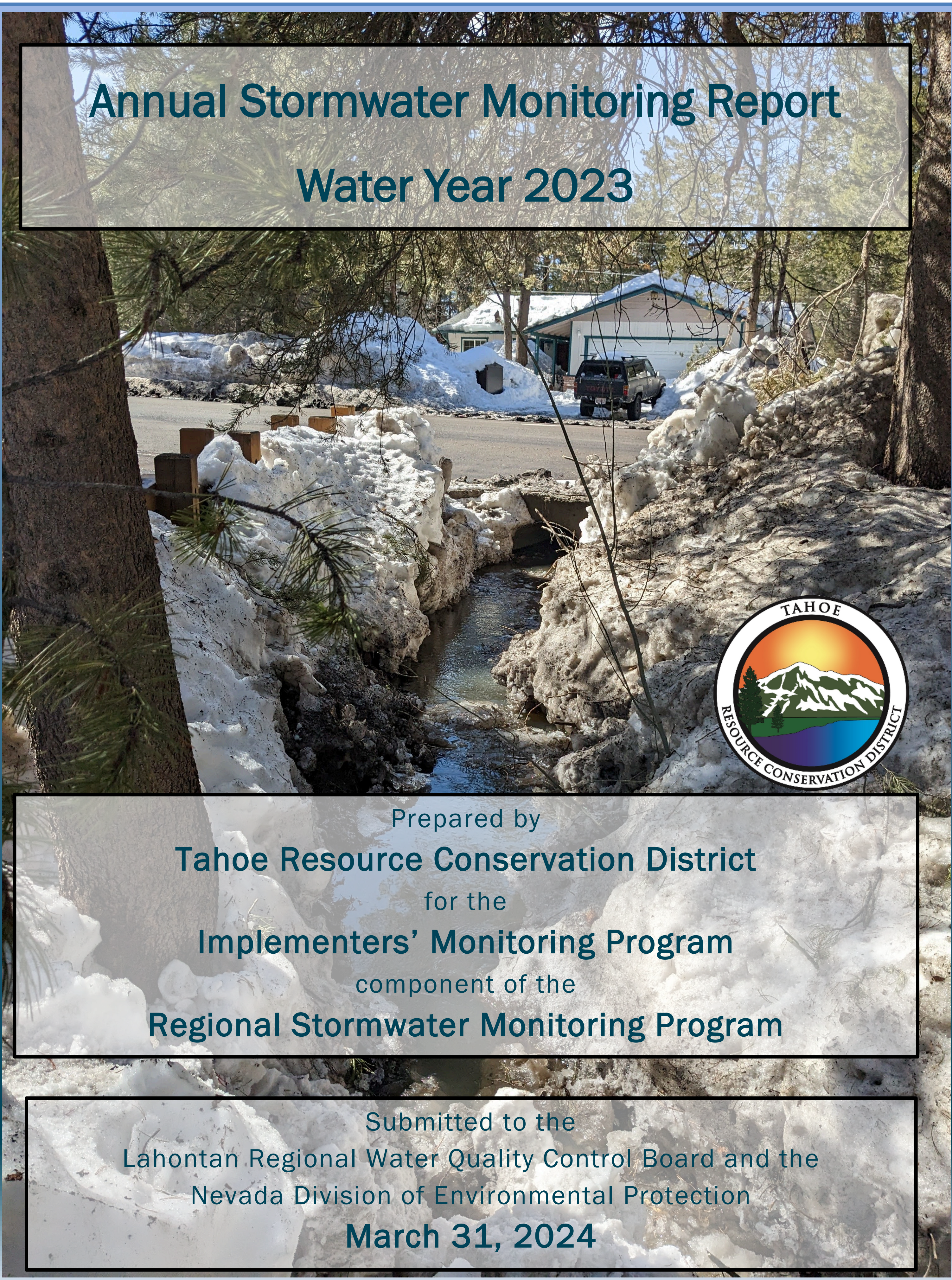

Annual Stormwater Monitoring Report

Water Year 2023

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

March 31, 2024

Annual Stormwater Monitoring Report

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

Funding for this project is currently provided in full through agreements with the City of South Lake Tahoe, El Dorado County, Placer County, Douglas County, Washoe County, the California Department of Transportation, and the Nevada Department of Transportation.

Funding for this project has previously been provided in part by the USDA Forest Service Lake Tahoe Basin Management Unit through the Southern Nevada Public Lands Management Act and the Department of Conservation.

Funding has previously been provided in part through an agreement with the State Water Resources Control Board using funds from Proposition 84.

The contents of this document do not necessarily reflect the views and policies of the foregoing, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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
SR431	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. The NPDES permit issued to California jurisdictions for the second five-year term aligned all monitoring activities with the 2017 update of the RSWMP Framework and Implementation Guidance Document (RSWMP FIG, Tahoe RCD et al 2017). In the second permit term (WY17-WY21), California jurisdictions were 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. No changes were made to the permit requirements in the third permit term (WY22-WY26). The 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 is 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 2023 (WY23), nine monitoring sites (catchments) 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 by one additional outfall. At the August 2019 IMP meeting, it was agreed that all seven outfalls would continue to be monitored during WY20 and WY21 to support continuity of data. In the summer of 2021, IMP agreed to make no changes to the monitoring network for WY22. No changes were made for WY23 either. 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, each located within two miles of their paired 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.

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 treatment types 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

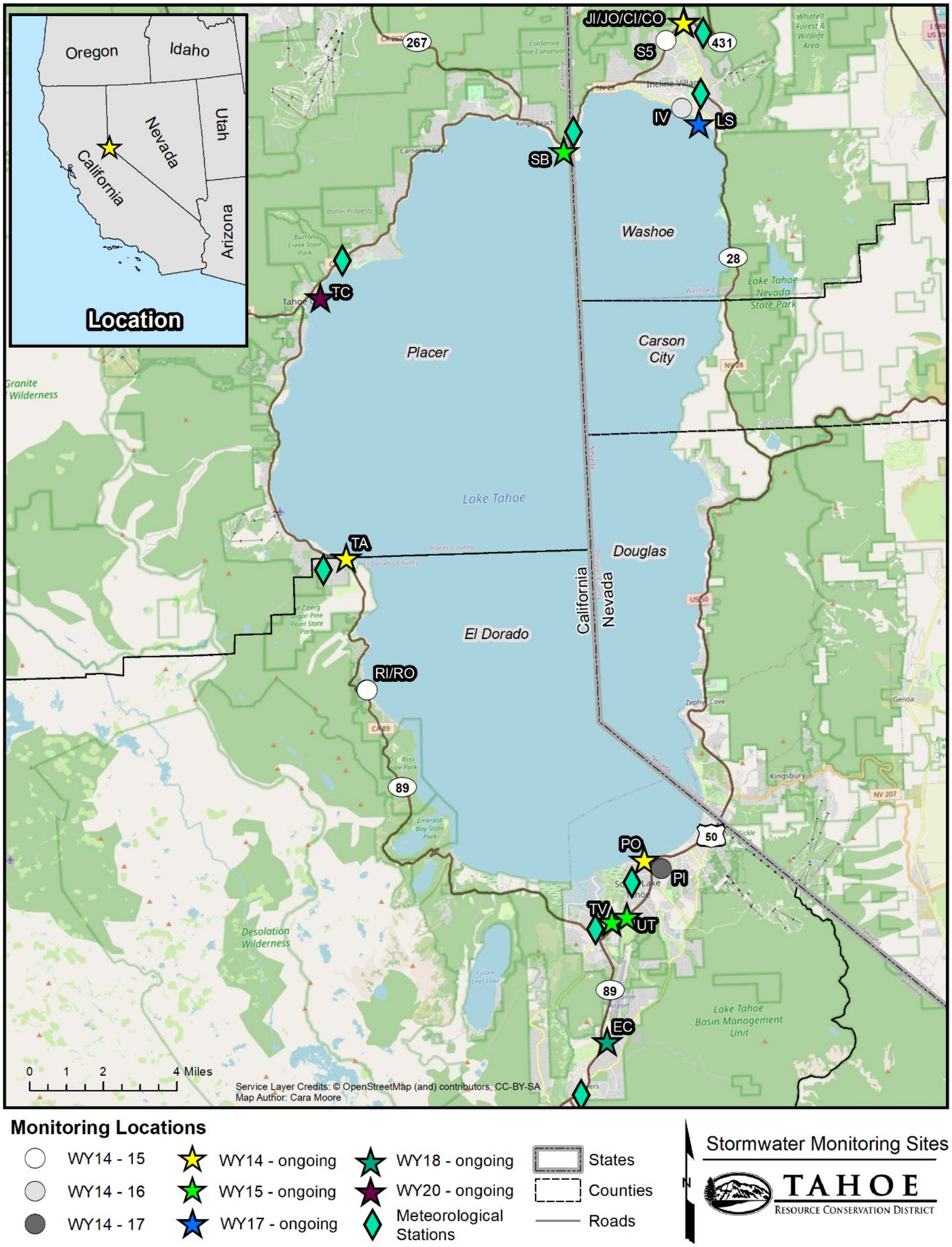

Figure 1 Past and current stormwater monitoring sites and ongoing meteorological stations. Jellyfish Inflow (JI), Jellyfish Outflow (JO), Contech MFS Inflow (CI), Contech MFS Outflow (CO), SR431 outfall (S5), Incline Village (IV), Lakeshore (LS), Speedboat (SB), Tahoma (TA), Rubicon Inflow (RI), Rubicon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

2.1 SR431 Catchment Description

The SR431 monitoring site was established WY14 and 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 had a catchment outfall location that was monitored for two years (WY14-15), but this station gave very little useful information due to a variety of factors including redundancy with vault discharge measurements and it being poorly configured for monitoring equipment. SR431 is now only monitored for evaluating and comparing the effectiveness of two adjacent stormwater treatment vaults, the Contech MFS and the Jellyfish. The Contech MFS vault contains media filled cartridges and the Jellyfish vault contains filtering membranes (WY14 - ongoing). There are currently 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). 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 treatment types can be performed. In October of 2020, NDOT installed a Jensen Deflective Separator (hydrodynamic separator) between the existing drop inlet and the diversion manhole as a pre-treatment system to capture bulk sediment, trash, and debris before it enters the splitter chamber. With this system in place the existing media filtration systems should no longer be overwhelmed with coarse sediment and can more effectively treat fine sediment.

Runoff enters a transverse drain across a parking pull-out directly adjacent to SR431. As of WY21, runoff then flows into the hydrodynamic separator installed in October 2020. 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 can fill with accumulated sediment and without proper consistent maintenance the volume often does not get split evenly. Though the hydrodynamic separator has alleviated this problem to some extent, flows are not necessarily always 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 was established WY18 and is located on the northwest corner of Elks Club Drive and Bel Aire Circle in El Dorado County. It is monitored as 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 fairly steep and 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 from WY18 (pre project) and WY19 (post project) 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 in WY19 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. This site has been monitored continuously since WY18 to provide several years of post-project water quality data that could be used to determine the rate at which a road degrades and its effect on water quality over time.

2.3 Lakeshore Catchment Description

The Lakeshore monitoring site was established WY17 and is located in the roadside channel on the northern side of Lakeshore Boulevard, near Third Creek, replacing the old Incline Village site. Incline Village is no longer monitored because it rarely receives any flow. Lakeshore 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 treatment vault 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 Boulevard east of Village Boulevard as well as some overland flow originating upslope of Lakeshore Boulevard.

2.4 Pasadena Catchment Description

The Pasadena monitoring site was established WY14 and is located at the northernmost end of Pasadena Avenue in the City of South Lake Tahoe (City). It was monitored as a catchment outfall and BMP effectiveness site beginning WY14. 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. Several in-situ infiltration BMPs, including 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 in 2010 at the end of the catchment before discharge to the lake through the 36-inch CMP. Pasadena Inflow (PI) was a monitoring station located at the inflow to the pre-treatment Vortechnics vault and two Stormfilter cartridge filter vaults but below the in-situ BMPs. Pasadena Outflow (PO) is located in the 36-inch outfall CMP.

Beginning WY18 Pasadena was monitored as a catchment outfall only at PO. Inflow monitoring was suspended at PI because it wasn’t truly monitoring untreated inflow as it was located downstream of the in-situ infiltration BMPs that provide some pretreatment. 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). The vaults and filters are inspected every year per the manufacturer’s specifications. The pre-treatment Vortechnics vault is fully cleaned every one to two years. Material accumulation in the Stormfilter vault and on the filters has not yet triggered a need to fully replace the filter cartridges as of WY23.

2.5 Speedboat Catchment Description

The Speedboat monitoring site was established WY15 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 18-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, low flows flow directly to an infiltration vault. Higher flows flow through a vegetated channel to the infiltration vault. The highest flows flow first through an infiltration basin and then to the infiltration vault if the basin overflows. The infiltration vault discharges 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 was established WY20 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 the second smallest and is monitored as a catchment outfall at a single monitoring station (TC). The catchment is 62% impervious and dominant land uses include primary roads, commercial/industrial/communications/utilities (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 was established WY15 and is located on the eastern side of Tahoe Keys Boulevard just north of the intersection with Sky Meadows Court in South Lake Tahoe, near the entrance to the Sky Meadows Condominium Complex. With an area of 338.4 acres, it is the largest catchment monitored. It is a relatively flat, highly urbanized catchment consisting primarily of 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

The Tahoma monitoring site was established WY14 and is located at the bottom of Pine Street right at the lake's edge in Tahoma. It 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.

The culvert pipe at this site was vactored on June 12, 2023 to remove all accumulated sediment.

2.9 Upper Truckee Catchment Description

The Upper Truckee monitoring site was established WY15 and 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. 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 third 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 high-density polyethylene (HDPE) pipe 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 HDPE pipe 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 loads for WY20, WY21, and WY22 are lower than any previous pre-project year (this is not true for WY23) (see section 8.10). Though four years of post-project data are not enough to state conclusively that low loads in WY20-WY22 are due to treatment of Highway 50 runoff in the vault, it is an indication that treatment may be effective.

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 WY23 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 fine sediment particle (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 monthly 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 being sent to 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 in 2019, 2020, 2021, 2022, and 2023.

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 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	35 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	35 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

Level, flow, turbidity, precipitation, and temperature data series and sample dates and times are logged continuously through the RSWMP Data Management System (DMS). The RSWMP DMS is a proprietary two-component online system housed, hosted, and maintained by the Desert Research Institute and Geosyntec. All data are downloaded from the DMS and input into Excel workbooks for storing continuous parameters and sample dates and times and for conducting QAQC. 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. 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 QAQC protocols outlined in the RSWMP FIG sections 10.2.1.7 for flow and 10.2.2.5 for turbidity.

Seasonal and annual flow volumes are calculated by the DMS in accordance with RSWMP FIG sections 10.2.1.8 and 10.2.1.9. Results of particle size distribution analysis for the percent of particles less than 16 μm is multiplied by the TSS concentration to obtain FSP concentration from water quality samples. These results and the results of lab analysis for TN and TP concentration in water quality samples 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. Sites are inspected annually to ensure the equipment is working properly. Occasionally precipitation gauges will get clogged with debris (dirt, wasp nests, pine needles etc.) but with weekly review of the continuous data via the online DMS these issues are identified quickly and remedied. 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.

Average annual loads for FSP, TN, and TP presented in section 8, Trends Analysis, 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 as runoff.

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 a statistically significant upward, downward, or neutral trend in pollutant loading 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, which in this case are water year and 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 water years will always be ranked in order from 2014 through 2023. 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.

6. Catchment Outfall Monitoring

6.1 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 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 92-year precipitation record (water years 1932-2023) from this station, WY23, at 46.86 total inches, falls within the fourth quartile for this period of record and is therefore designated a very wet year (Table 4, Figure 2). In WY23 approximately 73% of the precipitation fell during the fall/winter season, approximately 22% fell during the spring season, and approximately 5% fell during the summer season.

Table 4 Annual precipitation statistics from the Tahoe City meteorological reference station, water years 1932-2023.

WY 1932-2023	Annual Precipitation (in)	Designation
1st quartile	8.8 - 22.4	very dry
2nd quartile	22.5 - 29.7	dry
Median	29.8	average
3rd quartile	29.9 - 40	wet
4th quartile	40.1 - 69.8	very wet

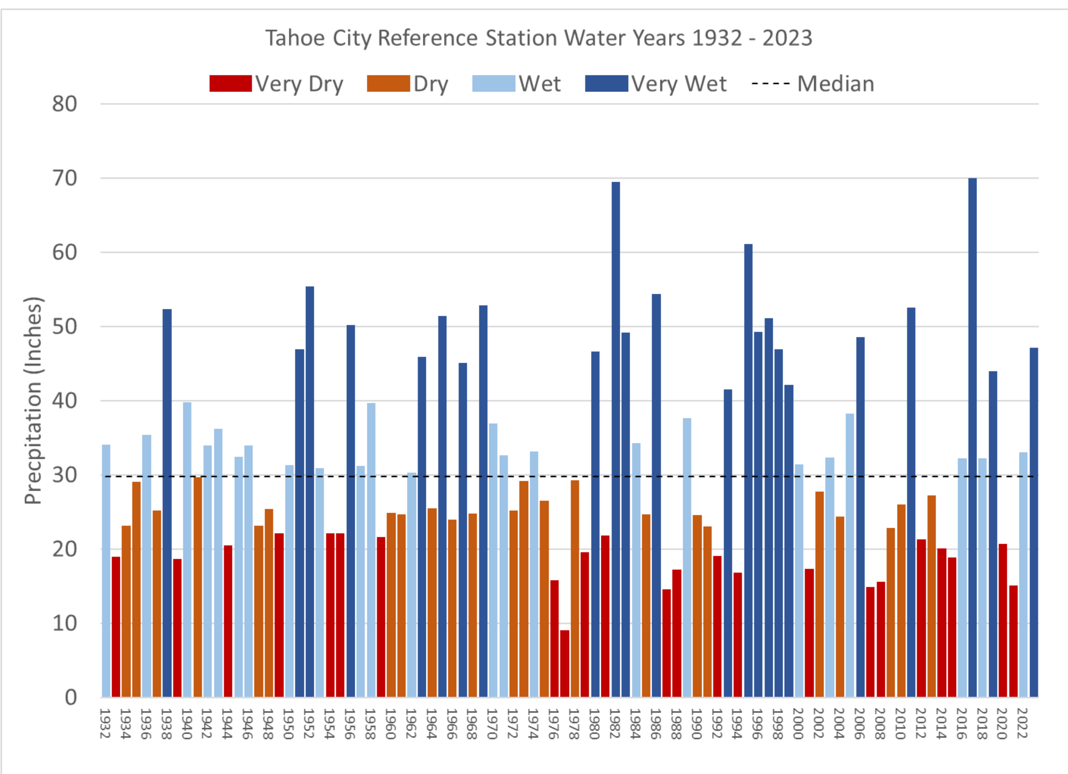

Figure 2 Long-term precipitation record at the Tahoe City meteorological station, water years 1932-2023.

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 WY23 for all sites. Sites differ in their ability to capture low flows. For instance, the Jellyfish Outflow may flow sooner than the Contech MFS Outflow because the large Contech MFS vault capacity retains about 3000 cf before it flows out. 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 as well as 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. Percent FSP denotes the average seasonal and annual percentages of total suspended sediment that is fine sediment particles at each site. 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 WY23. Top table shows seasonal and annual precipitation and runoff volumes; the second table shows seasonal and annual FSP concentrations and loads based on samples and estimated from continuous turbidity; the third table shows seasonal and annual percentages of TSS that is FSP and seasonal and annual estimated FSP loads in number of particles; and the bottom table shows seasonal and annual TN and TP concentrations and loads based on samples.

Water Year 2023 (October 1, 2022 - September 30, 2023)			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	20.43	7.94	4.55	32.93	6,947	7,048	7,483	21,477
	Contech Out	CO	20.43	7.94	4.55	32.93	5,279	4,859	5,228	15,365
	Jellyfish In	JI	20.43	7.94	4.55	32.93	7,929	8,355	7,781	24,066
	Jellyfish Out	JO	20.43	7.94	4.55	32.93	6,806	7,811	6,227	20,843
Elk's Club	Elk's Club	EC	25.75	8.96	3.71	38.42	206,217	604,477	115,635	926,329
Lakeshore	Lakeshore	LS	15.77	7.21	3.53	26.50	33,338	201,351	3,658	238,346
Pasadena	Pasadena Out	PO	12.93	4.18	2.09	19.19	18,181	4,309	6,512	29,003
Speedboat	Speedboat	SB	16.30	7.13	2.19	25.62	178,755	158,939	31,352	369,046
Tahoe City	Tahoe City	TC	22.46	6.76	3.21	32.43	158,663	1,736,358	27,882	1,922,904
Tahoe Valley	Tahoe Valley	TV	19.12	6.22	3.08	28.43	1,311,492	7,943,955	535,894	9,791,341
Tahoma	Tahoma	TA	27.84	9.50	2.48	39.82	194,208	1,414,755	70,665	1,679,628
Upper Truckee	Upper Truckee	UT	19.12	6.22	3.08	28.43	162,819	127,098	25,999	315,916

Water Year 2023 (October 1, 2022 - September 30, 2023)			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 (mg/L)	Seasonal Estimated FSP Loads (lbs)			Total Annual Estimated FSP 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	97	569	52	236	42	250	25	317	146	39	39	74	63	17	18	99
	Contech Out	CO	76	401	64	175	25	122	21	168	123	193	18	109	40	59	6	105
	Jellyfish In	JI	97	579	57	251	48	302	28	378	112	67	27	69	56	35	13	104
	Jellyfish Out	JO	88	425	61	206	38	207	24	268	93	14	3	36	40	7	1	47
Elk's Club	Elk's Club	EC	24	5	82	19	303	201	591	1,094	7	6	4	6	84	236	28	348
Lakeshore	Lakeshore	LS	45	3	30	9	93	40	7	139	40	6	28	12	84	81	6	172
Pasadena	Pasadena Out	PO	19	58	30	27	22	16	12	50	20	70	33	30	22	19	13	54
Speedboat	Speedboat	SB	108	74	162	98	1,203	739	318	2,260	127	45	47	85	1,416	442	93	1,950
Tahoe City	Tahoe City	TC	61	20	81	24	604	2,157	141	2,902	57	12	21	16	564	1,293	37	1,895
Tahoe Valley	Tahoe Valley	TV	26	6	7	9	2,108	2,866	248	5,221	19	20	7	19	1,596	9,689	245	11,529
Tahoma	Tahoma	TA	14	4	20	6	166	336	89	591	40	8	12	12	482	680	54	1,217
Upper Truckee	Upper Truckee	UT	148	122	23	127	1,500	968	37	2,505	142	153	16	136	1,446	1,217	26	2,689

Water Year 2023 (October 1, 2022 - September 30, 2023)			Average Seasonal %FSP			Average Annual %FSP	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)	
SR431	Contech In	CI	49%	55%	24%	43%	5.98E+15	1.57E+15	1.45E+15	9.00E+15
	Contech Out	CO	50%	57%	30%	46%	3.69E+15	5.71E+15	3.85E+14	9.79E+15
	Jellyfish In	JI	50%	55%	26%	44%	5.17E+15	3.40E+15	1.04E+15	9.62E+15
	Jellyfish Out	JO	52%	59%	25%	47%	3.52E+15	5.54E+14	5.75E+13	4.13E+15
Elk's Club	Elk's Club	EC	61%	25%	28%	33%	6.38E+15	1.75E+16	2.19E+15	2.61E+16
Lakeshore	Lakeshore	LS	71%	14%	42%	22%	6.89E+15	5.69E+15	4.23E+14	1.30E+16
Pasadena	Pasadena Out	PO	51%	46%	32%	46%	1.66E+15	1.63E+15	9.41E+14	4.23E+15
Speedboat	Speedboat	SB	63%	51%	46%	57%	1.43E+17	3.87E+16	7.11E+15	1.89E+17
Tahoe City	Tahoe City	TC	52%	34%	30%	35%	5.32E+16	1.02E+17	2.85E+15	1.58E+17
Tahoe Valley	Tahoe Valley	TV	46%	24%	21%	27%	1.33E+17	8.16E+17	1.67E+16	9.66E+17
Tahoma	Tahoma	TA	28%	20%	20%	21%	5.62E+16	5.94E+16	4.07E+15	1.20E+17
Upper Truckee	Upper Truckee	UT	68%	56%	32%	60%	1.42E+17	1.17E+17	1.69E+15	2.60E+17

Water Year 2023 (October 1, 2022 - September 30, 2023)			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	816	1,895	1,426	1,382	0.4	0.8	0.7	2	734	2,906	366	1,318	0.3	1.3	0.2	1.8
	Contech Out	CO	949	1,714	1,631	1,423	0.3	0.5	0.5	1	675	2,562	447	1,194	0.2	0.8	0.1	1.1
	Jellyfish In	JI	940	1,925	1,544	1,477	0.5	1.0	0.8	2	815	3,203	455	1,528	0.4	1.7	0.2	2.3
	Jellyfish Out	JO	866	1,690	2,293	1,601	0.4	0.8	0.9	2	710	2,817	432	1,416	0.3	1.4	0.2	1.8
Elk's Club	Elk's Club	EC	306	222	1,180	360	3.9	8.4	8.5	21	149	175	624	225	1.9	6.6	4.5	13.0
Lakeshore	Lakeshore	LS	741	730	1,349	741	1.5	9.2	0.3	11	335	169	366	195	0.7	2.1	0.1	2.9
Pasadena	Pasadena Out	PO	1,077	2,019	3,400	1,738	1.2	0.5	1.4	3	240	420	653	359	0.3	0.1	0.3	0.7
Speedboat	Speedboat	SB	971	785	2,491	1,020	10.8	7.8	4.9	24	720	309	1,124	577	8.0	3.1	2.2	13.3
Tahoe City	Tahoe City	TC	1,266	609	2,733	694	12.5	66.0	4.8	83	622	646	920	648	6.2	70.0	1.6	77.8
Tahoe Valley	Tahoe Valley	TV	896	755	1,009	788	73.4	374.5	33.8	482	255	255	149	249	20.9	126.4	5.0	152.3
Tahoma	Tahoma	TA	465	310	1,699	386	5.6	27.4	7.5	40	174	67	420	94	2.1	5.9	1.9	9.9
Upper Truckee	Upper Truckee	UT	1,441	1,231	2,532	1,446	14.6	9.8	4.1	29	806	763	385	754	8.2	6.1	0.6	14.9

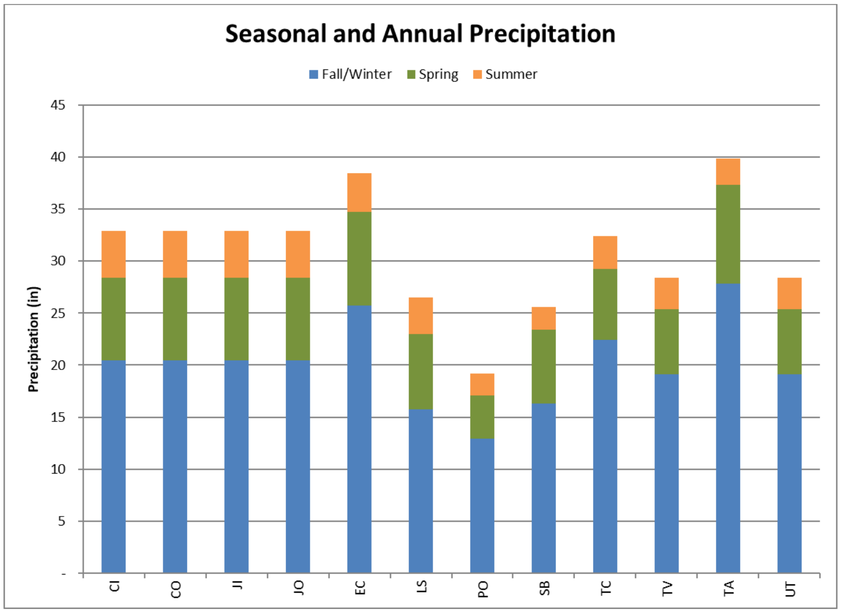

Figure 3 Precipitation totals at each monitoring station, WY23.

Precipitation

- The northwest corner and most southerly region of the lake received the most precipitation (TA and EC).
- The eastern side of south shore (PO) received the least amount of precipitation, the northeast corner of the lake received comparatively little as well (LS and SB).
- 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.

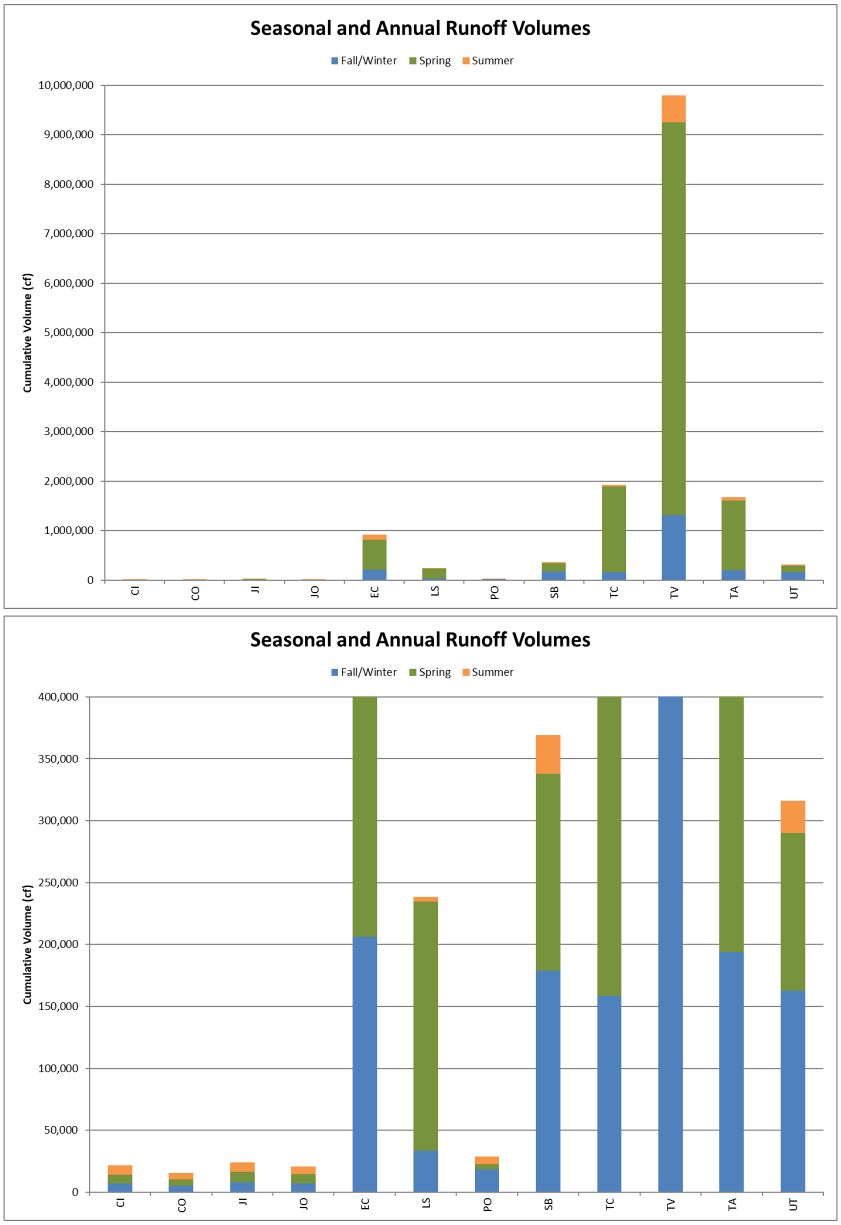

Figure 4 Runoff volumes at each monitoring station, WY23.

Runoff Volumes

Note: Top graph shows all sites, bottom graph changes y-axis so CI, CO, JI, JO, and PO can be seen.

- Catchment size influences runoff volume. TV, the largest catchment, had the most runoff. SR431 (CI, CO, JI, CO), the smallest catchment, had the least runoff.
- Infiltration features influence runoff volume. LS, the second largest catchment, contains numerous infiltration features and measured relatively low runoff volumes in WY23.
- Impervious area influences runoff volumes. Though the TC catchment area is about one twentieth the size of PO, it had far greater runoff volume. TC is 62% impervious and PO is 39% impervious. Additionally, PO has many catchment-wide infiltration features.
- Precipitation totals influence runoff volumes. In most years, most catchments have the most runoff in the fall/winter, mirroring seasonal precipitation totals. However, due to the record snowfall in WY23, many of the sites had the most runoff during the spring snowmelt (Table 5).

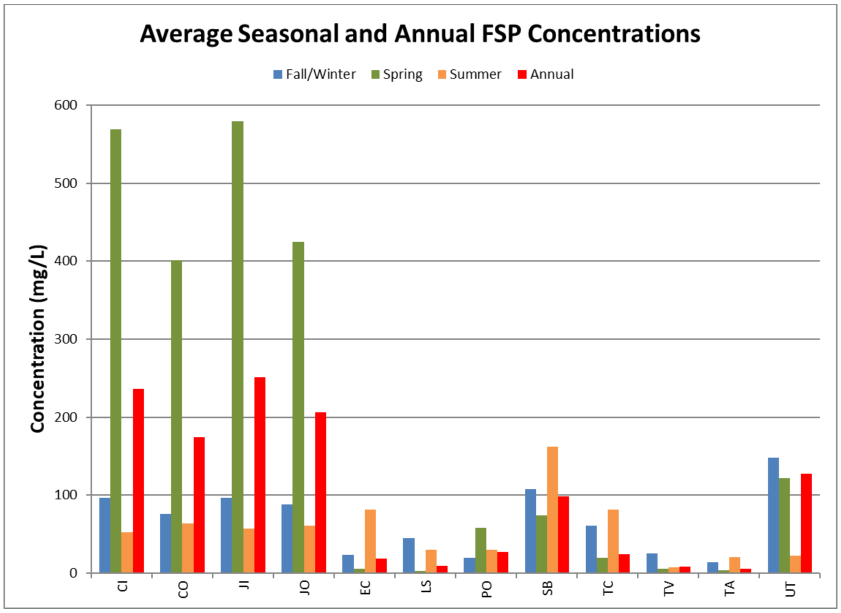

Figure 5 FSP concentrations based on samples at each monitoring station, WY23.

FSP Concentrations Based on Samples

- Average seasonal FSP concentrations were highest in the spring at SR431 (CI, CO, JI, JO), and PO; highest in the fall/winter at LS, TV and UT; and highest in summer at EC, SB, TC, and TA.
- The highest average seasonal FSP concentration was observed during the spring season at the SR431 (CI, CO, JI, JO). 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 EC, LS, TV, and TA.

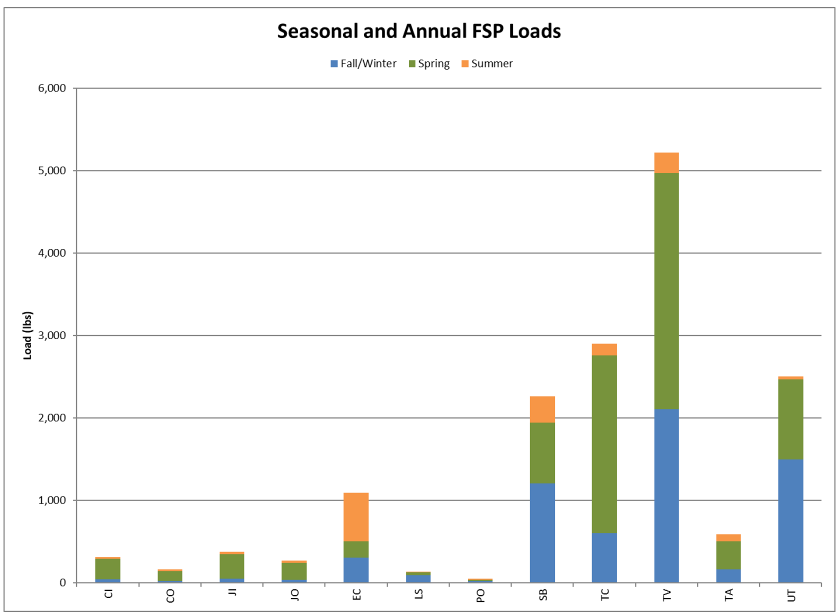

Figure 6 FSP loads based on samples at each monitoring station, WY23.

FSP Loads Based on Samples

- Runoff volumes influence loads. TV, despite having low FSP concentrations, had the largest load because of high runoff volume. Similarly, SR431 (CI, CO, JI, JO) had high concentrations but small runoff volumes and therefore low loads.
- Concentrations influence loads. SB and UT, with low runoff volumes but the highest FSP concentrations had relatively high FSP loads.

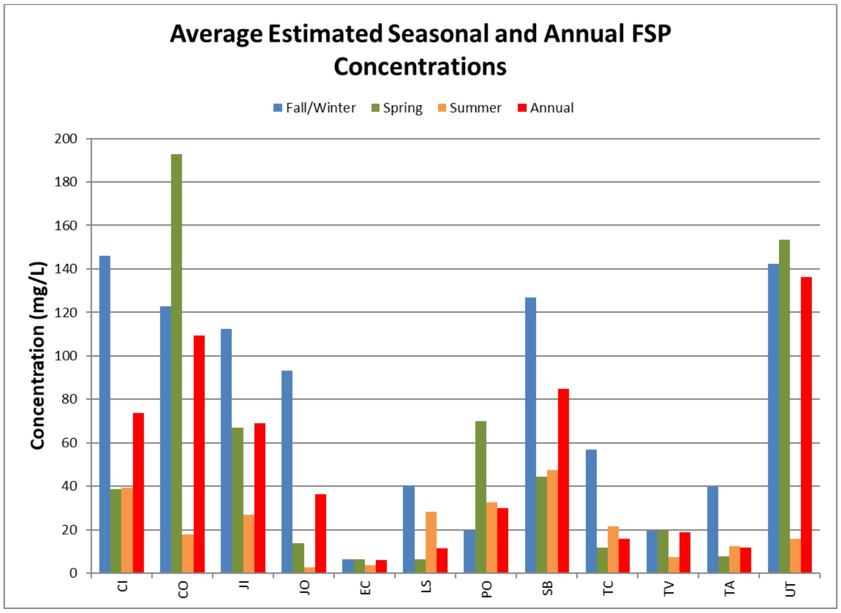

Figure 7 FSP concentrations estimated from turbidity at each monitoring station, WY23.

FSP Concentrations Estimated from Turbidity

- Average estimated seasonal FSP concentrations were highest in the fall/winter at SR431 (CI, JI, JO), EC, LS, SB, TC, and TA; and highest in the spring at CO, PO, TV, and UT;
- The highest average estimated seasonal FSP concentrations were observed during the spring at CO and UT, and during the fall/winter at CI, SB, and UT.
- Average estimated annual FSP concentrations were highest at CO and UT.
- Average estimated annual FSP concentrations were lowest at EC, LS, TC, TV, and TA.

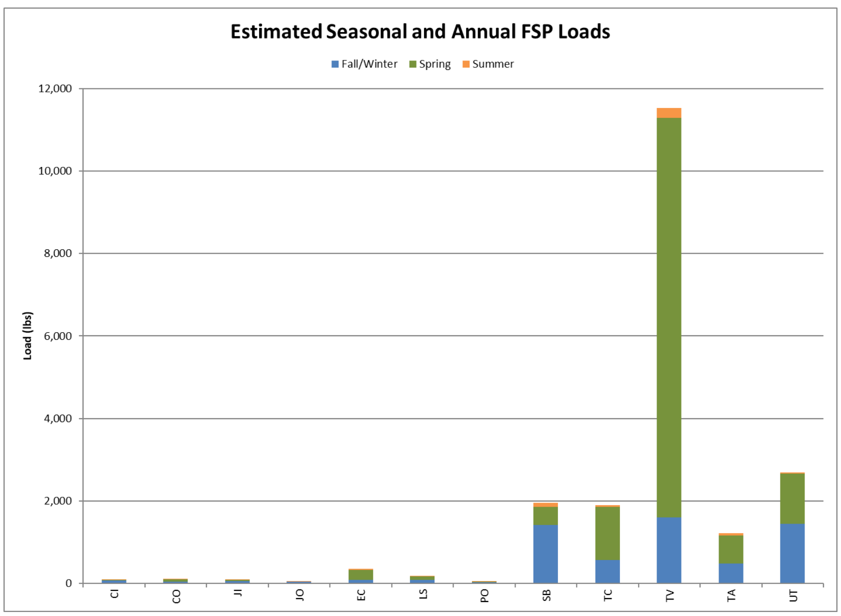

Figure 8 FSP loads estimated from turbidity at each monitoring station, WY23.

FSP Loads Estimated from Turbidity

- Runoff volumes influence loads. TV, despite having fairly low estimated FSP concentrations, had the largest load because of high runoff volume. Similarly, SR431 (CI, CO, JI, JO) had high concentrations but small runoff volumes and therefore low loads.
- Concentrations influence loads. SB and UT, with relatively low runoff volumes but the highest estimated FSP concentrations (aside from SR431) had the second and third highest estimated FSP loads.

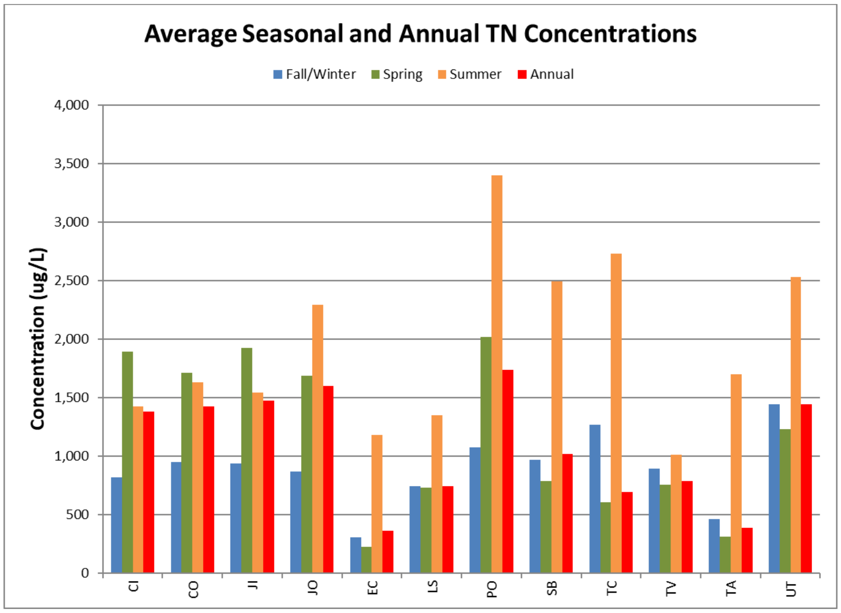

Figure 9 TN concentrations at each monitoring station, WY23.

TN Concentrations

- Average seasonal TN concentrations were highest in the summer at JO, EC, LS, PO, SB, TC, TV, TA, and UT, and highest in the spring at SR431 (CI, CO, JI).
- The highest average seasonal TN concentration was observed during the summer at PO.
- Average annual TN concentrations were highest at SR431, PO and UT.
- Average annual TN concentrations were lowest at EC and TA.

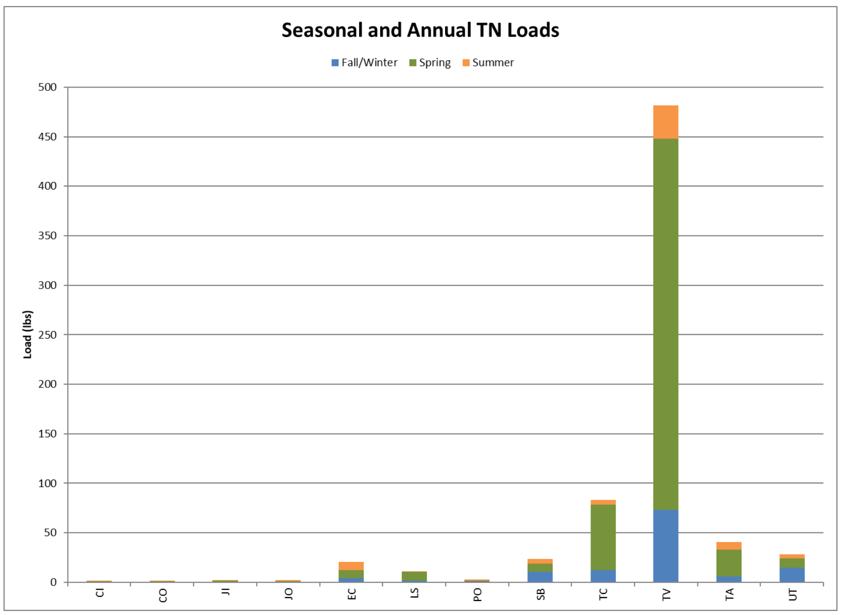

Figure 10 TN loads at each monitoring station, WY23.

TN Loads

- Runoff volumes influence loads. With the largest runoff volume, TV had the largest TN load, despite having an average annual TN concentration similar to other sites. Similarly, SR431 (CI, CO, JI, JO) had high concentrations but small runoff volumes and therefore low loads.
- Concentrations influence loads. TC had the second highest load because it had the second highest concentration.

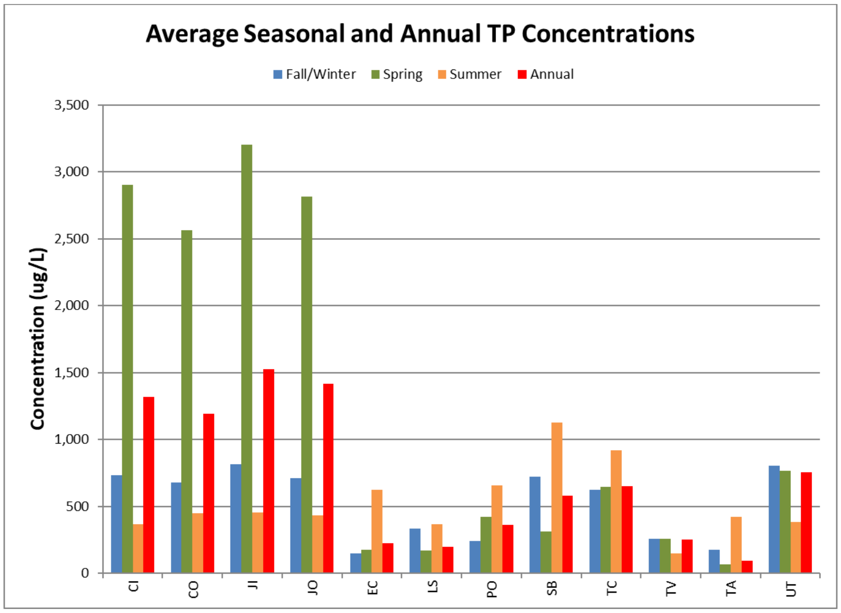

Figure 11 TP concentrations at each monitoring station, WY23.

TP Concentrations

- Average seasonal TP concentrations were highest in the spring at SR431 (CI, CO, JI, JO); highest in the fall/winter at UT; and highest in the summer at EC, LS, PO, SB, TC, and TA. TV was equal in the fall/winter and spring.
- The highest average seasonal TP concentration was observed during the spring at JI.
- Average annual TP concentrations were highest at SR431 (CI, CO, JI, JO).
- Average annual TP concentrations were lowest at EC, LS, TV, and TA.

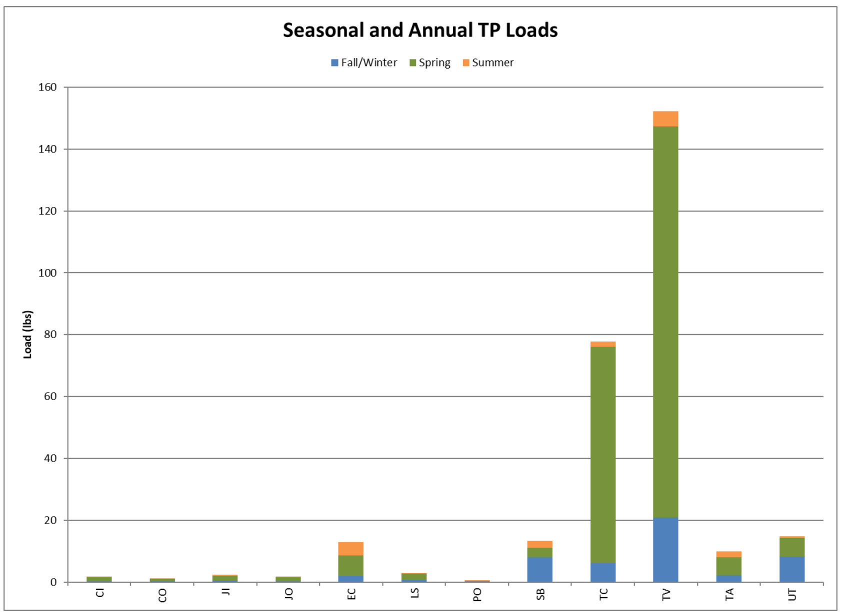

Figure 12 TP loads at each monitoring station, WY23.

TP Loads

- Runoff volumes influence loads. With the largest runoff volume, TV had the largest TP load, despite having a relatively low average annual TP concentration. Similarly, SR431 (CI, CO, JI, JO) had high concentrations but small runoff volumes and therefore low loads.
- Concentrations influence loads. TC and UT had the second and third highest loads respectively because they had the second and first highest concentrations respectively.

6.2 Summary Data for Individual Catchments

6.2.1 SR431

Figure 13 shows the average daily inflow and cumulative precipitation for WY23 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 or possibly seeping out through cracks in the vault instead of passing through the outflow and accounts for the difference between inflow and outflow volumes in Table 5 (compare CI annual volume to CO annual volume in Table 5).

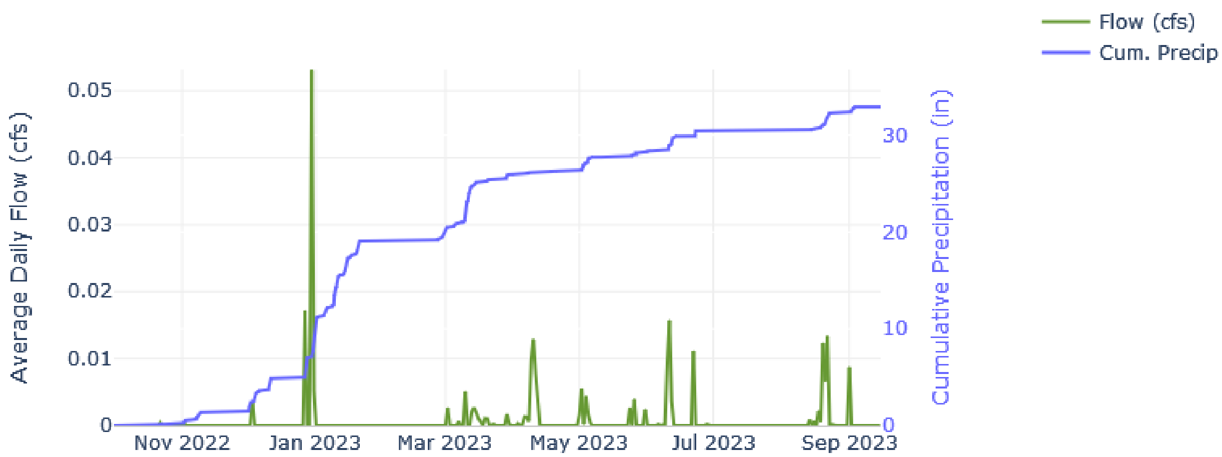

Figure 13 Average daily inflow and cumulative precipitation at the SR431 treatment vaults, WY23.

- 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.
- 32.92 inches of total precipitation (20.43 inches in the fall/winter, 7.95 inches in the spring, and 4.54 inches in the summer) were recorded at the NDOT weather station.
- 54 precipitation events occurred (19 fall/winter events, 19 spring events, 16 summer events).
- The largest storm event produced 4.31 inches of precipitation and occurred during an atmospheric river rain on snow event (that started as rain and ended as snow) from December 28, 2022-January 1, 2023.
- 69% of storms were less than half an inch.
- The largest runoff volume occurred during the December 30-31, 2022 atmospheric river rain on snow event (5,047cf).
- Highest average daily flows occurred on December 30, 2022 during the atmospheric river rain event.
- 25 days of snowmelt occurred in the fall/winter and spring seasons, resulting in 4,176 cf of runoff (19% of the total flow).
- The highest instantaneous peak precipitation was 0.11 inches in 5 minutes during a snow event on January 19, 2023.

- The highest instantaneous peak flow was 0.56 cfs during the thunderstorm event on June 22, 2023.

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 EMC data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

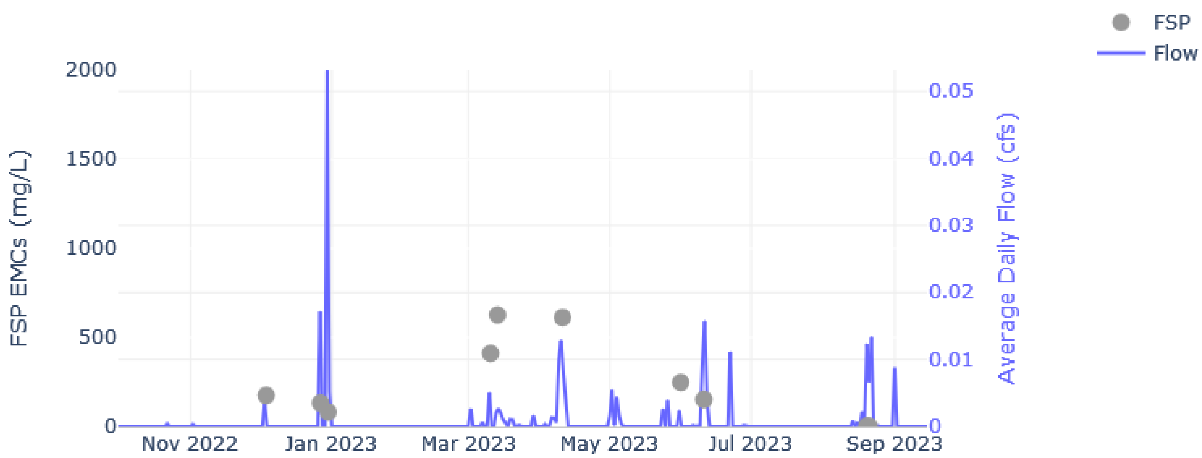

Figure 14 Daily inflow and FSP EMC summary at the Contech MFS, WY23.

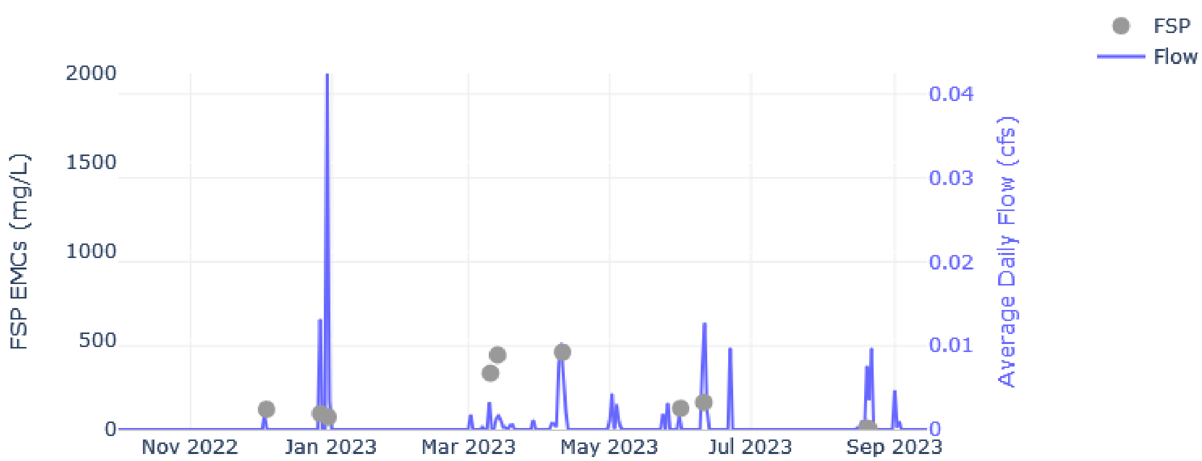

Figure 15 Daily outflow and FSP EMC summary at the Contech MFS, WY23.

- Ten events were sampled for FSP at Contech MFS inflow and outflow (three in the fall/winter, four in the spring, three in the summer).
- In seven out of ten events with samples at both the inflow and outflow, FSP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest FSP EMC at the inflow occurred during the March 13-14, 2023 atmospheric river rain on snow event.

- The highest FSP EMC at the outflow occurred during the non-event snowmelt April 10-11, 2023.
- The lowest FSP EMC at the inflow and outflow occurred during the Hurricane Hillary rain event August 20-21, 2023.
- The highest FSP load at the inflow and outflow occurred during the non-event snowmelt April 10-11, 2023.
- The lowest FSP load at the inflow and outflow occurred during the thunderstorm event August 19-20, 2023.

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 EMC data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

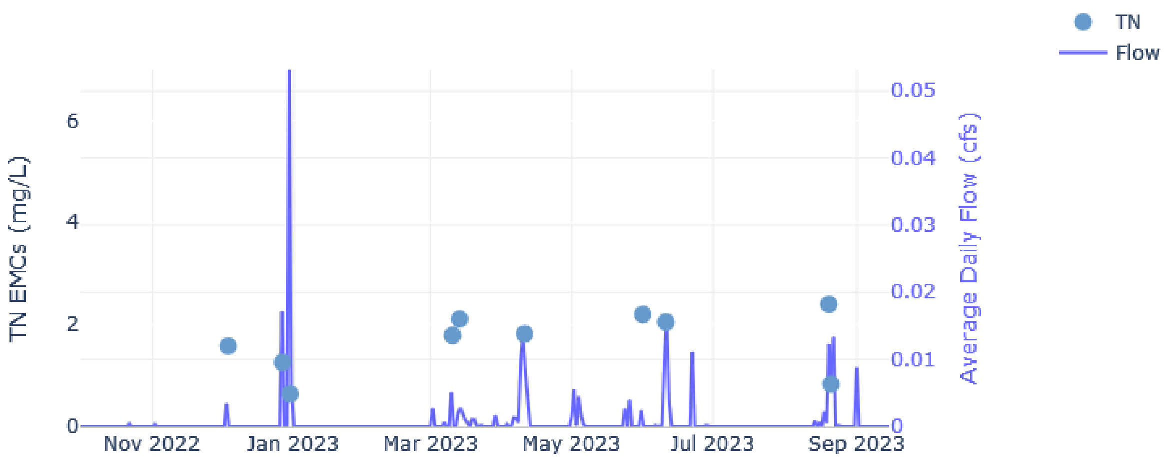

Figure 16 Daily inflow and TN EMC summary at the Contech MFS, WY23.

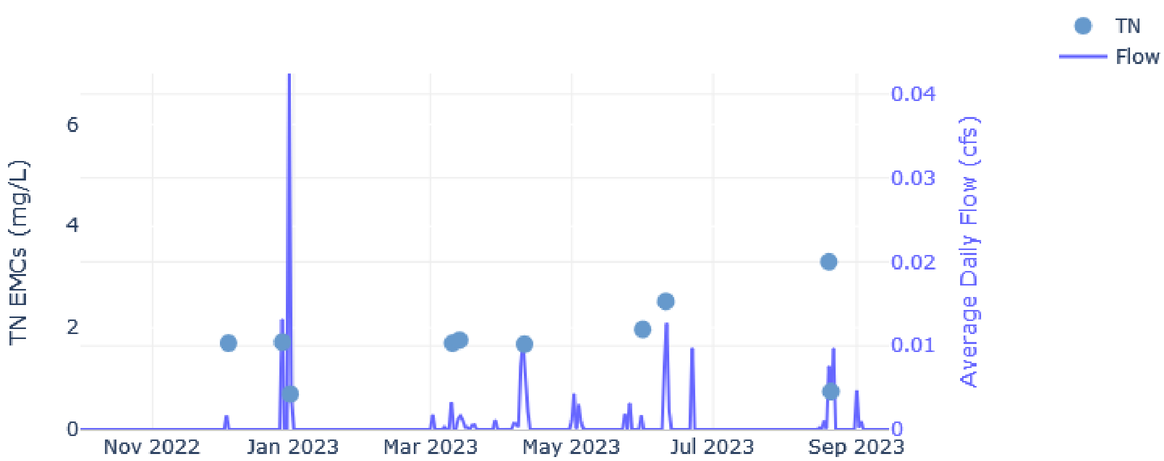

Figure 17 Daily outflow and TN EMC summary at the Contech MFS, WY23.

- Ten events were sampled for TN at Contech MFS inflow (three in the fall/winter, four in the spring, three in the summer).

- In five out of ten events with samples at both the inflow and outflow, TN EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TN EMC at the inflow and outflow occurred during the thunderstorm event on August 19-20, 2023.
- The lowest TN EMC at the inflow and outflow occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The highest TN load at the inflow occurred during the April 10-11, 2023 non-event snowmelt.
- The highest TN load at the outflow occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest TN load at the inflow and outflow occurred during the atmospheric river rain on snow event March 10, 2023.

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 EMC data in tabular form. Table 6 also presents the load data referenced in some bullet points below.

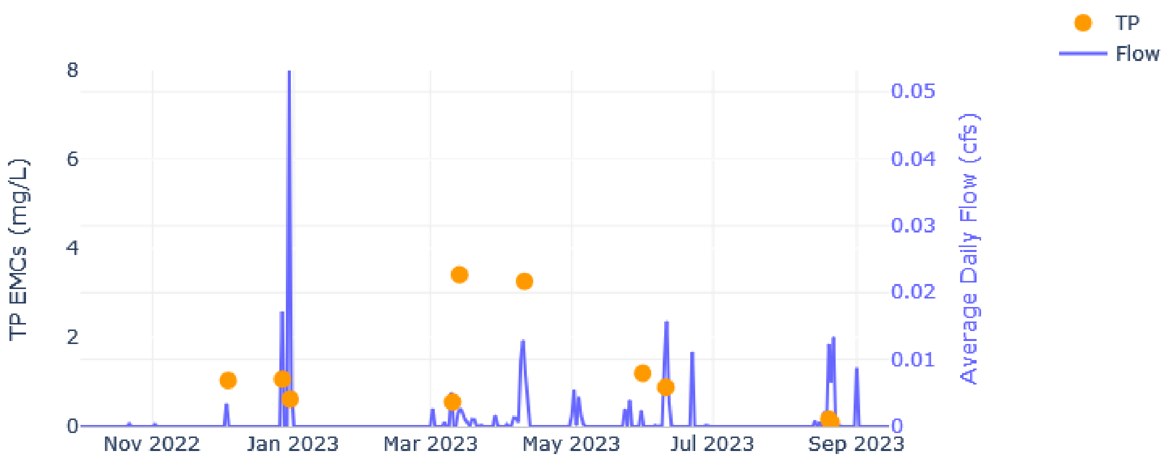

Figure 18 Daily inflow and TP EMC summary at the Contech MFS, WY23.

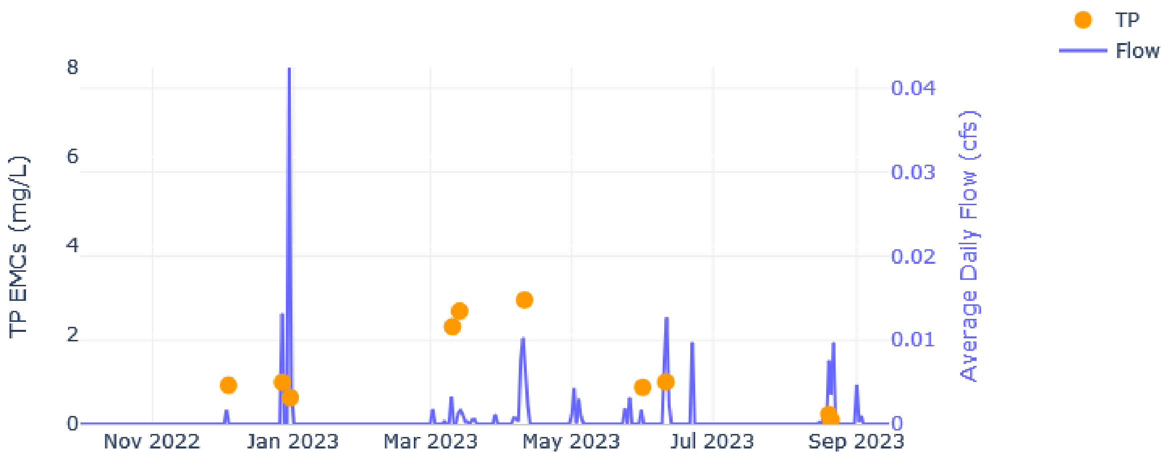

Figure 19 Daily outflow and TP EMC summary at the Contech MFS, WY23.

- Ten events were sampled for TP at Contech MFS inflow (three in the fall/winter, four in the spring, three in the summer).
- In seven out of ten events with samples at both the inflow and outflow, TP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TP EMC at the inflow occurred during the atmospheric river rain on snow event March 13-14, 2023.
- The highest TP EMC at the outflow occurred during the non-event snowmelt April 10-11, 2023.
- The lowest TP EMC at the inflow and outflow occurred during the Hurricane Hillary rain event August 20-21, 2023.
- The highest TP load at the inflow and outflow occurred during the non-event snowmelt April 10-11, 2023.
- The lowest TP load at the inflow and outflow occurred during the thunderstorm event August 19-20, 2023.

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.

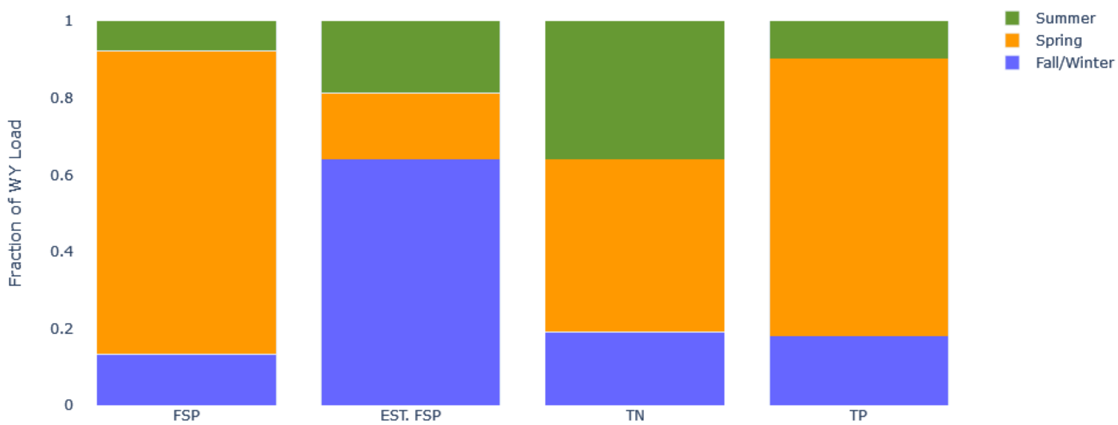

Figure 20 Seasonal load as a fraction of the water year load at the Contech MFS inflow, WY23. The first FSP column represents the FSP load calculated using event mean concentrations and the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

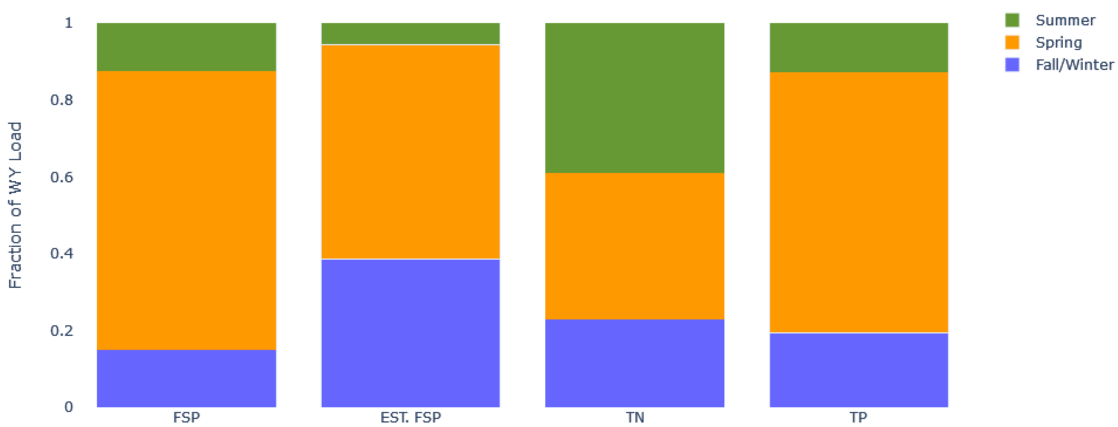

Figure 21 Seasonal load as a fraction of the water year load at the Contech MFS outflow, WY23. The first FSP column represents the FSP load calculated using event mean concentrations and the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) 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 fall/winter

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

Ten events were sampled at the Contech inflow and Contech outflow in WY23. Event summary data is presented in Table 6.

Table 6 Event summary data at the Contech MFS treatment vault, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
CI	Fall/Winter	12/3/2022 14:40	12/3/2022 20:00	5:20	298	0.05	684	0.50	Rain on Snow	175	3.24	79.0	1,580	0.03	1,036	0.02
CO	Fall/Winter	12/3/2022 15:20	12/3/2022 19:45	4:25	147	0.03	416	0.50	Rain on Snow	114	1.04	68.1	1,700	0.02	871	0.01
CI	Fall/Winter	12/27/2022 1:10	12/27/2022 9:45	8:35	1,485	0.17	1,262	2.05	Rain on Snow	133	12.31	46.1	1,260	0.12	1,066	0.10
CO	Fall/Winter	12/27/2022 1:15	12/27/2022 9:45	8:30	1,143	0.15	712	2.05	Rain on Snow	90	6.43	44.9	1,720	0.12	939	0.07
CI	Fall/Winter	12/30/2022 5:05	12/31/2022 3:55	22:50	5,047	0.16	742	2.48	Rain on Snow	82	25.76	48.7	640	0.20	618	0.19
CO	Fall/Winter	12/30/2022 5:35	12/31/2022 3:50	22:15	3,972	0.15	494	2.48	Rain on Snow	71	17.47	51.1	700	0.17	592	0.15
CI	Spring	3/10/2023 11:55	3/10/2023 16:40	4:45	208	0.05	203	0.17	Rain on Snow	411	5.34	63.8	1,790	0.02	552	0.01
CO	Spring	3/10/2023 12:05	3/10/2023 16:25	4:20	126	0.03	567	0.17	Rain on Snow	317	2.50	65.8	1,700	0.01	2,186	0.02
CI	Spring	3/13/2023 11:45	3/14/2023 18:05	30:20	418	0.04	271	0.54	Rain on Snow	626	16.33	65.1	2,110	0.06	3,412	0.09
CO	Spring	3/13/2023 12:05	3/14/2023 18:05	30:00	248	0.02	779	0.54	Rain on Snow	419	6.47	73.8	1,760	0.03	2,535	0.04
CI	Spring	4/10/2023 13:00	4/11/2023 20:45	31:45	1,790	0.10	13	0.00	Non-event Snowmelt	612	68.35	52.4	1,820	0.20	3,265	0.36
CO	Spring	4/10/2023 13:10	4/11/2023 20:30	31:20	1,399	0.08	357	0.00	Non-event Snowmelt	435	37.99	55.1	1,680	0.15	2,786	0.24
CI	Spring	5/31/2023 14:40	5/31/2023 15:30	0:50	214	0.17	352	0.19	Thunderstorm	248	3.31	53.5	2,200	0.03	1,199	0.02
CO	Spring	5/31/2023 14:45	5/31/2023 15:45	1:00	149	0.10	77	0.19	Thunderstorm	119	1.11	45.7	1,970	0.02	827	0.01
CI	Summer	6/10/2023 13:55	6/10/2023 16:45	2:50	829	0.55	340	0.41	Thunderstorm	152	7.87	37.0	2,050	0.11	884	0.05
CO	Summer	6/10/2023 13:55	6/10/2023 16:55	3:00	652	0.47	114	0.41	Thunderstorm	153	6.21	38.5	2,520	0.10	947	0.04
CI	Summer	8/19/2023 15:20	8/20/2023 4:10	12:50	307	0.03	37	0.23	Thunderstorm	4	0.07	14.6	2,400	0.05	168	<0.1
CO	Summer	8/19/2023 23:45	8/20/2023 3:45	4:00	106	0.01	34	0.23	Thunderstorm	9	0.06	33.1	3,300	0.02	218	<0.1
CI	Summer	8/20/2023 20:55	8/21/2023 7:05	10:10	1,372	0.11	47	0.60	Rain	3	0.27	18.7	830	0.07	98	0.01
CO	Summer	8/20/2023 21:00	8/21/2023 6:50	9:50	858	0.07	58	0.60	Rain	3	0.18	22.8	750	0.04	95	0.01

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 EMC data in tabular form. Table 7 also presents the load data referenced in some bullet points below.

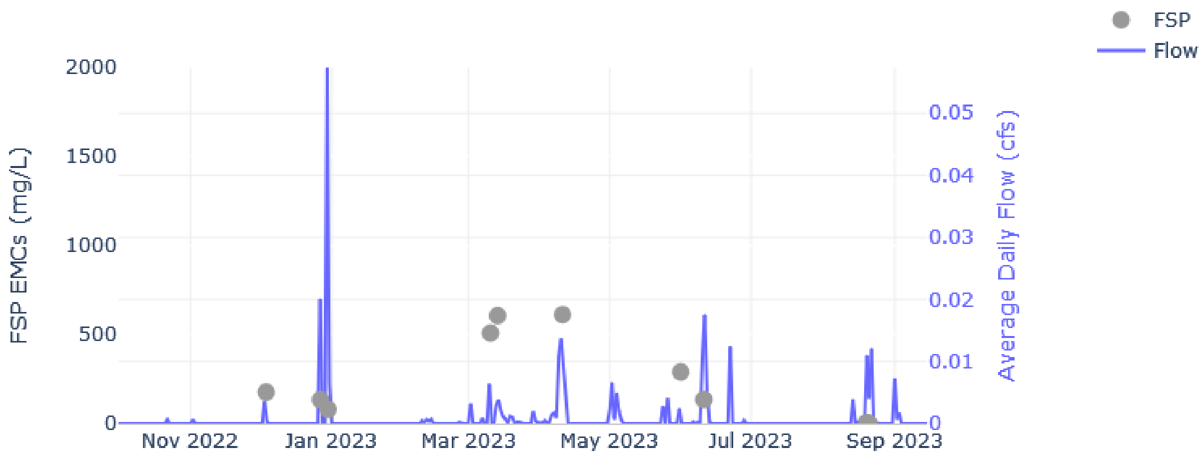

Figure 22 Daily inflow and FSP EMC summary at the Jellyfish, WY23.

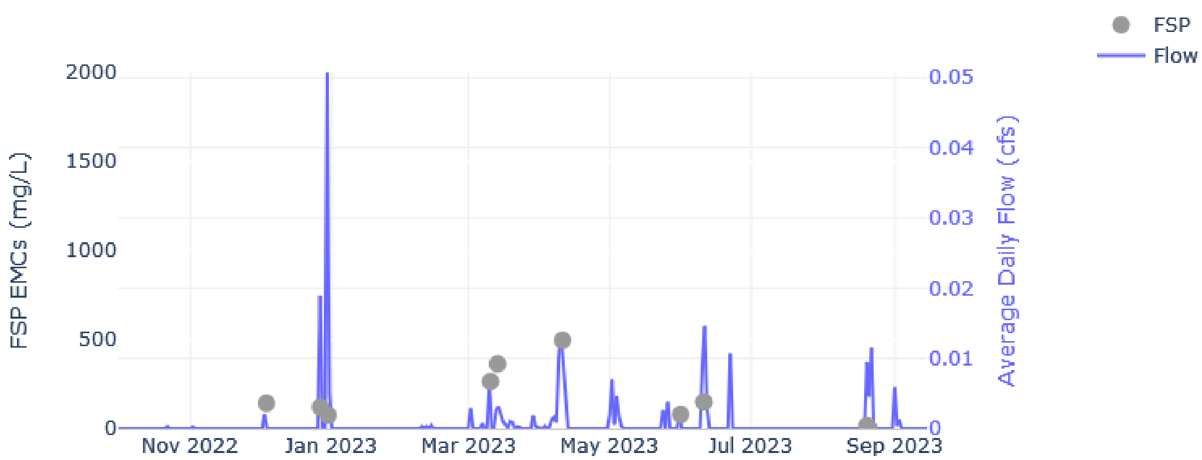

Figure 23 Daily outflow and FSP EMC summary at the Jellyfish, WY23.

- Ten events were sampled for FSP at Jellyfish inflow (three in the fall/winter, four in the spring, three in the summer.
- In eight out of ten sampled events with samples at both the inflow and outflow, FSP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest FSP EMCs and loads at the inflow and outflow occurred during the non-event snowmelt April 10-11, 2023.
- The lowest FSP EMC at the inflow and outflow occurred during the Hurricane Hillary rain event August 20-21, 2023.

- The lowest FSP load at the inflow occurred during the thunderstorm event August 19-20, 2023.
- The lowest FSP load at the outflow occurred during the Hurricane Hillary rain event August 20-21, 2023.

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

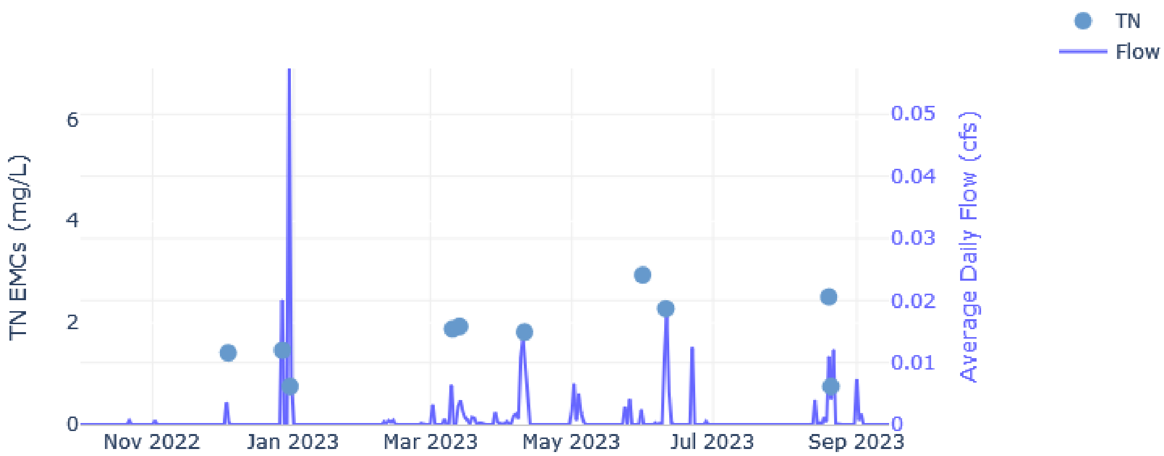

Figure 24 Daily inflow and TN EMC summary at the Jellyfish, WY23.

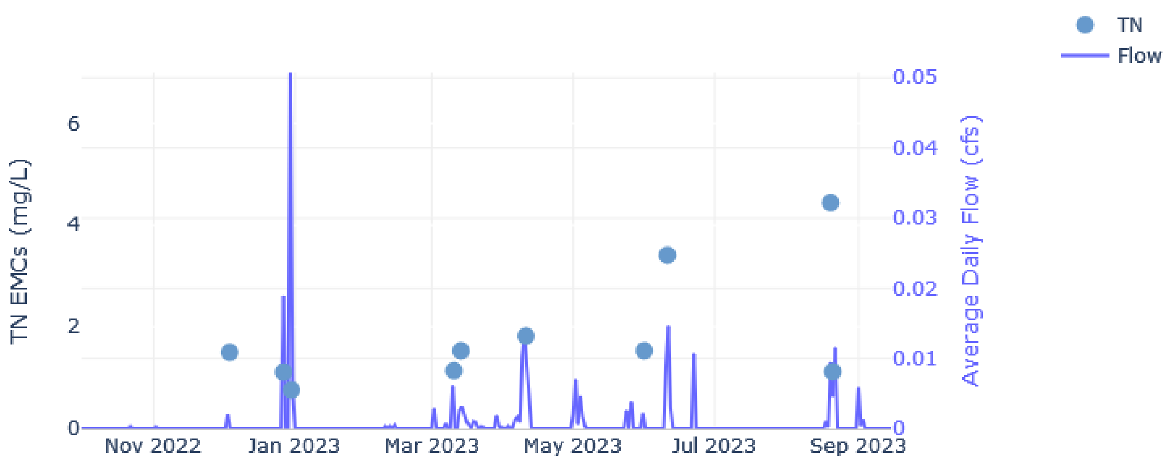

Figure 25 Daily outflow and TN EMC summary at the Jellyfish, WY23.

- Ten events were sampled for TN at Jellyfish inflow (three in the fall/winter, four in the spring, three in the summer).
- In four out of ten sampled events with samples at both the inflow and outflow, TN EMCs were lower at the outflow than the inflow indicating some treatment occurred.
- The highest TN EMC at the inflow occurred during the thunderstorm event on May 31, 2023.
- The highest TN EMC at the outflow occurred during a thunderstorm event August 19-20, 2023.

- The lowest TN EMCs at the inflow was a tie; it occurred during the atmospheric river rain on snow event December 30-31, 2022 *and* the Hurricane Hillary rain event August 20-21, 2023.
- The lowest TN EMC at the outflow occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The highest TN load at the inflow and outflow occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest TN load at the inflow and outflow occurred during the rain on snow event December 3, 2022.

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

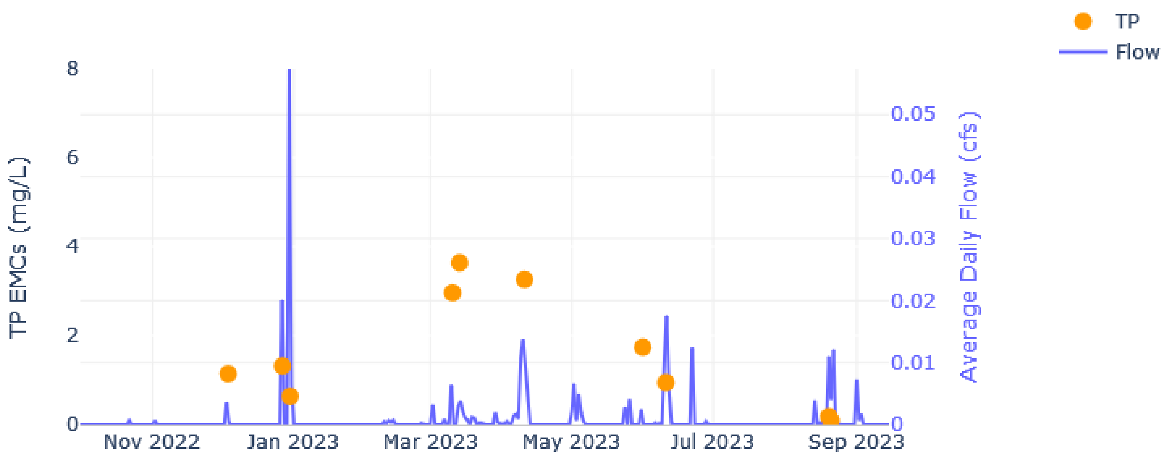

Figure 26 Daily inflow and TP EMC summary at the Jellyfish, WY23.

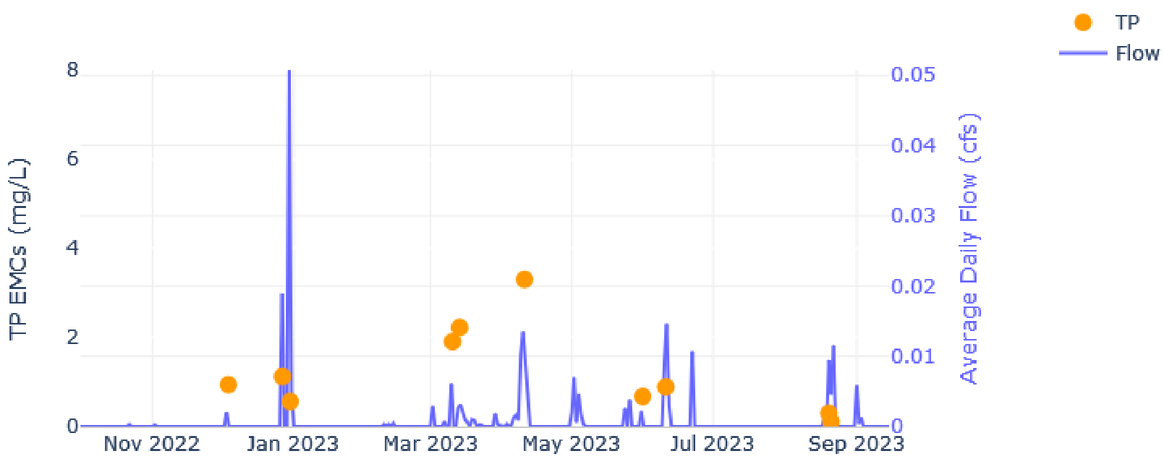

Figure 27 Daily outflow and TP EMC summary at the Jellyfish, WY23.

- Ten events were sampled for TP at Jellyfish inflow (three in the fall/winter, four in the spring, three in the summer.
- In seven out of ten sampled events with samples at both the inflow and outflow, TP EMCs were lower at the outflow than the inflow indicating treatment occurred.
- The highest TP EMC at the inflow occurred during the atmospheric river rain on snow event March 13-14, 2023.
- The highest TP EMC at the outflow occurred during the non-event snowmelt April 10-11, 2023.
- The lowest TP EMCs at the inflow and outflow occurred during the Hurricane Hillary rain event August 20-21, 2023.
- The highest TP loads at the inflow and outflow occurred during the non-event snowmelt April 10-11, 2023.
- The lowest TP loads at the inflow and outflow occurred during the thunderstorm event August 19-20, 2023.

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.

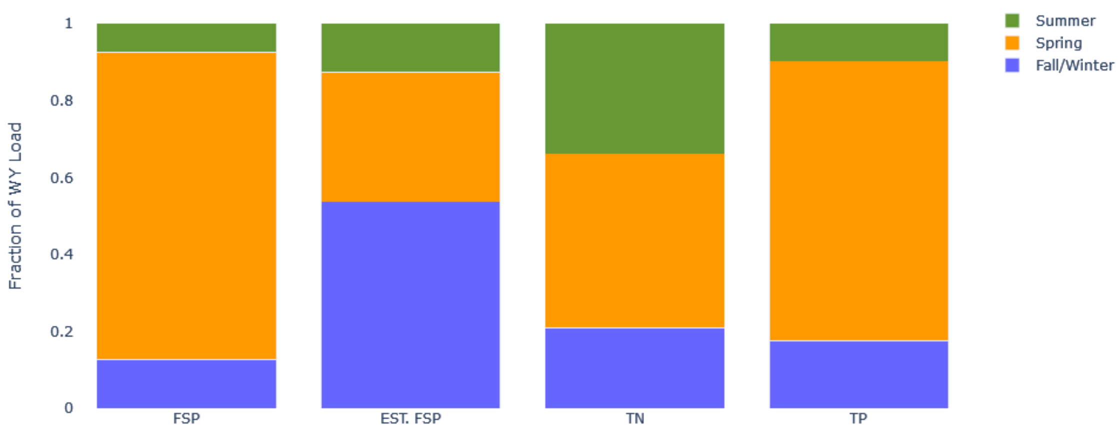

Figure 28 Seasonal load as a fraction of the water year load at the Jellyfish inflow, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

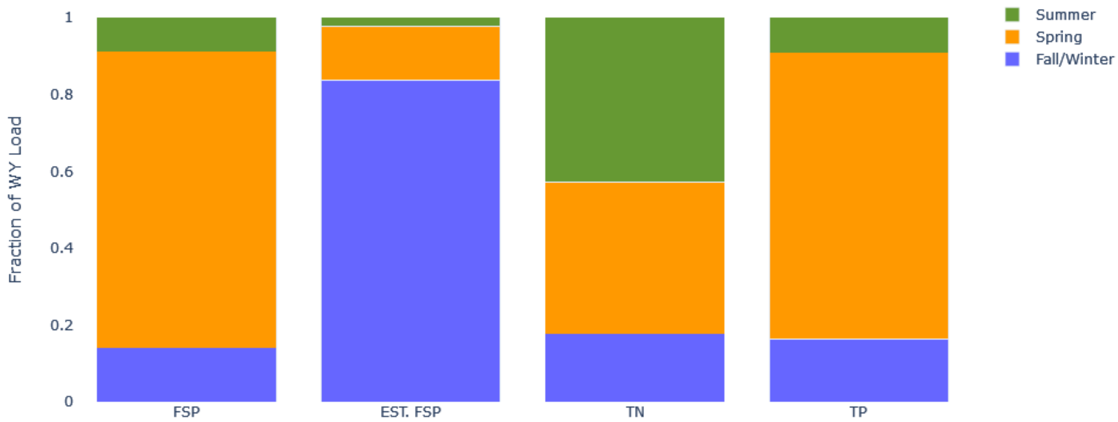

Figure 29 Seasonal load as a fraction of the water year load at the Jellyfish outflow, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- 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 samples) at the outflow was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) at the inflow was generated in the fall/winter.
- The largest fraction of FSP loads (based on continuous turbidity) at the outflow was generated in the fall/winter.
- FSP loads calculated from sample concentrations are lab certified results and therefore reliable, however, not all runoff volume is sampled. Estimated FSP loads calculated from turbidity are less precise, but turbidity measurements are taken continuously on all runoff. This discrepancy accounts for the difference between FSP and estimated FSP results.
- The largest fraction of TN loads at the inflow was generated in the spring.
- 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 spring.

Ten events were sampled at Jellyfish inflow and Jellyfish outflow in WY23. Event summary data is presented in Table 7.

Table 7 Event summary data at the Jellyfish treatment vault, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
JI	Fall/Winter	12/3/2022 14:35	12/3/2022 20:10	5:35	298	0.04	499	0.50	Rain on Snow	177	3.29	73.0	1,410	0.03	1,145	0.02
JO	Fall/Winter	12/3/2022 17:45	12/3/2022 20:00	2:15	173	0.04	320	0.50	Rain on Snow	142	1.54	76.5	1,500	0.02	941	0.01
JI	Fall/Winter	12/27/2022 0:30	12/27/2022 12:45	12:15	1,742	0.18	872	2.05	Rain on Snow	135	14.64	48.8	1,460	0.16	1,320	0.14
JO	Fall/Winter	12/27/2022 1:10	12/27/2022 10:00	8:50	1,637	0.30	555	2.05	Rain on Snow	121	12.37	52.2	1,110	0.11	1,123	0.11
JI	Fall/Winter	12/30/2022 4:15	12/31/2022 5:15	25:00	5,512	0.17	606	2.48	Rain on Snow	81	27.68	49.1	750	0.26	637	0.22
JO	Fall/Winter	12/30/2022 5:15	12/31/2022 4:10	22:55	4,819	0.16	391	2.48	Rain on Snow	75	22.64	50.9	760	0.23	561	0.17
JI	Spring	3/10/2023 11:40	3/10/2023 17:05	5:25	273	0.06	434	0.17	Rain on Snow	509	8.67	67.3	1,880	0.03	2,967	0.05
JO	Spring	3/10/2023 11:55	3/10/2023 17:15	5:20	262	0.05	104	0.17	Rain on Snow	264	4.32	67.7	1,140	0.02	1,906	0.03
JI	Spring	3/13/2023 11:45	3/14/2023 20:05	32:20	584	0.04	529	0.54	Rain on Snow	606	22.08	64.9	1,930	0.07	3,641	0.13
JO	Spring	3/13/2023 12:00	3/14/2023 19:45	31:45	496	0.04	116	0.54	Rain on Snow	363	11.24	72.4	1,530	0.05	2,224	0.07
JI	Spring	4/10/2023 9:05	4/11/2023 21:55	36:50	1,985	0.09	21	0.00	Non-event Snowmelt	612	75.80	52.4	1,820	0.23	3,265	0.40
JO	Spring	4/10/2023 12:50	4/11/2023 21:50	33:00	1,948	0.09	7	0.00	Non-event Snowmelt	497	60.34	57.0	1,820	0.22	3,303	0.40
JI	Spring	5/31/2023 14:40	5/31/2023 15:35	0:55	216	0.17	188	0.19	Thunderstorm	291	3.91	34.5	2,940	0.04	1,742	0.02
JO	Spring	5/31/2023 14:45	5/31/2023 15:30	0:45	194	0.15	16	0.19	Thunderstorm	80	0.96	36.9	1,530	0.02	675	0.01
JI	Summer	6/10/2023 13:50	6/10/2023 17:35	3:45	923	0.57	176	0.41	Thunderstorm	135	7.80	37.4	2,280	0.13	947	0.05
JO	Summer	6/10/2023 13:55	6/10/2023 16:50	2:55	777	0.52	24	0.41	Thunderstorm	150	7.26	38.0	3,410	0.17	890	0.04
JI	Summer	8/19/2023 15:20	8/20/2023 3:25	12:05	214	0.03	14	0.23	Thunderstorm	6	0.08	23.2	2,510	0.03	183	<0.1
JO	Summer	8/19/2023 15:25	8/20/2023 3:55	12:30	170	0.02	4	0.23	Thunderstorm	17	0.18	46.4	4,440	0.05	300	<0.1
JI	Summer	8/20/2023 21:00	8/21/2023 6:25	9:25	1,115	0.11	22	0.60	Rain	2	0.16	16.7	750	0.05	101	0.01
JO	Summer	8/20/2023 21:00	8/21/2023 7:05	10:05	1,052	0.09	8	0.60	Rain	2	0.13	11.7	1,120	0.07	114	0.01

6.2.2 Elks Club

Figure 30 shows the average daily flow and cumulative precipitation for WY23 at the Elks Club catchment outfall.

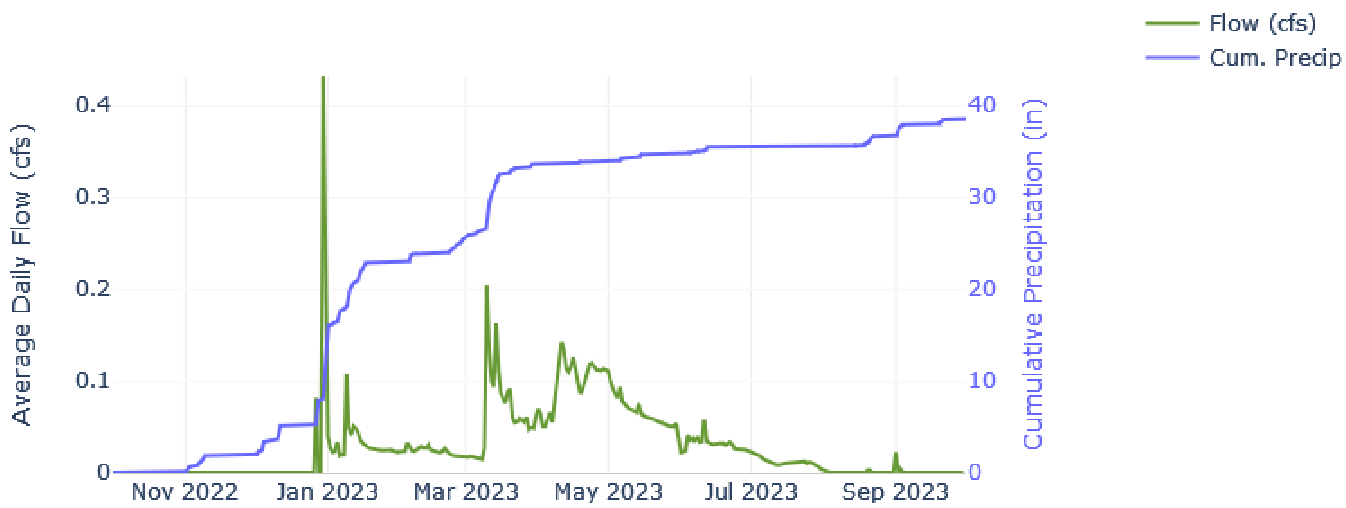

Figure 30 Average daily flow and cumulative precipitation at the Elks Club catchment outfall, WY23.

- 38.42 inches of total precipitation (25.75 inches in the fall/winter, 8.96 inches in the spring, 3.71 inches in the summer) were recorded at the Shakori (SHK) weather station.
- 57 precipitation events occurred (20 fall/winter events, 20 spring events, 17 summer events).
- The largest storm event produced 8.16 inches of precipitation and occurred during an atmospheric river rain on snow event from December 29, 2022- January 1, 2023.
- 75% of storms were less than half an inch.
- The largest runoff volume was caused by continuous snowmelt from April 18, 2023- May 1, 2023 (126,314 cf).
- The largest runoff volume that wasn't snowmelt occurred during the December 29-31, 2022 atmospheric river rain on snow event (57,693 cf).
- Highest average daily flows occurred on December 30, 2022 during the atmospheric river rain on snow event.
- 216 days of snowmelt occurred in the fall/winter, spring and summer resulting in 741,007 cf of runoff (80% of the total flow).
- The highest instantaneous peak precipitation was 0.19 inches in 10 minutes during a thunderstorm event on September 19, 2023.
- The highest instantaneous peak flow was 1.11 cfs on December 30, 2022 during the atmospheric river rain on snow event.

Daily flow and the FSP EMC summary at Elks Club are presented in Figure 31. Table 8 presents EMC 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, WY23.

- Ten events were sampled for FSP (three in the fall/winter, four in the spring, and three in the summer).
- The highest FSP EMC occurred during a thunderstorm event on June 4, 2023.
- The highest FSP load occurred during the atmospheric river rain on snow event from December 29-31, 2022.
- The lowest FSP EMC occurred during an atmospheric river rain on snow event from March 14-15, 2023.
- The lowest FSP load occurred during a thunderstorm event on May 30, 2023.

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

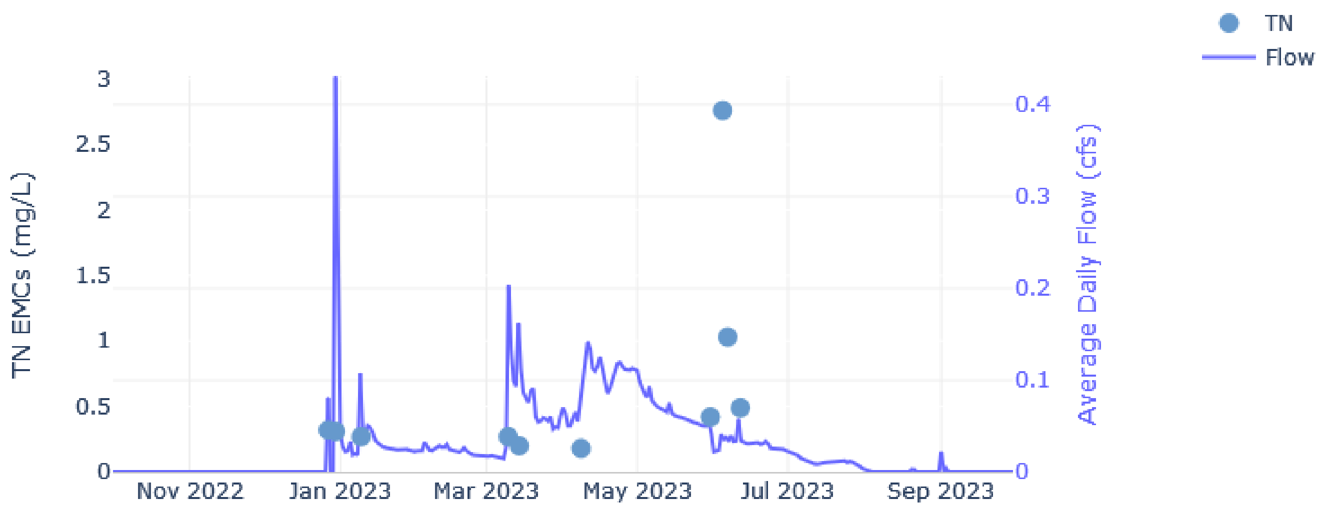

Figure 32 Daily flow and TN EMC summary at the Elks Club catchment outfall, WY23.

- Ten events were sampled for TN (three in the fall/winter, four in the spring, and three in the summer).
- The highest TN EMC occurred during a thunderstorm event on June 4, 2023.
- The highest TN load occurred during an atmospheric river rain on snow event December 29-31, 2022.
- The lowest TN EMC occurred during a non-event snowmelt from April 8-11, 2023.
- The lowest TN load occurred during a thunderstorm event on June 6, 2023.

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

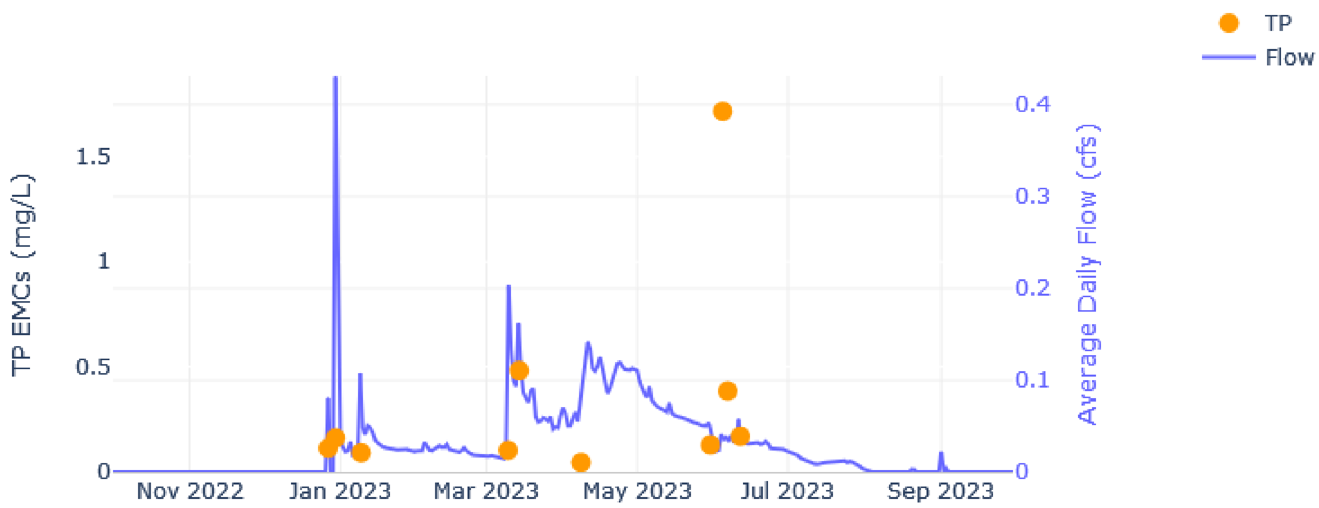

Figure 33 Daily flow and TP EMC summary at the Elks Club catchment outfall, WY23.

- Ten events were sampled for TP (three in the fall/winter, four in the spring, and three in the summer).
- The highest TP EMC occurred during a thunderstorm event on June 4, 2023.
- The highest TP load occurred during an atmospheric river rain on snow event December 29-31, 2022.
- The lowest TP EMC occurred during a non-event snowmelt from April 8-11, 2023.
- The lowest TP load occurred during a thunderstorm event on June 6, 2023.

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.

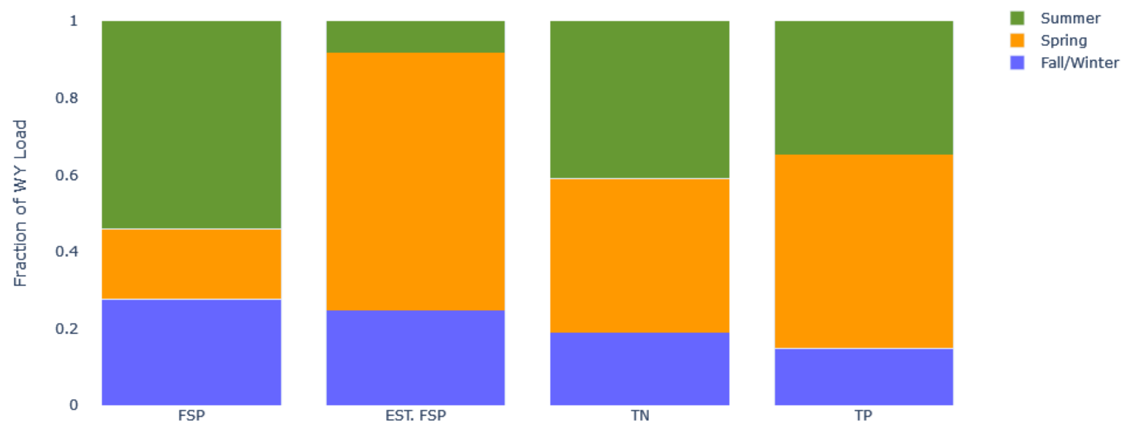

Figure 34 Seasonal load as a fraction of the water year load at the Elks Club catchment outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads from samples was generated in the summer.
- The largest fraction of FSP from continuous turbidity was generated in the spring.
- FSP loads calculated from sample concentrations are lab certified results and therefore reliable, however, not all runoff volume is sampled. Estimated FSP loads calculated from turbidity are less precise, but turbidity measurements are taken continuously on all runoff. This discrepancy accounts for the difference between FSP and estimated FSP results.
- The largest fraction of TN loads was split nearly evenly between the spring (40.15%) and summer (40.91%).
- The largest fraction of TP loads was generated in the spring.

Ten events were sampled at Elks Club in WY23. Event summary data is presented in Table 8.

Table 8 Event summary data at the Elks Club catchment outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
EC	Fall/Winter	12/27/2022 0:55	12/28/2022 0:15	23:20	7,041	0.21	132	2.59	Rain on Snow	7	2.94	26.6	320	0.14	113	0.05
EC	Fall/Winter	12/29/2022 23:35	12/31/2022 23:40	48:05	57,693	1.11	499	8.16	Rain on Snow	28	101.50	70.4	310	1.12	162	0.58
EC	Fall/Winter	1/9/2023 3:25	1/9/2023 21:55	18:30	8,625	0.33	176	1.65	Rain on Snow	6	3.34	26.0	270	0.15	92	0.05
EC	Spring	3/9/2023 18:30	3/11/2023 7:55	37:25	21,810	0.34	121	3.18	Rain on Snow	5	7.35	22.5	270	0.37	103	0.14
EC	Spring	3/14/2023 6:20	3/15/2023 10:00	27:40	15,987	0.36	135	0.86	Rain on Snow	5	4.79	21.9	200	0.20	483	0.48
EC	Spring	4/8/2023 6:40	4/11/2023 5:45	71:05	25,204	0.22	104	0.00	Non-event Snowmelt	5	8.33	29.2	180	0.28	45	0.07
EC	Spring	5/30/2023 13:35	5/30/2023 21:25	7:50	1,752	0.11	429	0.12	Thunderstorm	9	1.01	22.0	420	0.05	129	0.01
EC	Summer	6/4/2023 13:45	6/4/2023 17:05	3:20	1,419	0.73	1,318	0.06	Thunderstorm	240	21.27	35.7	2,760	0.24	1,716	0.15
EC	Summer	6/6/2023 13:45	6/6/2023 15:55	2:10	505	0.16	267	0.07	Thunderstorm	54	1.68	38.2	1,030	0.03	385	0.01
EC	Summer	6/11/2023 16:55	6/12/2023 1:10	8:15	3,131	0.29	198	0.43	Thunderstorm	15	2.89	22.8	490	0.10	170	0.03

6.2.3 Lakeshore

Figure 35 shows the average daily flow and cumulative precipitation for WY23 at the Lakeshore catchment outfall.

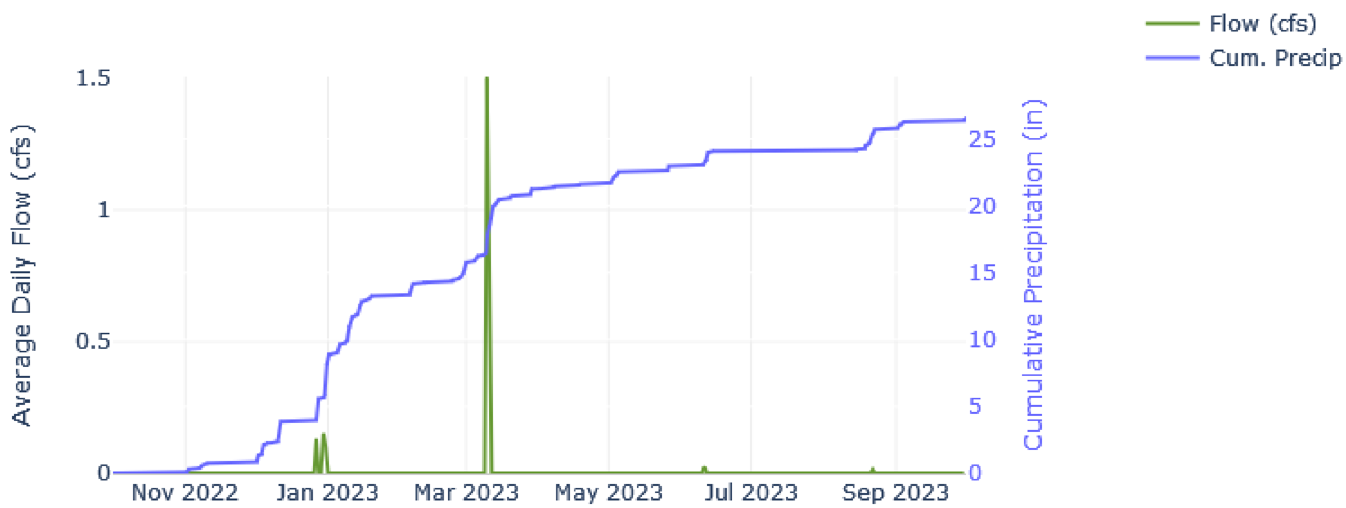

Figure 35 Average daily flow and cumulative precipitation at the Lakeshore catchment outfall, WY23.

- 26.50 inches of total precipitation (15.77 inches in the fall/winter, 7.21 inches in the spring, and 3.53 inches in the summer) were recorded at the TERC weather station.
- 55 precipitation events occurred (19 fall/winter events, 19 spring events, 17 summer events).
- The largest storm event produced 4.08 inches of precipitation and occurred during an atmospheric river rain on snow event from March 9-14, 2023.
- 75% of storms were less than half an inch.
- The largest runoff volume occurred during the March 10-11, 2023 atmospheric river rain on snow event (200,515 cf).
- Highest average daily flows occurred on March 11, 2023 during the atmospheric river rain on snow event.
- Eight days of snowmelt occurred in the spring, resulting in 489 cf of runoff (0.21% of the total flow).
- The highest instantaneous peak precipitation was 0.11 inches in 5 minutes during the thunderstorm event on May 26, 2023.
- The highest instantaneous peak flow was 7.24 cfs on March 10, 2023 during the atmospheric river rain on snow event.

Daily flow and FSP EMC summaries at Lakeshore are presented in Figure 36. Table 9 presents EMC data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

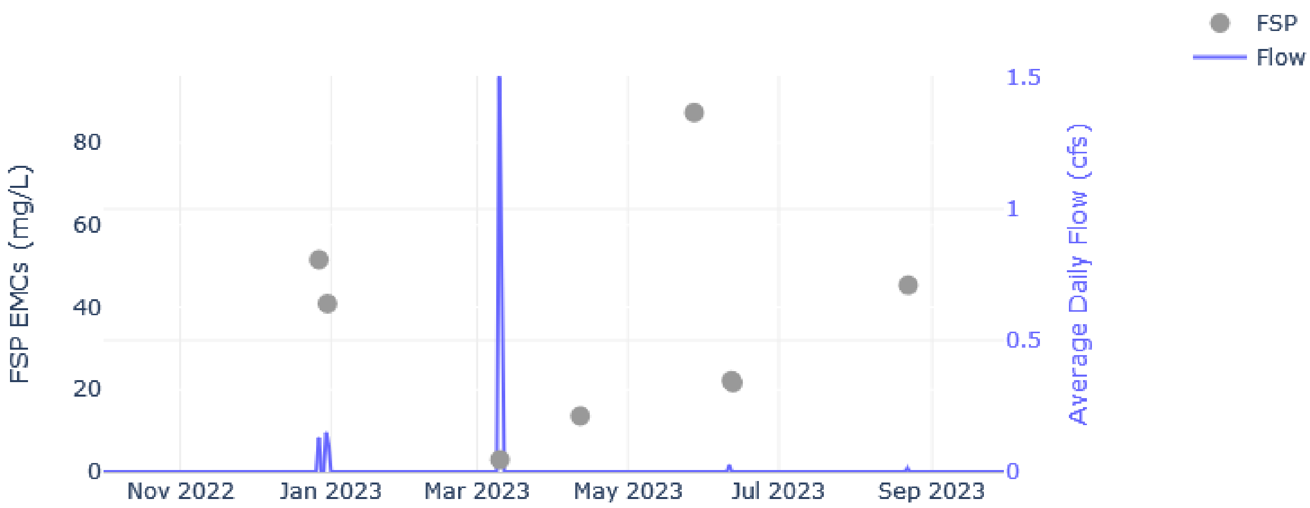

Figure 36 Daily outflow and FSP EMC summary at the Lakeshore catchment outfall, WY23.

- Eight events were sampled for FSP (two in the fall/winter, three in the spring, three in the summer).
- The highest FSP EMC occurred during a thunderstorm event on May 27, 2023.
- The highest FSP load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest FSP EMC occurred during the atmospheric river rain on snow event March 10-11, 2023.
- The lowest FSP load occurred during the thunderstorm event on June 12, 2023.

The daily flow and TN EMC summaries at Lakeshore are presented in Figure 37. Table 9 presents EMC data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

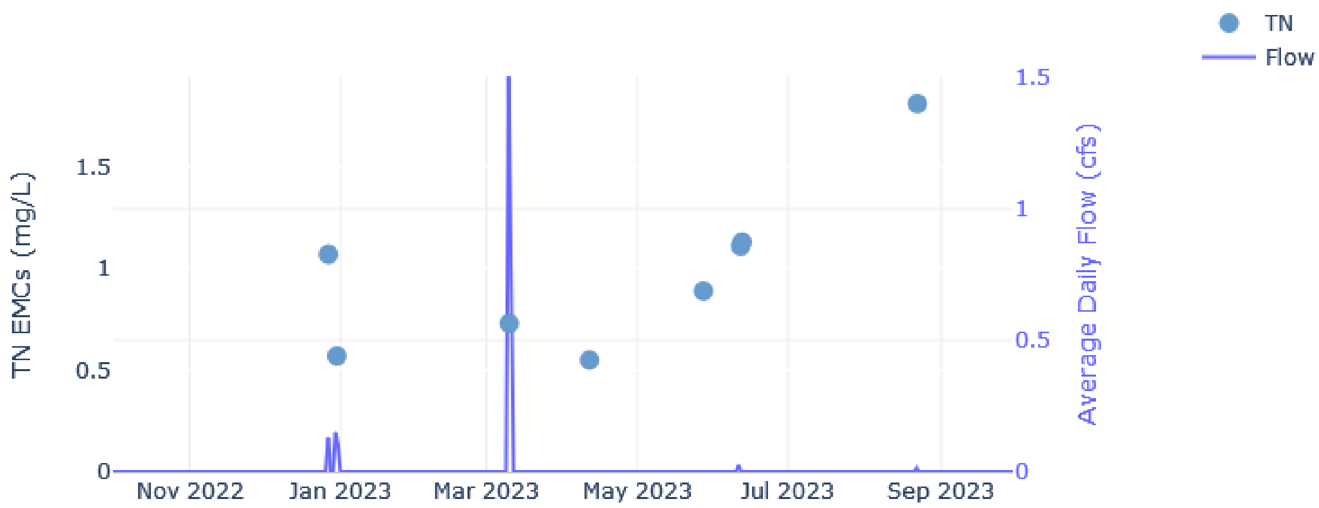

Figure 37 Daily outflow and TN EMC summary at the Lakeshore catchment outfall, WY23.

- Eight events were sampled for TN (two in the fall/winter, three in the spring, three in the summer).
- The highest TN EMC occurred during the thunderstorm event on August 22, 2023.
- The highest TN load occurred during the atmospheric river rain on snow event March 10-11, 2023.
- The lowest TN EMC occurred during the non-event snowmelt from April 11-12, 2023.
- The lowest TN load occurred during the thunderstorm event on June 12, 2023.

The daily flow and TP EMC summary at Lakeshore are presented in Figure 38. Table 9 presents EMC data in tabular form. Table 9 also presents the load data referenced in some bullet points below.

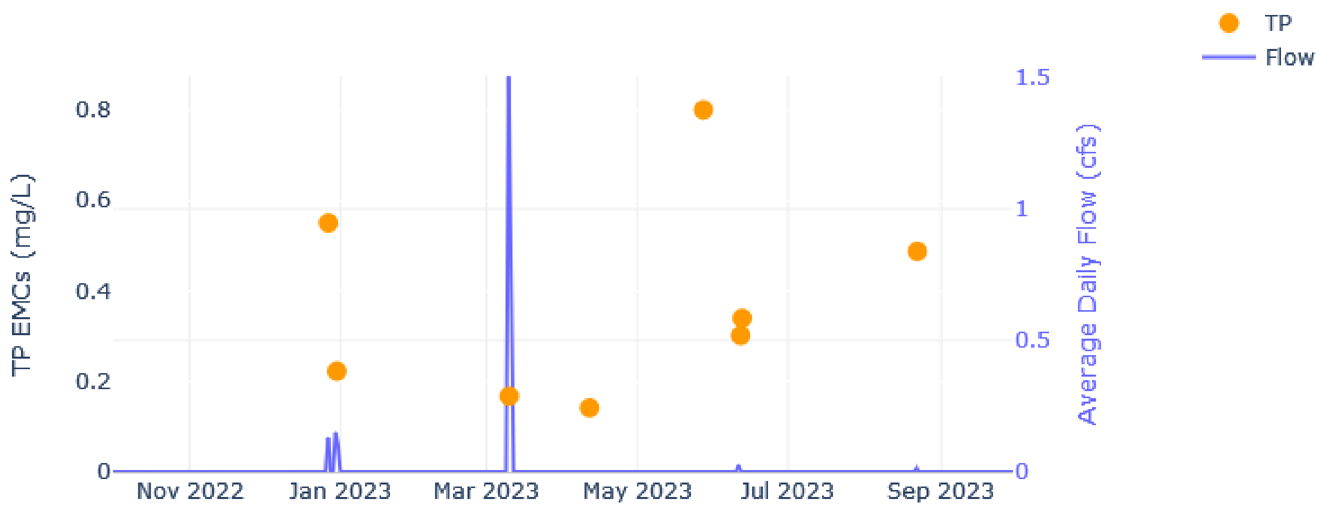

Figure 38 Daily outflow and TP EMC summary at the Lakeshore catchment outfall, WY23.

- Eight events were sampled for TP (two in the fall/winter, three in the spring, three in the summer).
- The highest TP EMC occurred during the thunderstorm event on May 27, 2023.
- The highest TP load occurred during the atmospheric river rain on snow event March 10-11, 2023.
- The lowest TP EMC occurred during the non-event snowmelt April 11-12, 2023.
- The lowest TP load occurred during the thunderstorm event on June 12, 2023.

Seasonal load as a fraction of the water year load at Lakeshore are presented in Figure 39. Event loads are presented in tabular form in Table 9.

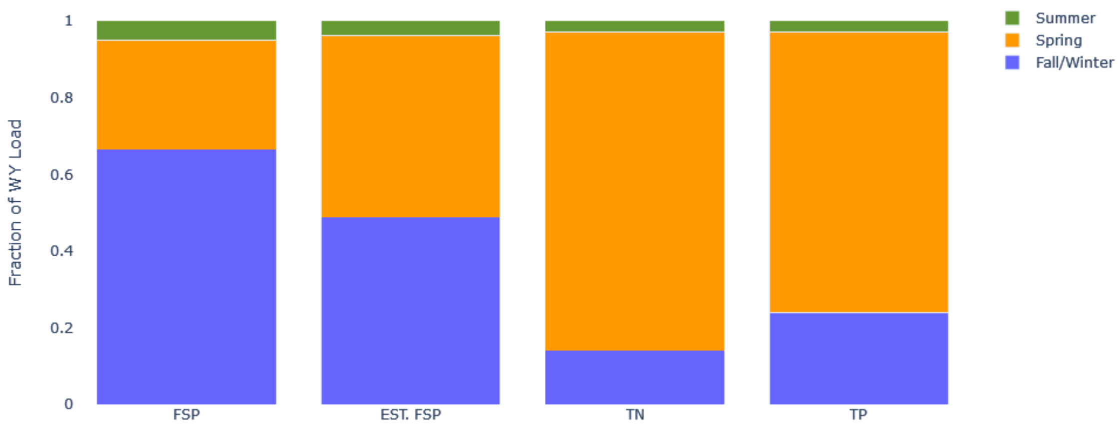

Figure 39 Seasonal load as a fraction of the water year load at the Lakeshore catchment outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads from samples was generated in the fall/winter.
- The largest fraction of FSP from continuous turbidity was generated in the fall/winter.
- FSP loads calculated from sample concentrations are lab certified results and therefore reliable, however, not all runoff volume is sampled. Estimated FSP loads calculated from turbidity are less precise, but turbidity measurements are taken continuously on all runoff. This discrepancy accounts for the difference between FSP and estimated FSP results.
- The largest fraction of TN loads was generated in the spring.
- The largest fraction of TP loads was generated in the spring.

Eight events were sampled at the Lakeshore catchment outfall in WY23. Event summary data is presented in Table 9.

Table 9 Event summary data at the Lakeshore catchment outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
LS	Fall/Winter	12/27/2022 2:15	12/27/2022 13:30	11:15	11,398	0.68	386	1.70	Rain on Snow	52	36.69	46.1	1,070	0.76	551	0.39
LS	Fall/Winter	12/30/2022 13:05	12/31/2022 8:05	19:00	21,887	0.74	371	3.34	Rain on Snow	41	55.85	83.5	570	0.78	223	0.30
LS	Spring	3/10/2023 5:10	3/11/2023 13:40	32:30	200,515	7.24	34	2.64	Rain on Snow	3	37.53	13.6	730	9.13	168	2.10
LS	Spring	4/11/2023 15:35	4/12/2023 1:40	10:05	313	0.03	20	0.00	Non-event Snowmelt	14	0.27	79.9	550	0.01	142	0.00
LS	Spring	5/27/2023 18:25	5/27/2023 20:30	2:05	347	0.16	874	0.33	Thunderstorm	87	1.89	44.3	890	0.02	801	0.02
LS	Summer	6/11/2023 20:10	6/11/2023 22:55	2:45	2,386	0.56	72	0.56	Thunderstorm	22	3.30	42.7	1,110	0.17	302	0.04
LS	Summer	6/12/2023 11:05	6/12/2023 12:05	1:00	26	0.02	114	0.17	Thunderstorm	22	0.03	36.8	1,130	0.00	340	0.00
LS	Summer	8/22/2023 7:20	8/22/2023 9:50	2:30	1,246	0.45	233	0.42	Thunderstorm	45	3.53	42.0	1,810	0.14	488	0.04

6.2.4 Pasadena

Figure 40 shows the average daily flow and cumulative precipitation for WY23 at the Pasadena outfall.

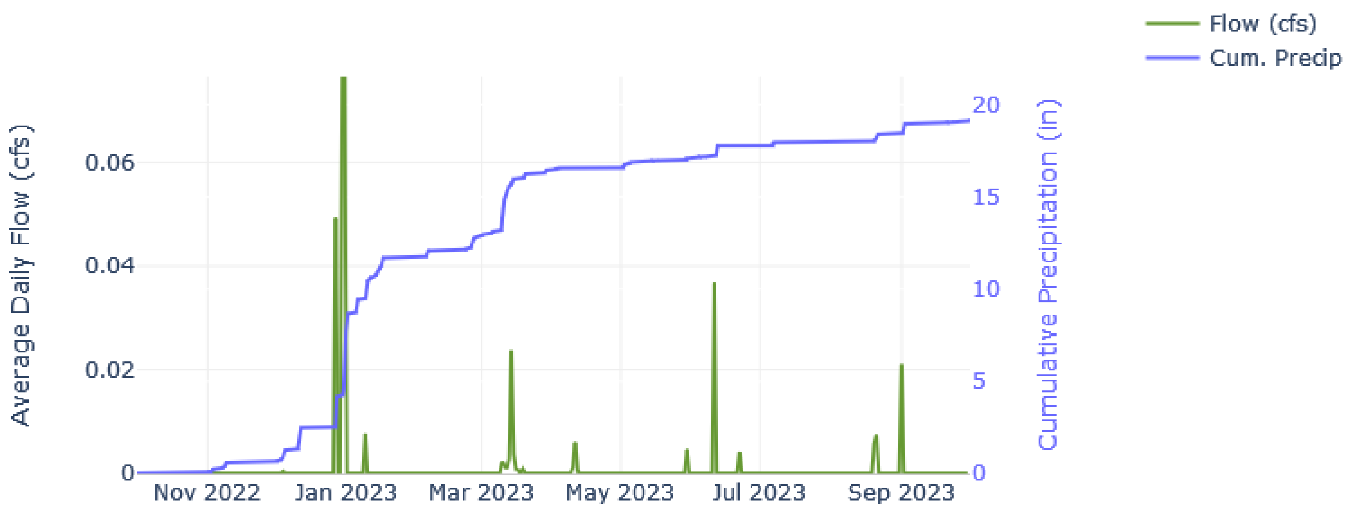

Figure 40 Average daily flow and cumulative precipitation at the Pasadena outfall, WY23.

- 19.19 inches of total precipitation (12.92 inches in the fall/winter, 4.18 inches in the spring, and 2.09 inches 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.
- 59 precipitation events occurred (21 fall/winter events, 20 spring events, 18 summer events).
- The largest storm event produced 4.48 inches of precipitation and occurred during an atmospheric river rain on snow event December 29, 2022 – January 1, 2023.
- 81% of storms were less than half an inch.
- The largest runoff volume occurred during the December 30-31, 2022 atmospheric river rain on snow event (13,197 cf).
- Highest average daily flow occurred on December 30, 2022 during the atmospheric river rain on snow event.
- Nine days of snowmelt occurred in the spring, resulting in 1,200 cf of runoff (4% of the total flow).
- The highest instantaneous peak precipitation was 0.09 inches in 5 minutes during a rain event on July 6, 2023.
- The highest instantaneous peak flow was 0.70 cfs on June 11, 2023 during a thunderstorm event.

Daily flow and FSP EMC summaries at the Pasadena outfall are presented in Figure 41. Table 10 presents EMC data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

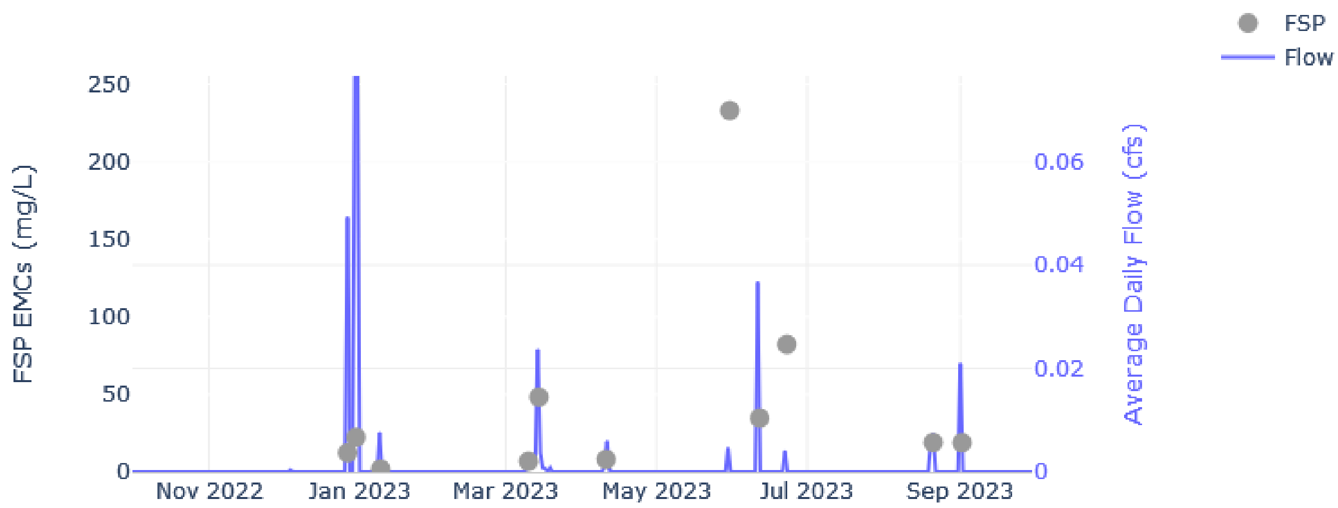

Figure 41 Daily outflow and FSP EMC summary at the Pasadena outfall, WY23.

- Eleven events were sampled for FSP (three in the fall/winter, four in the spring, and four in the summer).
- The highest FSP EMC occurred during the thunderstorm event on May 30, 2023.
- The highest FSP load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest FSP EMC and load occurred during the atmospheric river rain on snow event January 9, 2023.

The daily flow and TN EMC summaries at the Pasadena outfall are presented in Figure 42. Table 10 presents EMC data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

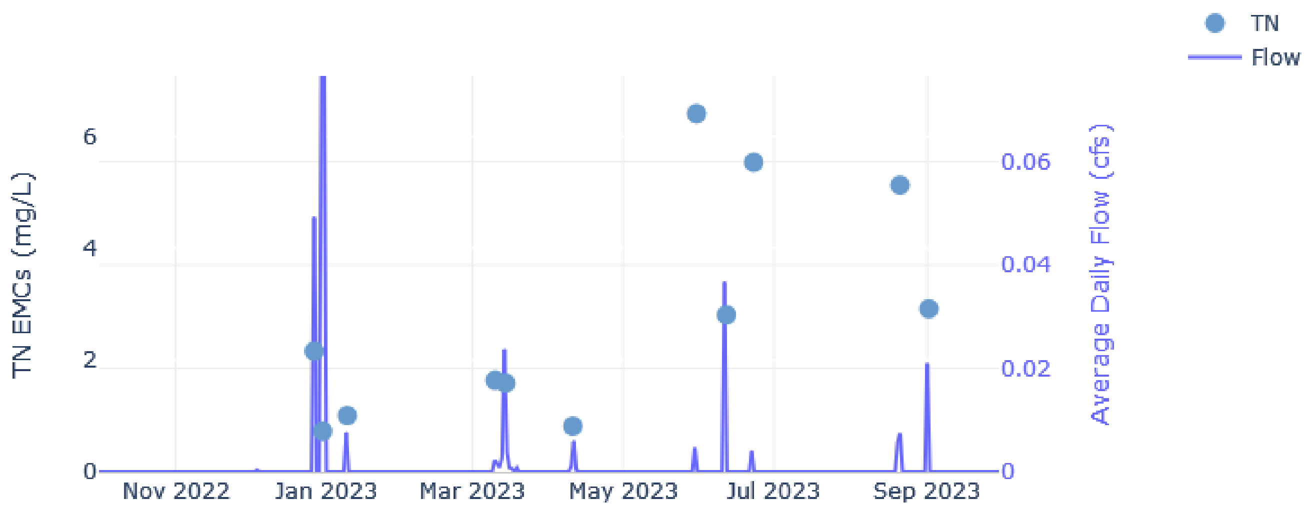

Figure 42 Daily outflow and TN EMC summary at the Pasadena outfall, WY23.

- Eleven events were sampled for TN (three in the fall/winter, four in the spring, and four in the summer).
- The highest TN EMC occurred during the thunderstorm event on May 30, 2023.
- The highest TN load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest TN EMC occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest TN load occurred during the non-event snowmelt from April 10-11, 2023.

The daily flow and TP EMC summary at the Pasadena outflow are presented Figure 43. Table 10 presents EMC data in tabular form. Table 10 also presents the load data referenced in some bullet points below.

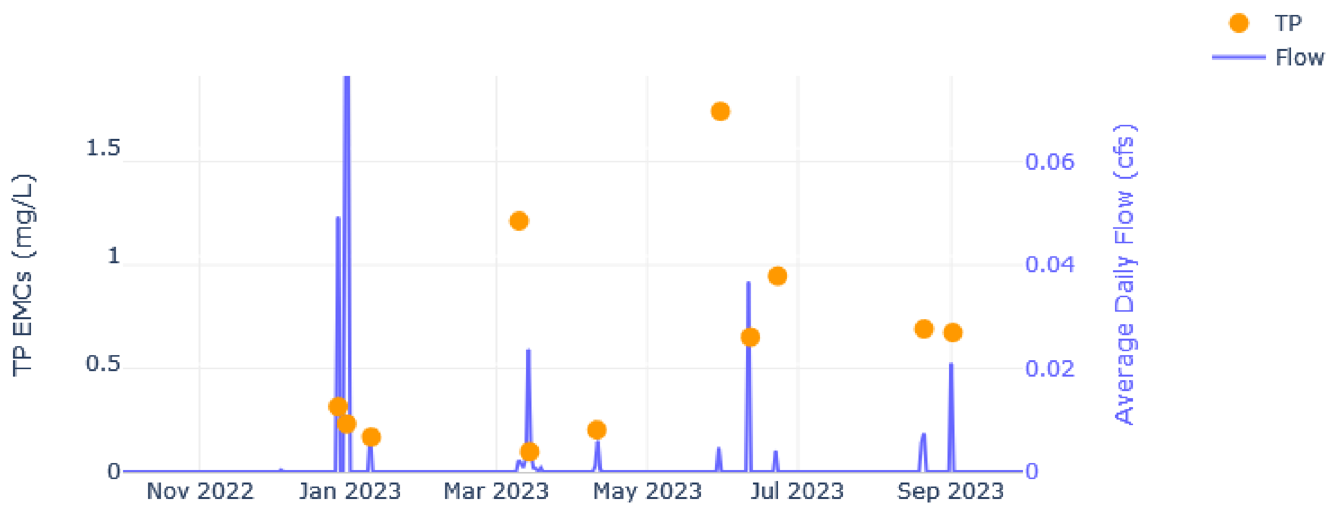

Figure 43 Daily outflow and TP EMC summary at the Pasadena outfall, WY23.

- Eleven events were sampled for TP (three in the fall/winter, four in the spring, and four in the summer).
- The highest TP EMC occurred during the thunderstorm event on May 30, 2023.
- The highest TP load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest TP EMC occurred during the atmospheric river rain on snow event March 14, 2023.
- The lowest TP load occurred during the atmospheric river rain on snow event January 9, 2023.

Seasonal load as a fraction of the water year load at the Pasadena outflow are presented in Figure 44. Event loads are presented in tabular form in Table 10.

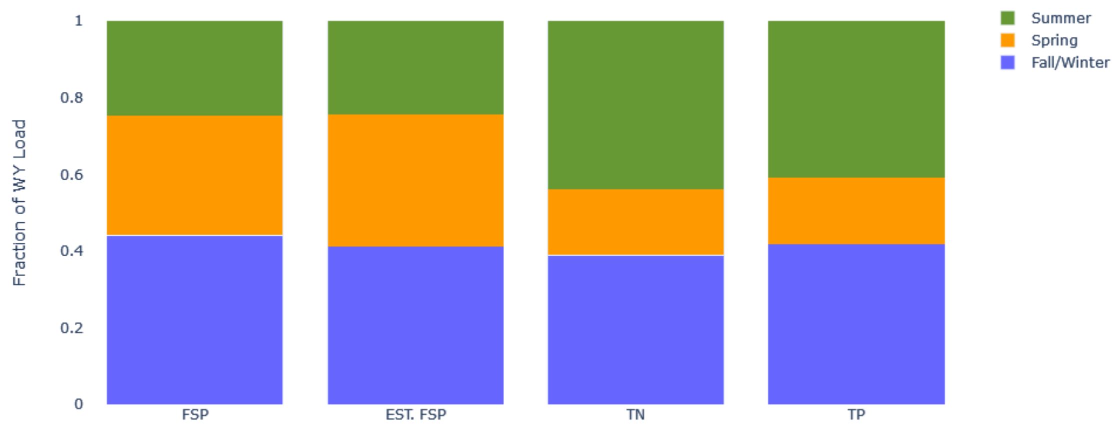

Figure 44 Seasonal load as a fraction of the water year load at the Pasadena outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

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

Eleven events were sampled at Pasadena in WY23. Event summary data is presented in Table 10.

Table 10 Event summary data at the Pasadena outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
PO	Fall/Winter	12/27/2022 0:10	12/27/2022 20:45	20:35	4,266	0.37	86	1.69	Rain on Snow	12	3.30	38.9	2,160	0.57	303	0.08
PO	Fall/Winter	12/30/2022 11:00	12/31/2022 11:10	24:10	13,197	0.61	127	2.90	Rain on Snow	22	18.44	56.1	730	0.60	223	0.18
PO	Fall/Winter	1/9/2023 9:25	1/9/2023 19:50	10:25	669	0.04	22	0.40	Rain on Snow	2	0.08	24.2	1,010	0.04	162	0.01
PO	Spring	3/10/2023 3:05	3/12/2023 16:10	61:05	406	0.04	97	1.40	Rain on Snow	7	0.17	28.7	1,640	0.04	1,163	0.03
PO	Spring	3/14/2023 9:35	3/14/2023 23:30	13:55	2,055	0.20	228	0.20	Rain on Snow	48	6.19	53.7	1,590	0.20	94	0.01
PO	Spring	4/10/2023 14:50	4/11/2023 18:40	27:50	637	0.04	85	0.00	Non-event Snowmelt	8	0.33	34.2	820	0.03	195	0.01
PO	Spring	5/30/2023 15:35	5/30/2023 17:00	1:25	409	0.33	464	0.02	Thunderstorm	233	5.96	46.8	6,410	0.16	1,671	0.04
PO	Summer	6/11/2023 18:10	6/11/2023 23:30	5:20	3,185	0.70	200	0.56	Thunderstorm	35	6.92	35.5	2,810	0.56	625	0.12
PO	Summer	6/22/2023 18:35	6/22/2023 20:20	1:45	361	0.30	262	0.00	Thunderstorm	82	1.85	42.0	5,540	0.12	908	0.02
PO	Summer	8/20/2023 23:10	8/21/2023 4:15	5:05	1,144	0.57	157	0.29	Thunderstorm	19	1.36	22.3	5,130	0.37	663	0.05
PO	Summer	9/1/2023 14:35	9/1/2023 21:05	6:30	1,822	0.24	98	0.51	Thunderstorm	19	2.15	31.0	2,920	0.33	646	0.07

6.2.5 Speedboat

Figure 45 shows the average daily flow and cumulative precipitation for WY23 at the Speedboat catchment outfall.

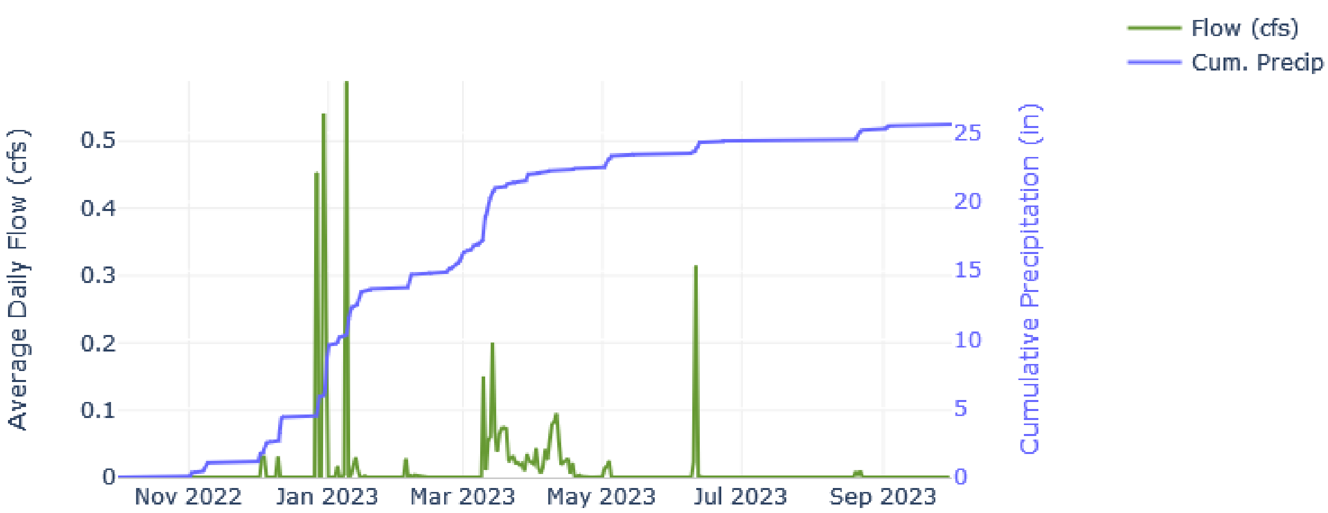

Figure 45 Average daily flow and cumulative precipitation at the Speedboat catchment outfall, WY23.

- 25.62 inches of total precipitation (16.30 inches in the fall/winter, 7.13 inches in the spring, and 2.19 inches in the summer) were recorded at the Nugget (NG) weather station.
- 51 precipitation events occurred (21 fall/winter events, 14 spring events, 16 summer events).
- The largest storm event produced 3.89 inches of precipitation and occurred during an atmospheric river rain on snow event from March 9-14, 2023.
- 73% of storms were less than half an inch.
- The largest runoff volume was caused by continuous snowmelt from March 15, 2023 - April 8, 2023 (69,228 cf).
- The largest runoff volume that wasn't snowmelt occurred during the December 30-31, 2022 atmospheric river rain on snow event (68,638 cf).
- Highest average daily flows occurred on January 9, 2023 during an atmospheric river rain event.
- 74 days of snowmelt occurred in the fall/winter and spring, resulting in 124,217 cf of runoff (34% of the total flow).
- The highest instantaneous peak precipitation was 0.09 inches in 10 minutes during a thunderstorm event on June 10, 2023.
- The highest instantaneous peak flow was 13.1 cfs during the atmospheric river rain on snow event on January 9, 2023.

Daily flow and the FSP EMC summary at Speedboat are presented in Figure 46. Table 11 presents EMC data in tabular form. Table 11 also presents the load data referenced in some bullet points below.

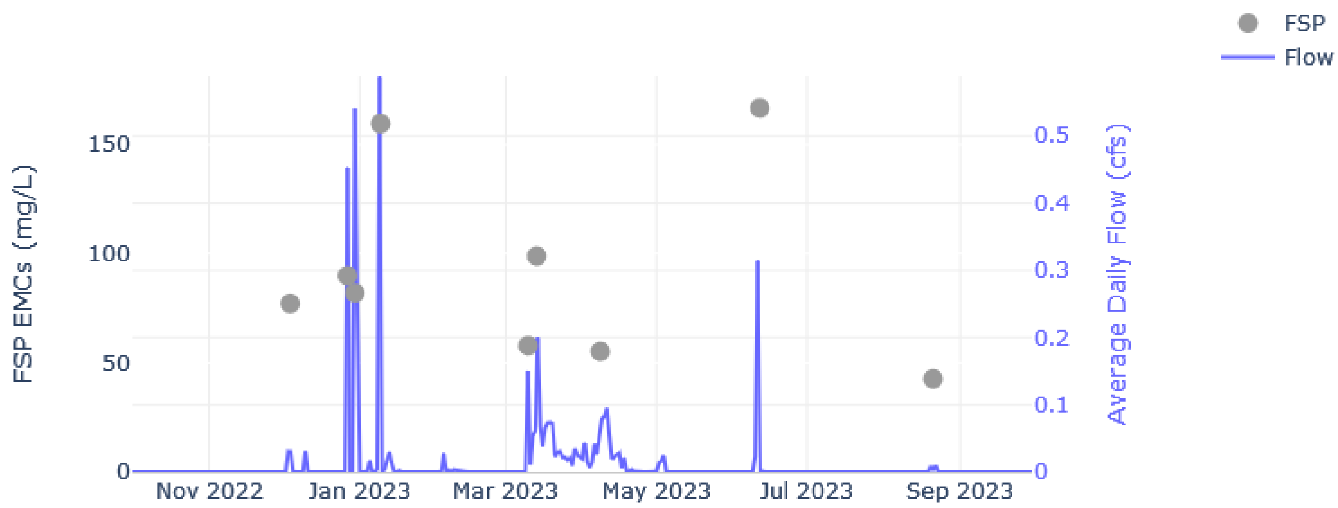

Figure 46 Daily flow and FSP EMC summary at the Speedboat catchment outfall, WY23.

- Nine events were sampled for FSP (four in the fall/winter, three in the spring, and two in the summer).
- The highest FSP EMC occurred during an thunderstorm event on June 11, 2023.
- The highest FSP load occurred during an atmospheric river rain on snow event January 9, 2023.
- The lowest FSP EMC and load occurred during a rain event (Hurricane Hillary) August 20-21, 2023.

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

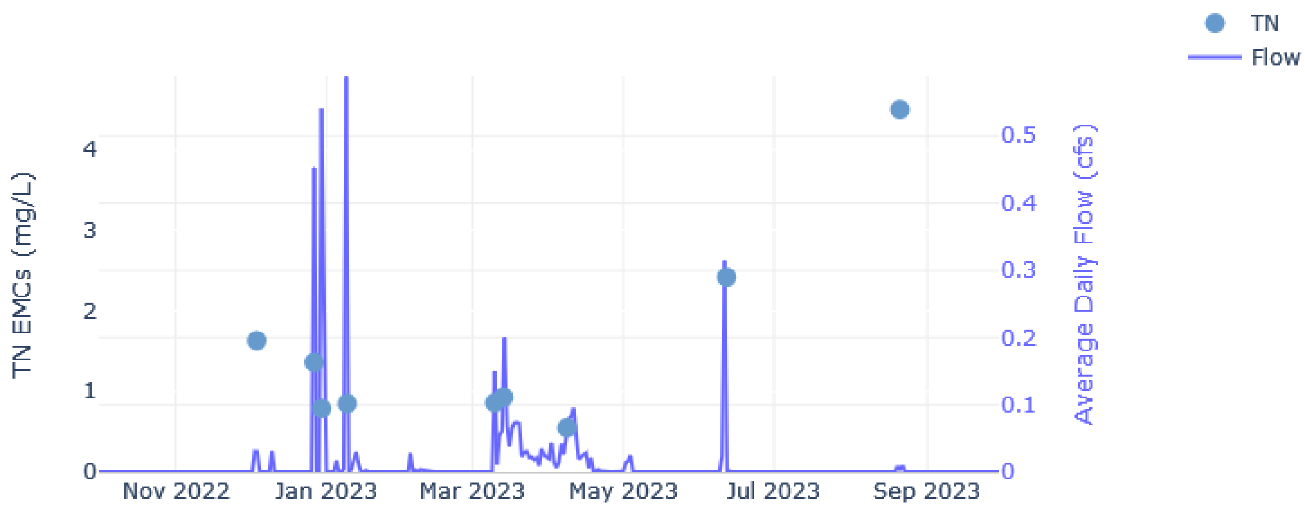

Figure 47 Daily flow and TN EMC summary at the Speedboat catchment outfall, WY23.

- Nine events were sampled for TN (four in the fall/winter, three in the spring, and two in the summer).
- The highest TN EMC occurred during the rain event (Hurricane Hillary) August 20-21, 2023.
- The highest TN load occurred during the thunderstorm on June 11, 2023.
- The lowest TN EMC occurred during the non-event snowmelt April 8-11, 2023.
- The lowest TN load occurred during the rain event (Hurricane Hillary) August 20-21, 2023.

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

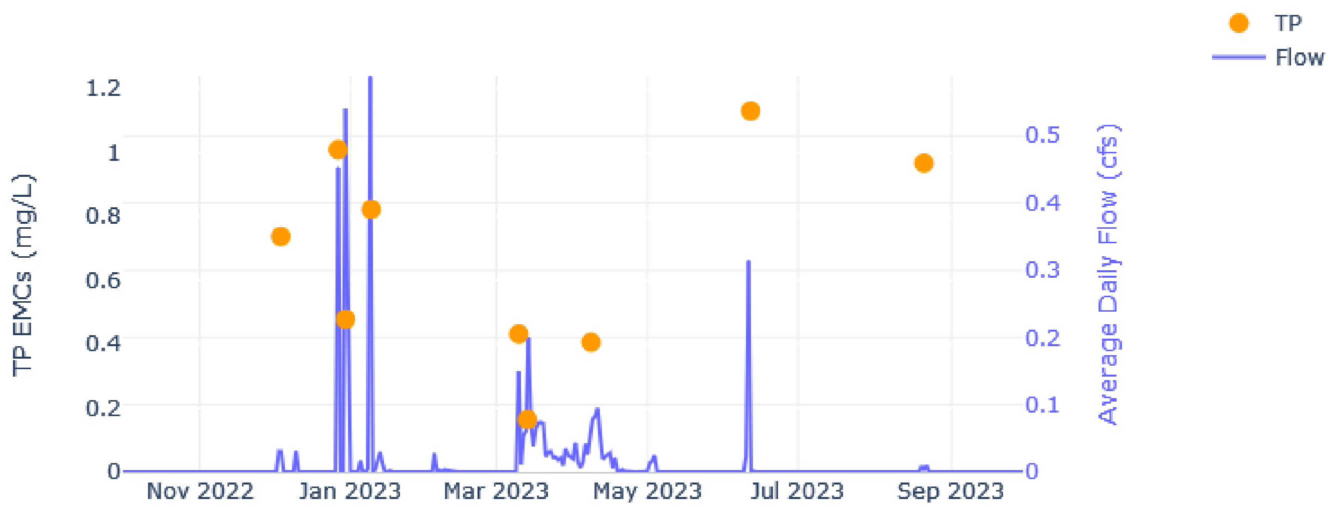

Figure 48 Daily flow and TP EMC summary at the Speedboat catchment outfall, WY23.

- Nine events were sampled for TP (four in the fall/winter, three in the spring, and two in the summer).
- The highest TP EMC occurred during the thunderstorm event on June 11, 2023.
- The highest TP load occurred during the atmospheric river rain on snow event January 9, 2023.
- The lowest TP EMC occurred during the atmospheric river rain on snow event March 13-15, 2023.
- The lowest TP load occurred during the rain event (Hurricane Hillary) on August 20-21, 2023.

Seasonal load as a fraction of the water year load at Speedboat is presented in Figure 49. Event loads are presented in tabular form in Table 11.

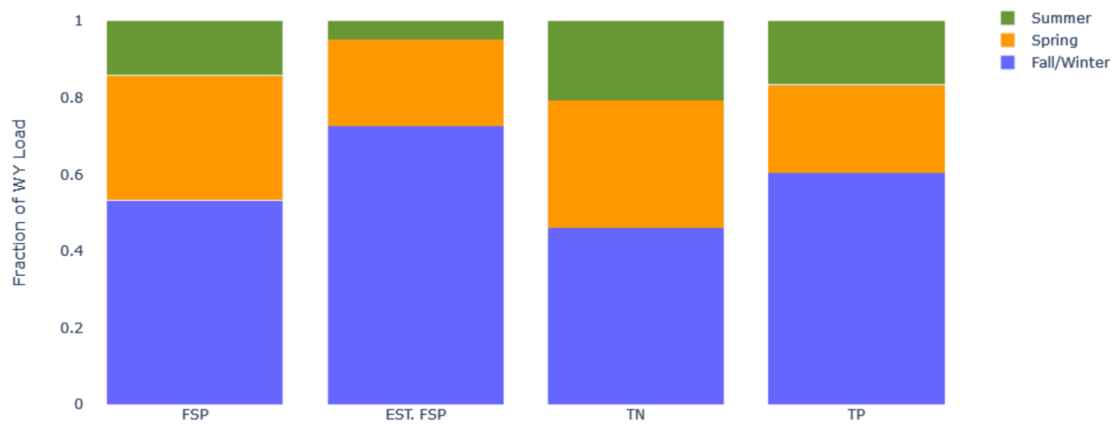

Figure 49 Seasonal load as a fraction of the water year load at the Speedboat catchment outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP, TN, and TP load was generated in the fall/winter.
- FSP loads calculated from sample concentrations are lab certified results and therefore reliable, however, not all runoff volume is sampled. Estimated FSP loads calculated from turbidity are less precise, but turbidity measurements are taken continuously on all runoff. This discrepancy accounts for the difference between FSP and estimated FSP results.

Nine events were sampled at Speedboat in WY23. Event summary data is presented in Table 11.

Table 11 Event summary data at the Speedboat catchment outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
SB	Fall/Winter	12/3/2022 18:50	12/4/2022 4:45	9:55	5,110	0.64	758	0.65	Rain on Snow	77	24.61	56.8	1,630	0.52	737	0.23
SB	Fall/Winter	12/27/2022 0:15	12/27/2022 17:40	17:25	39,206	2.23	1,260	1.39	Rain on Snow	90	219.89	42.8	1,360	3.33	1,009	2.47
SB	Fall/Winter	12/30/2022 0:00	12/31/2022 7:50	31:50	68,638	2.59	395	2.14	Rain on Snow	82	351.13	64.1	790	3.38	478	2.05
SB	Fall/Winter	1/9/2023 5:00	1/9/2023 22:25	17:25	50,879	13.14	596	1.21	Rain on Snow	160	506.59	79.0	850	2.70	822	2.61
SB	Spring	3/10/2023 0:45	3/11/2023 2:20	25:35	12,996	0.40	225	1.77	Rain on Snow	58	46.95	53.6	860	0.70	432	0.35
SB	Spring	3/13/2023 8:00	3/15/2023 8:30	48:30	23,621	0.55	282	2.12	Rain on Snow	99	145.74	52.6	930	1.37	164	0.24
SB	Spring	4/8/2023 6:10	4/11/2023 6:25	72:15	18,774	0.42	96	0.00	Non-event Snowmelt	55	64.65	47.2	550	0.64	406	0.48
SB	Summer	6/11/2023 19:40	6/11/2023 22:30	2:50	27,252	9.53	248	0.31	Thunderstorm	167	283.41	47.1	2,420	4.11	1,130	1.92
SB	Summer	8/20/2023 22:05	8/21/2023 6:15	8:10	961	0.29	1,013	0.36	Rain	43	2.56	19.4	4,500	0.27	967	0.06

6.2.6 Tahoe City

Figure 50 shows the average daily flow and cumulative precipitation for WY23 at the Tahoe City catchment outfall.

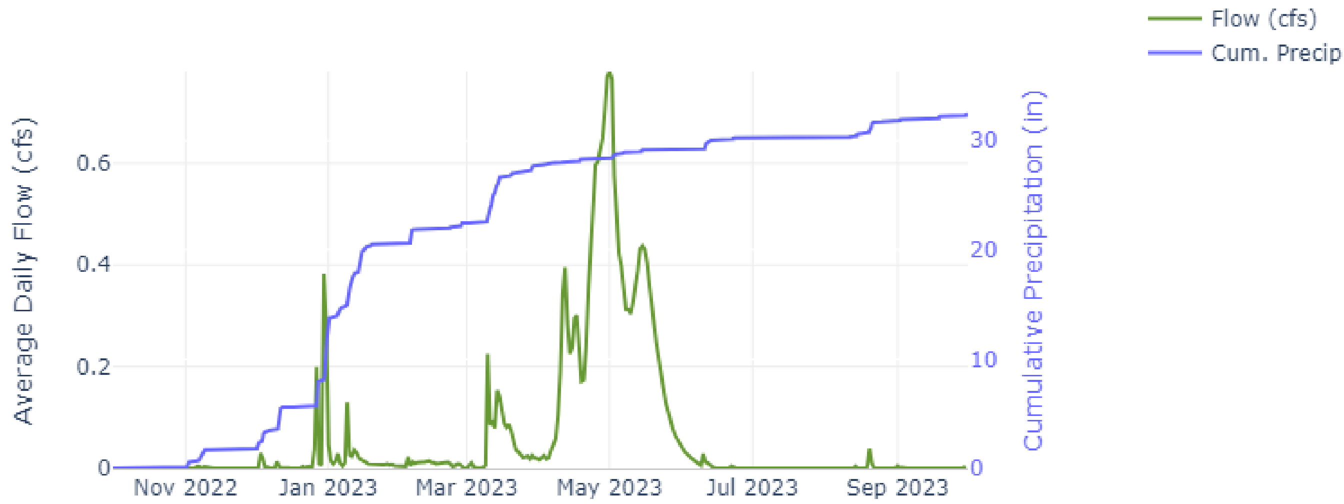

Figure 50 Average daily flow and cumulative precipitation at the Tahoe City catchment outfall, WY23.

- 32.43 inches of total precipitation (22.46 inches in the fall/winter, 6.76 inches in the spring, and 3.21 inches in the summer) were recorded at the Hatchery (HATCH) weather station.
- 59 precipitation events occurred (21 fall/winter events, 16 spring events, 22 summer events).
- The largest storm event produced 5.75 inches of precipitation and occurred during an atmospheric river rain on snow event December 29, 2022-January 1, 2023.
- 78% of storms were less than half an inch.
- The largest runoff volume was caused by continuous snowmelt from April 18, 2023 – May 1, 2023 (577,210 cf).
- The largest runoff volume that wasn't snowmelt was December 29, 2022-January 1, 2023 during an atmospheric river rain on snow event (60,726 cf).
- Highest average daily flows occurred on May 1, 2023 during an event-snowmelt event.
- 188 days of snowmelt occurred in the fall/winter, spring, and summer, resulting in 1,720,472 cf of runoff (89% of the total flow).
- The highest instantaneous peak precipitation was 0.13 inches in 5 minutes during a thunderstorm event on June 10, 2023.
- The highest instantaneous peak flow was 1.97 cfs during an atmospheric river rain on snow event December 26, 2022.

Daily flow and the FSP EMC summary at Tahoe City are presented in Figure 51. Table 12 presents EMC data in tabular form. Table 12 also presents the load data referenced in some bullet points below.

Figure 51 Daily flow and FSP EMC summary at the Tahoe City catchment outfall, WY23.

- 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 a thunderstorm event August 19-20, 2023.
- The highest FSP load occurred during the atmospheric river rain on snow event December 26-28, 2022.
- The lowest FSP EMC occurred during the non-event snowmelt May 30, 2023.
- The lowest FSP load occurred during the rain event October 22, 2022.

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

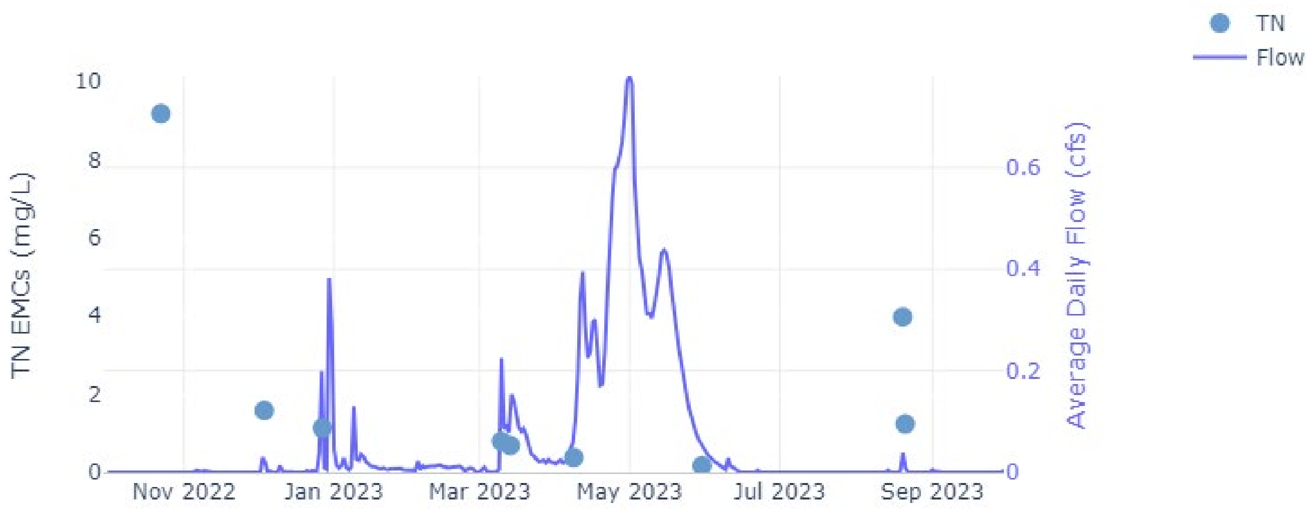

Figure 52 Daily flow and TN EMC summary at the Tahoe City catchment outfall, WY23.

- 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 rain event October 22, 2022.
- The highest TN load occurred during an atmospheric river rain on snow event March 9-13, 2023.
- The lowest TN EMC and load occurred during a non-event snowmelt on May 30, 2023.

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

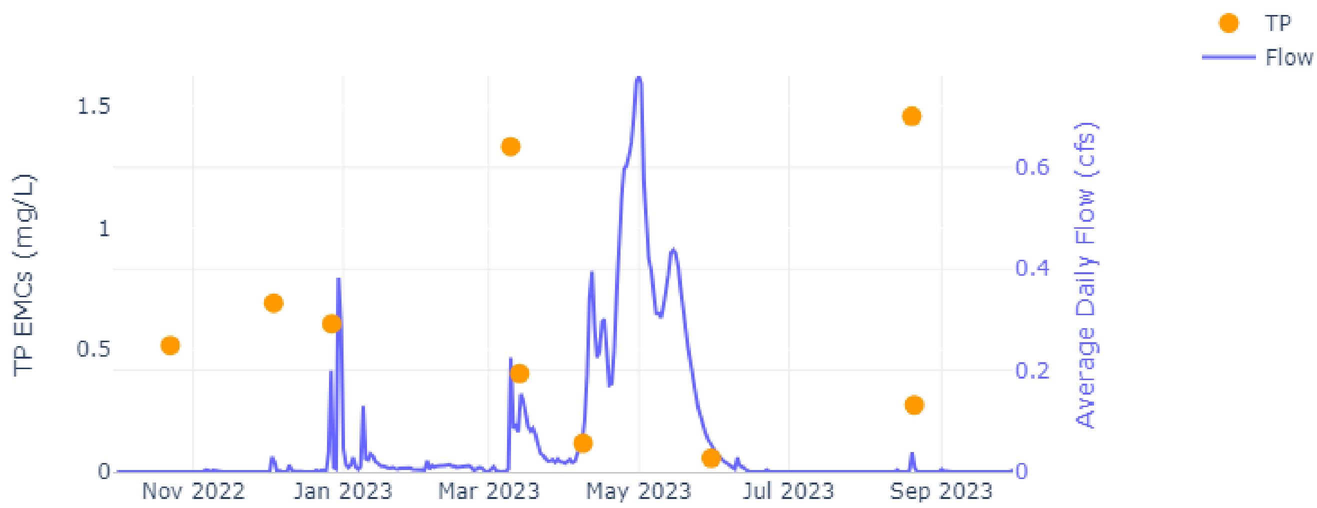

Figure 53 Daily flow and TP EMC summary at the Tahoe City catchment outfall, WY23.

- 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 the thunderstorm event August 19-20, 2023.
- The highest TP load occurred during the atmospheric river rain on snow event March 9-13, 2023.
- The lowest TP EMC occurred during the non-event snowmelt May 30, 2023.
- The lowest TP load occurred during the rain event October 22, 2022.

Seasonal load as a fraction of the water year load at Tahoe City is presented in Figure 54. Event loads are presented in tabular form in Table 12.

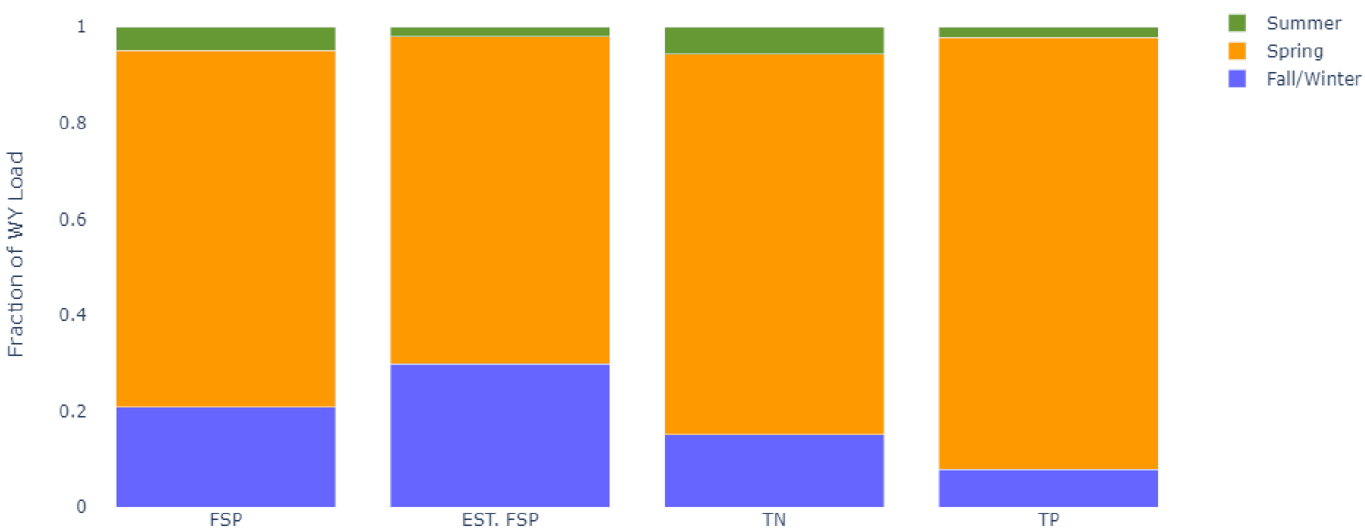

Figure 54 Seasonal load as a fraction of the water year load at the Tahoe City catchment outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in spring.
- FSP loads calculated from sample concentrations are lab certified results and therefore reliable, however, not all runoff volume is sampled. Estimated FSP loads calculated from turbidity are less precise, but turbidity measurements are taken continuously on all runoff. This discrepancy accounts for the difference between FSP and estimated FSP results.
- The largest fraction of TN loads was generated in the spring.
- The largest fraction of TP loads was generated in the spring.

Nine events were sampled at Tahoe City in WY23. Event summary data is presented in Table 12.

Table 12 Event summary data at the Tahoe City catchment outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TC	Fall/Winter	10/22/2022 15:40	10/22/2022 19:20	3:40	148	0.03	84	0.11	Rain	17	0.16	31.1	9,190	0.09	519	0.00
TC	Fall/Winter	12/3/2022 15:15	12/5/2022 4:30	37:15	4,282	0.21	376	1.61	Rain on Snow	79	21.08	68.6	1,590	0.42	693	0.19
TC	Fall/Winter	12/26/2022 23:20	12/28/2022 0:15	24:55	20,364	1.97	965	2.38	Rain on Snow	58	73.05	48.7	1,140	1.45	608	0.77
TC	Spring	3/9/2023 18:20	3/13/2023 8:20	86:00	36,800	0.83	579	3.27	Rain on Snow	25	57.62	48.2	800	1.84	1,335	3.06
TC	Spring	3/13/2023 8:20	3/15/2023 8:55	48:35	22,939	0.35	431	0.88	Rain on Snow	34	48.66	37.0	690	0.99	404	0.58
TC	Spring	4/8/2023 6:35	4/11/2023 6:20	71:45	35,465	0.30	90	0.00	Non-event Snowmelt	6	13.94	18.5	380	0.84	118	0.26
TC	Spring	5/30/2023 10:05	5/30/2023 18:40	8:35	1,796	0.07	5	0.00	Non-event Snowmelt	2	0.25	10.7	170	0.02	57	0.01
TC	Summer	8/19/2023 22:35	8/20/2023 15:55	17:20	2,392	1.08	520	0.56	Thunderstorm	140	20.81	31.7	3,980	0.59	1,459	0.22
TC	Summer	8/20/2023 22:00	8/21/2023 8:25	10:25	1,997	0.27	107	0.39	Rain	11	1.41	27.0	1,240	0.15	275	0.03

Tahoe City bypass flow is shown in Figure 55. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Delaware Sandfilter, resulting in reduced overall treatment efficiency.

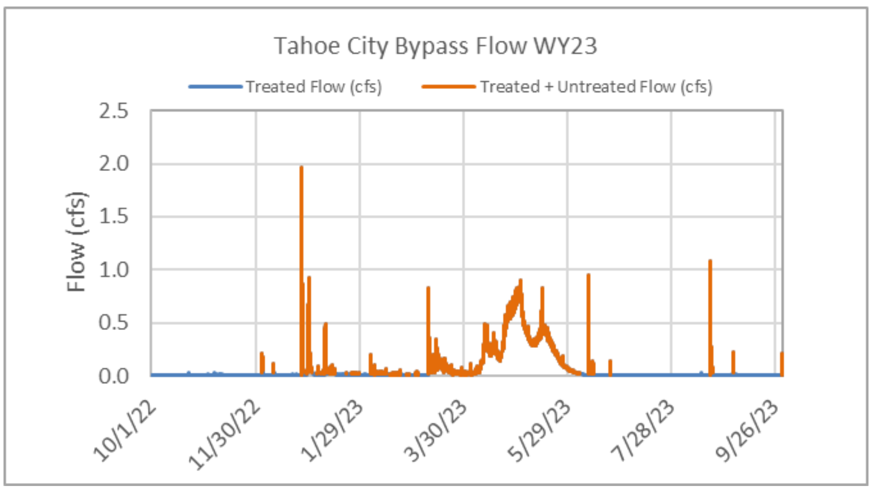

Figure 55 Bypass data for Tahoe City WY23. The orange line indicates bypass occurred.

- In WY23, the Delaware Sandfilter was in bypass mode 55.4% of the time there was flow at the TC site, which represents up to 97% of the total annual flow volume (1,869,370 cf of bypass flow out of 1,922,904 cf of total flow). 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 23 runoff events and 8 out of 9 sampled events had untreated (bypass) flow.
  - December 3-4, 2022 during a sampled rain on snow event that produced 1.61 inches of precipitation.
  - December 10, 2022 during a rain and snow event that produced 2.10 inches of precipitation.
  - December 26, 2022-January 1, 2023 during a sampled atmospheric river rain on snow event that produced 8.13 inches of precipitation.
  - January 4-6, 2023 during a rain on snow event that produced 0.81 inches of precipitation.
  - January 8-15, 2023 during non-event snowmelt, event snowmelt, and a rain on snow event that produced 5.56 inches of precipitation.

- January 17, 2023 during an event snowmelt that produced 0.05 inches of precipitation.
- January 21, 2023 during a non-event snowmelt. Zero inches of precipitation occurred during this time.
- January 24-28, 2023 during a non-event snowmelt. Zero inches of precipitation occurred during this time.
- February 4-13, 2023 during a non-event snowmelt, event snowmelt, a rain on snow event that produced 1.38 inches of precipitation.
- February 15-21, 2023 during a non-event snowmelt. Zero inches of precipitation occurred during this time.
- February 21, 2023 during a sampled rain on snow event that produced 0.172 inches of precipitation.
- February 25-26, 2023 during an event snowmelt that produced 0.32 inches of precipitation.
- March 2-3, 2023 during a non-event snowmelt. Only 0.004 inches of precipitation fell in a 5-minute period during this event.
- March 9-June 5, 2023 during two sampled atmospheric river rain on snow events, non-event snowmelt, sampled non-event snowmelt, event snowmelt, rain on snow, and a thunderstorm event that produced 6.71 inches of precipitation.
- June 10, 2023 during a thunderstorm event that produced 0.44 inches of precipitation.
- June 11, 2023 during a thunderstorm event that produced 0.22 inches of precipitation.
- June 12, 2023 during a thunderstorm event that produced 0.11 inches of precipitation.
- June 13, 2023 during a thunderstorm event that produced 0.09 inches of precipitation.
- June 22, 2023 during a thunderstorm event that produced 0.12 inches of precipitation.
- August 19-20, 2023 during a thunderstorm event that produced 0.56 inches of precipitation.
- August 20-21, 2023 during the sampled Hurricane Hillary rain event that produced 0.39 inches of precipitation.
- September 1, 2023 during a thunderstorm event that produced 0.20 inches of precipitation.
- September 30, 2023 during a rain event that produced 0.22 inches of precipitation.

6.2.7 Tahoe Valley

Figure 56 shows the average daily flow and cumulative precipitation for WY23 at the Tahoe Valley catchment outfall.

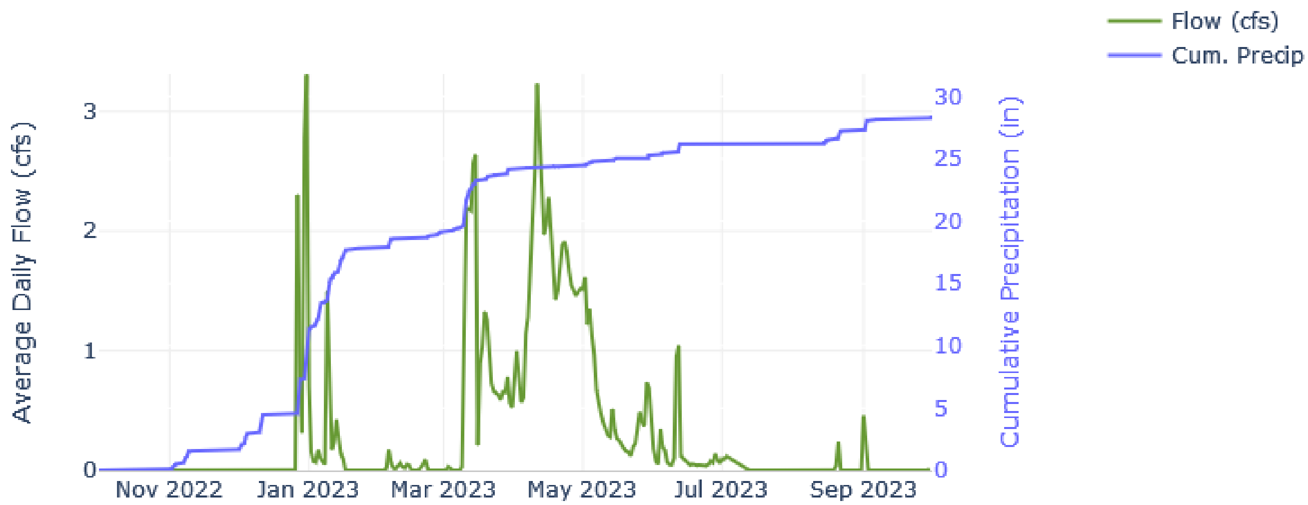

Figure 56 Average daily flow and cumulative precipitation at the Tahoe Valley catchment outfall, WY23.

- 28.42 inches of total precipitation (19.12 inches in the fall/winter, 6.22 inches in the spring, 3.08 inches in the summer) were recorded at the Raph's Shop (RAPH) weather station.
- 60 precipitation events occurred (20 fall/winter events, 18 spring events, 22 summer events).
- The largest storm event produced 4.18 inches of precipitation and occurred during an atmospheric river rain on snow event from December 29, 2022 - January 1, 2023.
- 75% of storms were less than half an inch.
- The largest runoff volume occurred during the snowmelt event April 18, 2023 - May 1, 2023 (1,879,676cf).
- The largest event that wasn't snowmelt occurred during the December 30-31, 2022 atmospheric river rain on snow event (512,075 cf).
- Highest average daily flows occurred on December 31, 2022 during the atmospheric river rain on snow event.
- 152 days of snowmelt occurred in the fall/winter, spring, and summer, resulting in 7,454,222 cf of runoff (76% of the total flow).
- The highest instantaneous peak precipitation was 0.12 inches in 5 minutes on May 29, 2023 during a thunderstorm event.
- The highest instantaneous peak flow (11.25 cfs) occurred on December 31, 2022 during the atmospheric river rain on snow event.

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

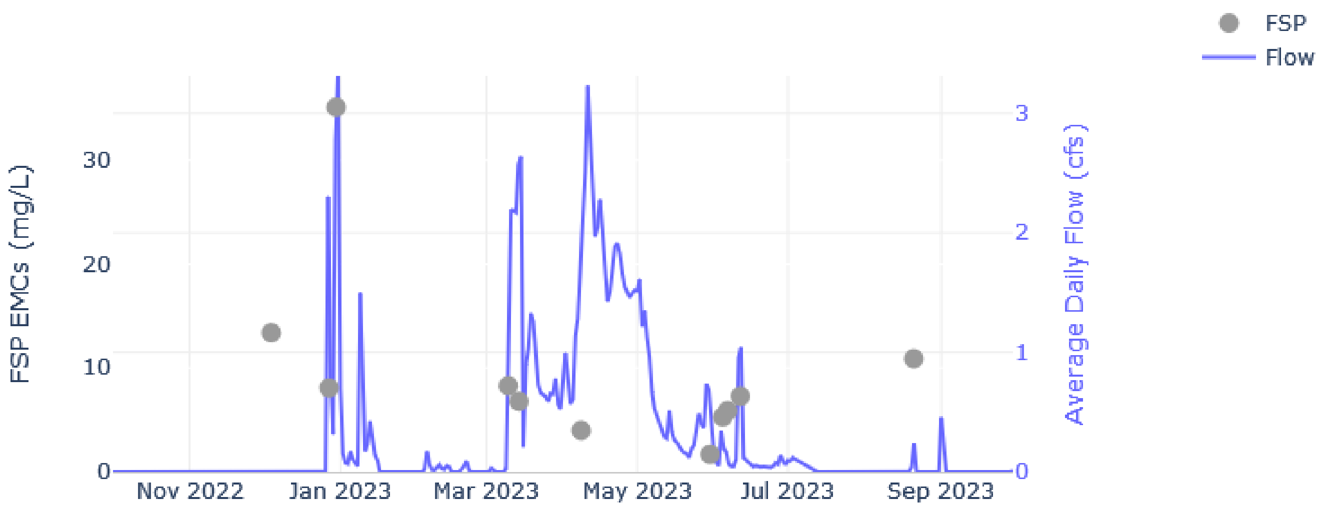

Figure 57 Daily flow and FSP EMC summary at the Tahoe Valley catchment outfall, WY23.

- Eleven events were sampled for FSP (three in the fall/winter, four in the spring, and four in the summer).
- The highest FSP EMC and load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest FSP EMC occurred during the thunderstorm event May 30-31, 2023.
- The lowest FSP load occurred during the rain on snow event December 3-4, 2022.

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

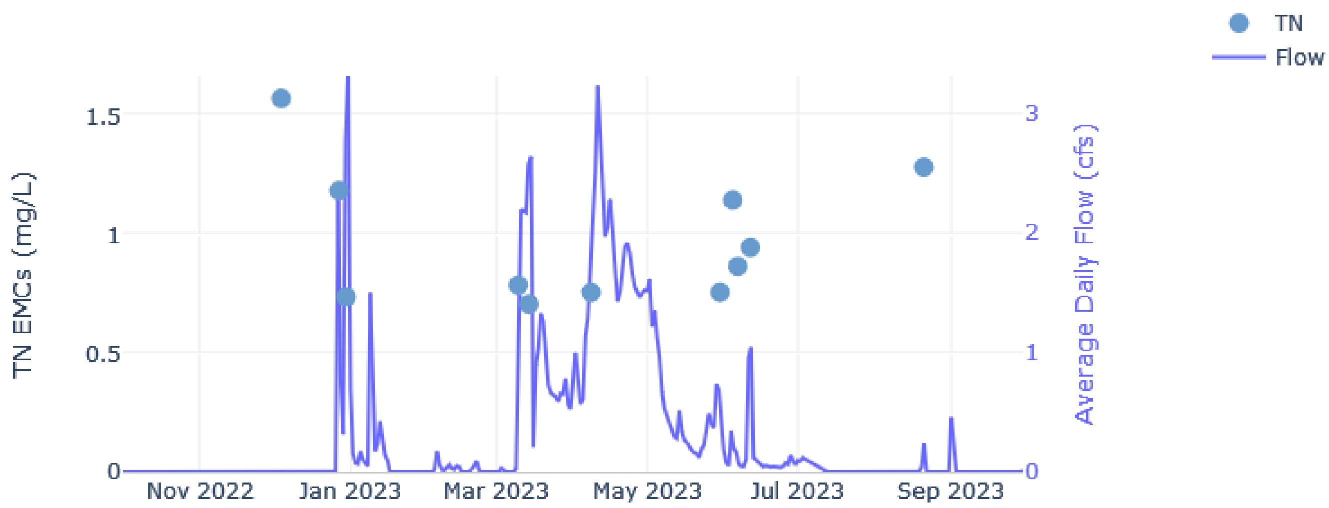

Figure 58 Daily flow and TN EMC summary at the Tahoe Valley catchment outfall, WY23.

- Eleven events were sampled for TN (three in the fall/winter, four in the spring, and four in the summer).
- The highest TN EMC occurred during the rain on snow event December 3-4, 2022.
- The highest TN load occurred during the non-event snowmelt April 8-11, 2023.
- The lowest TN EMC occurred during the atmospheric river rain on snow event March 14-15, 2023.
- The lowest TN load occurred during the rain on snow event December 3, 2022.

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

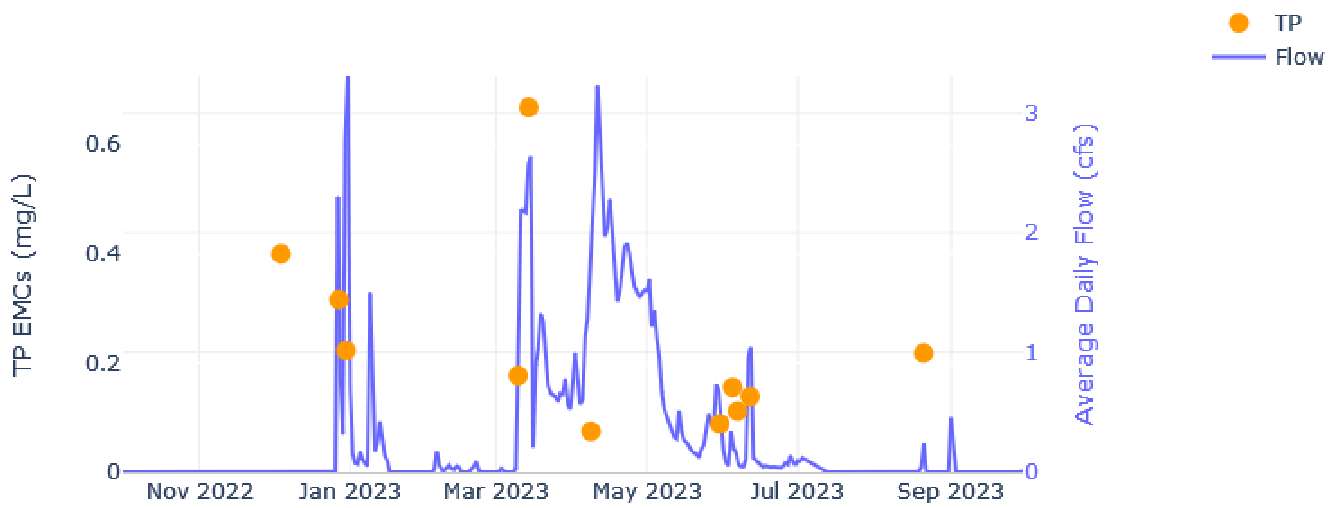

Figure 59 Daily flow and TP EMC summary at the Tahoe Valley catchment outfall, WY23.

- Eleven events were sampled for TP (three in the fall/winter, four in the spring, and four in the summer).
- The highest TP EMC and load occurred during the atmospheric river rain on snow event March 14-15, 2023.
- The lowest TP EMC occurred during the non-event snowmelt April 8-11, 2023.
- The lowest TP load occurred during the rain on snow event December 3-4, 2022.

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

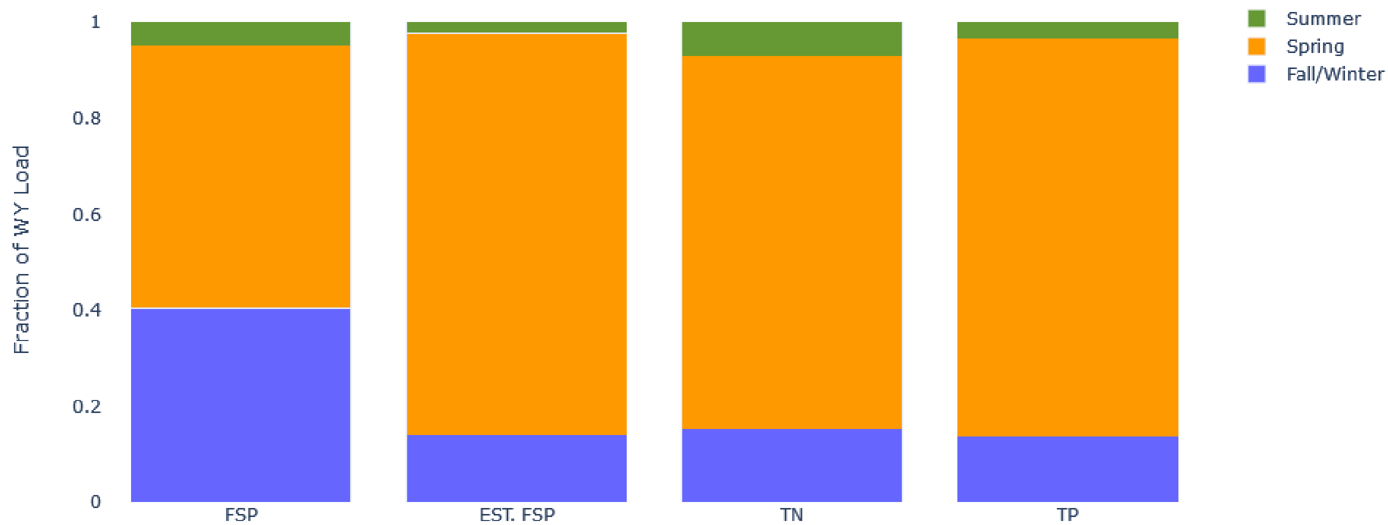

Figure 60 Seasonal load as a fraction of the water year load at the Tahoe Valley catchment outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in the spring.
- FSP loads calculated from sample concentrations are lab certified results and therefore reliable, however, not all runoff volume is sampled. Estimated FSP loads calculated from turbidity are less precise, but turbidity measurements are taken continuously on all runoff. This discrepancy accounts for the difference between FSP and estimated FSP results.
- The largest fraction of TN loads was generated in the spring.
- The largest fraction of TP loads was generated in the spring.

Eleven events were sampled at Tahoe Valley in WY23. Event summary data is presented in Table 13.

Table 13 Event summary data at the Tahoe Valley catchment outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TV	Fall/Winter	12/3/2022 18:30	12/4/2022 2:50	8:20	299	0.13	214	0.49	Rain on Snow	13	0.25	31.1	1,580	0.03	400	0.01
TV	Fall/Winter	12/26/2022 23:15	12/29/2022 2:05	50:50	271,354	4.17	1,473	2.77	Rain on Snow	8	137.12	15.8	1,190	20.15	316	5.35
TV	Fall/Winter	12/30/2022 6:05	12/31/2022 18:40	36:35	512,076	11.25	777	3.57	Rain on Snow	35	1121.33	62.7	740	23.64	223	7.12
TV	Spring	3/9/2023 19:20	3/12/2023 9:45	62:25	352,090	2.95	203	2.90	Rain on Snow	8	182.32	26.0	790	17.35	177	3.89
TV	Spring	3/14/2023 2:45	3/15/2023 10:50	32:05	335,049	3.79	424	0.38	Rain on Snow	7	142.14	22.6	710	14.84	668	13.96
TV	Spring	4/8/2023 6:20	4/11/2023 7:00	72:40	569,582	4.88	68	0.00	Non-event Snowmelt	4	142.14	25.1	760	27.01	75	2.67
TV	Spring	5/30/2023 10:50	5/31/2023 9:10	22:20	52,707	1.10	12	0.06	Thunderstorm	2	5.59	12.7	760	2.50	89	0.29
TV	Summer	6/4/2023 14:00	6/4/2023 23:50	9:50	27,554	1.74	468	0.12	Thunderstorm	5	9.11	17.8	1,150	1.98	156	0.27
TV	Summer	6/6/2023 13:40	6/6/2023 17:30	3:50	6,262	0.83	428	0.06	Thunderstorm	6	2.30	19.1	870	0.34	112	0.04
TV	Summer	6/11/2023 16:40	6/12/2023 15:25	22:45	164,752	4.98	529	0.61	Thunderstorm	7	75.03	19.7	950	9.76	139	1.43
TV	Summer	8/20/2023 20:35	8/21/2023 9:25	12:50	24,054	1.25	702	0.52	Rain	11	16.36	37.6	1,290	1.94	218	0.33

6.2.8 Tahoma

Figure 61 shows the average daily flow and cumulative precipitation for WY23 at the Tahoma catchment outfall.

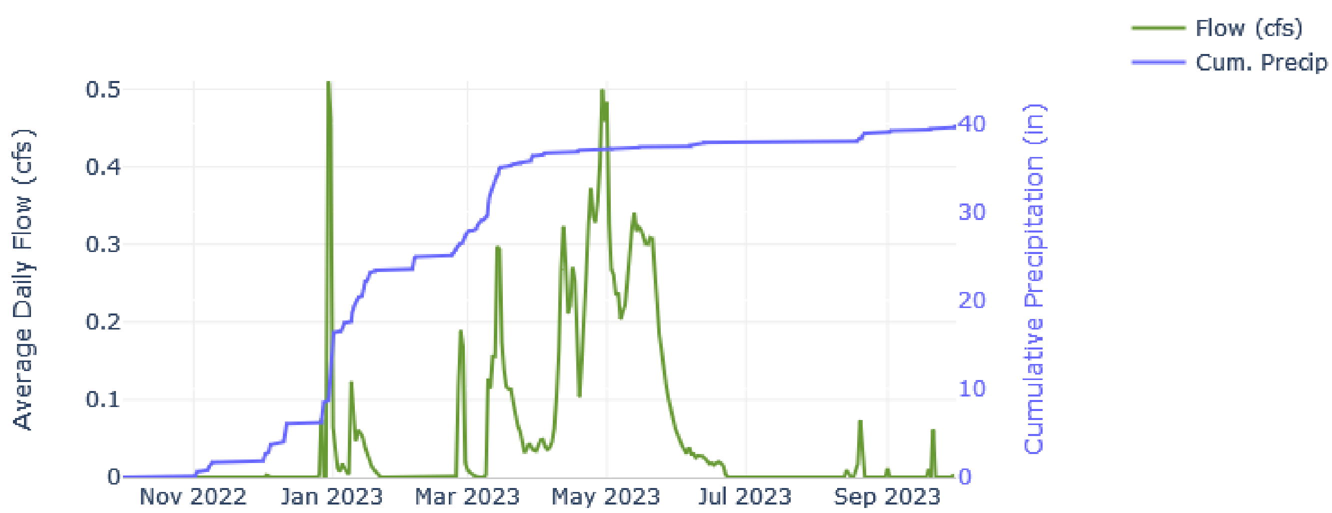

Figure 61 Average daily flow and cumulative precipitation at the Tahoma catchment outfall, WY23.

- 39.82 inches of total precipitation (27.84 inches in the fall/winter, 9.50 inches in the spring, 2.48 inches in the summer) were recorded at the El Dorado County Yard (EDCY) weather station.
- 53 precipitation events occurred (19 fall/winter events, 17 spring events, 17 summer events).
- The largest storm event produced 7.82 inches of precipitation and occurred during an atmospheric river rain on snow event December 29, 2022 – January 1, 2023.
- 73% of storms were less than half an inch.
- The largest runoff volume occurred during the non-event snowmelt from April 18, 2023 – May 1, 2023 (375,612 cf).
- The largest runoff volume that wasn't snowmelt occurred during the December 30-31, 2022 atmospheric river rain on snow event (82,964 cf).
- Highest average daily flows occurred on December 30, 2022 during the atmospheric river rain on snow event.
- 133 days of snowmelt occurred in the fall/winter, spring, and summer, resulting in 1,489,640 cf of runoff (89% of the total flow).
- The highest instantaneous peak precipitation was 0.08 inches in 5 minutes during an atmospheric river rain on snow event December 26, 2022.
- The highest instantaneous peak flow was 1.92 cfs on December 30, 2022 during the atmospheric river rain on snow event.

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

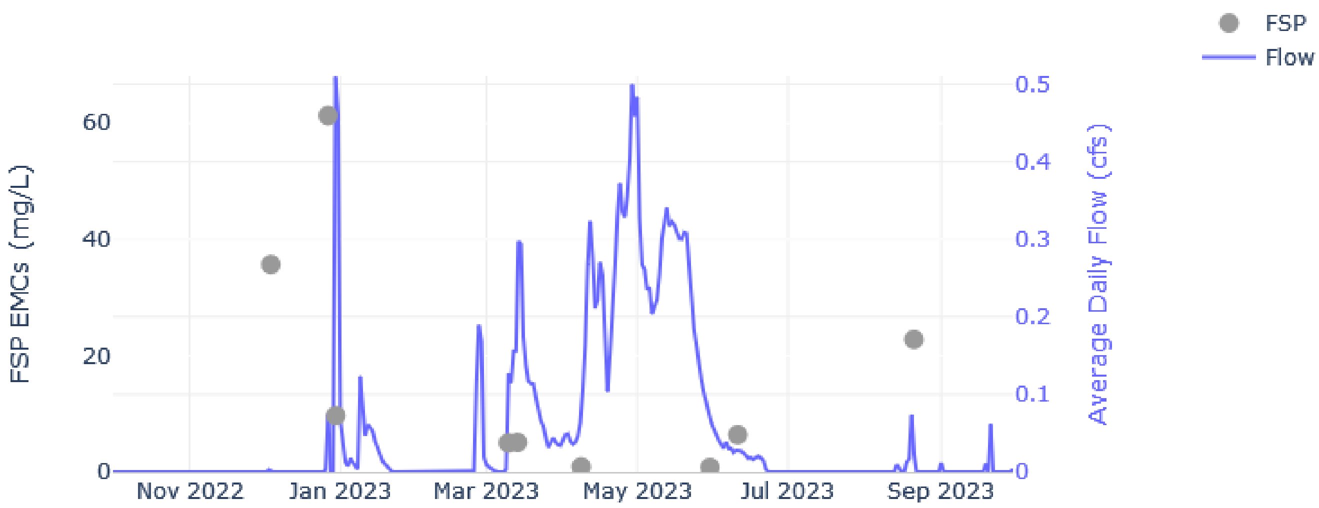

Figure 62 Daily flow and FSP EMC summary at the Tahoma catchment outfall, WY23.

- 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 atmospheric river rain on snow event December 26-27, 2022.
- The highest FSP load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest FSP EMC occurred during the non-event snowmelt May 30, 2023.
- The lowest FSP load occurred during the thunderstorm event June 10, 2023.

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

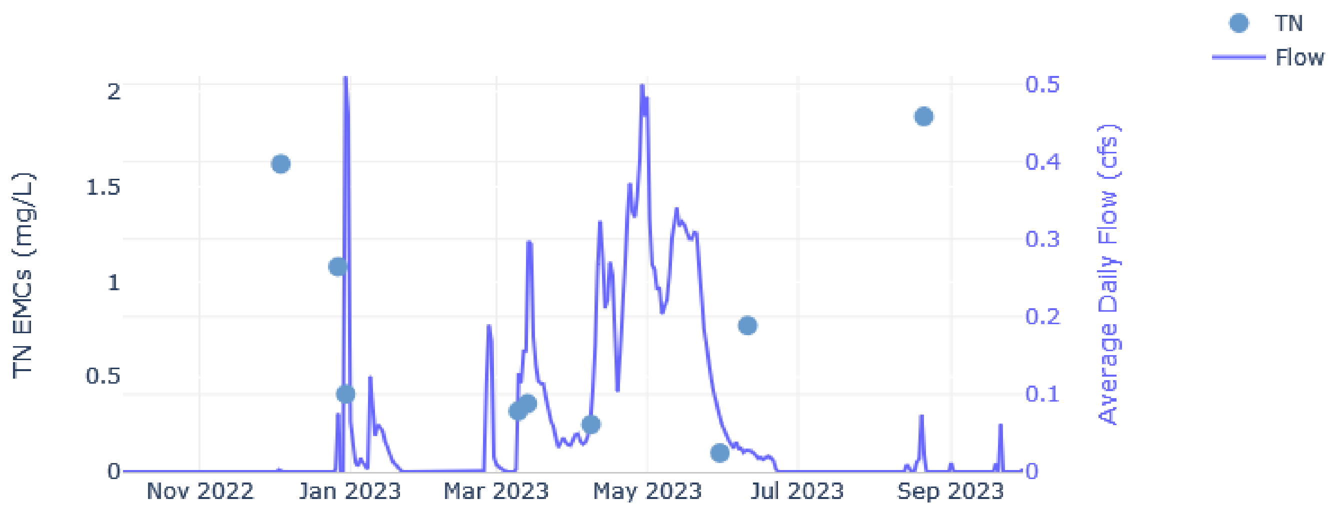

Figure 63 Daily flow and TN EMC summary at the Tahoma catchment outfall, WY23.

- 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 the rain event (Hurricane Hillary) August 20-21, 2023.
- The highest TN load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest TN EMC occurred during the non-event snowmelt May 30, 2023.
- The lowest TN load occurred during the thunderstorm event June 10, 2023.

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

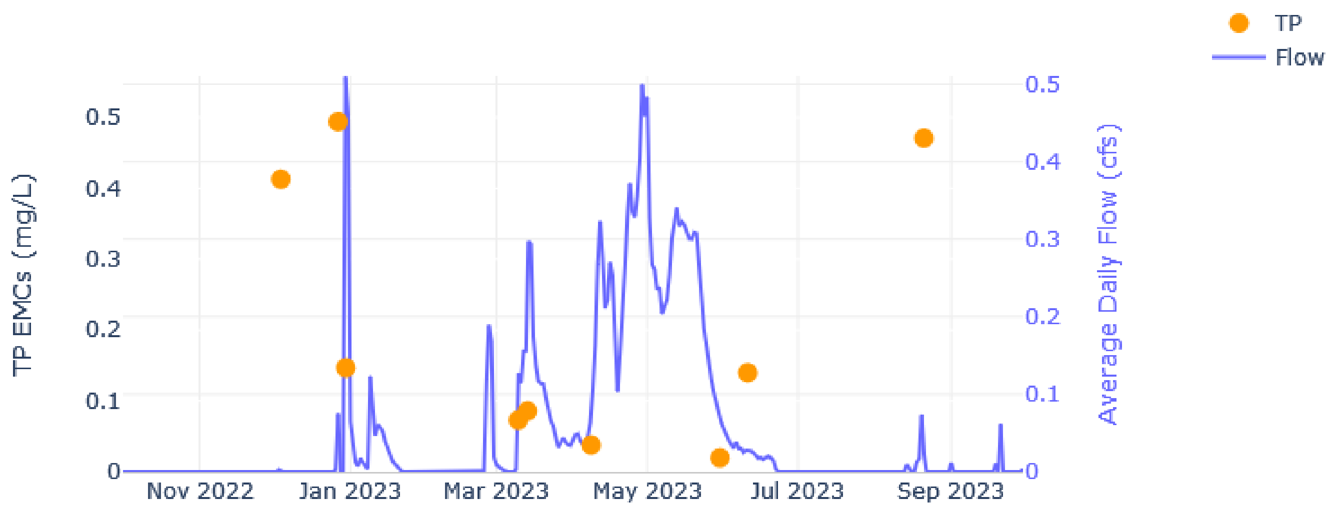

Figure 64 Daily flow and TP EMC summary at the Tahoma catchment outfall, WY23.

- 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 the atmospheric river rain on snow event December 26-27, 2022.
- The highest TP load occurred during the atmospheric river rain on snow event December 30-31, 2022.
- The lowest TP EMC occurred during the non-event snowmelt May 30, 2023.
- The lowest TP load occurred during the thunderstorm event June 10, 2023.

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

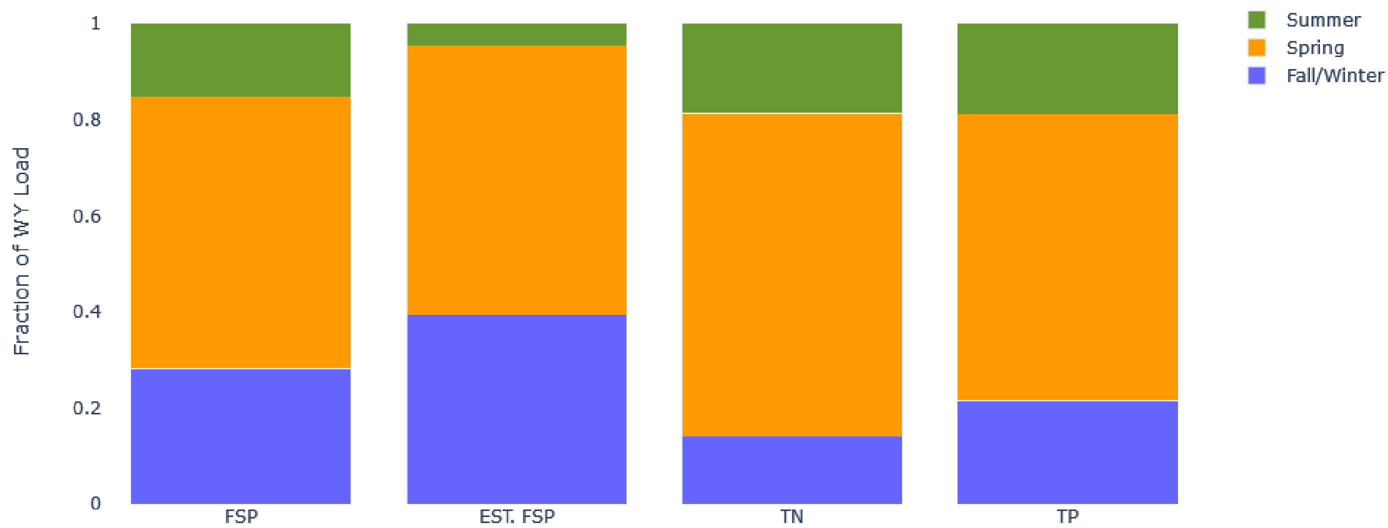

Figure 65 Seasonal load as a fraction of the water year load at the Tahoma catchment outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction of FSP loads (based on samples) was generated in the spring.
- The largest fraction of FSP loads (based on continuous turbidity) was generated in the spring.
- FSP loads calculated from sample concentrations are lab certified results and therefore reliable, however, not all runoff volume is sampled. Estimated FSP loads calculated from turbidity are less precise, but turbidity measurements are taken continuously on all runoff. This discrepancy accounts for the difference between FSP and estimated FSP results.
- The largest fraction of TN loads was generated in the spring.
- The largest fraction of TP loads was generated in the spring.

Nine events were sampled at Tahoma in WY23. Event summary data is presented in Table 14.

Table 14 Event summary data at the Tahoma catchment outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
TA	Fall/Winter	12/3/2022 19:40	12/4/2022 2:20	6:40	342	0.10	21	0.54	Rain on Snow	36	0.76	51.8	1,620	0.03	413	0.01
TA	Fall/Winter	12/26/2022 23:30	12/27/2022 20:45	21:15	6,812	0.35	1,886	2.33	Rain on Snow	61	26.05	44.4	1,080	0.46	494	0.21
TA	Fall/Winter	12/30/2022 2:30	12/31/2022 21:10	42:40	82,963	1.92	694	7.62	Rain on Snow	10	50.21	26.9	410	2.12	147	0.76
TA	Spring	3/9/2023 20:15	3/13/2023 9:00	84:45	38,851	0.26	96	4.49	Rain on Snow	5	12.12	27.9	320	0.78	73	0.18
TA	Spring	3/13/2023 9:00	3/15/2023 10:15	49:15	46,829	0.70	170	1.12	Rain on Snow	5	14.90	21.2	360	1.05	86	0.25
TA	Spring	4/8/2023 6:45	4/11/2023 8:05	73:20	33,103	0.24	344	0.00	Non-event Snowmelt	1	1.86	8.4	250	0.52	38	0.08
TA	Spring	5/30/2023 9:00	5/30/2023 22:50	13:50	5,735	0.07	171	0.00	Non-event Snowmelt	1	0.29	15.1	100	0.04	20	0.01
TA	Summer	6/10/2023 15:10	6/10/2023 20:00	4:50	716	0.08	237	0.10	Thunderstorm	6	0.29	22.1	770	0.03	140	0.01
TA	Summer	8/20/2023 21:10	8/21/2023 2:25	5:15	3,974	0.38	129	0.46	Rain	23	5.65	20.0	1,870	0.46	471	0.12

6.2.9 Upper Truckee

Figure 66 shows the average daily flow and cumulative precipitation for WY23 at the Upper Truckee catchment outfall.

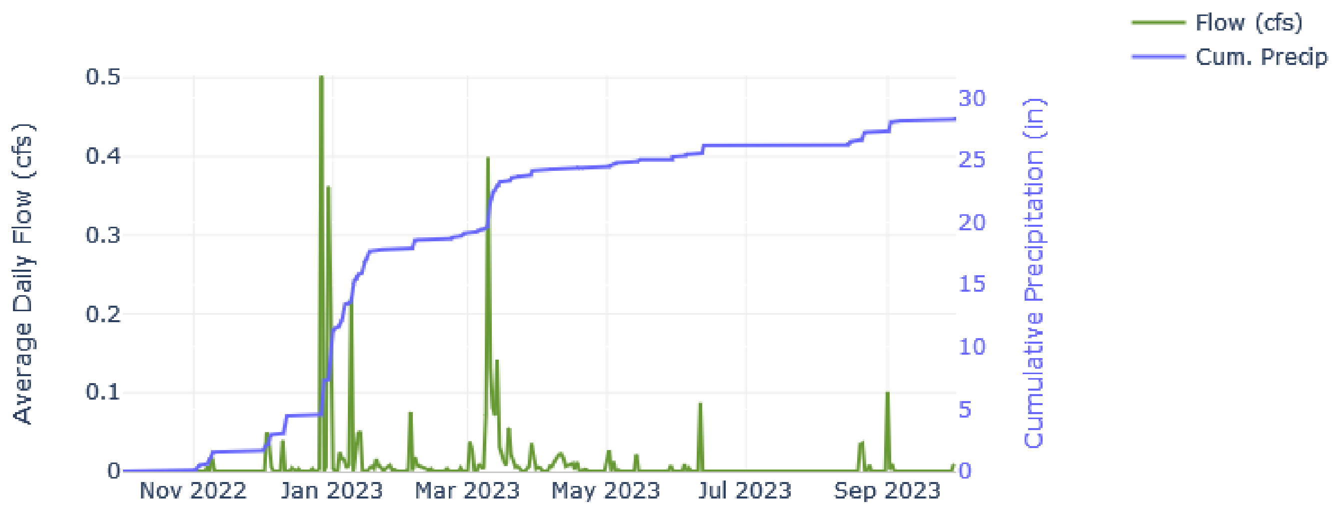

Figure 66 Average daily flow and cumulative precipitation at the Upper Truckee catchment outfall, WY23.

- 28.42 inches of total precipitation (19.12 inches in the fall/winter, 6.22 inches in the spring, 3.08 inches in the summer) were recorded at the Raph's Shop (RAPH) weather station.
- 60 precipitation events occurred (20 fall/winter events, 18 spring events, 22 summer events).
- The largest storm event produced 4.18 inches of precipitation and occurred during an atmospheric river rain on snow event from December 29, 2022 - January 1, 2023.
- 75% of storms were less than half an inch.
- The largest runoff volume occurred during an atmospheric river rain on snow event March 9-12, 2023 (59,149 cf).
- Highest average daily flows occurred on December 27, 2022 during the atmospheric river rain on snow event.
- 86 days of snowmelt occurred in the fall/winter and spring resulting in 83,824 cf of runoff (27% of the total flow).
- The highest instantaneous peak precipitation was 0.12 inches in 5 minutes on May 29, 2023 during a thunderstorm event.
- The highest instantaneous peak flow (2.57 cfs) occurred on March 10, 2023 during the atmospheric river rain on snow event.

Daily flow and the FSP EMC summary at Upper Truckee are presented in Figure 67. Table 15 presents EMC data in tabular form. Table 15 also presents the load data referenced in some bullet points below.

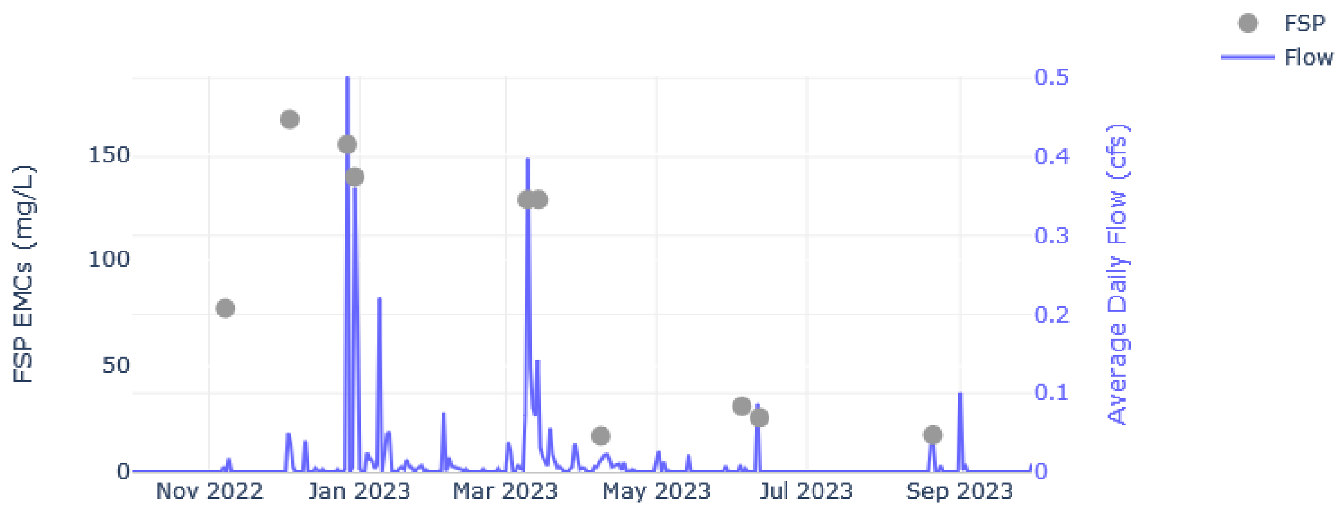

Figure 67 Daily flow and FSP EMC summary at the Upper Truckee catchment outfall, WY23.

- Ten events were sampled for FSP (four in the fall/winter, three in the spring, and three in the summer).
- The highest FSP EMC occurred during the rain on snow event December 3-4, 2022.
- The highest FSP load occurred during the rain on snow event March 9-12, 2023.
- The lowest FSP EMC occurred during the non-event snowmelt April 8-10, 2023.
- The lowest FSP load occurred during the thunderstorm event June 4, 2023.

Daily flow and the TN EMC summary at Upper Truckee are presented in Figure 68. Table 15 presents EMC data in tabular form. Table 15 also presents the load data referenced in some bullet points below.

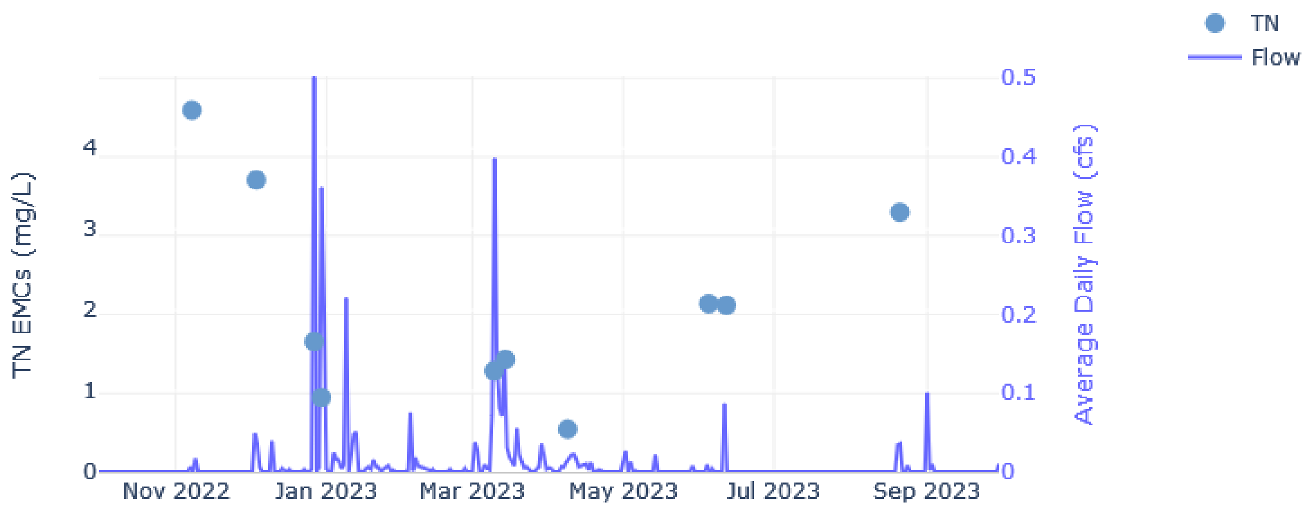

Figure 68 Daily flow and TN EMC summary at the Upper Truckee catchment outfall, WY23.

- Ten events were sampled for TN (four in the fall/winter, three in the spring, and three in the summer).
- The highest TN EMC occurred during an event snowmelt on November 7, 2022.
- The highest TN load occurred during an atmospheric river rain on snow event March 9-12, 2023.
- The lowest TN EMC occurred during a non-event snowmelt April 8-10, 2023.
- The lowest TN load occurred during a thunderstorm event on June 4, 2023.

Daily flow and the TP EMC summary at Upper Truckee are presented in Figure 69. Table 15 presents EMC data in tabular form. Table 15 also presents the load data referenced in some bullet points below.

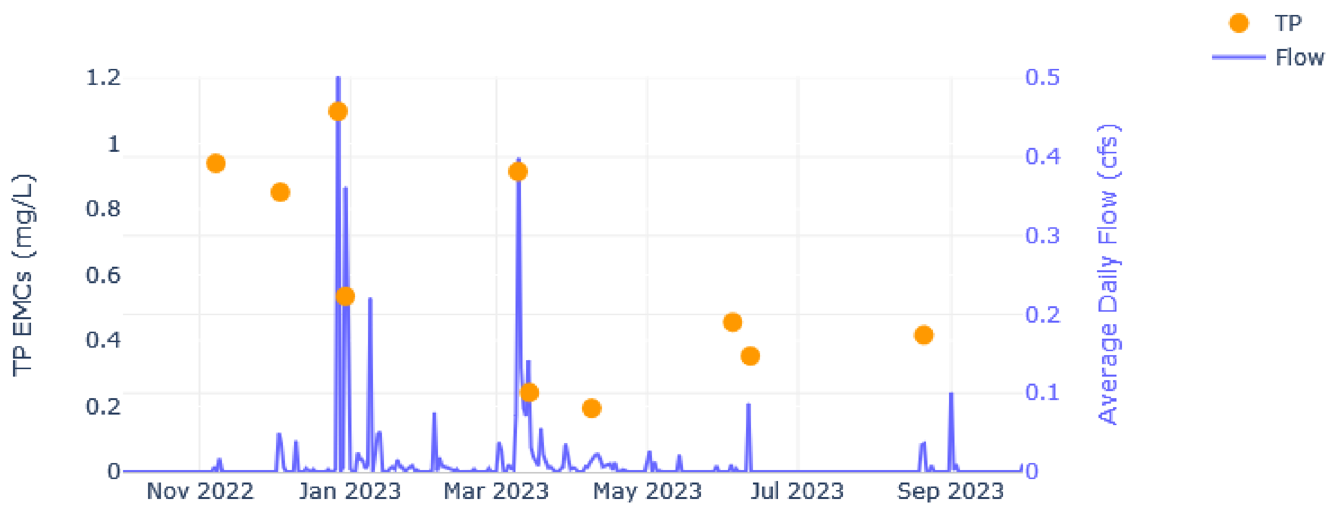

Figure 69 Daily flow and TP EMC summary at the Upper Truckee catchment outfall, WY23.

- Ten events were sampled for TP (four in the fall/winter, three in the spring, and three in the summer).
- The highest TP EMC occurred during an atmospheric river rain on snow event December 26-27, 2022.
- The highest TP load occurred during an atmospheric river rain on snow event March 9-12, 2023.
- The lowest TP EMC occurred during a non-event snowmelt April 8-10, 2023.
- The lowest TP load occurred during a thunderstorm event June 4, 2023.

Seasonal load as a fraction of the water year load at Upper Truckee is presented in Figure 70. Event loads are presented in tabular form in Table 15.

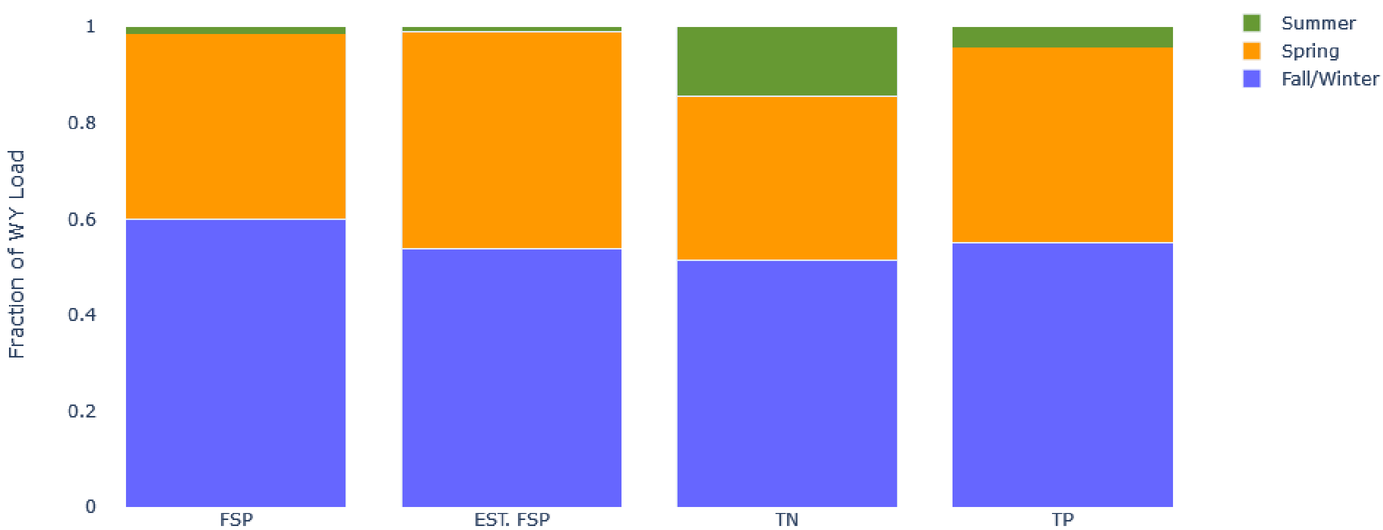

Figure 70 Seasonal load as a fraction of the water year load at the Upper Truckee catchment outfall, WY23. The first FSP column represents the FSP load calculated using event mean concentrations, while the second FSP column (EST. FSP) represents the FSP load estimated using continuous turbidity data.

- The largest fraction FSP load (based on samples) was generated in the fall/winter.
- The largest fraction of FSP load (based on 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.

Ten events were sampled at Upper Truckee in WY23. Event summary data is presented in Table 15.

Table 15 Event summary data at the Upper Truckee catchment outfall, WY23.

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	FSP EMC (mg/L)	FSP event load (lbs)	%FSP	TN EMC (ug/L)	TN event load (lbs)	TP EMC (ug/L)	TP event load (lbs)
UT	Fall/Winter	11/7/2022 14:00	11/7/2022 16:10	2:10	582	0.11	378	0.44	Event Snowmelt	77	2.80	34.6	4,470	0.16	940	0.03
UT	Fall/Winter	12/3/2022 14:45	12/4/2022 14:30	23:45	7,505	0.75	1,281	0.84	Rain on Snow	166	77.91	58.8	3,610	1.69	852	0.40
UT	Fall/Winter	12/26/2022 23:50	12/27/2022 18:55	19:05	43,740	2.08	749	2.77	Rain on Snow	155	421.87	53.3	1,610	4.39	1,098	3.00
UT	Fall/Winter	12/29/2022 22:35	12/31/2022 7:40	33:05	48,831	1.52	513	3.25	Rain on Snow	139	424.36	82.9	920	2.80	535	1.63
UT	Spring	3/9/2023 18:45	3/12/2023 21:55	75:10	59,149	2.57	892	3.09	Rain on Snow	129	474.18	58.4	1,250	4.61	915	3.38
UT	Spring	3/14/2023 7:50	3/15/2023 1:10	17:20	12,403	0.90	564	0.38	Rain on Snow	129	99.43	51.8	1,390	1.08	242	0.19
UT	Spring	4/8/2023 12:40	4/10/2023 19:50	55:10	4,446	0.07	278	0.00	Non-event Snowmelt	17	4.72	34.0	530	0.15	194	0.05
UT	Summer	6/4/2023 14:35	6/4/2023 15:55	1:20	801	0.74	176	0.12	Thunderstorm	31	1.55	29.1	2,080	0.10	456	0.02
UT	Summer	6/11/2023 17:25	6/11/2023 23:55	6:30	7,552	0.90	169	0.60	Thunderstorm	26	12.06	30.8	2,060	0.97	353	0.17
UT	Summer	8/20/2023 21:25	8/21/2023 6:35	9:10	5,801	0.45	446	0.52	Rain	18	6.33	33.6	3,210	1.16	417	0.15

7. BMP Effectiveness Monitoring

7.1 SR431

Data collected from matched inflow and outflow sampling at the Contech MFS stormwater treatment vault and at the Jellyfish stormwater treatment 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 WY23.

- On October 25, 2022, Tahoe RCD staff changed out all four turbidimeter sensors and cleared the four flumes and four stilling wells of all sediment,
- On November 11, 2022, NDOT maintenance crews rinsed and vactored the hydrodynamic separator, flow splitter, pipes between splitter and inflow flumes, the Contech MFS vault and all filters, and the Jellyfish vault and all tentacles.
- On August 15, 2023 the stilling wells were cleared of sediment.

On September 15, 2023 a truck hit the housing containing the data logger and tore off all sensor cords, rendering the site inoperable for the remainder of the water year. There was one rain event of 0.22 inches recorded at the nearest meteorological station (approximately 3 miles away) on September 30, 2023 which may have produced some runoff.

Table 16 presents the seasonal and annual summary data on load removal efficiency for each treatment vault at SR431 in WY23 based on samples taken during sampled events (FSP, TN, TP) and continuous turbidity (estimated FSP).

Table 16	Seasonal and annual efficiency data from the Contech MFS and Jellyfish vaults at SR431, WY23.

Water Year 2023 (October 1, 2022 - September 30, 2023)			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	42.0	250.2	24.5	316.8	63.4	17.0	18.4	98.7	0.35	0.83	0.67	1.85	0.32	1.28	0.17	1.77
	Contech Out	CO	25.0	121.6	20.9	167.5	40.5	58.5	5.8	104.8	0.31	0.52	0.53	1.37	0.22	0.78	0.15	1.15
		Load Reduction	17.0	128.6	3.6	149.2	22.9	-41.5	12.5	-6.1	0.04	0.31	0.13	0.49	0.10	0.50	0.03	0.62
		% Change	-40%	-51%	-15%	-47%	-36%	244%	-68%	6%	-12%	-38%	-20%	-26%	-30%	-39%	-15%	-35%
SR431	Jellyfish In	JI	47.9	302.0	27.8	377.7	55.6	34.9	13.0	103.5	0.47	1.00	0.75	2.22	0.40	1.67	0.22	2.30
	Jellyfish Out	JO	37.5	207.2	23.6	268.3	39.6	6.7	1.0	47.3	0.37	0.82	0.89	2.08	0.30	1.37	0.17	1.84
		Load Reduction	10.4	94.8	4.2	109.4	16.0	28.3	12.0	56.2	0.10	0.18	-0.14	0.14	0.10	0.30	0.05	0.45
		% Change	-22%	-31%	-15%	-29%	-29%	-81%	-92%	-54%	-21%	-18%	19%	-6%	-25%	-18%	-24%	-20%

- The Contech MFS reduced annual FSP loads by 47% and increased annual FSP loads by 6% based on samples and estimated from continuous turbidity respectively. The greatest FSP reduction efficiency occurred in the spring at 51% based on samples and in the summer at 68% estimated from continuous turbidity. The poorest FSP reduction efficiency occurred in the summer at 15% based on samples and in the spring at +244% estimated from continuous turbidity. The apparent discharge of sediment from the Contech MFS in the spring based on continuous turbidity is likely due to the turbidity sensor being covered in sediment. Due to the high volume of snow covering the access portals to the sensors in the spring of WY23, these sites could not be adequately maintained.
- The Contech MFS reduced annual TN by 26%. The greatest TN reduction efficiency occurred in the spring at 38% and the poorest TN reduction efficiency occurred in the fall/winter at 12%.
- The Contech MFS reduced annual TP loads by 35%. The greatest TP reduction efficiency occurred in the spring at 39% and the poorest TP reduction efficiency occurred in the summer at 15%.
- The Jellyfish reduced annual FSP loads by 29% and 54% based on samples and estimated from continuous turbidity respectively. The greatest FSP reduction efficiency occurred in the fall/winter at 31% based on samples and in the summer at 92% based on continuous turbidity. The poorest FSP reduction efficiency occurred in the summer at 15% based on samples and in the fall/winter at 29% based on continuous turbidity.
- The Jellyfish reduced annual TN loads by 6%. The greatest TN reduction efficiency occurred in the fall/winter at 21% and the poorest TN reduction efficiency occurred in the summer at +19%. The discharge of TN in the summer was likely due to poor maintenance.
- The Jellyfish reduced annual TP loads by 20%. The greatest TP reduction efficiency occurred in the fall/winter at 25% and the poorest TP reduction efficiency occurred in the spring at 18%.
- The Contech MFS was moderately better than the Jellyfish in its ability to reduce pollutants WY23, averaging around 35% and 27% efficiency respectively overall. This is poorer than in years past, but snow loads made access and maintenance impossible during the majority of the fall/winter and spring seasons.

Table 17 presents the efficiency of the Contech MFS at reducing concentrations and loads of all three pollutants for the individual events sampled in WY23.

Table 17 Event efficiency data from the Contech MFS vault at SR431, WY23.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			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
12/3/2022	1.4%	175	114	-35%	3	1	-68%	1,580	1,700	8%	0.03	0.02	-47%	1,036	871	-16%	0.02	0.01	-59%
12/27/2022	6.9%	133	90	-32%	12	6	-48%	1,260	1,720	37%	0.12	0.12	5%	1,066	939	-12%	0.10	0.07	-32%
12/30/2022	23.5%	82	71	-14%	26	17	-32%	640	700	9%	0.20	0.17	-14%	618	592	-4%	0.19	0.15	-25%
3/10/2023	1.0%	411	317	-23%	5	2	-53%	1,790	1,700	-5%	0.02	0.01	-42%	552	2,186	296%	0.01	0.02	140%
3/13/2023	1.9%	626	419	-33%	16	6	-60%	2,110	1,760	-17%	0.06	0.03	-51%	3,412	2,535	-26%	0.09	0.04	-56%
4/10/2023	1.2%	612	435	-29%	68	38	-44%	1,820	1,680	-8%	0.20	0.15	-28%	3,265	2,786	-15%	0.36	0.24	-33%
5/31/2023	6.5%	248	119	-52%	3	1	-66%	2,200	1,970	-10%	0.03	0.02	-38%	1,199	827	-31%	0.02	0.01	-52%
6/10/2023	0.7%	152	153	0%	8	6	-21%	2,050	2,520	23%	0.11	0.10	-3%	884	947	7%	0.05	0.04	-16%
8/19/2023	3.9%	4	9	146%	0.1	0.1	-15%	2,400	3,300	38%	0.05	0.02	-52%	168	218	30%	<0.1	<0.1	-55%
8/20/2023	1.4%	3	3	6%	0.3	0.2	-34%	830	750	-10%	0.07	0.04	-43%	98	95	-3%	0.01	0.01	-39%

- The majority of events show a reduction in both concentration and load for all pollutants. However, efficiencies were generally lower in WY23 compared to years past. (FSP loads and concentrations were based on samples.)
- FSP concentrations were higher at the outflow than the inflow in the summer months, however, loads were still reduced because of the very small flow volumes.
- TN concentrations were higher at the outflow than the inflow in December and two of three summer events, however, TN loads were only increased during the December 27, 2022 event.
- TP concentrations were higher at the outflow than the inflow during the March 10, 2023, June 10, 2023, and August 19, 2023 events, however loads only increased during the March 10, 2023 event.

Contech MFS vault water level and bypass flow are presented in Figure 71. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Contech MFS vault, resulting in reduced overall treatment efficiency.

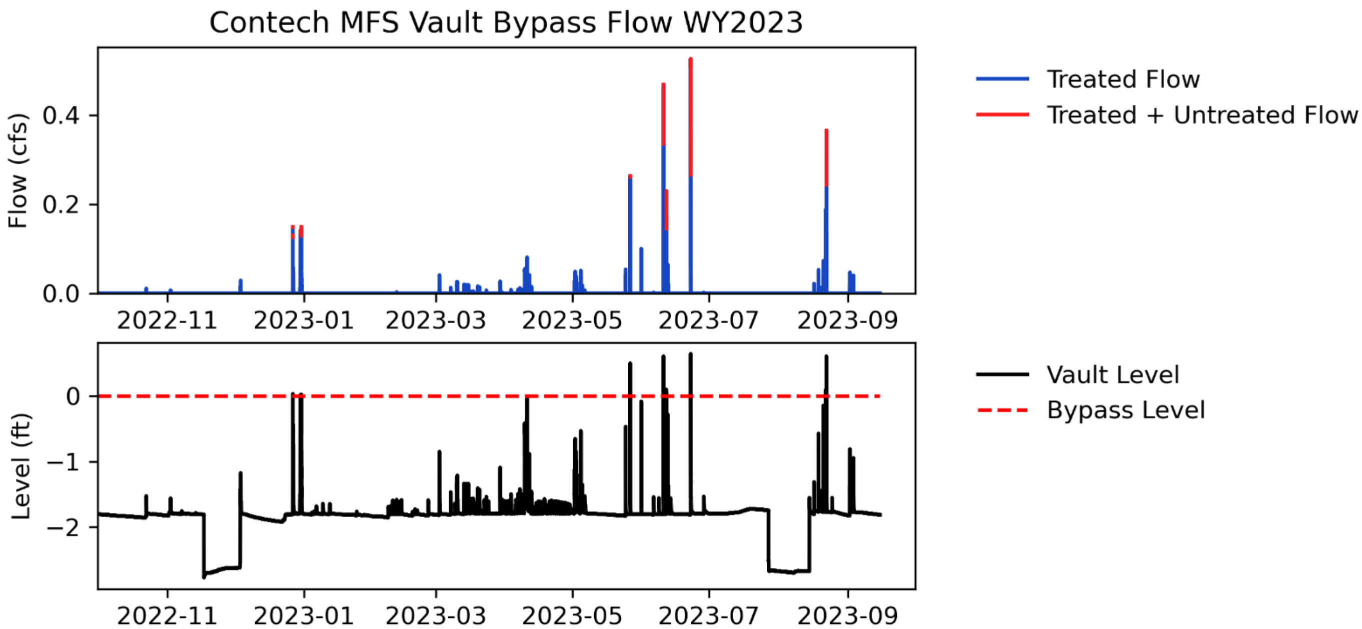

Figure 71 Contech MFS vault level at SR431, WY23 (bottom). Contech MFS outflow shown at top for reference. Vault level greater than 0 indicates bypass flow. The Contech MFS vault bypassed one time in WY23.

- During periods of flow, the Contech MFS filter was in bypass mode 1.38% of the time in WY23 which represents up to 12% of the flow volume (2,489 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 7 runoff events:
    - December 27, 2022 during a sampled atmospheric river rain on snow event that produced 2.05 inches of precipitation.
    - December 30, 2022 during a sampled atmospheric river rain on snow event that produced 4.31 inches of precipitation.
    - May 26, 2023 during a thunderstorm event that produced 0.42 inches of precipitation.
    - June 10, 2023 during a sampled thunderstorm event that produced 0.41 inches of precipitation.
    - June 11, 2023 during a sampled thunderstorm event that produced 0.63 inches of precipitation.
    - June 22, 2023 during a thunderstorm event that produced 0.575 inches of precipitation.
    - August 22, 2023 during the sampled Hurricane Hillary rain event that produced 0.548 inches of precipitation.
- It is possible bypass occurred September 15-30, 2023, but data is not available for this time period because of the car accident.

Table 18 presents the efficiency of the Jellyfish at reducing concentrations and loads of all three pollutants for the individual events sampled in WY23.

Table 18 Event efficiency data from the Jellyfish vault at SR431, WY23.

Event Start Date	Event Volume as a % of Total Annual Volume (cf)	FSP Concentration (mg/L)			FSP Load (lbs)			TN Concentration (ug/L)			TN Load (lbs)			TP Concentration (ug/L)			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
12/3/2022	1.2%	177	142	-19%	3	2	-53%	1,410	1,500	6%	0.03	0.02	-38%	1,145	941	-18%	0.02	0.01	-52%
12/27/2022	7.2%	135	121	-10%	15	12	-16%	1,460	1,110	-24%	0.16	0.11	-29%	1,320	1,123	-15%	0.14	0.11	-20%
12/30/2022	22.9%	81	75	-6%	28	23	-18%	750	760	1%	0.26	0.23	-11%	637	561	-12%	0.22	0.17	-23%
3/10/2023	1.1%	509	264	-48%	9	4	-50%	1,880	1,140	-39%	0.03	0.02	-42%	2,967	1,906	-36%	0.05	0.03	-38%
3/13/2023	2.4%	606	363	-40%	22	11	-49%	1,930	1,530	-21%	0.07	0.05	-33%	3,641	2,224	-39%	0.13	0.07	-48%
4/10/2023	8.2%	612	497	-19%	76	60	-20%	1,820	1,820	0%	0.23	0.22	-2%	3,265	3,303	1%	0.40	0.40	-1%
5/31/2023	0.9%	291	80	-73%	4	1	-75%	2,940	1,530	-48%	0.04	0.02	-53%	1,742	675	-61%	0.02	0.01	-65%
6/10/2023	3.8%	135	150	11%	8	7	-7%	2,280	3,410	50%	0.13	0.17	26%	947	890	-6%	0.05	0.04	-21%
8/19/2023	0.9%	6	17	188%	0.1	0.2	129%	2,510	4,440	77%	0.03	0.05	41%	183	300	64%	<0.1	<0.1	30%
8/20/2023	0.7%	2	2	-13%	0.2	0.1	-18%	750	1,120	49%	0.05	0.07	41%	101	114	13%	0.01	0.01	6%

- The majority of events show a reduction in both concentration and load for all pollutants. However, efficiencies were generally lower in WY23 compared to years past. (FSP loads and concentrations were based on samples.)
- FSP concentrations were higher at the outflow than the inflow during the June 10, 2023 and August 19, 2023 events, however, only the August 19, 2023 event showed an increase in FSP load.
- TN concentrations were higher at the outflow than the inflow for two of three events in December and all summer events, however, TN loads were only increased during the summer events.
- TP concentrations were higher at the outflow than the inflow during the April 10, 2023 event and both August events, however TP load were only increased during the August events.

Jellyfish vault water level and bypass flow are presented in Figure 72. When bypass occurs, untreated flow comingles with treated flow in the outflow from the Jellyfish vault, resulting in reduced overall treatment efficiency.

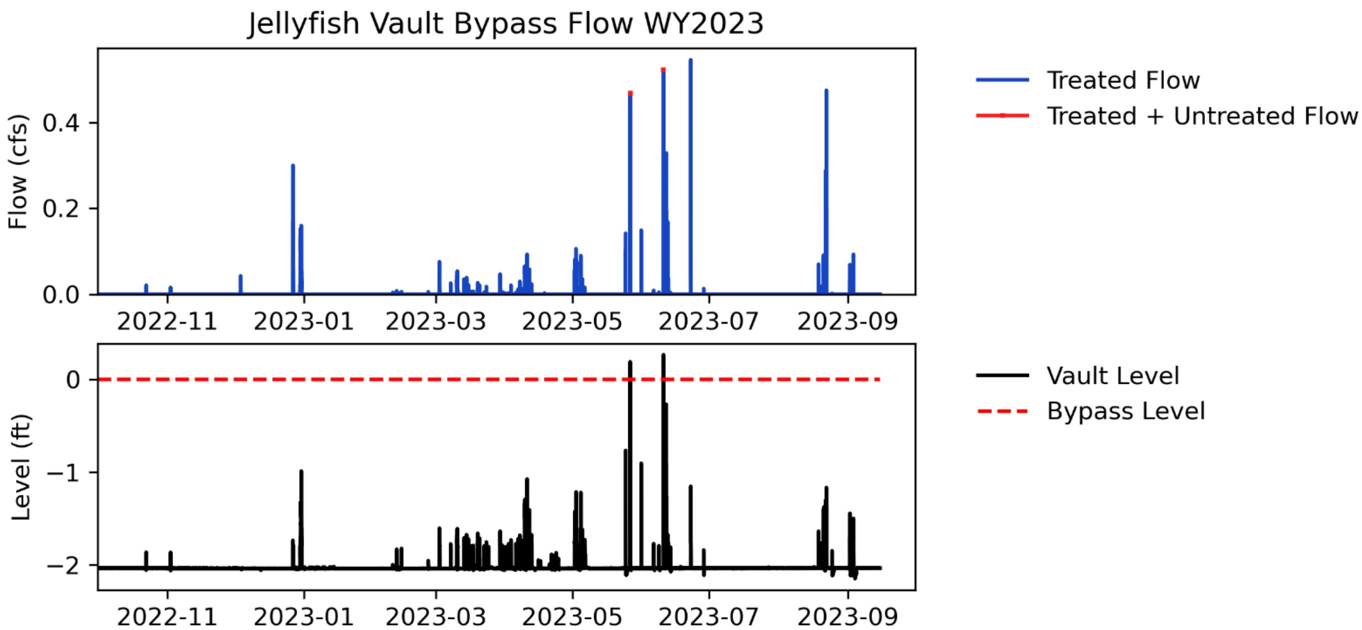

Figure 72 Jellyfish vault level at SR431, WY23 (bottom). Jellyfish outflow shown at the top for reference. Vault level greater than 0 indicates bypass flow. The Jellyfish vault bypassed zero times in WY23.

- During periods of flow, the Jellyfish filter was in bypass mode 0.065% of the time in WY23 which represents up to 1.29% of the flow volume (311 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. Both events were brief (only 5 minutes of bypass):
  - May 26, 2023 during a thunderstorm event produced from 0.42 inches of precipitation.
  - June 10, 2023 during a sampled thunderstorm event produced from 0.41 inches of precipitation.
- It is possible bypass occurred September 15-30, 2023, but data is not available for this time period because of the car accident.

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, WY20, WY21, WY22, and WY23 represent post-paving conditions. Prior to repaving (WY18), Elk's Club Drive was in poor condition, covered in cracks and potholes (Figure 73 - PCI*: 29). In August 2018 (just prior to WY19) it was repaved to excellent condition (Figure 74 - PCI*: 99). Three years later, in October 2021, the average PCI was still excellent (Figure 75 – PCI*: 89).

Figure 73 Elks Club Drive prior to repaving. (R Wigart)

Figure 74 Elks Club Drive after repaving. (A Buxton)

Figure 75 Elks Club Drive three years later. (C Moore)

* 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.

Samples from all water years are analyzed for the same analytes as all other stormwater samples in accordance with RSWMP protocols. In addition to sediment and nutrients, Elks Club runoff samples from 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.

Table 19 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) after pavement condition improvement.

Table 19 Results of Elks Club source apportionment analysis. P-values* less than 0.001 indicate highly significant results (highlighted in green). P-values less than 0.05 indicate significant results (highlighted in yellow).

		Source Apportionment Analysis					Sediment Concentrations and Loads			
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 76 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 of 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 19 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).

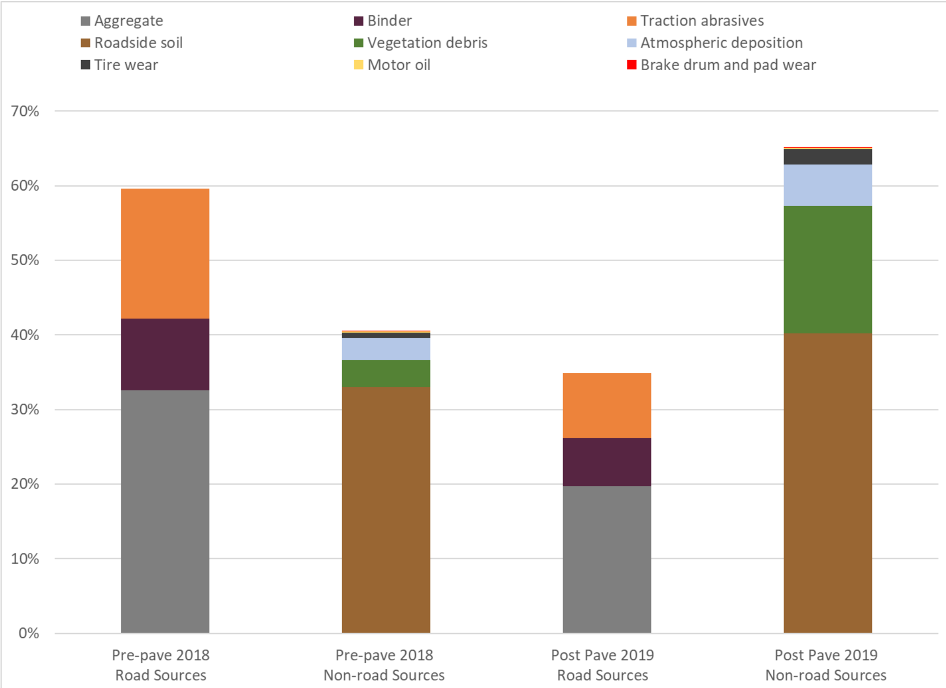

Figure 76 Average annual FSP load attributable to road and non-road sources at Elks Club, WY18 and WY19. 60% and 35% of the FSP in stormwater runoff from Elks Club Drive originated from road sources (asphalt aggregate, asphalt binder, and traction abrasives) in the pre- and post-pave conditions respectively.

Table 20 shows the substantial impact that improving pavement condition on Elk's Club Drive has on water quality in terms of reduced sediment concentrations and loads since repaving. 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. (Normalized load values account for catchment size and remove year to year variability in precipitation frequency, size, intensity, and duration.) 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 when compared to the pre-restoration condition of WY18. WY20 was a very dry year which may have contributed to higher concentrations but lower loads as compared to the previous post restoration data of WY19. WY21 was an extremely dry year, and TSS and FSP concentrations were reduced by 46% and 33% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 89% and 67% respectively when compared to the pre-paving condition of WY18. WY22 was a wet year and TSS and FSP concentrations were reduced by 63% and 79% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 90% and 89% respectively when compared to the pre-paving condition of WY18. WY23 was a very wet year and TSS and FSP concentrations were reduced by 47% and 54% respectively, which resulted in mean annual normalized TSS and FSP load reductions of 73% and 67% when compared to the pre-paving condition of WY18. All post-paving years show a substantial improvement over the pre-paving condition of WY18 with regards to concentration and load reductions for all pollutants.

Table 20 Mean annual sediment and nutrient concentrations and normalized load reductions for WY19, WY20, WY21, WY22 and WY23 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)	TN concen-tration (mg/L)	Normalized TN load (lbs/acre/in)	TP concen-tration (mg/L)	Normalized TP load (lbs/acre/in)
Pre Paving 2018	84	6.3	33	1.5	0.72	0.03	0.26	0.01
Post Paving 2019	23	0.6	7	0.1	0.42	0.01	0.09	0.00
Post Paving 2020	49	0.3	16	0.1	0.55	0.00	0.23	0.00
Post Paving 2021	46	0.7	22	0.6	0.52	0.00	0.17	0.00
Post Paving 2022	31	0.6	7	0.2	0.52	0.00	0.16	0.00
Post Paving 2023	44	1.7	15	0.5	0.39	0.00	0.19	0.00
2019 % Reduction	**73%**	**90%**	**79%**	**93%**	**42%**	**65%**	**67%**	**77%**
2020 % Reduction	**41%**	**95%**	**50%**	**93%**	**24%**	**100%**	**12%**	**100%**
2021 % Reduction	**46%**	**89%**	**33%**	**60%**	**28%**	**100%**	**34%**	**100%**
2022 % Reduction	**63%**	**90%**	**79%**	**87%**	**28%**	**100%**	**38%**	**100%**
2023 % Reduction	**47%**	**73%**	**54%**	**67%**	**46%**	**100%**	**28%**	**100%**

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. 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 reduction in pollutant loading to the lake.

Trend analyses are only performed on monitoring sites with at least five years of continuous data. WY23 marked the tenth year of monitoring at SR431, Pasadena, and Tahoma, the ninth year of monitoring at Speedboat, Tahoe Valley, and Upper Truckee, the seventh year of monitoring at Lakeshore, the sixth year of monitoring at Elks Club, and the fourth year for Tahoe City. 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. Tahoe City has four years of monitoring data; therefore, trends analyses were not performed on the data from this site. It is included in this section for annual sediment and nutrient load comparisons to annual precipitation only.

8.1 SR431 Contech MFS Inflow

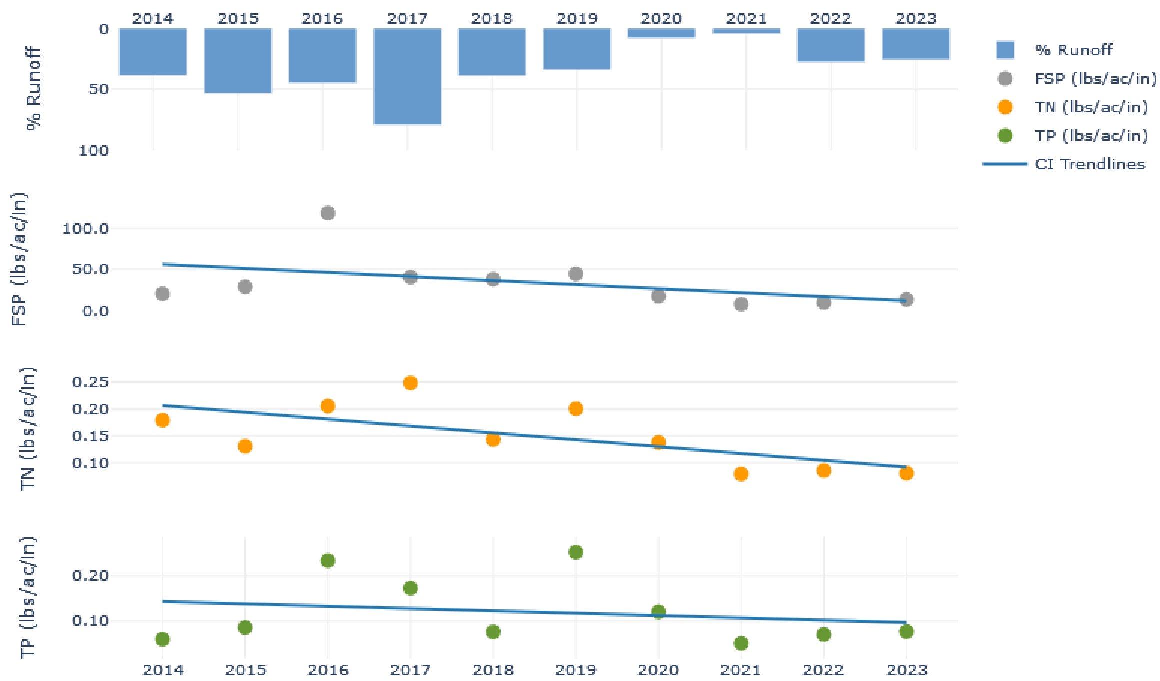

Figure 77 10-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Contech MFS Inflow, WY14-23.

- Percent runoff varied between 4.4% in WY21 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 (p>0.05). However, there is a significant decreasing trend in the normalized fall/winter FSP load (p=0.025 and Tau= -0.556.)
- There is no significant trend in normalized annual TN loads (p>0.05). However, there is a significant decreasing trend in the normalized fall/winter TN load (p=0.040 and Tau= -0.511.)
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 21 10-year seasonal and annual rainfall normalized pollutant loads at the Contech MFS Inflow, WY14-23.

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
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
2021	4.4%	2.493	22.475	23.756	8.003	0.010	0.130	0.671	0.079	0.016	0.132	0.185	0.051
2022	27.7%	3.203	44.055	10.439	10.133	0.050	0.191	0.184	0.085	0.030	0.267	0.076	0.070
2023	25.7%	2.939	45.010	7.690	13.743	0.025	0.150	0.209	0.080	0.022	0.230	0.054	0.077
Tau	na	-0.556	-0.156	0.067	-0.378	-0.511	-0.200	0.200	-0.467	-0.333	0.156	0.244	-0.111
P-Value	na	0.025	0.531	0.788	0.128	0.040	0.421	0.421	0.060	0.180	0.531	0.325	0.655
Theil Slope (per year)	na	-3.346	-2.760	0.095	-2.713	-0.018	-0.009	0.027	-0.013	-0.008	0.012	0.008	-0.001

Figure 78 through Figure 85 show sediment and nutrient loads for the Contech MFS compared to total annual precipitation for WY14 through WY23. This illustrates how loading and precipitation have varied over the monitored period.

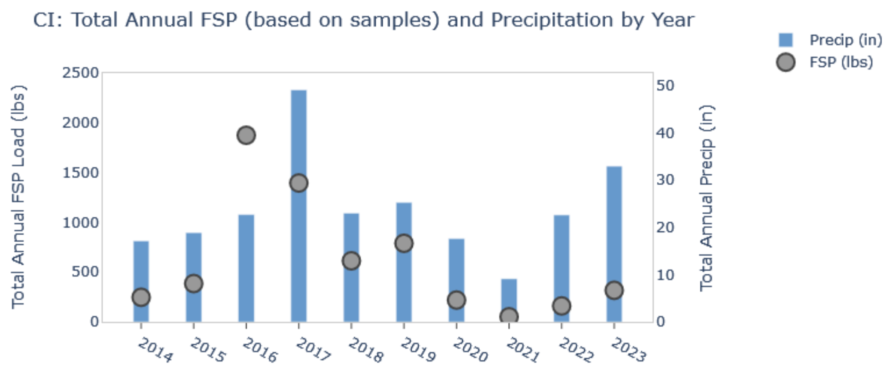

Figure 78 Total annual FSP load (based on samples) and precipitation by year for Contech MFS Inflow WY14-WY23.

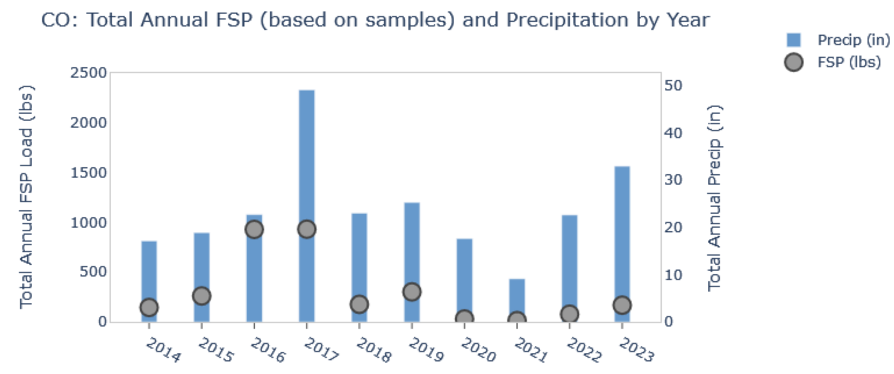

Figure 79 Total annual FSP load (based on samples) and precipitation by year for Contech MFS Outflow WY14-WY23.

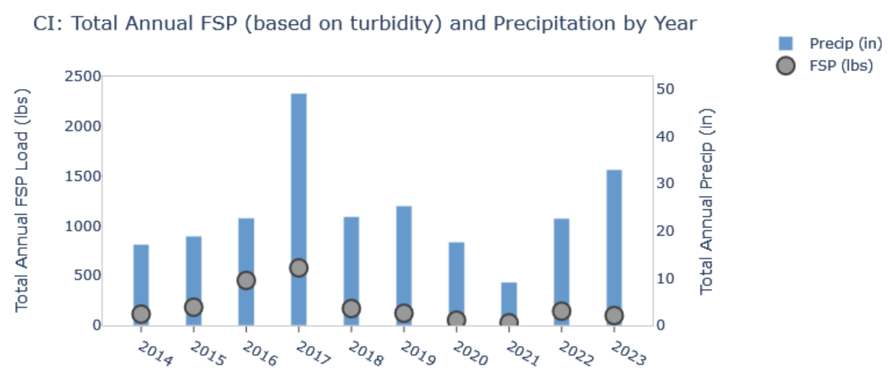

Figure 80 Total annual FSP load (based on continuous turbidity) and precipitation by year for Contech MFS Inflow WY14-WY23.

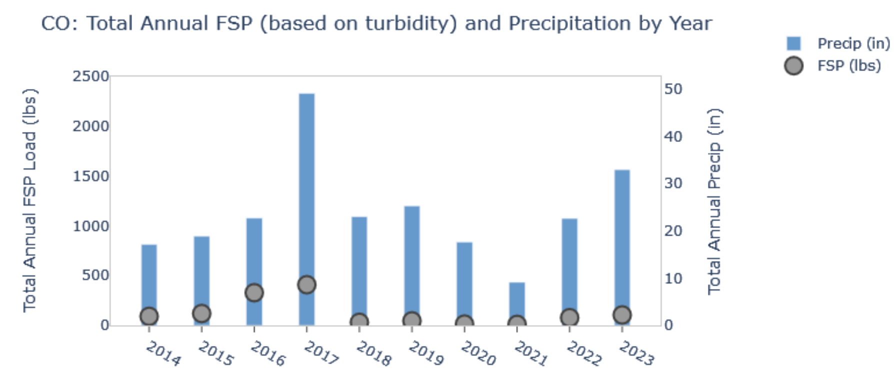

Figure 81 Total annual FSP load (based on continuous turbidity) and precipitation by year for Contech MFS Outflow WY14-WY23.

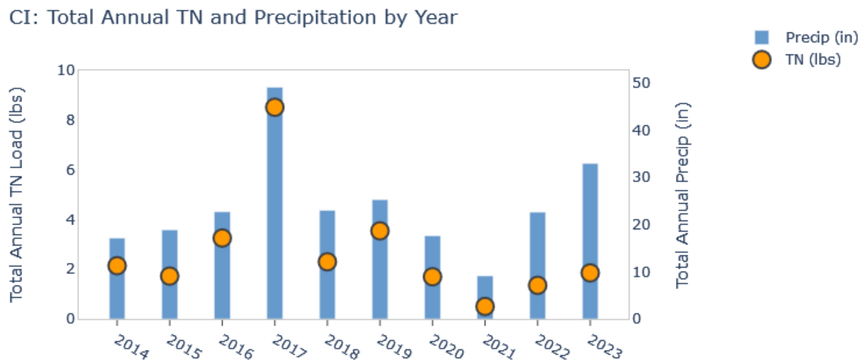

Figure 82 Total annual TN load and precipitation by year for Contech MFS Inflow WY14-WY23.

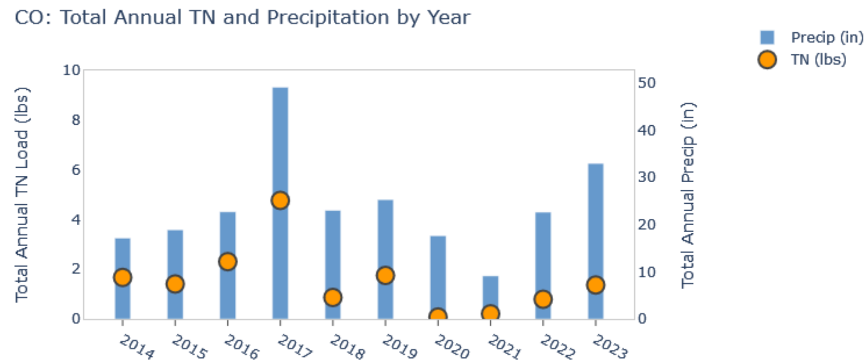

Figure 83 Total annual TN load and precipitation by year for Contech MFS Outflow WY14-WY23.

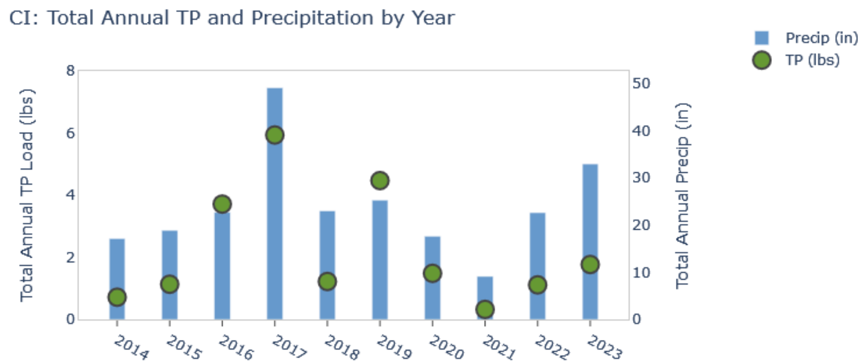

Figure 84 Total annual TP load and precipitation by year for Contech MFS Inflow WY14-WY23.

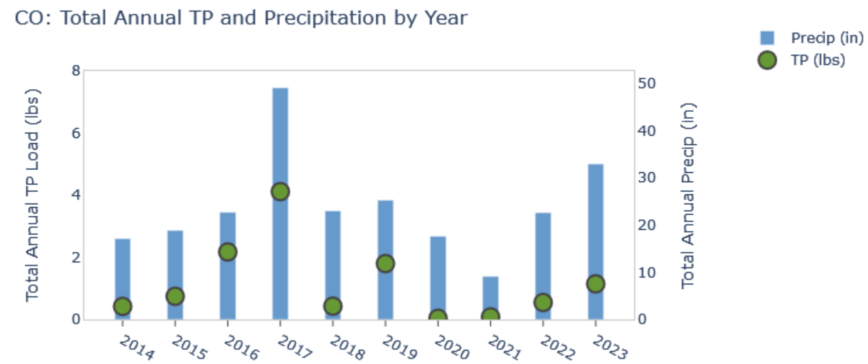

Figure 85 Total annual TP load and precipitation by year for Contech MFS Outflow WY14-WY23.

8.2 SR431 Jellyfish Inflow

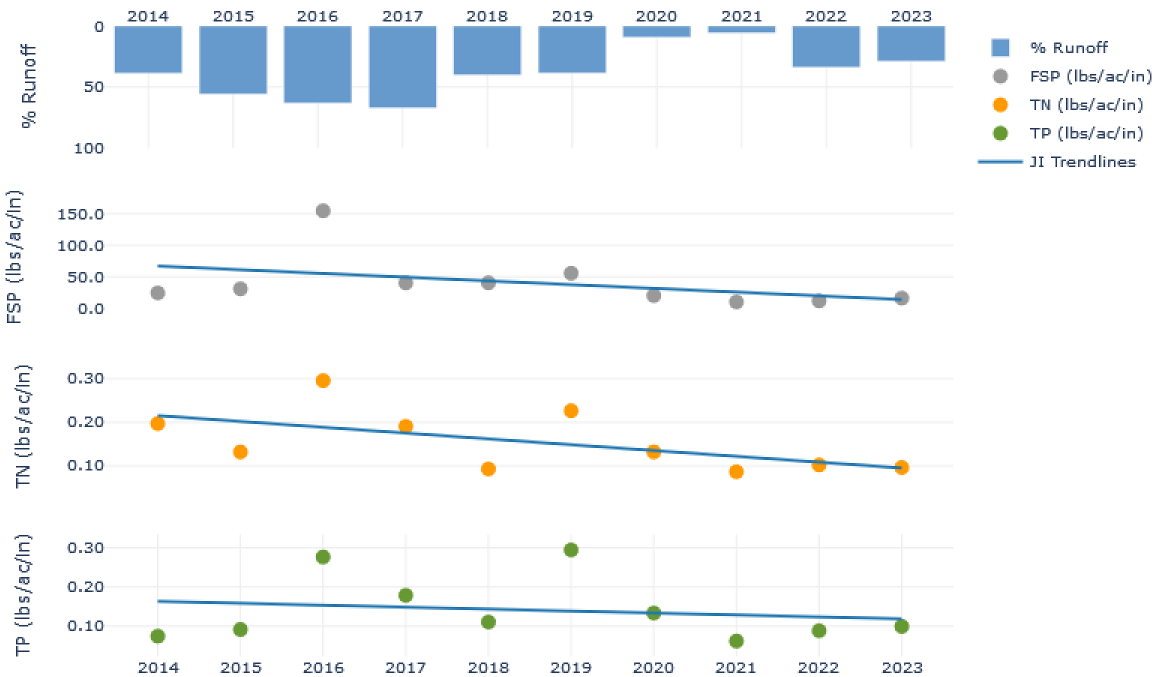

Figure 86 10-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Jellyfish Inflow, WY14-23.

- Percent runoff varied between 5.7% in WY21 to 67.2% 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 (p>0.05). However, there is a significant decreasing trend in the normalized fall/winter FSP load (p=0.009 and Tau= -0.644.)
- There is no significant trend in normalized annual TN loads (p>0.05). However, there is a significant decreasing trend in the normalized fall/winter TN load (p=0.025 and Tau= -0.556.)
- There is no significant trend in normalized annual TP loads (p>0.05). However, there is a significant decreasing trend in the normalized fall/winter TP load (p=0.040 and Tau= -0.511.)

Table 22 10-year seasonal and annual rainfall normalized pollutant loads at the Jellyfish Inflow, WY14-23.

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
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
2021	5.7%	2.562	32.779	26.575	10.351	0.011	0.166	0.672	0.087	0.016	0.183	0.197	0.062
2022	33.7%	3.405	54.860	11.002	11.978	0.060	0.253	0.189	0.102	0.039	0.331	0.094	0.089
2023	28.8%	3.350	54.324	8.714	16.387	0.033	0.181	0.235	0.096	0.028	0.300	0.069	0.100
Tau	na	-0.644	-0.200	0.067	-0.333	-0.556	-0.111	0.244	-0.422	-0.511	0.200	0.289	-0.067
P-Value	na	0.009	0.421	0.788	0.180	0.025	0.655	0.325	0.089	0.040	0.421	0.245	0.788
Theil Slope (per year)	na	-3.457	-1.315	0.290	-2.723	-0.010	-0.006	0.034	-0.012	-0.008	0.012	0.010	-0.002

Figure 87 through Figure 94 show sediment and nutrient loads for the Jellyfish compared to total annual precipitation for WY14 through WY23. This illustrates how loading and precipitation have varied over the monitored period.

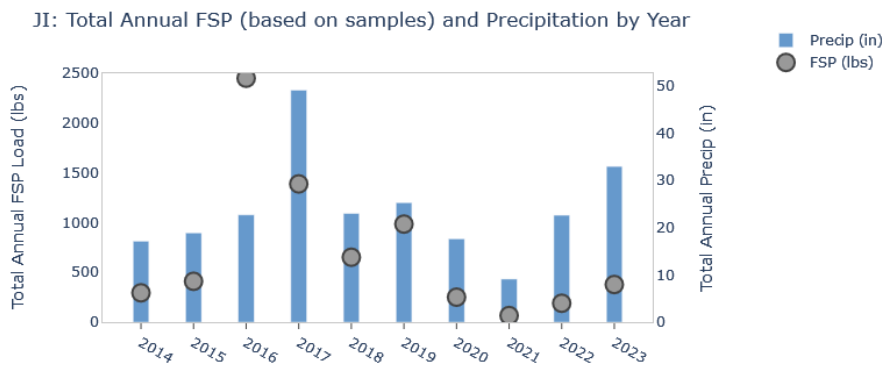

Figure 87 Total annual FSP load (based on samples) and precipitation by year for Jellyfish Inflow WY14-WY23.

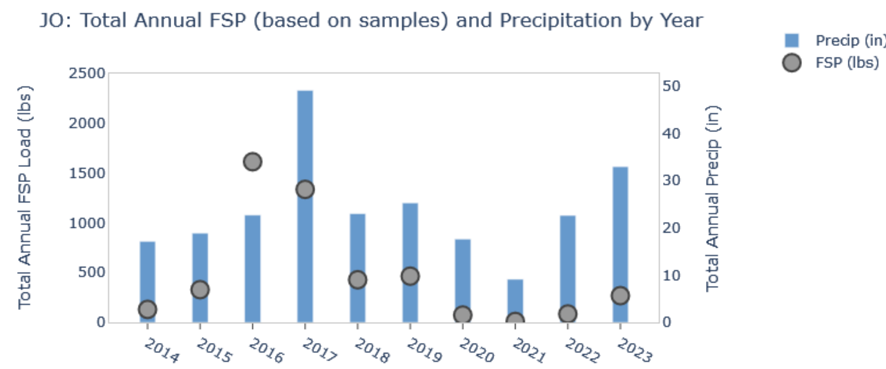

Figure 88 Total annual FSP load (based on samples) and precipitation by year for Jellyfish Outflow WY14-WY23.

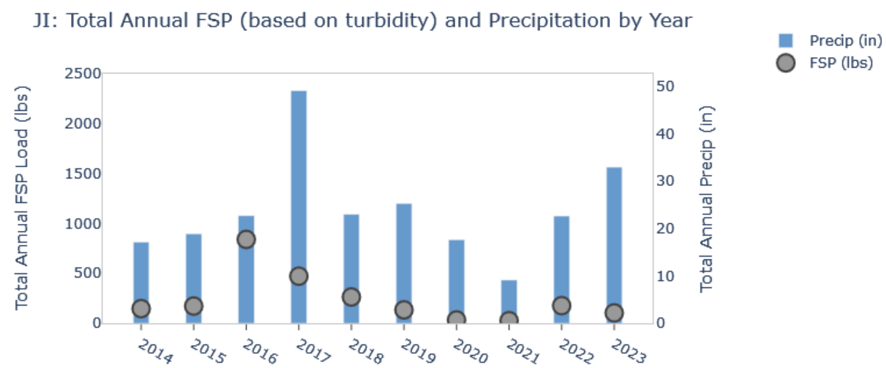

Figure 89 Total annual FSP load (based on continuous turbidity) and precipitation by year for Jellyfish Inflow WY14-WY23.

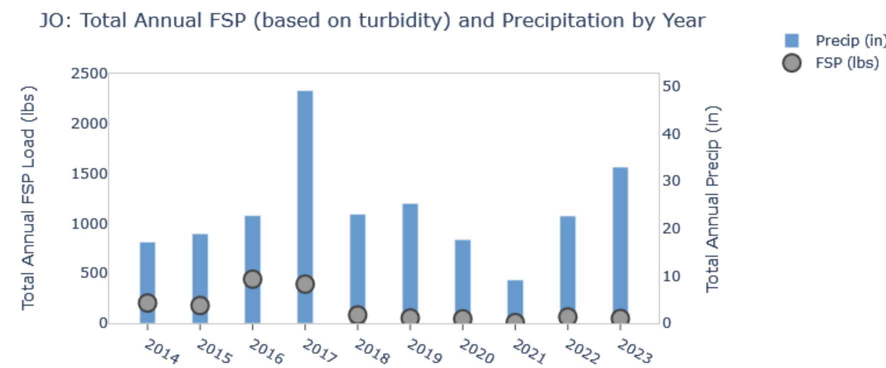

Figure 90 Total annual FSP load (based on continuous turbidity) and precipitation by year for Jellyfish Outflow WY14-WY23.

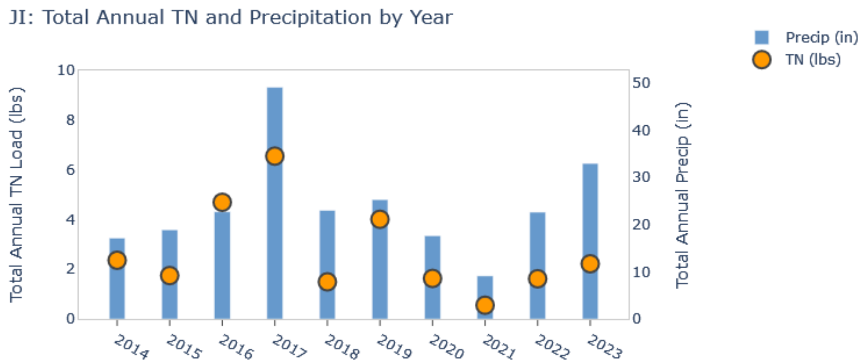

Figure 91 Total annual TN load and precipitation by year for Jellyfish Inflow WY14-WY23.

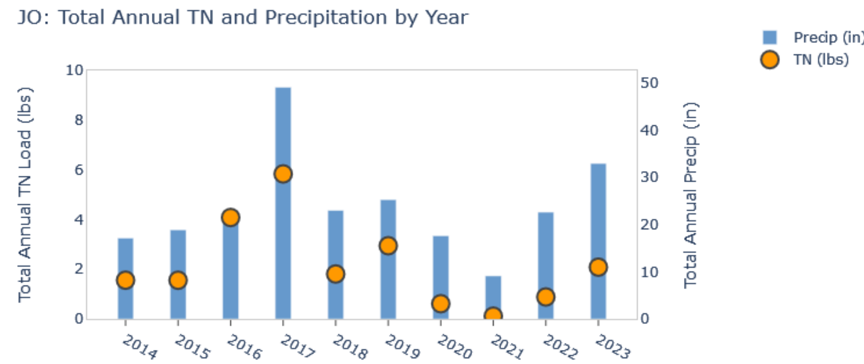

Figure 92 Total annual TN load and precipitation by year for Jellyfish Outflow WY14-WY23.

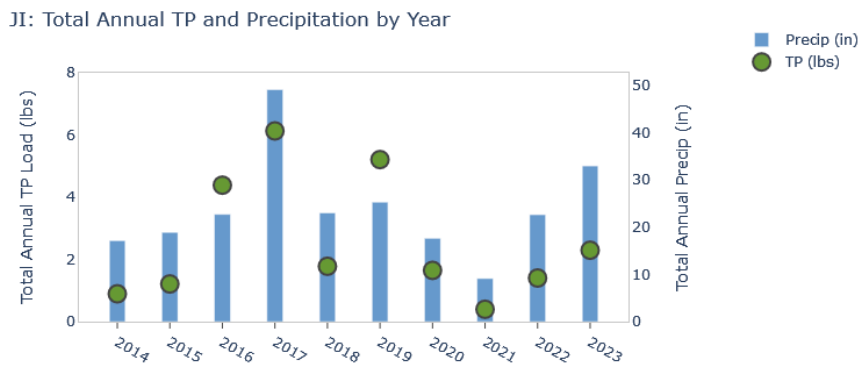

Figure 93 Total annual TP load and precipitation by year for Jellyfish Inflow WY14-WY23.

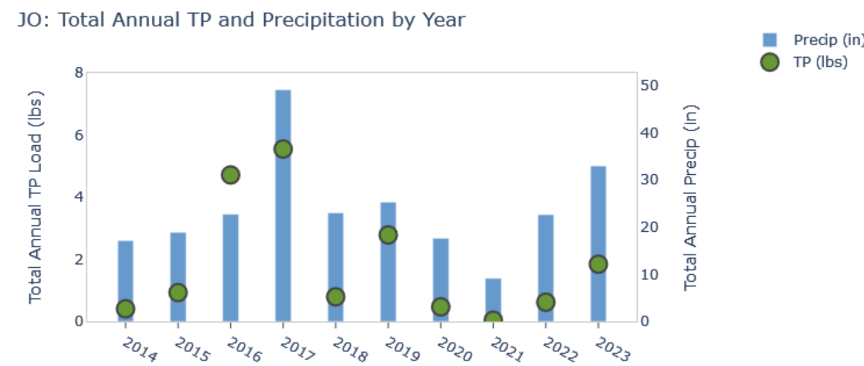

Figure 94 Total annual TP load and precipitation by year for Jellyfish Outflow WY14-WY23.

8.3 Elks Club

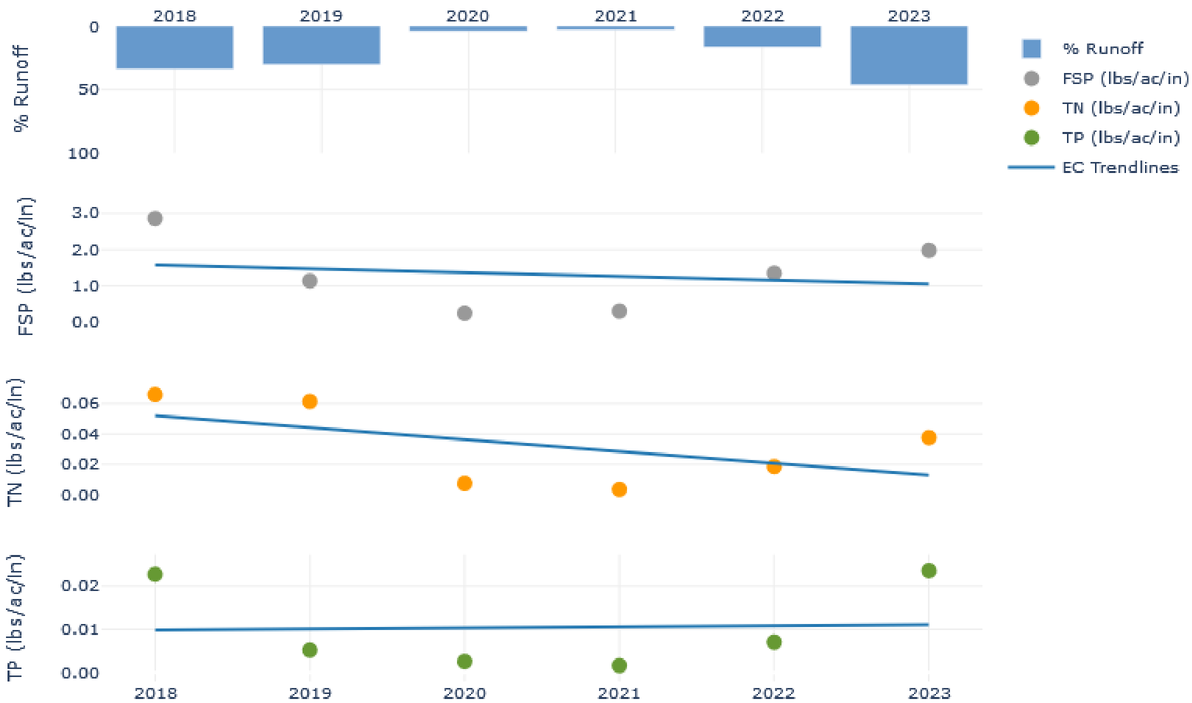

Figure 95 6-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Elks Club, WY17-23.

- Percent runoff varied between 2.81% in WY21 to 46.12% in WY23.
- There is no significant trend in normalized annual FSP loads (p>0.05).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 23 6-year seasonal and annual rainfall normalized pollutant loads at Elks Club, WY17-23.

		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
2018	33.77%	0.347	5.367	0.000	2.860	0.037	0.095	0.000	0.066	0.007	0.038	0.000	0.023
2019	30.34%	0.102	1.893	12.354	1.138	0.008	0.051	0.960	0.061	0.002	0.012	0.012	0.005
2020	3.81%	0.190	0.033	1.762	0.248	0.009	0.001	0.034	0.007	0.003	0.001	0.013	0.003
2021	2.81%	0.004	1.352	0.000	0.307	0.001	0.014	0.000	0.004	0.000	0.007	0.000	0.002
2022	16.32%	0.144	7.760	0.251	1.361	0.009	0.050	0.043	0.019	0.004	0.019	0.011	0.007
2023	46.12%	0.818	1.555	11.046	1.978	0.011	0.065	0.159	0.038	0.005	0.051	0.084	0.024
Tau	na	0.067	-0.067	0.138	0.067	0.067	-0.067	0.276	-0.333	0.067	0.200	0.414	0.067
P-Value	na	0.851	0.851	0.697	0.851	0.851	0.851	0.437	0.348	0.851	0.573	0.243	0.851
Theil Slope (per year)	na	0.014	-0.085	0.063	0.059	0.000	0.000	0.011	-0.006	0.001	0.003	0.007	0.000

Figure 96 through Figure 99 show sediment and nutrient loads for Elks Club compared to total annual precipitation for WY18-WY23. This illustrates how loading and precipitation have varied over the monitored period.

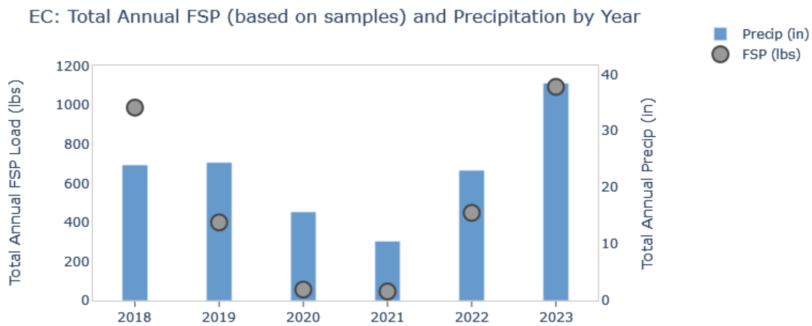

Figure 96 Total annual FSP load (based on samples) and precipitation by year for Elks Club WY18-WY23.

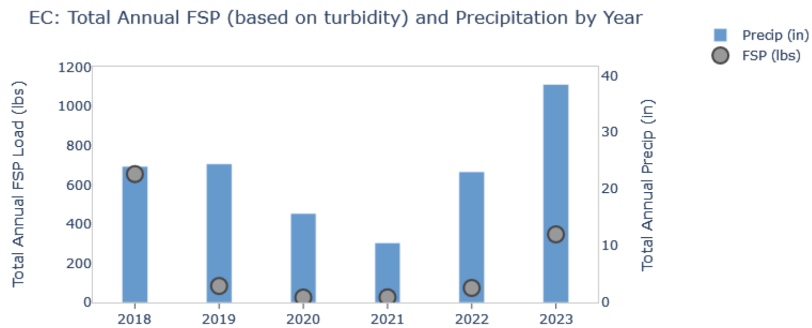

Figure 97 Total annual FSP load (based on continuous turbidity) and precipitation by year for Elks Club WY18-WY23.

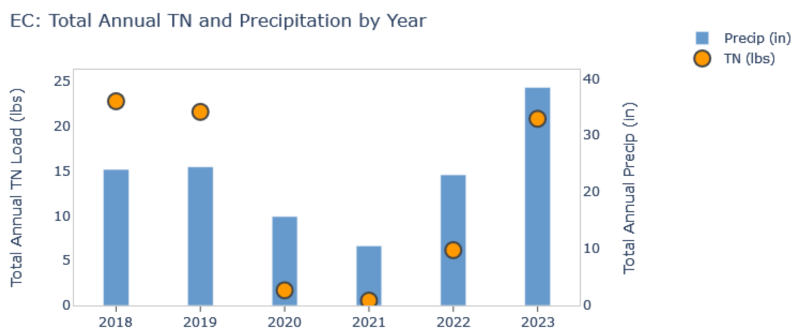

Figure 98 Total annual TN load and precipitation by year for Elks Club WY18-WY23.

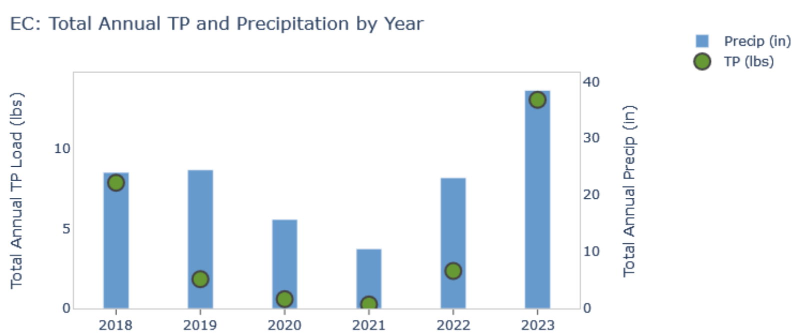

Figure 99 Total annual TP load and precipitation by year for Elks Club WY18-WY23.

8.4 Lakeshore

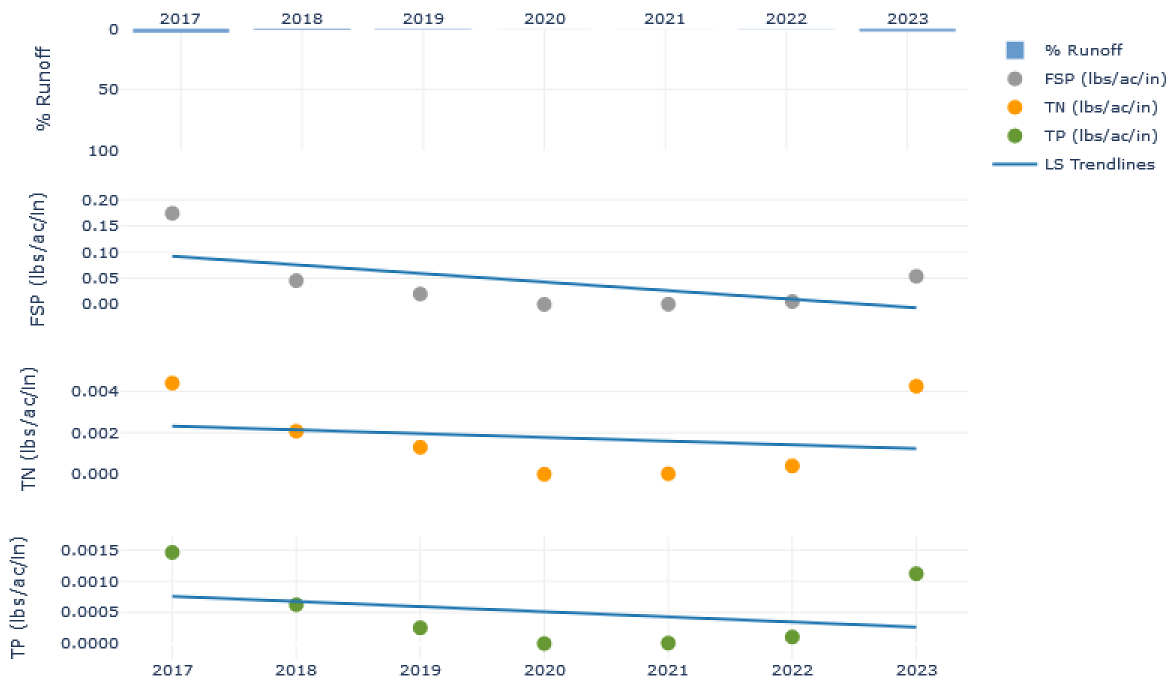

Figure 100 7-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Lakeshore, WY17-23.

- Percent runoff was less than 4% in all monitored water years but varied between 0.0% in WY20 to 3.58% in WY17.
- There is no significant trend in normalized annual FSP loads (p>0.05).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 24 7-year seasonal and annual rainfall normalized pollutant loads at Lakeshore, WY17-23.

		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
2017	3.58%	0.173	0.211	0.000	0.174	0.004	0.006	0.000	0.004	0.001	0.002	0.000	0.001
2018	1.25%	0.037	0.053	0.000	0.045	0.003	0.001	0.000	0.002	0.001	0.001	0.000	0.001
2019	0.98%	0.024	0.005	0.030	0.020	0.002	0.000	0.001	0.001	0.000	0.000	0.000	0.000
2020	0.00%	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2021	0.01%	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2022	0.18%	0.007	0.000	0.000	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2023	2.53%	0.060	0.056	0.020	0.054	0.001	0.013	0.001	0.004	0.000	0.003	0.000	0.001
Tau	na	-0.238	-0.411	0.197	-0.238	-0.429	-0.309	0.197	-0.238	-0.333	-0.309	0.329	-0.238
P-Value	na	0.453	0.210	0.568	0.453	0.176	0.347	0.568	0.453	0.293	0.347	0.342	0.453
Theil Slope (per year)	na	-0.012	-0.005	0.000	-0.010	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure 101 through Figure 104 show sediment and nutrient loads for Lakeshore compared to total annual precipitation for WY17-WY23. This illustrates how loading and precipitation have varied over the monitored period.

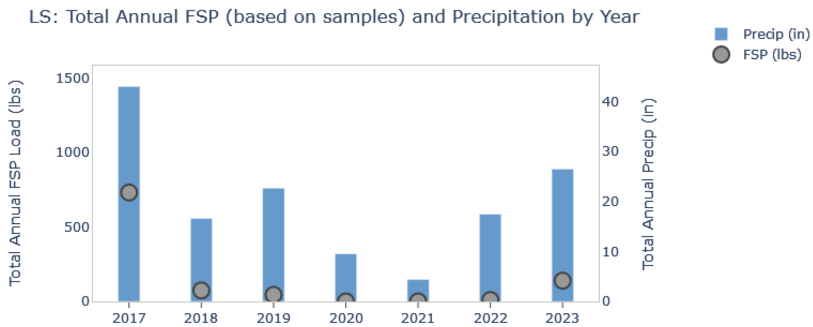

Figure 101 Total annual FSP load (based on samples) and precipitation by year for Lakeshore WY17-WY23.

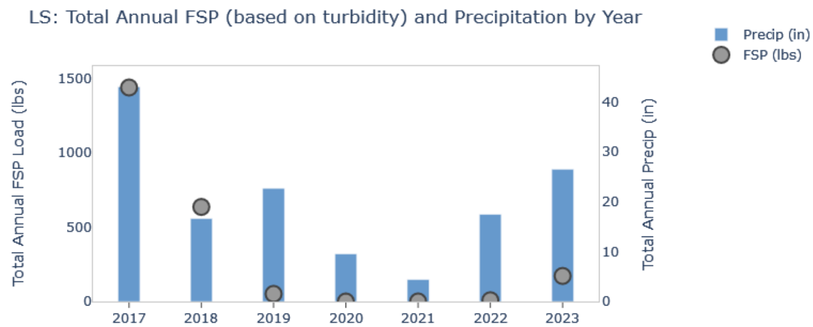

Figure 102 Total annual FSP load (based on continuous turbidity) and precipitation by year for Lakeshore WY17-WY23.

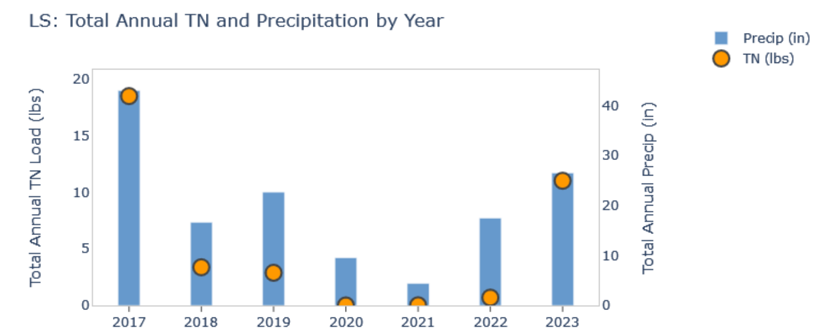

Figure 103 Total annual TN load and precipitation by year for Lakeshore WY17-WY23.

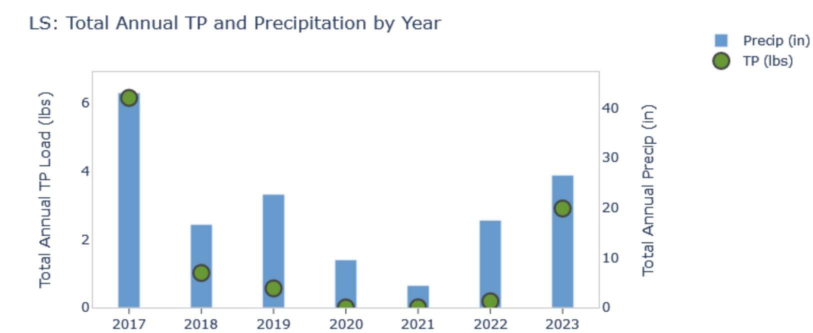

Figure 104 Total annual TP load and precipitation by year for Lakeshore WY17-WY23.

8.5 Pasadena

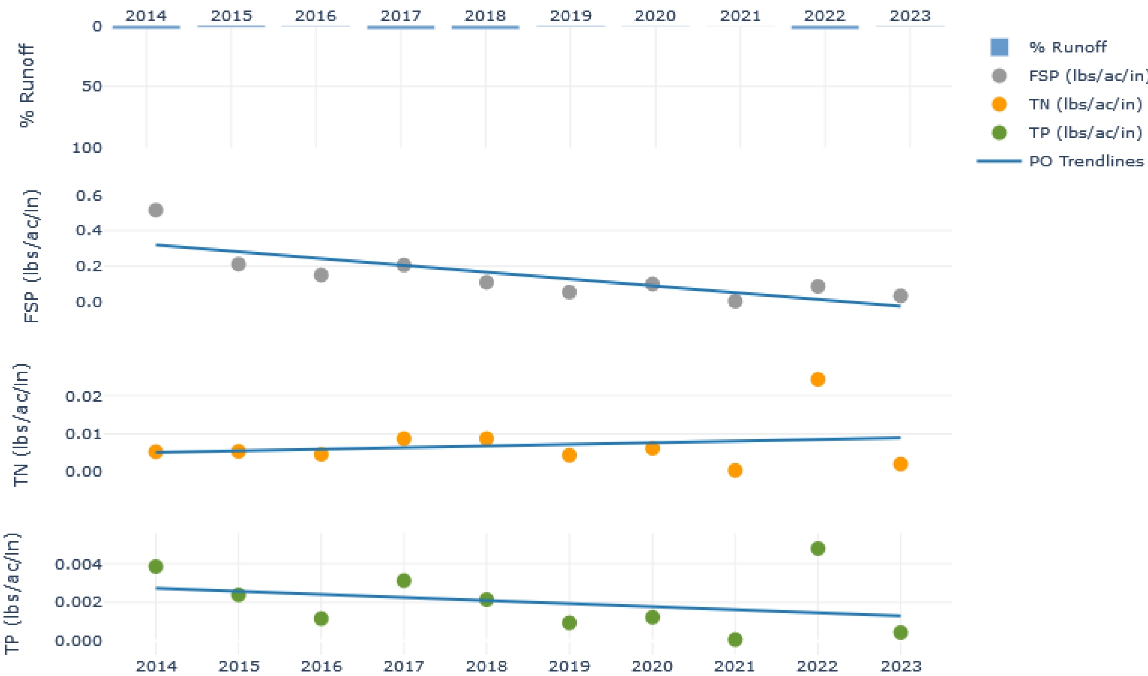

Figure 105 10-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Pasadena Outflow, WY14-23.

- Percent runoff was less than 4% in all monitored water years but varied between 0.05% in WY21 to 3.2% in WY17 and WY22.
- There is a significant decreasing trend in normalized annual FSP loads (p=.002 and Tau= -0.778) and normalized fall/winter FSP loads (p=0.016 and Tau=-0.600).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 25 10-year seasonal and annual rainfall normalized pollutant loads at the Pasadena Outflow, WY14-23

		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
2021	0.05%	0.003	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2022	3.2%	0.100	0.036	0.000	0.086	0.030	0.002	0.000	0.024	0.006	0.000	0.000	0.005
2023	0.5%	0.021	0.047	0.075	0.033	0.001	0.002	0.008	0.002	0.000	0.000	0.002	0.000
Tau	na	-0.600	-0.138	-0.315	-0.778	-0.022	-0.046	-0.135	-0.067	-0.289	-0.046	-0.315	-0.378
P-Value	na	0.016	0.579	0.205	0.002	0.929	0.853	0.587	0.788	0.245	0.853	0.205	0.128
Theil Slope (per year)	na	-0.032	-0.001	-0.051	-0.029	0.000	0.000	-0.001	0.000	0.000	0.000	-0.001	0.000

Figure 106 through Figure 109 show sediment and nutrient loads for Pasadena compared to total annual precipitation for WY14-WY23. This illustrates how loading and precipitation have varied over the monitored period.

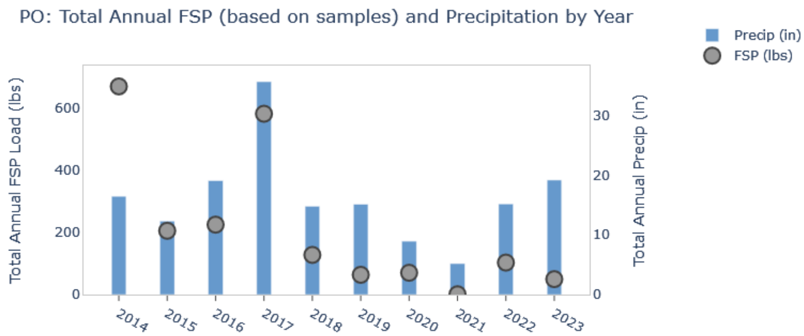

Figure 106 Total annual FSP load (based on samples) and precipitation by year for Pasadena WY14-WY23.

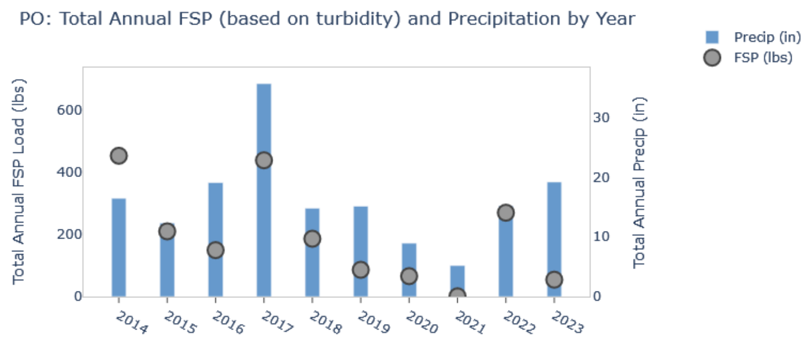

Figure 107 Total annual FSP load (based on continuous turbidity) and precipitation by year for Pasadena WY14-WY23.

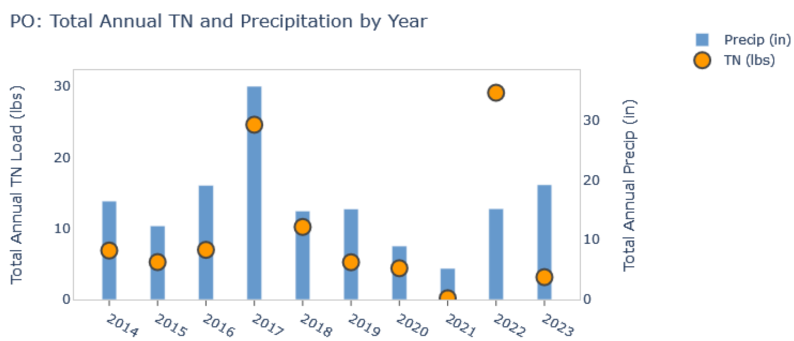

Figure 108 Total annual TN load and precipitation by year for Pasadena WY14-WY23.

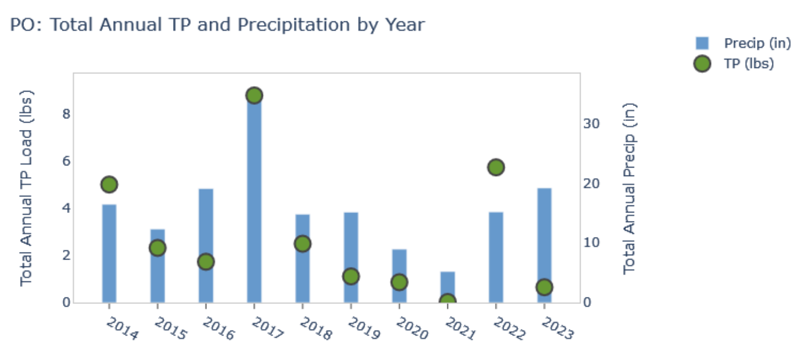

Figure 109 Total annual TP load and precipitation by year for Pasadena WY14-WY23.

8.6 Speedboat

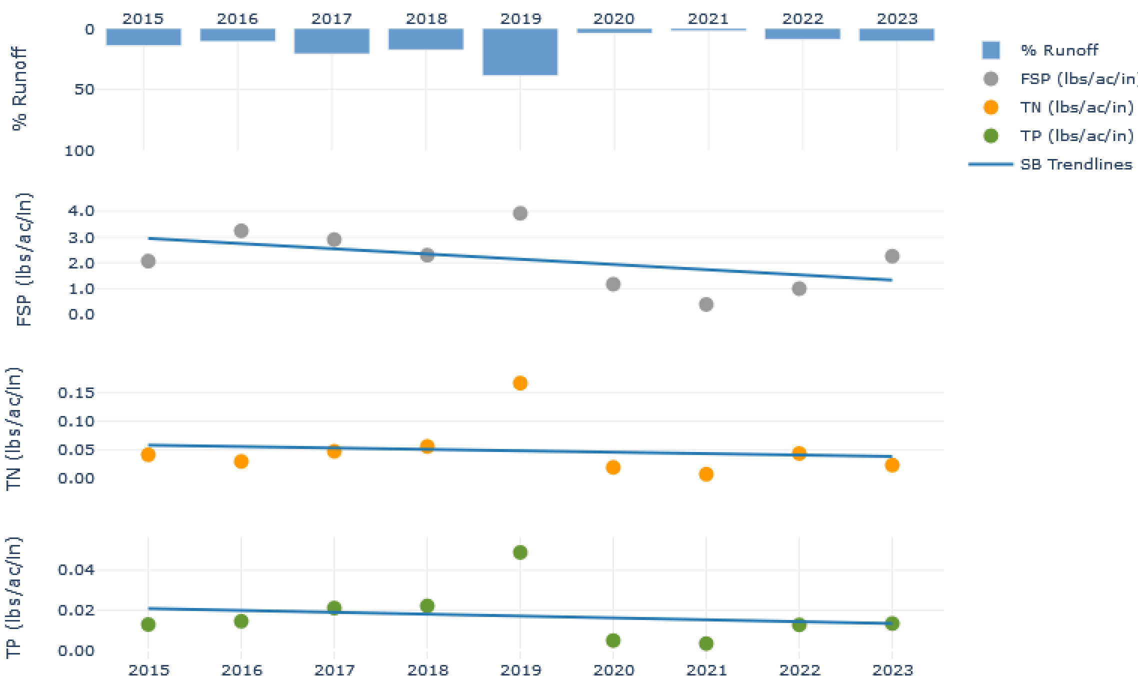

Figure 110 9-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Speedboat, WY15-23.

- Percent runoff varied between 1.8% in WY21 to 38.4% in WY19.
- There is no significant trend in normalized annual FSP loads (p>0.05).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 26 9-year seasonal and annual rainfall normalized pollutant loads at Speedboat, WY15-23.

		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
2021	1.8%	0.446	0.156	0.046	0.391	0.009	0.002	0.003	0.008	0.004	0.001	0.001	0.003
2022	8.7%	0.765	1.319	2.509	1.005	0.045	0.016	0.076	0.044	0.011	0.009	0.031	0.013
2023	10.2%	1.893	2.657	3.732	2.262	0.017	0.028	0.057	0.024	0.013	0.011	0.026	0.013
Tau	na	-0.444	-0.222	0.111	-0.333	-0.167	-0.278	0.056	-0.167	-0.222	-0.167	0.167	-0.111
P-Value	na	0.095	0.404	0.677	0.211	0.532	0.297	0.835	0.532	0.404	0.532	0.532	0.677
Theil Slope (per year)	na	-0.234	-0.317	0.264	-0.230	-0.002	-0.003	0.002	-0.002	-0.001	-0.001	0.002	0.000

Figure 111 through Figure 114 show sediment and nutrient loads for Speedboat compared to total annual precipitation for WY15-WY23. This illustrates how loading and precipitation have varied over the monitored period.

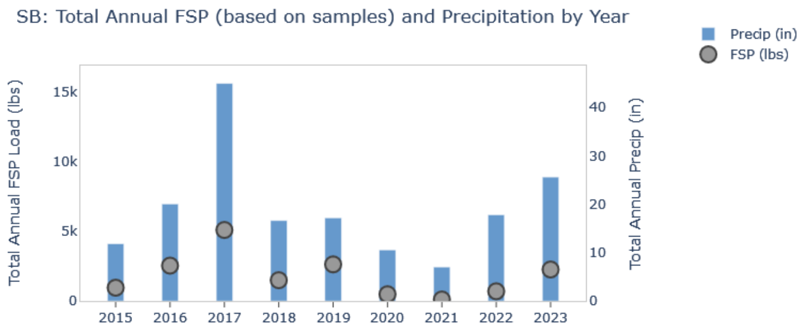

Figure 111 Total annual FSP load (based on samples) and precipitation by year for Speedboat WY15-WY23.

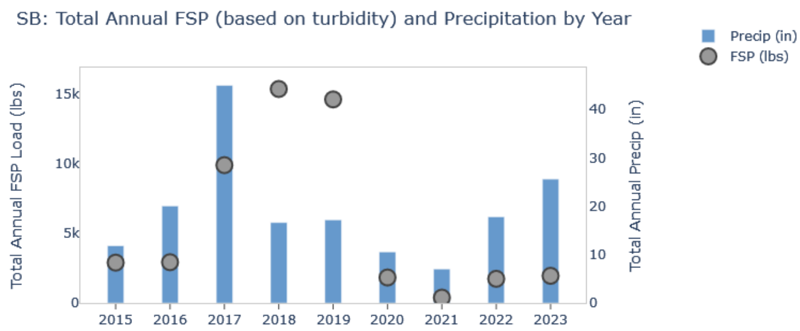

Figure 112 Total annual FSP load (based on continuous turbidity) and precipitation by year for Speedboat WY15-WY23.

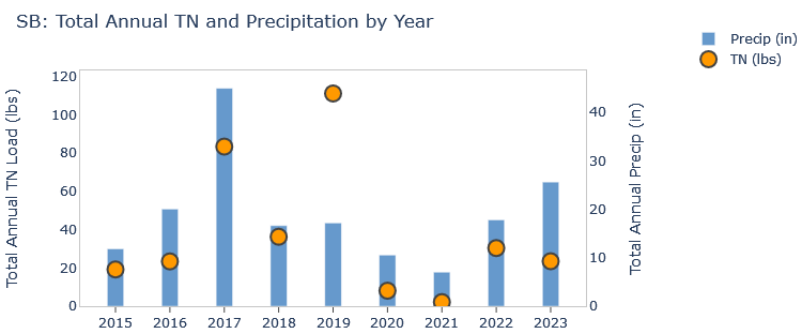

Figure 113 Total annual TN load and precipitation by year for Speedboat WY15-WY23.

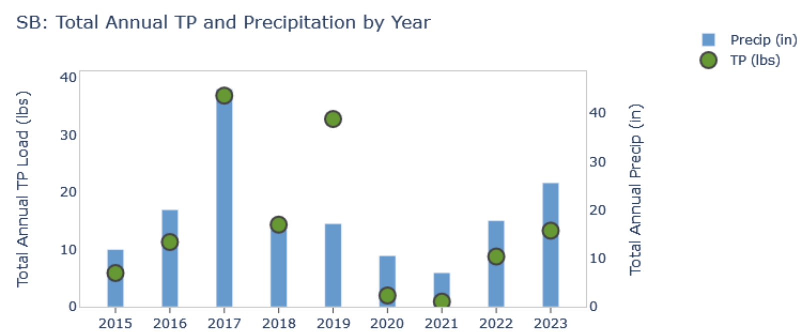

Figure 114 Total annual TP load and precipitation by year for Speedboat WY15-WY23.

8.7 Tahoe City

Figure 115 through Figure 119 show sediment and nutrient loads for Tahoe City compared to total annual precipitation for WY20-WY23. This illustrates how loading and precipitation have varied over the monitored period.

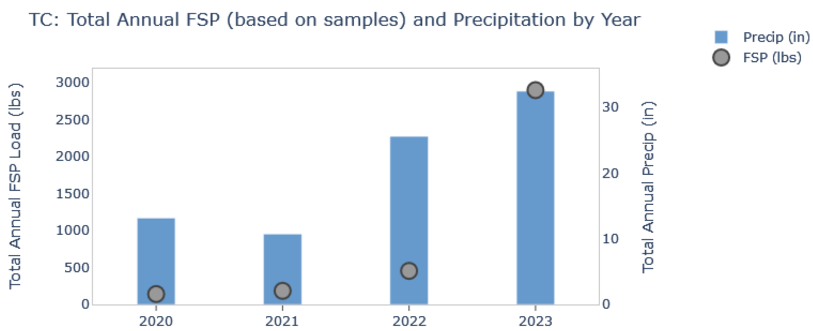

Figure 115 Total annual FSP load (based on samples) and precipitation by year for Tahoe City WY20-WY23.

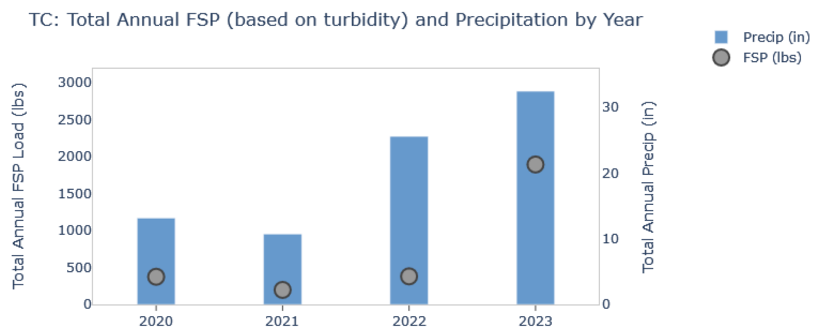

Figure 116 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoe City WY20-WY23.

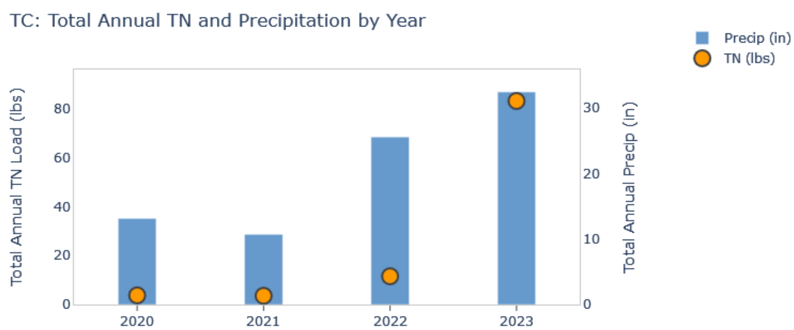

Figure 117 Total annual TN load and precipitation by year for Tahoe City WY20-WY23.

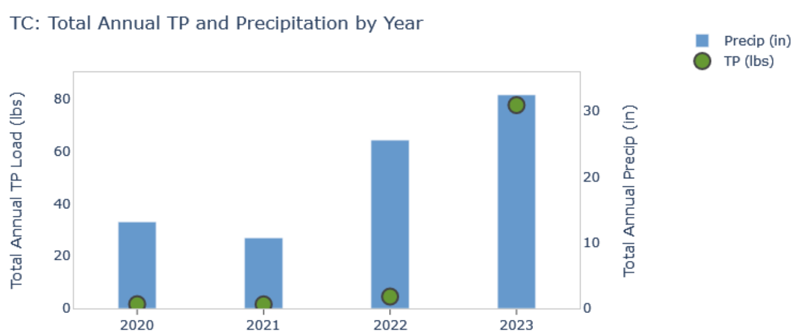

Figure 118 Total annual TP load and precipitation by year for Tahoe City WY20-WY23.

8.8 Tahoe Valley

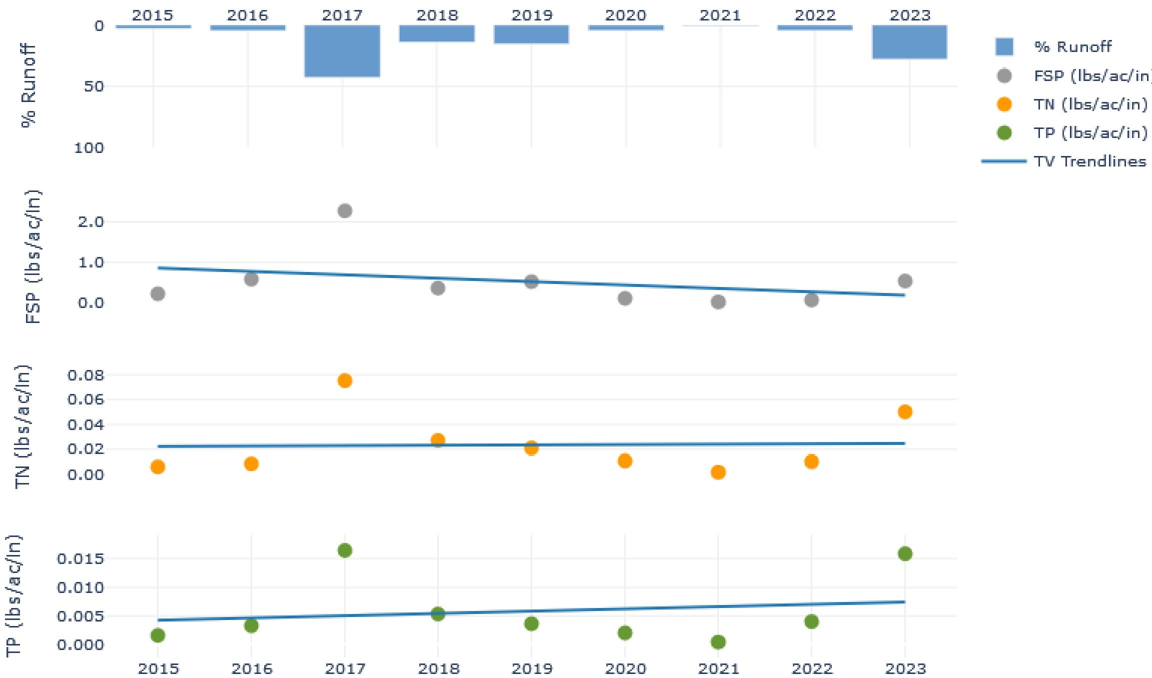

Figure 119 9-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Tahoe Valley, WY15-23.

- Percent runoff varied between 0.4% in WY21 to 42.6% in WY17.
- There is no significant trend in normalized annual FSP loads (p>0.05).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 27 9-year seasonal and annual rainfall normalized pollutant loads at Tahoe Valley, WY15-23.

		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	42.6%	1.948	3.292	2.933	2.269	0.053	0.144	0.137	0.075	0.013	0.025	0.025	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
2021	0.4%	0.018	0.080	0.019	0.030	0.002	0.003	0.002	0.002	0.000	0.001	0.000	0.000
2022	4.5%	0.074	0.122	0.000	0.076	0.012	0.008	0.000	0.010	0.005	0.002	0.000	0.004
2023	28.0%	0.326	1.361	0.237	0.543	0.011	0.178	0.032	0.050	0.003	0.060	0.005	0.016
Tau	na	-0.278	0.000	-0.167	-0.278	-0.056	0.111	-0.056	0.056	0.056	0.167	-0.056	0.111
P-Value	na	0.297	1.000	0.532	0.297	0.835	0.677	0.835	0.835	0.835	0.532	0.835	0.677
Theil Slope (per year)	na	-0.034	0.006	-0.026	-0.028	-0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000

Figure 120 through Figure 123 show sediment and nutrient loads for Tahoe Valley compared to total annual precipitation for WY15-WY23. This illustrates how loading and precipitation have varied over the monitored period.

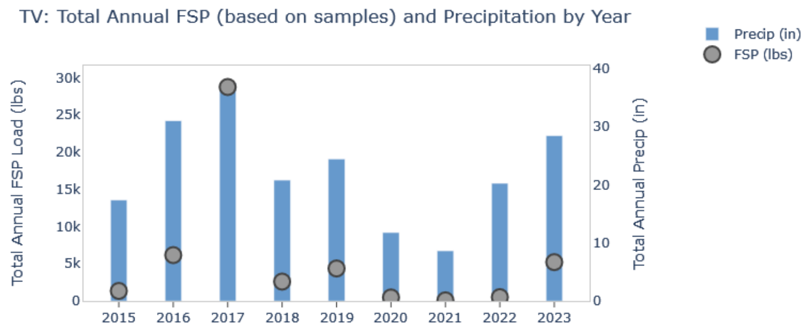

Figure 120 Total annual FSP load (based on samples) and precipitation by year for Tahoe Valley WY15-WY23.

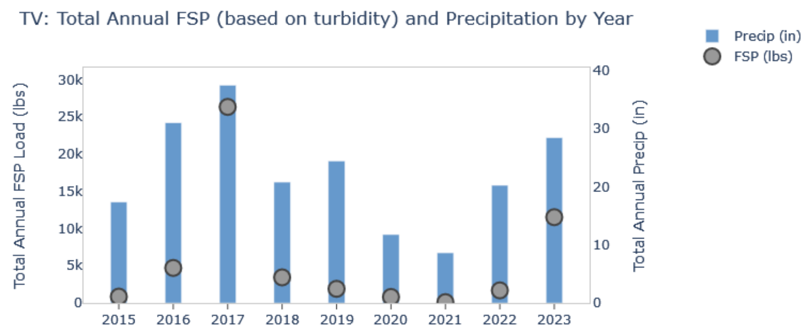

Figure 121 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoe Valley WY15-WY23.

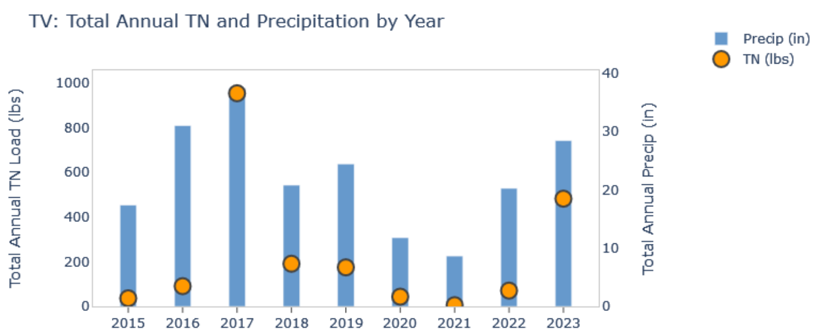

Figure 122 Total annual TN load and precipitation by year for Tahoe Valley WY15-WY23.

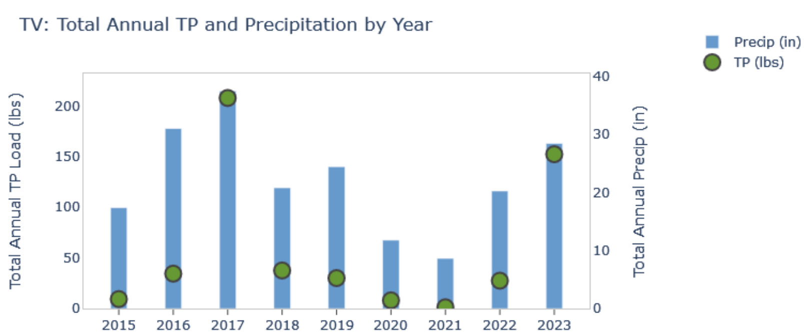

Figure 123 Total annual TP load and precipitation by year for Tahoe Valley WY15-WY23.

8.9 Tahoma

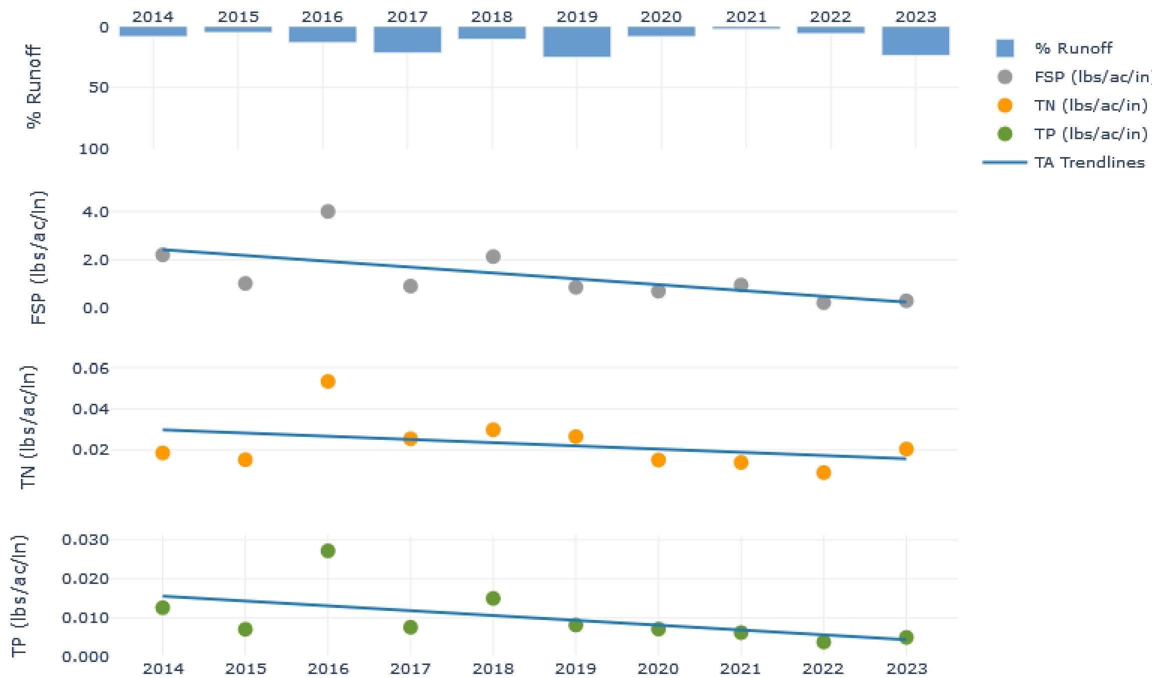

Figure 124 10-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Tahoma, WY14-23.

- Percent runoff varied between 2.0% in WY21 to 23.5% in WY23. Backwatered conditions in WY19 may have resulted in a falsely elevated percent runoff.
- There is a significant decreasing trend in normalized annual FSP loads (p=0.009 and Tau=-0.644), and fall/winter FSP loads (p=0.009 and Tau= -0.644).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is a significant decreasing trend in normalized annual TP loads (p=0.025 and Tau=-0.556).

Table 28 10-year seasonal and annual rainfall normalized pollutant loads at Tahoma, WY14-23. 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
2021	2.0%	0.057	5.031	0.179	0.954	0.002	0.068	0.021	0.014	0.001	0.032	0.003	0.006
2022	5.8%	0.062	0.993	0.087	0.224	0.006	0.023	0.009	0.009	0.003	0.009	0.002	0.004
2023	23.5%	0.120	0.714	0.727	0.300	0.004	0.058	0.061	0.021	0.002	0.013	0.015	0.005
Tau	na	-0.644	-0.111	-0.180	-0.644	-0.422	0.333	-0.045	-0.333	-0.422	0.111	-0.135	-0.556
P-Value	na	0.009	0.655	0.469	0.009	0.089	0.180	0.856	0.180	0.089	0.655	0.587	0.025
Theil Slope (per year)	na	-0.142	-0.026	-0.141	-0.179	-0.003	0.005	-0.001	-0.001	-0.001	0.000	-0.001	-0.001

Figure 125 through Figure 128 show sediment and nutrient loads for Tahoma compared to total annual precipitation for WY14-WY23. This illustrates how loading and precipitation have varied over the monitored period.

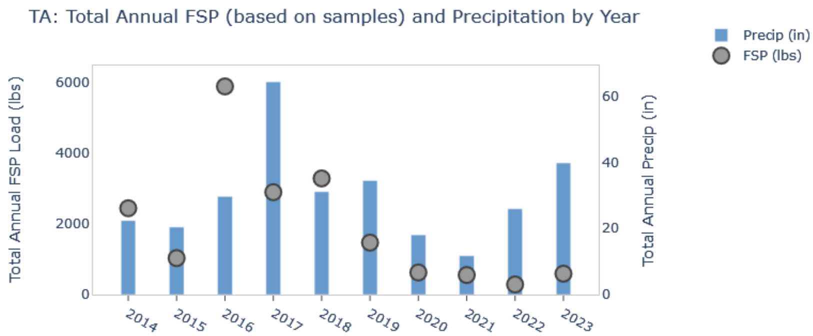

Figure 125 Total annual FSP load (based on samples) and precipitation by year for Tahoma WY14-WY23.

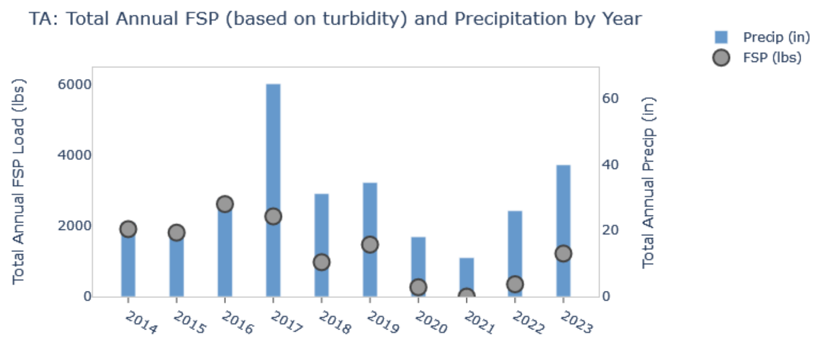

Figure 126 Total annual FSP load (based on continuous turbidity) and precipitation by year for Tahoma WY14-WY23.

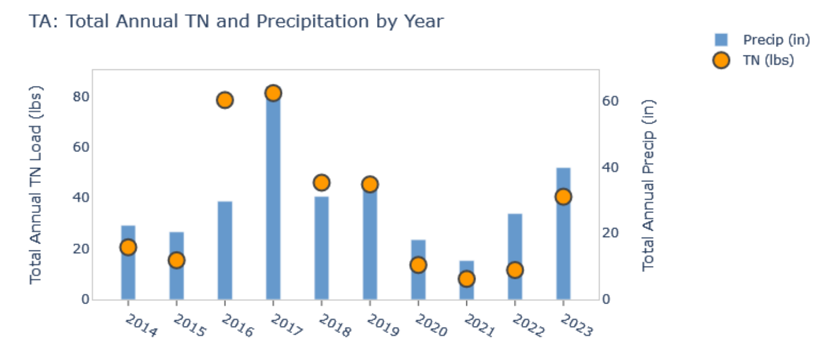

Figure 127 Total annual TN load and precipitation by year for Tahoma WY14-WY23.

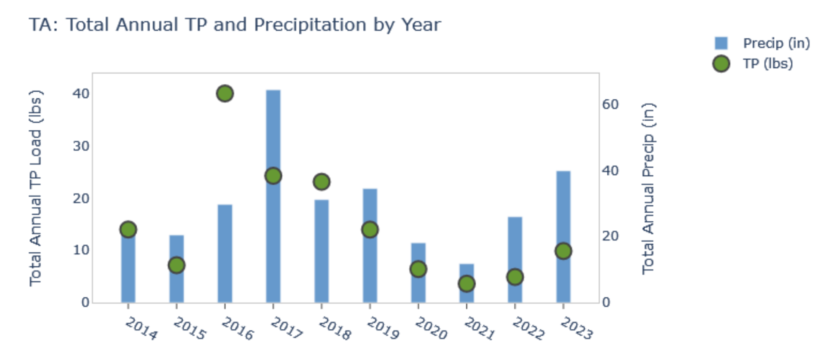

Figure 128 Total annual TP load and precipitation by year for Tahoma WY14-WY23.

8.10 Upper Truckee

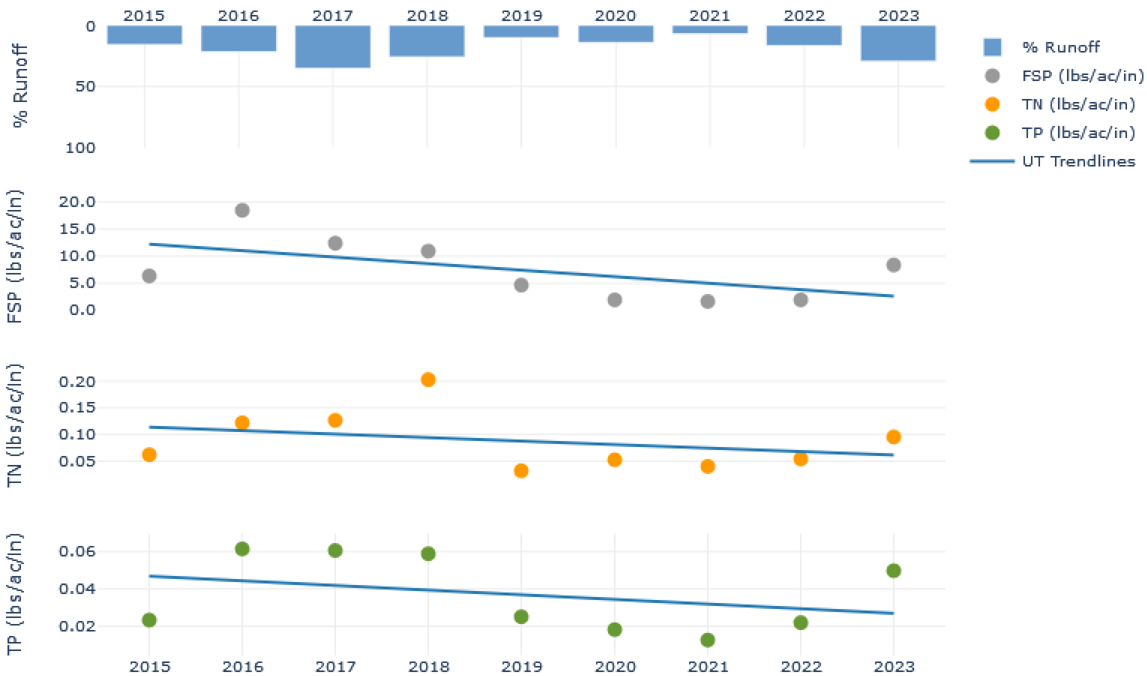

Figure 129 9-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at Upper Truckee, WY15-23.

- Percent runoff varied between 6.4% in WY21 to 34.8% in WY17.
- There is no significant trend in normalized annual FSP loads (p>0.05).
- There is no significant trend in normalized annual TN loads (p>0.05).
- There is no significant trend in normalized annual TP loads (p>0.05).

Table 29 9-year seasonal and annual rainfall normalized pollutant loads at Upper Truckee, WY15-23.

		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	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	34.8%	11.426	13.747	22.499	12.420	0.095	0.137	0.580	0.127	0.055	0.062	0.143	0.061
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
2021	6.4%	1.632	2.119	0.000	1.653	0.039	0.057	0.000	0.040	0.013	0.015	0.000	0.013
2022	16.2%	1.960	2.513	0.637	1.943	0.047	0.077	0.093	0.054	0.023	0.024	0.009	0.022
2023	29.2%	7.472	14.816	1.133	8.392	0.073	0.149	0.127	0.096	0.041	0.093	0.019	0.050
Tau	na	-0.389	-0.333	0.261	-0.444	-0.167	-0.222	0.327	-0.111	-0.222	-0.222	0.327	-0.389
P-Value	na	0.144	0.211	0.326	0.095	0.532	0.404	0.220	0.677	0.404	0.404	0.220	0.144
Theil Slope (per year)	na	-0.939	-1.759	0.000	-1.177	-0.003	-0.009	0.002	-0.003	-0.002	-0.005	0.000	-0.002

Figure 130 through Figure 133 how sediment and nutrient loads for Upper Truckee compared to total annual precipitation for WY15-WY23. This illustrates how loading and precipitation have varied over the monitored period.

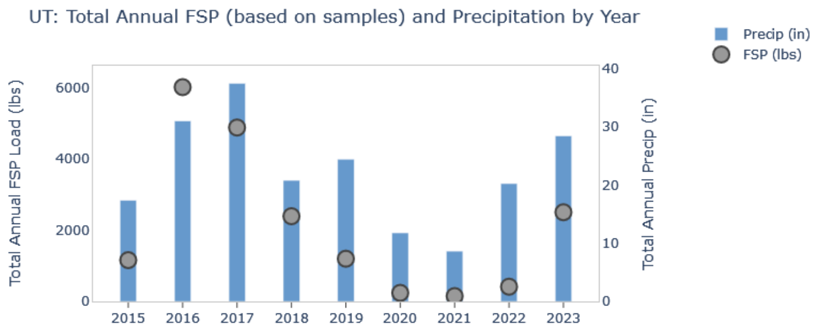

Figure 130 Total annual FSP load (based on samples) and precipitation by year for Upper Truckee WY15-WY23.

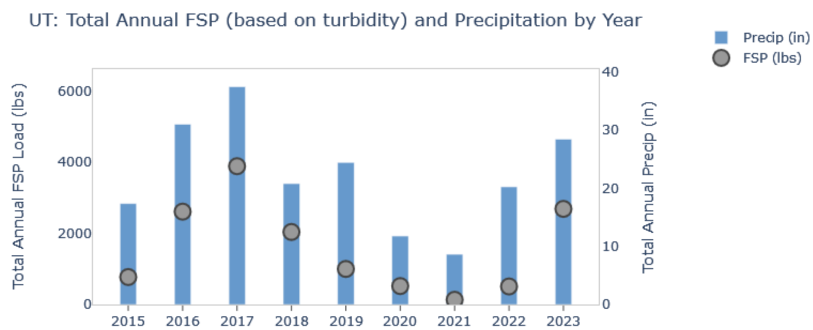

Figure 131 Total annual FSP load (based on continuous turbidity) and precipitation by year for Upper Truckee WY15-WY23.

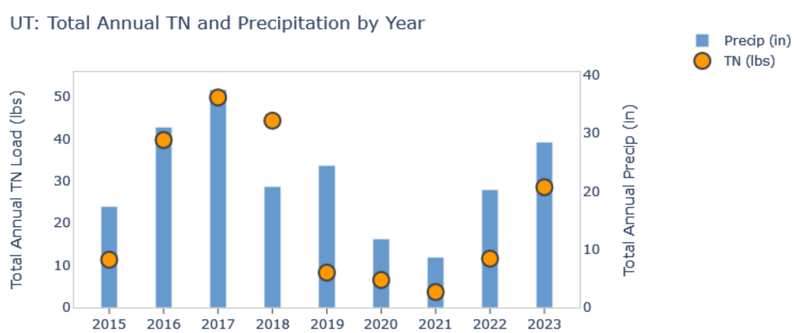

Figure 132 Total annual TN load and precipitation by year for Upper Truckee WY15-WY23.

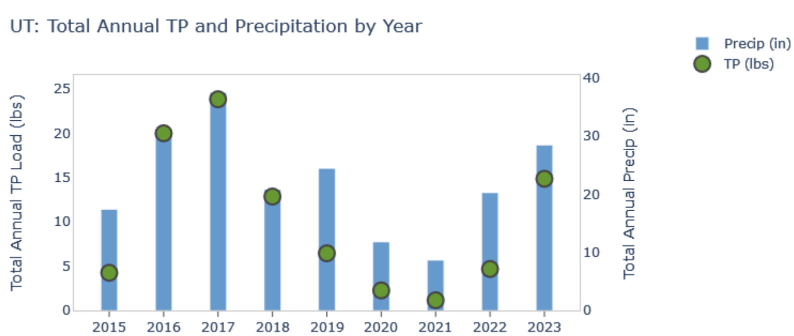

Figure 133 Total annual TP load and precipitation by year for Upper Truckee WY15-WY23.

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.

The Lakeshore PLRM model used for this analysis was sourced directly from Washoe County (built by NTCD) therefore matches the registered model exactly. The SR431 model was built by Tahoe RCD staff and uses average CEC values from WY14-19 and registered road operations for the Jellyfish and Contech MFS filters. The Tahoe Valley model was originally provided by the City of South Lake Tahoe, modified by Tahoe RCD staff, and includes baseline 2004 conditions, current private parcel BMPs, and registered road operations. Upper Truckee was originally provided by the City of South Lake Tahoe, modified by Tahoe RCD staff, and includes all registered and unregistered stormwater treatment BMPs and registered road operations, and uses baseline parcel BMPs. Both Tahoe Valley and Upper Truckee PLRM models match the models built for registrations as closely as possible, but don't match the official registered catchments exactly because their areas are slightly different and they are pieced together from two jurisdictions (Caltrans and City of South Lake Tahoe). The Pasadena model was originally provided by the City of South Lake Tahoe and was modified by Tahoe RCD staff; it uses baseline conditions from 2004, current parcel BMP status, average filter characteristic effluent concentrations from WY14-17 and registered road operations. Speedboat, Tahoe City, and Tahoma are unregistered catchments and these models assume baseline conditions from 2004 and current parcel BMP status.   Elks Club is also unregistered and uses baseline conditions from 2004, current parcel BMP status and the median Road RAM measurement from WY20-WY22.

Tahoe RCD compared average annual runoff volumes and pollutant loads predicted by PLRMv2.1 to annual volumes and pollutant loads measured in WY23 at all sites; results are presented in Table 30. 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.**

WY23 was a very wet precipitation year for the Tahoe basin, therefore field measured runoff volumes and FSP, TN, and TP loads are expected to be slightly higher than PLRM modeled values. For measured runoff, Elks Club, Speedboat, Tahoe City, Tahoe Valley, and Tahoma were higher than PLRM modeled values, and Contech Inflow, Contech Outflow, Jellyfish Inflow, Jellyfish Outflow, Pasadena, and Upper Truckee were lower than PLRM modeled values. For FSP, TN, and TP, all measured values were lower than PLRM modeled results, with the exception of FSP (from samples), TN and TP at Tahoe City, and TP at Elks Club and Upper Truckee. Despite variations in model performance, most models provide reasonable ranges for runoff volume 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 and pollutant loading of all sites, which was predicted by PLRM. 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 30 PLRM predicted and WY23 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 2023 Oct. 1, 2022 - Sept. 30, 2023		Catchment Registered for BMPs?	Catchment Registered for Roads?	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	No	Yes	43,560	21,477	810	317	810	99	10.0	1.9	3.0	1.8
	Contech Outflow	No	Yes	43,560	15,365	810	168	279	105	4.0	1.4	3.0	1.1
	Jellyfish Inflow	No	Yes	43,560	24,066	810	378	810	104	10.0	2.2	3.0	2.3
	Jellyfish Outflow	No	Yes	43,560	20,843	810	268	318	47	4.0	2.1	3.0	1.8
Elk's Club	Elk's Club	No	No	187,308	926,329	2,431	1,094	2,431	348	34.0	20.8	9.0	13.0
Lakeshore	Lakeshore	Yes	Yes	357,192	238,346	2,885	139.4	2,885	171.9	56.0	11.0	14.0	2.9
Pasadena	Pasadena Out	No	Yes	135,036	29,003	420	50	420	54	12.0	3.1	5.0	0.7
Speedboat	Speedboat	No	No	322,344	369,046	4,926	2,260	4,926	1,950	58.0	23.5	17.0	13.3
Tahoe City	Tahoe City	No	No	213,444	1,922,904	2,868	2,902	2,868	1,895	32.0	83.3	8.0	77.8
Tahoe Valley	Tahoe Valley	No	Yes	6,172,452	9,791,341	50,800	5,221	50,800	11,529	829.0	481.7	203.0	152.3
Tahoma	Tahoma	No	No	662,112	1,679,628	10,784	591	10,784	1,217	126.0	40.5	37.0	9.9
Upper Truckee	Upper Truckee	Yes	Yes	352,836	315,916	2,875	2,505	2,875	2,689	46.0	28.5	10.0	14.9

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.

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 has helped to alleviate this problem but batteries must be continuously checked and changed.

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.

Construction activities can impact monitoring sites. In WY22 construction activities severed a pressure transducer cord at SR431, which caused an electrical short that caused a power outage and damaged one of the control ports on the datalogger. Luckily this was the extent of the damage, as this could have caused much more costly damage to the equipment. When construction activities are planned near monitoring sites, it is prudent to communicate the plans with Tahoe RCD staff as well as the construction staff to ensure equipment isn't damaged.

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. NDOT maintenance crews must be called ahead of sample collection to remove the snow with heavy equipment. In WY23 a truck hit the housing containing the data logger and tore all sensor cords, rendering the site inoperable. The site took three and a half months to rebuild and began recording reliable data at the end of December 2023 (see destroyed equipment at SR431 in Figure 134). Unanticipated events can occur that require additional staff hours to address.

When snow accumulation is frequent and excessive, it is very important to stay on top of site maintenance (See Figure 135). 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.

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 understated. 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.

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 134 Boxes containing monitoring equipment at SR431 before the car accident on September 15, 2023 (first image), and after the car accident showing ripped cables where equipment boxes used to be (image 2) and box pushed down the embankment (image 3).

Figure 135 Snow at Tahoma March 7, 2023 before snow removal (image 1) and after snow removal (image 2). It is critical to stay on top of snow removal after snowfall events to maintain access to stormwater monitoring sites.

11. Changes: Accepted and Proposed

Changes Accepted

The NPDES permit issued to California jurisdictions in 2017 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 only stormwater runoff from state route 89 in Tahoe City was installed in August of 2019. Monitoring of this site began October 1, 2019 at the commencement of WY20.

Changes Proposed

Because annual precipitation during all seasons is highly variable, and summer thunderstorms 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 years like WY20, it did not flow at all. In WY21 it only flowed once. Due to the difficulty of finding suitable monitoring sites, it was decided that nothing would change for WY22, WY23, or WY24, but RSWMP recommends replacing Lakeshore with another site when a suitable one can be found.

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Appendix A: Raw Analytical Data

Table A.1-Table A.10 present all available raw analytical data for autosampler composite (AC) samples. Other than QAQC samples, only AC samples were analyzed in WY23. 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 WY23.

Sample	Sample Start (Date/Time)	Total 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	12/3/2022 15:01	221	124	175	1,583	1,036	0.58	6.13	17.7	33.2	54.0	79.0	87.3	100	100	100	100	100	100
CI-AC	12/27/2022 1:19	288	373	133	1,261	1,066	0.29	3.06	8.83	17.2	30.0	46.1	52.1	82.2	93.6	100	100	100	100
CI-AC	12/30/2022 9:38	168	226	82	643	618	0.25	2.57	7.27	14.5	27.8	48.7	56.6	89.3	96.5	100	100	100	100
CI-AC	3/10/2023 12:09	644	661	411	1,786	552	0.38	3.99	11.1	21.5	39.1	63.8	71.9	98.2	99.8	100	100	100	100
CI-AC	3/13/2023 13:13	962	883	626	2,110	3,412	0.41	4.25	11.6	22.0	39.2	65.1	73.9	100	100	100	100	100	100
CI-AC	4/10/2023 14:06	1,168	922	612	1,823	3,265	0.20	2.18	6.56	14.3	29.0	52.4	60.9	94.5	99.7	100	100	100	100
CI-AC	5/31/2023 14:49	463	196	248	2,201	1,199	0.25	2.53	6.95	13.9	28.2	53.5	63.1	99.3	100	100	100	100	100
CI-AC	6/10/2023 14:03	411	157	152	2,048	884	0.20	1.98	5.03	9.28	18.4	37.0	44.8	85.1	95.9	100	100	100	100
CI-AC	8/19/2023 23:42	24	16	4	2,399	168	0.10	0.89	2.09	3.74	6.92	14.6	18.5	53.1	79.1	95.1	99.4	100	100
CI-AC	8/20/2023 21:05	17	11	3	831	98	0.10	0.96	2.56	4.93	9.16	18.7	23.5	58.8	82.7	92.9	97.0	100	100
CO-AC	12/3/2022 18:33	167	210	114	1,695	871	0.54	5.61	15.8	29.5	47.2	68.1	75.8	98.4	100	100	100	100	100
CO-AC	12/27/2022 1:18	201	304	90	1,724	939	0.28	2.95	8.64	16.9	29.5	44.9	50.6	80.8	93.6	100	100	100	100
CO-AC	12/30/2022 10:40	138	197	71	703	592	0.26	2.73	7.96	16.3	30.4	51.1	58.6	89.5	97.2	100	100	100	100
CO-AC	3/10/2023 12:14	482	512	317	1,698	2,186	0.42	4.35	12.3	23.9	42.2	65.8	73.4	98.7	99.9	100	100	100	100
CO-AC	3/13/2023 13:11	568	623	419	1,758	2,535	0.49	5.03	13.9	26.4	46.3	73.8	82.3	100	100	100	100	100	100
CO-AC	4/10/2023 14:06	790	717	435	1,684	2,786	0.22	2.32	7.04	15.5	31.7	55.1	63.3	93.4	98.3	100	100	100	100
CO-AC	5/31/2023 14:49	261	130	119	1,966	827	0.22	2.23	6.16	12.5	24.9	45.7	53.4	87.4	97.0	100	100	100	100
CO-AC	6/10/2023 14:01	397	162	153	2,519	947	0.20	1.98	5.09	9.61	19.4	38.5	46.3	84.2	95.5	100	100	100	100
CO-AC	8/19/2023 23:55	26	16	9	3,304	218	0.16	1.56	4.13	8.10	15.5	33.1	41.7	87.6	96.7	100	100	100	100
CO-AC	8/20/2023 21:08	15	9	3	751	95	0.13	1.31	3.41	6.32	11.5	22.8	28.1	62.9	81.8	93.0	98.4	100	100

Table A.2 Raw analytical data for samples taken at the inflow and outflow of the SR431 Jellyfish in WY23.

Sample	Sample Start (Date/Time)	Total 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	12/3/2022 14:54	242	252	177	1,414	1,145	0.56	5.90	16.7	31.1	50.2	73.0	80.7	99.2	100	100	100	100	100
JI-AC	12/27/2022 1:18	276	316	135	1,462	1,320	0.30	3.23	9.40	18.3	31.8	48.8	55.0	84.8	95.0	100	100	100	100
JI-AC	12/30/2022 8:49	164	244	81	753	637	0.25	2.65	7.51	15.0	28.4	49.1	56.8	87.6	95.9	100	100	100	100
JI-AC	3/10/2023 12:08	756	729	509	1,875	2,967	0.41	4.20	11.6	22.3	40.8	67.3	76.1	100	100	100	100	100	100
JI-AC	3/13/2023 13:11	934	872	606	1,934	3,641	0.41	4.24	11.6	21.9	39.1	64.9	73.7	99.9	100	100	100	100	100
JI-AC	4/10/2023 14:02	1,168	922	612	1,823	3,265	0.20	2.18	6.56	14.3	29.0	52.4	60.9	94.5	99.7	100	100	100	100
JI-AC	5/31/2023 14:49	842	175	290	2,942	1,742	0.19	1.90	4.72	8.51	16.9	34.5	42.3	84.2	95.2	100	100	100	100
JI-AC	6/10/2023 14:03	362	145	135	2,283	947	0.20	1.98	5.07	9.37	18.6	37.4	45.4	85.9	96.9	100	100	100	100
JI-AC	8/19/2023 23:42	25	16	6	2,512	183	0.15	1.39	3.33	6.15	11.5	23.2	28.7	66.7	82.8	86.0	94.2	100	100
JI-AC	8/20/2023 21:05	14	8	2	749	101	0.09	0.92	2.43	4.62	8.40	16.7	20.9	54.7	80.1	94.2	98.4	100	100
JO-AC	12/3/2022 18:09	186	223	142	1,500	941	0.62	6.55	18.6	34.6	54.6	76.5	83.6	99.2	100	100	100	100	100
JO-AC	12/27/2022 1:20	232	320	121	1,109	1,123	0.31	3.28	9.62	19.0	33.3	52.2	58.7	87.2	96.5	100	100	100	100
JO-AC	12/30/2022 9:41	148	182	75	756	561	0.25	2.64	7.59	15.5	29.6	50.9	58.6	89.6	97.2	100	100	100	100
JO-AC	3/10/2023 12:10	390	418	264	1,144	1,906	0.42	4.44	12.6	24.4	43.3	67.7	75.4	99.4	100	100	100	100	100
JO-AC	3/13/2023 13:13	502	500	363	1,526	2,224	0.49	5.09	14.2	26.9	46.3	72.4	80.6	100	100	100	100	100	100
JO-AC	4/10/2023 14:04	871	727	496	1,824	3,303	0.24	2.54	7.63	16.6	33.2	57.0	65.4	95.0	98.8	100	100	100	100
JO-AC	5/31/2023 14:52	216	127	80	1,530	675	0.19	1.91	5.16	10.0	19.5	36.9	43.8	77.6	91.7	99.9	100	100	100
JO-AC	6/10/2023 14:03	394	162	150	3,406	890	0.20	1.98	5.00	9.25	18.7	38.0	46.1	85.0	95.9	100	100	100	100
JO-AC	8/20/2023 0:15	36	27	17	4,444	300	0.11	1.27	4.20	9.44	20.6	46.4	58.1	99.9	100	100	100	100	100
JO-AC	8/20/2023 21:09	17	11	2	1,115	114	0.06	0.58	1.50	2.81	5.52	11.7	14.9	32.0	39.5	44.4	53.4	77.9	100

Table A.3 Raw analytical data for samples taken at Elks Club in WY23.

Sample	Sample Start (Date/Time)	Total 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	12/27/2022 1:03	25	30	7	317	113	0.12	1.20	3.15	6.12	12.4	26.6	33.7	78.5	94.7	100	100	100	100
EC-AC	12/29/2022 23:51	40	28	28	314	162	0.49	4.96	13.5	26.2	45.8	70.4	78.1	96.6	99.7	100	100	100	100
EC-AC	1/9/2023 7:53	24	20	6	273	92	0.13	1.27	3.31	6.24	12.2	26.0	32.6	71.8	87.9	99.4	100	100	100
EC-AC	3/9/2023 20:20	24	27	5	265	103	0.11	1.09	2.84	5.32	10.3	22.5	28.8	67.8	84.7	97.8	100	100	100
EC-AC	3/14/2023 6:55	22	28	5	198	483	0.11	1.12	2.99	5.65	10.5	21.9	28.0	69.7	88.1	98.0	100	100	100
EC-AC	4/8/2023 7:03	18	7	5	175	45	0.03	0.41	1.87	4.66	11.1	29.2	38.0	89.1	99.9	100	100	100	100
EC-AC	5/30/2023 14:31	42	27	9	423	129	0.09	0.91	2.59	5.38	10.9	22.0	27.1	61.0	80.7	96.2	100	100	100
EC-AC	6/4/2023 13:50	673	420	240	2,758	1,716	0.19	1.88	4.77	9.00	18.2	35.7	42.9	81.9	92.6	100	100	100	100
EC-AC	6/6/2023 13:51	140	92	53	1,032	385	0.19	1.88	5.02	10.1	20.4	38.2	44.9	78.6	92.9	100	100	100	100
EC-AC	6/11/2023 17:38	65	36	15	485	170	0.10	1.02	2.72	5.42	11.2	22.8	28.0	63.5	83.2	97.8	100	100	100

Table A.4 Raw analytical data for samples taken at Lakeshore in WY23.

Sample	Sample Start (Date/Time)	Total 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
LS-AC	12/27/2022 2:28	112	121	52	1,073	551	0.23	2.38	6.73	13.8	26.8	46.1	53.3	88.0	97.7	100	100	100	100
LS-AC	12/30/2022 13:13	49	50	41	565	223	0.59	6.06	16.7	32.0	54.2	83.5	91.6	99.9	100	100	100	100	100
LS-AC	3/10/2023 5:50	22	16	3	726	168	0.04	0.42	1.13	2.25	5.2	13.6	18.3	51.0	72.5	94.4	100	100	100
LS-AC	4/11/2023 17:35	17	9	14	548	142	0.95	8.52	19.0	31.1	51.1	79.9	90.7	100	100	100	100	100	100
LS-AC	5/27/2023 18:33	197	230	87	889	801	0.24	2.58	7.92	16.5	29.4	44.3	49.7	76.4	96.1	100	100	100	100
LS-AC	6/11/2023 20:18	52	41	22	1,105	302	0.23	2.34	6.58	13.3	25.0	42.7	49.3	81.7	93.8	99.8	100	100	100
LS-AC	6/12/2023 11:18	59	84	22	1,133	340	0.20	2.09	6.02	12.1	22.1	36.8	42.4	75.8	93.5	100	100	100	100
LS-AC	8/22/2023 7:30	108	81	45	1,806	488	0.20	2.09	5.86	12.0	23.6	42.0	49.1	85.0	97.8	100	100	100	100

Table A.5 Raw analytical data for samples taken at Pasadena in WY23.

Sample	Sample Start (Date/Time)	Total 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	12/27/2022 1:18	32	28	12	2,160	303	0.15	1.55	4.45	9.54	19.7	38.9	46.8	86.5	97.0	100	100	100	100
PO-AC	12/30/2022 11:13	40	34	22	731	223	0.30	3.05	8.33	16.7	31.9	56.1	65.0	92.3	98.6	100	100	100	100
PO-AC	1/9/2023 9:33	8	11	2	1,006	162	0.11	1.10	2.90	5.51	10.7	24.2	31.4	79.2	96.4	99.6	100	100	100
PO-AC	3/10/2023 5:06	24	25	7	1,636	1,163	0.13	1.35	3.69	7.33	14.3	28.7	35.4	75.1	90.2	98.7	100	100	100
PO-AC	3/14/2023 10:11	90	123	48	1,587	94	0.26	2.68	7.65	16.1	31.8	53.7	61.2	93.0	99.2	100	100	100	100
PO-AC	4/10/2023 15:18	24	25	8	824	195	0.16	1.64	4.50	9.11	17.7	34.2	41.7	84.4	95.2	99.9	100	100	100
PO-AC	5/30/2023 15:41	498	293	233	6,414	1,671	0.21	2.13	5.61	11.5	24.5	46.8	55.1	90.5	97.7	100	100	100	100
PO-AC	6/11/2023 18:18	98	72	35	2,814	625	0.18	1.84	4.94	9.82	19.2	35.5	42.1	80.2	95.0	100	100	100	100
PO-AC	6/22/2023 18:43	196	109	82	5,544	908	0.20	2.05	5.54	11.2	22.7	42.0	49.6	86.7	96.8	100	100	100	100
PO-AC	8/20/2023 23:16	85	61	19	5,125	663	0.11	1.10	2.99	5.96	11.5	22.3	27.7	69.0	94.3	100	100	100	100
PO-AC	9/1/2023 14:45	61	48	19	2,924	646	0.15	1.48	4.13	8.50	16.5	31.0	37.3	74.3	92.2	99.7	100	100	100

Table A.6 Raw analytical data for samples taken at Speedboat, WY23.

Sample	Sample Start (Date/Time)	Total 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	12/3/2022 18:55	136	88	77	1,634	737	0.35	3.64	10.2	19.8	34.9	56.8	64.8	93.5	99.0	99.9	100	100	100
SB-AC	12/27/2022 0:21	210	200	90	1,363	1,009	0.23	2.34	6.50	12.9	24.4	42.8	49.8	83.9	94.1	99.9	100	100	100
SB-AC	12/30/2022 0:38	128	85	82	794	478	0.50	5.16	14.0	25.6	42.0	64.1	71.6	93.2	99.3	100	100	100	100
SB-AC	1/9/2023 9:03	202	176	160	846	822	0.55	6.01	18.0	34.5	56.2	79.0	85.0	96.5	99.6	100	100	100	100
SB-AC	3/10/2023 1:33	108	150	58	864	432	0.34	3.55	9.89	18.7	32.3	53.6	61.9	95.5	99.4	100	100	100	100
SB-AC	3/13/2023 14:28	188	157	99	926	164	0.31	3.13	8.51	16.4	30.6	52.6	60.9	94.8	98.9	100	100	100	100
SB-AC	4/8/2023 7:05	117	75	55	551	406	0.24	2.40	6.41	12.5	25.0	47.2	55.5	90.0	98.1	100	100	100	100
SB-AC	6/11/2023 20:18	354	169	167	2,423	1,130	0.25	2.54	6.85	13.3	25.7	47.1	55.3	89.5	97.2	100	100	100	100
SB-AC	8/20/2023 22:33	220	123	43	4,498	967	0.13	1.26	3.18	5.75	10.4	19.4	23.8	60.7	93.1	99.9	100	100	100

Table A.7 Raw analytical data for samples taken at Tahoe City, WY23.

Sample	Sample Start (Date/Time)	Total 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	10/22/2022 15:46	56	53	17	9,188	519	0.13	1.38	4.11	8.70	16.5	31.1	38.0	79.1	93.7	100	100	100	100
TC-AC	12/3/2022 15:50	115	149	79	1,586	693	0.62	6.34	17.1	30.6	48.0	68.6	75.8	94.0	96.3	99.2	100	100	100
TC-AC	12/27/2022 5:36	118	150	57	1,135	608	0.29	3.01	8.35	16.3	29.8	48.7	55.6	87.7	97.5	100	100	100	100
TC-AC	3/9/2023 22:18	52	64	25	802	1,335	0.31	3.05	7.91	14.6	26.9	48.2	56.5	91.7	97.8	100	100	100	100
TC-AC	3/13/2023 12:58	92	89	34	687	404	0.21	2.13	5.48	10.4	20.2	37.0	43.8	81.4	95.4	100	100	100	100
TC-AC	4/8/2023 7:18	34	18	6	381	118	0.07	0.72	1.93	3.73	7.94	18.5	23.7	56.1	74.9	92.8	98.9	100	100
TC-AC	5/30/2023 10:21	21	4	2	166	57	0.01	0.13	0.49	1.19	3.39	10.7	14.6	39.9	61.4	88.2	98.3	100	100
TC-AC	8/19/2023 22:45	440	189	139	3,977	1,459	0.20	1.91	4.74	8.52	16.5	31.7	38.1	74.6	90.5	98.8	100	100	100
TC-AC	8/20/2023 22:10	42	28	11	1,242	275	0.20	1.96	5.08	9.14	15.5	27.0	32.2	65.3	84.3	96.9	98.8	100	100

Table A.8 Raw analytical data for samples taken at Tahoe Valley, WY23.

Sample	Sample Start (Date/Time)	Total 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	12/3/2022 23:28	43	36	13	1,577	400	0.13	1.26	3.89	8.94	16.8	31.1	38.2	72.6	80.3	86.3	96.9	100	100
TV-AC	12/27/2022 8:51	51	51	8	1,192	316	0.07	0.76	2.11	4.19	7.92	15.8	19.7	44.5	58.3	73.4	89.6	100	100
TV-AC	12/30/2022 6:16	56	39	35	742	223	0.41	4.11	11.1	21.2	37.6	62.7	71.3	92.9	97.8	99.7	100	100	100
TV-AC	3/9/2023 21:00	32	43	8	788	177	0.15	1.49	3.69	6.62	12.5	26.0	32.7	76.2	92.8	99.1	100	100	100
TV-AC	3/14/2023 3:20	30	41	7	712	668	0.11	1.03	2.61	4.95	10.2	22.6	28.6	74.3	93.6	100	100	100	100
TV-AC	4/8/2023 7:31	16	14	4	760	75	0.10	1.01	2.83	5.49	10.9	25.1	32.4	76.6	94.2	99.9	100	100	100
TV-AC	5/30/2023 11:01	13	9	2	760	89	0.02	0.22	0.65	1.39	3.85	12.7	17.7	54.8	79.8	98.0	100	100	100
TV-AC	6/4/2023 14:31	30	25	5	1,149	156	0.06	0.59	1.55	2.98	6.71	17.8	23.8	65.6	88.9	99.6	100	100	100
TV-AC	6/6/2023 14:08	31	10	6	867	112	0.04	0.37	0.97	2.03	6.13	19.1	25.8	67.9	88.4	99.4	100	100	100
TV-AC	6/11/2023 17:28	37	22	7	949	139	0.08	0.78	2.05	3.92	8.28	19.7	25.5	65.4	86.5	98.0	100	100	100
TV-AC	8/20/2023 20:45	29	19	11	1,290	218	0.22	2.28	6.27	12.3	21.8	37.6	44.5	77.9	92.3	99.5	100	100	100

Table A.9 Raw analytical data for samples taken at Tahoma, WY23.

Sample	Sample Start (Date/Time)	Total 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	12/3/2022 19:46	69	93	36	1,617	413	0.31	3.28	9.50	19.0	31.9	51.8	60.6	92.9	99.0	100	100	100	100
TA-AC	12/26/2022 23:38	138	114	61	1,079	494	0.27	2.68	7.17	13.8	26.0	44.4	51.6	84.8	93.8	99.6	100	100	100
TA-AC	12/30/2022 2:46	36	20	10	412	147	0.16	1.59	4.07	7.31	13.4	26.9	33.4	72.8	89.2	97.6	100	100	100
TA-AC	3/9/2023 20:53	18	13	5	321	73	0.13	1.30	3.45	6.70	13.3	27.9	34.3	75.3	92.8	99.8	100	100	100
TA-AC	3/13/2023 14:21	24	17	5	361	86	0.10	0.98	2.59	4.98	9.79	21.2	26.7	63.6	83.5	96.4	99.5	100	100
TA-AC	4/8/2023 7:20	11	6	1	253	38	0.02	0.18	0.61	1.41	3.19	8.43	11.6	38.7	61.6	86.2	97.8	100	100
TA-AC	5/30/2023 10:13	5	1	1	98	20	0.00	0.00	0.07	1.58	5.30	15.1	24.7	71.1	99.4	100	100	100	100
TA-AC	6/10/2023 15:31	29	23	6	770	140	0.11	1.12	3.06	6.05	11.5	22.1	27.0	59.5	79.9	96.2	100	100	100
TA-AC	8/20/2023 21:48	114	63	23	1,874	471	0.13	1.29	3.44	6.38	11.1	20.0	24.2	58.0	79.7	91.4	95.8	100	100

Table A.10 Raw analytical data for samples taken at Upper Truckee, WY23.

Sample	Sample Start (Date/Time)	Total 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	11/7/2022 14:10	223	299	77	4,468	940	0.21	2.12	5.89	11.4	20.2	34.6	40.8	77.9	93.5	100	100	100	100
UT-AC	12/3/2022 14:55	283	321	166	3,613	852	0.39	4.12	12.0	23.3	39.1	58.8	65.9	96.7	99.6	100	100	100	100
UT-AC	12/26/2022 23:53	290	289	155	1,605	1,098	0.29	3.06	8.73	17.6	32.9	53.3	60.1	87.6	97.0	100	100	100	100
UT-AC	12/29/2022 22:45	168	165	139	924	535	0.65	6.82	19.2	35.7	57.8	82.9	90.0	100	100	100	100	100	100
UT-AC	3/9/2023 18:55	220	273	128	1,250	915	0.36	3.67	10.2	19.9	36.0	58.4	66.1	96.7	99.5	100	100	100	100
UT-AC	3/14/2023 8:00	248	540	128	1,391	242	0.31	3.30	9.55	19.1	33.7	51.8	58.5	89.0	97.0	100	100	100	100
UT-AC	4/8/2023 12:50	50	68	17	528	194	0.19	1.97	5.49	10.7	19.5	34.0	40.1	79.7	95.8	100	100	100	100
UT-AC	6/4/2023 14:43	107	92	31	2,078	456	0.15	1.46	3.82	7.33	14.4	29.1	35.6	76.6	95.1	100	100	100	100
UT-AC	6/11/2023 17:36	83	70	26	2,059	353	0.14	1.44	3.97	7.96	15.7	30.8	37.3	70.2	88.0	99.7	100	100	100
UT-AC	8/20/2023 21:33	52	57	17	3,209	417	0.14	1.46	4.69	10.5	19.4	33.6	38.7	58.0	87.6	98.9	100	100	100

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/MS samples for several sediment indicators (TSS, turbidity, FSP, and particle size class) may be due to fluctuations in sediment concentrations from minute to minute. Two MS samples cannot be triggered at the same time and end up occurring 1-3 minutes apart. Differences in paired MS/GS samples for several sediment indicators are likely because the autosampler does not sample from the exact same place as the grab sample is taken from.

Table B.1 MS and GS sample data from WY23. Paired sample results with a difference between them of greater than 20% are highlighted pink.

Sample	Sample Start (Date/Time)	Total 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-MS	12/27/2022 14:01	26	20	12	4,629	123	0.41	4.04	9.80	15.4	23.9	45.4	55.4	91.4	97.9	99.8	100	100	100
TC-GS	12/27/2022 14:02	25	19	10	4,981	117	0.39	3.74	8.91	13.9	21.4	40.0	49.5	86.4	94.4	99.3	100	100	100
TA-MS	3/15/2023 11:31	13	11	4	322	78	0.16	1.67	4.51	8.5	15.7	30.6	38.4	83.3	97.1	99.8	100	100	100
TA-MS	3/15/2023 11:32	14	11	3	333	67	0.12	1.22	3.19	5.9	11.0	22.9	29.4	68.7	88.4	98.6	100	100	100
EC-MS	6/6/2023 13:53	279	165	140	2,352	978	0.26	2.63	7.18	14.5	28.9	50.3	57.8	88.9	97.1	100	100	100	100
EC-MS	6/6/2023 13:55	275	174	142	2,092	884	0.27	2.69	7.27	14.5	29.1	51.6	59.5	91.0	98.0	100	100	100	100
TA-MS	6/10/2023 15:48	74	54	22	1,557	324	0.17	1.73	4.65	9.1	17.0	29.4	34.4	66.5	83.7	97.3	100	100	100
TA-MS	6/10/2023 15:50	65	52	18	1,414	308	0.16	1.65	4.44	8.7	16.3	28.2	33.0	64.6	81.8	96.5	99.2	100	100
TV-MS	6/11/2023 18:41	112	73	29	2,065	413	0.11	1.09	2.96	6.1	12.5	25.5	31.4	70.4	90.2	100	100	100	100
TV-MS	6/11/2023 18:43	87	65	22	1,941	439	0.11	1.07	2.95	6.1	12.5	25.1	30.8	67.9	87.8	99.9	100	100	100
UT-MS	6/11/2023 19:01	102	94	33	3,263	353	0.15	1.51	4.13	8.2	16.4	32.2	38.8	75.1	92.9	100	100	100	100
UT-MS	6/11/2023 19:03	96	87	31	2,871	372	0.15	1.53	4.19	8.4	16.6	32.6	39.3	75.7	92.3	100	100	100	100
PO-MS	6/11/2023 19:05	174	94	71	4,224	827	0.20	1.98	5.37	10.9	22.0	41.0	48.6	87.5	98.0	100	100	100	100
PO-MS	6/11/2023 19:06	180	117	67	4,762	801	0.18	1.83	4.91	9.9	20.0	37.3	44.3	83.4	96.6	100	100	100	100

Table B.2 Field blank sample data from all sites in WY23. No values were greater than the method detection limit indicating no contamination. All samples were too clear for PSD analysis.

Sample	Sample Start (Date/Time)	Total 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-FB	12/28/2022 10:00	<0.4	0	na	<40	2	na	na	na	na	na	na	na	na	na	na	na	na	na
LS-FB	12/30/2022 14:30	<0.4	0	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na
PO-FB	12/28/2022 10:30	<0.4	0	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na
TA-FB	8/21/2023 7:00	<0.4	0	na	<40	5	na	na	na	na	na	na	na	na	na	na	na	na	na
TV-FB	12/28/2022 10:15	<0.4	0	na	<40	2	na	na	na	na	na	na	na	na	na	na	na	na	na
UT-FB	12/3/2022 15:01	<0.4	0	na	<40	<2	na	na	na	na	na	na	na	na	na	na	na	na	na