Kalama, Washougal and Lewis River Habitat Assessments

Chapter 6: The Washougal River Basin

Prepared for:

Lower Columbia Fish Recovery Board
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December 2004

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6. CHAPTER 6 – THE WASHOUGAL RIVER BASIN

6.1 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.

6.1.1 Hydromodifications

The hydromodifications analysis area for the Washougal River consisted of low gradient alluvial and semi-alluvial reaches located at the downstream end of the basin (RM 0 to RM 5.5). The analysis area included EDT Reaches 1 through 3. Field surveys for hydromodifications were completed 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 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 Washougal River channel over the past 150 years, or areas likely to have been inundated during large floods.

The only available historic information on channel condition and configuration for the Washougal River consisted of cadastral survey maps dating from 1857 (Allied Vaughn, 2000). The 1857 cadastral survey map, while providing useful information on gross changes in channel location and pattern since 1857, was not sufficiently detailed as to represent historic channel margins and off-channel habitats. As a result, historic channel margins were not estimated for the Washougal analysis area. Likely changes in channel margin habitat were discussed qualitatively based on the 1857 cadastral map and current conditions.

The historic generalized floodplain was delineated based on evidence of historic channel features that persist on topographic maps and aerial photos. Where no historic channel features were documented, the generalized floodplain was estimated to extend across the valley floor halfway to the second contour line encountered (10 to 30-feet above the rivers edge). Gage data from the historic Washougal River at Washougal gage indicated that flood stages in excess of 15 feet above the normal high flow stage have occurred in the past 50 years. As a result, the generalized floodplain delineated on the historic topographic map was likely a liberal estimate of the area inundated or affected by large floods.

The current floodplain was delineated based on the location of existing infrastructure (i.e., roads/levees) that affects natural geomorphic processes (e.g., lateral erosion or inundation) and thus constrains 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 are not considered to be functioning naturally.

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 only point data coverages of hydromodifications for WRIA 28, including the lower Washougal River area. New line and polygon hydromodifications coverages were developed for the Washougal analysis area.

Polygon hydromodifications were based on information derived from digital raster graphics (DRGs) of United States Geological Survey (USGS) 1:24,000 scale, 7.5 minute Camas and Washougal quadrangles and 4m black and white digital orthphotos dating from 2003 that were provided by the Lower Columbia Fish Recovery Board (LCFRB). Polygon hydromodification identified for this analysis included cities (city limits from USGS topographic maps), developed areas (derived from concentrations of houses outside of the city limits observed on photos), and excavated areas (from maps and photos). No attempt was made to map individual structures. Areas of intact forest cover were also delineated in the polygon coverage.

Line hydromodifications delineated for this analysis included roads, railroads, transmission lines, levees and bank armoring. Roads were derived from the Clark County geographic information system (GIS) layers. Railroads and transmission lines were delineated from USGS maps. Levees and bank armoring were documented during field surveys.

Channel Margins

The lateral channel margins of large rivers, including 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 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 (1998) found that banks without hydromodifications had a higher percentage of cover than non-hydromodified banks. For most species, juvenile fish abundance is 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 vegetated cover over time supported higher densities of juvenile salmonids (Beamer and Henderson 1996).

6.1.2 Riparian Habitat Conditions

The riparian habitat condition assessment was conducted from aerial photo interpretation of the Washington State Department of Natural Resources (DNR) 2003 4m orthophoto imagery provided digitally by the LCFRB and from 1m digital color infrared orthophotos dated 2002 provided by Clark County. The aerial photographs at an approximate scale of 1:12,000 were digitally reviewed to assess riparian cover conditions along 66 EDT reaches, representing approximately 80 miles of anadromous fish-bearing streams in the Washougal River Basin. 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 Chapter I: Introduction and Methods. These estimates were 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 that were 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.

6.1.3 Stream Surveys

Stream surveys were completed for Washougal River mainstem reaches on September 2 and 3, 2004 and for tributary reaches from September 22 to October 13, 2004. Habitat condition data were collected in 12 EDT reaches representing approximately 17.1 miles per the United States Forest Service (USFS) Level II Stream Reach Inventory methods including the designation of natural sequence orders (NSOs). The methods are described in Chapter 1 of this report. The twelve reaches surveyed included:

EDT Reach	Location (RM)
Mainstem Reaches	--
Washougal 2-tidal	0.7 – 1.7
Washougal 3	1.7 – 4.4
Washougal 9	13.3 – 13.9
Washougal 14	22.6 – 24.4
Tributary Reaches	--
Little Washougal 1	0.0 – 2.8
Little Washougal 1c	3.5 – 5.6
Little Washougal 2b	6.1 – 7.0
Boulder Creek	0.0 – 1.6
West Fork Washougal 1	0.0 – 0.75
West Fork Washougal 3	2.9 – 6.1
Wildboy 1	0.0 – 1.8
Wildboy2	1.8 – 2.5

6.2 RESULTS

6.2.1 Hydromodifications

The hydromodifications analysis area focused on the lower five and one-half miles of the Washougal River. The Washougal River traverses two distinct landforms within that length (Figure 6-1). From river mile (RM) 0 to approximately RM 4.2, the Washougal River flows west along the margin of the Columbia River floodplain. At RM 3.8 the Washougal River turns abruptly north, entering a narrow, bedrock controlled canyon near RM 4.2. The analysis area ends at RM 5, the confluence with the Little Washougal River.

Historically, the Washougal River would have deposited in an alluvial fan/delta that extended into the Columbia River floodplain. The river likely migrated across the delta as sediment built up in the distributary channels. However, the generally west trending channel path observed currently, as well as on the 1856 cadastral survey maps suggests that Columbia River fluvial processes have dominated in this area and kept the Washougal River channel confined against the sideslope. Topographic features visible on current maps indicated that the area occupied by the Steigerwald wildlife refuge historically may have supported Columbia River side or overflow channels that fed into the Washougal River near RM 4. Although these features may be related to Lake Missoula flood deposits and associated hydrologic regime, they are not mapped as such (Walsh *et al*. 1987). East-west trending sloughs identifiable on early maps and photos provided evidence of this process.

The disparity in basin size between the Columbia River (240,000 mi^2) and the Washougal River (approximately 108 mi^2) has given rise to some important differences in process and timing that have affected floodplain dynamics on the Washougal/Columbia River floodplain. The majority of the Columbia River basin drains interior areas that support a seasonal snowpack, and thus peak flows and sediment loads occur over a prolonged period in May and June. In contrast, the climatic and flow regime of the Washougal River is dominated by rainfall, with peak flows occurring in response to large rainstorm events in the fall and winter (November through February). Sediments originating in the upper Washougal basin were carried downstream, settled out in and adjacent to the mouth of the Washougal River where it entered the low gradient Columbia River floodplain. Sediments carried by the Columbia River during spring snowmelt also were deposited on the Washougal/Columbia River floodplain. In response to the combined depositional regime of the Washougal and Columbia rivers, the Washougal River naturally experienced multiple cycles of aggradation and degradation each year. The Columbia and lower

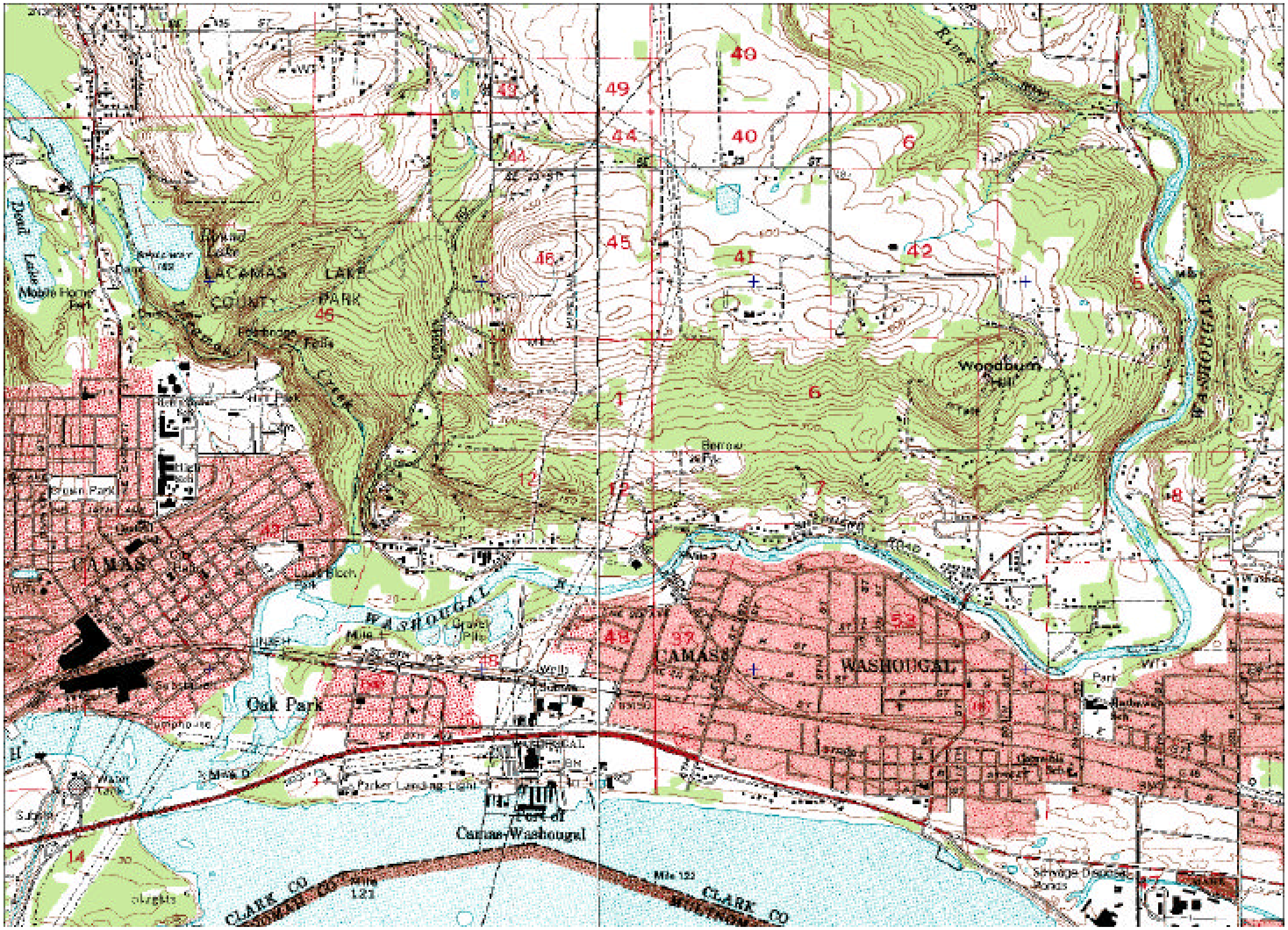


Figure 6-1. USGS 1:24,000 scale topographic map of the hydromodifications study area, (RM 0 to RM 5.5) for the Washougal River basin.

Washougal Rivers have in the past and continue to experience daily tidal fluctuations, although tidal stage changes in the Washougal River are likely small.

Generalized Floodplain

A comparison of the extent of the historic generalized floodplain and the current unconstrained floodplain of the Washougal River demonstrated that the area with natural geomorphic processes (e.g., sediment deposition, bank erosion, channel migration and off-channel habitat development) has been reduced by approximately 27 percent for the lowermost five and one half miles of river. Comparisons by EDT reach are provided in Table 6-1. Loss of historic floodplain has occurred primarily near RM 2, where approximately 31 acres including 13 acres of ponds produced by gravel mining are separated from the river by a levee. Another levee near RM 4.0 protects approximately 15 acres that appear to have been cleared for agriculture.

Table 6-1. Comparison of the approximate extent of the generalized floodplain associated with the Washougal 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 0.7)	124	90	<1	0	13%
2 (RM 0.7 to RM 1.8)	122	89	<1	0	30%
3 (RM 1.8 to RM 5.5)	249	184	18%	0	4%
Total	495	363	10%	0	13%

[1]Within Columbia River floodplain to RM 4.2

Within the combined floodplain of the Washougal River and the Columbia River, the 1857 cadastral survey maps indicated that the vegetation consisted of wetlands, or tree and shrub species that were tolerant of frequent inundation. Upstream of the influence of the Columbia River in the Washougal canyon, floodplain vegetation on terrace surfaces would most likely have consisted of a mosaic of forest types and age classes, ranging from young hardwood tree and shrub species on recent flood deposits to old growth conifer forests on older floodplain surfaces. On canyon sideslopes, 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 Washougal River basin is discussed in Section 6.2.2.

More recently, most floodplain surfaces adjacent to the Washougal River have been cleared and utilized for industrial and residential development or parks. Forest cover represented only 13 percent of the current floodplain area, and forested areas consisted of sparse to medium stocked stands of mixed forest (Chapter 6.1.2). At the time of this assessment, forests were concentrated in localized areas within the floodplain, with less than 10 percent of the historic generalized floodplain supporting relatively intact forest stands.

Washougal River floodplain surfaces have been incised within the Columbia River floodplain. Thus, the Washougal River floodplain area where natural geomorphic processes can occur has been constrained. It is unknown whether this incision was natural, resulted from filling in the area now occupied by the city of Washougal, or was related to changes in the Columbia River hydrologic regime. Many tributaries to the lower Columbia River have been incising through former Lake Missoula flood deposits (Wampler and Grant, 2003), thus it is possible the inset floodplain could be the result of natural processes.

There are extensive urban or developed areas adjacent to EDT reaches Washougal 1 and 2 associated with the cities of Camas and Washougal. However, most development has occurred above the Washougal River floodplain. At the time of this assessment, much of the floodplain area was occupied by parks, or by single family residences. Developed areas account for about 20 percent of the historic generalized floodplain in Washougal 1 and 2. In Washougal 3, rural residential development on discontinuous terrace surfaces within the canyon has some impact on floodplain function.

Channel Margins

The overall channel configuration was similar to that depicted in cadastral survey maps dating from 1857, and islands or major side channels were depicted on that map. Such features were noted elsewhere on similar maps. The amount of current margin and off channel habitat was thought to be relatively similar to historic conditions, as no evidence of historic off-channel habitat was noted and the area that typically would support such habitat was limited. However, hydromodifications have altered the quality of that habitat. The current length of lateral margin habitat (including banks, bars and side channels) is provided in Table 6-2.

Table 6-2. Comparison of the extent of margin habitat on the lower Washougal River historically and under current conditions.

EDT Reach	Current (mi)
1 (RM 0 to RM 0.7)	
Bank	1.6
Bar[1]	0.4
Connected side channel	0
Disconnected side channel/oxbow	0
2 (RM 0.7 to RM 1.8)	
Bank	2.8
Bar[1]	0
Connected side channel	0
Disconnected side channel/oxbow	0
3 (RM 1.8 to RM 5.5)	
Bank	8.0
Bar[1]	
Connected side channel	0
Disconnected side channel/oxbow	0

No existing side channels or off-channel habitats were identified through either air photo analysis or field surveys. There are a number of secondary flow channels (split flow paths around islands or bars within the bankfull channel) in Washougal 1. The lower end of Lacamas Creek also functions as a side channel/backwater habitat where it flows across the Washougal floodplain downstream of the 3rd Avenue Bridge. Several overflow channel features were noted in the vicinity of the Lacamas Creek confluence, but none had the morphologic features required to classify as a side channel (i.e., defined mineral bed and banks).

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 Washougal River has been unregulated. Small dams exist on Lacamas Creek and on Wildboy Creek, but these structures have affected flows from only a small portion of the basin and have not substantially affected channel forming flows. Although development within the Washougal River floodplain was limited, extensive development has occurred around the lower 4.2 miles of river, and includes a high proportion of impervious surfaces. Development in the floodplain has likely increased runoff from the lower watershed, and thus has potential to have adversely affected water quality. Forest clearing, agriculture, and residential development in upland areas likely changed hydrologic flow patterns and probably has degraded habitat. As for flood control, an evaluation of specific hydrologic effects was beyond the scope of this study. However, it must be recognized that urban development effects may constrain restoration opportunities in the lower Washougal River basin.

Habitat Connectivity

No changes in the connectivity of mainstem and off channel habitats could be documented in the lower Washougal basin due to the lack of historic maps or photos.

Direct Alteration of Bed and Banks

Approximately 19 percent of the river bank in the Washougal River analysis area was naturally constrained. Natural confinement in Washougal 1 and 2 consisted of short areas where the river impinged upon steep side slopes. At RM 4, approximately two-thirds of the way up Washougal 3, the river enters a canyon and becomes generally constrained by steep sideslopes on both sides of the river. Unconstrained areas in the upstream end of EDT Reach 3 consisted of narrow, discontinuous alluvial terraces. Many of these were occupied by single family residences that are protected by bank armoring.

Numerous activities that have altered the natural channel bed and banks were identified in both constrained and unconstrained reaches of the lower 5.5 mi of the Washougal River. Hydromodifications affecting bank habitat are summarized by EDT Reach in Table 6-3. Approximately 49 percent of the length of EDT Reach Washougal 1 was confined between levees or armored banks on both sides. Unconstrained areas consisted of a few bars and islands near the confluence with the Columbia River, and a small patch of forested land near the confluence with Lacamas Creek. Hydromodifications also have affected the banks in Washougal 2 and 3. These consisted of levees that protected a gravel mine and farm field, armored banks that protect roads or residences, and stream adjacent roads.

Table 6-3. 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 Washougal River.

EDT Reach	Total margin length (mi)	Naturally constrained[1] (%)	Levee (%)	Bank armoring (%)	Stream adjacent road[2] (%)	Unmodified[3] (%)
1 (RM 0 to RM 0.7)	1.8	15%	12%	37%	0%	51%
2 (RM 0.7 to RM 1.8)	2.8	3%	21%	0%	4%	75%
3 (RM 1.8 to RM 5.5)	8.0	25%	5%	15%	12%	68%

[1]Naturally constrained banks may have been hydromodified.

[2] Areas 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.

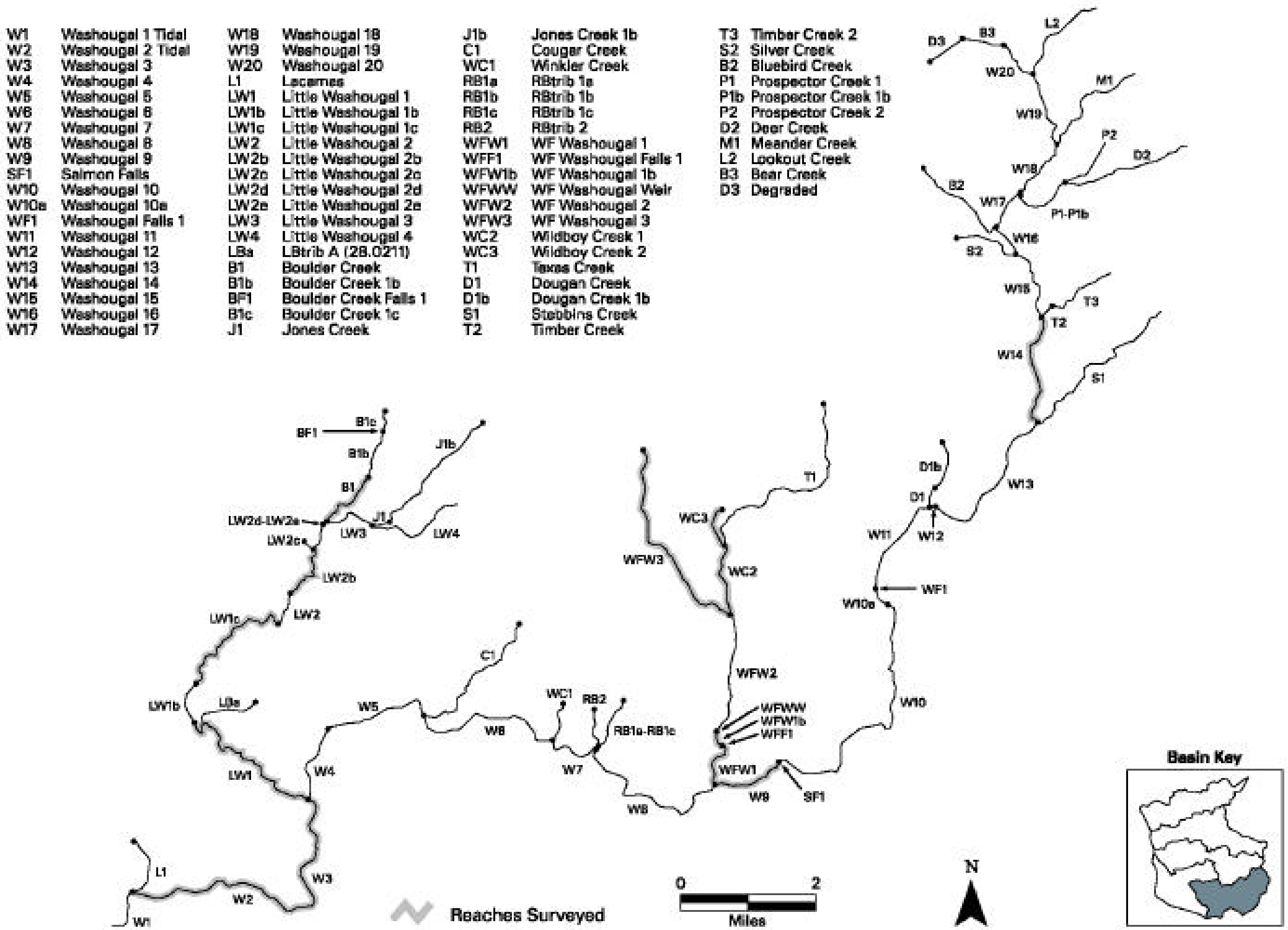
6.2.2 Riparian Habitat Conditions

The intent of the Phase II remote sensing assessment of riparian habitat conditions was to: (1) provide sufficient detail to judge the current level of riparian function related to potential LW recruitment and shade, (2) confirm the Phase I Integrated Watershed Assessment (IWA) results, as well as (3) provide input for refining EDT riparian input factors and for assessing potential restoration opportunities. These assessments are described below:

Existing Riparian Function

Large Wood (LW) Assessment: The location and current LW recruitment condition of 66 EDT reaches are shown in Map 6-1. The condition rating for each of the reaches is included in Appendix A.

Aerial photo assessment, along both shorelines of nearly 81 miles of anadromous fish streams, indicated the overall LW recruitment potential of riparian stands in the Washougal basin was moderate to relatively good. The riparian recruitment potential from the aerial photo assessment suggested good recruitment conditions were more frequent than other condition ratings based on total stream length.



Map 6-1. EDT reaches in Washougal Basin.

Large Wood Recruitment Potential

Condition	Frequency
Good	44%
Fair	34%
Poor	22%

Portions of Washougal 8, 10, 11, 13, 14, 15, 19, and 20, Little Washougal 1C, WF Washougal 2 and 3, Wildboy 1 and 2, Deer, Lacamas, Lookout, Meander, Prospector 1 and 2, Stebbins, Texas, and Timber creeks offered good current LW recruitment conditions (low recruitment hazard) on both sides of the stream (Map 6-2; Appendix A). Riparian vegetation in these situations consisted of dense stands of either large or medium-sized conifer or mixed species. The existing fair stand conditions were predominately sparse conifer or mixed stands or dense hardwood stands. A second cohort of conifer stand growth will be needed in these areas to support "functional" LW recruitment potential in the future. The poor existing stand situations appeared to be related to species composition, sparse density and tree sizes. Based on photographic interpretation, very few of the stands appeared to be dominated by deciduous species, whereas more than 1/2 of the stands were dominated by conifer species.

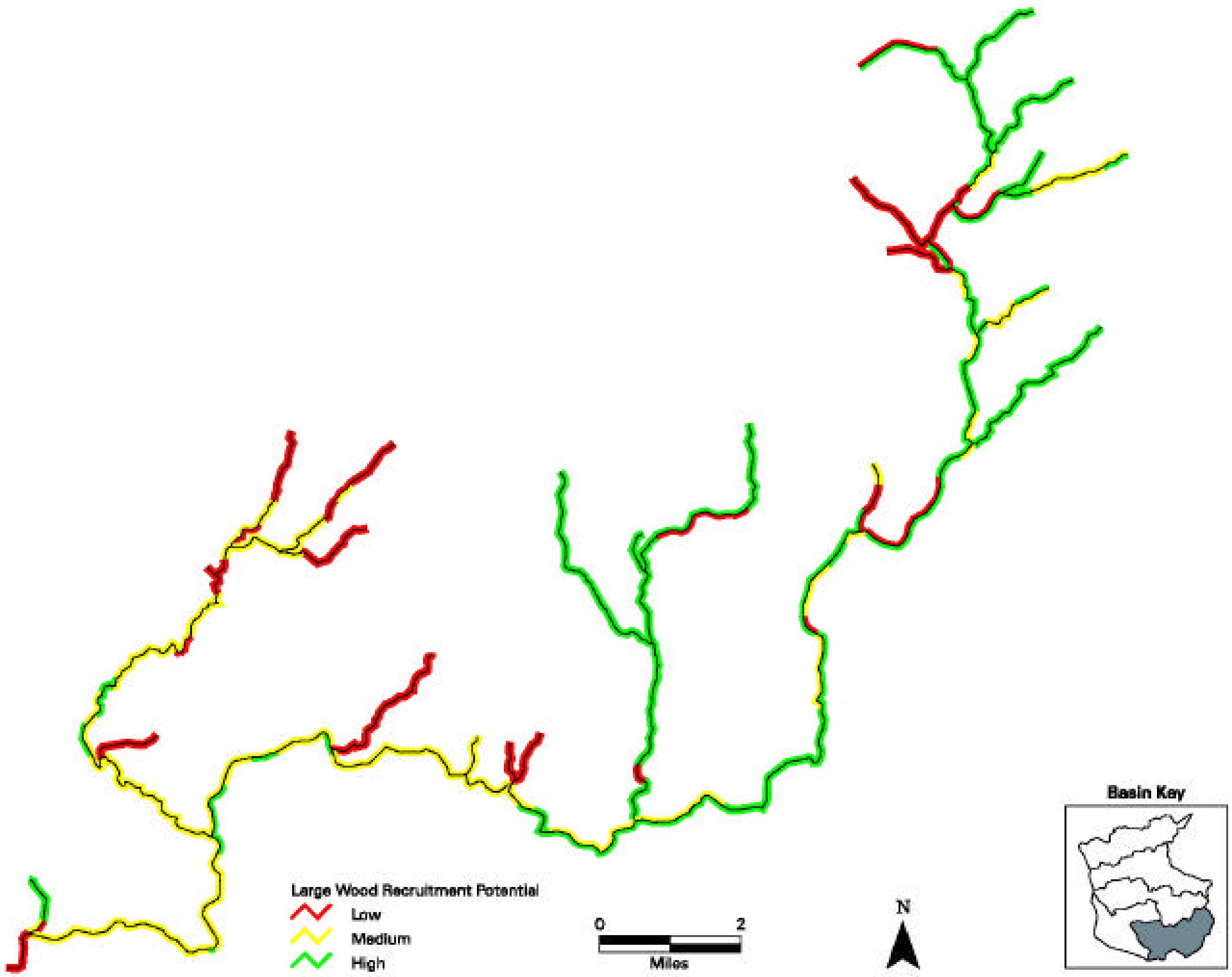
Riparian Species Composition

Type	Frequency
Conifer	58%
Mixed	38%
Hardwood	4%

Stand density data indicated there were more sparse stands than dense stands along the Washougal River EDT reaches, but the frequencies were close to 50:50.

Riparian Stand Density

Condition	Frequency
Sparse	54%
Dense	46%



Map 6-2. Large wood condition ratings for EDT reaches in the Washougal Basin.

The relative size of the trees in incremental size classes was predominately (67%) in the medium size class range (4.7–8.0 cm; 12–20”). Eleven percent of the stands were categorized in the large (> 8 cm; 20” dbh) size class. Within a few decades, riparian stand growth would contribute to the large size class of trees, enhancing future LW recruitment conditions for these streams.

Riparian Stand Size Class

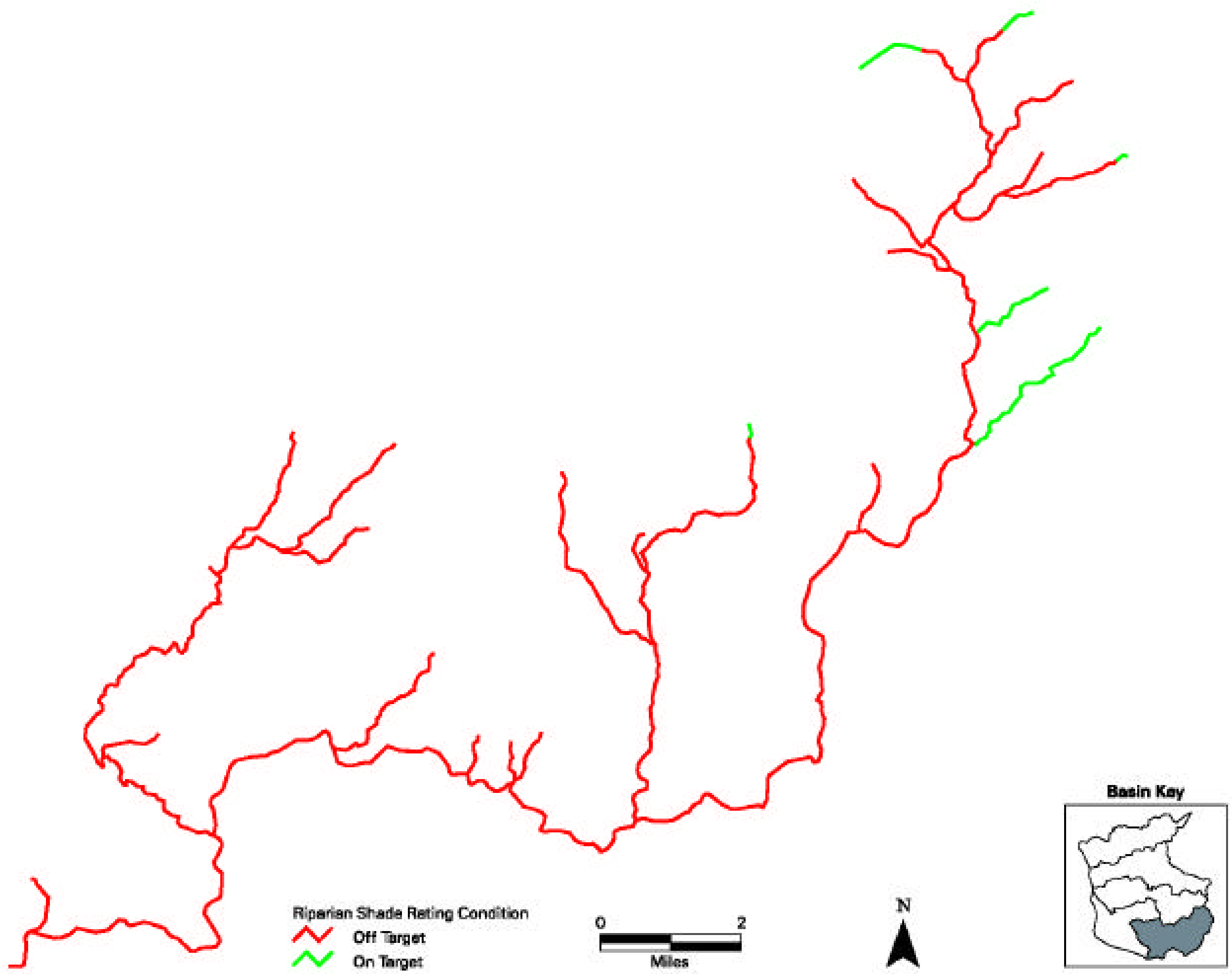
Condition	Size Class	Frequency
	(dbh)	(%)
Small	< 12”	23%
Medium	12 – 20”	67%
Large	> 20”	11%

As described in the Section 6.2.3; *Stream Survey*, urbanization (including all forms of land use development), roads, and clearcut timber harvesting and thinning along the shorelines have encroached within 30m (100 ft) riparian zones at several places along fish-bearing channels. These activities have adversely influenced the riparian LW recruitment potential.

Riparian Shade Assessment: The location and current shade condition of the 66 EDT reaches is shown in Map 6-3. The condition rating for each of the reaches is included in Appendix A.

Aerial photo assessment indicated, on average, the current condition of riparian stands was providing little effective shade. Existing shade levels ranged between 0 and 80 percent shade while the mean level was approximately 27 percent shade. According to the State Forest Practices shade/elevation screen, this average shade level would be insufficient to maintain water temperature standards for anadromous fish species anywhere within the basin since the accessible stream reaches lie entirely below 2,280 ft msl in elevation. Reaches at this elevation would need in the range of 40 percent shade to be effective at maintaining water temperature standards.

Almost all of the EDT reaches in the basin are currently off-target with respect to the State shade/elevation screen, representing high shade hazards for compliance with water temperature standards. Only the tips of a few reaches in the headwater areas support on-target shade levels (Map 6-3). Due to the predominately 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. The wide mainstem reaches along the lower Washougal River likely



Map 6-3. Shade condition ratings for EDT reaches in the Washougal Basin.

offered naturally open riparian canopies and historic warm stream temperature regimes due to frequent Columbia River floodplain disturbances.

Riparian Shade Condition

Shade Increment	Tally	Frequency
0	1	1%
0 – 20%	16	15%
20 – 40%	63	58%
40 – 70%	24	22%
70 – 90%	4	4%
90 – 100%	0	0%

IWA Verification

The IWA for the Washougal River basin provided information related to whether or not riparian conditions were either intact or degraded at the subwatershed level based on total stream length. The proportion of intact versus degraded riparian zones 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 functional in 4, moderately impaired in 18 and impaired in 7 of 29 subwatersheds in the Washougal basin. The four subwatersheds rated as generally providing functional riparian habitat conditions were all headwater basins including the upper WF Washougal River basin, # 60304; Bluebird Creek # 60102; Deer and Meander creeks # 60101; and Stebbins Creek #60202. All of these subwatersheds lie in the uppermost reaches of anadromous salmonid fish habitat in the Washougal Basin and were not assessed during this effort. Similarly, 5 of the 7 subwatersheds rated with impaired riparian habitat conditions were located in the upper Lacamas Creek basin upstream of anadromous fish distribution.

One of the impaired basins # 60501 encompasses the lower reaches of the Washougal River near its confluence with the Columbia River including surveyed reaches along the mainstem Washougal 2-tidal and Washougal 3. Both the aerial photo assessment and the field surveys indicated the riparian vegetation was dominated by a mixed species composition, many of which have moderate size and good density to generate fair LW recruitment ratings. However, the width of the mainstem river at this point is too wide for even mature riparian vegetation to function adequately for shade and temperature moderation. It should be regarded as an area of naturally occurring low shade levels (see VTS assessment below in Section 6.2.2) Due to this natural state, the collected data herein suggest the subwatershed should be regarded as “moderately impaired” with respect to offering future LW and canopy closure rather than impaired.

The balance of subwatersheds were rated in the IWA as moderately impaired. In general, a review of Maps 6-2 and 6-3 show the reaches with poor functioning riparian zones related to LW recruitment and shade, respectively. Although variable, concentrations of high hazard areas can be found throughout the basin area. Many areas may have experienced naturally poor riparian function.

Subwatershed # 60303, including Wildboy and Texas creeks, was rated moderately impaired under the IWA. These creeks were assessed during this review with good existing potential LW recruitment and very low risk to temperature exceedances due to a high degree of canopy closures. Based on the review of these stream reaches, it is our opinion the subwatershed should be rated as providing functional riparian zones.

Subwatershed # 60502 includes the Little Washougal River drainage. The photo assessment for wood recruitment potential indicates the IWA moderately impaired rating is appropriate. The VTS and photo assessment indicate the poorest riparian function occurs in the lowermost reach of Little Washougal 1 due to urban development, road construction and a sparse deciduous canopy. Otherwise the riparian function along other reaches in the subwatershed is rated mostly good to fair.

6.2.3 Stream Surveys

Habitat inventory data are summarized in this section of the Washougal River Basin document per individual EDT reach (Table 6-4 and 6-5). Habitat conditions for each of the surveyed reaches highlighted in Map 6-1 are presented in detail in Appendix B.

Channel Morphology

The channel morphologies for the EDT reaches surveyed in the Washougal River basin varied between wide, low gradient, floodplain channels with pool-riffle bedform in the lowland mainstem reaches to moderate gradient contained streams with mixed control features in the tributary reaches. The tributaries surveyed varied from low gradient (1.1%) in Little Washougal 1 to moderate gradients (4.5%) found in Wildboy 2. These type of streams offered pool:riffle to

Table 6-4. Channel Gradient, Confinement and Morphology in the Washougal Basin.

Reach	Map Gradient (%)	Confinement	Paustian Process Group	Montgomery Buffington bedform	Comments
Washougal 2	<1%	Mod – Unconfined	Large Floodplain	Pool-riffle	Occupies former Columbia River overflow channel. Steep hill to north, City of Camas to south. Floodplain incised into CR floodplain deposits. May have historically transmitted Columbia River flood flows from the east
Washougal 3	0.3%	Mod-unconfined	Large Floodplain to low gradient contained	pool-riffle	See above; no logical reason to break EDT Reach between 2-3. About 2/3 up the reach becomes low gradient contained, in bedrock canyon with occasional alluvial terraces.
Washougal 9	1.4% upper end; 0.5% lower end	Confined	Large, contained	Pool-riffle	Bedrock controls lateral migration and likely pool formation. Adjacent terrace appears to be above current flood levels
Washougal 14	1.5%	Confined to Moderate	Moderate gradient contained	pool-riffle	Lower ½ mile very narrow canyon; upper part bordered by alluvial terraces and pronounced alluvial fans from Timber Cr. and 2 unnamed tribs
West Fork Washougal 1	2.5%	Confined	Moderate gradient contained	pool-riffle to plane bed	Small enough that large wood or jams would be effective for trapping coarse sediment; pools likely controlled by BR
West Fork Washougal 3	2-2.5%	Moderate to High confinement	Moderate gradient contained	pool-riffle to plane bed	See above. This reach varies between tight canyon and moderately confined sections
Wildboy 1	3.5%	Mod – highly Confined	Moderate gradient mixed control	forced pool-riffle to step pool	Likely contains step-pool segments; responsive to LW. Plane-bed w/out LW
Wildboy 2	4.5%	Moderate	Moderate Gradient mixed control	step-pool	See above

Table 6-4. Channel Gradient, Confinement and Morphology in the Washougal Basin.

Reach	Map Gradient (%)	Confinement	Paustian Process Group	Montgomery Buffington bedform	Comments
Little Washougal 1	1.1%	Confined	Moderate gradient contained to moderate gradient mixed	pool riffle	Lower end narrow canyon, pool riffle to step-pool morphology forced by bedrock; high energy will reduce effectiveness of LW. Upstream of canyon moderately confined, more responsive to LW and sediment deposition
Little Washougal 1c	1.6%	Moderate to low confinement	Moderate gradient mixed control	Forced pool-riffle to plane bed	Responsive to LW, contained gravel deposits. Plane bed in absence of LW
Little Washougal 2b	2.0	Moderate to low confinement	Moderate gradient mixed control	Forced pool-riffle to plane bed	See above. Flows through relatively wide valley; may be unconfined in places
Boulder	3%	Moderately confined	Moderate gradient mixed control	Forced pool-riffle to plane bed; step-pool in steeper areas	LW would force channel avulsion and development of pool-riffle habitats. Sediment storage depends on LW; plane bed w/out wood

Table 6-5. Mean Habitat Inventory data in the Washougal Basin

	Wash. 2-Tidal	Wash. 3	Wash. 9	Wash. 14	Little Wash. 1	Little Wash. 1c	Little Wash. 2b	WF Wash. 1	WF Wash. 3	Wildboy 1	Wildboy 2	Boulder
Channel Morphology												
Pool %	19	30	49	32	44	23	25	28	35	42	40	24
Pool Tailout	5	9	25	37	32	17	30	35	29	32	27	41
Large Cobble Riffle	0	0	9	0	8	24	19	57	0	0	1	0
Small Cobble Riffle	22	48	22	55	37	41	53	0	38	42	44	71
Glide	60	23	14	10	11	0	3	5	6	5	3	2
Cascade	0	0	5	3	0	12	0	10	22	5	12	3
Other	0	0	0	0	0	0	0	0	0	6	0	0
Gradient	0.1	0.3	1.5	2.0	1.5	2.0	1.5		2.5	2.5	2.5	2.0
Channel Type												
Bedform												
Wetted channel width (m)	51	36	21.9	19.0	11.2	11.2	10.9	16.9	12.2	8.2	8.7	6.9
Active channel width (m)	-	-	28.0	24.0	13.2	14.0	13.4	20.7	16.9	10.8	6.2	8.1
Max. Riffle Depth	-	-	0.7	0.8	0.6	0.8	0.6	0.9	0.6	0.5	0.5	0.5
Res. Pool Depth (m)	4.3	3.9	1.3	1.5	0.5	0.6	0.6	1.7	1.4	0.9	0.8	0.5
Max Pool Depth (m)	4.9	4.4	1.7	1.9	0.9	1.0	1.1	2.1	1.9	1.2	1.1	0.8
Pools/km	1.3	2.4	10.1	12.7	8.6	12.7	9.5	6.5	11.7	21.0	17.9	19.2
Primary Pools/km	1.3	2.4	8.1	6.3	6.2	6.3	6.7	6.5	11.3	9.6	11.7	1.9

Table 6-5. Mean Habitat Inventory data in the Washougal Basin

	Wash. 2-Tidal	Wash. 3	Wash. 9	Wash. 14	Little Wash. 1	Little Wash. 1c	Little Wash. 2b	WF Wash. 1	WF Wash. 3	Wildboy 1	Wildboy 2	Boulder
LW												
Small Pieces/km	1.3	1.9	1.5	0.7	6.5	3.2	5.7	3.8	2.9	37.0	41.0	29.0
Medium Pieces/km	1.3	0.7	7.1	2.8	9.9	4.8	7.6	7.0	5.0	27.0	31.0	22.0
Large Pieces/km	0.6	0.4	2.5	4.6	1.8	0.0	2.9	1.6	2.5	3.7	3.4	31.0
Jams/km	0.6	0.0	0.0	0.0	0.8	0.0	1.9	0.0	0.0	5.5	1.2	2.4
Root Wads/km	0.0	0.2	1.0	0.0	3.9	0.0	1.0	0.0	0.4	0.0	0.0	12.4
Total LW/km	3.8	3.2	12.2	8.2	22.9	7.9	19.1	12.4	10.9	73.0	77.0	96.0
Substrate												
Sand	-	-	8%	5%	18%	14%	17%	7%	5%	8%	7%	10%
Gravel	56%	42%	24%	18%	34%	21%	24%	17%	16%	16%	17%	20%
Cobble	33%	38%	18%	22%	28%	18%	28%	29%	26%	18%	18%	39%
Boulder	18%	15%	17%	26%	11%	24%	21%	32%	29%	16%	15%	29%
Bedrock	-	4%	34%	29%	9%	23%	10%	16%	24%	41%	44%	1%
Cover Percent												
LW (%)	0	0	<1	<1	1	2	2	1	1	9	7	6
Undercut Banks (%)	0	0	0	0	0	0	0	0	0	<1	2	3
Overhanging Cover (%)	0	4	1	1	4	8	12	9	3	8	8	13
Depth > 1m (%)	33	40	18	17	10	22	14	2	18	8	19	13
Substrate (velocity) (%)	0	0	3	13	2	11	5	17	6	5	3	0
Total % Cover	33	44	21	31	18	25	32	29	27	30	39	34

Table 6-5. Mean Habitat Inventory data in the Washougal Basin

	Wash. 2-Tidal	Wash. 3	Wash. 9	Wash. 14	Little Wash. 1	Little Wash. 1c	Little Wash. 2b	WF Wash. 1	WF Wash. 3	Wildboy 1	Wildboy 2	Boulder
Riparian												
Distance to Left Bank (ft)	167	107	81	54	352	29	33	48	44	28	15	18
Angle	30	37	55	52	41	72	76	61	74	76	85	77
Distance to Right Bank (ft)	174	164	95	46	103	30	33	38	42	27	25	19
Angle	24	35	45	53	40	74	77	68	74	79	80	76
VTS %	68%	60%	44%	40%	51%	20%	14%	28%	18%	12%	9%	21%
Active channel width (m)	51	36	28	24	13	14	13	21	17	11	11	8
Elevation (ft) msl	20	55	375	835	100	295	500	400	685	725	835	680
Reference Temp ^{o}C	18.2	17.6	16.7	15.8	16.4	16.2	15.8	16.3	15.7	15.3	15.1	15.2
Current Est. Temp ^{o}C	21.1	20.3	18.3	17.6	19.5	16.9	16.1	17.3	16.1	15.6	15.3	16.4
Vegetation Community (%)												
LB Hardwood	100%	38%	13%	11%	56%	6%	0%	0%	-	-	-	-
Mixed	0%	50%	73%	83%	25%	44%	50%	47%	-	-	-	-
Conifer	0%	13%	13%	6%	19%	50%	50%	53%	-	-	-	-
RB Hardwood	100%	38%	17%	47%	69%	20%	0%	16%	-	-	-	-
Mixed	0%	50%	58%	42%	23%	47%	45%	53%	-	-	-	-
Conifer	0%	13%	25%	11%	8%	33%	55%	32%	-	-	-	-

Table 6-5. Mean Habitat Inventory data in the Washougal Basin

	Wash. 2-Tidal	Wash. 3	Wash. 9	Wash. 14	Little Wash. 1	Little Wash. 1c	Little Wash. 2b	WF Wash. 1	WF Wash. 3	Wildboy 1	Wildboy 2	Boulder
Bank Stability												
LB Unstable %	-	-	2	-	3	0	9	0	-	-	0	9
Disturbance %	39	53	1	21	57	16	11	31	18	7	0	11
Disturbance Type	U,T,C	U,T	R	R	U,R	U	C,T,U	R,U	U,C,T	C	-	C
RB Unstable %	-	-	2	-	3	0	16	9	-	-	0	3
Disturbance %	51	62	18	0	36	15	20	15	18	0	0	22
Disturbance Type	U,T	U,R,T	R,U	-	U,R	U	R,C,U	U,R	U,R,C,T	-	-	C

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 forced pool:riffle bedforms or step pools where channel structure was abundant. However, in the absence of large structure (woody debris, boulder clusters, or bedform controls) some sections would likely consist of plane bedded channels.

Habitat Types

The large lowland reach of Washougal 2-tidal consisted mostly of glide habitat. The glides were relatively deep as were the pool habitats in the tidal reach. Maximum pool depths averaged 4.9m (16 ft). Small gravel-cobble riffle habitat was the most frequent habitat type elsewhere throughout the basin, except in Washougal 9, Little Washougal 1 and Wildboy 1, where pool habitats were most prevalent. The pools were relatively deep in these reaches, with more than 50 percent of the total number of pools qualifying as primary pools (greater than 1.0 m [3.3 ft] in depth). Although pool habitat was less frequent in the balance of the surveyed reaches, nevertheless, they offered relatively deep pool habitats.

Large Wood Structure

On a relative basis, individual instream LW pieces were common in the tributary reaches of Little Washougal 1 and 2b, and they were abundant in Wildboy 1 and 2 and Boulder Creek. Few LW pieces were observed in the wide unconstrained lowland reaches of the Washougal mainstem.

The instream wood loading was primarily of the small and medium size categories except for Washougal 14 and Boulder Creek where large size classes were also represented. The presence of wood jams and pieces with attached root wads was very low throughout the survey, except in Little Washougal 1 and 2b and in Boulder Creek where it appears that channel restoration projects have been carried out.

The instream data indicated either the large wood recruitment to the lowland reaches of the Washougal basin has been low or the depletion rate has been high. As discussed in the previous section, long-term riparian growth on the order of a few decades would be needed to offer a high degree of LW recruitment potentials to these channels in the future.

Substrate

There was a low frequency of sand particle sizes and low embeddedness ratings at all of the surveyed reaches. The resistant nature of the parent geologic materials in the basin to erosion likely explains the observed lack of fines in the system. Refer to Section 6.2.4 for a detailed assessment of the sediment conditions in the reaches.

Cover

Water depth provided the primary cover type for fish species in the lowland reaches of the Washougal Basin. The upland tributaries offered more diverse cover types including large substrate clasts, LW, and overhanging vegetation. The most frequent cover type in the tributaries remained water depth, but LW offered the predominant cover type in Wildboy 1 where abundant instream LW occurred. Large substrate clasts were most prevalent in WF Washougal 3 as a function of channel morphology.

Riparian Condition

According to the stream survey information, deciduous species dominated the riparian species stand composition along the tidal reach of Washougal 2, whereas mixed and confer-dominated species stands were most abundant along the balance of the lowland reaches of Washougal 3, 9, and 14. Riparian zones of the tributary reaches of the Little Washougal and the WF Washougal were composed mostly of mixed and conifer stands. The exception was Little Washougal 1 that was dominated by sparse stands of hardwood species as a result of riparian stand disturbances and encroachment. 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. Nevertheless, the field inventory matched the photo assessment results at all sites with the exception of Washougal 2-tidal, where a greater presence of hardwood species was noted in the field surveys as compared to the remote assessment (Table 6-6).

Encroachment into the 30m (100 ft) riparian zone along the surveyed reaches in the Washougal basin resulted in disturbance ratings between 0 and 62 percent of the riparian area disturbed on either bank. The greatest frequency of disturbance types included urbanization, road development and clearcut timber harvesting or thinning operations (Table 6.2-3). Urbanization (all forms of development), including home developments and road construction had the highest overall effect on riparian zones in Washougal 3, within the City of Washougal, and along the lowermost reaches of the Little Washougal (1 and 1c) and the WF Washougal (1). Timber harvesting in riparian zones was a legacy effect prior to recent changes in the forest practices rules. Boulder Creek exhibited the highest frequency of prior harvesting adjacent to stream channels. Overall, Washougal 3 and Little Washougal 1 supported the highest level of riparian zone encroachment from all factors.

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

Disturb Type	Wash 2-tidal	Wash 3	Wash 9	Wash 14	L. Wash 1	L. Wash 1c	L. Wash 2b	WF Wash 1	WF Wash 3	Wild Boy Cr. 1	Wild Boy Cr. 2	Boul-der Cr.
Urbaniza-tion	6	23	8		16	10	2	14	1			
Roads	1	3	2	10	7		8	11	1			
Railroads												
Clearcut	1						6		6	2		18
Thinning	11	4					2		8			
Hydro-modifica-tions												
Total	19/20	30/32	10/32	10/40	23/38	10/32	18/40	25/38	16/40	2/40	0/42	18/40

Estimates of the average distance of trees beyond the bank full stage of the channel along the lowland Washougal River reaches ranged between 14 and 53 m (46 – 174 ft) on either side of the rivers. This zone was wide along the floodplain reaches, especially along Washougal 2-tidal and Washougal 3. The resulting mean view to sky angle from mid-channel ranged between 42 percent at Washougal 14 and 68 percent along Washougal 2-tidal (Table 6-6).

The lowermost mainstem reaches of Washougal 2-tidal and Washougal 3 were estimated to remain open to solar radiation even under the unlikely assumption of mature forest stands growing immediately adjacent to the channel, (e.g., VTS 88^o; 49% along Washougal 2-tidal and VTS 43^o; 24% along Washougal 3). As such, these reaches represented areas with naturally low shade levels and they 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 surface water temperatures were predicted to approach 17.6^oC and 18.1^oC at Washougal 3, and Washougal 2-tidal, respectively. The reference temperatures at Washougal 2-tidal would not be expected to comply with aquatic use criteria for anadromous salmonid fishes or interior resident trout under mature riparian stands simply due to the expanse of the channel width and the relatively low elevation of the river channel. Similarly, the reference temperature at Washougal 3 would not have been conducive to non-core anadromous salmon spawning and rearing temperatures in the Washougal basin as delineated in the state water temperature regulations (WAC 173-201A).

The current channel conditions were anticipated to increase the 7-DADmax on a relative basis between 2.7^oC and 2.9^oC at Washougal 3 and Washougal 2-tidal, respectively compared to reference conditions. As a consequence, the anticipated summer 7-DADmax surface water temperatures were estimated to range between 20.3°C and exceed 21.1°C at the lowland reaches under normal summer weather (air temperatures and stream flows) patterns.

Tree distances from the center of small tributary channels normally ranged between 5 – 15m (15-48 ft) with solar radiation blocking angles that allowed 8 to 28 percent VTS. The estimated increases in 7-DADmax surface water temperatures compared to reference thermal conditions ranged between 0.1°C and 1.2°C (Table 6-7). Little Washougal 1 was a material exception, where the distance to trees was 31m (103 ft) on the right bank and 107m (352 ft) on the left bank. This degree of open channel width was larger than the openings along the mainstem Washougal River. It resulted in an existing VTS angle of 47 percent and a 7-DADmax estimate of 19.5°C or 3.1°C higher than reference temperature conditions for this channel.

Table 6-7. 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/]			
Washougal River Basin	**EDT Reach**	**- (%)**	**+ T°C**	**Hazard[2/]**	**Comment**
Mainstem	Washougal 2	39%	2.9	Very High	Naturally High
	Washougal 3	36%	2.7	Very High	Naturally High
	Washougal 14	24%	1.7	Moderate	Restore
	Washougal 9	21%	1.6	Moderate	Restore
Tributaries	Little Washougal 1	42%	3.1	Very High	Restore
	Boulder Cr.	16%	1.2	Moderate	Restore
	WF Washougal 1	13%	1.0	Moderate	Restore
	Little Washougal 1c	10%	0.7	Low	Preservation
	WF Washougal 3	6%	0.5	Low	Preservation
	Little Washougal 2b	5%	0.3	Low	Preservation
	Wildboy 1	4%	0.3	Low	Preservation
	Wildboy 2	2%	0.1	Low	Preservation

Reference Temperature Condition occurring under the assumption of mature trees (46m; 150 ft high) growing at edge of active channel width.

Water Temperature hazard is the relative degree of risk for compliance with aquatic use categories compared to reference condition per reach.

These estimates predicted freshwater surface temperatures only based on elevation, channel width and canopy coverage. They did not consider the influence of tidal exchange, groundwater influx, additional heating due to runoff from wetlands or ponds or the effect of shallow channel cross-sections. Actual water temperatures will vary with Washougal River discharge, tidal stage, groundwater flux, the volume of ponded water runoff and local weather patterns.

Clark County Public Utilities (CPU) and Clark County Public Works (Water Resources) collected continuous surface water temperature recordings of 8 stations in the basin during 2004. Five of those sites overlapped EDT reaches surveyed during this effort including Washougal 3, WF Washougal 1 and Little Washougal 1, 1c and 2b. Comparison with VTS modeled results with 2004 temperature data measured by Clark County in the basin indicates actual surface water temperatures are in good agreement with individual segments of WF Washougal 1, but are warmer than predicted by the VTS model at most other sites (Appendix B). The data imply site-specific factors other than elevation and the relative degree of open riparian canopy are likely influencing local water temperatures. Washougal 3 and Little Washougal 1, 1c and 2b have a high frequency of small cobble riffles, implying a preponderance of shallow cross-sectional gradients in free-flowing sections of the creeks, and the Little Washougal reaches lack residual pool depth. These factors have the potential to increase the surface water thermal regimes in these creeks. Riparian stand conditions in Little Washougal 1, 2b and Washougal 3 consisted of primarily sparse stands of mixed or coniferous species composition. Little Washougal 1c supported a mixture of sparse and dense riparian stand conditions. The VTS model has a optional routine to address sparse riparian stand conditions by adjusting the height of radiation blocking elements to account for various levels of stand opacity. Based on the comparison of measured and predicted temperature levels, the next generation of the VTS model for the Washougal Creek basin should consider an adjustment for stand opacity.

Enhancement of Existing EDT Model

The Washougal Basin stream survey data were compared to existing attribute values in the EDT Stream Reach Editor (SRE) in an effort to enhance the current EDT 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 wetted or minimum stream width comparisons since the low flow 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 B. In general, the following major items were noted in the Washougal Basin:

1. Width: The greatest differences between the field survey and the SRE were seen in the lower mainstem Washougal reaches.

    a. In WF Washougal 3, the field stream width measurements were considerably greater than the minimum widths in the SRE.

    b. The recent measurements of width in Wildboy 2 were <u>greater than bankfull width</u>. In this situation it was necessary to compute a revised maximum width for the SRE. For the habitat units where the bankfull width was measured, the average ratio of the bankfull width to the wetted width was computed. The ratio was then applied to the average stream width value for the entire reach to compute a maximum width for the entire reach.

2. In general, the field observations measured less pool area and more small cobble riffle area relative to the SRE in the mainstem Washougal and Little Washougal reaches.

    a. Habitat Type differences between the two approaches were greatest in Little Washougal Creek.

3. In general, the field observations measured less small cobble riffle area relative to the SRE data in the WF Washougal, Wildboy and Boulder creeks.

4. Categorical ratings for fine sediment and embeddedness showed differences in the upper Washougal River and its tributaries.

    a. Field observations indicated embeddedness is appreciable, whereas the original SRE ratings indicated low embeddedness levels.

    b. The stream surveys also indicated higher amounts of fine sediment in the small cobble riffle habitats than designated in the SRE.

5. Categorical LW ratings showed relatively close agreement between the data in the SRE and the recent stream surveys, except in Wildboy Creek where the surveys indicated less in-channel wood.

Differences between the recent observations and the data in SRE may result in substantial revisions to estimates in fish performance measures in the EDT, depending upon the extent changes in the habitat attributes permeate through the model. Because the differences appear to be related to both habitat quantity (capacity) and habitat quality (productivity), the EDT is likely to be improved in terms of estimating population capacity and productivity.

6.2.4 Sediment Sources

Geology and Geomorphology

The Washougal River and its tributaries flow through a variety of geologic material (Figure 6-2). The headwaters and upper tributaries of the Washougal River flow through volcaniclastic rocks composed of coarse-grained breccia and fine-grained tuff materials (Walsh et al. 1987; Foster 1983). The river flows through isolated alluvial deposits upstream and downstream of Dougan Falls. Between Dougan Falls and Canyon Creek, the river also courses over basaltic andesite flows that control channel grade. Between Canyon Creek and Cougar Creek, the river flows through Quaternary landslide debris deposits. Tributaries between Dougan Falls and Cougar Creek flow through various basalt and andesite flows. Between Cougar Creek and the Columbia River valley, the river flows again through predominantly basaltic andesite flows. The lowermost 2 miles of the Washougal River flow through glacial Lake Missoula flood gravel-cobble-boulder deposits before entering the Columbia River.

The headwaters of the West Fork Washougal River drain an area of medium to coarse grained intrusive igneous rocks from the Miocene era, including granodiorite and quartz diorite materials. Most of Texas Creek and the upper portions of Wildboy Creek flow through volcaniclastic rocks composed of coarse-grained breccia and fine-grained tuff materials. The middle to lower sections of Wildboy Creek and West Fork Washougal River, and most of the Little Washougal River basin drain fine-grained igneous material composed of basaltic andesite.

The variable geology was reflected in longitudinal channel profiles throughout the basin. The mainstem, Little, and West Fork Washougal channels were moderately, strongly, and mildly concave, respectively (Figure 6-3). While Salmon Falls and Dougan Falls comprised the most prominent breaks in the long profile associated with geologic hard points, there were other relatively steep sections of the mainstem that also represented large scale profile breaks (Figure 6-4). Stream gradients between the slope breaks were generally less than 3 percent in the mainstem. Much of the Little and West Fork Washougal channels were also under 3 percent. Bedrock controls were most prominent in the mainstem, but were also present in the West Fork. The lower Little Washougal River had more of an alluvial nature than the other channels.

Figure 6-2. Geologic units in the Washougal River basin (Walsh et al. 1987) and EDT reach delineations. See Appendix C for listing of unit symbols.

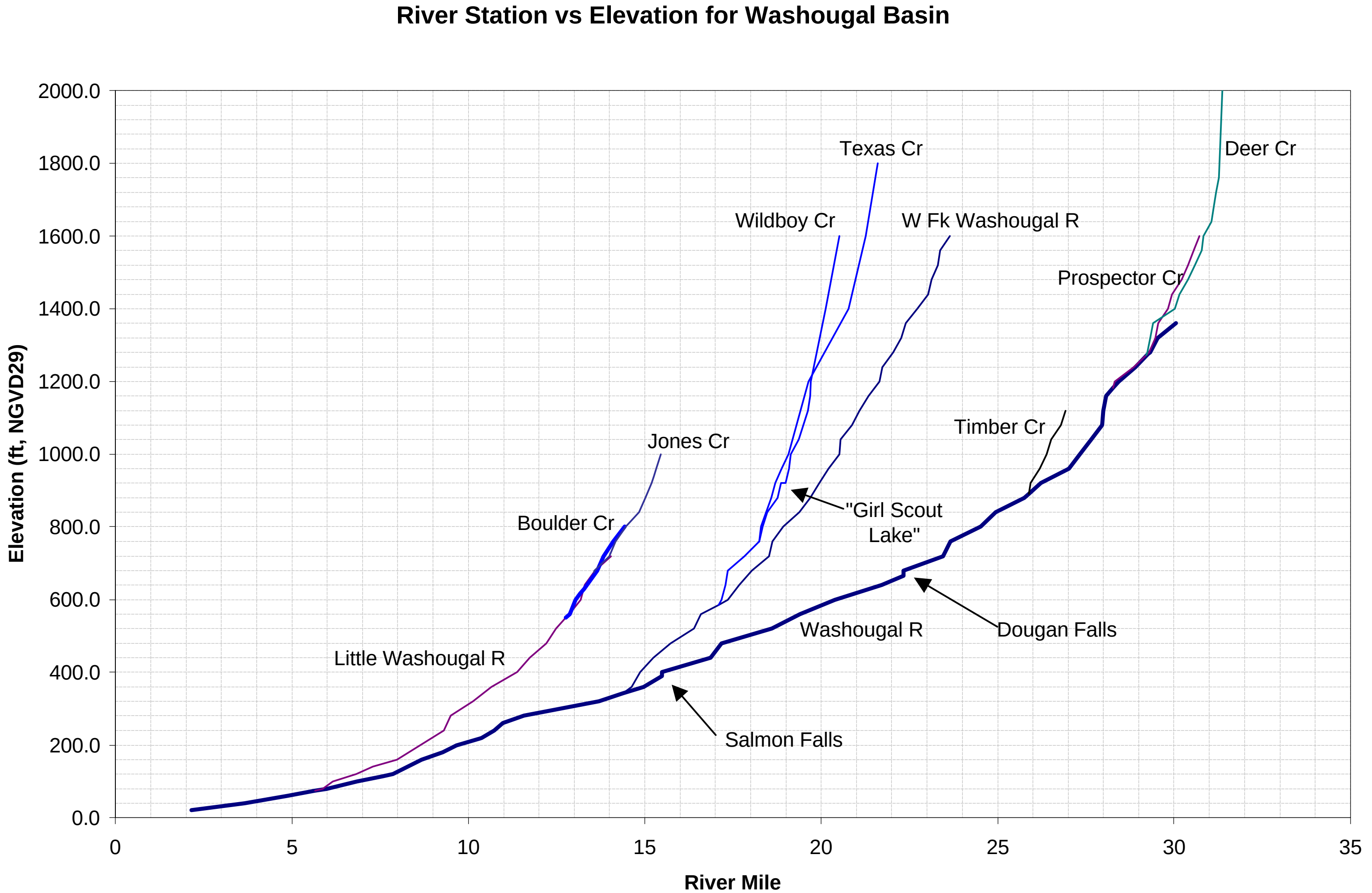


Figure 6-3. Average longitudinal elevation profiles of the mainstem Washougal River and tributaries surveyed for the sediment task.

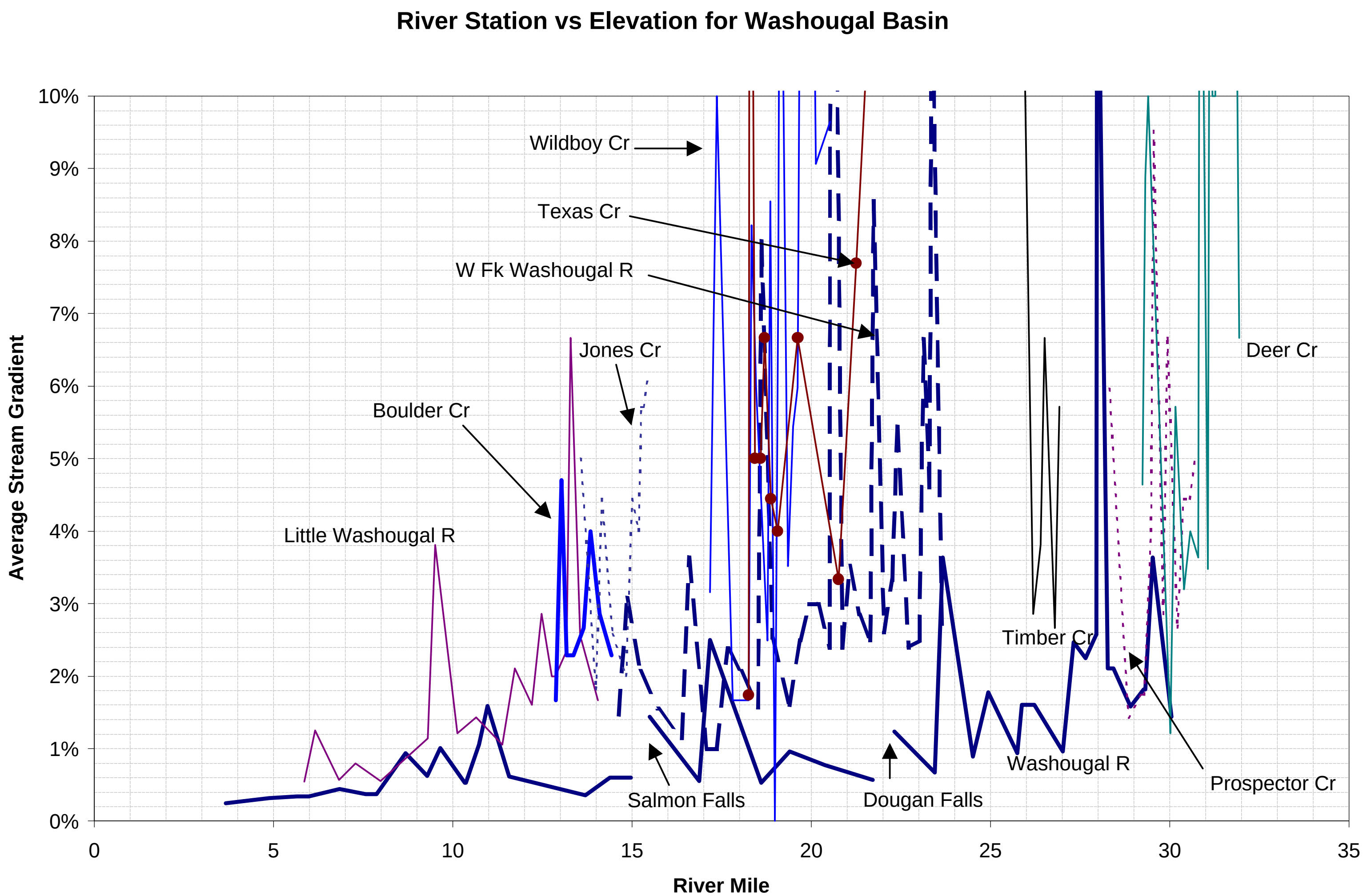


Figure 6-4. Average stream gradients in the mainstem Washougal River and tributaries surveyed for the sediment task.

Tributaries were steep but still accessible to salmon and steelhead, except for the presence of an impoundment on Wildboy Creek ("Girl Scout Lake"). Gradients in much of the lower mainstem Washougal and Little Washougal river channels fell between 0.1-1.0 percent, and thus, were characterized as "response" reaches where gravel deposition is possible under a favorable supply-transport balance (Montgomery and Buffington 1997).

Percent Embeddedness Data

Embeddedness levels were generally low throughout the Washougal basin (Table 6-8). Elevated fine sediment levels were thought to be most significant in two EDT reaches:

Table 6-8. Percent embeddedness classes and pebble count percentiles collected in the Washougal River basin for the sediment task.

Basin	**EDT River Reach**	**Geomorphic Location of Pebble Count Sample**	**Average Stream Gradient** [1]	**Percent Embeddedness**	**D**50 (mm)	**D**90 (mm)
Washougal	Washougal River 2	Point Bar	0.001	25	32	88
	Washougal River 8	Flow Obstruction Deposit	0.004	0	37	71
	Washougal River 9	Point Bar	0.006	25	44	125
	Washougal River 12	Flow Obstruction Deposit	0.006	25	24	44
	Washougal River 14	Point Bar	0.016	25	112	242
	Timber Creek	No sample		50		
	Prospector Creek 1B	No sample		25		
	Prospector Creek 2	No sample		75		
	Deer Creek	No sample		25		
	Little Washougal River 1	Point Bar/Riffle Margin	0.006	50	83	127
	Little Washougal River 1	Point Bar	0.010		54	120
	Little Washougal River 1C	Point Bar	0.021	25	40	573
	Little Washougal River 2B	Point Bar	0.011	25	76	170
	Little Washougal River 2B	Point Bar	0.011		67	147
	Jones Creek	No sample		50		
	Boulder Creek	Point Bar	0.027	25	80	209
	West Fork Washougal River 1	Point Bar	0.015	25	146	324
	West Fork Washougal River 3	No sample		25		
	Wildboy Creek 1	Point Bar	0.017	25	136	296
	Wildboy Creek 2	Point Bar	0.025	25	26	128
	Texas Creek	Riffle Thalweg	0.018	25	32	87

[1] *- In sub-reach where pebble count was taken; derived from USGS 1:24,000 topographic maps (approximate)*

- Upper Prospector Creek, above the confluence with Deer Creek, was the only stream surveyed where embeddedness levels were high enough to be expected to significantly affect intragravel survival of salmonid embryos. The high levels in Prospector Creek may reflect past debris flows because there were also large lobes of gravel-sand deposits present that filled the channel. There was little evidence of a fine sediment signature in Prospector Creek below Deer Creek, reflecting the larger size and low fines load of Deer Creek. There appeared to be more spawning habitat available in Prospector Creek below the confluence than in Deer Creek, which may be related to supply from upper Prospector Creek.

- Fine sediment levels in Jones Creek appeared to be on the verge of significantly affecting intragravel survival, ranging on the high side of the 50 percent embeddedness class. The embeddedness levels may reflect input from the road, previous timber harvest, and possibly the initial stages of development.

Elsewhere, in-channel sediment levels did not appear to be strongly influenced by road inputs. For example, the road surface leading to Texas Creek from the Skamania Hatchery was composed of native fine-grained sediments that were easily eroded by traffic and precipitation runoff in many places. Yet Texas Creek below the road crossing was relatively clean. At present, fine sediments did not appear to be a significant problem in the Washougal River basin.

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

The EDT model defined percent embeddedness as the extent 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 applied in the EDT model to values in riffle and tailout habitat units, and 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 less than 10 percent embeddedness throughout the Washougal basin, based on an assumption relating fines and embeddedness. Current conditions were estimated indirectly in the EDT model assuming embeddedness levels correlate with percent fines levels. In additions, it was assumed percent fines (and thus, embeddedness) increased by 1.3 percent (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 data) in the nearby Wind River basin. A scale was developed relating road density to percent fines and embeddedness.

Comparison of the data collected during this habitat assessment study with the assigned EDT ratings in the registered SRE indicated that modeled embeddedness levels were under-estimated throughout the basin. If the EDT ratings were accurate, the points depicted in Figure 6-5 would have fallen within the diagonal range defining the EDT ratings. The EDT model should need to be revised to more accurately represent current conditions.

Pebble Count Data and Spawning Gravel Distributions

Spawning gravel deposits were relatively sparse in the Washougal River basin, reflecting in part the effects of historical LW removal, splash damming, and the Yacolt Burn (LCFRB 2004). Of the sub-basins surveyed, spawning of summer and winter steelhead was reported to occur in the mainstem Washougal River, and in tributaries of West Fork Washougal and Little Washougal rivers. Chinook salmon reportedly have spawned in the mainstem between RM 4.0 and Salmon Falls (LCFRB 2004). They were also observed during the field visit to spawn in a short section above the Washougal Hatchery fish weir, in the vicinity of the Washougal River Road bridge. Coho salmon reportedly have spawned primarily in the Little Washougal River.

The distribution of mainstem Washougal River spawning habitat above the Little Washougal River appeared to be sporadic and controlled more by localized gradient reductions than by specific tributary bedload inputs. For example, some of the more abundant spawning habitat was located in the Washougal 9 EDT reach upstream of the West Fork Washougal River. In addition, the spawning bed located above the Washougal Hatchery fish weir was composed of gravel and cobble that appeared to have been deposited in response to backwater caused by the weir during transport events.

The reverse situation appears to be the case near the Little Washougal River. Downstream of the confluence there was a distinct change in the amount of gravel present in the mainstem Washougal River. In comparison, little, if any, available spawning habitat was observed in the

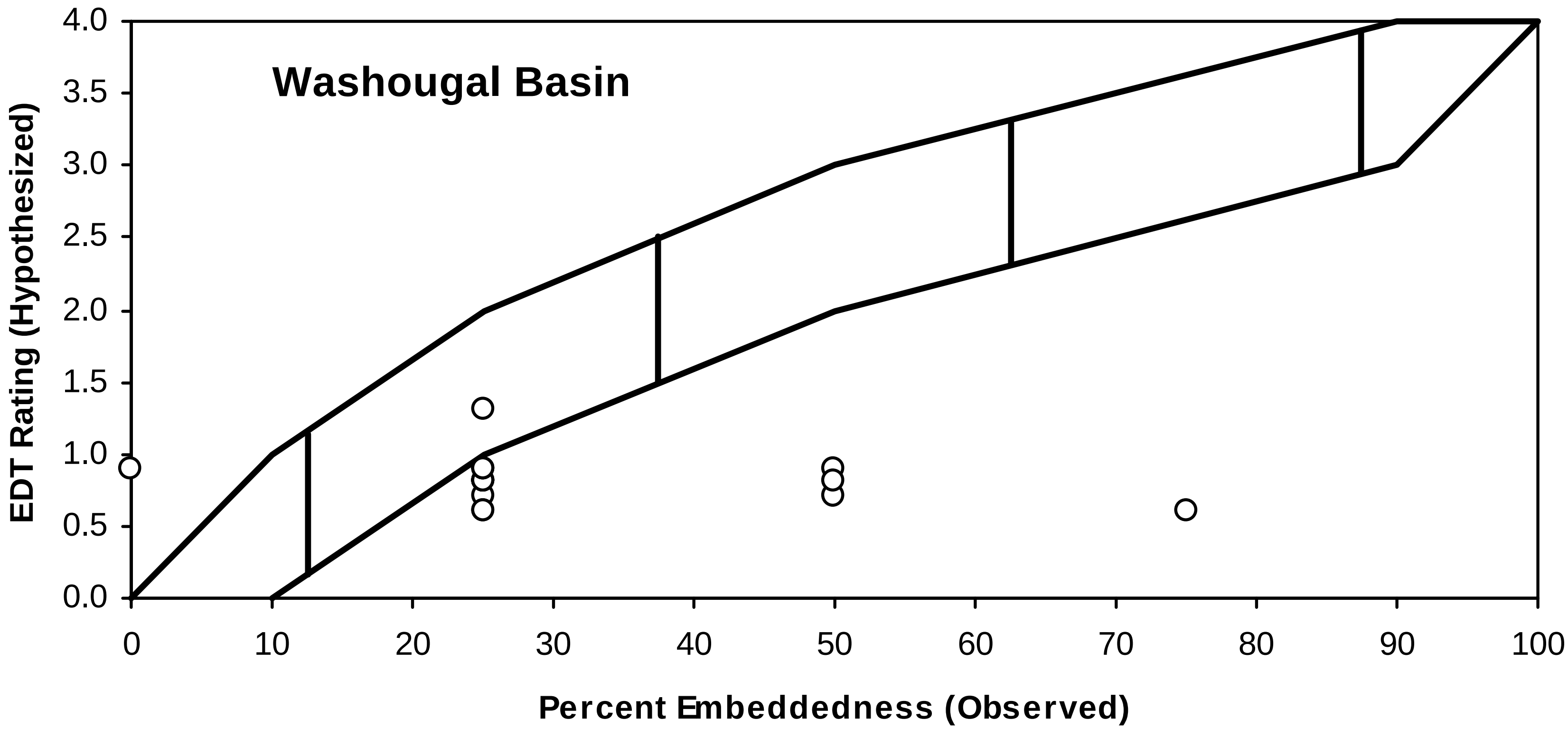


Figure 6-5. Comparison of embeddedness data collected in the Washougal River basin for the sediment task (horizontal axis) with ratings assigned to the respective EDT reach (and represented in LCFRB 2004). The hypothesized EDT ratings are accurate when the observed data points fall within the respective diagonal ranges (which define the range of embeddedness values assigned to each EDT rating)..

mainstem between the Little Washougal River and Cougar Creek where the river cuts through andesite flows (Figure 6-2). There were notable deposits of cobble and gravel a short distance below the confluence before the Washougal River transitions into the mainstem Columbia alluvium. Although the gradient drops in this section of the river, the presence of these deposits appeared to reflect input from the Little Washougal River rather than a reduction in transport capacity.

Based on pebble count data, most of the material suitable for salmon and steelhead spawning was found in localized patches in the mainstem below Dougan Falls (Figure 6-6, Table 6-8). However, the Washougal 8 and 12 samples were taken from hydraulically sheltered locations, where the main channel substrate was considerably coarser. The Washougal 2 and 9 samples were taken in low gradient sections where most mainstem spawning would be expected. Spawning substrates in the Little Washougal basin tended toward coarser cobble fractions, since most segment gradients were between 1-3 percent (Figures 6-7, 6-8) reflecting higher transport capacity than lower gradient reaches. The West Fork Washougal River appeared to have the lowest supply of gravel and cobble in the reaches surveyed, as indicated in the pebble counts for sites in the Wildboy 1 and mainstem West Fork EDT reaches (Figure 6-8).

Two tributaries containing some of the "best looking" spawning substrates are described below:

- Texas Creek contained a relatively large amount of gravel and cobble and it was likely a dominant source of the limited material found farther downstream in the West Fork.

- Jones Creek substrates upstream and downstream of the Jones Creek Road were composed predominantly of gravel and cobble. However, the material was somewhat angular and embedded by finer silts and clay.

Pebble count D_{90}'s overall exhibited a stronger positive relationship with average stream gradient than seen in samples from the Kalama and Lewis basins (Figure 6-9). This difference was indicative of the limiting factor status attributed to spawning gravel in the Washougal basin as a whole (LCFRB 2004). Based on the data and observations of this study, the low abundance of in-channel gravel in most of the Washougal basin likely reflects a stronger influence of supply limitation than excessive transport capacity. The imbalance between supply and transport may have been exacerbated by anthropogenic factors and the Yacolt burn. This hypothesis was indicated by:

- The restriction of gravel deposits to selected small tributaries and low gradient segments and hydraulically sheltered locations in the mainstem Washougal River,

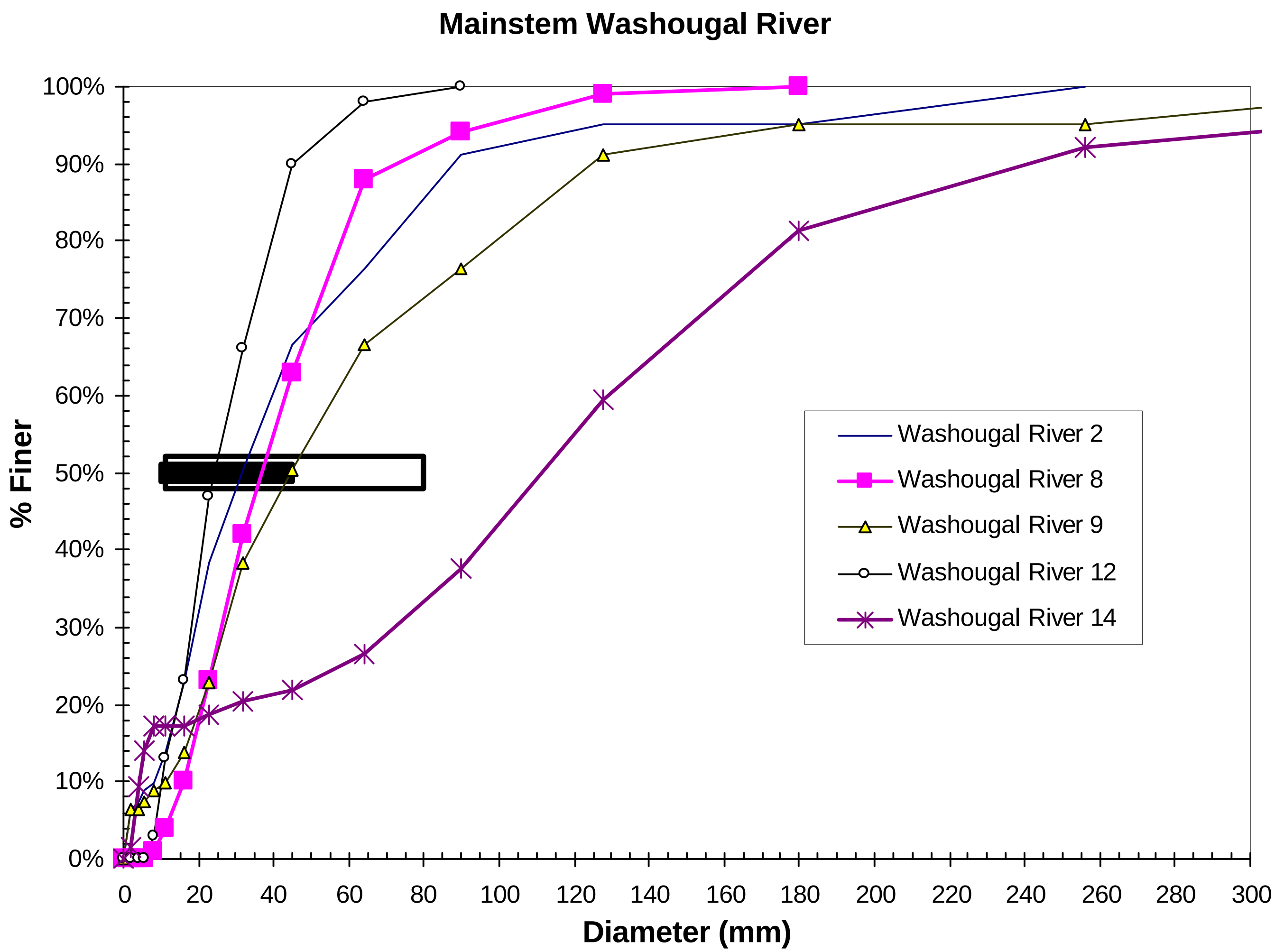


Figure 6-6. Grain size distributions of pebble counts collected in the Washougal River mainstem for the sediment task. The horizontal bars represent the range of D_{50}'s reported by Kondolf and Wolman (1993) as suitable for steelhead trout (filled bar) and Chinook salmon (open bar) spawning.

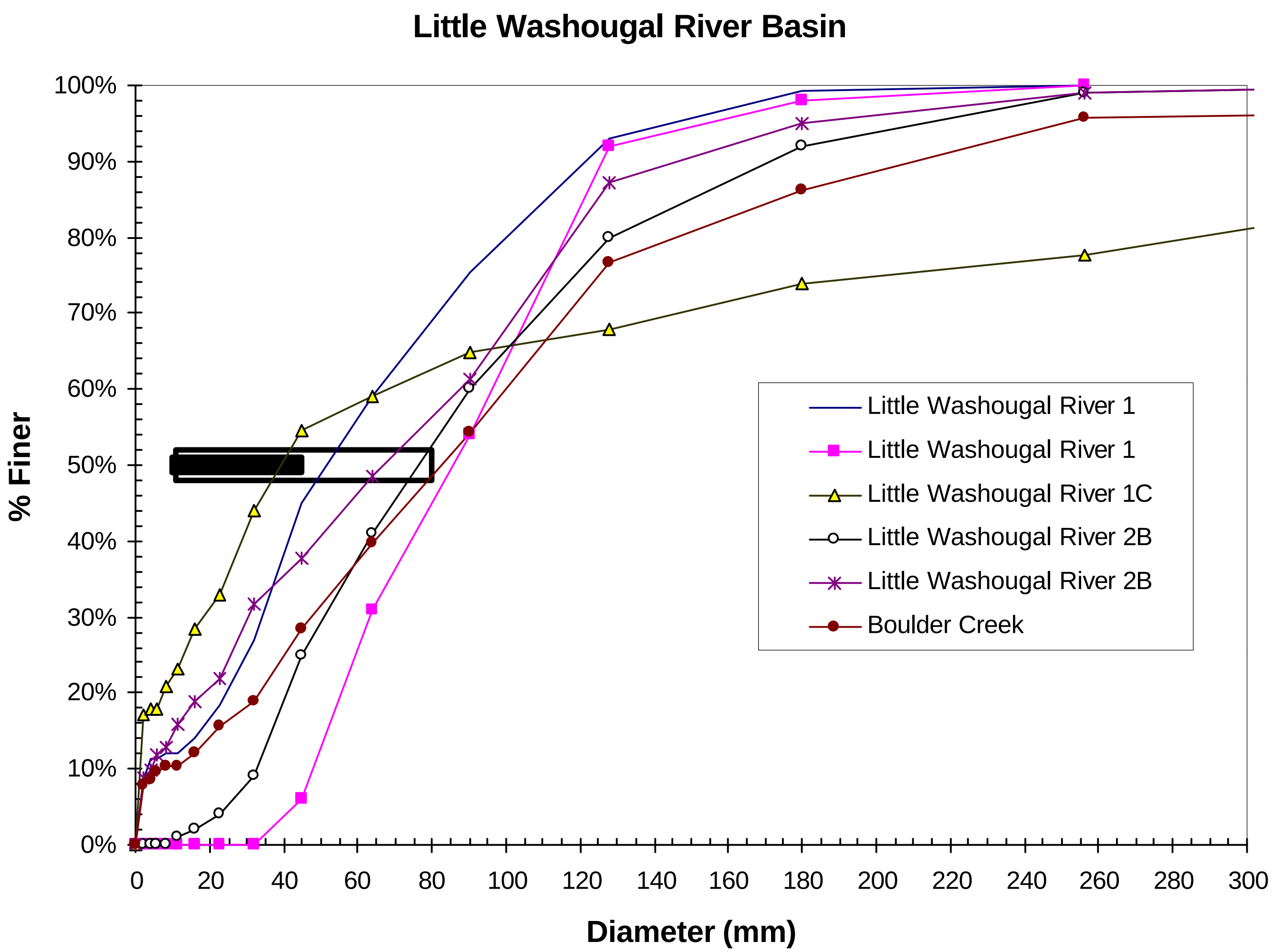


Figure 6-7. Grain size distributions of pebble counts collected in the Little Washougal River sub-basin for the sediment task. The horizontal bars represent the range of D_{50}'s reported by Kondolf and Wolman (1993) as suitable for steelhead trout (filled bar) and Chinook salmon (open bar) spawning.

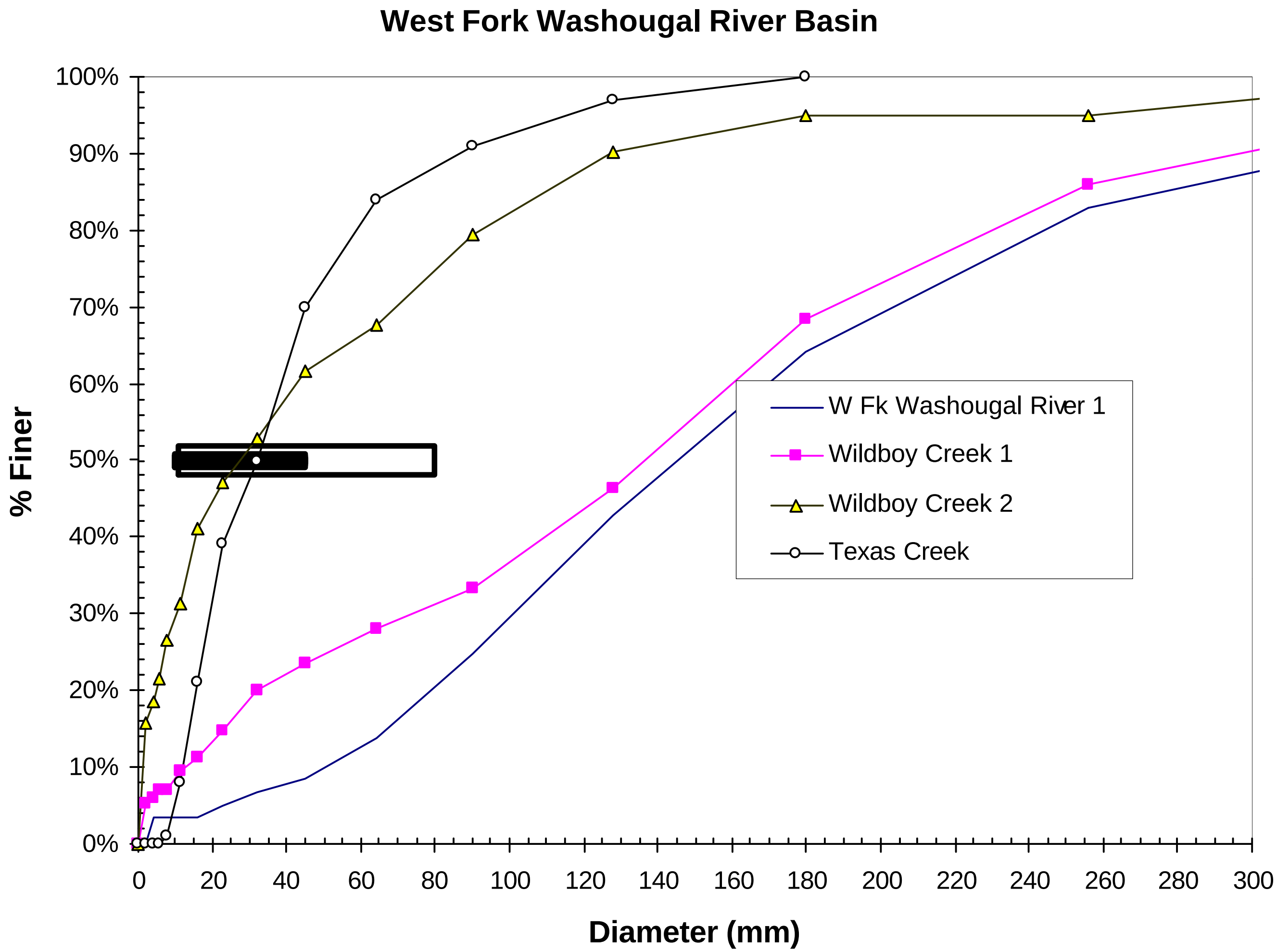


Figure 6-8. Grain size distributions of pebble counts collected in the West Fork Washougal River sub-basin for the sediment task. The horizontal bars represent the range of D_{50}'s reported by Kondolf and Wolman (1993) as suitable for steelhead trout (filled bar) and Chinook salmon (open bar) spawning.

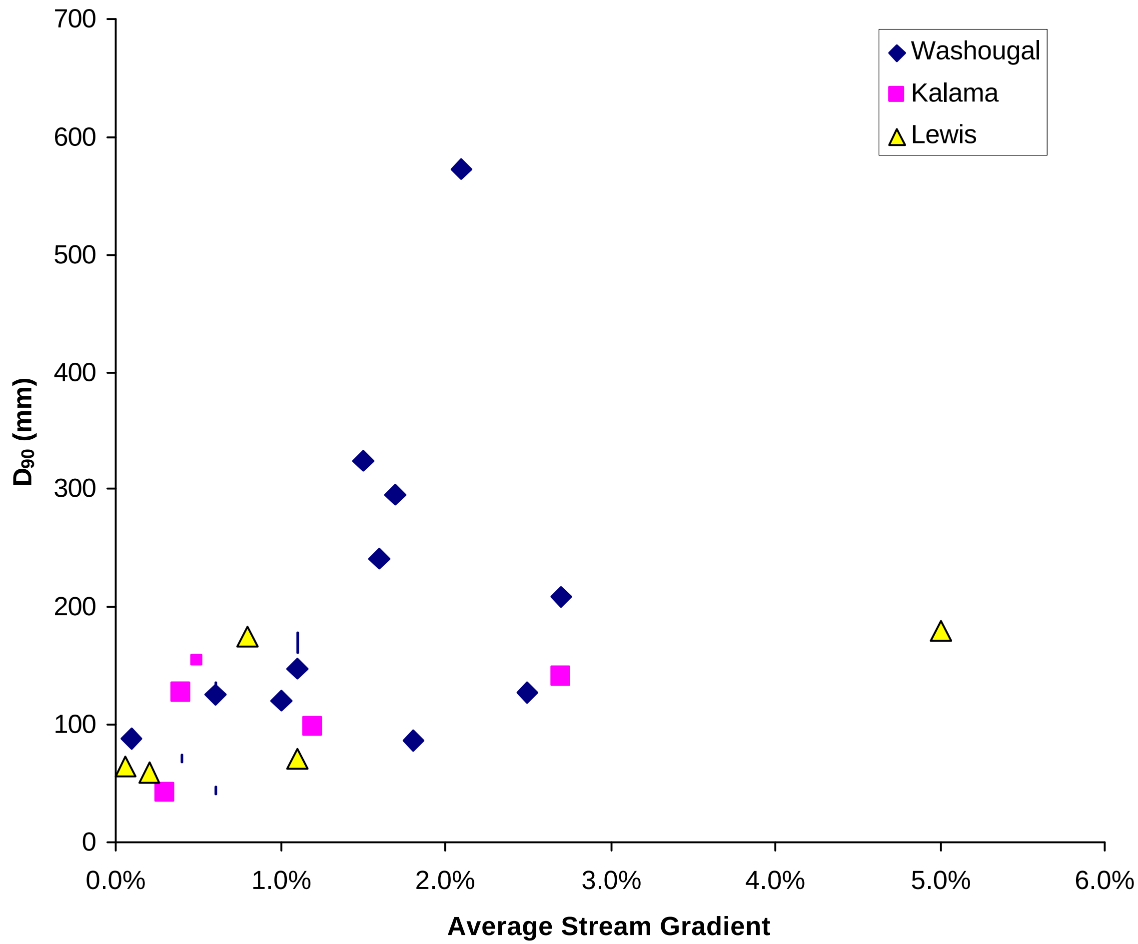


Figure 6-9. Comparisons of D_{90} values determined from pebble counts in the Washougal, Kalama, and lower North Fork Lewis basins. Large, intermediate size, and small symbols represent samples from point bars, riffle thalwegs, and flow obstruction deposits, respectively.

- No strong correlation of spawning habitat distribution with tributary bedload inputs in mainstem Washougal River reaches above Cougar Creek, and

- The 0.1-1.0 percent gradient in of most of the mainstem Washougal River below Prospector Creek was generally conducive to formation of gravel conditions under appropriate supply conditions (Figure 6-4).

In addition, although to a limited and relatively local extent, the dam on Wildboy Creek stops gravel transport to downstream reaches of Wildboy and the West Fork Washougal River.

6.3 SYSTEM WEAKNESSES, 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).

6.3.1 Identify System Weaknesses

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

- Within the lowermost 5.5 mi of the Washougal River, the floodplain has been reduced by 27 percent from it historic condition.

- Incision of the Washougal River floodplain surfaces have been incised into the Columbia River floodplain.

- Extensive urban development has affected floodplain processes in the lower 4.2 mi of river.

- Approximately 49 percent of banks in the Washougal 1-tidal, have been armored.

- Approximately 50 percent of the riparian stands throughout the Washougal River Basin were determined to be sparse.

- Due to its large size, the natural riparian conditions in the lower river have had little effect in moderating surface water temperatures.

- Current riparian conditions have allowed surface water temperature increases in many anadromous fish reaches such that state water quality standards are currently exceeded.

- Encroachment from urbanization, timber harvest, residential development, and the like, has led to high levels of riparian disturbance throughout the Washougal River.

- In Little Washougal 1, the riparian conditions are estimated to have increased surface water temperatures by 3^{o}C compared to reference conditions. Temperature increases of the predicted magnitude would result in exceedances of state water quality standards**.**

- Levels of fines in upper Prospect Creek are high enough to impair the development of salmonid fish embryos.

- Spawning gravel deposits are relatively sparse throughout much of the Washougal River basin.

- The Washougal River may be naturally supply limited with respect to spawning-sized gravels.

6.3.2 Identify System Strengths

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

- Quantity of channel margin and off-channel habitats appeared to have changed little from historic conditions.

- At the time of this assessment, the Washougal River was unregulated.

- Large wood recruitment potential was fair to good throughout the basin.

- Vegetation community composition was dominated by conifer species in more than half of the riparian stands in the basin.

- At the time of this assessment, Little Washougal 1 and 2, West Fork Washougal, Wildboy Creek, and Texas Creek provided functional riparian zones.

- Available spawning substrates appeared to be of good quality, i.e., low sand and low embeddedness.

- Texas Creek appeared to have a good amount of gravel and cobble for salmonid fish spawning purposes.

6.3.3 Preservation/Restoration Opportunities

The habitat conditions for the Washougal River basin were reviewed and 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.

Limited floodplain and off-channel habitats were found in the lower Washougal River. Although historic data are lacking, the geomorphic setting of the river suggests such features may have historically been less than other nearby basins such as the Kalama or North Fork Lewis River. The area around the current floodplain was highly developed. Thus, future restoration of hydromodified habitats in the lower Washougal River basin should focus on preserving existing natural channel margins and areas with existing functional floodplain habitats.

Recommended categories of management actions for the improvement of riparian conditions in the Washougal 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 improvements are limited in lower Washougal River mainstem since these reaches likely offered naturally low levels of shade and wood recruitment potential. The reaches lying in the existing and historic floodplain likely experienced a frequent disturbance history in the riparian zone.

With respect to in-channel habitat restoration opportunities, the large floodplain 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 Washougal. Wood placement is occurring in the tributary reaches and upstream portions of the Washougal River and should be encouraged at sites where the structures have a good likelihood of remaining during storm events.

Since embeddedness levels were relatively low in the Washougal basin overall, there were no EDT stream reaches identified where sediment abatement projects might result in measurable increases in production. The large quantity of fine sediments generated in upper Prospector

Creek appeared to be dispersed rapidly downstream. Throughout the basin, the logical future focus for sediment control should be related to preserving watershed processes of supply and transport and ensuring future development and timber harvest follow appropriate fine sediment control practice.

In general, the Washougal River basin contains a limited amount of spawning-sized gravel available for salmon and steelhead use. In the mainstem, gravel and cobble are available for spawning in a few segments. Over most of the length of the river, gravel patches were often found in locations potentially usable only during periods of high flow. Thus, use of such gravel deposits increases the risk of redd dewatering. The West Fork Washougal River appeared to be most gravel-deficient of the major EDT tributaries. However, efforts to increase gravel availability are not recommended. To be effective, instream gravel enhancement/restoration efforts would require heavy-handed, highly engineered measures. Specifically, measures would be required that result in significant backwatering during floods to create spawning deposits of meaningful size. For example, a channel spanning weir, such as the Washougal Hatchery fish weir, or construction of artificial choke points to constrict the channel would be needed. Without gravel augmentation, spawning deposits created by such measures would likely take a long time to reach desired target conditions given the relatively low supply of gravel and cobble in the basin. For instance, it seems unlikely that deposits of meaningful size would form upstream of a channel-spanning structure in the West Fork Washougal River. Although the Skamania Hatchery weir spans the channel, it has not filled in the bed upstream. In comparison, the Hatchery Creek weir in the Kalama basin, trapped enough gravel to re-graded the channel immediately upstream of the structure. Structures placed along the margins of either the mainstem or West Fork Washougal River channels would be expected to trap gravel only at elevations that may become dewatered or too shallow during most of the spawning season.

In addition, there is elevated risk of redd scouring unless a large spawning bed area can be created or long-term gravel supply rates can be increased. The increased risk of scour is related to the existing low local supply of fresh gravel that favors deep scour during periods of high sediment transport (DeVries 2000).

Active measures are consequently not expected to be highly effective in the mainstem Washougal River and West Fork Washougal River without significant expenditures. The degree of success may be limited regardless of the effort. Other gravel enhancement measures described below should have the best chance for increasing spawning habitat availability in the system. These measures should be monitored for 5-10 years before efforts are directed at the mainstem Washougal River and West Fork Washougal River:

The following list of restoration/protection opportunities in the Washougal River basin is prioritized in accordance with the 3-step restoration philosophy described above.

1. Preservation/possible off-channel development: south bank Washougal River, RM 0.8 to 1.2.

This area consists of a vegetated gravel bar located at the mouth of Lacamas Creek that currently supports a mosaic of bar, shrub and immature forest. This reach appears to be the only area within the existing floodplain where fluvial geomorphic processes (erosion, sedimentation, channel avulsion and side channel development) are currently functioning properly. Indistinct overflow channels also suggest floods periodically inundate this area.

This area is generally suited to the development of off-channel rearing habitat that would mimic natural side channel features. Because no relict side or off-channel habitat currently exist, development of this type of habitat would require extensive engineering and design work.

2. Preservation/restoration: north bank Washougal River, RM 3.7 to 4.0.

This area consists of a low gradient point bar. The feature currently contains some roads and residential development, but the southeast corner appears relatively undeveloped. Preservation of the undeveloped area, and restoration of riparian forest there would be beneficial. No information is available on the elevation of this surface relative to river. Thus, the potential for off channel habitat development could not be evaluated at this time.

3. Riparian Preservation.

The riparian zones along Washougal 2-tidal and 3 offer fair to good levels of existing LW recruitment potential. Left to grow, these zones could contribute appropriate levels of future wood debris sources. In addition, preservation strategies would be worthwhile to preclude future riparian degradation in Little Washougal 1c and 2b, WF Washougal 3, Wildboy 1 and 2, and Boulder Creek.

4. Wood placement in tributaries.

The low gradient portions of Little Washougal, WF Washougal and Boulder Creek offer good opportunities for further wood placement. Wood may not function as well in bedrock dominated channels compared to alluvial channels that are deformable, unless they can be engineered to wedge between the banks and remain in place during storm events. Should such features prove feasible, they would likely entrain the sediment bedload allowing deposition of small substrate sizes that are currently transported through the system due to lack of channel structure.

5. Riparian Enhancement.

Washougal 2-tidal (NSO #s 1, 2, 5, and 9), Washougal 3 (NSO #s 6, 12, 22, 24, 25, 27, 37, 39 and 40), Little Washougal 1 (NSO #s 5, 42, 48, 56 and 68) and Boulder Creek (NSO # 47) have specific opportunities for riparian plantings or other techniques to narrow the current VTS. It may be worth exploring opportunities of either: (1) hardwood conversion where soil conditions are conducive to conifer growth or (2) releasing conifers in mixed stands for enhance conifer growth rates at appropriate sites to increase the size (diameter) of standing timber; or (3) underplanting a second cohort to increase the stand densities.

6. Fines Reduction.

To help reduce levels of fines in tributaries, it may be prudent to encourage riparian re-vegetation efforts in the 3 miles of the Little Washougal River above the stream gage location, next to the most downstream bridge (County Bridge 307) on SE Blair Road. In addition, it appears prudent to ensure timber harvest and land development road BMPs continue to be implemented and monitored, especially in the Texas Creek, Boulder Creek, and Jones Creek sub-basins.

7. Spawning gravel enhancement in Little Washougal River 2b.

The channel size, relatively stable boulder substrates, good riparian condition, relatively low embeddedness, and apparent through-transport of moderate amounts of gravel and small cobble in the reach indicate it may be productive to implement gravel trapping measures that span more than ~50 percent of the channel width (e.g., partial log jam or rock grade control). While the dominant substrate was a mixture of boulder and medium to large cobble, there appeared to be enough gravel and small cobble transported that a spawning deposit may build within a reasonable time frame before the design life of LW structures ends. Rock-based structures may be more suited for this reach based on expected longevity. Given the relatively steep slope and essentially plane bed nature of the channel, it is possible gravel deposits may become trapped predominantly near the channel margins where they may be either exposed or too shallow during the spawning season. In addition, it would be important to ensure that structures did not influence private property bordering the reach through either erosion or flooding. Given the supply-transport imbalance evident in the basin, detailed hydraulic and sediment transport studies and sediment budgets are recommended to determine the feasibility of the above measure. No gravel retention or enhancement project should really be undertaken without first determining feasibility.

8. Spawning gravel enhancement in Boulder Creek.

Boulder Creek may also have a sufficient gravel and cobble supply to facilitate successful implementation of in-channel retention structures (e.g., LW jams, rock vanes). Active gravel retention measures could conceivably result in creating patches with a grain size distribution in the range considered suitable for salmon and steelhead spawning. Based on similar geologies, it should be possible to create spawning beds with grain size distributions similar to Jones Creek. Given the supply-transport imbalance evident in the basin, detailed hydraulic and sediment transport studies and sediment budgets are recommended to determine the feasibility of the above measure. No gravel retention or enhancement project should really be undertaken without first determining feasibility.

9. Restoration: West bank, Washougal River, RM 3.8 to 4.1.

This site consists of a cleared field separated from the river by a levee. The surface of the feature is fairly high relative to the current river surface, and no evidence of formerly side or off-channel habitats was noted. However, breaching of the levee and restoration of riparian forest could increase the amount of terrestrial floodplain habitats.

The other notable feature at this site is an ephemeral tributary that appears to have been routed along the east and south side of the field. This tributary appears to have a tendency for headcutting where it enters the Washougal River; large rock was observed at the outlet during river surveys. Assessment of the potential for restoration of tributary habitat associated with this features is unclear, and would require an intensive field evaluation. Based on limited available information it appears that habitat restoration/development on the tributary would require excavation.

10. Incorporation of LW into existing armored banks during maintenance.

Additional bank hardening should be limited throughout the hydromodifications analysis area. 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 margin (Beamer and Henderson 1996).

11. Restoration: south bank, Washougal River RM 1.0 to 1.8.

An area of former floodplain, cutoff from the current floodplain by levees, and has been mined for gravel between RM 1.0 and 1.8 on the south bank of the Washougal River. The current status of the mining operation is unknown. Removal of the levee and reconfiguration of the gravel ponds could restore floodplain habitat and provide off-channel habitat. However, several major concerns may exist, including the presence of non-native predator species and/or the potential for water quality contaminants in the ponds. These concerns should be evaluated to determine the feasibility of potential habitat restoration projects in this area. This restoration opportunity is given a low priority because of the degree of difficulty and potential concerns that arise as a result of past land use activities.

12. Removal of dam on Wildboy Creek.

Some of the most important mainstem Washougal River spawning habitat exists downstream of the mouth of the West Fork. It is conceivable dam removal on Wildboy Creek could increase delivery of gravel downstream. However, hydrologic and hydraulic feasibility studies would need to be performed to determine the efficacy of this potential opportunity in increasing sediment transport.

Table 6-9. Prioritized protection/enhancement opportunities for the Washougal River basin by geographic area. Detailed project descriptions are found in section 6.3 of the report. NA indicates no corresponding EDT reach.

Location	EDT Reach/ RM	Opportunity	Short Description	Priority
Mainstem Washougal	Washougal 2-tidal/ RM 0.8-1.2	Preservation and off-channel habitat development	A forested bar at the mouth of Lacamas Creek should be protected. This area is also suited to off-channel rearing habitat that would mimic natural side channel features.	1
Mainstem Washougal	Washougal 2-tidal and 3/ RM 1.0 to 1.8	Restoration of the south bank.	Restore floodplain and off-channel habitat by removal of levees and reconfiguration of old gravel ponds.	11
Mainstem Washougal	Washougal 2-tidal and 3/ RM 0.7 to 4.4	Riparian Preservation	These stands offer good LW potential if allowed to grow.	3
Mainstem Washougal	Washougal 2-tidal and 3/ RM 0.7 to 4.4	Riparian Enhancement	Opportunities exist where riparian plantings, hardwood conversion, or conifer release would help to narrow the current view-to-sky.	5
Mainstem Washougal	Washougal 3/ RM 3.8 to 4.1	Restoration of the south bank	Breaching a levee and restoration of riparian forest could increase the terrestrial floodplain habitat. Investigate potential for restoration of ephemeral tributary.	9
Mainstem Washougal	Washougal, 1,2,3/ RM 0.0 to 4.4	Add large wood to existing armored banks.	Take opportunities to add large wood into armored banks during future maintenance or repair activities.	10
Little Washougal	Basin wide	Large wood placement.	Placement of large wood in low gradient reaches to entrain sediment and encourage gravel deposition, as well as improve in-channel structure.	4
Little Washougal	Little Washougal 1/ RM 0 to 2.8.	Reduction of fine sediments.	Encouragement of riparian revegetation efforts would help reduce fine sediment levels. Also monitor to ensure timber harvest, land development, and road BMPs are implemented.	6

Table 6-9. Prioritized protection/enhancement opportunities for the Washougal River basin by geographic area. Detailed project descriptions are found in section 6.3 of the report. NA indicates no corresponding EDT reach.

Location	EDT Reach/ RM	Opportunity	Short Description	Priority
Little Washougal	Little Washougal 1/ RM 0.0 to 2.8 Boulder Creek/ RM 0.0 to 1.6	Riparian Enhancement	Opportunities exist where riparian plantings, hardwood conversion, or conifer release would help to narrow the current view-to-sky.	5
Little Washougal	Little Washougal 2b/ RM 6.1 to 7.0	Spawning gravel enhancement.	Implement gravel trapping measures that span more than 50% of the channel. Rock structures may be better suited than wood to this habitat. Additional sediment supply and transport analysis needed.	7
Little Washougal	Boulder Creek/ RM 0.0 to 1.6	Spawning gravel enhancement.	This tributary appears to have a gravel supply sufficient to facilitate successful in-channel retention structures. It is feasible to create spawning beds similar to those in Jones Creek.	8
West Fork Washougal	Basin wide	Large wood placement.	Placement of large wood in low gradient reaches to entrain sediment and encourage gravel deposition, as well as improve in-channel structure.	4
West Fork Washougal	Wildboy 2/ RM 1.8 to 2.5	Removal of Wildboy dam.	Dam removal should increase delivery of gravels to some of the best spawning habitat in the Washougal River downstream of the West Fork confluence.	13

6.4 REFERENCES

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APPENDIX 6A

Large Wood Recruitment Potential Rating for Each EDT Reach in Washougal Basin

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

WASHOUGAL RIVER BASIN

Case	EDT Reach Name	RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
		Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
1	Bear Cr	MSS	Poor	MMD	Good	3	55	3220		3220			3220	
2	Bluebird Cr	CSS	Poor	CSD	Poor	1	10	8322					8322	8322
3	Boulder Cr	CLS	Fair	CLS	Fair	2	30	2282			2282	2282		
4	Boulder Cr	MSS	Poor	CMS	Fair	1	10	3032				3032	3032	
5	Boulder Creek 1B	MSS	Poor	MSS	Poor	1	10	3899					3899	3899
6	Boulder Creek 1C	CSS	Poor	CSS	Poor	1	10	1808					1808	1808
7	Boulder Creek Culv1							4						
8	Boulder Creek Falls1							6						
9	Cougar Cr	CSS	Poor	CSS	Poor	2	30	12532					12532	12532
10	Deer Cr	HMD	Fair	MMS	Fair	3	55	5771			5771	5771		
11	Deer Cr	MMD	Good	MMD	Good	3	55	2551	2551	2551				
12	Deer Cr	MMD	Good	MMS	Fair	3	55	2238	2238			2238		
13	Degraded	MSS	Poor	MMD	Good	3	55	3167		3167			3167	
14	Dougan Cr	CSD	Poor	CMD	Good	3	55	1726		1726			1726	
15	Dougan Creek 1B	CSD	Poor	CSD	Poor	3	55	2239					2239	2239
16	Dougan Creek 1B	HMD	Fair	HMD	Fair	3	55	1733			1733	1733		
17	Dougan Creek Culv1							5						
18	Dougan Falls							5						
19	Jones Cr	CMS	Fair	CMS	Fair	2	30	1460			1460	1460		
20	Jones Creek 1B	CMS	Fair	CMS	Fair	1	10	2114			2114	2114		
21	Jones Creek 1B	CMS	Fair	CMS	Fair	2	30	1334			1334	1334		

WASHOUGAL RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
22	Jones Creek 1B	CMS	Fair	CSS	Poor	2	30	1893			1893			1893
23	Jones Creek 1B	CSS	Poor	CSS	Poor	2	30	6032					6032	6032
24	Jones Creek Culv1							5						
25	LB tribA (28.0211)	MSS	Poor	MSS	Poor	1	10	5279					5279	5279
26	Lacamas	CMD	Good	CMD	Good	3	55	3686	3686	3686				
27	Lacamas	DMS	Poor	MMS	Fair	2	30	1551				1551	1551	
28	Little Washougal 1	MMS	Fair	MMS	Fair	1	10	14720			14720	14720		
29	Little Washougal 1B	MMS	Fair	MMD	Good	2	30	2758		2758	2758			
30	Little Washougal 1B	MMS	Fair	MMS	Fair	2	30	812			812	812		
31	Little Washougal 1C	CMD	Good	CMD	Good	3	55	1117	1117	1117				
32	Little Washougal 1C	CMD	Good	MMS	Fair	3	55	2274	2274			2274		
33	Little Washougal 1C	CMS	Fair	CMD	Good	2	30	816		816	816			
34	Little Washougal 1C	MMS	Fair	MMS	Fair	1	10	6551			6551	6551		
35	Little Washougal	MSD	Poor	MMS	Fair	2	30	279				279	279	

WASHOUGAL RIVER BASIN

Case	EDT Reach Name	RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
		Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
	1C													
36	Little Washougal 2	MMS	Fair	MMS	Fair	2	30	1140			1140	1140		
37	Little Washougal 2	MSD	Poor	MMS	Fair	2	30	1594				1594	1594	
38	Little Washougal 2B	CMS	Fair	CMS	Fair	2	30	3507			3507	3507		
39	Little Washougal 2B	CSS	Poor	CSS	Poor	1	10	1585					1585	1585
40	Little Washougal 2C	CSS	Poor	CSS	Poor	1	10	971					971	971
41	Little Washougal 2D	CMS	Fair	CMS	Fair	2	30	883			883	883		
42	Little Washougal 2D	CSS	Poor	CSS	Poor	2	30	1454					1454	1454
43	Little Washougal 2E	CMS	Fair	CMS	Fair	2	30	365			365	365		
44	Little Washougal 3	CMS	Fair	CMS	Fair	2	30	4303			4303	4303		
45	Little Washougal 4	CMS	Fair	CMS	Fair	2	30	1918			1918	1918		
46	Little Washougal 4	CMS	Fair	MSS	Poor	2	30	355			355			355
47	Little Washougal 4	CSS	Poor	CSS	Poor	1	10	3953					3953	3953
48	Little Washougal 4	MSS	Poor	MSS	Poor	1	10	2317					2317	2317
49	Little Washougal Culv1							5						

WASHOUGAL RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
50	Little Washougal Culv2							5						
51	Lookout Cr	MMD	Good	MMD	Good	3	55	7920	7920	7920				
52	Meander Cr	MMD	Good	MMD	Good	3	55	9504	9504	9504				
53	Prospector Cr 1	CMD	Good	CMD	Good	3	55	336	336	336				
54	Prospector Cr 2	MMD	Good	MMD	Good	3	55	4734	4734	4734				
55	Prospector Creek 1B	MMD	Good	HMS	Poor	2	30	4838	4838					4838
56	Prospector Creek Culv1							5						
57	RB trib 1A	CMS	Fair	CMS	Fair	2	30	103			103	103		
58	RB trib 1B	CMS	Fair	CMS	Fair	1	10	269			269	269		
59	RB trib 1C	CSS	Poor	CSS	Poor	1	10	4436					4436	4436
60	RB trib 2	CSS	Poor	CSS	Poor	1	10	3220					3220	3220
61	Salmon Falls							5						
62	Silver Cr	CSD	Poor	CSD	Poor	2	30	5452					5452	5452
63	Stebbins C	MMD	Good	MMD	Good	4	80	15003	15003	15003				
64	Texas Cr	CMD	Good	CMD	Good	3	55	3179	3179	3179				
65	Texas Cr	CSS	Poor	CMD	Good	2	30	7974		7974			7974	
66	Texas Cr	MMD	Good	MMD	Good	3	55	6961	6961	6961				
67	Timber Cr	MMD	Good	MMD	Good	4	80	1239	1239	1239				
68	Timber Creek 2	HMD	Fair	MMD	Good	4	80	2800		2800	2800			
69	Timber Creek 2	HMD	Fair	MMS	Fair	4	80	3106			3106	3106		

WASHOUGAL RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
70	WF Washougal 1	MMD	Good	MMD	Good	3	55	3986	3986	3986				
71	WF Washougal 1B	CSS	Poor	CSD	Poor	2	30	1347					1347	1347
72	WF Washougal 2	CLD	Good	CLD	Good	2	30	10067	10067	10067				
73	WF Washougal 3	CLD	Good	CLD	Good	2	30	8592	8592	8592				
74	WF Washougal 3	CMD	Good	CMD	Good	3	55	8427	8427	8427				
75	WF Washougal Falls1							5						
76	WF Washougal Weir							5						
77	Washougal 1 tidal	DMS	Poor	DMS	Poor	2	30	3854					3854	3854
78	Washougal 10	CLD	Good	CLD	Good	2	30	14258	14258	14258				
79	Washougal 10	CLD	Good	MMS	Fair	2	30	1829	1829			1829		
80	Washougal 10	MMD	Good	MMS	Fair	2	30	6453	6453			6453		
81	Washougal 10A	MSS	Poor	MMD	Good	2	30	1662		1662			1662	
82	Washougal 11	MMD	Good	CMD	Good	2	30	2257	2257	2257				
83	Washougal 11	MMS	Fair	CMD	Good	2	30	1555		1555	1555			
84	Washougal 11	MMS	Fair	MMD	Good	2	30	4508		4508	4508			
85	Washougal 12	MMS	Fair	MSS	Poor	2	30	499			499			499
86	Washougal 13	CLS	Fair	CLD	Good	0	0	1372		1372	1372			
87	Washougal 13	CMD	Good	CLD	Good	2	30	2422	2422	2422				
88	Washougal 13	CMD	Good	CSS	Poor	2	30	9292	9292					9292
89	Washougal 14	MMD	Good	CLD	Good	2	30	4170	4170	4170				
90	Washougal 14	MMD	Good	MMS	Fair	2	30	2319	2319			2319		

WASHOUGAL RIVER BASIN

Case	EDT Reach Name	RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
		Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
91	Washougal 14	MMS	Fair	CLD	Good	2	30	3045		3045	3045			
92	Washougal 15	CLD	Good	CLD	Good	2	30	3247	3247	3247				
93	Washougal 15	CMD	Good	CMS	Fair	2	30	2861	2861			2861		
94	Washougal 16	CSD	Poor	CMD	Good	2	30	2736		2736			2736	
95	Washougal 17	CSD	Poor	CSD	Poor	2	30	3523					3523	3523
96	Washougal 18	CLS	Fair	CLD	Fair	3	55	3418			3418	3418		
97	Washougal 18	CSD	Poor	CSD	Poor	2	30	1773					1773	1773
98	Washougal 19	MMD	Good	MMD	Good	3	55	6423	6423	6423				
99	Washougal 2 tidal	MMS	Fair	MMS	Fair	2	30	5250			5250	5250		
100	Washougal 20	MMD	Good	MMD	Good	3	55	3564	3564	3564				
101	Washougal 3	MMD	Good	CMS	Fair	2	30	1683	1683			1683		
102	Washougal 3	MMD	Good	MMS	Fair	2	30	497	497			497		
103	Washougal 3	MMS	Fair	MMS	Fair	2	30	18483			18483	18483		
104	Washougal 4	CMD	Good	CMS	Fair	2	30	2560	2560			2560		
105	Washougal 4	CMS	Fair	CMS	Fair	2	30	1703			1703	1703		
106	Washougal 4	MMD	Good	CMS	Fair	2	30	1973	1973			1973		
107	Washougal 5	CMD	Good	CMS	Fair	2	30	3868	3868			3868		
108	Washougal 5	CMS	Fair	CMS	Fair	2	30	5127			5127	5127		
109	Washougal 6	CMD	Good	CMS	Fair	2	30	542	542			542		
110	Washougal 6	CMS	Fair	CMS	Fair	2	30	12103			12103	12103		
111	Washougal 7	CMS	Fair	CMS	Fair	2	30	4596			4596	4596		

WASHOUGAL RIVER BASIN

		RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
Case	EDT Reach Name	Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
112	Washougal 8	CMD	Good	CMS	Fair	2	30	1247	1247			1247		
113	Washougal 8	CMS	Fair	CMS	Fair	2	30	1709			1709	1709		
114	Washougal 8	MMD	Good	MMD	Good	2	30	2993	2993	2993				
115	Washougal 8	MMD	Good	MMS	Fair	2	30	8435	8435			8435		
116	Washougal 9	CLD	Good	MMS	Fair	2	30	5893	5893			5893		
117	Washougal Falls1							5						
118	Wildboy Cr 1	CLD	Good	CLD	Good	3	55	6000	6000	6000				
119	Wildboy Cr 2	CLD	Good	CLD	Good	3	55	3557	3557	3557				
120	Winkler Cr	CMS	Fair	CMS	Fair	1	10	3286			3286	3286		
						2.1	34							
	66 Reaches						Ft	423640	194995	173533	127647	159174	100937	90872
							Mi	80	37	33	24	30	19	17
							Km	129	59	53	39	49	31	28
			LB	RB	Total	(%)	Miles			70		54		36
	Conifer	C	61	64	125	58%				44%		34%		23%
	Mixed	M	41	41	82	38%								
	Hardwood	H	6	3	9	4%								
			108	108	216	100%								

WASHOUGAL RIVER BASIN

Case	EDT Reach Name	RIPARIAN							LW Recruitment Potential					
		lb		rb		Shade		Length						
		Code	Hazard	Code	Hazard	Code	(%)	(ft)	Good		Fair		Poor	
	Small	S	27	22	49	23%								
	Med	M	70	74	144	67%								
	Large	L	11	12	23	11%								
			108	108	216	100%								
	Sparse	S	54	62	116	54%								
	Dense	D	54	46	100	46%								
			108	108	216	100%								
				Shade Tally		0	1	1%						
						1	16	15%						
						2	63	58%						
						3	24	22%						
						4	4	4%						
						5	0	0%						
							108	100%						

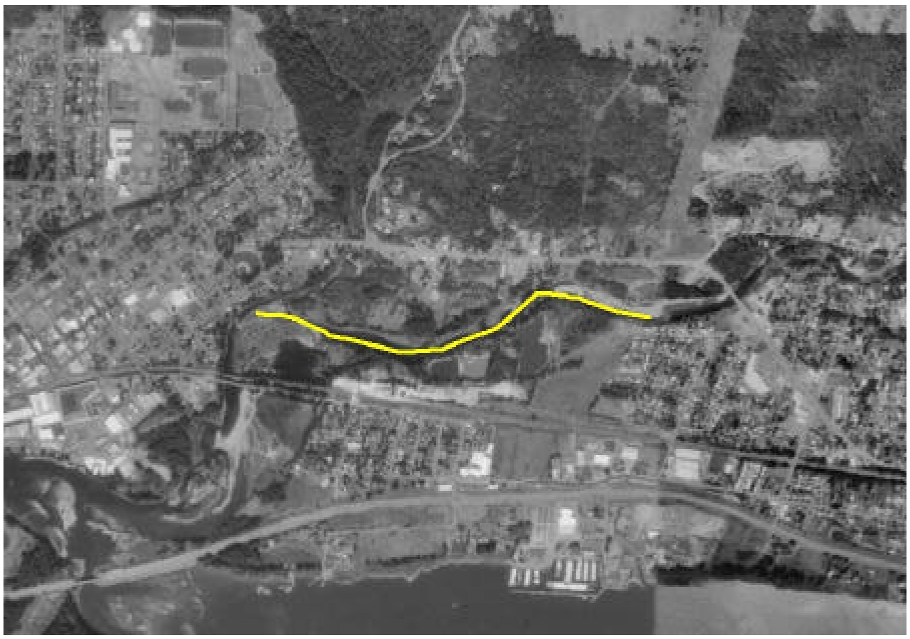
APPENDIX 6B

Stream Inventory
Reach Summaries
for Washougal Basin

WASHOUGAL RIVER 2-TIDAL

INTRODUCTION

Washougal River 2-tidal extends upstream from the confluence with Lacamas Creek to the upstream end of tidal influence at RM 1.8 (Map B-1). This reach is tidally influenced. The entire Reach was surveyed by boat.



Map B-1. Portion of Washougal 2-tidal surveyed.

The Washougal River has not developed a detectable floodplain of its own, and the entire length of Washougal River 2 flows along the edge of an area that was historically flooded by both the Columbia and Washougal rivers. The city of Washougal currently occupies the floodplain area between the Washougal and Columbia River, with the Washougal River flowing through a relatively narrow, incised channel along the base of the mountain slopes. It is unclear whether the Washougal has incised through Columbia River flood deposits or if the town of Washougal is built on fill. As a result of the incised natural of the channel, the floodplain is not separated from the river by levees, however many steep banks are currently armored to protect streamside business and residences.

CHANNEL MORPHOLOGY

Washougal 2 is a low gradient floodplain channel with dune-ripple to pool-riffle bedforms. It is comprised primarily of glide habitat type (59%) but also includes areas of pool and riffle (Figure B-1). Depending upon river discharge and the tidal stage, reverse stream flows are possible. This channel type forms pools primarily as a result of lateral flow oscillations and obstructions. It would be responsive to LW, although very large pieces or jams would be required to influence channel morphology. Channel banks are composed of unconsolidated sediments and are susceptible to erosion. Natural erosion would be expected on the outside of meander bends.

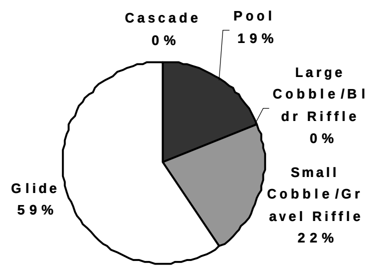


Figure B-1. Unit composition by percent surface area of Washougal 2-tidal.

Washougal 2 has a very low gradient (< 1 percent) and is currently moderately confined by an incised valley and periodic armored banks. The wetted width during the survey averaged 51 m (67 ft). The maximum depth of pools averaged greater than 4.9 m (16 ft). See Table B-1.

Table B-1. Average channel morphology characteristics of surveyed sections of Washougal 2 – tidal.

Parameter	Reach Value
Mean gradient	0.1%
Mean wetted width (m)	51 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual Pool depth (m)	4.3
Mean of the maximum pool depths (m)	4.9
Pools per kilometer (p/km)	1.3
Primary pools (>1.0m deep) per kilometer	1.3

WOOD

There were 3.8 pieces of large woody debris per kilometer (LW/km) recorded in Washougal 2 during the summer of 2004. Most of the wood encountered was of the small or medium 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 Washougal 2-tidal.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	1.3
Medium Pieces	20-50 cm diameter; > 2 m long	1.3
Large Pieces	> 50 cm diameter; > 2 m long	0.6
Jams	> 10 pieces in accumulation	0.6
Root wads	> 2 m long	0.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes was gravel and cobble, respectively (Table B-3). Based on the channel morphology and tidal influence, high levels of sand might be expected; sand lines were noted in some areas, but extensive sand deposits were not noted.

Table B-3. Substrate grain size composition in surveyed section of Washougal 2-tidal.

Category	Mean Frequency
Sand	0%
Gravel	56%
Cobble	32%
Boulder	18%
Bedrock	0%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 19 percent.

A pebble count was performed in Washougal 2-tidal. The D50 and D90 particle sizes were 32 mm and 88 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, Undercut banks, overhanging vegetation, deep water or substrate. Cover was rare in Washougal 2-tidal at low flow, and was provided only by water depth (Table B-4)

Table B-4. Presence of cover within the surveyed portion of Washougal 2-tidal. 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	33%
Substrate (Velocity Cover)	0%

RIPARIAN

Washougal 2-tidal is moderately confined floodplain channel that is generally open to the sky for most of its length. Extensive development has occurred on both banks, and riparian vegetation is generally limited to a narrow banks along the channel margin 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 consist exclusively of deciduous tree communities (Figure B-2). As such the open channel width to the sky averages 51 m (167 ft) of channel width plus an additional 104 m (341 ft) of open bank or a total of 155 m (508 ft)-wide zone without vegetative cover. The mean view to sky is 68 percent (Table B-5). Nearly 60 percent of the riparian zone is also currently disturbed by both urbanization and timber removal.

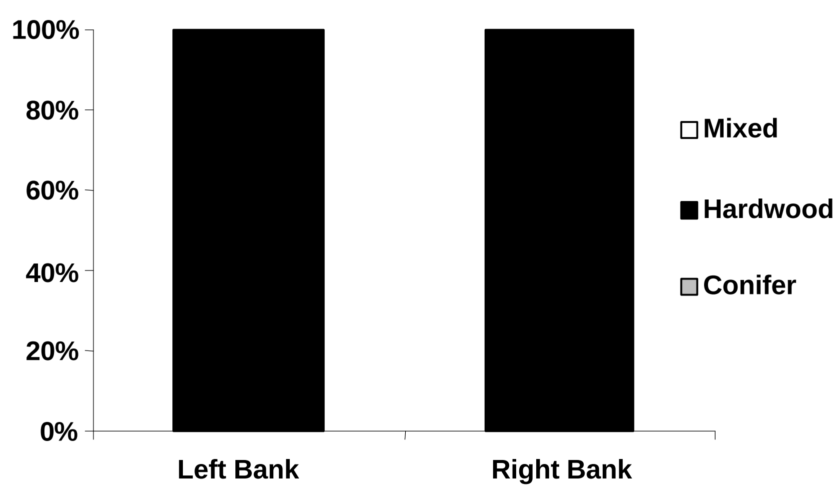


Figure B-2. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Historically, riparian vegetation was likely patchy consisting of a mixture of wetland and shrub and tree species tolerant of frequent prolonged inundation on the left (south) bank and forested uplands on the steeped sideslopes to the north. The area south of Washougal

2 is located within the Columbia River floodplain, and likely experiences frequent disturbance by floods in both the Washougal River and Columbia River.

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 naturally low 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 18.2^{o}C. The current channel condition (VTS 68%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 2.9^{o}C or peak at 21.1^{o}C.

These estimates predict freshwater surface temperatures solely based on elevation, channel width and canopy coverage. They do not consider the influence of marine water intrusion, groundwater influx or wetland runoff. Actual water temperatures will vary with Washougal River discharge, tidal stage, local weather patterns and the relative volume of groundwater, ponded water or tributary contributions. Washougal 2-tidal should be regarded as a transport reach and coldwater salmonid fishes would generally need to time their entry into the Washougal River during cooler periods than what may occur during late summer low flow conditions.

Table B-5. Riparian shading characteristics in survey section of Washougal 2-tidal. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	51 m
Mean distance to blocking vegetation – left bank (m)	51 m
Mean left bank canopy angle (degrees)	30 ^{o}
Mean distance to blocking vegetation – right bank (m)	53 m
Mean right bank canopy angle (degrees)	24 ^{o}
Mean view to sky (percent)	68%
Elevation (msl)	20’
Reference Temperature (T^{o}C) 7-DADmax	18.2^{o}C
Estimated Current Temperature (T^{o}C) 7-DADmax	21.1^{o}C

INSTABILITY AND DISTURBANCE

There was no bank instability recorded in the surveyed section of Washougal 2-tidal (Table B-6). Bank armoring was common, precluding bank instability. Other man-made disturbances included the urbanizing presence of structures, roads and railroads. Both banks were equally disturbed with average estimates of around 40 to 50 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 Washougal 2-tidal. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	39
Right bank disturbance (%)	51

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 greater minimum channel widths and (2) lower embeddedness levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-7 to B-9).

Table B-7. Comparison of EDT Level 2 attribute ratings assigned to Washougal 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)	107	167	24.7%
Channel width – maximum (ft)	171	NA	
Habitat Type – off-channel habitat factor (patient)	0.0%	0.0%	0.0%
Habitat Type – off-channel habitat factor (template)	10.0%	NO DATA	NA

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

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	48.0%	53.0%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	8.0%	4.1%	
Habitat Type – glides	26.0%	30.6%	
Habitat Type – small cobble/gravel riffles	9.0%	12.3%	
Habitat Type – large cobble/boulder riffles	9.0%	0.0%	

Table B-9. Comparison of EDT Level 2 attribute ratings assigned to Washougal 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 (%)	0.1%	<1%	
Confinement – natural	0	0	
Confinement – hydromodifications	2	2.0	
In-channel wood	4	4	
Embeddedness	1.3	0.7	
Fine sediment	2.8	NO DATA	

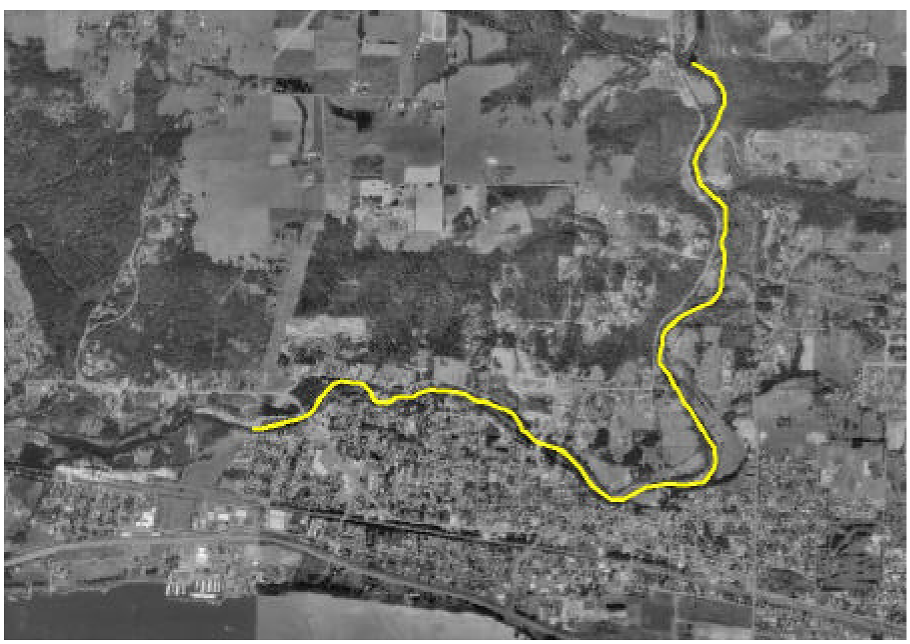
WASHOUGAL RIVER 3

INTRODUCTION

Washougal River 3 extends from the upstream end of tidal influence at RM 1.8 to the confluence with the Little Washougal River at RM 5.5. The entire reach was surveyed via boat (Map 2).

For the first 2.4 miles of this reach, the Washougal River flows along the edge of the historic Columbia River floodplain. The city of Washougal currently occupies the floodplain area between the Washougal and Columbia River, with the Washougal River flowing through a relatively narrow, incised channel along the base of the mountain slopes. It is unclear whether the Washougal has incised through Columbia River flood deposits or if the town of Washougal is built on fill. As a result of the incised natural of the channel, the floodplain is not separated from the river by levees, however many steep banks are currently armored to protect streamside business and residences.

Upstream of RM 4.2, the river enters a bedrock controlled canyon carved by the Washougal River. This section of the river is bordered generally by small discontinuous alluvial terrace features.



Map B-2. Portion of Washoughal 3 surveyed.

CHANNEL MORPHOLOGY

Washougal 3 exhibits two distinct channel morphologies. From RM 1.8 to RM 4.2 the channel is a low gradient floodplain type with pool-riffle bedforms. The river is moderately confined, and the channel is somewhat free to meander across a narrow (500-foot wide) incised in the Columbia River floodplain. Pools and riffle form as a result of alluvial sediment deposition, and the channel would be responsive to large pieces of LW or LW jams. Channel responses to LW would be lateral migration and pool scour. Unmodified banks consist primarily of unconsolidated sediments, and would be susceptible to erosion.

Upstream of RM 4.2, the Washougal becomes a low gradient contained channel type. Lateral migration is constrained by bedrock, and pool formation and spacing are largely forced by bedrock outcrops in the bed and bank. The channel would not be expected to be highly responsive to LW in this section. Individual pieces (including large logs) would be rapidly transported downstream during high energy flood flows. Large, channel spanning accumulations of LW could temporarily result in some sediment storage, but would be unlikely to persist for long periods due to the high stream energy. Banks are generally bedrock and are naturally resistant to erosion.

Washougal 3 has a very low gradient (0.3 percent) and is currently moderately confined by armored banks in the lower section and incised valley walls in the upper section. The wetted width during the survey averaged 36 m (118 ft). Pool habitat accounted for 38 percent of the length (Figure B-3). The maximum depth of pools averaged 4.4 m (14 ft). The remainder of the habitat consisted of riffles and glides. See Table B-10.

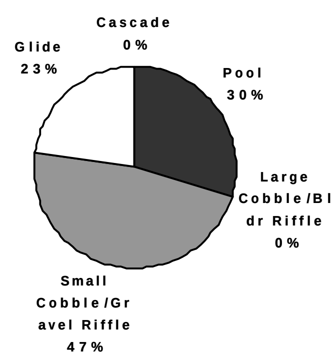


Figure B-3. Unit composition by percent surface area of Washougal 3.

Table B-10. Average channel morphology characteristics of surveyed sections of Washougal 3.

Parameter	Reach Value
Mean gradient	0.3%
Mean wetted width (m)	36.0 m
Mean active channel width (m)	NA
Mean of the maximum riffle depths (m)	NA
Mean residual Pool depth (m)	3.9 m
Mean of the maximum pool depths (m)	4.4 m
Pools per kilometer (p/km)	2.4
Primary pools (>1.0m deep) per kilometer	2.4

WOOD

There were 3.2 pieces of large woody debris per kilometer (LW/km) recorded in Washougal 3 during the summer of 2004. Most of the wood encountered was of the small size class of woody debris pieces (Table B-11). No jams and few root wads were observed during the survey.

Table B-11. Size and density of wood, jams and root wads in surveyed section of Washougal 3.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	1.9
Medium Pieces	20-50 cm diameter; > 2 m long	0.7
Large Pieces	> 50 cm diameter; > 2 m long	0.4
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.2

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes was gravel and cobble, respectively (Table B-12). Deposits of fine sediment were rare, and no units with substrate dominated by sand were encountered. Occasional bedrock outcrops were observed downstream of RM 4.2. Bedrock and boulders were more common in the canyon portion of Washougal 3.

Table B-12. Substrate grain size composition in surveyed section of Washougal 3.

Category	Mean Frequency
Sand	0%
Gravel	42%
Cobble	38%
Boulder	15%
Bedrock	4%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 10 percent.

No pebble count was performed in Washougal 3. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. Cover was rare in Washougal 3 at low flow, and was provided primarily by water depth, or in a few cases by overhanging vegetation (Table B-13)

Table B-13. Presence of cover within the surveyed portion of Washougal 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	4%
Water Depth > 1 m	40%
Substrate (Velocity Cover)	0%

RIPARIAN

Washougal 3 is a moderately confined floodplain channel that is generally open to the sky for most of the lower 2.4 miles of its length. Extensive development has occurred on both banks in that area, and riparian vegetation is generally limited to a narrow banks along the channel margin. 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 consist exclusively of deciduous tree communities (Figure B-4). As such the open channel width to the sky averages 36 m (118 ft) of channel width plus an additional 47 m (154 ft) of open bank or a total of 83 m wide zone without vegetative cover. The mean view to sky angle is 60 percent (Table B-14). Over 50 percent of the riparian zone on both banks is also currently disturbed by both urbanization, thinning and stream adjacent roads.

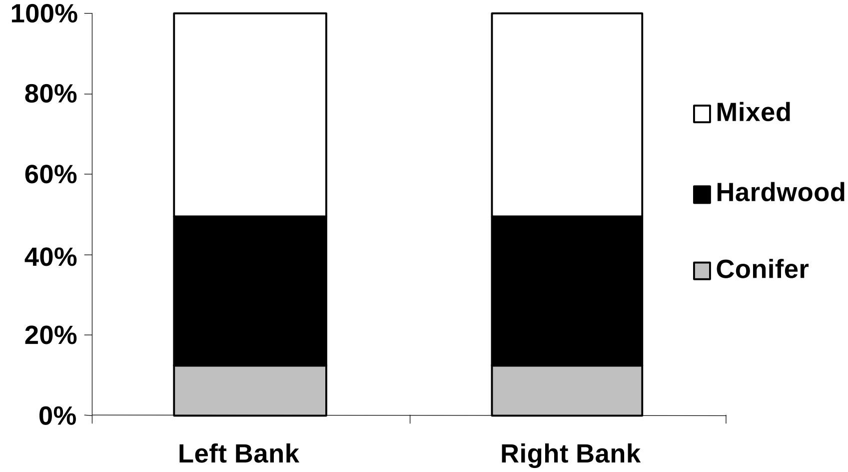


Figure B-4. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Historically, riparian vegetation was likely patchy consisting of a mixture of wetland and shrub and tree species tolerant of frequent prolonged inundation on the left bank and forested uplands on the steep sideslopes to the north. The area south of Washougal 3 is located within the Columbia River floodplain, and likely experiences frequent disturbance by floods in both the Washougal River and Columbia River.

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 17.6^{o}C. The current channel condition (V-T-S 60%) is anticipated to increase the 7-DADmax on a relative basis approximately 2.7^{o}C compared to reference conditions or peak at 20.3^{o}C. Estimates of the current 7-DADmax from surface water measurements collected by Clark County Public Works, Water Resources during the summer of 2004 was 24.7^{o}C. this measurement is substantially higher than the predicted VTS temperature and it exceeds incipient lethal limits for a number of salmonid fishes.

The VTS estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx wetland runoff or upstream thermal contributions. Actual water temperatures will vary with Washougal River discharge, local weather patterns and the relative volume of groundwater, ponded water and tributary contributions.

Table B-14. Riparian shading characteristics in survey section of Washougal 3. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	36 m
Mean distance to blocking vegetation – left bank (m)	33 m
Mean left bank canopy angle (degrees)	37^{o}
Mean distance to blocking vegetation – right bank (m)	50 m
Mean right bank canopy angle (degrees)	35^{o}
Mean view to sky (percent)	60%
Elevation (msl)	55’
Reference Temperature ($T^{o}C$)	$17.6^{o}C$
Estimated Current Temperature ($T^{o}C$)	$20.3^{o}C$

INSTABILITY AND DISTURBANCE

There was no bank instability recorded in the Washougal 3 (Table B-15). Bank armoring was common, precluding bank instability. Other man-made disturbances included the urbanizing presence of structures, roads and railroads. Both banks were equally disturbed with average estimates of around 50 to 60 percent of the 35m (100 ft) riparian zone influenced to some degree or another.

Table B-15. Bank instability and disturbance of surveyed section of Washougal 3. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	53
Right bank disturbance (%)	62

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 more minimum channel widths and less pool habitats with more riffle [especially small cobble/gravel riffle] and glide habitat; (2) more bank hydromodifications and less embeddedness and in-channel LW levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-16 to B-18).

Table B-16. Comparison of EDT Level 2 attribute ratings assigned to Washougal 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)	85	118	17.1%
Channel width – maximum (ft)	136	NO DATA	
Habitat Type – off-channel habitat factor (patient)	0.0%	0.0%	0.0%
Habitat Type – off-channel habitat factor (template)	0.0%	NO DATA	NA

Table B-17. Comparison of EDT Level 2 attribute ratings assigned to Washougal 3, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	46.0%	0.0%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	8.0%	0.0%	
Habitat Type – glides	25.0%	32.4%	
Habitat Type – small cobble/gravel riffles	11.0%	48.2%	
Habitat Type – large cobble/boulder riffles	10.0%	19.4%	

Table B-18. Comparison of EDT Level 2 attribute ratings assigned to Washougal 3, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

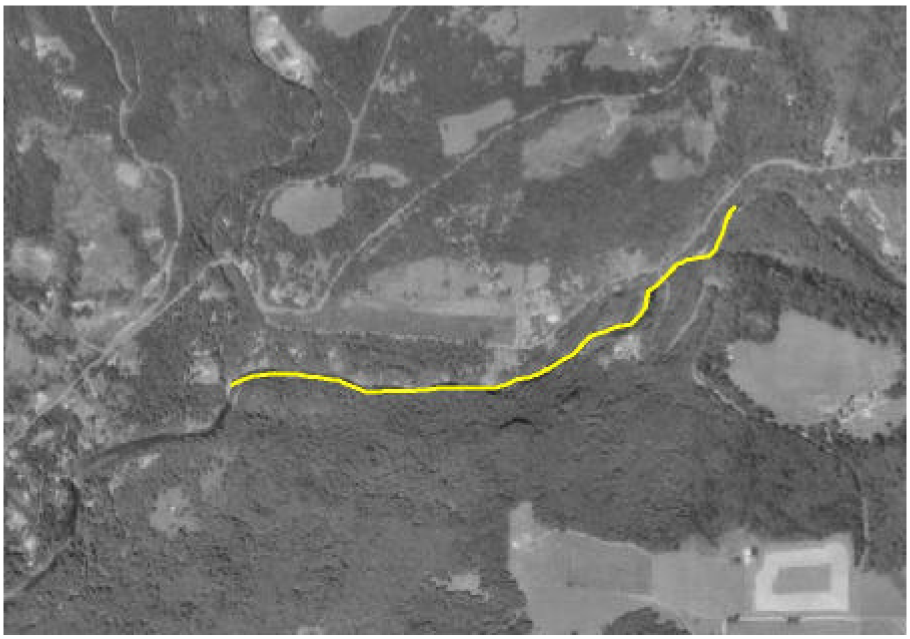
Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.3%	0.3%	
Confinement – natural	1	1	
Confinement – hydromodifications	1	2.2	
In-channel wood	3	3.9	
Embeddedness	1.3	0.3	
Fine sediment	2.8	NO DATA	

WASHOUGAL RIVER 9

INTRODUCTION

Washougal River 9 extends from the confluence with the West Fork Washougal River at RM 14.4 to Salmon Falls at RM 15.3. The entire reach downstream from Salmon falls was surveyed (Map B-3).

Washougal 9 is a large contained channel that flows through a steep-sided valley. Occasional high terrace features are present, but the terraces appear to be above the current river level. Confinement is generally tight, although short sections of moderate confinement bordered by current alluvial deposits are present.



Map B-3. Portion of Washougal 9 surveyed.

CHANNEL MORPHOLOGY

Washougal 9 is a large contained channel with a map gradient of 0.5 to 1.4 percent. The gradient steepens toward the upstream end as the river lies in the canyon forming Salmon falls. Bedforms consist predominantly of pools and riffles, with occasional cascades and glides. The channel type is moderately responsive to large pieces of LW or LW jams, particularly in semi-alluvial areas. However, lateral migration is largely constrained by sideslopes., Pool formation and spacing are frequently forced by bedrock outcrops in the bed and bank. Individual LW pieces (including large logs) would be rapidly transported downstream during high energy flood flows. Large, channel-spanning accumulations of

LW could temporarily result in some coarse sediment storage, but it is unlikely to persist for long periods due to the high stream energy.

Washougal 9 has a low to moderate gradient (0.5 to 1.4 percent) and is currently moderately to highly confined by valley sideslopes. The wetted width during the survey averaged 21.9 m (72 ft). Pool habitat accounted for 49 percent of the length (Figure B-5). The maximum depth of pools averaged 1.7 m (6 ft). The remainder of the habitat consisted of riffles, glides and cascades. See Table B-19.

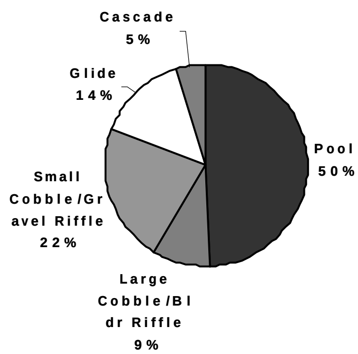


Figure B-5. Unit composition by percent surface area of Washougal 9.

Table B-19. Average channel morphology characteristics of surveyed sections of Washougal 9.

Parameter	Reach Value
Mean gradient	0.3%
Mean wetted width (m)	21.9 m
Mean active channel width (m)	28 m
Mean of the maximum riffle depths (m)	0.7
Mean residual Pool depth (m)	1.3
Mean of the maximum pool depths (m)	1.7
Pools per kilometer (p/km)	10.1
Primary pools (>1.0m deep) per kilometer	8.1

WOOD

There were 12.2 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Washougal 9 during the summer of 2004. Most of the wood encountered was of the small size class of woody debris pieces (Table B-20). Occasional jams or root wads were observed during the survey.

Table B-20. Size and density of wood, jams and root wads in surveyed section of Washougal 9.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	1.5
Medium Pieces	20-50 cm diameter; > 2 m long	7.1
Large Pieces	> 50 cm diameter; > 2 m long	2.5
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 bedrock and gravel, respectively (Table B-21). Based on the channel morphology and high stream energy, deposits of fine sediment are expected to be rare, and mobile sediments should accumulate only in the less of obstructions, backwater areas or along channel margins.

Table B-21. Substrate grain size composition in surveyed section of Washougal 9.

Category	Mean Frequency
Sand	8%
Gravel	24%
Cobble	18%
Boulder	17%
Bedrock	34%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 21 percent.

A pebble count was performed in Washougal 9. The D50 and D90 particle sizes were 44 mm and 125 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, cover in Washougal 9 consists primarily of deep water, and in a few cases substrate or overhanging vegetation (Table B-22).

Table B-22. Presence of cover within the surveyed portion of Washougal 9. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	<1%
Undercut Banks	0%
Overhanging Vegetation	1%
Water Depth > 1 m	18%
Substrate (Velocity Cover)	3%

RIPARIAN

Washougal 9 is large contained channel. 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 consist primarily of mixed deciduous and conifer tree communities (Figure B-6). As such the open channel width to the sky averages 28 m (92 ft) of channel width plus an additional 16 m (51 ft) of open bank or a total of 54 m (143 ft)-wide zone without vegetative cover. The mean view to sky is 44 percent (Table B-23). Less than 20 percent of the riparian zone is currently disturbed by roads or residential development.

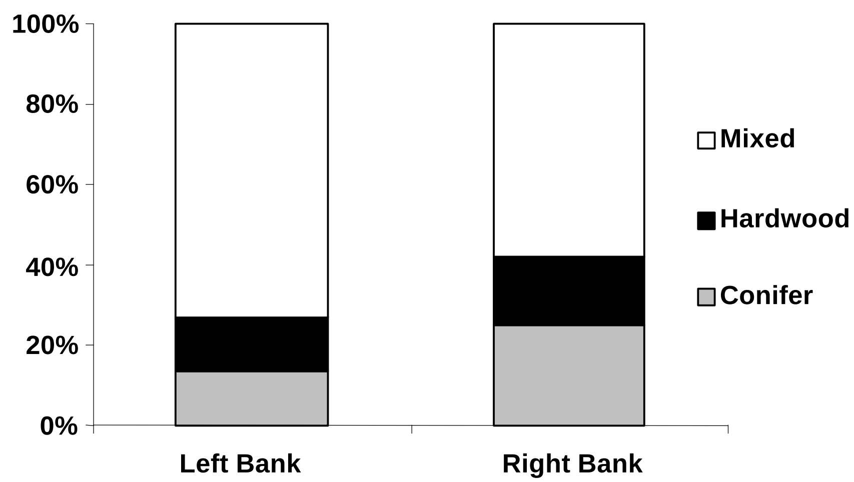


Figure B-6. Vegetation type by percent of units observed. Data presented as proceeding downstream.

With mature forest stands growing immediately adjacent to the channel, this reach is estimated to remain open to solar radiation (VTS; 18%). As such, it represents a naturally high hazard area 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 16.7°C. The current channel condition (VTS 40%) is anticipated to increase the 7-DADmax on a relative basis approximately 1.6°C compared to reference conditions or peak at 18.3°C.

These estimates predict freshwater surface temperatures solely based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx or wetland runoff. Actual water temperatures will vary with Washougal River discharge, local weather patterns and the relative volume of groundwater, ponded water and tributary contributions.

Table B-23. Riparian shading characteristics in survey section of Washougal 9. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	28 m
Mean distance to blocking vegetation – left bank (m)	20 m
Mean left bank canopy angle (degrees)	58°
Mean distance to blocking vegetation – right bank (m)	23 m
Mean right bank canopy angle (degrees)	51°
Mean view to sky (percent)	44%
Elevation (msl)	375’
Reference Temperature (T°C)	16.7°C
Estimated Current Temperature (T°C)	18.3°C

INSTABILITY AND DISTURBANCE

There was only minor bank instability recorded in the surveyed section of Washougal 9 (Table B-24). Bedrock outcrops were common in the bed and banks, precluding bank instability. Other man-made disturbances included the urbanizing presence of houses and roads. The left bank had minimal disturbance. The left bank was more disturbed with average estimates of around 18 percent of the 35m (100 ft) riparian zone influenced to some degree or another within the surveyed reach. Disturbance values for the surveyed section may be higher than for elsewhere in the reach, due to the presence of a streamside road and cluster of houses.

Table B-24. Bank instability and disturbance of surveyed section of Washougal 9. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	2
Right bank instability (%)	2
Left bank disturbance (%)	1
Right bank disturbance (%)	18

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 more natural confinement and large cobble/boulder riffle habitat and less glide habitat; and (2) more embeddedness and slightly less fine sediment levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-25 to B-27).

Table B-25. Comparison of EDT Level 2 attribute ratings assigned to Washougal 9, 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)	70	72	-7.7%
Channel width – maximum (ft)	112	94	
Habitat Type – off-channel habitat factor (patient)	0.0%	NO DATA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NO DATA	NA

Table B-26. Comparison of EDT Level 2 attribute ratings assigned to Washougal 9, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	46.0%	33.4%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	8.0%	13.5%	
Habitat Type – glides	25.0%	16.5%	
Habitat Type – small cobble/gravel riffles	11.0%	11.7%	
Habitat Type – large cobble/boulder riffles	10.0%	24.9%	

Table B-27. Comparison of EDT Level 2 attribute ratings assigned to Washougal 9, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

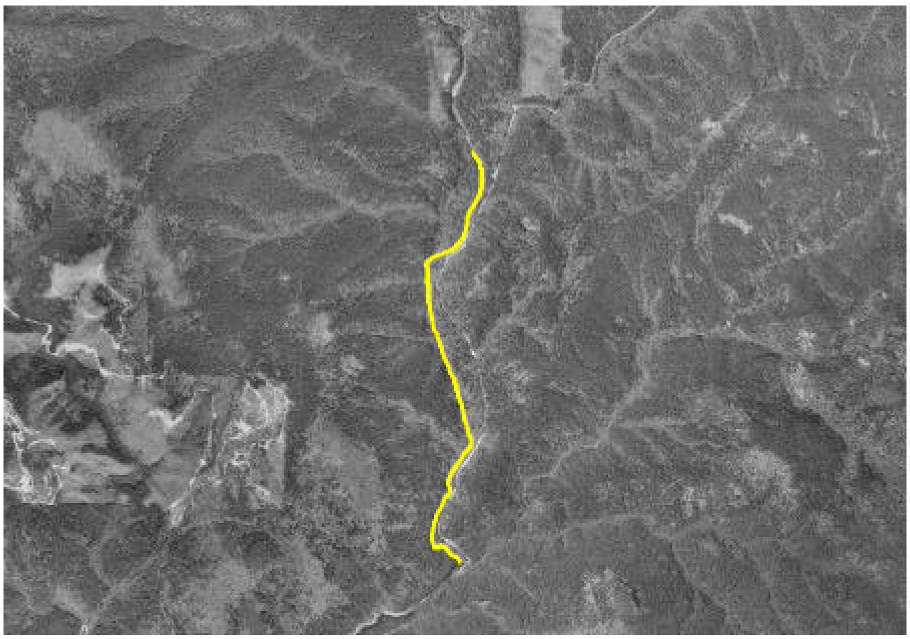
Attribute	SRE Rating	Rating from Survey	
Gradient (%)	0.3%	0.5-1.4%	
Confinement – natural	1	3-4	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	4	3.5	
Embeddedness	0.8	2.5	
Fine sediment	1.9	1.2	

WASHOUGAL RIVER 14

INTRODUCTION

Washougal 14 extends from the confluence with Stebbins Creek at RM 24.2 to the confluence with Timber Creek at RM 25.9. The entire reach was surveyed (Map B-4).

Washougal 14 is a moderate gradient contained channel flowing through a narrow to moderately wide (150 m; 500 feet) steep-sided valley. An alluvial terrace feature borders the channel from RM 24.6 to 25.2. Elsewhere the channel is confined either in a very narrow bedrock gorge (RM 24.2 to RM 24.6) or by alluvial fan deposits delivered by steep, unnamed tributaries (RM 24.6 to 25.9).



Map B-4. Portions of Washougal 14 surveyed.

CHANNEL MORPHOLOGY

Washougal 14 is a moderate gradient contained channel with a map gradient of 1.5 percent. The lower 0.4 miles of this reach is highly confined in a narrow bedrock gorge. Bedforms consist of a series of bedrock controlled steps, pool and cascades. Upstream of that point, the channel becomes moderately confined. The moderately confined section of channel would be moderately responsive to large pieces of LW or LW jams. However, lateral migration is largely constrained by sideslopes, and pool formation and spacing may be influenced by bedrock outcrops in the bed and bank. The absence of LW or other obstructions could result in the development of plane-bed morphology in reaches not controlled by bedrock.

Washougal 14 has a moderate gradient (1.5 percent). The wetted width during the survey averaged 19 m (62 ft). Pool habitat accounted for 32 percent of the surveyed length, with the remaining habitat comprised primarily of riffles and an occasional glide or cascade (Figure B-7). The maximum depth of pools averaged 1.9 m (6.2 ft). The channel morphologic characteristics in the surveyed reach are summarized in Table B- 28.

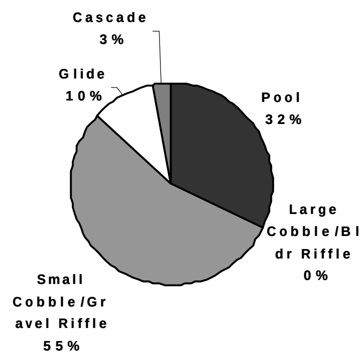


Figure B-7. Unit composition by percent surface area of Washougal 14.

Table B-28. Average channel morphology characteristics of surveyed sections of Washougal 14.

Parameter	Reach Value
Mean gradient	1.5%
Mean wetted width (m)	19 m
Mean active channel width (m)	24 m
Mean of the maximum riffle depths (m)	0.8
Mean residual Pool depth (m)	1.5
Mean of the maximum pool depths (m)	1.9
Pools per kilometer (p/km)	12.7
Primary pools (>1.0m deep) per kilometer	6.3

WOOD

There were 8.2 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Washougal 14 during the summer of 2004. Most of the wood encountered was of the large size class of woody debris pieces (Table B-29). No jams or root wads were observed during the survey.

Table B-29. Size and density of wood, jams and root wads in surveyed section of Washougal 14.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	0.7
Medium Pieces	20-50 cm diameter; > 2 m long	2.8
Large Pieces	> 50 cm diameter; > 2 m long	4.6
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 were bedrock and boulder, respectively (Table B-30). Based on the channel morphology and high stream energy, deposits of fine sediment are expected to be rare, and mobile sediments should accumulate only in the less of obstructions, backwater areas or along channel margins.

Table B-30. Substrate grain size composition in surveyed section of Washougal 14.

Category	Mean Frequency
Sand	5%
Gravel	18%
Cobble	22%
Boulder	26%
Bedrock	29%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 28 percent.

A pebble count was performed in Washougal 14. The D50 and D90 particle sizes were 112 mm and 242 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, cover in Washougal 14 consists primarily of deep water and substrate. Overhanging vegetation and LW provide minimal cover (Table B-31).

Table B-31. Presence of cover within the surveyed portion of Washougal 14. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	<1%
Undercut Banks	0%
Overhanging Vegetation	1%
Water Depth > 1 m	17%
Substrate (Velocity Cover)	13%

RIPARIAN

Washougal 14 is large contained channel generally open to the sky for most of its length. 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 consist primarily of mixed deciduous and conifer tree communities (Figure B-8). As such, the open channel width to the sky averages 24 m (79 ft) of channel width plus an additional 5 m (18 ft) of open bank or a total of 29 m (97 ft)-wide zone without vegetative cover. The mean view to sky is 40 percent (Table B-32). Less than 20 percent of the riparian zone is currently disturbed by roads or residential development.

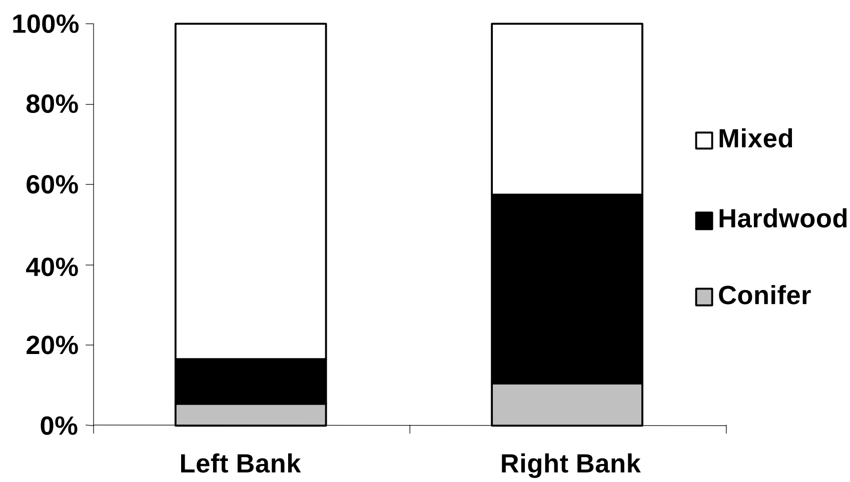


Figure B-8. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.8°C. The current channel condition (VTS 40%) is anticipated to increase the 7-DADmax on a relative basis approximately 1.8°C compared to reference conditions or peak at 17.6°C.

These estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx or wetland runoff. Actual water temperatures will vary with Washougal River discharge, local weather patterns slightly the relative volume of groundwater, ponded water and tributary contributions.

Table B-32. Riparian shading characteristics in survey section of Washougal 14. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	24 m
Mean distance to blocking vegetation – left bank (m)	16 m
Mean left bank canopy angle (degrees)	53 ^{o}
Mean distance to blocking vegetation – right bank (m)	13 m
Mean right bank canopy angle (degrees)	54 ^{o}
Mean view to sky (percent)	40%
Elevation (msl)	835’
Reference Temperature (T^{o}C)	15.8^{o}C
Estimated Current Temperature (T^{o}C)	17.6^{o}C

INSTABILITY AND DISTURBANCE

There was no bank instability recorded in the surveyed section of Washougal 14 (Table B-33). Bedrock outcrops were common in the bed and banks, generally precluding bank instability. The left bank was influenced by a stream adjacent road; 21 percent of the 35m (100 ft) riparian zone was influenced to some degree or another within the surveyed reach. No disturbance was noted on the right bank. Disturbance values for the surveyed section may be higher than for elsewhere in the reach, as only about 0.3 miles of the 1.7 mile long reach is affected by stream adjacent road.

Table B-33. Bank instability and disturbance of surveyed section of Washougal 14. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	21
Right bank disturbance (%)	0

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 wider minimum channel widths and more large cobble/boulder riffle habitat and less glide habitat; and (2) less in-channel LW loading levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-34 to B-36).

Table B-34. Comparison of EDT Level 2 attribute ratings assigned to Washougal 14, 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)	50	62	11.7%
Channel width – maximum (ft)	80	81	
Habitat Type – off-channel habitat factor (patient)	0.0%	NO DATA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NO DATA	NA

Table B-35. Comparison of EDT Level 2 attribute ratings assigned to Washougal 14, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	27.0%	16.1%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	3.0%	13.1%	
Habitat Type – glides	20.0%	10.2%	
Habitat Type – small cobble/gravel riffles	5.0%	0.0%	
Habitat Type – large cobble/boulder riffles	45.0%	60.6%	

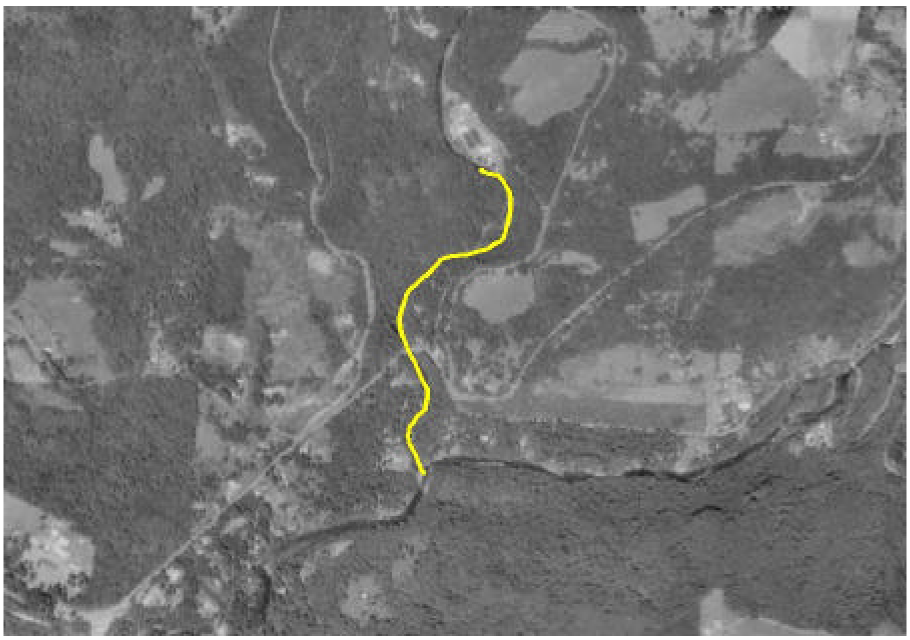
Table B-36. Comparison of EDT Level 2 attribute ratings assigned to Washougal 14, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	1.2%	1.5%	
Confinement – natural	3	3	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	3	3.7	
Embeddedness	0.7	NA - noRiff	
Fine sediment	1.3	NA - noRiff	

WEST FORK WASHOUGAL RIVER 1

INTRODUCTION

West Fork Washougal 1 extends from the confluence with the Washougal River to the site of the natural falls located near the Vogel Creek hatchery. WF Washougal 1 is a moderate gradient contained channel that flows through a narrow steep-sided valley. The entire reach was surveyed (Map B-5).



Map B-5. Portions of WF Washougal 1 surveyed.

CHANNEL MORPHOLOGY

WF Washougal 1 has a map gradient of 2.5 percent. The lower 1,000 feet flow across o weakly developed alluvial fan features. At about 1050 feet the river enters a bedrock controlled valley. Bedforms in this channel would be anticipated to consist of forced pools and riffles if LW or other obstructions were present. The channel is anticipated to be moderately responsive to large pieces of LW or LW jams, which could store sediment or form pools. However, lateral migration is largely constrained by sideslopes, and pool formation and spacing may be more influenced by bedrock outcrops in the bed and bank. Given the high stream energy associated with this relatively large channel, LW features would be expected to be short–lived. The absence of LW or other obstructions could result in the development of plane-bed morphology in areas not controlled by bedrock.

WF Washougal 1 has a moderate gradient (2.5 percent). The wetted width during the survey averaged 16.9 m (62 ft). Pool habitat accounted for 28 percent of the surveyed length. The majority of habitat observed was riffle, with some areas of glide and cascade (Figure B-9). The maximum depth of pools averaged 2.1 m (6.9 ft). Table B-37 summarizes channel morphologic characteristics in the surveyed reach.

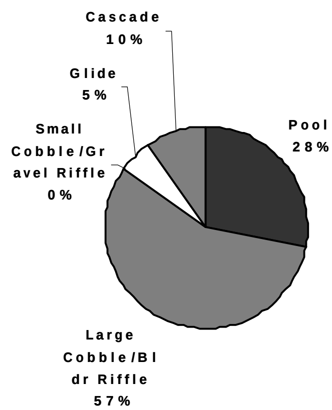


Figure B-9. Unit composition by percent surface area of West Fork Washougal 1.

Table B-37. Average channel morphology characteristics of surveyed sections of West Fork Washougal 1.

Parameter	Reach Value
Mean gradient	2.5%
Mean wetted width (m)	16.9 m
Mean active channel width (m)	20.7 m
Mean of the maximum riffle depths (m)	0.9
Mean residual Pool depth (m)	1.7
Mean of the maximum pool depths (m)	2.1
Pools per kilometer (p/km)	6.5
Primary pools (>1.0m deep) per kilometer	6.5

WOOD

There were 12.4 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of West Fork Washougal 1 during the summer of 2004. Most of the wood encountered was of the medium size class of woody debris pieces (Table B-38). No jams or root wads were observed during the survey.

Table B-38. Size and density of wood, jams and root wads in surveyed section of West Fork Washougal 1.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	3.8
Medium Pieces	20-50 cm diameter; > 2 m long	7.0
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 were boulder and cobble, respectively (Table B-39). Based on the channel morphology and high stream energy, deposits of fine sediment are expected to be rare, and mobile sediments should accumulate only in the less of obstructions, backwater areas or along channel margins.

Table B-39. Substrate grain size composition in surveyed section of West Fork Washougal 1.

Category	Mean Frequency
Sand	7%
Gravel	17%
Cobble	29%
Boulder	32%
Bedrock	16%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 22 percent.

A pebble count was performed in WF Washougal 1. The D50 and D90 particle sizes were 146 mm and 324 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, cover in WF Washougal 1 consists primarily of substrate and overhanging vegetation. Overhanging vegetation and deep water also provide minimal cover (Table B-40).

Table B-40. Presence of cover within the surveyed portion of West Fork Washougal 1. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	1%
Undercut Banks	0%
Overhanging Vegetation	9%
Water Depth > 1 m	2%
Substrate (Velocity Cover)	17%

RIPARIAN

WF Washougal 1 is moderate gradient contained channel that is generally shaded by topographic relief or streamside vegetation for most of its length. 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 consist primarily of conifer and mixed deciduous and conifer tree communities (Figure B-10). The open channel width to the sky averages 21 m (69 ft) of channel width plus an additional 5 m (16 ft) of open bank or a total of 26 m (85 ft)-wide zone without vegetative cover. The mean view to sky is 28 percent (Table B-41). Approximately 15 to 30 percent of the riparian zone is currently disturbed by roads and residential development.

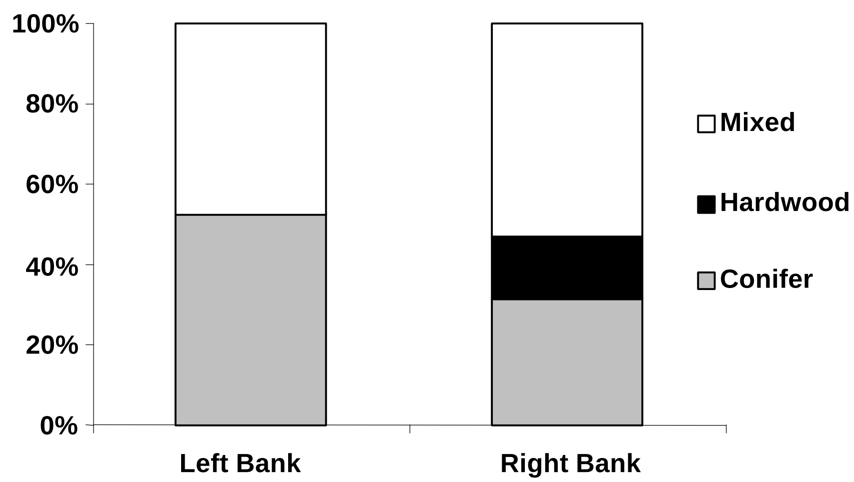


Figure B-10. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 16.3^{o}C. The current channel condition (VTS 27%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 1.0°C or peak at 17.3°C. Estimates of the current 7-DADmax from surface water measurements collected by Clark County Public Works, Water Resources during the summer of 2004 was 20.2°C.

The VTS estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx or wetland runoff. Actual water temperatures will vary with stream discharge, local weather patterns and the relative volume of groundwater, ponded water and tributary contributions.

Table B-41. Riparian shading characteristics in survey section of West Fork Washougal 1. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	21 m
Mean distance to blocking vegetation – left bank (m)	14 m
Mean left bank canopy angle (degrees)	61 °
Mean distance to blocking vegetation – right bank (m)	1` m
Mean right bank canopy angle (degrees)	69 °
Mean view to sky (percent)	28%
Elevation (msl)	400’
Reference Temperature (T°C) 7-DADmax	16.3°C
Estimated Current Temperature (T°C) 7-DADmax	17.3°C
Measured Temperature (T°C) 7-DADmax (est.)	20.2°C

INSTABILITY AND DISTURBANCE

There was minimal bank instability recorded in the surveyed section of WF Washougal 1 (Table B-42). Bedrock outcrops were common in the bed and banks, generally precluding bank instability. Both banks were influenced by a stream adjacent roads; 15 to 30 percent of the 35m (100 ft) riparian zone was influenced to some degree or another within the surveyed reach.

Table B-42. Bank instability and disturbance of surveyed section of West Fork Washougal 1. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	9
Left bank disturbance (%)	31
Right bank disturbance (%)	15

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 wider minimum channel widths, steeper gradients and more large cobble/boulder riffle habitat with subsequently less pool, glide, and small cobble/gravel riffle habitat; and (2) greater natural confinement ratings recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-43 to B-45).

Table B-43. Comparison of EDT Level 2 attribute ratings assigned to WF Wash. 1, 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)	47	55	10.0%
Channel width – maximum (ft)	66	68	
Habitat Type – off-channel habitat factor (patient)	2.6%	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 WF Wash. 1, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	29.0%	13.1%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	5.0%	9.0%	
Habitat Type – glides	12.0%	4.5%	
Habitat Type – small cobble/gravel riffles	27.0%	0.0%	
Habitat Type – large cobble/boulder riffles	27.0%	73.3%	

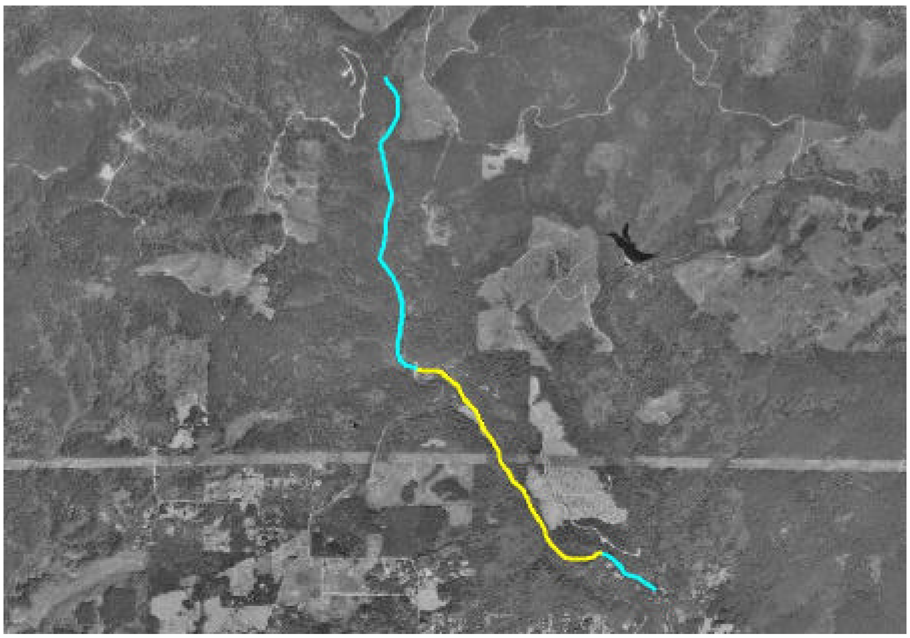
Table B-45. Comparison of EDT Level 2 attribute ratings assigned to WF Wash. 1, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	1.8%	2.5%	
Confinement – natural	2	3-4	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	3	3.5	
Embeddedness	0.8	NA - noRiff	
Fine sediment	2.0	NA - noRiff	

WEST FORK WASHOUGAL RIVER 3

INTRODUCTION

West Fork Washougal 3 extends from the Vogel Creek hatchery weir (RM 1) to the confluence with Wildboy Creek at RM 2.8. Approximately 3.3 mile was surveyed in 2004 as highlighted in yellow in Map B-6. WF Washougal 3 is a moderate gradient contained channel that flows through a narrow steep-sided valley. The stream is tightly confined for the first 1.3 miles. At RM 1.3 the valley width increases to around 75m to 90m (250-300 ft). The lower river is undeveloped, but there are a few houses in the upper, less confined section of this reach.



Map B-6. Portions of WF Washougal 3 surveyed.

CHANNEL MORPHOLOGY

WF Washougal 3 has a map gradient of 1.3 percent. The lower first 1.3 miles are a moderate gradient contained channel that is highly controlled by bedrock. The upper 0.5 miles is a moderate gradient mixed control channel. The upstream section of this channel would be anticipated to consist of forced pools and riffles if LW or other obstructions were present. The channel is anticipated to be highly responsive to large pieces of LW or LW jams, which could store sediment or form pools. However, lateral migration is largely constrained by sideslopes, and pool formation and spacing may be more influenced by bedrock outcrops in the bed and bank. The lower 1.5 miles are primarily influenced by bedrock, and would be anticipated to have structurally controlled pool-riffle of step pool bedforms. The canyon section is not likely to be highly responsive to

LW as a result of the high stream energy associated with this relatively large, confined channel.

WF Washougal 3 has a moderate gradient (1.5 to 2.5 percent). The wetted width during the survey averaged 12.2 m (40 ft). Pool habitat accounted for 35 percent of the surveyed length. The majority of habitat observed was riffle or cascade, with some areas of glide habitat (Figure B-11). The maximum depth of pools averaged 1.9 m (6.2 ft). Table B-46 summarizes channel morphologic characteristics in the surveyed reach.

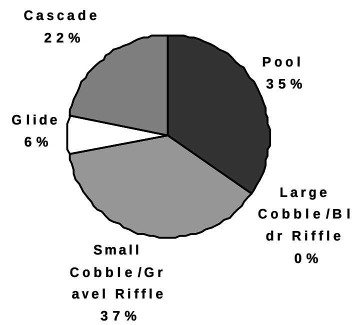


Figure B-11. Unit composition by percent surface area of West Fork Washougal 3.

Table B-46. Average channel morphology characteristics of surveyed sections of West Fork Washougal 3.

Parameter	Reach Value
Mean gradient	2.5%
Mean wetted width (m)	12.2 m
Mean active channel width (m)	16.9 m
Mean of the maximum riffle depths (m)	0.6
Mean residual Pool depth (m)	1.9
Mean of the maximum pool depths (m)	1.4
Pools per kilometer (p/km)	11.7
Primary pools (>1.0m deep) per kilometer	11.3

WOOD

There were 10.9 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of West Fork Washougal 3 during the summer of 2004. Most of the wood encountered was of the medium size class of woody debris pieces (Table B-47). No jams and few root wads were observed during the survey.

Table B-47. Size and density of wood, jams and root wads in surveyed section of West Fork Washougal 3.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	2.9
Medium Pieces	20-50 cm diameter; > 2 m long	5.0
Large Pieces	> 50 cm diameter; > 2 m long	2.5
Jams	> 10 pieces in accumulation	0.0
Root wads	> 2 m long	0.4

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were boulder and cobble, respectively (Table B-48). Based on the channel morphology and high stream energy, deposits of fine sediment are expected to be rare, and mobile sediments should accumulate only in the less of obstructions, backwater areas or along channel margins.

Table B-48. Substrate grain size composition in surveyed section of West Fork Washougal 3.

Category	Mean Frequency
Sand	5%
Gravel	16%
Cobble	29%
Boulder	26%
Bedrock	24%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 17 percent.

No pebble count was performed in WF Washougal 3. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, cover in WF Washougal 3 consists primarily of water depth. Overhanging vegetation and substrate also provide small amounts of (Table B-49).

Table B-49. Presence of cover within the surveyed portion of West Fork Washougal 3. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	1%
Undercut Banks	0%
Overhanging Vegetation	3%
Water Depth > 1 m	18%
Substrate (Velocity Cover)	6%

RIPARIAN

WF Washougal 3 is moderate gradient contained to mixed control channel that is generally shaded by topographic relief or streamside vegetation for most of its length. The open channel width to the sky averages 17 m (56 ft) of channel width plus an additional 12 m (40 ft) of open bank or a total of 29 m (96 ft)-wide zone without vegetative cover. The mean view to sky is 18 percent (Table B-50). Approximately 20 percent of the riparian zone is currently disturbed by roads, residential development or timber harvest.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.7^{o}C. The current channel condition (VTS 18%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 0.4^{o}C s or peak at 16.1^{o}C.

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

Table B-50. Riparian shading characteristics in survey section of West Fork Washougal 3. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	17 m
Mean distance to blocking vegetation – left bank (m)	14 m
Mean left bank canopy angle (degrees)	75 ^{o}
Mean distance to blocking vegetation – right bank (m)	15 m
Mean right bank canopy angle (degrees)	73 ^{o}
Mean view to sky (percent)	18%
Elevation (msl)	685'
Reference Temperature (T^{o}C)	15.7^{o}C
Estimated Current Temperature (T^{o}C)	16.1^{o}C

INSTABILITY AND DISTURBANCE

There was minimal bank instability recorded in the surveyed section of WF Washougal 3. Bedrock outcrops were common in the bed and banks, generally precluding bank instability. Both banks were influenced by timber harvest and development, and there was a stream adjacent road on the right bank; 18 percent of the 35m (100 ft) riparian zone was influenced to some degree or another within the surveyed reach. The surveyed section was located in the less confined section near the confluence with Wildboy Creek. The estimates of disturbance related to roads and residential development (Table B-51) may be higher than anticipated in the canyon segment.

Table B-51. Bank instability and disturbance of surveyed section of West Fork Washougal 3. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	18
Right bank disturbance (%)	18

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 more pool tailouts and large cobble/boulder riffle habitat with subsequently less small cobble/gravel riffle habitat; and (2) less in-channel LW loading levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-52 to B-54).

Table B-52. Comparison of EDT Level 2 attribute ratings assigned to WF Wash. 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)	40	40	0.5%
Channel width – maximum (ft)	56	57	
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 WF Wash. 3, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	22.0%	22.7%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	4.0%	12.6%	
Habitat Type – glides	7.0%	5.8%	
Habitat Type – small cobble/gravel riffles	34.0%	0.0%	
Habitat Type – large cobble/boulder riffles	33.0%	59.0%	

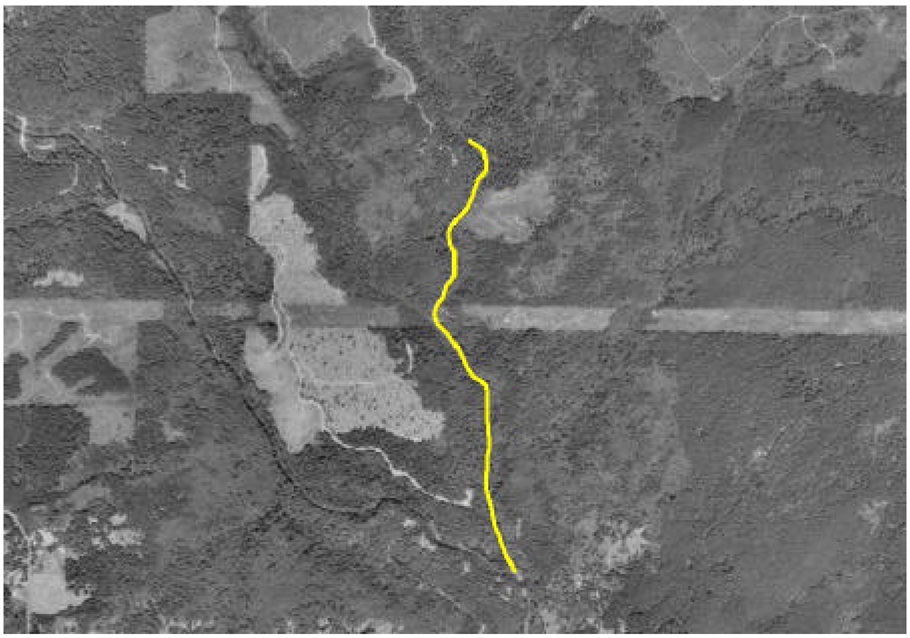
Table B-54. Comparison of EDT Level 2 attribute ratings assigned to WF Wash. 3, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	2.4%	2-2.5%	
Confinement – natural	4	4	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	3	3.7	
Embeddedness	0.8	NA - noRiff	
Fine sediment	2.0	NA - noRiff	

WILDBOY CREEK 1

INTRODUCTION

Wildboy Creek Reach 1 extends from confluence with the West Fork Washougal River (RM 0.0) to the confluence with Texas Creek near RM 1.1. The entire reach was surveyed (Map B-7). Wildboy 1 is a moderate gradient mixed control channel that flows through a narrow v-shaped valley. Gradient and confinement are variable, with lower gradient, less confined sections occurred at tributary junctions.



Map B-7. Portions of Wildboy 1 surveyed.

CHANNEL MORPHOLOGY

Wildboy 1 has a map gradient of 2 to 4 percent. This channel type is expected to be highly responsive to medium to large sized LW or jams, exhibiting forced pool and riffles morphology if LW or other obstructions were present, and plane bed topography in areas where LW is scarce. Wood is also likely to play a major role in sediment storage. Lateral migration is largely constrained by sideslopes, but meandering segments may occur near tributary junctions.

Wildboy 1 has a moderate gradient (2 to 4 percent). The wetted width during the survey averaged 8.2 m (27 ft). Pool habitat accounted for 42 percent of the surveyed length. The majority of habitat observed was riffle or cascade, with some areas of glide habitat (Figure B-12). The maximum depth of pools averaged 1.9 m (6.2 ft). Table B-55 summarizes channel morphologic characteristics in the surveyed reach.

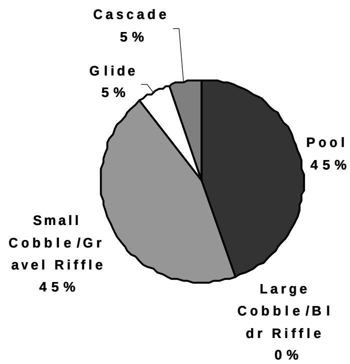


Figure B-12. Unit composition by percent surface area of Wildboy 1.

Table B-55. Average channel morphology characteristics of surveyed sections of Wildboy 1.

Parameter	Reach Value
Mean gradient	2.5%
Mean wetted width (m)	8.2 m
Mean active channel width (m)	10.8 m
Mean of the maximum riffle depths (m)	0.5
Mean residual Pool depth (m)	0.9
Mean of the maximum pool depths (m)	1.2
Pools per kilometer (p/km)	21.0
Primary pools (>1.0m deep) per kilometer	9.6

WOOD

There were 73 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Wildboy 1 during the summer of 2004. Most of the wood encountered was of the small and medium size classes of woody debris pieces (Table B-56). Several LW jams were also observed during the survey.

Table B-56. Size and density of wood, jams and root wads in surveyed section of Wildboy 1.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	37.0
Medium Pieces	20-50 cm diameter; > 2 m long	27.0
Large Pieces	> 50 cm diameter; > 2 m long	3.7
Jams	> 10 pieces in accumulation	5.5
Root wads	> 2 m long	0.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were bedrock and cobble, respectively (Table B-57). Based on the channel morphology and relatively high stream energy, deposits of mobile sediments are expected to be rare, and mobile sediments should accumulate only in the less of obstructions, backwater areas or along channel margins.

Table B-57. Substrate grain size composition in surveyed section of Wildboy 1.

Category	Mean Frequency
Sand	8%
Gravel	16%
Cobble	18%
Boulder	16%
Bedrock	41%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 22 percent.

A pebble count was performed in Wildboy 1. The D50 and D90 particle size classes were 136mm and 296mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, all types of cover were represented in Wildboy 1. Overhanging vegetation, depth and LW provided almost equal amounts of cover (Table B-58).

Table B-58. Presence of cover within the surveyed portion of Wildboy 1. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	9%
Undercut Banks	<1%
Overhanging Vegetation	8%
Water Depth > 1 m	8%
Substrate (Velocity Cover)	5%

RIPARIAN

Wildboy 1 is moderate gradient contained to mixed control channel that is generally shaded by topographic relief or streamside vegetation for most of its length. 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 consist primarily of conifer and mixed deciduous and conifer tree communities). The open channel width to the sky averages 11 m (35 ft) of channel width plus an additional 5 m (15 ft) of open bank or a total of 15 m (50 ft)-wide zone without vegetative cover. The mean view to sky is 12 percent (Table B-59). Less than 10 percent of the riparian zone is currently disturbed.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.3^{o}C. The current channel condition (VTS 12%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 0.3^{o}C s or peak at 15.6^{o}C.

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

Table B-59. Riparian shading characteristics in survey section of Wildboy 1. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	11 m
Mean distance to blocking vegetation – left bank (m)	7 m
Mean left bank canopy angle (degrees)	79 ^{o}
Mean distance to blocking vegetation – right bank (m)	8 m
Mean right bank canopy angle (degrees)	80 ^{o}
Mean view to sky (percent)	12%
Elevation (msl)	725'
Reference Temperature ($T^{o}C$)	15.3^{o}C
Estimated Current Temperature ($T^{o}C$)	15.6^{o}C

INSTABILITY AND DISTURBANCE

There was minimal bank instability recorded in the surveyed section of Wildboy 1 (Table B-60). Bedrock outcrops were common in the bed and banks, generally precluding bank instability. The left bank was slightly disturbed by forest harvest; 7 percent of the 35m (100 ft) riparian zone was influenced to some degree or another within the surveyed reach.

Table B-60. Bank instability and disturbance of surveyed section of Wildboy 1. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	7
Right bank disturbance (%)	0

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 channel widths, more pool and pool tailouts and large cobble/boulder riffle habitat with subsequently less small cobble/gravel riffle habitat; and (2) less in-channel LW loading levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-61 to B-63).

Table B-61. Comparison of EDT Level 2 attribute ratings assigned to Wildboy 1, 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)	34	27	-15.8%
Channel width – maximum (ft)	41	36	
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 Wildboy 1, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	21.0%	28.3%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	4.0%	14.7%	
Habitat Type – glides	6.0%	5.8%	
Habitat Type – small cobble/gravel riffles	35.0%	0.0%	
Habitat Type – large cobble/boulder riffles	34.0%	51.2%	

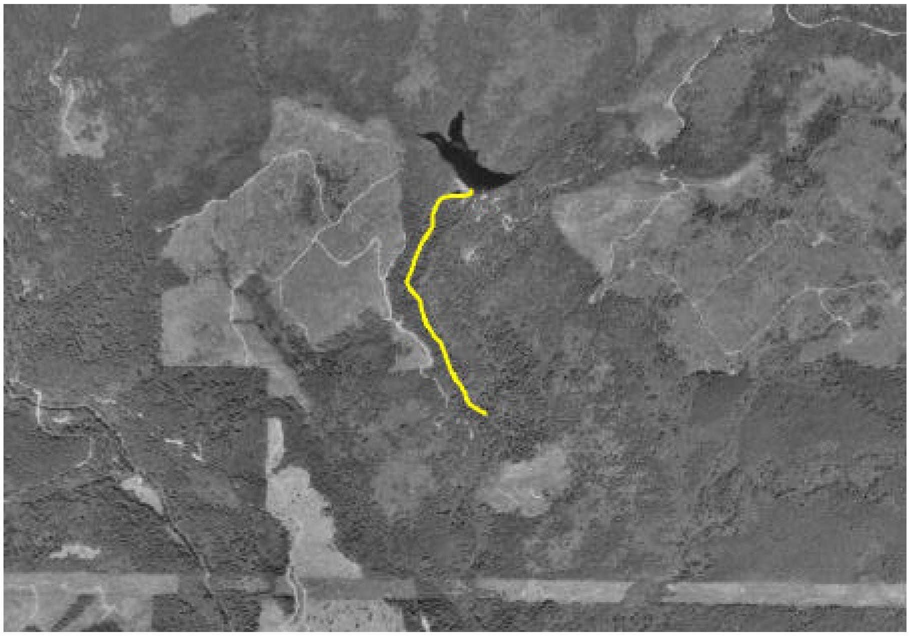
Table B-63. Comparison of EDT Level 2 attribute ratings assigned to Wildboy 1, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	2.9%	3.5%	
Confinement – natural	3	3	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	1	2.9	
Embeddedness	0.8	NA - noRiff	
Fine sediment	2.0	NA - noRiff	

WILDBOY CREEK 2

INTRODUCTION

Wildboy Creek Reach 2 extends from confluence with Texas Creek near RM 1.1 to the base of Wildboy Creek Dam. Wildboy 2 is a moderate gradient mixed control channel that flows through a narrow v-shaped valley. The entire reach was surveyed (Map B-8).



Map B-8. Portions of Wildboy 2 surveyed.

CHANNEL MORPHOLOGY

Wildboy 2 has a map gradient of 4.5 percent. This channel would be expected to be highly responsive to medium to large sized LW or jams, exhibiting forced pool and riffles morphology if LW or other obstructions were present, and plane bed to step-pool morphology in areas where LW is scarce. Wood is also likely to play a major role in sediment storage. Lateral migration is largely constrained by sideslopes, but meandering segments may occur near tributary junctions.

Wildboy 2 has a moderate to high gradient (4.5 percent). The wetted width during the survey averaged 8.2 m (27 ft). Pool habitat accounted for 40 percent of the surveyed length. The majority of habitat observed was riffle or cascade, with some areas of glide habitat (Figure B-13). The maximum depth of pools averaged 1.1 m (3.6 ft). Table B-64 summarizes channel morphologic characteristics in the surveyed reach.

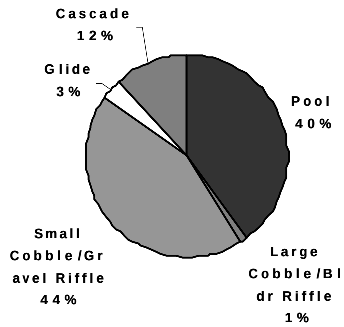


Figure B-13. Unit composition by percent surface area of Wildboy 2.

Table B-64. Average channel morphology characteristics of surveyed sections of Wildboy 2

Parameter	Reach Value
Mean gradient	2.5%
Mean wetted width (m)	6.2 m
Mean active channel width (m)	8.7 m
Mean of the maximum riffle depths (m)	0.5
Mean residual Pool depth (m)	0.8
Mean of the maximum pool depths (m)	1.1
Pools per kilometer (p/km)	17.9
Primary pools (>1.0m deep) per kilometer	11.7

WOOD

There were 77 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Wildboy 2 during the summer of 2004. Most of the wood encountered was of the small and medium size classes of woody debris pieces (Table B-65). Several LW jams were also observed during the survey.

Table B-65. Size and density of wood, jams and root wads in surveyed section of Wildboy 2.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	41.0
Medium Pieces	20-50 cm diameter; > 2 m long	31.0
Large Pieces	> 50 cm diameter; > 2 m long	3.4
Jams	> 10 pieces in accumulation	4.2
Root wads	> 2 m long	0.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were bedrock and cobble, respectively (Table B-66). Based on the channel morphology and relatively high stream energy, deposits of mobile sediments are expected to be rare, and mobile sediments should accumulate only in the less of obstructions, backwater areas or along channel margins.

Table B-66. Substrate grain size composition in surveyed section of Wildboy 2.

Category	Mean Frequency
Sand	7%
Gravel	17%
Cobble	18%
Boulder	15%
Bedrock	44%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 22 percent.

A pebble count was performed in Wildboy 2. The D50 and D90 particle size classes were 26 mm and 128 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, all types of cover were represented in Wildboy 2. Water depth was the primary cover type. Overhanging vegetation, LW, undercut banks and substrate also provided some cover (Table B-67).

Table B-67. Presence of cover within the surveyed portion of Wildboy 2. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	7%
Undercut Banks	2%
Overhanging Vegetation	8%
Water Depth > 1 m	19%
Substrate (Velocity Cover)	3%

RIPARIAN

Wildboy 2 is moderate gradient contained to mixed control channel that is well shaded by topographic relief and streamside vegetation for most of its length. 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 consist primarily of conifer and mixed deciduous and conifer tree communities (Figure 6.3-16?). The open channel width to the sky averages 11 m (36 ft) of channel width plus an additional 0.5 m (2 ft) of open bank or a total of 11.5 m (37 ft)- wide zone without vegetative cover. The mean view to sky is 9 percent (Table B-68). None of the riparian zone within the survey reach was rated as disturbed.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.1^{o}C. The current channel condition (VTS 9%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 0.2^{o}C or peak at 15.3^{o}C.

These estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx or wetland runoff. Actual water temperatures will vary with river discharge, local weather patterns, and the relative volume of groundwater, ponded water and tributary contributions to the channel.

Table B-68. Riparian shading characteristics in survey section of Wildboy 2. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	11 m
Mean distance to blocking vegetation – left bank (m)	4 m
Mean left bank canopy angle (degrees)	83 ^{o}
Mean distance to blocking vegetation – right bank (m)	7 m
Mean right bank canopy angle (degrees)	80 ^{o}
Mean view to sky (percent)	9%
Elevation (msl)	835'
Reference Temperature ($T^{o}C$)	15.1^{o}C
Estimated Current Temperature ($T^{o}C$)	15.3^{o}C

INSTABILITY AND DISTURBANCE

No bank instability or riparian disturbance was recorded in the surveyed section of Wildboy 2 (B-69). Bedrock outcrops were common in the bed and banks, generally precluding bank instability.

Table B-69. Bank instability and disturbance of surveyed section of Wildboy 2. Data oriented in downstream direction.

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

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 more pool habitat, especially beaver ponds, with subsequently less glide and riffle habitat; and (2) less in-channel LW loading levels and less fine sediment and embeddedness levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-70 to B-72).

Table B-70. Comparison of EDT Level 2 attribute ratings assigned to Wildboy 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)	34	29	NA
Channel width – maximum (ft)	41	18	
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 Wildboy 2, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	21.0%	8.6%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	73.5%	
Habitat Type – pool tailouts	4.0%	2.6%	
Habitat Type – glides	6.0%	0.8%	
Habitat Type – small cobble/gravel riffles	35.0%	0.4%	
Habitat Type – large cobble/boulder riffles	34.0%	14.0%	

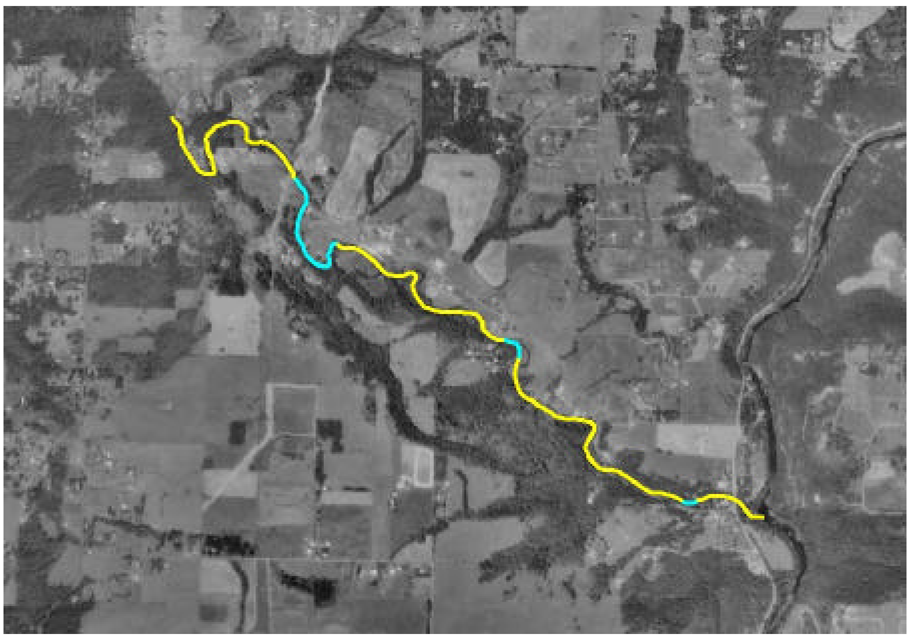
Table B-72. Comparison of EDT Level 2 attribute ratings assigned to Wildboy 2, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	4.3%	4.5%	
Confinement – natural	3	3	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	1	2.9	
Embeddedness	0.8	1.3	
Fine sediment	2.0	0.7	

LITTLE WASHOUGAL RIVER 1

INTRODUCTION

Little Washougal River Reach 1 extends from confluence with the Washougal River to the culvert near RM 2.7. The lower ½mile of Little Washougal 1 flows through a narrow bedrock controlled canyon. Above the canyon, the river flows through a valley with relatively gentle sideslopes. The majority of the reach was surveyed (Map B-9).



Map B-9. Portions of Little Washougal 1 surveyed.

CHANNEL MORPHOLOGY

Little Washougal 1 has a map gradient of 1.1 percent. This channel would be expected to be highly responsive to medium to large sized LW or jams. Pool depth and spacing are strongly elated to LW, and wood also likely contributes to sediment storage, particularly in the canyon section. Upstream of the canyon the channel is free to migrate within a small floodplain.

Little Washougal 1 has a moderate gradient. The channel transitions from a moderate gradient contained type in the canyon to a moderate gradient mixed control type for the remainder of the reach. Bedforms in the canyon consist of step pool to pool riffle sequences controlled by bedrock For most of the reach, the river is alluvial to semi alluvial in nature, with abundant in-channel gravel and cobble deposits. The wetted width during the survey averaged 11.2 m (37 ft). Pool habitat accounted for 44 percent of the surveyed length. The remainder of habitat observed was riffle or glide (Figure B-14).

The maximum depth of pools averaged 1.1 m (3.6 ft). Channel morphologic characteristics in the surveyed reach are summarized in Table B-73.

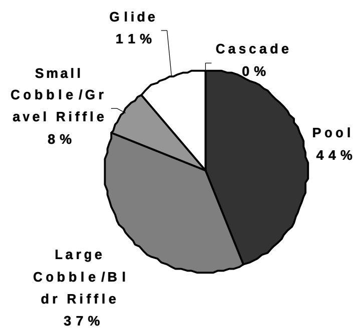


Figure B-14. Unit composition by percent surface area of Little Washougal 1.

Table B-73. Average channel morphology characteristics of surveyed sections of Little Washougal 1.

Parameter	Reach Value
Mean gradient	1.5%
Mean wetted width (m)	11.2 m
Mean active channel width (m)	13.2 m
Mean of the maximum riffle depths (m)	0.6
Mean residual Pool depth (m)	0.5
Mean of the maximum pool depths (m)	0.9
Pools per kilometer (p/km)	8.6
Primary pools (>1.0m deep) per kilometer	6.2

WOOD

There were 22.9 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Little Washougal 1 during the summer of 2004. Most of the wood encountered was of the small and medium size classes of woody debris pieces (Table B-74). LW jams and rootwads were also observed during the survey.

Table B-74. Size and density of wood, jams and root wads in surveyed section of Little Washougal 1.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	6.5
Medium Pieces	20-50 cm diameter; > 2 m long	9.9
Large Pieces	> 50 cm diameter; > 2 m long	1.8
Jams	> 10 pieces in accumulation	0.8
Root wads	> 2 m long	3.9

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were gravel and cobble, respectively (Table B-75). Those substrates are typical of what would be expected for these channel types.

Table B-75. Substrate grain size composition in surveyed section of Little Washougal 1

Category	Mean Frequency
Sand	18%
Gravel	34%
Cobble	28%
Boulder	11%
Bedrock	9%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 39 percent.

A pebble count was performed in Little Washougal 1. The D50 and D90 particle size classes were 54 mm and 120 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, all types of cover except undercut banks were represented in Little Washougal 1. Water depth was the primary cover type. Overhanging vegetation, LW and substrate also provided some cover (Table B-76).

Table B-76. Presence of cover within the surveyed portion of Little Washougal 1. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	1%
Undercut Banks	0%
Overhanging Vegetation	4%
Water Depth > 1 m	10%
Substrate (Velocity Cover)	2%

RIPARIAN

Little Washougal 1 is moderate gradient contained to mixed control channel. Riparian cover is high in the canyon, but many areas of the less confined valley have been cleared for residential development or agriculture. 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 consist primarily of hardwood tree communities (Figure B-15). The open channel width to the sky averages 13 m (43 ft) of channel width plus an additional 137 m (449 ft) of open bank or a total of 150 m (492 ft)-wide zone without vegetative cover. The mean view to sky is 51 percent (Table B-77).

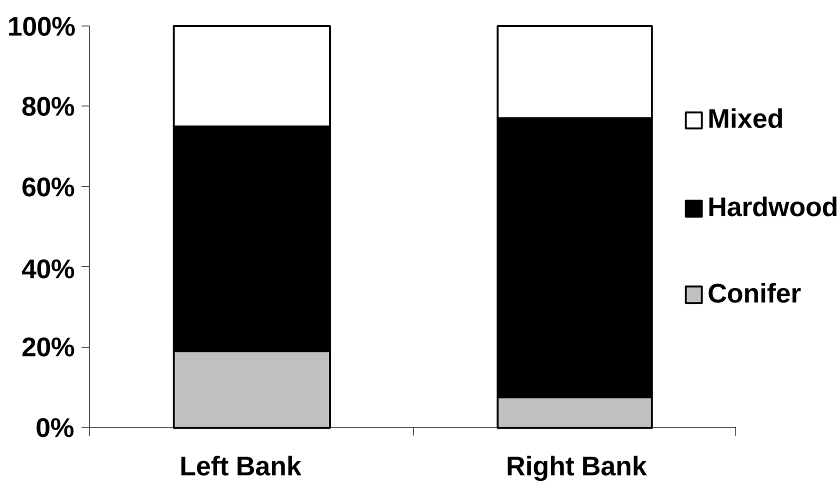


Figure B-15. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 16.4^{o}C. The current channel condition (VTS 51%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 3.1°C or peak at 19.5°C. Estimates of the current 7-DADmax from surface water measurements collected by Clark County Public Works, Water Resources during the summer of 2004 was 22.9°C.

The VTS estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx or wetland runoff. Actual water temperatures will vary with river discharge, local weather patterns and the relative volume of groundwater, ponded water and tributary contributions.

Table B-77. Riparian shading characteristics in survey section of Little Washougal 1. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	13 m
Mean distance to blocking vegetation – left bank (m)	131 m
Mean left bank canopy angle (degrees)	41 °
Mean distance to blocking vegetation – right bank (m)	19 m
Mean right bank canopy angle (degrees)	40 °
Mean view to sky (percent)	51%
Elevation (msl)	100’
Reference Temperature (T°C) 7-DADmax	16.4°C
Estimated Current Temperature (T°C) 7-DADmax	19.5°C
Measured Temperature (T°C) 7-DADmax (est.)	22.9°C

INSTABILITY AND DISTURBANCE

Approximately 3 percent of the banks on each side of the Little Washougal 1 survey segment were recorded as unstable (B-78). Between 36 and 57 percent of the riparian zone was disturbed by residential development or roads.

Table B-78. Bank instability and disturbance of surveyed section of Little Washougal 1. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	3
Right bank instability (%)	3
Left bank disturbance (%)	57
Right bank disturbance (%)	36

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 wider minimum channel widths and more pool and pool tailout and small cobble/gravel riffle habitat with subsequently less glide and large cobble/boulder riffle habitat; and (2) more natural channel confinement, less in-channel LW loading and fine sediment levels but more embeddedness levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-79 to B-81).

Table B-79. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 1, 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)	30	37	10.2%
Channel width – maximum (ft)	42	42	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-80. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 1, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	12.0%	36.3%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	8.0%	10.1%	
Habitat Type – glides	33.0%	12.5%	
Habitat Type – small cobble/gravel riffles	0.0%	32.6%	
Habitat Type – large cobble/boulder riffles	47.0%	8.4%	

Table B-81. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 1, 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 (%)	1.1%	1.1%	
Confinement – natural	0	3-4	
Confinement – hydromodifications	1	NO DATA	
In-channel wood	3	3.7	
Embeddedness	0.9	2.1	
Fine sediment	2.1	1.0	

LITTLE WASHOUGAL RIVER 1C

INTRODUCTION

Little Washougal River Reach-1c extends from the culvert at the road crossing at RM 3.25 to the confluence with an unnamed tributary entering from the left bank near RM 5.3. The lower 0.6 miles of Little Washougal-1c flows through a relatively narrow v-shaped valley. Upstream of RM 3.85, the valley widens and becomes generally unconfined. The portion of the reach surveyed is shown highlighted in yellow in Map B-10.

Map B-10. Portions of Little Washougal 1C surveyed.

CHANNEL MORPHOLOGY

Little Washougal-1c has a map gradient of 1.6 percent. The channel transitions from a moderate gradient contained type to a moderate gradient mixed control. Bedforms in the narrow valley consist of pool riffle sequences with some cascades. For most of the reach, the river is alluvial. The wetted width during the survey averaged 11.2 m (37 ft). Pool habitat accounted for 23 percent of the surveyed length. The majority of habitat was classified as riffle (Figure B-16). The maximum depth of pools averaged 1.1 m (3.6 ft). Table B-82 summarizes channel morphologic characteristics in the surveyed reach.

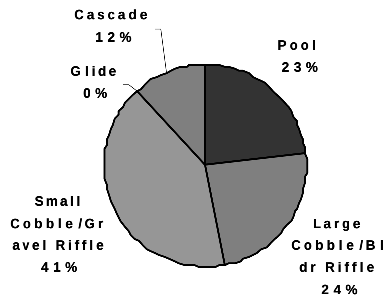


Figure B-16. Unit composition by percent surface area of Little Washougal 1c.

Little Washougal Reach 1c would be expected to be highly responsive to medium to large sized LW or jams. Pool depth and spacing are strongly elated to LW, and wood also likely contributes to sediment storage, particularly in the canyon section. Upstream of the canyon the channel is free to migrate within a small floodplain.

Table B-82. Average channel morphology characteristics of surveyed sections of Little Washougal 1c.

Parameter	Reach Value
Mean gradient	2.0%
Mean wetted width (m)	11.2 m
Mean active channel width (m)	14.0 m
Mean of the maximum riffle depths (m)	0.8
Mean residual Pool depth (m)	0.6
Mean of the maximum pool depths (m)	1.0
Pools per kilometer (p/km)	12.7
Primary pools (>1.0m deep) per kilometer	6.3

WOOD

There were 7.9 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Little Washougal 1c during the summer of 2004. All of the wood encountered was of the small and medium size classes of woody debris pieces (Table B-83). No LW jams or rootwads were observed during the survey.

Table B-83. Size and density of wood, jams and root wads in surveyed section of Little Washougal 1c.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	3.2
Medium Pieces	20-50 cm diameter; > 2 m long	4.8
Large Pieces	> 50 cm diameter; > 2 m long	0.0
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 boulder and bedrock respectively (Table B-84). Substrate was poorly sorted with all classes representing approximately the same amount of habitat.

Table B-84. Substrate grain size composition in surveyed section of Little Washougal 1c.

Category	Mean Frequency
Sand	14%
Gravel	21%
Cobble	18%
Boulder	24%
Bedrock	23%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 28 percent.

A pebble count was performed in Little Washougal 1c. The D50 and D90 particle size classes were 40 mm and 573 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, all types of cover except undercut banks were represented in Little Washougal 1c. Water depth was the primary cover type. Overhanging vegetation, LW and substrate also provided some cover (Table B-85).

Table B-85. Presence of cover within the surveyed portion of Little Washougal 1c. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	2%
Undercut Banks	0%
Overhanging Vegetation	8%
Water Depth > 1 m	22%
Substrate (Velocity Cover)	11%

RIPARIAN

Little Washougal 1c is moderate gradient contained to mixed control channel. Many areas of the less confined valley have been cleared for residential development or agriculture. 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 consist primarily of conifer and mixed hardwood/conifer tree communities (Figure B-17). The open channel width to the sky averages 14 m (46 ft) of channel width plus an additional 3 m (9 ft) of open bank or a total of 17 m (55 ft)-wide zone without vegetative cover. The mean view to sky is 20 percent (Table B-86). None of the riparian zone within the survey reach was rated as disturbed.

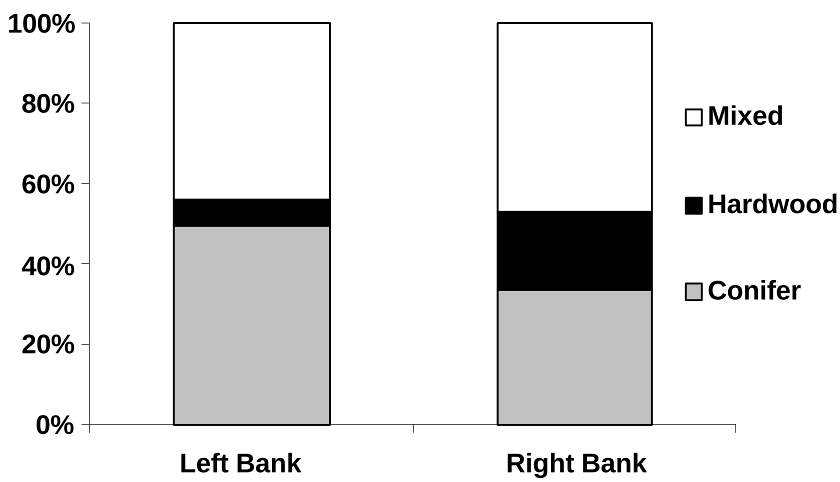


Figure B-17. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 16.2^{o}C. The current channel condition (VTS 20%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 0.7^{o}C or peak at 16.9^{o}C.

Estimates of the current 7-DADmax from surface water measurements collected by Clark County Public Works, Water Resources during the summer of 2004 was 20.9°C.

The VTS estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx or wetland runoff. Actual water temperatures will vary with river discharge, local weather patterns and the relative volume of groundwater, ponded water or tributary contributions.

Table B-86. Riparian shading characteristics in survey section of Little Washougal 1c. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	14 m
Mean distance to blocking vegetation – left bank (m)	9 m
Mean left bank canopy angle (degrees)	702 °
Mean distance to blocking vegetation – right bank (m)	89 m
Mean right bank canopy angle (degrees)	75 °
Mean view to sky (percent)	20%
Elevation (msl)	295’
Reference Temperature (T°C) 7-DADmax	16.2°C
Estimated Current Temperature (T°C) 7-DADmax	16.9°C
Measured Temperature (T°C) 7-DADmax (est.)	20.9°C

INSTABILITY AND DISTURBANCE

No unstable banks were observed in the Little Washougal 1c survey segment (B-87). Approximately 15 percent of the riparian zone on each bank was disturbed by residential development.

Table B-87. Bank instability and disturbance of surveyed section of Little Washougal 1c. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	0
Right bank instability (%)	0
Left bank disturbance (%)	15
Right bank disturbance (%)	16

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 wider channel widths and more riffle habitat with subsequently less glide habitat; and (2) less in-channel LW loading and fine sediment levels but more embeddedness levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-88 to B-90).

Table B-88. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 1c, 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)	30	37	15.9%
Channel width – maximum (ft)	42	46	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-89. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 1c, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	22.0%	18.8%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	4.0%	4.4%	
Habitat Type – glides	27.0%	0.0%	
Habitat Type – small cobble/gravel riffles	2.0%	24.9%	
Habitat Type – large cobble/boulder riffles	45.0%	51.9%	

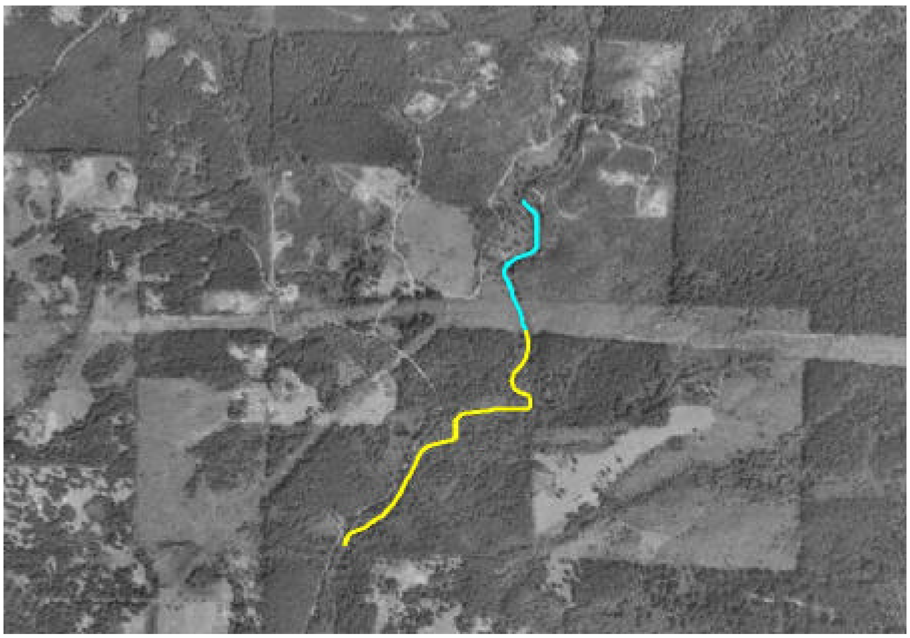
Table B-90. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 1c, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	1.1%	1.6%	
Confinement – natural	0	1	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	3	3.9	
Embeddedness	0.9	2.3	
Fine sediment	2.1	1.2	

LITTLE WASHOUGAL RIVER 2B

INTRODUCTION

Little Washougal River Reach 2b extends from the barrier culvert at RM 5.8 to the confluence with an unnamed tributary entering from the right bank near RM 6.7. Reach 2b flows through a gently sloping v-shaped valley, and given the small channel width has a generally moderate to low confinement. The lowermost 0.7 miles was surveyed (Map B-11).



Map B-11. Portions of Little Washougal 2b surveyed.

CHANNEL MORPHOLOGY

Little Washougal 2b has a map gradient of 2.0 percent. The channel is a moderate gradient mixed control type. Bedforms would naturally consist of forced pool riffle sequences when wood is abundant, to plane-bed when large wood is scarce. For most of the reach, the channel is semi alluvial. The wetted width during the survey averaged 10.9 m (35.8 ft). Pool habitat accounted for 25 percent of the surveyed length. The majority of habitat was classified as riffle (Figure B-18). The maximum depth of pools averaged 1.1 m (3.6 ft). Table B-91 summarizes channel morphologic characteristics in the surveyed reach.

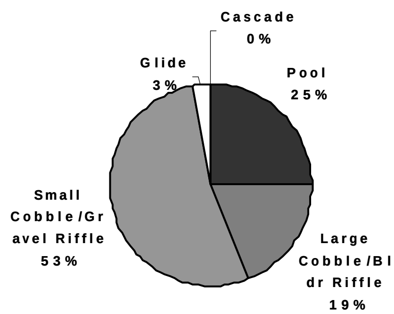


Figure B-18. Unit composition by percent surface area of Little Washougal 2b.

Little Washougal Reach 1c would be expected to be highly responsive to medium to large sized LW or jams. Pool depth and spacing are strongly elated to LW, and wood also likely contributes to sediment storage, particularly in the canyon section. Upstream of the canyon the channel is free to migrate within a small floodplain.

Table B-91. Average channel morphology characteristics of surveyed sections of Little Washougal 2b.

Parameter	Reach Value
Mean gradient	1.5%
Mean wetted width (m)	10.9 m
Mean active channel width (m)	13.4 m
Mean of the maximum riffle depths (m)	0.6
Mean residual Pool depth (m)	0.6
Mean of the maximum pool depths (m)	1.1
Pools per kilometer (p/km)	9.5
Primary pools (>1.0m deep) per kilometer	6.7

WOOD

There were 19.1 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Little Washougal 2b during the summer of 2004. The majority of the wood encountered was of the small and medium size classes of woody debris pieces (Table B-92). Occasional LW jams and rootwads were observed during the survey.

Table B-92. Size and density of wood, jams and root wads in surveyed section of Little Washougal 2b.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	5.7
Medium Pieces	20-50 cm diameter; > 2 m long	7.6
Large Pieces	> 50 cm diameter; > 2 m long	2.9
Jams	> 10 pieces in accumulation	1.9
Root wads	> 2 m long	1.0

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were boulder and gravel respectively (Table B-93).

Table B-93. Substrate grain size composition in surveyed section of Little Washougal 2b.

Category	Mean Frequency
Sand	17%
Gravel	24%
Cobble	21%
Boulder	28%
Bedrock	10%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 35 percent.

A pebble count was performed in Little Washougal 2b. The D50 and D90 particle size classes were 67 mm and 147 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, all types of cover except undercut banks were represented in Little Washougal 2b. Water depth was the primary cover type. Overhanging vegetation, LW and substrate also provided some cover (Table B-94).

Table B-94. Presence of cover within the surveyed portion of Little Washougal 2b. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	2%
Undercut Banks	0%
Overhanging Vegetation	12%
Water Depth > 1 m	14%
Substrate (Velocity Cover)	5%

RIPARIAN

Little Washougal 2b is moderate gradient mixed control channel. Many areas of the less confined valley have been cleared for residential development or agriculture. 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 consist primarily of conifer and mixed hardwood/conifer tree communities (Figure B-19). The open channel width to the sky averages 13 m (44 ft) of channel width plus an additional 7 m (23 ft) of open bank or a total of 20 m (67 ft)-wide zone without vegetative cover. The mean view to sky is 14 percent (Table B-95).

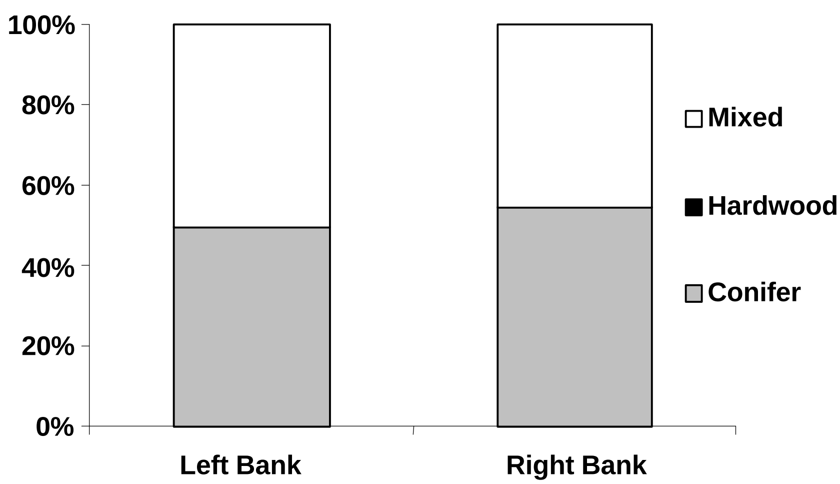


Figure B-19. Vegetation type by percent of units observed. Data presented as proceeding downstream.

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.8^{o}C. The current channel condition (VTS 14%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 03^{o}C or peak at 16.1^{o}C.

Estimates of the current 7-DADmax from surface water measurements collected by Clark County Public Works, Water Resources during the summer of 2004 was 20.0^{o}C.

The VTS estimates predict freshwater surface temperatures only based on elevation, channel width and canopy coverage. They do not consider the influence of groundwater influx or wetland runoff. Actual water temperatures will vary with river discharge, local weather patterns and the relative volume of groundwater, ponded water and tributary contributions.

Table B-95. Riparian shading characteristics in survey section of Little Washougal 2b. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	13 m
Mean distance to blocking vegetation – left bank (m)	10 m
Mean left bank canopy angle (degrees)	79 ^{o}
Mean distance to blocking vegetation – right bank (m)	11 m
Mean right bank canopy angle (degrees)	76 ^{o}
Mean view to sky (percent)	14%
Elevation (msl)	500’
Reference Temperature (T^{o}C) 7-DADmax	15.8^{o}C
Estimated Current Temperature (T^{o}C) 7-DADmax	16.1^{o}C
Measured Temperature (T^{o}C) 7-DADmax (est.)	20.0^{o}C

INSTABILITY AND DISTURBANCE

Approximately 10 to 15 percent of the banks were classified as unstable in the Little Washougal 2b survey segment (Table B-96). Ten to 20 percent of the riparian zone on each bank was disturbed by residential development, roads or forest harvest.

Table B-96. Bank instability and disturbance of surveyed section of Little Washougal 2b. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	9
Right bank instability (%)	16
Left bank disturbance (%)	11
Right bank disturbance (%)	20

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 more small cobble/gravel riffle habitat with subsequently less pools, glide and large cobble/boulder riffle habitat; and (2) less in-channel LW loading and fine sediment levels but more embeddedness levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-97 to B-99).

Table B-97. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 2b, 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)	30	36	10.0%
Channel width – maximum (ft)	42	43	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-98. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 2b, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	32.0%	15.5%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	14.0%	7.3%	
Habitat Type – glides	8.0%	3.0%	
Habitat Type – small cobble/gravel riffles	2.0%	53.4%	
Habitat Type – large cobble/boulder riffles	44.0%	20.8%	

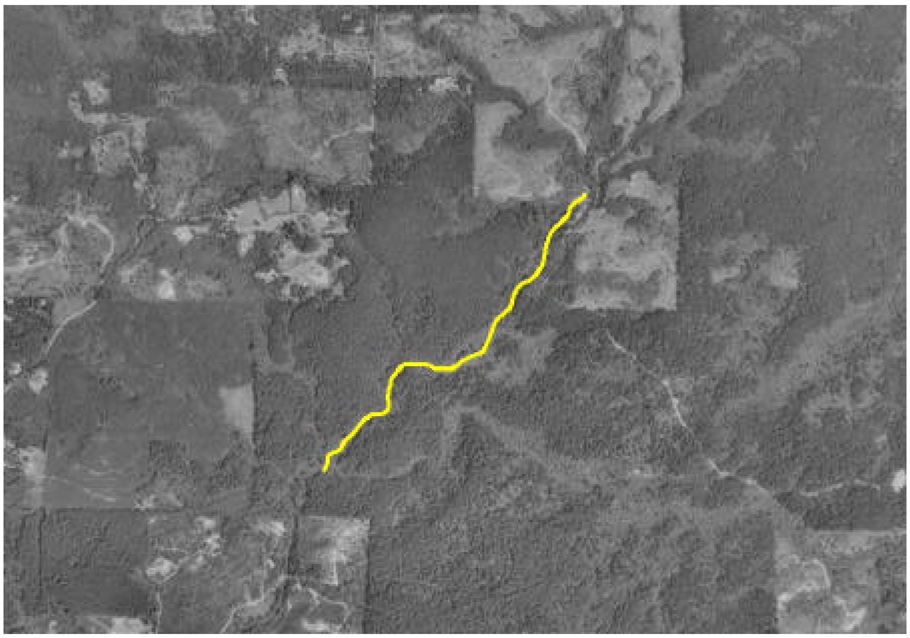
Table B-99. Comparison of EDT Level 2 attribute ratings assigned to L. Wash. 2b, and EDT ratings based on 2004 stream survey and hydromodification analysis results for attributes relevant to data collected.

Attribute	SRE Rating	Rating from Survey	
Gradient (%)	1.7%	2.0%	
Confinement – natural	0	1	
Confinement – hydromodifications	1	NO DATA	
In-channel wood	3	3.7	
Embeddedness	0.9	2.3	
Fine sediment	2.1	1.0	

BOULDER CREEK REACH 1

INTRODUCTION

Boulder Creek Reach 1 extends from the confluence with the Little Washougal River to the barrier culvert near RM 1.0. This section of Boulder Creek flows through a narrow v-shaped valley, but, given the small channel width, it has a generally moderate confinement levels. The entire reach was surveyed (Map B-12).



Map B-12. Portions of Boulder 1 surveyed.

CHANNEL MORPHOLOGY

Boulder Creek Reach 1 has a map gradient of 3.0 percent. The channel is a moderate gradient mixed control type. Bedforms would naturally consist of forced pool riffle sequences when wood is abundant, to plane-bed when large wood is scarce. For most of the reach, the channel is semi alluvial. The wetted width during the survey averaged 6.9 m (22.6 ft). Pool habitat accounted for 24 percent of the surveyed length. The majority of habitat was classified as riffle (Figure B-20). The maximum depth of pools averaged 0.8 m (2.6 ft). Table B-100 summarizes channel morphologic characteristics in the surveyed segment.

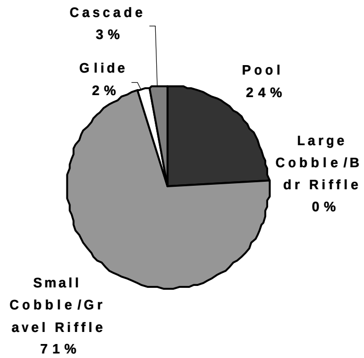


Figure B-20. Unit composition by percent surface area of Boulder Creek Reach 1.

Boulder Creek Reach 1 would be expected to be highly responsive to LW or jams. Pool depth and spacing in this channel type are strongly related to LW, and wood also likely contributes to sediment storage, particularly in higher gradient areas.

Table B-100. Average channel morphology characteristics of surveyed sections of Boulder 1

Parameter	Reach Value
Mean gradient	2.0%
Mean wetted width (m)	6.9 m
Mean active channel width (m)	8.1 m
Mean of the maximum riffle depths (m)	0.5
Mean residual Pool depth (m)	0.5
Mean of the maximum pool depths (m)	0.8
Pools per kilometer (p/km)	19.2
Primary pools (>1.0m deep) per kilometer	1.9

WOOD

There were 96 pieces of large woody debris per kilometer (LW/km) recorded in the surveyed section of Boulder Creek Reach 1 during the summer of 2004. Wood encountered in Boulder Creek Reach 1 consisted of a mixture of small, medium and large individual pieces (Table B-101). LW jams and rootwads were also observed during the survey.

Table B-101. Size and density of wood, jams and root wads in surveyed section of Boulder 1.

Wood Category	Definition	# per kilometer
Small Pieces	10-20 cm diameter; > 2 m long	29.0
Medium Pieces	20-50 cm diameter; > 2 m long	22.0
Large Pieces	> 50 cm diameter; > 2 m long	31.0
Jams	> 10 pieces in accumulation	2.4
Root wads	> 2 m long	12.4

SUBSTRATE

Characterization of substrate based on visual observation showed the dominant and sub-dominant substrate classes were cobble and boulder respectively (Table B-102).

Table B-102. Substrate grain size composition in surveyed section of Boulder 1.

Category	Mean Frequency
Sand	10%
Gravel	20%
Cobble	39%
Boulder	29%
Bedrock	1%

Embeddedness was rated in each habitat unit according to four categories (0-25%, 25-50%, 50-75% and 75-100%). The overall mean embeddedness level was 24 percent.

A pebble count was performed in Boulder 1. The D50 and D90 particle size classes were 80 mm and 209 mm respectively. Refer to report section 6.2.4 for a more complete discussion of pebble count results.

COVER

Cover for salmonid fishes may be provided by LW, undercut banks, overhanging vegetation, deep water or substrate. At low flow, all types of cover except velocity breaks caused by substrate were represented in Boulder 1. Overhanging vegetation and water depth were the primary cover types. Undercut banks and LW also provided some cover (Table B-103).

Table B-103. Presence of cover within the surveyed portion of Boulder 1. Measured as percent of surface area of stream unit covered.

Cover Type	Average Percent Cover
Large Woody Debris	6%
Undercut Banks	3%
Overhanging Vegetation	13%
Water Depth > 1 m	13%
Substrate (Velocity Cover)	0%

RIPARIAN

Boulder 1 is moderate gradient mixed control channel. The Boulder Creek Reach 1 flows through a generally undisturbed valley except for adjacent timber harvest activities. The open channel width to the sky averages 8 m (25 ft) of channel width plus an additional 4 m (12 ft) of open bank or a total of 11 m (37 ft)-wide zone without vegetative cover. The mean view to sky is 21 percent (Table B-104).

Assuming mature forest timber stands could develop and grow adjacent to the channel banks, the 7-DADmax reference temperature would be anticipated to approach 15.2^{o}C. The current channel condition (VTS 21%) is anticipated to increase the reference condition 7-DADmax on a relative basis approximately 1.2^{o}C or peak at 16.4^{o}C.

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

Table B-104. Riparian shading characteristics in survey section of Boulder 1. Data oriented in downstream direction.

Parameter	Result
Active Channel Width (m)	8 m
Mean distance to blocking vegetation – left bank (m)	5 m
Mean left bank canopy angle (degrees)	72 ^{o}
Mean distance to blocking vegetation – right bank (m)	7 m
Mean right bank canopy angle (degrees)	70 ^{o}
Mean view to sky (percent)	21%
Elevation (msl)	680’
Reference Temperature ($T^{o}C$)	$15.2^{o}C$
Estimated Current Temperature ($T^{o}C$)	$16.4^{o}C$

INSTABILITY AND DISTURBANCE

Approximately 5 to 10 percent of the banks were classified as unstable in the Little Washougal 2b survey segment (Table B-105). Ten to 20 percent of the riparian zone on each bank was disturbed by clearcuts.

Table B-105. Bank instability and disturbance of surveyed section of Boulder 1. Data oriented in downstream direction.

Parameter	Result
Left bank instability (%)	9
Right bank instability (%)	3
Left bank disturbance (%)	11
Right bank disturbance (%)	22

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 more large cobble/boulder riffle habitat with subsequently less small cobble/gravel riffle habitat; and (2) less in-channel LW loading levels recorded during the 2004 stream surveys than previously estimated in the SRE database (Tables B-106 to B-108).

Table B-106. Comparison of EDT Level 2 attribute ratings assigned to Boulder, 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)	18	23	6.8%
Channel width – maximum (ft)	29	26	
Habitat Type – off-channel habitat factor (patient)	0.0%	NA	NA
Habitat Type – off-channel habitat factor (template)	0.0%	NA	NA

Table B-107. Comparison of EDT Level 2 attribute ratings assigned to Boulder, and EDT ratings based on 2004 stream survey results for habitat diversity attributes.

Attribute	SRE Rating	Rating from Survey	
Habitat Type – primary pools	20.0%	12.7%	
Habitat Type – backwater pools	0.0%	0.0%	
Habitat Type – beaver ponds	0.0%	0.0%	
Habitat Type – pool tailouts	4.0%	9.9%	
Habitat Type – glides	3.0%	1.9%	
Habitat Type – small cobble/gravel riffles	12.0%	0.0%	
Habitat Type – large cobble/boulder riffles	61.0%	75.4%	

Table B-108. Comparison of EDT Level 2 attribute ratings assigned to Boulder, 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	2	2	
Confinement – hydromodifications	0	NO DATA	
In-channel wood	2	2.9	
Embeddedness	0.9	NA - noRiff	
Fine sediment	2.1	NA - noRiff	

APPENDIX 6C

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