Appendix A

Wenatchee River Stream Habitat Assessment

River Mile 35.5 to 54.2

Survey: August 2011

Table of Contents

Special Thanks:
to Bryon Newell, the Upper Valley Museum, and the Wenatchee Valley Museum and Cultural Center for providing historical information and photographs (including aerial photos).

1 Introduction

The Wenatchee River is located on the east slope of the Cascade Mountains in Chelan County, WA. It flows into the Columbia River upstream of Rock Island Dam, near the town of Wenatchee. A habitat survey was conducted along the upper 18.7 river miles of the Wenatchee River from the top of Tumwater Canyon (Hwy 2 Bridge) to Lake Wenatchee (Figure 1). This survey was conducted from August 9 to August 31, 2011 from approximately RM 35.51 to RM 54.15. Stream flow during the survey period ranged from 1,210 to 2,940 cubic feet per second (cfs) at the USGS Wenatchee River at Plain, WA gage (#12457000) located at RM 46.2.

The objective of the Habitat Assessment is to characterize the habitat quantity and quality for salmonid species native to the Wenatchee River by quantifying in-channel morphologic features, characterizing riparian conditions, and identifying anthropogenic features influencing aquatic habitat. This information is used to inform potential restoration/preservation actions and will provide a baseline for evaluating future habitat trends and for measuring the effectiveness of restoration efforts. To our knowledge, this is the first comprehensive stream habitat survey and assessment for this portion of the upper Wenatchee River.

Chinook salmon (spring and summer runs), coho, sockeye, steelhead (summer run), rainbow trout, bull trout, west slope cutthroat trout, and mountain whitefish are native salmonid species of the Wenatchee River. The upper Wenatchee River is utilized for spawning, rearing, and as a migration corridor for Chinook, coho, sockeye, and steelhead. The Washington Department of Fish and Wildlife (WDFW) has determined that the Wenatchee River watershed offers fair to excellent spawning and rearing habitat and is considered one of the best salmon producing systems in eastern Washington (WDFW 1990).

The results of this assessment highlight habitat deficiencies by reach that will be useful for establishing objectives and performance targets to guide enhancement, restoration, and preservation activities.

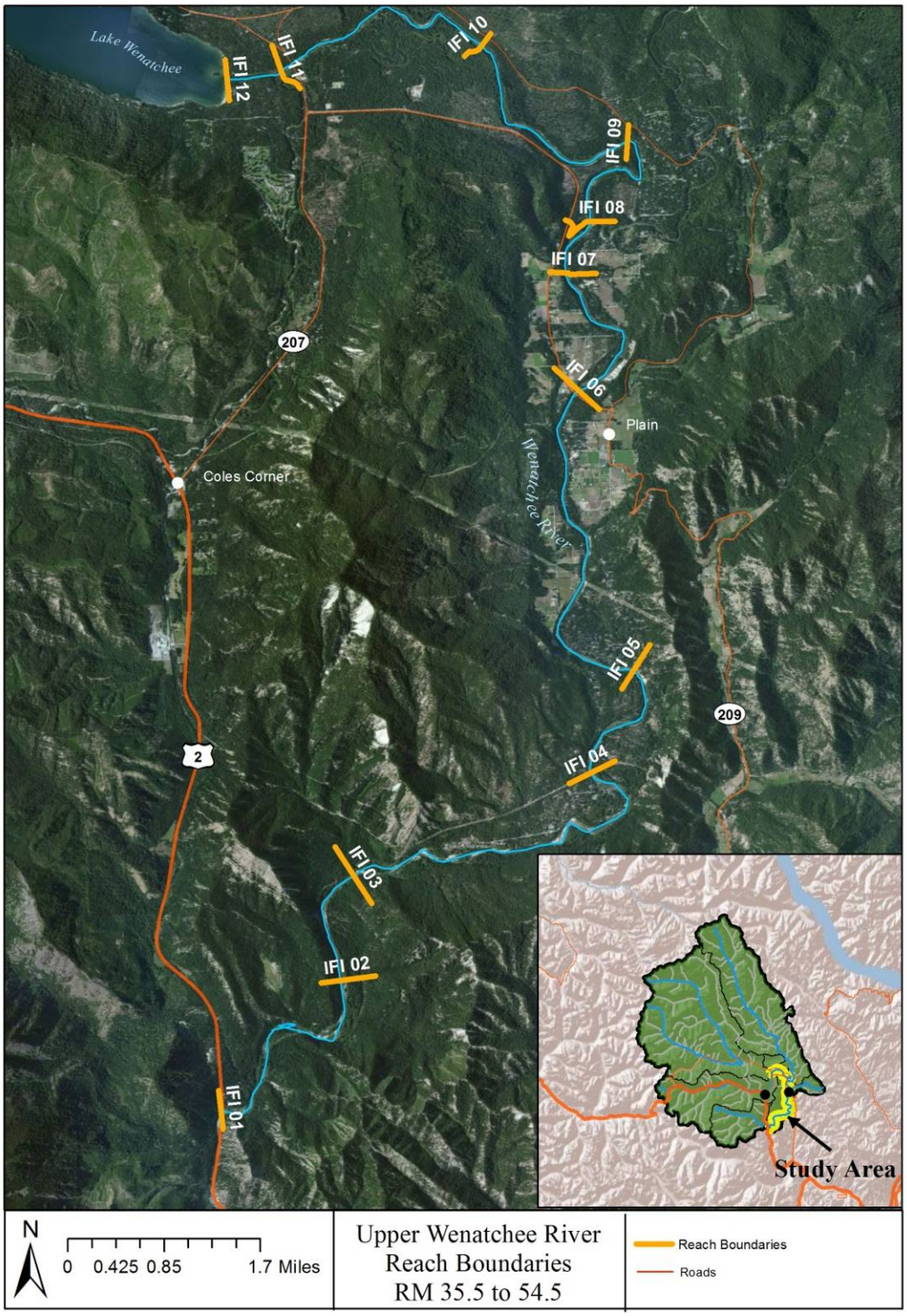


Figure 1. Locator map of the Habitat Assessment area showing the stream habitat survey reaches used in the assessment.

2 Methods

Eleven geomorphic reaches have been delineated as part of the reach assessment. These same reaches were used for both the stream habitat and geomorphology assessments to maintain consistency for this and future inventories. Data collected in this survey is intended to compliment preexisting data for the Wenatchee Basin.

Field methods for the habitat survey used the USFS Region 6 Level II Stream Survey Protocol Version 2.6 (USFS 2006). The protocol was modified because the Wenatchee River is not a wadeable stream. Therefore, this stream habitat survey was conducted by navigating the river from Lake Wenatchee to Tumwater Canyon using inflatable kayaks. Record snow pack throughout the Cascade Mountain range during the winter of 2010/2011 provided the Wenatchee River with extremely high spring and summer stream flows. Due to scheduling constraints and spring Chinook spawning timing, the survey was unable to be conducted during minimum stream flows. Stream flows were recorded at 2,940 cfs on August 9, and continued to decrease throughout the stream habitat survey period to 1,210 cfs on August 31, 2011.

An additional modification was made to the protocol with respect to the n^{th} unit measurement frequency. Due to varying reach lengths and the scale of habitat units along the upper Wenatchee River, every habitat unit was measured to obtain consistent quantitative data throughout the entire study area. Habitat unit length was measured using GPS points taken in the field and analyzed for approximate length within 20 feet of accuracy. Habitat unit width was measured with a hand-held range finder at several locations along the unit and averaged for best accuracy. Habitat unit depths were collected with measuring rods (i.e. wading rods and graduated paddles) to a depth of 7 feet and conservatively estimated when unit depth exceeded the measuring rod.

Data collection in fast water units (i.e. riffles and glides) was challenging and in some reaches impossible due to deep and swift water. Bankfull measurements and Wolman pebble counts (Wolman 1954) were collected when stream conditions allowed (i.e. wadeable). Bankfull measurements were collected at 29% of the fast water units, including one glide and 20 riffles. Visual (ocular) estimates of bed sediment composition (considered a “forest option” in the USFS protocol) were recorded for every fast water unit. The lengths of unstable banks were visually estimated for every unit.

Side-channel units were identified when the main channel split to form a stable island with soil or fine sediment deposits and vegetation older than 2 to 3 years old, or in places where large cobble deposits have persisted for over 40 years (verified with 1966 DOT aerial photos). Each side-channel was designated as either a pool, riffle, or glide based on the dominant habitat type. Off-channel marshlands were identified and inventoried during this survey following specifications of the USFS Region 6 Level II Stream Survey Protocol.

For the riparian assessment, the Level II survey manual indicates that it is a "forest option" to designate either a single 100-ft wide zone or two adjacent riparian zones (inner and outer zones) totaling 100 feet in width (USFS 2006). For reasons best suited to this assessment, one single 100-ft wide riparian zone was designated for the Wenatchee River study area. Survey methods dictate defining a dominant class of vegetation type for the riparian zone (e.g. large trees, small trees, shrubs), then defining the dominate species observed in the over and understory.

3 Summary of Results

This section summarizes the results across all eleven reaches. Detailed reach summaries with reach-specific results are included in Appendix A.

3.1 Channel Morphology

Upper Wenatchee River reaches were dominated by pool-riffle and plane-bed morphology. Channel bed substrate consisted primarily of cobbles and gravels, with a moderate frequency of boulders and sand in some reaches. Bedrock occurred relatively infrequently.

Channel widths did not vary substantially between stream reaches but did increase slightly in Reach 1 and Reach 2 (Figure 2). Limited channel widening in the downstream direction may be attributed to channel simplification and artificial channel confinement that affects stream width throughout much of the study area. Mean bankfull widths were 276.3 ft (stdev 39.1). Bankfull depths, however, are more variable, both among and within individual reaches (Figure 3). Mean bankfull depth was 5.9 ft (stdev 1.0). Bankfull depth ranged from 3.4 to 9.5 feet, with the largest bankfull depths occurring in Reach 10. Floodprone widths vary considerably throughout the upper Wenatchee study area (Figure 4), with a mean floodprone width of 749.5 ft (stdev 315.4). Reaches 1 and 3 had the widest active floodplains (>1,000 ft) and Reach 5 was the most disconnected (<400 ft).

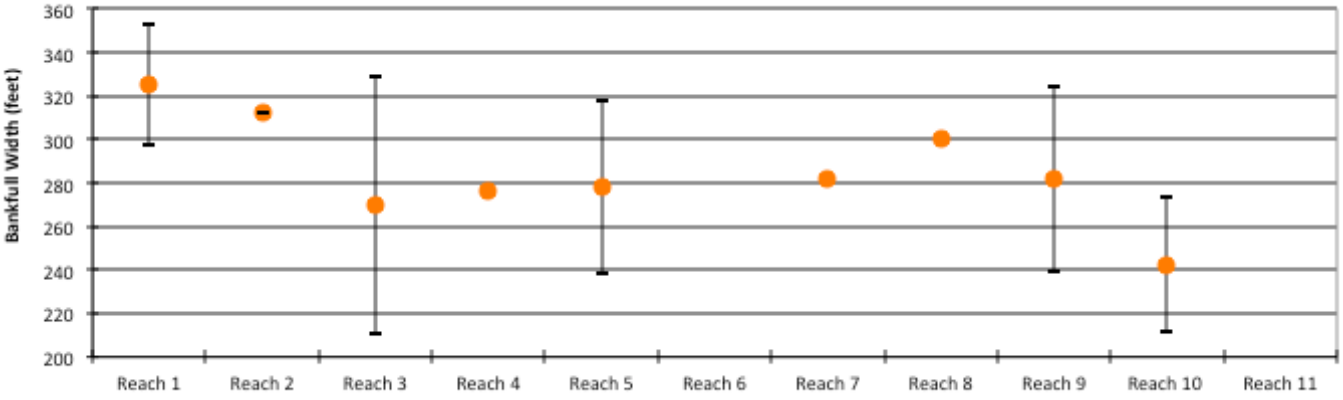


Figure 2. Plot of mean bankfull widths for each reach with error bars representing the standard deviation.

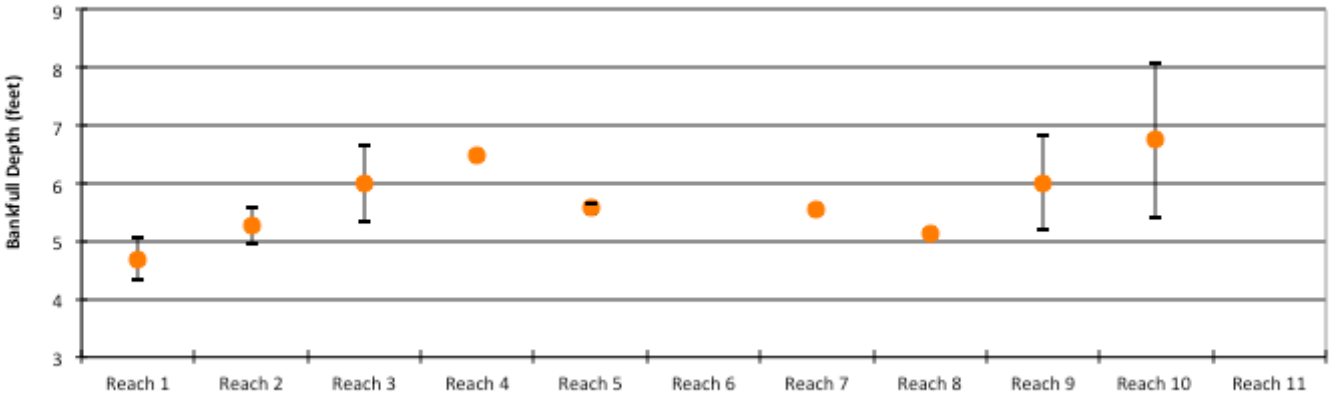


Figure 3. Plot of mean bankfull depths for each reach with error bars representing the standard deviation. Each value is an average of three individual measurements taken at wadeable riffle units (n= 0 to 6) in each reach.

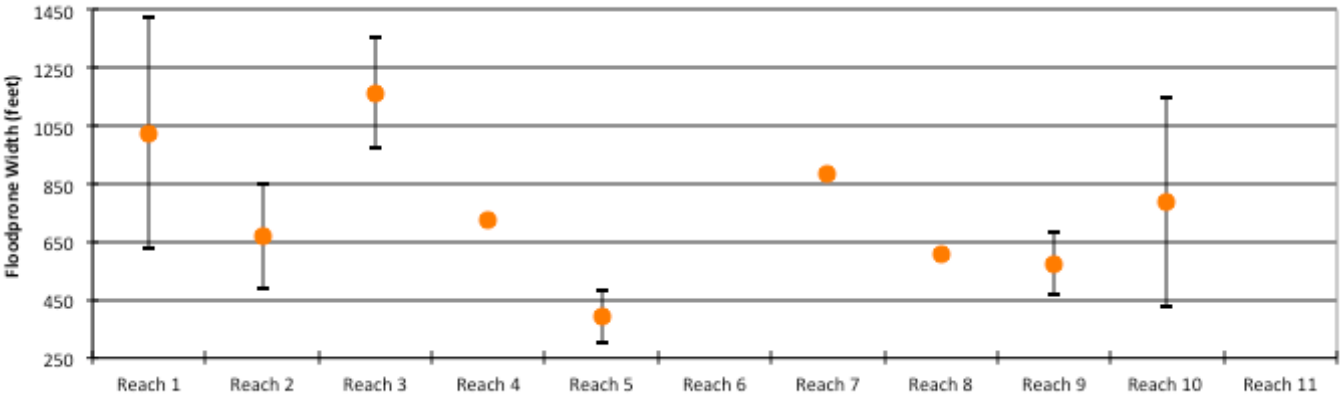


Figure 4. Plot of mean floodprone widths for each reach with error bars representing the standard deviation.

3.2 Habitat Unit Composition

Riffles, pools, and glides made up equal portions of the total habitat unit composition for the study area (31%, 30%, and 30%, respectively). The remaining 9% was side channel habitat (Figure 5).

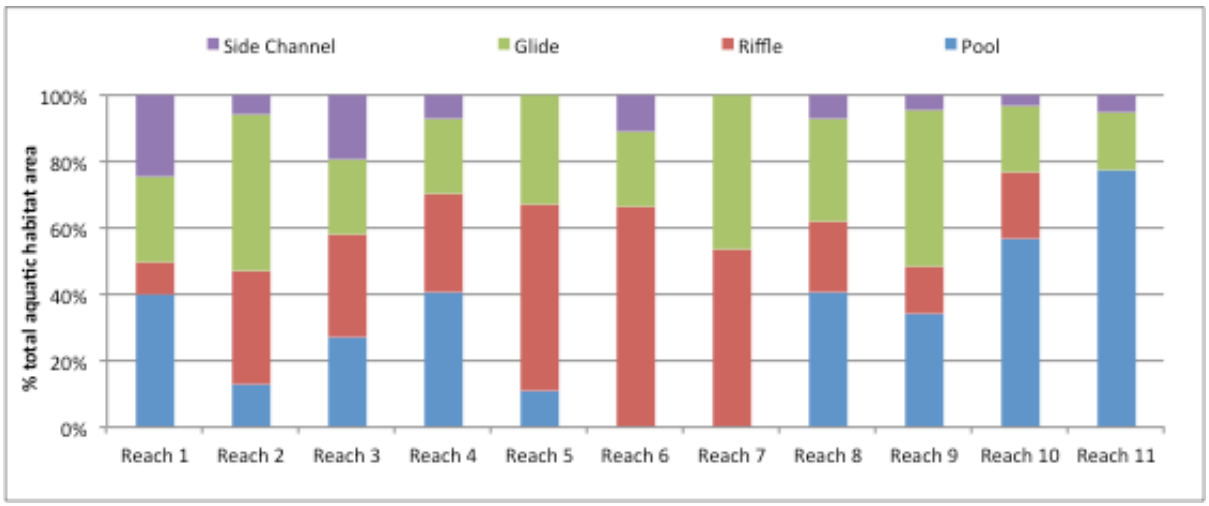


Figure 5. Habitat unit composition by reach.

Pool frequency ranged from 0.0 to 2.7 pools/mile, with a mean pool spacing of 8.0 to 28.3 channel widths per pool. Reach 6 and 7 had no pool habitat. Reaches 10 and 11 had the greatest proportion of pool habitat (57% and 77%, respectively), although Reach 1 had the greatest number of pools/mile (2.7). Reaches 1 and 11 had the shortest pool spacing (9.4 and 8.0 channel widths per pool, respectively). Reaches 1 and 3 had the greatest number of deep pools with residual depths exceeding 3 ft (6 pools in each reach). The majority of the pools throughout the study area were relatively deep, with shallow residual depths (<3 ft) comprising less than 7% of total pools.

Mean wetted widths were 206.4 feet (stdev 10.9). Mean riffle depths were 2.7 feet (stdev 0.8) with mean maximum depths of 4.6 feet (stdev 1.5). Riffle depths should not present a problem for migrating fish, as minimum depths reported necessary to maintain Chinook and large trout passage (0.8 feet and 0.6 feet, respectively: Thompson 1972) were well exceeded throughout the upper Wenatchee study area. However, riffle depths at the lowest summer flow period would be lower than those reported here.

Average unit lengths for the three habitat types (pools, riffles, and glides) are presented in Figure 6. Reaches 8, 9, 10, and 11 had the longest pools. Reaches 5, 6, and 7 had the longest riffles and Reach 9 had the longest glides. In general, reaches 6, 7, and 9 had longer habitat units, which were comprised mostly of long riffles and glides.

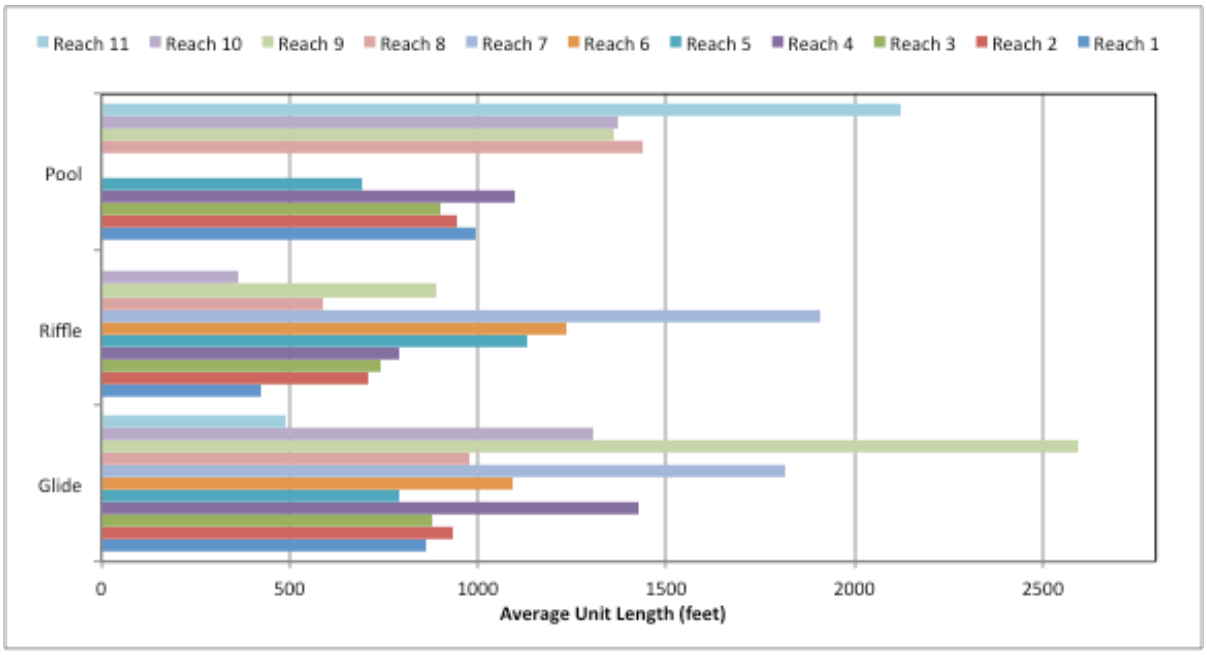


Figure 6. Comparison of average habitat unit lengths for Reaches 1-11 in the upper Wenatchee River.

3.3 Off-Channel Habitat

Side-channel habitat accounts for approximately 19% of the surveyed length along the upper 18.7 miles of the Wenatchee River. A total of 33 wetted side-channel habitat units were measured during the survey. Reach 1 had the greatest area of side-channel habitat and Reach 3 had the greatest number of side-channel units. Reaches 5 and 7 had no side-channel habitat. Side-channel riffles (n=21) accounted for 64% of all side-channel units. Side-channel pools (n=8) accounted for 24%, all occurring in Reaches 1 and 3. Side-channel glides (n=4) were the least common off-channel habitat observed throughout the study area. Average and maximum side-channel depths were 1.7 feet (stdev 0.9) and 3.7 feet (stdev 1.8), respectively, with the deepest side-channels observed in Reach 8.

In addition to side-channels, the upper Wenatchee study area had nine marshes ranging from small backwaters to large open water ponds. These off-channel marshlands often provided food sources (invertebrates), LWD, refuge, and rearing habitat for fish and wildlife species. Off-channel marshes were identified in Reach 1, 8, 9, and 10. Reach 9 had the greatest number of marsh units (n=3) and Reach 10 had the largest marsh habitat within the study area.

Natural and artificial confinement limits off-channel habitat throughout some portions of the study area. In some areas, human development of riparian areas and floodplains also impairs floodplain and channel migration processes that are necessary to create and maintain off-channel habitats. The primary impairments to off-channel habitat occur along the reaches that flow through the community of Plain, from Reach 4 through Reach 7. Roads, bank armoring, berms, and channel/floodplain filling have reduced the abundance and connectivity of off-channel

habitat and have impaired the floodplain and channel migration dynamics necessary to create and maintain off-channel habitats over time.

3.4 Large Wood

An average of 123 pieces of wood per mile were counted in the upper Wenatchee River; 48% of these were "small" pieces with diameters between 6 and 12 inches and lengths greater than 20 feet (Figure 7). Reaches 1 and 3 had the highest number of "large" LWD pieces per mile (133 and 211, respectively), and overall these two reaches also contained the highest frequencies of LWD at 294 and 252 pieces per mile, respectively. The numbers of pieces per mile in each reach ranged from 13 to 294.

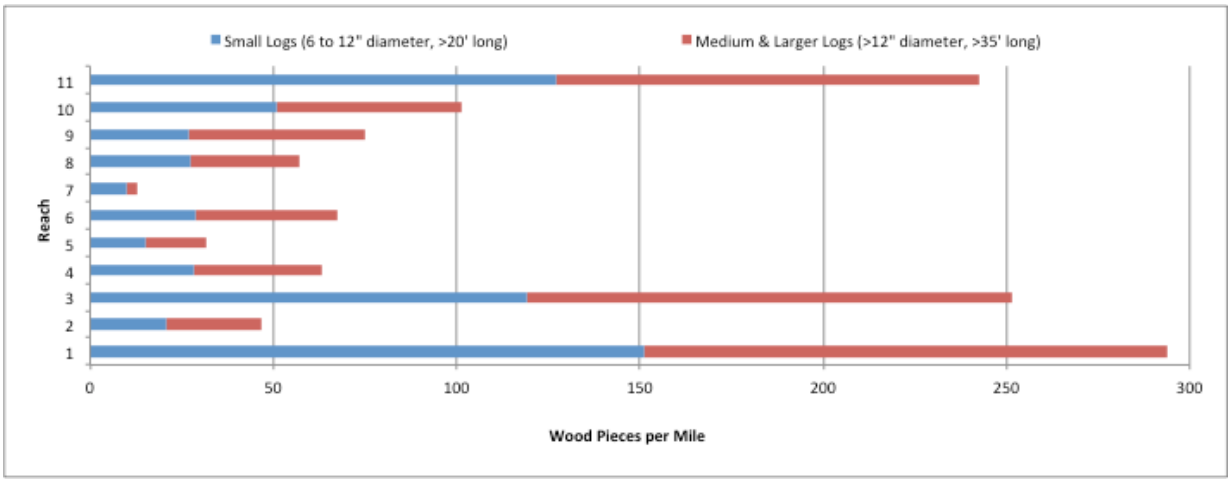


Figure 7. Small and medium/large wood pieces/mile for each reach.

3.5 Substrate and Fine Sediment

Bed substrate was based on ocular estimates at each habitat unit and pebble counts at one or two representative locations within each of the eleven reaches (when wading conditions allowed). Riffle pebble counts were not achievable for reaches 4, 6, and 7 due to high flow velocity and depth. One pebble count was collected for reaches 1, 2, 5, 8, and 11. Two pebble counts were collected for reaches 2, 9, and 10. The ocular estimates and pebble counts correlate well with respect to cobble dominance. Percent coverage of sand, gravel, and boulder varies. In general, bed substrate in the upper Wenatchee River was gravel and cobble, with smaller amounts of boulder, bedrock and sand (Figure 8 and Figure 9). Bedrock was rare and was mostly observed in the lower four reaches and in Reach 6. Results of the ocular estimates demonstrate that reaches 8 and 9 have the highest proportion of sand whereas reaches 6 and 7 had the highest proportion of boulders.

Sediment measurements indicated that the presence of fine sediment (<2mm) was at low to moderate levels throughout much of the upper Wenatchee study area. An excess of fine sediment does appear to be a concern in reaches 4, 8, and 9.

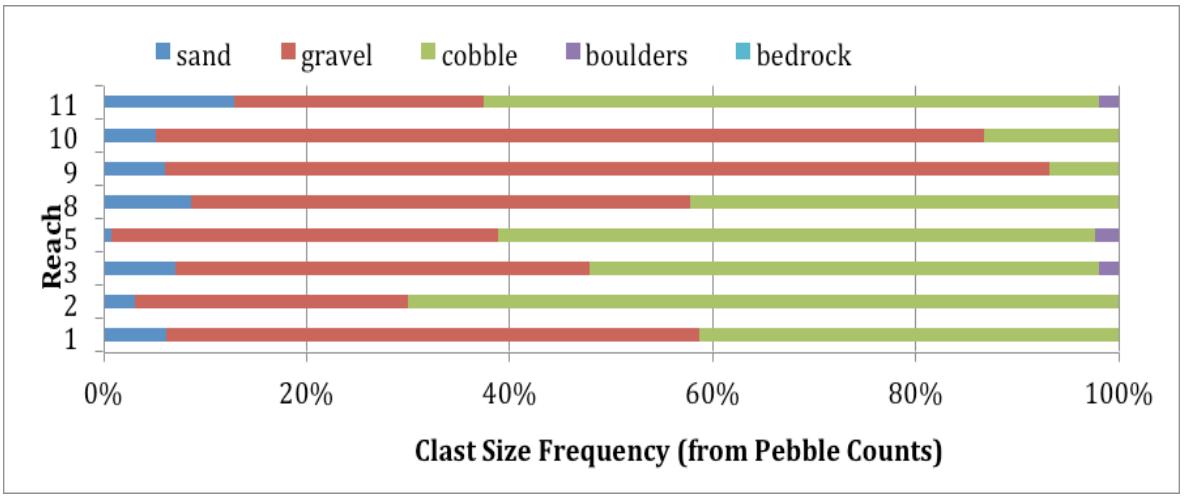


Figure 8. Pebble count classification of substrate by reach for the upper Wenatchee River. Riffle pebble counts were not achievable for Reaches 4, 6, and 7 due to high flow velocity and depth.

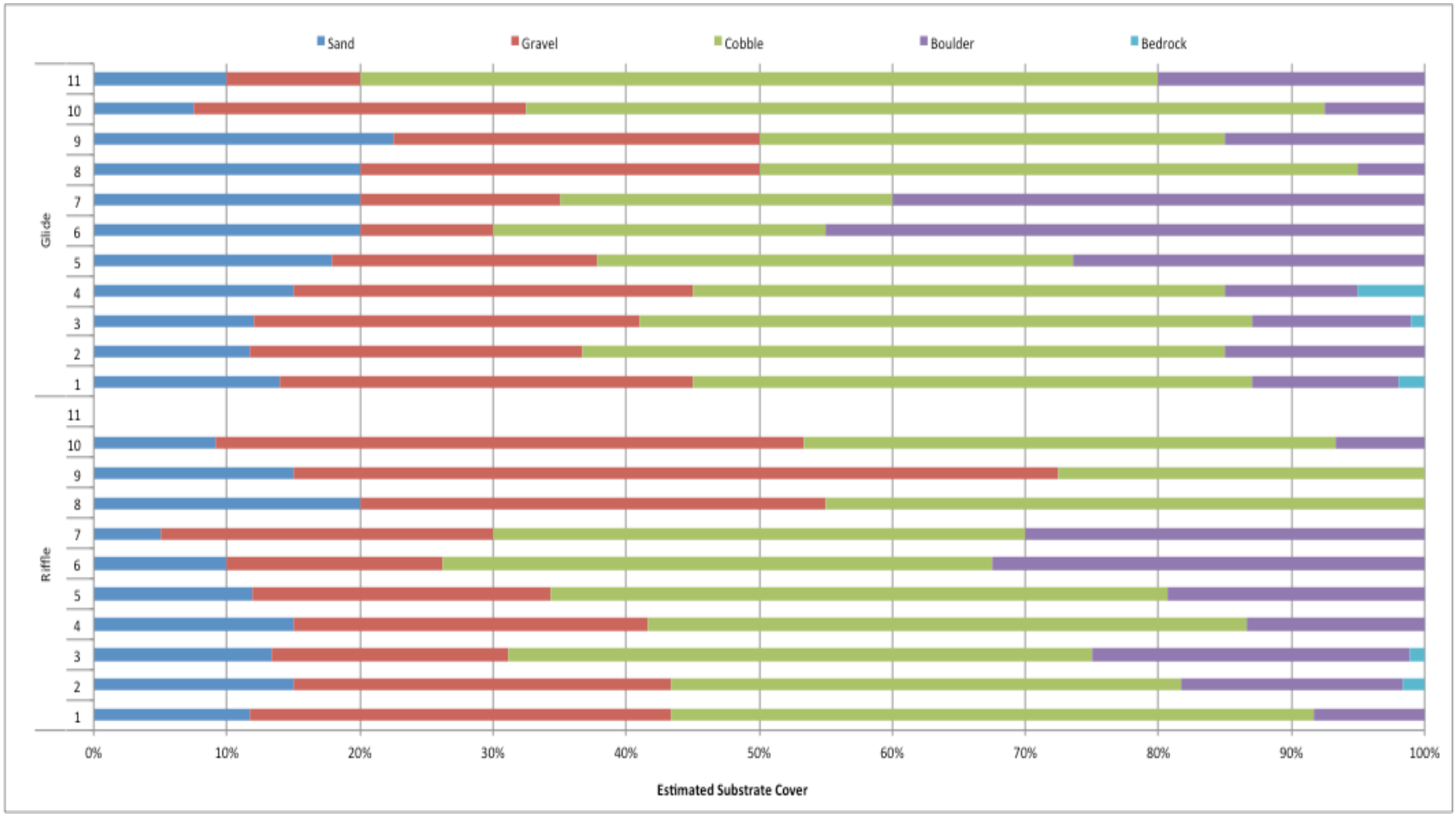


Figure 9. Ocular estimates of substrate by habitat unit type and reach for the upper Wenatchee River.

3.6 Instability and Disturbance

There has been significant human alteration along portions of the channel, riparian zone, and floodplain throughout the study area. These alterations are related to past and ongoing land-uses in the upper Wenatchee River Valley, including timber harvest, agriculture, road building, and residential development. Artificial channel confinement in the form of bridges, floodplain fill, berms, and bank armoring affects channel and floodplain dynamics in many areas. Reaches 4 through Reach 7 flow through the community of Plain and experience the greatest modifications that alter channel and floodplain processes. The other seven reaches have low-to-moderate amounts of human disturbance. Active erosion and disturbance was often related to natural valley confinement throughout the study area.

In total, 12% of the streambanks along the upper 18.7 miles of the Wenatchee River were actively eroding. The greatest amount of bank erosion was observed in reaches 9 and 10, where an average of 23% and 18% (respectively) of the streambanks displayed active erosion. The other nine reaches contained between 0% to 16% bank erosion overall. Bank erosion was observed in all habitat unit types (Figure 10), but was most common along pool habitat. Twenty-eight percent (28%) of all pool habitat in the study area exhibited bank erosion. Much of the erosion is natural process and is related to the natural incision of the channel into terrace deposits of glacial origin. In some cases, the incision and related bank erosion has been exacerbated by human alterations including past riparian clearing, past splash damming/log drives, and bank armoring. Streambank erosion has been halted at some locations by riprap, spur dikes, concrete retaining walls, and other bank hardening features.

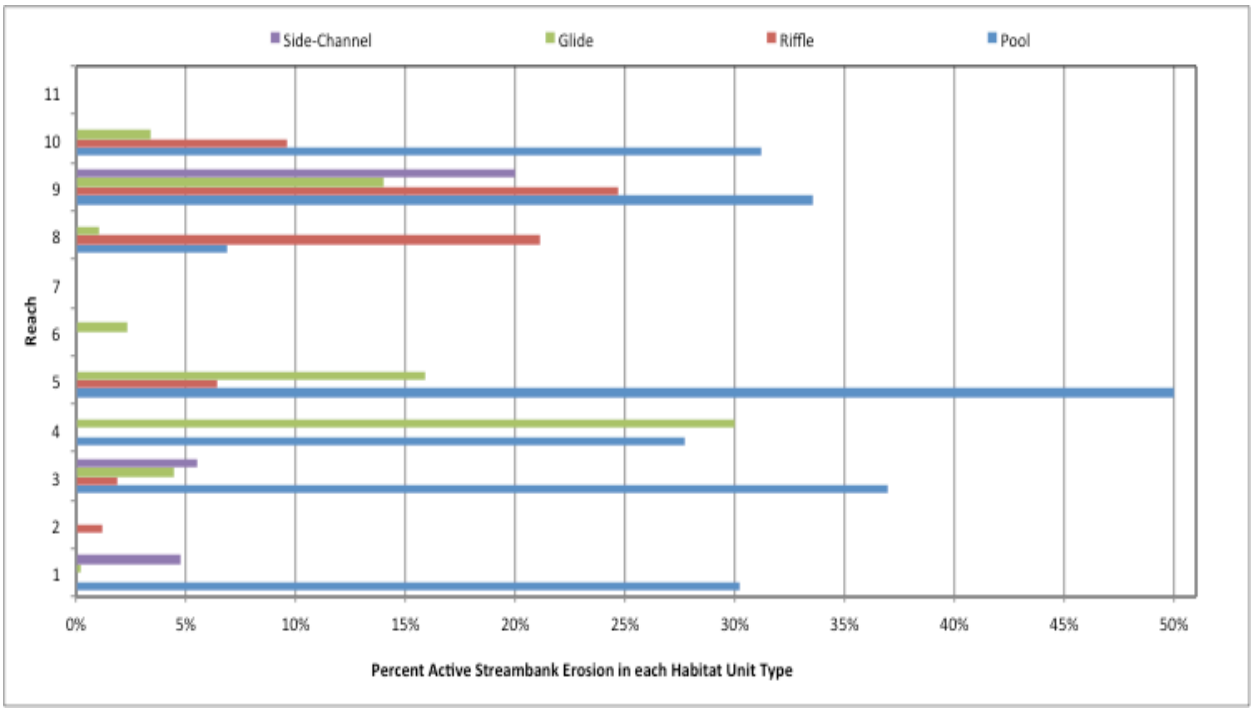


Figure 10. Percent active streambank erosion in each habitat unit type.

3.7 Fish Passage Barriers

There were no fish passage barriers in the study area. Access to some off-channel areas may be limited during low flow periods. Low flow, especially during low water years, may impact adult fish passage in localized shallow riffles and side-channel units.

3.8 Riparian Corridor

Much of the upper Wenatchee Basin was heavily logged in the early 1900s. Reforested timberlands now dominate the riparian buffers but the trees are considerably smaller than what would be expected under non-harvested conditions. Only a handful of areas have cleared riparian conditions. However, in many reaches, particularly those with heavy residential development (Reaches 3-8 and 10), the understory has been cleared of shrubs and small trees to facilitate human uses and views of the river.

The upper Wenatchee riparian zone was typically dominated by large trees (52%). Small trees were dominant in 41% of units and the sapling/pole size class was dominant in just 7% of units (Figure 11). The riparian overstory was primarily conifer (70%) (Figure 12) and ponderosa pine was the dominant overstory species. Overstory species also included cottonwood and Douglas fir. The understory was composed mostly of shrubs (58%) and hardwoods (39%), and exhibited greater species diversity than the overstory. Understory species included (in order of frequency) willow, alder, dogwood, and cottonwood.

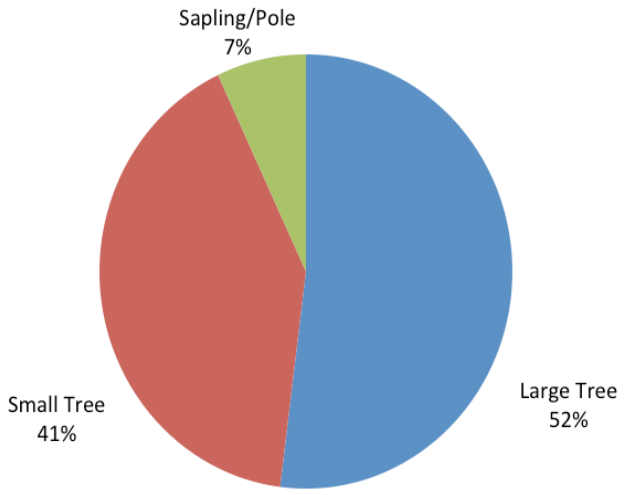


Figure 11. Distribution of the dominant size class category for the riparian inner zones, all reaches combined.

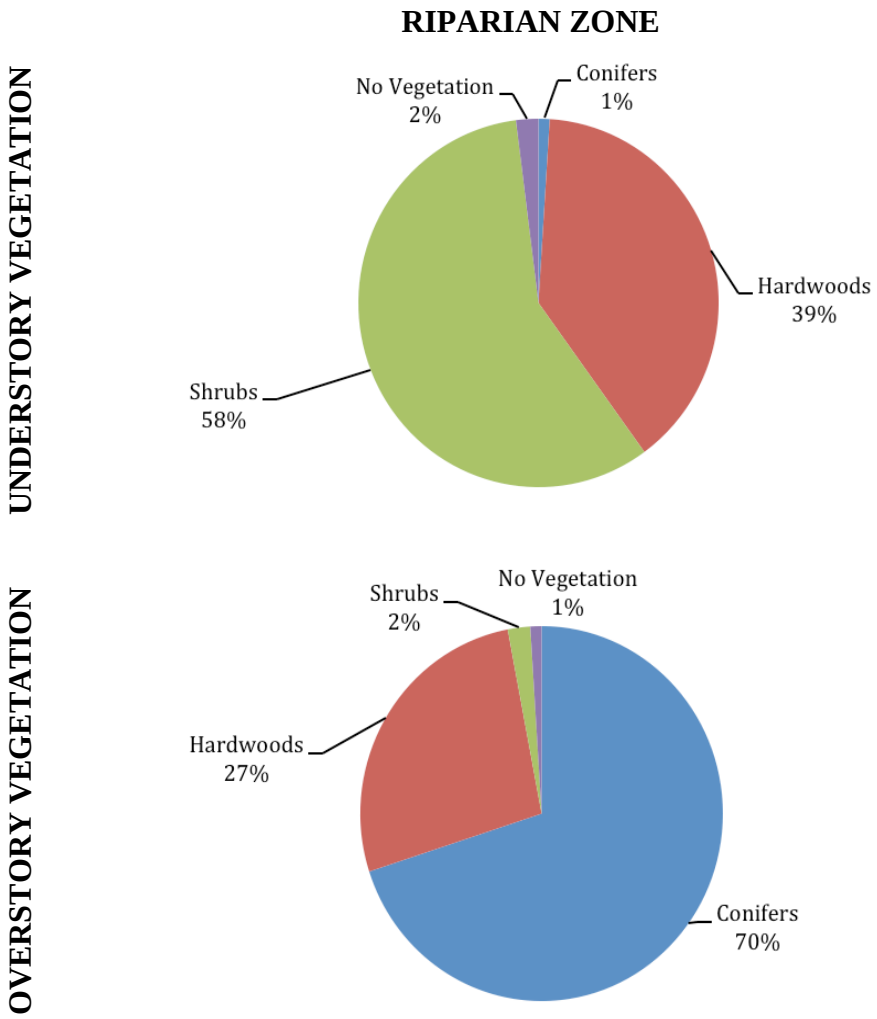


Figure 12. Proportions of vegetation cover types in the riparian zone along the upper 18.7 miles of the Wenatchee River.

Table 1. Upper Wenatchee River Data Summary: RM 35.5 to RM 54.2.

	Total	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11
Reach Mileage Boundaries	35.5 – 54.2	35.5 – 37.6	37.6 – 38.6	38.6 – 41.9	41.9 – 43.1	43.1 – 46.5	46.5 – 47.9	47.9 – 48.4	48.4 – 49.7	49.7 – 51.7	51.7 – 53.7	53.7 – 54.2
Channel Morphology		Pool-riffle	Plane-bed	Pool-riffle	Pool-riffle	Plane-bed	Plane-bed	Plane-bed	Pool-riffle	Plane-bed	Pool-riffle	Plane-bed
Slope												
Average	0.07%	0.07%	0.07%	0.10%	0.07%	0.08%	0.10%	0.07%	0.03%	0.01%	0.04%	0.04%
Wetted Width (ft)												
Pool												
Mean	201.9	207.3	178.0	186.5	212.3	186.0	n=0	n=0	194.0	214.7	191.8	330.0
Median	197.0	196.5	178.0	196.0	225.0	190.0	n=0	n=0	194.0	200.0	177.0	330.0
StDev	42.1	43.5	n=1	46.6	35.7	14.4	n=0	n=0	2.8	27.2	38.3	n=1
Riffle												
Mean	209.3	222.7	215.7	172.2	235.0	220.0	258.8	228.0	232.5	193.5	189.2	n=0
Median	210.0	235.0	206.0	156.0	255.0	210.0	265.0	228.0	232.5	193.5	206.0	n=0
StDev	57.8	52.6	32.6	68.8	65.3	33.6	39.7	n=1	74.2	87.0	68.8	n=0
Glide												
Mean	207.9	182.0	230.0	193.6	270.0	211.6	192.5	205.0	216.0	220.0	170.0	324.0
Median	200.0	182.0	236.0	195.0	270.0	200.0	192.5	205.0	216.0	220.0	170.0	324.0
StDev	36.8	28.0	35.4	35.4	n=1	20.1	10.6	n=1	0.0	14.1	14.1	n=1
Water Depth (ft)												
Pool Maximum Depth												
Mean	11.1	12.5	6.5	9.6	10.0	11.3	n=0	n=0	11.0	15.0	10.2	12.0
Median	10.0	12.5	6.5	9.0	9.0	12.0	n=0	n=0	11.0	15.0	10.0	12.0
StDev	3.4	5.0	n=1	2.9	4.6	1.2	n=0	n=0	1.4	0.0	1.8	n=1

Pool Residual Depth												
Mean	7.4	9.1	3.5	6.2	6.7	7.8	n=0	n=0	7.5	10.0	6.1	8.0
Median	7.3	9.4	3.5	5.5	6.7	8.5	n=0	n=0	7.5	10.2	7.0	8.0
StDev	3.2	4.8	n=1	3.0	4.3	1.6	n=0	n=0	1.4	0.4	2.4	n=1
Maximum Riffle Depth												
Mean	4.6	3.7	3.2	4.7	3.8	4.5	5.0	6.5	3.5	2.8	6.3	n=0
Median	4.0	3.5	2.1	4.3	4.0	4.0	4.8	6.5	3.5	2.8	6.3	n=0
StDev	1.5	0.8	1.8	1.1	0.3	1.0	1.5	n=1	0.0	1.8	2.0	n=0
Average Riffle Depth												
Mean	2.7	2.5	2.2	3.1	2.0	2.9	3.2	3.5	2.1	1.5	2.8	n=0
Median	2.5	2.5	1.5	3.0	2.0	2.5	3.3	3.5	2.1	1.5	3.0	n=0
StDev	0.8	0.6	1.6	0.5	0.5	0.9	0.6	n=1	0.1	0.8	0.3	n=0
Maximum Glide Depth												
Mean	6.6	5.8	5.1	6.4	10.0	6.4	6.8	8.0	7.0	8.3	7.8	5.5
Median	6.5	6.0	5.1	6.2	10.0	6.0	6.8	8.0	7.0	8.3	7.8	5.5
StDev	1.4	0.8	0.7	1.0	n=1	1.3	1.8	n=1	0.7	1.1	1.1	n=1
Average Glide Depth												
Mean	4.0	3.6	3.5	3.9	5.0	4.4	3.9	4.8	3.6	4.2	4.0	3.0
Median	3.9	3.8	3.5	4.0	5.0	4.3	3.9	4.8	3.6	4.2	4.0	3.0
StDev	0.7	0.5	0.5	0.5	n=1	0.9	0.6	n=1	0.8	0.2	0.3	0.7
Bankfull Characteristics												
Width (ft)												
Mean	280.3	325.5	312.0	270.0	276.0	278.0	NA	282.0	300.0	282.0	242.5	360.0
StDev	42.3	27.6	0.0	59.4	NA	39.9	NA	NA	NA	42.4	30.9	NA
Depth (ft) Averaged over 3 depth measurements												
Mean	5.9	4.7	5.3	6.0	6.5	5.6	NA	5.6	5.1	6.0	6.8	4.7
StDev	1.0	0.4	0.3	0.7	NA	0.1	NA	NA	NA	0.8	1.3	NA
Maximum Depth (ft)												
Mean	7.6	6.4	6.3	8.3	7.3	7.2	NA	6.4	6.1	7.2	9.1	7.2

	StDev	1.7	0.8	0.8	2.8	NA	1.1	NA	NA	NA	0.6	2.0	NA
Width:Depth Ratio													
	Mean	49.8	69.7	59.2	44.7	42.5	49.9	NA	50.7	58.4	46.8	37.9	76.1
	StDev	13.9	11.5	3.4	5.0	NA	7.8	NA	NA	NA	0.6	13.4	NA
Floodprone Width (ft)													
	Mean	741.9	1025.5	671.0	1164.0	726.0	395.0	NA	882.0	605.0	575.0	786.7	590.0
	StDev	309.4	396.7	182.4	192.3	NA	91.4	NA	NA	NA	106.1	358.1	NA
Habitat Area %													
Pool		30%	40%	13%	27%	41%	11%	0%	0%	41%	35%	57%	77%
Riffle		31%	10%	34%	31%	30%	56%	67%	54%	21%	14%	20%	0%
Glide		30%	26%	47%	23%	22%	33%	23%	46%	31%	47%	20%	18%
Side Channel		9%	24%	6%	19%	7%	0%	10%	0%	7%	4%	3%	5%
Pools													
Pools per mile		1.6	2.7	0.9	1.9	2.2	1.0	0.0	0.0	1.8	1.4	2.3	2.0
Residual Depth (% of pools)													
	Pools < 3 ft	7%	0%	0%	0%	33%	0%	0%	0%	0%	0%	20%	0%
	Pools 3-6 ft	20%	33%	100%	50%	0%	0%	0%	0%	0%	0%	0%	0%
	Pools 6-9 ft	43%	17%	0%	33%	34%	67%	0%	0%	100%	0%	80%	100%
	Pools 9-12 ft	27%	33%	0%	17%	33%	33%	0%	0%	0%	100%	0%	0%
	Pools > 12 ft	3%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Riffle:Pool Ratio		1.4	0.5	3.0	1.5	1.0	2.7	NA	NA	1.0	0.7	1.2	0.0
Mean Pool Spacing (channel widths per pool)		16.1	9.4	28.3	14.9	9.9	27.0	n=0	n=0	14.0	17.6	12.7	8.0
Large Wood													
Total Number Pieces													
	Total	*2329*	642	52	785	85	100	91	9	65	157	223	120
	Small (6 in x 20 ft)	1120	331	23	372	38	48	39	7	31	56	112	63
	Medium (12 in x 35 ft)	611	178	9	202	15	24	23	1	13	44	64	38
	Large (20 in by 35 ft)	598	133	20	211	32	28	29	1	21	57	47	19

Number of Pieces/Mile												
Total	123	294	47	252	63	32	67	13	57	75	101	242
Small (6 in x 20 ft)	59	151	21	119	28	15	29	10	27	27	51	127
Medium (12 in x 35 ft)	32	81	8	65	11	8	17	1	11	21	29	77
Large (20 in by 35 ft)	32	61	18	68	24	9	21	1	18	27	21	38
Bank Erosion (% eroding banks)												
Mainstem Total	12%	11%	0%	11%	16%	15%	1%	0%	6%	22%	18%	0%
Pool	28%	30%	0%	37%	28%	50%	n=0	n=0	7%	34%	31%	0%
Riffle	5%	0%	1%	2%	0%	6%	0%	0%	21%	25%	10%	n=0
Glide	7%	0%	0%	4%	30%	16%	2%	0%	1%	14%	3%	0%
Side-Channel	4%	5%	0%	5%	0%	n=0	0%	n=0	0%	20%	0%	0%
Substrate (Ocular Estimate)												
Total												
% Sand	16%	17%	13%	19%	19%	15%	8%	12%	28%	26%	10%	10%
% Gravel	27%	32%	26%	28%	29%	21%	17%	20%	30%	47%	36%	10%
% Cobble	41%	43%	44%	37%	42%	41%	45%	33%	39%	22%	49%	60%
% Boulder	15%	7%	15%	12%	8%	23%	30%	35%	3%	5%	5%	20%
% Bedrock	1%	1%	2%	4%	2%	0%	0%	0%	0%	0%	0%	0%
Riffle												
% Sand	13%	12%	15%	13%	15%	12%	10%	5%	20%	15%	9%	n=0
% Gravel	30%	32%	28%	18%	27%	23%	16%	25%	35%	58%	44%	n=0
% Cobble	42%	48%	38%	44%	45%	46%	41%	40%	45%	27%	40%	n=0
% Boulder	15%	8%	17%	24%	13%	19%	33%	30%	0%	0%	7%	n=0
% Bedrock	0%	0%	2%	1%	0%	0%	0%	0%	0%	0%	0%	n=0
Glide												
% Sand	15%	14%	12%	12%	15%	18%	20%	20%	20%	22%	8%	10%
% Gravel	23%	31%	25%	29%	30%	20%	10%	15%	30%	28%	25%	10%
% Cobble	42%	42%	48%	46%	40%	36%	25%	25%	45%	35%	60%	60%

% Boulder	19%	11%	15%	12%	10%	26%	45%	40%	5%	15%	7%	20%
% Bedrock	1%	2%	0%	1%	5%	0%	0%	0%	0%	0%	0%	0%
Side-Channels												
% Sand	19%	20%	12%	23%	25%	n=0	8%	n=0	22%	40%	12%	10%
% Gravel	32%	33%	25%	30%	30%	n=0	17%	n=0	43%	55%	40%	10%
% Cobble	39%	42%	45%	32%	43%	n=0	45%	n=0	32%	5%	46%	60%
% Boulder	9%	5%	13%	9%	2%	n=0	30%	n=0	3%	0%	2%	20%
% Bedrock	1%	0%	5%	6%	0%	n=0	0%	n=0	0%	0%	0%	0%
Riffle Pebble Count *(1-2 samples per reach when stream conditions allowed)*												
% Sand	6%	6%	3%	7%	NA	1%	NA	NA	9%	6%	5%	13%
% Gravel	50%	53%	27%	40%	NA	38%	NA	NA	49%	87%	82%	24%
% Cobble	43%	41%	70%	51%	NA	58%	NA	NA	42%	7%	7%	61%
% Boulder	1%	0%	0%	2%	NA	3%	NA	NA	0%	0%	0%	2%
% Bedrock	0%	0%	0%	0%	NA	0%	NA	NA	0%	0%	0%	0%
Vegetation (% of sampled units)												
Riparian Zone (100-ft wide zone averaged between both banks)												
Sapling/Pole	7%	9%	11%	16%	0%	0%	0%	0%	0%	0%	6%	0%
Small Trees	41%	36%	33%	44%	22%	39%	87%	0%	63%	38%	19%	100%
Large Trees	52%	55%	56%	40%	78%	61%	13%	100%	37%	62%	75%	0%

4 References

Thompson, K.E. 1972. Determining stream flows for fish life: Proceedings of the Instream Flow Requirement Workshop, March 15-16, 1972, Portland, Oregon: Pacific Northwest River Basins Commission, p. 31-50.

US Forest Service (USFS) 2006. Stream inventory handbook: Levels 1 and 2. Region 6 version 2.6. Portland, OR: Pacific Northwest Region.US Department of Agriculture.

Washington Department of Fish and Wildlife (WDFW). 1990. Wenatchee River Subbasin Salmon and Steelhead Production Plan. Columbia Basin System Planning. Wash. Dept. of Fish and Wildlife. Olympia, Washington.

Wolman, M.G. 1954. A method of sampling coarse river-bed material: Transactions of the *American Geophysical Union*, vol. 35: 951-956.

This page left blank for printing purposes.

5 Stream Habitat Reach Reports

A-1 Reach 1

Location: River mile 35.5 to 37.6

Survey Date: August 17, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-1.1 Reach Overview

Reach 1 is located upstream of Tumwater Canyon from the Hwy 2 Bridge at RM 35.5 to a small (right bank) backwater marsh at RM 37.6. This complex reach is low gradient (0.19%) and the channel flows through a partially confined valley. Channel form is braided with alternating riffle-glide and pool-riffle morphology. Steep hillslopes, the historical floodplain terrace of Chiwaukum Creek, and expansive low-elevation floodplains border the channel. Chiwaukum Creek enters the channel from river-right at RM 35.9 supplying additional sediment and discharge to the system. The modern floodplain surfaces offer complex off-channel habitat in most meander scars. Surrounding land is US Forest Service. Reach 1 was historically used for timber harvest and logging operations. Evidence of splash dams and other logging practices remain today. A Forest Service campground (RM 35.6) and primitive road provides recreational opportunities along river-right. There is very little development or human infrastructure found in Reach 1. Disturbance is limited to the area surrounding the Hwy 2 Bridge (RM 35.5). Large boulder riprap and current bridge re-construction at this location confines the channel, disturbs the streambank, and fragments the riparian corridor.

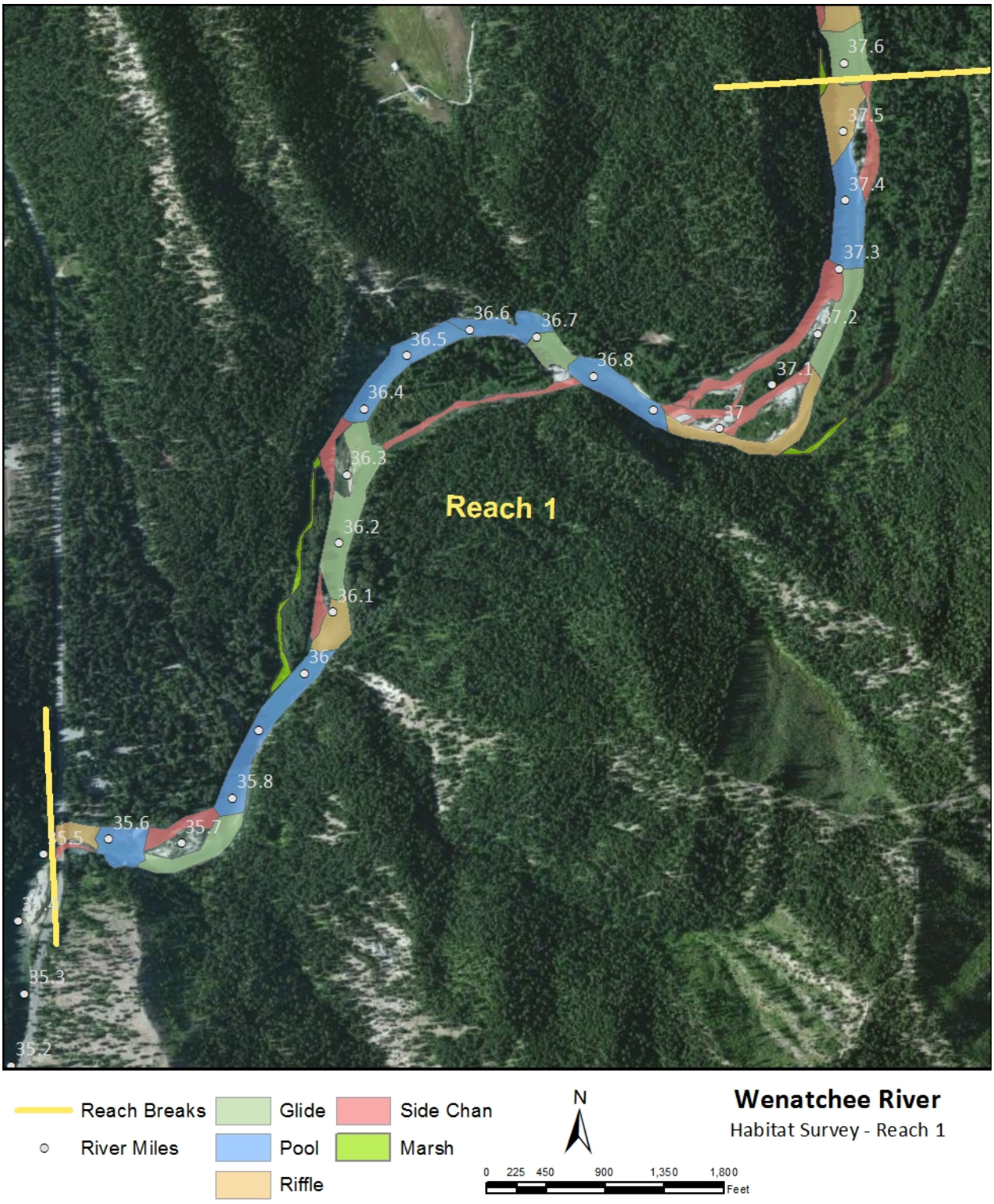


Figure 13. Reach 1 locator and habitat unit composition map.

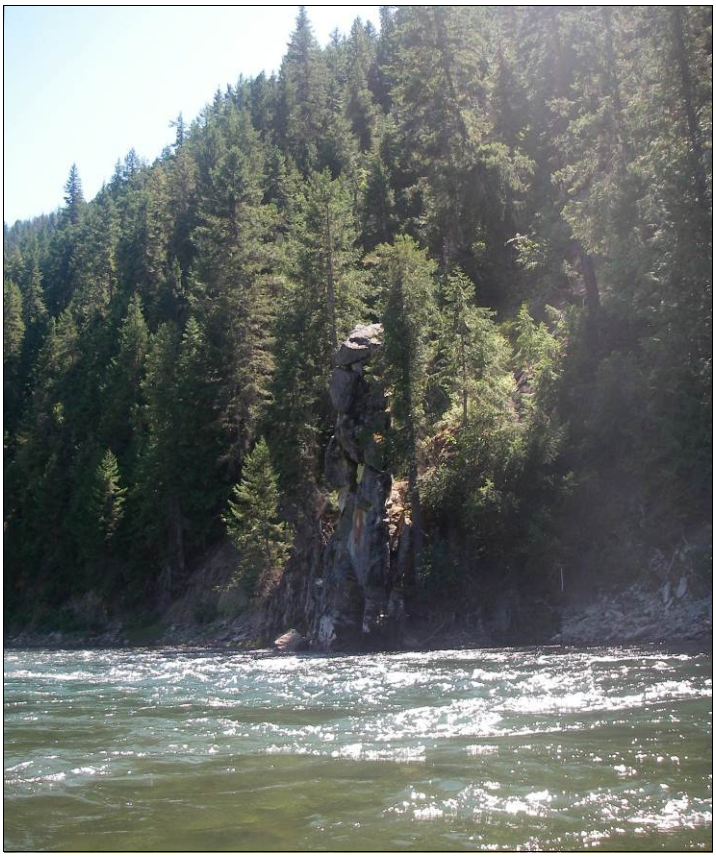


Figure 14. View looking upstream towards the left bank sedimentary conglomerate hillslope at RM 36.8 (August 2011).

A-1.2 Habitat Unit Composition

Reach 1 consisted of 40% pool, 26% glide, 24% side-channel, and 10% riffle habitat (Figure 3 and Figure 4). Pool frequency was 2.7 pools/mile, with mean pool spacing of 9.4 channel widths per pool. Average residual pool depth was 7.4 feet. Average maximum pool depth was 11.1 feet.

Reach 1 had the highest pool count (6) and the two deepest pools when compared to other reaches in the Upper Wenatchee study area. The maximum pool depths were estimated to be at least 15 and 20 feet. Additionally, Reach 1 had the highest side-channel habitat by area (24%) and second highest count of side-channel units (8).

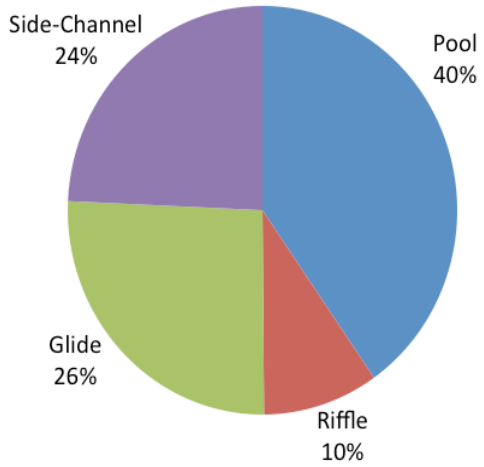


Figure 15. Habitat unit composition for Reach 1.

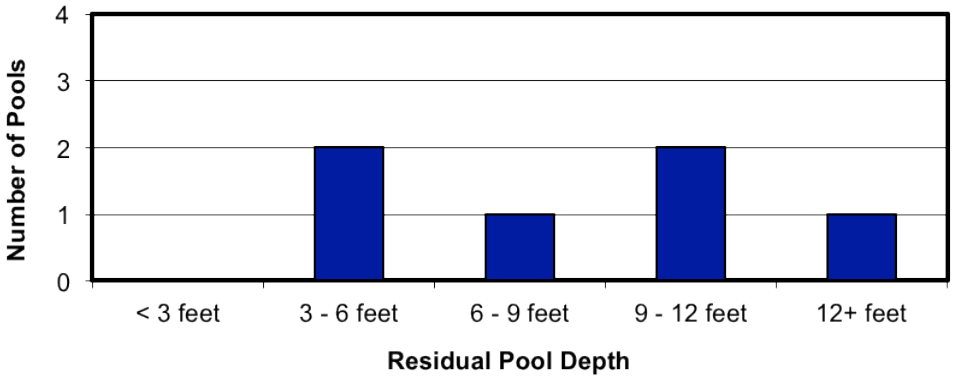


Figure 16. Reach 1 residual pool depths.

A-1.3 Off-Channel Habitat

Reach 1 had the greatest diversity of off-channel habitats found throughout the Upper Wenatchee study area. Eight side channels and two backwater marshes were observed in Reach 1. All backwater marshes and side-channels had evidence of being activated during high flow and flood events. Beaver and bear activity was observed throughout the reach, especially in off-channel and floodplain habitats. Reach 1 had two distinct braided side-channel complexes with high habitat diversity.

The first side-channel complex (RM 35.95 to 36.35) was located in a wide well-connected floodplain valley. A backwater marsh that appeared to be historically used for splash damming (based on remnant creosote pilings in the channel) paralleled the main channel (RM 35.95 to RM 36.30) (Figure 5). Thick shrubs and wetland vegetation (spirea, dogwood, alder, willow, and

cottonwood) lined the channel. Large Woody Debris (LWD) and beaver activity were found throughout the marsh. Additionally, there was a large LWD jam at the upstream end (RM 36.3) blocking regular streamflow from entering the channel. Two small side-channels flowed along the right bank (RM 36.15 and RM 36.35) and were separated from main channel flow by cobble bars vegetated with young willows. Both side-channels had spawning gravels and canopy cover and would provide juvenile salmonid refuge during high mainstem flows (Figure 6). Creosote pilings were found embedded in both side-channels.

Further upstream (RM 36.90 to 37.25) was a second side-channel complex located where the floodplain narrowed and became confined by steep sedimentary hillslopes (along both banks). A straight side-channel (Figure 7) paralleled the mainstem along the right bank, separated by a well-vegetated island with small ponderosa pine, willow, alder, and dogwood. Streamflow was deep and swift, providing little spawning or rearing habitat, with the exception of the pool tail-out at the downstream end. Abundant LWD was found throughout the side-channel, including both remnant harvested (cut ends) and naturally recruited logs. The main channel flowed along a left bank connected floodplain and split into an additional side-channel (RM 37.1) with small braids towards the downstream end. A backwater marsh located along the left bank (RM 37.05) abutted the steep sedimentary hillslope at a meander bend. Ponded along the downstream end (Figure 8), the channel narrowed to two small beaver damned pools. Salmonid fry were observed in these pools. This backwater marsh may function as a high flow channel during flood events, yet year-round inputs persist with hyporheic flow.

Between these two complexes was a meander bend side-channel (RM 36.35 to RM 36.80). It flowed along a left bank terrace separated from the main channel by a densely vegetated island. The side-channel may have been simplified by historical logging operations. This side-channel appeared to provide spawning, rearing, and flood refuge habitat (Figure 9).

Additional off-channel habitat was observed along the upstream portion of Reach 1, including a left bank disconnected side-channel (RM 37.40 to RM 37.55) and a right bank backwater marsh (RM 37.55). The side-channel was well defined and appeared to function as a high flow channel during flood events. This disconnected side-channel had an elongated pond along the floodplain surface and upstream hyporheic flow inputs. Waterfowl and bear foraging was observed. The backwater marsh was located along a river-right floodplain surface and was maintained by small seeps or hyporheic flow. It was densely vegetated with mature alder and willow.

Figure 17. A backwater marsh (RM 35.95to RM 36.30) has filed in a historical splash dam channel along the right bank floodplain surface in Reach 1 (August 2011).

Figure 18. View looking downstream at a side-channel near RM 36.15 that provides spawning, rearing, and refuge habitat in Reach 1 (August 2011).

Figure 19. View looking downstream towards a river-right side-channel at RM 37.25.

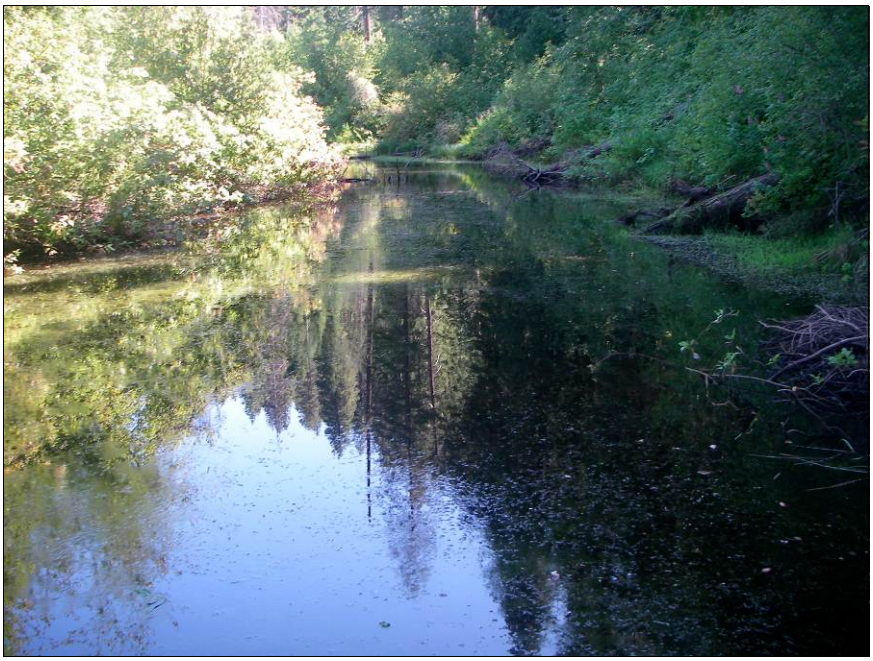


Figure 20. View looking upstream along a ponded backwater marsh at RM 37.05 (river-left). A left bank steep forested hillslope confines and shades the marsh while providing large and small woody debris (August 2011).

Figure 21. View looking upstream at a meander bend side-channel (RM 36.35 to RM 36.80) with sparsely vegetated cobble bars and LWD.

A-1.4 Large Woody Debris

Reach 1 had the second highest LWD count in the study area, totaling 642 pieces (Table 1). Reach 1 had the highest LWD frequency for the study area, at 294 pieces/mile. "Small" pieces comprised 51% of all LWD counted in the reach, "medium" comprised 21%, and "large" pieces comprised 28%. LWD recruitment potential is very high both in the short and long-term. Local topography and off-channel habitats recruit large quantities of woody material (Figure 10).

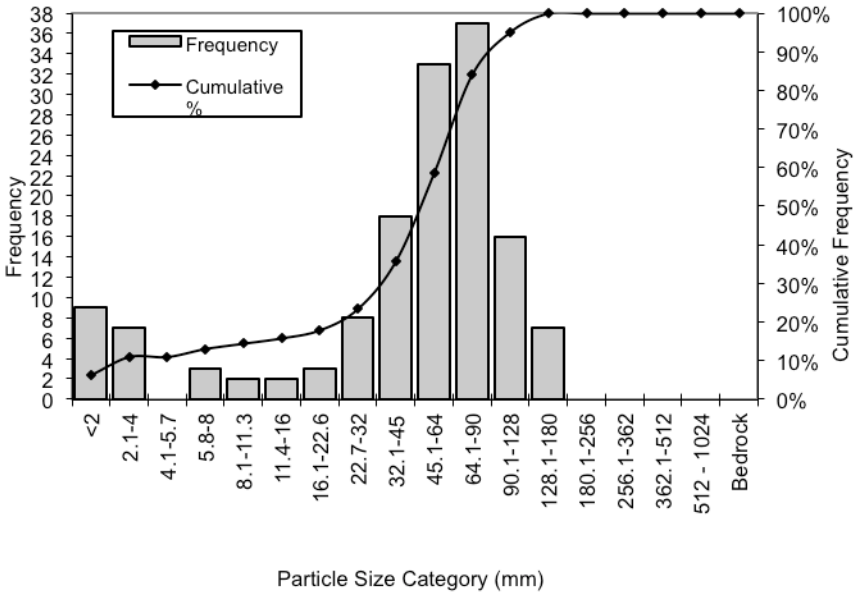
Table 2. Large woody debris quantities in Reach 1.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	331	178	133	642
Number of Pieces/Mile	151	81	61	294

Figure 22. LWD jams contribute to island formation and bank stabilization, Reach 1 (August 2011).

A-1.5 Substrate and Fine Sediment

Bed substrate was dominated by gravels and cobbles. Boulders made up 7% of the distribution. Bedrock was observed in two isolated units in Reach 1 and made up less than 0.5% of the distribution. Bedrock was encountered where the steep sedimentary hillslope abutted the channel at RM 35.9 and RM 37.0. Percent fines (<2mm) were low to moderate (6-17%) based on the ocular estimates and pebble counts. Only one pebble count was attainable in Reach 1 due to high water conditions. A side-channel riffle was sampled; mainstem riffles were too deep and swift. The pebble count and size class data are depicted in Figure 11 and Figure 12.



Material	Percent Composition
Sand	6%
Gravel	52%
Cobble	41%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	<2
D16	16
D50	57
D84	90
D95	126

Figure 23. Grain size distribution and particle size classes from pebble count taken at RM 35.75.

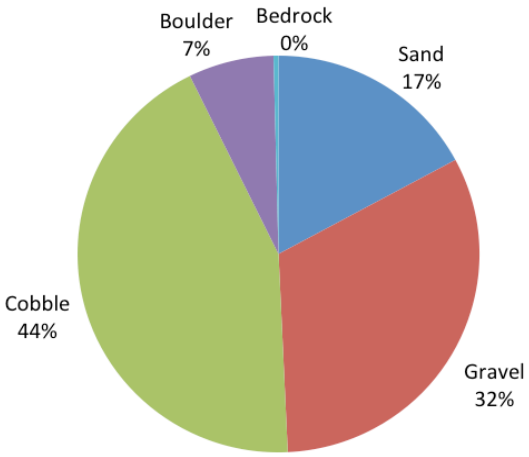


Figure 24. Percent composition of bed substrate based on ocular estimates, Reach 1.

A-1.6 Instability and Disturbance

Human activities have impacted the channel, floodplain, and associated riparian corridor within the reach. The primary elements of disturbance were remnants from historical timber harvest and logging operations throughout Reach 1 (Figure 13). Embedded creosote logs and straightened splash dam channels remain at several locations throughout the reach. There is a campground (RM 35.6) and hiking trail along the right bank but their level of disturbance is low. The Hwy 2 Bridge had localized riprap armoring and construction disturbance. It is unlikely that there will be future floodplain development or vegetation clearing within Reach 1 under current US Forest Service management.

Erosion was moderate when compared to other reaches within the Upper Wenatchee study area. Reach 1 had a total of 4,266 feet of actively eroding streambank (measured above bankfull), consisting of 11% of the reach length along both banks. Bank disturbance was associated with steep banks and exposed sedimentary hillslopes primarily along left bank pool habitats. Active erosion was observed along the left bank floodplain surface of the meander bend side-channel (RM 36.35 to RM 36.80).

Figure 25. Wood pilings that are presumed to be remnants from historical log drives are found throughout Reach 1.

A-1.7 Available Spawning and Rearing Habitat

There was abundant spawning and rearing habitat in Reach 1. Bed substrate was dominated by gravels (32-52%) and cobbles (41-44%). Many of the side-channels and pool tail-outs provided substrate for both Chinook (13-102 mm) and steelhead (6-102 mm). Coho may use the smaller, more protected, braided side-channels (Figure 14). Several large Chinook were observed (August 17, 2011) holding in the reach's deep pools.

Reach 1 had abundant pool habitat. This reach provided refugia and canopy cover in off-channel habitats and along lateral margins. LWD was plentiful and will continue to provide habitat and complexity in Reach 1.

Figure 26. Spawning gravel and rearing habitat near RM 36.9 where the channel becomes confined at the downstream end of a side-channel complex (August 2011).

A-1.8 Riparian Corridor

Reach 1 had a healthy and undisturbed forested riparian corridor. Very little development or human infrastructure was found in Reach 1. Disturbance of the riparian corridor was limited to the area surrounding the Hwy 2 Bridge (RM 35.5) and campground.

The riparian zone along Reach 1 was dominated by large trees (55%) (Figure 15), primarily consisting of conifers (59% conifers, 36% hardwoods, 5% shrubs). Small trees were subdominant (36%). Douglas fir, ponderosa pine, cottonwood, willow, dogwood, alder, and oceanspray were the most prevalent riparian species. Side-channels and backwater marshes found in Reach 1 also had wetland vegetation that included, cottonwood, willow, dogwood, alder, spirea, carex, rushes, sedges, and assorted floating aquatics.

The level of stream shade provided by the riparian canopy and local topography was high throughout Reach 1. A dense understory also provided canopy cover and refuge along lateral margins. Large snags were observed along the steep hillslopes bordering Reach 1.

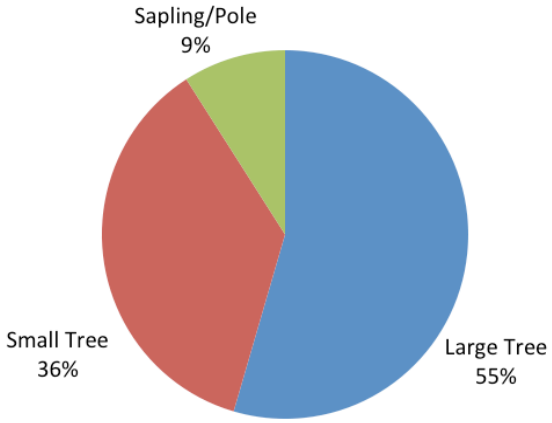


Figure 27. Distribution of the dominant size class category for the riparian zone, Reach 1.

A-2 Reach 2

Location: River mile 37.6 to 38.6

Survey Date: August 16, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-2.1 Reach Overview

Reach 2 is a marginally transport dominant reach that runs from RM 37.6 to RM 38.6. The reach is low gradient (0.25%) and flows through a partially-confined valley of alternating alluvial surfaces and steep hillslopes. Channel form is slightly meandering and morphology is plane-bed. The reach lies within a slightly more confined valley than adjacent reaches. Fast water habitat dominates much of Reach 2 (Figure 16). Land is managed by the US Forest Service. There is no bank armor or human built features directly impacting this reach. Reach 2 is connected to narrow elongate floodplains along most channel margins. See reach locator and habitat unit map in Figure 17.

Figure 28. View looking upstream at the reach boundary near RM 38.5 (August 2011).

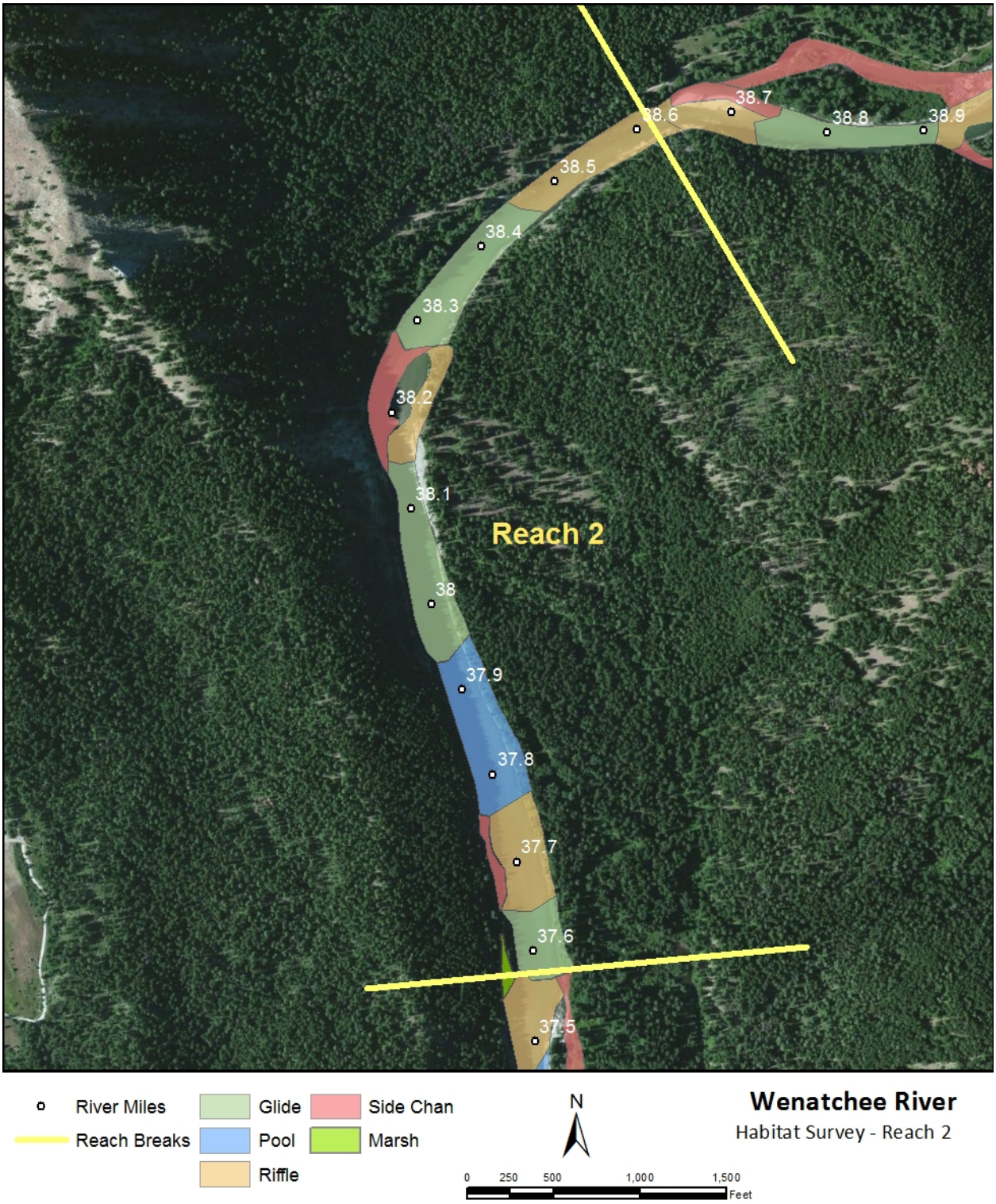


Figure 29. Reach 2 locator and habitat unit composition map.

A-2.2 Habitat Unit Composition

Reach 2 consisted of 47% glide, 34% riffle, 13% pool, and 6% side-channel habitat (Figure 18 and Figure 19). Pool frequency was 0.9 pools/mile, with mean pool spacing of 28.3 channel widths per pool. Reach 2 had one of the lowest pool quantities (1 pool) when compared to other reaches within the study area. Residual pool depth was 3.5 feet. Maximum pool depth was 6.5 feet.

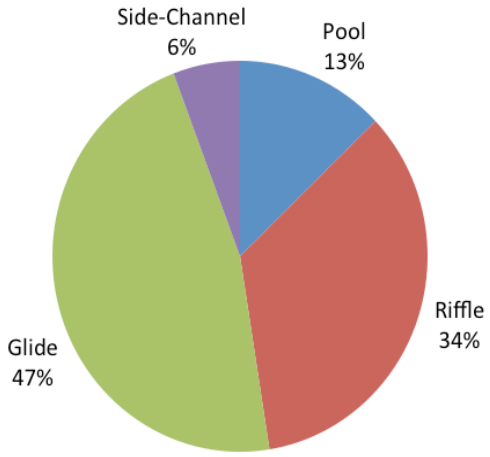


Figure 30. Habitat unit composition for Reach 2.

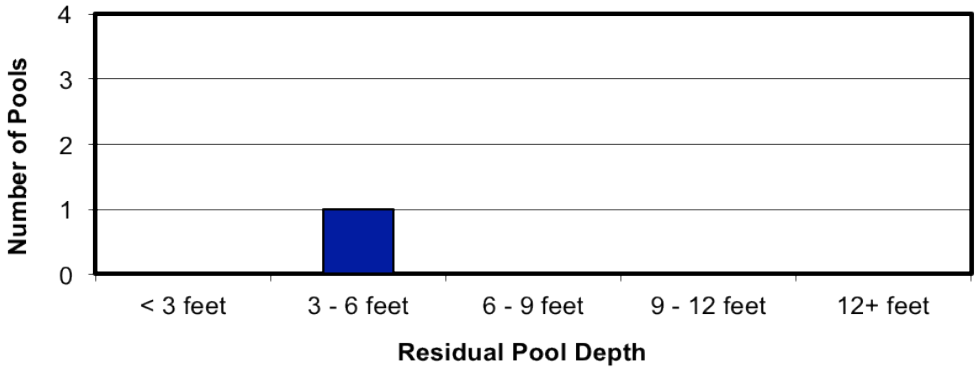


Figure 31. Reach 2 residual pool depths.

A-2.3 Off-Channel Habitat

There were two side-channels in Reach 2. A small side-channel, located at RM 37.7, provided some of the only slow water refuge, canopy cover, and LWD observed throughout Reach 2 (Figure 21). It was located near a narrow elongate floodplain surface that abuts the steep hillslope on river-right. A small sparsely vegetated (rushes, grasses, and small willows) sandbar separated this off-channel unit from the mainstem. A second side-channel (RM 38.2) was wide,

shallow, and dominated by small cobbles (Figure 21). It lacked habitat features common throughout many of the off-channel units of the Upper Wenatchee study area.

Figure 32. View looking downstream at a river-right side-channel near RM 37.7 that has a frequently inundated sandbar with willow and grasses (August 2011).

Figure 33. View looking downstream at a shallow, fast water side-channel near RM 38.2 (August 2011).

A-2.4 Large Woody Debris

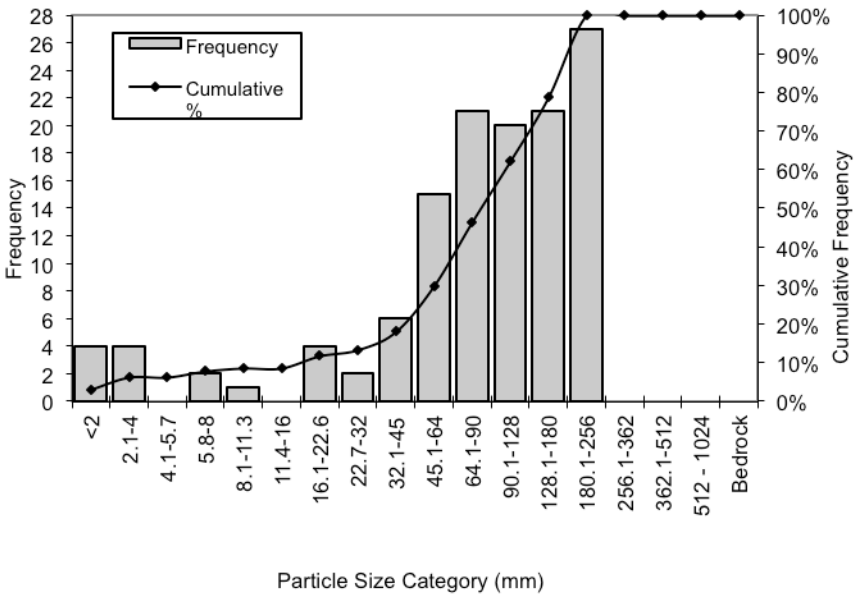
LWD quantities were relatively low in Reach 2 compared to other reaches in the study area. LWD frequency was 47 pieces/mile, with "small" pieces comprising 44% of all LWD counted in the reach (Table 2). "Medium" and "Large" wood pieces comprised 56% of the LWD in the reach; 17% and 38% respectively. LWD recruitment potential was limited in the short-term because Reach 2 lacks channel complexity and off-channel habitats that aid in recruitment. Long-term LWD sources were available along the steep hillslopes bordering Reach 2 and from upstream sources.

Table 3. Large woody debris quantities in Reach 2.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	23	9	20	52
Number of Pieces/Mile	21	8	18	47

A-2.5 Substrate and Fine Sediment

Bed substrate was dominated by cobbles. Gravels were subdominant. Boulders made up 15% of the distribution. Bedrock was observed in two isolated units in Reach 2 and made up less than 2% of the total distribution. Bedrock was encountered where the steep sedimentary hillslope abutted the channel at RM 37.9 and RM 38.6. Percent fines (<2mm) were low (3-13%) based on the ocular estimates and pebble counts. Only one pebble count was attainable in Reach 2 due to high water conditions. The pebble count and size class data are depicted in Figure 22 and Figure 23.



Material	Percent Composition
Sand	3%
Gravel	27%
Cobble	70%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	3
D16	39
D50	99
D84	199
D95	238

Figure 34. Grain size distribution and particle size classes from pebble count taken at RM 38.3.

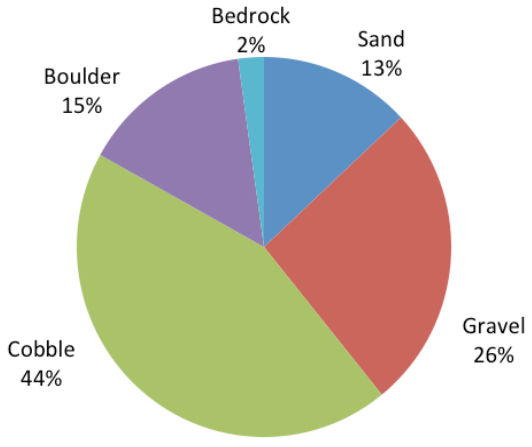


Figure 35. Percent composition of bed substrate based on ocular estimates, Reach 2.

A-2.6 Instability and Disturbance

Human activities have had minimal recent impact to the channel, floodplain, and associated riparian corridor within the reach. Any disturbance within Reach 2 was either related to natural process or remnants from historical logging operations. It is unlikely that there will be future floodplain development or vegetation clearing within Reach 2 under current US Forest Service management.

Erosion was very low when compared to other reaches within the Upper Wenatchee study area. Reach 2 had a total of 49 feet of actively eroding streambank (measured above bankfull), consisting of 0.4% of the reach length along both banks. Similar to what was observed in Reach 1, bank disturbance was associated with unstable banks along floodplain surfaces and exposed sedimentary hillslopes along the left bank. The only active erosion observed in Reach 2 was along a left bank steep hillslope at the gradual meander bend near RM 38.55. Additional disturbance was observed along a left bank terrace near RM 38.2 that was noticeably void of understory vegetation.

A-2.7 Available Spawning and Rearing Habitat

There was a moderate amount of spawning and rearing habitat available in Reach 2. The dominant substrate in the riffles was cobble (70%) and subdominant was gravel (27%). Although steelhead and spring Chinook spawning occurs in this reach, many of the pool tail-outs and side-channel areas consisted of large cobbles (> 128 mm) that are larger than the ideal size for Chinook (i.e. 13 – 102 mm) and steelhead (6 – 102 mm) spawning. However, coarse bed material provided areas of localized velocity refuge that may be utilized during migration and by rearing juvenile steelhead.

Pool quantity within Reach 2 was low. The one pool (13% of reach total) provided adequate residual depth greater than 3 feet. This reach primarily functions as a spawning and migration reach, as it lacks both LWD and off-channel rearing areas.

A-2.8 Riparian Corridor

Reach 2 had a healthy and undisturbed forested riparian corridor, with the exception of a lack of understory vegetation along the left bank floodplain surface near RM 38.2. No development or human infrastructure has recently affected the riparian corridor in Reach 2.

The riparian zone along Reach 2 was dominated by large trees (56%) (Figure 24), primarily consisting of conifers (78% conifers, 22% hardwoods). Small trees were subdominant (33%). Douglas fir, ponderosa pine, cottonwood, maple, willow, alder, and rose were the most prevalent riparian species.

The level of stream shade provided by the riparian canopy and local topography was moderate throughout Reach 2. Small shrubs and saplings have recruited along low-elevation floodplains (Figure 25), providing canopy cover and localized refuge along lateral margins.

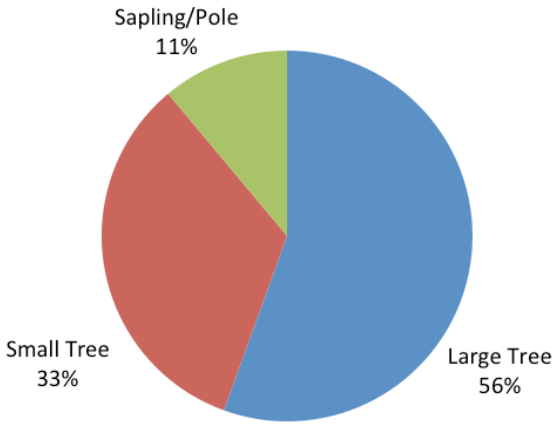


Figure 36. Distribution of the dominant size class category for the riparian zone, Reach 2.

Figure 37. Small shrubs and saplings have recruited on a low-elevation floodplain along Reach 2 (August 2011).

A-3 Reach 3

Location: River mile 38.6 to 41.9

Survey Date: August 15, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-3.1 Reach Overview

Reach 3 extends from a side-channel complex at RM 38.6 to the Burlington Northern Railroad Bridge at RM 41.9. It flows through an artificially and naturally partially-confined valley, bordered by low-elevation floodplains, moderately sloping banks, steep terrace banks (of the Chumstick formation), and bank hardening materials. Channel form is meandering with braiding in the lower portion of the reach. The reach has a gradient of 0.29%. Bed morphology is primarily pool-riffle with some riffle-glide units. Land use in Reach 3 is predominantly private residential property along river-right and US Forest Service managed land along river-left. There are homes, roads, and a railroad along the river-right floodplain from RM 39.0 to 41.9. River Road parallels the channel from RM3 9.4 to RM 41.9 on river-right. Road dissection, vegetation removal/alteration, homesite construction, and bank hardening material are common throughout this portion of Reach 3. Despite human disturbance along much of the reach, Reach 3 had relatively abundant off-channel habitat and LWD (Figure 26). See Figure 27 for a reach overview and habitat unit map.

Figure 38. View looking downstream towards a high-flow side-channel along the left bank at RM 39.0 (August 2011).

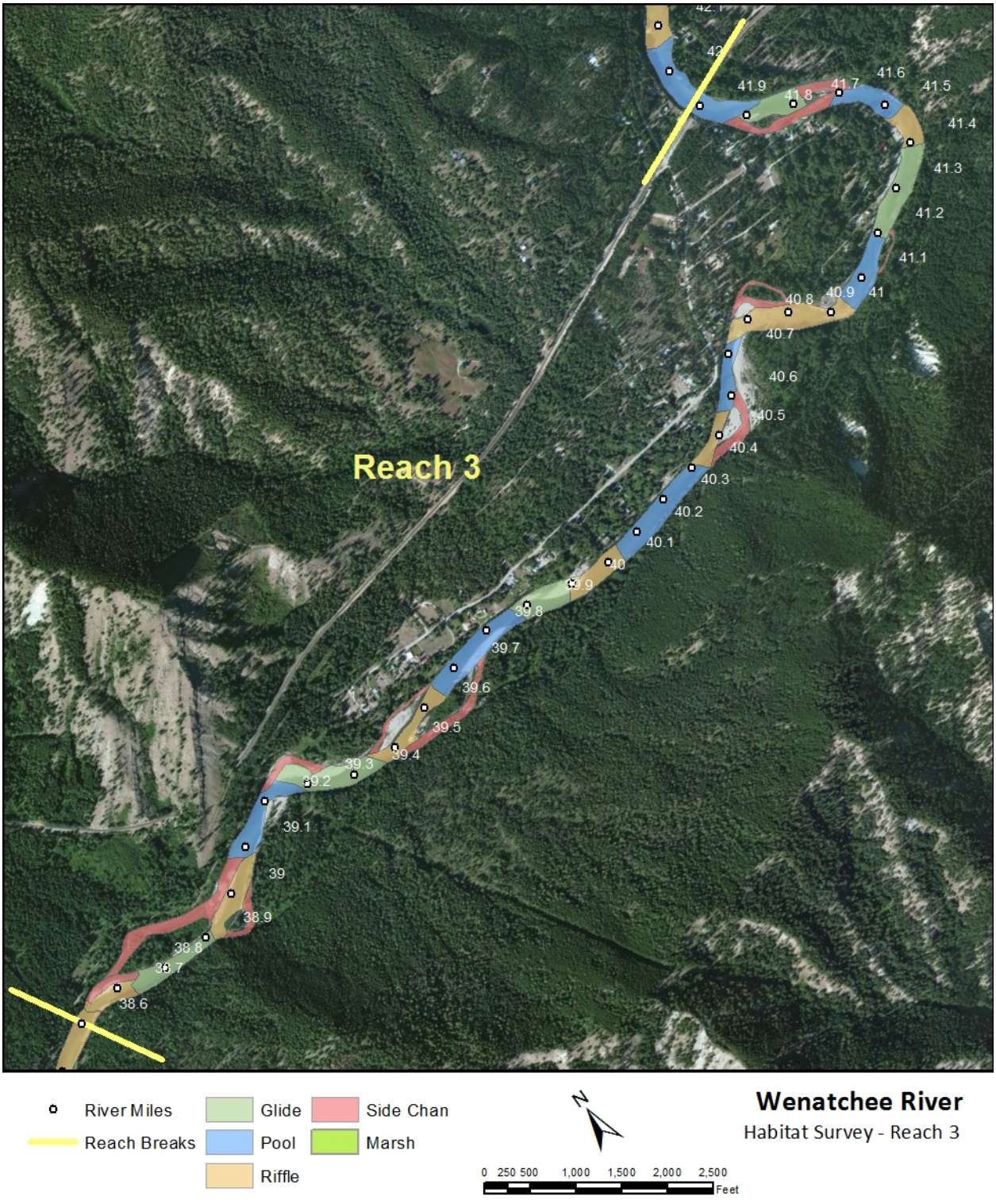


Figure 39. Reach 3 locator and habitat unit composition map.

A-3.2 Habitat Unit Composition

Reach 3 consisted of 31% riffle, 27% pool, 23% glide, and 19% side-channel habitat (Figure 28 and Figure 29). Pool frequency was 1.9 pools/mile, with a mean pool spacing of 14.9 channel widths per pool. Average residual pool depth was 6.2 feet. Average maximum pool depth was 9.6 feet. Reach 3 had the second highest proportion of side-channel habitat by area and the highest number of side-channel units (12).

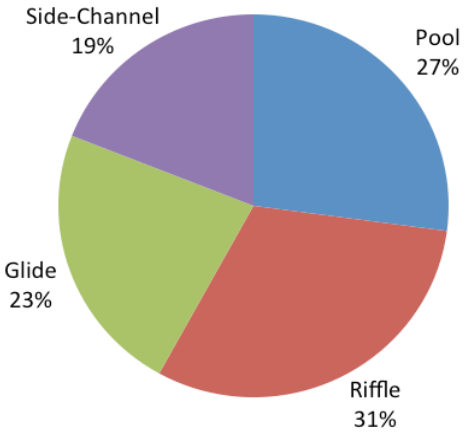


Figure 40. Habitat unit composition, Reach 3.

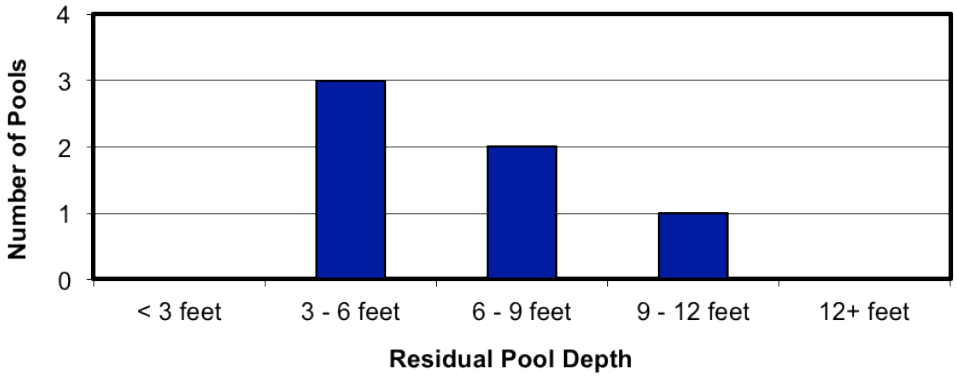


Figure 41. Reach 3 residual pool depths.

A-3.3 Off-Channel Habitat

There were 12 side-channels in Reach 3, comprising 19% of the total reach area. This was the second highest proportion of side-channel habitat by area and the highest number of side-channel units compared to other reaches in the Upper Wenatchee study area. Side-channels generally had vegetated island and bar development, and were often associated with LWD jams and beaver activity.

A side-channel complex just upstream of the reach boundary (RM 38.6 to RM 39.1) included a large forested island and expansive cobble bar. The cobble bar accumulated three LWD jams and extended nearly 0.2 RMs upstream from the stable mid-channel island (RM 38.70-38.95). Large conifers, mature cottonwoods, and a dense understory provided island refuge for deer and other riparian mammals. A right bank side-channel braided through additional LWD jams, gravel bars, and small-vegetated islands (Figure 30). Several spring Chinook were observed actively spawning throughout the lower braided side-channel (August 16, 2011). A small high-flow side-channel was found along the left bank floodplain at RM 38.9 to RM 39.0. Ponded water was observed along the downstream end where the channel abuts a steep sedimentary hillslope, which continues downstream and confines the side-channel along the left bank (Figure 31).

Several narrow disconnected high-flow side-channels were found along the developed floodplain surfaces further upstream in Reach 3. Many of these side-channels flowed around sparsely vegetated, yet highly stable cobble bars that have endured for over 40 years (verified with 1966 WSDOT aerial photos). High water or hyporheic flow maintains these wetted disconnected side-channels (Figure 32). Fry, waterfowl, and wetland vegetation was found in many of the off-channel units in Reach 3. The narrow floodplain surfaces and off-channel habitats throughout Reach 3 are impacted by residential development (Figure 33).

No off-channel marshes were identified within this reach. Reach 3 likely had higher historical off-channel complexity that has been reduced as a result of development and river management, especially along the right bank.

Figure 42. A right bank braided side-channel provides excellent spawning and rearing habitat near RM 38.75 in the lower portion of Reach 3 (August 2011).

Figure 43. Left bank floodplain and off-channel habitat at RM 38.9 to RM 39.0 abuts a steep sedimentary hillslope that continues downstream confining the side-channel complex along river-left (August 2011).

Figure 44. Representative disconnected (at average flows) side-channel found throughout the upper portion of Reach 3. Many of these side-channels flow around sparsely vegetated, yet highly stable cobble bars. High water or hyporheic flow maintains surface water in these side-channels (August 2011).

Figure 45. A low elevation floodplain surface along river-right affected by clearing and residential impacts (RM 40.1).

A-3.4 Large Woody Debris

LWD quantities were high in Reach 3. Reach 3 had the highest LWD count in the upper Wenatchee study area, totaling 785 pieces (Figure 34). LWD frequency was 252 pieces/mile, with "small" pieces comprising 47% of all LWD counted in the reach (Table 3). "Medium" and "Large" wood pieces comprised 53% of the LWD in the reach, with 26% and 27% respectively. Reach 3 had the second highest LWD frequency compared to other reaches in the study area. LWD recruitment potential was very high both in the short and long-term. Local topography and off-channel habitats recruit large quantities of woody material (Figure 35).

Table 4. Large woody debris quantities in Reach 3.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	372	202	211	785
Number of Pieces/Mile	119	65	68	252

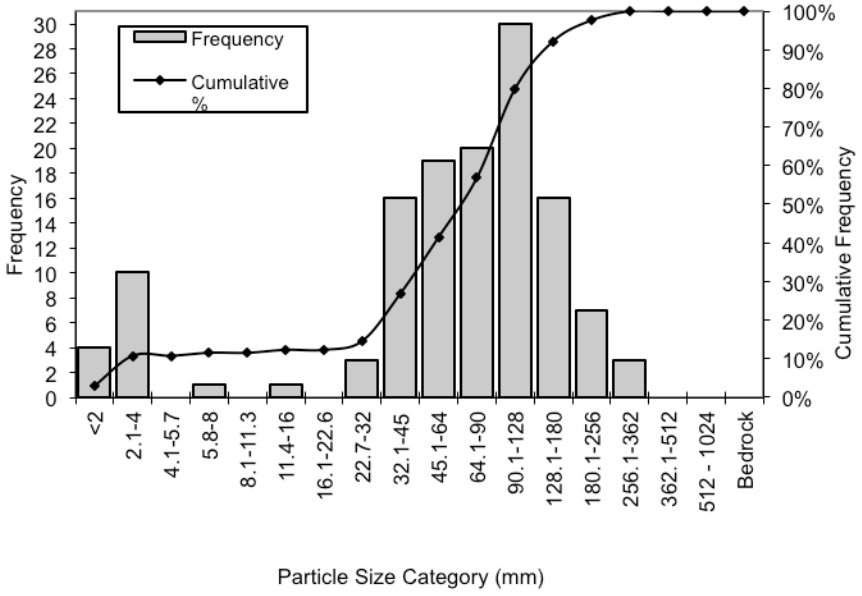
Figure 46. The largest LWD jam observed throughout the Upper Wenatchee study area was located in Reach 3, just downstream of the Burlington Northern Railroad Bridge at RM 41.8 (August 2011).

Figure 47. LWD with attached root wad provides habitat complexity and refuge in Reach 3 (August 2011).

A-3.5 Substrate and Fine Sediment

Bed substrate was dominated by cobbles. Gravels were subdominant, and boulders made up 12% of the distribution. Bedrock was observed in Reach 2 but made up less than 4% of the total

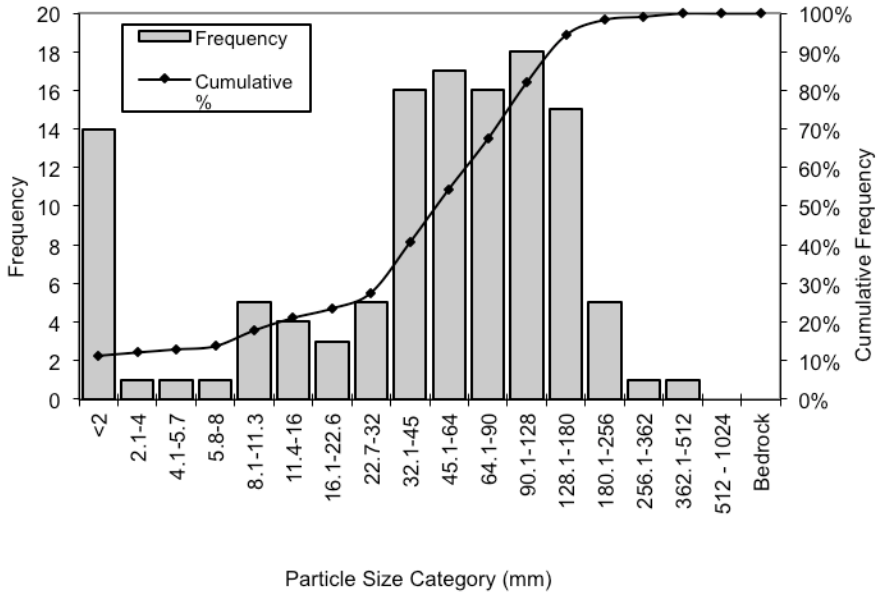
distribution. Larger quantities of bedrock were encountered along two left bank side-channels at RM 39.0 and RM 40.55. Percent fines (<2mm) were low to moderate ranging from 3-19% based on the ocular estimates and pebble counts. The pebble count and size class data are depicted in Figure 36, Figure 37, and Figure 38.



Material	Percent Composition
Sand	3%
Gravel	38%
Cobble	56%
Boulder	2%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	3
D16	33
D50	78
D84	145
D95	218

Figure 48. Grain size distribution and particle size classes from pebble count taken at RM 38.7.



Material	Percent Composition
Sand	11%
Gravel	43%
Cobble	44%
Boulder	2%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	<2
D16	10
D50	76
D84	136
D95	193

Figure 49. Grain size distribution and particle size classes from pebble count taken at RM 41.0.

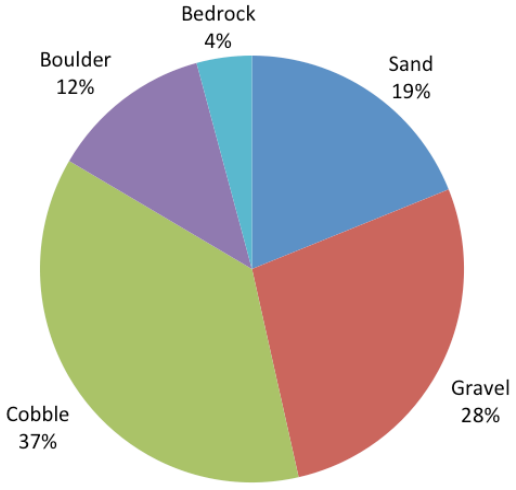


Figure 50. Percent composition of bed substrate based on ocular estimates, Reach 3.

A-3.6 Instability and Disturbance

Human activities have modified the channel, floodplain, and associated riparian corridor within the reach. Primary elements of disturbance include channel simplification, channel confinement, bank armoring, floodplain development, loss of an intact riparian buffer, the railroad, and roadways.

Bank erosion was moderate when compared to other reaches within the study area. Reach 3 had a total of 5,721 feet of actively eroding streambank (measured above bankfull), consisting of 11% of the reach length along both banks. Bank disturbance was often associated with land clearing, roadways, residential uses, river access, and steep banks along terrace surfaces. Erosion was greatest between RM 39.7 to RM 39.9 and from RM 40.3 to RM 40.7 (1,100 and 1,284 feet, respectively). This portion of Reach 3 has been straightened and highly armored with large boulder riprap and spur dikes. Additional bank hardening material was observed near RM 39.55-39.7, RM 41.1-41.2, and RM 41.53-41.81 (Figure 39).

Other areas of impact include: the Burlington Northern Railroad Bridge (RM 41.9) crossing; River Rd abuts and parallels the channel (RM 39.4 to RM 40.7); and a power line corridor (RM 39.22) crosses the channel. These sites are associated with fill and grading, bank armor, land clearing, clearing of riparian buffers, and fragmentation of the riparian corridor and floodplain. Localized artificial channel constriction is present at the upstream end of the reach from bridge abutments and associated riprap related to the railroad. Natural bank disturbance occurred at few isolated locations in Reach 3 (Figure 40).

Figure 51. Concrete bank armor and riprap prevent natural channel process along much of Reach 3's right bank as seen near RM 41.7 (August 2011).

Figure 52. Erosion along the right bank continues upstream at this meander bend near RM 39.25.

A-3.7 Available Spawning and Rearing Habitat

Off-channel units provided abundant spawning and rearing habitat in Reach 1. Mean riffle substrate was dominated by cobbles (51%), with gravels subdominant (40%, from ocular estimates). Many of the side-channels and pool tail-outs provided substrate for both Chinook (13-102 mm) and steelhead (6-102 mm) spawning, yet mainstem riffle substrates were often larger than these ranges (Figure 41). Spring Chinook were observed actively spawning (August 16, 2011) throughout the side-channel complex in lower Reach 3 and along the right bank channel from RM 38.6 to RM 39.1. This portion of Reach 3 provided some of the best spawning and rearing habitat observed throughout the Upper Wenatchee study area.

Reach 3 had moderate pool habitat (27% total reach area). This reach provided refugia and canopy cover in off-channel habitats and along lateral margins. LWD was relatively abundant but log jam frequency was relatively low.

Figure 53. Large substrate was encountered throughout many mainstem Reach 3 riffles and bars (August 2011).

A-3.8 Riparian Corridor

The presence and width of the forested riparian buffer varied within Reach 3. The riparian corridor was disconnected and fragmented by private residential properties, roads, and the railroad along most of the right bank from RM 39.0 to RM 41.9. The presence of a riparian buffer was scarce and fragmented along right bank residential properties, some with lawns extending to the top of bank (Figure 42). Conifer forest dominated the US Forest Service Lands along river-left, while cottonwood and shrubs were dominant along floodplain surfaces along river-right.

The riparian zone along Reach 3 was dominated by small trees (44%) (Figure 43), primarily consisting of conifers (50% conifers; 47% hardwoods, 3% shrubs). Large trees were subdominant (40%). Cottonwood, Douglas fir, ponderosa pine, willow, and alder were the most prevalent riparian species.

The level of stream shade provided by the riparian canopy was moderate throughout Reach 3. Local topography and large conifers provided ample morning and afternoon shade.

Figure 54. Riparian buffers were scarce and highly fragmented along much of Reach 3's right bank (August 2011).

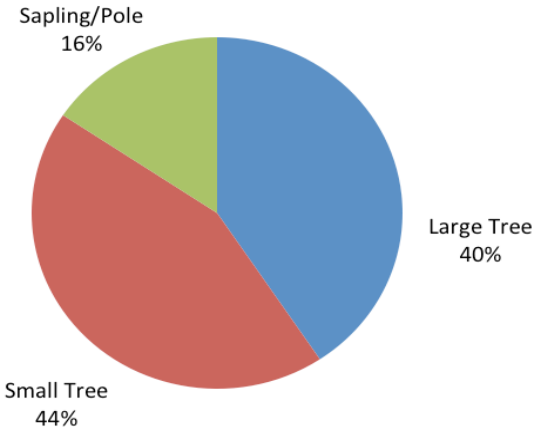


Figure 55. Distribution of the dominant size class category for the riparian zone, Reach 3.

A-4 Reach 4

Location: River mile 41.9 to 43.1

Survey Date: August 12, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-4.1 Reach Overview

Reach 4 is located in a naturally confined valley from the Burlington Northern Railroad Bridge at RM 41.9 to RM 43.1. Steep terrace banks and gradually sloping floodplains alternate throughout this reach (Figure 44). Overall slope of the reach is 0.24%. Channel form is meandering and bed morphology is pool-riffle. Reach 4 has good habitat complexity and potential for additional enhancement opportunities. Land use throughout Reach 4 includes large private land parcels, residential property, and roadways. Localized artificial channel constriction is present at the downstream end of the reach from bridge abutments and associated riprap related to the railroad. Riprap is located upstream of the railroad bridge and along the channel at a few scattered private properties.

Several low elevation floodplain surfaces and narrow elongate floodplains are scattered between steep terrace banks. Loss of floodplain functions results from road building, fill and grading, vegetation removal/alteration, and development of homesites. See Figure 45 for a reach overview and habitat unit map.

Figure 56. View looking upstream at the boundary of Reach 4 (RM 43.1). High bank exposure from the Chumstick formation confines the channel along river-left (August 2011).

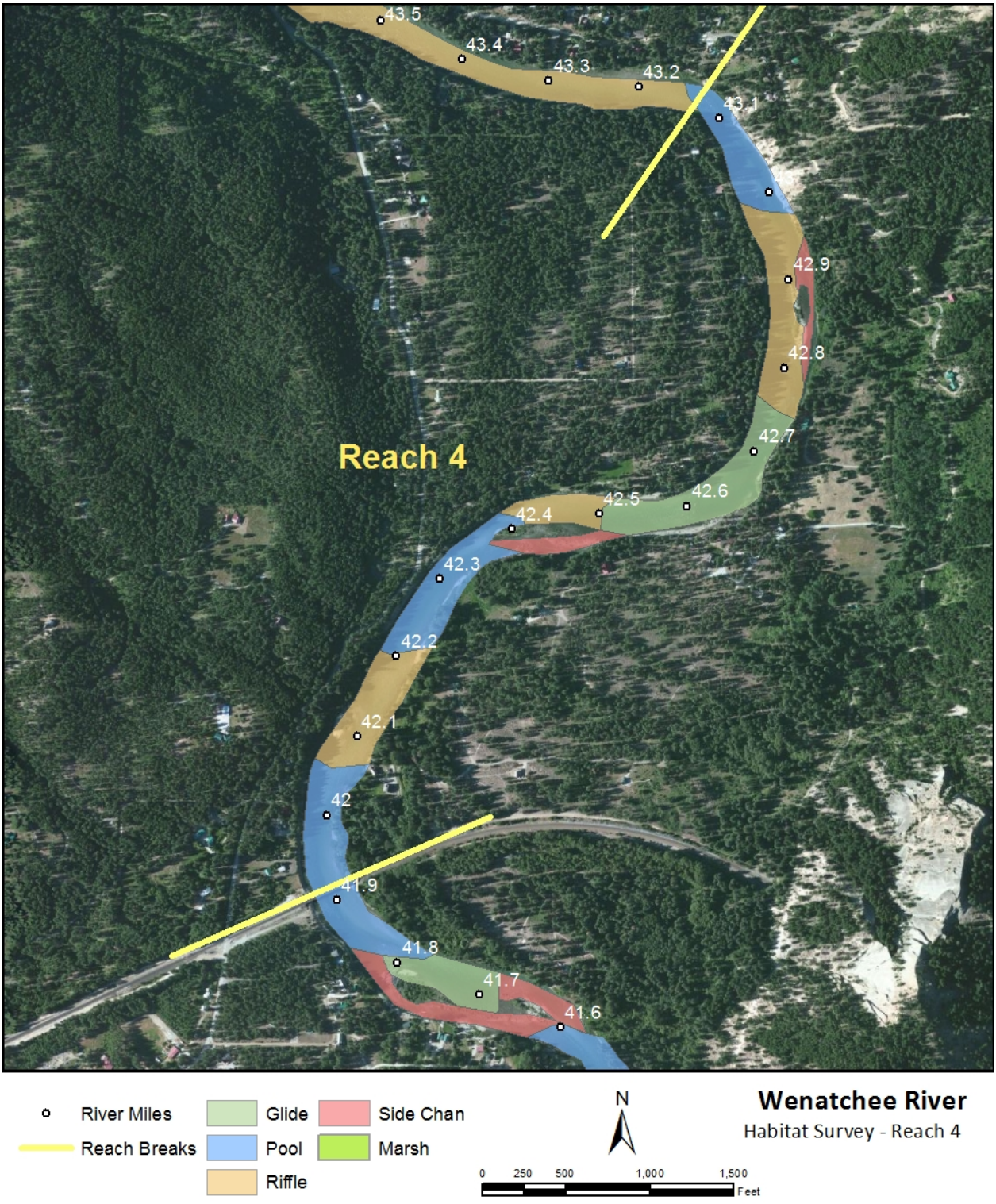


Figure 57. Reach 4 locator and habitat unit composition map.

A-4.2 Habitat Unit Composition

Reach 4 consisted of 41% pool, 30% riffle, 22% glide, and 7% side-channel habitat (Figure 46 and Figure 47). Pool frequency was 2.2 pools/mile, with mean pool spacing of 9.9 channel widths per pool. Average residual pool depth was 6.7 feet. Average maximum pool depth was 10.0 feet. Reach 4 had the second highest pool frequency when compared to other reaches within the study area.

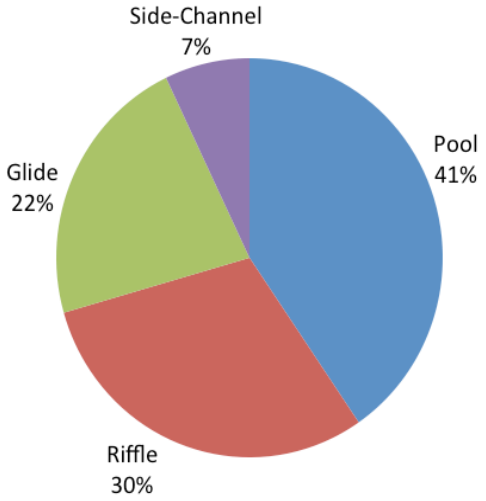


Figure 58. Habitat unit composition, Reach 4.

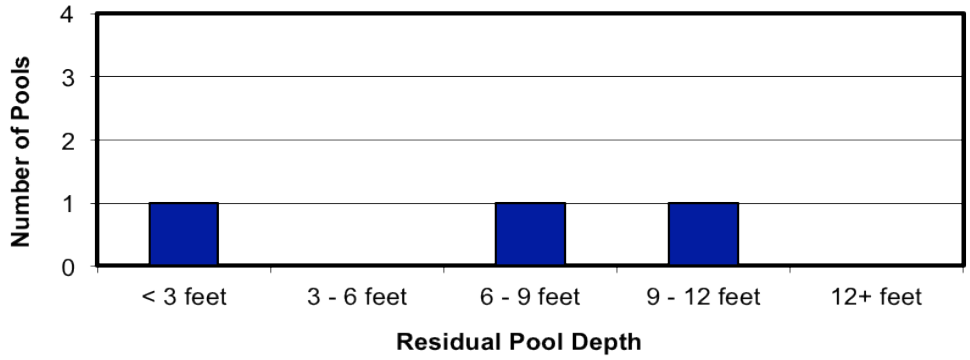


Figure 59. Reach 4 residual pool depths.

Figure 60. View looking downstream towards riffle habitat and the right bank terrace towards the downstream end of Reach 4, near RM 42.1 (August 2011).

A-4.3 Off-Channel Habitat

There were two side-channels in Reach 4. A fast-water side-channel (Figure 49), located from RM 42.8 to RM 42.9, bends away from a steep exposed cliff as the floodplain widens. A braided side-channel, located from RM 42.4 to RM 42.5, collects considerable LWD and provides refuge from mainstem flows. Both side-channels flowed along left bank floodplain surfaces with wetland vegetation that included rushes, spirea, and willow. A deep left bank alcove, located at RM 42.66, provided refugia from mainsteam flow and collected woody debris and fine sediment.

Figure 61. Representative fast water side-channel, Reach 4 (August 2011).

A-4.4 Large Woody Debris

LWD quantities were low-to-moderate in Reach 4 when compared to other reaches in the study area. LWD frequency was 63 pieces/mile, with "small" pieces comprising 45% of all LWD counted in the reach (Table 4). "Medium" and "Large" wood pieces comprised 18% and 37%, respectively. LWD recruitment potential was low within this reach. Reach 4 receives minimal wood input from upstream sources and lacks mature trees within the riparian corridor (Figure 50).

Table 5. Large woody debris quantities in Reach 4.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	38	15	32	85
Number of Pieces/Mile	28	11	24	63

Figure 62. Downstream view looking at side-channel habitat and small LWD accumulation along the left bank near RM 42.5 (August 2011).

A-4.5 Substrate and Fine Sediment

Bed substrate was dominated by large gravels and cobbles. Cobble was dominant, comprising 43% of the total bed composition. Boulders were found in all habitat types throughout this reach. Bedrock was prevalent along the channel margins and in portions of the channel due to exposure of the Chumstick formation. Bedrock consisted of just 2% of the bed composition for measured units. Fine sediment (<2mm) made up approximately 15-30% of the substrate distribution. No pebble count data were attainable for riffle habitat within Reach 4 due to high water conditions. Results of the ocular substrate measures are depicted in Figure 51.

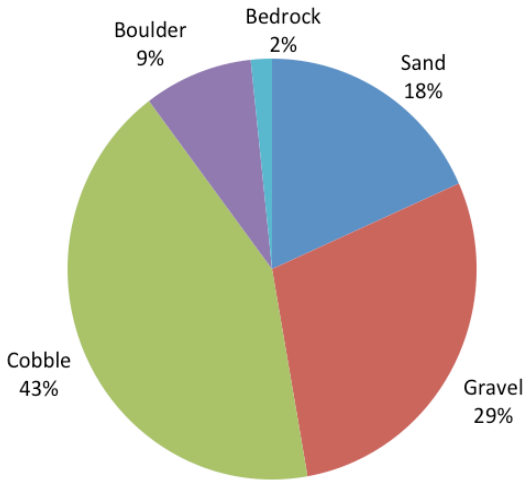


Figure 63. Percent composition of bed substrate based on ocular estimates, Reach 4.

A-4.6 Instability and Disturbance

Human development has modified the channel, floodplain, and riparian corridor within Reach 4. Bank erosion was moderately high when compared to other reaches within the Upper Wenatchee study area. Reach 4 had a total of 2,679 feet of actively eroding streambank (measured above bankfull), consisting of 16% of the reach length along both banks.

Bank disturbance was amplified in Reach 4 by the presence of steep terrace banks and human influence (Figure 52). Erosion was observed primarily along the undercut floodplain terrace from RM 42.5 to RM 42.7, and along the Burlington Northern Railroad Bridge (RM 41.9).

Riprap was scattered along steep streambanks at some private properties throughout the reach. Instream pilings and associated riprap surround the Burlington Northern Railroad Bridge, constraining the natural both upstream and downstream of the reach boundary.

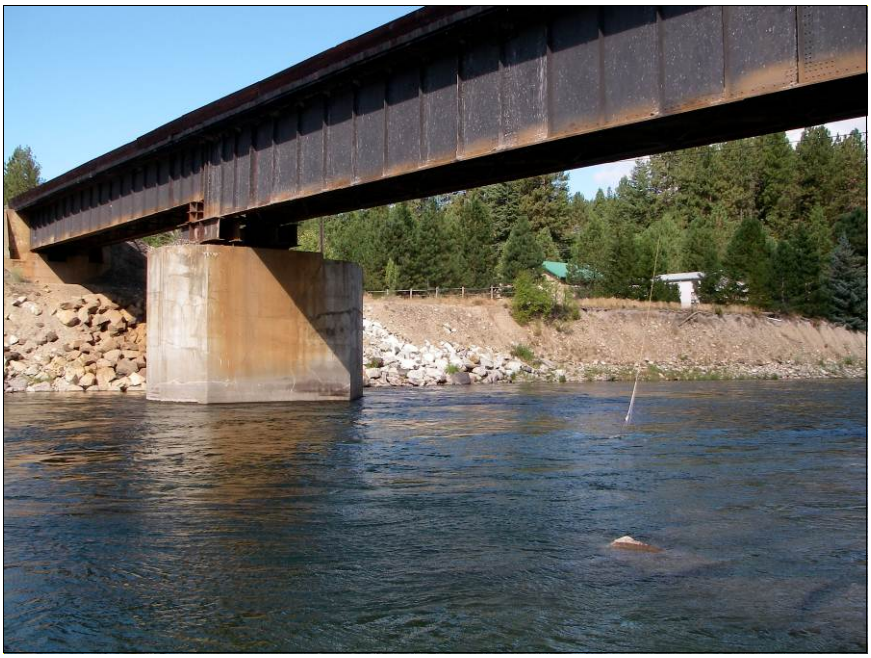


Figure 64. View looking upstream towards the right bank terrace, riprap armoring, and Burlington Northern Railroad Bridge at RM 41.9 (August 2011).

A-4.7 Available Spawning and Rearing Habitat

Substrate within Reach 4 was dominated by large gravels and cobbles (based on ocular estimates only). Riffles had between 0 to 30% boulders. It is unlikely that salmon species other than Chinook would be able to spawn within the coarse substrate. Adult salmon and steelhead would be expected to primarily use this reach as a migration corridor. Long pool tail-outs and side-channels may provide potential spawning habitat.

Reach 4 had two deep pools with residual depths greater than 3 feet. Pool habitat (41% total area) would be expected to provide adult holding and juvenile rearing opportunity for multiple salmonid species. Juvenile steelhead may use the fast water side-channels for rearing.

A-4.8 Riparian Corridor

The width of the forested riparian buffer varied within Reach 4. The riparian corridor is disconnected and fragmented by scattered residential properties. Ponderosa pine dominates the terraces and floodplain surfaces throughout much of the reach. Small trees and shrubs (including willow, alder, cottonwood, and hawthorn) were only found along channel margins and floodplain surfaces.

The riparian zone along Reach 4 was dominated by large trees (78%) (Figure 53), primarily consisting of conifers (89% conifer; 11% hardwood). Ponderosa pine, Douglas fir, cottonwood, willow, alder, and hawthorn were the most prevalent species within the riparian corridor. Reach 4 generally lacked a riparian understory.

The level of stream shade provided by the riparian canopy was low-to-moderate throughout Reach 4. Local topography and large conifers may provide morning and afternoon shade.

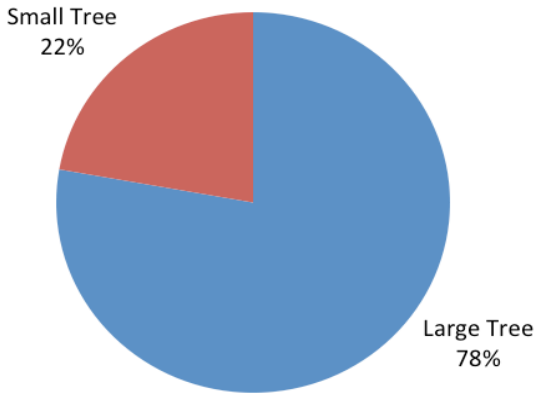


Figure 65. Distribution of the dominant size class category for the riparian zone, Reach 4.

A-5 Reach 5

Location: River mile 43.1 to 46.5

Survey Date: August 11, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-5.1 Reach Overview

Reach 5 flows through a confined alluvial valley that extends from RM 43.1 to the confluence of Beaver Creek at RM 46.5 (Figure 54). The channel and floodplain are further confined as the stream passes through the unincorporated community of Plain. Overall reach slope is 0.25%. Channel form is meandering and bed morphology is primarily riffle-glide with periodic sequences of pool-riffle. Dominated by fast water units, Reach 5 lacks off-channel and side-channel habitat. Reach 5 streambanks vary from narrow low-elevation floodplains to steep exposed terraces of the Chumstick formation. Present land use is primarily rural residential, agricultural, and transportation corridors.

Modern floodplains and terrace surfaces surrounding Reach 5 have been extensively logged and cleared for pasture and homesites. In the early 1900s, the river was blasted and straightened to transport logs to the Leavenworth Mill (Bryon Newell, personal communication, Sept. 24, 2011). Streambanks were cleared of vegetation and logjams were removed. Riparian conditions have improved since the late-1920s. Historical and recent photos of this reach are included in Figure 55 and Figure 56. Anthropogenic alterations to the floodplain include land clearing, irrigation diversions, road building, and filling and grading. Riprap, concrete retaining walls, and large river rock armor most of the streambank. Exposed steep outcroppings of the Chumstick formation confine the channel along isolated portions of the reach (especially at RM 44.85 and RM 43.85).

The Old Plain Bridge (RM 46.2), Beaver Valley Rd Bridge (RM 46.4), and a transmission line (RM 44.45) bisect the channel and floodplain in the upper portion of Reach 5. River Rd parallels the channel along the river-right floodplain for much of the reach. The road directly abuts the channel from RM 43.6 to RM 44.1.

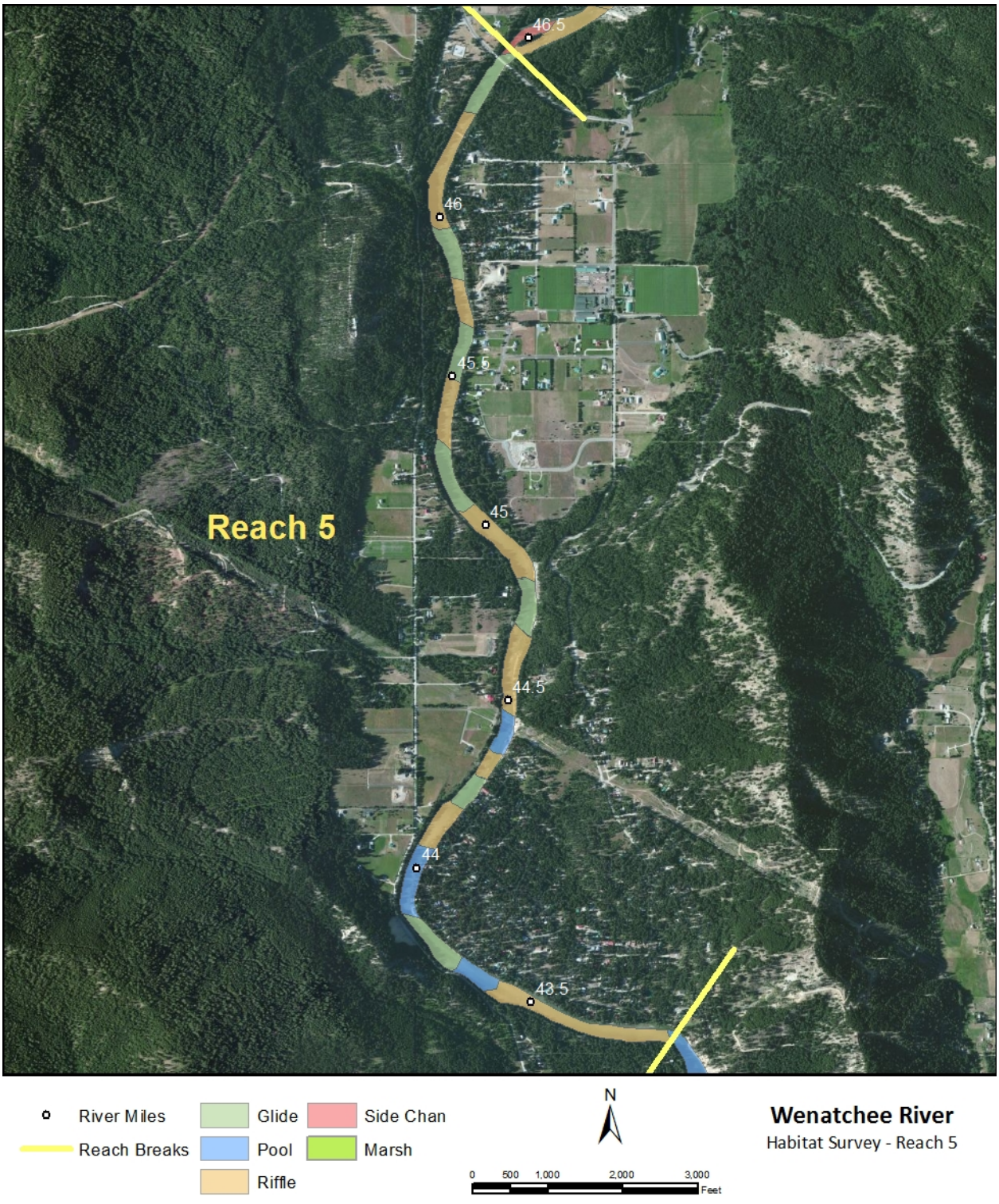


Figure 66. Reach 5 locator and habitat unit composition map.

Figure 67. Historical photo (late 1920s) taken from the Old Plain Bridge looking upstream towards a logged right bank alluvial terrace (left-hand side of photo).

Figure 68. Recent photo (2011) from the Plain Bridge looking upstream. Historical logged right bank alluvial terrace is revegetated (left-hand side of photo).

A-5.2 Habitat Unit Composition

Reach 5 consisted of 56% riffle, 33% glide, and 11% pool habitat (Figure 57 and Figure 58). No side-channel habitat was present within this reach. Pool frequency was 1.0 pool/mile, with mean pool spacing of 27.0 channel widths per pool. Average residual pool depth was 7.8 feet. Average maximum pool depth was 11.3 feet.

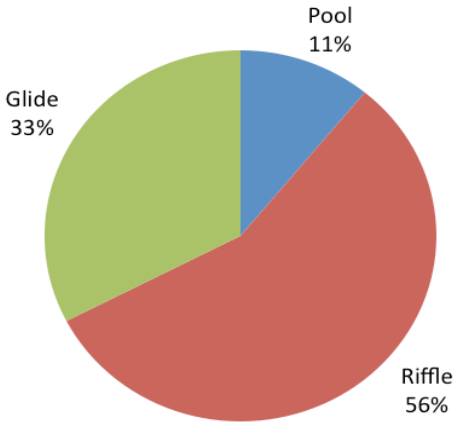


Figure 69. Habitat unit composition, Reach 5.

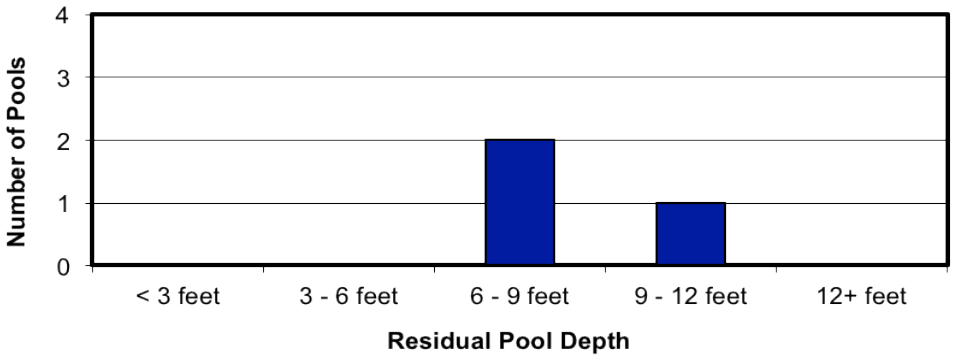


Figure 70. Reach 5 residual pool depths.

A-5.3 Off-Channel Habitat

Reach 5 has no side-channel habitat or off-channel marshlands. This area likely had a greater amount of historical off-channel habitat that has been reduced as a result of human development of riparian areas and floodplains.

A-5.4 Large Woody Debris

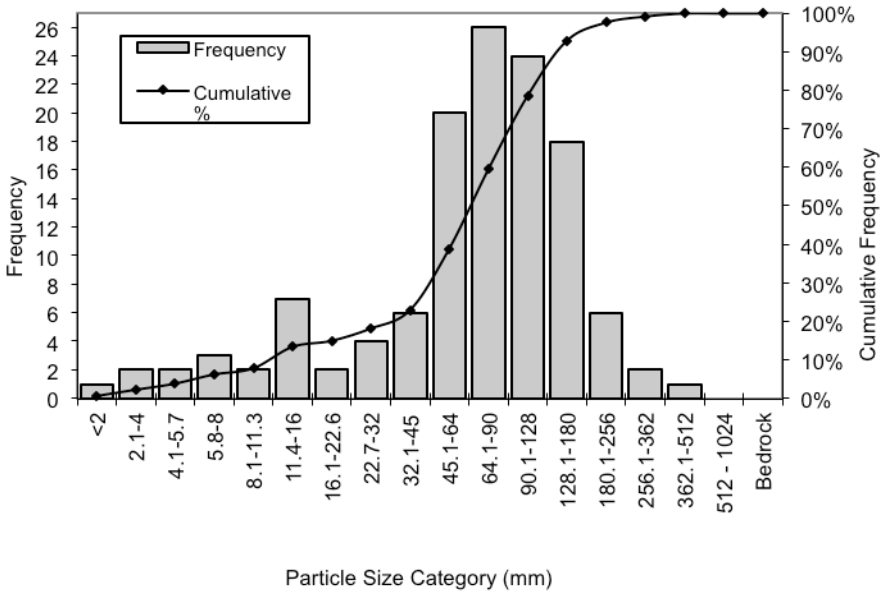
LWD quantity was moderate but LWD frequency was low in Reach 5 compared to other reaches in the study area. LWD frequency was 32 pieces/mile, with "small" pieces comprising 48% of all LWD counted in the reach (Table 5). "Medium" and "large" wood pieces comprised 52% of the LWD in the reach (24% and 28%, respectively). Reach 5 LWD recruitment potential was limited both in the short and long-term. This reach had low riparian species diversity and lacked mature trees.

Table 6. Large woody debris quantities in Reach 5.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	48	24	28	100
Number of Pieces/Mile	15	8	9	32

A-5.5 Substrate and Fine Sediment

Bed substrate was dominated by cobbles, with gravels and boulders subdominant. Bedrock was not observed. Sand composed 15% of the total ocular estimate, ranging from between 5-25% for all measured units. The percentage of fine sediment (<2mm) varied greatly between ocular estimates (15%) and the riffle pebble count (1%). Only one pebble count was attainable within the fast moving riffles representative of Reach 5. The pebble count and size class data are depicted in Figure 59 and Figure 60.



Material	Percent Composition
Sand	1%
Gravel	38%
Cobble	59%
Boulder	2%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	7
D16	25
D50	78
D84	148
D95	214

Figure 71. Grain size distribution and particle size classes from riffle pebble count taken at RM 43.6.

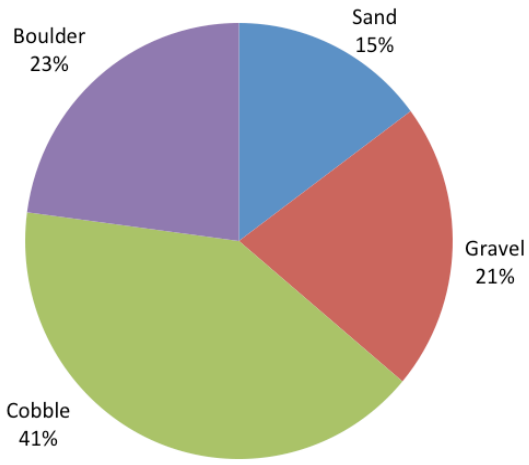


Figure 72. Percent composition of bed substrate based on ocular estimates, Reach 5.

A-5.6 Instability and Disturbance

Human activities have modified the channel, floodplain, and associated riparian corridor within the reach. The primary elements of disturbance include channel simplification, channel confinement, bank armoring, floodplain residential development, clearing of riparian vegetation, bridge crossings, and roadways. Few isolated pools and slow-water eddies were found throughout Reach 5.

Bank erosion was moderately high when compared to other reaches within the study area. Reach 5 had a total of 5,000 feet of actively eroding streambank (measured above bankfull), consisting of 15% of the reach length along both banks. Bank disturbance was often associated with land clearing, roadways, residential uses, river access, and steep terrace banks.

Areas of greatest impact include: the Old Plain Bridge (RM 46.2) crossing; Beaver Valley Rd Bridge (RM 46.4); River Rd where it abuts the channel (RM 43.6 to RM 44.1); and a transmission line (RM 44.45) crossing. These sites were associated with bank armor, land clearing, removal of riparian vegetation, and/or fragmenting the riparian corridor and floodplain. Examples of these impacts are included in Figure 61 and Figure 62.

Figure 73. Beaver Valley Rd Bridge bisects the upper portion of Reach 5, where the channel is artificially confined by riprap armoring (August 2011).

Figure 74. Transmission line clearing affects the riparian buffer and erosion near RM 44.45 (August 2011).

A-5.7 Available Spawning and Rearing Habitat

Substrate within Reach 5 riffles was coarse, consisting primarily of cobbles (58%). Although Chinook spawning occurs in this reach, many of the riffles provide minimal substrate within the range suitable for spawning (13-102 mm). It is unlikely that salmon species other than Chinook would be able to spawn within Reach 5.

Reach 5 provides low-to-moderate rearing habitat. Pool frequency is 1.0 pools/mile, yet three deep pools (residuals depths >3ft) would be expected to provide juvenile rearing, adult holding, and overwintering opportunity. Additionally, large boulders throughout the reach create small eddy pockets with localized velocity refuge.

LWD was below adequate levels and the potential LWD recruitment was poor in both the short and long-term.

A-5.8 Riparian Corridor

The presence and width of the forested riparian buffer varied within the reach. Past land clearing for timber, agriculture, roads, and housing results in a narrow forested or highly fragmented riparian buffer along most of Reach 5. This also includes areas of localized vegetation clearing.

Most of the riparian zone was dominated by large trees (61%) (Figure 63), primarily conifers (100% of units dominated by conifers). Ponderosa pine, alder, and cottonwood were the most prevalent species.

The level of stream shade provided by the riparian canopy varied throughout the reach. Large ponderosa pines provided morning and afternoon shade. Topographic shading was provided by steep terrace walls at localized sites throughout the reach.

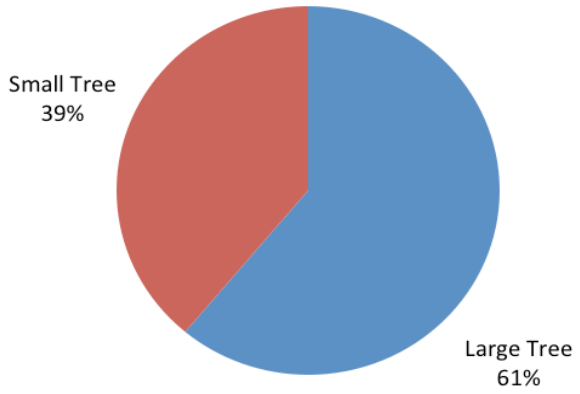


Figure 75. Distribution of the dominant size class category for the riparian zone, Reach 5.

A-6 Reach 6

Location: River mile 46.5 to 47.9

Survey Date: August 11, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-6.1 Reach Overview

Reach 6 is located in a partially confined valley from the confluence of Beaver Creek (RM 46.5) to Shuggart Flats (RM 47.9). This reach is a low gradient (0.35%) reach primarily bordered by historically abandoned terrace deposits (river-right) and steep sedimentary rock formations (Chumstick formation, river-left) (Figure 64). Channel form is meandering and bed morphology is primarily riffle-glide. Two stable and well-vegetated islands (RM 46.5 and RM 46.9) are located in the lower portion of Reach 6. See Figure 65 for a reach overview and habitat unit map.

As described for Reach 5, this reach was also used for log transport in the early 1900s (Bryon Newell, personal communication, Sept. 24, 2011). Streambanks were cleared of vegetation and logjams were removed. Riparian conditions have improved since the late-1920s. Historical and recent photos of this reach are included in Figure 66 and Figure 67.

Floodplain functions have been impacted by homesite construction, fill, and grading. A narrow low-elevation floodplain (RM 47.2 to RM 47.9) borders the upper portion of this reach near Shuggart Flats. Localized bank armoring and riparian clearing were observed along residential properties in the upper portion of the reach.

Figure 76. The Chumstick formation confines much of Reach 6 along river-left. This steep exposed sedimentary rock formation extends from RM 46.7 to RM 46.9 (August 2011).

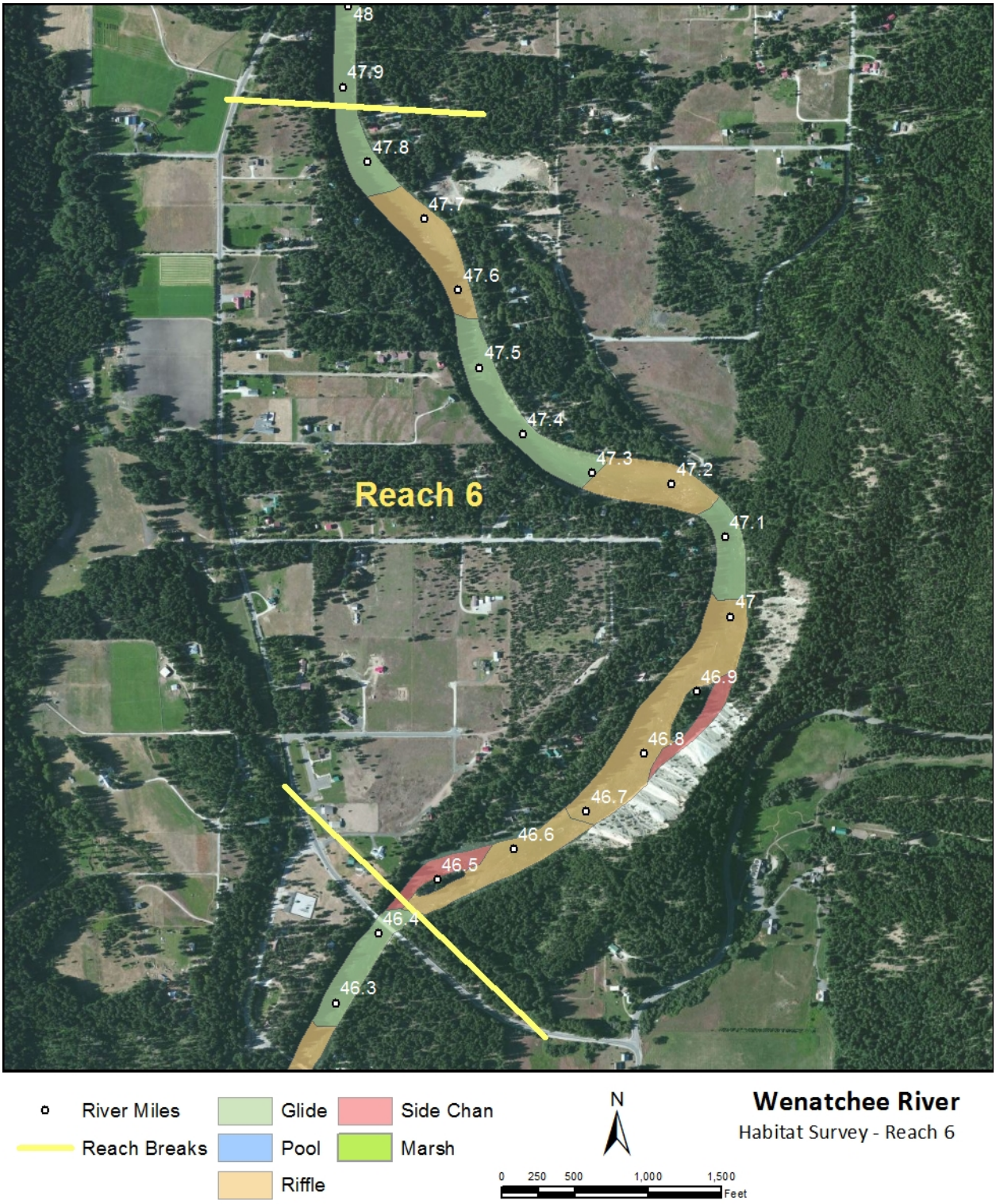


Figure 77. Reach 6 locator and habitat unit composition map.

Figure 78. Historic photo (circa 1920-1930) looking upstream towards the present day location of Beaver Valley Rd Bridge. Photo courtesy of Bryon Newell.

Figure 79. View looking upstream from the Beaver Valley Road Bridge (RM 46.5) (September 2011).

A-6.2 Habitat Unit Composition

Reach 6 was dominated by fast water units, consisting of 67% riffle, 23% glide, and 10% side-channel habitat (Figure 68). No pool habitat was present within this reach.

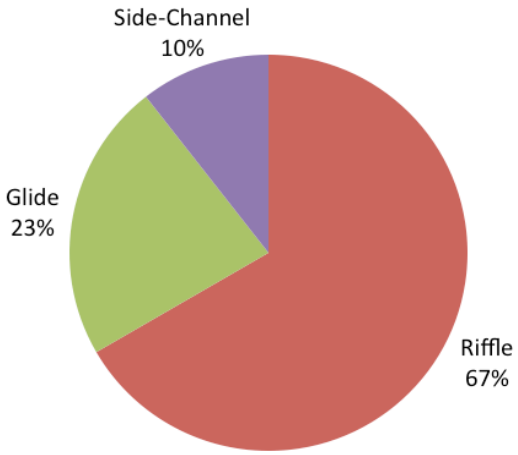


Figure 80. Habitat unit composition, Reach 6.

A-6.3 Off-Channel Habitat

Two fast water side-channels were found in Reach 6 (Figure 69). Both had large islands that split the channel. Each island had well-established vegetation composed of mixed trees (conifers and deciduous) and shrubs. LWD jams along the upstream margins of the islands created small back water eddies providing localized velocity refuge and juvenile rearing habitat. These jams appear to continue to recruit and trap woody material and fine sediments.

The side-channel at RM 46.9 flowed along river-right (opposite the sedimentary rock formation). It was composed primarily of cobbles (30%) and boulders (50%), providing little spawning habitat and limited velocity refuge. Riparian vegetation along the right bank did provide stream shade despite understory clearing and home building.

The second side-channel (RM 46.5) flowed along the left bank over gravels (20%) and cobbles (60%). Beaver Creek flows into the downstream end of this unit, delivering sediment inputs. Local topography and tall conifers shade portions of the side-channel. No off-channel marshlands were observed in Reach 6.

Figure 81. A side-channel (RM 46.9) flows along river-right opposite the steep sedimentary rock formation of Reach 6 (August 2011).

A-6.4 Large Woody Debris

LWD quantities were moderate in Reach 6 compared to other reaches in the study area. LWD frequency was 67 pieces/mile, with "small" pieces comprising 43% of all LWD counted in the reach (Table 6). "Medium" and "Large" wood pieces comprised 57% of the LWD in the reach (25% and 32%, respectively). LWD recruitment appeared high throughout Reach 6 although there is a lack of large and mature trees in the riparian area. The presence of mid-channel islands (Figure 70) would be expected to continue to trap and retain fluvial wood transported from upstream sources (including the Chiwawa River).

Table 7. Large woody debris quantities in Reach 6.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	39	23	29	91
Number of Pieces/Mile	29	17	21	67

Figure 82. LWD jams have formed along the upstream margins of both mid-channel islands in Reach 6 (August 2011).

A-6.5 Substrate and Fine Sediment

Bed substrate was dominated by cobbles. Boulders were subdominant. Sand and gravels were less common, making up 7% and 18% of the bed substrate, respectively. No bedrock was observed within the stream channel despite its close proximity to the Chumstick formation. No pebble count data were collected due to high water conditions at the time of the survey. Results of the ocular substrate measures are depicted in Figure 71.

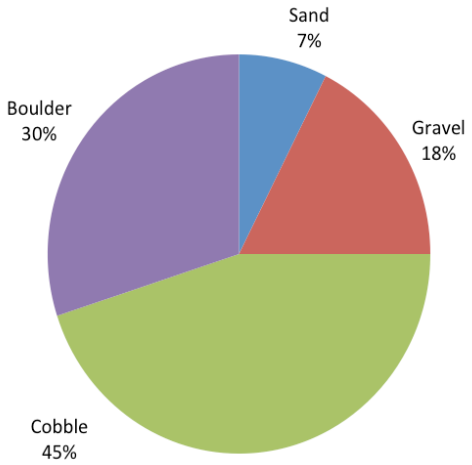


Figure 83. Percent composition of bed substrate based on ocular estimates, Reach 6.

A-6.6 Instability and Disturbance

Human activities have impacted the channel, floodplain, and associated riparian corridor within the reach. The primary elements of disturbance include bank armoring, floodplain development, and vegetation clearing. River access and associated disturbance was observed along the narrow low-elevation floodplains throughout Reach 6 (Figure 72). Bank armoring (RM 47.85) made of tires and rock, and an earthen levee (RM 47.55 to RM 47.67), have been constructed along the left bank.

As a result of bank armoring and natural confinement, actively eroding streambanks were uncommon in Reach 6 when compared to other reaches in the study area. Reach 6 had a total of 100 feet of actively eroding streambank (measured above bankfull), consisting of 1% of the reach length along both banks. Bank disturbance was associated with failed riprap armoring along the right bank.

Figure 84. Vegetation clearing and river access impacts riparian buffers at residential properties in Reach 6 (August 2011).

A-6.7 Available Spawning and Rearing Habitat

There was very minimal available spawning and rearing habitat in Reach 6. Large substrates dominated this reach, consisting primarily of cobbles (45%) and boulders (30%). Riffle substrate (ocular estimates) ranged from 10-20% gravels, 30-60% cobbles and 10-50% boulders. Fine sediment was at adequate levels, averaging just 5% of the total bed composition (ocular estimate). It is unlikely that salmon would make much spawning use of Reach 6 due to its coarse substrate composition and water velocity. Adult salmon and steelhead would be expected to primarily use this reach as a migration corridor.

Reach 6 had no pool habitat. The reach lacked flood refugia and provided minimal canopy cover along lateral margins. Reach 6 only had a few areas of localized velocity refuge near LWD jams. Large boulders throughout the upper portion of Reach 6 may also provide velocity refuge for rearing and during upstream migration.

A-6.8 Riparian Corridor

The width of the forested riparian buffer varied within the reach. Past land clearing for timber harvest and residential development has resulted in a fragmented riparian buffer along Shuggart Flats (river-left from RM 47.2 to 47.9) and along the right bank throughout the reach. The riparian buffer is sparsely vegetated along the sedimentary rock formation (river-left from RM 46.7 to RM 46.9) due to the steep grade and exposed growing conditions. Cottonwood, willow, and spirea grow along the alluvial deposits near Beaver Creek, providing localized species diversity and canopy cover.

The riparian zone throughout Reach 6 was dominated by small trees (88%) (Figure 73), primarily consisting of conifers (75% conifer; 25% hardwood). Ponderosa pine, cottonwood, and alder were the most prevalent species.

The level of stream shade provided by the riparian canopy was low throughout the upper portion of Reach 6. Moderate shading was provided by two well-vegetated mid-channel islands and the steep exposed sedimentary rock formation along the downstream portion of the reach (RM 46.5–47.1).

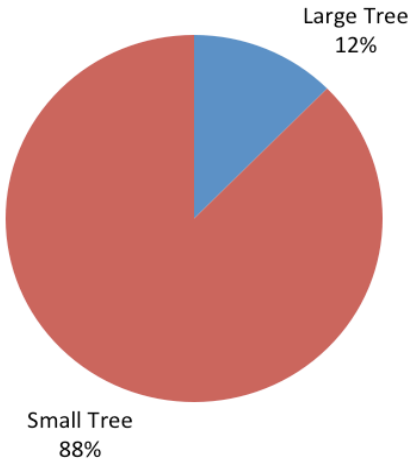


Figure 85. Distribution of the dominant size class category for the riparian zone, Reach 6.

A-7 Reach 7

Location: River mile 47.9 to 48.4

Survey Date: August 11, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-7.1 Reach Overview

Reach 7 flows through a partially-confined alluvial valley from Shuggart Flats (RM 47.9) to the confluence of the Chiwawa River (RM 48.4). It is a low gradient reach (0.25%). Channel form is slightly meandering and bed morphology is mostly riffle-glide. Reach 7 is influenced by sediment and water inputs from the Chiwawa River (Figure 75). Entering from river-left, the Chiwawa River originates in the Glacier Peak Wilderness and drains 183 square miles of national forest and wilderness. Land use throughout Reach 7 is primarily rural residential. Reach 7 has been altered as a result of road building, fill, grading, vegetation removal/clearing, and homesite construction.

Beaver Valley Rd bisects the floodplain and riparian corridor, paralleling this reach along river-right. Chiwawa River alluvial deposits (sand and gravel) create a vegetated low-elevation floodplain throughout the upstream portion of this reach along the left bank. This portion of Reach 7 experiences minor inundation during seasonal high-flow/flood events. Slightly higher alluvial terraces border this reach along river-right. See Figure 74 for a reach overview and habitat unit map.

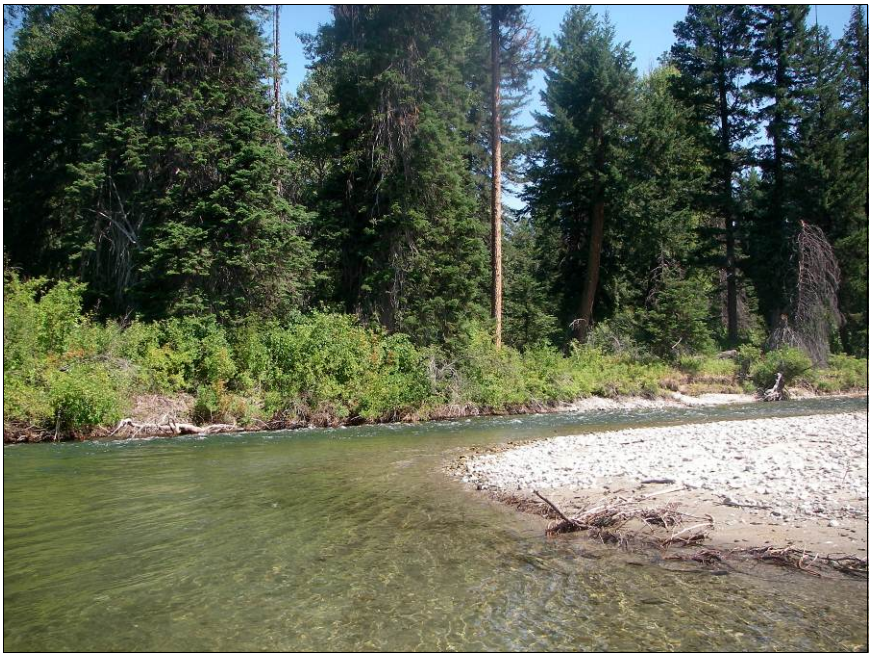


Figure 86. Sand and gravel alluvial deposits form a bar along the upper portion of Reach 7 on river-left just downstream of the Chiwawa River confluence (August 2011).

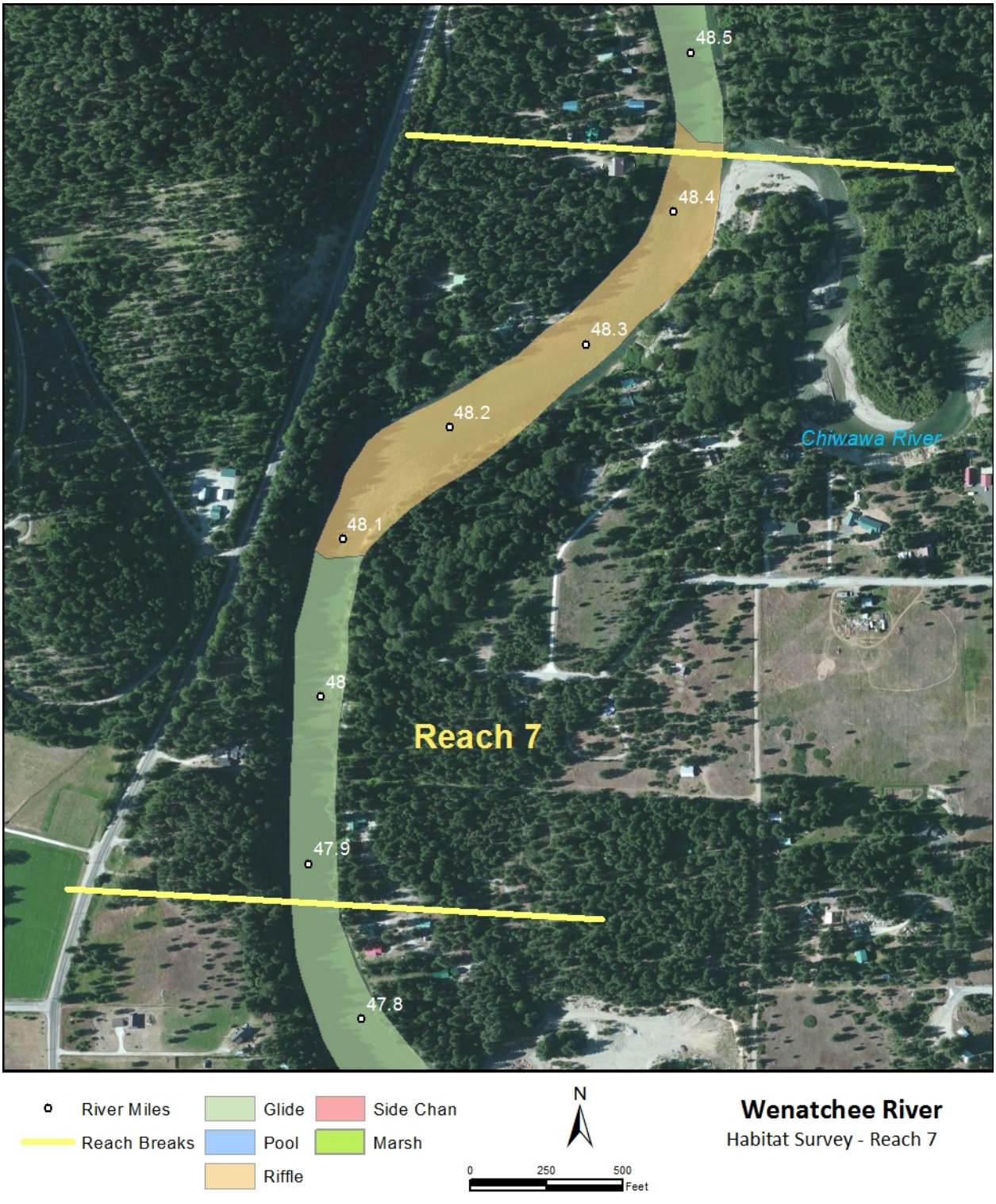


Figure 87. Reach 7 locator and habitat unit composition map.

A-7.2 Habitat Unit Composition

Reach 7 was the second shortest reach in the Upper Wenatchee study area, measuring 0.54 miles in length. This reach was composed of 54% riffle and 46% glide habitat (Figure 76).

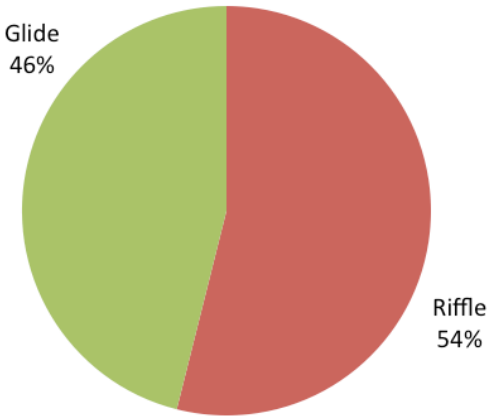


Figure 88. Habitat unit composition, Reach 7.

A-7.3 Off-Channel Habitat

Reach 7 has no side-channel habitat or off-channel marshlands. Off-channel habitat is limited due to natural confinement throughout much of the reach but has also been limited to some degree by human development in riparian areas and floodplains.

A-7.4 Large Woody Debris

LWD quantity and frequency were the lowest observed throughout the study area. LWD frequency was 13 pieces/mile, with "small" pieces comprising 78% of all LWD counted in the reach (Table 7). "Medium" and "Large" wood pieces comprised 22% of the total LWD count, with only one piece of each observed in Reach 7. LWD recruitment potential was low within this reach. Reach 7 receives wood inputs from upstream sources (both the Chiwawa and Wenatchee River), yet low channel sinuosity and fast water channel units limit the ability of the reach to retain wood. Additionally, LWD recruitment potential is limited by the lack of natural channel migration.

Table 8. Large woody debris quantities in Reach 7.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	7	1	1	9
Number of Pieces/Mile	10	1	1	13

A-7.5 Substrate and Fine Sediment

Bed substrate was dominated by cobbles and boulders. Boulders were dominant, comprising 35% of the total bed composition; cobbles were subdominant (33%). No bedrock was observed in Reach 7. Sand comprised 12% of the total bed composition. Pebble count data were not collected within Reach 7 due to high water conditions. Results of the ocular substrate measures are depicted in Figure 77.

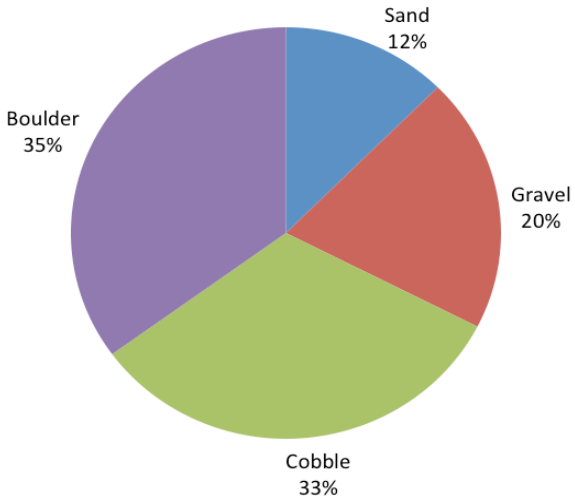


Figure 89. Percent composition of bed substrate based on ocular estimates, Reach 7.

A-7.6 Instability and Disturbance

No instability or recent disturbance was observed in Reach 7.

A-7.7 Available Spawning and Rearing Habitat

Spawning and rearing habitat was limited in Reach 7. Large substrates consisting of cobbles and boulders dominated this reach. Riffle substrate (ocular estimate) observed in Reach 7 was 5% sand, 25% gravels, 40% cobbles, and 30% boulders. Alluvial deposits from the Chiwawa River (Figure 78) and a small right bank tributary create areas of localized spawning gravel. Chinook and steelhead would likely use these small spawning areas. However, salmon and steelhead would most likely use this reach primarily as a migration corridor. Large boulders throughout Reach 7 may provide areas of localized velocity refuge.

Reach 7 had no substantial pool habitat. This reach lacked LWD and off-channel habitat. Riparian vegetation provided canopy cover along lateral margins for most of Reach 7.

Figure 90. Alluvial gravel deposits from the Chiwawa River create areas of localized spawning habitat in Reach 7 (August 2011).

A-7.8 Riparian Corridor

The width of the forested riparian buffer varied within the reach. Past land clearing and development throughout Shuggart Flats has resulted in a fragmented forest riparian buffer along river-left.

The riparian zone throughout Reach 7 was dominated by large trees (100% of units), consisting of both conifers (50%) and hardwoods (50%). Douglas fir, cottonwood, willow, and alder were the most prevalent species.

The level of stream shade provided by the riparian canopy was moderate throughout the reach. Low-elevation floodplains and alluvial terraces were vegetated with hardwoods and small shrubs providing stream shading along much of Reach 7.

A-8 Reach 8

Location: River mile 48.4 to 49.7

Survey Date: August 11, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-8.1 Reach Overview

Reach 8 is located in a partially confined valley from the confluence of the Chiwawa River at RM 48.4 to a meander bend at RM 49.7 (Figure 79). This reach is low gradient (0.12%). Channel form is meandering and bed morphology is pool-riffle with interspersed glide units.

Land use throughout Reach 8 includes private residential (Figure 80), private community access (Chiwawa Community Association), US Forest Service land, and a Washington Department of Fish and Wildlife (WDFW) fish hatchery (Chiwawa Ponds facility). The WDFW facility is protected by a short section of concrete retaining wall along river-left (Figure 81). Bank armoring at this location may be responsible for channel simplification and disconnection of a side-channel just downstream of the retaining wall.

Floodplain functions have been impacted as a result of road building, fill and grading, vegetation removal/alteration, and homesite construction. Reach 8 is bordered by historically abandoned terrace deposits and road fill from the construction of Beaver Valley Road along the river-right bank. The left bank has been altered by both current and historical land uses including residential development and logging activities.

Figure 91. Reach 8 locator and habitat unit composition map.

Figure 92. Glide habitat (RM 49.5) bordered by homesites in the upstream portion of Reach 8 (August 2011).

Figure 93. Small concrete retaining wall at meander bend just upstream from the WDFW hatchery facility (August 2011).

A-8.2 Habitat Unit Composition

Reach 8 consisted of 41% pool, 31% glide, 21% riffle, and 7% side-channel habitat (Figure 82 and Figure 83). Pool frequency was 1.8 pools/mile, with a mean pool spacing of 14.0 channel widths per pool. Average residual pool depth was 7.5 feet. Average maximum pool depth was 11.0 feet.

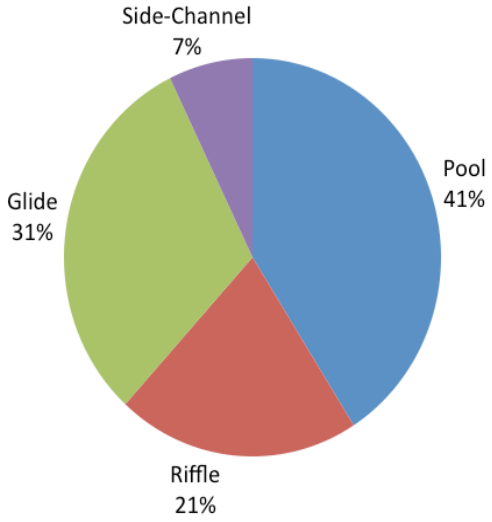


Figure 94. Habitat unit composition, Reach 8.

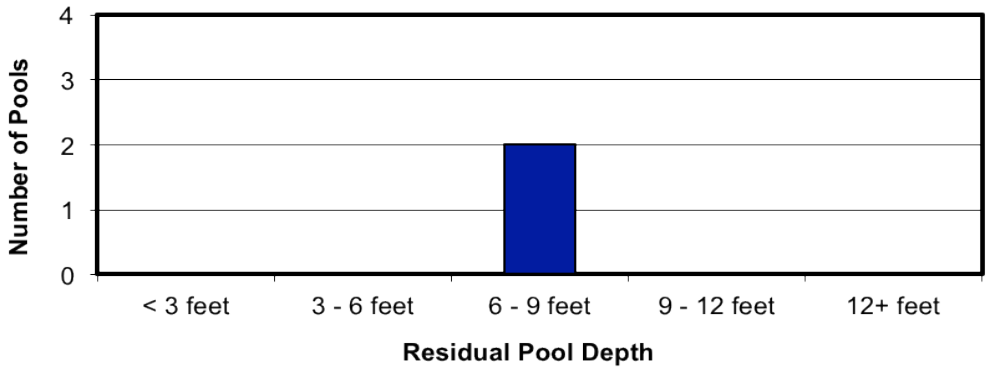


Figure 95. Reach 8 residual pool depths.

A-8.3 Off-Channel Habitat

Reach 8 had two side-channels. The first side-channel was located downstream of the WDFW facility at RM 49.2. It was a fast water (riffle) unit flowing along the right bank terrace. LWD had accumulated throughout the side-channel creating deep pockets and refugia. A mid-channel cobble bar collected soil and sand along the downstream margins and was sparsely vegetated with young willows.

The second side-channel flowed along the river-left bank at RM 48.8. It was a fast water (riffle) unit separated from the main channel by a sparsely vegetated cobble bar (Figure 84). This side-channel appeared to provide both spawning and rearing habitat (gravels and cover).

An off-channel marsh (Figure 85) was observed in an abandoned side-channel (meander scar) downstream of the WDFW facility along the river-left bank. Evidence of large wood and scour deposits indicated that this is a high flow channel during floods.

Figure 96. View downstream at a sparsely vegetated cobble bar and right bank terrace in the lower portion of Reach 8 near RM 48.8 (August 20011).

Figure 97. Off-channel marsh along the river-left bank at RM 49.1 (August 2011).

A-8.4 Large Woody Debris

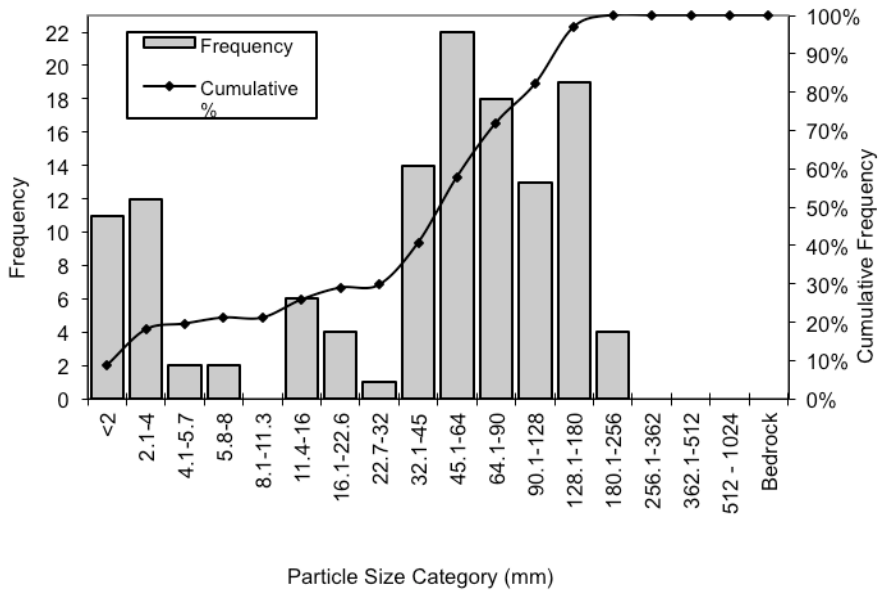
LWD quantities were moderately low in Reach 8 compared to other reaches in the study area. LWD frequency was 57 pieces/mile, with "small" pieces comprising 48% of all LWD counted in the reach (Table 8). "Medium" and "Large" wood pieces comprised 52% of the LWD in the reach (20% and 32%, respectively). Throughout Reach 8, LWD recruitment potential was limited both in the short and long-term. This reach had low riparian species diversity that lacked large and mature trees. The high-flow channel and marsh at RM 49.1 had collected LWD (8 pieces) that may become active in future flood events.

Table 9. Large woody debris quantities in Reach 8.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	31	13	21	65
Number of Pieces/Mile	27	11	18	57

A-8.5 Substrate and Fine Sediment

Bed substrate was dominated by cobbles, with gravels subdominant. Bedrock was not observed. Sand comprised 28% of the total ocular estimates and averaged 20% for all measured riffles. The percentage of fine sediment (<2mm) varied greatly between ocular estimates (20%) and the riffle pebble count (9%). Only one riffle pebble count was recorded within Reach 8 due to high water conditions. The pebble count and size class data are depicted in Figure 86 and Figure 87.



Material	Percent Composition
Sand	9%
Gravel	49%
Cobble	42%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	<2
D16	1
D50	55
D84	135
D95	173

Figure 98. Grain size distribution and particle size classes from pebble count taken at RM 48.8.

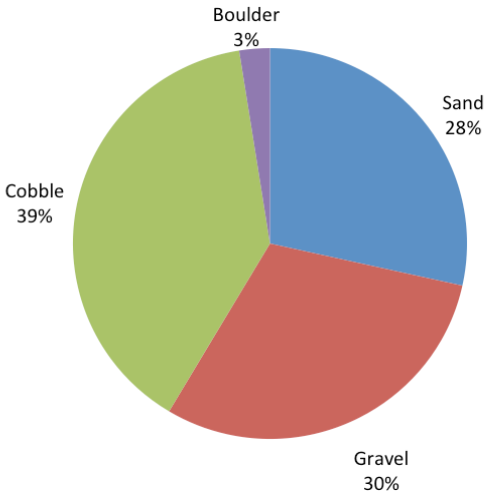


Figure 99. Percent composition of bed substrate based on ocular estimates, Reach 8.

A-8.6 Instability and Disturbance

Human development has modified the channel, floodplain, and riparian corridor within Reach 8. Bank erosion was moderate when compared to other reaches in the study area. Reach 8 had a total of 931 feet of actively eroding streambank (measured above bankfull), consisting of 6% of the reach length along both banks.

Bank disturbance primarily occurred along the steep right bank terrace. Erosion was observed along both banks throughout the pool bordering the WDFW facility (RM 49.3) and along the steep terraces from RM 48.8 to RM 49.0. The WDFW hatchery facility was bordered by a concrete retaining wall (Figure 88).

Figure 100. Concrete intake structure at the WDFW hatchery facility (August 2011).

A-8.7 Available Spawning and Rearing Habitat

There was a moderate amount of spawning and rearing habitat available in Reach 8. The dominant substrate in riffles was gravels (49%) and subdominant was cobbles (42%). Riffle pebble count data suggested that Reach 8 had ideal substrate for both Chinook (13-102 mm) and steelhead (6-102 mm) spawning. Spawning would likely occur near side-channels and throughout the downstream portion of Reach 8. Pool frequency and quality were high within Reach 8 (41% pool habitat), which would support high juvenile salmonid rearing use.

A-8.8 Riparian Corridor

The width of the forested riparian buffer varied within the reach, especially along the upper half mile of the reach. Past land clearing and residential development has resulted in a fragmented

riparian buffer along river-left from RM 49.2 to 49.7. The remaining riparian buffer has been sparsely reforested by ponderosa pine.

The riparian zone throughout Reach 8 was dominated by small trees (63%) (Figure 89), primarily consisting of conifers (88% conifer; 13% shrub). Ponderosa pine, willow, and alder were the most prevalent species. Generally, Reach 8 lacked both species and age-class diversity.

The level of stream shade provided by the riparian canopy was low throughout the reach. Topographic shading was provided by the steep right bank terrace along the downstream portion of the reach (RM 48.4 – 49.2).

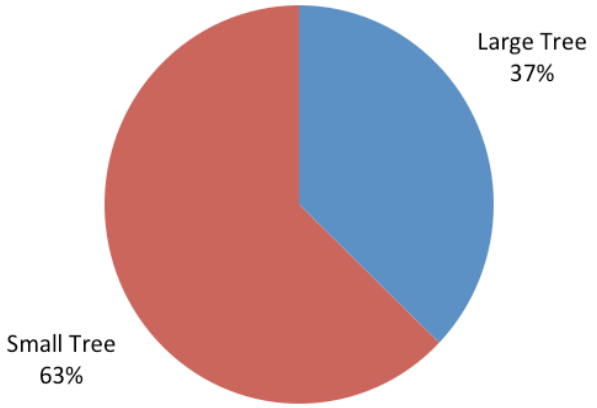


Figure 101. Distribution of the dominant size class category for the riparian zone, Reach 8.

A-9 Reach 9

Location: River mile 49.73 to 51.65

Survey Date: August 10, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-9.1 Reach Overview

Reach 9 is located in a partially confined alluvial valley from RM 49.73 to 51.65 (Figure 91). This reach is very low gradient (0.04%) (Figure 90). Channel form is slightly meandering with bed morphology that is primarily plane-bed. Accessible floodplain areas and steep terraces alternate along the streambanks. Reach 9 lacks both channel complexity and habitat differentiation. Presently, lands along Reach 9 are managed by the US Forest Service and have minimal human development. Beaver Valley Road parallels the main channel along river-right from RM 50.2 to 50.9. This section of road limits floodplain connectivity and access to off-channel habitat. See Figure 91 for a reach overview and habitat unit map.

Figure 102. Typical slow deep-water habitat and alternating narrow floodplains and steep terraces in Reach 9 (August 2011).

Figure 103. Reach 9 locator and habitat unit composition map.

A-9.2 Habitat Unit Composition

Reach 9 consisted of 47% glide, 35% pool, 14% riffle, and 4% side-channel habitat (Figure 92 and Figure 93). Pool frequency was 1.4 pools/mile, with mean pool spacing of 17.6 channel widths per pool. Average residual pool depth was 10.0 feet. Average maximum pool depth was 15.0 feet.

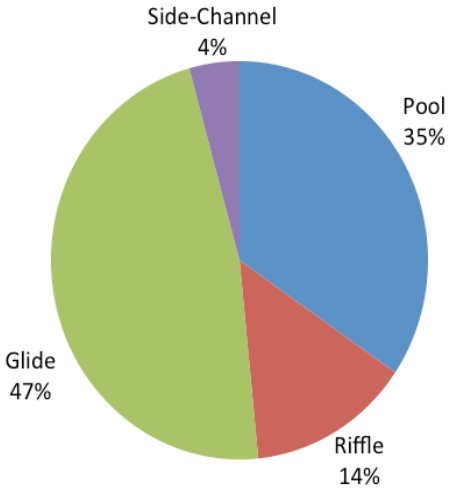


Figure 104. Habitat unit composition, Reach 9.

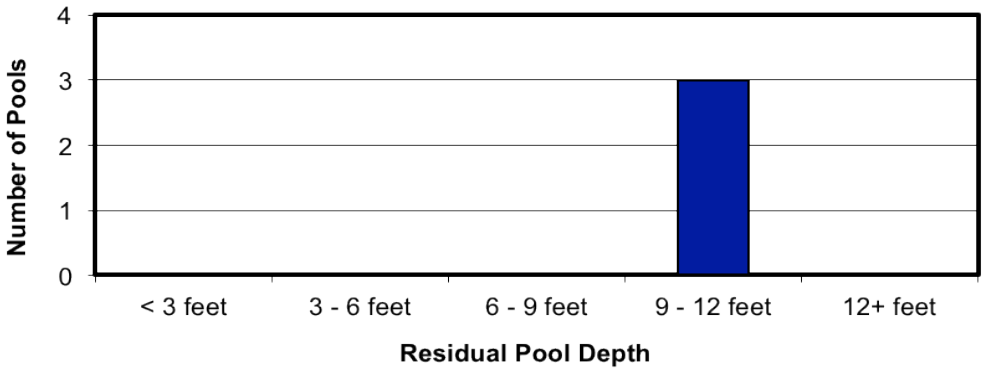


Figure 105. Reach 9 residual pool depths.

A-9.3 Off-Channel Habitat

Reach 9 had one side-channel near RM 50. Side-channel habitat was short and limited within this reach, yet would be expected to provide both spawning and rearing habitat. At the time of the survey, spring Chinook were observed spawning in the river-right channel that provided shallower riffle habitat with adequately sized gravel and small cobble (Figure 94).

Three small backwater marshes were identified in Reach 3. These were located at RM 50 and RM 50.75 on river-left and at RM 50.9 on river-right. Each provided minimal-to-no LWD. Beaver activity was observed within each of the backwater marshlands in Reach 9 (Figure 95).

Figure 106. Reach 9 side-channel habitat provides adequately sized spawning gravels (August 2011).

Figure 107. Beaver activity was observed along a river-right backwater near RM 50.9 (August 2011).

A-9.4 Large Woody Debris

LWD quantities were moderate in Reach 9 compared to other reaches in the study area. LWD frequency was 75 pieces/mile, with "small" pieces comprising 36% of all LWD counted in the reach (Table 9). "Medium" and "Large" wood pieces comprised 64% of the LWD in the reach (28% and 36%, respectively). Beaver activity was observed at scattered locations along the reach and may contribute to LWD recruitment. Large wood recruited and retained along channel margins provides rearing cover and contributes to low water off-channel development in some locations (Figure 96). Surrounding US Forest Service timberlands also have the potential to contribute LWD in the long-term.

Table 10. Large woody debris quantities in Reach 9.

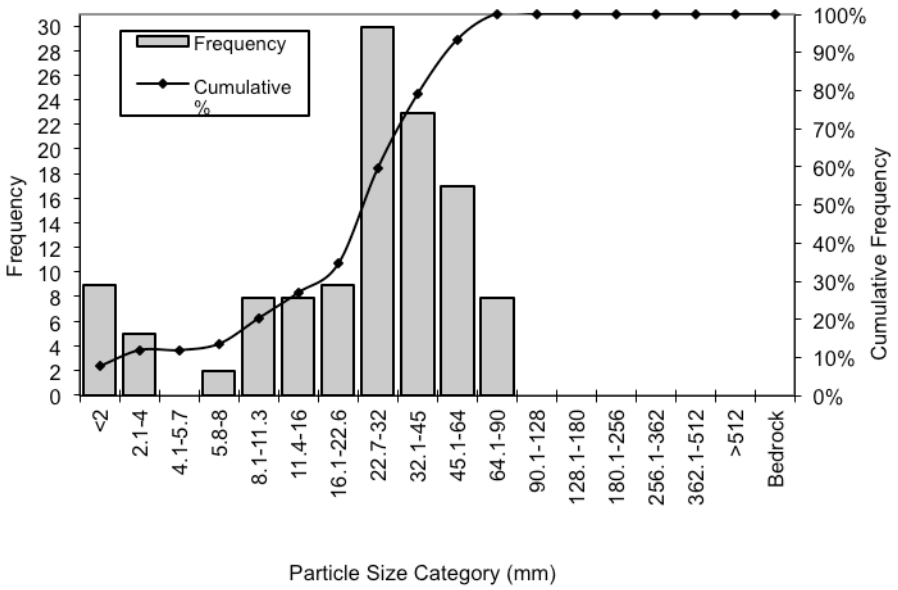
	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	56	44	57	157
Number of Pieces/Mile	27	21	27	75

Figure 108. Woody debris accumulations upstream of the off-channel marsh (RM 50.0) along river-left (August 2011).

A-9.5 Substrate and Fine Sediment

Bed substrate was dominated by gravels, with cobbles subdominant. No bedrock was observed in Reach 1 and boulders made up no greater than 5% of the distribution. The percentage of fine

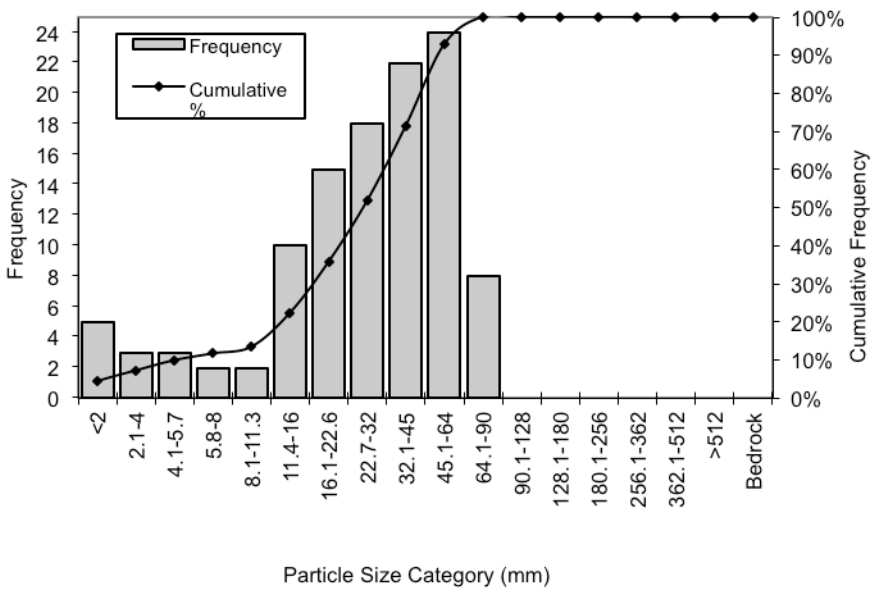
sediment (<2mm) was variable, making up approximately 4-26% of the substrate distribution. The pebble count and size class data are depicted in Figure 97, Figure 98, and Figure 99.



Material	Percent Composition
Sand	8%
Gravel	86%
Cobble	7%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	<2
D16	9
D50	28
D84	52
D95	71

Figure 109. Grain size distribution and particle size classes from pebble count taken at RM 50.0.



Material	Percent Composition
Sand	4%
Gravel	88%
Cobble	7%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	2
D16	13
D50	31
D84	56
D95	72

Figure 110. Grain size distribution and particle size classes from pebble count taken at RM 50.4.

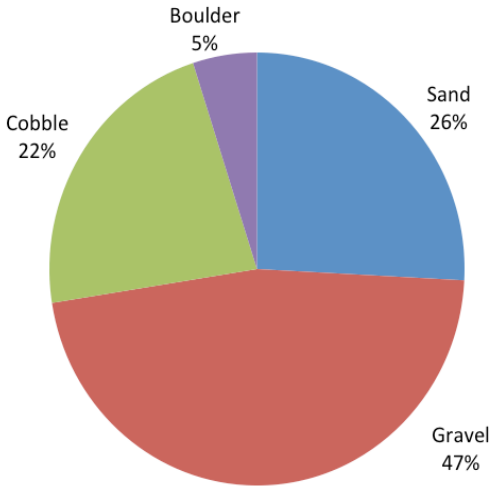


Figure 111. Percent composition of bed substrate based on ocular estimates, Reach 9.

A-9.6 Instability and Disturbance

Bank erosion was high, with the greatest amount of actively eroding streambanks observed in the study area. Reach 9 had a total of 5,455 feet of actively eroding streambank (measured above bankfull), consisting of 22% of the reach length along both banks. Bank erosion was primarily associated with steep terrace banks bordering much of Reach 9 (Figure 100), and is largely a natural erosion process that may be exacerbated by loss of mature riparian trees and loss of LWD jams along the channel margin.

Beaver Valley Rd parallels Reach 9 along river-right from RM 50.2 to 50.9 and bisects a portion of the floodplain.

Figure 112. Bank instability was observed along many of the steep terrace banks throughout Reach 9 (August 2011).

A-9.7 Available Spawning and Rearing Habitat

There was a moderate amount of spawning and rearing habitat available in Reach 9. The dominant substrate in riffles was gravels (86-88%). Riffle pebble count data suggested that Reach 8 offers substrate for both Chinook (13-102 mm) and steelhead (6-102 mm) spawning. Chinook were observed (August 10, 2011) spawning and holding (Figure 101) along channel margins where cobble was present. Coho may also utilize the slower water spawning riffles (Figure 102) and off-channel habitats found in Reach 9. Pool frequency and quality were moderate within Reach 9 (35% of total area).

Figure 113. Submerged woody material provides refugia for Chinook in Reach 9 (August 2011).

Figure 114. Low velocity riffles and small gravels provide moderate spawning habitat in Reach 9 (August 2011).

A-9.8 Riparian Corridor

The width of the forested riparian buffer varied within Reach 9, especially along the middle portion of the reach that parallels Beaver Valley Road from RM 50.3 to 50.9. Generally, the forested riparian buffer was greater than 100 feet wide along the entire reach. Reach 9 had minimal streamside development and lacked the riparian fragmentation seen in Reaches 3 through 8. Second-growth timber surrounds Reach 9.

The riparian zone along Reach 9 was dominated by large trees (62%) (Figure 103), primarily consisting of conifers (88% conifer; 12% hardwood). Ponderosa pine, cottonwood, willow, and alder were the most prevalent species within the riparian zone. Due to the topography and lack of recent human disturbance, Reach 9 has developed a densely vegetated riparian buffer and intact understory compared to downstream reaches. The three off-channel marshlands and the presence of beavers add species and age-class diversity to the riparian buffer.

The level of stream shade provided by the riparian canopy was moderate throughout Reach 9. Large ponderosa pines provided morning and afternoon shade along much of the stream channel.

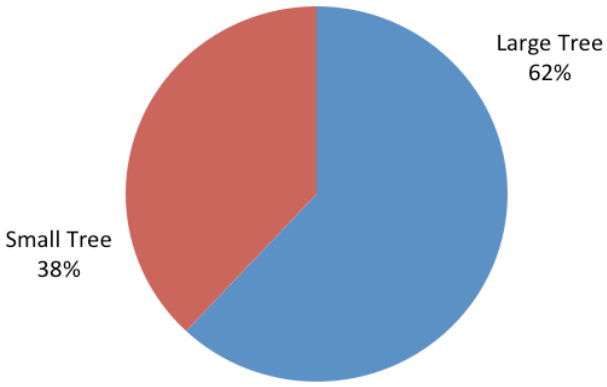


Figure 115. Distribution of the dominant size class category for the riparian zone, Reach 9.

A-10 Reach 10

Location: River mile 51.65 to 53.67

Survey Date: August 9 - 10, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-10.1 Reach Overview

Reach 10 extends from RM 51.65 upstream to the confluence with Nason Creek at RM 53.67 (Figure 106). This portion of the Wenatchee River flows through a wide partially-confined alluvial valley. Channel gradient is 0.11%. Channel form is slightly meandering and bed morphology is a mix of pool-riffle and plane-bed glide units.

On river-right there is scattered development and human infrastructure, including houses, businesses, roadways, and bank armoring (Figure 104). WDFW maintains and seasonally operates a rotary smolt trap for juvenile sockeye monitoring. The trap is secured to cables just upstream of the Hwy 207 Bridge.

Hwy 207 crosses the Wenatchee River at RM 53.6 and disconnects the Nason Creek alluvial fan by reducing the potential range of lateral migration of lower Nason Creek. Riprap and the Hwy 207 bridge abutments constrain the Wenatchee River channel in the vicinity of the bridge. Private infrastructure near the upper portion of this reach experiences periodic flooding (Figure 105).

Residential development (primarily vacation homes) is located along river-right (Braeburn Road) for most of Reach 10. River-left is dominated by low elevation floodplain areas and moderately steep-banked terraces topped with ponderosa pine forests. There are two large open-water marshlands within river-left floodplains that offer connected aquatic refugia and marsh habitat.

Figure 116. Bank armoring and channel confinement near the Hwy 207 Bridge, Reach 10 (August 2011).

Figure 117. The Headwaters Tavern experienced flooding after a winter rain-on-snow event in the 1990s. The Tavern is located on river-right downstream of the confluence with Nason Creek. Photo courtesy of Bryon Newell.

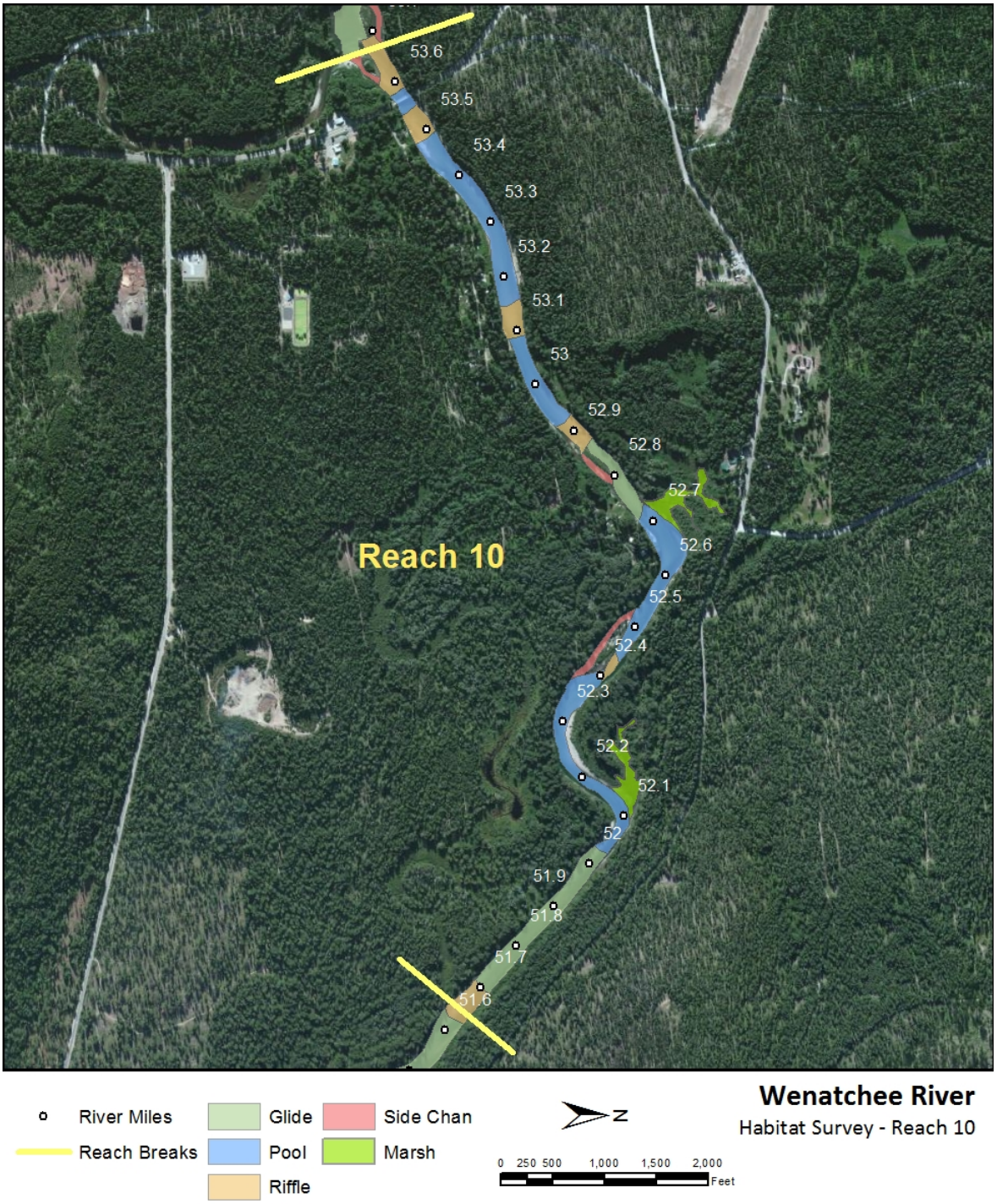


Figure 118. Reach 10 locator and habitat unit composition map.

A-10.2 Habitat Unit Composition

Reach 10 consisted of 57% pool, 20% riffle, 20% glide, and 3% side-channel habitat (Figure 107 and Figure 108). Pool frequency was 2.3 pools/mile, with mean pool spacing of 12.7 channel widths per pool. Average residual pool depth was 6.1 feet. Average maximum pool depth was 10.2 feet. Figure 109 shows a representative glide unit in this reach.

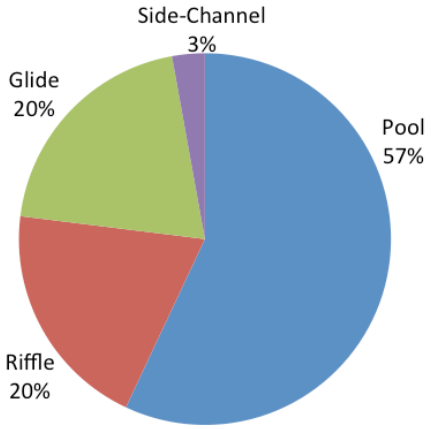


Figure 119. Habitat unit composition, Reach 10.

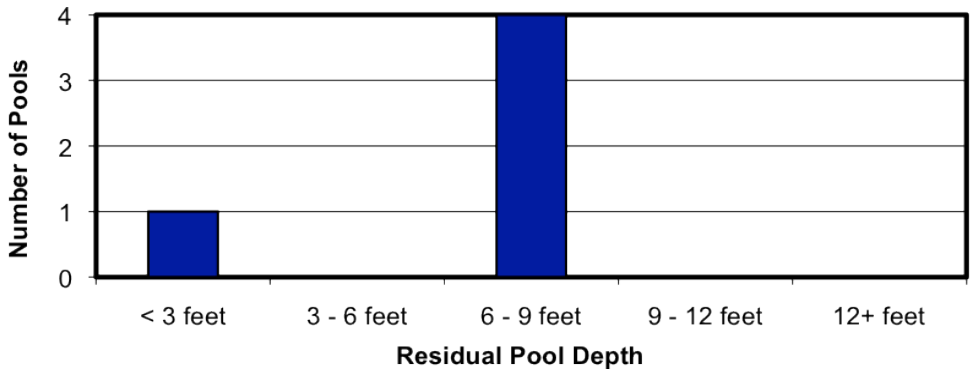


Figure 120. Reach 10 residual pool depths.

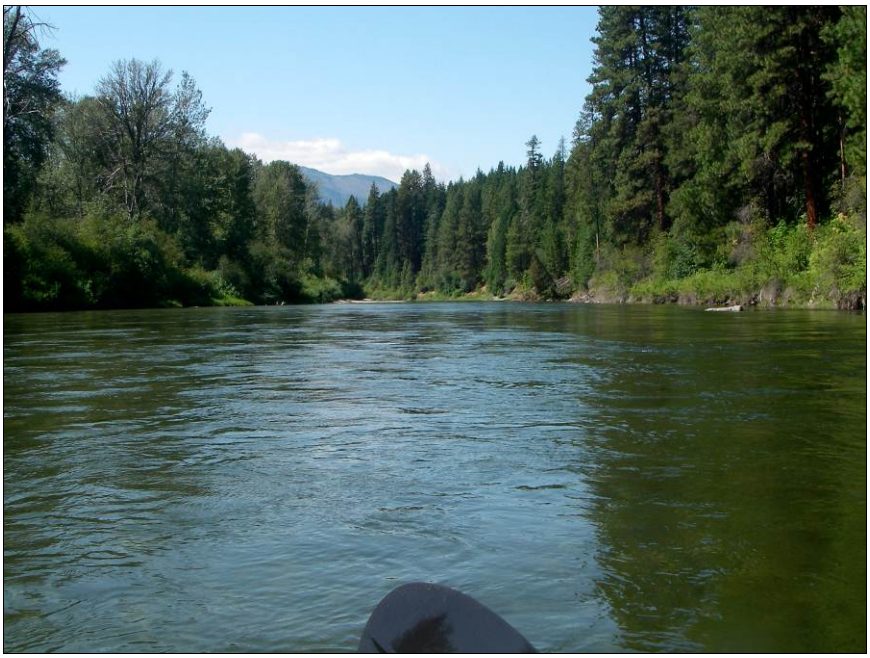


Figure 121. View looking upstream at a representative glide in Reach 10, near RM 51.8 (August 2011).

A-10.3 Off-Channel Habitat

There were three side-channels in Reach 10. Each side-channel provides spawning and rearing habitat not found in many of the faster mainstem riffles. These side-channels were composed of smaller substrate preferred by steelhead and coho.

Reach 10 contained two large open-water marshlands along river-left at RMs 52.1 and 52.7 (Figure 110). High densities of salmonid juveniles and cyprinid fry were observed (August 10, 2011) throughout both marshes (Figure 111). Wetland vegetation (cottonwood, willow, dog wood, spirea, carex, reed canary grass, and yellow pond lily) provided shading and refuge for both fish and wildlife species. Waterfowl and great blue herons were observed utilizing these protected off-channel areas to feed. Reach 10 likely had higher historical off-channel complexity that has been reduced as a result of residential development and associated floodplain filling and grading, especially along the right bank.

The large right bank off-channel complex (Natapoc) along Reach 10 was not counted as off-channel habitat in this reach because it was not connected via surface flow at the time of the survey.

Figure 122. One of two extensive open water marshlands on river-left, Reach 10 (August 2011).

Figure 123. Fry were observed throughout the open-water marshes in Reach 10 (August 2011).

A-10.4 Large Woody Debris

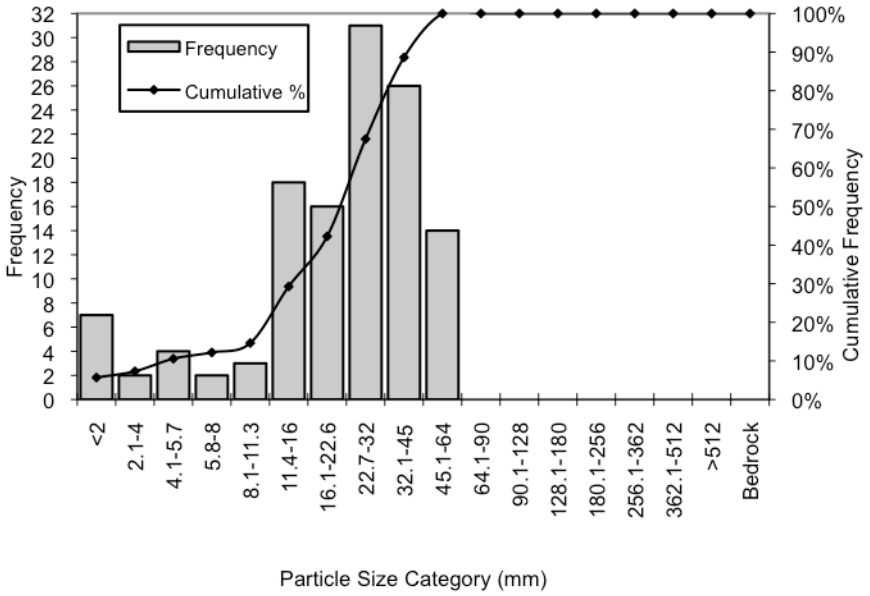
LWD quantities were moderate in Reach 10 compared to other reaches in the study area. LWD frequency was 101 pieces/mile, with "small" pieces comprising 50% of all LWD counted in the reach (Table 10). "Medium" and "large" wood pieces also comprised 50% of the LWD in the reach (29% and 21%, respectively). Reach 10 has a good short and long-term wood supply from the forested left-bank terrace and upstream sources (from both Nason Creek and Lake Wenatchee). Anthropogenic constraints (e.g. bridge, riprap, fill) along the right-bank from RM 52.4 to 53.6 limit lateral channel dynamics that would otherwise recruit wood. Beaver activity provides a limited amount of wood to the reach, particularly in off-channel areas.

Table 11. Large woody debris quantities in Reach 10.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	112	64	47	223
Number of Pieces/Mile	51	29	21	101

A-10.5 Substrate and Fine Sediment

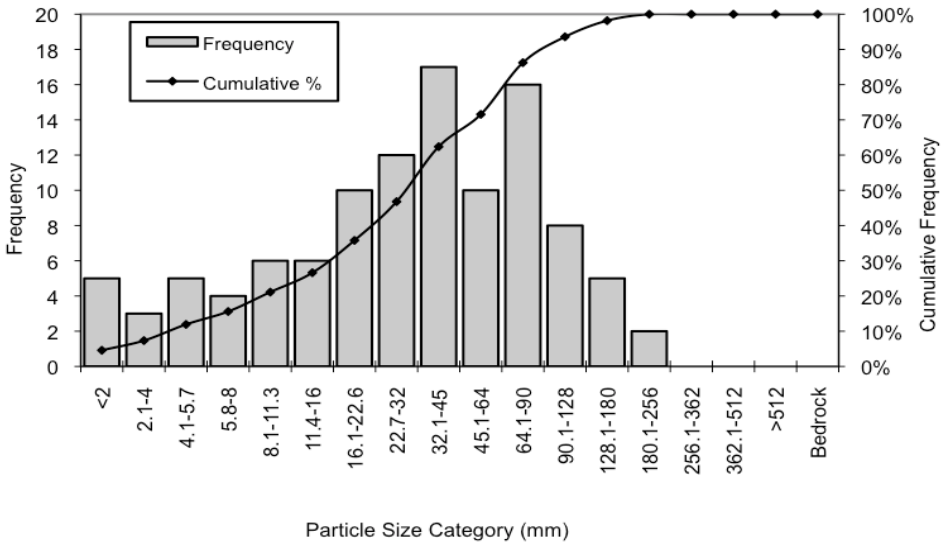
Bed substrate was dominated by cobbles. Gravels were subdominant. No bedrock was observed in Reach 10 and boulders made up no greater than 5% of the distribution. The percentage of fine sediment (<2mm) was relatively low, making up approximately 5-10% of the substrate distribution. The pebble count and size class data are depicted in Figure 112, Figure 113, and Figure 114.



Material	Percent Composition
Sand	6%
Gravel	94%
Cobble	0%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	<2
D16	12
D50	25
D84	42
D95	56

Figure 124. Grain size distribution and particle size classes from pebble count taken at RM 51.7.



Material	Percent Composition
Sand	5%
Gravel	67%
Cobble	28%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	2
D16	8
D50	35
D84	86
D95	144

Figure 125. Grain size distribution and particle size classes from pebble count taken at RM 53.1.

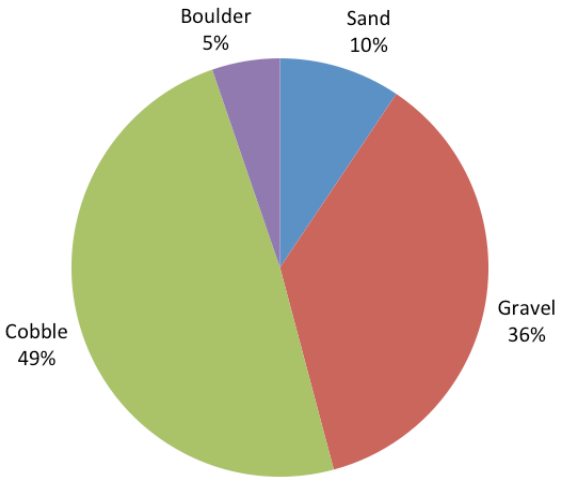


Figure 126. Percent composition of bed substrate based on ocular estimates, Reach 10.

A-10.6 Instability and Disturbance

Human activities have modified the channel, floodplain, and riparian corridor in Reach 10. Bank erosion was relatively high compared to other reaches in the study area. Reach 10 had a total of 4,866 feet of actively eroding streambank (measured above bankfull), consisting of 18% of the reach length along both banks.

Scattered development and human infrastructure has altered natural channel processes throughout the upper portion of Reach 10, especially from RM 52.6 to RM 53.7. This includes recreational access, houses, businesses, roadways (HWY 207), and bank armoring. Channel confinement and bank armoring is responsible for most of the disturbance in the upstream portion of Reach 10 (Figure 115).

Bank erosion was primarily associated with the moderately steep banked terraces bordering much of Reach 10 along river-left (Figure 116).

Figure 127. View looking upstream at a concrete retaining wall that borders a residential property along river-right near RM 53.1 (August 2011).

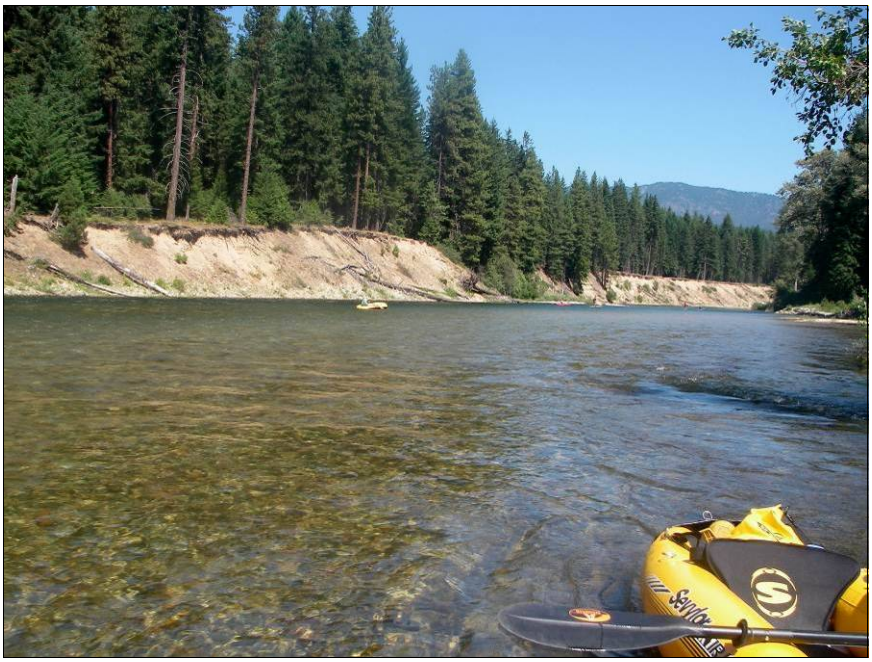


Figure 128. Bank erosion was primarily associated with moderately steep bank terraces along Reach 10 on river-left (August 2011).

A-10.7 Available Spawning and Rearing Habitat

There is spawning and rearing habitat available in Reach 10. The dominant substrate in riffles (derived from one representative pebble count) was gravel (81%) and subdominant was cobble (14%). Substrate within this reach was ideal size for steelhead (6-102 mm) and Chinook (13-102 mm). Pool quantity and residual pool depths are suitable for juvenile salmonid rearing. Reach 10 had a total of five pools, making up 57% of the total channel area, plus two additional off-channel units. Four pools (80% of reach total) had residual depths greater than 3 feet. LWD was limited, although there is potential for short and long term recruitment.

The side-channel directly downstream from the Nason Creek confluence provides suitable habitat for steelhead and coho spawning. Lower in Reach 10, spring Chinook were observed (August 10, 2011) holding in deeper riffle pockets, presumably waiting for stream flows to drop. Figure 117 shows riffle habitat representative of Reach 10.

Figure 129. Gravel was the dominant substrate found in spawning riffles throughout Reach 10 (August 2011).

A-10.8 Riparian Corridor

The width of the forested riparian buffer varied within Reach 10, especially along the right bank from RM 52.4 to RM 53.6. Residential development and road building throughout this portion has resulted in a fragmented riparian buffer with little understory vegetation.

The riparian zone along Reach 10 was dominated by large trees (75%) (Figure 118), primarily consisting of conifers (56% conifer; 38% hardwood, 6% no vegetation). Small trees were subdominant (19%). Ponderosa pine, cottonwood, willow, dogwood, and alder were the most prevalent species in the riparian zone. Side-channels and open water marshlands found in Reach 10 also had wetland vegetation that included cottonwood, willow, dogwood, spirea, carex, reed canary grass, and yellow pond lily.

The level of stream shade provided by the riparian canopy was low-to-moderate throughout Reach 10. Small trees and shrubs provided ample shading and refugia within the open water marshes and side-channels. Large ponderosa pines only provided morning and afternoon shade along portions of the main channel.

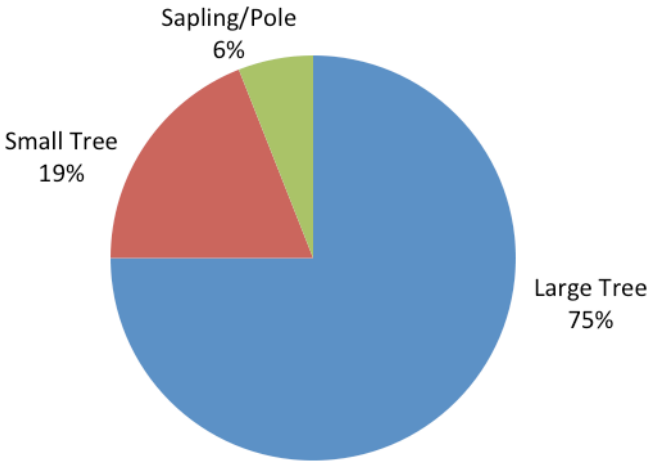


Figure 130. Distribution of the dominant size class category for the riparian zone, Reach 10.

A-11 Reach 11

Location: River mile 53.67 to 54.15

Survey Date: August 9, 2011

Survey Crew: Christa Strickwerda Heller and Adrianne Zuckerman (Inter-Fluve)

A-11.1 Reach Overview

Reach 11 is the upstream-most reach of the mainstem Wenatchee River. This short reach is located between the confluence of Nason Creek (RM 53.7) and the outlet of Lake Wenatchee (RM 54.15). Reach 11 has a mix of lacustrine and riverine geomorphology (Figure 119). The slope of the channel is < 0.10%. Channel form is almost straight and bed morphology is plane-bed glide with limited complexity. The upper 0.5 miles is confined within steep banked terraces and the lower 0.1 miles is influenced by sediment and discharge from Nason Creek.

The Lake Wenatchee State Park sits at the headwaters of the Wenatchee River along river-right. The Park uses include both summer and winter recreation activities, including cross-country skiing, camping, fishing, boating, and swimming. In the early 1900s, the State Park had been the site of the Lake Wenatchee Mill. Evidence of past logging practices remains today. See Figure 120 for a reach overview and habitat unit map.

Figure 131. View looking upstream towards Lake Wenatchee and the plane-bed channel of Reach 11 (August 2011).

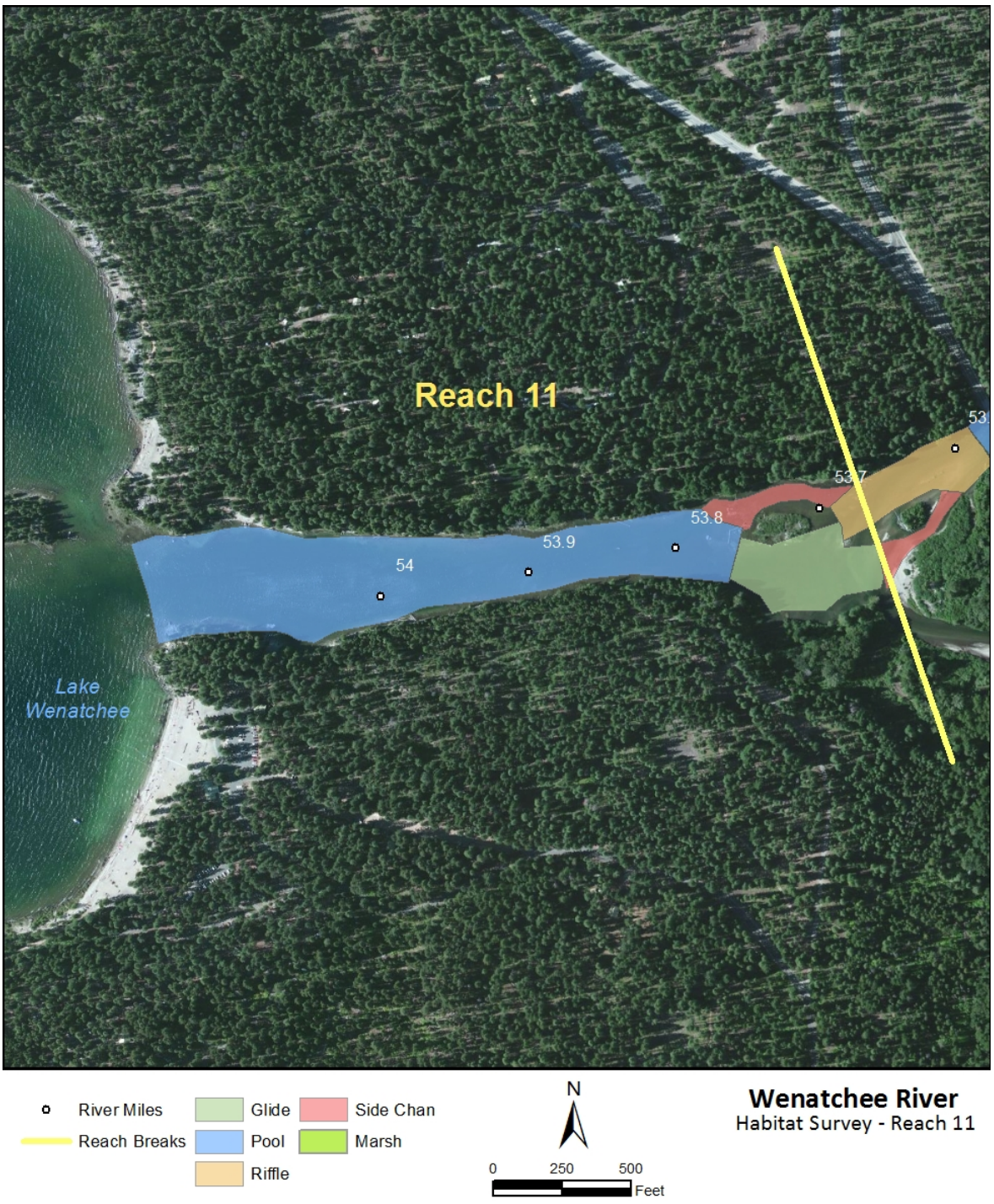


Figure 132. Reach 11 locator and habitat unit composition map.

A-11.2 Habitat Unit Composition

Reach 11 was the shortest reach in the Upper Wenatchee study area, measuring just 0.48 miles in length. This reach consisted of only 3 habitat units and was composed of 77% pool, 18% glide, and 5% side-channel habitat (Figure 121 and Figure 122). Pool frequency was 2.0 pools/mile, with mean pool spacing of 8.0 channel widths per pool. Average pool depth was 8.0 feet and maximum pool depth was 12.0 feet.

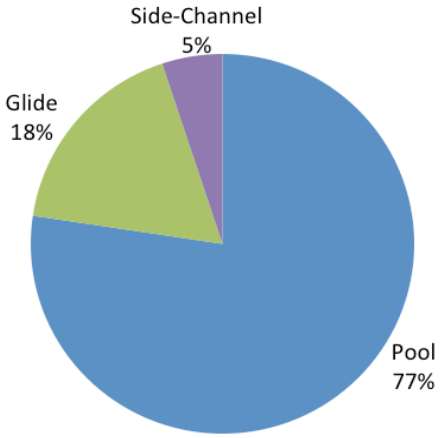


Figure 133. Habitat unit composition, Reach 11.

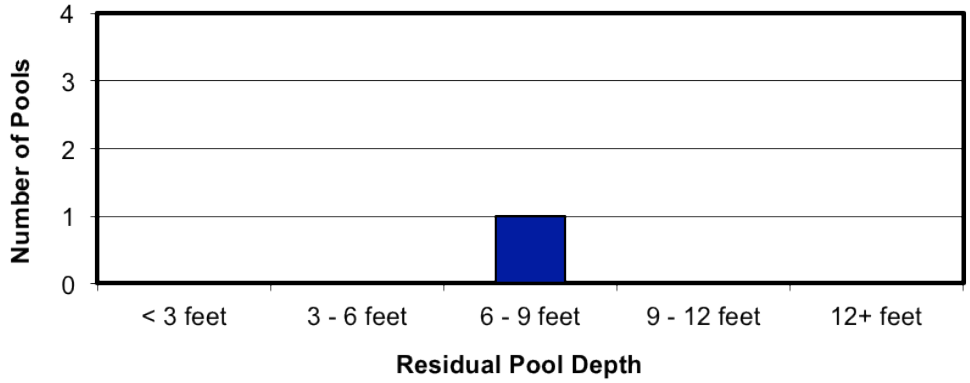


Figure 134. Reach 11 residual pool depth.

A-11.3 Off-Channel Habitat

There was one side-channel in Reach 11. It was relatively short, shallow, and faster than the main channel glide (Figure 123). Old pilings, which are potentially remnants of past log-driving activities, remained embedded in the channel along the left bank. Lateral margins of the channel offer shallow water refuge along the frequently inundated and vegetated sloping streambank. A small backwater area, located approximately 130 feet upstream of the Nason Creek confluence,

receives surface water from Nason Creek in addition to hyporheic flow from both the Wenatchee River and Nason Creek.

Figure 135. Side-channel habitat during moderate summer stream flow, Reach 11 (August 2011).

A-11.4 Large Woody Debris

LWD frequency was high in Reach 11, having the third highest wood count per mile within the upper Wenatchee study area. There were many submerged cut logs throughout the upper 0.4 miles of the reach, possibly remnants from historical logging operations. LWD frequency was 242 pieces/mile, with "small" pieces comprising 52% of all LWD counted in the reach (Table 11). "Medium" and "Large" wood pieces comprised 48% of LWD in the reach (32% and 16%, respectively). Reach 11 has high LWD recruitment potential from upstream sources, which includes drift from Lake Wenatchee and streams higher in the basin (Figure 124). High winds funnel into the upper reach that may aid in LWD recruitment. In contrast, near-term LWD recruitment potential is low due to a lack of large, mature trees in the riparian area. Only a few snags were observed along the left bank.

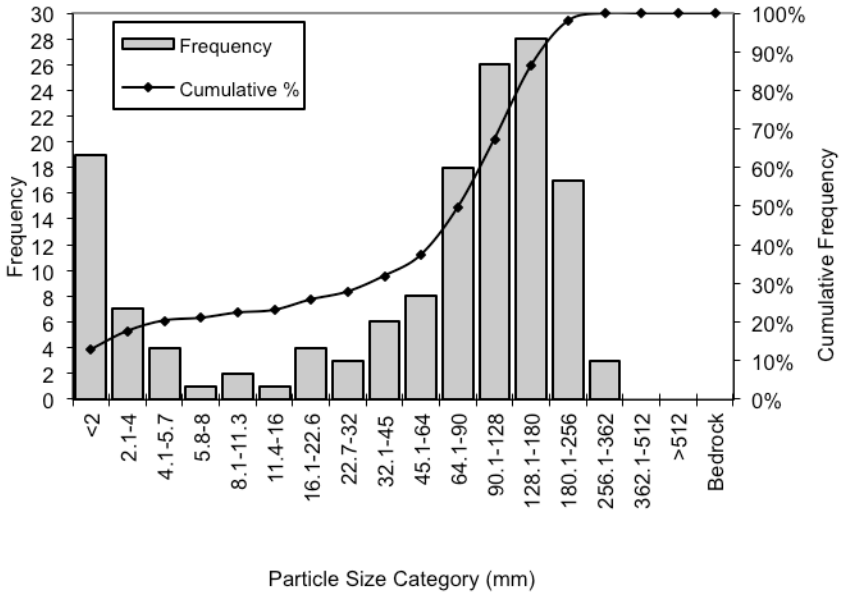
Table 12. Large woody debris quantities in Reach 11.

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	63	38	19	120
Number of Pieces/Mile	127	77	38	242

Figure 136. Pool habitat in Reach 11 has accumulated moderate quantities of large wood along river-right (August 2011).

A-11.5 Substrate and Fine Sediment

Bed substrate was dominated by cobbles; boulders were subdominant (20%). Sand and gravel both made up 10% of the distribution. No bedrock was observed in Reach 11. The pebble count was unable to be collected in a riffle unit, as Reach 11 is void of this habitat type; therefore the pebble count was collected at the upstream end of a glide. Pebble count data were consistent with the ocular estimates for substrate composition with the exception of boulders. The pebble count and size class data are depicted in Figure 125 and Figure 126.



Material	Percent Composition
Sand	13%
Gravel	24%
Cobble	61%
Boulder	2%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	<2
D16	3
D50	91
D84	173
D95	237

Figure 137. Grain size distribution and particle size classes from pebble count taken at RM 53.8.

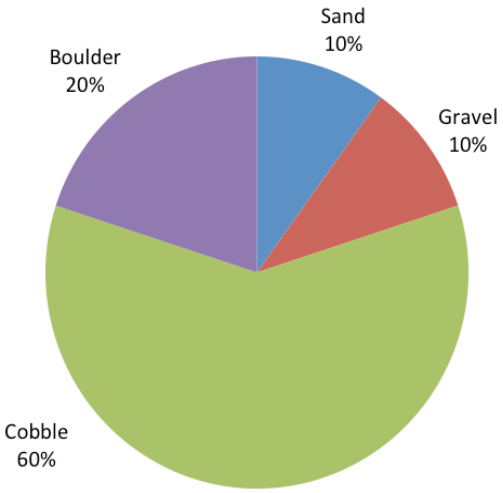


Figure 138. Percent composition of bed substrate based on ocular estimates, Reach 11.

A-11.6 Instability and Disturbance

Remnant concrete pilings are located in the upper portion of this reach along both banks (Figure 127). At the upstream end on river-right, small trails and river access associated with the State Park limit understory growth.

Figure 139. Remnant concrete pilings on river-left, Reach 11 (August 2011).

A-11.7 Available Spawning and Rearing Habitat

The slow, lacustrine nature of this reach provides minimal spawning habitat. Spawning is unlikely to occur in the cobble dominant (60%) side-channel. Many large cobbles and boulders (> 128 mm) were also present, which is not ideal substrate for Chinook (13-102 mm) or steelhead spawning (6-102 mm). Reach 11 had one pool (77% of reach total area) with a residual depth greater than 3 feet, which provides adequate rearing habitat for juvenile salmonids.

Adult sockeye use this reach as a migration corridor and holding area prior to accessing the spawning beaches and tributaries of Lake Wenatchee.

A-11.8 Riparian Corridor

The width of the forested riparian buffer was fairly consistent throughout Reach 11. The riparian buffer was dominated by small trees (dominant within 100% of units), with the overstory comprised nearly entirely of conifers (100% of units). Douglas fir, ponderosa pine, willow, and alder were the most prevalent species in the riparian zone. Rushes and other frequently inundated grasses were growing throughout the lateral margins of the upper reach.

The level of stream shade provided by the riparian canopy was low throughout Reach 11. Douglas fir and ponderosa pine provide limited morning and afternoon shade along the main channel.