRAWN TIGHT WITH NO FOLDS, ROLLS, OR GAPS.
6. INSERT STAKES AT 18" TO 24" FROM SOIL LIFT FACE SO THAT SUBSEQUENT LIFTS COVER STAKES.
7. VEGETATE TOP OF SOIL LIFTS PER PLANTING PLANS.

EXAMPLE OF VEGETATED SOIL LIFTS FOLLOWING CONSTRUCTION (LEFT) AND DURING THE SECOND GROWING SEASON (RIGHT)

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Whitefish, Montana
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Corvallis, Oregon
311 SW Jefferson
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VEGETATED SOIL LIFT W/ TOE LOG

STOUT CREEK

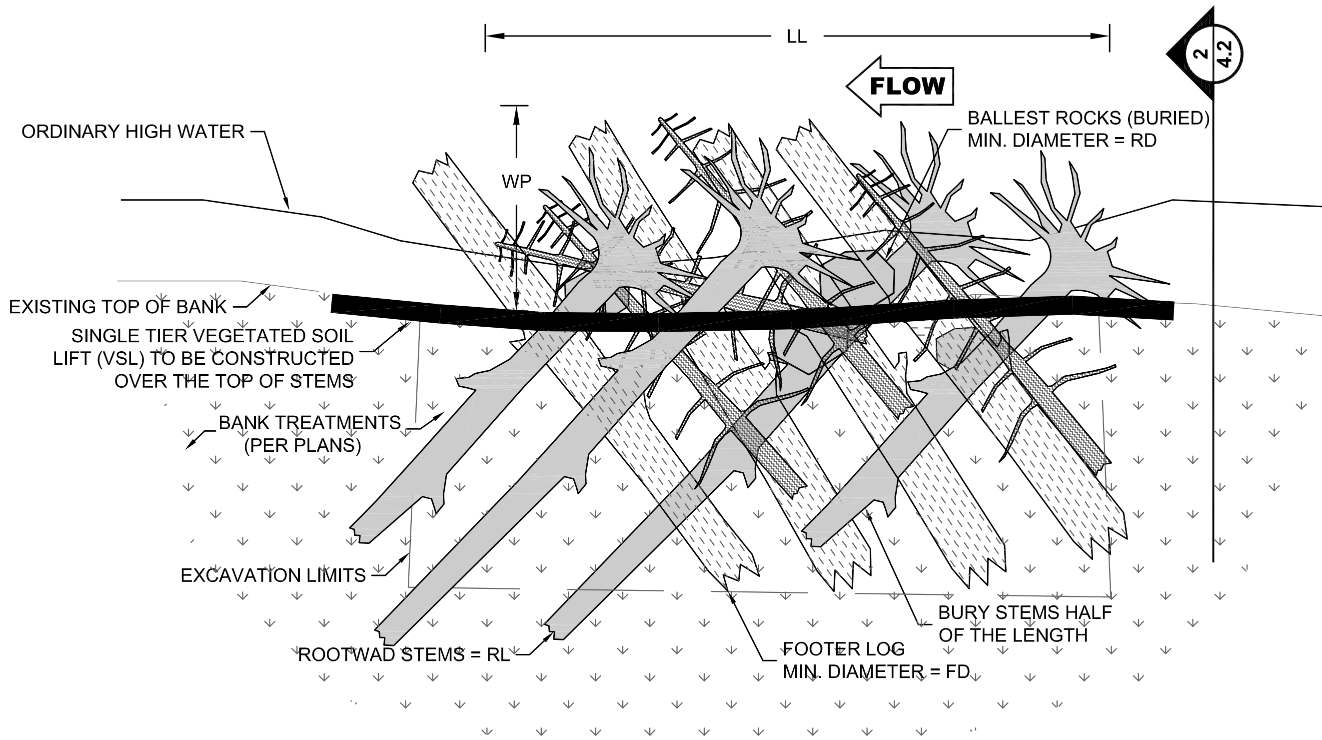
NORTH SANTIAM WATERSHED COUNCIL - STAYTON, OREGON

Fieldwork:	XX
Date:	XX
Design:	TB
Drawn:	RB
Checked:	SW

PROJECT NUMBER
RDG-08-051

REVISION	DATE
X	XX/XX/XX

DRAWING NUMBER
1.2



1 **PLAN VIEW**

1" = 10'

DESIGN INTENT

THE INTENT OF THE ENGINEERED LOG JAM IS TO PROVIDE BANK STABILIZATION BY REDUCING NEAR-BANK STRESS AND REDIRECTING FLOW AWAY FROM THE BANK. THE STRUCTURE IS DESIGNED TO ALLOW FISH PASSAGE AT ALL FLOW LEVELS AND DISSIPATE ENERGY IN THE FORM OF A DOWNSTREAM SCOUR POOL. STRUCTURE PERFORMANCE IS DEPENDENT UPON PLACEMENT WITHIN A SEQUENCE OF OTHER BANK STABILIZATION AND GRADE CONTROL STRUCTURES.

THE STRUCTURE IS DESIGNED TO BE NATURAL IN APPEARANCE AND INCORPORATE LARGE WOOD, ROCK, BIOENGINEERING, AND VEGETATION. THE STRUCTURE IS DESIGNED TO HAVE NO ABRUPT AFFECT ON THE WATER SURFACE PROFILE AT ALL FLOW LEVELS. THE STRUCTURE EXTENDS APPROXIMATELY 5-10 FEET INTO THE CHANNEL, LEAVING 30TO 35 FEET OF THE CHANNEL WIDTH UNOBSTRUCTED FOR BEDLOAD AND DEBRIS TRANSPORT, AND RECREATIONAL PASSAGE. OVER TIME, THE STRUCTURE WILL DECOMPOSE AND/OR BECOME ABANDONED AND REPLACED BY RIPARIAN VEGETATION THAT WILL BE PLANTED IN AND AROUND THE STRUCTURE.

CONSTRUCTION NOTES

EXCAVATE TRENCH AND SET FOOTER LOGS AT SPECIFIED DEPTH. USE FOOTER LOGS WITH MINIMUM DIAMETER AND STEM LENGTH AS SPECIFIED. FOOTER LOGS SHALL NOT HAVE A ROOTFAN. IF POSSIBLE, BACKFILL UP TO TOP OF FOOTER LOGS WITH SPECIFIED ALLUVIAL BACKFILL. DOUSE BACKFILL PERIODICALLY WITH WATER TO IMPROVE COMPACTION AND MINIMIZE VOID SPACES.

SET ROOTWAD LOGS ON FOOTER LOGS. PLACE LOG STEMS SLOPING DOWNWARD INTO BANK FROM EDGE OF WATER. USE ROOTWADS WITH MINIMUM ROOTFAN DIAMETER AND STEM LENGTH AS SPECIFIED. BACKFILL WITH NATIVE MATERIAL UP TO TOP OF ROOTWAD LOGS AND PLACE BALLAST ROCKS ON TOP OF ROOTWAD LOGS AT LOCATIONS WHERE ROOTWAD LOGS INTERSECT FOOTER LOGS. DOUSE BACKFILL PERIODICALLY WITH WATER TO IMPROVE COMPACTION AND MINIMIZE VOID SPACES.

ADD ADDITIONAL TIER OF FOOTER LOGS AND ROOTWAD LOGS AS DESCRIBED ABOVE. COVER BALLAST ROCKS AND TOP OF STRUCTURE WITH VEGETATED SOIL LIFT AS SPECIFIED.

PLACE ADDITIONAL LOGS AND WOODY DEBRIS INTO TRENCH TO ACT AS DEFLECTOR LOGS AND ADDITIONAL BALLASTING. NUMBER AND SIZE OF HABITAT LOGS MAY VARY FROM STRUCTURES SHOWN.

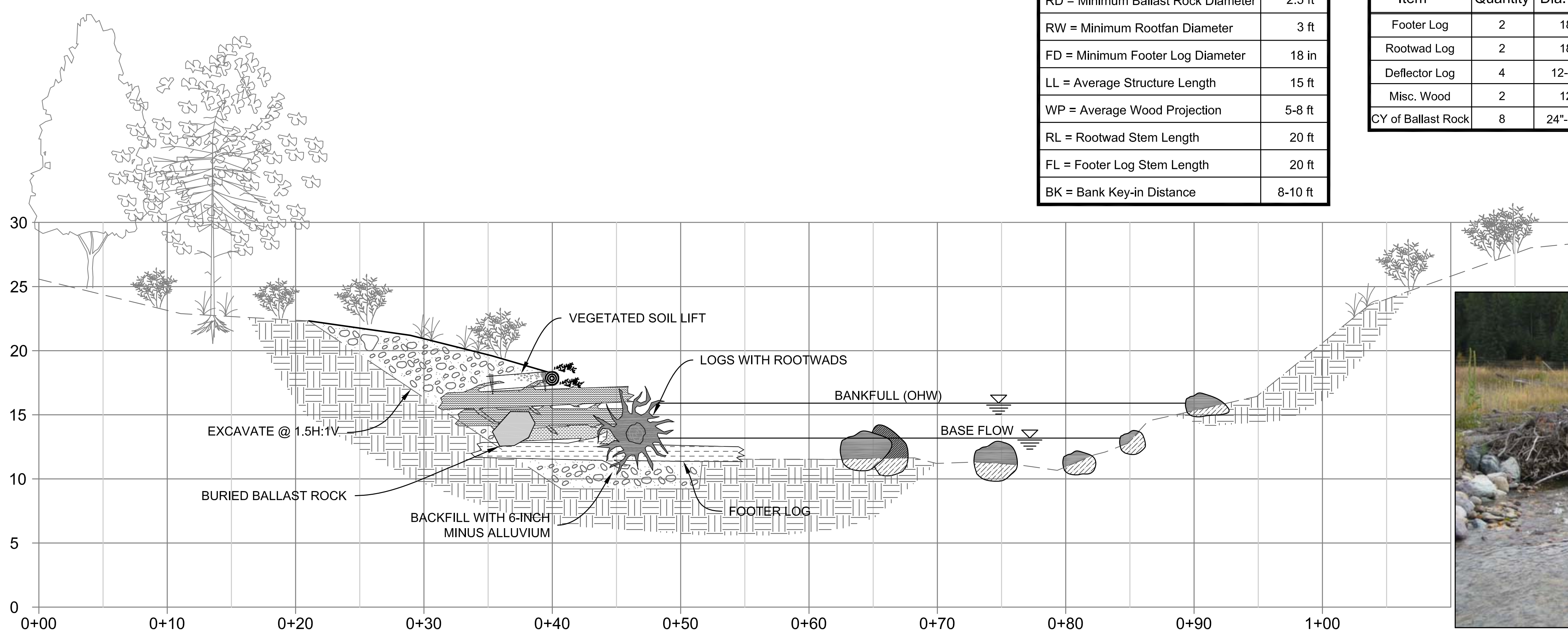
THE CONSTRUCTION MANAGER SHALL INSPECT AND APPROVE ALL FOOTER LOGS AND ROOTWAD LOGS PRIOR TO BACKFILLING. NOTIFY CONSTRUCTION MANAGER OF ANY PROPOSED CHANGES PRIOR TO IMPLEMENTATION. THE CONSTRUCTION MANAGER RESERVES THE RIGHT TO MODIFY STRUCTURE DESIGN SPECIFICATIONS DURING CONSTRUCTION IF WARRANTED DUE TO UNFORESEEN CONDITIONS.

STRUCTURE DIMENSIONS

RD = Minimum Ballast Rock Diameter	2.5 ft
RW = Minimum Rootfan Diameter	3 ft
FD = Minimum Footer Log Diameter	18 in
LL = Average Structure Length	15 ft
WP = Average Wood Projection	5-8 ft
RL = Rootwad Stem Length	20 ft
FL = Footer Log Stem Length	20 ft
BK = Bank Key-in Distance	8-10 ft

MATERIAL SCHEDULE (PER STRUCTURE)

Item	Quantity	Dia. (in)	Length (ft)	Rootwad (Y/N)
Footer Log	2	18	20	No
Rootwad Log	2	18	20	Yes - 3 ft Dia. Min.
Deflector Log	4	12-18	15-20	Optional - 3-4 ft
Misc. Wood	2	12	10	No
CY of Ballast Rock	8	24"-36"		



2 **STRUCTURE CROSS SECTION**

HORIZ 1" = 10'
VERT 1" = 10'

CONSTRUCTED LARGE WOOD HABITAT STRUCTURE WITH ADDITIONAL WOOD ADDED FOR HABITAT ENHANCEMENT

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Corvallis, Oregon
311 SW Jefferson
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ENGINEERED LOG JAM (ELJ)

STOUT CREEK

NORTH SANTIAM WATERSHED COUNCIL - STAYTON, OREGON

Fieldwork: XX
Date: XX
Design: TB
Drawn: RB
Checked: SW

PROJECT NUMBER
RDG-08-051

REVISION	DATE
X	XX/XX/XX

DRAWING NUMBER
1.3

Drawing 3 of 3

APPENDIX G
TYPICAL COSTS

Typical Construction Costs

Feature	Item	Unit	Unit Cost	Comment
Site Preparation	Mobilization/Demobilization	mi	$5-$10	Per piece of equipment, depends on equipment and distance to site
	Site preparation, materials distribution		$2,000 - $5000	Depends on site, access, project complexity
	BMP: Straw wattles materials and installation	lf	$4	
	BMP: Local site dewatering and isolation	ls	$1,000 - $5,000	Depends on site, flow, work area isolation plan complexity, and how the plan elements are implemented during the project
Backwater and Off-channel Habitat Construction	Excavate and haul	cy	$8 - $25	Depends on site conditions, material to be excavated and disposal requirements
	Ballast rock	cy	$35 - $100	Depends on source distance and material
	Tree (with rootwad)	ea	$200 - $300	Whole tree delivered
	Coir log	lf	$25	Includes labor and materials
	Vegetated soil lift (2-tier)	lf	$70	Includes labor and materials
	Vegetated soil lift (3-tier)	lf	$100	Includes labor and materials
Vegetation	Seeding	ac	$400	Depends on seed mix
	Mulching	ac	$1,500	
	Plant riparian vegetation	ea	$8	Depends on species, plant size and weed/browse treatment
	Plant upland vegetation	ea	$8	Depends on species, plant size and weed/browse treatment
Equipment Operation	Excavator	hr	$150	200 class excavator rate $125-$150, $135 average
	Off-road dump truck (10 cy)	hr	$100	Rate range $85-$100, $90 average
	Tracked skid steer	hr	$85	Rate range $85-$100, $90 average