Seasonal Progress Report #20
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: 2022

Period: Summer Season, June 1, 2022 –September 30, 2022

Submission Date: October 31, 2022

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
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
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 #20 for the summer season of water year 2022.

Task 2: Stormwater Monitoring

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

The summer season of WY22 began on June 1, 2022 and ended September 30, 2022. Continuous flow and turbidity were successfully monitored for the summer season at all sites, with the exception of a power outage at the end of August until mid-September. The cord to the pressure transducer in the Jellyfish Vault was severed by construction activities on August 25, 2022, which caused a system wide power outage until September 14, 2022 when power was restored to everything except for the pressure transducers in both vaults. The power surge on August 25 also fried a control port (C5) on the data logger, so Contech Vault data was also out until the Jellyfish Vault pressure transducer was replaced and the control port was switched on September 29, 2022.

See Figure 1-Figure 4 for photos of construction activity, the severed Jellyfish Vault pressure transducer, and troubleshooting the pressure transducer wiring at SR431 over the summer of 2022.

Figure 1 Construction activity at SR431 on July 21, 2022.

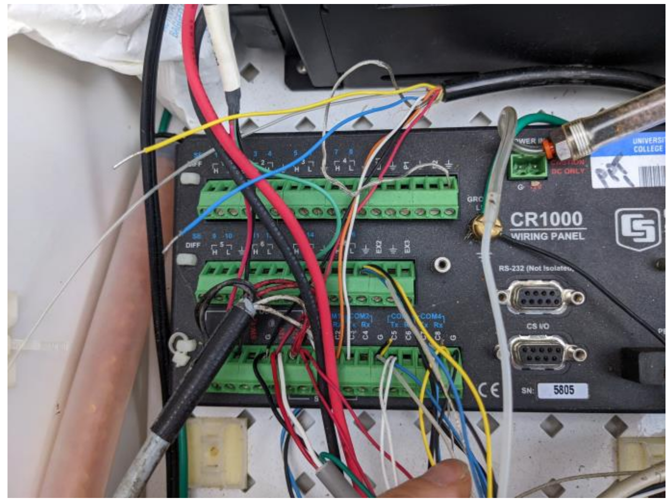

Figure 2 Troubleshooting pressure transducer wiring on September 29, 2022.

Figure 3 Severed pressure transducer cord discovered on September 14, 2022.

Figure 4 Construction activity on September 29, 2022.

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

During the summer season, three events were successfully sampled at Contech Inflow (CI), Jellyfish Inflow (JI), and Contech Outflow (JO), and two events were successfully sampled at Jellyfish Outflow (JO) (a thunderstorm event on August 5, 2022 at CI, JI, and CO; a thunderstorm event on August 19, 2022 at all sites; and a rain event on September 19-21, 2022 at all sites). Samples failed at JO duirng the August 5, 2022 due to a blown fuse at the ISCO sampler. 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 August 18, 2022 thunderstorm event at all sites (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 eleven sampled events at Jellyfish Inflow and Contech Inflow, ten sampled events at Jellyfish Outflow, and nine sampled events at 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. The cord to the pressure transducer in the Jellyfish Vault was severed by construction activities on August 25, 2022, which caused a system wide power outage until September 14, 2022 when power was restored to everything except for the pressure transducers in both vaults. The power surge on August 25 also fried a control port (C5) on the data logger, so Contech Vault data was also out until the Jellyfish Vault pressure transducer was replaced and the control port was switched on September 29, 2022. One storm occurred during this time period, from September 19-21, 2022, and bypass may have occurred during this time. With the exception of not knowing if bypass occurred during the data gap, pressure transducer data indicate that during the summer of WY22 the Contech MFS cartridge filters and the Jellyfish filters were bypassed zero times (Figure 5 & Figure 6).

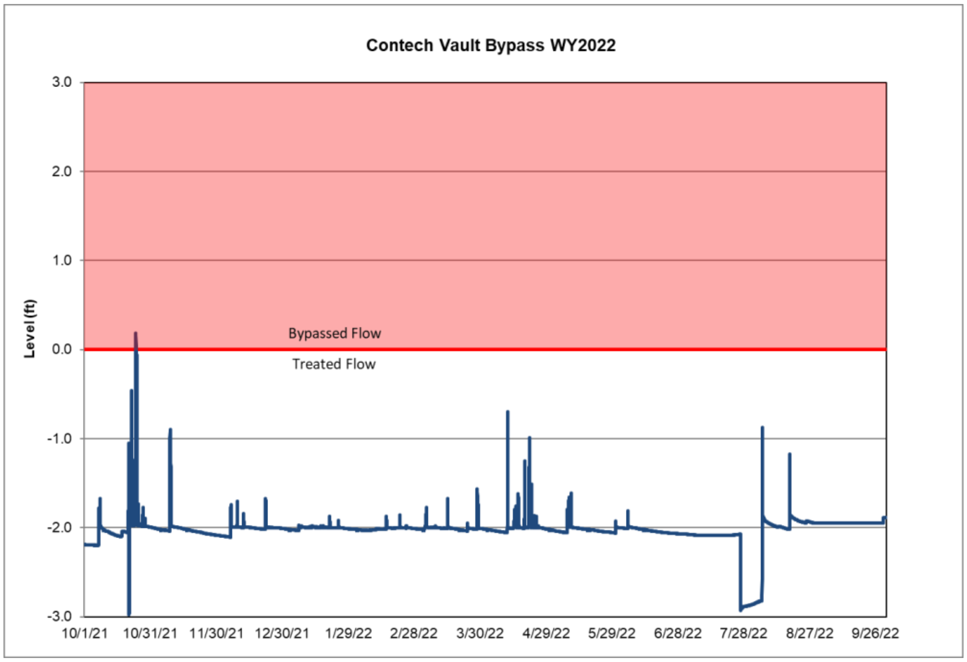

Figure 5 Bypassed flow in the Contech MFS vault for WY22.

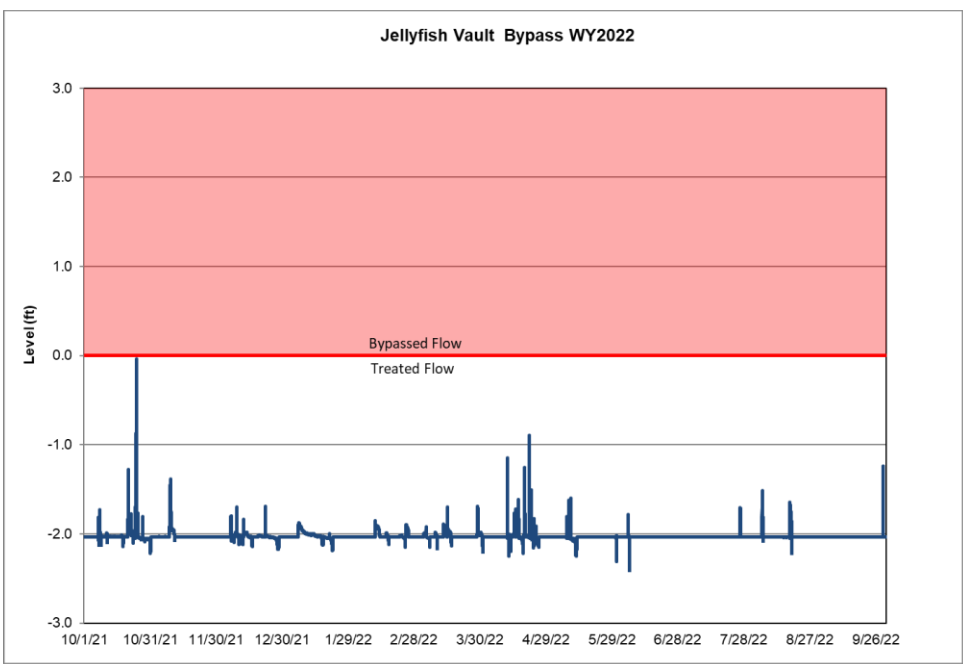

Figure 6 Bypassed flow in the Jellyfish vault for WY22.

5. Provide precipitation data to date

Table 2 provides summary data for all 41 fall/winter, spring, and summer 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. 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, spring, and summer precipitation events at SR431 for WY22. 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	--	--	9/28/2021 2:00	--	--	--	--	--	--	--
NDOT	NDOT-22-01	10/6/2021 20:10	10/8/2021 7:05	1.455	8.8	0.2720	0.031	1	12	Snow, Rain
NDOT	NDOT-22-02	10/11/2021 2:45	10/11/2021 16:10	0.559	2.8	0.0440	0.008	-4	1	Snow
NDOT	NDOT-22-03	10/13/2021 11:25	10/13/2021 11:50	0.017	1.8	0.0080	0.004	2	4	Rain
NDOT	NDOT-22-04	10/17/2021 21:45	10/18/2021 12:15	0.604	4.4	0.1600	0.012	-5	0	Snow, Rain
NDOT	NDOT-22-05	10/20/2021 21:30	10/22/2021 17:05	1.816	2.4	1.0540	0.023	0	9	Rain
NDOT	NDOT-22-06	10/23/2021 11:25	10/25/2021 16:15	2.201	0.8	6.0550	0.039	-2	5	Rain, Snow
NDOT	NDOT-22-07	11/1/2021 17:00	11/1/2021 17:25	0.017	7.0	0.0080	0.004	3	4	Rain
NDOT	NDOT-22-08	11/6/2021 10:20	11/6/2021 14:45	0.184	4.7	0.0200	0.004	0	4	Rain/Snow
NDOT	NDOT-22-09	11/8/2021 21:30	11/10/2021 13:05	1.649	2.3	1.0940	0.035	-2	7	Rain
NDOT	NDOT-22-10	12/6/2021 14:10	12/7/2021 6:30	0.681	26.0	0.3040	0.008	0	3	Rain
NDOT	NDOT-22-11	12/8/2021 17:05	12/9/2021 8:25	0.639	1.4	0.2240	0.012	-3	1	Rain, Snow
NDOT	NDOT-22-12	12/12/2021 4:45	12/14/2021 7:00	2.094	2.8	3.8770	0.043	-8	0	Snow
NDOT	NDOT-22-13	12/15/2021 11:25	12/16/2021 14:50	1.142	1.2	0.2240	0.008	-6	-1	Snow
NDOT	NDOT-22-14	12/22/2021 4:30	12/29/2021 10:55	7.267	5.6	3.1400	0.024	-11	1	Rain, Snow
NDOT	NDOT-22-15	2/15/2022 1:10	2/15/2022 8:05	0.288	47.6	0.0720	0.012	-8	-4	Snow
NDOT	NDOT-22-16	2/21/2022 5:25	2/22/2022 13:45	1.347	5.9	0.3120	0.008	-11	-2	Snow
NDOT	NDOT-22-17	3/4/2022 8:35	3/5/2022 14:45	1.257	9.8	0.2040	0.016	-11	3	Rain, Snow
NDOT	NDOT-22-18	3/9/2022 15:55	3/9/2022 23:55	0.333	4.0	0.0560	0.012	-3	2	Snow
NDOT	NDOT-22-19	3/13/2022 1:35	3/13/2022 7:40	0.253	3.1	0.0200	0.008	-4	-1	Rain
NDOT	NDOT-22-20	3/15/2022 3:45	3/15/2022 9:25	0.236	1.8	0.1280	0.012	-1	1	Rain
NDOT	NDOT-22-21	3/19/2022 17:10	3/20/2022 0:45	0.316	4.3	0.0080	0.004	-3	-1	Rain/Snow
NDOT	NDOT-22-22	3/28/2022 17:20	3/29/2022 4:05	0.448	8.7	0.3450	0.027	-2	0	Rain/Snow
NDOT	NDOT-22-23	4/11/2022 5:00	4/11/2022 14:40	0.403	13.0	0.4000	0.016	-5	-2	Snow
NDOT	NDOT-22-24	4/13/2022 23:20	4/15/2022 11:15	1.497	2.4	0.2280	0.008	-4	3	Rain/Snow
NDOT	NDOT-22-25	4/16/2022 3:40	4/16/2022 16:05	0.517	0.7	0.3580	0.019	-2	2	Snow
NDOT	NDOT-22-26	4/19/2022 3:35	4/19/2022 9:30	0.247	2.5	0.3000	0.016	-1	-1	Rain/Snow
NDOT	NDOT-22-27	4/21/2022 0:10	4/22/2022 9:45	1.399	1.6	0.9980	0.023	-7	2	Snow
NDOT	NDOT-22-28	5/8/2022 12:10	5/10/2022 21:10	2.375	16.1	0.2840	0.012	-9	-2	Snow
NDOT	NDOT-22-29	5/28/2022 17:45	5/28/2022 20:30	0.115	17.9	0.0320	0.004	3	5	Rain
NDOT	NDOT-22-30	5/30/2022 16:30	5/30/2022 19:10	0.111	1.8	0.0640	0.008	2	6	Rain
NDOT	NDOT-22-31	6/5/2022 0:40	6/5/2022 14:35	0.580	5.2	0.0800	0.008	6	15	Rain
NDOT	NDOT-22-32	6/12/2022 7:45	6/12/2022 12:10	0.184	6.7	0.0200	0.004	9	13	Rain
NDOT	NDOT-22-33	6/18/2022 14:00	6/18/2022 14:05	0.003	6.1	0.0080	0.004	1	2	Thunderstorm
NDOT	NDOT-22-34	8/1/2022 5:55	8/1/2022 6:15	0.014	43.7	0.0080	0.004	13	14	Thunderstorm
NDOT	NDOT-22-35	8/5/2022 2:45	8/5/2022 12:30	0.406	3.9	0.4710	0.019	13	16	Thunderstorm
NDOT	NDOT-22-36	8/8/2022 11:30	8/8/2022 11:35	0.003	3.0	0.0270	0.019	19	21	Thunderstorm
NDOT	NDOT-22-37	8/16/2022 10:55	8/16/2022 10:55	0.000	8.0	0.0040	0.004	20	20	Thunderstorm
NDOT	NDOT-22-38	8/17/2022 18:10	8/17/2022 21:15	0.128	1.3	0.1440	0.012	12	17	Thunderstorm
TERC2	NDOT-22-39	9/6/2022 17:25	9/6/2022 18:40	0.052	19.8	0.0320	0.016	20	27	Thunderstorm
TERC2	NDOT-22-40	9/12/2022 16:55	9/13/2022 3:15	0.431	5.9	0.0360	0.004	11	15	Thunderstorm
NDOT	NDOT-22-41	9/18/2022 17:40	9/21/2022 11:10	2.729	5.6	1.4890	0.078	3	10	Rain

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 WY22.

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 WY 22 there was minimal sediment accumulation in the Jellyfish vault and some accumulation in the Contech vault.

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

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 WY22 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.

Many events occurred in the fall/winter of WY22, the majority of them were very small and had removal efficiencies of 100% because 100% of the flow was retained in the vault. This occurred more often at the Contech MFS because of the larger vault capacity. The FSP removal efficiency for the three largest events (flow volumes greater than 1000 cf) at the Contech MFS; October 23-24, 2021, November 8-9, 2021, and October 21-22, 2021; were 48%, 53%, and 61% respectively. The FSP removal efficiency for the three largest events (flow volumes greater than 1000 cf) at the Jellyfish; October 23-24, 2021, October 21-22, 2021, and November 8-9, 2021; were 64%, 67%, and 62% respectively. The spring season of WY22 also saw many small events, all less than 1000 cf. Negative FSP removal efficiencies for the Contech MFS (highlighted in red in Table 4) indicate that there was biofouling of the turbidimeter as samples taken during events at this time show a reduction in FSP. The hydrodynamic separator installed at the upstream end of the system has kept sediment from inundating the turbidimeters, but biofilms sometimes still occur. FSP removal efficiencies at the Jellyfish averaged between 50% and 60% with the exception of the last event in the spring between May 8-10, 2022 where some biofouling was also occurring as samples from that event indicate a reduction in FSP. The problem of biofouling was corrected by cleaning all turbidimeters on May 18, 2022.

Table 4 Contech MFS FSP removal efficiency for each event of fall/winter, spring, and summer WY22.

CONTECH MFS WY22									
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
10/7/21 11:05	10/8/21 5:20	Rain	18:15	76	15	0.49	0.05	91%	80%
10/21/21 0:30	10/21/21 8:55	Rain	8:25	371	194	4.21	1.71	59%	48%
10/21/21 11:15	10/22/21 12:40	Rain	25:25	1,048	541	10.09	3.98	61%	48%
10/23/21 14:35	10/23/21 17:00	Rain	2:25	31	0	0.13	0.00	100%	100%
10/23/21 22:25	10/24/21 22:05	Rain	23:40	7,339	5,256	22.78	11.94	48%	28%
10/25/21 13:05	10/25/21 14:40	Event Snowmelt	1:35	65	12	0.60	0.02	96%	81%
10/27/21 14:40	10/27/21 17:25	Snowmelt	2:45	70	0	0.53	0.00	100%	100%
10/28/21 15:30	10/28/21 15:40	Snowmelt	0:10	1	0	0.00	0.00	100%	100%
11/8/21 23:55	11/9/21 14:45	Rain	14:50	1,073	515	9.14	4.30	53%	52%
12/6/21 16:20	12/6/21 22:25	Rain	6:05	226	36	0.96	0.19	80%	84%
12/9/21 12:05	12/9/21 13:25	Rain, Snow	1:20	65	15	1.23	0.15	88%	77%
12/12/21 13:25	12/12/21 13:55	Event Snowmelt	0:30	9	0	0.04	0.00	100%	100%
12/22/21 12:05	12/22/21 14:55	Rain on Snow	2:50	194	60	3.07	1.47	52%	69%
1/20/22 16:30	1/20/22 17:05	Snowmelt	0:35	4	0	0.03	0.00	100%	100%
2/15/22 11:00	2/15/22 11:50	Event Snowmelt	0:50	5	0	0.01	0.00	100%	100%
2/21/22 11:55	2/21/22 12:25	Event Snowmelt	0:30	7	0	0.04	0.00	100%	100%
3/5/22 12:00	3/5/22 14:30	Rain, Snow	2:30	40	18	0.47	0.33	30%	55%
3/15/22 6:10	3/15/22 10:25	Rain on Snow	4:15	139	85	1.12	4.64	-313%	39%
3/28/22 19:40	3/29/22 5:50	Rain/Snow	10:10	154	101	2.19	2.10	4%	34%
4/11/22 12:10	4/11/22 16:55	Event Snowmelt	4:45	249	189	3.23	7.23	-124%	24%
4/14/22 17:20	4/14/22 19:10	Rain/Snow	1:50	31	16	0.15	0.27	-81%	49%
4/15/22 7:00	4/15/22 10:55	Rain/Snow	3:55	108	68	0.54	2.02	-275%	37%
4/16/22 4:55	4/16/22 17:25	Event Snowmelt	12:30	434	316	1.30	9.15	-606%	27%
4/19/22 9:25	4/19/22 13:00	Rain/Snow	3:35	366	297	0.98	9.32	-847%	19%
4/21/22 9:45	4/21/22 17:15	Event Snowmelt	7:30	622	490	0.53	7.72	-1352%	21%
4/22/22 8:50	4/22/22 13:20	Event Snowmelt	4:30	255	170	0.23	2.29	-910%	34%
5/8/22 13:50	5/10/22 12:15	Event Snowmelt	46:25	246	127	0.09	0.84	-801%	48%
6/5/22 9:35	6/5/22 10:00	Thunderstorm	0:25	6	0	0.02	0.00	100%	100%
8/5/22 8:55	8/5/22 13:00	Thunderstorm	4:05	457	364	6.06	3.50	42%	20%
8/17/22 20:15	8/17/22 21:25	Thunderstorm	1:10	108	75	1.47	0.52	64%	30%
9/19/22 16:35	9/21/22 11:35	Rain	43:00	2,109	1,537	8.49	4.42	48%	27%

Table 5 Jellyfish FSP removal efficiency for each event of fall/winter, spring, and summer WY22.

JELLYFISH WY22									
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
10/7/21 11:05	10/8/21 6:50	Rain	19:45	138	28	0.79	0.03	96%	80%
10/21/21 2:40	10/21/21 9:35	Rain	6:55	528	225	4.28	1.16	73%	57%
10/21/21 11:15	10/22/21 15:25	Rain	28:10	1,526	581	9.91	3.23	67%	62%
10/23/21 14:30	10/24/21 22:10	Rain	31:40	8,771	5,556	18.45	6.68	64%	37%
10/25/21 13:05	10/25/21 16:45	Event Snowmelt	3:40	187	21	1.38	0.01	99%	89%
10/27/21 14:15	10/27/21 20:20	Snowmelt	6:05	229	8	1.07	0.01	99%	96%
10/28/21 13:25	10/28/21 17:30	Snowmelt	4:05	97	0	0.29	0.00	100%	100%
11/8/21 23:55	11/9/21 15:15	Rain	15:20	1,103	616	5.94	2.26	62%	44%
12/6/21 16:20	12/6/21 22:50	Rain	6:30	233	74	0.40	0.09	77%	68%
12/9/21 12:00	12/9/21 14:15	Rain, Snow	2:15	135	22	1.44	0.03	98%	83%
12/12/21 13:25	12/12/21 14:25	Event Snowmelt	1:00	31	0	0.07	0.00	100%	100%
12/22/21 12:05	12/22/21 15:25	Rain on Snow	3:20	215	90	1.97	0.33	83%	58%
1/20/22 16:15	1/20/22 18:25	Snowmelt	2:10	34	30	1.65	0.01	100%	12%
1/24/22 15:55	1/24/22 17:50	Snowmelt	1:55	25	21	1.28	0.00	100%	16%
2/15/22 10:00	2/15/22 14:20	Event Snowmelt	4:20	66	56	0.66	0.07	89%	15%
2/21/22 10:55	2/21/22 14:25	Event Snowmelt	3:30	35	29	0.58	0.03	95%	16%
3/5/22 11:55	3/5/22 15:30	Rain, Snow	3:35	106	93	4.68	0.20	96%	13%
3/15/22 4:50	3/15/22 10:25	Rain on Snow	5:35	216	203	9.12	2.46	73%	6%
3/28/22 19:40	3/29/22 6:00	Rain/Snow	10:20	244	240	14.27	6.58	54%	2%
4/11/22 12:10	4/11/22 17:35	Event Snowmelt	5:25	267	257	11.54	5.14	55%	4%
4/14/22 14:45	4/14/22 19:40	Rain/Snow	4:55	69	61	1.82	0.64	65%	10%
4/15/22 6:30	4/15/22 12:10	Rain/Snow	5:40	121	110	4.34	1.65	62%	10%
4/16/22 4:50	4/16/22 19:20	Event Snowmelt	14:30	510	482	13.59	7.56	44%	6%
4/19/22 4:40	4/19/22 14:00	Rain/Snow	9:20	392	357	13.22	5.90	55%	9%
4/21/22 9:45	4/21/22 21:15	Event Snowmelt	11:30	676	625	9.54	6.95	27%	7%
4/22/22 8:30	4/22/22 17:25	Event Snowmelt	8:55	338	303	4.18	2.36	44%	10%
5/8/22 13:50	5/10/22 13:50	Event Snowmelt	48:00	286	273	1.02	1.14	-11%	5%
6/5/22 9:35	6/5/22 10:10	Thunderstorm	0:35	4.2	3.7	0.01	0.003	76%	11%
8/5/22 8:50	8/5/22 13:05	Thunderstorm	4:15	410	311	4.20	2.56	39%	24%
8/17/22 20:10	8/17/22 21:30	Thunderstorm	1:20	101	98	1.20	0.41	66%	3%
9/19/22 16:35	9/21/22 11:35	Rain	43:00	2,286	1,866	6.35	5.36	16%	18%

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. 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, 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 2021. 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 WY21.

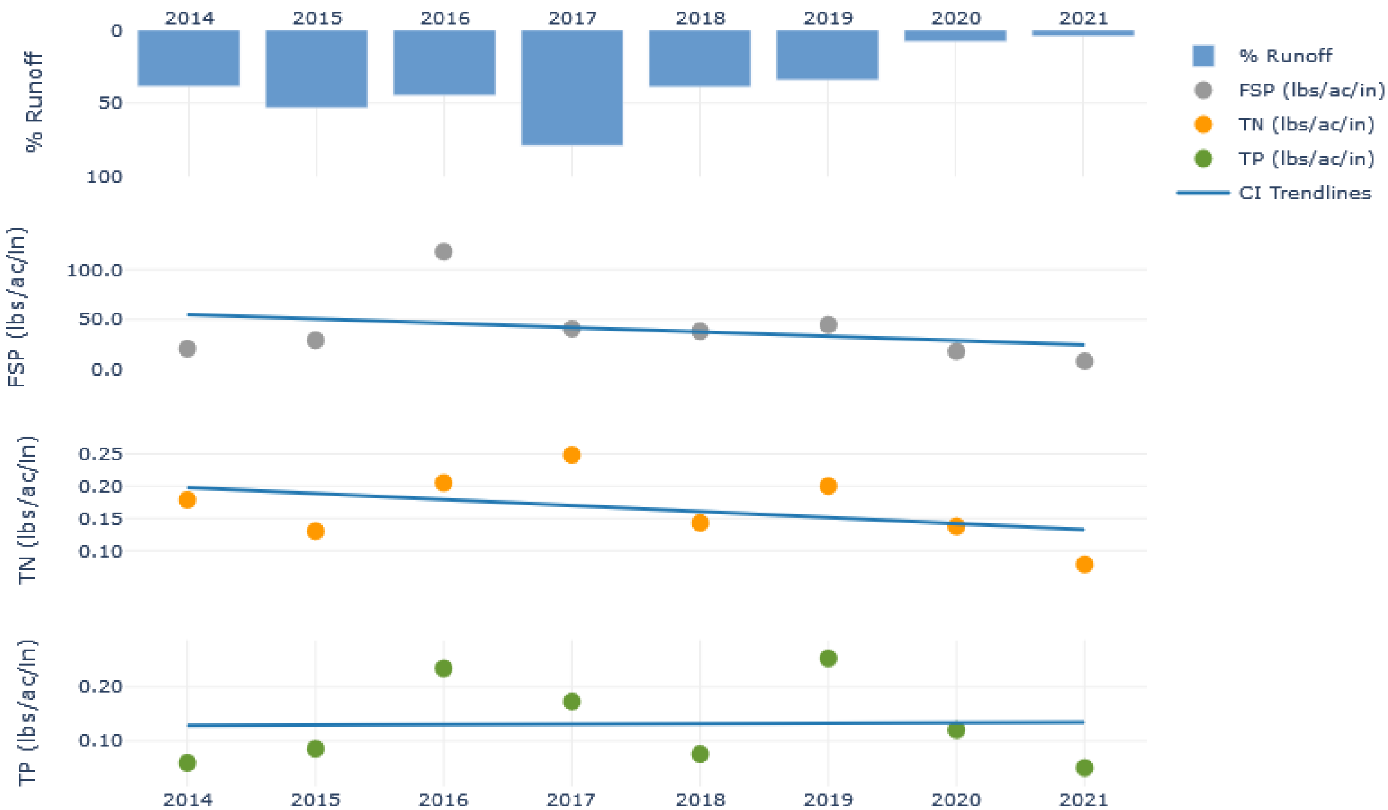

Figure 7 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Contech MFS Inflow, WY14-21.

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

		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
Tau	na	-0.429	-0.286	0.357	-0.214	-0.429	-0.214	0.429	-0.286	-0.214	0.143	0.500	0.000
P-Value	na	0.138	0.322	0.216	0.458	0.138	0.458	0.138	0.322	0.458	0.621	0.083	1.000
Theil Slope (per year)	na	-4.091	-3.082	1.845	-2.370	-0.020	-0.014	0.066	-0.009	-0.007	0.006	0.026	0.001

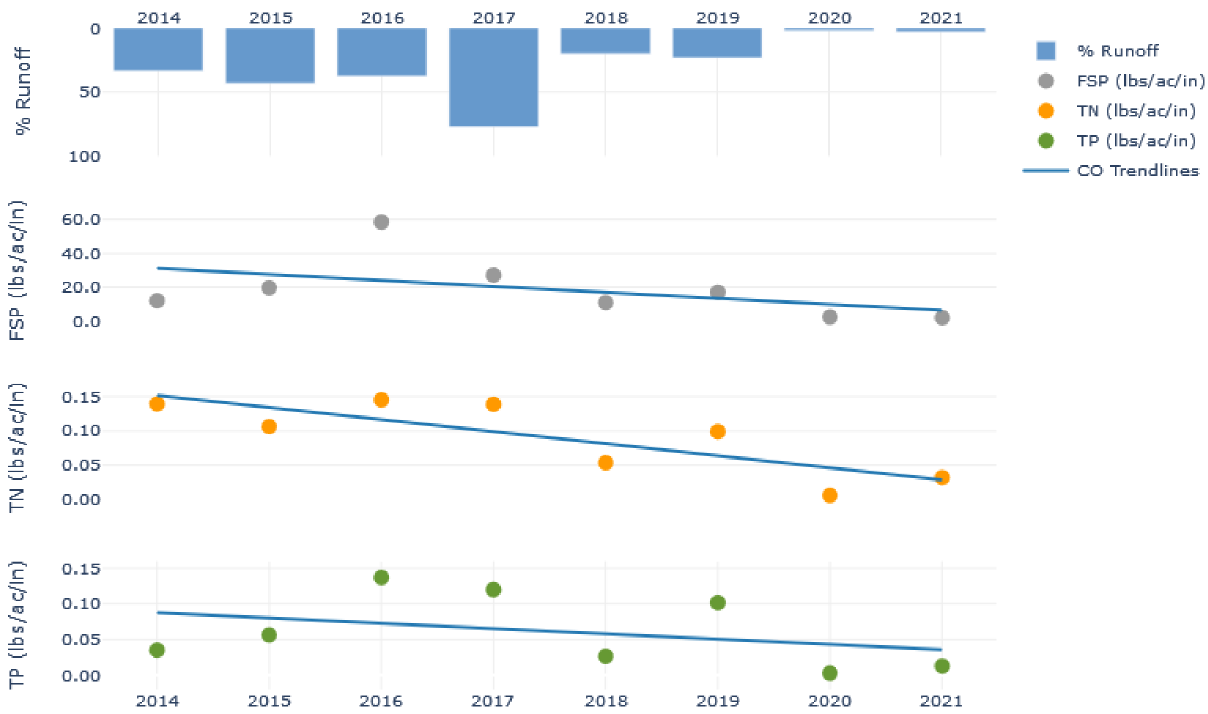

Figure 8 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Contech MFS Outflow, WY14-21.

- 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=0.034 and Tau=-0.618).
- There is a significant trend in normalized annual TN loads (p=0.026 and Tau=-0.643).
- 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 8-year seasonal and annual rainfall normalized pollutant loads at the Contech MFS Outflow, WY14-21.

		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	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
Tau	na	-0.618	-0.286	0.000	-0.500	-0.546	-0.214	0.000	-0.643	-0.473	-0.143	0.143	-0.357
P-Value	na	0.034	0.322	1.000	0.083	0.061	0.458	1.000	0.026	0.105	0.621	0.621	0.216
Theil Slope (per year)	na	-3.568	-3.864	0.313	-2.974	-0.016	-0.018	0.002	-0.019	-0.010	-0.003	0.003	-0.008

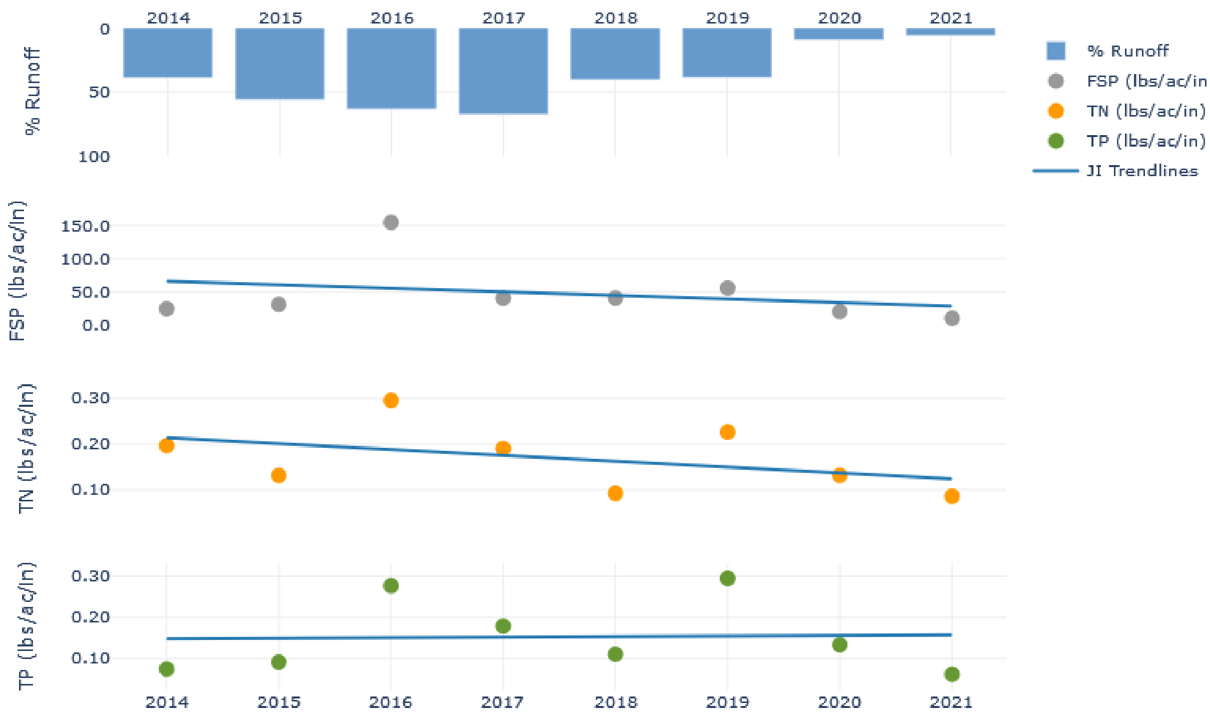

Figure 9 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Jellyfish Inflow, WY14-21.

- 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). There is a significant decreasing trend for normalized seasonal fall/winter FSP loads (p=0.048 and Tau= -0.571)
- 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 8-year seasonal and annual rainfall normalized pollutant loads at the Jellyfish Inflow, WY14-21.

		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
Tau	na	-0.571	-0.286	0.357	-0.143	-0.500	-0.143	0.500	-0.357	-0.429	0.214	0.500	0.071
P-Value	na	0.048	0.322	0.216	0.621	0.083	0.621	0.083	0.216	0.138	0.458	0.083	0.805
Theil Slope (per year)	na	-4.484	-3.816	2.794	-2.085	-0.017	-0.003	0.056	-0.014	-0.008	0.010	0.027	0.006

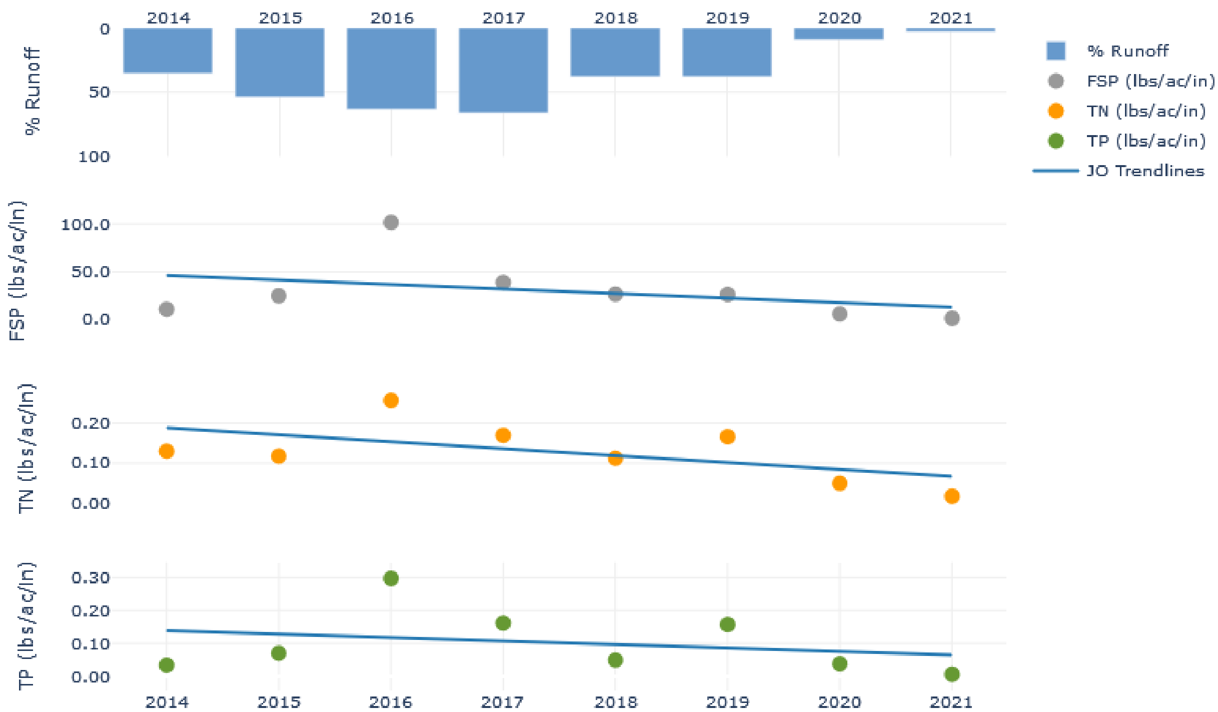

Figure 10 8-year rainfall normalized annual pollutant load trends in FSP, TN, and TP loads at the Jellyfish Outflow, WY14-21.

- 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 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 9 8-year seasonal and annual rainfall normalized pollutant loads at the Jellyfish Outflow, WY14-21.

		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
Tau	na	-0.500	-0.357	-0.071	-0.357	-0.429	-0.357	-0.071	-0.500	-0.429	-0.214	-0.071	-0.286
P-Value	na	0.083	0.216	0.805	0.216	0.138	0.216	0.805	0.083	0.138	0.458	0.805	0.322
Theil Slope (per year)	na	-4.032	-7.342	-0.392	-4.171	-0.014	-0.016	-0.007	-0.016	-0.010	-0.007	-0.002	-0.007

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.

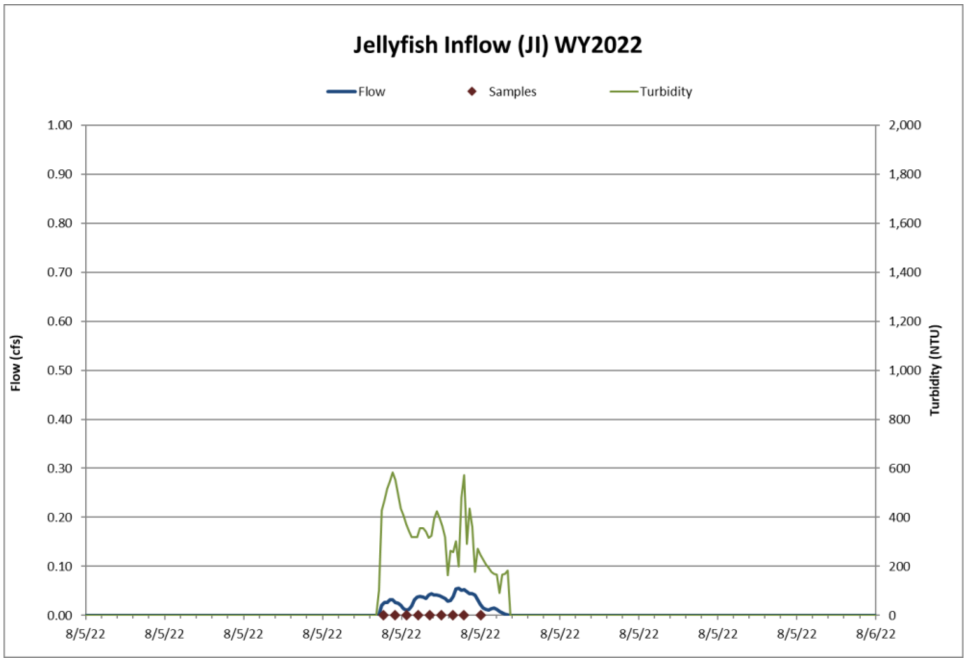

Figure 11 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Inflow for the 8/5/2022 thunderstorm event.

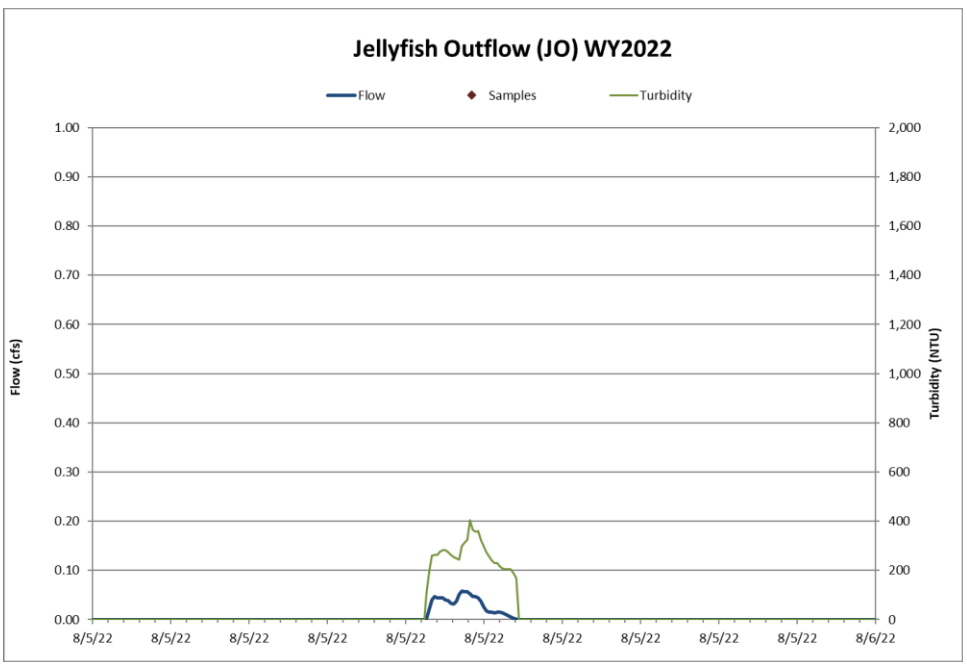

Figure 12 Hydrograph and continuous turbidity at the Jellyfish Outflow for the 8/5/2022 thunderstorm event. Samples failed during this event at Jellyfish Outflow.

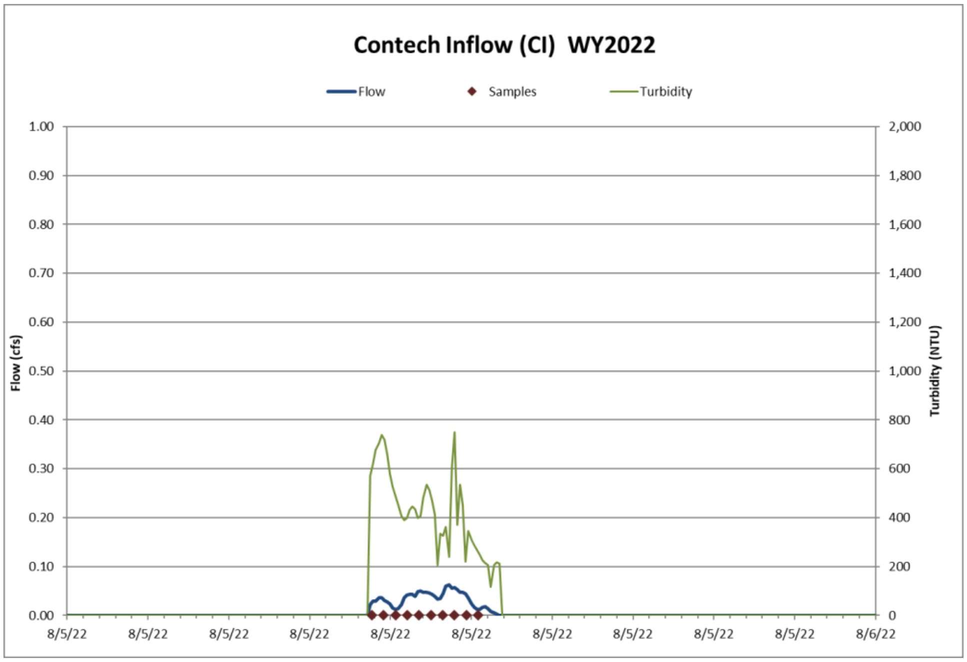

Figure 13 Hydrograph, continuous turbidity, and sample distribution at the Contech Inflow for the 8/5/2022 thunderstorm event.

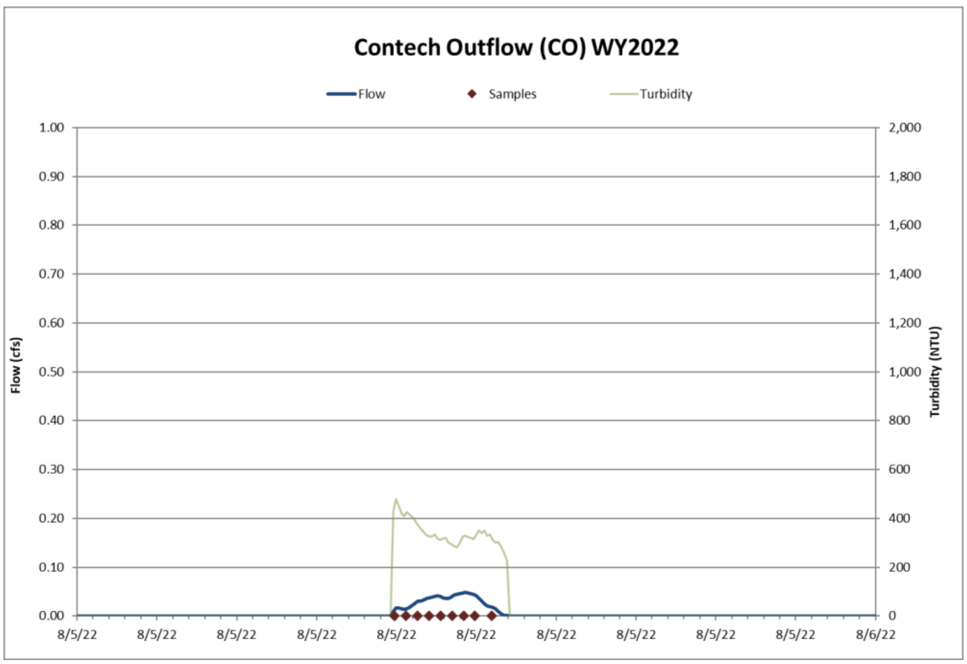

Figure 14 Hydrograph continuous turbidity, and sample distribution at the Contech Outflow for the 8/5/2022 thunderstorm event.

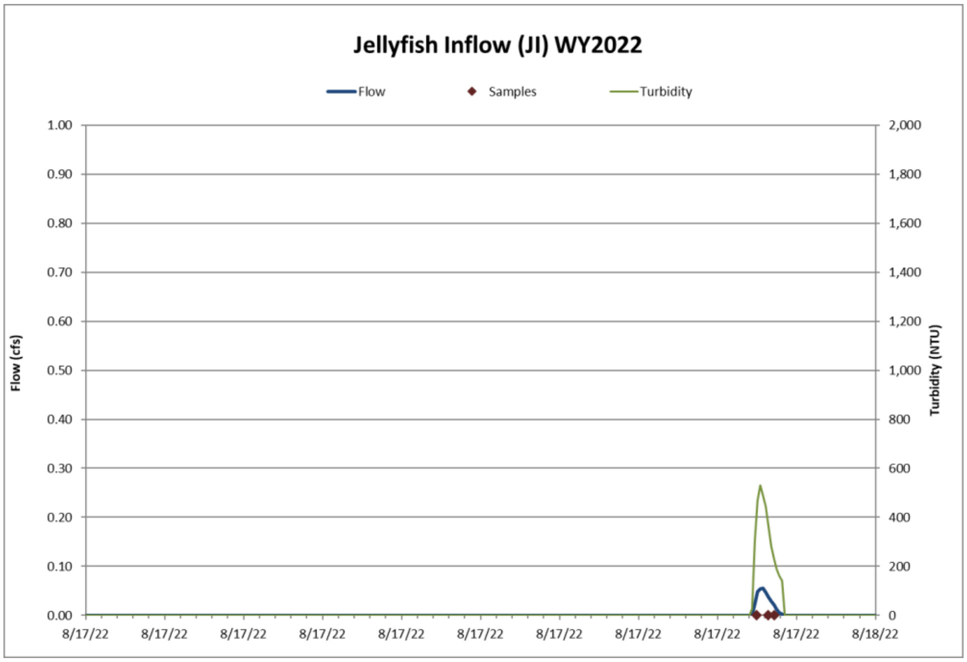

Figure 15 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Inflow for the 8/17/2022 thunderstorm event.

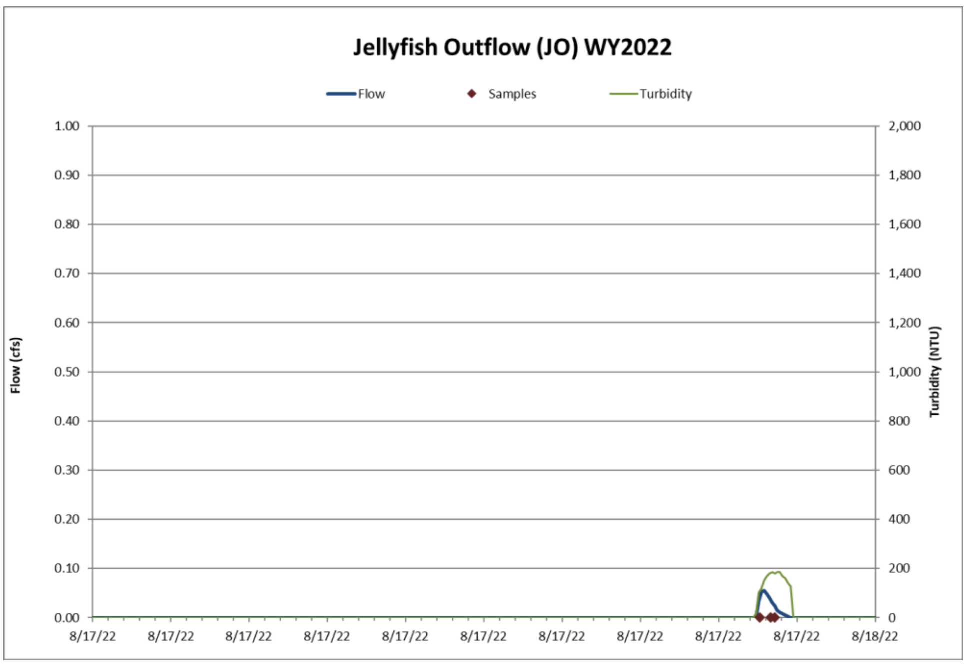

Figure 16 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Outflow for the 8/17/2022 thunderstorm event.

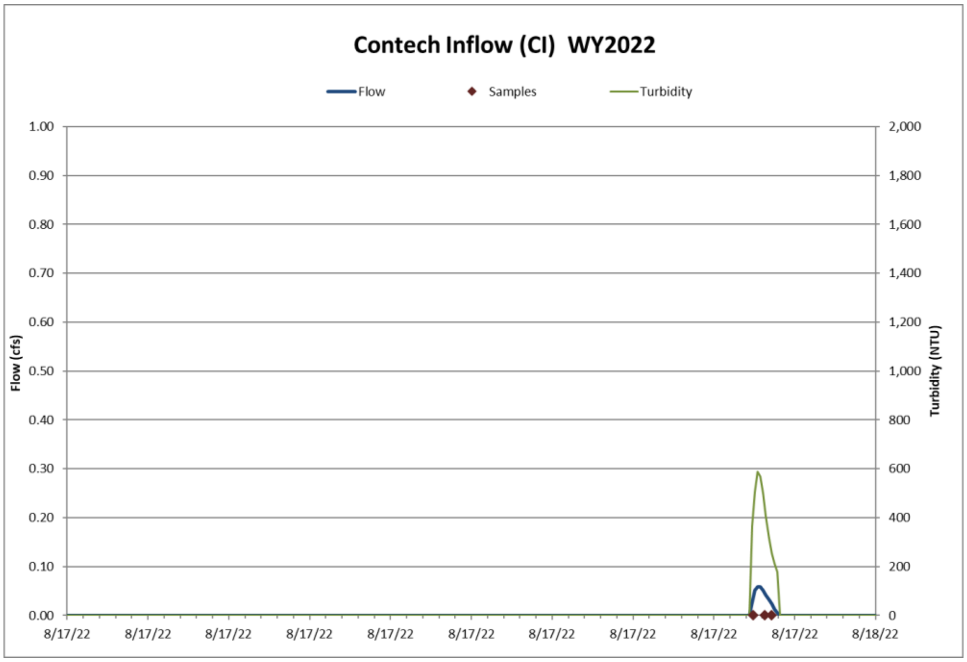

Figure 17 Hydrograph, continuous turbidity, and sample distribution at the Contech Inflow for the 8/17/2022 thunderstorm event.

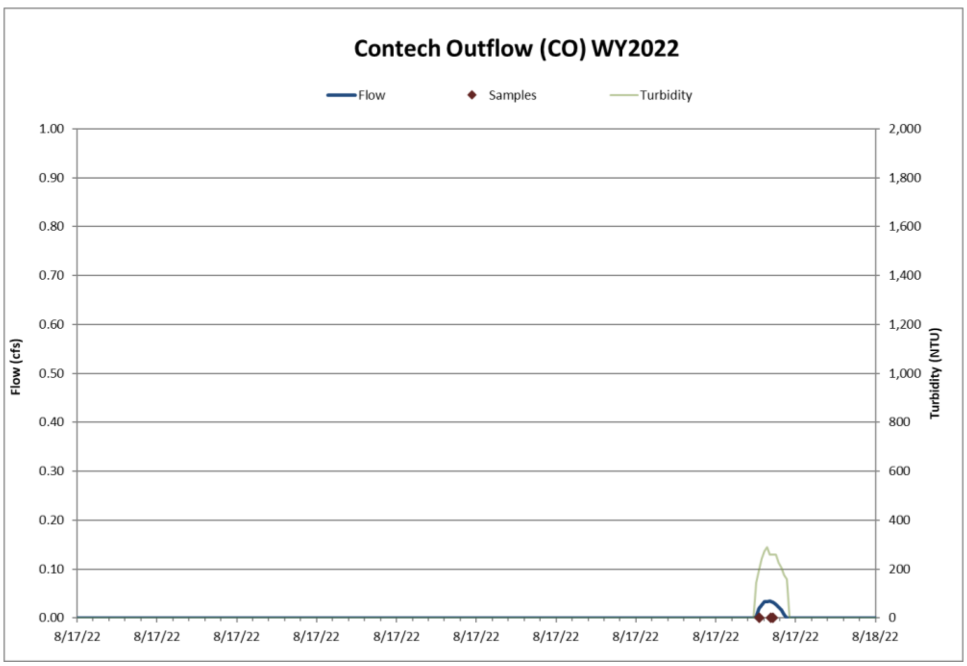

Figure 18 Hydrograph, continuous turbidity, and sample distribution at the Contech Outflow for the 8/17/2022 thunderstorm event.

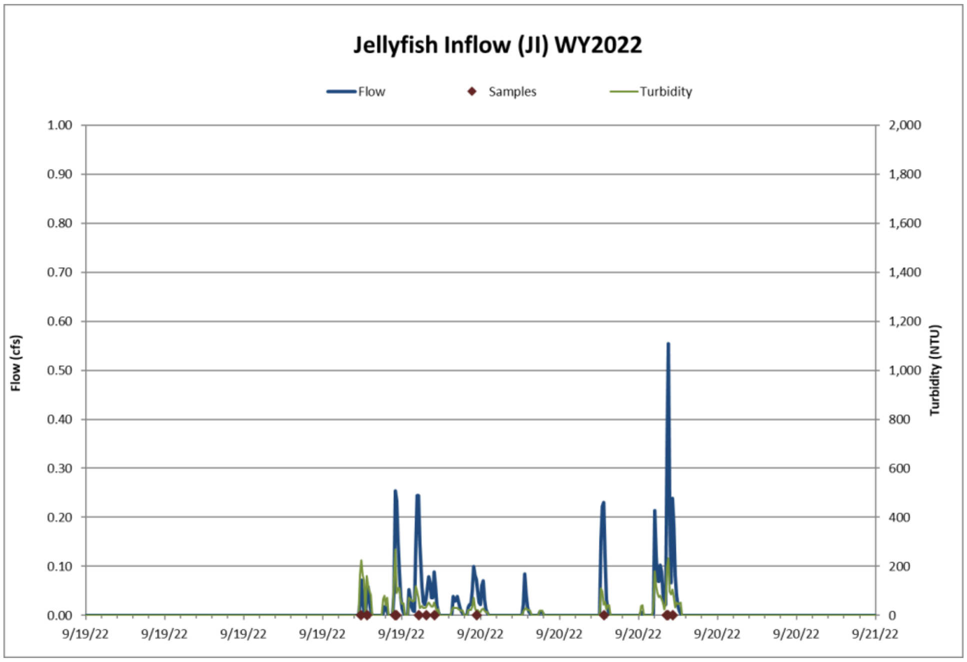

Figure 19 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Inflow for the 9/19/2022-9/21/2022 rain event.

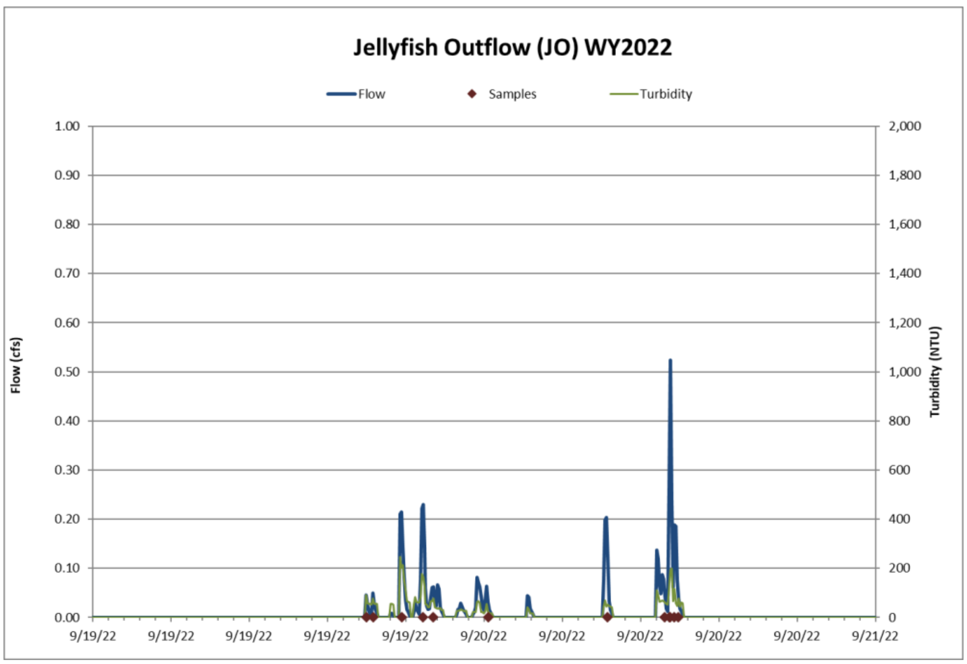

Figure 20 Hydrograph, continuous turbidity, and sample distribution at the Jellyfish Outflow for the 9/19/2022-9/21/2022 rain event.

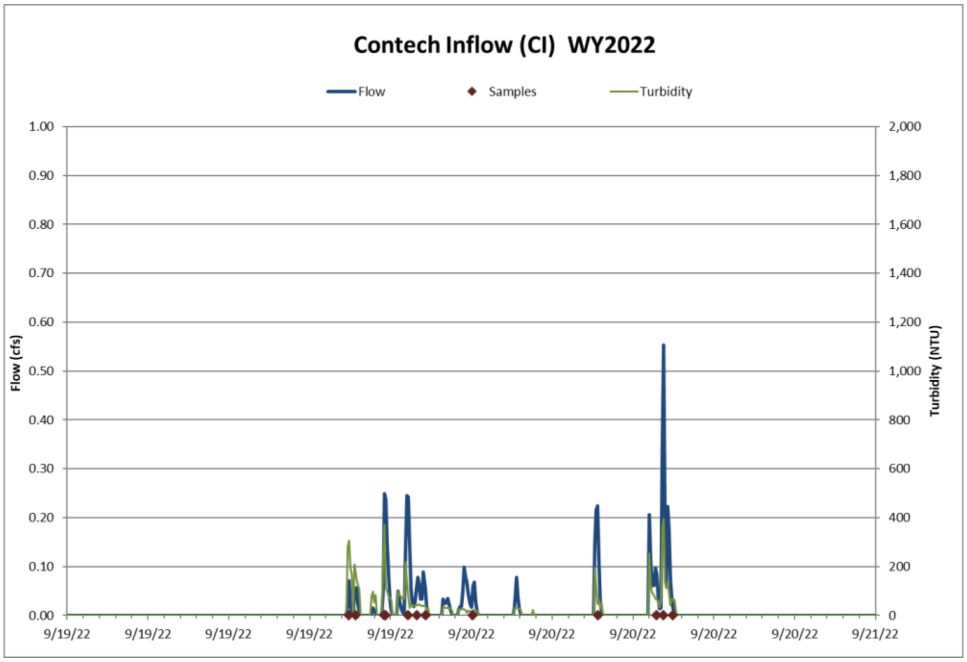

Figure 21 Hydrograph, continuous turbidity, and sample distribution at the Contech Inflow for the 9/19/2022-9/21/2022 rain event.

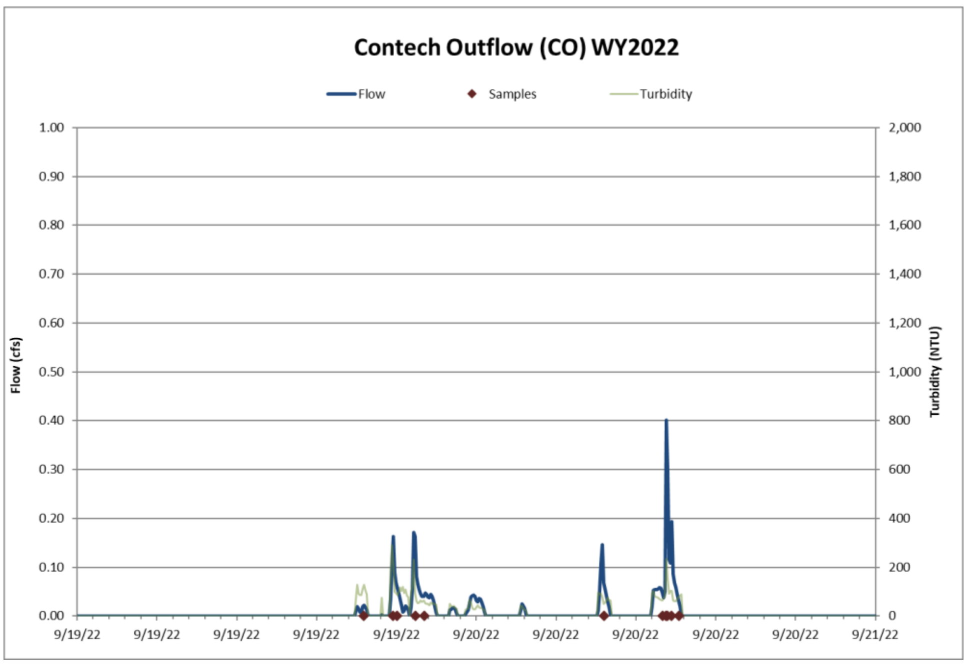

Figure 22 Hydrograph, continuous turbidity, and sample distribution at the Contech Outflow for the 9/19/2022-9/21/2022 rain event.

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