Susitna-Watana Hydroelectric Project Document
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Title: Geomorphology study (Study 6.5), 2014 update of sediment-transport relationships and a revised sediment balance for the middle and lower Susitna River segments, technical memorandum	**SuWa 238**
Author(s) – Personal:	
Author(s) – Corporate: Tetra Tech, Inc.	
AEA-identified category, if specified: September 17, 2014 technical memorandum filings	
AEA-identified series, if specified:	
Series (ARLIS-assigned report number): Susitna-Watana Hydroelectric Project document number 238	**Existing numbers on document:**
Published by: [Anchorage, Alaska : Alaska Energy Authority, 2014]	**Date published:** September 2014
Published for: Prepared for Alaska Energy Authority	**Date or date range of report:**
Volume and/or Part numbers: Attachment J	**Final or Draft status, as indicated:**
Document type: Technical memorandum	**Pagination:** 83 p. in various pagings
Related work(s): Cover letter to this report: Susitna-Watana Hydroelectric Project, FERC Project no. 14241-000; Initial filing of September 2014 technical memoranda. (SuWa 228) Attachments A-I (SuWa 229 - 237)	**Pages added/changed by ARLIS:** Added cover letter
Notes:	

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SUSITNA-WATANA HYDRO

ALASKA ENERGY AUTHORITY

September 17, 2014

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: Susitna-Watana Hydroelectric Project, Project No. 14241-000

Initial Filing of September 2014 Technical Memoranda

Dear Secretary Bose:

By letter dated January 28, 2014, the Federal Energy Regulatory Commission (Commission or FERC) extended the procedural schedule for the preparation and review of the Initial Study Report (ISR) for the proposed Susitna-Watana Hydroelectric Project, FERC Project No. 14241 (Project).[1] In particular, the Commission's January 28 letter established a deadline of June 3, 2014 for the Alaska Energy Authority (AEA) to file the ISR, and provided a 120-day period for licensing participants to review the ISR prior to the ISR meetings, which are scheduled to begin the week of October 13.[2] The purpose of this filing is to provide several technical memoranda to Commission Staff and licensing participants prior to the ISR meetings.

As required by the Commission's January 28 letter, AEA filed the ISR with the Commission on June 3. Among other things, the ISR detailed AEA's planned work during the 2014 field season.[3] As AEA was preparing this 2014 work plan, it recognized that data gathered during the 2014 field season, together with other study work conducted prior to the October 2014 ISR meetings, could assist Commission Staff, AEA, and other licensing participants in developing the Project's licensing study program for 2015. For this reason, the ISR provided for AEA to prepare certain technical memoranda and other information based on 2014 work.

AEA recognizes that Commission Staff and licensing participants need a reasonable amount of time prior to the ISR meetings to review this additional information. AEA and licensing participants consulted with Commission Staff on this

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[1] Letter from Jeff Wright, Federal Energy Regulatory Commission, to Wayne Dyok, Alaska Energy Authority, Project No. 14241-000 (issued Jan. 28, 2014) [hereinafter, "January 28 letter"].

[2] The full schedule for the ISR meetings appears in Section 1.5 of the ISR, as well as on AEA's licensing website, http://www.susitna-watanahydro.org/meetings/.

[3] *E.g.*, Initial Study Report § 1.3 & Table 3, Project No. 14241-000 (filed June 3, 2014) [hereinafter, "ISR"].

matter, and Staff directed that any additional information should be filed with the Commission and made available to licensing participants no later than 15 days prior to the ISR meetings, consistent with the typically applicable deadline under the Commission's Integrated Licensing Process regulations.[4]

With this letter, AEA is filing and distributing the first set of technical memoranda and other information generated during the 2014 study season, as described below. As part of its continued implementation of the study plan, AEA expects to file certain additional technical memoranda prior to October 1, 2014, in accordance with Commission Staff direction.

This first set of technical memoranda and other information consists of the following:

- Attachment A: *Proposal to Eliminate the Chulitna Corridor from Further Study*. As explained in the ISR, throughout the licensing process AEA has continually evaluated its proposal for Project development based on environmental review, technical feasibility, practical considerations, and other factors. As part of this iterative process, AEA notified the Commission and licensing participants in the ISR that it was evaluating whether to continue study of the Chulitna Corridor.[5] Attachment A details AEA's conclusion that development of the Chulitna Corridor is not a reasonable alternative, and therefore AEA proposes to eliminate the corridor from further study. AEA seeks any comments or information on this proposal from federal and state resource agencies and other participants in the licensing process.

- Attachment B: *Ice Processes in the Susitna River Study (Study 7.6), Detailed Ice Observations October 2013 – May 2014 Technical Memorandum.* The ISR indicated that AEA would provide a summary of the 2014 break-up observations.[6] This technical memorandum describes all field activities and observations between October 16, 2013 and May 15, 2014 for the Ice Processes in the Susitna River Study (Study 7.6).

- Attachment C: *Study of Fish Distribution and Abundance in the Upper Susitna River (Study 9.5), Proposed 2015 Modifications to Fish Distribution and Abundance Study Plan Implementation Technical Memorandum.* Based on AEA's experience in implementing the study plan for the Study of Fish Distribution and Abundance in the Upper Susitna River (Study 9.5) during 2014, this technical memorandum proposes to continue certain modifications to the implementation of this study during 2015.

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4 *See* 18 C.F.R. § 5.15(c)(2).

5 *See* ISR, ISR Overview § 1.4.

6 *See id.*, Ice Processes in the Susitna River Study, Study Plan 7.6, Part C § 7.2.

- Attachment D: *Study of Fish Distribution and Abundance in the Middle and Lower Susitna River Study (Study 9.6), 2013-2014 Winter Fish Study Technical Memorandum.* At the time the ISR was filed, AEA was still in the process of conducting data entry, quality control, and analysis of winter sampling for this study. AEA reported in the ISR that it would develop plans for completing this study in a technical memorandum to be filed with the Commission.[7] This technical memorandum fulfills this commitment and sets forth AEA's proposal for winter efforts, including proposed methodologies and modifications.

- Attachment E: *Characterization and Mapping of Aquatic Habitats (Study 9.9), 2013 and 2014 Aquatic Habitat Mapping Field Season Completion Progress Technical Memorandum.* In the ISR, AEA reported that its 2014 activities for the Characterization and Mapping of Aquatic Habitats Study (Study 9.9) would consist of various ground-truthing surveys and collection of habitat information for the 12 lakes within the potential reservoir inundation zone.[8] This technical memorandum reports on these activities.

- Attachment F: *Eulachon Run Timing, Distribution, and Spawning in the Susitna River (Study 9.16), 2015 Proposed Eulachon Spawning Habitat Study Modifications Technical Memorandum.* After reviewing the 2013 and 2014 results from the Cook Inlet Beluga Whale Study (Study 9.17) and discussing the results with the National Marine Fisheries Service, AEA has determined that additional data are needed regarding eulachon spawning habitats. This technical memorandum describes a proposed modification to the Study of Eulachon Run Timing, Distribution and Spawning in the Susitna River (Study 9.16) to include an assessment of eulachon spawning habitats.

- Attachment G: *Fish and Aquatics Instream Flow Study (Study 8.5), Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables Technical Memorandum*. Consistent with the Commission's study plan determination,[9] this technical memorandum provides a detailed evaluation of the comparison of fish abundance measures with specific microhabitat variable measurements where sampling overlaps. This memorandum is used to determine whether a relationship between a specific microhabitat variable and fish abundance is evident.

- Attachment H: *Fish and Aquatics Instream Flow Study (Study 8.5), 2013-2014 Instream Flow Winter Studies Technical Memorandum*. In the ISR, AEA reported that it would distribute its finding concerning the 2013-2014

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[7] *See id.*, Study of Fish Distribution and Abundance in the Middle and Lower Susitna River Study, Study Plan 9.6, Part C § 7.1.2.5.

[8] *See id.*, Characterization and Mapping of Aquatic Habitats, Study Plan 9.9, Part C § 7.1.

[9] *See* Study Plan Determination on 14 Remaining Studies for the Susitna-Watana Hydroelectric Project, Appendix B at B-84 to B-86, Project No. 14241-000 (issued Apr. 1, 2013).

winter activities in 2014.[10] This technical memorandum describes the methods applied, and data and information collected, as part of the Instream Flow Study 2013-2014 winter studies.

- Attachment I: *Geomorphology Study (Study 6.5), Susitna River Historical Cross Section Comparison (1980s to Current) Technical Memorandum*. As specified in Revised Study Plan Section 6.5.4.1.2.3, this technical memorandum describes changes within the main and side channels of the Susitna River by comparing historical survey data from the 1980s with survey data from the current Project.

- Attachment J: *Geomorphology Study (Study 6.5), 2014 Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments Technical Memorandum*. The purpose of this technical memorandum is to update the sediment load rating curves and preliminary estimates of the overall sediment balance in the Middle and Lower River segments under pre-Project conditions that were initially provided in "Development of Sediment-Transport Relationships and an Initial Sediment Balance for the Middle and Lower Susitna River Segments," (Tetra Tech, Inc. 2013a). This update is based on additional data collected by the U.S. Geological Survey in 2012 and 2013.

AEA appreciates the opportunity to provide this additional information to the Commission and licensing participants, which it believes will be helpful in determining the appropriate development of the 2015 study plan as set forth in the ISR. If you have questions concerning this submission please contact me at wdyok@aidea.org or (907) 771-3955.

Sincerely,

Wayne M Dyok

Wayne Dyok
Project Manager
Alaska Energy Authority

Attachments

cc: Distribution List (w/o Attachments)

[10] *See* ISR, Fish and Aquatics Instream Flow Study, Study Plan 8.5, Part C § 7.5.2.

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Geomorphology Study (Study 6.5)

2014 Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Tetra Tech, Inc.

September 2014

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
AEA	Alaska Energy Authority
cfs	cubic feet per second
FERC	Federal Energy Regulatory Commission
ILP	Integrated Licensing Process
M	Million
Mm	Millimeter
MVUE	Minimum Variance Unbiased Estimator
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NWIS	National Water Information System
OS	Operation Scenario
PRM	Project River Mile
RM	River Mile
RSP	Revised Study Plan
sq mi	square mile
USGS	U.S. Geological Survey
WY	Water Year

SUMMARY

The purpose of the study effort was to update the sediment load rating curves and preliminary estimates of the overall sediment balance in the Middle and Lower River segments under pre-Project conditions that were initially provided in "Development of Sediment-Transport Relationships and an Initial Sediment Balance for the Middle and Lower Susitna River Segments," (Tetra Tech, Inc. 2013a). This update is based on additional data collected by the U.S. Geological Survey (USGS) in 2012 and 2013. The sediment rating curves are applied in this memorandum to develop the sediment balance along the Susitna River mainstem and they will be used as sediment inflow rating curves for the 1-D Fluvial Geomorphology Modeling Study (Study 6.6) tasks. A sediment balance is the determination of the difference between the inflowing sediment (supply) to a reach and the outflowing sediment from the reach (transport). If the sediment inflow to the reach is greater than the outflow, then sediment is stored within the reach. If the sediment supply into the reach is less than the sediment outflow from the reach, then sediment is removed from the reach. In the former case, the reach is considered depositional and in the latter case it is considered aggradational. If the sediment inflow and outflow are nearly equal, the reach is considered in balance with its sediment supply and transport.

Sediment transport relationships (sediment load versus water discharge) were developed at five locations on the mainstem Susitna River: Denali, Cantwell (Vee Canyon), Gold Creek, Sunshine, and Susitna Station, and on the three largest tributaries, the Chulitna, Talkeetna and Yentna Rivers. Since the ability of the river to transport sediment and its response to the sediment being supplied varies greatly with the size of the sediment, relationships were developed for three sizes of sediment, wash load (silts and clay), sand load and gravel load. These are the same size classes used in the preliminary sediment transport analysis in 2013 (Tetra Tech, Inc. 2013a). Just as in Tetra Tech, Inc. 2013a, the relationships were applied to the long term hydrologic conditions represented by existing (pre-Project) conditions. This was done primarily as a check for consistency with the preliminary analysis. Unlike the 2013 analyses, operational conditions were not considered as part of this task because 1-D bed evolution modeling will be used to develop sediment transport information throughout the river between the proposed Watana Dam location and PRM 29.9 for both existing and operational conditions. The modeling will not only provide sediment loading for the various scenarios, but will be used to evaluate channel change (e.g. aggradation, degradation, and sediment gradations) and the resulting changes in hydraulics (e.g. water surface elevations, flow depths, and flow velocities). All future reach-scale sediment transport analyses will be performed with the 1-D bed evolution modeling to evaluate pre-Project to the range of operational scenarios.

The data collected in 2012 and 2013 are very similar to previous data collected by the USGS. The sediment rating curves have been updated to include all the data, are also similar but are considered more representative than the earlier rating curves. Therefore, the data and rating curves are sufficient for all remaining analyses. Except for measurements made in 2014, no additional data collection will be performed. Any data collected by the USGS in 2014 will be reviewed, but AEA does not anticipate further revision of the sediment rating curves or calculations of annual sediment loads reported in this TM.

1. INTRODUCTION

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project using the Integrated Licensing Process. The Project is located on the Susitna River, an approximately 300-mile-long river in the south-central region of Alaska. The Project's dam site will be located at Project River Mile (PRM) 187.1. The results of this study will provide information needed to support the FERC's National Environmental Policy Act analysis for the Project license.

The 2012 study effort G-S4: Reconnaissance-level Geomorphic and Aquatic Habitat Assessment of Project Effects on Lower River Channel study plan included, among other objectives, a preliminary evaluation of the relative magnitude of changes in the sediment regime associated the Susitna-Watana Hydroelectric Project. The previous memorandum (Tetra Tech 2013a) summarized work performed under the *Sediment Load Comparison* section of the *Sediment Transport Assessment* task to meet this objective, including the development of sediment-transport relationships using the available sediment-transport data, and an initial sediment balance for the Middle and Lower Susitna River segments, based on the pre-Project hydrology and post-Project hydrology under an operations scenario referred to as Maximum Load Following Operation Scenario 1 (OS-1). These two hydrology scenarios were analyzed in detail in Tetra Tech (2013b).

The primary purpose of this technical memorandum is to update the sediment transport relationships (sediment rating curves) for gages located on the mainstem Susitna River and three of the gages are located on major tributaries (the Chulitna, Talkeetna and Yentna Rivers). The update effort is part of the Geomorphology Study (Study 6.5) and is identified as part of RSP Section 6.5.4.3 *Study Component: Sediment Supply and Transport Middle and Lower Susitna River Segments*. The relationships are used to estimate sediment loads along the Susitna River and contributed from the major tributaries. The primary uses of these relationships are as input to the 1-D bed evolution modeling and to evaluate model performance at gages located within the model reaches. The pre-Project sediment load analysis was performed for six streamflow gages located in the Susitna Basin using 61 years of extended hydrologic records developed by the U.S. Geological Survey (USGS 2012) for the period from Water Year (WY) 1950 through WY2010.

The main components of the sediment-transport analysis include the following:

- A review of previously published relationships between discharge and (1) suspended sediment load, (2) bed load, and (3) total sediment load (Knott et al. 1987), and refinement of those relationships using all additional available data.
- Application of selected relationships to both the pre-Project flow records to estimate annual sediment loads for suspended silt/clay (i.e., wash load), total sand load based on independent estimates of the amount of sand being carried in suspension and as bed load, and the gravel component of the bed load.
- Comparison of the estimated annual sediment loads to provide an approximate sediment balance in the river reaches between the mainstem gages in the Middle and Lower Rivers.

2. STUDY OBJECTIVES

The overall objective of this memorandum is to make preliminary estimates of the overall sediment balance in the Middle and Lower River segments under pre-project conditions including the specific assessments of the following, interrelated topics:

- Determination of the suitability of previously published sediment transport relationships between discharge and sediment load and update the relationships if necessary.
- Selection of the most appropriate sediment transport relationships for use in the preliminary sediment balance.
- Use the selected sediment transport relationships to estimate the pre-Project annual loads. The sediment loads will be divided into wash load (silt and clay), sand load and gravel load.
- Comparison of estimated annual sediment loads at the three mainstem Susitna River gages to characterize the overall sediment balance under pre-Project conditions.
- Provide sediment transport relationships that will be used for 1-D bed morphology modeling tasks. These will be used as sediment boundary conditions at Watana Dam site and the three major tributaries (Chulitna, Talkeetna, and Yentna Rivers).

A sediment balance is the determination of the difference between the inflowing sediment (supply) to a reach and the outflowing sediment from the reach (transport). If the sediment inflow to the reach is greater than the outflow, then sediment is stored within the reach. If the sediment supply into the reach is less than the sediment outflow from the reach, then sediment is removed from the reach. In the former case, the reach is considered depositional and in the latter case it is considered aggradational. If the sediment inflow and outflow are nearly equal, then the reach is considered in balance or in equilibrium in terms of sediment supply and transport. Other sources of sediment, especially tributary sediment inputs, must also be considered. The three major tributaries are included based on the available data. Minor tributaries may also have significant local effects and cumulative effects at the reach scale. Minor tributaries will be incorporated as this information is further developed in 2015.

3. STUDY AREA AND AVAILABLE DATA

The Susitna River, located in Southcentral Alaska, drains an area of approximately 20,010 square miles and flows about 320 miles from its headwaters at the Susitna, West Fork Susitna and East Fork Susitna glaciers to the Cook Inlet (USGS 2012). The Susitna River basin is bounded on the west and north by the Alaska Range, on the east by the Talkeetna Mountains and Copper River Lowlands and on the south by Cook Inlet. The highest elevations in the basin are at Mt. McKinley at 20,320 feet while its lowest elevations are at sea level where the river discharges into Cook Inlet. Major tributaries to the Susitna River between the headwaters and Cook Inlet include the Chulitna, Talkeetna and Yentna Rivers that are also glacially fed in their respective headwaters. The basin receives, on average, 35 inches of precipitation annually with average annual air temperatures of approximately 29^{o}F.

There are 14 USGS streamflow gages located in the Susitna River Basin plus one on the Little Susitna River that was used as an index station (Table 3.0-1 and Figure 3.0-1). The period of recorded data available for these gages ranges from 58 years at the Gold Creek gage to less than

10 years at gages such as the Yentna River at Susitna Station and the Susitna River at Sunshine gages. The data available from many of these gages may not adequately represent long-term streamflow conditions in the Susitna River Basin because of the short period of record and the distribution of years during which data were collected (USGS 2012). To provide a consistent long-term record, the USGS extended the record of 11 of these gages to 61 years (WY1950 – WY2010). WY1950 was selected for the start of the record because this was the first full water year of data collection for the primary index station at Gold Creek. The Montana Creek (Mont), Deception Creek (Decep), and the Deshka River (Desh) gages were not included in the extended record analysis because they could not be adequately correlated to any long-term index station for the entire study period (USGS 2012).

Three main stem gages and three primary tributary gages locations downstream of the Project site PRM 187.1 (Figure 3.0-1) were used to characterize the sediment-transport regime under the 61-year hydrology record for each portion of the reach, as follows:

- Main Steam Gages
    - Middle River Mainstem: Susitna River at Gold Creek Gage (15292000) and Susitna River near Talkeetna Gage (15292100)[1]
    - Lower River mainstem below Three Rivers Confluence: Susitna River at Sunshine Gage (15292780)
    - Lower River mainstem below Yentna River: Susitna River at Susitna Station Gage (15294350)
- Primary Tributary Gages
    - Tributary Supply to Three River Confluence (Chulitna River near Talkeetna Gage (15292400) and the Chulitna River below canyon near Talkeetna gage (15292410)[1)]
    - Talkeetna River near Talkeetna Gage (15292700)
    - Tributary Supply to Lower River: Yentna River near Susitna Station Gage (15294345)
- Other Locations
    - Upper River Mainstem: Susitna River near Denali Gage (15291000)
    - Upper River Tributary: Maclaren River near Paxson Gage (15291200)
    - Upper River Mainstem: Susitna River near Cantwell Gage (15291500)
    - Middle River Tributary: Portage Creek near Gold Creek (625000149223500)[2]
    - Middle River Tributary: Indian Creek near Gold Creek (624718149393600)[2]

The number and types of sediment samples, and the dates of sampling vary among the gages, but generally include both the magnitude and gradation of the suspended sediment and bed load for samples collected between the late-1970s and the late-1980s (Table 3.0-2). The bulk of these

[1] Data from both these gages were combined into a single data set for the USGS (Knott et al. 1987) analysis; this approach was adopted for this preliminary study, as well.

[2] Suspended and bed load sampling conducted in WY1984 and reported in Knott et al. (1986).

data that were collected through WY1985 were previously analyzed by Knott et al. (1987). As part of the current analysis, the available data for each of the gages were downloaded from the USGS National Water Information System (NWIS) website (http://waterdata.usgs.gov), and relevant data collected after 1985 were added to the data sets. Data for Portage Creek and Indian River were obtained from Tables 2 and 3 of Knott et al. (1986).

4. METHODS

This section describes the methods used to select or develop relationships between discharge and sediment load for each component of the sediment load at the six USGS gaging stations, and apply these relationships, with the minimum variance unbiased estimator (MVUE) bias-correction technique, to the pre-Project extended flow records to estimate the annual sediment loads for each size range.

4.1. Variations from Study Plan

The Study Plan calls for comparison of the total sediment load at the Sunshine and Susitna Station gaging stations for an average, wet, and dry year between pre-Project and adjusted post-Project conditions using adjusted post-Project rating curves. Because the 61-year daily flow record was available for pre-Project and Maximum Load Following OS-1 conditions, the full record was used for this purpose in lieu of selecting specific years for the analysis, with sediment loads compared on an average annual basis over all years, and the variability assessed by considering the range of annual loads from the 61-year record. This more comprehensive approach to assessing sediment loads provides a better assessment of the long-term project influence on sediment transport than considering only the three "representative" years.

4.2. Sediment Load Rating Curves

Knott et al. (1987) used the data collected through WY1985 at the six gages to characterize sediment-transport conditions in the reach. This included development of relationships between discharge and sediment loads from data for four components of the total sediment load collected during the period between October 1984 and September 1985, data collected from WY1981 through WY1984, and historical records (USGS 1953 to 1980):

- Suspended silt/clay
- Suspended sand
- Sand bed load,
- Gravel bed load

The Knott et al. (1987) relationships were of the power-function form:

$$Q_s = a(Q)^b \qquad (4.2\text{-}1)$$

where:

Q_s = sediment load (tons/day)
a = coefficient
b = exponent
Q = discharge (cubic feet/second)

For consistency with Knott et al. (1987) and standard practice in developing sediment load rating curves (USGS, 1992), power function relationships were also used for the current study.

As an initial step in the analysis, the available data through WY1985 in each size-range at each of the gages was plotted and compared with the data plots in Knott et al. (1987). This comparison revealed a limited number of available data points from the NWIS database that were not used in the Knott et al. (1987) analysis. No explanation was provided in their report for why these data points were not used. In an attempt to ascertain the reason(s), Mr. Gary Solin at the USGS Alaska Science Center, where the original data collection and analysis were performed, was contacted. Mr. Solin indicated that the individuals who performed the analysis were either retired and out of contact; thus, he was not able to provide specific information about the issue. He did, however, suggest that the data points used in the analysis were probably limited to those directly collected by the study team and/or for which the study team had specific knowledge. Because including the additional, recently (2012 and 2013) collected data is desirable to develop the most representative sediment load information, all appropriate prior data were included in this analysis. A data point was excluded when it was an obvious outlier that significantly impacted the resulting relationship.

The data sets were updated by adding relevant data collected since WY1985 (2014 data have not been received from the USGS and were not included in the analysis). Power-function regression lines were then fit to the extended data sets using the least-squares regression technique and compared to the Knott et al. (1987) line-of-best-fit. The new regression equations are presented in Table 4.1-1 and Appendix A. In some cases, no relationship was evident. In these cases a power function relationship was passed through the means of the log-transformed data (a requirement of linear regression) and a slope was selected that represented the observable trends. This was only done for some bed load sand and gravel data, which are small in comparison to suspended load sand.

4.3. Bias Correction and Annual Load Estimates

The selected relationships between discharge and the various components of the sediment load were then used with the MVUE bias-correction technique to estimate daily sediment loads for the entire 61-year record of mean daily flows for pre-Project conditions. The MVUE technique was used to correct for the statistical bias that occurs in basic power-function regression, based guidance from USGS (1992). Previous studies have demonstrated that the bias occurs in the process of linearizing the data set by transforming it into the logarithmic domain and then back-transforming the resulting relationship into the arithmetic domain (Walling 1977b; Thomas 1985; Ferguson 1986). Various procedures are available to address the bias, including accounting for seasonal differences in sediment transport and accounting for hysteresis related to rising and falling limbs of flood hydrographs (Guy 1964; Walling 1974). Koch and Smillie (1986) and Cohn and Gilroy (1991) described methods of numerically correcting for the bias that depend on the expected distribution of errors. USGS (1992) endorsed the recommendations in Cohn and Gilroy (1991) to use the MVUE bias correction for normally distributed errors, or the Smearing Estimator (Duan 1983) when a non-normal error distribution is identified. The MVUE method was selected in this analysis to remove the bias from the log-transformed sediment loads because the errors are generally normally-distributed. The MVUE technique was also used to convert the sediment load regression lines into sediment load rating curves for use as boundary conditions in the 1-D bed evolution models.

5. RESULTS

This section summarizes the annual sediment yields developed using the methods described in Section 4. As noted above, Knott et al. (1987) divided the total sediment load into four components, primarily because of the manner in which the data are collected. It is, however, more meaningful from a river-process perspective to re-group these components into three components, consisting of the wash load (i.e., silt/clay that is almost exclusively carried in suspension), the sand component of the bed material load that consists of the sand that is carried both in suspension and as bed load, and the gravel component of the bed load. The sand load is being treated separately in this analysis because it may be strongly supply-limited in the Middle River, and thus more correctly categorized as part of the wash load in the Middle River and some tributaries; however, in the Lower River especially in the area of Susitna Station and further downstream, the sand load may be transport limited. The significant presence of sand in the Lower River and differences between the Middle and Lower River bed material are described in Tetra Tech (2014). The bed in the Middle River is very armored but the bed in the Lower River is very mobile.

Under pre-Project conditions, the estimated total annual sediment loads at the Gold Creek/near Talkeetna gage average about 3.4 million (M) tons, varying from about 680,000 tons to 9.3M tons (Figure 5.1-1). Of these amounts, the silt/clay, wash load accounts for about 57 percent (2.0M tons) of the total, on average, while the sand accounts for about 42 percent (1.4M tons) and the gravel bed load accounts for only about 1 percent (20,000 tons) of the total.

At the Sunshine gage, the average, pre-Project total annual sediment load increases to about 15.8M tons, ranging from about 4.8M to 25.5M tons (Figure 5.1-2). The relative proportion of wash load increases to about 61 percent (9.6M tons) of the total, with the sand and gravel loads accounting for about 38 and 1.5 percent (6M and 240,000 tons) of the total, respectively.

The annual total load at the Susitna Station gage averages about 33.7M tons, and ranges from 18.3M to 52M tons (Figure 5.1-3). The silt/clay load accounts for about 58 percent (19.4M tons), and the sand and gravel loads account for about 42 percent (14.1M tons) and less than 1 percent (169,000 tons) of the total, respectively, at this location.

The three primary tributaries supply a significant amount of the sediment to the mainstem. The annual load from the Chulitna River, for example, averages about 8.6M tons, ranging from 4.5M tons to 20.5M tons (Figure 5.1-4), and the Talkeetna River supplies an average of about 1.9M tons/year, ranging from about 420,000 to 6.9M tons/year (Figure 5.1-5). The Yentna River carries the largest total load of the three, averaging about 14.5M tons/year and ranging from 8.2M to 25M tons/year (Figure 5.1-6). The transported load in the Chulitna River includes a higher proportion of gravel than either the mainstem or the other two major tributaries (about 5 percent versus < 1, 2.3 and 1.3 percent for the mainstem, Talkeetna and Yentna Rivers, respectively). Wash load comprises 48 percent of the sediment transported by the Yentna River compared to 57 percent on the mainstem, and 60 and 50 percent for the Chulitna and Talkeetna Rivers, respectively.

Based on these results, the Middle River supplies about 24 percent of the total sediment load to the Three Rivers Confluence, and the Chulitna and Talkeetna Rivers supply about 62 and 14 percent of the total load, respectively (Figure 5.1-7). On a by-size-fraction basis, the relative contributions of silt/clay and sand are about the same as the total load; however, the Chulitna

River supplies the bulk of the gravel load that is key to the channel morphology (about 87 percent of the total, compared to about 4 percent from the Middle River and 9 percent from the Talkeetna River). The total sediment load from the Yentna River represents about 48 percent of the total load at Susitna Station, and about 44 percent of the gravel load. A tabulation of the estimated annual loads under pre-Project conditions for each component of the load at each of the six gages is provided Appendix B.

The tributary loads referenced above assume that these loads are delivered from the point of measurement, which is well upstream from the tributary mouth in each case (approximately 12, 4 and 12 miles for the Chulitna, Talkeetna, and Yentna Rivers). The lower 8 miles of the Chulitna and lower 2 miles of both the Talkeetna and Yentna River exhibit channel forms (braid plains, island and bar systems, and multiple channel networks) that are indicative of long-term sediment storage. Therefore, the sediment loads associated with these major tributaries are probably not being entirely delivered to the Susitna River. This is one reason why the 1-D bed evolution modeling includes the Chulitna and Talkeetna Rivers as individual reaches.

6. DISCUSSION

The sediment load analyses presented in the previous sections provide a basis for development of a preliminary sediment balance for the Middle and Lower Rivers. In general, sediment rating curves developed using regression equations tended to have lower slopes than those presented in Knott et al. (1987), which were predominantly used in the prior analyses (Tetra Tech 2013a). This results in very comparable long-term loads (mean annual) but tends to decrease loads for high flow years and increase loads for low flow years.

This Technical Memorandum completes Study Component described in RSP (AEA 2012) Section 6.5.4.2, *Bedload and Suspended Load Data Collection at Tsusena Creek, Gold Creek and Sunshine Gage Stations on the Susitna River, Chulitna River near Talkeetna, ant he Talkeetna River near Talkeetna*. The data collected in 2012 and 2013 are very similar to previous data. Although the regression analyses included in this TM generally produce lower slopes than the earlier USGS relationships, it is the improved method of analysis, rather than the data, that produces the change. The sediment rating curves were updated to include all the data and are considered more representative of transport conditions than the earlier rating curves. The data and rating curves are sufficient for all remaining analyses. Except for measurements made in 2014, no additional sediment transport measurements will be performed. Any data collected by the USGS in 2014 will be reviewed, but AEA does not anticipate further revision of the sediment rating curves or calculations of annual sediment loads reported in this TM.

The effects of the dam on the sediment balance would vary between the silt/clay, sand and gravel loads and will be evaluated based on sediment transport modeling. Initial estimates are that the dam would likely cut off at least 90 percent of the silt/clay supply and essentially all of the sand and gravel supply to the head of the Middle River. The effects on all components of the sediment load would diminish in the downstream direction due to contributions from the tributaries and entrainment of material that is currently stored in the channel. The silt/clay load is carried almost exclusively in suspension. As a result, the effects of sediment trapping in the reservoir on downstream silt/clay loads would be felt within a very short time-frame (i.e., on the order of the travel time of the water) throughout the Middle and Lower Rivers after closure of the dam.

A significant change in this analysis from the initial sediment balance analysis (Tetra Tech 2013a) is in the estimates of ungaged tributary loads. In the initial sediment balance the loads were estimated based on assuming sediment loading in proportion to drainage area. This is appropriate for reasonably similar basin conditions, but in this instance does not address differences in glaciated versus non-glaciated basins. Field observations indicate that other than the Chulitna, Talkeetna, and Yentna Rivers, the Middle and Lower River tributaries are clear-water supplying virtually no wash load and little sand to the Susitna River. Data were collected by the USGS at Portage Creek and Indian River in 1984 and are presented in Table 6.0-1. These data are in significant contrast to the mainstem sediment conditions. Where the mainstem and major tributaries are dominated by wash load and sand with orders of magnitude less gravel, the Middle River tributaries have negligible amounts of wash load (silt/clay), slightly higher amounts of sand, and yet larger amounts of gravel.

The information from Section 5 was used to develop a preliminary sediment balance for the Lower and Middle Rivers under pre-Project and presented in Table 6.0-1. Ungaged tributaries between the Watana Dam site and the Gold Creek gage account for about 16 percent of the total drainage at Gold Creek, and ungaged tributaries between Sunshine and Susitna Station account for about 11 percent of the total drainage area at Susitna Station. Sediment loading from the Middle River tributaries is based on 3ppm silt/clay, 7 ppm sand, and 20 ppm gravel. For the wash load and sand, the loads are negligible. For the gravel, the loading from tributaries exceeds the transport capacity at the lower end of the Middle River. If this is actually the case, then the gravel is either being stored in fans at the tributary mouths, or is being stored along the Middle River channel. Although fan storage is considered more likely, if the entire 34,000 tons/year of tributary-supplied gravel at 100 lb/ft^3 bulk weight were distributed over a 600 ft channel width and 70 miles of the Middle River (excluding Devils Canyon), the resulting aggradation would average only 0.3 ft in 100 years.

For the Lower River it was assumed that all ungaged tributary loads are negligible. In many cases these tributaries cross terraces before feeding into side channels. There are also no significant fan deposits at these tributaries. Although these estimates are low, the amounts of sediment delivered from non-major tributaries is insignificant compared to the Susitna River transport. Sediment transport models are being developed to estimate tributary sediment supply to the Lower River, but field observations indicate that these loads are minimal for all but the major tributaries. These results do bring into question some of the values in Table 6.0-2, primarily when the supply above Sunshine (or Susitna Station) is less than the amount computed at Sunshine (or Susitna Station). Although these differences could be attributed to tributary inputs, other factors could be contributing to these differences. The factors include bank erosion into terraces, landslides that briefly produce large amounts of sediment, or uncertainties in computing the loads. The differences are less than 10 percent for total load, which for sediment load estimates is well within the uncertainties.

To demonstrate the differences between the glacially fed source areas and minor tributaries, Table 6.0-3 shows mean annual sediment concentrations in PPM by weight. At low concentrations these PPM values are essentially the same as concentration in mg/l. In table 6.0-3 silt/clay loads along the Susitna River and its major tributaries range from 200 to 600 PPM, sand loads range from 150 to 500 ppm, and gravel from 3 to 50 PPM. This compares to less than 10 PPM for silt/clay and sand for the measurements at Indian River and Portage Creek and generally between 10 and 20 ppm for gravel. In terms of sediment concentration (weight of

sediment divided by the weight of water-sediment mixture), the Middle River tributary flows may contain only 0.01 times the concentration of silt/clay, 0.04 times the concentration of sand, but as much as 10 times the gravel than mainstem Middle River flows. The values for ungaged Middle and Lower River tributaries will be refined using sediment transport capacity calculations for surveyed tributaries.

These analyses will be used to support the following analyses:

1. The updated sediment-transport rating curves for Watana dam location and the major tributary gages will be used as inputs to the reach-scale 1-D sediment-transport model. The rating tables are presented in Appendix C of this report.
2. The updated sediment-transport rating curves for the mainstem gages will be used to calibrate the sediment-transport rates in the reach-scale 1-D sediment-transport model.
3. In the current analysis, sediment loading from all ungaged sources was lumped into the "ungaged tributary" category. In reality, sediment is also supplied to the river from bank erosion and mass wasting from unstable hillslopes. Estimates of the sediment loading from all of these sources, including the ungaged tributaries, will be segregated and improved based on field observations, evaluation of lateral bankline shifting and bed material measurements and transport capacity calculations in the lower end of a selected number of the larger ungaged tributaries. As described in RSP Section 6.6.4.1.2.6 (AEA 2012), sediment-load rating curves for the ungaged tributaries will be developed by surveying cross sections and collecting bed material samples in an appropriate reach near the mouth, developing 1-D hydraulic conditions using either step-backwater or normal depth calculations, as appropriate, and applying an appropriate bed material transport equations with the measured bed material gradations. For those tributaries that enter the river within the Focus Areas, the hydraulic and sediment-transport analysis to assess the response of the Susitna River channel to Project conditions will be performed using the 2-D model(s). For the selected tributaries outside the focus areas, the analysis will be performed using 1-D hydraulic modeling with relatively closely spaced cross sections in the vicinity of the confluence.
4. The tributary-specific sediment loads estimated in the previous task will be used to assess the potential impact of changes in flow and sediment load in the mainstem on the sediment-transport behavior at the tributary mouths. A key question to be answered by this analysis is the extent to which the coarse-grained sediment from the tributaries will be entrained and transported downstream away from the tributary mouth versus building of the delta in a manner that could potentially affect fish passage into the tributary and/or constrict the river causing other impacts to water-surface elevations and channel stability. Similar to the sediment loading analysis, the analysis for those tributaries that are located within a Focus Area will be conducted using the 2-D mobile-boundary model. At the selected tributaries outside the Focus Areas, additional mainstem cross sections (typically 5 to 7, in total) will be surveyed in the vicinity of the mouth, and 1-D hydraulic modeling and sediment-transport calculations will used to perform the assessment.
5. AEA has extended the 1-D sediment-transport model downstream to at least Susitna Station (PRM 29) (Tetra Tech 2013c). Based on bed material samples, the bed is primarily gravel with median (D_{50}) size in the range of 50 to 100 millimeters (mm), and only a small amount of sand (typically <5 percent) at Sunshine. In contrast, the bed material at Susitna Station is primarily sand (D_{50}~0.4 mm and nearly 90 percent <2 mm based on one sample). This

indicates aggradation of gravel sizes between Sunshine and Susitna Station. The results for sand are not as clear. Although from the rating curve analysis it appears that sand may be in balance along the lower river, the channel form indicates potential for aggradation. This determination will be important in understanding potential Project effects and will be based on the sediment transport modeling results. The sediment-transport behavior of mainstem at the tributary mouths will also be an important factor in understanding Project effects in the Middle and Lower Rivers, particularly in the reaches upstream from the gravel-sand transition zone.

The 1-D bed morphology modeling will be an important tool in making comparisons of pre-Project and the range of operational scenarios, as well as providing input to the detailed Focus Area (2-D) bed morphology models. The sediment-transport relationships contained in this Technical Memorandum are a key input for the 1-D bed morphology models, which will be used for all future reach-scale sediment transport analyses.

7. REFERENCES

AEA (Alaska Energy Authority). 2012. Revised Study Plan: Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2012. Prepared for the Federal Energy Regulatory Commission by the Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/study-plan.

Cohn, T.A., and E.J. Gilroy. 1991. Estimating Loads from Periodic Records. *U.S. Geological Survey Branch of Systems Analysis Technical Report* 91.01. 81 p.

Duan, N. 1983. Smearing Estimate: A Nonparametric Retransformation Method. *Journal of the American Statistical Association*, v 78(383): 605–610.

Ferguson, R.I. 1986. River Loads Underestimated by Rating Curves. *Water Resources Research*, v 22(1): 74–76.

Guy, H.P. 1964. An Analysis of Some Storm-Period Variables Affecting Stream Sediment Transport. *U.S. Geological Survey Professional Paper* No. 462E.

Interagency Advisory Committee on Water Data (IACWD). 1982. Guidelines for determining flow frequency: Reston, Va., U.S. Geological Survey, Office of Water Data Coordination, *Hydrology Subcommittee Bulletin* 17B.

Koch, R.W. and G.M. Smillie. 1986. Bias in Hydrologic Prediction Using Log-Transformed Regression Models. *Journal of the American Water Resources Association*. v 22: 717–723.

Knott, J.M., S.W. Lipscomb, and T.W. Lewis. 1986. Sediment Transport Characteristics of Selected Streams in the Susitna River Basin, Alaska: October 1983 to September 1984. U.S. Geological Survey Open-File Report 86-424W. Prepared in cooperation with the Alaska Power Authority. Anchorage, Alaska. 73 p.

Knott, J.M., S.W. Lipscomb, and T.W. Lewis. 1987. Sediment Transport Characteristics of Selected Streams in the Susitna River Basin, Alaska: Data for Water Year 1985 and Trends in Bed-load Discharge, 1981-95. U.S. Geological Survey Open-File Report 87-229. Prepared in cooperation with the Alaska Power Authority. Anchorage, Alaska. 51 p.

MWH. 2012. Susitna-Watana Hydroelectric Project, Preliminary Susitna River Pre-Project and Post-Project Flow Stages, presented at Technical Work Group Meetings, October 23-25.

Tetra Tech, Inc. 2013a Development of Sediment-Transport Relationships and an Initial Sediment Balance for the Middle and Lower Susitna River Segments (FERC No. 14241). Prepared for Alaska Energy Authority, 39 p. plus appendices.

Tetra Tech, Inc. 2013b. Streamflow Assessment, Susitna-Watana Hydroelectric Project (FERC No. 14241). Prepared for Alaska Energy Authority, 94 p. plus appendices.

Tetra Tech, Inc. 2013c. Reconnaissance Level Assessment of Potential Channel Change in the Lower Susitna River Segment, Susitna-Watana Hydroelectric Project (FERC No. 14241). Prepared for Alaska Energy Authority.

Tetra Tech, Inc. 2014. Winter Sampling of Main Channel Bed Material, Susitna-Watana Hydroelectric Project (FERC No. 14241). Prepared for Alaska Energy Authority.

Thomas, R.B. 1985. Estimating Total Suspended Sediment Yield with Probability Sampling. *Water Resources Research*. v 21(9): 1381–1388.

U.S. Geological Survey. 1992. Recommendations for Use of Retransformation Methods in Regression Models Used to Estimated Sediment Loads ["The Bias Correction Problem"]. *Office of Surface Water Technical Memorandum* No. 93.08. December 31.

U.S. Geological Survey. 2012. Streamflow Record Extension for Selected Streams in the Susitna River Basin, Alaska (*Scientific Investigations Report* 2012–5210).

Walling, D.E. 1974. Suspended Sediment and Solute Yields from a Small Catchment Prior to Urbanization. *Institute of British Geographers Special Publication* No. 6: 169–192.

Walling, D.E. 1977a. Limitations of the Rating Curve technique for Estimating Suspended Sediment Loads, with Particular Reference to British Rivers. *In*: Erosion and Solid Matter Transport in Inland Waters, *Proceedings of Paris Symposium*. July. IAHS Publication No. 122: 34–48.

Walling, D.E. 1977b. Assessing the Accuracy of Suspended Sediment Rating Curves for a Small Basin. *Water Resources Research*. v 13(3): 531–538.

Wolman, M.G. and J.P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. *Journal of Geology*. v 68(1): 54–74.

8. TABLES

Table 3.0-1. List of streamflow gages.

Gage Number	Gage Name	Drainage Area (sq mi)	Gage Datum (NGVD 29, feet)	Latitude	Longitude	Available Record	Extended Record	Main Stem River Mile
15290000	Little Susitna River near Palmer	63	917	61° 42' 37"	149° 13' 47"	1948 - 2011		-
15291000	Susitna River near Denali	950	2,440	63° 06' 14"	147° 30' 57"	1957 - 1966; 1968 - 1986	Yes	291
15291200	Maclaren River near Paxson	280	2,866	63° 07' 10"	146° 31' 45"	1958 - 1986	Yes	-
15291500	Susitna River near Cantwell	4,140	1,900	62° 41' 55"	147° 32' 42"	1961 - 1972; 1980 - 1986	Yes	223
15292000	Susitna River at Gold Creek	6,160	677	62° 46' 04"	149° 41' 28"	1949 - 1996; 2001 – 2014	Yes	136
15292400	Chulitna River near Talkeetna	2,570	520	62° 33' 31"	150° 14' 02"	1958 - 1972; 1980 - 1986, 2012-2014	Yes	-
15292700	Talkeetna River near Talkeetna	1,996	400	62° 20' 49"	150° 01' 01"	1964 – 2013	Yes	-
15292780	Susitna River at Sunshine	11,100	270	62° 10' 31.3"	150° 10' 13.5"	1981 - 2014	Yes	84
15292800	Montana Creek near Montana	164	250	62° 06' 19"	150° 03' 27"	2005 - 2006; 2008 - 2011		-
15294005	Willow Creek near Willow	166	350	61° 46' 51"	149° 53' 04"	1978 - 1993; 2001 - 2011	Yes	-
15294010	Deception Creek near Willow	48	250	61° 44' 52"	149° 56' 14"	1978 - 1985		-
15294100	Deshka River near Willow	591	80	61° 46' 05"	150 20' 13"	1978 - 1986; 1998 - 2001		-
15294300	Skwentna River near Skwentna	2,250	200	61° 52' 23"	151 22' 01"	1959 - 1982	Yes	-
15294345	Yentna River near Susitna Station	6,180	80	61° 41' 55"	150 39' 02	1980 - 2014	Yes	-
15294350	Susitna River at Susitna Station	19,400	40	61° 32' 41"	150 30' 45	1974 - 2014	Yes	28

Table 3.0-2. Sediment-transport data summary.

Gage Number	Gage Name	Number of Samples								Record
		Suspended Silt/Clay		Suspended Sand		Bed-load Sand		Bed-load Gravel		
		Pre-2012	2012/2013	Pre-2012	2012/2013	Pre-2012	2012/2013	Pre-2012	2012/2013	
15292000	Susitna River at Gold Creek	50	13	51	13	42	9	37	9	1962 - 2013
15292400	Chulitna River near Talkeetna	50	11	48	11	46	8	46	8	1973 - 2013
15292700	Talkeetna River near Talkeetna	76	6	78	6	44	5	38	4	1967 - 2013
15292780	Susitna River at Sunshine	54	11	55	11	47	10	47	10	1971 - 2013
15294345	Yentna River near Susitna Station	24	5	24	5	11	4	11	4	1981 - 2013
15294350	Susitna River at Susitna Station	46	5	44	5	15	4	13	4	1975 - 2013

Table 4.1-1. Summary of sediment load relationships used for the analysis.

Gage Number	Gage Name	Suspended Load		Bed Load	
		Silt/Clay	Sand	Sand	Gravel
15292000	Susitna River at Gold Creek	$2.11E\text{-}8\ Q^{2.67}$	$2.90E\text{-}11\ Q^{3.29}$	$1.86E\text{-}6\ Q^{1.85}$	$2.45E\text{-}18\ Q^{4.34}$
		n = 63 (50/13), R^2 = 0.74	n = 64 (51/13), R^2 = 0.86	n = 51 (42/9), R^2 = 0.40	n = 46 (37/9), R^2 = 0.46
15292400	Chulitna River near Talkeetna	$2.18E\text{-}7\ Q^{2.59}$	$8.46E\text{-}6\ Q^{2.16}$	$0.12\ Q^{1.00}$ (see note below)	$7.20E\text{-}6\ Q^{2.00}$ (see note below)
		n = 61 (50/11), R^2 = 0.90	n = 59 (48/11), R^2 = 0.86	n = 54 (46/8)	n = 54 (46/8)
15292700	Talkeetna River near Talkeetna	$2.75E\text{-}8\ Q^{2.79}$	$2.48E\text{-}6\ Q^{2.32}$	$2.78E\text{-}2\ Q^{1.08}$	$1.94E\text{-}10\ Q^{2.99}$
		n = 82 (76/6), R^2 = 0.76	n = 84 (78/6), R^2 = 0.86	n = 49 (44/5), R^2 = 0.30	n = 42 (38/4), R^2 = 0.65
15292780	Susitna River at Sunshine	$4.97E\text{-}8\ Q^{2.54}$	$3.60E\text{-}6\ Q^{2.10}$	$6.65\ Q^{0.48}$	$5.08E\text{-}4\ Q^{1.32}$
		n = 65 (54/11), R^2 = 0.82	n = 66 (55/11), R^2 = 0.83	n = 57 (47/10), R^2 = 0.09	n = 57 (47/10), R^2 = 0.20
15294345	Yentna River near Susitna Station	$6.10E\text{-}7\ Q^{2.33}$	$7.90E\text{-}3\ Q^{1.43}$	$1.47E+3\ Q^{0.15}$	$1.03E\text{-}7\ Q^{2.32}$ (see note below)
		n = 29 (24/5), R^2 = 0.91	n = 29 (24/5), R^2 = 0.88	n = 15 (11/4), R^2 = 0.03	n = 15 (11/4)
15294350	Susitna River at Susitna Station	$7.13E\text{-}8\ Q^{2.42}$	$1.77E\text{-}3\ Q^{1.52}$	$4.60E\text{-}1\ Q^{0.83}$	$2.98E\text{-}5\ Q^{1.50}$
		n = 51 (46/5), R^2 = 0.86	n = 49 (44/5), R^2 = 0.74	n = 19 (15/4), R^2 = 0.46	n = 17 (13/4), R^2 = 0.62

Notes:

Sediment load in tons/day (tpd)
Q = Water discharge in cfs
n = Total number of sample points (pre-2012 data/2012 & 2013 data)
Note: Relationships noted above do not use a least squares regression. These relationships use one or more lines of best fit to estimate transported material.

Table 6.0-1. 1984 sediment transport measurements at Portage Creek and Indian River (Knott et al. 1986).

Location	Date	Q (cfs)	Q_s (t/d)	Sorted (t/d)			Concentration, PPM-wt			
				Silt/Clay	Sand	Gravel	Silt/Clay	Sand	Gravel	Total
Portage Creek	30-May-84	597	21.4	4.4	6.4	10.7	3	4	7	13
	26-Jun-84	1440	96	4.0	37.6	54.4	1	10	14	25
	24-Jul-84	782	53.3	4.7	8.6	40.0	2	4	19	25
	27-Sep-84	392	7.5	6.4	1.1	0.0	6	1	0	7
Indian River	30-May-84	339	7.3	1.8	3.7	1.7	2	4	2	8
	27-Jun-84	481	36.6	0.9	9.8	25.8	1	8	20	28
	25-Jul-84	388	22.1	1.7	7.1	13.3	2	7	13	21
	27-Sep-84	195	1.6	1.1	0.5	0.0	2	1	0	3

Table 6.0-2. Comparison of average annual sediment loads under pre-Project conditions.

Gage[1]	Drainage Area (mi^2)	Water Discharge (acre-ft)	Average Annual Load (tons)				
			Wash Load	Bed Material			Total Load
			Silt/Clay	Sand	Gravel	Total	
Denali[2]	950	2,017,000	1,662,000	1,294,000	NA	NA	2,957,000
Maclaren[2]	280	711,000	324,000	183,000	NA	NA	507,000
Cantwell (Vee Canyon)[2]	4,140	4,486,000	2,688,000	1,981,000	NA	NA	4,669,000
Watana	5,180	5,803,000	1,952,000	1,443,000	20,000	1,463,000	3,415,000
Ungaged Tributaries	980	1,242,000	5,000	12,000	34,000	46,000	51,000
Supply above Gold Creek	6,160	7,045,000	1,957,000	1,455,000	54,000	1,509,000	3,466,000
Gold Creek/Susitna nr Talkeetna	6,160	7,045,000	1,952,000	1,443,000	20,000	1,463,000	3,415,000
Talkeetna	1,996	2,938,000	950,000	921,000	45,000	966,000	1,916,000
Chulitna	2,570	6,231,000	5,195,000	2,985,000	429,000	3,414,000	8,609,000
Supply above Sunshine	10,726	16,213,000	8,097,000	5,349,000	495,000	5,844,000	13,941,000
Sunshine	11,100	17,426,000	9,627,000	5,958,000	239,000	6,197,000	15,824,000
Ungaged Tributaries	2,120	3,654,000	0	0	0	0	0
Yentna	6,180	14,102,000	6,918,000	7,392,000	191,000	7,583,000	14,500,000
Supply above Susitna Station	19,400	35,182,000	16,545,000	13,350,000	430,000	13,779,000	30,324,000
Susitna Station	19,400	35,182,000	19,401,000	14,149,000	169,000	14,318,000	33,719,000

Notes:
1 Susitna River gages are shown in bold.
2 Only suspended sediment measurements were collected at these locations. No bed-load data are available.

Table 6.0-3. Comparison of sediment concentration under pre-Project conditions.

Gage[1]	Drainage Area (mi^2)	Water Discharge (acre-ft)	Average Annual Sediment Concentration (PPM-wt)				
			Wash Load	Bed Material			Total Load
			Silt/Clay	Sand	Gravel	Total	
Denali[2]	950	2,017,000	606	472	NA	NA	1,078
Maclaren[2]	280	711,000	335	189	NA	NA	524
Cantwell (Vee Canyon)[2]	4,140	4,486,000	441	325	NA	NA	765
Watana	5,180	5,803,000	247	183	3	185	433
Ungaged Tributaries	980	1,242,000	3	7	20	27	30
Supply above Gold Creek	6,160	7,045,000	204	152	6	158	362
Gold Creek/Susitna nr Talkeetna	6,160	7,045,000	204	151	2	153	357
Talkeetna	1,996	2,938,000	238	231	11	242	480
Chulitna	2,570	6,231,000	613	352	51	403	1,016
Supply above Sunshine	10,726	16,213,000	367	243	22	265	632
Sunshine	11,100	17,426,000	406	251	10	261	668
Ungaged Tributaries	2,120	3,654,000	0	0	0	0	0
Yentna	6,180	14,102,000	361	385	10	395	756
Supply above Susitna Station	19,400	35,182,000	346	279	9	288	634
Susitna Station	19,400	35,182,000	405	296	4	299	705

Notes:
1 Susitna River gages are shown in bold.
2 Only suspended sediment measurements were collected at these locations. No bed-load data are available.

9. FIGURES

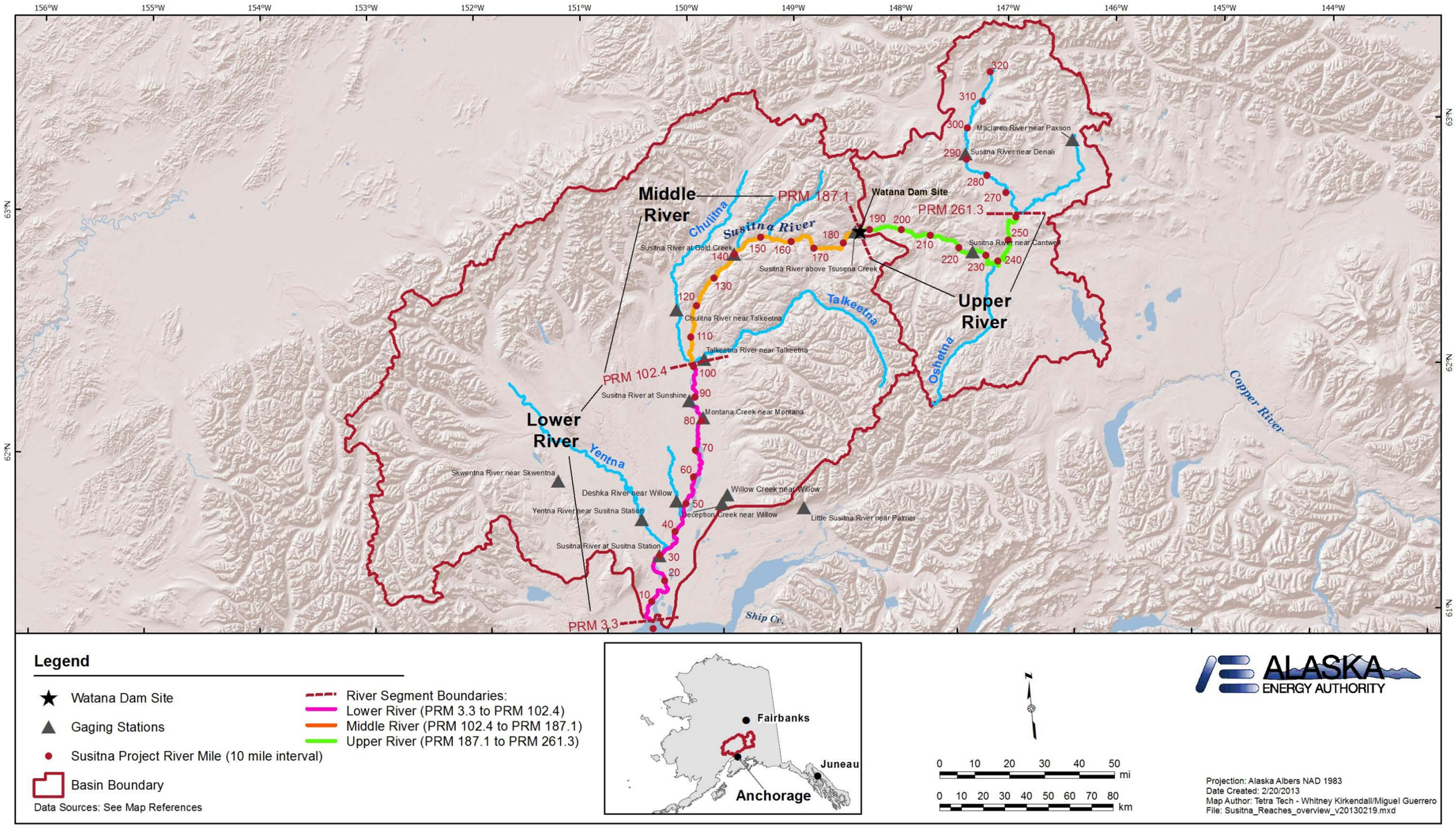

Figure 3.0-1. Susitna River study area and large-scale river segments.

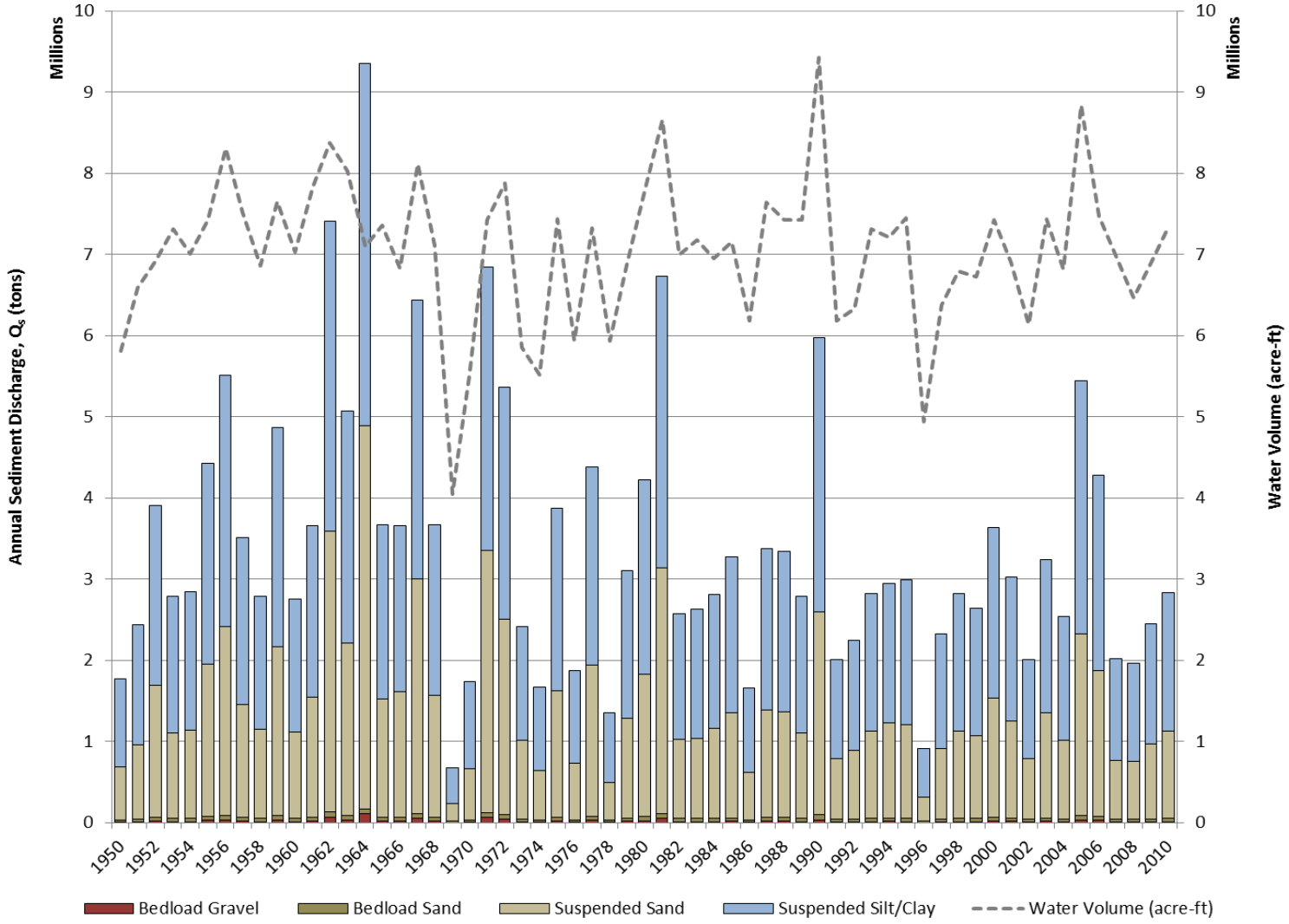

Figure 5.1-1. Estimated annual silt/clay, sand and gravel loads at the Gold Creek (Gage No. 15292000)/, Susitna River near Talkeetna (Gage No. 15292100) gage over the 61-year period of flows under pre-Project conditions. Also shown is the annual flow volume for each of the years.

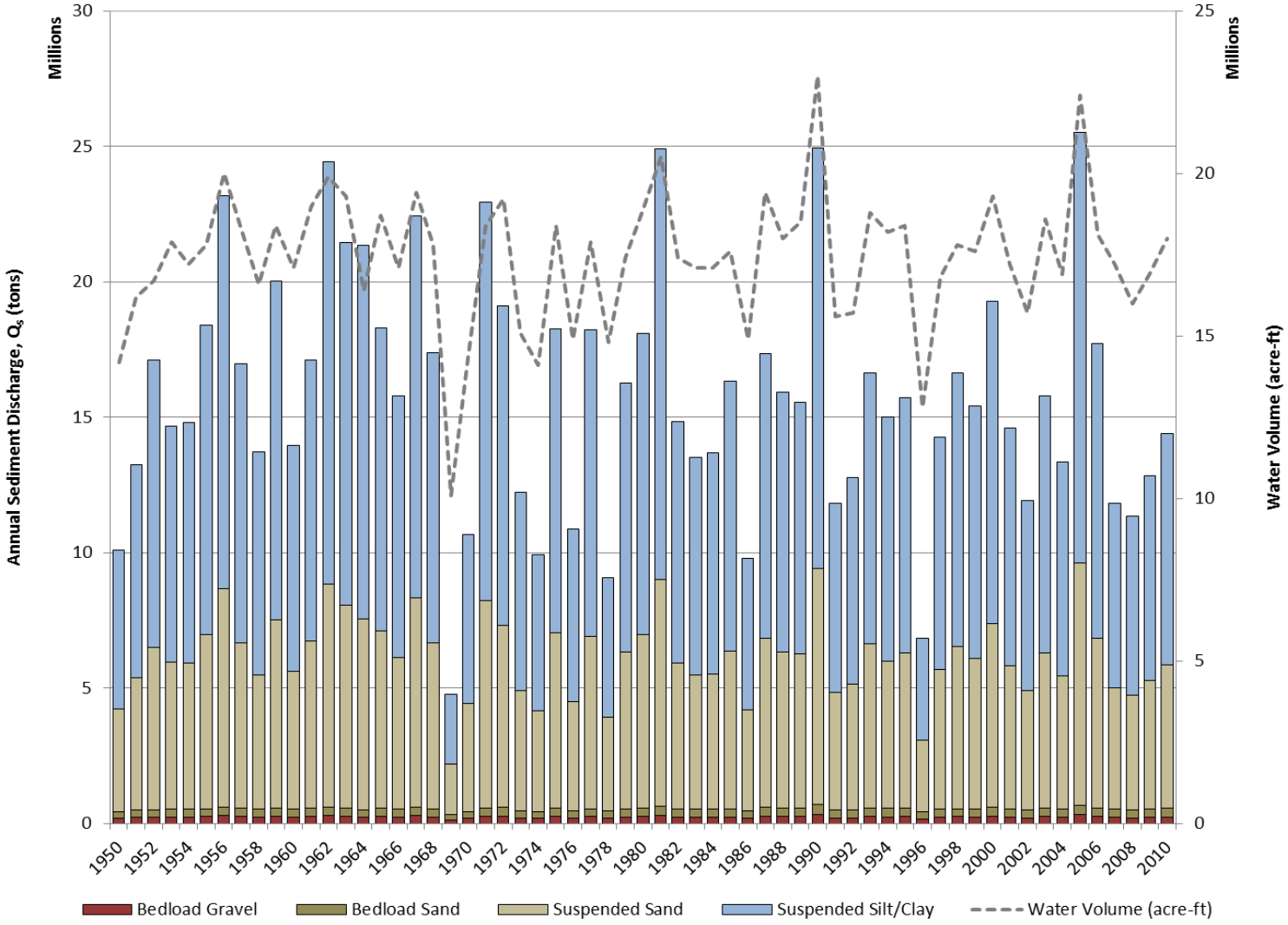

Figure 5.1-2. Estimated annual silt/clay, sand and gravel loads at the Susitna River at Sunshine (Gage No. 15292780) gage over the 61-year period of flows under pre-Project conditions. Also shown is the annual flow volume for each of the years.

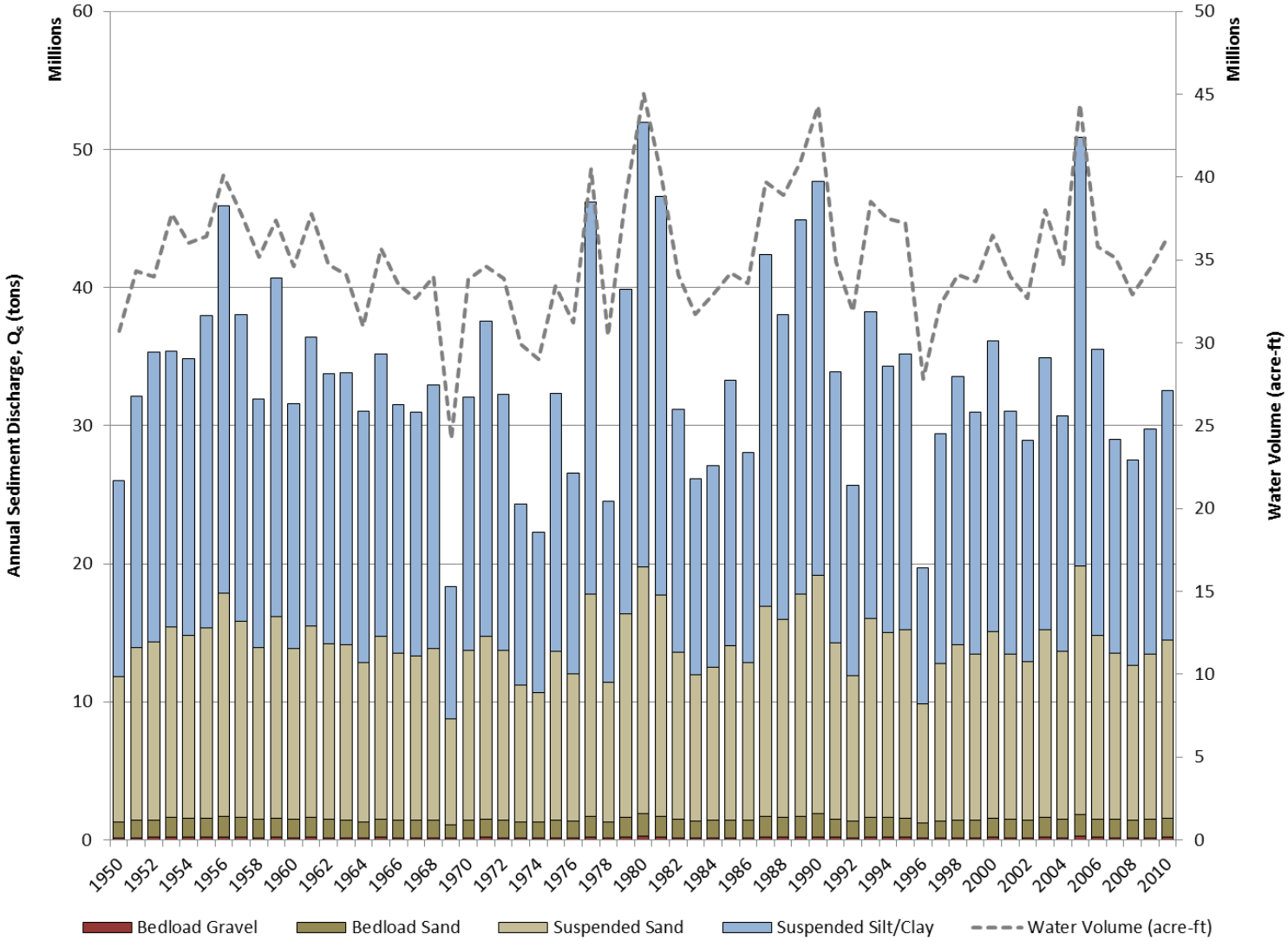

Figure 5.1-3. Estimated annual silt/clay, sand and gravel loads at the Susitna River at Susitna Station (Gage No. 15294350) gage over the 61-year period of flows under pre-Project conditions. Also shown is the annual flow volume for each of the years.

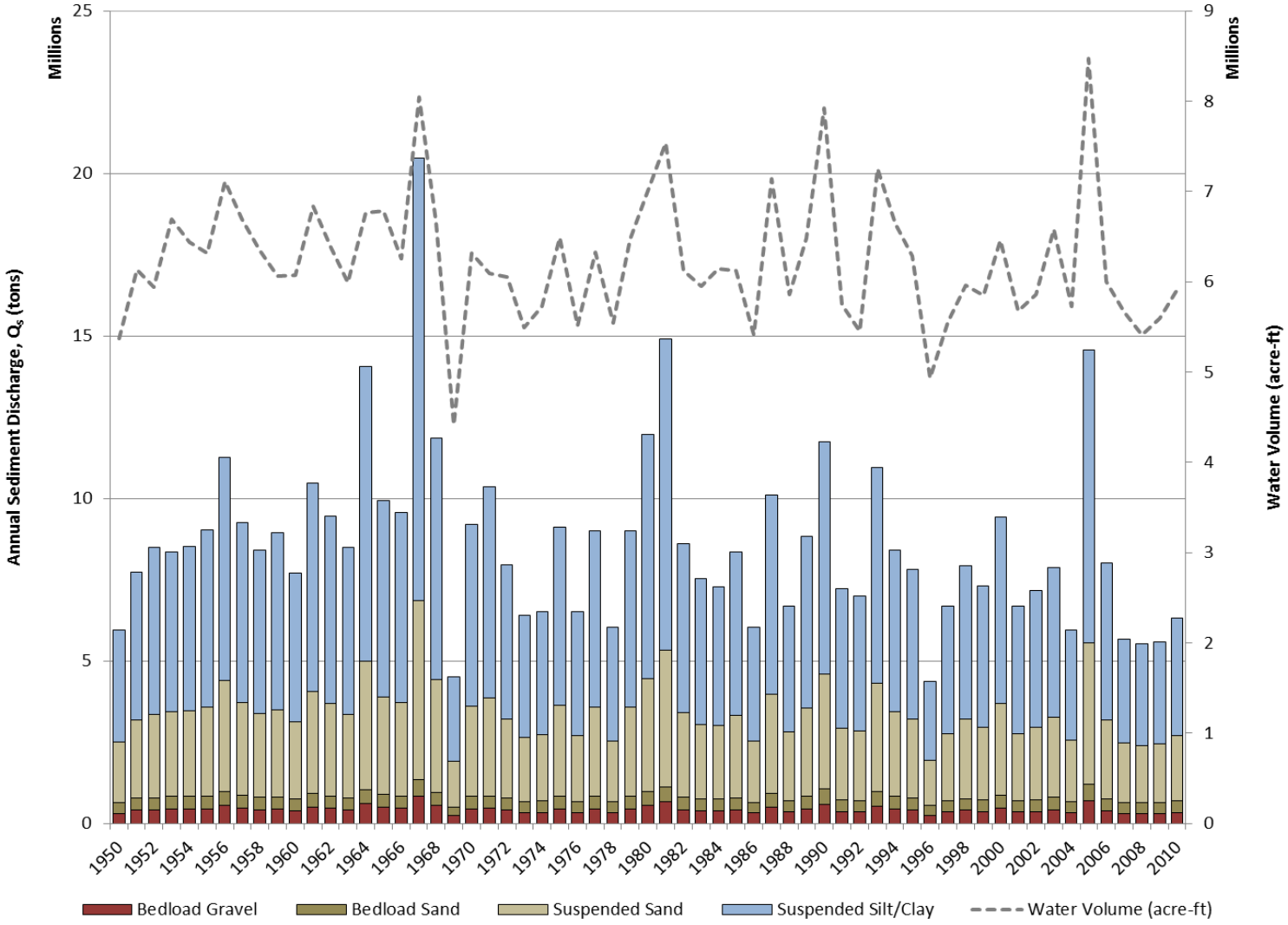

Figure 5.1-4. Estimated annual silt/clay, sand and gravel loads at the Chulitna River near Talkeetna (Gage No. 15292400), Chulitna River below Canyon near Talkeetna (Gage No. 15292410) gage over the 61-year period of flows under pre-Project conditions. Also shown is the annual flow volume for each of the years.

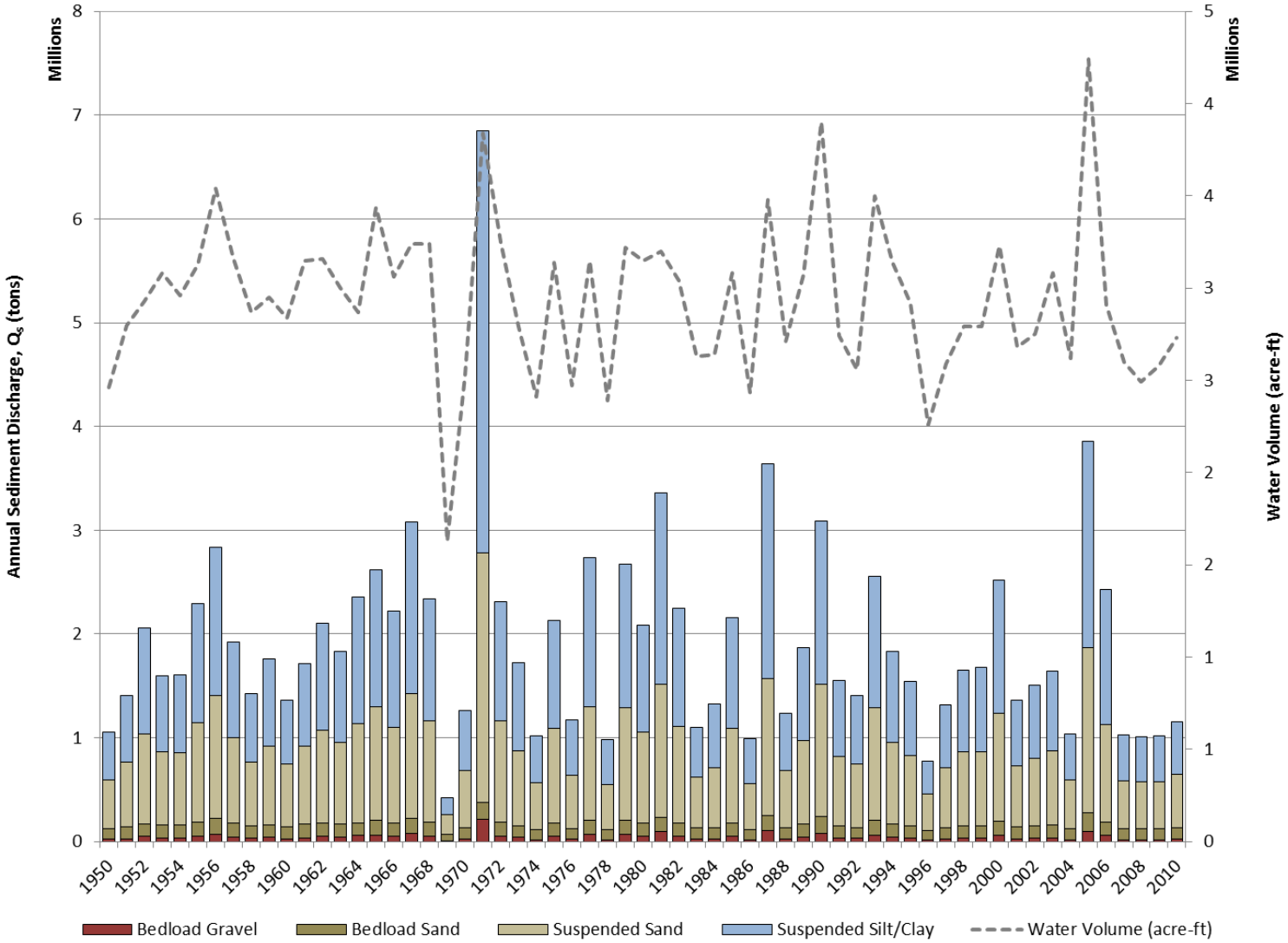

Figure 5.1-5. Estimated annual silt/clay, sand and gravel loads at the Talkeetna River near Talkeetna (Gage No. 15292700) gage over the 61-year period of flows under pre-Project conditions. Also shown is the annual flow volume for each of the years.

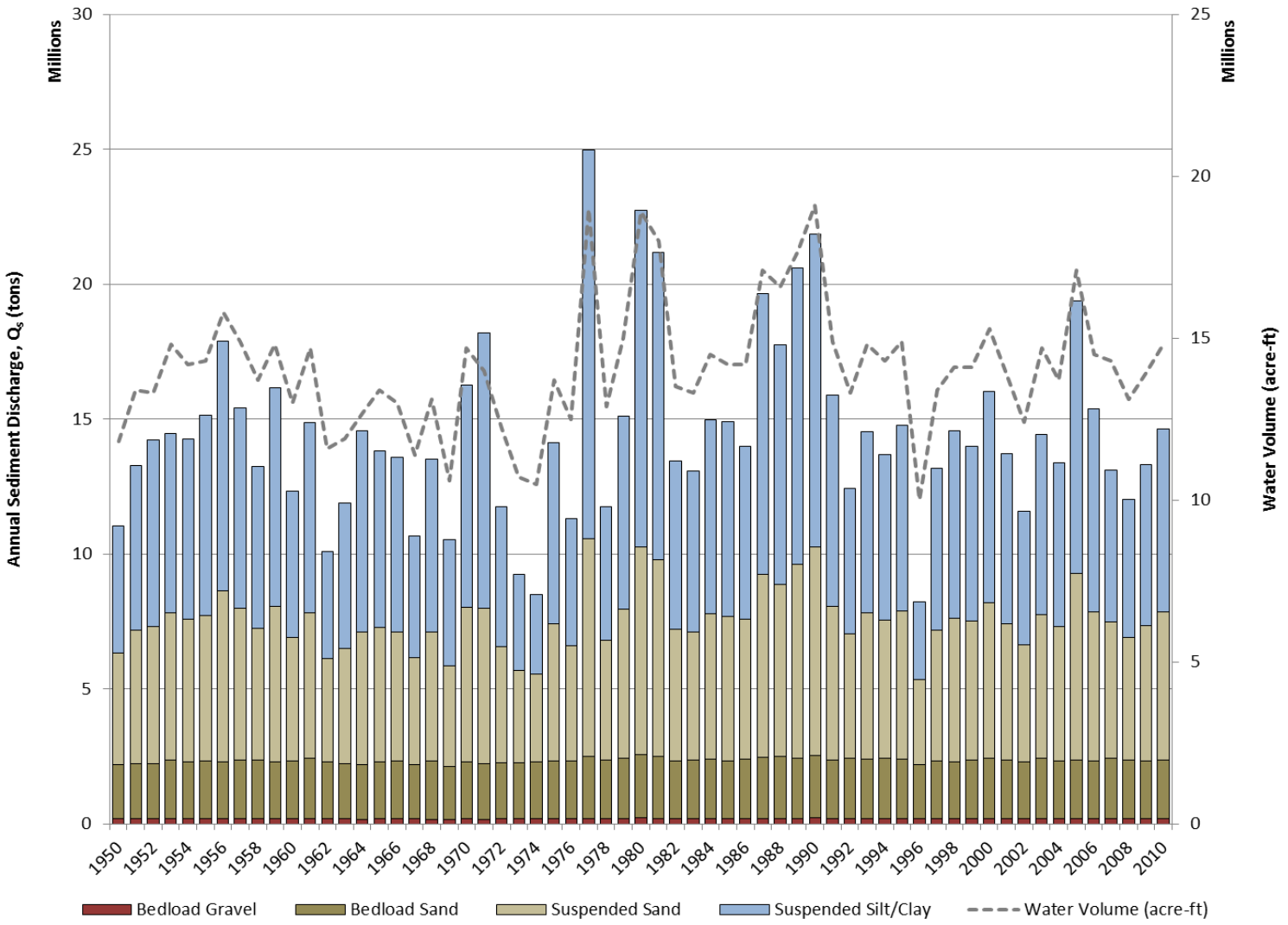

Figure 5.1-6. Estimated annual silt/clay, sand and gravel loads at the Yentna River near Susitna Station (Gage No. 15294345) gage over the 61-year period of flows under pre-Project conditions. Also shown is the annual flow volume for each of the years.

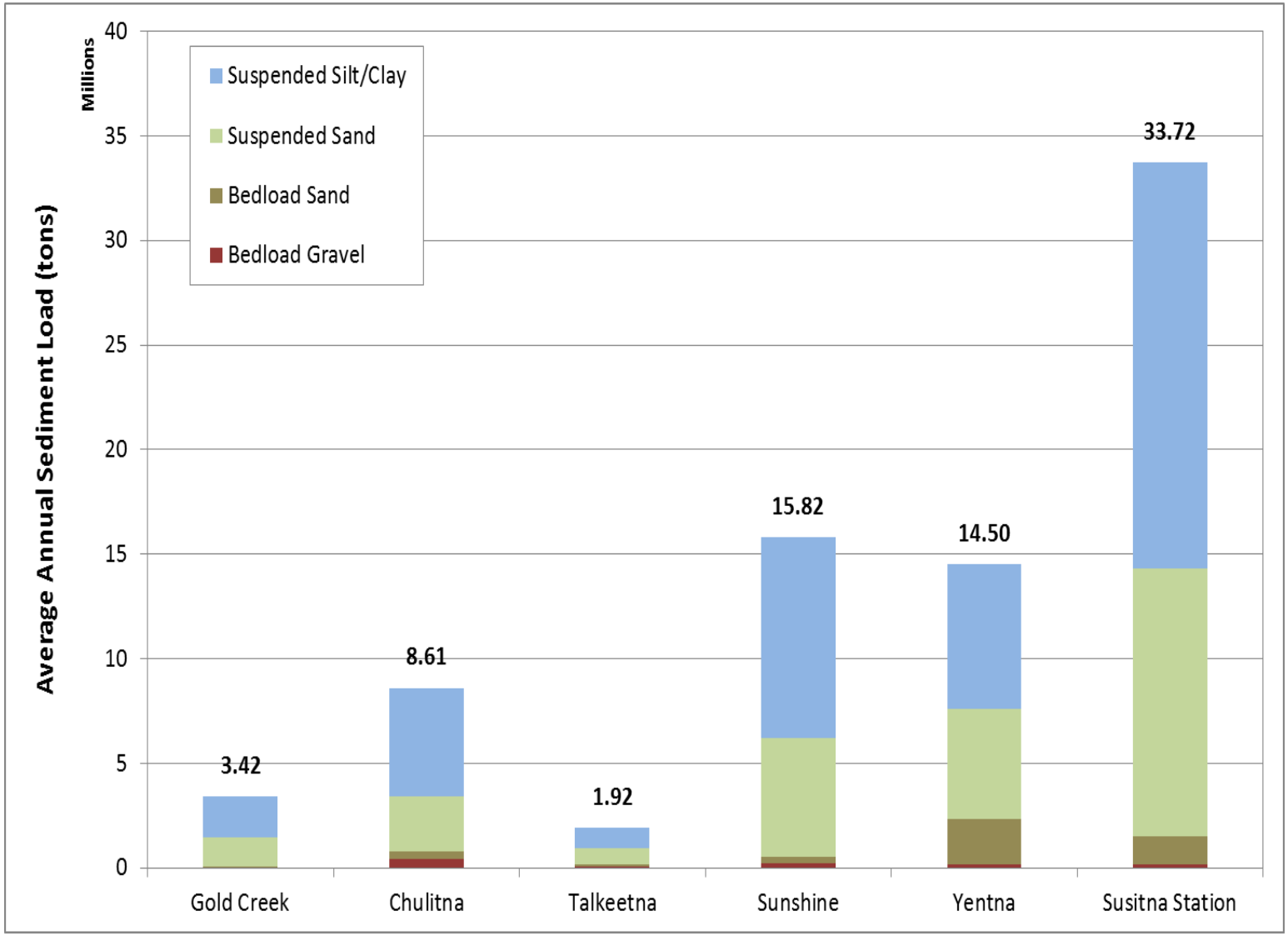

Figure 5.1-7. Average annual silt/clay, sand and gravel loads under pre-Project conditions for the three mainstem gages and three major tributary gages considered in the analysis.

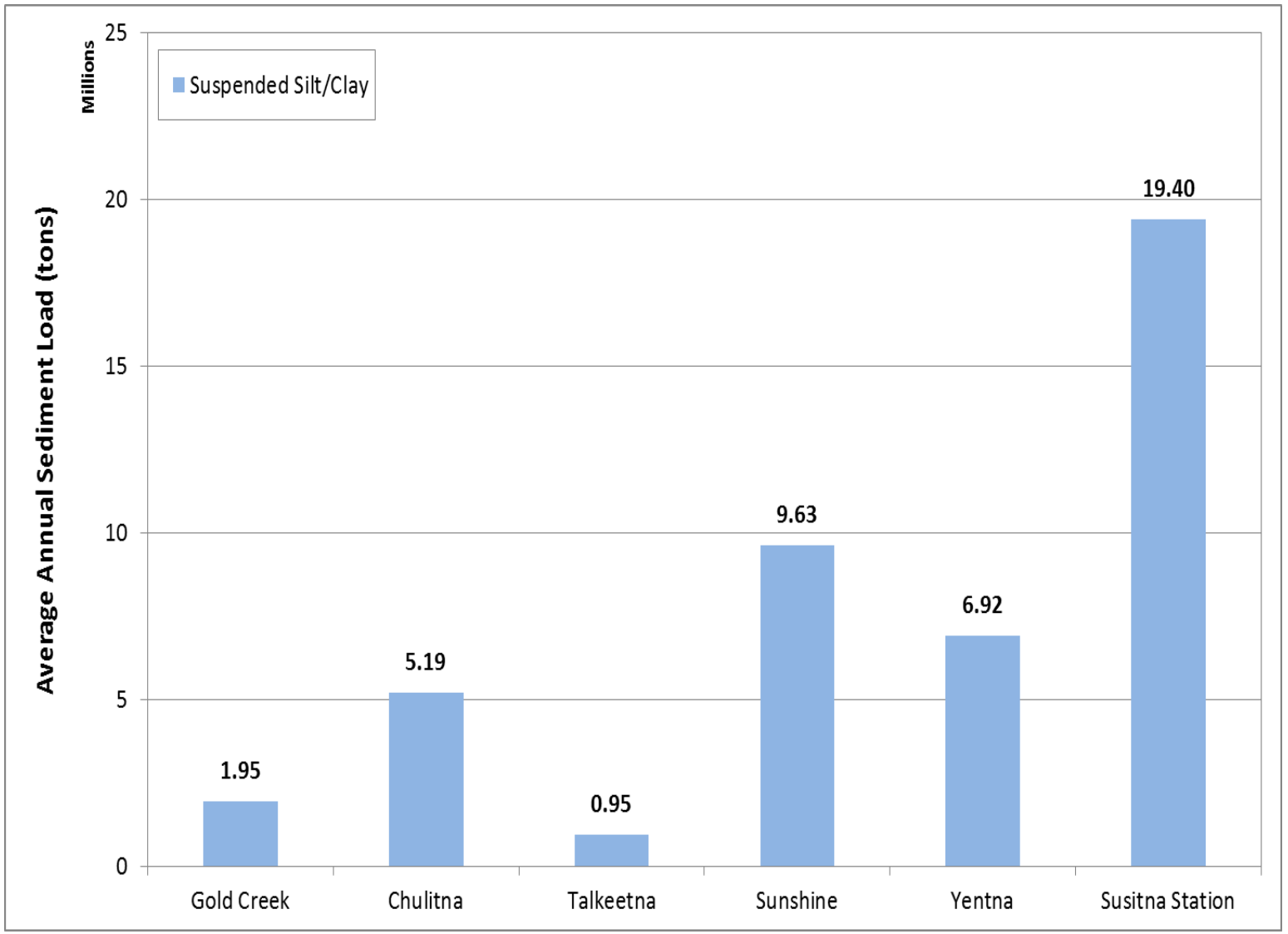

Figure 6.0-1. Average annual silt/clay loads at the three mainstem gages and the three primary tributary gages under pre-Project conditions.

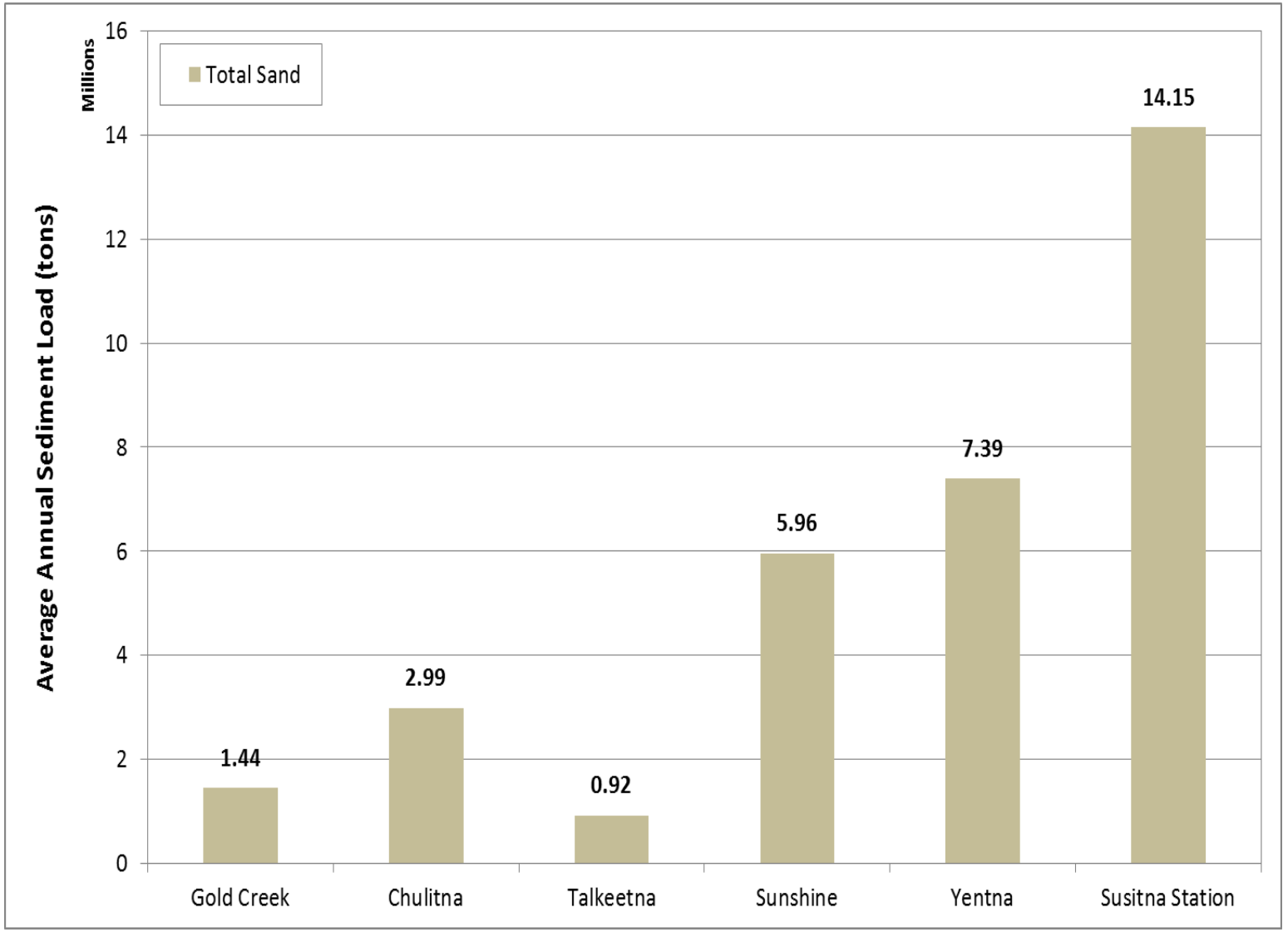

Figure 6.0-2. Average annual sand loads at the three mainstem gages and the three primary tributary gages under pre-Project conditions.

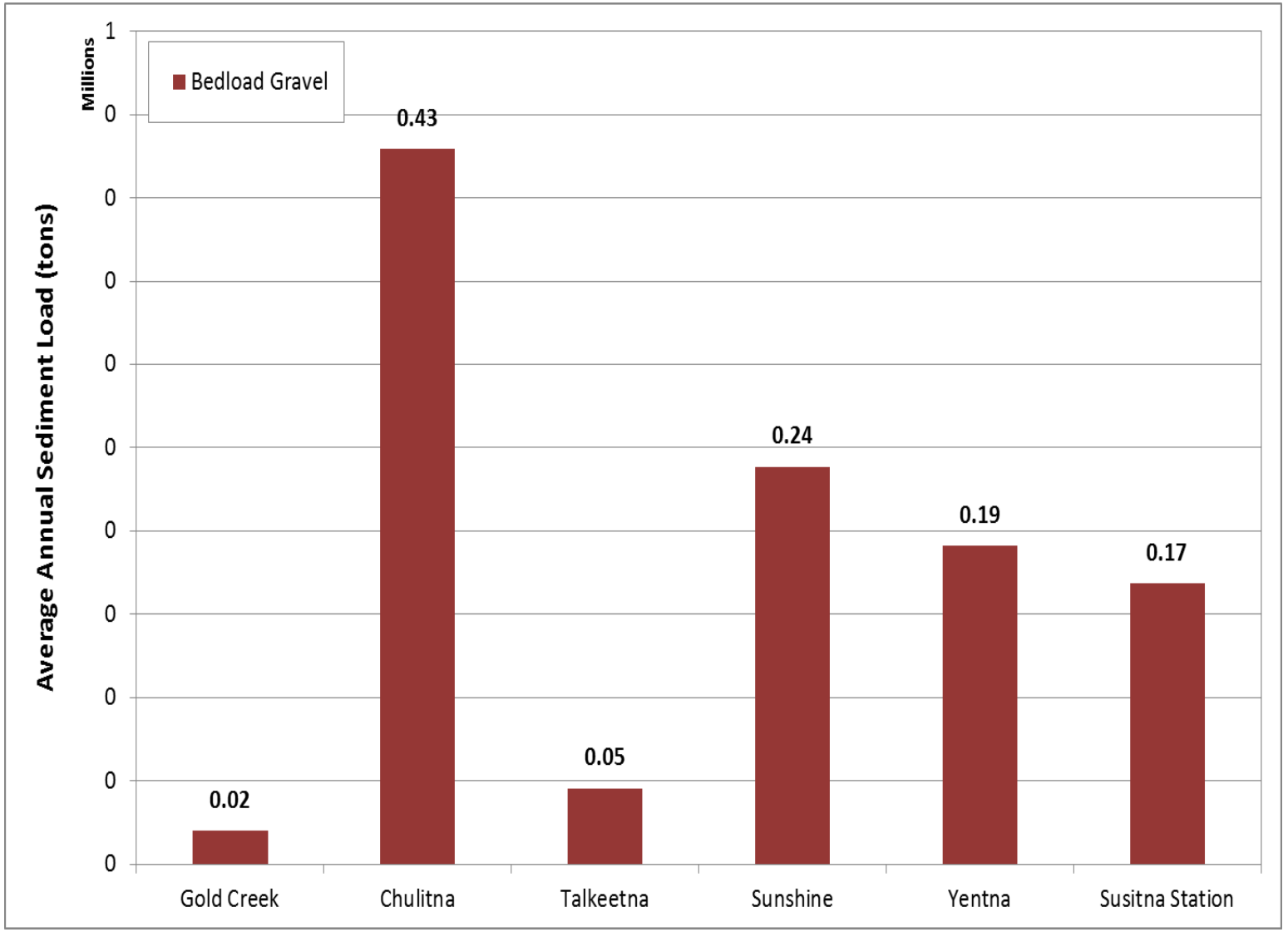

Figure 6.0-3. Average annual gravel loads at the three mainstem gages and the three primary tributary gages under pre-Project conditions.

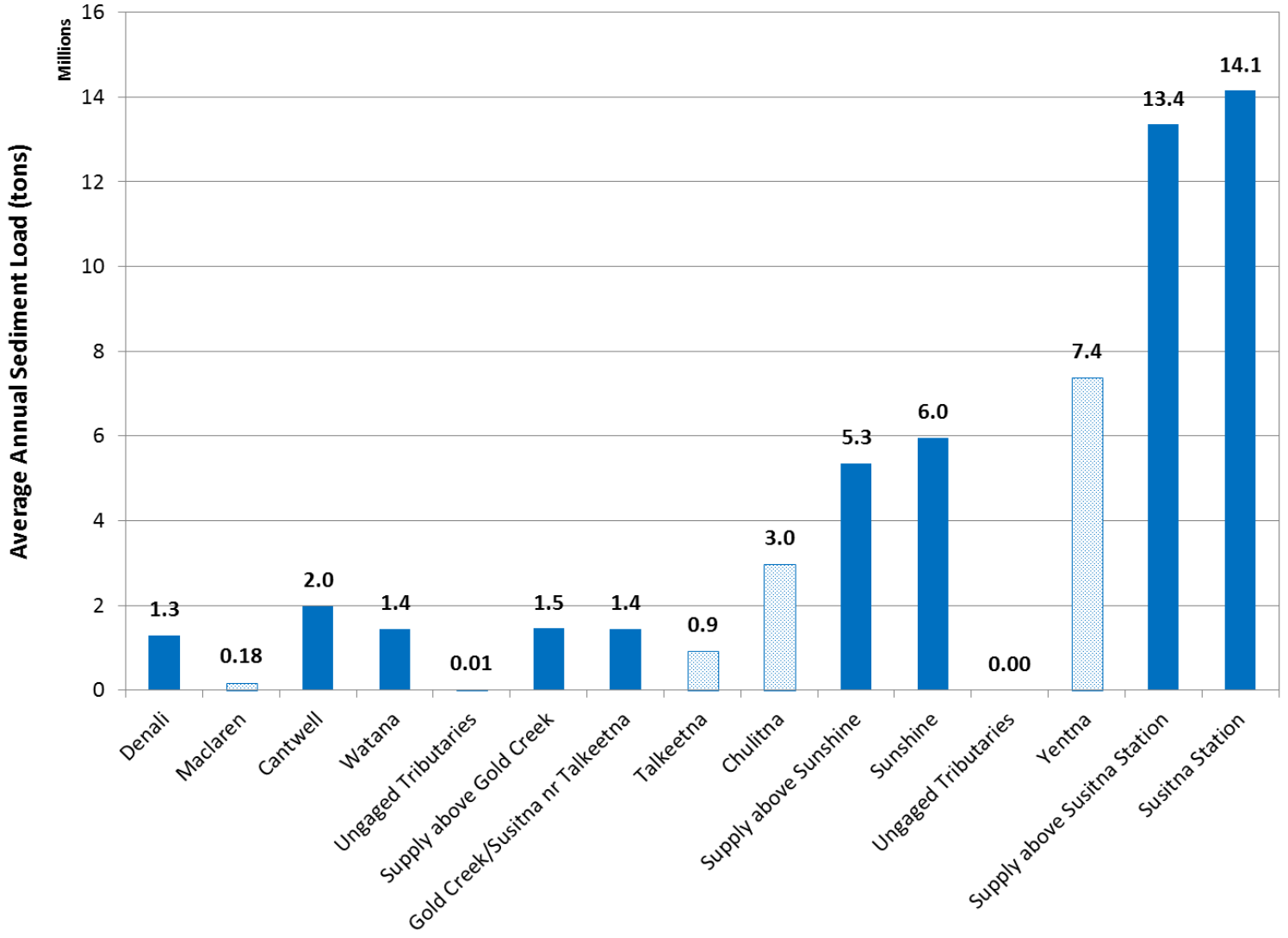

Figure 6.0-4. Average annual sand loads at the mainstem (dark blue) and tributary (light blue) gages, along with the estimated annual sand load from ungaged tributaries, under pre-Project conditions. Also shown is the accumulated sediment supply to key points along the reach based on the gaged and ungaged sand loads.

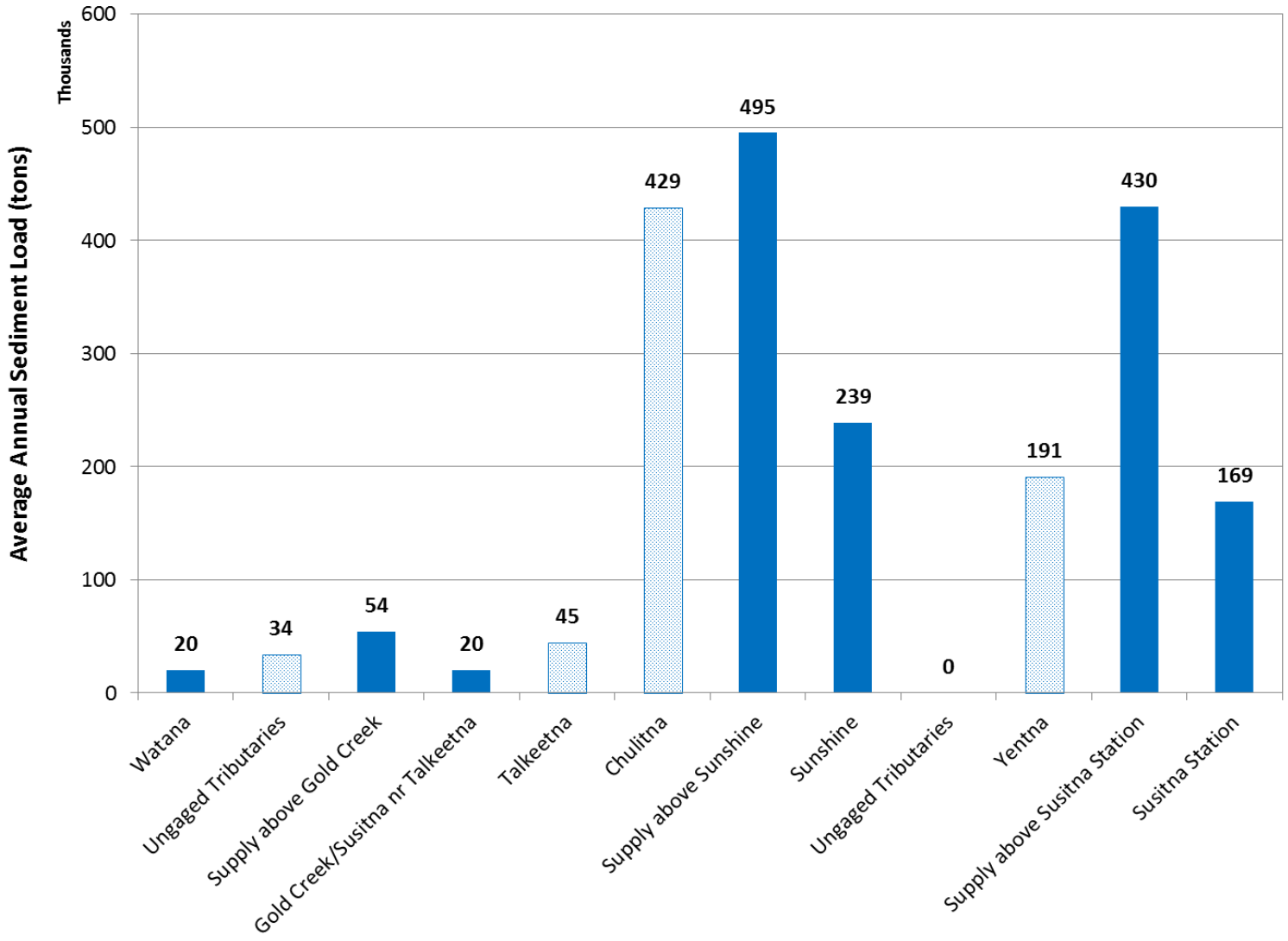

Figure 6.0-5. Average annual gravel loads at the mainstem (dark blue) and tributary (light blue) gages, along with the estimated annual gravel load from ungaged tributaries, under pre-Project conditions. Also shown is the accumulated sediment supply to key points along the reach based on the gaged and ungaged gravel loads.

APPENDIX A. SEDIMENT TRANSPORT DATA AND REGRESSION SUMMARY

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Geomorphology Study (Study 6.5)

2014 Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Tetra Tech, Inc.

September 2014

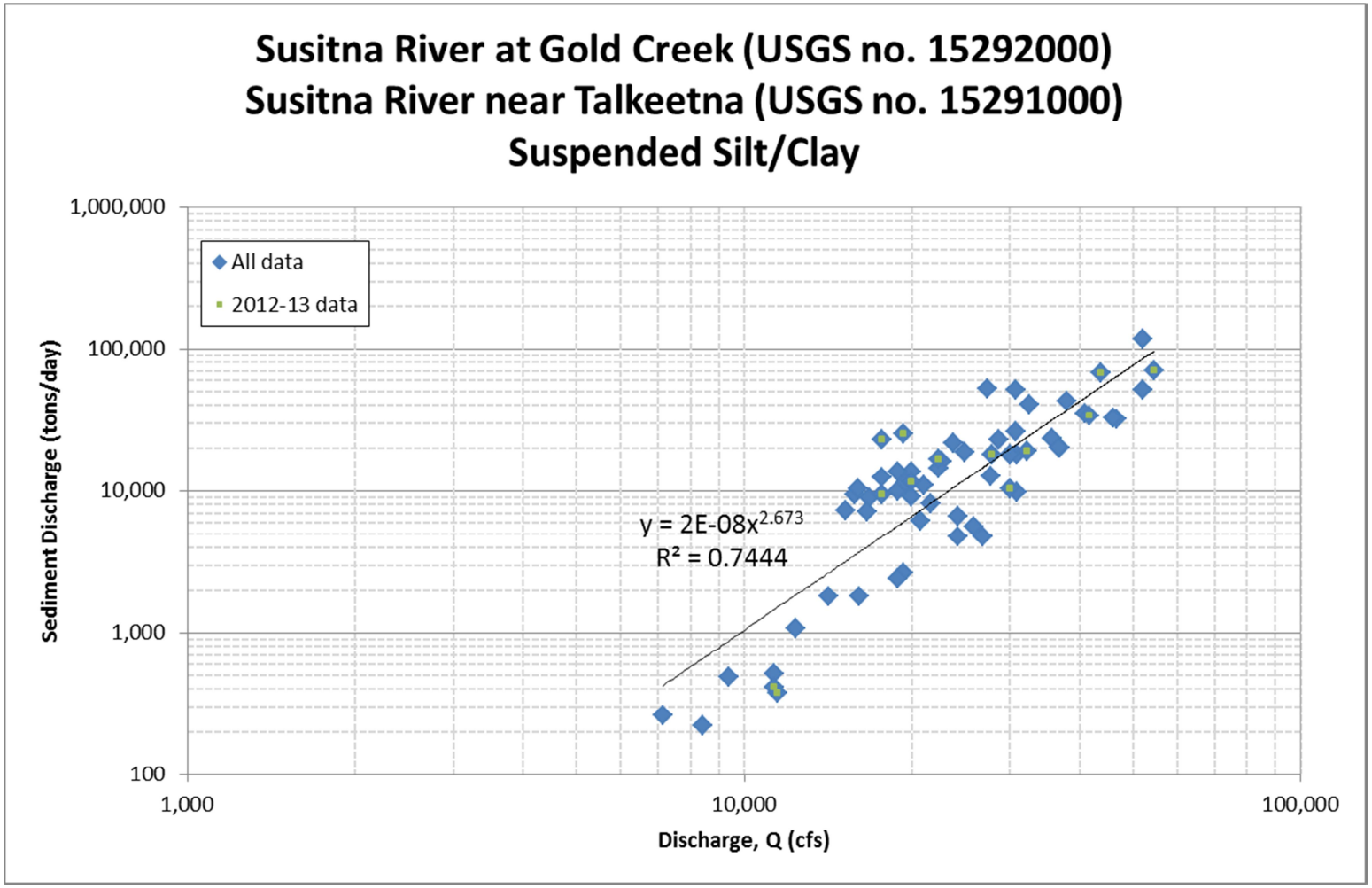

Figure A.1. Suspended silt/clay sediment-transport data and rating equation for Susitna River at Gold Creek and Susitna River near Talkeetna

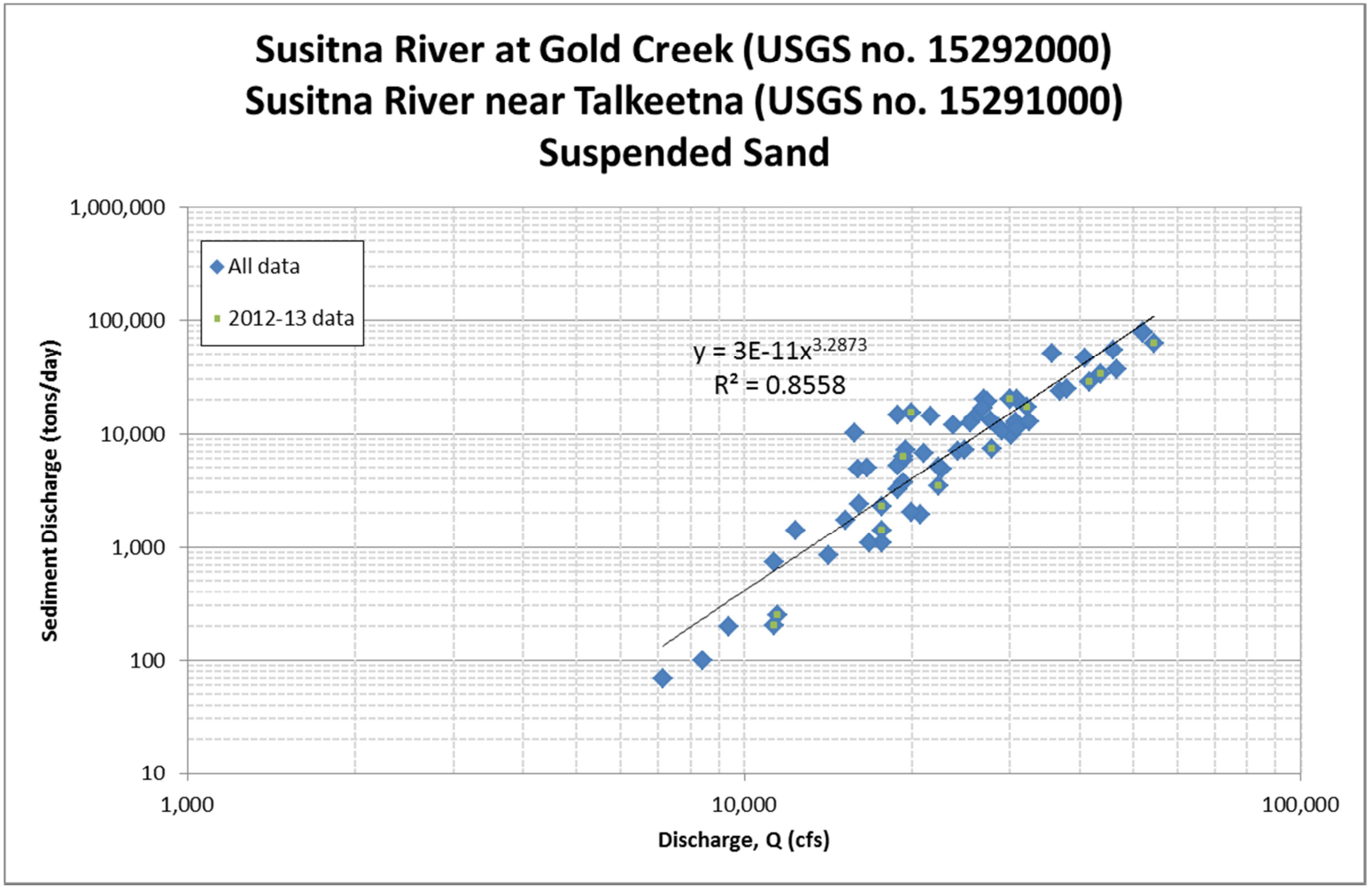

Figure A.2. Suspended sand sediment-transport data and rating equation for Susitna River at Gold Creek and Susitna River near Talkeetna

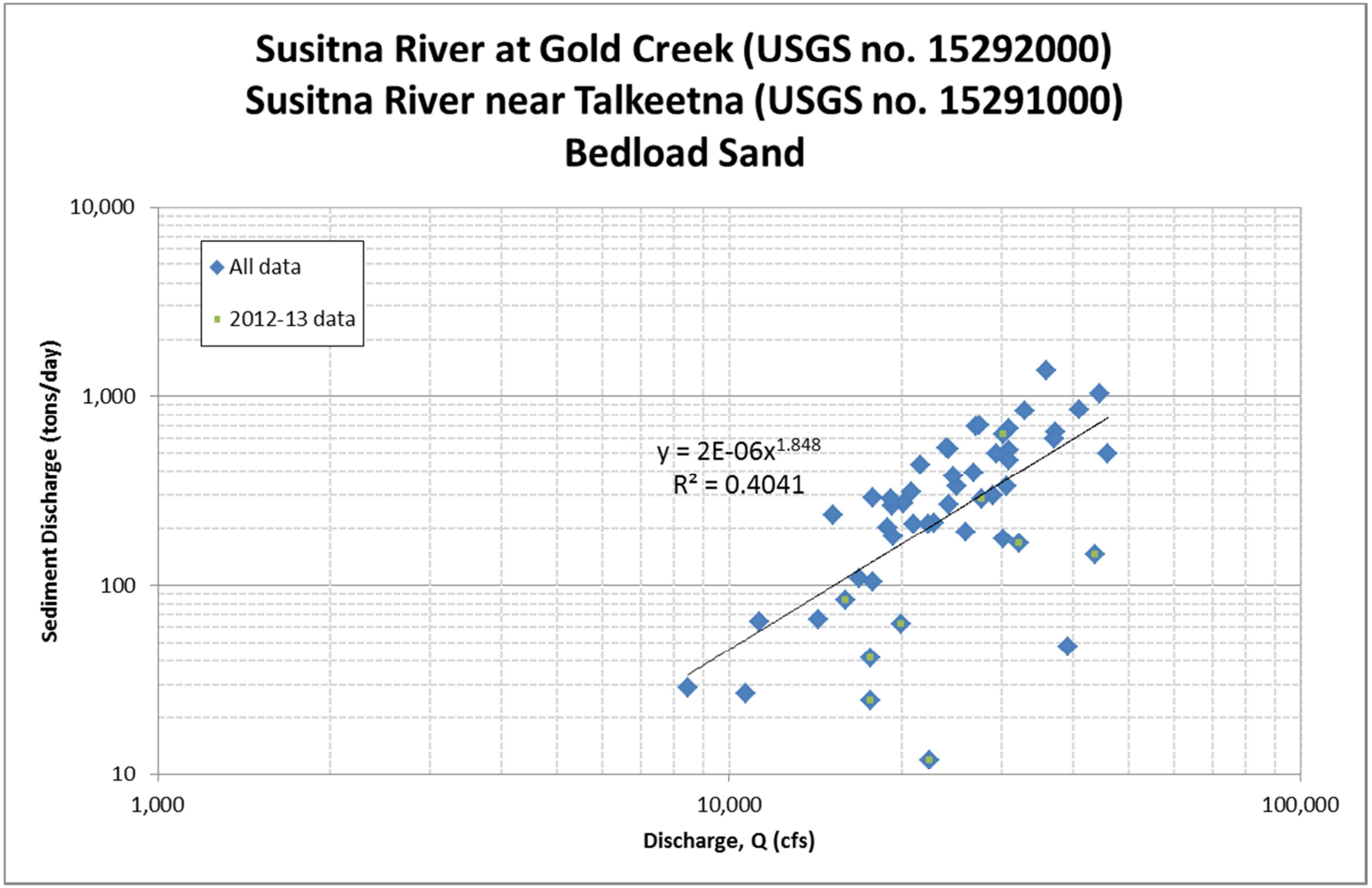

Figure A.3. Bed-load Sand sediment-transport data and rating equation for Susitna River at Gold Creek and Susitna River near Talkeetna

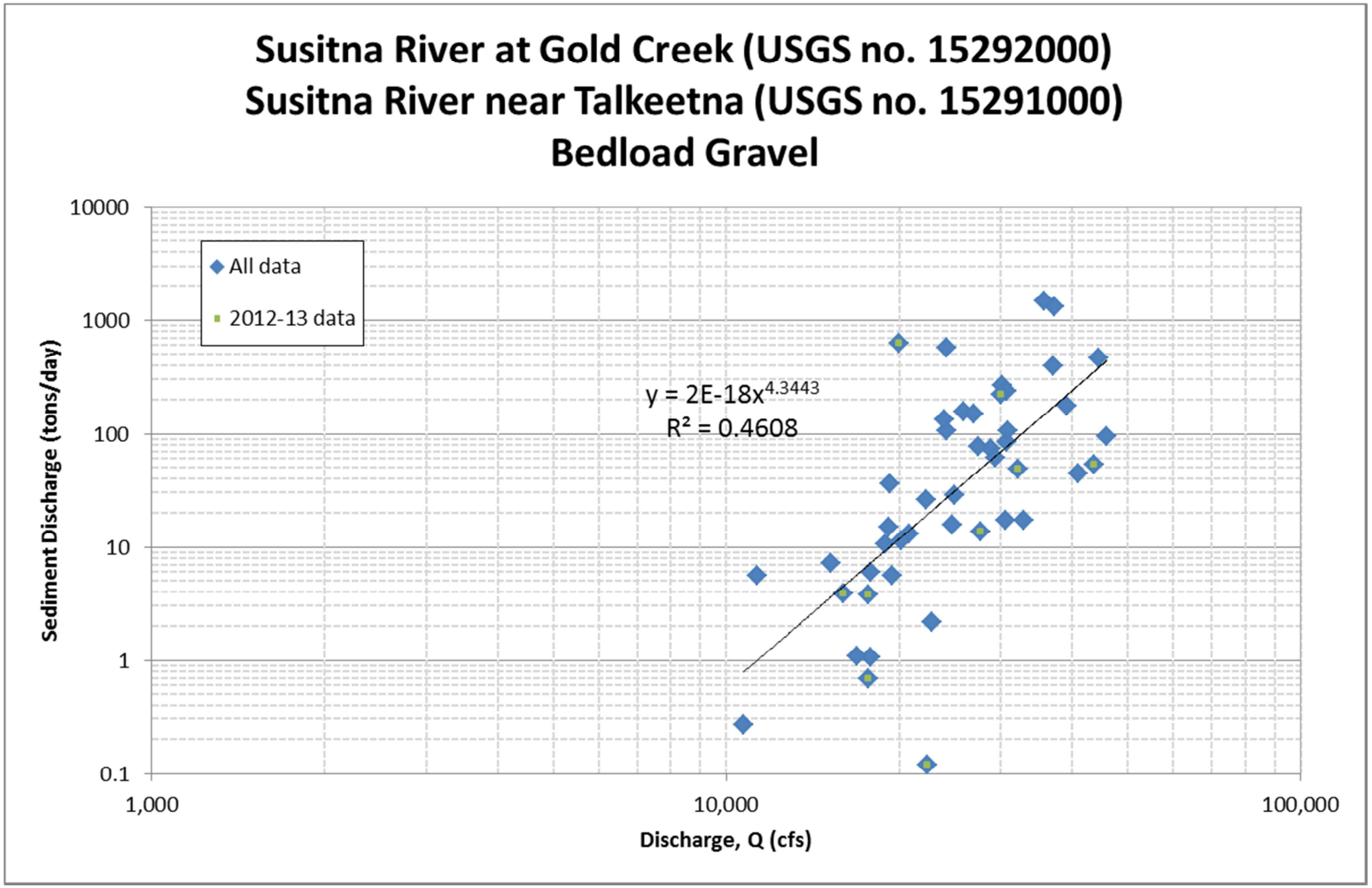

Figure A.4. Bed-load gravel sediment-transport data and rating equation for Susitna River at Gold Creek and Susitna River near Talkeetna

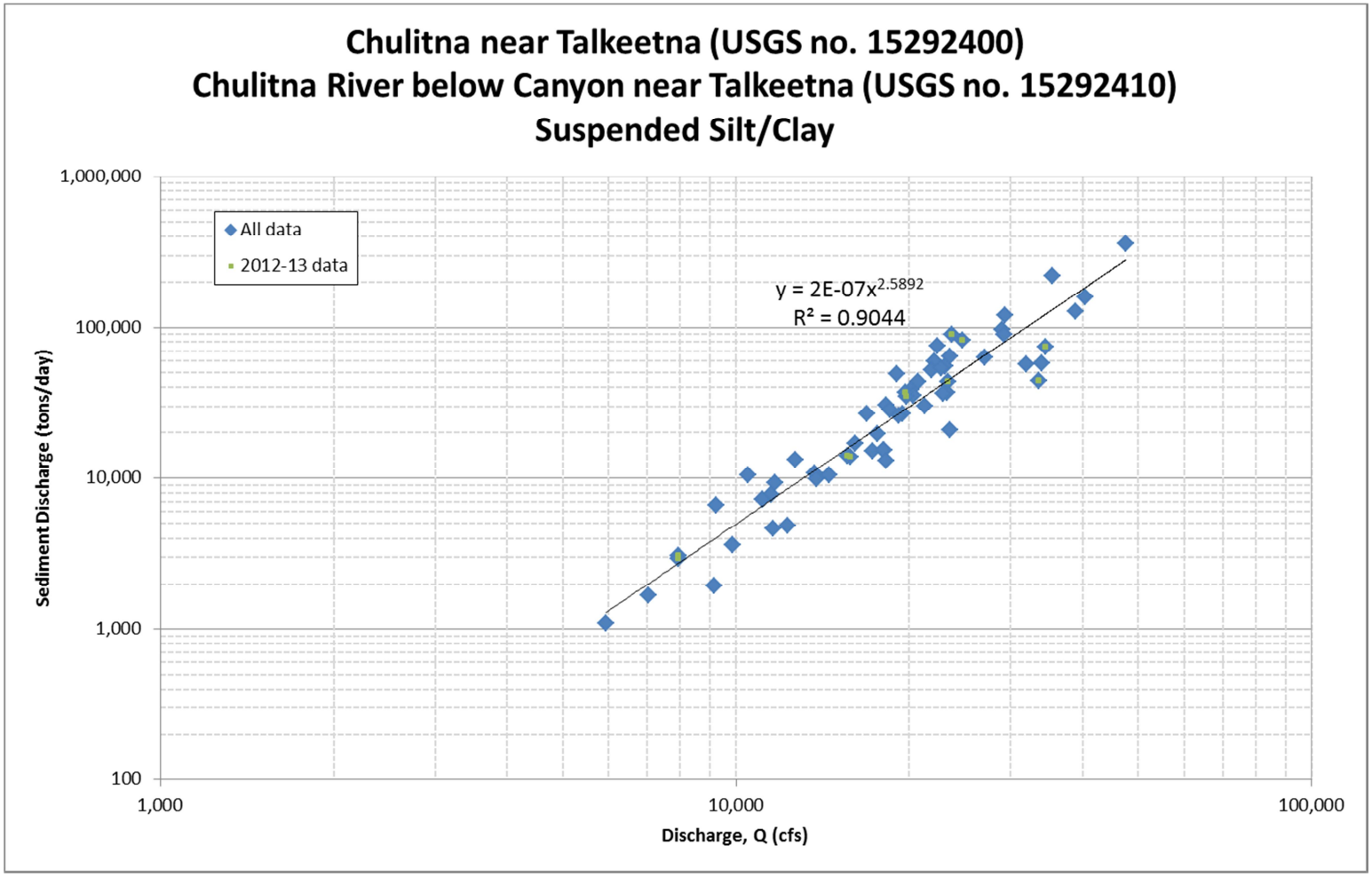

Figure A.5. Suspended silt/clay sediment-transport data and rating equation for Chulitna River near Talkeetna and Chulitna River below Canyon near Talkeetna

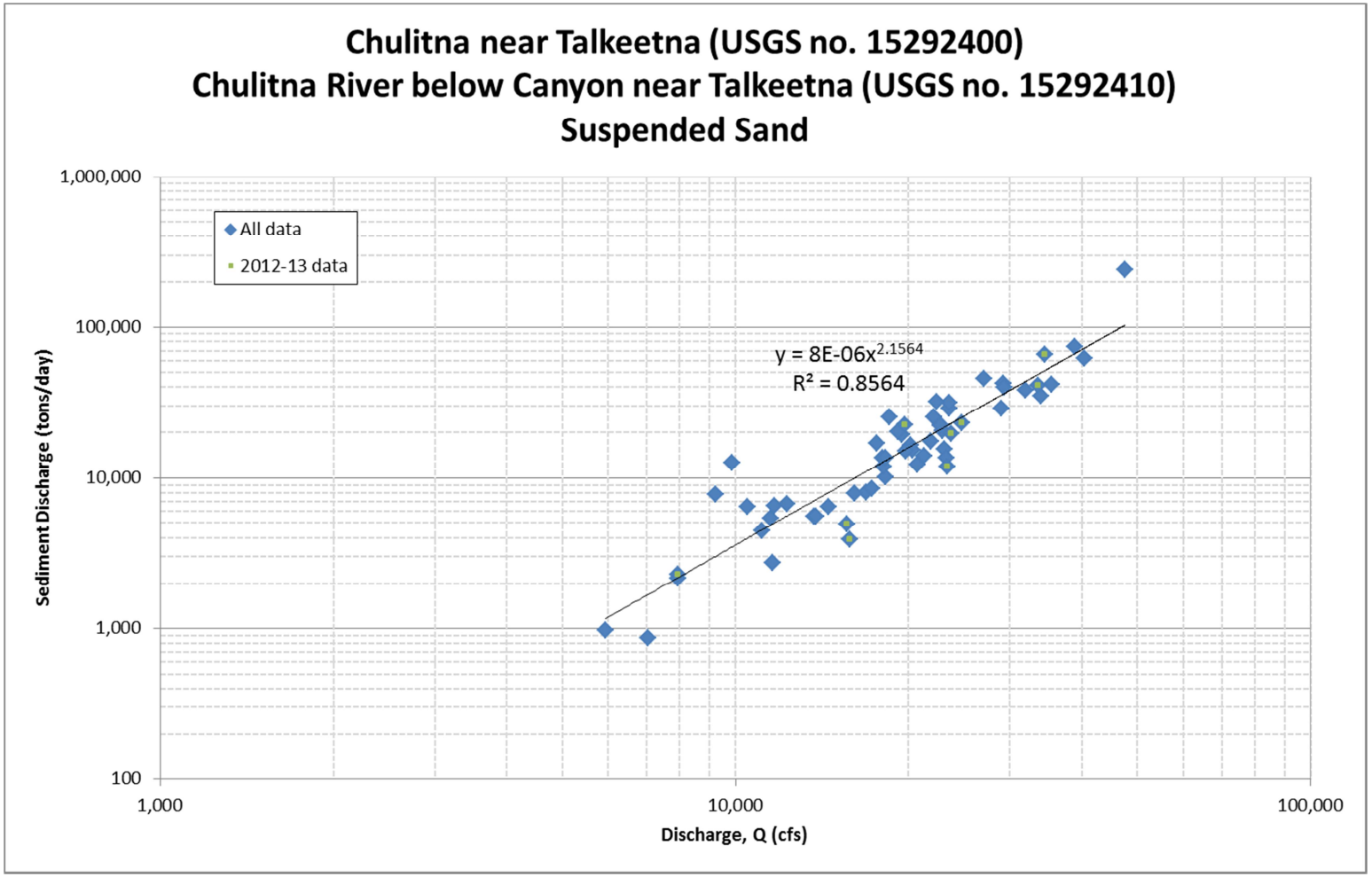

Figure A.6. Suspended sand sediment transport data and rating equation for Chulitna River near Talkeetna and Chulitna River below Canyon near Talkeetna

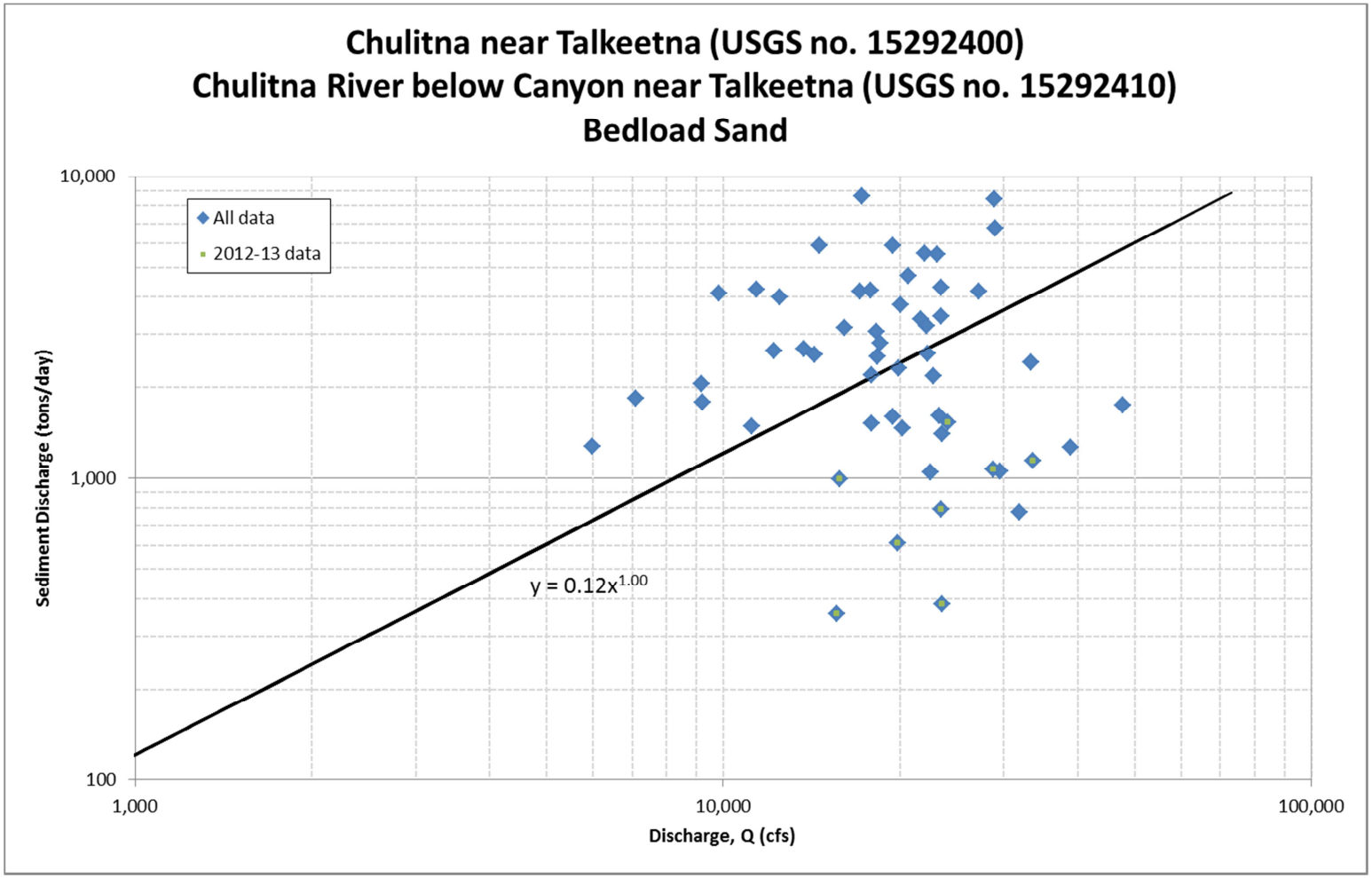

Figure A.7. Bed-load sand sediment-transport data and rating equation for Chulitna River near Talkeetna and Chulitna River below Canyon near Talkeetna

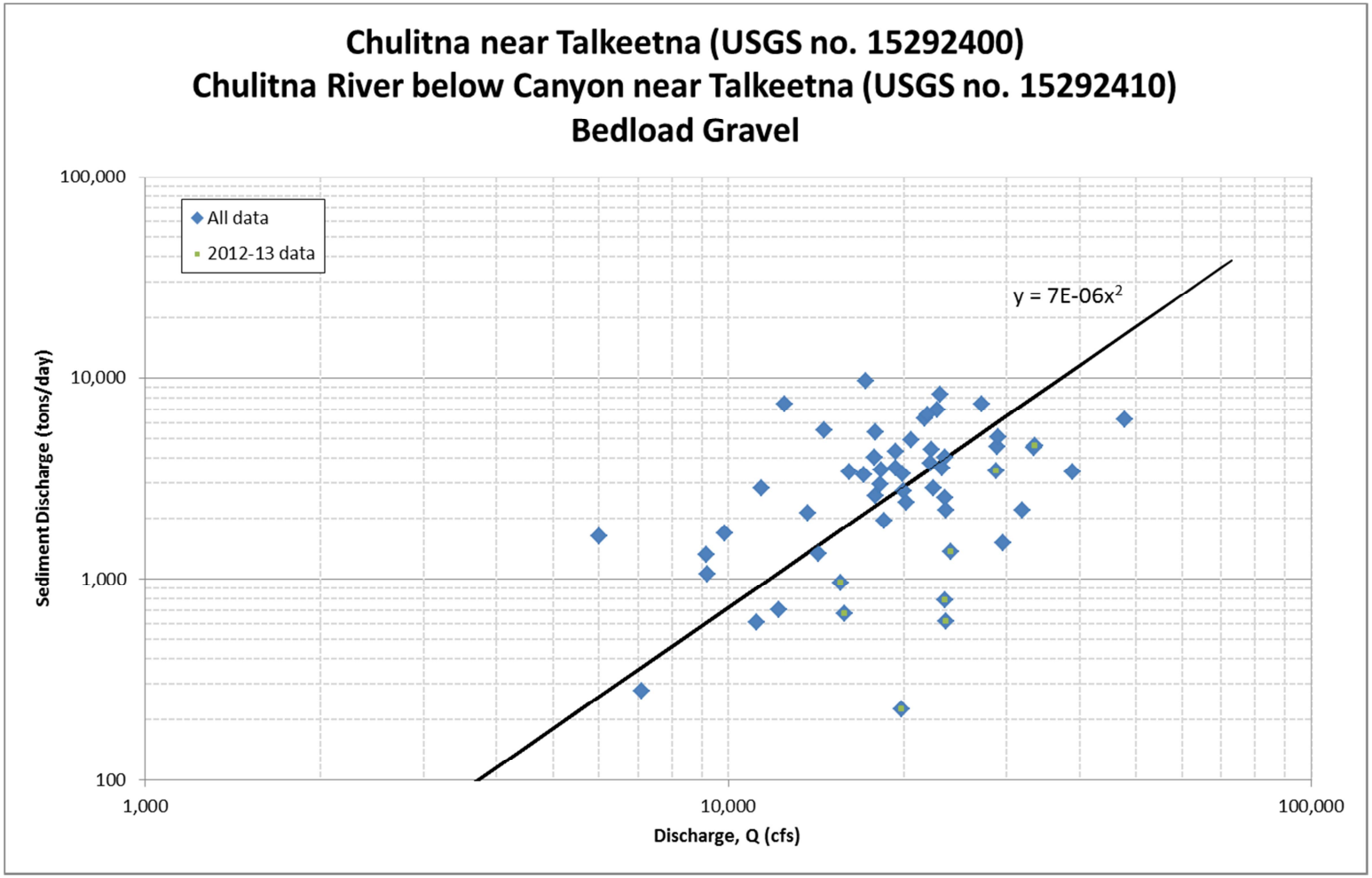

Figure A.8. Bed-load gravel sediment-transport data and rating equation for Chulitna River near Talkeetna and Chulitna River below Canyon near Talkeetna

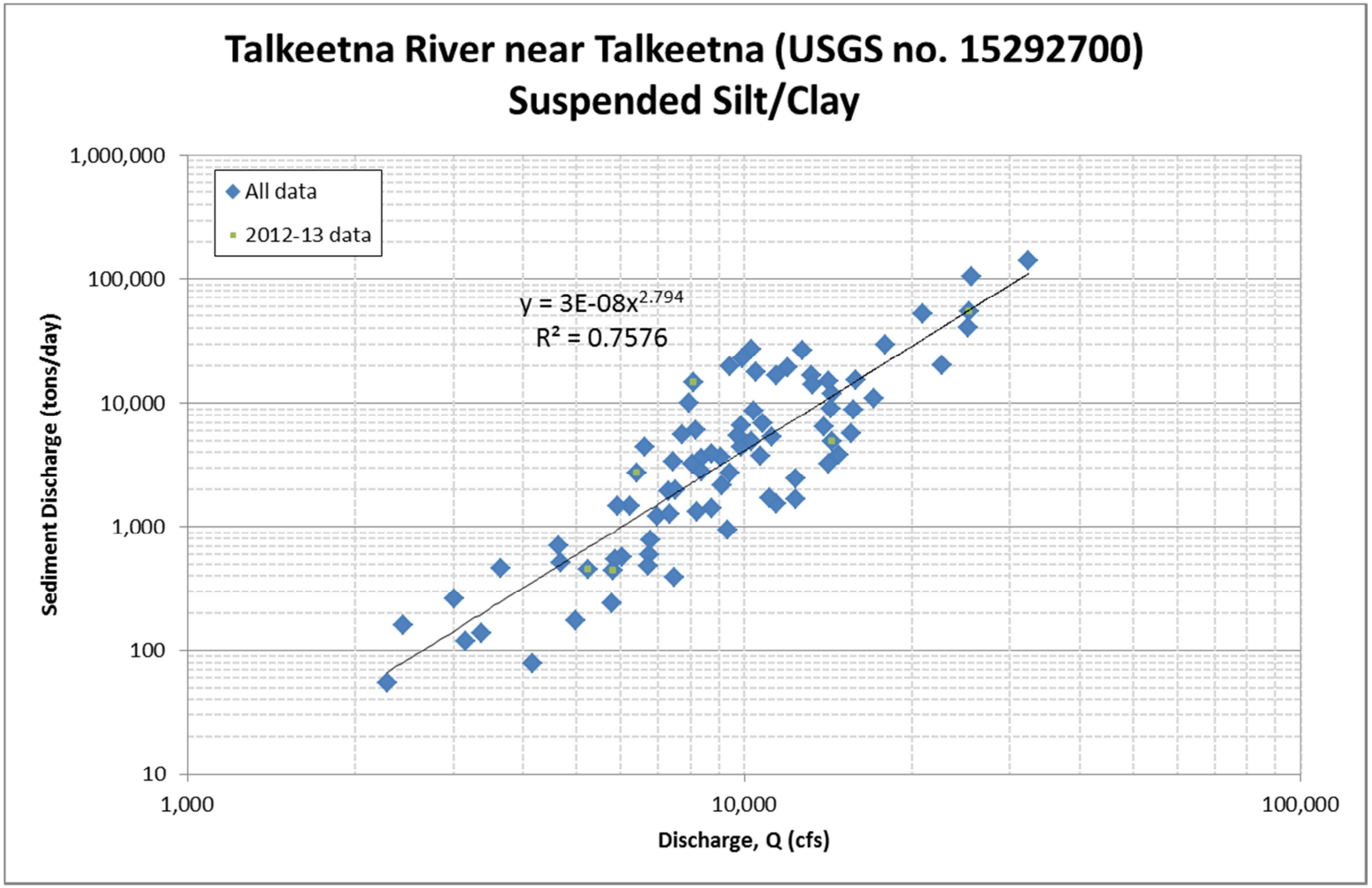

Figure A.9. Suspended silt/clay sediment-transport data and rating equation for Talkeetna River near Talkeetna

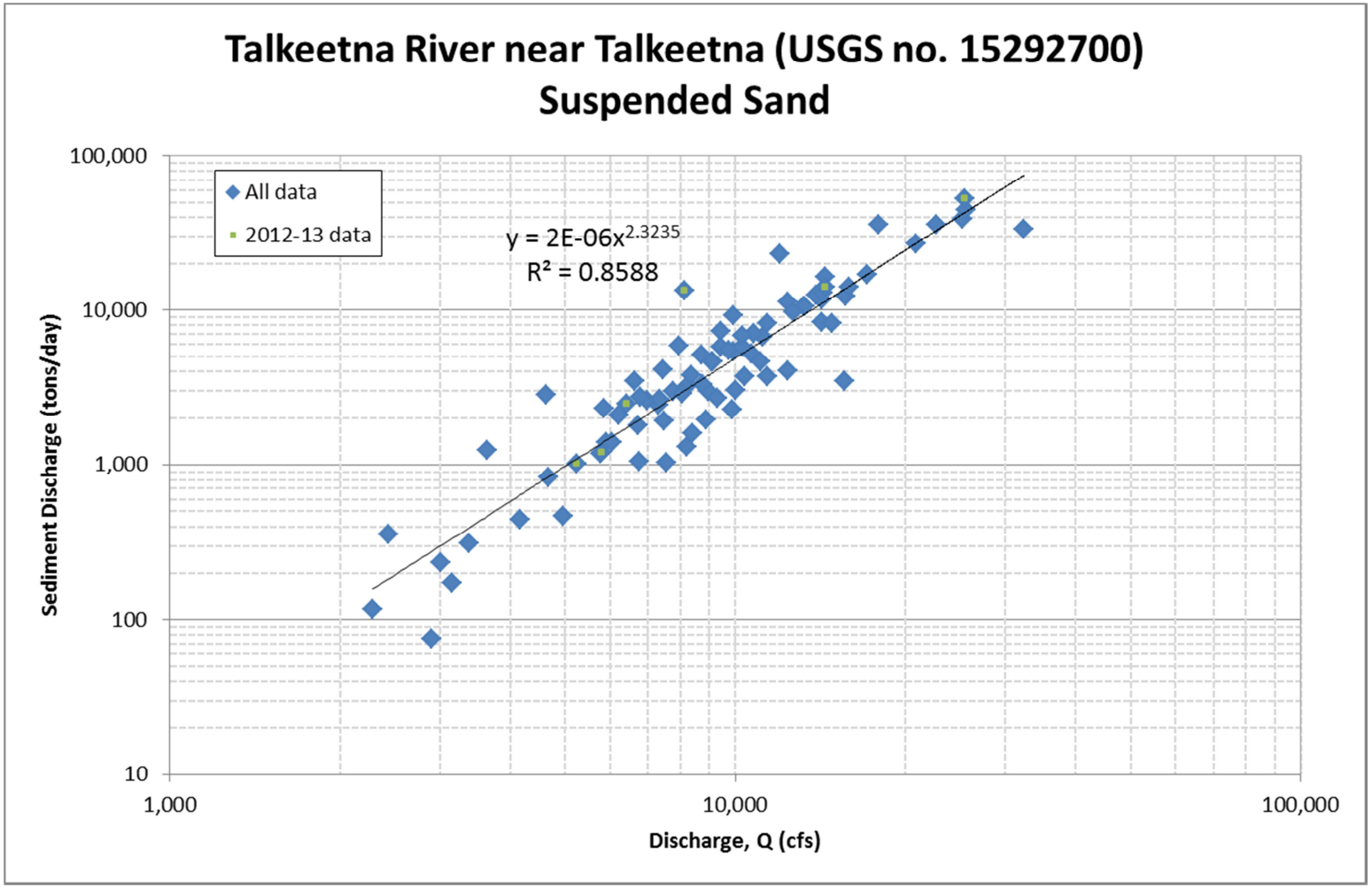

Figure A.10. Suspended sand sediment-transport data and rating equation for Talkeetna River near Talkeetna

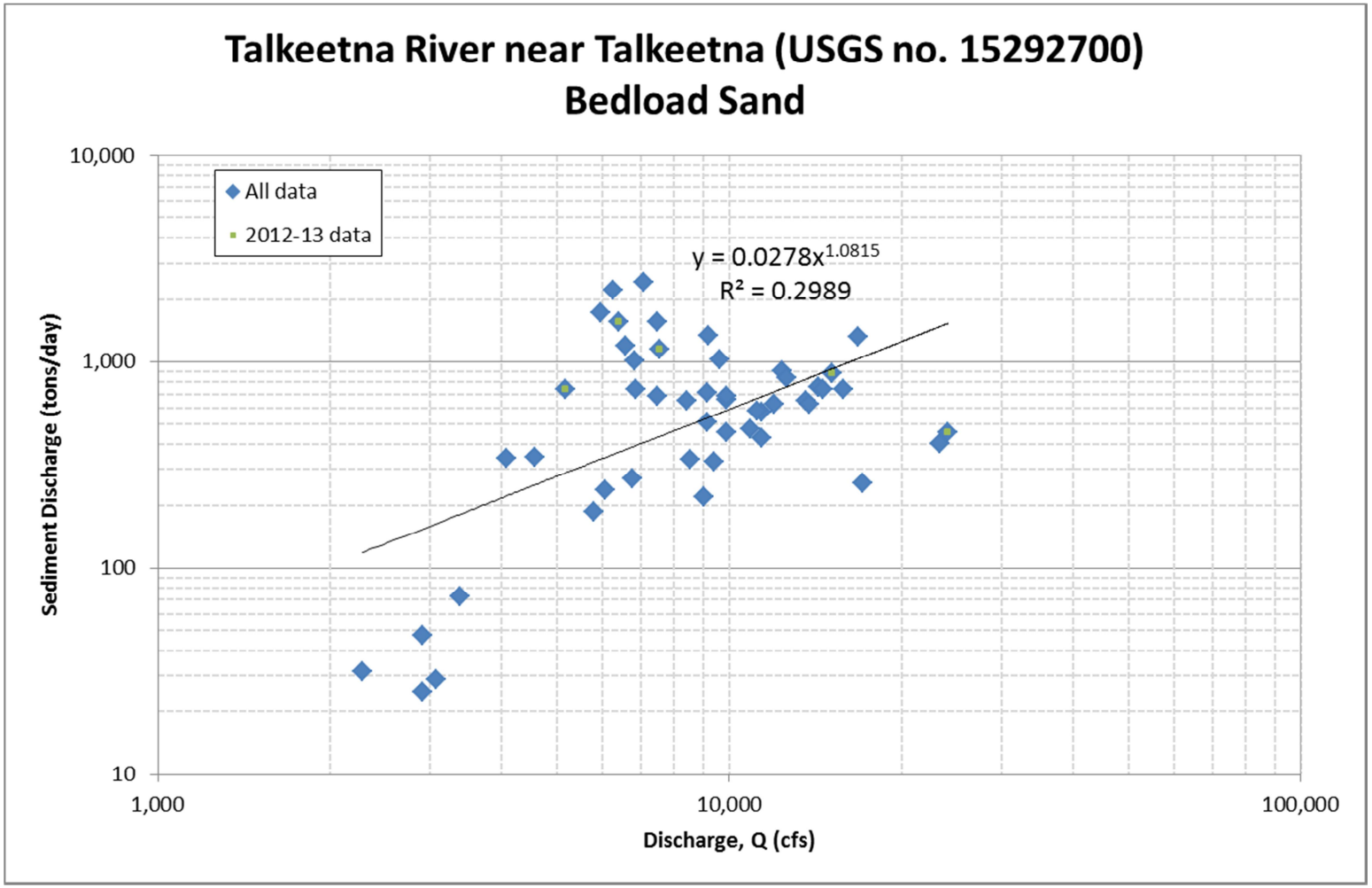

Figure A.11. Bed-load sand sediment-transport data and rating equation for Talkeetna River near Talkeetna

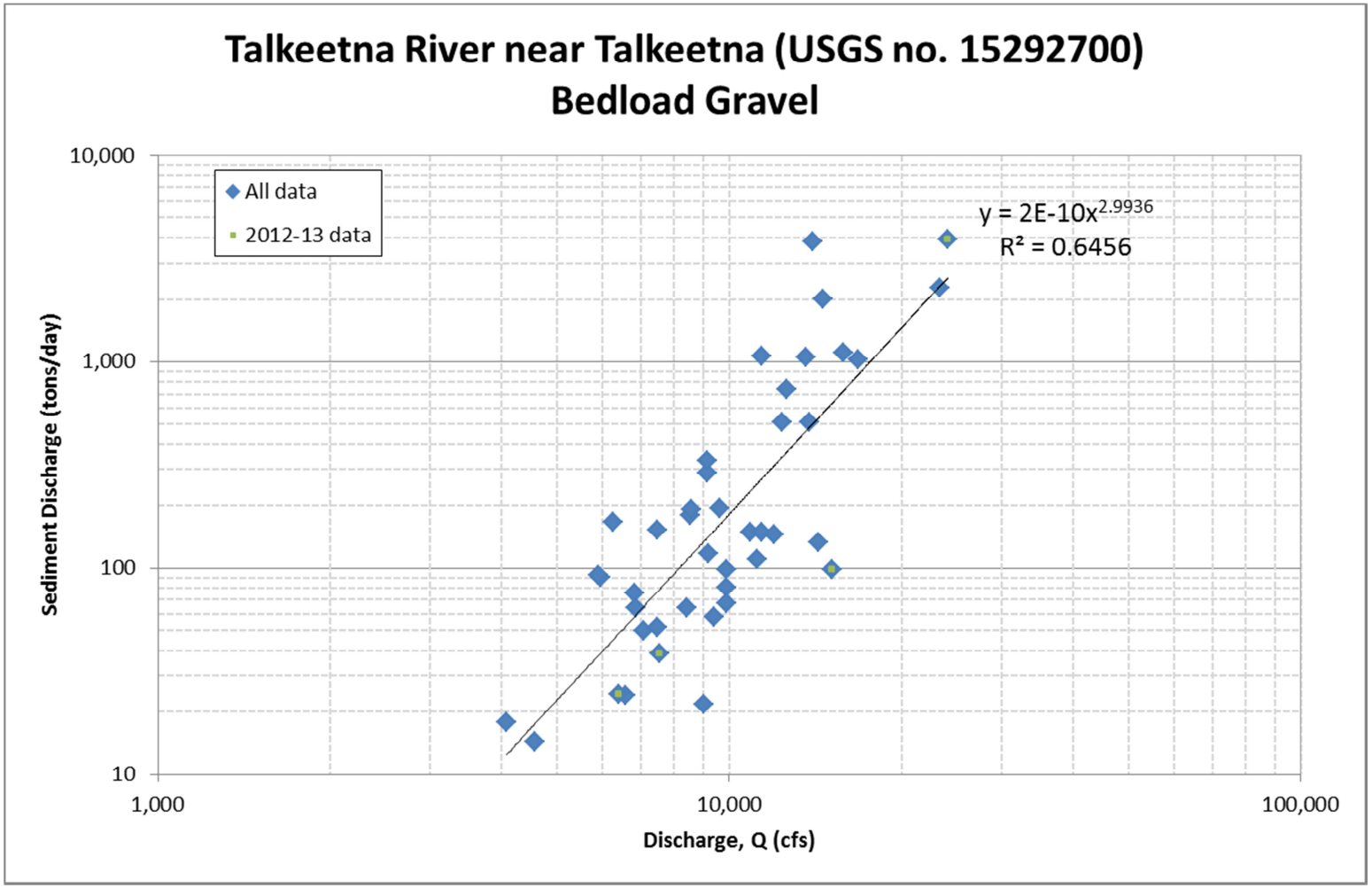

Figure A.12. Bed-load gravel sediment-transport data and rating equation for Talkeetna River near Talkeetna

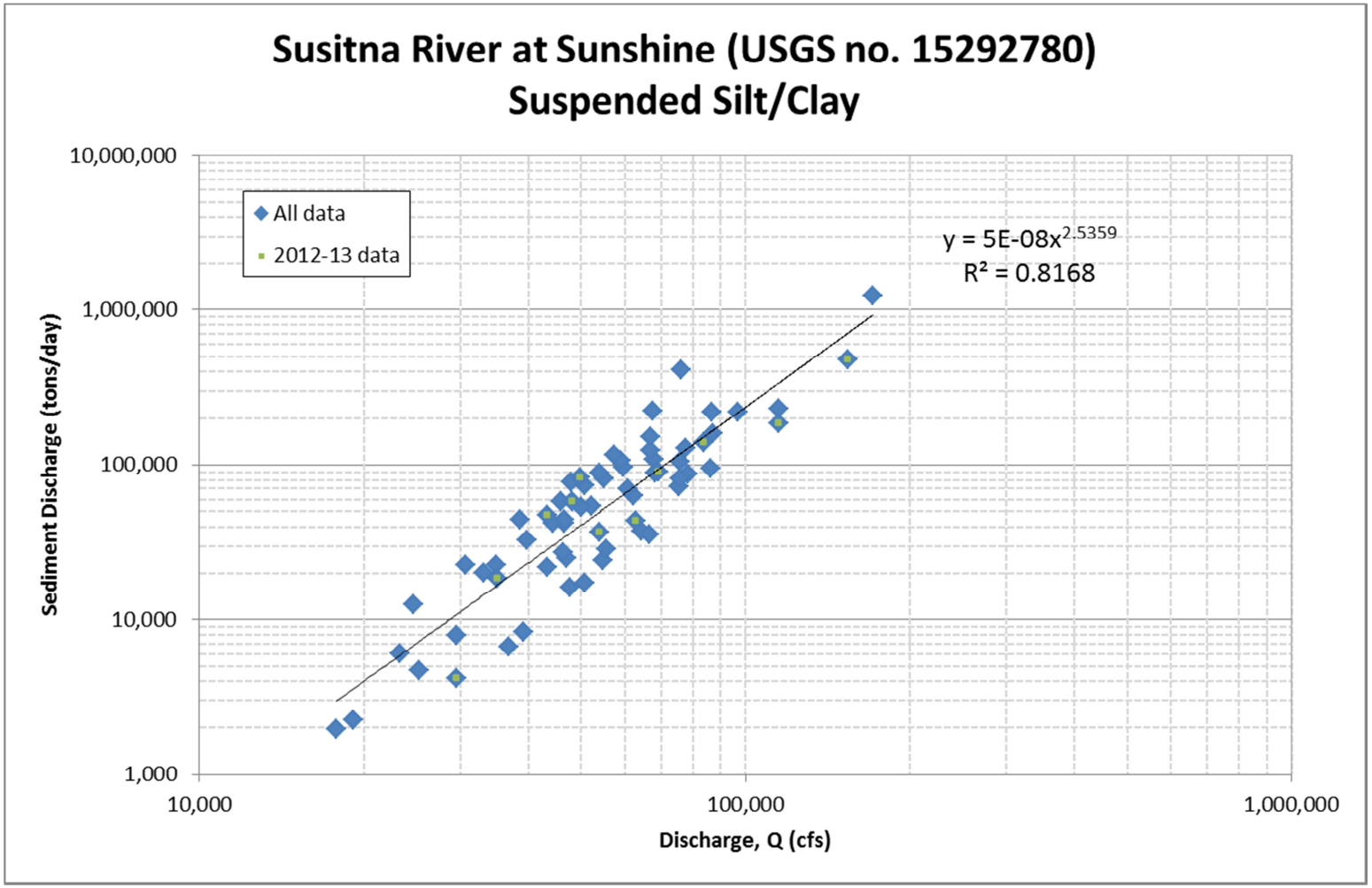

Figure A.13. Suspended silt/clay sediment-transport data and rating equation for Susitna River at Sunshine

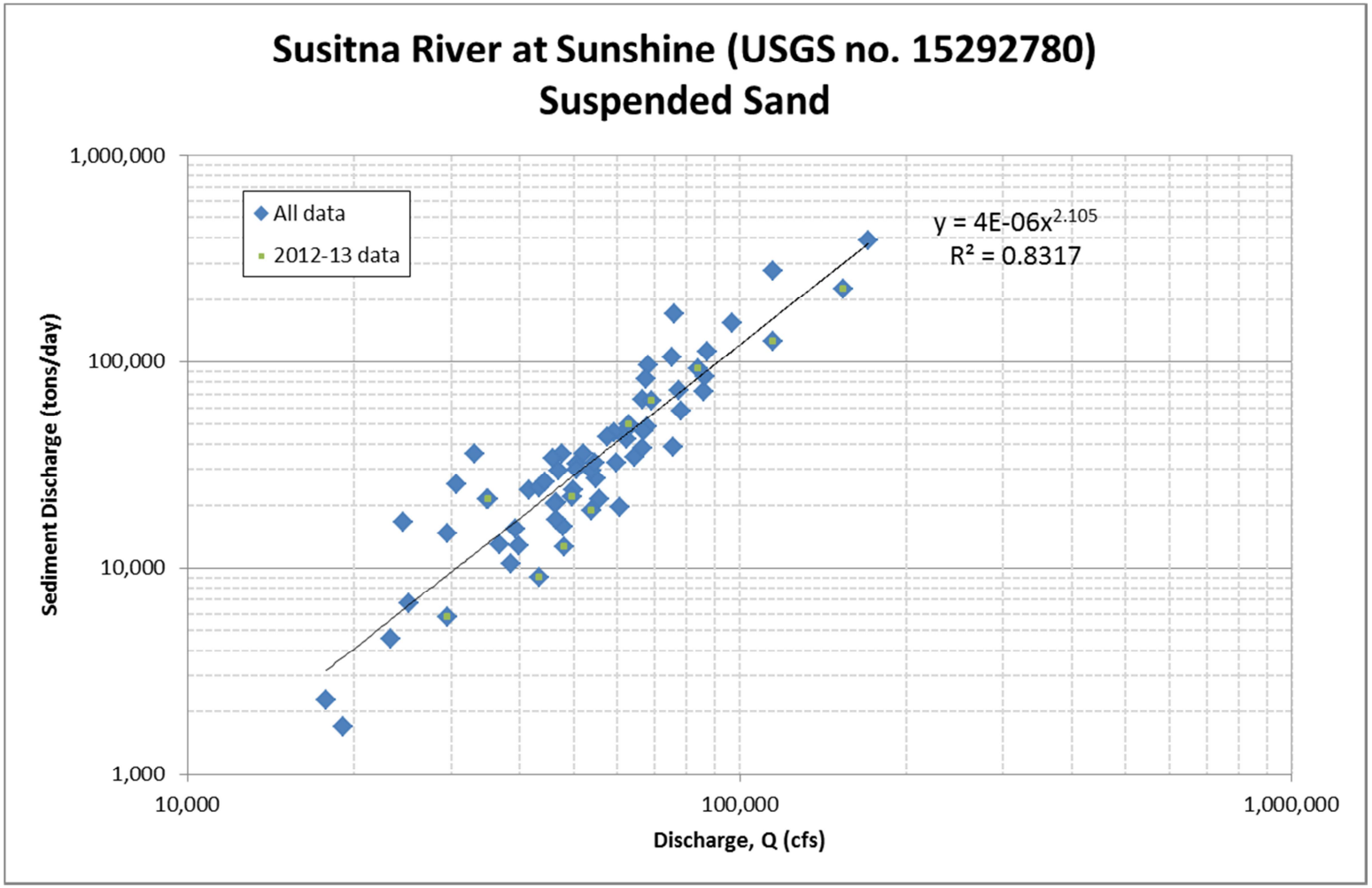

Figure A.14. Suspended sand sediment-transport data and rating equation for Susitna River at Sunshine

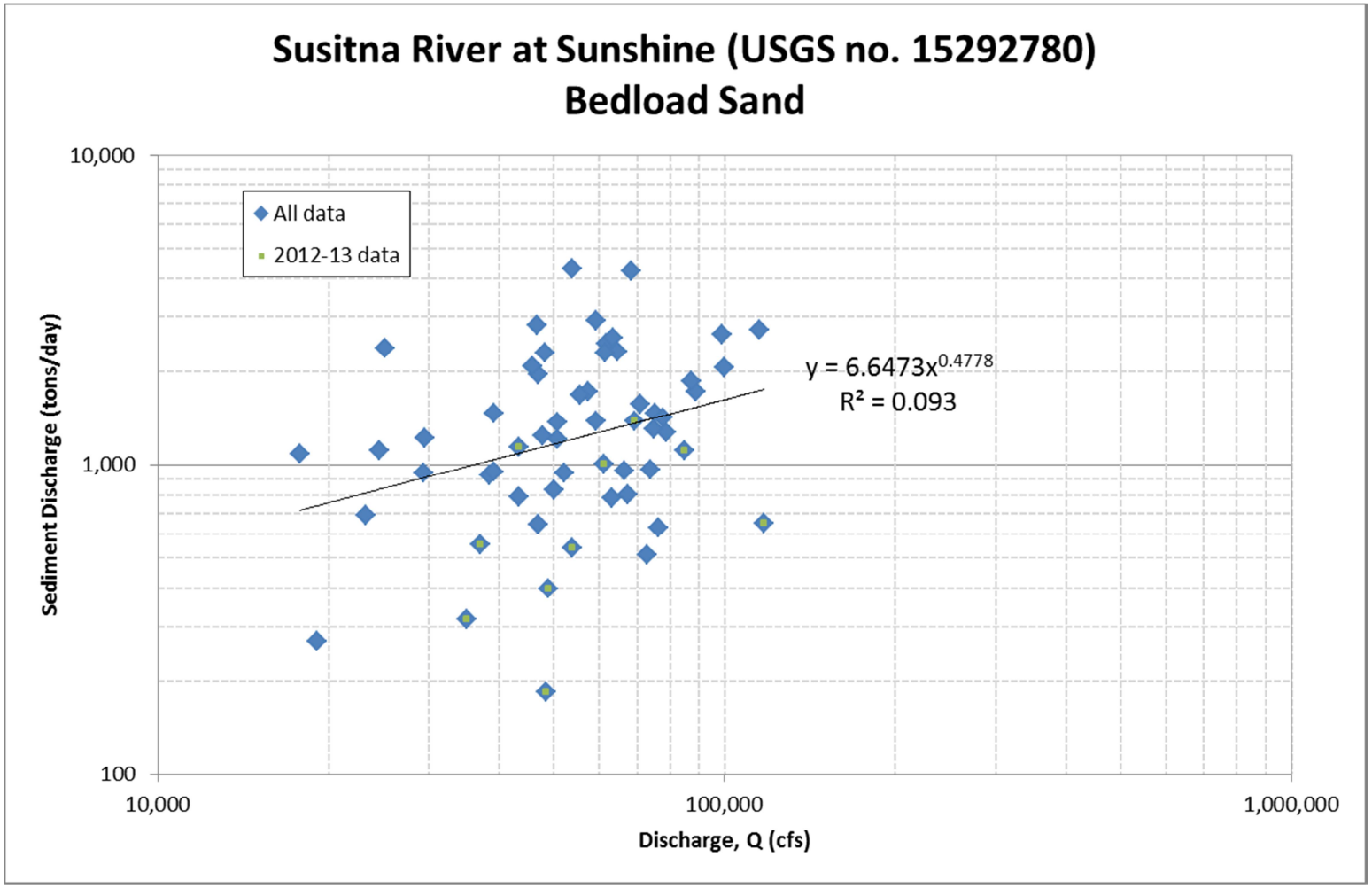

Figure A.15. Bed-load sand sediment-transport data and rating equation for Susitna River at Sunshine

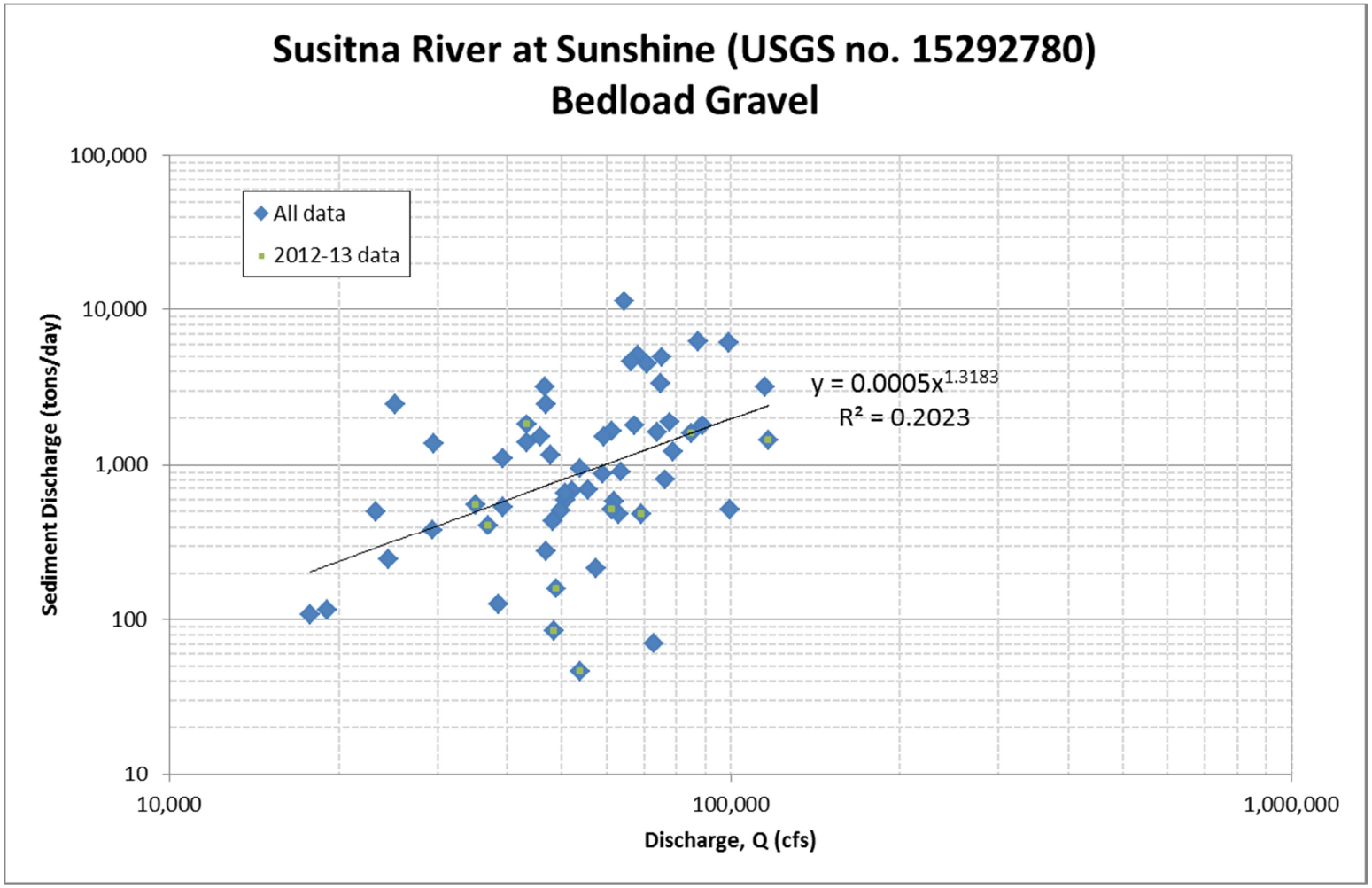

Figure A.16. Bed-load gravel sediment-transport data and rating equation for Susitna River at Sunshine

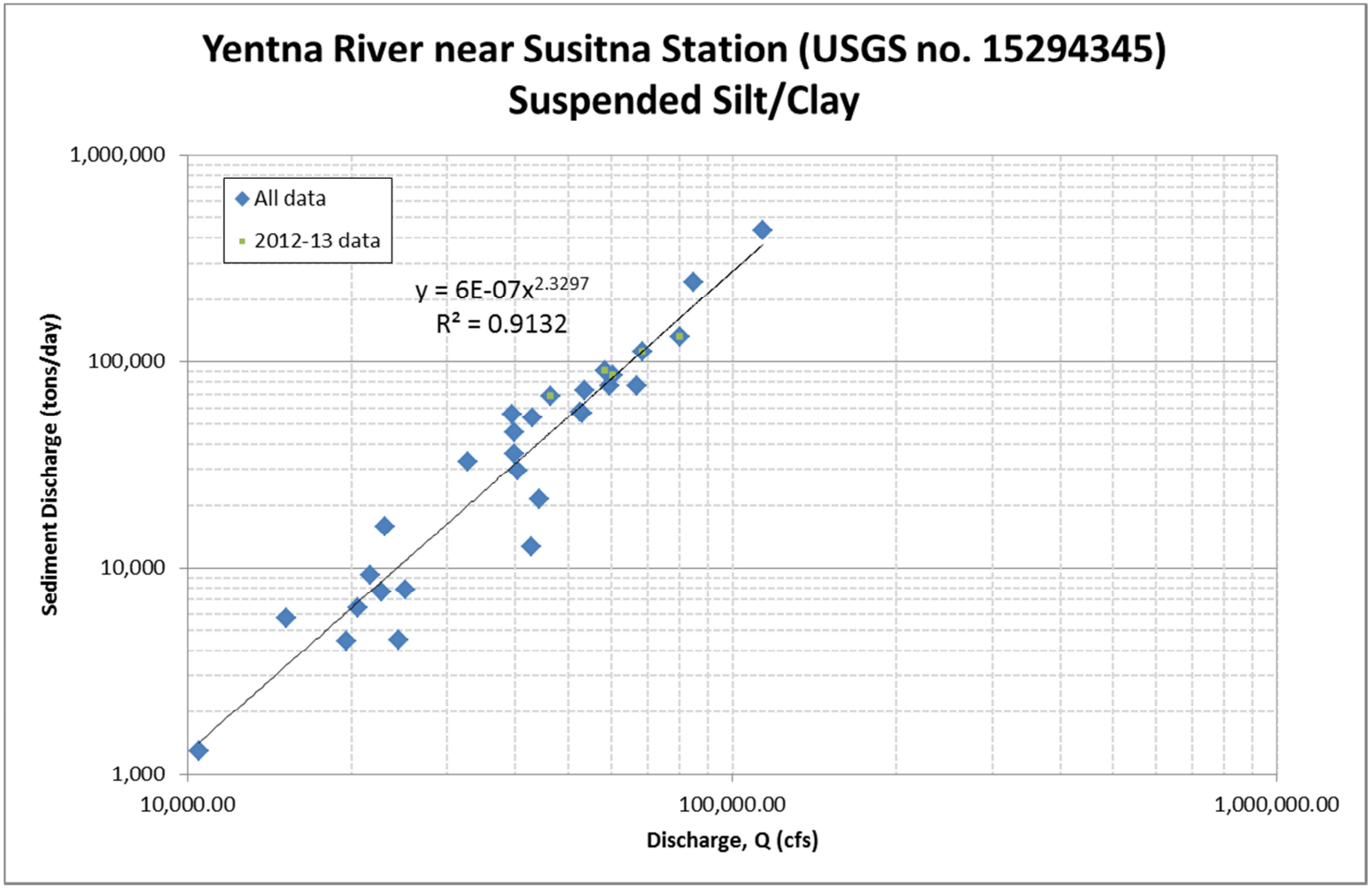

Figure A.17. Suspended silt/clay sediment-transport data and rating equation for Yentna River near Susitna Station

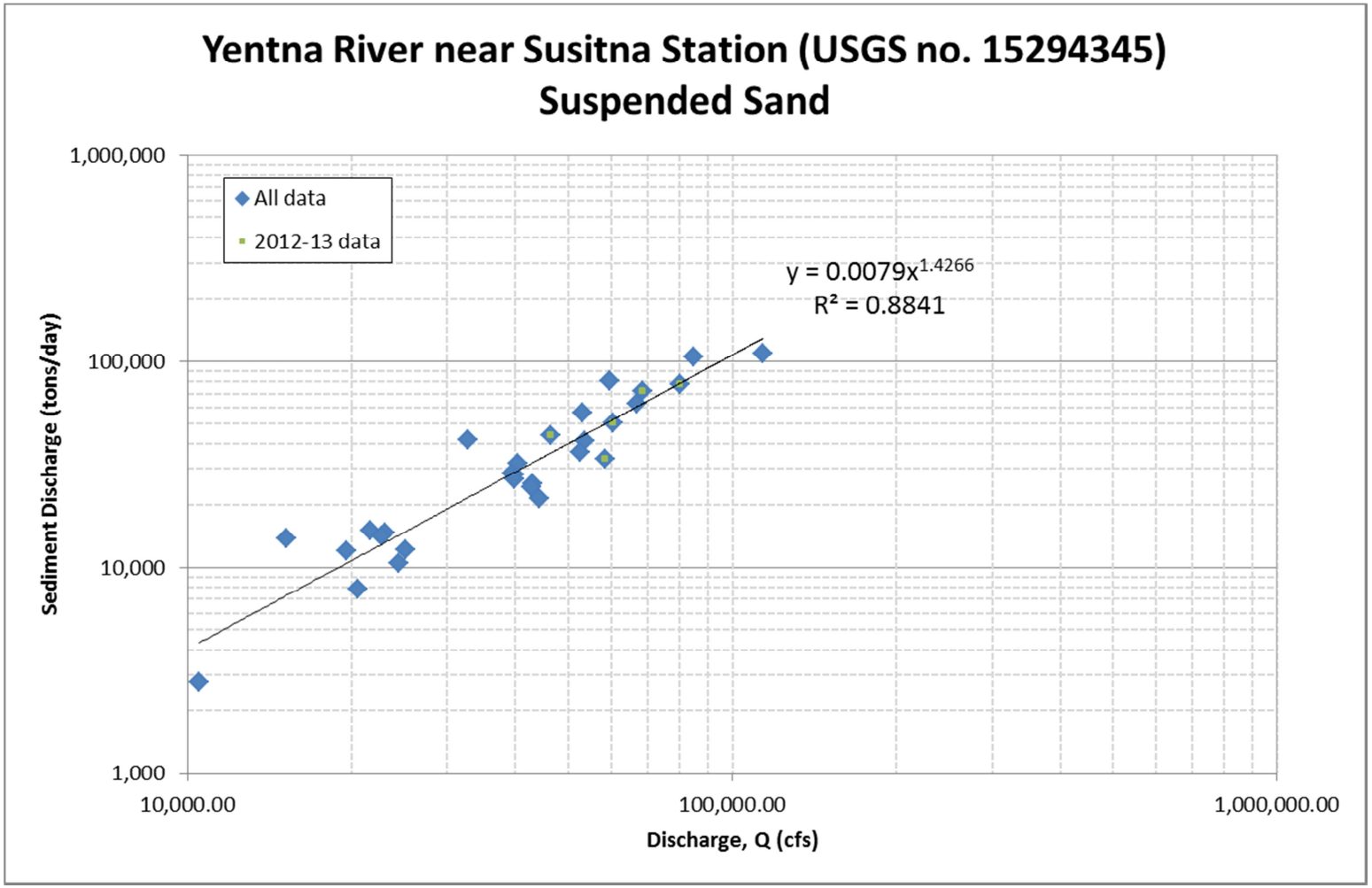

Figure A.18. Suspended sand sediment-transport data and rating equation for Yentna River near Susitna Station

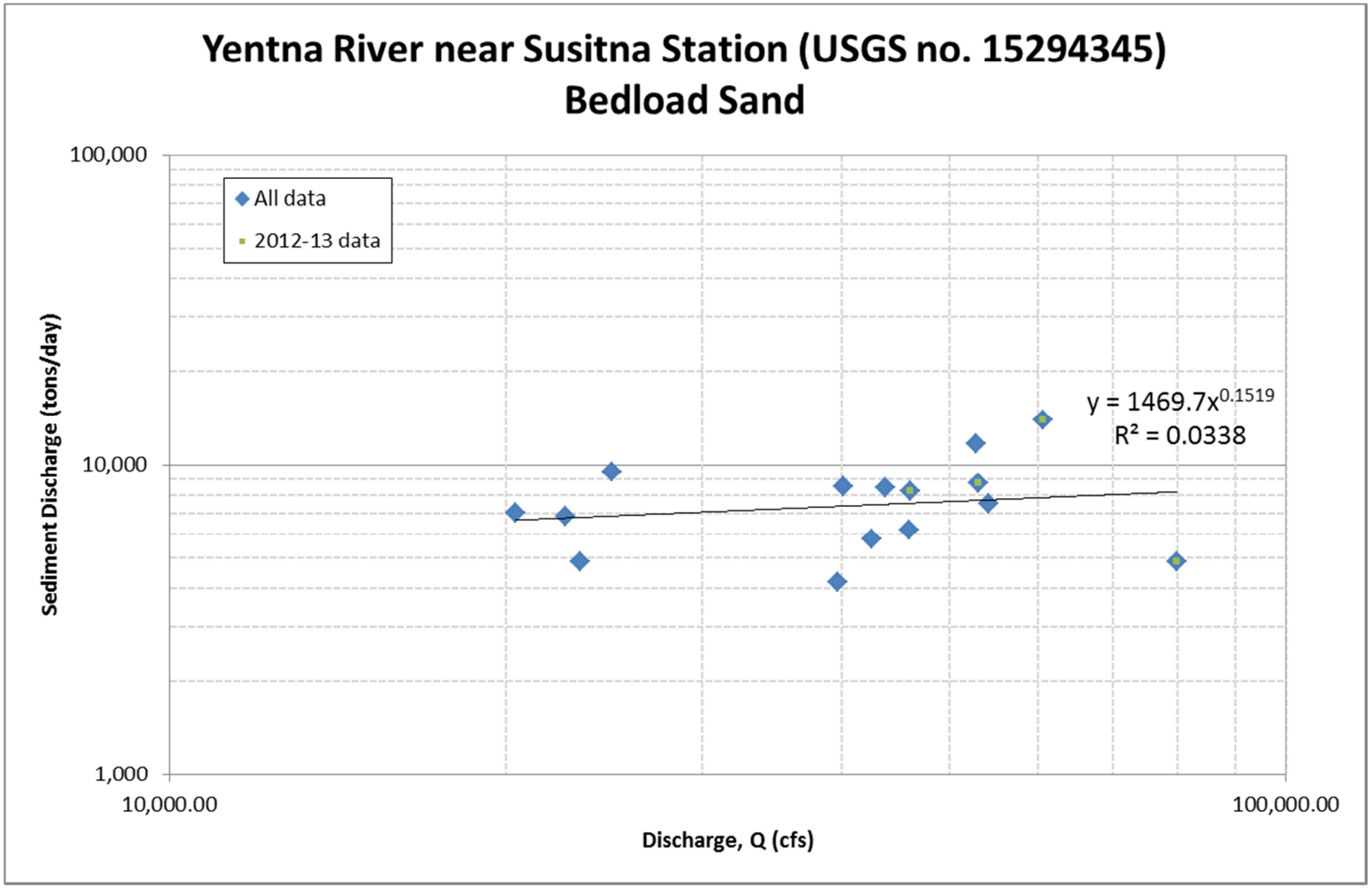

Figure A.19. Bed-load sand sediment-transport data and rating equation for Yentna River near Susitna Station

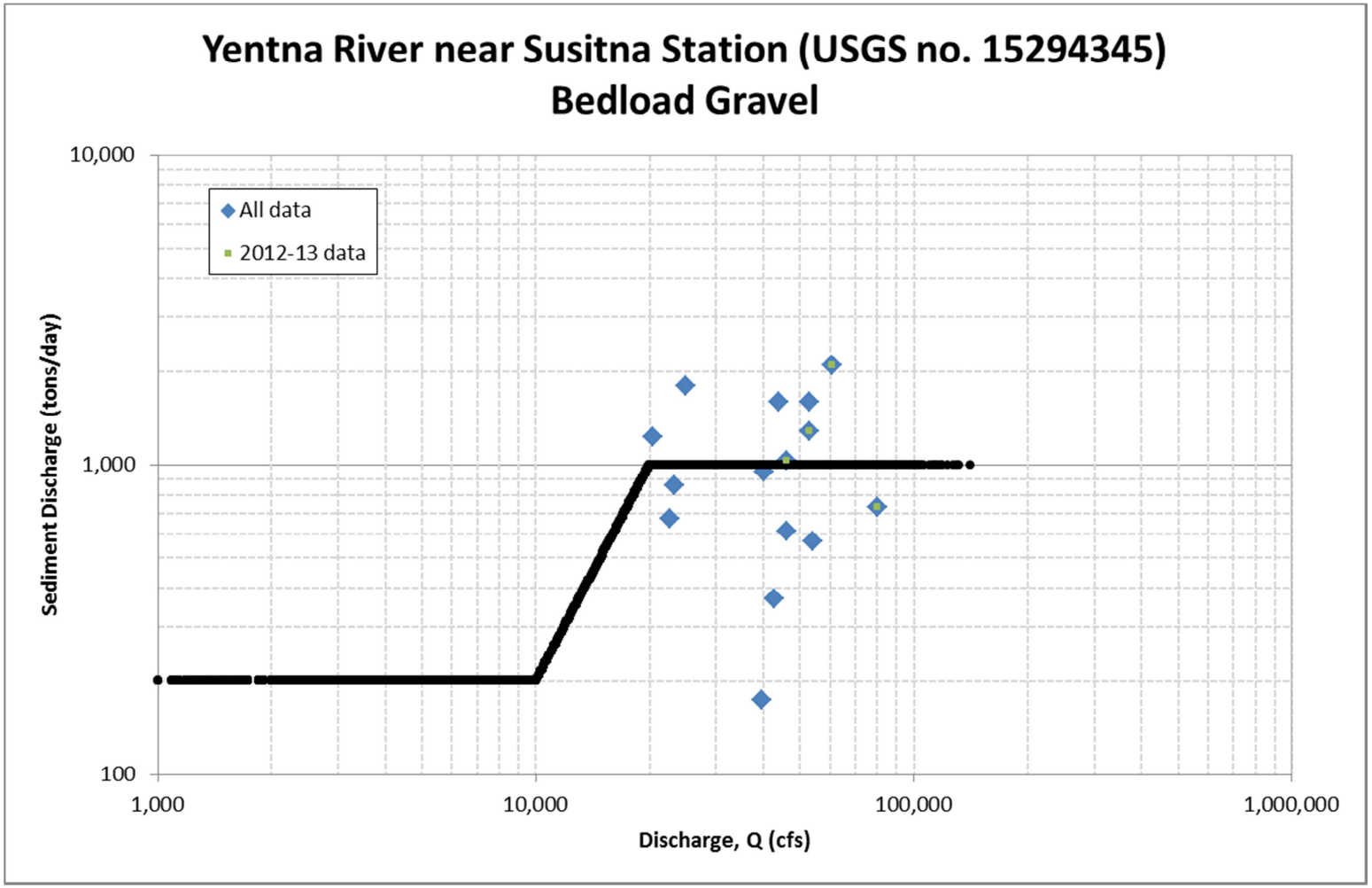

Figure A.20. Bed-load gravel sediment-transport data and rating equation for Yentna River near Susitna Station

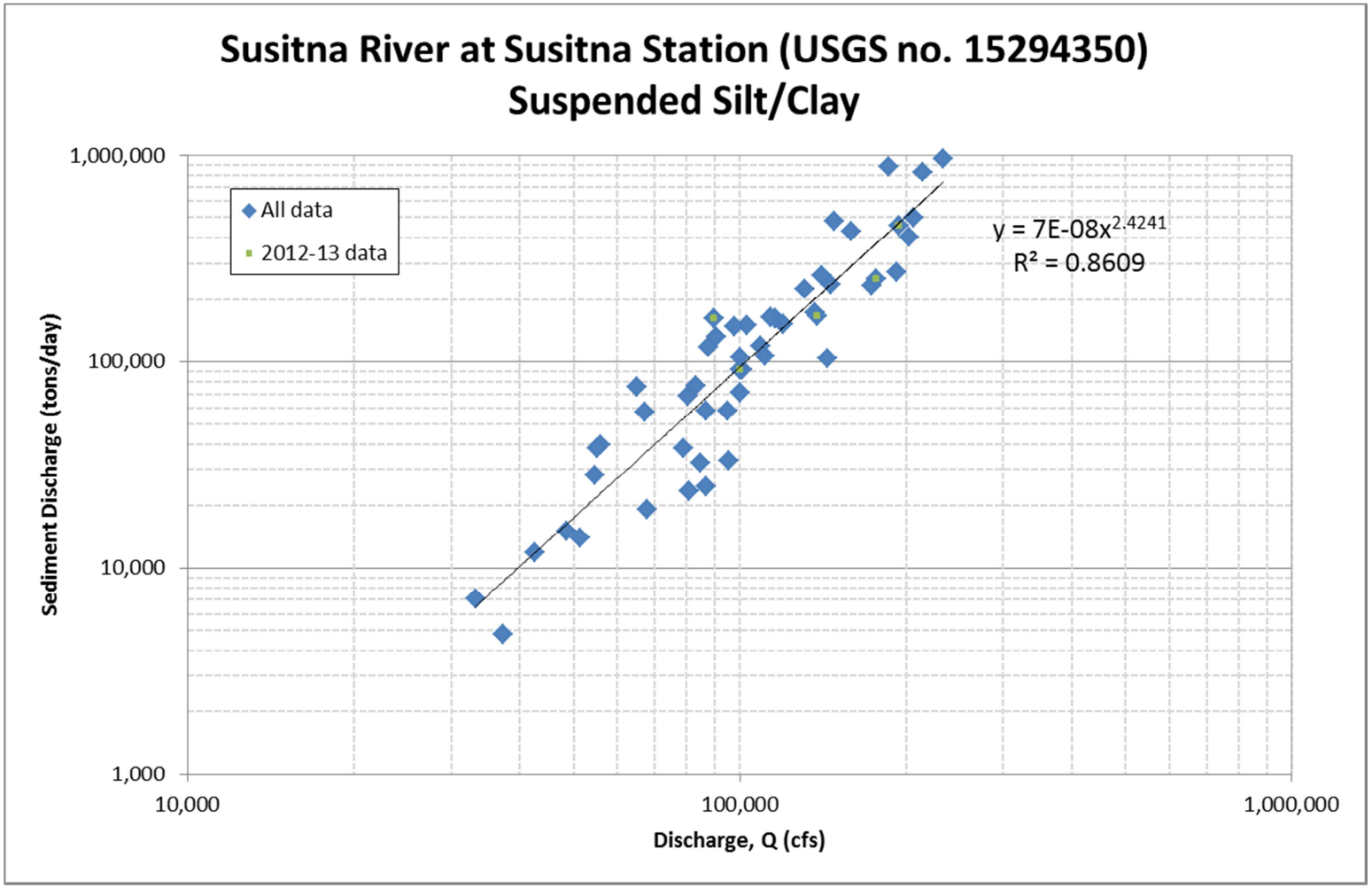

Figure A.21. Suspended silt/clay sediment-transport data and rating equation for Susitna River near Susitna Station

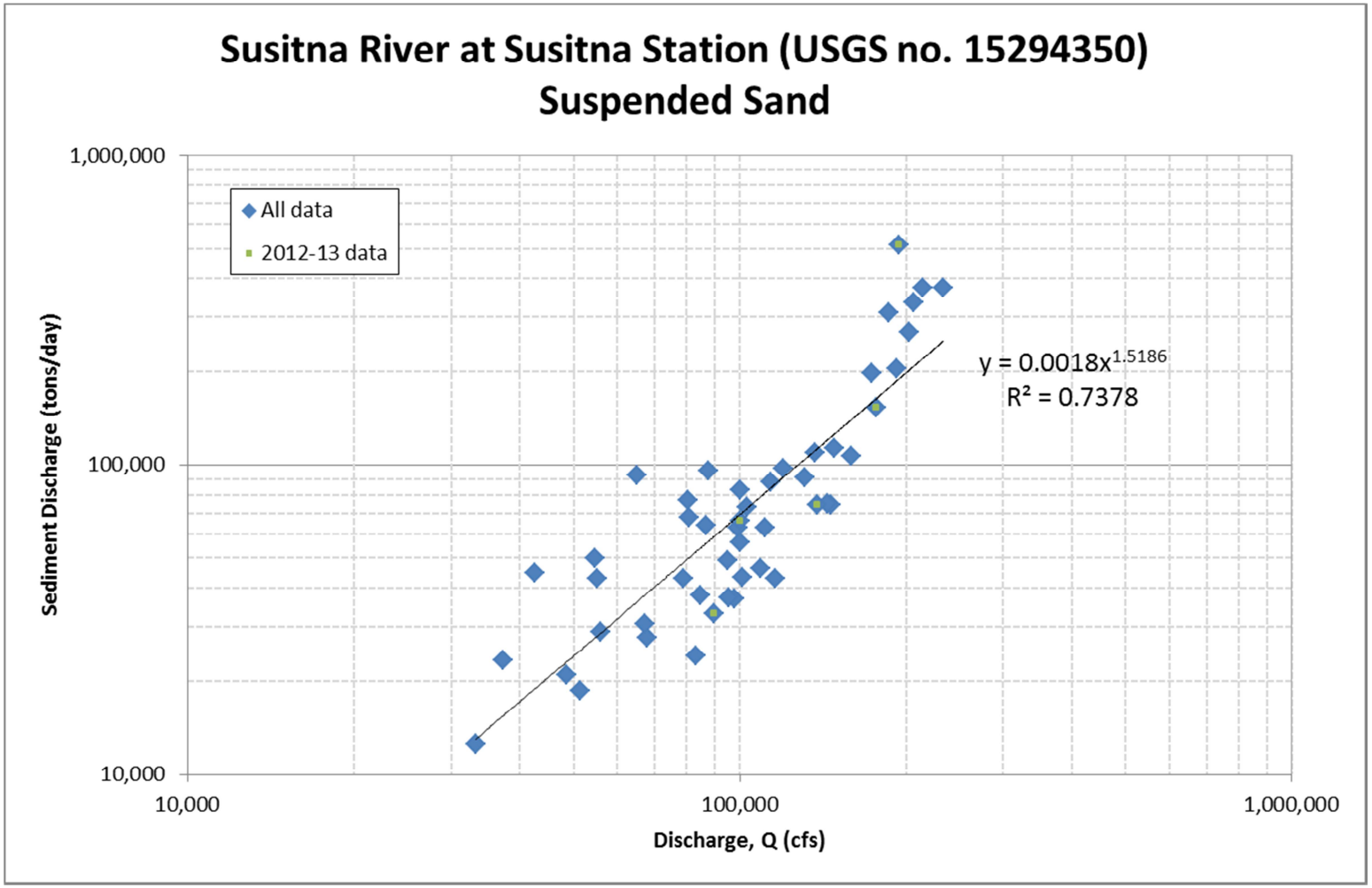

Figure A.22. Suspended sand sediment-transport data and rating equation for Susitna River near Susitna Station

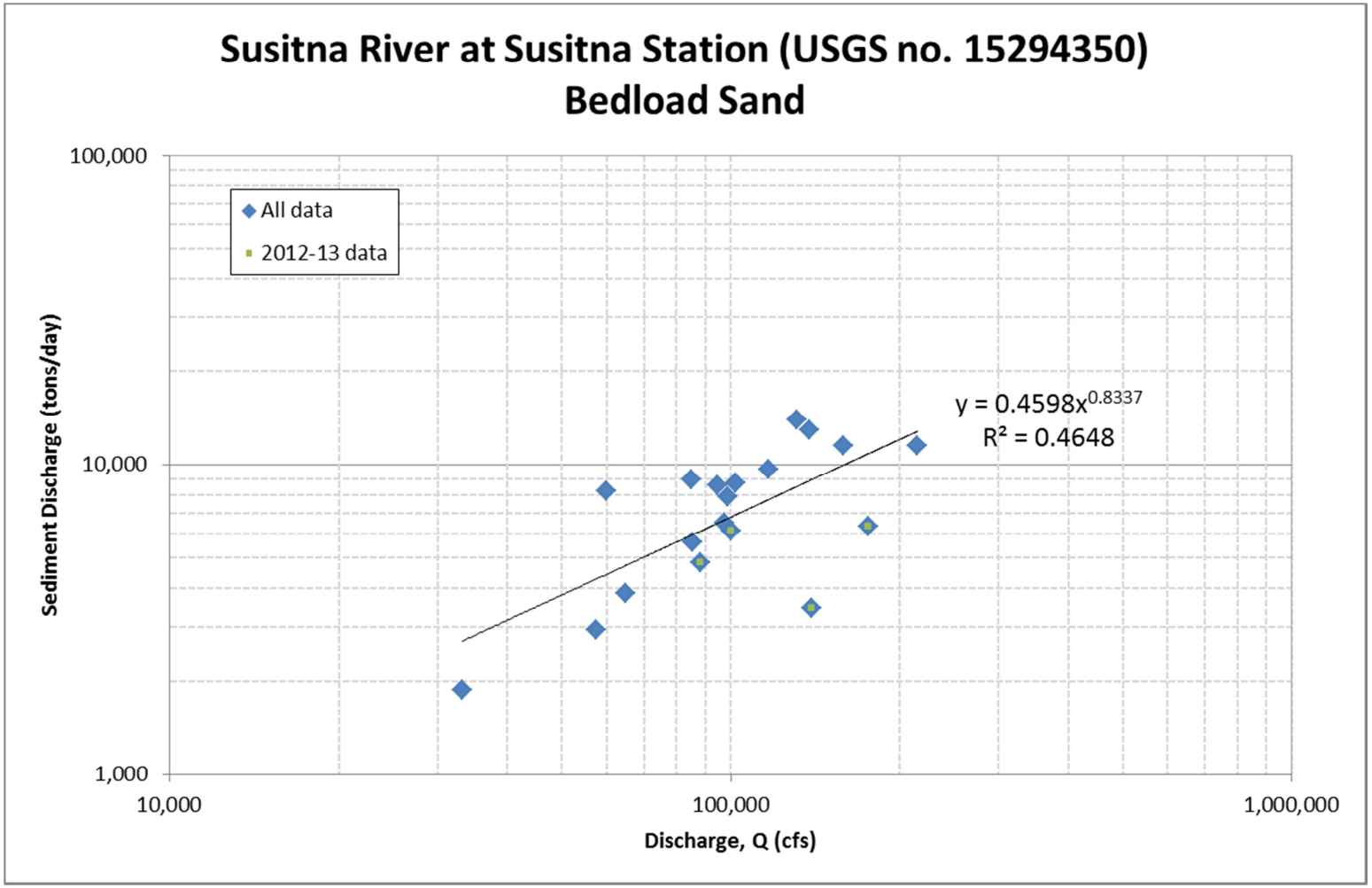

Figure A.23. Bed-load sand sediment-transport data and rating equation for Susitna River near Susitna Station

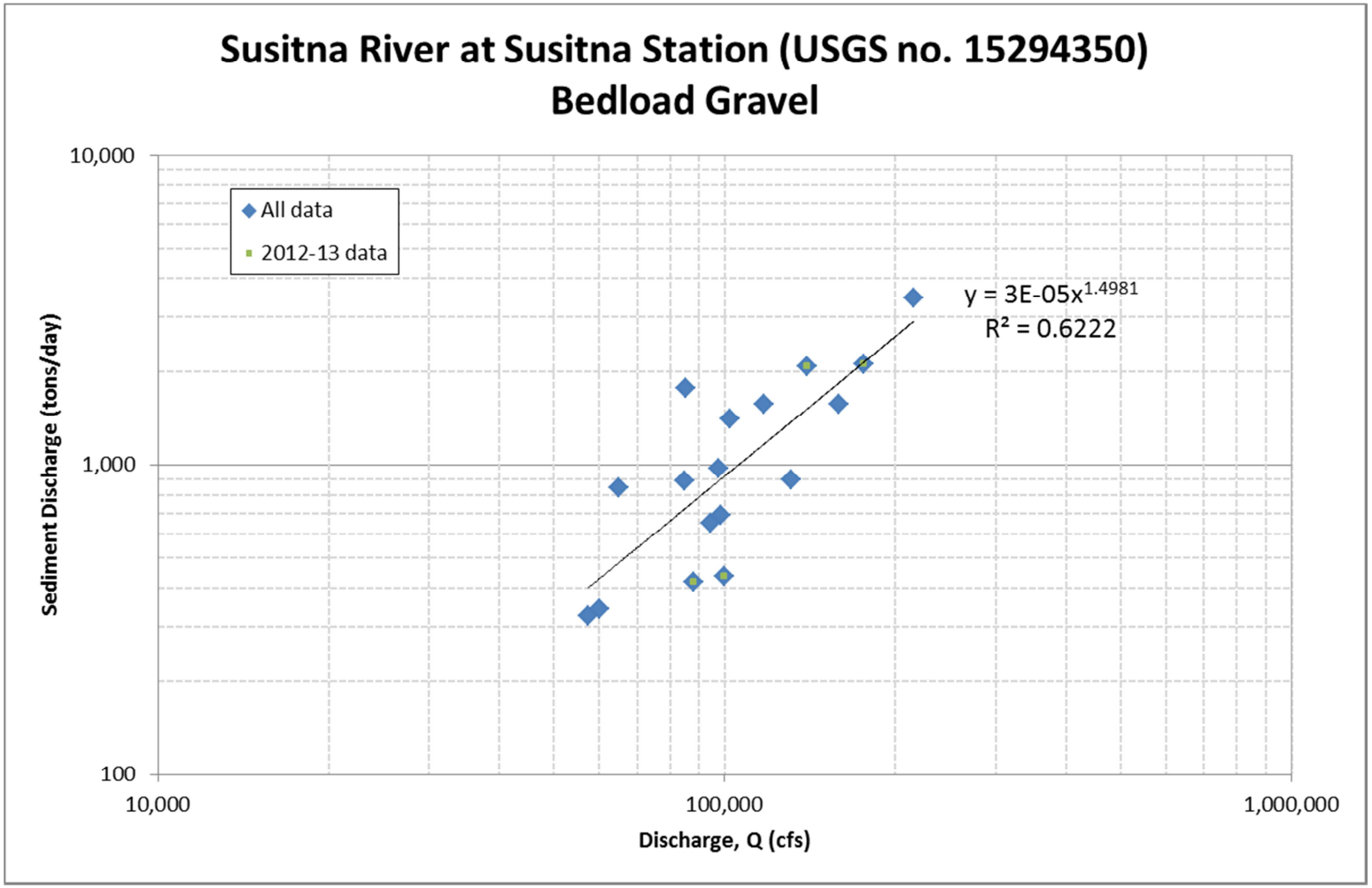

Figure A.24. Bed-load gravel sediment-transport data and rating equation for Susitna River near Susitna Station

APPENDIX B. ANNUAL SEDIMENT LOAD TABULAR SUMMARY FOR PRE-PROJECT CONDITIONS

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Geomorphology Study (Study 6.5)

2014 Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

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Prepared by

Tetra Tech, Inc.

September 2014

Table B.1. Annual Sediment Load for Pre-Project Conditions for Susitna River at Gold Creek

Susitna River at Gold Creek - 15292000								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1950	5,810,000	1,090,000	646,000	1,736,000	28,900	6,390	35,290	1,771,290
1951	6,590,000	1,480,000	908,000	2,388,000	36,700	9,490	46,190	2,434,190
1952	6,920,000	2,220,000	1,620,000	3,840,000	44,500	22,700	67,200	3,907,200
1953	7,310,000	1,680,000	1,050,000	2,730,000	40,800	11,700	52,500	2,782,500
1954	7,010,000	1,700,000	1,090,000	2,790,000	40,100	12,300	52,400	2,842,400
1955	7,430,000	2,480,000	1,870,000	4,350,000	48,200	28,200	76,400	4,426,400
1956	8,310,000	3,100,000	2,320,000	5,420,000	59,200	33,800	93,000	5,513,000
1957	7,520,000	2,060,000	1,390,000	3,450,000	45,300	17,300	62,600	3,512,600
1958	6,860,000	1,640,000	1,100,000	2,740,000	37,400	14,000	51,400	2,791,400
1959	7,650,000	2,700,000	2,080,000	4,780,000	51,600	32,300	83,900	4,863,900
1960	7,030,000	1,640,000	1,060,000	2,700,000	38,700	12,600	51,300	2,751,300
1961	7,830,000	2,110,000	1,480,000	3,590,000	45,800	20,200	66,000	3,656,000
1962	8,370,000	3,820,000	3,460,000	7,280,000	61,600	68,200	129,800	7,409,800
1963	8,020,000	2,850,000	2,130,000	4,980,000	54,900	31,000	85,900	5,065,900
1964	7,100,000	4,460,000	4,720,000	9,180,000	58,500	109,000	167,500	9,347,500
1965	7,360,000	2,140,000	1,460,000	3,600,000	46,000	18,500	64,500	3,664,500
1966	6,830,000	2,040,000	1,550,000	3,590,000	41,100	24,400	65,500	3,655,500
1967	8,120,000	3,440,000	2,890,000	6,330,000	59,600	51,500	111,100	6,441,100
1968	7,110,000	2,110,000	1,500,000	3,610,000	43,700	20,200	63,900	3,673,900
1969	4,050,000	442,000	220,000	662,000	14,800	1,580	16,380	678,380
1970	5,500,000	1,070,000	634,000	1,704,000	28,000	6,270	34,270	1,738,270
1971	7,420,000	3,500,000	3,230,000	6,730,000	54,800	64,500	119,300	6,849,300
1972	7,880,000	2,860,000	2,410,000	5,270,000	51,500	43,600	95,100	5,365,100
1973	5,850,000	1,400,000	966,000	2,366,000	31,600	12,900	44,500	2,410,500
1974	5,520,000	1,030,000	609,000	1,639,000	27,200	6,200	33,400	1,672,400
1975	7,440,000	2,250,000	1,560,000	3,810,000	47,200	20,300	67,500	3,877,500
1976	5,930,000	1,150,000	691,000	1,841,000	29,700	7,150	36,850	1,877,850
1977	7,320,000	2,440,000	1,870,000	4,310,000	47,000	28,800	75,800	4,385,800
1978	5,930,000	863,000	465,000	1,328,000	25,600	3,880	29,480	1,357,480
1979	6,870,000	1,820,000	1,230,000	3,050,000	40,400	15,000	55,400	3,105,400

Susitna River at Gold Creek - 15292000								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1980	7,780,000	2,400,000	1,750,000	4,150,000	48,600	24,900	73,500	4,223,500
1981	8,660,000	3,600,000	3,020,000	6,620,000	61,800	52,400	114,200	6,734,200
1982	7,000,000	1,550,000	976,000	2,526,000	37,800	10,800	48,600	2,574,600
1983	7,180,000	1,590,000	990,000	2,580,000	38,800	10,700	49,500	2,629,500
1984	6,950,000	1,650,000	1,110,000	2,760,000	37,900	14,000	51,900	2,811,900
1985	7,150,000	1,910,000	1,300,000	3,210,000	41,900	16,400	58,300	3,268,300
1986	6,180,000	1,040,000	583,000	1,623,000	29,100	5,210	34,310	1,657,310
1987	7,640,000	1,980,000	1,330,000	3,310,000	44,500	16,500	61,000	3,371,000
1988	7,420,000	1,970,000	1,310,000	3,280,000	44,200	15,600	59,800	3,339,800
1989	7,420,000	1,680,000	1,050,000	2,730,000	40,700	11,600	52,300	2,782,300
1990	9,420,000	3,370,000	2,500,000	5,870,000	65,400	35,800	101,200	5,971,200
1991	6,180,000	1,220,000	746,000	1,966,000	31,000	7,850	38,850	2,004,850
1992	6,330,000	1,360,000	848,000	2,208,000	33,200	9,070	42,270	2,250,270
1993	7,310,000	1,700,000	1,070,000	2,770,000	40,700	11,700	52,400	2,822,400
1994	7,210,000	1,720,000	1,170,000	2,890,000	39,300	15,300	54,600	2,944,600
1995	7,450,000	1,790,000	1,150,000	2,940,000	42,100	13,100	55,200	2,995,200
1996	4,940,000	591,000	295,000	886,000	19,400	2,120	21,520	907,520
1997	6,370,000	1,410,000	874,000	2,284,000	34,300	9,350	43,650	2,327,650
1998	6,790,000	1,690,000	1,080,000	2,770,000	39,300	12,200	51,500	2,821,500
1999	6,730,000	1,570,000	1,020,000	2,590,000	36,900	12,100	49,000	2,639,000
2000	7,430,000	2,100,000	1,470,000	3,570,000	44,800	19,100	63,900	3,633,900
2001	6,910,000	1,770,000	1,200,000	2,970,000	39,500	15,000	54,500	3,024,500
2002	6,140,000	1,220,000	745,000	1,965,000	31,100	7,900	39,000	2,004,000
2003	7,440,000	1,890,000	1,290,000	3,180,000	42,200	16,800	59,000	3,239,000
2004	6,820,000	1,530,000	962,000	2,492,000	37,100	10,700	47,800	2,539,800
2005	8,840,000	3,120,000	2,230,000	5,350,000	62,300	29,800	92,100	5,442,100
2006	7,470,000	2,410,000	1,800,000	4,210,000	47,900	26,900	74,800	4,284,800
2007	6,990,000	1,260,000	719,000	1,979,000	34,400	6,590	40,990	2,019,990
2008	6,460,000	1,210,000	715,000	1,925,000	31,900	7,120	39,020	1,964,020
2009	6,880,000	1,480,000	917,000	2,397,000	36,800	9,980	46,780	2,443,780
2010	7,340,000	1,710,000	1,070,000	2,780,000	41,100	11,900	53,000	2,833,000

Table B.2. Annual Sediment Load for Pre-Project Conditions for Chulitna River near Talkeetna

Chulitna River near Talkeetna - 15292400								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1950	5,370,000	3,440,000	1,870,000	5,310,000	328,000	317,000	645,000	5,955,000
1951	6,130,000	4,540,000	2,410,000	6,950,000	374,000	403,000	777,000	7,727,000
1952	5,940,000	5,130,000	2,580,000	7,710,000	363,000	424,000	787,000	8,497,000
1953	6,690,000	4,900,000	2,600,000	7,500,000	408,000	436,000	844,000	8,344,000
1954	6,440,000	5,060,000	2,640,000	7,700,000	393,000	439,000	832,000	8,532,000
1955	6,320,000	5,450,000	2,740,000	8,190,000	386,000	450,000	836,000	9,026,000
1956	7,110,000	6,880,000	3,400,000	10,280,000	434,000	555,000	989,000	11,269,000
1957	6,690,000	5,530,000	2,840,000	8,370,000	408,000	470,000	878,000	9,248,000
1958	6,350,000	5,030,000	2,560,000	7,590,000	387,000	424,000	811,000	8,401,000
1959	6,060,000	5,460,000	2,690,000	8,150,000	370,000	440,000	810,000	8,960,000
1960	6,070,000	4,580,000	2,370,000	6,950,000	371,000	395,000	766,000	7,716,000
1961	6,840,000	6,420,000	3,130,000	9,550,000	418,000	511,000	929,000	10,479,000
1962	6,380,000	5,760,000	2,830,000	8,590,000	390,000	463,000	853,000	9,443,000
1963	5,990,000	5,150,000	2,570,000	7,720,000	365,000	422,000	787,000	8,507,000
1964	6,760,000	9,060,000	3,960,000	13,020,000	413,000	622,000	1,035,000	14,055,000
1965	6,780,000	6,050,000	2,990,000	9,040,000	414,000	490,000	904,000	9,944,000
1966	6,260,000	5,860,000	2,860,000	8,720,000	382,000	466,000	848,000	9,568,000
1967	8,050,000	13,600,000	5,520,000	19,120,000	491,000	848,000	1,339,000	20,459,000
1968	6,660,000	7,430,000	3,460,000	10,890,000	406,000	554,000	960,000	11,850,000
1969	4,420,000	2,600,000	1,410,000	4,010,000	270,000	240,000	510,000	4,520,000
1970	6,320,000	5,580,000	2,770,000	8,350,000	386,000	453,000	839,000	9,189,000
1971	6,090,000	6,500,000	3,010,000	9,510,000	371,000	483,000	854,000	10,364,000
1972	6,050,000	4,750,000	2,430,000	7,180,000	369,000	403,000	772,000	7,952,000
1973	5,490,000	3,760,000	1,990,000	5,750,000	335,000	333,000	668,000	6,418,000
1974	5,730,000	3,780,000	2,040,000	5,820,000	349,000	345,000	694,000	6,514,000
1975	6,490,000	5,490,000	2,780,000	8,270,000	396,000	458,000	854,000	9,124,000
1976	5,510,000	3,810,000	2,020,000	5,830,000	336,000	339,000	675,000	6,505,000
1977	6,330,000	5,440,000	2,740,000	8,180,000	386,000	450,000	836,000	9,016,000
1978	5,540,000	3,480,000	1,890,000	5,370,000	338,000	320,000	658,000	6,028,000
1979	6,470,000	5,410,000	2,740,000	8,150,000	395,000	453,000	848,000	8,998,000

Chulitna River near Talkeetna - 15292400								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1980	7,010,000	7,520,000	3,460,000	10,980,000	428,000	555,000	983,000	11,963,000
1981	7,540,000	9,560,000	4,210,000	13,770,000	460,000	665,000	1,125,000	14,895,000
1982	6,120,000	5,210,000	2,600,000	7,810,000	374,000	428,000	802,000	8,612,000
1983	5,950,000	4,480,000	2,300,000	6,780,000	363,000	382,000	745,000	7,525,000
1984	6,140,000	4,280,000	2,250,000	6,530,000	375,000	377,000	752,000	7,282,000
1985	6,120,000	5,020,000	2,530,000	7,550,000	374,000	417,000	791,000	8,341,000
1986	5,410,000	3,510,000	1,890,000	5,400,000	330,000	319,000	649,000	6,049,000
1987	7,140,000	6,140,000	3,030,000	9,170,000	436,000	498,000	934,000	10,104,000
1988	5,860,000	3,880,000	2,100,000	5,980,000	358,000	354,000	712,000	6,692,000
1989	6,480,000	5,280,000	2,710,000	7,990,000	396,000	448,000	844,000	8,834,000
1990	7,920,000	7,140,000	3,530,000	10,670,000	484,000	579,000	1,063,000	11,733,000
1991	5,750,000	4,270,000	2,220,000	6,490,000	351,000	369,000	720,000	7,210,000
1992	5,450,000	4,150,000	2,150,000	6,300,000	333,000	357,000	690,000	6,990,000
1993	7,250,000	6,660,000	3,320,000	9,980,000	442,000	543,000	985,000	10,965,000
1994	6,640,000	4,990,000	2,590,000	7,580,000	405,000	432,000	837,000	8,417,000
1995	6,290,000	4,600,000	2,430,000	7,030,000	384,000	407,000	791,000	7,821,000
1996	4,930,000	2,420,000	1,400,000	3,820,000	301,000	244,000	545,000	4,365,000
1997	5,550,000	3,930,000	2,070,000	6,000,000	339,000	347,000	686,000	6,686,000
1998	5,960,000	4,730,000	2,440,000	7,170,000	364,000	405,000	769,000	7,939,000
1999	5,850,000	4,330,000	2,240,000	6,570,000	357,000	373,000	730,000	7,300,000
2000	6,460,000	5,740,000	2,830,000	8,570,000	394,000	462,000	856,000	9,426,000
2001	5,680,000	3,920,000	2,070,000	5,990,000	347,000	347,000	694,000	6,684,000
2002	5,860,000	4,210,000	2,220,000	6,430,000	358,000	372,000	730,000	7,160,000
2003	6,580,000	4,620,000	2,450,000	7,070,000	401,000	411,000	812,000	7,882,000
2004	5,730,000	3,380,000	1,890,000	5,270,000	350,000	323,000	673,000	5,943,000
2005	8,470,000	9,020,000	4,340,000	13,360,000	517,000	701,000	1,218,000	14,578,000
2006	6,000,000	4,820,000	2,420,000	7,240,000	366,000	400,000	766,000	8,006,000
2007	5,670,000	3,200,000	1,810,000	5,010,000	346,000	311,000	657,000	5,667,000
2008	5,410,000	3,140,000	1,760,000	4,900,000	330,000	300,000	630,000	5,530,000
2009	5,600,000	3,160,000	1,790,000	4,950,000	342,000	306,000	648,000	5,598,000
2010	5,920,000	3,630,000	2,000,000	5,630,000	361,000	340,000	701,000	6,331,000

Table B.3. Annual Sediment Load for Pre-Project Conditions for Talkeetna River near Talkeetna

Talkeetna River near Talkeetna - 15292700								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1950	2,460,000	467,000	469,000	936,000	101,000	20,800	121,800	1,057,800
1951	2,800,000	641,000	622,000	1,263,000	117,000	28,900	145,900	1,408,900
1952	2,930,000	1,020,000	867,000	1,887,000	123,000	48,400	171,400	2,058,400
1953	3,080,000	732,000	699,000	1,431,000	129,000	33,200	162,200	1,593,200
1954	2,960,000	747,000	702,000	1,449,000	124,000	34,100	158,100	1,607,100
1955	3,130,000	1,150,000	956,000	2,106,000	132,000	55,200	187,200	2,293,200
1956	3,540,000	1,430,000	1,190,000	2,620,000	151,000	68,800	219,800	2,839,800
1957	3,160,000	920,000	829,000	1,749,000	133,000	42,800	175,800	1,924,800
1958	2,870,000	652,000	621,000	1,273,000	119,000	29,600	148,600	1,421,600
1959	2,950,000	838,000	761,000	1,599,000	124,000	38,800	162,800	1,761,800
1960	2,840,000	617,000	600,000	1,217,000	118,000	27,800	145,800	1,362,800
1961	3,150,000	801,000	749,000	1,550,000	132,000	36,700	168,700	1,718,700
1962	3,160,000	1,030,000	891,000	1,921,000	133,000	48,600	181,600	2,102,600
1963	3,000,000	879,000	791,000	1,670,000	126,000	40,900	166,900	1,836,900
1964	2,870,000	1,220,000	960,000	2,180,000	121,000	59,900	180,900	2,360,900
1965	3,440,000	1,320,000	1,090,000	2,410,000	146,000	63,300	209,300	2,619,300
1966	3,060,000	1,120,000	918,000	2,038,000	128,000	54,300	182,300	2,220,300
1967	3,240,000	1,650,000	1,210,000	2,860,000	137,000	82,500	219,500	3,079,500
1968	3,240,000	1,170,000	976,000	2,146,000	136,000	55,900	191,900	2,337,900
1969	1,630,000	164,000	189,000	353,000	63,500	6,870	70,370	423,370
1970	2,530,000	583,000	553,000	1,136,000	105,000	26,600	131,600	1,267,600
1971	3,840,000	4,070,000	2,400,000	6,470,000	165,000	215,000	380,000	6,850,000
1972	3,250,000	1,150,000	970,000	2,120,000	137,000	54,600	191,600	2,311,600
1973	2,790,000	851,000	716,000	1,567,000	115,000	40,700	155,700	1,722,700
1974	2,410,000	453,000	449,000	902,000	98,400	20,200	118,600	1,020,600
1975	3,140,000	1,040,000	908,000	1,948,000	132,000	49,100	181,100	2,129,100
1976	2,470,000	535,000	510,000	1,045,000	101,000	24,300	125,300	1,170,300
1977	3,150,000	1,430,000	1,100,000	2,530,000	133,000	70,400	203,400	2,733,400
1978	2,390,000	432,000	432,000	864,000	97,300	19,200	116,500	980,500
1979	3,220,000	1,380,000	1,090,000	2,470,000	136,000	67,300	203,300	2,673,300

Talkeetna River near Talkeetna - 15292700								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1980	3,150,000	1,030,000	870,000	1,900,000	132,000	49,300	181,300	2,081,300
1981	3,200,000	1,840,000	1,290,000	3,130,000	135,000	93,500	228,500	3,358,500
1982	3,040,000	1,140,000	930,000	2,070,000	128,000	54,900	182,900	2,252,900
1983	2,630,000	486,000	488,000	974,000	108,000	21,600	129,600	1,103,600
1984	2,640,000	619,000	570,000	1,189,000	109,000	28,600	137,600	1,326,600
1985	3,080,000	1,070,000	907,000	1,977,000	130,000	51,000	181,000	2,158,000
1986	2,430,000	433,000	440,000	873,000	99,400	19,200	118,600	991,600
1987	3,480,000	2,070,000	1,320,000	3,390,000	147,000	107,000	254,000	3,644,000
1988	2,710,000	555,000	548,000	1,103,000	112,000	24,900	136,900	1,239,900
1989	3,070,000	894,000	802,000	1,696,000	129,000	41,600	170,600	1,866,600
1990	3,900,000	1,580,000	1,270,000	2,850,000	166,000	77,000	243,000	3,093,000
1991	2,740,000	737,000	668,000	1,405,000	114,000	34,200	148,200	1,553,200
1992	2,560,000	662,000	611,000	1,273,000	106,000	30,500	136,500	1,409,500
1993	3,500,000	1,270,000	1,080,000	2,350,000	149,000	60,400	209,400	2,559,400
1994	3,140,000	880,000	784,000	1,664,000	131,000	41,100	172,100	1,836,100
1995	2,920,000	712,000	673,000	1,385,000	122,000	32,500	154,500	1,539,500
1996	2,260,000	324,000	349,000	673,000	91,600	13,900	105,500	778,500
1997	2,590,000	611,000	576,000	1,187,000	107,000	27,900	134,900	1,321,900
1998	2,790,000	787,000	711,000	1,498,000	117,000	36,500	153,500	1,651,500
1999	2,790,000	814,000	707,000	1,521,000	116,000	38,500	154,500	1,675,500
2000	3,230,000	1,280,000	1,040,000	2,320,000	136,000	61,700	197,700	2,517,700
2001	2,680,000	631,000	591,000	1,222,000	111,000	28,900	139,900	1,361,900
2002	2,750,000	710,000	652,000	1,362,000	115,000	32,800	147,800	1,509,800
2003	3,080,000	773,000	709,000	1,482,000	128,000	35,700	163,700	1,645,700
2004	2,620,000	446,000	465,000	911,000	107,000	19,500	126,500	1,037,500
2005	4,240,000	1,990,000	1,590,000	3,580,000	183,000	97,000	280,000	3,860,000
2006	2,910,000	1,300,000	941,000	2,241,000	121,000	65,000	186,000	2,427,000
2007	2,600,000	445,000	461,000	906,000	107,000	19,500	126,500	1,032,500
2008	2,490,000	441,000	451,000	892,000	102,000	19,400	121,400	1,013,400
2009	2,580,000	438,000	455,000	893,000	106,000	19,200	125,200	1,018,200
2010	2,730,000	506,000	512,000	1,018,000	112,000	22,400	134,400	1,152,400

Table B.4. Annual Sediment Load for Pre-Project Conditions for Susitna River at Sunshine

Susitna River at Sunshine - 15292780								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1950	14,200,000	5,860,000	3,770,000	9,630,000	263,000	184,000	447,000	10,077,000
1951	16,200,000	7,860,000	4,890,000	12,750,000	276,000	221,000	497,000	13,247,000
1952	16,700,000	10,600,000	5,990,000	16,590,000	279,000	234,000	513,000	17,103,000
1953	17,900,000	8,720,000	5,400,000	14,120,000	302,000	244,000	546,000	14,666,000
1954	17,200,000	8,880,000	5,400,000	14,280,000	290,000	237,000	527,000	14,807,000
1955	17,800,000	11,400,000	6,440,000	17,840,000	296,000	250,000	546,000	18,386,000
1956	20,000,000	14,500,000	8,070,000	22,570,000	303,000	297,000	600,000	23,170,000
1957	18,300,000	10,300,000	6,100,000	16,400,000	305,000	255,000	560,000	16,960,000
1958	16,600,000	8,230,000	4,960,000	13,190,000	298,000	221,000	519,000	13,709,000
1959	18,400,000	12,500,000	6,970,000	19,470,000	296,000	265,000	561,000	20,031,000
1960	17,100,000	8,330,000	5,100,000	13,430,000	299,000	230,000	529,000	13,959,000
1961	19,000,000	10,400,000	6,140,000	16,540,000	323,000	261,000	584,000	17,124,000
1962	19,900,000	15,600,000	8,230,000	23,830,000	314,000	290,000	604,000	24,434,000
1963	19,300,000	13,400,000	7,460,000	20,860,000	305,000	279,000	584,000	21,444,000
1964	16,400,000	13,800,000	7,040,000	20,840,000	266,000	237,000	503,000	21,343,000
1965	18,700,000	11,200,000	6,540,000	17,740,000	304,000	264,000	568,000	18,308,000
1966	17,100,000	9,660,000	5,610,000	15,270,000	295,000	234,000	529,000	15,799,000
1967	19,400,000	14,100,000	7,750,000	21,850,000	304,000	284,000	588,000	22,438,000
1968	17,800,000	10,700,000	6,120,000	16,820,000	305,000	246,000	551,000	17,371,000
1969	10,100,000	2,580,000	1,860,000	4,440,000	227,000	114,000	341,000	4,781,000
1970	14,300,000	6,260,000	3,970,000	10,230,000	260,000	188,000	448,000	10,678,000
1971	18,400,000	14,700,000	7,670,000	22,370,000	296,000	265,000	561,000	22,931,000
1972	19,200,000	11,800,000	6,710,000	18,510,000	319,000	268,000	587,000	19,097,000
1973	15,100,000	7,330,000	4,420,000	11,750,000	277,000	198,000	475,000	12,225,000
1974	14,100,000	5,760,000	3,720,000	9,480,000	264,000	183,000	447,000	9,927,000
1975	18,400,000	11,200,000	6,490,000	17,690,000	301,000	260,000	561,000	18,251,000
1976	14,900,000	6,380,000	4,040,000	10,420,000	274,000	194,000	468,000	10,888,000
1977	17,900,000	11,300,000	6,370,000	17,670,000	301,000	250,000	551,000	18,221,000
1978	14,800,000	5,160,000	3,450,000	8,610,000	288,000	183,000	471,000	9,081,000
1979	17,400,000	9,920,000	5,790,000	15,710,000	297,000	239,000	536,000	16,246,000

Susitna River at Sunshine - 15292780								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1980	18,900,000	11,100,000	6,410,000	17,510,000	318,000	262,000	580,000	18,090,000
1981	20,500,000	15,900,000	8,380,000	24,280,000	325,000	296,000	621,000	24,901,000
1982	17,400,000	8,910,000	5,380,000	14,290,000	301,000	236,000	537,000	14,827,000
1983	17,100,000	8,050,000	4,950,000	13,000,000	304,000	226,000	530,000	13,530,000
1984	17,100,000	8,180,000	4,980,000	13,160,000	307,000	225,000	532,000	13,692,000
1985	17,600,000	9,970,000	5,830,000	15,800,000	301,000	242,000	543,000	16,343,000
1986	14,900,000	5,610,000	3,710,000	9,320,000	282,000	190,000	472,000	9,792,000
1987	19,400,000	10,500,000	6,240,000	16,740,000	324,000	266,000	590,000	17,330,000
1988	18,000,000	9,610,000	5,770,000	15,380,000	306,000	248,000	554,000	15,934,000
1989	18,500,000	9,300,000	5,680,000	14,980,000	316,000	252,000	568,000	15,548,000
1990	23,000,000	15,500,000	8,740,000	24,240,000	353,000	334,000	687,000	24,927,000
1991	15,600,000	6,980,000	4,360,000	11,340,000	288,000	204,000	492,000	11,832,000
1992	15,700,000	7,620,000	4,650,000	12,270,000	285,000	208,000	493,000	12,763,000
1993	18,800,000	10,000,000	6,050,000	16,050,000	316,000	260,000	576,000	16,626,000
1994	18,200,000	8,990,000	5,440,000	14,430,000	317,000	243,000	560,000	14,990,000
1995	18,400,000	9,430,000	5,730,000	15,160,000	313,000	251,000	564,000	15,724,000
1996	12,800,000	3,760,000	2,650,000	6,410,000	263,000	153,000	416,000	6,826,000
1997	16,800,000	8,570,000	5,180,000	13,750,000	294,000	226,000	520,000	14,270,000
1998	17,800,000	10,100,000	5,980,000	16,080,000	298,000	248,000	546,000	16,626,000
1999	17,600,000	9,320,000	5,550,000	14,870,000	305,000	239,000	544,000	15,414,000
2000	19,300,000	11,900,000	6,790,000	18,690,000	320,000	270,000	590,000	19,280,000
2001	17,200,000	8,790,000	5,270,000	14,060,000	304,000	231,000	535,000	14,595,000
2002	15,700,000	7,020,000	4,410,000	11,430,000	284,000	207,000	491,000	11,921,000
2003	18,600,000	9,520,000	5,710,000	15,230,000	319,000	251,000	570,000	15,800,000
2004	16,900,000	7,890,000	4,920,000	12,810,000	299,000	226,000	525,000	13,335,000
2005	22,400,000	15,900,000	8,940,000	24,840,000	333,000	332,000	665,000	25,505,000
2006	18,100,000	10,900,000	6,270,000	17,170,000	301,000	252,000	553,000	17,723,000
2007	17,200,000	6,810,000	4,460,000	11,270,000	310,000	224,000	534,000	11,804,000
2008	16,000,000	6,620,000	4,240,000	10,860,000	294,000	207,000	501,000	11,361,000
2009	16,900,000	7,530,000	4,770,000	12,300,000	299,000	225,000	524,000	12,824,000
2010	18,000,000	8,540,000	5,310,000	13,850,000	310,000	243,000	553,000	14,403,000

Table B.5. Annual Sediment Load for Pre-Project Conditions for Yentna River near Susitna Station

Yentna River near Susitna Station - 15294345								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1950	11,800,000	4,700,000	4,140,000	8,840,000	2,020,000	184,000	2,204,000	11,044,000
1951	13,400,000	6,080,000	4,970,000	11,050,000	2,030,000	192,000	2,222,000	13,272,000
1952	13,300,000	6,920,000	5,060,000	11,980,000	2,060,000	180,000	2,240,000	14,220,000
1953	14,800,000	6,640,000	5,460,000	12,100,000	2,140,000	208,000	2,348,000	14,448,000
1954	14,200,000	6,680,000	5,290,000	11,970,000	2,100,000	195,000	2,295,000	14,265,000
1955	14,300,000	7,420,000	5,410,000	12,830,000	2,140,000	182,000	2,322,000	15,152,000
1956	15,800,000	9,240,000	6,350,000	15,590,000	2,090,000	193,000	2,283,000	17,873,000
1957	14,900,000	7,400,000	5,640,000	13,040,000	2,170,000	190,000	2,360,000	15,400,000
1958	13,700,000	6,000,000	4,890,000	10,890,000	2,180,000	188,000	2,368,000	13,258,000
1959	14,800,000	8,120,000	5,760,000	13,880,000	2,110,000	186,000	2,296,000	16,176,000
1960	13,000,000	5,400,000	4,580,000	9,980,000	2,150,000	188,000	2,338,000	12,318,000
1961	14,700,000	7,020,000	5,410,000	12,430,000	2,230,000	197,000	2,427,000	14,857,000
1962	11,600,000	3,960,000	3,820,000	7,780,000	2,130,000	181,000	2,311,000	10,091,000
1963	11,900,000	5,410,000	4,260,000	9,670,000	2,050,000	180,000	2,230,000	11,900,000
1964	12,700,000	7,440,000	4,900,000	12,340,000	2,040,000	171,000	2,211,000	14,551,000
1965	13,400,000	6,550,000	4,970,000	11,520,000	2,120,000	188,000	2,308,000	13,828,000
1966	13,000,000	6,490,000	4,760,000	11,250,000	2,150,000	184,000	2,334,000	13,584,000
1967	11,400,000	4,510,000	3,960,000	8,470,000	2,020,000	181,000	2,201,000	10,671,000
1968	13,100,000	6,400,000	4,810,000	11,210,000	2,140,000	174,000	2,314,000	13,524,000
1969	10,600,000	4,690,000	3,720,000	8,410,000	1,960,000	159,000	2,119,000	10,529,000
1970	14,700,000	8,250,000	5,720,000	13,970,000	2,100,000	191,000	2,291,000	16,261,000
1971	14,000,000	10,200,000	5,760,000	15,960,000	2,060,000	166,000	2,226,000	18,186,000
1972	12,200,000	5,180,000	4,310,000	9,490,000	2,090,000	184,000	2,274,000	11,764,000
1973	10,700,000	3,530,000	3,450,000	6,980,000	2,070,000	183,000	2,253,000	9,233,000
1974	10,500,000	2,940,000	3,270,000	6,210,000	2,100,000	184,000	2,284,000	8,494,000
1975	13,700,000	6,730,000	5,090,000	11,820,000	2,130,000	185,000	2,315,000	14,135,000
1976	12,500,000	4,690,000	4,280,000	8,970,000	2,140,000	194,000	2,334,000	11,304,000
1977	19,000,000	14,400,000	8,060,000	22,460,000	2,310,000	195,000	2,505,000	24,965,000
1978	12,900,000	4,950,000	4,430,000	9,380,000	2,170,000	198,000	2,368,000	11,748,000
1979	15,000,000	7,130,000	5,550,000	12,680,000	2,220,000	199,000	2,419,000	15,099,000

Yentna River near Susitna Station - 15294345								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1980	18,900,000	12,500,000	7,670,000	20,170,000	2,360,000	216,000	2,576,000	22,746,000
1981	18,000,000	11,400,000	7,270,000	18,670,000	2,300,000	208,000	2,508,000	21,178,000
1982	13,500,000	6,230,000	4,880,000	11,110,000	2,160,000	187,000	2,347,000	13,457,000
1983	13,300,000	5,980,000	4,720,000	10,700,000	2,190,000	187,000	2,377,000	13,077,000
1984	14,500,000	7,190,000	5,400,000	12,590,000	2,190,000	194,000	2,384,000	14,974,000
1985	14,200,000	7,190,000	5,370,000	12,560,000	2,140,000	190,000	2,330,000	14,890,000
1986	14,200,000	6,430,000	5,190,000	11,620,000	2,180,000	202,000	2,382,000	14,002,000
1987	17,100,000	10,400,000	6,780,000	17,180,000	2,260,000	208,000	2,468,000	19,648,000
1988	16,600,000	8,890,000	6,360,000	15,250,000	2,300,000	197,000	2,497,000	17,747,000
1989	17,700,000	11,000,000	7,170,000	18,170,000	2,230,000	205,000	2,435,000	20,605,000
1990	19,100,000	11,600,000	7,700,000	19,300,000	2,330,000	217,000	2,547,000	21,847,000
1991	14,900,000	7,840,000	5,680,000	13,520,000	2,180,000	191,000	2,371,000	15,891,000
1992	13,300,000	5,400,000	4,620,000	10,020,000	2,240,000	184,000	2,424,000	12,444,000
1993	14,800,000	6,700,000	5,410,000	12,110,000	2,220,000	194,000	2,414,000	14,524,000
1994	14,300,000	6,130,000	5,110,000	11,240,000	2,240,000	201,000	2,441,000	13,681,000
1995	14,900,000	6,870,000	5,490,000	12,360,000	2,220,000	195,000	2,415,000	14,775,000
1996	10,000,000	2,860,000	3,140,000	6,000,000	2,030,000	182,000	2,212,000	8,212,000
1997	13,400,000	6,010,000	4,850,000	10,860,000	2,140,000	184,000	2,324,000	13,184,000
1998	14,100,000	6,950,000	5,310,000	12,260,000	2,120,000	183,000	2,303,000	14,563,000
1999	14,100,000	6,460,000	5,150,000	11,610,000	2,180,000	196,000	2,376,000	13,986,000
2000	15,300,000	7,830,000	5,780,000	13,610,000	2,220,000	200,000	2,420,000	16,030,000
2001	13,900,000	6,310,000	5,030,000	11,340,000	2,190,000	191,000	2,381,000	13,721,000
2002	12,400,000	4,960,000	4,330,000	9,290,000	2,110,000	183,000	2,293,000	11,583,000
2003	14,700,000	6,660,000	5,340,000	12,000,000	2,230,000	200,000	2,430,000	14,430,000
2004	13,700,000	6,050,000	4,980,000	11,030,000	2,150,000	188,000	2,338,000	13,368,000
2005	17,100,000	10,100,000	6,920,000	17,020,000	2,160,000	197,000	2,357,000	19,377,000
2006	14,500,000	7,510,000	5,530,000	13,040,000	2,130,000	195,000	2,325,000	15,365,000
2007	14,300,000	5,630,000	5,030,000	10,660,000	2,240,000	207,000	2,447,000	13,107,000
2008	13,100,000	5,100,000	4,550,000	9,650,000	2,170,000	192,000	2,362,000	12,012,000
2009	13,900,000	5,950,000	5,020,000	10,970,000	2,140,000	203,000	2,343,000	13,313,000
2010	14,800,000	6,780,000	5,480,000	12,260,000	2,180,000	200,000	2,380,000	14,640,000

Table B.6. Annual Sediment Load for Pre-Project Conditions for Susitna River at Susitna Station

Susitna River at Susitna Station - 15294350								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1950	30,700,000	14,200,000	10,500,000	24,700,000	1,180,000	139,000	1,319,000	26,019,000
1951	34,300,000	18,200,000	12,500,000	30,700,000	1,290,000	165,000	1,455,000	32,155,000
1952	34,000,000	21,000,000	12,900,000	33,900,000	1,270,000	169,000	1,439,000	35,339,000
1953	37,800,000	20,000,000	13,800,000	33,800,000	1,420,000	182,000	1,602,000	35,402,000
1954	36,000,000	20,000,000	13,300,000	33,300,000	1,350,000	176,000	1,526,000	34,826,000
1955	36,400,000	22,600,000	13,800,000	36,400,000	1,360,000	181,000	1,541,000	37,941,000
1956	40,100,000	28,000,000	16,200,000	44,200,000	1,470,000	212,000	1,682,000	45,882,000
1957	37,800,000	22,200,000	14,200,000	36,400,000	1,420,000	187,000	1,607,000	38,007,000
1958	35,200,000	18,000,000	12,400,000	30,400,000	1,350,000	163,000	1,513,000	31,913,000
1959	37,400,000	24,500,000	14,600,000	39,100,000	1,390,000	192,000	1,582,000	40,682,000
1960	34,600,000	17,700,000	12,400,000	30,100,000	1,320,000	163,000	1,483,000	31,583,000
1961	37,800,000	20,900,000	13,900,000	34,800,000	1,430,000	183,000	1,613,000	36,413,000
1962	34,700,000	19,600,000	12,700,000	32,300,000	1,310,000	167,000	1,477,000	33,777,000
1963	34,100,000	19,700,000	12,700,000	32,400,000	1,280,000	166,000	1,446,000	33,846,000
1964	31,000,000	18,200,000	11,500,000	29,700,000	1,170,000	150,000	1,320,000	31,020,000
1965	35,700,000	20,500,000	13,200,000	33,700,000	1,340,000	174,000	1,514,000	35,214,000
1966	33,500,000	18,000,000	12,100,000	30,100,000	1,270,000	159,000	1,429,000	31,529,000
1967	32,700,000	17,700,000	11,900,000	29,600,000	1,240,000	156,000	1,396,000	30,996,000
1968	34,000,000	19,100,000	12,400,000	31,500,000	1,290,000	162,000	1,452,000	32,952,000
1969	24,200,000	9,620,000	7,670,000	17,290,000	955,000	101,000	1,056,000	18,346,000
1970	33,800,000	18,300,000	12,300,000	30,600,000	1,270,000	162,000	1,432,000	32,032,000
1971	34,600,000	22,800,000	13,300,000	36,100,000	1,290,000	175,000	1,465,000	37,565,000
1972	33,900,000	18,500,000	12,300,000	30,800,000	1,280,000	162,000	1,442,000	32,242,000
1973	29,900,000	13,100,000	9,920,000	23,020,000	1,170,000	131,000	1,301,000	24,321,000
1974	29,000,000	11,600,000	9,410,000	21,010,000	1,130,000	124,000	1,254,000	22,264,000
1975	33,400,000	18,700,000	12,200,000	30,900,000	1,260,000	161,000	1,421,000	32,321,000
1976	31,200,000	14,500,000	10,700,000	25,200,000	1,200,000	141,000	1,341,000	26,541,000
1977	40,500,000	28,400,000	16,100,000	44,500,000	1,490,000	211,000	1,701,000	46,201,000
1978	30,400,000	13,100,000	10,100,000	23,200,000	1,180,000	133,000	1,313,000	24,513,000
1979	38,900,000	23,500,000	14,700,000	38,200,000	1,450,000	194,000	1,644,000	39,844,000

Susitna River at Susitna Station - 15294350								
WY	Water Volume (acre-ft)	Suspended Load			Bed Load			Total Load
		Silt/Clay	Sand	Total	Sand	Gravel	Total	
1980	45,000,000	32,200,000	17,900,000	50,100,000	1,650,000	235,000	1,885,000	51,985,000
1981	40,300,000	28,900,000	16,000,000	44,900,000	1,490,000	210,000	1,700,000	46,600,000
1982	34,100,000	17,600,000	12,100,000	29,700,000	1,300,000	159,000	1,459,000	31,159,000
1983	31,700,000	14,200,000	10,600,000	24,800,000	1,230,000	140,000	1,370,000	26,170,000
1984	32,900,000	14,600,000	11,100,000	25,700,000	1,280,000	146,000	1,426,000	27,126,000
1985	34,200,000	19,200,000	12,600,000	31,800,000	1,290,000	165,000	1,455,000	33,255,000
1986	33,600,000	15,200,000	11,400,000	26,600,000	1,290,000	150,000	1,440,000	28,040,000
1987	39,700,000	25,500,000	15,200,000	40,700,000	1,480,000	200,000	1,680,000	42,380,000
1988	38,900,000	22,100,000	14,300,000	36,400,000	1,470,000	188,000	1,658,000	38,058,000
1989	40,900,000	27,100,000	16,100,000	43,200,000	1,510,000	211,000	1,721,000	44,921,000
1990	44,300,000	28,500,000	17,300,000	45,800,000	1,640,000	227,000	1,867,000	47,667,000
1991	34,900,000	19,600,000	12,800,000	32,400,000	1,320,000	168,000	1,488,000	33,888,000
1992	31,900,000	13,800,000	10,500,000	24,300,000	1,240,000	138,000	1,378,000	25,678,000
1993	38,500,000	22,200,000	14,400,000	36,600,000	1,440,000	190,000	1,630,000	38,230,000
1994	37,500,000	19,300,000	13,400,000	32,700,000	1,430,000	176,000	1,606,000	34,306,000
1995	37,200,000	20,000,000	13,600,000	33,600,000	1,400,000	179,000	1,579,000	35,179,000
1996	27,800,000	9,820,000	8,630,000	18,450,000	1,100,000	114,000	1,214,000	19,664,000
1997	32,300,000	16,600,000	11,400,000	28,000,000	1,230,000	150,000	1,380,000	29,380,000
1998	34,100,000	19,400,000	12,700,000	32,100,000	1,280,000	167,000	1,447,000	33,547,000
1999	33,700,000	17,500,000	12,000,000	29,500,000	1,290,000	158,000	1,448,000	30,948,000
2000	36,500,000	21,100,000	13,500,000	34,600,000	1,380,000	177,000	1,557,000	36,157,000
2001	34,000,000	17,600,000	12,000,000	29,600,000	1,300,000	158,000	1,458,000	31,058,000
2002	32,700,000	16,000,000	11,500,000	27,500,000	1,250,000	151,000	1,401,000	28,901,000
2003	38,000,000	19,700,000	13,600,000	33,300,000	1,440,000	179,000	1,619,000	34,919,000
2004	34,700,000	17,000,000	12,200,000	29,200,000	1,320,000	161,000	1,481,000	30,681,000
2005	44,400,000	31,000,000	18,000,000	49,000,000	1,620,000	237,000	1,857,000	50,857,000
2006	35,800,000	20,700,000	13,300,000	34,000,000	1,350,000	175,000	1,525,000	35,525,000
2007	35,100,000	15,500,000	12,000,000	27,500,000	1,350,000	158,000	1,508,000	29,008,000
2008	32,900,000	14,900,000	11,200,000	26,100,000	1,270,000	148,000	1,418,000	27,518,000
2009	34,500,000	16,300,000	12,000,000	28,300,000	1,320,000	159,000	1,479,000	29,779,000
2010	36,400,000	18,100,000	12,900,000	31,000,000	1,390,000	170,000	1,560,000	32,560,000

APPENDIX C. SEDIMENT TRANSPORT RATING CURVES DATA

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Geomorphology Study (Study 6.5)

2014 Update of Sediment-Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Tetra Tech, Inc.

September 2014

Table C.1. Sediment loads over a range of discharges for Pre-Project Conditions for Susitna River at Gold Creek.

Susitna River at Gold Creek - 15292000								
Q, (cfs)	Suspended Silt/Clay		Suspended Sand		Bedload Sand		Bedload Gravel	
	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)
5,000	163	201	42	49	13	16	0	0
10,000	1,040	1,320	409	485	46	62	1	2
15,000	3,070	3,950	1,550	1,850	97	134	3	11
20,000	6,620	8,550	3,990	4,780	165	230	12	41
25,000	12,000	15,500	8,320	9,960	249	348	31	109
30,000	19,600	25,200	15,100	18,100	349	486	69	238
40,000	42,200	54,200	39,000	46,500	594	818	241	793
50,000	76,600	97,900	81,200	96,400	896	1,220	634	1,960
60,000	125,000	158,000	148,000	175,000	1,260	1,680	1,400	4,050
70,000	188,000	238,000	245,000	289,000	1,670	2,200	2,740	7,370
80,000	269,000	337,000	381,000	446,000	2,140	2,770	4,890	12,300
90,000	369,000	460,000	561,000	653,000	2,660	3,390	8,150	19,100
100,000	489,000	605,000	793,000	920,000	3,230	4,060	12,900	28,100

Table C.2. Sediment loads over a range of discharges for Pre-Project Conditions for Chulitna River near Talkeetna.

Chulitna River near Talkeetna - 15292400								
Q, (cfs)	Suspended Silt/Clay		Suspended Sand		Bedload Sand		Bedload Gravel	
	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)
5,000	825	878	801	856	605	605	180	180
10,000	4,970	5,330	3,570	3,850	1,210	1,210	720	720
15,000	14,200	15,200	8,560	9,250	1,820	1,820	1,620	1,620
20,000	29,900	32,100	15,900	17,200	2,420	2,420	2,880	2,880
25,000	53,300	57,200	25,800	27,800	3,030	3,030	4,500	4,500
30,000	85,400	91,700	38,200	41,200	3,630	3,630	6,480	6,480
40,000	180,000	193,000	71,000	76,500	4,840	4,840	11,500	11,500
50,000	321,000	342,000	115,000	123,000	6,050	6,050	18,000	18,000
60,000	514,000	548,000	170,000	182,000	7,260	7,260	25,900	25,900
70,000	766,000	815,000	237,000	254,000	8,470	8,470	35,300	35,300
80,000	1,080,000	1,150,000	317,000	337,000	9,680	9,680	46,100	46,100
90,000	1,470,000	1,550,000	408,000	434,000	10,900	10,900	58,300	58,300
100,000	1,930,000	2,040,000	512,000	543,000	12,100	12,100	72,000	72,000

Table C.3. Sediment loads over a range of discharges for Pre-Project Conditions for Talkeetna River near Talkeetna.

Talkeetna River near Talkeetna - 15292700								
Q, (cfs)	Suspended Silt/Clay		Suspended Sand		Bedload Sand		Bedload Gravel	
	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)
2,000	46	63	116	130	103	143	1	2
5,000	595	835	973	1,100	279	406	23	32
10,000	4,130	5,830	4,870	5,530	589	866	183	264
15,000	12,800	18,000	12,500	14,200	914	1,330	615	880
20,000	28,600	40,000	24,400	27,600	1,250	1,790	1,450	2,040
25,000	53,400	74,200	41,000	46,200	1,590	2,260	2,840	3,890
30,000	88,900	123,000	62,600	70,500	1,930	2,710	4,900	6,560
40,000	199,000	271,000	122,000	137,000	2,640	3,620	11,600	14,900
50,000	370,000	500,000	205,000	229,000	3,360	4,510	22,600	27,800
60,000	616,000	823,000	313,000	349,000	4,090	5,380	39,000	46,200
70,000	948,000	1,250,000	448,000	497,000	4,830	6,250	61,900	70,700
80,000	1,380,000	1,810,000	611,000	676,000	5,590	7,100	92,300	102,000

Table C.4. Sediment loads over a range of discharges for Pre-Project Conditions for Susitna River at Sunshine.

Susitna River at Sunshine - 15292780								
Q, (cfs)	Suspended Silt/Clay		Suspended Sand		Bedload Sand		Bedload Gravel	
	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)
5,000	119	129	220	231	389	421	38	49
10,000	691	771	946	1,010	542	620	95	144
15,000	1,930	2,190	2,220	2,390	657	771	163	265
20,000	4,010	4,570	4,070	4,410	754	896	238	403
25,000	7,060	8,080	6,510	7,070	839	1,000	319	554
30,000	11,200	12,900	9,550	10,400	915	1,100	406	715
40,000	23,200	26,800	17,500	19,100	1,050	1,270	593	1,060
50,000	40,900	47,200	28,000	30,500	1,170	1,420	796	1,430
60,000	65,000	74,900	41,100	44,800	1,270	1,540	1,010	1,820
70,000	96,100	111,000	56,900	62,000	1,370	1,660	1,240	2,220
80,000	135,000	155,000	75,300	82,000	1,460	1,770	1,480	2,630
90,000	182,000	209,000	96,500	105,000	1,550	1,860	1,730	3,060
100,000	237,000	272,000	120,000	131,000	1,630	1,960	1,980	3,490
110,000	302,000	346,000	147,000	160,000	1,700	2,040	2,250	3,920
120,000	377,000	431,000	177,000	192,000	1,780	2,120	2,520	4,360
130,000	462,000	527,000	209,000	227,000	1,840	2,200	2,800	4,810
140,000	557,000	636,000	245,000	265,000	1,910	2,270	3,090	5,260
150,000	664,000	756,000	283,000	306,000	1,980	2,340	3,390	5,710
160,000	782,000	889,000	324,000	350,000	2,040	2,410	3,690	6,170
170,000	912,000	1,030,000	368,000	398,000	2,100	2,470	3,990	6,630
180,000	1,050,000	1,190,000	415,000	448,000	2,150	2,540	4,310	7,090

Table C.5. Sediment loads over a range of discharges for Pre-Project Conditions for Susitna River at Yentna River near Susitna Station

Yentna River near Susitna Station - 15294345								
Q, (cfs)	Suspended Silt/Clay		Suspended Sand		Bedload Sand		Bedload Gravel	
	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)
5,000	253	263	1,490	1,530	5,360	5,060	100	100
10,000	1,270	1,350	4,020	4,150	5,960	5,980	200	200
15,000	3,270	3,510	7,170	7,430	6,330	6,520	513	513
20,000	6,400	6,900	10,800	11,200	6,620	6,890	1,000	1,000
25,000	10,800	11,600	14,900	15,500	6,850	7,180	1,000	1,000
30,000	16,500	17,800	19,300	20,100	7,040	7,400	1,000	1,000
40,000	32,200	34,800	29,000	30,300	7,350	7,750	1,000	1,000
50,000	54,100	58,500	39,900	41,600	7,610	8,010	1,000	1,000
60,000	82,700	89,400	51,800	53,900	7,820	8,210	1,000	1,000
70,000	118,000	128,000	64,500	67,100	8,000	8,380	1,000	1,000
80,000	162,000	174,000	78,100	81,100	8,170	8,510	1,000	1,000
90,000	213,000	229,000	92,300	95,900	8,320	8,630	1,000	1,000
100,000	272,000	292,000	107,000	111,000	8,450	8,730	1,000	1,000
110,000	340,000	364,000	123,000	127,000	8,570	8,810	1,000	1,000
120,000	416,000	445,000	139,000	144,000	8,690	8,890	1,000	1,000
130,000	501,000	535,000	156,000	161,000	8,790	8,960	1,000	1,000
140,000	595,000	635,000	173,000	179,000	8,890	9,020	1,000	1,000
150,000	699,000	744,000	191,000	198,000	8,990	9,070	1,000	1,000
160,000	813,000	863,000	210,000	216,000	9,080	9,120	1,000	1,000
170,000	936,000	993,000	229,000	236,000	9,160	9,170	1,000	1,000
180,000	1,070,000	1,130,000	248,000	256,000	9,240	9,210	1,000	1,000

Table C.6. Sediment loads over a range of discharges for Pre-Project Conditions for Susitna River at Susitna Station

Susitna River at Susitna Station - 15294350								
Q, (cfs)	Suspended Silt/Clay		Suspended Sand		Bedload Sand		Bedload Gravel	
	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)	Q_s, (tons/day)	Unbiased Q_s, (tons/day)
5,000	66	67	731	742	557	488	10	7
10,000	354	374	2,090	2,190	994	949	29	25
15,000	947	1,020	3,880	4,120	1,390	1,380	54	50
20,000	1,900	2,060	6,000	6,440	1,770	1,800	83	80
25,000	3,270	3,560	8,420	9,080	2,130	2,200	115	115
30,000	5,080	5,560	11,100	12,000	2,480	2,590	152	155
40,000	10,200	11,200	17,200	18,700	3,160	3,340	233	245
50,000	17,500	19,400	24,100	26,400	3,800	4,060	326	348
60,000	27,300	30,200	31,800	34,800	4,420	4,750	428	463
70,000	39,600	43,900	40,200	44,100	5,030	5,420	539	587
80,000	54,800	60,800	49,200	54,000	5,620	6,070	659	719
90,000	72,900	80,900	58,900	64,600	6,200	6,700	786	860
100,000	94,100	104,000	69,100	75,800	6,770	7,320	920	1,010
110,000	119,000	132,000	79,900	87,700	7,330	7,920	1,060	1,160
120,000	146,000	162,000	91,100	100,000	7,890	8,510	1,210	1,320
130,000	178,000	197,000	103,000	113,000	8,430	9,090	1,360	1,490
140,000	213,000	236,000	115,000	126,000	8,970	9,660	1,520	1,660
150,000	251,000	279,000	128,000	140,000	9,500	10,200	1,690	1,840
160,000	294,000	326,000	141,000	155,000	10,000	10,800	1,860	2,020
170,000	340,000	377,000	155,000	169,000	10,500	11,300	2,040	2,210
180,000	391,000	433,000	169,000	185,000	11,100	11,800	2,220	2,400
190,000	446,000	493,000	183,000	200,000	11,600	12,400	2,410	2,590
200,000	505,000	558,000	198,000	216,000	12,100	12,900	2,600	2,790
210,000	568,000	628,000	213,000	233,000	12,600	13,400	2,800	2,990
220,000	636,000	702,000	229,000	250,000	13,100	13,900	3,000	3,200
230,000	708,000	782,000	245,000	267,000	13,600	14,400	3,210	3,410
240,000	785,000	866,000	261,000	285,000	14,100	14,900	3,420	3,620
250,000	867,000	955,000	278,000	303,000	14,500	15,400	3,630	3,840
260,000	954,000	1,050,000	295,000	321,000	15,000	15,900	3,850	4,060
270,000	1,040,000	1,150,000	312,000	340,000	15,500	16,400	4,080	4,280
280,000	1,140,000	1,250,000	330,000	359,000	16,000	16,800	4,300	4,510
290,000	1,240,000	1,370,000	348,000	378,000	16,500	17,300	4,540	4,730
300,000	1,350,000	1,480,000	366,000	398,000	16,900	17,800	4,770	4,960