2.2 SEDIMENT TRANSPORT

2.2. SEDIMENT TRANSPORT

EXECUTIVE SUMMARY

Sediment and its transport from source to the downstream reaches of the river is an important process that produces and maintains salmonid habitat. In a properly functioning system, sediment provides a quality substrate for salmon egg incubation, food source production and cover from predators. When the process is disrupted, as with excessive landslides or dam construction, fish habitat degradation results.

Forestry activities, such as logging, road construction and bank stabilization in the Upper Green River sub-watershed have increased both the rate of mass wasting and the amount of fine sediment input from road surfaces. Aggradation of low gradient reaches has in some instances resulted in flows going subsurface during the late summer (USFS 1996). Gravel samples taken from within the upper watershed also contain moderate to high levels of fine sediment (Fox 1996).

The effects of the increased coarse sediment yields do not extend into the middle and lower Green River sub-watersheds because of the presence of Howard Hanson Dam (HHD). The dam effectively prevents delivery of coarse sediment from the upper basin to downstream reaches, although suspended sediment continues to be carried past the dam. The elimination of the coarse sediment supply from the upper basin is believed to have had a profound effect on habitat conditions in the Middle Green River sub-watershed. The upper basin formerly supplied over 90 percent of the alluvial gravel deposited in the Green River floodplain downstream of Flaming Geyser State Park at RM 45. The reduction in gravel supply has resulted in a decrease in the amount of sediment stored within the channel both above and below the Green River gorge (RM 45 to RM 57). Flows released from HHD during the winter are sufficient to transport coarse sediment, thus material stored in the channel is carried downstream without being replenished, and the channel incises until an armor layer formed of coarse sediments that cannot be readily transported develops. Based on an analysis of channel morphology and historic air photo sequences, armoring is believed to have altered the reach between RM 61 and RM 57, and may be beginning to affect the river downstream of the Green River gorge (Perkins 1993; Perkins 2000). As armor layer formation progresses downstream, spawning gravels are lost, and channel incision may reduce the amount of available rearing habitat by increasing the amount of time that side channels are disconnected from the mainstem. Figure Sed-1 provides a conceptual illustration of the effect of HHD on downstream sediment transport.

The reduction in the supply of sediment from upstream reaches has increased the significance of streamside landslides downstream of the dam. Landslides in the Middle Green River sub-watershed contribute material that is predominantly sand size or smaller (Perkins 1993; Perkins 1998), and, because of the reduction in coarse sediment inputs from upstream, that sand sized material now comprises a much larger proportion of the total bedload. The majority of streamside landslides occur where the channel flows adjacent to the steep valley side slopes downstream of Flaming Geyser Sate Park. One such slide, near RM 43, was reactivated by a major flood in 1996 (Cropp 1999). This slide is estimated to have delivered up to 50,000 cubic yards of sediment to the channel (Perkins 1998). This slide has been linked to pool filling and degradation of spawning gravels for at least a mile downstream (Cropp 1999).Several other events have effected the sediment regime of the lower Green River. Diversion of the sediment-rich White River in 1906 dramatically reduced the supply of sediment to reaches downstream of RM 32. An analysis of floodplain deposits suggest that the White River formerly supplied approximately 75 percent of the sediment to the river downstream of RM 32 (Mullineaux 1970). In response to the diversion of the White River, the Green River downstream of Auburn has formed a new, smaller floodplain within the former floodplain of the combined White and Green Rivers. Since then, development and erosion in tributary channels as a result of increased peak flows have increased the amount of fine sediment delivered to the lower river from smaller basins.

KEY FINDINGS:

UPPER GREEN RIVER SUB-WATERSHED (RM 64.5 TO RM 93)

Possible Impacts to Salmonids Resulting from Changes in Sediment Transport Regime in the Upper Green River Sub-watershed

Currently the upper watershed doesn’t have access for adult anadromous salmonids, future adult transport to the upper watershed is anticipated.

Spawning and Incubation

- Road related sediment yields exceeded 50 percent of background in several subbasins in the Lester WAU. In addition, the volumetric proportion of fine sediment was elevated in potential spawning gravels collected from various sites throughout the Lester WAU. High levels of fine sediment smother or trap incubating eggs and alevins and could limit the reproductive success of salmonids. The exact sediment concentrations are being compared to threshold values known to impact the reproductive success of salmonids.

- Storage of floodwaters behind Howard Hanson Dam reduces upstream river flow velocities resulting in at least 7.2 miles of river channel sedimentation to an extent that is detrimental to salmonid egg incubation.

Juvenile Rearing

- Landslides and mass wasting associated with logging practices has led to coarse and fine sediment inputs that fill pools and dramatically increase width to depth ratios in streams and rivers, reducing the area of habitat available for juvenile salmonid rearing. Landslides have negatively impacted juvenile salmonid rearing habitat in 2.6 of the 4.7 miles of stream surveyed in the Lester WAU.

MIDDLE GREEN RIVER SUB-WATERSHED (RM 32 TO RM 64.5)

Spawning and Incubation

- Entrapment of coarse volcanic origin cobbles and gravels behind Howard Hanson Dam has resulted in a reduction of suitable spawning gravels in Middle Green River sub watershed, particularly in the reach between RM 64.5 and RM 57.

- Large amounts of fine sediments are being released from slides in this sub watershed and their downstream deposition are detrimental to the successful spawning and incubation of salmonid eggs and alevins.The reduced coarse sediment supply is believed to have led to river channel incision. This could reduce the connectivity of important off-channel salmon spawning habitat such as side channels, groundwater fed channels and tributaries.

Juvenile Rearing

- The reduced coarse sediment supply has led to river channel incision. This has reduced the connectivity of off channel rearing habitat such as side channels, groundwater fed channels/ponds and tributaries.

- Increased fine sediment inputs have been observed to fill pools and the interstitial spaces within substrates near RM 43. This reduces the amount and quality of habitat (i.e., reduces food supply by lowering benthic invertebrate productivity, fills interstitial spaces used as cover) available for rearing juvenile salmonids. Although such effects have not been document, similar impacts are expected to have resulted downstream of other slide zones in this reach.

LOWER GREEN RIVER SUB-WATERSHED (RM 11 TO RM 32)

Spawning and Incubation

- Diversion of the White River into the Puyallup River Watershed substantially reduced the delivery of coarse sediment to the lower Green River. This also may have reduced the availability of suitable anadromous salmonid spawning habitat.

Juvenile Rearing

- Increased fine sediment delivery from upstream reaches and urbanized tributaries is filling pools and substrate interstitial spaces, thereby reducing the amount and quality of habitat available for rearing juvenile salmonids.

- As a result of the diversion of the White River and Cedar/Black River the Green River bed and floodplain has lowered. This lowering has disconnected off channel juvenile salmonid rearing habitat. This change has been compounded further and masked by the construction of levees.

MAJOR TRIBUTARIES TO THE GREEN RIVER

Upstream Migration

- The increased sediment delivery to alluvial fans and low gradient reaches of the Green River, in combination with the decrease in low flows impedes adult chinook attempting to migrate upstream into tributaries.

Spawning and Incubation

Increased fine sediment delivery and deposition into low gradient reaches of the tributaries may be sufficient to reduce salmonid reproductive success. High levels of fine sediment can smother or trap incubating salmonid eggs and alevins.

Juvenile Rearing

- The increase of fine sediment inputs may fill pools and the interstitial spaces within substrate. This would result in a reduction of the amount and quality of habitat (i.e., reduces food supply by lowering benthic invertebrate productivity, fills interstitial spaces used as cover) available for rearing juvenile salmonids.

DATA GAPS

- Watershed-wide sediment contribution information at the sub-watershed scale was not available.The downstream progression of the armor layer on the mainstem has not been estimated for almost ten years.

OVERVIEW

Sediment inputs, transport capacity and vulnerability to changes induced by human activities in WRIA 9 are largely a result of the geologic and topographic characteristics of the basin. The Green River basin is primarily comprised of four types of geological deposits: volcanic rocks forming the Cascade Mountains, sedimentary rocks of the Puget Group, glacial deposits from the Pleistocene, and alluvium deposited by rivers since the last glaciation. Bedrock in the Upper Green River sub-watershed is formed of volcanic rocks such as basalt and andesite. Resistant volcanic rocks are an important source of suitable spawning gravel and cobbles that are supplied to the Green River channel primarily through episodic mass-wasting events. Samples of alluvial materials collected downstream of Flaming Geyser Sate Park indicate that over 90 percent of the alluvium was derived from volcanic parent materials (Mullineaux 1970).

Downstream of HHD in the upper portion of the middle Green sub-watershed, bedrock consists primarily of the Puget Group, a series of soft and erodible rock units that were deposited in a large coastal plain around 50 to 60 million years ago (Mullineaux 1970). These deposits are exposed in the Green River Gorge. The sandstones and mudstones of the Puget Group are easily broken down into fines and do not persist as cobble and gravel-sized particles after entering the river (Dunne and Dietrich 1978).

During the Pleistocene (from about 1 million years to approximately 12,000 years ago) large lobes of glaciers up to 3,000 feet thick extended south from British Columbia and covered the lowlands around Puget Sound. These glacial advances and retreats scoured existing bedrock and left a complex array of glacial outwash, till, alluvium, and lacustrine deposits (Mullineaux 1970). Glacially derived, unconsolidated sediments cover most of WRIA 9 downstream of the Green River Gorge and are the main source of gravel in the major tributaries draining to the Middle Green River sub-watershed.Since the Pleistocene, the Green River incised a new meandering route through the unconsolidated glacial sediments to around Auburn, where it was joined by the White and Cedar/Black Rivers. Creation of a wide, alluvial valley effectively disconnected the Green River from the glacial deposits, except at isolated locations where the channel impinges directly on the steep valley walls.Around 5,000 years ago, the Osceola Mudflow swept down from the slopes of Mount Rainier through the valley of the White River. This major geological event covered the lowlands from Enumclaw to approximately 4 miles north of Auburn with mudflow deposits up to 75 feet thick, well into the present Lower Green River sub-watershed (Mullineaux 1970). The combined effects of these depositional processes eventually filled in the Duwamish embayment to form a broad lowland characterized by meandering river channels and extensive wetlands.

METHODS AND APPROACH

The investigation of alterations in the sediment delivery and transport regime of the mainstem Green River was based on a review of existing literature. The following section presents the results of the literature review for each sub-watershed.

RESULTS

UPPER GREEN RIVER SUB-WATERSHED (RM 64.5 TO RM 93)

In the Upper Green River sub-watershed, the headwater streams with gradients in excess of four percent can generally transport more sediment than they receive, and are typified by bedrock and boulder-dominated channels. Under undisturbed conditions, coarse sediments enter the stream system by means of periodic mass wasting and rock fall, and collect in the lower gradient reaches of the upper valley area, where narrow, discontinuous alluvial deposits are created and reworked. Fine sediment production in the Upper Green River sub-watershed is low relative to other nearby, glacially-fed rivers such as the White River (Mullineaux 1970).

FOREST MANAGEMENT

Modeling of the mass wasting potential in the Upper Green River sub-watershed suggests that approximately 15 percent of the basin has a high mass wasting potential rating, and 69 percent of the basin has a moderate mass wasting potential rating (USFS 1996). Large scale logging began circa 1880-1910 in the Lower and Middle Green River sub-watersheds and rapidly moved upstream into the Upper Green River sub-watershed between 1910 and 1930. Logging has extended to the highest portions of the upper basin in recent years. Private lands were logged extensively in the 1960s and 1970s. Forest management activities have increased the delivery of coarse and fine textured sediment to the mainstem Green River. Many of the landslides identified during watershed analysis were associated with timber harvest or logging roads (Reynolds 1996). Landslide inventories conducted as part of Watershed Analysis have identified a suite of landforms with varying rates of mass wasting (Reynolds 1996; Ryan 1999).Debris flows and dam-break floods, such as those described by the Channel Assessment for the Lester Watershed Analysis (Cupp and Metzler 1996) have scoured a number of tributary channels. In the Lester Watershed Administrative Unit (WAU), over half of the channel segments surveyed for the Fish Habitat Module (2.6 miles of the total 4.7miles) had been disturbed by debris flows or dam-break floods at some time in the past (Fox 1996). Coarse sediment produced by mass wasting is routed downstream to low-gradient response reaches. Excessive coarse sediment inputs can fill pools and dramatically increase width to depth ratios. Such impacts were noted in portions of the mainstem Green River dominated by alluvial processes, and on floodplain tributaries and alluvial fans (Cupp and Metzler 1996).

Watershed analysis also suggests that forest roads have increased the production of fine sediment. Fine sediment increases greater than 50 percent are generally considered to be detectable and have the potential to adversely impact aquatic habitat (WFPB 1997). The Champion Creek, Rock Creek and Friday Creek subbasins within the Lester WAU each had estimated sediment yield increases of between 50 to 94 percent (Table Sed-1). Preliminary results of the draft Upper Green/Sunday Watershed Analysis indicate that the Upper Sunday, West, Snow, Lower Sunday, Pioneer, Tacoma and Lower Green River subbasins also had road-related fine sediment increases that were greater than 50 percent of the background sediment delivery rate (Evans 1997). Persistent increases in fine sediment would be expected to result in increased deposition of fines in pool tails and side channel pools. Moderate to high levels of fines (>12 % by volume) were noted in 8 of the 9 samples collected from various channel locations within the Lester WAU (Fox 1996), thus management-related sediment yield increases are a concern in the Upper Green River sub-watershed (USFS 1996).

HOWARD HANSON DAM

The impoundment of water behind HHD has altered the sediment transport capacity of inundated portions of the mainstem Green River and its tributaries. As discussed in earlier, the turbidity pool behind the dam is maintained year-round. This results in decreased velocity and water slope near the dam, which reduces the river's ability to transport sediment. As a result, the 1.8 miles of channel permanently inundated by the turbidity pool is slowly being buried by fine sediment (USACE 1994).

During the fall and winter, Howard Hanson reservoir is drawn down, and outflows from the dam generally match inflows until there is a threat of a flooding. During flood control operation, outflow from HHD is restricted and water is impounded behind the dam. As the reservoir fills, the flow depth increases, velocity decreases dramatically, and the ability of the flow to transport sediment is reduced by the sharp decrease in velocity and water surface slope. Because of the rapid decrease in transport capacity, coarse sediments drop out at the upstream end of the impounded area, and only suspended material is transported past HHD. Deposited sediment has resulted in embeddedness levels of up to 100 percent in much of the 5.4 miles of seasonally inundated habitat upstream of the turbidity pool (Wunderlich and Toal 1992). Deposition of fine sediment has also affected reaches just upstream of the seasonally inundated zone, where embeddedness levels exceeded 40 percent in six of nine reaches surveyed (Wunderlich and Toal

1992). Modeling suggests that from 6,500 to 19,700 tons of gravel per year that was formerly routed from the Upper Green River sub-watershed to downstream reaches prior to construction of HHD is now depositing upstream of the dam (USACE 1998).

The majority of suspended sediments continue to be transported through the reservoir past HHD. Some of those sediments are deposited in the turbidity pool. A recent study by the USACE suggests that the turbidity pool is filling with sediment more rapidly than expected (USACE 1994) supporting the conclusion of recent Watershed Analyses (Coho 1996; USFS 1996) that fine sediment inputs have increased as a result of roads and forest management activities in the Upper Green River sub-watershed.

MIDDLE GREEN RIVER SUB-WATERSHED (RM 32 TO RM 64.5)

HOWARD HANSON DAM

Between HHD (RM 64.5) and Kanasket State Park (RM 57), the mainstem Green River was historically a moderate gradient mountain channel, with occasional gravel bars and side channels in less-confined areas. Examination of historic aerial photos (USACE 1944) revealed only sporadic large, in-channel sediment storage sites (i.e. gravel bars), most of which were located just upstream of Kanasket State Park or near Palmer junction.The construction of the Headworks did not seriously impair gravel movement to downstream reaches since the facility has a storage capacity equivalent to approximately one years supply of bedload and filled quickly following construction. However, the construction of HHD significantly reduced the supply of gravel to the Middle Green River sub-watershed. Modeling indicates that moderate flows (>1,000 cfs) are capable of mobilizing gravel and cobble size sediments in the reach between HHD and Kanasket State Park, and this is believed to have resulted in the formation of an “armor layer” downstream of the dam, as smaller sediments are transported out of the reach without being replaced by material from upstream.Between RM 57 and RM 45.6, the Green River flows through a steep gorge with a channel bed composed predominantly of bedrock and boulders. Occasional patches of gravel deposit only in protected areas along channel margins or behind large boulders. Because it occupies a steep, narrow canyon, the gorge has always functioned primarily as a sediment transport conduit between the upstream sources and downstream depositional/alluvial areas. Salmonid spawning habitat is limited compared to lower gradient, less confined reaches located downstream, but habitat in the gorge is currently used by chinook where available (Malcom 1999). The availability of gravels suitable for spawning salmonids in the canyon reach has likely decreased as a result the reduction in sediment supply caused by construction of HHD.

The lower reach of the Middle Green River sub-watershed, below RM 45.6, represents a transition zone between sediment transport and depositional processes. Historically, much of the lower reach was braided and the stream meandered freely across the floodplain (Perkins 1993). There is some evidence that the effects of HHD on gravel supply are beginning to extend downstream of the Green River gorge (Perkins 1993; Perkins 2000), an area that is now the most significant site of spawning in the mainstem Green River. Localized bank revetment construction in portions of this reach may have helped accelerate the armoring process by straightening and confining the channel, thereby increasing its sediment transport capacity.In a study of channel migration in the reach between RM 25 and RM 45, Perkins (1993) noted that changes in channel morphology upstream of RM 40.2 since 1962 are consistent with a reduction in sediment supply.

Her conclusions are based on the observation that "braided areas have diminished, the channel has narrowed [and] active sediment storage sites have decreased in size and number" since construction of HHD. In contrast, she reported that the presence of numerous large active gravel bars below RM 40.2 indicate that the sediment load continues to exceed the transport capacity there, suggesting that the reduction in sediment supply has not yet impacted that reach. Armor layer formation is estimated to be advancing downstream at 700 to 900 feet per year in the middle Green River (Perkins 1993).

It has been suggested that the effect of gravel depletion will continue to migrate further downstream over time (Fuerstenberg et al. 1996). In addition, modeling suggests that flows greater than approximately 2,000 cubic feet per second (cfs) are capable of mobilizing gravel and cobble size sediments in the middle Green river (USACE 1998). Howard Hanson Dam operations have increased the frequency and duration of flows between 3,500 and 9,100 cfs (Figure Sed-2), and this increase, in combination with the limited supply of sediment below HHD, may have increased the annual sediment transport capacity by as much as 30% (Dunne and Dietrich 1978).Impacts from changes in the hydrologic and sediment transport regimes have influenced aquatic habitats in the middle Green sub-watershed. The decreased sediment supply, in combination with the increased frequency of flows capable of mobilizing gravels may have increased the frequency of redd scour. Moreover, downstream progression of armoring will continue to reduce the availability of spawning gravel. If the channel incises as a result of armor layer formation, formerly accessible off channel habitats such as side channels, ground water channels and wall based tributaries will become disconnected at lower flows (USACE 1998). Figures Sed-3a and Sed-3b provide a conceptual illustration of the effects of gravel starvation on an alluvial gravel bed river such as the middle Green River.

LANDSLIDES

Following glaciation, the Green River rapidly cut down through the unconsolidated glacial sediments, forming a wide alluvial valley bordered by steep bluffs formed of the glacial materials (Figure Sed-5). In many areas these unconsolidated glacial sediments are composed primarily of fine-grained silts and sands. Landslides that occur where the Green River undercuts these bluffs deliver large amounts of fine sediment to the channel (Figure Sed-6a and b). While this process has been ongoing since the glaciers retreated, the recent reduction in large floods and coarse sediment inputs from upstream mean that sediment inputs from valley sideslopes in the Middle Green sub-watershed now comprise a greater proportion of the total bed material load.One such landslide located just downstream of Flaming Geyser State Park, near RM 43, was reactivated during major floods in 1996 and 1997 (Cropp 1999). Recent analysis suggests this large slide has delivered up to 50,000 cubic yards of sediment to the river (Perkins 1998). The landslide is primarily delivering sand-sized material to the river (Figure Sed-6b), and has filled pools and buried spawning gravels downstream of the site (Cropp 1999). Delivery of large amounts of sediment from that slide in 1999 has coincided with a reduction in the number of juvenile chinook caught in a nearby side channel, and may be having a significant impact on fry emergence and survival (Hilgert 1999).

LOWER GREEN RIVER SUB-WATERSHED (RM 11 TO RM 32)

DIVERSION OF THE WHITE RIVER

When the White River historically joined the Green River near RM 31, it is estimated to have contributed roughly 75 percent of the total sediment load to the lower basin (Mullineaux 1970). Since the diversion of the White River and the Cedar/Black River, the channel downstream of RM 32 has narrowed by forming a new floodplain within the old channel (Perkins 1993). The new floodplain surface is at least 7 feet lower than the former floodplain (Dunne and Dietrich 1978).While the White River previously contributed a great deal of coarse and fine sediment to the Lower Green River sub-watershed, the majority of the coarse material (gravel and cobble) deposited on an alluvial fan that does not appear to have extended downstream much beyond RM 27 (Dunne and Dietrich 1978). Southwest of Renton, valley floor deposits are composed of silt, clay and fine sand interbedded with peat (Mullineaux 1970). With the exception of coarse materials associated with a smaller alluvial fan that formed near the mouth of the Cedar/Black Rivers, these deposits of fine material form the substrate of the lower Green/Duwamish River (Mullineaux 1970). Therefore, it is unlikely that this sub-watershed ever provided important spawning habitat for anadromous salmonids downstream of RM 27. Spawning surveys conducted between RM 27 and RM 30 indicated that use by spawning chinook is currently low compared to upstream reaches (Cropp 1999).

A number of studies suggest that erosion in small tributary basins has increased as a result of increased peak flows and urban development (KCM 1986a: KCM 1986b; Entranco et al. 1997; Booth et al. 1994). While coarse sediment eroded from these small, low energy streams probably deposits in local storage reaches, the amount of fine sediment delivered to the lower Green River from small tributaries has probably increased. No significant changes in channel location, pattern, or bedform have been reported as a result of increased fine sediment inputs from landslides or small tributaries. However, pool infilling has been observed in this segment (Malcom 1999), and increased fine sediment delivery may be impacting water quality, as discussed in Chapter 1.

MAJOR TRIBUTARIES TO THE GREEN RIVER

URBANIZATION AND INCREASED STORMFLOWS

The major tributaries are located in the lower part of the basin that was formed from glacial outwash. Slopes there are relatively gentle and sediment is input primarily by fluvial erosion as the channels slowly incise through the unconsolidated sediments. Major tributary streams have low-relief headwaters with frequent lakes and wetlands, then briefly flow through deep, steep-sided ravines where they cross the steep valley sidewalls formed by the Green River. When the tributary channels reach the flat alluvial floodplain of the mainstem, they become low gradient pool-riffle type channels that meandering widely before joining the Green River. Both Newaukum and Soos Creek have formed small alluvial fans where they enter the Green River Valley (Mullineaux 1970). Because it joins the mainstem Green River almost immediately after emerging from the steep canyon reach, Newaukum Creek represents an important source of sediment to the middle Green River (Perkins 1993). In contrast, most of the coarse sediment transported by Soos Creek settles out in low gradient reaches prior to reaching the Green River (King County 1989).Urban development increases sediment inputs by exposing soils to surface erosion, and by removing stream bank vegetation which is important for filtering fine sediments and maintaining bank stability. In addition, increased peak flows have a higher erosive ability, and require larger channels, which results in accelerated bank erosion. Localized increases in erosion and sedimentation are described in the Soos Creek Basin Plan (King County 1989) and Mill Creek Basin Study (King County1986). Anecdotal evidence suggests that sediment yields from Newuakum Creek have also increased, primarily as a result of livestock grazing. Sediment produced from increased erosion in the headwater reaches settles out in short low gradient reaches, or where the main tributary channel crosses the Green River floodplain. Increased sediment yields degrade spawning gravel and fill pool or slough habitat utilized by rearing salmonids.

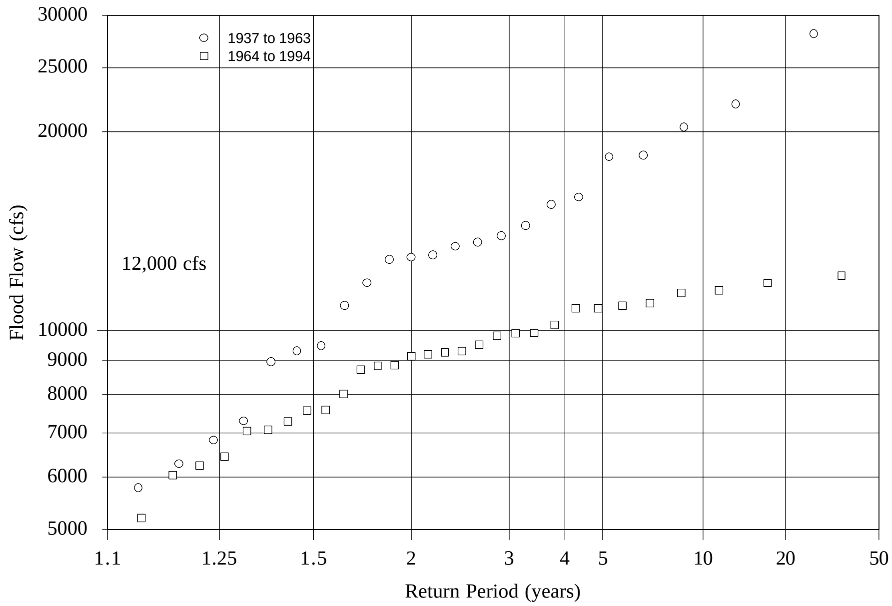

Figure SED-4. Flood-frequency relationships for USGS Gage 12113000 Green River near Auburn, prior to and after construction of Howard Hanson Dam

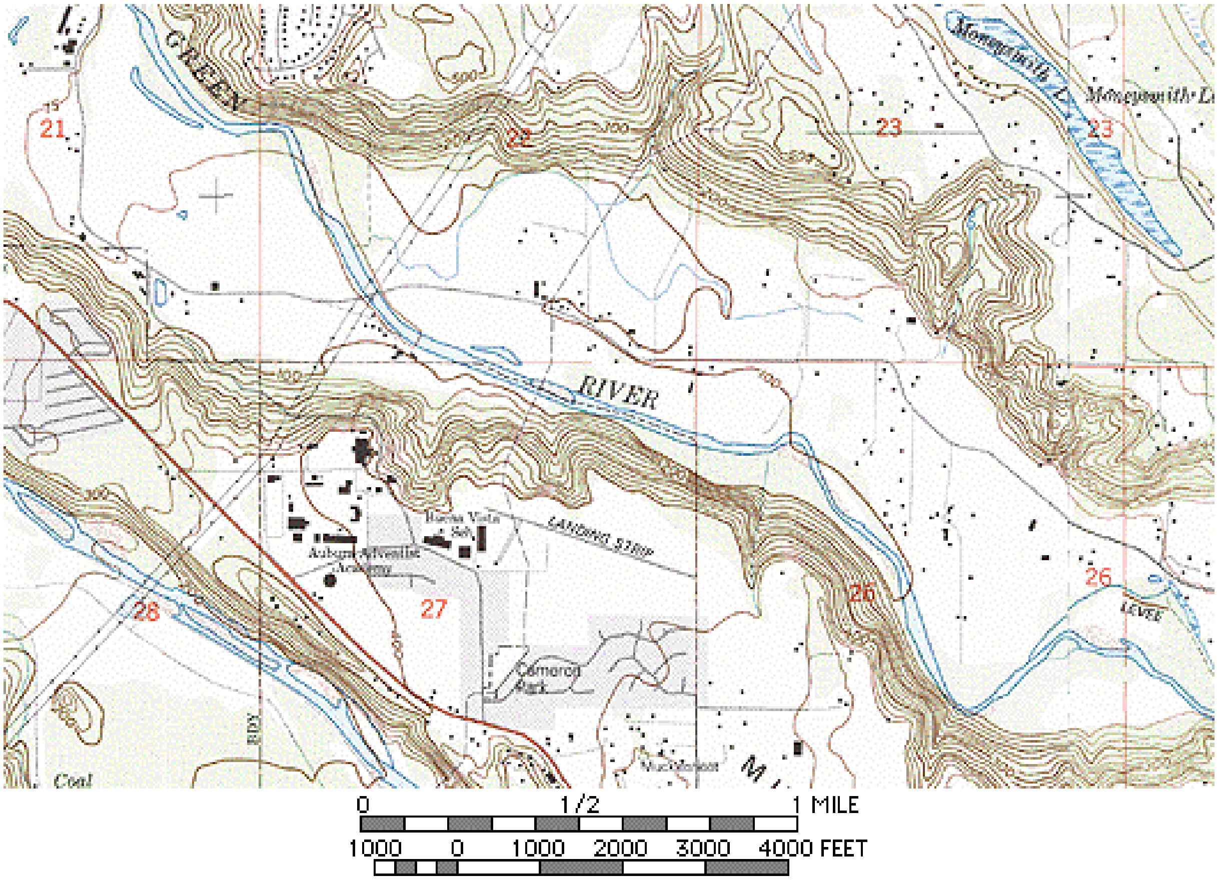

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Figure Sed-5. Topographic map of the middle Green River basin illustrating wide alluvial valley and steep valley walls.

Table SED-1. Hydrologic Changes in Tributaries to the Green River, Upper Green Subbasin (RM 64.5 to Headwaters) as Predicted Using the Hydrology Module of the Washington Forest Practices Board Manual (1997).				
Stream Name	**D.A (mi^2)**	**Peak Flow Increase[1] (%)**	**Sediment Yield Increase**	**Reference**
Wolf Creek		<10%	44%	Coho1996
Green Canyon Creek		<10%	39%	Coho1996
Champion Creek	6.61	<10%	92%	Coho1996
Rock Creek		<10%	92%	Coho1996
McCain Creek		<10%	35%	Coho1996
Lester		<10%	1%	Coho1996
Sawmill Creek	7.9	>10%	15%	Coho1996
Friday Creek		>10%	102%	Coho1996
East Creek		<10%	49%	Evans 1997
West Creek		<10%	77%	Evans 1997
Snow Creek		<10%	65%	Evans 1997
Upper Sunday Creek		<10%	70%	Evans 1997
Lower Sunday Creek		<10%	95%	Evans 1997
Pioneer Creek		<10%	109%	Evans 1997
Lower Green River		<10%	78%	Evans 1997
Tacoma Creek		<10%	78%	Evans 1997
Twin Camp Creek		<10%	33%	Evans 1997
Upper Green River		<10%	12%	Evans 1997
Intake Creek		<10%	28%	Evans 1997

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