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## Summary of Water Year 2017 precipitation, discharge, and sediment conditions at selected locations in Arroyo de la Laguna watershed, with a focus on Arroyo Mocho

Prepared by  
Sarah Pearce and Lester McKee  
San Francisco Estuary Institute

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## Executive Summary

This report summarizes the precipitation, discharge, and sediment conditions observed from October 1, 2016 to September 30, 2017 (Water Year (WY) 2017) in the Arroyo de la Laguna watershed, with a focus on the Arroyo Mocho watershed. This information was collected by the Zone 7 Water Agency to support operation and maintenance of their flood control facilities. Additionally, this and similar information collected in WY 2018 and 2019 will be utilized to update the Arroyo Mocho watershed sediment budget during 2020.

Water Year 2017 was a very wet year, with the Livermore Municipal Airport receiving 184% of the mean annual precipitation. Precipitation was delivered in 20 total storms, with four of those storms causing significant flows within the channel network. Data from five gauge station locations are summarized: Arroyo Las Positas at Livermore (ALP), Arroyo Mocho at Livermore (Hagemann) (AMH), Arroyo Mocho near Pleasanton (AMP), Alamo Canal near Pleasanton (ACNP), and Arroyo de la Laguna at Verona (ADLL).

## Introduction

This report summarizes the precipitation, discharge, and sediment conditions observed from October 1, 2016 to September 30<sup>th</sup>, 2017 (Water Year (WY) 2017) in the Arroyo de la Laguna watershed, with a focus on the Arroyo Mocho watershed. This information was collected by the Zone 7 Water Agency to support operation and maintenance of their flood control facilities. Additionally, this and similar information collected in WY 2018 and 2019 will be utilized to update the sediment budget that was constructed by SFEI staff in 2015 (Pearce et al., 2015). Each of the pertinent datasets are being stored by SFEI, in preparation for the future sediment budget update.

## Precipitation

Overall, WY 2017 was a wet year, with higher than average annual precipitation totals reported at stations in the East and South Bay. Daily precipitation data were collected from six stations in the Tri-Valley area (Las Trampas, Danville Library, Dublin Fire Station, Pleasanton, Livermore Airport, and Altamont) (Table 1). In addition, the average for WY 2011-2015 (the reporting period for the sediment budget) are shown; WY 2017 was much wetter than the drought period that marked the sediment budget reporting period. Based upon a mean annual precipitation of 13.95 inches at the Livermore Municipal Airport, WY 2017 had 184% of the mean annual precipitation. A nearby gauge also in Livermore, with a record spanning 1903 to 2012 has a reported mean annual precipitation of 14.18 inches (<https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4997>); thus the precipitation reported at Livermore Municipal Airport would be 181% of mean annual precipitation.

**Table 1.** Rainfall (inches) at selected gauging locations within the vicinity of Zone 7 facilities. Stations in the table are generally organized northwest to southeast.

	Las Trampas <sup>1</sup>	Danville Library <sup>2</sup>	Dublin Fire Station <sup>2</sup>	Pleasanton 1.8 SSE CA US <sup>3</sup>	Livermore Municipal Airport CA US <sup>3</sup>	Altamont <sup>1</sup>
WY 2017	24.59 ***	42.07	27.33	24.57	25.68	16.33
Average of WY 2011 – WY 2015	22.0	20.0	12.1	12.3	11.4	7.9
Mean Annual Precipitation	26.8 <sup>a</sup>	23.29 <sup>c</sup>	15.18 <sup>c</sup>	15.75 <sup>c</sup>	13.95 <sup>d</sup>	10.2 <sup>b</sup>
WY17 as a Percent of Mean Annual Precipitation	91.8% ***	181%	180%	156%	184%	160%

1 Source: RAWs; website <http://www.raws.dri.edu/wraws/ccaF.html>

2 Source: CDEC; website [http://cdec.water.ca.gov/snow\\_rain.html](http://cdec.water.ca.gov/snow_rain.html)

3 Source: NOAA; website <http://gis.ncdc.noaa.gov/map/viewer/#app=cdo>

<sup>a</sup> Average based upon data from 1995-2017 for years with complete data

<sup>b</sup> Average based upon data from 2010 to 2017 for years with complete data

<sup>c</sup> Average based upon data from 2009 to 2017

<sup>d</sup> Average based upon data from 1999 to 2017

\*\*\* Data is missing for a significant portion of December 2016 and January 2017. This location likely received about 12-18 additional inches of rain that is not recorded in this data.

## Discharge

Due to the higher than average precipitation totals, discharge in streams across the Zone 7 service area was also higher than normal. Discharge was measured at five locations within the Arroyo de la Laguna watershed (Table 2). Zone 7 operated the flow gages in cooperation with the USGS at four of the locations: Arroyo Las Positas at Livermore (ALP), Arroyo Mocho at Livermore (Hagemann) (AMH), Arroyo Mocho near Pleasanton (AMP), and Alamo Canal near Pleasanton (ACNP). Stage and discharge were recorded at each station. Ryan Gromer (Zone 7) collected and QA'ed the flow records at the four stations. In addition to these four stations, the USGS operated the downstream station at Arroyo de la Laguna at Verona (ADLL). Hydrographs from each station are shown in Figure 1.

ALP- Has 15 minute records from 10/1/16 to 6/9/17. The peak discharge occurred on 2/20/17 at 20:45, recording a discharge of 2,636 cfs and a corrected gage height of 6.700 ft.

AMH- Has 15 minute records from 10/1/16 to 5/1/17. The peak discharge occurred on 2/21/17 at 00:15, recording a discharge of 1,471 cfs and a corrected gage height of 10.20 ft.

AMP- Has 15 minute records from 10/1/16 to 6/1/17. The peak discharge occurred on 2/20/17 at 21:00, recording a discharge of 5,625 cfs and a corrected gage height of 12.715 ft.

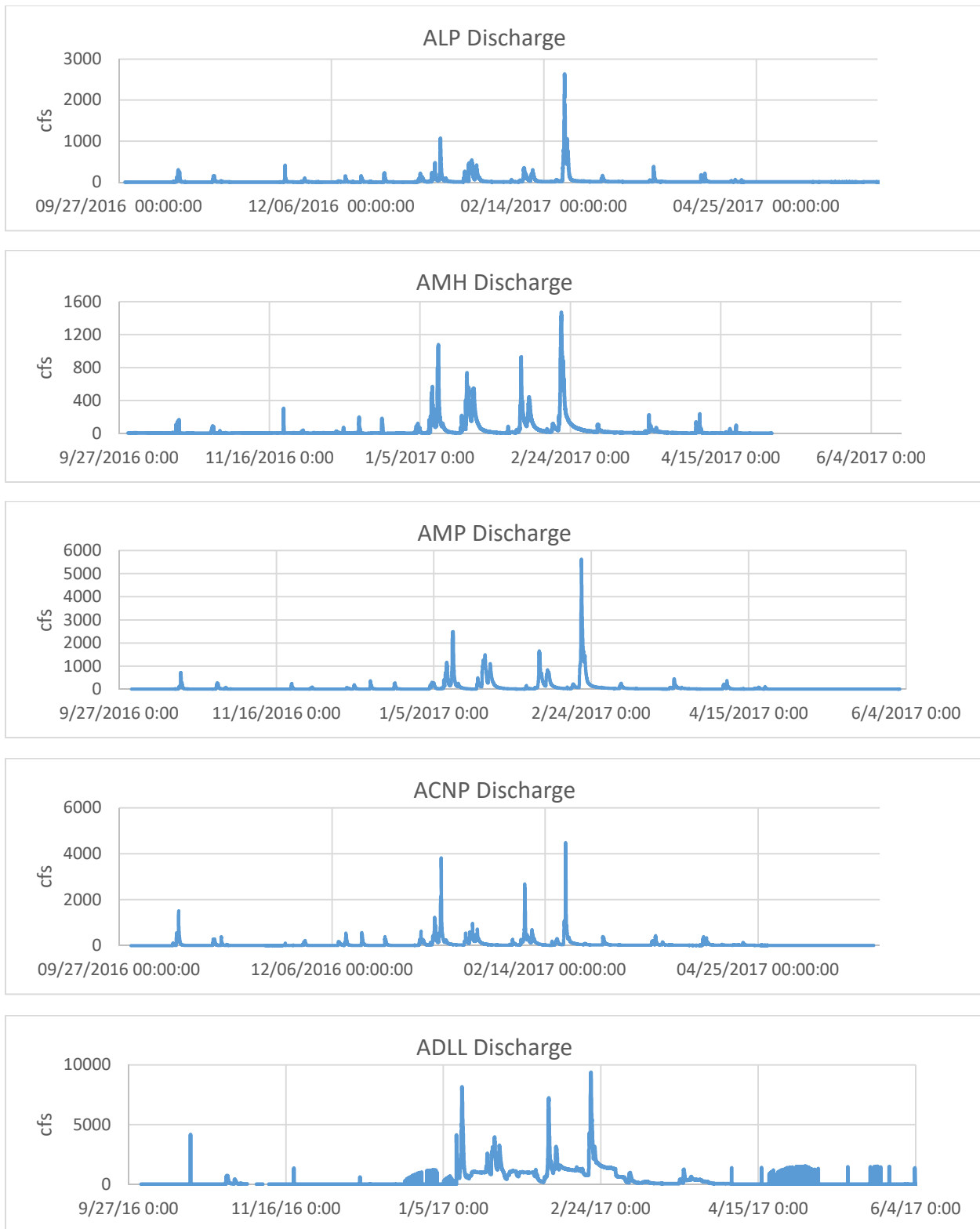
ACNP- Has 15 minute records from 10/1/16 to 9/30/17. The peak discharge occurred on 2/20/17 at 18:30, recording a discharge of 4,480 cfs and a gage height of 14.79 ft.

ADLL- Has 15 minute records from 10/1/16 to 9/30/17. The peak discharge occurred on 2/20/17 at 19:52, recording a discharge of 9,390 cfs and a gage height of 18.36 ft.

These records reveal that 4 major storms occurred during WY17, but in total 20 storms occurred, including the much smaller events that caused smaller flows in the channel. In looking at the ADLL gage, WY 2017 was the largest peak flow recorded at the current gage location (WY 2005-2017), followed by WY 2006 with a New Year's Eve storm peak discharge of 8,960 cfs. However, if we include records from the previous gage location (USGS 11177000 Arroyo De La Laguna near Pleasanton), the peak flow of WY 2017 becomes the third largest in the post-dam era, following WY 1982 and 1983. For the larger Alameda Creek watershed, the Alameda Creek at Niles gage (USGS 11179000) recorded WY 2017 as the second largest peak discharge (17,700 cfs) in the post-dam era, only 200 cfs smaller than WY 1998.

**Table 2.** Gage station locations where discharge was measured.

Name	Code	Latitude	Longitude	Datum	USGS gage number
Arroyo Las Positas at Livermore	ALP	37°41'59"	-121°46'21"	NAD 27	11176145
Arroyo Mocho at Livermore (Hagemann)	AMH	37°40'37"	-121°48'48"	NAD 27	11176090
Arroyo Mocho near Pleasanton	AMP	37°41'26"	-121°52'20"	NAD 27	11176200
Alamo Canal near Pleasanton	ACNP	37°41'40"	-121°55'10"	NAD 83	11174600
Arroyo de la Laguna at Verona	ADLL	37°37'36"	-121°52'55"	NAD 27	11176900



**Figure 1.** Discharge records for: (first) Arroyo Las Positas at Livermore (ALP); (second) Arroyo Mocho at Livermore (Hagemann) (AMH); (third) Arroyo Mocho near Pleasanton (AMP); (fourth) Alamo Canal near Pleasanton (ACNP); and (fifth) Arroyo De La Laguna at Verona (ADLL).

## Sediment

Sediment data was collected by both Zone 7 staff and USGS staff at the four upstream gage stations, and only by USGS staff at ADLL. At three of the four upstream stations, Zone 7 staff were responsible for the installation and maintenance of the turbidity probe and the ISCO automatic samplers; no turbidity probe or ISCO was installed at Alamo Canal during WY 17. Samples collected by the ISCO were taken to the Zone 7 laboratories and the entire sample volume was filtered and analyzed for suspended sediment concentration (SSC). Note, that the lab erroneously labeled the analysis as TSS, but the lab manager was able to confirm that the analyses were actually SSC (Pony Yim, personal communication). During the wet season, USGS staff also periodically collected SSC samples to support the wet season estimates of suspended sediment discharge.

The Zone 7 data includes a continuous turbidity record and a number of SSC samples (Table 3). From this data, a relationship between turbidity and SSC can be plotted and compared to previous year's data (Figure 2). At the AMH and AMP sites, the turbidity probe maxed out, and thus these SSC samples will be vital for estimating turbidity values beyond the probe's capability. Without paired turbidity and SSC samples, sediment estimates would not be able to be made during these critical time periods.

**Table 3.** Turbidity and SSC samples collected by Zone 7.

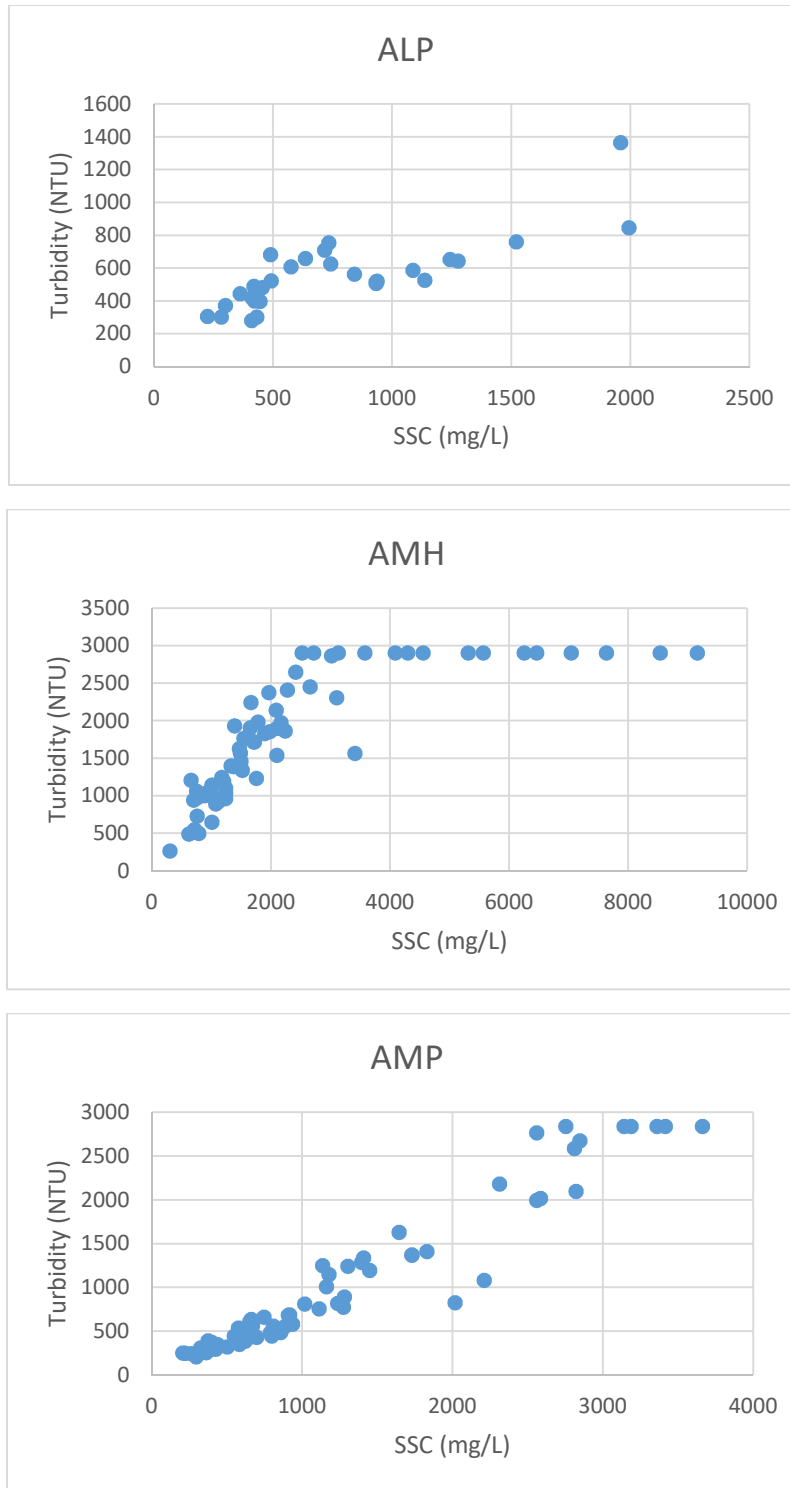
Station	Turbidity start	Turbidity end	Number of SSC samples
ALP	10/27/16	7/11/17	29
AMH	10/28/16	6/8/17	66
AMP	10/26/16	6/2/17	64

ALP- Has a 5 minute turbidity data record from 10/27/16 to 7/11/17. The peak turbidity was measured on 2/20/17 at 21:55 with a value of 2,783 NTU.

AMH- Has a 5 minute turbidity data record from 10/28/16 to 2/21/17, and 15 minute turbidity data record from 2/21/17 to 6/8/17. The turbidity sensor maxed out at a value of 2,903 NTU, and recorded this value for multiple time steps on 1/11/17, 1/20/17, 2/7/17, 2/20/17, 2/21/17, and a single time step on 5/11/17 and 5/27/17. These last two values are likely erroneous.

AMP- Has a 5 minute turbidity data record from 10/26/16 to 2/21/17, and 15 minute turbidity data record from 2/21/17 to 6/2/17. The turbidity sensor maxed out at a value of 2,840 NTU, and recorded this value for multiple time steps on 1/10/17, 1/11/17, 2/7/17, 2/20/17, and 2/21/17.

Turbidity was not measured at ACNP during WY 2017.



**Figure 2.** WY 17 relationship between Suspended Sediment Concentration (SSC) (mg/L) and Turbidity (NTU). The point where the turbidity probe maxes out (where data becomes a horizontal line) is visible on the AMH and AMP graphs. During the period when the turbidity sensor was exceeded, the SSC samples will allow for estimates of sediment load during that period.



It is important to remember that if this continuous turbidity record will be used in estimating annual sediment load calculations in the future, it must be “despiked”, as we know that spikes can occur for many reasons (e.g. probe out of water, algae growth on the lens, etc). These records have not yet been “despiked”, following the protocol taught by Rand Eads in the training for SFEI and Zone 7 staff in 2015.

The USGS also collected sediment data at all five stations, namely occasional manually collected SSC samples (Table 4). From these samples, an estimate of daily suspended sediment concentration (based upon the relationship with discharge) was created, allowing for an estimate of daily suspended sediment discharge. Next, the daily suspended sediment discharge values can be summed to estimate the wet season total suspended sediment load. Note, units are in tons, not in metric tonnes. Due to contracting issues, the season estimates begin on December 1<sup>st</sup>, rather than October 1<sup>st</sup>.

The USGS does not use the turbidity record to assist in estimating load; turbidity data is only used to assist in timing. Also, the USGS did look at the Zone 7 SSC data, but does not publish that data. And finally, in addition to suspended sediment samples, the ALP location had four bedload samples, however no estimate of season total bedload was produced due to the low number of samples.

**Table 4.** USGS SSC samples and total wet season suspended sediment load.

Station	Dates	Total number of SSC samples	Samples collected during February 20/21 <sup>st</sup>	Total estimated suspended sediment load (tons)
ALP	12/1/16 to 4/30/17	19	0	10,365
AMH	12/1/16 to 4/30/17	4	0	33,011
AMP	12/1/16 to 4/30/17	6	0	59,583
ACNP	12/1/16 to 4/30/17	4	0	26,196
ADLL	10/1/16 to 4/30/17	257	21	315,283*

\*ADLL full Water Year estimate is 318,088 tons

The USGS gage station Arroyo De La Laguna at Verona (ADLL) (USGS station 11176900) estimated daily suspended sediment load using discharge and SSC samples for both the wet season (reported here) and the entire Water Year. A total of 257 suspended sediment concentration samples were collected by USGS staff, including 21 during the January 20/21<sup>st</sup> high flow event. No bedload samples were collected at this station. Although there was a turbidity probe installed, it was damaged during high flows and has significant time periods missing. The turbidity record was intended to assist with the timing, rather than providing a turbidity surrogate method for calculating sediment load (Anthony Guerriero, personal communication). The turbidity record was not QA’ed by USGS staff, and thus is not available. The load reported for WY 2017 (315,283 US tons) is the largest recorded for the period of record (WY 2000-2003 at 11177000 ADLL near Pleasanton and WY 2007-2017 at 11176900 (ADLL at Verona).

## Summary Statistics

The pertinent information for WY17 data collection is summarized below in Table 5. This data, along with summaries following WYs 2018 and 2019, will be used by SFEI at the conclusion of WY 2019 to update the sediment budget for the Arroyo Mocho watershed.

**Table 5.** Summary statistics for WY17.

	ALP	AMH	AMP	ACNP	ADLL
Peak discharge (cfs)	2,636	1,471	5,625	4,480	9,390
Peak gage height (ft)	6.700	10.20	12.715	14.79	18.36
Total annual discharge (acre-feet)	13,002	15,658	36,310	30,477	160,643
Peak turbidity (NTU)	2,783	2,903 maxed out sensor	2,840 maxed out sensor	No probe	Incomplete record
Number of storms	20, 10 with discharge >300 cfs	20, 8 with discharge >300 cfs	20, 8 with discharge >500 cfs	20, 12 with discharge >500 cfs	Many, 4 with discharge >=4000 cfs
Zone 7 Period of sediment measurement	10/27/16 to 7/11/17	10/28/16 to 6/8/17	10/26/16 to 6/2/17	None	None
USGS Period of sediment measurement	10/1/16 to 4/30/17	10/1/16 to 4/30/17	10/1/16 to 4/30/17	10/1/16 to 4/30/17	10/1/16 to 4/30/17
Number of Zone 7 SSC samples	29	66	64	0	0
Number of USGS SSC samples	19	4	6	4	257
Number of bedload samples	4; no bedload estimate produced	0	0	0	0
Sample characteristics	Post storm, falling limb	Post storm, falling limb	Post storm, falling limb	Post storm, falling limb	Mostly low Q, but one sample at 3000 cfs
Total Suspended Sediment load estimate (tons)	10,365 suspended only, wet season	33,011 suspended only, wet season	59,583 suspended only, wet season	26,196 suspended only, wet season	315,283 tons, suspended only, wet season

## References

Pearce, S.A., Gilbreath, A.N., and McKee, L.J., 2015. Sediment supply, deposition and transport in the Flood Control Facilities of Arroyo Mocho and Arroyo Las Positas from 2006-2014. A technical report prepared for the Zone 7 Water Agency by the Watersheds Focus Area of the Clean Water Program, San Francisco Estuary Institute, Richmond CA. Contribution No. 771.

<https://www.sfei.org/documents/sediment-supply-deposition-and-transport-flood-control-facilities-arroyo-mocho-and-arroyo>