

_README

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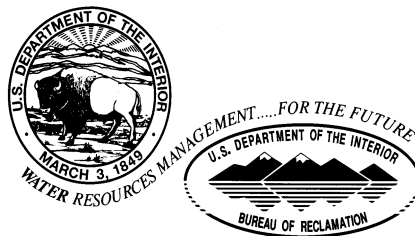
The file cover contains the cover, title page, etc. for the report. The files Rs01_12, Rs13_24, and Rs25_34 contain the river section logs from the report.

**ELWHA RIVER ECOSYSTEM AND
FISHERIES RESTORATION PROJECT,
WASHINGTON**

**ELWHA TECHNICAL SERIES
PN-95-5**

**ALLUVIUM DISTRIBUTION IN THE
ELWHA RIVER CHANNEL
BETWEEN
GLINES CANYON DAM
AND THE
STRAIT OF JUAN DE FUCA,
WASHINGTON**

**U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
PACIFIC NORTHWEST REGION
BOISE, IDAHO**



MARCH 1996

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MARCH 1996

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<u>Plate No.</u>	<u>Title</u>
1440-100-14	Locations of River Cross Sections

Appendix A. — River Cross Section Logs

RS-1	RS-2	RS-3	RS-4
RS-5	RS-6	RS-7	RS-8
RS-9	RS-10	RS-11	RS-12
RS-13	RS-14	RS-15	RS-16
RS-17	RS-18	RS-19	RS-20
RS-21	RS-22	RS-23	RS-24
RS-25	RS-26	RS-27	RS-28
RS-29	RS-30	RS-31	RS-32
RS-33	RS-34		

SUMMARY

Reconnaissance geology mapping of 34 river cross section sites was conducted in 1994 by the U.S. Bureau of Reclamation (Reclamation) on the 13.5-mile-long lower reach of the Elwha River between Glines Canyon Dam and the Strait of Juan de Fuca. The purpose of this investigation was to define existing sediment gradation ranges and distribution for the channel armor and sub-armor layers in the active channel of the lower Elwha River.

The Elwha River, located in northwest Washington, flows north from the central portion of the Olympic Peninsula into the Strait of Juan de Fuca near the town of Port Angeles. Since construction of Elwha Dam and Glines Canyon Dam in 1912 and 1926, respectively, Elwha River flows have remained similar to pre-dam levels, but sediment loads have decreased significantly due to entrapment by Lake Mills and Lake Aldwell reservoirs.

Sediment mapping, limited laboratory sampling, and visual sediment classifications by Reclamation (this study) and by Hosey and Associates Engineering Company in 1987 (Hosey, 1988) show that between river mile (RM) 13.5 and RM 4.0, bedrock controls the river gradient and post-dam river flows have produced extensive armoring and stabilization of the active channel. Between RM 2.5 and RM 0.0, bedrock control of the river gradient is absent and post-dam river flows have produced moderate channel migration and channel downcutting. Channel armoring is present in this reach, but is not as well-developed nor as coarse-grained as in the upper reach. The section of the Elwha River between RM 4.0 and RM 2.5 appears to be a short transition section between bedrock control of river gradient and the lack of such control.

Several sets of fluvial terraces associated with the Elwha River were noted during this investigation. Four terrace sets at 3-4 feet, 5-7 feet, 10-12 feet, and 15-18 feet above the Elwha River can be seen in surveyed river cross section profiles. The two lowest terraces may reflect erosion of the Elwha River bed following closure of the river by Glines Canyon Dam and Elwha Dam.

Fluvial sediment in 3- to 18-foot-high terraces adjacent to the active channel of the Elwha River and in channel sub-armor deposits are considered representative of sediment gradations in the river bed prior to dam construction. These deposits constitute the best estimate of sediment gradation ranges to be expected in the lower Elwha River channel following removal of the dams and transport of the excessive fines stored in Lake Mills and Lake Aldwell.

CHAPTER 1. INTRODUCTION

Purpose

This report presents the results of a U.S. Bureau of Reclamation (Reclamation) reconnaissance geologic mapping program conducted on the lower Elwha River, Washington, on September 19-22, 1994. The purpose of this study is to document prior to dam removal the particle size ranges and distribution in the channel armor layer and, where possible, the sub-armor material at selected locations in the active channel of the Elwha River below Glines Canyon Dam.

The geologic mapping and sampling program was conducted by personnel of Reclamation's Pacific Northwest Region Geology, Exploration and Instrumentation Services. The River Cross Section Selection Group was led by Tim Randle of the Sedimentation Section in Reclamation's Technical Service Center in Denver.

Location

The study area is located on the Elwha River, which flows north on the Olympic Peninsula into the Strait of Juan de Fuca near the town of Port Angeles (Figure 1). The 13.5-mile-long study area comprises the lower reach of the river from Glines Canyon Dam powerplant to the Strait of Juan de Fuca.

Previous Investigations

Hosey and Associates Engineering Company (Hosey) conducted a brief reconnaissance survey of the lower Elwha River in 1987 at the request of the owner of the Glines Canyon and Elwha Projects (James River II, Inc.). The findings of this study are presented in Appendix 5 of Hosey (1988). The Hosey study briefly discussed the available sediment supply in the Elwha drainage basin and pre- and post-project sediment transport in the river channel below Glines Canyon Dam.

During the 1980's, the Seattle office of the U.S. Army Corps of Engineers (Corps) intermittently studied the flood hydrology of the lower Elwha River. The Corps currently maintains several levies adjacent to the active channel in this reach of the river. Thirteen topographic cross sections were established by the Corps in the mid-1980's for flood studies between RM 0.0 and RM 3.0 (1950 datum), but the sediments in this reach were not described. In cooperation with the Corps, these sections were resurveyed, renumbered and incorporated into the present study.

Concurrent with the present study, sedimentation studies were conducted by Reclamation personnel at Lake Mills and Lake Aldwell. The findings of these studies are presented in *Alluvium Distribution in Lake Mills, Glines Canyon Project and Lake Aldwell, Elwha Project, Washington* (Reclamation, 1995) and in *Geologic Design Data Report for Removal of Elwha Dam* (Reclamation, 1996).

Present Investigations

On September 8 and 9, 1994, a team of Reclamation sedimentologists, geologists, and survey personnel chose 34 river cross section sites along the lower reach of the river, below the Glines Canyon Dam powerplant. Reconnaissance geologic mapping was done at 31 of the 34 cross section sites on September 19-22, 1994. Most of the cross section sites have poor or no access from existing roads and had to be mapped by wading and from kayaks. Representative views of most sites were stereoscopically photographed in 35mm color slide format.

Geologic mapping was completed before the cross sections were survey located. Section sites were field located and map data recorded on 1:12,000 scale (1 inch = 1,000 feet) color aerial photographs. One of the sites, RS-3, could not be field located by the author and was not geologically logged. Poor water clarity, deep water, and hazardous access or river conditions prevented geologic mapping of the river channel at two other sites, RS-22 and RS-25.

This study documents particle size ranges and distribution in the armor layer and, where possible, in fluvial terrace deposits and channel sub-armor deposits at selected locations in the active channel of the Elwha River. In general, thick vegetation and thin

coverings of sand prevented mapping and description of materials outside the active river channel. There was very limited surface sampling for laboratory analysis due to difficulty in transporting the required volumes of the predominantly coarse-grained sediments. No subsurface sampling was done.

Visual estimates of in-place gradations were made at most cross section sites. Sediment gradation sizes reported in this study are in metric units; linear measurements are in English units. The Unified Soils Classification Systems (USBR 5000-Laboratory Method and USBR 5005-Visual Method) were used for all laboratory gradation analysis and field gradation estimates (Reclamation, 1990). The single exception was the subdivision of the plus 300 mm (plus 12-inch) category (boulders) into four subcategories. These were 300-455 mm (12-18 inches), 455-610 mm (18-24 inches), 610-915 mm (24-36 inches) and plus 915 mm (plus 36-inches) sizes. The Unified Soils Classification System requires all visual and laboratory classifications of sediments less than 75 mm to be reported by mass and all sediments greater than 75 mm to be reported by volume. In the summary tables, all fractions are presented as percentages of the total sample by volume. Proportioning sediment fractions originally reported in mass units into volume units is not rigorously accurate, but is sufficiently accurate for the purposes of this study.

River mile designations used in this report represent 1950 datum and are approximate. River channel migration below about RM 3.0 during the past 45 years has invalidated the 1950 datum for all but approximate locations. Revised river mile points for the current river location have not been established.

CHAPTER 3. GEOLOGIC CONSIDERATIONS

A detailed discussion of the complex subduction zone geology of the Olympic Peninsula is beyond the scope of this report. For a general discussion of regional and site geology, refer to Reclamation (1995) and Reclamation (1996).

Drawing 1440-100-14 shows the locations of the 34 Reclamation river cross section sites on the lower reach of the Elwha River. Geologic sections, logs, and photographs of the sites are included in the appendix.

Existing Channel Configuration

The Elwha River is a coarse-bed stream with an average daily discharge of about 1,500 cubic feet per second (cfs), with minimum flows of about 300 to 500 cfs common in the fall (Randle and Lyons, 1995). The two-year flood is about 13,000 cfs (Randle and Lyons, 1995). The river in the study area flows through narrow bedrock canyons alternating with relatively wide alluvial reaches. Alluvial particles in the Elwha River drainage are generally elongate, with a 2:1 length-to-width ratio common.

River closure by construction of Elwha and Glines Canyon Dams changed the natural regime of the Elwha River. The dams are operated as run-of-the-river facilities, with Lake Mills (Glines Canyon Dam) and Lake Aldwell (Elwha Dam) reservoirs providing only minimal flood control (Randle and Lyons, 1995). Post-dam river flows are similar to pre-dam flows, but reservoir entrapment has significantly decreased the sediment available to the lower portion of the river.

Unless constrained by competent bedrock or other gradient controls, a river with unchanged flows but a significantly decreased bedload generally responds by eroding its channel. This response produces channel deepening, channel widening, increased meandering, or channel armoring and stabilization. Reconnaissance mapping for this study shows that the Elwha River responded to river closure by extensively armoring its channel from about RM 13.5 to RM 4.0 and by channel deepening, migration, and armoring from about RM 2.5 to its mouth at Freshwater Bay on the Strait of Juan de Fuca. The reach between RM 4.0 and RM 2.5 appears to be a transition reach between these two conditions.

Channel Armor Composition

River Mile 13.5 to River Mile 4.0 — Bedrock control of the Elwha River gradient occurs upstream of the Altaire Bridge near RM 12.5 and below Elwha Dam between RM 5.0 and RM 4.0. High flows prevented examination of the river bed at river cross section site RS-25 (MacDonald Bridge site), but rock exposures in the walls of the narrow channel at this location suggest that bedrock also controls the river gradient near RM 8.5. Between RM 8.0 and about RM 5.0, Elwha Dam and Lake Aldwell artificially

control river gradient through the central portion of the study area. The gradient controls between RM 13.5 and RM 4.0 limit the amount of downcutting and channel migration possible in the lower reach of the Elwha River.

Hosey (1988) concluded:

“...The present river slope does not differ appreciably from the 1926 river slope (Jones, 1927), indicating channel incision below (Glines Canyon Dam) has not occurred. Comparisons of channel configurations from present air photos and the pre-project river survey map (Jones, 1927) show that excessive channel migration has not occurred and the channel configuration has indeed been fixed by the canyon reaches. Thus the Elwha River between Lake Mills and Lake Aldwell has responded to dam closure by bed armoring and stabilization of channel features. This is to be expected because the majority of the sediment input was cut off, high flows continue to move sediment in the reach, the sediment in the channel includes particles large enough to be stable even under high flows, and there are few sources of sediment between the two dams.”

Geologic mapping for this study at 12 river cross section sites between RM 13.5 and RM 4.0, confirm the Hosey conclusion. The Elwha River channel in this reach is stabilized by an extensive armor of cobbles and boulders. The river channel contains only minor gravel, sand, and silt deposits, mostly as mid- or side-channel bars in relatively protected locations. Descriptions, profiles, and photographs of river cross section sites RS-21 to RS-34 in the RM 13.5 to RM 4.0 reach are presented in the appendix. The composition of the armor layer in this reach is summarized in Table 1.

In the RM 13.5 to RM 4.0 reach, almost 40 percent of the armor layer is boulders 300 mm or greater in diameter, while about 50 percent of the armor layer is cobbles (75-300 mm). Only about 10 percent of the layer is less than 75 mm in diameter. This extensive coarse armor layer effectively prevents channel deepening or migration except under high flows.

Table 1. — Sediment Composition Surface Samples and Armor Layer,
Lower Elwha River Channel (RM 13.5 to 4.0)

River Cross Section	Clay, Silt	Sand	Gravel	Cobbles		Boulders			
	<0.075 mm	0.075-5 mm	5-75 mm	75-125 mm	125-300 mm	300-455 mm	455-610 mm	610-915 mm	>915 mm
RS-21 (Unit 1)			5	5	15	15	25	25	
RS-21 (Unit 2)				15	30	30	20	5	
RS-22		NO	DATA						
RS-23	*	10	25	55	10				
RS-24	tr	tr	15	35	50				
RS-25		NO	DATA						
RS-26		tr	10	20	35	25	10	tr	tr
RS-27		tr	10	20	35	25	10	tr	tr
RS-28	**	**	**	15	30	25	10	5	5
RS-29	*	2	8	20	45	20	5	tr	
RS-30	**	**	**	25	50	15			
RS-31 (Unit 3)	1	1	8	20	30	30	10	tr	
RS-31 (Unit 4)	1	1	9	20	35	35	tr		
RS-32		4	11	15	30	40	tr		
RS-33				15	20	30	15	20	
RS-34				5	15	30	30	20	
Average	tr	2	8	21	31	23	10	5	tr

Note: Sediment composition is by percent of total sample volume.

* Wet sediments or underwater sediments; fines not described.

** Minus 75 mm fraction not described; minus 75 mm fraction is 10 percent of total deposit.

River Mile 4.0 to River Mile 2.5— This section of the Elwha River channel appears to be a short transition section between bedrock control of river gradient and the lack of such control. Bedrock is present in the east channel wall at the Elwha River Road bridge, but it is not clear whether bedrock crops out in the river channel. Ten river cross section sites, RS-11 to RS-20, were examined and described in this reach. Descriptions, profiles and photographs of these cross section sites are presented in the appendix. The composition of the armor layer in this reach is summarized in Table 2.

The armor layer in this reach is not as coarse-grained as the previous one. Only about 10 percent of the armor layer is 300 mm or greater, while 75 percent of the armor is cobbles (75-300 mm). About 15 percent of the material is less than 75 mm, similar to the previous reach.

Table 2. — Sediment Composition Surface Samples and Armor Layer,
Lower Elwha River Channel (RM 4.0 to RM 2.5)

River Cross Section	Clay, Silt	Sand	Gravel	Cobbles		Boulders	
	<0.075 mm	0.075-5 mm	5-75 mm	75-125 mm	125-300 mm	300-455 mm	455-610 mm
RS-11			5	20	60	10	5
RS-12			5	20	60	10	5
RS-13			5	20	60	10	5
RS-14			5	20	60	10	5
RS-15			20	30	35	15	tr
RS-16 (Unit 1)	*	7	28	45	20	tr	
RS-16 (Unit 2)			15	30	45	10	
RS-16 (Unit 3)			15	25	40	15	5
RS-17	*	7	28	45	20	tr	
RS-18			15	25	40	15	5
RS-19 (Unit 2)	*	1	9	40	50		
RS-19 (Unit 3)	*	3	27	55	15		
RS-20			5	40	55		
Average	tr	2	14	32	43	7	2

Note: Sediment composition is by percent of total sample volume.

* Wet sediments or underwater sediments; fines not described.

River Mile 2.5 to River Mile 0.0 — Starting at about RM 2.5 and extending to the mouth of the river at Freshwater Bay, the Elwha River canyon widens and is entrenched in relatively easily eroded glacial deposits. The river responded to the lack of bedrock gradient control in this reach by moderate channel migration and channel downcutting. Channel armor is present, but is not as well-developed or as coarse-grained as seen in the upper reaches. Ten river cross section sites, RS-1 to RS-10, were examined and described in this reach. Descriptions, profiles, and photographs of these cross section sites are presented in the appendix. The composition of the armor layer in this reach is summarized in Table 3.

No particles greater than 300 mm were observed in this reach. About 55 percent of the particles were cobbles (75-300 mm) and about 45 percent were less than 75 mm.

Table 3. — Sediment Composition Surface Samples and Armor Layer,
Lower Elwha River Channel (RM 2.5 to 0.0)

River Cross Section	Clay, Silt	Sand	Gravel	Cobbles	
	<0.075 mm	0.075-5 mm	5-75 mm	75-125 mm	125-300 mm
RS-1	*	7	38	40	15
RS-2	*	7	38	40	15
RS-3		NO	DATA		
RS-4	*	7	38	30	25
RS-5	*	7	38	30	25
RS-6	*	7	38	30	25
RS-7	*	7	38	30	25
RS-8		12	28	45	15
RS-9		12	28	45	15
RS-10		12	28	45	15
Average	tr	9	35	37	19

Note: Sediment composition is by percent of total sample volume.

* Wet sediments or underwater sediments; fines not described.

Terrace and Sub-armor Composition

Where exposed, fluvial terrace deposits and channel sub-armor deposits at the river cross section sites were described. Terrace deposits generally were exposed in 3- to 18-foot-high terrace risers adjacent to the active channel of the Elwha River. The height of these sediments above the active river channel indicate that they are pre-dam in age, and represent pre-dam sediment gradations in the Elwha River channel. Descriptions of these sediments are presented in the appendix and their composition is summarized in Table 4.

Table 4. — Sediment Composition, Surface Samples, Sub-armor Layer, and Terrace Deposits, Lower Elwha River Channel (RM 13.5 to 1.0)

River Cross Section	Clay, Silt	Sand	Gravel	Cobbles		Boulders	
	<0.075 mm	0.075-5 mm	5-75 mm	75-125 mm	125-300 mm	300-455 mm	455-610 mm
RS-1	6	12	42	35	5	—	—
RS-4*	4	11	40	45	—	—	—
RS-6	11	19	45	5	20	—	—
RS-7	11	19	45	5	20	—	—
RS-8*	3	18	64	15	—	—	—
RS-9	20	40	20	—	—	—	—
RS-10	—	12	28	45	15	—	—
RS-13*	3	12	34	51	—	—	—
RS-14	**	14	26	40	20	tr	—
RS-15	7	10	33	35	15	—	—
RS-18	57	19	19	5	tr	—	—
RS-19*	15	46	39	—	—	—	—
RS-23	**	10	25	55	10	—	—
RS-24	**	10	30	20	40	—	—
RS-27	25	25	50	—	—	—	—
RS-28*	26	34	40	—	—	—	—
RS-31	23	23	54	—	—	—	—
RS-32*	22	45	33	—	—	—	—
RS-33	—	4	21	35	30	10	tr
Average	12	20	36	22	9	1	tr

Note Sediment composition is by percent of total sample volume.

* Based on laboratory data presented in Hosey, 1988 for a location near the river cross section site. Gradation percentages are approximate due to use of non-Reclamation standard sieves.

** Wet sediment or underwater sediments; fines not described.

Laboratory analysis of channel sub-armor sediment samples taken by Hosey (1988) were incorporated into this study when the Hosey sample sites were adjacent to Reclamation river cross section sites. Six Hosey (1988) sites are included with the corresponding Reclamation river cross section sites in the appendix and are marked with an asterisk in Table 4. Some extrapolation of the Hosey (1988) lab data is required for compatibility with the Reclamation visual classifications, as non-Reclamation standard sieves were used on the Hosey samples.

There is reasonably good agreement between the Reclamation visual classifications (this study) and the Hosey (1988) laboratory classifications. Except for about 10 percent boulders at river cross section site RS-33 (drawing 1440-100-14), pre-dam terrace deposits and channel sub-armor sediments examined between RM 13.5 and RM 1.0 showed relatively uniform gradations.

Terrace Development

Several sets of fluvial terraces associated with the Elwha River were noted during this investigation. The terraces were not mapped or studied in detail due to the lack of suitable large-scale topographic maps and detailed survey control. Aerial photogeologic study and selected river cross section profiles suggest that there are at least 4 distinct terrace sets in the lower reach of the Elwha River below Glines Canyon Dam. Terrace sets at 3-4 feet, 5-7 feet, 10-12 feet, and 15-18 feet above the Elwha River are discernable in the river cross sections. Terraces representing all four sets usually are not present at each cross section site. The lower terraces may reflect erosion of the Elwha River bed following closure of the river by Glines Canyon Dam and Elwha Dam.

CHAPTER 4. CONCLUSIONS

Sediment mapping, limited laboratory sampling, and visual sediment classifications show that between RM 13.5 and RM 4.0, bedrock controls the river gradient and post-dam river flows have produced extensive armoring and stabilization of the active channel. The average sediment gradation of the armor layer in this reach is shown in Table 5.

The section of the Elwha River between RM 4.0 and RM 2.5 appears to be a short transition section between bedrock control of river gradient and the lack of such control. The average sediment gradation of the armor layer in this reach is shown in Table 5.

Between RM 2.5 and RM 0.0, bedrock control of the river gradient is absent and post-dam river flows have produced moderate channel migration and channel downcutting. Channel armoring is present in this reach, but is not as well-developed nor as coarse-grained as in the upper reach. The average sediment gradation of the armor layer in this reach is shown in Table 5.

Table 5. — Average Sediment Composition, Surface Samples, Armor Layer,
Lower Elwha River Channel (below RM 13.5)

River Cross Section	Clay, Silt	Sand	Gravel	Cobbles		Boulders			
	<0.075 mm	0.075-5 mm	5-75 mm	75-125 mm	125-300 mm	300-455 mm	455-610 mm	610-915 mm	>915 mm
13.5-4.0	tr	2	8	21	31	23	10	5	tr
4.0-2.5	tr	2	14	32	43	7	2	—	—
2.5-1.0	tr	9	35	37	19	—	—	—	—

Note: Sediment composition is by percent of total sample volume.

The average gradation of sub-armor channel deposits and pre-dam terrace deposits shown in Table 6 is the best estimate of the sediment gradation ranges to be expected in the lower Elwha River channel following removal of the dams and transport of excessive fines stored in Lake Mills and Lake Aldwell.

Table 6. — Average Sediment Composition, Surface Samples, Sub-armor Layer, and Terrace Deposits, Lower Elwha River
Channel (RM 13.5 to 1.0)

Clay, Silt	Sand	Gravel	Cobbles		Boulders	
<0.075 mm	0.075-5 mm	5-75 mm	75-125 mm	125-300 mm	300-455 mm	455-610 mm

12	20	36	22	9	1	tr
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Note: Sediment composition is by percent of total sample volume.

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PEER REVIEW DOCUMENTATION

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Section/Chapter	Author/Preparer	Peer Reviewer
_____	_____	_____
_____	_____	_____
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Peer Reviewer: I have reviewed the assigned Sections/Chapters noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Reclamation policy.

Reviewer: _____	Date: _____
(Signature)	
Reviewer: _____	Date: _____
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Reviewer: _____	Date: _____
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Reviewer: _____	Date: _____
(Signature)	

Preparer(s): I have discussed the above document and review requirements with the Peer Reviewer(s) and believe that this review is completed, and that the document will meet the requirements of the project.

Team Member: _____
(Signature)

Team Member: _____
(Signature)

Team Member: _____
(Signature)

Date: _____

Date: _____

Date: _____