

**Figure 2.** Bank-operated cableway system and D-74 suspended-sediment sampler viewed from the U.S. Geological Survey gaging station Elwha River above Lake Mills (12044900), Elwha River basin, Clallam County, Washington. Photograph taken by Christopher P. Konrad, U.S. Geological Survey, 2006.

## Suspended-Sediment Sample Collection

During water years 2006 and 2007, the EDI method was used to collect depth-integrated suspended-sediment samples along a cross section, with sample locations determined by a preceding measurement of streamflow. Depth-integrated samples were collected using a D-74 suspended-sediment sampler and pint-sized glass bottles in accordance with USGS sediment data-collection protocol (Edwards and Glysson, 1999). Measurements of suspended-sediment concentration were made over a range of flows throughout the study period and the data were used with previous measurements to develop a regression model expressing the relation between suspended-sediment concentration and streamflow.

Measurements of suspended-sediment concentration were made during water years 1995–98 at the gaging station upstream of Lake Mills and used the Equal Width Increment (EWI) method to collect depth-integrated samples (Edwards and Glysson, 1999). These measurements subsequently were used with samples collected from an automated pump sampler at this site to calculate daily, monthly, and annual suspended-sediment loads for water years 1995–97 (Wiggins and others, 1995, 1996, and 1997).

## Regression Analysis

For the regression model, concentration and discharge values were transformed to base-10 logarithmic values, and an ordinary least-squares (OLS) regression was computed. Re-expressing estimates from a log-regression equation into original units can result in a low bias (Helsel and Hirsch, 1992), so a correction factor determined from the mean of the re-transformed residuals expressed in original units was applied to all estimates of suspended-sediment concentration. The resulting regression model expressed as a power equation and corrected for bias takes the form:

$$C_S = c_f \times a \times Q^b, \quad (1)$$

where

$C_S$  is the suspended-sediment concentration in milligrams per liter;

$c_f$  is the bias correction factor;

$a$  and  $b$  are the coefficients determined from the regression analysis; and

$Q$  is streamflow in cubic meters per second (Bragg and others, 2007).

The regression model was used to determine hourly estimates of suspended-sediment concentration based on the corresponding hourly streamflow record of the gaging station.

These hourly estimates of suspended-sediment concentration then were used in the Graphical Constituent Loading Analysis Software (GCLAS; Koltun and others, 2006) with the continuous record of streamflow at the gaging station to estimate monthly and annual sediment loads.

## Bedload Sample Collection

Bedload is defined as fluvial sediment that moves by sliding, rolling, or bouncing along on the streambed (Edwards and Glysson, 1999). Following the Lake Mills drawdown study in 1994 (Childers and others, 1999), the USGS continued to collect bedload measurements in anticipation of the imminent removal of the Glines Canyon and Elwha Dams. From November 1994 to October 1997, measurements were made over a range of flows using the EWI method.

Measurements of bedload discharge were made using the sampling device, the “Elwha sampler,” that was designed and used for the Lake Mills drawdown study (Childers and others, 1999). The Elwha sampler has a  $10.2 \times 20.3$ -cm intake nozzle with an expansion ratio of 1.40. The sampler generally was used from a boat, although a modified hand-held version was used at low flows when the channel could be waded. To obtain a bedload sample, the sampler was placed on the channel bed for a specified period, usually 30 seconds with the intake facing upstream. After 30 seconds, the sampler was raised and emptied of sediment. Thirteen bedload samples generally were collected at evenly spaced stations along the cross section. Samples collected at each cross section were composited prior to analysis. All bedload samples were analyzed for dry weight and grain-size distribution by the USGS Cascades Volcano Observatory sediment laboratory in Vancouver, Washington.

Bedload discharges were calculated from the measurements using this equation:

$$Q_B = (K \times W_T \times M_T)(t_T \times N_w), \quad (2)$$

where

$Q_B$  is the bedload discharge in megagrams per day;

$K$  is a unit conversion factor equal to 0.0864;

$W_T$  is the total width of the stream cross-section in meters;

$M_T$  is the total mass of sample collected in the cross-section in grams;

$t_T$  is the total time the sampler was on the bed in seconds; and

$N_w$  is the sampler width in meters (Edwards and Glysson, 1999).

### Elwha River at McDonald Bridge (12045500)

The gaging station at McDonald Bridge, at RK 13.9, is installed in a bedrock-confined reach 1.7 km upstream of Lake Aldwell and 7.7 km downstream of the Glines Canyon Dam at RK 13.9 (fig. 3). The gage measures streamflow that drains an area covering 697 km<sup>2</sup> or 84 percent of the total area of the Elwha River basin. The gaging station has a streamflow record that spans more than a century, from October 1897 to December 1901 and from October 1918 to the present (2007). The Glines Canyon Dam is operated by the Bureau of Reclamation as “run-of-the-river,” a water-management strategy that attempts to minimize regulation and maintain natural flows (Kevin Yancy, Bureau of Reclamation, written commun., 2007).

An automatic pump sampler was installed at this gaging station and operated from October to July, the primary months of sediment transport, during water years 2006 and 2007.

The automatic sampler collected daily water samples by pumping water from an intake that extended into the river. The sampling frequency was adjusted to 4-hour intervals during a single large flood event on November 6–7, 2006. Because samples collected with a pump sampler may not have been representative of the entire cross section, samples also were collected manually from the cableway using the EDI sampling method. Depth-integrated samples were collected along the cross section using a D-74 suspended-sediment sampler with pint-sized glass bottles. Sediment concentrations determined from the manually-collected samples were used to correct any bias associated with the location of the intake of the automatic pump sampler. Daily, monthly, and annual suspended-sediment loads were calculated using GCLAS based on the continuous record of streamflow and sediment concentrations determined from the automatic pump sampler and manual sampling methods.



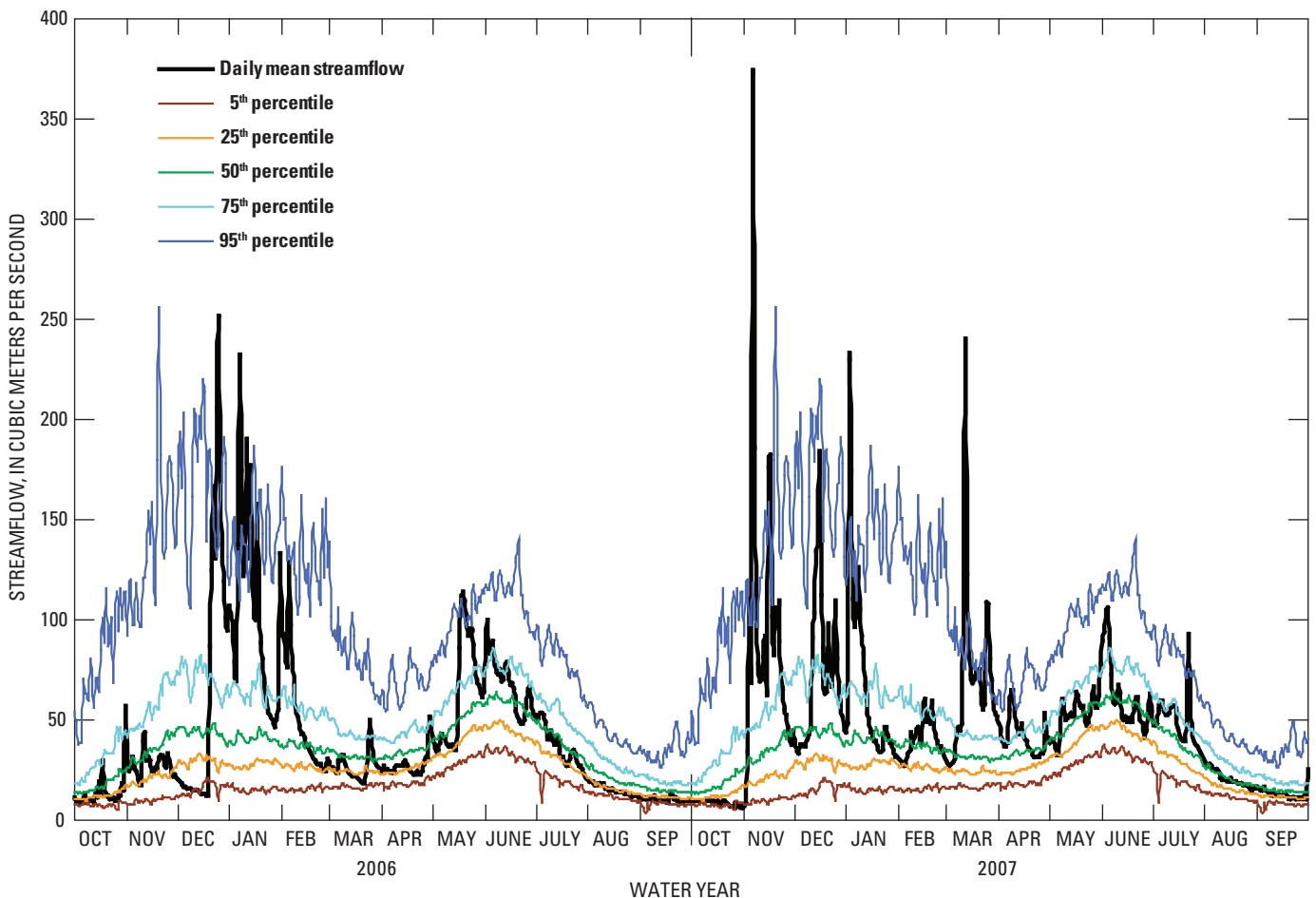
**Figure 3.** Elwha River looking downstream of U.S. Geological Survey gaging station Elwha River at McDonald Bridge (12045500), Elwha River basin, Clallam County, Washington. Photograph taken by Christopher P. Konrad, U.S. Geological Survey, 2006.

## Estimates of Sediment Load

Variability in the magnitude, timing, and frequency of streamflow can greatly influence the amount of sediment transport that occurs from year to year. In analyzing the results of sediment monitoring for any given year, the discharge conditions for that year should be considered relative to the historical record. The magnitude and timing of streamflow during the study period relative to the mean daily streamflow for the period of record at the Elwha River at McDonald Bridge gaging station is shown in [figure 4](#). Similar to most mountain-fed rivers in the Pacific Northwest, most of the annual streamflow in the Elwha River usually occurs during winter, as a result of direct runoff from precipitation and during summer, as a result of melting snowpack. Compared to the long-term annual mean streamflow at the McDonald

Bridge gaging station ( $42.8 \text{ m}^3/\text{s}$ , based on the 92-year period of record), streamflow for water year 2006 was average ( $42.4 \text{ m}^3/\text{s}$ ), and for water year 2007 was 14 percent above average ( $48.7 \text{ m}^3/\text{s}$ ) (U.S. Geological Survey, 2008).

Peak river flows during the study period occurred as a result of “pineapple-express” events, a type of regional weather pattern characterized by unseasonably warm temperatures and intense rainfall. The largest of these peaks occurred in early November during water year 2007,  $346 \text{ m}^3/\text{s}$  at the gaging station upstream of Lake Mills and  $592 \text{ m}^3/\text{s}$  at the gaging station at McDonald Bridge (U.S. Geological Survey, 2008). By comparison, peak flows occurred in late December during water year 2006,  $262 \text{ m}^3/\text{s}$  at the gaging station upstream of Lake Mills and  $329 \text{ m}^3/\text{s}$  at the gaging station at McDonald Bridge (U.S. Geological Survey, 2008).



**Figure 4.** Daily mean streamflow and percentiles based on 92 years of record (1897–2005), Elwha River at McDonald Bridge (12045500), Clallam County, Washington, water years 2006 and 2007.

## Elwha River above Lake Mills (12044900)

Suspended-sediment data collected from the Elwha River at the gaging station upstream of Lake Mills during water years 2006–07 are summarized in [table 1](#). Most samples were collected using the EDI method and samples with low suspended-sediment concentrations generally were composited in the laboratory prior to analysis. The highest suspended-sediment concentrations and river flows recorded during the study period occurred near the peak of a precipitation-driven flood on November 6, 2006, for which an instantaneous streamflow of 346 m<sup>3</sup>/s was recorded at 10:45 AM (Pacific Standard Time). Two sets of EDI measurements (10 samples) and 2 grab samples were collected near the peak of the flood. Suspended-sediment concentrations in these samples ranged from 5,703 to 7,325 mg/L and were higher than concentrations recorded during the 1994 drawdown study by Childers and others (1999). Suspended-sediment samples also were collected 3 days prior to the flood peak and ranged from 304 to 504 mg/L, and streamflow was about 85 m<sup>3</sup>/s ([fig. 5](#)).

The mass percentage of suspended sediment finer than 0.0625 mm was determined for all EDI samples collected before and during the flood peak. Results from this limited size analysis ([fig. 5](#)) indicate that the percentage of fine suspended sediment (that is, silts and clays) increased as the flood progressed. This increase in fine sediment load likely was due to the magnitude and timing of this precipitation-driven event, which was exceptionally large and the “first flush” of the river basin following a dry summer.

Because a continuous record of suspended-sediment concentration was not available at this site for 2006–07, a regression model was determined for suspended-sediment concentration and streamflow to estimate monthly and annual suspended-sediment loads. Concentration data from samples collected during water years 2006–07 ([table 1](#)) and data collected by the USGS at this site during water years 1995–98 ([appendix A](#)) were used with corresponding streamflow data to develop the regression model. During development of the model, it was observed that streamflow measurements less than 30 m<sup>3</sup>/s heavily influenced the coefficients of the regression line, yet the percentage of total suspended-sediment load contributed from streamflows less than 30 m<sup>3</sup>/s was minor (less than 0.5 percent). Because the regression line was unduly influenced by concentrations measured in this flow range, these measurements were trimmed from the data set and were not used in the model ([fig. 6](#)). This approach is consistent with the method of developing sediment-transport curves over specific flow regimes as outlined by Glysson (1987), except that a separate curve for low flows was not necessary for this analysis.

**Table 1.** Suspended-sediment and streamflow data from samples collected at Elwha River above Lake Mills (12044900), Elwha River basin, Clallam County, Washington, water years 2006 and 2007.

[**Streamflow:** Instantaneous streamflow recorded at the streamflow-gaging station at the time of sample collection. **Abbreviations:** m<sup>3</sup>/s, cubic meter per second; mg/L, milligram per liter; mm, millimeter; <, less than; –, no data]

Date	Time	Streamflow (m <sup>3</sup> /s)	Suspended-sediment concentration (mg/L)	Percent fines (grain size <0.0625 mm)
11-02-05	12:58	22.4	5	–
11-02-05	13:03	22.4	5	–
12-05-05	14:26	14.4	1	–
12-05-05	14:26	14.4	1	–
<sup>1</sup> 12-29-05	11:00	88.1	106	–
05-04-06	10:20	34.8	21	–
05-04-06	10:25	34.8	3	–
05-17-06	12:08	91.5	77	70
05-17-06	12:13	91.8	78	67
11-03-06	15:26	86.7	345	64
11-03-06	15:38	86.7	366	62
11-06-06	12:00	326	6,810	78
11-06-06	12:30	320	6,770	78

<sup>1</sup> Grab sample only.

To consider possible hysteresis, data points with concentrations greater than 50 mg/L were identified as having been measured on a rising or falling limb of a flood peak. However, no evidence for hysteresis was apparent due to the limited data set at the upper end of the flow regime.

The OLS regression equation, which includes a correction factor for bias associated with the log-transformation of variables, is expressed as:

$$C_S = cf_S \times 1.17 \times 10^{-4} \times Q_W^{3.0}, \quad (3)$$

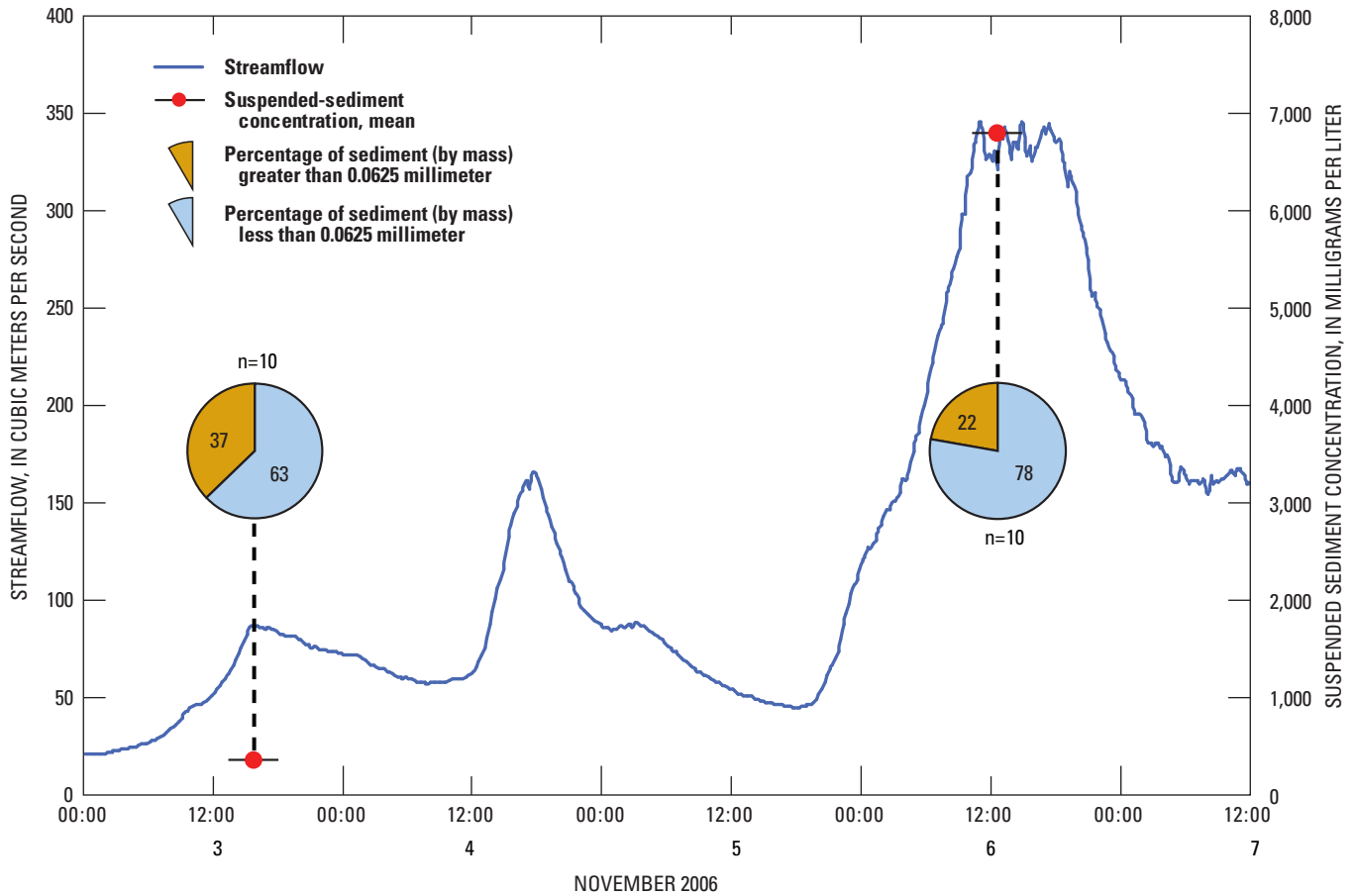
where

$C_S$  is the suspended-sediment concentration in milligrams per liter;

$cf_S$  is the bias correction factor equal to 1.07; and

$Q_W$  is streamflow in cubic meters per second.

The coefficient of determination ( $R^2$ ) for the regression equation is 0.92.



**Figure 5.** Streamflow, mean suspended-sediment concentrations of equal discharge increment (EDI), and percentage of fine sediment by mass, November 3 and 6, 2006 Elwha River above Lake Mills (12044900), Clallam County, Washington.

The regression model (equation 3) and the continuous streamflow record at the gaging station were used with GCLAS to estimate monthly and annual suspended-sediment loads (appendix B). The annual suspended-sediment load at the gaging station upstream of Lake Mills was estimated at 186,000 and 233,000 Mg for water years 2006 and 2007, respectively.

To quantify the uncertainty in the regression model, the 95 percent confidence intervals for prediction and the mean were computed. The confidence interval for prediction is the likely range of suspended-sediment concentrations for a single measurement made at a particular streamflow, whereas the confidence interval for the mean is the likely range of concentrations for the mean of a set of independent measurements made at a particular streamflow (Helsel and Hirsch, 1992).

## Suspended-Sediment Discharge

The rate of suspended-sediment discharge in a river can be calculated from the product of the mean suspended-sediment concentration and the streamflow (Guy, 1970). The regression model developed for determining suspended-sediment concentration as a function of streamflow, equation 3, was modified to calculate suspended-sediment discharge as follows:

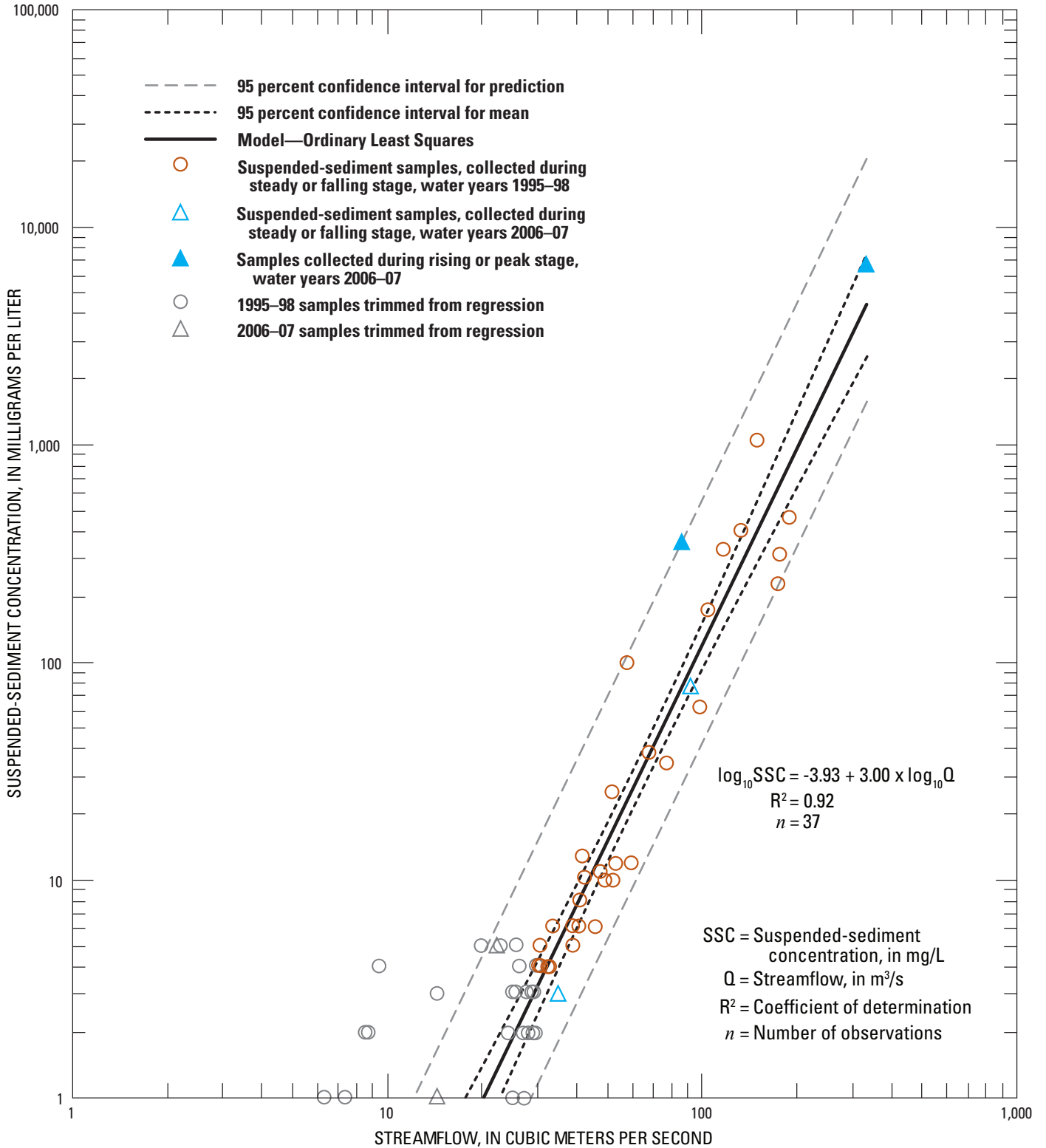
$$Q_S = 1.25 \times 10^{-4} \times Q_W^{4.0} \times K, \quad (4)$$

where

$Q_S$  is the suspended-sediment discharge in megagrams per day;

$Q_W$  is streamflow in cubic meters per second; and

$K$  is a unit conversion factor equal to 0.0864.



**Figure 6.** Regression model used to estimate suspended-sediment concentration from streamflow, Elwha River above Lake Mills (12044900), Clallam County, Washington, water years 1995–98 and 2006–07.

## Bedload Discharge

During water years 1995–98, 25 bedload measurements were made on the Elwha River at the gaging station upstream of Lake Mills (appendix C). Bedload discharge for each cross section measured was calculated using equation 2. During the 1994 Lake Mills drawdown study by Childers and others (1999), 19 measurements were made at this site and were included in this analysis. All measurements were matched with corresponding streamflows recorded at the gaging station and an OLS regression on log-transformed variables was used to describe a bedload transport curve relating bedload as a function of streamflow (fig. 7). The transport curve equation used for estimating bedload discharge is:

$$Q_B = cf_B \times 0.01 \times Q_W^{2.41}, \quad (5)$$

where

$Q_B$  is the bedload discharge in megagrams per day;

$cf_B$  is the bias correction factor equal to 1.13; and

$Q_W$  is streamflow in cubic meters per second.

The  $R^2$  for the linear-regression equation is 0.77.

The uncertainty in the bedload transport model for prediction and mean was determined at the 95 percent confidence level.

## Total Sediment Load Estimates

The regression models developed for suspended-sediment and bedload transport as a function of streamflow were used to estimate the total sediment load into Lake Mills. A flow-duration/sediment-rating curve approach as outlined by Julien (1998) was used to estimate total load. The flow-duration curve is a cumulative-frequency curve showing the percentage of time specific streamflows were equaled or exceeded (Searcy, 1959). A flow-duration curve based on 8 years of daily streamflow data (water years 1995–98 and 2005–08) obtained from the gaging station upstream of Lake Mills was developed using the Weibull plotting position formula as explained by Helsel and Hirsch (1992). The flow-duration curve was combined with the sediment transport equations for suspended sediment (equation 4) and bedload (equation 5) to determine an estimate of total annual sediment load (appendix D). Using this approach, the total load at the gaging station upstream of Lake Mills was estimated to be 327,000 Mg/yr with a range of uncertainty of +57 to -34 percent (217,000–513,000 Mg/yr) at the 95 percent confidence level. The percentage of suspended-sediment load was estimated at 77 percent (251,000 Mg/yr), and the percentage of annual bedload was estimated to be 23 percent (75,500 Mg/yr).

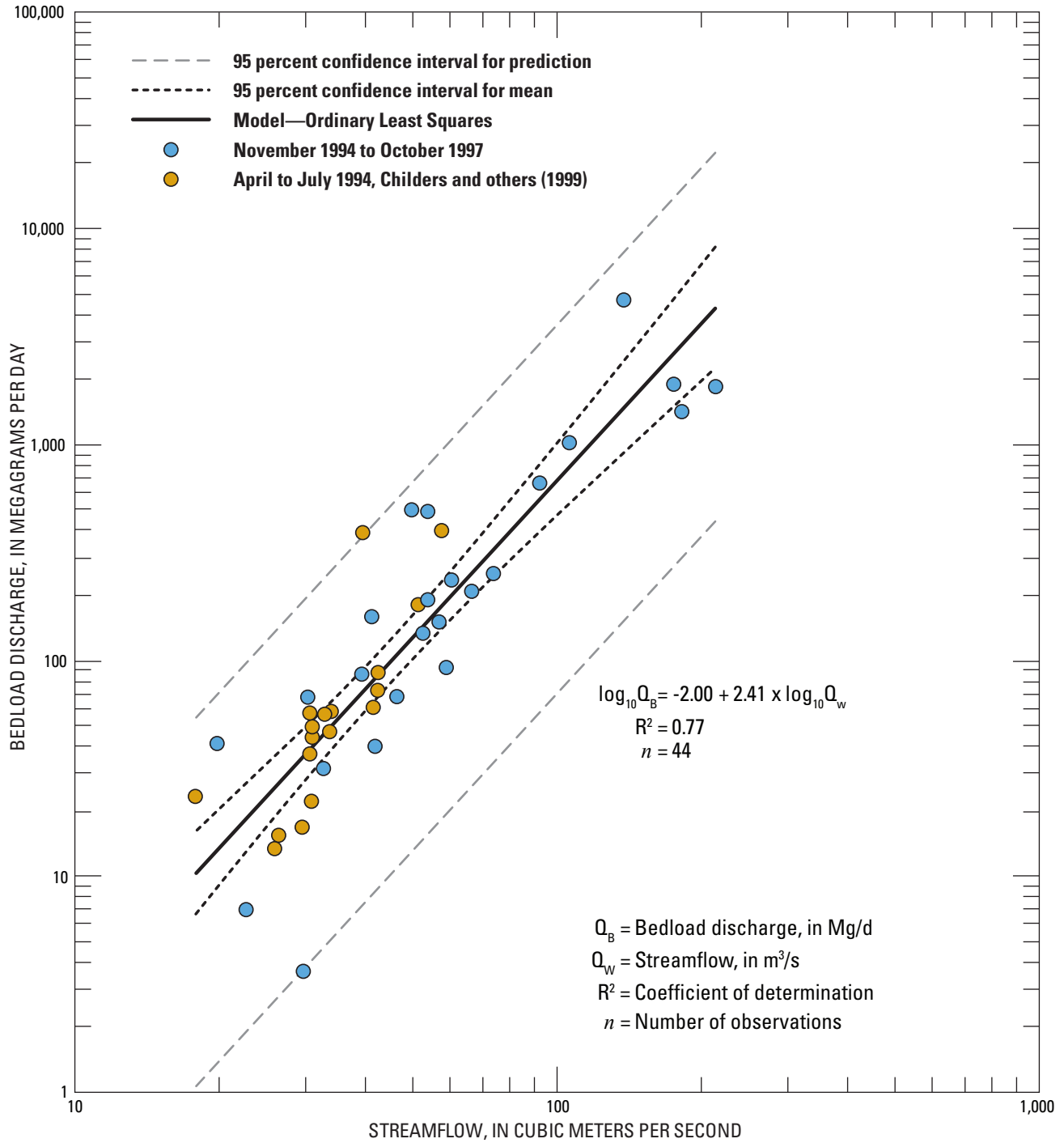
## Elwha River at McDonald Bridge (12045500)

An automated sampler was used to collect 451 pumped samples from the Elwha River at the gaging station at McDonald Bridge during water years 2006–07 and 16 EDI measurements were made in water year 2006 (table 2). The highest recorded suspended-sediment concentration at this site was 946 mg/L from a pumped sample during the pineapple express flood of November 6, 2006. The peak streamflow recorded during this flood was 592 m<sup>3</sup>/s at 12:45 PM. The flood was anticipated, and the sampling frequency of the pump sampler was increased to 4-hour intervals 3 days prior to the flood peak and continued throughout the peak and during the recession. During the course of the flood, the peak in suspended-sediment concentration lagged the streamflow peak by about 8 hours (fig. 8). Delayed sediment peaks of 2–3 days were measured in the reservoir drawdown study by Childers and others (1999) when streamflow was much lower than during the November 2006 flood event. During the November 2006 event, delayed sediment peaks were the result of slower sediment transport through the reservoir relative to the propagation of the flood peak.

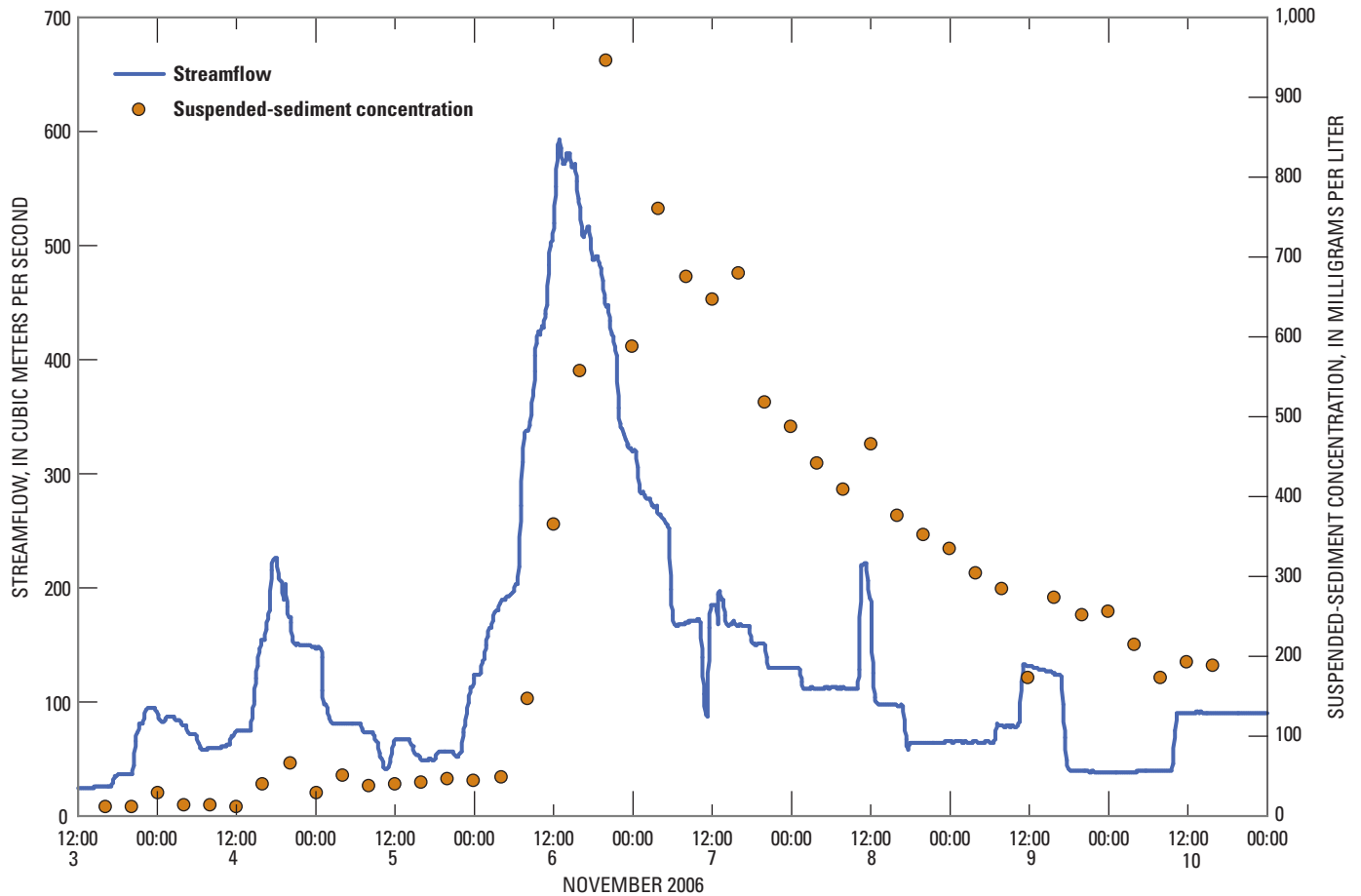
**Table 2.** Suspended-sediment concentrations and streamflow from samples collected using the equal discharge increment method at Elwha River at McDonald Bridge (12045500), Elwha River basin, Clallam County, Washington.

[Samples analyzed at the Cascades Volcano Observatory, Vancouver, Washington. **Streamflow:** Instantaneous streamflow recorded at the streamflow-gaging station at the time of sample collection. **Abbreviations:** m<sup>3</sup>/s, cubic meter per second; mg/L, milligram per liter]

Date	Time	Streamflow (m <sup>3</sup> /s)	Suspended-sediment concentration (mg/L)
11-02-05	15:10	23.0	3
11-02-05	15:15	23.0	2
12-05-05	13:39	17.1	0
12-05-05	13:41	17.1	1
12-29-05	12:52	101	117
12-29-05	12:57	101	122
01-23-06	11:38	57.2	21
01-23-06	11:40	57.2	21
02-16-06	13:30	37.4	6
02-16-06	13:34	36.5	7
03-13-06	11:54	22.9	5
03-13-06	11:58	22.9	4
04-04-06	11:28	25.1	2
04-04-06	11:31	25.1	2
05-04-06	13:19	36.0	1
05-04-06	13:23	36.0	1



**Figure 7.** Transport curve used to estimate bedload discharge from streamflow, Elwha River above Lake Mills (12044900), Clallam County, Washington, April–July 1994 and November 1994–October 1997.



**Figure 8.** Suspended-sediment concentrations and streamflow from samples collected at Elwha River at McDonald Bridge (12045500), Elwha River basin, Clallam County, Washington, November 3–10, 2006.

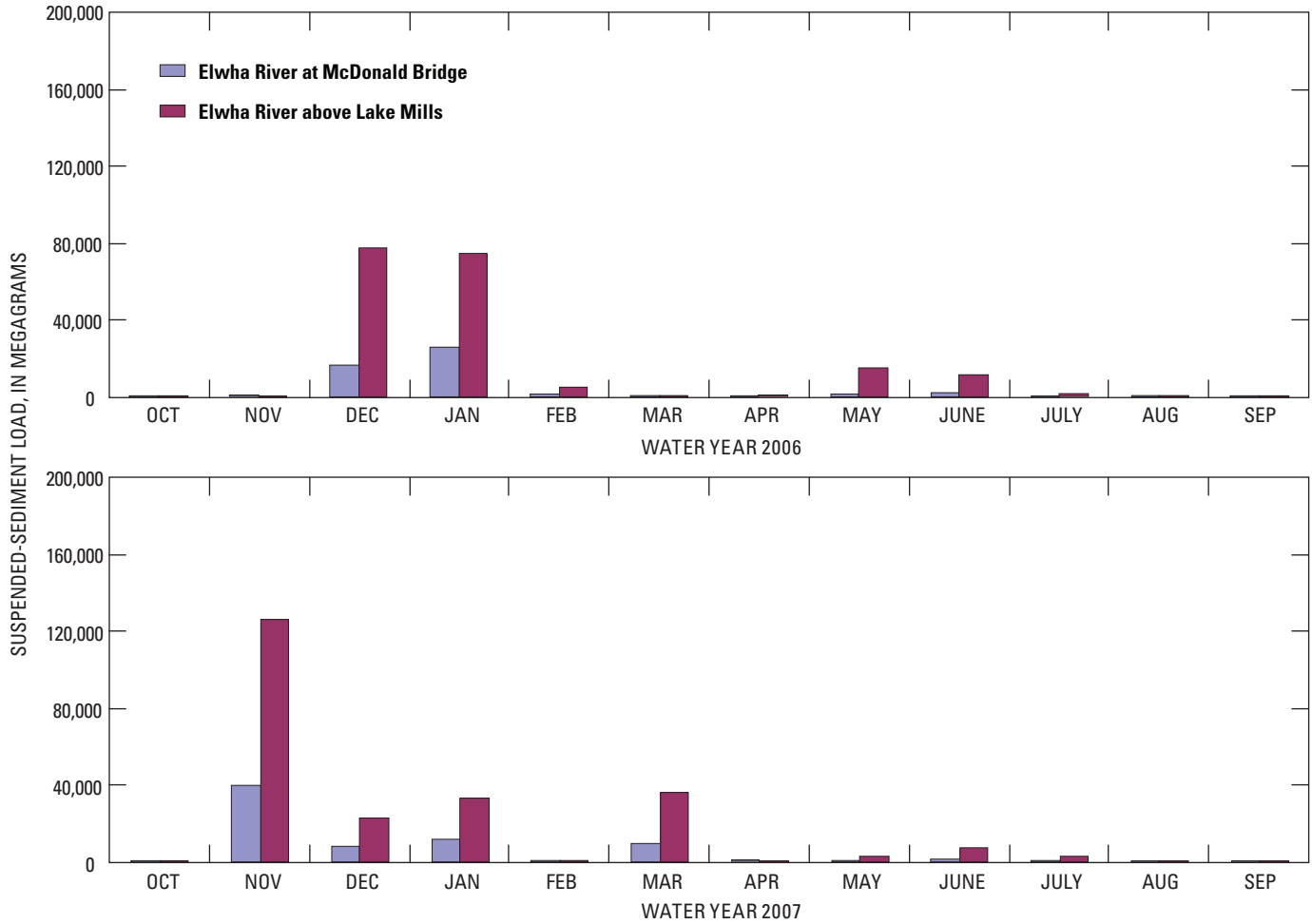
A limited particle-size analysis was done on 16 automated pump samples collected from December 2005 to January 2006, with suspended-sediment concentrations ranging from 69–454 mg/L. Of these, 14 samples were predominantly fine sediment (less than 0.0625 mm) with an average of 91 percent by mass. The percentage of fine sediment in samples at this site generally was higher than samples collected from the site upstream of Lake Mills, indicating that sand-sized particle settling occurs in Lake Mills.

Suspended-sediment concentrations of samples collected using the EDI method and automated pump sampler were combined in GCLAS with the record of instantaneous streamflow at this gaging station to calculate the daily, monthly, and annual suspended-sediment loads ([appendix E](#)).

### Comparisons of Sediment Load and Determination of Trap Efficiency of Lake Mills

Monthly suspended-sediment loads determined at both gaging stations on the Elwha River indicate that most sediment transport occurs during the winter flood season (November–February) with a smaller contribution occurring during mid-summer as a result of higher flows from snowmelt ([fig. 9](#)).

At the gaging station upstream of Lake Mills, the annual suspended-sediment load was 186,000 Mg in water year 2006 and 233,000 Mg in water year 2007 ([appendix B](#)).



**Figure 9.** Comparison of monthly suspended-sediment loads at Elwha River above Lake Mills (12044900) and Elwha River at McDonald Bridge (12045500), Elwha River basin, Clallam County, Washington, water years 2006 and 2007.

Downstream of Glines Canyon Dam, the annual suspended-sediment load at the McDonald Bridge gaging station was 49,300 Mg in water year 2006 and 75,200 Mg in water year 2007 (appendix E). The suspended-sediment yield for the basin upstream of the gaging station upstream of Lake Mills, calculated from the annual load divided by the drainage area (513 km<sup>2</sup>), was 363 Mg/km<sup>2</sup> for water year 2006 and 454 Mg/km<sup>2</sup> for water year 2007.

The ability of a reservoir to force the deposition of suspended particles and accumulate sediment over time can be quantified as the trap efficiency. The trap efficiency of a reservoir can be calculated as:

$$T_E = (Ls_i - Ls_o) / Ls_i, \tag{6}$$

where

$T_E$  is the trap efficiency of the reservoir (dimensionless);

$Ls_i$  is the sediment load flowing into the reservoir in megagrams; and

$Ls_o$  is the sediment load flowing out of the reservoir in megagrams.

The trap efficiency for Lake Mills was determined from the annual loads calculated at the gaging stations upstream and downstream of the reservoir. However, because the Lake Mills and McDonald Bridge gaging stations are not immediately upstream and downstream of the dam (4.3 km upstream and 7.6 km downstream, respectively), the additional sediment

loads contributed from the drainage areas of these reaches were estimated using the sediment yield determined for the basin upstream of the gaging station upstream of Lake Mills. To estimate the additional loads, the sediment yield was multiplied by the drainage areas associated with the reaches immediately upstream and downstream of the dam (122 and 62 km<sup>2</sup>, respectively). The resulting estimated load upstream of the dam was added to the annual sediment load at the gaging station upstream of Lake Mills to determine  $LS_u$ . The estimated load downstream of the dam was subtracted from the annual load determined at the McDonald Bridge gaging station to determine  $LS_o$ . The mean trap efficiency calculated from equation 6 was 0.86 for water years 2006 and 2007.

## Summary

The two dams on the Elwha River in Washington State are scheduled for removal in the near future: the Elwha Dam, which forms Lake Aldwell, and the Glines Canyon Dam, which forms Lake Mills. In an effort to estimate suspended-sediment loads prior to dam removal, the U.S. Geological Survey (USGS) collected suspended-sediment samples during water years 2006 and 2007 at two gaging stations on the Elwha River. One gaging station is in the free-flowing river upstream of Lake Mills and the other gaging station is downstream of Glines Canyon Dam. At the gaging station upstream of Lake Mills, samples of suspended sediment were collected over a range of flows including a large peak in November 2006 when suspended-sediment concentrations exceeded 7,000 milligrams per liter, the highest ever recorded on the river. A limited size analysis of samples collected before and during this flood peak indicated that the percentage of fine sediment (less than 0.0625 millimeters) increased as the flood progressed, likely due to the magnitude and seasonal timing of the flood. Suspended sediment measurements made during this study were combined with previously published measurements made during water years 1995–98 to develop a regression equation for estimating suspended-sediment concentration as a function of streamflow. This equation was used to estimate monthly and annual suspended-sediment loads for water years 2006 and 2007 using the USGS software program Graphical Constituent Loading Analysis Software (GCLAS). Additionally, a regression equation for estimating bedload discharge was developed from measurements made during the Lake Mills drawdown study and measurements made during water years 1995–98. On the basis of these regression equations, a flow-duration approach using the streamflow record upstream of Lake Mills produced an estimate of the average total annual sediment load from the Elwha River into Lake Mills of 327,000 megagrams with a range of uncertainty of +57 to -34 percent (217,000–513,000 megagrams) at the 95 percent confidence level. Of this total, 77 percent was estimated suspended-sediment load and 23 percent was estimated bedload.

At the McDonald Bridge gaging station downstream of Glines Canyon Dam, daily suspended-sediment samples were obtained with an automated pump sampler. These samples were used in Graphical Constituent Loading Analysis Software (GCLAS) to compute a record of daily, monthly, and annual suspended-sediment loads. At this site, a time lag of about 8 hours was observed between sediment concentration and streamflow peaks due to the slower transport of sediment through the reservoir relative to the propagation of the flood peak.

A comparison between the annual suspended-sediment loads at both gaging stations determined loads of 186,000 megagrams and 233,000 megagrams in water years 2006–07 upstream of Lake Mills and 49,300 megagrams and 75,200 megagrams, respectively, for the same period downstream of Glines Canyon Dam. Substantially more sediment load measured upstream compared with downstream of the reservoir indicates the extent to which Lake Mills traps and accumulates sediment. A trap efficiency of 0.86 was determined for the Lake Mills reservoir, based on suspended-sediment loads upstream and downstream of the lake. These pre-dam-removal estimates of suspended-sediment loads and sediment-discharge relations provide a baseline of data that will be useful to planners and scientists monitoring geomorphic and habitat changes in the river as it reaches a dynamic equilibrium following the removal of the dams.

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## Appendixes

Data files that contain suspended-sediment measurements and loads (appendixes A–D) and flow-duration/sediment rating curve calculations (appendix E) are presented in five Microsoft® Excel spreadsheets. The appendixes can be accessed and downloaded at URL <http://pubs.usgs.gov/sir/2009/5221/>.

**Appendix A.** Suspended-Sediment Measurements at U.S. Geological Survey Gaging Station Elwha River Above Lake Mills (12044900), Elwha River Basin, Clallam County, Washington, Water Years 1995–98

**Appendix B.** Estimates of Monthly and Annual Suspended-Sediment Load at U.S. Geological Survey Gaging Station Elwha River Above Lake Mills (12044900), Elwha River Basin, Clallam County, Washington, Water Years 2006–07

**Appendix C.** Bedload Measurements at U.S. Geological Survey Gaging Station Elwha River Above Lake Mills (12044900), Elwha River Basin, Clallam County, Washington, Water Years 1995–98

**Appendix D.** Flow-Duration/Sediment Rating Curve Calculations for Determining Estimated Total Annual Sediment Load into Lake Mills, Elwha River Basin, Clallam County, Washington

**Appendix E.** Daily, Monthly, and Annual Suspended-Sediment Load at U.S. Geological Survey Gaging Station Elwha River at McDonald Bridge (12045500), Elwha River Basin, Clallam County, Washington, Water Years 2006–07

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