Appendix A

Stream Habitat Assessment

Middle Twisp River (RM 7.8 – 18.12)

Survey: October 2013

Contents

1 Introduction & Background

The Twisp River is located on the east slopes of the Cascade Mountains in Okanogan County, Washington. It flows into the Methow River near the town of Twisp, Washington. A study of the Middle Twisp River was conducted on October 22 – October 29, 2013 from RM 7.8 – RM 18.12. The study follows a 2009 Stream Habitat Assessment of the Lower Twisp River (Inter-Fluve 2010). Stream flow was measured on October 29, 2013 at the beginning and end point of study area. Stream flow measured 96 cfs at RM 7.8 (beginning of study area) and measured 62 cfs at RM 17.85. According to the USGS gauging station located at RM 1.6 of the Twisp River, near Twisp, WA (gage number 12448998), stream flow during the time of the survey measured from 96 – 127 cubic feet per second (cfs)

The objective of the Habitat Assessment is to characterize the habitat quantity and quality for salmonid species native to the Twisp River and the Upper Columbia River basin by quantifying in-channel morphologic features and qualitatively describing riparian conditions that influence 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 assessment on this section of the Twisp River since a 2001 Stream Survey Report was conducted by the Methow Valley Ranger District of the Okanogan-Wenatchee National Forest and the Pacific Watershed Institute (PWI).

Spring Chinook and steelhead utilize the Twisp River from RM 0 – 15 for migration, spawning, and juvenile rearing. Bull trout also present in the Twisp River, utilizing it for foraging, migration, and over-wintering. Most of the spring Chinook and all of the bull spawning occurs between RM 12 – 27 (USBR, 2008).

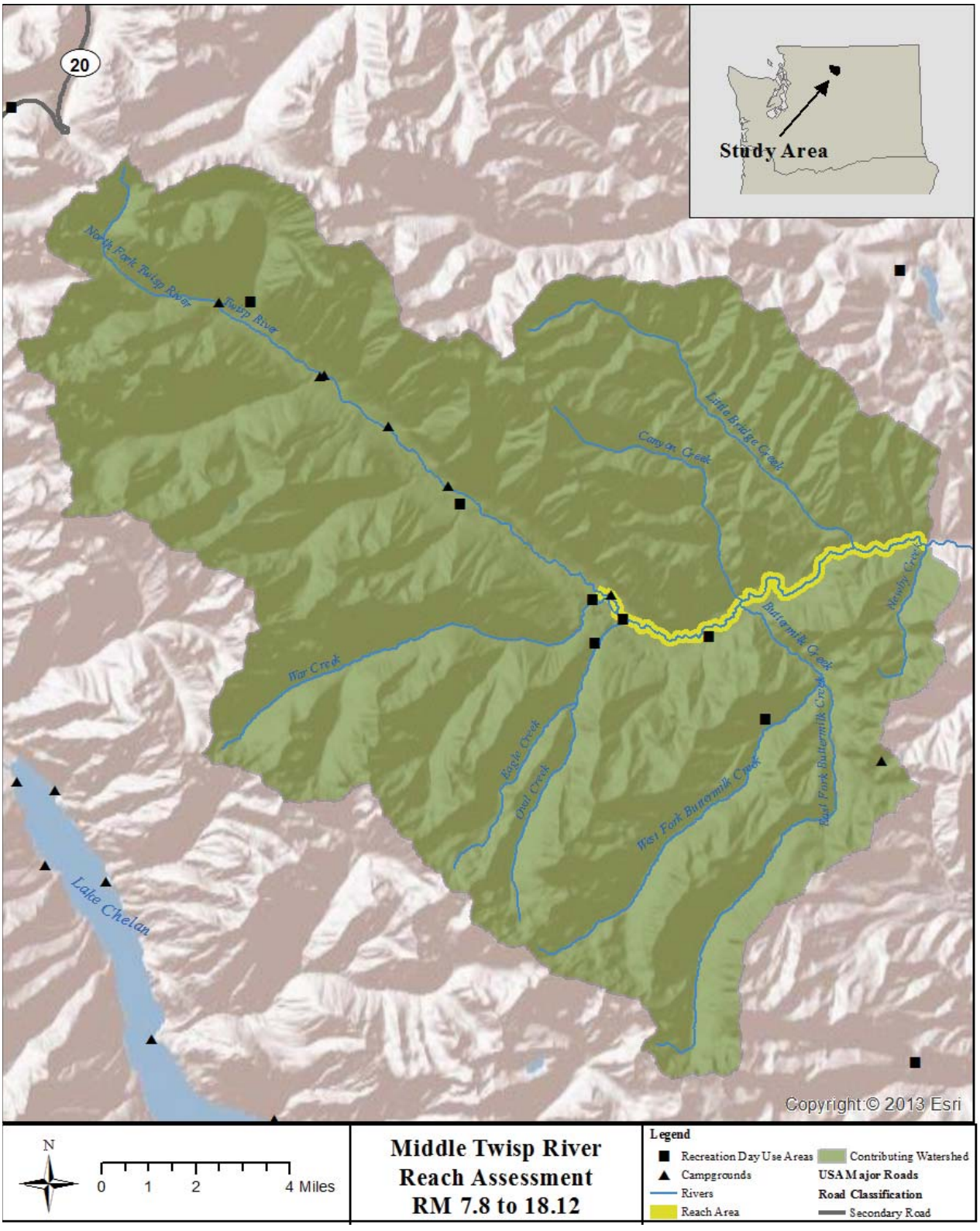


Figure 1. Overview of Middle Twisp study area from RM 7.8 to 18.12.

2 Methods

Six geomorphic reaches were delineated in this stream assessment. The same reach delineations were used for both the stream assessment and the geomorphology assessment to maintain consistency.

Field methods for the habitat survey used the USFS Region 6 Level I & II Stream Inventory Handbook, Version 2.12 (USDA Forest Service 2012). All protocols and most forest options were observed during the survey due to favorable wading depths and conditions. Flow rates were slightly above average, ranging from 96 – 127 cfs (median averages for these dates range from 52 – 68 cfs) according to USGS Twisp River gauge 12448998.

All reach-scale metrics were calculated using GIS measurements as opposed to reach lengths measured in the field by tape. We chose GIS measurements because GIS provides a more accurate measurement at a reach scale.

The measured n^{th} unit measurement frequency was 20%, or 1 unit measured in every 5. This choice was made to ensure that enough n^{th} unit measurements would be made. At nth units, ocular wet width measurements were estimated by the observer and then measured by the recorder with a 100' tape. The average difference between the actual measured width and ocular values was 0.3 feet. Floodprone widths were only measured in the field when accurate measurements were possible. Others were measured in the office using LIDAR images.

Two pebble counts were performed in each of the six reaches. To maintain consistency, the first pebble count of each reach was performed around the first 25% of the entire length of the reach; the second pebble count was performed at approximately 75% of the entire length the reach. For example, if a reach was one mile long, we tried to perform a pebble count at 0.25 miles and 0.75 miles. A gravelometer was used to measure pebble counts. When more than one person was taking measurements, a survey rod was used to measure pebble size. In addition to pebble count, visual (ocular) measurements of bed sediment (considered a "forest option" in the USFS protocol), were recorded at every n^{th} unit.

Depths of pools, riffles and glides were measured using a 9-foot graduated survey rod carried by the observer. Where water velocity or depth appeared unsafe, the observer either estimated depths or measured outside the thalweg.

Off-channel marshland was measured and recorded when connected to the main river. At times, marshland and side channel backwaters were challenging to differentiate. In these instances, vegetation was used as the primary indicator.

Side channels 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. Each side channel was determined to be fast or slow, and its average width and length measured. Length was recorded as wetted length, with a second column measuring total length (including dry channel length). Where side channels were either too long (one side channel measured just short of 1 mile), or too thick with downed wood, GIS was used to measure side channel length. LWD was counted for each side channel.

Floodprone width (FPW) is defined as the width of the floodplain at twice the max bankfull depth. Survey crews measured floodprone width in the field where it was possible to achieve accurate measurements. Where the floodplain was excessively wide, FPW was calculated in the office using LIDAR combined with n^{th} unit measurements.

Reach 5 and some of Reach 6 are highly complex, low gradient, sinuous reaches. Within these reaches, several channel units were designated as "braided" when there was a series of three or more roughly

parallel channels structured during bankfull flow and separated from each other by unstable islands. In these units, channel width was recorded as the *average* wetted channel widths for each of the multiple channels with flowing water. This is a deviation from the handbook, which suggests using the *sum* of the wetted channel widths. Due to the highly complex nature of these reaches, it is likely that several more of the channel units could be designated as braided.

LWD was counted using the USFS Stream Inventory Guidebook guidelines. In the case of log jams, only wood that conformed to Guidebook guidelines was counted.

3 Summary of Results

This section summarizes the results of the habitat assessment for all six reaches. Detailed reach summaries with reach-specific results are included in Appendix A.

3.1 CHANNEL MORPHOLOGY

Channel bed substrate consisted primarily of cobble, gravel, and boulder in reaches 1 and 2, and cobble and gravel in reaches 3 through 6. Bedrock and sand occurred infrequently.

Bankfull widths throughout the study area were not highly variable in reaches 1,2, 4, and 6 (Table 1). Reach 3 and 5 had moderately variable bankfull widths, ranging from 61 – 180 feet wide (Reach 3) and 48 – 200 feet wide (Reach 5). The average bankfull width throughout the study area was 87.3 feet (stdev 34.6). Average bankfull depths for each reach ranged from 2 – 5 feet (Table 2). The average bankfull depth throughout the entire study area was 3.2 (stdev 1.3). Floodprone widths varied considerably throughout the Middle Twisp River. Floodprone widths averages varied from 121 feet in Reach 4, to 393 feet in Reach 5, with an average standard deviation of 247. The floodprone width averaged 269 feet throughout the entire project area.

Table 1. Max, Min, and mean bankfull widths for reaches 1 – 6 in feet.

Bankfull Widths (feet)						
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 6**
Min	66	75	61	68	48	56
Max	91	107	180	90	200	90
Mean	81.6	91	102.2	79.5	92.6	72
St Dev	13.7	22.6	48	9	49.5	13.3

Table 2. Max, Min, and mean bankfull depths for reaches 1-6 in feet. Mean values are an average of the three individual measurements taken at multiple n^{th} units in each reach.

Bankfull Depths (feet)						
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 6**
Min	3.3	3	2.5	2.3	0.2	1.2
Max	5	6.4	4.5	4.9	4.5	3.3
Mean	4.3	5.0	3.7	4.0	2.3	2.0
St Dev	0.5	1.2	0.5	0.9	1.1	0.6

Table 3. Max, min, and mean floodprone depths for reaches 1- 6 (in feet). Mean values are an average of all measurements taken in each reach at n^{th} units. Where floodprone width could not be calculated in the field, it was estimated using LIDAR.

Floodprone Width (feet)						
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 6**
Min	100	100	210	98	110	63
Max	195	135	375	160	900	865
Mean	170	118	320	121	393	261
St Dev	61	25	69	29	338	340

3.2 HABITAT UNIT COMPOSITION

Riffles were by far the dominant habitat area in the study area, with lesser percentages of glide and pool. (60%, 20%, and 15% respectively). The remaining 5% of habitat area was composed by side channel (Figure 2). Less than 1% of braided channel habitat was measured in the study area as well. At the reach level, Reach 5 was the most unique reach with nearly equal proportions of side channels, glides, riffles, pools (Figure 3).

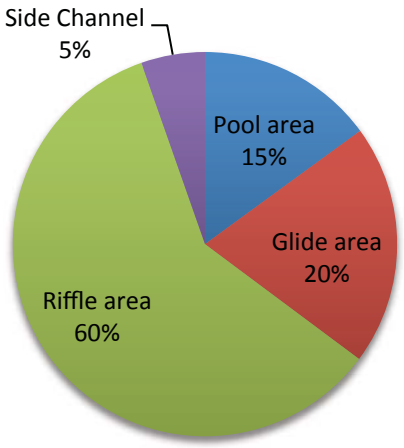


Figure 2. Habitat area composition of Reaches 1-6 in the Middle Twisp River.

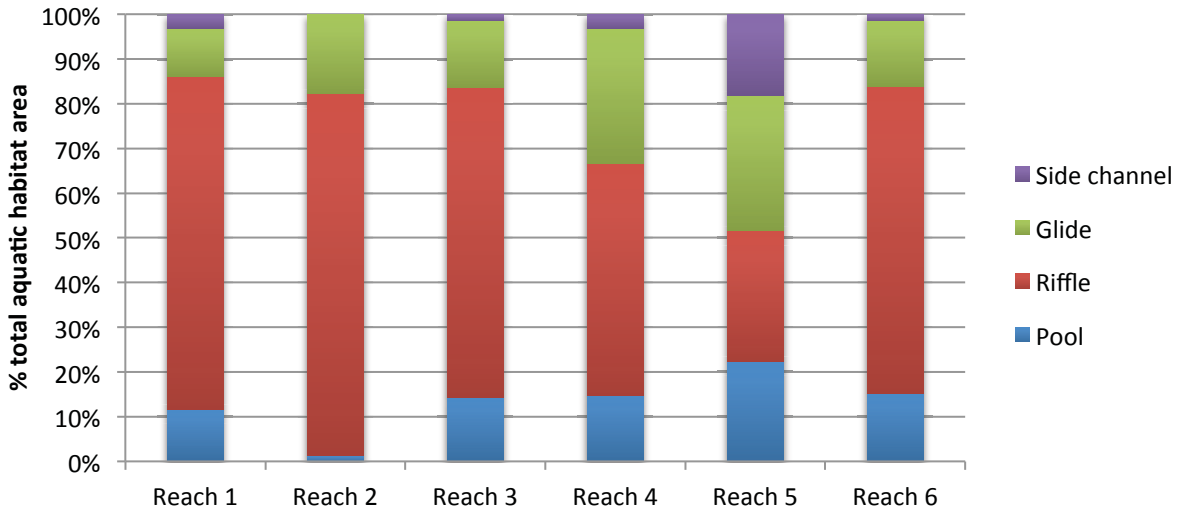


Figure 3. Habitat unit composition of Reach 1-6 in the Middle Twisp River.

Pool frequency ranged from 1.53 pools/mile (Reach 2) to 13.12 pools/mile (Reach 5), with a mean frequency of 6.88 pools/mile. Frequency was calculated as the number of pools divided by the length of the reach in miles. Pool spacing values were calculated by using the frequency (*f*) to determine spacing over a mile, then normalizing those distances using the average bankfull width (W_{bf}):

$$\frac{5{,}280 \text{ ft}/f}{W_{bf}}$$

Reach 5 had the great proportion of pool area habitat (23%) while Reach 2 had the least (1%) (Figure 3). Mean pool spacing was 15.4 bankful widths. Spacing ranged from 4.2 at the most closely space (Reach 5), to 36.8 in Reach 2. Reaches 3 and 5 had the greatest pool area in the study area (Figure 4) with 34% and 26% of the habitat area, respectively. Average residual pool depth was 2.84, with a range of between 2.1 feet for the most shallow residual pool depth in Reach 6, to 2.95 feet for the deepest residual pool depth in Reach 4. The deep residual pool depth measured was 8 feet.

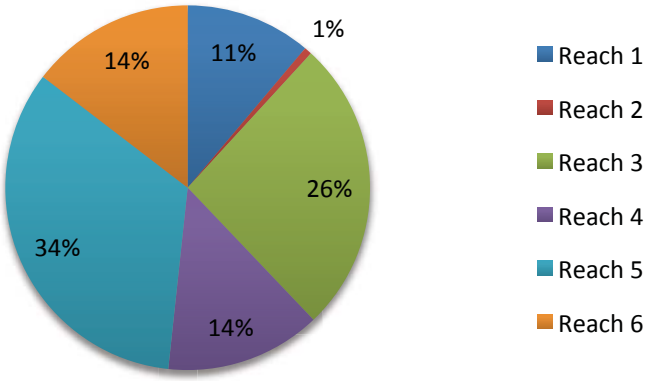


Figure 4. Percent of total area (square feet) of pools in each reach of the 10.32 mile study area.

Mean wetted pool width was 43.6 feet (StDev of 16 feet). Reach 5 had both the widest pool at 100 feet, and narrowest pool at 22 feet. The average pool length in the study area was 140 feet (StDev of 63 feet). Reach 2 had the shortest average pool length at 78 feet (only one pool was measured in Reach 2). Reach 4 had the longest average pool length at 194 feet.

3.3 OFF-CHANNEL HABITAT

Side channel habitat units accounted for 5% of habitat area in the study reach. A total of 28 side channel units were counted during the survey. Of the 28 side channels, 23 were slow, and 5 were fast-moving. Reach 5 had the most side channel habitat area of all reaches in the study area (Figure 5), accounting for 73% of the side channel habitat area in the study area. Except Reach 2, all reaches had side channel habitat. The mean side channel length was 670 feet (StDev 989), with a maximum side channel length measuring 4,956 feet (Reach 5) and minimum observed length of 20 feet (Reach 5). Mean side channel width was 11.0 feet (StDev 10.3), ranging from 2-40 feet.

In addition to side channels, the study area had five marshes ranging from small ponds to large connecting backwater ponds. These off channel marshlands contain food sources (invertebrates), LWD, refuge, and rearing habitat for fish and wildlife species. One off channel marsh was identified in Reach 4, the remaining five were identified in Reach 5.

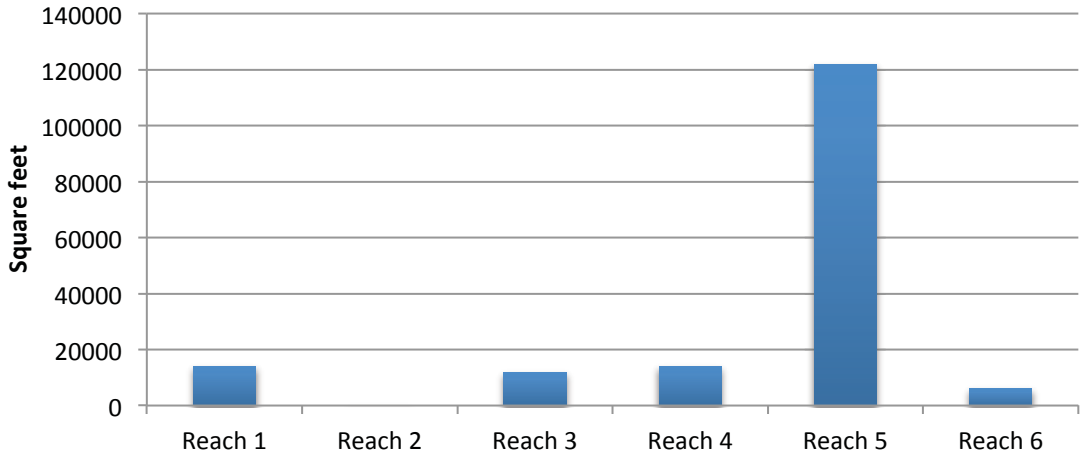


Figure 5. Side channel habitat area by reach. Reach 5 accounted for 73% of the side channel habitat area.

3.4 LARGE WOOD

An average of 96 pieces of LWD/mile was counted in the study area; 71% was "small" wood, measuring between 6 – 12 inches in diameter with lengths greater than 20 feet (Figure 6). Medium and large wood, measuring more than 12" diameter and more than 35' long), accounted for the remaining 29% of wood in the study area. Wood counts varied from as low as 28 pieces of small, medium and large wood per mile (Reach 2), to as high as 207 pieces per mile in Reach 5. Reach 5 also had the most wood overall with 54% of the total wood count. A total of 17 log jams were counted throughout the study area. Log jams are defined as having 10 or more pieces of contiguous LWD. Rates of log jams ranged from 0 log jams/mile for reaches 1 and 2, to a max of 3.86 log jams/mile in Reach 5. Wood counts in log jams ranged from a minimum of 10 pieces to a max of 35 pieces. Side channels account for 17% of the entire wood count (167 pieces of the 991 total pieces counted).

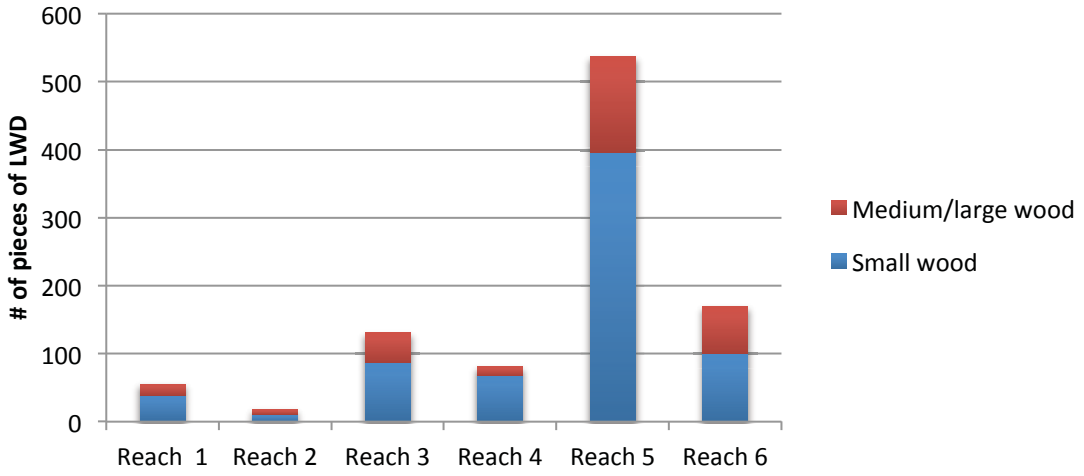


Figure 6. Small (6 – 12" diameter, >20 ' long) and medium/large wood (>12" diameter, >35' long) counts by reach.

3.5 SUBSTRATE & FINE SEDIMENT

Bed substrate and fine sediment measurements are based on pebble count (two in each reach) (Figure 8) and ocular measurements (Figure 7) conducted at each measured habitat unit throughout the study area. In general, substrate increased in coarseness going downstream. Cobble was the dominant substrate in all six reaches except Reach 5, where cobble and gravel were of equal proportions.

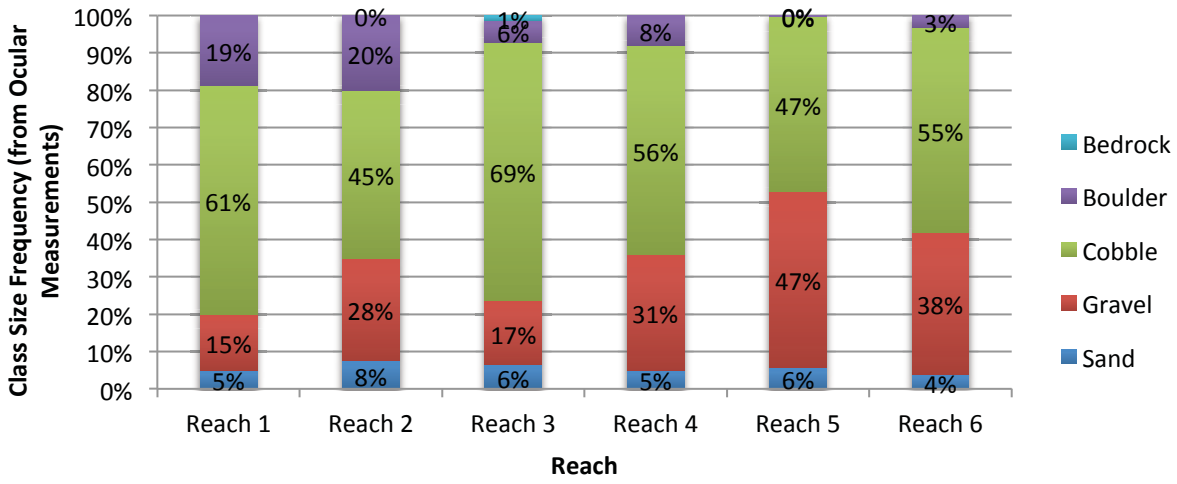


Figure 7. Ocular estimates of substrate by reach for the 10.32 mile study area of the Middle Twisp River.

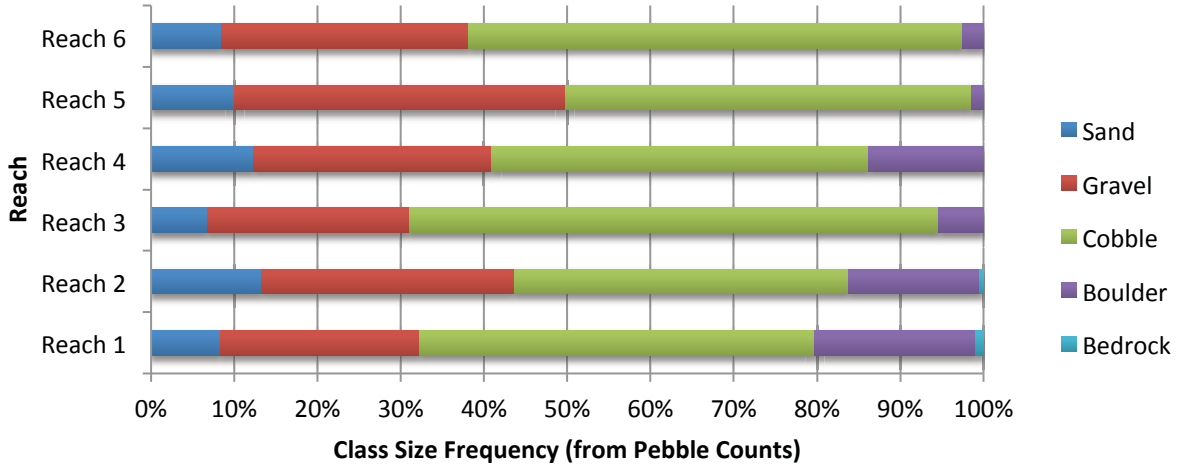


Figure 8. Pebble count classification of substrate by Reach for the MIddle Twisp River. Pebble counts percent composition were averaged between the two pebble counts from each reach.

Pebble counts show similar results in the distribution of sediments. Average sand counts ranges from 8% - 13%. The highest average sand count (<2mm) in the pebble count was 13% composition in Reach 2 compared to 8% in the ocular measurements.

3.6 INSTABILITY & DISTURBANCE

All reaches had significant human impacts, including residential development on the floodplain, channelization, roads, and agriculture clearing adjacent to the river and riparian areas. There was more significant human alteration at the lower half of the study area. Twisp River Road is adjacent to lower reaches, deviating away from the river at the start of Reach 5 where the valley widens.

Anthropogenically-caused bank erosion was minimal throughout the entire study area. In total, 285 linear feet of bank erosion was identified at n^{th} unit measurement in the lower four reaches. No anthropogenically caused bank erosion was identified in reaches 5 and 6.

3.7 FISH PASSAGE BARRIERS

There were no anthropogenic fish passage barriers in the study area. Access to some off-channel habitat may be limited in low-flow, low-water years, and may impact adult fish passage.

3.8 RIPARIAN CORRIDOR

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 (USDA 2010). For reasons best suited to this assessment, one single 100-ft wide riparian zone was designated for the Twisp River study area. Survey methods dictate defining a dominant size class of vegetation type for the riparian zone (i.e. large trees, small trees, shrubs), then defining the dominate species observed in the over and understory respectively.

In total, 40 nth-unit measurements were completed within the six reaches of the study area. Riparian measurements identified small trees measuring 9.0 – 20.9 inches in diameter as the dominant size class (40%). The remainder of the riparian zone measured was dominated by shrub/seedling cover measuring 1.0 – 4.9 inches in diameter (23%); grassland/forb (15%); sapling/pole measuring 5.0 – 8.9 inches in diameter (12%); and large trees measuring 21 – 31.9 inches in diameter (2%). Figure 9). The riparian overstory measured was dominated by Douglas fir (42%) as well as cottonwood (35%), alder (15%), and ponderosa (8%)(Figure 10). Understory was dominated by alder (63%). Other species included (in order of frequency) dogwood, cottonwood, other/unknown, Douglas fir, and willow.

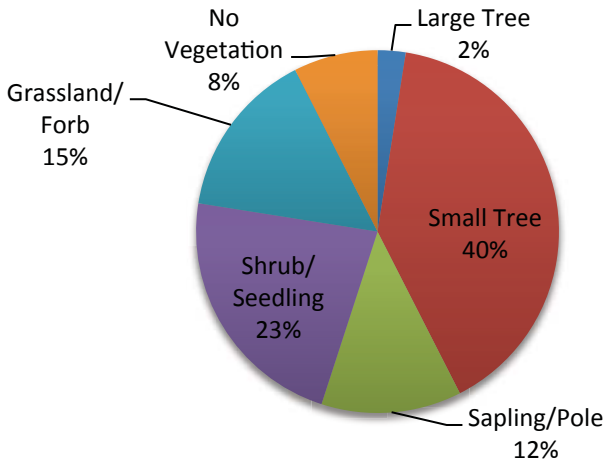


Figure 9. Distribution of the dominant size class category of vegetation observed within the 40 n^{th} units measured throughout the study area..

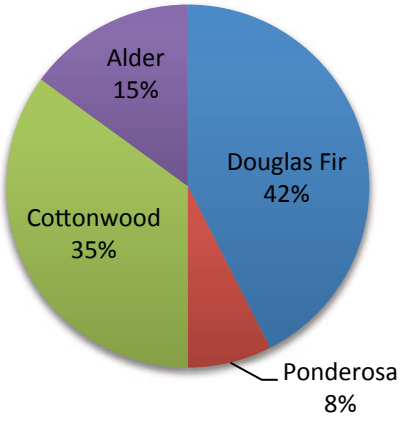


Figure 10. Proportions of vegetation cover observed in the overstory of the riparian zone within the 40 nth units measured throughout the study area.

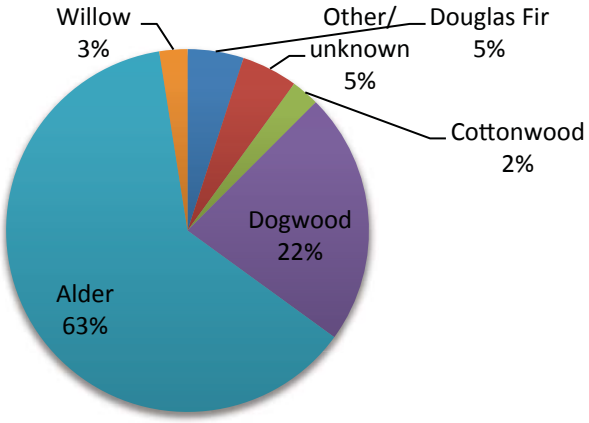


Figure 11. Proportions of vegetation cover observed in the understory of the riparian zone within the 40 nth units measured throughout the study area.

Table 4. Middle Twisp Reach Data Summary. RM 7.8 – 18.12.

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	TOTAL
Reach Mileage Boundaries	7.8-9.14	9.14 – 9.79	9.79 – 12.22	12.22 – 13.60	13.60 – 16.19	16.19 – 18.12	7.8 – 18.12
Wetted Width (ft)							
All Habitat Types(Main Channel)							
Mean	65.1	62.7	65.1	59.3	41.1	41.8	51
StDev	8.7	10.6	12.5	12	13.8	13.2	16.6
Pool							
Mean	57.8	40.0	58.5	56.7	37.4	37.1	43.6
StDev	9.5	n=1	13.6	15.4	14.2	11.8	16.1
Glide							
Mean	63.3	40.3	64.8	57.4	45.8	46.0	53.1
StDev	8.3	5.8	12.9	10.2	12.2	12.0	13.5
Riffle							
Mean	69.5	68.3	69.8	62.1	43.2	43.3	55.9
StDev	6.0	7.5	9.9	11.8	13.2	14.4	16.8
Side Channel							
Mean	40	N/A	14	15	8.4	5.5	11.0
StDev	n=1	N/A	10.1	15.7	6.3	0.7	10.3
Water Depth (ft)							
Pool Maximum Depth							
Mean	3.8	4.2	3.9	4.2	4.1	3.3	3.9
StDev	0.9	n=1	1.5	2.6	1.3	1	1.4
Pool Residual Depth							
Mean	2.4	2.7	2.8	3	2.9	2.1	2.7
StDev	0.7	n=1	1.5	2.7	1.3	0.9	1.4
Glide Maximum Depth							
Mean	2.6	2.8	1.9	2	2.2	1.8	2.1
StDev	0.3	0.3	0.4	0.6	0.8	0.5	0.6
Glide Average Depth							
Mean	1.8	1.8	1.3	1.4	1.3	1.2	1.4
StDev	0	0.2	0.4	0.3	0.6	0.3	0.4
Riffle Maximum Depth							
Mean	2.6	2.5	2	1.6	1.5	1.7	1.9
StDev	0.4	0.9	0.5	0.4	0.6	0.7	0.6
Side Channel							

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	TOTAL
Maximum Depth							
Mean	2.8	0	1.7	2.2	2.2	1.5	2.1
StDev	n=1	0	0.6	1.8	1.1	1.4	1.1
Bankful Characteristics							
Width (ft)							
Mean	81.7	91	102.2	79.5	92.6	72	87.3
StDev	13.7	22.6	48	9	49.5	13.3	34.6
Average Depth (ft)							
Mean	4.3	5	3.7	3.8	2.3	2	3.2
StDev	0.5	1.2	0.5	0.9	1.1	0.6	1.2
Maximum Depth (ft)							
Mean	4.9	6	4.3	4.6	3.2	2.7	3.9
StDev	0.3	0.7	0.3	0.3	1.1	0.7	1.2
Width: Depth Ratio							
Mean	19.2	18.2	27.4	20.1	39.7	35.3	20.2
StDev	2.4	7.7	11.5	4	87	14	49.4
Floodprone Width							
Mean	170	118	320	121	393	260	269
StDev	61	25	69	29	338	340	247
Habitat Area %							
Pool	12%	1%	14%	14%	23%	15%	15%
Glide	11%	18%	15%	15%	29%	15%	59%
Riffle	74%	81%	69%	69%	21%	69%	20%
Side Channel	3%	0	2%	2%	18%	1%	6%
Pools							
Pools Per Mile	3.7	1.5	4.5	4.3	13.1	7.8	7
Residual Depth (% of pools)							
Pools < 3 ft	40%	0%	18%	67%	26%	53%	35%
Pools 3-6 ft	60%	100%	73%	17%	71%	47%	61%
Pools 6-9 ft	0%	0%	9%	17%	3%	0%	4%
Pools 9-12 ft	0%	0%	0%	0%	0%	0%	0%
Riffle: Pool Ratio							
Riffle: Pool Ratio	6.4	59.7	4.9	3.5	1.3	4.5	4
Riffle & Glide: Pool Ratio	7.4	72.9	5.9	5.6	2.7	5.5	5.3
Mean Pool Spacing (Bankfull Channel Widths Per Pool)	15.8	36.8	10.5	15.7	4.2	9.2	15.4

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	TOTAL
Large Wood							
Total Number Pieces							
Total	55	18	131	81	537	169	991
Large (20 in by 35 ft)	4	4	17	1	47	35	108
Medium (12 in by 35 ft)	12	3	27	12	94	34	182
Large and Medium	16	7	44	13	141	69	290
Small (6 in x 20 ft)	39	11	87	68	396	100	701
Number of Pieces/Mile							
Total	41.0	27.7	53.9	58.7	207.3	87.6	96
Large (20 in by 35 ft)	3.0	6.2	7.0	0.7	18.1	18.1	10
Medium (12 in by 35 ft)	9.0	4.6	11.1	8.7	36.3	17.6	18
Large and Medium	11.9	10.8	18.1	9.4	54.4	35.8	28
Small (6 in x 20 ft)	29.1	16.9	35.8	49.3	152.9	51.8	68
Log Jams							
Total	0	0	2	2	10	3	17
Log Jams Per Mile	0	0	0.8	1.4	3.9	1.6	1.6
Bank Erosion							
Total % Bank Erosion	1%	1%	<1%	<1%	0	0	<1%
Substrate (ocular estimates)							
Total							
% Sand	5%	8%	6%	5%	6%	4%	5%
% Gravel	15%	28%	17%	31%	47%	38%	34%
% Cobble	61%	45%	69%	56%	47%	55%	55%
% Boulder	19%	20%	6%	8%	0%	3%	6%
% Bedrock	0%	0%	1%	0%	0%	0%	0%
Fast Water Units							
% Sand	5%	8%	8%	4%	4%	3%	5%
% Gravel	15%	28%	20%	23%	42%	36%	30%
% Cobble	60%	45%	66%	65%	53%	56%	58%
% Boulder	20%	20%	6%	9%	1%	5%	7%
% Bedrock	0%	0%	0%	0%	0%	0%	0%
Slow Water Units							
% Sand	5%	0%	3%	10%	8%	5%	6%

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	TOTAL
% Gravel	15%	0%	10%	65%	54%	42%	42%
% Cobble	62%	0%	78%	20%	38%	53%	48%
% Boulder	14%	0%	5%	5%	0%	0%	2%
% Bedrock	0%	0%	5%	0%	0%	0%	1%
Vegetation (% of sampled units)							
Riparian zone (100-foot-wide zone averaged between both banks)							
Dominant Overstory Size Class							
Mature Tree (*32 in.*)	0%	0%	0%	0%	0%	0%	0%
Large Tree (*21 – 31.9 in.*)	0%	0%	14%	0%	0%	0%	3%
Small Tree (*9 – 20.9 in.*)	25%	100%	29%	60%	21%	63%	40%
Sapling/Pole (*5.0 – 8.9 in.*)	0%	0%	14%	0%	29%	0%	13%
Shrub/Seedling (*1-4.9 in.*)	0%	0%	14%	0%	43%	25%	23%
Grassland/Forb	75%	0%	29%	20%	0%	0%	15%
No Vegetation	0%	0%	0%	20%	7%	12%	8%
Overstory Species Composition							
Conifer (Undifferentiated)	0%	0%	0%	0%	0%	0%	0%
Douglas Fir	50%	100%	43%	20%	21%	75%	43%
Ponderosa Pine	25%	0%	14%	20%	0%	0%	8%
Cedar	0%	0%	0%	0%	0%	0%	0%
Spruce	0%	0%	0%	0%	0%	0%	0%
Hardwood (Undifferentiated)	0%	0%	0%	0%	0%	0%	0%
Cottonwood	25%	0%	43%	60%	43%	13%	35%
Alder	0%	0%	0%	0%	36%	13%	15%
Understory Species Composition							
Conifer (Undifferentiated)	0%	0%	0%	0%	0%	0%	0%
Douglas Fir	50%	0%	0%	0%	0%	0%	5%
Ponderosa Pine	0%	0%	0%	0%	0%	0%	0%
Cedar	0%	0%	0%	0%	0%	0%	0%
Spruce	0%	0%	0%	0%	0%	0%	0%
Other/unknown	25%	50%	0%	0%	0%	0%	5%
Cottonwood, ash, poplar	0%	0%	0%	0%	7%	0%	3%

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	TOTAL
Dogwood	0%	0%	14%	0%	36%	38%	23%
Alder	0%	50%	86%	100%	57%	63%	63%
Willow	25%	0%	0%	0%	0%	0%	3%

4 Comparison to 1994 USFWS Survey

The Methow Valley Ranger District of the Okanogan-Wenatchee National Forest and the Pacific Watershed Institute (PWI), a non-profit watershed restoration organization, conducted a stream survey of the Twisp River in 2001. A total of 30.4 miles of the Twisp River was surveyed, beginning at the mouth, and ending at the confluence of the North and South forks of the Twisp River. The Twisp River was also surveyed by the USFS in 1993.

Comparisons to previous surveys allow us to detect trends in habitat characteristics over time. Because reach breaks from the 2013 Inter-Fluve survey do not exactly coincide with reach breaks in the 2001 and 1993 surveys (Table 5), exact comparisons between the 1993, 2001, and 2013 surveys is not possible. While reach breaks in the 2001 survey are similar to the 2013 survey for the entire study area, only two of three reach breaks in 2001 can be compared to the much coarser 1993 survey. Protocol between survey years were also different (see Table 7 summary below for differences in protocol for surveying pools), as well as conditions on the river. Water levels during the 2001 survey were extremely low as compared to 2013 water levels, which were slightly high.

In an attempt to standardize data, we lumped comparable reaches from the 2013 survey together so they could be compared to the 2001 and 1993 results. In general, the 1993 and 2001 survey reaches were longer. Reach 6 of the 2001 survey includes both Reach 1 (T4a) and Reach 2 (T4b) of the 2013 survey. Reach 7 of the 2001 survey includes both Reach 3 (T5a) and Reach 4 (T5b) of the 2013 survey. Reach 8, however, is approximately 0.27 miles shorter than the combined length of both Reach 5 (T6) and Reach 6 (T7) from the 2013 survey. Comparisons between the 2001 survey and 2013 survey should be accessed with understanding of this discrepancy.

4.1 SUMMARY

It is possible to document general trends for the entire study area between the 2013 and 2001 surveys, and for the later four reaches of the 2013 study with the 1993 survey. Pool and side channel habitat area slightly decreased between 2001 and 2013, while fast water slightly increased between 2001 and 2013.

Pool characteristics identified between surveys are likely unreliable due to the differences in protocol. The 2001 survey identified pools in side channels as well as pools that were greater than half the channel width, whereas the 2013 survey didn't identify pools in side channels and identified pools as needing to be at least one channel width long. This discrepancy likely resulted in the elevated numbers of pools in the 2001 survey.

LWD per mile in general trended upward between the 1993, 2001, and 2013. Small LWD saw the largest gains in the number of pieces of LWD, with nearly three times more small wood per mile in 2013 than 1993. Medium and large wood per mile generally trended upwards as well.

Bankful widths and width/depth ratios weren't as consistent in trends. While 2013 reaches 3 and 4 saw an increase in bankfull width, reaches 5 and 6 decreased. The width/depth ratio identifies a high point in 2001 for reaches 3, 4, 5, and 6.

Table 5. Equivalent reaches and associated river miles for 2001 and 2013 surveys.

Reach Comparisons			
2001 Survey Reach	**2001 Survey Description**	**2013 Survey Reach**	**2013 Survey Description**
Reach 6	RM 8.04 (Newby Creek) – RM 9.96 (Little Bridge Creek) **[1.92 miles total]**	Reach 1 (T4a) Reach 2 (T4b)	RM 7.8 (Newby Creek) – RM 9.14 **[1.34 miles]** RM 9.14 – RM 9.79 (Little Bridge Creek) **[0.65 miles]** **[1.99 miles total]**
Reach 7	RM 9.96 (Little Bridge Creek) – RM 13.72 (Buttermilk Creek) **[3.76 miles total]**	Reach 3 (T5a) Reach 4 (T5b)	RM 9.79 (Little Bridge Creek) – RM 12.22 **[2.43 miles]** RM 12.22 – RM 13.6 (Buttermilk Creek) **[1.38 miles]** **[3.81 miles total]**
Reach 8	RM 13.72 (Buttermilk Creek) – RM 17.6 (War Creek Campground) **[3.88 miles total]**	Reach 5 (T6) Reach 6 (T7)	RM 13.6 (Buttermilk Creek) – 16.19 **[2.59 miles]** RM 16.19 – RM 17.85[1] **[1.93 miles]** **[4.52 miles total]**

[1] Reach 6 (T7) of the 2013 survey ends 0.27 miles beyond Reach 8 of the 2001 survey.

Table 6. Comparison of percent habitat areas for habitat units measured in 2001 and 2013.

Habitat Unit Area Composition							
2001 Survey Reach	**2013 Survey Reaches**	**% Pool Area**		**% Fast Water Area[2]**		**% Side Channel Area**	
		2001	**2013**	**2001**	**2013**	**2001**	**2013**
Reach 6	Reach 1, 2	11.2%	8%	86%	90%	2.8%	2%
Reach 7	Reach 3, 4	23.6%	14%	73.4%	84%	3.0%	2%
Reach 8[1]	Reach 5, 6	30.2%	19%	58.9%	69%	10.9%	12%

[1] Reach 6 (T7) of the 2013 survey ends approximately 0.27 miles beyond Reach 8 of the 2001 survey.
[2] The 2001 survey did not separate out fast water units into glides and riffles.

Table 6 compares habitat unit area measured in 2001 and 2013 (1993 habitat area not available). Pool area decreased in all reaches in the 2013 survey results. Conversely, fast water frequency increased in 2013 survey results. Side channel habitat area had less change, with slight increases in the 2013 reaches 1-4, and a slight decrease in 2013 reaches 5 and 6.

Table 7. Comparison of pools between 1993, 2001, and 2013. Note that 1993 statistics for pools > 3 ft deep, and average pool residual depth are not available.

Pool Characteristics									
1993 Survey Reach	**2001 Survey Reach**	**2013 Survey Reaches**	**1993 Pools per Mile**	**2001 Pools per Mile**	**2013 Pools per Mile**	**2001 Stream Survey Pools >3' Deep/Mile**	**2013 Stream Survey Pools >3' Deep/Mile**	**Average Pool Residual Depth 2001**	**Average Pool Residual Depth 2013**
N/A	Reach 6	Reach 1, 2	N/A[2]	5.7	3.0	5.2	0.5	1.75	2.5
Reach 2	Reach 7	Reach 3, 4	5.0	7.4	4.5	4.8	1.3	2.54	2.8
Reach 2, 3	Reach 8[1]	Reach 5, 6	11.6	14.7	10.8	9.8	3.5	2.69	2.7

[1] *Reach 6 (T7) of the 2013 survey ends approximately 0.27 miles beyond Reach 8 of the 2001 survey.*
[2] *1993 reach breaks for Reach 1 do not coincide with 2001 and 2013 reach breaks.*

Table 7 provides a summary comparison of pool characteristics between 1993, 2001, and 2013. Data is not available for 1993 regarding pools more than 3 ft deep/mile, and average residual depth. The data shows a slight decrease in pools per mile, far fewer pools more than 3 ft deep/mile, and a slight increase in the average residual depth of pools. While pools per mile have overall decreased between the 1993 and 2013 survey, the 2001 survey identified the highest ratio of pools/mile, specifically in reaches 5 and 6 where there were 14.7 pools/mile. The greatest disparity in data between the 2001 and 2013 surveys was found in comparing pools more than 3 ft deep/mile. The data show a decrease by approximately 75% between 2001 and 2013 in pools more than 3 ft deep/mile. The most dramatic decrease was seen in the lower reaches (2013 reaches 1 and 2) of the 2013 study area, where pools more than 3 ft deep/mile decreased by over 90%. Conversely, the average residual depth in pools increased between 2001 and 2013 between 0.1 ft – 0.75 ft.

One reason for the rather disparate pool data in Table 6 and Table 7 is likely related to a difference in survey protocol for measuring pools. Survey protocol in 2001 called for identifying pools "that span at least half the channel and are at least 3 feet deep at low flow, or at least 1.5 deep with 40% or better hiding cover," whereas the 2013 survey only identified pools that spanned an entire channel width. Additionally, the 2001 protocol also appears to have identified pools in the side channels. The 2013 survey did not identify side channel pools. Because of this difference it survey protocol, it is likely that 2001 data are inflated in comparison to 2013 data, and that pool data cannot be accurately compared between the two surveys.

Table 8. LWD per mile compared between reaches in 1993, 2001, and 2013. All LWD is in-channel wood (does not include side channels). The 1993 and 2001 surveys had leaning and standing trees removed from the count.

LWD Per Mile													
1993 Survey Reaches	2001 Survey Reaches[2]	2013 Survey Reaches	Small (>20' L) (6 – 12" D)			Medium (>35' L) (12'- 20" D)			Large (>35'L) (>20"D)			Medium & Large		
			1993	2001	2013	1993	2001	2013	1991	2001	2013	1991	2001	2013
N/A[3]	Reach 6	Reach 1, 2	N/A[2]	20.0	23.1	N/A	1.7	67.0	N/A	1.5	4.0	N/A	3.2	11.1
Reach 2	Reach 7	Reach 3, 4	7.2	15.9	20.4	1.6	5.5	4.6	1.6	0.5	3.9	3.2	6.0	8.6
Reach 2, 3	Reach 8	Reach 5, 6	19.6	57.2	57.3	10.3	22.6	14.4	8.2	8.2	10.4	18.5	30.8	24.8

[1]Reach 6 (T7) of the 2013 survey ends approximately 0.27 miles beyond Reach 8 of the 2001 survey.
[2]Corresponds to the metric "Hankin Reeves: In-Channel Only (no standing trees, no side channels)" from the 2001 survey.
[3] 1993 reach breaks for Reach 1 do not coincide with 2001 and 2013 reach breaks.

Table 8 compares LWD between 1993, 2001, and 2013. In general, LWD per mile increased between 1993 and 2013 in all reaches. Small LWD had the most dramatic increases with nearly three times more small LWD in reaches 1-4 in 2013 than 1993. Medium LWD increased in 2001 and slightly decreased in 2013. Large LWD trended up on a whole, but decreased in 2013 reaches 3 and 4 before increased in 2013.

Table 9. Bankful width averages, and average width/depth ratios compared between 1993, 2001, and 2013.

Width and Width/Depth Ratio								
1993 Survey Reaches	2001 Survey Reaches2	2013 Survey Reaches	Bankfull Width			Width/Depth Ratio		
			1993	2001	2013	1993	2001	2013
N/A[2]	Reach 6	Reach 1, 2	N/A[2]	81.3	85.4	N/A[2]	28.5	18.1
Reach 2	Reach 7	Reach 3, 4	75.5	90.0	92.1	21.4	35.4	24.5
Reach 2, 3	Reach 8[1]	Reach 5, 6	101.2	96.0	84.7	39.7	49.2	38.1

[1]Reach 6 (T7) of the 2013 survey ends approximately 0.27 miles beyond Reach 8 of the 2001 survey.
[2] 1993 reach breaks for Reach 1 do not coincide with 2001 and 2013 reach breaks.

Table 9 compares bankfull width and the width/depth ratio between 1993, 2001, and 2013. Overall, bankfull widths did not have a consistent trend between 1993 and 2013. Reaches 1 and 2 decreased over time; reaches 3 and 4 increased; and reaches 5 and 6 decreased. Width/depth ratios, similarly, did not consistently trend between 1993 and 2013. Reaches 1 and 2 trended upward; reaches 3, 4, 5, and 6 peaked in 2001 and then decreased in 2013.

5 Stream Habitat Reach Reports

5.1 REACH 1

Location: River mile 7.8 - 9.14 (1.34 miles). From the confluence of Newby Creek to RM 9.14. This reach corresponds to the downstream portion of Reach T4 from the Methow Subbasin Geomorphic Assessment (USBR 2008).

Survey Date: 10/22/2013

Survey Crew: Jonathan Graca, Ben Gardner, Gardner Johnston

Figure 12. Representative view of a Reach 1 riffle. Riffles composed 74% of the reach.

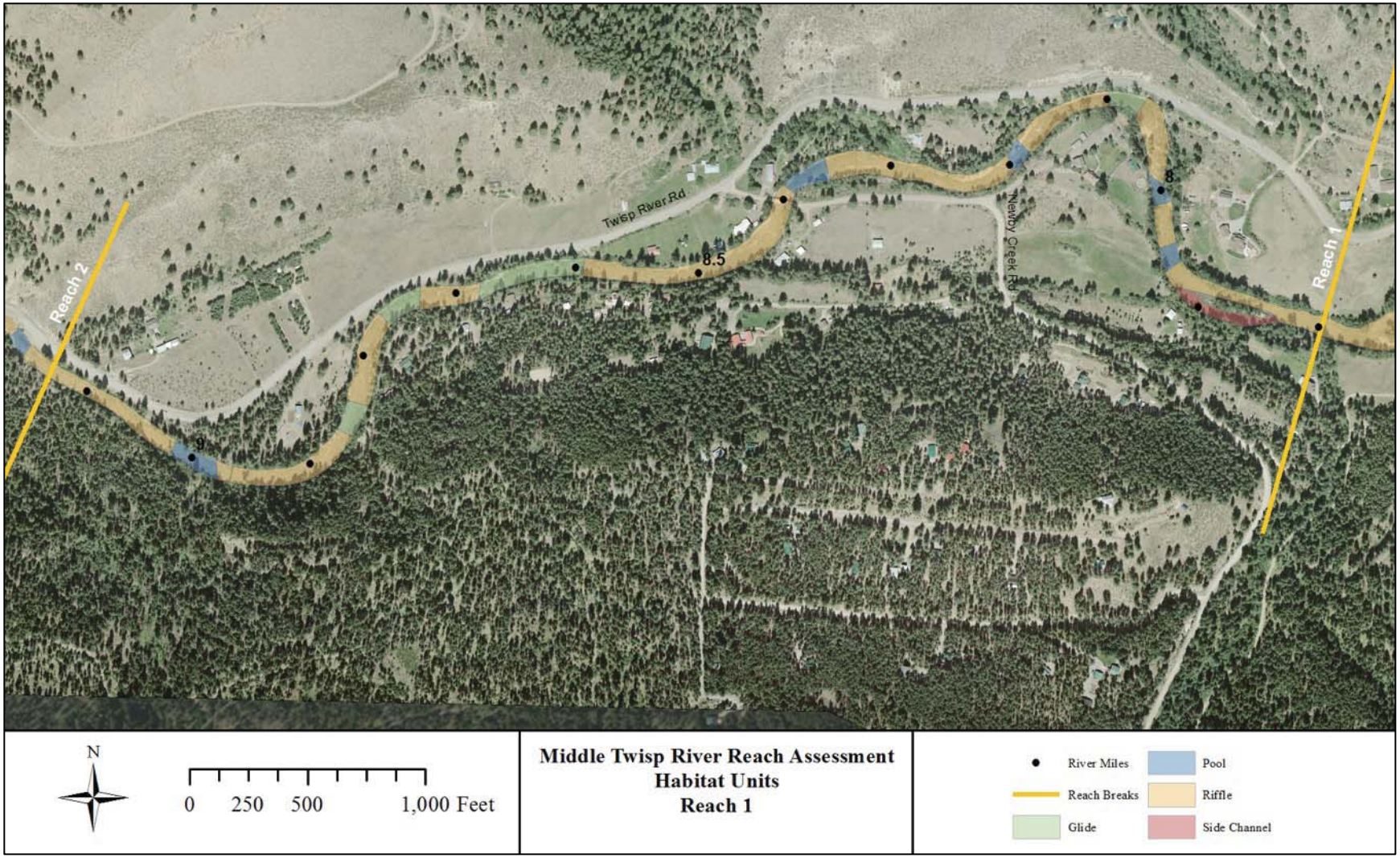


Figure 13. Reach 1 locator and habitat unit composition map.

5.1.1 Habitat Unit Composition

Relative to upper reaches in the study area, Reach 1 was high-gradient with fast water units (glides and riffles) comprising 85% of the area of reach (Figure 14). Five pools accounted for 12% area of reach. Reach 1 was relatively uniform with no braided channels and only one side channel that accounts for 3% of the habitat area in the reach.

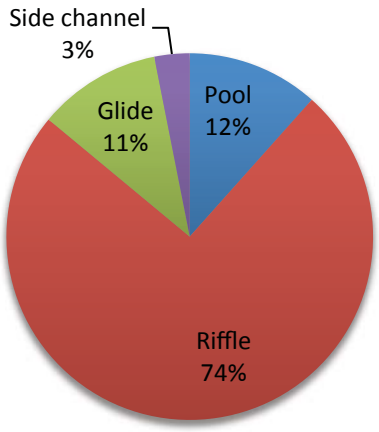


Figure 14. Habitat area composition for Reach 1.

5.1.2 Pools

Five pools were observed in Reach 1, composing 12% of the habitat area (Figure 14) and averaging 3.7 pools/mile (the entire study area averages 7 pools/mile). None had high-quality habitat. All had substrate that is relatively large and 80% had residual depths of under 3 feet (Figure 16). Eighty percent of the pools do have large woody material in the channel to provide complexity and cover. Pools occur at a mean spacing of 15.8 bankfull channel widths/pool in Reach 1 – nearly the same as the study area average of 15.4 bankful channel widths/pool. Average residual pool depth was 2.4 feet with a maximum residual depth of 3.2 ft.

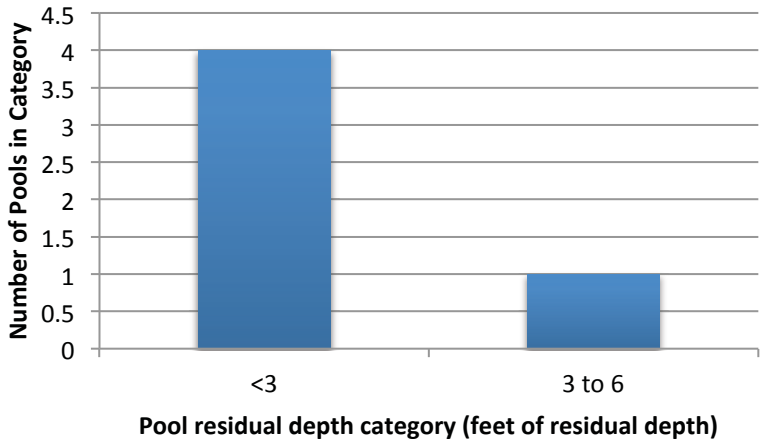


Figure 15. Reach 1 residual pool depth and count of total pools in the reach.


Figure 16. One of five pools in Reach 1 at RM 7.95 (left). Measuring bankful width (right).

5.1.3 Side Channels

Reach 1 had little side channel habitat area relative to other reaches in the study area. The only side channel observed in this study area was a 348-foot-long fast-moving channel located between RM 7.8 to 7.9 that was well connected to the main channel (Table 10). Four small and one medium pieces of wood were observed in the side channel. No off-channel wetland was identified in Reach 1.

Table 10. Side channels identified in Reach 1.

Location	Length (feet)	Dominant unit type	Wood count
RM 7.9	348	Fast water	5

5.1.4 Large Woody Material

Large wood quantities in Reach 1 were the second lowest amongst the six reaches in the study area for both average wood per mile (40) and total wood count (55). The average throughout the study reach was 96 pieces/mile. Of the 55 pieces of wood counted, 71% were small; 22% were medium, and 7% were large. No log jams were present. Most of the woody material in the reach was found in fast moving water (85% of woody material).

Table 11. Large woody material quantities in Reach 1 (1.38 miles).

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	39	12	4	55
Number of Pieces/Mile	29	9	3	41
Num. of medium/large pieces	16			
Num. of medium/large pieces/mi	11.9/mile			
Number of jams/mile	0 jams/mile			
Number of Jams*	0			

Jams consist of at least 10 qualifying pieces of wood whose numbers are reflected in the total wood count.

5.1.5 Substrate and Fine Sediment

Bed substrate was primarily cobble (61%) with smaller portions of boulder, gravel, and sand (19%, 15%, and 5% respectively). Percent fines (<2mm) were low, ranging from 5-9% based on the ocular estimates (Figure 17) and pebble counts (Figure 18 and Figure 19).

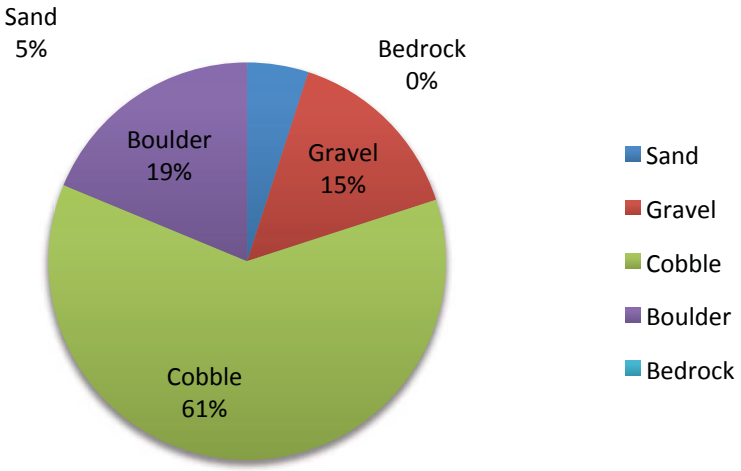
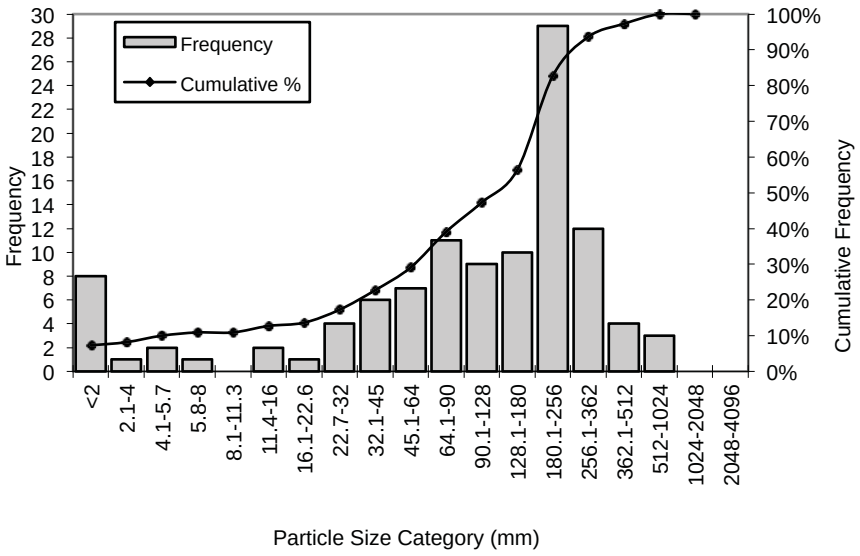


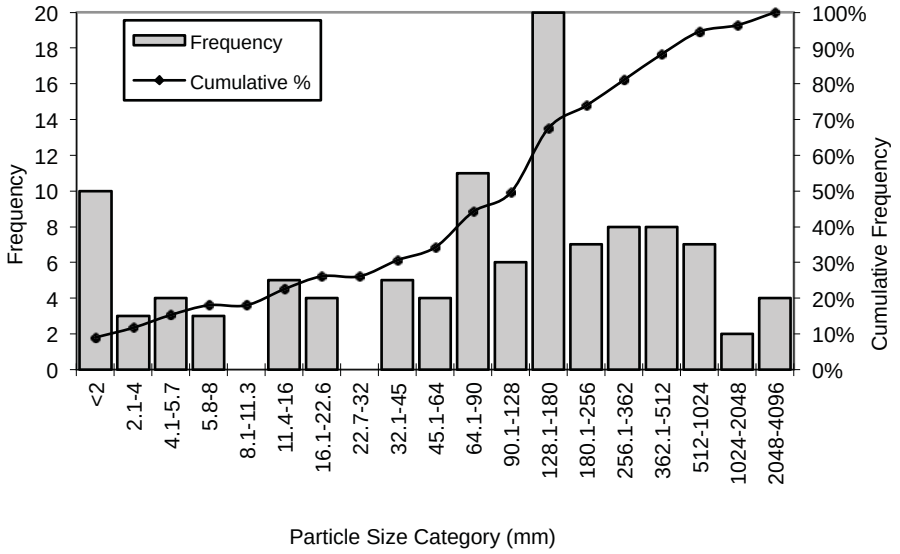
Figure 17. Percent composition of bed substrate based on ocular estimates, Reach 1.



Material	Percent Composition
Sand	7%
Gravel	22%
Cobble	54%
Boulder	17%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	29
D50	141
D84	338
D95	418

Figure 18. Grain size distribution and particle size classes from pebble count taken at RM 8.07, Reach 1.



Material	Percent Composition
Sand	9%
Gravel	25%
Cobble	40%
Boulder	21%
Bedrock	2%

Size Class	Size percent finer than (mm)
D5	1
D16	6
D50	131
D84	423
D95	1057

Figure 19. Grain size distribution and particle size classes from pebble count taken at RM 8.65, Reach 1.

5.1.6 Riparian Corridor

Reach 1 had a variable riparian corridor with significant cleared areas for roads and residential yards. The majority of the riparian clearing was prevalent on the south side of the river for the first half of the reach, and on the north side of the river for the second half of the reach. The four nth units measured in Reach 1 classified 25% of the riparian area within 100 feet of the measurement as small trees measuring 9 – 20.9 in. diameter; the remaining 75% measured was classified as grassland/forbes. Understory species composition was variable with a majority of species identified as Hawthorne, dogwood, and willow. The overstory was largely composed of cottonwood, Douglas fir, and ponderosa pine.

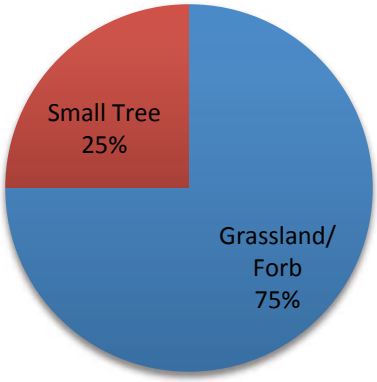


Figure 21. Dominant riparian vegetation identified within 100 feet of river by ocular estimates, Reach 1.

Figure 20. Reach 1 is bordered on the north by the Twisp River Rd and on the south by several residences. The reach is relatively fast moving with little wood retention. Both images taken at RM 8.1.

5.2 REACH 2

Location: River mile 9.14 – 9.79 (Confluence with Little Bridge Creek) (0.65 miles).

Survey Date: 10/22/2013

Survey Crew: Jonathan Graca, Ben Gardner, Gardner Johnston

Figure 22. Downstream view of a riffle in Reach 2 with high percentages of boulders.

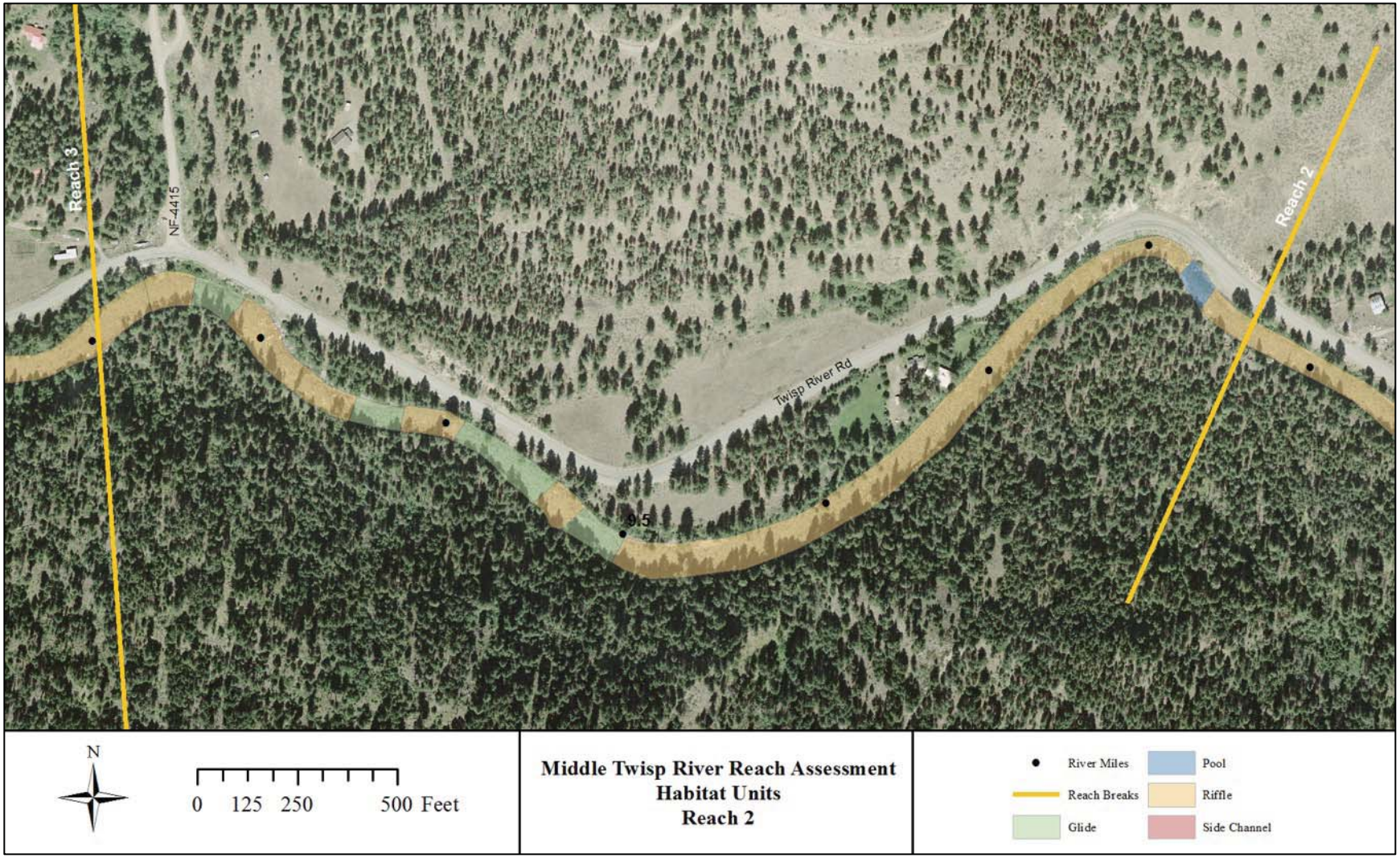


Figure 23. Reach 2 locator and habitat unit composition map.

5.2.1 Habitat Unit Composition

Reach 2 was the shortest reach in the study area. It is a high gradient reach, largely constrained by road on the north (left side of photo in Figure 22) and residential housing with push-up leeves and rip-rap on the south side of the river. Fast water units (glides and riffles) comprised 99% of the reach area habitat (Figure 24). Only one pool was identified in the Reach, accounting for 1% of the reach area. No side channels were present in this reach.

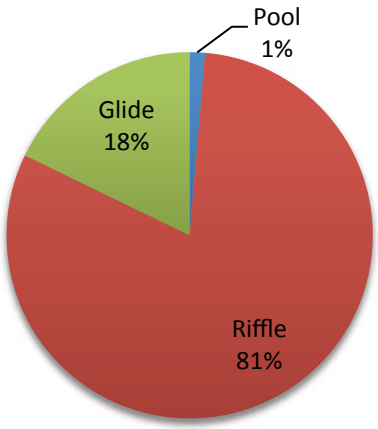


Figure 24. Habitat Composition for Reach 2.

5.2.2 Pools

One pool was identified in Reach 2, equating to a pool frequency of 1.54 pools per mile (compared to a study area average of 7 pools/mile). While the pool did have a residual depth of 2.7, it was not exemplary of good salmon habitat (Figure 26) due to fast current, large substrate, and no wood or significant cover. Reach 2 had a frequency of 36.8 channel widths/pool (verses the average of 15.4 channel width/pool observed within the study area).

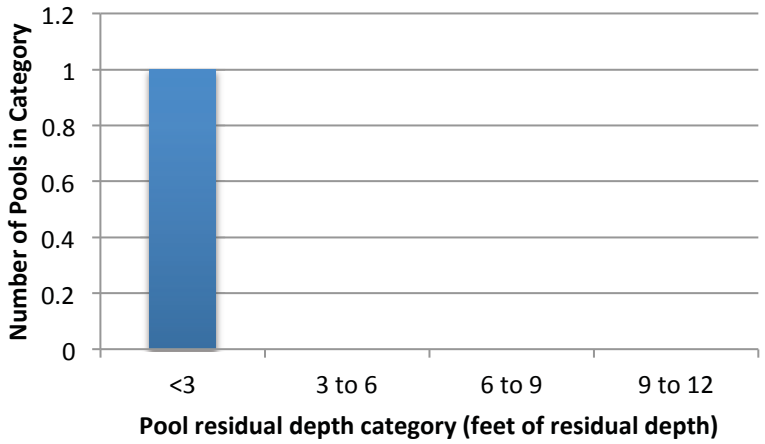


Figure 25. Residual pool depth and total count of pools in reach 2.

Figure 26. A relatively high-gradient reach, only one pool was identified in Reach 2. While the residual depth qualified this unit as a pool, due to fast current, large substrate, and no wood or cover, this pool is not representative of good habitat.

5.2.3 Side Channels

No side channels or off-channel wetland were identified in Reach 2.

5.2.4 Large Woody Material

Reach 2 had the lowest wood counts of the study area, with 27 pieces of wood per mile, and 18 total pieces of wood counted. No jams were present in the reach. LWD included 61% small wood; 17% medium wood; and 22% large wood. All wood counted in Reach 2 was located in riffles or glides, which composed 98% of this higher gradient reach.

Table 12. Large woody material quantities in Reach 2 (0.65 miles).

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	11	3	4	18
Number of Pieces/Mile	17	5	6	28
Num. of medium/large pieces	7			
Number of medium/large pieces/mile	10.8			
Number of jams/mile	0 jams/mile			
Number of Jams*	0			

* Jams consist of at least 10 qualifying pieces of wood whose numbers are reflected in the total wood count.

5.2.5 Substrate and Fine Sediment

Bed substrate was primarily cobble (45%), with smaller yet significant portions of gravel and boulders (28% and 20% respectively). Percent fines (<2mm) were low to moderate, ranging from 7% (ocular measurements) (Figure 27), to 14% and 15% based on two pebble counts in Reach 2 (Figure 28, and Figure 29).

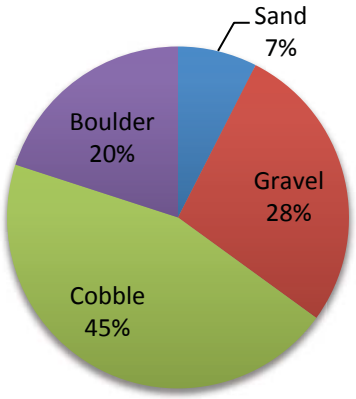
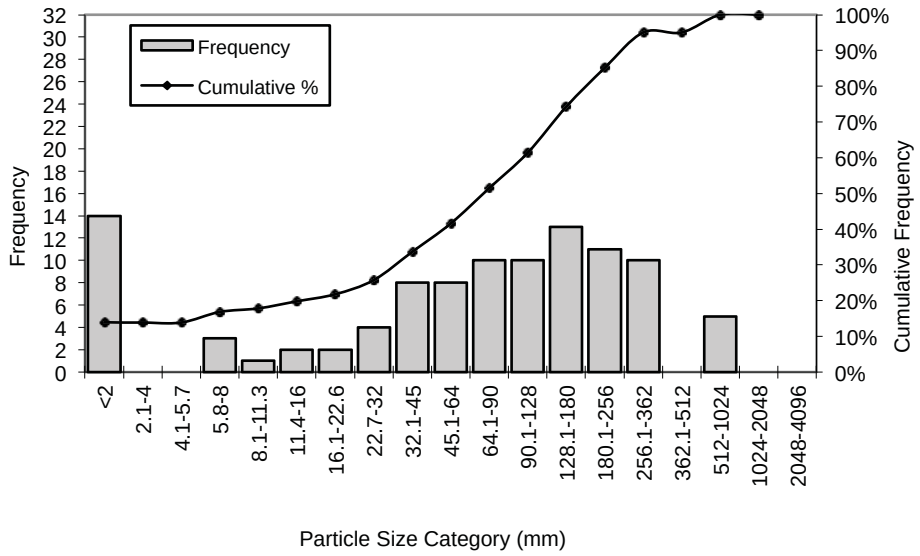


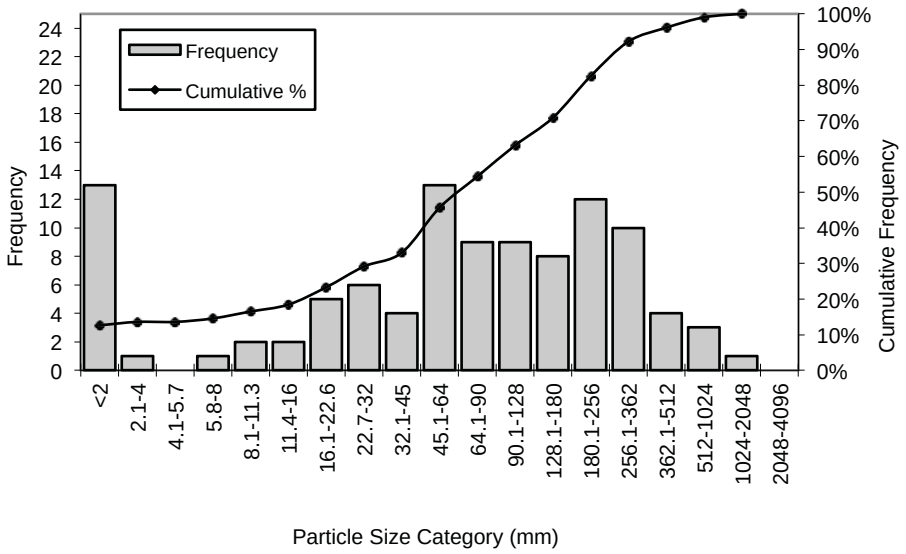
Figure 27. Percent composition of bed substrate based on ocular estimates, Reach 2.



Material	Percent Composition
Sand	14%
Gravel	28%
Cobble	44%
Boulder	15%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	7
D50	86
D84	248
D95	361

Figure 28. Grain size distribution and particle size classes from pebble count taken at RM 9.5 in Reach 2.



Material	Percent Composition
Sand	13%
Gravel	33%
Cobble	37%
Boulder	17%
Bedrock	1%

Size Class	Size percent finer than (mm)
D5	1
D16	10
D50	77
D84	272
D95	569

Figure 29. Grain size distribution and particle size classes from pebble count taken at RM 9.69, Reach 2.

Figure 30. Upstream and downstream photos at RM 9.33 show large cobbles and boulders.

5.2.6 Riparian Corridor

Riparian vegetation within the two nth units measured in Reach 2 was dominated by small trees measuring 9 – 20.9 in. diam. The overstory species distribution within the two units was comprised of Douglas fir trees (100%). Understory was 50% unknown softwoods and 50% alder. The level of stream shade along the southern edge of the river was robust throughout Reach 2, providing valuable shaded river habitat. The north side of the reach was often impacted by the road, limiting shade. About 75 feet of unstable bank was identified during an nth unit measurement at RM 9.65 on river left.

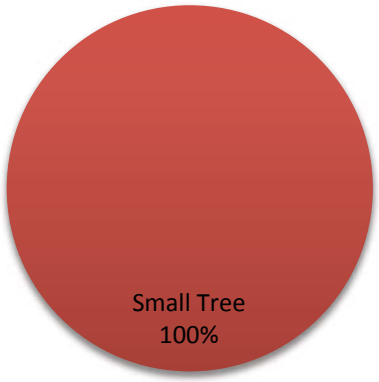


Figure 31. Dominant riparian vegetation identified within 100 feet of river by ocular estimates, Reach 2.

5.3 REACH 3

Location: River mile 9.79 (Little Bridge Creek confluence) - 12.22 (2.43 miles)

Survey Date: 10/23/2013

Survey Crew: Jonathan Graca, Ben Gardner, Gardner Johnston

Figure 32. Representative view of a Reach 3 glide.

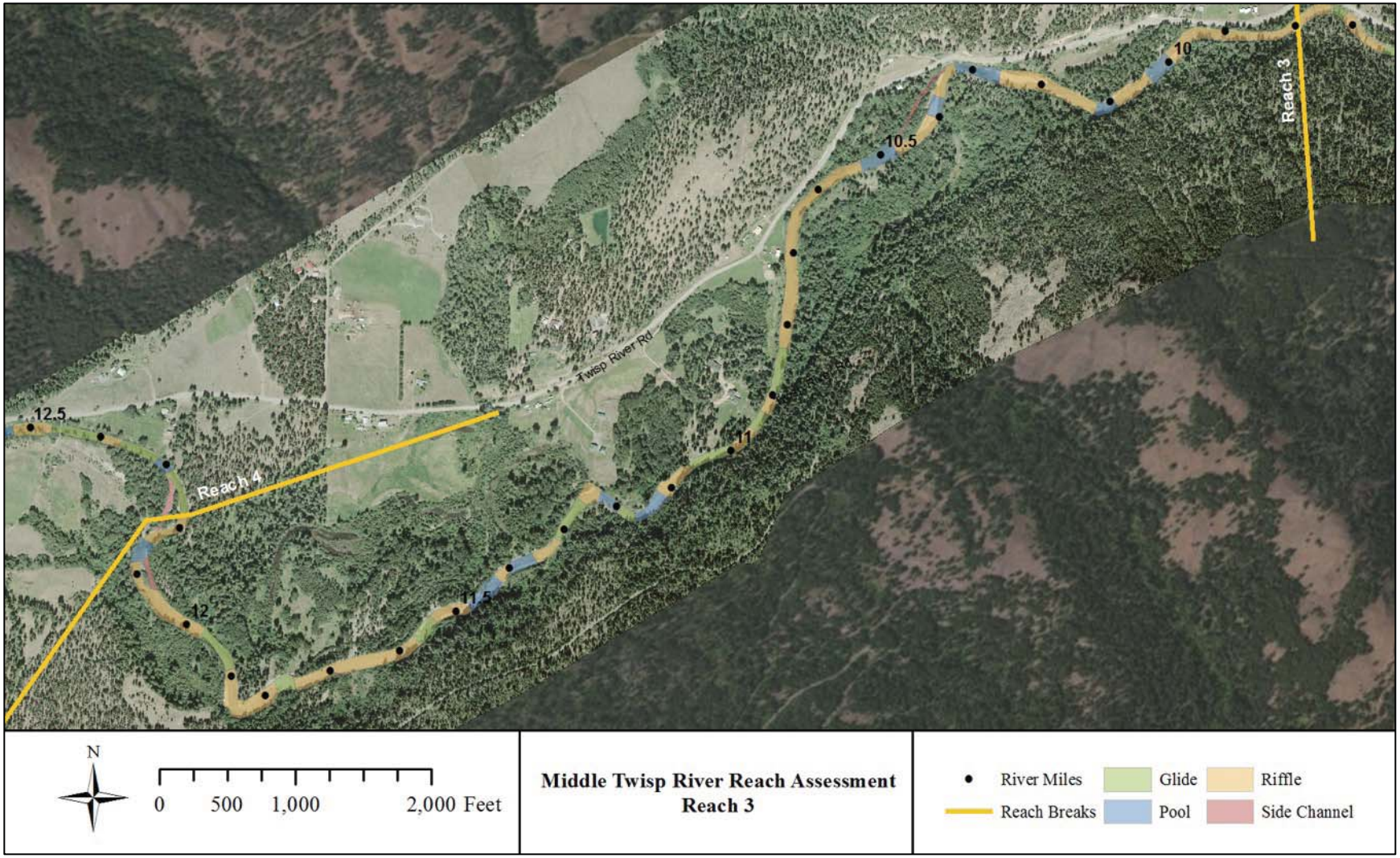


Figure 33. Reach 3 locator and habitat unit composition map.

5.3.1 Habitat Unit Composition

Reach 3 habitat area was slightly more diverse in comparison to downstream reaches as gradient decreased and the road moved away from the river. Fast-water units dominated the reach with riffles accounting for 84% of the reach area (glides accounted for 15%, and riffles for 69%). Pools accounted for 14% or habitat area, and side channels for 2% (Figure 34).

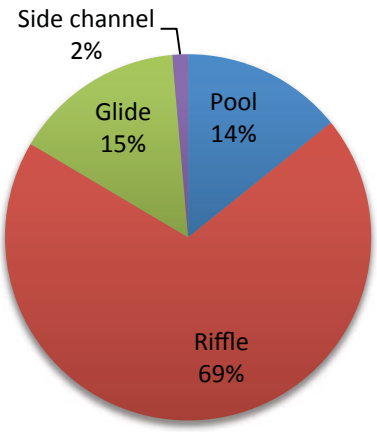


Figure 34. Habitat unit composition Reach 3.

5.3.2 Pools

Reach 3 had 11 pools (Figure 35), and a pool frequency of 4.5 pools/mile. Pool habitat comprised 15% of the reach area (Figure 35), with 73% of the pools having residuals depths of under 3 feet. Two pools had residual depths of 3 – 6 feet, and one pool had a residual depth of six feet. Reach three had a frequency of 10.5 channel widths/pool, compared to the study average of 15.4 channel widths/pool. Fifteen pieces of LWD were counted in the 11 pools.

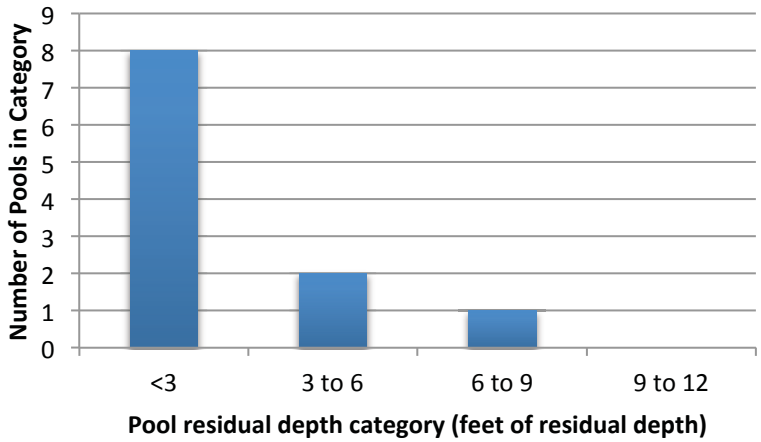


Figure 35. Reach 1 residual pool depth and count of total pools in the reach.

5.3.3 Side Channels

Reach 3 had three side channels (two slow-moving, one fast), accounting for 2% of the habitat area of the reach (Figure 34). Total wood count in the side channels was 7 (Figure 36). No off-channel wetland was identified in Reach 3.

Location	Length (feet)	Dominant unit type	Wood count
RM 10.72	505	Slow water	3
RM 12.1	225	Fast water	0
RM 12.25	35	Slow water	4
TOTAL	**765**		**7**

Figure 36. Side channels identified in Reach 3.

Figure 37. Reach 3 had 765 feet of side channel. Above is an image a 505-ft-long side channel that enters the Twisp River at RM 10.35

5.3.4 Large Woody Material

Large wood in Reach 3 averaged 54 pieces/mile (compared to the study area average of 96 pieces/mile). Small wood was the most prevalent, composing 66% of the total wood count and 35 pieces per mile (Table 13). Reach 3 had two log jams present, both apex log jams. Together, the two jams composed 37% of the wood found in the Reach. Approximately 12% of the wood was in pools.

Table 13. Large woody material quantities in Reach 3 (2.43 miles).

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	87	27	17	131
Number of Pieces/Mile	35	11	7	54
Num. of medium/large pieces	44			
Num. of medium/large pieces/mile	18.1			
Number of jams/mile	.82 jams/mile			
Number of Jams*	2			

* Jams consist of at least 10 qualifying pieces of wood whose numbers are reflected in the total wood count.

Figure 38. Two log jams were present in Reach 3. This apex log jam at RM 12.1 had 10 medium and 25 small pieces of wood.

5.3.5 Substrate and Fine Sediment

Bed substrate in Reach 3 was primarily cobble (69%) with 17% gravel, 6% boulder, and 1% bedrock (Figure 39). While cobble counts were relatively similar to downstream reaches, the boulder count was significantly lower than Reach 1 and 2 (19% and 20% respectively).

Percent fines (<2m) were low and relatively consistent between the ocular measurements and pebble counts. Ocular measurements estimate 7% sand (Figure 39). The two pebble counts in Reach 3 estimate 9% and 5% (Figure 40 and Figure 41).

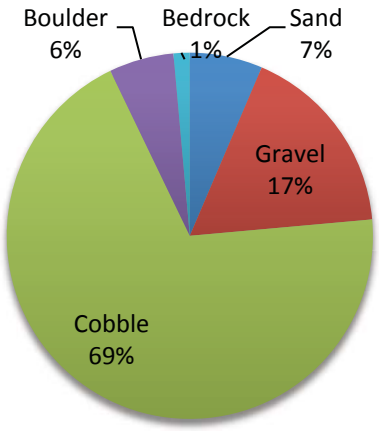
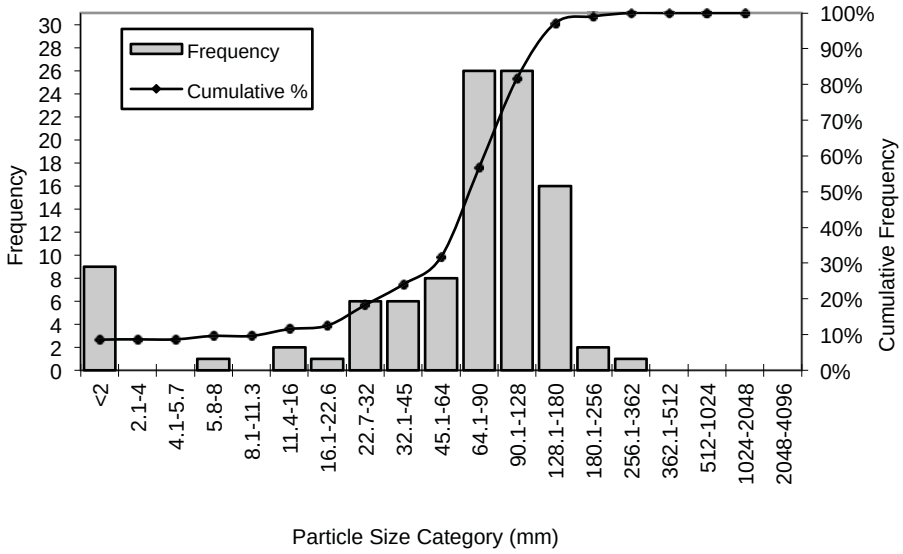


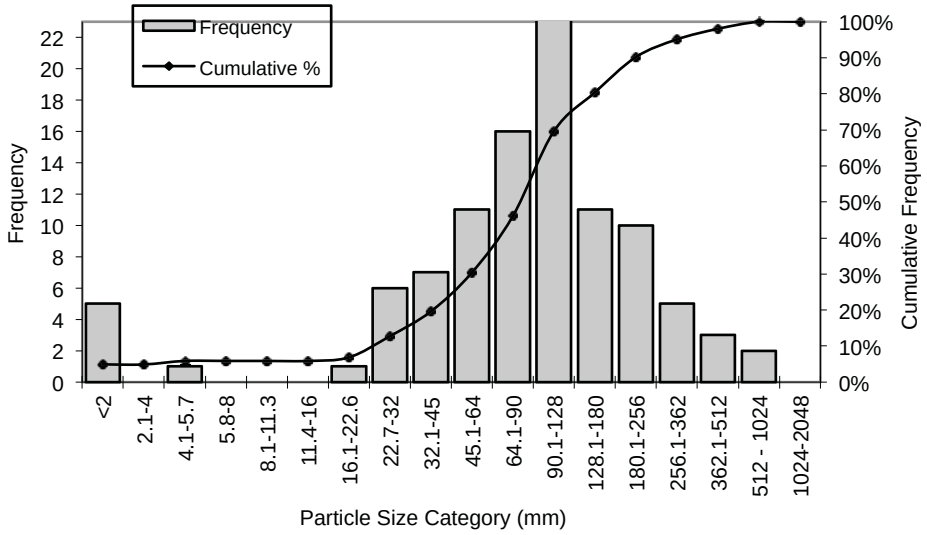
Figure 39. Percent composition of bed substrate based on ocular estimates, Reach 3.



Material	Percent Composition
Sand	9%
Gravel	23%
Cobble	67%
Boulder	1%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	28
D50	83
D84	136
D95	173

Figure 40. Grain size distribution and particle size classes from pebble count observed at RM 10.15, Reach 3.



Material	Percent Composition
Sand	5%
Gravel	25%
Cobble	60%
Boulder	10%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	25
D50	99
D84	208
D95	360

Figure 41. Grain size distribution and particle size classes from pebble count taken at RM 11.18, Reach 3.

5.3.6 Riparian Corridor

Reach 3 had a highly variable riparian corridor. Five n^{th} unit measurements in the reach measured 29% grassland/forbs, and 29% small trees measuring 9 – 20.9 in. diam.; large trees measuring 21 – 31.9 in. diam., sapling/pole measuring 5 – 8.9 in diam, and shrub/seedling measuring 1 – 4.9 in diam. each accounted for 14% of the riparian corridor (Figure 42). The overstory was also variable, mostly composed of cottonwoods and Douglas fir, but also containing some ponderosa. Understory was dominated by alder with some dogwood.

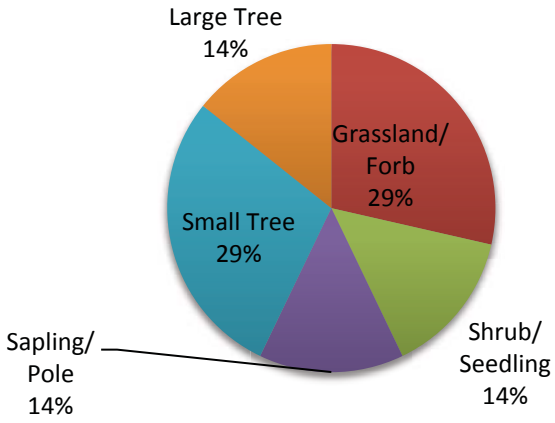


Figure 42. Dominant riparian vegetation identified within 100 feet of river by ocular estimates, Reach 3.

5.4 REACH 4

Location: River mile 12.22 – 13.60 (confluence with Buttermilk Creek) (1.38 miles)

Survey Date: 10/24/2013

Survey Crew: Jonathan Graca, Ben Gardner

Figure 43. Looking upstream at a 9-foot-deep pool at RM 12.55 in Reach 4.

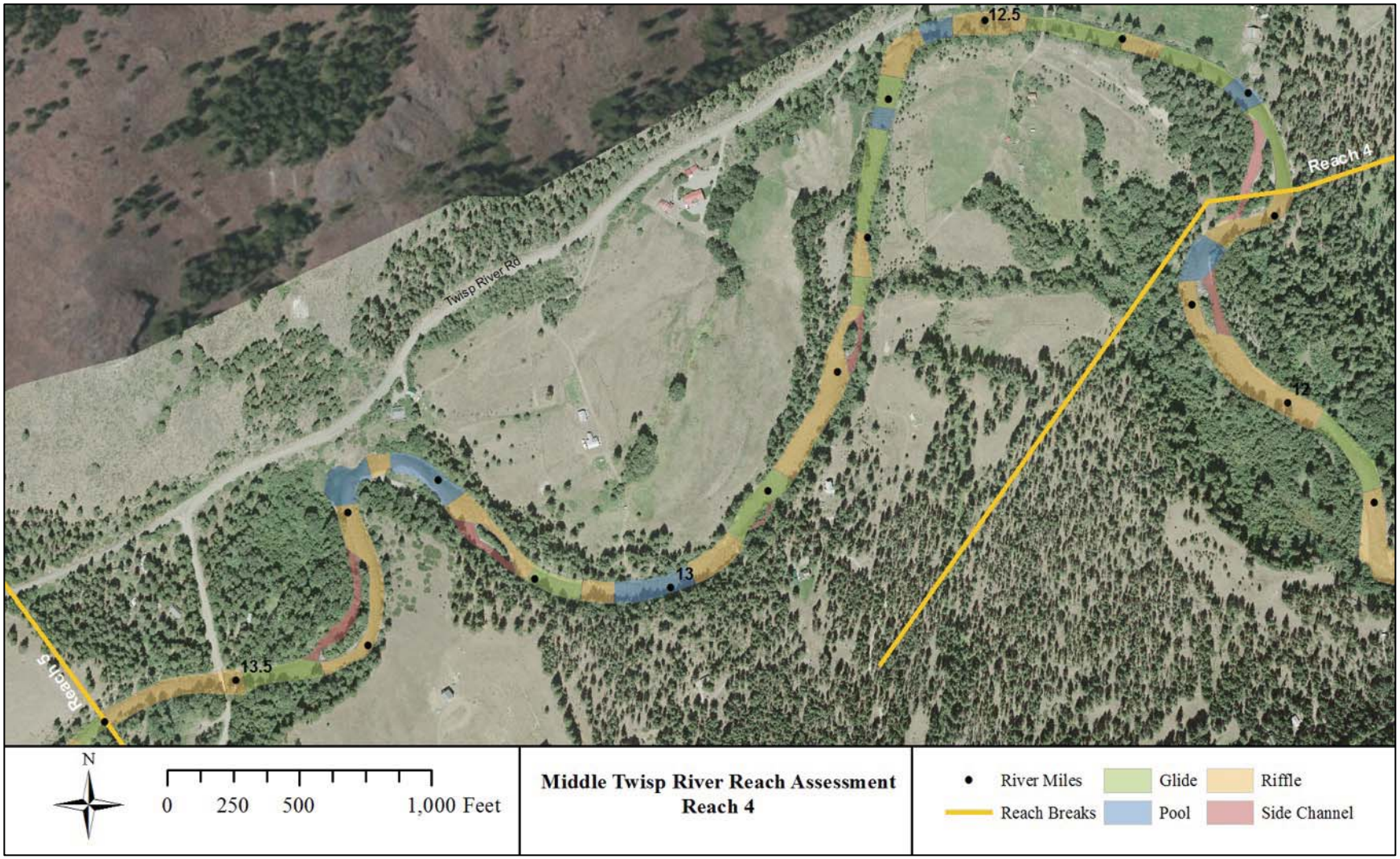


Figure 44. Reach 4 locator and habitat unit composition map.

5.4.1 Habitat Unit Composition

Habitat composition of Reach 4 was similar to that of Reach 3 with fast water reaches accounting for 84% of the habitat area, 14% of the habitat area as pool, and 2% side channel (Figure 45).

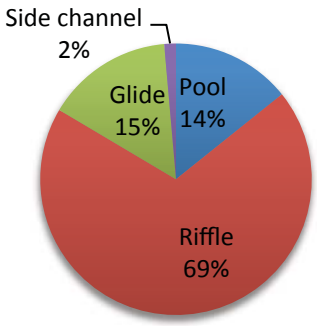


Figure 45. Habitat Composition for Reach 1.

5.4.2 Pools

Reach 4 had a pool frequency of 4.3 pools per mile compared to an average of 7 pools/mile for the entire study area (Figure 45). Pool frequency was measured at 15.7 channel widths/pool, compared to an average of 15.6 channel widths/pool throughout the study area. A total of 6 pools were recorded, including four under 3 feet residual depth, one between 3 – 6 feet residual depth, and one between 6 – 9 feet residual depth (Figure 46). All pools but one had wood in them.

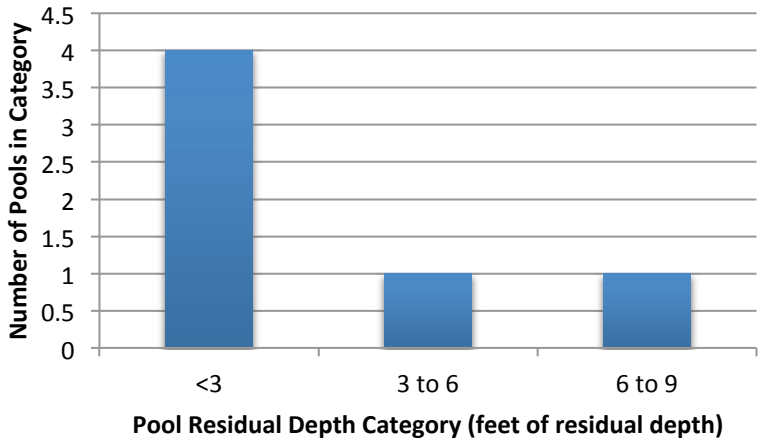


Figure 46. Reach 4 residual pool depth and count of total pools in the reach.

5.4.3 Side Channels

Side channels in Reach 4 accounted for 2% of the habitat area of the reach. A total of four side channels were identified with 5 pieces of wood total. An apex log jam was identified at the upstream end of the RM 12.77 side channel (Figure 48). The RM 13.4 side channel also had a log jam at its upstream end,

creating a split-flow condition around a stable, well-vegetated island. One small off channel wetland was identified in Reach 4 that measured approximately 25 feet by 25 feet.

Location	Length (feet)	Dominant unit type	Wood count
RM 12.77	130	Slow water	1
RM 12.91	140	Fast water	0
RM 13.15	200	Fast water	3
RM 13.4	310	Fast water	1
TOTAL	**780**		**5**

Figure 47. Side channels identified in Reach 4.

Figure 48. Slow-moving side channel at RM 12.77 with apex log jam at the upstream end.

5.4.4 Large Woody Material

Reach 4 averaged 59 pieces of wood per mile (compared to the study average of 96 pieces/mile) (Table 14). The frequency of wood is largely due to the high number of small wood found in the reach. Total wood count was 81, with 84% small, 15% medium, and 1% large. Two log jams were present, both apex log jams. One jam had 5 medium logs and 15 small qualifying logs; the other had 1 medium and 9 small. Together, the log jams composed 34% of large wood.

Table 14. Large woody material quantities in Reach 4 (1.38 miles)

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	68	12	1	81
Number of Pieces/Mile	49	9	1	59
Num. of medium/large pieces	13			
Num. of medium/large pieces/mile	9.4			
Number of jams/mile	2.17 jams/mile			
Number of Jams*	2			

* Jams consist of at least 10 qualifying pieces of wood whose numbers are reflected in the total wood count.

5.4.5 Substrate and Fine Sediment

Based on ocular estimates, Reach 4 bed substrate was primarily cobble (58%) with gravel and boulder subdominant (31% and 8% respectively) (Figure 49). Boulder counts were significantly lower than Reaches 1 and 2, which had boulder counts of 19% and 20%, respectively.

Percent fines (<2mm) were low to moderate with moderate consistency. Ocular measurements estimated 5% sand (Figure 49) whereas pebble counts estimate fines at 13% and 12% (Figure 49, and Figure 50).

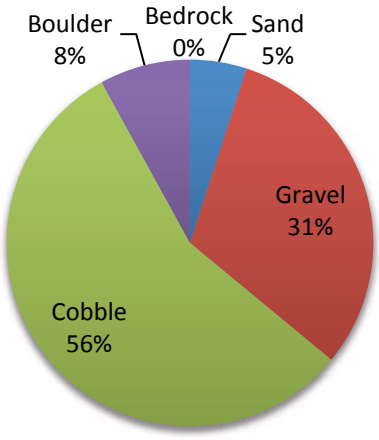
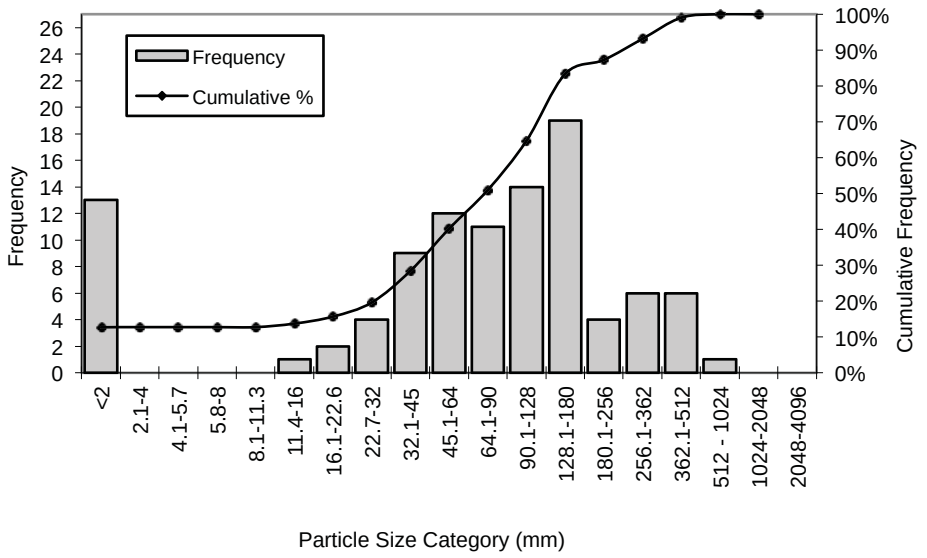


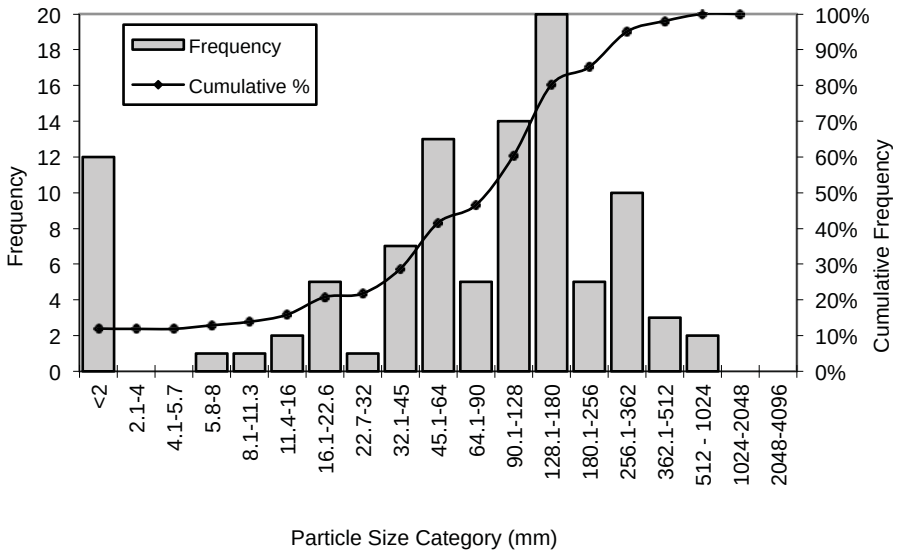
Figure 49. Percent composition of bed substrate based on ocular estimates, Reach 4.



Material	Percent Composition
Sand	13%
Gravel	27%
Cobble	47%
Boulder	13%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	24
D50	88
D84	193
D95	410

Figure 50. Grain size distribution and particle size classes from pebble count taken at RM 12.45, Reach 4.



Material	Percent Composition
Sand	12%
Gravel	30%
Cobble	44%
Boulder	15%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	16
D50	40
D84	190
D95	407

Figure 51. Grain size distribution and particle size classes from pebble count taken at RM 13.05, Reach 4.

5.4.6 Riparian Corridor

Reach 4 has a narrow riparian corridor, with significant human impacts near the river from residences, farming practices, and roads on both the north and south sides of the river

Four nth unit measurements were performed in Reach 4. Within the four units, 20% of the riparian corridor was identified as having no vegetation, 20% as grassland/forb, and 60% as small trees measuring 9.0 – 20.9 in. diam. (Figure 52). The overstory is dominated by cottonwoods, with additional units of ponderosa and Douglas fir. The understory was dominated by alder.

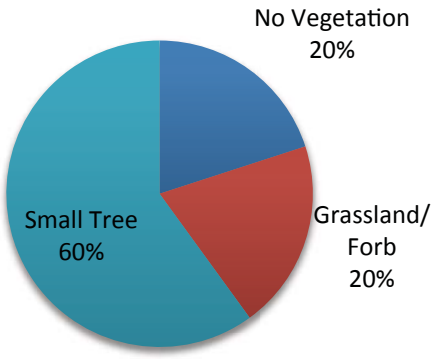


Figure 52. Dominant riparian vegetation identified within 100 feet of river by ocular estimates, Reach 4.

5.5 REACH 5

Location: River mile 13.60 (confluence with Buttermilk Creek) – 16.19 (2.59 miles)

Survey Date: 10/25/2013 – 10/28/2013

Survey Crew: Jonathan Graca, Ben Gardner

Figure 53. Reach 5 is a lower gradient, highly braided reach with vastly improved habitat characteristics compared to lower reaches in this study area.

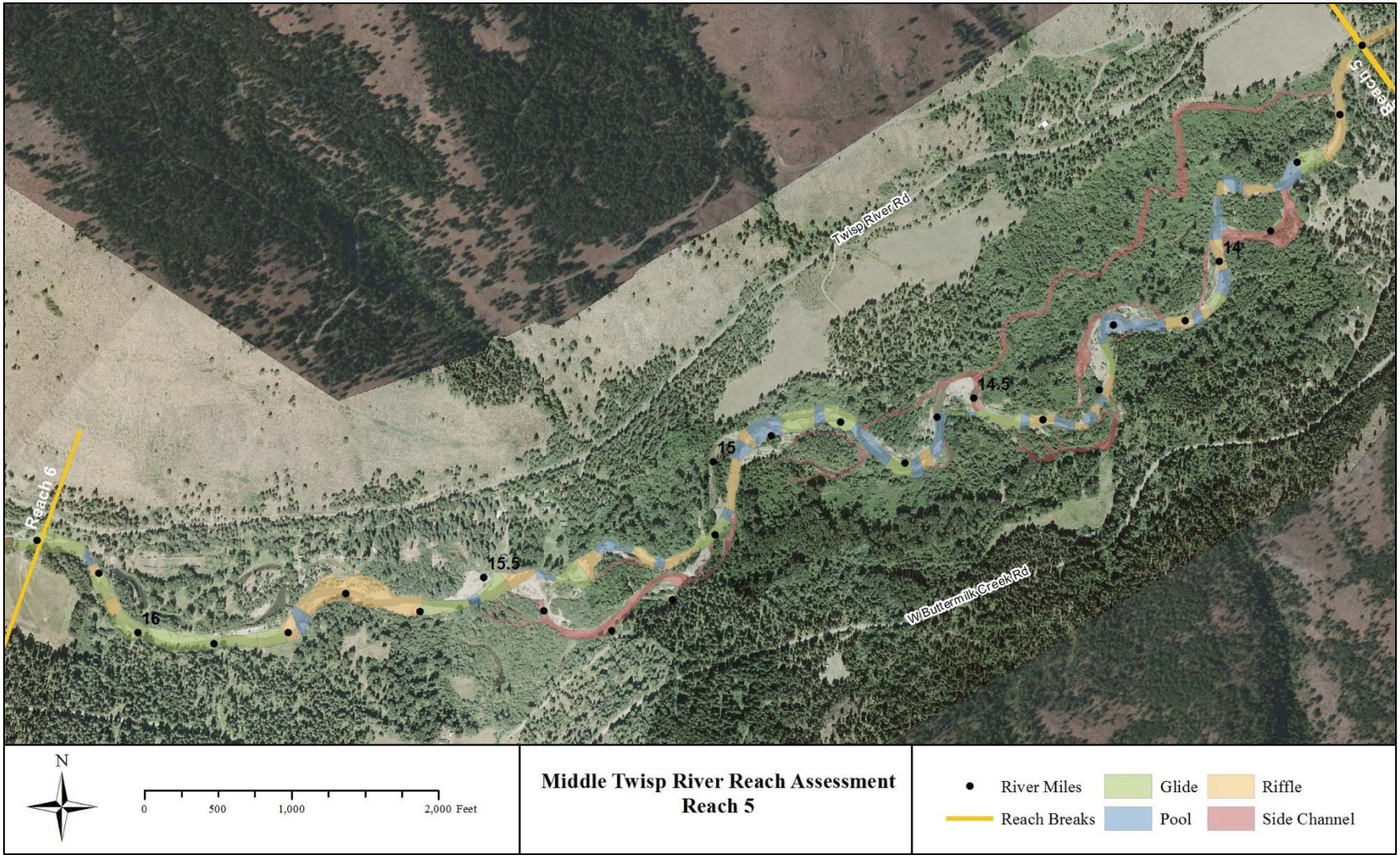


Figure 54. Reach 5 locator and habitat unit composition map.

5.5.1 Habitat Unit Composition

Reach 5 is a dynamic, lower gradient, braided reach with excellent habitat. Habitat area composition was relatively equal amongst the four habitat characteristics: Fast-moving water accounted for the majority of the habitat area with 30% glides and 29% riffles. The 19 side channels within the reach accounted for 18% of the habitat area of the reach, and 34 pools accounted for 23% of the habitat area. This is the highest percentage of both side channels and pools within the study area (Figure 55).

Four habitat units were designated "braided" where three or more roughly parallel channels were structured during bankfull flow and separated from each other by unstable islands. While only the four units were designated as braided, much of the reach could potentially be considered braided because of its highly sinuous nature and significant number of side channels that wind in and out of the main channel. More channel units were not designated as braided during the study because of the complexities in identification of braided streams. Specifically, it was difficult to accurately identify bankfull flow indicators within this low gradient, meandering reach.

Figure 55. Habitat Composition for Reach 5.

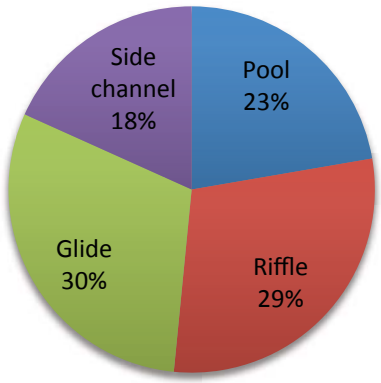


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Figure 56. Bankful widths varied from 48 – 200 feet in Reach 5. The above photo is taken near RM 15.4 where the bankfull width was recorded at 200 feet.

5.5.2 Pools

There is significant high-quality pool habitat throughout Reach 5, including 20 pools with 1-3 feet of residual depth and 14 pools of 3-6 feet residual depth. Pool frequency is 13.12 pools/mile (compared to the study area average of 7 pools/mile) (Figure 57) and 4.2 channel widths/pool – the lowest frequency in the study area. Unlike downstream reaches, many of the pools are formed in a back-to-back sequence, with short (non-qualifying) riffles or glides between them. Dozens of salmon redds were observed in marked and unmarked areas throughout the reach.

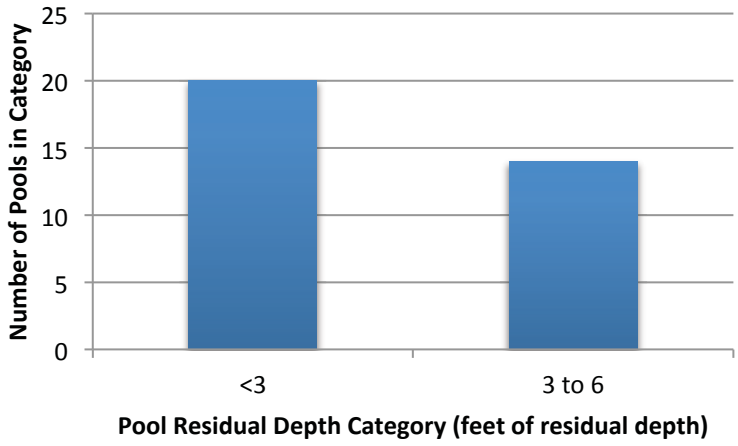


Figure 57. Reach 1 residual pool depth and count of total pools in the reach.

Figure 58. Looking downstream at a six-foot deep pool at RM 14.35. Note side channel entering on river right.

5.5.3 Side Channels

Reach 5 had the most side channel habitat area within the study area. Nineteen side channels were identified, accounting for 18% of the habitat area (Figure 55) within the reach. In total, side channels measured 3 linear miles. Of the 19 side channels, 18 were slow-water side channels and 1 was a fast-water side channel. Reach 5 had the longest side channel, measuring nearly a mile (4956 feet). While this channel had significant wood accumulation throughout the channel, only a fraction of the wood (34 pieces) quantified as LWD. Much of the wood was slightly shorter than the minimum length for a small piece of LWD and thus was not counted.

Four off-channel wetlands were also identified in Reach 5, ranging in size from 150 square feet to approximately 8000 square feet. In total, the off-channel wetlands identified comprised 12,050 square feet.

Location	Length (feet)	Dominant unit type	Wood count
RM 13.65	4956	Slow water	34
Enters RM 13.65 side channel	120	Slow water	4
RM 14.16	775	Slow water	5
RM 14.05	400	Slow water	4
RM 14.14	375	Slow water	9
RM 14.15	110	Slow water	0
RM 14.21	820	Slow water	11
RM 14.31	1255	Slow water	13
RM 14.32	100	Slow water	3
RM 14.65	750	Slow water	14
RM 14.74	1900	Slow water	9
RM 15.07	900	Slow water	6
RM 15.43	2156	Slow water	22
RM 15.12	273	Slow water	3
RM 15.18	20	Fast water	0
RM 15.24	400	Slow water	7
RM 15.46	100	Slow water	0
RM 15.4	350	Slow water	2
TOTAL	**15760**		**146**

Figure 59. Side channels identified in Reach 5.

Figure 60. Downstream end of 4956-foot side channel that exits at RM 13.65. While there was significant wood throughout the channel (see left of photo), most of the wood was not long enough to quantify as small wood. As a result, only 34 pieces of wood quantified as LWD.

5.5.4 Large Woody Material

Reach 5 had the most wood in the reach with 537 pieces distributed at a rate of 207 pieces per mile– the highest wood count and wood per mile in the study area (Table 15). Small wood comprised 74% of the wood count; medium accounted for 18% of the wood count; and large accounted for 8%. This low-gradient reach was heavily braided and sinuous, encouraging large wood to accumulate at apex points and along low-angle gravel bars. With over 15,000 feet of side channel in Reach 5, the side channels accounted for 27% (145 pieces) of the total wood count for the reach. In total, they comprised 155 pieces of wood in Reach 5. Ten log jams were present in the reach, measuring 3.9 jams/mile, also the high rate with the study area.

While the reach had excellent habitat overall, a significant amount of wood was observed in the river near RM 15.4, including a log jam in SO 181, that appeared to have been cut instream just upriver.

Figure 61. Significant portions of wood were observed in SO 181 that appeared to have been cut instream just upstream of where this photo was captured.

Table 15. Large woody material quantities in Reach 5 (2.59 miles).

	Small (6 in x 20 ft)	Medium (12 in x 35 ft)	Large (20 in x 35 ft)	Total
Number of Pieces	396	94	47	537
Number of Pieces/Mile	153	36	18	207
Num. of medium/large pieces	141			
Num. of medium/large pieces/mile	54.4			
Number of jams/mile	3.86 jams/mile			
Number of Jams*	10			

* Jams consist of at least 10 qualifying pieces of wood whose numbers are reflected in the total wood count.

5.5.5 Substrate and Fine Sediment

Ocular estimates for substrate in reach 5 varied significantly from downstream channels. Cobble and Gravel both accounted for 47%. Boulder and bedrock were not observed in our ocular estimates. Percent fines (<2mm) were low, and relatively consistent amongst measurement techniques. Ocular observations estimated 6% sand (Figure 62). Both pebble counts estimate 10% sand (Figure 63, and Figure 64). This relatively low observed distribution of fines was consistent with the observed lower gradient of the reach and improved spawning potential observed throughout Reach 5.

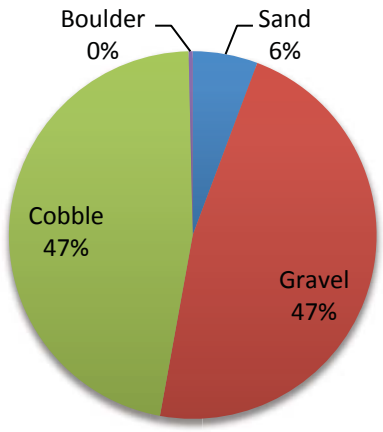
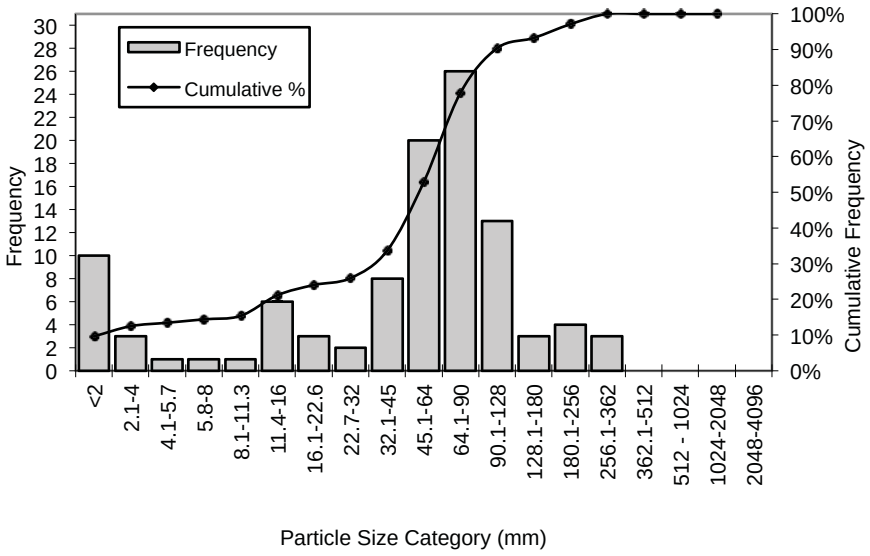


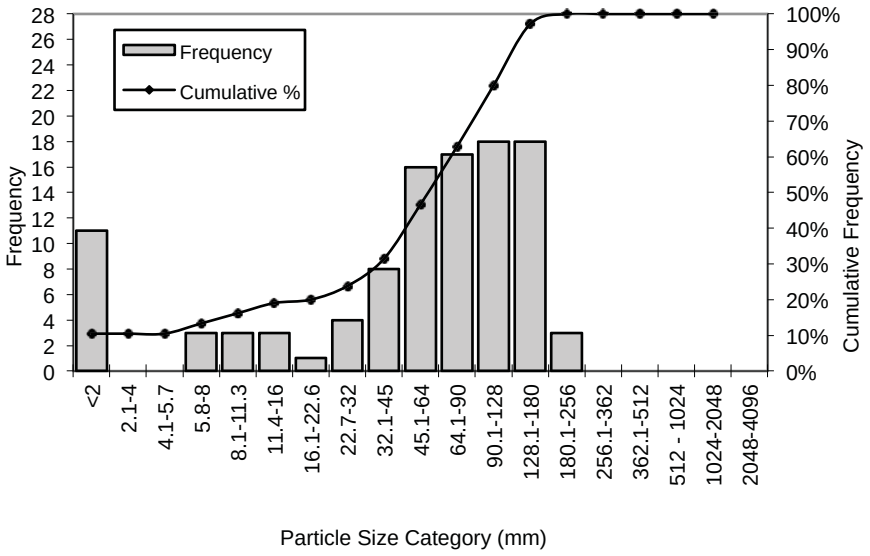
Figure 62. Percent composition of bed substrate based on ocular estimates, Reach 5.



Material	Percent Composition
Sand	10%
Gravel	43%
Cobble	44%
Boulder	3%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	15
D50	61
D84	109
D95	214

Figure 63. Grain size distribution and particle size classes from pebble count taken at RM13.65, Reach 5.



Material	Percent Composition
Sand	10%
Gravel	36%
Cobble	53%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	11
D50	69
D84	140
D95	174

Figure 64. Grain size distribution and particle size classes from pebble count taken at RM 16.86, Reach 5.

5.5.6 Riparian Corridor

Reach 5 had a variable but relatively young riparian corridor. With the road 1,000 feet or more from the river along most of the reach, the riparian buffer along Reach 5 is much wider on average than downstream reaches where the road is often within 50 – 100 feet of the river.

In total, 14 nth unit measurements were performed along Reach 5. Shrub/seedling measuring 1 – 4.9 in. diam. accounted for 43% of the riparian habitat measured ; 29% sapling/pole measuring 5 – 8.9 in. diam.; 21% small trees measuring 9 – 20.9 in. diam.; and 7% having no vegetation. Overstory was composed of primarily cottonwoods and alders. Understory was primarily alder and dogwood with one unit of cottonwood understory. No human-caused unstable banks were observed within within nth unit measurements.

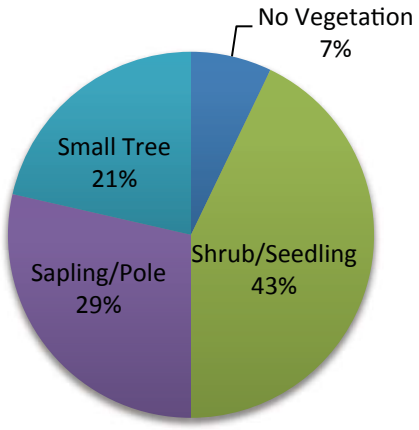


Figure 65. Dominant riparian vegetation identified within 100 feet of river by ocular estimates, Reach 5.

5.6 REACH 6

Location: River mile 16.19 – 18.12 (1.93 miles)

Survey Date: 10/28/2013 – 10/29/2013

Survey Crew: Jonathan Graca, Ben Gardner

Figure 66. Reach 6 had 15 pools translating into 7.7 pools per mile. While pools were prevalent, they were relatively short in length, many only slightly longer than the channel width. Note the pool/glide/pool sequence at RM 16.9.

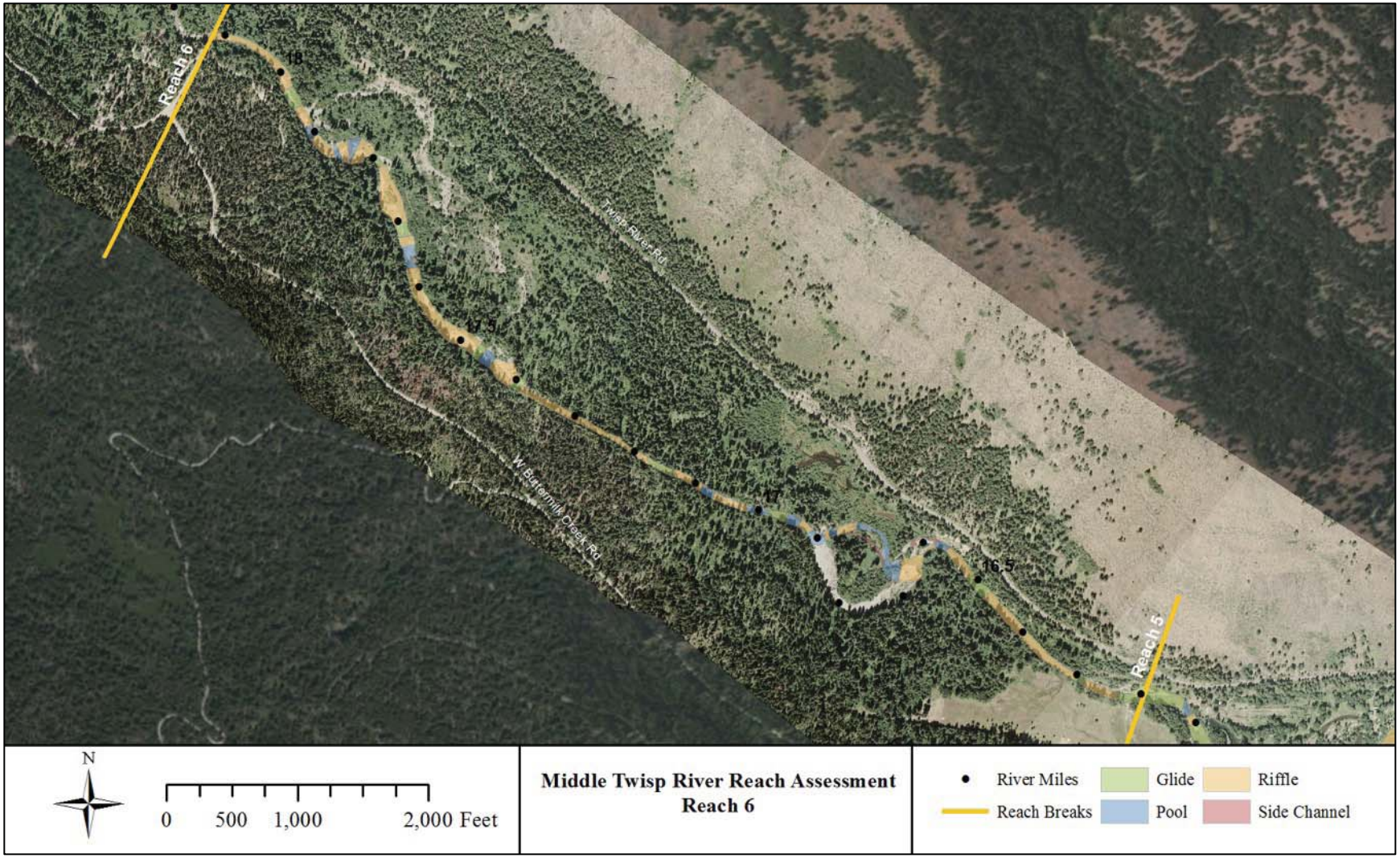


Figure 67. Reach 6 locator and habitat unit composition map

5.6.1 Habitat Unit Composition

While Reach 6 riffles and glides together composed 84% of the habitat area (69% and 15% respectively), there was a high pool frequency as well (7.7 pools/mile), which accounted for 15% of the habitat area. Side channels composed only 1% of the habitat area (Figure 68).

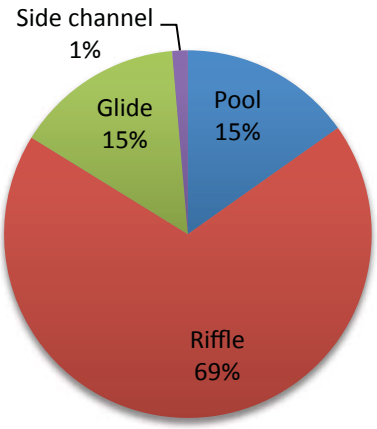


Figure 68. Habitat Composition for Reach 6.

5.6.2 Pools

High quality pool habitat was prevalent in Reach 6. Fifteen pools were identified, translating into a pool frequency of 7.7 pools/mile – the second highest frequency in the study area – and a frequency of 9.2 channel widths/pool. Of the 15 pools, 13 have residual depths of 1 – 3 feet and 2 have residual depths of 3 – 6 feet. Reach 6, more than others, is composed of long spans of fast water punctuated by high densities of relatively short pools in between.

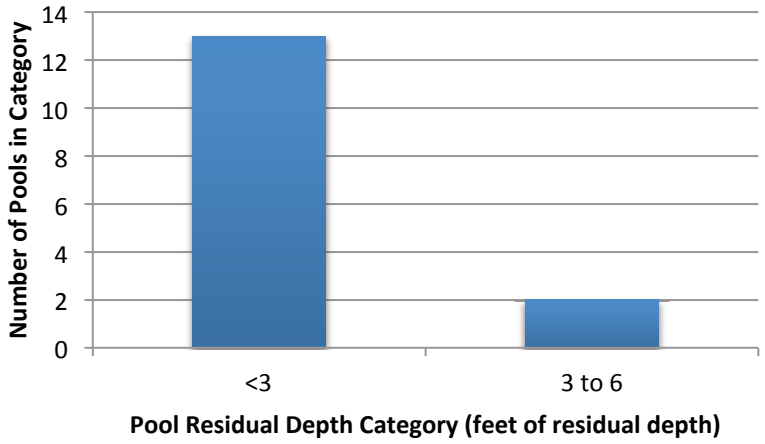


Figure 69. Residual pool depth and count of total pools in Reach 6.

5.6.3 Side Channels

Two side channels totaling 1,125 feet were identified in Reach 6 (Table 16), accounting for 1% of the habitat area of the reach (Figure 68). Both are slow moving side channels totaling 5 pieces of LWD.

Table 16. Side channels identified in Reach 6.

Location	Length (feet)	Dominant unit type	Wood count
RM 16.59	625	Slow water	2
RM 16.65	500	Slow water	3

5.6.4 Large Woody Material

Reach 6 had the second highest count of large wood in the study area with 169 pieces distributed at 88 pieces/mile (Table 17). Reach 6 had significantly more large wood than other reaches in the study area. Small wood accounted for 59% of the total wood count; medium wood accounted for 20% of the total wood count; and large wood accounted for 21% of the total wood count. Reach 6 had the second highest log jam count, with three jams totaling 30 logs.

Table 17. Large woody material 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	100	34	35	169
Number of pieces/mile	52	18	18	88
Num. of medium/large pieces		36		
Num. of medium/large pieces per mile		18.7		
Number of jams/mile		1.56 jams/mile		
Number of jams*		3		

* Jams consist of at least 10 qualifying pieces of wood whose numbers are reflected in the total wood count.

5.6.5 Substrate and Fine Sediment

Ocular observations estimated a majority of the substrate was cobble (55%) with gravel subdominant (38%). Boulders account for an additional 3%. Percent fines (<2mm) is low to moderate, ranging from 4% in ocular observations, to 13% and 4% observed in the two pebble counts (Figure 70, and Figure 71).

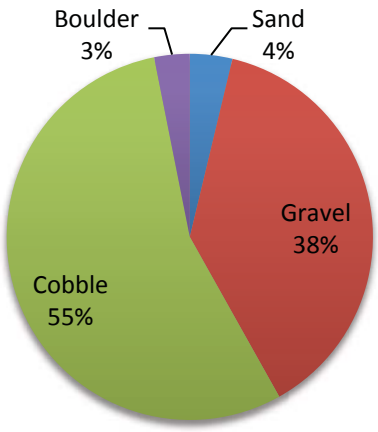
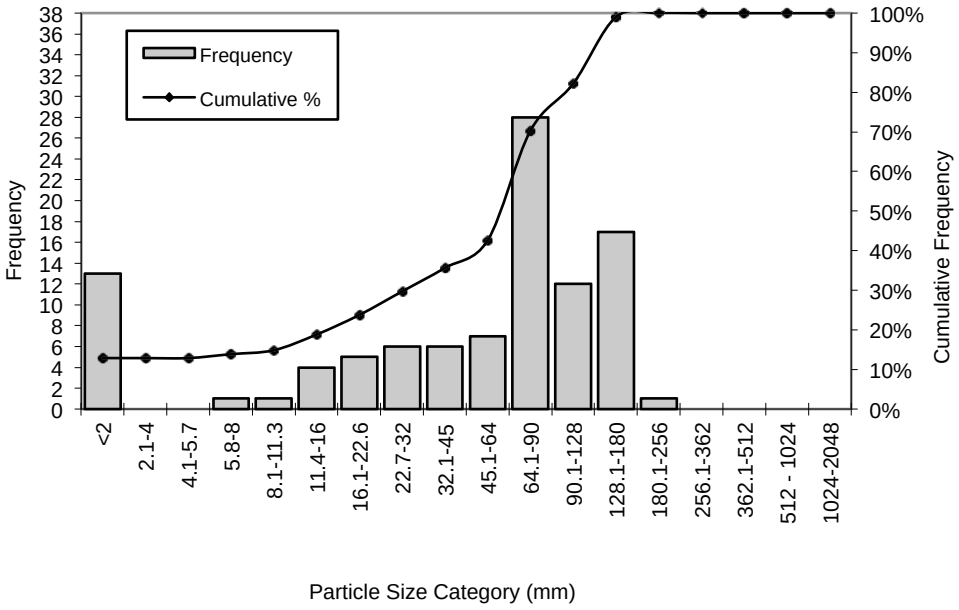


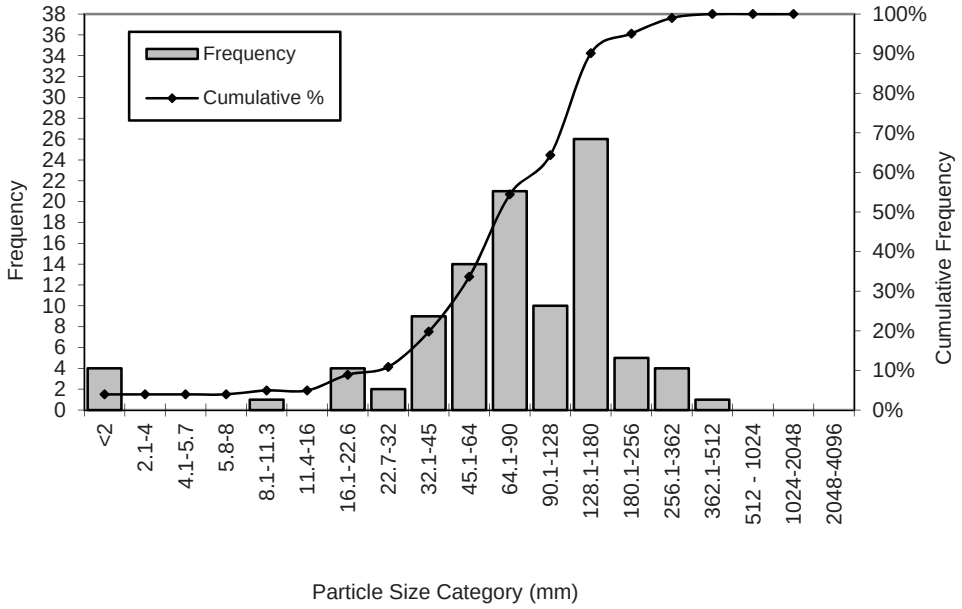
Figure 70. Percent composition of bed substrate based on ocular estimates, Reach 6.



Material	Percent Composition
Sand	13%
Gravel	30%
Cobble	57%
Boulder	0%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	1
D16	13
D50	29
D84	134
D95	168

Figure 71. Grain size distribution and particle size classes from pebble count taken at RM 16.94, Reach 6.



Material	Percent Composition
Sand	4%
Gravel	30%
Cobble	61%
Boulder	5%
Bedrock	0%

Size Class	Size percent finer than (mm)
D5	11
D16	39
D50	84
D84	168
D95	255

Figure 72. Grain size distribution and particle size classes from pebble count taken at RM 18.11, Reach 6.

5.6.6 Riparian Corridor

Eight nth unit measurements were completed in Reach 6. The riparian corridor observed in these units consisted of largely younger vegetation with 63% small trees measuring 9 – 20.9 in. diam.; 25% shrub/seedling measuring 1 – 4.9 in. diam.; and 12% identified as having no vegetation. The young vegetation is primarily a result of recent flood disturbance to the riparian areas sampled.

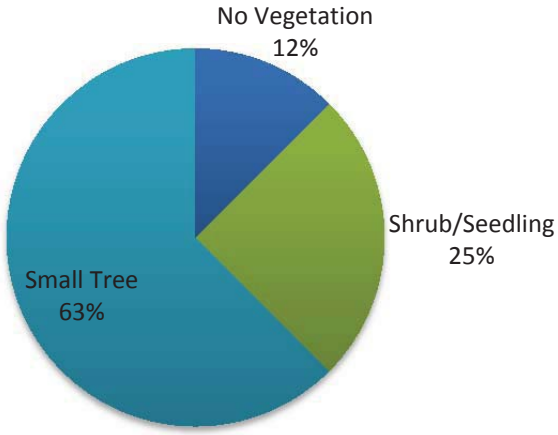


Figure 73. Dominant riparian vegetation identified within 100 feet of river by ocular estimates, Reach 6.

6 References

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