Annual Stormwater Monitoring Report

Water Year 2020

Prepared by

Tahoe Resource Conservation District

for the

Implementers' Monitoring Program

component of the

Regional Stormwater Monitoring Program

Submitted to the
Lahontan Regional Water Quality Control Board and the
Nevada Division of Environmental Protection

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Annual Stormwater Monitoring Report

Implementers' Monitoring Program (IMP), component of the Regional Stormwater Monitoring Program (RSWMP)

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Submitted by:

California

El Dorado County

Placer County

City of South Lake Tahoe

California Department of Transportation

Nevada

Douglas County

Washoe County

Nevada Department of Transportation

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List of Acronyms

AC	Autosampler Composite Sample
Autosamplers	ISCO brand automated samplers
BMP	Best Management Practice
cf	cubic feet
cfs	cubic feet per second
CI	Contech MFS Inflow
CICU	Commercial, Industrial, Communications, Utilities
CMP	Corrugated Metal Pipe
CPP	Corrugated Plastic Pipe
CO	Contech MFS Outflow
CPC	Characteristic Pollutant Concentration
CRC	Characteristic Runoff Concentration
DMS	Data Management System
EC	Elks Club
EDCY	El Dorado County Yard meteorological station
EMC	Event Mean Concentration
FB	Field Blank
FIG	Framework and Implementation Guidance document for RSWMP
FSP	Fine Sediment Particles
GS	Grab Sample
IMP	Implementers' Monitoring Program
JI	Jellyfish Inflow
JO	Jellyfish Outflow
Lahontan	Lahontan Regional Water Quality Control Board
LS	Lakeshore
MS	Manual Sample
NDEP	Nevada Division of Environmental Protection
NDOT	Nevada Department of Transportation
NPDES	National Pollutant Discharge Elimination System
NTU	Nephlometric Turbidity Units
PD	Pasadena
PI	Pasadena Inflow
PO	Pasadena Outflow
PLRM	Pollutant Load Reduction Model
PSD	Particle Size Distribution
QAPP	Quality Assurance Project Plan
QAQC	Quality Assurance, Quality Control
ROW	Right-of-Way
RSWMP	Regional Stormwater Monitoring Program
SAP	Sampling and Analysis Protocol
SB	Speedboat
SR	State Route 431
TA	Tahoma
Tahoe RCD	Tahoe Resource Conservation District

TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
TV	Tahoe Valley
USDA	United States Department of Agriculture
UT	Upper Truckee
WY	Water Year

1. Monitoring Purpose

Stormwater monitoring began in 2013 under the Implementers' Monitoring Program (IMP) to collectively fulfill California National Pollutant Discharge Elimination System (NPDES) Permit requirements and Nevada Interlocal Agreement commitments. IMP is a partnership between the California and Nevada implementing jurisdictions and was inspired by permit language that encouraged jurisdictions to comply collaboratively with regulatory requirements to promote cost savings through economies of scale. IMP is a partnership between the City of South Lake Tahoe, El Dorado County, Placer County, the California Department of Transportation (Caltrans), Douglas County, Washoe County, and the Nevada Department of Transportation (NDOT). Regulations require that California and Nevada jurisdictions in the Lake Tahoe Basin take measures to decrease pollutant loading from stormwater runoff in urbanized areas by implementing pollutant controls to decrease fine sediment particles (FSP, particles less than 16 microns) and nutrient inputs to Lake Tahoe. The Regional Stormwater Monitoring Program (RSWMP) was developed by Tahoe Resource Conservation District (Tahoe RCD) in partnership with IMP in 2015. A new NPDES permit was issued to California jurisdictions on March 9, 2017 for the second five-year term and aligned all monitoring activities with the 2017 update of the RSWMP Framework and Implementation Guidance Document (FIG, Tahoe RCD et al 2017). In the second permit term (water years 2017-2021), California jurisdictions are collectively required to monitor urban catchment outfalls at a minimum of six sites and Best Management Practices (BMPs) at a minimum of two sites for flow volumes and pollutant loads. The renewed Nevada Interlocal Agreements require participation in IMP. Monitoring provides empirical data that will be used to assess nutrient and sediment loading in chosen catchments and evaluate BMP effectiveness at chosen BMPs.

All data has been collected in a manner consistent with RSWMP monitoring protocols outlined in the RSWMP FIG designed to provide consistent data collection, management, analysis, and reporting approaches so that results can easily align with RSWMP objectives. Data collected for permit and agreement compliance initiate efforts to satisfy RSWMP's primary objective of establishing sites around the Lake Tahoe Basin for long-term stormwater monitoring. Long-term data are useful in identifying status and trends in the watershed.

2. Study Design

During Water Year 2020 (WY20), nine catchments (monitoring sites) were monitored for continuous flow and sampled for water quality at twelve monitoring stations. The monitoring stations include seven catchment outfall monitoring sites (seven catchments - seven stations), one BMP monitoring site at the outfall of the Elks Club catchment (one catchment - one station), and one BMP monitoring site at SR431, a side-by-side BMP study that monitors the inflows and outflows of two BMPs (one catchment - four stations). This exceeds the minimum regulatory requirement of six monitored catchment outfalls and two monitored BMPs in the second term. At the August 2020 IMP meeting, it was agreed that all seven outfalls would continue to be monitored during WY20 to support continuity of data. The two side-by-side BMPs at SR431 are supported through additional funding from the Nevada Department of Transportation. The catchments were chosen because of their direct hydrologic connectivity to Lake Tahoe, diversity of urban land uses, range of sizes, and a reasonably equitable distribution among the participating jurisdictions. BMP effectiveness sites were selected because of their potential efficacy in treating storm water runoff characteristic of the Lake Tahoe Basin, the broad interest in data regarding the efficiency of the selected BMPs in reducing runoff volumes and pollutant loads (especially FSP), and the importance of determining maintenance intervals required to retain effectiveness. Eight meteorological stations, located within one mile of the monitoring site, are monitored for precipitation and temperature. One of the meteorological stations is shared by two monitoring sites. See Figure 1 for stormwater monitoring sites and meteorological station locations.

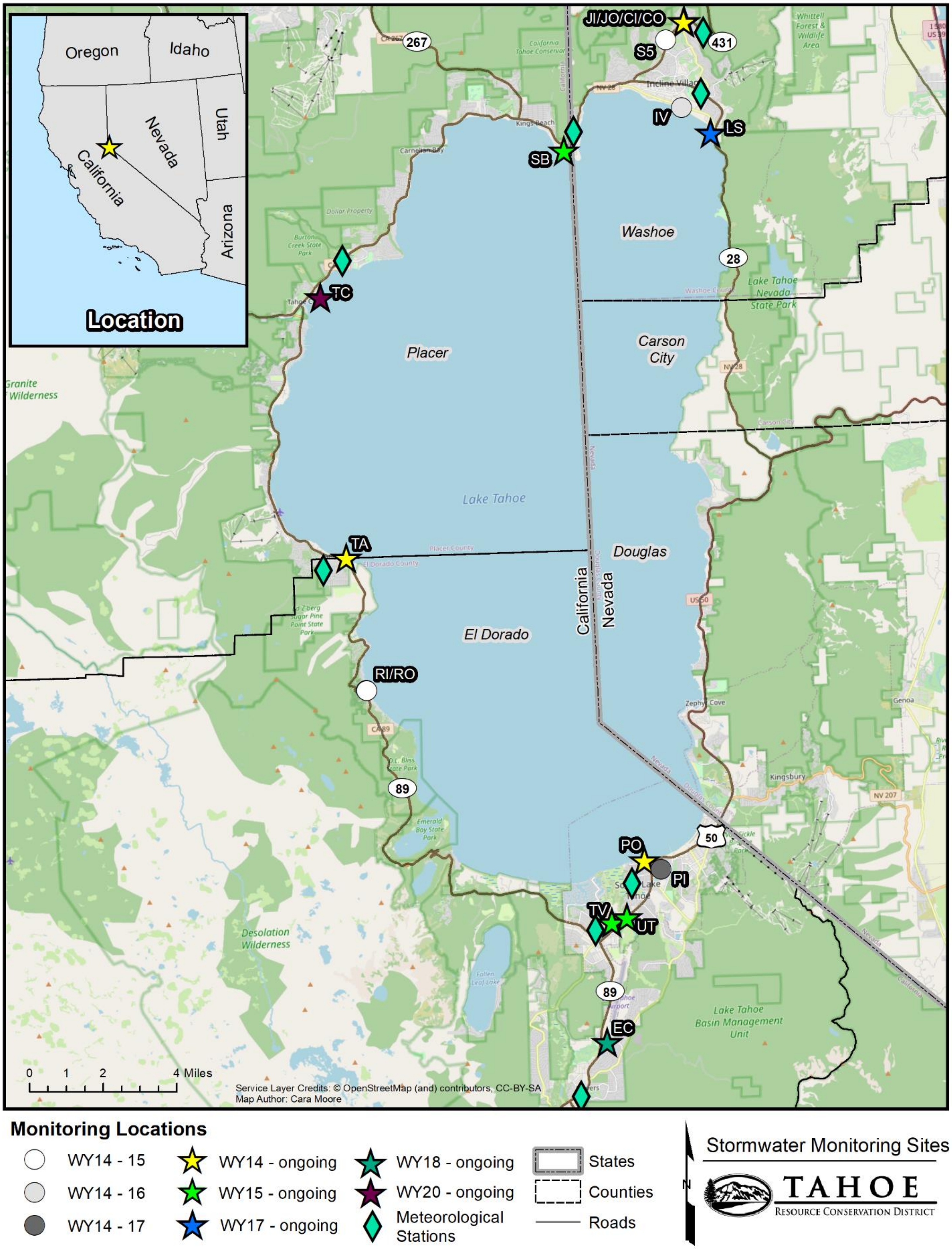

Figure 1 Past and current stormwater monitoring sites and ongoing meteorological stations. Jellyfish Inflow (JI), Jellyfish Outflow (JO), Contech MFS Inflow (CI), Contech MFS Outflow (CO), SR431 outfall (S5), Incline Village (IV), Lakeshore (LS), Speedboat (SB), Tahoma (TA), Rubicon Inflow (RI), Rubicon Outflow (RO), Tahoe City (TC), Tahoe Valley (TV), Upper Truckee (UT), Pasadena Inflow (PI), Pasadena Outflow (PO), and Elks Club (EC).

Table 1 summarizes the selected catchments and their corresponding designation as a catchment outfall monitoring site and/or BMP effectiveness monitoring site. Also included are the number of monitoring stations in the catchment, jurisdiction, total catchment area, percent impervious area, and dominant land uses in each catchment.

Table 1 Monitoring site specifics. Dominant urban land use is highlighted in dark pink, second most dominant in medium pink, and the third most dominant in light pink. The vegetated class was not considered in this ranking. SR431 has two checkmarks under BMP because there are two different cartridge filters at this site.

Catchment Name	Outfall	BMP	# Monitoring Stations	Jurisdiction	Total Acres	Impervious Area	Landuse: Single Family Residential	Multi-Family Residential	CICU*	Primary Roads	Secondary Roads	Vegetated
SR431		√√	4	NDOT	1.4	89%	0%	0%	0%	89%	0%	11%
Elks Club		√	1	El Dorado	14.4	29%	50%	0%	0%	9%	19%	22%
Lakeshore	√		1	Washoe	97.8	41%	2%	43%	31%	1%	10%	13%
Pasadena	√		1	CSLT	78.8	39%	52%	13%	5%	0%	16%	14%
Speedboat	√		1	Placer	29.0	30%	49%	3%	9%	4%	10%	25%
Tahoe City	√		1	Placer, Caltrans	4.4	62%	12%	10%	23%	49%	0%	6%
Tahoe Valley	√		1	CSLT, Caltrans	338.4	39%	19%	12%	20%	2%	13%	34%
Tahoma	√		1	Placer, El Dorado, Caltrans	49.5	30%	41%	4%	12%	3%	15%	25%
Upper Truckee	√		1	CSLT, Caltrans	10.5	72%	14%	7%	39%	14%	18%	8%

*Commercial, Industrial, Communications, Utilities

2.1 SR431 Catchment Description

The SR431 monitoring site is located on State Route 431 in Washoe County above Incline Village, Nevada. The 1.4-acre catchment encompasses NDOT right-of-way (ROW) of which approximately 89% is impervious. During winter months, when snow and ice may occasionally block stormwater infrastructure (like drop inlets) this catchment area may increase, though this is difficult to verify. This is the smallest catchment monitored and the outfall discharges directly into a perennial stream called Deer Creek which connects with Incline Creek and discharges into Lake Tahoe, giving this site the distinction of being directly connected to the lake despite being 2.5 miles away. SR431 was monitored as a catchment outfall site for two years (WY14-15), but is now only monitored for evaluating and comparing the effectiveness of two adjacent stormwater cartridge filter vaults, the Contech MFS and the Jellyfish, containing different types of cartridge filters (WY14 - ongoing). There are four monitoring stations at SR431: the inflow and outflow to the Contech MFS vault (CI, CO), and the inflow and outflow to the Jellyfish vault (JI, JO). Though located in a rural area with moderate highway traffic density, SR431 is the only site that isolates runoff from primary roads and can therefore be used to characterize runoff from one land use type. In addition, SR431 is the only site currently available where a true side-by-side comparison of stormwater cartridge filter types can be performed.

Runoff enters a transverse drain across a parking pull-out directly adjacent to SR431. It then flows through a pipe to a splitter chamber that should theoretically route equal amounts of flow through two inflow pipes, one to the Contech MFS inflow flume and then to the Contech MFS vault, and one to the Jellyfish inflow flume and then to the Jellyfish vault. This splitter chamber gets filled with accumulated sediment very quickly and without proper, consistent maintenance the volume often does not get split evenly. After the runoff has been treated in each vault, the flow exits the vaults through respective pipes that lead either to the Contech MFS outflow flume or the Jellyfish outflow flume and then to Deer Creek.

2.2 Elks Club Catchment Description

The Elks Club monitoring site is located on the northwest corner of Elks Club Drive and Bel Aire Circle in El Dorado County. It is monitored as a catchment outfall and a BMP at one monitoring station (EC). At 14.4 acres, it is a relatively small catchment comprised primarily of single family residential and secondary road land uses. Elks Club Drive is a fairly steep road that serves as the primary access road for this neighborhood. Runoff is channelized along the north side of the road and routed directly to the monitoring location adjacent to the roadside.

Prior to the summer of 2018, Elks Club Drive was in poor condition, covered in cracks and potholes. Visual observations and a pilot study on Pioneer Trail in El Dorado County from 2012-2014 suggested that the degraded road surface itself was contributing a substantial amount of fine sediment to stormwater runoff. The Elks Club monitoring site was established to determine if improving road condition would result in decreased FSP loads in stormwater runoff from this catchment. In the summer of 2018, El Dorado County completed an erosion control project in this catchment that included completely reconstructing Elks Club Drive and armoring the road shoulders and roadside channels with asphalt and rocks. A repaved road is more durable and less likely to deteriorate under the heavy equipment and plow blades used for snow removal operations. The smooth surface is easier to sweep and therefore more road abrasives can be recovered. New roads also look nicer and provide a better driving experience. The primary purpose of this monitoring site is to conduct pre- and post-project monitoring and perform source apportionment analyses on runoff samples to determine what portion of the fine sediment originates from native soil (road shoulder erosion), traction abrasives (road sand), and asphalt plus asphalt binder (the road itself).

Post project data collected at Elks Club indicates that repaving a road contributes to improved water quality (less sediment). Improved pavement condition should be recognized as a water quality BMP, not only to garner credits for the Lake Tahoe TMDL Clarity Crediting Program but also to potentially open up water quality improvement funds for road maintenance and vice versa. New roads would be beneficial for public safety, vehicle maintenance costs, aesthetic appeal, driving pleasure, road maintenance and sweeping operations, long term durability, snow removal operations, stormwater quality, and lake clarity.

2.3 Lakeshore Catchment Description

The Lakeshore monitoring site is located in the roadside channel on the northern side of Lakeshore Blvd., near Third Creek, replacing the old Incline Village site. It is monitored as a catchment outfall at one monitoring station (LS). At 97.8 acres, this is the second largest catchment monitored and includes runoff from Washoe County and NDOT jurisdictions. The catchment drains a relatively steep, highly urbanized area of Incline Village with dominant urban land uses consisting of moderate to high density residential, commercial, and secondary roads. Forty-one percent of the catchment area is impervious and there is a lack of any intervening natural dispersion and infiltration areas due to steep slopes and high-density development. Runoff discharges into Third Creek which discharges into Lake Tahoe.

As part of the Central Incline Village Phase II Water Quality Improvement Project, constructed during the summer of 2015, substantial improvements were made in the catchment upstream of the monitoring site. New infiltration features that reduce roadway runoff in the catchment include: (1) a series of three upstream infiltration basins that receive 1.8 cfs of low flow from the pipe network, (2) two small roadside infiltration pools, and (3) 450 linear feet of roadside infiltration channels. A Jellyfish cartridge filter similar to the one installed at SR431 (see section 2.1) was also installed downstream of the new infiltration features. A Vortechnics treatment vault routes low flow through the Jellyfish to be discharged to the lake through a 30-inch corrugated metal pipe (CMP) that passes through the old Incline Village monitoring site. High flows are routed through the roadside channel to the new Lakeshore monitoring site. The drainage area for this outfall is similar to the old

Incline Village catchment but receives additional flow from Lakeshore Blvd. east of Village Blvd as well as some overland flow originating upslope of Lakeshore Blvd.

2.4 Pasadena Catchment Description

The Pasadena monitoring site is located at the northernmost end of Pasadena Ave in the City of South Lake Tahoe (City). It was monitored as a catchment outfall and BMP effectiveness site beginning WY14. Beginning WY18 it was monitored as a catchment outfall only as inflow monitoring was suspended. A 36-inch outfall CMP emerging from the side of the steep slope at the end of Pasadena Avenue conveys runoff directly to Lake Tahoe. The pipe is the terminus of a 78.8-acre catchment designated the "G12" urban planning catchment by the City. The dominant land uses are moderate density single-family residential, multi-family residential and secondary roads. Thirty-nine percent of the catchment is impervious. In addition to the upstream permeable and porous road shoulders and perforated storm drain pipes, a pre-treatment Vortechnics storm vault and two Contech Stormfilter cartridge filter vaults were installed in parallel at the end of the catchment before discharge to the lake through the 36-inch CMP. Prior to WY14 monitoring, one of the Contech Stormfilters was not receiving any flow due to a missing orifice plate and the filter cartridges were therefore clean. The cartridges in the other Contech Stormfilter were replaced at the same time the missing orifice plate was installed (September 30, 2013). BMP RAM results and manufacturer's inspection method indicate that replacing the filters again is not yet necessary as of WY20. This may be due, in part, to the fact that City has been sweeping streets and vactoring sediment traps annually to maintain the whole system. Pasadena Inflow (PI) was a monitoring station located at the inflow to the pre-treatment Vortechnics vault and two Stormfilter cartridge filter vaults (below the in-situ infiltration BMPs), and Pasadena Outflow (PO) is located in the 36-inch outfall CMP, the outflow from the pre-treatment vault and two Stormfilter cartridge filter vaults.

2.5 Speedboat Catchment Description

The Speedboat monitoring site is located midway along the western side of Speedboat Avenue just south of Dip Street in Kings Beach, California. The 29.0-acre catchment is monitored as a catchment outfall at a single monitoring station (SB). It receives co-mingled runoff from Placer County and Caltrans jurisdictions delivered by a 12-inch CMP. The catchment is comprised of thirty percent impervious surfaces and drains a steep area that is characterized predominately by single family residences, vegetation, and secondary road land uses. After passing through a Palmer-Bowlus flume at the monitoring station, runoff from the catchment drains untreated through a series of CMPs along a pedestrian footpath at the intersection of Lake Street and Harbor Avenue directly to Lake Tahoe.

This site was monitored from 2003 to 2012 by the University of California, Davis, Tahoe Environmental Research Center (UCD TERC) and the Desert Research Institute (DRI). Data collected from this site was included in the initial Total Maximum Daily Load (TMDL) study that ultimately populated the Pollutant Load Reduction Model (PLRM) used to estimate pollutant loading from urban catchments.

2.6 Tahoe City Catchment Description

The Tahoe City monitoring station is located at the outflow from a Delaware Sandfilter installed by Caltrans along highway 28, half a mile to the east of the Tahoe City commercial corridor. The 4.4-acre catchment is monitored as a catchment outfall at a single monitoring station (TC). The catchment is 62% impervious and dominant land uses include primary roads, CICU, and single-family residential. Curb and gutter along highway 28 direct flow to the Sandfilter. The outflow from the Sandfilter enters a small, shallow infiltration basin before discharging into Lake Tahoe. The Sandfilter was installed in approximately 2015 to reduce concentrations of fine sediment in stormwater runoff from a section of highway 28.

Monitoring at this site began WY20, not to assess the effectiveness of the Sandfilter, only to track the quality of the stormwater after treatment and before discharge to Lake Tahoe.

2.7 Tahoe Valley Catchment Description

The Tahoe Valley monitoring site is located on the eastern side of Tahoe Keys Boulevard just north of the intersection with Sky Meadows Court in South Lake Tahoe, California near the entrance to the Sky Meadows Condominium Complex. With an area of 338.4 acres, this is the largest catchment monitored. It is a relatively flat, highly urbanized catchment consisting primarily of commercial/industrial/communications/utilities (CICU), single family residences, secondary roads, and vegetation land uses. Thirty-nine percent of the catchment is impervious. This site is monitored as a catchment outfall at a single monitoring site (TV). Runoff to the site is delivered by a 36-inch "squashed" CMP from the City of South Lake Tahoe jurisdiction. After passing by the TV monitoring station, runoff is conveyed through a vegetated swale along the northwest edge of the Sky Meadows Condominium Complex directly to the Upper Truckee River and eventually to Lake Tahoe.

Many water quality improvement projects have been implemented in this catchment in the last 25+ years. The existing Helen Basin and almost 3,200 linear feet of vegetated swales were built as part of the Tahoe Valley Erosion Control Project (ECP) in 1989 to increase stormwater infiltration upstream of the current monitoring site. This area was maintained under a contract with the California Conservation Corps in 2014 and included removing sediment that was blocking pipes, excess vegetation in the basin and swales, drug paraphernalia, empty liquor bottles, and human waste. Additionally, Caltrans completed the $12 Million US Highway 50 water quality improvement project in 2012 which included curb, gutter, rock-lined swales, infiltration chambers and basins along Highways 50 and 89 to address highway runoff in the catchment. Lastly, to ensure high infiltration rates, the City of South Lake Tahoe removed accumulated sediment, excess vegetation, and trash in the Caltrans swales upstream of Tahoe Keys Boulevard near Council Rock Road and behind the storage units on Eloise in May and June of 2015, also under a contract with the California Conservation Corps. Nearby homeless camps littered with trash, human waste, empty liquor bottles, and used needles were also removed.

2.8 Tahoma Catchment Description

Tahoma is monitored as a catchment outfall at one monitoring station (TA). The 49.5-acre catchment straddles the Placer County/El Dorado County border and comingles runoff from both jurisdictions, plus waters from the Caltrans maintained Highway 89. The land uses in this catchment are primarily moderate density residential and secondary roads in the Tahoe Cedars subdivision, but also include some CICU and primary roads. Thirty percent of the catchment area is impervious. The runoff from this catchment discharges directly into Lake Tahoe via a 36-inch oval "squashed" CMP at the bottom of the Water's Edge North condominium complex driveway without infiltration or treatment. Because of the high direct connectivity between the catchment and Lake Tahoe, this storm drain system has great potential to deliver high FSP loads to the lake.

A water quality improvement project completed in the fall of 2014 installed nine sediment traps to decrease flow rates and capture coarse sediment, one new drop inlet to more effectively capture and route flow, and more than 80 feet of perforated infiltration pipe to decrease runoff volumes to the catchment outflow.

2.9 Upper Truckee Catchment Description

The Upper Truckee monitoring site is located on the eastern bank of the Upper Truckee River at the intersection of Highway 50 and River Drive a short distance upstream of the bridge on Highway 50 that crosses the Upper Truckee River in the City of South Lake Tahoe, California. The 10.5-acre catchment drains a highly urbanized area which is primarily composed of CICU, primary and secondary roads, and single-family residences. This is the second smallest catchment monitored, but with a high percentage of impervious coverage (72%) it receives relatively high volumes of co-mingled runoff from the City of South Lake Tahoe and Caltrans jurisdictions. The site is monitored as a catchment outfall site at a single location (UT).

Improvements were made in this catchment by the City of South Lake Tahoe in the summer of 2015 that included an 8,100 cubic foot infiltration gallery, 394 linear feet of perforated pipe and infiltration trenches, seven sediment traps/dry wells, and 3,340 linear feet of stabilized road shoulders. Runoff originating from City streets flows through these treatments, and discharges through a corrugated plastic pipe (CPP) to a small rock-lined basin installed by Caltrans in 2019. However, since the majority of runoff in this catchment originates from Highway 50, under Caltrans' jurisdiction, volume and pollutant reductions attributable to the improvements made by the City are hard to detect.

In the summer of 2019 Caltrans completed installation of a large underground concrete vault (dimensions: 54' long x 11'7" wide x 10' deep) that captures and treats Caltrans Highway 50 runoff only. A 6' wall about halfway down the 54' chamber separates it into 2 parts (total volume capacity 3,753 cubic feet). The first half is for settling out the larger particles. Once the water reaches a depth of 6' it spills over the wall into the second half which contains a sand filter to filter out FSP. It then goes over a weir and out the same CPP used by City runoff described above. The pipe discharges into the small rock-lined basin installed by Caltrans which overflows onto an unarmored slope that leads directly to the Upper Truckee River and eventually to Lake Tahoe. The vault was designed to be large enough to capture the estimated amount of flow that could enter the vault in any given storm. This site offers the unique opportunity to monitor pre and post project conditions. Rainfall normalized annual FSP load for WY20 is lower than any previous pre-project year (see section 8.9). However, one year of post project data is not enough state conclusively that this is due to treatment of Highway 50 runoff in the vault.

3. Data Collection Methods, Sampling Protocols, Analytic Methods

Continuous hydrology and stormwater samples are collected using ISCO brand automated samplers (autosamplers) per RSWMP protocols (RSWMP FIG 2015 section 10.2.1, Tahoe RCD et al 2017) at all twelve monitoring stations in WY20 to support seasonal [fall/winter (October 1-February 28), spring (March 1-May 31), and summer (June 1-September 30)] volume and load reporting. Autosamplers were installed and sites maintained according to protocols outlined in the RSWMP FIG sections 10.1.2.2 and 10.2.1.3 respectively. Continuous turbidity was collected at all sites with an FTS DTS-12 turbidimeter. Turbidimeters were installed and maintained as outlined in the RSWMP FIG sections 10.2.2.1 and 10.2.2.2. Equations that relate turbidity to FSP concentration have been developed specifically for the Tahoe Basin and were applied to estimate FSP loads (2NDNATURE et al 2014). Continuous meteorological data is recorded using a Davis Instruments Vantage Pro weather station or weather station equipment sold by Campbell Scientific. The weather stations are installed at eight locations in the vicinity of the nine monitored catchments and maintained following recommendations in the RSWMP FIG sections 10.2.3.1 and 10.2.3.2. All weather stations are maintained by Tahoe RCD, with the exception of Shakori, which is maintained by El Dorado County. Meteorological data is used to calculate seasonal and annual precipitation totals (RSWMP FIG section 10.2.3.5) and to estimate the amount of flow that can be expected in a particular catchment for a particular amount of precipitation to aid with autosampler programming for event-based sampling (RSWMP FIG section 10.2.1.4).

Continuous data (flow, turbidity, and meteorology) are logged at a constant time interval, generally every 5 minutes. Flow and turbidity data are QAQC'd with frequent stage and turbidity field measurements to ensure that no drift has occurred in the readings and sensors are performing optimally (RSWMP FIG sections 10.2.1.7 and 10.2.2.5). Visual observations are used to confirm when a flume or pipe is dry and stage and turbidity should read zero. Visual observations are also used to determine if ice in the flume or pipe is causing stage errors that need to be adjusted to zero. Visual observations and field measurements are made every two weeks at a minimum but more often during precipitation events. Recalibration of stage measuring equipment is done by adjusting the level measurement on the autosampler. Turbidimeter accuracy was verified on all in-situ turbidimeters with a solution of known turbidity in late September/early October 2016, June 2017, and May/June 2018. Starting in 2019, all turbidimeters are sent into the manufacturer for annual calibration. Tahoe RCD does not have an extra set of turbidimeters for all sites, so it is not possible to send all turbidimeters in for calibration at the same time. To maintain data continuity, turbidimeters were sent in for calibration in batches of 3-5 at a time during the summer and fall of 2019 and the summer and fall of 2020.

Weather is monitored closely and autosamplers are programmed to sample at the beginning of each runoff event in accordance with RSWMP FIG sections 10.2.1.4 and 10.2.1.5. Individual aliquots from single samples are combined into flow-weighted composites (RSWMP FIG section 10.2.1.10) based on their occurrence in the hydrograph. Full event composites and quality control samples are analyzed for total nitrogen (TN) concentration, total phosphorus (TP) concentration, total suspended solid (TSS) concentration, turbidity, and particle size distribution (PSD) to determine fine sediment particle (FSP) concentration at the UC Davis Tahoe Environmental Research Center Laboratory in Incline Village, NV, the UC Davis Laboratory in Davis, CA, or the High Sierra Water Laboratory, Inc. in Oakland, OR. Table 2 summarizes the sample type acronyms and their meaning. Table 3 summarizes the analytical methods and detection limits for all analyses. Raw analytical data for all samples is presented in Appendix A.

Table 2 Sample types and acronyms.

Sample Acronym	Sample Type
AC	**A**uto-sampler **C**omposite, flow-weighted composite of whole or part of hydrograph
FB	**F**ield **B**lank (QA/QC)
GS	**G**rab **S**ample single (QA/QC)
MS	**M**anually triggered auto-**S**ampler single (QA/QC)

Table 3 Analytical methods and detection limits.

Analyte	Methods	Description	Detection Limit	Target Reporting Limit
Total Suspended Solids	EPA 160.2 or SM 2540-D	Gravimetric	0.4 mg/L	1 mg/L
Turbidity	EPA 180.1 or SM 2130-B	Nephelometric	0.05 NTU	0.1 NTU
Total Kjeldahl Nitrogen	EPA 351.1; or EPA 351.2	Colorimetric, block digestion, phenate	40 µg/L	100 µg/L
Nitrate + Nitrite	TERC Low Level Method	Colorimetric, NO3 + NO2 Hydrazine Method, low level	2 µg/L	10 µg/L
Total Nitrogen as N	N/A	Total Kjeldahl Nitrogen + Nitrate + Nitrite	40 µg/L	100 µg/L
Total Phosphorus as P	TERC Low Level Method	Colorimetric, Total Phosphorus, Persulfate digestion, low level	2 µg/L	10 µg/L
Particle Size Distribution	SM 2560 or RSWMP addendum SOP	Laser backscattering	0.5 mg/L	1 mg/L

Sample handling and processing includes proper labeling of samples in the field, transporting samples to a laboratory immediately after collection in a cooler with ice, compositing individual aliquots from single samples on a flow-weighted basis, taking turbidity measurements with a calibrated instrument, shipping to an analytical laboratory with proper chain-of-custody procedures, and filtering samples within the proper holding time. A minimum of 10% of all samples analyzed were QAQC samples to identify any potential problems related to field sampling and sample processing (RSWMP FIG section 10.2.1.6). Analytical data for all QAQC samples is presented in Appendix B.

4. Data Management Procedure

Continuous data series and sample dates and times are collected through the RSWMP Data Management System (DMS) at the time samples are collected, when maintenance is required, or every two weeks during dry periods. All data are input into Excel workbooks for storing continuous parameters and sample dates and times. Any other field measurements and observations are recorded in a field notebook or the ArcGIS Survey123 app and transcribed into Excel workbooks. Samples are transported to a processing lab immediately after collection. The DMS automatically calculates the recipe for compositing individual aliquots from single samples into an event composite for each monitoring station. All composite samples are measured for turbidity using a benchtop turbidimeter (Hach 2100N or TL2300) or a portable turbidimeter (Hach 2100P) and values are recorded on standard data sheets in the laboratory and entered into an Excel workbook for storing nutrient and sediment data. All samples are sent to analytical laboratories within appropriate holding times for TSS, TN, TP, and PSD analysis. For a complete description of holding times for sampled parameters, see the RSWMP Quality Assurance Project Plan (QAPP) (DRI et al 2011a). Results from analytical laboratories are entered into the same Excel workbook for storing nutrient and sediment data. All Excel workbooks are housed on one central server (with backup device) and managed by Tahoe RCD staff. All data management procedures described above follow protocols outlined in the RSWMP FIG section 10.2.1.

5. Catchment Outfall Monitoring

5.1 Summary Data for All Monitoring Sites

A meteorological station at the Tahoe City Dam located in the northwest corner of the lake at an elevation of 6,235 feet is maintained under the Truckee River Operating Agreement (TROA). Per RSWMP protocols, this station is to be used as a reference station to determine if a particular water year is wet, average, or dry (assuming that a wet, average, or dry season in Tahoe City will be the same around the lake). Using an 88-year precipitation record (water years 1933-2020) from this station, WY20, at **20.47 total inches**, falls within the first quartile for this period of record and is therefore designated a very dry year (Table 4, Figure 2). In WY20 approximately 58% of the precipitation fell during the fall/winter season, approximately 39% fell during the spring season, and approximately 3% fell during the summer season.

Table 4 Annual precipitation statistics from the Tahoe City meteorological reference station, water years 1933-2020.

WY 1933-2020	Annual Precipitation (in)	Designation
1st quartile	8.8 - 21.9	very dry
2nd quartile	22.0 - 29.3	dry
Median	29.3	average
3rd quartile	29.4 - 39.5	wet
4th quartile	39.6 - 69.8	very wet

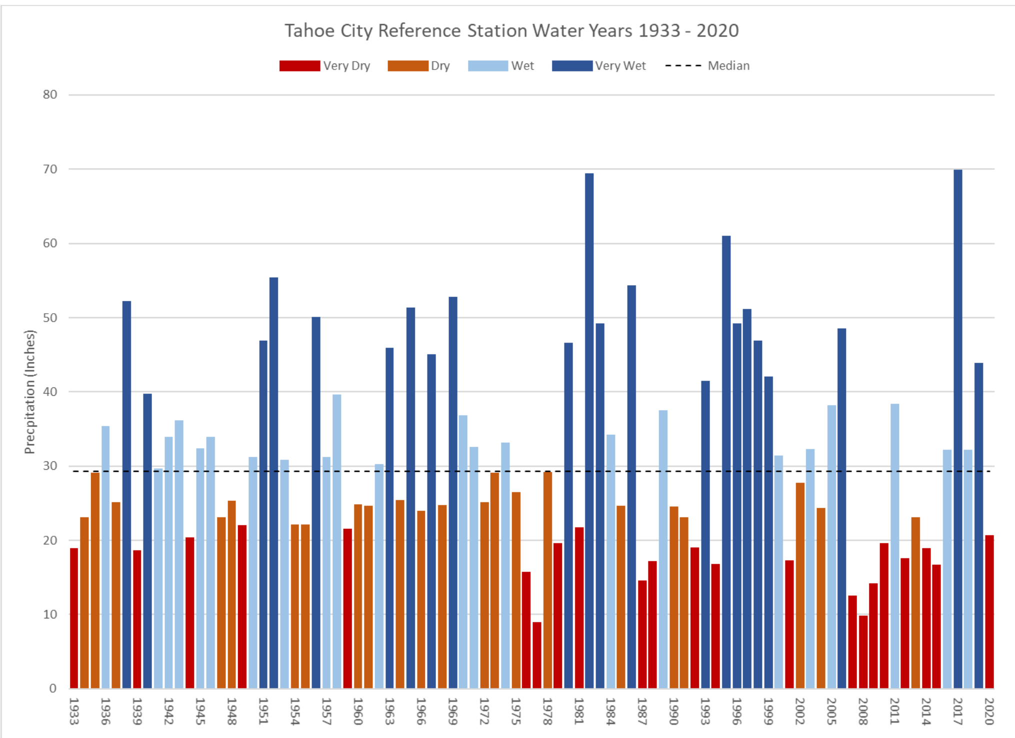

Figure 2 Long-term precipitation record at the Tahoe City meteorological station, water years 1933-2020.

Three primary "seasons" are defined by the NPDES permit; fall/winter (October 1 - February 28), spring (March 1 - May 31), and summer (June 1 - September 30). These are the seasons used by RSWMP and are defined as such to better fit with precipitation patterns and storm event types that occur in the Tahoe Basin. The primary event types in the fall/winter are frontal rain storms, rain on snow, mixed rain/snow, or event snowmelt. An event snowmelt occurs during and shortly after a snow event when enough snow melts (generally on the roads from the heat generated by automobile traffic) to produce runoff at a given monitoring site. Spring event types include the fall/winter event types plus non-event snowmelts. A non-event snowmelt generally occurs in the spring when temperatures are greater than 50 degrees Fahrenheit and accumulated snowpack melts. Most monitoring sites do not receive sufficient spring non-event snowmelt to sample. Summer events are primarily thunderstorms and frontal rain storms.

The intention is to sample 6-12 runoff events per year in each catchment, and this target was met in WY20 for Elks Club, Speedboat, Tahoma, Tahoe City, Tahoe Valley, and Upper Truckee. Because there was very little runoff, it was not possible to sample 6-12 events at Contech MFS Inflow (3 events), Contech MFS Outflow (1 event), Jellyfish MFS Inflow/Outflow (5 events), Lakeshore (0 events), and Pasadena (4 events).

Summary data for all sites are presented in Table 5. Figure 3- Figure 12 illustrate Table 5 in graphical form. Runoff volumes are calculated from instantaneous flow rates (cubic feet per second) taken every 5 minutes by assuming the flow rate was constant for the 5 minute period. FSP loads are calculated from event sampling and estimated from continuous turbidity, and TN and TP loads are calculated from event sampling. As not every runoff event was sampled during the year; the seasonal and annual loads represent an average (volume weighted) load calculation for the respective period based on the events that were sampled in that period. FSP loads estimated from continuous turbidity include all periods of flow, not just those that were sampled. In Figure 3- Figure 12, SR431 is represented by its four sites: Contech MFS Inflow (CI), Contech MFS Outflow (CO), Jellyfish Inflow (JI), and Jellyfish Outflow (JO); Elk's Club is EC, Lakeshore is LS, Pasadena is PO, Speedboat is SB, Tahoe City is TC, Tahoe Valley is TV, Tahoma is TA, and Upper Truckee is UT.

Table 5 Summary statistics for all catchments for WY20. Top table shows seasonal and annual precipitation and runoff volumes; middle table shows seasonal and annual FSP concentrations and loads based on samples and estimated from continuous turbidity; bottom table shows seasonal and annual TN and TP concentrations and loads based on samples.

Water Year 2020 (October 1, 2019 - September 30, 2020)			Seasonal Precipitation (in)			Total Annual Precip (in)	Seasonal Runoff Volumes (cf)			Total Annual Runoff Volumes (cf)
Catchment Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
SR431	Contech In	CI	10.73	5.18	1.71	17.61	677	1,589	1,297	3,563
	Contech Out	CO	10.73	5.18	1.71	17.61	72	14	786	871
	Jellyfish In	JI	10.73	5.18	1.71	17.61	966	1,783	1,329	4,078
	Jellyfish Out	JO	10.73	5.18	1.71	17.61	952	1,760	1,324	4,036
Elk's Club	Elk's Club	EC	7.95	6.50	1.23	15.68	26,109	3,474	1,650	31,233
Lakeshore	Lakeshore	LS	5.46	3.32	0.57	9.35	0	0	0	0
Pasadena	Pasadena Out	PO	5.59	2.64	0.72	8.95	579	0	5,067	5,646
Speedboat	Speedboat	SB	6.61	3.36	0.58	10.55	44,467	3,601	7,149	55,217
Tahoe City	Tahoe City	TC	7.69	5.17	0.27	13.13	37,373	9,882	131	47,386
Tahoe Valley	Tahoe Valley	TV	6.11	5.12	0.56	11.78	419,114	239,953	1,783	660,849
Tahoma	Tahoma	TA	10.70	6.69	0.70	18.08	180,460	85,699	2,525	268,684
Upper Truckee	Upper Truckee	UT	6.11	5.12	0.56	11.78	31,422	27,907	2,064	61,392

Water Year 2020 (October 1, 2019 - September 30, 2020)			Average Seasonal FSP Concentrations (mg/L)			Average Annual FSP Concen-trations (mg/L)	Seasonal FSP Loads (lbs)			Total Annual FSP Loads (lbs)	Average Estimated Seasonal FSP Concentrations (mg/L)			Average Estimated Annual FSP Concen-trations	Seasonal Estimated FSP Loads (lbs)			Total Annual Estimated FSP Loads (lbs)	Seasonal Estimated FSP Loads (#particles)			Total Annual Estimated FSP Loads (#particles)
Catchment Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
SR431	Contech In	CI	1,760	981	587	986	74	97	48	219	309	239	190	235	13	24	15	52	1.43E+15	2.67E+15	1.17E+15	5.27E+15
	Contech Out	CO	na	na	591	533	na	na	29	29	395	147	222	235	2	0.1	11	13	2.04E+14	1.39E+13	8.27E+14	1.04E+15
	Jellyfish In	JI	960	1,419	420	985	58	158	35	251	234	33	178	128	14	4	15	33	1.49E+15	3.40E+14	1.17E+15	3.00E+15
	Jellyfish Out	JO	469	383	40	291	28	42	3	73	292	96	190	173	17	11	16	44	1.91E+15	9.65E+14	1.21E+15	4.09E+15
Elk's Club	Elk's Club	EC	13	14	303	29	22	3	31	56	4	12	153	13	7	3	16	25	5.52E+14	1.86E+14	1.06E+15	1.80E+15
Lakeshore	Lakeshore	LS	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Pasadena	Pasadena Out	PO	8	na	221	199	<1	na	70	70	17	na	206	187	<1	na	65	66	4.68E+13	0.00E+00	4.49E+15	4.53E+15
Speedboat	Speedboat	SB	48	145	714	140	133	33	319	484	509	328	769	531	1,413	74	343	1,830	1.53E+17	7.81E+15	2.91E+16	1.90E+17
Tahoe City	Tahoe City	TC	50	40	<1	47	116	25	na	140	119	155	35	127	278	96	<1	374	2.88E+16	9.17E+15	0.00E+00	3.80E+16
Tahoe Valley	Tahoe Valley	TV	12	9	117	11	319	141	13	473	18	20	214	20	482	302	24	808	3.69E+16	2.23E+16	1.83E+15	6.10E+16
Tahoma	Tahoma	TA	34	45	6	37	381	243	1	624	19	10	5	16	209	55	1	264	1.92E+16	6.31E+15	4.45E+13	2.55E+16
Upper Truckee	Upper Truckee	UT	56	66	107	63	111	116	14	240	131	146	58	135	258	254	7	519	2.34E+16	2.31E+16	5.60E+14	4.70E+16

Water Year 2020 (October 1, 2019 - September 30, 2020)			Average Seasonal TN Concentrations (ug/L)			Average Annual TN Concen-trations (ug/L)	Seasonal TN Loads (lbs)			Total Annual TN Loads (lbs)	Average Seasonal TP Concentrations (ug/L)			Average Annual TP Concen-trations (ug/L)	Seasonal TP Loads (lbs)			Total Annual TP Loads (lbs)
Catchment Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
SR431	Contech In	CI	7,042	5,408	10,660	7,630	0.3	0.5	0.9	1.7	12,031	6,366	4,254	6,674	0.5	0.6	0.3	1.5
	Contech Out	CO	na	na	1,540	1,388	na	na	<0.1	<0.1	na	na	732	660	na	na	<0.1	0.04
	Jellyfish In	JI	4,257	5,576	9,067	6,401	0.3	0.6	0.8	1.6	7,162	8,548	3,183	6,471	0.4	1.0	0.3	1.6
	Jellyfish Out	JO	3,044	2,590	1,778	2,431	0.2	0.3	0.1	0.6	2,873	2,445	362	1,863	0.2	0.3	<0.1	0.5
Elk's Club	Elk's Club	EC	600	528	5,780	865	1.0	0.1	0.6	1.7	185	228	2,252	299	0.3	<0.1	0.2	0.6
Lakeshore	Lakeshore	LS	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Pasadena	Pasadena Out	PO	2,076	na	13,671	12,482	<0.1	na	4.3	4.4	361	na	2,689	2,450	<0.1	na	0.9	0.9
Speedboat	Speedboat	SB	903	1,259	11,872	2,347	2.5	0.3	5.3	8.1	450	909	1,149	571	1.2	0.2	0.5	2.0
Tahoe City	Tahoe City	TC	1,282	1,222	na	1,266	3.0	0.8	na	3.7	564	454	na	539	1.3	0.3	na	1.6
Tahoe Valley	Tahoe Valley	TV	1,115	857	11,228	1,048	29.2	12.8	1.2	43.3	223	131	2,390	196	5.8	2.0	0.3	8.1
Tahoma	Tahoma	TA	781	619	9,429	811	8.8	3.3	1.5	13.6	394	347	722	382	4.4	1.9	0.1	6.4
Upper Truckee	Upper Truckee	UT	1,485	1,680	5,269	1,701	2.9	2.9	0.7	6.5	496	676	872	590	1.0	1.2	0.1	2.3

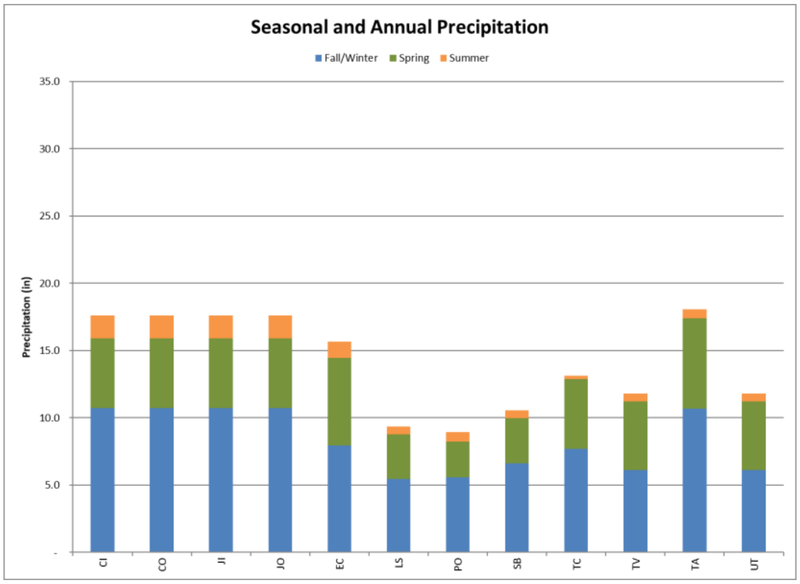

Figure 3 Precipitation totals at each monitoring station, WY20.

Precipitation

- The west shore received the most precipitation (TA).
- The eastern side of the north shore received almost as much precipitation as the west shore (CI, CO, JI, JO).
- The eastern side of south shore (PO) received the least amount of precipitation.
- There are no stations on the east shore.
- All regions of the lake received the greatest amount of precipitation during the fall/winter season and least during the summer.

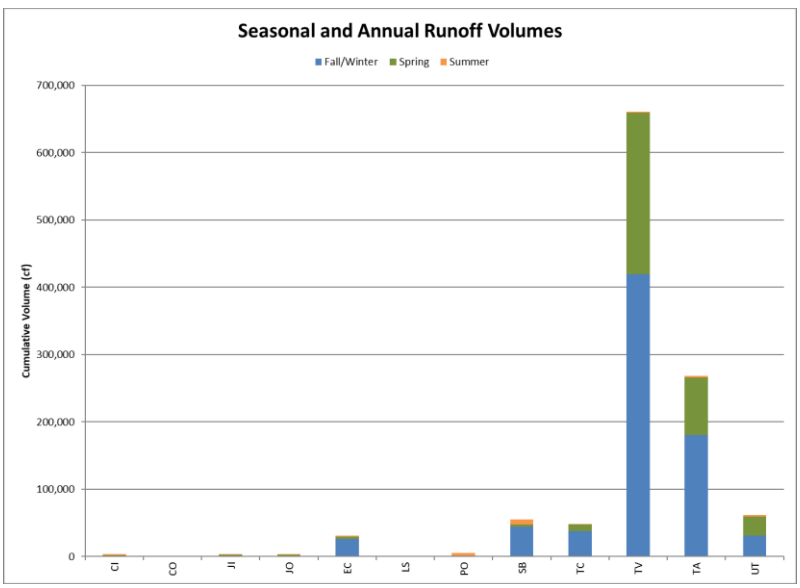

Figure 4 Runoff volumes at each monitoring station, WY20.

Runoff Volumes

- Catchment size influences runoff volume. Tahoe Valley is the largest catchment and had the greatest runoff volume. SR431 is the smallest catchment and had a very small runoff volume.
- Infiltration features influence runoff volume. Though Tahoma is approximately half the size of Lakeshore, its runoff volume is much greater. Lakeshore is downstream of numerous infiltration features and received no runoff in WY20.
- Impervious area influences runoff volumes. Though the Upper Truckee catchment area is about one eighth the size of Pasadena, it has a much greater runoff volume. Upper Truckee is 72% impervious and Pasadena is 39% impervious.
- Precipitation totals influence runoff volumes. All catchments had the most runoff in the fall/winter and the least runoff in the summer, with the exception of Pasadena, which had very little runoff in the fall/winter and the most runoff in the summer due to a large summer thunderstorm event.

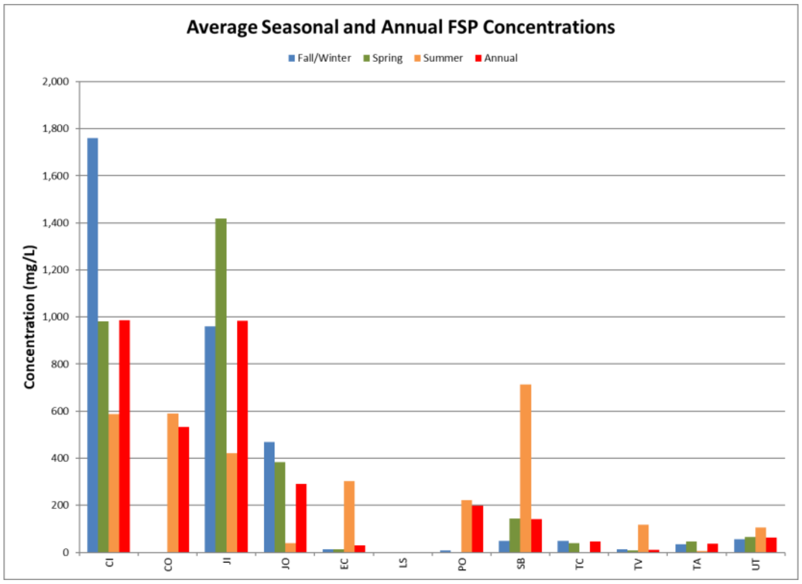

Figure 5 FSP concentrations based on samples at each monitoring station, WY20.

FSP Concentrations Based on Samples

- Average seasonal FSP concentrations were highest in the summer at all sites that received runoff in the summer except for Contech MFS Inflow (CI), Jellyfish Inflow (JI), Jellyfish Outflow (JO), Tahoe City (TC), and Tahoma (TA). Contech MFS outflow (CO) was also highest in the summer, but the only event sampled at this site was in the summer.
- The highest average seasonal FSP concentration was observed during the fall/winter season at the SR431 Contech MFS inflow (CI), during the spring season at the Jellyfish inflow (JI), and during the summer season at Speedboat (SB). All three of these sites are highly influenced by primary road.
- Average annual FSP concentrations were highest at the SR431 inflows (CI, JI).
- Average annual FSP concentrations were lowest at Elks Club (EC), Tahoe City (TC), Tahoe Valley (TV), Tahoma (TA) and Upper Truckee (UT). (Lakeshore (LS) received no flow and therefore FSP concentrations were 0 mg/L.)

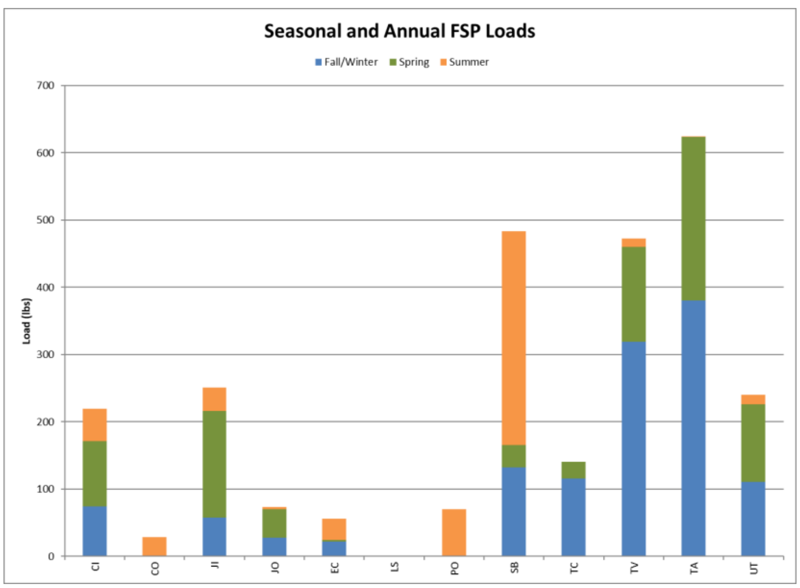

Figure 6 FSP loads at each monitoring station, WY20.

FSP Loads Based on Samples

- Runoff volume has the largest influence on loads. Tahoma and Tahoe Valley contributed the greatest FSP loads to the lake, yet they had one of the lowest average seasonal FSP concentrations.
- Concentrations influence loads. Speedboat summer volumes were very low, but very high summer concentrations resulted in the highest summer load.

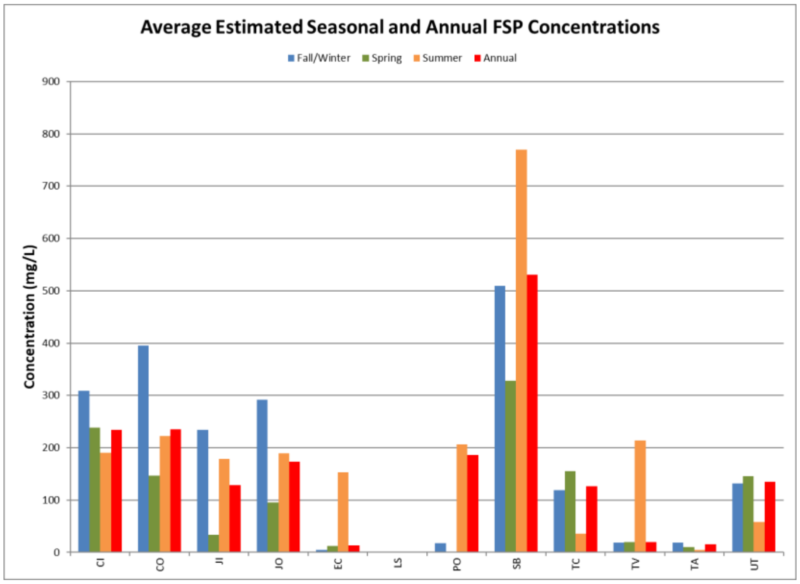

Figure 7 FSP concentrations estimated from turbidity at each monitoring station, WY20.

FSP Concentrations Estimated from Turbidity

- Average estimated seasonal FSP concentrations were highest in the summer at all sites that received runoff in the summer except for SR431 (CI, JI, CO, JO), Tahoe City (TC), Tahoma (TA), and Upper Truckee (UT).
- The highest average estimated seasonal FSP concentration was observed during the summer at Speedboat (SB).
- Average estimated annual FSP concentrations were higher at CO than CI in the fall/winter and summer and higher at JO than JI in all seasons, likely due to sediment accumulation on the turbidimeter.
- Average estimated annual FSP concentrations were highest at Speedboat (SB).
- Average estimated annual FSP concentrations were lowest at Elk's Club (EC), Lakeshore (LS), Tahoe Valley (TV), and Tahoma (TA).

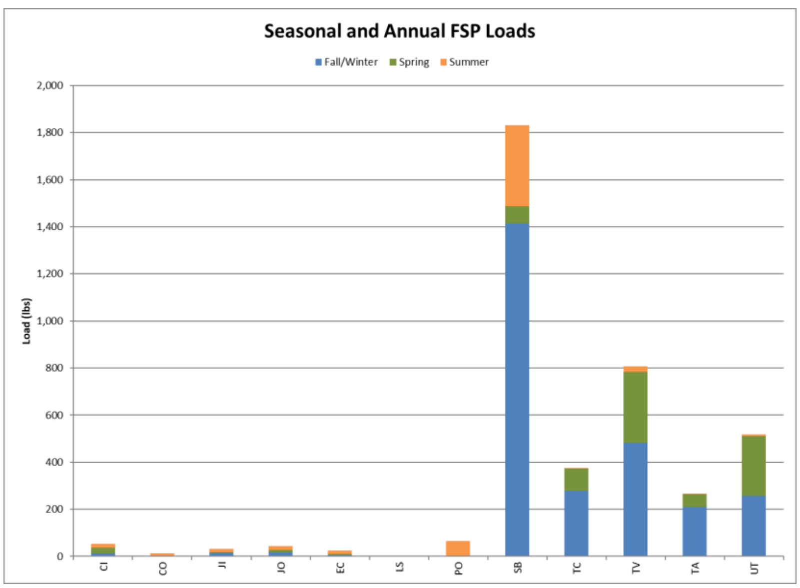

Figure 8 FSP loads at each monitoring station, WY20.

FSP Loads Estimated from Turbidity

- Runoff volume has the largest influence on loads. Tahoe Valley contributed the second highest estimated FSP load to the lake, yet it had one of the lowest estimated average seasonal FSP concentrations in all seasons.
- Concentrations influence loads. Speedboat had the third highest flows, but the largest estimated concentrations and therefore the largest estimated loads.

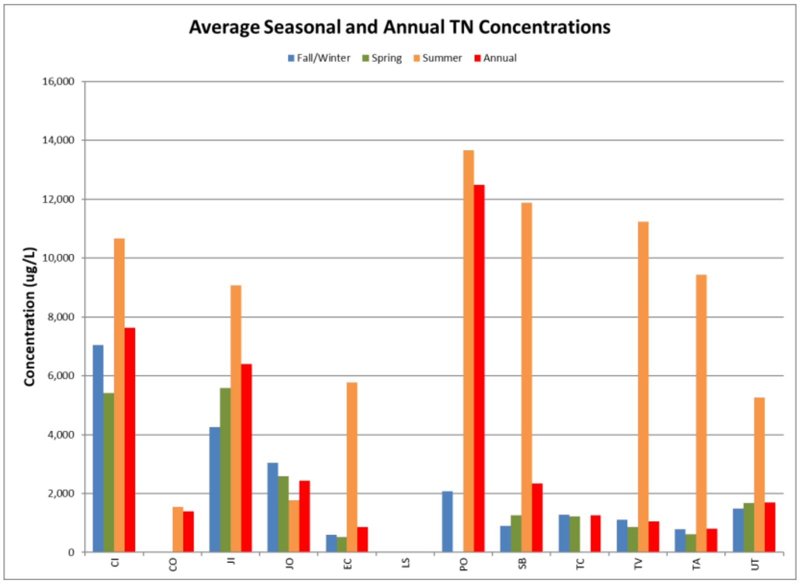

Figure 9 TN concentrations at each monitoring station, WY20.

TN Concentrations

- Average seasonal TN concentrations were substantially higher in the summer than any other season at all sites that were sampled during the summer except JO.
- The highest average seasonal TN concentration was observed during the summer at Pasadena.
- Average annual TN concentrations were highest at Pasadena (PO) and SR431 inflows (CI, JI).
- Average annual TN concentrations were lowest at Elk's Club (EC) and Tahoma (TA). (Lakeshore (LS) received no flow and therefore TN concentrations were 0 mg/L.)

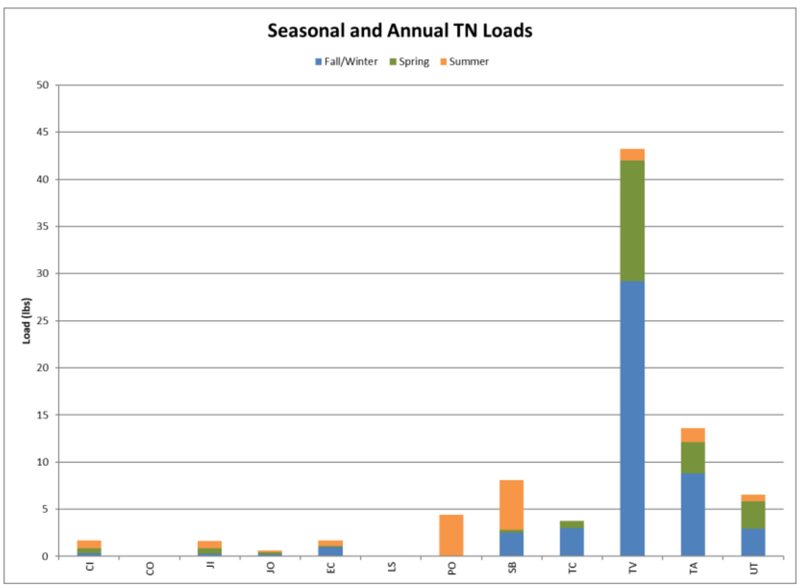

Figure 10 TN loads at each monitoring station, WY20.

TN Loads

- Runoff volume has the largest influence on loads. Tahoe Valley contributed substantially more TN to the lake than any other site, yet it had average seasonal TN concentrations similar to other sites in all seasons.
- Concentrations influence loads. Though runoff volumes are universally low in the summer, high average seasonal TN concentrations resulted in proportionally higher summer TN loads at Pasadena and Speedboat.

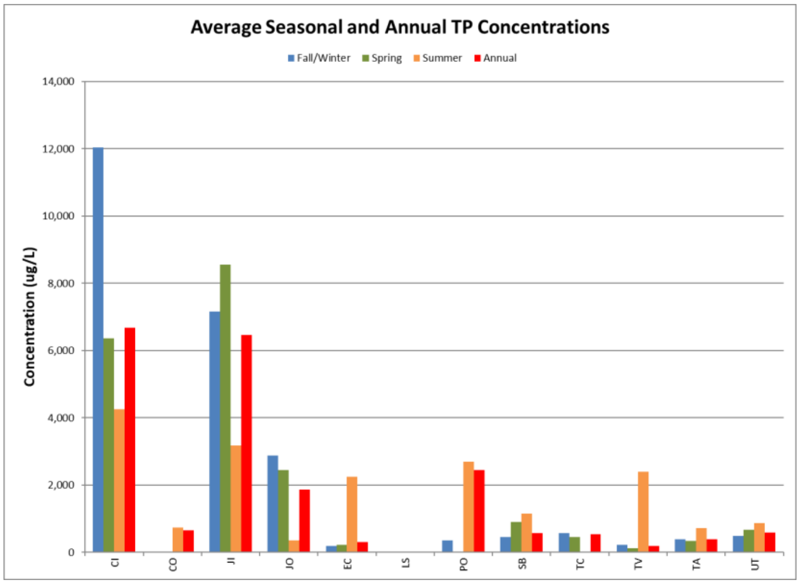

Figure 11 TP concentrations at each monitoring station, WY20.

TP Concentrations

- Average seasonal TP concentrations were highest in the summer at all sites that received runoff except SR431 at CI, JI, and JO. Tahoe City (TC) was not sampled in the summer.
- The highest average seasonal TP concentration was observed during the fall/winter at CI.
- Average annual TP concentrations were highest at SR431 inflows (CI, JI).
- Average annual TP concentrations were lowest at Elks Club (EC), Tahoe Valley (TV), and Tahoma (TA). (Lakeshore (LS) received no flow and therefore TP concentrations were 0 mg/L.)

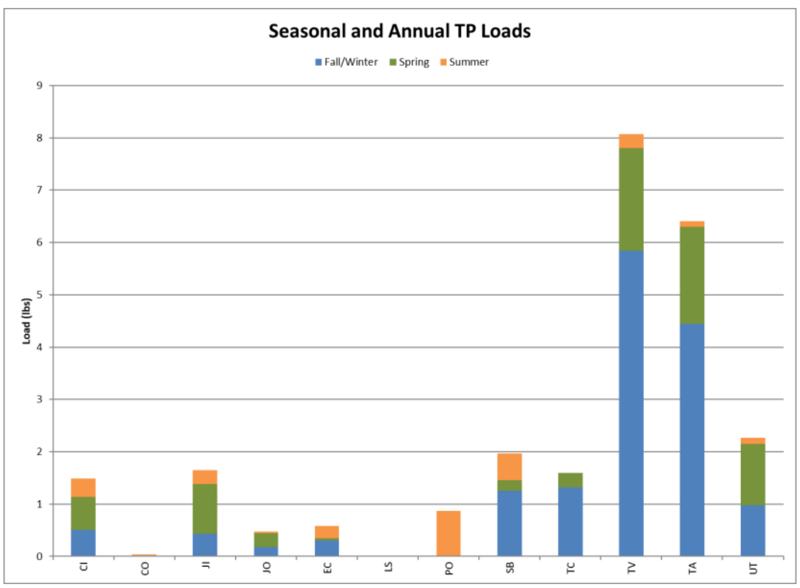

Figure 12 TP loads at each monitoring station, WY20.

TP Loads

- Runoff volume has the largest influence on loads. Tahoe Valley (TV) contributed the greatest TP load to the lake, yet it had low average seasonal TP concentrations in the fall/winter and spring.
- Concentrations influence loads. Though runoff volumes were universally low in the summer, high average seasonal TP concentrations resulted in proportionally higher summer TP loads at Pasadena (PO) and Speedboat (SB).

5.2 Summary Data for Individual Catchments

5.2.1 SR431

Figure 13 shows the average daily inflow and cumulative precipitation for WY20 at the SR431 treatment vaults. The treatment vaults are not designed to reduce flows so outflows are roughly equal to inflows for the Jellyfish. However, the Contech MFS vault has a capacity of about 3,000 cf. This results in a substantial amount of runoff evaporating from the vault instead of passing through the outflow and accounts for the large difference between inflow and outflow volumes in Table 5 (compare CI annual volume to CO annual volume in Table 5).

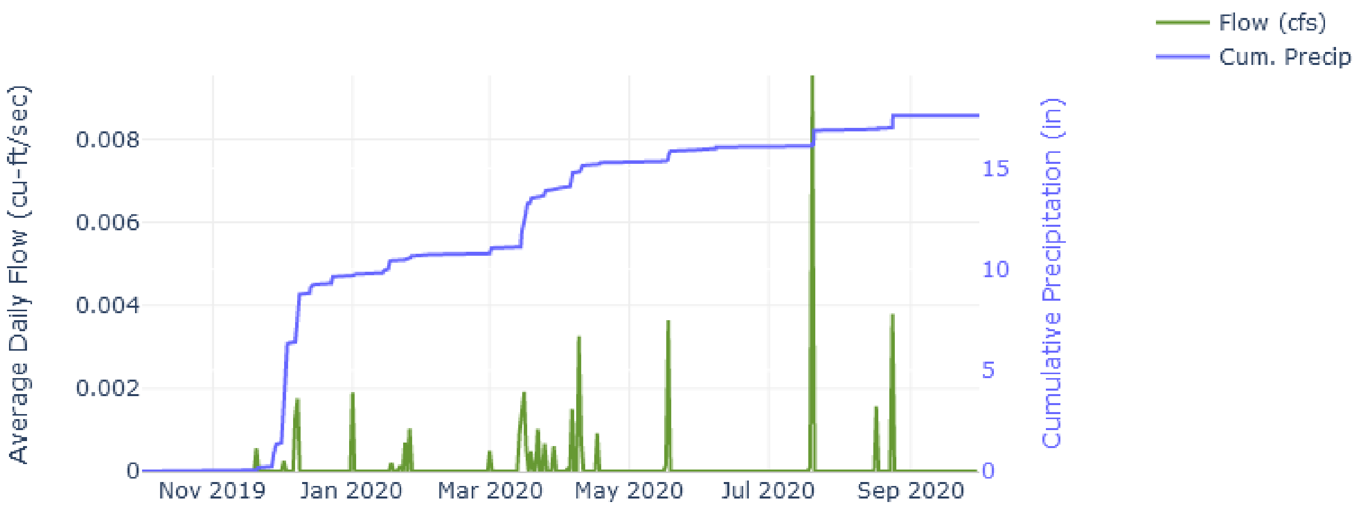

Figure 13 Average daily inflow and cumulative precipitation at the SR431 treatment vaults, WY20.

- Average daily flow in Figure 13 is from CI, but JI is similar so it is not shown. The occasional difference in inflow volume between CI and JI is attributable to unequal split of the flow in the splitter chamber when sediment accumulates.
- 17.61 inches of total precipitation (10.72 in the fall/winter, 5.18 in the spring, and 1.71 in the summer) were recorded at the NDOT weather station.
- 40 precipitation events occurred (20 fall/winter events, 12 spring events, 8 summer events).
- The largest storm event produced almost 5 inches of precipitation and occurred during an atmospheric river rain and snow event from November 30, 2019 to December 2, 2019.
- 80% of storms were less than half an inch.
- Highest average daily flows occurred in during the thunderstorm event on July 20, 2020.
- 13 days of snowmelt occurred in the fall/winter and spring seasons.
- The highest instantaneous peak precipitation was 0.17 inches in 5 minutes during a thunderstorm event on July 20, 2020.
- The highest instantaneous peak flow was 0.58 cfs during the thunderstorm event on July 20, 2020.
- The July 20, 2020 thunderstorm event produced the most runoff (824 cf).

Contech MFS

Daily flow and FSP EMC summaries for the Contech MFS inflow and outflow are presented in Figure 14 and Figure 15, respectively. Table 6 presents this data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

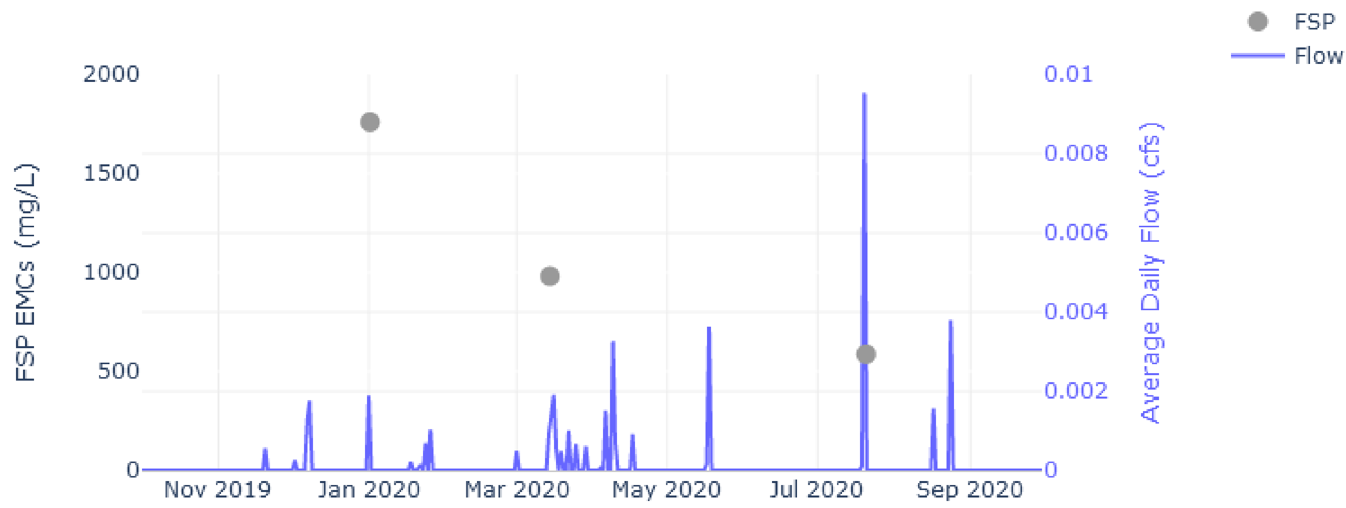

Figure 14 Daily inflow and FSP EMC summary at the Contech MFS, WY20.

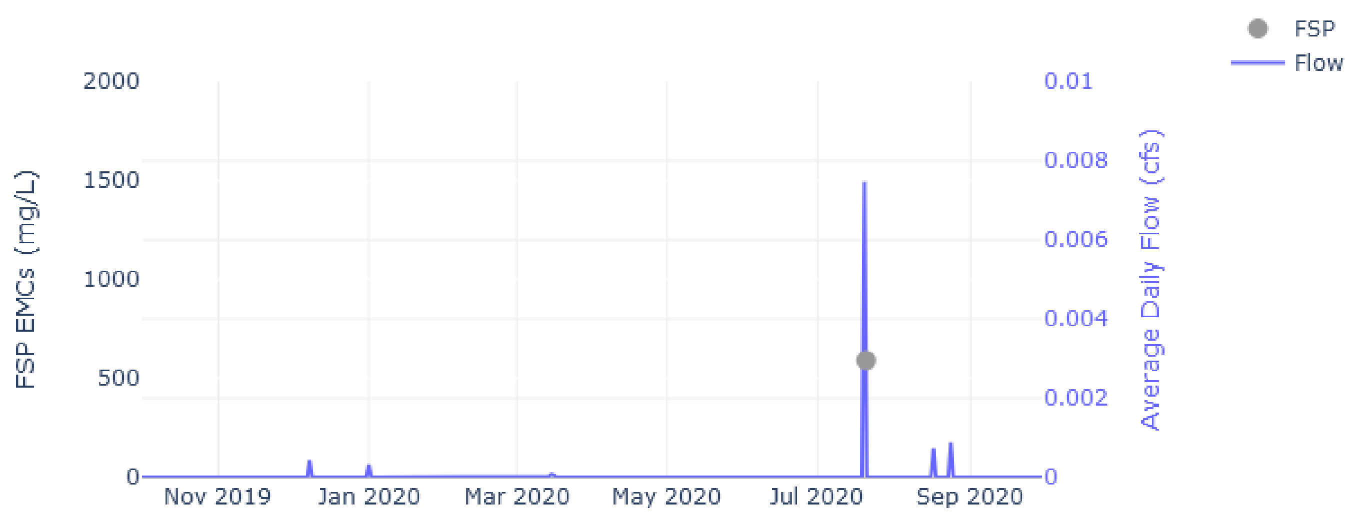

Figure 15 Daily outflow and FSP EMC summary at the Contech MFS, WY20.

- Three events were sampled for FSP at Contech MFS inflow (one in the fall/winter, one in the spring, one in the summer) and one event was sampled for FSP at Contech MFS outflow (one in the summer).
- For the one event sampled at both the inflow and the outflow, FSP EMCs were higher at the outflow than the inflow indicating a release of sediment from the Contech MFS vault.
- The highest FSP EMC at the inflow occurred during the rain on snow event on January 1, 2020.

- The highest FSP load at the inflow occurred during the snowmelt from March 14-29, 2020. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The lowest FSP EMC at the inflow occurred during the thunderstorm event on July 20, 2020.
- The lowest FSP load at the inflow occurred during the rain on snow event on January 1, 2020.
- The highest and lowest FSP EMCs and load at the outflow occurred during the thunderstorm event on July 20, 2020, because that was the only event sampled.

Daily flow and TN EMC summaries for the Contech MFS inflow and outflow are presented in Figure 16 and Figure 17, respectively. Table 6 presents this data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

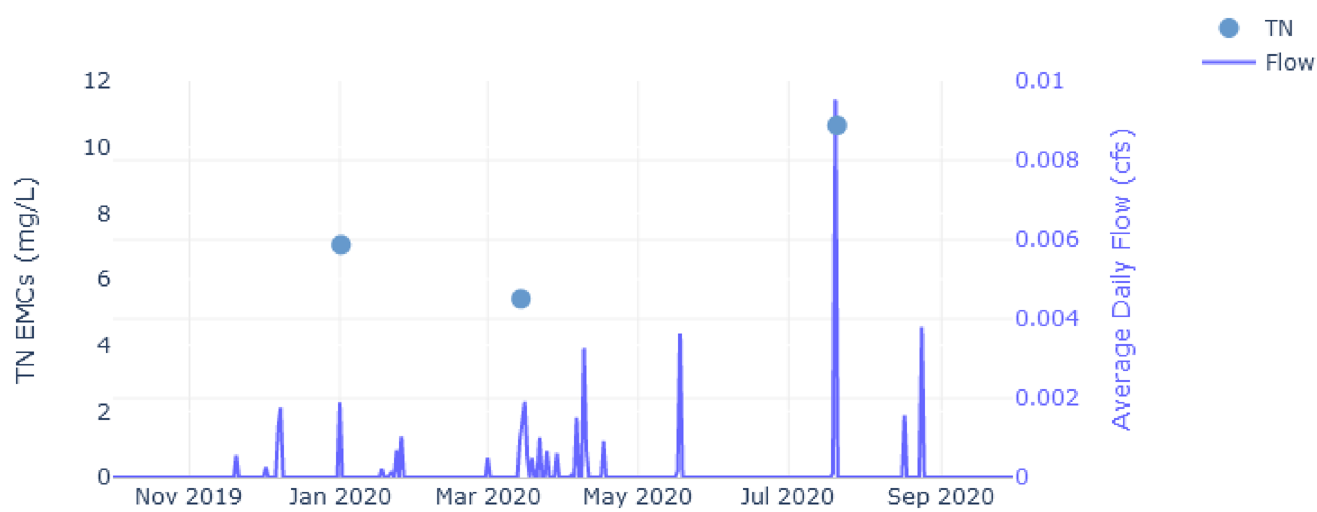

Figure 16 Daily inflow and TN EMC summary at the Contech MFS, WY20.

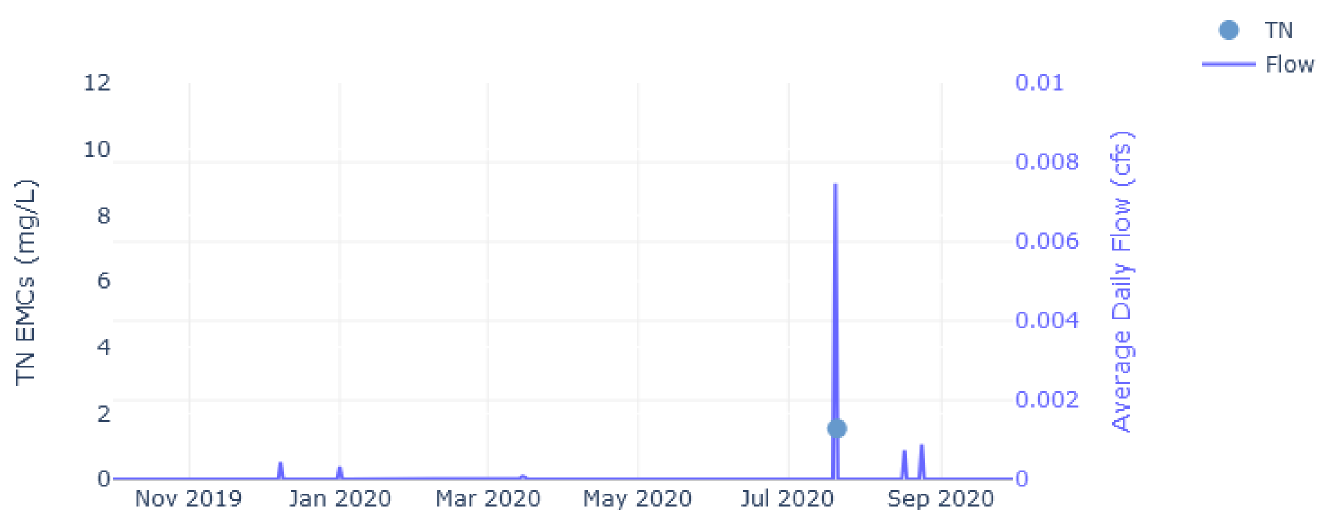

Figure 17 Daily outflow and TN EMC summary at the Contech MFS, WY20.

- Three events were sampled for TN at Contech MFS inflow (one in the fall/winter, one in the spring, one in the summer) and one event was sampled for TN at Contech MFS outflow (one in the summer).
- For the one event sampled at both the inflow and the outflow, TN EMCs were lower at the outflow than the inflow indicating treatment occurred in the Contech MFS.
- The highest TN EMC and load at the inflow occurred during the thunderstorm event on July 20, 2020.
- The lowest TN EMC at the inflow occurred during the event snowmelt from March 14-29, 2020. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The lowest TN load at the inflow occurred during the rain on snow event on January 1, 2020.
- The highest and lowest TN EMCs and load at the outflow occurred during the thunderstorm event on July 20, 2020, because that was the only event sampled.

Daily flow and TP EMC summaries for the Contech MFS inflow and outflow are presented in Figure 18 and Figure 19, respectively. Table 6 presents this data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

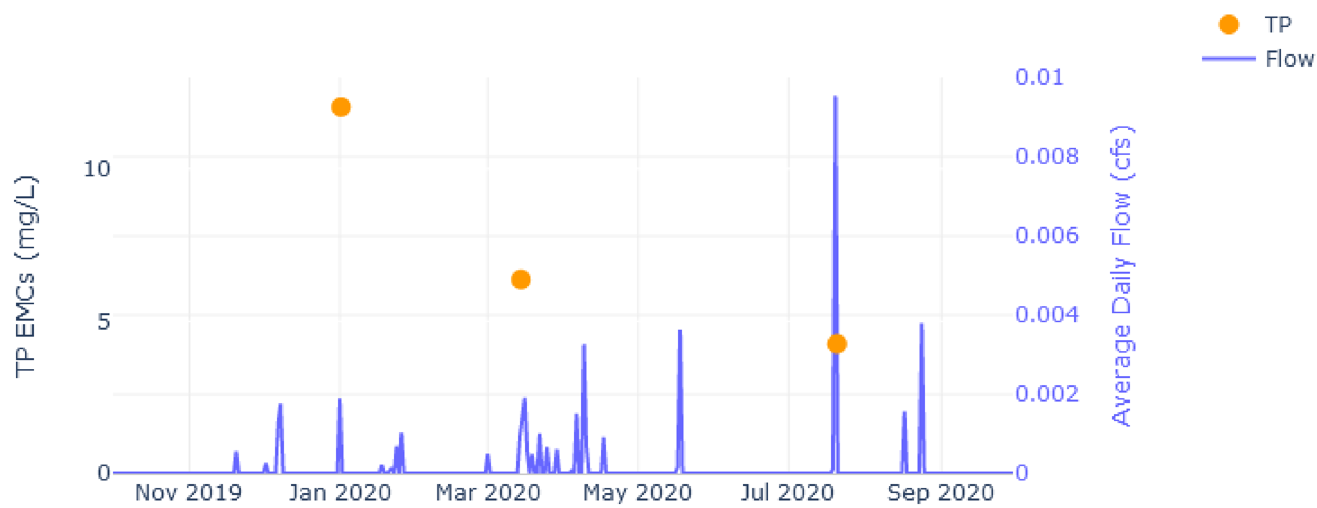

Figure 18 Daily inflow and TP EMC summary at the Contech MFS, WY20.

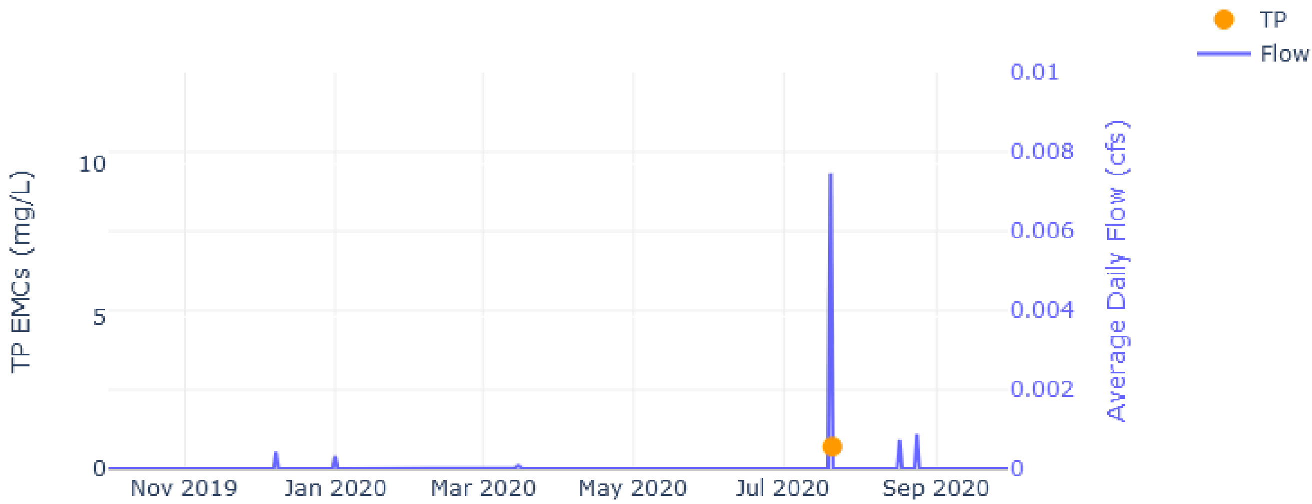

Figure 19 Daily outflow and TP EMC summary at the Contech MFS, WY20.

- Three events were sampled for TP at Contech MFS inflow (one in the fall/winter, one in the spring, one in the summer) and one event was sampled for TP at Contech MFS outflow (one in the summer).
- For the one event sampled at both the inflow and the outflow, TP EMCs were lower at the outflow than the inflow indicating treatment occurred in the Contech MFS.
- The highest TP EMC at the inflow occurred during a rain on snow event on January 1, 2020.
- The highest TP load at the inflow occurred during an event snowmelt from March 14-29, 2020. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The lowest TP EMC at the inflow occurred during the thunderstorm event on July 20, 2020.
- The lowest TP load at the inflow occurred during the rain on snow event on January 1, 2020.
- The highest and lowest TN EMCs and load at the outflow occurred during the thunderstorm event on July 20, 2020, because that was the only event sampled.

Seasonal load as a fraction of the water year load for the Contech MFS inflow and outflow are presented in Figure 20 and Figure 21, respectively. Event loads are presented in tabular form in Table 6.

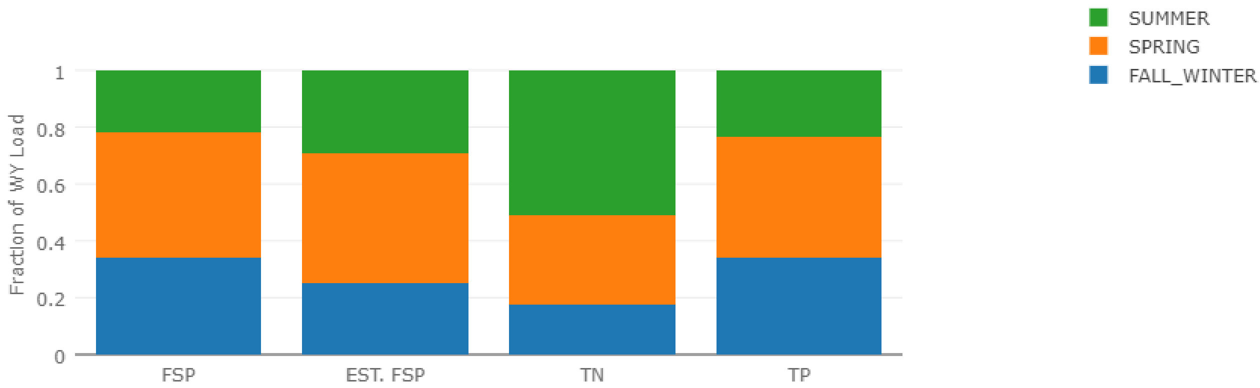

Figure 20 Seasonal load as a fraction of the water year load at the Contech MFS inflow, WY20. The first FSP column represents the FSP load calculated using event mean concentrations and the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

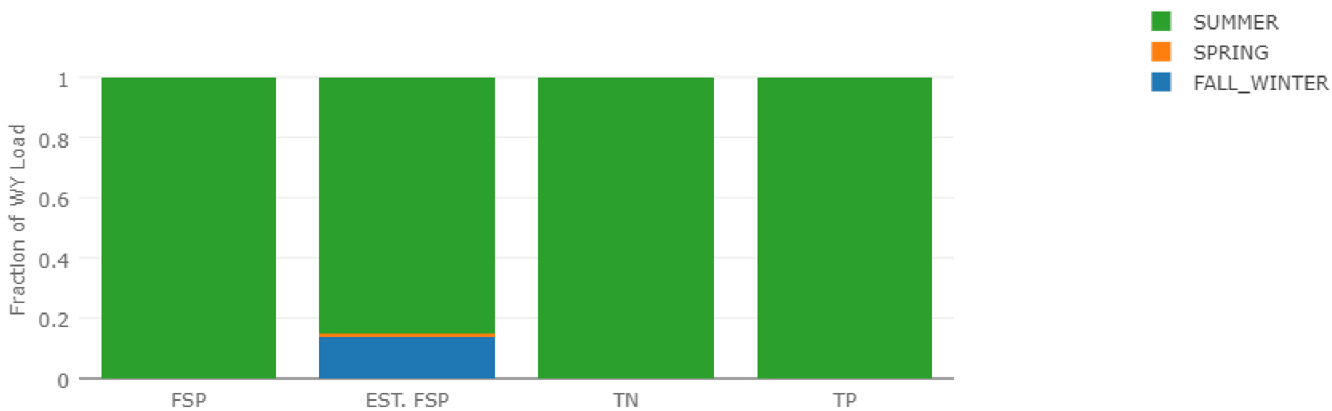

Figure 21 Seasonal load as a fraction of the water year load at the Contech MFS outflow, WY20. The first FSP column represents the FSP load calculated using event mean concentrations and the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples and continuous turbidity) at the inflow was generated in the spring.
- The largest fraction of FSP loads (based on samples and continuous turbidity) at the outflow was generated in the summer.
- The largest fraction of TN loads at the inflow was generated in the summer.
- The largest fraction of TN loads at the outflow was generated in the summer.
- The largest fraction of TP loads at the inflow was generated in the spring.
- The largest fraction of TP loads at the outflow was generated in the summer.

Jellyfish

Daily flow and FSP EMC summaries for the Jellyfish inflow and outflow are presented in Figure 22 and Figure 23, respectively. Table 7 presents this data in tabular form. Table 7 also presents the load data referenced in some bullet points below.

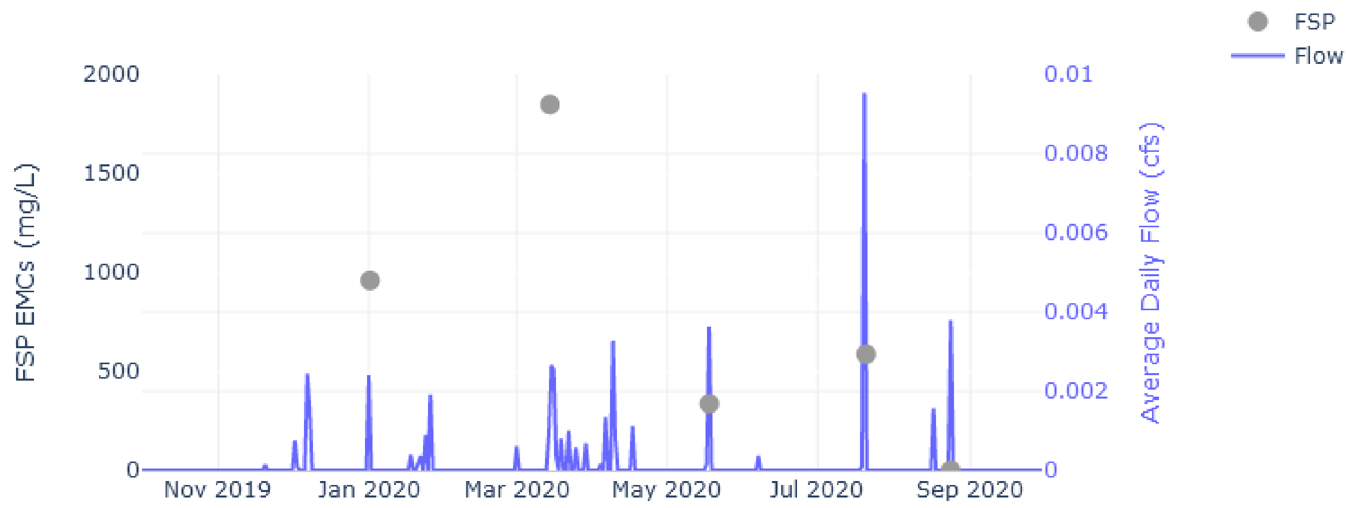

Figure 22 Daily inflow and FSP EMC summary at the Jellyfish, WY20.

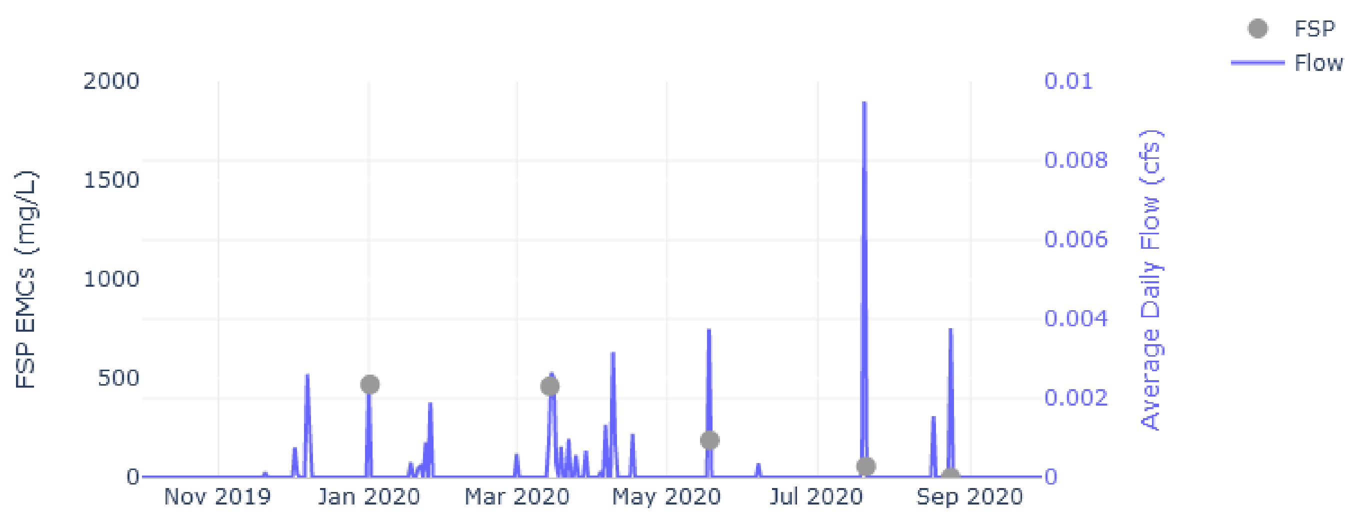

Figure 23 Daily outflow and FSP EMC summary at the Jellyfish, WY20.

- Five events were sampled for FSP (one in the fall/winter, two in the spring, two in the summer).
- In all sampled events, FSP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest FSP EMC and load at the inflow occurred during the March 14-29, 2020 event snowmelt. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The highest FSP EMC at the outflow occurred during the rain on snow event on January 1, 2020.

- The highest FSP load at the outflow occurred during the March 14-29, 2020 event snowmelt. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The lowest FSP EMCs and loads at the inflow and outflow occurred during a thunderstorm event on August 24, 2020.

Daily flow and TN EMC summaries for the Jellyfish inflow and outflow are presented in Figure 24 and Figure 25, respectively. Table 7 presents this data in tabular form. Table 7 also presents the load data referenced in some bullet points below.

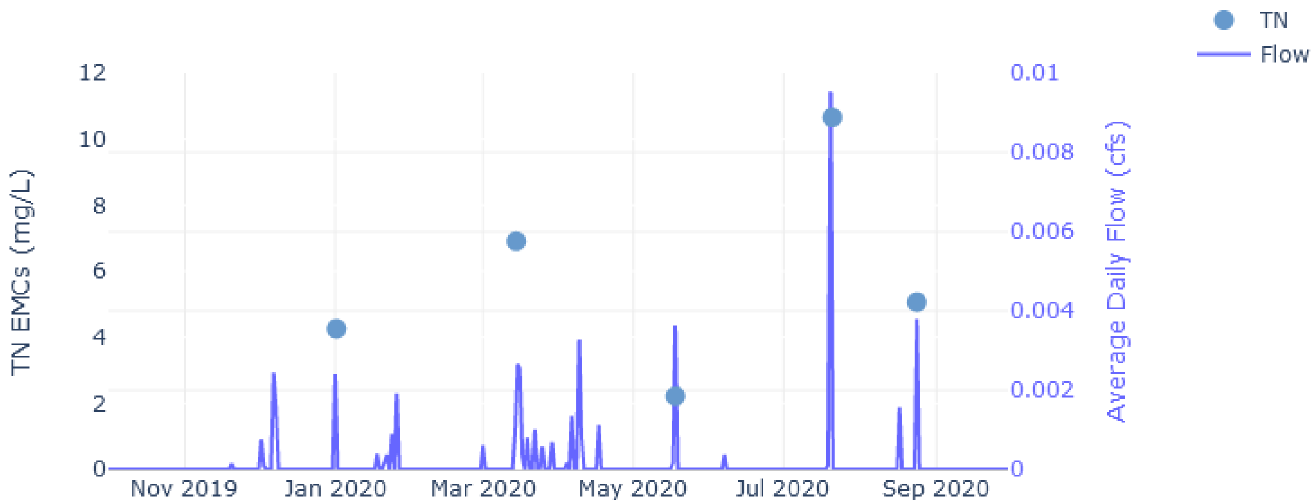

Figure 24 Daily inflow and TN EMC summary at the Jellyfish, WY20.

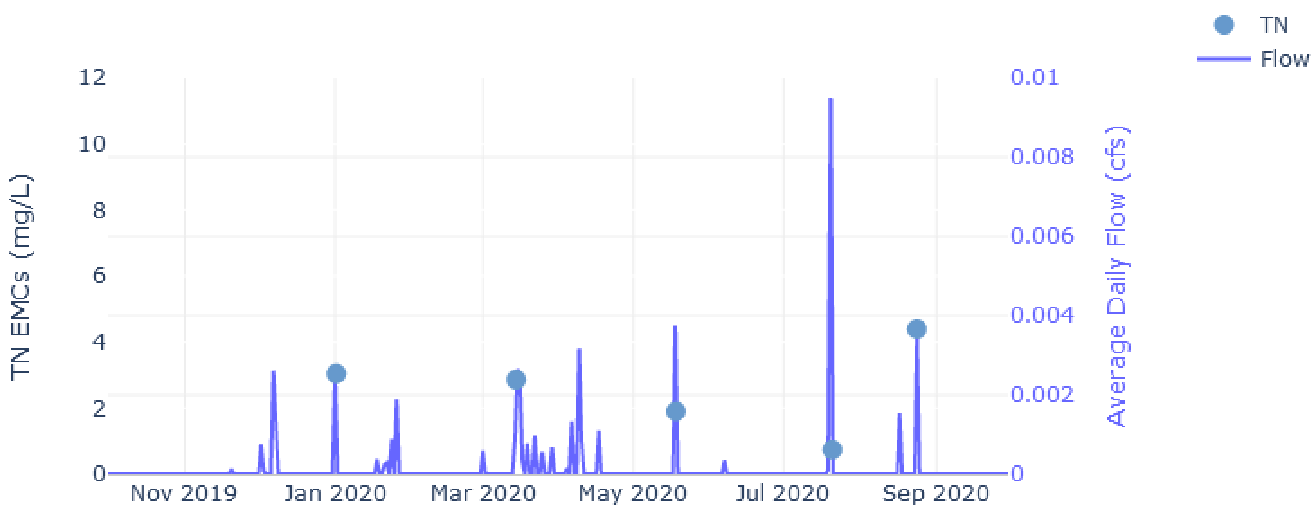

Figure 25 Daily outflow and TN EMC summary at the Jellyfish, WY20.

- Five events were sampled for TN (one in the fall/winter, two in the spring, two in the summer).

- In all sampled events, TN EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TN EMC and load at the inflow occurred during the thunderstorm event on July 20, 2020.
- The highest TN EMC at the outflow occurred during the thunderstorm event on August 24, 2020.
- The highest TN load at the outflow occurred during the March 14-29, 2020 event snowmelt. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The lowest TN EMC and load at the inflow occurred during the rain event on May 17-18, 2020.
- The lowest TN EMC and load at the outflow occurred during the thunderstorm event on July 20, 2020.

Daily flow and TP EMC summaries for the Jellyfish inflow and outflow are presented in Figure 26 and Figure 27, respectively. Table 7 presents this data in tabular form. Table 7 also presents the load data referenced in some bullet points below.

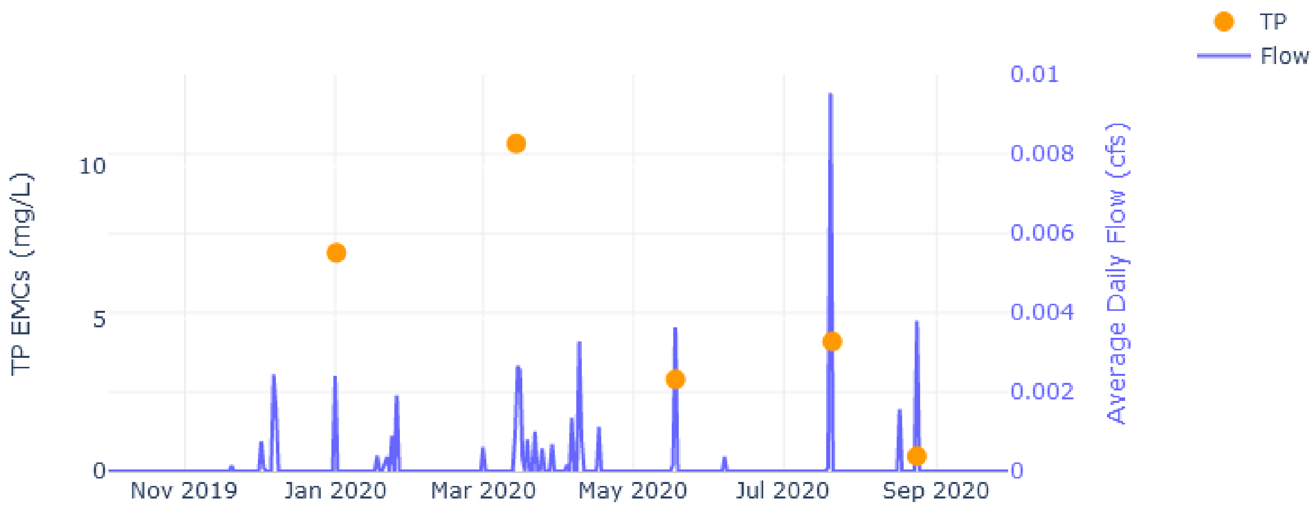

Figure 26 Daily inflow and TP EMC summary at the Jellyfish, WY20.

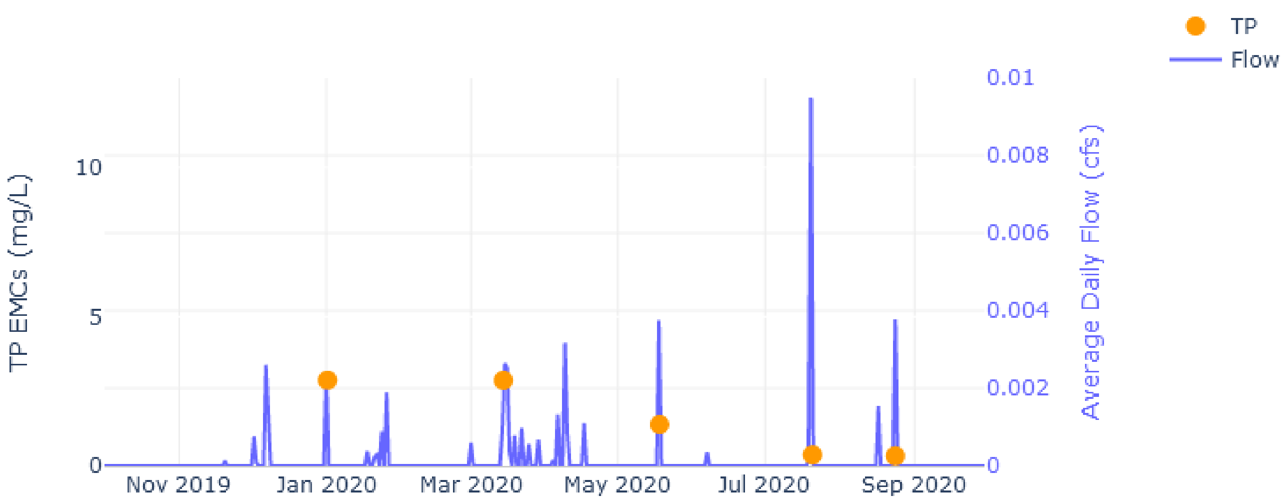

Figure 27 Daily outflow and TP EMC summary at the Jellyfish, WY20.

- Five events were sampled for TP (one in the fall/winter, two in the spring, two in the summer).
- In all sampled events, TP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TP EMC and load at the inflow occurred during the March 14-29, 2020 event snowmelt. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The highest TP EMC at the outflow occurred during the rain on snow event on January 1, 2020.
- The highest TP load at the outflow occurred during the March 14-29, 2020 event snowmelt. This event consisted of several small event and post-event snowmelts over a series of days that were composited as one event.
- The lowest TP EMCs and loads at the inflow and outflow occurred during the thunderstorm event on August 24, 2020.

Seasonal load as a fraction of the water year load for the Jellyfish inflow and outflow are presented in Figure 28 and Figure 29, respectively. Event loads are presented in tabular form in Table 7.

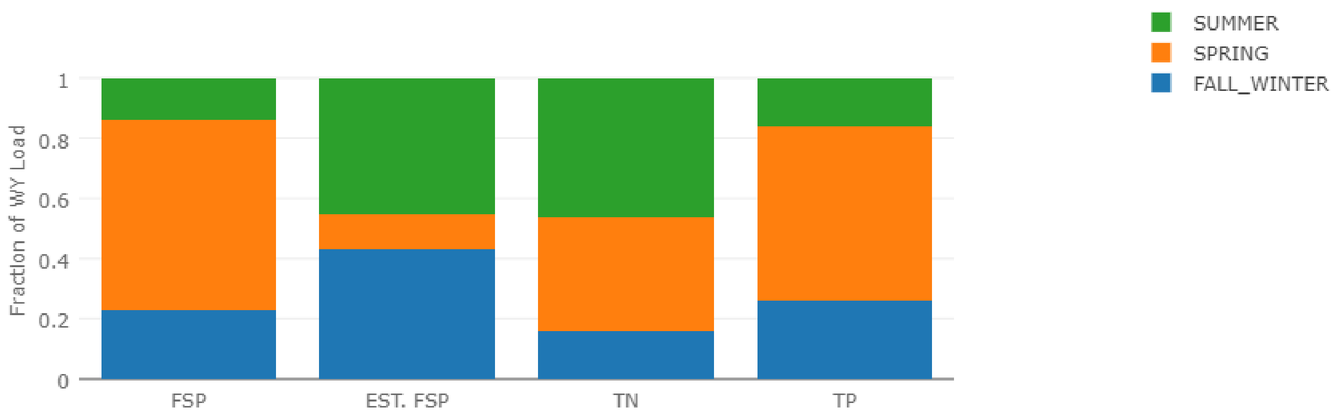

Figure 28 Seasonal load as a fraction of the water year load at the Jellyfish inflow, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

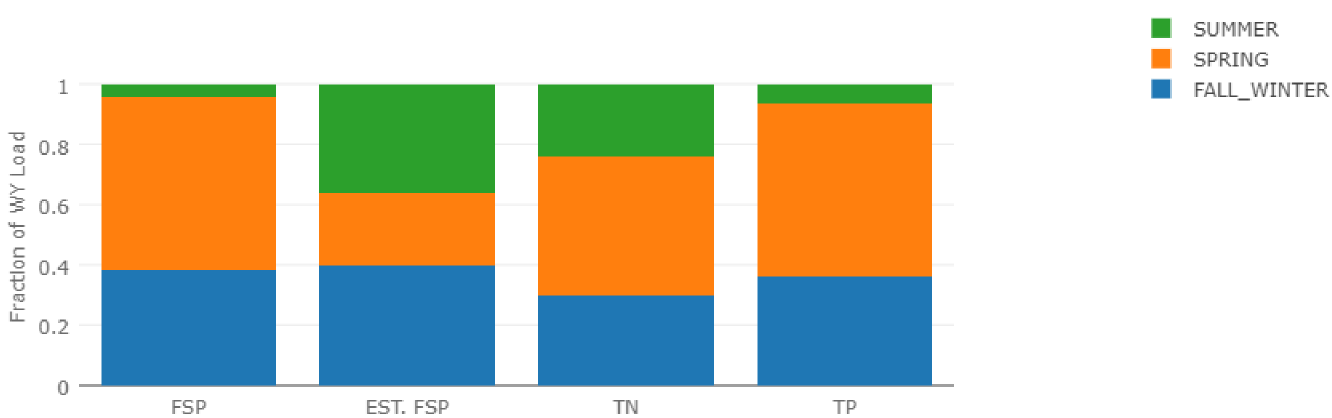

Figure 29 Seasonal load as a fraction of the water year load at the Jellyfish outflow, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) at the inflow was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) at the inflow was generated in the summer.
- The largest fraction of FSP loads (based on samples) at the outflow was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) at the outflow was generated in the fall/winter.
- The largest fraction of TN loads at the inflow was generated in the summer.
- The largest fraction of TN loads at the outflow was generated in the spring.
- The largest fraction of TP loads at the inflow was generated in the spring.
- The largest fraction of TP loads at the outflow was generated in spring.

Three events were sampled at the Contech MFS inflow (with one event at Contech MFS outflow), and five events were sampled at the Jellyfish (both inflow and outflow) in WY20. Event summary data for the Contech MFS and Jellyfish treatment vaults is presented in Table 6 and Table 7 respectively.

Table 6 Event summary data at the Contech MFS treatment vault, WY20.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
CI	Fall/Winter	1/1/2020 11:55	1/1/2020 13:55	48:00	164	0.07	759	0.08	Rain on snow	100%	1,760	18	7,042	0.1	12,031	0.1
CI	Spring	3/14/2020 9:30	3/29/2020 12:05	8702:00	663	0.08	1,432	2.98	Event Snowmelt	100%	981	41	5,408	0.2	6,366	0.3
CI	Summer	7/20/2020 16:00	7/20/2020 17:00	24:00	824	0.56	658	0.78	Thunderstorm	100%	587	30	10,660	0.5	4,254	0.2
CO	Summer	7/20/2020 16:05	7/20/2020 17:05	24:00	645	0.52	576	0.78	Thunderstorm	100%	591	24	1,540	0.1	732	<0.1

Table 7 Event summary data at the Jellyfish treatment vault, WY20.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
JI	Fall/Winter	1/1/2020 11:55	1/1/2020 14:10	54:23	208	0.08	441	0.08	Rain on snow	100%	960	12	4,257	0.1	7,162	0.1
JO	Fall/Winter	1/1/2020 11:55	1/1/2020 14:45	68:00	208	0.07	960	0.08	Rain on snow	100%	469	6	3,044	<0.1	2,873	<0.1
JI	Spring	3/14/2020 9:30	3/29/2020 12:40	8716:00	825	0.09	165	2.98	Event Snowmelt	100%	1,848	95	6,908	0.4	10,744	0.6
JO	Spring	3/14/2020 9:35	3/29/2020 13:35	8736:00	813	0.06	442	2.98	Event Snowmelt	100%	460	23	2,863	0.1	2,867	0.1
JI	Spring	5/17/2020 20:30	5/18/2020 11:10	352:00	327	0.08	53	0.49	Rain	100%	337	7	2,219	<0.1	3,015	0.1
JO	Spring	5/18/2020 5:35	5/18/2020 11:40	146:00	324	0.07	112	0.49	Rain	100%	188	4	1,906	<0.1	1,387	<0.1
JI	Summer	7/20/2020 16:00	7/20/2020 17:00	24:00	824	0.56	658	0.78	Thunderstorm	100%	587	30	10,660	0.5	4,254	0.2
JO	Summer	7/20/2020 16:00	7/20/2020 17:05	26:00	821	0.58	638	0.78	Thunderstorm	100%	56	3	743	<0.1	373	<0.1
JI	Summer	8/24/2020 0:00	8/24/2020 4:05	98:00	328	0.06	106	0.63	Thunderstorm	100%	1	<0.1	5,064	0.1	494	<0.1
JO	Summer	8/24/2020 0:10	8/24/2020 4:05	94:00	326	0.05	67	0.63	Thunderstorm	100%	1	<0.1	4,392	0.1	336	<0.1

5.2.2 Elks Club

Figure 30 shows the average daily flow and cumulative precipitation for WY20 at the Elks Club catchment outfall.

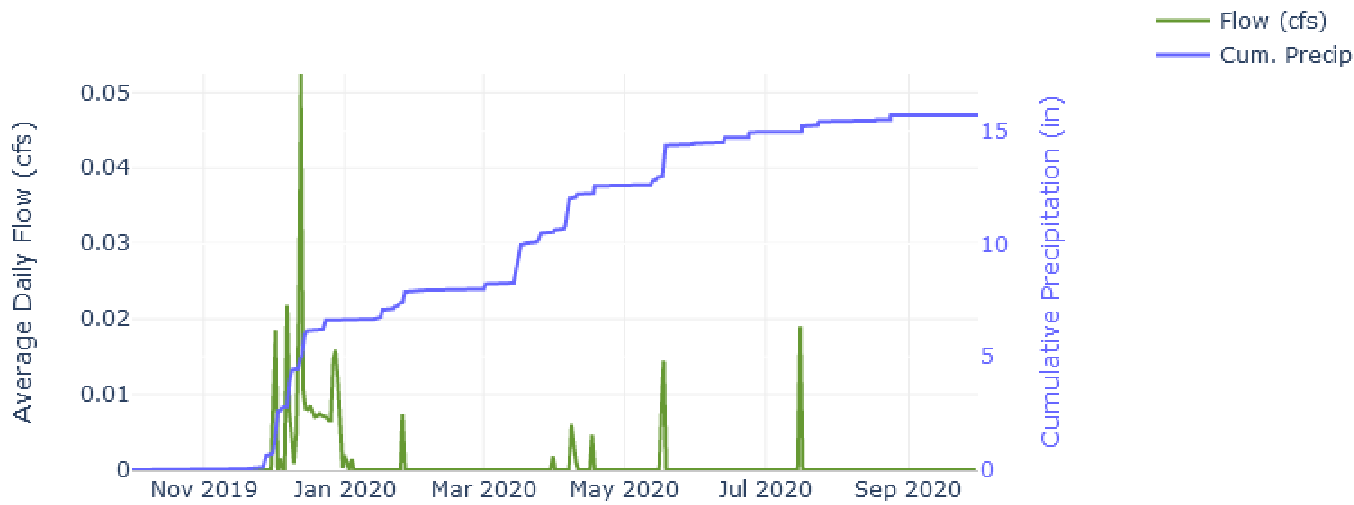

Figure 30 Average daily flow and cumulative precipitation at the Elks Club catchment outfall, WY20.

- 15.68 inches of total precipitation (7.95 in the fall/winter, 6.5 in the spring, 1.23 in the summer) were recorded at the Shakori (SHK) weather station.
- 41 precipitation events occurred (15 fall/winter events, 15 spring events, 11 summer events).
- The largest storm, with 1.97 inches of precipitation, occurred during an atmospheric river rain and snow event that occurred on November 29, 2019 to December 2, 2019.
- 80% of storms were less than half an inch.
- Highest average daily flows occurred during the December 11-15, 2019 rain and snow event.
- 23 days of snowmelt runoff occurred in the fall/winter, and spring.
- The highest instantaneous peak precipitation was 0.13 inches in 10 minutes during a thunderstorm event on June 23, 2020.
- The highest instantaneous peak flow was 1.48 cfs during a thunderstorm event on July 16, 2020.
- The largest runoff event was produced by *snowmelt*, which occurred in the fall/winter (12,150 cf). The most runoff caused by a precipitation event occurred during the December 11-15, 2019 atmospheric river rain and snow event (7,683 cf).

Daily flow and the FSP EMC summary at Elks Club are presented in Figure 31. Table 8 presents this data in tabular form. Table 8 also presents the load data referenced in some bullet points below.

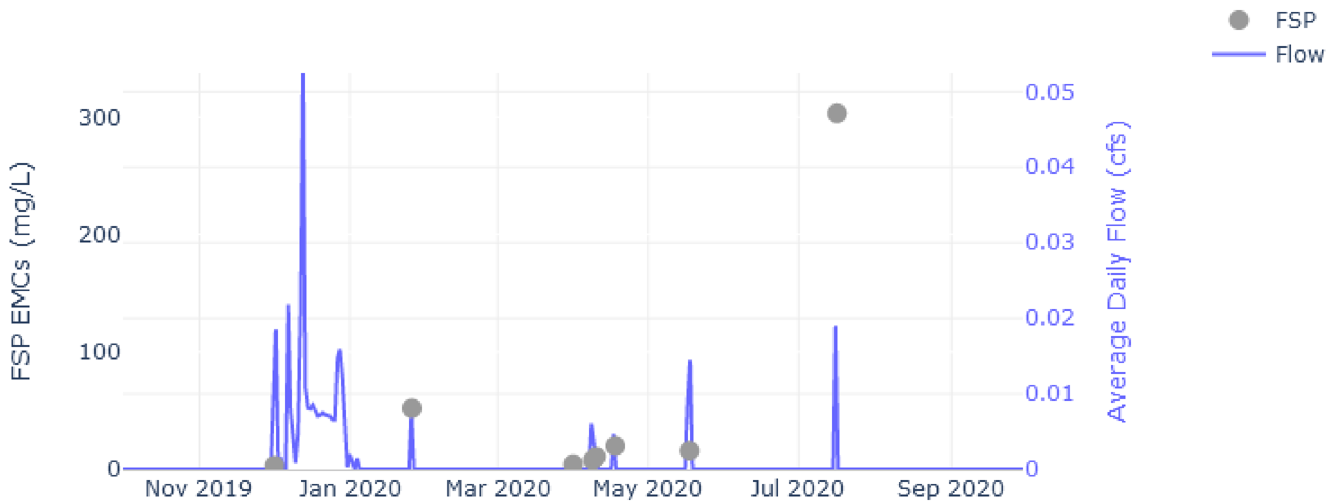

Figure 31 Daily flow and FSP EMC summary at the Elks Club catchment outfall, WY20.

- Eight events were sampled for FSP (two in the fall/winter, five in the spring, and one in the summer).
- The highest FSP EMC and load occurred during the thunderstorm event on July 16, 2020.
- The lowest FSP EMC occurred during the atmospheric river rain on snow even from December 1-2, 2019.
- The lowest FSP load occurred during a rain on snow event on March 31, 2020.

Daily flow and the TN EMC summary at Elks Club are presented in Figure 32. Table 8 presents this data in tabular form. Table 8 also presents the load data referenced in some bullet points below.

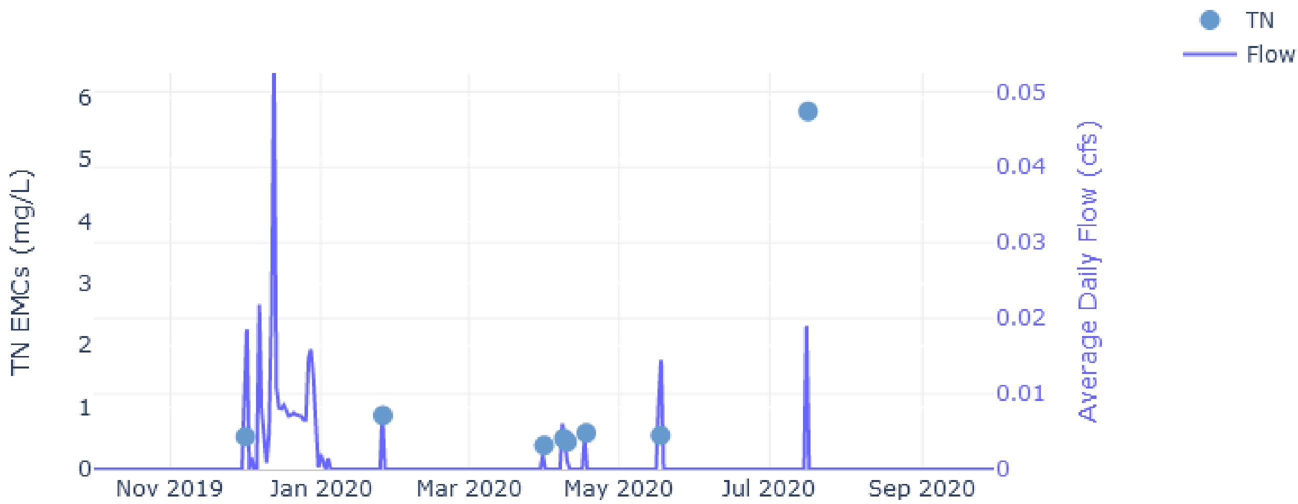

Figure 32 Daily flow and TN EMC summary at the Elks Club catchment outfall, WY20.

- Eight events were sampled for TN (two in the fall/winter, five in the spring, and one in the summer).
- The highest TN EMC and load occurred during the thunderstorm event on July 16, 2020.
- The lowest TN EMC and load occurred during a rain on snow event on March 31, 2020.

Daily flow and the TP EMC summary at Elks Club are presented in Figure 33. Table 8 presents this data in tabular form. Table 8 also presents the load data referenced in some bullet points below.

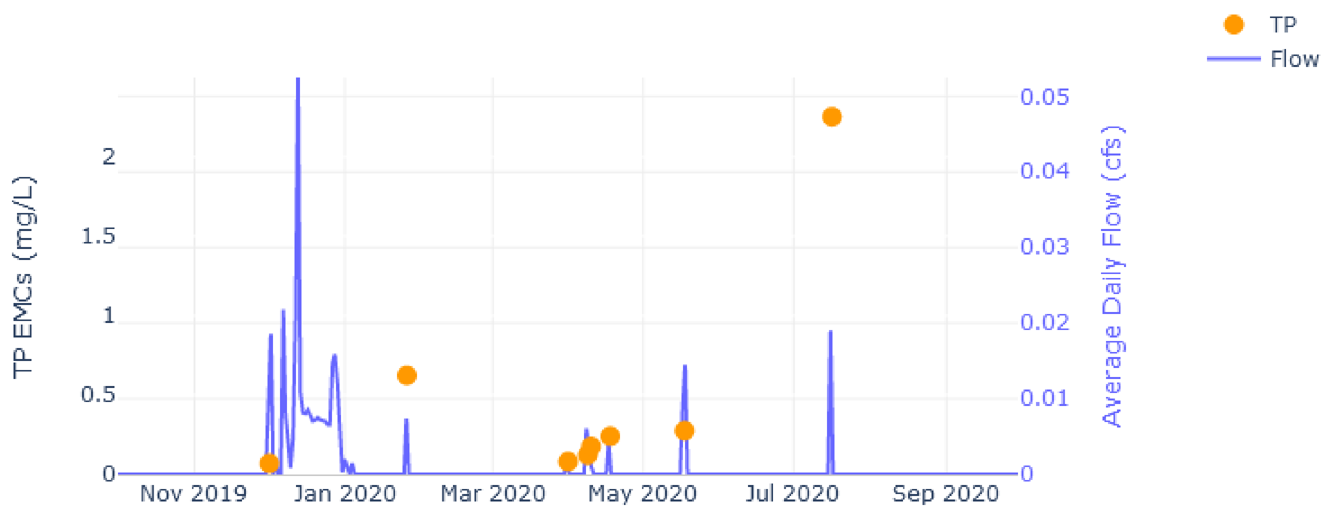

Figure 33 Daily flow and TP EMC summary at the Elks Club catchment outfall, WY20.

- Eight events were sampled for TP (two in the fall/winter, five in the spring, and one in the summer).
- The highest TP EMC and load occurred during the thunderstorm event on July 16, 2020.
- The lowest TP EMC occurred during the atmospheric river rain on snow event from December 1-2, 2019.
- The lowest TP load occurred during a rain on snow event on March 31, 2020.

Seasonal load as a fraction of the water year load at Elks Club is presented in Figure 34. Event loads are presented in tabular form in Table 8.

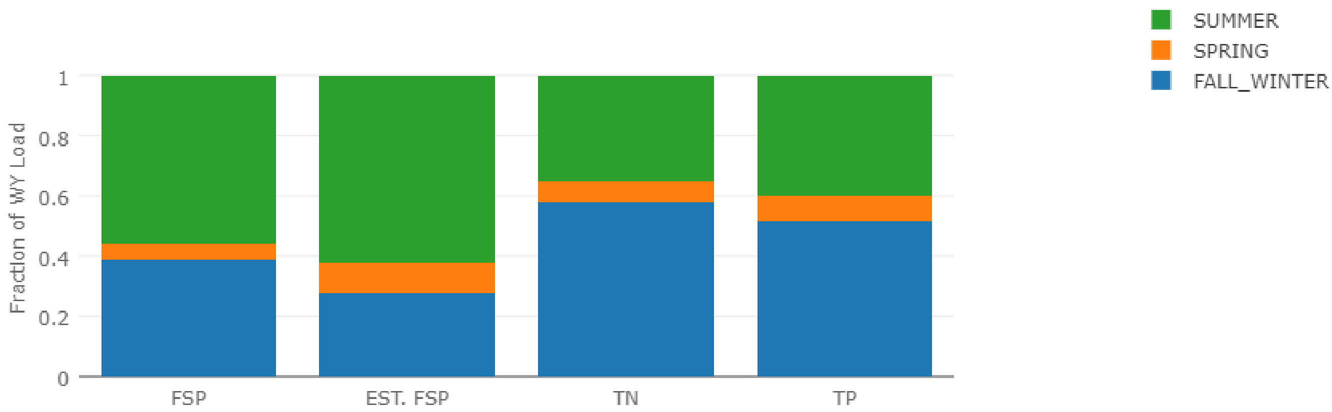

Figure 34 Seasonal load as a fraction of the water year load at the Elks Club catchment outfall, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads was generated in the summer.
- The largest fraction of TN loads was generated in the fall/winter.
- The largest fraction of TP loads was generated in the fall/winter.

Eight events were sampled at Elks Club in WY20. Event summary data is presented in Table 8.

Table 8 Event summary data at the Elks Club catchment outfall, WY20

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
EC	Fall/Winter	12/1/2019 4:55	12/2/2019 23:00	1010:00	2,422	0.03	8	1.97	Rain on snow	100%	3	<0.1	528	0.1	69	<0.1
EC	Fall/Winter	1/26/2020 3:50	1/26/2020 14:10	248:00	639	0.08	253	0.51	Event Snowmelt	100%	52	2	871	<0.1	623	<0.1
EC	Spring	3/31/2020 13:15	3/31/2020 16:45	84:00	164	0.02	16	0.11	Rain on snow	100%	4	<0.1	388	<0.1	81	<0.1
EC	Spring	4/8/2020 11:45	4/8/2020 17:30	138:00	522	0.06	36	0.00	Non-event Snowmelt	100%	8	<0.1	500	<0.1	122	<0.1
EC	Spring	4/9/2020 20:55	4/10/2020 1:25	108:00	362	0.05	41	0.18	Rain on snow	100%	11	<0.1	446	<0.1	176	<0.1
EC	Spring	4/17/2020 15:50	4/17/2020 18:50	72:00	403	0.09	82	0.34	Rain	100%	20	1	589	<0.1	240	<0.1
EC	Spring	5/17/2020 19:00	5/18/2020 11:10	388:00	2,023	0.12	142	1.40	Rain	100%	16	2	549	0.1	275	<0.1
EC	Summer	7/16/2020 14:05	7/16/2020 20:55	164:00	1,642	1.37	441	0.26	Thunderstorm	100%	303	31	5,780	0.6	2,252	0.2

5.2.3 Lakeshore

Figure 35 shows the average daily flow and cumulative precipitation for WY20 at the Lakeshore catchment outfall.

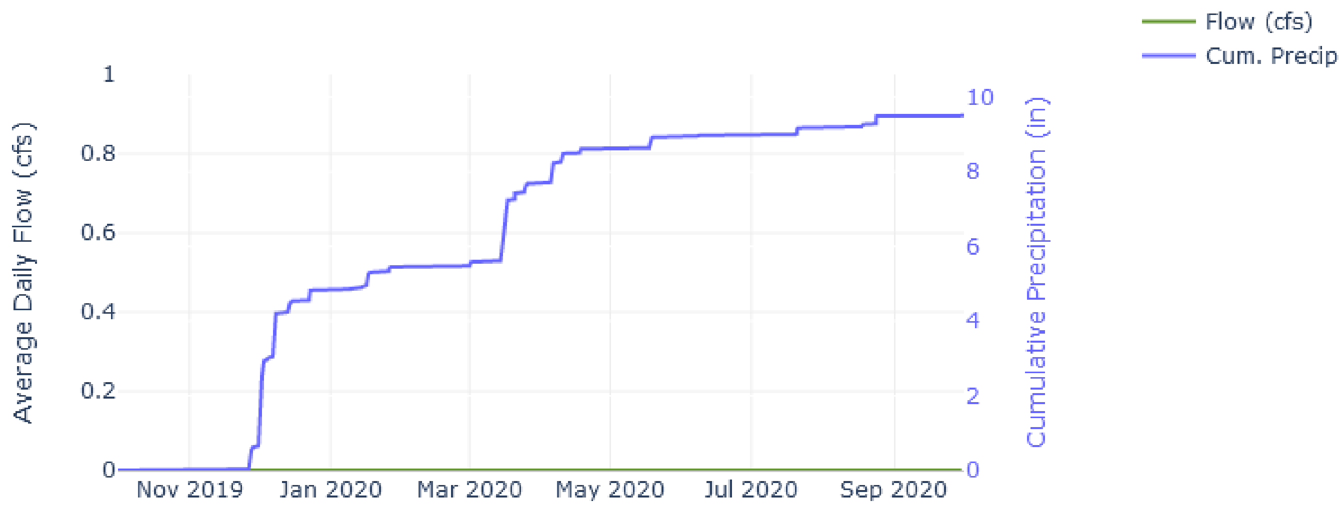

Figure 35 Average daily flow and cumulative precipitation at the Lakeshore catchment outfall, WY20.

- 9.35 inches of total precipitation (5.46 in the fall/winter, 3.32 in the spring, and 0.57 in the summer) were recorded at the TERC weather station.
- 37 precipitation events occurred (15 fall/winter events, 12 spring events, 10 summer events).
- The largest storm, with over 2.27 inches of precipitation, was an atmospheric river rain on rain and snow event that occurred from November 29, 2019 to December 2, 2019.
- 86% of storms were less than half an inch.
- The highest instantaneous peak precipitation was 0.09 inches in 5 minutes during the thunderstorm event on July 20, 2020.
- WY20 was a very dry year and produced zero runoff at Lakeshore.
- Zero events were sampled at Lakeshore in WY20.

5.2.4 Pasadena

Figure 36 shows the average daily flow and cumulative precipitation for WY20 at the Pasadena outfall.

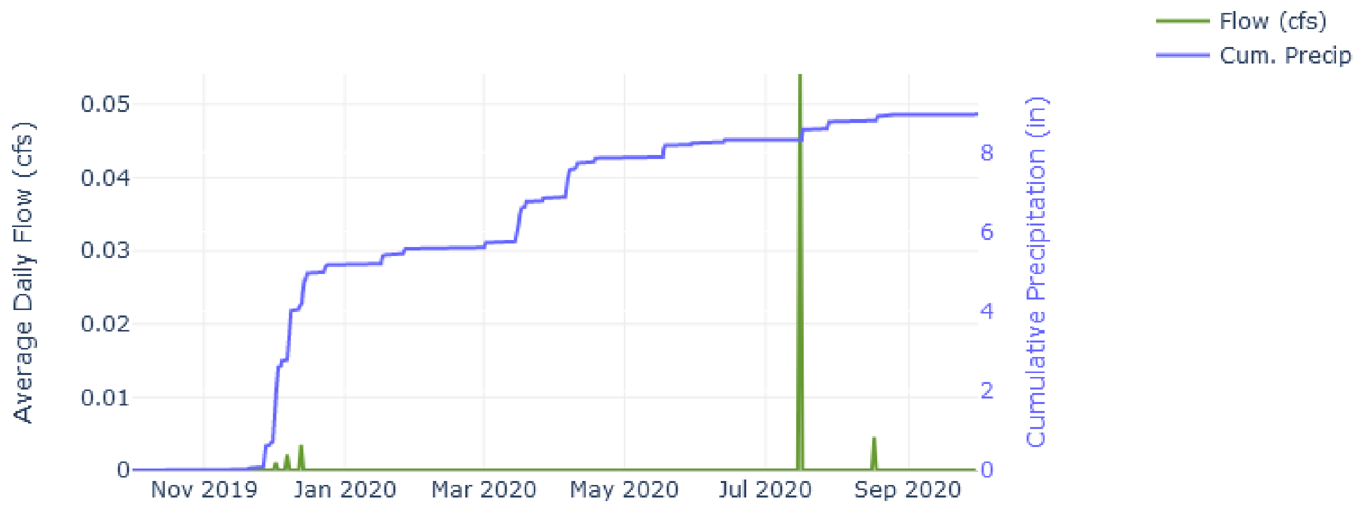

Figure 36 Average daily flow and cumulative precipitation at the Pasadena outfall, WY20.

- 8.95 inches of total precipitation (5.59 in the fall/winter, 2.64 in the spring, and 0.72 in the summer) were recorded at the Bellevue (BV) weather station. The Bellevue weather station is located at the edge of a meadow and likely gets high winds during precipitation events, and therefore may be subject to undercatch.
- 31 precipitation events occurred (13 fall/winter events, 10 spring events, 8 summer events).
- The largest storm, with 1.97 inches of precipitation, was an atmospheric river rain and snow event that occurred from November 29, 2019 to December 2, 2019.
- 81% of storms were less than half an inch.
- Highest average daily flow occurred during a thunderstorm on July 16, 2020.
- There were zero days of snowmelt.
- The highest instantaneous peak precipitation was 0.047 inches in 5 minutes during a thunderstorm event on July 16, 2020.
- The highest instantaneous peak flow was 2.03 cfs during the thunderstorm event on July 16, 2020.
- The July 16, 2020 thunderstorm event produced the most runoff (4,677 cf).

Daily flow and FSP EMC summaries at the Pasadena outfall are presented in Figure 37. Table 9 presents this data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

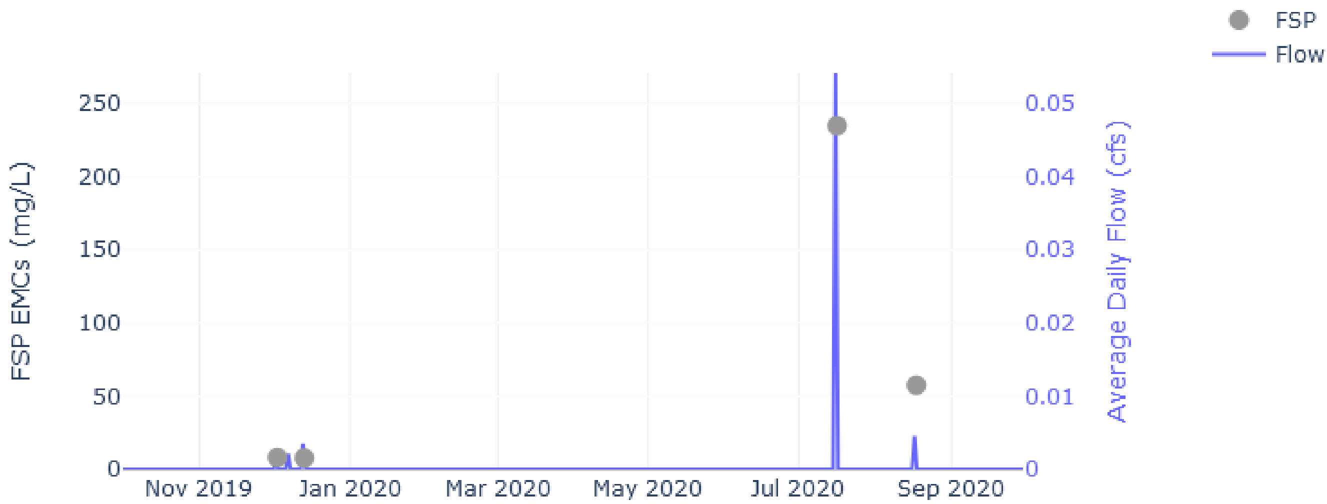

Figure 37 Daily outflow and FSP EMC summary at the Pasadena outfall, WY20.

- Four events were sampled for FSP (two in the fall/winter, zero in the spring, two in the summer).
- The highest FSP EMC and load occurred during the thunderstorm event on July 16, 2020.
- The lowest FSP EMC occurred during the rain on snow event on December 13, 2019.
- The lowest FSP load occurred during the atmospheric river rain on snow event on December 2, 2019.

The daily flow and TN EMC summaries for the Pasadena outfall are presented in Figure 38. Table 9 presents this data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

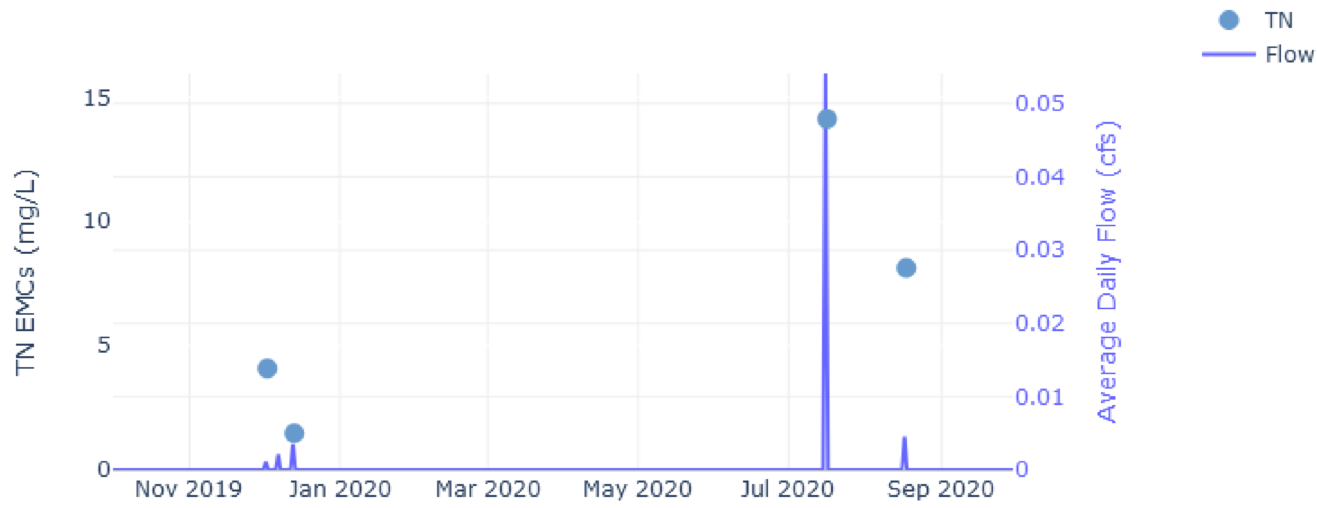

Figure 38 Daily outflow and TN EMC summary at the Pasadena outfall, WY20.

- Four events were sampled for TN (two in the fall/winter, zero in the spring, two in the summer).
- The highest TN EMC and load occurred during the thunderstorm event on July 16, 2020.
- The lowest TN EMC occurred during the December 13, 2019 rain on snow event.
- The lowest TN load occurred during the atmospheric river rain on snow event on December 2, 2019.

The daily flow and TP EMC summary for the Pasadena outflow are presented Figure 39. Table 9 presents this data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

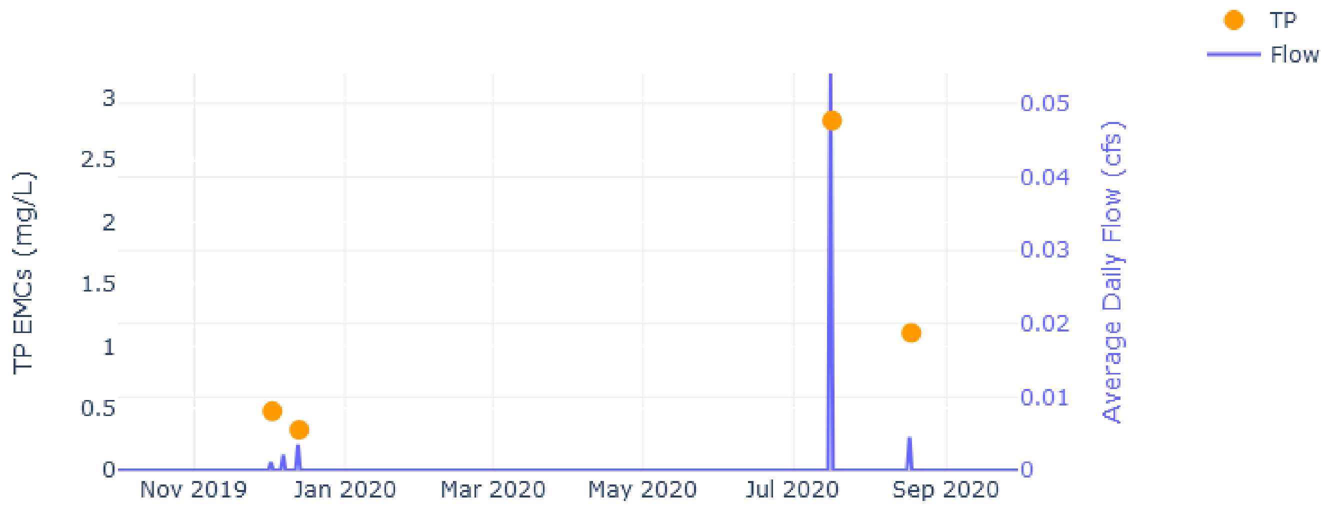

Figure 39 Daily outflow and TP EMC summary at the Pasadena outfall, WY20.

- Four events were sampled for TP (two in the fall/winter, zero in the spring, two in the summer).
- The highest TP EMC and load occurred during the thunderstorm event on July 16, 2020.
- The lowest TP EMC occurred during the December 13, 2019 rain on snow event.
- The lowest TP load occurred during the atmospheric river rain on snow event on December 2, 2019.

Seasonal load as a fraction of the water year load for the Pasadena outflow are presented in Figure 40. Event loads are presented in tabular form in Table 9.

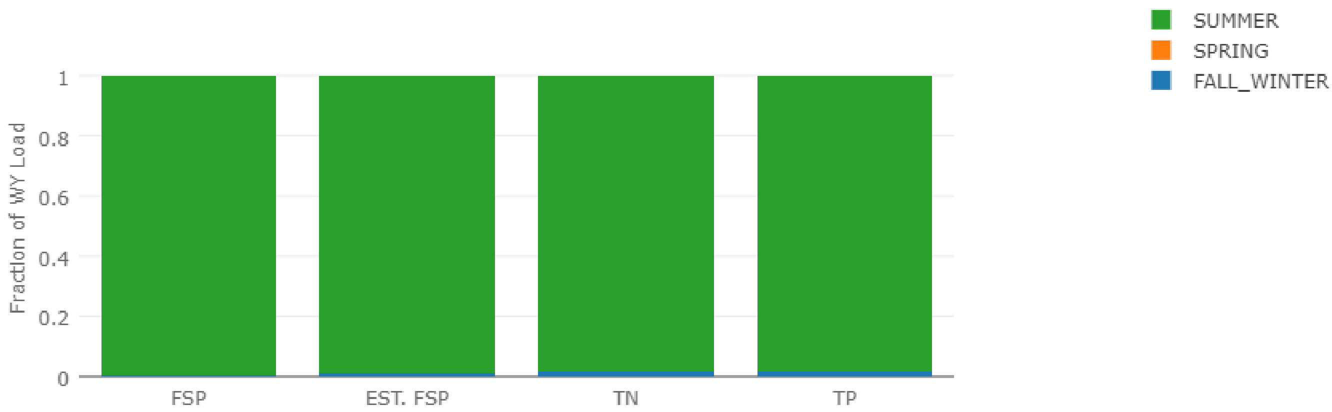

Figure 40 Seasonal load as a fraction of the water year load at the Pasadena outfall, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP load was generated in the summer.
- The largest fraction of TN was generated in the summer.
- The largest fraction of TP was generated in the summer.
- Very small fractions of FSP, TN, and TP loads were generated in the fall/winter.
- No FSP, TN, or TP loads were generated in the spring because there was no runoff.

Four events were sampled at Pasadena in WY20. Event summary data for the Pasadena outfall is presented in Table 9.

Table 9 Event summary data at the Pasadena outfall, WY20

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
PO	Fall/Winter	12/2/2019 14:10	12/2/2019 15:55	42:00	91	0.02	47	1.97	Rain on snow	100%	8	<0.1	4,083	<0.1	476	<0.1
PO	Fall/Winter	12/13/2019 12:20	12/13/2019 23:10	260:00	304	0.03	88	0.75	Rain on snow	100%	8	<0.1	1,471	<0.1	326	<0.1
PO	Summer	7/16/2020 14:45	7/16/2020 19:15	108:00	4,676	1.74	609	0.26	Thunderstorm	100%	235	69	14,134	4.1	2,821	0.8
PO	Summer	8/17/2020 17:35	8/17/2020 20:00	58:00	391	0.19	183	0.12	Thunderstorm	100%	58	1	8,131	0.2	1,108	<0.1

5.2.5 Speedboat

Figure 41 shows the average daily flow and cumulative precipitation for WY20 at the Speedboat catchment outfall.

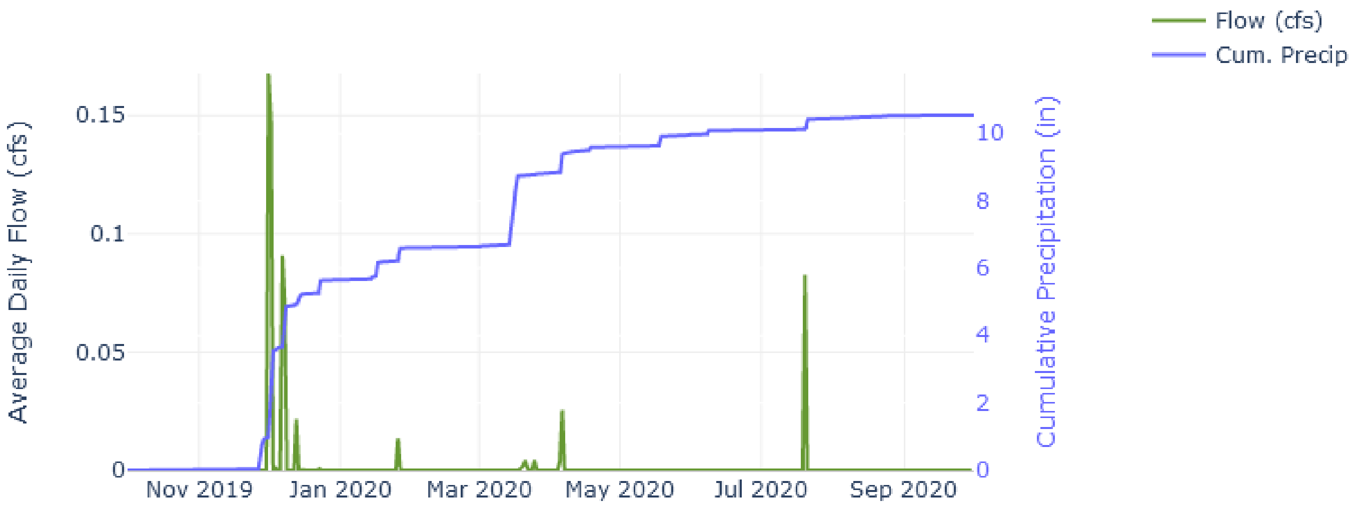

Figure 41 Average daily flow and cumulative precipitation at the Speedboat catchment outfall, WY20.

- 10.55 inches of total precipitation (6.61 in the fall/winter, 3.36 in the spring, and 0.58 in the summer) were recorded at the Nugget (NG) weather station.
- 38 precipitation events (17 fall/winter events, 12 spring events, 9 summer events).
- The largest storm, with 2.6 inches of precipitation, was an atmospheric river rain and snow event that occurred from November 30, 2019 to December 2, 2019.
- 87% of storms were less than half an inch.
- Highest average daily flows occurred during the November 30, 2019 to December 2, 2019 atmospheric river rain on snow event.
- 17 days of intermittent snowmelt occurred in the fall/winter, spring and summer. The summer snowmelt was due to a late season snowstorm on June 7, 2020.
- The highest instantaneous peak precipitation was 0.12 inches in 10 minutes during a thunderstorm on July 20, 2020.
- The highest instantaneous peak flow was 8.19 cfs during the thunderstorm event on July 20, 2020.
- The November 3, 2019 to December 2, 2019 atmospheric river rain on snow event produced the most runoff (27,304 cf).

Daily flow and the FSP EMC summary at Speedboat are presented in Figure 42. Table 10 presents this data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

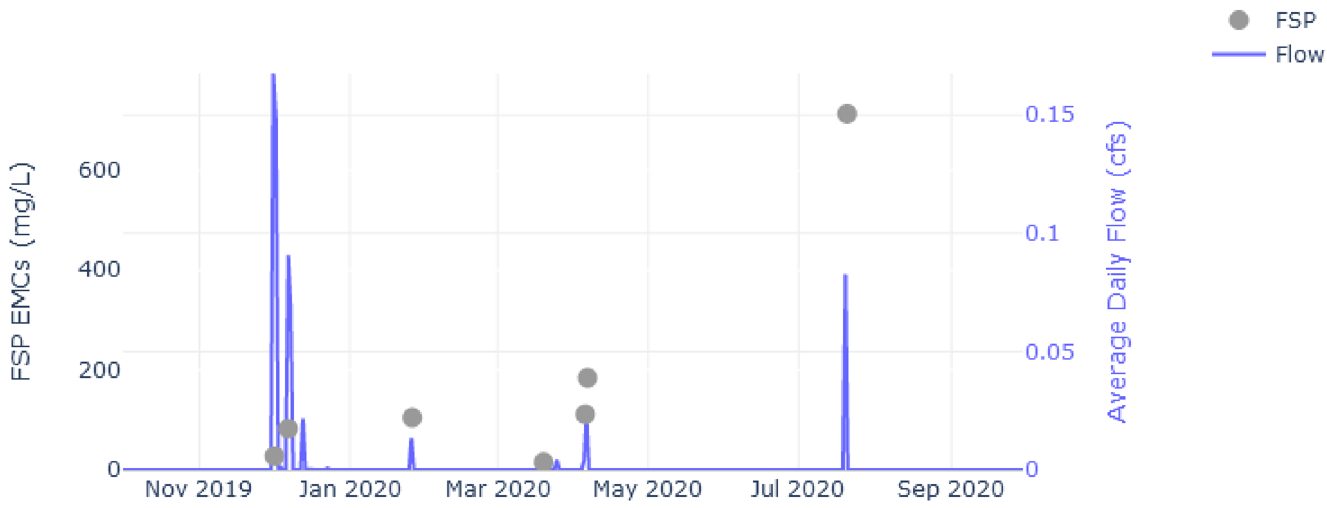

Figure 42 Daily flow and FSP EMC summary at the Speedboat catchment outfall, WY20.

- Seven events were sampled for FSP (three in the fall/winter, three in the spring, and one in the summer).
- The highest FSP EMC and load occurred during the thunderstorm on July 20, 2020.
- The lowest FSP EMC and load occurred during the non-event snowmelt from March 19-21, 2020.

Daily flow and the TN EMC summary are presented in Figure 43. Table 10 presents this data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

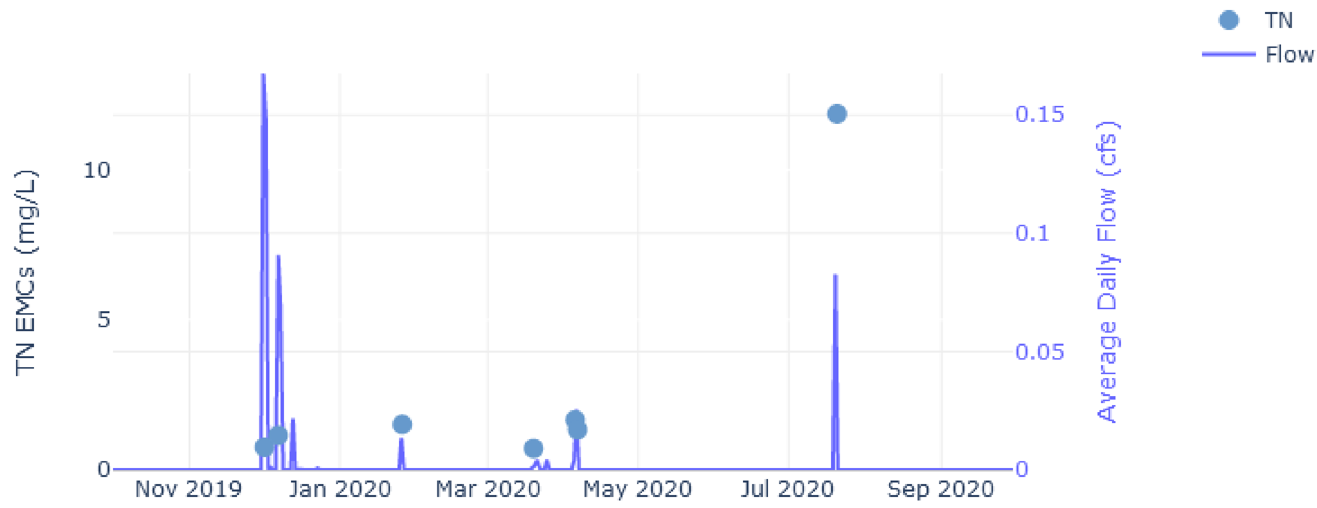

Figure 43	Daily flow and TN EMC summary at the Speedboat catchment outfall, WY20.

- Seven events were sampled for TN (three in the fall/winter, three in the spring, and one in the summer).
- The highest TN EMC and load occurred during the thunderstorm on July 20, 2020.
- The lowest TN EMC and load occurred during the non-event snowmelt from March 19-21, 2020.

Daily flow and the TP EMC summary are presented in Figure 44. Table 10 presents this data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

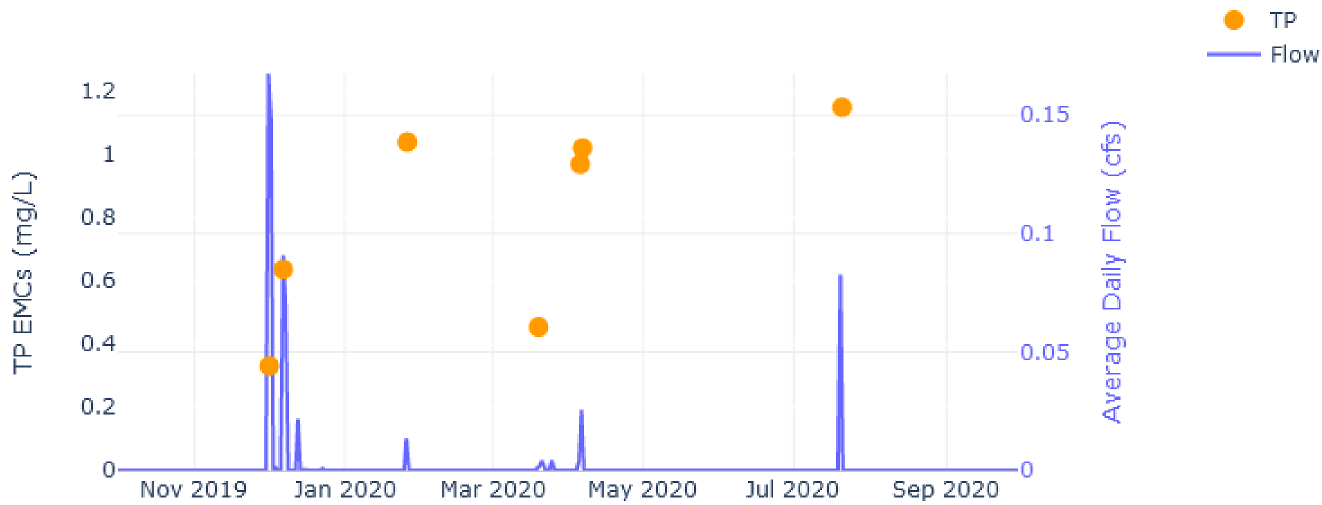

Figure 44 Daily flow and TP EMC summary at the Speedboat catchment outfall, WY20.

- Seven events were sampled for TP (three in the fall/winter, three in the spring, and one in the summer).
- The highest TP EMC occurred during the thunderstorm on July 20, 2020.
- The highest TP load occurred during the atmospheric river rain on snow event on December 1-2, 2019.
- The lowest TP EMC occurred during the atmospheric river rain on snow event on December 1-2, 2019.
- The lowest TP load occurred during the non-event snowmelt from March 19-21, 2020.

Seasonal load as a fraction of the water year load is presented in Figure 45. Event loads are presented in tabular form in Table 10

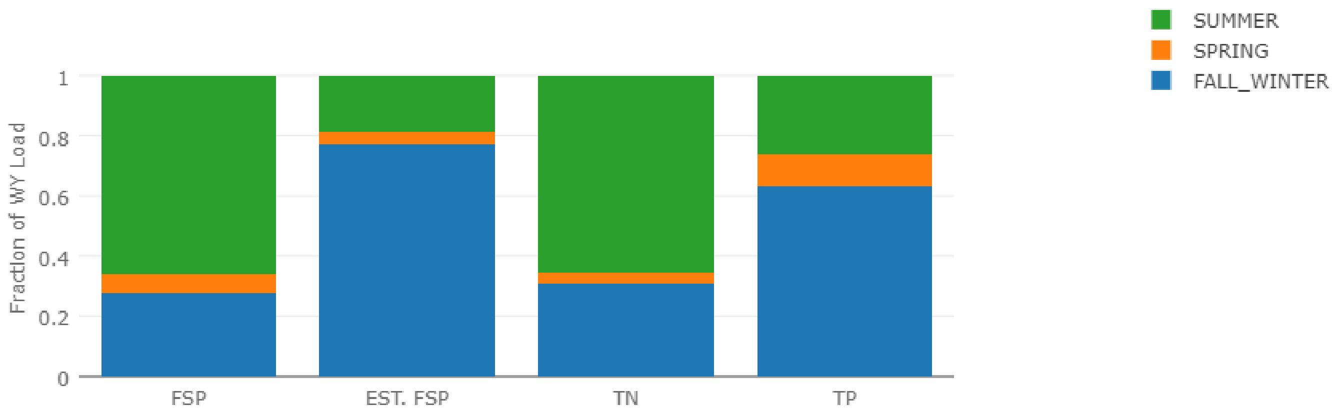

Figure 45 Seasonal load as a fraction of the water year load at the Speedboat catchment outfall, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (FSP EST) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the summer.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in the fall/winter.
- The largest fraction of TN loads was generated in summer.
- The largest fraction of TP loads was generated in the fall/winter.

Seven events were sampled at Speedboat in WY20. Event summary data is presented in Table 10.

Table 10 Event summary data at the Speedboat catchment outfall, WY20.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
SB	Fall/Winter	12/1/2019 8:35	12/2/2019 17:45	796:00	27,304	1.72	1,985	2.62	Rain on snow	100%	28	47	753	1.3	330	0.6
SB	Fall/Winter	12/7/2019 0:30	12/8/2019 17:10	976:00	13,929	0.80	1,985	1.22	Rain on snow	100%	83	72	1,147	1.0	636	0.6
SB	Fall/Winter	1/26/2020 7:10	1/26/2020 12:25	126:00	1,168	0.15	297	0.38	Event Snowmelt	100%	105	8	1,514	0.1	1,039	0.1
SB	Spring	3/19/2020 13:40	3/21/2020 17:35	1246:00	581	0.04	1,984	0.00	Non-event Snowmelt	100%	15	1	711	<0.1	454	<0.1
SB	Spring	4/5/2020 11:30	4/5/2020 17:25	142:00	350	0.05	1,477	0.42	Event Snowmelt	100%	111	2	1,662	<0.1	969	<0.1
SB	Spring	4/6/2020 9:35	4/6/2020 16:15	160:00	2,204	0.43	1,902	0.02	Non-event Snowmelt	100%	184	25	1,339	0.2	1,020	0.1
SB	Summer	7/20/2020 16:05	7/20/2020 17:35	36:00	7,148	5.21	1,534	0.25	Thunderstorm	100%	714	319	11,872	5.3	1,149	0.5

5.2.6 Tahoe City

Figure 46 shows the average daily flow and cumulative precipitation for WY20 at the Tahoe City catchment outfall.

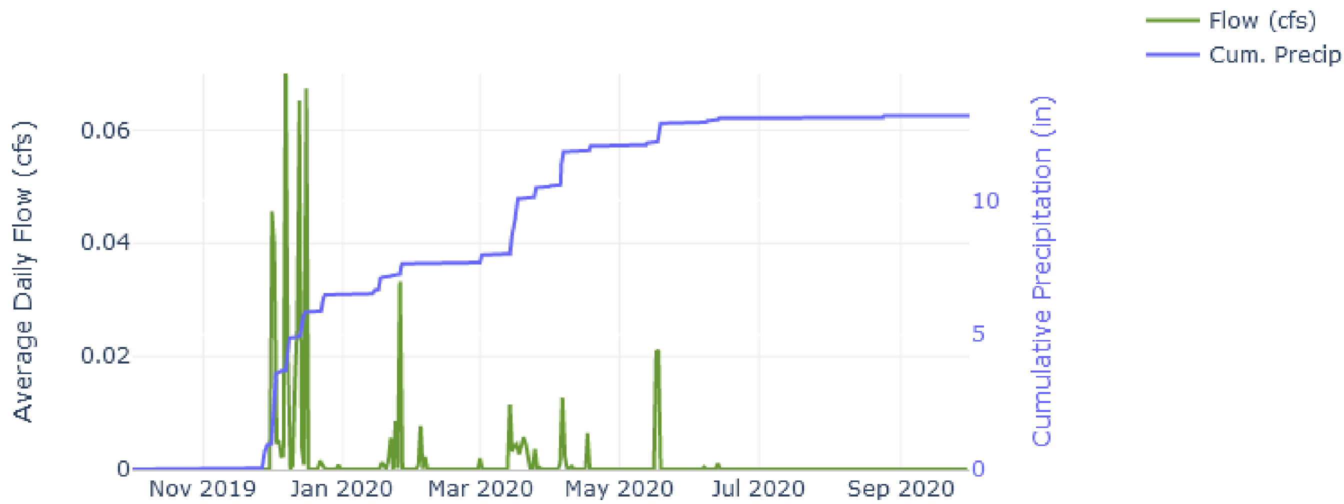

Figure 46 Average daily flow and cumulative precipitation at the Tahoe City catchment outfall, WY20.

- 13.13 inches of total precipitation (7.69 in the fall/winter, 5.17 in the spring, and 0.27 in the summer) were recorded at the Hatchery (HATCH) weather station.
- 37 precipitation events (17 fall/winter events, 14 spring events, 6 summer events).
- The largest storm, with 2.6 inches of precipitation, was an atmospheric river rain and snow event that occurred from November 30, 2019 to December 2, 2019.
- 78% of storms were less than half an inch.
- Highest average daily flows occurred during the atmospheric river events in December 2019.
- 31 days of intermittent snowmelt occurred in the fall/winter, spring and summer. The summer snowmelt was due to a late season snowstorm on June 7, 2020.
- The highest instantaneous peak precipitation was 0.05 inches in 5 minutes during the atmospheric river rain and snow event on December 1, 2019.
- The highest instantaneous peak flow was 1.03 cfs during snowmelt on December 16, 2019.
- The December 11-15, 2019 atmospheric river rain on snow event produced the most runoff (9,417 cf).

Daily flow and the FSP EMC summary at Tahoe City are presented in Figure 47. Table 11 presents this data in tabular form. Table 11 also presents the load data referenced in some bullet points below.

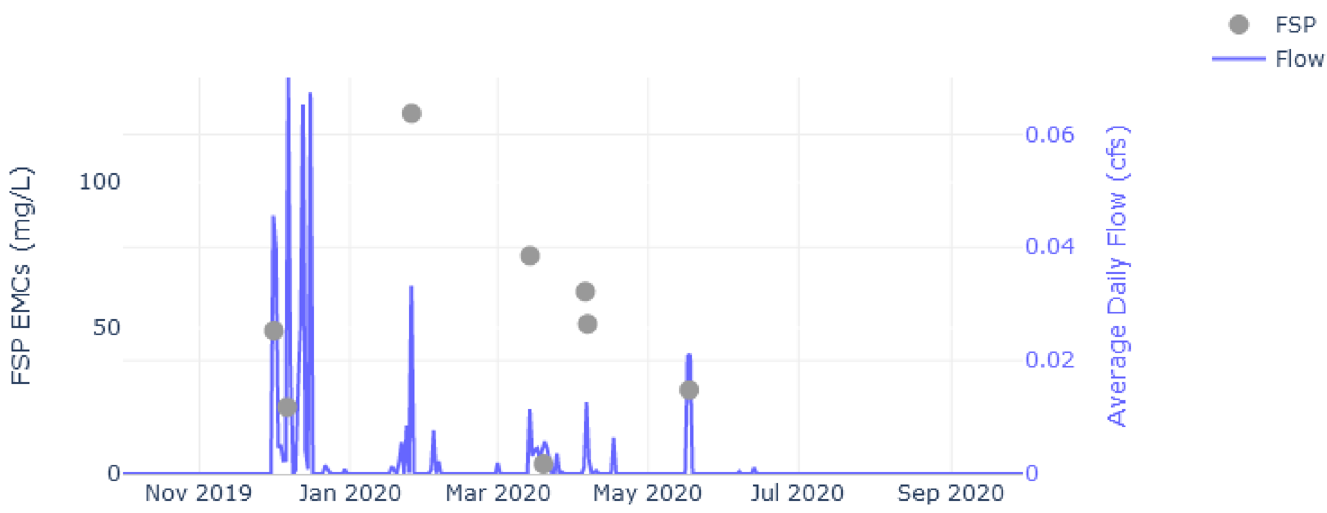

Figure 47 Daily flow and FSP EMC summary at the Tahoe City catchment outfall, WY20.

- Eight events were sampled for FSP (three in the fall/winter, five in the spring, and zero in the summer).
- The highest FSP EMC occurred during an event snowmelt on January 26, 2020.
- The highest FSP load occurred during the atmospheric river rain on snow event December 1-2, 2019.
- The lowest FSP EMC and load occurred during the non-event snowmelt from March 19-21, 2020.

Daily flow and the TN EMC summary are presented in Figure 48. Table 11 presents this data in tabular form. Table 11 also presents the load data referenced in some bullet points below.

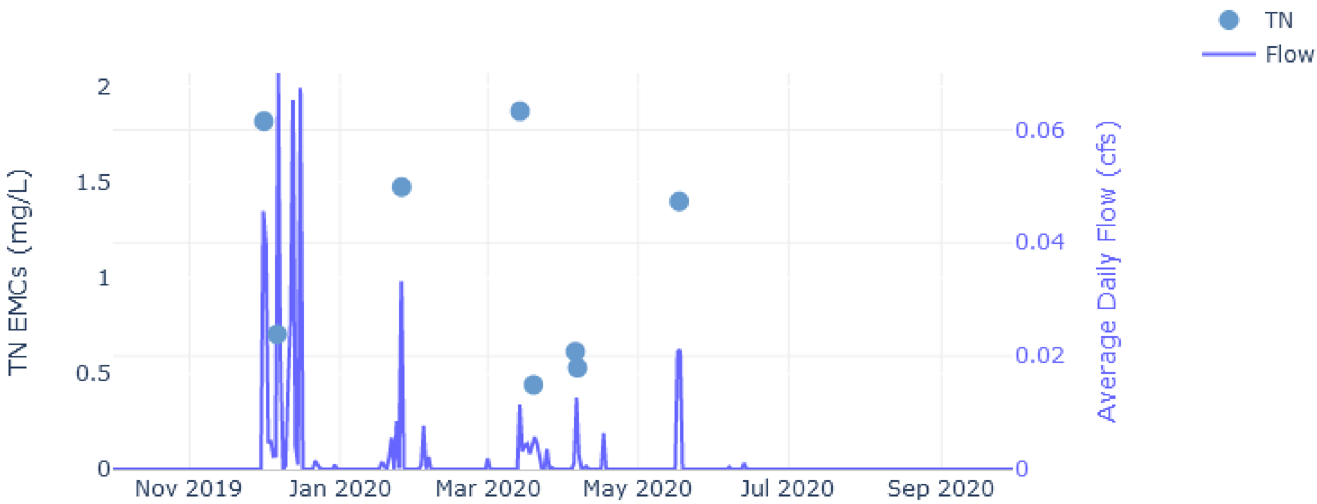

Figure 48 Daily flow and TN EMC summary at the Tahoe City catchment outfall, WY20.

- Eight events were sampled for TN (three in the fall/winter, five in the spring, and zero in the summer).
- The highest TN EMC occurred during the event snowmelt on March 14-17, 2020.
- The highest TN load occurred during the atmospheric river rain on snow event December 1-2, 2019.
- The lowest TN EMC occurred during the non-event snowmelt from March 19-21, 2020.
- The lowest TN load occurred during the event snowmelt on April 5, 2020.

Daily flow and the TP EMC summary are presented in Figure 49. Table 11 presents this data in tabular form. Table 11 also presents the load data referenced in some bullet points below.

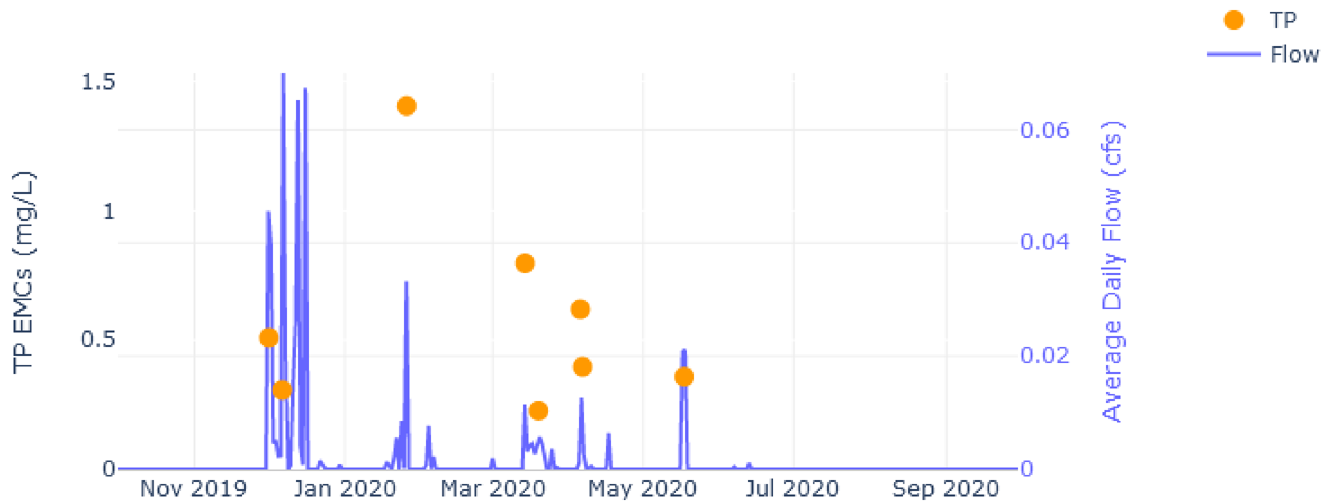

Figure 49 Daily flow and TP EMC summary at the Tahoe City catchment outfall, WY20.

- Eight events were sampled for TN (three in the fall/winter, five in the spring, and zero in the summer).
- The highest TP EMC and load occurred during the event snowmelt on January 26, 2020.
- The lowest TP EMC occurred during the non-event snowmelt on March 19-21, 2020.
- The lowest TP load occurred during the event snowmelt on April 5, 2020.

Seasonal load as a fraction of the water year load is presented in Figure 50. Event loads are presented in tabular form in Table 11.

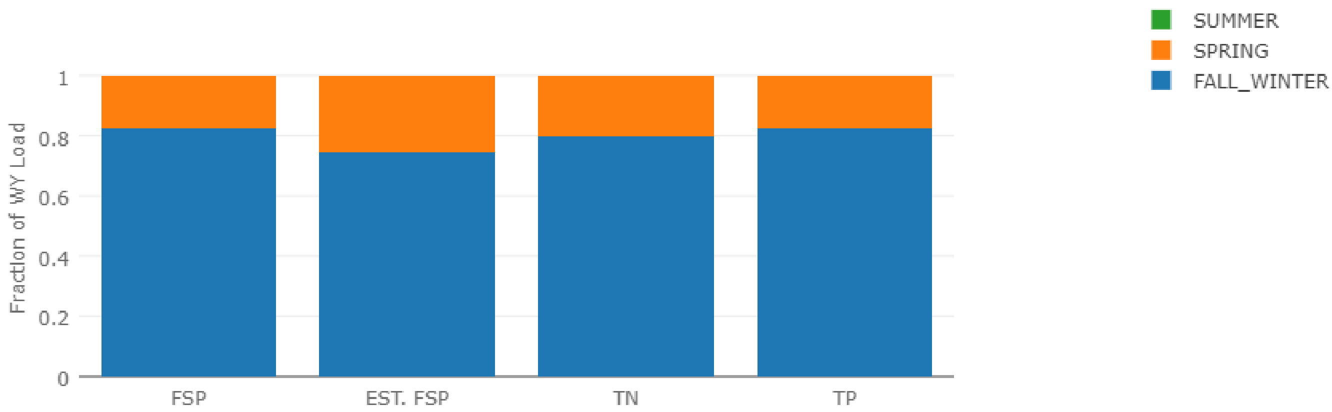

Figure 50 Seasonal load as a fraction of the water year load at the Tahoe City catchment outfall, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (FSP EST) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the fall/winter.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in the fall/winter.
- The largest fraction of TN loads was generated in the fall/winter.
- The largest fraction of TP loads was generated in the fall/winter.
- Summer produced a very small fraction of the load (not visible) because there was very little flow.

Eight events were sampled at Tahoe City in WY20. Event summary data is presented in Table 11.

Table 11 Event summary data at the Tahoe City catchment outfall, WY20.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TC	Fall/Winter	12/1/2019 5:15	12/2/2019 23:20	1010:00	7,373	0.15	677	2.62	Rain on snow	100%	49	23	1,819	0.8	509	0.2
TC	Fall/Winter	12/6/2019 13:45	12/8/2019 22:45	1368:00	7,847	0.23	287	1.22	Rain on snow	100%	23	11	706	0.3	307	0.2
TC	Fall/Winter	1/26/2020 1:20	1/26/2020 19:25	434:00	2,870	0.21	1,574	0.38	Event Snowmelt	100%	124	22	1,475	0.3	1,405	0.3
TC	Spring	3/14/2020 1:30	3/17/2020 21:45	2214:00	2,006	0.05	696	2.09	Event Snowmelt	100%	75	9	1,871	0.2	797	0.1
TC	Spring	3/19/2020 13:25	3/21/2020 19:55	1308:00	1,261	0.03	187	0.00	Non-event Snowmelt	100%	3	<0.1	442	<0.1	227	<0.1
TC	Spring	4/5/2020 12:45	4/5/2020 18:45	144:00	98	0.01	356	1.26	Event Snowmelt	100%	63	<0.1	615	<0.1	619	<0.1
TC	Spring	4/6/2020 9:45	4/7/2020 18:30	786:00	1,302	0.06	367	0.00	Post-event Snowmelt	100%	51	4	531	<0.1	397	<0.1
TC	Spring	5/17/2020 15:55	5/18/2020 14:50	550:00	3,617	0.30	403	0.72	Rain	100%	29	7	1,400	0.3	358	0.1

5.2.7 Tahoe Valley

Figure 51 shows the average daily flow and cumulative precipitation for WY20 at the Tahoe Valley catchment outfall.

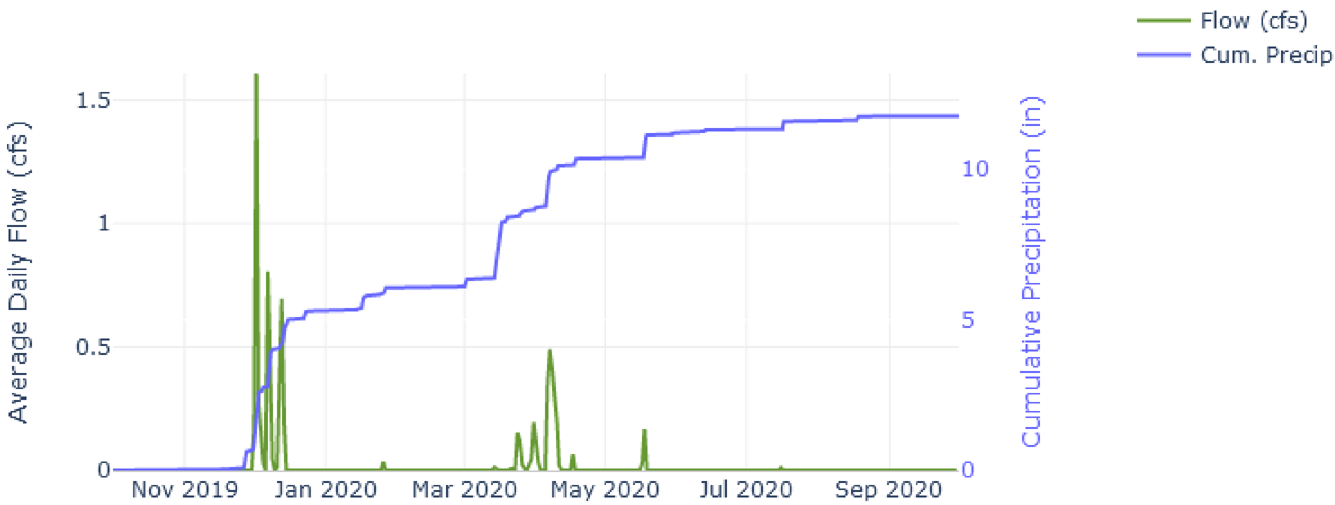

Figure 51 Average daily flow and cumulative precipitation at the Tahoe Valley catchment outfall, WY20.

- 11.78 inches of total precipitation (6.10 in the fall/winter, 5.12 in the spring, 0.56 in the summer) were recorded at the Raph's Shop (RAPH) weather station.
- 38 precipitation events occurred (15 fall/winter events, 15 spring events, 8 summer events).
- The largest storm, with 1.97 inches of precipitation, occurred during an atmospheric river rain and snow event from November 29, 2019 to December 2 2019.
- 79% of storms were less than half an inch.
- Highest average daily flows occurred during the November 30, 2019 to December 2, 2019 atmospheric river rain on snow event.
- 29 days of continuous and intermittent snowmelt runoff occurred in the fall/winter and spring.
- The highest instantaneous peak precipitation was 0.05 inches in 5 minutes during a thunderstorm event on July 16, 2020.
- The highest instantaneous peak flow (3.5 cfs) occurred on December 2, 2019 during an atmospheric river rain and snow event.
- The most event runoff was generated by the November 29, 2019 to December 2, 2019 atmospheric river rain on snow event (168,689 cf).

Daily flow and the FSP EMC summary at Tahoe Valley are presented in Figure 52. Table 12 presents this data in tabular form. Table 12 also presents the load data referenced in some bullet points below.

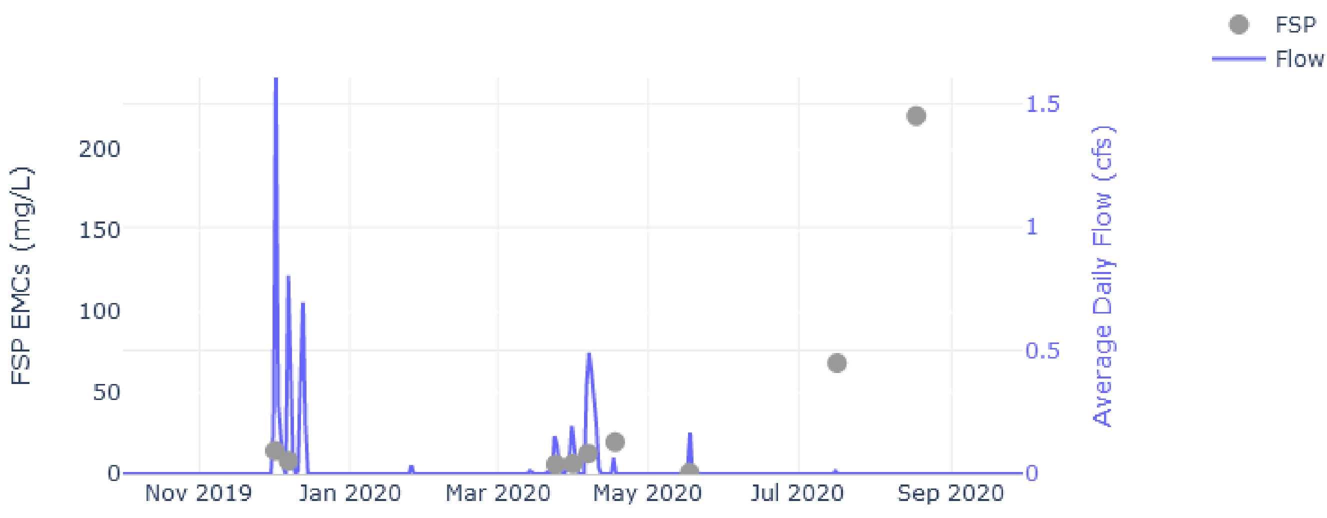

Figure 52 Daily flow and FSP EMC summary at the Tahoe Valley catchment outfall, WY20.

- Nine events were sampled for FSP (two in the fall/winter, five in the spring, and two in the summer).
- The highest FSP EMC occurred during the thunderstorm event on August 17, 2020.
- The highest FSP load occurred during the atmospheric river rain on snow event from December 1-3, 2019.
- The lowest FSP EMC and load occurred during the rain event on May 17-18, 2020.

Daily flow and the TN EMC summary at Tahoe Valley are presented in Figure 53. Table 12 presents this data in tabular form. Table 12 also presents the load data referenced in some bullet points below.

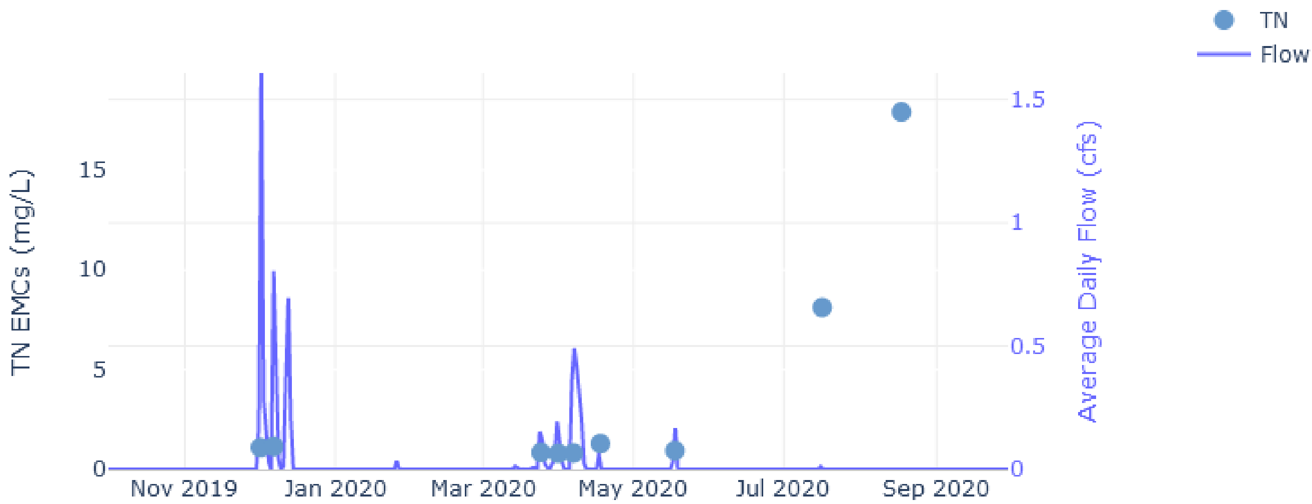

Figure 53 Daily flow and TN EMC summary at the Tahoe Valley catchment outfall, WY20.

- Nine events were sampled for TN (two in the fall/winter, five in the spring, and two in the summer).
- The highest TN EMC occurred during the thunderstorm event on August 17, 2020.
- The highest TN load occurred during the atmospheric river rain on snow event from December 1-3, 2019.
- The lowest TN EMC occurred during the rain on snow event March 31, 2020.
- The lowest TN load occurred during the rain event on April 17, 2020.

Daily flow and the TP EMC summary at Tahoe Valley are presented in Figure 54. Table 12 presents this data in tabular form. Table 12 also presents the load data referenced in some bullet points below.

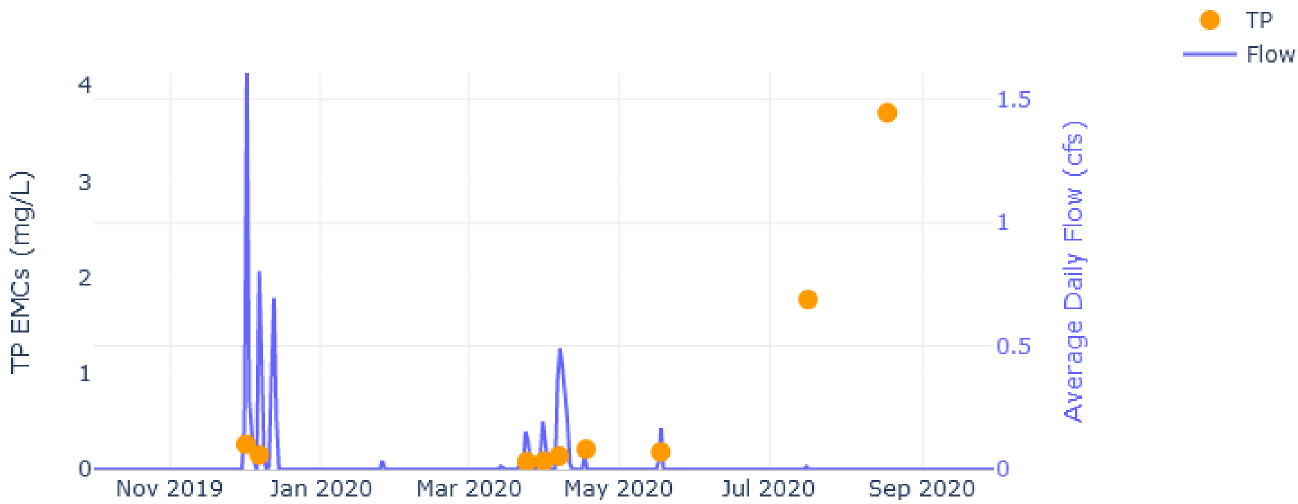

Figure 54 Daily flow and TP EMC summary at the Tahoe Valley catchment outfall, WY20.

- Nine events were sampled for TP (two in the fall/winter, five in the spring, and two in the summer).
- The highest TP EMC occurred during the thunderstorm event on August 17, 2020.
- The highest TP load occurred during the atmospheric river rain on snow event from December 1-3, 2019.
- The lowest TP EMC occurred during the spring snowmelt from March 24-26, 2020.
- The lowest TP load occurred during the rain event on April 17, 2020.

Seasonal load as a fraction of the water year load at Tahoe Valley is presented in Figure 55. Event loads are presented in tabular form in Table 12.

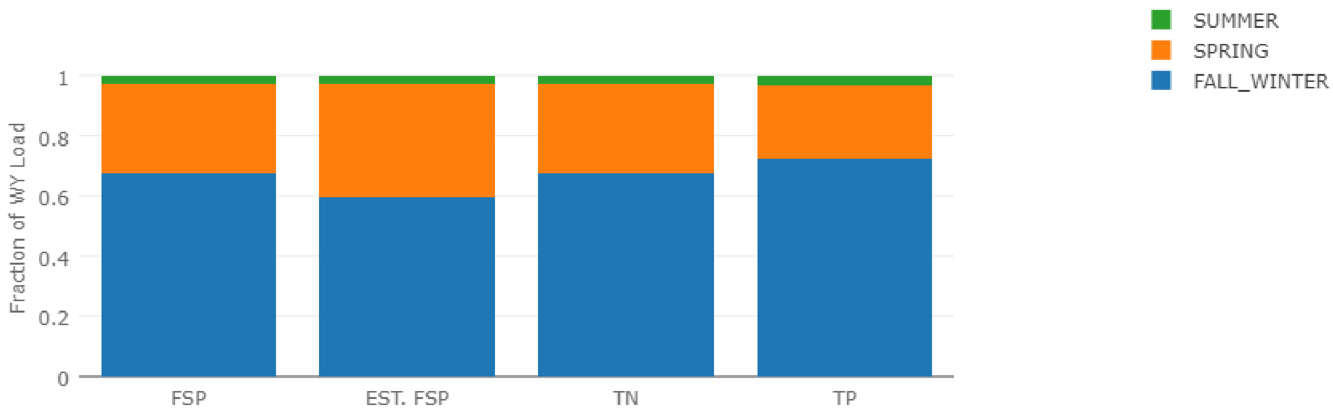

Figure 55 Seasonal load as a fraction of the water year load at the Tahoe Valley catchment outfall, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads was generated in the fall/winter.
- The largest fraction of TN loads was generated in the fall/winter
- The largest fraction of TP loads was generated in the fall/winter.
- Very small fractions of FSP, TN, and TP were generated in the summer.

Nine events were sampled at Tahoe Valley in WY20. Event summary data is presented in Table 12.

Table 12 Event summary data at the Tahoe Valley catchment outfall, WY20.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TV	Fall/Winter	12/1/2019 8:10	12/3/2019 11:20	1228:00	168,762	3.36	614	1.97	Rain on snow	100%	14	151	1,096	11.5	261	2.7
TV	Fall/Winter	12/7/2019 0:55	12/8/2019 12:20	850:00	87,448	1.71	658	1.27	Rain on snow	100%	8	44	1,151	6.3	150	0.8
TV	Spring	3/24/2020 0:40	3/26/2020 7:15	1310:00	25,058	0.39	3	0.14	Event Snowmelt	100%	6	9	849	1.3	81	0.1
TV	Spring	3/31/2020 5:10	3/31/2020 22:25	414:00	15,697	0.57	472	0.11	Rain on snow	100%	6	6	802	0.8	84	0.1
TV	Spring	4/6/2020 8:55	4/7/2020 22:25	900:00	72,450	1.15	625	1.21	Event Snowmelt	100%	13	57	819	3.7	141	0.6
TV	Spring	4/17/2020 14:30	4/17/2020 22:20	188:00	5,522	0.33	473	0.24	Rain	100%	20	7	1,294	0.4	211	0.1
TV	Spring	5/17/2020 15:50	5/18/2020 17:00	604:00	17,015	0.88	619	0.72	Rain	100%	1	1	940	1.0	182	0.2
TV	Summer	7/16/2020 14:05	7/16/2020 15:15	28:00	983	0.52	954	0.26	Thunderstorm	100%	68	4	8,120	0.5	1,772	0.1
TV	Summer	8/17/2020 17:10	8/17/2020 17:45	14:00	457	0.48	604	0.12	Thunderstorm	100%	221	6	17,916	0.5	3,719	0.1

5.2.8 Tahoma

Figure 56 shows the average daily flow and cumulative precipitation for WY20 at the Tahoma catchment outfall.

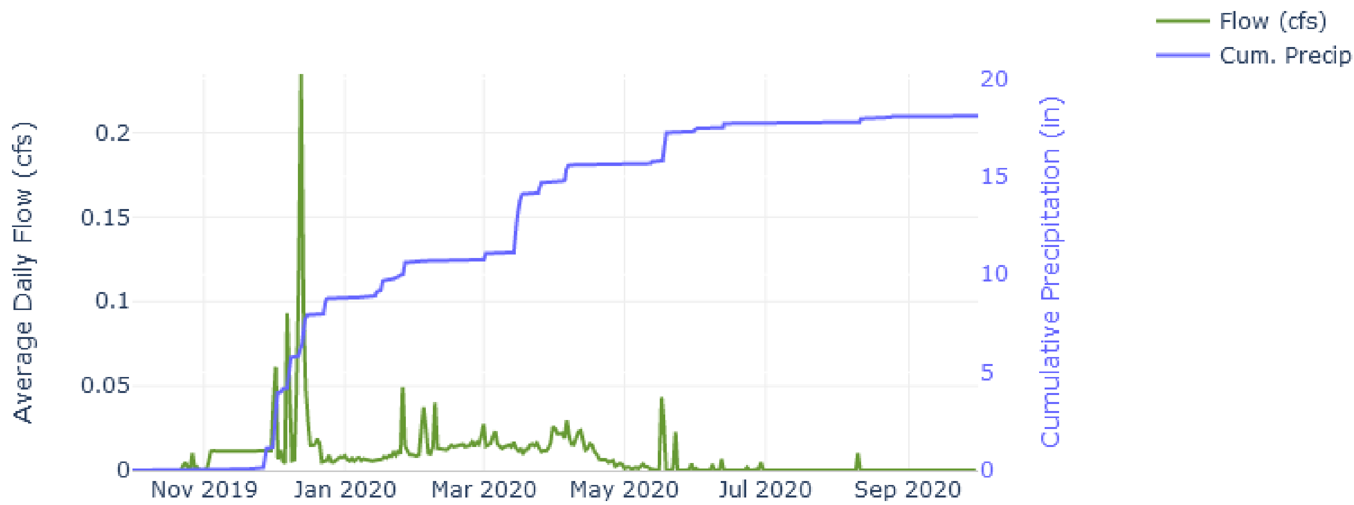

Figure 56 Average daily flow and cumulative precipitation at the Tahoma catchment outfall, WY20.

- 18.08 inches of total precipitation (10.70 in the fall/winter, 6.68 in the spring, 0.70 in the summer) were recorded at the El Dorado County Yard (EDCY) weather station.
- 42 precipitation events occurred (20 fall/winter events, 14 spring events, 8 summer events).
- The largest storm, with 3 inches of precipitation, occurred during a snow event from March 14-17, 2020.
- 74% of storms were less than half an inch.
- Highest average daily flows occurred during the December 11-16, 2019 rain and snow event.
- 14 days of continuous snowmelt runoff occurred in the spring and summer. The summer snowmelt was due to a late season post-event snowmelt on June 8, 2020.
- The highest instantaneous peak precipitation was 0.03 inches in 5 minutes during the rain on snow event on January 24, 2020.
- The highest instantaneous peak flow was 0.84 cfs during the rain event on May 17, 2020.
- The December 11-15, 2019 rain and snow event produced the most runoff in a single event (49,427 cf).

Daily flow and the FSP EMC summary at Tahoma are presented in Figure 57. Table 13 presents this data in tabular form. Table 13 also presents the load data referenced in some bullet points below.

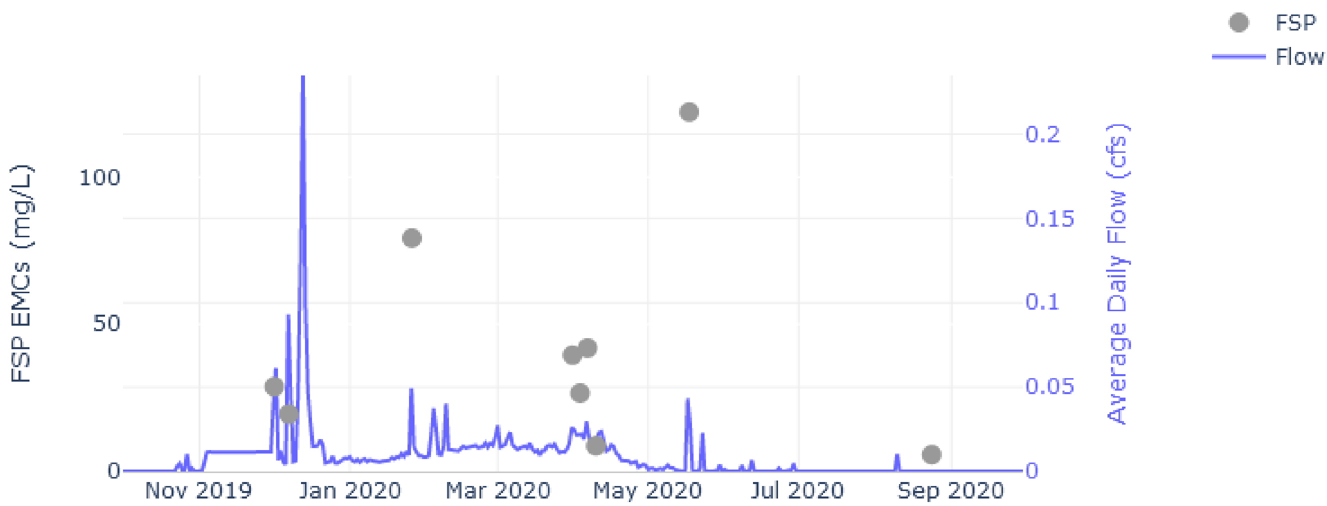

Figure 57 Daily flow and FSP EMC summary at the Tahoma catchment outfall, WY20.

- Nine events were sampled for FSP (three in the fall/winter, five in the spring, and one in the summer).
- The highest FSP EMC and load occurred during the rain event on May17-18, 2020.
- The lowest FSP EMC and load occurred during the thunderstorm event on August 24, 2020.

Daily flow and the TN EMC summary at Tahoma are presented in Figure 58. Table 13 presents this data in tabular form. Table 13 also presents the load data referenced in some bullet points below.

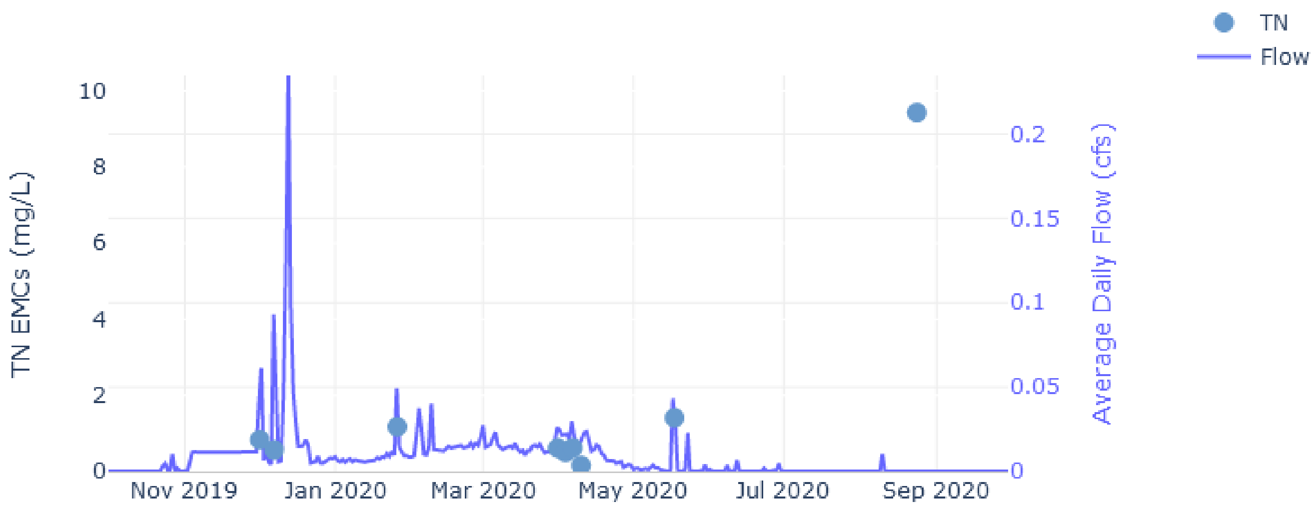

Figure 58 Daily flow and TN EMC summary at the Tahoma catchment outfall, WY20.

- Nine events were sampled for TN (three in the fall/winter, five in the spring, and one in the summer).
- The highest TN EMC occurred during the thunderstorm event on August 24, 2020.
- The highest TN load occurred during the rain event on May 17-18, 2020.
- The lowest TN EMC occurred during the post-event snowmelt from April 9-15, 2020.
- The lowest TN load occurred during the thunderstorm event on August 24, 2020.

Daily flow and the TP EMC summary at Tahoma are presented in Figure 59. Table 13 presents this data in tabular form. Table 13 also presents the load data referenced in some bullet points below.

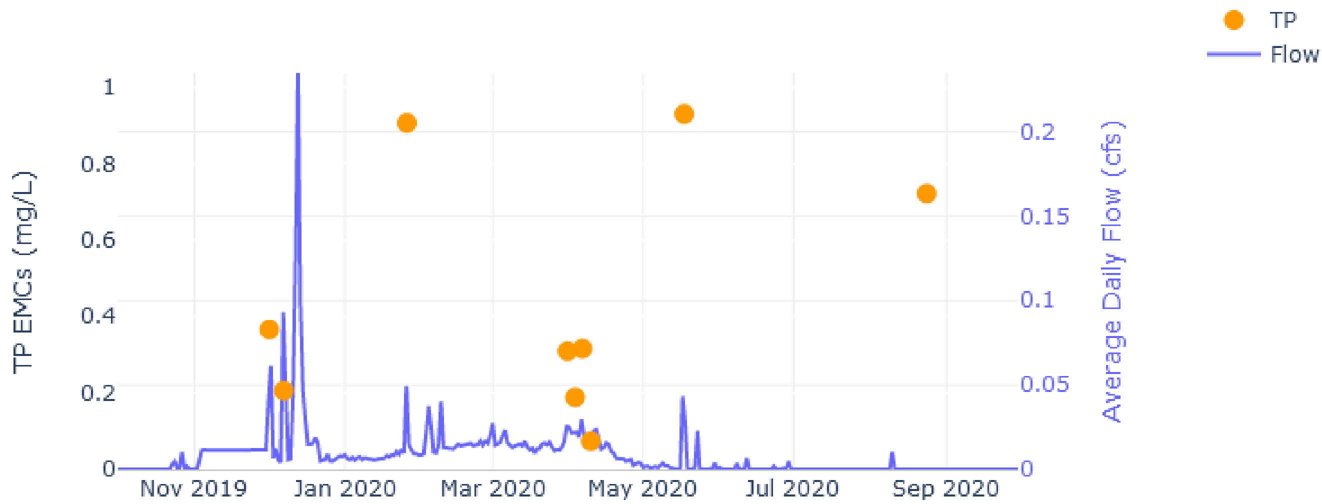

Figure 59 Daily flow and TP EMC summary at the Tahoma catchment outfall, WY20.

- Nine events were sampled for TP (three in the fall/winter, five in the spring, and one in the summer).
- The highest TP EMC and load occurred during the rain event on May 17-18, 2020.
- The lowest TP EMC occurred during the post-event snowmelt from April 9-15, 2020.
- The lowest TP load occurred during the thunderstorm event on August 24, 2020.

Seasonal load as a fraction of the water year load at Tahoma is presented in Figure 60. Event loads are presented in tabular form in Table 13.

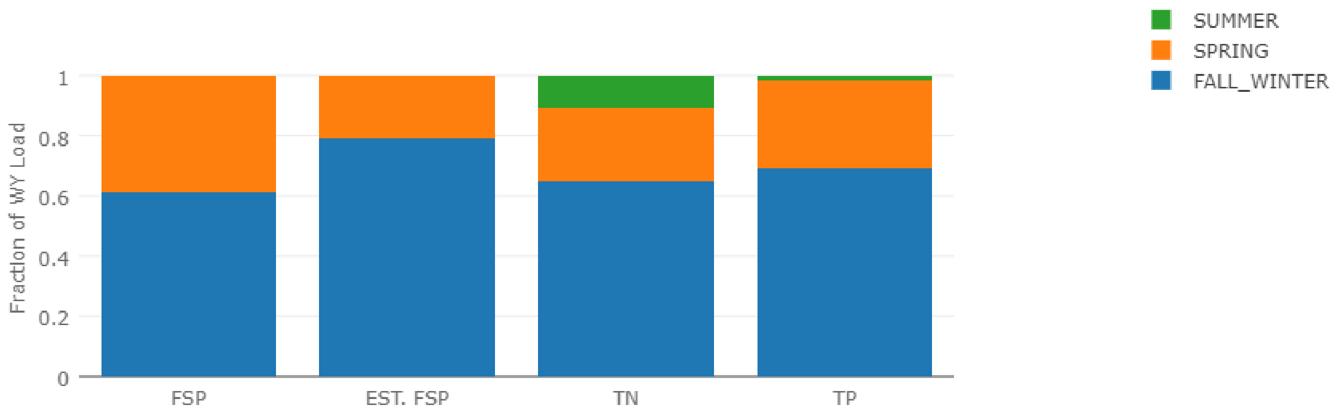

Figure 60 Seasonal load as a fraction of the water year load at the Tahoma catchment outfall, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads was generated in the fall/winter.
- The largest fraction of TN loads was generated in the fall/winter.
- The largest fraction of TP loads was generated in the fall/winter.
- Very small fractions of TP were generated in the summer.
- The fraction of FSP generated in the summer was negligible and is not visible.

Nine events were sampled at Tahoma in WY20. Event summary data is presented in Table 13.

Table 13 Event summary data at the Tahoma catchment outfall, WY20.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TA	Fall/Winter	12/1/2019 3:05	12/2/2019 20:05	984:00	8,426	0.18	589	2.78	Rain on snow	100%	29	15	834	0.4	366	0.2
TA	Fall/Winter	12/7/2019 2:45	12/8/2019 6:20	662:00	8,905	0.37	227	1.61	Rain on snow	100%	20	11	566	0.3	206	0.1
TA	Fall/Winter	1/26/2020 1:30	1/26/2020 15:45	342:00	3,734	0.23	204	0.66	Rain on snow	100%	79	18	1,174	0.3	907	0.2
TA	Spring	3/31/2020 7:15	4/2/2020 0:25	988:00	3,983	0.07	67	0.06	Rain on snow	100%	40	10	615	0.2	310	0.1
TA	Spring	4/3/2020 8:40	4/5/2020 18:00	1376:00	4,570	0.06	3	0.00	Non-event Snowmelt	100%	27	8	502	0.1	189	0.1
TA	Spring	4/6/2020 8:35	4/8/2020 20:25	1436:00	5,123	0.10	121	0.84	Event Snowmelt	100%	42	13	620	0.2	316	0.1
TA	Spring	4/9/2020 17:50	4/15/2020 10:45	3286:00	9,188	0.10	34	0.00	Post-event Snowmelt	100%	9	5	156	0.1	74	<0.1
TA	Spring	5/17/2020 10:55	5/18/2020 21:15	824:00	6,055	0.54	1,040	1.47	Rain	100%	122	46	1,411	0.5	930	0.4
TA	Summer	8/24/2020 0:05	8/24/2020 2:55	68:00	41	0.02	1	0.10	Thunderstorm	100%	6	<0.1	9,429	<0.1	722	<0.1

5.2.9 Upper Truckee

Figure 61 shows the average daily flow and cumulative precipitation for WY20 at the Upper Truckee catchment outfall.

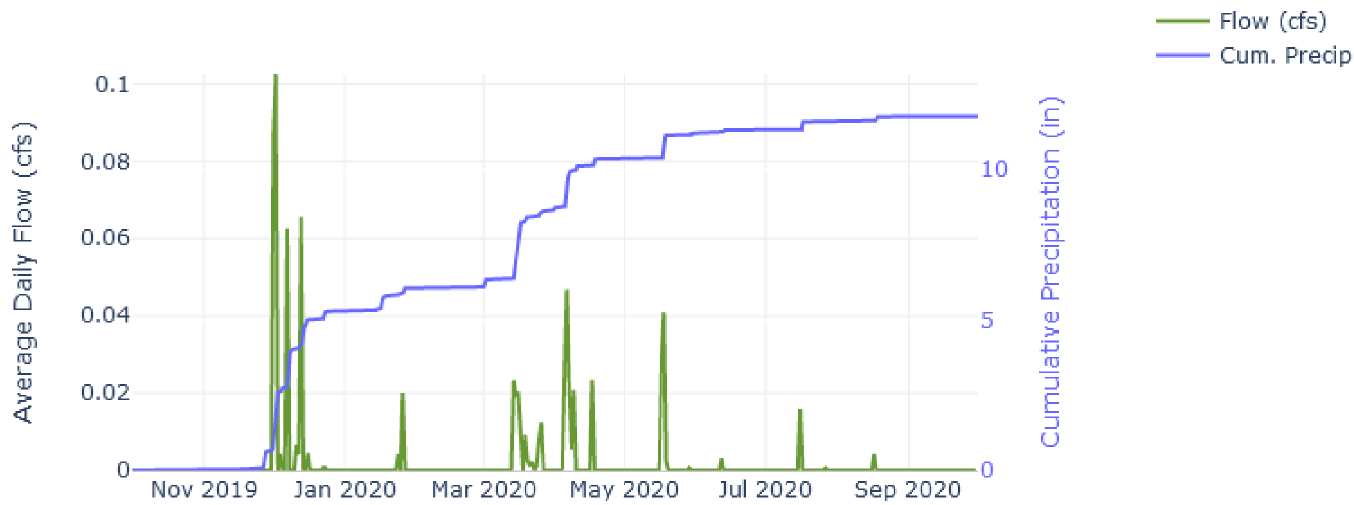

Figure 61 Average daily flow and cumulative precipitation at the Upper Truckee catchment outfall, WY20.

- 11.78 inches of total precipitation (6.10 in the fall/winter, 5.12 in the spring, 0.56 in the summer) were recorded at the Raph's Shop (RAPH) weather station.
- 38 precipitation events occurred (15 fall/winter events, 15 spring events, 8 summer events).
- The largest storm, with 1.97 inches of precipitation, occurred during an atmospheric river rain and snow event from November 29, 2019 to December 2 2019.
- 79% of storms were less than half an inch.
- Highest average daily flows occurred in during the November 30, 2019 to December 2, 2019 atmospheric river rain on snow event.
- 17 days of intermittent snowmelt runoff occurred in the fall/winter and spring.
- The highest instantaneous peak precipitation was 0.05 inches in 5 minutes during a thunderstorm event on July 16, 2020.
- The highest instantaneous peak flow was 0.99 cfs during thunderstorm event on July 16, 2020.
- November 30, 2019 to December 2, 2019 atmospheric river rain on snow event produced the most runoff (16,407 cf).

Daily flow and the FSP EMC summary at Upper Truckee are presented in Figure 62. Table 14 presents this data in tabular form. Table 14 also presents the load data referenced in some bullet points below.

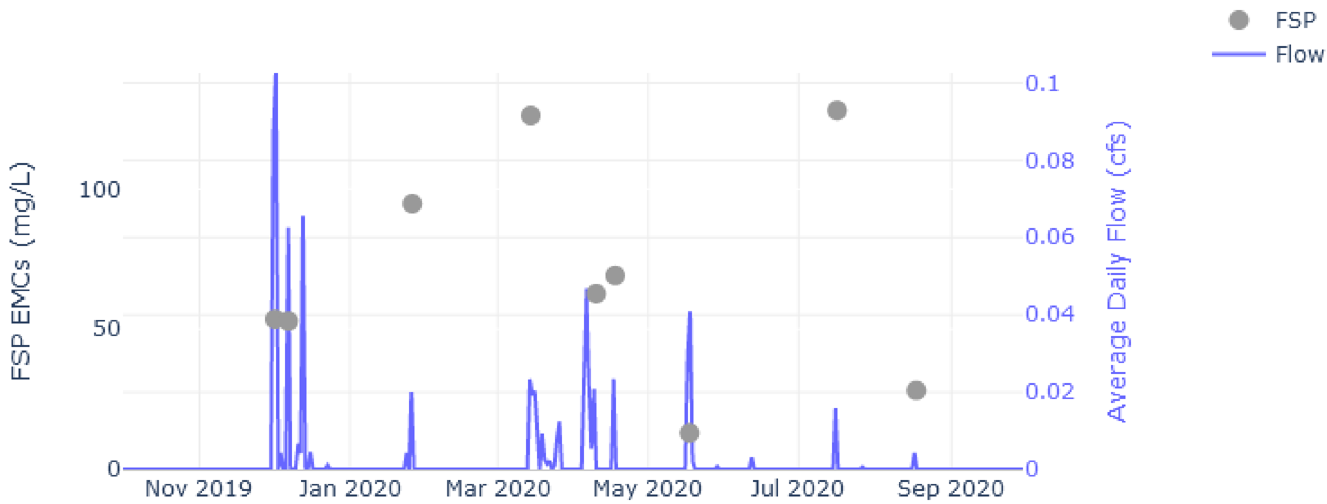

Figure 62 Daily flow and FSP EMC summary at the Upper Truckee catchment outfall, WY20.

- Nine events were sampled for FSP (three in the fall/winter, four in the spring, and two in the summer).
- The highest FSP EMC occurred during the summer thunderstorm event on July 16, 2020.
- The highest FSP load occurred during the atmospheric river rain on snow event from December 1-2, 2019.
- The lowest FSP EMC occurred during the May 17-18, 2020 rain event.
- The lowest FSP load occurred during the thunderstorm event on August 17, 2020.

Daily flow and the TN EMC summary at Upper Truckee are presented in Figure 63. Table 14 presents this data in tabular form. Table 14 also presents the load data referenced in some bullet points below.

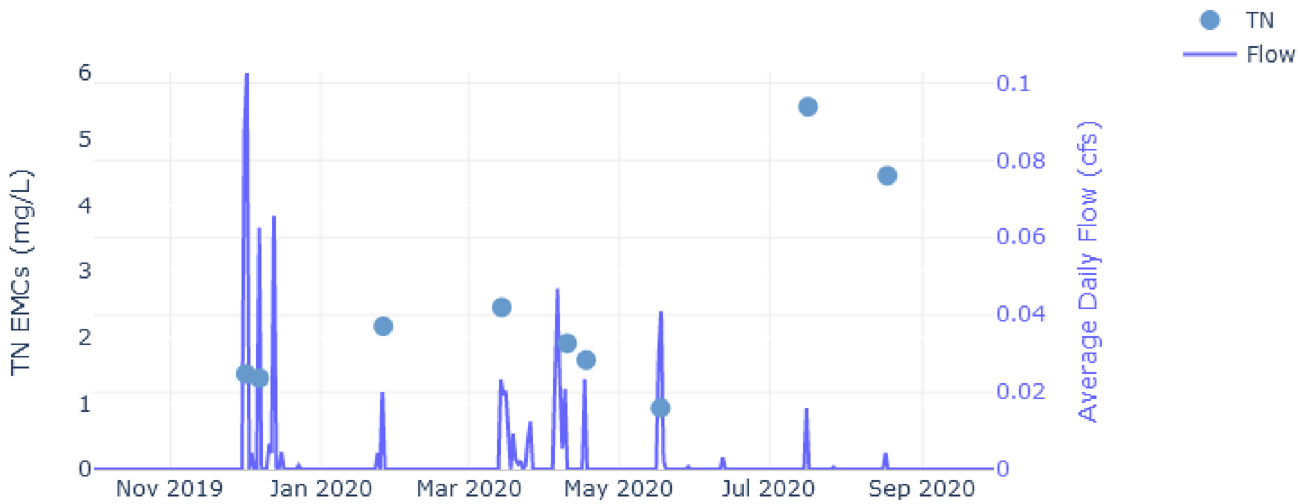

Figure 63 Daily flow and TN EMC summary at the Upper Truckee catchment outfall, WY20.

- Nine events were sampled for TN (three in the fall/winter, four in the spring, and two in the summer).
- The highest TN EMC occurred during a thunderstorm event on July 16, 2020.
- The highest TN load occurred during the atmospheric river rain on snow event from December 1-2, 2019.
- The lowest TN EMC occurred during the May 17-18, 2020 rain event.
- The lowest TN load occurred during the thunderstorm event on August 17, 2020.

Daily flow and the TP EMC summary at Upper Truckee are presented in Figure 64. Table 14 presents this data in tabular form. Table 14 also presents the load data referenced in some bullet points below.

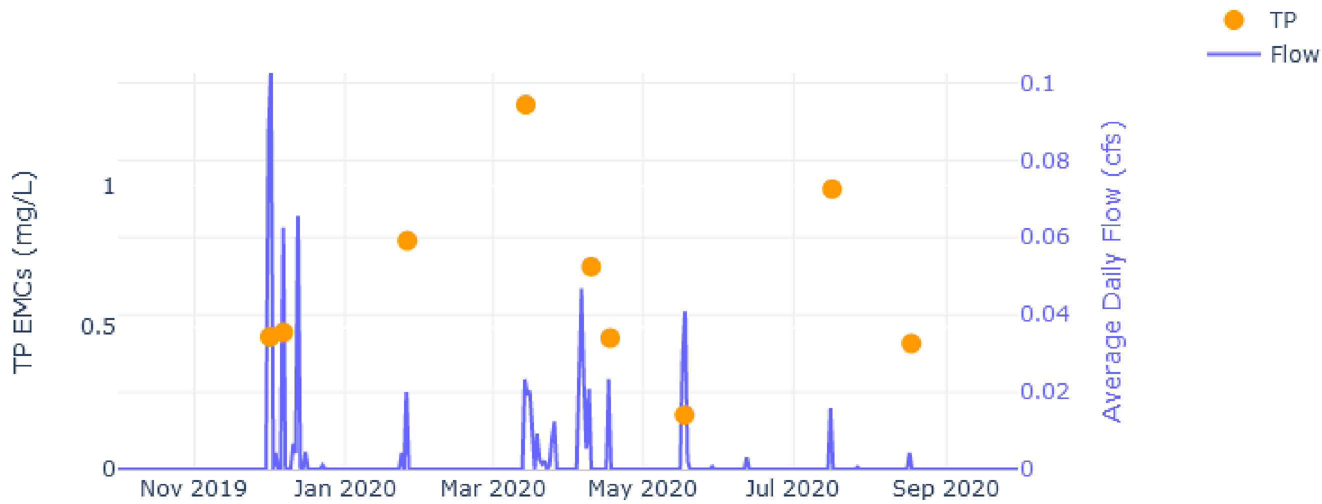

Figure 64 Daily flow and TP EMC summary at the Upper Truckee catchment outfall, WY20.

- Nine events were sampled for TP (three in the fall/winter, four in the spring, and two in the summer).
- The highest TP EMC occurred during an event snowmelt on March 14-16, 2020.
- The highest TP load occurred during the atmospheric river rain on snow event from December 1-2, 2019.
- The lowest TP EMC occurred during the May 17-18, 2020 rain event.
- The lowest TP load occurred during the thunderstorm event on August 17, 2020.

Seasonal load as a fraction of the water year load at Upper Truckee is presented in Figure 65. Event loads are presented in tabular form in Table 14.

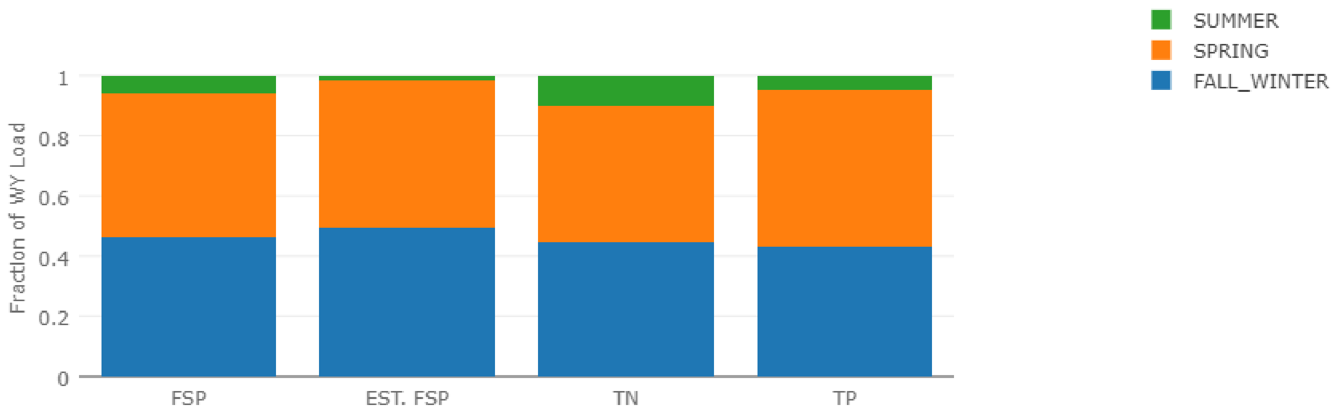

Figure 65 Seasonal load as a fraction of the water year load at the Upper Truckee catchment outfall, WY20. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples and turbidity) was pretty evenly split between fall/winter and spring,
- The largest fraction FSP load (based on samples) was generated in the spring.
- The largest fraction of FSP load (based on turbidity) was generated in the fall/winter.
- The largest fraction of TN loads was evenly split between fall/winter (0.45) and spring (0.45).
- The largest fraction of TP loads was generated in the spring.
- Summer produced the smallest fraction of the load for FSP, TN, and TP.

Nine events were sampled at Upper Truckee in WY20. Event summary data is presented in Table 14.

Table 14 Event summary data at the Upper Truckee catchment outfall, WY20.

Station Acronym	Season	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Runoff Volume (cf)	Peak Flow (cfs)	Peak Turb (NTU)	Storm Total (in)	Event Type	% of Storm Sampled	FSP EMC (mg/L)	FSP event load (lbs)	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
UT	Fall/Winter	12/1/2019 13:20	12/2/2019 16:35	654:00	16,407	0.37	686	1.97	Rain on snow	100%	54	55	1,447	1.5	467	0.5
UT	Fall/Winter	12/7/2019 1:55	12/7/2019 19:45	428:00	5,408	0.38	316	0.68	Rain on snow	100%	53	18	1,383	0.5	483	0.2
UT	Fall/Winter	1/26/2020 7:25	1/26/2020 12:05	112:00	1,734	0.23	498	0.20	Event Snowmelt	100%	95	10	2,168	0.2	806	0.1
UT	Spring	3/14/2020 8:50	3/16/2020 17:50	1368:00	5,426	0.25	856	1.68	Event Snowmelt	100%	126	43	2,455	0.8	1,285	0.4
UT	Spring	4/9/2020 20:55	4/10/2020 0:20	82:00	1,829	0.37	233	0.17	Rain on snow	100%	63	7	1,910	0.2	715	0.1
UT	Spring	4/17/2020 14:55	4/17/2020 22:10	174:00	2,026	0.30	193	0.24	Rain	100%	69	9	1,657	0.2	463	0.1
UT	Spring	5/17/2020 19:10	5/18/2020 12:05	406:00	6,093	0.47	219	0.72	Rain	100%	13	5	930	0.4	192	0.1
UT	Summer	7/16/2020 14:30	7/16/2020 16:35	50:00	1,366	0.76	151	0.26	Thunderstorm	100%	128	11	5,492	0.5	988	0.1
UT	Summer	8/17/2020 17:35	8/17/2020 19:20	42:00	371	0.17	931	0.12	Thunderstorm	100%	28	1	4,449	0.1	444	<0.1

6. Data Analysis

The raw hydrologic data set includes stage, velocity (at select sites), flow (determined by an equation relating stage in a weir, flume or pipe, or stage and velocity in a pipe to flow), and turbidity recorded every 5 minutes throughout the water year. Data gaps are short and rare. Erroneous readings are corrected and data gaps are filled following protocols outlined in the RSWMP FIG sections 10.2.1.7 for flow and 10.2.2.5 for turbidity.

Seasonal and annual volumes are calculated by the DMS in accordance with RSWMP FIG sections 10.2.1.8 and 10.2.1.9. Results from lab analysis are used by the DMS to calculate a flow-weighted event mean concentration (EMC) as outlined in section 10.2.1.10 of the RSWMP FIG. The DMS groups EMCs by season and calculates a seasonal characteristic pollutant concentration for each site; the DMS then applies these concentrations to each hydrologic measurement for that season. The DMS calculates loads by summing concentrations multiplied by runoff volumes over time as outlined in section 10.1.2.11 of the RSWMP FIG. Turbidity is converted to FSP concentration (in both mass per liter and number of particles per liter) using equations relating turbidity to FSP (2NDNATURE et al 2014) and integrated over time to calculate seasonal and annual load estimates in pounds and number of particles (RSWMP FIG sections 10.2.2.6 and 10.2.2.7). Rainfall normalized seasonal and annual trends are calculated for catchments with at least five years of continuous data according to protocols outlined in the RSWMP FIG section 10.4.3.

Raw meteorological data include a precipitation and a temperature reading every 5 or 10 minutes (depending on the station) throughout the water year. Precipitation occurring as snow is converted to inches of water by a heated tipping bucket at the meteorological station that melts falling snow upon contact with the device. Data is QAQC'd by comparing event, seasonal and annual totals to the closest neighboring meteorological station. Data gaps are rare, but are filled with data from a neighboring station when they occur (RSWMP FIG section 10.2.3.4). The DMS calculates seasonal and annual precipitation totals for reporting purposes.

7. BMP Effectiveness Monitoring

7.1 SR431

Data collected from matched inflow and outflow sampling at the Contech MFS stormwater cartridge filter vault and at the Jellyfish stormwater cartridge filter vault at SR431 have historically shown variable removal efficiencies for sediment and nutrients. The variability is due, in large part, to system maintenance or lack thereof. Below is a summary of the maintenance that occurred during WY20. No maintenance was done until the spring, however, in July of 2019, a few months before the beginning of WY20, the system was completely cleaned, and all filters in both vaults were replaced.

- On May 13 and 21, 2020, NDOT crews rinsed and vactored sediment from the splitter chamber, all flumes, and both vaults. Inflow pipes were not cleaned.
- On June 17, 2020, Tahoe RCD staff rinsed both inflow pipes but they were not vactored. The mobilized sediment continued through the rest of the system.
- On October 19, 2020, installation of a pretreatment chamber was complete. The purpose of the pretreatment chamber is to capture bulk sediment, trash and debris so that existing media filtration systems will no longer be overwhelmed with coarse sediment and will more effectively treat fine sediment.

Table 15 presents the seasonal and annual summary data on load removal efficiency for each treatment vault at SR431 in WY20 based on samples taken during sampled events (FSP, TN, TP) and continuous turbidity (estimated FSP).

Table 15 Seasonal and annual efficiency data from the Contech MFS and Jellyfish vaults at SR431, WY20.

Water Year 2020 (October 1, 2019 - September 30, 2020)			Seasonal FSP Loads (lbs)			Total Annual FSP Loads (lbs)	Estimated Seasonal FSP Loads (lbs)			Estimated Total Annual FSP Loads (lbs)	Seasonal TN Loads (lbs)			Total Annual TN Loads (lbs)	Seasonal TP Loads (lbs)			Total Annual TP Loads (lbs)
Catchment Name	Station Name	Station Acronym	Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)		Fall/Winter (Oct1-Feb28)	Spring (Mar1-May31)	Summer (Jun1-Sep30)	
SR431	Contech In	CI	74.4	97.3	47.5	219.2	13.1	23.7	15.4	52.2	0.30	0.54	0.86	1.70	0.51	0.63	0.34	1.48
	Contech Out	CO	0.0	0.0	29.0	29.0	1.8	0.1	10.9	12.8	0.00	0.00	0.08	0.08	0.00	0.00	0.04	0.04
		Load Reduction	74.4	97.3	18.5	190.2	11.3	23.6	4.5	39.4	0.30	0.54	0.79	1.62	0.51	0.63	0.31	1.45
		% Change	-100%	-100%	-39%	-87%	-86%	-99%	-29%	-75%	-100%	-100%	-91%	-96%	-100%	-100%	-90%	-98%
SR431	Jellyfish In	JI	57.9	158.0	34.9	250.7	14.1	3.7	14.8	32.6	0.26	0.62	0.75	1.63	0.43	0.95	0.26	1.65
	Jellyfish Out	JO	27.9	42.0	3.3	73.3	17.4	10.5	15.7	43.6	0.18	0.28	0.15	0.61	0.17	0.27	0.03	0.47
		Load Reduction	30.0	115.9	31.6	177.4	-3.2	-6.8	-0.9	-10.9	0.08	0.34	0.61	1.02	0.26	0.68	0.23	1.18
		% Change	-52%	-73%	-91%	-71%	23%	184%	6%	34%	-29%	-54%	-80%	-62%	-60%	-72%	-89%	-72%

- The Contech MFS reduced annual FSP loads by 87% and 75% (based on samples and estimated from continuous turbidity respectively).
- The Contech MFS annual load reductions were greater than 75% for all pollutants.
- The Contech MFS reduced all seasonal loads based on samples by 100% in the fall/winter and spring because there was not enough outflow from the vault during those two seasons to sample effectively. Estimated FSP loads during fall/winter and spring are correspondingly high because flows were very low.
- The Contech MFS reduced seasonal FSP and estimated FSP loads during the summer by 39% and 29% respectively.
- The Contech MFS reduced seasonal TN and TP loads during the summer by 91% and 90% respectively.
- The Jellyfish reduced annual FSP loads by 71% (based on samples). However, annual FSP loads estimated from continuous turbidity show a 34% increase. This may indicate that the turbidimeter at the outflow (JO) was inundated by sediment.
- The Jellyfish reduced annual TN loads by 62%. The greatest TN reduction efficiency occurred in the summer at 80%.
- The Jellyfish reduced annual TP loads by 72%. The greatest TP reduction efficiency occurred in the summer at 89%.
- The Contech MFS appears to be more efficient than the Jellyfish at reducing all pollutants in WY20. However, there was very little outflow from the Contech MFS, which gives the impression of 100% efficiency. (The capacity of the Contech MFS vault is approximately 3,000 cf while the capacity of the Jellyfish is approximately 100 cf.) Additionally, only one event was sampled during each season at the Contech MFS, and of those, only the summer event outflowed. Thus, no definitive conclusion can be made about which vault was most effective at reducing pollutants in WY20.

Table 16 presents the efficiency of the Contech MFS at reducing concentrations and loads of all three pollutants for the individual events sampled in WY20. Only one event (July 20, 2020) was successfully sampled at the Contech MFS outflow in WY20 because there was very little flow during the year.

Table 16 Event efficiency data from the Contech MFS vault at SR431, WY20.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration			FSP Load (lbs)			TN Concentration			TN Load (lbs)			TP Concentration			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
1/1/2020	5%	1,760	na	-100%	18	na	-100%	7,042	na	-100%	0.07	na	-100%	12,031	na	-100%	0.12	na	-100%
3/14/2020	19%	981	na	-100%	41	na	-100%	5,408	na	-100%	0.22	na	-100%	6,366	na	-100%	0.26	na	-100%
7/20/2020	23%	587	591	1%	30	24	-21%	10,660	1,540	-86%	0.55	0.06	-89%	4,254	732	-83%	0.22	0.03	-87%

- Concentration and load reductions efficiencies of 100% for the January 1, 2020 and March 14, 2020 events are due to the fact that there was no outflow from the Contech MFS vault for those events.
- The July 20, 2020 event showed a load reduction for FSP of 21% despite a 1% increase in concentration because outflow volumes were very low.
- The July 20, 2020 event showed load reductions for TN and TP of 89% and 87% respectively.

Contech MFS vault water level and bypass flow are presented in Figure 66. Water level is measured by a pressure transducer in the MFS vault. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Contech MFS vault, resulting in reduced overall treatment efficiency.

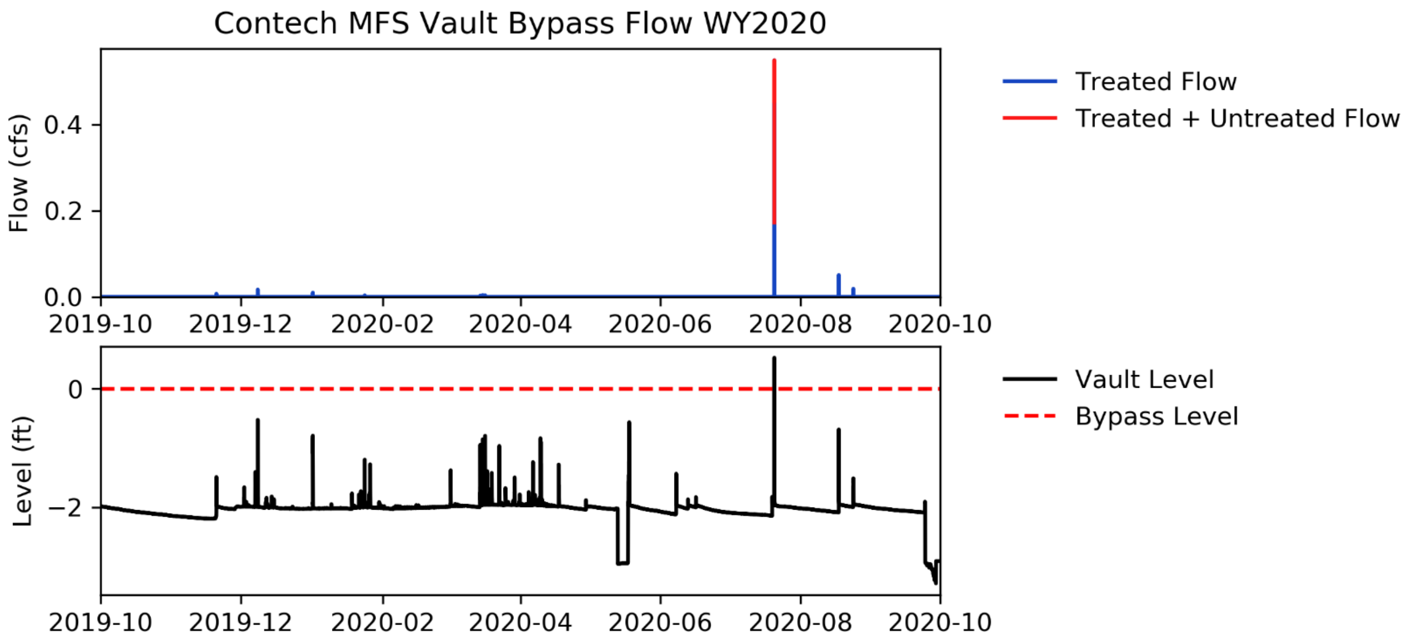

Figure 66 Contech MFS vault water level at SR431, WY20 (bottom). Contech MFS outflow shown at top for reference. Vault level greater than 0 indicates bypass flow.

- During periods of flow, the Contech MFS filter was in bypass mode 6% of the time in WY20 which represents up to 68% of the flow volume (591 cf). All of this bypass flow occurred during a summer thunderstorm event. During bypass mode treated flow is co-mingled with untreated (bypass) flow, so the exact amount of untreated flow is difficult to determine.
- Bypass occurred during 1 runoff event:
  - July 20, 2020 during a thunderstorm event that produced 0.66 inches of precipitation.
- The one sampled event had untreated (bypass) flow.

Table 17 presents the efficiency of the Jellyfish at reducing concentrations and loads of all three pollutants for the individual events sampled in WY20.

Table 17 Event efficiency data from the Jellyfish vault at SR431, WY20.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration			FSP Load (lbs)			TN Concentration			TN Load (lbs)			TP Concentration			TP Load (lbs)		
		in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change	in-flow	out-flow	% change
1/1/2020	5%	960	469	-51%	12	6	-51%	4,257	3,044	-28%	0.06	0.04	-28%	7,162	2,873	-60%	0.09	0.04	-60%
3/14/2020	20%	1,848	460	-75%	95	23	-75%	6,908	2,863	-59%	0.36	0.15	-59%	10,744	2,867	-73%	0.55	0.15	-74%
5/17/2020	8%	337	188	-44%	7	4	-45%	2,219	1,906	-14%	0.05	0.04	-15%	3,015	1,387	-54%	0.06	0.03	-55%
7/20/2020	20%	587	56	-91%	30	3	-91%	10,660	743	-93%	0.55	0.04	-93%	4,254	373	-91%	0.22	0.02	-91%
8/24/2020	8%	1.0	0.5	-50%	0.02	0.01	-50%	5,064	4,392	-13%	0.10	0.09	-14%	494	336	-32%	0.010	0.007	-32%

- The highest FSP concentration and load reductions occurred during the thunderstorm event beginning July 20, 2020.
- The lowest FSP concentration and load reductions occurred during the rain event beginning May 17, 2020 when inflow concentrations were relatively low.
- The highest TN concentration and load reductions occurred during the thunderstorm event beginning July 20, 2020 when inflow concentrations were highest.
- The lowest TN concentration and load reductions occurred the thunderstorm event beginning August 24, 2020.
- The highest TP concentration and load reductions occurred during the thunderstorm event beginning July 20, 2020.
- The lowest TP concentration and load reductions occurred during the thunderstorm event beginning August 24, 2020 when inflow concentrations were low.

Jellyfish vault water level and bypass flow are presented in Figure 67. Water level is measured by a pressure transducer in the Jellyfish vault. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Jellyfish vault, resulting in reduced overall treatment efficiency.

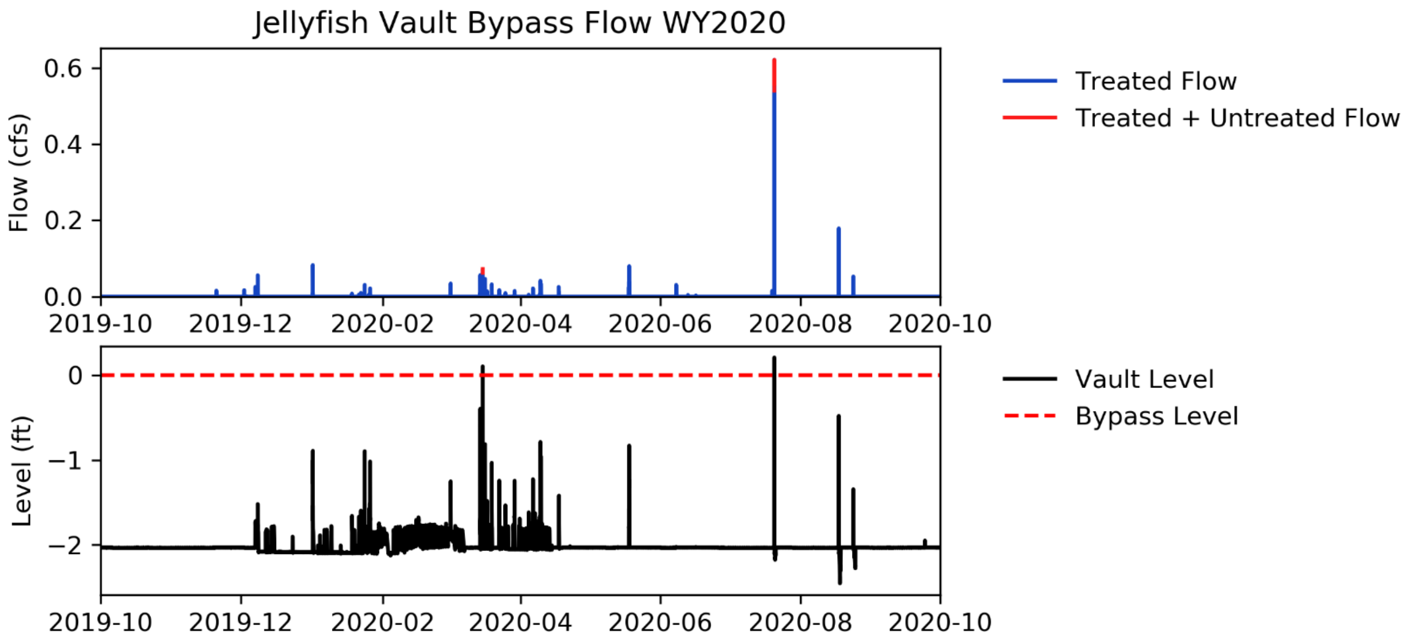

Figure 67 Jellyfish vault level at SR431, WY20 (bottom). Jellyfish outflow shown at the top for reference. Vault level greater than 0 indicates bypass flow.

- During periods of flow, the Jellyfish filter was in bypass mode 1% of the time in WY20 which represents up to 15% of the flow volume (596 cf). During bypass mode treated flow is co-mingled with untreated (bypass) flow, so the exact amount of untreated flow is difficult to determine.
- Bypass occurred during 2 runoff events:
  - March 15, 2020 during a snowmelt event.
  - July 20, 2020 during a thunderstorm event that produced 0.66 inches of precipitation.
- Two of the five sampled events had untreated (bypass) flow.

7.2 Elks Club

Elks Club Drive was repaved in August 2018, right before the start of WY19. Data collected at Elks Club in WY18 represents pre-paving conditions. Data collected in WY19 and WY20 represent post-paving conditions. Prior to repaving, Elk's Club Drive was in poor condition, covered in cracks and potholes (Figure 68 - PCI*: 29). In August 2018 it was repaved to excellent conditions (Figure 69 - PCI*: 99).

Figure 68 Elks Club Drive prior to repaving. (R Wigart)

Figure 69 Elks Club Drive after repaving. (A Buxton)

In addition to analyzing samples for sediment and nutrient content, Elks Club runoff samples for WY18 and WY19 also underwent a source apportionment analysis. Samples of asphalt aggregate, asphalt binder, roadside soil (i.e. soil that erodes off the adjacent road shoulder of adjoining land), traction abrasives (i.e. road sand), and vegetation debris collected near the monitoring site were submitted at the beginning of the project and molecular markers were identified for each of these sediment types. Subsequent runoff samples were then analyzed using the molecular markers and a chemical mass balance model to determine what portion of the sediment in each sample originated from each source.

* PCI is a numerical index between 0 and 100 used to indicate the general condition of pavement. It requires a manual survey and is widely used by transportation departments to evaluate road condition. PCI was developed by the United States Army Corps of Engineers and surveying and calculation methods were standardized by the American Society for Testing Materials (ASTM). The method is based on a visual survey of the number and types of distresses in the pavement including alligator cracking, block cracking, bumps and sags, corrugations, longitudinal and transverse cracking, patching and utility cut patching, potholes, swelling, weathering, raveling, etc. Assessing PCI on roads is the most widely used and accepted method for determining road surface condition so that condition can be tracked and roads can be prioritized for funding for repaving or resurfacing.

Table 18 Results of Elks Club study. P-values* less than 0.001 indicate highly significant results (highlighted in green). P-values less than 0.05 indicate significant results (highlighted in orange).

Water Year	Statistic	Asphalt aggregate + binder (%)	Traction abrasives (%)	Road side soil (%)	Vegetation debris (%)	Atmos-pheric deposition (%)	TSS concen-tration (mg/L)	Normalized TSS load (lbs/acre/in)	FSP concen-tration (mg/L)	Normalized FSP load (lbs/acre/in)
Pre Paving 2018	Mean	45.00	16.60	34.00	3.00	2.70	83.90	6.30	32.50	1.50
	Standard Deviation	6.51	5.26	6.66	0.95	1.25	50.66	7.58	22.12	1.32
	Min	36.00	10.00	24.00	1.50	1.00	17.50	0.25	3.82	0.14
	Median	45.00	17.00	34.00	3.00	3.00	101.30	3.60	37.26	1.83
	Max	56.00	25.00	45.00	4.50	5.00	137.50	22.11	67.58	3.28
Post Paving 2019	Mean	24.90	8.20	42.20	16.50	5.00	22.70	0.60	6.90	0.10
	Standard Deviation	6.10	2.76	6.83	4.33	1.63	15.47	0.82	5.77	0.08
	Min	14.80	3.00	33.00	10.00	2.00	10.00	0.03	0.57	0.01
	Median	26.20	9.00	41.00	16.00	5.00	15.25	0.29	5.10	0.07
	Max	33.70	11.00	55.00	23.00	8.00	57.00	2.47	19.10	0.27
	T-test p-value	**0.000**	**0.004**	**0.023**	**0.000**	**0.003**	**0.018**	**0.050**	**0.013**	**0.026**

*A t-test is a statistical test, resulting in a p-value, that is used to determine if there is a significant difference between the means of two sets of data. If the p-value is less than 0.001, then results are highly significant, meaning that there is only a 0.1% chance that the differences between the two sets of data were by chance. If the p-value is less than 0.05, results are significant, meaning that there is only a 5% chance the differences between the two sets of data were by chance.

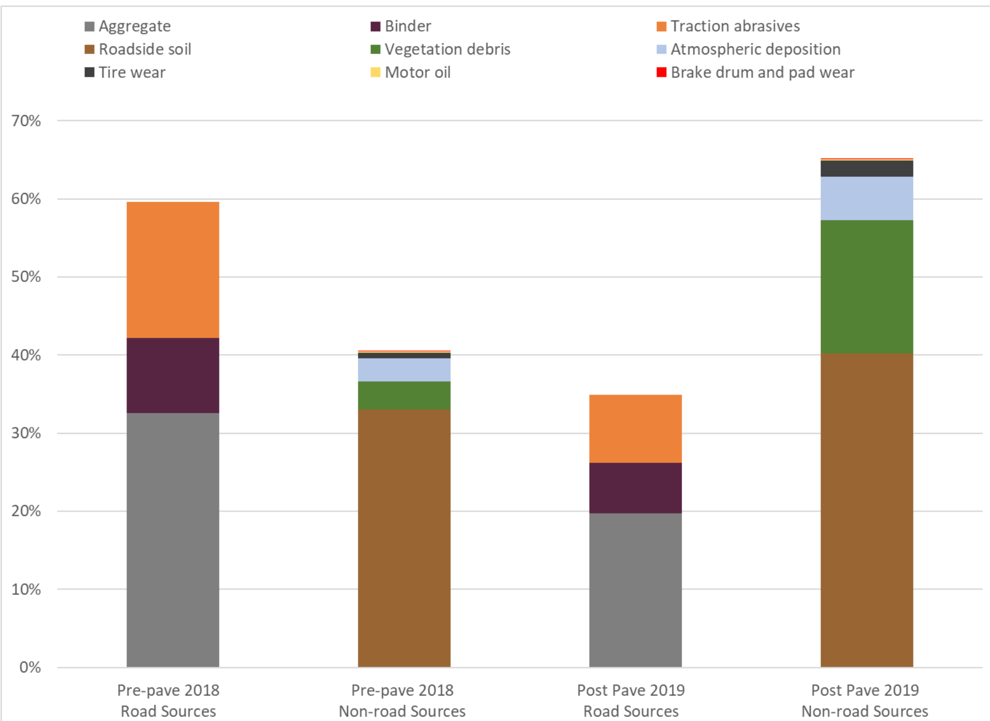

Figure 70 Average annual FSP load attributable to road and non-road sources at Elks Club, WY18 and WY19. 60% and 35% of the FSP in stormwater runoff from Elks Club Drive originated from road sources (asphalt aggregate, asphalt binder, and traction abrasives) in the pre- and post-pave conditions respectively.

Table 18 shows that there was a statistically significant decrease in the relative contribution of particles from road sources (asphalt aggregate plus binder and traction abrasives), and a significant increase in relative contribution of particles from non-road sources (roadside soil, vegetation debris, and atmospheric deposition) before and after pavement condition improvement. Figure 70 shows the percent composition of FSP in stormwater before and after paving. When relative contributions of asphalt aggregate plus binder and traction abrasives decrease, the relative contributions of naturally occurring roadside soil, vegetation debris, and atmospheric deposition increase as these contributions are not changed by improving pavement condition. Assuming that traction abrasive application practices remain fairly consistent from year to year, the decrease in the relative contribution of traction abrasives with improved pavement condition can be reasonably attributed to more efficient sweeping. Street sweeping on a smooth road surface is more effective than on a road surface marred by cracks and potholes allowing more sediment to be recovered. Percent contribution to FSP from each source category in the pre- and post- pave condition describes only how the composition of FSP in stormwater changed, it does not indicate if total sediment loads decreased. However, Table 18 also shows statistically significant decreases in total suspended sediment (TSS) concentration, FSP concentration, normalized TSS load, and normalized FSP load (pounds of sediment per acre per inch of rain).

Table 19 shows the substantial impact that improving pavement condition on Elk's Club Drive had on water quality in terms of reduced sediment concentrations and loads. In WY19, mean annual TSS and FSP concentrations were reduced by 73% and 79% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 90% and 93% respectively. In WY20, mean annual TSS and FSP concentrations were reduced by 41% and 50% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 95% and 93% respectively. (Normalized load values account for catchment size and remove year to year variability in precipitation frequency, size, intensity, and duration.)

Table 19 Mean annual sediment concentrations and normalized load reductions for WY19 and WY20 compared to WY18.

Water Year	TSS concen-tration (mg/L)	Normalized TSS load (lbs/acre/in)	FSP concen-tration (mg/L)	Normalized FSP load (lbs/acre/in)
Pre Paving 2018	83.90	6.30	32.50	1.50
Post Paving 2019	22.70	0.60	6.90	0.10
Post Paving 2020	49.30	0.30	16.30	0.10
2019 % Reduction	**73%**	**90%**	**79%**	**93%**
2020 % Reduction	**41%**	**95%**	**50%**	**93%**

8. Trends Analysis

In accordance with the RSWMP FIG section 2.1, monitoring for trends at urban catchment outfalls is important because it provides information needed for evaluating progress toward TMDL and other regulatory goals. Trend analyses are only performed on monitoring sites with at least five years of continuous data. The objective of the trends monitoring is to detect and report the cumulative load reduction benefits of all actions implemented within the catchment over long time frames and ultimately demonstrate a local and regional improvement in pollutant loading to the lake.

Water year 2020 marked the seventh year of monitoring at SR431, Pasadena, and Tahoma and the sixth year of monitoring at Speedboat, Tahoe Valley, and Upper Truckee. Trend analyses will only be reported for the inflow locations at SR431 (CI and JI) as these results will indicate trends in pollutant loading from the catchment. Trend analyses on the outflow locations (CO and JO) are an indication of how well the vaults are maintained over the years and will be included in the seasonal progress reports submitted to NDOT and available on Tahoe RCD's website. Elks Club, Lakeshore, and Tahoe City have three, four, and one year of monitoring data respectively, therefore trends analyses were not performed on the data from these sites. They are included in this section for annual sediment and nutrient load comparisons to annual precipitation only.

Average annual loads for FSP, TN, and TP presented in this report are normalized by both catchment size (acres) and inches of precipitation. Normalizing by catchment size only allows for comparison between sites, but this analysis is not highlighted here as the objective of trends analysis is to detect load reductions resulting from improved management activities within each catchment, not between catchments. Normalizing by precipitation allows for comparison between water years in a particular catchment, which addresses the objective. Percent runoff (runoff coefficient) is a function of catchment size, the amount of rainfall received, and the volume measured at the catchment outfall. It represents the fraction of runoff that was measured at the outfall compared to what would theoretically be expected if all the rainfall that fell in the catchment were measured at the outfall.

Normalized average annual load charts for each site with five or more years of data show whether there is an upward, downward, or neutral trend in average annual loading of FSP, TN, and TP at each site. Also presented for each site with five or more years of data is a table that shows average annual percent runoff and normalized seasonal and average annual loads and trend statistics. The trend statistics (Tau, p-value, and Theil slope) indicate if there has been an upward, downward, or neutral trend in pollutant loading over the last six or seven years in the selected catchments. Tau is a non-parametric measure of the relationship between data when data does not have a normal distribution, similar to the r^2 value in a regression on normally distributed data. Tau is a measure of the correspondence between two rankings, in this case between the water year and the normalized pollutant load. Tau is a correlation coefficient that returns a value between -1 and 1 where 0 is no relationship, 1 is a perfect identical relationship and -1 is a perfect opposite relationship with regards to ranked pairs. The pairs in this case are water year and pollutant load. The water years will always be ranked in order from 2014 through 2020. The pollutant loads are then ranked from least to most as well. The rankings of the pairs are then compared. If pollutant load steadily increases from year to year there will be a perfect identical ranking between the pairs, resulting in a Tau of 1. If pollutant load steadily decreases from year to year there will a perfect opposite ranking of the pairs, resulting in a Tau of -1. The p-value indicates the confidence level in Tau; a p-value less than 0.05 ($p<0.05$) denotes a significant relationship. The Theil slope is similar to the slope for a regression on normalized data, but used for data that is not normally distributed. Lastly, charts showing annual sediment and nutrient loads and annual precipitation totals for each site are included to help visualize how precipitation and loads have varied over the period of record for each site.

8.1 SR431 Contech MFS Inflow

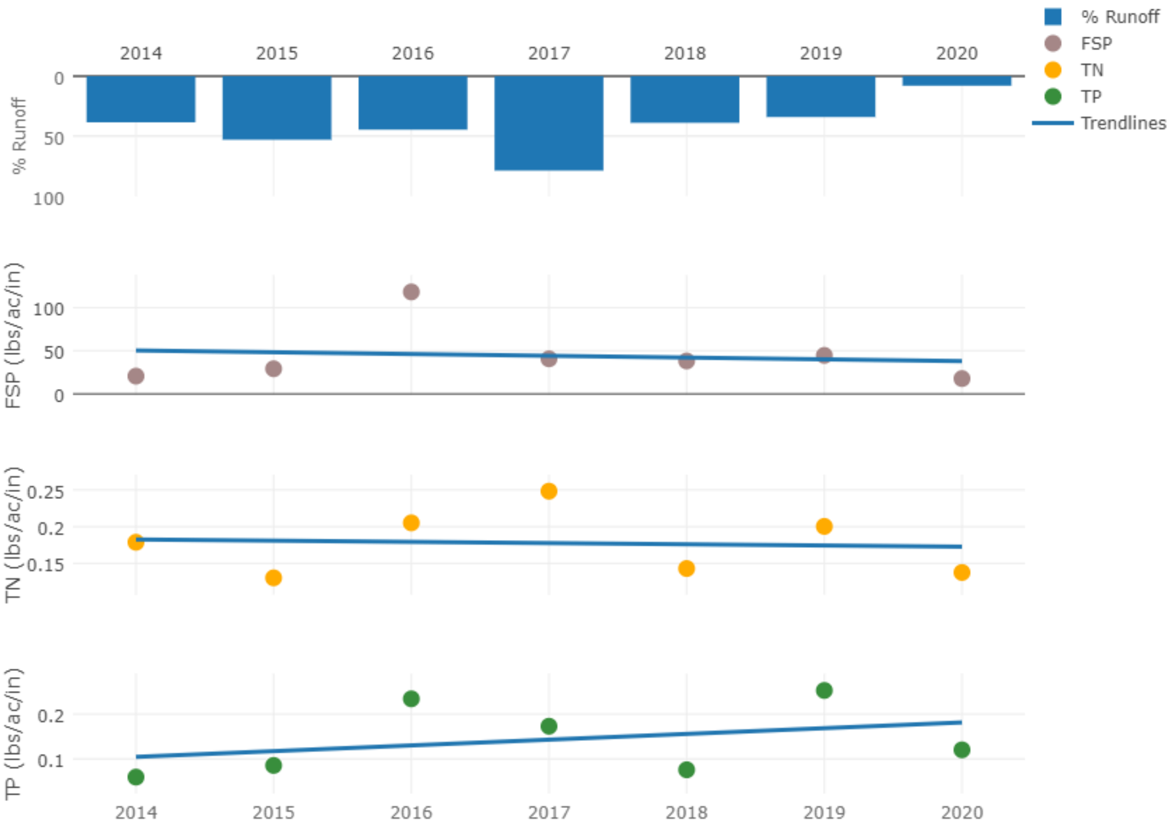

Figure 71 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Contech MFS Inflow, WY14-20.

- Percent runoff varied between 8.0% in WY20 to 78.9% in WY17. Differences in % runoff between CI and JI are attributed to sediment accumulation in the splitter chamber that caused an unequal division of runoff to each vault.
- There is no significant trend in normalized annual FSP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TN loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.

Table 20 7-year seasonal and annual rainfall normalized pollutant loads at the Contech MFS Inflow, WY14-20.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	38.6%	8.358	43.467	23.094	20.612	0.065	0.230	0.386	0.179	0.021	0.122	0.079	0.060
2015	53.2%	29.875	41.461	7.517	29.122	0.127	0.164	0.086	0.130	0.097	0.110	0.015	0.086
2016	44.7%	84.812	183.564	0.000	118.153	0.179	0.260	0.000	0.205	0.149	0.399	0.000	0.234
2017	78.9%	19.239	139.993	20.235	40.646	0.178	0.611	0.048	0.248	0.064	0.688	0.035	0.173
2018	39.0%	23.391	51.881	20.808	38.173	0.136	0.116	0.554	0.143	0.083	0.068	0.113	0.076
2019	34.2%	11.578	153.825	8.569	44.624	0.083	0.565	0.227	0.200	0.066	0.866	0.070	0.253
2020	8.0%	9.896	26.907	39.794	17.783	0.040	0.148	0.723	0.138	0.068	0.175	0.288	0.120
Tau	na	-0.238	-0.048	0.200	0.048	-0.238	-0.048	0.333	-0.048	0.048	0.238	0.467	0.333
P-Value	na	0.453	0.881	0.573	0.881	0.453	0.881	0.348	0.881	0.881	0.453	0.188	0.293
Theil Slope (per year)	na	-3.114	-2.006	0.572	1.989	-0.011	-0.003	0.056	-0.002	0.001	0.053	0.017	0.010

Figure 72 through Figure 79 show sediment and nutrient loads for the Contech MFS compared to total annual precipitation for WY14 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

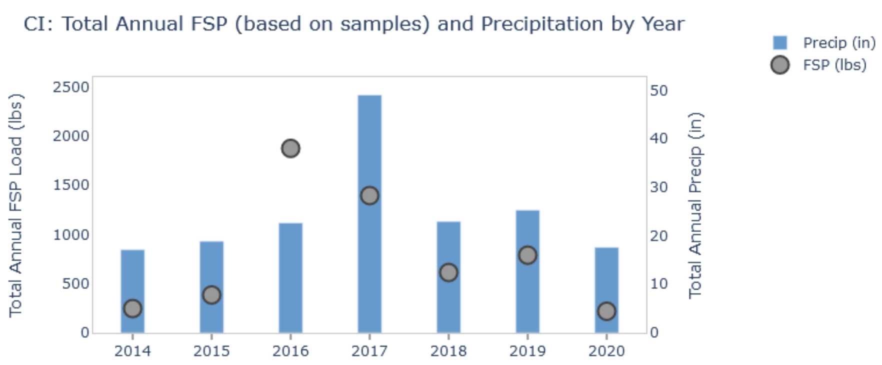

Figure 72 Total annual FSP load (based on samples) and precipitation by year for Contech MFS Inflow WY14-WY20.

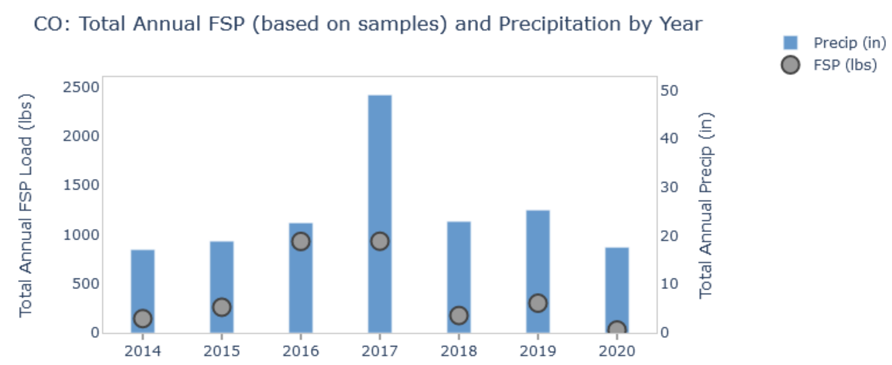

Figure 73 Total annual FSP load (based on samples) and precipitation by year for Contech MFS Outflow WY14-WY20.

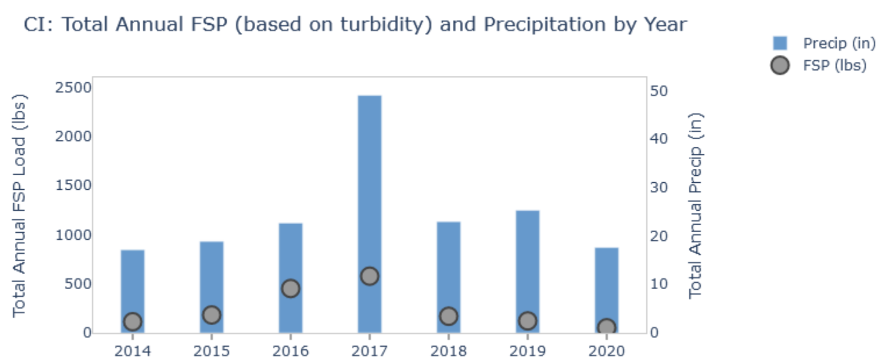

Figure 74 Total annual FSP load (based on continuous turbidity) and precipitation by year for Contech MFS Inflow WY14-WY20.

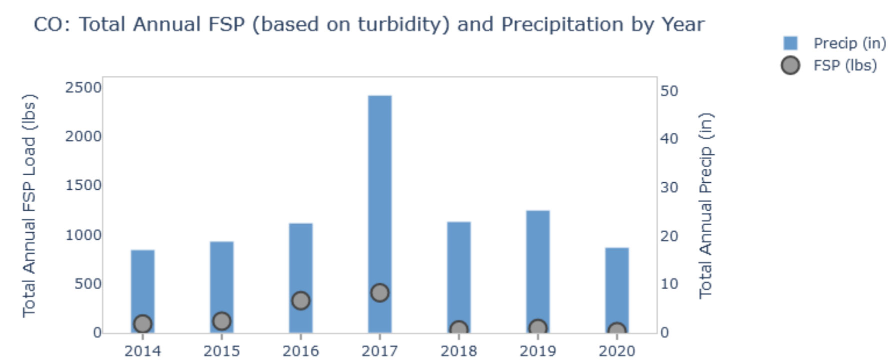

Figure 75 Total annual FSP load (based on continuous turbidity) and precipitation by year for Contech MFS Outflow WY14-WY20.

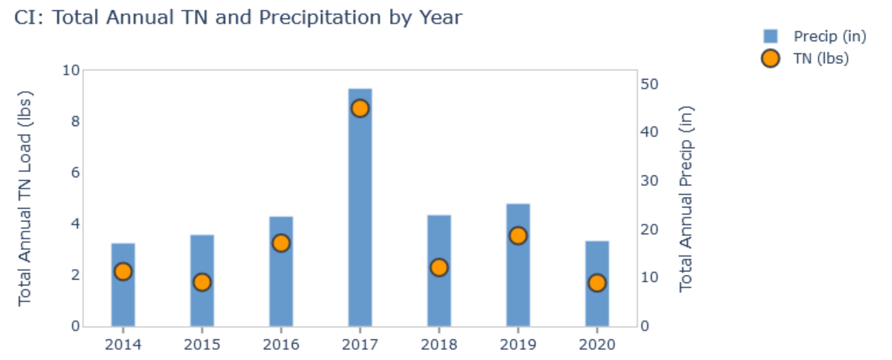

Figure 76 Total annual TN load and precipitation by year for Contech MFS Inflow WY14-WY20.

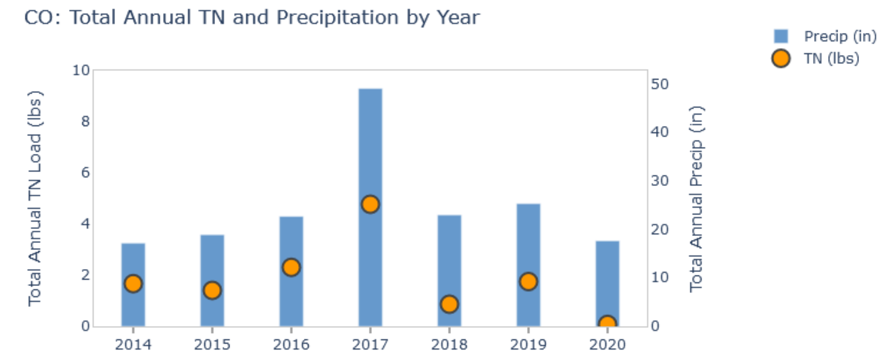

Figure 77 Total annual TN load and precipitation by year for Contech MFS Outflow WY14-WY20.

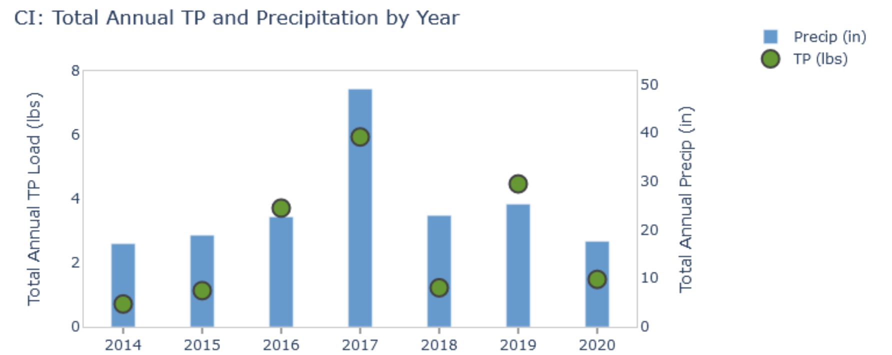

Figure 78 Total annual TP load and precipitation by year for Contech MFS Inflow WY14-WY20.

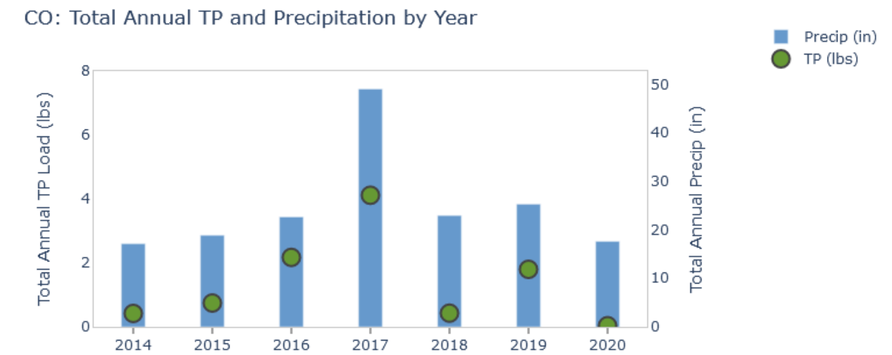

Figure 79 Total annual TP load and precipitation by year for Contech MFS Outflow WY14-WY20.

8.2 SR431 Jellyfish Inflow

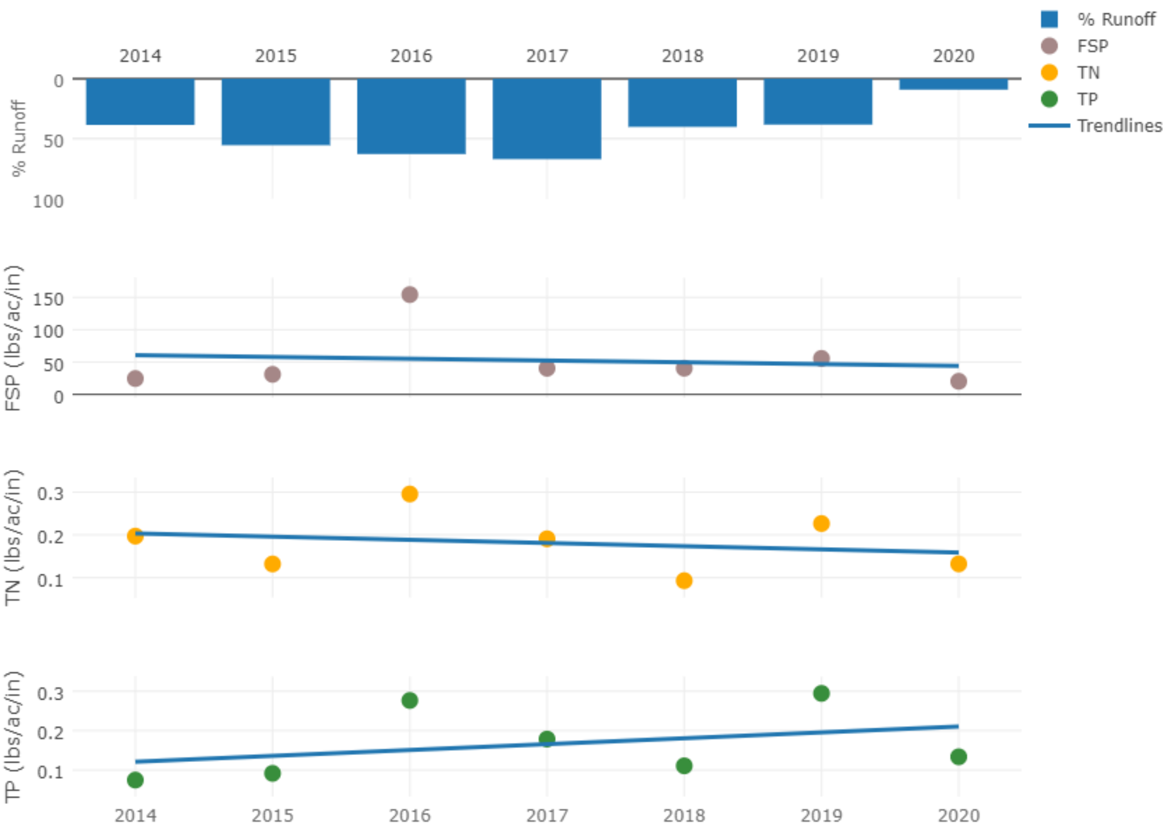

Figure 80 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Jellyfish Inflow, WY14-20.

- Percent runoff varied between 9.1% in WY20 to 79.1% in WY17. Differences in % runoff between CI and JI are attributed to sediment accumulation in the splitter chamber that caused an unequal division of runoff to each vault.
- There is no significant trend in normalized annual FSP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TN loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.

Table 21 7-year seasonal and annual rainfall normalized pollutant loads at the Jellyfish Inflow, WY14-20.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	38.6%	13.733	51.563	18.989	24.558	0.060	0.313	0.384	0.197	0.033	0.160	0.075	0.075
2015	55.5%	30.438	46.614	8.065	31.038	0.116	0.174	0.109	0.132	0.095	0.133	0.017	0.092
2016	62.9%	117.285	228.200	0.000	154.437	0.214	0.457	0.000	0.296	0.223	0.385	0.000	0.276
2017	67.2%	19.818	137.664	15.455	40.456	0.096	0.643	0.061	0.191	0.065	0.714	0.033	0.179
2018	40.2%	20.067	59.455	18.262	40.577	0.072	0.076	0.526	0.093	0.070	0.146	0.105	0.111
2019	38.3%	12.118	199.427	9.225	55.670	0.090	0.649	0.263	0.227	0.059	1.068	0.071	0.294
2020	9.1%	7.699	43.672	29.192	20.335	0.034	0.172	0.630	0.132	0.057	0.263	0.221	0.134
Tau	na	-0.429	-0.048	0.200	0.143	-0.333	0.048	0.333	-0.143	-0.238	0.333	0.467	0.429
P-Value	na	0.176	0.881	0.573	0.652	0.293	0.881	0.348	0.652	0.453	0.293	0.188	0.176
Theil Slope (per year)	na	-4.040	-0.589	1.701	3.180	-0.010	0.003	0.041	-0.011	-0.003	0.059	0.019	0.010

Figure 81 through Figure 88 show sediment and nutrient loads for the Jellyfish compared to total annual precipitation for WY14 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

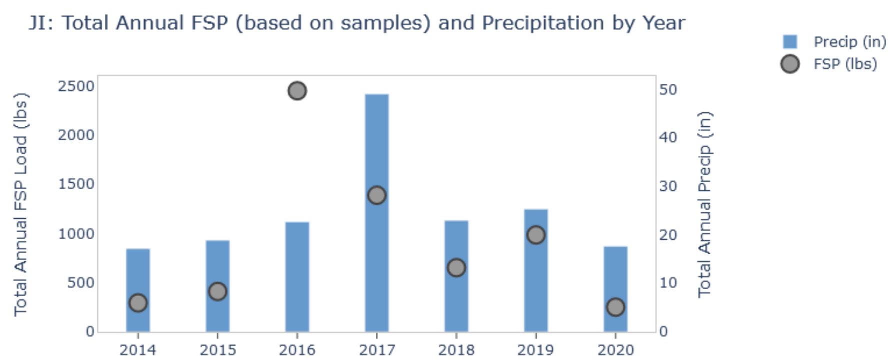

Figure 81 Total annual FSP load (based on samples) and precipitation by year for Jellyfish Inflow WY14-WY20.

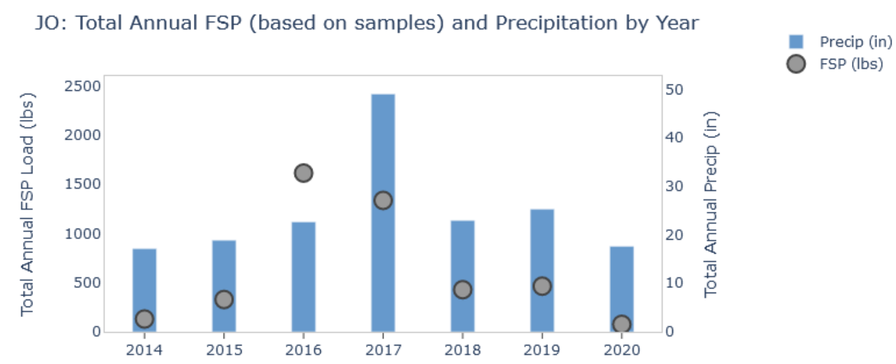

Figure 82 Total annual FSP load (based on samples) and precipitation by year for Jellyfish Outflow WY14-WY20.

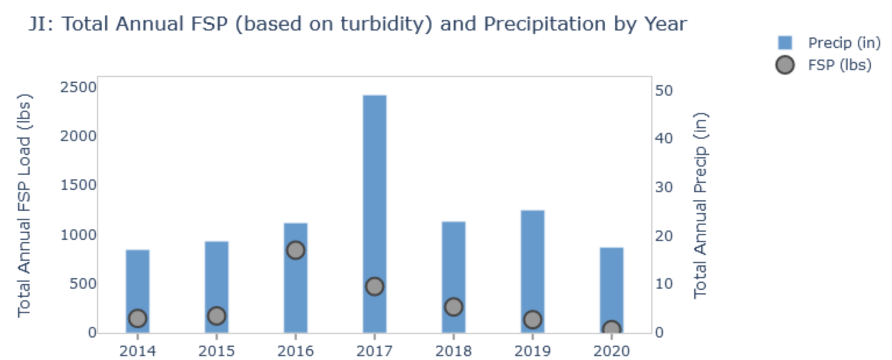

Figure 83 Total annual FSP load (based on continuous turbidity) and precipitation by year for Jellyfish Inflow WY14-WY20.

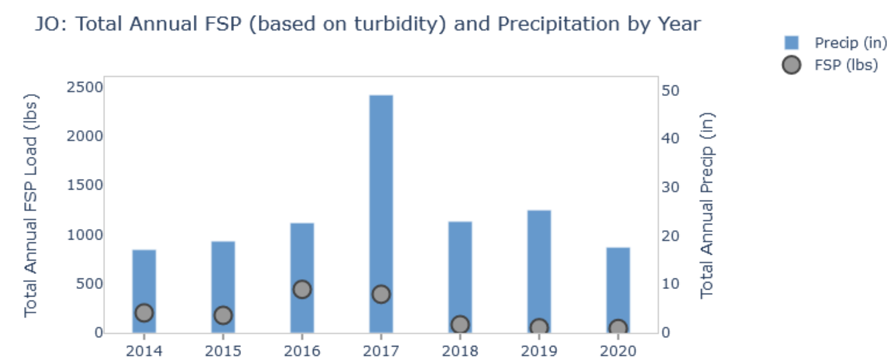

Figure 84 Total annual FSP load (based on continuous turbidity) and precipitation by year for Jellyfish Outflow WY14-WY20.

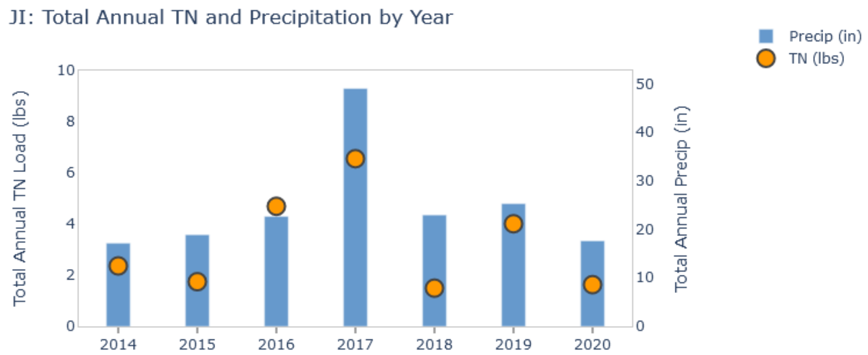

Figure 85 Total annual TN load and precipitation by year for Jellyfish Inflow WY14-WY20.

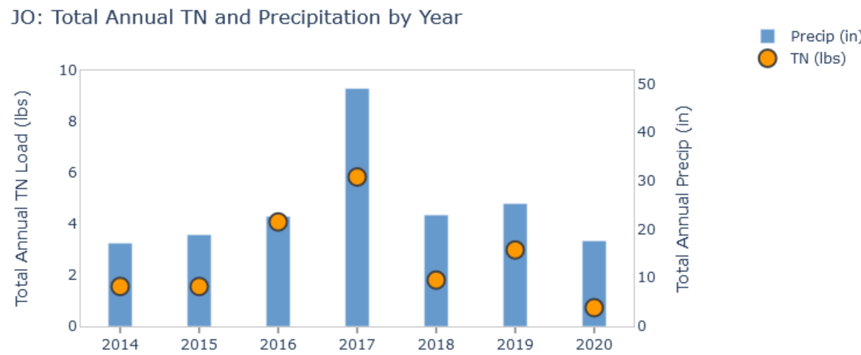

Figure 86 Total annual TN load and precipitation by year for Jellyfish Outflow WY14-WY20.

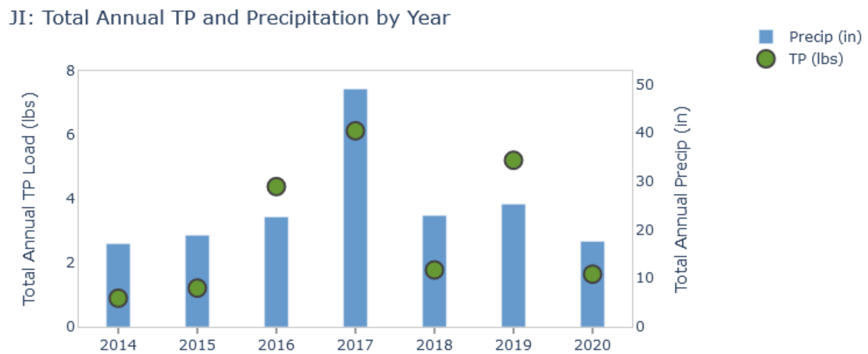

Figure 87 Total annual TP load and precipitation by year for Jellyfish Inflow WY14-WY20.

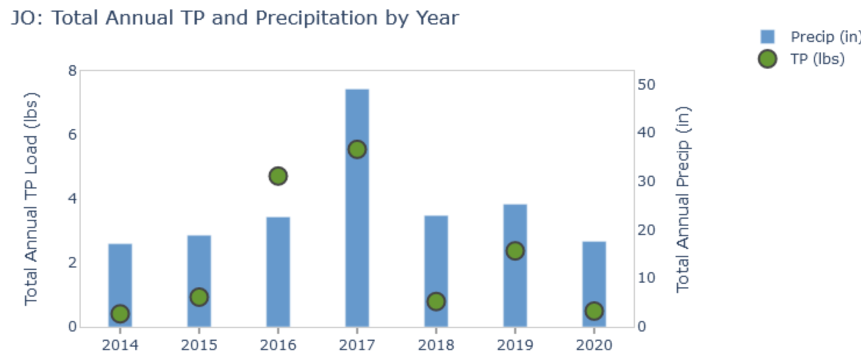

Figure 88 Total annual TP load and precipitation by year for Jellyfish Outflow WY14-WY20.

8.3 Elks Club

Figure 89 through Figure 92 show sediment and nutrient loads for Elks Club compared to total annual precipitation for WY18 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

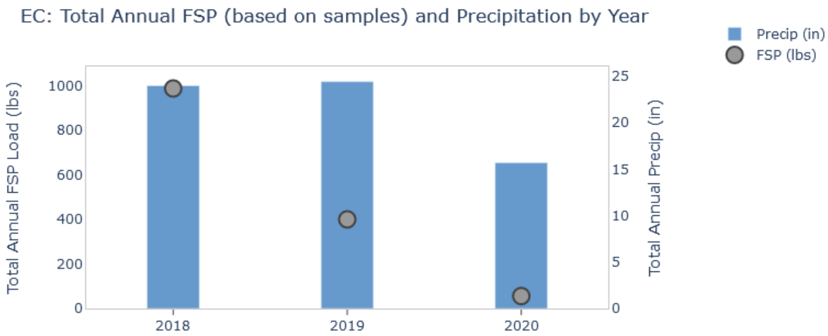

Figure 89 Total annual FSP load (based on samples) and precipitation by year for Elks Club WY18-WY20.

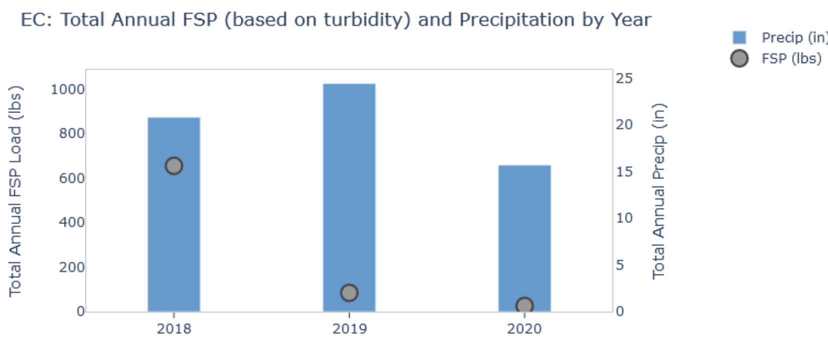

Figure 90 Total annual FSP load (based on continuous turbidity) and precipitation by year for Elks Club WY18-WY20.

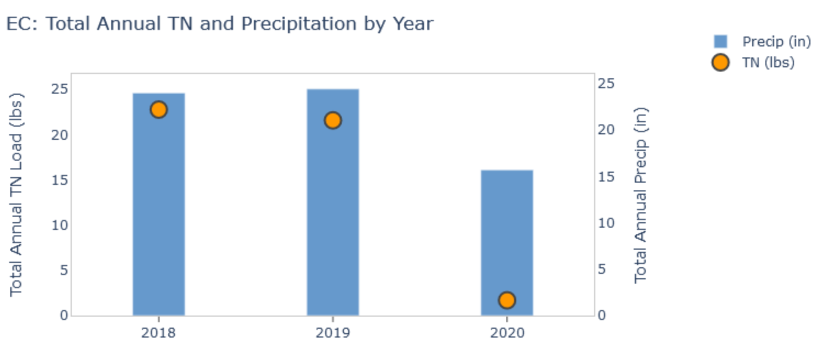

Figure 91 Total annual TN load and precipitation by year for Elks Club WY18-WY20.

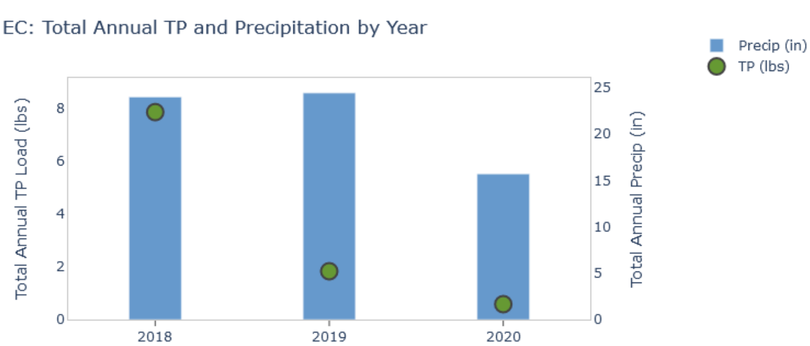

Figure 92 Total annual TP load and precipitation by year for Elks Club WY18-WY20.

8.4 Lakeshore

Figure 93 through Figure 96 show sediment and nutrient loads for Lakeshore compared to total annual precipitation for WY17 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

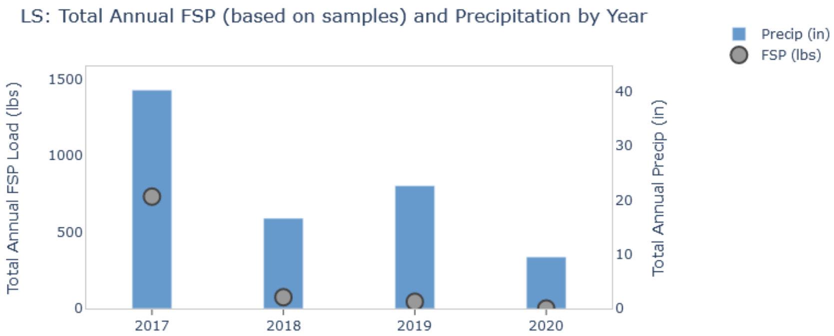

Figure 93 Total annual FSP load (based on samples) and precipitation by year for Lakeshore WY17-WY20.

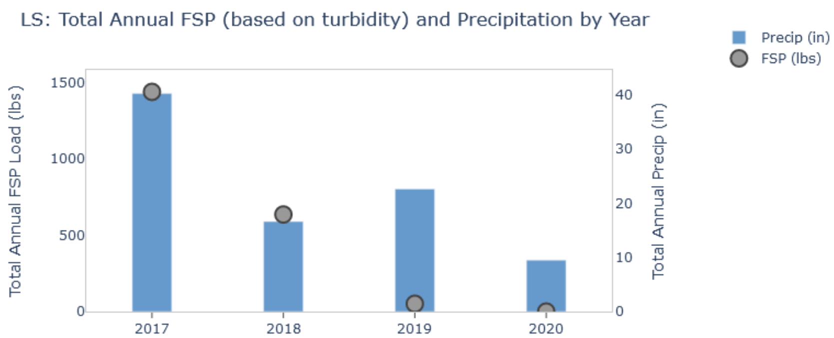

Figure 94 Total annual FSP load (based on continuous turbidity) and precipitation by year for Lakeshore WY17-WY20.

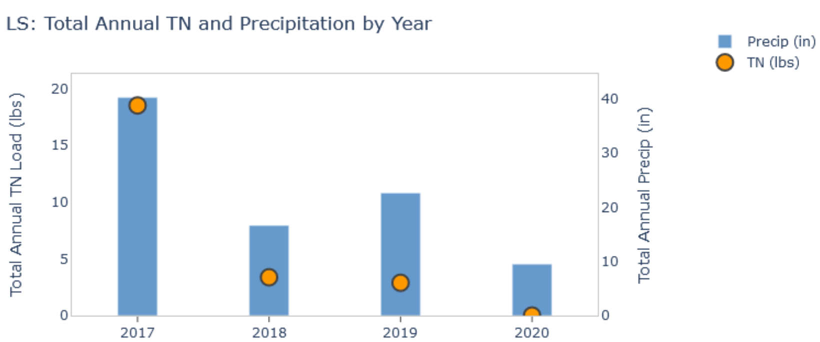

Figure 95 Total annual TN load and precipitation by year for Lakeshore WY17-WY20.

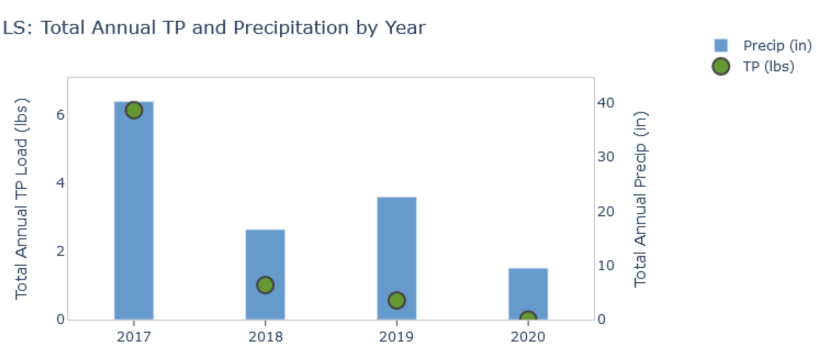

Figure 96 Total annual TP load and precipitation by year for Lakeshore WY17-WY20.

8.5 Pasadena

Figure 97 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Pasadena Outflow, WY14-20.

- Percent runoff was less than 4% in all 7 water years but varied between 0.2% in WY20 to 3.2% in WY17.
- There is a significant decreasing trend in normalized annual and fall/winter FSP loads as indicated by a Tau value close to -1 and a p-value less than 0.05.
- There is no significant trend in normalized annual TN loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.

Table 22 7-year seasonal and annual rainfall normalized pollutant loads at the Pasadena Outflow, WY14-20.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	2.8%	0.453	0.000	1.042	0.517	0.006	0.000	0.009	0.005	0.004	0.000	0.007	0.004
2015	1.4%	0.166	0.038	0.495	0.212	0.004	0.001	0.013	0.005	0.002	0.000	0.006	0.002
2016	0.8%	0.129	0.178	0.000	0.150	0.006	0.002	0.000	0.005	0.001	0.001	0.000	0.001
2017	3.2%	0.213	0.137	0.307	0.207	0.009	0.003	0.020	0.009	0.003	0.001	0.004	0.003
2018	3.1%	0.140	0.082	0.090	0.110	0.014	0.003	0.012	0.009	0.003	0.001	0.002	0.002
2019	1.0%	0.074	0.003	0.039	0.053	0.006	0.001	0.005	0.004	0.001	0.000	0.000	0.001
2020	0.2%	0.001	0.000	1.240	0.100	0.000	0.000	0.077	0.006	0.000	0.000	0.015	0.001
Tau	na	-0.714	-0.400	-0.333	-0.810	0.048	0.000	0.200	0.143	-0.524	0.000	-0.333	-0.524
P-Value	na	0.024	0.327	0.348	0.011	0.881	1.000	0.573	0.652	0.099	1.000	0.348	0.099
Theil Slope (per year)	na	-0.070	-0.044	-0.114	-0.040	0.000	0.000	0.003	0.000	0.000	0.000	-0.001	0.000

Figure 98 through Figure 101 show sediment and nutrient loads for Pasadena compared to total annual precipitation for WY14 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

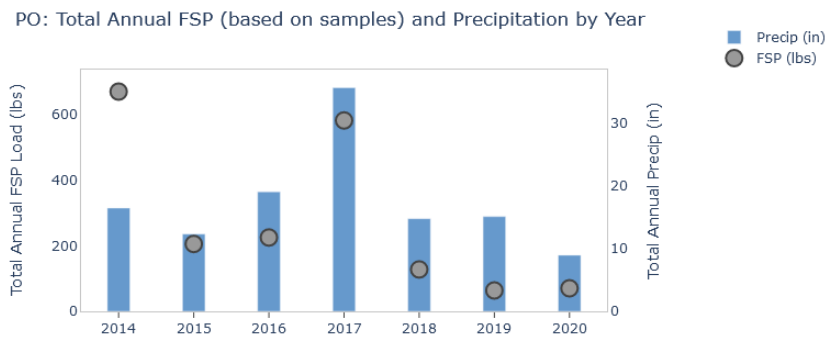

Figure 98 Total annual FSP load (based on samples) and precipitation by year for Pasadena WY14-WY20.

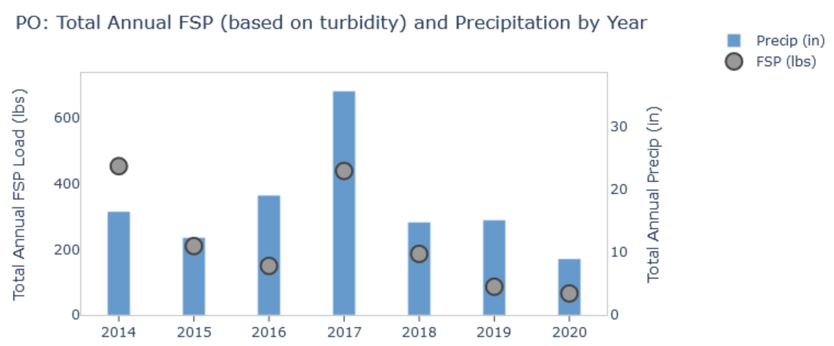

Figure 99 Total annual FSP load (based on continuous turbidity) and precipitation by year for Pasadena WY14-WY20.

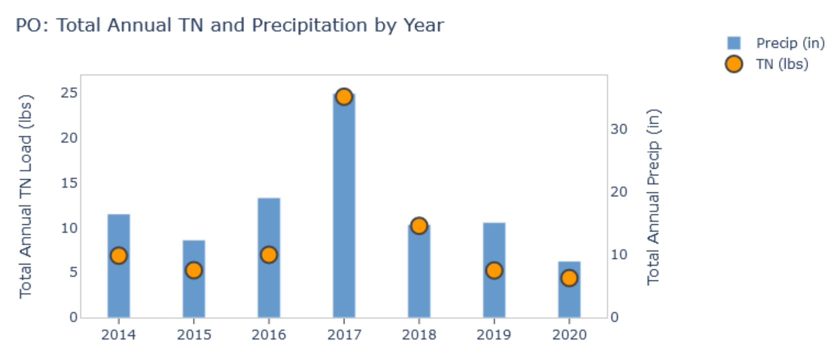

Figure 100 Total annual TN load and precipitation by year for Pasadena WY14-WY20.

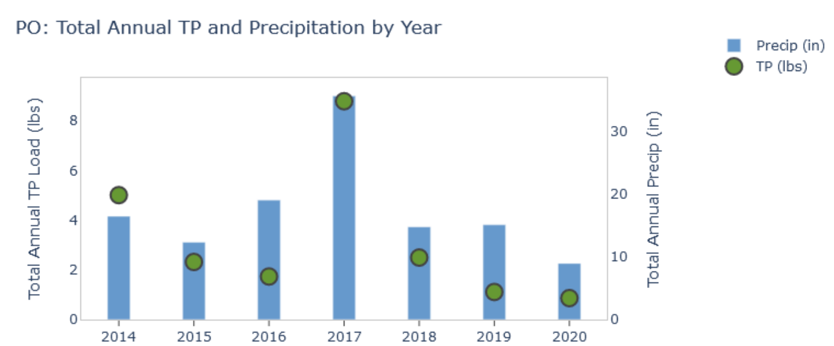

Figure 101 Total annual TP load and precipitation by year for Pasadena WY14-WY20.

8.6 Speedboat

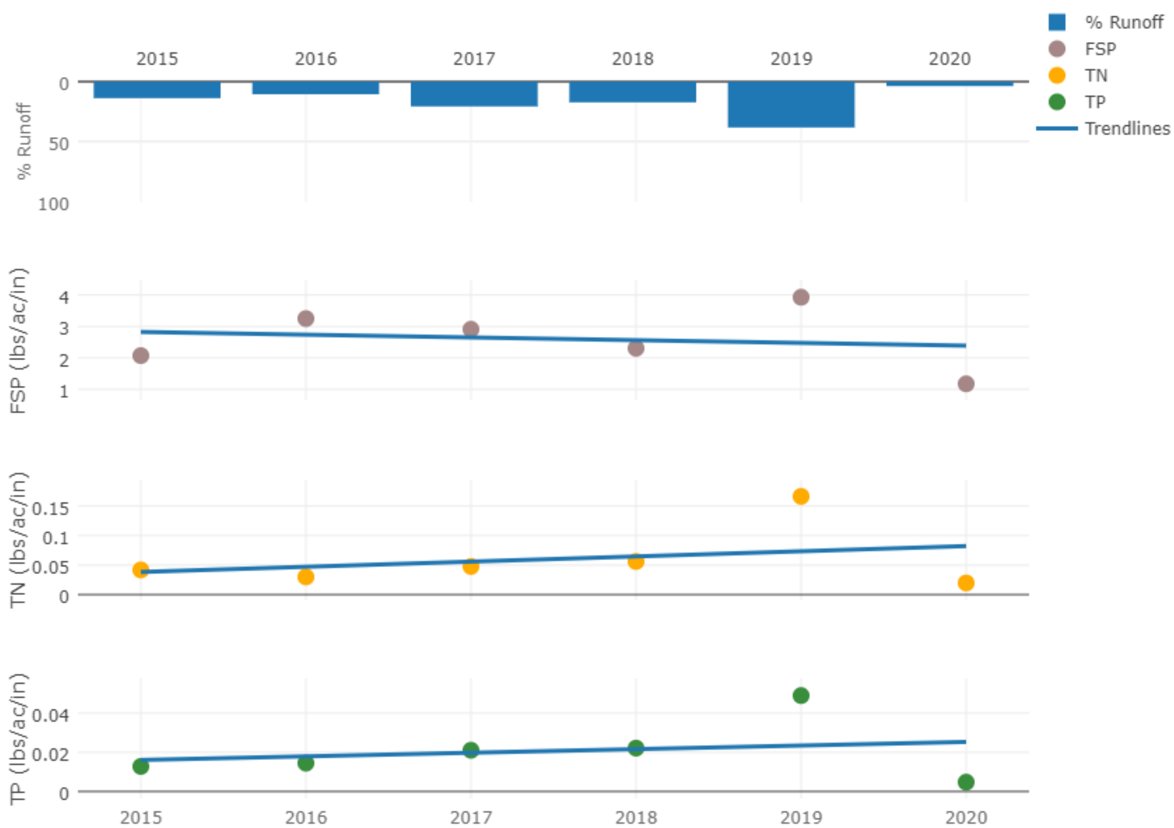

Figure 102 6-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Speedboat, WY15-20.

- Percent runoff varied between 3.7% in WY20 to 38.4% in WY19.
- There is no significant trend in normalized annual FSP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TN loads as indicated by a Tau value close to 0 and p-value greater than 0.05
- There is no significant trend in normalized annual TP loads as indicated by a Tau value close to 0 and p-value greater than 0.05

Table 23 6-year seasonal and annual rainfall normalized pollutant loads at Speedboat, WY15-20.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2015	13.8%	2.342	2.125	1.110	2.071	0.039	0.037	0.060	0.042	0.015	0.010	0.008	0.013
2016	10.6%	2.532	4.798	0.317	3.247	0.031	0.028	0.035	0.030	0.014	0.015	0.007	0.014
2017	20.7%	2.379	6.468	0.270	2.909	0.037	0.113	0.021	0.048	0.017	0.049	0.004	0.021
2018	17.3%	1.171	3.236	0.000	2.303	0.081	0.037	0.000	0.056	0.017	0.027	0.000	0.022
2019	38.4%	1.262	7.682	14.491	3.925	0.191	0.107	0.158	0.166	0.045	0.054	0.069	0.049
2020	3.7%	0.514	0.249	14.011	1.176	0.010	0.002	0.233	0.020	0.005	0.002	0.023	0.005
Tau	na	-0.600	0.067	0.200	-0.067	0.067	-0.067	0.400	0.200	0.200	0.200	0.200	0.333
P-Value	na	0.091	0.851	0.624	0.851	0.851	0.851	0.327	0.573	0.573	0.573	0.624	0.348
Theil Slope (per year)	na	-0.390	0.371	2.963	-0.179	0.006	-0.003	0.038	0.005	0.000	0.005	0.003	0.003

Figure 103 through Figure 106 show sediment and nutrient loads for Speedboat compared to total annual precipitation for WY15 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

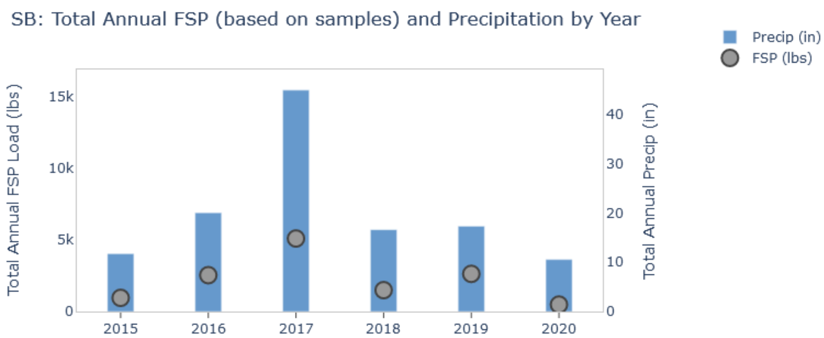

Figure 103 Total annual FSP load (based on samples) and precipitation by year for Speedboat WY15-WY20.

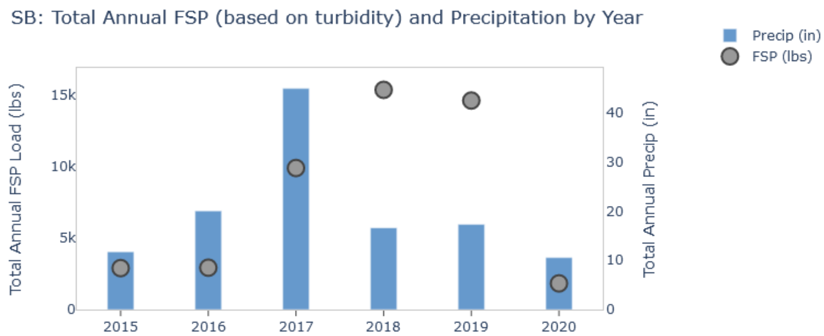

Figure 104 Total annual FSP load (based on continuous turbidity) and precipitation by year for Speedboat WY15-WY20.

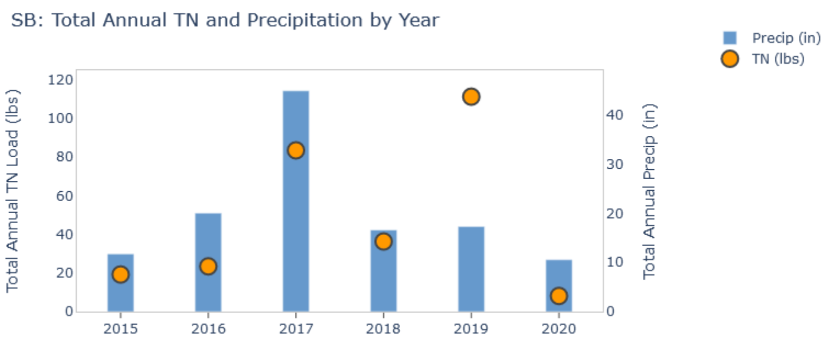

Figure 105 Total annual TN load and precipitation by year for Speedboat WY15-WY20.

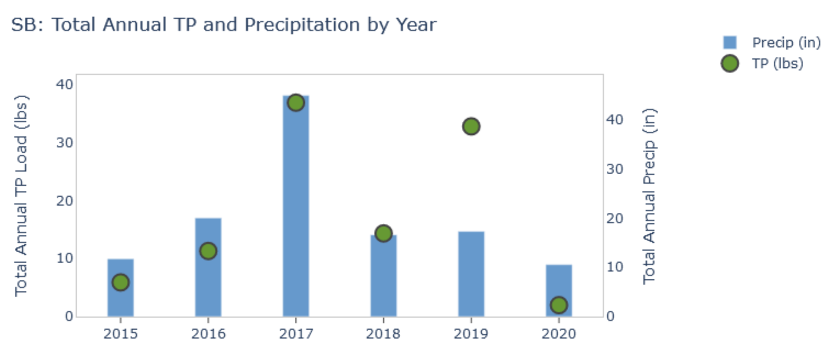

Figure 106 Total annual TP load and precipitation by year for Speedboat WY15-WY20.

8.7 Tahoe Valley

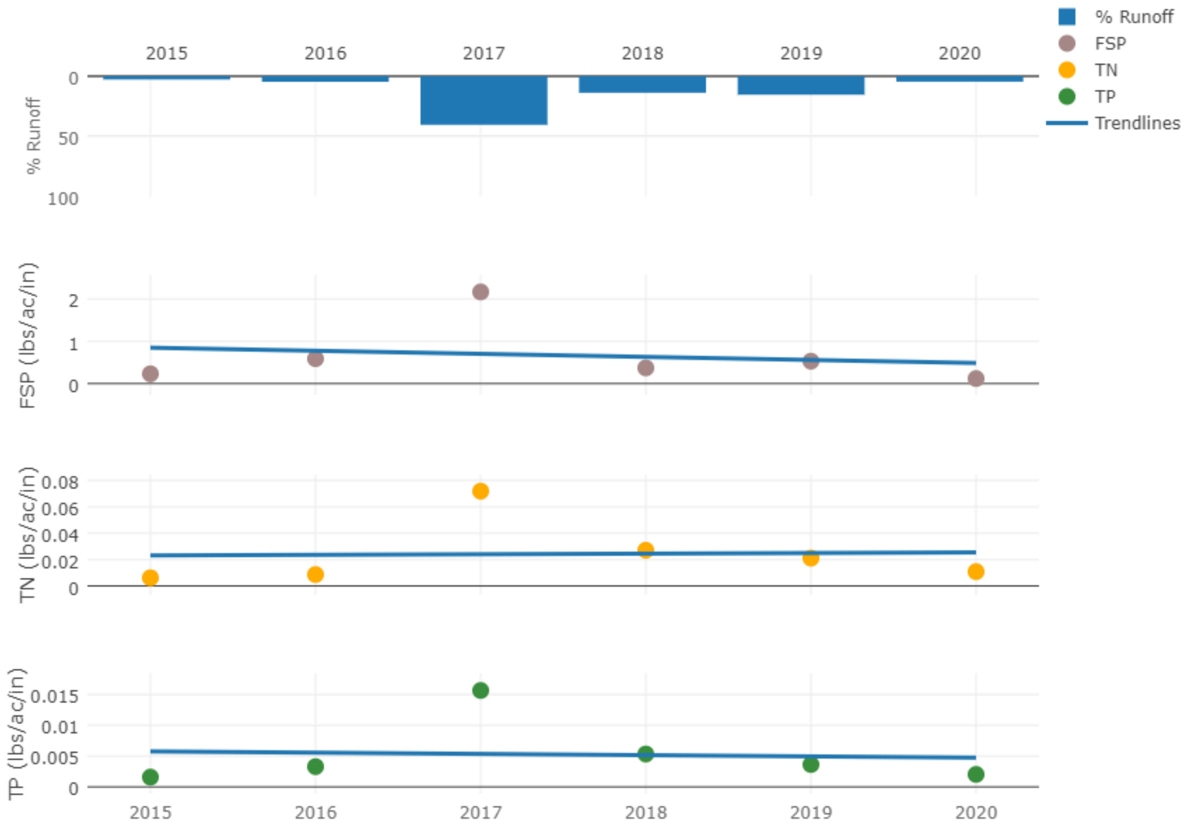

Figure 107 6-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Tahoe Valley, WY15-20.

- Percent runoff varied between 2.7% in WY15 to 40.7% in WY17.
- There is no significant trend in normalized annual FSP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TN loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.

Table 24 6-year seasonal and annual rainfall normalized pollutant loads at Tahoe Valley, WY15-20.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2015	2.7%	0.320	0.001	0.194	0.230	0.008	0.003	0.004	0.006	0.002	0.001	0.001	0.002
2016	4.7%	0.439	0.919	0.000	0.588	0.006	0.014	0.000	0.009	0.002	0.005	0.000	0.003
2017	40.7%	1.401	120.326	0.000	2.168	0.038	5.272	0.000	0.072	0.010	0.920	0.000	0.016
2018	13.9%	0.089	0.623	0.238	0.370	0.028	0.027	0.018	0.027	0.004	0.007	0.003	0.005
2019	15.5%	0.113	1.787	0.945	0.529	0.009	0.058	0.047	0.021	0.001	0.012	0.001	0.004
2020	4.6%	0.154	0.081	0.069	0.119	0.014	0.007	0.007	0.011	0.003	0.001	0.001	0.002
Tau	na	-0.200	0.067	-0.200	-0.200	0.200	0.200	0.000	0.200	0.067	0.200	-0.200	0.067
P-Value	na	0.573	0.851	0.624	0.573	0.573	0.573	1.000	0.573	0.851	0.573	0.624	0.851
Theil Slope (per year)	na	-0.052	0.016	-0.055	-0.022	0.001	0.007	-0.003	0.001	0.000	0.001	-0.001	0.000

Figure 108 through Figure 111 show sediment and nutrient loads for Tahoe Valley compared to total annual precipitation for WY15 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

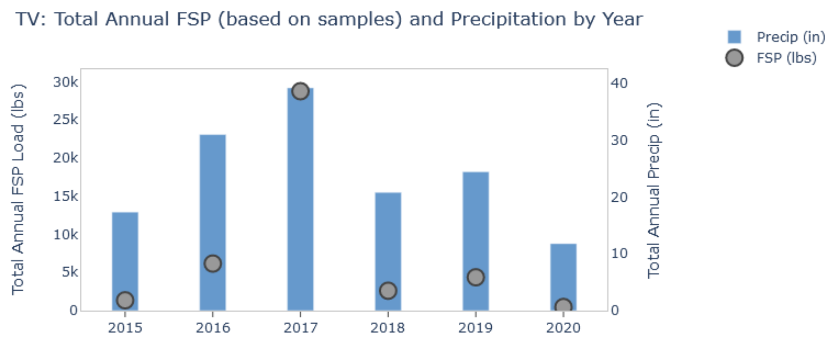

Figure 108 Total annual FSP load (based on samples) and precipitation by year for Tahoe Valley WY15-WY20.

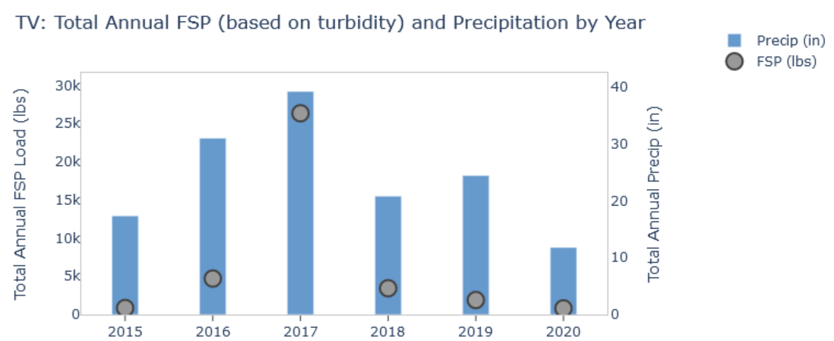

Figure 109 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoe Valley WY15-WY20.

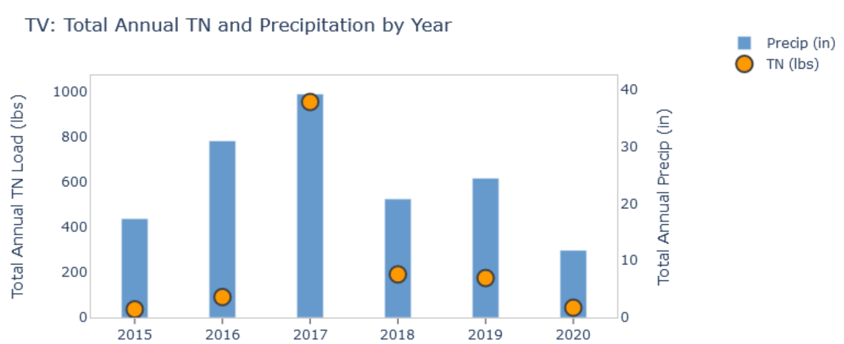

Figure 110 Total annual TN load and precipitation by year for Tahoe Valley WY15-WY20.

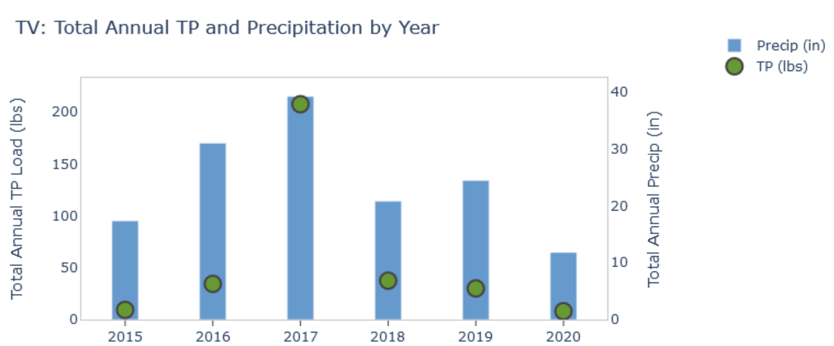

Figure 111 Total annual TP load and precipitation by year for Tahoe Valley WY15-WY20.

8.8 Tahoma

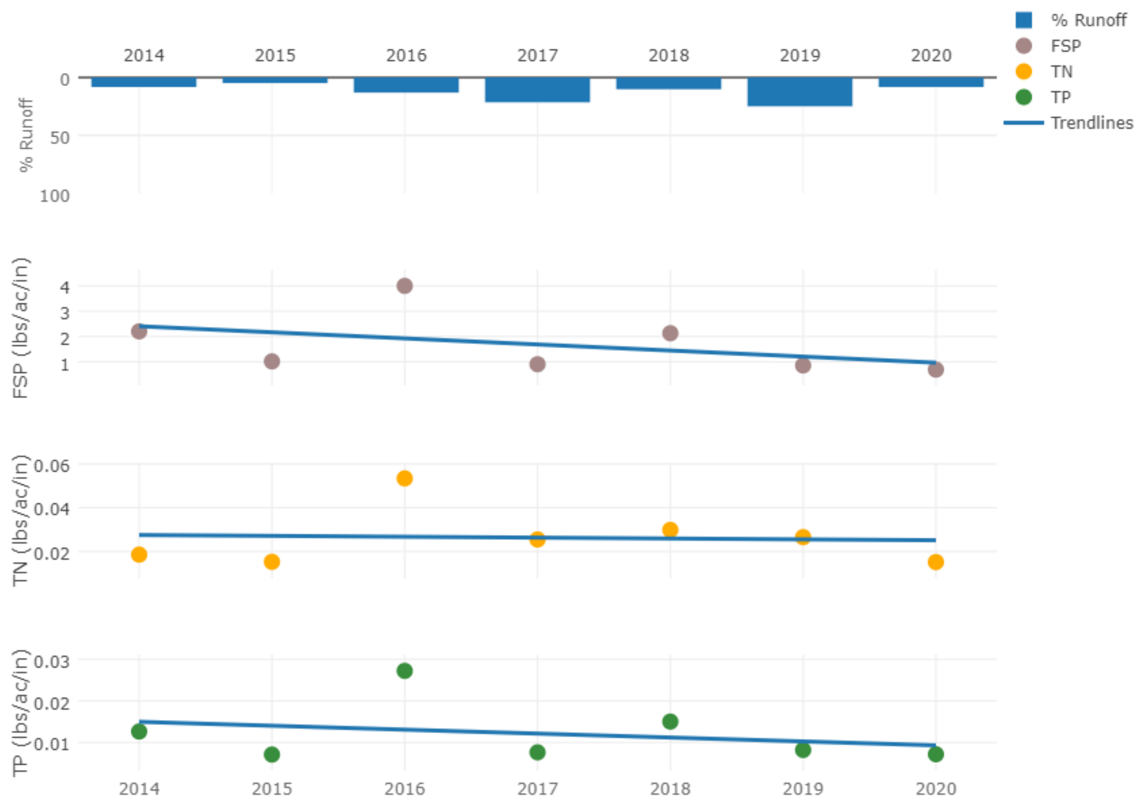

Figure 112 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Tahoma, WY14-20.

- Percent runoff varied between 4.8% in WY15 to 21.5% in WY17. Backwatered conditions in WY19 may have resulted in a falsely elevated percent runoff.
- There is no significant trend in normalized annual FSP loads as indicated by a p-value greater than 0.05. However, the Tau value is -0.619 and p-value is 0.051, which could indicate this site is approaching a significant decreasing trend.
- There is no significant trend in normalized annual TN loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.

Table 25 7-year seasonal and annual rainfall normalized pollutant loads at Tahoma, WY14-20. Percent runoff in 2019 highlighted in pink may be artificially high due to runoff volume errors associated with backwatering.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	8.2%	1.231	3.876	4.412	2.205	0.009	0.031	0.042	0.019	0.006	0.022	0.029	0.013
2015	4.8%	0.971	0.567	1.858	1.020	0.006	0.009	0.067	0.015	0.006	0.003	0.015	0.007
2016	13.1%	4.410	2.797	9.639	4.002	0.036	0.016	0.634	0.053	0.028	0.010	0.181	0.027
2017	21.5%	0.970	0.810	0.000	0.908	0.026	0.029	0.000	0.025	0.008	0.008	0.000	0.008
2018	10.1%	0.220	4.032	0.000	2.132	0.020	0.041	0.000	0.030	0.004	0.027	0.000	0.015
2019	24.9%	0.296	2.689	0.251	0.861	0.016	0.062	0.015	0.027	0.005	0.019	0.000	0.008
2020	8.3%	0.719	0.733	0.026	0.697	0.017	0.010	0.043	0.015	0.008	0.006	0.003	0.007
Tau	na	-0.524	-0.143	-0.600	-0.619	0.048	0.238	0.000	-0.048	0.048	-0.048	-0.400	-0.143
P-Value	na	0.099	0.652	0.142	0.051	0.881	0.453	1.000	0.881	0.881	0.881	0.327	0.652
Theil Slope (per year)	na	-0.169	-0.036	-0.566	-0.164	0.001	0.006	-0.002	0.000	0.000	-0.001	-0.004	-0.001

Figure 113 through Figure 116 show sediment and nutrient loads for Tahoma compared to total annual precipitation for WY14 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

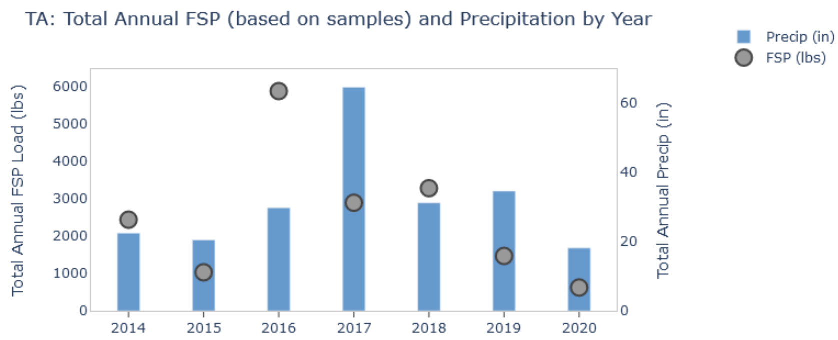

Figure 113 Total annual FSP load (based on samples) and precipitation by year for Tahoma WY14-WY20.

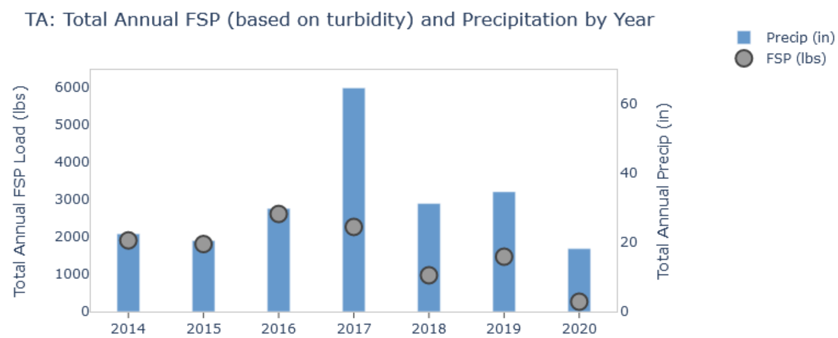

Figure 114 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoma WY14-WY20.

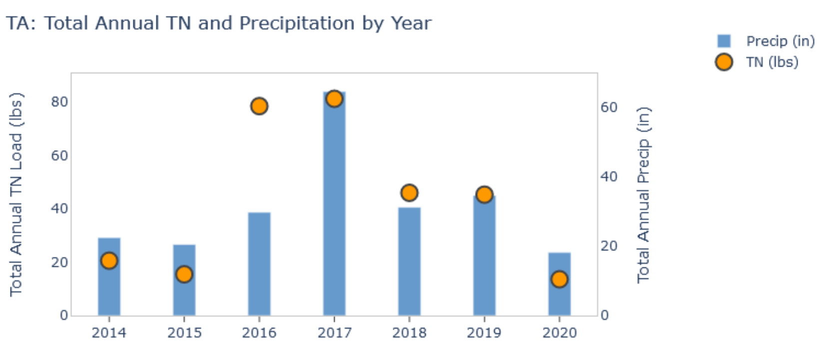

Figure 115 Total annual TN load and precipitation by year for Tahoma WY14-WY20.

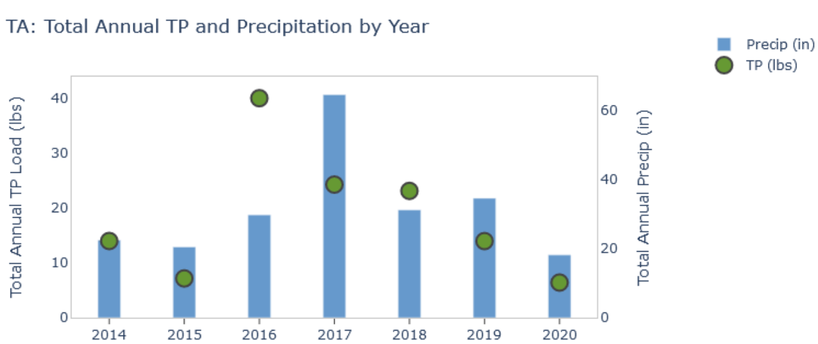

Figure 116 Total annual TP load and precipitation by year for Tahoma WY14-WY20.

8.9 Upper Truckee

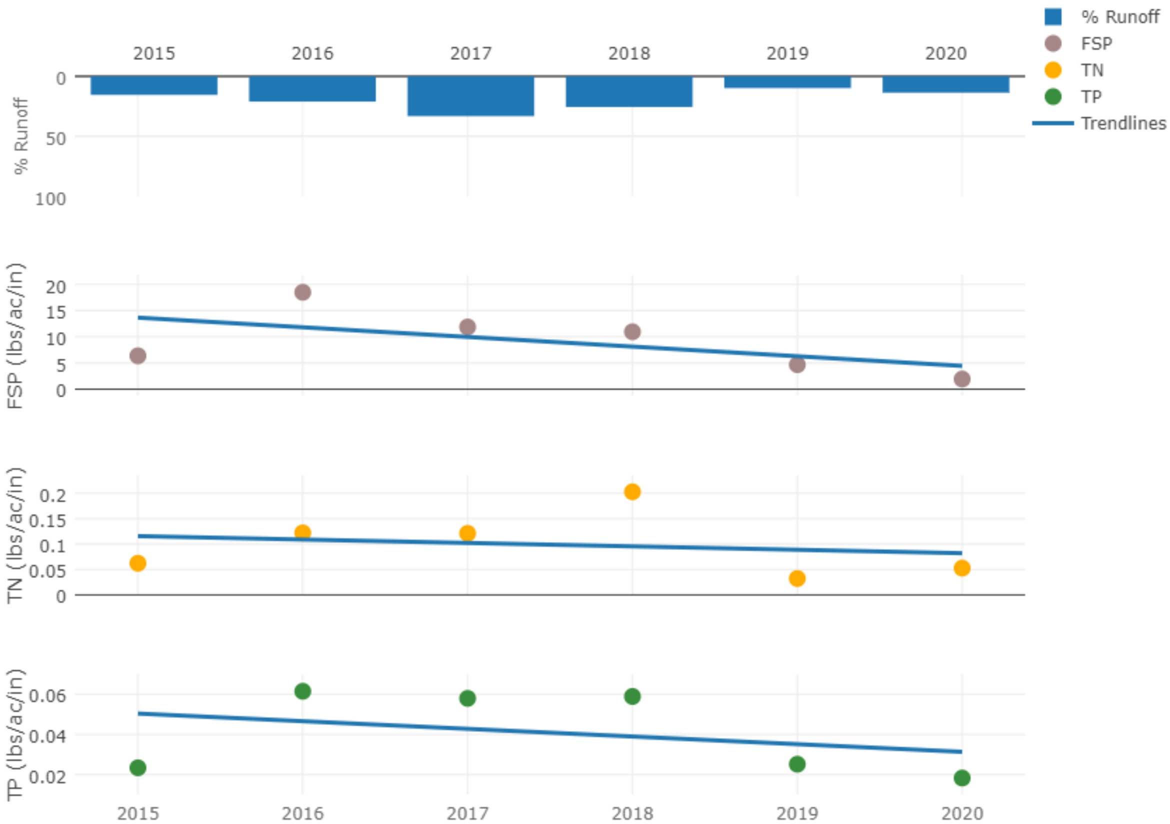

Figure 117 6-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Upper Truckee, WY15-20.

- Percent runoff varied between 9.8% in WY19 to 33.3% in WY17.
- Although the normalized annual and fall/winter FSP load Tau values are approaching -1 (-0.600), there is no significant trend in normalized annual FSP loads as indicated p-value greater than 0.05.
- There is no significant trend in normalized annual TN loads as indicated by a Tau value close to 0 and p-value greater than 0.05.
- There is no significant trend in normalized annual TP loads as indicated by a Tau value close to 0 and p-value greater than 0.05.

Table 26 6-year seasonal and annual rainfall normalized pollutant loads at Upper Truckee, WY15-20.

Year	% Runoff	FSP (lbs/acre/inch) Fall/ Winter	FSP Spring	FSP Summer	FSP Annual	TN (lbs/acre/inch) Fall/ Winter	TN Spring	TN Summer	TN Annual	TP (lbs/acre/inch) Fall/ Winter	TP Spring	TP Summer	TP Annual
2015	15.5%	6.297	11.878	0.000	6.367	0.049	0.151	0.000	0.062	0.022	0.047	0.000	0.023
2016	21.1%	14.220	28.052	0.000	18.498	0.121	0.128	0.000	0.122	0.053	0.081	0.000	0.061
2017	33.3%	8.219	502.504	6.832	11.869	0.069	5.003	0.579	0.121	0.040	2.253	0.143	0.058
2018	25.6%	7.244	15.326	0.000	10.956	0.350	0.100	0.000	0.203	0.048	0.075	0.000	0.059
2019	9.8%	4.188	6.599	0.000	4.673	0.027	0.053	0.000	0.032	0.022	0.037	0.000	0.025
2020	13.7%	1.728	2.150	2.339	1.940	0.045	0.054	0.115	0.053	0.015	0.022	0.019	0.018
Tau	na	-0.600	-0.467	na	-0.600	-0.200	-0.600	na	-0.200	-0.333	-0.467	na	-0.333
P-Value	na	0.091	0.188	na	0.091	0.573	0.091	na	0.573	0.348	0.188	na	0.348
Theil Slope (per year)	na	-2.164	-6.363	na	-3.310	-0.006	-0.023	na	-0.002	-0.007	-0.015	na	-0.004

Figure 118 through Figure 121 show sediment and nutrient loads for Upper Truckee compared to total annual precipitation for WY15 through WY20. This illustrates how loading and precipitation have varied over the monitored period.

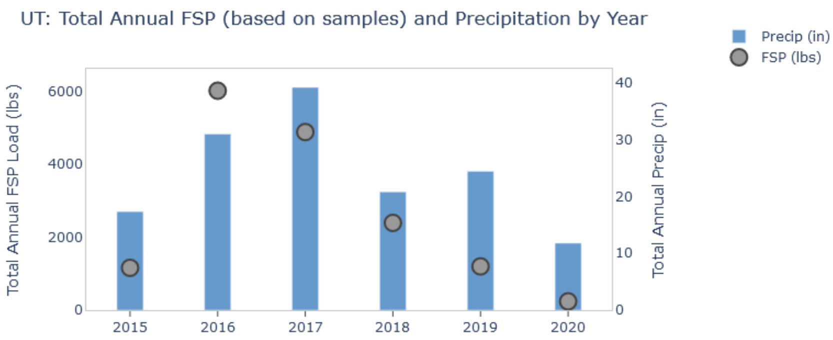

Figure 118 Total annual FSP load (based on samples) and precipitation by year for Upper Truckee WY15-WY20.

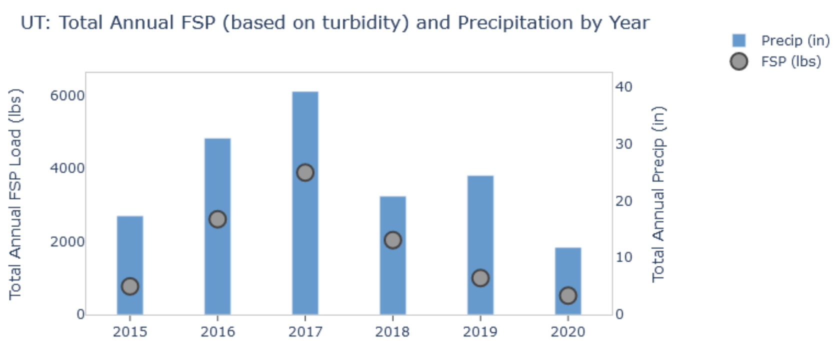

Figure 119 Total annual FSP load (based on continuous turbidity) and precipitation by year for Upper Truckee WY15-WY20.

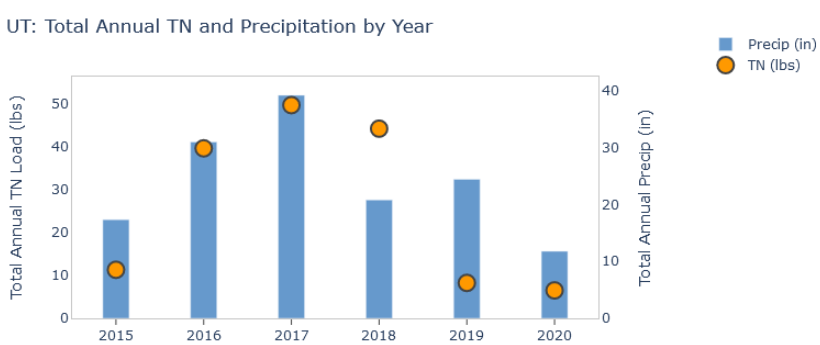

Figure 120 Total annual TN load and precipitation by year for Upper Truckee WY15-WY20.

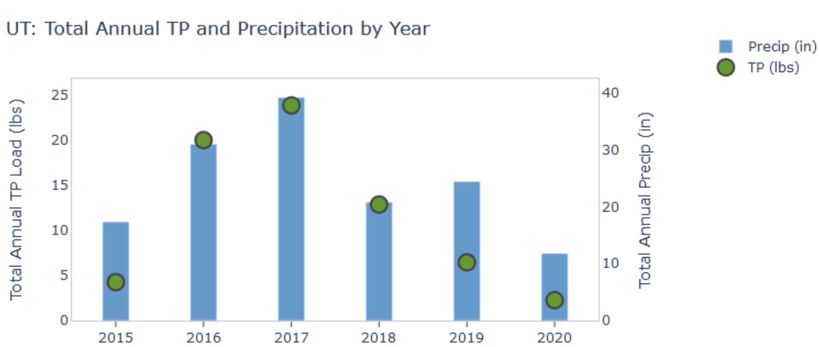

Figure 121 Total annual TP load and precipitation by year for Upper Truckee WY15-WY20.

9. PLRM Modeling Results

PLRM is the standard basin-wide model for pollutant load reduction estimates for the Lake Tahoe TMDL. All seven jurisdictions in two states are required to use the same modeling tool for estimating pollutant loads, allowing for comparisons of pollutant load reductions to be made across jurisdictions.

PLRM models in registered catchments were sourced from Washoe County (Lakeshore), NDOT (SR431), the City of South Lake Tahoe (Upper Truckee), and Caltrans (Upper Truckee) and include all registered BMPs and improved road operations (Lakeshore and SR431 models were built by the Nevada Tahoe Conservation District on behalf of Washoe County and NDOT, respectively). Models in unregistered catchments assume baseline conditions from 2004 and current parcel BMP status, with the exception of Elks Club Drive which uses the median Road RAM measurement from WY20.

Tahoe RCD compared average annual runoff volumes and pollutant loads predicted by PLRMv2.1 to annual volumes and pollutant loads measured in WY20 at all sites; results are presented in Table 27. In reviewing model performance, **it is important to highlight that PLRM represents average annual conditions based on an 18-year meteorological average, and each water year is unique. Therefore, differences between PLRM estimates and measured values are expected.**

WY20 was a very dry precipitation year for the Tahoe basin, therefore field measured runoff volumes, and FSP, TN, and TP loads are expected to be lower than PLRM modeled values. As expected, all measured volumes and pollutant loads were lower than the PLRM modeled runoff volumes and pollutant loads.

It is unrealistic to expect the model to perform perfectly; however, PLRM estimates relative conditions. For example, Tahoe Valley has the greatest annual runoff volume of all sites, which was predicted by PLRM. Also, in this very dry water year, PLRM performed as expected and modeled values greater than what was measured. Additionally, PLRM assumes that roads and commercial properties tend to be the highest polluting land uses, while multi-family residential and single family residential are less so, which conforms to our basic understanding of Tahoe stormwater pollutant sources.

Table 27 PLRM predicted and WY20 measured values for all monitored catchments. The first FSP column represents the FSP load calculated using event mean concentrations based on samples, while the second FSP column represents the FSP load estimated using continuous turbidity data. Registered catchments use models that include BMPs and improved road operations. Unregistered catchments use models based on baseline (2004) conditions with current parcel BMP status.

Water Year 2020 Oct. 1, 2019 - Sept. 30, 2020		Annual Runoff Volumes (cf)		Annual FSP Loads (Based on Samples) (lbs)		Annual FSP Loads (Based on Turbidity) (lbs)		Annual TN Loads (lbs)		Annual TP Loads (lbs)	
Catchment Name	Station Name	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured	PLRM	Measured
SR431	Contech Inflow	43,560	3,563	810	219	810	52	10.0	1.7	3.0	1.5
	Contech Outflow	43,560	871	810	29	279	13	4.0	0.1	3.0	0.0
	Jellyfish Inflow	43,560	4,078	810	251	810	33	10.0	1.6	3.0	1.6
	Jellyfish Outflow	43,560	4,036	810	73	318	44	4.0	0.6	3.0	0.5
Elk's Club	Elk's Club	187,308	31,233	2,266	56	2,266	25	33.0	1.7	9.0	0.6
Lakeshore	Lakeshore	357,192	0	2,885	na	2,885	na	56.0	na	14.0	na
Pasadena	Pasadena Out	143,748	5,646	446	70	446	66	13.0	4.4	5.0	0.9
Speedboat	Speedboat	322,344	55,217	4,956	484	4,956	1,830	59.0	8.1	17.0	2.0
Tahoe City	Tahoe City	213,444	47,386	2,868	140	2,868	374	32.0	3.7	8.0	1.6
Tahoe Valley	Tahoe Valley	6,037,416	660,849	60,014	473	60,014	808	852.0	43.3	221.0	8.1
Tahoma	Tahoma	662,112	268,684	10,787	624	10,787	264	126.0	13.6	37.0	6.4
Upper Truckee	Upper Truckee	352,836	61,392	2,875	240	2,875	519	46.0	6.5	10.0	2.3

10. Lessons Learned

Monitoring stations should be checked regularly, especially during runoff events, to identify any potential equipment malfunctions that may result in data gaps. There are a multitude of technical difficulties that can be encountered with stormwater monitoring, including equipment failure, freezing conditions, power failure, vandalism, and obstruction by sediment, snow, trash or other debris. Identifying and correcting these problems early results in a more accurate data set with fewer and shorter data gaps. Beginning WY17 all monitoring and weather stations are remotely accessible. This enables access to the stations and their status during all weather conditions and any time of day or night and allows for problems to be detected and remedied earlier than was previously possible when site visits were required to know station status. Additionally, alarms are set to send email alerts when certain parameters reach a pre-determined threshold.

The biggest cause of data gaps is power failure. Although all stations are equipped with solar panels to recharge batteries, some stations do not have enough sun exposure to keep batteries continuously charged (especially during winter), and during periods of extended cloud cover or snow blockage and subsequent decrease in solar recharge, all stations are subject to power failure. Checking battery voltage remotely on a regular basis and having alerts sent when charge drops below a voltage threshold has alleviated this problem but batteries must be continuously checked and changed.

When snow accumulation is frequent and excessive, it is very important to stay on top of site maintenance. Keeping the sites dug out and unfrozen is a continuous task necessary to maintain data integrity. The remote access system is beneficial in identifying when the sites are frozen and in need of maintenance.

High lake levels following WY17 and WY19 caused intermittent backwatered conditions at Tahoma. Previously, under backwatered conditions flow monitoring was not possible. On August 1, 2019 a replicate set of monitoring sensors were installed about 50 feet upstream of the original sensors at Tahoma. They are now available for use during backwatered conditions.

Field verifying data as a QAQC procedure is essential to ensure an accurate and reliable dataset. Tahoe RCD staff members regularly check stage and make note of precipitation type and totals during storms to ensure equipment is functioning properly. The greater the level of QAQC during precipitation events, the higher the level of certainty the dataset is representative. The importance of detailed field notes and photographs cannot be overstated. With passing time, the human memory lapses, while field notes and photographs can be referred to years and even decades after a monitoring event to explain what happened throughout the monitoring period.

Short duration, high intensity thunderstorms can be particularly difficult to sample, as the sometimes unpredictably large flow volumes can quickly fill all 24 sample bottles in the autosampler if the flow pacing is set too low. The result is that a portion of the end of the runoff hydrograph is not sampled. Due to the short nature of these events, it is incredibly difficult for staff to reach sites before runoff has ended to replace the full bottles with empty ones. Summer thunderstorms also tend to be very episodic in nature, and not all sites receive runoff over the summer period. As a result, several requisite summer events can easily be missed or do not produce enough runoff to sample, but the remote equipment makes successfully sampling these events more feasible. One mitigating method is to sample based on time rather than flow. Even with time-based sampling, flow weighted composites can be made. (See Figure 122 of Pasadena flowing during a summer thunderstorm event).

Storm events not captured in a particular season due to insufficient runoff can be substituted by a different storm in the next season to meet permit and agreement requirements of one storm event per season as approved by the Lahontan Regional

Water Quality Control Board (Lahontan). **All efforts are made to successfully sample several events during each season so that average seasonal pollutant concentrations and loads can be calculated. However, annual precipitation patterns are highly variable, and in some years, there is insufficient runoff for sampling in any given season. Approval of the annual permit/ILA monitoring requirement should not be withheld for this reason.** Fortunately, estimated FSP concentrations and loads can be calculated from the continuous turbidity data, so these values should never be missing from any season unless there is no runoff at all.

Figure 122 Flow during a thunderstorm event at Pasadena on July 16, 2020. Thunderstorm events can be difficult to monitor due to their short duration and episodic nature. Remote monitoring equipment makes sampling these events much more reliable.

Monitoring equipment at SR431 is located under the pavement in a wide pull-out and accessed through two hatches, one for the inflow locations and one for the outflow locations. Often, the hatches are located under many feet of hard icy snow that has been plowed off SR431 and stored in the pull-out making access impossible (Figure 123). NDOT maintenance crews must be called before sample collection to remove the snow with heavy equipment ahead of time.

Figure 123 Snow berms covering access to monitoring equipment at SR431, January 7, 2020. Even in low snow years, single snow events can make access to the sampling equipment difficult.

11. Changes: Accepted and Proposed

Changes Accepted

A new NPDES permit was issued to California jurisdictions in 2017. The new permit aligned all monitoring activities with the Regional Stormwater Monitoring Program (RSWMP) Framework and Implementation Guidance Document (Tahoe RCD et al 2015), most notably that six (rather than four) catchment outfalls and two (rather than three) BMPs must be monitored. Additionally, the first flush sampling requirement was dropped as sample analysis costs are high and continuous turbidimeter readings can replace this information. The Nevada Inter-local Agreements (ILAs) were issued in 2016 and require participation in IMP.

In the spring of WY17 Tahoe RCD proposed a new BMP monitoring site. The new location was approved by IMP, Lahontan, NDEP and monitoring equipment was removed from the Pasadena Inflow and installed at Elks Club Drive as described in section 2.2. Monitoring at Elks Club began in WY18. Elks Club Drive is considered a BMP site as resurfacing the road with a polymer enhanced asphalt mixture should be considered a best management practice for reducing FSP in stormwater runoff since it will be easier to sweep and less prone to degradation from chains, heavy equipment, plow blades, and the freeze/thaw cycle.

In the winter of WY19 the California Department of Transportation (Caltrans) joined IMP. A new site capturing stormwater runoff from state route 89 and adjacent commercial and residential areas in Tahoe City was installed in August of 2019. Monitoring of this site began October 1, 2019 at the commencement of water year 2020.

Changes Proposed

Because annual precipitation during all seasons is highly variable, and summer thunderstorms in particular tend to be very episodic in nature, not all sites receive sufficient runoff to sample the requisite number of events in every season, especially in the summer. **It may be advisable to amend permit and agreement language to acknowledge that all efforts are made to successfully sample several events during each season so that average seasonal pollutant concentrations and loads can be calculated. However, this is not always possible, and approval of the annual permit/ILA monitoring requirement should not be withheld for this reason.**

The Lakeshore monitoring site receives very little flow. In an especially dry year like WY20, it did not flow at all. RSWMP recommends replacing Lakeshore with another site in Nevada beginning WY22.

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Appendix A: Raw Analytical Data

Table A.1-Table A.9 present all available raw analytical data for autosampler composite (AC) samples. Other than QAQC samples, only AC samples were analyzed in WY20. Raw analytic data shows turbidity; TSS, FSP, TN, and TP concentrations; and particle size distribution.

Table A.1 Raw analytical data for samples taken at the inflow and outflow of the SR431 Contech MFS in WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
CI-AC	1/1/2020 12:03	1882.0	5990.0	1759.7	7,042	12,031	0.59	6.59	20.4	40.5	67.8	93.5	96.9	100	100	100	100	100	100
CI-AC	3/14/2020 11:00	1422.0	1100.0	981.2	5,408	6,366	0.42	4.48	13.10	26.1	46.3	69.0	76.0	96.1	99.7	100	100	100	100.0
CI-AC	7/20/2020 16:08	1525.0	515.0	587.1	10,660	4,254	0.23	2.22	5.61	10.4	20.4	38.5	46.2	87.2	96.5	100	100	100	100.0
CO-AC	7/20/2020 16:14	1211.0	513.0	591.0	1,541	732	0.27	2.67	6.77	12.8	26.2	48.8	57.2	90.0	96.7	100	100	100	100.0

Table A.2 Raw analytical data for samples taken at the inflow and outflow of the SR431 Jellyfish in WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
JI-AC	1/1/2020 12:03	1237.0	2396.0	959.9	4,257	7,162	0.54	5.98	18.80	37.2	58.6	77.6	82.6	95.4	99.2	100	100	100	100.0
JI-AC	3/14/2020 11:00	2910.0	3462.0	1847.9	6,908	10,744	0.37	3.95	11.40	22.8	41.5	63.5	70.6	93.3	98.4	100	100	100	100.0
JI-AC	5/18/2020 2:01	777.0	591.0	337.2	2,219	3,015	0.39	4.22	12.40	24.5	43.4	65.9	72.9	93.7	98.8	100	100	100	100.0
JI-AC	7/20/2020 16:08	1525.0	515.0	587.1	10,660	4,254	0.23	2.22	5.61	10.4	20.4	38.5	46.2	87.2	96.5	100.0	100.0	100	100.0
JI-AC	8/24/2020 0:16	80.0	49.2	1.0	5,064	494	0.00	0.03	0.23	0.4	0.8	1.3	1.5	2.2	2.8	6.0	37.3	95.4	100.0
JO-AC	1/1/2020 12:03	558.0	703.0	469.3	3,044	2,873	0.58	6.43	19.90	39.0	63.1	84.1	88.9	97.8	99.8	100	100	100	100.0
JO-AC	3/14/2020 11:01	618.0	742.0	460.4	2,863	2,867	0.46	5.00	15.30	30.6	51.0	74.5	82.1	100.0	100.0	100	100	100	100.0
JO-AC	5/18/2020 6:31	321.0	300.0	187.8	1,906	1,387	0.53	5.84	17.70	34.6	58.5	83.2	89.9	100.0	100.0	100	100	100	100.0
JO-AC	7/20/2020 16:08	175.0	183.0	55.7	743	373	0.27	2.57	5.90	9.8	17.3	31.8	38.5	83.1	96.3	100.0	100	100	100.0
JO-AC	8/24/2020 0:19	55.0	30.4	0.1	4,392	336	0.00	0.01	0.05	0.1	0.1	0.2	0.3	0.8	1.6	5.0	14.1	29.0	100.0

Table A.3 Raw analytical data for samples taken at Elks Club in WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
EC-AC	12/1/2019 10:33	13.5	6.7	3.1	528	69	0.03	0.38	1.39	3.3	8.2	22.8	31.5	89.9	100.0	100.0	100.0	100.0	100.0
EC-AC	1/26/2020 3:56	128.0	180.0	52.1	871	623	0.25	2.61	7.26	13.9	24.4	40.7	47.5	86.4	96.9	100.0	100	100	100.0
EC-AC	3/31/2020 13:18	23.5	12.8	4.3	388	81	0.05	0.51	1.32	2.7	6.8	18.5	24.9	69.4	89.6	99.9	100	100	100.0
EC-AC	4/8/2020 11:48	35.5	27.0	7.9	500	122	0.12	1.18	3.18	6.2	11.6	22.3	28.2	61.1	79.0	92.7	96.7	100.0	100.0
EC-AC	4/9/2020 21:00	37.0	43.3	10.9	446	176	0.15	1.52	4.12	8.1	15.4	29.5	35.9	70.1	87.1	95.5	96.6	100	100.0
EC-AC	4/17/2020 15:56	57.5	52.7	20.0	589	240	0.18	1.82	4.83	9.1	17.4	34.8	42.8	82.1	94.2	100.0	100.0	100	100.0
EC-AC	5/17/2020 19:03	50.0	40.6	15.9	549	275	0.16	1.62	4.21	8.0	15.7	31.8	39.0	80.1	95.5	100	100	100	100.0
EC-AC	7/16/2020 14:13	752.0	680.0	303.1	5,780	2,252	0.19	1.92	5.27	11.0	22.4	40.3	46.9	81.4	95.0	100.0	100.0	100	100.0

Table A.4 Raw analytical data for samples taken at Pasadena in WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
PO-AC	12/2/2019 14:23	35.5	17.8	8.2	4,083	476	0.04	0.47	1.60	4.1	9.9	23.1	29.6	74.9	92.6	100.0	100	100	100.0
PO-AC	12/13/2019 12:30	39.0	36.7	7.8	1,471	326	0.07	0.65	1.74	3.6	8.5	20.0	25.7	69.9	91.9	100.0	100.0	100	100.0
PO-AC	7/16/2020 14:55	592.0	567.0	235.0	14,134	2,821	0.11	1.20	4.32	12.0	24.8	39.7	45.2	74.6	96.1	100.0	100.0	100.0	100.0
PO-AC	8/17/2020 17:45	148.0	83.4	57.6	8,131	1,108	0.19	1.88	5.20	10.9	21.8	38.9	45.6	80.5	95.8	100	100	100	100.0

Table A.5 Raw analytical data for samples taken at Speedboat, WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
SB-AC	12/1/2019 11:15	69.5	54.9	27.5	753	330	0.14	1.58	5.39	13.0	24.4	39.6	45.6	77.0	89.1	95.6	97.4	100.0	100.0
SB-AC	12/7/2019 0:35	170.5	136.0	82.7	1,147	636	0.28	2.92	8.17	15.8	28.9	48.5	55.6	85.5	94.9	98.8	99.4	100	100.0
SB-AC	1/26/2020 7:21	222.0	268.0	104.6	1,514	1,039	0.29	3.09	8.88	17.4	30.4	47.1	53.5	86.4	96.5	100.0	100	100	100.0
SB-AC	3/19/2020 14:10	90.5	85.9	15.2	711	454	0.11	1.18	3.42	6.5	11.0	16.8	18.9	25.1	26.5	32.3	53.3	87.5	100.0
SB-AC	4/5/2020 11:33	173.0	177.0	111.4	1,662	969	0.38	4.02	11.40	22.5	40.8	64.4	72.6	99.8	100.0	100	100	100	100.0
SB-AC	4/6/2020 9:43	250.0	201.0	184.3	1,339	1,020	0.43	4.59	13.30	26.6	48.5	73.7	80.9	97.9	99.6	100.0	100.0	100	100.0
SB-AC	7/20/2020 16:10	2118.0	1070.0	713.8	11,872	1,149	0.19	1.88	4.79	9.1	18.0	33.7	40.4	77.2	93.0	100.0	100.0	100	100.0

Table A.6 Raw analytical data for samples taken at Tahoe City, WY20

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TC-AC	12/1/2019 5:28	99.0	121.0	49.1	1,819	509	0.41	4.16	11.40	20.7	33.1	49.6	55.9	84.0	93.1	99.1	99.6	100	100.0
TC-AC	12/6/2019 14:00	56.5	65.1	22.9	706	307	0.27	2.75	7.60	14.5	25.0	40.6	46.7	80.7	95.0	100.0	100.0	100	100.0
TC-AC	1/26/2020 1:35	231.0	376.0	123.6	1,475	1,405	0.39	4.13	12.00	22.7	37.5	53.5	59.4	86.9	96.0	100.0	100.0	100	100.0
TC-AC	3/14/2020 1:40	153.0	213.0	74.8	1,871	797	0.43	4.32	11.50	20.3	31.8	48.9	56.5	91.2	98.9	100.0	100.0	100	100.0
TC-AC	3/19/2020 13:35	40.5	52.0	3.4	442	227	0.10	0.87	2.07	3.5	5.5	8.3	9.5	14.2	16.4	23.0	46.9	86.9	100.0
TC-AC	4/5/2020 12:58	106.0	149.0	62.5	615	619	0.40	4.32	12.70	23.8	38.1	59.0	67.5	99.8	100.0	100.0	100.0	100	100.0
TC-AC	4/6/2020 9:56	75.5	97.9	51.4	531	397	0.55	5.88	17.00	31.6	48.9	68.1	75.0	93.4	97.4	99.7	100.0	100	100.0
TC-AC	5/17/2020 16:05	58.5	64.5	28.8	1,400	358	0.31	3.26	9.16	17.7	30.3	49.2	56.5	85.7	95.9	99.6	99.8	100	100.0

Table A.7 Raw analytical data for samples taken at Tahoe Valley, WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TV-AC	12/1/2019 16:18	39.0	37.1	14.3	1,096	261	0.19	1.94	5.54	11.1	20.2	36.7	44.0	82.1	94.4	100.0	100.0	100.0	100.0
TV-AC	12/7/2019 1:15	30.5	28.7	8.1	1,151	150	0.18	1.77	4.34	7.4	13.3	26.7	33.3	75.8	93.3	100.0	100.0	100	100.0
TV-AC	3/24/2020 11:31	26.0	15.0	5.8	849	81	0.04	0.48	1.46	3.3	8.3	22.3	29.8	86.2	100.0	100	100	100	100.0
TV-AC	3/31/2020 11:20	29.5	14.0	6.3	802	84	0.07	0.73	2.03	4.2	8.8	21.2	27.9	65.2	83.8	98.5	99.6	100.0	100.0
TV-AC	4/6/2020 15:31	45.0	48.3	12.6	819	141	0.14	1.30	3.07	5.4	11.5	28.1	36.3	82.9	95.3	100.0	100.0	100	100.0
TV-AC	4/17/2020 14:36	66.5	54.0	19.7	1,294	211	0.15	1.48	3.73	6.8	13.4	29.6	37.4	79.0	93.9	100.0	100.0	100.0	100.0
TV-AC	5/17/2020 20:16	31.0	36.1	0.7	940	182	0.01	0.16	0.39	0.7	1.2	2.3	2.9	6.1	8.3	14.0	33.0	69.6	100.0
TV-AC	7/16/2020 14:20	362.0	328.0	68.4	8,120	1,772	0.08	0.87	2.78	6.6	12.4	18.9	21.2	36.2	47.1	58.8	71.5	90.6	100.0
TV-AC	8/17/2020 17:20	542.0	479.0	221.1	17,916	3,719	0.21	2.17	5.94	11.9	23.5	40.8	47.0	76.8	87.7	96.3	98.0	100	100.0

Table A.8 Raw analytical data for samples taken at Tahoma, WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
TA-AC	12/1/2019 9:50	90.0	72.4	28.8	834	366	0.17	1.74	4.66	9.2	17.3	32.0	38.4	78.6	93.2	100.0	100.0	100.0	100.0
TA-AC	12/7/2019 5:31	58.5	42.4	19.5	566	206	0.17	1.67	4.38	8.5	17.0	33.3	40.0	76.9	91.9	99.9	100	100	100.0
TA-AC	1/26/2020 3:55	176.0	204.0	79.2	1,174	907	0.26	2.64	7.16	14.2	27.0	45.0	51.6	84.0	95.1	100	100	100	100.0
TA-AC	3/31/2020 7:51	97.5	66.6	39.5	615	310	0.25	2.50	6.54	12.1	21.9	40.5	48.3	84.2	94.1	100	100	100	100.0
TA-AC	4/3/2020 9:58	63.5	44.5	26.6	502	189	0.23	2.43	7.00	14.0	24.8	41.9	48.8	81.4	93.9	99.0	99.4	100	100.0
TA-AC	4/6/2020 9:28	88.5	87.1	41.9	620	316	0.28	2.86	8.10	16.0	29.1	47.3	53.8	82.1	93.9	100	100	100	100.0
TA-AC	4/9/2020 18:31	24.0	12.7	8.7	156	74	0.17	1.71	4.57	8.9	17.8	36.2	44.0	81.9	94.5	100	100	100	100.0
TA-AC	5/17/2020 16:03	330.5	155.0	122.0	1,411	930	0.23	2.26	5.83	10.6	19.8	36.9	44.2	80.4	91.8	98.4	98.7	100	100.0
TA-AC	8/24/2020 0:11	125.0	71.4	5.7	9,429	722	0.03	0.28	0.74	1.4	2.5	4.5	5.4	10.6	14.7	22.1	51.0	87.3	100.0

Table A.9 Raw analytical data for samples taken at Upper Truckee, WY20.

Sample	Sample Start (Date/Time)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5	%< 1	%< 2	%< 4	%< 8	%< 16	%< 20	%< 63	%< 125	%< 250	%< 500	%< 1000	%< 2000
UT-AC	12/1/2019 15:03	137.5	181.0	53.6	1,447	467	0.27	2.75	7.56	14.2	23.9	39.0	45.5	83.0	95.3	100.0	100.0	100.0	100.0
UT-AC	12/7/2019 2:06	126.5	164.0	52.9	1,383	483	0.28	2.90	8.09	15.3	26.3	41.8	47.9	80.3	93.4	100.0	100.0	100.0	100.0
UT-AC	1/26/2020 7:35	192.0	269.0	94.8	2,168	806	0.34	3.51	9.89	18.6	31.4	49.4	56.6	91.7	97.9	100	100	100	100.0
UT-AC	3/14/2020 8:58	251.0	413.0	126.3	2,455	1,285	0.31	3.26	9.52	18.8	32.3	50.3	57.2	91.1	98.6	100	100	100	100.0
UT-AC	4/9/2020 22:03	128.5	278.0	62.7	1,910	715	0.36	3.68	10.10	18.8	31.6	48.8	54.8	81.9	93.7	100	100	100	100.0
UT-AC	4/17/2020 15:05	133.5	185.0	69.2	1,657	463	0.31	3.20	9.01	17.8	31.4	51.8	59.8	90.9	95.5	98.9	99.4	100	100.0
UT-AC	5/17/2020 19:16	43.0	61.1	13.0	930	192	0.15	1.49	4.07	8.1	15.7	30.2	36.7	72.8	91.1	99.2	99.3	100.0	100.0
UT-AC	7/16/2020 14:38	284.0	248.0	128.1	5,492	988	0.25	2.52	6.95	14.0	26.7	45.1	50.9	76.2	96.5	100.0	100.0	100.0	100.0
UT-AC	8/17/2020 17:45	73.0	44.6	28.2	4,449	444	0.21	2.13	5.69	11.4	22.2	38.6	44.2	68.0	86.6	95.6	98.3	100.0	100.0

Appendix B: Quality Assurance/Quality Control Summary

Field duplicates are samples collected at the same time and treated identically and are used to assess the reproducibility of collected data. This provides a measure of analytical precision and can be used for detecting problems in sample collection, handling, transport processing, and analysis. The actual procedures for collecting field duplicate samples depend on the sampling methods and protocols used. When automated sampling equipment is used, duplicates need to be collected manually either by: (a) triggering the sampler manually twice in quick succession (two MS samples) or (b) manually triggering a sample and then collecting a grab sample at the same time (one MS sample and one GS sample), (RSWMP SAP, 2011). Differences in paired samples greater than 20% indicate a problem. Field blanks (FB) are collected to identify sample contamination occurring during field collection, handling, transport, storage, and during laboratory handling and analysis. Field blanks are collected throughout the sampling season by pouring reagent-grade "blank" water into the autosampler bottles in the field and then exposing them to conditions equivalent to the standard sample bottles.

Paired sample results with a difference between them of greater than 20% are highlighted in pink in Table B.1. The difference between the paired MS/GS samples at Tahoma on May 17, 2020 may be due to sediment inundation at the sample intake tube. The accumulated sediment was subsequently cleared from the intake tube. The difference between the paired MS/MS samples at Upper Truckee on May 18, 2020 may be due to fluctuations in sediment concentrations from minute to minute.

Table B.1 MS and GS sample data from WY20. Paired sample results with a difference between them of greater than 20% are highlighted pink.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5 um	%< 1 um	%< 2 um	%< 4 um	%< 8 um	%< 16 um	%< 20 um	%< 63 um	%< 125 um	%< 250 um	%< 500 um	%< 1000 um	%< 2000 um
EC-MS	5/18/2020 9:58	23.5	14.9	0.4	277	96	0.02	0.21	0.45	0.77	1.6	3.8	5.0	13.7	19.5	27.3	47.4	82.2	100.0
EC-MS	5/18/2020 10:00	23.0	14.6	0.4	281	93	0.02	0.22	0.47	0.81	1.7	4.0	5.1	13.6	19.8	27.8	47.5	81.2	100.0
SB-MS	12/1/2019 11:16	110.5	79.5	47.3	1,447	476	0.15	1.63	5.72	14.60	27.6	42.8	48.4	76.5	87.4	93.6	96.1	100.0	100.0
SB-MS	12/1/2019 11:17	105.5	76.3	48.0	1,456	489	0.15	1.70	6.11	15.70	29.8	45.5	51.1	79.4	89.8	95.5	97.3	100.0	100.0
TA-MS	12/2/2019 9:52	58.0	49.7	19.5	598	255	0.18	1.82	4.89	9.49	17.8	33.6	40.6	78.3	93.0	99.6	100.0	100.0	100.0
TA-GS	12/2/2019 9:53	61.5	49.2	19.5	608	284	0.18	1.77	4.71	9.02	16.8	31.7	38.2	75.1	92.4	100.0	100.0	100.0	100.0
TA-MS	5/17/2020 18:20	219.0	102.0	28.7	1,371	679	0.09	0.85	2.16	3.87	6.9	13.1	16.0	33.5	40.4	48.2	64.6	90.5	100.0
TA-GS	5/17/2020 18:21	77.0	45.7	8.6	1,321	383	0.08	0.77	2.00	3.70	6.5	11.2	13.4	23.5	28.7	36.1	58.1	90.1	100.0
UT-MS	5/18/2020 10:03	35.5	62.3	0.6	987	160	0.03	0.23	0.57	1.01	1.8	3.2	3.8	8.3	11.5	17.4	37.0	76.4	100.0
UT-MS	5/18/2020 10:05	34.5	55.3	7.6	954	166	0.17	1.83	5.64	12.00	22.1	41.2	50.0	92.4	100.0	100.0	100.0	100.0	100.0

Table B.2 Field blank sample data from all sites in WY20. No values were greater than the method detection limit indicating no contamination. All samples were too clear for PSD analysis.

Sample	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	TN (ug/L)	TP (ug/L)	%< 0.5 um	%< 1 um	%< 2 um	%< 4 um	%< 8 um	%< 16 um	%< 20 um	%< 63 um	%< 125 um	%< 250 um	%< 500 um	%< 1000 um	%< 2000 um
TA-FB	5/17/2020 18:22	<0.3	0.5	na	<35	1	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-FB	5/18/2020 10:10	<0.3	0.8	na	<35	1	na	na	na	na	na	na	na	na	na	na	na	na	na
UT-FB	1/26/2020 11:00	<0.3	0.1	na	<35	<1	na	na	na	na	na	na	na	na	na	na	na	na	na