Seasonal Progress Report #21
SR431 Treatment Vault Effectiveness Monitoring

Agreement Number: P367-18-018

Submitted by: Tahoe Resource Conservation District

Submitted to: Nevada Department of Transportation

Current Contract Term: July 1, 2021 – June 30, 2023

Water Year: 2023

Period: Summer Season, October 1, 2022 –February 28, 2023

Submission Date: April 19, 2023

Two stormwater filter vaults, a Contech Media Filtration System (MFS) and a Jellyfish Filter, were installed by the Nevada Department of Transportation (NDOT) on State Highway 431 (SR431) above Incline Village, Nevada in 2013. Monitoring equipment was installed at the inflows and outflows of these two vaults. The Tahoe Resource Conservation District (Tahoe RCD) continued the effectiveness monitoring efforts of the Desert Research Institute (DRI) at the four monitoring stations on May 1, 2015 and will continue to monitor through the spring of water year 2023 (May 31, 2023) and beyond if funding allows. A new contract was executed for July 1, 2021 - June 30, 2023 to allow for this. Tahoe RCD follows sampling protocols outlined in the Regional Stormwater Monitoring Program Framework and Implementation Guidance document (RSWMP FIG Update, Tahoe RCD et al 2017). Tahoe RCD appreciates the opportunity to provide these water quality monitoring services for NDOT and looks forward to continuing the partnership.

Tasks and subtasks associated with this project and a summary of work completed to date are described below. Table 1 provides a summary of tasks, due dates and percent completion to date for the current agreement. ASWMR refers to the Annual Stormwater Monitoring Report submitted each year to the Nevada Division of Environmental Protection (NDEP) on March 31st as part of the IMP partnership.

Table 1 Summary of tasks, due dates, and percent completion to date.

Task	Description	Due Date	% Of Work Complete	Date Submitted
1	Project Administration			
1.1	Quarterly Invoices	10/31/21, 1/31/22, 4/30/22, 7/31/22, 10/31/22, 1/31/23, 4/30/23, 7/31/23	ongoing	11/8/21, 3/23/22, 6/17/22, 7/28/22, 2/23/23
1.2	Seasonal Progress Reports	10/31/21, 3/31/22, 6/30/22, 10/31/22, 3/31/23, 6/30/23	ongoing	11/5/21, 3/31/22, 6/30/22, 10/31/22, 4/19/23
2	Stormwater Monitoring			
2.1	Collect continuous flow and turbidity data at four monitoring stations	5/31/2023	ongoing	Available on Acuity
2.2	Collect stormwater runoff samples during eight events per year	5/31/2023	ongoing	NA
2.3	Collect three diurnal non-event snowmelt events if conditions allow	5/31/2023	ongoing	NA
2.4	Collect flow bypass data in both vaults	5/31/2023	ongoing	Available in Seasonal Progress Reports
2.5	Provide precipitation data to date	5/31/2023	ongoing	Available in Seasonal Progress Reports
2.6	Provide hydrograph, turbidity, and sample distribution graphs to date	5/31/2023	ongoing	Available in Seasonal Progress Reports
3	Condition Assessments			
3.1	Estimate Road RAM score prior to eight sampled events	Discontinued as of June 1, 2021	100%	NA
3.2	Measure depth of sediment in both vaults after sampled events	5/31/2023	ongoing	Available in Seasonal Progress Reports
4	Final Report			
4.1	Provide raw data	3/31/2022, 3/31/2023	ongoing	ASWMR
4.2	Provide treatment effectiveness analysis	3/31/2022, 3/31/2023	ongoing	ASWMR
4.3	Correlate Road RAM score to pollutant concentration and load	Discontinued WY20	100%	ASWMR
4.4	Provide mass loading v. volume calculations for select events	6/30/2016	100%	3/31/16, 6/30/16

Task 1: Project Administration

1. Invoices

Quarterly invoices will be submitted for this project covering the following periods:

1) July 1, 2021 - September 30, 2021 (due October 31, 2021)
2) October 1, 2021 - December 31, 2021 (due January 31, 2022)
3) January 1, 2022 - March 31, 2022 (due April 30, 2022)
4) April 1, 2022 - June 30, 2022 (due July 31, 2022)
5) July 1, 2022 - September 30, 2022 (due October 31, 2022)
6) October 1, 2022 - December 31, 2022 (due January 31, 2023)
7) January 1, 2023 - March 31, 2023 (due April 30, 2023)
8) April 1, 2023 - June 30, 2023 (due July 31, 2023)

2. Progress Reports

Progress reports are not concurrent with quarterly invoices. Seasonal progress reports will be submitted for this project covering the following periods (report number is consistent with prior agreement's reports beginning May 2015):

#17: Summer: June 1, 2021 - September 30, 2021 (due October 31, 2021)
#18: Fall/winter: October 1, 2021 - February 28, 2022 (due March 31, 2022)
#19: Spring: March 1, 2022 - May 31, 2022 (due June 30, 2022)
#20: Summer: June 1, 2022 - September 30, 2022 (due October 31, 2022)
#21: Fall/winter: October 1, 2022 - February 29, 2023 (due March 31, 2023)
#22: Spring: March 1, 2023 - May 31, 2023 (due June 30, 2023)

Please accept this report as seasonal progress report #21 for the fall/winter season of water year 2023.

Task 2: Stormwater Monitoring

1. Maintain four stormwater monitoring stations to collect continous flow and turbidity data

The record-breaking fall/winter season of WY23 began on October 1, 2022 and ended February 28, 2023. Continuous flow and turbidity were successfully monitored for the fall/winter season at all sites.

See Figure 1-Figure 4 for photos of the historic snowfall at SR431.

Figure 1 Berm at SR431 pullout on January 6, 2023.

Figure 2 Berm at SR431 pullout on January 6, 2023.

Figure 3 Berm at SR431 pullout on January 31, 2023.

Figure 4 Berm at SR431 pullout on January 31, 2023.

2. Collect stormwater runoff samples at four monitoring sites during eight runoff events per year

During the fall/winter season, three events were successfully sampled at Contech Inflow (CI), Jellyfish Inflow (JI), Jellyfish Outflow (JO), and Contech Outflow (JO), (a rain on snow event on December 3, 2022, an atmospheric river rain on snow event on December 27, 2022, and an atmospheric river rain on snow event on December 29-30, 2022). No samples were taken in January and February due to insufficient flow for sampling. Typically 6-12 samples should be taken per event at each site, however due to low flow and brief periods of flow, less than 6 samples were collected during the December 3, 2023 rain on snow event at Contech Outflow and Jellyfish Outflow (see Appendix A, Figure 11-Figure 22 at the end of this report for hydrographs, continous turbidity, and sample distributions for the events sampled). The successful samples were composited and sent to the lab for analysis. This brings the water year total to three sampled events at Jellyfish Inflow, Contech Inflow, Jellyfish Outflow, and Contech Outflow.

3. If conditions allow for non-event snowmelt sampling, analyze a rising and a falling limb composite during three diurnals (counts as one of the eight events)

This task is only applicable in the spring season.

4. Install a pressure transducer in each treatment vault to identify when there is bypass flow

New pressure transducers were installed in June 2016 and linked to the remote access data management system currently used at the SR431 monitoring site. Data indicate that during the fall/winter of WY23 the Contech MFS cartridge filters bypassed two times (on December 27, 2022 and December 30, 2022 during at atmospheric river rain on snow event) and the Jellyfish filters were bypassed zero times (Figure 5 & Figure 6).

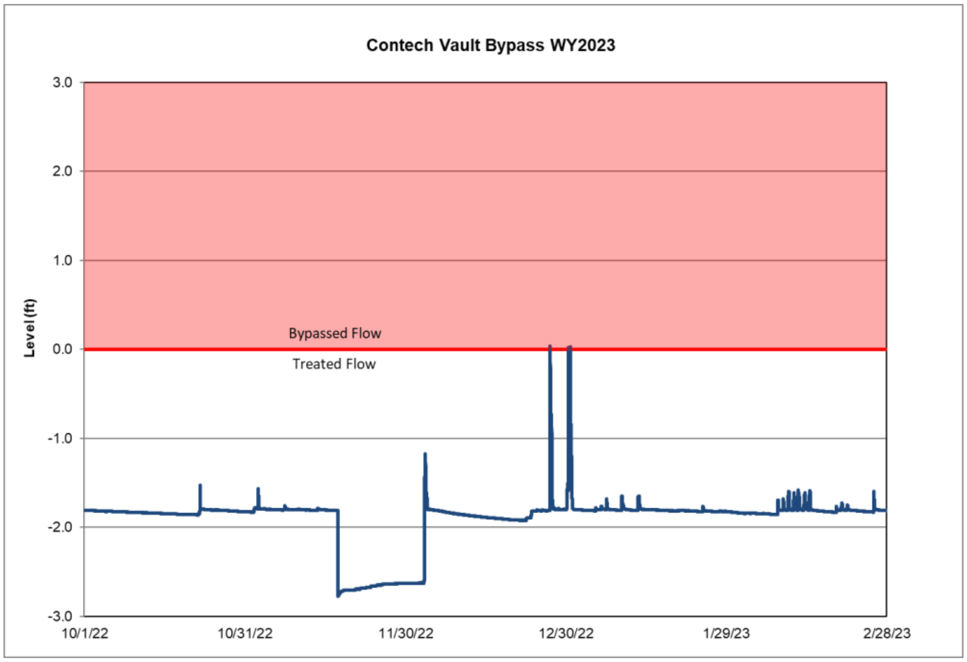

Figure 5 Bypassed flow in the Contech MFS vault for WY23.

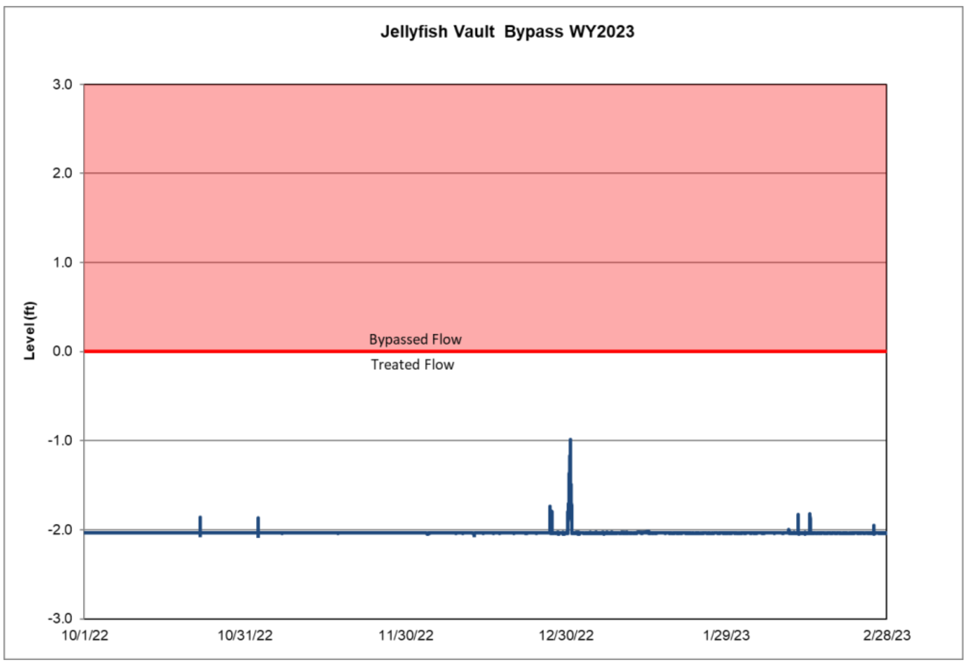

Figure 6 Bypassed flow in the Jellyfish vault for WY23.

5. Provide precipitation data to date

Table 2 provides summary data for all 27 fall/winter WY22 precipitation events recorded at the NDOT meteorological stations including event start and end dates, total precipitation, peak precipitation, minimum and maximum temperature, and precipitation type. Due to historic snowfall amounts, during the February 24, 2023 snow event, the weather station became buried. Data from the nearby TERC2 weather station are substituted for the time period after burial until the weather station melts out. Events highlighted in green were sampled for water quality. Because of its high elevation, precipitation often falls in the form of snow during fall/winter and spring and thus does not always generate sufficient runoff for sampling. In general, events consisting of less than 0.5 inches of rain do not produce sufficient runoff for sampling. However, some events less than 0.5 inches can be successfully sampled.

Table 2 Summary of fall/winter precipitation events at SR431 for WY23. Highlighted rows indicate events that were sampled.

Station ID	Precip Event (#)	Precipitation event start (PST)	Event end (PST)	Event duration (days)	Interevent duration (days)	Event precipitation (inches)	Event peak precipitation (inch/5min)	Event minimum temp (°C)	Event maximum temp (°C)	Type of Precipitation
NDOT	--	--	9/21/2022 11:10	--	--	--	--	--	--	--
NDOT	NDOT-23-01	10/22/2022 6:25	10/22/2022 15:30	0.378	30.8	0.1400	0.016	-2	8	Rain, Snow
NDOT	NDOT-23-02	11/1/2022 14:05	11/2/2022 18:20	1.177	9.9	0.4030	0.019	-6	-1	Snow
NDOT	NDOT-23-03	11/6/2022 0:00	11/9/2022 8:35	3.358	3.2	0.8220	0.019	-8	5	Rain, Snow
NDOT	NDOT-23-04	11/12/2022 15:00	11/12/2022 21:50	0.285	3.3	0.1080	0.008	-5	-2	Snow
NDOT	NDOT-23-05	11/26/2022 7:25	11/26/2022 7:35	0.007	13.4	0.0120	0.008	-2	-1	?
NDOT	NDOT-23-06	12/1/2022 6:00	12/6/2022 3:30	4.896	4.9	2.1230	0.019	-14	4	Rain/Snow
NDOT	NDOT-23-07	12/8/2022 20:50	12/9/2022 1:45	0.205	2.7	0.0720	0.004	-5	-4	Snow
NDOT	NDOT-23-08	12/10/2022 6:05	12/12/2022 13:35	2.313	1.2	1.2620	0.047	-13	-1	Rain, Snow
NDOT	NDOT-23-09	12/26/2022 23:35	1/2/2023 21:25	6.910	14.4	6.3640	0.031	-13	3	Rain/Snow
NDOT	NDOT-23-10	1/4/2023 9:00	1/5/2023 22:50	1.576	1.5	0.8680	0.016	-4	4	Rain/Snow
NDOT	NDOT-23-11	1/7/2023 17:40	1/11/2023 23:35	4.247	1.8	3.3960	0.027	-6	0	Rain/Snow
NDOT	NDOT-23-12	1/13/2023 12:45	1/16/2023 21:45	3.375	1.5	2.0160	0.027	-8	3	Snow
NDOT	NDOT-23-13	1/18/2023 19:55	1/21/2023 13:20	2.726	1.9	1.4750	0.105	-14	6	Snow
NDOT	NDOT-23-14	1/29/2023 10:20	1/29/2023 10:20	0.000	7.9	0.0040	0.004	-7	-7	Snow
NDOT	NDOT-23-15	1/30/2023 20:35	1/30/2023 20:35	0.000	1.4	0.0040	0.004	-9	-9	Snow
NDOT	NDOT-23-16	2/5/2023 4:35	2/7/2023 19:30	2.622	5.3	0.0440	0.004	-12	7	Snow
NDOT	NDOT-23-17	2/12/2023 3:50	2/12/2023 3:50	0.000	4.3	0.0040	0.004	-3	-3	Snow
NDOT/TERC2	NDOT-23-18	2/24/2023 11:15	3/1/2023 12:25	5.049	12.3	1.3440	0.012	-11	2	Snow
NDOT/TERC2	NDOT-23-19	3/4/2023 12:40	3/5/2023 19:45	1.295	3.0	0.4320	0.016	-5	-2	Snow
NDOT/TERC2	NDOT-23-20	3/7/2023 1:55	3/7/2023 6:20	0.184	1.3	0.0640	0.008	-3	-3	Snow
NDOT/TERC2	NDOT-23-21	3/8/2023 7:35	3/8/2023 13:40	0.253	1.1	0.0960	0.016	-3	-2	Snow
NDOT/TERC2	NDOT-23-22	3/9/2023 15:10	3/14/2023 21:20	5.257	1.1	4.0820	0.035	-2	-1	Rain/Snow
NDOT/TERC2	NDOT-23-23	3/19/2023 9:25	3/20/2023 0:45	0.639	4.5	0.2640	0.012	-1	-1	Snow
NDOT/TERC2	NDOT-23-24	3/21/2023 10:05	3/22/2023 1:25	0.639	1.4	0.0520	0.008	-1	-1	Snow
NDOT/TERC2	NDOT-23-25	3/23/2023 6:45	3/23/2023 7:25	0.028	1.2	0.0240	0.008	-1	-1	Snow
NDOT/TERC2	NDOT-23-26	3/28/2023 9:50	3/29/2023 19:40	1.410	5.1	0.4680	0.012	-1	-1	Snow
NDOT/TERC2	NDOT-23-27	4/2/2023 22:30	4/3/2023 10:35	0.503	4.1	0.0680	0.012	-3	-2	Snow

6. Provide hydrograph, continuous turbidity, and sample distribution graphs for each sampled event

See Appendix A, Figure 11 - Figure 22 at the end of this report for hydrographs, continous turbidity, and sample distributions for the events sampled in the summer season of WY23.

Task 3: Condition Assessments

1. Estimate Road RAM score prior to monitored runoff events

This task was initiated in November 2015 following a meeting between Tahoe RCD and NDOT where it was decided that determining a Road RAM score prior to runoff events was valuable. However, after five and a half years of collecting this data, it was clear that there is no relationship between Road RAM score and event mean sediment concentration at the SR431 site and this task was discontinued beginning June 1, 2021 (summer season of water year 2021).

2. Measure depth of sediment in vaults after eight monitored runoff events

This task was initiated November 2015 following the meeting between Tahoe RCD and NDOT mentioned above where it was determined that post event sediment depth was valuable information. The depths shown in Table 3 represent the average depth in each vault in feet. All clean-outs restored sediment depth in the respective vaults to near zero. Summer and fall of WY18 were dry and minimal sediment accumulation occurred by January of 2019 (~0.1 feet for both the Contech MFS and the Jellyfish). No sediment accumulation measurements were conducted during the lapse of funding that occurred July 2018-December 2018. February 2019 was the snowiest month on record for many areas in the Tahoe basin, and therefore it was not possible to conduct sediment accumulation until May 2019 due to lack of access to the vaults. By May 2019 substantial sediment had entered the system and a cleanout was performed in June 2019, restoring the sediment depth to zero. A small amount of sediment accumulation occurred by the end of summer WY19 due to a series of thunderstorms in September. Little to no sediment accumulation occurred during the fall/winter of WY20. Some sediment accumulation was observed during the spring of WY20. Both vaults were vactored on May 12, 2020. Little to no sediment accumulation was observed at the Contech vault over the summer of WY20, possibly due to the fact that sediment accumulation in the splitter chamber was preferentially routing flow to the Jellyfish. The Jellyfish vault saw 0.13 feet of summertime sediment accumulation (from 0.11 feet in June 2020 to 0.24 feet in September 2020). Little to no sediment accumulation occurred during the fall/winter of WY21 in either vault. Both the Contech and the Jellyfish vaults were vactored on March 8, 2021. A small amount of sediment accumulation occurred during the spring of WY21. The pipes from the splitter vault to the outflows were cleaned with a pressure washer by Tahoe RCD on May 11, 2021. Minimal sediment accumulation occurred over the summer of WY21. The system was fully vactored and rinsed on October 21, 2021, and the filters to both the Contech MFS and the Jellyfish were replaced. There was minimal sediment accumulation during the fall/winter and spring of WY22. In the summer of WY22 there was minimal sediment accumulation in the Jellyfish vault and some accumulation in the Contech vault. On November 17, 2022 NDOT rinsed the Contech MFS filters and vactored the hydrodynamic separator, the splitter vault, splitter to inflow pipes, and Contech MFS vault. In the record-breaking fall/winter of WY23, the manhole access to the vaults became inaccessible, so sediment depth was not recorded after the sampled events.

Table 3 Average depth of sediment in vaults.

Date Time	Contech MFS (ft)	Jellyfish (ft)
12/30/2015	0.33	0.92
3/16/2016	0.58	1.14
4/15/2016	0.61	na
4/22/2016	0.56	na
6/3/2016	0.75	2.17
8/3/2016	1.10	2.05
10/20/2016	na	1.92
12/30/2016	0.10	0.05
4/3/2016	1.00	2.30
4/20/2017	1.90	2.85
5/1/2017	0.10	0.43
5/18/2017	0.08	0.37
5/22/2017	0.10	0.46
6/19/2017	0.12	0.38
8/19/2017	0.00	0.00
9/21/2017	0.01	0.10
10/5/2017	0.03	0.15
10/24/2017	0.00	0.04
11/14/2017	0.10	1.19
11/17/2017	0.00	0.10
2/2/2018	0.17	0.30
4/7/2018	0.00	0.05

Table 3 Continued.

Date Time	Contech MFS (ft)	Jellyfish (ft)
5/17/2018	0.08	0.36
1/2/2019	0.10	0.09
5/8/2019	0.25	0.38
6/25/2019	0.00	0.00
10/21/2019	0.10	0.09
2/26/2020	0.10	0.12
4/22/2020	0.19	0.38
6/17/2020	0.10	0.11
8/7/2020	0.10	0.13
9/3/2020	0.10	0.24
11/4/2020	0.08	0.22
2/16/2021	0.06	0.22
3/22/2021	0.06	0.09
5/11/2021	0.10	0.11
6/9/2021	0.10	0.03
10/13/2021	0.06	0.09
10/26/2021	0.06	0.09
1/27/2022	0.00	0.09
3/30/2022	0.06	0.07
4/22/2022	0.06	0.09
5/18/2022	0.06	0.09
9/29/2022	0.15	0.09
10/25/2022	0.10	0.09

Task 4: Final Report

1. Provide raw data

Final reporting for each water year is provided as part of the Annual Stormwater Monitoring Report (due March 31st of each year), but raw data can be viewed at any time on Acuity.

2. Provide treatment effectiveness analysis following formats outlined in the RSWMP FIG

Final reporting for each water year is provided as part of the Annual Stormwater Monitoring Report (due March 31st of each year) which includes treatment effectiveness evaluations for FSP, TN, and TP on a seasonal and annual basis as well as for sampled events. The data for FSP in the Annual Stormwater Monitoring Report is based on water quality samples and continuous turbidity. However, treatment effectiveness for FSP for WY23 is provided for all events for the Contech MFS in Table 4 and the Jellyfish in Table 5 based on continuous turbidity, a proxy measurement for FSP (2NDNATURE et al 2014). Removal efficiencies in red indicate that FSP was flushed from the system or that outflow turbidity sensors were inundated with accumulated sediment. A removal efficiency of 100% indicates no outflow from the Contech MFS vault, which occurs when influent volumes are less than 3,000 cubic feet (the approximate storage capacity of the Contech MFS vault) and the vault can accommodate the new flow. Sometimes the vault is full from a previous event and even small inflow volumes will result in outflow. The holding capacity of the Contech MFS is likely what allows it to generally be more efficient than the Jellyfish; not only because it often doesn't outflow, but also because sediment has the opportunity to settle out during the longer residence time in the vault.

For both the Contech MFS and the Jellyfish in general, FSP removal efficiency steadily declined from October 2023 through December 2023, from 97% to 29% in the Contech MFS and from 90% to 17% in the Jellyfish. The large runoff events occurred in this period and there was likely a significant build up of sediment in the system that contributed to the decline. There was no flow recorded at either site during January. In February there were several periods of very low flow snowmelt. At the Contech MFS removal efficiencies were 100% because 100% of the flow was retained in the vault. Likewise, removal efficiencies in the Jellyfish were between 95% and 99% in February because of very low flows and half or more of the flow being retained in the vault.

Table 4 Contech MFS FSP removal efficiency for each event of fall/winter WY23.

CONTECH MFS WY23									
Runoff Start Date Time	Runoff End Date Time	Runoff Type	Event Duration	Influent Volume (cf)	Effluent Volume (cf)	Influent FSP (lbs)	Effluent FSP (lbs)	FSP Removal Efficiency	Volume Retained
10/22/22 15:15	10/22/22 15:50	Rain, Snow	0:35	34	10	0.14	0.02	88%	70%
11/2/22 12:40	11/2/22 13:25	Event Snowmelt	0:45	27	5	0.25	0.01	97%	80%
12/3/22 14:40	12/4/22 0:00	Rain on Snow	9:20	301	147	2.82	1.27	55%	51%
12/27/22 1:10	12/27/22 9:45	Rain on Snow	8:35	1,485	1,143	27.35	15.95	42%	23%
12/30/22 5:05	12/31/22 3:55	Rain on Snow	22:50	5,047	3,972	32.90	23.29	29%	21%
2/9/23 15:45	2/9/23 17:30	Snowmelt	1:45	12	0	0.08	0.00	100%	100%
2/10/23 16:05	2/10/23 16:45	Snowmelt	0:40	3	0	0.02	0.00	100%	100%
2/11/23 10:55	2/11/23 11:45	Snowmelt	0:50	15	0	0.07	0.00	100%	100%
2/13/23 14:50	2/13/23 16:10	Snowmelt	1:20	15	0	0.03	0.00	100%	100%
2/25/23 13:05	2/25/23 14:25	Event Snowmelt	1:20	7	0	0.02	0.00	100%	100%

Table 5 Jellyfish FSP removal efficiency for each event of fall/winter WY23.

JELLYFISH WY23									
Runoff Start Date Time	Runoff End Date Time	Runoff Type	Event Duration	Influent Volume (cf)	Effluent Volume (cf)	Influent FSP (lbs)	Effluent FSP (lbs)	Removal Efficiency	Volume Retained
10/22/22 15:15	10/22/22 16:10	Rain, Snow	0:55	54	25	0.20	0.02	90%	54%
11/2/22 12:40	11/2/22 14:20	Event Snowmelt	1:40	57	21	0.34	0.03	90%	63%
12/3/22 14:35	12/4/22 1:50	Rain on Snow	11:15	341	183	2.17	1.34	38%	46%
12/27/22 0:30	12/27/22 12:45	Rain on Snow	12:15	1,742	1,637	22.54	16.61	26%	6%
12/30/22 4:15	12/31/22 5:15	Rain on Snow	25:00	5,512	4,819	25.93	21.42	17%	13%
2/9/23 13:25	2/9/23 17:55	Snowmelt	4:30	54	25	1.50	0.07	95%	54%
2/10/23 14:55	2/10/23 17:25	Snowmelt	2:30	30	8	0.80	0.02	98%	73%
2/11/23 10:55	2/11/23 15:35	Snowmelt	4:40	76	27	1.61	0.03	98%	65%
2/12/23 13:50	2/12/23 17:20	Snowmelt	3:30	32	8	0.45	0.01	98%	75%
2/13/23 11:45	2/13/23 16:30	Snowmelt	4:45	85	39	1.26	0.04	97%	54%
2/25/23 13:00	2/25/23 14:50	Event Snowmelt	1:50	26	13	0.75	0.01	99%	50%

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. This statement holds true for the inflow sites at SR431. For the outflow sites at SR431, trend analysis will give insight into the effectiveness of maintenance activities in sustaining FSP removal efficiencies of the treatment vaults.

Average annual loads for FSP, TN, and TP presented in this section are normalized by both catchment size (acres) and inches of precipitation to detect load reductions resulting from improved management activities within the catchment and for comparison between water years. 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 the SR431 catchment show whether there is an upward, downward, or neutral trend in average annual loading of FSP, TN, and TP at each site. Also presented 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 catchment. Tau is a non-parametric measure of the relationship between data when data does not have a normal distribution, similar to the r^2 value in a regression on normally distributed data. Tau is a measure of the correspondence between two rankings, in this case 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 2022. 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. Trends data is updated annually with the Annual Stormwater Monitoring Report, so data shown here is only through the end of WY22.

Trends data for the Contech MFS inflow is shown in Figure 7 and Table 6. Trends data for the Contech MFS outflow is shown in Figure 8 and Table 7. Trends data for the Jellyfish inflow is shown in Figure 9 and Table 8. Trends data for the Jellyfish outflow is shown in Figure 10 and Table 9.

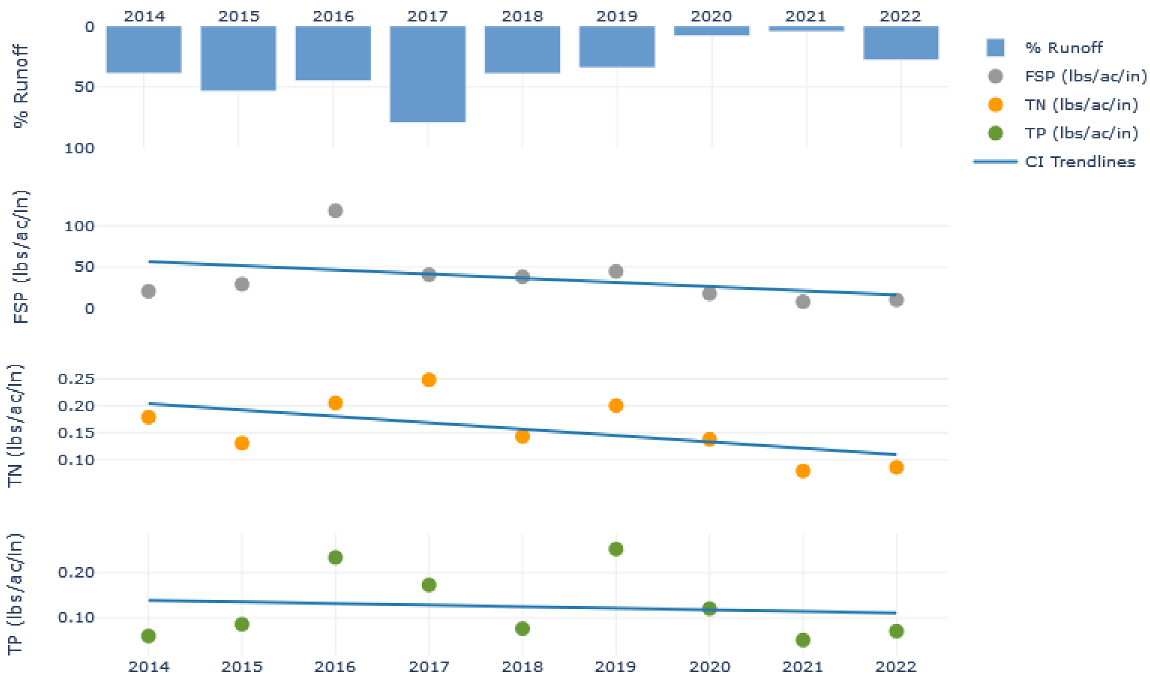

Figure 7 9-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Contech MFS Inflow, WY14-22.

- 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).
- 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 6 9-year seasonal and annual rainfall normalized pollutant loads at the Contech MFS Inflow, WY14-22.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	38.6%	8.358	43.467	23.094	20.612	0.065	0.230	0.386	0.179	0.021	0.122	0.079	0.060
2015	53.2%	29.875	41.461	7.517	29.122	0.127	0.164	0.086	0.130	0.097	0.110	0.015	0.086
2016	44.7%	84.812	183.564	0.000	118.153	0.179	0.260	0.000	0.205	0.149	0.399	0.000	0.234
2017	78.9%	19.239	139.993	20.235	40.646	0.178	0.611	0.048	0.248	0.064	0.688	0.035	0.173
2018	39.0%	23.391	51.881	20.808	38.173	0.136	0.116	0.554	0.143	0.083	0.068	0.113	0.076
2019	34.2%	11.578	153.825	8.569	44.624	0.083	0.565	0.227	0.200	0.066	0.866	0.070	0.253
2020	8.0%	9.896	26.907	39.794	17.783	0.040	0.148	0.723	0.138	0.068	0.175	0.288	0.120
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%	3.207	44.045	10.423	10.133	0.050	0.191	0.183	0.085	0.030	0.267	0.076	0.070
Tau	na	-0.500	-0.222	0.222	-0.333	-0.444	-0.167	0.278	-0.389	-0.278	0.167	0.389	-0.111
P-Value	na	0.061	0.404	0.404	0.211	0.095	0.532	0.297	0.144	0.297	0.532	0.144	0.677
Theil Slope (per year)	na	-3.820	-2.955	0.595	-3.116	-0.018	-0.009	0.040	-0.013	-0.008	0.011	0.014	-0.002

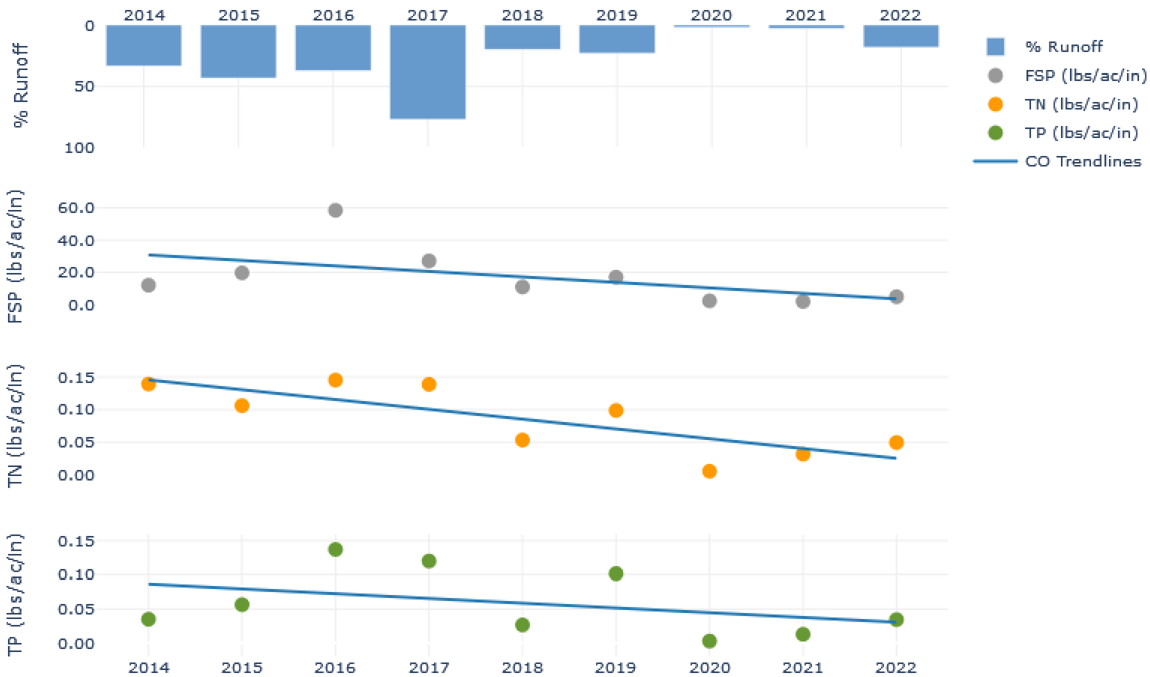

Figure 8 9-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Contech MFS Outflow, WY14-22.

- Percent runoff varied between 1.9% in WY21 to 76.9% in WY17.
- Differences in % runoff between CI and CO are due to the holding capacity of the Contech MFS vault.
- There is no significant trend in normalized annual FSP loads (p>0.05). There is a significant trend in the normalized seasonal fall/winter FSP Loads (p=0.028 and Tau=-0.592).
- There is a significant trend in normalized annual TN loads (p=0.022 and Tau=-0.611). There is also a significant trend in the normalized seasonal fall/winter TN Loads (p=0.046 and Tau=-0.535).
- There is no significant trend in normalized annual TP loads (p>0.05).
- Significant trends in normalized loads may indicate improved maintenance of the Contech MFS vault.

Table 7 9-year seasonal and annual rainfall normalized pollutant loads at the Contech MFS Outflow, WY14-22.

Year	% Runoff	FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
		Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	33.4%	5.379	24.072	13.952	12.066	0.049	0.148	0.340	0.139	0.012	0.065	0.054	0.035
2015	43.0%	21.341	26.666	4.092	19.693	0.095	0.119	0.120	0.106	0.062	0.071	0.018	0.056
2016	37.3%	51.444	73.789	0.000	58.555	0.115	0.207	0.000	0.145	0.115	0.181	0.000	0.137
2017	76.9%	14.183	88.657	9.395	27.130	0.063	0.500	0.041	0.139	0.041	0.494	0.016	0.120
2018	19.8%	12.986	9.207	11.693	10.958	0.063	0.025	0.325	0.054	0.048	0.005	0.076	0.027
2019	23.1%	4.984	56.048	9.371	17.041	0.041	0.271	0.163	0.099	0.028	0.340	0.060	0.102
2020	1.9%	0.000	0.000	24.274	2.351	0.000	0.000	0.063	0.006	0.000	0.000	0.030	0.003
2021	2.7%	0.000	8.591	3.190	1.971	0.000	0.069	0.271	0.032	0.000	0.051	0.036	0.013
2022	18.3%	1.630	20.140	5.956	4.877	0.027	0.098	0.149	0.050	0.014	0.129	0.042	0.034
Tau	na	-0.592	-0.278	-0.056	-0.500	-0.535	-0.222	0.000	-0.611	-0.423	-0.056	0.167	-0.333
P-Value	na	0.028	0.297	0.835	0.061	0.046	0.404	1.000	0.022	0.116	0.835	0.532	0.211
Theil Slope (per year)	na	-2.827	-3.364	-0.081	-2.933	-0.011	-0.012	0.000	-0.016	-0.008	-0.002	0.003	-0.006

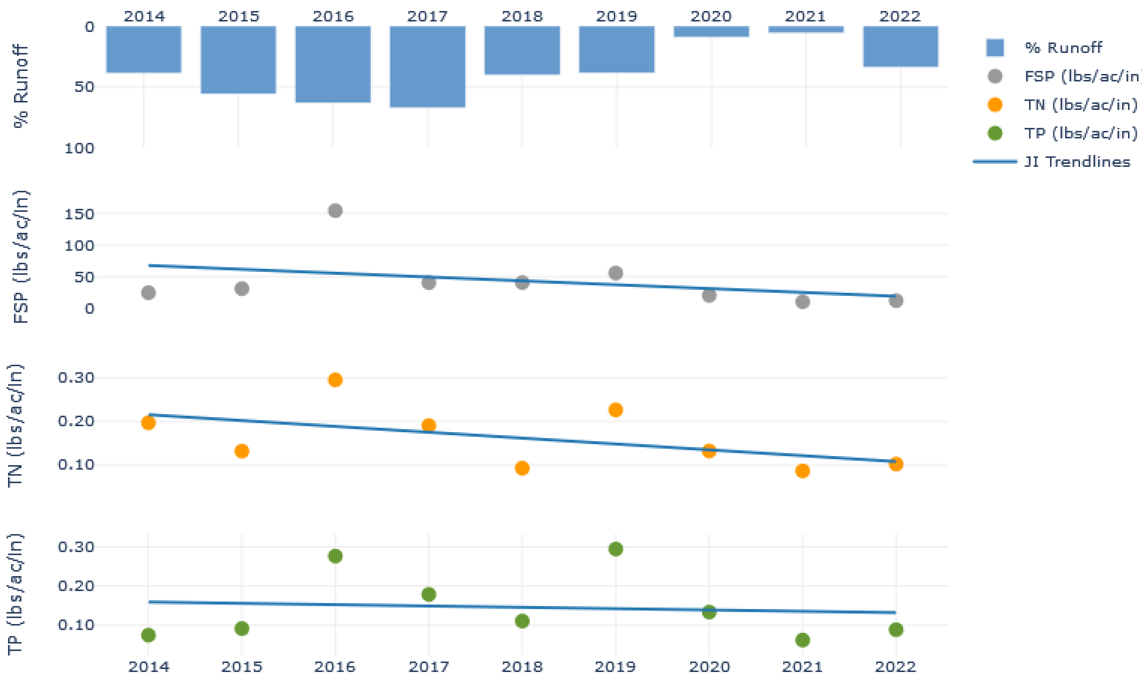

Figure 9 9-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Jellyfish Inflow, WY14-22.

- 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=0.022 and Tau= -0.611.)
- 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 8 9-year seasonal and annual rainfall normalized pollutant loads at the Jellyfish Inflow, WY14-22.

		FSP (lbs/acre/inch)				TN (lbs/acre/inch)				TP (lbs/acre/inch)			
Year	% Runoff	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual	Fall/ Winter	Spring	Summer	Annual
2014	38.6%	13.733	51.563	18.989	24.558	0.060	0.313	0.384	0.197	0.033	0.160	0.075	0.075
2015	55.5%	30.438	46.614	8.065	31.038	0.116	0.174	0.109	0.132	0.095	0.133	0.017	0.092
2016	62.9%	117.285	228.200	0.000	154.437	0.214	0.457	0.000	0.296	0.223	0.385	0.000	0.276
2017	67.2%	19.818	137.664	15.455	40.456	0.096	0.643	0.061	0.191	0.065	0.714	0.033	0.179
2018	40.2%	20.067	59.455	18.262	40.577	0.072	0.076	0.526	0.093	0.070	0.146	0.105	0.111
2019	38.3%	12.118	199.427	9.225	55.670	0.090	0.649	0.263	0.227	0.059	1.068	0.071	0.294
2020	9.1%	7.699	43.672	29.192	20.335	0.034	0.172	0.630	0.132	0.057	0.263	0.221	0.134
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	33.8%	3.407	54.852	10.986	11.976	0.060	0.253	0.189	0.102	0.039	0.331	0.094	0.089
Tau	na	-0.611	-0.222	0.222	-0.278	-0.500	-0.111	0.333	-0.389	-0.444	0.222	0.444	-0.056
P-Value	na	0.022	0.404	0.404	0.297	0.061	0.677	0.211	0.144	0.095	0.404	0.095	0.835
Theil Slope (per year)	na	-4.102	-2.495	1.392	-3.085	-0.010	-0.003	0.041	-0.014	-0.008	0.015	0.017	-0.001

Figure 10 9-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Jellyfish Outflow, WY14-22.

- Percent runoff varied between 2.7% in WY21 to 66.1% in WY17.
- Differences in % runoff between JI and JO are due to the holding capacity of the Jellyfish vault.
- There is no significant trend in normalized annual FSP loads (p>0.05). There is a significant trend in the normalized seasonal fall/winter FSP Loads (p=0.037 and Tau=-0.556).
- 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).
- Significant trends in normalized loads may indicate improved maintenance of the Jellyfish vault.

Table 9 9-year seasonal and annual rainfall normalized pollutant loads at the Jellyfish Outflow, WY14-22.

		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	35.3%	3.083	22.706	15.463	10.860	0.031	0.134	0.355	0.130	0.008	0.062	0.062	0.034
2015	53.6%	25.300	36.630	4.932	24.843	0.090	0.172	0.110	0.118	0.075	0.094	0.020	0.070
2016	63.1%	71.162	161.372	0.000	101.704	0.149	0.465	0.000	0.257	0.142	0.593	0.000	0.297
2017	66.1%	17.727	138.446	14.408	38.923	0.085	0.578	0.036	0.170	0.054	0.673	0.014	0.162
2018	37.7%	17.617	34.894	17.625	26.646	0.092	0.104	0.432	0.113	0.059	0.036	0.110	0.049
2019	37.7%	9.904	80.714	5.312	26.244	0.078	0.424	0.300	0.166	0.051	0.509	0.043	0.157
2020	9.0%	3.712	11.625	2.770	5.942	0.024	0.079	0.123	0.050	0.023	0.074	0.025	0.038
2021	2.7%	0.384	2.610	10.160	1.492	0.004	0.044	0.090	0.018	0.003	0.016	0.017	0.006
2022	22.0%	0.979	26.676	5.393	5.324	0.025	0.148	0.147	0.056	0.013	0.167	0.041	0.039
Tau	na	-0.556	-0.333	-0.056	-0.444	-0.444	-0.278	0.000	-0.500	-0.444	-0.111	0.000	-0.278
P-Value	na	0.037	0.211	0.835	0.095	0.095	0.297	1.000	0.061	0.095	0.677	1.000	0.297
Theil Slope (per year)	na	-3.818	-5.336	-0.392	-4.171	-0.013	-0.013	0.000	-0.015	-0.010	-0.006	0.000	-0.006

3. Provide mass loading v. volume calculations for select events

Seasonal Progress Report #3 provides this analysis for events that occurred in the fall/winter and spring of water year 2016. Seasonal Progress Report #1 included a similar study based on four events that occurred in the late spring and early summer of water year 2015. Analyses have consistently shown that in general, turbidities (and thus FSP) mirror the flow and therefore no first flush phenomenon exists at SR431 with respect to FSP. This may indicate that the primary road serves as a constant source of sediment. Due to consistent results this analysis has not been repeated since Seasonal Progress Report #3. This analysis can be repeated upon request.

Appendix A

Hydrographs, continuous turbidity, and sample distribution for all sampled events.

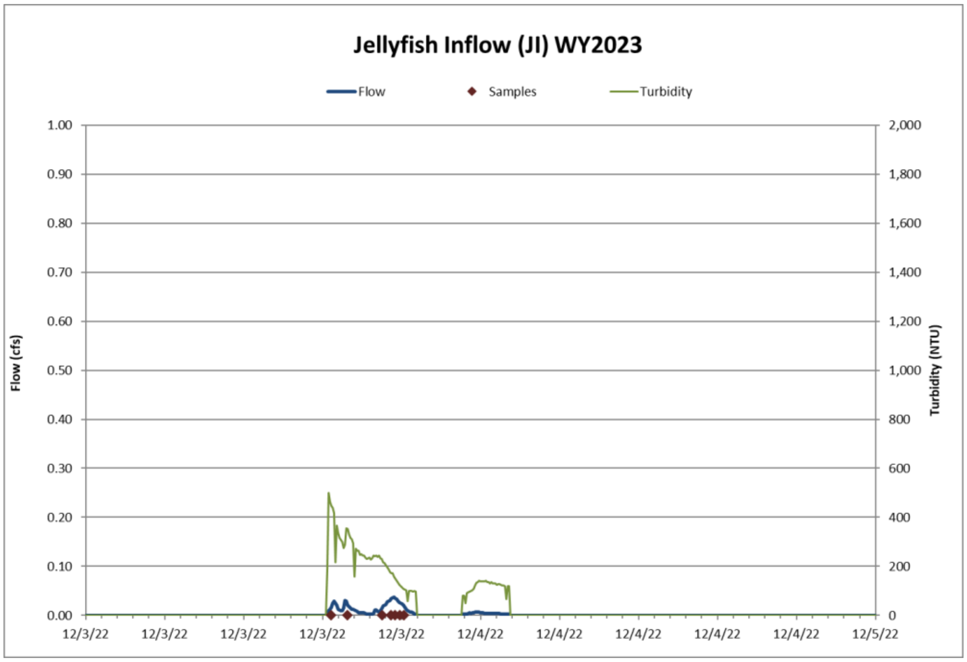

Figure 11 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Inflow for the 12/3/2022 rain on snow event.

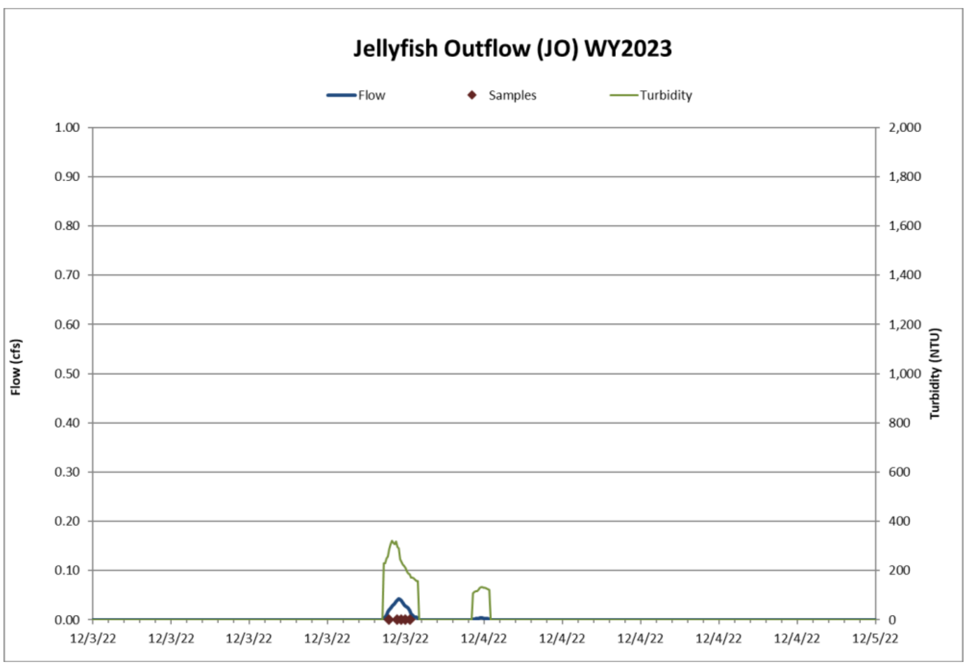

Figure 12 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Outflow for the 12/3/2022 rain on snow event.

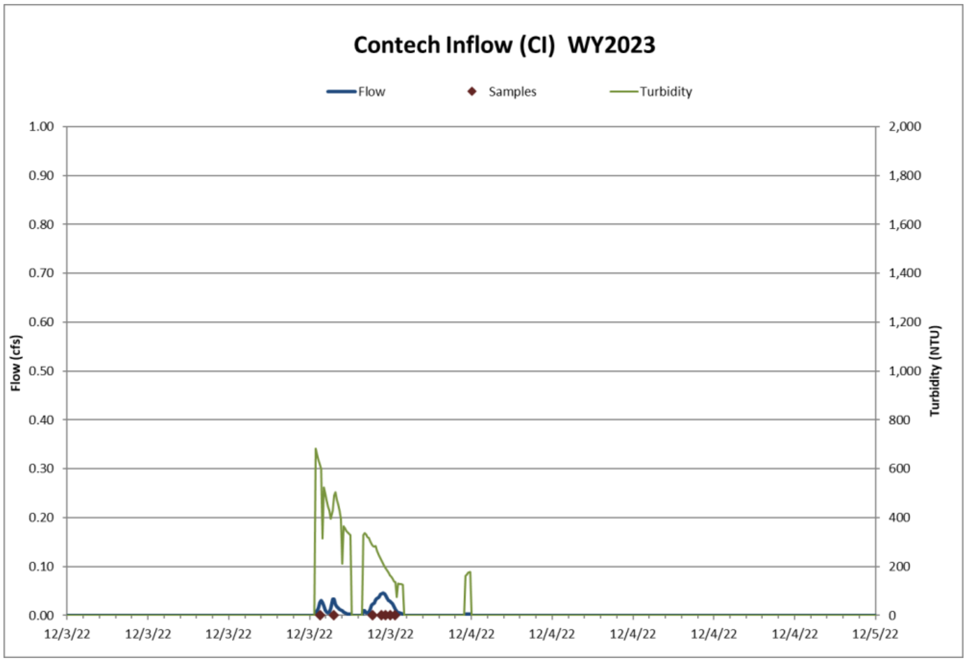

Figure 13 Hydrograph, continuous turbidity, and sample distribution at the Contech Inflow for the 12/3/2022 rain on snow event.

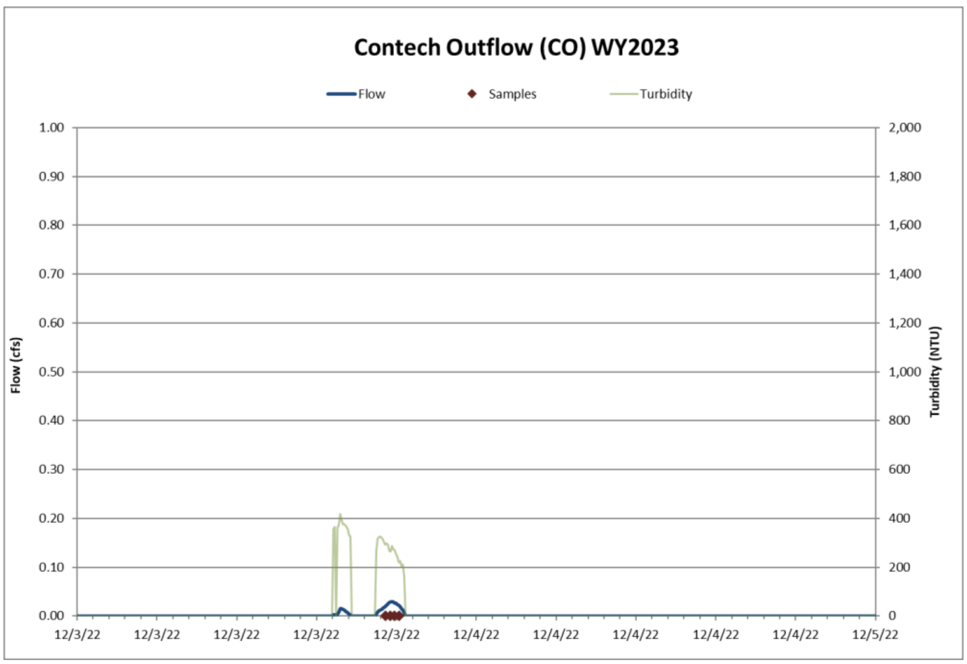

Figure 14 Hydrograph continuous turbidity, and sample distribution at the Contech Outflow for the 12/3/2022 rain on snow event.

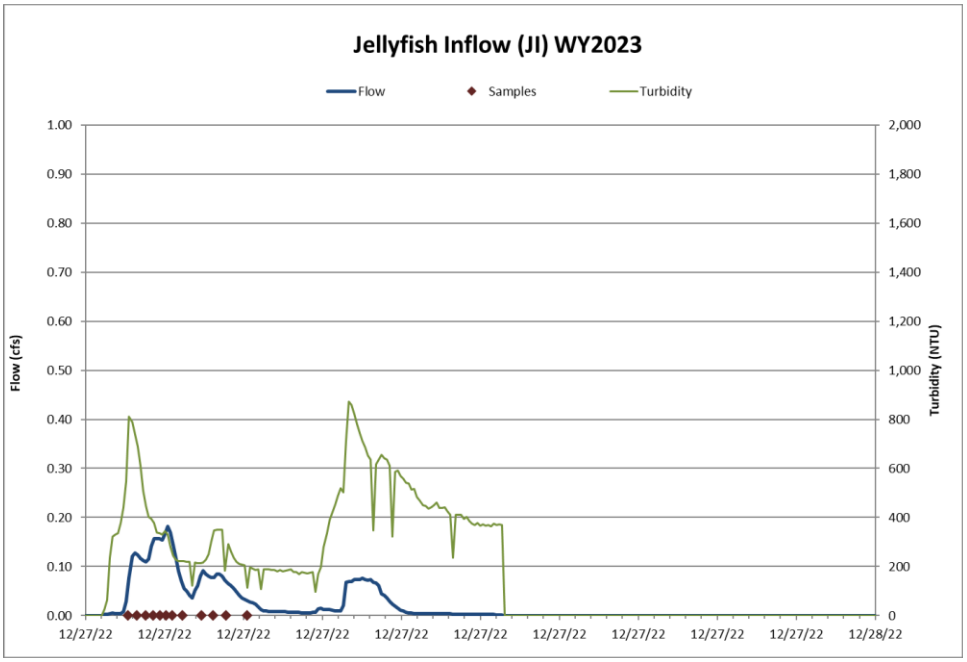

Figure 15 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Inflow for the 12/27/2022 atmospheric river rain on snow event.

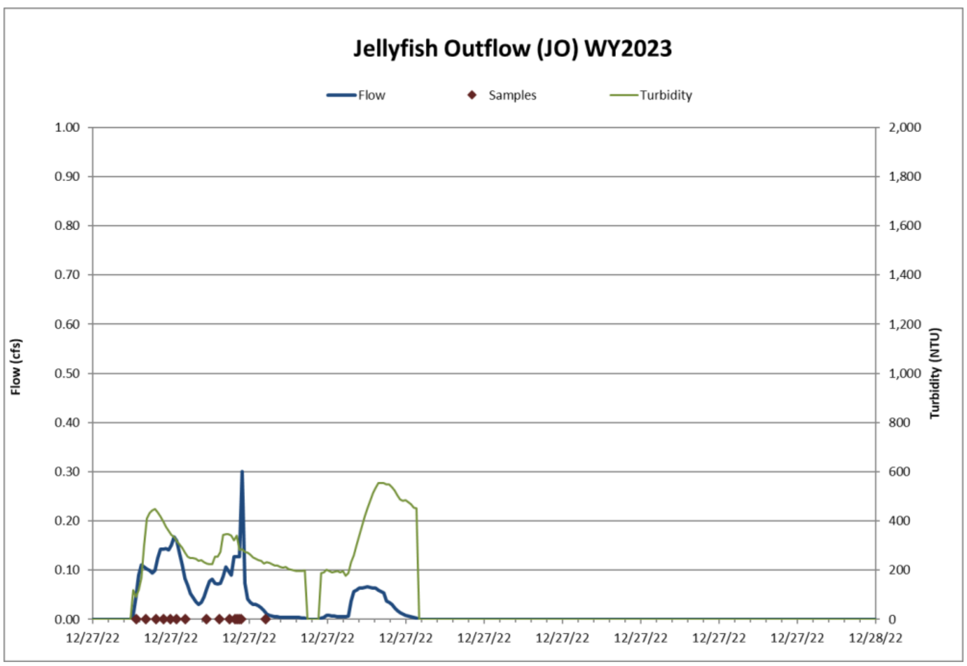

Figure 16 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Outflow for the 12/27/2022 atmospheric river rain on snow event.

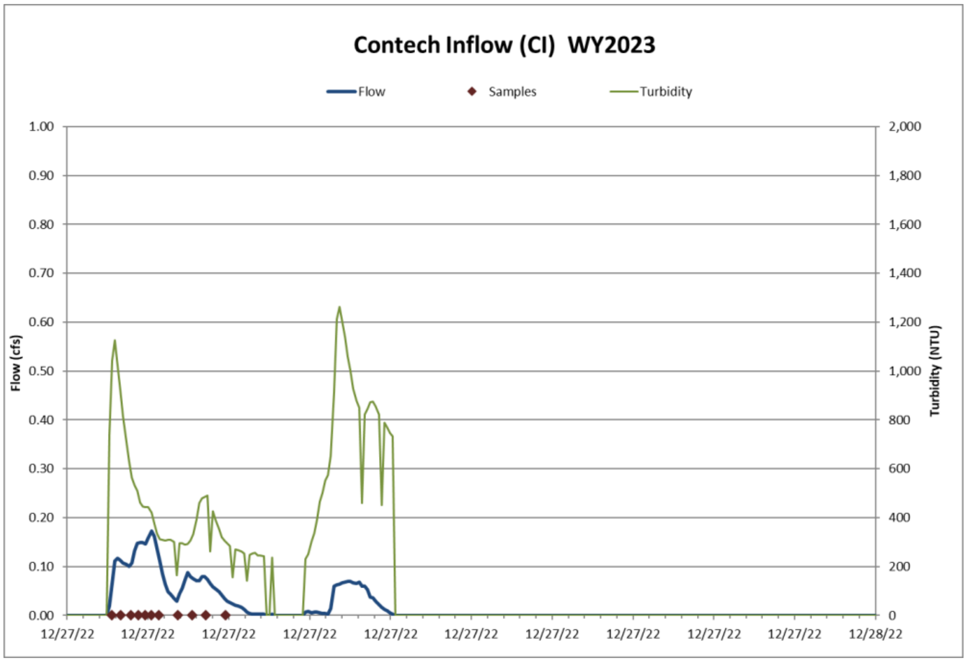

Figure 17 Hydrograph, continuous turbidity, and sample distribution at the Contech Inflow for the 12/27/2022 atmospheric river rain on snow event.

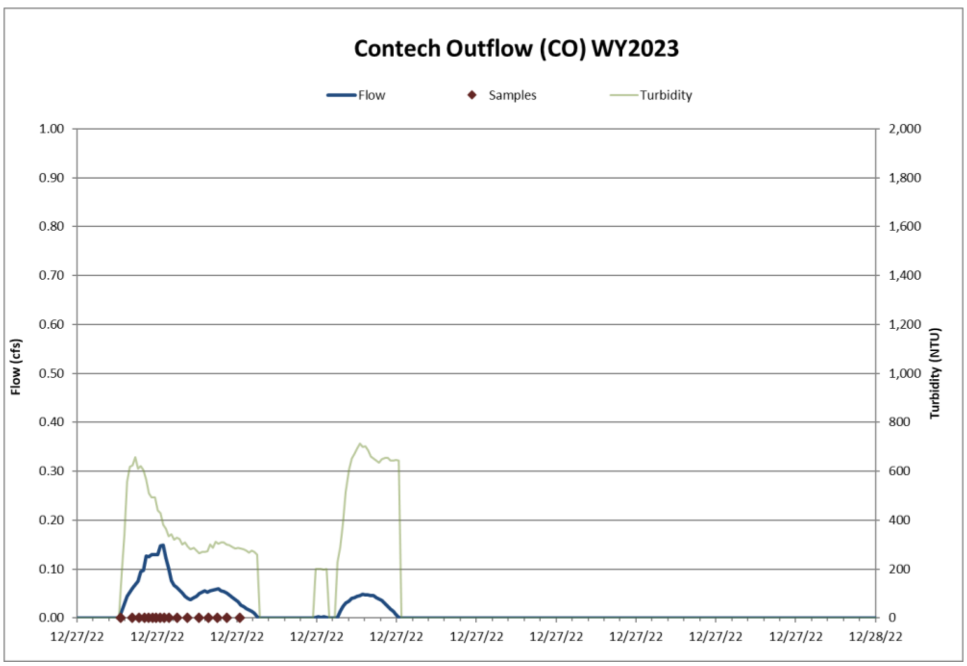

Figure 18 Hydrograph, continuous turbidity, and sample distribution at the Contech Outflow for the 12/27/2022 atmospheric river rain on snow event.

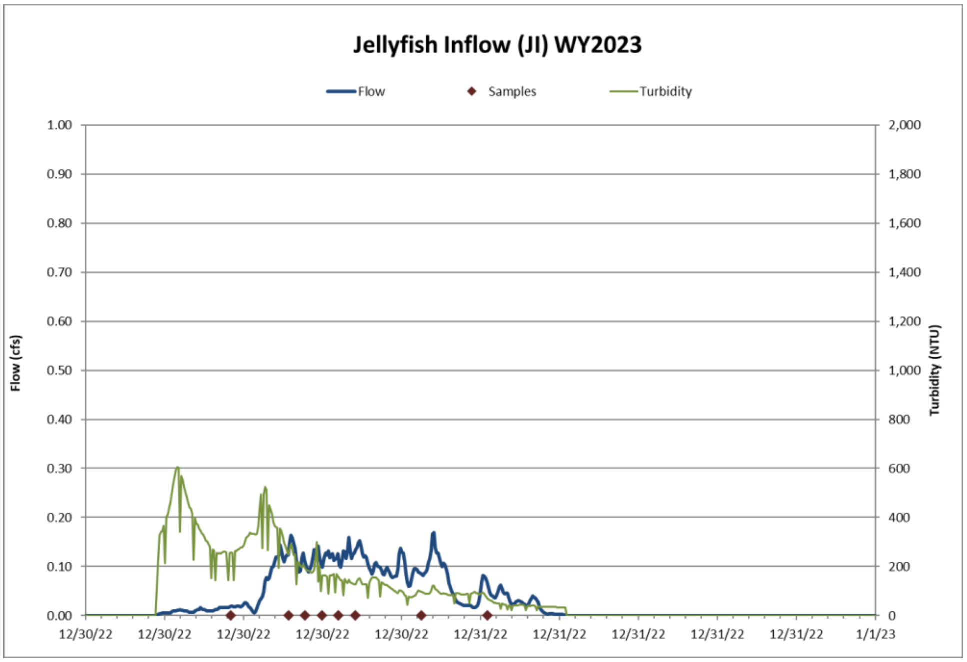

Figure 19 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Inflow for the 12/30/2022 atmospheric river rain on snow event.

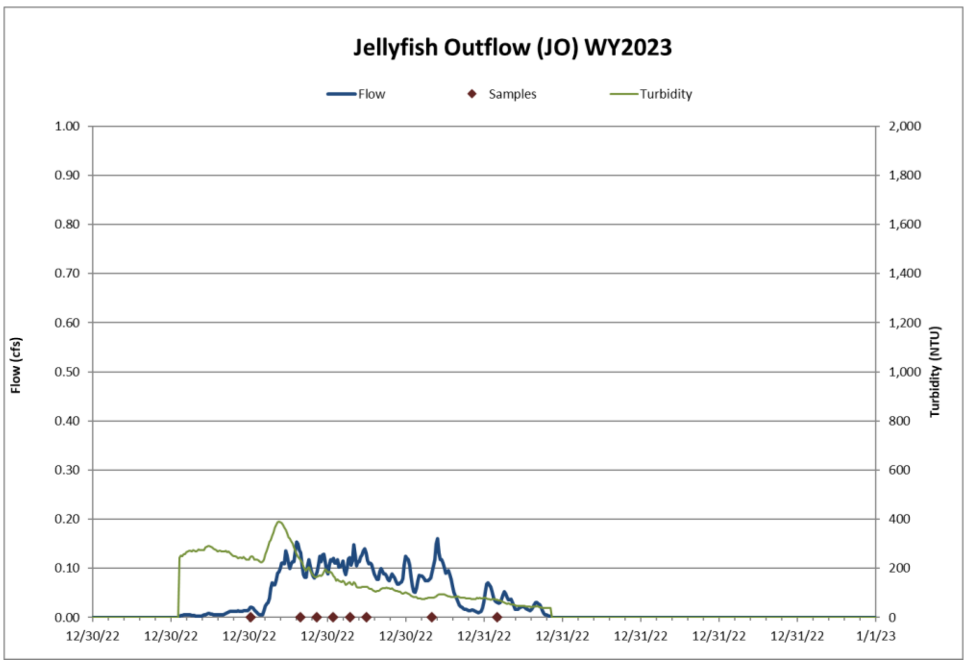

Figure 20 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Outflow for the 12/30/2022 atmospheric river rain on snow event.

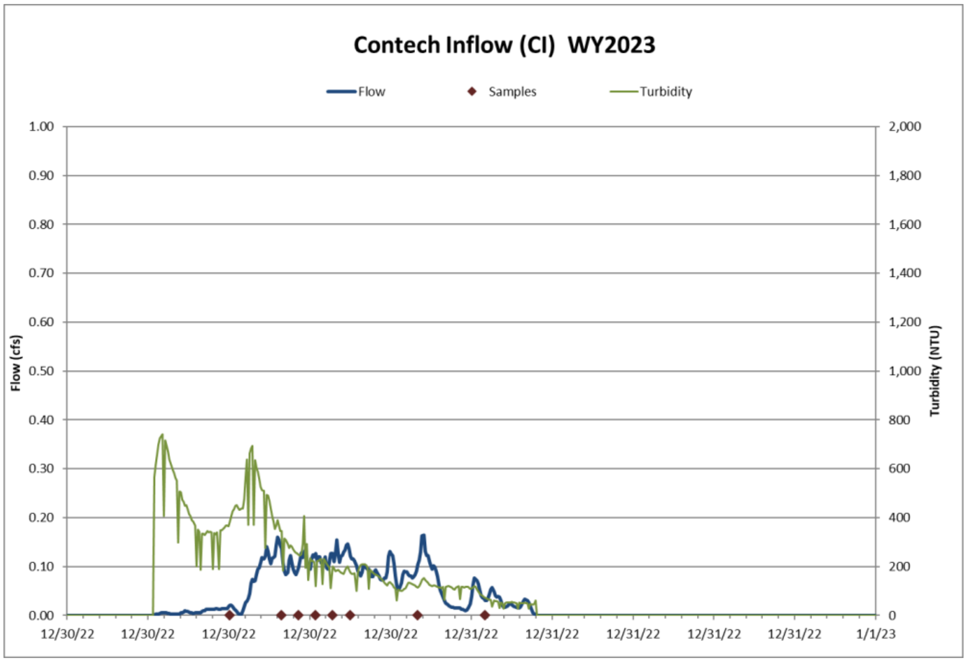

Figure 21 Hydrograph, continuous turbidity, and sample distribution at the Contech Inflow for the 12/30/2022 atmospheric river rain on snow event.

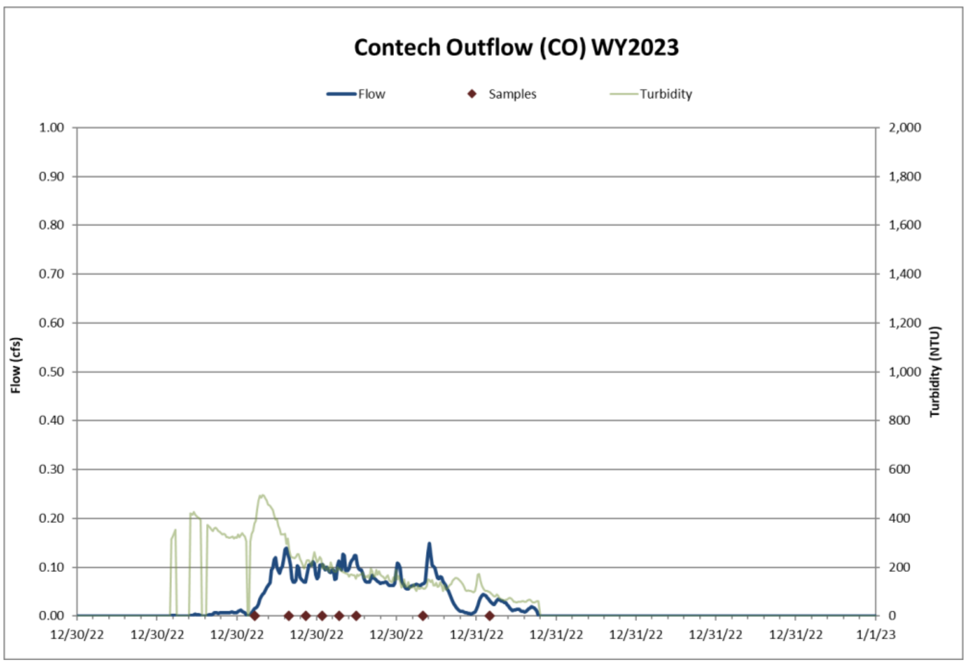

Figure 22 Hydrograph, continuous turbidity, and sample distribution at the Contech Outflow for the 12/30/2022 atmospheric river rain on snow event.

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