2017 TRINITY RIVER SEDIMENT TRANSPORT MONITORING REPORT

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Prepared for:

The Trinity River Restoration Program (TRRP)
1313 South Main Street
Weaverville, CA 96093
(530) 623-1800

Prepared by:

Smokey Pittman
GMA Hydrology, Inc. (GMA)
1973 Smith Flat Rd.
Placerville, CA 95667
(530) 623-0402

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Hydrology – Geomorphology – Stream Restoration
Land and Hydrographic Surveys

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GMA Hydrology, Incorporated

Graham Matthews – Principal Investigator
Smokey Pittman – Senior Geomorphologist, Author
Cort Pryor – Trinity River Geophysical Project Manager, Survey Manager
Brooke Pittman – Sediment Lab Manager, Senior Hydrologist, Streamflow and Sediment Discharge Computations
Geoff Hales – Professional Geologist, Oversight, Report Review

GMA Field Crews, Lab Analysts, Hydrographers, and Surveyors:

Brooke Pittman	Dennis Eagan
Sami Hawkins	Dan Sheldon
Smokey Pittman	Graham Matthews
Cort Pryor	Jason Bates
Darcy Gaechter	Kary Danielson
Tom Grey	Don Beveridge

US Bureau of Reclamation: Trinity River Restoration Program

Dave Gaeuman, Geomorphologist

TRINITY RIVER RESTORATION PROGRAM
WY 2017 SEDIMENT TRANSPORT MONITORING
FINAL REPORT

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EXECUTIVE SUMMARY

This report presents the results of Water Year (WY) 2017 sediment transport monitoring efforts on the Trinity River near Weaverville, California. As part of an ongoing study for the Trinity River Restoration Program (TRRP), GMA Hydrology (GMA, formerly Graham Matthews and Associates) conducted bedload and suspended sediment sampling at four monitoring locations. Secondary hydrologic and geomorphic data such as water surface slope, streamflow measurements, cross section surveys, pebble counts and turbidity were collected as part of the study. New for 2017 was: (1) bulk sampling, pebble counts, bed elevation and scour monitors at bars upstream of sampling sites, (2) reduced effort at the Lewiston site, (3) suspended sediment sampling effort was reduced, and (4) partitioned bedload data were provided for the Lewiston and Douglas City sites to support hydroacoustic computations. WY2017 marks the 13th year (2004-2013, 2015-2017) of Trinity River sediment transport monitoring by GMA Hydrology for TRRP.

Historic impacts to the Trinity River and their effects on anadromous fish habitat are described in the Introduction (Section 1.0) of this report and are documented extensively elsewhere (McBain and Trush, 1997). In short, physical changes in the channel resulting from mining, increased sediment loads related to logging and flow reduction due to impoundment resulted in a severely degraded channel in the mainstem while the Trinity and Lewiston dams cut off anadromous salmonids from the upper 700 square miles of the watershed.

TRRP’s restoration strategy involves a combination of Spring Flow Releases, fine and coarse sediment management, and mechanical channel rehabilitation. This 2017 study is conducted as part a sediment budget approach to understanding sediment-related habitat issues. We provide sediment load estimates at four locations along the river: at Lewiston (TRAL), near Grass Valley Creek (TRGV), at Limekiln Gulch (TRLG), and near Douglas City (TRDC). The sediment load estimates inform gravel injection strategies (locations and volumes) and hydrograph development for Spring Flow Releases.

Suspended sediment and bedload sampling were conducted from cataraft platforms attached to temporary cableways. Samplers (US D-74 for suspended sediment and TR-2 with 0.5mm mesh for bedload) are lowered and raised using cranes equipped with winches. Each station is located near a stream gage operated by either US Geological Survey (USGS) or GMA. Continuous turbidity was collected for use as a surrogate for suspended sediment concentration (SSC) at three sites. Cross section surveys and pebble counts were conducted before and after the 2017 Spring Flow Release. Surface texture, scour and bed elevation monitoring was conducted at and upstream of two stations: TRLG and TRAL.

WY2017 was determined to be an “Extremely Wet” water year (TRRP 2017). A two-week long 1,530 cfs flow bench (April 5 to April 19) preceded the planned Spring Flow Release. The approved release hydrograph (mean daily flows) included a 5 day rise from base flow to 11,000 cfs. The planned peak included two days of 11,000 cfs and one day of 10,000 cfs. A sharp decline over 5 days to approximately 2,500 cfs was to be followed by 5 days of approximately 2,500 cfs. A second bench of 4,800 to 5,400 cfs was to begin May 10 and last for 9 days. A gradual tailout spanned most of the summer with the hydrograph dropping back to summer base (450 cfs) in mid August.
This “double peaked” hydrograph was the second of this type to be implemented for a Trinity River Spring Flow Release.

GMA sampling crews collected suspended sediment and bedload measurements for 14 days over both flow benches between April 25 and May 15, 2017. Crews collected two to eight one-pass bedload samples and up to one suspended sediment sample each day. Bedload variability testing was performed once at each site by sampling repeatedly at one location along the cross section for at least 30 minutes. Water surface slope was measured each day. SSC samples were processed for three particle-size ranges (<0.063mm, 0.063 - <0.5mm and >0.5mm) and bedload samples were processed for total mass and grain size analysis. Sediment loads were computed using a variety of standard and modified methods (Sections 2.3.3, 2.3.4 and Appendix [Station Analyses]). Suspended sediment loads were computed for the three size classes mentioned and bedload was computed for 0.5 - <8mm (fine) and ≥8mm (coarse) loads. The computational period for sediment load estimates is April 1, 2017 to July 31, 2017.

Suspended sediment loads for all size classes increased in the downstream direction, with one exception (≥0.5mm at TRLG). Loads for all size classes are provided in Table 16 of the report. Total suspended load (the sum of <0.063, 0.063-0.5mm and ≥0.5mm) is provided here:

- TRAL: NA
- TRGV: 9,450 tons
- TRLG: 12,310 tons
- TRDC: 23,000 tons

TRDC is at the downstream boundary and represents the combined contribution of all tributaries in the study reach.

Crews collected between 21 and 68 single-pass bedload samples during the 2017 Spring Flow Release. The fine (0.5 - <8mm) bedload for each station was:

- TRAL: 412 tons
- TRGV: 1,110 tons
- TRLG: 1,740 tons
- TRDC: 5,510 tons

The progressive downstream increase in fine bedload is presumably due to the contribution of more tributaries and more channel bank length in the downstream direction. Changes in transport capacity between sites (not evaluated here) can also influence differences in sediment load magnitude.

Coarse bedload (≥8mm) is of particular interest as it is a critical geomorphic habitat component (e.g. spawning gravel, bar/riffle composition) and it represents the supply introduced by gravel injection. 2017 coarse bedload for each station was:

- TRAL: 4,330 tons
- TRGV: 8,390 tons
- TRLG: 3,110 tons
- TRDC: 18,200 tons

TRAL is located in a reach strongly influenced by gravel injection. At TRGV, gravel was injected prior to the flow release. TRLG and TRDC are less influenced by gravel injection.

Of particular interest in 2017, considering the double-peak hydrograph, is the question of how the loads compare for each peak flow bench. We examined each site relative to its own hydrograph and summed the ≥8mm loads for each peak flow bench. Computational periods were defined as the time the hydrograph exceeded the low flow point between the two flow peaks (noted as "Q start" in Table 17). By this definition, the second peak is up to four times longer than the first, though approximately half the (peak flow) magnitude. For TRAL, the first peak transported 3,570 tons (82 percent) and the second transported 769 tons. At TRGV, the first peak transported 8,270 tons (99 percent) and the second transported 126 tons. TRLG transported 2,790 (90 percent) and 324 tons. TRDC transported 16,700 (92 percent) tons and 1,490 tons.

(*Excerpted*) **Table 17. >8mm bedload totals for each peak flow bench, WY2017.**

		Peak #1			Peak #2		
SEDIMENT MONITORING STATION	Q Start (cfs)	Bedload >8mm (Tons)	# Hrs	Q Peak (cfs)	Bedload >8mm (Tons)	# Hrs	Q Peak (cfs)
Trinity River at Lewiston (TRAL)	1,910	3,570	322	12,000	769	1,412	5,480
Trinity River above Grass Valley Creek (TRGV)	1,780	8,270	321	12,200	126	1,214	5,450
Trinity River below Limekiln Gulch (TRLG)	2,190	2,790	320	12,800	324	1,114	5,740
Trinity River near Douglas City (TRDC)	2,370	16,700	358	13,400	1,490	1,042	6,230

All values rounded using methods by Porterfield (1972)

The magnitude of Spring Flow Release sediment loads is dependent upon numerous factors, including: peak flow magnitude, hydrograph shape, sediment augmentation efforts, changes in transport capacity (e.g. from channel and floodplain restoration) and tributary sediment contributions. We examined potential trends in the coarse bedload (≥8mm) Spring Flow Release load totals from 2004 to 2017. In the previous 12 years of sediment sampling, there have been four “Dry” type releases (2007, 2009, 2013, 2015), five “Normal” releases (2004, 2005, 2008, 2010, and 2012), and three “Extremely Wet” releases (2006, 2011 and 2016). The distinction between water year type and Spring Flow release type is important because there were some variations (e.g. 2011 was a Wet water year type, but had an Extremely Wet release, 2004 was a wet year, but had a Normal Year release type). WY2017 was classified an Extremely Wet water year and had a modified Extremely Wet flow release type and a double peak.

We examined coarse bedload transport at all stations over the 13 monitored flow releases dating back to 2004 (11 years at TRGV). 2006, 2011 and 2017 clearly dominated the coarse bedload transport at all stations although at TRGV, 2016 produced the third highest computed load. All stations exhibited an apparent downward trend in ≥8mm transport during Normal Release types. The trend among Dry Flow Release types is less clear (2007, 2009, 2013 and 2015), though 2015 clearly transported larger loads than the other three years. 2015 with its “Dry (modified)” release type (that is a dry year restoration total release [453,000 af] with an 8,500 cfs flow bench) showed an evident increase over preceding “Dry-type” flow releases at all stations. At TRGV, WY2015 exceeds some wet years and at TRAL and TRDC, WY2015 approximates the magnitude of “Normal” flow release types (Section 2.5.4).

WY 2017 bedload sample particle-size distributions were compared to examine general variations in grain size, both between stations and between peak flow benches. TRAL was only sampled for the first peak flow bench. TRGV and TRLG show the first bench transported much coarser material than the second. TRDC shows the same relation, though much less pronounced. Higher flows transport coarser material at all sites. Interestingly, the D50 for the first flow bench is almost identical at TRGV, TRLG and TRDC (32-38mm); TRAL, with its dearth of finer material, is much coarser at 63mm.

The D50 for each bedload sample collected in 2017 was plotted with individual site-hydrographs. At TRAL, the mean (cumulative) D50 appears to decrease over the initial rise to the first peak flow bench around 7,000 cfs, but no samples were collected on the second day of the release and the moving average simply bridges this period. Beginning on the third day of the release, the D50 begins a gradual increase from about 52mm to about 65mm. No data were collected for the second peak flow bench at TRAL.

At TRGV the D50 increases with increasing discharge to around the 44-49mm range and essentially remains constant through the first peak flow bench. For the second flow bench, the mean D50 barely rises above 1mm. At TRLG the mean D50 constantly increases across the first flow bench to about 45mm. For the second flow bench, the D50 drops from 39mm to hover in the low-20mm range. At TRDC, the D50 increases from 39 to 52mm early in the first peak, then gradually decreases back to 39mm. The D50 for the second bench is much smaller but shows a progressive increase from 12 to 28mm. For TRGV, TRLG and TRDC, the sampling effort on the second flow bench was more dispersed (three days apart) and the moving average trace bridges these un-sampled periods.

Bedload discharge is highly variable across a sampling section. Sample data reveal that two to three stations (locations) can transport most of the bedload along a sampling section (which generally contain 11-14 stations). Bedload discharge is also temporally variable. In 2017, we sampled the highest-transport location along the sampling section (at each site) repeatedly for at least 30 minutes yielding 6 to 10 samples. We examined variability in fine, coarse and total bedload discharge (total is the sum of fine and coarse) over the 30 minute period (though the units are transformed into tons per day).

At TRAL, the fine bedload varied over a range of 111 tons per day while the coarse load varied over a range of 383 tons per day. The relative contribution of the fine bedload ranges from 8 to 34 percent. TRAL shows the highest (average) coarse percentage (77 percent is the average of the six samples), which is likely due to the fact that only one small tributary enters between TRAL and the dam (Deadwood Creek), thus limiting the potential for fine bedload recruitment.

The effect of gravel injection on supply (and flow decrease) appears in the TRGV data. At the time the bedload variability samples were collected on May 1, coarse bedload transport had begun to plummet. Four zeroes appear in the coarse bedload data while the fine bedload transport remains fairly constant. The coarse bedload appears to move in bursts, while the fine fraction transport is less variable. Coarse bedload (during this time period) composed 35 percent of the total bedload transport.

Unlike TRAL, TRLG reveals heterogeneity in the relative contribution of fine and coarse bedload. Six samples are >50 percent coarse bedload while the remaining four are comprised primarily of fine bedload. TRLG also illustrates a progressive decline in overall bedload transport over the 40 minute sampling period. At TRDC, the samples in the 2017 variability test are composed primarily of fine bedload (78 percent on average).

Since TRAL is starved of fines (located so close to the dam) and since both TRAL and TRGV are so strongly influenced by coarse-gravel injection, TRLG and TRDC results are likely more representative of temporal variability in magnitude and composition of bedload transport in the Trinity River.

WY2017 crews reported most of the sediment load is typically generated at one to three stations. If we apply the spatial inference mentioned previously (most of the load is transported at 3 to 4 stations) to the bedload variability study, then we can assume that at TRDC foe example, that loads computed from samples collected at slightly different times could vary widely. TRGV, with its zero transport values is even more compelling, both in suggesting the question of how to handle zeroes in computing a mean (we included them) and in the implication of sampling a zero transport period which occurs a few minutes after a 50 tons/day period.

While the variability study data are far from conclusive, they do suggest a need for more sampling at fewer stations (i.e., over a narrower width of the cross section where the most sediment load is being transported) in order to derive a more accurate estimate of average bedload discharge. These data also support the need for a better surrogate than discharge such as passive hydroacoustics. The 2017 findings from the USGS (and other researchers who deployed hydrophones during the Spring Flow Release) will be highly relevant for improving future monitoring efforts.

In an effort to improve future sediment transport monitoring efforts, we offer the following recommendations:

- The potential trend of reduced bedload transport in Normal and Dry Year type Spring Flow Releases, as discussed in Section 2.5.4, may warrant further investigation. Clearly, the modified Dry release hydrograph applied in WY2015 was successful in moving more sediment than was observed in other Dry water years.
- Consider altering the bedload sampling protocols to use multiple occupations of single verticals along the same cross section, with the number of replicates based on the variability and magnitude of transport rates. At low transport rate verticals, a single long duration sample will provide a reasonable estimate of mean transport, while in high rate verticals, multiple samples would provide a more robust estimate of the mean. Such an approach will increase the accuracy of estimating a mean daily value to guide sedigraph development.
- Water surface slope measurement at some stations (e.g. TRGV, TRLG) is strongly influenced by overbank flow slope reduction. The reported highest-flow slopes are really floodplain water surface slope. Presumably, analysts are more interested in the slope responsible for grain mobilization which is typically steeper than that measured on the floodplain. We suggest installing taller stage references at selected locations to improve the accuracy of water surface slope measures, or install simple pressure transducers (e.g. Onset hobo) above and below the sampling section.
- Cableway anchors (trees) at TRDC are failing. For future monitoring efforts, new anchors must be constructed.
- Suspended sediment data collection efforts were greatly reduced in 2017. Total number of samples per site was reduced to four one-pass samples. With one pass samples, it is impossible to critique outliers. For example, at TRGV where Sample #4 was censored as an outlier, the computed suspended load dropped by 12 percent. A second pass could have verified censoring or inclusion of this sample. The cost of collecting a second SSC pass is quite small compared to the cost of collecting the initial pass and provides a much more robust dataset. We recommend collecting two-pass samples in the future.
- Passive hydro acoustics appear more promising than ever for estimating bedload discharge. USGS has published bedload discharge data for TRAL WY2015-2016

(https://nwis.waterdata.usgs.gov/nwis/uv?cb_72298=on&cb_72302=on&format=gif_default&site_no=11525525&period=&begin_date=2016-04-28&end_date=2016-05-30). We highly recommend supplementing the existing data collection protocols with hydrophone data collection during future Spring Flow Releases.

1.0 INTRODUCTION

The mainstem Trinity River drains a 2,036 square mile (mi^2) watershed (excluding the South Fork Trinity) joining the Klamath River at Weitchpec, some 43 miles above the Klamath's entry into the Pacific Ocean. The Trinity River is the largest tributary to the Klamath River and historically produced large runs of Chinook salmon (*Oncorhynchus tshawytscha)*, Coho salmon (*Oncorhynchus kisutch*), and steelhead trout (*Oncorhynchus mykiss*). Impacts from industrial gold mining and logging in the early to mid-1900s substantially changed the mainstem and tributary channels. Placer mining overturned the streambeds and washed hillslopes into stream channels; while logging of highly erosive watersheds, such as Grass Valley Creek, introduced considerable quantities of sand into the mainstem. Following the start of construction and resulting flow regulation in November 1960, the Trinity River Diversion Project (TRD) was fully completed in 1964 to increase water supplies to the Central Valley Irrigation Project. The TRD, which included both Trinity and Lewiston dams, blocked the upper 700 square miles of the watershed to fish passage, eliminated upstream large wood and sediment contributions, and severely reduced streamflow; in all, TRD diverted nearly 90 percent of the streamflow; however, downstream of the TRD, tributaries continued to remain largely unregulated, contributing streamflow, sediment, and wood at their natural (pre-TRD) rates Constant low flow releases below Lewiston Dam failed to transport the tributary sediment contributions, and formed large deltas, commonly containing significant quantities of granitic sand . The low flows and large quantities of fine sediment provided the optimum conditions for riparian encroachment and berm development along the low-flow channel margin. Combined, these essentially eliminated channel migration, rendered the larger pre-dam alluvial features immobile, and greatly simplified stream channel geometry (e.g., continuous rectangular channel). The subsequent habitat loss and aquatic species decline were documented in numerous studies by the U.S. Fish and Wildlife Service, the Hoopa Valley Tribe, and other agencies e.g., Trinity River Maintenance Flow Study (McBain and Trush, 1997).

In an effort to restore the Trinity River fish and wildlife, the U.S. Secretary of the Interior directed the U.S. Fish and Wildlife Service to prepare the Trinity River Flow Evaluation Study in 1981 (TRFE, U.S. Fish and Wildlife Service and Hoopa Valley Tribe, 1999). The TRFE produced recommendations "to fulfill fish and wildlife mandates" of the Congressional Act authorizing the Trinity River Diversion. The study also provided the basis for the Trinity River Mainstem Fishery Restoration Environmental Impact Statement/Environmental Impact Report (U.S. Fish and Wildlife Service [USFWS], 2000) and the Record of Decision signed in 2000 (ROD, U.S. Dept. of Interior, 2000). The ROD established the Trinity River Restoration Program (TRRP), which included minimum water volume allocations based annually on water year type. The TRRP's purpose is to restore and maintain the natural production of fish and wildlife populations in the Trinity River, downstream of Lewiston Dam. To achieve this goal, the TRFE and ROD provide the scientific framework and management strategy to reestablish natural physical processes that promote a dynamic alluvial system which, in turn, are intended to enhance aquatic habitat conditions capable of restoring salmonid populations. Restoration efforts focus on the Trinity River mainstem from Lewiston Dam downstream to the confluence with the North Fork Trinity River (Figure 1). The restoration strategy requires a combination of Spring Flow Releases, fine and coarse sediment management, and mechanical channel rehabilitation. This monitoring report focuses on the sediment management component.

Managing dam releases to route fine and coarse sediment through a river system requires an accounting of the sediment inputs, outputs, and a change in stream channel storage (i.e., a sediment budget). The simplest form of a sediment budget is expressed by the mass balance relation:

Input – Output = Change in Storage

On the Trinity River, sediment inputs downstream from Trinity and Lewiston dams are delivered naturally into each cell (Figure 2) by tributaries, and by managed coarse sediment injections, which are necessary to supplement lost upstream supplies or disconnected tributary supplies (i.e. Grass Valley Creek). Sediment outputs are simply the sediment transported by the mainstem at the downstream end of each sediment budget cell in Figure 2. The study reach and sub-reaches (cells, bounded by sampling stations) are further described in Section 2.1.

Several sediment budgets have been computed for the Trinity River between Lewiston Dam and Douglas City, including: the Trinity River Maintenance Flow Study (TRMFS, McBain & Trush, 1997); the Sediment Source Analysis for the Mainstem Trinity River (GMA, 2001); the Draft Sediment Budget and Monitoring Plan (SBMP, Wilcock, 2004); and the 2010 Bed-Material Sediment Budget Update (Gaeuman and Krause, 2011). Each sediment budget used the most current streamflow data, sediment transport measurements, tributary delta volumetric estimates, particle-size distribution measurements, and streamflow and sediment transport models to estimate the inputs and outputs.

The TRFE, ROD, and subsequent scientific contributions (Wilcock, 2004; Gaeuman and Krause, 2011), specify monitoring actions to address sediment budgeting related hypotheses and questions, and evaluate specific sediment management objectives. "A sediment budget provides a consistent and comprehensive framework within which the sediment objectives of the TRRP may be evaluated" (Wilcock, 2004). The central TRRP *sediment budgeting* objectives outlined in the TRFE are to:

- Reduce fine sediment storage in the mainstem;
- Increase and maintain coarse sediment storage in the mainstem Trinity River;
- Route coarse sediment supply through all reaches of the mainstem; and
- Reduce fine sediment inputs to the Trinity River.

Sediment transport monitoring is intended to estimate the inputs and outputs to mainstem sediment budget cells, which support flow scheduling (e.g., determining flow magnitude and duration) and other related sediment management efforts.

1.1 Sediment Management Objectives

The following section focuses on the flow-induced geomorphic processes and partially explains the flow evaluation process described in the TRMFS and TRFE. The magnitude, duration, frequency, timing, and rate of change of the ROD hydrographs were developed based on:

- thresholds required to initiate specific geomorphic processes (e.g., the flow magnitude necessary to scour a certain depth),

- the flow required to maintain a geomorphic process (e.g., flow duration required to transport various quantities of sediment), or
- historical attributes of the flow regime (e.g. historically, snowmelt flows occurred annually from April to June).

Previous monitoring on the Trinity River indicates sediment transport rates vary considerably over time and space, and can span up to several orders of magnitude; based on this, GMA (2006b) and Wilcock (2004) conclude direct measurement (as opposed to historical transport curves or mathematical models), provides the best method for estimating continuous sediment transport and annual loads. Sediment load computations inform gravel injection strategies, flow release hydrograph development, restoration design and other management decisions.

1.2 Report Organization

This report presents the results of WY2017 mainstem sediment transport monitoring efforts. The scope, scale and historical context of sediment sampling on the Trinity River are detailed in Section 2.0. WY2017 Methods and Results are described in their respective sections (2.3 and 2.4). Results are compared to those from previous years to examine general trends, which may be of use by Trinity River managers for predictive purposes and to assess management actions such as gravel augmentation and channel/floodplain restoration. Explanatory figures and tables are included in the text, whereas larger datasets are included as appendices. All data and seminal report files are included in a digital format. Less relevant documents (staff certification and SLQA compliance) are included with the digital files.

Definitions useful for this report:

“Site” and “Station” are used interchangeably to refer to the sediment monitoring locations. “Station” may also refer to a sampling location along a cross section (aka “vertical”) – though in this case, we attempt to clarify in the associated text.

“Sediment discharge” is often used to describe both the instantaneous rate of sediment transport and/or the cumulated load over time. While others’ definitions may vary, in this report we attempt to distinguish between sediment discharge and sediment load as follows:

(1) Sediment discharge: an instantaneous sediment transport rate, expressed in mass or volume per unit time (tons/day). For example, “a bedload discharge of 105 tons/day was measured on the Trinity River below Limekiln Gulch, sample measurement #7, on 5/6/12 at 13:15;” and
(2) Sediment load: a mass or volume of sediment transported over a pre-defined unit of time (tons). This is the rate (sediment discharge) integrated over a period of time. For example, “674 tons of bedload were transported past the Trinity River below Limekiln Gulch monitoring station during the WY 2013 Spring Flow Release”.

In this report, *sediment discharge* describes sediment in transport, and *sediment load* describes the quantity that was accumulated over a longer time period. A useful comparison is with streamflow: discharge is the instantaneous rate (cfs, analogous to sediment discharge) and yield is the volume of water cumulated over time (acre feet, analogous to sediment load).

“Hysteresis” refers to (directional) varying concentration at a common discharge.

2.0 SEDIMENT TRANSPORT MONITORING

WY2017 marks the 13th year (2004-2013, 2015-2017) of mainstem Trinity River sediment transport monitoring by GMA Hydrology (GMA, formerly Graham Matthews and Associates) for TRRP. Sediment transport monitoring, in various forms, has periodically occurred at a range of sites in the TRRP study area during the last thirty years. For example, the U.S. Geological Survey (USGS) collected sediment data from 1976-1999 at the Grass Valley Creek at Fawn Lodge gaging station, and from 1981-1991 at the Trinity River below Limekiln Gulch gaging station. Most of these sediment monitoring efforts supported the TRFE process, or were conducted for watershed restoration and fine sediment reduction efforts occurring in tributary basins such as Grass Valley Creek. Previous results and data collection methods were described in detail in other reports, including the TRMFS; the Sediment Source Analysis for the Mainstem Trinity River Report (GMA, 2001); and the Annual Sediment Transport Monitoring Reports from WY 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2013, 2014 (GMA, 2003, 2006a, 2006b, 2007, 2008, 2009, 2010, 2013, 2014, 2015, 2016).

In WY 2002, following recommendations from the ROD and TRFE, the Trinity River Restoration Program began operating several tributary and mainstem streamflow and sediment monitoring stations. Subsequent recommendations laid out in the SBMP (2004) focused the sediment transport monitoring efforts on three major tributaries and four mainstem sites (Figure 1). Sediment monitoring on the tributaries was discontinued after WY 2006.

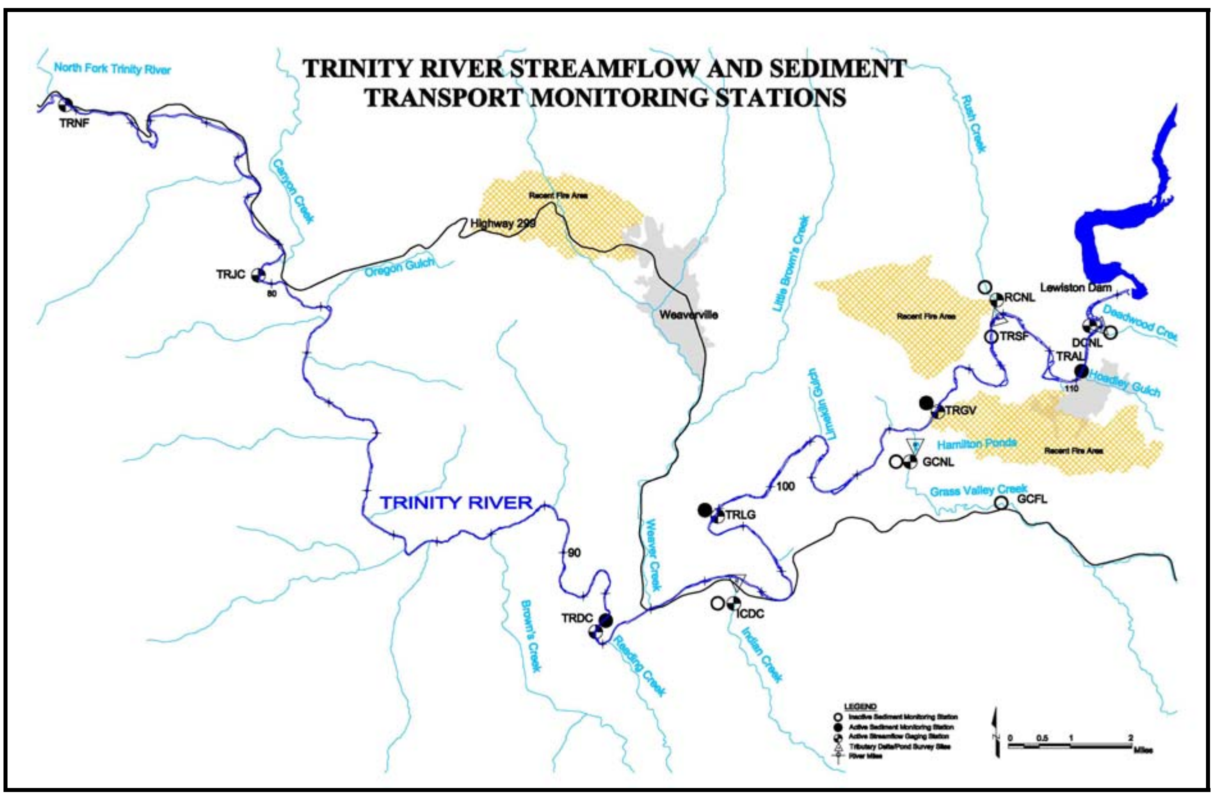


Figure 1. Location Map for the Trinity River Spring Flow Release Sediment Transport Monitoring. Black circles describe locations of the four mainstem sampling stations.

2.1 Sediment Transport Monitoring Locations

In WY 2017, sediment transport data were collected at four mainstem Trinity River monitoring stations during the Spring Flow Release: Trinity River at Lewiston (TRAL, USGS gage #11525500, approximate River Mile [distance upstream from confluence with Klamath River, RM] 109.95), Trinity River above Grass Valley Creek near Lewiston (TRGV, GMA gage #11525540, RM 104.5), Trinity River below Limekiln Gulch near Douglas City (TRLG, USGS gage #11525655, RM 98.7), and Trinity River at Douglas City (TRDC, USGS gage #11525670, RM 92.6) (Figure 1). These are the same stations used for previous annual GMA monitoring, with the exception of TRGV, which was relocated in 2006. The USGS operated the streamflow gages at the TRAL, TRLG, and TRDC stations. GMA operated the seasonal streamflow gaging station at TRGV.

The monitoring stations were designed to provide sediment flux data for the four mainstem sediment budget cells between Lewiston Dam and Douglas City (Figure 2). The larger tributaries (site name initials provided for reference in Figure 1), Deadwood (DCNL), Rush (RCNL), Grass Valley (GCFL, GCNL), Indian (ICDC), Weaver, and Reading Creeks, provide the majority of the natural sediment contributions for the mainstem within the study area. The downstream-most sediment budget boundary is located near Douglas City, where additional streamflow and sediment contributions (from Indian, Weaver, and Reading Creeks) significantly reduce the coarse sediment and streamflow deficits. Below Douglas City, dam releases and natural runoff events are generally capable of transporting sediment influxes (TRFE, 1999; GMA, 2007).

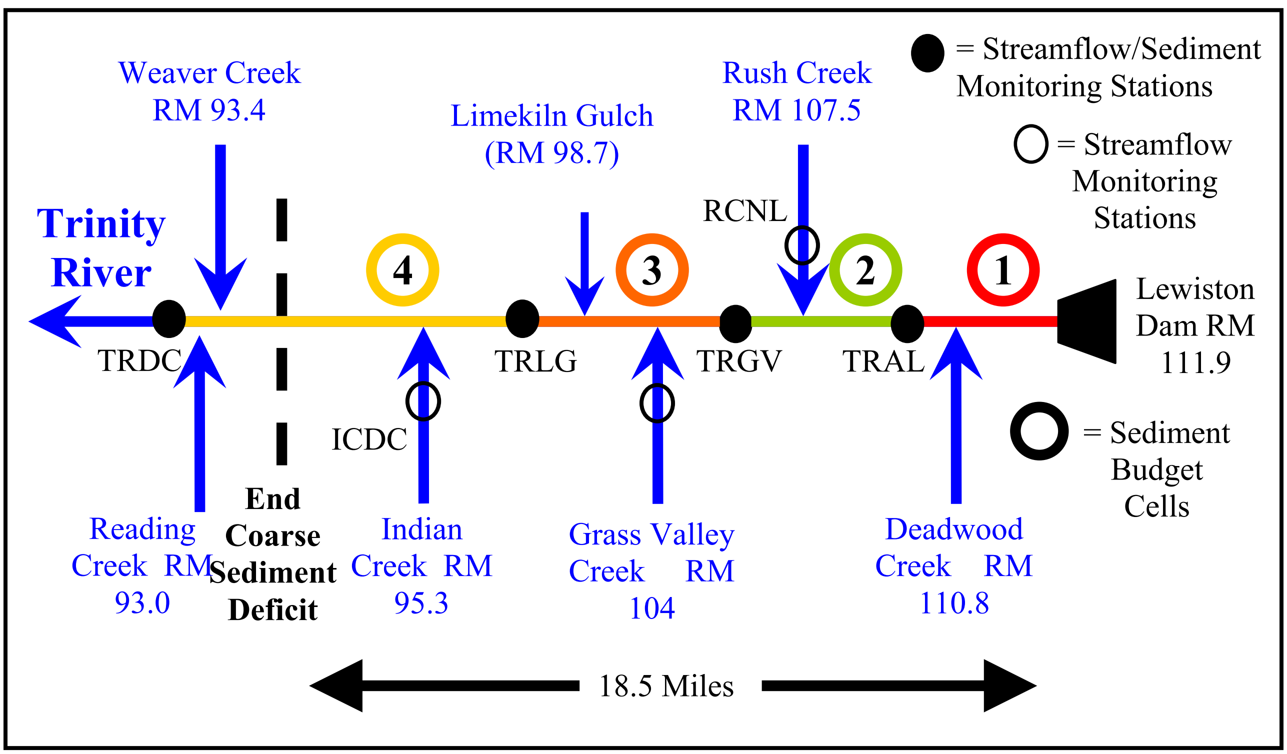


Figure 2. Schematic drawing of the Trinity River Sediment Budget, showing sediment sources and routing. The river has been divided into cells (1 through 4) bounded by stations, which are used for monitoring, measurement and analysis to compute sediment transport and storage.

2.2 Sediment Transport Monitoring: Objectives and Tasks

WY 2017 sediment transport monitoring occurred during the Spring Flow Release period. The overall WY 2017 objectives were to determine the rate, volume (load) and texture of total sediment load at the four monitoring locations.

Primary sediment monitoring tasks designed to accomplish these objectives included:

- Operating mainstem sediment transport monitoring stations at: the Old Lewiston Bridge (TRAL); above the Grass Valley Creek confluence (TRGV); at the USGS gaging station below Limekiln Gulch (TRLG); and just downstream of the USGS streamflow gaging station at the Bureau of Land Management (BLM) Douglas City Campground (TRDC);
- Collecting continuous turbidity at three of the four mainstem sampling stations TRGV, TRLG, TRDC;
- Collecting streamflow measurements and continuous stage data at TRGV during the Spring Flow Release period;
- Updating stage/discharge relationships and computing streamflow records for TRGV;
- Developing turbidity/suspended sediment concentration (SSC) relationships, discharge/SSC, and discharge/bedload relationships as required;
- Computing continuous bedload and suspended sediment discharge using sediment samples we collected and using methods developed by the USGS. Sediment sample analyses were performed to provide transport rates by size fraction: <0.063mm (suspended), 0.063-<0.5mm (suspended), ≥0.5mm (suspended), 0.5-<8.0mm (bedload), and ≥8.0mm (bedload); and
- Computing bedload and suspended sediment load estimates for these size classes for the Spring Flow release period.
- Additional data were collected to support sediment transport computations, and subsequent sediment budgeting efforts, including: water surface slope measurements (during the flow release), bed-surface particle size distributions and cross section surveys at the sediment transport monitoring stations (pre- and post-flow release) (Appendices A, B, C, D). We also conducted experimental "bedload variability testing" (repeat sampling at one location) to assess the potential range in magnitude of bedload transport.

New for 2017 (TRRP, personal communication):

- We collected bulk sample, bed elevation, bed surface texture and scour information at supply locations (bars upstream of or at sampling sites).
- Bedload sampling effort was reduced at TRAL and the section was divided into thirds to provide left, middle and right section transport for hydrophone calibration. USGS is responsible for computing the bedload discharge at TRAL using passive hydroacoustics (hydrophones) as a surrogate.
- We also provided partial-section bedload transport data (as described above) for hydro acoustic calibration at TRDC.
- We decreased emphasis in suspended sediment load measurement and computation. Sample passes were reduced to one pass per sample and the approved number of samples was reduced to four per site.
- No suspended sediment data was collected at TRAL, nor was a suspended sediment load computed at TRAL.

2.3 Sediment Transport Monitoring Methods

Sampling protocols and methods, lab analysis, data entry, quality assurance, and sediment computation methods are described in detail in previous reports (e.g., GMA, 2006b); thus the following section provides only the absolutely essential descriptions.

2.3.1 Streamflow Monitoring and Computational Methods at TRGV

Streamflow monitoring and continuous-discharge computation for the Trinity River above Grass Valley Creek was carried out using standard or modified USGS methods. Continuous stage was recorded using a Design Analysis H-310 pressure transducer. The H-310 has an accuracy of less than or equal to 0.025 percent of the full-scale output (FSO). Continuous stage readings were recorded in the data collection platform (DCP) at 15-minute intervals. Stage observations from staff plates were recorded on all site visits. All surface water data including electronic gage data, staff-height readings, the gage datum, and discharge measurements were entered and processed in the WISKI Suite (Water Information Management System Kisters), developed by KISTERS AG. WISKI is a Windows-based time-series hydrological data management package, based on a relational database client-server platform such as Microsoft Sequel Server. The WISKI Suite is comprised of three components: WISKI, BIBER, and SKED. The main WISKI shell is the hydrologic workbench where all data are organized and where computations on time-series data are carried out. BIBER is used to evaluate and manage discharge measurements as well as track current meters and personnel using those meters. SKED is a rating curve editor that uses a graphical user interface to assist the hydrologist in developing, maintaining, and applying rating curves. The U.S. version of WISKI uses standard hydrologic computations and techniques as set forth by the USGS. Full details of computations can be found in the station analyses contained in Appendix B.

2.3.2 Mainstem Sediment Sampling

All sediment sampling was conducted from cataraft-based sampling platforms as in previous years. The catarafts were attached to tensioned cableways (temporary cableways of 5/16” galvanized wire rope) securely attached to trees or other anchors on either side of the channel. Various types of equipment were deployed from the cataraft platforms, including 12 inch wide TR-2 bedload samplers with 0.5mm mesh (Figure 3) and US D-74 suspended sediment samplers. This was the 11th year that TR-2 bedload samplers were utilized at all four stations. In previous years, 6 inch Helley-Smith samplers were utilized.

GMA personnel at each site consisted of two crew on the cataraft and one safety kayaker. All GMA staff have completed First Aid and CPR training and Swift Water Rescue Training courses. Crews collected up to 15 one-pass bedload samples, one one-pass suspended sediment sample, and one water surface slope measurements per day. On the first day of sampling, crews were assigned two sites per day, with the modified goal of collecting up to four one-pass bedload samples, one one-pass suspended sediment sample and one water surface slope measurement. For the second peak flow bench (approximately 5,000 cfs), one crew covered the three downstream sites for two days each.

TRGV, TRLG, and TRDC were each fitted with a Forest Technology Systems DTS-12 in-situ turbidity probe and a Campbell CR200 data collection platform, set to record on 15-minute intervals. Articulating booms used in previous years were again used in 2017 to deploy the turbidity probes, whereas prior to 2011 the probes had been mounted in fixed locations. The articulated booms (Figure 4) allow turbidity probes to shed debris and produce much cleaner turbidity records. For all stations, Station Analyses, detailing sediment data collection and computational methods, were developed for each sampling station (Appendices A, B, C, D). Quality Assurance plans for both laboratories are available to interested parties.

Suspended sediment measurements, were collected over a range of flows and at various positions on the hydrograph during the 2017 Spring Flow Release. \Cross-sections were sampled at 11-15 verticals. Protocols followed standard USGS procedures (Edwards and Glysson, 1999) for Equal Width Increment (EWI) sampling. Information recorded for each sample included: time, date, site, stage, bottle #, pass #, method, equipment used, etc. All suspended sediment samples were transported to GMA's fine sediment laboratory in Placerville, CA, where they were processed and summarized for three particle-size ranges (<0.063mm, 0.063-<0.5mm or ≥0.5mm).

Bedload measurements were collected on 14 days within the release period. The sampling down-times (i.e., time the sampler rested on the bed actively collecting sediment) ranged from 5 to 300 seconds. Bedload samples were also transported to the GMA sediment lab in Placerville, CA where they were processed and the data were summarized (Figure 5).

Figure 3. A 200 lb twin-tube TR2 bedload sampler deployed from a cataraft at the TRLG sampling site in April, 2017.

Figure 4. An articulating turbidity boom and gage house box deployed at TRGV in 2017.

Figure 5. GMA Coarse Sediment Laboratory, Placerville, CA.

2.3.3 Continuous Suspended Sediment Discharge and Load Computations

The computational period for the mainstem stations was defined as April 1, 2017 00:00 to July 31, 2017 23:45. (encompassing the Spring Flow Release, as stipulated by TRRP). Computations were performed as follows. First, suspended sediment transport curves were developed from the sample data paired with streamflow and/or turbidity . Next, the curves were analyzed to investigate whether streamflow or turbidity provided the best surrogate for predicting continuous suspended sediment concentration. Then, continuous concentration sedigraphs were generated from either the streamflow or the turbidity time series. The plotted traces were adjusted to pass through the sample data points. Finally, continuous concentration was transformed into continuous suspended sediment discharge (SSD) using the standard equation:

$$Q \text{ (cfs)} * SSC \text{ (mg/l)} * 0.002697 = SSD \text{ (tons/day)}$$

Continuous suspended sediment discharge was summed over the computational period to compute the load for the following size classes (partial loads): < 0.063mm, 0.063mm - <0.5mm, and ≥ 0.5mm. Mainstem total suspended sediment load was computed by summing the partial loads. For detailed information on suspended sediment discharge computations see the individual Station Analyses in Appendices A, B, C, and D.

2.3.4 Continuous Bedload Discharge and Bedload Computations

The computational period for the mainstem stations was April 1, 2017 00:00 to July 31, 2017 23:45 (i.e. the Spring Flow Release, same as per the suspended sediment computations). Continuous partial-bedload discharge was computed for 0.5-<8mm and ≥ 8mm size classes. Single (or multiple) sediment transport curves were fitted through distinct groupings of measured bedload vs water discharge points. Continuous bedload sediment discharge was estimated as a function of stream discharge for the two size classes. Bedload sedigraphs (graphical depictions of continuous sediment discharge) were constructed and were manually fitted through the measured sediment discharge points or through a daily average of the sampled points. This employs a combined approach (utilizing multiple temporal transport curves and sedigraph fitting through measured data points) which is more accurate for assessing the transport variability on the Trinity River (observed during previous flow releases) than the application of a single, general transport curve for the entire release period. While comparisons between the combined and single-curve approaches have shown minor differences in computed bedload discharge totals (GMA 2006b; 2007), the combined method highlights short term trends which the single regression method does not. In WY2017, the single general equation and multiple equation approaches were applied as appropriate.

The TR-2 samplers were equipped with 0.5mm mesh sampler bags, which allowed an unknown portion of the <0.5mm size sediment particles to pass through the samplers. Therefore, continuous bedload discharge was not computed for the <0.5mm size fraction. For simplicity, the 0.5-<8mm and ≥ 8mm size classes are hereafter referred to as “fine” and “coarse” bedload. Continuous total bedload discharge ≥ 0.5mm was computed by summing these partial bedload discharges. Bedload was estimated for the release period by summing the area under the respective sedigraph. For detailed information on bedload discharge and bedload computations see the individual Station Analyses in Appendices A, B, C, and D.

2.3.5 Cross Sections, Water Surface Slope and Pebble Counts

Water surface elevation (stage) monitoring was recorded at each station. Stage references consisted of posts or staff plates which had their elevation established using leveling methods detailed in Harrelson et al. (1994). The distance between posts was measured and stage measurements during peak flows facilitated calculation of water surface slope.

One cross section at each sediment monitoring site was surveyed pre- and post-Spring Flow Release (SFR) cross sections were surveyed per standard methods (Harrelson et al. 1994) to assess topographic changes at the sampling section. Topographic change along cross sections was calculated in MS Excel by creating a common 1 foot stationing between sequential surveys and interpolating surveyed elevations to these stations, resulting in both surveys having elevations for the same stationing. Topographic change was computed incrementally, (elevation difference multiplied by a 1 foot width), and then summed, to create cut/fill tables and calculate total pre- and post-SFR cross section area change.

In addition, pebble counts (n=100+ particles) were collected along the cross sections to examine textural changes related to the flow release (Wolman 1954). Pebble count results are used to describe the texture of the dominant bedload transport feature (e.g. a transverse gravel bar).

2.3.6 Bulk Sampling and Scour Monitoring in Supply Reaches

In order to (1) compare the grain size distribution of bedload samples to that of supply areas (upstream bars), and (2) investigate the contribution potential (scour rates) of those bars, we conducted bulk sampling and scour monitoring upstream of sampling sites at TRAL and TRLG. We also sampled local transport features: bars that crossed the sampling sections and were known to provide high rates of transport. Pre-SFR streamflow was too high to perform the same tasks at TRDC and at TRGV, gravel injection activities precluded such experiments.

Pebble counts were conducted at gravel-supply sites using the procedure described in section 2.3.5. For bulk sampling, a 24 inch cylindrical McNeil sampler was used to facilitate excavation to approximately one foot. Surface samples (defined as the depth corresponding to the width of the C axis of the largest particle in the sample) were separated from the sub-surface samples. Sample locations were documented by tri-laterating to adjacent reference marks (rebar pins, spikes etc) with a measuring tape and relative elevations were recorded by leveling from the marks to the sample location using an auto-level. Sample locations were later surveyed using an RTK GNSS receiver to tie the locations into the TRRP control network. Bulk sample voids were back-filled with painted cobbles to create a scour core. Post-flow release, bulk samples were repeated to the depth of any remaining scour rocks (or to one foot if no painted rocks were encountered). Scour cores were resurveyed when painted rocks were found, approximating the maximum depth of scour at that location during the Spring Flow Release.

2.4 Sediment Transport Monitoring Results

2.4.1 Hydrology and Streamflow

The following is a description of the Water Year 2017 hydrologic setting and the resulting flow release hydrograph. WY2017 was determined to be an "Extremely Wet" water year (TRRP 2017). A two-week long 1,530 cfs flow bench (April 5 to April 19) preceded the planned Spring Flow Release.

The approved release hydrograph (mean daily flows) included a 5 day rise from base flow to 11,000 cfs. The planned peak included two days of 11,000 cfs and one day of 10,000 cfs. A sharp decline over 5 days to approximately 2,500 cfs was to be followed by 5 days of approximately 2,500 cfs. A second bench of 4,800 to 5,400 cfs was to begin May 10 and last for 9 days. A gradual tailout spanned most of the summer with the hydrograph dropping back to summer base (450 cfs) in mid August.

Examination of the 15 minute discharge data USGS gage near Lewiston (11525500, Figure 6) shows the flow release closely tracked the planned hydrograph. A short bench (19 hours) occurred on the rising limb at approximately 7,000 cfs on April 25. The peak flow bench (above 11,000 cfs) began on April 26 at 12:15 and lasted nearly three days, dropping below 11,000 cfs on April 29 at 09:45. The actual peak flow was 12,000 cfs, though most of the peak flow bench hovered around 11,500 cfs. The initial decline, the 2,500 cfs trough and the second 4,800-5,000 cfs bench closely tracked the planned release hydrograph. Between May 23 and June 1, some flow cycling occurred with four short (approximately 24 hour) 4,400 cfs benches separated by 3,800 cfs troughs.

2.4.2 Mainstem Sediment Transport Monitoring

GMA sampling crews collected suspended sediment and bedload measurements for 14 days over both flow benches between April 25 and May 15, 2017. Crews collected two to eight one-pass bedload samples and up to one suspended sediment sample each day. Table 1 summarizes the number of bedload and suspended sediment samples collected by station. For 2017, experimental bedload-variability testing (repeated sampling at a high-transport location to examine short-term temporal variability) was performed for a 30 minute period at each site. Crews collected four discharge measurements during the release period (and one before and one after) for computing continuous discharge at TRGV. Appendices A, B, C and D provide hydrographs displaying the timing of bedload and suspended sediment samples at each station.

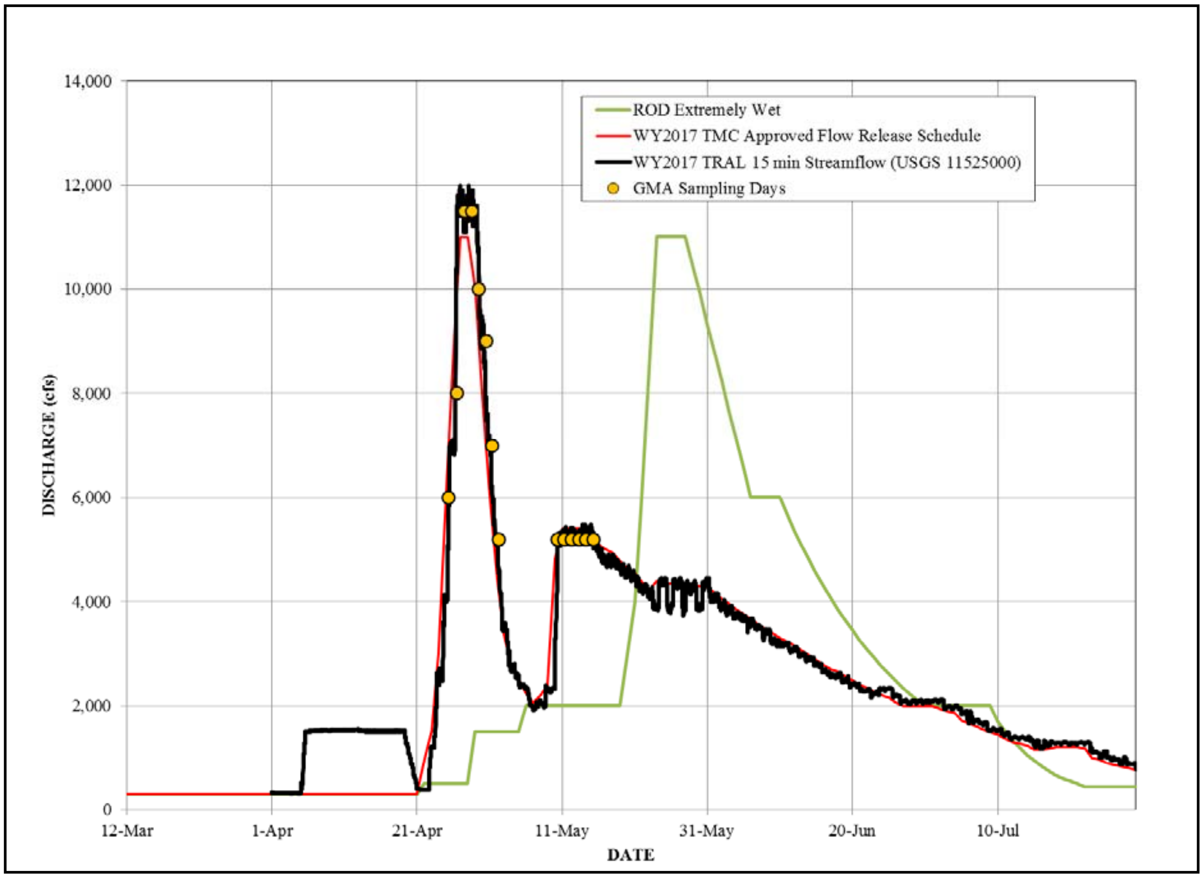


Figure 6. ROD Extremely Wet hydrograph, TMC Approved hydrograph, and recorded (actual) Streamflow for USGS Gage #11525500, Trinity River at Lewiston, CA for the WY2017 Spring Flow Release.

Table 1. WY 2017 Mainstem Sediment Sample Summary

SEDIMENT MONITORING STATION	SUSPENDED SEDIMENT SAMPLES (# collected)	BEDLOAD SAMPLES (# collected)
Trinity River at Lewiston (TRAL)	0	21
Trinity River above Grass Valley Creek (TRGV)	5	53
Trinity River below Limekiln Gulch (TRLG)	6	68
Trinity River near Douglas City (TRDC)	4	39

2.4.2.1 Trinity River at Lewiston

Station Description

The TRAL station defines the end of the first sediment budgeting cell which starts at Lewiston Dam (Figure 1, Figure 7). Since WY 2005, sediment transport monitoring has occurred directly beneath the old Lewiston Bridge. Previous sediment transport monitoring occurred 1,150 ft upstream, near the USGS Trinity River at Lewiston gaging station cableway. The USGS streamflow gaging station (#11525500) is located farther upstream, just below the old fish weir.

Suspended Sediment Transport Data

As directed by TRRP, no suspended sediment data were collected at TRAL in 2017.

Figure 7. Downstream view of TRAL Sampling Site, WY2017. Flow is approximately 11,600 cfs.

Bedload Data

Twenty-one bedload samples were collected at TRAL during the Spring Flow Release. All samples were one-pass samples. Bedload sample data are displayed in Table 2. Bedload sample times were plotted on the hydrographs in Appendix A-3 and displayed in the Bedload Summary in Appendix A-5. WY 2017 fine, coarse, and total bedload discharge samples were plotted with historic data in Figures 8-10. Measured total bedload discharge (sum of fine and coarse bedload) ranged from a peak of 1,650 tons/day on April 28 to a minimum of 23 tons/day on May 2. The bedload transport curves used to compute continuous bedload discharge are provided in Appendix A-2.

Table 2. Trinity River at Lewiston -- USGS #11525500, Bedload Sampling Summary -- WY2017

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	> 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRAL-BLM2017-01	04/25/2017 11:03	6,770	303	277	25
TRAL-BLM2017-02	04/25/2017 11:58	6,940	155	140	15
TRAL-BLM2017-03	04/25/2017 12:41	6,910	437	344	92
TRAL-BLM2017-04	04/25/2017 13:52	6,950	206	155	50
TRAL-BLM2017-05	04/25/2017 14:27	6,970	212	179	32
TRAL-BLM2017-06	04/25/2017 15:02	6,990	246	204	41
TRAL-BLM2017-07	04/27/2017 10:14	11,600	582	507	74
TRAL-BLM2017-08	04/27/2017 11:05	11,400	667	574	92
TRAL-BLM2017-09	04/27/2017 11:50	11,300	1,050	958	86
TRAL-BLM2017-10	04/27/2017 12:21	11,200	827	746	79
TRAL-BLM2017-11	04/28/2017 10:09	11,700	862	822	39
TRAL-BLM2017-12	04/28/2017 11:00	11,600	1,190	1,110	78
TRAL-BLM2017-13	04/28/2017 12:32	11,600	682	631	50
TRAL-BLM2017-14	04/28/2017 13:13	11,500	806	725	79
TRAL-BLM2017-15	04/28/2017 14:18	11,600	1,650	1,590	55
TRAL-BLM2017-16	04/28/2017 15:12	11,600	951	837	112
TRAL-BLM2017-17	04/29/2017 09:52	11,000	617	529	86
TRAL-BLM2017-18	04/29/2017 10:36	10,800	627	573	54
TRAL-BLM2017-19	04/29/2017 13:13	10,100	887	859	28
TRAL-BLM2017-20	05/02/2017 10:10	4,580	23	19	4.6
TRAL-BLM2017-21	05/02/2017 10:39	4,300	27	26	0.13

Values Rounded According to Porterfield (1972)

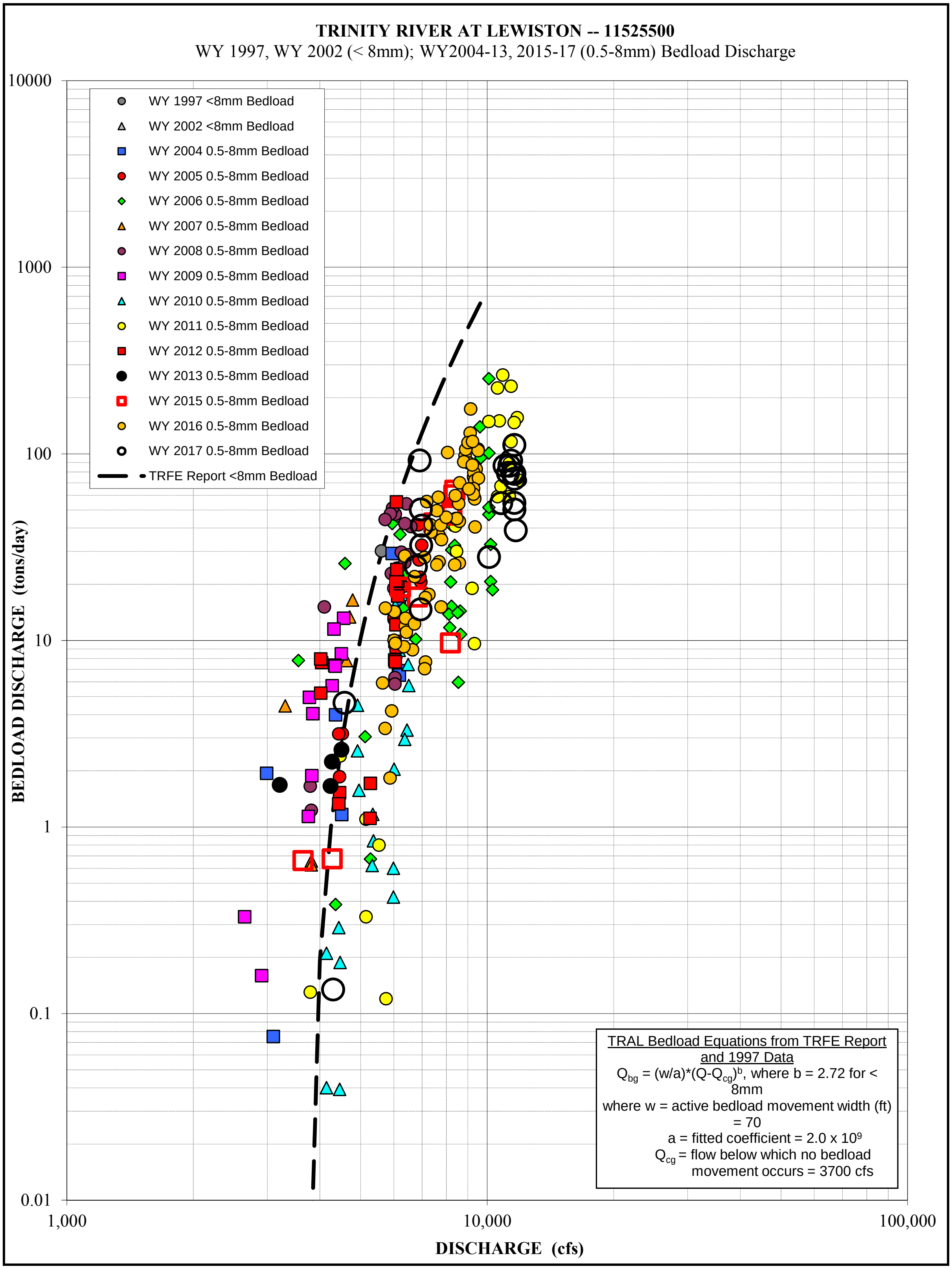


Figure 8. Fine Bedload Discharge (0.5-<8mm) at TRAL, WY1997-2017.
The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG (shown in the inset box on chart). The equation is plotted and shown here as the dashed black line and is included for comparison with subsequent measured bedload transport rates.

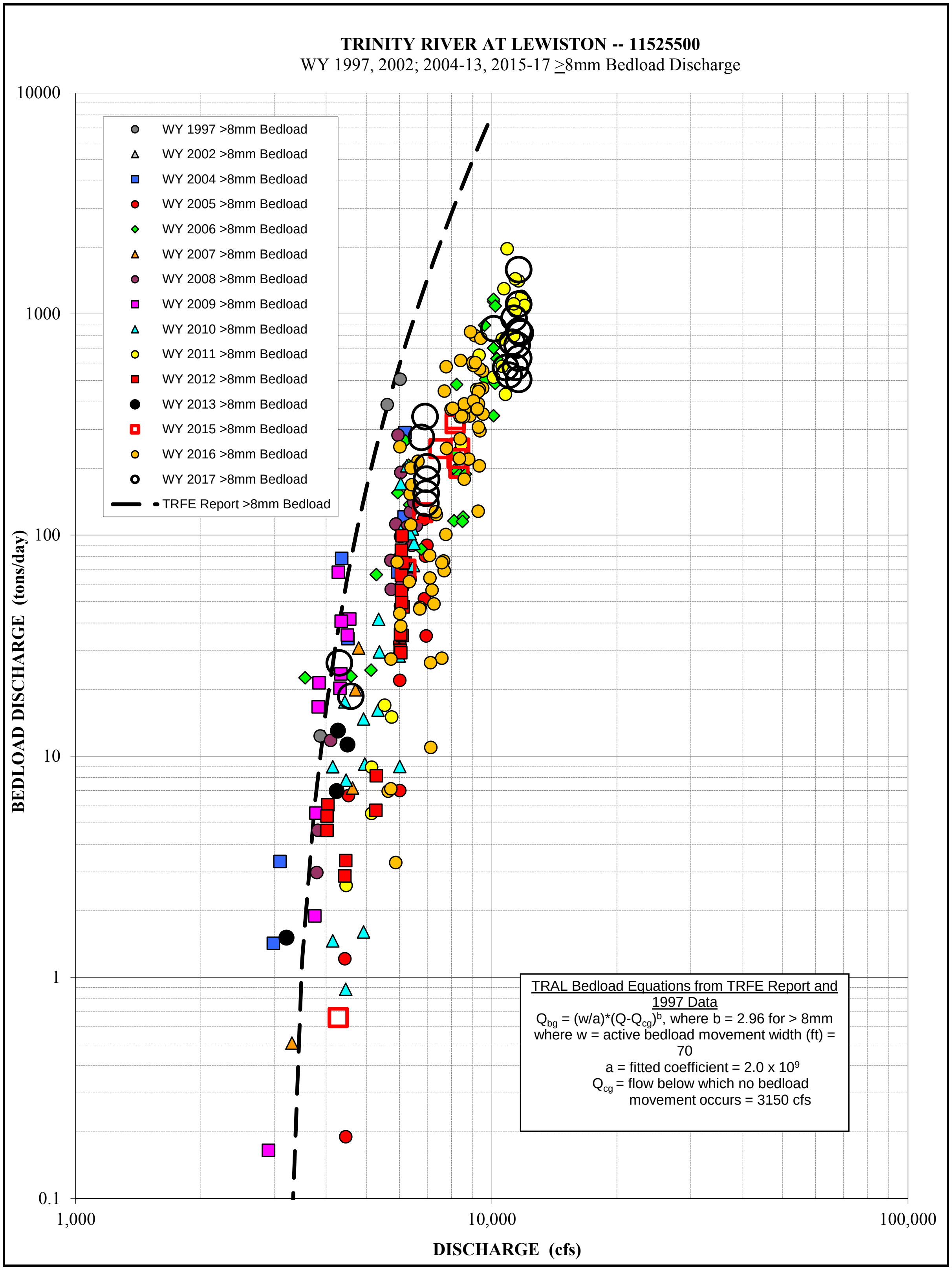


Figure 9. Coarse Bedload Discharge (≥8mm) at TRAL, WY1997-2017.

The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG (shown in the inset box on chart). The equation is plotted and shown here as the dashed black line and is included for comparison with subsequent measured bedload transport rates.

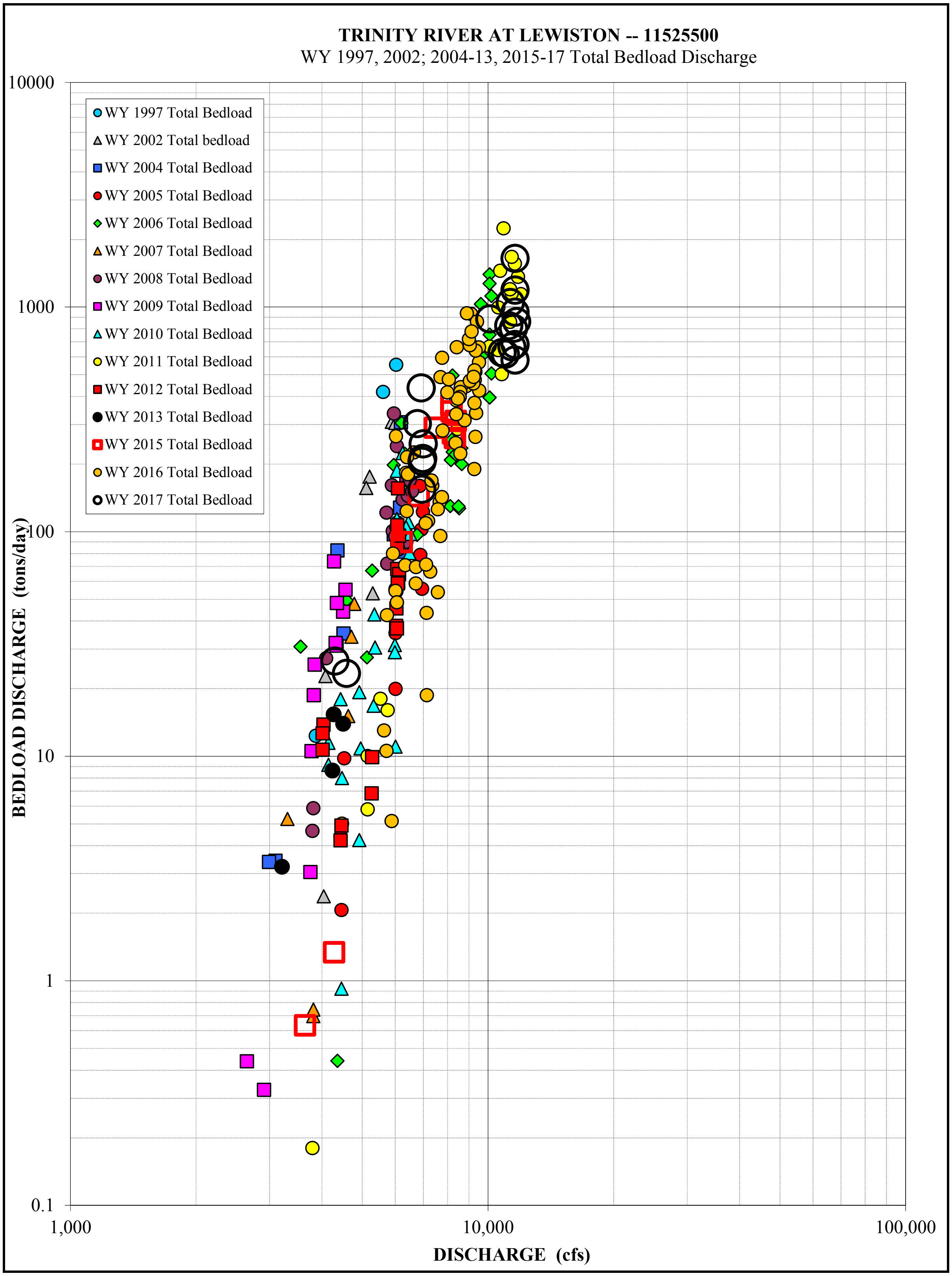


Figure 10. Total Bedload Discharge at TRAL, WY1997-2017.

Continuous bedload-discharge sedigraphs are displayed in Appendix A-3. Flow release estimates for fine, coarse, and total bedload in WY 2017 were 412, 4,330 and 4,740 tons, respectively (Table 3). Detailed explanations of the bedload discharge load computations are provided in the Station Analysis (Appendix A-1). Appendix A-5 contains the particle size distributions, sample data, (e.g. sample times, weights, computed transport rates) and bedload computation values. As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations; however, this fraction is included for graphical comparisons with historic values (e.g. Figure 10).

Table 3. Trinity River at Lewiston, CA -- USGS Gage #11525500, Bedload -- WY2017

0.5-<8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
412	**4,330**	**4,740**

Values Rounded According to Porterfield (1972)

Water Surface Slope, Cross Section Changes and Pebble Count Changes

The WY2017 peak water surface slope through the reach was 0.0017. Surveyed changes in the cross section are presented in Figure 11. Below the 1,806 foot elevation, the channel cross section showed 12.9 ft^2 of scour and 4.2 ft^2 of fill for a net change of 8.7 ft^2 of scour.

The particle size distribution derived from the pebble count data is provided in Figure 12. The November 2016 pebble count was held as the 2017 pre-SFR condition. The deeper, coarser left side of the channel is not included in the annual pebble count, which represents the right half of the low flow channel. The coarse (upper) half of the particle size distribution grew somewhat coarser, with the D50 (grain size for which 50 percent of the sample is smaller) increasing from 55 to 60mm. Above the 90^{th} percentile, the distribution shows more coarsening, and the D90 increase from 84 to 122mm.

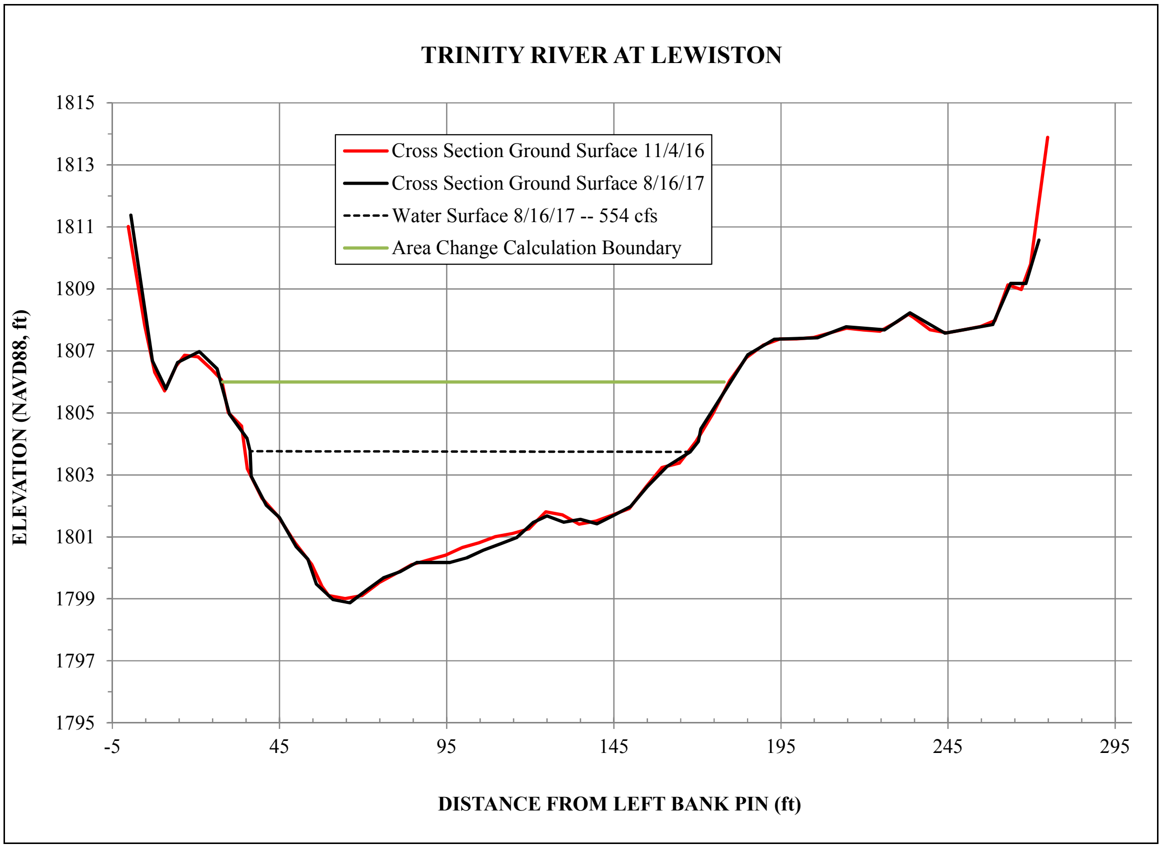


Figure 11. Cross Section changes at TRAL, pre/post Spring Flow Release 2017. Downstream view.

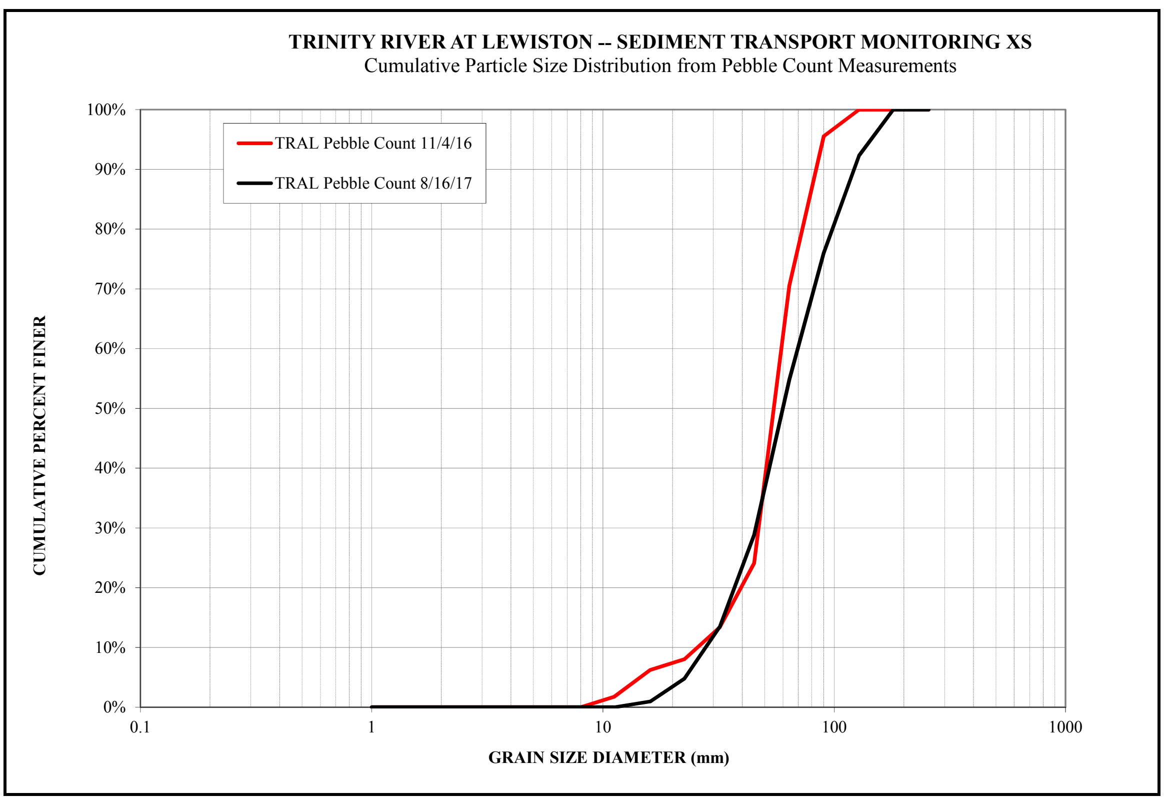


Figure 12. Changes in bed texture at TRAL, pre/post Spring Flow Release 2017.

Bulk Sample and Scour Data

Bulk samples were collected (1) to determine if the sub-surface grain size distribution of "supply areas" (upstream or adjacent bars) represents the grain size distribution of bedload during peak flow events and (2) to examine changes to sub-surface grain size distributions resulting from the Spring Flow Release. Pebble counts at each site facilitate an examination of bed texture before and after the Spring Flow Release and scour cores reveal whether and to what degree a feature is activated (scoured).

Two sites were evaluated near the TRAL sampling site. The first is in the first bar/riffle below the new Lewiston Bridge located approximately 3,600 feet upstream of the TRAL sampling location (Upper TRAL, a supply area, Figures 13, 14). The second is located 20 feet downstream of the sampling section at the Old Lewiston Bridge, along a transverse bar which crosses the sampling section (Figures 13, 15).

Upper TRAL (New Bridge)

The pre- and post-SFR pebble counts showed coarsening of the bed across nearly the entire distribution; the D50 increased from 64 to 91mm and the D90 increased from 88 to 141mm (Figure 16). No scour rocks were recovered in the post-event monitoring effort. We excavated >1 foot, to an elevation 0.4 feet deeper than the bottom of the April scour core, implying that this feature scoured to a depth of at least 1.4 foot.

A comparison of the pre-SFR sub-surface samples versus the mean of all bedload samples collected at the highest flow (approximately 11,600 cfs on April 28) shows that below the 25th percentile, the bedload is finer, but over much of the rest of the distribution, the bedload is coarser than the sub-surface, with a D50 of 75mm versus 59mm (Figure 17). The "post" bulk sample is considerable finer across almost the entire distribution, has a D50 of 38mm and does not appear to represent the bedload as well as the pre-SFR sample (Figure 17).

Lower TRAL (Old Bridge)

The lower site was located along the right side of the sampling section approximately 25 feet downstream of the cableway at the Old Lewiston Bridge (Figures 13, 15). The pebble count area is the same as the one monitored for the sampling site and showed coarsening (see previous section and Figure 12). The scour core location showed 0.4 feet of scour and no fill. The painted scour rocks were discovered at the surface of the riverbed so no post-bulk sample was collected. The green trace in Figure 17 represents the pre-SFR sample. This material was not activated (scoured) by the Spring Flow Release, nor does it appear to represent the bedload.

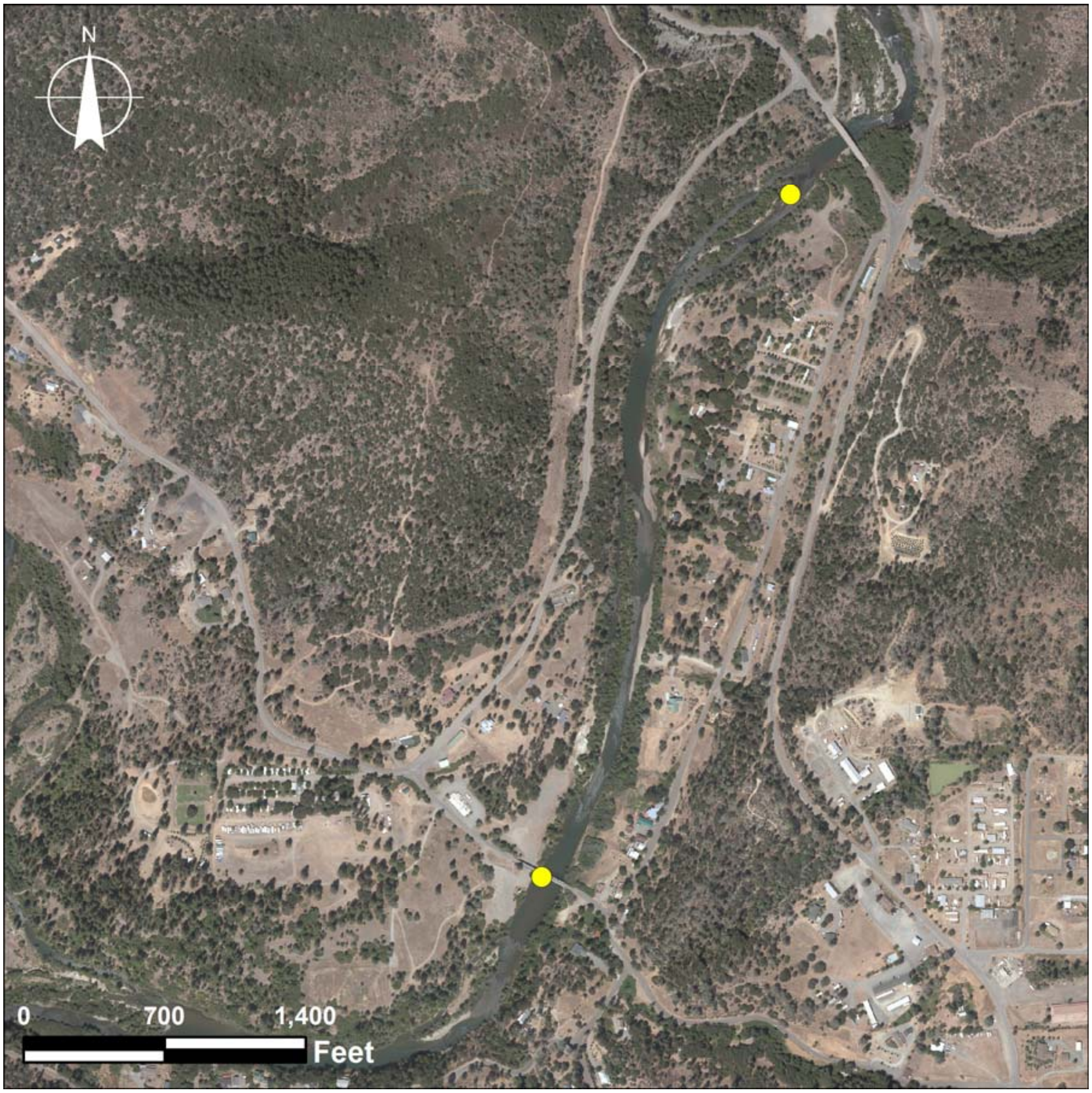


Figure 13. Location map showing 2017 TRAL bulk sampling/scour monitoring sites.

Figure 14. Upper TRAL bulk sampling site, August 2017.

Figure 15. Lower TRAL (Old Bridge) bulk sampling site, August 2017.

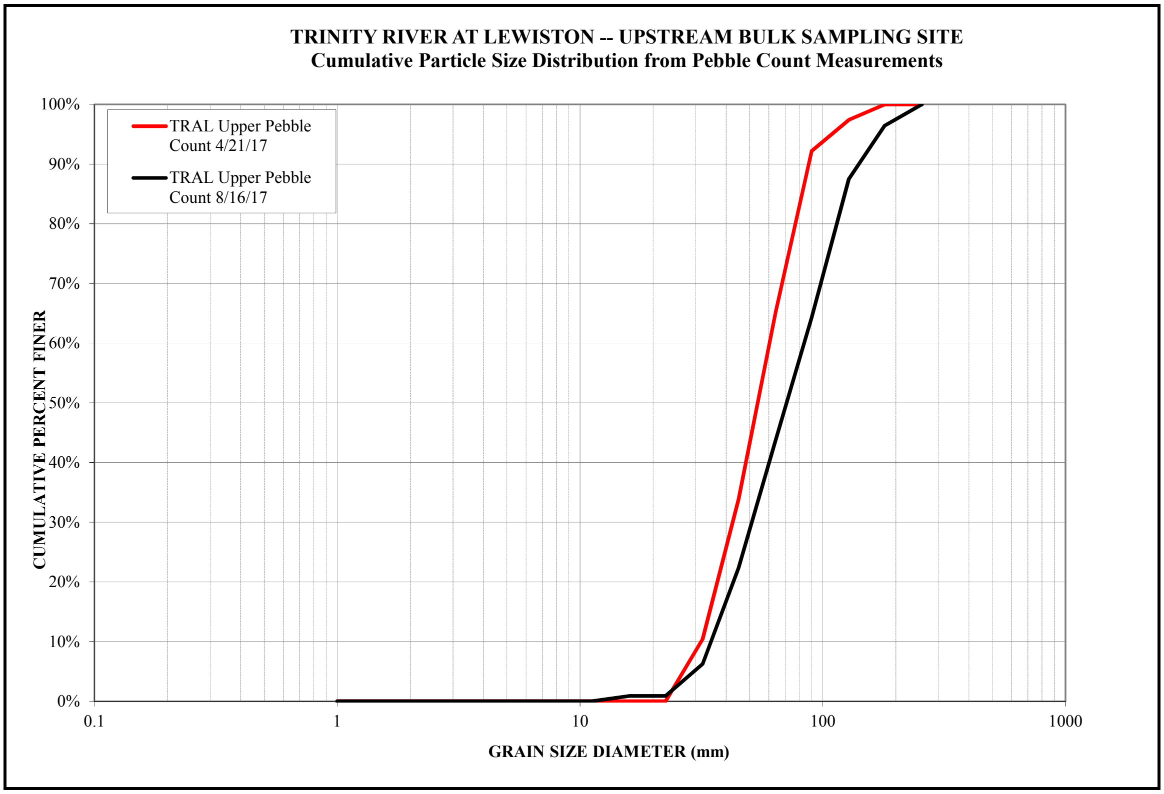


Figure 16. Changes in bed texture at Upper TRAL, pre/post Spring Flow Release 2017.

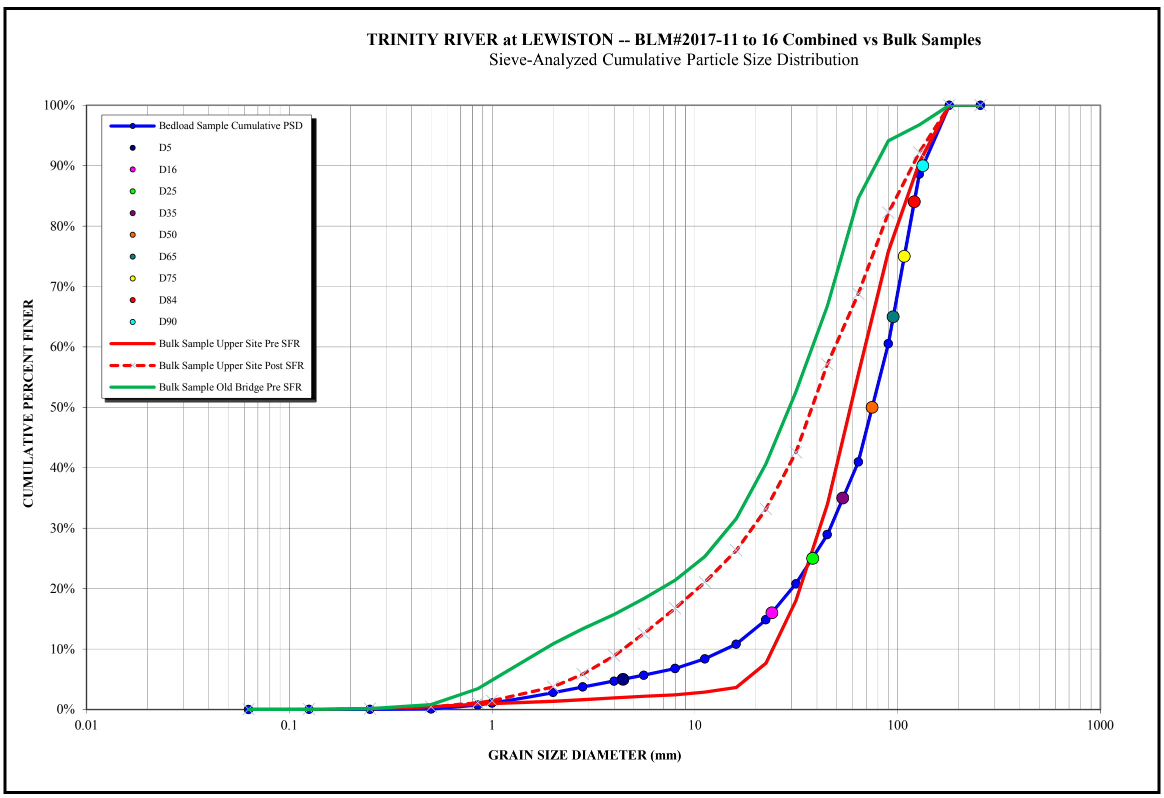


Figure 17. A comparison of pre/post 2017 Spring Flow Release sub-surface grain size distributions versus the mean grain size distribution of the April 28 (11,600 cfs) bedload samples.

2.4.2.2 Trinity River above Grass Valley Creek

Station Description

The TRGV sediment transport monitoring station is located approximately 1,800 feet upstream of the Grass Valley Creek confluence on the BLM Lowden Ranch property (Figure 1). A seasonal streamflow and turbidity gaging station was established at TRGV (Appendix B-1) just prior to the WY 2006 Spring Flow Release. The station was originally located in a relatively straight and uniformly-shaped low-gradient section of the Trinity River. The station was relocated about 200 feet downstream in WY 2011 as a result of restoration construction activities in 2010 which created a forced meander only a short distance upstream from the original gage site. Gravel injection frequently occurs just upstream of the sampling site during flow releases. In 2017, a large gravel berm was placed in the river immediately upstream of the sampling location.

The gage was operated from April 4 to July 31. Streamflow data from April 1 through April 4 was estimated by summing Trinity River at Lewiston and Rush Creek streamflow records. The TRGV gage defines the downstream end of the second sediment budget cell (Figures 1 and 2). A cable was strung between two large conifers above the active channel to allow cataraft sampling. The TRGV site provided an excellent sediment sampling location and a fair streamflow gaging site, despite upstream gravel injection which causes deposition at the gaging site resulting in shifts in the stage-discharge relation.

On the first day of sampling, during a discharge measurement, suspended debris struck and damaged the ADCP and the measurement was aborted. The ADCP was reconfigured for deployment on a river board and on April 27, discharge measurements were resumed. Also on April 27, crews noted a shift in bedload transport from the right side of the channel to the left – shortly after this observation, the right bank cableway anchor tree (a 16-inch Ponderosa pine) was observed to be leaning toward the channel (Figure 18). Senior staff immediately responded to the site and determined that the cableway must be removed for obvious safety reasons. The TRGV crew was deployed to TRAL the following day while GMA and TRRP discussed priorities. On April 29, GMA skipped sampling at TRDC to support an attempt to re-establish a cableway at TRGV. A four-person crew successfully constructed a new cableway at 11,000 cfs. The new cableway is located approximately 150 feet downstream of the old one. Sampling activities resumed at 14:00 hrs on April 29 and a discharge measurement was collected late in the day.

Figure 18. Photograph of TRGV sampling cableway anchor leaning toward mid-channel. View is downstream.

Streamflow Gaging

The relatively straight, uniform channel created by the riparian berms and old mining activities provided an ideal streamflow gaging reach for the 2006-2010 period. The reach was modified substantially during construction of the restoration project in 2010. Removal of the left bank riparian berm and tailing piles and construction of a floodplain resulted in a channel with a substantial floodplain flow component at the higher discharges. Continuous stage height readings were recorded from April 4 through August 3, but streamflow records were computed (or estimated) for the Spring Flow Release period (April 1 through July 31). Six discharge measurements were collected during the computation period (Appendix B-1; B-5). Measured discharge for the period ranged from 431 cfs to 10,700 cfs. Computed instantaneous discharge ranged from 415 cfs to 12,200 cfs.

The stage-discharge relationship, Rating 6.0, was established in WY 2016 to extend the low end of Rating 5.1 (Appendix B-2). Rating 6.0 was used during Water Year 2017 with no shift applied. A detailed explanation of the methods and assumptions used to compute the discharge record are provided in the Streamflow Station Analysis (Appendix B-1a).

Figure 19. Photograph of sediment sampling crew on a cataraft at TRGV in 2016. Flow is right to left, approximately 6,500 cfs.

Suspended Sediment Transport Data

Five one-pass suspended sediment samples were collected between April 26 and May 13, 2017 at TRGV (Table 4). Measured SSC fluctuated from a peak of 81 mg/l on April 26 at 8,810 cfs, to a low of 7 mg/l on May 13 at 5,330 cfs. The associated transport rates were 1,930 and 101 tons/day respectively. WY 2017 suspended sediment discharge values are plotted in Figure 20 along with sample data from WY 2006-2016.

Table 4. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Suspended Sediment Sampling Summary -- WY2017

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC (mg/l)	Average SSD (tons/day)
TRGV-SSCT2017-01	4/26/2017 9:51	8,810	81	1,930
TRGV-SSCT2017-02	4/30/2017 10:01	8,870	12	287
TRGV-SSCT2017-03	5/2/2017 9:36	4,590	10	124
TRGV-SSCT2017-04	5/10/2017 14:41	5,230	36	508
TRGV-SSCT2017-05	5/13/2017 13:01	5,330	7	101

Values Rounded According to Porterfield (1972)

Turbidity versus SSC proved suitable in WY2017, unlike 2016 when gravel augmentation activities at the site sporadically affected turbidity values at the turbidity probe, which is located along the left bank. Continuous suspended sediment discharge for the three size classes was computed using the turbidity versus SSC relationships (Appendix B-1; B-4). Partial and total suspended sediment load for the Spring Flow Release were 3,880, 4,200, 1,460 and 9,540 tons for the <0.063mm, 0.063-<0.50mm, ≥0.50mm size classes and total load respectively (Table 5). The Sediment Station Analysis (Appendix B-1b) details the relationships and periods of record for which the transport curves were applied. Appendix B-10 contains the sample data and SSC computations.

Table 5. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Suspended Sediment Loads -- WY2017

< 0.063 mm (tons)	0.063 mm-<0.50 mm (tons)	≥0.50 mm (tons)	Total Load (tons)
3,880	4,200	1,460	9,540

Values Rounded According to Porterfield (1972)

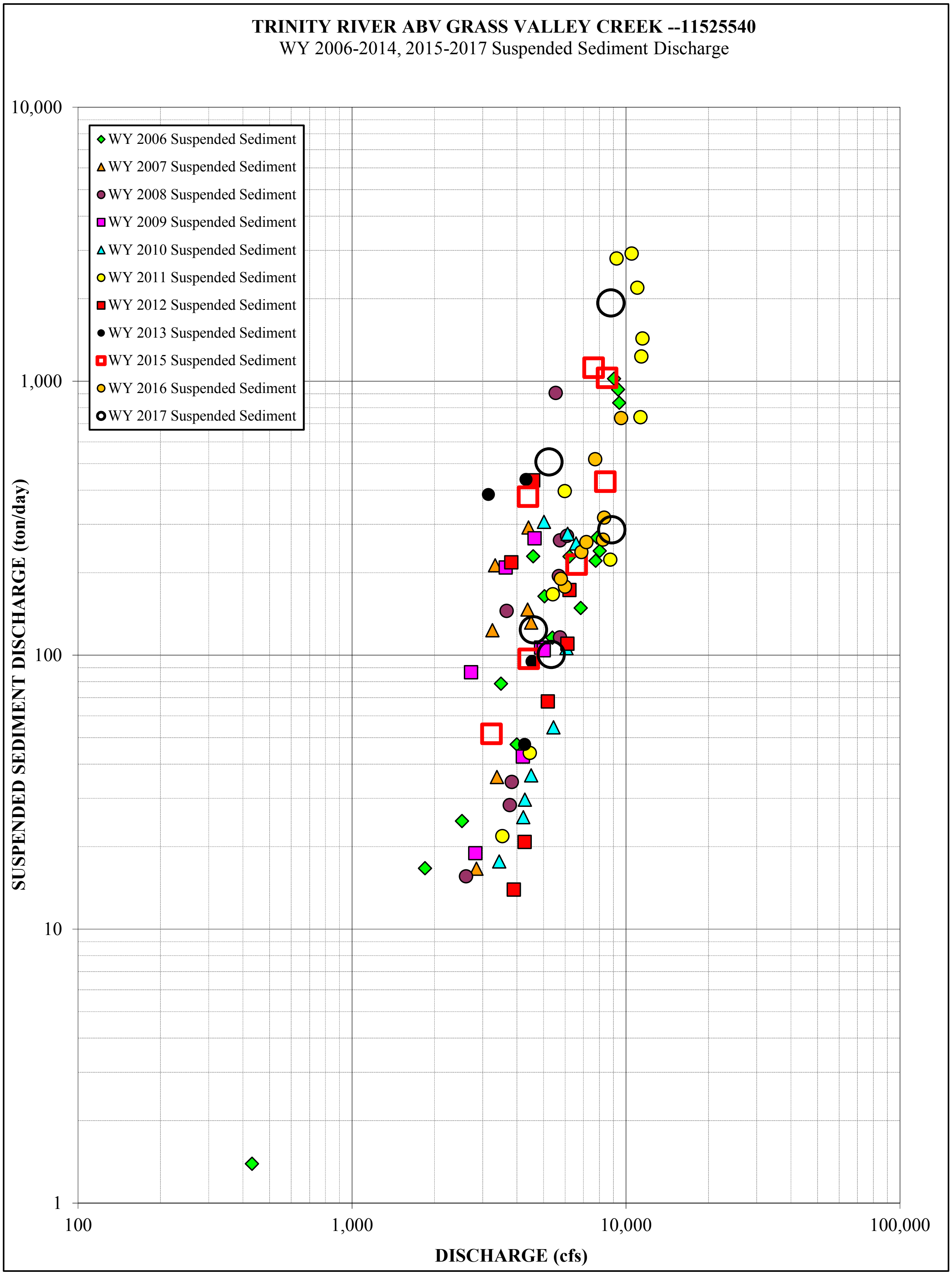


Figure 20. Suspended Sediment Discharge at TRGV, WY2006-2013, 2015-2017.

Bedload Data

Forty one-pass bedload samples were collected at TRGV between April 25 and May 13, 2017. Bedload sampling times were plotted on hydrographs in Appendix B-5. Bedload sample data and bedload discharge computations are summarized in Table 6. Fine, coarse, and total bedload discharge rates for WY 2006-17 are plotted in Figures 21-23. As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations; however, this fraction is included for graphical comparisons with historic values (e.g. Figure 23).

The measured (Total) transport rates started at 1,400 tons/day at 6,580 cfs on April 25 and peaked at 5,180 tons/day at 11,700 cfs on April 26 (Table 6). The Sediment Station Analysis (Appendix B-1) describes the development of the bedload transport curves and the periods of record over which each was applied. The transport curves and bedload measurements were used to compute continuous bedload discharge and load estimates (Appendix B-10). Appendix B-3 contains the bedload transport curves and Appendix B-6 contains the bedload sedigraphs. Fine, coarse, and total bedload estimates for the period April 1 to July 31, 2017 were 1,110, 8,390 and 9,500 tons (Table 7). Appendix B-9 contains the sample data (weights and computed transport rates) and bedload computation values.

Table 6. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Bedload Sediment Sampling Summary -- WY2017

Table 1/2

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	> 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRGV-BLM2017-01	04/25/2017 12:24	6,580	1,400	1,330	54
TRGV-BLM2017-02	04/25/2017 14:14	7,280	789	723	55
TRGV-BLM2017-03	04/25/2017 14:57	7,230	2,830	2,760	49
TRGV-BLM2017-04	04/26/2017 10:29	9,190	1,420	1,200	206
TRGV-BLM2017-05	04/26/2017 11:05	9,400	2,500	2,100	392
TRGV-BLM2017-06	04/26/2017 12:58	10,500	4,250	3,910	322
TRGV-BLM2017-07	04/26/2017 13:46	10,900	2,730	2,290	402
TRGV-BLM2017-08	04/26/2017 15:05	11,700	5,180	4,460	677
TRGV-BLM2017-09	04/26/2017 15:42	11,800	4,900	4,560	321
TRGV-BLM2017-10	04/27/2017 08:45	12,000	2,380	2,150	221
TRGV-BLM2017-11	04/27/2017 09:17	12,000	1,830	1,450	377
TRGV-BLM2017-12	04/27/2017 12:58	11,500	1,530	1,250	274
TRGV-BLM2017-13	04/27/2017 13:34	11,400	1,240	1,060	180
TRGV-BLM2017-14	04/27/2017 14:49	11,500	1,320	1,140	175
TRGV-BLM2017-15	04/27/2017 15:17	11,500	1,360	1,150	205
TRGV-BLM2017-16	04/29/2017 14:52	10,400	198	143	54
TRGV-BLM2017-17	04/29/2017 15:30	10,300	512	425	85
TRGV-BLM2017-18	04/29/2017 16:07	9,980	206	167	37
TRGV-BLM2017-19	04/30/2017 10:36	8,840	255	210	43

Values Rounded According to Porterfield (1972)

Table 2/2

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	> 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRGV-BLM2017-20	**04/30/2017 11:28**	**8,730**	**115**	**78**	**36**
TRGV-BLM2017-21	**04/30/2017 12:08**	**8,430**	**172**	**146**	**25**
TRGV-BLM2017-22	**04/30/2017 13:33**	**8,190**	**70**	**47**	**22**
TRGV-BLM2017-23	**04/30/2017 14:27**	**8,160**	**134**	**105**	**27**
TRGV-BLM2017-24	**05/01/2017 10:14**	**6,360**	**86**	**64**	**22**
TRGV-BLM2017-25	**05/01/2017 11:13**	**6,320**	**65**	**41**	**23**
TRGV-BLM2017-26	**05/01/2017 13:54**	**6,120**	**20**	**7.9**	**12**
TRGV-BLM2017-27	**05/02/2017 12:12**	**4,410**	**17**	**5.5**	**11**
TRGV-BLM2017-28	**05/02/2017 13:23**	**4,140**	**13**	**2.6**	**10**
TRGV-BLM2017-29	**05/10/2017 08:35**	**3,940**	**43**	**5.3**	**36**
TRGV-BLM2017-30	**05/10/2017 09:29**	**4,440**	**46**	**3.5**	**38**
TRGV-BLM2017-31	**05/10/2017 10:33**	**5,160**	**85**	**5.6**	**72**
TRGV-BLM2017-32	**05/10/2017 11:25**	**5,250**	**41**	**2.0**	**35**
TRGV-BLM2017-33	**05/10/2017 13:06**	**5,230**	**64**	**9.4**	**52**
TRGV-BLM2017-34	**05/10/2017 13:56**	**5,230**	**65**	**10**	**51**
TRGV-BLM2017-35	**05/10/2017 15:18**	**5,240**	**57**	**24**	**31**
TRGV-BLM2017-36	**05/10/2017 16:12**	**5,220**	**39**	**4.6**	**33**
TRGV-BLM2017-37	**05/13/2017 09:29**	**5,350**	**26**	**10**	**15**
TRGV-BLM2017-38	**05/13/2017 10:19**	**5,330**	**31**	**14**	**17**
TRGV-BLM2017-39	**05/13/2017 11:19**	**5,340**	**17**	**2.0**	**15**
TRGV-BLM2017-40	**05/13/2017 11:45**	**5,310**	**56**	**17**	**14**

Values Rounded According to Porterfield (1972)

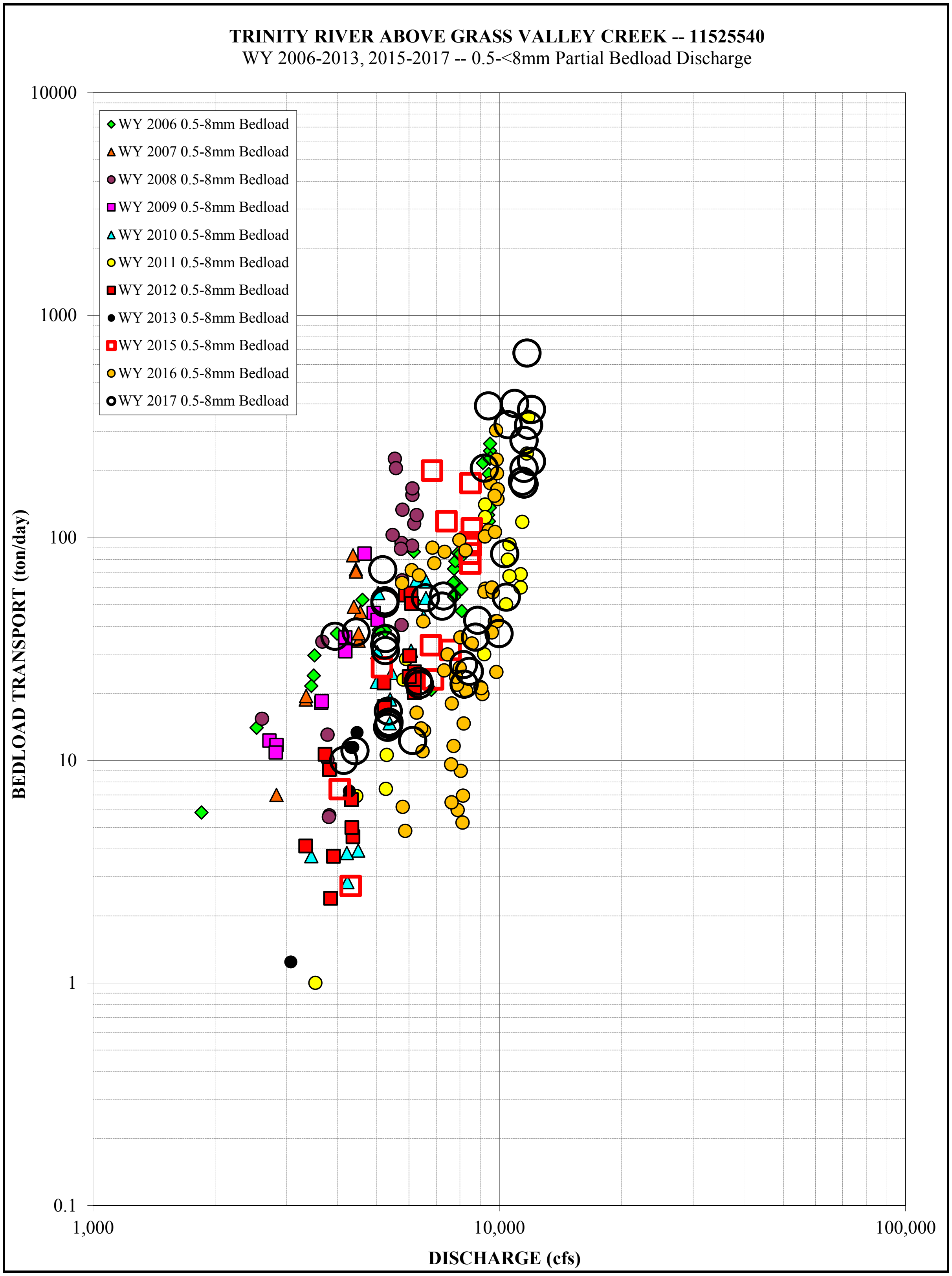


Figure 21. Fine Bedload Discharge (0.5-8mm) at TRGV, WY2006-2013, 2015-2017.

The 1999 TRFE bedload equations that were used to develop flow recommendations did not include this site. Thus, no transport curve is presented as was for Figure 9.

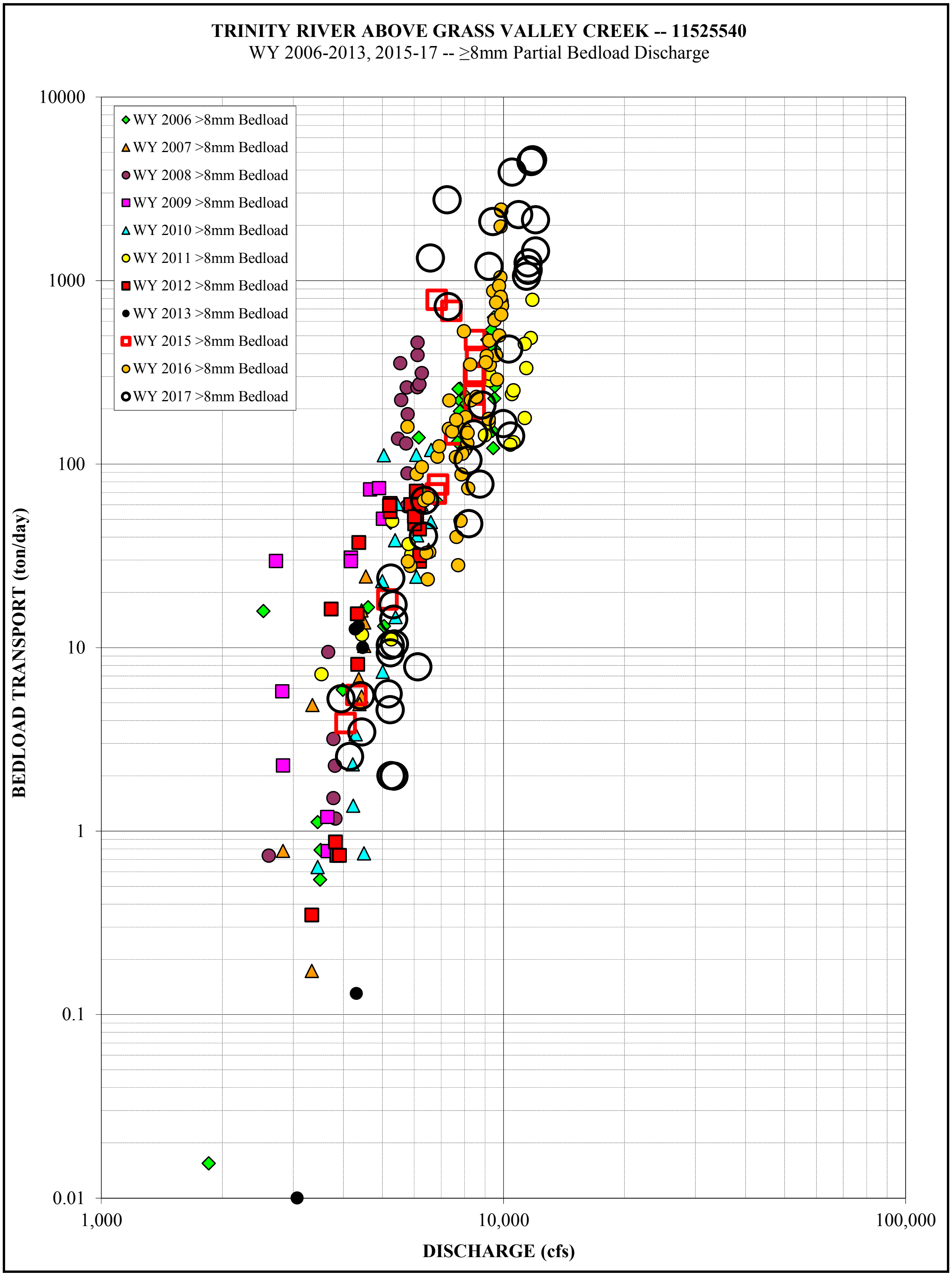


Figure 22. Coarse Bedload Discharge (≥8mm) at TRGV, WY2006-2013, 2015-2017.
The 1999 TRFE bedload equations that were used to develop flow recommendations did not include this site. Thus, no transport curve is presented as was for Figure10.

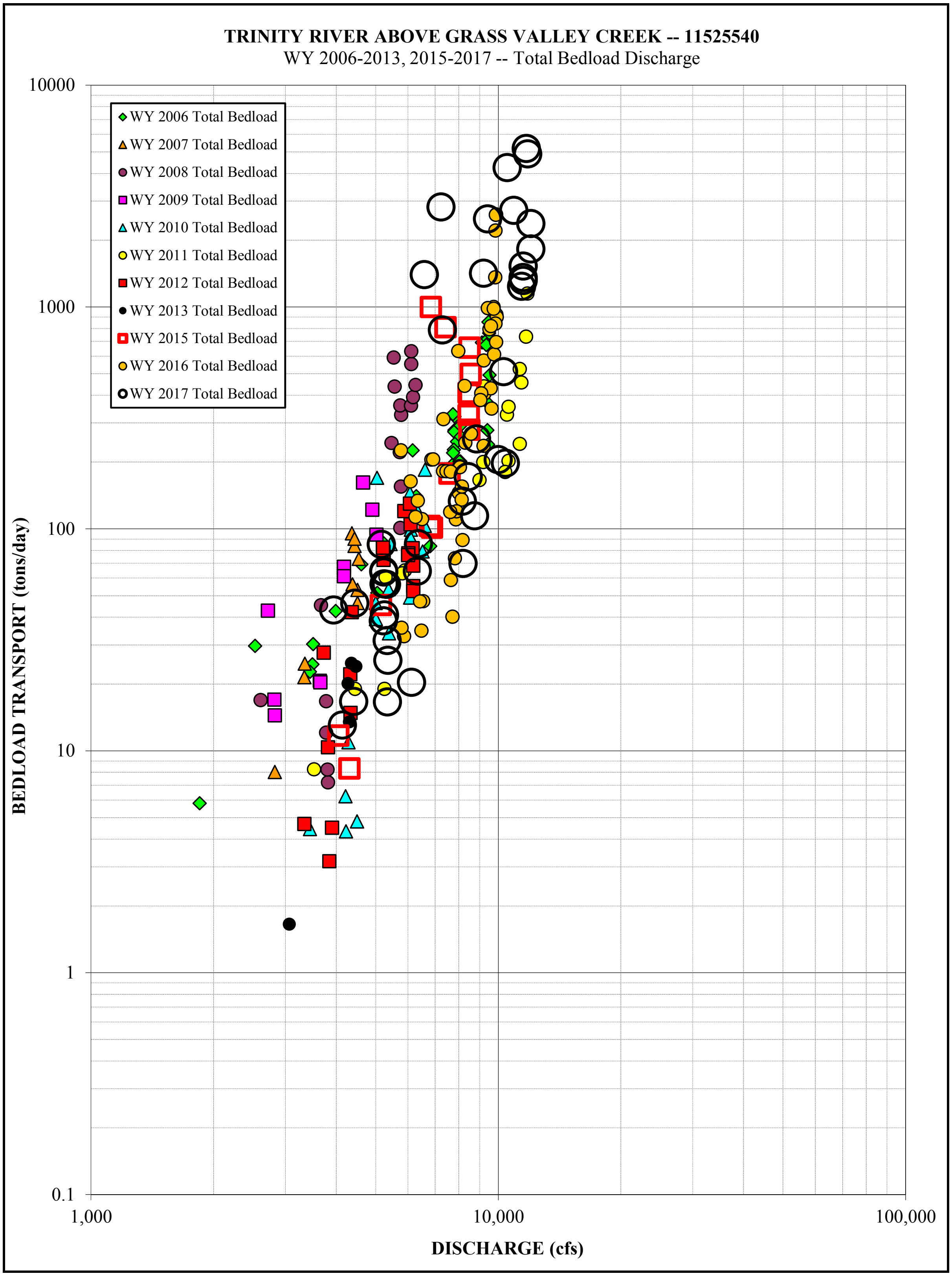


Figure 23. Total Bedload Discharge at TRGV, WY2006-2013, 2015-2017.

Table 7. Trinity River above Grass Valley Creek -- GMA Gage #11525540, Bedload -- WY2017

0.5-<8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
1,110	**8,390**	**9,500**

Values Rounded According to Porterfield (1972)

Water Surface Slope, Cross Section Changes and Pebble Count Changes

The 2017 water surface slope for 8,800 cfs was 0.0013. This value is, however approximately double every other measurement collected in 2016 and 2017 (0.0006 to 0.0007). We could not find a source of error and this value should be used with caution. The gravel injection berm may have elevated the water surface at the upstream end.

Cross section (Figure 24) and pebble count (Figure 25) data were collected at the TRGV sediment monitoring site pre- and post-SFR to assess changes at the sampling section. The thalweg along the far right side of the channel scoured approximately 0.5 ft while the streambed in the main channel aggraded up to 1.1 ft. Total computed scour was 14.6 ft^2, total fill was 41.5 ft^2 for a net change of 26.9 ft^2 fill.

The dominant transport feature through the sampling section appears to be a transverse bar which is developing in response to gravel injection. This bar extends from the injection site down to the low-flow hydraulic control (approximately 400 feet). Pebble counts characterize this transverse bar where it intersects the sampling section, though the rest of the section appears somewhat coarser. The pebble count (n=100+ particles) grain-size distribution curve (Figure 25) shows uniform coarsening. The D50 increased from 29 to 72mm and the D90 increased from 58 to 125mm.

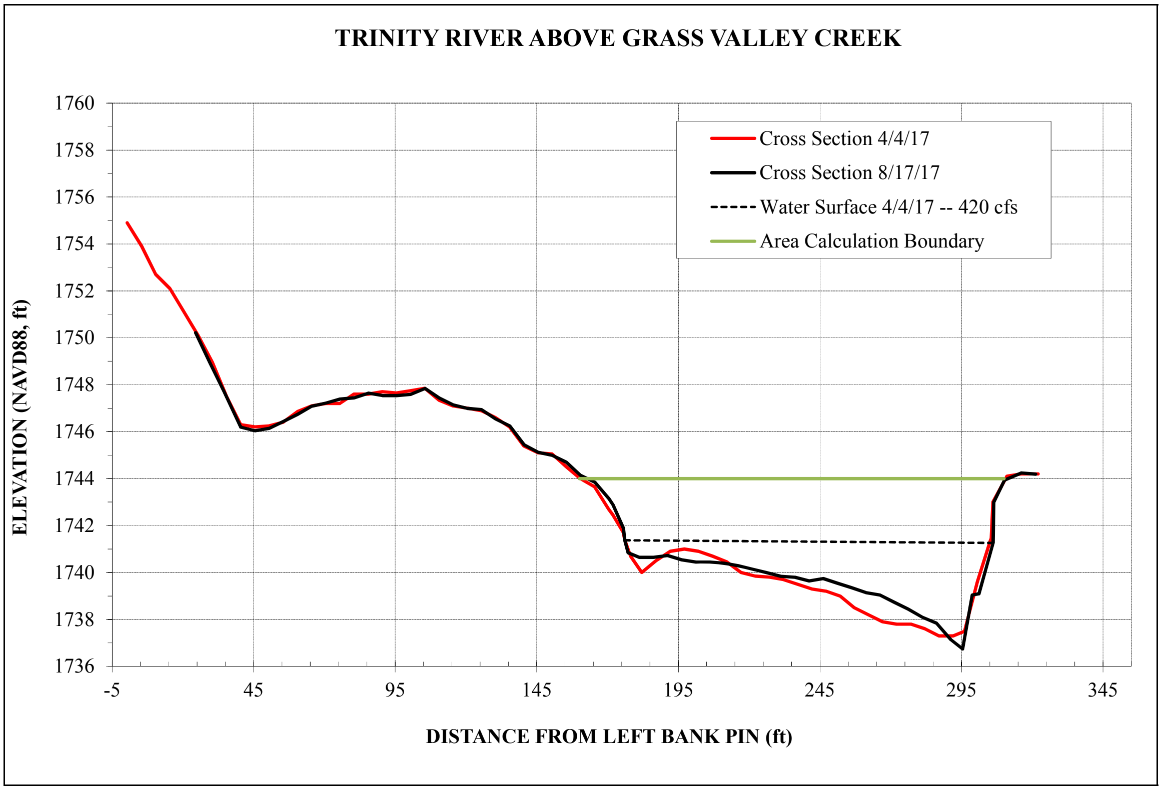


Figure 24. Cross Section Changes at TRGV, pre/post-Spring Flow Release 2017. Downstream view.

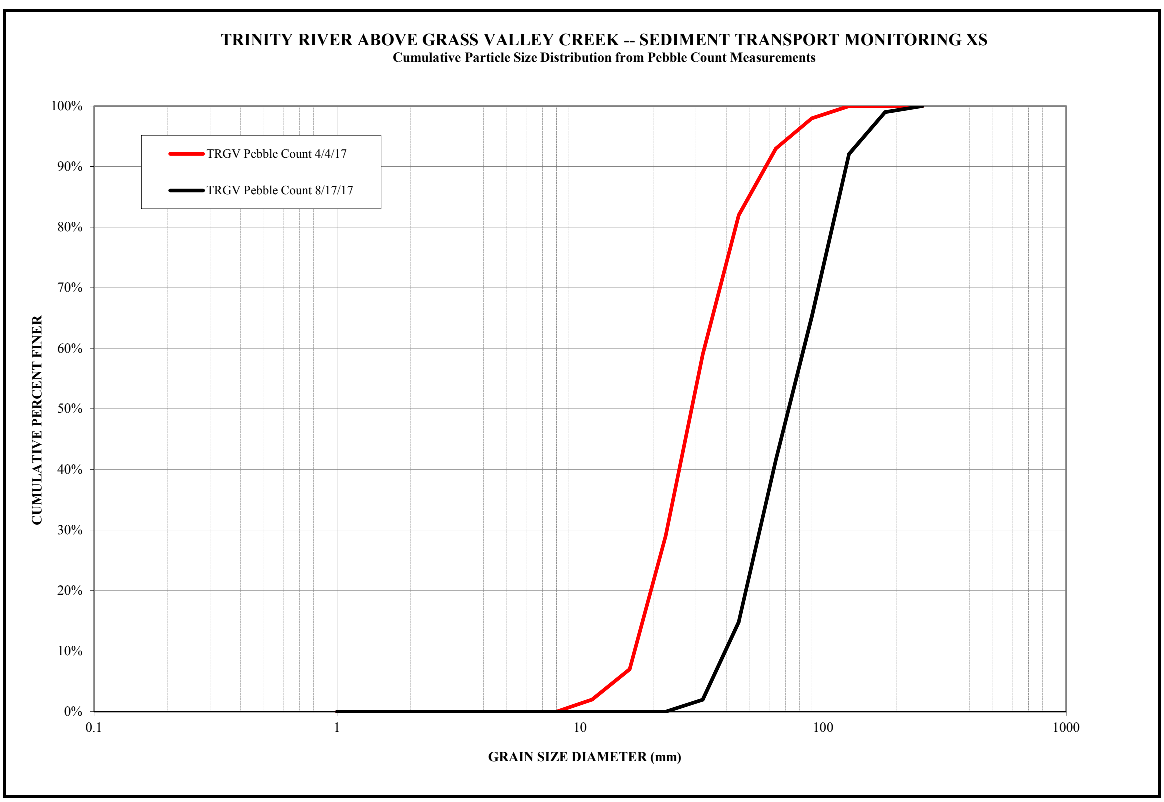


Figure 25. Changes in bed texture at TRGV, pre/post Spring Flow Release 2017.

2.4.2.3 Trinity River below Limekiln Gulch

Station Description

The station is located 60 feet downstream of the USGS streamflow gaging station (#11525655) and 250 feet downstream of the GMA turbidimeter. The section is located upstream of a heavily wooded island with a side channel flowing around the left side (Figure 26). Sampling has occurred at the current sampling location or approximately 30 ft upstream since WY 1998. A two-person cataraft crew collected 68 bedload and six suspended sediment samples at TRLG during the 2017 Spring Flow Release.

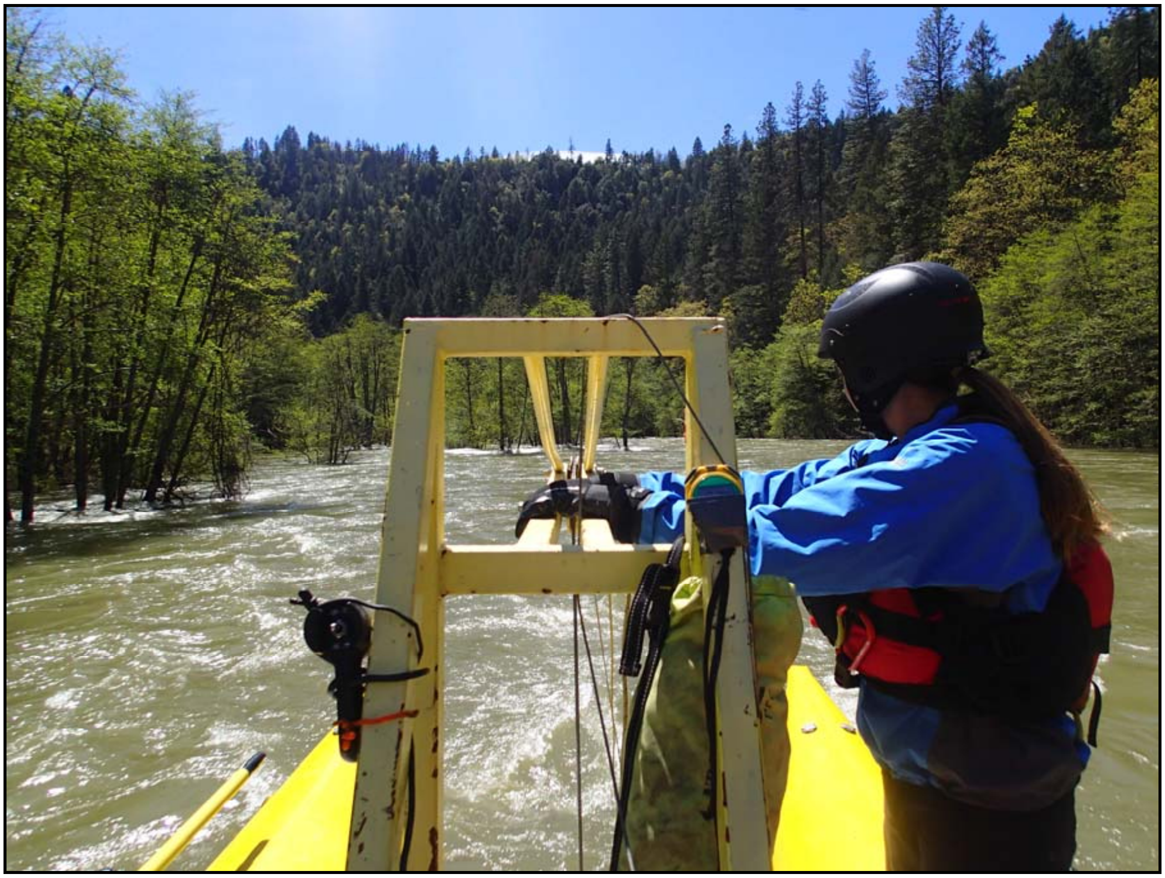


Figure 26. Photograph: downstream view of TRLG sampling site at 12,500 cfs.

Suspended Sediment Transport Data

Six one-pass suspended sediment samples were collected during the Spring Flow Release (Table 8). Measured SSC ranged from a high of 102 mg/l during the first peak on April 25 to a low of 8 mg/l on May 14. The computed suspended sediment discharges for the highest measurement was 1,950 tons/day at 7,080 cfs (Table 8). A power failure resulted in a period of missing turbidity data through May 3 (Appendix C-4). Therefore, additional SSC samples (six in all) were collected and discharge vs SSC relations (Appendix C3) were used to compute <0.063mm, 0.063mm-<0.5mm and ≥0.5mm (partial) suspended sediment discharge. Partial discharges were computed for all three size classes and then summed to compute total SS discharge (Appendix C-1). Partial and total suspended sediment load for the Spring Flow Release were 7,340, 4,210, 760 and 12,310 tons for the <0.063mm, 0.063-<0.50mm, ≥0.50mm size classes and total load respectively (Table 9). The computational methods, assumptions, surrogate relationships, and period of records for which they were applied are described in detail in the Station Analysis (Appendix C-1). Appendix C-10 contains the sample data and SSC computations.

Table 8. Trinity River below Limekiln Gulch -- USGS Gage #11525655, Suspended Sediment Sampling Summary -- WY2017

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC (mg/l)	Average SSD (tons/day)
TRLG-SSCT2017-01	4/25/2017 15:32	7,080	102	1,950
TRLG-SSCT2017-02	4/26/2017 9:24	7,840	49	1,040
TRLG-SSCT2017-03	4/27/2017 12:08	12,300	50	1,660
TRLG-SSCT2017-04	5/1/2017 13:19	6,510	12	211
TRLG-SSCT2017-05	5/11/2017 12:10	5,700	13	200
TRLG-SSCT2017-06	5/14/2017 13:57	5,680	8	123

Values Rounded According to Porterfield (1972)

Table 9. Trinity River below Limekiln Gulch-- USGS Gage #11525655, Suspended Sediment Loads -- WY2017

< 0.063 mm (tons)	0.063 mm-<0.50 mm (tons)	≥0.50 mm (tons)	Total Load (tons)
7,340	4,210	760	12,300

Values Rounded According to Porterfield (1972)

Total suspended sediment discharge values were plotted in Figure 27 along with all historic transport data collected at TRLG, including the historic USGS data from multiple natural winter storm events. Hysteresis (directional changes in concentration at a common discharge) was evident during most Spring Flow Releases (Figure 28); suspended sediment concentrations rise rapidly with the rising flow and drop off quickly during the various flow benches. In Water Year 2017, with a much reduced sampling effort, hysteresis in the sample data was less evident.

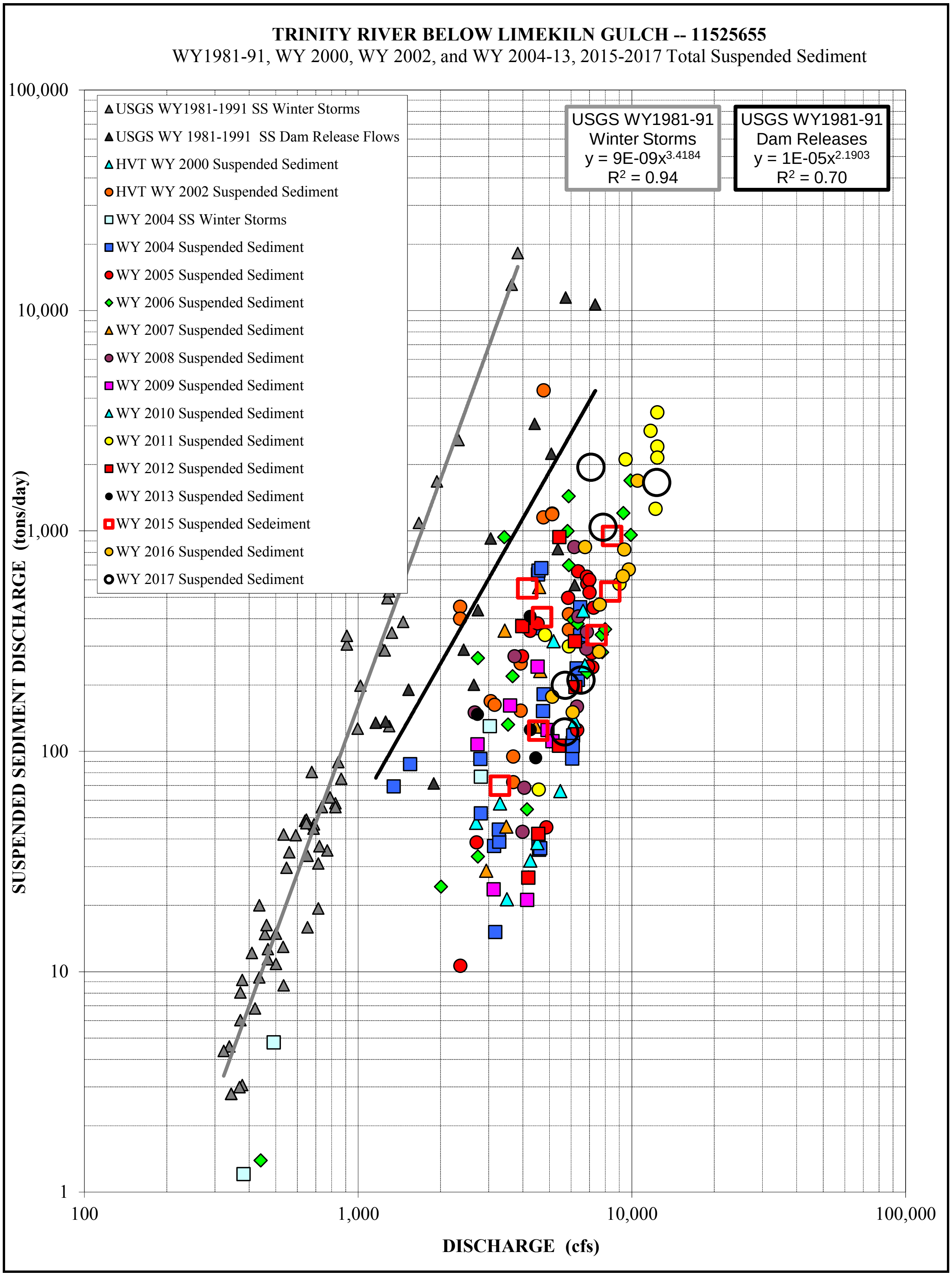


Figure 27. Suspended Sediment Discharge at TRLG, WY1981-1991, 2000, 2002, 2004-2013, 2015-2017.

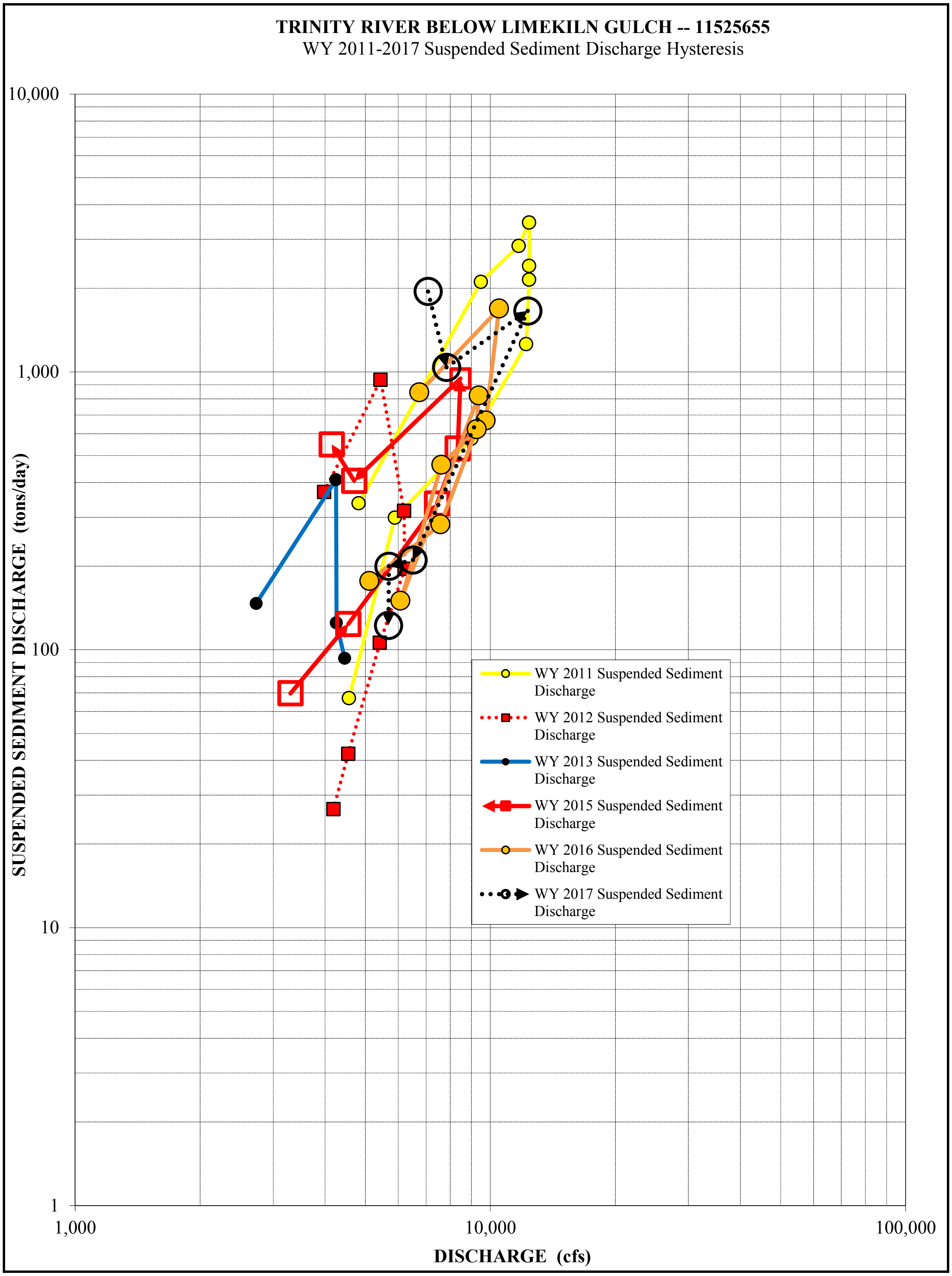


Figure 28. Suspended Sediment Discharge Hysteresis at TRLG, WY 2011-2017.

Bedload Transport Data

Sixty-eight one-pass bedload samples were collected during the Spring Flow Release (Table 10). Appendix C-5 displays the bedload sample collection times on the Spring Flow Release hydrograph. The highest bedload transport rate of 2,120 tons/day was measured at 12,600 cfs on April 28, while the lowest, 12 tons/day was measured at 5,050 cfs on May 2. All measured fine, coarse, and total bedload discharge rates were plotted in Figures 29-31 along with historic data from WY 1981-2016. Details regarding the samples and the sediment discharge computations are provided in the Station Analysis (Appendix C-1).

Bedload transport curves were fit to the WY 2017 bedload discharge data in WISKI. For both fine and coarse bedload, no obvious patterns of hysteresis or changes in rate between flow peaks were observed, therefore, a single generalized transport curve was developed (Appendix C-2). The Sediment Station Analysis (Appendix C-1) describes the time periods over which the transport curves were used for estimating continuous bedload discharge.

Appendix C-5 displays the continuous fine, coarse, and total bedload discharge rates for the Spring Flow Release period. Detailed explanations of assumptions and relationships developed for computing continuous bedload discharge are provided in the Station Analysis (Appendix C-1). All bedload transport curves used to compute continuous sediment discharge are included in Appendix C-2. Appendix C-9 contains the sample data (e.g. weights and computed transport rates) and continuous bedload computation values.

The fine, coarse, and total bedload computed estimates for WY 2017 were 1,740, 3,110 and 4,850 tons, respectively (Table 11). As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations; however, this fraction is included for graphical comparisons with historic values (e.g. Figure 31). We did not compute the 2017 average fraction, but in 2015 the <0.5mm component comprised an average of 3 percent of bedload sample masses.

Table 10. Trinity River below Limekiln Gulch -- USGS Gage #11525655, Bedload Sediment Sampling Summary -- WY2017.

Table 1/2

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	> 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRLG-BLM2017-01	4/25/17 10:58	5,150	45	2	40
TRLG-BLM2017-02	4/25/17 11:46	5,580	49	3	44
TRLG-BLM2017-03	4/25/17 12:59	6,100	81	10	68
TRLG-BLM2017-04	4/25/17 13:27	6,370	63	2	56
TRLG-BLM2017-05	4/25/17 13:58	6,790	37	2	32
TRLG-BLM2017-06	4/25/17 14:30	6,920	133	27	101
TRLG-BLM2017-07	4/26/17 10:17	8,420	135	65	70
TRLG-BLM2017-08	4/26/17 11:01	8,790	180	94	84
TRLG-BLM2017-09	4/26/17 11:52	9,270	416	316	96
TRLG-BLM2017-10	4/26/17 12:37	9,680	418	324	90
TRLG-BLM2017-11	4/26/17 14:30	11,100	316	187	126
TRLG-BLM2017-12	4/26/17 15:20	11,800	871	680	180
TRLG-BLM2017-13	4/27/17 8:52	12,700	770	623	142
TRLG-BLM2017-14	4/27/17 9:39	12,600	913	649	259
TRLG-BLM2017-15	4/27/17 10:53	12,400	691	435	248
TRLG-BLM2017-16	4/27/17 11:22	12,500	637	443	190
TRLG-BLM2017-17	4/27/17 13:50	12,300	880	521	347
TRLG-BLM2017-18	4/27/17 14:26	12,200	561	409	148
TRLG-BLM2017-19	4/28/17 9:25	12,700	1,630	892	736
TRLG-BLM2017-20	4/28/17 10:22	12,600	1,040	841	196
TRLG-BLM2017-21	4/28/17 11:19	12,700	1,640	1,030	607
TRLG-BLM2017-22	4/28/17 12:05	12,700	971	667	300
TRLG-BLM2017-23	4/28/17 13:54	12,700	1,330	848	475
TRLG-BLM2017-24	4/28/17 14:37	12,700	1,320	886	432
TRLG-BLM2017-25	4/28/17 15:38	12,600	2,120	1,590	518
TRLG-BLM2017-26	4/28/17 16:15	12,600	1,540	1,120	418
TRLG-BLM2017-27	4/29/17 8:52	12,300	665	480	181
TRLG-BLM2017-28	4/29/17 9:30	12,200	1,200	922	273
TRLG-BLM2017-29	4/29/17 10:24	11,900	979	693	281
TRLG-BLM2017-30	4/29/17 11:00	12,000	1,060	851	206
TRLG-BLM2017-31	4/29/17 12:51	11,700	875	698	172
TRLG-BLM2017-32	4/29/17 13:27	11,700	923	703	216
TRLG-BLM2017-33	4/29/17 14:17	11,400	574	435	136
TRLG-BLM2017-34	4/29/17 14:55	11,300	657	535	118
TRLG-BLM2017-35	4/30/17 9:31	9,270	391	322	68
TRLG-BLM2017-36	4/30/17 10:02	9,180	418	329	87
TRLG-BLM2017-37	4/30/17 10:45	9,190	460	369	89
TRLG-BLM2017-38	4/30/17 11:16	9,150	421	336	83
TRLG-BLM2017-39	4/30/17 12:45	8,940	502	429	71
TRLG-BLM2017-40	4/30/17 13:18	8,810	230	168	62
TRLG-BLM2017-41	4/30/17 15:12	8,340	213	157	55
TRLG-BLM2017-42	4/30/17 15:42	8,340	423	352	69
TRLG-BLM2017-43	5/1/17 8:43	7,010	261	221	39
TRLG-BLM2017-44	5/1/17 10:09	6,670	170	140	29

Values Rounded According to Porterfield (1972)

Table 2/2

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	> 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRLG-BLM2017-45	5/1/17 10:42	6,680	192	161	31
TRLG-BLM2017-46	5/1/17 11:12	6,620	312	266	45
TRLG-BLM2017-47	5/1/17 13:47	6,450	62	15	46
TRLG-BLM2017-48	5/1/17 14:28	6,420	115	64	50
TRLG-BLM2017-49	5/2/17 9:21	5,030	28	14	14
TRLG-BLM2017-50	5/2/17 10:09	5,040	66	57	8
TRLG-BLM2017-51	5/2/17 11:11	4,980	21	6	15
TRLG-BLM2017-52	5/2/17 11:45	5,050	12	3	9
TRLG-BLM2017-53	5/2/17 13:25	4,840	40	13	27
TRLG-BLM2017-54	5/2/17 13:59	4,630	26	6	20
TRLG-BLM2017-55	5/2/17 14:47	4,660	39	30	10
TRLG-BLM2017-56	5/11/17 9:00	5,720	86	59	26
TRLG-BLM2017-57	5/11/17 9:41	5,670	46	14	32
TRLG-BLM2017-58	5/11/17 10:45	5,700	44	3	40
TRLG-BLM2017-59	5/11/17 10:57	5,700	45	13	32
TRLG-BLM2017-60	5/11/17 12:45	5,690	32	8	23
TRLG-BLM2017-61	5/11/17 13:30	5,740	51	23	27
TRLG-BLM2017-62	5/11/17 14:15	5,720	59	24	34
TRLG-BLM2017-63	5/14/17 9:33	5,630	98	57	40
TRLG-BLM2017-64	5/14/17 10:08	5,680	44	10	34
TRLG-BLM2017-65	5/14/17 10:42	5,640	52	23	28
TRLG-BLM2017-66	5/14/17 11:16	5,670	31	5	26
TRLG-BLM2017-67	5/14/17 11:55	5,640	98	63	34
TRLG-BLM2017-68	5/14/17 12:13	5,660	64	17	47

Values Rounded According to Porterfield (1972)

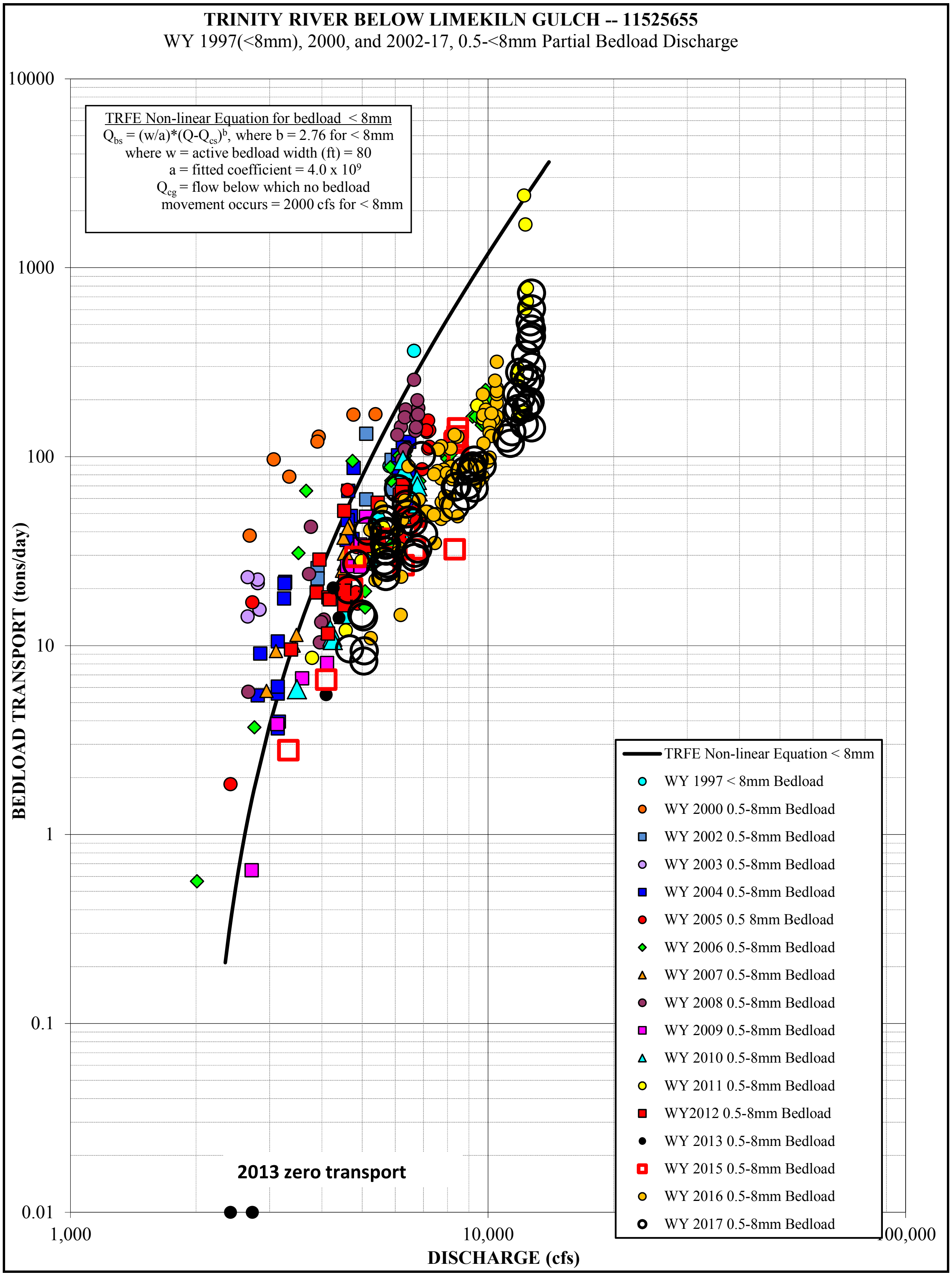


Figure 29. Fine Bedload Discharge (0.5-<8mm) at TRLG, WY1997-2013, 2015-2017.
The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG (shown in the inset box on chart). The equation is plotted and shown here as the dashed black line and is included for comparison with subsequent measured bedload transport rates.

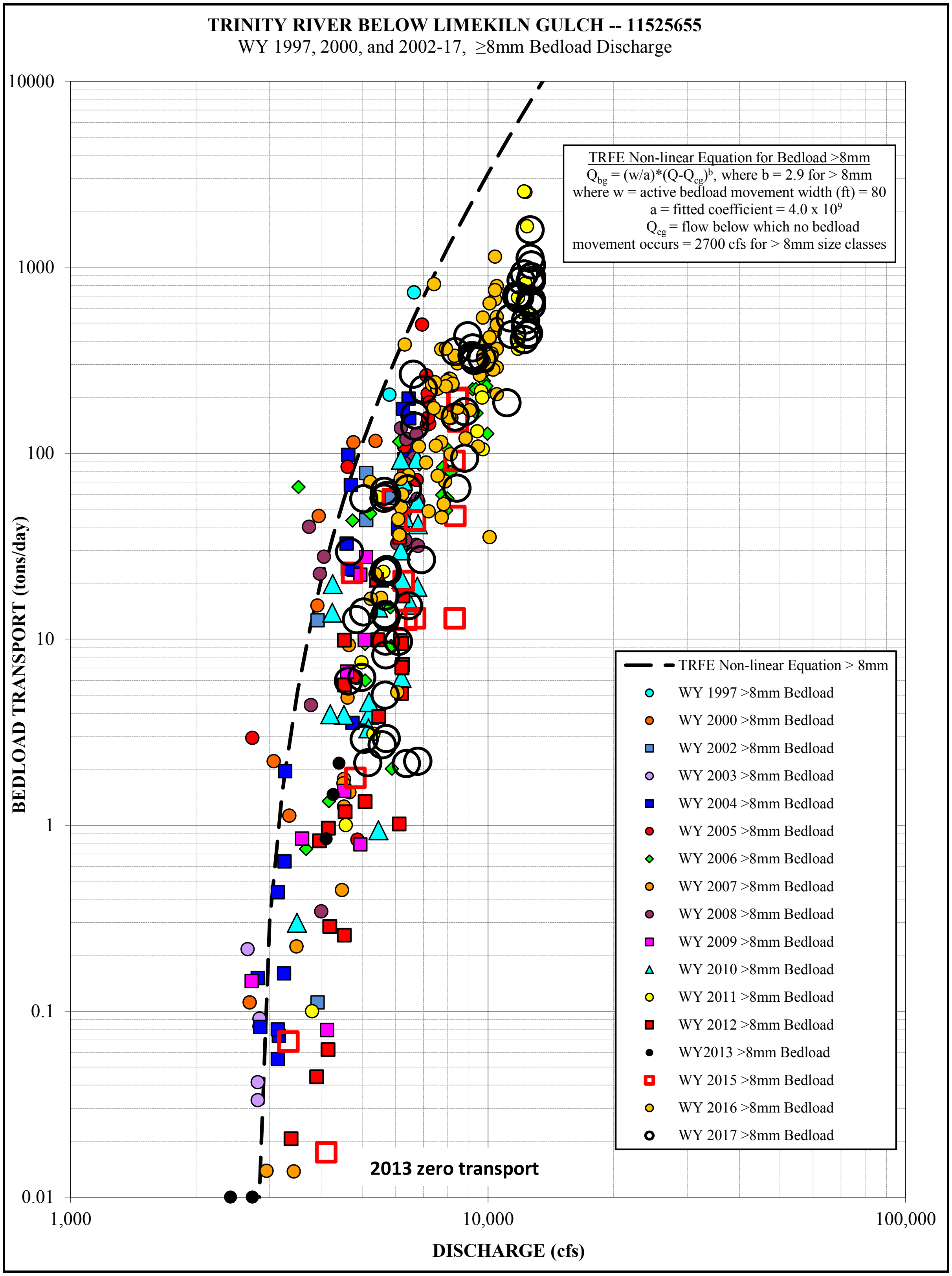


Figure 30. Coarse Bedload Discharge (≥8mm) at TRLG, WY1997-2013, 2015-2017.

The 1999 TRFE bedload equations were used to develop flow recommendations based in part on bedload discharge predictions at TRAL and TRLG (shown in the inset box on chart). The equation is plotted and shown here as the dashed black line and is included for comparison with subsequent measured bedload transport rates.

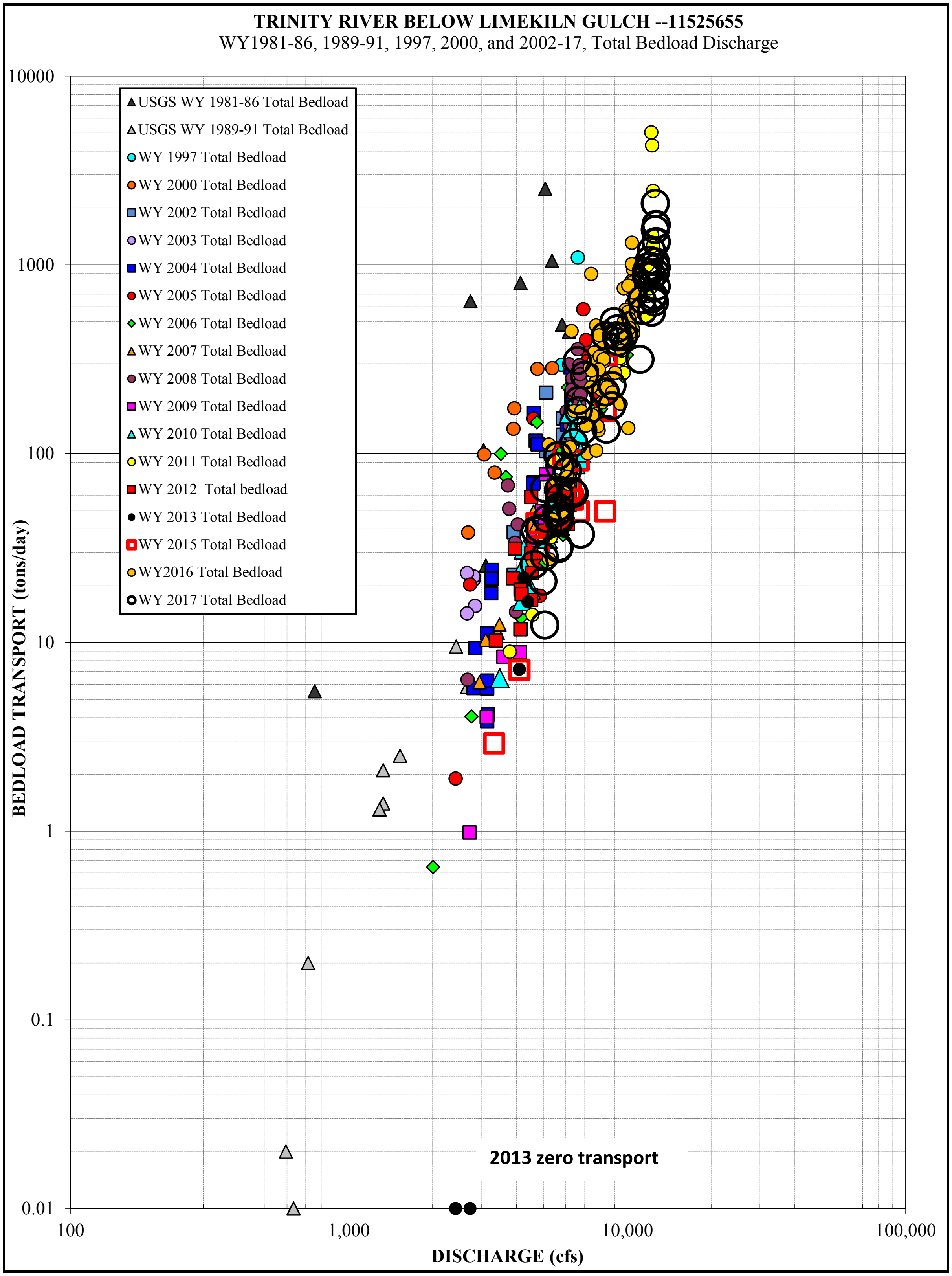


Figure 31. Total Bedload Discharge at TRLG, WY1997-2013, 2015-2017.

Table 11. Trinity River below Limekiln Gulch -- USGS Gage #11525655, Bedload -- WY2017

0.5-<8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
1,740	3,110	4,850

Values Rounded According to Porterfield (1972)

Water Surface Slope, Cross Section Changes and Pebble Count Changes

The 2017 water surface slope at 12,600 cfs was 0.0028. Cross section and pebble count data were collected at the TRLG sediment monitoring site pre- and post-SFR to assess changes at the sampling section. Changes in the cross section and particle size distribution from the pebble count data are shown in Figures 32 and 33. The total computed scour at the sampling section was 22 ft^2, the total fill was 26 ft^2, for a net fill of 4.0 ft^2. The pebble count at this site describes the transverse riffle intersecting the right quarter (near station 200) of the sampling section. The left half of the section is deeper with bedrock fins and coarser boulder elements. The pebble count pre- and post-SFR curves suggest coarsening which is more pronounced at the coarse end of the distribution where separation of the curves is greater (Figure 33). The D50 increased from 41 to 52mm and the D90 increased from 63 to 99mm.

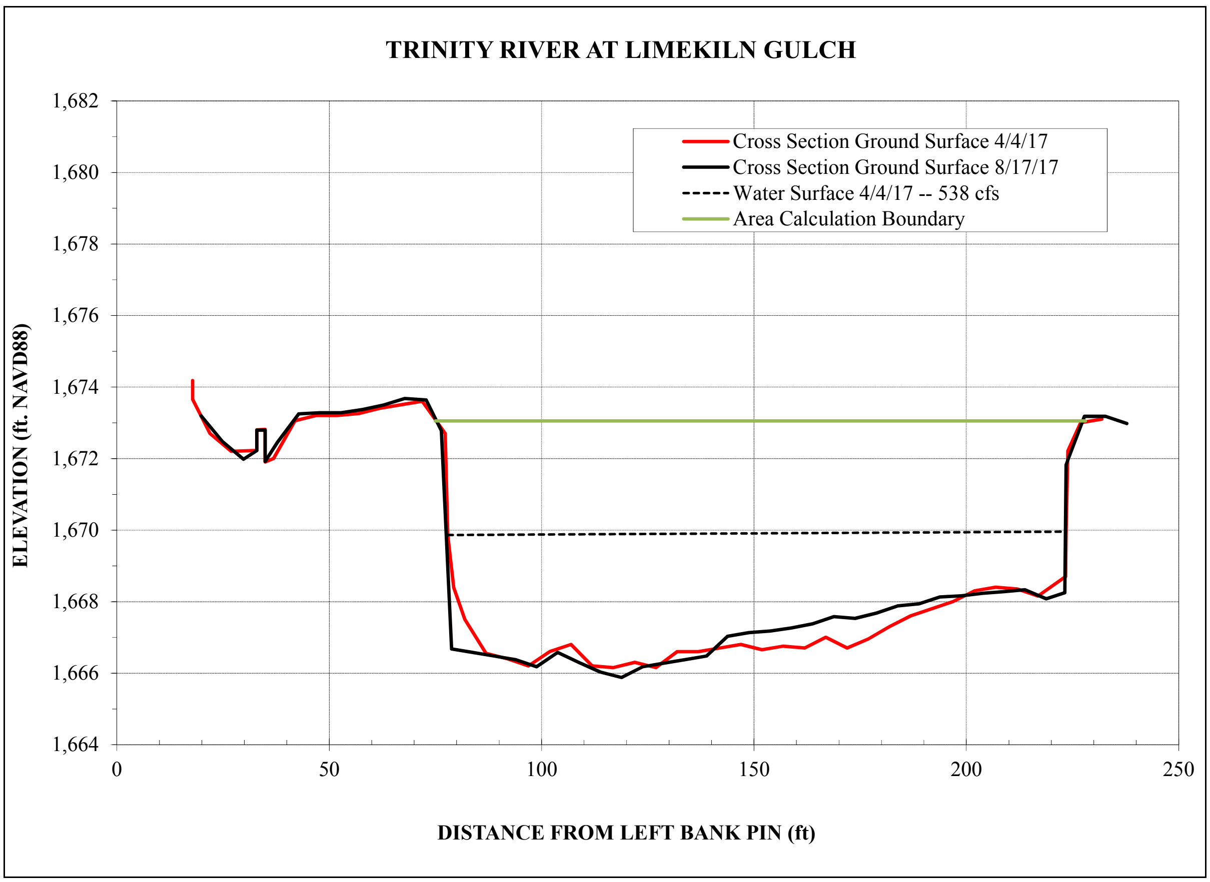


Figure 32. TRLG Cross Section Changes, pre/post-Spring Flow Release 2017.

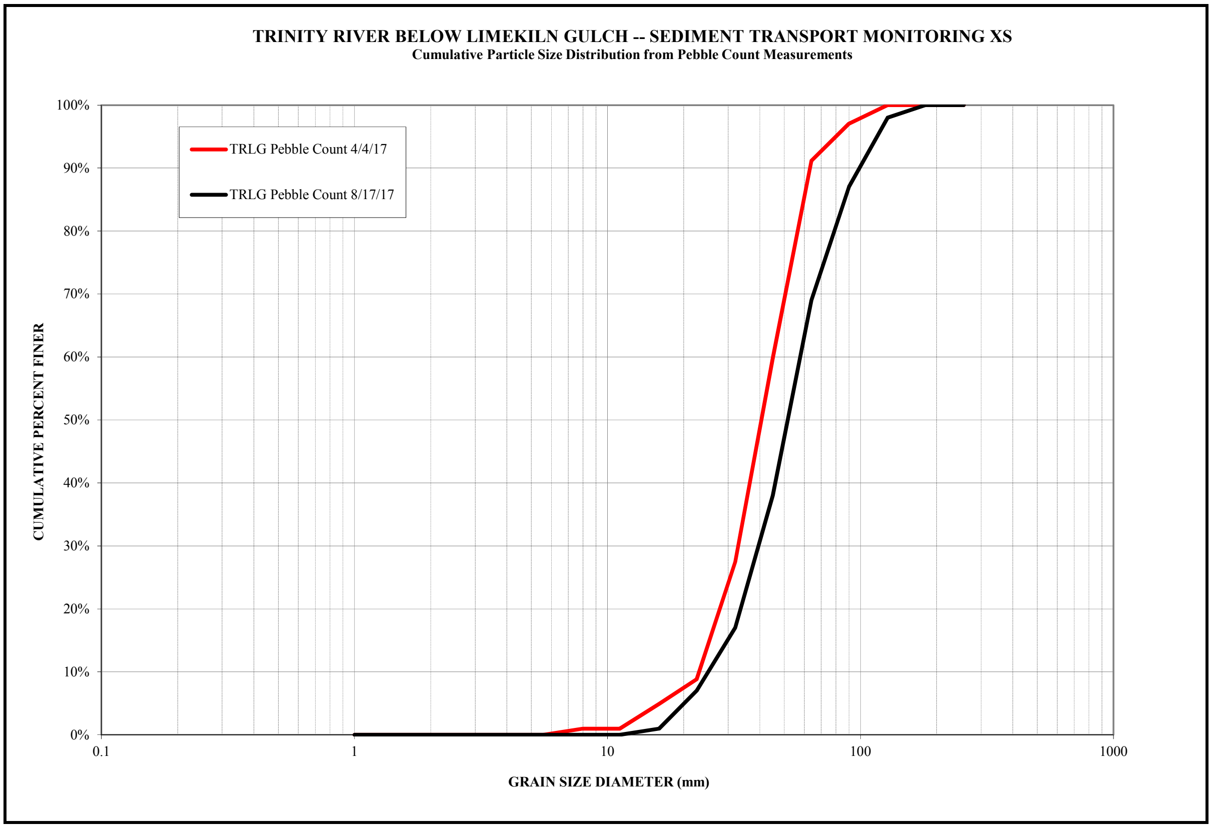


Figure 33. Changes in bed texture at TRLG, pre/post Spring Flow Release 2017.

Bulk Sample and Scour Data

Bulk samples were collected (1) to determine if the sub-surface grain size distribution of "supply areas" (upstream or adjacent bars) represents the grain size distribution of bedload during peak flow events and (2) to examine changes to sub-surface grain size distributions resulting from the Spring Flow Release. Pebble counts at each site facilitate an examination of bed texture before and after the Spring Flow Release and scour cores reveal whether and to what degree a feature is activated (scoured).

Two sites were evaluated near the TRLG sampling site. The first is in the bar/riffle above the BLM Steel Bridge river access point, approximately 950 feet upstream of the cableway (Upper TRLG). The other is 20 feet downstream of the sampling section cableway (at station 175) along the right bank (Lower TRLG, Figure 34, 35).

<u>TRLG Upper</u>

The pre- and post-SFR pebble counts site showed very little change; the D50 decreased from 71 to 69mm (Figure 36). No scour core rocks were recovered in the post-event monitoring effort. A level survey indicated that the post-Spring Flow Release bed surface was exactly 1 foot lower. We collected a subsurface bulk sample to compare with the pre-SFR sample and with the mean of the 12,600 cfs bedload samples collected on April 28 (Figure 37). The pre and post samples appear quite similar with D50s of 46 and 49mm respectively. Other than at the tails of the distributions, where for example the D90 for the pre-SFR bulk samples is

120mm and the bedload D90 is 117mm, the bulk samples are much coarser than the bedload sample with a D50 of 46 to 49mm versus 31mm for the bedload D50.

Lower TRLG

The lower site was located along the right side of the sampling section approximately 20 feet downstream of the cableway. The pebble count area is the same as the one monitored for the sampling site and showed coarsening (see previous section and Figure 33). The scour core location showed 0.3 feet of scour and no fill. The painted scour rocks were discovered at the surface of the riverbed so no post-bulk sample was collected.

A comparison of the lower TRLG sub-surface sample versus the mean of all bedload samples collected at the highest flow shows that the distributions cross near the 50th percentile. However, this material was not activated (scoured) below 0.3 feet by the Spring Flow Release.

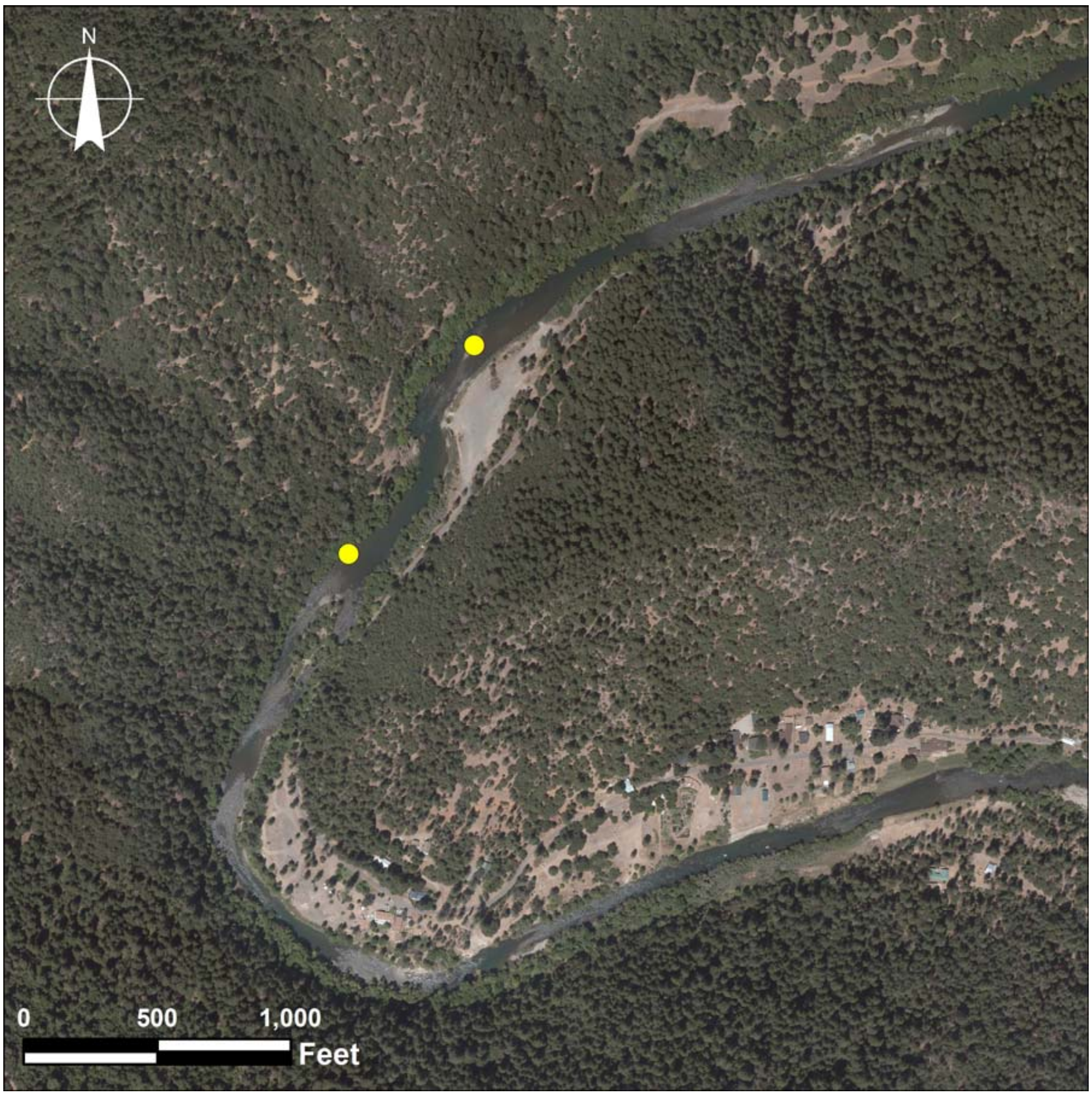


Figure 34. Location map showing 2017 TRLG bulk sampling/scour monitoring sites.

Figure 35. Bulk sampling pre Spring flow release at TRLG cableway. View is downstream.

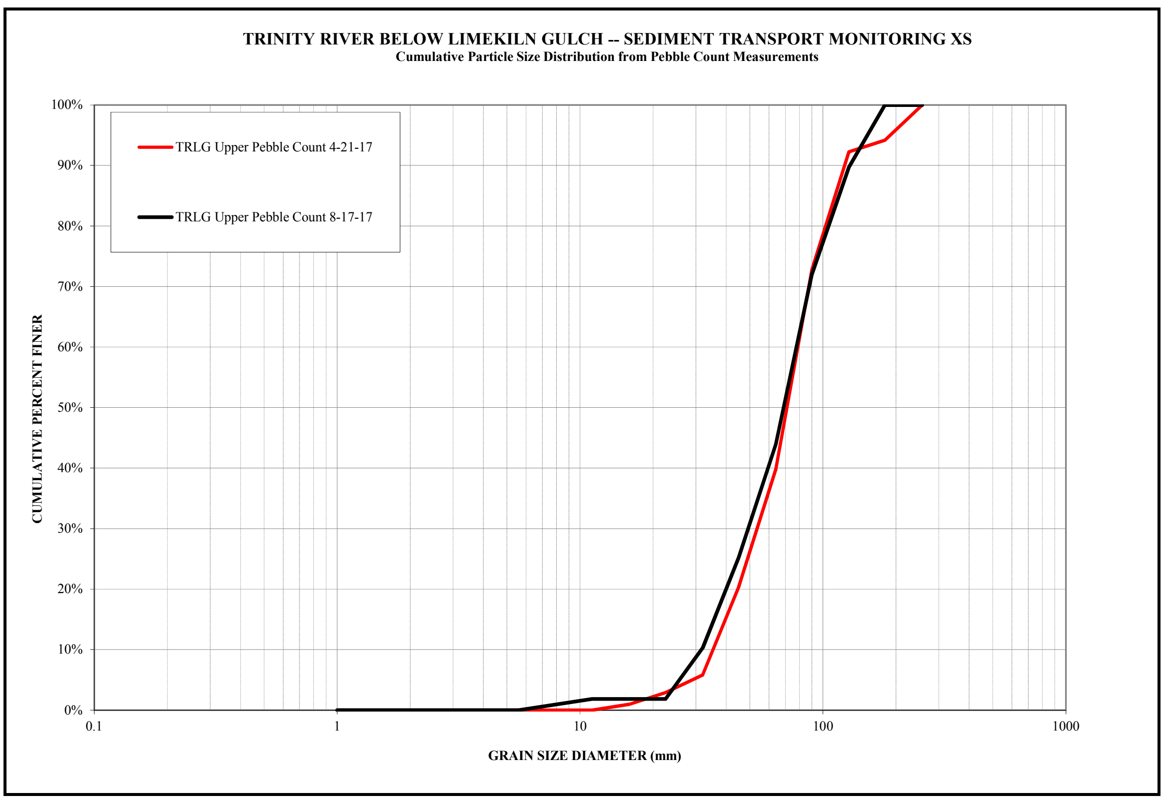


Figure 36. Surface grain size distributions at Upper TRLG, pre/post 2017 Spring Flow Release.

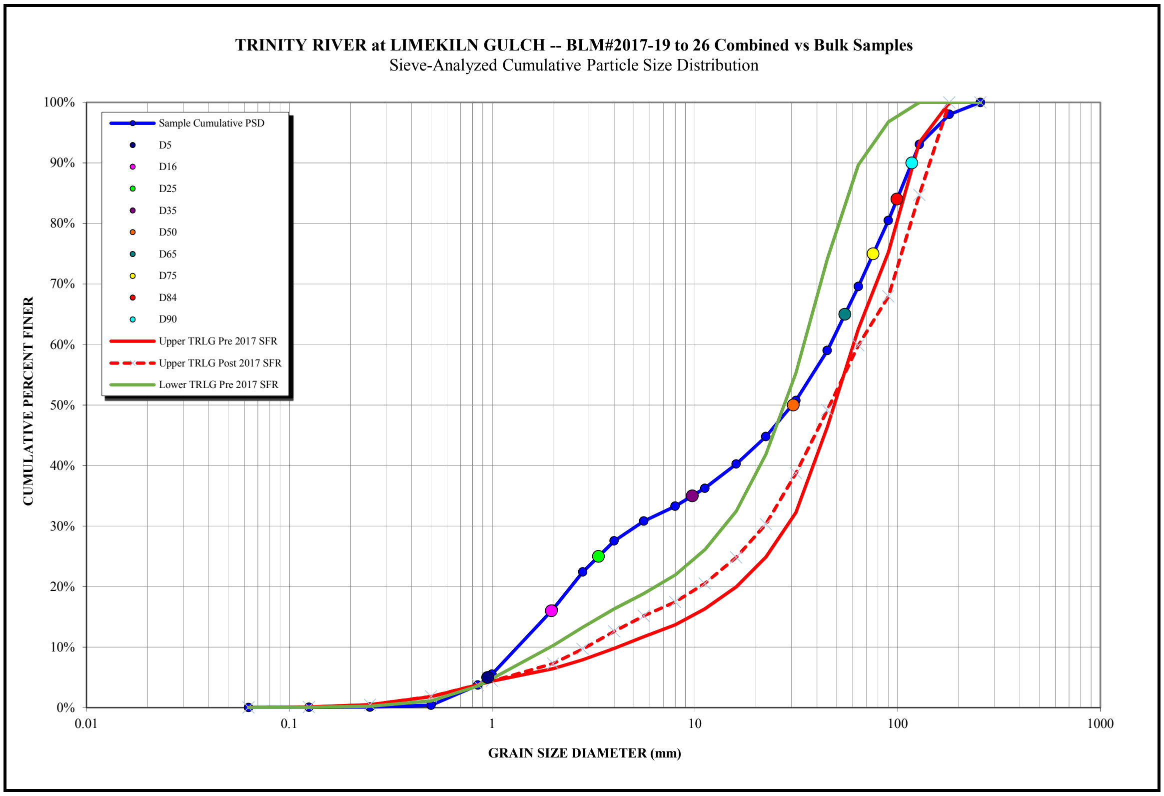


Figure 37. A comparison of pre/post-2017 Spring Flow Release sub-surface grain size distributions versus the mean grain size distribution of the April 28 (12,600 cfs) bedload samples.

<u>2.4.2.4 Trinity River near Douglas City</u>

Station Description

The TRDC sediment monitoring cross-section (Figure 38) was relocated approximately 200 feet downstream in 2012 from its 2011 location due to hydraulic complexity and bedrock elements at and upstream of the sampling section. The more favorable hydraulic conditions at the new sampling location facilitate better sampling coverage and presumably results in higher quality sediment transport data. The water surface slope is the highest of all the mainstem stations at 0.003 (2017 at approximately 13,000 cfs). Sediment transport monitoring has occurred at TRDC since WY 2004. The USGS gaging station is now located at the upstream end of the BLM Douglas City Campground, and the sediment transport monitoring station is located approximately two hundred and forty feet downstream of the gaging station.

As is typical during very high flow releases, TRDC presented numerous challenges to the sampling crew. No data were collected on the first day due to the logistical challenges of covering TRAL and TRDC. No data were collected on April 29 due to the crew's deployment to TRGV to resurrect the cableway there. The very large old growth cottonwood located along the right bank at TRDC fell into the river, across the cableway on April 26. The tree severely stressed the cableway system so the crew inspected all elements, re-tensioned the system and resumed sampling. The right bank of the sampling section, de-stabilized by the missing tree's root mass, rapidly eroded and increased the width of the sampling section by about 10 feet. During the release, both TRDC cableway anchors showed evidence of compromise (leaning toward mid-channel) and both were temporarily stabilized with back-stay ground anchors.

Figure 38. View from right bank at TRDC on April 26, 2017 at 11,000 cfs.

Suspended Sediment Transport Data

All four suspended sediment samples consisted of one pass samples. Measured SSC ranged from a high of 153 mg/l on April 26, to 24 mg/l on May 2, the last day of suspended sediment sampling. The associated computed suspended sediment discharges were 3,960 and 337 tons/day which were measured at 9,590 and 5,210 cfs (Table 12). Total suspended sediment discharge values are plotted in Figure 39, with transport data from WY 2004-2017.

Continuous turbidity was measured beginning April 5, 2017 at 11:45 (Appendix D-4). The turbidity versus SSC relationship proved adequate for the two smaller size classes and turbidity was used as a surrogate for SSC (Appendix D-3). A discharge relation better represented the ≥0.5mm class and was used to compute the load. Suspended sediment discharges for the three classes were summed to compute the total suspended sediment discharge (Appendix D-6). The <0.063mm, 0.063-<0.5mm, and ≥0.5mm partial loads and total load were 8,300, 9,750, 4,940 and 23,000 tons (Table 13). Appendix D-10 contains the sample data and SSC computations.

Table 12. Trinity River at Douglas City-- USGS Gage #11525854, Suspended Sediment Sampling Summary -- WY2017

Sample Number	Date & Mean Time	Average Discharge (cfs)	Average SSC (mg/l)	Average SSD (tons/day)
TRDC-SSCT2017-01	4/26/2017 12:32	9,590	153	3,960
TRDC-SSCT2017-02	4/28/2017 10:12	13,200	108	3,850
TRDC-SSCT2017-03	4/30/2017 10:10	10,400	44	1,230
TRDC-SSCT2017-04	5/2/2017 15:13	5,210	24	337

Values Rounded According to Porterfield (1972)

Table 13. Trinity River at Douglas City-- USGS Gage #11525854, Suspended Sediment Loads -- WY2017

< 0.063 mm (tons)	0.063 mm-<0.50 mm (tons)	≥0.50 mm (tons)	Total Load (tons)
8,300	9,750	4,940	23,000

Values Rounded According to Porterfield (1972)

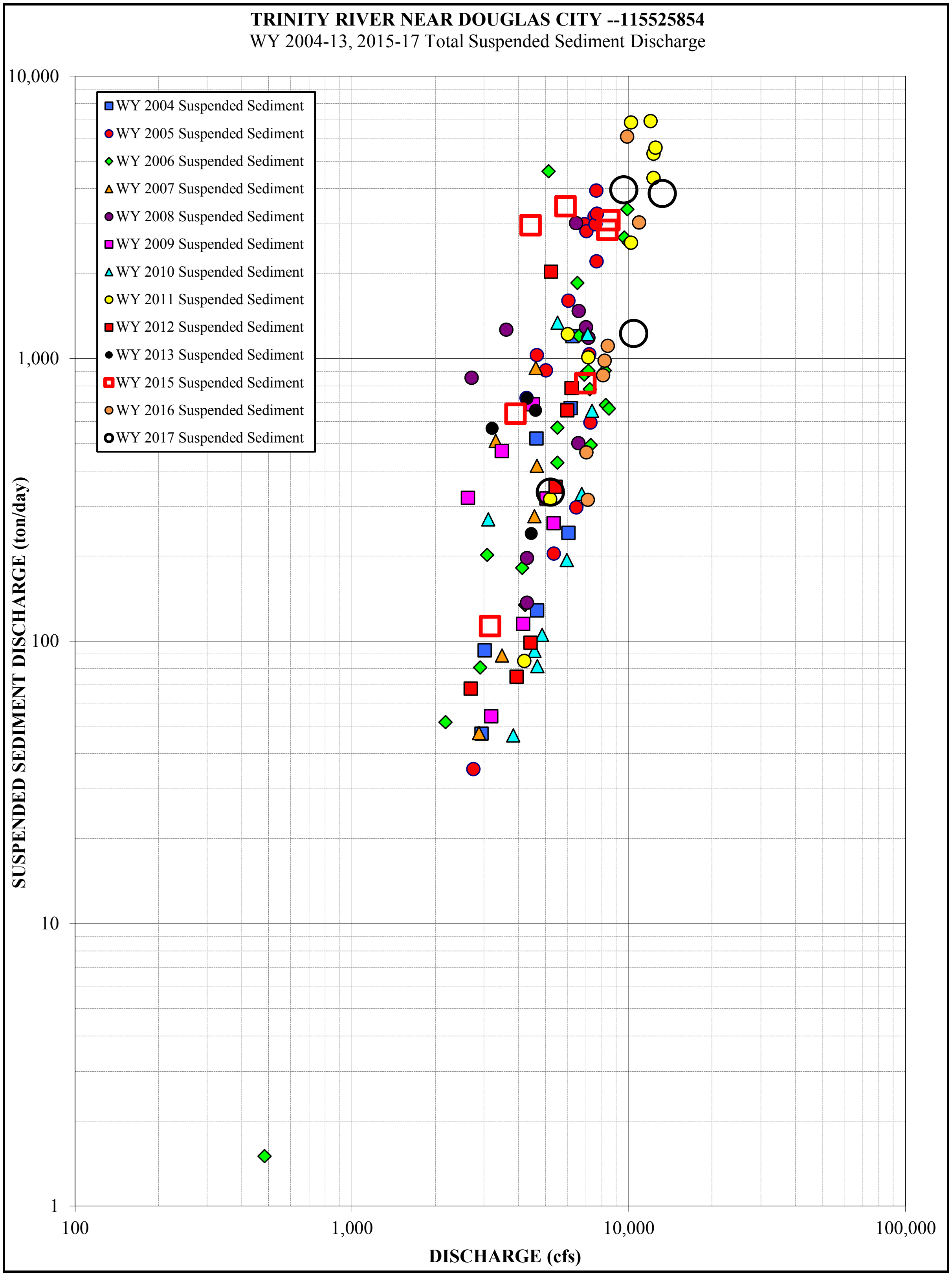


Figure 39.Total Suspended Sediment Discharge at TRDC, WY2004-2013, 2015-2017.

Bedload Transport Data

Thirty nine bedload samples were collected during the Spring Flow Release. Table 14 summarizes the sample bedload discharge data. Measured bedload discharge for Total bedload peaked on April 26 at 15,000 tons/day at 10,900 cfs (Table 14). Appendix D-9 contains the sample data (e.g. weights and computed transport rates) and bedload computation values. Bedload discharge rates were plotted in Figures 40-42 with the previous nine years of data. Bedload transport rates for fine and coarse sediment were computed using a single generalized equation developed from WY 2017 bedload samples (Appendix D-2). Fine, coarse, and total bedload estimates were 5,510, 18,200 and 23,700 tons, respectively (Table 15). As discussed in section 2.3.4, the <0.5mm fraction is omitted from bedload data and computations; however, this fraction is included for graphical comparisons with historic values (e.g. Figure 42).

The partial transport curves used to compute continuous bedload discharge are included in Appendix D-4. A complete explanation of assumptions and techniques employed in the continuous bedload discharge and load computation process is provided in the Station Analysis (Appendix D-1). The bedload sedigraphs are shown in Appendix D-2. Bedload samples were partitioned to support hydrophone experiments conducted by USGS, NOAA Fisheries and University of Mississippi.

Table 14. Trinity River at Douglas City -- USGS Gage #11525854, Bedload Sediment Sampling Summary -- WY2017

Sample Number	Date & Mean Time	Average Discharge (cfs)	Total Bedload Discharge (tons/day)	> 8mm Bedload Discharge (tons/day)	0.5-8 mm Bedload Discharge (tons/day)
TRDC-BLM2017-01	04/26/2017 10:37	8,650	3,470	2,420	1,000
TRDC-BLM2017-02	04/26/2017 11:37	9,220	3,220	2,450	710
TRDC-BLM2017-03	04/26/2017 13:23	10,100	6,910	5,450	1,340
TRDC-BLM2017-04	04/26/2017 15:09	10,900	15,000	13,300	1,540
TRDC-BLM2017-05	04/26/2017 15:48	11,300	6,950	5,280	1,450
TRDC-BLM2017-06	04/27/2017 15:10	12,900	3,760	3,330	414
TRDC-BLM2017-07	04/27/2017 15:50	12,800	3,640	2,960	661
TRDC-BLM2017-08	04/28/2017 10:28	13,000	5,140	4,090	1,020
TRDC-BLM2017-09	04/28/2017 11:29	13,100	830	556	264
TRDC-BLM2017-10	04/28/2017 12:02	13,200	4,250	3,090	1,140
TRDC-BLM2017-11	04/28/2017 13:53	13,000	4,510	2,560	1,910
TRDC-BLM2017-12	04/28/2017 14:32	13,100	4,520	4,160	338
TRDC-BLM2017-13	04/30/2017 10:42	10,300	1,920	1,450	451
TRDC-BLM2017-14	04/30/2017 11:30	10,100	2,250	1,650	580
TRDC-BLM2017-15	04/30/2017 11:58	10,300	996	681	307
TRDC-BLM2017-16	04/30/2017 12:58	10,200	1,150	846	295
TRDC-BLM2017-17	04/30/2017 13:53	10,000	1,070	885	174
TRDC-BLM2017-18	04/30/2017 14:38	9,670	1,250	828	409
TRDC-BLM2017-19	04/30/2017 15:11	9,490	876	481	385
TRDC-BLM2017-20	05/01/2017 09:32	8,090	1,110	699	409
TRDC-BLM2017-21	05/01/2017 10:11	7,890	323	229	91
TRDC-BLM2017-22	05/01/2017 13:20	7,530	462	298	155
TRDC-BLM2017-23	05/01/2017 13:52	7,560	792	459	323
TRDC-BLM2017-24	05/01/2017 14:37	7,330	898	538	351
TRDC-BLM2017-25	05/01/2017 15:17	7,230	278	226	50
TRDC-BLM2017-26	05/02/2017 13:55	5,400	308	154	146
TRDC-BLM2017-27	05/02/2017 14:24	5,330	190	112	76
TRDC-BLM2017-28	05/12/2017 08:56	6,090	420	304	112
TRDC-BLM2017-29	05/12/2017 09:48	6,130	470	249	211
TRDC-BLM2017-30	05/12/2017 10:57	6,100	295	123	164
TRDC-BLM2017-31	05/12/2017 11:33	6,100	329	182	140
TRDC-BLM2017-32	05/12/2017 13:36	6,090	299	178	114
TRDC-BLM2017-33	05/12/2017 13:42	6,040	379	148	222
TRDC-BLM2017-34	05/15/2017 09:47	6,020	133	99	33
TRDC-BLM2017-35	05/15/2017 10:30	5,980	104	74	29
TRDC-BLM2017-36	05/15/2017 11:22	5,960	153	98	53
TRDC-BLM2017-37	05/15/2017 12:03	5,980	314	248	65
TRDC-BLM2017-38	05/15/2017 12:46	5,800	180	96	80
TRDC-BLM2017-39	05/15/2017 13:22	5,830	113	91	21

Values Rounded According to Porterfield (1972)

Table 15. Trinity River at Douglas City -- USGS Gage #11525854, Bedload -- WY2017

0.5-<8 mm (tons)	≥8 mm (tons)	Total Bedload (tons)
5,510	18,200	23,700

Values Rounded According to Porterfield (1972)

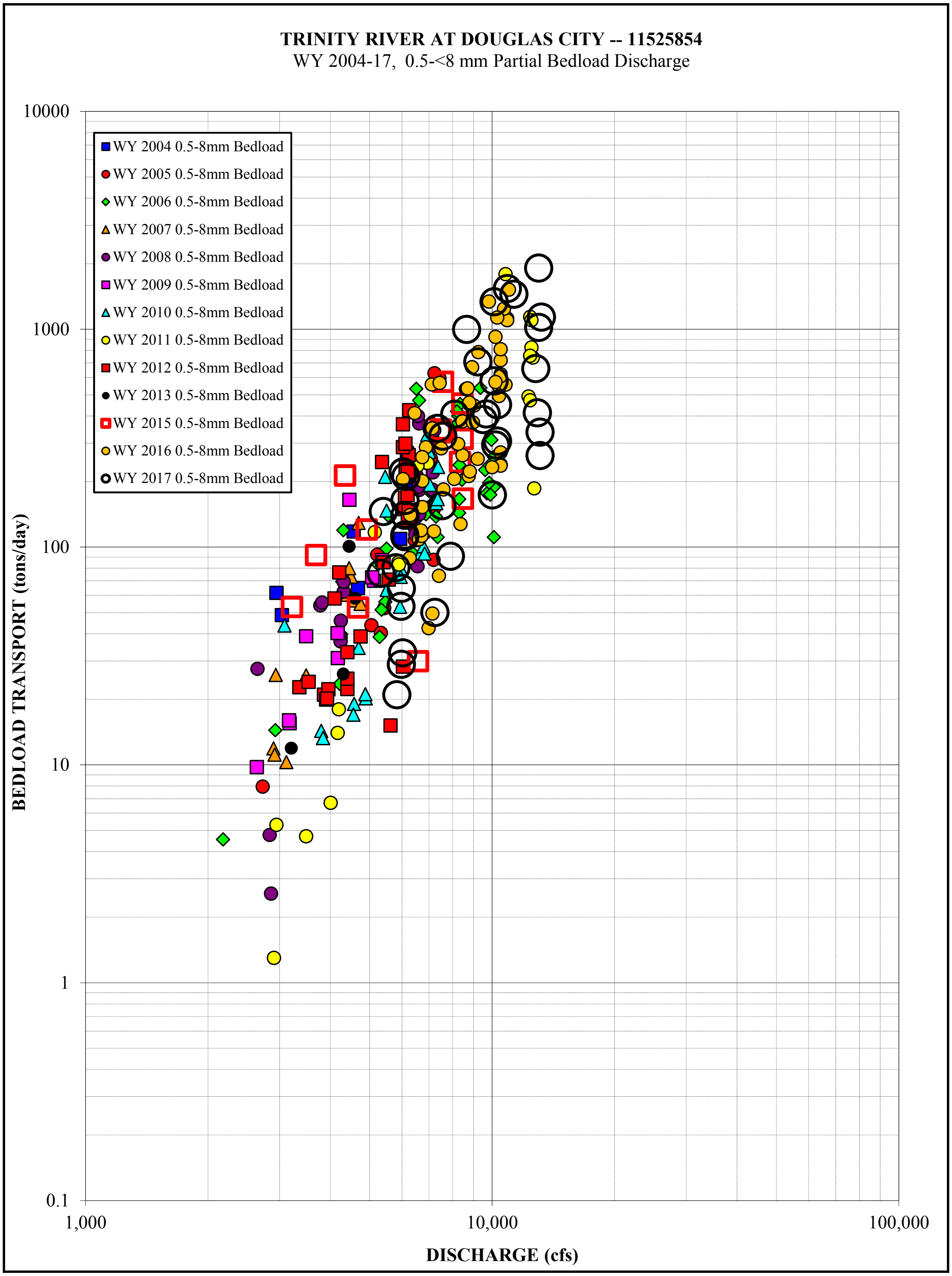


Figure 40. Fine Bedload Discharge at TRDC, WY2004-2013, 2015-2017.

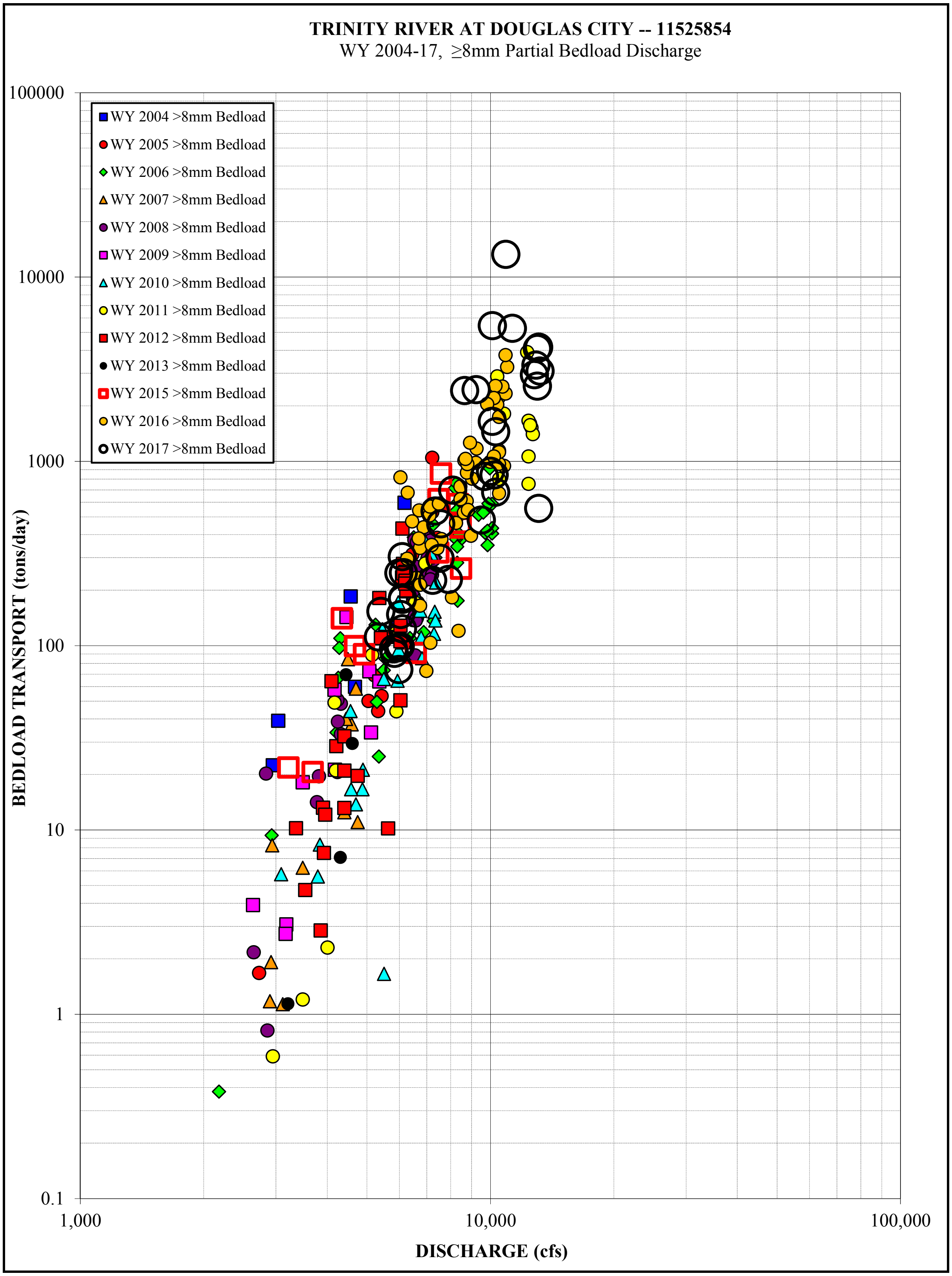


Figure 41. Coarse Bedload Discharge at TRDC, WY2004-2013, 2015-2017.

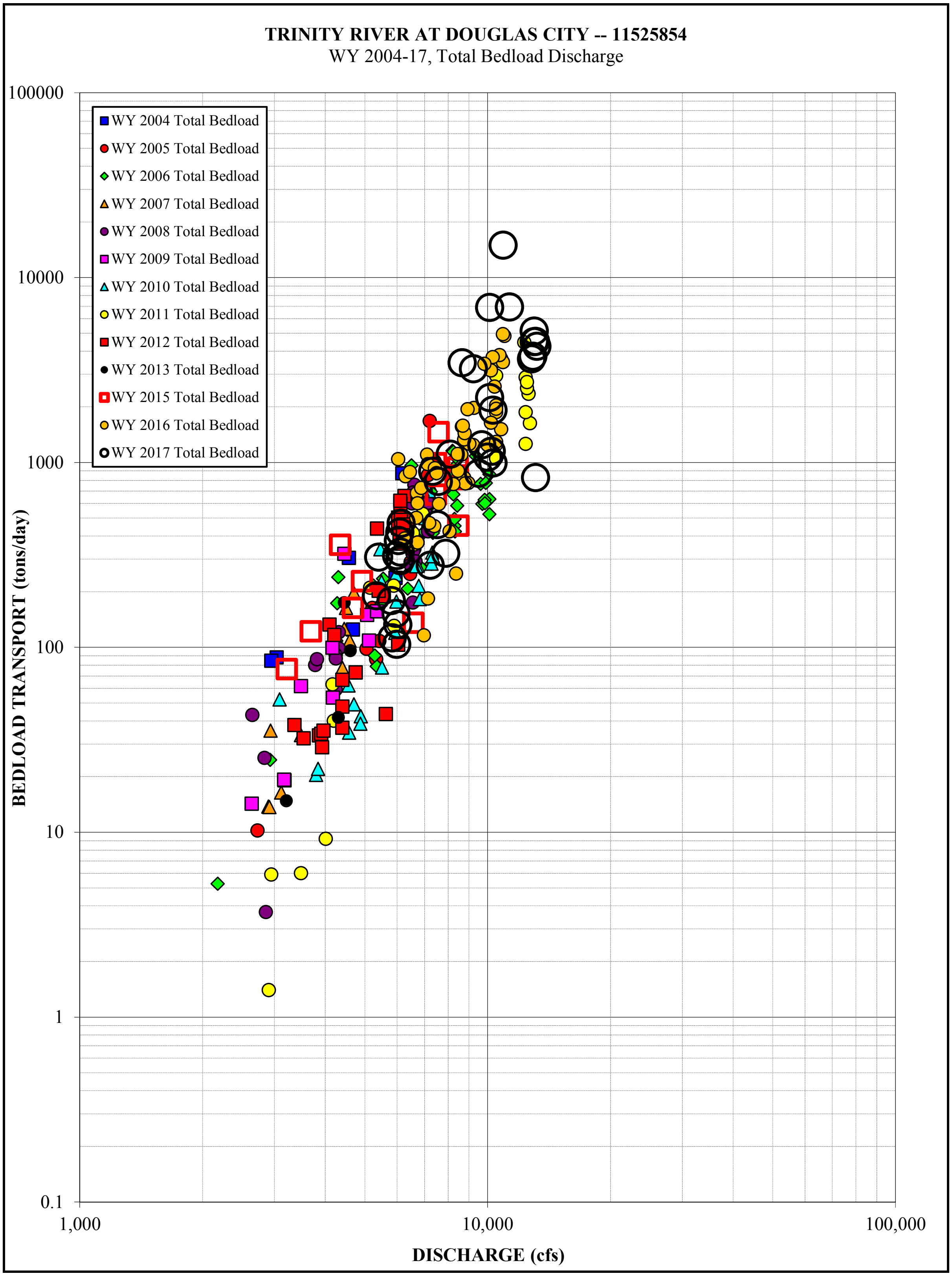


Figure 42. Total Bedload Discharge at TRDC, WY2004-2013, 2015-2017.

Water Surface Slope, Cross Section Changes and Pebble Count Changes

The 2017 13,000 cfs water surface slope was 0.003. Cross section and pebble count data were collected at the TRDC sediment monitoring station pre- and post-SFR to assess textural changes at the sampling section. Changes in the cross section and particle size distribution are shown in Figures 43 and 44. The cross section showed over 1.1 feet of fill among the bedrock protrusions along the left side of the channel. The area change calculation for the cross section below the 1,606 foot elevation revealed 51.9 ft^2 of scour and 38.5 ft^2 of fill for a net scour of 13.4 ft^2. The scour along the right bank associated with the cottonwood tree fall was 42.6 ft^2. The transverse riffle crossing the sampling section shows 29.1 ft^2 of fill in mid-channel. The pebble count describes this mid-channel portion of the transverse riffle. The pebble count showed coarsening across the distribution, with the D50 increasing from 42 to 62mm (Figure 44).

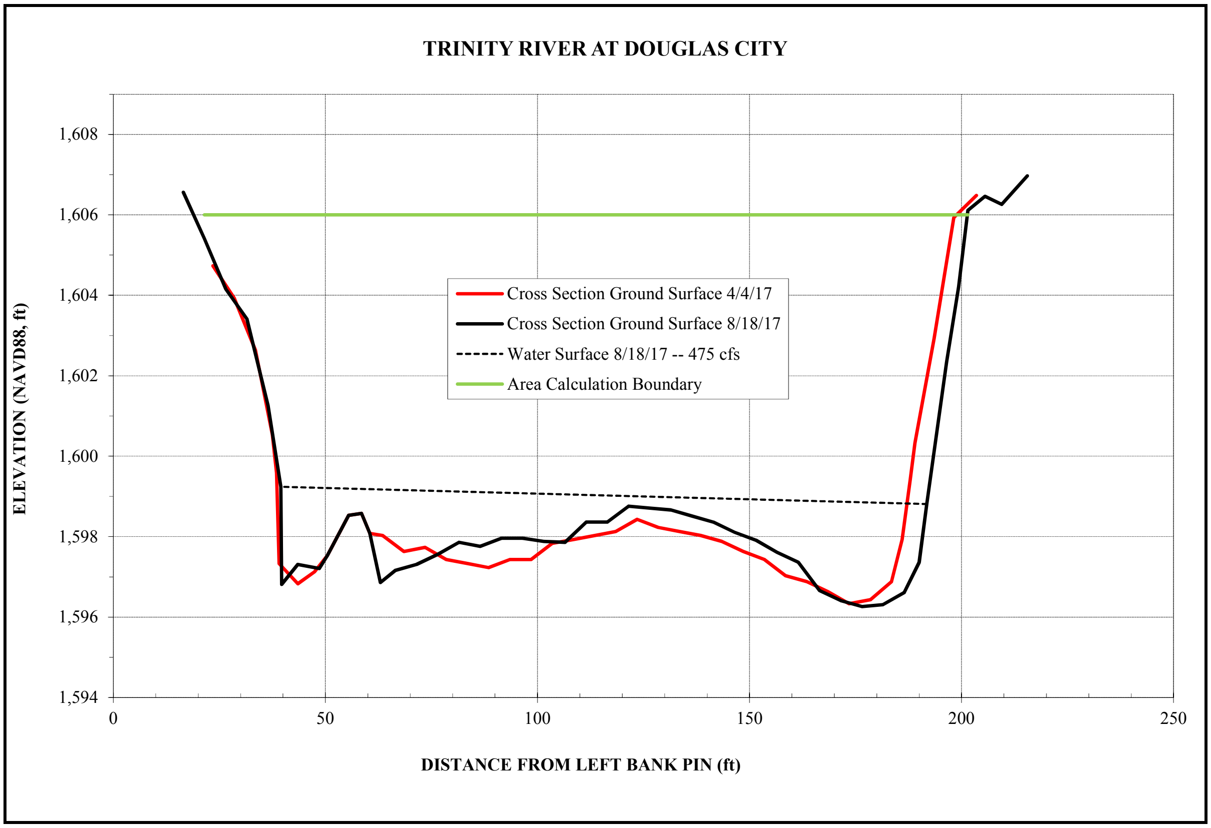


Figure 43. Cross section changes at TRDC, pre/post Spring Flow Release 2017.

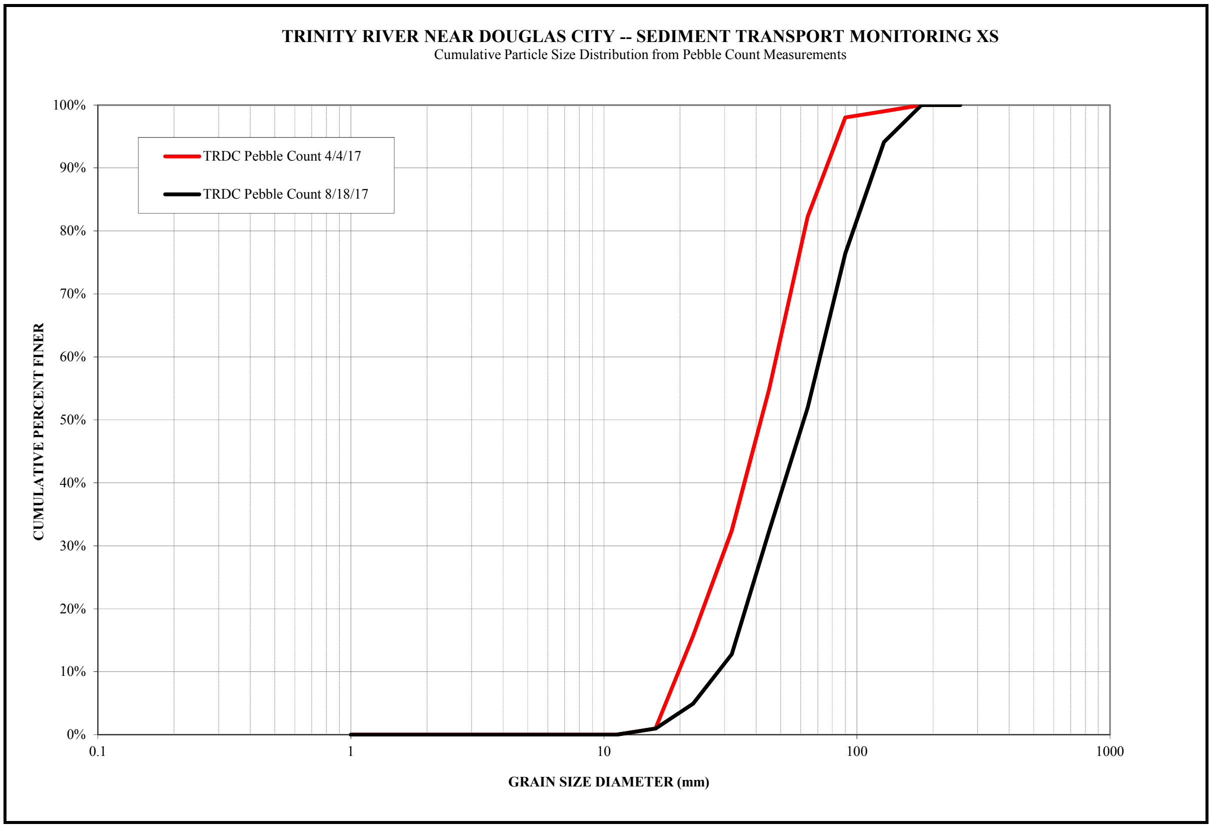


Figure 44. Changes in bed texture at TRDC, Spring Flow Release 2017.

2.5 Focused Results and Discussion

Sediment transport rates derived from field samples display considerable inter- and intra-annual variability. For example, the bedload transport rates at long-term sediment transport monitoring stations TRAL and TRLG show over an order of magnitude variation for a given discharge for a given year (Figures 8-10; 29-31). The suspended sediment data display less variation (Figure 28). The need to accurately estimate sediment transport rates for sediment load computations and to differentiate periods of higher or lower sediment transport (via transport curve comparison) provides the impetus for repeat annual sampling efforts.

The sediment budgeting objectives outlined in the TRFE and SBMP require an accounting of sediment inputs and outputs to sediment budget cells. These values are used to determine the dam release flow duration required to transport sediment, the sediment quantities, and the particle sizes needed to augment various reaches. Monitoring results which inform sediment budgets, and are ultimately used to help explain the linkages between management actions and desired restoration outcomes (e.g. as described in TRFE, 1999) include:

- Differences in sediment discharge (transport rates) between stations;
- Differences in sediment loads between stations;
- Differences in bedload sediment particle sizes;
- Changes in sediment loads at a station over time;
- Changes in sediment discharge (transport rates) at a station over time.

We focus on each of these topics in the following sections. We also explore uncertainty in some of the sediment load calculations as implied by temporal bedload discharge variation (also done previously in 2015 and 2016); the results of this pilot study are presented in section 2.5.5.

Data evaluations in this section are based on visual estimates of data trends and no statistical analyses were performed (with exception of Sec 2.5.6 -- Table 19). So although data may suggest clear trends, we do not provide statistical inference.

2.5.1 Differences in Sediment Discharge between Stations

2.5.1.1 Mainstem Suspended Sediment

WY 2017 suspended sediment discharge data for three mainstem stations were plotted together (Figure 45) to highlight downstream transport variation. Mainstem suspended sediment transport rates increase (shift upward) with distance downstream from the dam. Assuming all stations are transporting below their potential SSD transport capacity, the progressive downstream increase in transport rate indicates that fine sediment supply increases with distance downstream. This is likely due to both tributary contributions and cumulative increase in channel bank (e.g. sandy lateral berms) available to recruit fine material. The USGS dam release data from1981-1991sits well to the left of the 2017 data, which suggests that the mainstem produced more fine sediment at TRLG than it does today (Figure 45). Much of the scatter within each of the mainstem stations' data is attributed to hysteresis during the Spring Flow Release.

The WY 2017 sedigraphs for total and partial suspended sediment discharge were plotted with their respective site hydrographs to highlight sediment discharge variation across the hydrograph (at a station) and in the downstream direction (between stations) (Figures 46, 47). All three stations (with minor exceptions) show an overall rapid rise in SSD with both peaks of the 2017 SFR hydrograph, though the magnitude of suspended sediment discharge for the second flow bench is but a fraction as that of the first flow bench. In Figure 46, the TRLG sedigraph peaks lower than the next site upstream, TRGV. This is likely due to the turbidimeter failure at TRLG and the fact that a discharge relation was used to compute SSD. Another possible explanation is that higher concentrations resulted at TRGV due flushing of the gravel injection upstream. After the initial rise and throughout the first peak flow bench, SSD drops off (Figures 46, 47). The sedigraph doesn't mirror the hydrograph on the decline as it did on the initial rise, presumably due to hysteresis (resulting from a rapid winnowing of fines from the system). In Figure 47, the pink trace sits below the green and red, illustrating that the fraction $\geq$0.5mm constitutes the smallest portion of the suspended load.

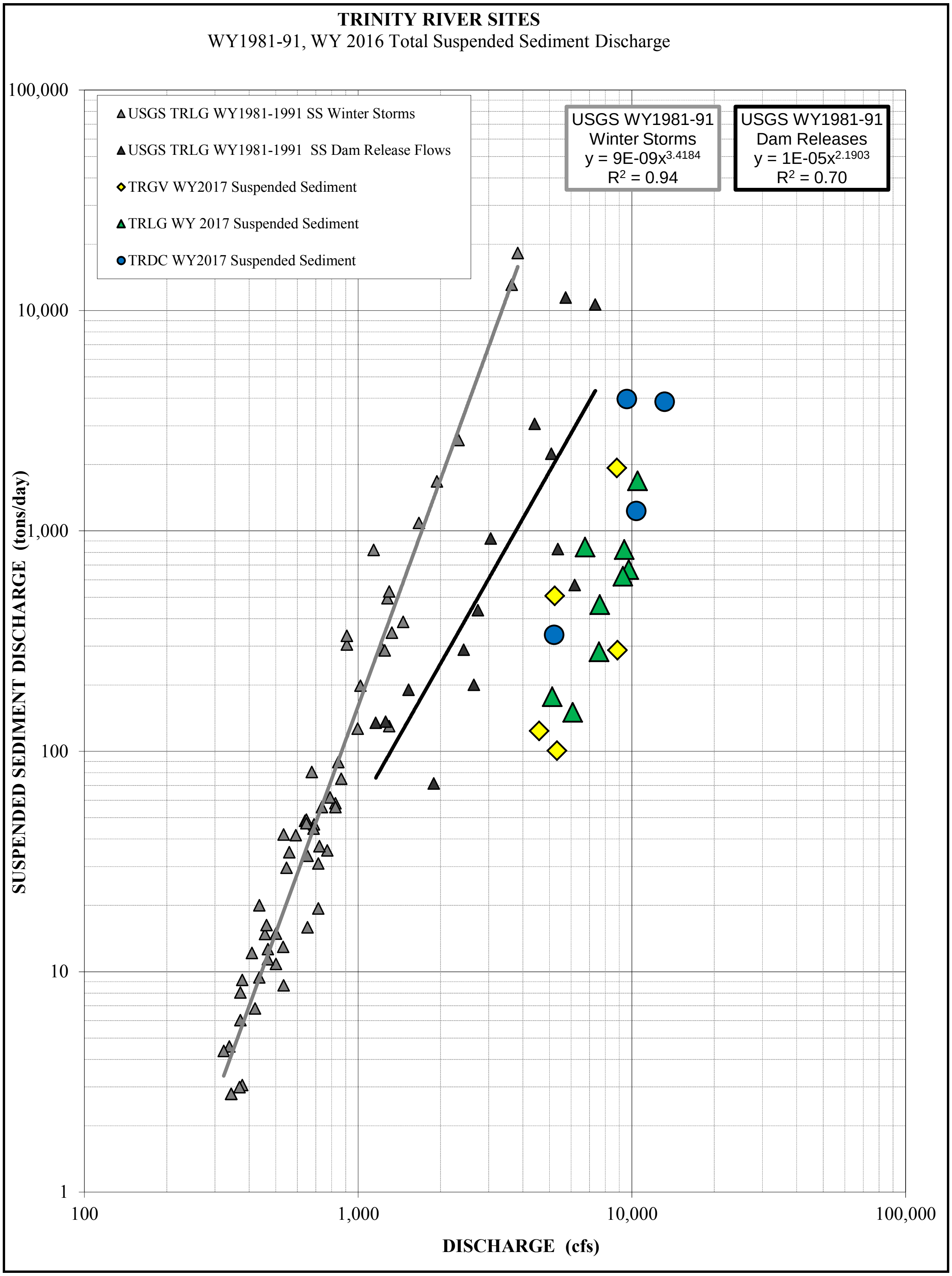
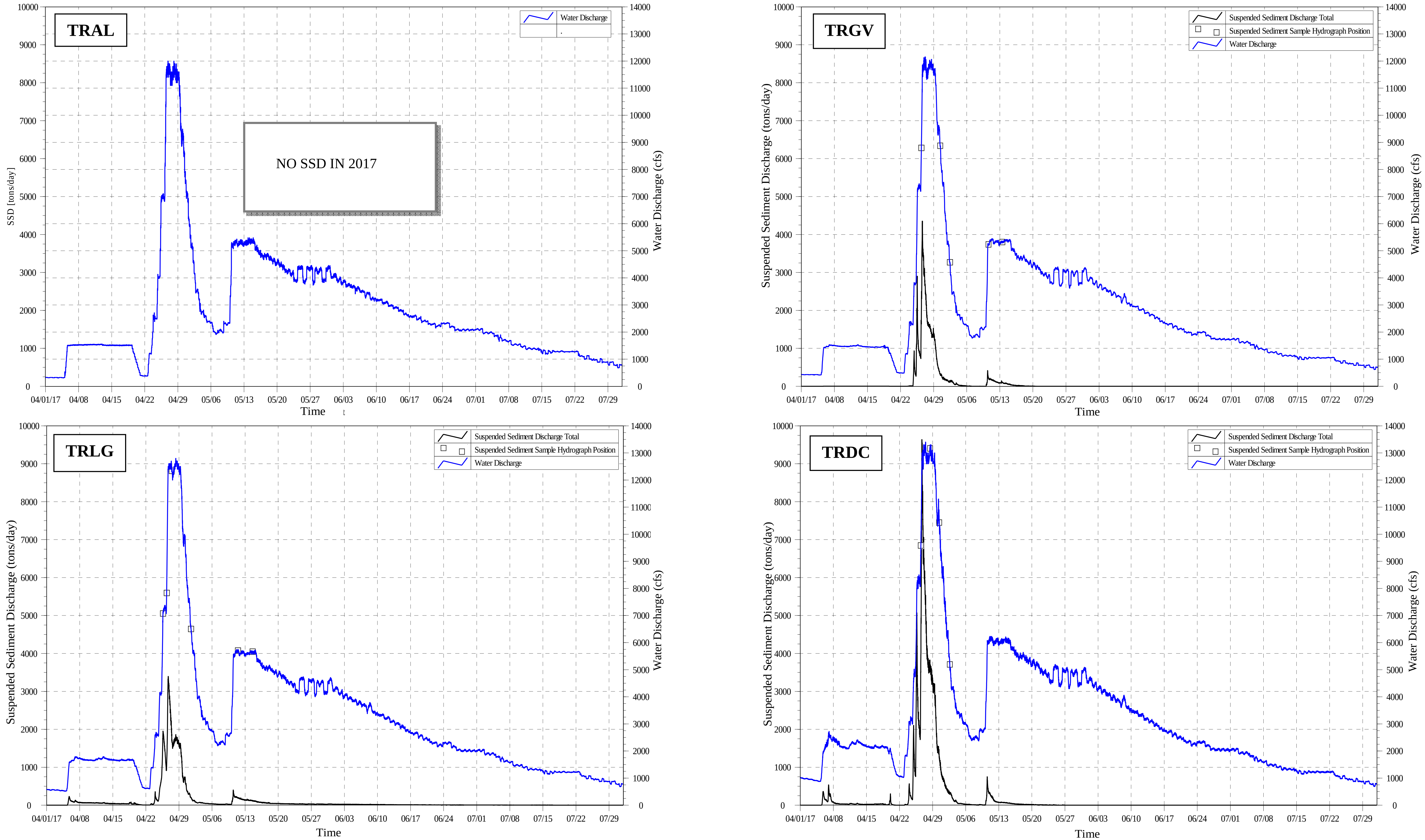


Figure 45. Suspended Sediment Discharge, Mainstem Trinity River Monitoring Stations, WY 2017 with TRLG Data from 1981-1991 for comparison.
See Figures 1 and 2 for sampling site locations.

TRINITY RIVER MAINSTEM STATIONS

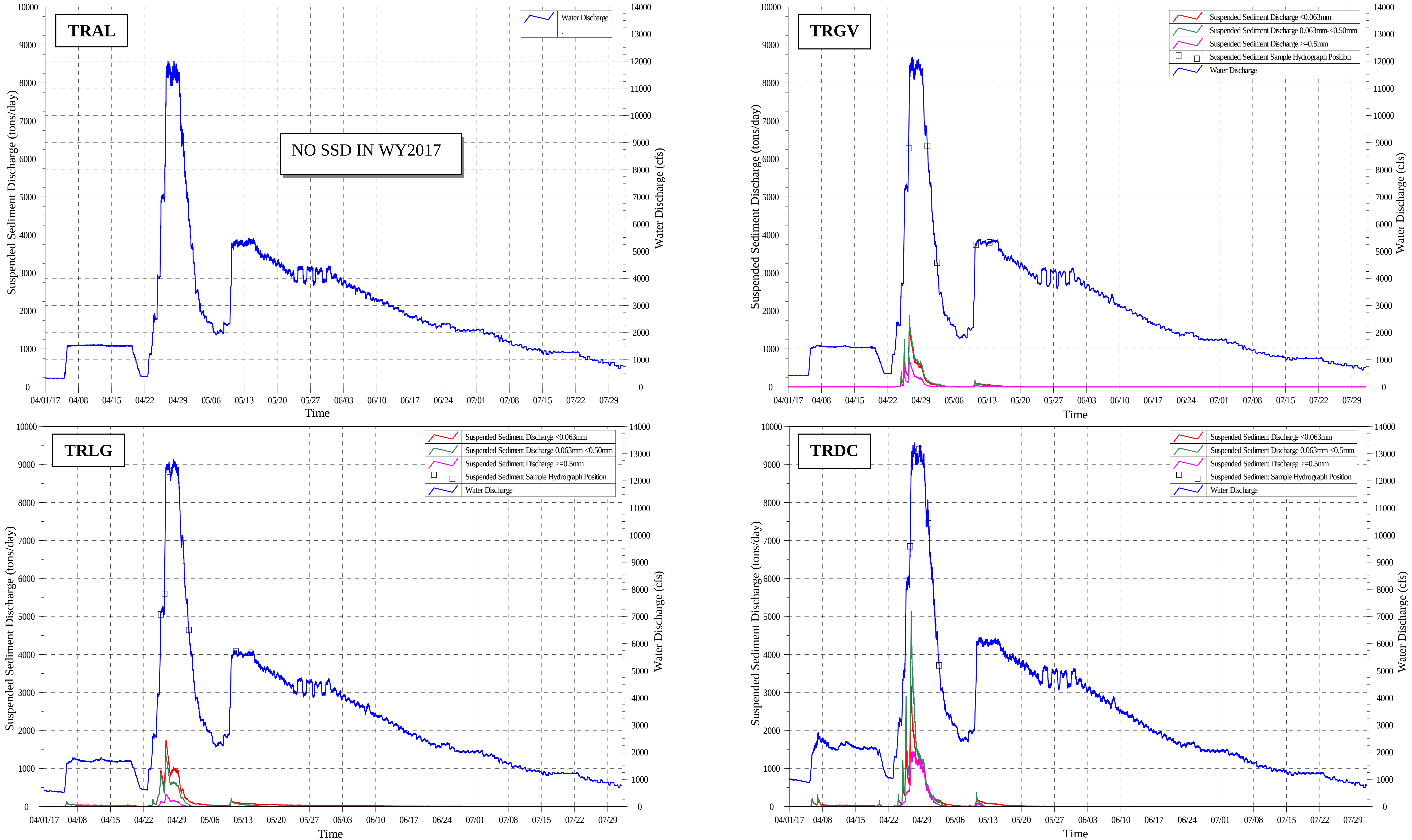
Suspended Sediment Discharge -- Spring Flow Release WY 2017



WY2017 SEDIMENT TRANSPORT MONITORING REPORT	TRINITY RIVER RESTORATION PROGRAM	GMA Hydrology | Geomorphology | Stream Restoration	FIGURE 46

TRINITY RIVER MAINSTEM STATIONS

Suspended Sediment Discharge -- Spring Flow Release WY 2017



WY2017 SEDIMENT TRANSPORT MONITORING REPORT	TRINITY RIVER RESTORATION PROGRAM	GMA Hydrology | Geomorphology | Stream Restoration	FIGURE 47

2.5.1.2 Mainstem Bedload

The WY 2017 total bedload discharge (BLD) measurements for all stations were plotted together in Figure 48. Trend lines were added strictly to aid in distinguishing relative trends. We attribute data-point scatter to: the hysteresis that often occurs across flow benches, the inherent variability in sample particle-size distributions (e.g. periodic large particles biasing the sample), and the inherent temporal variability in bedload transport.

TRGV bedload shows the highest rate of increase (exponent = 4.42 in the power function). TRAL, TRLG and TRDC all have similar rates of increase (exponents of 3.27 to 3.73). The high rate of increase at TRGV is likely due to the 2017 gravel injection placed immediately above the sampling site. TRGV also exhibits a very wide range in individual sample transport rates: 13 to 5,180 tons/day (Figure 48).

At TRDC, BLD magnitudes for individual samples clearly plot much higher than at the other three stations and the curve sits to the left of the others. TRDC generally transports more bedload due to the greater availability of sediment for transport towards the downstream end of the study area related to tributary inputs. In 2017 however, TRGV produced several samples early in the release (#6 to #10, Table 8) which plotted with and even higher than the TRDC data, despite the higher transport capacity at TRDC (much steeper water surface slope). Again, this is likely due to the 2017 gravel injection effort.

The four mainstem total bedload sedigraphs and partial-bedload sedigraphs for fine (0.5-<8mm) and coarse (≥ 8mm) bedload size fraction (Figures 49, 50) illustrate bedload discharge variation across the Spring Flow Release hydrograph and in the downstream direction. All sites show higher transport on the first peak of the hydrograph and all sites show the coarser fraction to constitute most of the bedload (Figure 50). At TRDC, the fine fraction of bedload is greater than at the other three sites, again presumably due to its position lower in the watershed (fine sediment supply increases with distance downstream).

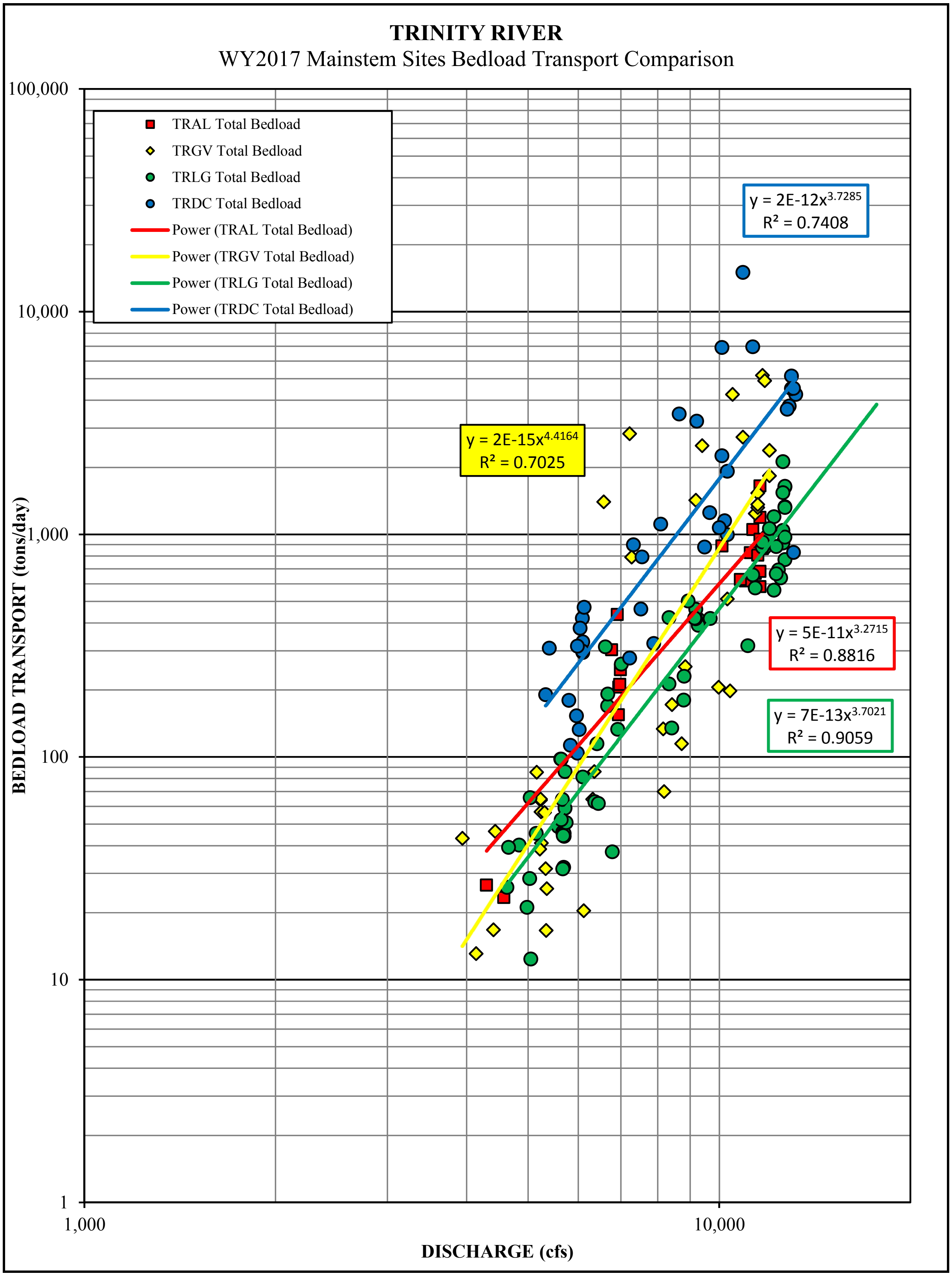
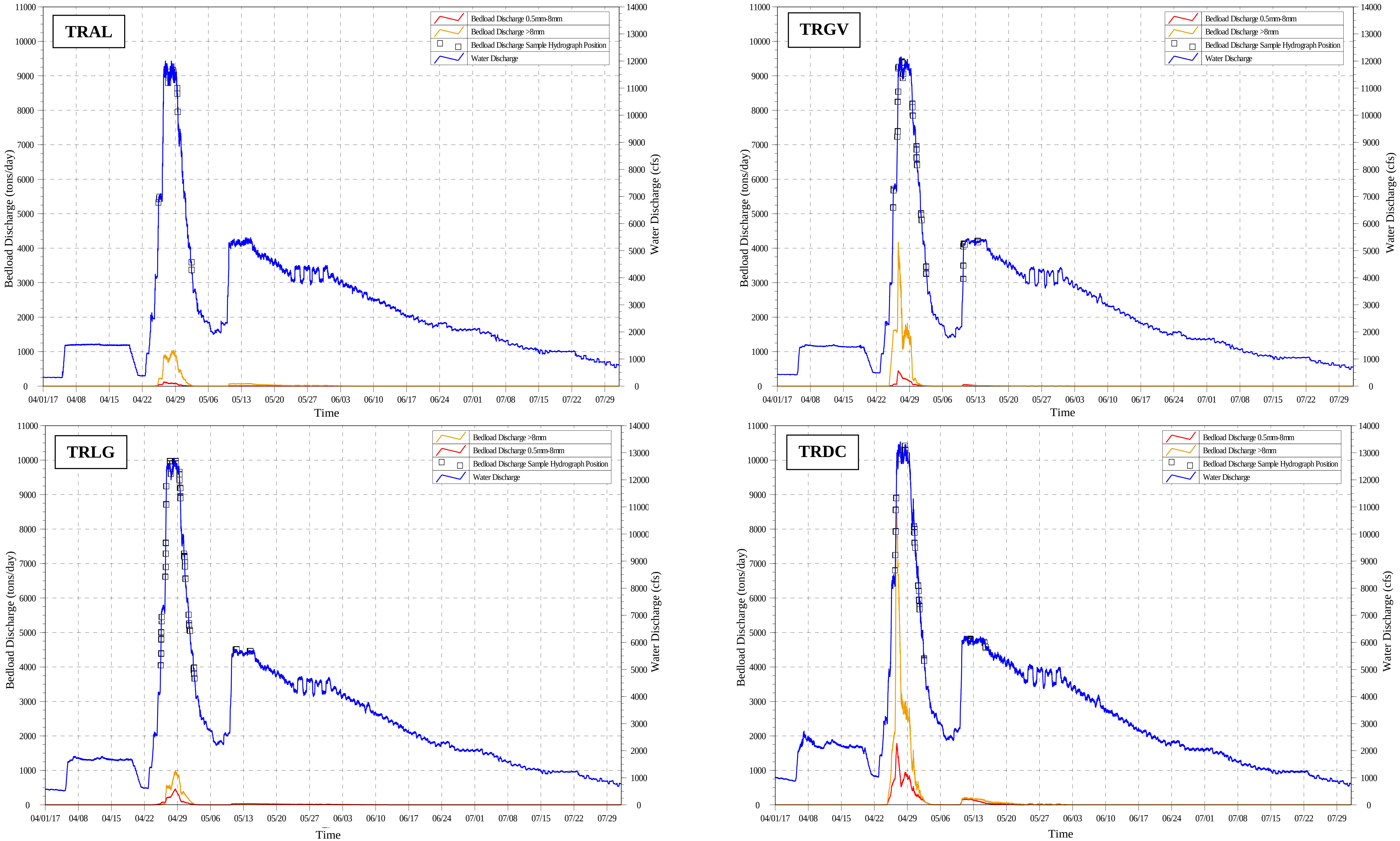


Figure 48. Total Bedload Discharge, Mainstem Trinity River Monitoring Stations, WY2017.
See Figures 1 and 2 for sampling station locations.

TRINITY RIVER MAINSTEM STATIONS

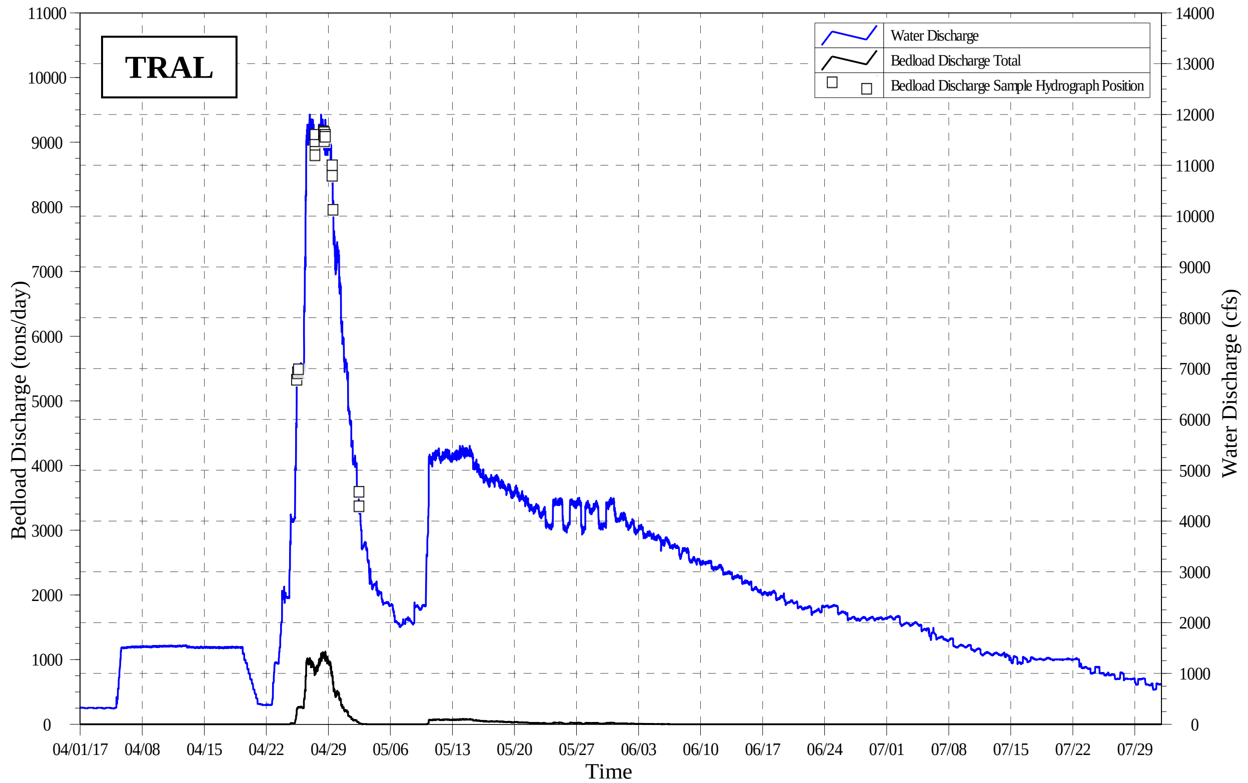
Partial Bedload Discharge -- Spring Flow Release WY 2017

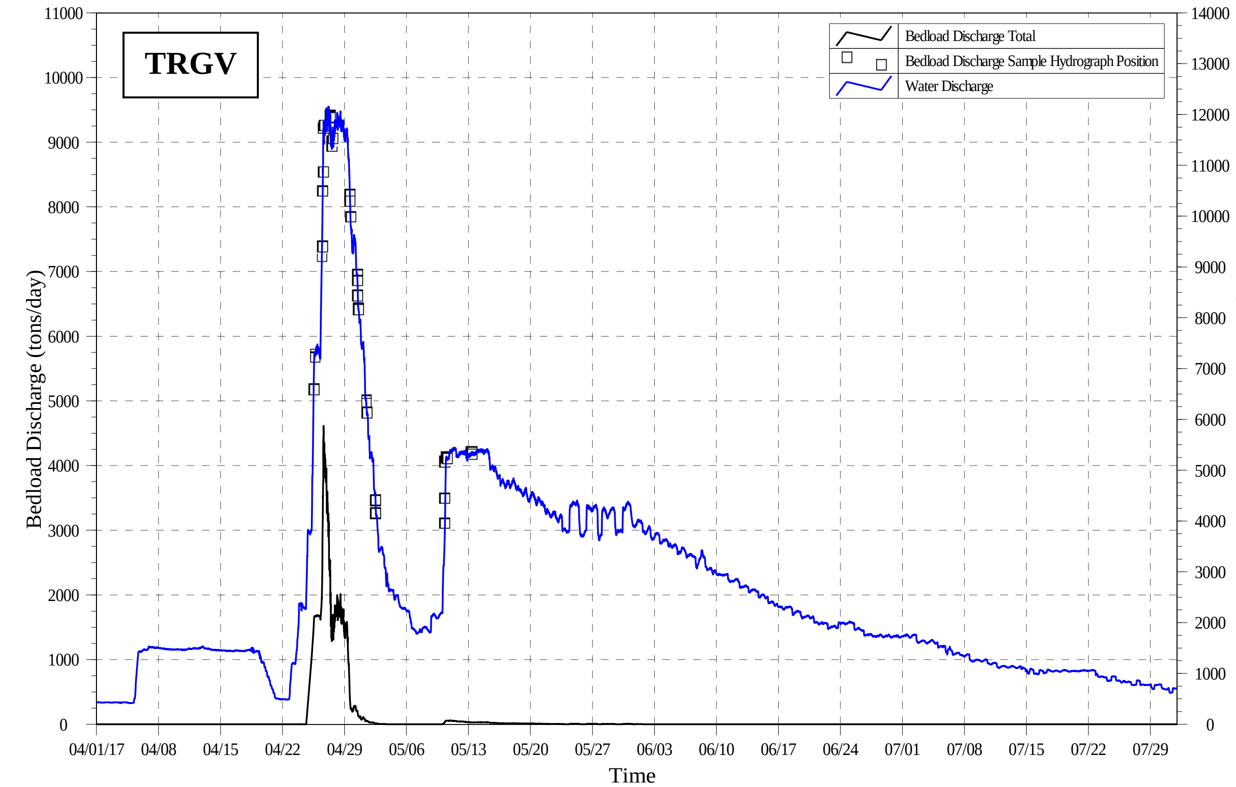


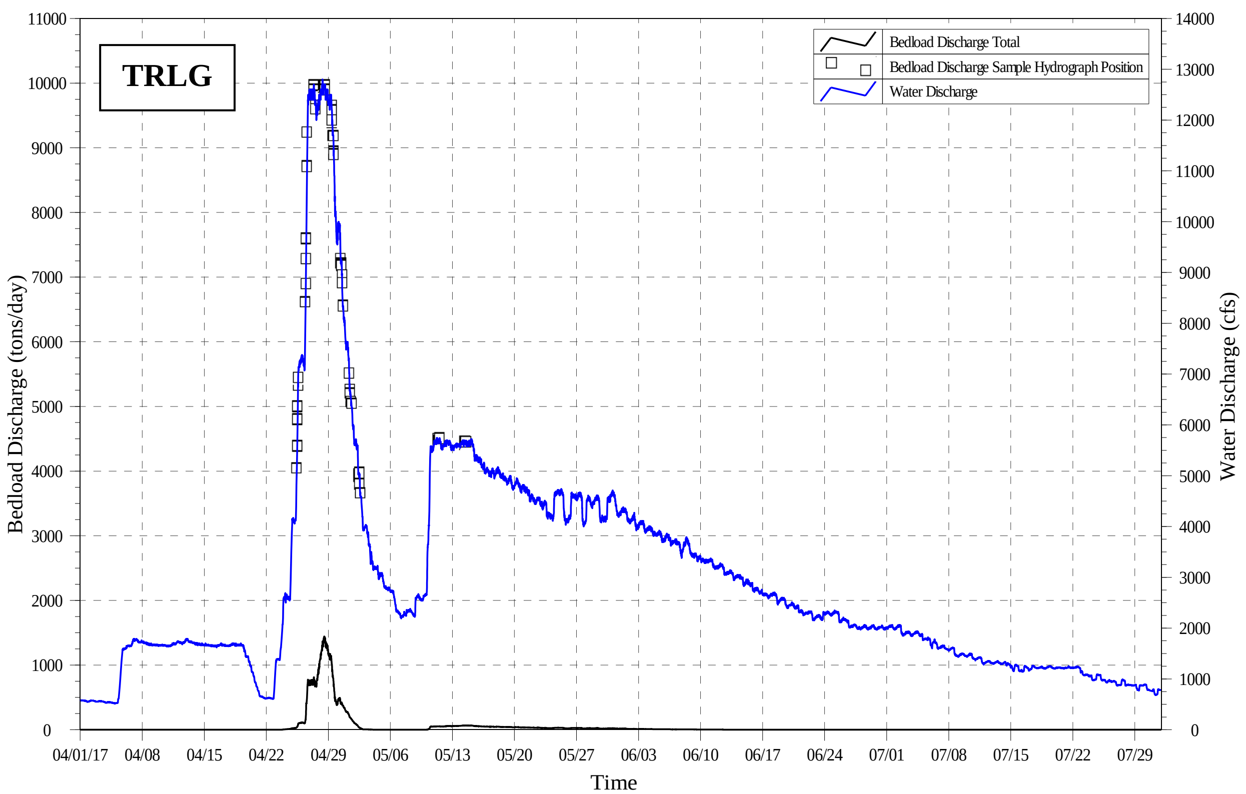
WY2017 SEDIMENT TRANSPORT MONITORING REPORT	TRINITY RIVER RESTORATION PROGRAM	GMA Hydrology | Geomorphology | Stream Restoration	FIGURE 49

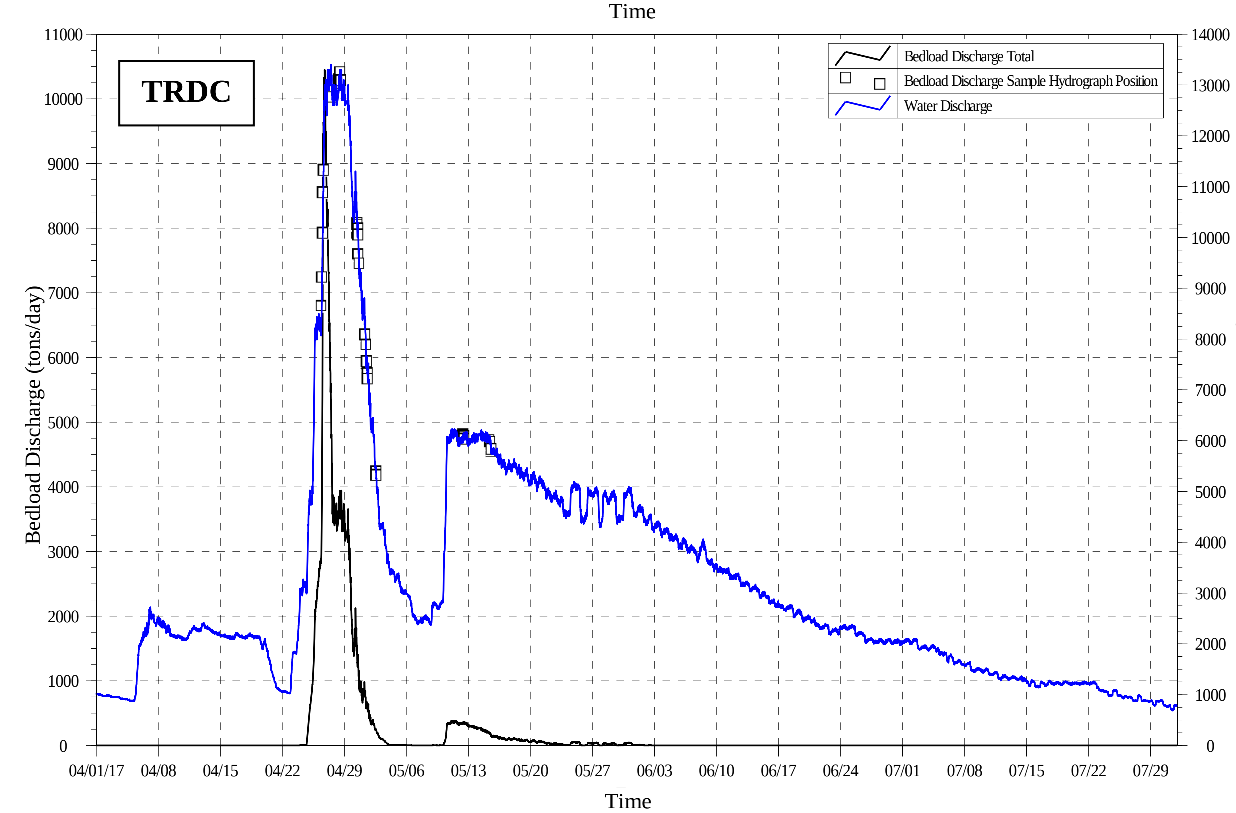
TRINITY RIVER MAINSTEM STATIONS

Bedload Discharge -- Spring Flow Release WY 2017









WY2017 SEDIMENT TRANSPORT MONITORING REPORT	TRINITY RIVER RESTORATION PROGRAM	GMA Hydrology | Geomorphology | Stream Restoration	FIGURE 50

2.5.2 Differences in Sediment Load between Stations

2.5.2.1 Mainstem Suspended Sediment Loads

The computed partial and total suspended sediment loads for the WY2017 Spring Flow Release are presented in Table 16. Suspended sediment loads increased in the downstream direction: from 9,540 tons at TRGV, to 12,310 tons at TRLG, and 23,000 tons at TRDC. TRGV showed a higher instantaneous peak SSD (Figure 46) but the load computed for the entire release period is greater at TRLG (Table 16).

2.5.2.2 Mainstem Bedload

Bedload does not show the same downstream increase as was observed for suspended load. Total bedload estimates for TRAL, TRGV, TRLG, and TRDC in WY2017 were 4,740, 9,500, 4,850 and 23,700 tons, respectively (Table 16). Gravel injection at the TRGV site prior to the flow release undoubtedly increases bedload measured at the sampling station.

Table 16. WY 2017 Mainstem Sediment Loads

	Suspended Sediment				Bedload		
SEDIMENT MONITORING STATION	SS <0.063 mm (tons)	SS 0.063 mm - <0.50 mm (tons)	SS ≥0.50 mm (tons)	SS Total (tons)	Bedload 0.50-<8 mm (tons)	Bedload ≥8 mm (tons)	Total Bedload (tons)
Trinity River at Lewiston (TRAL)	NA	NA	NA	NA	412	4,330	4,740
Trinity River above Grass Valley Creek (TRGV)	3,880	4,200	1,460	9,540	1,110	8,390	9,500
Trinity River below Limekiln Gulch (TRLG)	7,340	4,210	760	12,310	1,740	3,110	4,850
Trinity River near Douglas City (TRDC)	8,300	9,750	4,940	23,000	5,510	18,200	23,700

All values rounded using methods by Porterfield (1972)

The relative percentage of fine and coarse bedload varied between stations. TRAL had 9 percent fine, TRGV was 12 percent, TRLG was 36 percent and TRDC was 23 percent. Comparison of the ratio of suspended load or bedload to total load at the various mainstem sites can provide additional insight into transport dynamics. TRAL generally has a much higher percentage of bedload versus total load compared to the other sites, with 53 percent (in WY2016). For WY2017, TRGV bedload was 50 percent of the total, TRLG was 28 percent and TRDC was 51 percent.

Of particular interest in 2017, considering the double-peak hydrograph, is the question of how the loads compare for each peak flow bench. We examined each site relative to its own hydrograph and summed the ≥8mm loads for each peak flow bench. Computational periods were defined as the time the hydrograph exceeded the low flow point between the two flow peaks (noted as "Q start" in Table 17). By this definition, the second peak is up to four times longer than the first, though approximately half the (peak flow) magnitude. For TRAL, the first peak transported 3,570 tons (82 percent) and the second transported 769 tons. At TRGV, the first peak transported 8,270 tons (99 percent) and the second transported 126 tons. TRLG transported 2,790 (90 percent) and 324 tons. TRDC transported 16,700 (92 percent) tons and 1,490 tons. *Very minor rounding discrepancies appear between this table and Table 16.*

Table 17. ≥8mm bedload totals for each peak flow bench, WY2017

		Peak #1			Peak #2		
SEDIMENT MONITORING STATION	Q Start (cfs)	Bedload >8mm (Tons)	# Hrs	Q Peak (cfs)	Bedload >8mm (Tons)	# Hrs	Q Peak (cfs)
Trinity River at Lewiston (TRAL)	1,910	3,570	322	12,000	769	1,412	5,480
Trinity River above Grass Valley Creek (TRGV)	1,780	8,270	321	12,200	126	1,214	5,450
Trinity River below Limekiln Gulch (TRLG)	2,190	2,790	320	12,800	324	1,114	5,740
Trinity River near Douglas City (TRDC)	2,370	16,710	358	13,400	1,490	1,042	6,230

All values rounded using methods by Porterfield (1972)

2.5.3 Differences in Bedload Sample Particle Size Distributions

The bedload sample particle-size distributions for the mainstem stations were compared to examine general variations in grain size, both between stations and between peak flow benches. Particle-size distributions were averaged for all samples collected during each 2017 peak flow bench (Figure 51). TRAL was only sampled for the first peak flow bench. TRGV and TRLG show the first bench transported much coarser material than the second. TRDC shows the same relation, though much less pronounced. Higher flows transport coarser material at all sites. The extreme disparity between TRGV curves may also be due to supply limitations during the second bench. Interestingly, the D50 for the first flow bench is almost identical at TRGV, TRLG and TRDC (32-38mm); TRAL, with its dearth of finer material, is much coarser at 63mm (Figure 51).

The D50 for each bedload sample collected during the 2017 SFR is provided by individual site-hydrograph in Figure 52. At TRAL, the mean (cumulative) D50 appears to decrease over the initial rise to the first peak flow bench around 7,000 cfs, but no samples were collected on the second day of the release and the moving average simply bridges this period. Beginning on the third day of the release, the D50 begins a gradual increase from about 52mm to about 65mm. No data were collected for the second peak flow bench at TRAL.

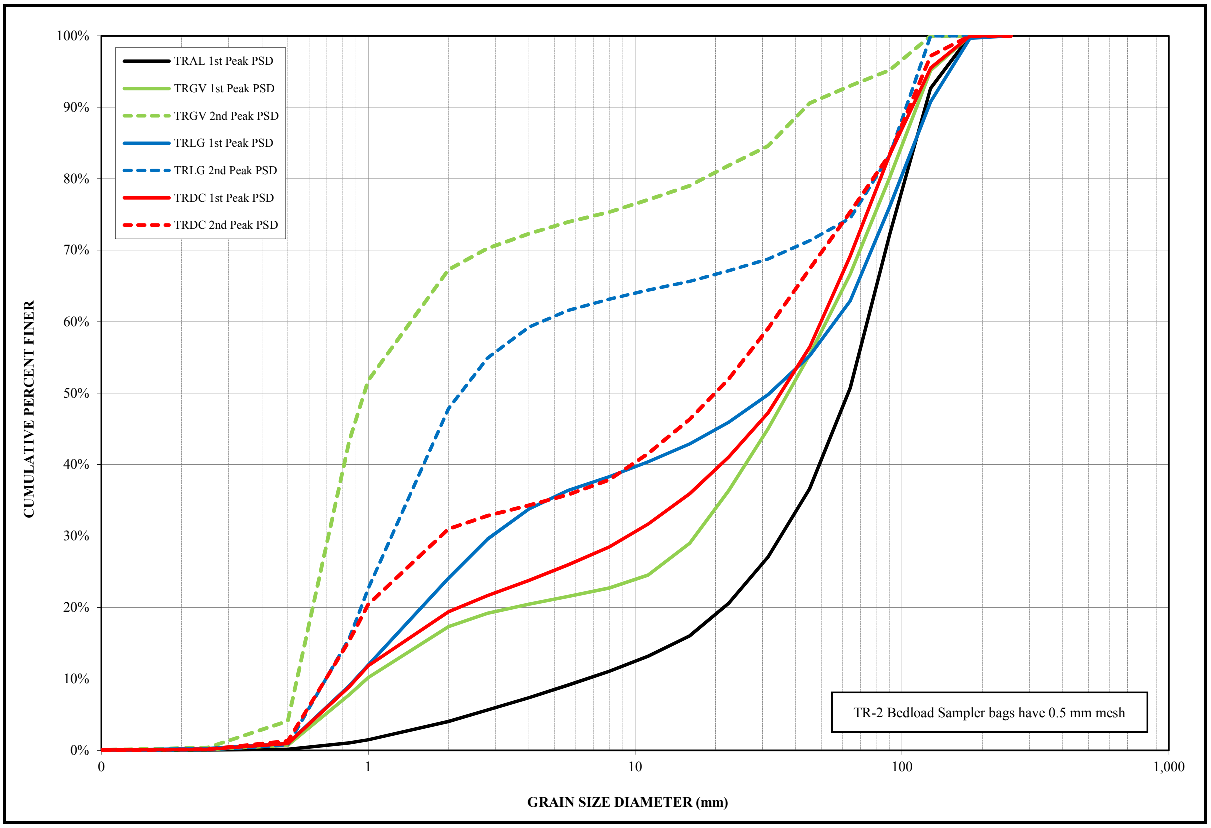
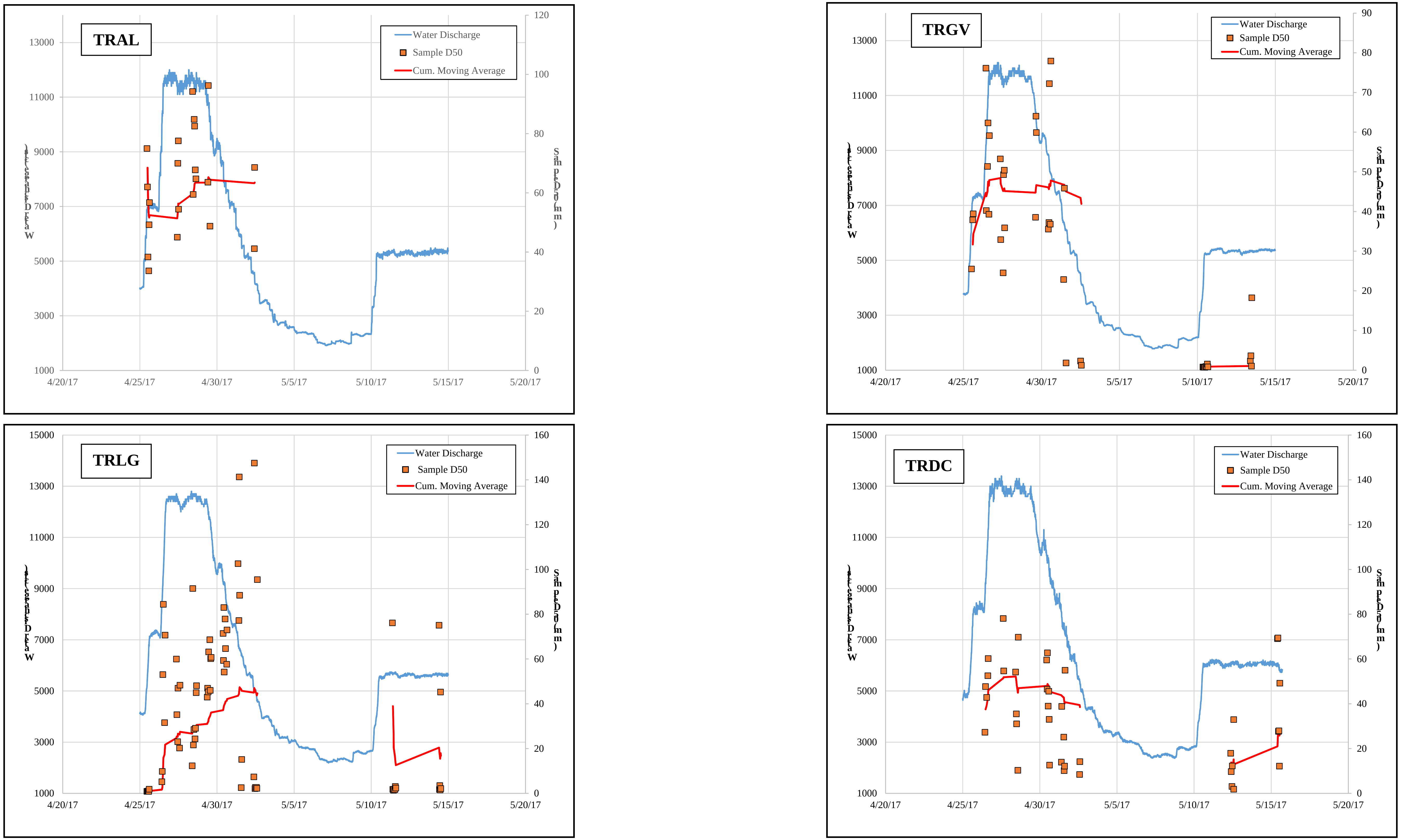


Figure 51. Peak Flow Bench Averaged Bedload Particle Size Distributions from the WY2017 Spring Flow Release.
See Figures 1 and 2 for sampling station locations.

At TRGV the D50 increases with increasing discharge to around the 44-49mm range and essentially remains constant through the first peak flow bench. For the second flow bench, the mean D50 barely rises above 1mm. At TRLG the mean D50 constantly increases across the first flow bench to about 45mm (Figure 52). For the second flow bench, the D50 drops from 39mm to hover in the low-20mm range. At TRDC, the D50 increases from 39 to 52mm early in the first peak, then gradually decreases back to 39mm (Figure 52). The D50 for the second bench is much smaller but shows a progressive increase from 12 to 28mm. For TRGV, TRLG and TRDC, the sampling effort on the second flow bench was more dispersed (three days apart) and the moving average trace bridges these un-sampled periods.

TRINITY RIVER MAINSTEM STATIONS

Bedload Sample D50 -- Spring Flow Release WY 2017



WY2017 SEDIMENT TRANSPORT MONITORING REPORT

TRINITY RIVER RESTORATION PROGRAM

GMA
Hydrology | Geomorphology | Stream Restoration

FIGURE

52

2.5.4 Changes in Sediment Loads Over Time

The magnitude of Spring Flow Release sediment loads is dependent upon numerous factors, including: peak flow magnitude, hydrograph shape, sediment augmentation efforts, changes in transport capacity (e.g. from channel and floodplain restoration) and tributary sediment contributions. Here, we examine potential trends in the coarse bedload (≥8mm) Spring Flow Release load totals from 2004 to 2017. Table 18 provides water year types, release volumes and peak flow magnitudes for WY2004-2017. In addition, Table 18 also provides the Spring Flow Release type (as described in the TRFE recommendations). In the previous 12 years of sediment sampling, there have been four "Dry" type releases (2007, 2009, 2013, 2015), five "Normal" releases (2004, 2005, 2008, 2010, and 2012), and three "Extremely Wet" releases (2006, 2011 and 2016). The distinction between water year type and Spring Flow release type is important because there were some variations (e.g. 2011 was a Wet water year type, but had an Extremely Wet release, 2004 was a Wet year, but had a Normal Year release type). WY2017 was classified an Extremely Wet water year and had a modified Extremely Wet flow release type.

Table 18. Water Year Types, Restoration Release Volumes, Flow Release Type and Peak Flow Release Magnitudes: 2004-2017 (source: TRRP 2017)

Water Year	Forecast Water Year Type	Actual Restoration Release (acre feet)	Spring Flow Release Type	Peak Release Magnitude (cfs)*
2004	Wet	651,000	Normal	6,200
2005	Normal	647,600	Normal	6,970
2006	Ex Wet	809,900	Ex Wet	10,100
2007	Dry	453,700	Dry	4,750
2008	Normal	648,700	Normal	6,470
2009	Dry	445,500	Dry	4,410
2010	Normal	656,700	Normal	6,840
2011	Wet	721,800	Ex wet	11,600
2012	Normal	647,100	Normal	6,080
2013	Dry	451,900	Dry	4,420
2014	Crit. Dry	370,500	Crit. Dry	3,410
2015	Dry	450,700	Dry (modified)	8,500
2016	Wet	708,800	Ex Wet (modified)	10,000
2017	Ex Wet	**	Ex Wet (modified)	11,600

**Mean daily discharge at Trinity River at Lewiston (USGS 11525500)*

*** Not available at time of reporting*

Figures 53-56 compare the computed ≥8mm bedload at all stations for the 12 years of monitoring (10 years at TRGV). The ≥8mm component of bedload is of primary interest for creating beneficial channel and habitat characteristics (alternate bars, spawning riffles etc, TRRP 2011). Evaluating the ≥8mm component also removes much of the tributary influence, because the <8mm component is not included in gravel injections, and therefore it must be either delivered by tributaries or derived from in-channel sources, adjacent banks or hillslopes.

2006, 2011 and 2017 clearly dominate the ≥8mm bedload transport at TRAL (Figure 53). At TRGV, 2017 produced by far the largest load, more than twice the magnitude of the next highest year, 2011 (Figure 54). At TRLG, 2017 was very similar to 2006, yet still less than 2011 (Figure 55). At TRDC, 2017 exceeded 2006 and 2011 (Figure 56).

All stations exhibit an apparent downward trend in ≥8mm transport during Normal Release types (Figures 53-56). The trend among Dry Flow Release types is less clear (2007, 2009, 2013 and 2015), though 2015 clearly transported larger loads than the other three years. 2015 with its "Dry (modified)" release type (that is a dry year restoration total release (453,000 af) with an 8,500 cfs flow bench) showed an evident increase over preceding "Dry-type" flow releases at all stations.

At TRGV, WY2015 exceeds some wet years (Figure 54) and at TRAL and TRDC, WY2015 approximates the magnitude of "Normal" flow release types (Figures 53, 56). Despite the differences in hydrograph shape, Extremely Wet years transport more bedload than the others, yet no consistent trend is apparent. Supply attributes (e.g. consistent gravel injection efforts at TRGV in recent years) have a considerable effect on load magnitude as well.

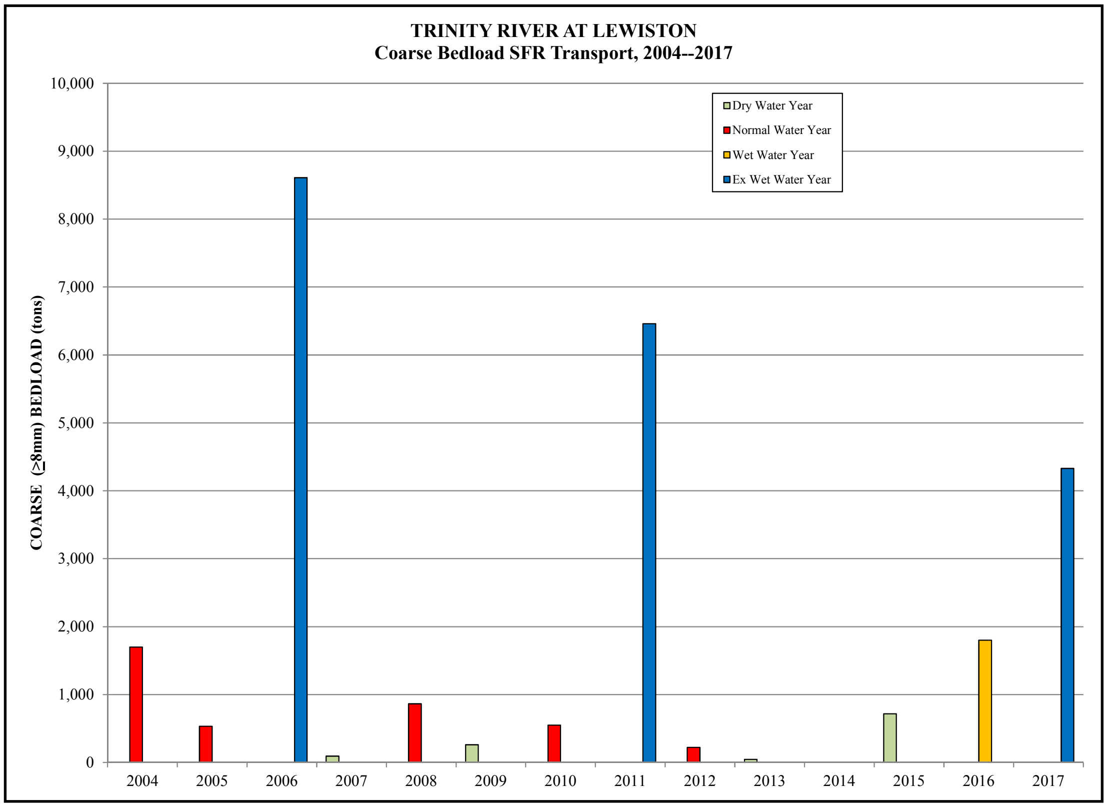


Figure 53. Trinity River at Lewiston, ≥8mm Bedload 2004-2013, 2015-2017.

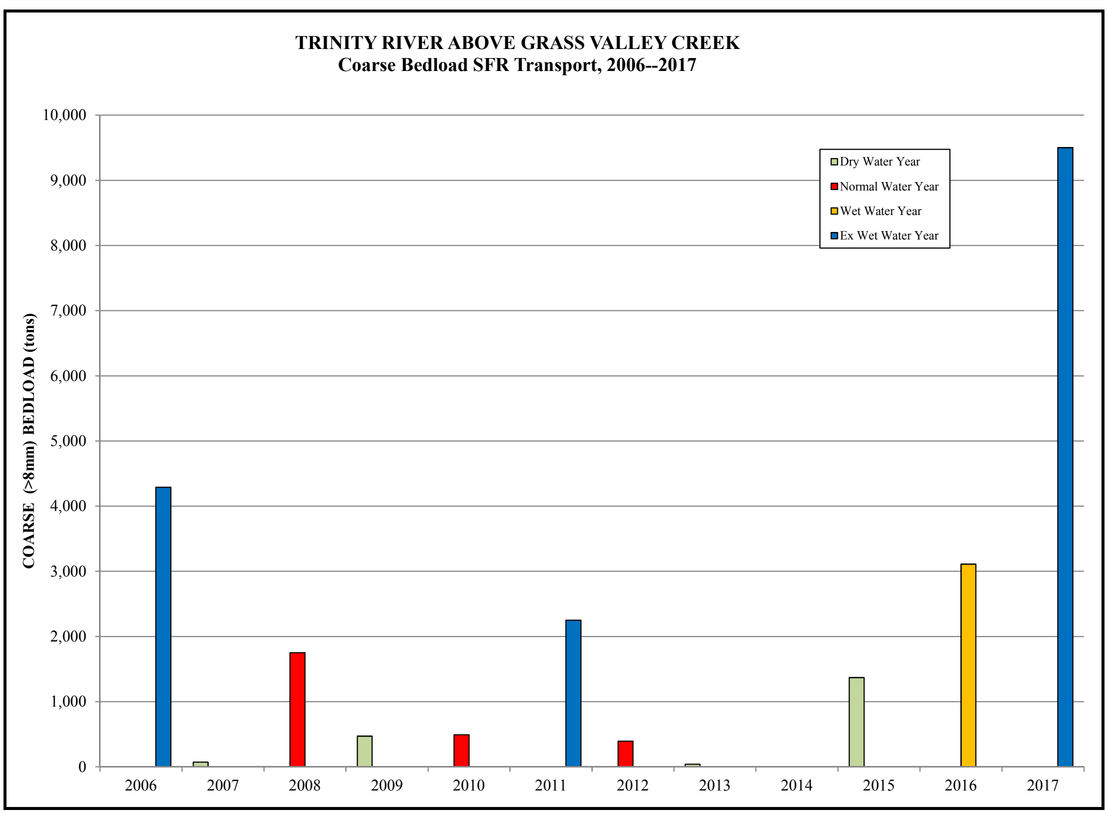


Figure 54. Trinity River above Grass Valley Creek, ≥8mm Bedload 2006-2013, 2015-2017.

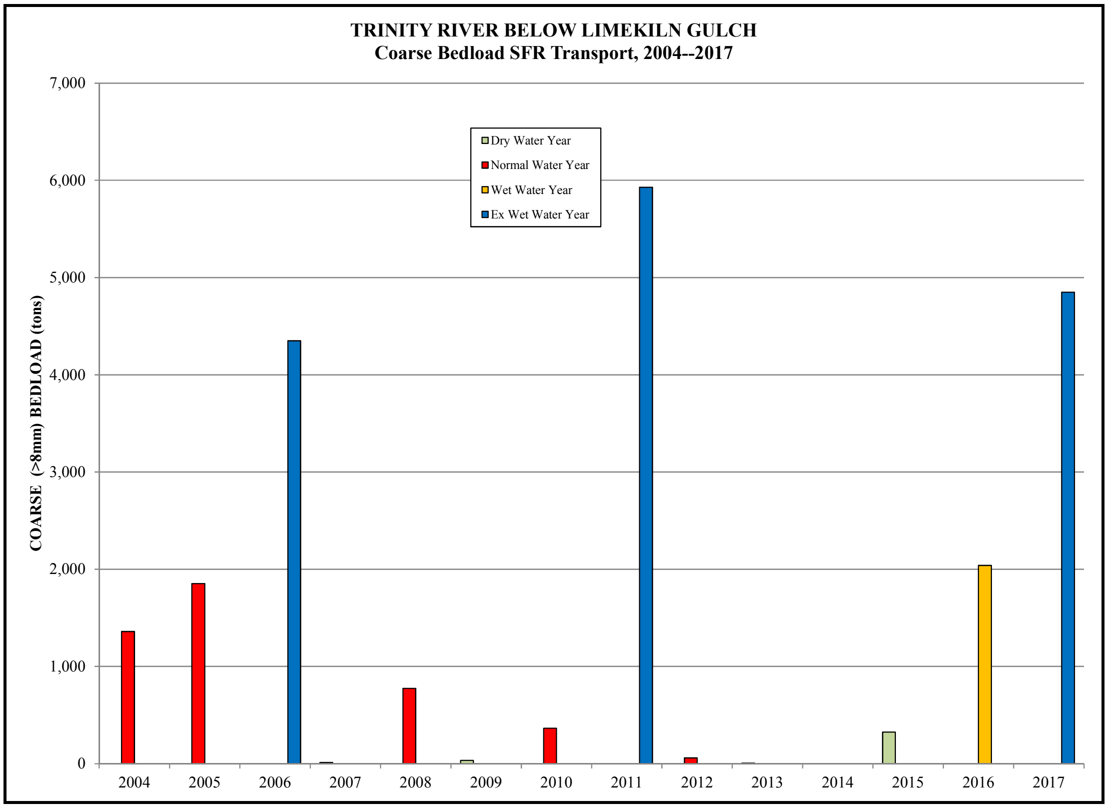


Figure 55. Trinity River below Limekiln Gulch, ≥8mm Bedload 2004-2013, 2015-2017.

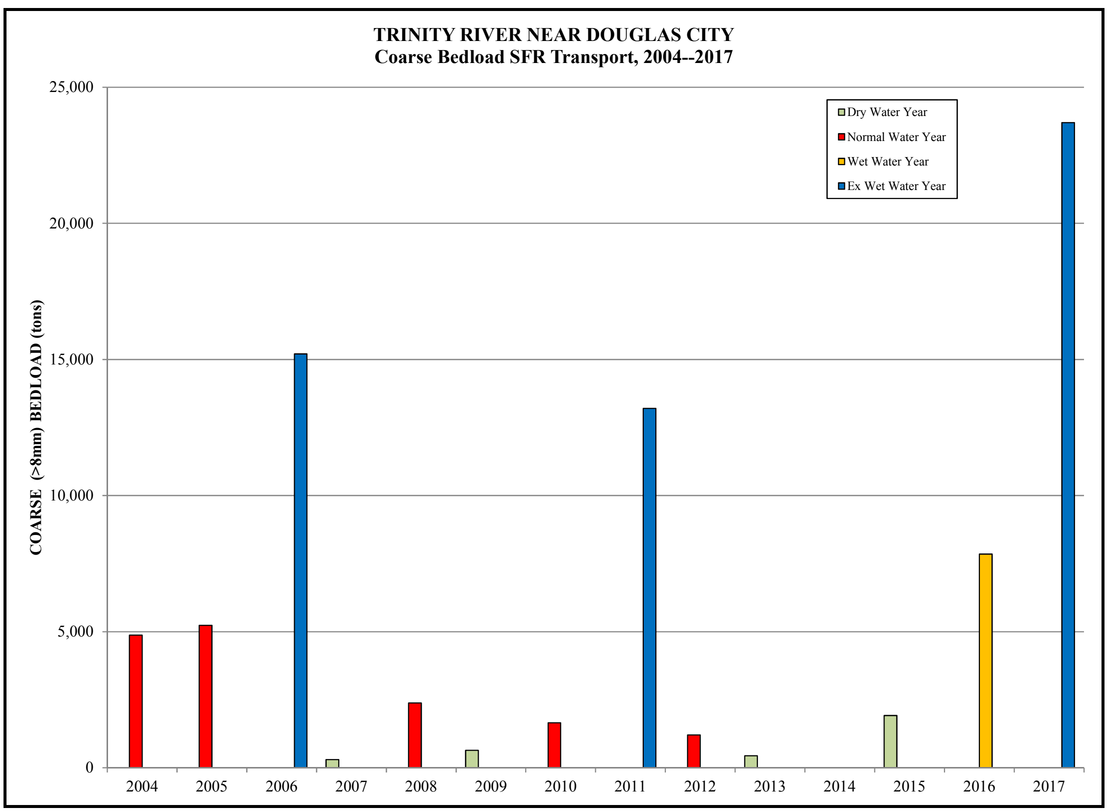


Figure 56. Trinity River below Limekiln Gulch, ≥8mm Bedload 2004-2013, 2015-2017.

2.5.5 Changes in Sediment Transport Rate Over Time

This discussion is limited to the long-term mainstem monitoring stations used in the TRFE to predict the fine and coarse fractions of bedload transport: TRAL and TRLG.

2.5.4.1 Trinity River at Lewiston, CA

The total bedload transport rates for WY 1997, WY 2002, WY 2004-2013 and WY2015-2017 appear in Figure 10. The WY2017 data plotted well within the overall cloud of points. Due to the wide range of variability within each year (e.g. WY2016 data spans a full order of magnitude at around 6,000 cfs), it is difficult to discern changes over time. Intra year comparisons are further compounded at TRAL by: changes in sampling location, the use of different types of samplers and winter storm samples lumped with flow release samples. The 2009 data sit to the left of most of the data, suggesting total bedload transport rates were higher in that year.

For the 0.5-<8mm and ≥8mm bedload classes (Figures 8 and 9), all but one of the 2016-2017 samples fell to the right of the TRFE curve. This suggests that today's measured transport rates are lower than those used in the TRFE.

2.5.4.2 Trinity River below Limekiln Gulch

Partial and total bedload discharge data are available for TRLG during WY 1981-86, WY 1989-91, WY 1997, WY 2000, WY 2002-2014 and WY2015-2017 (Figures 29-31). The WY 2017 ≥8mm data fall generally within the cloud of historic data points but sit to the right of the TRFE curve (Figure 30). The 0.5-<8mm class follows the same pattern and sit even further right of the TRFE curve at the highest flows (Figure 29). This suggests that today's measured transport rates are lower than those used in the TRFE.

2.5.6 Spatial and Temporal Variation in Bedload Discharge

Variation across a sampling section

We provide this description from 2006 in order to illustrate how bedload varies across a section and to illustrate how we choose high transport zones for the experiment described in the next section. In 2006, between May 25 and June 12, at flows in the 5,000-10,000 cfs range, GMA conducted a number of experiments at the TRDC station (GMA 2007). Bedload samples were collected at 11 sampling locations (stations) along the cross section and were processed separately to examine the variability in bedload transport across the section (Figure 49). Samples are typically composited. These data clearly indicate where most of the transport is occurring (station 75 and from 105-125). Note that while, peak transport shifts among stations within the 105-125 range on different days, the peak always remains within this range. Figure 57 is intended to provide context for the next section, where samples are repeated at a high-transport location along a sampling section.

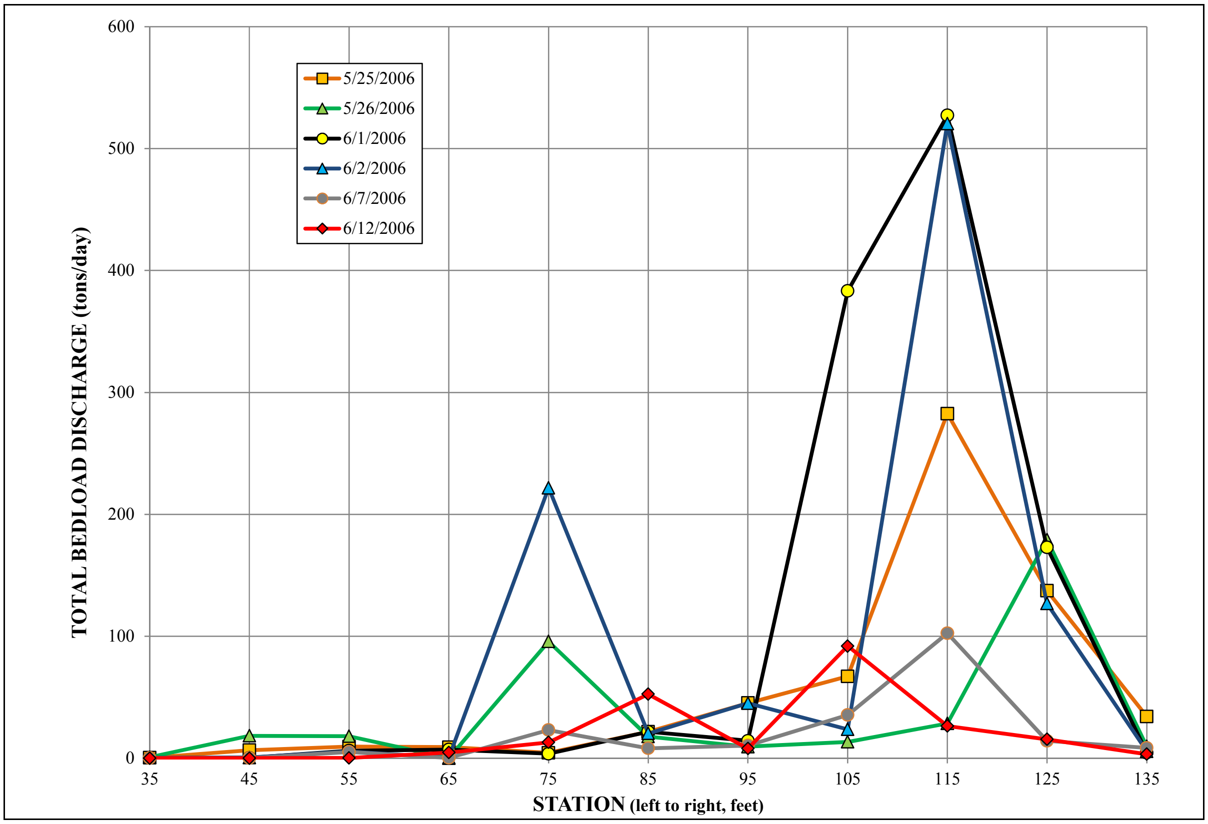


Figure 57. Spatial variation at a sampling section - total bedload discharge at TRDC in WY2006. Downstream view.

<u>Variation over 30 minutes</u>

In 2017 for the third consecutive year, GMA assessed the potential temporal variation in bedload measurements by sampling repeatedly at a single vertical over period of at least 30 minutes (at each site). Crews were instructed to sample a high transport location on a high transport day. Down-times were held constant (e.g. 60 seconds) and since sample handling time was relatively constant, the method allowed for a systematic sample over the 30 minute period, e.g. the sampler hits the streambed every 4 minutes. Bedload discharge was computed over a 10 foot width, equivalent to a single computational cell in the SEWI computational method. Total bedload is the sum of the fine and coarse loads. Sample sizes are relatively small (n=6-10) and only very basic summary statistics were computed from the data (Table 19).

Table 19. 2017 Bedload Variability Sampling Summary

Sample	TRAL Total Transport Rate (tons/day)	TRAL Transport ≥ 8mm (tons/day)	TRAL Transport 0.5-8 mm (tons/day)	TRGV Total Transport Rate (tons/day)	TRGV Transport ≥ 8mm (tons/day)	TRGV Transport 0.5-8 mm (tons/day)	TRLG Total Transport Rate (tons/day)	TRLG Transport ≥ 8mm (tons/day)	TRLG Transport 0.5-8 mm (tons/day)	TRDC Total Transport Rate (tons/day)	TRDC Transport ≥ 8mm (tons/day)	TRDC Transport 0.5-8 mm (tons/day)
#1	66.2	49.7	16.5	53.3	49.9	3.4	70.8	61.4	9.4	171.1	35.0	136.1
#2	472.3	432.9	39.4	0.8	0.0	0.8	29.4	21.4	8.0	315.1	151.9	163.3
#3	357.5	258.2	99.3	30.6	29.4	1.2	19.8	10.4	9.4	158.2	32.8	125.5
#4	376.6	249.5	127.1	1.8	0.3	1.4	20.2	10.5	9.8	162.3	28.1	134.2
#5	222.0	165.8	56.2	0.7	0.0	0.7	15.1	10.5	4.5	332.9	60.2	272.7
#6	322.5	271.9	50.6	1.9	1.3	0.6	15.5	5.7	9.9	258.2	43.4	214.8
#7				0.5	0.0	0.5	14.8	7.5	7.3	275.3	50.3	225.1
#8				0.7	0.0	0.7	3.5	0.6	2.9	259.3	57.0	202.3
#9							11.5	4.0	7.5	62.2	0.4	61.8
#10							5.0	3.6	1.3	390.4	138.9	251.5
mean	302.9	238.0	64.8	11.3	10.1	1.2	20.6	13.6	7.0	238.5	59.8	178.7
SD	141.5	126.8	40.8	19.9	19.0	0.9	19.2	17.8	3.1	98.8	48.3	65.6
min	66.2	49.7	16.5	0.5	0.0	0.5	3.5	0.6	1.3	62.2	0.4	61.8
max	472.3	432.9	127.1	53.3	49.9	3.4	70.8	61.4	9.9	390.4	151.9	272.7
range	406.1	383.3	110.6	52.8	49.9	2.9	67.3	60.8	8.5	328.2	151.5	210.9
Values are not rounded as per Porterfield 1972												

Figures 58-61 are provided as visual representation of WY 2017 bedload variability for individual stations (sites) within the study and Figure 62 portrays all four stations together.

At TRAL, the fine bedload varied over a range of 111 tons per day while the coarse load varied over a range of 383 tons per day (Table 20). The relative contribution of the fine bedload ranges from 8 to 34 percent. TRAL shows the highest (average) coarse percentage (77 percent is the average of the six samples), which is likely due to the fact that only one small tributary enters between TRAL and the dam (Deadwood Creek), thus limiting the potential for fine bedload recruitment.

The effect of gravel injection on supply (and flow decrease) appears in the TRGV data. Figure 49 suggests that at the time the bedload variability samples were collected on May 1, coarse bedload transport had begun to plummet. Four zeroes appear in the coarse bedload data while the fine bedload transport remains fairly constant (Table 20). The coarse bedload appears to move in bursts, while the fine fraction transport is less variable (Figure 59). Coarse bedload (during this time period) composed 35 percent of the total bedload transport.

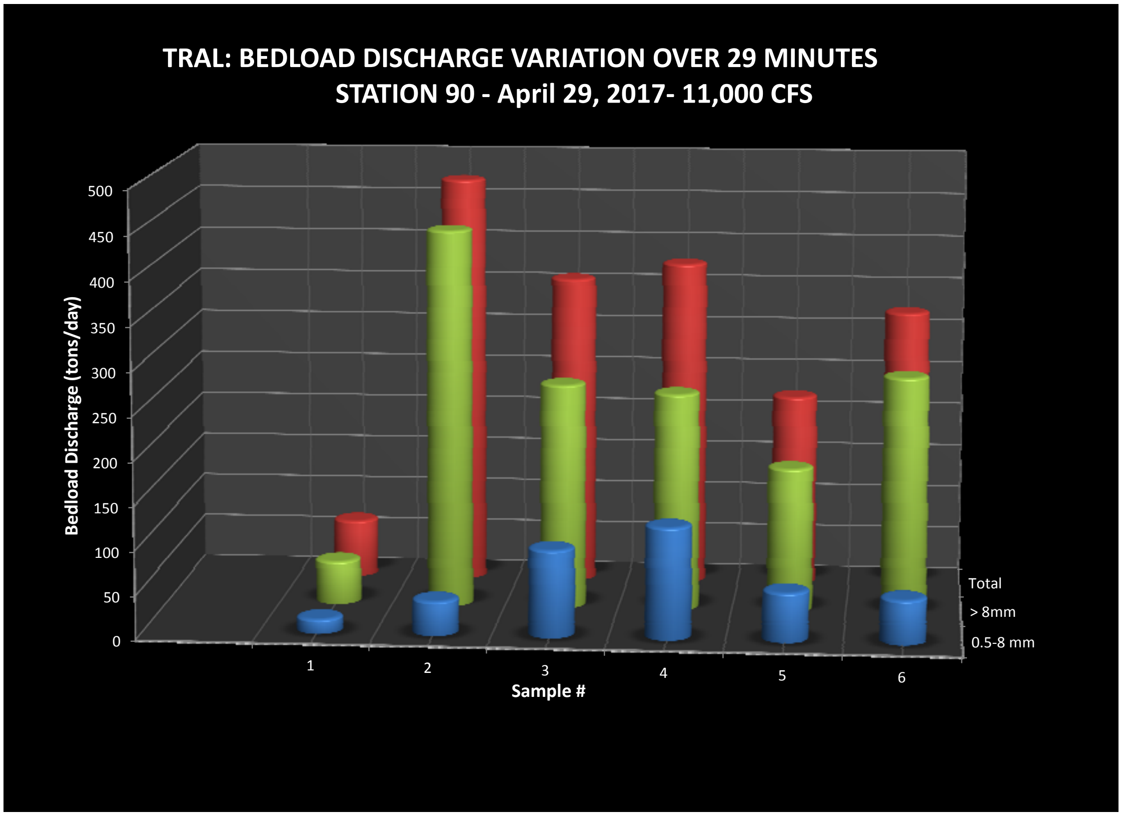


Figure 58. Bedload discharge at TRAL over 29 minutes at 60 second downtimes.

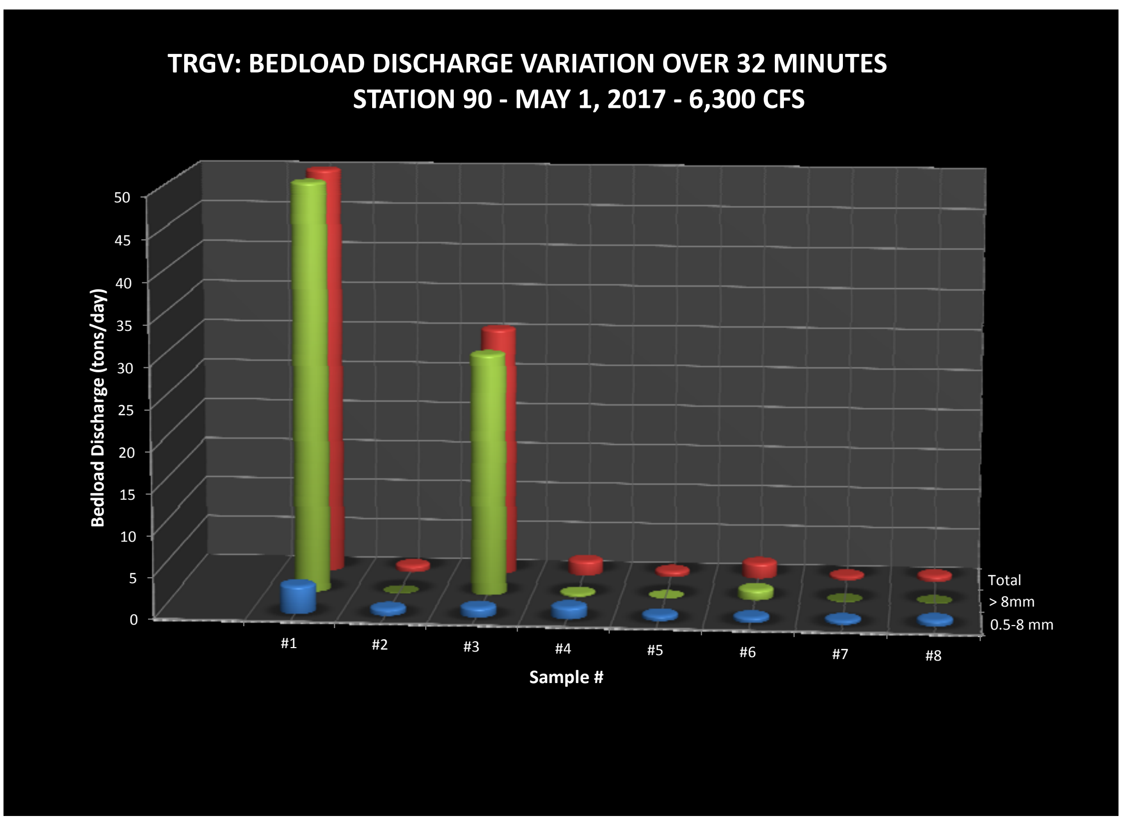


Figure 59. Bedload discharge at TRGV over 32 minutes at 120 second downtimes.

Unlike at TRAL, TRLG reveals heterogeneity in the relative contribution of fine and coarse bedload. Six samples are >50 percent coarse bedload while the remaining four are comprised primarily of fine bedload (Table 20). TRLG also illustrates a progressive decline in overall bedload transport over the 40 minute sampling period (Figure 60). At TRDC, the samples in the 2017 variability test are composed primarily of fine bedload (78 percent on average, Table 20).

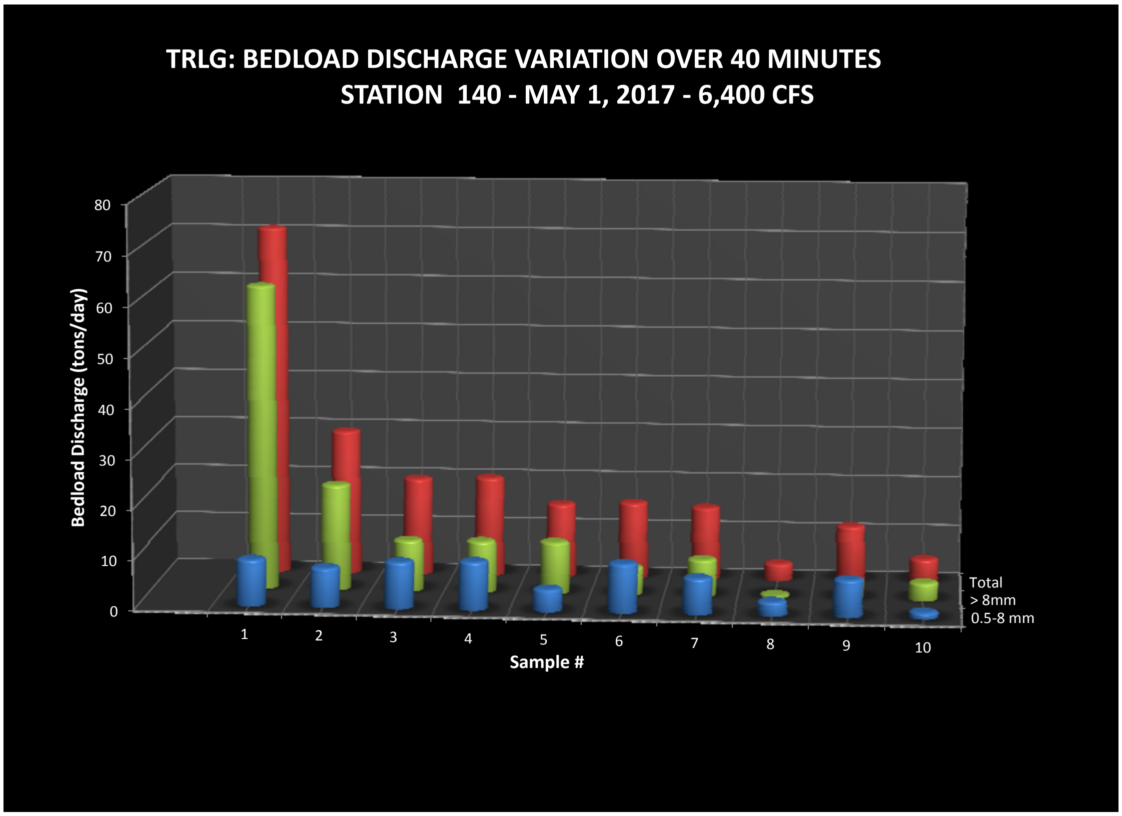


Figure 60. Bedload discharge at TRLG over a 36 minute period at 120 second downtimes.

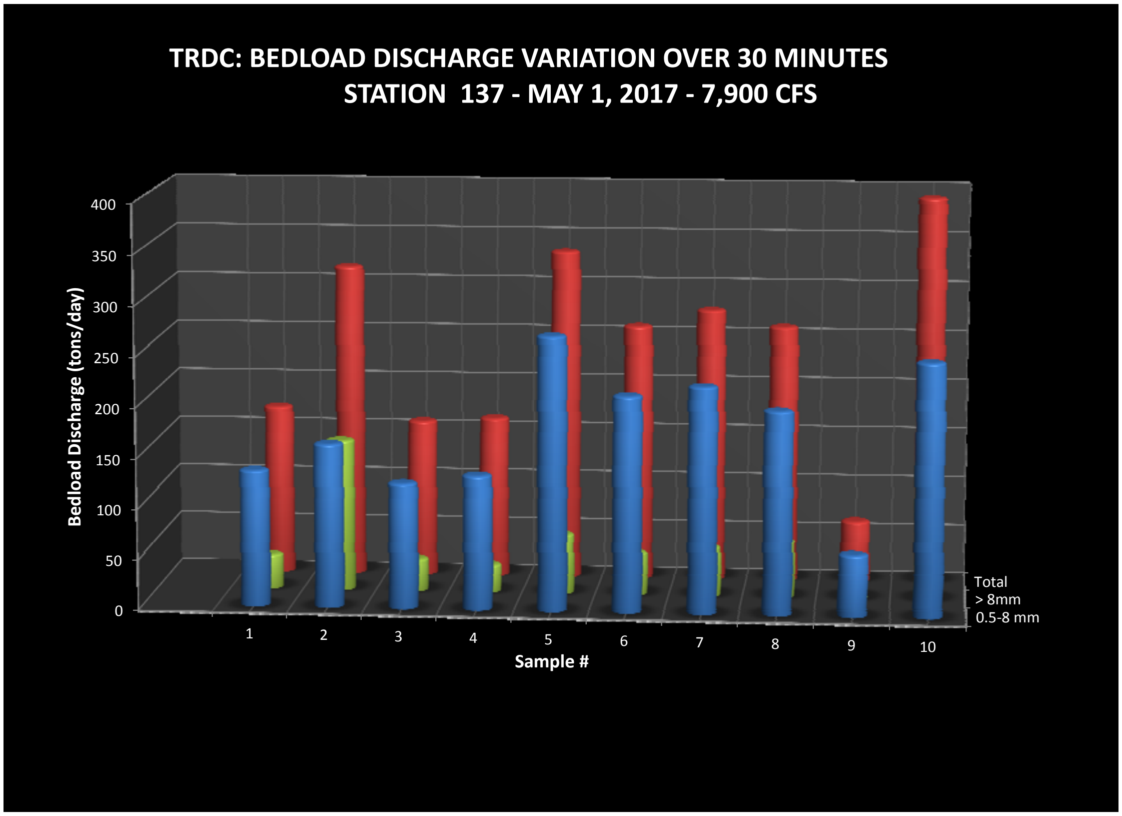


Figure 61. Bedload discharge at TRDC over a 36 minute period at 30 second downtimes.

Since TRAL is starved of fines (located so close to the dam) and since both TRAL and TRGV are so strongly influenced by coarse-gravel injection, TRLG and TRDC results are likely more representative of temporal variability in magnitude and composition of bedload transport in the Trinity River. While all sites are highly variable, TRAL and TRDC demonstrated the greatest range in 2017 total bedload discharge (Figure 62).

WY2017 crews reported most of the sediment load is typically generated at one to three stations. If we apply the 2006 spatial inference (most of the load is transported at 3 to 4 stations) to the bedload variability study, then we can assume that at TRDC, a full cross section total load computed from data collected at time #10 will differ greatly (>80 percent) from a load computed from time #9 (Figure 61). TRGV, with its zero transport values is even more compelling, both in suggesting the question of how to handle zeroes in computing a mean (we included them) and in the implication of sampling a zero transport period which occurs a few minutes after a 50 tons/day period (Table 20).

While the variability study data are far from conclusive, they do suggest a need for more sampling at fewer stations (i.e., over a narrower width of the cross section where the most sediment load is being transported) in order to derive a more accurate estimate of average bedload discharge. These data also support the need for a better surrogate than discharge such as passive hydroacoustics. The 2017 findings from the USGS (and other researchers who deployed hydrophones during the Spring Flow Release) will be highly relevant for improving future monitoring efforts.

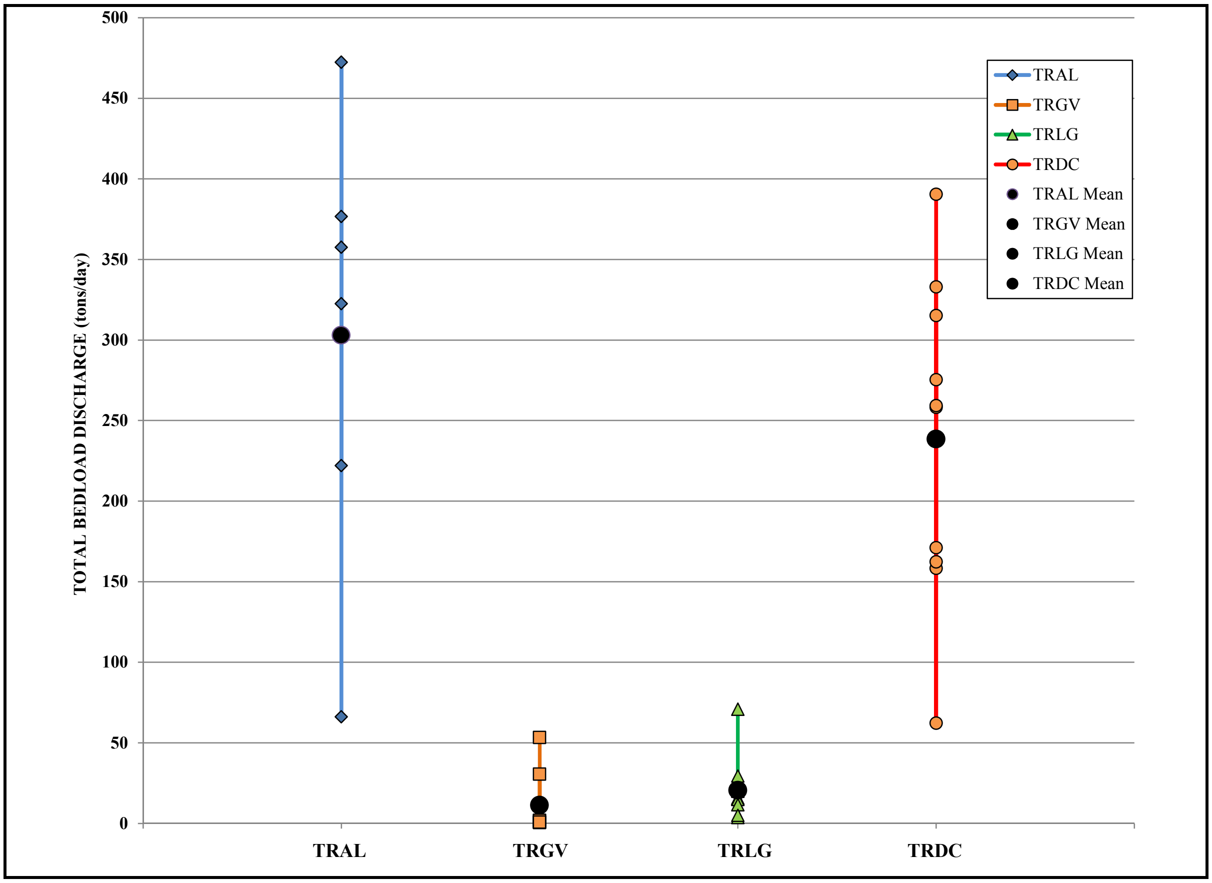


Figure 62. Total bedload discharge (range and mean values) during the variability pilot study at the four Trinity River sampling locations.

3.0 MONITORING RECOMMENDATIONS

In an effort to improve future sediment transport monitoring efforts, we offer the following recommendations:

- The potential trend of reduced bedload transport in Normal and Dry Year type Spring Flow Releases, as discussed in Section 2.5.4, may warrant further investigation. Clearly, the modified Dry release hydrograph applied in WY2015 was successful in moving more sediment than was observed in other Dry water years.
- Consider altering the bedload sampling protocols to use multiple occupations of single verticals along the same cross section, with the number of replicates based on the variability and magnitude of transport rates. At low transport rate verticals, a single long duration sample will provide a reasonable estimate of mean transport, while in high rate verticals, multiple samples would provide a more robust estimate of the mean. Such an approach will increase the accuracy of estimating a mean daily value to guide sedigraph development.
- Water surface slope measurement at some stations (e.g. TRGV, TRLG) is strongly influenced by overbank flow slope reduction. The reported highest-flow slopes are really floodplain water surface slope. Presumably, analysts are more interested in the slope responsible for grain mobilization which is typically steeper than that measured on the floodplain. We suggest installing taller stage references at selected locations to improve the accuracy of water surface slope measures, or install simple pressure transducers (e.g. Onset hobo) above and below the sampling section.
- Cableway anchors (trees) at TRDC are failing. For future monitoring efforts, new anchors must be constructed.
- Suspended sediment data collection efforts were greatly reduced in 2017. Total number of samples per site was reduced to four one-pass samples. With one pass samples, it is impossible to critique outliers. For example, at TRGV where Sample #4 was censored as an outlier, the computed suspended load dropped by 12 percent. A second pass could have verified censoring or inclusion of this sample. The cost of collecting a second SSC pass is quite small compared to the cost of collecting the initial pass and provides a much more robust dataset. We recommend collecting two-pass samples in the future.
- Passive hydro acoustics appear more promising than ever for estimating bedload discharge. USGS has published bedload discharge data for TRAL WY2015-2016 (https://nwis.waterdata.usgs.gov/nwis/uv?cb_72298=on&cb_72302=on&format=gif_default&site_no=11525525&period=&begin_date=2016-04-28&end_date=2016-05-30). We highly recommend supplementing the existing data collection protocols with hydrophone data collection during future Spring Flow Releases.

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2017 TRINITY RIVER SEDIMENT TRANSPORT MONITORING FINAL REPORT

TECHNICAL APPENDIXES

Prepared for:

U.S. Department of Interior
The Trinity River Restoration Program (TRRP)
1313 South Main Street
Weaverville, CA 96093
(530) 623-1800

Prepared by:

GMA Hydrology, Inc. (GMA)
1973 Smith Flat Rd.
Placerville, CA 95667
(530) 623-0402

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Hydrology – Geomorphology – Stream Restoration
Land and Hydrographic Surveys

WY 2017 SEDIMENT TRANSPORT MONITORING REPORT

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Appendix A

Trinity River at Lewiston
USGS Gage # 11525500

11525500 Trinity River at Lewiston, CA

BEDLOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2017: (April 1 to July 31)

Records collected at station.-- Daily streamflow has been collected continuously since 1911 and peak streamflow has been recorded since 1860. Various bedload and suspended-load data have been collected by the USGS and other entities since 1997. Instantaneous air and water temperature data have been collected since 1990. The purpose for collecting sediment data at this site is to quantify sediment discharge delivered from this portion of the mainstem, versus the discharge measured at sediment collection stations downstream. This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2017 spring flow release by GMA Hydrology (GMA), under contract to the Trinity River Restoration Program.

Equipment.--Sampling equipment consists of a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5mm mesh collection bag deployed from a crane-mounted electric winch. Sampling was performed from a cataraft-based sampling platform attached to a temporary cableway. Stage references were installed near cableways. Photographs were taken with a digital camera.

Sampling program.--Total (flow release) load season for this site is from April 1 to July 31. Sampling was reduced at this site during Water Year 2017 to 4 partial days and 1 full day of bedload sampling. No suspended sediment data was collected. A minimum of two bedload-discharge samples were collected on each of the sampling days. Bedload samples consisted of one pass and were sub-divided to provide calibration for USGS hydroacoustic monitoring efforts. The sampling days and samples collected are as follows:

April 25	6 bedload discharge	0 suspended-sediment discharge
April 27	4 bedload discharge	0 suspended-sediment discharge
April 28	6 bedload discharge	0 suspended-sediment discharge
April 29	3 bedload discharge	0 suspended-sediment discharge
May 2	2 bedload discharge	0 suspended-sediment discharge

Sampling crews consisted of a safety kayaker, and two on-river personnel specifically trained in cataraft-based sediment data collection techniques. Sediment data were generally collected according to USGS protocols. Bedload samples were sent to the GMA Coarse Sediment Lab, located in Placerville, CA.

USGS Field Review. -- No USGS field review was conducted during the 2017 Spring Flow Release.

Data summary for WY 2017 spring flow release.--

Total number of samples:

Suspended sets …………………………………………………………	0
Single pass suspended samples ………………………………………	0
Box sample sets …………………………………………………………	0
Single box samples …………………………………………………………	0
Bedload sets …………………………………………………………………	0
Single pass bedload samples ………………………………………	21
Three pass bedload samples ………………………………………	0

Number of field turbidities measured 0
Number of suspended sediment size analysis samples:
    Particle size analysis 0
    0.063mm break 0
    0.50mm break 0
Number of bedload sediment size analysis samples:
    Particle size analysis 21
Number of suspended sediment discharge measurements 0
Number of bedload discharge measurements 21
Number of visits by Field Office 0
Maximum flow sampled by:
    GMA technicians, ft^3/s 11,700
Range sampled by:
    GMA technicians, mg/l .... NA
    GMA technicians, ton/d 23-1,650
Peak flow during flow release, ft^3/s 12,000
Periods of faulty record .... NA

Coefficients -- None Used

Total suspended sediment-discharge computations. -- None

Size analysis. -- None

Partial suspended sediment-discharge computations. – None

Bed material.-- None.

Bedload measurement. -- Twenty one bedload discharge samples were collected during the computational period. All were single pass samples.

Bedload-discharge computations. -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the 0.5mm-<8mm and the ≥8mm size fractions.

Partial Bedload-discharge computations – Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-8mm and ≥8mm size classes. 2017 had a double peak hydrograph, however the smaller dataset generated by the reduced sampling effort (compared to previous years) precluded an examination of rise/fall relations. No outliers were identified during analysis of either size class.

For the 0.5mm-<8mm size class, the transport curve is shown in Equation (1). No obvious pattern of hysteresis were seen, so a single generalized equation was used for the entire time period.

$$BLD = 4.52e - 013 * Disch\arg e^{3.52}, \qquad r^2 = 0.77 \qquad (1)$$

The transport curve was developed using samples 1-21. The transport curve is used from April 1 at 00:00 hrs until July 31 at 23:45 hours. Eqn. (1) has a valididated range between 4,300 cfs and 11,700 cfs. Zero transport for the rising limb was estimated using previous years' data at 1,600 cfs. For the falling limb, zero transport was determined by fitting the sedigraph to sample 22 and occurs at 4,200 cfs.

For the ≥8mm size class, the transport curve is defined by Eqn. (2).

$$BLD = 2.21e-005*(Discharge-3000)^{1.93}, \qquad r^2 = 0.95 \qquad (2)$$

Eqn. (2) was developed using samples 1-21 and is valid from April 1, 2016 at 00:00 until May 9, 2016 at 18:00. The transport curve is used from April 1 at 00:00 hrs until July 31 at 23:45 hours. Eqn. (2) has a valididated range between 4,300 cfs and 11,700 cfs. Zero transport for the rising limb was estimated using previous years' data during transport curve development at 3,000 cfs. For the falling limb, zero transport was determined by fitting the sedigraph to an average of sample 21 and 22 and occurs at approximately 3,400 cfs. There were no samples collected on the second hydrograph peak at this site. Each transport curve was used with no shifts applied to it over the approximate 5,000 cfs bench. The zero tranport for the second peak was assumed to be the same as the falling limb zero transport of the first peak for both size classes. The sedigraphs were fit between the end of the 5,000 cfs bench and the estimated zero transport.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted to the sample values to pass through the sample data The continuous bedload traces were adjusted using fitting and proportional fitting techniques.

Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous bedload) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When bedload is not highly correlated with discharge, it is not possible to evaluate this assumption and therefore it is a potential source of error .

Due to the inherent high variability in bedload sampling, during flow benches sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload transport trace.

Remarks. – The bedload discharge record is rated as follows:

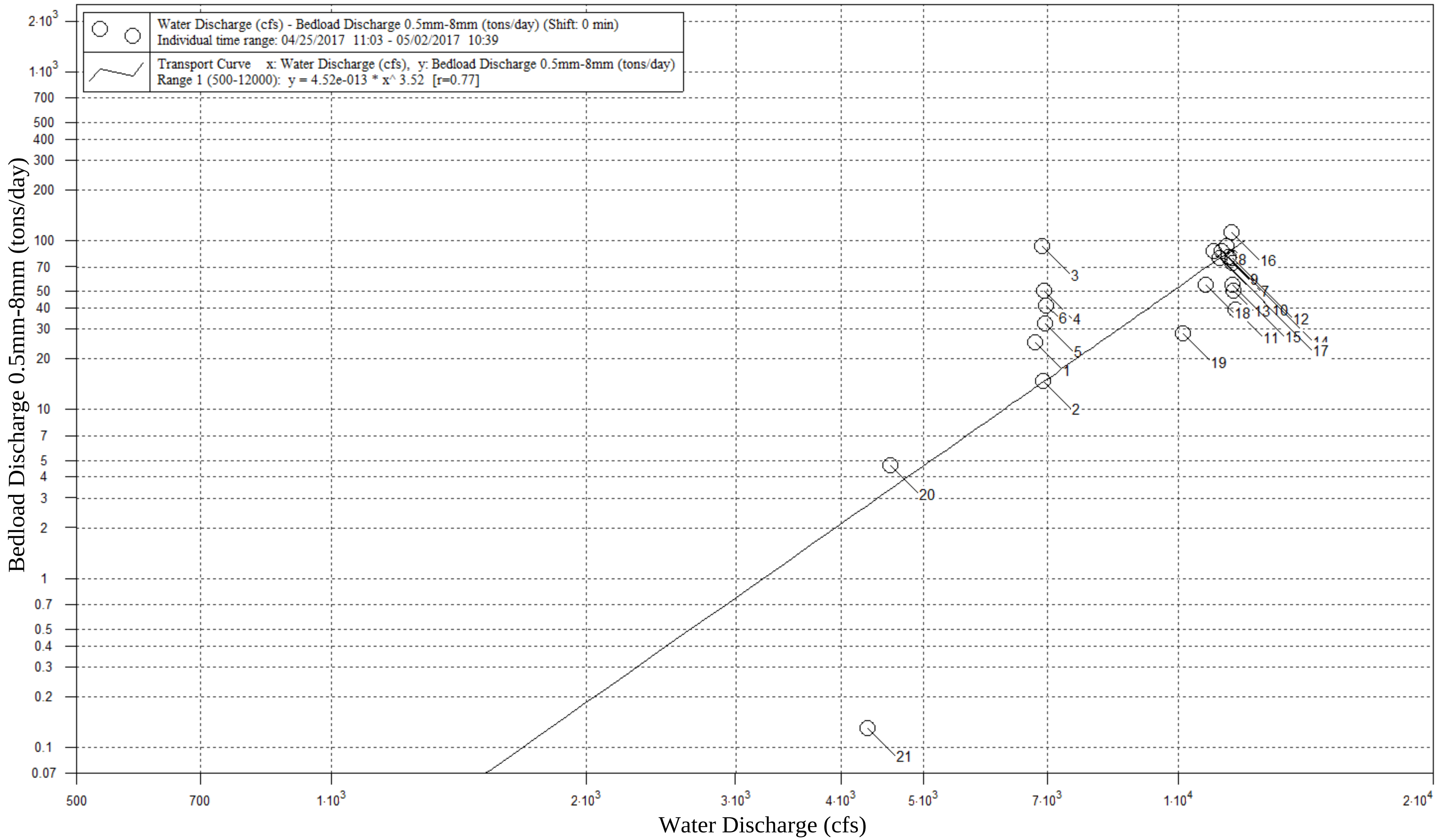
April 1 (00:00) to April 24 (23:45)	Estimated
April 25 (00:00) to May 2 (23:45)	Good
May 3 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December 2017

Reviewed by: Smokey Pittman, December 2017

TRINITY RIVER AT LEWISTON --11525500

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2017



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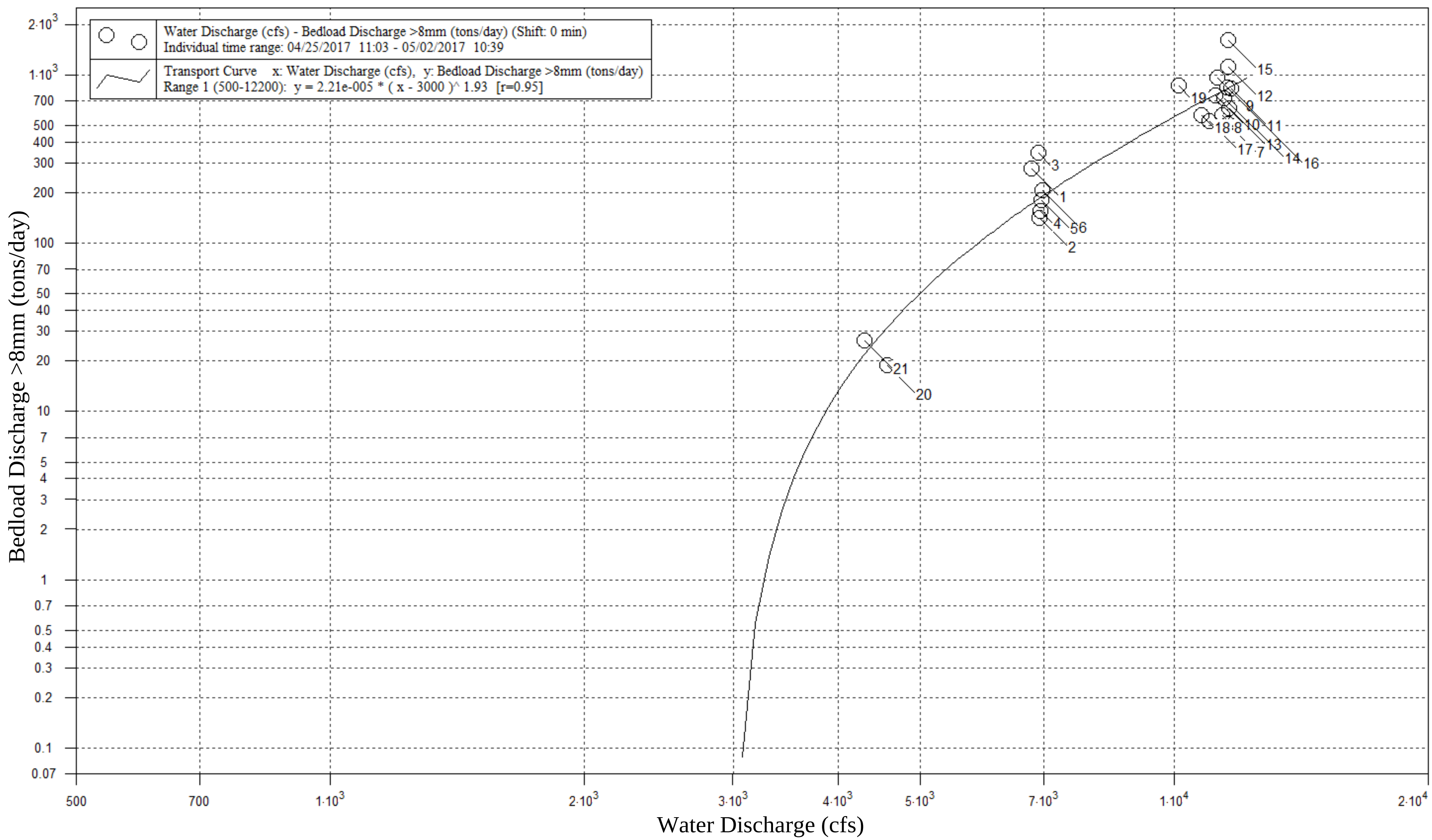
TRINITY RIVER AT LEWISTON --11525500

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2017



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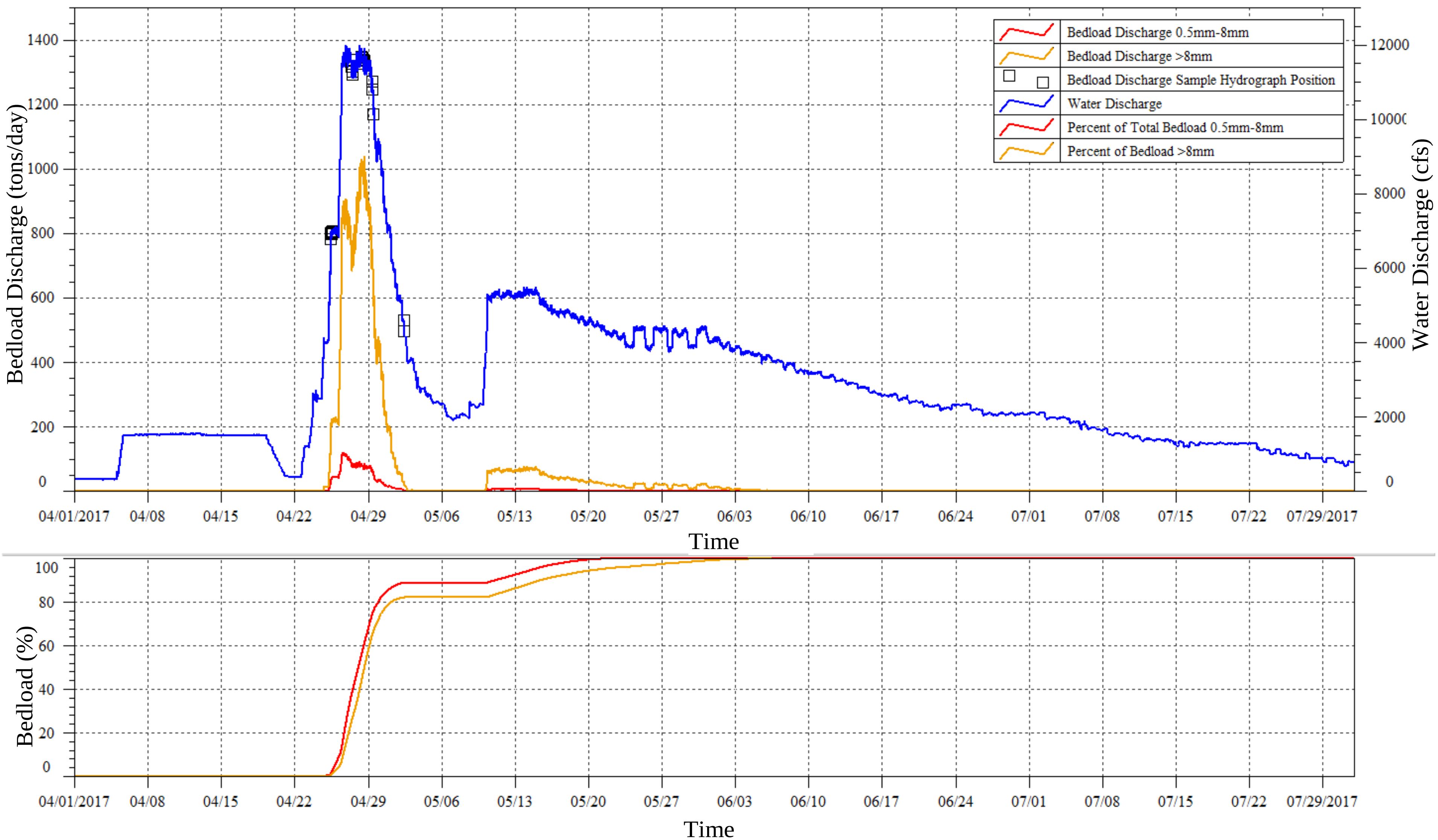
TRINITY RIVER AT LEWISTON –11525500

Bedload Discharge – Spring Flow Release WY 2017



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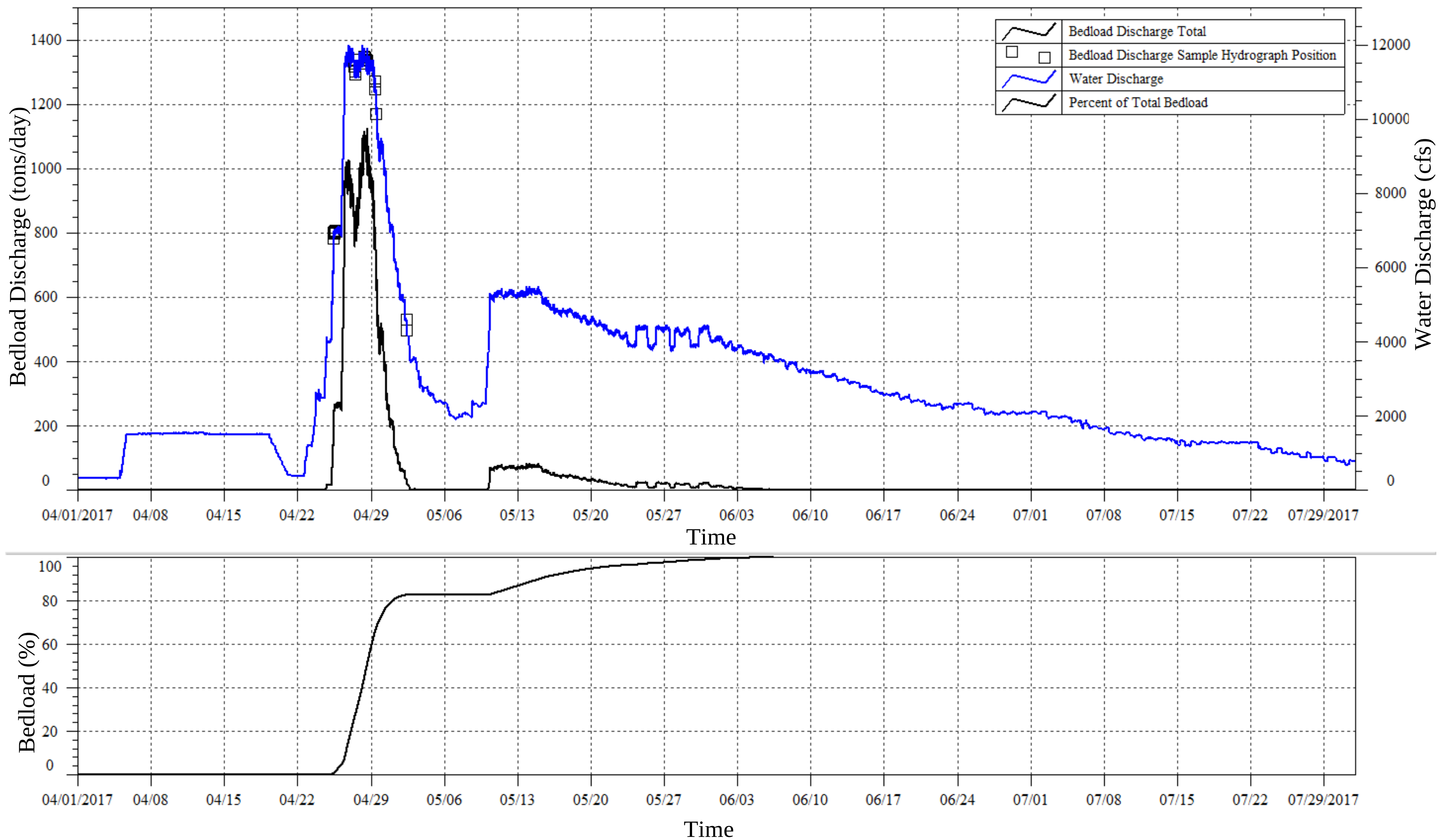
TRINITY RIVER AT LEWISTON –11525500

Bedload Discharge – Spring Flow Release WY 2017



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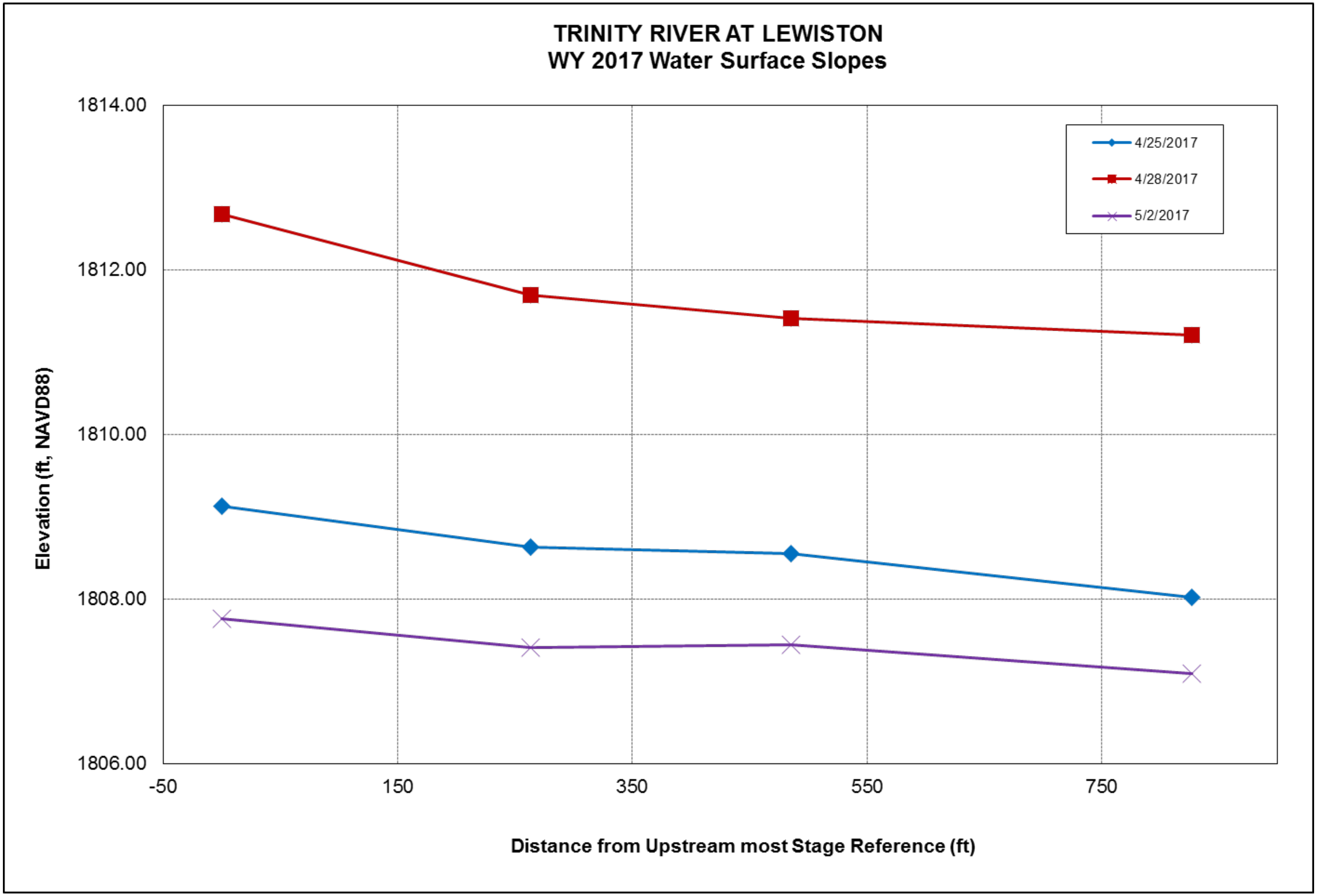

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Appendix B

Trinity River above Grass Valley Creek
USGS Gage # 11525540

11525540 Trinity River Above Grass Valley Cr. near Lewiston

STATION ANALYSIS

SURFACE WATER RECORD

Spring Flow Release WY 2017: (April 1 to July 31)

LOCATION – Lat 40°41’51”, long 122°,15’11” referenced to North American Datum of 1983

RECORDS – Surface Water. The purpose for collecting streamflow at this site is to provide accurate streamflow records for bedload and supended sediment discharge computations. Potential flow increases from tributaries between the Trinity River at Lewiston streamflow gage (11525500) and the Trinity River above Grass Valley Creek Sediment Monitoring Station require the establishment of a seasonal streamflow gaging station. This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) discharge measurement efforts during and (2) records computed for the WY 2017 Spring Flow Release by GMA, under contract to the TRRP. This gage is operated during the Spring Flow Release period.

Prior to the WY 2011 Spring Flow Release this station was located 166 ft upstream. During the summer of 2010 TRRP completed a channel and floodplain restoration project in the reach which required moving the surface water monitoring station.

EQUIPMENT – Graham Matthews & Associates re-established this site in April of Water Year 2011. A Campbell Scientific Inc. CR200 DCP, Design Analysis Associates Water Log H-310 pressure transducer, and a Forest Technology Systems DTS-12 are installed at the site.

Inside recording gage: Design Analysis H-310 (Accuracy to ± 0.007 ft)
Forest Technology Systems DTS-12 (Accuracy (0-499.99 NTU ± 2% +0.2 NTU), (500.00 to 1600 NTU ± 4%))

Outside staff gage: Three enameled sections (0.00 ft – 9.99 ft).

GAGE HEIGHT RECORDS – Record is incomplete for the computational period. The gage was reinstalled on April 4, 2017 at 11:15. During the computational period the maximum gage height of 10.54 ft. occurred on April 27 at 03:30 hours. The minimum gage height for the computational period of 1.82 ft. occurred on April 4 at 19:00 hours.

Staff height readings were compared to recorded gage height values. Staff height readings made during the period indicated that corrections to the electronic gage data were necessary. From April 4, 2017 at 11:15, the time of installation, until April 5, 2017 at 08:45, a correction of 0.33 ft was applied to the gage record. On April 5 at 09:00 the gage height correction was changed in the data collection platform and a new gage height correction of 0.01’ was applied to the gage record. Staff height observation on April 5, 2017, May 13 and June 23 show a 0.01’ correction, which indicates that the pressure transducer did not drift during the spring flow release computational period. A gage height correction of 0.01’ was used for the entire period. Gage height corrections were held constant and not increased with increasing stage as was done in previous years to account for backwatering on floodplain staff plates.

DATUM CORRECTIONS – No correction necessary. A level survey was performed on April 5, 2017 and August 17, 2017. The control, BM1 (5/8-inch capped rebar), for the station was set on April 14, 2011 and is located 20 ft upstream of the gage and roughly 140 ft to the east.

CONTROL – The low water control at the site is a downstream riffle. The low water control is prone to shifts. At high flows, channel control dominates. The high flow channel was significantly altered during restoration activities in 2010. The floodplain was lowered and a significant amount of vegetation was removed from the left bank.

RATING – Six discharge measurements (93-98) were made during the computational period. Measurements were made with a Sontek M9 ADCP, a Price AA meter and Aquacalc Pro or a Sontek FlowTracker2 ADV. Measured discharge for the period ranged from 431 cfs to 10,700 cfs. Computed instantaneous discharged ranged from 415 cfs to 12,200 cfs.

Rating 6.0 was developed in Water Year 2016 to extend the low end of Rating 5.1. Stage variable shift SV16-01 was in use at the end of the previous computational period. Measurements were plotted and inspected for use during the period. Measurement 90, taken during Water Year 2016, suggested a shift back to Rating 6.0, however it was a Poor measurement, so a shift back to the rating was not implemented at the close of the previous computational period.

All measurements taken during Water Year 2017 fall within acceptable limits of Rating 6.0 and don’t follow the trend of SV16-01. SV16-01 was ended and Rating 6.0 was used with no stage variable shifts for the entire Water Year 2017 computational period.

Rating 6.0 has a validated range between 1.71 ft (366 cfs) and 10.1 ft (11,400 cfs).

DISCHARGE –Rating 6.0 is used as follows:

April 1 to Jul. 31 (23:45) Rating 6.0

SPECIAL COMPUTATIONS – Hydrographic comparison with discharge records from Trinity River near Lewiston (11525500) and Trinity River below Limekiln Gulch near Douglas City (11525655) were used to verify the accuracy of the computed record.

Prior to the gage being installed on the April 4, 2017, discharge records were estimated using the Trinity River at Lewiston, CA (TRAL, 11525500) and the Rush Cr near Lewiston, CA (RCNL, 11525530) gaging records.

REMARKS – The record should be considered **Fair** for the computational period. The record should be considered estimated from April 1, 2017 through April 4, 2017 when the record was estimated using TRAL and RCNL data.

Record Worked by: B. Pittman, November 2017
Record Reviewed by: S. Pittman, December 2017

11525540 Trinity River Above Grass Valley Cr. near Lewiston

TOTAL LOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2017: (April 1 to July 31)

Records collected at station.— GMA Hydrology established this site in May of Water Year 2006. In April 2011 the electronic monitoring equipment was moved 166 feet downstream and the sampling cableway was moved roughly 300 feet downstream. Relocation of the station was necessary due to restoration activities that occurred during the summer of 2010. On April 27, 2017, the right bank anchor tree, which suspends the sampling cableway became compromised. On April 29, 2017 the sampling cross section was moved approximately 150 feet downstream. A Campbell Scientific Inc. CR200 data collection platform (DCP), Design Analysis Assoc. WaterLog H-310 pressure transducer, and a Forest Technology Systems DTS-12 are installed at the site. The purpose for collecting sediment data at this site is to quantify sediment discharge delivered from this portion of the mainstem. This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2017 high flow release by GMA, under contract to the Trinity River Restoration Program (TRRP).

Equipment.-- Sampling equipment consists of a D-74 and DH-48 for suspended-sediment sampling, and a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5mm mesh collection bag. The D-74 suspended-sediment sampler and the TR-2 bedload sampler were deployed from a crane-mounted E-reel or B-Reel. The E-reel was driven by a battery operated power-drive during periods of the release and the B-reel was operated by hand. Sediment sampling was performed from a cataraft-based platform attached to a temporary cableway. Stage references were installed near the cableway at the streamflow gaging station. A Forest Technology Systems DTS-12 turbiditimeter was installed on April 4, 2017 at 10:30 and operated until August 7, 2017 at 13:30. Photographs were taken with a digital camera.

Sampling program.-- Total (flow release) load season for this site is from April 1 to July 31. The program consisted of 9 sampling days. A minimum of three bedload-discharge samples were collected on each of the sampling days. The sampling days and samples collected are as follows:

April 25	3 bedload discharge	0 suspended-sediment discharge
April 26	6 bedload discharge	1 suspended-sediment discharge
April 27	6 bedload discharge	0 suspended-sediment discharge
April 29	3 bedload discharge	0 suspended-sediment discharge
April 30	5 bedload discharge	1 suspended-sediment discharge
May 1	3 bedload discharge	0 suspended-sediment discharge
May 2	2 bedload discharge	1 suspended-sediment discharge
May 10	8 bedload discharge	1 suspended-sediment discharge
May 13	4 bedload discharge	1 suspended-sediment discharge

Sampling crews consisted of a safety kayaker, and two on-river personnel specifically trained in cataraft-based sediment data collection techniques. All samples were reviewed by the site technicians and individual analyses were standardized for suspended sediment (concentration, particle size analysis) and bedload samples (total dry mass, particle size analysis). Sediment data were generally collected according to USGS protocols with the following exceptions: test-velocity ratings for sampler nozzles were occasionally exceeded. Suspended-sediment samples were sent to the GMA Suspended-Sediment Lab and bedload samples were analyzed at the GMA Coarse Sediment Lab, both located in Placerville, CA for analysis.

USGS Field Review. **--** No USGS field review was conducted in during the 2017 spring flow release.

Data summary for WY 2017 spring flow release.--

Total number of samples:

- Suspended sediment sets ………… 0
- Single pass suspended sediment samples………… 5
- Box sample sets ………… 0
- Single box samples ………… 0
- Bedload sets ………… 0
- Single pass bedload samples ………… 40
- Three pass bedload samples ………… 0

Number of field turbidities measured ………… 0

Number of suspended sediment size analysis samples:

- Particle size analysis ………… 0
- 0.063mm break ………… 5
- 0.500mm break ………… 5

Number of bedload sediment size analysis samples:

- Particle size analysis ………… 40

Number of suspended sediment discharge measurements ………… 5

Number of bedload discharge measurements ………… 40

Number of visits by Field Office ………… 0

Maximum flow sampled by:

- GMA technicians, ft^3/s ………… 12,000

Range sampled by:

- GMA technicians, mg/l ………… 7-81
- GMA technicians, ton/d………… 13-5,180

Peak flow during flow release, ft^3/s ………… 12,200

Periods of faulty record …………

Turbidity

April 4, 2017 at 02:45 – April 23, 2016 at 18:30
July 6, 2017 at 15:15 – July 31, 2017 at 23:45

Coefficients.-- None used.

Continuous Turbidity.-- At the end of the previous computational period the DTS-12 turbidity probe, H-310 pressure transducer, and DCP were removed from the site. The equipment was re-installed on April 4 at 10:30 and operated until August 7 at 13:30. The turbidity record is incomplete for the computational period.

The turbidity record is faulty from the time of installation until April 23, 2017 at 18:30 and from July 6, 2017 at 15:15 until the end of the period due to probe being out of the water.

Once the turbidity record was cleaned, the record was inspected to see if application of a turbidity offset was necessary. Analysis indicated that an offset of -2.0 FNU was necessary during the period. Offsets are determined by averaging turbidity values at base flows when turbidity should be at or close to 0.0 FNU.

During 2015 and 2016, gravel augmentation upstream of the gaging station caused isolated plumes of sediment to move past the turbidity probe, which created spikes in turbidity that were not representative of the entire sampling cross section. These effects were not seen during the current computational period. The turbidity record was compared to the Trinity River at Douglas City record and the timing and magnitude of turbidity increases agree.During the computational period the maximum turbidity was 32.7 FNU on April 25 at 12:45, and the minimum turbidity was 0.05 FNU, which occurred on July 1 at 11:00.

Total suspended sediment-discharge computations. -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis. – Five cross-sectional, depth-integrated samples were analyzed using a split at <0.063mm and ≥0.50mm. Prior to 2011 splits were made at 0.50mm.

Partial suspended sediment-discharge computations. – Turbidity versus SSC transport curves were analyzed for use during the computational period. Discharge versus SSC transport curves were developed for <0.063mm and 0.063mm-0.5mm size classes to be used for the period prior to the turbidity probe becoming submerged: from April 1, 2017 until April 23, 2017 at 18:30. A discharge versus SSC transport curve was not necessary for the ≥0.50mm size class, because no ≥0.5mm transport occurred prior to the turbidity probe being submerged. Sample 2017-04 was identified as an outlier and was not used in transport curve or sedigraph development.

For the <0.063mm size class, the turbidity versus SSC transport curve is defined by Eqn.(1) and discharge versus SSC transport curve is defined by Eqn.(2).

$$SSC = 2.09 * Turbidity - 7.21895, \qquad r^2 = 0.99 \qquad (1)$$

$$SSC = 4.39e-007 * Discharge^{1.88}, \qquad r^2 = 0.63 \qquad (2)$$

Eqn.(1) is used from April 23, 2017 at 18:45 through July 31, 2017 . Eqn. (1) has a validated range between 4,590 cfs and 8,870 cfs. Eqn.(2) was used from April 1, 2017 through April 23, 2017 at 18:30. Because no samples were collected near zero transport on the rising and falling limbs it was necessary to estimate zero transport based on previous years' data. For the start of the computational period, zero transport was estimated during discharge versus SSC transport curve development and reviewing previous years' low flow sample data, and occurs at 800 cfs. Between hydrograph peaks, the zero transport was determined by fitting the sedigraph to sample 3 and occurs at approximately 3.6 FNU. The second hydrograph peak falling limb zero transport was estimated by fitting the sedigraph to sample 5 and occurs at approximately 2.6 FNU.

For the 0.063mm-<0.50mm size class, the turbidity versus SSC transport curve is defined by Eqn.(3) and discharge versus SSC transport curve is defined by Eqn.(4).

$$SSC = 2.29 * Turbidity - 7.76, \qquad r^2 = 0.99 \qquad (3)$$

$$SSC = 3.14e-008 * Discharge^{2.19}, \qquad r^2 = 0.68 \qquad (4)$$

Eqn.(3) is used from April 23, 2017 at 18:45 through July 31, 2017 . Eqn. (3) has a validated range between 4,590 cfs and 8,870 cfs. Eqn.(4) was used from April 1, 2017 through April 23, 2017 at 18:30. Because no samples were collected near zero transport on the rising and falling limbs it was necessary to estimate zero transport based on previous years' data. For the start of the computational period, zero transport was estimated during discharge versus SSC transport curve development and reviewing previous years' low flow sample data, and occurs at 1,300 cfs. Between hydrograph peaks, the zero transport was determined by fitting the sedigraph to sample 3 and occurs at approximately 3.5 FNU. The second hydrograph peak falling limb zero transport was estimated by fitting the sedigraph to sample 5 and occurs at approximately 3.2 FNU.

For the ≥0.50mm size class, the turbidity versus SSC transport curve is defined by Eqn. (5).

$$SSC = 0.99 * Turbidity - 4.72 , \qquad r^2 = 0.99 \qquad (5)$$

Eqn.(5) is used from April 1, 2016 through July 31, 2016 . Eqn. (1) has a validated range between 4,590 cfs and 8,870 cfs. Because no samples were collected near zero transport on the rising and falling limbs it was necessary to estimate zero transport based on previous years' data and by evaluating the discharge versus SSC relationship. Zero transport for the start of the compuational period was estimated at 1,800 cfs. Between hydrograph peaks, the zero transport was determined by fitting the sedigraph to sample 3 and occurs at approximately 5.4 FNU. The second hydrograph peak falling limb zero transport was estimated by fitting the sedigraph to sample 5 and occurs at approximately 3.65 FNU.

The tranport curves were used to develop continuous concentration curves for the <0.063mm, 0.063mm-<0.50mm, and the ≥0.5mm size classes during the computational period. Once the continuous concentration data had been developed, the sample data were used to adjust the continuous concentration curves so that they passed through all sample points. The continuous concentration curves were adjusted using fitting and proportional fitting techniques.

Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When SSC is not highly correlated with discharge or turbidity, it is not possible to evaluate this assumption and therefore it is a potential source of error. Suspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material.-- None.

Bedload measurement. -- Forty bedload discharge samples were collected during the Spring Flow Release.

Bedload-discharge computations. -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the >0.5mm-8mm and the ≥8mm size fractions.

Partial bedload-discharge computations -- Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-8mm and ≥8mm size classes. 2017 had a double peak hydrograph and sample data was analyzed for the entire flow release period, with each peak broken out seperately and for rise and fall patterns of hysteresis.

For the 0.5mm-<8mm size class, a complicated pattern of hysterisis was observed, so a single generalized transport curve was developed and is shown in Eqn. (6). Hysteresis was addressed during sedigraph development by shifting to sample values. No outliers were identified.

$$BLD = 9.74e - 009 * Discharge^{2.53}, \qquad r^2 = 0.76 \qquad (6)$$

The transport curve was developed using samples 1-40. The transport curve is used from April 1 at 00:00 hrs until July 31 at 23:45 hours and has a valididated range between 3,490 cfs and 12,000 cfs. Zero transport for the first hydrographic peak rising limb was estimated by fitting the sedigraph to an average of samples 1-3 and occurs at 1,900 cfs. For the falling limb of the first hydrographic peak and the rise of the second peak, zero tranport was estimated by fitting the sedigraph to the average of samples 27-28 and occurs at 2,600 cfs. Zero transport for the second peak falling limb was estimated during sedigraph development by fitting to an average of samples 37-40 and it occurs at 3,790 cfs.

For the ≥8mm size class, a complicated pattern of hysterisis was observed, so a single generalized transport curve was developed and is shown in Eqn. (7). Hysteresis was addressed during sedigraph development by shifting to sample values. No outliers were identified, however, the largest particles were censored from sample 40. Field notes indicate that several hard touch downs of the TR-2 sampler occurred which increases the likelihood of accidentally scooping large particles. Thecensored grain sizes were not present in the other samples collected that day.

$$BLD = 7.00e - 23 * Discharge^{6.25}, \qquad r^2 = 0.87 \qquad (7)$$

The transport curve defined by Eqn. (7) was developed using samples 1-40 is used from April 1, 2016 at 00:00 hours through July 31, 2016 at 23:45 hours and has a valididated range between 3,490 cfs and 12,000 cfs. Zero transport for the first hydrograph peak rising limb was estimated using previous years' data at 2,500 cfs. Zero transport between the peaks was estimated during sedigraph development using previous years' data at 3,000 cfs. Zero transport for the falling limb of the second peak was estimated using previous years' sample data and occurs at 3,800 cfs.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted to the sample values using the same techniques as was described for the partial suspended-sediment discharge computations. Due to the inherent high variability in bedload sampling, during flow benches, sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload sedigraph.

Remarks. – The suspended sediment discharge record is rated as follows:

April 1 (00:00) to April 25 (23:45)	Estimated
April 26 (00:00) to May 13 (23:45)	Good
May 14 (00:00) to July 31 (23:45)	Estimated

The bedload discharge record is rated as follows:

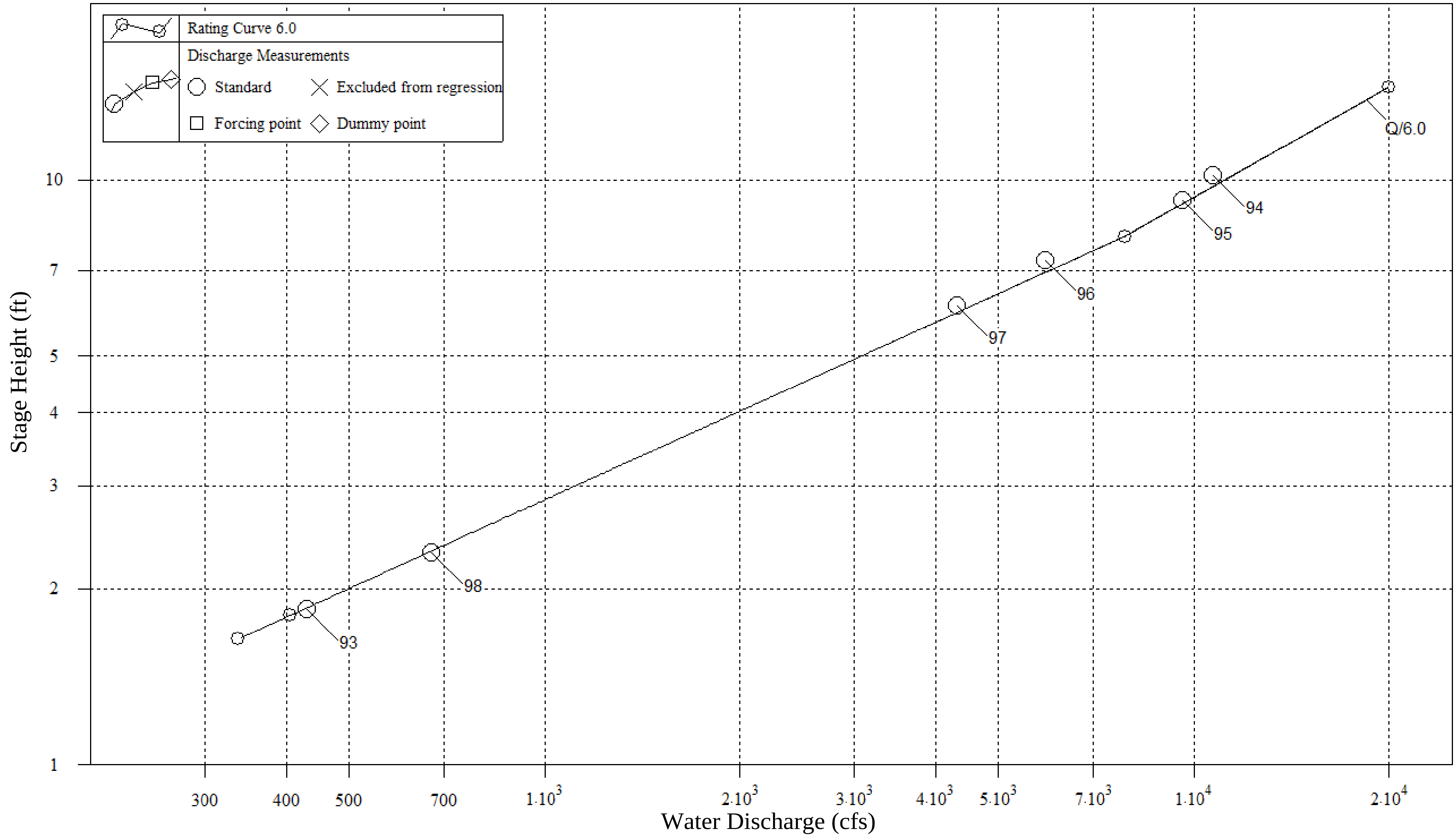
April 1 (00:00) to April 24 (23:45)	Estimated
April 25 (00:00) to May 13 (23:45)	Good
May 14 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December 2017

Reviewed by: Smokey Pittman, December 2017

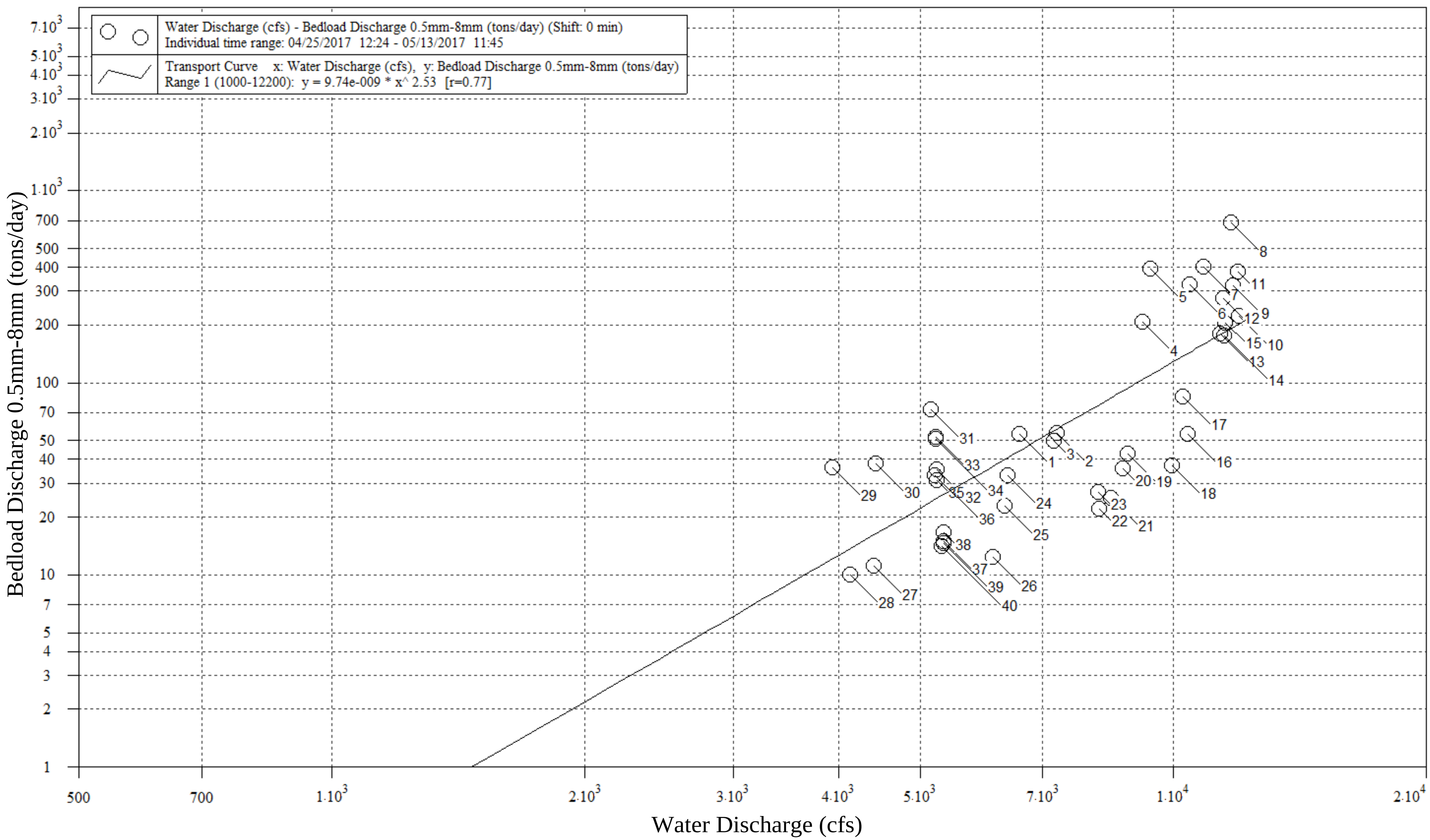
TRINITY RIVER ABOVE GRASS VALLY NEAR LEWISTON --11525540

Discharge Rating Curve 6.0 – Valid From April 1, 2016 – Present



TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON --11525540

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2017



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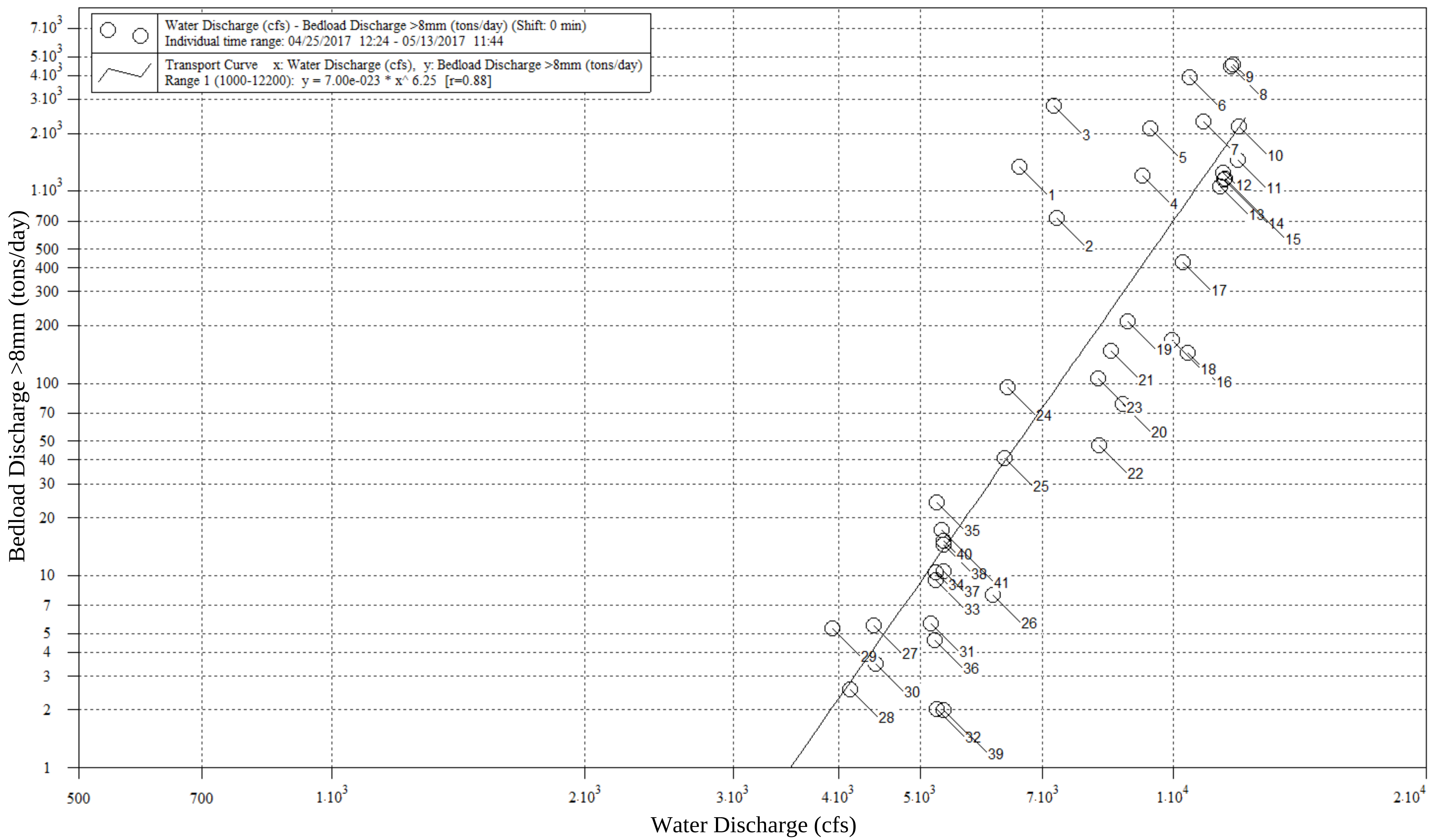
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON --11525540

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2017



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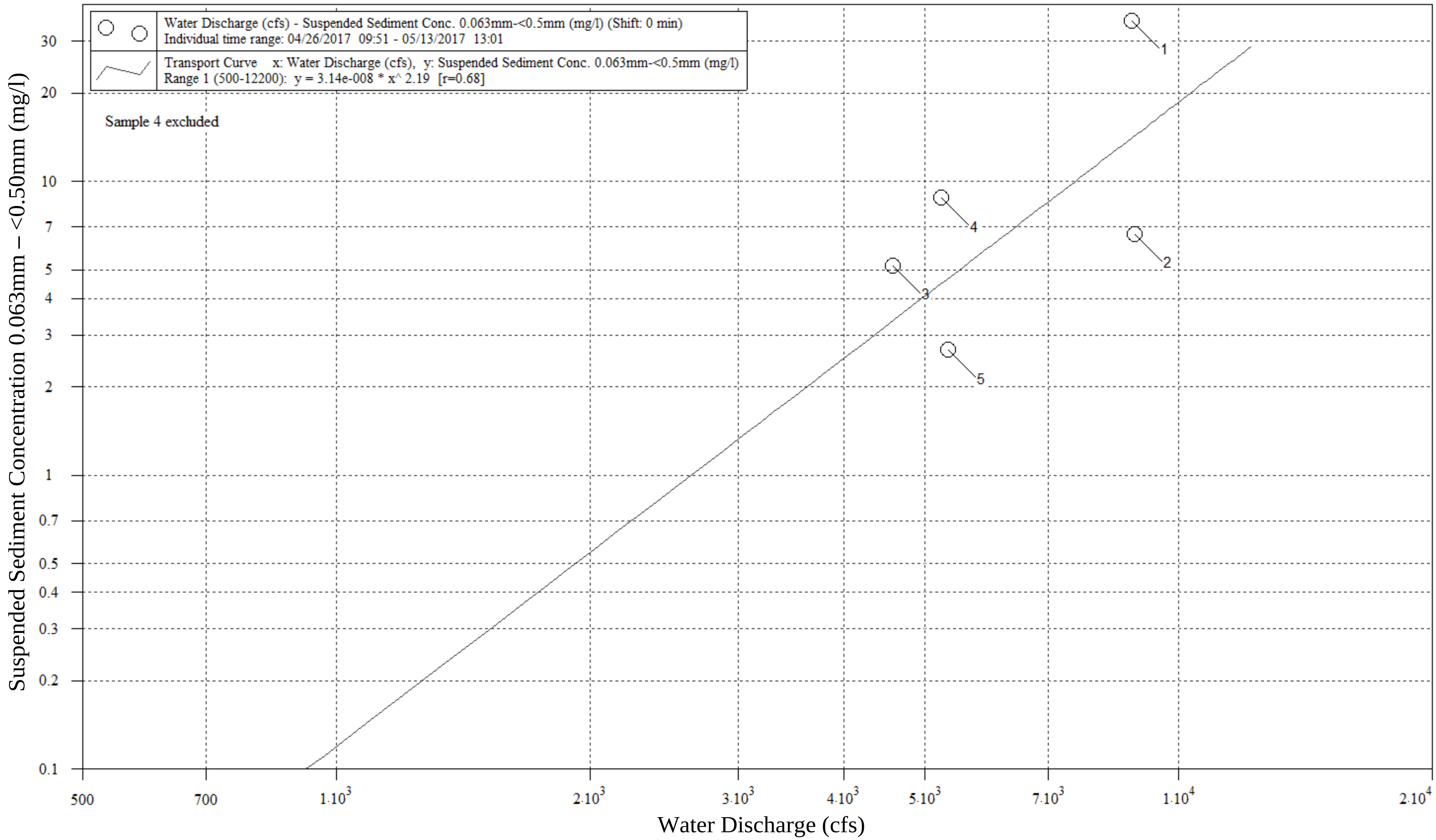
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Water Discharge (cfs) Versus Suspended Sediment Concentration 0.063mm - <0.5mm (mg/l): Spring Flow Release WY 2017



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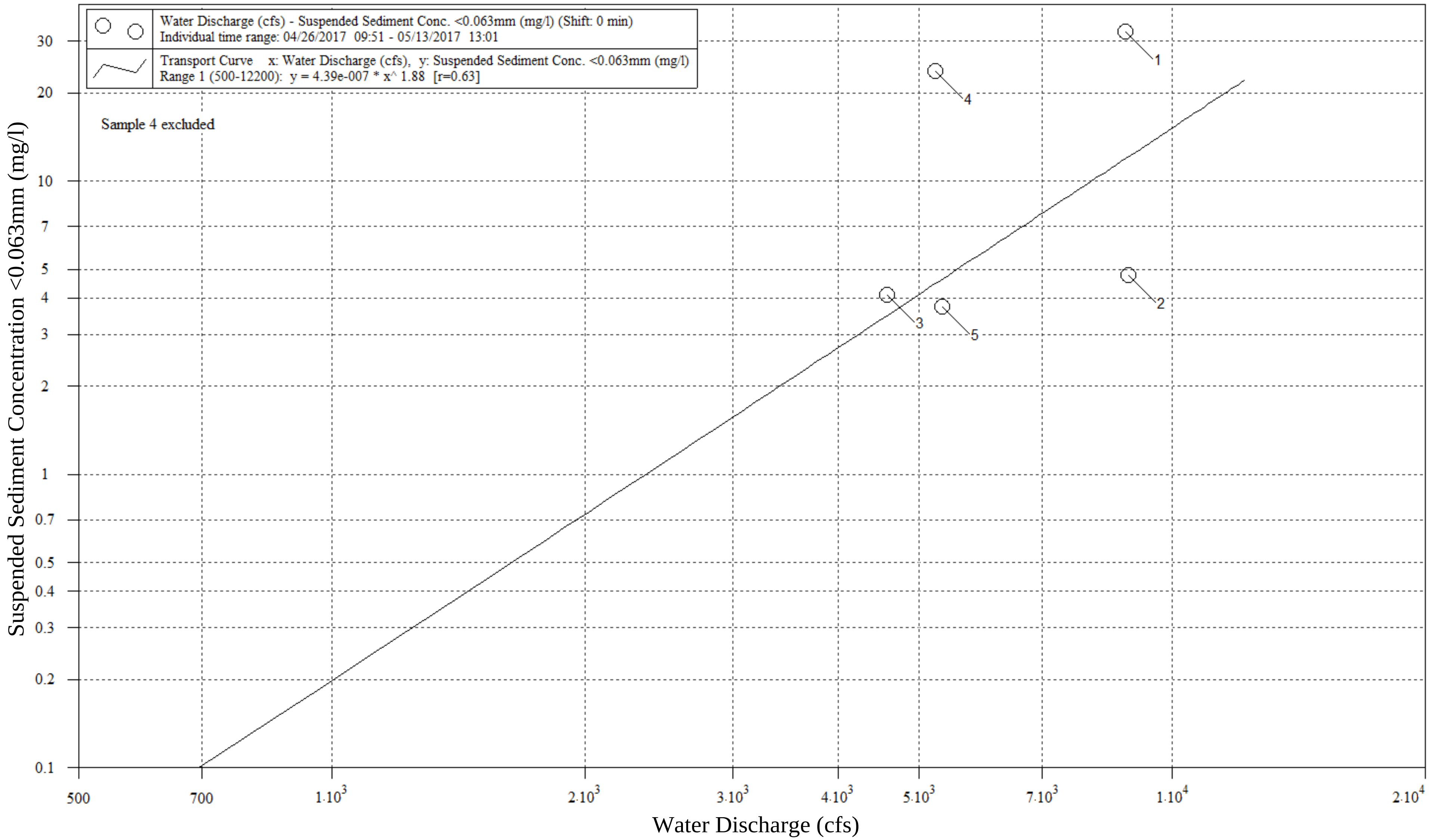
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Water Discharge (cfs) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release WY 2017



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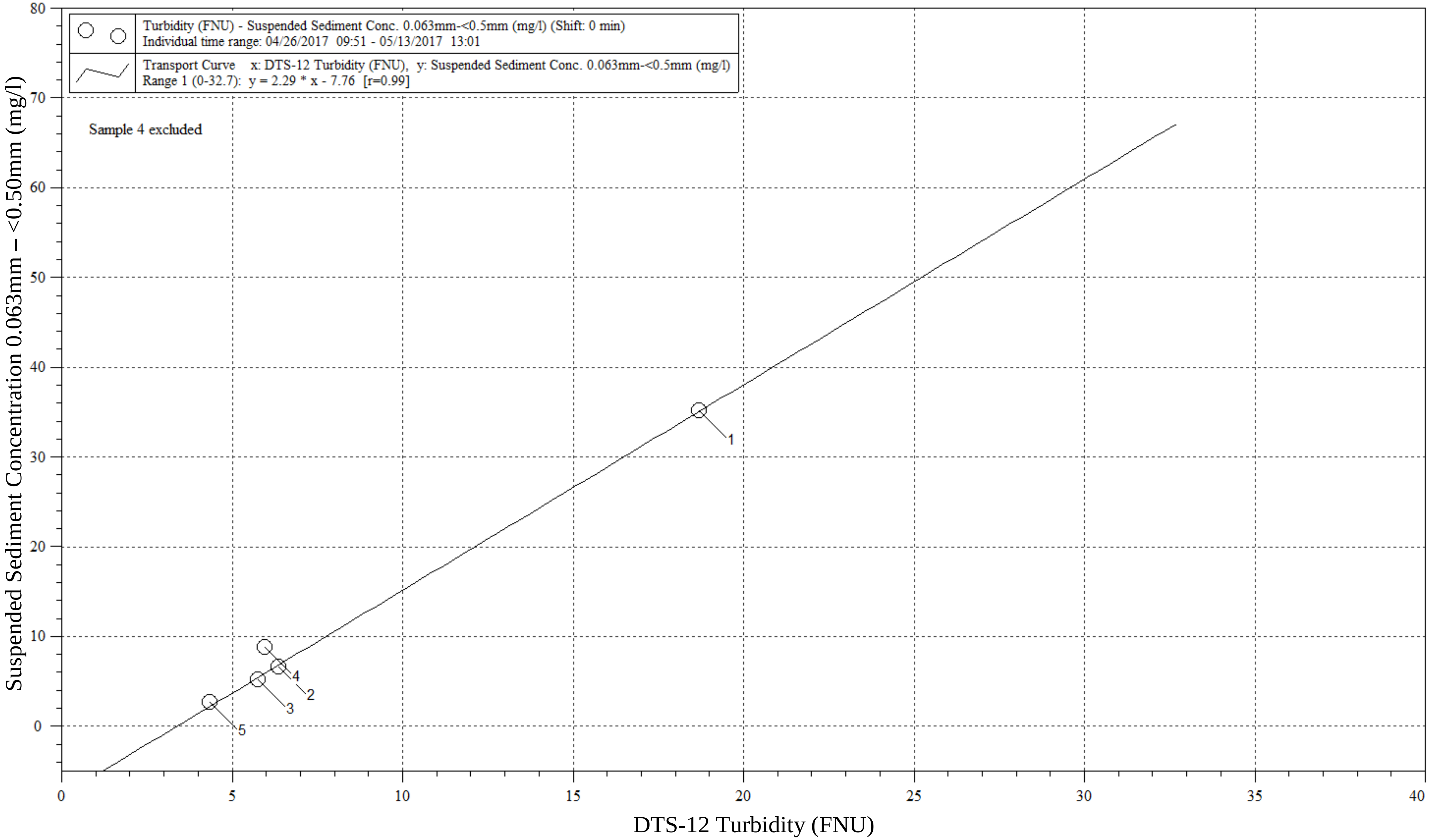
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Turbidity (FNU) Versus Suspended Sediment Concentration 0.063mm – <0.50mm (mg/l): Spring Flow Release WY 2017



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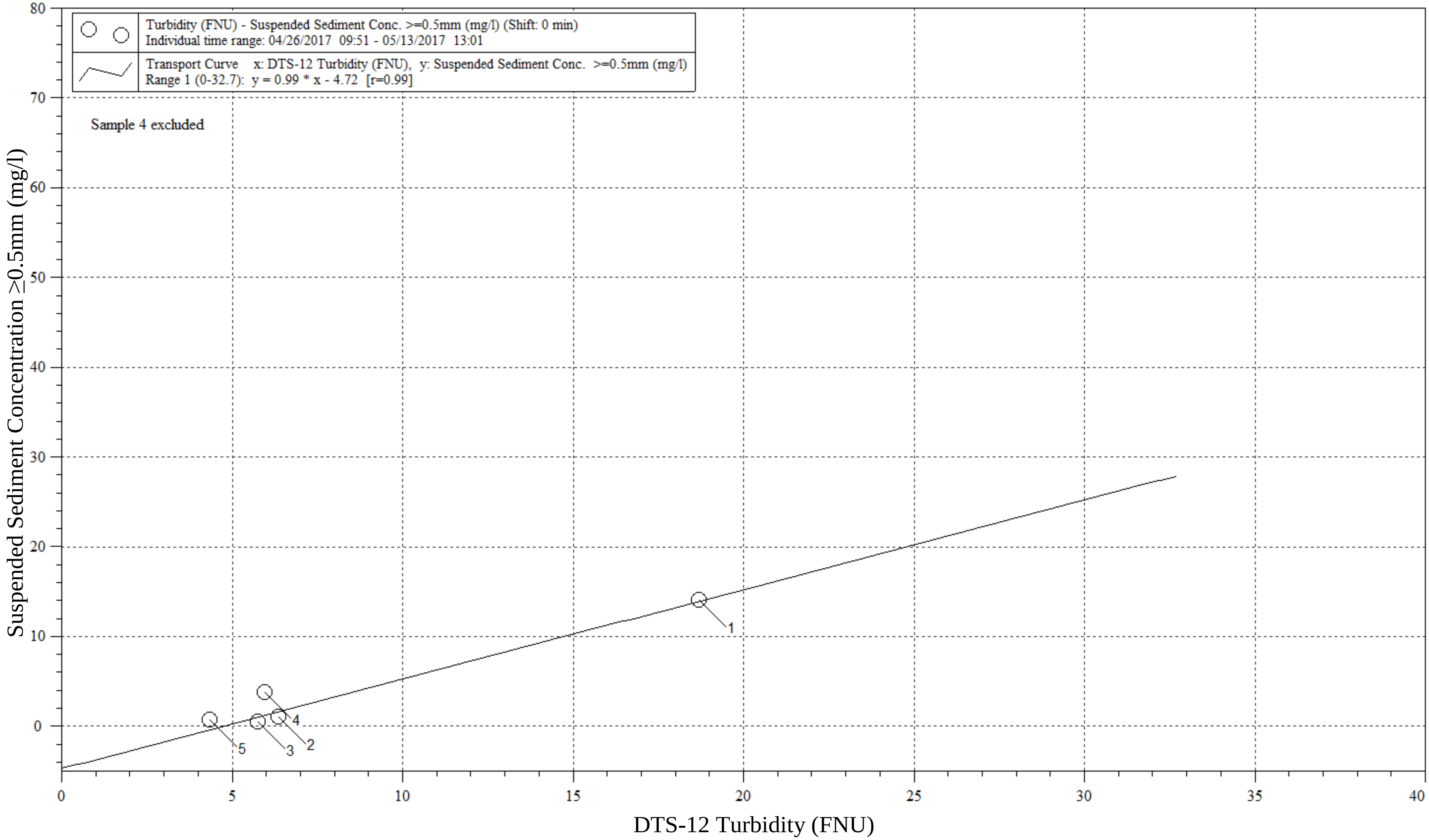
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Turbidity (FNU) Versus Suspended Sediment Concentration ≥ 0.50mm (mg/l): Spring Flow Release WY 2017



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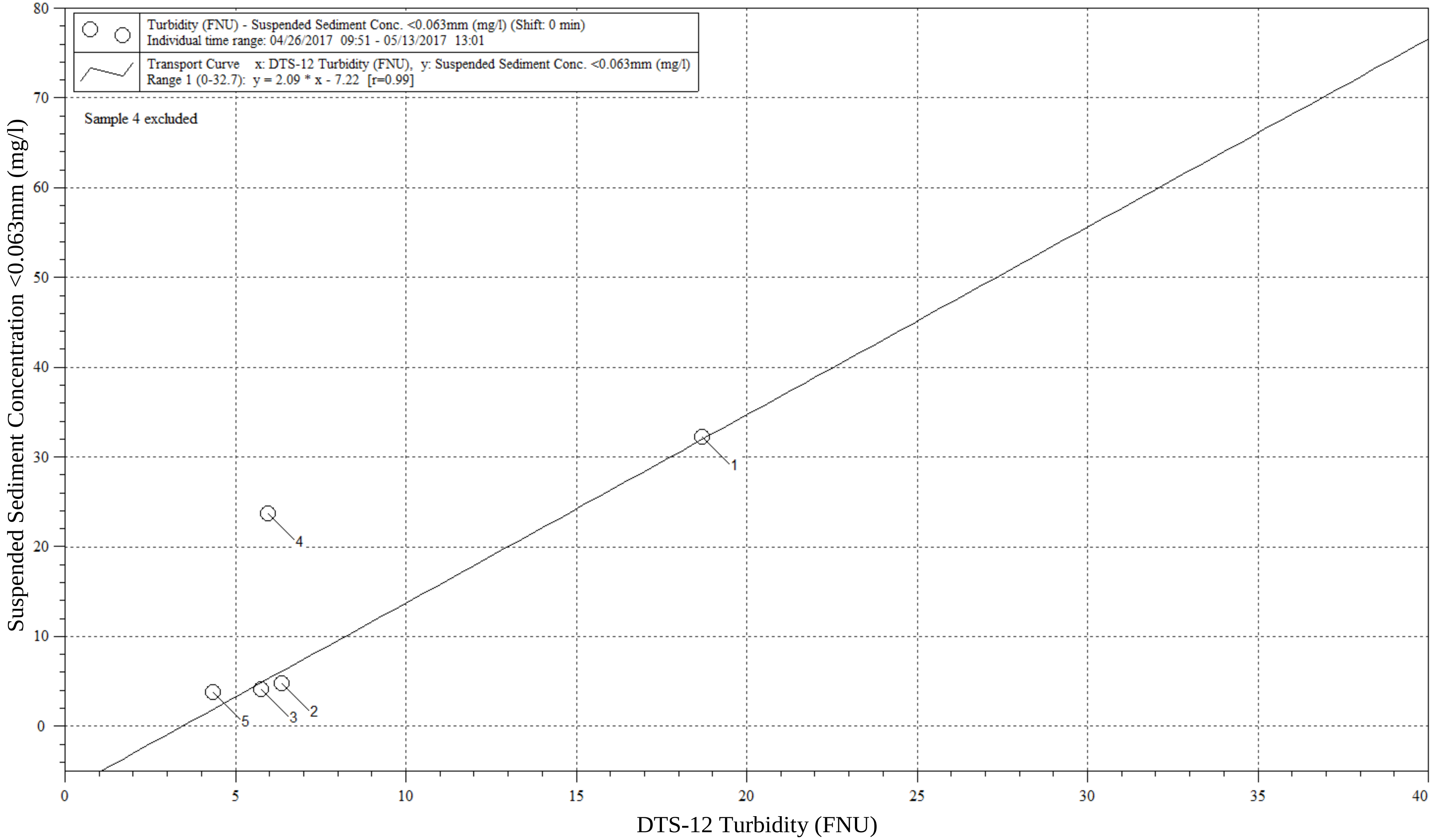
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON -- 11525540

Turbidity (FNU) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release WY 2017



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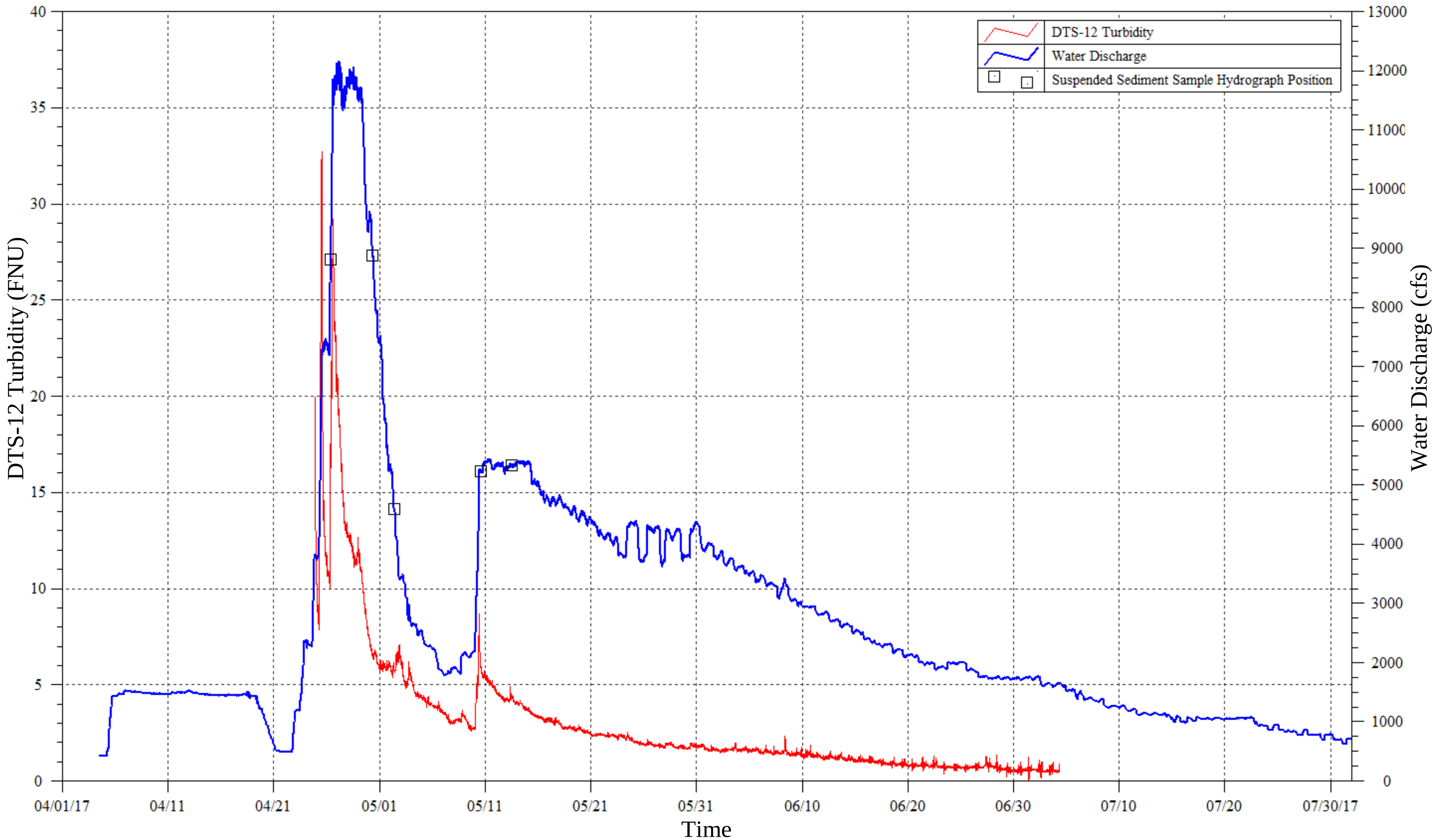
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

DTS-12 Turbidity – Spring Flow Release WY 2017



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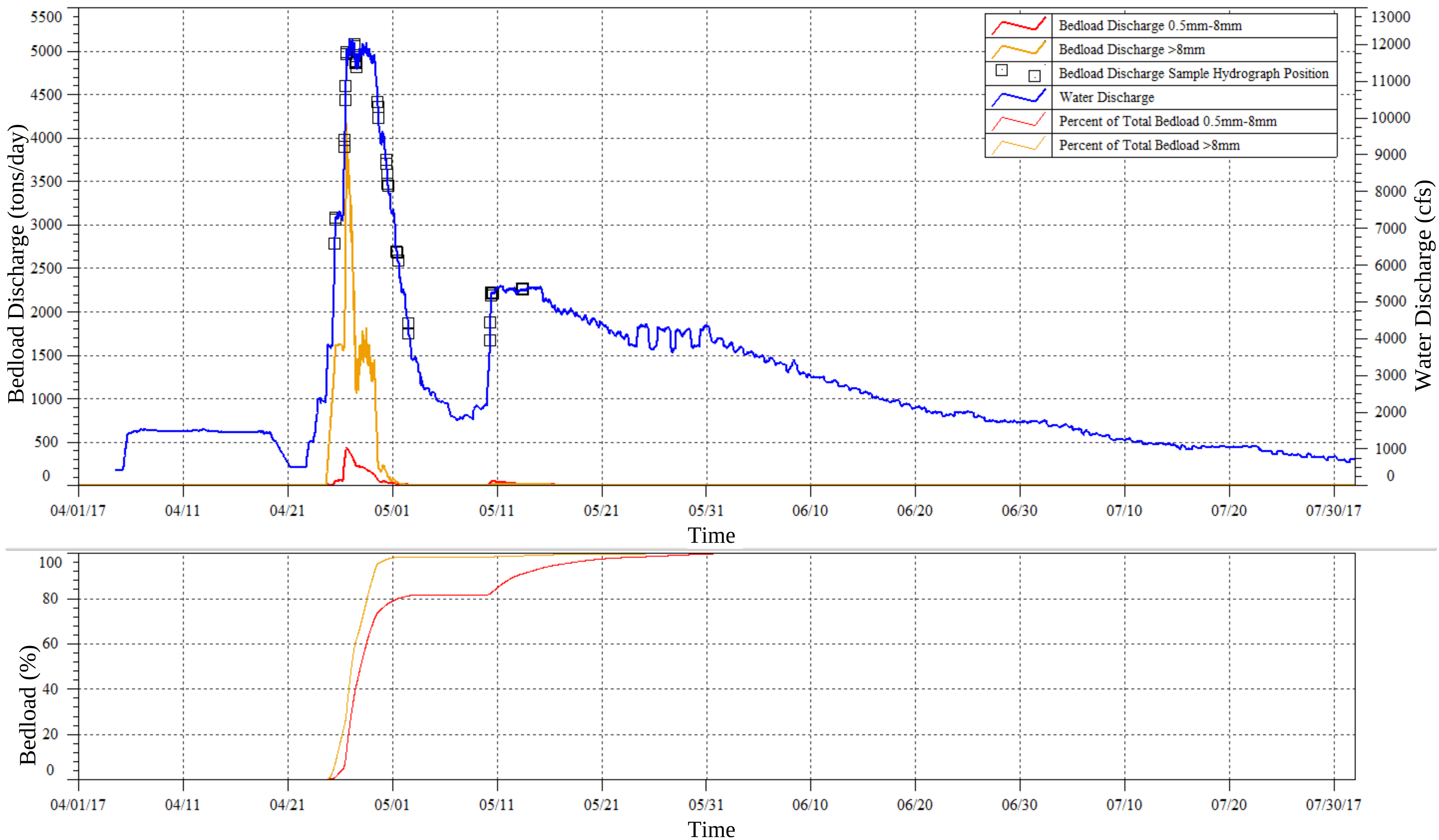
Bedload Discharge – Spring Flow Release WY 2017



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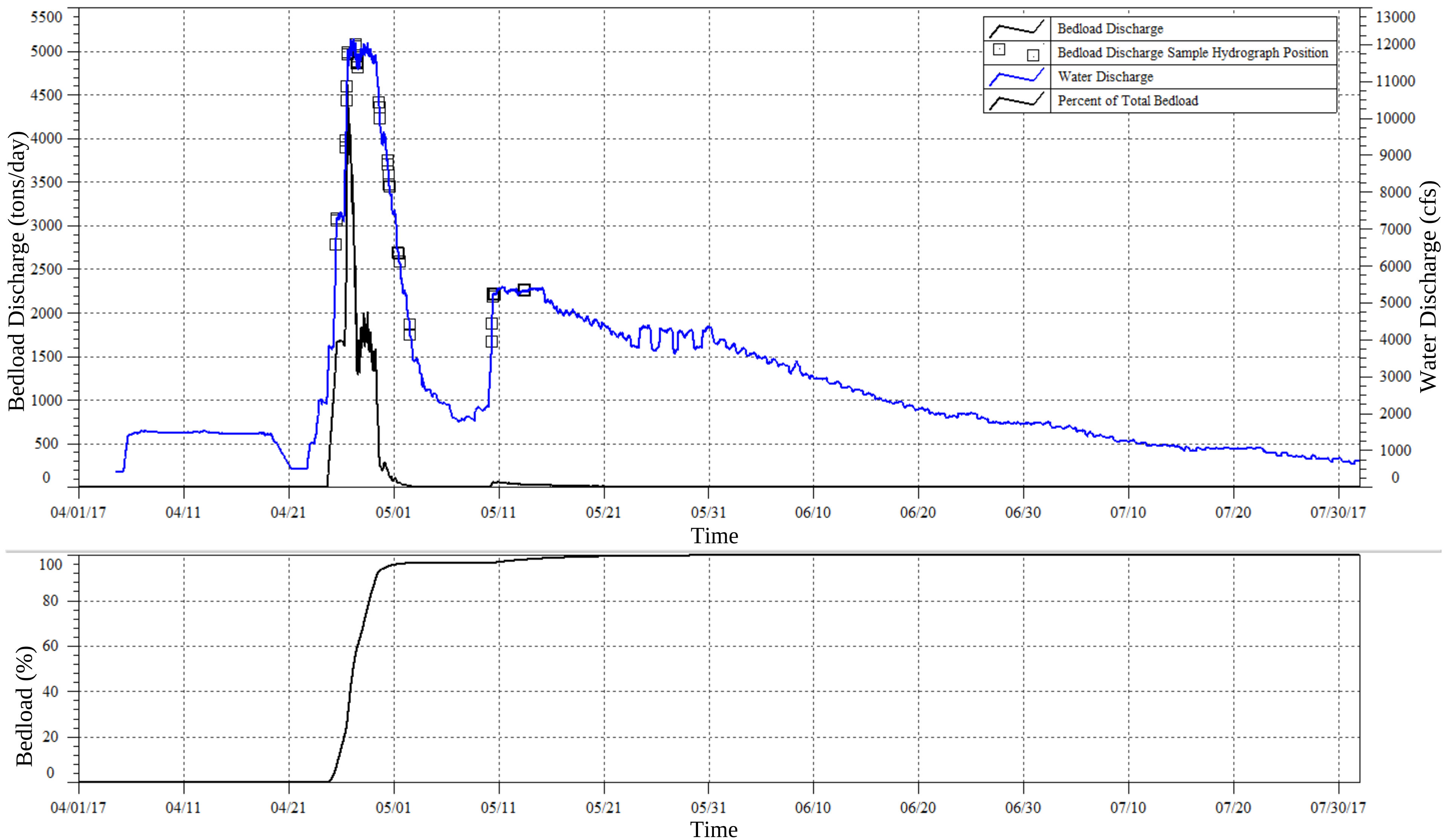
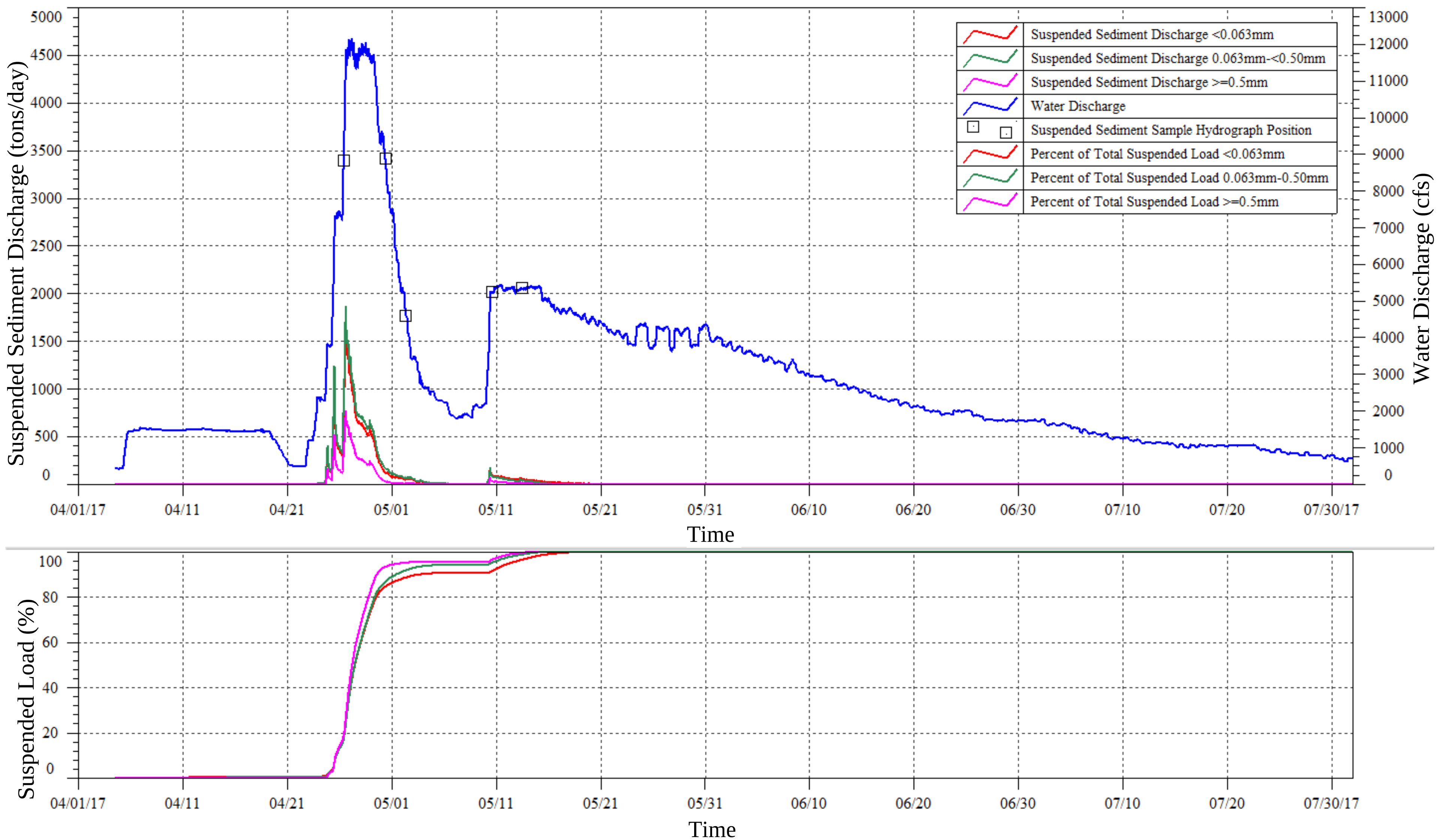
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

Bedload Discharge – Spring Flow Release WY 2017



TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

Suspended Sediment Discharge – Spring Flow Release WY 2017



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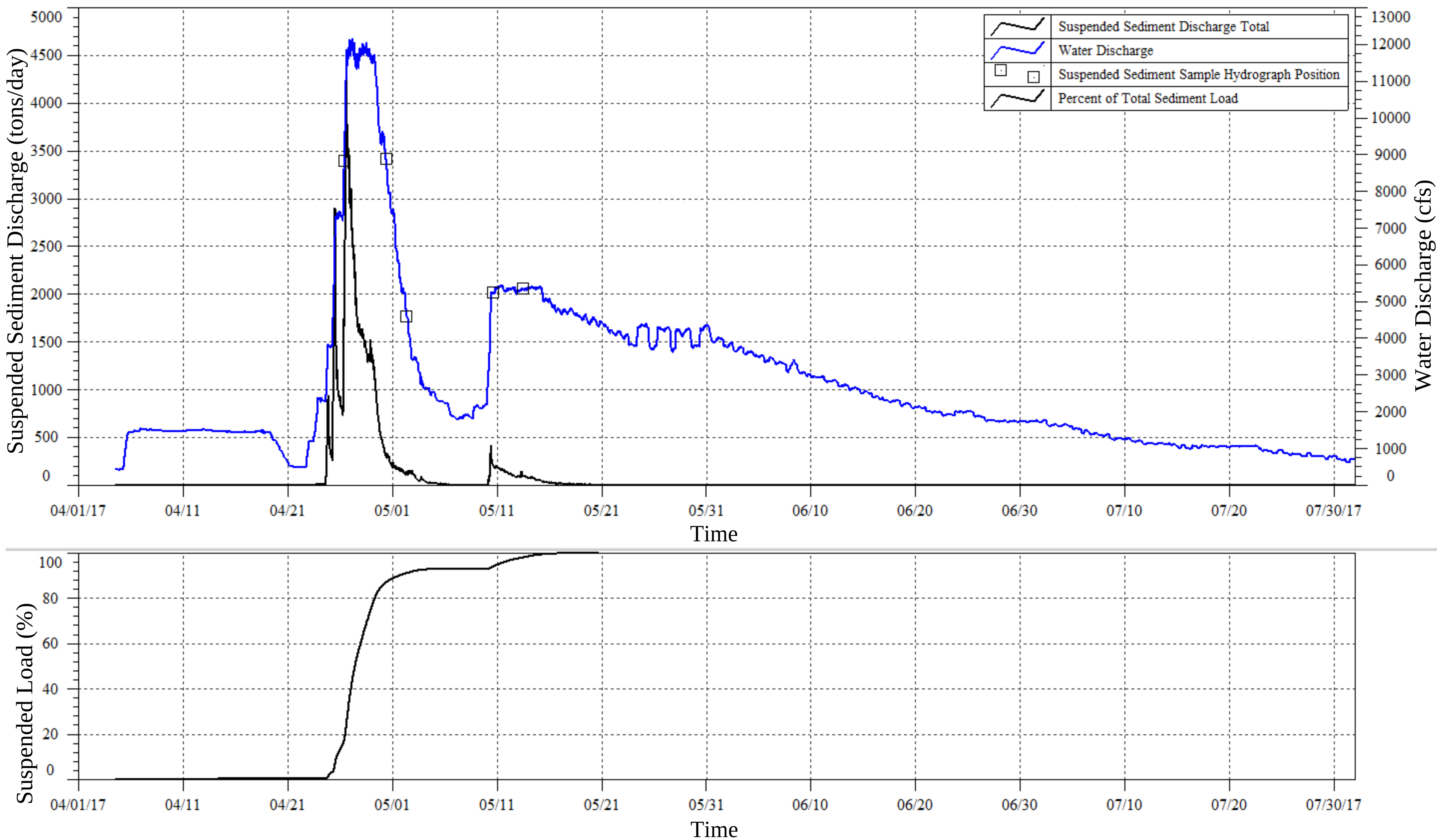
TRINITY RIVER ABOVE GRASS VALLEY C. NEAR LEWISTON –11525540

Suspended Sediment Discharge – Spring Flow Release WY 2017



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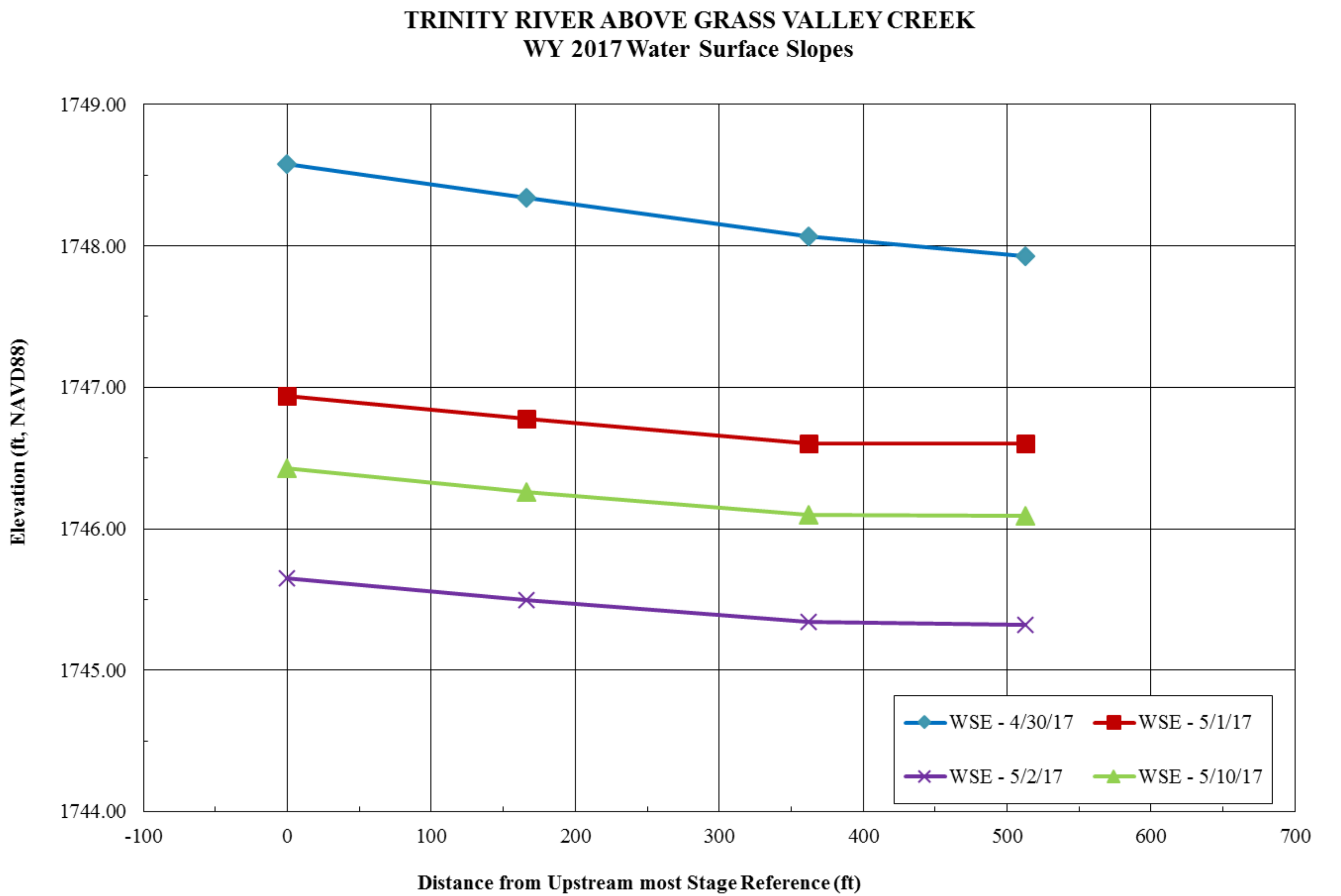

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Appendix C

Trinity River below Limekiln Gulch
USGS Gage # 11525655

11525655 Trinity River Below Limekiln Gulch near Douglas City, CA

TOTAL LOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2017: (April 1 to July 31)

Records collected at station.-- Daily streamflow has been collected for the following periods: WY1981-1991, WY1999-2004 by the Hoopa Valley Tribe and 2005-present by the USGS. This site was operated as a daily sediment station from 1981-1991. Sediment sampling (storm season and flow release) has occurred intermittently since 1998 by the Hoopa Valley Tribe. Sediment sampling (flow release) has occurred on a regular basis from 2004-2013 and 2015-2017. A turbidimeter recorded data during the WY 2017 spring flow release period: a Forest Technology Systems DTS-12 linked to a Campbell CR200 data collection platform (DCP), installed and operated by GMA Hydrology, Inc (GMA). The purpose of collecting sediment data at this site is to quantify sediment discharge transported through this portion of the mainstem, versus the sediment discharge measured at sediment collection stations either upstream or downstream: Trinity River at Lewiston (11525500), Trinity River above Grass Valley Creek near Lewiston (11525540), and Trinity River at Douglas City (11525854). This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2017 spring flow release by GMA, under contract to the TRRP.

Equipment.-- Sampling equipment consists of a D-74 for suspended-sediment sampling, and a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5 mm mesh collection bag. The D-74 suspended-sediment sampler was deployed using a hand-operated B-reeel and the TR-2 bedload sampler was deployed from a crane-mounted 12V winch. Sediment sampling was performed from a cataraft-based platform attached to a temporary cableway. Stage references were installed near the cableway and upstream of the streamflow gaging station. A Forest Technology Systems DTS-12 turbidimeter was installed and operated during the sediment sampling period. Photographs were taken with a digital camera.

Sampling program.-- Total (flow release) load season for this site is from April 1 to July 31. The program consisted of 10 sampling days. A minimum of six bedload-discharge samples were collected on each of the sampling days. The sampling days and samples collected are as follows:

April 25	6 bedload discharge	1 suspended-sediment discharge
April 26	6 bedload discharge	1 suspended-sediment discharge
April 27	6 bedload discharge	1 suspended-sediment discharge
April 28	8 bedload discharge	0 suspended-sediment discharge
April 29	8 bedload discharge	0 suspended-sediment discharge
April 30	8 bedload discharge	0 suspended-sediment discharge
May 1	6 bedload discharge	1 suspended-sediment discharge
May 2	7 bedload discharge	0 suspended-sediment discharge
May 11	7 bedload discharge	1 suspended-sediment discharge
May 14	6 bedload discharge	1 suspended-sediment discharge

Sampling crews consisted of two on-river personnel specifically trained in cataraft-based sediment data collection techniques, and a safety kayaker. All samples were reviewed by the site technicians and individual analyses were standardized for suspended sediment (concentration, particle size analysis) and bedload samples (total dry mass, particle size analysis). Sediment data were generally collected according to USGS protocols with the following exceptions: test-velocity ratings for sampler nozzles were occasionally exceeded. Suspended-sediment samples were sent to the GMA Suspended-Sediment Lab and bedload samples were sent to the GMA Coarse-Sediment Lab, both located in Placerville, CA for analysis.

USGS Field Review. -- No USGS field review was conducted during the 2017 spring flow release.

Data summary for WY 2017 spring flow release. --

Total number of samples:	
Suspended sets ……	0
Single pass suspended samples ……	6
Box sample sets ……	0
Single box samples ……	0
Bedload sets ……	0
Single pass bedload samples ……	68
Three pass bedload samples ……	0
Number of field turbidities measured ……	0
Number of suspended-sediment size analysis samples:	
Particle size analysis ……	0
0.063mm break ……	6
0.50mm break ……	6
Number of bedload sediment size analysis samples:	
Particle size analysis ……	68
Number of suspended-sediment discharge measurements ……	6
Number of bedload discharge measurements ……	68
Number of visits by Field Office ……	0
Maximum flow sampled by:	
GMA technicians, ft^3/s ……	12,700
Range sampled by:	
GMA technicians, mg/l ……	8-102
GMA technicians, ton/d ……	12-2,120
Peak flow during flow release, ft^3/s ……	12,800
Periods of faulty record ……	
Turbidity……	April 1 to April 5 April 24 to May 3

Coefficients.-- None used.

Continuous Turbidity.-- The turbidity record is incomplete for the computational period. The turbidity probe had been removed at the end of the previous computational period and was not re-installed until April 5, 2017 at 10:30 hours. Additionally, following a gage download on April 24, 2017 at 15:00, the gage station's battery connection was knocked loose and the gage did not log data from that time unitl May 3, 2017, when the battery was re-connected. Two small turbidity spiked were removed and filled by linear interpolation on April 13 and April 18, 2017.

Once the turbidity record was cleaned, the record was inspected to determine if a turbidity offset was necessary. Inspection of the record indicated that a shift of -1.0 FNU was necessary. Offsets are determined by averaging turbidity values at base flows when turbidity should be at or close to 0.0 FNU.

During the computational period, the maximum turbidity was 24.0 FNU on April 5 at 18:30, and the minimum turbidity was 0.02 FNU, which occurred on August 4, 2017 at 17:00.

Total suspended sediment-discharge computations. -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis. -- Six cross-sectional, depth-integrated samples were analyzed using a split at 0.063mm and 0.50mm.

Partial suspended sediment-discharge computations. -- The continuous turbidity record is missing when 4 of the 6 suspended sediment samples were collected. As a result, no (new) turbidity versus SSC transport curves were developed for the Water Year 2017 release period. Discharge versus SSC transport curves were developed for all size classes. Samples collected during Water Year 2015 through 2017 were analyzed together and Water Year 2017 samples were broken into rise and fall and analyzed for hysteresis. It was determined that the historic samples did not improve relationships and that there weren't enough samples collected during 2017 to develop rising and falling limb transport curves. Generalized transport curves were developed using all samples collected during Water Year 2017. No outliers were identified.

For the <0.63mm size class, the discharge versus SSC transport curve is defined by Eqn. (1) and the turbidity versus SSC transport curve is defined by Eqn.(2).

$$SSC = 3.06 * Discharge^{1.99}, \qquad r^2 = 0.63 \qquad (1)$$

$$SSC = 1.03 * Turbidity - 0.3, \qquad (2)$$

Eqn. (1) is used from April 24, 2017 at 15:00 through May 3, 2017 at 10:00. Eqn. (1) has a validated range between 5,680 cfs and 12,300 cfs. Review of the sedigraph created by the discharge versus SSC transport curve suggested that the relation underpredicts sediment discharge during the early April 2,000 cfs flow bench. High turbidity values were recorded during this bench. The Water Year 2016 turbidity versus SSC transport curve was shifted to fit sample 2017-05 and 2017-06, which were collected when the turbidity probe was funtioning. Eqn.(2) was used when the turbidity record was present from April 5, 2017 at 10:45 through April 24, 2017 at 14:45 and May 3, 2017 at 10:30 through July 31, 2017. Zero transport was estimated for the rising limb using previous years' data, at 700 cfs and was determined by applying the transport curve to the turbidity record for the falling limb and occurs at 740 cfs and 0.6 FNU.

For the 0.063mm-<0.50mm size class, the discharge versus SSC transport curve is defined by Eqn. (3) and the turbidity versus SSC transport curve is defined by Eqn.(4).

$$SSC = 9.04e-009 * Discharge^{2.33}, \qquad r^2 = 0.57 \qquad (3)$$

$$SSC = 1.54 * Turbidity - 5.7, \qquad (4)$$

Eqn. (3) is used from April 24, 2017 at 15:00 through May 3, 2017 at 10:00. Eqn. (3) has a validated range between 5,680 cfs and 12,300 cfs. As with <0.063mm size class, review of the sedigraph created by the discharge versus SSC transport curve suggested that the relation underpredicts sediment discharge during the early April 2,000 cfs flow bench. The Water Year 2016 turbidity versus SSC transport curve was shifted to fit 2017 samples., Eqn.(4) was used when the turbidity record was present from April 5, 2017 at 10:45 through April 24, 2017 at 14:45 and May 3, 2017 at 10:30 through July 31, 2017. Zero transport was estimated for the rising limb using previous years' data, at 800 cfs and was determined by applying the transport curve to the turbidity record for the falling limb and occurs at 5,000 cfs and 3.76 FNU.

For the ≥0.5mm size class discharge versus SSC data were analyzed. Discharge versus SSC produced a reasonable relationship for ≥0.5mm SSC at TRLG. The ≥0.5mm transport curve is defined by Eqn. (5).

$$SSC = 8.67e-013 * Discharge^{3.17}, \qquad r^2 = 0.65 \qquad (5)$$

The transport curve is used between April 1 at 00:00 hours and July 31 at 00:00 hours. The transport curve has a validated range between 5,680 cfs and 12,300 cfs. Zero transport of 3,500 cfs for the rising limb and 5,000 cfs for the falling limb was estimated during transport curve development.

The tranport curves were used to develop continuous concentration curves for the <0.063mm, ≥0.063mm-<0.50mm, and the ≥0.5mm size classes during the computational period. Once the continuous concentration data had been developed, the sample data were used to adjust the continuous concentration trace so that they passed through all sample points. The continuous concentration trace was adjusted using fitting and proportional fitting techniques.

Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When SSC is not highly correlated with discharge or turbidity, it is not possible to evaluate this assumption and therefore it is a potential source of errorSuspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

Bed material-- None.

Bedload measurement -- Sixty-eight bedload discharge samples were collected during the Spring Flow Release.

Bedload-discharge computations -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the ≥0.5mm-8mm and the ≥8mm size fractions.

Partial bedload-discharge computations -- Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-8mm and ≥8mm size classes. 2017 had a double peak hydrograph and sample data was analyzed for the entire flow release period, with each peak broken out seperately and for rise and fall patterns of hysteresis.

For the 0.5mm-<8mm size class, no obvious patterns of hysteresis or changes in transport rates between the two peaks were observed so a single generalized transport curve was developed and is shown in Eqn. (6). No outliers were identified

$$BLD = 8.07e - 010 * Discharge^{2.81}, \qquad r^2 = 0.93 \qquad (6)$$

The transport curve was developed using samples 1-68. The transport curve is used from April 1 at 00:00 hrs until July 31 at 23:45 hours and has a valididated range between 4,630 cfs and 12,700 cfs. Zero transport for the both hydrographic peak rising limb was estimated during sedigraph development and occurs at 1,800 cfs. For the falling limb of the first hydrographic peak, zero tranport was estimated by fitting the sedigraph to the average of sample 49-55 and occurs at 3,000 cfs. Zero transport for the rise and fall of the second peak is assumed to be the same as the falling limb of the first peak and occurs at 3,000 cfs.

For the ≥8mm size class, no obvious patterns of hysteresis or changes in transport rates between the two peaks were observed so a single generalized transport curve was developed and is shown in Eqn. (7).

$$BLD = 7.57e - 018 * Discharge^{4.89}, \qquad r^2 = 0.88 \qquad (7)$$

The transport curve defined by Eqn. (7) was developed using samples 1-68 is used from April 1, 2016 at 00:00 hours through July 31, 2016 at 23:45 hours and has a valididated range between 4,630 cfs and 12,700 cfs. Zero transport for the first hydrograph peak rising limb was estimated during sedigraph development by fitting the sedigraph to and average of sample 1-2 and occurs at 5,160 cfs. Zero transport between the peaks and for the falling limb of the second hydrograph peak was estimated during sedigraph development using previous years' sample data and occurs at 4,000 cfs.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted to the sample values using the same techniques as was described for the partial suspended-sediment discharge computations. Due to the inherent high variability in bedload sampling, during flow benches, sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload transport trace.

Remarks. – The suspended sediment discharge record is rated as follows:

April 1 (00:00) to April 24 (23:45)	Estimated
April 25 (00:00) to May 14 (23:45)	Good
May 15 (00:00) to July 31 (23:45)	Estimated

The bedload discharge record is rated as follows:

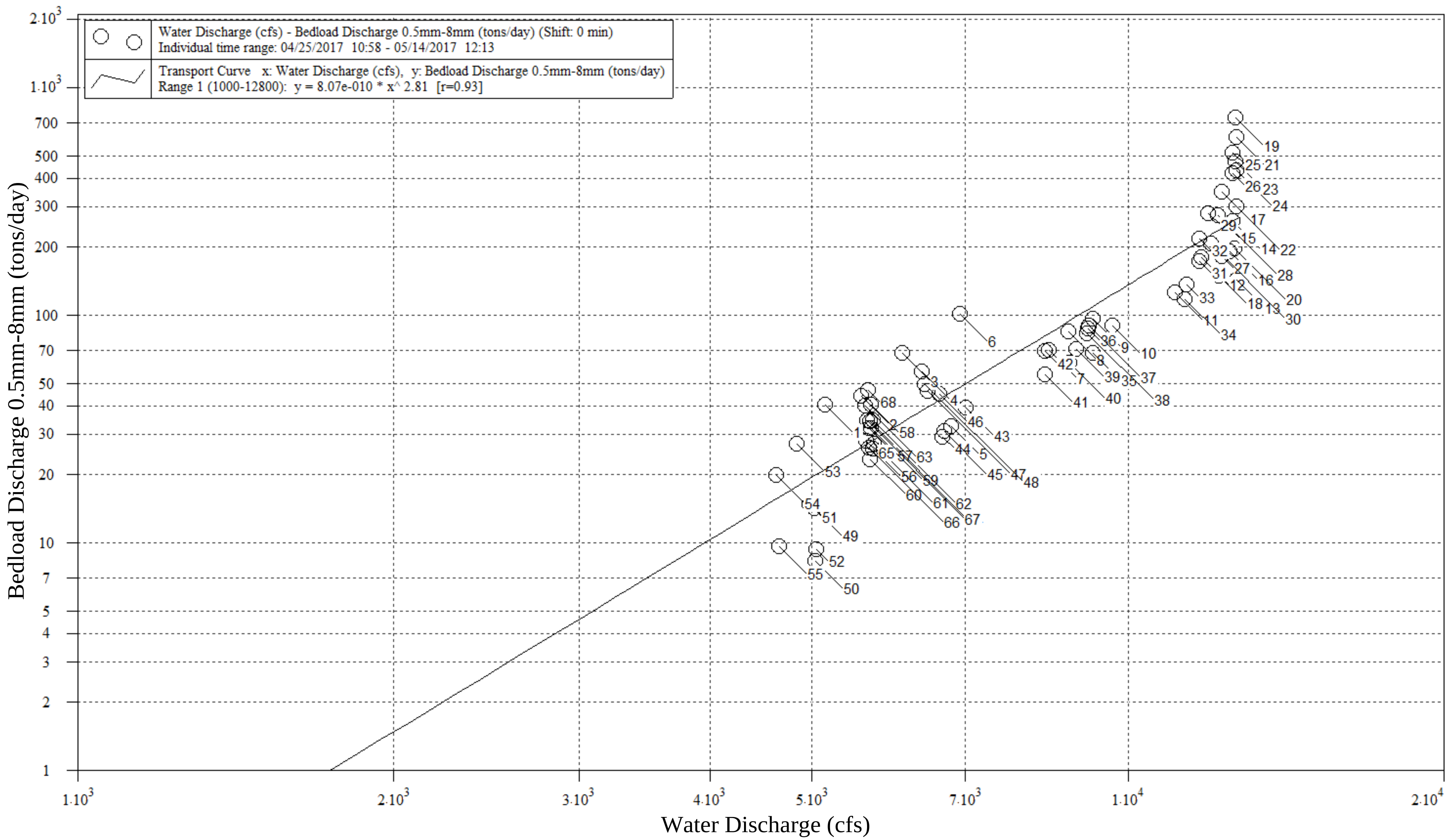
April 1 (00:00) to April 24 (23:45)	Estimated
April 25 (00:00) to May 14 (23:45)	Good
May 15 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December 2017

Reviewed by: Smokey Pittman, December 2017

TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2017



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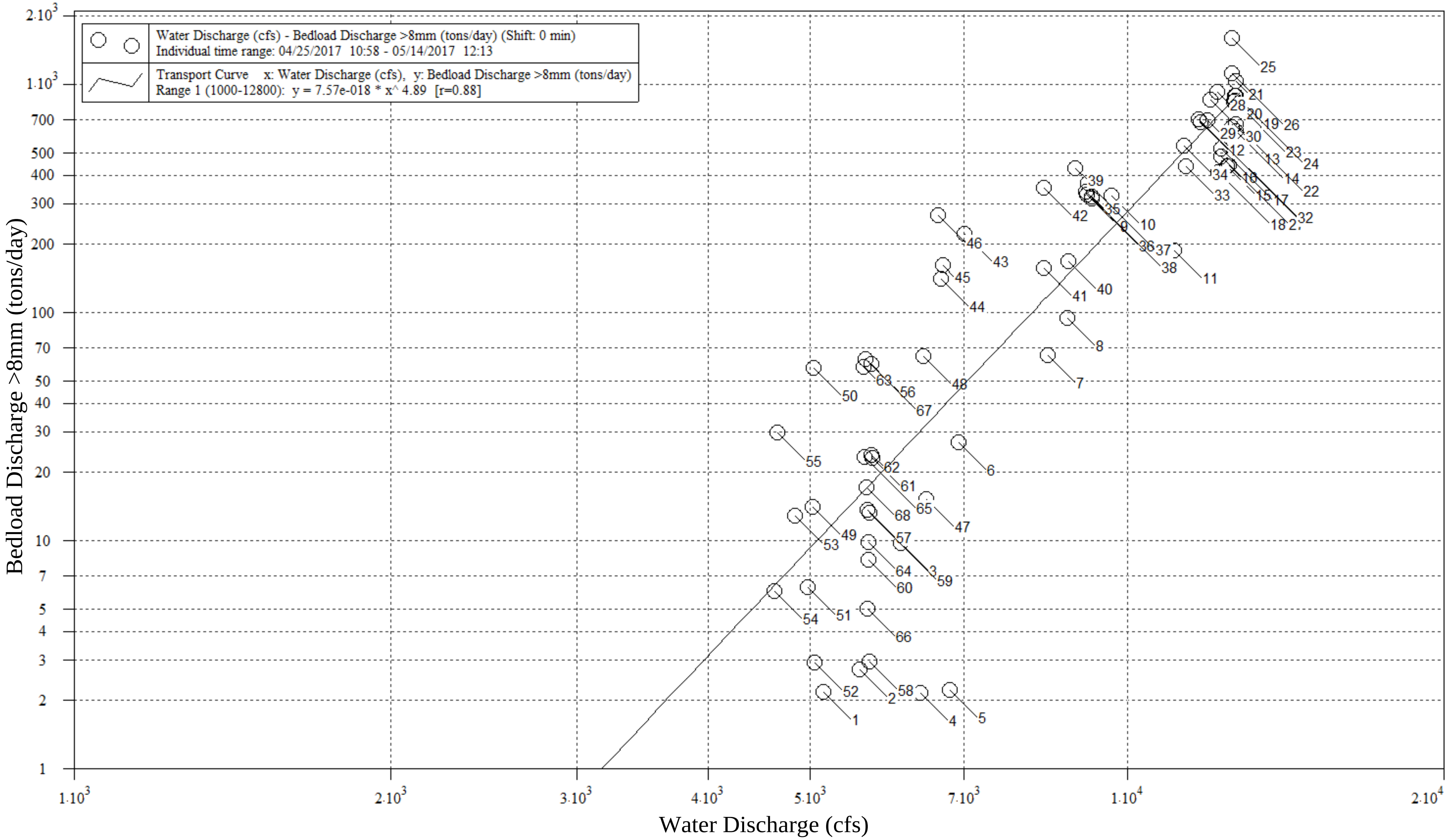
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2017



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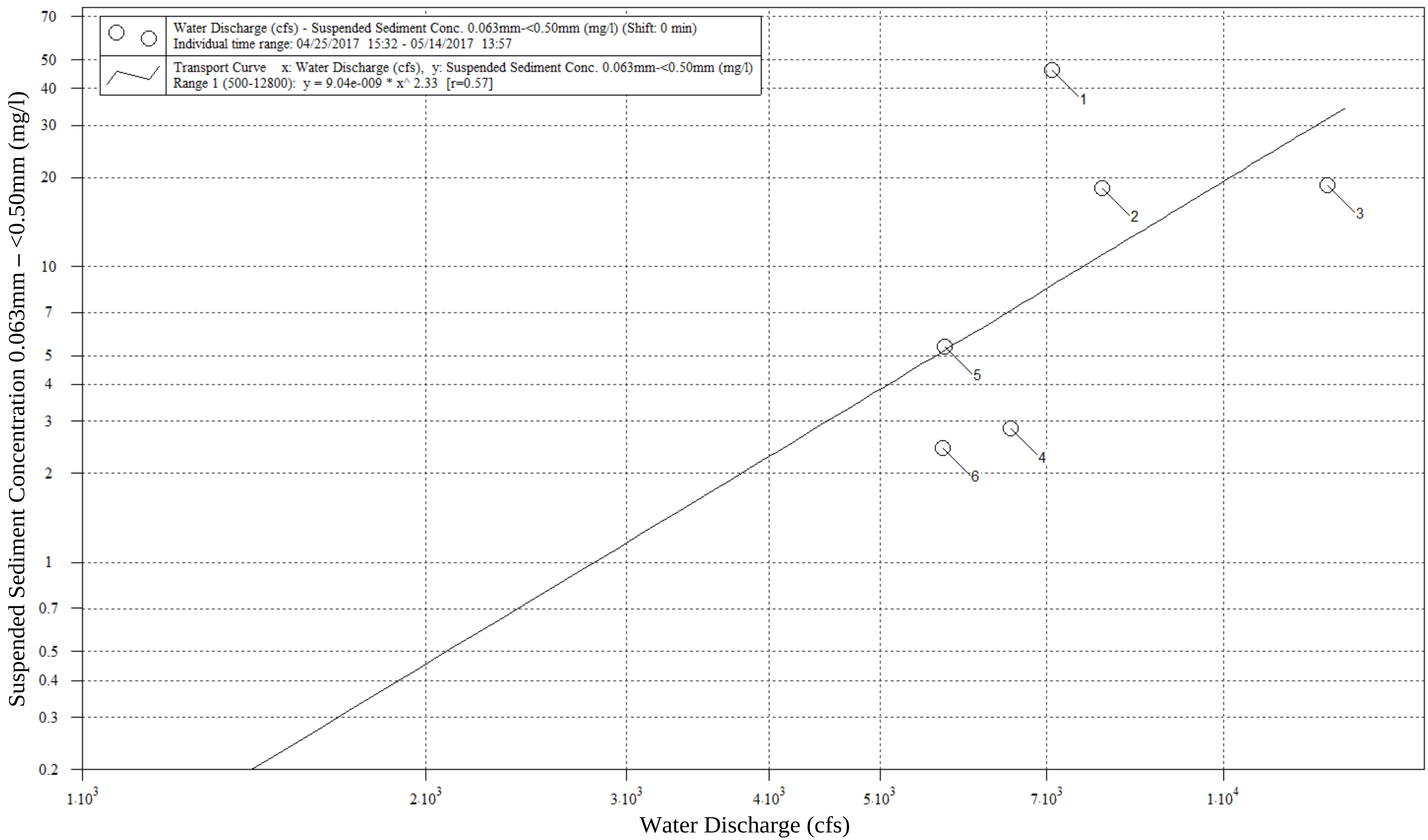
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Water Discharge (cfs) Versus Suspended Sediment Concentration 0.063mm - <0.50mm (mg/l): Spring Flow Release WY 2017



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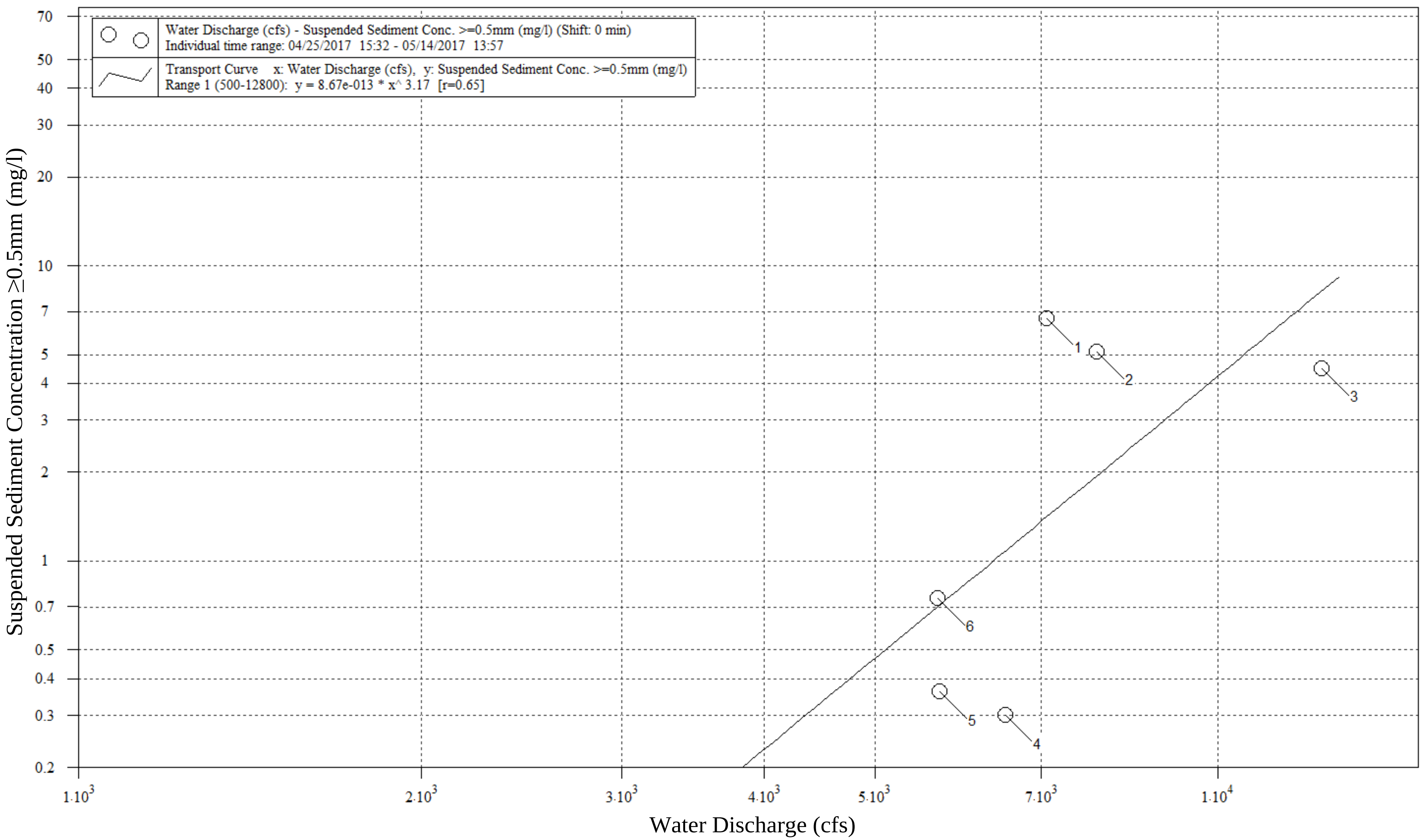
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Water Discharge (cfs) Versus Suspended Sediment Concentration ≥0.5mm (mg/l): Spring Flow Release WY 2017



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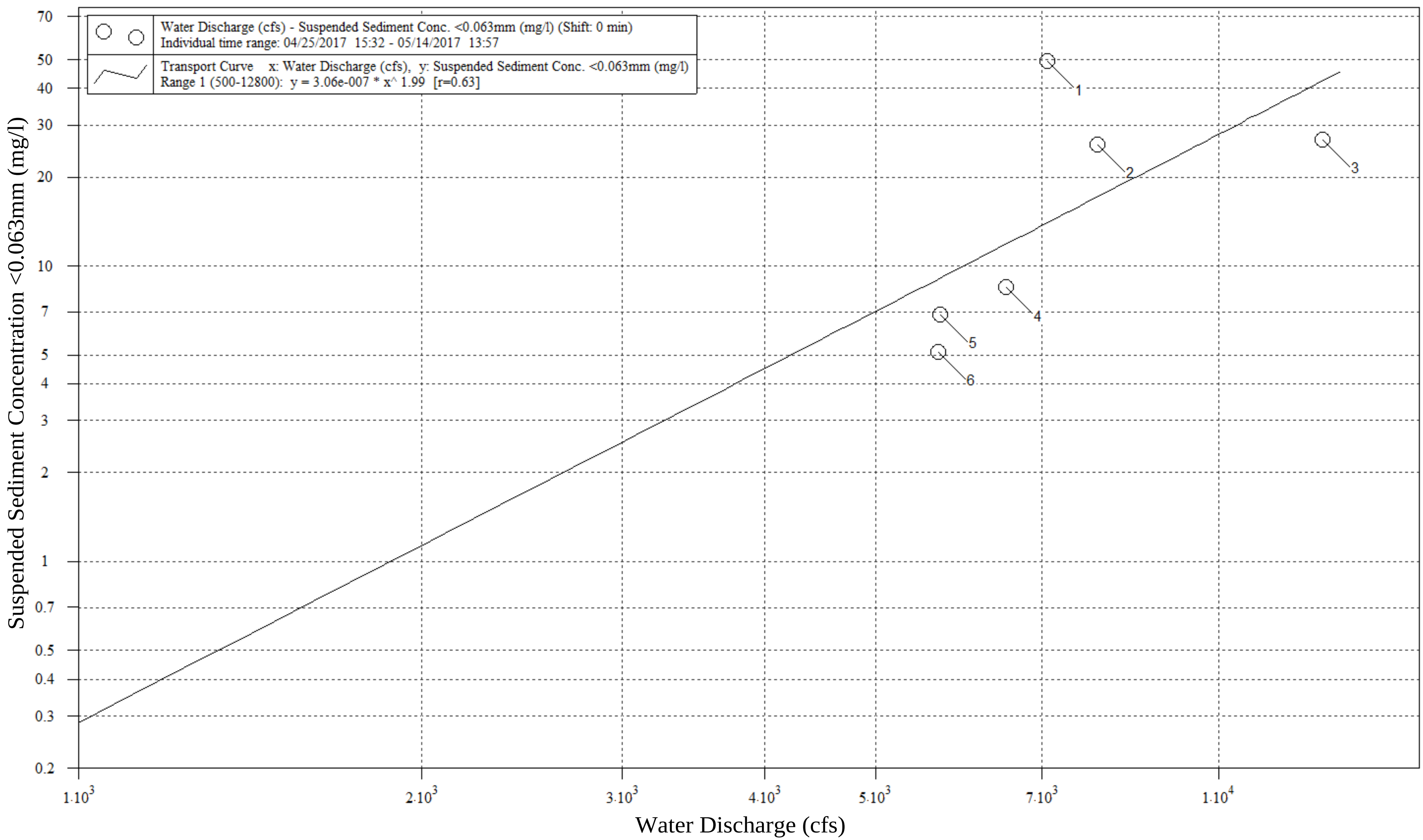
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Water Discharge (cfs) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release WY 2017



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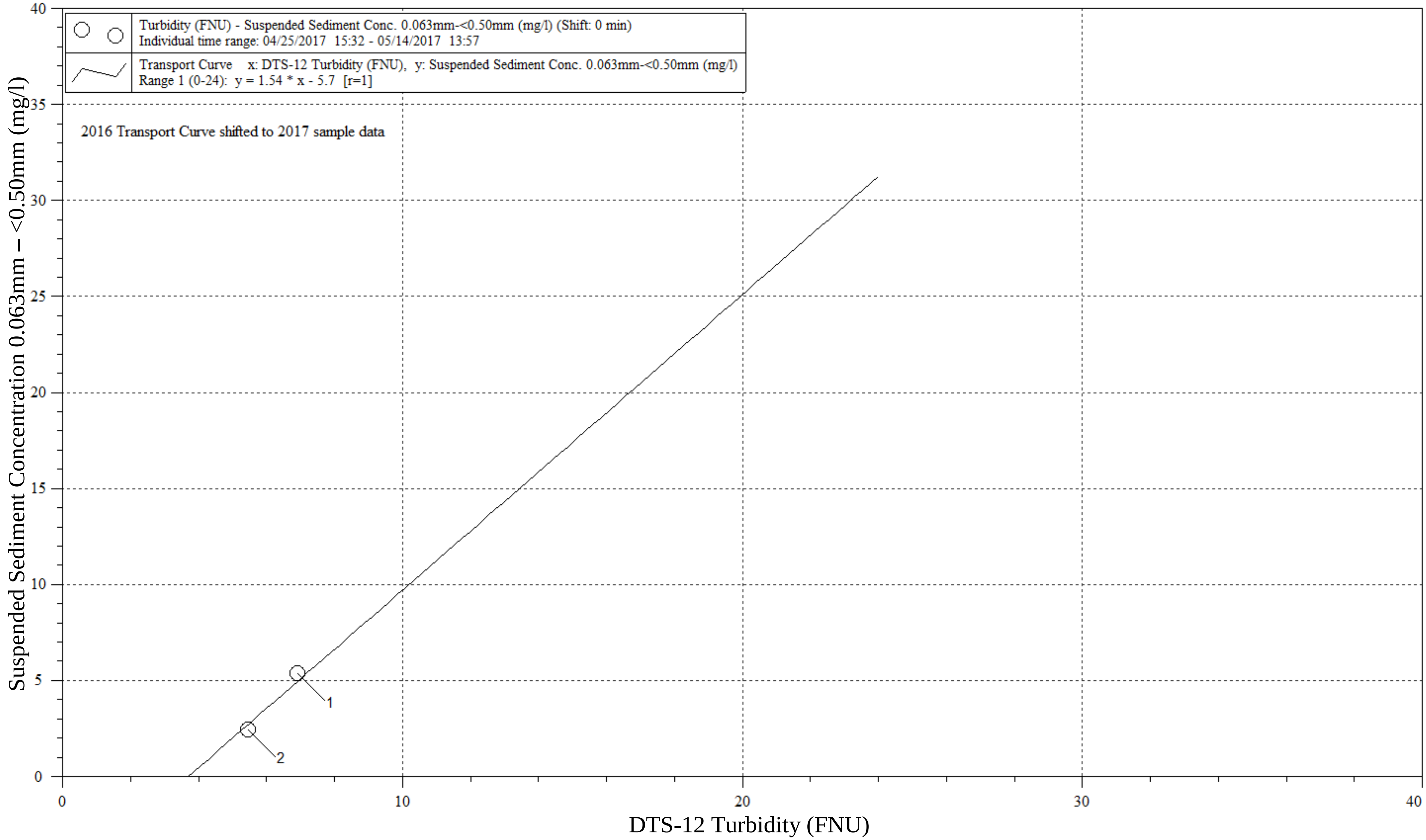
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Turbidity (FNU) Versus Suspended Sediment Concentration 0.063mm - <0.50mm (mg/l): Spring Flow Release WY 2017



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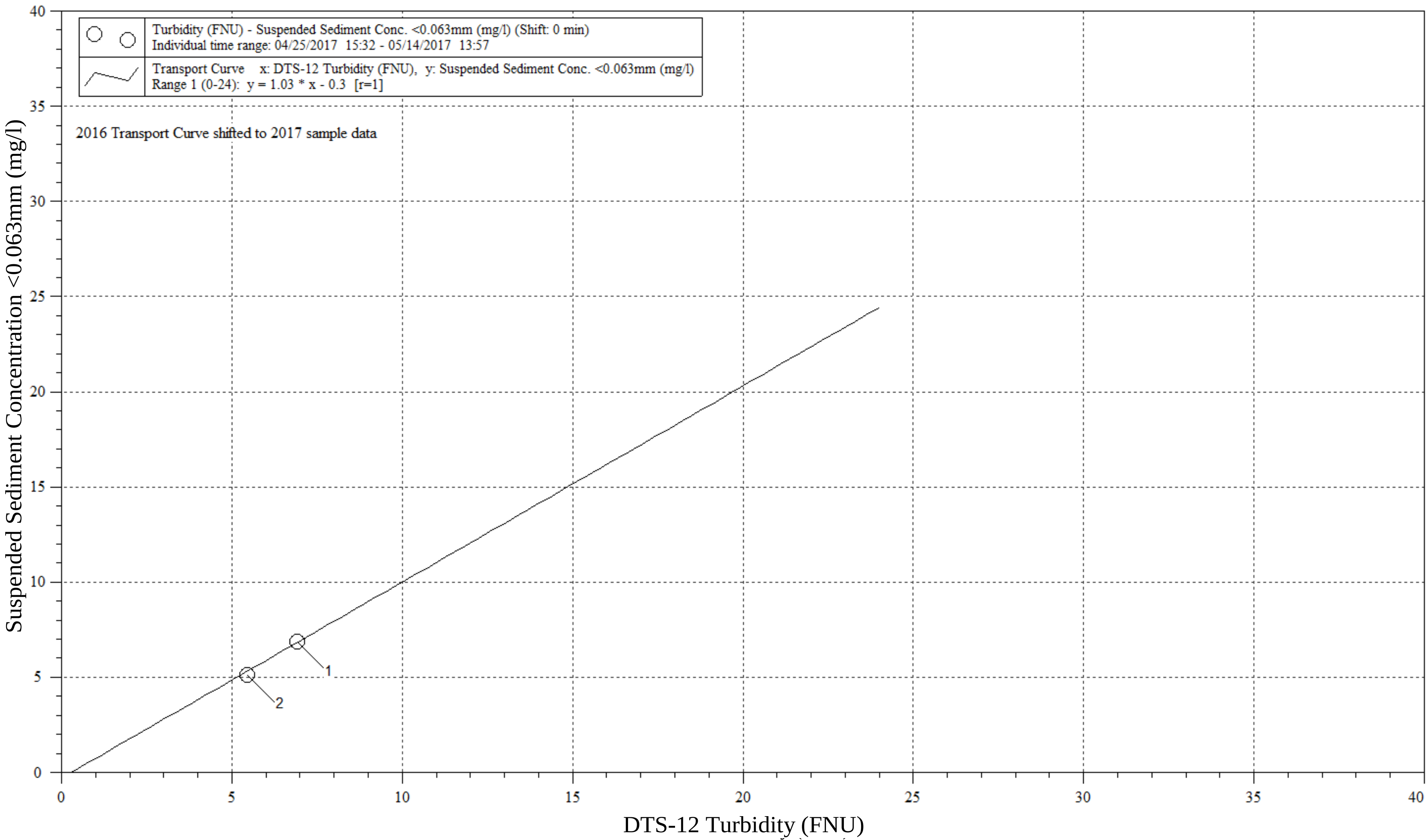
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

Turbidity (FNU) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release WY 2017



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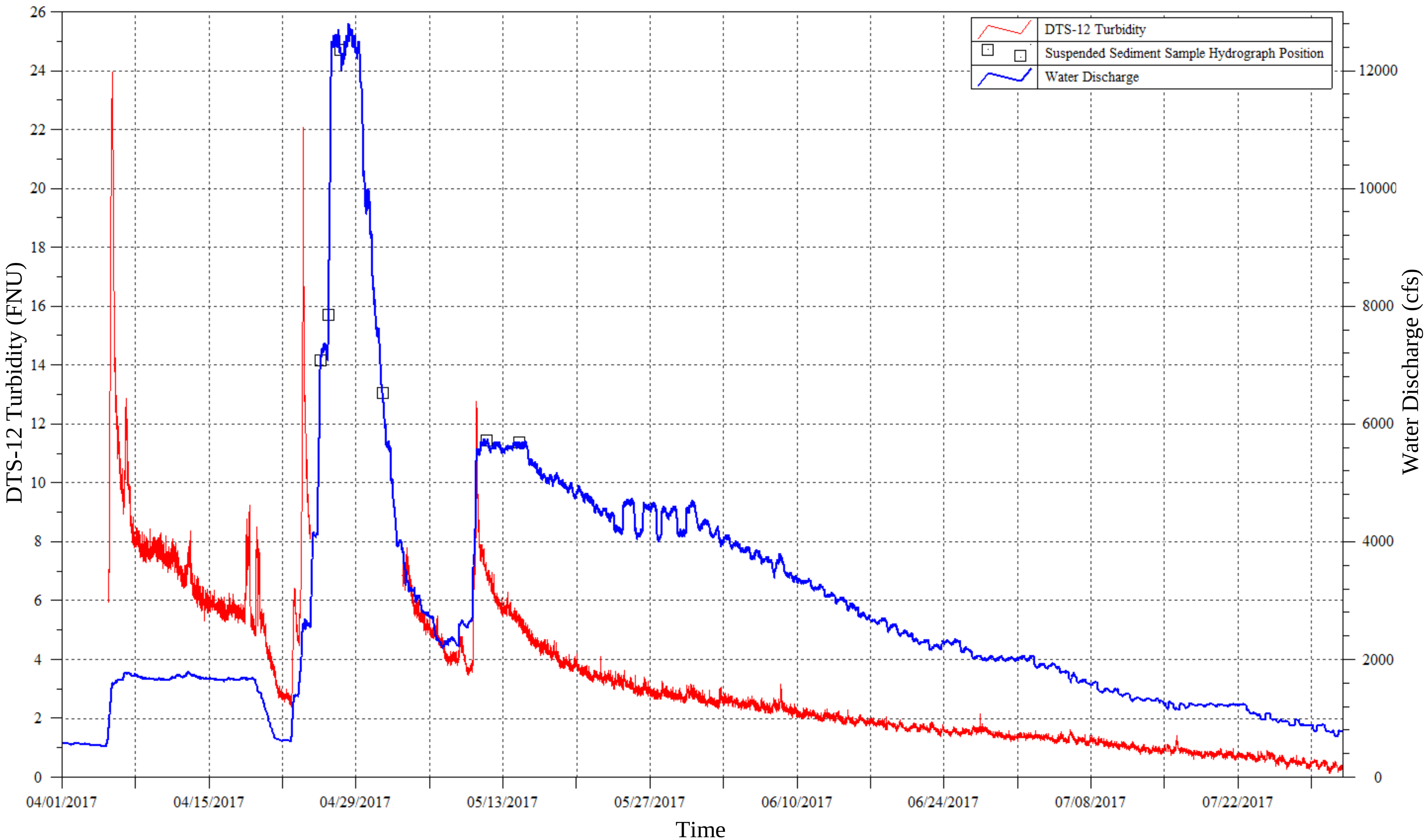
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY --11525655

DTS-12 Turbidity – Spring Flow Release WY 2017



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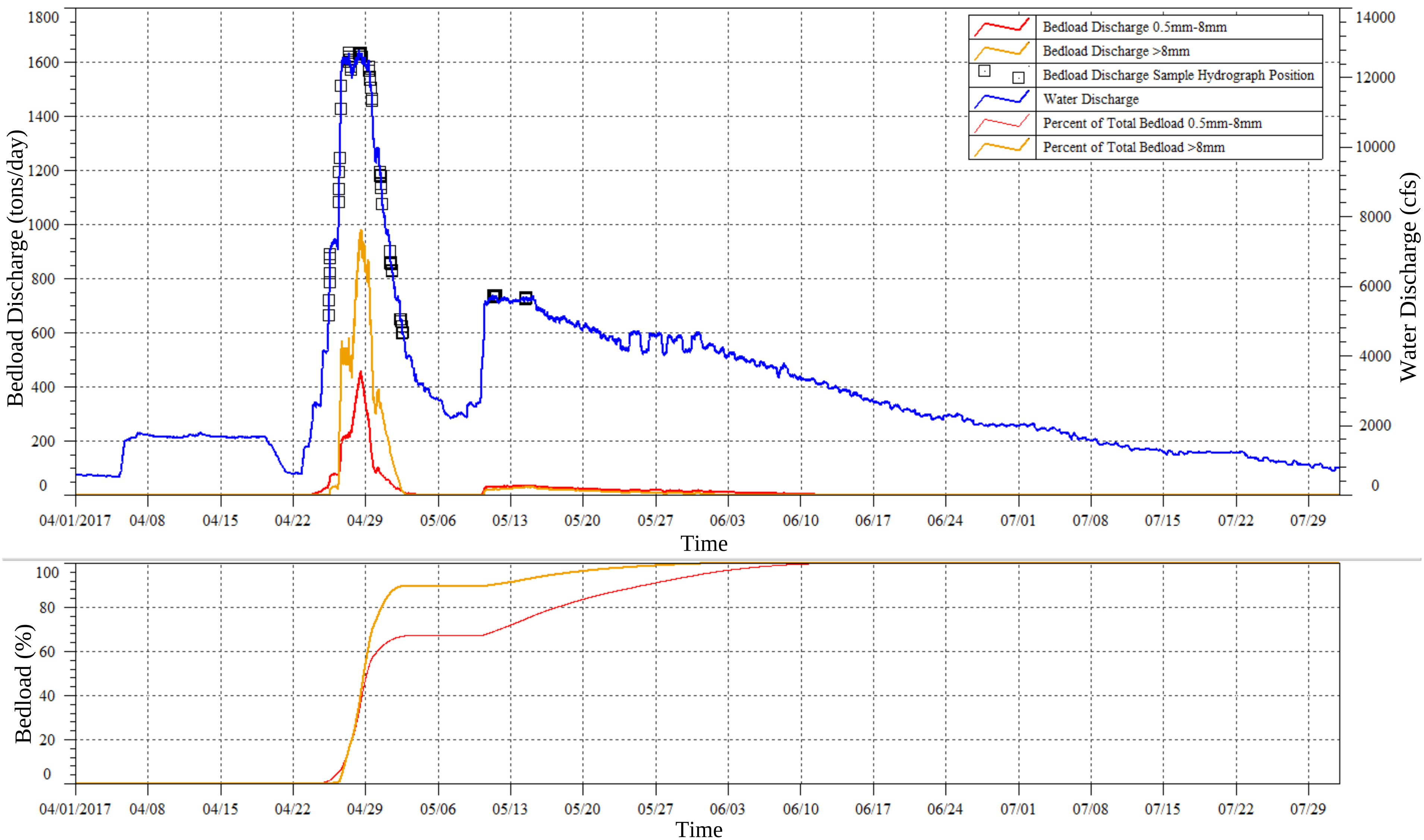
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

Bedload Discharge – Spring Flow Release WY 2017



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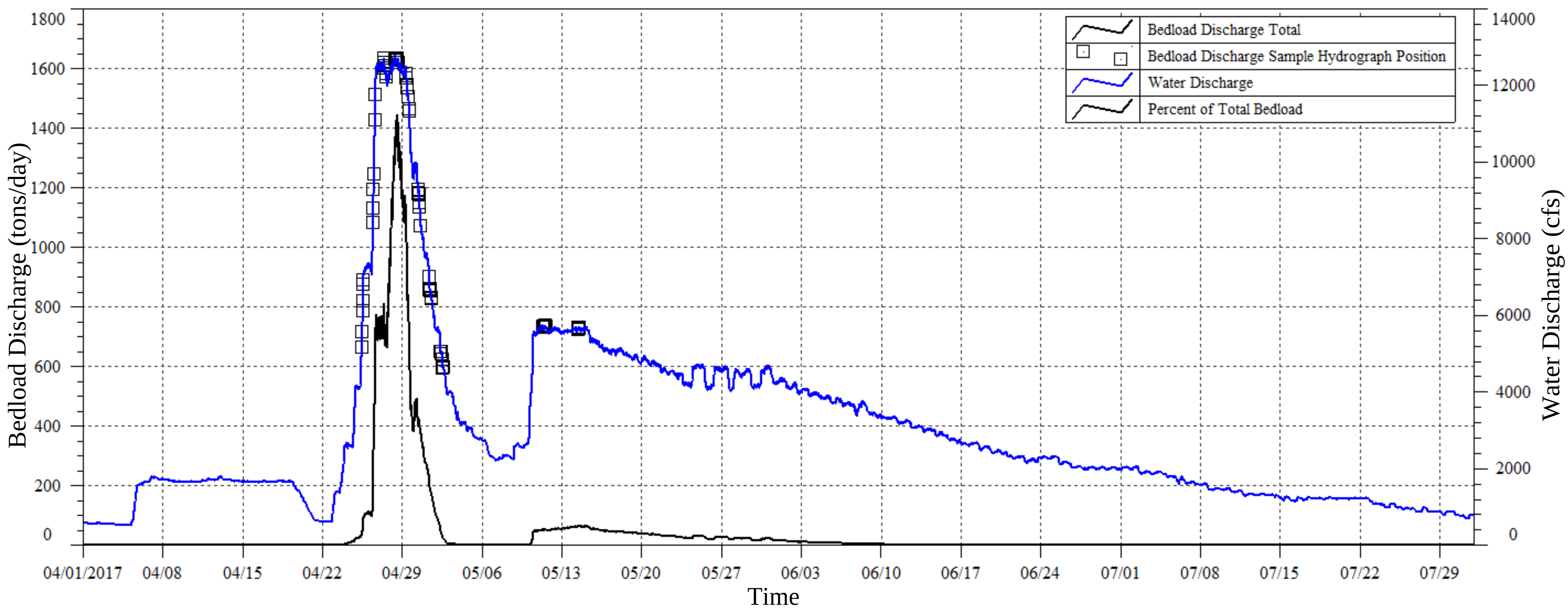
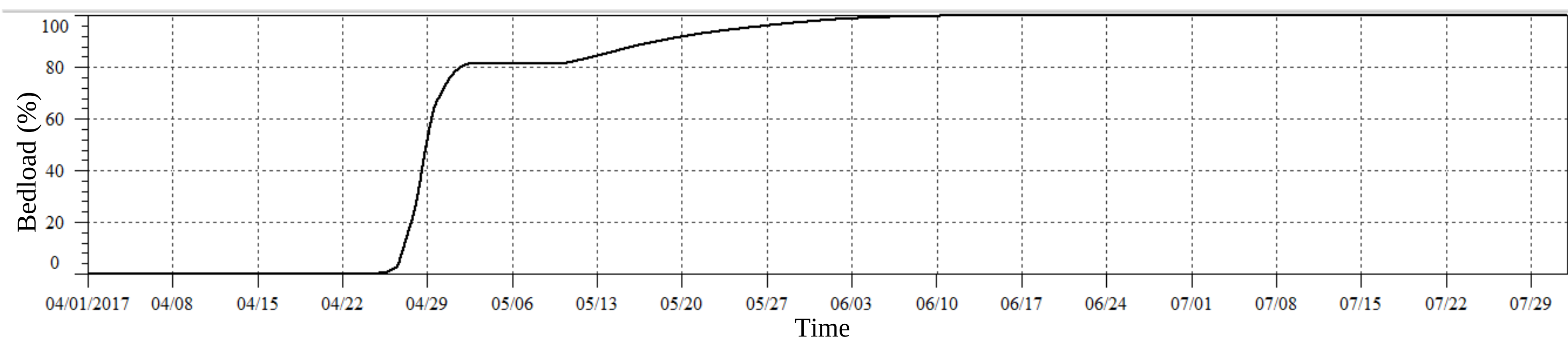
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

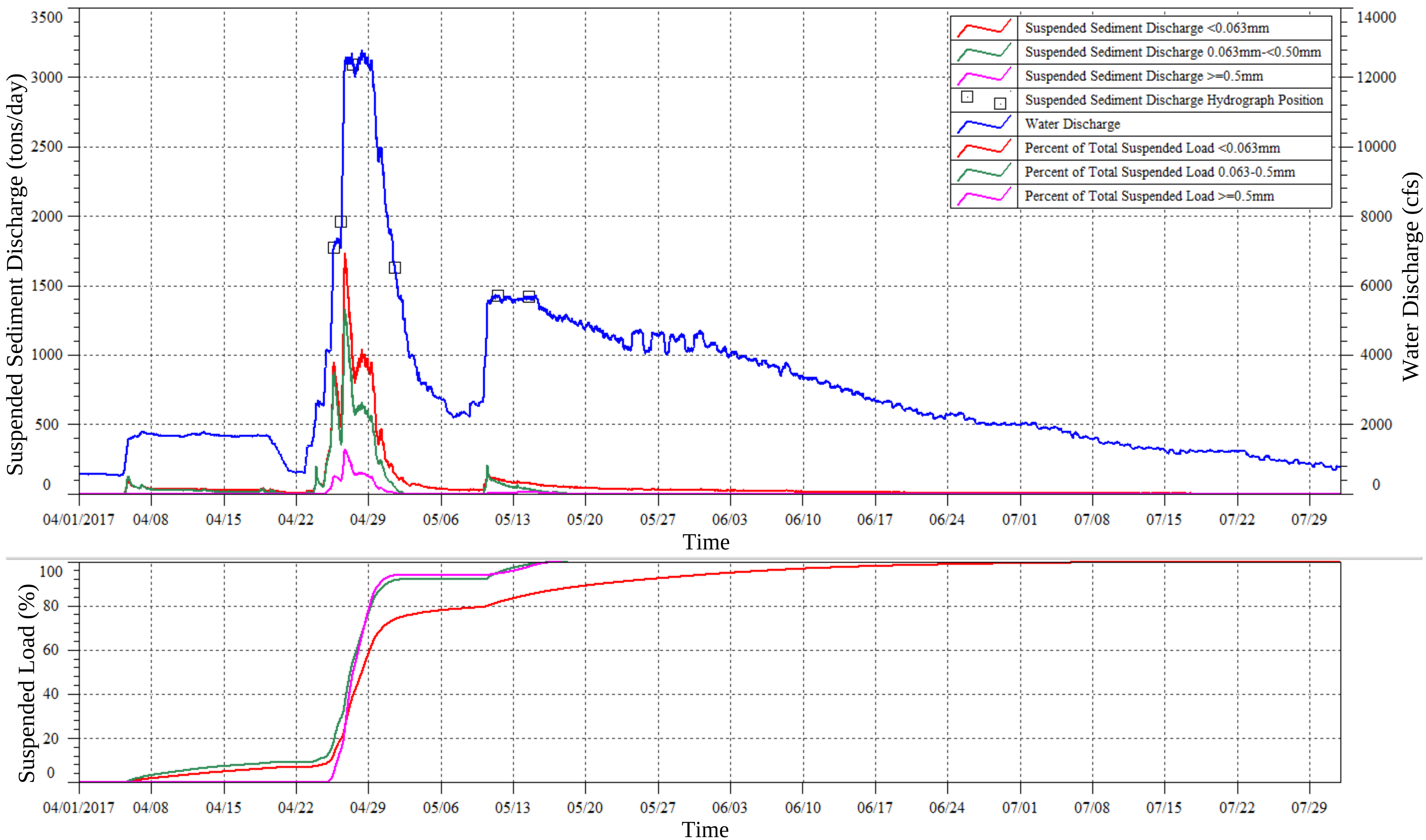
Bedload Discharge – Spring Flow Release WY 2017





TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

Suspended Sediment Discharge – Spring Flow Release WY 2017



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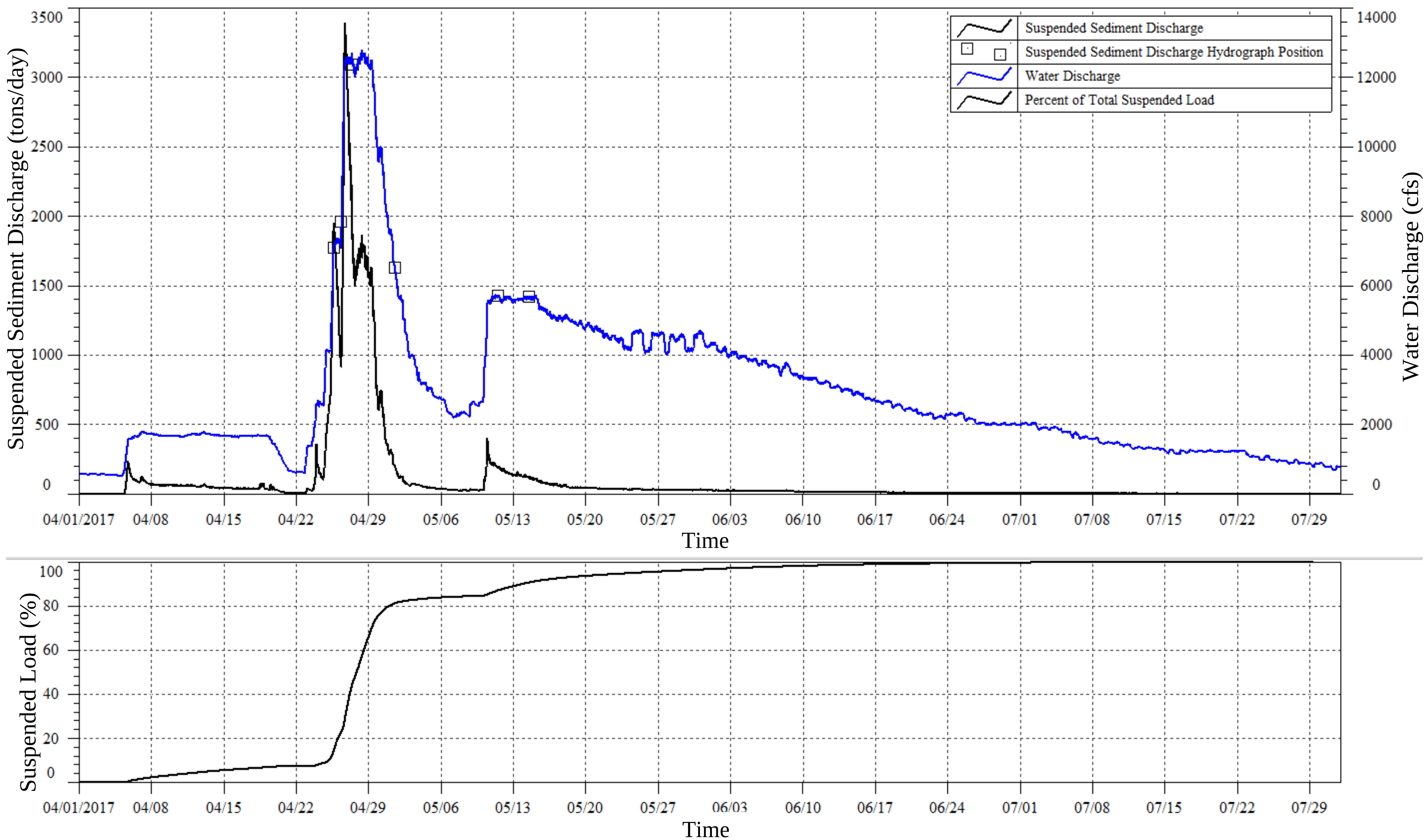
TRINITY RIVER BELOW LIMEKILN GULCH NEAR DOUGLAS CITY –11525655

Suspended Sediment Discharge – Spring Flow Release WY 2017



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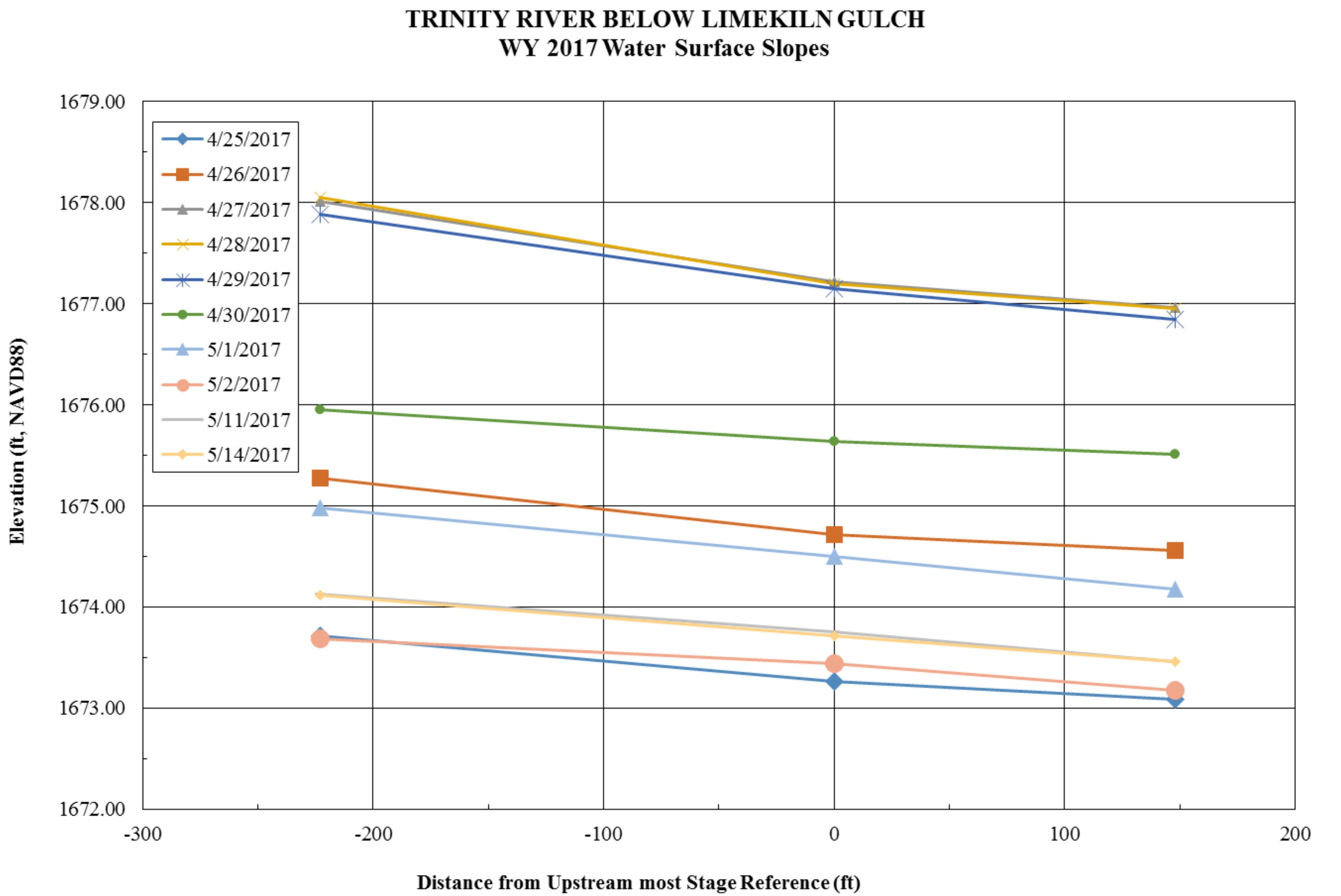

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Appendix D

Trinity River near Douglas City
USGS Gage # 11525854

11525854 Trinity River at Douglas City, CA

TOTAL LOAD SEDIMENT DISCHARGE RECORD

Spring Flow Release WY 2017: (April 1 to July 31)

Records collected at station. -- Daily streamflow has been collected continuously since 1995 by the Hoopa Valley Tribe and since 2005 by USGS. Sediment sampling (flow release) has occurred in 2002 and 2004-13, 2015-17. Instantaneous water temperature data have been collected since 1992. A Forest Technology Systems DTS-12 turbidity probe collects continuous turbidity data during the spring flow release. The purpose for collecting sediment data at this site is to quantify sediment discharge delivered from this portion of the main stem, versus the sediment discharge measured at sediment collection stations upstream, notably Trinity River at Limekiln Gulch (11525655). This effort is part of a long-term study of sediment transport in the Trinity River, under the Trinity River Restoration Program (TRRP), sponsored by the U.S. Department of Interior, Bureau of Reclamation. This station analysis describes (1) sampling efforts during and (2) records computed from the WY 2017 spring flow release by GMA Hydrology (GMA), under contract to the TRRP.

In 2012, the sampling section was moved to a location 225 ft downstream of the USGS gaging station. The Forest Technology Systems DTS-12 turbidity probe is now located at the USGS stream gage.

Equipment .-- Sampling equipment consists of a D-74 for suspended-sediment sampling, and a cable-deployed 12-inch x 6-inch Toutle River 2 bedload sampler (TR-2) with a 0.5 mm mesh collection bag. The D-74 suspended-sediment sampler was deployed using a hand-operated B-reeel and the TR-2 bedload sampler was deployed from a crane-mounted 12V winch. Sediment sampling was performed from a cataraft-based platform attached to a temporary cableway. Stage references were installed near the cableway and upstream of the streamflow gaging station. A Forest Technology Systems DTS-12 turbidimeter was installed and operated during the sediment sampling period. Photographs were taken with a digital camera.

Sampling program. -- Total (flow release) load season for this site is from April 1 to July 31. The program consisted of 8 sampling days. A minimum of two bedload-discharge samples was collected on each of the sampling days. The sampling days and samples collected are as follows:

April 26	5 bedload discharge	1 suspended-sediment discharge
April 27	2 bedload discharge	0 suspended-sediment discharge
April 28	5 bedload discharge	1 suspended-sediment discharge
April 30	7 bedload discharge	1 suspended-sediment discharge
May 1	6 bedload discharge	0 suspended-sediment discharge
May 2	2 bedload discharge	1 suspended-sediment discharge
May 12	6 bedload discharge	0 suspended-sediment discharge
May 15	6 bedload discharge	0 suspended-sediment discharge

Sampling crews consisted of two on-river personnel specifically trained in cataraft-based sediment data collection techniques and a safety kayaker. All samples were reviewed by the site technicians and individual analyses were standardized for suspended-sediment (concentration, particle size analysis) and bedload samples (total dry mass, particle size analysis). Sediment data were generally collected according to USGS protocols with the following exception: test-velocity ratings for sampler nozzles were occasionally exceeded. Suspended-sediment samples were sent to the GMA Suspended-Sediment Lab and bedload samples were sent to the GMA Coarse-Sediment Lab, both located in Placerville, CA for analysis.

USGS Field Review. -- No USGS field review was conducted during the 2017 spring flow release.

Data summary for WY 2017 Spring Flow Release --

Total number of samples:	
Suspended sets ……	0
Single pass suspended samples ……	4
Box sample sets……	0
Single box samples ……	0
Bedload sets ……	0
Single pass bedload samples ……	39
Three pass bedload samples ……	0
Number of field turbidities measured ……	0
Number of suspended sediment size analysis samples:	
Particle size analysis ……	0
0.063mm break ……	4
0.50mm break ……	4
Number of bedload sediment size analysis samples:	
Particle size analysis ……	39
Number of suspended sediment discharge measurements ……	4
Number of bedload discharge measurements ……	39
Number of visits by Field Office ……	0
Maximum flow sampled by:	
GMA technicians, ft^3/s ……	13,200
Range of concentrations sampled by:	
GMA technicians, mg/l ……	24-153
GMA technicians, ton/d……	104-15,000
Peak flow during flow release, ft^3/s ……	13,400
Periods of faulty record ……	
Turbidity	April 1 to April 5

Coefficients -- None used.

Continuous Turbidity.-- The turbidity record is incomplete for the computational period. At the end of the 2016 spring flow release the turbidity probe at the site was removed for calibration. The probe was reinstalled April 5, 2017 at 11:45.

Once the turbidity record was cleaned, the record was inspected to determine if a turbidity offset was necessary. An offset of -1.0 FNU was applied to the entire record.

During the computational period the maximum turbidity was 50.1 FNU on April 26 at 17:45, and the minimum turbidity was 0.00 FNU, which occurred numerous times throughout the record.

Total suspended sediment-discharge computations -- Total suspended-sediment discharge was computed by summing the partial suspended-sediment discharges.

Size analysis -- Four cross-sectional, depth-integrated samples were analyzed using a split at 0.063mm and ≥0.50mm.

Partial suspended sediment-discharge computations -- Turbidity versus SSC and discharge versus SSC transport curves were inspected for use during the period. For the <0.063mm and 0.063mm –

0.5mm size classes, turbidity showed a good relation with SSC and was used for transport curve development. For the ≥0.5mm size class, a discharge versus SSC better represented the data. Data was also compared to Water Year 2016 data, however, all size classes showed that the SSC relationship with turbidity and discharge had shifted. Generalized transport curves were developed using all samples collected during Water Year 2017 only. No outliers were identified.

For the <0.63mm size class, the turbidity versus SSC transport curve is defined by Eqn. (1).

$$SSC = 1.93 * Turbidity - 5.3, \qquad r^2 = 0.99 \qquad (1)$$

Eqn. (1) is used from April 5 at 11:45 hours to July 31 at 23:45 hours. Eqn. (1) has a validated range between 7.53 FNU and 28.0 FNU. Zero transport was determined during transport curve development and occurs at 2.69 FNU.

For the 0.063mm-<0.50mm size class, the turbidity versus SSC transport curve is defined by Eqn. (2).

$$SSC = 3.21 * Turbidity - 17.7, \qquad r^2 = 0.97 \qquad (2)$$

Eqn. (1) is used from April 5 at 11:45 hours to July 31 at 23:45 hours. Eqn. (1) has a validated range between 7.53 FNU and 28.0 FNU. Zero transport was determined during transport curve development and occurs at 5.50 FNU.

For the ≥0.5mm size class the discharge versus SSC transport curve developed for the computational period is defined by Eqn. (3).

$$SSC = 2.25e-009 * Discharge^{2.47}, \quad r^2 = 0.96 \qquad (3)$$

Eqn. (3) was used from April 1 to July 31 and has a validated range between 5,210 cfs and 13,200 cfs. Zero transport was estimated during sedigraph development using previous years' data. For the rising limb, a zero transport of 1,500 cfs was used. Zero transport between the two peak benches was determined by fitting the sedigraph to sample 4, and occurs at 3,400 cfs. For the falling limb of the second bench, 6,000 cfs was used as zero tranpsort.

The tranport curves were used to develop continuous concentration curves for the <0.063mm, 0.063mm-<0.50mm, and the ≥0.5mm size classes during the computational period. Once the continuous concentration data had been developed the sample data were used to adjust the continuous concentration curves so that they passed through all sample points. The continuous concentration curves were adjusted using fitting and proportional fitting techniques.

Proportional fitting calculates the ratio between two sequential sample values and then scales the appropriate time series (e.g. continuous SSC) by this ratio. When applied between sequential pairs of data, the ratio is decayed or increased linearly to match the end-points. Fitting and proportional fitting techniques recognize short-term correlations and address hysteresis effects by using subsets of data. When only a single sample exists on a flow bench, the proportional fitting technique assumes that the determined ratio applies for the duration of that flow bench. When SSC is not highly correlated with discharge or turbidity, it is not possible to evaluate this assumption and therefore it is a potential source of error.

Suspended-sediment discharge was computed directly from the continuous concentration once the continuous concentration data had been checked and its accuracy verified.

<u>Bed material</u> -- None.

<u>Bedload measurement</u> – Thirty-nine bedload samples were collected during the Spring Flow Release. All were single pass samples.

<u>Bedload-discharge computations</u> -- The sample analysis contains the portion of sample <0.5mm but the total bedload discharge was determined by summing the partial discharges for the $\geq$0.5mm-8mm and the $\geq$8mm size fractions.

<u>Partial Bedload-discharge computations</u> -- Sediment transport curves were developed and partial bedload discharges were computed for the 0.5mm-8mm and $\geq$8mm size classes. 2017 had a double peak hydrograph and sample data was analyzed for the entire year, with each peak broken out seperately and for rise and fall patterns of hysteresis. No outliers were identified.

For the 0.5mm-<8mm size class, no obvious patterns of hysteresis or changes in transport rates between the two peaks were observed so a single generalized transport curve was developed and is shown in Eqn. (4). No outliers were identified

$$BLD = 1.87e-006 * (Discharge - 2200)^{2.15}, \qquad r^2 = 0.78 \qquad (4)$$

The transport curve is used from April 1 at 00:00 hours through July 31 at 23:45 hours. The transport curve has a validated range between 5,330 cfs and 13,200 cfs. Zero transport for the rising limb was estimated during transport curve development and occurs at 2,200 cfs. No hysteresis was observed in the sample data collected during the first hydrograph peak and so zero transport is assumed to be 2,200 cfs and is not reached between peaks. For the second hydrograph peak, zero transport was determined by fitting the sedigraph to an average of sample 34-39 and occurs at 4,800 cfs.

For the $\geq$8mm size class, the transport curve developed for use during the computational period is defined by Eqn. (5).

$$BLD = 7.43e-008 * (Discharge - 2800)^{2.66}, r^2 = 0.88 \qquad (5)$$

The transport curve is used from April 1 at 00:00 hours through July 31 at 23:45 hours. The transport curve has a validated range between 5,330 cfs and 13,200 cfs. Zero transport for the rising limb was estimated during transport curve development and occurs at 2,800 cfs. No hysteresis was observed in the sample data collected during the first hydrograph peak and so zero transport occurs at 2,800 cfs. For the second hydrograph peak, zero transport was determined by fitting the sedigraph to an average of sample 34-39 and occurs at 4,430 cfs.

Once the continuous bedload-discharge traces were developed using the above transport curves, they were adjusted using the sample values using the same techniques as was described for the partial suspended-sediment discharge computations. Due to the inherent high variability in bedload sampling, during flow benches, sample values were averaged on days where multiple samples were collected to produce average transport values. These average transport values were used to adjust the continuous bedload transport trace.

Remarks. – The suspended sediment discharge record is rated as follows:

April 1 (00:00) to April 25 (23:45)	Estimated
April 26 (00:00) to May 2 (23:45)	Good
May 3 (00:00) to July 31 (23:45)	Estimated

The bedload discharge record is rated as follows:

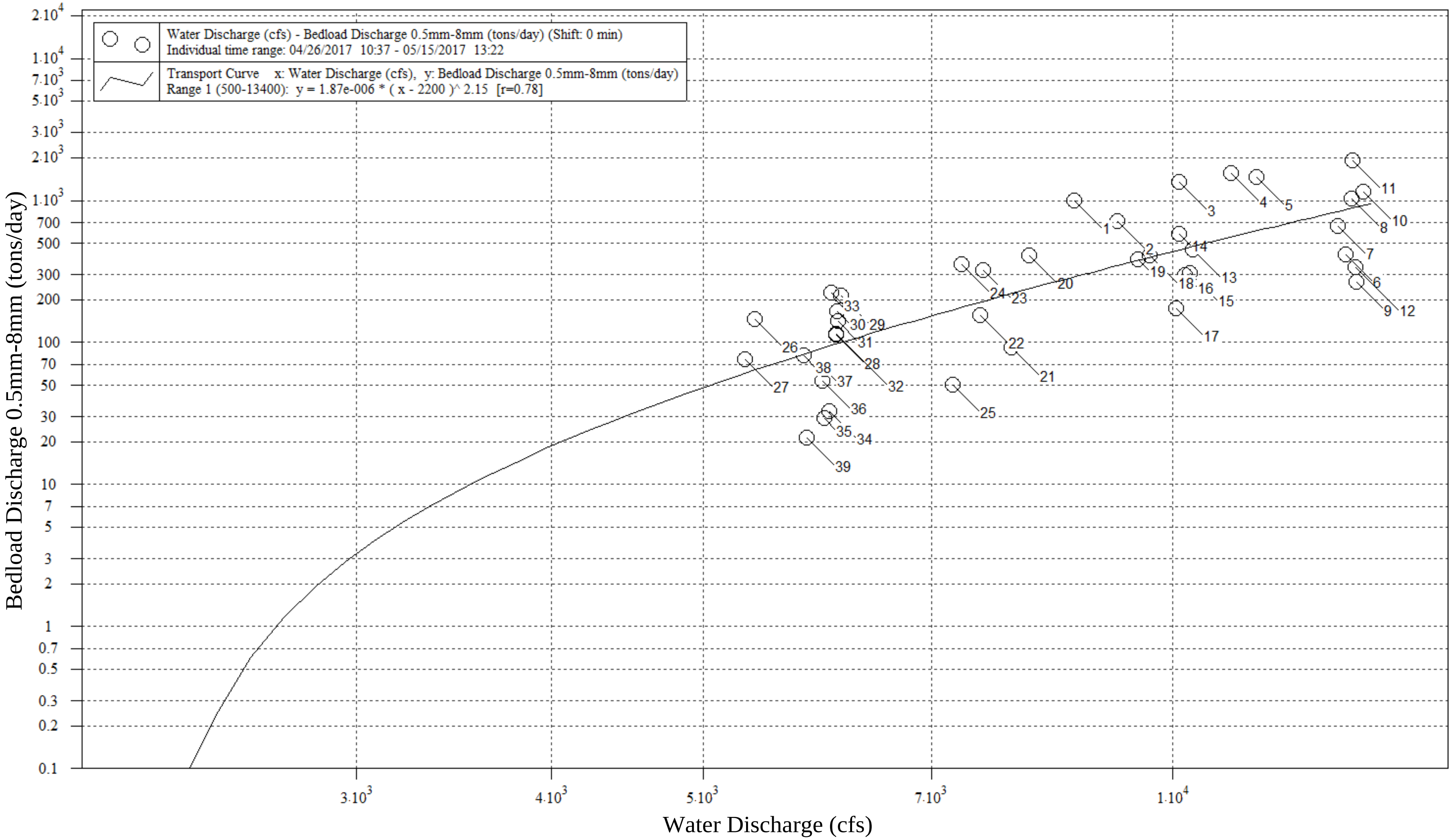
April 1 (00:00) to April 25 (23:45)	Estimated
April 26 (00:00) to May 15 (23:45)	Good
May 16 (00:00) to July 31 (23:45)	Estimated

Computed by: Brooke Pittman, December 2017

Reviewed by: Smokey Pittman, December 2017

TRINITY RIVER AT DOUGLAS CITY --11525854

Water Discharge (cfs) Versus Bedload Discharge 0.5mm-<8mm (tons/day): Spring Flow Release WY 2017



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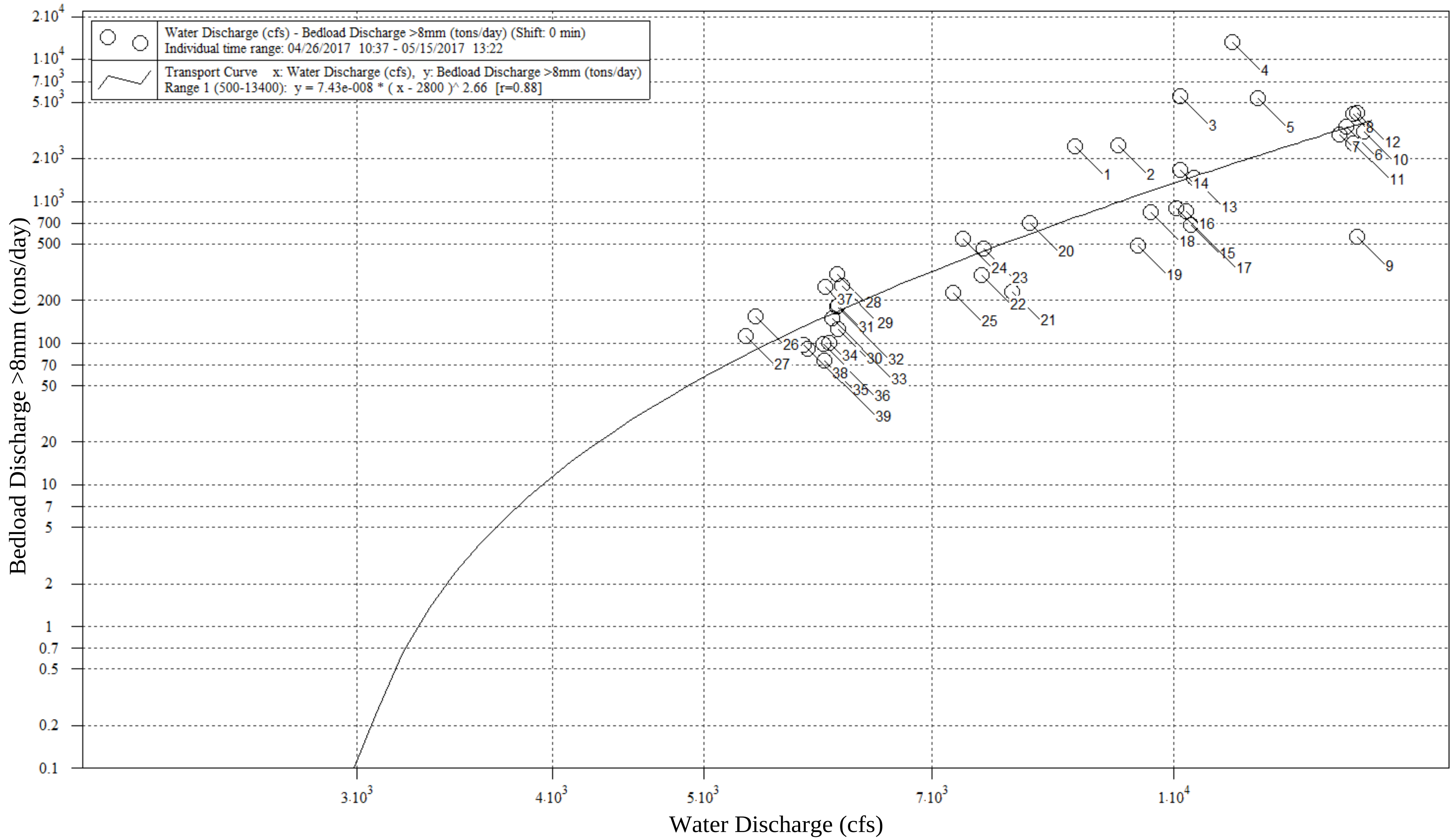
TRINITY RIVER AT DOUGLAS CITY --11525854

Water Discharge (cfs) Versus Bedload Discharge ≥8mm (tons/day): Spring Flow Release WY 2017



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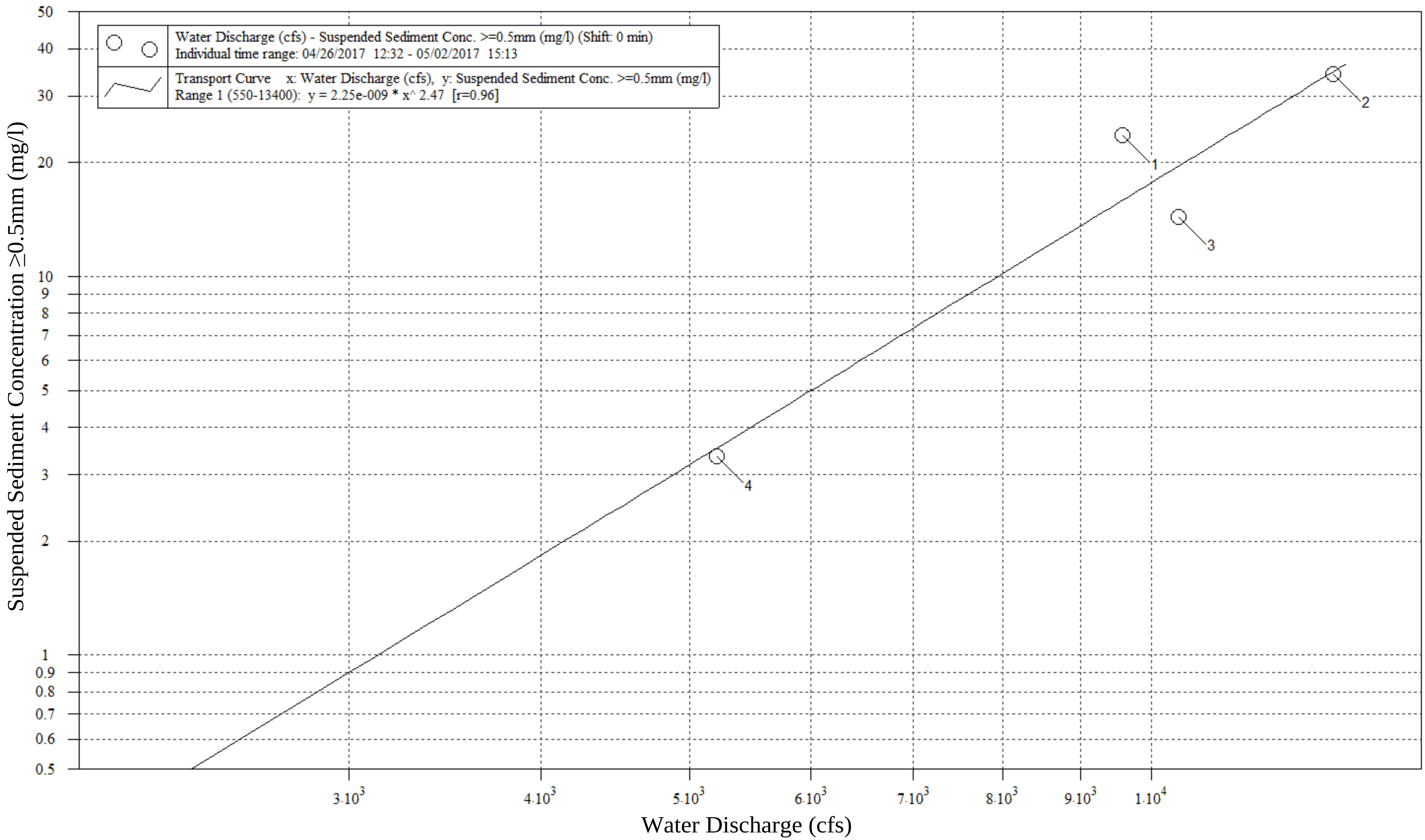
TRINITY RIVER AT DOUGLAS CITY –115525854

Water Discharge (cfs) Versus Suspended Sediment Concentration ≥0.50mm (mg/l): Spring Flow Release Samples WY2017



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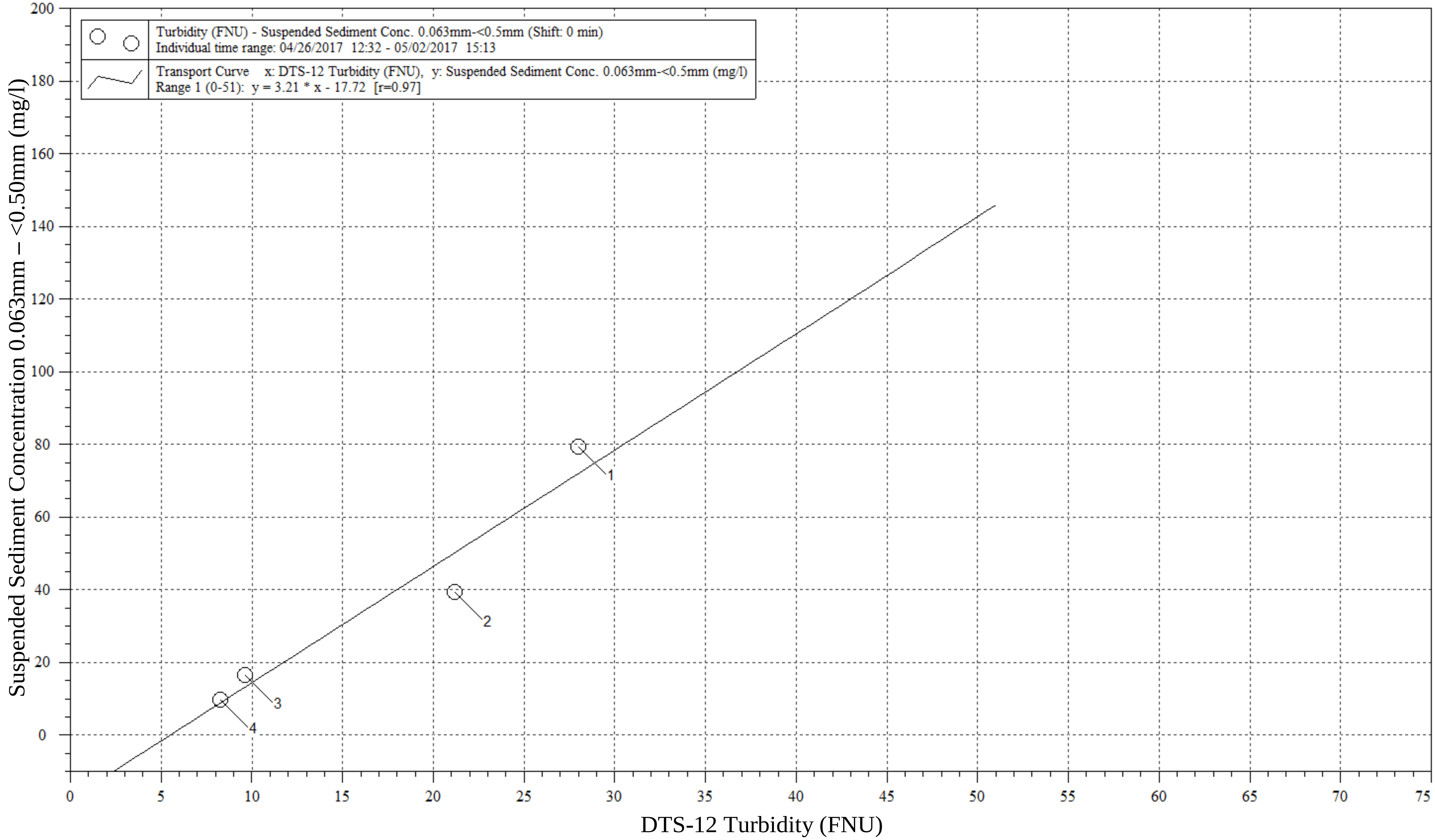
TRINITY RIVER AT DOUGLAS CITY –115525854

Turbidity (FNU) Versus Suspended Sediment Concentration 0.063mm-<0.50mm (mg/l): Spring Flow Release Samples WY2017



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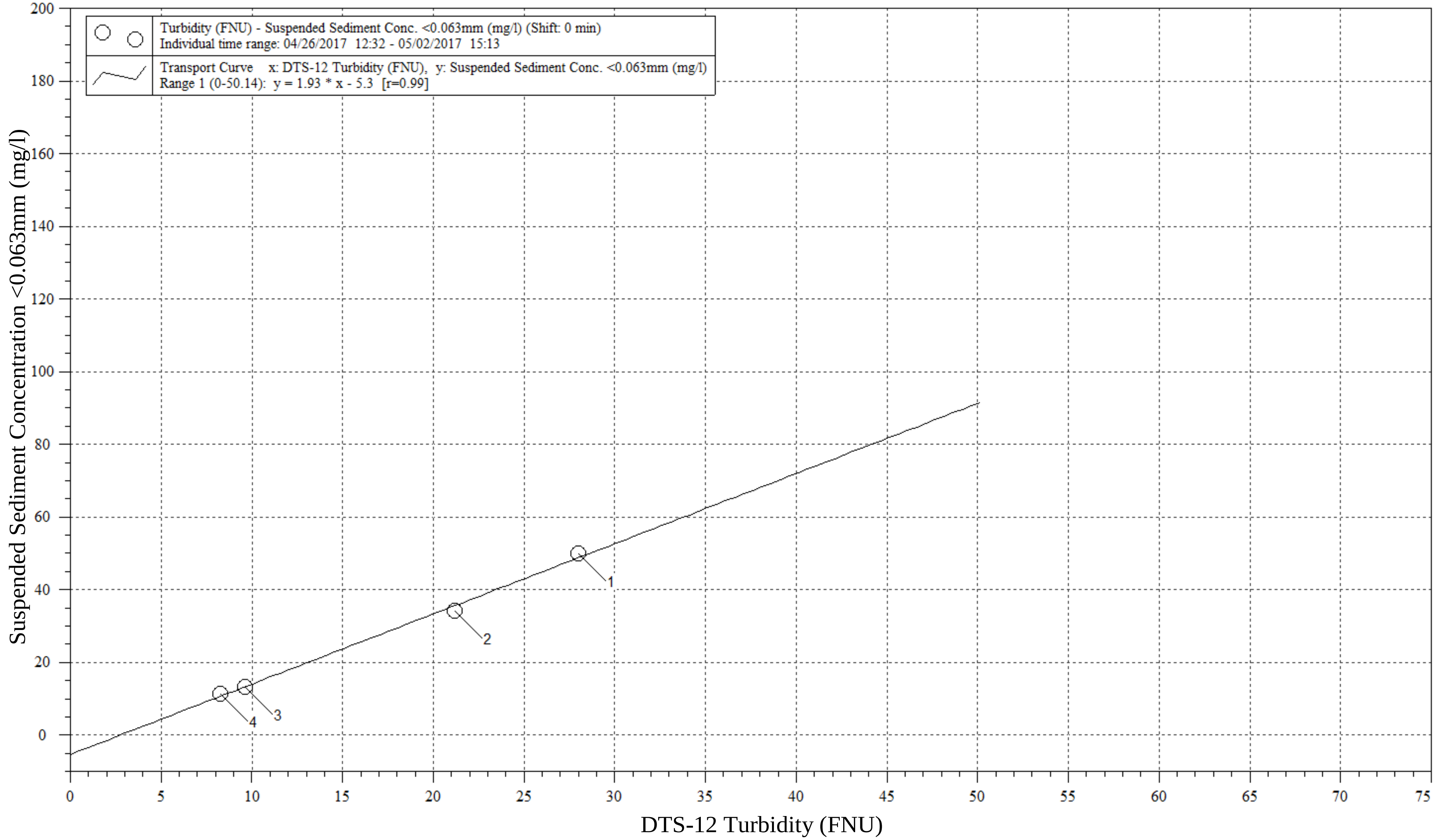
TRINITY RIVER AT DOUGLAS CITY –115525854

Turbidity (FNU) Versus Suspended Sediment Concentration <0.063mm (mg/l): Spring Flow Release Samples WY2017



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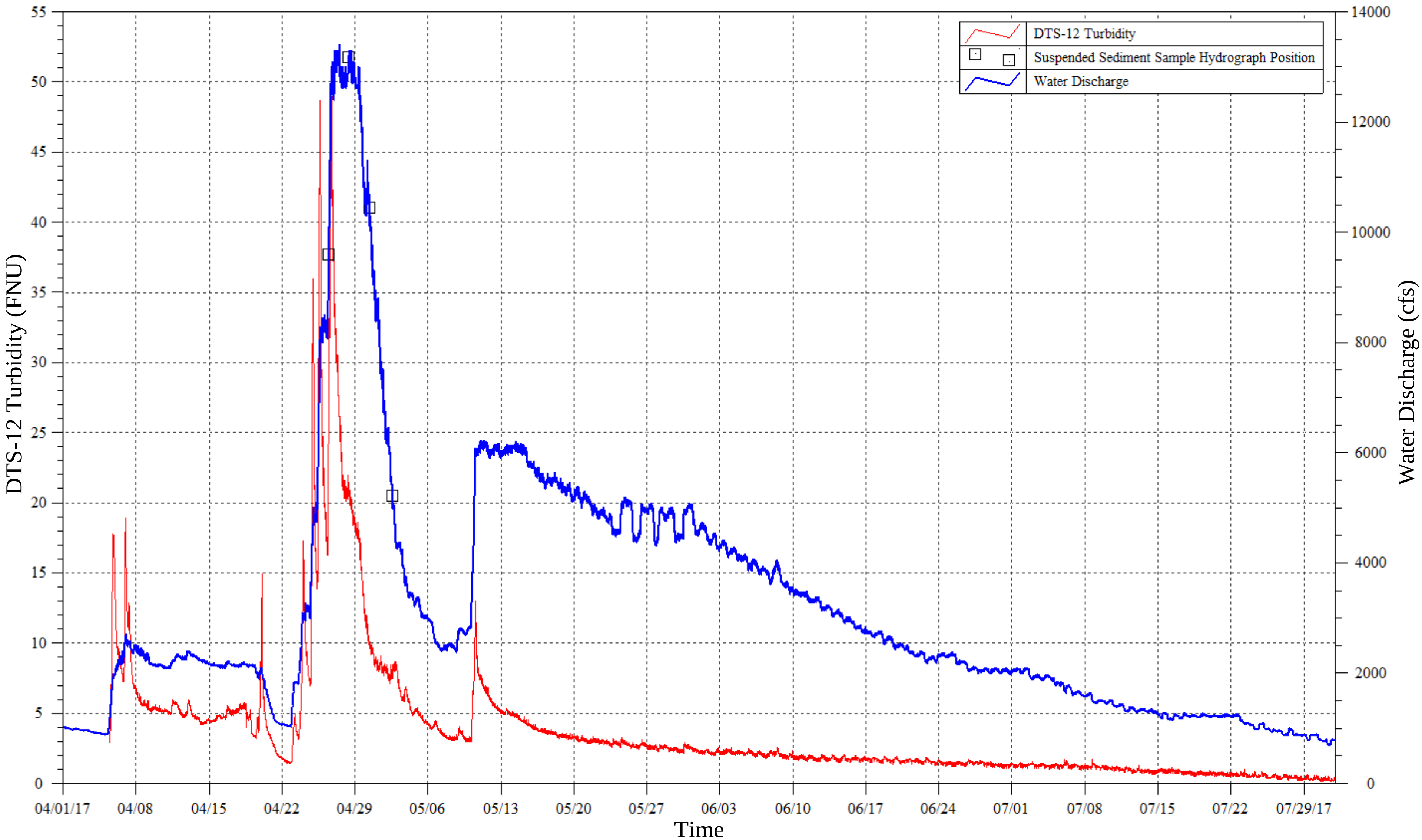
DTS-12 Turbidity – Spring Flow Release WY 2017



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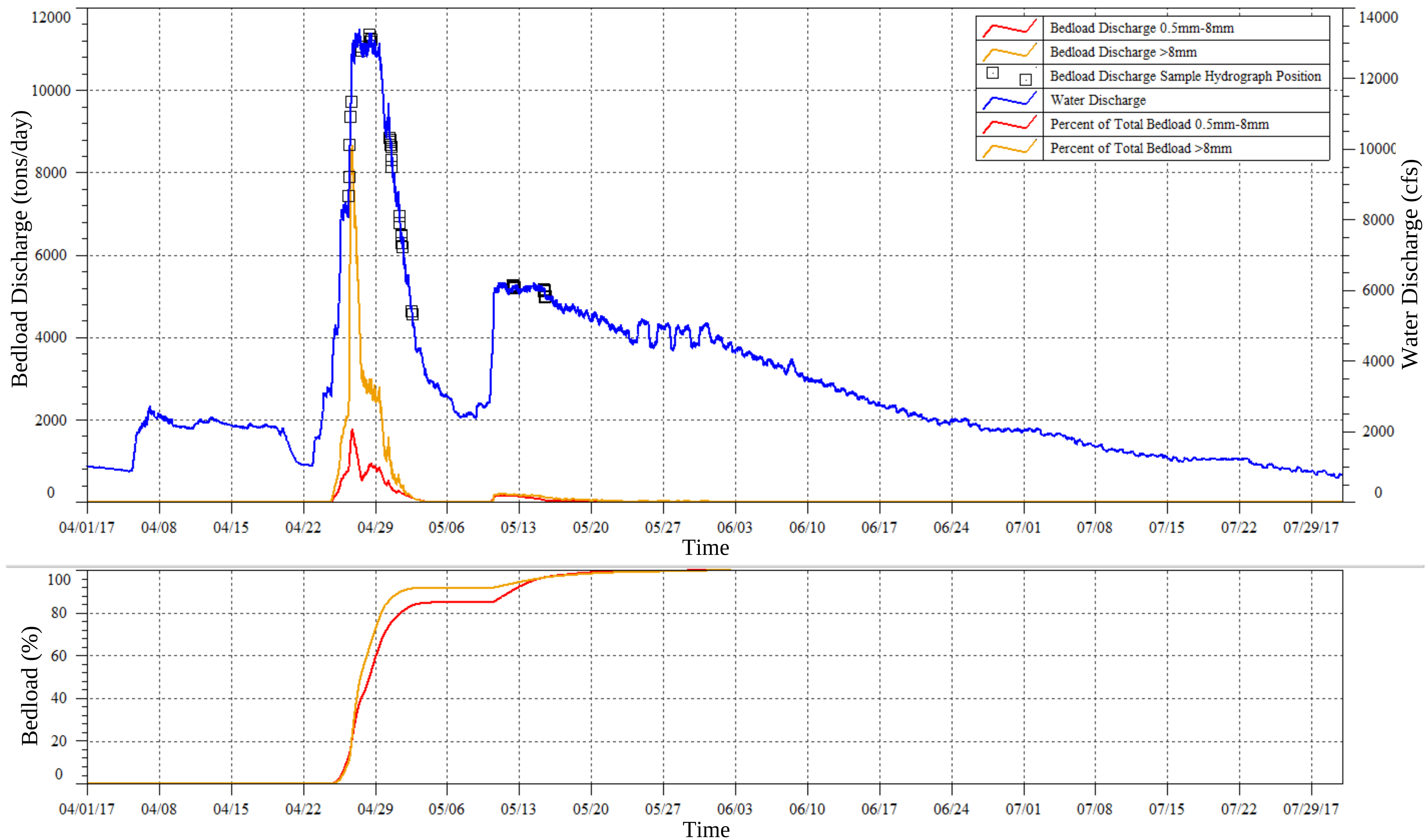
Bedload Discharge – Spring Flow Release WY 2017



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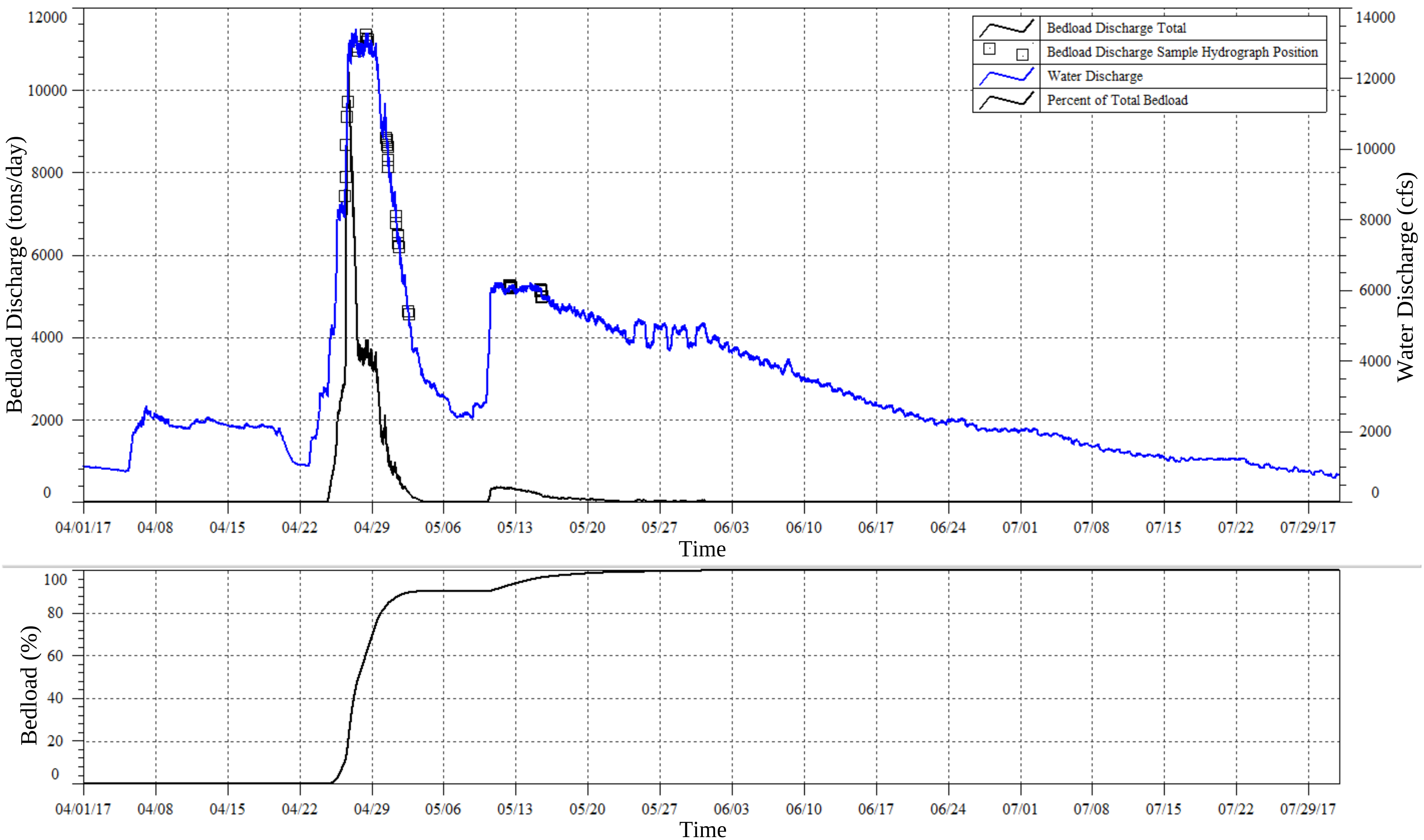
TRINITY RIVER AT DOUGLAS CITY –115525854

Bedload Discharge – Spring Flow Release WY 2017



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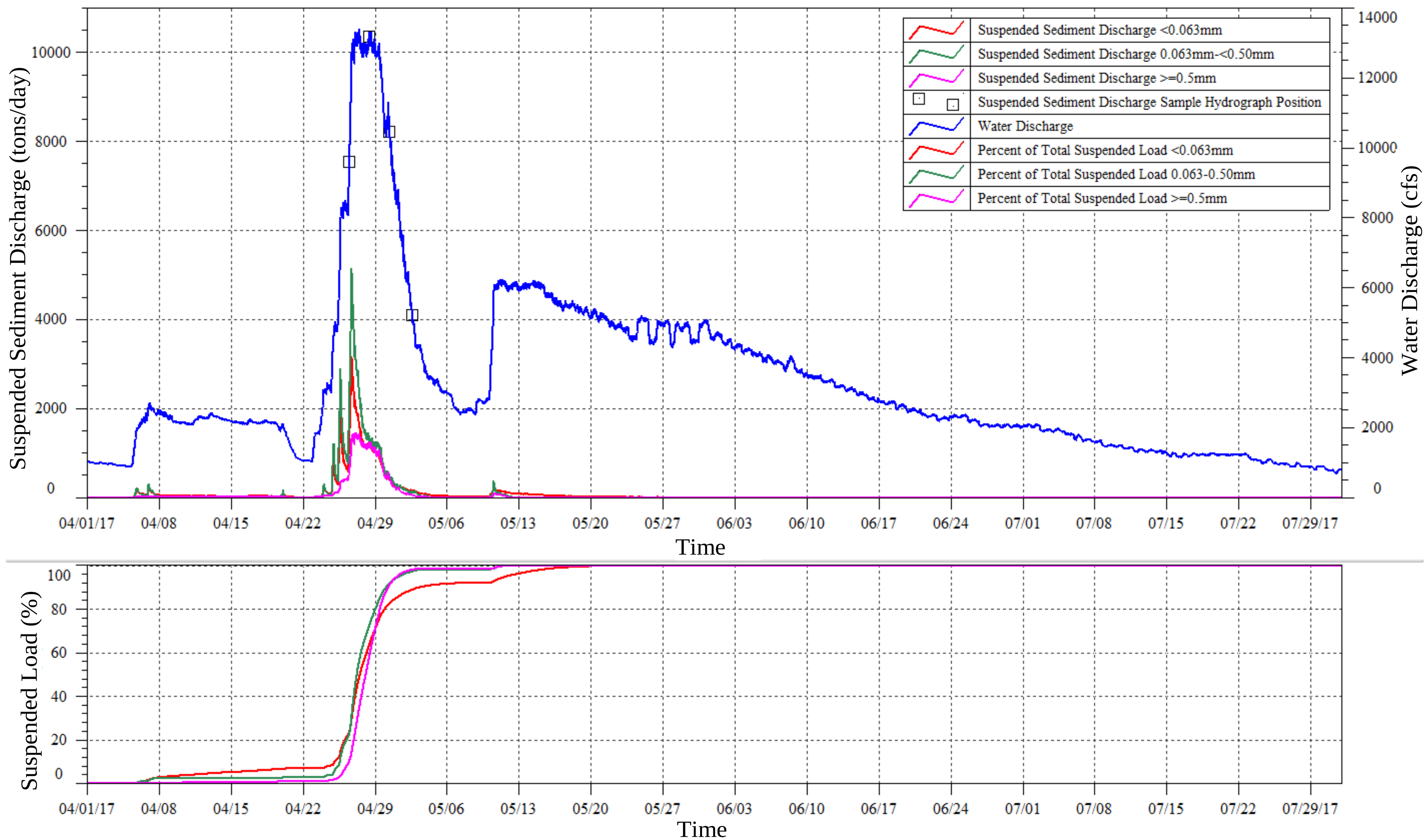
Suspended Sediment Discharge – Spring Flow Release WY 2017



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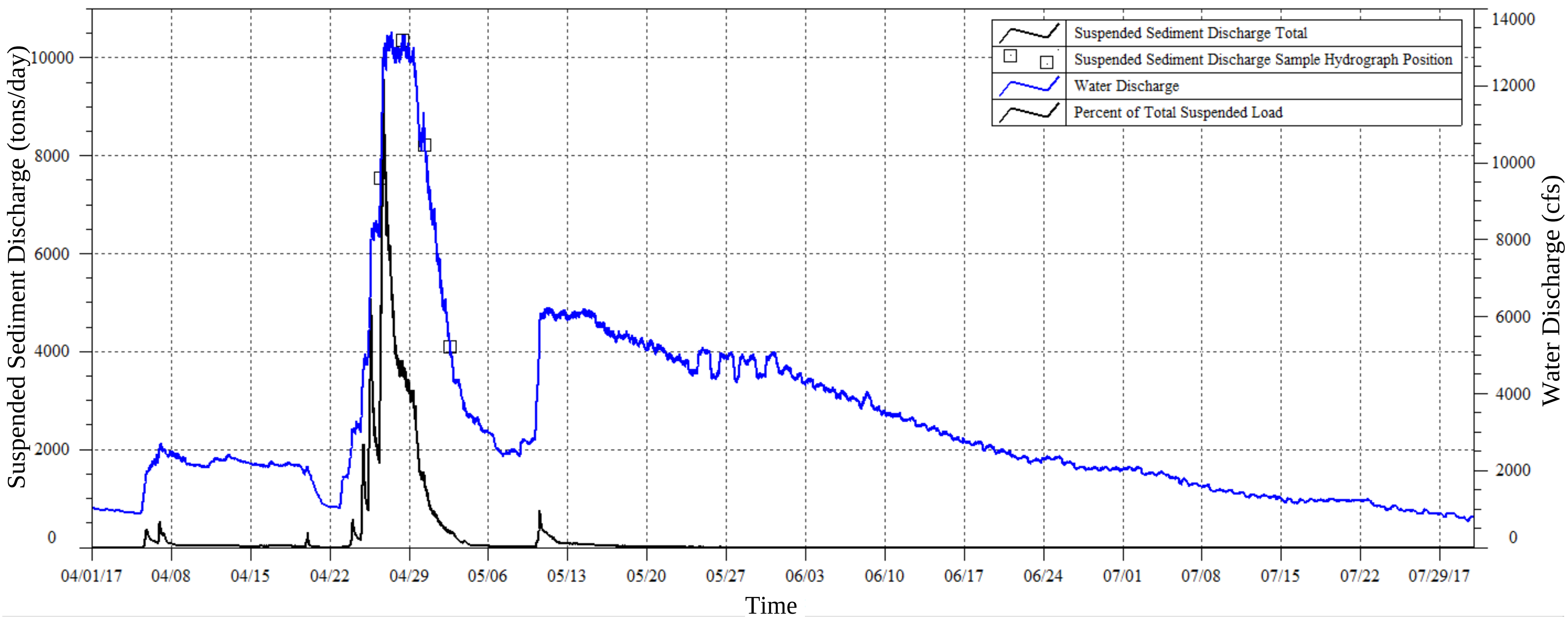
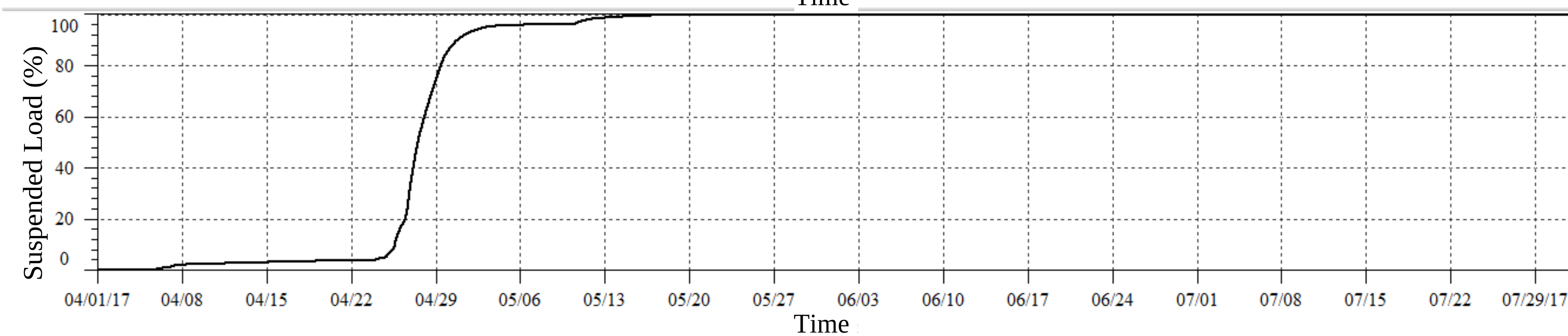
TRINITY RIVER AT DOUGLAS CITY –115525854

Suspended Sediment Discharge – Spring Flow Release WY 2017





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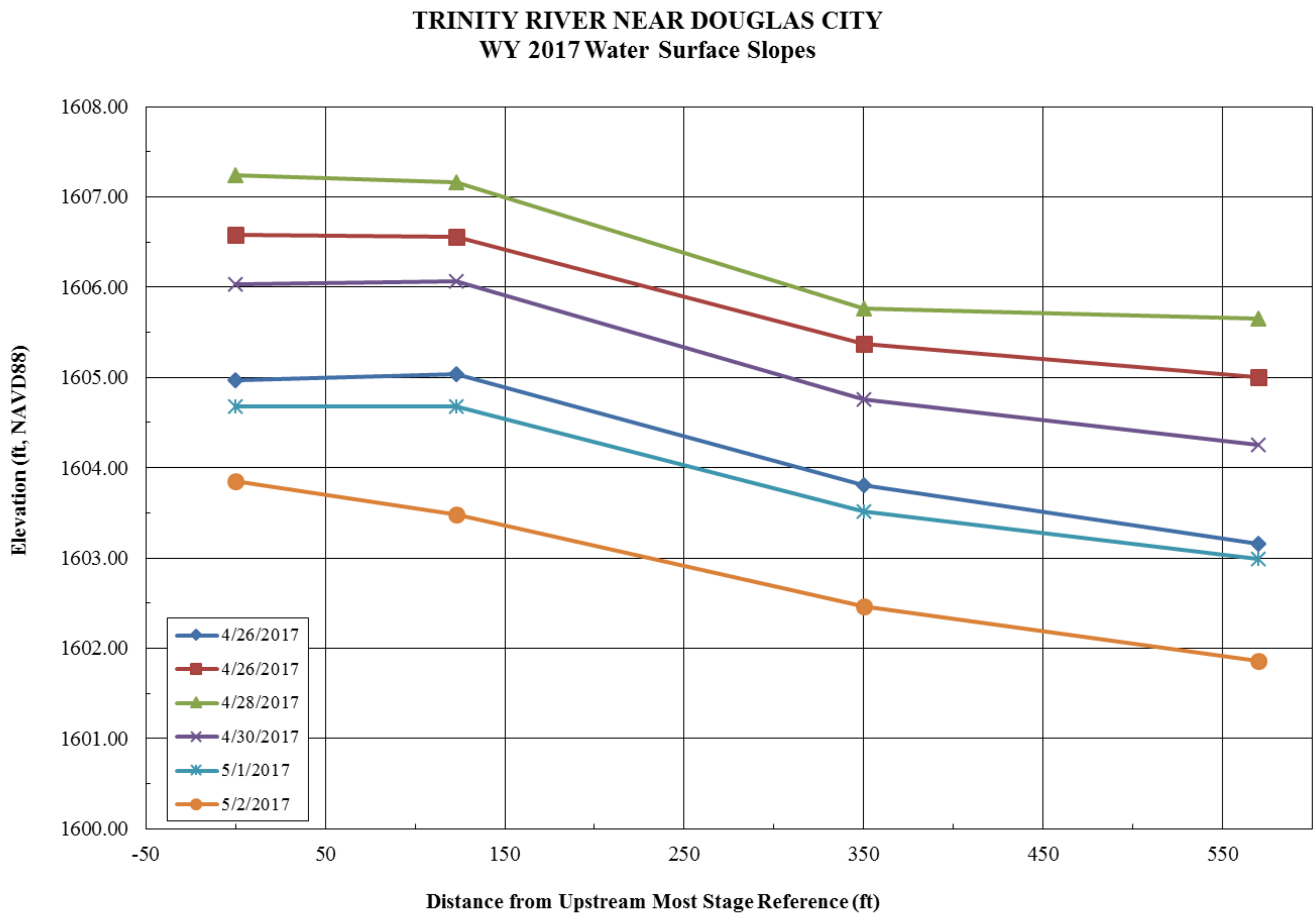

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