Kalama, Washougal and Lewis River Habitat Assessments

Chapter 2: The Kalama River Basin

Prepared for:

Lower Columbia Fish Recovery Board
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In association with:

Mobrand Biometrics, Inc.

December 2004

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2. CHAPTER 2 – THE KALAMA RIVER BASIN

2.1 BASIN SPECIFIC METHODOLOGY

The available information to complete the watershed assessments varied among the targeted river basin, as did the current conditions assessed through field and remote techniques. As such, the methods used were adjusted to match the conditions for each river basin. This section describes all necessary deviations, additions, or deletions to the general methods described in Chapter 1.

2.1.1 Hydromodifications

The hydromodifications analysis area for the Kalama River consisted of low gradient alluvial and semi-alluvial reaches located at the downstream end of the basin (RM 0.0 to RM 10.5). The analysis area included previously delineated reaches for the Ecosystem Diagnosis and Treatment (EDT) model, EDT Reaches 1 through 5. Hydromodifications field surveys were conducted from September 13-17, 2004.

Generalized Floodplain

The first step in mapping hydromodifications was to identify the lateral extent of the analysis area and map the historic and current channel margins. The Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) protocol called for delineation of the *generalized floodplain* (Washington Department of Fish and Wildlife [WDFW] 2001). The generalized floodplain represented the area that, in the absence of hydromodifications, would have been affected by fluvial geomorphic processes. For this analysis, the historic extent of the generalized flood plain was estimated by identifying areas occupied by the Kalama River channel over the past 150 years, or areas likely to have been inundated during large floods.

Historic information on channel condition and configuration for the Kalama River consisted of cadastral survey maps dating from 1857 (Allied Vaughn, 2000) and 1942 aerial photographs from the United States Army Corps of Engineers (USACE) (USACE 1944). The 1857 cadastral survey map, while providing useful information on gross changes in channel location and pattern between 1857 and 1942, was not sufficiently detailed to represent historic channel margins and off-channel habitats. Historic channel margins, former channel locations and off-channel habitats, therefore, were delineated on mylar overlays of the 1942 USACE photos. The mylar overlays were scanned and geo-referenced to current digital raster graphics (DRGs) of United States Geological Survey (USGS) 1:24,000 scale 7.5-minute Kalama and Woolford Creek quadrangles based on a series of horizontal control points identifiable on both the DRGs and historic aerial photos. A geographic information system (GIS) layer of historic channel margins was delineated from the geo-referenced overlays using ArcView.

The historic generalized floodplain was delineated from the DRGs using ArcView. Historic maps and photos provided information on floodplain areas occupied by the Kalama River channel over the past 150 years. Where no evidence of past channel migration was documented, the generalized floodplain was estimated to extend across the valley floor to the first contour line (20-foot contour interval with occasional intervening 10-foot contours). Gage data from various sites on the Kalama River indicated that peak flood flows have been typically up to about 15 feet higher than the gage datum. As a result, the generalized floodplain delineated up to the 20-ft contour on the 1:24,000 scale topographic map was likely a liberal estimate of the area inundated or affected by large floods.

No digital data depicting the extent of the current 100-year floodplain were available for Cowlitz County rivers. In lieu of this information, the current floodplain was delineated based on the locations of existing infrastructure (i.e., roads/levees) that were considered to affect natural geomorphic processes (e.g., lateral erosion or inundation) and to constrain the area where those processes function naturally. The current floodplain was assumed to extend from the existing channel margin to the nearest levee, paved road, railroad or developed area on each bank. Although flood flows may inundate or overtop areas beyond these features, such areas were not considered to be functioning naturally and thus, were not included in the delineation of the current floodplain.

Hydromodifications

Within the historic generalized floodplain, hydromodifications mapped by SSHIAP were confirmed and additional features previously identified, either on aerial photos or through field surveys, were added to the SSHIAP database. The SSHIAP database contained point, line and polygon coverages of hydromodifications for WRIA 27, including the lower Kalama River area. The SSHIAP map layers provided by WDFW were developed primarily based on existing remote sensing resources (i.e., maps and digital data layers provided by various federal, state and local agencies). New features added to the database for this analysis consisted primarily of armored banks and “developed” areas. Developed areas identified for this analysis were treated as polygon features and they were assigned the SSHIAP code for structures (44). These areas represented cleared land and clusters of multiple contiguous dwellings visible on current air photos and were perceived to be of a sufficient density to affect runoff. However, they were outside of the official city limits mapped as "city" in the WDFW SSHIAP coverage. No attempt was made to map individual structures.

Channel Margins

The lateral channel margins of large rivers, including the submerged river bank, are areas of high use by juvenile salmonid fishes. Based on Hayman et al. (1996), banks can be classified into three general types: (1) banks, where the shoreline is vertical or nearly vertical and vegetative cover varies from bare to densely-vegetated; (2) bars, which have a shallow gradient and are typically unvegetated; and (3) backwaters, enclosed, low velocity areas separated from the main channel. Beamer and Henderson (1996) found that banks without hydromodifications had a higher percentage of cover than non-hydromodified banks. For most species, juvenile fish abundance has been positively correlated to cover, in particular large wood cover. This finding was true for both natural and hydromodified banks – i.e., hydromodified banks that incorporated or had accumulated wood and vegetative cover over time supported higher densities of juvenile salmonids (Beamer and Henderson 1996).

Historic lateral margins habitats in the Kalama River were delineated on mylar overlays of the USACE 1942 aerial photos and digitized into an ArcView coverage. Current channel margins were digitized from the 2003 black and white digital orthphotos provided by the Lower Columbia Fish Recovery Board (LCFRB). For each coverage, mainstem margins were classified as bank or bar. Backwater habitats were generally not evident on maps or photos used for this analysis. However, side channels and other off-channel habitats connected to the mainstem were delineated and quantified for both historic and current conditions.

The estimate of historic channel margin length was derived from digitized mylar overlays depicting the channel configuration and off-channel habitats evident on aerial photographs flown in 1942. Based on historic photographs, some development had occurred in the lower Kalama basin by 1942, but the overall channel configuration was similar to that depicted in cadastral survey maps dating from 1857. Major side channels were clearly visible in areas cleared for agriculture and development. Unless off-channel habitats appeared to be naturally disconnected from the mainstem river, these features were all classified as connected to reflect conditions prior to Euroamerican settlement.

2.1.2 Riparian Habitat Conditions

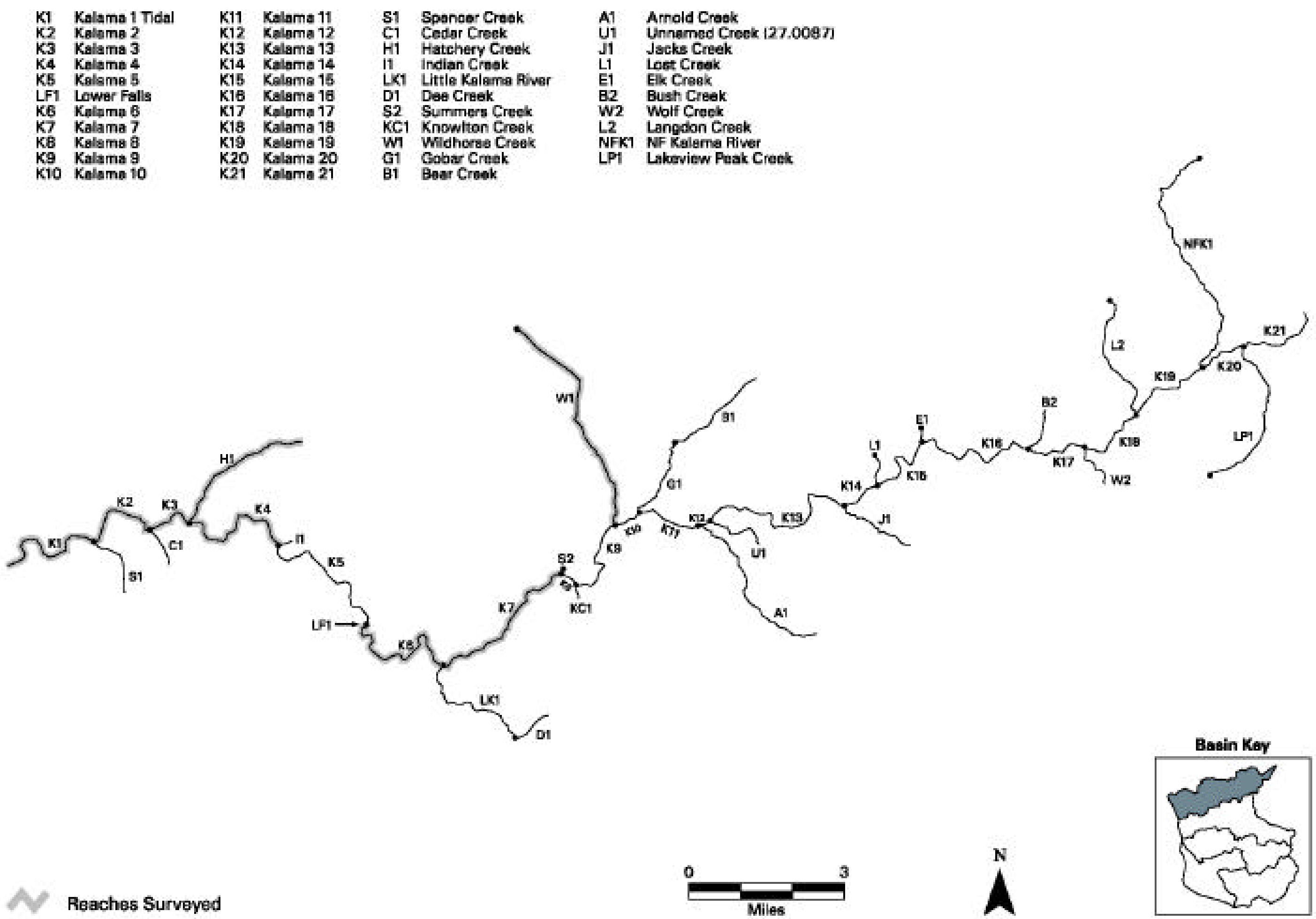
The riparian habitat condition assessment was conducted from aerial photo interpretation of the Washington State DNR 2003 4-m orthophoto imagery provided digitally by the LCFRB. The imagery consisted of black and white aerial photographs taken by the DNR in July 2003 at an approximate scale of 1:12,000. These photographs were digitally reviewed to assess riparian cover conditions along 45 EDT reaches, representing approximately 77 miles of anadromous fish-bearing streams in the Kalama River Basin (Map 2-1). The methods for delineating riparian conditions and assessing the large wood (LW) recruitment potential and current shade levels were in accordance with Washington Forest Practices Board (WFPB) guidelines for conducting watershed analysis methodology (Ver. 4.0; WFPB 1997).

Each riparian condition unit was identified using personal computer and ArcInfo computer software to project delineated reaches onto digital aerial photograph images. The riparian stand species composition, relative size, density and percent of stream surface and stream banks visible was estimated from the onscreen image along both banks of the stream reaches as described in Volume I, Methods. These estimates were then converted to LW recruitment potential and incremental shade levels, based on criteria in the Standard Methodology for Conducting Watershed Analysis (WFPB 1997).

Shade levels were determined in the photographic assessment in accordance with shade intervals based on the degree of the channel visible on the photo. The existing shade categories were compared to target shade levels based on elevation in accordance with the western Washington temperature/elevation screen (WFPB 1997) that was designed to offer sufficient shade to comply with state water temperature standards. This approach is a top down assessment looking through the riparian canopy closure to the channel. It can be compared on a relative basis to the bottom-up approach (stream channel looking skyward) in the View-to-the-Sky assessment discussed in the subsequent section, Chapter 1, Section 2.3.2 Stream Surveys.

2.1.3 Stream Surveys

Stream surveys were completed in the Kalama River Basin from September 20 - October 28 2004. Habitat condition data were collected in 8 EDT reaches representing approximately 14 miles per the USFS Level II Stream Reach Inventory methods described in Chapter 1 of this report. The eight reaches surveyed in the Kalama River Basin included the following.



Map 2-1. EDT reaches in Kalama River Basin

EDT Reach	Location (RM)
Mainstem Reaches	--
Kalama 1 Tidal	0.0 – 2.6
Kalama 2	2.6 – 4.3
Kalama 3	4.3 – 5.3
Kalama 4	5.3 – 8.0
Kalama 6	11.0 – 14.1
Kalama 7	14.1 – 17.3
Tributary Reaches	--
Hatchery Creek	0.0 – 3.0
Wildhorse Creek	0.0 – 4.8

2.1.4 Sediment Sources

No changes to sediment sources methods were made. Surveys were completed from September 13-17, 2004.

2.2 RESULTS

2.2.1 Hydromodification

The hydromodifications analysis area focused on the lower ten miles of the Kalama River. Evaluation of topographic maps revealed that the Kalama River traverses three distinct landforms within the lower ten miles (Figure 2-1). The first distinct reach identified was from river mile (RM) 0.0 to approximately RM 1.5, where the Kalama River flows across the Columbia River floodplain. The second reach was between RM 1.5 and RM 2.8, where the Kalama River occupies its own floodplain. The third reach was upstream of RM 2.8, where the river is naturally confined within a bedrock canyon, bordered by narrow, discontinuous floodplain deposits. The floodplain deposits were relatively common from RM 2.8 to RM 6.0, but were virtually absent throughout the remainder of the analysis area.

Historically, the Kalama River deposited sediment in a delta that extended into the Columbia River floodplain. The river migrated north and south across that feature as sediment built up in delta distributary channels. East-west trending sloughs identified on early maps and photos provided evidence of this process. The area of Columbia River floodplain north of the mouth of the Kalama River was included in this analysis because channel features identified in that area were related to the Kalama River.

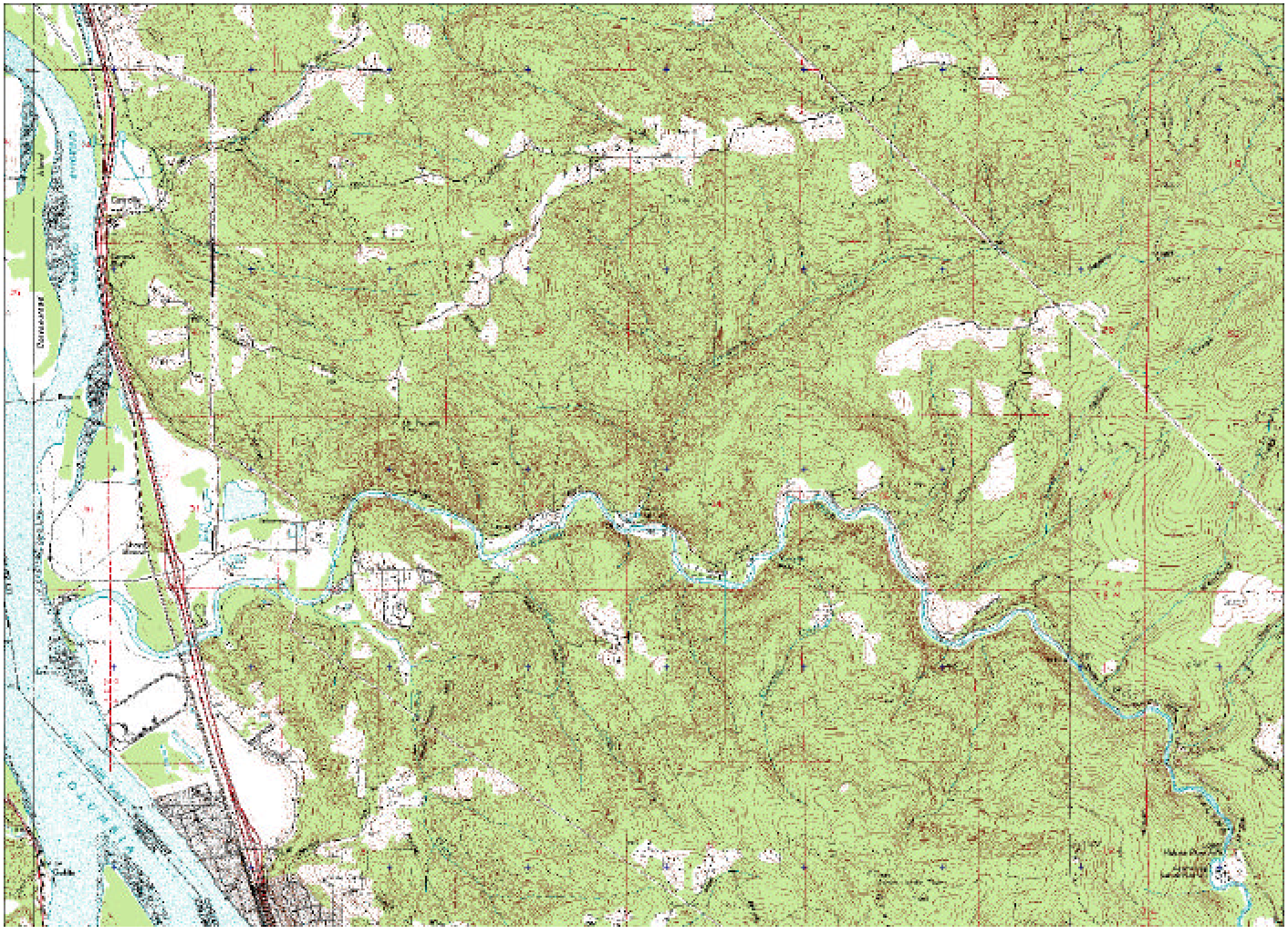


Figure 2-1. USGS 1:24,000 scale topographic map of the hydromodifications study area, (RM 0 to RM 10.5) for the Kalama basin.

The disparity in basin size between the Columbia River (>250,000 mi^2) and the Kalama River (approximately 200 mi^2) has given rise to some important differences in process and timing that have affected floodplain dynamics on the Kalama/Columbia River floodplain. The majority of the Columbia River basin drains interior areas that support seasonal snow packs, and thus, peak flows and sediment loads occur over a prolonged period in spring (May through June). In contrast, the climatic and flow regime of the Kalama River is dominated by rainfall, with peak flows occurring in response to large rainstorm events in the fall and winter (November through February). Sediments that originated in the upper Kalama basin were carried downstream, settled out in and adjacent to the mouth of the Kalama River where the Kalama entered the low gradient Columbia River floodplain. Sediments carried by the Columbia River during spring snowmelt also were deposited on the Kalama/Columbia River floodplain. In response to the combined depositional regime of the Kalama and Columbia rivers, the Kalama River naturally experienced multiple cycles of aggradation and degradation each year. Historically, the outlet of the Kalama shifted back and forth across the delta in response to deposition in its lower reaches. This action resulted in a widening of the depositional zone and the creation of a network of former distributary channels represented now by east-west trending sloughs. The Columbia and lower Kalama Rivers also experienced daily tidal fluctuations. Thus abandoned Kalama River distributary channels persisted on the landscape as marshy tidal sloughs.

The boundary between the Kalama River floodplain and Columbia River floodplain is not clearly defined, as both rivers may inundate the same areas at different times. However, assuming that the Columbia River floodplain generally followed the western edge of the valley sideslopes up and downstream of the Kalama River, the area downstream of RM 1.5 would have been dominated by the geomorphic regime of the Columbia River. The area upstream of approximately RM 1.5 would have been dominated by the geomorphic regime of the Kalama River. Between RM 1.5, and RM 2.8 (the downstream end of the Kalama canyon), the Kalama River exhibits features typical of alluvial rivers, such as meander cutoffs, point bars with indistinct high flow channels along the back side, and eroding floodplain terrace deposits on the outside of meander bends.

Upstream of RM 2.8 the Kalama River flowed through a narrow, bedrock-controlled canyon. Alluvial deposits were rare, and consisted primarily of discontinuous cobble and boulder bars. Bedrock outcrops constrained lateral channel migration and prevented the development of off-channel habitats.

Generalized Floodplain

A comparison of the extent of the historic generalized floodplain and the current unconstrained floodplain of the Kalama River suggested that the area in which natural geomorphic processes (e.g., sediment deposition, bank erosion, channel migration and off-channel habitat development) has been reduced by approximately 84 percent for the entire hydromodifications analysis area. Comparisons by EDT reach are provided in Table 2-1.

Table 2-1. Comparison of the approximate extent of the generalized floodplain associated with the Kalama River historically and under current conditions, and area of existing disturbed and undisturbed features.

		Current Generalized Floodplain			
EDT Reach	**Historic GF Area (acres)**	**Total Area (acres)**	**Percent Developed**	**Percent Excavated/ Filled**	**Percent forested**
1 (RM 0 to RM 2.3)	1,588	167	29%	1%	12%
2 (RM 2.3 to RM 3.9)	82	63	0%	4%	10%
3 (RM 3.9 to RM 4.9)	26	0	0%	0%	0%
4 (RM 4.9 to RM 7.5)	45	9	1%	0%	0%
5 (RM 7.5 to RM 10.5)	0	0	0%	0%	0%

Within the combined floodplain of the Kalama River and the Columbia River, the 1857 cadastral survey maps indicated that the vegetation consisted historically of wetlands or tree and shrub species that were tolerant of frequent inundation. Upstream of the influence of the Columbia River, floodplain vegetation most likely would have consisted of a mosaic of forest types and age classes that ranged from young hardwood tree and shrub species on recent flood deposits to old growth conifer forests on older floodplain surfaces. Within the canyon, riparian stands most likely consisted of narrow bands of shrub or deciduous trees in frequently flooded zones, bordered by mixed conifer and hardwood stands. Bedrock outcrops were prominent throughout the canyon, and historically may have limited the density and composition of riparian vegetation. The current status of riparian vegetation throughout the Kalama River basin is discussed in Section 2.2.2

More recently, floodplain surfaces adjacent to the Kalama River have been cleared and utilized for agriculture or residential development. Forest cover represented only 10 percent of the current generalized floodplain area, and forested areas that consisted of sparse to medium stocked stands of mixed forest (Section 2.2.2). No dense urban areas were present in the Kalama

River generalized floodplain, although there were small areas that have been developed for residential uses. In EDT Reaches Kalama 3 and 4 in particular, development was concentrated on small floodplain features. Thus, the majority of generalized floodplain area mapped in those areas has been hydromodified.

Excavation, presumably for gravel extraction, has further modified floodplain habitats. Within the current floodplain, only a few small excavated ponds were present. However, several large ponds were created within the historic generalized floodplain. Excavation has modified approximately 3 percent of the historic generalized floodplain associated with EDT Reach Kalama 1-tidal. At least one of these ponds was currently managed as a recreational fishing area by WDFW.

Channel Margins

Throughout the hydromodifications analysis area, the current length of channel margins was estimated to be approximately 5 percent less than for pre-settlement conditions. The primary cause of this reduction in length was the loss of two major side channels. On the 1942 aerial photos both of these channels provided extensive aquatic habitat and clearly transmitted some flow from the mainstem during floods. One of those side channels was located in Kalama 1 on the south bank of the river downstream of Interstate 5. That side channel appeared to have been completely filled to above flood levels. Recently it was developed as an industrial park. The second disconnected side channel was located in Kalama 1 on the north bank of the river just upstream of Interstate 5. This side channel has become largely terrestrial zed, but contained a few pounded areas that remained connected to the river channel at its downstream end. The land around that channel appeared to be part of a small farm.

Differences in the amount of margin habitat elsewhere in the Kalama appeared to have resulted from minor channel shifting. Comparisons of margin habitat by EDT reach are provided in Table 2-2.

Table 2-2. Comparison of the extent of margin habitat on the lower Kalama River historically and under current conditions.

EDT Reach	Historic (ft)	Current (ft)
1 (RM 0 to RM 2.3)		
Bank	24,574	25,271
Bar[1]	3,981	2,264
Connected side channel	8,038	4,126
Disconnected side channel/oxbow	0	5,111
2 (RM 2.3 to RM 3.9)		
Bank	19,097	20,222
Bar[1]	4,464	1,627
Connected side channel	1,890	0
Disconnected side channel/oxbow	0	0
3 (RM 3.9 to RM 4.9)		
Bank	10,830	10,594
Bar[1]	0	320
Connected side channel	0	0
Disconnected side channel/oxbow	0	0
4 (RM 4.9 to RM 7.5)		
Bank	29,471	28,765
Bar[1]	1,604	522
Connected side channel	0	0
Disconnected side channel/oxbow	0	0
5 (RM 7.5 to RM 10.5)		
Bank	32,031	31,904
Bar[1]	890	0
Connected side channel	0	0
Disconnected side channel/oxbow	0	0

[f]low at time of both photo sets was unknown thus direct comparison of bar may reflect differences due to stage or increased/decreased sediment deposition.

Hydromodifications

Three primary types of hydromodifications were recognized in this analysis: (1) changes in the hydrologic regime (e.g., flood control or impervious area); (2) activities that alter habitat connectivity (e.g., floodplain land conversion, levees, gravel extraction) and (3) direct alteration of the channel bed and bank (bank armoring, dredging).

Hydrologic Regime

The Kalama River has not been regulated by upstream flood control dams. Thus, the existing hydrologic regime was generally consistent with the natural flow regime. A report by the U.S. Forest Service (1996) suggested that Kalama River flows may have been affected by forest harvest. Drainages in the upper basin where harvest had occurred may have experienced peaks flows more than 10 percent greater than peak flows for unmanaged drainages (USFS 1996). The Integrated Watershed Analysis (IWA) indicated that peak flow increases are likely for lower subbasins as well (LCFRB 2004) Evaluation of peak flow effects related to forest management were beyond the scope of this analysis.

At the time of this assessment, approximately 5 percent of the delineated Kalama River historic generalized floodplain consisted of developed areas with a moderate proportion of impervious surfaces. May et al. (1998) indicated that minor peak flow effects have resulted from urbanization when the total impervious area is less than approximately 5 percent. Since the generalized floodplain represented a small proportion of the overall basin, and the developed areas were not 100 percent impervious, hydromodifications within in the analysis area were not currently considered to have adversely effected the Kalama River flow regime. However, floodplain development may have had local impacts on local floodplain processes.

Habitat Connectivity

Changes in habitat connectivity within the hydromodifications analysis area consisted primarily of disconnection of off-channel habitat and reductions in the amount of functional floodplain habitat as described above. Structures crossing the channel in the Kalama River generally consisted of bridges and did not interfere with the upstream passage of anadromous fish. An exception to this finding was the temporary hatchery rack located in Kalama 2 near RM 2.6. That rack is erected seasonally to facilitate collection of Chinook salmon for the Kalama hatchery. Construction of the rack requires annual trenching across the river bed.

Direct Alteration of Bed and Banks

Overall, approximately 53 percent of the river bank in the Kalama River analysis area was determined to be naturally constrained, including part of Kalama 2, 3 and 4 and virtually all of Kalama 5. Numerous activities that have altered the natural channel bed and banks of the Kalama River were identified within the hydromodifications analysis area in both constrained and naturally unconstrained reaches. Sixty-six percent of the total bank length in the analysis area has been armored or bordered by levees. The extent of hydromodifications observed in the Kalama River hydromodifications analysis area by EDT Reach are listed in Table 2-3.

Table 2-3. Summary of the length of mainstem channel banks affected by hydromodification located within 50-feet of the OHWM for the lower 10 miles of the Kalama River.

EDT Reach	Total margin length (ft)	Naturally constrained[1] (%)	Levee (%)	Bank armoring (%)	Stream adjacent road (%)	Unmodified (%)
1 (RM 0 to RM 2.3)	25,271	3	26	36	3	36
2 (RM 2.3 to RM 3.9)	20,222	41	0	34	2	64
3 (RM 3.9 to RM 4.9)	10,594	35	0	86	0	14
4 (RM 4.9 to RM 7.5)	28,765	60	0	41	6	53
5 (RM 7.5 to RM 10.5)	31,904	100	0	0	6	94

[1]Naturally constrained banks may have been hydromodified.

[2] Areas with affected by both stream adjacent roads and armored banks were counted as armored banks. The value in column 5 represents only those areas where stream adjacent roads were present and either no armoring was document during surveys, or no survey data was collected.

[3]Unmodified bank refers to those sites with no hydromodifications located immediately adjacent to the channel, and includes both unconstrained and naturally constrained areas.

Hydromodified banks were concentrated in the downstream part of Kalama 1, or consisted of rip-rap banks that protect stream adjacent roads or residences. Hydromodifications were notably absent from stream banks in the between RM 1.3 and RM 2.5 (upstream part of Kalama 1 and downstream part of Kalama 2). Some high eroding banks were observed in this part of the river, and in some cases those features were associated with areas of riparian vegetation that had been cleared. The majority of high eroding banks observed were likely the natural conditions occurring when the outside edge of meander bend moves laterally across the floodplain

Armoring of the channel banks and construction of levees along the downstream end of the river have constrained the channel and prevented natural channel migration, particularly within the portion of channel formerly flowing across the Columbia River floodplain. In addition to reducing the quality of lateral margin and off-channel habitat, these changes have also affected the depositional regime of the river. Historically the river was free to migrate back and forth across the Columbia River floodplain as sediment accumulated in its channel. In recent times, 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. This modification resulted in formation of an offshore bar reported to adversely effect upstream fish passage due to the shallow flow depth and potential for increased water temperatures. No data were located describing historic dredging of accumulated sediments in the Kalama River, but dredging was historically common practice in nearby rivers such as the Lewis River.

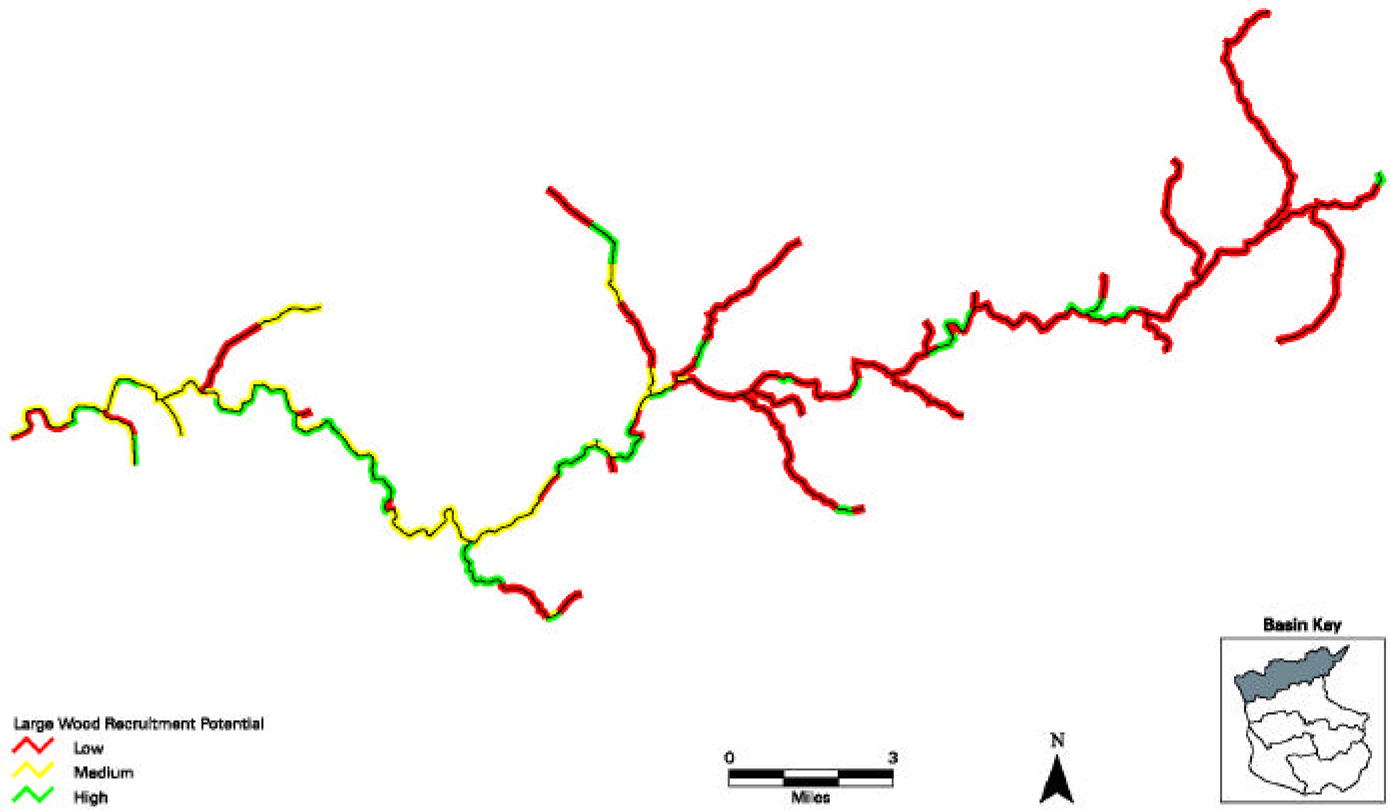
2.2.2 Riparian

The intent of the Phase II remote sensing assessment of riparian habitat conditions was to provide sufficient detail to judge the current level of riparian function related to potential LW recruitment and shade. The assessment was also intended to confirm the Phase I Integrated Watershed Assessment (IWA) results, as well as to provide input for refining EDT riparian input factors and for assessing potential restoration opportunities.

Existing Riparian Function

Large Wood (LW) Assessment: The location and current LW recruitment condition of 43 EDT reaches are shown in Map 2-2. The condition rating for each of the reaches is included in Appendix A.

Aerial photo assessment, along both shorelines of nearly 77 miles of anadromous fish streams, indicates the overall LW recruitment potential of riparian stands in the Kalama basin is relatively poor.



Map 2-2. Large wood condition ratings for EDT reaches in the Kalama Basin.

Large Wood Recruitment Potential

Condition	Frequency
Good	18%
Fair	19%
Poor	63%

Portions of Kalama 5, 7, 9, 15, and 21, the little Kalama River, Arnold, Bush, Gobar, Summers and Wildhorse creeks offered good current LW recruitment conditions [low recruitment hazard] on both sides of the stream. Riparian vegetation in these situations consisted of dense stands of either large or medium-sized conifer or mixed species.

However, most of the reaches in the basin represented poor [high hazard] LW recruitment conditions. The existing poor stand conditions were not reflected in species composition of riparian stands. Based on photographic interpretation, only 3 percent of the stands appeared to be dominated by deciduous species. Conversely, conifer and mixed conifer/hardwood stands were prevalent at 96 percent of total. The poor existing stand situation appeared to be related to the size of riparian trees rather than the species composition or the density of the stands.

Riparian Species Composition

Type	Frequency
Conifer	30%
Mixed	66%
Hardwood	3%

Similarly, the stand density showed equal representation as either sparse or dense tree growth along the streams.

Riparian Stand Density

Condition	Frequency
Sparse	51%
Dense	49%

The relative size of the trees in incremental size classes was on the small side. Only 5 percent of the stands were categorized in the large (> 8 cm 20” dbh) size class. This result indicated a number of decades (20 to 40 years) of growth would be needed for the development of a large size class of trees to contribute to the LW recruitment conditions for these streams.

Riparian Stand Size Class

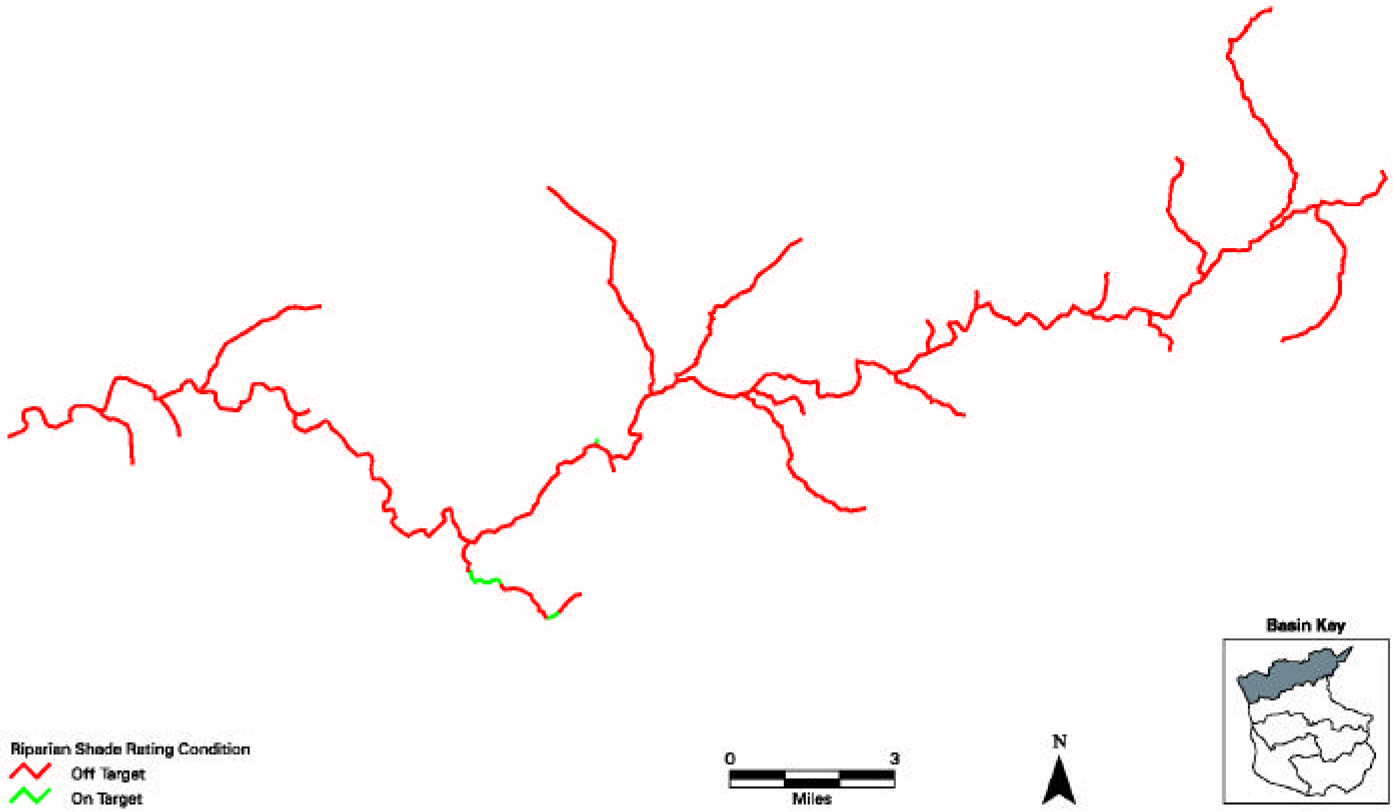
Condition	Size Class	Frequency
	(dbh)	(%)
Small	< 12”	55%
Medium	12 – 20”	39%
Large	> 20”	5%

As described in the Section 2.2.3 *Stream Surveys*, urbanization, roads, clearcutting, thinning and hydromodifications to the shorelines have encroached within 30m (100 ft) of riparian zones at several places along fish-bearing channels. These habitat changes and hydromodifications have adversely influenced the riparian LW recruitment potential of the Kalama River.

Riparian Shade Assessment:

The location and current shade condition of the 43 EDT reaches is shown in Map 2-3. The condition rating for each of the reaches is included in Appendix A.

Aerial photo assessment suggested, on average, that the riparian stands provide little in the way of effective shade. Existing shade levels ranged between 0 and 80 percent shade while the mean level is approximately 28 percent shade. According to the State shade/elevation screen, this amount of shade is anticipated to maintain water temperature standards in streams located upstream of approximately the 760m (2,500 ft) msl elevation in the basin.



Map 2-3. Shade condition ratings for EDT reaches in the Kalama Basin

Riparian Shade Condition

Shade Increment	Tally	Frequency
0	2	2%
0 – 20%	37	36%
20 – 40%	43	42%
40 – 70%	17	17%
70 – 90%	4	4%
90 – 100%	0	0%

IWA Verification

The IWA for the Kalama River basin indicated riparian conditions were either intact or degraded at the subwatershed level based on total stream length. The proportion of intact versus degraded was then used to assume a level of riparian functionality in three classes; impaired, moderately impaired or functional riparian buffer areas. Subwatersheds were classified according to their existing level of functional riparian conditions. Conditions were rated as moderately impaired in 17 of 18 subwatersheds in the Kalama basin. Only one subwatershed, Kalama Headwaters (# 40102), was rated as currently providing functional riparian habitat conditions. There were no EDT reaches in the Kalama Headwaters subwatershed, so direct verification of IWA results with the reach-level riparian assessment in the Headwaters subwatershed was not possible.

The Integrated Watershed Assessment document offered the following information on Riparian vegetation conditions in the Kalama River watershed:

> *"Most of the watershed, including riparian forests, was logged in the late 1960s through the early 1980s. Many of the areas are in early stages of recovery. According to an analysis in 1994 and 1996 aerial photos, riparian forests on 85 of 97 miles of anadromous stream channels are "clearly lacking" riparian vegetation and/or contain mostly deciduous species (Lewis County GIS 1999 as cited in Wade 2000). It is believed that riparian conditions along some of the most productive steelhead streams are in poor condition. Riparian conditions throughout the watershed are slowly recovering under more restrictive timber harvest regulations, with recovery in some areas limited by moderate to high streamside road densities and residential development along the Kalama River mainstem. Riparian conditions are predicted to trend toward gradual recovery in most areas of the watershed except the lower mainstem and tributaries.*
>
> *The lower Kalama River mainstem and tributaries pose a more complex problem. Almost the entire floodplain of the lower Kalama River has been disconnected from the river by*

> *the construction of dikes and levees. The construction of US Intrastate-5 first cut off the lower floodplain, and then development on Port of Kalama property completed the channelization of the river. Riparian conditions in the lower mainstem Kalama are expected to trend downward over the next 20 years, as development pressure around the town of Kalama increases. Channelization in these downstream subwatersheds limits the potential for riparian recovery."*

Direct verification of IWA results with the reach-level riparian assessment conducted herein, is not possible. However, in general, a review of Maps 2-2 and 2-3 show the reaches with high existing hazards to riparian functions of LW recruitment and shade, respectively. Nearly all of the EDT reaches in the basin are currently off-target with respect to the State shade/elevation screen, representing high shade hazards. Due to the low elevation of lands along the EDT reaches accessible to anadromous fish species, a high level of shade is required to comply with aquatic use temperature criteria. Although variable, concentrations of high LW hazard areas can be found in the lower basin in Kalama 1-tidal, lower Hatchery Creek, upper Little Kalama, and all headwater mainstem and tributary EDT reaches upstream of Wildhorse Creek. Kalama 1-tidal may have experienced natural high hazards to riparian function as a function of the Columbia River floodplain.

The IWA indicated all 17 of the subwatershed encompassing EDT reaches in the Kalama basin were moderately impaired. The aerial photo assessment of EDT reaches per WFPB (1997) watershed analysis guidelines suggest the reaches highlighted in red in Map 2-2 represent "impaired" riparian conditions and reaches highlighted in yellow represent "moderately riparian conditions. The balance of reaches in green offer current "functional" riparian conditions.

2.2.3 Stream Surveys

Habitat inventory data are summarized for the Kalama River Basin as a whole in this section (Tables 2-4 and 2-5). Habitat conditions for each of the surveyed reaches shown in Map 2-1 are presented in detail in Appendix B.

Table 2-4. Channel Gradient, Confinement and Morphology in the Kalama Basin

Reach	Map Gradient	Confinement	Paustian Process Group	Montgomery Buffington bedform	Comments
Kalama 1	<1%	Unconfined	Large palustrine to Large estuarine	Dune-ripple to weak pool-riffle (i.e., mostly glide habitat)	Substrate likely sand. First 1.4 miles tidal, in Columbia River floodplain and constrained by armored banks or levees on both sides. From RM 1.4 to 2.2 unconstrained by levees, tidal, but Kalama River FP so vegetation likely would have been forest.
Kalama 2a	0.5-1%	Unconfined	Wide, low gradient floodplain	pool-riffle	This reach should be separated into two geomorphic reaches. The first 0.6 miles of this reach (RM2.2-2.8) are unconfined; the rest is confined within a canyon. This portion of Reach 2 (2a) flows over Kalama River floodplain and was likely forested.
Kalama 2b	<1%	Moderate	Large, contained	pool-riffle	Narrow, discontinuous floodplain features border channel. Likely bedrock in places. Plenty of gravel, although D50 may be slightly large. This section is likely less responsive to LW than 2a, but more responsive than canyon reaches further upstream
Kalama 3	<1%	Moderate	Large, contained	pool-riffle	Same as 2b
Kalama 4	0.3%	Confined	Large, contained	pool-riffle	Expect bedrock control to be more common; low responsiveness to LW, although it could provide cover. Most pools probably BR, jams would not last long.
Kalama 6	0.3%	Confined (few moderate sections)	Large, contained	pool-riffle	Much like Kalama 4, but there are few terrace features. Check for old lahar deposits geology map
Kalama 7	0.6%	Confined	Large, contained	pool-riffle	Highly confined, probably lots of BR

Table 2-4. Channel Gradient, Confinement and Morphology in the Kalama Basin

Reach	Map Gradient	Confinement	Paustian Process Group	Montgomery Buffington bedform	Comments
Hatchery	2-4%	Confined to moderately confined depending on stream width. Somewhat less confined in upper valley	Moderate Gradient mixed control	Forced pool riffle – to plane bed without LW or large obstructions	First quarter mile is small, fairly confined alluvial fan feature (1% grad/moderate confinement). Thereafter in steep sided valley. Highly responsive to LW both for pools and gravel storage
Wildhorse	3%	Moderately confined	Moderate Gradient mixed control	Forced pool riffle – to plane bed without LW or large obstructions	Fairly consistent gradient throughout. Valley width varies considerable from narrow canyon, to at least moderately confined, and possibly unconfined in some areas given stream size. Highly responsive to LW both for pools and gravel storage

Table 2-5. Mean Habitat Inventory data in the Kalama Basin

	Kalama 1	**Kalama 2**	**Kalama 3**	**Kalama 4**	**Kalama 6**	**Kalama 7**	**Wildhorse**	**Hatchery**
Channel Morphology								
Pool %	0	21	13	34	43	31	13	22
Pool Tailout	0	10	10	17	8	12	37	33
Large Riffle	0	21	44	43	0	16	1	49
Small Riffle	0	20	0	0	38	29	86	19
Glide	100	38	43	23	19	19	1	2
Cascade	0	0	0	0	0	5	0	1
Other	0	0	0	0	0	0	0	5
Gradient	<1	<1	<1	<1	<1	<1	3	2 - 4
Channel Type	Pal/Est	FP	LC	LC	LC	LC	MGMC	MGMC
Bedform	DR	PR	PR	PR	PR	PR	FPR-PB	FPR-PB
Wetted channel width (m)	64	39	44	42	33	30	3.8	6.9
Active channel width (m)	-	-	-	-	-	-	4.9	6.4
Max. Riffle Depth (m)	-						0.4	0.4
Res. Pool Depth (m)	-	2.0	1.0	2.2	1.7	2.1	0.3	0.3
Max Pool Depth (m)	>3	2.7	>3	>3	2.4	2.8	1.6	1.8
Pools/km	0.0	1.0	1.5	2.3	4.1	2.5	14.1	17.1
Primary Pools/km	0.0	1.0	1.5	2.3	4.1	2.5	0	1.2
% side channels								
LW								
Small Pieces/km	21.5	13.8	8.0	12.1	12.5	5.3	23.0	28.0
Medium Pieces/km	11.5	10.0	3.6	5.2	5.3	6.2	41.0	27.0
Large Pieces/km	1.6	1.7	2.2	2.6	2.6	4.8	49.0	26.0
Jams/km	0.5	0.0	0.0	0.6	0.0	0.4	0.0	0.0
Root Wads/km	0.0	0.7	0.0	0.3	1.0	0.5	4.5	0.0
Total LW/km	35.2	26.2	13.8	20.8	21.4	17.2	118.0	81.0
Substrate								
Sand	95	12	2	-	18	6	33	23
Gravel	5	39	29	34	43	25	33	38
Cobble	-	46	57	49	33	40	24	22
Boulder	-	3	12	15	5	23	7	7
Bedrock	-	-	-	3	1	6	3	10

Table 2-5. Mean Habitat Inventory data in the Kalama Basin

	Kalama 1	Kalama 2	Kalama 3	Kalama 4	Kalama 6	Kalama 7	Wildhorse	Hatchery
Cover								
LW	1	0	0	0	0	0	5	4
Undercut Banks	0	0	0	0	0	0	0	0
Overhanging Cover	0	2	2	0	0	0	27	9
Depth > 1m	63	38	37	58	44	60	0	15
Substrate (velocity)	0	0	0	0	0	0	0	2
Riparian								
Distance to Left Bank	146	166	117	97	88	79	48	40
Angle	19	34	37	55	50	49	77	75
Distance to Right Bank	153	139	193	105	98	73	39	40
Angle	16	32	28	41	52	60	76	76
VTS %	81%	63%	64%	47%	43%	39%	15%	16%
Active channel width	64	39	44	42	33	30	4.9	6.4
Elevation	10	30	45	65	225	295	500	225
Reference Temp ^{o}C	18.7	17.7	18.0	17.8	17.2	17.0	15.3	15.8
Current Est. Temp ^{o}C	21.6	20.5	20.3	19.2	19.0	18.4	16	16.2
Vegetation Community (%)								
LB Hardwood	100%	69%	33%	11%	47%	6%	60%	-
Mixed		8%	33%	50%	32%	47%	40%	-
Conifer		23%	33%	39%	21%	47%	0%	-
RB Hardwood	100%	62%	83%	44%	47%	0%	43%	-
Mixed		31%	0%	22%	16%	35%	57%	-
Conifer		8%	17%	33%	26%	65%	0%	-
Bank Stability								
LB Unstable %	0	4	1	1	2	-	41	10
Disturbance %	55	30	34	14	33	75	6	31
Disturbance Type	UT	CURT	UR	RU	UH	H	CC	URCO
RB Unstable %	0	0	8	9	1	-	41	2
Disturbance %	64	63	65	57	77	27	6	47
Disturbance Type	TU	UR	RU	RU	RRUT	TUR	TH	RUC

Channel Codes
Pal = Palustrine; Est = Estuarine; FP = Flood Plain; LC = Large, Contained; MGMC = Moderate Gradient, Mixed Control
Bedform Codes
DR = Dune-ripple; PR = Pool-riffle; FPR = Forced pool-riffle; PB = Plain bed; SP = Step Pool
Riparian Disturbance Code
U = Urbanization; R = Road; RR = Railroad; C = Clearcut; T = Thinning; H = Hydromodification

Channel Morphology

The channel morphologies for the mainstem EDT reaches surveyed in the Kalama River basin varied from large palustrine to estuarine channels with dune-ripple bedform in the tidal zone to low gradient bedrock contained channels with pool-riffle bedform upstream of RM 3. The tributaries surveyed were moderate gradient, 2 to 4 percent, moderately-confined streams with mixed control features. These type of streams contained pool:riffle bedforms when channel structure was abundant. However, some stream sections had deteriorated to plane bedded channels in the absence of large structure (large wood, boulder clusters, or bedform controls).

Habitat Types

The tidal reach, Kalama 1-tidal, contained 100 percent deep, glide habitat with an abundance of sand and very little usable spawning habitats. It appeared suitable as a transportation corridor for migrating adults to upstream habitats and as an estuarine acclimation area for juvenile outmigrants prior to entering the Columbia River.

Upstream of the tidal influence, pools were frequent and deep in the mainstem reaches. On average, the pools exceeded 1m (3.3 ft) in depth. They were considered primary pools and offered good holding habitat for returning adult fish prior to spawning. Riffle habitat was also prevalent in the mainstem reaches. Since gravel and cobbles with low levels of fines dominated the substrate types, the low gradient mainstem reaches of Kalama 2,3,4,6 and 7 contained good spawning conditions.

Pool habitats were infrequent and shallow in the tributary reaches surveyed. In contrast to mainstem habitats, riffles dominated the channel habitat types. Gravel-cobble riffles were prevalent in Wildhorse Creek, while larger cobble-boulder riffles dominated the habitat structure in Hatchery Creek. Although the channel morphology and gradients are similar in both tributaries, the substrate particle sizes are smaller in Wildhorse than in Hatchery Creek. This situation may be a function of lower stream power and more abundant woody debris pieces in Wildhorse than in Hatchery Creek that allow finer materials to settle out.

Large Wood Structure

On a relative basis, individual instream LW pieces were common in the tributary reaches with a full complement of wood piece sizes available. They were less common in the mainstem reaches and the instream wood loading was primarily of the small size category; too small to properly function in large channels of this nature. The presence of wood jams and pieces with attached root wads was very low throughout the survey.

The instream data signal indicated either that the large wood recruitment potential to the lower reaches of the Kalama mainstem has been low, the stream power has been sufficient to redistribute the LW input, wood was historically removed from the channels and/or that splash-damming was historically present along the mainstem Kalama River. As discussed in the previous section, long-term riparian growth on the order of two or four decades would be needed to offer higher LW recruitment potentials to these channels in the future.

Substrate

The prevalence of sand and high embeddedness ratings were only recorded during the habitat inventories in the palustrine reach of Kalama 1-tidal and in Wildhorse Creek. The balance of the reaches surveys showed low levels of sand and similarly, low embeddedness ratings. See Section 2.2.4 for a more comprehensive view of sediment issues in the basin.

Cover

Cover for fishes in the mainstem was primarily in the form of water depth. The tributaries contained more diverse cover types. Hatchery Creek cover was still dominated by pockets of deep (>1m, 3.3 ft) water refuge, while the most frequent cover type in Wildhorse Creek was overhanging vegetation.

Riparian Condition

The riparian species composition was dominated by deciduous species in the lowland, becoming more mixed and conifer-dominated in the upstream direction along the mainstem Kalama River. Direct comparison with the riparian conditions collected during the photographic assessment was difficult, since riparian stand composition information was collected during the stream inventory on an occasional (nth unit) basis and summarized over the length of the reach, whereas the photo interpretation was performed continuously along long homogeneous reaches. The field inventory indicated a greater presence of deciduous hardwood species than the photo assessment, although the prevalence of mixed and confer species was apparent in both the field surveys and the photo assessment at Kalama 3 and other upstream reaches in the mainstem (Table 2-5).

Encroachment into the 30m (100 ft) riparian zone along the Kalama mainstem has resulted in ratings that ranged from 36 to 60 percent disturbance of the riparian area. The greatest frequency of disturbance types included urbanization and roads (Table 2-6).

Table 2-6. Number of habitat units reporting riparian zone disturbance on either shore.

Distributary Type	Kalama 1-tidal	Kalama 2	Kalama 3	Kalama 4	Kalama 6	Kalama 7	Wildhorse	Hatchery
Urbanization	12	10	8	13	8	3		
Roads		6	3	10	10	11		4
Clearcut		1					3	3
Thinning	4	1				2	4	
Hydro-modification						11		
Total	16	18	11	23	26	27	7	7

Estimates of the average distance of trees beyond the bank full stage of the channel along the mainstem Kalama River reaches ranged from 22 to 59 m (73-193 ft) on either side of the river. This zone was wide along the floodplain reaches and narrowed in the canyon. The resulting mean view to sky angle from mid-channel ranged from a high of 81 percent in the lowland in Kalama 1-tidal to 39 percent upstream in Kalama 7 (Table 2-5).

These reaches were estimated to remain open to solar radiation even under the unlikely assumption of mature forest stands growing immediately adjacent to the channel, (VTS 69 ^{o}; 39%). As such, these reaches represent areas with naturally low shade levels and they likely supported historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference surface water temperatures were projected to range between 17.0^{o}C and 18.7^{o}C depending upon elevation. These temperatures would not be expected to comply with aquatic use criteria for core salmon and trout spawning and rearing purposes under mature riparian stands.

The current channel conditions were projected to increase the 7-DADmax on a relative basis between 1.4^{o}C and 3.1^{o}C compared to reference conditions. As a consequence, the anticipated summer 7-DADmax surface water temperature was estimated to range between 18.5^{o}C and 21.4^{o}C under normal summer weather (air temperatures and stream flows) patterns.

These estimates predicted freshwater surface temperatures only based on elevation, channel width and canopy coverage. They did not consider the influence of tidal exchange or groundwater influx. Actual water temperatures would vary with Kalama River discharge, tidal stage and local weather patterns.

Conversely, tree distances from the center of tributary channels ranged between 12 and 15m (39 – 48 ft) with solar radiation blocking angles that allow only 15 to 16 percent VTS. Canopy closure over the small channel widths was very near to reference conditions in both tributaries with a projected increase in surface water temperatures of between 0.4°C and 0.7°C (Table 2-7). It is very likely that with current conditions, both tributaries could comply with state water temperature standards under normal weather conditions.

Table 2-7. Anticipated Stream Temperature Conditions along EDT Reaches based on Channel View-to-the-Sky (VTS).
(Estimated Hot Spots in the LCFRB basins in sequential order)

		Current Change from Reference Temperature[1/]			
Kalama River Basin	**EDT Reach**	**- (%)**	**+ T°C**	**Hazard[2/]**	**Comment**
Mainstem	Kalama 1	42%	3.1	Very High	Naturally High
	Kalama 2	38%	2.8	Very High	Naturally High
	Kalama 3	31%	2.3	High	
	Kalama 6	25%	1.8	Moderate	
	Kalama 4	19%	1.4	Moderate	
	Kalama 7	18%	1.3	Moderate	
Tributaries	Wildhorse	9%	0.7	Low	Preservation
	Hatchery	4%	0.3	Low	Preservation

1) Reference Temperature Condition occurring under the assumption of mature trees (46m; 150 ft high) growing at edge of active channel width.
2) Water Temperature hazard is the relative degree of risk to complying with aquatic use categories compared to reference condition per reach.

Enhancement of Existing EDT Model

The Kalama Basin stream survey data were compared to existing attribute values in the EDT Stream Reach Editor (SRE) in an effort to enhance the current modeling effort with site-specific data. In general, categorical ratings for wood, sediment and embeddedness were relatively consistent between the data in the SRE and the recent field observations. However, measurement data, primarily width and habitat types, occasionally differed between the SRE and the recent field observations. Caution is advised when interpreting stream width comparisons since widths are a function of stream flow levels during the surveys and vary between wet and dry years.

Specific comparisons between the SRE and the current stream surveys are itemized in Appendix 2B. In general, the following major differences were noted in the Kalama basin:

1. Width: The greatest width differences were seen in Wildhorse and Hatchery creeks.
    a. In Wildhorse, the recent field width measurements were substantially less than SRE widths, especially maximum channel width. This result might be a factor of the Level II stream survey subsampling approach compared to the entire reach characteristics. Conversely, the result might be related to overall overestimation originally in the SRE dataset.
    b. The recent measurements of width in Hatchery Creek were substantially less than the SRE.

2. Pool Area: In general, the SRE data showed greater pool area and lesser small cobble riffle relative to the more recent field observations. Differences in Habitat Type were greatest in Wildhorse Creek compared to other reaches surveyed. The original SRE data portrayed Wildhorse as primarily pool habitat whereas the survey data indicated the channel type consisted of primarily small cobble riffle.

3. Fine Sediment and Embeddedness: Categorical ratings for Fine Sediment and Embeddedness showed differences in the Kalama. The recent observations indicated Fine Sediment and Embeddedness in the lower Kalama River basin was near pristine conditions, whereas the original SRE ratings showed appreciable sediment levels.

4. Large Wood and Channel Confinement: Categorical ratings for Wood and Confinement (both natural and artificial) showed relatively close agreement between data in the SRE and the recent stream survey observations.

The extent of differences between the recent observations and the data in SRE may result in substantial differences in estimated fish performance measures in EDT, depending upon the extent the changes permeate through the model. Because the differences appear to be greatest in the width and habitat types, the EDT is likely to be improved in terms of estimating population capacity. Information related to productivity or quality of the habitat (wood, fine sediment) is more similar between the two datasets than the habitat capacity attributes.

2.2.4 Sediment Sources

Geology and Geomorphology

The Kalama River basin geology is relatively uniform compared to the nearby Lewis and Washougal River basins (Figure 2-2). 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 majority of tributaries were steep, with gradients greater than 3 percent. Lower stream gradients prevail near the confluence of the tributaries with the Kalama River and in short sub-reaches (Figure 2-3). Steeper segments can be characterized as “transport reaches” as defined by Montgomery and Buffington (1997). Gravel and cobble suitable for spawning for most anadromous salmonids species would, therefore, be expected to be transported downstream rather than collected in extensive deposits in the steep stream reaches.

Of the tributaries surveyed in the middle Kalama basin, Wildhorse Creek had the longest segment with a gradient below 3 percent. This low gradient segment would be expected to provide significant spawning habitat for a number of salmonid species (Figure 2-4). Summers Creek appeared too steep to support significant spawning. Based on stream gradient, Spencer Creek and Hatchery Creek would be expected to support spawning habitat in the low gradient reaches near their confluence with the Kalama River (although see notes on embeddedness below for Spencer Creek).

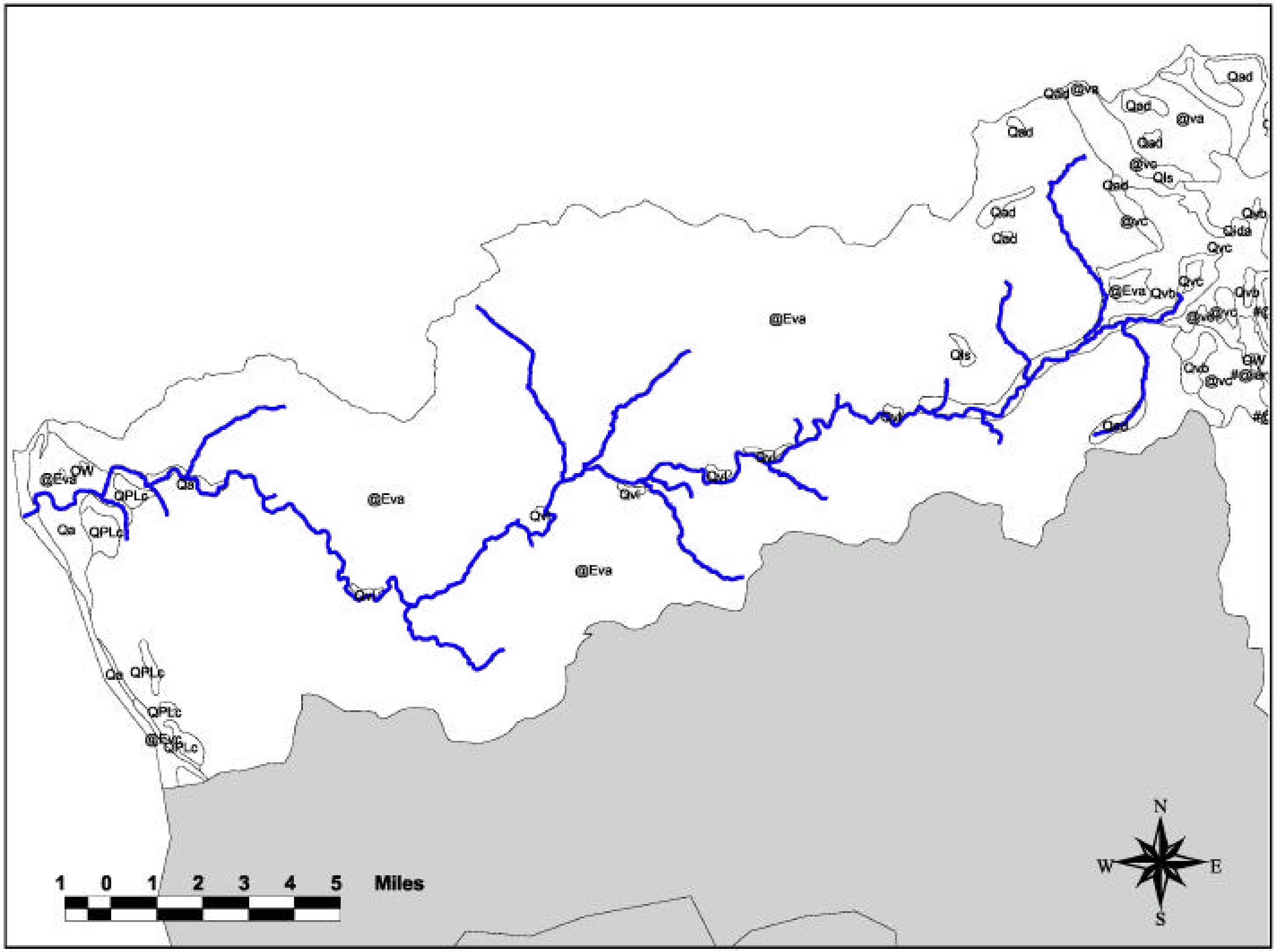


Figure 2-2. Geologic units in the Kalama River basin (Walsh et al. 1987) and EDT reach delineations. See Appendix C for listing of unit symbols.

The lower and upper falls on the mainstem Kalama River are located at large scale gradient breaks (Figure 2-3). The longitudinal profiles suggested that most mainstem spawning habitat would be concentrated within a few miles below upper Kalama Falls where the gradient drops, and for several miles below lower Kalama Falls. Based on gradient, there would likely be some spawning areas above lower Kalama Falls (Figure 2-3). Mainstem gradients are generally greater than 3 percent in most segments above upper Kalama Falls (Figure 2-4). Gravel and cobble would therefore be expected to be transported downstream rather than collect in extensive, usable deposits above upper Kalama Falls. However, much of the river is confined and the most extensive mainstem spawning habitat is currently located below lower Kalama Falls.

Percent Embeddedness and Fine Sediment Levels

The Kalama River below Arnold Creek showed signs of high embeddedness and a heavy fine sediment load (Table 2-8). Embeddedness levels ranged between the 50 and 75 percent classes in all surveyed mainstem reaches upstream of the tidal influence zone. Embeddedness was 100 percent within the tidally influenced reach (EDT Reach 1). Embeddedness levels were also high

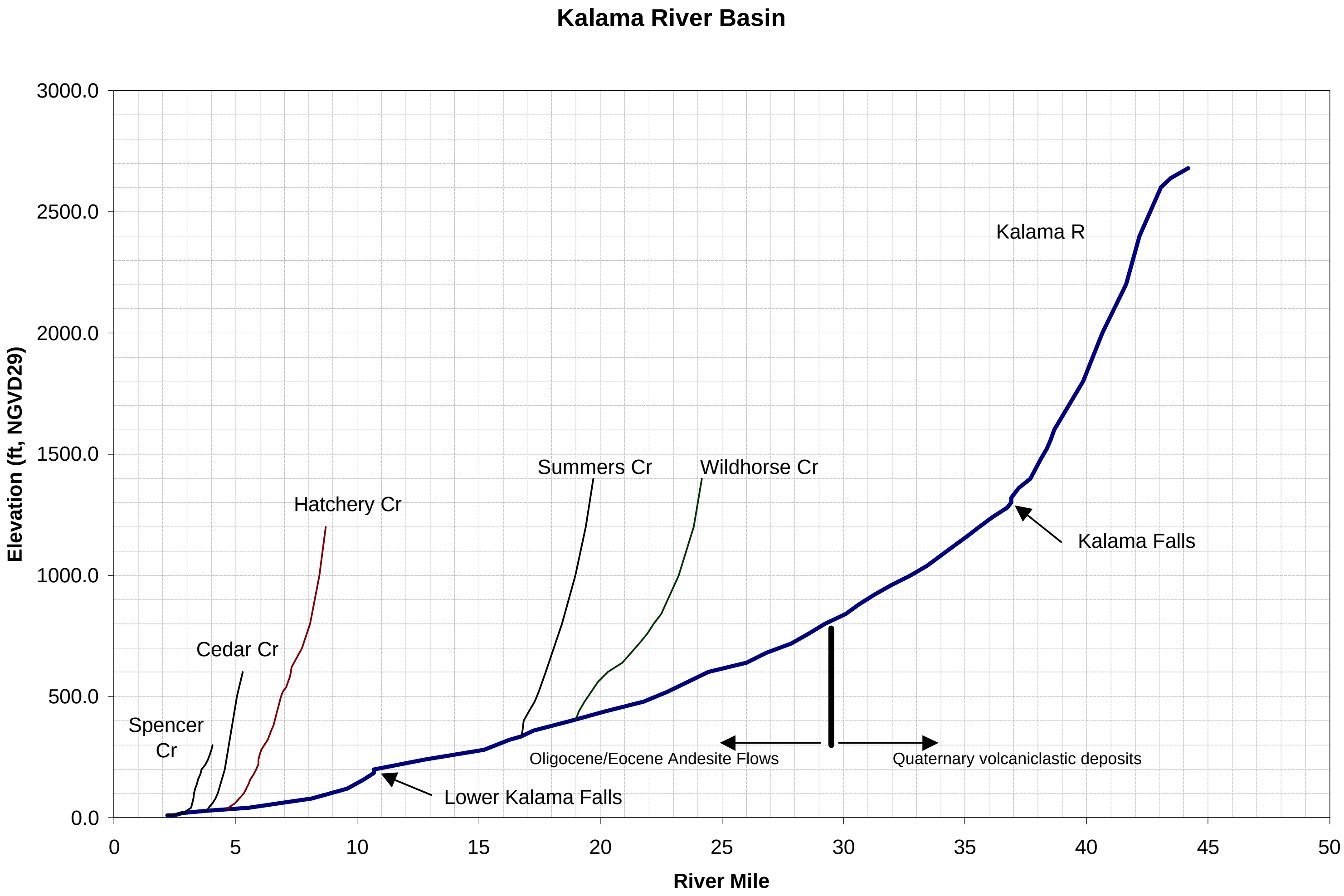


Figure 2-3. Average longitudinal elevation profiles of the mainstem Kalama River and tributaries surveyed for the sediment task.

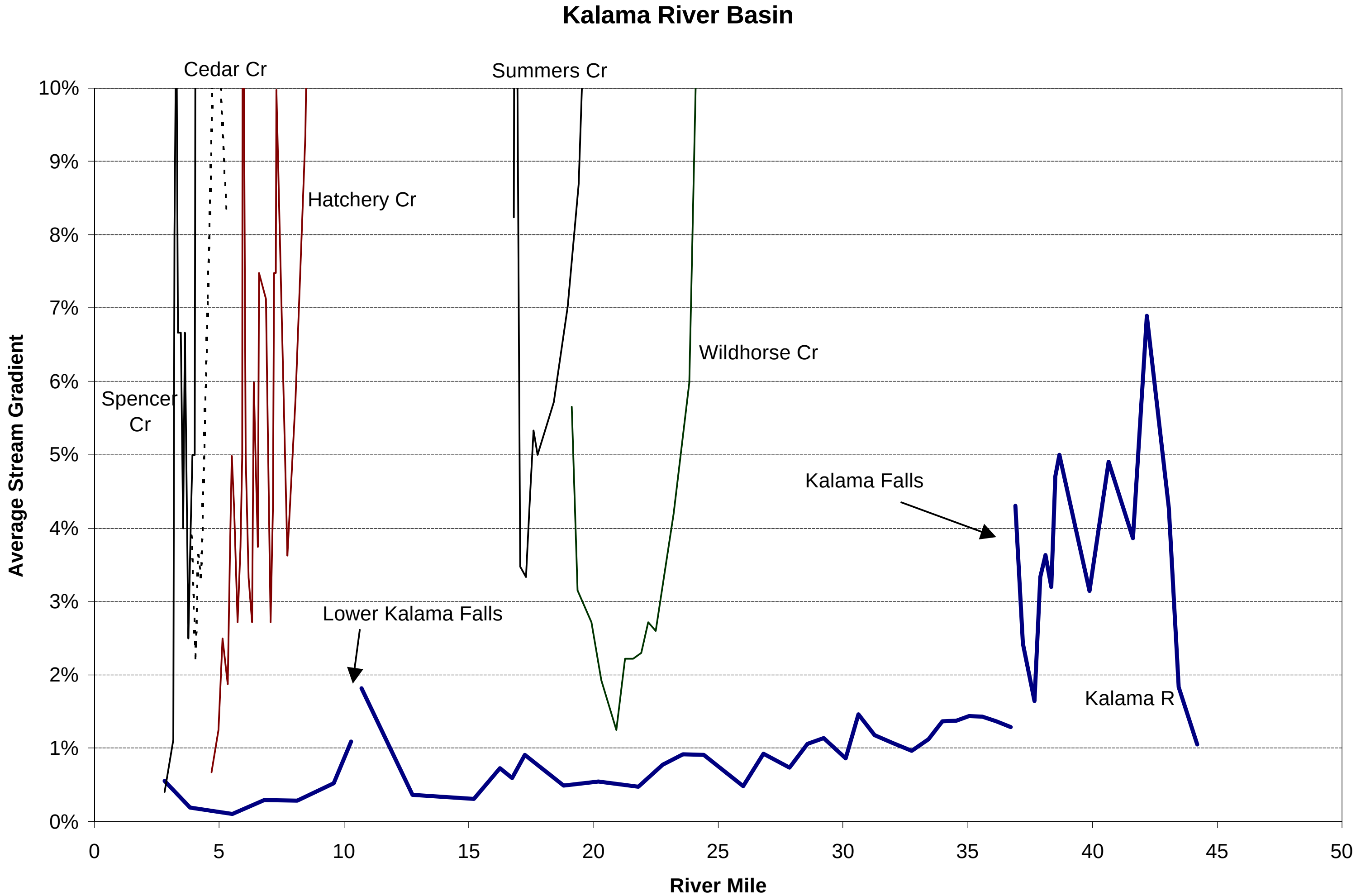


Figure 2-4. Average stream gradients in the mainstem Kalama River and tributaries surveyed for the sediment task.

above upper Kalama Falls, but the nature of the fines differed substantially from fines below the falls. Below Arnold Creek, fines included a large fraction of fine to medium sands, whereas above upper Kalama Falls fines were more ash- and clay-like in nature. In addition, the fines in the upper river formed a cohesive matrix between large substrate particles that was not readily eroding. There were few in-channel deposits of fines between the lowermost alluvial section and upper Kalama Falls. The upstream-downstream difference and limited presence of in-channel storage indicated the source of fines to salmon and steelhead spawning beds in the mainstem Kalama River below Kalama Falls was derived from tributaries. Embeddedness levels in most of the tributaries visited was high, in the 75-100 percent classes (Table 2-8). These levels were high relative to streams draining comparable geologic units within the Washougal River basin. Thus, we expect a significant land use activity has influenced sediment delivery to tributary channels.

Of the tributaries surveyed, embeddedness levels were lowest in Hatchery Creek (Table 2-8), where the magnitude (around 25 percent) was associated with good conditions for salmonid fish reproductive success (Chapman and McLeod 1987). Embeddedness levels observed in the other tributaries surveyed were associated with much poorer reproductive conditions for salmonids as influenced by fine sediments, as described below.

- Spencer Creek was observed to be heavily embedded throughout its lower gradient reaches up to and above the road crossing near elevation 20 ft, including the upper alluvial reaches with heavy riparian vegetation. In part, this embeddedness may have been a reflection of the local low gradient, such that transport capacity has been insufficient to balance the sediment supply. Spencer Creek flows across the Kalama River floodplain, which is comprised of primarily sand and silt in the upper 8-10 ft strata near the stream’s mouth. Suitable spawning habitat is probably restricted to a short section in the vicinity of the first major change in slope, near the elevation 40 ft contour on the Kalama 1:24,000 topographic map and above the Kalama River floodplain. However, access was not obtained to verify this assumption. Channel gradients are generally greater than 3 percent above elevation 40 ft (Figure 2-4).

- The lowermost reaches of Cedar Creek are steeper than Spencer Creek and had lower observed embeddedness levels (Table 2-8). However, embeddedness levels were still relatively high, including upstream of the Faber Road crossing at elevation 240 ft. The high fines load may have been a reflection of a combination of natural geology, development, and timber harvest. The channel is small and would not be expected to have a high sediment transport capacity.

- Summers Creek was observed to contain large sand deposits, and there was active timber harvest occurring upstream. Lobes of sub-angular gravel were seen near the mouth and may have been a reflection of episodic input and transport events. These lobes could conceivably support limited spawning, but the current high fines load may preclude good reproductive conditions. In addition, the channel passes through a culvert under the Kalama River Road near its mouth that appeared to pose a passage barrier.

- Wildhorse Creek contained coarser sand deposits than Summers Creek. There were relatively fewer deposits of fines and small gravel seen at the mouth, suggesting a moderate sediment load overall in Wildhorse compared to Summers Creek. Embeddedness levels collected during the Level II stream surveys higher in the Wildhorse basin, averaged near the 50 percent class. These data appeared to be lower than embeddedness ratings near the mouth (~75 percent; Table 2-8). Nonetheless, sand composed a large fraction (33 percent) of substrate surface area in the Level II surveyed reach, which had an average longitudinal gradient around 3 percent. This result indicates increased fine sediment delivery over natural conditions.

Sedimentation at Mouth of Kalama River

A sand/silt deposit at the mouth of the Kalama River has been thought to present an upstream passage barrier to adults during low tide, and potentially increased vulnerability of outmigrating smolts to avian predation in shallow water (LCFRB 2004). The deposited materials likely originated mostly from the Kalama basin, which can be inferred from the Kalama 1:24,000 USGS topographic map by the presence of tidal sand flats extending across the mouth and downriver in the Columbia River. The condition of the deposit may have been influenced by reduced spring freshets caused by construction and operation of the Federal Columbia River Power System (FCPRS; NOAA 2004). It is possible that increased sediment delivery from mid-basin tributaries and erosion of unprotected banks in the lower river have contributed to the deposition.

Implications of Embeddedness Data

The Kalama basin has experienced a large number of mass wasting events since 1996 (LCFRB 2004). In addition, the aerial photographs and USGS 1:24,000 topographic maps indicate the middle basin has experienced substantial timber harvest and road building activity between and including the Summers Creek/Knowleton Creek sub-basins and the North Fork/Lakeview Peak Creek sub-basins. Each major tributary within the sub-basins drain a large number of unpaved road crossings compared with the other project basins. Access restrictions made it impossible to visit most mid-watershed tributaries. The tributaries visited had high levels of embeddedness (e.g., Summers Creek, where active timber harvest was underway). This observation suggests fine sediment delivery to channels was occurring in association with, at minimum, a high density of logging road crossings.

Comparison of Data With the EDT Model's Hypothesized Embeddedness Ratings

The EDT model defined percent embeddedness as the extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. In this assessment, embeddedness was determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. The embeddedness attribute only applies in the EDT model to values in riffle and tailout habitat units, and only where cobble or gravel substrates occur. The ratings applied in the model are as follows.

Percent Embeddedness	EDT Rating
0-9%	0
10-24%	1
25-49%	2
50-89%	3
90-100%	4

In the EDT model, the pristine (template) conditions were assumed to be associated with a rating 0.5 for embeddedness (i.e., generally less than 10%) throughout the Kalama basin, based on expert opinion (attributed to Glaser). Current conditions were estimated indirectly assuming that embeddedness levels correlate with percent fines levels. It was assumed further that percent fines (and thus embeddedness) increased by 1.3% (assumed here to be absolute) as road density increased by 1 mile per square mile of drainage area. This factor was reported in the EDT database as having been determined by Rawding (unpublished citation) in the nearby Wind River basin. A scale was developed relating road density to percent fines and embeddedness. Road density values were taken from the LCFRB IWA data set for Hydrologic Unit Code (HUCs) in the Kalama watershed, and ranged from 5.1 to 7.4 mi/sq. mi. for HUCs with associated EDT reaches.

Comparison of the data collected in this study with the assigned EDT ratings indicated that modeled embeddedness levels were underestimated throughout the basin. If the EDT categorical ratings were accurate, the points depicted in Figure 2-5 would have been expected to fall within the diagonal range defining the EDT ratings. The EDT model should be revised to more accurately reflect current conditions.

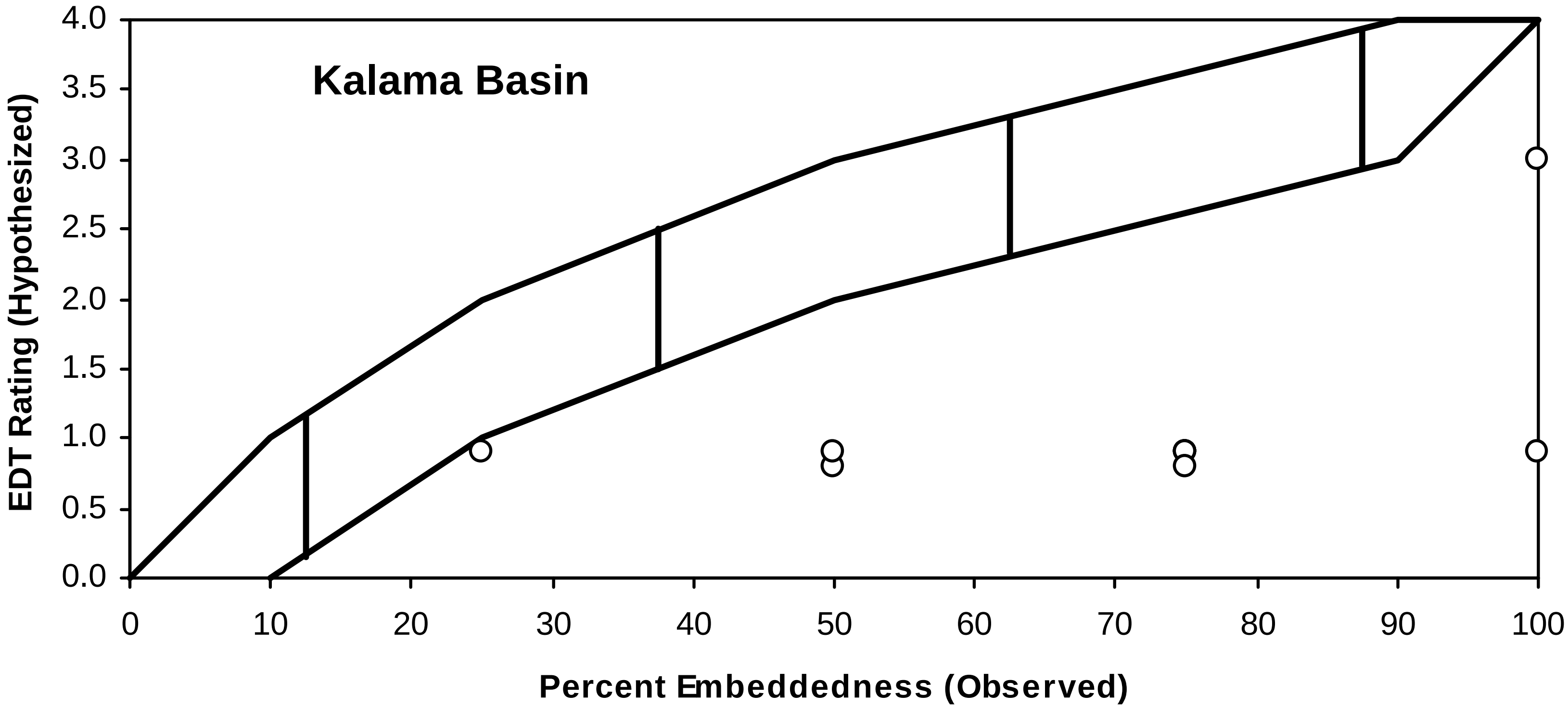


Figure 2-5. Comparison of embeddedness data collected in the Kalama basin for the sediment task (horizontal axis) with ratings assigned to the respective EDT reach (and represented in LCFRB 2004). The hypothesized EDT ratings were consistent with field data when the observed data points fall within the respective diagonal ranges (which define the range of embeddedness values assigned to each EDT rating).

Pebble Counts and Spawning Gravel Distributions

Of the sub-basins surveyed, coho salmon were either known or presumed to spawn in the mainstem Kalama below lower Kalama Falls, Spencer Creek, and Cedar Creek. Steelhead trout spawning was the most widely distributed, having been documented in the mainstem below upper Kalama Falls and in nearly all tributaries surveyed except Summers Creek, which may reflect the presence of the Kalama River Road culvert. Chinook salmon were reported to spawn primarily in the mainstem Kalama River between RM 4.8 and lower Kalama Falls, although some spawning has been noted above the falls. Chum salmon historically spawned in the mainstem Kalama River between RM 2.4 and lower Kalama Falls (LCFRB 2004). Of the stream channels sampled for this project, Hatchery Creek and Wildhorse Creek contained the best mix of spawning gravels for salmon and steelhead (Figure 2-6).

The pebble counts indicated the Kalama River was not gravel-starved with respect to supplying spawning mainstem habitat. However, most usable deposits appeared to be concentrated below lower Kalama Falls. The point bar deposit sampled immediately upstream of lower Kalama Falls in Kalama 6 contained the best mix of spawning sized material of the three mainstem sites where pebble counts were performed (Figure 2-6). Above the falls, the channel was confined with a bed composed of primarily boulder, large cobble, and bedrock, and spawning substrate material was most evident as high elevation deposits across the channel cross-section, either on point or mid-channel bars. The pebble count in Kalama 11 was conducted over a mid-channel bar, which appeared to exist in response to a nearly buried bedrock and boulder control. The bar did not appear usable in general for spawning, and little mainstem spawning habitat was evident between Arnold Creek and lower Kalama Falls during the survey. Most mainstem spawning that might occur upstream would be expected to occur nearer upper Kalama Falls at the major gradient change (Figure 2-3).

The Little Kalama River and Hatchery Creek were observed to have more prominent alluvial deposits of gravel and cobble at their mouths than other tributaries below Arnold Creek (access was not provided above Arnold Creek). Most tributaries appeared to have relatively little gravel at their mouths. Hence, it can be inferred that Hatchery Creek and the Little Kalama River would likely contain the highest quantity of tributary spawning habitat.

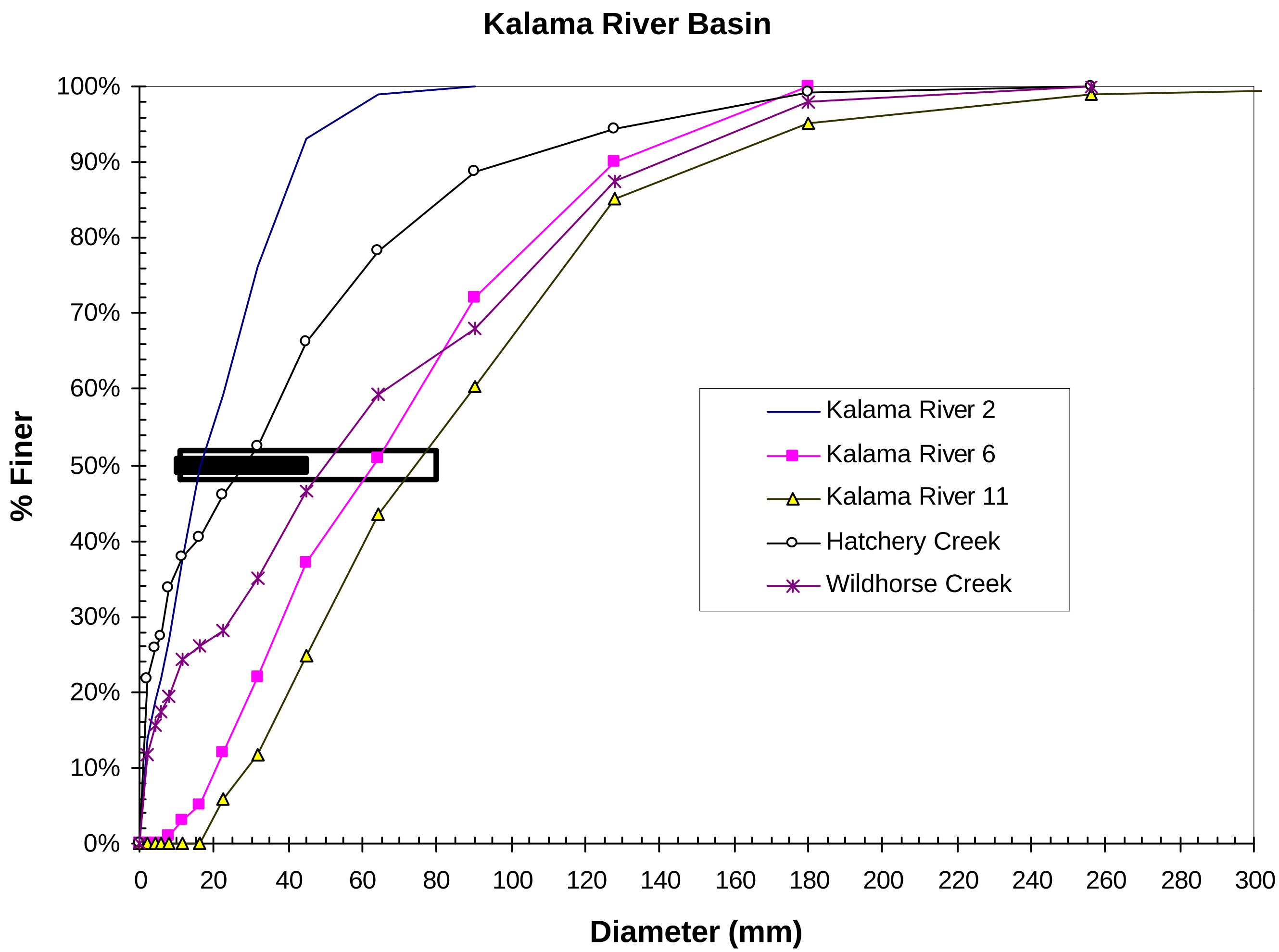


Figure 2-6. Grain size distributions of pebble counts collected in the Kalama River basin for the sediment task. The horizontal bars represent the range of D_{50}'s reported by Kondolf and Wolman (1993) as suitable for steelhead trout (filled bar) and Chinook salmon (open bar) spawning.

2.3 SYSTEM WEAKNESS, STRENGTHS AND OPPORTUNITIES

The primary goal of the enhancement strategy for the Lower Columbia Watershed Assessment was to identify system strengths and weaknesses and where appropriate identify restoration opportunities. Restoration was focused on re-establishing natural watershed processes that formed and maintained fish habitat prior to changes resulting from historic and current land-use practices. Restoration, therefore, includes three main components: (1) restoration of habitat connectivity; (2) restoration of upslope and riparian geomorphic processes; and (3) rehabilitation of degraded habitats. This restoration approach is consistent with that outlined by NMFS scientists in their NWFSC Watershed Program (Roni et al. 2002).

2.3.1 Identification of System Weakness

Habitat weaknesses identified during the watershed assessment process are summarized below.

- 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.
- Pool habitats were infrequent and shallow in the tributaries reaches surveyed.

- 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.

2.3.2 Identification of System Strengths

Habitat strengths identified during the watershed assessment process are summarized below.

- Hydromodifications were notably absent from stream banks in the between RM 1.3 and RM 2.5 (upstream part of Kalama 1 and downstream part of Kalama 2).
- Approximately only 5 percent of historic generalized floodplain, has been developed and contains a moderate proportion of impervious surfaces. Thus, hydromodifications within in the analysis area were not considered to have adversely affected the Kalama River flow regime.
- Conifer and mixed conifer:hardwood stands were prevalent at 96 percent of total riparian habitat.
- Substrate in Kalama reaches 2, 3, 4, 6 and 7 indicated the presence of good spawning habitat.
- On a relative basis, the instream LW was common in tributary reaches surveyed.
- Wildhorse Creek appeared to be good habitat for salmonid spawning as it contained an abundance of spawning gravels and high counts of large wood.
- Hatchery Creek and the little Kalama River contain more extensive tributary spawning habitat.

2.3.3 Restoration/Protection Opportunities

The habitat conditions for the Kalama basin were reviewed and the data from subdisciplines were synthesized into appropriate opportunities for preservation and or protection throughout the basin. Potential restoration opportunities were prioritized by: (1) emphasizing preservation and protection of areas that currently function normally, (2) considering actions that help to restore overall system function and (3) considering the distribution of and likely habitat use by anadromous salmonid fishes.

As compared with the nearby Lewis and Washougal River basins, the Kalama River has the greatest remaining proportion of unmodified, naturally functioning floodplain habitat. Because the spatial area subject to hydromodifications extends beyond the channel itself, future restoration should focus on preserving areas with existing functional floodplain and natural channel margins.

Recommended categories of management actions for the improvement of riparian conditions in the Kalama River Basin, include protecting existing riparian vegetation and promoting recovery were possible. Efforts to preclude future human-induced encroachment into the riparian zone or reversal of prior encroachment should be considered. Riparian restoration project can be implemented where opportunities arise to breach dikes and in areas where floodplain connectivity is re-established. Riparian improvements are limited in lower Kalama mainstem since these reaches likely offered a naturally low shade and wood recruitment level. The reaches lying in the existing and historic Kalama River and Columbia River floodplains likely experienced a frequent disturbance history in the riparian zone.

With respect to in-channel habitat restoration opportunities, the large, contained mainstem reaches offer a good level of stream power. Wood placement opportunities may be restricted to massive engineered log-jams in the unconstrained portions of the lower Kalama River. Channel morphologies in the large, contained canyon reaches are less responsive to woody debris inputs than the unconfined reaches and in-channel restoration effort is not recommended.

Instream fine sediment levels were very high in the Kalama basin. Given the extent of road crossings and timber harvest in most of the tributaries discharging into the middle Kalama River below upper Kalama Falls, it does not appear feasible at this time to improve mainstem fine sediment levels by focusing on one or a few tributary basins. Effective measures must be applied in essentially all major tributaries to significantly reduce fine sediment loading from timber harvest activities, including road crossings.

No active measures are recommended at this time to directly create, enhance, or restore mainstem spawning habitat, given the high level of fines that limit the utility of spawning gravel enhancement in the mainstem. Fine sediment inputs should be reduced first throughout the basin. In addition, the confined nature of the channel between lower Kalama Falls and Arnold Creek (the upper limit to this survey) is not conducive to implementing active measures for trapping substrates in quantities and locations suitable for spawning. The mid-channel bar sampled in the Kalama 11 EDT reach indicates that any efforts to trap gravel and small cobble would be successful only through creation of a significant hydraulic control to force local deposition. Such a measure would likely be expensive and require extensive engineering and geomorphic analysis. Even if undertaken, there is some risk the project would result in trapping material at elevations that may not be usable during the spawning season or be protected from scour during winter and spring floods.

It is beyond the scope of this analysis to suggest measures that would change sedimentation conditions at the mouth of the Kalama River. A detailed sediment budget would be required to determine if sediment abatement-related restoration measures could potentially have a meaningful effect on the rate of fine sediment delivery to the mouth. In addition, hydraulic and sediment transport analyses would be needed to determine to what extent (if any) the condition reflects operations of the FCPRS, and if so, if there are any feasible operation changes that could potentially improve the situation. Moreover, such analyses would also be needed to determine if there are any feasible structural measures to change hydraulic and sediment transport conditions at the mouth. For example, such analyses are critical to determining if channel narrowing could help flush the channel, or if reconnection of the lower river to its floodplain would lead to deposition throughout the floodplain or whether aggradation would occur at or near the mouth regardless of any specific measure.

The following list of prioritized protection/restoration opportunities, based on the data and field observations, have the greatest potential for success and benefits to salmonid fishes. However, it is strongly recommended that additional, detailed studies be conducted to determine feasibility of these potential opportunities.

1. Preservation: south bank, RM 1.5 to 2.2

This area consists of a gently sloping alluvial terrace that currently supports intact forest, although the riparian stand age is not mature. At the upstream end of the area (RM 1.9 to 2.2) a large backwater/tributary confluence feature exists representing some of the only off-channel habitat found in the lower Kalama basin. The WDFW SSHIAP coverage depicts a road within this area, and occasional houses are mapped on USGS quad maps dating from 1990.

2. Preservation/restoration: north bank, RM 2.0 to 2.4

This area consists of an accreting point bar associated with a meander bend that has been slowly migrating downstream since 1942. The bar supports a 200 to 300 foot-wide band of intact, but sparsely stocked, forest. The area behind the forest is cleared but not developed and could be replanted to increase the extent of floodplain forest. A small backbar channel was noted on the historic photos of this area, but is not discernable on the current photo coverage. The bar configuration and possible presence of a relict channel suggest this site could represent an area where construction of artificial spawning channels or off-channel habitat fed by hyporheic flow could be developed.

3. Preservation/restoration: south bank, RM 2.2 to 2.35
This area consists of a high alluvial floodplain/terrace deposit where the river is actively eroding along the outside of a meander bend. Structures depicted on the 1990 topographic maps have been removed, and the area currently appears to be used as a park. Planting/restoration of forest vegetation in cleared areas could produce recruitable LW over the long-term, although the natural tendency for erosion may result in recruitment before the planted stand matures.

This area contains some existing forest including a low swale that was consistent with the 1942 Kalama channel location. The swale was currently bisected by a blocked dirt road, and an old excavated area forms a pond near the center of the former meander. The downstream end of this feature appeared to have been filled long ago. The potential for development of off-channel habitat at this site is limited due to the elevation of the alluvial terrace. However, there may be some potential to develop off-channel rearing habitat at the upstream end of the swale. Removal of the road and connection of the existing pond would require further study, and is not recommended at this time due to concerns regarding non-native predator species and elevated temperatures. Any project to develop off-channel rearing habitat at this site would require an intensive field-based feasibility study and engineering design work.

4. Preservation of the riparian habitat in Wildhorse and Hatchery creeks from encroachment is critical in these two tributaries to the Kalama River. Both tributaries offer good spawning habitat for salmonid fishes.

5. Prevent degradation of and enhance spawning substrates in Hatchery Creek and Wildhorse Creek. Currently, Hatchery Creek appears to contain a moderate fine sediment load. The basin has a notably lower road crossing density than upstream tributaries to the Kalama River. Preservation efforts should be concentrated in this sub-basin first, because it also contains a relatively large amount of spawning habitat with respect to the Kalama River basin as a whole. Of the streams surveyed, Wildhorse Creek had a relatively long segment with suitable gradient and adequate gravel supply, and thus, restoration measures in this tributary may have a reasonable probability of leading to measurable increases in salmonid production. However, fine sediment delivery must also be corrected for gravel enhancement efforts to be most productive. Nevertheless, this tributary appears to be most suited for spawning gravel retention measures of the tributaries surveyed.

6. Investigate the potential to increase the pool habitat area and the depth of pools in Wildhorse and Hatchery Creeks.

7. Investigate the potential for increased rearing habitat in low gradient areas between RM 1 and 2 on Wildhorse Creek.

8. Riparian Plantings.
Native riparian plantings are recommended for the following surveyed reaches: Kalama 1, 2, 3, 4, 6, 7, lower Hatchery Creek and un-surveyed reaches with "impaired" riparian function ratings shown in Map 2-2.

9. Treat fine sediment sources upstream of Langdon Creek. It is possible that focusing first on tributaries above Langdon Creek could improve fine sediment levels in steelhead spawning areas near upper Kalama Falls (although the condition of the river in that reach could not be ascertained because of access limitation).

10. Limit bank hardening. If future maintenance or reconstruction projects are required, incorporation of large wood into armored banks would improve habitat conditions for juvenile salmonid fishes rearing along the stream margins.

11. Fine sediment levels in both Cedar and Spencer creeks are high. The extent of fine sediment abatement activities needed to measurably improve spawning habitat conditions would likely be extensive. It could take a relatively long time for the two channels to process their existing loads until embeddedness levels reach 50 percent or lower. Consequently, restoration measures to reduce fine sediment levels in these two streams should be accorded lower priority than in Hatchery Creek, Wildhorse Creek, and potentially in the Little Kalama River.

12. Consider development of a chum salmon spawning channel along north bank near RM 2.0. See North Bank preservation/restoration opportunity #2.

13. Substrate enhancement in the Little Kalama. While the Little Kalama River was not surveyed in the field as part of this project, a review of the 1:24,000 scale topographic maps and impressions based on visual observations of the deposit at the confluence with the Kalama River stream suggest this tributary might also benefit from focused restoration efforts to reduce fine sediments and enhance spawning gravel. Segments with suitable gradients (<3 percent) exist,

gravel supply appears favorable and large portions of the riparian zone offer functional habitat conditions, such that further analysis of this sub-basin for restoration potential is recommended.

14. Depending on how much effect the hatchery stock has had on the local gene pool, and the future role of the hatchery in restoring wild populations (Brannon et al. 2004), resolving passage issues at the hatchery weir would open up some of good tributary spawning habitat in the basin to more fish.

15. One important, indirectly related measure for improving reproductive success was indicated during the field survey, which was conducted during the Chinook spawning season. Large numbers of fishermen were observed to be attempting to catch spawning Chinook throughout the river below lower Kalama Falls. Restriction of this fishery would likely be more effective at increasing production than in-channel restoration measures, given that there appear to be few if any cost-effective opportunities for increasing mainstem spawning habitat abundance.

Table 2-8. Prioritized protection/enhancement opportunities for the Kalama River basin by geographic area. Detailed project descriptions are found in section 2.3 of the report. NA indicates no corresponding EDT reach.

Location	EDT Reach/RM	Opportunity	Short Description	Priority
Mainstem Kalama	Kalama 1 & 2/ RM 1.5 to 2.2	Preservation of South bank.	Maintain alluvial terrace and intact forest. Maintain off channel habitat associated with a large backwater/tributary confluence near the upstream end of the area (RM 1.9 to 2.2).	1
Mainstem Kalama	Kalama 2/ RM 2.0	Spawning channel development.	Consider the development of a chum spawning channel along the North bank.	13
Mainstem Kalama	Kalama 2/ RM 2.0 to 2.4	Preservation and restoration of North bank.	Maintain accreting point bar and associated forest. Replant cleared but undeveloped area behind the forest	2
Mainstem Kalama	Kalama 2/ RM 2.2 to 2.35	Preservation and restoration of the South bank.	Riparian planting in cleared areas. Creation of off channel habitat at upstream end of the existing swale.	3
Mainstem Kalama	Kalama 1,2,3,4,6,7/ RM 0.0 to 17.3	Riparian Planting	Plant native riparian vegetation in surveyed areas.	8
Mainstem Kalama	Kalama 1,2,3,4,5,6,7/ RM 0.0 to 17.3	Limit bank modification.	Avoid future bank hardening. If future projects require bank protection incorporate large wood into these efforts to improve fish habitat.	10
Mainstem Kalama	Kalama 1,2,3,4,5,6,7/ RM 0.0 to 17.3	Add large wood to existing armored banks.	Take opportunities to add large wood into armored banks during future maintenance or repair activities.	11
Mainstem Kalama	Kalama Falls	Tighter Fishery Regulations or enforcement.	Reduce numbers of returning Chinook salmon removed from the population by the fishery below Kalama Falls.	16
Hatchery Creek	Hatchery Creek/RM 1 to 3	Riparian habitat preservation.	Protect healthy riparian habitat from encroachment to preserve good spawning conditions for salmon.	4
Hatchery Creek	Hatchery Creek/ RM 1 to 3	Prevent degradation of spawning substrates.	Hatchery Creek has moderate fine sediment load. Keep road crossing density low to maintain healthy spawning habitat.	5
Hatchery Creek	Hatchery Creek/ RM 1 to 3	Enhance pool habitat.	Increase the number of deep pools in the creek.	6

Table 2-8. Prioritized protection/enhancement opportunities for the Kalama River basin by geographic area. Detailed project descriptions are found in section 2.3 of the report. NA indicates no corresponding EDT reach.

Location	EDT Reach/RM	Opportunity	Short Description	Priority
Hatchery Creek	Hatchery Creek/ RM 1 to 3	Passage at the hatchery weir.	Consider passage at the hatchery weir to open up better spawning habitat above to wild fish.	15
Little Kalama River	NA	Substrate enhancements.	Efforts to determine potential for reducing fine sediments and enhance spawning gravels are recommended.	14
Wildhorse Creek	Wildhorse Creek/ RM 1 to 4.8	Improve spawning substrates.	Wildhorse Creek has a long segment with suitable spawning gravels and good supply. Fine sediment delivery is too high and needs to be corrected. Gravel retention measures may also be effective in this tributary.	5
Wildhorse Creek	Wildhorse Creek/ RM 1 to 4.8	Preservation of riparian habitat.	Protect healthy riparian habitat from encroachment to preserve good spawning conditions for salmon.	4
Wildhorse Creek	Wildhorse Creek/ RM 1 to 4.8	Enhance pool habitat.	Increase the number of deep pools in the creek.	6
Wildhorse Creek	Wildhorse Creek/ Between RM 1 and 2.	Enhance rearing habitat.	Investigate the potential to increase salmon rearing habitat in low gradient areas.	7
Upper Tributaries	NA	Reduce sediment inputs.	Reduced sediment from tributaries above Langdon Creek could improve spawning conditions in lower mainstem river reaches.	9
Spencer and Cedar creeks	NA	Reduce sediment levels.	Extensive and long term fine sediment abatement activities would be needed to measurably improve spawning habitat conditions.	12

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APPENDIX 2A

Large Wood Recruitment Potential and Shade Ratings for Each EDT Reach in Kalama Basin

Based on
Aerial Photograph Assessment Data
(2002/2003 Photo Data Sets)

Case	Freq.	EDT Reach Name	lb		rb		Shade		Length	Length (ft)					
			Code	Hazard	Code	Hazard	Code	(%)	(ft)						
1	1	Arnold Creek	CSD	High	CSD	High	1	10	5833					5833	5833
2	1	Arnold Creek	CSD	High	MSS	High	1	10	3600					3600	3600
3	1	Arnold Creek	MMD	Low	MMD	Low	3	55	1832	1832	1832				
4	5	Arnold Creek	MSD	High	MSD	High	2	30	7254					7254	7254
5	1	Arnold Creek	MSS	High	MSS	High	1	10	1046					1046	1046
6	1	Bear Creek	MSS	High	MSS	High	1	10	11146					11146	11146
7	1	Bush Creek	MMD	Low	MMD	Low	3	55	2426	2426	2426				
8	1	Bush Creek	MSD	High	MSS	High	1	10	2346					2346	2346
9	1	Cedar Creek	MMS	Mod	MMS	Mod	2	30	4212			4212	4212		
10	1	Dee Creek	CMD	Low	CMS	Mod	4	80	1515	1515			1515		
11	1	Dee Creek	CSS	High	CSD	High	3	55	2809					2809	2809
12	1	Elk Creek	MSS	High	MSS	High	1	10	1541					1541	1541
13	1	Gobar Creek	MMD	Low	MMD	Low	3	55	1973	1973	1973				
14	1	Gobar Creek	MMD	Low	MSS	High	2	30	880	880					880
15	3	Gobar Creek	MSS	High	MSS	High	1	10	6666					6666	6666
16	1	Hatchery Creek	CMS	Mod	CMS	Mod	2	30	6722			6722	6722		
17	1	Hatchery Creek	MSS	High	MSS	High	1	10	9141					9141	9141
18	1	Indian Creek	MSS	High	MSS	High	1	10	1461					1461	1461
19	1	Jacks Creek	CSD	High	CSD	High	3	55	2858					2858	2858
20	1	Jacks Creek	CSS	High	CSS	High	1	10	6186					6186	6186
21	2	Kalama 1 tidal	MMD	Low	MMS	Mod	2	30	4926	4926			4926		
22	1	Kalama 1 tidal	MSS	High	MMS	High	1	10	8630					8630	8630
23	1	Kalama 10	MMD	Low	MMS	Mod	3	55	2108	2108			2108		
24	2	Kalama 10	MSD	High	MMS	Mod	2	30	873				873	873	
25	1	Kalama 11	MSD	High	MMS	Mod	2	30	1164				1164	1164	
26	2	Kalama 11	MSD	High	MSS	High	2	30	5531					5531	5531
27	2	Kalama 12	MSS	High	MSS	High	1	10	1341					1341	1341

Case	Freq.	EDT Reach Name	lb		rb		Shade		Length	Length (ft)					
			Code	Hazard	Code	Hazard	Code	(%)	(ft)						
28	1	Kalama 13	CLD	Low	MSS	High	2	30	1871	1871					1871
29	1	Kalama 13	CMD	Low	CSD	High	2	30	1784	1784					1784
30	2	Kalama 13	CSD	High	CSD	High	1	10	3938					3938	3938
31	3	Kalama 13	CSD	High	MSS	High	1	10	5331					5331	5331
32	1	Kalama 13	CSS	High	CSD	High	1	10	3209					3209	3209
33	1	Kalama 13	MSD	High	MSS	High	1	10	2301					2301	2301
34	1	Kalama 13	MSS	High	MSS	High	1	10	1070					1070	1070
35	2	Kalama 14	CSD	High	MSS	High	1	10	425					425	425
36	1	Kalama 14	CSD	High	MSS	High	2	30	1372					1372	1372
37	1	Kalama 14	MSS	High	MSS	High	1	10	2381					2381	2381
38	1	Kalama 15	CMD	Low	MMD	Low	3	55	2442	2442	2442				
39	1	Kalama 15	CMD	Low	MSS	High	1	10	1052	1052					1052
40	2	Kalama 15	CSD	High	MMD	Low	2	30	2779		2779			2779	
41	1	Kalama 15	MSS	High	MMD	Low	2	30	2927		2927			2927	
42	2	Kalama 16	CSD	High	CMD	Low	2	30	2398		2398			2398	
43	3	Kalama 16	CSD	High	MSS	High	1	10	4050					4050	4050
44	1	Kalama 16	MSS	High	CSD	High	1	10	2159					2159	2159
45	2	Kalama 16	MSS	High	MSS	High	1	10	5567					5567	5567
46	1	Kalama 17	MSD	High	MMD	Low	3	55	5898		5898			5898	
47	2	Kalama 17	MSD	High	MSS	High	2	30	744					744	744
48	2	Kalama 18	CSD	High	CSD	High	1	10	2311					2311	2311
49	1	Kalama 18	MSS	High	CSD	High	1	10	756					756	756
50	1	Kalama 18	MSS	High	MSS	High	1	10	4431					4431	4431
51	3	Kalama 19	CSD	High	CSD	High	2	30	5463					5463	5463
52	1	Kalama 19	CSD	High	CSS	High	2	30	4038					4038	4038
53	1	Kalama 2	CLD	Low	MMS	Mod	2	30	3017	3017			3017		
54	2	Kalama 2	MMS	Mod	MMS	Mod	2	30	6057			6057	6057		

Case	Freq.	EDT Reach Name	lb		rb		Shade		Length	Length (ft)					
			Code	Hazard	Code	Hazard	Code	(%)	(ft)						
55	2	Kalama 20	MSD	High	MSD	High	2	30	5160					5160	5160
56	1	Kalama 21	C;L	Low	CLD	Low	3	55	1486	1486	1486				
57	1	Kalama 21	CSD	High	CSD	High	2	30	7716					7716	7716
58	2	Kalama 3	MMS	Mod	MMS	Mod	2	30	5327			5327	5327		
59	2	Kalama 4	MMD	Low	MMS	Mod	2	30	12512	12512			12512		
60	1	Kalama 4	MMS	Mod	MMS	Mod	2	30	1549			1549	1549		
61	1	Kalama 5	MMD	Low	MMD	Low	2	30	2168	2168	2168				
62	1	Kalama 5	MMD	Low	MMD	Low	3	55	4813	4813	4813				
63	2	Kalama 5	MMD	Low	MMS	Mod	2	30	8966	8966			8966		
64	3	Kalama 6	HMD	Mod	MMS	Mod	2	30	11013			11013	11013		
65	1	Kalama 6	MMD	Low	DSS	High	2	30	1724	1724					1724
66	1	Kalama 6	MMS	Mod	DSS	High	2	30	649			649			649
67	1	Kalama 6	MMS	Mod	MMS	Mod	2	30	2860	2860	2860				
68	1	Kalama 7	CLD	Low	MMD	Low	3	55	3792	3792	3792				
69	1	Kalama 7	CSS	High	MMS	Mod	2	30	3101				3101	3101	
70	1	Kalama 7	MMD	Low	MMD	Low	2	30	1041	1041	1041				
71	2	Kalama 7	MMD	Low	MMS	Mod	2	30	731	731			731		
72	1	Kalama 7	MMS	Mod	MMS	Mod	2	30	3624			3624	3624		
73	1	Kalama 7	MMS	Mod	MMS	Mod	3	55	4957			4957	4957		
74	1	Kalama 8	MMD	Low	MMS	Mod	2	30	1945	1945			1945		
75	1	Kalama 9	MMD	Low	MMD	Low	3	55	3570	3570	3570				
76	3	Kalama 9	MMD	Low	MMS	Mod	2	30	1176	1176			1176		
77	1	Kalama 9	MMS	Mod	MLS	Mod	2	30	1069			1069	1069		
78	1	Kalama 9	MMS	Mod	MMS	Mod	2	30	472			472	472		
79	1	Kalama 9	MSS	High	MLS	Mod	2	30	1063				1063	1063	
80	1	Kalama 9	MSS	High	MMD	Low	2	30	2801		2801			2801	
81	1	Knowlton Creek	HSD	High	HSD	High	2	30	1509					1509	1509

Case	Freq.	EDT Reach Name	lb		rb		Shade		Length	Length (ft)					
			Code	Hazard	Code	Hazard	Code	(%)	(ft)						
82	2	Lakeview Peak Creek	CSD	High	CSD	High	1	10	4540					4540	4540
83	2	Lakeview Peak Creek	MSS	High	MSS	High	1	10	13391					13391	13391
84	1	Langdon Creek	CSD	High	CSD	High	1	10	14795					14795	14795
85	1	Little Kalama River	CLD	Low	CLD	Low	4	80	3417	3417	3417				
86	1	Little Kalama River	CSD	High	CSD	High	3	55	2772					2772	2772
87	2	Little Kalama River	CSD	High	CSS	High	2	30	3445					3445	3445
88	1	Little Kalama River	MMD	Low	MMD	Low	4	80	4324	4324	4324				
89	1	Lost Creek	MSS	High	MSS	High	1	10	3487					3487	3487
90	1	Lower Falls					0	0	5						
91	4	NF Kalama River	CSD	High	CSD	High	2	30	15809					15809	15809
92	1	NF Kalama River	CSD	High	MSS	High	1	10	2423					2423	2423
93	2	NF Kalama River	MSS	High	CSD	High	1	10	4244					4244	4244
94	2	NF Kalama River	MSS	High	MSS	High	1	10	5856					5856	5856
95	1	Spencer Creek	MMS	Mod	MMD	Low	3	55	2944		2944	2944			
96	1	Spencer Creek	MMS	Mod	MSS	High	1	10	4142			4142			4142
97	1	Summers Creek	MMD	Low	MMD	Low	4	80	679	679	679				
98	1	Unnamed Creek (27.0087)	MSS	High	MSS	High	1	10	7011					7011	7011
99	1	Wildhorse Cr	CLD	Low	CLD	Low	3	55	5219	5219	5219				
100	2	Wildhorse Cr	HSS	High	HSS	High	1	10	12865					12865	12865
101	1	Wildhorse Cr	MMS	Mod	MMS	Mod	0	0	2933			2933	2933		
102	1	Wildhorse Cr	MMS	Mod	MMS	Mod	1	10	4322			4322	4322		
103	1	Wolf Creek	CSD	High	CSD	High	3	55	5377					5377	5377
							103	28	406583	86246	61789	59991	95351	260341	249439
	43 EDT Reaches								77	16	12	11	18	49	47

Case	Freq.	EDT Reach Name	lb		rb		Shade		Length	Length (ft)					
			Code	**Hazard**	**Code**	**Hazard**	**Code**	**(%)**	**(ft)**						
		LW Recruitment Potential	Poor	58	Poor	56	114	56%	124	26	19	18	29	79	76
			Fair	16	Fair	26	42	21%							
			Good	28	Good	20	48	24%	154		28		29		97
											18%		19%		63%
		Observations	N =	102		102	204	100%							
											Good		Fair		Poor
		Conifer	C	36	C	26	62	30%			LW Recruitment Potential				
		Mixed	M	63	M	72	135	66%							
		Deciduous	D	3	D	4	7	3%							
							204	100%							
		Small	S	58	S	55	113	55%							
		Medium	M	38	M	42	80	39%							
		Large	L	6	L	5	11	5%							
							204	100%							
		Sparse	S	42	S	62	104	51%							
		Dense	D	60	D	40	100	49%							
							204	100%							

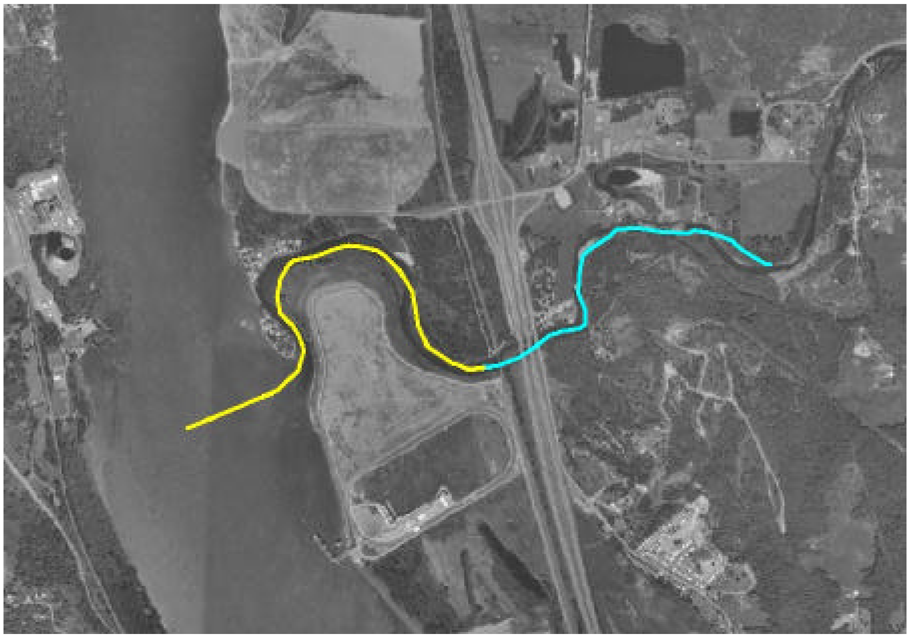
APPENDIX 2B

Stream Inventory
Reach Summaries
for Kalama Basin

KALAMA RIVER 1-TIDAL

INTRODUCTION

Kalama River 1-tidal is the lowermost mainstem reach of the Kalama River as it enters the Columbia River at RM. This reach is tidally influenced. In the lowermost 1.4 river miles the river lies within the historic Columbia River floodplain and the channel is constrained by armored banks or levees on both sides. From RM 1.4 to 2.2 the channel is unconstrained by levees, but it remains tidal in nature. The lowermost 1.2 miles of this reach were floated by boat as highlighted in yellow in Map B-1.



Map B-1. Portion of Kalama 1-tidal surveyed.

CHANNEL MORPHOLOGY

Kalama 1-tidal is a large palustrine to estuarine channel with a dune-ripple bedform. It is comprised entirely of glide habitat type (Figure B-1). Depending upon river discharge and the tidal stage, reverse stream flows are possible.

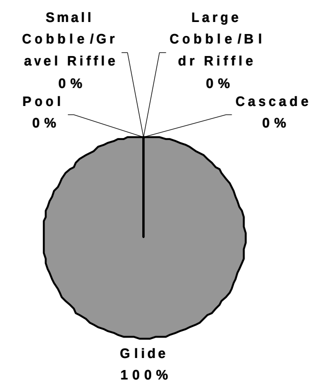


Figure B-1. Unit composition by percent surface area of the surveyed section of Kalama 1-tidal.

Kalama 1 is very low gradient < 1 percent and currently confined within levees and armored banks. The wetted width during the survey averaged 64 m (210 ft). The maximum depth of pools averaged greater than 3 m (10 ft). See Table B-1.

Table B-1. Average channel morphology characteristics of surveyed sections of Kalama 1-tidal.

Parameter	Reach Value
Mean gradient	< 1.0%
Mean wetted width (m)	64.0 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual Pool depth (m)	NA
Mean of the maximum pool depths (m)	> 3 m
Pools per kilometer (p/km)	0.0
Primary pools (>1.0m deep) per kilometer	0.0

WOOD

There were 35.2 pieces of large woody debris per kilometer (LW/km) recorded in Kalama 1 during the summer of 2004, but most (> 60%) were of the small size class of woody debris pieces (Table B-2). There were no jams or root wads observed during the survey.

Table B-2. Size and density of wood, jams and root wads in surveyed section of Kalama 1-tidal.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	21.5
Medium Pieces	20-50 cm diameter; > 2 m long	11.5
Large Pieces	> 50 cm diameter; > 2 m long	1.6
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes in the glide habitat were sand and gravels, respectively. Based on the channel morphology sand is the most likely dominant particle size (Table B-3).

Table B-3. Substrate grain size composition in surveyed section of Kalama 1-tidal.

Category	Mean Frequency
Sand	95%
Gravel	5%
Cobble	0%
Boulder	0%
Bedrock	0%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Given the depth of the stream flow and the sand dominated character of the channel, embeddedness for Kalama 1-tidal was not estimated.

There were no pebble counts performed in Kalama 1-tidal. Refer to report section 2.2.4 for a discussion of pebble count results.

COVER

Cover is provided in Kalama 1-tidal in each of the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. The dominant cover form is water depth with the balance of cover in the reach coming from LW (Table B-4)

Table B-4. Presence of cover within the surveyed portion of Kalama 1-tidal. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	1%
Undercut Banks	0%
Overhanging Vegetation	0%
Water Depth > 1 m	63%
Substrate (Velocity Cover)	0%

RIPARIAN

Kalama 1-tidal is a wide floodplain bottom channel that is open to the sky. Riparian vegetation on both banks is provided in the inner zone by grasses, forbs, small shrubs and saplings. The vegetation stands along the outer riparian zone primarily consist of sparse, young, deciduous communities (Figure B-2). Estimates of the distance of trees beyond the bank full stage of the channel range between 13.5 and 63 m (45-207 ft) and average 32 m (104 ft) of open bank. This zone represents an area of Kalama River floodplain disturbance where tree growth is difficult to establish. As such the open channel width to the sky averages 64 m (210 ft) of channel width plus an additional 32 m (104 ft) of open bank or a total of 96 m wide zone without vegetative cover. The mean view to sky angle is 145 degrees or nearly 81 percent (Table B-5). Nearly 60 percent of the riparian zone is also currently disturbed by both urbanization and forest harvest.

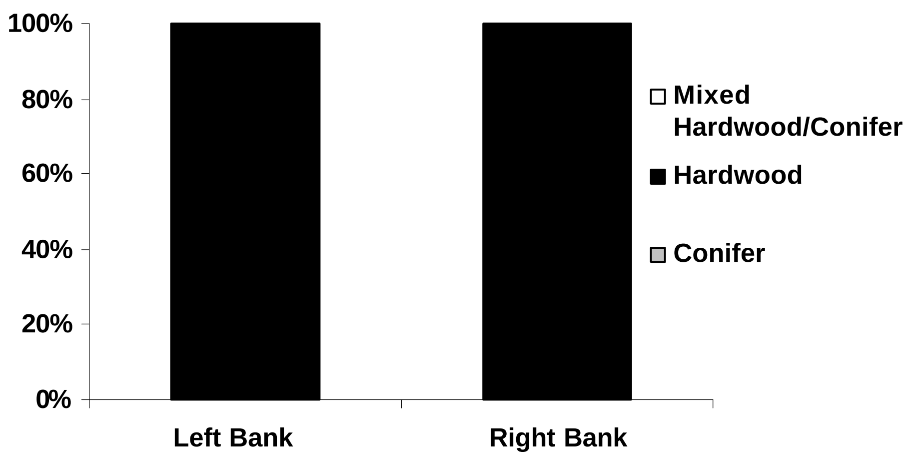


Figure B-2. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-5. Riparian shading characteristics in survey section of Kalama 1-tidal. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	64 m
Mean distance to blocking vegetation – left bank (m)	47 m
Mean left bank canopy angle (degrees)	19 ^{o}
Mean distance to blocking vegetation – right bank (m)	49 m
Mean right bank canopy angle (degrees)	16 ^{o}
Mean view to sky (percent)	81%
Elevation (msl)	10’
Reference Temperature (T^{o}C)	18.7^{o}C
Estimated Current Temperature (T^{o}C)	21.6^{o}C

With mature forest stands growing immediately adjacent to the channel, this reach is estimated to remain open to solar radiation (V-T-S 39%). As such, it represents an area that has a naturally high hazard to shade and it likely offered historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 18.7^{o}C. The current channel condition (V-T-S 81%) is anticipated to increase the 7-DADmax on a relative basis approximately 2.9^{o}C compared to reference conditions or peak at 21.6^{o}C.

These estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of marine water intrusion or groundwater influx. Actual water temperatures will vary with Kalama River discharge, tidal stage and local weather patterns. Kalama 1-tidal should be regarded as a transport reach and coldwater salmonid fishes would generally need to time their entry into the Kalama River during cooler periods than what may occur during late summer low flow conditions.

INSTABILITY AND DISTURBANCE

There was no bank instability recorded in the surveyed section of Kalama 1-tidal (Table B-6). Confinement by levees and bank armoring was predominant, precluding bank instability. Other man-made disturbances included the urbanizing presence of structures, roads, railroads, the I-5 corridor, and docks. Both banks were equally disturbed with average estimates of nearly 60 percent of the 35m (100 ft) riparian zone influenced to some degree or another.

Table B-6. Bank instability and disturbance of surveyed section of Kalama 1-tidal. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	55
Right bank disturbance (%)	64

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) a shift to 100 percent glide habitat from an estimate of 50 percent pools, 40 percent glide and small percentage of small cobble riffles and (2) more off-channel habitat under the current conditions than previously estimated (Tables B-7 to B-10).

Table B-7. Comparison of EDT Level 2 attribute ratings assigned to Kalama 1-Tidal, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	125	210	NA
Channel width – maximum (ft)	162	NA	
Habitat Type – off-channel habitat factor (patient)	1.0%	8.2%	7.1%
Habitat Type – off-channel habitat factor (template)	20.0%	16.4%	-3.6%

Table B-8. Comparison of EDT Level 2 attribute ratings assigned to Kalama 1-Tidal, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	50.0%	0.0%	
Habitat Type – backwater pools	2.1%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	0.9%	0.0%	
Habitat Type – glides	40.0%	100.0%	
Habitat Type – small cobble/gravel riffles	7.0%	0.0%	
Habitat Type – large cobble/boulder riffles	0.0%	0.0%	

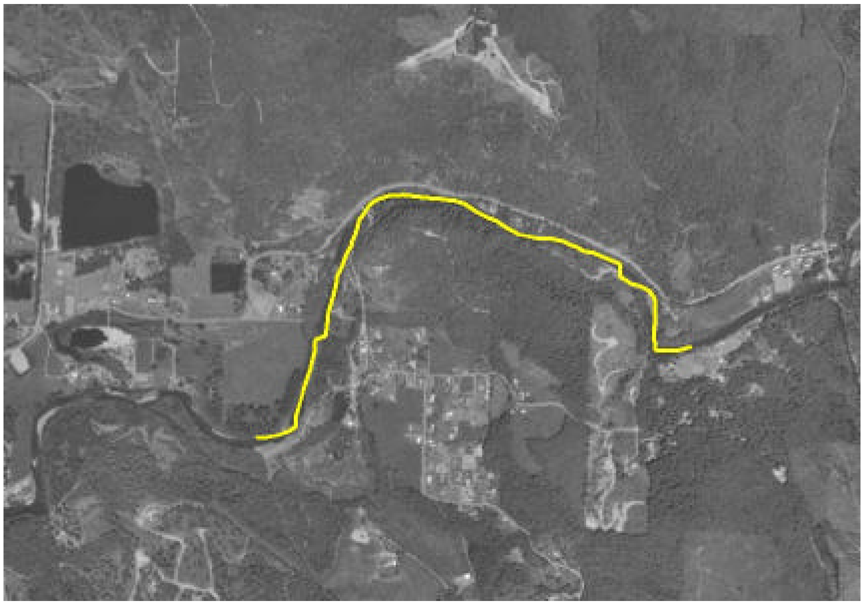
Table B-9. Comparison of EDT Level 2 attribute ratings assigned to Kalama 1-Tidal, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.0%	<1%	
Confinement – natural	0	0	
Confinement – hydromodifications	4	3.1	
In-channel wood	4	3.6	
Embeddedness	3	NA - no small cobble riffles	
Fine sediment	4	NA - no small cobble riffles	

KALAMA RIVER 2

INTRODUCTION

Kalama River 2 is a mainstem reach lying immediately upstream of the tidal reach between RM 2.2 and RM 3.9. This reach is a free-flowing, freshwater reach that is not influenced by tidal action in the Columbia River. One hundred percent of this reach was floated during the 2004 survey (Map B-2).



Map B-2. Portion of Kalama 2 surveyed.

CHANNEL MORPHOLOGY

Kalama 2 is a large, low gradient (0.5 to 1.0 percent) floodplain channel with pool-riffle bedform throughout its length. It is unconfined in the lowermost 0.6 miles flowing over the Kalama River floodplain and is moderately confined in a canyon along the upstream section of the reach. Within the canyon, narrow, discontinuous floodplain features border the channel.

Kalama 2 remains dominated by glide habitat types, but it includes a relatively equal contribution of pool, small riffle and large riffle habitat features (Figure B-3).

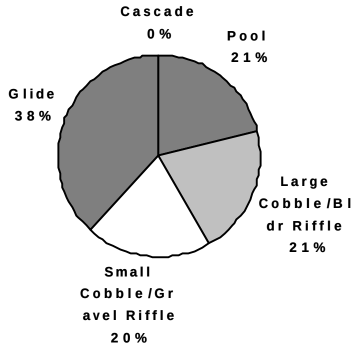


Figure B-3. Unit composition by percent surface area of the surveyed section of Kalama 2.

Kalama 2 is narrower than Kalama 1-tidal The wetted width during the survey averaged 39 m (128 ft). The maximum depth of pools averaged 2.7m (8.9 ft) with residual pool depths of 2.0m (6.6 ft) [Table B-10].

Table B-10. Average channel morphology characteristics of surveyed sections of Kalama 2

Parameter	Reach Value
Mean gradient	< 1.0%
Mean wetted width (m)	39.0 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual Pool depth (m)	2.0 m
Mean of the maximum pool depths (m)	2.7 m
Pools per kilometer (p/km)	1.0
Primary pools (>1.0m deep) per kilometer	1.0

WOOD

There were 26.2 pieces of large woody debris per kilometer (LW/km) recorded in Kalama 2 during the summer of 2004, but most (> 53%) were of the small size class of woody debris pieces (Table B-11). There were no jams and only a few root wads observed during the survey.

Table B-11. Size and density of wood, jams and root wads in surveyed section of Kalama 2

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	13.8
Medium Pieces	20-50 cm diameter; > 2 m long	10.0
Large Pieces	> 50 cm diameter; > 2 m long	1.7
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.7

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and cobble, respectively (Table B-12).

Table B-12. Substrate grain size composition in surveyed section of Kalama 2.

Category	Mean Frequency
Sand	12%
Gravel	39%
Cobble	46%
Boulder	3%
Bedrock	0%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Although the water was murky during the habitat survey, the embeddedness rating of 20% fell into the low category of < 25 percent.

There were no pebble counts performed in Kalama 2. Refer to report section 2.2.4 for a discussion of pebble count results.

COVER

Cover provided in Kalama 2 was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. The dominant cover form in the mainstem remains as water depth with the balance of cover in the reach coming from overhanging vegetation (Table B-13)

Table B-13. Presence of cover within the surveyed portion of Kalama 2. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	0%
Undercut Banks	0%
Overhanging Vegetation	1%
Water Depth > 1 m	15%
Substrate (Velocity Cover)	0%

RIPARIAN

Kalama 2 is a wide floodplain channel that is open to the sky, even in the canyon. Riparian vegetation on both banks is provided in the inner zone by grasses, forbs, small shrubs and saplings. The vegetation stands along the outer riparian zone primarily consist of sparse, young, deciduous communities but mixed conifer and hardwood stands and conifer dominated stands exist (Figure B-4). Estimates of the distance of trees beyond the bank full stage of the channel range between 23 and 155 m (75-510 ft) and average 55 m (180 ft) of open bank. This zone represents an area of Kalama River floodplain disturbance where tree growth is difficult to establish. As such the open channel width to the sky averages 39 m (128 ft) of channel width plus an additional 55 m (180 ft) of open bank or a total of 94 m wide zone without vegetative cover. The mean view to sky angle is 114 degrees or 63 percent open (Table B-14).

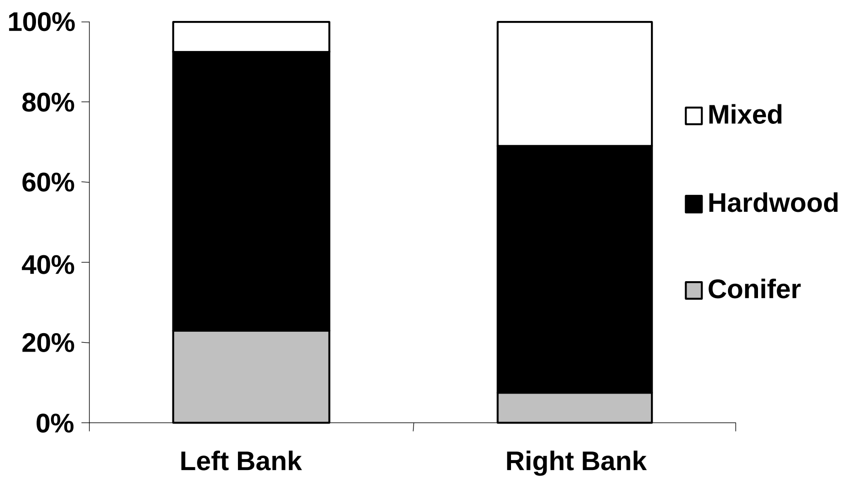


Figure B-4. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-14. Riparian shading characteristics in survey section of Kalama 2. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	39 m
Mean distance to blocking vegetation – left bank (m)	51 m
Mean left bank canopy angle (degrees)	34^{o}
Mean distance to blocking vegetation – right bank (m)	42 m
Mean right bank canopy angle (degrees)	32^{o}
Mean view to sky (percent)	63%
Elevation (msl)	30'
Reference Temperature ($T^{o}C$)	$17.7^{o}C$
Estimated Current Temperature ($T^{o}C$)	$20.5^{o}C$

With mature forest stands growing immediately adjacent to the channel, this reach is estimated to remain open to solar radiation (VTS 25%). As such, it represents an area that has a naturally high hazard to shade and it likely offered historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach $17.7^{o}C$. The current channel condition (VTS 63%) is anticipated to increase the 7-DADmax on a relative basis approximately $2.8^{o}C$ compared to reference conditions or peak at $20.5^{o}C$.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with Kalama River discharge, local weather patterns and the volume of groundwater contribution.

INSTABILITY AND DISTURBANCE

There was little observed signs of bank instability recorded in the surveyed section of Kalama 2. The left bank in NSO #16 showed some erosion, but averaged over the entire reach, the instability represented less than 4 percent of the left bank total reach area Table B-15).

Confinement in the bedrock canyon section precluded much bank instability. Other man-made disturbances included the urbanizing presence of structures, roads, and forest practices and development. Both banks were disturbed with average estimates of nearly 30 percent of the 35m (100 ft) riparian zone along the left bank and 63 percent of the right bank.

The riparian zone is also currently disturbed by both urbanization, roads, clear cuts and thinning.

Table B-15. Bank instability and disturbance of surveyed section of Kalama 2. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	4
Right bank instability (%)	0
Left bank disturbance (%)	30
Right bank disturbance (%)	63

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less primary pools and more glide and small cobble riffle habitat; (2) more historic off-channel habitat; and (3) less substrate loading of fine sediment than previously estimated in the SRE (Tables B-16 – B-18).

Table B-16. Comparison of EDT Level 2 attribute ratings assigned to Kalama 2, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	135	128	-2.3%
Channel width – maximum (ft)	168	NA	
Habitat Type – off-channel habitat factor (patient)	0.0%	0.0%	0.0%
Habitat Type – off-channel habitat factor (template)	1.0%	5.0%	3.9%

Table B-17. Comparison of EDT Level 2 attribute ratings assigned to Kalama 2, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	55.5%	20.1%	
Habitat Type – backwater pools	2.1%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	5.0%	1.9%	
Habitat Type – glides	20.4%	40.6%	
Habitat Type – small cobble/gravel riffles	17.0%	37.3%	
Habitat Type – large cobble/boulder riffles	0.0%	0.0%	

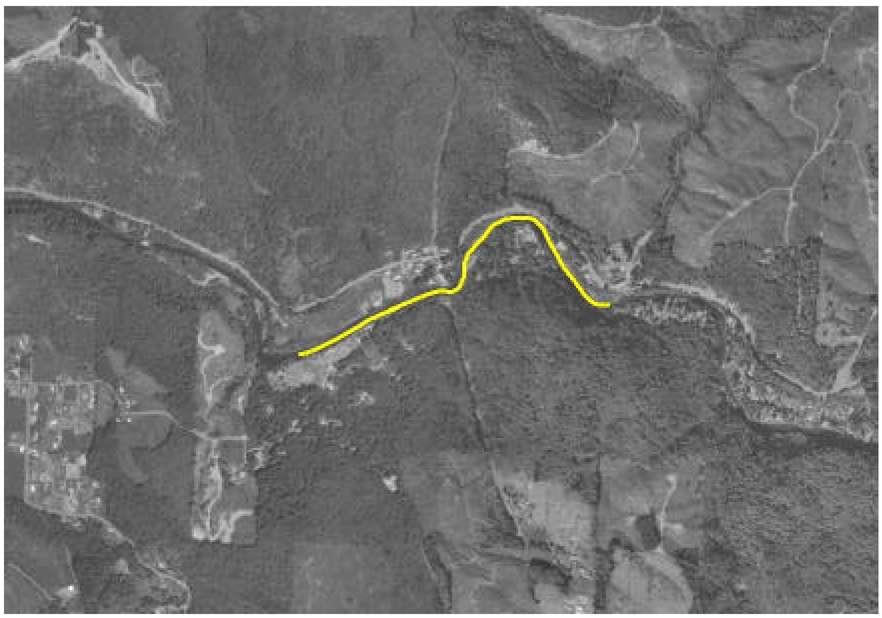
Table B-18. Comparison of EDT Level 2 attribute ratings assigned to Kalama 2, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.2%	<1%	
Confinement – natural	3	2-4	
Confinement – hydromodifications	2	2.4	
In-channel wood	3	2.5	
Embeddedness	0.9	0.8	
Fine sediment	2.2	0.6	

KALAMA RIVER 3

INTRODUCTION

Kalama River 3 is a mainstem reach located within the lower Kalama River canyon between Cedar Creek (RM 3.9) and Hatchery Creek (RM 4.9). One hundred percent of this reach was floated during the 2004 survey (Map B-3).



Map B-3. Portion of Kalama 3 surveyed.

CHANNEL MORPHOLOGY

Kalama 3 is a large, contained channel throughout its length. It is moderately confined, and bordered by a combination of discontinuous floodplain deposits and steep, bedrock controlled sideslopes. The dominant bedform is pool-riffle, however pool spacing and depths are largely structurally controlled. Pools account for 13 percent of the habitat by length, with glides and riffles making up the rest (Figure B-5).

Kalama 3 is expected to be only moderately responsive to LW, as the large size and high stream energy mean that accumulations of wood or large logs will be mobilized relatively frequently compared with smaller channels. Sediment is stored in association with channel obstructions (boulders, bedrock outcrops or stable LW accumulations). This reach is generally semi-alluvial except during periods of extremely high sediment supply (e.g., volcanic episodes). However, good deposits of spawning gravel exist in locally low gradient areas.

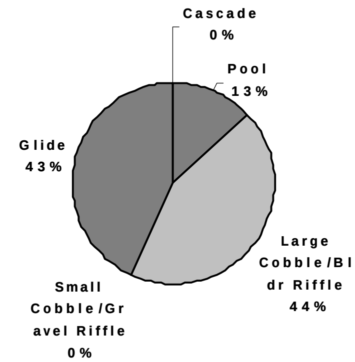


Figure B-5. Unit composition by percent surface area of the surveyed section of Kalama 3.

The wetted width of Kalama 3 during the survey averaged 44 m (144 ft). The maximum depth of pools was greater than 3 m (10 ft) with residual pool depths of approximately 1.0m (3.3 ft) [Table B-19].

Table B-19. Average channel morphology characteristics of surveyed sections of Kalama 3

Parameter	Reach Value
Mean gradient	< 1.0%
Mean wetted width (m)	44.0 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual pool depth (m)	1.0 m
Mean of the maximum pool depths (m)	>3 m
Pools per kilometer (p/km)	1.5
Primary pools (>1.0m deep) per kilometer	1.5

WOOD

There were 13.8 pieces of large woody debris per kilometer (LW/km) recorded in Kalama 3 during the summer of 2004, but most (58%) were of the small size class of woody debris pieces (Table B-20). There were no jams and only a few root wads observed during the survey.

Table B-20. Size and density of wood, jams and root wads in surveyed section of Kalama 3

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	8.0
Medium Pieces	20-50 cm diameter; > 2 m long	3.6
Large Pieces	> 50 cm diameter; > 2 m long	2.0
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were cobble and gravel, respectively (Table B-21).

Table B-21. Substrate grain size composition in surveyed section of Kalama 3.

Category	Mean Frequency
Sand	2%
Gravel	29%
Cobble	57%
Boulder	12%
Bedrock	0%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Embeddedness was estimated to be 12%.

There were no pebble counts performed in Kalama 3. Refer to report section 2.2.4 for a discussion of pebble count results.

COVER

Cover provided in Kalama 3 was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. The dominant cover form in the mainstem was water depth with the balance of cover in the reach coming from overhanging vegetation (Table B-22)

Table B-22. Presence of cover within the surveyed portion of Kalama 3. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	0%
Undercut Banks	0%
Overhanging Vegetation	2%
Water Depth > 1 m	37%
Substrate (Velocity Cover)	0%

RIPARIAN

Kalama 3 is a wide, moderately confined channel that is open to the sky, even in the canyon. Riparian vegetation on both banks is provided in the inner zone by grasses, forbs, small shrubs and saplings. The vegetation stands along the outer riparian zone primarily consist of hardwood or mixed hardwood conifer communities, although there are some mature conifer stands in undeveloped areas along the left bank (Figure B-6). The open channel width to the sky averages 44 m (144 ft) of channel width plus an additional 51 m (167 ft) of open bank or a total of 95 m wide zone without vegetative cover. The mean view to sky angle is 64 percent (Table B-23). From 30 to 50 percent of the riparian zone on both banks is currently disturbed by urbanization and stream adjacent roads.

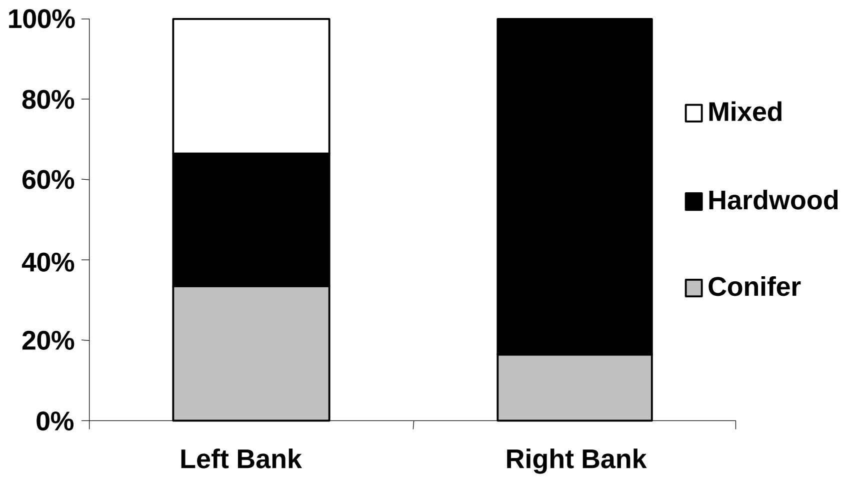


Figure B-6. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-23. Riparian shading characteristics in survey section of Kalama 3. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	44 m
Mean distance to blocking vegetation – left bank (m)	36 m
Mean left bank canopy angle (degrees)	37^{o}
Mean distance to blocking vegetation – right bank (m)	59 m
Mean right bank canopy angle (degrees)	28^{o}
Mean view to sky (percent)	64%
Elevation (msl)	45'
Reference Temperature ($T^{o}C$)	$18^{o}C$
Estimated Current Temperature ($T^{o}C$)	$20.3^{o}C$

Even with mature forest stands growing immediately adjacent to the channel, this reach is estimated to remain open to solar radiation. As such, it represents an area that has a naturally high hazard to shade and it likely offered historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach $18^{o}C$. This temperature is greater than aquatic use criteria for salmon and trout spawning and rearing. The current channel condition (VTS 64%) is anticipated to increase the 7-DADmax on a relative basis approximately $2.3^{o}C$ compared to reference conditions or peak at $20.3^{o}C$.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with Kalama River discharge, local weather patterns and the volume of groundwater contribution.

INSTABILITY AND DISTURBANCE

There was little observed signs of bank instability recorded in the surveyed section of Kalama 3. The right bank showed some erosion, but averaged over the entire reach, the instability represented less than 8 percent of the right bank total reach area (Table B-24).

Riparian zones on both banks were disturbed with average estimates of 65 percent of the 35m (100 ft) riparian zone along the left bank and 34 percent of the right bank. Man-made disturbances included residential development and roads.

Table B-24. Bank instability and disturbance of surveyed section of Kalama 3. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	1
Right bank instability (%)	8
Left bank disturbance (%)	34
Right bank disturbance (%)	65

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less primary pools and pool tailouts and more glide and small cobble riffle habitat; (2) greater minimum widths; and (3) less substrate loading of fine sediment and embeddedness than previously estimated in the SRE (Tables B-25 – B-27).

Table B-25. Comparison of EDT Level 2 attribute ratings assigned to Kalama 3, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	129	144	5.4%
Channel width – maximum (ft)	168	NA	
Habitat Type – off-channel habitat factor (patient)	0.0%	0.0%	0.0%
Habitat Type – off-channel habitat factor (template)	1.0%	0.0%	-1.0%

Table B-26. Comparison of EDT Level 2 attribute ratings assigned to Kalama 3, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	40.9%	10.6%	
Habitat Type – backwater pools	0.7%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	16.5%	1.2%	
Habitat Type – glides	12.8%	38.7%	
Habitat Type – small cobble/gravel riffles	26.3%	49.5%	
Habitat Type – large cobble/boulder riffles	2.9%	0.0%	

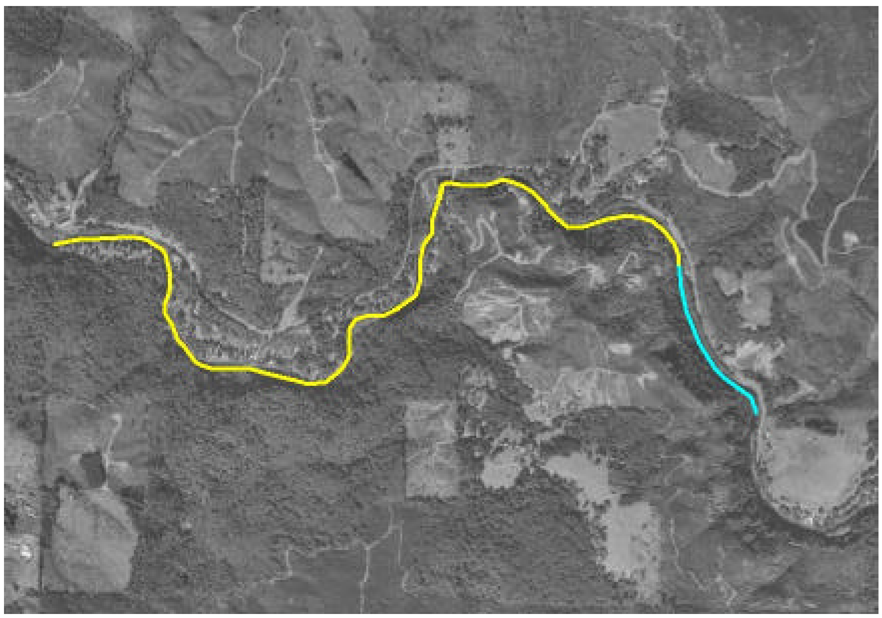
Table B-27. Comparison of EDT Level 2 attribute ratings assigned to Kalama 3, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.1%	<1%	
Confinement – natural	2	2-3	
Confinement – hydromodifications	3	3.8	
In-channel wood	4	3.1	
Embeddedness	0.9	0.5	
Fine sediment	2.2	0	

KALAMA RIVER 4

INTRODUCTION

Kalama River 4 is a mainstem reach located within the lower Kalama River canyon between Hatchery Creek (RM 4.9) and Indian Creek (RM 7.5). The lowermost 2.1 miles of this reach were floated during the 2004 survey as highlighted in yellow in Map B-4.



Map B-4. Portion of Kalama 4 surveyed.

CHANNEL MORPHOLOGY

Kalama 4 is a large, contained channel throughout its length. It is tightly confined by steep bedrock sideslopes. The dominant bedform is pool-riffle, however pool spacing and depths are largely structurally controlled. Pools account for 34 percent of the habitat by length, with glides and riffles making up the rest (Figure B-7).

Kalama 4 is not expected to be responsive to LW, as the large size and high stream energy mean that accumulations of wood or large logs will be mobilized relatively frequently compared with smaller channels. Sediment is stored in areas of divergent flow or velocity breaks downstream of channel obstructions (primarily boulders or bedrock outcrops). This reach is generally supply limited and semi-alluvial. However, good deposits of spawning gravel exist in locally low gradient areas.

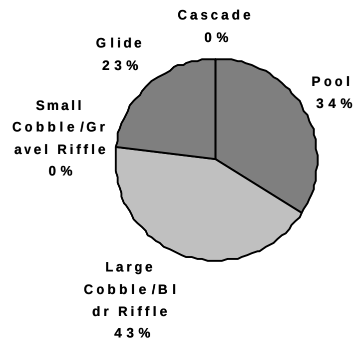


Figure B-7. Unit composition by percent surface area of the surveyed section of Kalama 4.

The wetted width of Kalama 4 during the survey averaged 42 m (138 ft). The maximum depth of pools was greater than 3 m (10 ft) with residual pool depths of approximately 2.2 m (7.2 ft) [Table B-28].

Table B-28. Average channel morphology characteristics of surveyed sections of Kalama 4

Parameter	Reach Value
Mean gradient	< 1.0%
Mean wetted width (m)	44.0 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual pool depth (m)	2.2 m
Mean of the maximum pool depths (m)	>3 m
Pools per kilometer (p/km)	2.3
Primary pools (>1.0m deep) per kilometer	2.3

WOOD

There were 20.8 pieces of large woody debris per kilometer (LW/km) recorded in Kalama 4 during the summer of 2004, but most (58%) were of the small size class of woody debris pieces (Table B-29). There were few no jams and root wads observed during the survey.

Table B-29. Size and density of wood, jams and root wads in surveyed section of Kalama 4

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	12.1
Medium Pieces	20-50 cm diameter; > 2 m long	5.2
Large Pieces	> 50 cm diameter; > 2 m long	2.6
Jams	> 10 pieces in accumulation	0.6
Root wads	> 2 m long	0.3

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were cobble and gravel, respectively (Table B-30).

Table B-30. Substrate grain size composition in surveyed section of Kalama 4.

Category	Mean Frequency
Sand	0%
Gravel	34%
Cobble	48%
Boulder	15%
Bedrock	3%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Embeddedness was estimated to be 11%.

There were no pebble counts performed in Kalama 4. Refer to report section 2.2.4 for a discussion of pebble count results.

COVER

Cover provided in Kalama 4 was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. The only cover form observed in the mainstem was water depth (Table B-31).

Table B-31. Presence of cover within the surveyed portion of Kalama 4. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	0%
Undercut Banks	0%
Overhanging Vegetation	0%
Water Depth > 1 m	58%
Substrate (Velocity Cover)	0%

RIPARIAN

Kalama 4 is a wide, confined channel that is open to the sky, even in the canyon. Riparian vegetation on both banks is provided in the inner zone by grasses, forbs, small shrubs and saplings. The vegetation stands along the outer riparian zone primarily consist of hardwood or mixed hardwood conifer communities, although there are some mature conifer stands in undeveloped areas along the left bank (Figure B-8). The open channel width to the sky averages 42 m (138 ft) of channel width plus an additional 20 m (66 ft) of open bank or a total of 62 m wide zone without vegetative cover. The mean view to sky angle is 47 percent (Table B-32).

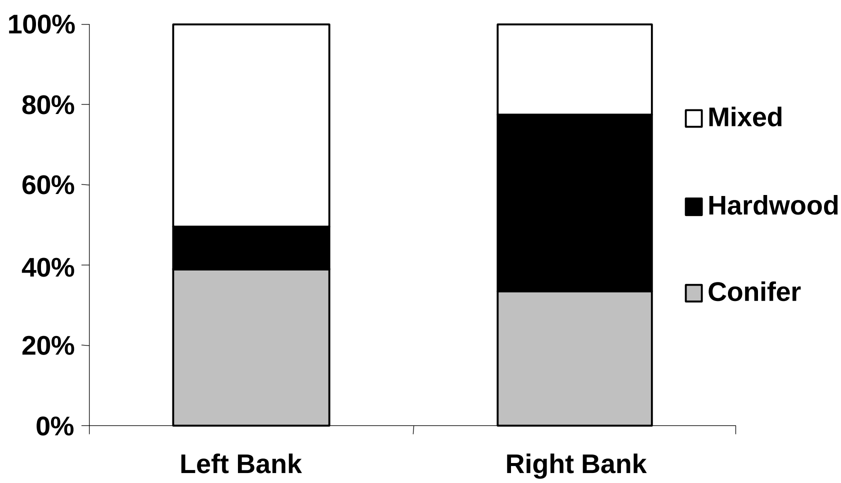


Figure B-8. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-32. Riparian shading characteristics in survey section of Kalama 4. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	44 m
Mean distance to blocking vegetation – left bank (m)	30 m
Mean left bank canopy angle (degrees)	55^{o}
Mean distance to blocking vegetation – right bank (m)	32 m
Mean right bank canopy angle (degrees)	41^{o}
Mean view to sky (percent)	47%
Elevation (msl)	65’
Reference Temperature ($T^{o}C$)	$17.8^{o}C$
Estimated Current Temperature ($T^{o}C$)	$19.2^{o}C$

Even with mature forest stands growing immediately adjacent to the channel, this reach is estimated to remain open to solar radiation. As such, it represents an area that has a naturally high hazard to shade and it likely offered historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach $18^{o}C$. This temperature is greater than aquatic use criteria for salmon and trout spawning and rearing. The current channel condition (VTS 47%) is anticipated to increase the 7-DADmax on a relative basis approximately $1.4^{o}C$ compared to reference conditions or peak at $19.2^{o}C$.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with Kalama River discharge, local weather patterns and the volume of groundwater contribution.

INSTABILITY AND DISTURBANCE

Confinement in the bedrock canyon section generally precludes much bank instability in Kalama 4. The right bank showed some erosion, but averaged over the entire reach, the instability represented less than 10 percent of the right bank total reach area (Table B-3).

The riparian zones on the right bank was disturbed with average estimates of 57 percent of the 35m (100 ft) riparian zone along the left bank. Less disturbance (14%) was noted for the left bank riparian zone. Right bank disturbances consisted primarily of roads and residential development.

Table B-33. Bank instability and disturbance of surveyed section of Kalama 4. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	1
Right bank instability (%)	9
Left bank disturbance (%)	14
Right bank disturbance (%)	57

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less primary pools and pool tailouts and more glide and small cobble riffle habitat; (2) greater minimum channel widths; (3) less in-channel LW loading and (4) less substrate loading of fine sediment and embeddedness than previously estimated in the SRE (Tables B-34 – B-36).

Table B-34. Comparison of EDT Level 2 attribute ratings assigned to Kalama 4, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	108	138	13.0%
Channel width – maximum (ft)	140	NA	
Habitat Type – off-channel habitat factor (patient)	0.0%	0.0%	0.0%
Habitat Type – off-channel habitat factor (template)	0.0%	0.0%	0.0%

Table B-35. Comparison of EDT Level 2 attribute ratings assigned to Kalama 4, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	40.9%	29.7%	
Habitat Type – backwater pools	0.7%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	16.5%	4.1%	
Habitat Type – glides	12.8%	23.4%	
Habitat Type – small cobble/gravel riffles	26.3%	40.1%	
Habitat Type – large cobble/boulder riffles	2.9%	2.7%	

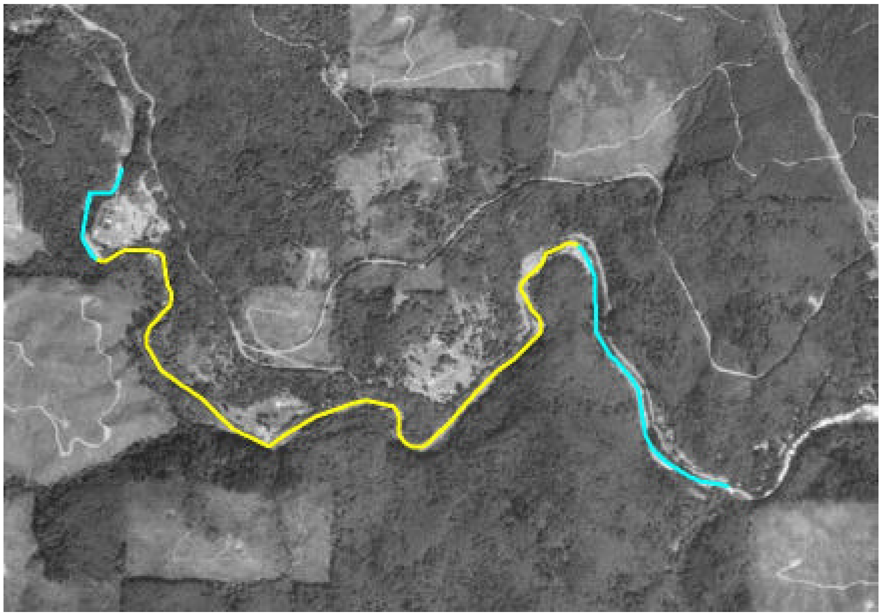
Table B-36. Comparison of EDT Level 2 attribute ratings assigned to Kalama 4, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.4%	<1.0%	
Confinement – natural	3	3-4	
Confinement – hydromodifications	2	2.7	
In-channel wood	4	2.7	
Embeddedness	0.9	0.5	
Fine sediment	2.2	0	

KALAMA RIVER 6

INTRODUCTION

Kalama River 6 is a mainstem reach located within the Kalama River canyon between Lower Kalama Falls (RM 10.5) and the Little Kalama River (RM 13.6). The channel meanders through a steep-sided bedrock controlled canyon. . A majority of this reach was surveyed (Map B-5).



Map B-5. Portion of Kalama 6 surveyed.

CHANNEL MORPHOLOGY

Kalama 6 is a large, contained channel throughout its length. It is tightly confined by steep bedrock sideslopes, and has a map gradient of 0.3 percent. Some moderately confined areas are present near the downstream end of the reach. The dominant bedform is pool-riffle, however pool spacing and depths are largely structurally controlled. Pools account for 43 percent of the habitat by length, with glides and riffles making up the rest (Figure B-9).

Kalama 6 is not expected to be responsive to LW, as the large size and high stream energy mean that accumulations of wood or large logs will be mobilized relatively frequently compared with smaller channels. Sediment is stored in areas of divergent flow or velocity breaks downstream of channel obstructions (primarily boulders or bedrock outcrops). This reach is generally supply limited and semi-alluvial. However, good deposits of spawning gravel exist in locally low gradient areas.

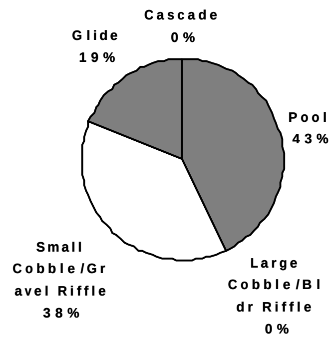


Figure B-9. Unit composition by percent surface area of the surveyed section of Kalama 6.

The wetted width of Kalama 6 during the survey averaged 33 m (108 ft). The maximum depth of pools was 2.4 m (7.8 ft) with residual pool depths of approximately 1.7 m (5.6 ft) [Table B-37].

Table B-37. Average channel morphology characteristics of surveyed sections of Kalama 6

Parameter	Reach Value
Mean gradient	< 1.0%
Mean wetted width (m)	33.0 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual pool depth (m)	1.7 m
Mean of the maximum pool depths (m)	2.4 m
Pools per kilometer (p/km)	4.1
Primary pools (>1.0m deep) per kilometer	4.1

WOOD

There were 21.4 pieces of large woody debris per kilometer (LW/km) recorded in Kalama 6 during the summer of 2004, but most (58%) were of the small size class of woody debris pieces (Table B-38). There were no jams and few root wads observed during the survey.

Table B-38. Size and density of wood, jams and root wads in surveyed section of Kalama 6

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	12.5
Medium Pieces	20-50 cm diameter; > 2 m long	5.3
Large Pieces	> 50 cm diameter; > 2 m long	2.6
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	1.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and cobble, respectively (Table B-39).

Table B-39. Substrate grain size composition in surveyed section of Kalama 6.

Category	Mean Frequency
Sand	18%
Gravel	43%
Cobble	33%
Boulder	5%
Bedrock	1%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Embeddedness was estimated to be 42%.

A pebble count was performed in Kalama 6. The D50 and D90 particle sizes were 63 mm and 128 mm respectively. Refer to report section 2.2.4 for a discussion of pebble count results.

COVER

Cover provided in Kalama 6 was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. The only cover form observed in the mainstem was water depth (Table B-40).

Table B-40. Presence of cover within the surveyed portion of Kalama 6. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	0%
Undercut Banks	0%
Overhanging Vegetation	0%
Water Depth > 1 m	44%
Substrate (Velocity Cover)	0%

RIPARIAN

Kalama 6 is a wide channel that is open to the sky, even in the canyon. Riparian vegetation on both banks is provided in the inner zone by grasses, forbs, small shrubs and saplings. The vegetation stands along the outer riparian zone primarily consist of hardwood or mixed hardwood conifer communities, although there are some mature conifer stands in undeveloped areas along the left bank (Figure B-10). The open channel width to the sky averages 33 m (108 ft) of channel width plus an additional 24 m (79 ft) of open bank or a total of 57 m wide zone without vegetative cover. The mean view to sky angle is 43 percent (Table B-41).

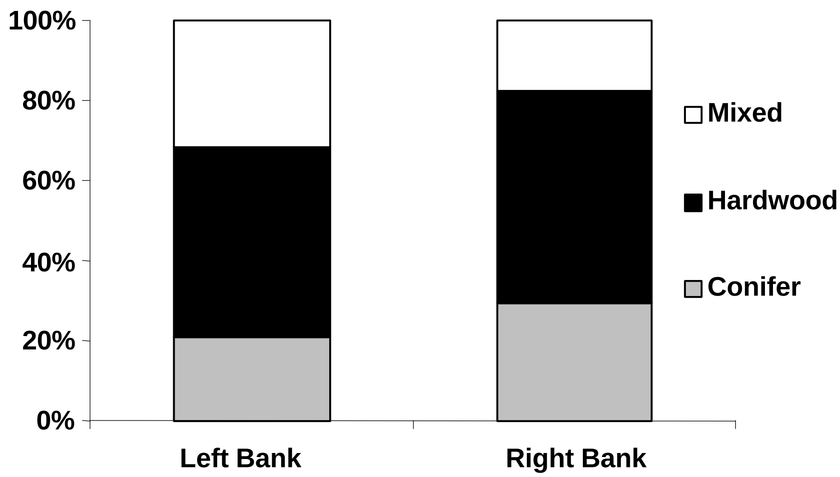


Figure B-10. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-41. Riparian shading characteristics in survey section of Kalama 6. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	33 m
Mean distance to blocking vegetation – left bank (m)	27 m
Mean left bank canopy angle (degrees)	50^{o}
Mean distance to blocking vegetation – right bank (m)	30 m
Mean right bank canopy angle (degrees)	52^{o}
Mean view to sky (percent)	43%
Elevation (msl)	225'
Reference Temperature ($T^{o}C$)	17.2^{o}C
Estimated Current Temperature ($T^{o}C$)	19.0^{o}C

Even with mature forest stands growing immediately adjacent to the channel, this reach is estimated to remain open to solar radiation. As such, it represents an area that has a naturally high hazard to shade and it likely offered historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to exceed 17^{o}C. This temperature is greater than aquatic use criteria for salmon and trout spawning and rearing. The current channel condition (VTS 43%) is anticipated to increase the 7-DADmax on a relative basis approximately 1.8^{o}C compared to reference conditions or peak at 19.0^{o}C.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with Kalama River discharge, local weather patterns and the volume of groundwater contribution.

INSTABILITY AND DISTURBANCE

Confinement in the bedrock canyon section generally precludes much bank instability in Kalama 6. Averaged over the entire reach, the instability represented only 1 to 2 percent of the total area of each bank (Table B-42).

The riparian zones on the right bank was disturbed with average estimates of 77 percent of the 35m (100 ft) riparian zone along the left bank. Less disturbance (33%) was noted for the left bank riparian zone. Man-made disturbances consisted primarily of roads, residential development and forest harvest.

Table B-42. Bank instability and disturbance of surveyed section of Kalama 6. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	2
Right bank instability (%)	1
Left bank disturbance (%)	33
Right bank disturbance (%)	77

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less primary pools and pool tailouts; less large cobble/boulder riffles and more small cobble/gravel riffle habitat; and (2) greater minimum channel widths than previously estimated in the SRE (Tables B-43 – B-45).

Table B-43. Comparison of EDT Level 2 attribute ratings assigned to Kalama 6, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	93	108	7.4%
Channel width – maximum (ft)	121	NA	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-44. Comparison of EDT Level 2 attribute ratings assigned to Kalama 6, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	50.6%	36.8%	
Habitat Type – backwater pools	0.4%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	9.1%	3.2%	
Habitat Type – glides	19.0%	18.1%	
Habitat Type – small cobble/gravel riffles	11.3%	41.8%	
Habitat Type – large cobble/boulder riffles	9.6%	0.0%	

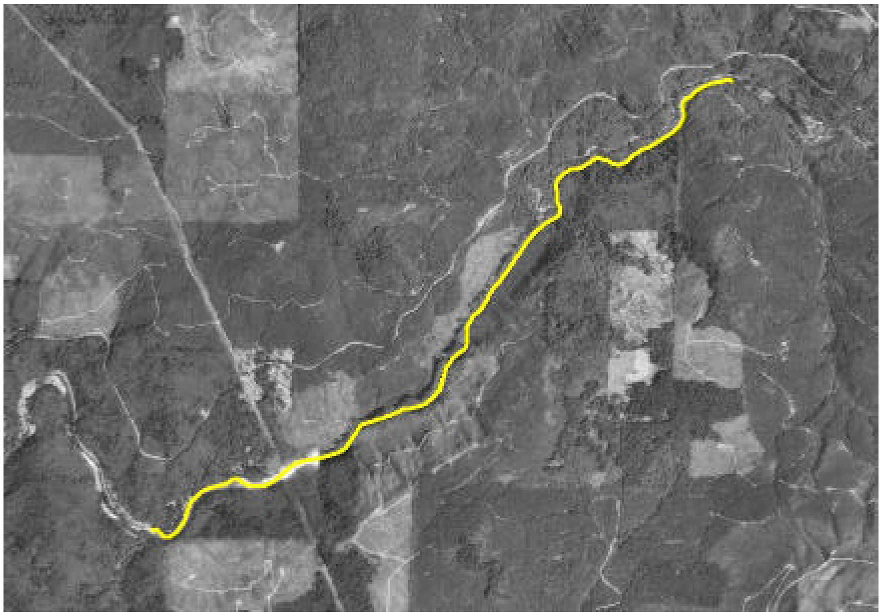
Table B-45. Comparison of EDT Level 2 attribute ratings assigned to Kalama 6, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.5%	<1%	
Confinement – natural	3	3	
Confinement – hydromodifications	0	NA	
In-channel wood	3	2.9	
Embeddedness	0.8	0.6	
Fine sediment	2.1	2.1	

KALAMA RIVER 7

INTRODUCTION

Kalama River 7 is a mainstem reach located within the Kalama River canyon between Little Kalama River (RM 13.6) and Summers Creek (RM 16.8). The channel meanders through a steep-sided bedrock controlled canyon throughout its length. The entire length of Kalama 7 was surveyed (Map B-6).



Map B-6. Portion of Kalama 7 surveyed.

CHANNEL MORPHOLOGY

Kalama 7 is a large, contained channel that is tightly confined by steep bedrock sideslopes. The reach has a map gradient of 0.6 percent. The dominant bedform is pool-riffle, however pool spacing and depths are largely structurally controlled. Pools account for 1 percent of the habitat by length, with glides, riffle, and cascade making up the rest (Figure B-11).

Kalama 7 is not expected to be responsive to LW, as the large size and high stream energy mean that accumulations of wood or large logs will be mobilized relatively frequently compared with smaller channels. Sediment is stored in areas of divergent flow or velocity breaks downstream of channel obstructions (primarily boulders or bedrock outcrops). This reach is generally supply limited and semi-alluvial. However, good deposits of spawning gravel exist in locally low gradient areas.

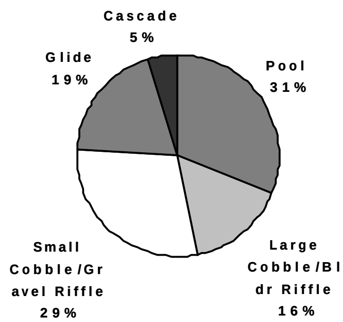


Figure B-11. Unit composition by percent surface area of the surveyed section of Kalama 7.

The wetted width of Kalama 7 during the survey averaged 30 m (98 ft). The maximum depth of pools was 2.8 m (9.2 ft) with residual pool depths of approximately 2.1 m (6.9 ft) [Table B-46].

Table B-46. Average channel morphology characteristics of surveyed sections of Kalama 7

Parameter	Reach Value
Mean gradient	< 1.0%
Mean wetted width (m)	30.0 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual pool depth (m)	2.1 m
Mean of the maximum pool depths (m)	2.8 m
Pools per kilometer (p/km)	2.5
Primary pools (>1.0m deep) per kilometer	2.5

WOOD

There were 17.2 pieces of large woody debris per kilometer (LW/km) recorded in Kalama 7 during the summer of 2004. Wood observed in Kalama 7 was distributed almost equally in the small, medium and large size class of woody debris pieces (Table B-47). There were few jams and few root wads observed during the survey.

Table B-47. Size and density of wood, jams and root wads in surveyed section of Kalama 7

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	5.2
Medium Pieces	20-50 cm diameter; > 2 m long	6.3
Large Pieces	> 50 cm diameter; > 2 m long	4.8
Jams	> 10 pieces in accumulation	0.4
Root wads	> 2 m long	0.5

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and cobble, respectively (Table B-48).

Table B-48. Substrate grain size composition in surveyed section of Kalama 7.

Category	Mean Frequency
Sand	6%
Gravel	25%
Cobble	40%
Boulder	23%
Bedrock	6%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Embeddedness was estimated to be 31%. No pebble count was performed in Kalama 7.

COVER

Cover provided in Kalama 7 was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. The only cover form observed in the mainstem was water depth (Table B-49).

Table B-49. Presence of cover within the surveyed portion of Kalama 7. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	0%
Undercut Banks	0%
Overhanging Vegetation	0%
Water Depth > 1 m	60%
Substrate (Velocity Cover)	0%

RIPARIAN

Kalama 7 is a wide channel that is open to the sky, even in the canyon. Riparian vegetation on both banks is provided in the inner zone by grasses, forbs, small shrubs and saplings. The vegetation stands along the outer riparian zone primarily consist of conifer or mixed hardwood conifer communities (Figure B-12). The open channel width to the sky averages 30 m (98 ft) of channel width plus an additional 16 m (52 ft) of open bank or a total of 46 m wide zone without vegetative cover. The mean view to sky angle is 39 percent (Table B-50).

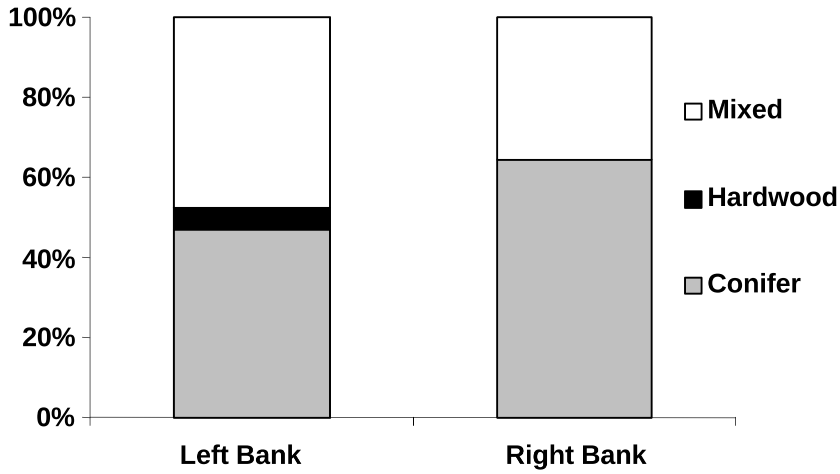


Figure B-12. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-50. Riparian shading characteristics in survey section of Kalama 7. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	30 m
Mean distance to blocking vegetation – left bank (m)	24 m
Mean left bank canopy angle (degrees)	49 ^{o}
Mean distance to blocking vegetation – right bank (m)	22 m
Mean right bank canopy angle (degrees)	60 ^{o}
Mean view to sky (percent)	39%
Elevation (msl)	295’
Reference Temperature (T^{o}C)	17.0^{o}C
Estimated Current Temperature (T^{o}C)	18.4^{o}C

Even with mature forest stands growing immediately adjacent to the channel, this reach is estimated to remain open to solar radiation. As such, it represents an area that has a naturally high hazard to shade and it likely offered historically warm surface water temperatures. Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to exceed 17^{o}C. This temperature is greater than aquatic use criteria for salmon and trout spawning and rearing. The current channel condition (VTS 39%) is anticipated to increase the 7-DADmax on a relative basis approximately 1.4^{o}C compared to reference conditions or peak at 18.4^{o}C.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with Kalama River discharge, local weather patterns and the volume of groundwater contribution.

INSTABILITY AND DISTURBANCE

Confinement in the bedrock canyon section generally precludes much bank instability in Kalama 7. No unstable banks were recorded (Table B-51).

The riparian zones on both banks were disturbed with average estimates of 75 percent of the 35m (100 ft) riparian zone along the left bank. Less disturbance (27%) was noted for the right bank riparian zone. Man-made disturbances consisted primarily of hydromodifications, roads, residential development and forest harvest.

Table B-51. Bank instability and disturbance of surveyed section of Kalama 7. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	75
Right bank disturbance (%)	27

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less primary pools and pool tailouts; and more small cobble/gravel and large cobble/boulder riffle habitat; and (2) less substrate loading of fine sediment and embeddedness levels than previously estimated in the SRE (Tables B-52 – B-54).

Table B-52. Comparison of EDT Level 2 attribute ratings assigned to Kalama 7, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	93	98	2.5%
Channel width – maximum (ft)	121	NA	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-53. Comparison of EDT Level 2 attribute ratings assigned to Kalama 7, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	50.6%	28.1%	
Habitat Type – backwater pools	0.4%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	9.1%	3.7%	
Habitat Type – glides	19.0%	16.8%	
Habitat Type – small cobble/gravel riffles	11.3%	31.0%	
Habitat Type – large cobble/boulder riffles	9.6%	20.4%	

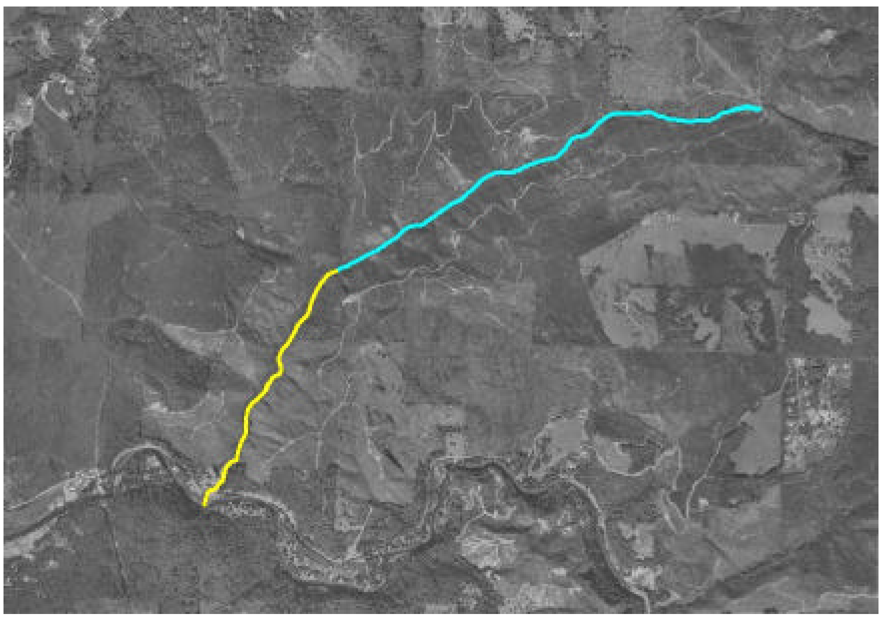
Table B-54. Comparison of EDT Level 2 attribute ratings assigned to Kalama 7, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.5%	<1%	
Confinement – natural	4	4	
Confinement – hydromodifications	0	NA	
In-channel wood	3	3.2	
Embeddedness	0.9	0.3	
Fine sediment	2.3	0.5	

HATCHERY CREEK

INTRODUCTION

Hatchery Creek is a tributary to the Kalama River that enters the Kalama from the North bank near RM 5.0. Hatchery Creek crosses a small alluvial fan at its mouth for approximately 1/4 mile, then enters a narrow v-shaped valley. Habitat surveys were conducted in a 1.70-km (1.1 mile) long segment of Hatchery Creek beginning at the mouth (Map B-7). The entire EDT Reach is approximately 3.0 miles long and ends at an impassable falls. The stream is named for the hatchery located on the alluvial fan at the confluence with the Kalama River.



Map B-7. Portion of Hatchery Creek surveyed.

CHANNEL MORPHOLOGY

Hatchery Creek is a moderate gradient mixed control stream. Confinement ranges from moderate to high depending on the valley width, and is somewhat less in the upper part of the reach. Hatchery Creek has a map gradient of 2 to 4 percent. The dominant bedform is expected to be pool-riffle, however pool spacing and depths are strongly related to LW. Pools account for 22 percent of the habitat by length. The remainder of the survey segment consisted largely of riffle habitat, although other types were noted (Figure B-13). In the absence of LW, plane-bed morphology would be expected to form.

Given the overall valley morphology (narrow valley, moderate gradient), Hatchery Creek functions mainly as a transport reach. Sediment storage is expected to be strongly correlated with LW loading. Sediment accumulates where LW blocks the channel or forms velocity breaks.

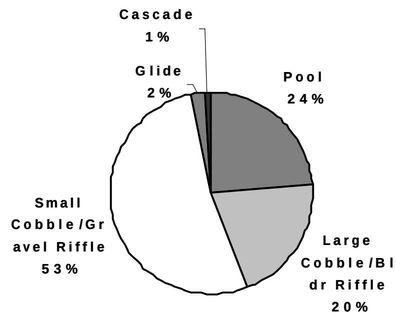


Figure B-13. Unit composition by percent surface area of the surveyed section of Hatchery Creek.

The wetted width of Hatchery Creek during the survey averaged 6.4 m (21 ft). The maximum depth of pools was 1.8 m (5.9 ft) with residual pool depths of approximately 0.3 m (1.0 ft) [Table B-55].

Table B-55. Average channel morphology characteristics of surveyed sections of Hatchery Creek

Parameter	Reach Value
Mean gradient	3.0%
Mean wetted width (m)	6.4 m
Mean active channel width (m)	6.9 m
Mean of the maximum riffle depths (m)	0.4 m
Mean residual pool depth (m)	0.3 m
Mean of the maximum pool depths (m)	1.8 m
Pools per kilometer (p/km)	17.1
Primary pools (>1.0m deep) per kilometer	1.2

WOOD

There were 81 pieces of large woody debris per kilometer (LW/km) recorded in Hatchery Creek during the summer of 2004. Wood observed in Hatchery Creek was predominantly in the medium and large size class of woody debris pieces (Table B-56). There were no jams or root wads observed during the survey.

Table B-56. Size and density of wood, jams and root wads in surveyed section of Hatchery Creek

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	28.0
Medium Pieces	20-50 cm diameter; > 2 m long	27.0
Large Pieces	> 50 cm diameter; > 2 m long	26.0
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and sand, respectively (Table B-57).

Table B-57. Substrate grain size composition in surveyed section of Hatchery Creek.

Category	Mean Frequency
Sand	23%
Gravel	38%
Cobble	22%
Boulder	7%
Bedrock	10%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Embeddedness was estimated to be 26%.

A pebble count was performed in Hatchery Creek. The D50 and D90 particle sizes were 29 mm and 98 mm respectively. Refer to report section 2.2.4 for a more complete discussion of pebble count results.

COVER

Cover provided in Hatchery Creek was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Cover in Hatchery Creek was provided primarily by water depth and overhanging vegetation (Table B-58). Substrate and velocity also provided some cover.

Table B-58. Presence of cover within the surveyed portion of Hatchery Creek. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	4%
Undercut Banks	0%
Overhanging Vegetation	9%
Water Depth > 1 m	15%
Substrate (Velocity Cover)	2%

RIPARIAN

Hatchery Creek is a small channel that well shaded by both vegetation and topography. The open channel width to the sky averages 6.4 m (21 ft) of channel width plus an additional 18 m (58 ft) of open bank or a total of 24 m wide zone without vegetative cover. The mean view to sky angle is 16 percent (Table B-59).

Table B-59. Riparian shading characteristics in survey section of Hatchery Creek. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	6.4 m
Mean distance to blocking vegetation – left bank (m)	12 m
Mean left bank canopy angle (degrees)	75 ^{o}
Mean distance to blocking vegetation – right bank (m)	12 m
Mean right bank canopy angle (degrees)	76 ^{o}
Mean view to sky (percent)	16%
Elevation (msl)	225’
Reference Temperature (T^{o}C)	15.8^{o}C
Estimated Current Temperature (T^{o}C)	16.2^{o}C

Hatchery Creek was currently predicted to be only slightly higher than aquatic use criteria for salmon and trout spawning and rearing. Assuming mature forest timber stands developed adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to be approximately 15.8^{o}C. The current channel condition (VTS 16%) was anticipated to increase the 7-DADmax on a relative basis by less than 1^{o}C compared to reference conditions.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with discharge, local weather patterns and the volume of groundwater contribution.

INSTABILITY AND DISTURBANCE

Less than 10 percent of each bank was classified as unstable within the surveyed segment (Table B-60). Unstable banks in this channel type can occur naturally where the channel is forced laterally around LW accumulations. The extent to which timber harvest and development in the upper basin influence bank stability in Hatchery Creek is unknown.

The riparian zones on both banks were only slightly disturbed with average estimates of percent of the 35m (100 ft) riparian zone along each bank. Man-made disturbances consisted of residential development, roads and forest harvest.

Table B-60. Bank instability and disturbance of surveyed section of Hatchery Creek. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	10
Right bank instability (%)	2
Left bank disturbance (%)	31
Right bank disturbance (%)	47

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less primary pools and glides; and more small cobble/gravel and large cobble/boulder riffle habitat than previously estimated in the SRE (Tables B-61 – B-63).

Table B-61 Comparison of EDT Level 2 attribute ratings assigned to Hatchery, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	12	23	NA
Channel width – maximum (ft)	19	20	5.3%
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-62. Comparison of EDT Level 2 attribute ratings assigned to Hatchery, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	32.6%	13.8%	
Habitat Type – backwater pools	0.7%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	10.1%	8.6%	
Habitat Type – glides	14.4%	2.3%	
Habitat Type – small cobble/gravel riffles	8.4%	14.3%	
Habitat Type – large cobble/boulder riffles	33.8%	61.0%	

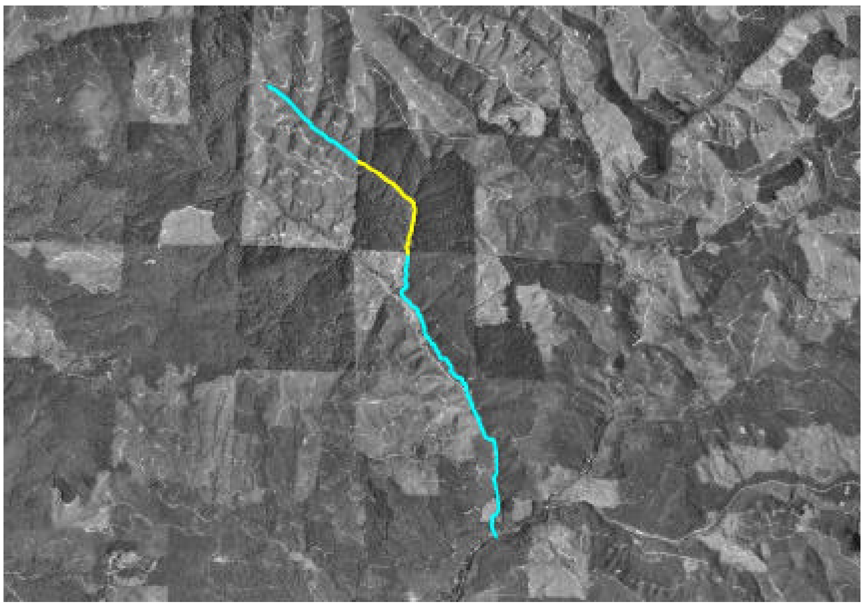
Table B-63 Comparison of EDT Level 2 attribute ratings assigned to Hatchery, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	4.0%	2 – 4%	
Confinement – natural	4	3	
Confinement – hydromodifications	0	NA	
In-channel wood	2	3.2	
Embeddedness	0.9	1	
Fine sediment	2.3	1.7	

WILDHORSE CREEK

INTRODUCTION

Wildhorse Creek is a tributary to the Kalama River that enters from the north bank near RM 19. Wildhorse Creek crosses a very weakly developed alluvial fan with prominent bedrock, then enters a narrow v-shaped valley for the remainder of the approximately 4.8 mile reach length. Habitat surveys were conducted in a 1.78-km (1.1 mile) long segment of Wildhorse Creek near the middle of the EDT reach (Map B-8).



Map B-8. Portion of Wildhorse Creek surveyed.

CHANNEL MORPHOLOGY

Wildhorse Creek is a moderate gradient mixed control stream. Confinement ranges from moderate to high depending on the valley width, and is somewhat less in the upper part of the reach where some short unconfined segments may be present. Wildhorse Creek has a map gradient of 3 percent. The dominant bedform is expected to be forced pool-riffle, with pool spacing and depths are strongly related to LW. In the absence of LW, plane-bed morphology would be expected to form. Pools accounted for 13 percent of the habitat by length. The remainder of the survey segment consisted largely of riffle habitat, with a minor amount of glide (Figure B-15).

Given the overall valley morphology (narrow valley, moderate gradient), Wildhorse Creek functions mainly as a transport reach. Sediment storage is expected to be strongly correlated with LW loading. Sediment accumulates where LW blocks the channel or forms velocity breaks.

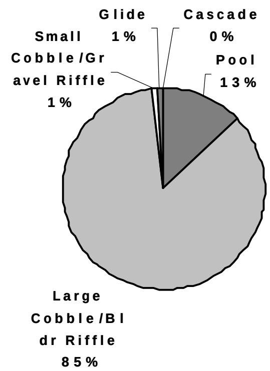


Figure B-14. Unit composition by percent surface area of the surveyed section of Wildhorse Creek.

The wetted width of Wildhorse Creek during the survey averaged 3.8 m (12.5 ft). The maximum depth of pools was 1.6 m (5.2 ft) with residual pool depths of approximately 0.6 m (2.0 ft) [Table B-64].

Table B-64. Average channel morphology characteristics of surveyed sections of Wildhorse Creek

Parameter	Reach Value
Mean gradient	3.0%
Mean wetted width (m)	3.8 m
Mean active channel width (m)	4.9 m
Mean of the maximum riffle depths (m)	0.4m
Mean residual pool depth (m)	0.6 m
Mean of the maximum pool depths (m)	1.6 m
Pools per kilometer (p/km)	14.1
Primary pools (>1.0m deep) per kilometer	0.0

WOOD

There were 118 pieces of large woody debris per kilometer (LW/km) recorded in Wildhorse Creek during the summer of 2004. Wood observed in Wildhorse Creek was predominantly in the medium and large size class of woody debris pieces (Table B-65). There were no jams, but some root wads observed during the survey.

Table B-65. Size and density of wood, jams and root wads in surveyed section of Wildhorse Creek

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	23.0
Medium Pieces	20-50 cm diameter; > 2 m long	41.0
Large Pieces	> 50 cm diameter; > 2 m long	49.0
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	4.5

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were sand and gravel, respectively (Table B-66).

Table B-66. Substrate grain size composition in surveyed section of Wildhorse Creek.

Category	Mean Frequency
Sand	33%
Gravel	33%
Cobble	24%
Boulder	7%
Bedrock	3%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). Embeddedness was estimated to be 54%.

A pebble count was performed in Wildhorse Creek. The D50 and D90 particle sizes were 51 mm and 141 mm respectively. Refer to report section 2.2.4 for a more complete discussion of pebble count results.

COVER

Cover provided in Wildhorse Creek was classified using the five different cover forms recognized by the protocol including: LW, undercut banks, overhanging cover, depth and substrate velocity breaks. Cover in Hatchery Creek was provided primarily by overhanging vegetation and LW (Table B-67).

Table B-67. Presence of cover within the surveyed portion of Wildhorse Creek. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	5%
Undercut Banks	0%
Overhanging Vegetation	27%
Water Depth > 1 m	0%
Substrate (Velocity Cover)	0%

RIPARIAN

Wildhorse Creek is a small channel that well shaded by both vegetation and topography. Riparian vegetation stands consist of hardwood and mixed hardwood/conifer communities (Figure B-16). The open channel width to the sky averages 4.9 m (16 ft) of channel width plus an additional 22 m (72 ft) of open bank or a total of 27 m wide zone without vegetative cover. The mean view to sky angle is 15 percent (Table B-68).

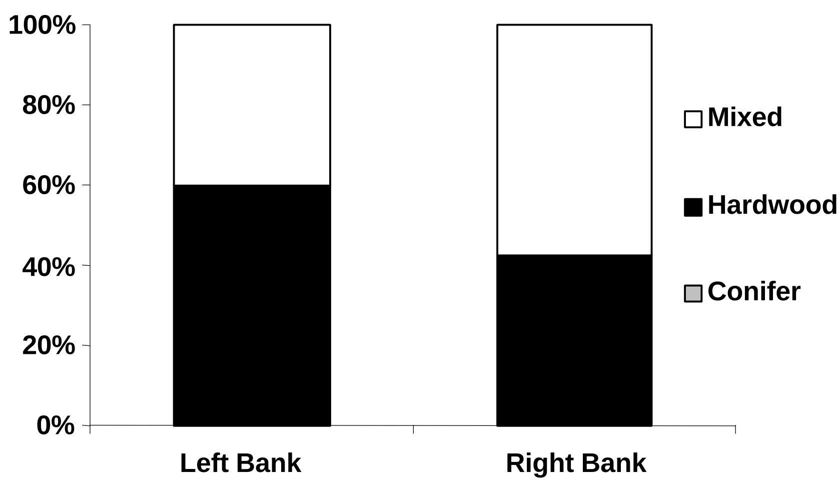


Figure B-15. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Table B-68. Riparian shading characteristics in survey section of Wildhorse Creek. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	4.9 m
Mean distance to blocking vegetation – left bank (m)	15 m
Mean left bank canopy angle (degrees)	77 ^{o}
Mean distance to blocking vegetation – right bank (m)	12 m
Mean right bank canopy angle (degrees)	76 ^{o}
Mean view to sky (percent)	15%
Elevation (msl)	500’
Reference Temperature ($T^{o}C$)	15.3^{o}C
Estimated Current Temperature ($T^{o}C$)	16.0^{o}C

Wildhorse Creek was currently predicted to meet aquatic use criteria for salmon and trout spawning and rearing. Assuming mature forest timber stands developed adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to be approximately 15.3^{o}C. The current channel condition (VTS 15%) was anticipated to increase the 7-DADmax on a relative basis by less than 1^{o}C compared to reference conditions.

These estimates predict surface water temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of cool groundwater influx or warm wetland runoff. Actual water temperatures will vary with discharge, local weather patterns and the volume of groundwater contribution.

INSTABILITY AND DISTURBANCE

Approximately 41 percent of each bank was classified as unstable within the surveyed segment (Table B-69). Unstable banks in this channel type can occur naturally where the channel is forced laterally around LW accumulations. The extent to which timber harvest in the upper basin influences bank stability in Wildhorse Creek is unknown.

The riparian zones on both banks were only slightly disturbed with average estimates of percent of the 35m (100 ft) riparian zone along each bank. Man-made disturbances consisted primarily of forest harvest.

Table B-69. Bank instability and disturbance of surveyed section of Wildhorse Creek. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	41
Right bank instability (%)	41
Left bank disturbance (%)	6
Right bank disturbance (%)	6

COMPARISON TO EDT VALUES

EDT patient scores were generally similar to scores assigned based on the 2004 survey results. Important differences include: (1) channel morphology adjustments based on less primary pools, glides and large cobble/boulder riffles; and substantially more small cobble/gravel riffle habitat: (2) less channel width and (3) more substrate loading with fine sediment and higher embeddedness ratings than previously estimated in the SRE (Tables B-70 – B-72).

Table B-70. Comparison of EDT Level 2 attribute ratings assigned to Wildhorse, and EDT ratings based on 2004 stream survey and hydromodification analysis results for habitat quantity attributes.

Attribute	SRE Rating	Rating from Survey	% Change in Habitat Quantity
Channel width – minimum (ft)	25	12	-57.6%
Channel width – maximum (ft)	41	15	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-71. Comparison of EDT Level 2 attribute ratings assigned to Wildhorse, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	32.6%	7.8%	
Habitat Type – backwater pools	0.7%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	10.1%	4.5%	
Habitat Type – glides	14.4%	0.9%	
Habitat Type – small cobble/gravel riffles	8.4%	85.2%	
Habitat Type – large cobble/boulder riffles	33.8%	1.6%	

Table B-72. Comparison of EDT Level 2 attribute ratings assigned to Wildhorse, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	3.0%	3.0%	
Confinement – natural	4	3-4	
Confinement – hydromodifications	1	NA	
In-channel wood	3	3.1	
Embeddedness	0.8	2.4	
Fine sediment	2.1	3.3	

APPENDIX 2C

Geologic Map Units

Table C-1. Definition of geologic map units found in Kalama, lower North Fork Lewis, and Washougal basins (edited from Walsh et al. 1987).

Database Symbol	Unit Name	Description
Qa	Alluvium	Silt, sand, and gravel deposited in streambeds and fans; surface relatively undissected
Qls	Landslide debris	Clay, silt, sand, gravel, and larger blocks; unstratified and poorly sorted; surface commonly hummocky. Includes the 1980 debris avalanche of Mt St Helens, talus, and all other mass wasting deposits
Qt	Terraced sediments	Silt, sand, and gravel of diverse compositions and origins, such as proglacial outwash, glacial outburst deposits, older alluvium, lahars, and uplifted coastal marine and estuarine deposits.
Qfs	Flood sand and silt (Glacial Lake Missoula Outburst deposits)	Silt, sand, and clay, commonly grading into unit Qfg; contains slackwater deposits and cross-bedded fine grained surge deposits, and some interbedded gravels
Qfg	Flood gravel (Glacial Lake Missoula Outburst deposits)	Boulder to cobble gravel with sandy matrix and minor silt interbeds
Qap	Undifferentiated drift	Glacial till and outwash sand and gravel.
QPlc	Continental sediments	Gravel, sand, silt and clay; deposits of ancestral Columbia River contain distinctive orange quartzite clasts thought to be derived from northeast Washington
Qvb	Quaternary basalt flows	Light gray to black, microphyric to coarsely phyric olivine basalt and olivine-clinopyroxene basalt
Qvc	Quaternary volcaniclastic deposits, undivided	Ash- to block-sized lithic and pumice-rich pyroclastic deposits, debris flows, laharic deposits, pumice lapilli, and ash tephra, and fluvial gravels, sand, and silt; deposited by pyroclastic flows, lahars, and debris avalanches; at Mt St Helens, lithic clasts consist of gray to pink hornblende-hypersthene dacite and andesite and lesser black andesite and basalt, locally interbedded with glacial till
Qvl	Quaternary lahars	Unsorted to poorly sorted, generally unstratified mixtures of cobbles and boulders supported by a matrix of sand or mud; also contains lesser stratified fluvial deposits
Qplva	Pleistocene-Pliocene andesite flows	Gray olivine-hypersthene, pyroxene, hornblende, and hypersthene-hornblende andesite flows and associated breccias; erupted from vents
QPlvb	Pleistocene-Pliocene basalt flows	Gray to gray-black, aphyric and plagioclase-olivine-phyric and pyroxene-olivine-phyric basalt; commonly trachytic; platy, blocky, and columnar jointed; commonly scoriaceous; erupted from multiple vents distinguished by cinder cones
@va	Oligocene andesite flows	Aphyric to porphyritic andesite flows and flow breccia; in southwest Skamania County, thick flows of clinopyroxene basaltic andesite.
@vc	Oligocene volcaniclastic rocks	Greenish to brown and maroon, andesitic to basaltic lithic breccia, tuff, and tuff breccia, and volcanic siltstone, sandstone, and conglomerate; interbedded with basalt and andesite flows and rare dacite to rhyolite flows and tuffs; breccias typically unstratified, crudely graded, or very thickly bedded, poorly sorted, with clasts of pyroclastic rock, porphyritic basaltic andesite to dacite, aphyric to glassy lava, in a matrix of altered plagioclase, devitrified glass ahards and clay; sandstone and ash to lapilli tuff commonly form well-bedded, graded, parallel laminated, poorly to well sorted sequences

Table C-1. Definition of geologic map units found in Kalama, lower North Fork Lewis, and Washougal basins (edited from Walsh et al. 1987).

Database Symbol	Unit Name	Description
@vt	Oligocene tuff	Crystal-lithic and pumice-lithic tuff and tuff-breccia; in the Mt St Helens area, dominantly pyroxene- and plagioclase-phyric with lesser quartz-phyric, block to lapilli tuffs, commonly unstratified and poorly sorted; interbedded with volcanic sedimentary rocks and dacitic to andesitic flows or plugs
@Eva	Lower Oligocene to upper Eocene andesitic flows	Platy to massive, vesicular to dense, porphyritic basaltic andesite flows and flow breccia, with lesser andesite, basalt, and dacite; flows commonly have oxidized, wavy bases and thin interbeds of shale, tuff, or volcanic sandstone and conglomerate; forms complexes of numerous thin, irregularly shaped flows of limited areal extent; most flows are plagioclase-clinopyroxene phyric; two-pyroxene or olivine-phyric flows also present; zeolites and calcite common in amygdules and fractures
#igd	Miocene granodiorite	Porphyritic to equigranular, Fine- to medium-grained, hornblende-biotie or pyroxene granodiorite and lesser quartz monzonite and quartz diorite
#iq	Miocene quartz diorite	Equigranular to porphyritic quartz diorite
#ian / #@ian	Miocene / Miocene-Oligocene intrusive andesite	Aphanitic to porphyritic pyroxene and hornblende andesite and basaltic andesite / aphyric to porphyritic hornblende-, pyroxene-, and hornblende-pyroxene andesite; forms dikes, dike swarms, sills, small plugs, and stocks
#id / #@id	Miocene / Miocene-Oligocene diorite	Fine- to medium-grained and commonly porphryitic pyroxene diorite, pyroxene-hornblende diorite, and hornblende diorite; occurs as sills, dikes, small stocks, and cupulas of major plutons; contains lesser quartz diorite
#vt / #@vt	Miocene / Miocene-Oligocene tuff	Welded to non-welded, vitric to crystalline, lithic and pumiceous dacite and rhyolite tuffs and tuff breccias; commonly quartz phyric; contains pyroclastci flows and airfall tuff with minor silic lava flows and volcaniclastic sedimentary rocks,
#va	Miocene andesite flows	Pyroxene andesite and two-pyroxene andesite and balsatic andesite flows and flow breccia; also contains minor hornblende-pyroxene andesite and clinopyroxene basalt flows interbedded with volcaniclastic breccia, tuff, and volcanic sandstone; lavas commonly porphryitic
#vc	Miocene volcaniclastic rocks	Massive to well-bedded volcaniclastic breccias and conglomerates, tuffs, tuff breccias, and volcanic sandstones and siltstones
#vg	Middle Miocene Grande Ronde basalt	Fine grained, aphyric to very sparsely phyric flood-basalt with basaltic andesite chemistry, forms broad sheet flows with sedimentary interbeds of tuffaceous sandstone, siltstone, and conglomerate
#vw	Middle Miocene Wanapum basalt	Fine- to coarse-grained, sparsely phyric to abundantly phyric theoleiitic basalts, forming sheet flows that have thin sedimentary interbed and a few intracanyon flows
#cg	Miocene continental sedimentary rocks, conglomerate	Conglomerate with abundant dark-colored porphyritic andesite clasts, debris flow breccia, pebbly volcaniclastic sandstone, siltstone, and minor airfall tuff; commonly thick bedded