Seasonal Progress Report #9
SR431 Treatment Vault Effectiveness Monitoring

Agreement Number: P367-18-018

Submitted by: Tahoe Resource Conservation District

Submitted to: Nevada Department of Transportation

Water Year: 2019

Period: Fall/Winter Season, October 1, 2018 – February 28, 2019

Submission Date: March 27, 2019

Two stormwater cartridge 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 2020 (May 30, 2020) and beyond if funding allows. Tahoe RCD follows sampling protocols outlined in the Regional Stormwater Monitoring Program Framework and Implementation Guidance document (RSWMP FIG, Tahoe RCD et al 2015).

A new agreement to continue monitoring for water year 2019 (WY19) and part of WY20 and complete the annual monitoring reports for WY18 and WY19 was fully executed in December 2018 for an 18 month term (January 1, 2019 - June 30, 2020). This new agreement is a continuation of agreement number P423-13-019 (November 12, 2013 – June 30, 2018) with a lapse in funding between June 30, 2018 and January 1, 2019. Despite the lapse in funding between these two grants, stormwater monitoring continued uninterrupted using funds from the Regional Stormwater Monitoring Program (RSWMP) Implementers' Monitoring Program (IMP) partnership. Tasks specific to this contract (outside of the scope of the partnership) did not continue.

The 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. RSWMP ASWMR refers to the RSWMP Annual Stormwater Monitoring Report submitted each year to the Nevada Division of Environmental Protection (NDEP) on March 15th as part of the RSWMP IMP partnership.

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

Task	Description	Due Date	% Of Work Complete	Date (s) Submitted
1	Project Administration			
1.1	Quarterly Invoices	Quarterly	0%	
1.2	Seasonal Progress Reports	Seasonally	20%	3/27/19
2	Stormwater Monitoring			
2.1	Collect continuous flow and turbidity data at four monitoring stations	6/30/2020	ongoing	Available on Acuity
2.2	Collect stormwater runoff samples during eight events per year	6/30/2020	ongoing	RSWMP ASWMR
2.3	Collect three diurnal non-event snowmelt events if conditions allow	5/31/2020	ongoing	RSWMP ASWMR
2.4	Collect flow bypass data in both vaults	6/30/2020	ongoing	RSWMP ASWMR
2.5	Provide precipitation data to date	6/30/2020	20%	3/27/19
2.6	Provide hydrograph, turbidity, and sample distribution graphs to date	6/30/2020	20%	3/27/19
3	Condition Assessments			
3.1	Estimate Road RAM score prior to eight sampled events per year if conditions allow	6/30/2020	20%	3/27/19
3.2	Measure depth of sediment in both vaults after sampled events if conditions allow	6/30/2020	20%	3/27/19
4	Reporting			
4.1	Provide raw data	NA	ongoing	Available on Acuity
4.2	Provide treatment effectiveness analysis	Seasonally	20%	3/27/19
4.3	Correlate Road RAM score to pollutant concentration and load	Seasonally	20%	3/27/19
4.4	Provide mass loading v. volume calculations for select events	Upon request	NA	NA

Task 1: Project Administration

1. Invoices

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

#1: January 1, 2019 - March 31, 2019 (due April 30, 2019)
#2: April 1, 2019 - June 30, 2019 (due July 31, 2019)
#3: July 1, 2019 - September 30, 2019 (due October 31, 2019)
#4: October 1, 2019 - December 31, 2019 (due January 31, 2020)
#5: January 1, 2020 - March 31, 2020 (due April 30, 2020)
#6: April 1, 2020 - June 30, 2020 (due July 31, 2020)

2. Progress Reports

Progress reports are not concurrent with quarterly invoices. Three seasonal progress reports for WY19 and two for WY20 will be submitted for this project covering the following periods (report number is consistent with prior agreement's reports beginning May 2015):

#9: Fall/winter: - October 1, 2018 - February 28, 2020 (due March 31, 2019)
#10: Spring: March 1, 2019 - May 31, 2019 (due June 30, 2019)
#11: Summer: June 1, 2019 - September 30, 2019 (due October 31, 2019)
#12: Fall/winter: October 1, 2019 - February 29, 2020 (due March 31, 2020)
#13: Spring: March 1, 2020 - May 31, 2020 (due June 30, 2020)

Please accept this report as seasonal progress report #9.

Task 2: Stormwater Monitoring

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

The fall/winter season of WY19 began on October 1, 2018 and ended February 28, 2019. October and November were relatively dry and December-February produced a lot of snow, with February being the snowiest month on record for many of the local ski resorts. Continuous flow and continuous turbidity were successfully monitored for the fall/winter season. The road surface of SR431 was very clean at the beginning of the season (Figure 1-2). By mid-February, the road shoulders were covered in a snow berm , making access to monitoring equipment difficult (Figure 3-4).

Figure 1: October 12, 2019 SR431 pullout.

Figure 2: October 12, 2019 sediment on road.

Figure 3: February 19, 2019 pullout, showing berm along pullout and road. Access doors are under berm.

Figure 4: February 28, 2019 berm on road. Access doors are under several feet of snow in the pullout.

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

During the fall/winter of WY19 four events were successfully sampled (a thunderstorm event on October 3, 2018; a rain event on November 23, 2018; and two rain on snow events on February 2, 2019 and February 13, 2019 respectively). These events bring the water year total to four events. Although the winter of 2019 produced substantial amounts of precipitation, many storm events fell as snow and produced little to no runoff. February was a record-breaking month for snowfall, and made sample collection and site maintenance challenging even with frequent communication with NDOT maintenance staff. (See Figure 3-4).

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 during 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 WY19 the Contech MFS cartridge filters were bypassed during 8 events (the 10/3/18 thunderstorm event, the 11/23/2018 rain event, the 12/24/2018 rain on snow event; 1/19/2019 snowmelt event; 1/23/2019 snowmelt event; the 2/2/2019 rain on snow event; the 2/13/2019-2/14/2019 rain on snow event, and the 2/23/2019 -2/24/2019 snowmelt event (Figure 5). During fall/winter 2019 the Jellyfish filters bypassed very briefly during the 2/2/2019 rain on snow event and during the 2/13/2019 rain on snow event (Figure 6).

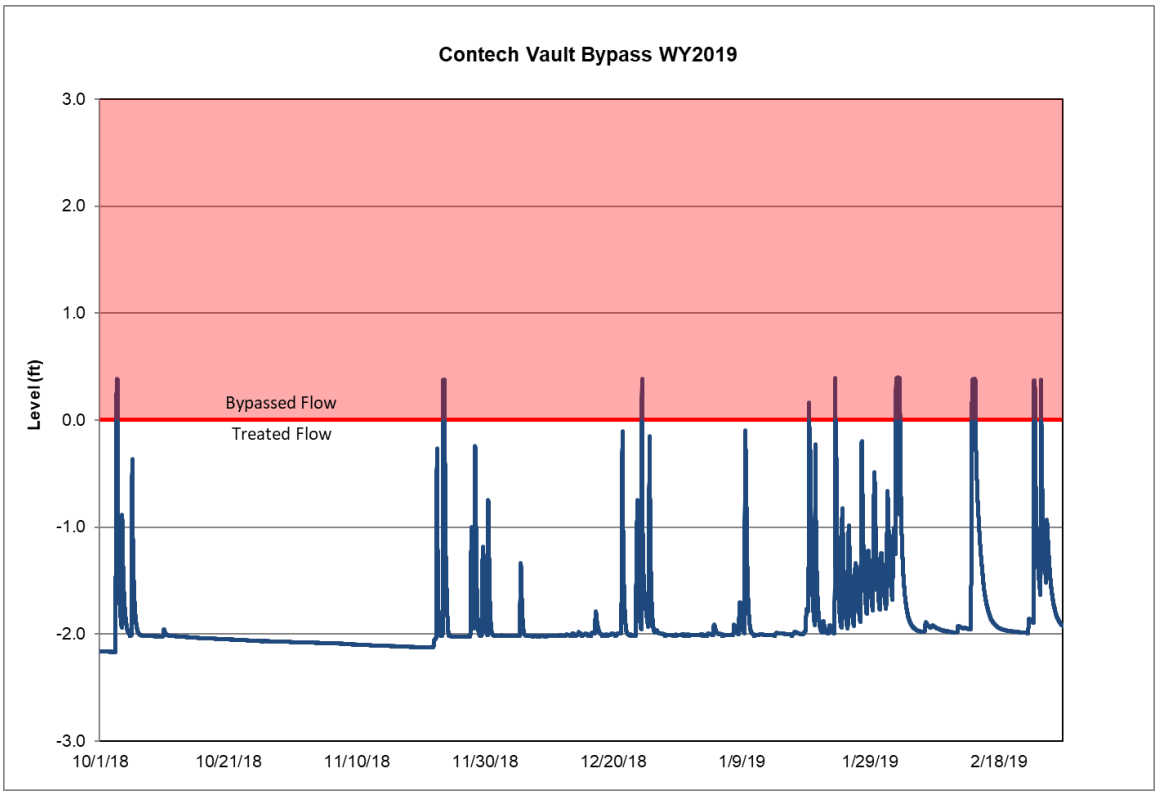

Figure 5: Bypassed flow in Contech MFS vault WY19 to date.

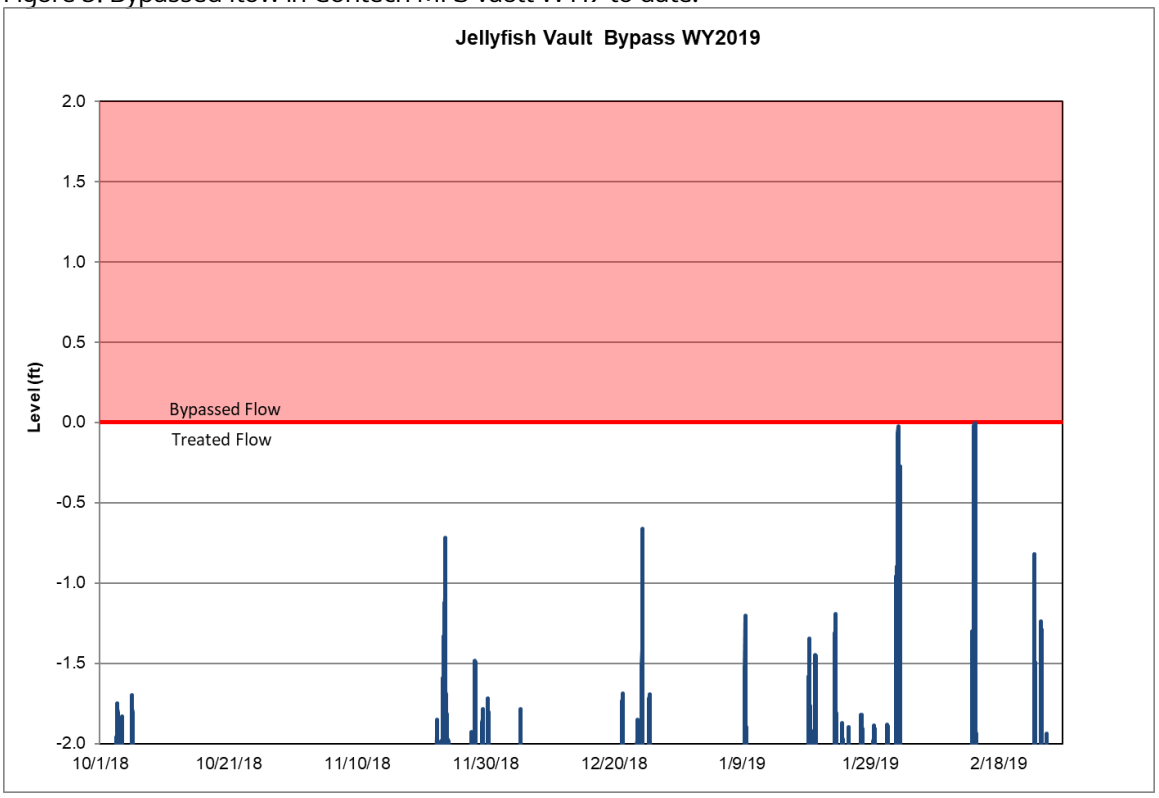

Figure 6: Bypassed flow in Jellyfish vault WY19 to date.

5. Provide precipitation data to date.

Table 2 provides summary data for all 20 fall/winter precipitation events recoreded at the NDOT and TERC2 meteorological stations including event start and end dates, total precipitation, peak precipitation, minimum and maximum temperature, and preciptation type. Events highlighted in pink were sampled for water quality. Because of it's high elevation, preciptation often falls in the form of snow during fall/winter and thus does not always generate sufficient runoff for sampling. The NDOT tipping bucket became non-functional on January 20, 2019 due to damage from snow blowers. Between February 25, 2019 and March 14, 2019 all other sensors became buried due to excessive snow accumulation. Meteorological data from the TERC2 weather station located on the roof of the Sierra Nevada College Tahoe Center for Environmental Science building in Incline Village was substituted for this period.

Table 2: Summary of fall/winter precipitation events at SR431 for WY19. 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	--	--	7/31/2018 7:40	--	--	--	--	--	--	--
NDOT	NDOT-17-01	10/3/2018 9:05	10/4/2018 12:35	1.1	64.1	0.41	0.023	4	10	Rain
NDOT	NDOT-17-02	10/5/2018 20:55	10/6/2018 18:55	0.9	1.3	0.1000	0.008	1	9.47	Rain
NDOT	NDOT-17-03	10/10/2018 20:40	10/11/2018 6:10	0.4	4.1	0.028	0.012	1	3.628	Rain
NDOT	NDOT-17-04	11/21/2018 19:30	11/23/2018 23:20	2.2	41.6	1.3840	0.016	-3	2	Rain
NDOT	NDOT-17-05	11/27/2018 13:15	12/2/2018 4:15	4.6	3.6	1.5080	0.016	-9	3	Rain on Snow
NDOT	NDOT-17-06	12/5/2018 0:25	12/5/2018 10:05	0.4	2.8	0.068	0.008	-5	-0.81	Snow
NDOT	NDOT-17-07	12/10/2018 15:40	12/10/2018 15:40	0.0	5.2	0.004	0.004	0	-0.098	Snow
NDOT	NDOT-17-08	12/17/2018 1:15	12/17/2018 7:10	0.2	6.4	0.056	0.004	-2	-0.284	Snow
NDOT	NDOT-17-09	12/21/2018 0:25	12/21/2018 10:10	0.4	3.7	0.1120	0.008	-1	1	Rain on Snow
NDOT	NDOT-17-10	12/23/2018 12:35	12/26/2018 11:15	2.9	2.1	1.1400	0.016	-9	2	Rain, Snow
NDOT	NDOT-17-11	12/27/2018 21:35	12/27/2018 21:35	0.0	1.4	0.0040	0.004	-9	-9	Other
NDOT	NDOT-17-12	1/5/2019 16:10	1/7/2019 18:05	2.1	8.8	1.1120	0.016	-7	-1	Snow, Rain
NDOT	NDOT-17-13	1/9/2019 3:00	1/9/2019 16:15	0.6	1.4	0.1640	0.016	-1	1	Rain on Snow
NDOT	NDOT-17-14	1/14/2019 21:45	1/18/2019 6:20	3.4	5.2	2.5720	0.133	0	0	Snow, Rain, Snow, Rain
TERC2	NDOT-17-15	1/20/2019 8:45	1/21/2019 11:55	1.1	2.1	0.7920	0.016	0	0	Rain, Snow
TERC2	NDOT-17-16	2/2/2019 0:25	2/5/2019 16:55	3.7	11.5	2.3760	0.024	0	0	Rain, Snow
TERC2	NDOT-17-17	2/9/2019 4:25	2/10/2019 13:40	1.4	3.5	0.7320	0.012	0	0	Rain, Snow
TERC2	NDOT-17-18	2/13/2019 0:00	2/17/2019 15:55	4.7	2.4	4.4280	0.032	-9	2	Rain, Snow
TERC2	NDOT-17-19	2/20/2019 14:30	2/20/2019 14:30	0.0	2.9	0.0040	0.004	-7	-7	Snow
TERC2	NDOT-17-20	2/25/2019 14:50	2/28/2019 9:05	2.8	5.0	1.4880	0.012	-4	6	Rain/Snow

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

See Figures 8-23 at the end of this report for hydrographs, continous turbidity, and sample distributions for the events sampled in the fall/winter season of WY19.

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. This procedure is expected to help establish a site-specific relationship between road condition and inflow FSP concentration in runoff. However, Figure 7 indicates that no significant relationship can be established with the data collected to date.

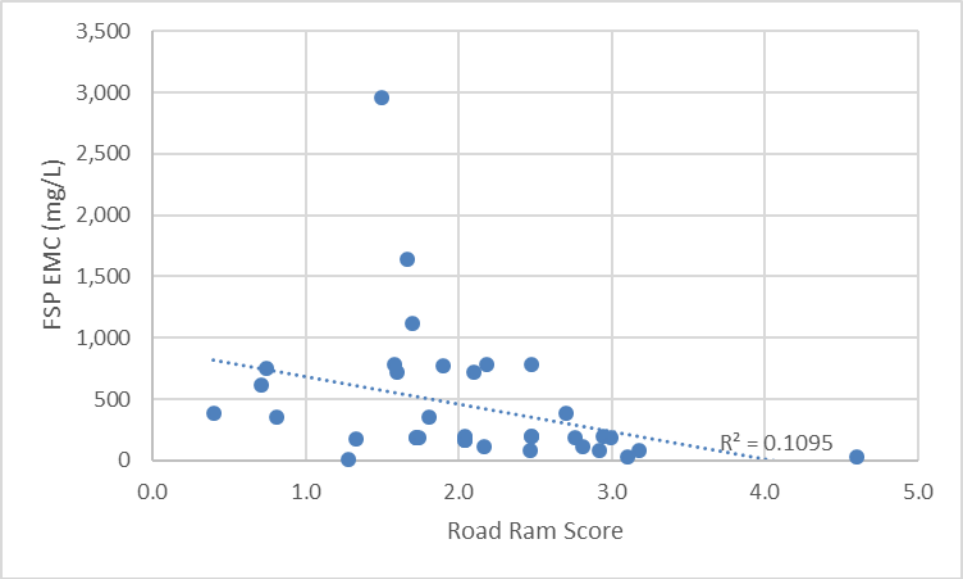

Figure 7: Relationship between Road Ram Score and inflow FSP EMC; very low R^2 indicates no significant relationship.

Since November 2015, thirty-six Road RAM scores have been determined. Road RAM scores assess road condition and are expressed on a scale from 0 to 5. A score of 0 indicates road conditions that present a high risk to downslope water quality, while a score of 5 indicates road conditions with minimal risk to downslope water quality (2NDNATURE et al 2015). This season, Road RAM was conducted September 2018 through November 2018, but not December 2018 through February 2019 because the road surface was consistently too wet (Road RAM is not possible on wet roads). Road RAM scores correspond to an estimated FSP concentration range that can be expected in runoff events as outlined in the Road RAM Technical Document (2NDNATURE et al 2015). Efforts are made to take Road RAM scores close to the beginning of sampled runoff events, but this can not always occur.

Observed Road RAM scores thus far cover nearly the full range of possible measurements (0.4 to 4.6); however the majority of scores indicate that the roads were relatively dirty prior to most runoff events (Table 3 - sorted from dirtiest to cleanest Road RAM scores.) Table 3 summarizes the Road RAM scores, days between RAM determination and runoff event, the expected FSP concentrations associated with that score, actual inflow FSP concentrations (an average of the event mean concentrations (EMCs) measured at the Contech MFS inflow and the Jellyfish inflow), and the percent difference between the expected FSP based on RAM score and the measured FSP concentration. The worst scores tend to occur in the spring (March – May), and the best scores tend to occur in the fall (October – November).

Table 3: Summary of Road RAM scores and FSP concentrations WY16, WY17, WY18, and WY19 to date.

Road RAM date	Runoff event date	Days between RAM and runoff event	Road RAM Score	Expected FSP concentration * (mg/L)	Average JI&CI inflow FSP EMC (mg/L)	FSP Percent Difference (%)
4/8/16	5/5/16	27	0.4	1133	387	-98%
4/11/17	4/16/17	6	0.7	872	612	-35%
3/15/17	4/6/17	23	0.7	847	746	-13%
5/1/17	5/6/17	6	0.8	802	352	-78%
5/12/17	5/19/17	7	1.3	537	13	-191%
4/20/18	5/16/18	26	1.3	516	177	-98%
2/24/16	3/4/16	8	1.5	445	2,955	148%
12/27/17	3/20/18	83	1.6	415	783	62%
12/2/15	12/10/15	8	1.6	409	722	55%
3/29/18	4/6/18	8	1.7	388	1,639	123%
1/28/15	1/29/16	1	1.7	375	1,118	99%
7/5/17	8/19/17	46	1.7	367	186	-65%
7/20/17	8/19/17	31	1.7	367	186	-65%
6/5/17	8/19/17	76	1.7	363	186	-64%
5/5/17	5/6/17	2	1.8	343	352	3%
12/7/16	12/8/16	1	1.9	317	774	84%
8/7/17	8/19/17	13	2.0	281	186	-41%
8/25/17	9/21/17	27	2.0	281	167	-51%
8/25/17	9/21/17	27	2.0	281	167	-51%
10/5/17	11/16/17	42	2.0	281	201	-33%
12/8/15	12/10/15	2	2.1	267	722	92%
5/30/18	7/22/18	53	2.2	252	114	-75%
1/13/18	3/20/18	66	2.2	248	783	104%
9/18/18	10/3/18	15	2.5	195	82	-81%
10/19/17	11/16/17	28	2.5	195	201	3%
11/1/17	11/16/17	15	2.5	195	201	3%
12/14/17	3/20/18	96	2.5	195	783	120%
5/4/16	5/5/16	1	2.7	160	387	83%
11/16/18	11/23/18	7	2.8	152	190	22%
6/20/18	7/22/18	32	2.8	147	114	-25%
7/26/18	10/3/18	69	2.9	134	82	-48%
11/11/17	11/16/17	5	2.9	130	201	43%
10/12/18	11/23/18	42	3.0	124	190	41%
10/12/16	10/27/16	15	3.1	114	34	-109%
8/16/18	10/3/18	48	3.2	107	82	-26%
10/11/16	10/27/16	16	4.6	32	34	6%

*FSP concentrations expected with particular RAM score (from PLRM Road Methodology nhc et al. 2009)

According to the Road RAM Technical Document scores between 0 and 1.0 are considered "poor" and expected FSP concentrations in runoff from roads in this category range from 680-1,592 mg/L. Actual average inflow FSP EMCs were less than expected FSP concentrations in all cases for poor scores. Poor scores constitute 11% of scores determined to date and all occurred in the spring.

Road RAM scores greater than 1.0 and less than or equal to 2.0 fall into the "degraded" category. The range of FSP concentrations that can be expected in runoff from roads in this condition is 291-679 mg/L. However, the actual average inflow FSP EMCs from runoff events within this score range were higher than the expected FSP concentrations for Road RAM estimations made in the fall/winter and spring seasons but lower for estimations made in the summer season for this category of scores. This may indicate a seasonal influence on the dependability of Road RAM to predict actual concentrations. Degraded scores constitute 44% of scores determined to date.

Road RAM scores greater than 2.0 and less than or equal to 3.0 fall into the "fair" category where the range of expected FSP concentrations in runoff is 124-290 mg/L. The actual average inflow FSP EMCs from runoff events within this score range tended to fall within that range in the fall, above that range in the winter, and below that range in the summer. Fair scores constitute 36% of scores determined to date.

Road RAM scores greater than 3.0 and less than or equal to 4.0 are considered "acceptable" and expected FSP concentrations range from 53-123 mg/L. The actual average inflow FSP EMCs from runoff events within this score range were either within this range or less than 53. Acceptable scores constitute 8% of scores determined to date and occurred between August and October.

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 4 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 was 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 during this month due to lack of access to the vaults.

Table 4: 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
5/17/2018	0.08	0.36
1/2/2019	0.10	0.09

Task 4: Reporting

1. Provide raw data.

Final reporting for each water year is provided as part of the Annual Stormwater Monitoring Report (due March 15th 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 15th 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. However, treatment effectiveness for FSP for fall/winter of WY19 is provided for all events for the Contech MFS in Table 5 and the Jellyfish in Table 6. Removal efficiencies highlighted in pink 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 filter vault.

Table 5: Contech MFS FSP removal efficiency for each event of fall/winter WY9.

CONTECH MFS WY19 Fall/Winter: October 1, 2018 - February 28, 2019							
Runoff Start Date Time	Runoff End Date Time	Runoff Type	Event Duration	Influent Volume (cf)	Influent FSP (lbs)	Effluent FSP (lbs)	Removal Efficiency
10/3/2018 10:05	10/3/2018 19:00	rain	8:55	754	4.332	1.726	-60%
10/4/2018 10:35	10/4/2018 11:45	rain	1:10	49	0.241		-100%
10/5/2018 23:50	10/6/2018 1:45	rain	1:55	90	0.394		-100%
11/22/2018 10:50	11/22/2018 13:35	rain, snow	2:45	163	2.146	0.189	-91%
11/23/2018 10:10	11/23/2018 18:10	rain, snow	8:00	791	10.404	3.998	-62%
11/27/2018 18:55	11/28/2018 12:40	rain, snow	17:45	135	1.817		-100%
11/29/2018 13:45	11/29/2018 15:15	non-event snowmelt	1:30	15	0.181		-100%
11/30/2018 9:50	11/30/2018 12:25	non-event snowmelt	2:35	55	0.350		-100%
12/5/2018 11:25	12/5/2018 12:40	snow	1:15	24	0.866		-100%
12/21/2018 8:05	12/21/2018 11:05	rain	3:00	108	2.535	0.144	-94%
12/23/2018 12:55	12/23/2018 18:00	snow	5:05	50	0.639		-100%
12/24/2018 9:55	12/24/2018 11:30	rain	1:35	153	2.556	0.177	-93%
12/25/2018 13:05	12/25/2018 16:20	non-event snowmelt	3:15	97	0.586	0.006	-99%
1/9/2019 10:55	1/9/2019 15:30	rain	4:35	150	3.372	0.036	-99%
1/19/2019 9:50	1/19/2019 16:15	non-event snowmelt	6:25	225	3.459	0.074	-98%
1/20/2019 9:35	1/20/2019 11:20	rain	1:45	64	0.521		-100%
1/23/2019 11:35	1/23/2019 17:15	non-event snowmelt	5:40	243	3.551	0.296	-92%
1/24/2019 14:00	1/24/2019 15:00	non-event snowmelt	1:00	10	0.014		-100%
1/25/2019 13:55	1/25/2019 15:40	non-event snowmelt	1:45	9	0.018		-100%
1/27/2019 13:15	1/27/2019 17:05	non-event snowmelt	3:50	46	0.037		-100%
1/29/2019 11:35	1/29/2019 16:15	non-event snowmelt	4:40	16	0.003		-100%
1/31/2019 14:40	1/31/2019 16:45	non-event snowmelt	2:05	7	0.001		-100%
2/1/2019 23:50	2/2/2019 16:00	rain	16:10	1,018	8.022	1.357	-83%
2/13/2019 20:05	2/14/2019 10:20	rain	14:15	1,655	6.804	0.908	-87%
2/23/2019 11:45	2/23/2019 16:40	non-event snowmelt	4:55	313	3.986	0.314	-92%
2/24/2019 13:35	2/24/2019 16:10	non-event snowmelt	2:35	141	1.703	0.076	-96%
2/25/2019 11:00	2/25/2019 11:30	snow	0:30	6	0.028		-100%

Table 6: Jellyfish FSP removal efficiency for each event of fall/winter WY19.

JELLYFISH WY19 Fall/Winter: October 1, 2018 - February 28, 2019							
Runoff Start Date Time	Runoff End Date Time	Runoff Type	Event Duration	Influent Volume (cf)	Influent FSP (lbs)	Effluent FSP (lbs)	Removal Efficiency
10/3/2018 10:05	10/3/2018 18:45	rain	8:40	738	3.863	2.161	-44%
10/4/2018 10:35	10/4/2018 11:35	rain	1:00	55	0.312	0.195	-38%
10/6/2018 0:05	10/6/2018 1:40	rain	1:35	97	0.170	0.282	65%
11/22/2018 10:50	11/22/2018 15:50	rain, snow	5:00	165	2.062	0.084	-96%
11/23/2018 10:05	11/24/2018 3:40	rain, snow	17:35	801	7.650	3.930	-49%
11/27/2018 18:30	11/28/2018 15:40	rain, snow	21:10	164	1.596	0.000	-100%
11/29/2018 12:35	11/29/2018 21:35	non-event snowmelt	9:00	81	0.751	0.019	-98%
11/30/2018 9:45	11/30/2018 15:50	non-event snowmelt	6:05	74	0.367	0.119	-68%
12/5/2018 11:25	12/5/2018 12:50	snow	1:25	34	0.543	0.009	-98%
12/17/2018 4:50	12/17/2018 5:10	snow	0:20	2	0.006		-100%
12/21/2018 8:05	12/21/2018 11:25	rain	3:20	91	1.062	0.500	-53%
12/23/2018 12:55	12/23/2018 17:55	snow	5:00	45	0.250	0.012	-95%
12/24/2018 9:50	12/24/2018 11:55	snow	2:05	152	1.501	1.090	-27%
12/25/2018 12:10	12/25/2018 16:40	non-event snowmelt	4:30	143	0.517	0.543	5%
1/9/2019 10:55	1/9/2019 17:30	rain	6:35	210	5.908	1.876	-68%
1/19/2019 9:45	1/19/2019 16:55	non-event snowmelt	7:10	305	5.329	1.047	-80%
1/20/2019 9:35	1/20/2019 11:25	rain	1:50	86	0.899	0.150	-83%
1/23/2019 11:35	1/23/2019 18:05	non-event snowmelt	6:30	326	5.417	0.616	-89%
1/24/2019 12:50	1/24/2019 15:50	non-event snowmelt	3:00	21	0.032	0.009	-73%
1/25/2019 13:20	1/25/2019 15:50	non-event snowmelt	2:30	18	0.007		-100%
1/27/2019 12:50	1/27/2019 17:45	non-event snowmelt	4:55	91	0.010	0.083	719%
1/29/2019 11:25	1/29/2019 16:25	non-event snowmelt	5:00	50	0.001	0.002	258%
1/31/2019 14:05	1/31/2019 16:50	non-event snowmelt	2:45	27	0.000	0.002	8590%
2/1/2019 23:45	2/2/2019 16:05	rain	16:20	1,106	8.649	0.439	-95%
2/13/2019 18:25	2/14/2019 11:10	rain	16:45	1,568	7.694	0.775	-90%
2/23/2019 11:45	2/23/2019 16:55	non-event snowmelt	5:10	367	5.241	0.254	-95%
2/24/2019 13:35	2/24/2019 16:30	non-event snowmelt	2:55	193	2.240	0.070	-97%
2/25/2019 10:55	2/25/2019 11:45	snow	0:50	11	0.035		-100%

3. Correlate Road RAM score to pollutant concentration and load.

See task 3.1.

4. 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 consistenly 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.

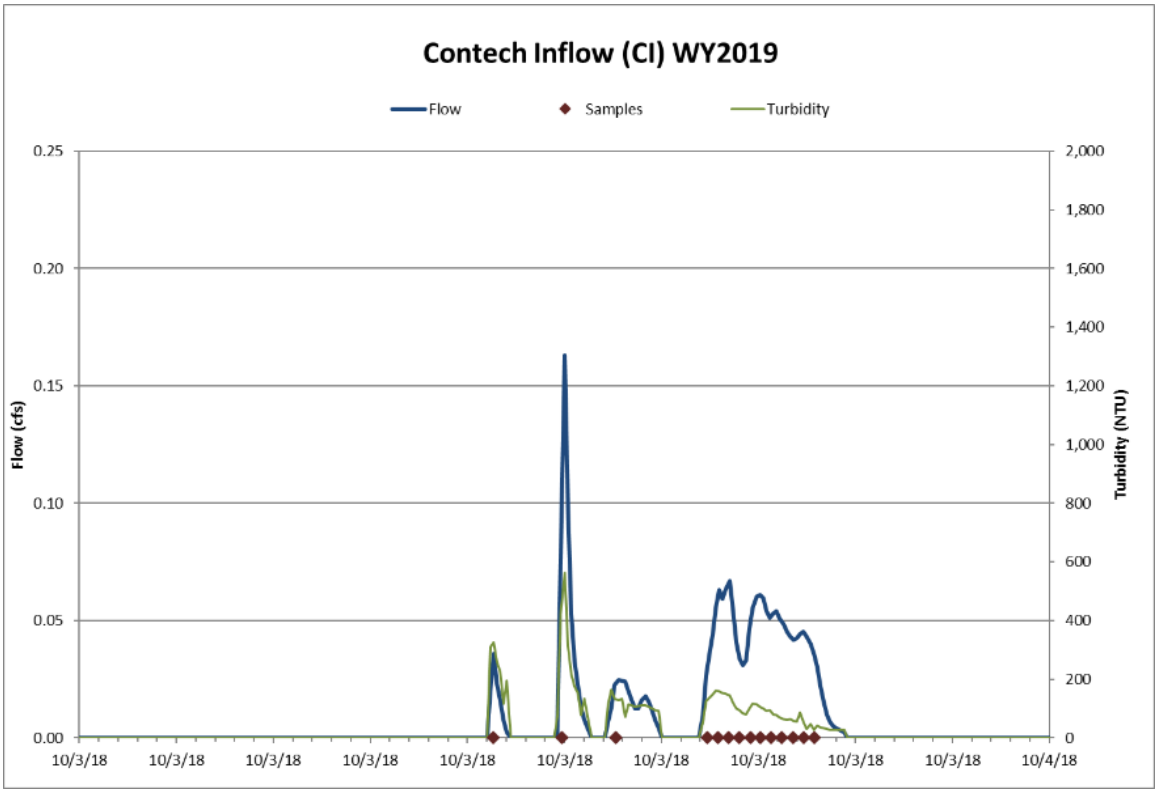

Figure 8: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Inflow for the 10/3/18 thunderstorm event.

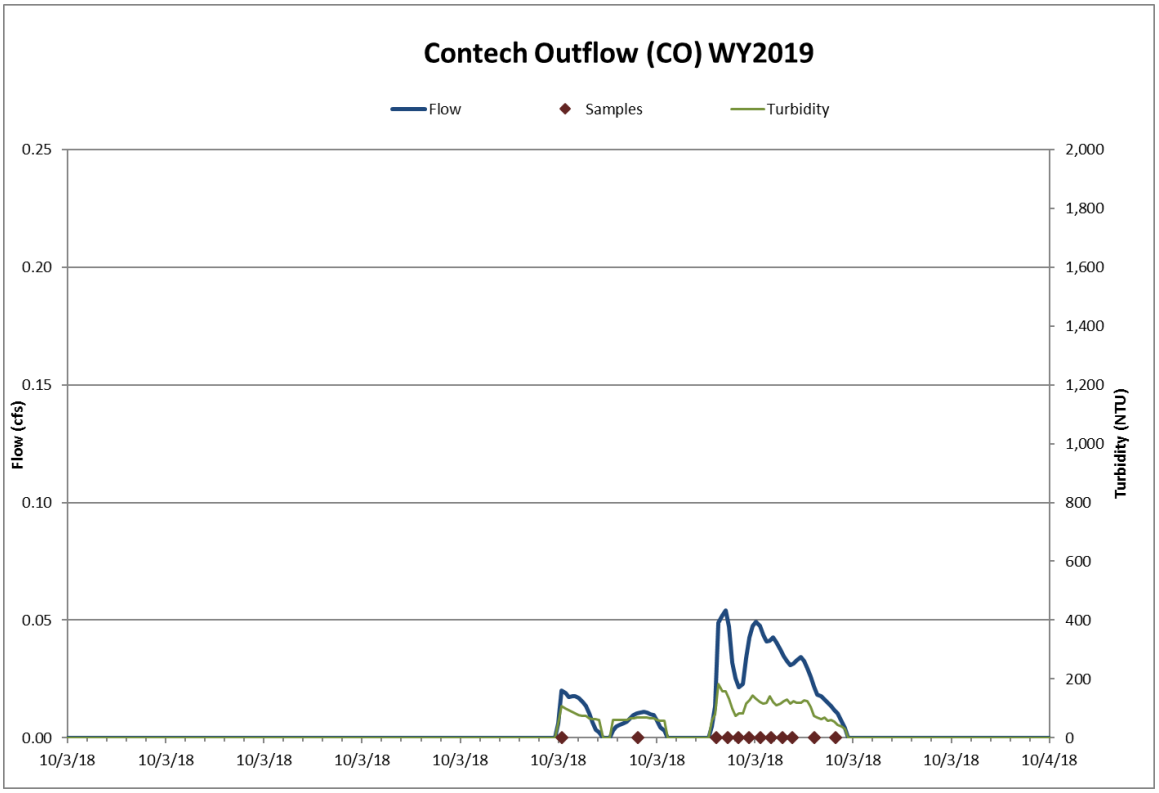

Figure 9: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Outflow for the 10/3/18 thunderstorm event.

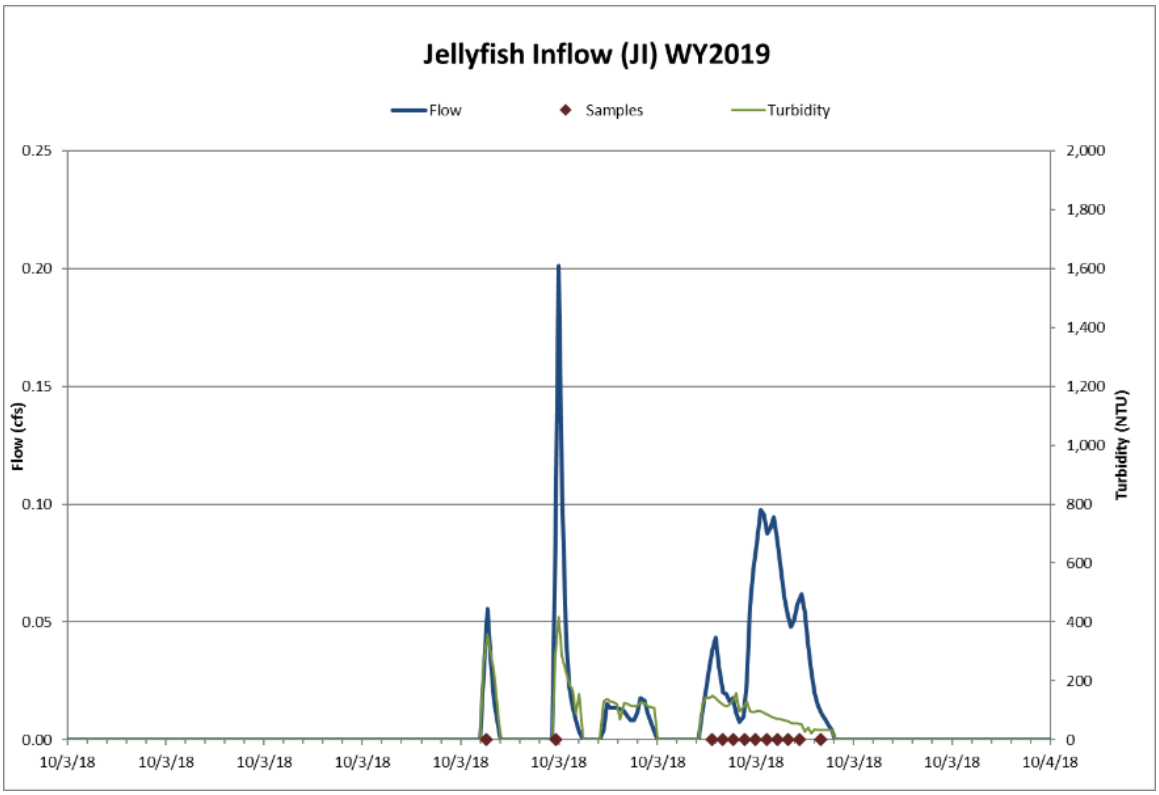

Figure 10: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Inflow for the 10/3/18 thunderstorm event.

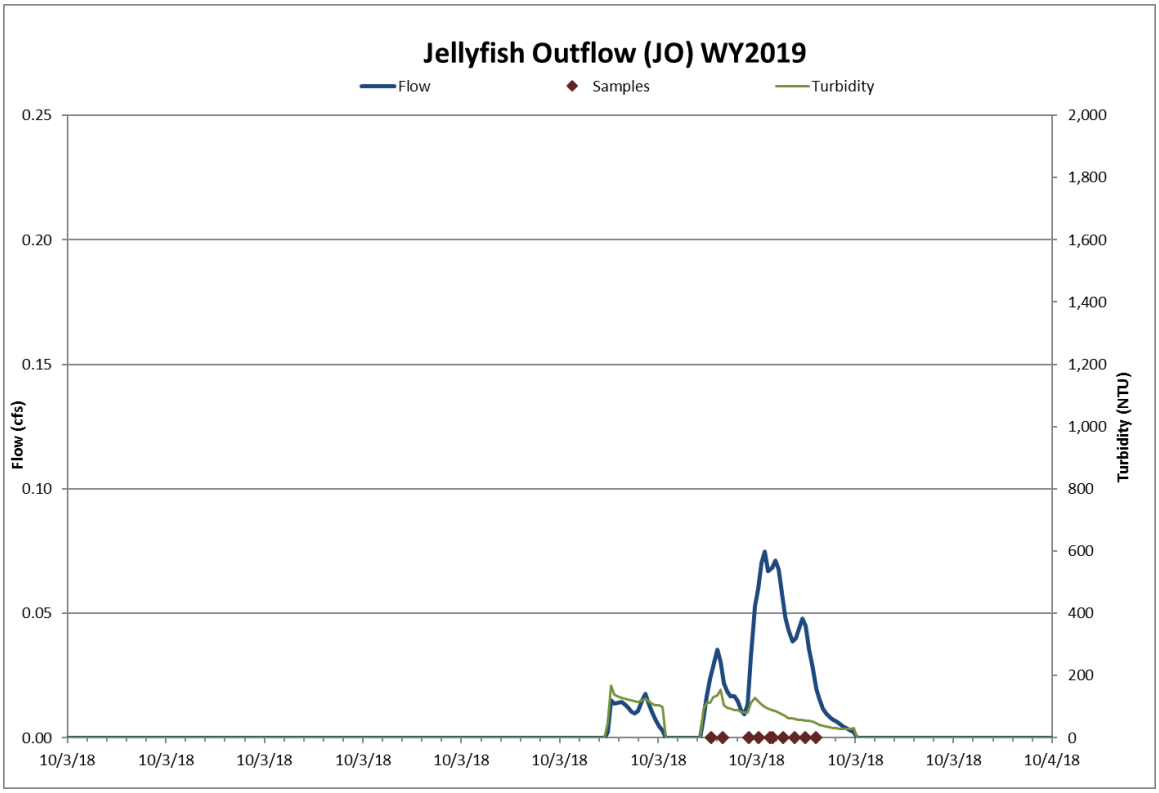

Figure 11: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Outflow for the 10/3/18 thunderstorm event.

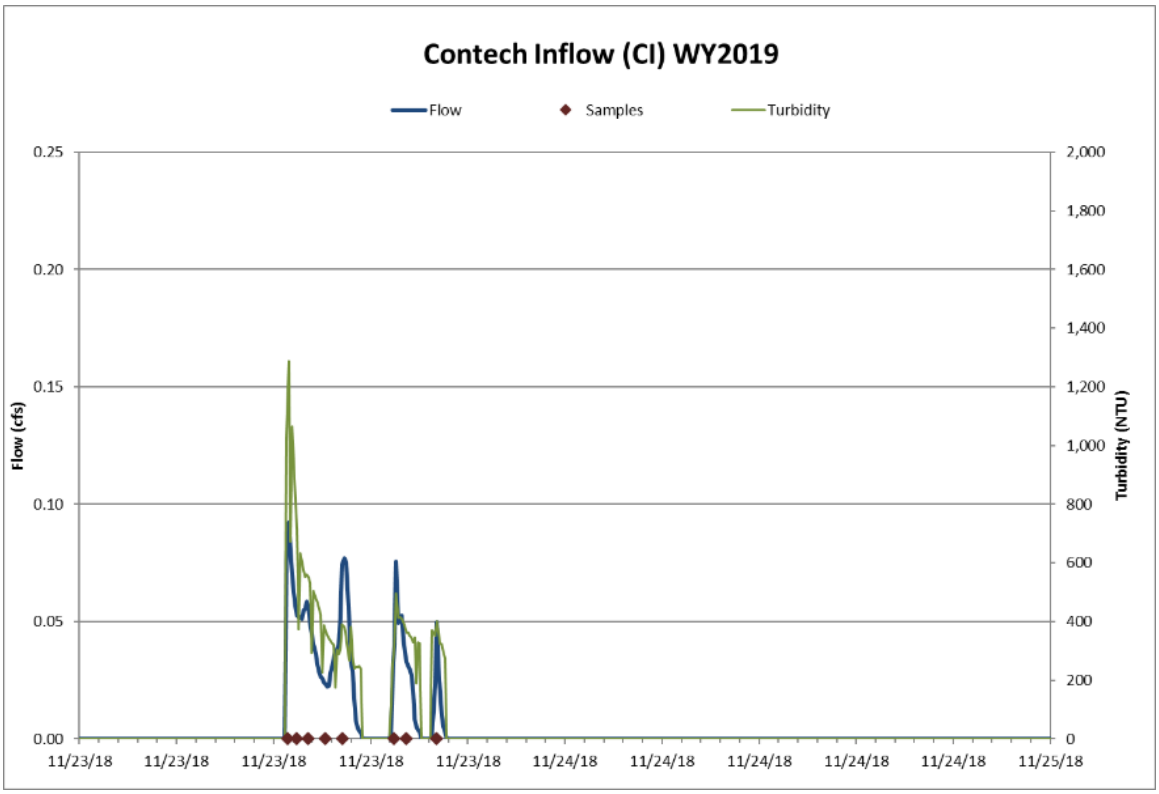

Figure 12: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Inflow for the 11/23/18 rain event.

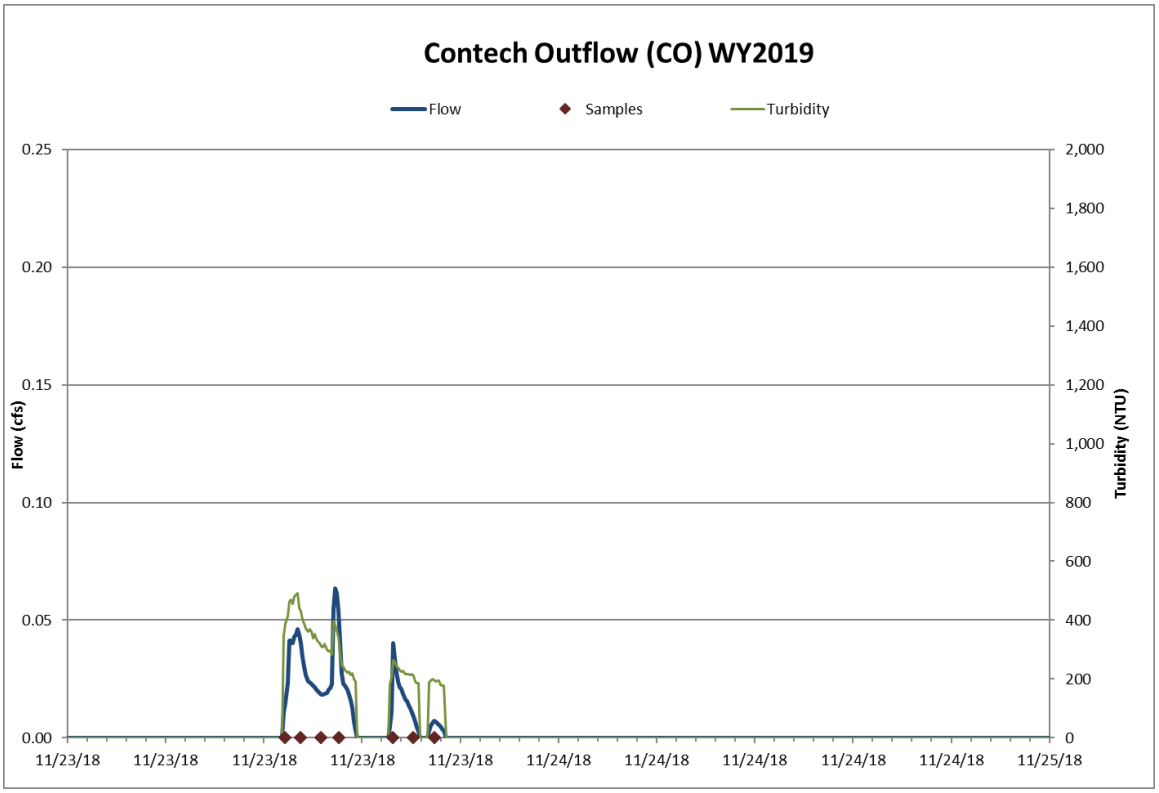

Figure 13: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Outflow for the 11/23/18 rain event.

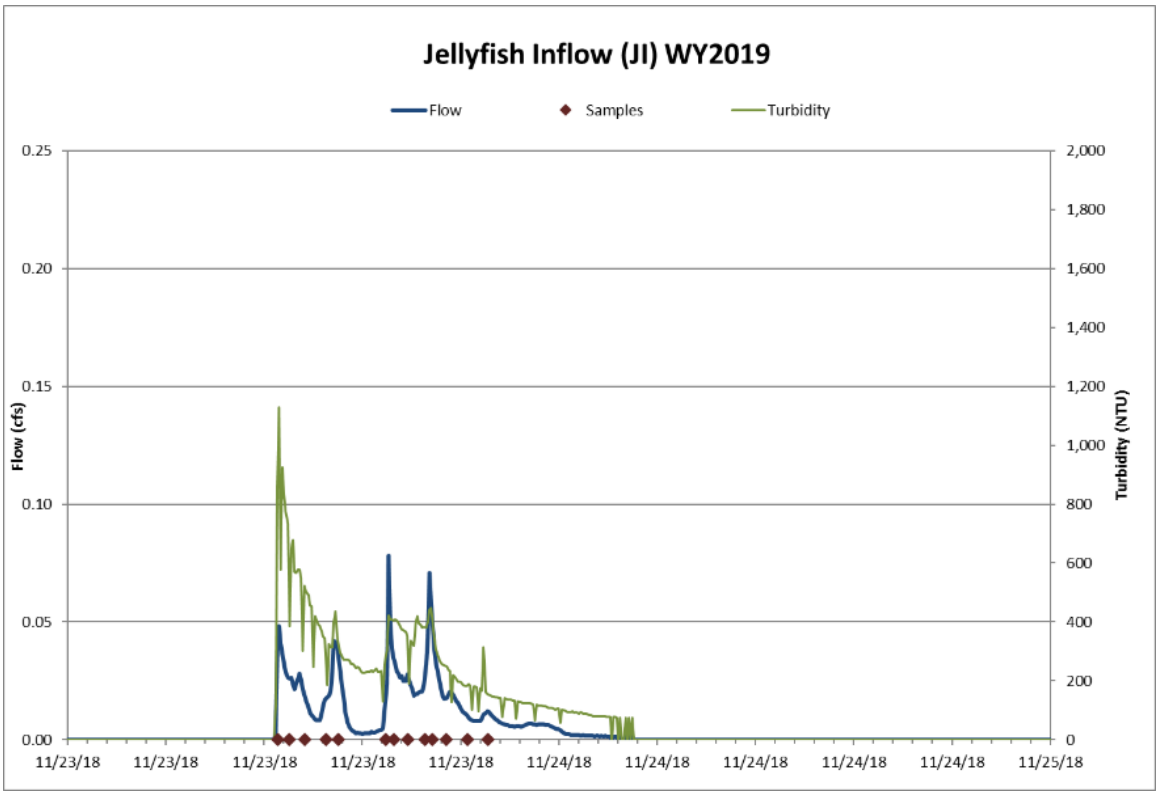

Figure 14: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Inflow for the 11/23/18 rain event.

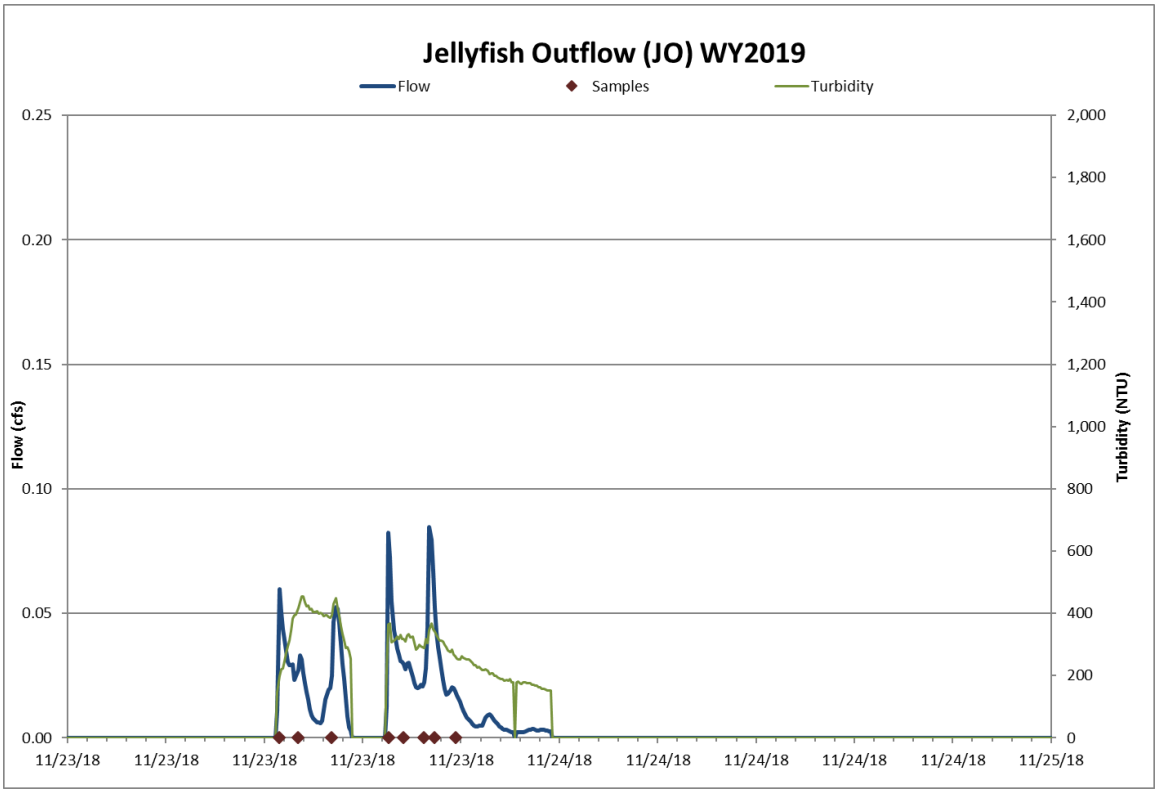

Figure 15: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Outflow for the 11/23/18 rain event.

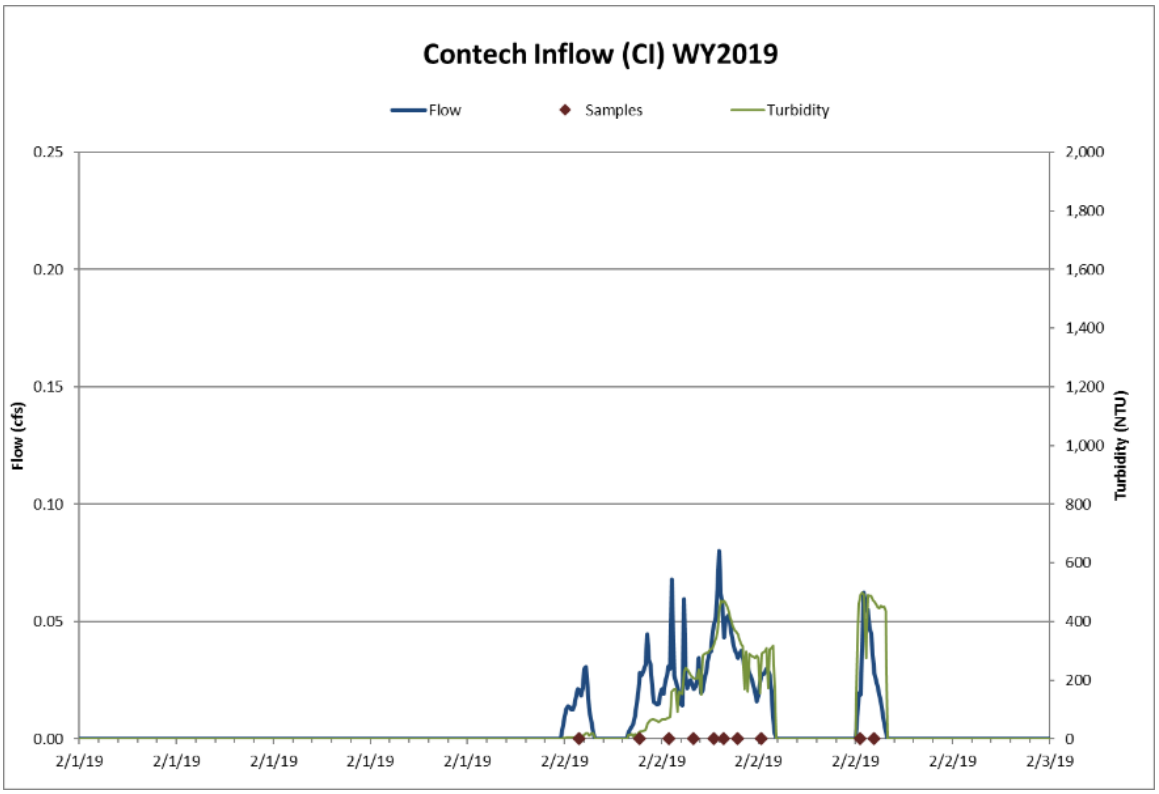

Figure 16: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Inflow for the 2/2/19 rain-on-snow event.

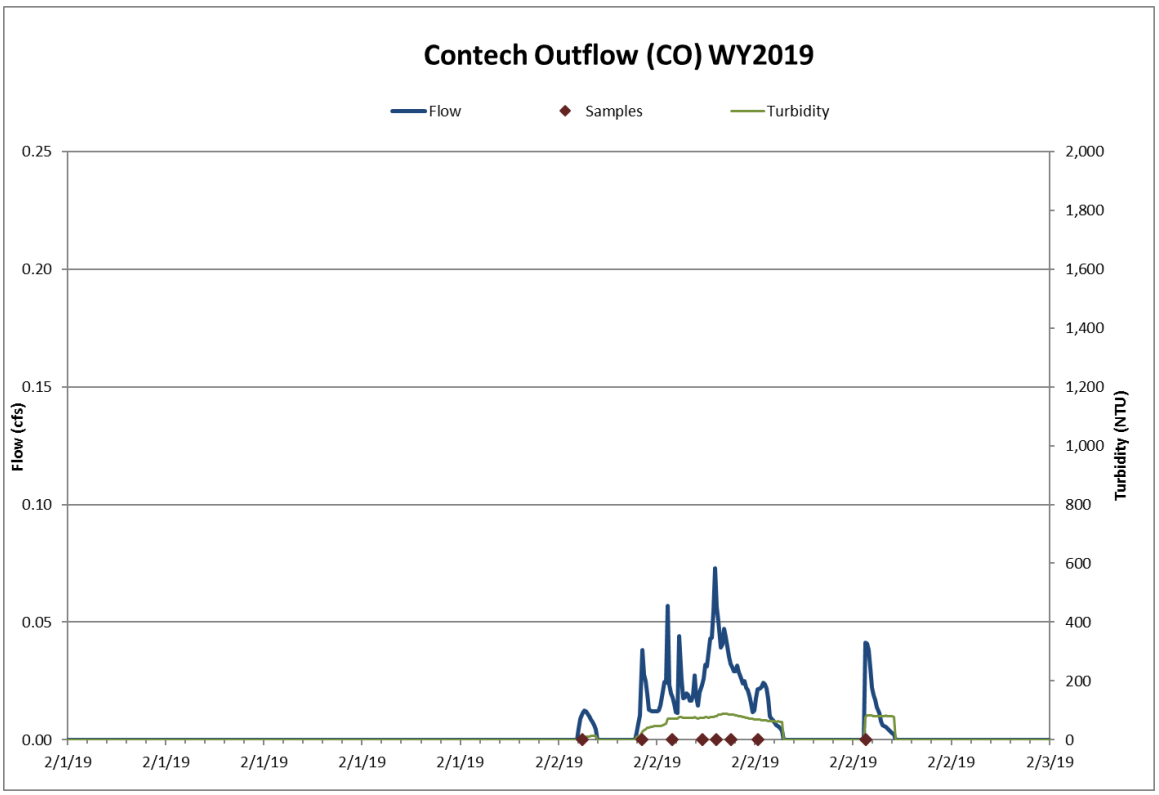

Figure 17: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Outflow for the 2/2/19 rain-on-snow event.

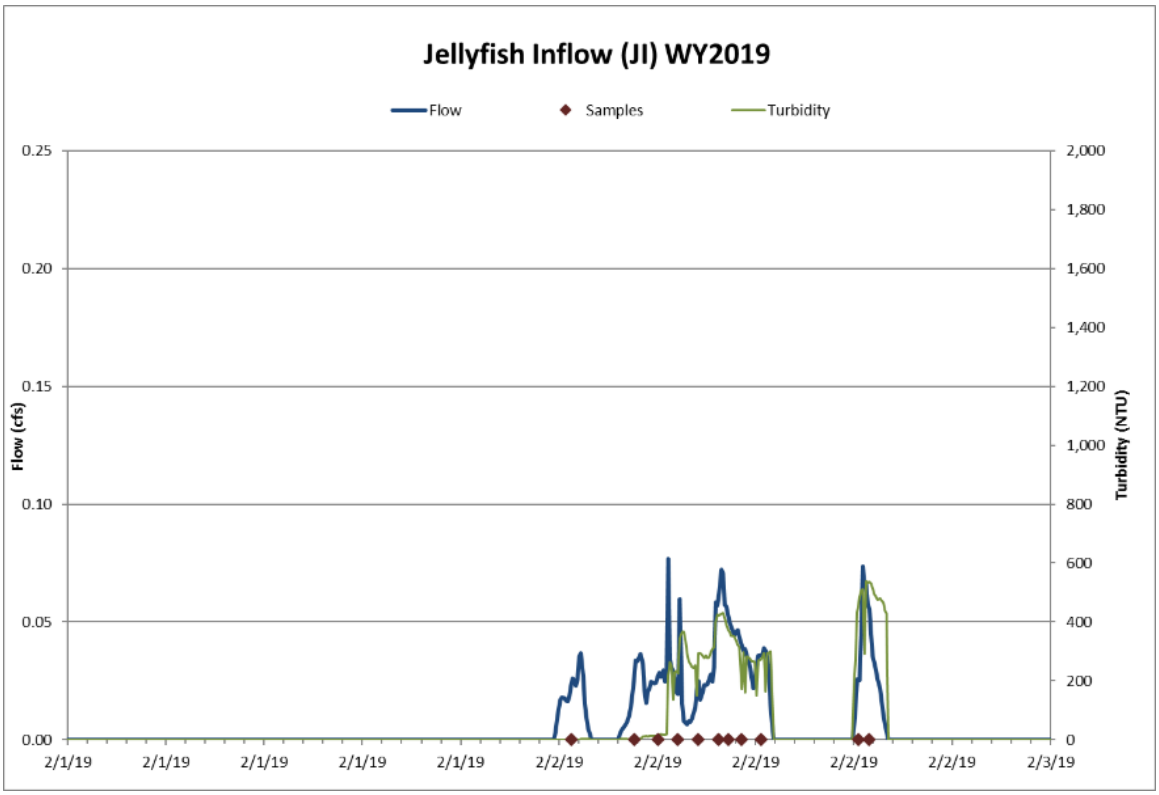

Figure 18: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Inflow for the 2/2/19 rain-on-snow event.

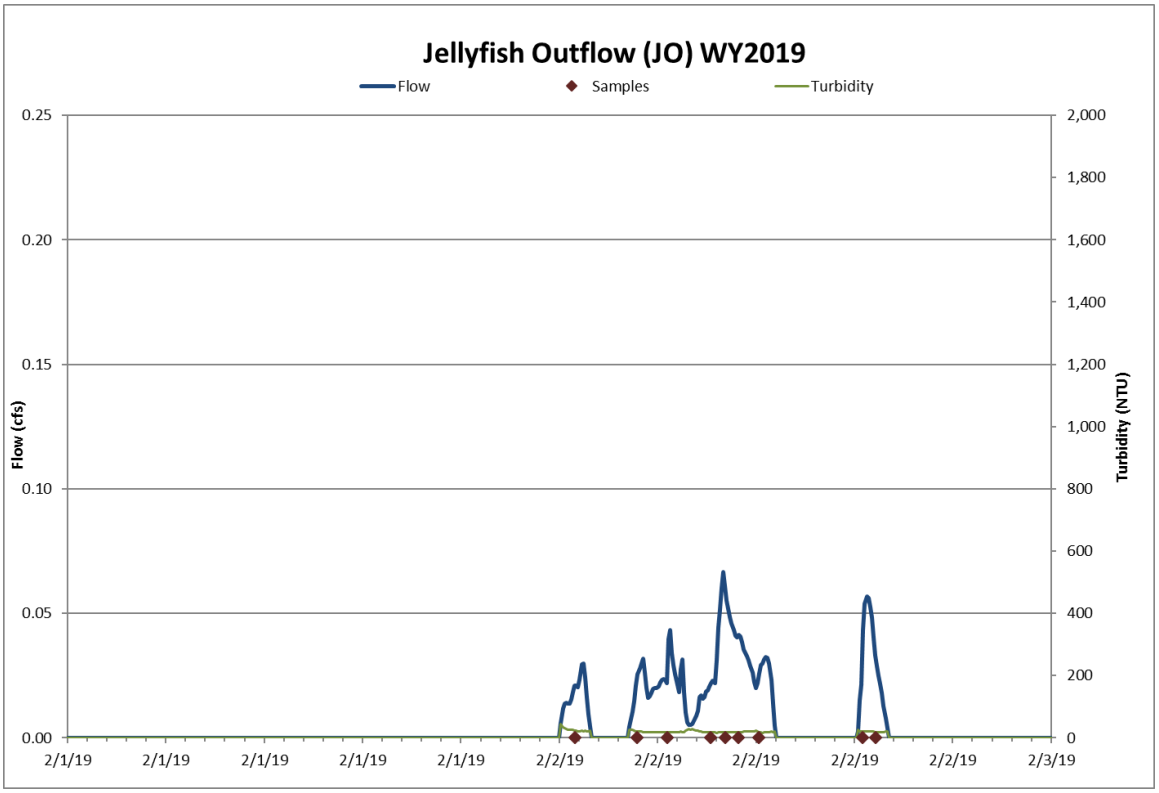

Figure 19: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Outflow for the 2/2/19 rain-on-snow event.

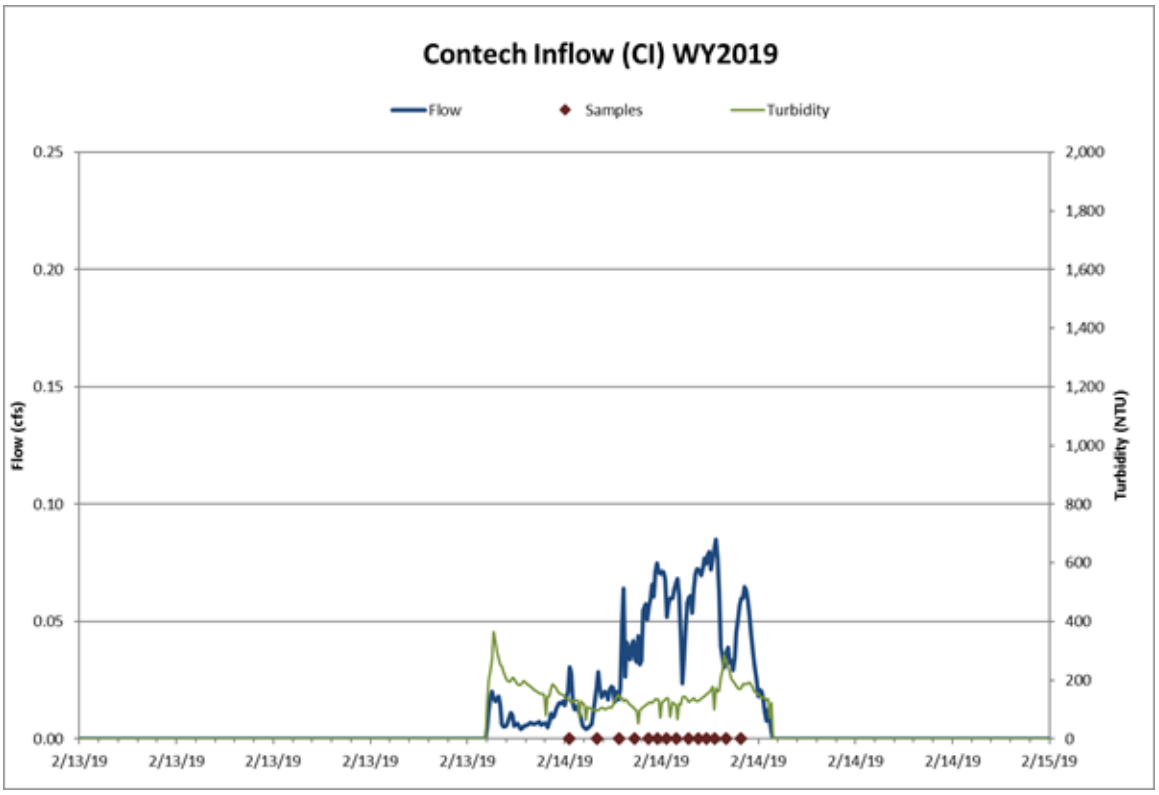

Figure 20: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Inflow for the 2/13/19 rain-on-snow event.

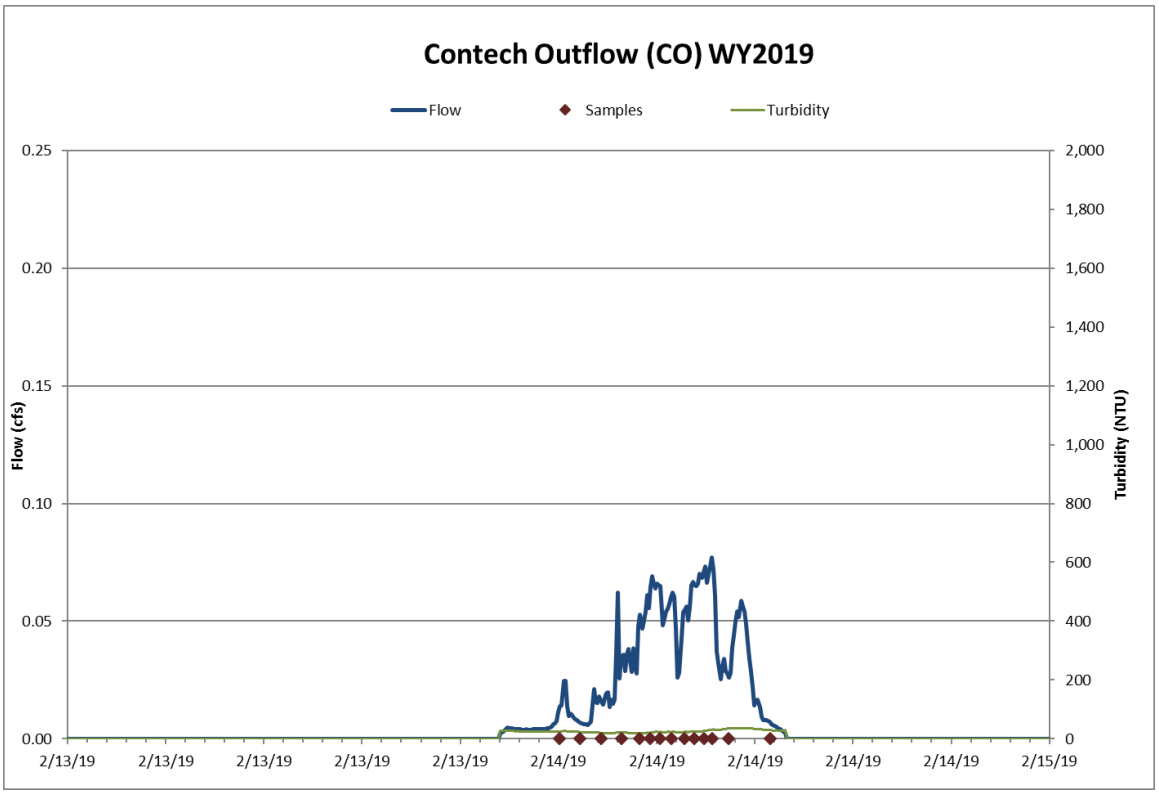

Figure 21: Hydrograph, continuous turbidity and sample distribution at the Contech MFS Outflow for the 2/13/19 rain-on-snow event.

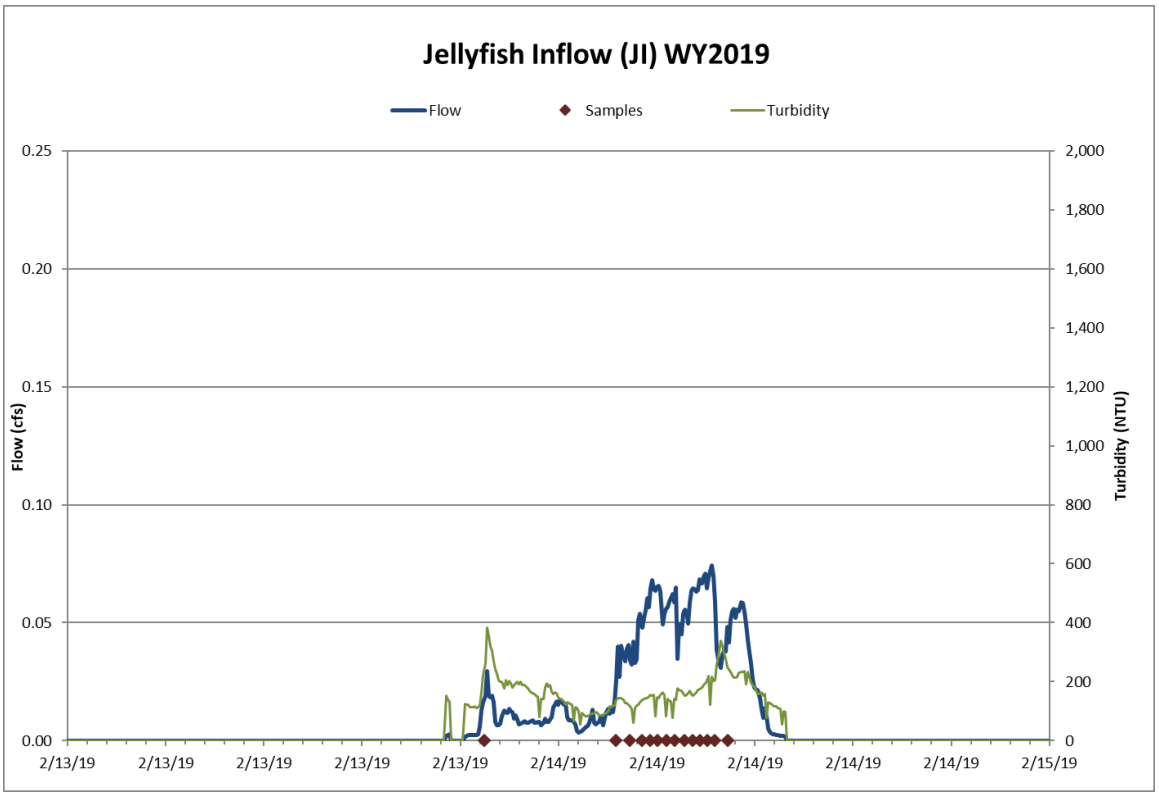

Figure 22: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Inflow for the 2/13/19 rain-on-snow event.

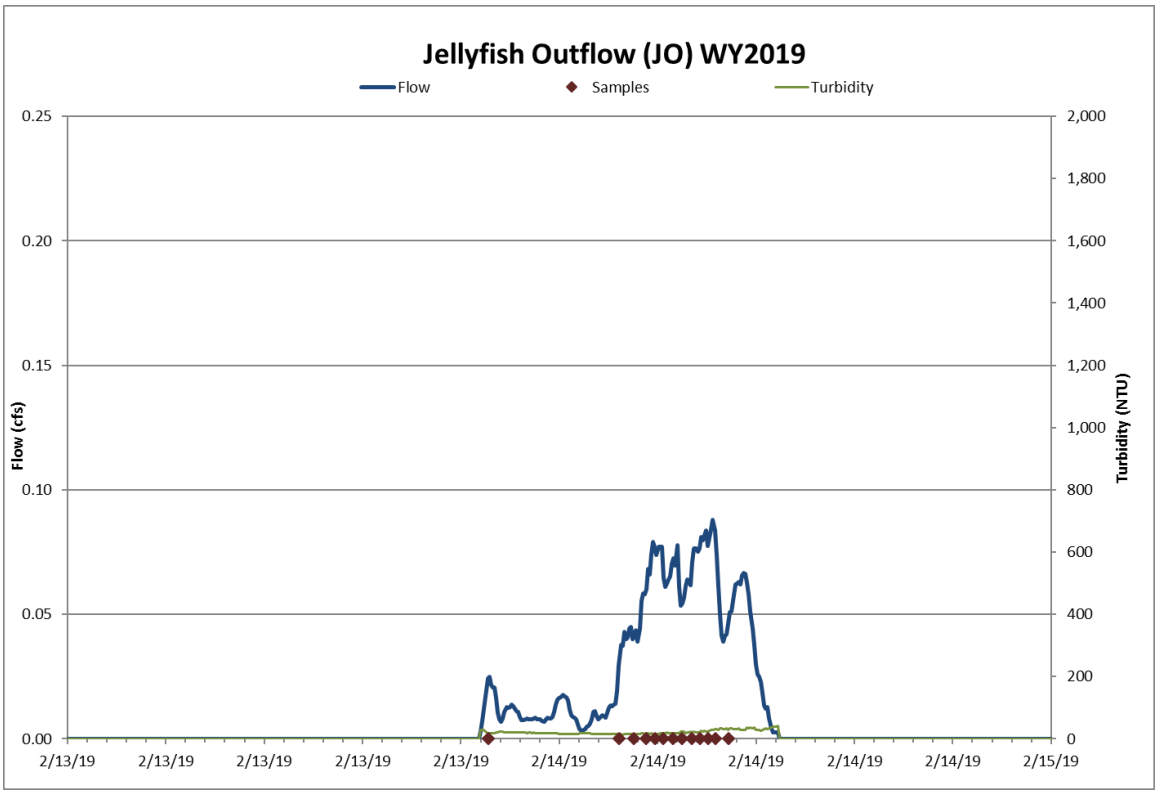

Figure 23: Hydrograph, continuous turbidity and sample distribution at the Jellyfish Outflow for the 2/13/19 rain-on-snow event.

Appendix A: Special Request

A special request was made by NDOT staff during the review of the Annual Stormwater Monitoring Report WY18 to provide continuous FSP concentrations as estimated from continuous turbidity on the daily flow and FSP EMC summary charts for WY18. They are provided in Figures A-D.

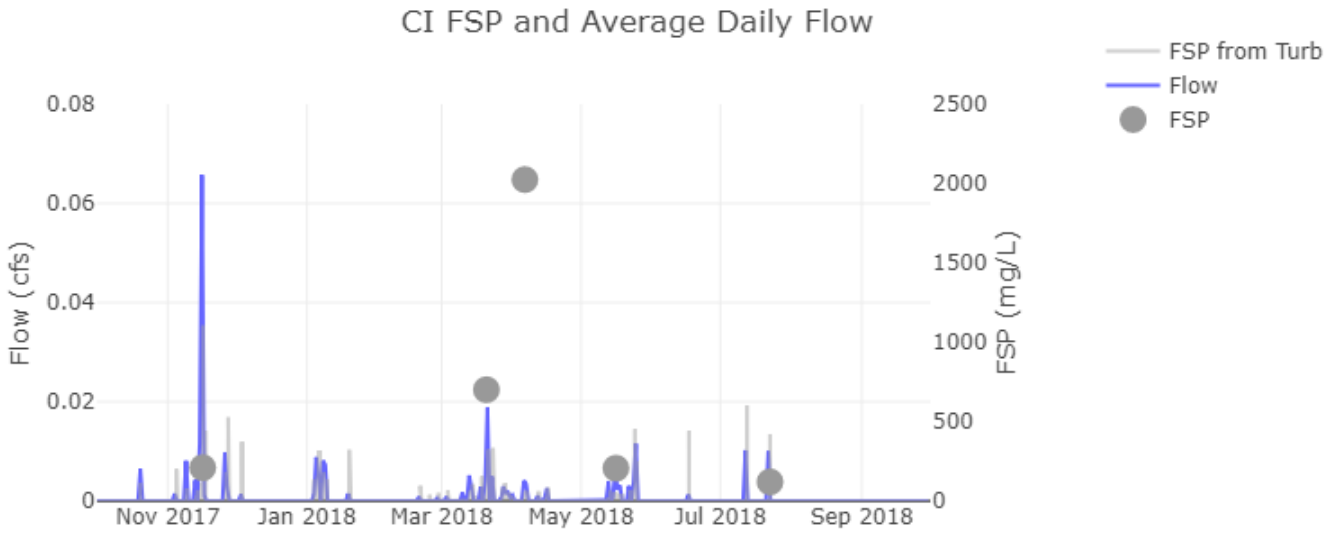

Figure A: Daily Flow, FSP EMCs for sampled events, and continuous FSP estimated from continuous turbidity at the Contech Inflow for WY18.

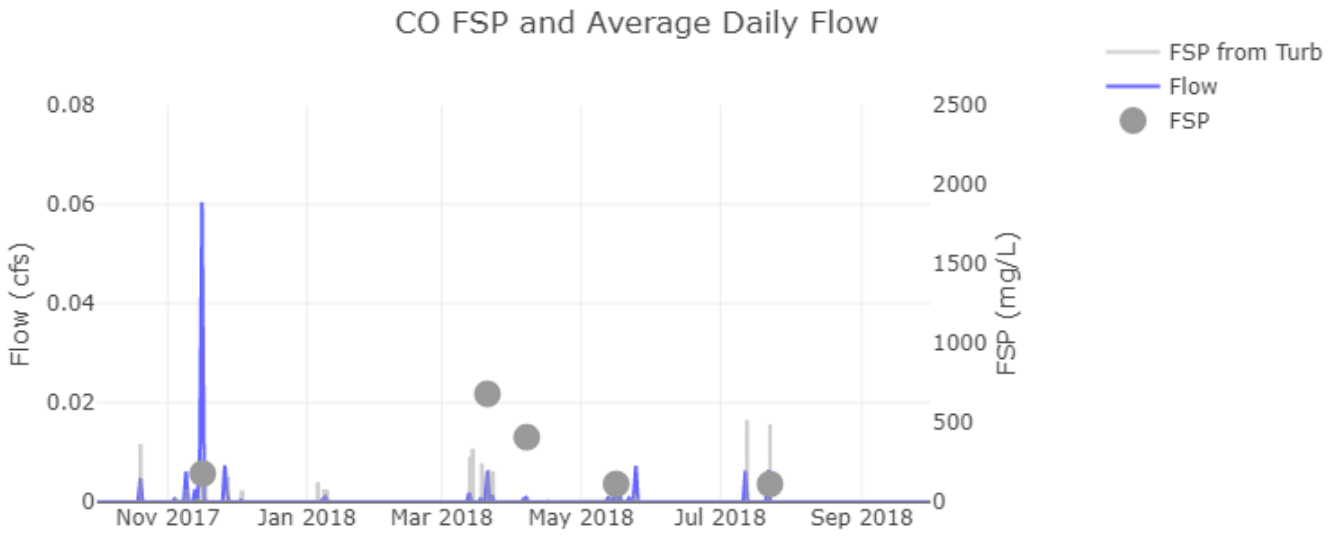

Figure B: Daily Flow, FSP EMCs for sampled events, and continuous FSP estimated from continuous turbidity at the Contech Outflow for WY18.

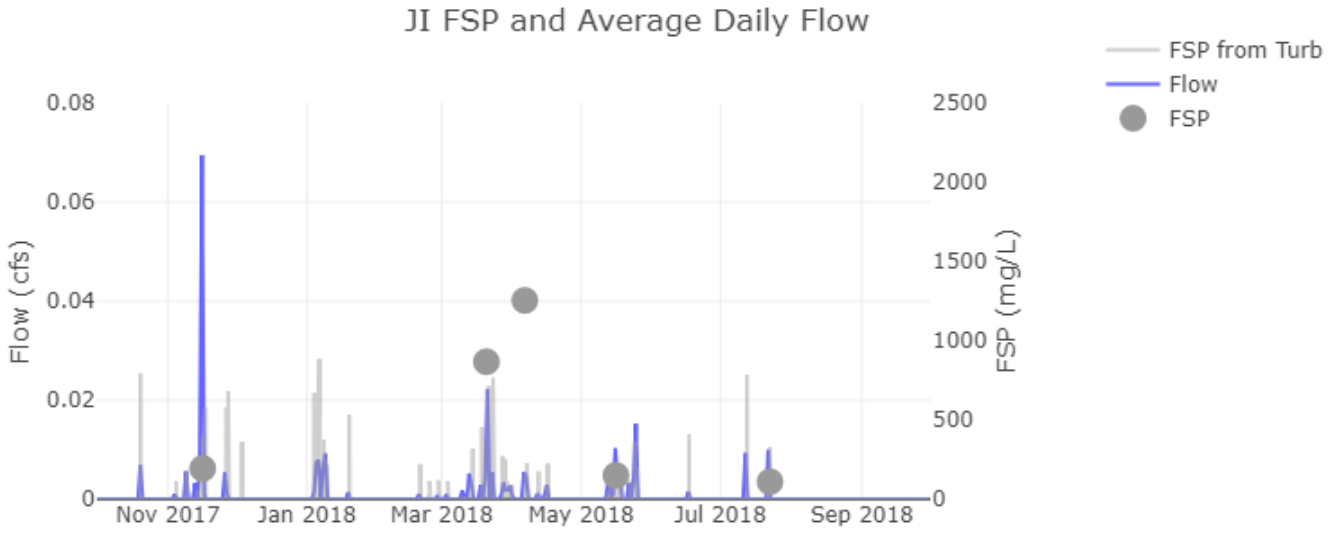

Figure C: Daily Flow, FSP EMCs for sampled events, and continuous FSP estimated from continuous turbidity at the Jellyfish Inflow for WY18.

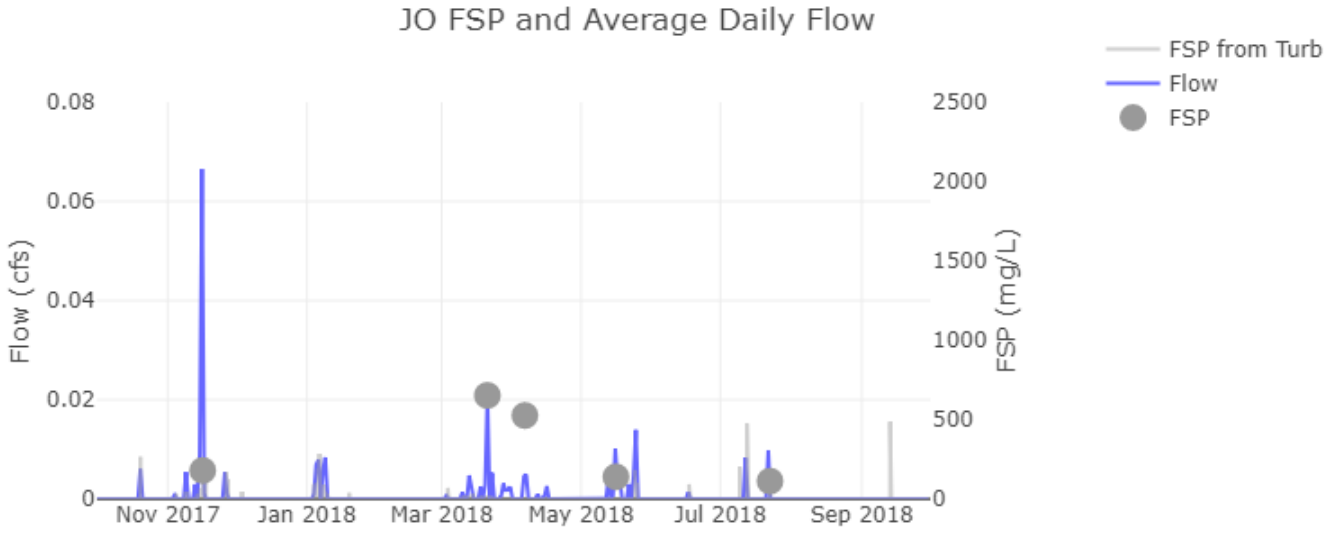

Figure D: Daily Flow, FSP EMCs for sampled events, and continuous FSP estimated from continuous turbidity at the Jellyfish Outflow for WY18.

References

2NDNATURE LLC, Northwest Hydraulic Consultants, Environmental Incentives, 2015. *Road Rapid Assessment Methodology (Road RAM) User Manual v2, Tahoe Basin. Final Document*. Prepared for the Nevada Division of Environmental Protection and Lahontan Regional Water Quality Control Board. May 2015.

PLRM Model Development Document 2009. NHC, Geosyntec, and 2ndNature.

Tahoe Resource Conservation District, 2NDNATURE, Desert Research Institute, Northwest Hydraulic Consultants. 2015. *RSWMP Framework and Implementation Guidance Document*. Submitted the California State Water Board. March 30, 2015.