



# Middle Green River Habitat and Large Woody Debris Monitoring



*Prepared for:*  
**U.S. Army Corps of Engineers**  
**Seattle District**  
and  
**Tacoma Public Utilities**

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## **2007 Data Report**

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Seattle District  
and  
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## EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (Corps) and Tacoma Public Utilities (TPU) are monitoring reach scale habitat trends in the middle Green River as part of the Howard Hanson Dam Additional Water Storage Project (AWSP) and the Tacoma Water Habitat Conservation Plan (HCP). Monitoring variables include delineating habitat units, large woody debris (LWD), grain size, and shade. The middle Green River monitoring is intended to track long-term reach scale trends in habitat conditions. This report describes results of the August 2007 LWD survey of the middle Green River and compares those results to the August 2006 and 2005 LWD studies and the baseline habitat monitoring study completed in August/September 2001 (R2 2002). R2 2002 outlined methods for the subsequent surveys.

Habitat data analysis consisted of the generation of simple statistics including the average bankfull width, wetted width, canopy cover and LWD frequency. The spacing of pools by reach length, percent of pools formed by LWD, and the  $D_{50}$  at randomly selected pebble count sites were also calculated for each reach. Habitat and woody debris surveys encompassed the study area from Tacoma Headworks at RM 61.0 to Auburn Narrows at RM 32.0. The study area was subdivided into the following reaches based on channel morphology.

- Reach 1: RM 64.5 (Howard Hanson Dam) to RM 61.0 (Tacoma Headworks) – (not surveyed in 2007)
- Reach 2: RM 61.0 (Tacoma Headworks) to RM 57 (Kanaskat State Park)
- Reach 3: RM 57 (Kanaskat State Park) to RM 45 (Flaming Geyser State Park)
- Reach 4: RM 45 (Flaming Geyser State Park) to RM 40 (Newaukum Creek)
- Reach 5: RM 40 (Newaukum Creek) to RM 38 (Loans Levee)
- Reach 6: RM 38 (Loans Levee) to RM 32 (Auburn Narrows)

Overall the general habitat condition of the Green River in 2007 was similar to that found in 2001. Average bankfull and wetted widths were similar as was pool formation factors. However, there were some notable differences. In Reach 2, the average  $D_{50}$  was lower in 2007 than in 2001. This is likely an indication of the pebble counts being taken in areas influenced by the gravel augmentation program. Reaches 3 and 5 had a decrease in pool habitat. Surveys of Reach 3 were performed at a higher streamflow in 2007 than in 2001, possibly increasing surface turbulence and altering the habitat type. Also, there have been significant changes in the flow pattern of the mainstem Green River in Reach 5 since 2001. These changes have influence the habitat composition present in the later survey. In 2001 Reach 6 had a larger percentage of glide

habitat and less area of run habitat. These two slow water habitat types are very similar and proportions of each can be easily influenced by small changes in the streamflow.

The 2007 mainstem only survey (not taking side channels into account) indicates a decrease in individual pieces of LWD over 2006 totals (970 vs. 1,140 pieces respectively) and an increase in the number of LWD jams (66 in 2006 to 79 in 2007). Similar results are seen when you incorporate the side channel data. Taken on a reach by reach case, the upper reaches (2-4) had fewer individual pieces and an increase in jams while the lower reaches (5 and 6) had an increase in individual pieces as well as more jams than in 2006. It appears that Reach 3, which contains the Green River Gorge, has a high level of LWD mobility, including both individual pieces and LWD jams. This is illustrated by the downstream movement of jams from 2006 to 2007, particularly between RM 49.5 and RM 52.

## **1. INTRODUCTION**

This report presents the results of the fourth survey effort in a series of reach scale monitoring surveys of large woody debris (LWD) and second of habitat monitoring in the middle mainstem Green River conducted by the U.S Army Corps of Engineers (Corps) and Tacoma Public Utilities as part of the Howard Hanson Dam Additional Water Storage Project (AWSP) and the Tacoma Water Habitat Conservation Plan (HCP). The monitoring program is being conducted to track reach scale trends in habitat conditions of which LWD is one component. Documenting the number and distribution of LWD over the entire study reach provides a means to evaluate whether restoration programs implemented as part of the AWSP and HCP are achieving the desired goals. In particular, the Green River Flow Management Committee, NOAA Fisheries and the U.S. Fish and Wildlife Service will use the data to evaluate achievement of program goals as outlined in RFM-03 in the Tacoma Water Habitat Conservation Plan. The mainstem Green River physical habitat monitoring described here will be repeated at 5 to 10 year intervals for a period of 50 years. Habitat monitoring provides a means to evaluate effectiveness of various habitat projects including gravel nourishment, wood transport around HHD, flow management, and engineered log jam placement.

A principle component of the habitat restoration is collection of wood debris from Eagle Gorge Reservoir behind Howard Hanson Dam and placement of that wood into the Green River downstream of the dam at RM 60 (Corps 2004). This includes both large wood debris (LWD) and small wood debris as defined in the AWSP biological opinions and the HCP. The project was initiated in 2004 with the placement of three pieces of LWD. All 2004 LWD was marked with blue spray paint. In 2005, 35 pieces of LWD and 5 trash trucks of small debris were placed at RM 60. This debris was at least 12 inches diameter at breast height and 12 feet long. 2005 LWD was marked with orange spray paint. In 2007, 45 pieces of large woody debris and 5 trash trucks of small wood debris were placed in water at RM 60. This wood was marked with red spray paint to facilitate identification (Appendix F). Special attention was given to identifying the location of these pieces during the survey; however, the majority of the restoration wood was under the minimum length (30 ft) to be considered individual LWD during the survey. These logs would however, contribute to forming jams and would count as logs as part of a jam (12 ft minimum length).

Restoration activities also included construction of two engineered log jams at RM 60 in 2003 and annual gravel nourishment. Gravel has been placed in the river beginning in August of 2003. As of August 2006 a total of 17,207 cubic yards have been added to the river near RM 60

(Zone 1). More details about these projects can be found in applicable monitoring reports (Corps 2005).

The report is organized into six sections, including this Introduction in Section 1. Section 2 provides a brief description of the study area and Section 3 presents field methods used to conduct the surveys. The results of the 2007 survey and a comparison with data collected during the 2001, 2005, and 2006 surveys are presented in Section 4 and Section 5. Section 6 presents a summary of conclusions. Appendices A-F contain quality assurance spreadsheets, LWD summary data tables, pebble count data charts, tables of the LWD jams and pools, a summary of habitat data collected in the side channels and an inventory of placed woody debris.

## 2. ENVIRONMENTAL SETTING

### 2.1 STUDY AREA

The Green River drains an area of 484 square miles located in the southern part of King County Washington. The mainstem Green River flows north and west for approximately 84 miles from its headwaters in the Cascade Mountains. At RM 11 the Green River is joined by the Black River to form the Duwamish River before emptying into Puget Sound at Elliot Bay.

Historically, Lake Washington and Lake Sammamish, the Cedar River and the Green and White River all drained to the Duwamish River, forming one of the largest basins in Puget Sound, with a drainage area of 1,639 mi<sup>2</sup>. Beginning in 1906, a series of natural and man-made events resulted in the separation of the Duwamish basin into three separate and smaller basins: the Lake Washington Basin (663 mi<sup>2</sup>), which includes Lakes Washington and Sammamish and the Cedar River basin; the White River (494 mi<sup>2</sup>); and the Green River (484 mi<sup>2</sup>). A large flood in 1906 formed a log jam that blocked the confluence of the Green and White Rivers and shifted the majority of the White River flow south into the Puyallup River. Through channelization efforts authorized by the State Legislature in 1909, this shift was made permanent, and the former White River channel was filled. In 1912, a public improvement district diverted the Cedar River into Lake Washington to maintain the elevation of the lake once the Ship Canal was completed, further reducing the drainage area of the Green River basin (City of Seattle 1998).

The Green River watershed can effectively be subdivided into three subbasins. The upper Green River extends from the headwaters to Tacoma's Headworks Diversion Dam at River Mile 61.0, which is located 3.5 miles downstream of HHD. The Tacoma Headworks diversion dam previously blocked the upstream migration of anadromous salmonids. In 2007 construction of an upstream fish passage facility was completed by TPU. The first salmon (pink salmon) were passed above the dam in the fall of 2007. Plans are in place to pass other species in the future. Currently a downstream juvenile fish passage facility is under construction. The middle Green River includes areas draining to the mainstem between the Tacoma Headworks and the confluence with Soos Creek near Auburn at RM 33.8. The lower Green River continues to the confluence with the Black River at RM 11, which is the upstream extent of the estuary. The baseline habitat monitoring described in this document focuses on mainstem river habitats between RM 32 and RM 64.5 in the middle Green River subbasin (Figure 2-1).

The 2007 LWD and habitat survey extended from the Tacoma Headworks (RM 61.0) downstream to the Auburn Narrows at approximately RM 32.0 (Figure 2-1). This survey length

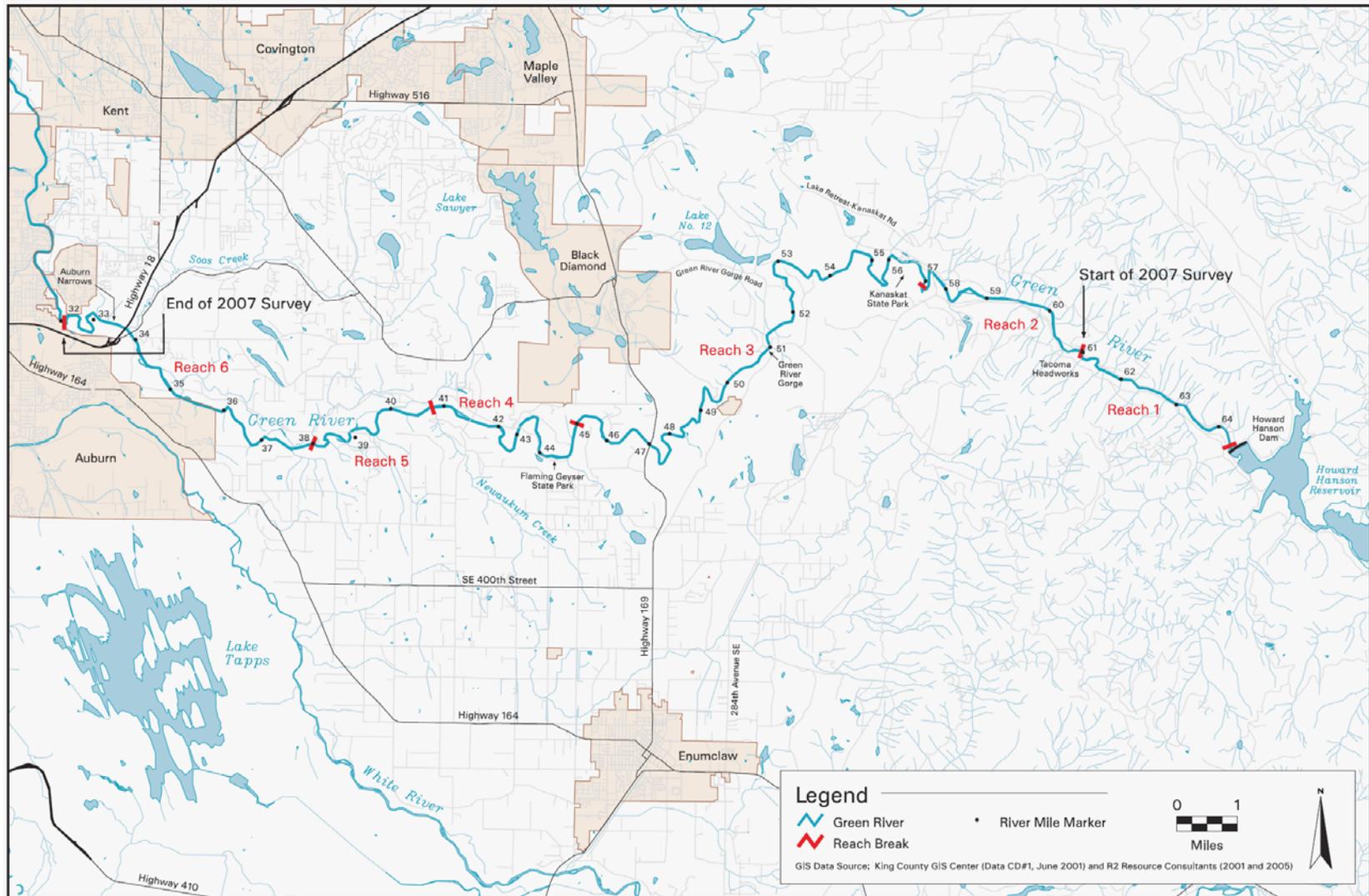


Figure 2-1. Middle Green River LWD and habitat monitoring area.

is slightly shorter than the 2001 survey, which included Reach 1, the reach from Howard Hanson Dam (RM 64.5) to the Tacoma Headworks (Table 2-1). The 2006 LWD survey included all six reaches, ending at the Auburn Narrows (RM 32.0). The 2005 LWD survey also only encompassed Reaches 2 through 6 beginning at the Tacoma Headworks at RM 61.0 but extending only to the Hwy 18 Bridge at RM 33.8.

The six reaches identified in the survey effort include:

Reach 1: RM 64.5 (Howard Hanson Dam) to RM 61.0 (Tacoma Headworks)

Reach 2: RM 61.0 (Tacoma Headworks) to RM 57 (Kanaskat State Park)

Reach 3: RM 57.0 (Kanaskat State Park) to RM 45.0 (Flaming Geyser State Park)

Reach 4: RM 45.0 (Flaming Geyser State Park) to RM 40.8 (Newaukum Creek)

Reach 5: RM 40.8 (Newaukum Creek) to RM 38 (Loans Levee)

Reach 6: RM 38.0 (Loans Levee) to RM 32.0 (Auburn Narrows) (in 2005 to RM 33.8 Hwy 18 Bridge)

Table 2-1. Start and end locations of survey reaches in the middle Green River, Washington.

<b>Survey Year</b>	<b>LWD Survey</b>	<b>Habitat Survey</b>	<b>RM Start</b>	<b>RM End</b>	<b>Does Data Include Side Channels?</b>
2001	Yes	Yes	64.5	32.0	No
2005	Yes	No	61.0	33.8	Yes (not separated in data)
2006	Yes	No	64.5	32.0	Yes (separated in data)
2007	Yes	Yes	61.0	32.0	Yes (separated in data)

These reaches were delineated as part of the 2001 baseline habitat monitoring (R2 2002). Each reach is defined as a length of channel with relatively consistent channel morphology (gradient, confinement, flow, bedform, and substrate). With the noted exceptions, the reach designations developed as part of the 2001 monitoring survey were used in the subsequent surveys to ensure consistent comparison of results between years.

The middle Green River basin lies within the Puget Lowland ecoregion, which is characterized by open hills and flat lacustrine and glacial deposits. This region once contained extensive wetlands; however, the lower portion of the basin was historically developed for agricultural use. Forested areas were cleared for pastureland, and riparian zones were restricted by levees. The

Duwamish River historically consisted of extensive saltwater and brackish marshes. Much of the lower basin has since been developed as urban areas and includes the cities of Auburn and Kent (Corps 1996).

The majority of the Green River watershed upstream of the estuary was historically forested. Lowland forests along the mainstem river consisted of stands of western red cedar and hemlock, mixed with younger stands of cottonwood and alder on more frequently disturbed floodplain features. Trees in the riparian zone would fall into the headwater tributaries and mainstem, thereby providing biologic and geomorphic functions such as creating pool habitat, and retaining gravel and organic material.

The upper half of the middle Green River (Reaches 1, 2, and 3) flows through confined mountains and a steep gorge with a channel bed of bedrock, boulders, and occasional patches of gravel. The gorge parent material is relatively erodible sandstone and mudstone, and thus was not an important historical source of gravel for spawning habitat found farther downstream (Dunne and Dietrich 1978). Hence, the primary fluvial geomorphic function of the gorge was as a sediment transport reach between the upstream source areas and downstream depositional/alluvial areas. The gorge area (Reach 4) served primarily as a passage corridor for anadromous salmonids, providing rearing/holding habitat for juvenile and adult anadromous and resident fish alike. The lower portion of the middle Green River basin, below RM 45.0 (Reaches 4, 5, and 6), represents a gradient transition zone between sediment transport and deposition. Historically, much of the lower reach was braided and the stream meandered freely across the floodplain. The White River historically joined the Green River near RM 31 and contributed a large percentage of the total sediment load to the lower basin (Tacoma Public Utilities 2001). Sediment also originated from local landslides of glacially compacted valley floor material.

Peak stream flows occur during the winter and spring months as rainfall and snow melt runoff. Riparian wetlands bordered the channel along most of its length downstream of RM 45 (Reaches 4, 5, and 6), and episodic floods would cause the river to overflow its banks onto the floodplain. Adjacent wetlands and valley soils retained water during precipitation events and high flows, and subsequently supplemented the river's streamflow during summer and early fall low flow periods. Side channels were also present throughout much of the river in lower gradient reaches, providing rearing habitat for juvenile salmonids. Tributaries, both small and large, provided habitat for salmonids and other fish species.

Howard Hanson Dam has affected geomorphic processes and channel morphology in the Green River basin in a number of ways. Prevention of floods greater than 12,000 cfs (formerly

equivalent to a 2-year return interval event) has reduced the river's ability to form and maintain off-channel habitats. The dam also traps LWD and sediment generated in the upper Green River basin. The interruption of downstream transport of LWD is believed to have reduced the amount of LWD in the middle Green River (Tacoma Public Utilities 2001). The trapping of sediment has reduced delivery of coarse sediment to downstream reaches, resulting in bed armoring below the dam and the gradual loss of gravel and cobble-sized material important for anadromous fish spawning (Tacoma Public Utilities 2001).

### 3. METHODS

#### 3.1 MONITORING OVERVIEW

Stream system health can be monitored through the systematic collection of data on environmental parameters that are linked to beneficial uses and known to be sensitive to land management activities and natural events (Spence et al. 1996). Monitoring changes in habitat conditions that result from restoration is one of the primary goals of the middle Green River monitoring. Reach scale monitoring is important for detecting the effects of mitigation and restoration measures (e.g., flow management, gravel nourishment, LWD placement). Reach scale monitoring is also needed to evaluate overall changes in habitat conditions resulting from integrated implementation of multiple projects. The specific objective of the LWD monitoring described in this report is to assess current conditions and evaluate the long term trend in LWD quantity and distribution within the middle mainstem Green River.

#### 3.2 PROJECT APPROACH

##### 3.2.1 LWD Monitoring

To ensure consistency between the 2001 and later LWD surveys, large woody debris was consistently surveyed using methods described in the August 2002 Green River Baseline Habitat Monitoring Report (R2 2002). The LWD survey methods described in the 2002 monitoring report were based on a modified version of the Level 1 protocol<sup>1</sup> outlined in the TFW Method Manual for LWD Survey (Schuett-Hames et al. 1999). Only wood located wholly or partially within Zone 1 (wetted channel) or Zone 2 (bankfull channel) was counted (Figure 3-1). Zone 1 was defined as the portion of the bankfull channel that was wetted at the time of survey, regardless of whether the water was flowing or stagnant. Zone 2 was defined as the area between the bankfull channel edge on both banks, below an imaginary line that connects these points, above the wetted channel surface. A piece was assigned to Zone 1 if a minimum of 3.9 inches (0.1 meter) of its length was within the water. Similarly, a piece was assigned to Zone 2 if a minimum of 3.9 inches (0.1 meter) was within the bankfull channel, but did not extend the minimum length into the water. A piece of wood must be a least 4 inches (10 cm) in diameter and 12 feet (3.65 m) long to count as a piece of LWD, and a debris jam must contain 10 pieces of LWD to count as a debris jam. Debris jams were categorized by size as follows: 10 to 50

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<sup>1</sup> The TFW manual (Schuett-Hames et al. 1999) describes two levels of survey intensity. Level 1 surveys are appropriate for extensive reach-scale efforts. Intensive Level 2 surveys are most appropriate for short survey segments and best suited for site-specific monitoring.

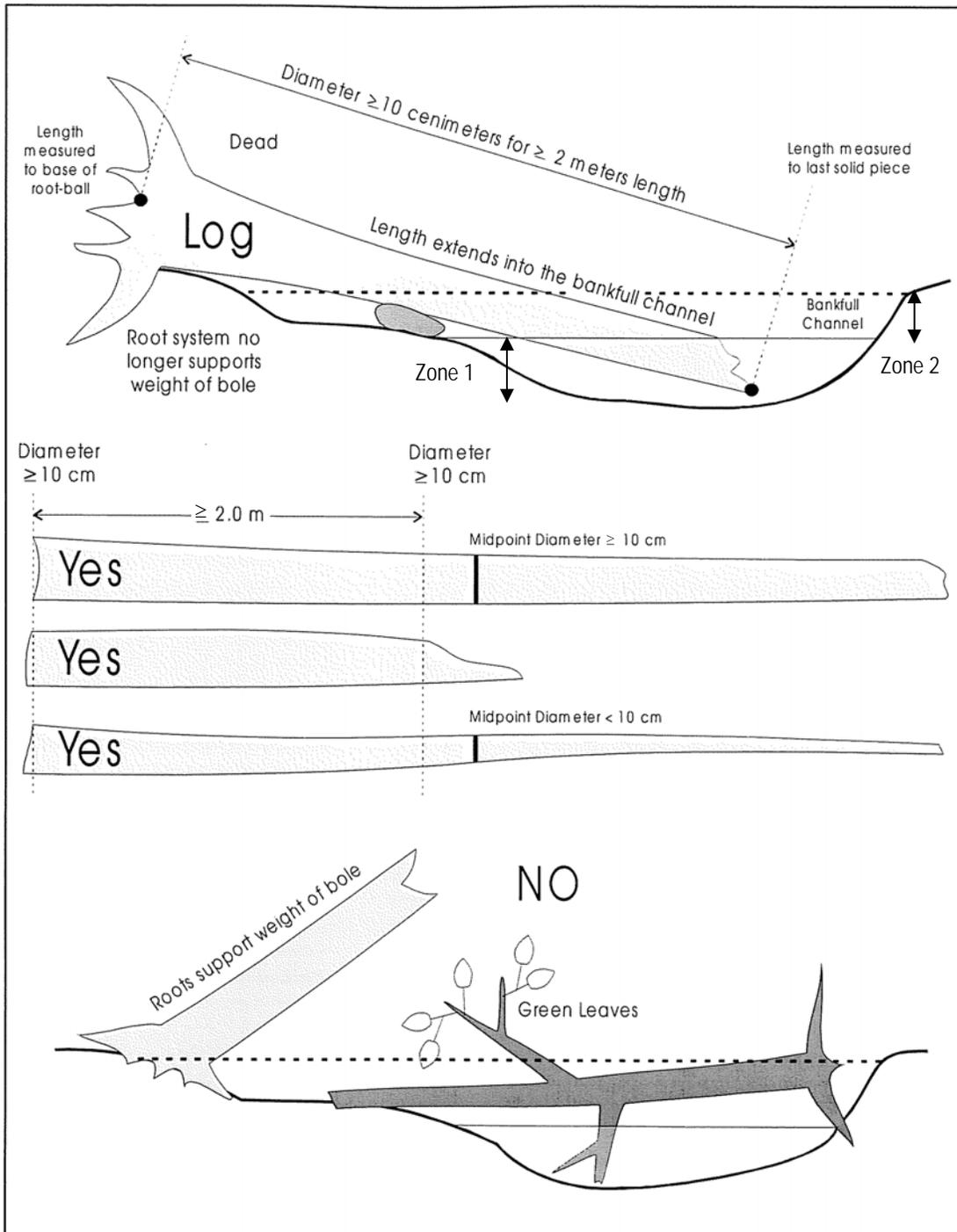


Figure 3-1. Size criteria for identification of individual log utilized in 2001, 2005, and 2006 monitoring surveys of the mainstem middle Green River, King County, Washington (after Schuett-Hames et al. 1999).

pieces, small; 50 to 100 pieces, medium; and greater than 100 pieces, large. The location of all large-sized LWD jams and most small and medium-sized jams were marked on aerial photographs.

Individual pieces of LWD with a diameter smaller than 12 inches (30.5 cm) and a length of less than 30 feet (9.1 m) were counted only when they occurred as part of a qualifying debris jam. Small individual pieces of wood that are not incorporated into a jam are unlikely to remain stable in the channel or influence channel morphology. Single pieces of LWD were tallied by size class as follows: diameter 12 inches (30.5 cm) to 20 inches (50 cm), medium log; diameter greater than or equal to 20 inches (50 cm) but less than 33.5 inches (85 cm), large log; diameter greater than or equal to 33.5 inches (85 cm), key piece.<sup>2</sup> The count of wood further noted whether individual pieces of wood that are not part of a debris jam were cut and whether they had an attached rootball or not. To qualify as a rootball, the size of the rootmass must be a minimum of 4 feet (1.2 m) in diameter.

### **3.2.2 Habitat Monitoring**

A set of key parameters were developed at the monitoring workshop (R2 2002) and were utilized as part of the middle Green River reach scale habitat monitoring program. Key parameters represent habitat attributes that: 1) are expected to be most responsive to management actions or restoration and mitigation projects and 2) can be accurately quantified with minimal measurement error or observer bias.

Key parameters that were quantitatively measured throughout the survey area during reach scale habitat monitoring included bankfull width (where practical), canopy cover, pool habitat unit location and dimensions, and riffle particle size distributions. Habitat survey transects were established every 300 meters of the survey. At each transect a photo was taken, bankfull width was estimated, canopy coverage was measured and location was noted. Definitions and procedures used to measure attributes of each of these key parameters are described below.

#### ***Bankfull Width***

Bankfull width is the distance between the bankfull channel edges, which are defined by the abrupt changes in bank morphology, composition and vegetation (Figure 3-2). The extreme width of the bankfull channel of the middle mainstem Green necessitated the estimation of bankfull width at most locations. The location of bankfull width transects were recorded using

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<sup>2</sup> Perkins (1999) estimated that the minimum size of a key piece of LWD in the mainstem Green River is 85 cm in diameter and at least 10 meters long.

GPS and marked on laminated copies of aerial photographs covering the river corridor. All GPS measurements were subject to available satellite reception. Stream canopy coverage was especially heavy in the side channel surveys, inhibiting GPS reception. Photographs were taken at each bankfull width transect.

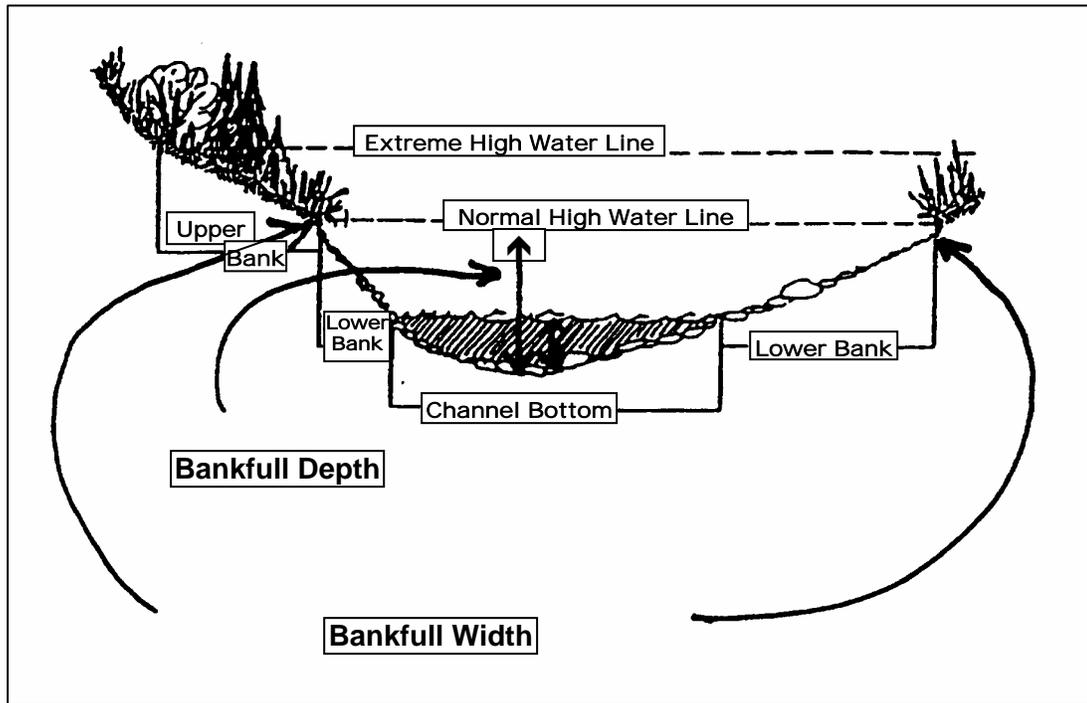


Figure 3-2. Identification of bankfull width, bankfull depth, and lower bank (adapted from Pfunkuch 1975).

### ***Canopy Cover***

Canopy cover refers to the amount of area over the stream channel that is shaded by riparian trees or shrubs. At each habitat survey transect a spherical densitometer was used to assess canopy cover. Canopy cover data shall be collected in the center of the wetted channel at four locations.

### ***Habitat Units***

Habitat units represent short reaches of channel with unique depth, velocity and morphologic characteristics. All habitat units identified during the surveys shall be delineated on the aerial photo basemaps. However, based on the results of the literature review documenting major difficulties in the repeatability and accuracy of measurements conducted in habitat types other

than pools, quantitative measurements were only collected in pool habitat units. Habitat units were classified according to a modified version of the hierarchical system developed by Hawkins et al. (1993). This system recognizes two basic classes of habitat: fast water habitat and slow water habitats. For this survey, those basic habitat classes were further broken down into seven habitat types (Figure 3-3).

Slow water habitat types consist of pools and backwaters. Pool habitats are areas where water is impounded within a closed topographical depression. Such depressions commonly form where water has scoured out a concavity in the channel bed or where the channel has been dammed. Pool habitats were further stratified as scour or dammed and by their formative characteristics (Figure 3-3). Backwater habitats are areas of low or no velocity separated from the main flow hydraulically and physically.

Fast water habitat types generally have a velocity that is greater than 0.3 meters per second. Fast water habitat types are further characterized as turbulent or non-turbulent. Fastwater habitats exhibiting surface turbulence include cascades and riffles. Turbulent, fast water habitats with a water surface slope greater than 4 percent are classified as cascades. Turbulent fast water habitats with a water surface slope less than 4 percent are classified as riffles.

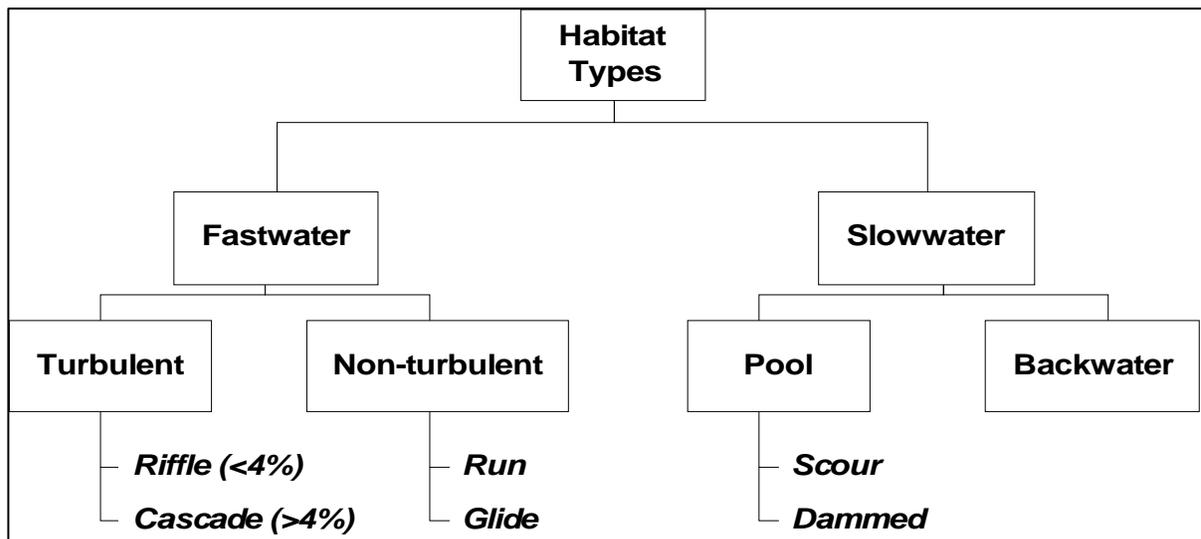


Figure 3-3. Habitat type classification system for upper Green River baseline mainstem habitat monitoring (adapted from Hawkins et al. 1993).

Fast water habitats that do not exhibit surface turbulence often appear pool-like because of their depth and lack of surface agitation. However, unlike pools, non-turbulent fastwater habitats do not exhibit a well-developed depression. Non-turbulent habitat units that are deep and swift with a well-defined thalweg are classified as runs. Non-turbulent fastwater habitats with low to moderate velocity, a uniform bed, and no defined thalweg were classified as glides.

### **Pools**

Pool habitat units are bounded by an upstream pool head and a downstream riffle crest (Figure 3-4). For the unit to be classified as a pool habitat unit, the concave depressional area was required to occupy at least 25 percent of the wetted channel width and have a residual depth greater than 1.0 meter.<sup>3</sup> Smaller pool units were noted on the map and described in field notes, but not measured. Quantitative measurements were collected at each pool habitat unit. Each pool habitat unit was located using GPS (where possible). Pool length and width were measured using a laser rangefinder. The length of each pool shall be measured along the center of the wetted channel. Three to six width measurements per pool perpendicular to the pool centerline were obtained depending on the pool length and complexity. The maximum pool depth was measured using a graduated wading rod or a 2-pound weight attached to a surveyors tape. Riffle crest depths were measured to the nearest 0.1 meter graduated wading rod.

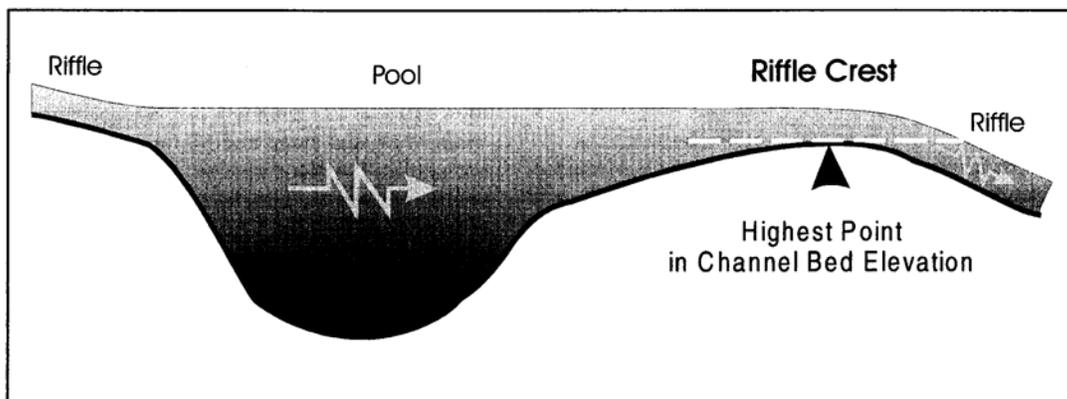


Figure 3-4. Upstream and downstream boundaries used when defining a pool habitat unit (adapted from Pleus et al. 1999).

<sup>3</sup> The minimum residual depth of 1.0 meter was selected to delineate pools of sufficient size as to be stable for comparison in future surveys.

The factor responsible for forming each pool was also be recorded. Pool forming factors include both natural and man-made features. Natural pool-forming factors include LWD, bedrock, boulders, bedforms or the confluence with a tributary or side channel. Pools formed by bedforms include those formed by bed steps (a bed step is a transverse rib of boulders or cobbles that extends across the entire channel) and those formed by the hydraulics associated with a riffle/pool sequence. Pools are defined as being formed by boulders where single large individual boulders or groups of boulders result in local scour. Man-made pools include those formed by dams, culverts, bridge abutments or constructed and anchored LWD or engineered log jams (ELJs). In addition to the pool forming factor, the pool type was also recorded. Pool types include scour or dammed.

### ***Riffle Substrate***

Riffles represent locations within the channel where bedload is stored between high flow events. They are generally composed of well-sorted material that is representative of the size of sediments transported through a given stream reach. As such, they represent they represent good locations to obtain a sample of sediment when the goal is to characterize bedload composition.

Riffle substrate was characterized by conducting five pebble counts per reach in randomly selected riffle habitat units (Wolman 1954). The b-axis of 100 randomly selected particles will be measured for each pebble count. Where the river is wadable, pebble count surveys will traverse the entire active channel. If the river is not wadable, pebble counts will be extended from the bankfull channel margin to a point where the water depth exceeded approximately 2 feet. The location of sites where pebble counts were conducted was recorded using GPS (where possible) and marked on the aerial photograph based on readily recognized landmarks.

### ***Side Channel Units***

One significant difference between the 2001 and later surveys methods was the decision to include side channel areas. The 2001 survey focused solely on mainstem habitat attributes and so side channels were not included. Side channels were included in the 2005 through 2007 surveys to ensure a thorough count of all LWD within the middle mainstem Green River and for long-term monitoring needs. However, the side channel data were not kept separate from the mainstem totals until 2006. In 2006, all side channels with noticeable inlet flow at the time of the survey were surveyed. Thirty side channels were surveyed in 2006, measuring a total of approximately 5 miles. In 2007, side channels were identified on aerial photography prior to field work. All of the identified channels and a few more that were identified in the field were surveyed regardless of their flow level. This included all of the side channels surveyed in 2006.

In total, parts of fifty-nine side channel complexes were surveyed in 2007 totaling approximately 13.5 miles. These side channels are noted on the appropriate maps in Section 4.

### 3.2.3 Quality Assurance/Quality Control

The quality assurance quality control (QA/QC) program is a critical part of a successful monitoring project. For the mainstem Green River Habitat Monitoring Program, QA/QC measures were implemented at a variety of levels.

#### *Equipment Calibration and Gear*

Field equipment used to measure LWD attributes was checked for damage and calibration at the beginning and end of field work. Measuring tapes and calipers were checked by comparing them to a new survey grade open reel tape. Table 3-1 lists equipment used to conduct LWD surveys of the mainstem middle Green River in 2007.

Table 3-1. Equipment used to conduct habitat surveys for LWD surveys of the mainstem middle Green River in 2007.

<b>Item</b>	<b>Size</b>	<b>Accuracy</b>	<b>Condition</b>
Garmin GPS 76 Satellite Navigator	NA	±15 m	Good
LWD Calipers	24 inches	1/8 inch	Good
Open Reel Fiberglass tape	100 feet	1/4 inch	Good
Spencer Logger's Tape	50 feet	1/8 inch	Good
Optio Digital Cameras	Handheld	NA	Good

#### *LWD Calibration*

Team members jointly estimated then measured the length and width of the first twenty-five pieces of LWD encountered (Figure 3-5). Additionally, five to ten pieces were estimated and then measured throughout each subsequent field day. Appendix A contains observer estimates and LWD piece measurements.

Similar methods were used to count and determine channel location of LWD during the 2001, 2005, 2006, and 2007 surveys. To ensure consistent interpretation of sampling protocol between the surveys, one of the crew members from the 2001 survey was present during the 2005, 2006, and 2007 surveys. Other members of the survey crew were cross trained to reduce crew bias. One significant difference between the 2001 and the later surveys was the inclusion of side channel areas. The 2001 survey focused only on mainstem habitat attributes and so side

channels were not included. However, side channel woody debris tallies were kept separate from mainstem numbers in 2007. Including side channel areas effectively increased the area surveyed during the 2007 effort.

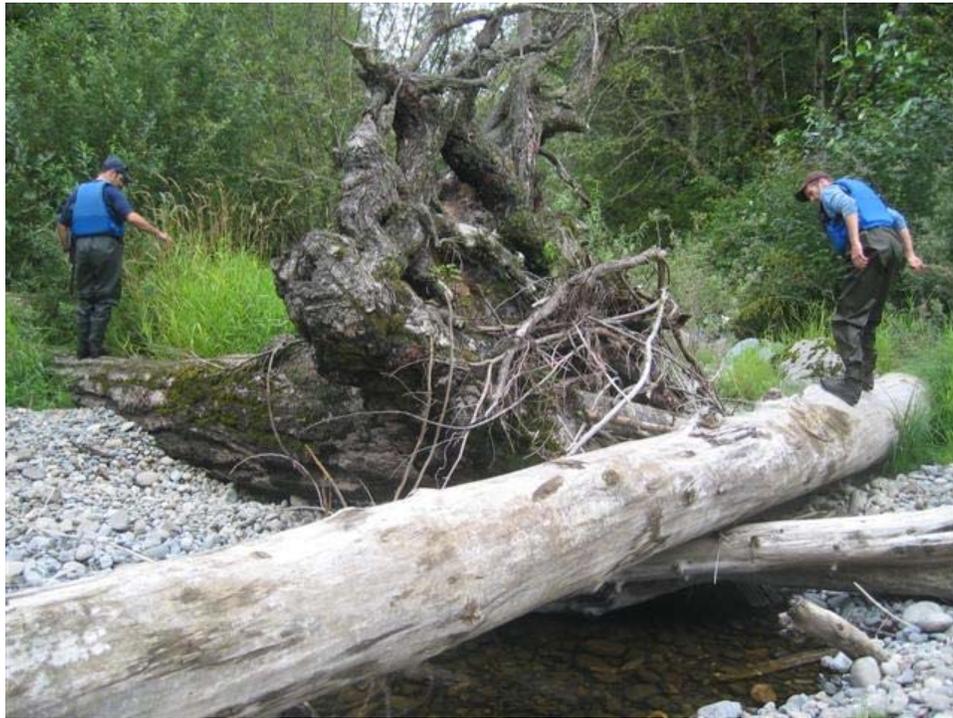


Figure 3-5. Surveyors estimating the size of LWD on the Green River, Washington, 2007.

### ***Data Entry Check***

All data forms, field books, and calculations were reviewed for errors and discrepancies following the end of field surveys. Questionable data points were corrected or eliminated from the analysis. Data was entered into MS EXCEL spreadsheets then cross-checked against the original field forms by a second person who had also been involved in the field work. The date and initials of the individual responsible for the original data entry and the data review were recorded both on the original field notes and in the electronic files.

### **3.3 DATA ANALYSIS**

Data analyses were conducted using MS EXCEL and ArcInfo GIS tools. New high resolution aerial photographic coverage was supplied by the Corps in 2007. All reach break, habitat unit, pebble count, and LWD jam data were identified on the aerial coverage.

## 4. HABITAT SURVEY RESULTS

### 4.1 MAINSTEM

Habitat surveys were conducted in the Green River from August 20 through August 24 and the following week, August 27 through August 31, 2007. The following sections provide a reach by reach summary of habitat forming processes and existing channel conditions based on the results of the baseline habitat monitoring surveys. These results are also compared to the 2001 baseline habitat survey. Streamflow during the 2007 survey was slightly higher than in 2001, ranging from 301 to 331cfs in 2007 and 263 to 326cfs in 2001 (as measured at the Auburn gage #12113000). The results of the large woody debris survey are presented in Section 5.

#### 4.1.1 REACH 1 – Howard Hanson Dam (RM 64.5) to Tacoma Headworks (RM 61.0)

This reach was not included in the 2007 habitat survey. See R2 2002 for results from the 2001 habitat survey.

#### 4.1.2 REACH 2 – Headworks (RM 61.0) to Kanaskat Park (RM 57.1)

Reach 2 was surveyed on August 20 and 21 (Figure 4-1). The reach is approximately 4.0 miles long extending from the Tacoma Headworks (RM 61.0) to Kanaskat State Park (RM 57.0) (Figure 4-2). The flow at the time of the survey was 153 cubic feet per second (cfs) as measured at the Palmer, Washington stream gage (USGS #12106700). This flow level is a similar low flow to the surveys conducted in 2001. Six side channel complexes were surveyed in Reach 2 including two large named meanders: Palmer and Kanaskat Sloughs (see Section 4.2 for complete side channel descriptions). Summary statistics for habitat data collected in Reach 2 are presented in Table 4-1.

The dominant habitat type was riffle, comprising more than half of the habitat length (51.6%). Pools were the next most common habitat type, comprising approximately 25 percent of the reach by length. Runs, cascades and glides were also present (17.4, 4.7, and 1.9% respectively). These ratios are very similar to those found in the 2001 habitat survey. Sixteen pools were identified in Reach 2. The majority of the pools were formed by bedrock. Only one pool (6.3%) was formed by wood. Five mainstem and two side channel LWD jams were identified in Reach 2. All of the jams were small in size (Appendix D).

Substrate in Reach 2 consisted primarily of bedrock and boulders. Pebble counts were conducted in riffle habitat types that tended to be composed of smaller material than was observed in the steeper stream sections. The mean  $D_{50}$  for the four pebble counts was 69.8 mm,

ranging from 54.7 to 86.0 mm. Gravel added as part of augmentation efforts is noticeable in this reach and has likely affected the pebble count results, lowering the average  $D_{50}$  from the 2001 results.

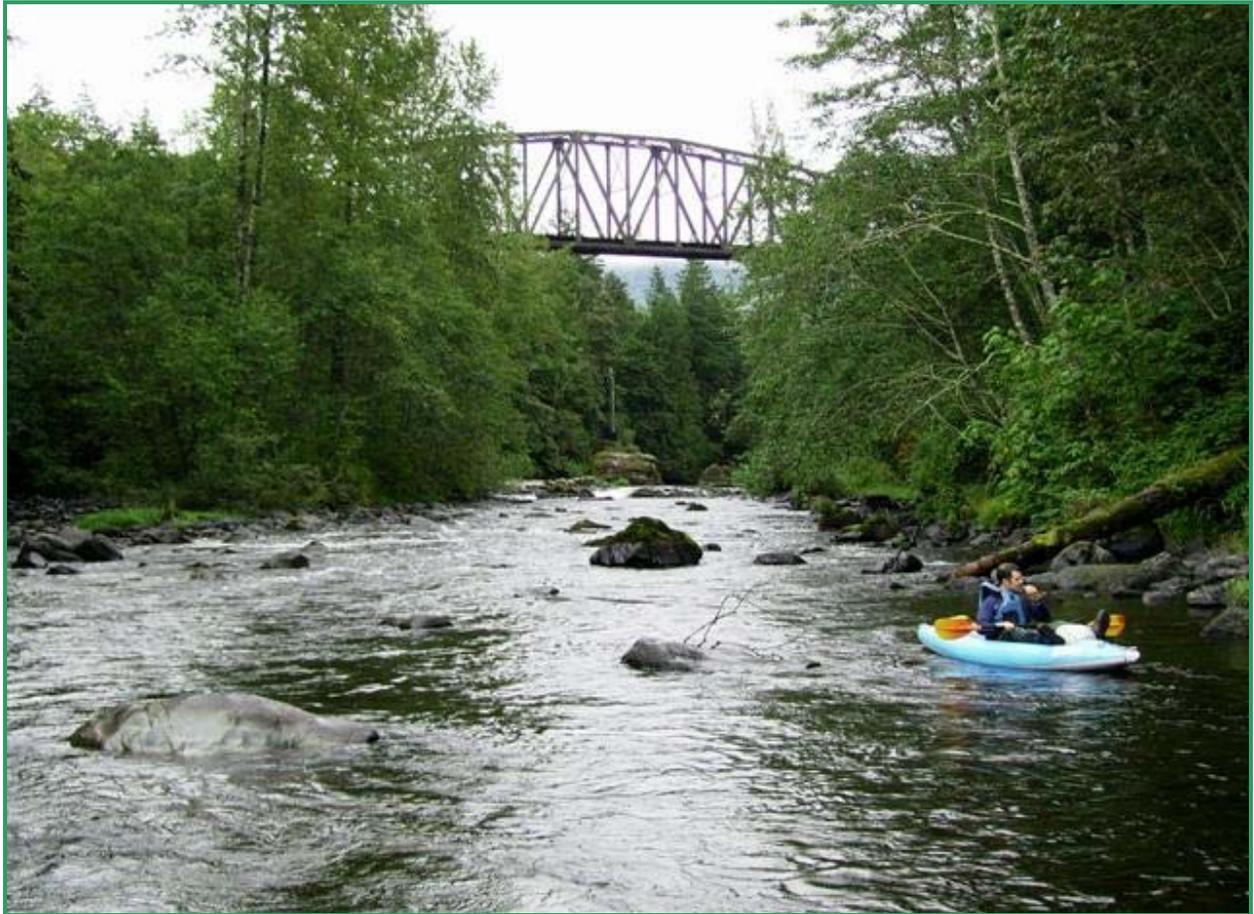


Figure 4-1. Representative habitat of Reach 2, Tacoma Headworks to Kanaskat Park, Green River, Washington 2007.

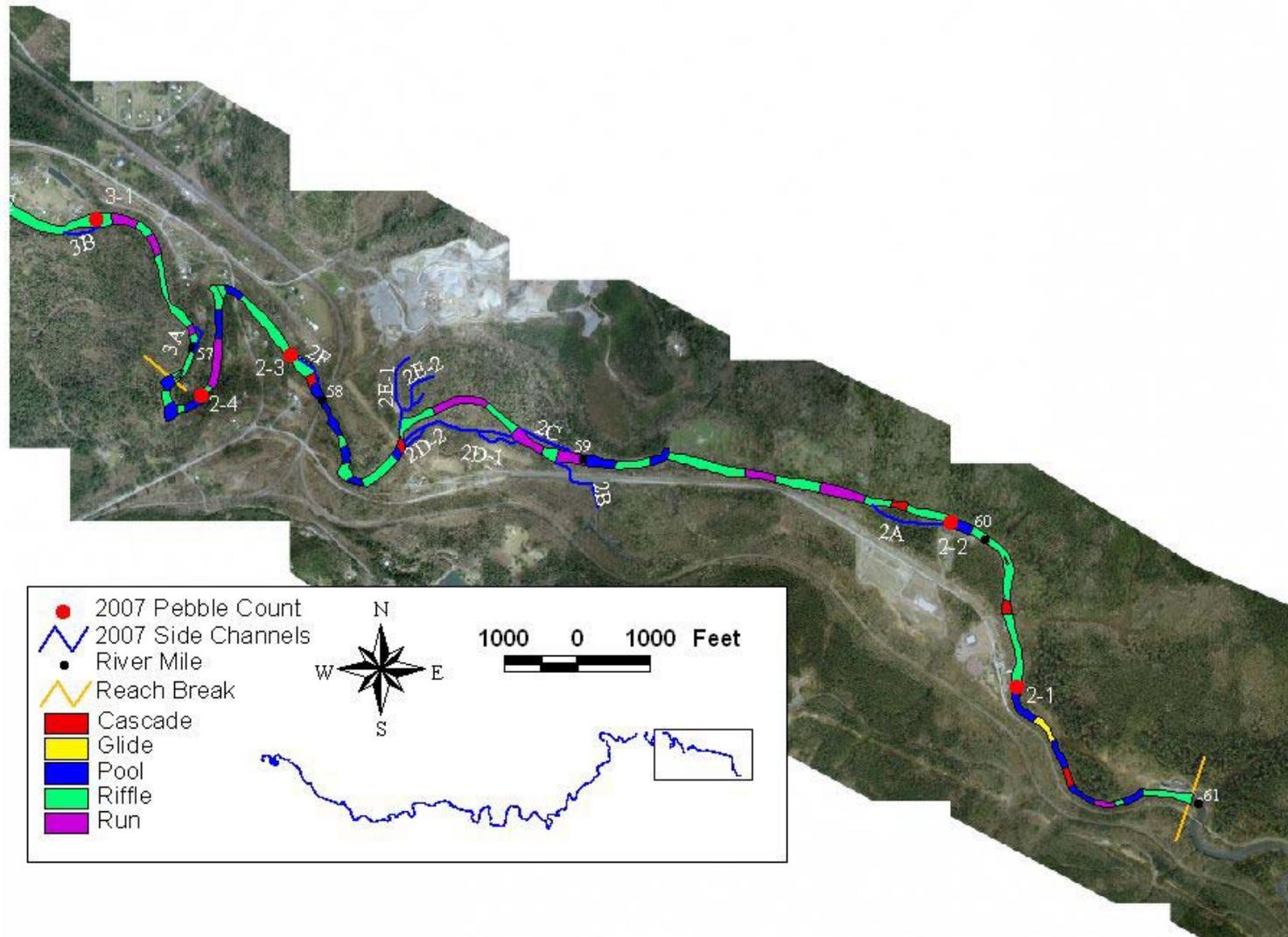
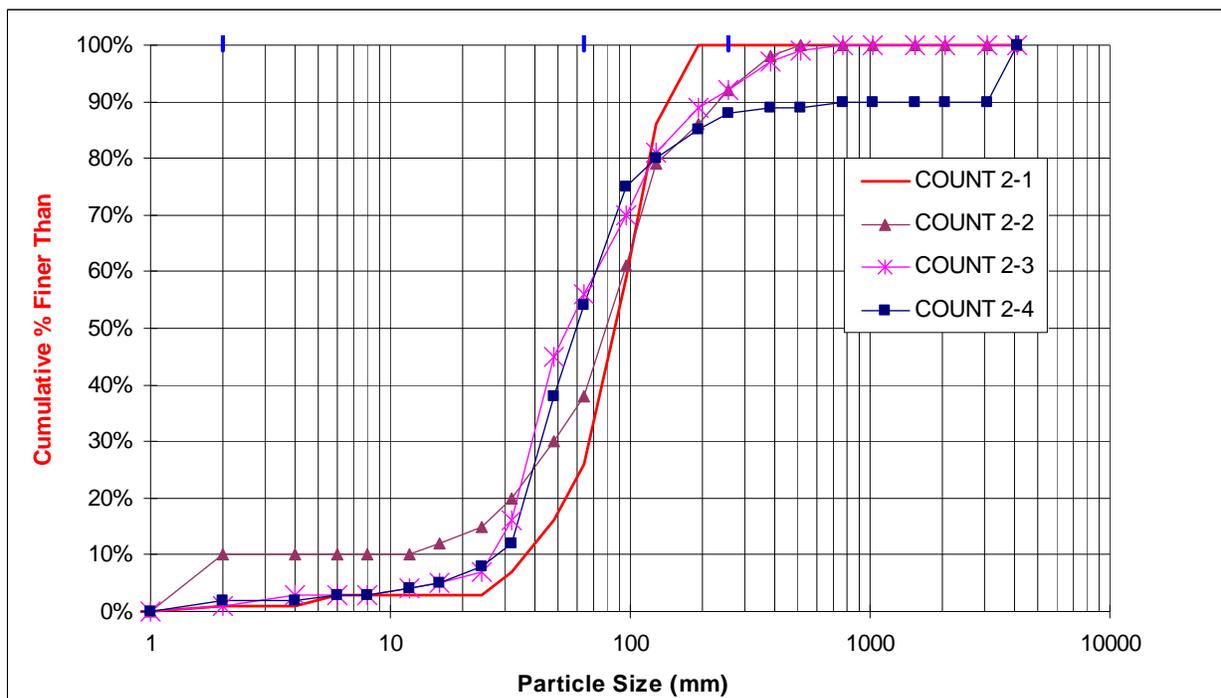


Figure 4-2. Middle Green River physical habitat in Reach 2, 2007.

Table 4-1. Summary data for Reach 2 of the 2001 and 2007 Middle Green River habitat surveys, King County, Washington.

Reach 2	2001	2007
Location	RM 61.0 – 57.0	RM 61.0 – 57.0
Confinement	Unconfined	Unconfined
Length (m)	6,437 (4.0 miles)	6,437 (4.0 miles)
Side Channel Length (m) (n=6)	N/A	2410.4 (7,908 ft)
Gradient	0.80%	0.80%
Average streamflow at Palmer (cfs)	133	153
Average bankfull width (m)	41.2 (135 ft)	35.4 (116 ft)
Average wetted width (m)	32.0 (105 ft)	29.3 (96 ft)
Pool Frequency (channel widths / pool)	11	14
Percent pool by length	26%	25%
Percent pool by area	20%	27%
Average residual pool depth (m)	3.0 (9.8 ft)	2.8 (9.2 ft)
Dominant pool forming factor	Bedrock	Bedrock
% Pools formed by LWD	0.0%	6.3%
Average D 16 mm	25	35
Average D 50 mm	137	70
Average D 84 mm	317	156
Average shade	17%	44%



### 4.1.3 REACH 3 – Kanaskat Park (RM 57.1) to Flaming Geyser (RM 45.0)

Reach 3 encompasses a deep bedrock canyon known as the Green River gorge (Figure 4-3). The survey of Reach 3 took place over August 22, 23, and 24. The reach is approximately 12 miles long extending from Kanaskat State Park (RM 57) to Flaming Geyser State Park (RM 45) (Figures 4-4 and 4-5). The average stream flow during the survey was 311 cfs as measured at the Auburn, Washington stream gage (USGS #12113000) and 182 cfs as measured at the Palmer Washington stream gage (USGS #121067000). Summary statistics for habitat data collected in Reach 3 are presented in Table 4-2.



Figure 4-3. Representative habitat of Reach 3, Green River, Washington 2007.

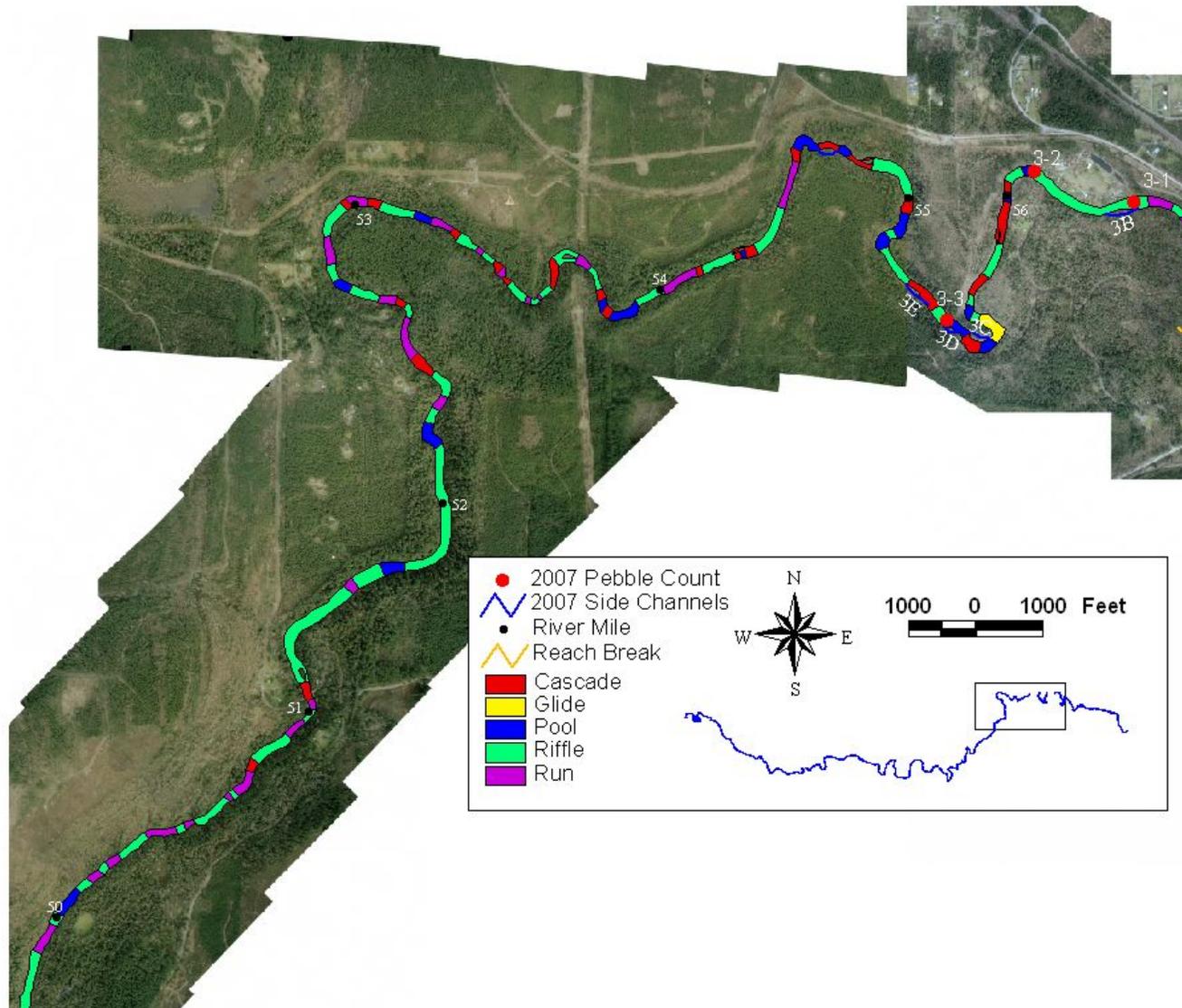


Figure 4-4. Middle Green River physical habitat in the upstream half of Reach 3, 2007.

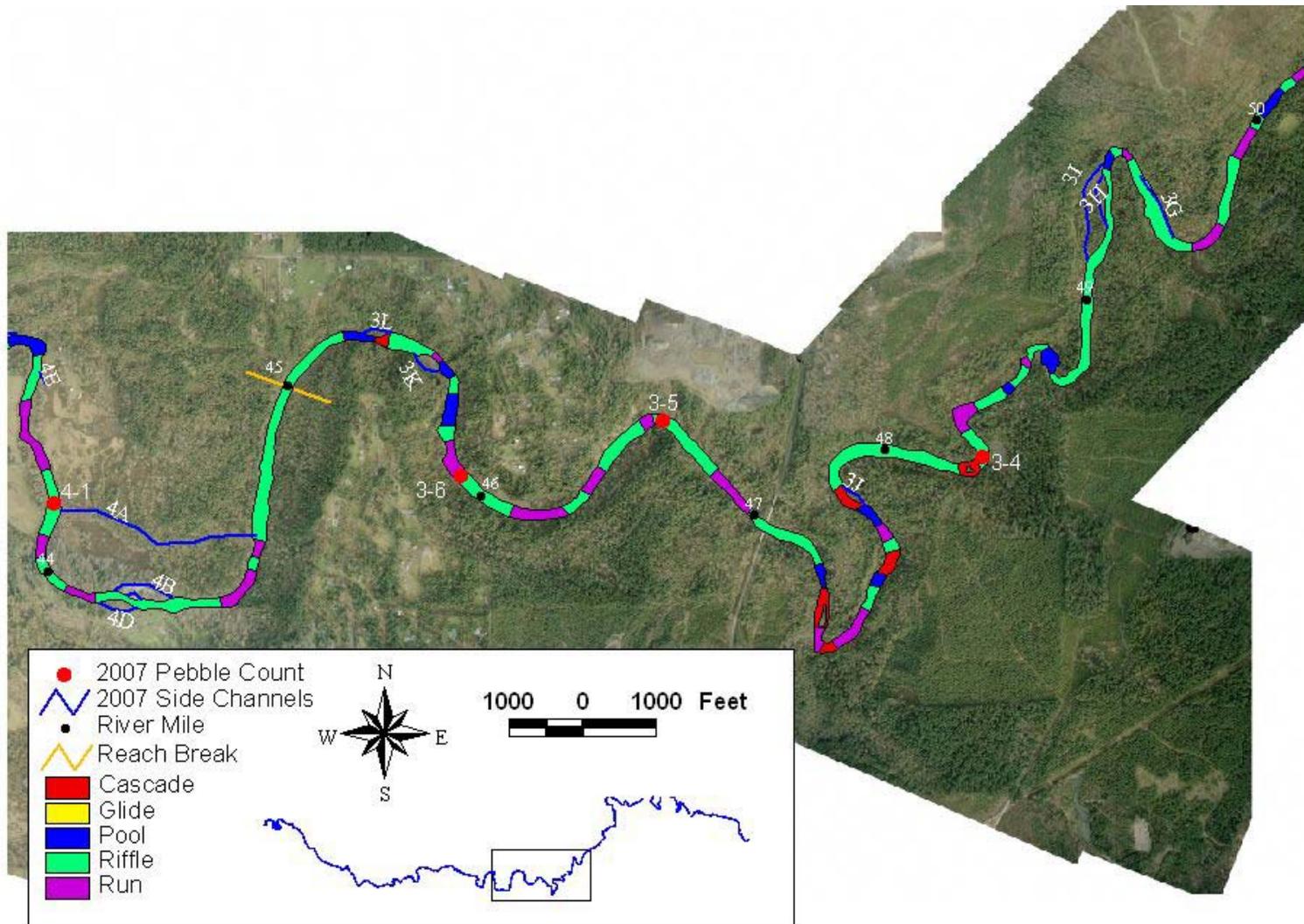
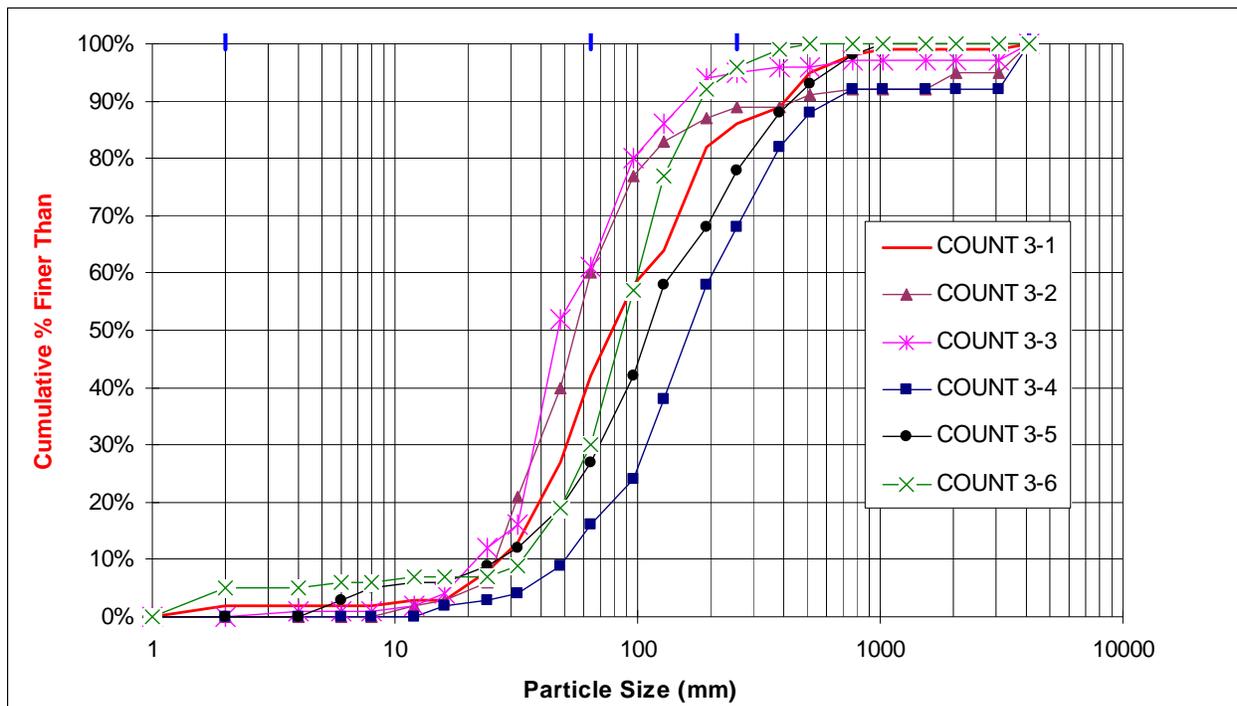


Figure 4-5. Middle Green River physical habitat in the downstream half of Reach 3.

Table 4-2. Summary data for Reach 3 of the 2001 and 2007 Middle Green River habitat surveys, King County, Washington.

Reach 3	2001	2007
Location	RM 45.0-57.0	RM 45.0-57.0
Confinement	Confined	Confined
Length (m)	19,311 (12 miles)	19,311 (12 miles)
Side Channel Length (m) (n=12)	N/A	2,082.7 (6,833 ft)
Gradient	0.80%	0.80%
Average streamflow at Palmer (cfs)	109 – 131 cfs	182
Average bankfull width (m)	39.0 (128 ft)	39.6 (130 ft)
Average wetted width (m)	28.0 (92 ft)	29.3 (96 ft)
Pool Frequency (channel widths / pool)	9	25
Percent pool by length	25%	12%
Percent pool by area	21%	12%
Average residual pool depth (m)	2.8 (9.2 ft)	3.2 (10.5 ft)
Dominant pool forming factor	Bedrock	Bedrock
% Pools formed by LWD	0.0%	0.0%
Average D 16 mm	29	41
Average D 50 mm	81	90
Average D 84 mm	209	231
Average shade	26%	40%



The dominant habitat type in Reach 3 was riffle, which comprised 56.5% of the habitat by length. 19% of the reach consisted of run habitat. Pools only accounted for 11.5% of the habitat in Reach 3. Cascade units accounted for 13 percent of the reach by length. A total of 27 pools were identified in Reach 3. The dominant pool formation factor was bedrock, responsible for the formation of 88.9 percent (n=24) of the pools. The 2007 survey took place at a higher flow level than the 2001 survey, possibly increasing surface turbulence of pools causing fewer units to be labeled pool habitat and more units to be runs instead. Twelve side channels were surveyed in Reach 3 (Section 4.2). A total of 33 LWD jams were counted in Reach 3, all located within the mainstem river. These were all small jams, with the exception of four medium sized jams (Appendix D).

Reach 3 contained several steep cascades and bedrock shelves. The substrate in this reach was primarily bedrock and boulder. The mean  $D_{50}$  particle size of all six pebble counts was 90.2 mm, ranging from 46.9 to 163.3 mm. As was similar in Reach 2, the substrates of the steeper sections of this reach were underrepresented by the pebble counts which were taken in lower velocity riffle areas.

#### 4.1.4 REACH 4 – Flaming Geyser (RM 45.0) to Newaukum Creek (RM 40.8)

Reach 4 was surveyed on August 27, 2007. The reach is approximately 4.2 miles long extending from Flaming Geyser State Park (RM 45) to Newaukum Creek (RM 40.8) (Figures 4-6 and 4-7). The average stream flow during the survey was 331 cfs as measured at the Auburn, Washington stream gage (USGS #12113000). Reach 4 consists of a wider floodplain channel than upstream with predominately riffle-pool or riffle-run bedforms.

Summary statistics for Reach 4 are presented in Table 4-3. The dominant habitat type in Reach 4 was riffle (60.0%). Run was the next most common type, accounting for 23.1% by length of the habitat. Cascade and pool units were also present (4.9 and 11.1% respectively). Only five pools were identified in Reach 4. Bedrock was the dominant pool formation factor. Eight side channel complexes were surveyed in Reach 4 (Section 4.2). A total of 14 mainstem and 5 side channel jams were identified in Reach 4 (Appendix D).



Figure 4-6. Representative habitat of Reach 4, Green River, Washington 2007.

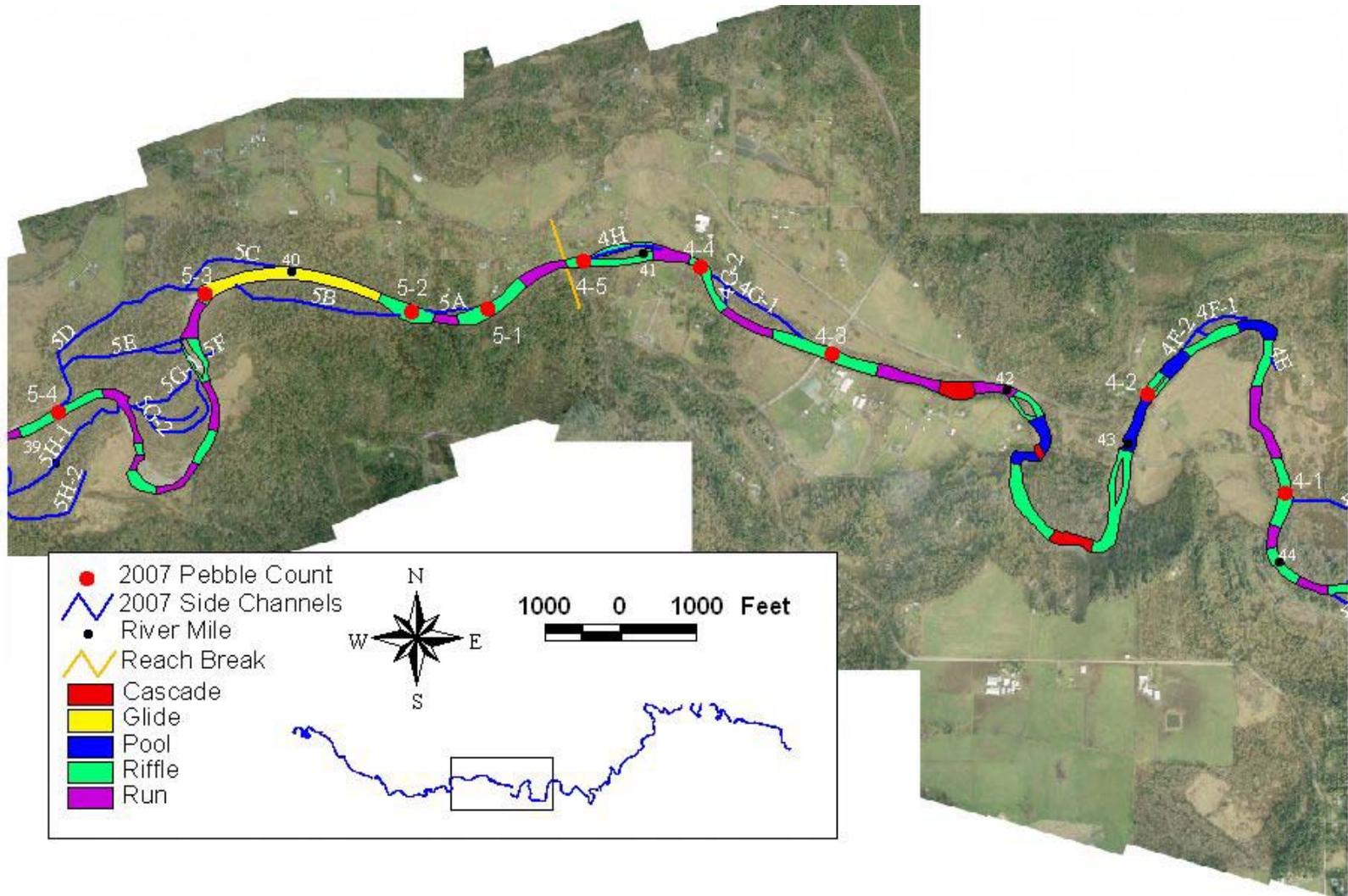
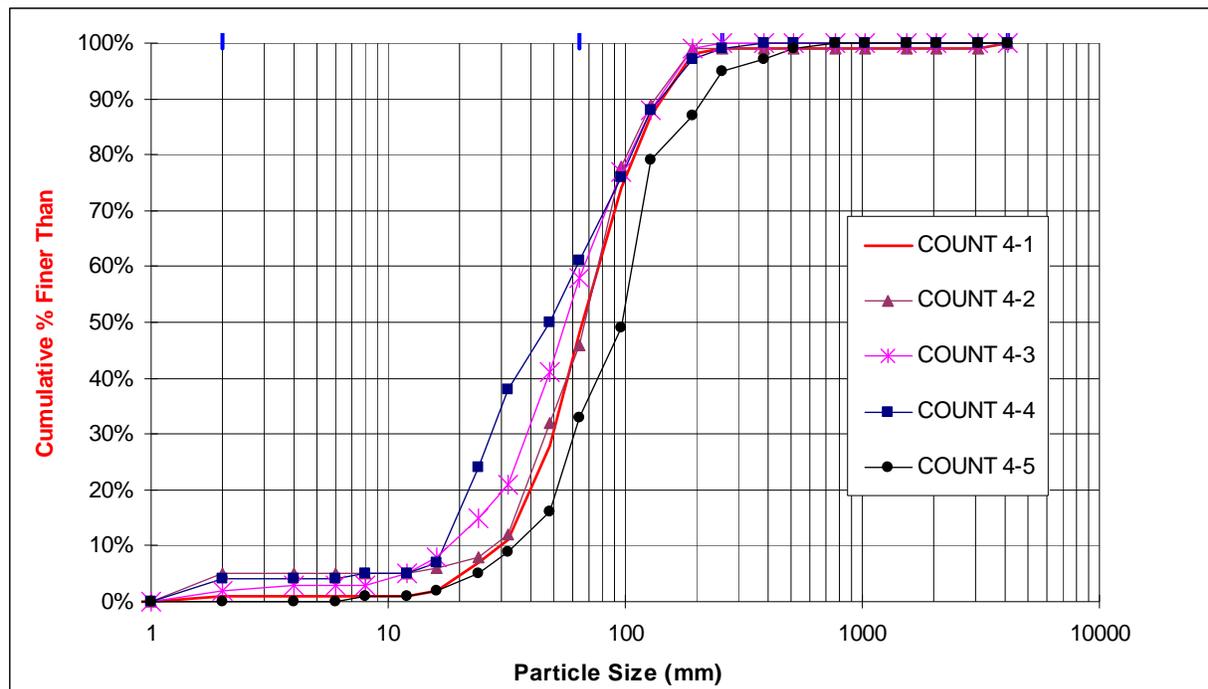


Figure 4-7. Middle Green River physical habitat in Reach 4, 2007.

Substrate in Reach 4 is primarily gravel and cobble. The average D<sub>50</sub> particle size for five pebble counts was 66.8 mm, ranging from 48.0 to 96.9 mm.

Table 4-3. Summary data for Reach 4 of the 2001 and 2007 Middle Green River habitat surveys, King County, Washington.

Reach 4	2001	2007
Location	RM 40.8-45.0	RM 40.8-45.0
Confinement	Unconfined	Unconfined
Length (m)	6,758 (4.2 miles)	6,758 (4.2 miles)
Side Channel Length (m) (n=8)	N/A	2,595.4 (8,515 ft)
Gradient	0.20%	0.20 %
Average streamflow at Auburn (cfs)	252 - 256 cfs	331 cfs
Average bankfull width (m)	39.9 (131 ft)	44.2 (145 ft)
Average wetted width (m)	31.1 (102 ft)	37.5 (123 ft)
Pool Frequency (channel widths / pool)	34	37
Percent pool by length	7%	11%
Percent pool by area	4%	12%
Average residual pool depth (m)	2.5 (8.2 ft)	2.3 (7.7 ft)
Dominant pool forming factor	Bedrock	Bedrock
% Pools formed by LWD	0.0%	0.0%
Average D 16 mm	36	33
Average D 50 mm	69	67
Average D 84 mm	138	126
Average shade	16%	24%



#### 4.1.5 REACH 5 – Newaukum Creek (RM 40.8) to RM 38.0

Reach 5 was surveyed on August 28 and 29 (Figure 4-8). The reach is approximately 2.8 miles long extending from Newaukum Creek (RM 40.8) to Loans Levee (RM 38.0) (Figure 4-9). The average stream flow during the survey was 314 cfs as measured at the Auburn, Washington stream gage (USGS #12113000). This reach of the middle mainstem Green River has experienced frequent channel shifts in the past ten to twenty years and contains numerous side channels that were not surveyed as part of the 2001 survey. Since the winter of 1996-1997, almost half of the mainstem flow had been redirected into a large side channel near RM 40 (R2 2002). The main river channel has now shifted significantly since the 2001 survey from flowing in a meander back to a more direct mainstem route just before RM 38.0. Habitat summary statistics are presented in Table 4-4.



Figure 4-8. Representative habitat of Reach 5, Green River, Washington 2007.

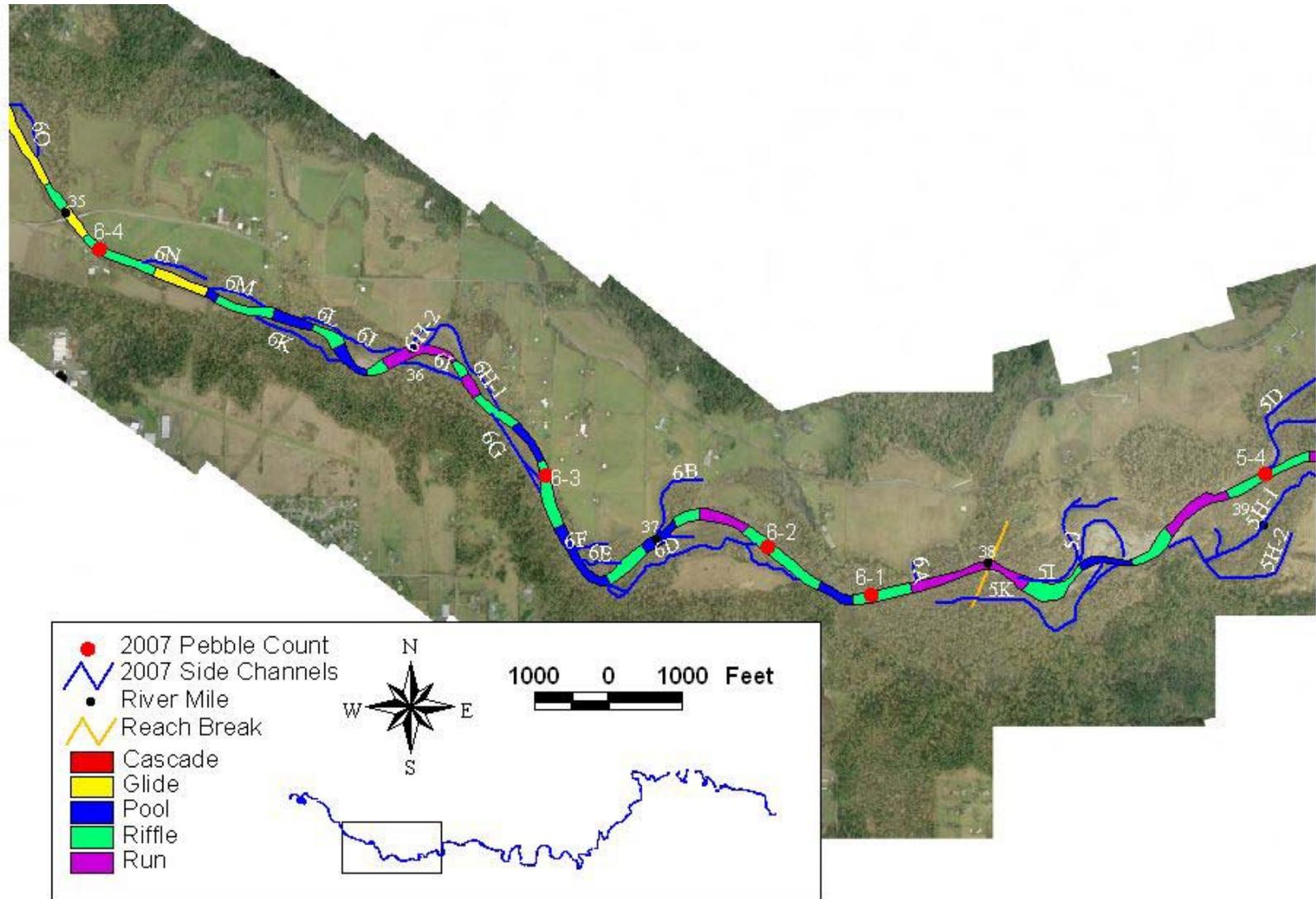
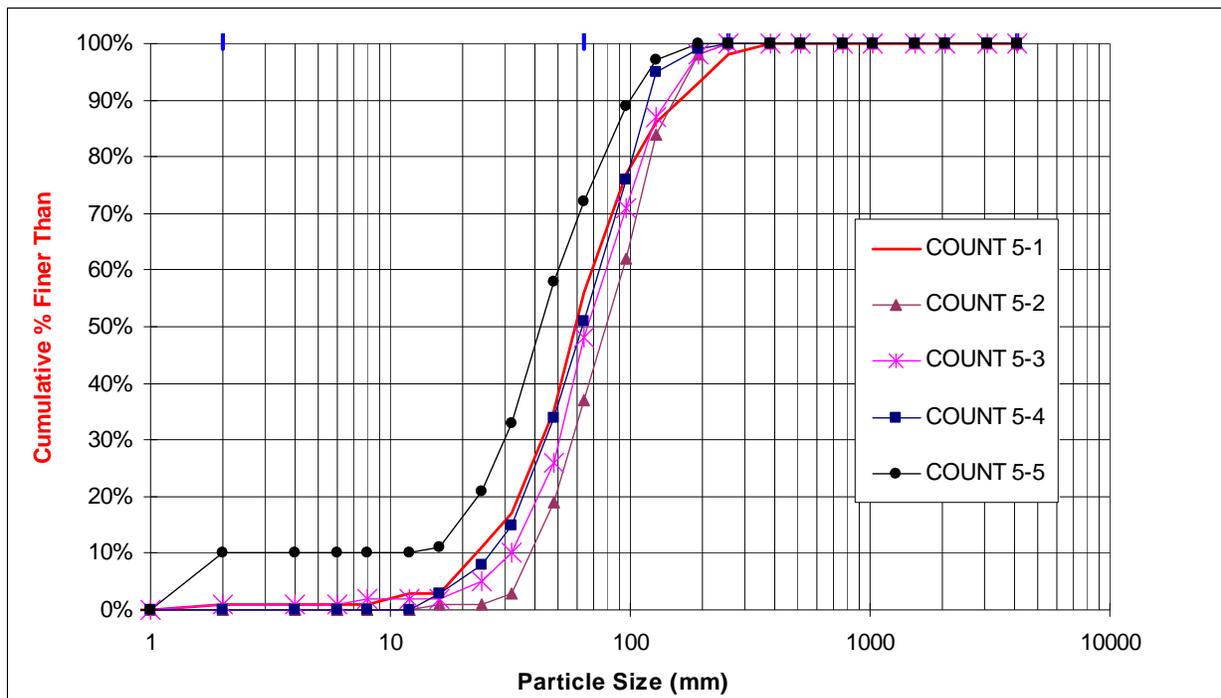


Figure 4-9. Middle Green River physical habitat in Reach 5, 2007.

Table 4-4. Summary data for Reach 5 of the 2001 and 2007 Middle Green River habitat surveys, King County, Washington.

Reach 5	2001	2007
Location	RM 38.0-40.8	RM 38.0-40.8
Confinement	Unconfined	Unconfined
Length (m)	4,506 (2.8 miles)	4,506 (2.8 miles)
Side Channel Length (m) (n=11)	N/A	7,358.8 (24,143 ft)
Gradient	0.30 %	0.30%
Average streamflow at Auburn (cfs)	256-356	314
Average bankfull width (m)	39.9 (131 ft)	38.4 (126 ft)
Average wetted width (m)	25.0 (82 ft)	25.3 (83 ft)
Pool Frequency (channel widths / pool)	11	180
Percent pool by length	24%	5%
Percent pool by area	19%	4%
Average residual pool depth (m)	1.6 (5.3 ft)	2.1 (7.0 ft)
Dominant pool forming factor	Bedform	Log
% Pools formed by LWD	30%	100%
Average D 16 mm	25	33
Average D 50 mm	56	62
Average D 84 mm	99	113
Average shade	14%	13%



The dominant habitat type in Reach 5 was riffle, measuring 42.9% by length. Run was the next most common measuring 36.4%. No cascade units were present in this reach. Only one pool was present in Reach 5 (4.8% by length). The return of the river to a more direct route near RM 38.5 has eliminated a large number of pools identified in the 2001 habitat survey. The single pool was formed by woody debris. Reach 5 is a braided channel with multiple flow paths and gravel bars. Eleven side channel complexes were surveyed in this reach (see Section 4.2). Eight mainstem and 13 side channel LWD jams were counted in Reach 5 (Appendix D).

Five pebble counts were completed in Reach 5, with a mean  $D_{50}$  of 61.9 mm. Mean  $D_{50}$  for the five counts ranged from 42.2 mm to 79.0 mm. Average shade and pebble count data were very similar between 2001 and 2007 surveys.

#### **4.1.6 REACH 6 – RM 38.0 to LWD jam downstream of Hwy 18 (RM 32.1)**

The survey of Reach 6 took place from August 29 through August 31. The survey reach was approximately 6.0 miles long extending from Loans Levee (RM 38.0) to the Auburn Narrows (RM 32.0) (Figure 4-10 and 4-11). The average stream flow during the survey was 314 cfs as measured at the Auburn, Washington stream gage (USGS # 12113000). This reach is currently constrained between levees for most of its length. Jam 6-Q is a very large channel spanning jam located near the Auburn Narrows at RM 33. Habitat summary statistics for Reach 6 are presented in Table 4-5.



Figure 4-10. Representative habitat of Reach 6, Green River, Washington 2007.

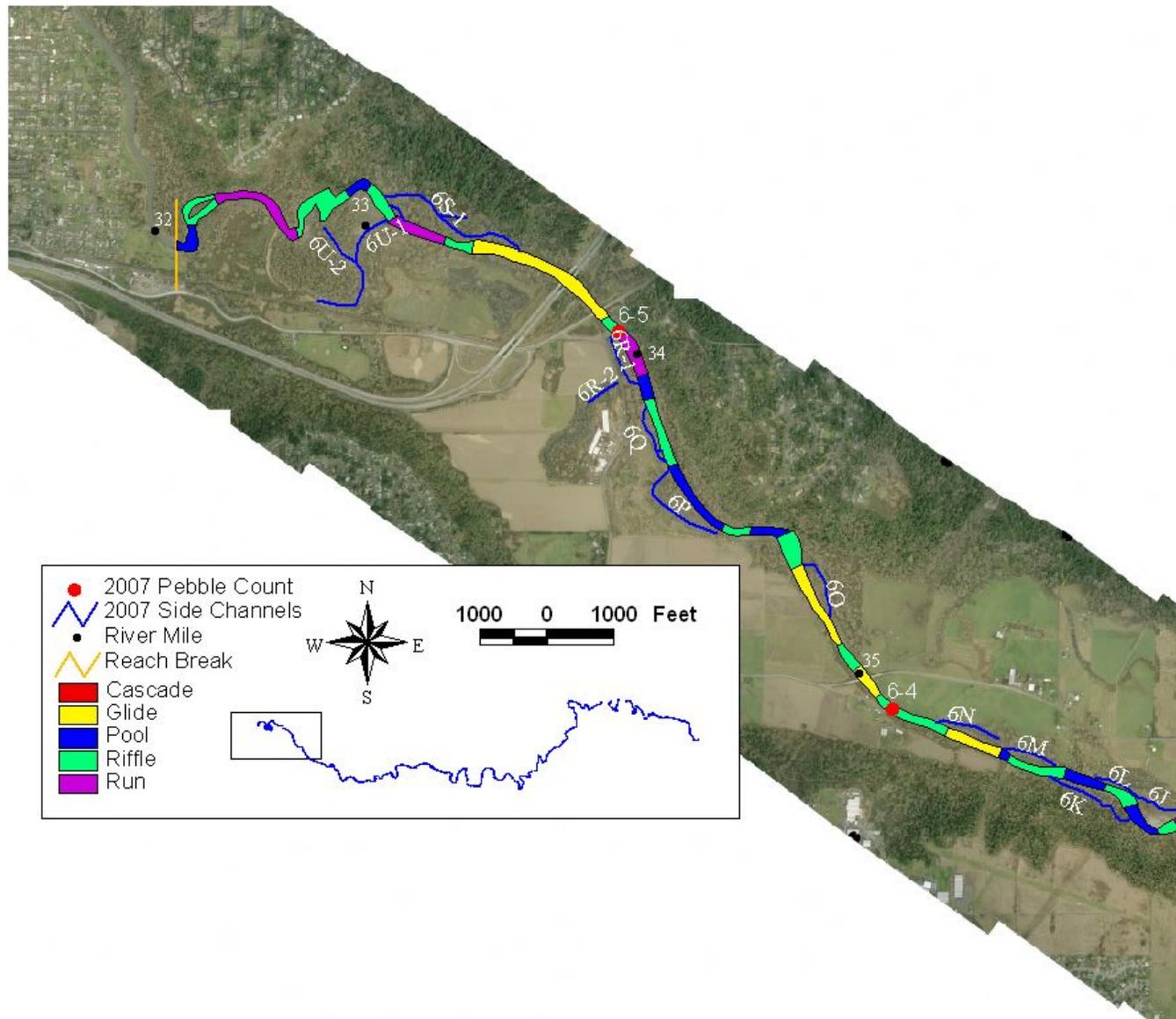
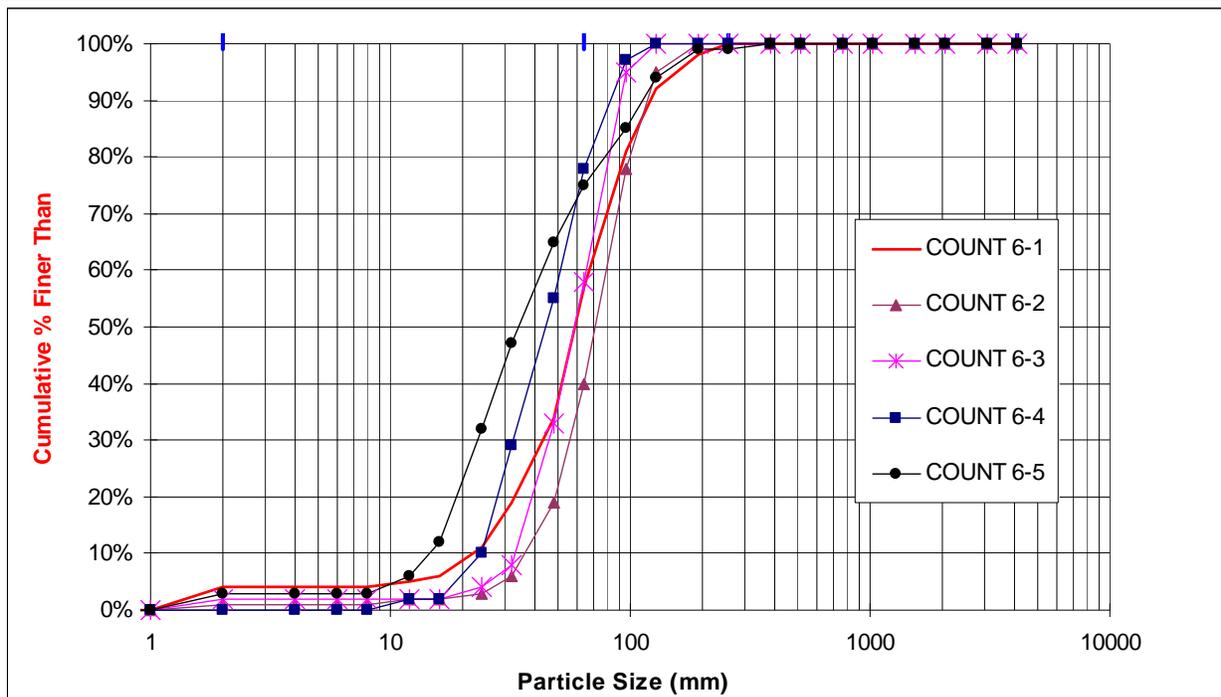


Figure 4-11. Middle Green River physical habitat in Reach 6, 2007.

Table 4-5. Summary data for Reach 6 of the 2001 and 2007 Middle Green River habitat surveys, King County, Washington.

Reach 6	2001	2007
Location	RM 32.0-38.0	RM 32.0-38.0
Confinement	Unconfined	Unconfined
Length (m)	9,656.1 (6.0 miles)	9,656.1 (6.0 miles)
Side Channel Length (m) (n-21)	N/A	7,467.9 (24,501 ft)
Gradient	0.20%	0.20%
Average streamflow at Auburn (cfs)	266-300	314
Average bankfull width (m)	45.1 (148 ft)	41.5 (136 ft)
Average wetted width (m)	29.9 (98 ft)	32.3 (106 ft)
Pool Frequency (channel widths / pool)	12	25
Percent pool by length	23%	19%
Percent pool by area	14%	22%
Average residual pool depth (m)	2.0 (6.6 ft)	2.6 (8.6 ft)
Dominant pool forming factor	Rip-Rap	Bedrock / Bedform
% Pools formed by LWD	24%	23%
Average D 16 mm	22	31
Average D 50 mm	42	53
Average D 84 mm	80	92
Average shade	13%	22%



The dominant habitat unit measured in Reach 6 was riffle, accounting for 41.9% of the habitat by length. Run units comprised 25.2% and pool units 19.1% of the habitat. Thirteen pool units were identified in Reach 6. Bedrock and bedform were the dominant pool formation factors. Three pools (23%) were formed by wood. Twenty-two side channel complexes were surveyed in Reach 6 (see Section 4.2). A total of 19 mainstem and 9 side channel jams were counted in this reach (Appendix D).

Substrate in Reach 6 is primarily gravel and cobble. Five pebble counts were completed in Reach 6 with an average  $D_{50}$  measuring 53.4 mm. The mean  $D_{50}$  ranged from 34.2 mm to 71.2 mm. The 2007 pebble count results are very similar to the 2001 results. Canopy coverage averaged 22% in Reach 6.

#### **4.2 SIDE CHANNEL SUMMARY**

Side channel habitat was surveyed concurrent with the mainstem habitat survey. The side channels to be surveyed were outlined prior to the start of field work from aerial photos. Habitat data (i.e., pool/riffle composition) was collected in side channels that were actively flowing with a discharge that was sufficient to distinguish habitat units. Side channels with only one discernable connection to the mainstem were surveyed upstream until passage was blocked or the entering channel appeared to leave the floodplain area of the mainstem river. A total of 59 side channel complexes were delineated, and named with an alphanumeric code consisting of the reach number and side channel letter in a downstream direction and then a number for the branch of the channel within the side channel unit (i.e., 2E-1). A summary table of side channels is provided in Table 4-6. Maps labeling the side channels are presented in Section 4.1 with the mainstem summary data.

Table 4-6. Habitat information for side channels surveyed in the middle Green River 2007.

<b>ID</b>	<b>RM</b>	<b>Bank</b>	<b>Survey Length (ft)</b>	<b>Wetted width (ft)</b>	<b>Bankfull width (ft)</b>	<b>Est. Flow (cfs)</b>	<b>Inlet Condition</b>	<b>Outlet Condition</b>	<b>Channel Condition</b>	<b>Habitat units identified</b>
2A	59.9	Left	1,071	15	30	8	flowing	flowing	flowing	No
2B	58.9	Left	1,017	12	20	1.5	no connection to mainstem	flowing	flowing	Yes
2C	58.9	Right	755	n/a	20	n/a	dry	dry	dry	No
2D-1	58.8	Left	550	n/a	45	n/a	dry	dry	dry	No
2D-2	58.8	Left	1,775	20	45	<2	flowing	flowing	flowing	Yes
2E-1	58.4	Right	1,087	n/a	35	n/a	no connection to mainstem	backwatered	dry	No
2E-2	58.4	Right	773	n/a	20	n/a	no connection to mainstem	backwatered	dry	No
2E-3	58.4	Right	355	n/a	20	n/a	no connection to mainstem	backwatered	dry	No
2F	57.9	Right	525	22	45	10	flowing	flowing	flowing	Yes
3A	57.0	Right	427	n/a	45	n/a	residual pools	residual pools	residual pools	No
3B	56.5	Left	516	24	48	20	flowing	flowing	flowing	Yes
3C	55.6	Right	326	n/a	50	n/a	dry	dry	dry	No
3D	55.5	Left	298	n/a	22	n/a	slightly wetted	slightly wetted	slightly wetted	No
3E	55.3	Left	466	50	60	60	flowing	flowing	flowing	No
3F	54.7	Left	327	n/a	52	n/a	dry	dry	dry	No

Table 4-6. Habitat information for side channels surveyed in the middle Green River 2007.

<b>ID</b>	<b>RM</b>	<b>Bank</b>	<b>Survey Length (ft)</b>	<b>Wetted width (ft)</b>	<b>Bankfull width (ft)</b>	<b>Est. Flow (cfs)</b>	<b>Inlet Condition</b>	<b>Outlet Condition</b>	<b>Channel Condition</b>	<b>Habitat units identified</b>
3G	49.6	Right	976	25	48	30	flowing	flowing	flowing	Yes
3H	49.4	Right	1,411	n/a	32	n/a	dry	dry	dry	No
3I	49.4	Right	776	n/a	40	n/a	dry	dry	dry	No
3J	47.9	Left	441	n/a	51	n/a	dry	dry	dry	No
3K	45.6	Left	439	n/a	58	<1	flowing	wetted	intermittent flow	No
3L	45.5	Right	430	n/a	28	n/a	wetted	wetted	wetted	No
4A	44.6	Right	2,801	n/a	22	n/a	dry	flowing	intermittent flow	No
4B	44.3	Right	854	n/a	55	n/a	dry	dry	dry	No
4C	44.3	Right	266	5	20	1.5	flowing	flowing	flowing	Yes
4D	44.3	Left	549	n/a	20	<1	dry	flowing	intermittent flow	No
4E	43.6	Right	179	n/a	3	n/a	no connection to mainstem	wetted	dry	No
4F-1	43.5	Right	713	n/a	5	<2	wetted	flowing	intermittent flow	No
4F-2	43.4	Right	460	n/a	35	<1	wetted	flowing	intermittent flow	No
4G-1	44.5	Right	1457	20	45	1.5	flowing	flowing	flowing	Yes

Table 4-6. Habitat information for side channels surveyed in the middle Green River 2007.

<b>ID</b>	<b>RM</b>	<b>Bank</b>	<b>Survey Length (ft)</b>	<b>Wetted width (ft)</b>	<b>Bankfull width (ft)</b>	<b>Est. Flow (cfs)</b>	<b>Inlet Condition</b>	<b>Outlet Condition</b>	<b>Channel Condition</b>	<b>Habitat units identified</b>
4G-2	44.5	Right	252	20	30	1.5	flowing	flowing	flowing	No
4H	41.0	Right	984	38	75	60	flowing	flowing	flowing	Yes
5A	40.6	Right	622	n/a	17	n/a	dry	dry	residual pool	No
5B	40.3	Left	2,231	n/a	indistinct	n/a	dry	dry	dry	No
5C	40.0	Right	1,369	8	13	4	flowing	flowing	flowing	Yes
5D	39.8	Right	2,980	36	55	50	flowing	flowing	flowing	Yes
5E	39.7	Right	1,700	20	25	30	flowing	flowing	flowing	Yes
5F	39.7	Right	147	n/a	indistinct	n/a	no connection to mainstem	dry	dry	No
5G-1	39.6	Right	1,006	10	12	<1	dry	residual pool	intermittent flow	No
5G-2	39.6	Right	1,748	10	12	<1	dry	flowing	intermittent flow	No
5G-3	39.6	Right	779	n/a	n/a	<1	not distinct	flowing	intermittent flow	No
5H-1	39.6	Left	2,468	n/a	35	<1	not distinct	dry	residual pools	No
5H-2	39.6	Left	2,497	5	30	<1	no connection to mainstem	flowing	ponded	No
5I	38.7	Right	2,500	40	48	60	no connection to mainstem	flowing	intermittent flow	Yes

Table 4-6. Habitat information for side channels surveyed in the middle Green River 2007.

<b>ID</b>	<b>RM</b>	<b>Bank</b>	<b>Survey Length (ft)</b>	<b>Wetted width (ft)</b>	<b>Bankfull width (ft)</b>	<b>Est. Flow (cfs)</b>	<b>Inlet Condition</b>	<b>Outlet Condition</b>	<b>Channel Condition</b>	<b>Habitat units identified</b>
5J	38.5	Right	1,334	10	20	<1	wetted	flowing	flowing	No
5K	38.4	Left	2,762	n/a	12	n/a	dry	wetted	dry	No
6A	37.8	Right	254	n/a	45	n/a	no connection to mainstem	dry	wetted	No
6B	37.0	Right	1,172	n/a	20	n/a	no connection to mainstem	residual pools	dry	No
6C	37.0	Left	362	15	19	n/a	no connection to mainstem	residual pools	wetted	No
6D	37.4	Left	3,150	15-30	n/a	<2	dry	flowing	partially flowing	No
6E	36.9	Right	579	n/a	5	n/a	no connection to mainstem	dry	dry	No
6F	36.7	Right	446	8	15	n/a	no connection to mainstem	wetted	residual pool	No
6G	36.5	Left	1,300	n/a	40	1.5	wetted	flowing	residual pools	No
6H-1	36.3	Right	2,008	n/a	50	<2	residual pool	backwatered	intermittent flow	No
6H-2	36.3	Right	298	n/a	15	n/a	wetted	residual pool	residual pools	No
6I	36.1	Left	895	n/a	8	n/a	dry	wetted	residual pools	No
6J	36.0	Right	822	n/a	17	n/a	dry	dry	residual pools	No

Table 4-6. Habitat information for side channels surveyed in the middle Green River 2007.

<b>ID</b>	<b>RM</b>	<b>Bank</b>	<b>Survey Length (ft)</b>	<b>Wetted width (ft)</b>	<b>Bankfull width (ft)</b>	<b>Est. Flow (cfs)</b>	<b>Inlet Condition</b>	<b>Outlet Condition</b>	<b>Channel Condition</b>	<b>Habitat units identified</b>
6K	35.8	Left	1,328	n/a	12	n/a	dry	wetted	dry	No
6L	35.7	Right	650	15	n/a	n/a	no connection to mainstem	residual pool	residual pool	No
6M	35.5	Right	777	n/a	20	n/a	dry	wetted	residual pools	No
6N	35.2	Right	903	5	pond	<1	no connection to mainstem	flowing	flowing from pool	No
6O	34.8	Right	881	n/a	20	n/a	dry	dry	intermittent wetted	No
6P	34.5	Left	1,472	n/a	pond	n/a	dry	dry	isolated pond	No
6Q	34.3	Left	900	n/a	45	n/a	wetted	backwatered	residual pools	No
6R-1	34.1	Left	839	n/a	24	n/a	backwatered	dry	residual pools	No
6S-1	33.3	Right	2,162	9	22	<1	flowing	flowing	flowing	Yes
6S-2	33.3	Right	403	14	20	<.25	no connection to mainstem	flowing	pool	No
6T	33.0	Right	315	18	22	10	flowing	flowing	flowing	Yes
6U-1	33.0	Left	772	n/a	30	n/a	dry	dry	residual pools	No
6U-2	33.0	Left	1,813	n/a	50	n/a	dry	dry	residual pools	No

#### **4.2.1 REACH 1 – Howard Hanson Dam (RM 64.5) to Tacoma Headworks (RM 61.0)**

This reach was not included in the 2007 habitat survey.

#### **4.2.2 REACH 2 – Headworks (RM 61.0) to Kanaskat Park (RM 57.1)**

##### ***Side Channel 2A***

The inlet to channel 2A is located on the left bank (looking downstream) at RM 59.9, near the Tacoma Watershed office. The channel was actively flowing at the inlet and outlet during the survey. Flow in the channel was estimated at less than 5% of the total Green River flow (about 5 cfs). Due to the low flow in the side channel no detailed habitat measurements were recorded, however it was noted habitat in the channel at this low flow consisted primarily of riffle. Bankfull width was approximately 25-35 feet and the total length of the channel was 1,071 feet. Wetted width measured 15 feet. Substrate was primarily comprised of gravel and cobble.

##### ***Side Channel 2B (Palmer Slough)***

Channel 2B (Palmer Slough) has surface hydraulic connection at its outlet only; there is no apparent inlet or upstream surface hydraulic connection to the mainstem channel. The outlet is located on the left bank at RM 58.9. Palmer Slough was actively flowing at the outlet to the Green River during the survey with approx 1-2 cfs. The channel is low gradient and is backwatered during high flow periods in the mainstem Green River. A series of beaver dams were present throughout the channel. This channel was surveyed upstream 1,017 feet from the mainstem.

##### ***Side Channel 2C***

The inlet to channel 2C is located on the right bank at RM 58.9. The channel was dry at the inlet and outlet during the survey. The channel appeared to have been actively flowing during the previous high flow period. Average bankfull width was approximately 20 feet and total length of the channel was 755 feet.

##### ***Side Channel 2D***

There are two inlets to channel 2D, 2D-1 was dry and led to 2D-2. Both are located on the left bank at RM 58.8. 2D-2 was actively flowing at the inlet and outlet during the survey. Flow in the channel was estimated to be not more than 2 cfs. Bankfull width of the channel was approximately 45 feet and total length was 1,775 feet.

### ***Side Channel 2E (Kanaskat Slough)***

Side Channel 2E is a complex of three smaller channels (2E-1, 2E-2 and 2E-3) that drain to the mainstem Green River at RM 58.4. No inlet or upstream hydraulic connection to the mainstem channel was visible. It appeared likely that the lower end of the channel would be backwatered during high flow periods in the mainstem Green River. The channel complex was not actively flowing at the outlet during the survey; however a large ponded area was observed approximately 75 feet from the mainstem channel. The outlet to the channel was 3 feet wide and had been engineered with log weirs to presumably control flow in the channel. The large pond was approximately 400 ft<sup>2</sup>, with maximum depth of about 4 feet. The three small channels, none of which were actively flowing, fed the pond. Bankfull width of the largest of the three channels, side channel 2E-1, was approximately 35 feet wide. Channel 2E-1 was backwatered from the pond more than 500 feet. Bankfull width of the second channel, side channel 2E-2, was approximately 20 feet. Channel 2E-2 was not backwatered. The third channel, side channel 2E-3, was approximately 20 feet wide at bankfull, and was backwatered approximately 100 feet from the pond. All channels were low gradient, with silt/sand substrate and abundant wetland vegetation.

### ***Side Channel 2F***

The inlet to channel 2F is located on the right bank at RM 57.9. The channel was actively flowing at the inlet and outlet during the survey measuring an estimated 10 cfs. Instream habitat in the channel was comprised primarily of riffle type habitat, with one pool measuring 50 feet by 20 feet with a maximum depth of 2.0 feet. Bankfull width of the channel was 45 feet and total length was 525 feet. The wetted channel averaged 22 feet wide.

## **4.2.3 REACH 3 – Kanaskat Park (RM 57.1) to Flaming Geyser (RM 45.0)**

### ***Side Channel 3A***

The inlet to channel 3A is located on the right bank (looking downstream) at RM 57.0. Channel 3A was not actively flowing at the inlet or outlet during the survey. Residual pools were present, indicating that the channel was likely flowing during the most recent high flow period. Total length of the channel was 427 feet. Bankfull width was estimated at 45 feet.

### ***Side Channel 3B***

The inlet to channel 3B is located on the left bank at RM 56.5. Channel 3B was actively flowing at the inlet and outlet during the survey; estimated flow in the channel was approximately 10% of the total Green River flow, or 20 cfs. Habitat in channel 3B was comprised entirely of riffle.

Wetted width of the channel was 24 feet and bankfull width was 48 feet. Total length of the channel was 516 feet.

### ***Side Channel 3C***

The inlet to channel 3C is located on the right bank at RM 55.6. Channel 3C was not wetted or flowing at the inlet or outlet during the survey. Total channel length measured 326 feet. Bankfull width measured 50 feet.

### ***Side Channel 3D***

The inlet to channel 3D is located on the left bank at RM 55.5. Channel 3D was wetted, but not actively flowing during the survey. Channel 3D measured 298 feet with a bankfull width of 22 feet.

### ***Side Channel 3E***

The inlet to channel 3E is located on the left bank at RM 55.3. Channel 3E was actively flowing at the inlet and outlet during the survey; flow in the channel was estimated to be approximately 30% of total Green River flow, or 60 cfs. Channel 3E measured 466 feet in length. Wetted width averaged 50 feet, and bankfull width measured 60 feet. This channel could be described more accurately as a braided channel rather than a side channel unit. Channel 3E parallels the mainstem flow closely and did not have a large amount of mature vegetation separating the channels. Habitat in 3E consisted entirely of riffle bordering on cascade units.

### ***Side Channel 3F***

The inlet to channel 3F is located on the left bank at RM 54.7. Channel 3F was dry during the survey. Bankfull width was estimated at 52 feet. The channel measured 327 feet in length.

### ***Side Channel 3G***

The inlet to channel 3G is located on the right bank at RM 49.6. Channel 3G was actively flowing at the inlet and outlet during the survey. Flow in the channel was estimated to be 15% of the total Green River flow or 30 cfs. Total length of the channel measured 976 feet. Wetted width averaged 25 feet. Bankfull width was estimated at 48 feet. Habitat in 3G consisted entirely of riffle units.

### ***Side Channel 3H***

The inlet to channel 3H is located on the right bank at RM 49.4. Channel 3H was not actively flowing at the inlet and outlet during the survey, and the channel was dry. It appeared during the

survey that the channel had been actively flowing within the past year, based on the presence of exposed mineral channel and lack of vegetation. The total length of Channel 3H measured 1,411 feet. The average bankfull width was 32 feet.

### ***Side Channel 3I***

The inlet to channel 3I is located on the right bank at RM 49.4. Channel 3I was not actively flowing at the inlet and outlet during the survey, and the channel was dry. It appeared during the survey that the channel had been actively flowing within the past year, based on the presence of exposed mineral channel and lack of vegetation in the channel. Bankfull width averaged 40 feet. Channel 3I measured 776 feet in length.

### ***Side Channel 3J***

The inlet to channel 3J is located on the left bank at RM 47.9. Channel 3J was not actively flowing at the inlet and outlet during the survey. The stream channel was dry. It appeared during the survey that the channel had been actively flowing within the past year, based on the presence of exposed mineral channel and lack of vegetation in the channel. The bankfull width averaged 51 feet. A total of 186 feet of channel were surveyed.

### ***Side Channel 3K***

The inlet to channel 3K is located on the left bank at RM 45.6. Channel 3K was slightly flowing at the inlet with less than 1 cfs during the survey. The outlet was backwatered approximately 200 feet by the mainstem channel, inundating a large pool approximately 800 ft<sup>2</sup> in size. The entire channel was surveyed, measuring 439 feet. Bankfull width was estimated to be 58 feet.

### ***Side Channel 3L***

The inlet to channel 3L is located on the right bank at RM 45.5. The channel was slightly wetted at the time of the survey. Total channel length measured 430 feet. Bankfull width was estimated to be 28 feet.

## **4.2.4 REACH 4 – Flaming Geyser (RM 45.0) to Newaukum Creek (RM 40.8)**

### ***Side Channel 4A***

The inlet to channel 4A is located on the right bank (looking downstream) at RM 44.6, opposite Flaming Geyser State Park. Channel 4A was not flowing at the inlet at the time of the survey, however slight (<1 cfs) surface flow was observed approximately 500 feet downstream from the inlet. Less than 1 cfs was flowing at the outlet. Based on this observed flow accretion, it is

likely that flow in Channel 4A is supplemented by a subsurface source. Channel 4A was approximately 2,801 feet long and bankfull width was about 22 feet. Due to the low flow, no habitat survey was conducted; however, several pools were present in the channel, with maximum depth ranging from 1.5-3.0 feet. The substrate consisted primarily of gravel with some cobble, boulder and bedrock. Juvenile salmonids (likely coho?), ranging in size from 40-60 mm, were observed in several pools throughout the channel.

#### ***Side Channel 4B***

The inlet to channel 4B is located on the right bank at RM 44.3, opposite Flaming Geyser State Park. Channel 4B was not actively flowing at the inlet or outlet during the survey, and no residual pools were present. Channel 4B was approximately 854 feet long and bankfull width averaged 55 feet. The channel appeared to have been flowing within the previous year based on exposed mineral substrate in the channel. The substrate consisted primarily of gravel and cobble.

#### ***Side Channel 4C***

The inlet to channel 4C is located on the right bank at RM 44.3, opposite Flaming Geyser State Park. The channel was actively flowing at the inlet and outlet during the survey with approximately 1-2 cfs and a wetted width of approximately 5 feet. Channel 4C was 266 feet long and 20 feet wide at bankfull. During high flow periods, it appeared that channels 4B and 4C become hydraulically connected. The habitat in Channel 4C consisted primarily of riffle with one larger pool with a maximum depth of about 2 feet.

#### ***Side Channel 4D***

The inlet to channel 4D is located on the left bank at RM 44.3, at Flaming Geyser State Park. The channel was not actively flowing at the inlet, however slight surface flow was observed downstream of the inlet. The outlet was actively flowing with <1 cfs. Channel 4D was about 549 feet long and 20 feet wide at bankfull. Due to the low flow, no habitat survey was conducted; however, two pools were observed in the channel in conjunction with two LWD jams (4D-A and 4D-B). Maximum depth of each pool was approximately 2-2.5 feet.

#### ***Side Channel 4E***

The outlet to channel 4E is located on the right bank at RM 43.6. No upstream surface hydraulic connection to the mainstem channel was observed. Channel 4E was not actively flowing at the outlet during the survey. The channel appeared to have been flowing within the past year. Bankfull width of channel was approximately 3 feet, and substrate was primarily gravel and

cobble. The channel was densely vegetated with willow and blackberry shrubs. The lower 100 feet were surveyed but the survey was discontinued at the blackberry thicket on the edge of field.

### ***Side Channel 4F-1, 4F-2***

Channel 4F is comprised of an upper channel, 4F-1, that supplements the larger lower channel, 4F-2. The inlet to channel 4F-1 is located on the right bank at RM 43.5 and the outlet is at the confluence with channel 4F-2. The inlet to lower channel 4F-2 is at RM 43.4 at a medium LWD jam (Zone 1) on the mainstem Green River. The inlet to channel 4F-1 was not actively flowing during the survey, however slight surface flow was observed approximately 300 feet downstream from the inlet. Flow at the outlet/confluence with channel 4F-2 was less than 2 cfs. Several active and residual pools, maximum depth of 1.0 feet, were present in channel 4F-1. Channel 4F-1 was about 713 feet long, and bankfull width was approximately 5 feet.

The inlet to channel 4F-2 was not actively flowing during the survey, however surface flow was present downstream of the confluence with channel 4F-1. A large pool (4,000 ft<sup>2</sup>) with estimated maximum depth of 3-4 feet was present at the confluence of the two channels. Less than 1 cfs was actively flowing from the pool and channel outlets. Channel 4F-2 was approximately 460 feet long and 35 feet wide at bankfull. Substrate in channel 4F-2 was gravel and cobble with some bedrock in the large pool.

### ***Side Channel 4G***

Side Channel 4G-1 is located on the right bank with an inlet at RM 44.5. Side Channel 4G-2 has an inlet at RM 44.3, and flows into 4G-1. The channel was actively flowing at both inlets and at the outlet with an estimated 2-3 cfs and a wetted average channel width of 20 feet. Small LWD jams were present at each side channel inlet. The total length of the side channel 4G-1 and 4G-2 was 1,457 feet and 252 feet respectively. Estimated average bankfull and wetted widths were 45 and 30 feet respectively. A large pool (1,600 ft<sup>2</sup>) was present at the confluence of the two channels. Maximum depth in the pool was about 3 feet. Substrate in the channels was gravel and cobble.

### ***Side Channel 4H***

The inlet to channel 4H is located on the right bank at RM 41.0. The channel was actively flowing at the inlet and outlet during the survey. Flow in side channel 4H was estimated to be 30% of the total Green River flow, or 60 cfs. The channel was 984 feet long, and average wetted width was approximately 38 feet. Habitat in the channel consisted primarily of riffle with one pool (4 foot maximum depth).

#### **4.2.5 REACH 5 – Newaukum Creek (RM 40.8) to RM 38.0**

##### ***Side Channel 5A***

The inlet to channel 5A is located on the right bank (looking downstream) at RM 40.6. Channel 5A was not actively flowing at the inlet or outlet during the survey, however one residual pool, approximately 2 feet deep was observed. The channel was approximately 17 feet wide at bankfull and 622 feet long. The channel appeared to have likely been flowing during the previous winter season.

##### ***Side Channel 5B***

The inlet to channel 5B is located on the left bank at RM 40.3. The channel was not actively flowing during the survey, and no ponded water was observed. The inlet to the channel was indistinct/slight swale, and was heavily vegetated. The outlet to the channel was a series of diffuse, braided rivulets that were vegetated. Substrate in the channel was primarily sand/silt. Based on vegetation and general appearance of channel 5B, it may have been actively flowing during previous high flow events, but level of flow in the channel was likely not significant. No channel dimensions were measured due to fact that distinct bankfull margins were not present. The channel was surveyed approximately 100 feet downstream from inlet and 200 feet upstream from outlet. Total channel length measured 2,231 feet.

##### ***Side Channel 5C***

The inlet to channel 5C is located on the right bank at RM 40.0, immediately downstream of a small right bank tributary. The channel was actively flowing at the inlet and outlet with approximately 3-5 cfs. The inlet was about 3 feet wide, but downstream of the inlet, Channel 5C had a consistent 8 foot wetted width and averaged 12-15 foot bankfull width. Stream habitat was primarily riffle/run/pool, with 3-4 pools of 1.5-2 feet maximum depth. Total length of the channel was 1,369 feet. The dominant substrate was silt with patches of gravel and cobble that were highly embedded. The channel outlets at the upper end of Side Channel 5D (MOASC). Juvenile salmonids were observed throughout the channel.

##### ***Side Channel 5D (MOASC)***

The inlet to channel 5D is located on the right bank at RM 39.8. Channel 5D (MOASC) was flowing at the inlet and outlet during the survey. Flow at the inlet was approximately 25% of the total Green River flow, or 50 cfs. Flow at the outlet of Channel 5D is greater than at the inlet due to flow from Side Channel 5E, which joins Channel 5D approximately 400 feet prior to the outlet. Flow at the outlet was estimated to be 40% of total Green River flow, or 80 cfs. Average wetted width of the channel was approximately 36 feet, and average bankfull width was

approximately 55 feet. Channel 5D was approximately 2,980 feet long. Instream habitat in Channel 5D was primarily riffle and run habitat types, with one pool observed in a split channel section. Several small, medium and large LWD jams were present throughout the channel. One large, channel spanning LWD jam extended for approximately 300-400 feet. Substrate in the channel was primarily gravel and cobble.

### ***Side Channel 5E***

Side Channel 5E is located on the right bank at RM 39.7. Two separate inlets to Channel 5E were apparent during the survey. Channel 5E was actively flowing at both inlets and at the outlet. Flow at the inlet was estimated to be approximately 20% of the mainstem Green River flow (30 cfs) downstream of Channel 5D. Flow levels appeared consistent through the length of the channel. The Channel 5E outlet to Channel 5D was approximately 400 feet upstream from the mainstem Green River. Average wetted width of the channel was approximately 20 feet, and average bankfull width was 25 feet. Channel 5E was 1,700 feet long. Instream habitat in Channel 5E was primarily riffle and run, with one pool estimated to be 5 feet deep and 400 ft<sup>2</sup>. Several small and medium LWD jams were observed in the channel. Substrate in the channel consisted primarily of gravel and cobble.

### ***Side Channel 5F***

The outlet to side channel 5F is located on the right bank at RM 39.7; there was no visible inlet or upstream hydraulic connection to the mainstem channel. The channel 5F outlet was not actively flowing during the survey. The channel is an indistinct swale, heavily vegetated with mature and herbaceous vegetation (i.e., trees, shrubs, grasses and blackberry). The substrate in channel 5F was primarily sand/silt. Based on vegetation and general appearance of the channel it may have been actively flowing during previous high flow event, but level of flow in channel 5F was likely not significant. The channel was surveyed approximately 150 feet upstream from outlet.

### ***Side Channel 5G***

Side Channel 5G is a complex of three small right bank channels which converge near the outlet (5G-1, 5G-2, and 5G-3). The upstream-most channel, 5G-1, was surveyed and no discernable inlet was seen. An inlet to Channel 5G-2 was identified at RM 39.6. Channel 5G-3 was a small branch to 5G-2 with no discernable inlet. None of the three channels were actively flowing or wetted at the inlets or upper extents of the channels. Each channel was very small and overgrown at their upper extent. In Channel 5G-1, surface flow was observed immediately upstream of the confluence with Channel 5G-2. A large pool, 1 foot deep and 10 feet wetted

width (400 ft<sup>2</sup>), was present upstream of the confluence. Less than 1 cfs was flowing from Channel 5G-1 at the confluence with 5G-2. Slight surface flow (<1 cfs) was first observed in Channels 5G-2 and 5G-3 just upstream of the confluence of the two channels. Average wetted width of the actively flowing sections of Channel 5G-1 and 5G-2 were approximately 10 feet and average bankfull width was about 12 feet. The channel complex was approximately 1,700 feet long. Substrate in 5G-1 and 5G-2 was gravel, cobble and silt/sand.

### ***Side Channel 5H***

Side Channel 5H is located on the left bank and consists of a large ponded area fed by two small channels, 5H-1 and 5H-2. The estimated inlet to Channel 5H-1 was an indistinct swale at RM 39.6; the inlet was not actively flowing during the survey. The inlet for channel 5H-1 was characterized by a slight swale that was densely vegetated with mature trees and shrubs, and grasses; there was no exposed mineral channel at the inlet site. The inlet did not appear to have been flowing or wetted significantly during the previous wet season. The outlet to the channel was about 3 feet wide and was actively flowing with less than 1 cfs. About 300 feet upstream of the outlet, a series of beaver dams impound the channel flow and create a large pond (90,000 ft<sup>2</sup>). Channel 5H-1 was dry upstream of the large ponded area, however some residual pools (0.5 feet deep) were present. Channel 5H-1 was about 35 feet wide at bankfull and 2,800 feet long; the ponded area.

There was no visible inlet or upstream hydraulic connection for Channel 5H-2. Channel 5H-2 was backwatered by the pond approximately 200 feet, and was actively flowing upstream of pond backwater (<1 cfs). Several beaver dams were present in Channel 5H-2. Wetted width of the actively flowing section of Channel 5H-2 was approximately 5 feet and bankfull width was about 30 feet. The origin of flow in Channel 5H-2 was not identifiable during the survey. Many young-of-year and year 1+ salmonids (likely coho) were observed in the backwatered portion of Channel 5H-2 and in the ponded area.

### ***Side Channel 5I***

The estimated inlet to channel 5I was located on the right bank at RM 38.7. The inlet was not easily identified and was not actively flowing during the survey; the inlet location was estimated using aerial photos. Surface flow at the lower end of a large backwatered pool in the upper portion of Channel 5I was estimated to be <1 cfs. The pool at the upper end of Channel 5I was approximately 1,000 feet long and 50 feet wide, and estimated to be 10 feet deep. The pooled area was backwatered from a connection with the mainstem channel and Channel 5J at RM 38.3. The lower portion of Channel 5I is actively flowing as a result of two inlets at RM 38.3. Flow in the lower portion of Channel 5I and at the outlet was estimated to be 30% of the total Green

River flow (60 cfs). The average wetted width of the lower portion of the channel was 40 feet and approximate bankfull width was 48 feet. Instream habitat in the lower portion was entirely riffle and run habitats. Total length of the channel from the origin of surface flow to the outlet was 2,500 feet, while the length of wetted channel during the 2007 survey was about 2,000 feet. A. Weybright and T Sullivan surveyed the length of the channel.

### ***Side Channel 5J***

The inlet to Channel 5J is located on the right bank at RM 38.5. Channel 5J was not actively flowing at the inlet, however slight surface flow (<1 cfs) was observed at the near outlet of a large backwater pool. The outlet to Channel 5J was backwatered from the mainstem channel. The backwater pool was approximately 20 feet wide, 1,334 feet long, and was about 5 feet deep. The control depth at the tailout of the backwater pool was 0.3 feet.

### ***Side Channel 5K***

There are two inlets to Channel 5K, approximately 100 feet apart, located on the left bank at RM 38.4. The Channel 5K inlets and outlet were not actively flowing during the survey. The channel is small at each inlet, approximately 3 feet wide, but widens downstream of the inlets to approximately 12 feet wide. The inlets and upper portion of the channel appeared to have been active during the previous wet season. Total length of the channel was approximately 4,000 feet long. The survey of the channel was discontinued about 2,000 feet from the inlet as the channel became very diffuse and difficult to follow. The survey was reconvened at the outlet. At the midpoint of the channel, it was not evident that the channel had been actively flowing during the previous wet season. The outlet to Channel 5K was not actively flowing, however residual pools were present. Substrate in the upper portion of the channel was sand/silt with patches of exposed gravel, while substrate at the outlet was sand/silt.

## **4.2.6 REACH 6 – RM 38.0 to LWD jam d/s of Hwy 18 (RM 32.1)**

### ***Side Channel 6A***

The outlet to channel 6A is located on the right bank (looking downstream) at RM 37.8. There was no visible inlet or upstream surface hydraulic connection to the mainstem channel; a rip-rap levee separates the upper side channel from the mainstem. The outlet was not actively flowing during the survey and no standing water was observed in the channel. The outlet was a slight swale with moist silt substrate. The channel did not appear to have been actively flowing in the recent past. The bankfull width was estimated to be 45 feet. A total of 255 feet were surveyed.

***Side Channel 6B***

The outlet to channel 6B is located on the right bank at RM 37.0. There was no visible inlet or upstream surface hydraulic connection to the mainstem channel; a levee separates the upper side channel from the mainstem. The outlet was not actively flowing during the survey; however several residual pools (maximum depth 2.5 feet) were present in the lower portion of the channel. The channel outlet was approximately 2 feet wide, but channel bankfull width widened upstream from outlet to about 15-25 feet. Channel has large amounts of SWD and LWD including one small LWD jam. Substrate in lower portion of channel was silt/sand. The survey was conducted from outlet to the culvert at a road crossing about 800 feet upstream from outlet. The channel continued past the culvert into a fenced private farm.

***Side Channel 6C***

The outlet to channel 6C is located on the left bank at RM 37.0. There was no visible inlet or upstream surface hydraulic connection to the mainstem channel. Channel 6C consisted of a large backwatered area, approximately 360 feet in length with wetted width of 15 feet (19 feet bankfull width). Maximum depth in the backwatered area was about 5 feet. Total length of the unit was approximately 300 feet. There was no inflow to the backwater area at the upper end of the unit.

***Side Channel 6D***

Two inlets were present at the upper end of Channel 6D; the upper inlet was located on the left bank at RM 37.4 and the lower inlet was at RM 37.3. Neither inlet was flowing during the survey; however, the outlet at RM 36.8 was actively flowing with approximately 2 cfs. Flow near the outlet was observed to be supplemented by a few seeps from a steep left bank. The upper extent of surface flow was observed to be approximately 1,500 upstream from the outlet, which was about 400 feet downstream from the lower inlet. Water temperature in the channel appeared to be cooler than mainstem water temperature, but no measurements were taken. Wetted width of the channel ranged from 15-30 feet, and total length of the channel from the upper inlet to the outlet was approximately 3,150 feet. Substrate in the channel was primarily sand/silt with patches of gravel. Several remnant beaver dams were present and many juvenile salmonids were observed.

***Side Channel 6E***

The estimated inlet to channel 6E is located on the right bank at RM 36.9. The inlet was not easily identified during the survey and was estimated from aerial photos. The channel inlet and outlet were not actively flowing during the survey and no residual pools were present. The upper portion of the channel was difficult to discern due to the diffuseness of the channel. It appeared

that the lower portion of the channel had been actively flowing during the last high flow period. Average width of the lower channel was approximately 5 feet and total length of the channel was about 400 feet. An improvised road was present along the upper end of the channel. The primitive road crossed Channel 6F and extended into the upper end of Channel 6E.

### ***Side Channel 6F***

Channel 6F consists of a backwater channel with no discernable inlet. The outlet is located on the right bank at RM 36.7. The outlet was wetted during the survey and was backwatered approximately 210 feet to form a slough with no distinct downstream control. Average wetted width of the backwatered portion of the channel was 8 feet and average bankfull width was approximately 15 feet. Maximum depth of the backwater area was 2.5 feet. There was no surface flow at the upstream end of the backwatered section. Total length of the channel was approximately 300 feet. A large berm crossing the channel about 250 feet upstream of the outlet appeared to have been graded to form a road or large path. Residual pools were present on either side of the road berm as there was no culvert crossing the berm.

### ***Side Channel 6G***

Two inlets were observed at the upstream end to Channel 6G. The inlets were located at the upstream end of a vegetated bar on the left bank at RM 36.5. Neither inlet was actively flowing during the survey; however the outlet was actively flowing with approximately 1-2 cfs. The separate channels originating from each inlet parallel each other and converge approximately 300 feet downstream from the inlet. The channel originating from the lower inlet was completely dry, however much of Channel 6G was wetted with a large residual pool that originated approximately 300 feet downstream from the upper inlet. The pool area was approximately 600 feet in length and about 40 feet wide. Maximum depth of the pool area was approximately 3.5 feet. At the tailout of the pool, near the channel outlet, the channel and pool narrows to 3 feet wide, with 1-2 cfs flowing from tailout. Some seepage was observed from a steep left bank along the length of the pool area in lower half of channel. Water temperature in the pooled area was qualitatively cooler than the mainstem temperature, possibly indicating subsurface source flow. Total length of the channel was approximately 1,300 feet.

### ***Side Channel 6H (Hama Kami)***

Two separate inlets to Channel 6H-1 were observed during the survey. The upper inlet is located at the upper end of a vegetated bar on the right bank at RM 36.3 and the lower inlet (connection) is located at a LWD jam at RM 36.1. The lower connection appeared to be the primary source of flow to the channel during high flow periods; however neither inlet was actively flowing during

the survey. A second channel splits off of 6H-1 (6H-2) near the outlet. The outlet was backwatered from the mainstem channel, but was estimated to be actively flowing with less than 2 cfs. Downstream of the lower inlet, channel 6H-1 is actively flowing with <1 cfs. The source of surface flow in channel 6H-1 appeared to be from the channel originating from the upper inlet. The upstream extent of flow was approximately 150 feet upstream of the lower inlet and was subsurface in origin. The upper inlet is approximately 5 feet wide and appeared to perhaps have had minimal flow during the previous high flow event.

Wetted width of Channel 6H-1 ranged from 5 feet at riffle sections to 40 feet at pools and runs. Maximum depth in runs and pools was 3 feet. Total length of Channel 6H-1 from the lower inlet to the outlet was approximately 1,200 feet. Surveyors observed many dace but no salmonids. A large LWD jam is present near the lower end of the channel. A small overflow channel near the outlet of Channel 6H-1 (6H-2) was not actively flowing but was wetted in places with small residual pools. Substrate throughout Channel 6H-1 and 6H-2 is primarily sand and silt with patches of gravel.

### ***Side Channel 6I***

The estimated inlet to channel 6I is located on the left bank at RM 36.1 across from Channel 6H (Hama Kami). The channel was not actively flowing at the inlet or outlet during the survey, but several residual pools, about 1 foot deep, were present at the lower end of the channel. Channel 6I was approximately 5-10 feet wide at the lower end, but became more diffuse and difficult to identify at the upper end. The inlet was estimated to be at the upper end of vegetated bar/bend. Total length of the channel was approximately 895 feet.

### ***Side Channel 6J***

The inlet to channel 6J is located on the right bank near the outlet of Channel 6H at RM 36.0. Channel 6J was not actively flowing at the inlet or outlet during the 2007, but several residual pools were present at the lower end of the channel. The channel appeared to have been flowing during previous high flow period. Channel 6J was 15-20 feet wide at the lower end, but became more diffuse approximately 300 feet upstream from the outlet. The inlet was about 5 feet wide. Total length of the channel was approximately 822 feet. Substrate was sand and silt throughout the channel.

### ***Side Channel 6K***

The inlet to channel 6K is located on the left bank at RM 35.8. Channel 6K was not actively flowing at the inlet or at the outlet during the survey, however, slight surface water was present

for a short distance near the outlet due likely to seepage from the left bank. The channel appears to have been flowing during previous high flow period. Average bankfull width throughout the channel measured about 12 feet. Total length of the channel was approximately 1,328 feet.

### ***Side Channel 6L***

Channel 6L, identified by the Corps using aerial imagery, did not appear to have any surface hydraulic connection to the mainstem channel. A large ponded area identifiable from aerial photos is separated from the mainstem channel by a large 10 foot high berm/levee. A small overflow channel, unconnected to the ponded area, parallels the levee on the mainstem side. This channel was noted at Channel 6L. The small channel was 15 feet wide but shallow and was estimated to originate near outlet of Channel J. The upper end of 6L is diffuse, while the outlet end is more defined. Approximate length of small channel was about 650 feet. The survey covered the outlet area highlighted by the Corps and approximately 300 feet of channel on mainstem side of the levee.

### ***Side Channel 6M***

The inlet to channel 6M is located on the right bank at RM 35.5. Channel 6M was not actively flowing at the inlet or at the outlet, however small residual pools, about 1 foot deep, were present at the lower end of the channel. The bankfull width of the channel was approximately 15 feet at the upper end of the channel and was 25 feet at the lower end. A small LWD jam was present 350 feet downstream of the inlet. The outlet of the channel was backwatered approximately 50 feet. Dace were observed in backwater area. Substrate throughout channel was gravel and cobble with sand at the outlet.

### ***Side Channel 6N***

Channel 6N is comprised of an off-channel pond on a private farm that outlets to the mainstem channel; no inlet was apparent. The outlet to channel 6N is located on the right bank at RM 35.2. A levee parallels the mainstem channel on the right bank, separating the ponded area and areas upstream of the pond from the mainstem. Downstream of the pond a small notch, approximately 5 feet wide, in the levee allowed for outflow from the pond. Less than 1 cfs was flowing from the outlet during the survey. The pond is approximately 60,000 ft<sup>2</sup> in size and is adjacent to a farm with free ranging cattle.

### ***Side Channel 6O***

The inlet to Channel 6O is located on the right bank at RM 34.8. Channel 6O was not completely dry over its entire length and appeared to perhaps have received some flow during

the previous high flow event. The channel was approximately 20 feet wide and 880 feet long. Substrate throughout the channel was sand.

### ***Side Channel 6P***

Channel 6P consists of a large off-channel pond separated from the mainstem channel by an 8-foot rip-rap levee, with the exception of two small outlets. The upper outlet to the pond is located on the left bank at RM 34.5 while the lower outlet is located at RM 34.4. Neither outlet was actively flowing during the survey. The outlets were small notches in the rip-rap levee; the upper outlet was about 8-10 feet wide and the lower outlet was approximately 10-15 feet wide. A small LWD jam was present in the upper outlet. The approximate length of the ponded area was 1,200 feet and average width was about 200 feet.

### ***Side Channel 6Q***

Channel 6Q has two inlets located about 80 feet apart. The inlets were located on the left bank at RM 34.3, immediately downstream of the Channel 6P lower outlet. The inlets to Channel 6Q were not actively flowing, however several residual pools were present throughout the upper end of the channel. The separate inlets appear to form two channels that are intermittently connected. The two channels convene near the outlet. The outlet to the channel was backwatered over 600 feet from the mainstem and did not appear to be actively flowing. The bankfull width at the inlet was about 15-20 feet, while the bankfull width at the outlet was approximately 45-50 feet. Total length of the channel was about 900 feet. Substrate in the channel was gravel at the inlet and silt and sand at the outlet. Channel 6Q was surveyed 100 feet downstream from the inlet and 500 feet upstream from the outlet.

### ***Side Channel 6R***

Side Channel 6R has two portions: 6R-1 and 6R-2. Channel 6R-1 is an active side channel with an inlet and outlet, while channel 6R-2 is perhaps a remnant channel or drainage channel. The inlet to channel 6R-1 is located on the left bank at RM 34.1, approximately 100 feet downstream of the outlet to Channel 6Q. Channel 6R-2 is located on the left bank adjacent to the Green River Valley Road, on the opposite side of the road as the mainstem channel. Channel 6R-1 was not actively flowing at the inlet or the outlet. The inlet was wetted with slight backwater from the mainstem and residual pools were present throughout the upper portion of the channel. Average bankfull width ranged from about 35 feet in the middle and upper end of the channel to approximately 12 feet at the lower end near the outlet; the outlet was only 3 feet wide. Total length of the channel was approximately 839 feet. Substrate in the channel was sand and silt

with patches of gravel. The upper 150 feet of channel 6R-1, a 200 foot section in the middle of the channel, and the lower 150 feet of the channel were surveyed.

Channel 6R-2 did not appear to have a surface hydraulic connection to the mainstem channel as the Green River Valley Road separated the channel from the Green River. There was no active flow or any sign that channel had been wetted within the last year. No culvert under the road was observed

### ***Side Channel 6S***

The inlet to channel 6S is located on the right bank at RM 33.3. Channel 6S-2 is a small tributary branch of 6S-1. Channel 6S-1 was actively flowing with less than 1 cfs at the inlet and outlet during the survey. Instream habitat in Channel 6S-1 consisted of slow moving run and pool habit with short sections of riffle. Maximum depth of pools ranged from 3 to 4 feet. Wetted width of the channel ranged from 5 feet in riffle sections to as much as 13 feet in pools. Bankfull width was approximately 20-25 feet. Total length of channel 6S-1 was approximately 1,458 feet. Substrate in Channel 6S-1 was gravel and silt. Juvenile salmonids were observed throughout the channel.

Side Channel 6S-2 enters Channel 6S-1 approximately 1,200 feet downstream of the inlet. The outlet of Channel 6S-2 was actively flowing with much less flow than Channel 6S-1 (<0.25 cfs). Channel consisted of pool extending approximately 100 feet upstream from tailout located near the outlet. Wetted width of the pool area was 14 feet, bankfull width was 20 feet, and maximum depth of the pool was 2 feet. Substrate in Channel 6S-2 was silt and sand. Juvenile salmonids were also observed in this pool area during the survey.

### ***Side Channel 6T***

The inlet to channel 6T is located on the right bank at RM 33.0. Channel 6T was actively flowing at the inlet and outlet. Flow in the channel was estimated to be approximately 5% (10 cfs) of the total mainstem Green River flow. Instream habitat in the channel consisted of riffle and run sequences, with maximum depth in the runs measuring approximately 2.5 feet. Total length of the channel was 315 feet. Substrate in the channel was gravel, sand and silt. Approximately 50 juvenile salmonids were observed in the channel.

### ***Side Channel 6U***

Channel 6U-1 and 6U-2 appear to perhaps be old remnant mainstem channels that become wetted at higher flows. The inlet to the upper channel (6U-1) was located on the left bank at RM

33.0 and the inlet to the lower channel (6U-2) was located at the large channel spanning jam at RM 32.8. Neither inlet was actively flowing during the survey. Large residual pools were present in channel 6U-1 and 6U-2. Channel 6U-1 outlets to Channel 6U-2 approximately 450 feet downstream from the lower inlet. The bankfull width in channel 6U-1 ranged from 15-40 feet, while the bankfull width in Channel 6U-2 ranged from approximately 45-60 feet. Total length of Channel 6U-1 was 772 feet, and the length of Channel 6U-2 was about 1,813 feet. Substrate in the channels was sand, silt and clay.

## 5. LWD SURVEY RESULTS

This section presents the results of the 2007 reach specific LWD counts, and comparison to the 2001, 2005 and 2006 surveys. Comparison of results from the 2001 and later LWD surveys should be made with caution as side channels were not included as part of the 2001 survey but were surveyed during the later surveys (2005 - 2007). No attempt was made to distinguish LWD located within side channel areas from LWD found within the main channel during the 2005 survey (Table 5-1). Side channel wood counts were kept separate from mainstem counts starting in 2006.

Table 5-1. Area included in the large woody debris surveys in mainstem Green River, Washington 2007.

Survey Year	Mainstem	Side Channel
2001	Yes	No
2005	Yes (data not separated from side channel tally)	Yes (data not separated from mainstem tally)
2006	Yes	Yes, separate from mainstem tally
2007	Yes	Yes, separate from mainstem tally

### 5.1 REACH 1

Reach 1 was not surveyed in 2005 or 2007. The reach is approximately 3.5 miles long extending from Howard Hanson Dam (RM 64.5) to Tacoma Headworks (RM 61.0). Results of the 2001 and 2006 large woody debris count and summary statistics for Reach 1 are provided in Table 5-2.

Table 5-2. Comparison of summary statistics for the 2001 and 2006 middle Green River LWD surveys, Reach 1 (RM 64.5, Howard Hanson Dam to RM 61.0, Tacoma Headworks).

	Survey Year		
	2001 Not Including Side Channel Data	2006 Including Side Channel Data	2006 Not Including Side Channel Data
Survey Length	3.5 miles	3.5 miles	3.5 miles
Flow @ Howard Hanson Dam	223-231 cfs	236 cfs	236 cfs
Total LWD <sup>1</sup>	18	94	94
Number of LWD <sup>1</sup> – Zone 1	9	37	37
Number of LWD <sup>1</sup> – Zone 2	9	57	57
LWD <sup>1</sup> per Mile	5.1	26.9	26.9
Percent Cut LWD	6%	6%	6%
Total Number Key LWD	1	2	2
Key Pieces per Mile	0.3	0.6	0.6
Total Number of LWD Jams	0	3	3
Percent Small Jams	0%	100%	100%
Percent Medium Jams	0%	0%	0%
Percent Large Jams	0%	0%	0%

<sup>1</sup> Includes medium and large logs, key pieces, and rootwads.

<sup>2</sup> 2001 survey did not include side channels.

## 5.2 REACH 2

Reach 2 was surveyed on August 20 and 21. The reach is approximately 4.0 miles long extending from the Tacoma Headworks (RM 61.0) to Kanaskat State Park (RM 57.0) (Figure 5-1). The flow at the time of the survey was 153 cubic feet per second (cfs) as measured at the Palmer, Washington stream gage (USGS #12106700). Summary statistics for Reach 2 are provided in Tables 5-3 to 5-5.

Reach 2 was the only reach of the five surveyed that had experienced placement of LWD since the 2001 survey. In August of 2003, the U.S. Army Corps of Engineers (Corps) in cooperation with the City of Tacoma constructed two bar apex type engineered log jams (Zone 1 Project) at RM 60, about three miles upstream from Kanaskat-Palmer State Park (Corps 2004). Jam ELJ1 contained 81 pieces of LWD and jam ELJ2 contained 88 pieces. Individual pieces placed within the jam ranged from 50-60 feet long and had a diameter at breast height (dbh) ranging from 48 to less than 24 inches (Corps 2005). The Corps had numbered each individual piece of LWD included in the jams with a small metal tag attached near one end. In subsequent years marked wood has been added annually to the river at RM 60 (see Appendix F for a complete listing of placed wood). In late August 2004, the Corps placed three individual logs (20-24 in dbh and ~30 ft long) on a gravel nourishment site located at the same location (RM 60) as the engineered log jams Scott Pozarycki, Corps, personal communication to Mike Gagner, R2, July 7, 2005). One end of each of these logs was painted blue at the time of placement to assist with future identification. In 2005, 35 pieces of LWD and 5 trash trucks of small debris were placed at RM 60, including 6 large rootwads. This debris was at least 12 inches diameter at breast height and 12 feet long. 2005 LWD was marked with orange spray paint. In 2007, 45 pieces of large woody debris and 5 trash trucks of small wood debris were placed in water at RM 60. This wood was marked with red spray paint to facilitate identification.

In 2007, Jam 2E (RM 57.3) contained two pieces of woody debris that were labeled #98 and #62. Log #98 and log #62 were initially placed as rack material in the construction of ELJ2 (Jam 2B) near RM 60 in 2003.

Supplemental gravel has also been placed in the Green River starting in August 2003 (Table 5-6). A total of 17,207 cubic yards has been placed over the previous three years. This gravel is visually distinguishable from the native gravel in the river, and was observed dispersed throughout Reach 2.

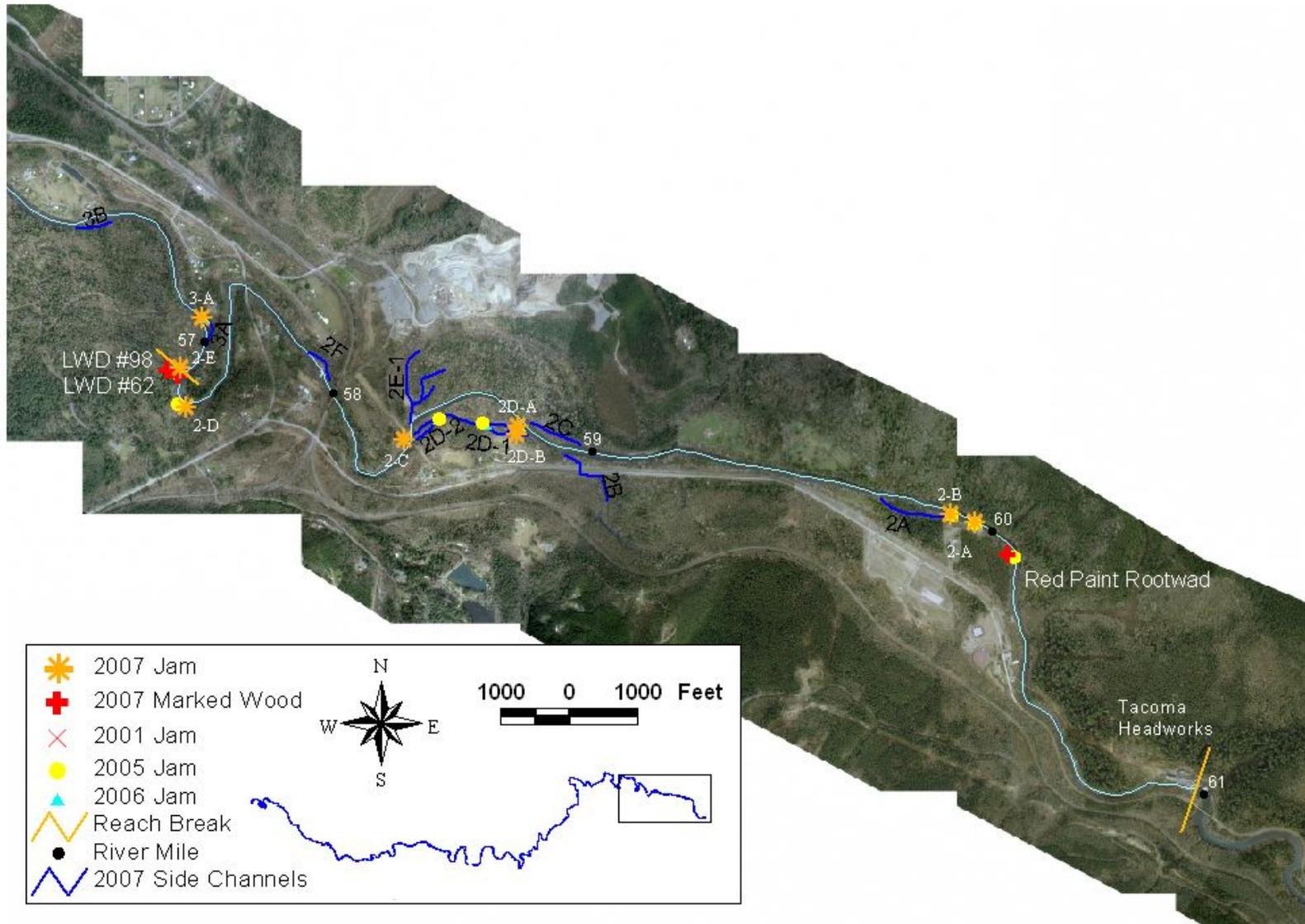


Figure 5-1. Middle Green River LWD in Reach 2, 2007.

Table 5-3. Large woody debris count by type and channel location in Reach 2, middle Green River, King County, Washington, 2007.

	Channel Zone			Totals	
	1	2	Side Channel	Mainstem and Side Channel	Mainstem Only
Log-Medium	19	10	0	29	29
Log-Medium with Rootwad	5	3	0	8	8
Log-Large	1	2	2	5	3
Log-Large with Rootwad	3	3	0	6	6
Key Piece	0	0	0	0	0
Key Piece with Rootwad	0	0	0	0	0
Rootwad	6	7	12	25	13
<b>Total</b>	<b>34</b>	<b>25</b>	<b>14</b>	<b>73</b>	<b>59</b>
Small Jam	2	2	2	6	4
Medium Jam	0	1	0	1	1
Large Jam	0	0	0	0	0

<sup>1</sup> Includes medium and large logs, key pieces, and rootwads.

Table 5-4. Comparison of summary statistics for the 2001-2007 mainstem Green River surveys of LWD in Reach 2 (RM 61.0, Tacoma Headworks to RM 57.0, Kanaskat State Park).

	Survey Year			
	2001	2005	2006	2007
LWD Data	MS only	MS and SC <sup>1</sup>	MS only	MS only
Mainstem Survey Length	4.0 mi	4.0 mi	4.0 mi	4.0 mi
Flow @ Palmer, WA	133 cfs	175 cfs	129 cfs	153 cfs
Flow @ Auburn, WA	257 cfs	296 cfs	248 cfs	304 cfs
Total LWD	36	88	103	59
Number of LWD – Zone 1	21	47	52	34
Number of LWD – Zone 2	15	41	51	25
LWD per Mile	9	22	25.8	14.8
Total Number Key LWD	2	6	8	0
Key Pieces per Mile	0.5	1.5	2	0.0
Total Number of LWD Jams	0	5	4	5
Percent Small Jams	0%	60%	50%	80%
Percent Medium Jams	0%	40%	50%	20%
Percent Large Jams	0%	0%	0%	0%

<sup>1</sup>-LWD counted in 2005 mainstem and side channel units was not kept in separate tallies.

Table 5-5. Comparison of summary statistics for the 2001-2007 mainstem and side channel Green River surveys of LWD in Reach 2 (RM 61.0, Tacoma Headworks to RM 57.0, Kanaskat State Park).

	Survey Year			
	2005	2006	2007	2007
LWD Data	MS and SC	MS and SC	MS and 2006 SC <sup>1</sup>	MS and all SC <sup>2</sup>
Side Channel Survey Length	unknown	5,103 ft	5,103 ft	7,908 ft
Flow @ Palmer, WA	175 cfs	129 cfs	153 cfs	153 cfs
Flow @ Auburn, WA	296 cfs	248 cfs	304 cfs	304 cfs
Total LWD	88	126	67	73
Number of LWD – Zone 1	47	57	34	39
Number of LWD – Zone 2	41	69	33	34
LWD per Mile	22	31.5	16.8	18.3
Total Number Key LWD	6	8	0	0
Key Pieces per Mile	1.5	2	0.0	0.0
Total Number of LWD Jams	5	6	7	7
Percent Small Jams	60%	67%	86%	86%
Percent Medium Jams	40%	33%	14%	14%
Percent Large Jams	0%	0%	0%	0%

<sup>1</sup>-For comparison purposes, this column represents 2007 side channel data only for the side channels that were surveyed in 2006.

<sup>2</sup>-This column represents side channel data for all side channel surveyed in 2007.

Table 5-6. Summary of gravel placed in Green River at RM 60 (Zone 1).

Sieve Size	August 2003 placed	August 2004 placed	August 2005 placed	August 2006 placed
	% finer	% finer	% finer	% finer
6 inch (152 mm)				
5 inch (127 mm)		99.4	100.0	100.0
4 inch (102 mm)	100	92.6	93.7	94.9
3 inch (76 mm)		76.8	87.0	77.3
2 inch (51mm)	65	55.3	65.8	55.0
1 inch (25 mm)	27	10.9	26.9	20.9
0.5 inch (13 mm)	6	2.1	2.0	2.6
<b>Quantity Placed</b>				
<i>Total tons:</i>	7,555	7,024	7,014	7,086
<i>cubic yards (0.6 cy/ton):</i>	4,533	4,214	4,208	4,252

### 5.3 REACH 3

The survey of Reach 3 took place over August 22 through 24. The reach is approximately 12 miles long extending from Kanaskat State Park (RM 57) to Flaming Geyser State Park (RM 45) (Figures 5-2 and 5-3). The average stream flow during the survey was 311 cfs as measured at the Auburn, Washington stream gage (USGS #12113000). Summary statistics for Reach 3 are provided in Tables 5-7, 5-8 and 5-9. One tagged log, #63 was located in Jam K (RM 52.7). Log #63 was originally placed as rack material in ELJ2 near RM 60 in 2003. Log #63 was observed in 2005 and 2006 in side channel 2D (RM 58.5). No other tagged wood was observed below this reach in 2007.

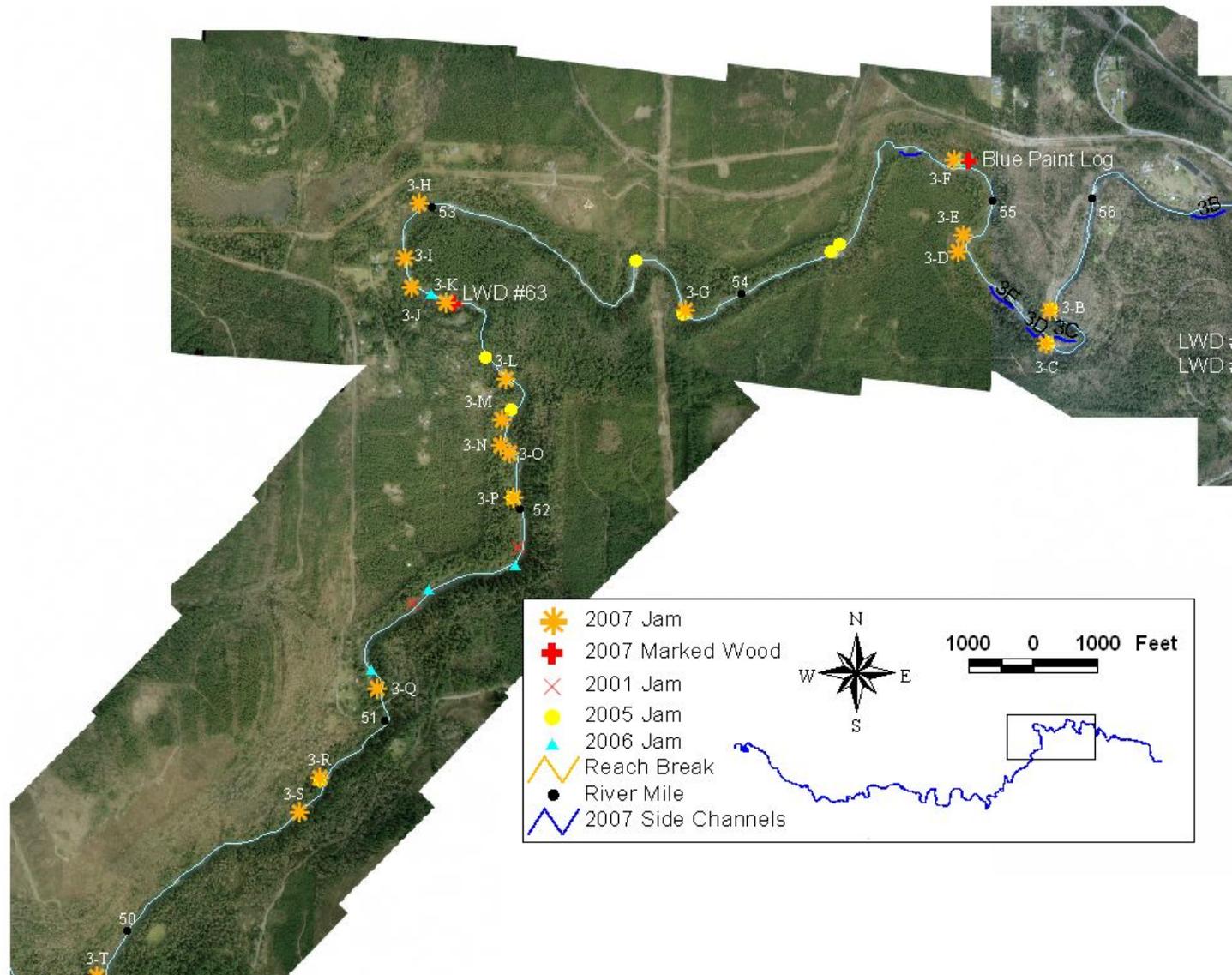


Figure 5-2. Middle Green River LWD in the upstream half of Reach 3, 2007.

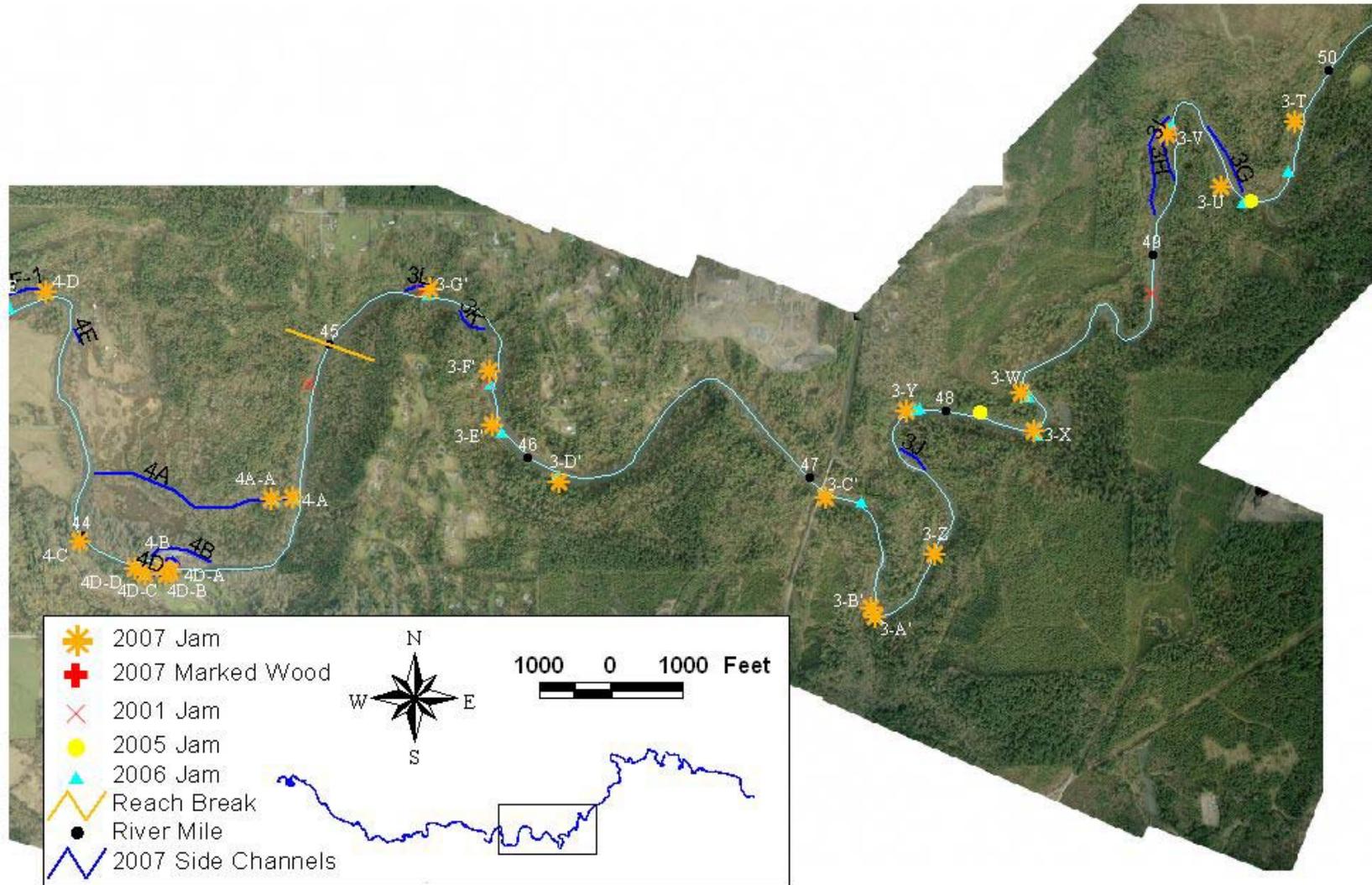


Figure 5-3. Middle Green River LWD in the downstream half of Reach 3, 2007.

Table 5-7. Large woody debris count by type and channel location in Reach 3, middle Green River, King County, Washington, August 2007.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	56	87	0	143	143
Log-Medium with Rootwad	44	42	0	86	86
Log-Large	14	27	0	41	41
Log-Large with Rootwad	17	18	0	35	35
Key Piece	0	3	0	3	3
Key Piece with Rootwad	8	3	0	11	11
Rootwad	27	53	2	80	78
<b>Total</b>	<b>166</b>	<b>233</b>	<b>2</b>	<b>399</b>	<b>397</b>
Small Jam	17	12	0	29	29
Medium Jam	2	2	0	4	4
Large Jam	0	0	0	0	0

Table 5-8. Comparison of summary statistics for the 2001-2007 mainstem Green River surveys of LWD in Reach 3 (RM 57, Kanaskat State Park to RM 45, Flaming Geyser State Park).

	Survey Year			
	2001	2005	2006	2007
LWD Data	MS only	MS and SC <sup>1</sup>	MS only	MS only
Mainstem Survey Length	12 mi	12 mi	12 mi	12 mi
Flow @ Palmer, WA	120 cfs	176 cfs	127 cfs	182 cfs
Flow @ Auburn, WA	259-360 cfs	304 cfs	249 cfs	311 cfs
Total LWD	164	352	562	397
Number of LWD – Zone 1	94	167	216	166
Number of LWD – Zone 2	70	185	346	231
LWD per Mile	13.6	29.4	46.8	33.1
Total Number Key LWD	11	23	30	14
Key Pieces per Mile	0.9	1.9	2.5	1.2
Total Number of LWD Jams	8	29	27	33
Percent Small Jams	100%	86%	93%	88%
Percent Medium Jams	0%	14%	7%	12%
Percent Large Jams	0%	0%	0%	0%

<sup>1</sup>-LWD counted in 2005 mainstem and side channel units was not kept in separate tallies.

Table 5-9. Comparison of summary statistics for the 2001-2007 mainstem and side channels of Green River surveys of LWD in Reach 3 (RM 57, Kanaskat State Park to RM 45, Flaming Geyser State Park).

	Survey Year			
	2005	2006	2007	2007
LWD Data	MS and SC	MS and SC	MS and 2006 SC <sup>1</sup>	MS and all SC <sup>2</sup>
Side Channel Survey Length	unknown	4,995 ft	4,995 ft	6,833 ft
Flow @ Palmer, WA	176 cfs	127 cfs	182 cfs	182 cfs
Flow @ Auburn, WA	304 cfs	249 cfs	311 cfs	311 cfs
Total LWD	352	584	397	399
Number of LWD – Zone 1	167	222	166	166
Number of LWD – Zone 2	185	362	231	233
LWD per Mile	29.4	48.7	33.1	33.3
Total Number Key LWD	23	30	14	14
Key Pieces per Mile	1.9	2.5	1.2	1.2
Total Number of LWD Jams	29	27	33	33
Percent Small Jams	86%	93%	88%	88%
Percent Medium Jams	14%	7%	12%	12%
Percent Large Jams	0%	0%	2%	1%

<sup>1</sup>-For comparison purposes, this column represents 2007 side channel data only for the side channels that were surveyed in 2006.

<sup>2</sup>-This column represents side channel data for all side channel surveyed in 2007.

## 5.4 REACH 4

Reach 4 was surveyed on August 27, 2007. The reach is approximately 4.2 miles long extending from Flaming Geyser State Park (RM 45) to Newaukum Creek (RM 40.8) (Figure 5-4). The average stream flow during the survey was 331 cfs as measured at the Auburn, Washington stream gage (USGS #12113000). Comparison of summary statistics for the 2001 and 2005-2007 LWD surveys of Reach 4 are presented in Tables 5-10 to 5-12.

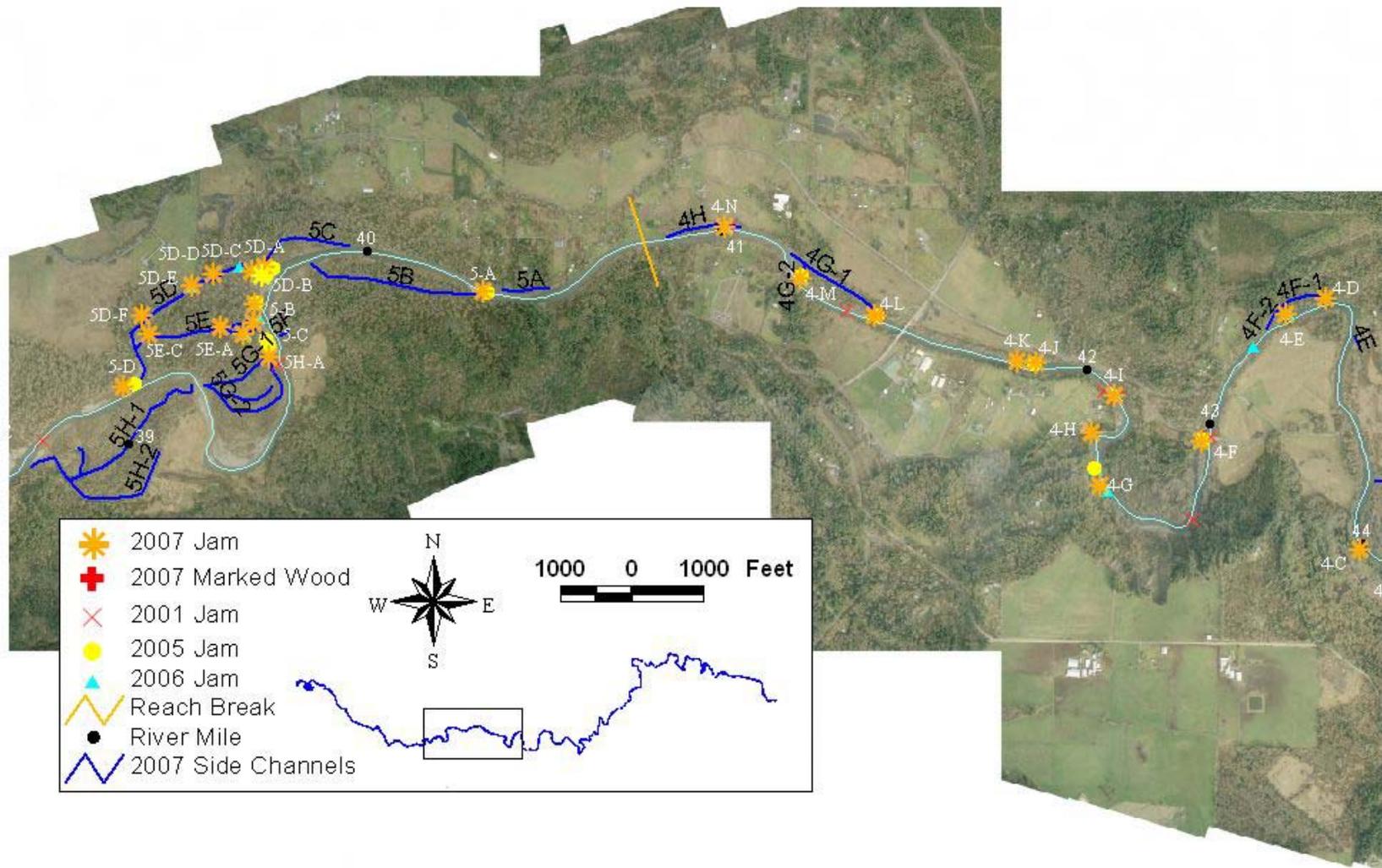


Figure 5-4. Middle Green River LWD in Reach 4, 2007.

Table 5-10. Large woody debris count by type and channel location in Reach 4, (RM 45, Flaming Geyser State Park to RM 40.8 Newaukum Creek), middle Green River, King County, Washington, August 2007.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	14	24	6	44	38
Log-Medium with Rootwad	18	9	12	39	27
Log-Large	3	5	3	11	8
Log-Large with Rootwad	3	1	3	7	4
Key Piece	1	0	0	1	1
Key Piece with Rootwad	0	0	0	0	0
Rootwad	36	8	14	58	44
<b>Total</b>	<b>75</b>	<b>47</b>	<b>38</b>	<b>160</b>	<b>122</b>
Small Jam	8	3	4	15	11
Medium Jam	3	0	1	4	3
Large Jam	0	0	0	0	0

Table 5-11. Comparison of summary statistics for the 2001-2007 mainstem Green River surveys of LWD in Reach 4 (RM 45, Flaming Geysers State Park to RM 40.8 Newaukum Creek).

	Survey Year			
	2001	2005	2006	2007
LWD Data	MS only	MS and SC	MS only	MS only
Mainstem Survey Length	4.2 mi	4.2 mi	4.2 mi	4.2 mi
Flow @ Palmer, WA	120 cfs	175 cfs	129 cfs	191 cfs
Flow @ Auburn, WA	252-256 cfs	292 cfs	250 cfs	331 cfs
Total LWD	33	61	96	122
Number of LWD – Zone 1	27	35	56	75
Number of LWD – Zone 2	6	26	40	47
LWD per Mile	7.9	14.7	22.9	29.0
Total Number Key LWD	4	1	4	1
Key Pieces per Mile	1	0.2	1	0.2
Total Number of LWD Jams	5	10	10	14
Percent Small Jams	100%	70%	90%	79%
Percent Medium Jams	0%	30%	0%	21%
Percent Large Jams	0%	0%	10%	0%

<sup>1</sup>-LWD counted in 2005 mainstem and side channel units was not kept in separate tallies.

Table 5-12. Comparison of summary statistics for the 2001-2007 mainstem and side channels of Green River surveys of LWD in Reach 4 (RM 45, Flaming Geyser State Park to RM 40.8, Newaukum Creek).

	Survey Year			
	2005	2006	2007	2007
LWD Data	MS and SC	MS and SC	MS and 2006 SC <sup>1</sup>	MS and all SC <sup>2</sup>
Side Channel Survey Length	unknown	7,818 ft	7,818 ft	8,515 ft
Flow @ Palmer, WA	175 cfs	129 cfs	191 cfs	191 cfs
Flow @ Auburn, WA	292 cfs	250 cfs	331 cfs	331 cfs
Total LWD	61	145	134	160
Number of LWD – Zone 1	35	68	81	95
Number of LWD – Zone 2	26	77	53	65
LWD per Mile	14.7	34.8	31.9	38.1
Total Number Key LWD	1	9	1	1
Key Pieces per Mile	0.2	2.1	0.2	0.2
Total Number of LWD Jams	10	14	19	19
Percent Small Jams	70%	93%	79%	79%
Percent Medium Jams	30%	0%	21%	21%
Percent Large Jams	0%	7%	0%	0%

<sup>1</sup>-For comparison purposes, this column represents 2007 side channel data only for the side channels that were surveyed in 2006.

<sup>2</sup>-This column represents side channel data for all side channel surveyed in 2007.

## 5.5 REACH 5

Reach 5 was surveyed on August 28 and 29, 2007. The reach is approximately 2.8 miles long extending from Newaukum Creek (RM 40.8) to Loans Levee (RM 38.0) (Figure 5-5). The average stream flow during the survey was 314 cfs as measured at the Auburn, Washington stream gage (USGS #12113000). This reach of the middle mainstem Green River has experienced frequent channel shifts in the past ten to twenty years and contains numerous side channels that were not surveyed as part of the 2001 LWD survey. Since the winter of 1996-1997, almost half of the mainstem flow has been redirected into a large side channel near RM 40 (R2 2002). This side channel was transmitting approximately forty to fifty percent of the flow at the time of the 2001 survey, but was not included as part of that survey (R2 2002). Summary statistics for the 2001, 2005, and 2006 LWD surveys of Reach 5 are presented in Tables 5-13, 5-14, and 5-15.

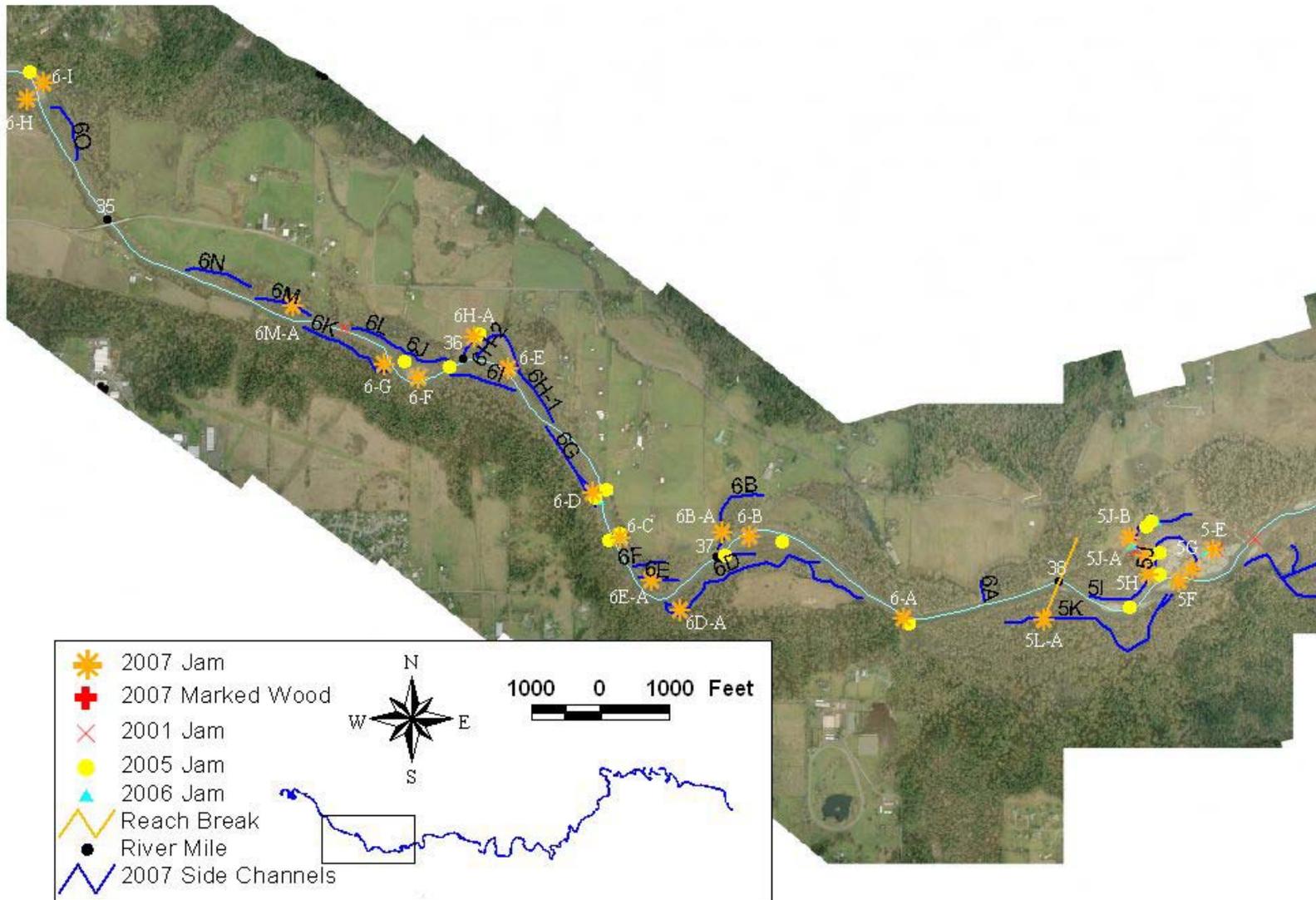


Figure 5-5. Middle Green River LWD in Reach 5, 2007.

Table 5-13. Large woody debris count by type and channel location in Reach 5, (RM 40.8, Newaukum Creek to RM 38, Loans Levee), of the middle Green River, King County, Washington, August 2007.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	6	23	7	36	29
Log-Medium with Rootwad	15	26	15	56	41
Log-Large	6	3	1	10	9
Log-Large with Rootwad	3	4	1	8	7
Key Piece	1	1	0	2	2
Key Piece with Rootwad	1	0	0	1	1
Rootwad	17	17	16	50	34
<b>Total</b>	<b>49</b>	<b>74</b>	<b>40</b>	<b>163</b>	<b>123</b>
Small Jam	1	4	9	14	5
Medium Jam	2	0	2	4	2
Large Jam	1	0	2	3	1

Table 5-14. Comparison of summary statistics for the 2001-2007 mainstem Green River surveys of LWD in Reach 5 (RM 40.8, Newaukum Creek to RM 38, Loans Levee).

	Survey Year			
	2001	2005	2006	2007
LWD Data	MS only	MS and SC	MS only	MS only
Mainstem Survey Length	2.8 mi	2.8 mi	2.8 mi	2.8 mi
Flow @ Palmer, WA	114-127 cfs	174 cfs	130 cfs	185 cfs
Flow @ Auburn, WA	256-356 cfs	292 cfs	250 cfs	314 cfs
Total LWD	70	111	86	123
Number of LWD – Zone 1	41	62	39	49
Number of LWD – Zone 2	29	49	47	74
LWD per Mile	25	39.6	30.7	43.9
Total Number Key LWD	3	2	0	3
Key Pieces per Mile	1.1	0.7	0	1.1
Total Number of LWD Jams	6	22	4	8
Percent Small Jams	67%	73%	100%	63%
Percent Medium Jams	17%	14%	0%	25%
Percent Large Jams	16%	13%	0%	12%

<sup>1</sup>-LWD counted in 2005 mainstem and side channel units was not kept in separate tallies.

Table 5-15. Comparison of summary statistics for the 2001-2007 mainstem and side channels of Green River surveys of LWD in Reach 5 (RM 40.8, Newaukum Creek to RM 38, Loans Levee).

	Survey Year			
	2005	2006	2007	2007
LWD Data	MS and SC	MS and SC	MS and 2006 SC <sup>1</sup>	MS and all SC <sup>2</sup>
Side Channel Survey Length	unknown	4,680 ft	4,680 ft	24,143 ft
Flow @ Palmer, WA	174 cfs	130 cfs	185 cfs	185 cfs
Flow @ Auburn, WA	292 cfs	250 cfs	314 cfs	314 cfs
Total LWD	111	132	150	163
Number of LWD – Zone 1	62	77	69	73
Number of LWD – Zone 2	49	55	81	90
LWD per Mile	39.6	47.2	53.6	58.2
Total Number Key LWD	2	0	3	3
Key Pieces per Mile	0.7	0	1.1	1.1
Total Number of LWD Jams	22	14	19	21
Percent Small Jams	73%	79%	68%	67%
Percent Medium Jams	14%	14%	21%	19%
Percent Large Jams	13%	7%	10.5%	14%

<sup>1</sup>-For comparison purposes, this column represents 2007 side channel data only for the side channels that were surveyed in 2006.

<sup>2</sup>-This column represents side channel data for all side channel surveyed in 2007.

## 5.6 REACH 6

Reach 6 was surveyed on August 29, 30, and 31, 2007. The survey reach was approximately 6.0 miles long extending from Loans Levee (RM 38.0) to the Auburn Narrows (RM 32.0) (Figure 5-6). The average stream flow during the survey was 314 cfs as measured at the Auburn, Washington stream gage (USGS # 12113000). There is a large amount of woody debris located between RM 32 and RM 33. Four jams were identified in the mainstem in this reach (6-Q to 6-T). The wood here is mobile and the exact number of jams has changed over the years according to what pieces are actually touching (definition of a jam includes all pieces that are in contact with each other). Jam 6-Q is the largest jam, a channel spanning structure that includes hundreds of individual pieces. Summary statistics for Reach 6 are presented in Tables 5-16, 5-17, and 5-18.

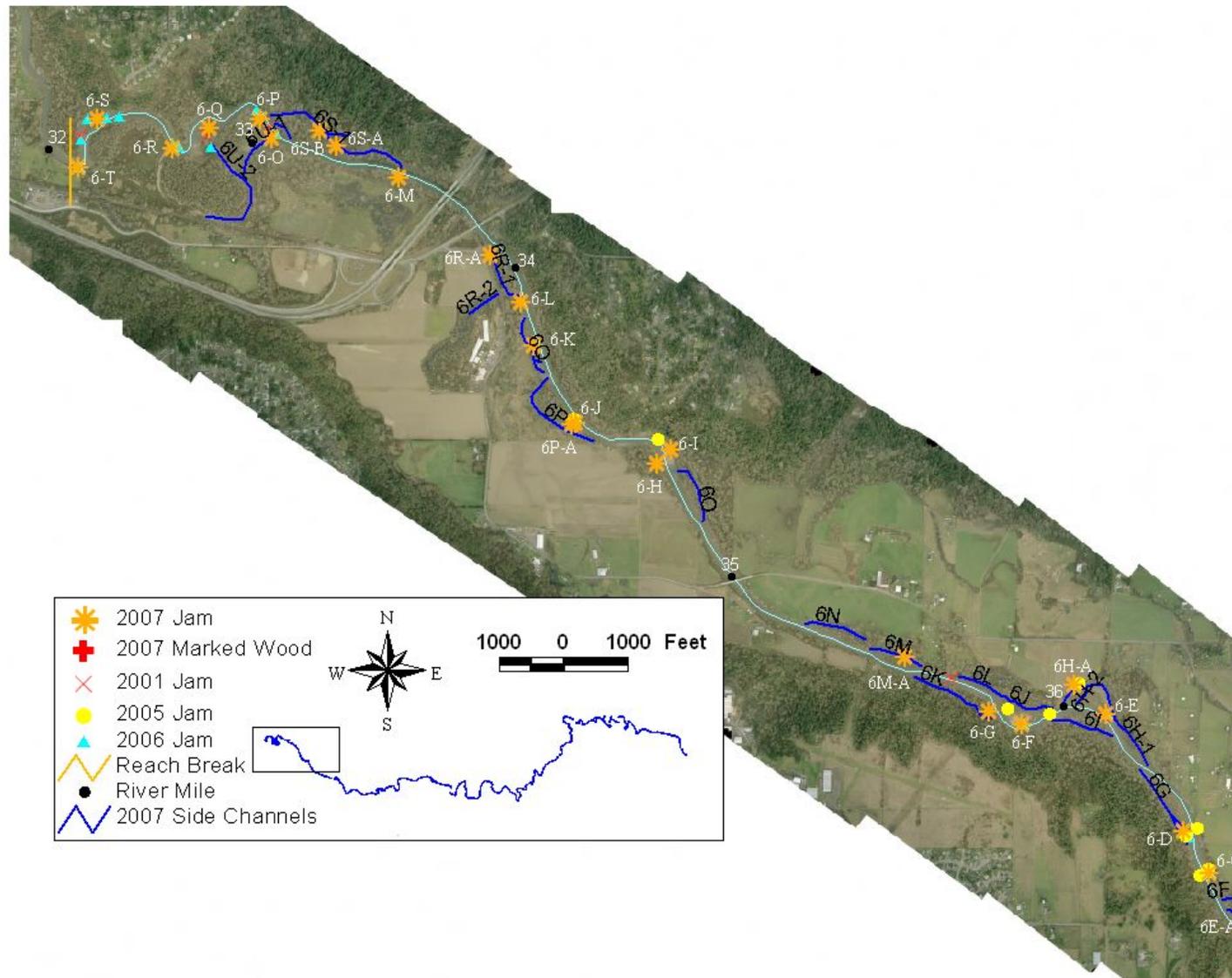


Figure 5-6. Middle Green River LWD in Reach 6, 2007.

Table 5-16. Large woody debris count by type and channel location in Reach 6, (RM 40.8, Newaukum Creek to RM 38, Loans Levee), of the middle Green River, King County, Washington, August 2007.

	Channel Zone			Totals	
	1	2	Side Channel	Total Including Side Channel Data	Total Not Including Side Channel Data
Log-Medium	65	22	30	117	87
Log-Medium with Rootwad	42	8	7	57	50
Log-Large	12	11	2	25	23
Log-Large with Rootwad	9	5	1	15	14
Key Piece			0	0	0
Key Piece with Rootwad	3		0	3	3
Rootwad	64	28	7	99	92
<b>Total</b>	<b>195</b>	<b>74</b>	<b>47</b>	<b>316</b>	<b>269</b>
Small Jam	13	1	7	21	11
Medium Jam	6	0	0	6	6
Large Jam	2	0	1	3	2

Table 5-17. Comparison of summary statistics for the 2001-2007 mainstem Green River surveys of LWD in Reach 6 (RM 38, Loans Levee to RM 32, Auburn Narrows).

	Survey Year			
	2001	2005	2006	2007
LWD Data	MS only	MS and SC	MS only	MS only
Mainstem Survey Length	6.0 mi	4.2 mi	6.0 mi	6.0 mi
Flow @ Palmer, WA	117-127 cfs	174 cfs	134 cfs	n/a
Flow @ Auburn, WA	266-326 cfs	287 cfs	250 cfs	314 cfs
Total LWD	131	112	216	269
Number of LWD – Zone 1	93	85	148	195
Number of LWD – Zone 2	38	27	51	74
LWD per Mile	21.8	26.7	33.2	44.8
Total Number Key LWD	3	2	2	3
Key Pieces per Mile	0.5	0.5	0.3	0.5
Total Number of LWD Jams	5	12	18	19
Percent Small Jams	80%	75%	78%	58%
Percent Medium Jams	0%	8%	17%	32%
Percent Large Jams	20%	17%	6%	10%

<sup>1</sup>-LWD counted in 2005 mainstem and side channel units was not kept in separate tallies.

Table 5-18. Comparison of summary statistics for the 2001-2007 mainstem and side channels of Green River surveys of LWD in Reach 6 (RM 38, Loans Levee to RM 32, Auburn Narrows).

	Survey Year			
	2005	2006	2007	2007
LWD Data	MS and SC	MS and SC	MS and 2006 SC <sup>1</sup>	MS and all SC <sup>2</sup>
Side Channel Survey Length	unknown	6,242 ft	6,242 ft	24,501 ft
Flow @ Palmer, WA	174 cfs	134 cfs	n/a	n/a
Flow @ Auburn, WA	287 cfs	250 cfs	314 cfs	314 cfs
Total LWD	112	216	285	316
Number of LWD – Zone 1	85	158	207	224
Number of LWD – Zone 2	27	58	78	92
LWD per Mile	26.7	36	47.5	52.7
Total Number Key LWD	2	2	3	3
Key Pieces per Mile	0.5	0.3	0.5	0.5
Total Number of LWD Jams	12	20	28	28
Percent Small Jams	75%	75%	65%	65%
Percent Medium Jams	8%	20%	26%	26%
Percent Large Jams	17%	5%	9%	9%

<sup>1</sup>-For comparison purposes, this column represents 2007 side channel data only for the side channels that were surveyed in 2006.

<sup>2</sup>-This column represents side channel data for all side channel surveyed in 2007.

## 6. ANALYSIS AND SUMMARY

### 6.1 HABITAT SUMMARY

Habitat maps and data produced as part of this study provide a useful means of tracking reach scale changes in habitat condition in the Green River. Summary habitat statistics for each reach are provided in Table 6-1. Overall, the general habitat condition of the Green River in 2007 was similar to that found in 2001.

In 2007, Reaches 3 and 5 had a decrease in pool habitat from 2001. Surveys of Reach 3 were performed at a higher streamflow in 2007 than in 2001. A higher streamflow may have served to change habitat from pool to run in some instances. There have been significant changes in the flow pattern of the mainstem Green River in Reach 5 since 2001. The number and areas of pool habitat has dropped substantially since 2001. These changes have influenced the habitat composition present in the later survey. In 2001, Reach 6 had a larger percentage of glide habitat and less area of runs. These two slow water habitats are very similar and proportions of each can be easily influenced by small changes in the streamflow, or observer bias. Overall, pool formation factors stayed similar for all reaches since the 2001 survey, with bedrock being the dominant formation factor in the Green River.

Average bankfull and wetted width measurements were generally similar between the 2001 and 2007 surveys. The greatest difference in average wetted width was found in Reach 4. The average wetted width increased from 31.1 meters (102 feet) in 2001 to 37.5 meters (123 feet) in 2007. However, the 2007 survey was completed at a slightly higher average streamflow than the 2001 (331 cfs versus 254 cfs).

The average  $D_{50}$  of all reaches was similar in 2007 and 2001, with the exception of Reach 2. In Reach 2, the average  $D_{50}$  was lower in 2007 than in 2001 (70 mm versus 137 mm). This is likely an indication of the pebble counts being taken in areas influenced by the gravel augmentation program. Augmentation gravel ranged in size from 12.7 mm to 101.6 mm (0.5 inches to 4.0 inches). Pebble counts in the steeper stream reaches (Reaches 2 and 3) were taken in riffle areas, and may not have accurately represented the abundance of larger boulder and cobble substrates that dominate the higher gradient reaches, such as those in steeper cascades and pools. While the average riffle  $D_{50}$  is a useful indicator of habitat condition an increased number of pebble counts (or more pebbles per count) may be necessary in the upper, higher gradient reaches to form any reliable conclusions. However, pebble counts were likely taken in similar areas in 2007 as in 2001.

Average shade values for Reaches 2 and 3 were higher in 2007 than in 2001. Average shade in Reach 2 rose from 17% in 2001 to 44% in 2007. Average shade in Reach 3 measured 26% in 2001 and 40% in 2007. Based on these results it seems likely streamside vegetation in Reaches 2 and 3 has increased since the 2001 survey. However, the 2001 survey of Reach 2 took place approximately three weeks later in the fall than the 2007 surveys, and may have had less leaf cover. Reaches 4 through 6 had similar shade values in 2001 and 2007.

The most notable changes in habitat since the 2001 survey are the shifting flow in the side channels in Reach 5 and the lower D<sub>50</sub> in Reach 2.

Table 6-1. Comparison of reach scale summary statistics for 2007 physical habitat and LWD monitoring in the mainstem Green River, Washington.

	REACH				
	2	3	4	5	6
Length (m)	6,437 (4.0 mi)	19,311 (12.0 mi)	6,758 (4.2 mi)	4,506 (2.8 mi)	9,656 (6.0 mi)
Side Channel length (m)	(7,908 ft)	(6,833 ft)	(8,515 ft)	(24,143 ft)	(24,501 ft)
Average streamflow at Palmer (cfs)	153	182			
Average streamflow at Auburn (cfs)		311	331	314	314
Average bankfull width (m)	35.3 (115.9 ft)	39.7 (130.3 ft)	44.2 (145.0 ft)	38.3 (125.5 ft)	41.3 (135.6 ft)
Average wetted width (m)	29.4 (96.3 ft)	11.0 (36.0 ft)	37.3 (122.4 ft)	25.3 (83.1 ft)	32.3 (105.9 ft)
Pool Frequency (channel widths / pool)	13.7	25.3	37.1	180.0	25.4
Percent pool by length	24.5%	11.5%	11.1%	4.8%	19.1%
Percent pool by area	26.9%	12.0%	11.7%	4.0%	21.7%
Average residual pool depth (m)	2.8 (9.2 ft)	3.2 (10.5 ft)	2.3 (7.7 ft)	2.1 (7.0 ft)	2.6 (8.6 ft)
Dominant pool forming factor	Bedrock	Bedrock	Bedrock	Log	Bedrock/ Bedform
Total LWD pieces (excluding s. channels)	59	397	122	123	269
Total Number of LWD Jams (excluding s. channels)	5	33	14	8	19
% Pools formed by LWD	6.3%	0.0%	0.0%	100.0%	23.1%
Average D 16	35	40	33	33	31
Average D 50	70	90	67	62	53
Average D 84	156	231	126	113	92
Average shade	44.0%	39.5%	23.8%	12.9%	22.2%

## 6.2 LWD SUMMARY

A large number of both LWD pieces and LWD jams are located in side channel areas of the Green River. Survey methods used during the 2005 LWD surveys did not include a system for coding or identification of LWD pieces and/or log jams found within side channel areas; making it impossible to separate the number of pieces located within these areas and the mainstem. The side channel data were kept separate from the mainstem data in the 2006 and 2007 surveys. In 2006 side channel wood accounted for approximately 12 percent of the total LWD counted in the river. In 2007, more side channels were included as part of the survey, but LWD counted in the side channels still only accounted for approximately 13 percent of the total LWD in the river. In 2007, out of 108 total LWD jams, 29 (27 percent) were located in the side channels. Comparison of woody debris totals over the three survey periods are provided in Tables 6-2, 6-3, and 6-5.

Overall, the 2007 survey of the mainstem indicates a decrease in individual pieces of LWD over 2006 totals (970 vs. 1,140 pieces respectively) and an increase in the number of LWD jams (66 in 2006 to 79 in 2007) (Table 6-2). Similar results are seen when you incorporate the side channel data (Table 6-2). Taken on a reach by reach case, the upper reaches (2-4) had fewer individual pieces and more jams while the lower reaches (5 and 6) had more individual pieces and more jams than in 2006.

Table 6-2. Comparison of summary statistics for the 2001-2007 mainstem Green River surveys of LWD in Reaches 1 through 6 of the mainstem Green River, Washington.

	Survey Year			
	2001	2005 <sup>1,2</sup>	2006	2007
Total LWD Pieces	434	724	1,140	970
Medium Size Pieces	259	503	682	538
Large Size Pieces	110	115	229	150
Key Size Pieces	23	34	46	21
Rootwads	42	72	183	261
Total LWD Jams	24	78	66	79
Small Jams	21	60	57	60
Medium Jams	1	13	7	16
Large Jams	2	5	2	3

<sup>1</sup>-LWD counted in 2005 mainstem and side channel units was not kept in separate tallies.

<sup>2</sup>2005 survey length was 5.3 miles shorter than the other years survey lengths.

Table 6-3. Comparison of summary statistics for the 2001-2007 mainstem and side channels of Green River surveys of LWD in all reaches surveyed.

	Survey Year			
	2005	2006	2007 – same as 2006	2007 – all side channels
Total LWD Pieces	724	1,297	1,053	1,111
Medium Size Pieces	503	777	570	615
Large Size Pieces	115	262	154	163
Key Size Pieces	34	51	21	21
Rootwads	72	207	288	312
Total LWD Jams	78	84	99	108
Small Jams	60	71	75	83
Medium Jams	13	10	18	19
Large Jams	5	3	6	6

Note: Side channels were not surveyed during 2001, and therefore that data is only included in Table 6-2, not 6-3.

The LWD jams identified in the Green River appear to be the most mobile within Reach 3, the steep Green River gorge section. In particular, several jams from RM 49.5 to RM 52 have relocated since the 2006 survey. The majority of the jams identified in 2006 below RM 49 and above RM 52 were found in the same locations in 2007. Three tagged logs were identified during the 2007 survey (Table 6-4). Since it was installed in ELJ2 (RM 60) in 2003, log #63 was observed at RM 58.5 in 2005 and 2006 and at RM 52.7 in 2007. Log #63 is a medium sized log with a rootwad measuring 34 feet in length (Corps 2004).

Table 6-4. Locations (River Mile) of tagged LWD observed in the Green River Washington 2003-2007.

	2003	2005	2006	2007
Log # 62	60.0 (ELJ 2)	not observed	not observed	57.3
Log # 63	60.0 (ELJ 2)	58.5	58.5	52.7
Log # 70	60.0 (ELJ 2)	57.2	57.2	not observed
Log # 98	60.0 (ELJ 2)	not observed	not observed	57.3

Table 6-5. Comparison of summary statistics for the 2001, 2005, 2006, and 2007 surveys of LWD in the middle Green River, Washington (RM 64.5, Howard Hanson Dam to RM 32, Auburn Narrows).

Reach <sup>1</sup>	Survey Year	Includes Side Channel Data?	Total LWD <sup>2</sup>	Total Key Piece	LWD Per Mile	Key Piece Per Mile	Total # Jams <sup>3</sup>	# of Jams Per Mile
1	2001	No	18	1	5.1	0.3	0	0.0
	2005		Reach 1 was not included in 2005 LWD survey					
	2006	Yes	94	2	26.9	0.6	3	0.9
	2006	No	94	2	26.9	0.6	3	0.9
	2007		Reach 1 was not included in the 2007 LWD survey					
2	2001	No	36	2	9.0	0.5	0	0.0
	2005	Yes	88	6	22.0	1.5	5	1.3
	2006	Yes	126	8	31.5	2.0	6	1.5
	2006	No	103	8	25.8	2.0	4	1.0
	2007	Yes	73	0	18.3	0	7	1.8
	2007	No	59	0	14.8	0	5	1.3
3	2001	No	164	11	13.6	0.9	8	0.7
	2005	Yes	352	23	29.3	1.9	29	2.4
	2006	Yes	584	30	48.7	2.5	27	2.3
	2006	No	562	30	46.8	2.5	27	2.3
	2007	Yes	399	14	33.3	1.2	33	2.8
	2007	No	397	14	33.1	1.2	33	2.8
4	2001	No	33	4	7.9	1.0	5	1.2
	2005	Yes	61	1	14.5	0.2	10	2.4
	2006	Yes	145	9	34.8	2.1	14	3.4
	2006	No	96	4	22.9	1.0	10	2.4
	2007	Yes	134	1	31.9	0.2	19	4.5
	2007	No	122	1	29.0	0.2	14	3.3
5	2001	No	70	3	25.0	1.1	6	2.1
	2005	Yes	111	2	39.6	0.7	22	7.9
	2006	Yes	132	0	47.2	0.0	14	5.0
	2006	No	86	0	30.7	0.0	4	1.4
	2007	Yes	150	3	53.6	1.1	21	7.5
	2007	No	123	3	43.9	1.1	8	2.9

Table 6-5. Comparison of summary statistics for the 2001, 2005, 2006, and 2007 surveys of LWD in the middle Green River, Washington (RM 64.5, Howard Hanson Dam to RM 32, Auburn Narrows).

Reach <sup>1</sup>	Survey Year	Includes Side Channel Data?	Total LWD <sup>2</sup>	Total Key Piece	LWD Per Mile	Key Piece Per Mile	Total # Jams <sup>3</sup>	# of Jams Per Mile
6	2001	No	131	3	21.8	0.5	5	0.8
	2005	Yes	112	2	26.7	0.5	12	2.9
	2006	Yes	216	2	36.0	0.3	20	3.3
	2006	No	199	2	33.2	0.3	18	3.0
	2007	Yes	269	3	44.8	0.5	28	4.7
	2007	No	285	3	47.5	0.5	19	3.2

<sup>1</sup>The surveyed length of Reach 6 was approximately 1.8 miles shorter during the 2005 survey.

<sup>2</sup>Includes medium and large logs, key-sized pieces and rootwads.

<sup>3</sup>Includes small, medium, and large jams.

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# **APPENDIX A**

## **2007 Quality Assurance and Quality Control Checks**

Table A-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Estimated Width (in)	Estimated Length (ft)	Measured Width (in)	Measured Length (ft)	% Error Width	% Error Length
1	14	70	17.4	64	19.5	9.4
2	9	18	8.4	15	7.1	20.0
3	12	35	13.2	35	9.1	0.0
4	14	19	14	21	0.0	9.5
5	16	18	17	18	5.9	0.0
6	18	21	17	21	5.9	0.0
7	9	25	11	30	18.2	16.7
8	30	50	32	67	6.3	25.4
9	11	28	13	25	15.4	12.0
10	18	34	17	38	5.9	10.5
11	15	65	17.4	64	13.8	1.6
12	8	15	8.4	15	4.8	0.0
13	12	40	13.2	35	9.1	14.3
14	12	23	14	21	14.3	9.5
15	15	20	17	18	11.8	11.1
16	17	22	17	21	0.0	4.8
17	10	30	11	30	9.1	0.0
18	32	60	32	67	0.0	10.4
19	11	26	13	25	15.4	4.0
20	17	36	17	38	0.0	5.3
21	12	45	10.5	47	14.3	4.3
22	18	30	17	34	5.9	11.8
23	25	25	27	27	7.4	7.4
24	12	35	12	41	0.0	14.6
25	11	45	10.5	43	4.8	4.7
26	12	28	12.2	26	1.6	7.7
27	16	35	13	34	23.1	2.9
28	20	12	22	12	9.1	0.0
29	18	28	17	28	5.9	0.0
30	8	26	9	24	11.1	8.3
31	11	34	11	35	0.0	2.9

Table A-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Estimated Width (in)	Estimated Length (ft)	Measured Width (in)	Measured Length (ft)	% Error Width	% Error Length
32	13	60	13	48	0.0	25.0
33	11	45	11	48	0.0	6.3
34	25	55	24	60	4.2	8.3
35	12	38	11	40	9.1	5.0
36	14	80	17	78	17.6	2.6
37	17	110	18	90	5.6	22.2
38	12	45	12	54	0.0	16.7
39	12	45	15	41	20.0	9.8
40	15	55	19	54	21.1	1.9
41	12	35	11	35	9.1	0.0
42	14	55	13	48	7.7	14.6
43	12	50	11	48	9.1	4.2
44	18	70	18	90	0.0	22.2
45	11	50	12	54	8.3	7.4
46	14	40	15	41	6.7	2.4
47	18	50	19	54	5.3	7.4
48	17	65	18	75	5.6	13.3
49	17	63	16	69	6.3	8.7
50	14	29	14	30	0.0	3.3
51	12	28	13	30	7.7	6.7
52	11	40	13	48	15.4	16.7
53	16	30	17	30	5.9	0.0
54	15	50	13	47	15.4	6.4
55	32	72	37	84	13.5	14.3
56	18	25	19	32	5.3	21.9
57	14	28	14	26	0.0	7.7
58	12.5	37	18	75	30.6	50.7
59	18	70	16	69	12.5	1.4
60	17	31	17	30	0.0	3.3
61	12.5	57	13	47	3.8	21.3
62	34	65	37	84	8.1	22.6

Table A-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Estimated Width (in)	Estimated Length (ft)	Measured Width (in)	Measured Length (ft)	% Error Width	% Error Length
63	11	35	11	42	0.0	16.7
64	13	38	15	45	13.3	15.6
65	22	44	22	46	0.0	4.3
66	16	50	15	54	6.7	7.4
67	24	24	26	24	7.7	0.0
68	18	52	23	60	21.7	13.3
69	16	28	17	26	5.9	7.7
70	22	46	23	57	4.3	19.3
71	14	42	14	48	0.0	12.5
72	34	68	35	70	2.9	2.9
73	12	40	11	42	9.1	4.8
74	15	55	15	54	0.0	1.9
75	22	28	26	24	15.4	16.7
76	20	50	23	57	13.0	12.3
77	12	44	14	48	14.3	8.3
78	35	65	35	70	0.0	7.1
79	11	70	10	75	10.0	6.7
80	15	51	17	57	11.8	10.5
81	18	110	16	105	12.5	4.8
82	16	90	15	81	6.7	11.1
83	12	43	11	42	9.1	2.4
84	28	90	28	84	0.0	7.1
85	20	85	16	120	25.0	29.2
86	12	38	11	39	9.1	2.6
87	10	35	8	36	25.0	2.8
88	14	63	14	75	0.0	16.0
89	30	85	28	84	7.1	1.2
90	18	85	16	120	12.5	29.2
91	16	75	14	75	14.3	0.0
92	19	34	21.4	32	11.2	6.3
93	8	35	9	36	11.1	2.8

Table A-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

Piece #	Estimated Width (in)	Estimated Length (ft)	Measured Width (in)	Measured Length (ft)	% Error Width	% Error Length
94	17	33	19	33	10.5	0.0
95	8	25	10	27	20.0	7.4
96	10	51	10	63	0.0	19.0
97	12	23	11	26	9.1	11.5
98	10	23	9	21	11.1	9.5
99	10	35	9	33	11.1	6.1
100	15	31	15	29	0.0	6.9
101	21.5	37	19	33	13.2	12.1
102	14.5	85	13.8	75	5.1	13.3
103	19	93	21.6	102	12.0	8.8
104	21	108	21	105	0.0	2.9
105	20	120	17.4	108	14.9	11.1
106	14	63	13.8	75	1.4	16.0
107	20	115	21.6	102	7.4	12.7
108	19	108	21	105	9.5	2.9
109	14	105	17.4	108	19.5	2.8
110	9	50	10	48	10.0	4.2
111	12	30	12	29.5	0.0	1.7
112	12	40	10	50	20.0	20.0
113	6	38	7	36	14.3	5.6
114	16	43	18	42	11.1	2.4
115	12	73	10	75	20.0	2.7
116	8	48	8	45	0.0	6.7
117	20	28	23	27	13.0	3.7
118	21	93	19	96	10.5	3.1
119	8	60	8.5	45	5.9	33.3
120	10	40	10	48	0.0	16.7
121	12	28	12	29.5	0.0	5.1
122	7	34	7	36	0.0	5.6
123	10	77	10	75	0.0	2.7
124	22	66	19	96	15.8	31.3

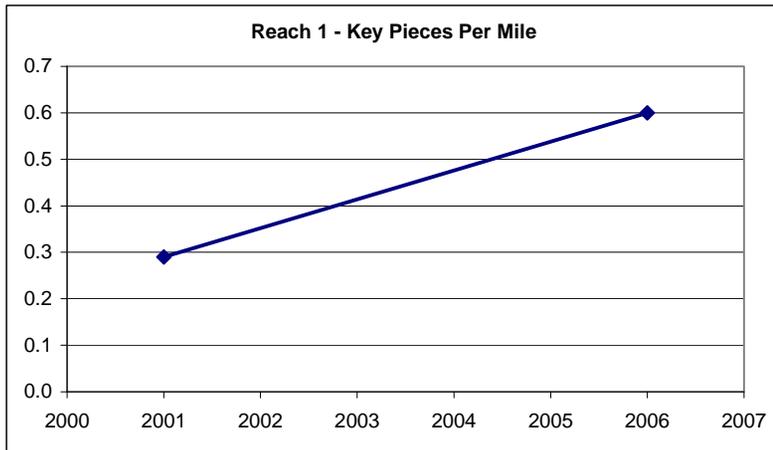
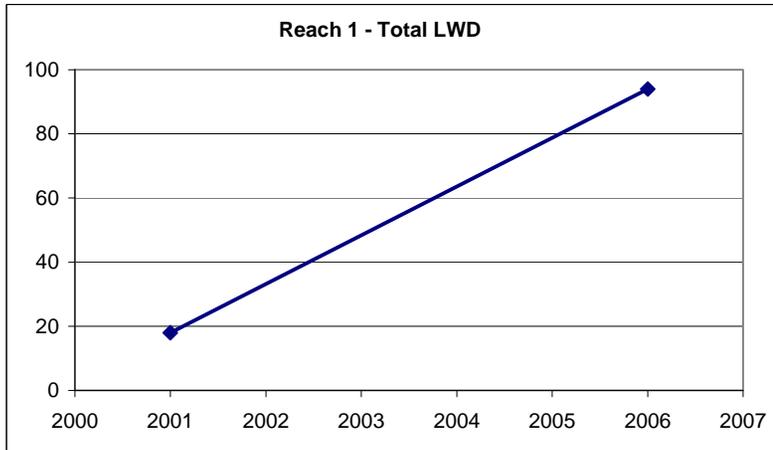
Table A-1. Crew Calibration 2006 Middle Mainstem Green River, Washington.

<b>Piece #</b>	<b>Estimated Width (in)</b>	<b>Estimated Length (ft)</b>	<b>Measured Width (in)</b>	<b>Measured Length (ft)</b>	<b>% Error Width</b>	<b>% Error Length</b>
125	6	47	8.5	45	29.4	4.4
126	10	43	10	45	0.0	4.4
127	17	30	19	31	10.5	3.2
128	18	30	17	28	5.9	7.1
129	11	43	10	45	10.0	4.4
130	16	107	14.8	99	8.1	8.1
131	13.5	31	12.2	33	10.7	6.1
132	14	67	13.4	79	4.5	15.2
133	15	105	17.2	102	12.8	2.9
134	18	74	17.2	102	4.7	27.5

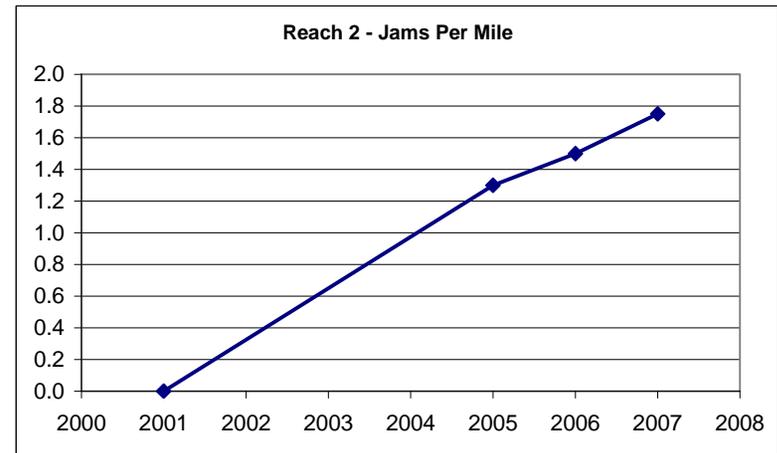
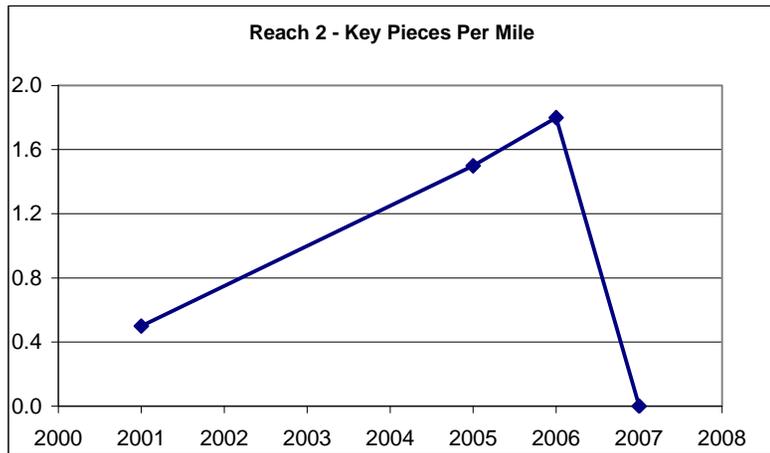
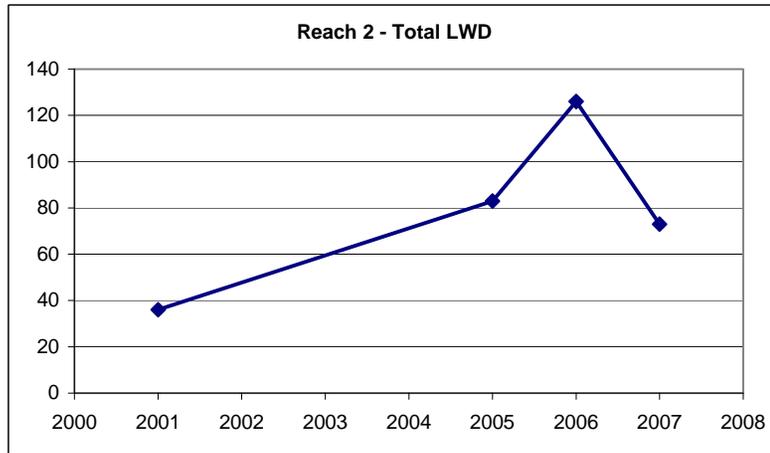
# **APPENDIX B**

## **LWD Data Comparison Tables**

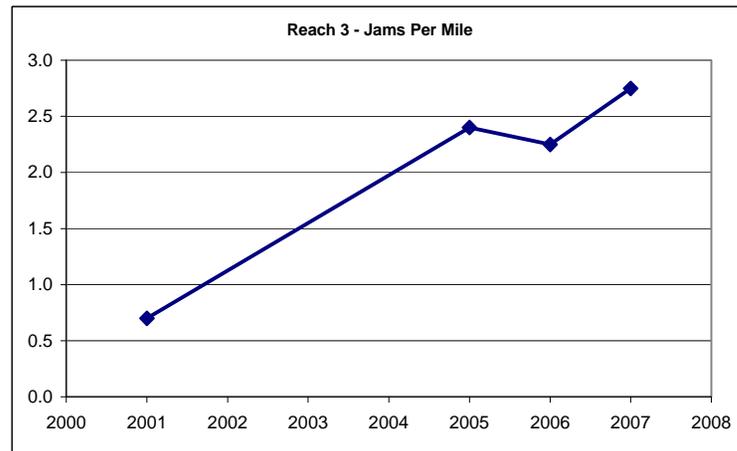
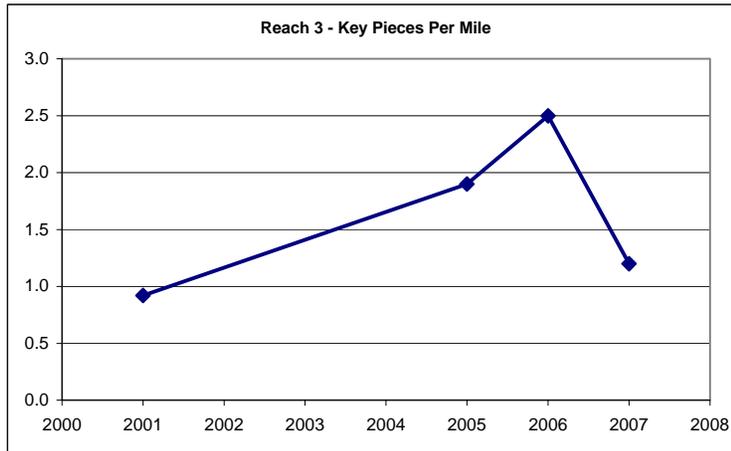
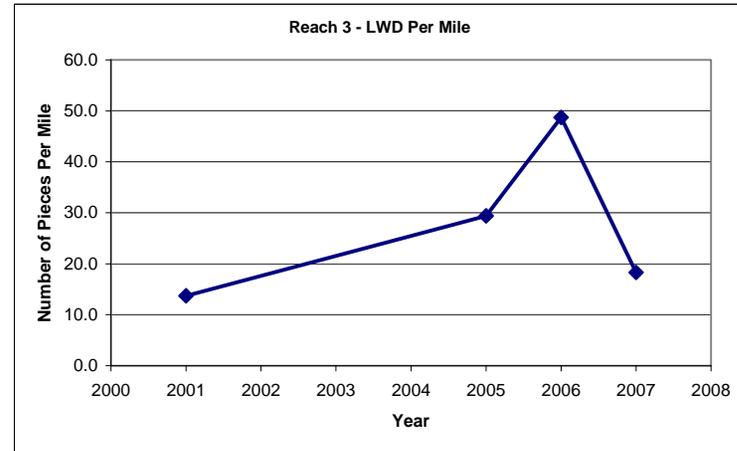
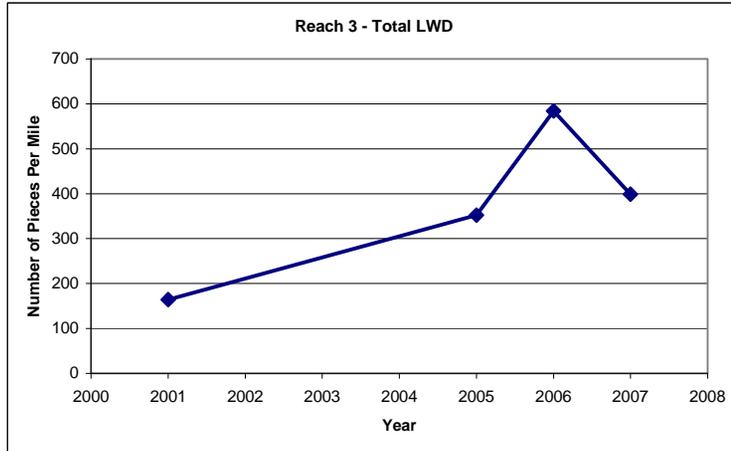
Reach 1	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	18	6	0.29	0
	2006	94	31.3	0.6	1



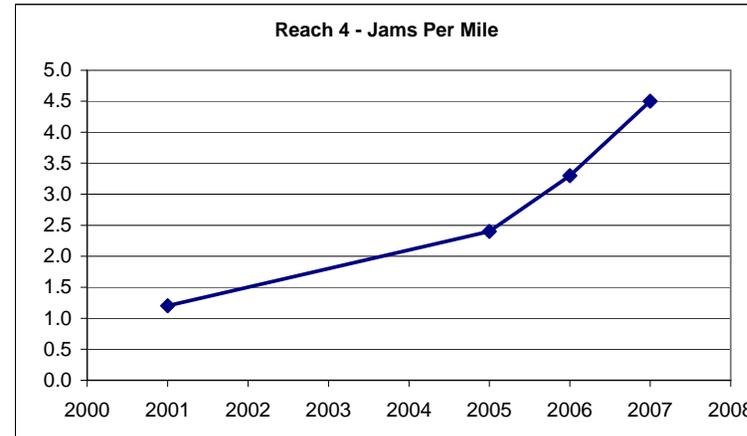
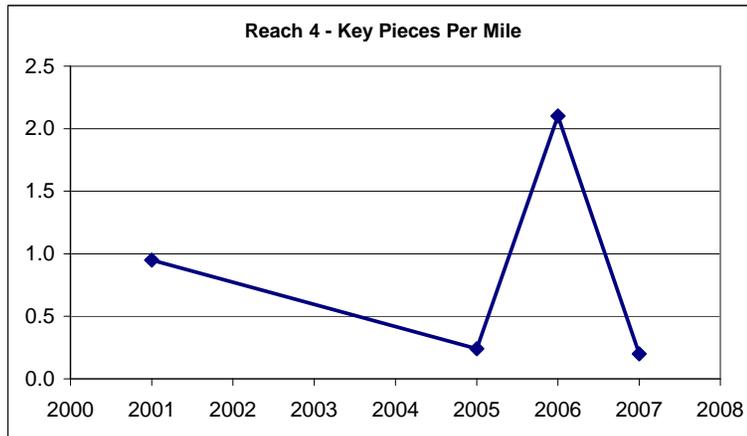
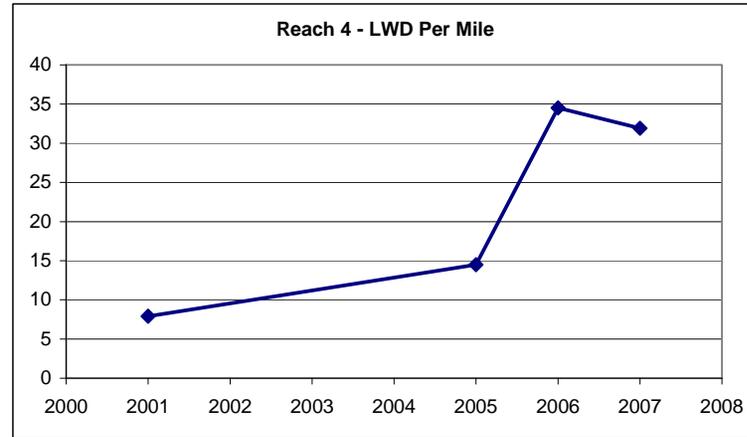
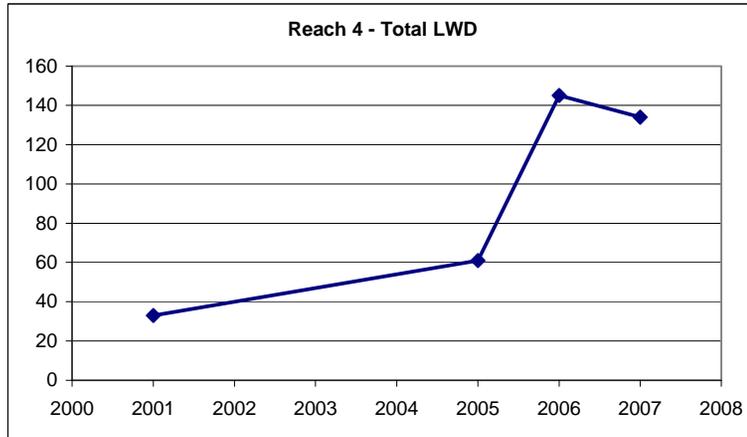
Reach 2	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	36	8.0	0.5	0.0
	2005	83	17.8	1.5	1.3
	2006	126	31.5	1.8	1.5
	2007	73	18.3	0.0	1.8



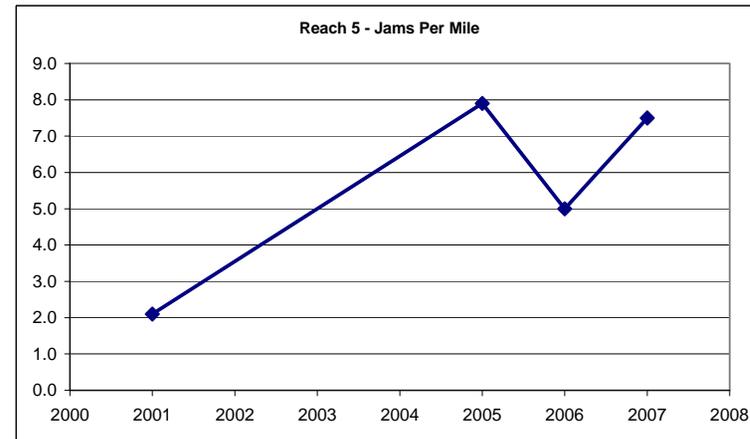
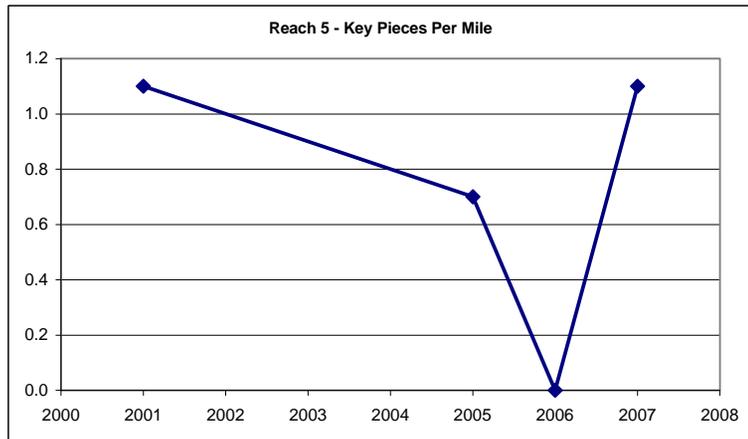
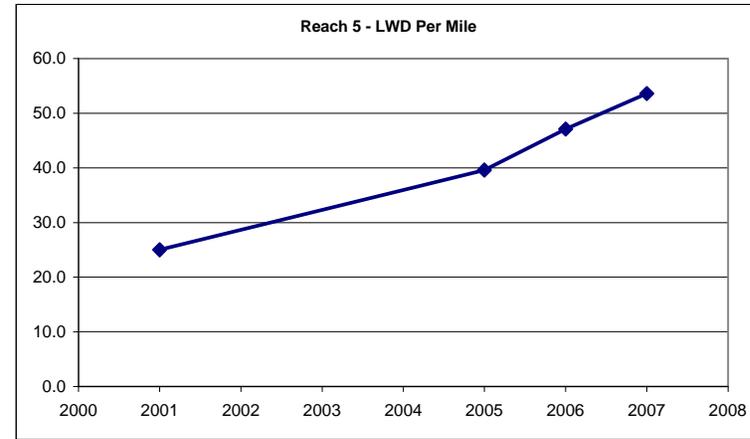
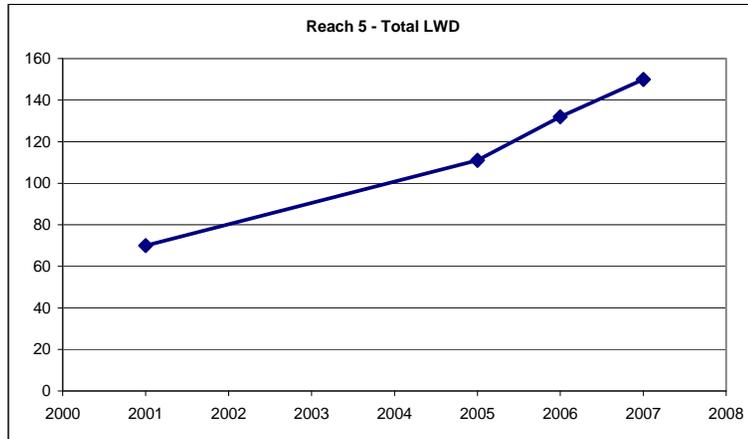
Reach 3	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	164	13.7	0.9	0.7
	2005	352	29.4	1.9	2.4
	2006	584	48.7	2.5	2.3
	2007	399	18.3	1.2	2.8



Reach 4	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	33	7.9	0.95	1.2
	2005	61	14.5	0.24	2.4
	2006	145	34.5	2.1	3.3
	2007	134	31.9	0.2	4.5

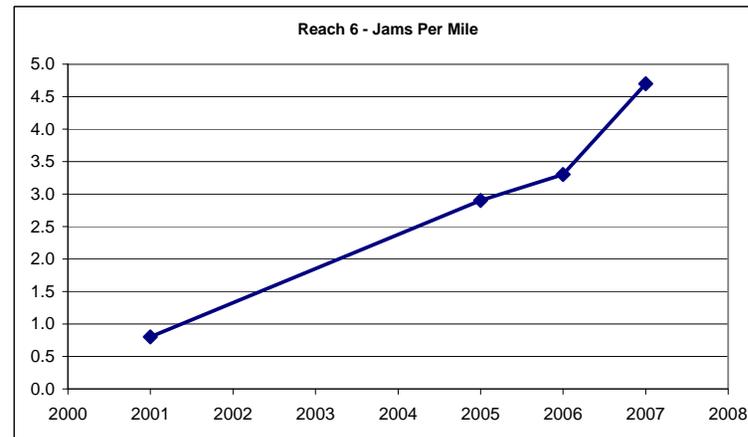
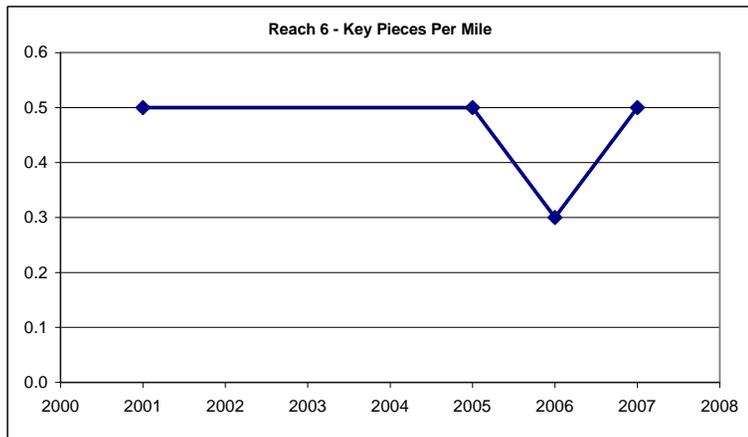
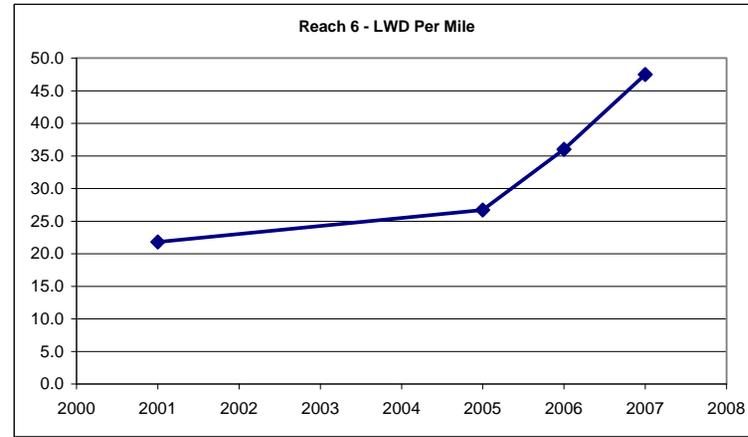
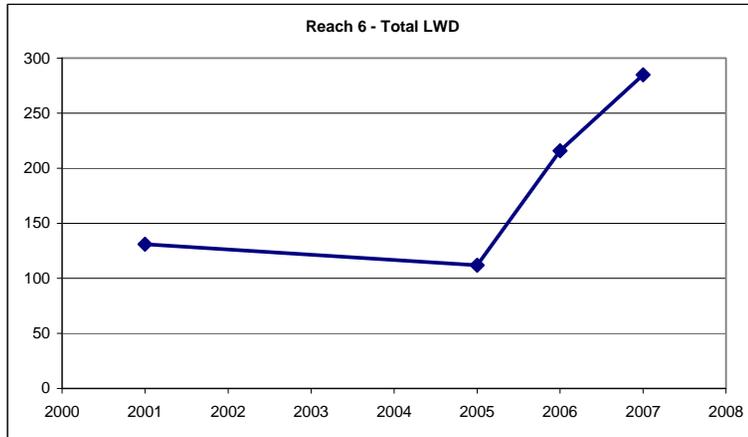


Reach 5	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	70	25.0	1.1	2.1
	2005	111	39.6	0.7	7.9
	2006	132	47.1	0.0	5.0
	2007	150	53.6	1.1	7.5



Reach 6	Survey Year	Total LWD	LWD Per Mile	Key Pieces Per Mile	Jams Per Mile
	2001	131	21.8	0.5	0.8
	2005	112	26.7	0.5	2.9
	2006	216	36.0	0.3	3.3
	2007	285	47.5	0.5	4.7

2005 survey reach length was 1.8 miles shorter than other surveys



# **APPENDIX C**

## **2007 Pebble Count Data**

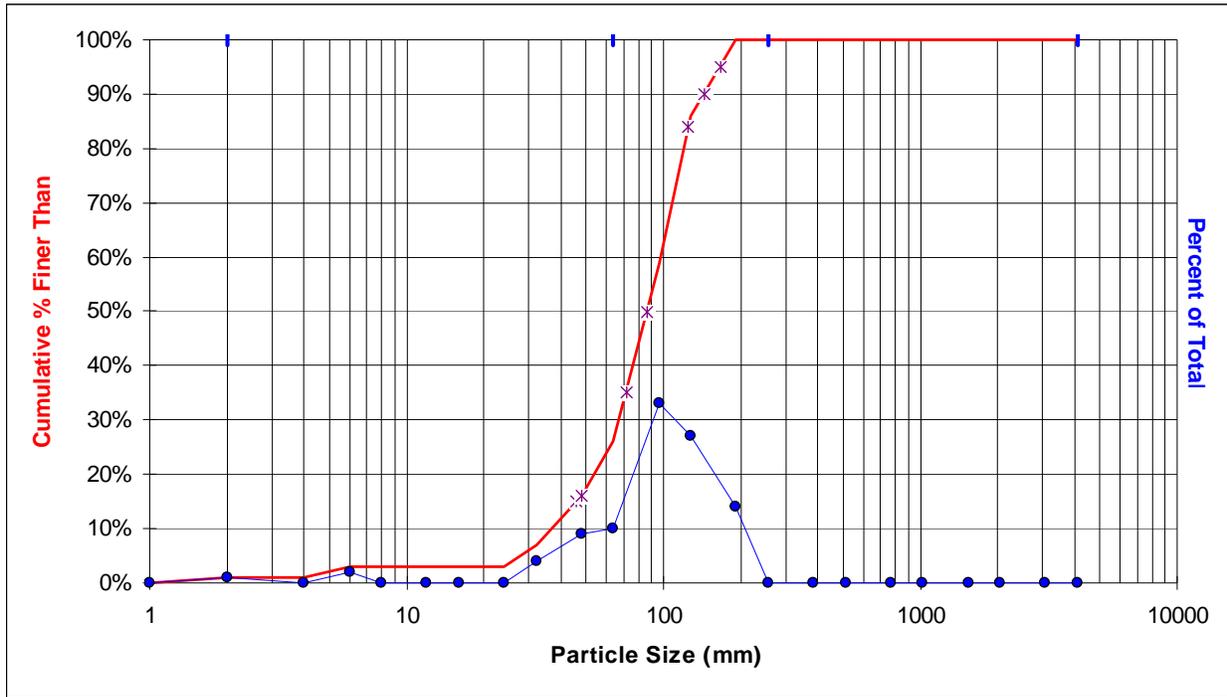


Figure C-1. Reach 2-1.

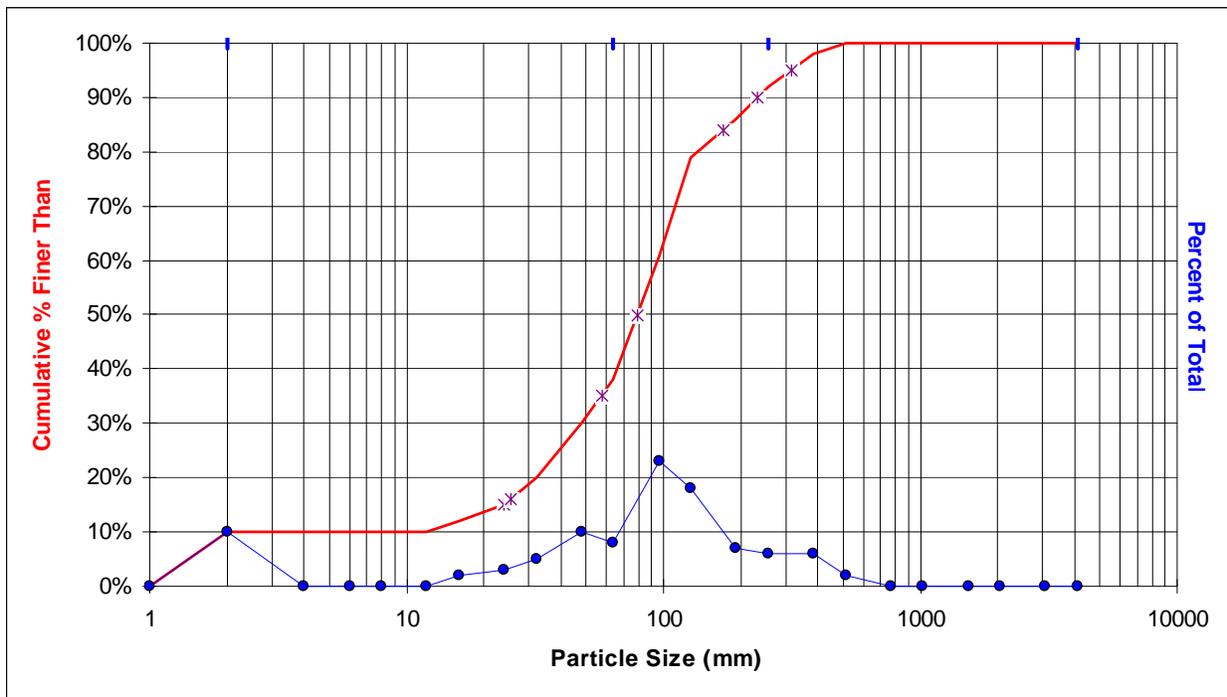


Figure C-2. Reach 2-2.

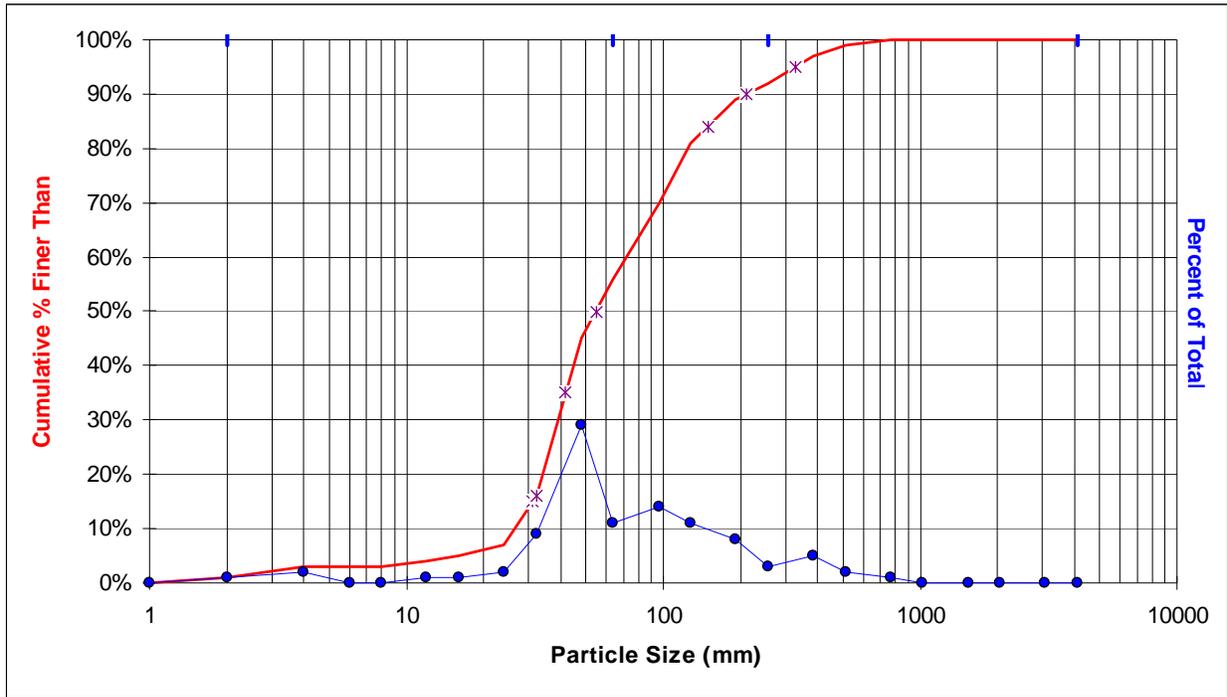


Figure C-3. Reach 2-3.

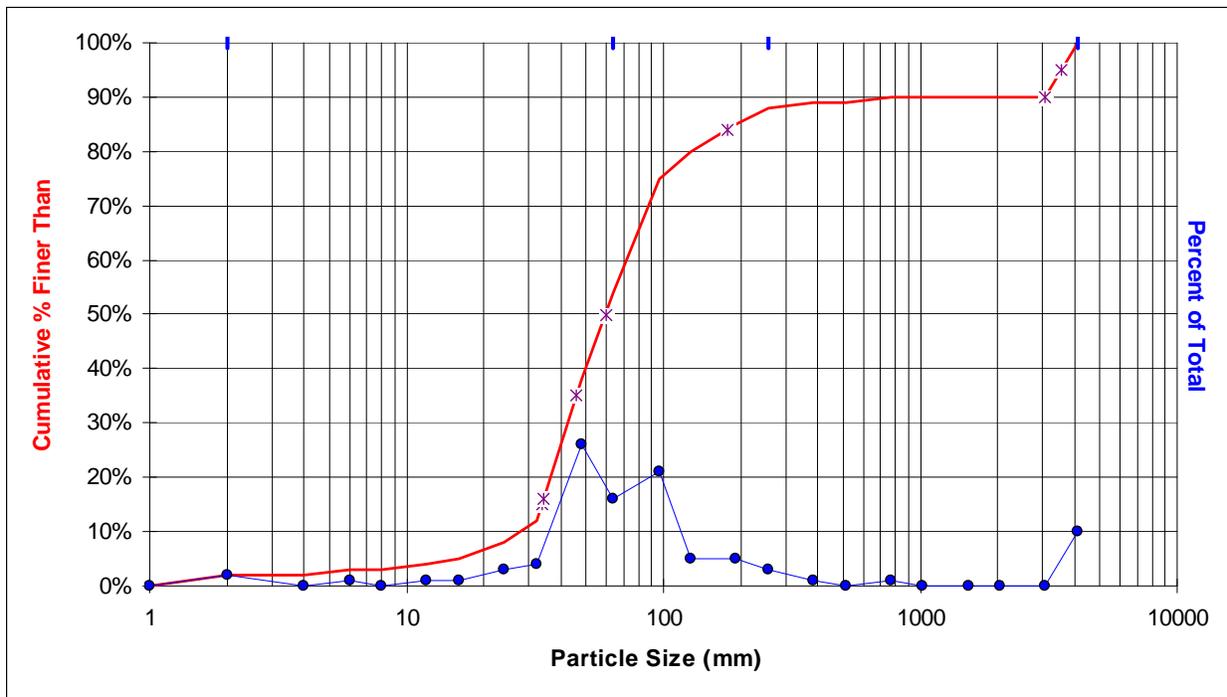


Figure C-4. Reach 2-4.

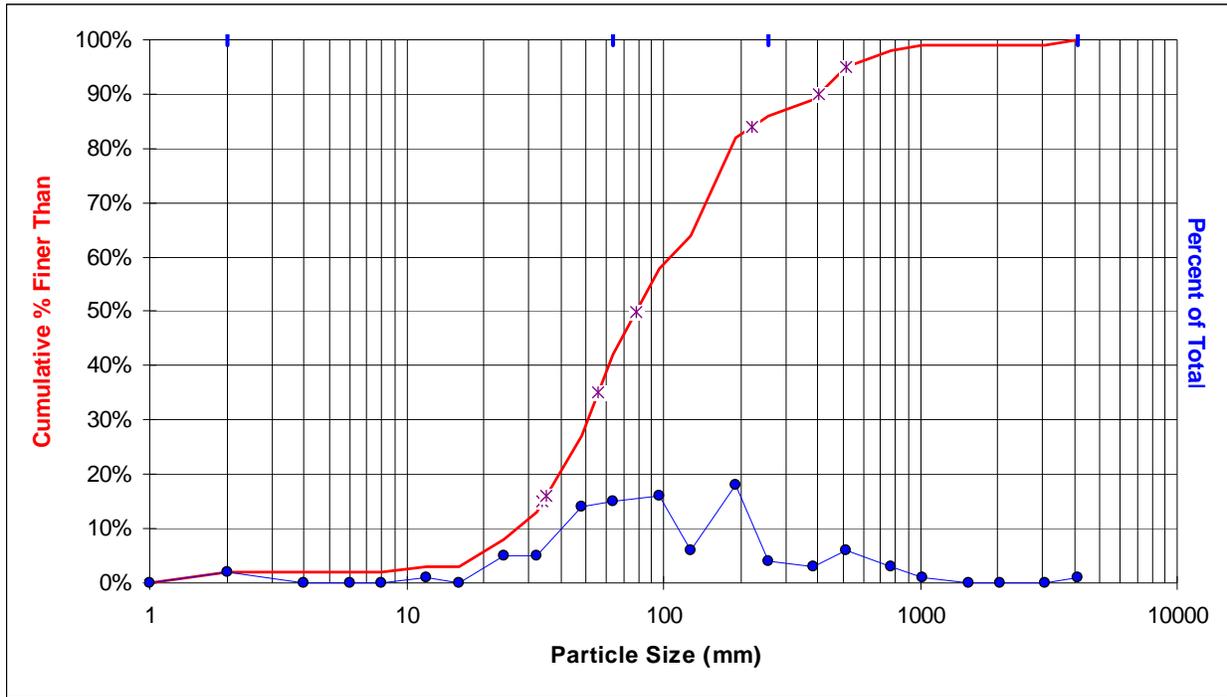


Figure C-5. Reach 3-1.

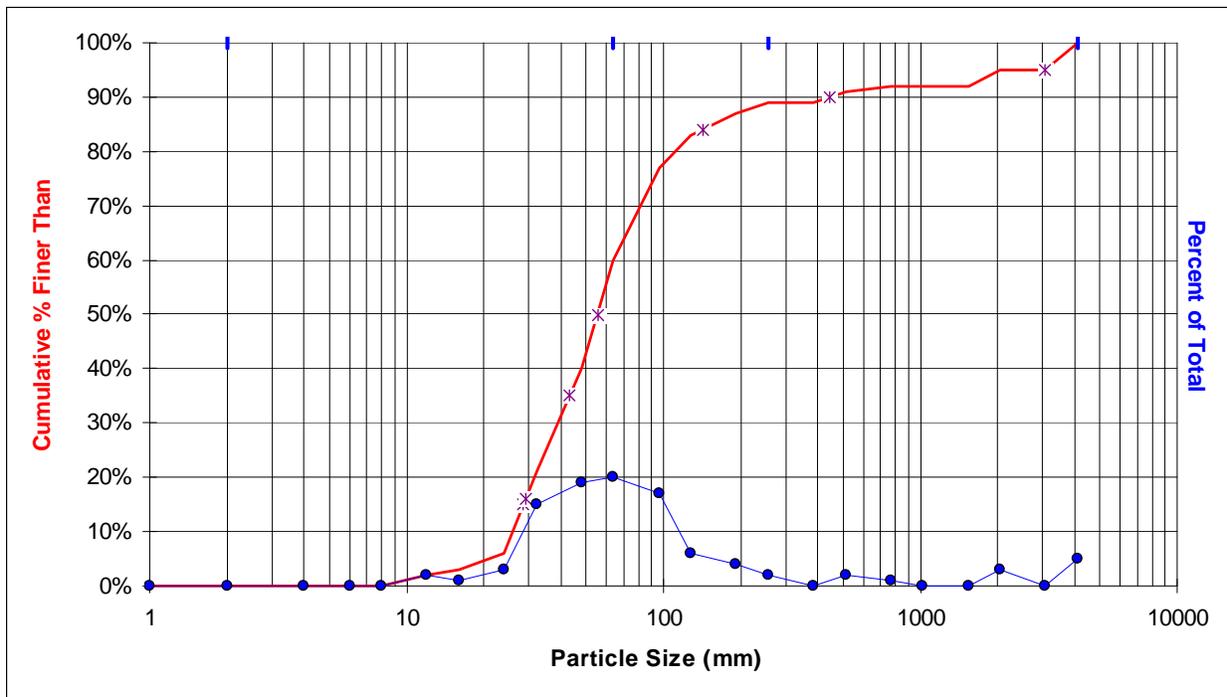


Figure C-6. Reach 3-2.

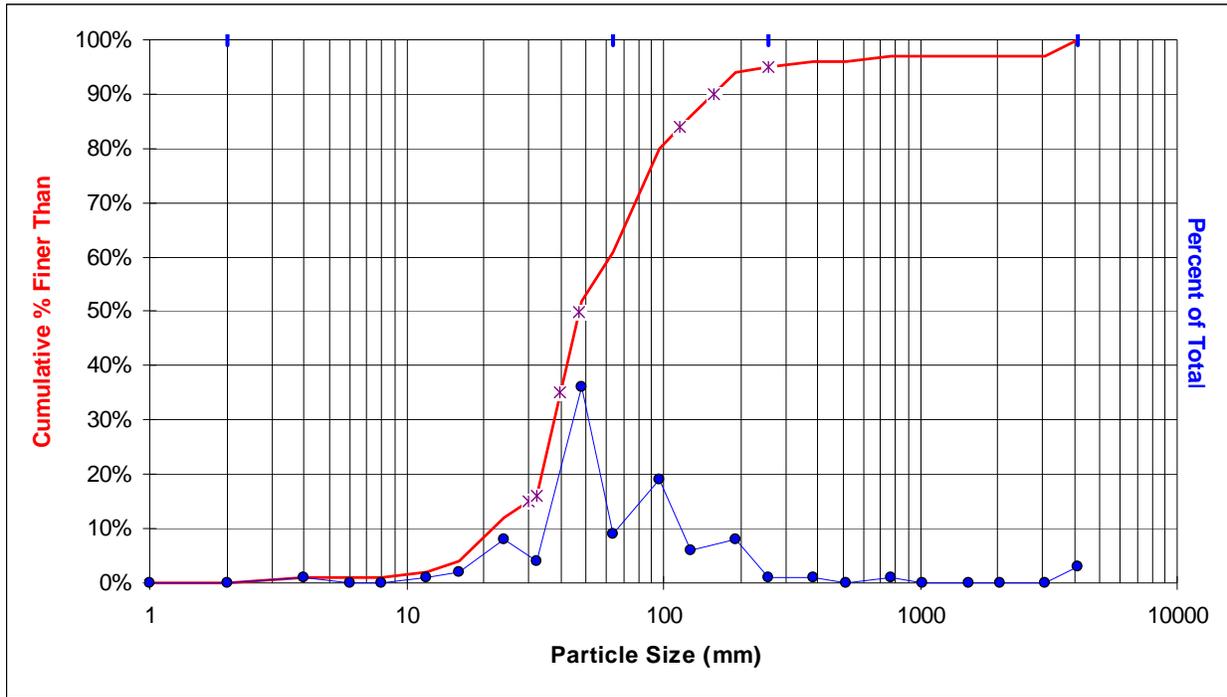


Figure C-7. Reach 3-3.

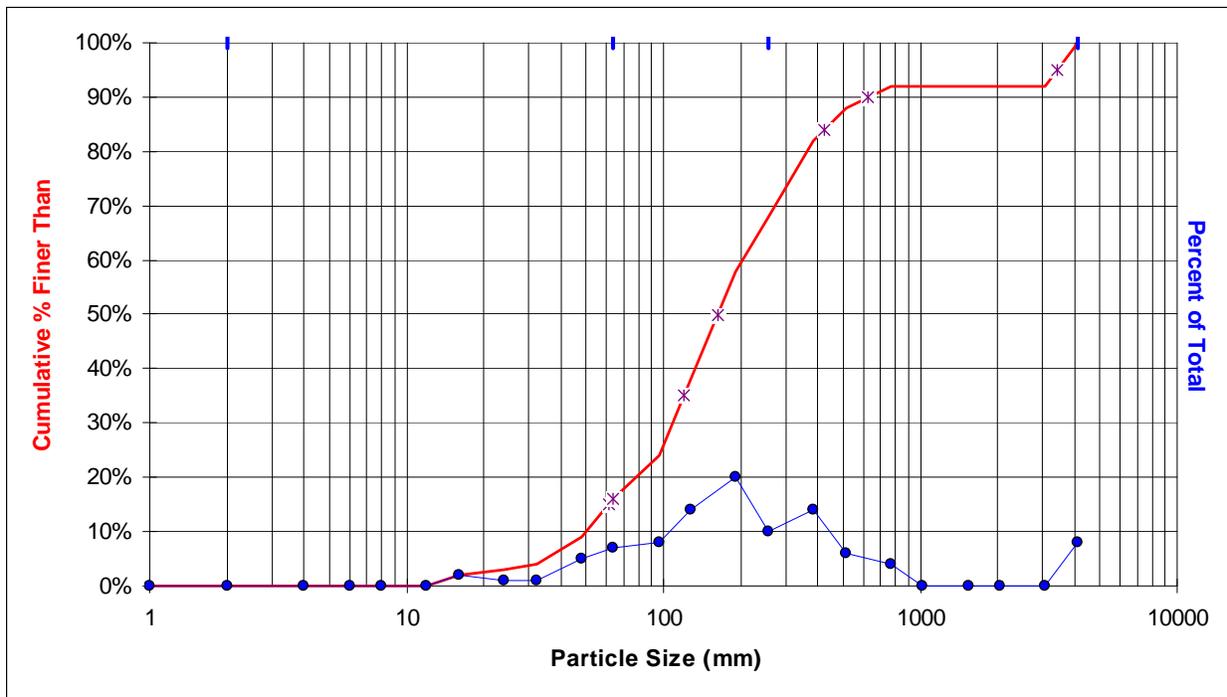


Figure C-8. Reach 3-4.

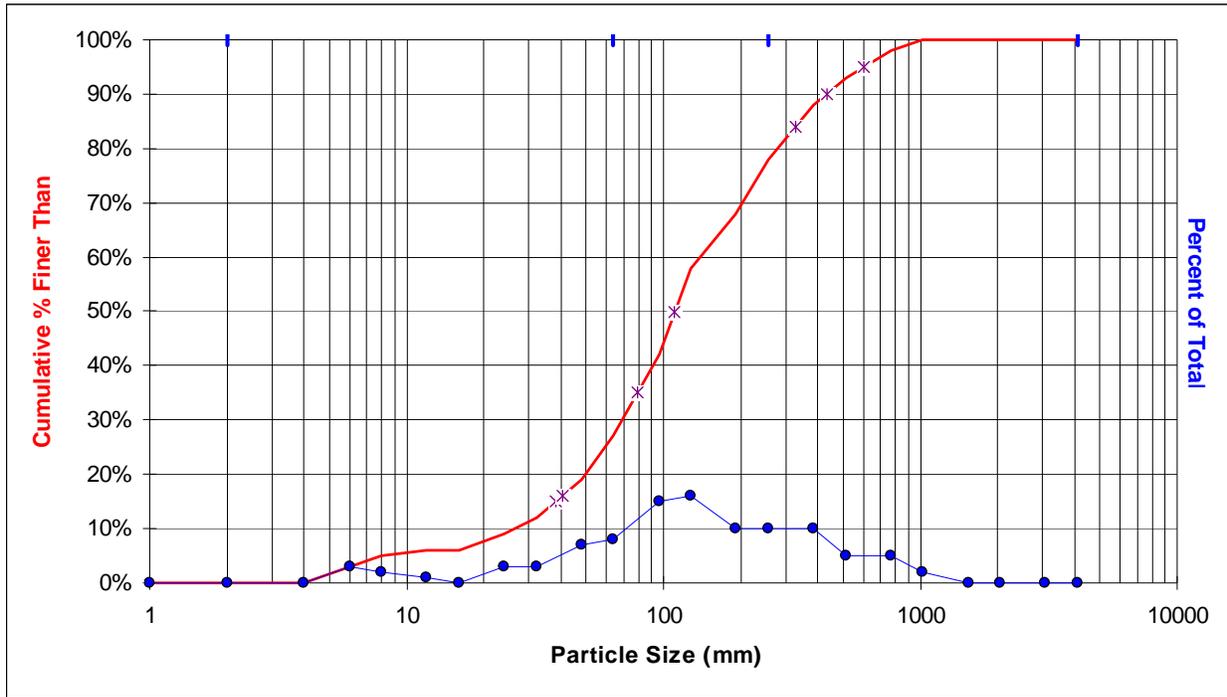


Figure C-9. Reach 3-5.

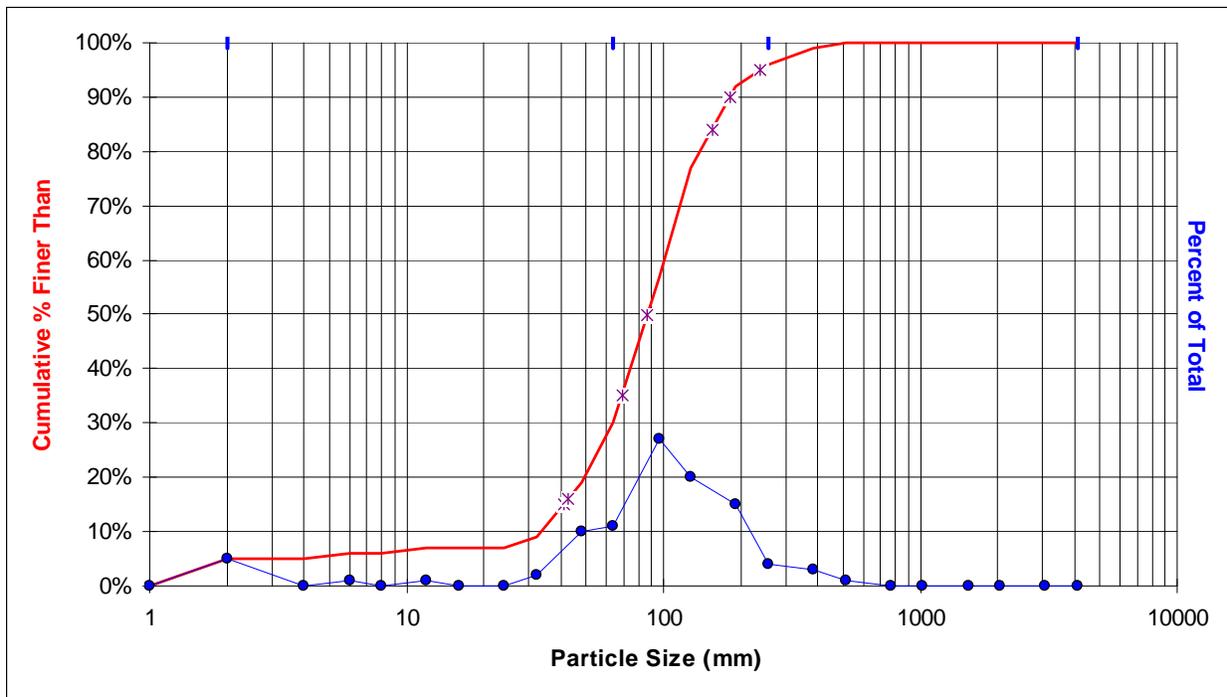


Figure C-10. Reach 3-6.

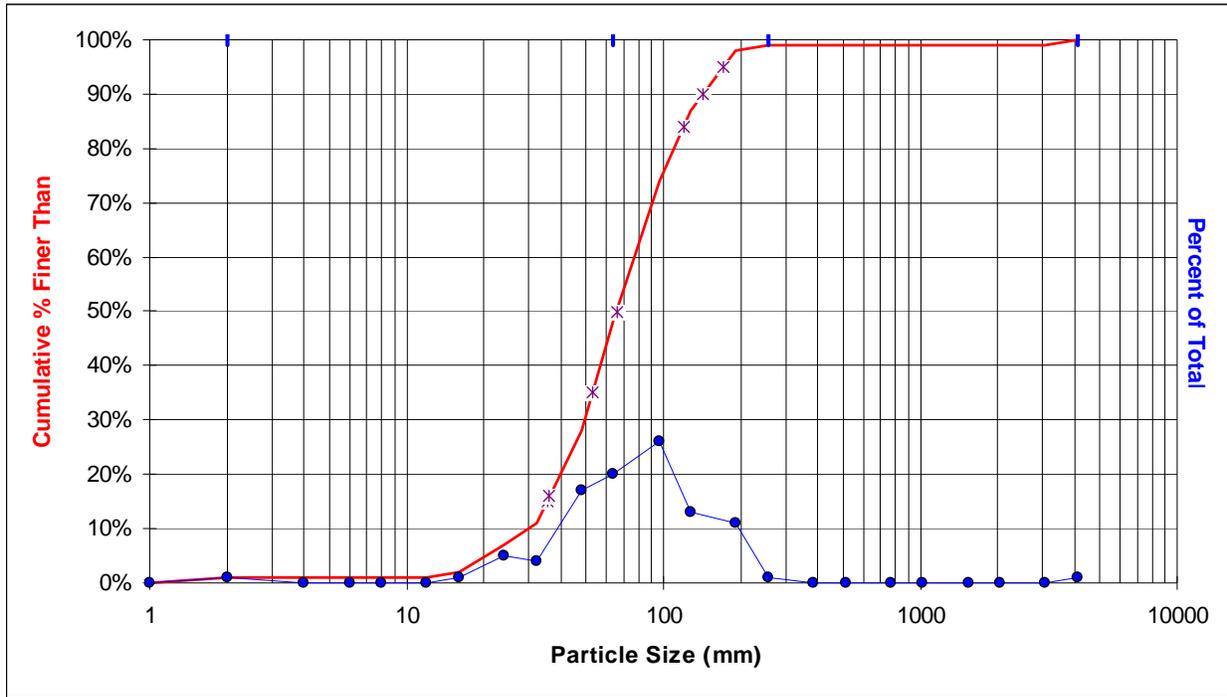


Figure C-11. Reach 4-1.

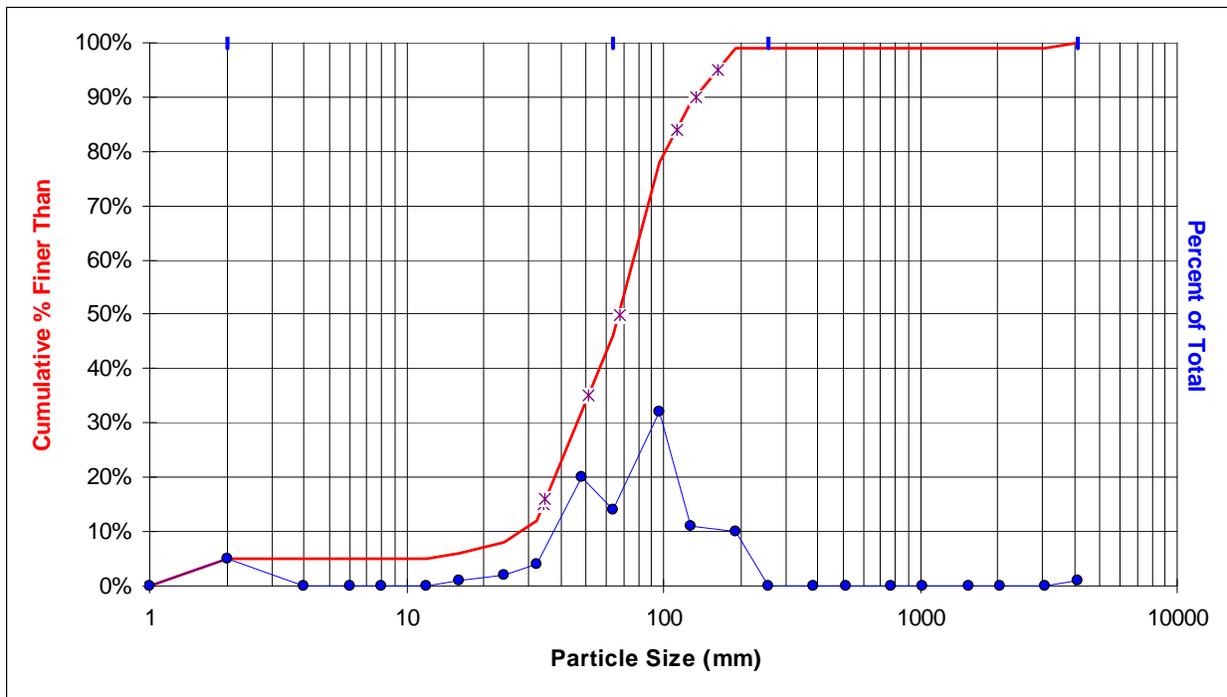


Figure C-12. Reach 4-2.

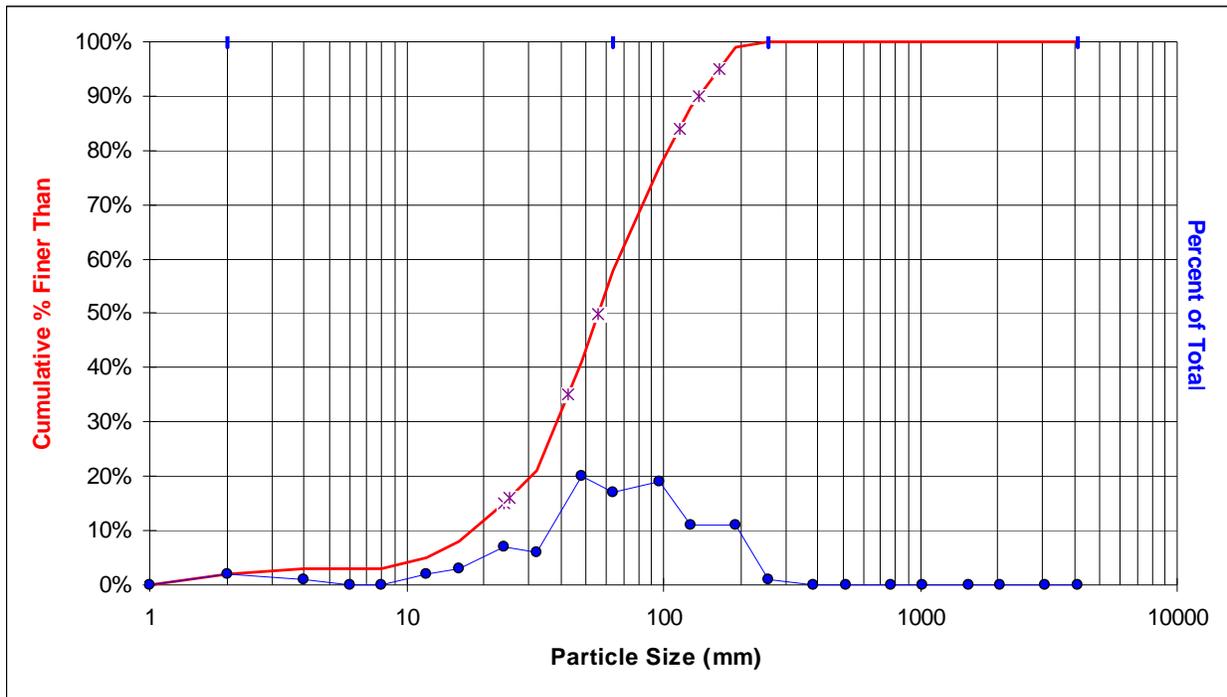


Figure C-13. Reach 4-3.

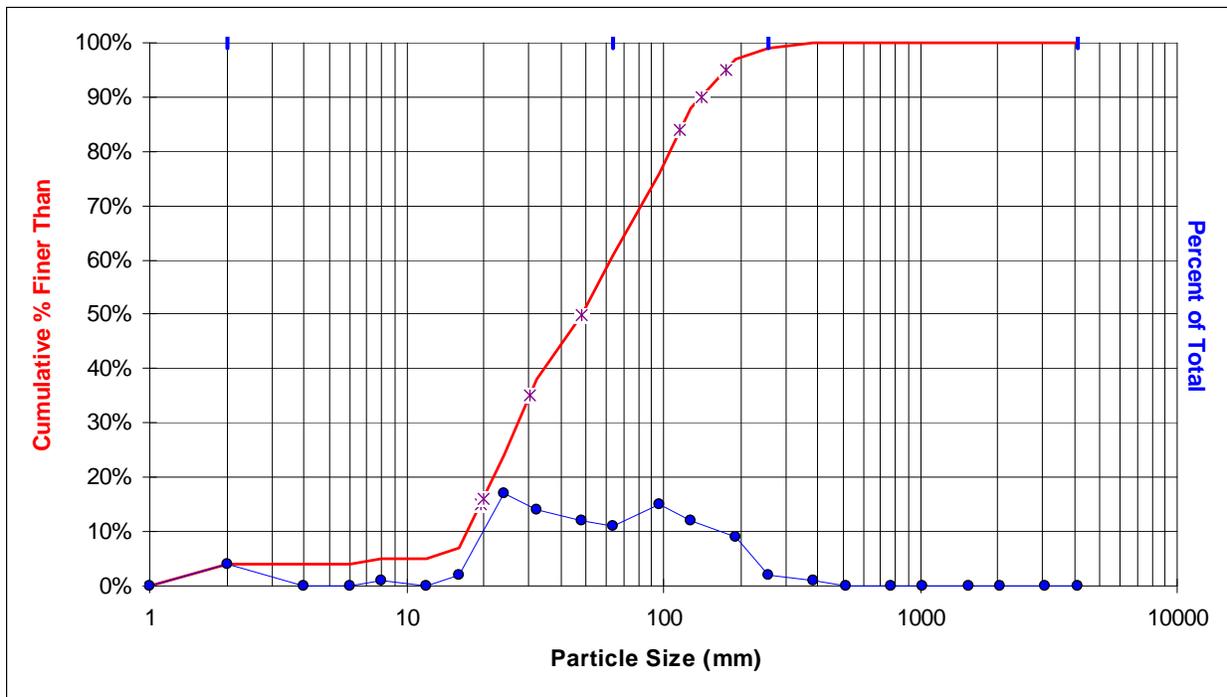


Figure C-14. Reach 4-4.

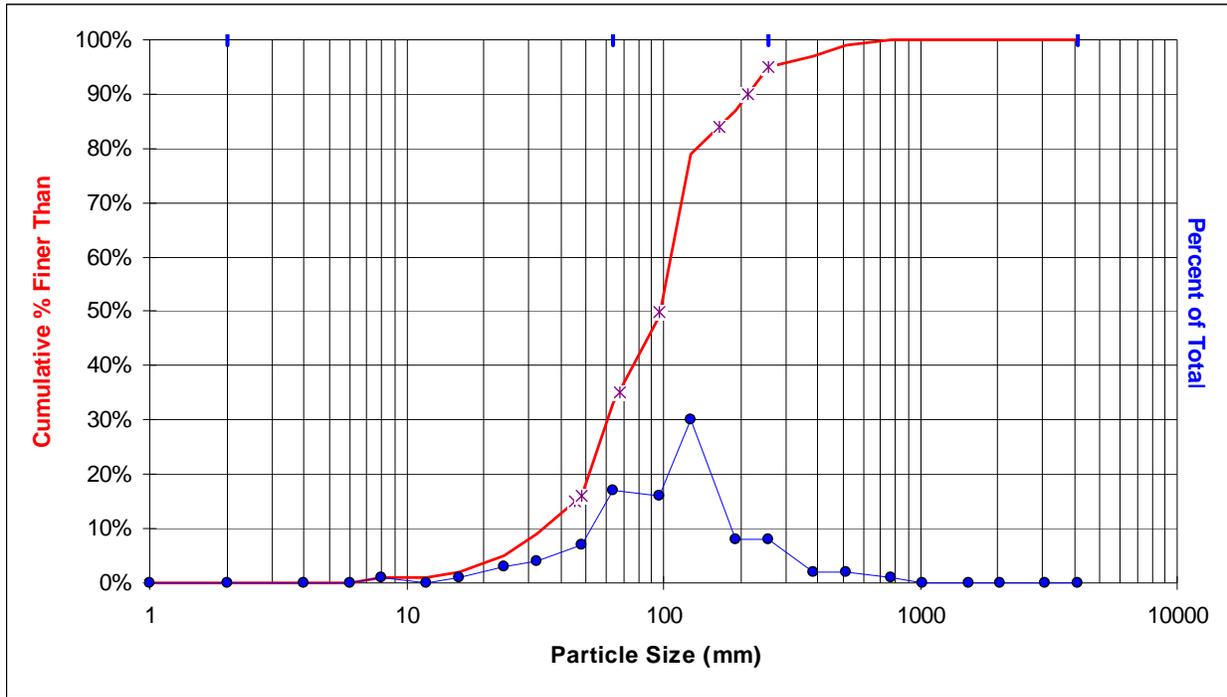


Figure C-15. Reach 4-5.

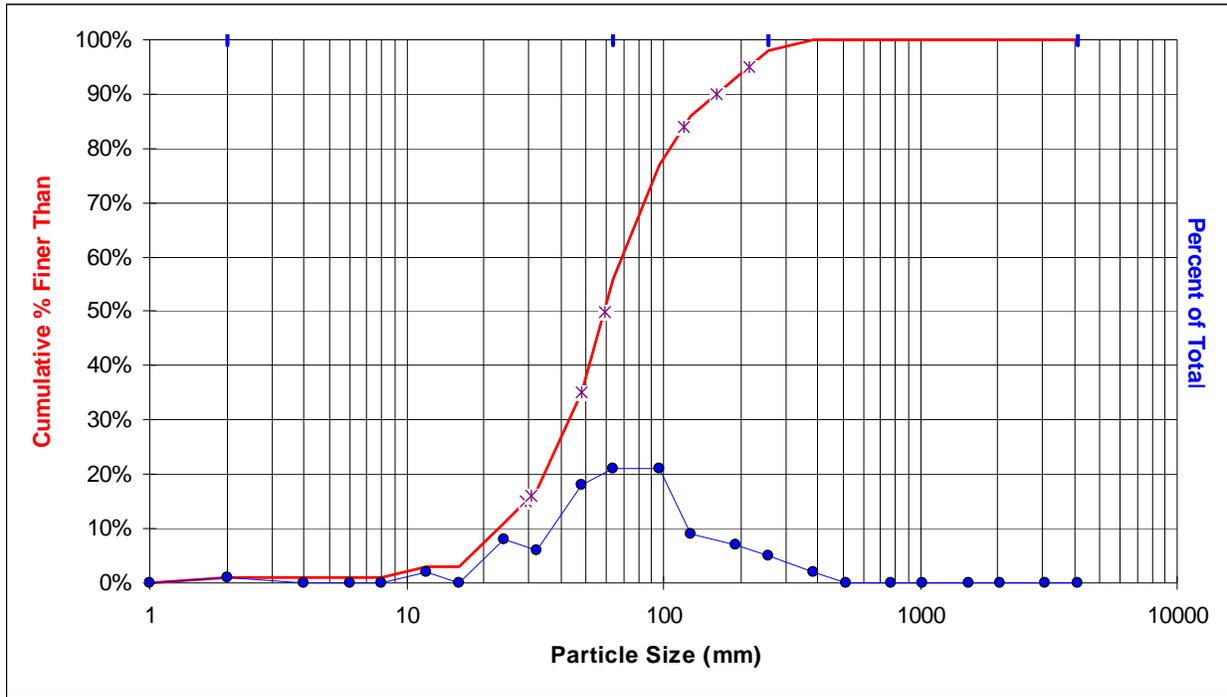


Figure C-16. Reach 5-1.

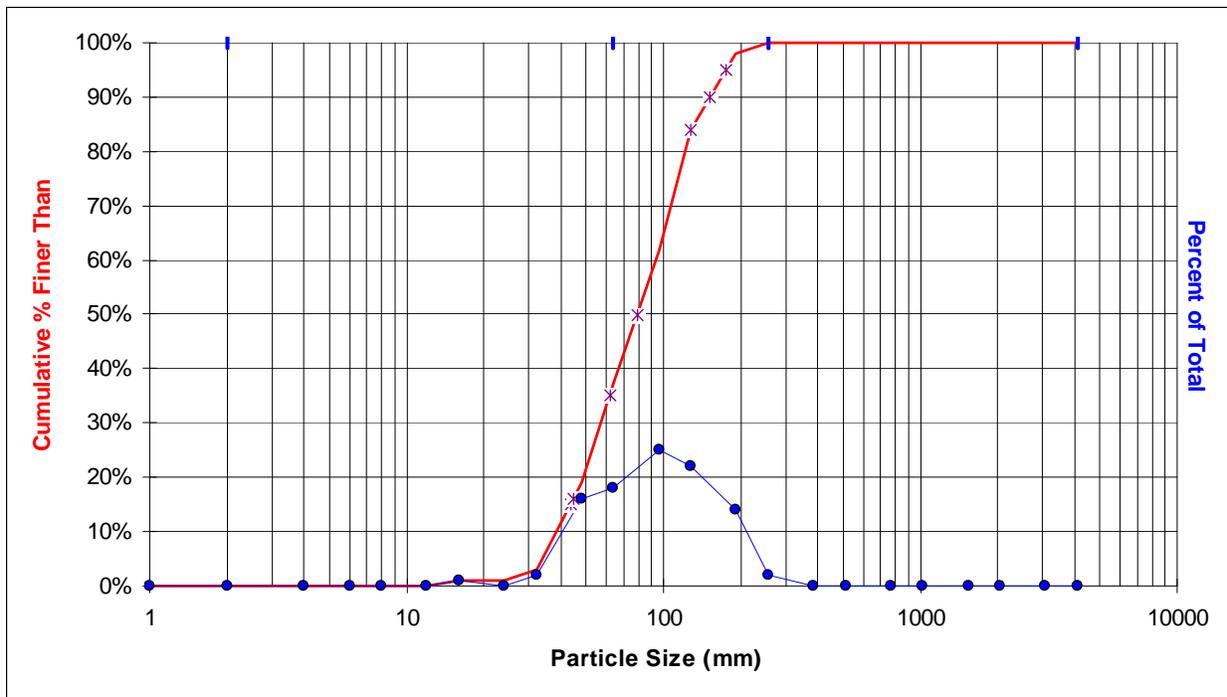


Figure C-17. Reach 5-2.

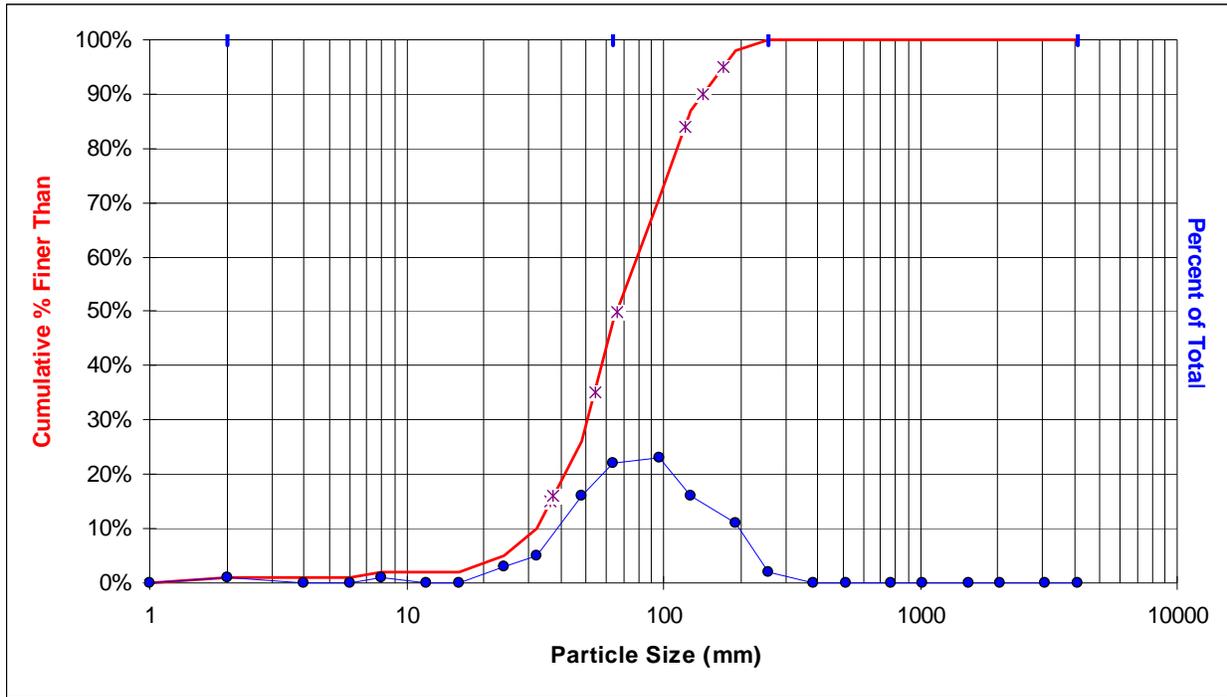


Figure C-18. Reach 5-3.

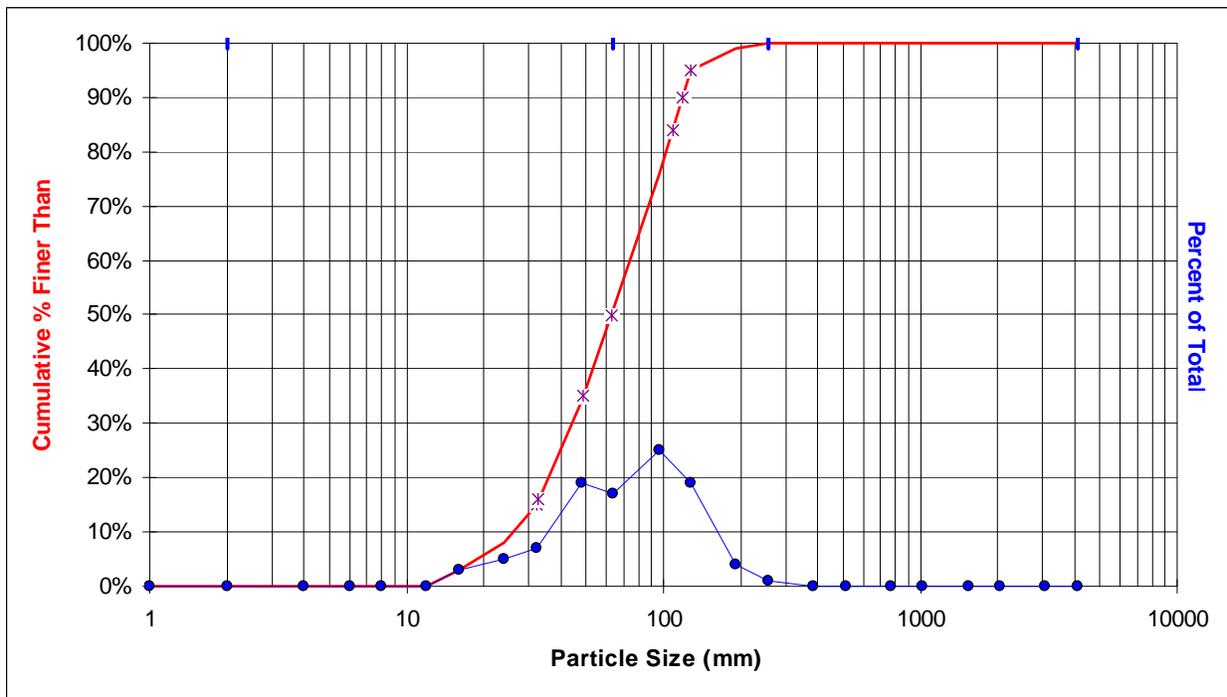


Figure C-19. Reach 5-4.

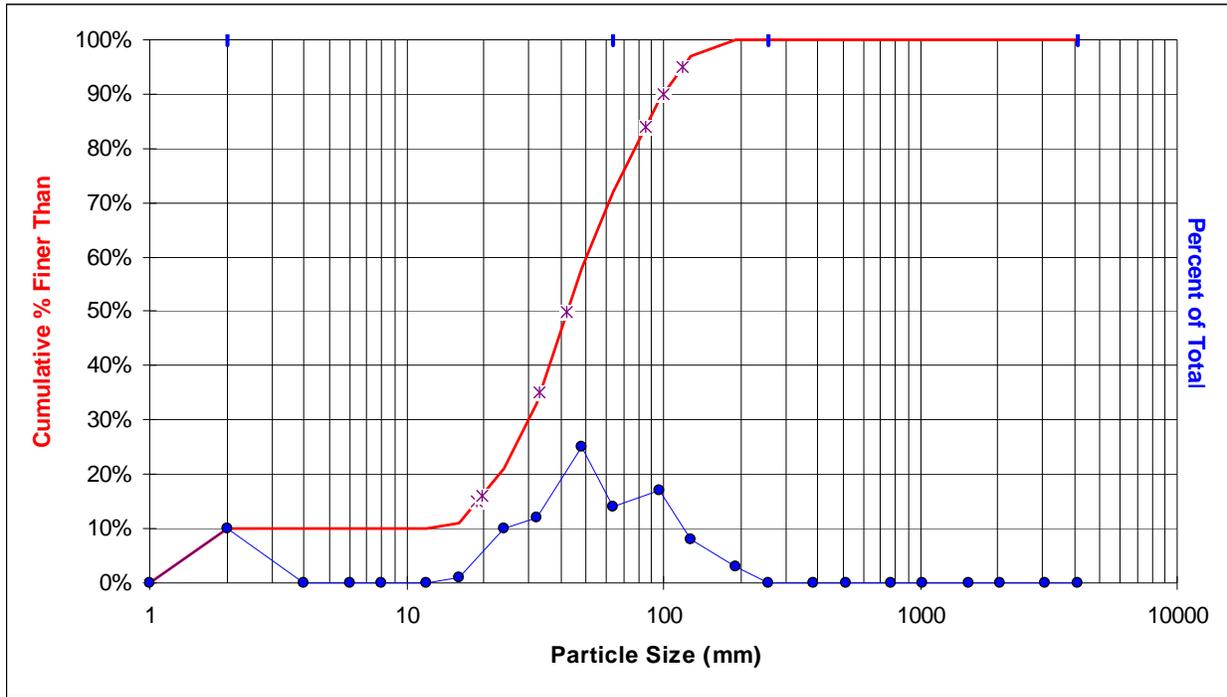


Figure C-20. Reach 5-5.

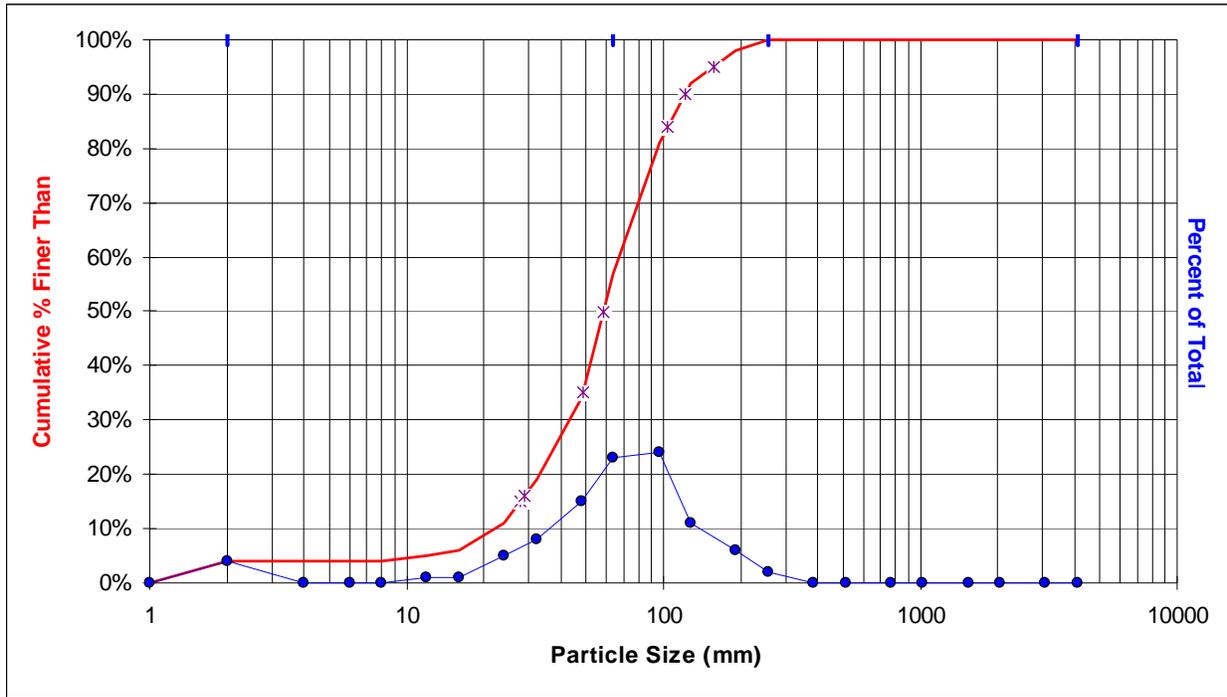


Figure C-21. Reach 6-1.

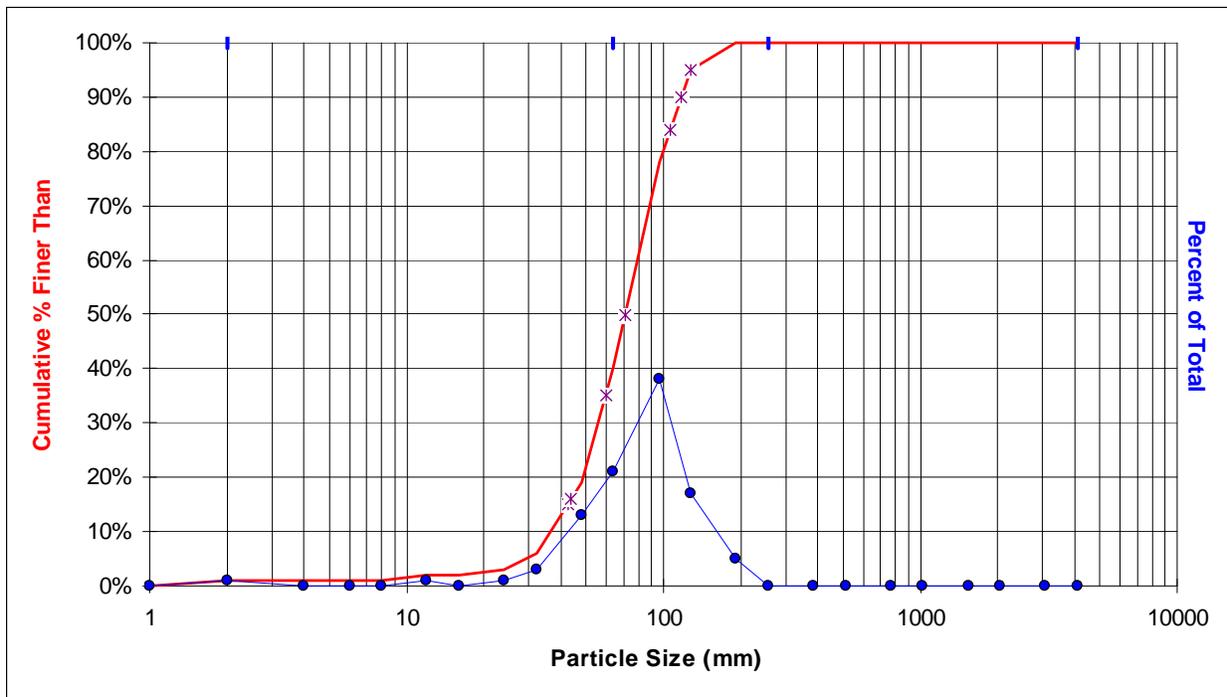


Figure C-22. Reach 6-2.

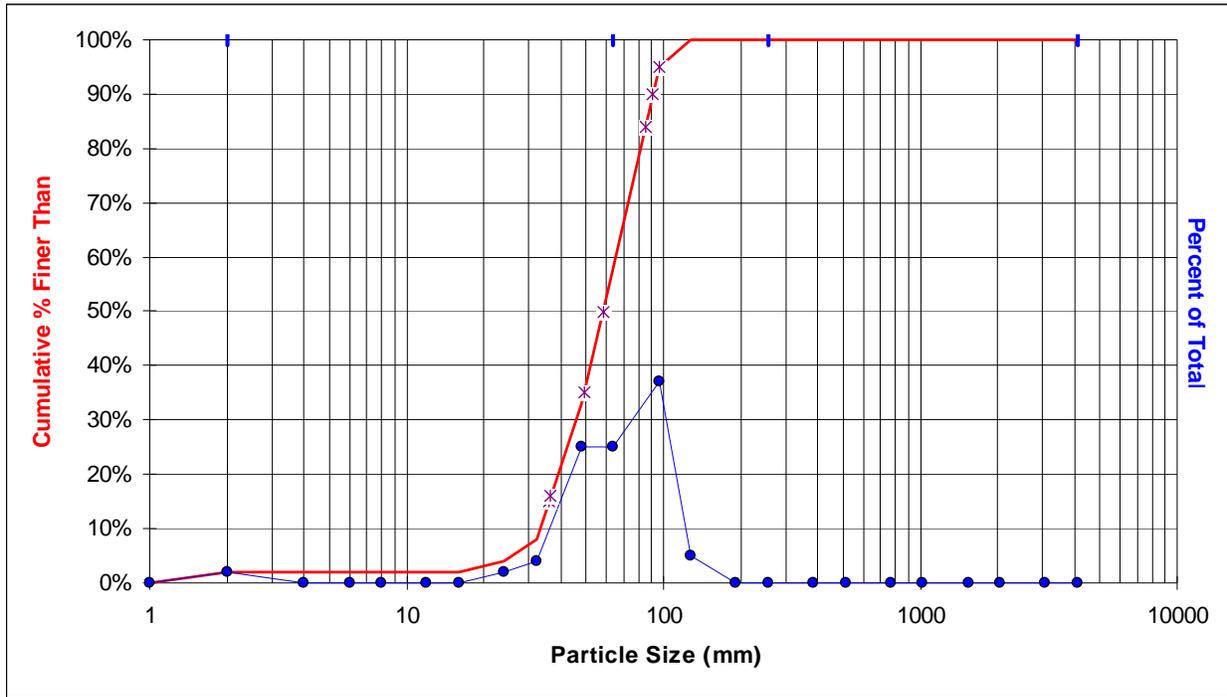


Figure C-23. Reach 6-3.

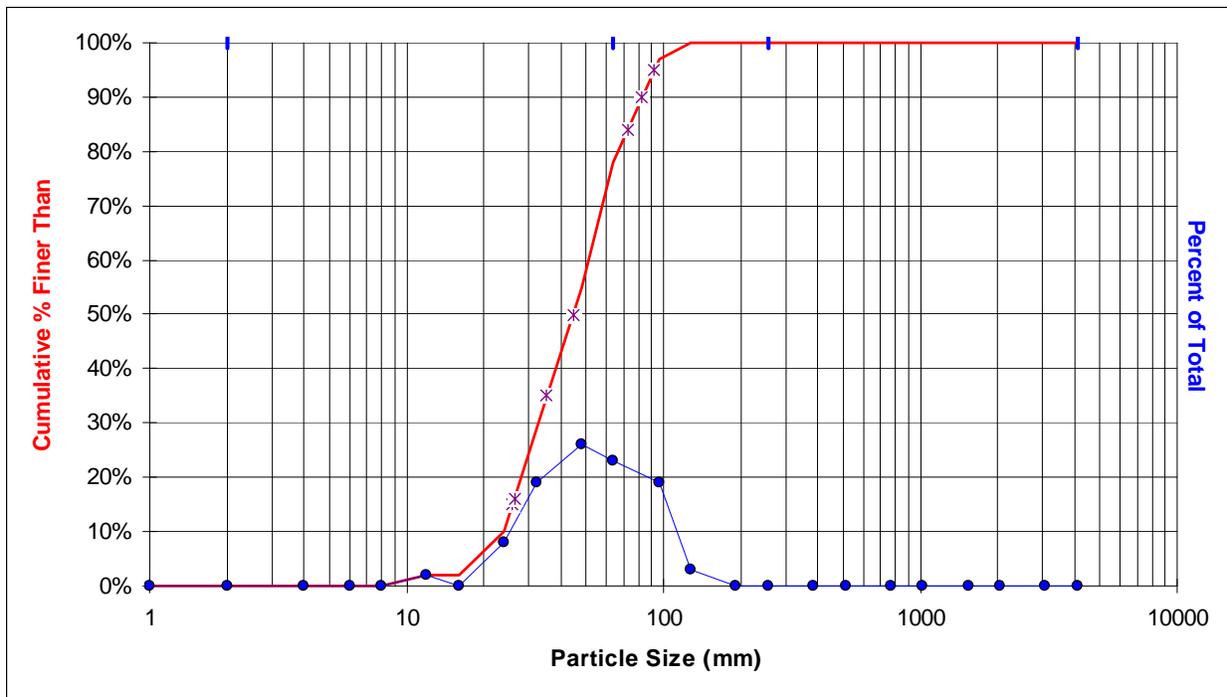


Figure C-24. Reach 6-4.

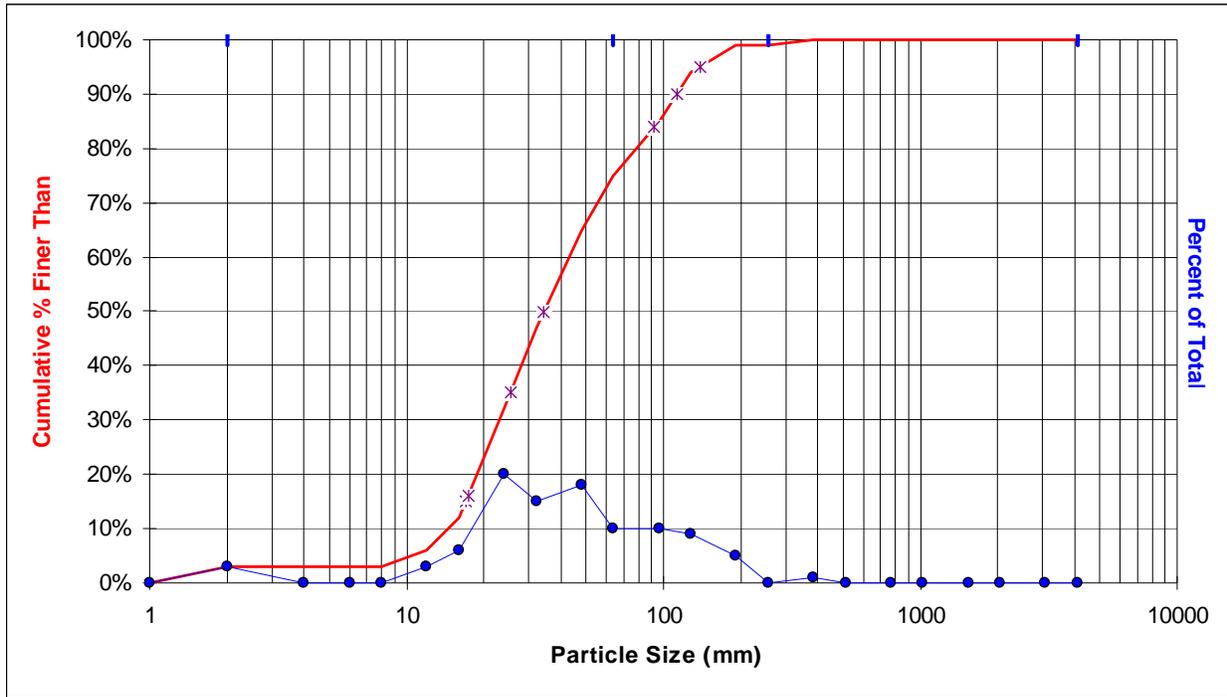


Figure C-25. Reach 6-5.

# **APPENDIX D**

## **2007 Pool and LWD Jam Tables**

Table D-1. Location, size and zone of LWD jams in the middle Green River, Washington, 2007.

Reach	Jam ID	Size	Type	Zone
2	2-A	small	Mainstem	1
2	2-B	small	Mainstem	1
2	2-C	small	Mainstem	2
2	2-D	small	Mainstem	2
2	2-E	medium	Mainstem	2
2	2D-A	small	Side Channel	2
2	2D-B	small	Side Channel	2
3	3-A	small	Mainstem	1
3	3-B	small	Mainstem	2
3	3-C	small	Mainstem	1
3	3-D	small	Mainstem	2
3	3-E	small	Mainstem	2
3	3-F	medium	Mainstem	1
3	3-G	small	Mainstem	1
3	3-H	small	Mainstem	2
3	3-I	small	Mainstem	2
3	3-J	small	Mainstem	2
3	3-K	medium	Mainstem	2
3	3-L	small	Mainstem	2
3	3-M	small	Mainstem	2
3	3-N	small	Mainstem	2
3	3-O	small	Mainstem	1
3	3-P	small	Mainstem	1
3	3-Q	small	Mainstem	1
3	3-R	small	Mainstem	1
3	3-S	small	Mainstem	1
3	3-T	small	Mainstem	2
3	3-U	small	Mainstem	2
3	3-V	medium	Mainstem	2
3	3-W	small	Mainstem	1
3	3-X	small	Mainstem	1
3	3-Y	small	Mainstem	1
3	3-Z	small	Mainstem	1
3	3-A'	small	Mainstem	2
3	3-B'	small	Mainstem	1
3	3-C'	small	Mainstem	1
3	3-D'	small	Mainstem	1
3	3-E'	medium	Mainstem	2
3	3-F'	small	Mainstem	1
3	3-G'	small	Mainstem	1
4	4-A	small	Mainstem	2
4	4-B	small	Mainstem	1
4	4-C	small	Mainstem	1
4	4-D	small	Mainstem	2

Reach	Jam ID	Size	Type	Zone
4	4-E	medium	Mainstem	1
4	4-F	medium	Mainstem	1
4	4-G	small	Mainstem	1
4	4-H	small	Mainstem	1
4	4-I	small	Mainstem	1
4	4-J	medium	Mainstem	1
4	4-K	small	Mainstem	1
4	4-L	small	Mainstem	1
4	4-M	small	Mainstem	2
4	4-N	small	Mainstem	1
4	4A-A	medium	Side Channel	1
4	4D-A	small	Side Channel	1
4	4D-B	small	Side Channel	1
4	4D-C	small	Side Channel	1
4	4D-D	small	Side Channel	1
5	5-A	small	Mainstem	2
5	5-B	small	Mainstem	2
5	5-C	medium	Mainstem	1
5	5-D	small	Mainstem	2
5	5-E	small	Mainstem	1
5	5F	large	Mainstem	1
5	5G	small	Mainstem	2
5	5H	medium	Mainstem	1
5	5D-A	small	Side Channel	1
5	5D-B	medium	Side Channel	1
5	5D-C	small	Side Channel	1
5	5D-D	large	Side Channel	1
5	5D-E	medium	Side Channel	1
5	5D-F	small	Side Channel	1
5	5E-A	small	Side Channel	1
5	5E-B	small	Side Channel	1
5	5E-C	small	Side Channel	1
5	5H-A	small	Side Channel	2
5	5J-A	large	Side Channel	1
5	5J-B	small	Side Channel	1
5	5L-A	small	Side Channel	1
6	6-A	small	Mainstem	1
6	6-B	small	Mainstem	2
6	6-C	small	Mainstem	1
6	6-D	medium	Mainstem	1
6	6-E	medium	Mainstem	1
6	6-F	medium	Mainstem	1
6	6-G	small	Mainstem	1
6	6-H	small	Mainstem	1
6	6-I	small	Mainstem	1

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<b>Reach</b>	<b>Jam ID</b>	<b>Size</b>	<b>Type</b>	<b>Zone</b>
6	6-J	small	Mainstem	1
6	6-K	small	Mainstem	1
6	6-L	medium	Mainstem	1
6	6-M	small	Mainstem	1
6	6-O	medium	Mainstem	1
6	6-P	medium	Mainstem	1
6	6-Q	large	Mainstem	1
6	6-R	small	Mainstem	1
6	6-S	large	Mainstem	1
6	6-T	small	Mainstem	1
6	6B-A	small	Side Channel	1
6	6D-A	small	Side Channel	1
6	6E-A	small	Side Channel	1
6	6H-A	large	Side Channel	1
6	6M-A	small	Side Channel	1
6	6P-A	small	Side Channel	1
6	6R-A	small	Side Channel	1
6	6S-A	small	Side Channel	1
6	6S-B	small	Side Channel	1

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Table D-2. Habitat statistics for pool units in the middle Green River, Washington, 2007.

Reach	Pool	Measured Length (yd)	Width (yd)	Max Depth (ft)	Control Depth (ft)	Residual Depth (ft)	Type	Formation
2	1	130	26	14.5	2.0	12.5	mcs	bf
2	2	175	22	13.5	2.8	10.7	mcs	bf
2	3	175	34	14.2	4.2	10.0	mcs	bed
2	4	160	36	14.2	1.5	12.7	lcs	bed
2	5	110	48	6.0	2.6	3.4	mcs	jam
2	6	120	50	16.5	1.5	15.0	lcs	bed
2	7	150	42	6.5	1.8	4.7	mcs	bf
2	8	45	40	7.2	3.2	4.0	lcs	bridge
2	9	60	26	7.8	3.1	4.7	lcs	bed
2	10	120	35	15.0	2.1	12.9	p	bed
2	11	250	36	11.2	3.2	8.0	mcs	bed
2	12	95	28	14.1	2.0	12.1	mcs	bed
2	13	100	30	9.8	1.4	8.4	lcs	bed
2	14	160	34	9.2	1.6	7.6	lcs	bed
2	15	60	46	12.0	2.6	9.4	mcs	bed
2	16	78	34	13.2	1.5	11.7	lcs	bed
<b>AVERAGE</b>		<b>124.3</b>	<b>35.4</b>	<b>11.6</b>	<b>2.3</b>	<b>9.2</b>		
3	1	80	40	11.4	1.4	10.0	lcs	bed
3	2	60	36	7.3	3.0	4.3	mcs	bld
3	3	75	36	9.0	2.8	6.2	p	bed
3	4	72	42	6.3	2.2	4.1	lcs	bed
3	5	120	22	10.6	1.4	9.2	mcs	bed
3	6	126	42	18.2	1.4	16.8	p	bed
3	7	85	36	15.0	2.5	12.5	mcs	bf
3	8	140	30	20.0	2.3	17.7	lcs	bed
3	9	70	36	14.0	2.0	12.0	mcs	bed
3	10	120	30	18.0	2.5	15.5	lcs	bed
3	11	70	30	12.0	3.6	8.4	mcs	bed
3	12	156	42	15.0	2.4	12.6	mcs	bed
3	13	58	22	6.5	2.2	4.3	mcs	bed
3	14	88	24	12.0	2.8	9.2	mcs	bed
3	15	96	26	9.0	2.5	6.5	mcs	bed
3	16	140	32	14.0	2.7	11.3	mcs	bed
3	17	135	27	17.0	2.4	14.6	mcs	bed
3	18	150	36	12.0	1.5	10.5	mcs	bed
3	19	64	24	13.0	2.0	11.0	lcs	bed
3	20	80	40	24.0	1.4	22.6	mcs	bed
3	21	54	30	11.0	2.0	9.0	mcs	bed
3	22	125	35	14.0	3.7	10.3	p	bed
3	23	105	40	7.5	2.2	5.3	mcs	bld
3	24	126	30	13.0	2.5	10.5	p	bed
3	25	134	36	9.0	1.8	7.2	lcs	bed

Reach	Pool	Measured Length (yd)	Width (yd)	Max Depth (ft)	Control Depth (ft)	Residual Depth (ft)	Type	Formation
3	26	100	38	14.0	2.5	11.5	mcs	bed
3	27	148	30	12.0	2.0	10.0	lcs	bed
<b>AVERAGE</b>		<b>102.9</b>	<b>33.0</b>	<b>12.8</b>	<b>2.3</b>	<b>10.5</b>		
4	1	180	45	10.2	1.8	8.4	lcs	bed
4	2	140	36	7.0	1.5	5.5	mcs	bf
4	3	260	42	10.8	2.0	8.8	lcs	bed
4	4	120	47	12.2	1.8	10.5	lcs	bed
4	5	210	45	7.8	2.5	5.3	lcs	bf
<b>AVERAGE</b>		<b>182.0</b>	<b>43.0</b>	<b>9.6</b>	<b>1.9</b>	<b>7.7</b>		
5	1	265	23	9.5	2.5	7.0	lcs	log
<b>AVERAGE</b>		<b>265</b>	<b>23</b>	<b>9.5</b>	<b>2.5</b>	<b>7</b>		
6	1	180	36	14.0	1.3	12.8	lcs	bed
6	2	230	32	10.2	1.1	9.1	lcs	bf
6	3	430	35	8.0	1.4	6.6	lcs	bf
6	4	210	33	8.0	1.2	6.8	lcs	bf
6	5	190	25	11.0	2.0	9.0	lcs	bed
6	6	215	30	7.0	1.5	5.5	lcs	bf
6	7	70	33	10.0	1.8	8.3	lcs	rr
6	8	170	21	11.0	1.7	9.3	lcs	bed
6	9	110	29	10.0	2.0	8.0	lcs	jam
6	10	170	22	12.0	2.0	10.0	lcs	bed
6	11	205	38	13.0	2.5	10.5	lcs	jam
<b>AVERAGE</b>		<b>198.2</b>	<b>30.4</b>	<b>10.4</b>	<b>1.7</b>	<b>8.7</b>		

# **APPENDIX E**

## **2007 Side Channel Habitat Information**

Table E-1. 2007 Side channel habitat data for the middle Green River, Washington, 2007.

Side Channel	Unit	Length	Average Width (ft)	Formation Factor	Max Depth (ft)
<b>2B</b> Palmer Slough	Glide	30	8		
	Run	50	5		
	Run	30	5		
	Riffle	15	8		
	Pool	100	8	Dam	4.0
	culvert	150			
	Pool	20	15	Dam	1.5
	Pool	20	20	Dam	1.2
	Pool	100	15	Dam	2.5
	Pool	75	50	Dam	3.0
	Pool	65	25	Dam	3.0
	Pool	160	25	Dam	3.5
<b>2D-2</b>	Riffle	200	15		
	Pool	150	15	Bedform	2.0
	Riffle	200	20		
	Pool	100	20	Bedform	1.0
	Riffle	250	25		
	Riffle	80	20		
	Pool	80	20	Jam	2.0
	Riffle	250	35		
<b>2F</b>	Riffle	200	25		
	Pool	50	20	Bedform	2.0
	Riffle	150	25		
<b>3B</b>	Riffle	516	24		
<b>3G</b>	Riffle	976	25		
<b>4C</b>	Riffle	108	5		
	Pool	50	5	Bedform	2.0
	Riffle	108	5		

Side Channel	Unit	Length	Average Width (ft)	Formation Factor	Max Depth (ft)
<b>4G-1</b>	Riffle	50	10		
	Pool	210	18		
	Riffle	210	15		
	Glide	150	20		
	Riffle	60	22		
	Glide	150	25		
	Riffle	210	25		
	Pool	40	20	Bedform	3.0
<b>4H</b>	Riffle	150	40		
	Pool	75	34	LCS	4.0
	Riffle	75	40		
<b>5C</b>	No detailed habitat measurements available for this side channel, see notes in section 4.2.5 for general description				
<b>5D</b> MOAS	Riffle	150	30		
	Run	160	25		
	Riffle	120	20		
	Run	90	24		
	Riffle	300	40		
	Pool	36	28	LWD	3.0
	Riffle	600	40		
	Run	550	40		
	Riffle	180	45		
	Run	180	45		
	Riffle	50	40		
	Run	150	45		
	Riffle	200	45		
<b>5E-1</b>	Run	69	18		
	Pool	21	18	Plunge	5.0
	Run	75	15		
	Riffle	165	18		
	Run	33	15		
	Riffle	54	10		

Side Channel	Unit	Length	Average Width (ft)	Formation Factor	Max Depth (ft)
<b>5I</b> lower end only	Run	90	36		
	Riffle	110	30		
	Run	235	48		
	Riffle	252	75		
<b>6S-1</b>	Riffle	72	3		
	Pool	828	13	LWD	4.0
	Riffle	15	5		
	Pool	1271	12	LWD	3.0
<b>6T</b>	Riffle	100	18		
	run	80	18		
	Riffle	135	18		

# **APPENDIX F**

## **Inventory of Placed LWD**

Wood debris transported around HHD and placed at Zone 1 in water year 2004

Date of wood placement: August 2004

Placement location: RM 60 upstream loading site

Grand Total transported and placed at Zone 1:

3 pieces of large wood (approximately 20-30 ft long and 24 inches dbh with rootwad).

Notes:

1. All LWD marked with blue paint.
2. LWD placed on constructed upstream gravel berm.

Wood debris transported around HHD and placed at Zone 1 in water year 2005

Date of wood placement: 10 October 2005

Placement location: all placed in-water at RM 60 upstream loading site except where noted.

Grand Total transported and placed at Zone 1:  
 35 pieces large wood (at least 12 inch dbh and 12 ft long).  
 5 trash truck loads of SWD that included 6 large rootwads.

LWD details:

<u>length (ft)</u>	<u>dbh (inches)</u>	<u>rootball</u>	<u>comments</u>
35	36	yes	
20	24	yes	
40	20	yes	
15	12	yes	
60	20	yes	
35	30	yes	
25	24	no	
20	20	yes	
15	12	yes	
40	24	yes	
35	20	yes	
35	36	yes	
20	20	yes	
20	20	yes	
15	14	yes	
15	20	yes	
15	20	no	
30	24	yes	
25	24	yes	
15	30	yes	
30	24	no	
35	24	no	
15	20	yes	
20	20	yes	
25	20	yes	
30	20	no	
20	30	no	
20	36	no	
35	36	yes	
15	30	no	
40	24	no	
35	24	no	
12	12	no	placed at downstream nourishment site
20	12	no	placed at downstream nourishment site
15	20	yes	placed at downstream nourishment site
6 rootwads 24 - 48 inch dbh			placed at downstream nourishment site

Notes:

1. Length and dbh are estimates made at time of placement.
2. All LWD and rootwads marked with orange paint.
3. One 100 ft long cottonwood was cut into 3 pieces and is accounted for as 3 pieces of LWD.

Wood debris transported around HHD and placed at Zone 1 in water year 2006

Date of wood placement: 26 February 2007

Placement location: all placed in-water at RM 60 upstream loading site

Grand Total transported and placed at upstream loading site:

45 pieces large wood

5 trash truck loads of small wood debris

LWD details:

<u>length (ft)</u>	<u>dbh (inches)</u>	<u>rootball</u>
35	12	yes
30	12	yes
20	18	yes
15	12	yes
20	12	yes
20	12	yes
30	12	yes
15	24	yes
30	12	yes
30	18	yes
25	12	yes
15	12	yes
20	12	yes
25	12	yes
20	>12	yes
25	24	yes
20	18	yes
20	>12	yes
30	24	yes
20	12	yes
20	<12	yes
15	12	yes
30	12	yes
20	<12	yes
30	24	yes
20	<12	yes
20	<12	yes
20	12	yes
20	12	yes
25	18	yes
30	12	yes
15	12	yes
30	24	yes
25	18	yes
30	12	yes
20	12	yes
30	12	yes
25	12	yes

20	12	yes
20	12	yes
10	12	no
20	24	no
25	30	no
30	12	yes
20	12	yes

Notes:

1. Length and dbh are estimates made at time of placement.
2. All LWD and rootwads marked with red spray paint.