Lower Kalama River
Off-Channel Habitat Assessment

Final Report
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Prepared for:

Lower Columbia Fish Enhancement Group
Vancouver, Washington

Lower Columbia Fish Recovery Board
Longview, Washington

Prepared by:

WATERFALL ENGINEERING

Waterfall Engineering, LLC
Patrick D. Powers, P.E.
Olympia, Washington

ECOLUTION
Marnie Tyler, Ph. D.
Olympia, Washington

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Donna (Hale) Bighouse	WDFW
Bryce Glaser	WDFW
Bernadette Graham-Hudson	LCFRB
Julius Ledgett	Landowner
Hal Mahnke	LCFEG
Nello Picinich	LCFEG
Patrick Powers	Waterfall Engineering
Marnie Tyler	Ecolution
Chris Wegemann	WDFW
Steve West	WDFW
Mark Wilson	Port of Kalama
Rick Yahrmarkt	LCFEG, Kalama Landowner

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EXECUTIVE SUMMARY

The Lower Kalama River Off-Channel Habitat Assessment was initiated to identify and prioritize potential salmonid habitat restoration projects in the lower reaches of the subbasin. Conceptual engineering designs and preliminary cost estimates were developed for top ranking projects. This habitat assessment was restricted to the lower 2.5 miles of the Kalama River. The lower portion of the Kalama mainstem has been heavily channelized, thus greatly reducing the abundance of off-channel habitat in the subbasin, particularly chum spawning and coho overwintering habitat (LCFRB 2004). This habitat assessment primarily focused on off-channel habitat creation and restoration, but also considered fish passage barriers, floodplain connectivity, bank stability, and riparian enhancement projects. These projects will benefit populations of adult chum and coho salmon as well as juvenile coho, steelhead, Chinook and cutthroat trout.

This habitat assessment builds upon the foundation of work incorporated into the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (hereafter referred to as the Recovery Plan, LCFRB 2004), the subsequent Habitat Work Schedule developed by the Lower Columbia Fish Recovery Board (LCFRB, 2008), and the Watershed Assessment Project (R2 2004) commissioned by the LCFRB. The Ecosystems Diagnosis and Treatment (EDT) and Integrated Watershed Assessment (IWA) models were prominent tools used in the development of the Salmon Recovery Plan, and in the prioritization of potential restoration projects. Simply put, the EDT Reach Analysis identifies the most important reaches affecting fish populations; the EDT Habitat Factor Analysis identifies which habitat factors are most limiting to fish populations within each reach. IWA identifies watershed processes impacting fish populations across the subbasin and rates the severity of impact for three watershed processes (riparian conditions, hydrology, and sediments).

To select potential projects in the Lower Kalama River, a work group was convened, with representation from the Lower Columbia Fish Enhancement Group, LCFRB, the Washington Department of Fish and Wildlife (WDFW), individual landowners, the Port of Kalama, and technical consultants. Work group members evaluated aerial photographs and remotely sensed data and participated in field reconnaissance by boat and land. Along the 2.5 RM study area, twelve potential projects were identified. Additional field investigations were conducted for the most promising projects, providing critical information for assessing project viability and developing construction designs. Field studies included collection of topographical, surface and groundwater water flow, and channel geomorphology data.

Potential projects were prioritized following a scoring approach developed by the LCFRB Technical Advisory Committee. The work group participated in the ranking process. One project was selected for engineering designs developed at a 30% completion level (KRL 2.5, Ledgett Ground Water Channel). Conceptual engineering design and cost estimates were developed for three additional projects (KRR 2.2, Port of Kalama Groundwater Channel System; KRR 0.7, WDFW Tidal and Groundwater Channel; and SC 0.5, Spencer Creek Riparian Restoration and Large Woody Debris). Engineering designs followed accepted practices promoted by WDFW and drew upon consultant experience from 48 similar projects within Washington State.

1. INTRODUCTION

1.1 Goals and Objectives

The Lower Columbia Fish Enhancement Group (LCFEG) initiated the Lower Kalama Off-Channel Habitat Assessment to identify and prioritize restoration opportunities in the lower 2.5 miles of the Kalama mainstem and tributaries. The ultimate objectives of this effort were to develop conceptual engineering designs and cost estimates for top ranking projects, focusing on off-channel habitat opportunities. Restoration projects were identified that could directly address primary limiting factors and priority measures and actions identified within the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (hereafter referred to as the Recovery Plan, LCFRB 2004). LCFEG intends to include select projects in future Salmon Recovery Funding Board (SRFB) funding requests; the project list will also be available for other entities to consider for possible restoration and mitigation activities. Species to benefit from this work include adult chum and coho salmon as well as juvenile coho, steelhead, Chinook and cutthroat trout. It is also hoped that the fine-scale data collected as a part of this project will inform and enhance future iterations of the LCFRB's 6-Year Habitat Work Schedule and Lead Entity Habitat Strategy (HWS).

1.2 Approach

This study initially targeted a single reach within the subbasin: Kalama 2. This is a Tier 1 reach which was identified as the top ranking reach in the HWS at the time the study was initiated. An individual property was identified based on landowner willingness and site suitability[1]. Proposed activities were aimed at creating off-channel habitat, and improving riparian condition and floodplain connectivity. A work group was convened to incorporate stakeholder input and technical expertise. The work group included representation from the LCFEG, the Lower Columbia Fish Recovery Board (LCFRB), the Washington Department of Fish and Wildlife (WDFW), individual landowners, the Port of Kalama, and technical consultants. The work group met at key junctures of the study to provide input on scope, objectives, restoration opportunities, and project prioritization and ranking. Per the suggestions of the work group, the scope was extended beyond the initial property to include the lower 2.5 miles of the Kalama River mainstem and Spencer Creek, and the number of projects for which designs were developed was increased.

The study builds upon previous efforts to identify and prioritize restoration opportunities in the subbasin, including the Recovery Plan (LCFRB 2004), HWS (LCFRB 2008), the Kalama, Washougal, and Lewis River Habitat Assessments (hereafter referred to as the Watershed Assessment Project, R2 2004), and similar project development and prioritization efforts in the Cowlitz subbasin (Tetra Tech 2007) and Woodward Creek (Tetra Tech and Anchor 2007). The study also includes new field investigations and monitoring of hydrologic conditions, including an inventory of potential restoration project sites and data collection essential for determining project feasibility.

[1] The reach has subsequently been split into Kalama 2A and Kalama 2B, with the identified property in reach Kalama 2A. Kalama 2A is identified as the second ranked reach in the 2008 update of the HWS.

2. LOWER KALAMA RIVER SUBBASIN DESCRIPTION

2.1 Subbasin Description

The Kalama River falls within the 205 square mile Kalama River subbasin (Figure 1) and is one of eleven major subbasins comprising the Washington side of the Lower Columbia Basin. The River originates on the southwest slopes of Mount St. Helens and enters the Columbia River at river mile (RM) 73.1. The Kalama River subbasin was historically populated with thousands of fall Chinook, winter steelhead, chum, and coho, however their numbers have fallen drastically. Chinook, chum, steelhead and coho are listed as threatened under the Endangered Species Act (ESA). Unless specifically referenced to another source, the information presented throughout Section 2.1 is derived from the Recovery Plan (LCFRB 2004).

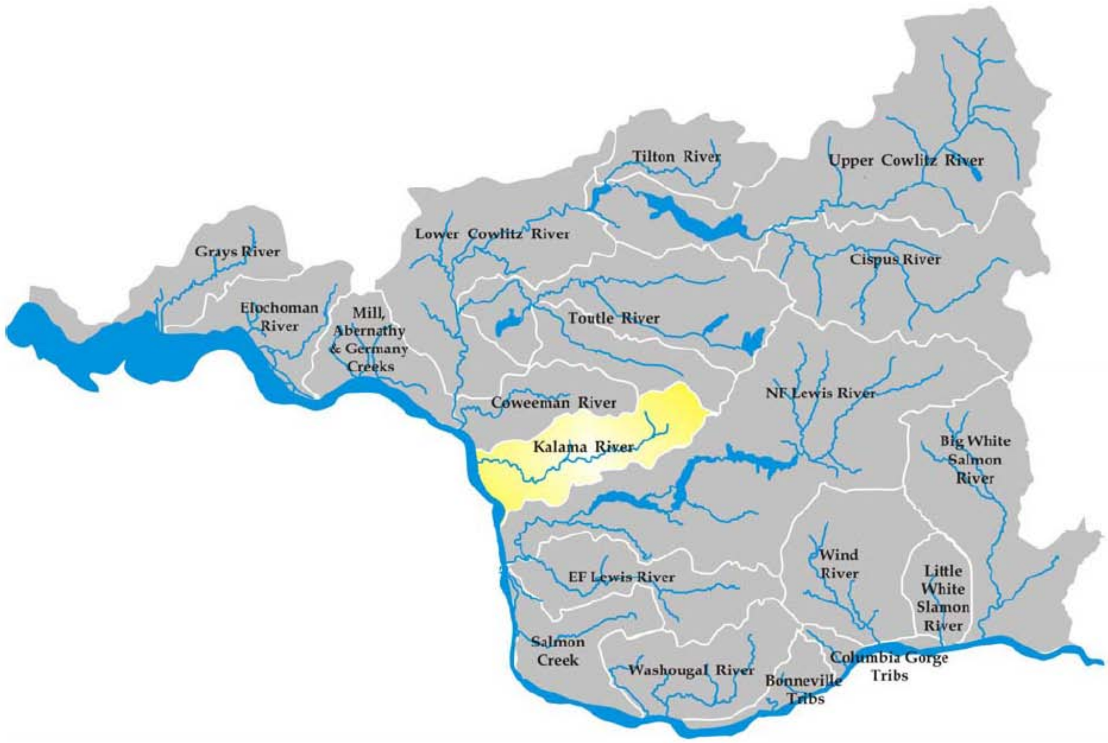

Figure 1. The Kalama River Subbasin and its relationship to the Lower Columbia Basin. Reproduced from the Recovery Plan (LCFRB 2004)

Based on criteria established by the Technical Recovery Team convened by NOAA, the Kalama Subbasin was identified as one of the most important subbasins for salmon recovery within Washington Cascade subbasins. To meet regional recovery objectives, Kalama River Chinook and steelhead will need to be restored to a high level of viability; coho and chum will need to be restored to medium and low levels of viability respectively.

The vast majority (96%) of the subbasin is managed for commercial timber production, however the lower portion of the subbasin has been heavily impacted by residential and industrial development, highway and road construction, agriculture and water withdrawals, gravel mining and other land use activities. Impacts from land use have resulted in channelization, degradation of riparian conditions, and loss of wetlands, side channels, oxbows, and meander scars. Most of the floodplain has been disconnected from the river and riparian conditions have been degraded (Wade 2000). The ultimate result has been the loss of salmonid spawning and rearing habitat. Without concerted efforts to reverse these trends, these losses can be expected to continue.

2.1.1 Study Area

The Kalama River mainstem has roughly 35 miles of anadromous fish distribution. The focus of the current assessment is on the lower 2.5 miles of the river and its tributaries (Figure 2), which includes the second ranked reach identified within the 2008 HWS. The gradient in this part of the basin is low and the entire area considered is influenced by tidal fluctuations to varying degrees. Land ownership within the study area is predominately private residential, but also includes industrial properties and lands owned by the Port of Kalama, and a small area owned by WDFW.

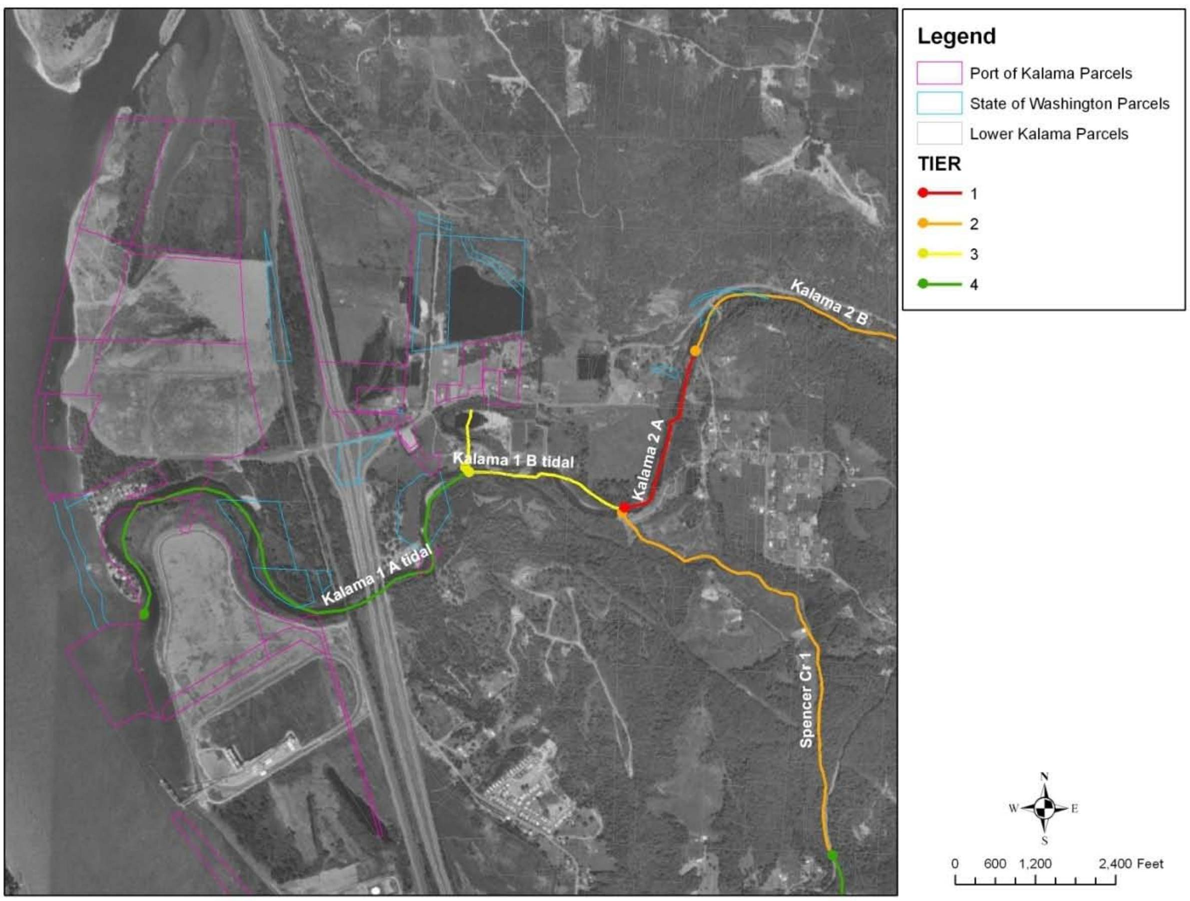

Figure 2. Lower Kalama River study area.

2.1.1 Geology

In the Watershed Assessment Project, R2 and MBI (2004) summarized geologic data presented in Washington Department of Natural Resource's *Geologic Map of Washington – Southwest Quadrant* (Walsh et al., 1987). R2 and MBI (2004, page 2-30) provides the following description of the geology and geomorphology of the subbasin:

> *"The Kalama River basin geology is relatively uniform compared to the nearby Lewis and Washougal River basins. The upper Kalama River flows through volcaniclastic deposits of pyroclastic flows, lahars, and debris avalanches, from its headwaters downstream to below Bush Creek near river mile (RM) 30 (Walsh et al. 1987). These deposits produce fine sediments that are typically composed of fine to medium size grains. There are isolated lahar areas distributed as patches throughout the middle Kalama River section, containing mixtures of cobble and boulders supported by a matrix of sand or mud. Between RM 30 and Marietta Falls near RM 6), the mainstem flows through fine grained igneous, Lower Oligocene to upper Eocene andesite flows. Most of the tributaries to the Kalama River entering below upper Kalama Falls also flow through the same fine grained igneous andesite flow material as the middle mainstem river (Walsh et al. 1987; Foster 1983). Below Marietta Falls, the Kalama River flows through predominantly alluvial deposits containing sand and gravel."*

The data collected by R2 for the Watershed Assessment Project suggest that EDT-modeled embeddedness values were underestimated throughout the basin. For a more thorough evaluation of substrate, sedimentation patterns and spawning suitability, the reader is referred to the Watershed Assessment Project itself (R2 2004).

2.1.2 Climate and Precipitation

The study area has a maritime climate with cool, wet winters and warm, dry summers. Mean annual precipitation is 68 inches at the Kalama Falls Hatchery, which is located within 3 miles of the study area. River flows are also influenced by precipitation in the upper reaches of the basin, which may exceed 120 inches. The bulk of the precipitation falls between October and March (LCFRB 2004).

2.1.3 Hydrology and Hydraulics

Daily exceedence flow duration curves for the Kalama River were developed by the Department of Ecology for an Instream Flow Incremental Methodology (IFIM) assessment (Caldwell, 1999). Values from the graph are shown in (Table 1). The 90 and 10 percent are recommended design flow ranges for the development of off-channel habitat. The 50 percent flow is included to show average conditions. Juvenile salmon typically migrate into and egress from off-channel areas during changes in stream flow and temperature. For the Kalama River this change occurs in the fall to winter period (October to December) and in the spring to summer period (May to July). Using these months to define the migration timing for juveniles, the design flows would range from 250 to 4000 cubic feet per second (cfs). Fish still may use off-channel habitat above and below these flows, but on a much smaller scale relative to the overall population.

Table 1. Kalama River flow exceedance values. Data from 1946 to 1983 USGS Gage 14223500 at RM 4.2

Month	Flow Exceedance (cfs)		
	90%	50%	10%
Oct	*200*	*300*	*1000*
Nov	*250*	*600*	*1800*
Dec	*600*	*1800*	*4000*
Jan	*1000*	*1800*	*3000*
Feb	*700*	*1800*	*4000*
Mar	*900*	*1700*	*3000*
Apr	*700*	*1600*	*2500*
May	*700*	*1200*	*2000*
Jun	*450*	*700*	*1200*
July	*300*	*450*	*700*
Aug	*230*	*300*	*450*
Sep	*200*	*280*	*450*

Kalama River peaks flows are available from a historical USGS gaging station (Kalama River Near Kalama 14223000; online at http://waterdata.usgs.gov/wa/nwis/), for 31 years from 1912 to 1947. USGS flood frequency analysis software PeakFq (available online at http://water.usgs.gov/software/PeakFQ/) yields the following peak flows and return periods.

8200 cfs	2-Year Flood
15000 cfs	10-Year Flood (Note: FEMA Flood Study used 16500 cfs)
20000 cfs	20-Year Flood
30000 cfs	100-Year Flood (Note: FEMA Flood Study used 25050 cfs)

For project longevity in terms of maintaining the project as designed it is recommended using the 20-year peak flood event. For risk assessment and potential liability to the Public, the 100-year peak flood flow event should be evaluated.

Tidal elevations at the mouth of the Kalama River vary from 6 to 14 feet. The actual point of tidal impact will vary from RM 1.0 at low flow, to 1.6 at high flow. Tidal impact (in terms of channel morphology) extends further upstream to around RM 2. Figure 3, shows the steeper water surface gradient just downstream from RM 2.

Groundwater has been studied extensively in the Lower Kalama (CH2MHill, 2002). Sediment in the Lower Kalama study area consists of recent Columbia River and Kalama River alluvial deposits overlying volcanic and sedimentary bedrock deposited during the building of the Cascade Mountains. Identified projects for off-channel enhancement are located within this alluvial delta of the Kalama River. The thickness of this sediment layer varies from 90 to 325 feet. In the lower portions of the study area the groundwater is tidally influenced. There were no data presented on groundwater elevations or flow directions in the CH2M Hill draft report. At the upper end of the project study reach, several wells exist (City of Kalama and Ledgett) on the left bank of the river. Groundwater pump tests performed showed a direct connection to the

Kalama River. In the lower portions of the study area, the groundwater corresponds directly to Columbia River levels.

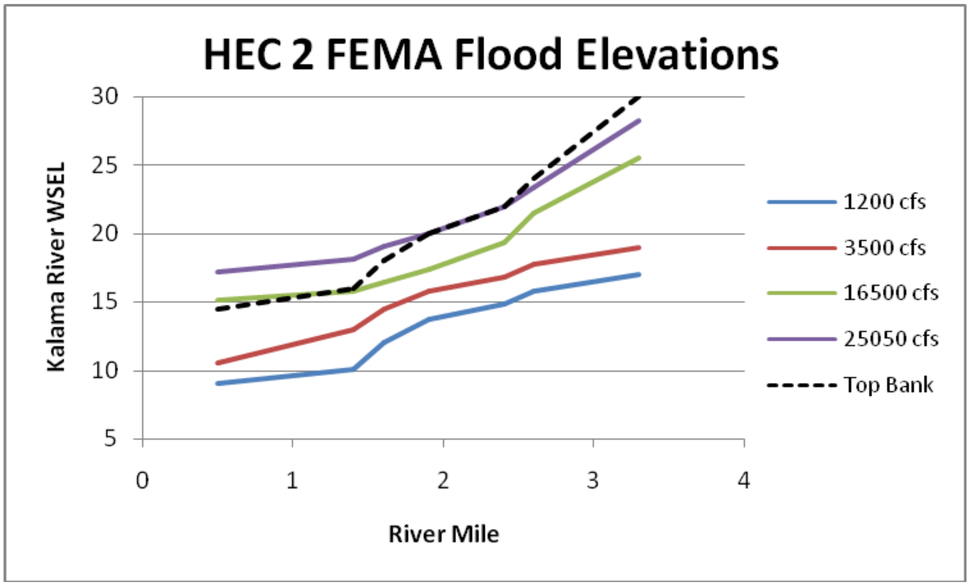

Figure 3. Water surface profile in the Lower Kalama River at various flood flows. Note: The top bank elevation above RM 2.0 appears to be near the 100-year flood line. This would indicate an incised channel through this reach and a loss of side channel connectivity. Although, observations of flooding have shown at RM 2.0 that floods above the 5 year event overtop the bank.

2.1.4 Vegetation and Land Use

Historically, this landscape was dominated by late seral coniferous forests. Dominant overstory species likely included western hemlock interspersed with Douglas-fir and western redcedar. Understory species were diverse plant associations of such species as salal, Oregon grape, vine maple, dogwood, huckleberry, salmonberry, and thimbleberry among others (Franklin and Dyrness 1988). Natural disturbance in the form of wind, fire, river meanders, insect and disease, resulted in a mosaic of patches of early and mid-seral forest interspersed within the late seral matrix. Riparian and floodplain areas were likely a mix of deciduous trees (e.g. black cottonwood, red alder, bigleaf maple), shrubs (predominately willows), emergent wetlands and grasses, and coniferous forests (predominately western redcedar and western hemlock).

Patterns of land use and development in the study area have greatly affected upland and riparian vegetation. Most of the watershed, including riparian areas, was logged between the late 1960s and early 1980s, resulting in a prevalence of early and mid-seral stages in forested areas of the subbasin (Lewis County GIS 1999, as cited in Wade 2000). R2 and MBI (2004) summarized riparian large woody debris (LWD) recruitment potential and stream shading levels. Overall, LWD recruitment potential is poor throughout the subbasin, however it is identified as high or moderate for three of the five reaches included in this study, as noted in the reach descriptions below. Riparian shade criteria however, are off target for all reaches (R2 and MBI 2004). Existing size classes are relatively small, with only 5% of riparian stands in size classes >20" diameter (for the subbasin overall). Riparian stands are ineffective in providing adequate shade and stream temperatures for salmonids and were labeled as 'impaired'. Disturbance in the riparian area is largely due to urban development and roads (R2 and MBI 2004). Non-native species such as Himalayan blackberry, Scot's broom and reed canary grass are present and increasing in extent in disturbed areas.

2.1.5 Fish Distribution

The focal species in the Kalama Subbasin include six salmonid species, all of which have been federally listed as threatened: fall Chinook, spring Chinook, chum, coho, summer steelhead, and winter steelhead (LCFRB 2004). Other species of interest in the Kalama River watersheds include coastal cutthroat trout and Pacific lamprey. There is a significant hatchery component in the subbasin for all focal species except chum. Additionally, many out-of-basin stocks may rely on estuarine habitat within the Kalama Subbasin for rearing, refuge and migration.

Current viability of focal populations is quite low, however recovery goals for these populations are generally high, due to the importance of these populations to recovery of the species within their Evolutionarily Significant Units (Table 2). All six of these species are present in the lower 2.5 miles of the Kalama River mainstem. Coho and chum are documented in both of the Spencer Creek reaches included in this analysis, and steelhead are also present in the downstream reach, Spencer Creek 1 (LCFRB 2008). The 2004 Watershed Assessment Project (R2 and MBI) indicates that coho spawning is documented or presumed in the mainstem Kalama below lower Kalama Falls and in Spencer Creek. Steelhead spawning is widely distributed across the subbasin and is documented in the lower Kalama mainstem and nearly all tributaries surveyed in the R2 report (Spencer Creek was not surveyed). Chinook spawning primarily occurs in the Kalama mainstem upstream from the study area. Chum historically have spawned at the upper end of the study area (beginning at RM 2.4) (R2 and MBI 2004).

Table 2. Current and recovery goal viability rating and population status for species in the study area (LCFRB 2004).

Species	Current Viability Rating	Recovery Goal Viability Rating	Recovery Scenario Population Importance
Fall Chinook	Low+	High	Primary
Spring Chinook	Very low	High	Primary
Chum	Very low	Low	Contributing
Coho	Low	Medium	Contributing
Summer Steelhead	Low+	High	Primary
Winter Steelhead	Medium+	High	Primary

2.2 Reach Descriptions

Reaches used within this report and throughout the project mirror those used in EDT analyses included within the HWS (Table 3). EDT Habitat Factor Analysis identifies key habitat quantity and habitat diversity as important habitat attributes for restoration across all species and reaches in the study area. Additionally, sediment load is moderately important for coho, chum, winter steelhead in some reaches, flow and harassment have moderate importance in Kalama 2A for chum; predation is moderately important in Kalama 1A and 1B tidal for coho and winter steelhead.

The HWS (LCFRB 2008) identifies the same multi-species project benefits for all reaches in the study area. Four of the five reaches have a high benefit, the fifth reach, Spencer Creek 2, also identifies these project benefits, but gives a moderate rating:

- stream channel habitat structure and bank stability,
- off-channel and side-channel habitat,
- floodplain function and channel migration processes,
- riparian conditions and functions,
- instream flows, and
- watershed conditions and hillslope processes.

Table 3. Reach description summary.

Reach	Description	Starting RM	Ending RM	Tier
Kalama 1 A tidal	Mouth to Right Bank (RB) Tributary 1	0.00	1.75	4
Kalama 1 B tidal	Kalama RB Tributary 1 to Spencer Creek	1.75	2.22	3
Spencer Creek 1	Mouth to Spencer Ck Rd. Culvert	0.00	1.80[2]	2
Spencer Creek 2	Spencer Ck Rd culvert to end of salmonid distribution	1.80[2]	2.00	4
Kalama 2A	Spencer Creek to confined canyon	2.22	2.75	1

2.2.1 Kalama 1A Tidal

Kalama 1A Tidal and 1B Tidal were lumped together as Kalama 1 tidal in the initial EDT analysis of the 2004 Recovery Plan. While Kalama 1 tidal was identified as a Tier 3 reach, Kalama 1A Tidal was classified as a Tier 4 in the 2008 HWS. This reach extends from the mouth of the Kalama River at the confluence with the Columbia River up to an unnamed tributary on the right bank at RM 1.75.

Tidal influence extends throughout this reach, affecting channel and floodplain morphology. The channel is of low gradient (<1%) and is geomorphically unconfined, however armored banks or levees constrain this reach on both sides. Habitat in this reach is entirely deep glide with a lot of sand, except at the mouth, where some large cobbles and gravels are found. With very little usable spawning habitat, the reach is useful as a transportation corridor for upstream migrating adults, and for acclimatization for outmigrating juveniles. LWD recruitment is identified as poor (R2 and MBI 2004).

As a Tier 4, this reach has low priority overall for restoration of multiple species of salmonids in the subbasin. The reach potential is moderate for coho, and low for steelhead, Chinook and chum (LCFRB 2008). Restoration opportunities within this reach include addressing passage issues at the mouth of the river (Figure 4), habitat enhancement of several tidal channels on Port of Kalama property (Figure 5), and creating a connection between the reach and possible groundwater channels on WDFW property at RM 0.7, and a groundwater channel at RM 1.4.

[2] The location of the mouth of Spencer Creek is incorrect in the 2008 HWS and thus the starting and ending RM listed here is different than that in the HWS.

Deposition of sediment at the mouth of the river has been thought to create an upstream passage obstruction for migrating salmonids, particularly during low tide, and to increase avian predation of outmigrating smolts (LCFRB 2004). The Kalama River channel is confined and transports sediment until connection with the Columbia River. It is possible that the quantity of deposition has been affected by the construction and ongoing operations of the Federal Columbia River Power System, and eroding banks of the lower river and midbasin tributaries (R2 and MBI 2004). Fisher and Associates, documented the use of several hundred ESA-listed juvenile salmon (fry and alevins) in this reach in a constructed off-channel area on Port of Kalama Property.

Figure 4. Reach Kalama 1A Tidal: deposition at mouth of Kalama River

Figure 5. Reach Kalama 1A: tidal channels on Port of Kalama property

2.2.2 Kalama 1B Tidal

Kalama 1A Tidal and 1B Tidal were lumped together as Kalama 1 Tidal in the initial EDT analysis included in the 2004 Recovery Plan. This reach extends from the unnamed right bank tributary at RM 1.75 up to the mouth of Spencer Creek (Kalama Mainstem RM 2.2). This reach is also influenced by tidal fluctuations, but to a lesser degree than Kalama 1A Tidal. The reach is flanked by a gently sloping alluvial terrace covered with predominately deciduous forest (Figure). LWD recruitment potential is high for this reach (R2 and MBI 2004).

Figure 6. Kalama 1B tidal

This is a Tier 3 reach; the reach potential is low for all six species found in the study area (LCFRB 2008). The reach is unconstrained by levees and dikes and offers some of the only off-channel habitat found in the lower basin: a large backwater/tributary confluence at the upper end of the reach, between RM 1.9 and 2.2. Habitat in this reach is entirely deep glide, with a lot of sand. With very little usable spawning habitat, it is useful as a transportation corridor for upstream migrating adults, and for acclimatization for outmigrating juveniles (R2 and MBI 2004).

2.2.3 Spencer Creek 1

This reach extends from the mouth of Spencer Creek (Kalama River mainstem RM 2.2) to Spencer Creek RM 1.8[3]. This is a very narrow, low-gradient, partially shaded channel (Figure 7). It flows through the Kalama River floodplain, which is comprised largely of sand and silt in the upper 8-10 feet near the mouth of Spencer Creek (R2 and MBI 2004). In the vicinity of the confluence with the Kalama mainstem there are several small excavated pits which have year-round groundwater. Beaver activity in the area regularly results in Spencer Creek forming several braided channels through the Kalama River floodplain. The creek's banks alternate between open grassy stretches and deciduous shrubs and trees (alder and cottonwood); reed canary grass and Himalayan blackberry are established in the area. LWD recruitment is poor (R2 and MBI 2004).

Spencer Creek 1 has a high reach potential for coho, and low potential for chum, and winter and summer steelhead (LCFRB 2008). The reach is heavily embedded, probably due to the low gradient and lack of stream velocity and sediment transport capacity (R2 and MBI 2004). Based on field reconnaissance, the best spawning habitat of this reach is located above the Kalama River floodplain, at the base of a rising, heavily vegetated slope (near the 40 foot contour on the contour on the Kalama 1:24,000 topographic map.

Figure 7. Mouth of Spencer Creek.

[3] The location of the mouth of Spencer Creek is incorrect in the 2008 HWS and thus the distance listed here is different than that in the HWS

The 2008 HWS assigns a high reach potential for coho to this Tier 2 reach, and gives a low rating for chum and winter and summer steelhead (Chinook are not present). The Watershed Assessment Project (R2 and MBI 2004) noted that reducing sediment levels would be a critical component of improving spawning conditions within the reach. Achieving this goal would require long-term, extensive sediment abatement efforts (R2 and MBI 2004).

2.2.4 Spencer Creek 2

This Tier 4 reach extends from Spencer Creek RM 1.8 to RM 2.0, the end of known salmonid distribution. This is a very narrow, shaded channel with gradient generally greater than 3%. Heavy riparian vegetation of mixed deciduous/conifer composition flanks the channel; LWD recruitment is identified as high (R2 and MBI 2004). The 2008 HWS assigns this reach a low species potential for coho and chum, the only species present.

2.2.5 Kalama 2A

Reach Kalama 2A is a Tier 1 reach extending from RM 2.2 to 2.75. The channel is confined on the right bank by rock vanes and riprap but unconfined on the left bank. Gradient ranges from 0.5-1%. The pool-riffle habitat complex has a substrate dominated by cobbles and gravel with a low level of fines, making spawning conditions favorable (R2 and MBI 2004). At the time this study was initiated, it was identified as the highest priority reach in the 2007 HWS; in the 2008 HWS, it is recognized as the second priority reach. This reach was identified in the Recovery Plan as having the greatest potential benefit to overall population abundance, productivity, and diversity. LWD recruitment is identified as moderate for this reach (R2 and MBI 2004).

Reach potential is high for fall Chinook and chum, and low for the other four species present in the study area (LCFRB 2008). The Recovery Plan (LCFRB 2004) specifically includes this reach in its top priority measure aimed at preservation of stream corridor structure and function. The 2004 Watershed Assessment Project (R2 and MBI) identifies riparian planting and addition of large wood as ideal restoration opportunities for this reach. Field reconnaissance also identified opportunities for removal of a natural gas pipeline (Figure 8) and rip rap (Figure 9).

Figure 8. Natural gas pipeline on Kalama 2A

Figure 9. Rip rap along banks of Kalama 2A

3. METHODS: IDENTIFYING POTENTIAL RESTORATION SITES

Much work has already been done to identify and prioritize restoration and recovery opportunities within the Kalama Subbasin. These previous efforts, combined with initiative from landowners interested in salmon recovery, have shaped the original scope of this habitat assessment. This assessment builds upon these prior efforts and provides additional detail necessary to implement recovery actions.

3.1 Previous Efforts

The primary previous efforts upon which this work builds, include the Recovery Plan (LCFRB 2004), the associated Habitat Work Schedule (LCFRB 2008), and the Watershed Assessment Project (R2 2004).

3.1.1 The Recovery Plan

Development of the Recovery Plan was an intensive collaborative effort which spanned several years, integrated technical expertise and analytical approaches across disciplines, and synthesized the best available technical information relevant to salmon recovery. In the interest of brevity and clarity, the depth and complexity of information presented in the Recovery Plan has been greatly simplified here. For a more complete understanding of the process and priorities identified in the Recovery Plan, the reader is encouraged to consult several chapters of the Recovery Plan, all of which are referenced here as LCFRB 2004, including the Regional Plan (Volume I), Kalama Subbasin Chapter (Volume II, Chapter F) and the assessment analyses of EDT and IWA (Appendix E, Chapters 6 and 4 respectively).

A number of analyses were used to identify priority actions and habitat measures in the Recovery Plan, essentially following a three-step process to identify the 1) priority geographic areas; 2) limiting factors; and 3) land-use threats for multiple species. Priority areas and limiting factors were determined based on technical assessments and models, primarily EDT and IWA. Selection of priority areas was also shaped by the relative importance of subbasin focal fish populations in the overall regional recovery objectives. Regional recovery objectives were identified through a collaborative stakeholder process and ultimately based on the recovery criteria outlined by the NOAA Fisheries-convened Technical Recovery Team. Land-use threats were identified based on a compilation of information, including the Washington Conservation Commission Limiting Factors Analyses, IWA, the State 303(d) list, air photo analysis, the Barrier Assessment, expert opinion, or documented cause-effect relationships between stream conditions and land-uses (LCFRB 2004).

3.1.1.1 EDT

The EDT model was an important analysis tool employed in the development of the Recovery Plan. EDT was used to draw linkages between reach-level habitat attributes and fish population performance, thus aiding in identifying which species and which life stages would most likely benefit from restoration and protection actions in specific reaches. EDT is a mechanistic model developed by Mobrand Biometrics, Inc. (MBI) that evaluates 46 reach-level habitat attributes to evaluate survival across all potential life history trajectories, and calculates four population performance parameters (population productivity, capacity, equilibrium abundance, and diversity; LCFRB 2004). The EDT model is one of several tools used to assess fish population performance and fish / habitat interactions in the Recovery Plan. Specifically, the model was used to estimate fish population performance based on characteristics of physical habitat. EDT targeted geographic areas and reach-specific habitat attributes that have been identified as the most limiting for salmonid populations (LCFRB 2004).

Two key EDT analyses are foundational elements of the Recovery Plan: reach analysis, and habitat factor analysis. Reach analysis prioritizes reaches by identifying which reaches are likely to significantly affect fish populations. Habitat factor analysis identifies habitat attributes in each reach that may be modified to produce an effect in that reach. Simply put, reach analysis identifies which reaches are most important for focal populations, and habitat factor analysis identifies habitat parameters most important within a given reach. All EDT analyses employ a comparison between the current (patient) and historical (template) habitat conditions, and also typically model Properly Functioning Condition (PFC) scenarios. Within the Kalama Subbasin, 103 reaches were identified and analyzed within EDT, including the 5 reaches that are a part of this assessment.

EDT reach analysis ranks reaches based on preservation value and restoration potential. Preservation and restoration priorities are in turn based on abundance, productivity, and life-history diversity for each species in each reach. The output of this analysis is the “ladder”, or “tornado” diagrams which identify the most important reaches for each species and identify the relative value of preservation and restoration in that reach. One aspect of the analysis that is important to recognize is that each reach is analyzed independently for restoration and degradation. If a downstream reach is severely degraded or impassable, upstream reaches may show no restoration value, even if a strong potential for restoration exists (LCFRB 2004). While this is an important consideration in decisions regarding project selection and sequencing in general, it should not affect this assessment, because all reaches included in this study are very low in the subbasin, and none are severely degraded or impassable.

EDT habitat factor analysis, or limiting factors analysis, identifies the habitat conditions that are limiting for each life stage of each species within a subbasin. The resulting “habitat impact attribute” charts describe habitat parameters limiting populations across all life stages (LCFRB 2004). The charts include a list of reaches for each species, prioritized for the relative importance to the species. Within this prioritized list of reaches, the habitat attributes most limiting in each reach for each species are identified, and the degree to which the habitat factor is limiting (high, medium, low, or indirect) is displayed. This diagram is often commonly referred to as the “consumer report” diagram, however MBI distinguishes the consumer report diagrams as the more detailed version of this analysis, which evaluates habitat parameters that are limiting for each life stage (these more detailed diagrams are called the “individual consumer reports” in the LCFRB 2008).

3.1.1.2 IWA

The Integrated Watershed Assessment (IWA) identifies watershed processes impacting focal fish populations. It is a GIS-based screening tool that aids in identification and prioritization of actions to address watershed impairments at the subwatershed scale (3,000-12,000 acres, LCFRB 2004). The condition of three key watershed processes are evaluated (riparian conditions, sediment supply, and hydrology (runoff)), using landscape conditions as model inputs (i.e. road density, impervious surfaces, vegetation, soil erodability, and topography). The level of impairment of sediment and hydrology is determined at the local scale (i.e. within subwatersheds, not including upstream drainage area) and watershed scale (i.e. integrating the entire drainage area upstream of each subwatershed).

The entire Kalama River Subbasin was divided into 18 subwatersheds. The tidally influenced Kalama mainstem and tributaries in the lower 2.5 miles of the river all fall within the same IWA subwatershed, identified as subwatershed 40501 in the analysis. This subwatershed is rated as impaired for hydrology at both the local and watershed scales, and is rated moderately impaired for riparian condition and sediment at both the local and watershed scales.

Hydrologic conditions are predicted to be impaired over the next 20 years, due to intense development pressures locally, and current and historic land use practices in upper reaches of the subbasin. Sedimentation is predicted to gradually improve in the lower reaches, due to improved conditions and practices in upper reaches of the subbasin, however this could be offset if development activities in the lower subbasin outstrip predicted levels. Riparian condition is expected to continue to degrade in the lower reaches over the next 20 years, due to the channelization of the river and discontinuous floodplain (LCFRB 2008). The high road densities in the riparian areas of these reaches have resulted in channelization of these reaches disconnected from the floodplain, which exacerbates the already impaired hydrologic conditions.

3.1.2 2008 Habitat Work Schedule

The HWS (LCFRB 2008) is an implementation tool for the Recovery Plan. It is updated as needed (which thus far has been annually) to reflect new information and analyses, and modification to population targets, and priority measures and actions. The HWS provides several tools for ranking projects, including the key priorities identified for the subbasin, the population priorities and viability goals, and summaries of the IWA and EDT analyses. Much of this information is synthesized within the Reach Priorities and Potential Restoration Activities Table, which is a component of the HWS.

The 2008 HWS does not reveal any modifications to population performance targets, however some changes were made since the 2007 HWS in the limiting factors by life stage, and in reach description and tier designations. New EDT analyses were conducted in 2007, largely because full EDT analyses had not been previously conducted for Lower Columbia River coho, which were not listed at the time the original Recovery Plan was finalized. New EDT analyses were conducted over the revised reaches at that time.

3.1.3 Summary of Limiting Factors and Priority Actions

The Recovery Plan broadly describes the most significant limiting factors affecting the Kalama Subbasin: habitat connectivity, habitat diversity, riparian function, floodplain function, stream flow, and substrate and sediment (LCFRB 2004). The predominant threats in the lower 2.5 miles of the Kalama River are agricultural and rural development, and forest practices (LCFRB 2004). The HWS (LCFRB 2008) identifies the most current understanding of the primary limiting factors by life stage (Table 4).

Table 4. Summary of Primary Limiting Factors for the Life Stages of Focal Salmonid, as derived from Habitat Factor Analysis (reproduced from LCFRB 2008)

Species and Lifestage		*Primary factors*	*Secondary factors*	*Tertiary factors*
Kalama Fall Chinook				
most critical	Egg incubation	sediment	channel stability	temperature, harassment
second	Prespawning holding	key habitat, habitat diversity	temperature, harassment, predation, flow	
third	Fry colonization	habitat diversity	channel stability, flow, predation, sediment, key habitat	
Kalama Spring Chinook				
most critical	Egg incubation	sediment	channel stability	
second	Prespawning holding	key habitat	habitat diversity, flow	
third	Spawning	habitat diversity	temperature	
Kalama Chum				
most critical	Egg incubation	channel stability, sediment	temperature	flow
second	Prespawning holding	flow	habitat diversity, temperature	pathogens, harassment, key habitat
third	Fry colonization	habitat diversity, sediment	flow	food
Kalama Coho				
most critical	0-age winter rearing	habitat diversity	key habitat, flow	channel stability
second	Egg incubation	channel stability, sediment		
third	0-age summer rearing	habitat diversity	key habitat, competition (hatchery)	channel stability, predation, pathogens, temperature
Kalama Summer Steelhead				
most critical	Egg incubation	sediment	channel stability	
second	0,1-age winter rearing	flow, habitat diversity	channel stability	
third	0-age summer rearing	habitat diversity	flow, competition (hatchery)	
Kalama Winter Steelhead				
most critical	Egg incubation	sediment	channel stability, temperature	
second	0,1-age winter rearing	flow, habitat diversity	channel stability, sediment	
third	0-age summer rearing	habitat diversity	flow, competition (hatchery), predation, pathogens	

The Recovery Plan also lists key priorities, priority measures and habitat actions designed to provide guidance on essential steps to recover focal species. The key priorities identified in the HWS (2008) reflect the most immediate needs for multi-species recovery in the subbasin and provide overarching goals for recovery efforts:

1. Manage forest lands to restore watershed processes;
2. Manage growth and development to protect watershed processes and habitat conditions;
3. Restore passage at culverts and other artificial barriers;
4. Align hatchery priorities with conservation objectives;
5. Manage fishery impacts so they do not impede progress toward recovery; and
6. Reduce out-of-subbasin impacts so that the benefits of in-basin actions can be realized.

Prioritized measures, or habitat measures, while still broad, are more specific descriptions of steps necessary for recovery in the subbasin. Prioritized measures are derived from the EDT and IWA analyses and based solely on biological and physical conditions. The HWS (LCFRB 2008) identifies the following prioritized measures for the Kalama Subbasin in rank order:

1. Protect stream corridor structure and function;
2. Protect hillslope processes;
3. Restore degraded hillslope processes on forest, agriculture, and developed lands;
4. Restore riparian conditions throughout the basin;
5. Restore access to habitat blocked by artificial barriers;
6. Restore floodplain function and channel migration processes in the mainstem and major tributaries;
7. Restore channel structure and stability;
8. Provide for adequate instream flows during critical periods;
9. Restore degraded water quality; and
10. Create/restore off-channel and side-channel habitat.

Habitat actions are also considered essential to salmonid recovery however they take into account existing conservation and recovery programs and not just biophysical parameters. The habitat actions are derived from the prioritized measures and provide still greater specificity. Sixteen habitat actions are included in the Recovery Plan which identify the prioritized measure addressed, the responsible party, spatial extent of the target area, the expected biophysical response, and the certainty of the outcome.

3.1.4 LCFRB Watershed Assessment Project, Phase 2

Phase 2 of the LCFRB Watershed Assessment Project was conducted by R2 and S.P. Cramer and Associates and was aimed at collecting field data on stream habitat conditions, riparian conditions, sediment sources, and hydromodifications within priority reaches of the Lower Columbia Subbasin (R2 2004). This information was intended to aid in identification and prioritization of recovery projects and to verify EDT and IWA model results.

R2 and MBI (2004, p. 2-41) identified the following habitat limitations over the entire subbasin:

- "*The area where natural geomorphic processes can occur has been reduced by approximately 84 percent in the lower 10 miles of the Kalama River.*
- *Forest cover represented only 10 percent of the current generalized floodplain area, and forests consisted of sparse to medium stocked stands of mixed forest.*
- *Within the lower 10 miles of river, the current length of channel margins was estimated to be reduced by 5 percent from pre-settlement conditions, due to the loss of two major side channels.*
- *Sixty-six percent of the total bank length in the lowermost 10 miles has been armored or bordered by levees.*
- *The Kalama River has been fixed in place by levees and armored banks. As a result depositional sediments formerly distributed across a wide area north and south of the river have been concentrated at the mouth of the river.*

- *The overall LW recruitment potential of riparian stands in the Kalama basin is relatively poor due to small size of riparian trees and human encroachment in the riparian zone.*
- *Riparian disturbance ranged from 36 to 60 percent of the habitats surveyed. The greatest frequency of disturbance types included urbanization and roads.*
- *Substrates required for salmonid spawning and incubation appears to be limited in the Kalama Basin. Embeddedness ratings were high in the lower river and several mainstem tributaries.*
- *The culvert at Kalama River Road in Summers Creek appears to be a fish passage barrier."*

Phase 2 of the Watershed Assessment also presented a prioritized list of protection/restoration opportunities across the subbasin, some of which were also identified in the current assessment of the lower 2.5 miles of the river.

3.2 Current Assessment

Fine-scale knowledge is necessary to identify specific restoration opportunities on the ground, assess feasibility, prioritize potential projects and develop engineering designs. To that end, field studies were undertaken in the lower 2.5 miles of the mainstem Kalama River and associated tributaries. In order to prioritize and select the best projects for implementation, the work group was involved and the project scoring methodology developed by the LCFRB was followed. The most promising projects were identified for groundwater and surface water monitoring and analysis. Projects were reevaluated after monitoring data were obtained, and the top scoring projects were selected for development of conceptual engineering designs.

Fine-scale data collection associated with this project included topographical, surface and groundwater water flow, and channel geomorphology data. Fish use observed during data collection efforts was also documented. Prioritization of projects followed the scoring approach developed by the LCFRB Technical Advisory Committee (TAC). Conceptual designs developed for top ranking projects followed accepted practices promoted by WDFW and drew upon consultant experience from 48 similar projects within Washington State.

This project follows basic principles of ecosystem restoration put forth by NRC (1992) and Roni et al. (2002) and summarized in the HWS (LCFRB 2008):

1. Protect existing functional habitats and the processes that sustain them;
2. Allow no further degradation of habitat or supporting processes;
3. Reconnect isolated habitat;
4. Restore watershed processes and ecosystem function;
5. Restore habitat structure; and Create new habitat where it is not recoverable.

Given that the objectives and funds of this project are not aimed at land purchase for preservation, this project emphasizes restoration of degraded habitats and processes and creation of new habitat, specifically off-channel habitat. In seeking to identify suitable sites for restoration activities, potential projects were sought that will work with natural processes and be self-sustaining and or restore a lost habitat floodplain function. Targeted sites should be maintained by natural processes, or are remediating natural processes that were curtailed by human development and modification. For example, the presence of groundwater is critical for the success of off-channel habitat creation projects. In addition to the physical parameters necessary to evaluate project feasibility, the project site must also meet logistical viability, such as landowner willingness and project expense.

3.2.1 Field Reconnaissance

Prior to actual fieldwork, initial assessment involved examination of aerial photographs and USGS quadrangle maps, looking for geologic conditions that would lend themselves to hyporheic upwelling, multiple river channels, oxbows, wall-base channels, abandoned gravel pits, and areas of shallow groundwater. Field surveys sought to identify groundwater sources, gravel river banks (which suggest porous floodplains), flood swales, elevation changes that could provide head for flow, levees and roads that disconnect the floodplain, and existing side channels.

Initial reconnaissance of potential restoration sites was conducted by a river float in August 2007 followed by an October 2007 walking field visit to areas identified as having potential on the float or from aerial photos. Reconnaissance efforts were aimed at identifying restoration opportunities and constraints. The area floated stretched from RM 2.8, just below the fish trap and extended down to the shallow delta at the mouth of the Kalama River. Work group members participated in the reconnaissance, including biologists, engineers, and geomorphologists from the LCFEG, Waterfall Engineering, LCFRB, WDFW, and private landowners. The reach descriptions provided in Section 2.2 are based on this reconnaissance effort and subsequent surveying on the ground. A memo to the work group summarizing the October field visit is included in Appendix C.

3.2.2 Potential Project List

Based on review of the Recovery Plan (LCFRB 2004), field reconnaissance described in section 3.2.1, and aerial photos, an initial project list was developed. The list was modified to incorporate comments from work group members and monitoring data, resulting in the Potential Project List (Table 5). Project vicinity maps and locations on aerial photos are shown in Appendix A. Restoration type refers to the multi-species project benefits categories identified in the LCFRB's HWS (2008) and used in the LCFRB project scoring methodology.

Projects were not selected based solely on their rank order, but on a combination of factors. The two projects with the highest rank score were included. However two of the projects, KRR 0.7 and SC 0.5, were not among the top four projects. A large reason for the inclusion of both of these projects was strong landowner support. In the case of SC 0.5, the project is in close proximity to the top-ranked project being developed at the 30% level, and the land is owned by the same individual. In the case of KRR 0.7, Phase 1 has already been funded and is slated for implementation in 2009. Finally, greater uncertainty is associated with some of the other, higher ranking projects which may be due to uncertain landowner support, or a lack of field data to assess project viability.

Table 5. Potential Project List.

Project RM[4]	Restoration Type	Description and Notes
KRL 0.0	Access to blocked habitat	Address low water fish passage concerns at the river mouth's tidal flat.
KRL 0.1	Off-channel/side-channel habitat	Extend and enhance tidal and backwater channels on Port of Kalama property. The Port has documented juvenile salmonid usage in these channels. Four years of quarterly monitoring data are available, including water levels, vegetation, salmonid usage, and presence of freshwater clams. Amphibian usage has also been observed.
KRR 0.7	Off-channel/side-channel habitat	Enhance and Create off-channel habitat on WDFW land upstream of the boat ramp. Water source will be tidal and groundwater. There is a potential for Chum spawning in the upper portions of this channel.
KRL 1.4	Off-channel/side-channel habitat	Excavate groundwater fed channel along base of bluff. Elevation change present here, providing head for groundwater flow. Possibly suitable for chum salmon spawning.
KRR1.8	Off-channel/side-channel habitat	An active side channel was observed during field reconnaissance, but additional data collection would be necessary to evaluate potential for off-channel habitat enhancement.
SC 0.5	Riparian restoration	Restore riparian conditions along Spencer Creek, at the base of steep slope with seeps. Remove noxious weeds, plant native species with good shade potential, and add LWD. This area currently serves as juvenile salmonid refuge, but lacks wood.
SC 1.8	Access to blocked habitat	Replace culvert at county road.
KRR 2.1	Off-channel/side-channel habitat.	Excavate off-channel habitat on Port of Kalama and private property. Water source would be groundwater. Landowner willingness is unknown.
KRR 2.2	Off-channel/side-channel habitat	Excavate off-channel habitat on Port of Kalama property. Water source would be groundwater and surface water from tributary in the winter months.

[4] KR refers to Kalama River (an additional L or R denotes the left or right bank); SC refers to Spencer Creek. Enumeration of RM traditionally begins from the river's mouth and increases as one goes upstream. However, notation of right and left bank refers to the bank one would see it as looking or floating downstream.

KRL 2.2	Stream channel habitat structure and bank stability.	Remove unused Olympic Gas Pipeline and add LWD on Port of Kalama property. LWD would include 3-4 small engineered logjams. Pipeline is visible at low flows and affects channel morphology
KRR 2.4	Stream channel habitat structure and bank stability.	Remove riprap and excavate to reconnect active side channel. Removing riprap could require mitigation with existing homes and properties downstream. The riprap was placed in the 1970s as an agricultural initiative.
KRL 2.5	Off-channel/side-channel habitat	Excavate off-channel habitat on private property. Water source would be groundwater. Landowner Julius Ledgett is willing and participating in work group. Old city pump house in vicinity was built 30 years ago and could possibly supplement GW channel, however could also contribute to sedimentation. Pump tests were completed on this site and confirmed presence of groundwater (see Appendix D). The city has done some prior studies on GW response to river levels for the Ranney well system.

3.2.3 Monitoring Surface and Groundwater at Potential Project Sites

Understanding the interaction between groundwater and surface water is important to the assessment and development of off-channel habitat. This section summarizes the results of the groundwater, surface water and water temperature data which were collected from October 10, 2007 to November 11, 2008. A total of 17 different monitoring sites were established along the lower 2.8 miles of the Kalama River to track surface water elevations, groundwater elevations and water temperature. The water elevation and temperature data are presented in Appendix B; groundwater pump tests results are in Appendix D.

The Stream Habitat Restoration Guidelines (Saldi-Caromile 2004) identify data collection needs for various types of off-channel habitat, from wall-based rearing areas for juvenile Coho to percolation-fed channels for adult chum salmon spawning. Groundwater and surface water were monitored in the vicinity of the most promising restoration opportunities. The type of data collected can be grouped into the following categories:

- Water flow (Kalama River, Spencer Creek, other surface runoff channels)
- Water elevation (River, Creek, Pond, Groundwater)
- Water temperature (Surface and groundwater)
- Groundwater flow potential (as measured from pump tests)
- Local rainfall amounts

Data were collected over a range of hydrologic conditions to understand the interaction and potential benefit to different life stages of salmonids. For each location a bench mark was established and related to the overall survey based on NGVD datum supplied by the Port of Kalama. Water levels were measured to the nearest tenths of a foot. Because the data were collected over a short period of time (less than two years), local weather conditions were also monitored to provide for some comparison to a normal condition (rainfall).

3.2.3.1 Monitoring Results: Water Elevation Data

The monitoring data (Appendix B) provide important information for developing concepts for off-channel design and can be used for the development of any future off channel projects in the Lower Kalama River. Once a site survey has been completed, the elevations can be compared to the river, pond, and groundwater elevations to determine a specific design elevation for that site.

The water elevations of the Kalama River relative to the flow in the river, is one useful component of this monitoring; six monitoring stations were established along the banks of the river. Some of the monitoring stations placed along the river reveal little influence of tidal fluctuations, whereas other stations have significant tidal influences at certain times of the year. In areas perennially outside of tidal influence, the water surface elevation shows a tight correlation with river flow. Areas within the tidal influence show much greater variation in water surface elevation relative to flow. In these areas, the fluctuation in water surface elevation is apparent twice daily when the Columbia River is low, but fluctuation is greatly reduced in the late spring and early summer when the Columbia River is high. In the tidal areas, the backwater provides good opportunities for fish to access off-channel habitat. When the Columbia River is high there is good access and when the river is low the tidal action provides access. The tidal action also provides groundwater recharge which could provide good spawning habitat for chum salmon if low swales were excavated and gravel added. For projects within RM 2.0 to RM 2.5, the Kalama River water surface varies from elevation 12 to 16 feet, at the recommended project design flows of 250 and 4000 cfs.

Groundwater elevations are also important in evaluating potential project viability and in developing concepts for off-channel habitat projects. Groundwater elevations were collected at two existing wells and at four excavated test pits (Appendix D). Groundwater pump tests conducted in isolated test pits revealed that groundwater elevations in the study area vary 2.5 to 3 feet between winter and summer. An exception is the tidally-influenced area near the mouth of the Kalama River (RM 0.7). In this area, groundwater elevation may vary as much as 6 feet due to backwater from the Columbia River and tidal fluctuations. Outside of the area if tidal influence, groundwater elevations are at the highest in January and at the lowest in August and September. In tidal areas (RM 0.0 to RM 1.6), groundwater elevations are highest in late May and early June. Development of off-channel projects should be excavated to a level which corresponds to the late spring or low summer flow levels to ensure year round flow (unless juvenile overwintering is a specific project goal). Collected data suggest that the high groundwater elevations found in the vicinity of Project KRR 2.5 provide a good opportunity for creating off-channel habitat.

Six monitoring stations were established to evaluate the water surface elevation of ponds. This information was then compared to groundwater elevations to identify the degree to which the ponds are recharged by groundwater or surface water. Most of the ponds have a surface water connection which gives them a higher water elevation in winter relative to groundwater. The pond located near the Bonneville Power Administration (BPA) transfer station had a water elevation that varied by seven feet over the 1-year monitoring period. There doesn't appear to be any surface connection to this pond, so it is likely that the local groundwater charges the system. Kress Lake levels are similar to this pond, but it is fed by a surface water stream in the winter months. In contrast to the BPA pond, a pond on the Ledgett property only varied 3 feet over the monitoring period.

3.2.3.2 Monitoring Results: Water Temperature Data

Water temperatures are critical to the growth and survival of juvenile salmon. Ideal rearing temperatures for juvenile coho range from 54 to 57° F. Growth often stops at 68° F and temperatures in excess of 77° F are lethal.

A common trend in low lying western Washington rivers is cool water temperatures in the winter, a gradual warming in the spring and warming water temperatures in the summer. This is true for the Kalama River. Data collected at Lower Kalama monitoring stations shows water temperature in the winter is all within the 40° to 45° F range for most of the monitoring sites. The Kalama River and groundwater sources remain low, between 45 to 50° F in May, while the Columbia River and large open ponds warm to 70 to 75°F. In spring, groundwater sources tend to be 3 to 5° warmer than the Kalama River. Towards the end of the summer this trend reverses and the Kalama River is 3 to 4° warmer than the groundwater. Water temperatures in the Kalama River for the monitoring period never got over 58°F, which is ideal for juvenile coho growth and rearing.

In the open ponds, the temperatures ranged from 40 to 45° in the winter to over 70° in the summer, with one exception: one pond on the Ledgett property remained cooler in May and June. The intent of collecting these data was to explore the options of connecting existing open ponds to the Kalama River so fish have access. For a successful project, the connection needs to intercept groundwater and be constructed in a manner such that riparian vegetation can shade the open water. The project objective would be to lower the pond level, initiate groundwater flow and therefore reduce the water temperatures.

3.2.3.3 Monitoring Results: Groundwater Pump Tests

Groundwater pump tests were completed at two of the monitoring sites over a two day period from April 3rd to 4th, 2008, to assess groundwater elevation, flow potential, substrate and water quality (Appendix D). The Kalama River flow was 1100 cfs. Water quality samples for dissolved oxygen and dissolved iron, were collected at three sites.

The drawdown index is one parameter measured in a pump test that is useful for evaluating project viability and design options. The drawdown index is a measure of the rate of drawdown compared to the recharge rate. In general a drawdown index of 1.0 or higher is very good, 1.0 to 0.5 is good and below 0.5 typically means there is a lack of groundwater flow potential to create a high quality spawning habitat. Sites where the drawdown index is less than 0.5 are typically developed as off-channel rearing habitats, due to the lack of flow which is often needed to attract adult fish for spawning.

A test pit was conducted at the location for the critical water supply to the proposed Ledgett Groundwater Channel. The pump test results are marginal in terms of creating a formal groundwater-fed spawning channel. It is recommended this site be developed mainly as a groundwater-fed, off-channel rearing area with the potential for adult spawning. Adult spawning would require an expensive import of spawning gravel. Detailed results for both pump tests are included in Appendix D.

3.2.4 Prioritizing Potential Restoration Projects

A scoring spreadsheet was developed to aid in evaluating projects' benefits to fish, certainty of success and ultimately to prioritize the project list. The scoring spreadsheet provides structure to the ranking process, minimizes personal bias of individuals scoring the projects, and documents the process. The LCFRB TAC scoring spreadsheet was used as a starting point, as adapted by Tetra Tech for a habitat restoration siting and design assessment project in the Lower Cowlitz River (Tetra Tech 2007). The scoring spreadsheet draws heavily on the data within the Subbasin Reach Priorities and Potential Restoration Activities Table within the HWS (LCFRB 2008). This table integrates information from EDT and IWA analyses and identifies the greatest restoration priorities across multiple species within each reach. One modification was made to the TAC/Tetra Tech scoring spreadsheet, per guidance from LCFRB: the Reach/Population Rating was elevated for reaches providing estuary rearing and migration benefits to stocks spawning in other subbasins. For example a Tier 4 reach with estuary benefits would be elevated from a Low to a Moderate Reach/Population Rating. All tidally influenced reaches were considered to offer estuary benefits. The estuary management action addressed by the project is noted in the Comments column of the spreadsheet. Management actions and threats are identified within the *Columbia River Estuary Recovery Plan Module* (LCREP 2007).

The scoring approach used by the LCFRB TAC equally weights the benefits to fish and the certainty of success. While many information gaps do exist relative to the recovery needs for these species, the benefits to fish score is more objective, incorporating physical data collected in the field from spawner surveys, smolt traps, habitat surveys, catch counts, as well as modeled data and predicted future population conditions. These parameters and their significance are described in great detail in the HWS and the Recovery Plan and include:

- Stream reach (and tier ranking);
- Importance of the reach to the population;
- Importance of the population to overall recovery of the species in the ESU;
- Number of listed salmonid species present,
- Restoration activity type (e.g. recovery measure) which determines the value of that activity in contributing to multi-species benefits in that reach;
- Area of habitat a restored by the project; and
- Anticipated effectiveness of the project in achieving restoration goals.

Per LCFRB Evaluation Criteria, the Lower Kalama Subbasin projects were initially grouped by their Benefit to Fish Rating (largely driven by the reach's tier rating) and then ranked within these groups by their Benefit to Fish score (Table 6). The complete scoring spreadsheet and ranked list are included in Appendix E.

Table 6. Ranked project list based on benefits to fish.

	Project	Overall Benefit to Fish		Certainty	RANK
ID	Description	Rating	Score	Rating	
KRL 2.5	Ledgett Groundwater Channel	H	47.00	H	**1**
KRR 2.2	Port of Kalama Groundwater Channel	H	43.40	H	**2**
KRR 2.1	GW Channel System (private)	H	42.80	M	**3**
KRR 2.4	Riprap Removal/Floodplain Reconnection	H	29.00	H	**4**
KRL 2.2	Pipeline Removal and LWD	H	29.00	M	**5**
KRR 0.7	WDFW Tidal and Groundwater Channels	M	33.40	H	**6**
KRL 0.0	Low Water Fish Passage	M	32.00	L	**7**
KRL 1.4	Groundwater Channel	M	29.80	M	**8**
KRR 1.8	Active Side Channel	M	23.96	L	**9**
KRL 0.1	Port Tidal and Backwater Channels	M	23.95	M	**10**
SC 0.5	Spencer Creek Riparian and LWD	M	17.44	M	**11**
SC 1.8	Fish Passage Culvert	L	7.90	H	**12**

The certainty rating aims to ascertain the degree to which a project will achieve stated goals and incorporates more subjective factors, such as "reasonable" cost, degree of community support, qualifications of sponsor, etc. Certainty factors are extremely important in weighing alternative projects, however it is difficult to develop a meaningful assessment of certainty before projects are more thoroughly scoped. Within this assessment, certainty scores are therefore qualitative (high, medium, low) and primarily address the project's ability to meet the stated goal based on technical considerations and landowner support where known; additional information on the factors affecting the certainty score are included within the scoring spreadsheet. It is important to note that the certainty rating may be low simply because information is lacking. This relative ranking should only be considered within the context of other projects in the Lower Kalama assessment. Other certainty parameters considered by the TAC include:

- Appropriateness of technical approach;
    - Project addresses causes of degraded habitat, not symptoms;
    - Approach is tried and proven;
    - Qualifications and experience of sponsor;
    - Monitoring and maintenance is included;
- Landowner willingness and community support;
- Coordination with other habitat restoration projects within the watershed;
    - Addresses priority processes and limiting factors identified in the LCFRB;
    - Project is logically sequenced with existing and planned efforts;
- Degree of uncertainty and constraints;
    - Including technical, legal, policy, funding, and permitting considerations;
- Estimated preliminary costs.

The initial scores for benefits to fish and certainty were developed by representatives from Waterfall Engineering, Ecolution, and LCFEG, with input on use of the scoring spreadsheet from LCFRB. These preliminary scores were presented to the work group with an explanation of the assumptions made about each project when scoring. The work group provided additional feedback on the scoring process. Assumptions and considerations affecting scoring for each project are included in the scoring spreadsheet (Appendix E).

4. CONCEPTUAL DESIGNS AND PRELIMINARY COST ESTIMATES

One project was selected for development of engineering designs to a 30%-completion level:

- KRL 2.5, Ledgett Groundwater Channel.

Three projects were selected for a more simplified "conceptual design":

- KRR 2.2, Port of Kalama Groundwater Channel;
- KRR 0.7, WDFW Tidal and Groundwater Channel; and
- SC 0.5, Spencer Creek Riparian Restoration and Large Woody Debris.

Designs and costs for these projects are included in Appendix G. Engineering designs followed accepted practices for the development of off channel habitat. From 1991 to 1999 WDFW designed and constructed over 70 off channel restoration projects in the Skagit, Stillaguamish, Hoh, Clearwater and Bogachiel River Basins. Some of this work and other design guidance can be found in Saldi-Caromile (2004), Slaney and Zaldokas (1997) and Powers (1993).

Conceptual level costs were developed for each of the four projects. Costs were developed from two sources: RSMeans (2006) and experience by the designer. RSMeans is a common manual used for estimating heavy construction, but many of the items, such as cubic yards of material excavated to create a groundwater channel or construction of large woody debris, are not covered in the manual. Total project costs were developed assuming a typical public works construction project. Obviously, with many stream restoration projects cost efficiencies can be found by using volunteer works groups, donated materials, etc. Specific assumptions underlying the cost estimates are noted within the estimates. Quantities were estimated from site surveys, measurements from CAD drawings and scaling from 2006 aerial photography and LiDAR files. These costs should be used for planning and budgeting purposes only, and should be revised as the designs become more complete, prior to construction contracting.

4.1 30% Design

4.1.1 Ledgett Groundwater Channel, KRL2.5

This project utilizes existing ponds and swales within the project site in combination with groundwater sources to create 10,400 square meters of year round rearing habitat with a potential for some spawning habitat. The channel length would be 2500 feet, with Pond 1 expanded to create an additional 2 acres of off channel rearing habitat (Appendix G, Section 1.0). In addition, the project will supply groundwater to existing downstream rearing habitats at the mouth of Spencer Creek. The project excavation amounts and depth were determined from the extensive groundwater monitoring (see Appendix B).

The key to this project is a connection to the groundwater sources identified from the monitoring near the upper end of the project (Test Pit 1 and Well Monitoring Station 2). Two layouts are presented to achieve this. The final layout needs to be decided with the landowner. Layout 2 creates more pond habitat and would be isolated more from overbank flooding. Layout 2 requires more excavation and some spoils will likely need to be removed from the site.

The project construction cost is estimated at $528,000. The project could be broken down in phases to reduce the overall cost. The first phase should include a connection to the groundwater sources. A constant groundwater source (that increases as the river stage increases) will create a sediment wedge near the channel outlet and keep fine sediment from moving upstream into the project area.

4.2 Conceptual Designs

4.2.1 KRR 2.2, Port of Kalama Groundwater Channel

This project (Appendix G, Section 2.0) is broken down into three phases because of the cost and floodplain issues to be resolved.

Phase 1 is fairly straight forward and would extend and deepen an existing swale along the right bank floodplain. The length would be 500 ft with an estimated construction cost of $104,000 and would create 650 square meters of off channel rearing habitat. It would also provide flow through the summer into an existing active side channel which goes dry. Test Pit 3 is located within this swale.

Phase 2 would extend the channel across the open field owned by the Port of Kalama to a location up to the Kalama River Road. Phase 2 would create an additional 1100 square meters of off channel habitat. The estimated construction cost is $364,000. Long-term channel viability and flooding need to be resolved at this location. Currently flood waters from upstream overtop the right bank and flow overland crossing into the proposed channel area. It is recommended that a floodway remain open for this water and that the alignment be revised based on a floodway analysis and project future use of the Port of Kalama field area. This overland flow impacts landowners upstream.

Phase 3 will add an additional 1400 square meters of habitat with a construction cost of $530,000 (the higher cost is due to the culvert installation under the Kalama River Road).

This project is located in the right bank floodplain of the Kalama River. Only the lower portion is within the 100 year floodplain (see Appendix G, Section 2.0, Sheet 2 of 3-Site Plan). The design proposes to excavate (in three phases) a 3700 foot long groundwater fed channel. The first Phase would be 500 feet long. The channel would outlet into an existing active side channel of the Kalama River on the right bank at RM 2.2. The upper end would be the end of an existing swale. Phase 2 would extend from Phase 1, to just downstream of the Kalama River Road (Test Pit 2 location). Phase 3 would be implemented after one season of flow and temperature monitoring of Phase 1 and 2, and would require excavation or boring of a culvert under the Kalama River Road. The channel would then extend to connect with the pond near the BPA substation and extend further upstream to connect a portion of the surface fed stream. A flow splitter would be required to maintain a portion of the flow to Kress Lake. The stream only flows in the winter and would provide pulses of clean water to the entire channel for fish attraction. The channel width would vary from 8 to 10 feet. Excavation depth varies from 7 to 11 feet. The excavation depth was determined based on groundwater monitoring. The channel slope is 0.13%, and the depth will be controlled by installing a series of plank weirs. Spawning gravel may be added in some sections. Phase 1 excavation is 4000 cubic yards, Phase 2 is 18,000 cubic yards and Phase 3 is 14,000 cubic yards. Material from the excavation will either be spoiled on site or hauled to an appropriate spoil location. Spoiling material on site in strategic locations may provide some additional flood protection. Once excavated the channel cross section will consist of a 1:1 slope rock toe 3 feet high (to protect groundwater source), and slopes cut back 2:1 and revegetated with a mixture of riparian plants and trees.

4.2.2 KRR 0.7, WDFW Tidal and Groundwater Channel

The project will create 2400 square meters of off channel habitat and the estimated construction cost is $350,000 (Appendix G, Section 3.0).

Located at RM 0.7, this project will create off channel habitat by excavating within the existing right bank floodplain existing low points and swales (see attached drawings). Two phases are proposed. Phase 1 is an extension of an existing side channel which has documented fish use and groundwater flow, and Phase 2 would allow fish to access a larger portion of the floodplain by cutting a channel through the WDFW access road (either open cut or culvert). Groundwater, substrate and water quality tests were done in support on this project (Appendix D). The Phase 1 project length is 800 feet with a cut depth of 2 to 4 feet. Pools will be excavated within the channel and LWD placed for habitat structure. There will be some rock lining of the channel and some spawning gravel placement. The channel width will vary from 6 to 10 feet. Total excavation for Phase 1 is 3500 cubic yards. Phase 1 has already been funded by the SRFB and is slated for implementation. Phase 2 is 2300 feet long and has a potential to provide spawning for chum salmon. The upper ends of this phase (where groundwater has been documented) will be over excavated and backfilled with spawning gravel. Phase 2 excavation is 9000 cubic yards. The water level in both channels will be controlled by tidal changes from the Columbia River, and by high Columbia River water levels in the late spring and early summer months.

4.2.3 SC 0.5, Spencer Creek Riparian Restoration and Large Woody Debris

The project will restore 4.6 acres of riparian habitat and 800 square meters of spawning and rearing habitat for an estimated construction cost of $78,000 (Appendix G, Section 4.0).

Spencer Creek enters the Kalama River at RM 1.8 on the left bank. Upstream 0.5 miles Spencer Creek flows through an open field. The channel is void of any habitat features, LWD and is dominated by reed canary grass. This area has been identified by water level and temperature monitoring as a viable location for rearing and potential spawning. This project proposes to restore 4.3 acres of pasture land to a forest canopy dominated by firs and cedars. In combination with the riparian planting, five rearing pools will be excavated and LWD installed for habitat. Immediately upstream of each pool, large wood will be installed to prevent channel incision.

4.3 Summary of Preliminary Cost Estimates

Table 7 summarizes the preliminary cost estimates across all four projects for which conceptual designs were generated. Most of the projects have phased approaches; costs are detailed in Appendix G.

Table 7. Summary of Preliminary Costs for Selected Projects

Project ID	*Description*	*Preliminary Construction Cost Estimate*
KRL 2.5	Ledgett GW Channel	$634,000 to $777,000
KRR 2.2	Port of Kalama GW Channel System (3 Phases)	$1,200,000
KRR 0.7	WDFW Tidal and Groundwater Channel (2 Phases)	$350,000
SC 0.5	Spencer Creek Riparian and LWD	$78,000

5. CONCLUSIONS AND RECOMMENDATIONS

This assessment of potential restoration projects identified the majority of off-channel habitat restoration opportunities within the lower 2.5 miles of the Lower Kalama River and ranked these projects in order of priority. While off-channel habitat creation was the focus of this assessment, fish passage barriers, floodplain connectivity, and bank stability projects were also considered. Engineering conceptual designs and preliminary costs estimates were developed for top ranked projects. Because this assessment evaluated only a portion of the subbasin, additional high priority projects may also exist in higher reaches of the subbasin.

Currently, engineering designs have been developed at a 30% design level for one project (Groundwater Channel, KRL 2.5). This project is the best candidate for immediate implementation: field monitoring has verified sufficient groundwater for a successful project, and the project has some landowner support.

The remaining projects with engineering designs have only been developed conceptually, meaning that the designs are not as complete. Further consideration should be given to these projects to adequately assess implementation costs, certainty and relative priority once these projects have been scoped more thoroughly. Of these, the Tidal and Groundwater Channel project on WDFW ownership (KRR 0.7) is a strong candidate for implementation. Field monitoring has confirmed adequate groundwater for a successful project and strong owner and local support exist for the project to move forward. Project SC 0.5 (Spencer Creek Riparian Restoration and LWD) is in close proximity to the mainstem KRL 2.5 project referenced above. It lies on the same property as the KRL 2.5 project and also has the some landowner support, and it would be a good pair to the Project KRL 2.5. Phase 1 of Project KRR 2.2, Ground Water Channel on Port of Kalama property is also a strong candidate for implementation and could be pursued in partnership with the Port. Flooding from the Kalama River upstream has been identified as a critical issue which needs to be understood before Phase 2 of this project can be implemented.

Remaining projects on the list for which engineering concepts have not been designed may still be attractive projects, however they would require further investigation, which might include additional field reconnaissance, monitoring, landowner contact, and other measures to ascertain factors contributing to a high certainty of success and costs that are reasonable for the benefit.

Project KRR2.1 appears to have good opportunities, and should be further investigated. In some of these cases, the current certainty rating is low, simply because information is lacking to determine the likelihood of success, or degree of landowner interest.

These projects address habitat diversity, habitat connectivity, riparian function, and floodplain function, all of which have been identified as limiting factors in the subbasin. This will result in improved pre-spawning holding, spawning, fry colonization, 0-age summer rearing , and 0, 1-age winter rearing. Implementation of these projects will add critical salmon habitat vital for recovery of the local populations of winter and summer steelhead, spring and fall Chinook, coho and chum, and will also contribute to stocks from other subbasins that utilize the estuary habitat of the Kalama Subbasin for rearing and refuge.

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