Snow Disposal Site Monitoring
2018 Data Report and Evaluation

Introduction

The Municipality of Anchorage (MOA) and the State of Alaska Department of Transportation and Public Facilities (DOT) are currently authorized to discharge stormwater from their combined Municipal Separate Storm Sewer System (MS4) to receiving waters as co-permittees (Permittees) under Alaska Pollutant Discharge Elimination System (APDES) Permit No. AKS-052558. During the second term of the Permit the Permittees were required to retrofit or build at least two snow disposal sites according to criteria developed by the MOA Watershed Management Section (WMS) "regarding siting, design and operation and/or using infiltration, evapotranspiration or reuse techniques", and to "quantitatively assess the effectiveness of their retrofits by measuring changes in chloride and turbidity in melt water..", documenting their evaluation results in a report. This was completed and reported in 2013.

In the third term of the Permit the permittees are required to quantitatively "assess the effectiveness of their retrofits by measuring changes in chloride and turbidity in melt water at least twice during the permit term and must document results in a final project report to be submitted in the fourth annual report." During the first year of the permit term there was very little snow fall and the snow disposal sites were not used. During the latter part of the winter in the second year Anchorage received sufficient snow to transport to disposal sites. Subsequently, during the spring of the second year, 2017, the first of two monitoring projects was performed. The winter of 2018 saw significant snowfall and the spring of the third year, 2018, the second of two monitoring projects was performed.

Site Descriptions

The Tudor Road snow storage site is located southwest of the intersection of Tudor Road and Campbell Air Strip Road. Tudor site meltwater discharges into an unnamed branch of Chester Creek.

The Spruce Street snow storage facility is located south of Dowling Road between Elmore Road and Spruce Street. Refer to Figures C1, C2, and C3 taken from the monitoring plan.

Two types of BMPs have been installed at the Tudor site. The first is an expansion of the pilot study V-swales that now encompass the entire area where snow is placed in windrows. As the snow melts, particulates that cause turbidity are retained within the swales. The V-pad discharges into the second BMP, a detention pond, which further removes solids by settling and serves to ameliorate the peak chloride concentrations.

The Spruce Street site was constructed in 2012 with V-swale technology on the snow pad and a detention pond to receive melt water from the entire snow storage site. The pond discharges through a weir and small outfall pipe into a second small settling pond before it is dispersed into an adjacent wetland.


Fig. C-1 Anchorage Snow Disposal Site
Monitoring Locations
Tudor Rd. Snow Disposal
Spruce St. Snow Disposal
N
0 3,750 7,500 15,000 22,500 30,000
Feet

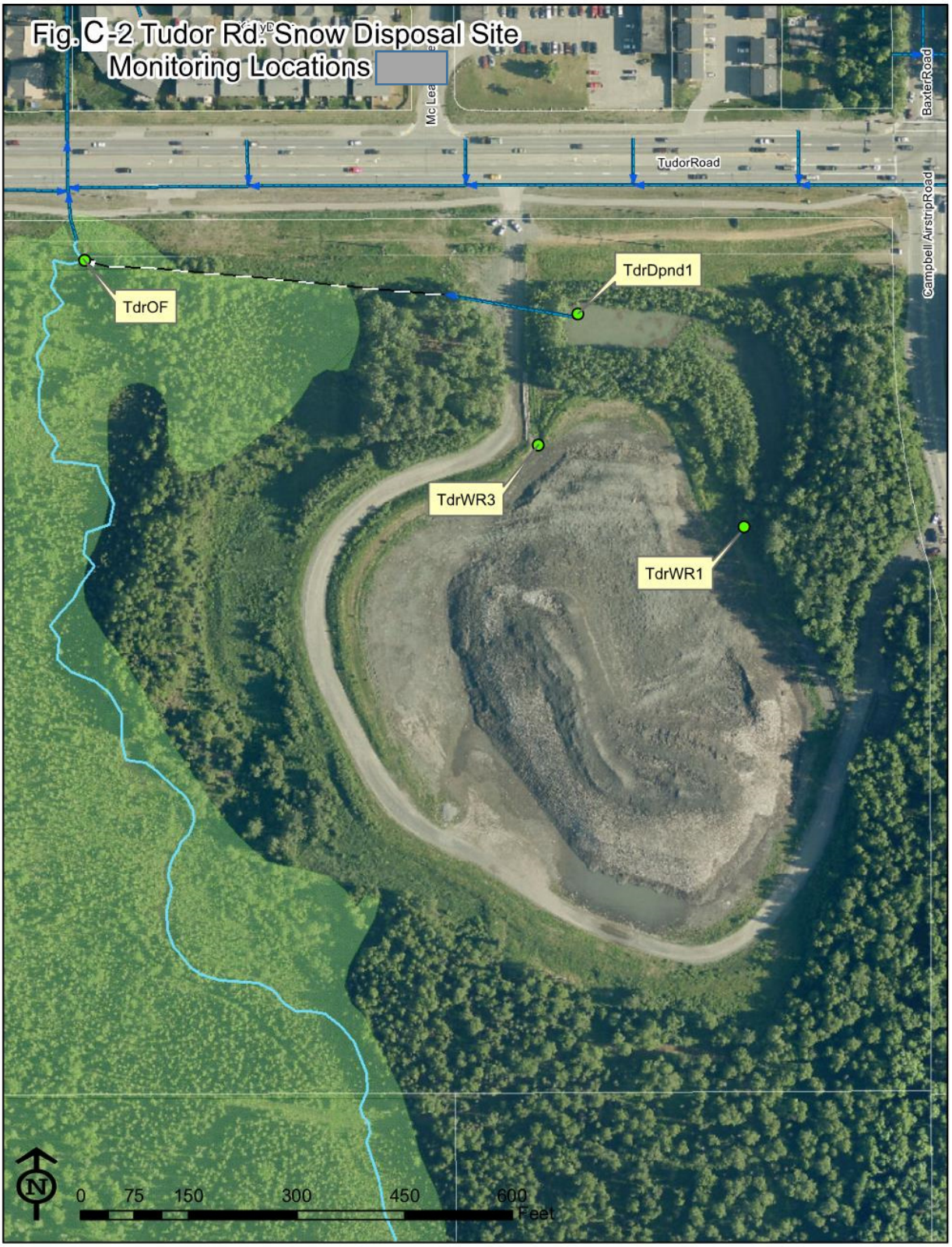


Fig. C-2 Tudor Rd. Snow Disposal Site
Monitoring Locations
TudorRoad
Baxter Road
Campbell Airstrip Road
TdrOF
TdrDpnd1
TdrWR3
TdrWR1
N
0
75
150
300
450
600
Feet

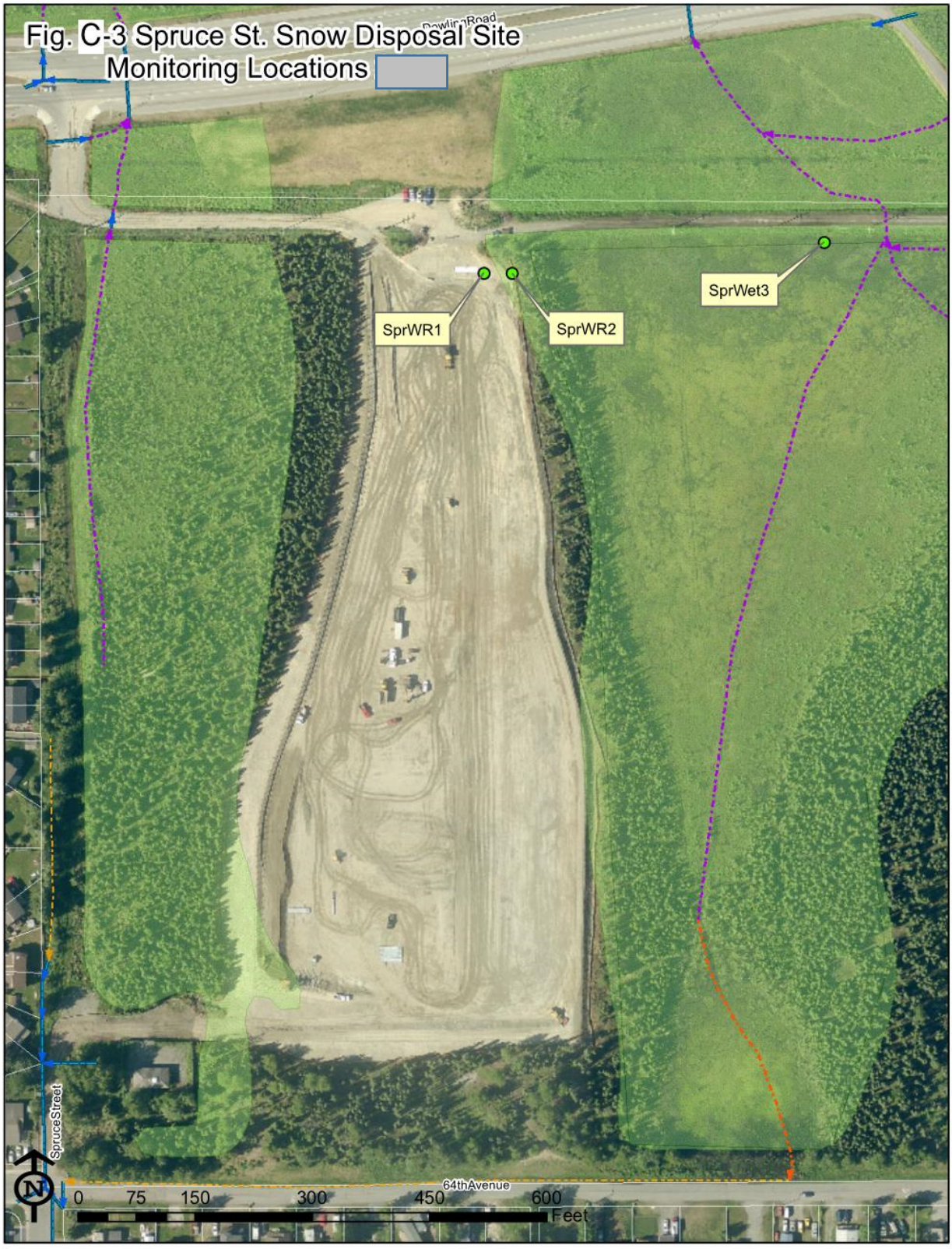


Fig. C-3 Spruce St. Snow Disposal Site
Monitoring Locations
SprWR1
SprWR2
SprWet3
SpruceStreet
64thAvenue
0
75
150
300
450
600
Feet

2018 Sampling Event Summary

Snow site visits for the 2018 snow melt monitoring season began on March 14th, 2018, and sites were monitored at least twice weekly until enough snow melt water for sampling was observed at sample locations. The first sampling for the Tudor snow storage site occurred on March 30th, 2018, and the first sampling for the Spruce Street site occurred on April 10th, 2018 when melt water was observed discharging from the pond outfall pipe for the first time in 2018 (Sample Location: SprWR1).

At the Tudor Road sampling locations snow melt water was sampled to measure both conductivity and turbidity in the melt water discharge. At both Tudor sample sites conductivity, the surrogate for chloride, was highest on March 30th, the first day enough snow melt water was present to sample. Conductivity samples taken at the Tudor outfall channel (TdrWR3) and Tudor detention pond (TdrDpnd1) on March 30th measured 9.719 millisiemens/centimeter (mS/cm) and 8.945 mS/cm respectively. Subsequent sampling at both Tudor snow melt sampling locations generally show a pattern of decreasing conductivity over time with conductivity numbers ranging from 0.129 to 9.719 mS/cm in the Tudor outfall channel and 0.145 to 8.945 mS/cm in the Tudor detention pond.

Turbidity measurements at both Tudor sampling locations started out low and ranged from 9.02 to 725 NTU in the outfall channel and 3.22 to 209 NTU in the detention pond. Turbidity remained relatively low and fluctuated at both snow melt sample locations throughout the early and middle portions of the melt period, and both rose in late May to early June, peaking on June 8th with measurements of 725 NTU in the channel and 209 NTU in the pond.

A location on Chester Creek (TdrOF), the closest receiving water point to the Tudor snow storage site, was also sampled several times throughout the 2018 sample period in order to serve as a downstream control and assess the water quality impact of the snow storage site on the receiving water. Both turbidity and conductivity measurements were low and remained fairly consistent throughout the monitoring period with numbers ranging from 1.02 to 6.23 NTU and 0.133 to 0.172 mS/cm respectively. These numbers suggest that the design and treatment controls implemented at the Tudor snow storage site are working as intended and the site has minimal to no impact on receiving water quality.

The Spruce Street snow storage site began melting later than the Tudor site and the first snow melt samples were taken on April 10th, the first time in the 2018 melt period that snow melt water was observed discharging from the detention pond outfall pipe (Sample Location: SprWR1). A conductivity sample taken at the detention pond outfall pipe (SprWR1) on April 10th measured 0.864 mS/cm, representing the highest conductivity/chloride concentration measured at that location during the 2018 sampling period. Conductivity did not peak at the Spruce Street wetland sampling site (SprWet3) until about a week later on April 18th, when it measured 0.651 mS/cm. Overall conductivity values ranged from 0.043 to 0.864 mS/cm at the detention pond outfall pipe (SprWR1) and from 0.026 to 0.651 mS/cm in the wetland (SprWet3).

Turbidity at the Spruce Street detention pond outfall sample site (SprWR1) peaked much later in the season than conductivity, occurring on May 31st with a peak value of 46.6 NTU. Turbidity ranged from 5.62 to 46.6 NTU at the pond outfall during the 2018 sampling season. Turbidity values measured at the Spruce Street wetland site (SprWet3) were lower and remained fairly consistent throughout the 2018 melt period, ranging between 1.32 and 7.82 NTU.

There was one notable deviation in this sampling activity compared to the monitoring plan developed in 2015. One of the sampling sites at Spruce was not sampled – the weir was omitted because it was very close to the outfall, and there was no discernable value in measuring both locations. The outfall was chosen to represent both locations and is reported as SprWR1 in this report.

2018 Data Trends Summary

- Tudor site saw overall much higher turbidity and conductivity than Spruce at both sample locations
    - Tudor Channel peak turbidity = 725 NTU on 6/8/18
    - Spruce Outfall peak turbidity = 46.6 NTU on 5/31/18
    - Tudor Pond peak turbidity = 209 NTU on 6/8/18
    - Spruce Wetland peak turbidity = 7.82 NTU on 4/10/18 (first sampling trip)
    - Tudor Channel peak conductivity = 9.719 mS/cm on 3/30/18 (first sampling trip)
    - Spruce Outfall peak conductivity = 0.864 mS/cm on 4/10/18 (first sampling trip)
    - Tudor Pond peak conductivity = 8.945 mS/cm on 3/30/18 (first sampling trip)
    - Spruce Wetland peak conductivity = 0.651 mS/cm on 4/18/18
- Estimated chloride concentrations for both Spruce Street sample locations were below SOA water supply/drinking water standards for chlorides (<250mg/L) for every sample event in 2018.
    - 2013 evaluation noted that snow hauled to the Spruce Street facility was assumed to have a relatively low initial chloride concentration due to the source of the snow. Snow hauled to the Spruce site is primarily from residential streets maintained by the MOA. Heated and covered winter sand storage implemented by the MOA has significantly reduced the amount of salt used during winter sanding (MOA, 2013).
- Estimated chloride concentrations for 2018 for all sample sites fell and remained below State of Alaska (SOA) water supply/drinking water standards for chlorides (<250mg/L) by April 25, 2018.

- Spruce Street site:
    - Conductivity peaks very early in the melt period.
        - Spruce outfall highest measurement was during first sample trip (0.864 mS/cm on 4/10/18).
        - Spruce wetland highest measurement was during third sample trip (0.651 mS/cm on 4/18/18).
        - Conductivity diminished to less than half of the peak value within 17 days, which is a longer time than that of the Tudor site in 2018 and data collected in 2000 and 2001 for the Tudor Road and Sitka Street snow storage sites. This is likely due much lower overall conductivity values measured at the Spruce Street site relative to the other sites.
    - Turbidity at the detention pond outfall peaks in late May towards the end of the melt period.
        - 5/31/18 peak 46.6 NTU @ Spruce detention pond outfall
        - The wetland site turbidity was highest during the first sampling trip on 4/10/18, but was only 7.82 NTU and wetland turbidity measured consistently low for all 2018 samples (ranging from 1.32 to 7.82 NTU).
- Tudor Road site:
    - Conductivity peaks very early in the melt period.
        - Tudor channel highest measurement was during the first sample trip (9.719 mS/cm on 3/30/18).
        - Tudor detention pond highest measurement was also during first sample trip (8.945 mS/cm on 3/30/18).
        - Conductivity diminished to less than half of the peak value within 5-7 days, which is consistent with the results of sampling runoff from the Tudor Road and Sitka Street snow storage sites in 2000 and 2001. This suggests that chlorides are readily mobilized, likely due to the high solubility of sodium and magnesium chloride, and concentrations peak very early in the melt period, and diminish quickly.
    - Turbidity peaks in early June toward end of the melt period.
        - 6/8/18 peak 725 NTU @ Tudor channel (TdrWR3)
        - 6/8/18 peak 209 NTU @ detention pond (TdrDpnd1)
    - The only water observed in channel downstream of pond appeared to be in-situ snowmelt and not runoff from detention pond. When sampled, both turbidity and conductivity values were much lower than those measured in the detention pond (9.88 NTU in the channel downstream of the pond vs. 38 NTU in the pond, and 0.234 mS/cm in the downstream channel vs. 1.845 mS/cm in the pond on 4/12/18).

- Values for background samples taken from Chester Creek just upstream of Tudor stream culvert (closest receiving water point downstream of Tudor snow storage site) were consistent throughout sampling events and suggest that the snow site has minimal to no effect on stream water quality.

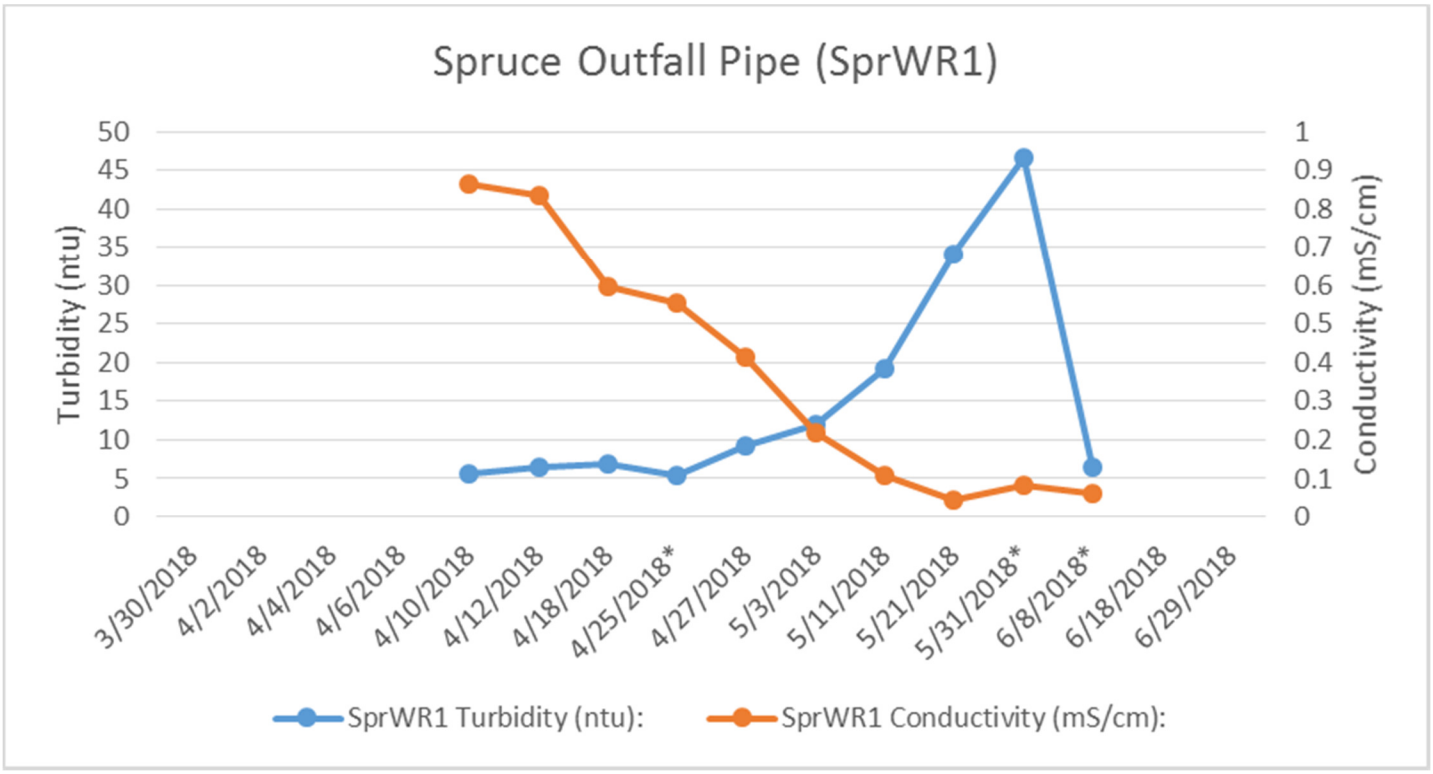
2018 Data Tables

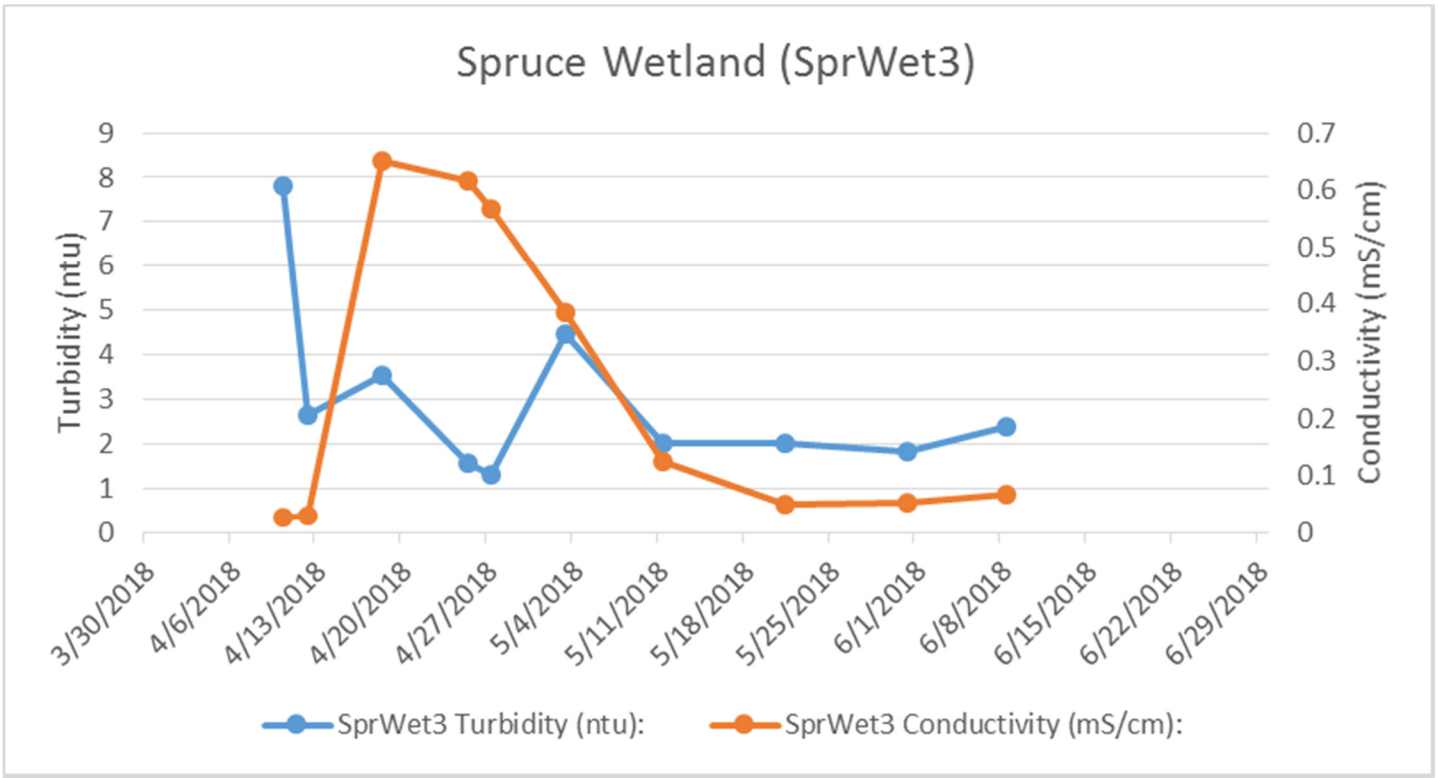
2018 Snow Site Monitoring						Two Sites:	Tudor Snow Dump		
Analytes:	turbidity, conductivity, pH						Spruce Snow Dump		
Date	**Site**	**ID**	**turb (NTU)**	**Cond (mS/cm)**	**pH**	**temp C**			
3/14/2018	*No discharge from either site								
3/19/2018	*No discharge from either site								
3/20/2018	*Not enough liquid runoff for sample								
3/23/2018	*Not enough liquid runoff for sample								
3/28/2018	*Not enough liquid runoff for sample								
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
3/30/2018	Spruce outfall	SprWR1	*Not enough liquid runoff for sample						
	Spruce wetlnd	SprWet3	*Not enough liquid runoff for sample						
	Tudor channel	TdrWR3	9.02	9.719	7.6	1.36	*Sample matrix = slushy water		
	Tudor pond	TdrDpnd1	3.22	8.945	7.85	2.42	*Sample matrix = slushy water		
	Blank		0.47						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/2/2018	Spruce outfall	SprWR1	*Not enough liquid runoff for sample						
	Spruce wetlnd	SprWet3	*Not enough liquid runoff for sample						
	Tudor channel	TdrWR3	7.7	6.664	7.08	-0.14			
	Tudor pond	TdrDpnd1	22.1	7.555	7.58	-0.25			
	Blank		0.21						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/4/2018	Spruce outfall	SprWR1	*Not enough liquid runoff for sample						
	Spruce wetlnd	SprWet3	*Not enough liquid runoff for sample						
	Tudor channel	TdrWR3	55.9	5.97	6.98	-0.17			
	Tudor pond	TdrDpnd1	20.3	2.57	6.97	-0.06			
	Blank		0.35, 0.14		4.02	17.6			
	Calib Cond 1.0 mS/cm			0.967			97%		
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/6/2018	Spruce outfall	SprWR1	*Not enough liquid runoff for sample						
	Spruce wetlnd	SprWet3	*Not enough liquid runoff for sample						
	Tudor channel	TdrWR3	26.7	3.041	6.46	-0.1			
	Tudor pond	TdrDpnd1	52	2.878	7.1	-0.11			
	Blank		0.22						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/10/2018	Spruce outfall	SprWR1	5.62	0.864	5.93	5.75			
	Spruce 2nd pond	SprWR2		0.057	4.8	2.09			
	Spruce wetlnd	SprWet3	7.82	0.026	5.48	1.06			
	Tudor channel	TdrWR3	53.2	1.839	7.31	5.24			
	Tudor pond	TdrDpnd1	15.9	1.977	7.27	2.66			
	Blank		0.31, 0.14						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/12/2018	Spruce outfall	SprWR1	6.45	0.834	6.5	5.65			
	Spruce wetlnd	SprWet3	2.65	0.028	6.79	3.33			
	Tudor channel	TdrWR3	60.6	1.592	7.11	6.38			
	Tudor pond	TdrDpnd1	38	1.845	7.29	5.54			
	Tudor channel #2 (dwnstrm pond		9.88	0.234	7.1	2.87			
	Blank		0.18, 0.17						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/18/2018	Spruce outfall	SprWR1	6.81	0.598	6.38	5.82			
	Spruce wetlnd	SprWet3	3.53	0.651	4.88	4.82			
	Tudor channel	TdrWR3	10.5	1.261	7.05	2.07			
	Tudor pond	TdrDpnd1	6.9	1.234	7.27	3.76			
	Tudor stream (upstrm of tudor cul		no sample	no sample	no sample	no sample			
	Blank		0.12, 0.03						

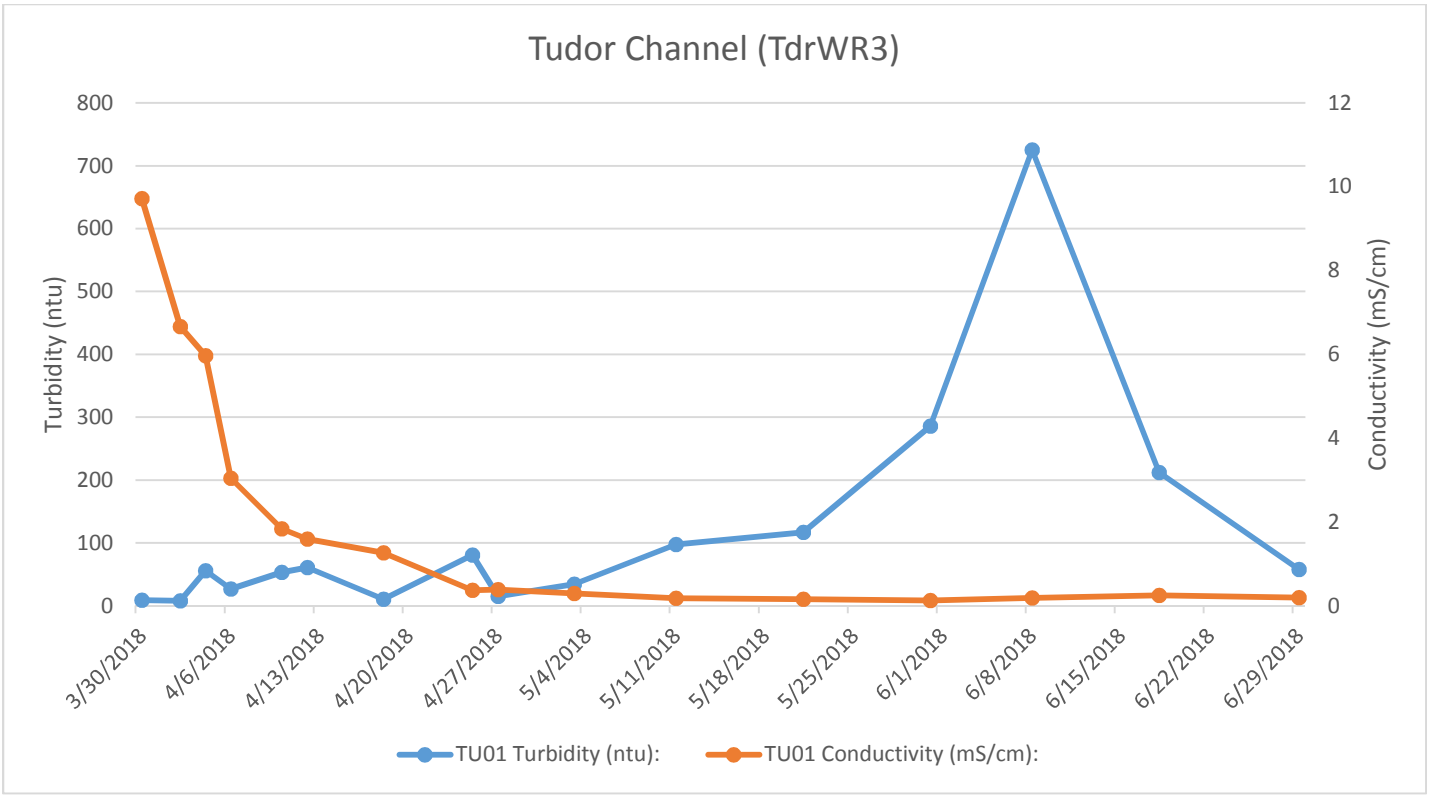
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/25/2018	*Spruce 2nd Pond (no	SprWR1*	5.46	0.554	7.2	10.53			
	Spruce wetlnd	SprWet3	1.55	0.615	5.15	6.8			
	Tudor channel	TdrWR3	80.7	0.37	7.25	7.86			
	Tudor pond	TdrDpnd1	11.6	0.458	7.41	8.65			
	Tudor stream (upstrm	TdrOF	3.4	0.172	5.93	4.56			
	Blank		0.19, 0.15						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
4/27/2018	Spruce outfall	SprWR1	9.33	0.415	5.52	6.95			
	Spruce wetlnd	SprWet3	1.32	0.566	5.06	7.29			
	Tudor channel	TdrWR3	15	0.389	6.26	4.12			
	Tudor pond	TdrDpnd1	6.35	0.388	7.3	4.79			
	Tudor stream (upstrm	TdrOF	*no sample						
	Blank		0.13, 0.12						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
5/3/2018	Spruce outfall	SprWR1	11.9	0.22	5.58	7.22			
	Spruce wetlnd	SprWet3	4.48	0.385	5.24	7.26			
	Tudor channel	TdrWR3	34.4	0.294	6.56	3.69			
	Tudor pond	TdrDpnd1	17.8	0.285	7.55	5.48			
	Tudor stream (upstrm	TdrOF	6.23	0.171	6.19	2.72			
	Blank		0.20, 0.75						
	Calib Cond 1.0 mS/cm			0.944			94%		
	Calib pH 4.0				4.13				
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
5/11/2018	Spruce outfall	SprWR1	19.2	0.107	7.24	11.1			
	Spruce wetlnd	SprWet3	2.02	0.124	5.8	8.6			
	Tudor channel	TdrWR3	97.6	0.178	7.17	10.18			
	Tudor pond	TdrDpnd1	39.7	0.208	7.34	11.83			
	Tudor stream (upstrm	TdrOF	*no sample						
	Blank		0.27, 0.2, 0.21						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
5/21/2018	Spruce outfall	SprWR1	34.1	0.043	5.66	11.91			
	Spruce wetlnd	SprWet3	2.01	0.05	4.39	9.72			
	Tudor channel	TdrWR3	117	0.157	6.99	10.96			
	Tudor pond	TdrDpnd1	32.2	0.161	7.35	12.03			
	Tudor stream (upstrm	TdrOF	1.28	0.14	5.82	5.59			
	Blank		0.24, 0.14						
	Calib Cond 1.0 mS/cm			0.95			95%		
	Calib pH 7.0				7.14				
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
5/31/2018	*Spruce 2nd pond (Dis	SprWR1*	46.6	0.083	5.56	15.73			
	Spruce wetlnd	SprWet3	1.84	0.052	4.16	13.65			
	Tudor channel	TdrWR3	286	0.129	6.04	11.82			
	Tudor pond	TdrDpnd1	78.1	0.145	6.9	12.73			
	Tudor stream (upstrm	TdrOF	1.46	0.138	5.04	5.75			
	Blank		0.10, 0.19						

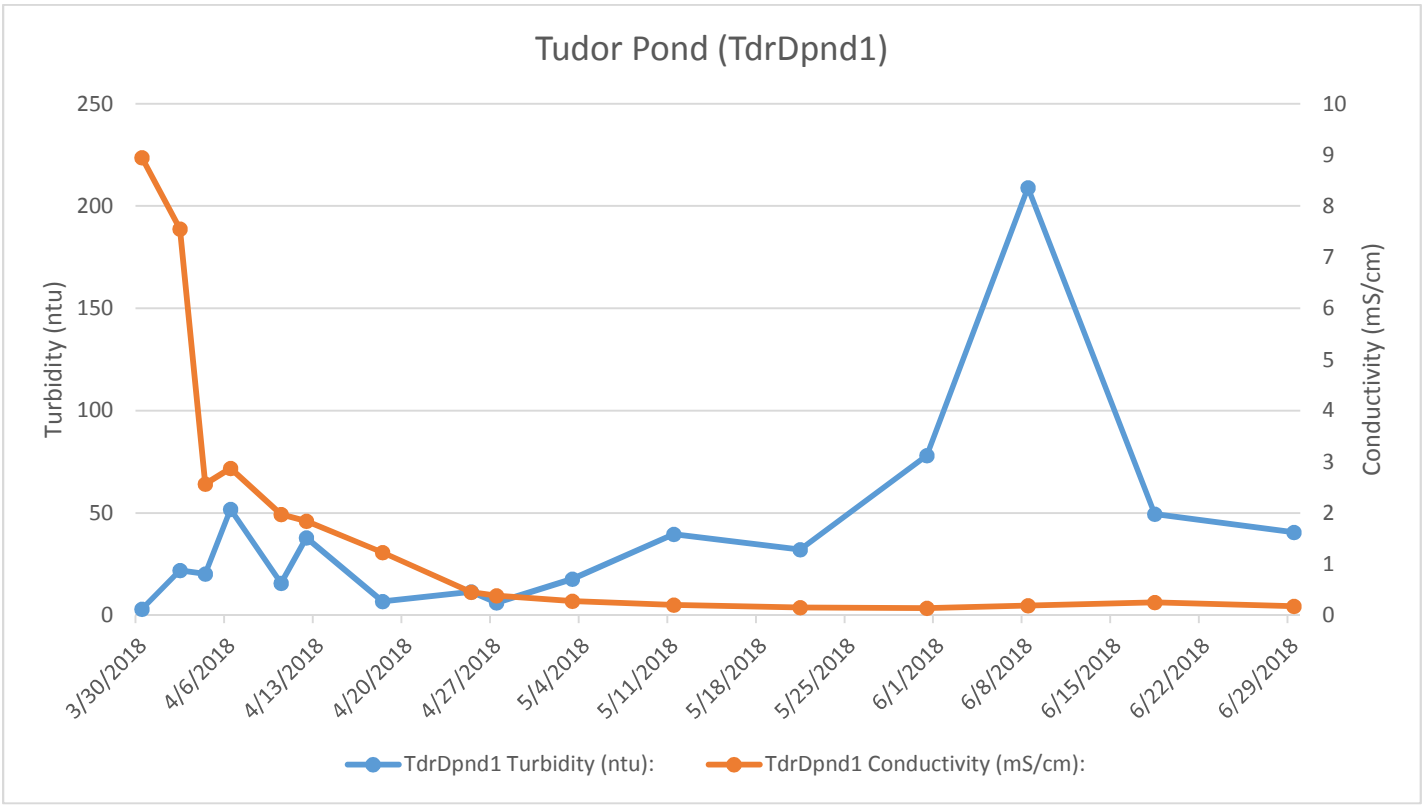
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
6/8/2018	*Spruce 2nd pond (Di	SprWR1*	6.57	0.063	7.24	22.43			
	Spruce wetlnd	SprWet3	2.37	0.066	4.85	14.75			
	Tudor channel	TdrWR3	**725**	0.187	6.89	19.9			
	Tudor pond	TdrDpnd1	**209**	0.198	7.08	19.93			
	Tudor stream (upstrm	TdrOF	*no sample						
	Blank		0.43, 0.21						
	Calib Cond 1.0 mS/cm			0.999			100%		
	Calib pH 7.0				7.05				
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
6/18/2018	Spruce outfall	SprWR1	*no discharge from pipe						
	Spruce wetlnd	SprWet3	*no discharge from 2nd pond to wetland						
	Tudor channel	TdrWR3	212	0.248	7.14	17.31			
	Tudor pond	TdrDpnd1	49.6	0.257	7.21	15.12			
	Tudor stream (upstrm	TdrOF	1.61	0.141	5.56	6.21			
	Blank		0.28, 0.19						
Date	Site	ID	turb (NTU)	Cond (mS/cm)	pH	temp C			
6/29/2018	Spruce outfall	SprWR1	*no discharge from pipe						
	Spruce wetlnd	SprWet3	*no discharge from 2nd pond to wetland						
	Tudor channel	TdrWR3	57.7	0.197	7.07	18.76			
	Tudor pond	TdrDpnd1	40.6	0.185	6.98	18.9			
	Tudor stream (upstrm	TdrOF	1.02	0.133	5.88	6.47			
	Blank		0.3						

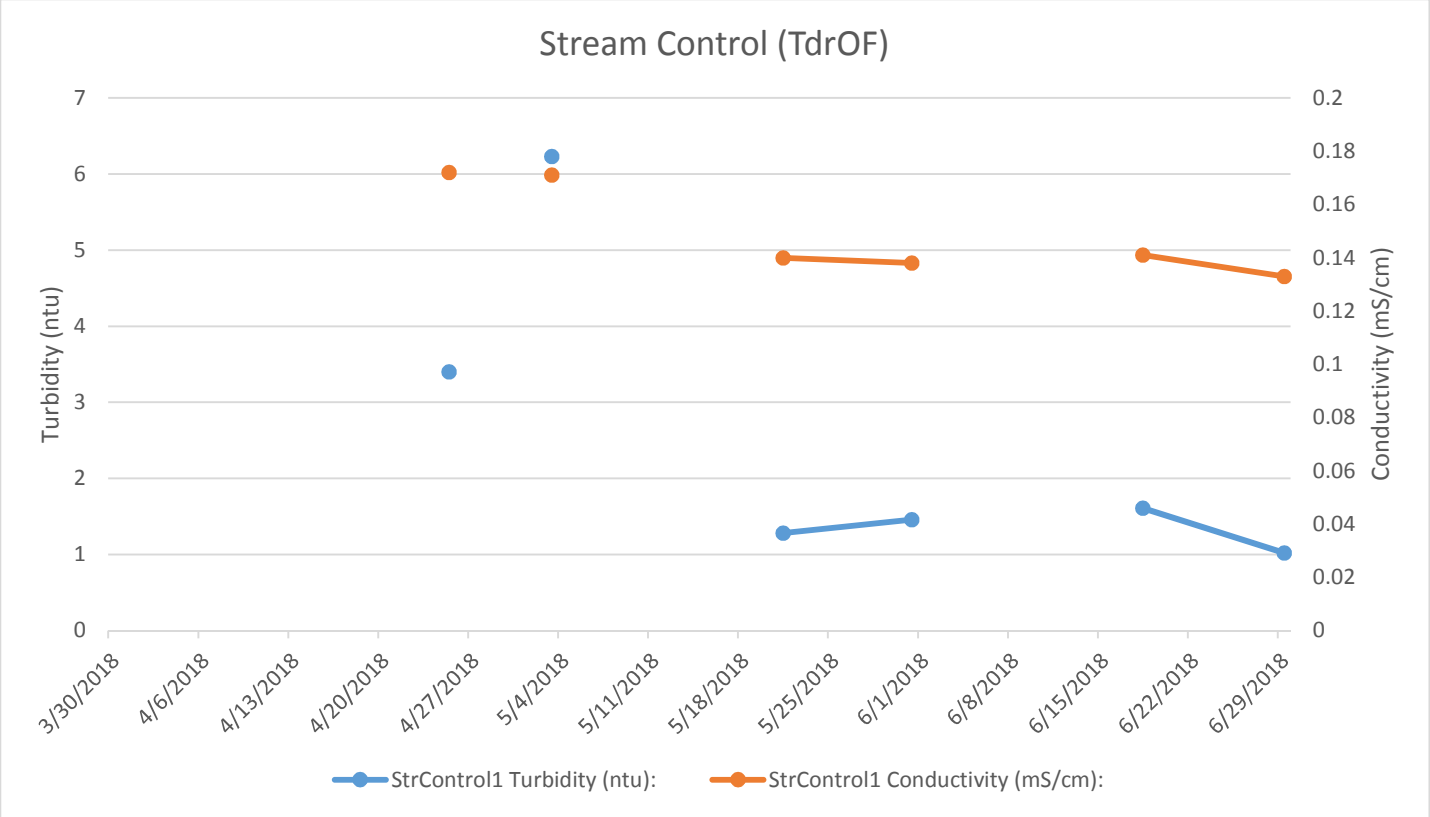
2018 Snow Melt Trends

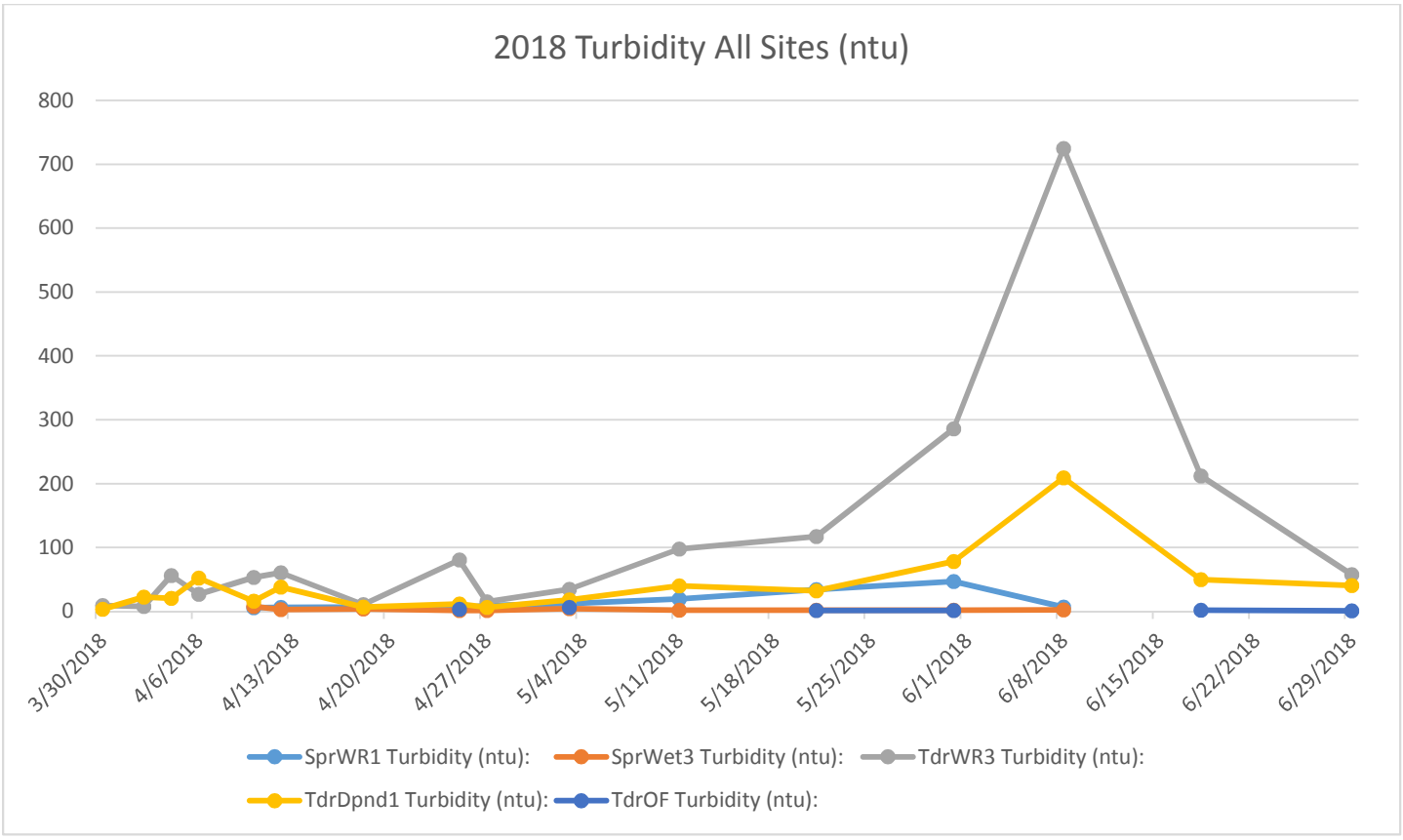


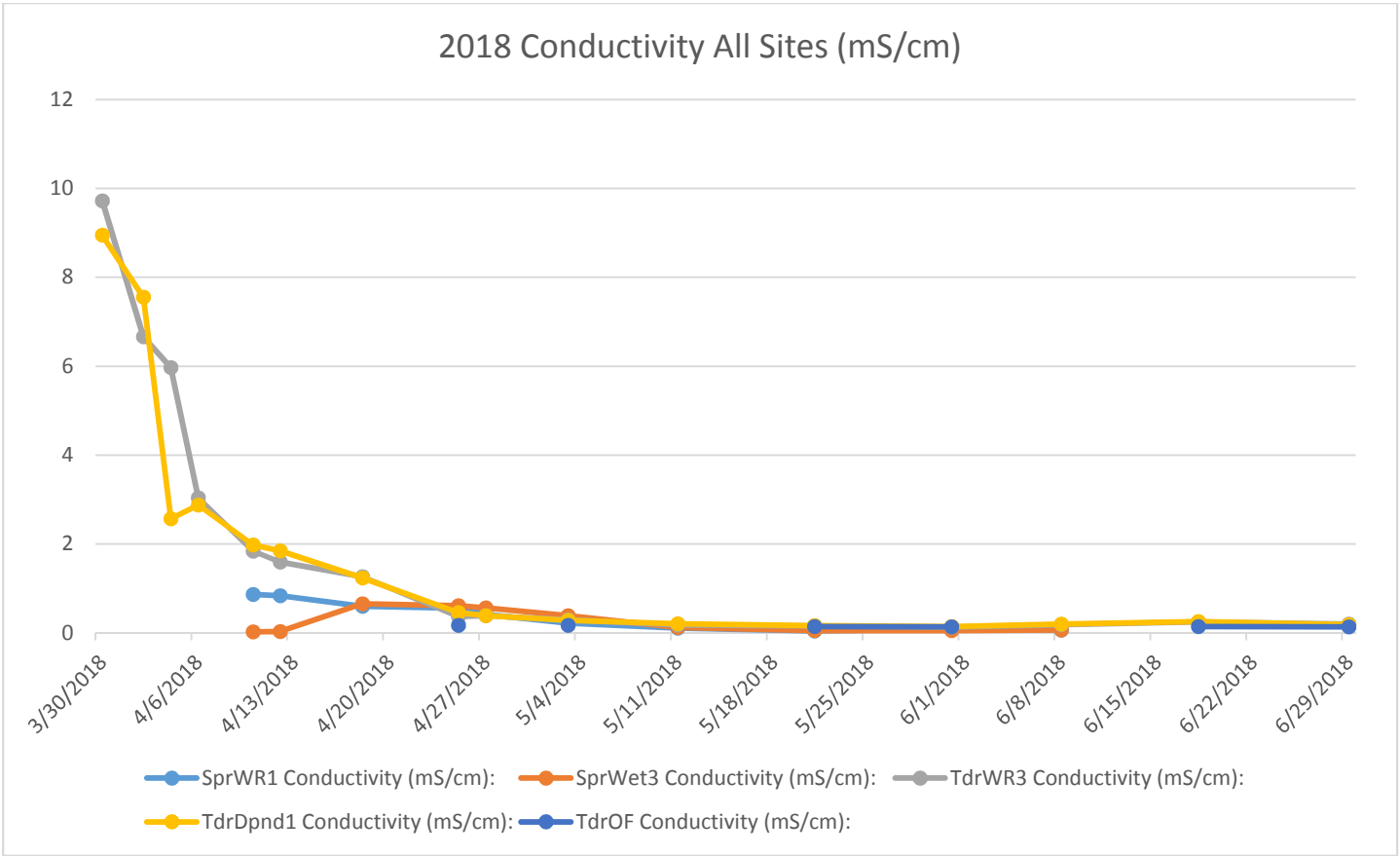



Tudor Channel (TdrWR3)
Turbidity (ntu)
Conductivity (mS/cm)
800
700
600
500
400
300
200
100
0
12
10
8
6
4
2
0
3/30/2018
4/6/2018
4/13/2018
4/20/2018
4/27/2018
5/4/2018
5/11/2018
5/18/2018
5/25/2018
6/1/2018
6/8/2018
6/15/2018
6/22/2018
6/29/2018
TU01 Turbidity (ntu):
TU01 Conductivity (mS/cm):


Tudor Pond (TdrDpnd1)
Turbidity (ntu)
Conductivity (mS/cm)
250
200
150
100
50
0
10
9
8
7
6
5
4
3
2
1
0
3/30/2018
4/6/2018
4/13/2018
4/20/2018
4/27/2018
5/4/2018
5/11/2018
5/18/2018
5/25/2018
6/1/2018
6/8/2018
6/15/2018
6/22/2018
6/29/2018
TdrDpnd1 Turbidity (ntu):
TdrDpnd1 Conductivity (mS/cm):


Stream Control (TdrOF)
Turbidity (ntu)
Conductivity (mS/cm)
0
1
2
3
4
5
6
7
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
3/30/2018
4/6/2018
4/13/2018
4/20/2018
4/27/2018
5/4/2018
5/11/2018
5/18/2018
5/25/2018
6/1/2018
6/8/2018
6/15/2018
6/22/2018
6/29/2018
StrControl1 Turbidity (ntu):
StrControl1 Conductivity (mS/cm):


2018 Turbidity All Sites (ntu)
800
700
600
500
400
300
200
100
0
3/30/2018
4/6/2018
4/13/2018
4/20/2018
4/27/2018
5/4/2018
5/11/2018
5/18/2018
5/25/2018
6/1/2018
6/8/2018
6/15/2018
6/22/2018
6/29/2018
SprWR1 Turbidity (ntu):
SprWet3 Turbidity (ntu):
TdrWR3 Turbidity (ntu):
TdrDpnd1 Turbidity (ntu):
TdrOF Turbidity (ntu):


2018 Conductivity All Sites (mS/cm)
12
10
8
6
4
2
0
3/30/2018
4/6/2018
4/13/2018
4/20/2018
4/27/2018
5/4/2018
5/11/2018
5/18/2018
5/25/2018
6/1/2018
6/8/2018
6/15/2018
6/22/2018
6/29/2018
SprWR1 Conductivity (mS/cm):
SprWet3 Conductivity (mS/cm):
TdrWR3 Conductivity (mS/cm):
TdrDpnd1 Conductivity (mS/cm):
TdrOF Conductivity (mS/cm):

Results and Comparison to 2017 Data

Based on the results of the snow storage site runoff sampling in both 2017 and 2018, it appears that conductivity/chloride concentrations in snow melt runoff peaks very early in the melt period, perhaps with the first release of melt water discharged from the pile. In 2018, conductivity measured highest for the first melt water sample collected at both Tudor Road sample locations (9.719 mS/cm @ TdrWR3, 8.945 mS/cm @ TdrDpnd1 measured on first sampling trip of 2018 on March 3rd, 2018). In 2017 at the Tudor Road site, conductivity in the channel was rising when sampling started, and it peaked shortly thereafter on April 27th. Conductivity in the pond had already peaked and was steadily declining. Conductivity values ranged from 0.103 to 0.891 mS/cm in the channel and 0.118 to 1.451 mS/cm in the pond in 2017. It is suspected that 2017 sampling may have missed the conductivity peak, and thus sampling began earlier in the melt period in 2018.

Conductivity peaked very early in the melt period at both Spruce Street sample locations with values diminishing from the peak of 0.864 mS/cm to 0.043 mS/cm at the outfall pipe, finishing at 0.063 mS/cm on June 8th, the final sample day for the Spruce Street site for the 2018 season. The conductivity peak of 0.651 mS/cm at the Spruce Street wetland sample location occurred eight days after the peak at the outfall pipe in 2018, a lag suggestive of the transport time for chloride across the wetland. In 2017 at the Spruce Street site, conductivity peaked in the outfall on April 27th and in the wetland on May 11th and then declined steadily. It was monitored until flow stopped at the outfall. Conductivity numbers ranged from 0.027 to 0.350 milliSiemens/centimeter (mS/cm) at the outfall and 0.031 to 0.126 mS/cm in the wetland for 2017. Overall, the chloride peaks sampled at the Spruce Street snow storage site are much lower than those sampled at the Tudor Road snow storage site, which is consistent with the results from 2017. It should be noted also that, as the wetland sampling site represents a high-value wetland receiving water, estimated chloride concentrations based on correlation with measured specific conductance were well below State of Alaska (SOA) water supply/drinking water standards for chlorides (<250mg/l) throughout the melt periods in both 2017 and 2018.

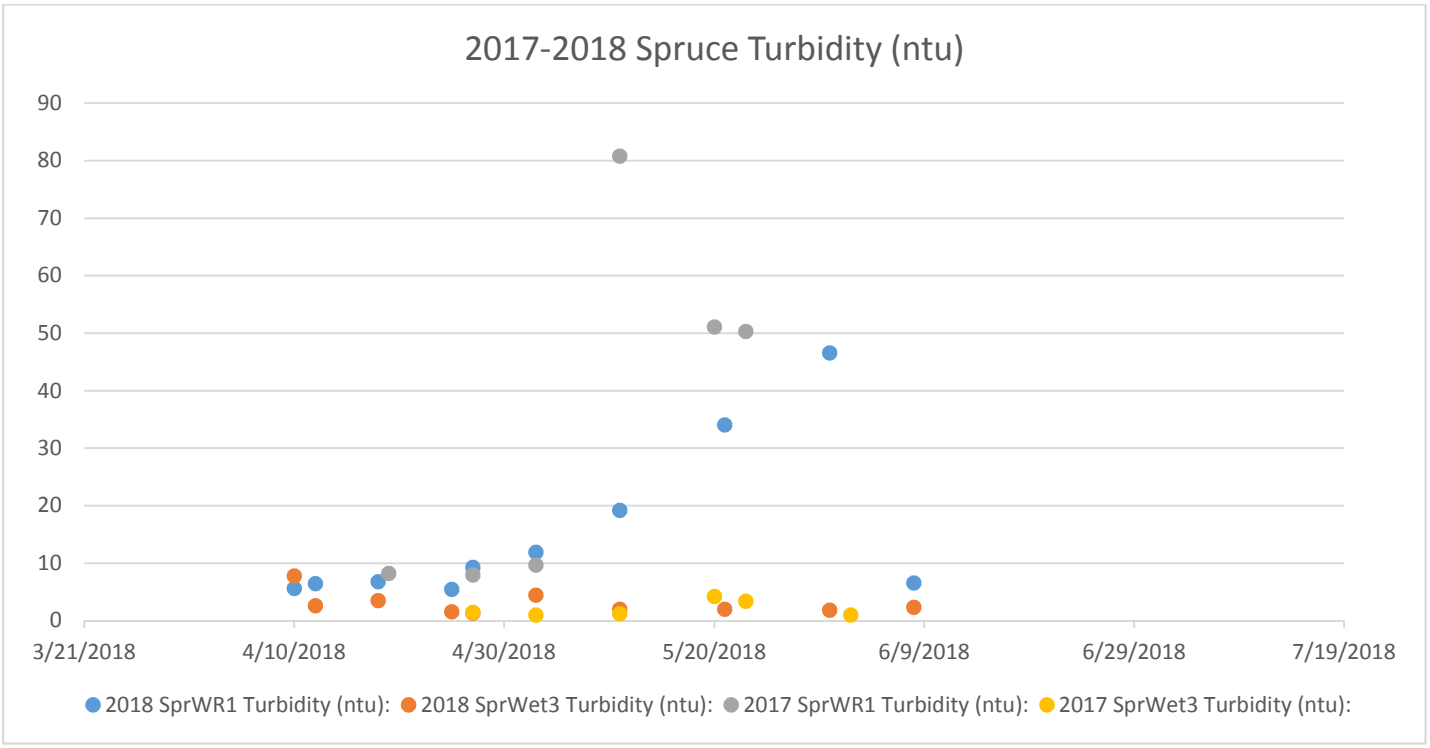
Turbidity values measured at the Tudor Road site peak in early June, toward end of melting, but before flow rates diminish significantly. Turbidity peaked on June 8th, 2018 at 725 NTU in the channel, and at 209 NTU in the detention pond. At the start of 2017 sampling, turbidity at Tudor was still low and rising. The channel was still rising slightly at the end of the sampling period, and the range was 14 to 60 NTU. Another week or two of sampling would have helped to demonstrate the full turbidity range and the sampling window was extended for 2018.

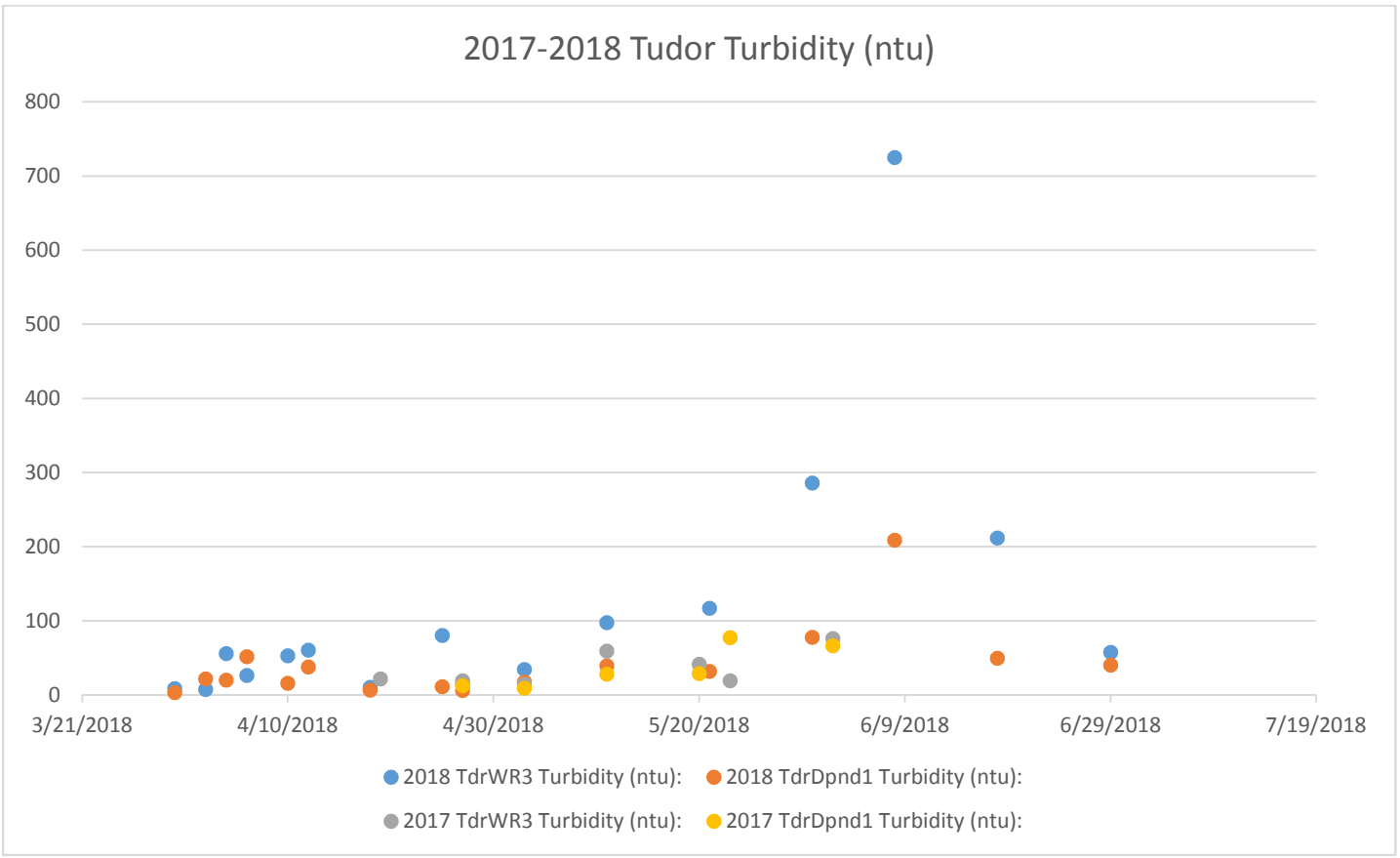
Turbidity values measured at the Spruce Street site tend to peak in mid to late May, towards the end of the melt period. Turbidity values measured at the Spruce Street detention pond outfall pipe (SprWR1) were much lower relative to those measured at the Tudor Road site, ranging from 5.62 NTU to a peak of 46.6 NTU on May 31st, 2018. In 2017, turbidity at the outfall pipe peaked on May 11th and then steadily declined. The turbidity values ranges from 8.2 to 81 NTU at the outfall.

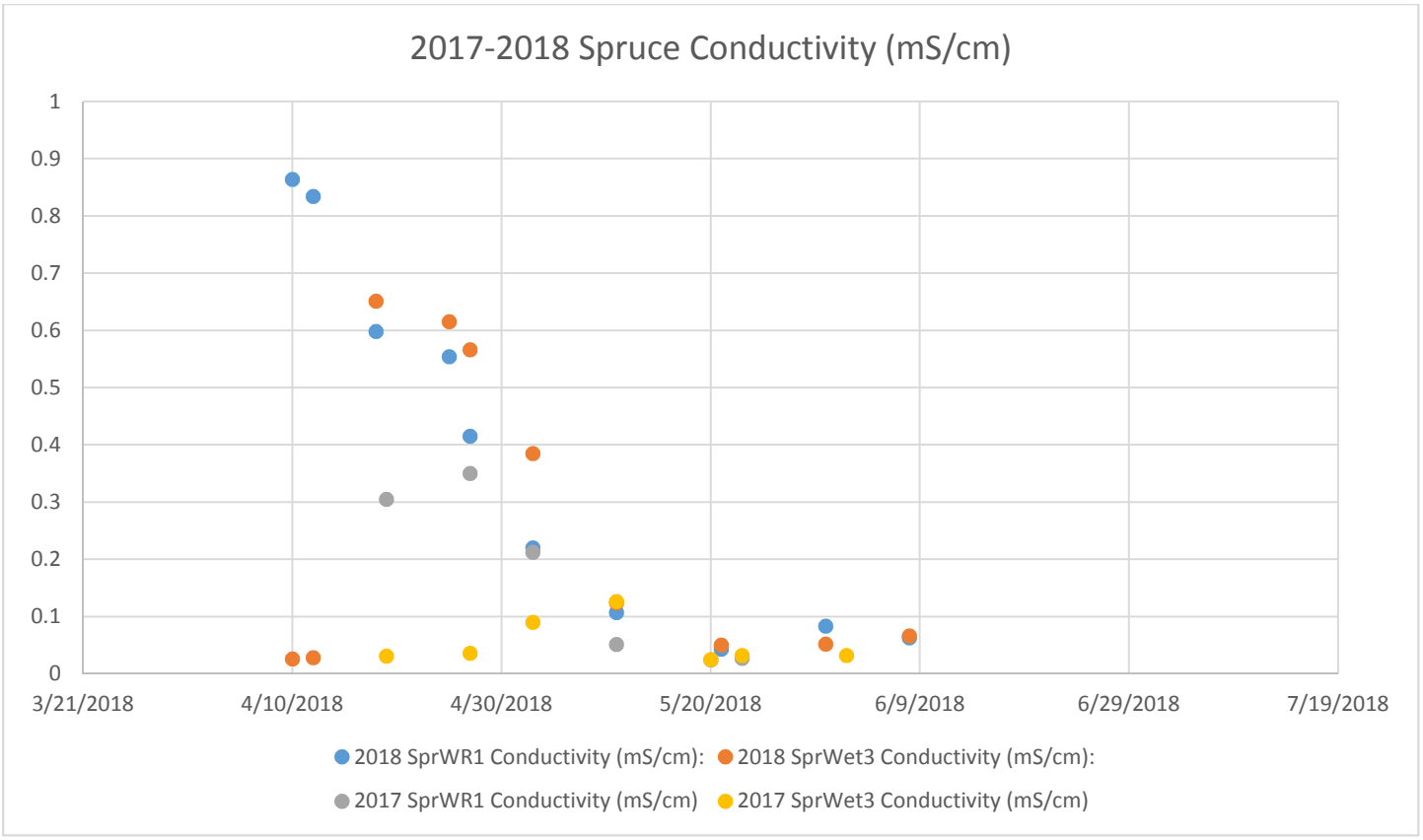
Turbidity values measured at the Spruce Street wetland site in 2018 (SprWet3) were lower and remained fairly consistent throughout the 2018 melt period, ranging between 1.32 and 7.82 NTU. Likewise, turbidity values measured at the Spruce Street wetland site were consistently low, ranging from 1.0 to 4.25 NTU. This suggests that the flow path and secondary rock detention pond that snow melt water flows into are doing a good job controlling for turbidity (by settling and depositing some of the fine grained particles remaining in the melt water after leaving the detention pond).

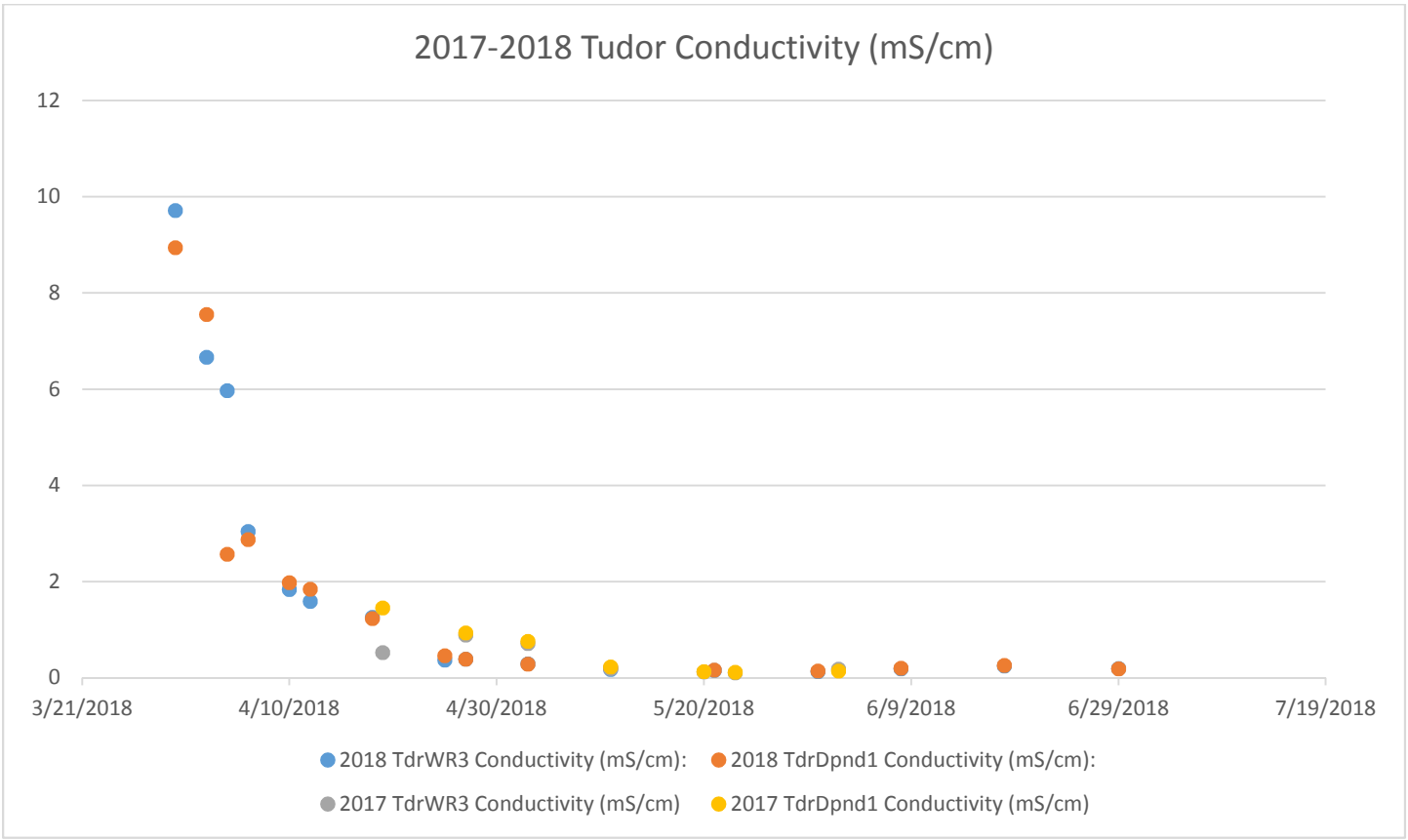
Overall, conductivity and turbidity values measured at the two sites were in line with past results. In 2013, chloride levels at Spruce peaked around 130 mg/L and chloride levels at Tudor were 1000mg/L. Turbidity at Spruce peaked around 20 NTU and turbidity at Tudor peaked at 500 NTU.

2017-18 Snow Melt Trends






2017-2018 Spruce Conductivity (mS/cm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3/21/2018
4/10/2018
4/30/2018
5/20/2018
6/9/2018
6/29/2018
7/19/2018
2018 SprWR1 Conductivity (mS/cm):
2018 SprWet3 Conductivity (mS/cm):
2017 SprWR1 Conductivity (mS/cm)
2017 SprWet3 Conductivity (mS/cm)


2017-2018 Tudor Conductivity (mS/cm)
12
10
8
6
4
2
0
3/21/2018
4/10/2018
4/30/2018
5/20/2018
6/9/2018
6/29/2018
7/19/2018
2018 TdrWR3 Conductivity (mS/cm):
2018 TdrDpnd1 Conductivity (mS/cm):
2017 TdrWR3 Conductivity (mS/cm)
2017 TdrDpnd1 Conductivity (mS/cm)

2017 Estimated Chloride Concentrations

2017 Chloride Concentration Estimates				
Date:	SiteID:	Conductivity (mS/cm):	Conductivity (uS/cm):	Est. Chlorides (mg/L):
4/19/2017	SprWR1	0.305	305	65
4/19/2017	SprWet3	0.031	31	*
4/19/2017	TdrWR3	0.525	525	128
4/19/2017	TdrDpnd1	**1.451**	**1451**	**394**
4/27/2017	SprWR1	**0.35**	**350**	**77**
4/27/2017	SprWet3	0.036	36	*
4/27/2017	TdrWR3	**0.891**	**891**	**233**
4/27/2017	TdrDpnd1	0.935	935	246
5/3/2017	SprWR1	0.212	212	38
5/3/2017	SprWet3	0.09	90	3
5/3/2017	TdrWR3	0.715	715	182
5/3/2017	TdrDpnd1	0.76	760	195
5/11/2017	SprWR1	0.051	51	*
5/11/2017	SprWet3	**0.126**	**126**	**13**
5/11/2017	TdrWR3	0.192	192	32
5/11/2017	TdrDpnd1	0.228	228	42
5/20/2017	SprWR1	0.024	24	*
5/20/2017	SprWet3	0.025	25	*
5/20/2017	TdrWR3	0.12	120	11
5/20/2017	TdrDpnd1	0.13	130	14
5/23/2017	SprWR1	0.027	27	*
5/23/2017	SprWet3	0.032	32	*
5/23/2017	TdrWR3	0.103	103	6
5/23/2017	TdrDpnd1	0.118	118	11
6/2/2017	SprWet3	0.032	32	*
6/2/2017	TdrWR3	0.18	180	29
6/2/2017	TdrDpnd1	0.144	144	18
Chloride values estimated using correlation equation between laboratory chloride data and				
specific conductance developed in 2013 (MOA, 2013, *Anchorage Snow Disposal Sites: 2013 Evaluation*)				
EC (uS/cm) = 3.4775*[Cl](mg/L) + 80.593				
Bold = peak value for sample location in 2018				
* = EC value below threshold to correlate to chloride concentration				

2018 Estimated Chloride Concentrations

2018 Chloride Concentration Estimates				
Date:	SiteID:	Conductivity (mS/cm):	Conductivity (uS/cm):	Est. Chlorides (mg/L):
3/30/2018	TdrWR3	**9.719**	**9719**	**2772**
3/30/2018	TdrDpnd1	**8.945**	**8945**	**2549**
4/2/2018	TdrWR3	6.664	6664	1893
4/2/2018	TdrDpnd1	7.555	7555	2149
4/6/2018	TdrWR3	3.041	3041	851
4/6/2018	TdrDpnd1	2.878	2878	804
4/10/2018	SprWR1	**0.864**	**864**	**225**
4/10/2018	SprWet3	0.026	26	*
4/10/2018	TdrWR3	1.839	1839	506
4/10/2018	TdrDpnd1	1.977	1977	545
4/12/2018	SprWR1	0.834	834	217
4/12/2018	SprWet3	0.028	28	*
4/12/2018	TdrWR3	1.592	1592	435
4/12/2018	TdrDpnd1	1.845	1845	507
4/18/2018	SprWR1	0.598	598	149
4/18/2018	SprWet3	**0.651**	**651**	**164**
4/18/2018	TdrWR3	1.261	1261	339
4/18/2018	TdrDpnd1	1.234	1234	332
4/25/2018	SprWR1	0.554	554	136
4/25/2018	SprWet3	0.615	615	154
4/25/2018	TdrWR3	0.37	370	83
4/25/2018	TdrDpnd1	0.458	458	109
4/25/2018	TdrOF	0.172	172	26
4/27/2018	SprWR1	0.415	415	96
4/27/2018	SprWet3	0.566	566	140
4/27/2018	TdrWR3	0.389	389	89
4/27/2018	TdrDpnd1	0.388	388	88
5/3/2018	SprWR1	0.22	220	40
5/3/2018	SprWet3	0.385	385	88
5/3/2018	TdrWR3	0.294	294	61
5/3/2018	TdrDpnd1	0.285	285	59
5/3/2018	TdrOF	0.171	171	26
5/11/2018	SprWR1	0.107	107	8
5/11/2018	SprWet3	0.124	124	12
5/11/2018	TdrWR3	0.178	178	28
5/11/2018	TdrDpnd1	0.208	208	37
5/21/2018	SprWR1	0.043	43	*
5/21/2018	SprWet3	0.05	50	*
5/21/2018	TdrWR3	0.157	157	22
5/21/2018	TdrDpnd1	0.161	161	23
5/21/2018	TdrOF	0.14	140	17
5/31/2018	SprWR1	0.083	83	1
5/31/2018	SprWet3	0.052	52	*
5/31/2018	TdrWR3	0.129	129	14
5/31/2018	TdrDpnd1	0.145	145	19
5/31/2018	TdrOF	0.138	138	17
6/8/2018	SprWR1	0.063	63	*
6/8/2018	SprWet3	0.066	66	*
6/8/2018	TdrWR3	0.187	187	31
6/8/2018	TdrDpnd1	0.198	198	34
6/18/2018	TdrWR3	0.248	248	48
6/18/2018	TdrDpnd1	0.257	257	51
6/18/2018	TdrOF	0.141	141	17
6/29/2018	TdrWR3	0.197	197	33
6/29/2018	TdrDpnd1	0.185	185	30
6/29/2018	TdrOF	0.133	133	15
Chloride values estimated using correlation equation between laboratory chloride data and				
specific conductance developed in 2013 (MOA, 2013, *Anchorage Snow Disposal Sites: 2013 Evaluation*)				
EC (uS/cm) = 3.4775*[Cl](mg/L) + 80.593				
Bold = peak value for sample location in 2018				
* = EC value below threshold to correlate to chloride concentration				

Cunningham 2/14/2019, Watershed Management Services

Correlation to Chloride Concentration and Previous Data

Comparison to Previous Sampling Results			Max Chloride Values		Max Turbidity Values
Snow Site	Sample Location Description	Sample Site ID	Estimated* (mg/L)	Lab Measured (mg/L)	Field Sampling Results (NTU)
	1998				
Tudor	Tudor melt water west (stn. 08)	08	8763	9170	not sampled
Commercial	Commercial melt water east (stn. 26)	26	12344	11200	not sampled
	2000				
Tudor Road	Discharge from NW edge of snow site into detention basin	TU01	436	428	3500
	Discharge from north central portion of snow site into detention basin	TU02	202	349	337
	Discharge from east edge of snow site into detention basin	TU03	226	333	353
	2001				
Tudor Road	Discharge from NW edge of snow site into detention basin	TU01	1338	1160	761
	Discharge from pilot area V-swales	TU03	821	not sampled	94
	2013				
Tudor Road	Discharge from NW edge of snow site	TU01	850	not sampled	550
	Discharge from pilot area V-swales	TU03	185	not sampled	65
Spruce Street	Meltwater from basin pond	SprWR1	50	not sampled	26
	Dischrage from distributory weir	SprWR2	10	not sampled	23
	2017				
Tudor Road	Discharge channel from NW edge of snow site (w/ V-swales and weir)	TdrWR3	233	not sampled	76.2
	Detention basin water	TdrDpnd1	394	not sampled	77.4
Spruce Street	Discharge from pond outfall	SprWR1	77	not sampled	80.8
	Wetland sample	SprWet3	13	not sampled	4.25
	2018				
Tudor Road	Discharge channel from NW edge of snow site (w/ V-swales and weir)	TdrWR3	2772	not sampled	725
	Detention basin water	TdrDpnd1	2549	not sampled	209
	Chester Creek (downstream receiving water)	TdrOF	26	not sampled	6.23
Spruce Street	Discharge from pond outfall	SprWR1	225	not sampled	46.6
	Wetland sample	SprWet3	164	not sampled	7.82

*2017-18 Chloride values estimated using correlation equation between laboratory measured chloride data and specific conductance developed in 2013 (MOA, 2013, *Anchorage Snow Disposal Sites: 2013 Evaluation)* EC (uS/cm) = 3.4775*[Cl](mg/L) + 80.593

Discussion and Recommendations

In order to assess the effectiveness of snow storage sites designed or retrofitted with V-swale and detention pond best management practices (BMPs) in controlling chloride and sediment discharge from the snow storage sites, turbidity and conductivity (specific conductance) data was collected in 2001, 2013, 2017, and 2018. Conductivity measurements were then correlated to estimated chloride concentration using the correlation developed in 2013 between laboratory measured chloride data and field measured specific conductance for each site.

Snow melt water discharged from snow storage sites with traditional flat-pad or slightly concave pad designs (as opposed to sites with V-swales) saw estimated chloride concentrations peak during the early portion of the melt period range from 1000 to over 10000 mg/L, and turbidity peak at over 1000 NTU near the end of the melt period (MOA, 2013). Snow melt water measured from sites designed or retrofitted with V-swale and detention pond BMPs ranged from 10 to 2772 mg/L in 2001 to 2018, for an overall chloride reduction of 3.6 to 10 times the concentrations measured at sites with traditional designs.

Likewise, turbidity measurements dropped for snow storage site employing V-swale and detention pond BMPs over those measured from sites with traditional designs. Turbidity values measured towards the end of the melt period were over 1000 NTU for sites with traditional designs (MOA, 2013), and were reduced to less than 209 NTU (the highest value measured in the Tudor detention pond in 2018) under a design utilizing snow site BMPs.

Sampling conducted in 2017 and 2018 suggest that the Tudor Road and Spruce Street snow storage sites, have little to no impact on downstream water quality. Samples taken from Chester Creek (at the closest point downstream from the Tudor Road site) in 2018 remained consistently low for both turbidity and conductivity throughout the 2018 sampling period, and at no time was melt water observed flowing from the detention pond

outfall. Turbidity measured in the Spruce Street wetland remained consistently low for all samples collected in 2017 and 2018. Conductivity measurements correlated to chloride concentration show all samples collected at both Spruce Street sample locations in 2017 and 2018 were below SOA water supply/drinking water standards for chlorides (<250mg/L). Estimated chloride concentrations for 2018 for all sites (Tudor and Spruce) fell and remained below State of Alaska (SOA) water supply/drinking water standards for chlorides by April 25, 2018.

Based on these measurements and observations, it is evident that proper snow storage site design (implementing V-swales and detention ponds), adherence to operational standards (proper snow pile staging, shape, and height), and seasonal facility maintenance (to periodically regrade V-swales and remove sediment form detention basins) can ensure that large scale snow storage sites can be designed and maintained to have minimal to no impact on receiving water quality. Annual inspections of snow storage site facility Stormwater Pollution Prevention Plans (SWPPPs) will take the place of water quality monitoring in the future. SWPPP inspections will ensure that snow storage site controls and BMPs are maintained adequately to ensure the continued treatment of snow melt runoff.

Prepared by Kyle Cunningham

MOA Watershed Management Services

References:

MOA, 2015, *Quality Assurance Plan Appendix C. Snow Storage Site Retrofit Monitoring Plan*

MOA, 2013*, Anchorage Snow Disposal Sites: 2013 Evaluation*

Attachment A

Field Notes

10 Sno Sites 2018 3/14/18
Visit 1 KBC/KB
1.0 mS/cm plafl
Calib: YSI @ ~~1000 uS/cm~~ cal solution
Reads: 0.939 mS/cm = 94%
(876 uS/cm)

HACH 2100P Turbidimeter:
Blank Reads: —

Tudor -
no flow in channel
second channel unaccessable
no signs meltwater discharge
some rotting in soil/is be perviet

Spruce
no flow into pond or channel
no discharge from outflow pipe

p1of1

Snow Sites 2018 3/19/18

Visit 2; ~3:15pm KBC
Air temp ~ 38°, sunny (rain overnight)

Spruce St. - No discharge from from outflow pipe, slush/ice in bottom of secondary pond but no water, no water in wetland

Tudor - More melting of snowpile, but channel from pile is still covered in snow + bottom of channel is slushy, but no water. Ponding evident in V-swales on upstream side of snowpiles.

Rite in the Rain

Snow Storage Sites 2018 3/20/18
VISIT #3 ~ 3:20pm EEC
Air Temp ~ 36° Partly cloudy p10f1

Spruce
More melting of in-stu snow, but no discharge from outfall pipe yet, ice @ bottom of 2nd pond (froze up last night, but no water.
No water in wetlands yet.

Tudor ~ 3:45pm, partly cloudy
Snow still covering channel from pile to pond. Hole dug through ~~ice~~ snow in channel reveals slush/saturated snow @ bottom of channel, but no flow or enough liquid for a grab sample

Snow Storage Sites 2018 3/23/18

Visit #4 ~ 2:35pm KEC
Air Temp ~ 36°, Mostly Sunny
Previous Night Low = 19°F

Spruce
Not much melting in past few days, no discharge from outfall pipe yet, solid ice @ base of 2nd pond area due to colder overnight temps. No water in wetlands

Tudor
Snow still covering channel from pile to pond, 1 hole in snow shows solid ice @ base of channel, no evidence of recent flow

Rite in the Rain

14

Snow Storage 2018 3/28/18

Visit #5 ~3:00pm

Cloudy + snowing slightly

Yoder

Ice/slush in outfall channel but not liquid runoff, maybe by end of week

Spruce - Did not visit

Snow Storage 2018 3/30/18

Visit #6 ~ 2:40 pm p1 of 1

Weather: Mostly sunny

Air Temp ~ 36°F Prev. Low = 28°F

Spruce

More melting evident as even light colored snow is now rotting. Snow in base of 2nd pond is corn/saturated w/ ice @ bottom. Still no liquid from discharge pipe evident. Snow still covering wetland.

Tudor Channel still covered in snow as is pond, but digging small hole in snow revealed slushy water in channel. Water does not appear to be flowing. Snow still covering pond, small amount of water @ surface near outfall pipe.

Tudor channel: Matrix = slushy water from hole

Temp: ~~2.5°C~~ ~~1.64°C~~ 1.36°C

Cond: (5334 µS/cm) Blank (1000 µS) = (9.719 mS/cm)

pH: 7.16

Turb: 9.02 ntu Blank = 0.47 ntu

Tudor Pond Temp: 2.42°C pH = 7.85

Cond: (5045 µS/cm) (8.945 mS/cm) Turb: 5.22 ntu (late in day, rising)

16

Snow Storage 2018 — 4/2/18
Visit 7 — p1 of 2 — KBC

Air Temp: ~39°F Sunny
Previous Low: 24°F

~~Spruce~~ Spruce ~ 3:20 pm

Still no discharge from outfall pipe, no liquid @ base of 2nd pond, ← no snow melt water appears to be entering wetland yet.

Tudor ~ 3:40 pm

Outfall channel still covered in snow, previous holes in snow have frozen melt water, but digging through snow reveals sloshy water in channel.

Liquid water ~ 10' diameter around outfall pipe, through water level ~ 1' below invert of standpipe

17

Snow Storage 2018 — 4/2/18
Visit 7 — p 2 of 2 — KBC

Tudor Channel
Temp: -0.14 °C
Cond: 6.664 mS/cm
3468 µS/cm
pH: 7.08
Turb: 7.70 ntu Blank: 0.21 ntu

Tudor Pond
Temp: -0.25 °C
Cond: 7.555 mS/cm
3911 µS/cm
pH: 7.58
Turb: 22.1 ntu

Rite in the Rain

18

Snow Storage 2018 4/4/18
~~Visit #8~~
Weather: Overcast, snowing slightly ~ 29°F p1 of 2
Previous Low: 23°F KBC

Spruce ~ 3:15 pm
Melting evident @ surface of pond for first time this year. Still no discharge from weir or outfall pipe. No liquid in base of 2nd pond. Snow still covering wetland.

Tudor ~ 3:45 pm
Outfall channel still covered w/ snow, but liquid water under snow cover.
Pond - water level has risen significantly since last observation, outfall pipe completely under water/ice, surface of pond frozen over, but grab sample obtained from beneath ice.

19

Snow Storage 2018 4/4/18
~~Visit #8~~
p 2 of 2
~~KBC~~

Tudor channel
Temp: -0.17°C
Cond: 5.970 mS/cm Blank: 0.967 mS/cm @ 1000 uS (97%)
3099 uS/cm
Sal: 3.15
pH: 6.98
Turb: 55.9 ntu Blank: 0.35 ntu

Tudor Pond
Temp: -0.06°C pH: ~~7.06~~ 6.97
Cond: 2.570 mS/cm
1340 uS/cm
Sal: 1.30
Turb: 20.3 ntu Blank: 0.14 ntu Rite in the Rain

Snow Storage 2018 — 4/6/18
Visit #9 — KBC
Weather: Overcast ~35°F — p1 of 2
Previous Low: ~21°F

Spruce ~ 3:50pm
Water around edges of pond + melting @ surface, still no discharge from outfall pipe or water @ base of 2nd pond. Snow still covering wetland, no discharge to wetland yet

Tudor ~ 4:20pm
More water in outfall channel through freezing over each night 2nd pond ~~pond~~ has appeared under fence, sampling further down channel to capture combined flows. Did not observe any water, melting or flow downstream of outfall pipe from pond. Pond + outfall standpipe covered in ice.

Snow Storage 2018 — 4/6/18
Visit #1 — KBC
p 2 of 2

Tudor channel
Temp: -0.1°C
Cond: 3.041 mS/cm
1583 uS/cm
Sal: 1.55
pH: 6.46
Turb: 26.7 ntu — Blank: 0.22 ntu

Tudor Pond
Temp: -0.11°C — pH: ~~7.13~~ 7.1
Cond: 2.878 mS/cm
1498 uS/cm
Sal: 1.46
Turb: 52.0 ntu

Rite in the Rain

22

Snow Storage 2018 — 4/10/18
Visit #10 — KBC
Weather: Overcast ~50°F — p1 of 2
Previous Low: ~35°F

~3:00pm
Spruce - Lots more melting, water is discharging from outfall pipe, 2nd pond is full of water, wetlands partially melted w/ water @ sample loc 2

Tudor 3:40pm
No discharge to stream, any discharge from pond is staying in snow covered ditch, stream frozen, w/ no liquid discharge from ditch/pond evident yet. Channel from V-swale now fully melted + flowing, Outfall pipe collar just visible above water

Tudor channel
Temp: 5.24°C — pH: 7.31
Cond: 1.839 mS/cm — Turb: 53.2 ntu
1145 µS/cm
Sal: 0.93 — Blank: 0.3 ntu

23

Snow Storage 2018 — 4/10/18
Visit #10 — KBC
p2 of 2

Spruce Outfall Pipe — ~3:00pm
Temp: 5.75°C — pH: 5.93
Cond: 0.864 mS/cm
574 µS/cm
Sal: 0.42
Turb: 5.62 ntu — Blank: 0.14 ntu

Spruce 2nd Pond
Temp: 2.09°C — pH: 4.8
Cond: 0.057 mS/cm
32 µS/cm

Spruce Wetland
Temp: 1.06°C — pH: 5.48
Cond: 0.026 mS/cm — Turb: 7.82 ntu
14.0 µS/cm
Sal: 0.01

Tudor Pond
Temp: 2.66 — pH: 7.27
Cond: 1.977 mS/cm — Turb: 15.9 ntu
1132 µS/cm
Sal: 1.00

Rite in the Rain

Snow Storage 2018 4/12/18
U3317#11 KBC
Weather: Sunny ~ 47°F p1of2
Previous Low: ~ 30°F

Spruce ~2pm
More flow from pipe, ice melted in bottom of 2nd pond. Pour pt. from 2nd pond to wetland established + flowing.

Spruce Outfall Pipe
Temp: 5.66°C pH: 6.5
Cond: 0.834mS/cm Turb: 6.45ntu
525 uS/cm Blank → 0.18ntu
Sal 0.41sal

Spruce Wetland
Temp: 3.33°C pH: 6.79
Cond: 0.028mS/cm Turb: 2.65ntu
15uS/cm
Sal 0.01

Snow Storage 2018 4/12/18
KBC
p2of2

Tudor - Channel nearly @ capacity w/ flow. Looks more turbid. Pond surface ~ 1/2 free of ice cover. Outfall standpipe ~ 3" above water level. No flow in ditch below pond, but I sampled water anyway.

Tudor Channel ~3pm
Temp: 6.38°C pH: ~~8.75~~ 7.11
Cond: 1.592mS/cm Turb: 60.6ntu
1022 uS/cm
Sal: 0.80

Tudor Pond
Temp: 5.54°C pH: 7.29
Cond: 1.845mS/cm Turb: 38.0ntu
1159 uS/cm
Sal 0.93

Tudor Channel #2 (below pond outfall)
Temp: 2.87° pH: 7.1
Cond 0.234mS/cm Turb: 9.88
136 uS/cm Blank: 0.17ntu
Sal 0.11

Rite in the Rain

Snow Storage 2018 4/18/18
Visit 12 KBC
Weather: Overcast ~ 44°F p1of2
previous Low: ~ 35°F

Spruce ~ 3:40pm
2nd pond is discharging to wetland @ constant rate (2nd pond full)

Spruce outfall Pipe
Temp: 5.82°C pH: 6.38
Cond: 0.598 mS/cm Turb: 6.8 ntu
379 uS/cm Blank → 0.12 ntu
Sal 0.29

Spruce wetland
Temp: 4.82 pH: 4.88
Cond: 0.651 mS/cm Turb: 3.53 ntu
~~Cond: 0.651 mS/cm~~
~~Sal~~ 399 uS/cm
Sal: 0.32

Snow Storage 2018 4/18/18
KBC
p2of2

Tudor ~ 4:40 pm
Outfall channel flow down from last visit. No flow in channel below pond. Pond water level has dropped ~ 10"-12".

Tudor channel
Temp: 2.07°C pH: 7.05
Cond: 1.261 mS/cm Turb: 10.3 ntu
709 uS/cm
Sal: 0.62 Blank → 0.03 ntu

Tudor Pond
Temp: 3.76°C pH: 7.27
Cond: 1.234 mS/cm
734 uS/cm Turb: 6.9 ntu
Sal 0.61

Rite in the Rain

Snow Storage 2018 4/25/18
Visit #13 KBC
Weather: Partly Sunny + windy p1 of 2
Temp: ~52°F Prev Low: 42°F

Spruce ~ 3:15pm
No discharge from pipe, 2nd pond is full + still discharging to wtlnd. 2nd pond full of debris from windstorm yesterday (* May impact turbidity)

Spruce 2nd Pond* (No discharge from pipe)
Temp: 10.53°C pH: 7.2
Cond: 0.554 mS/cm Turb: 5.46 ntu
401 mS/cm
Sal: 0.27 Blank → 0.19 ntu

Spruce Wetland
Temp: 6.8°C pH: ~~7.60~~ 5.15
Cond: 0.615 mS/cm Turb: ~~5.15~~ 1.55 ntu
403 mS/cm
Sal: 0.30

Snow Storage 2018 4/25/18
Visit #13 KBC
p2 of 2

Tudor ~~4:00 pm~~ 4:15 pm
Channel is @/above capacity. Flow is much more turbid than last visit. Pond water level appear to be down 1-2" from last visit. Some water ponded in chnl below pond, but no flow or active discharge from pond

Tudor Channel
Temp: 7.86°C pH: ~~7.67~~ 7.25
Cond: 0.370 mS/cm Turb: 80.7 ntu
249 mS/cm
Sal: 0.18 Blank → 0.15 ntu

Tudor Pond
Temp: 8.65°C pH: 7.41
Cond: 0.458 mS/cm Turb: 11.6 ntu
316 mS/cm
Sal: 0.22

Tudor Stream (~~upst~~ downstrm from chnnl)
Temp: 4.56°C pH: ~~7.60~~ 5.93
Cond 0.172 mS/cm Turb: 3.4 ntu Rite in the Rain
105 mS/cm
Sal: 0.08

Snow Storage 2018 — 4/29/18
Visit #14 — EBC
Weather: Cloudy ~ 46°F — p1 of 2
Previous Low ~ 33°F (rain yesterday)

Spruce ~ 2:45 pm
Outfall pipe is flowing again (evidence of debris blockage). 2nd Pond full + discharging to wetland

Spruce outfall Pipe
Temp: 6.95°C — pH: 5.52
Cond: 0.415 mS/cm — 272 uS/cm — Turb: 9.33 ntu
Sal: 0.20 — Blank: 0.13 ntu

Spruce wetland
Temp: 7.29°C — pH: 5.00
Cond: 0.566 mS/cm — 375 uS/cm — Turb: 1.32 ntu
Sal: 0.28

Snow Storage 2018 — 4/29/18
Visit #14 — EBC
p2 of 2

Tudor ~ 3:30 pm
Channel @ 3/4 capacity + flow not as turbid (high turbidity last trip was likely due to wind storm previous day). Pond water level is down 3-5" from last visit.

Tudor Channel — 6.26
Temp: 4.12°C — pH: ~~6.33~~
Cond: 0.389 mS/cm — 234 uS/cm — Turb: 15.0 ntu
Sal: 0.19

Tudor Pond
Temp: 4.79°C — pH: 7.3
Cond: 0.388 mS/cm — 238 uS/cm — Turb: 6.35 ntu
Sal: 0.12 — Blank: 0.12 ntu

Rite in the Rain

Snow Storage 2018 — 5/3/18
Visit #15 — KBC
Weather: Overcast ~ 44°F — p1 of 2
Previous Low: ~ 37°F

Spruce ~ 3:25pm
Water in pond + 2nd pond appears more turbid than previous observation
Water lvl in wetland down
* pH readings taking a long time + dropping → suspect pH data

Spruce Outfall Pipe
Temp: 7.22°C
pH*: ~~7.0~~ 5.58
Cond: 0.220 mS/cm (145 mS/cm)
Turb: 11.9 ntu
Sal: 0.10
Blank: 0.20 ntu
Cond Blank @ 1.0 mS/cm = 0.944 = 94.4%
pH Blank @ 4.0 pH = 4.13

Spruce Wetland
Temp: 7.26°C
pH*: ~~5.24~~ 5.24
Cond: 0.385 mS/cm (255 uS/cm)
Turb: 4.48 ntu
Sal: 0.19

Snow Storage 2018 — 5/3/18
Visit #15 — KBC
Tudor ~ 5:00pm — p2 of 2
Flow in channel + pond water level appear to be ~ same level as last trip.

Tudor Channel
Temp: 3.69°C
pH*: 6.56
Cond: 0.294 mS/cm (174 uS/cm)
Turb: 34.4 ntu
Sal: 0.14
Blank: 0.75 ntu

Tudor Pond
Temp: 5.48°C
pH*: ~~7.52~~ 7.55
Cond: 0.285 mS/cm (179 mS/cm)
Turb: 17.8 ntu
Sal: 0.14

Tudor Stream
Temp: 2.72°C
pH*: 6.19
Cond: 0.171 mS/cm (98 mS/cm)
Turb: 6.23
Sal: 0.08

Rite in the Rain

Snow Storage 2018 5/11/18
Visit #15 KBC
Weather: Partly sunny ~54°F p1of2
~~Tudor~~ Spruce
2nd Pond appears more turbid than before

Spruce ~~Pond~~ Outfall Pipe ~4pm
Temp: 11.1°C pH: 7.24
Cond: 0.107 mS/cm
78 uS/cm Turb: 19.2 ntu
Sal 0.05 Blank: 0.27 ntu

Spruce Wetland
temp: 8.6°C
Cond: 0.124 mS/cm
85 uS/cm pH: 5.8
Sal: 0.06 Turb*: 2.02 ntu
Blank: ~~0.00~~ 0.2
* More suspended algae than previous samples

Snow Storage 2018 5/11/18
Visit #15 p 2of2

Tudor
Channel flow @ Bankfull + pond.
Flow appears fairly Turbid

Tudor Channel ~5:08pm
Temp: 10.18°C pH: 7.17
Cond: 0.198 mS/cm
127 uS/cm Turb: 97.6 ntu
Sal: 0.08 Blank —

Tudor Pond
Temp: 11.83°C pH: 7.34
Cond: 0.208 mS/cm
155 uS/cm Turb: 39.7
Sal: 0.10 Blank: 0.21

Rite in the Rain

36

Snow Storage 2018 — 5/21/18

Visit #7 — KBC

Weather: Overcast w/ sprinkles — p1 of 2

Spruce - Pond water very turbid, snow pile down to ~4-5' high. Lots of flotsam/scum on surface near river.

Spruce Pond outfall Pike ~3pm

Temp: 11.91°C
Cond: 0.043 mS/cm
32 mS/cm
Sal: 0.02
pH*: 5.66 (YSI)
7.11 (Hanna)
Turb: 34.1 ntu
Blank: 0.24 ntu

Spruce Wetland

Temp: ~~9.0~~ 9.72°C
Cond: 0.050 mS/cm
36 uS/cm
Sal: 0.02
pH*: 4.39 (YSI)
6.9 (Hanna)
Turb: 2.01 ntu

YSI Calibration check:

Cond @ 1.0 mS/cm = 0.95 mS/cm = 95%
pH @ 7.0 = 7.14

37

Snow Storage 2018 — 5/21/18

Visit #7 — KBC — 2 of 2

Tudor: Channel flow @ capacity, flow is turbid.

Tudor Channel

Temp: 10.96°C
Cond: 0.157 mS/cm
115 uS/cm
Sal: 0.07
Flow: W=1.7' D=0.3' Vel = 0.65 ft/sec
pH*: 6.99 (YSI)
Turb: 117 ntu

Tudor Pond

Temp: 12.03°C
Cond: 0.161 mS/cm
121 uS/cm
Sal: 0.08
pH*: 7.35
Turb: 32.2 ntu

Tudor Stream

Temp: 5.59°C
Cond: 0.140 mS/cm
88 uS/cm
Sal: 0.07
pH*: 5.82 (YSI)
6.69 (Hanna)
Turb: 1.28 ntu
Blank: 0.14 ntu

Rite in the Rain

Snow Storage 2018 5/31/18
Visit #18 KBC plnk
Weather: Overcast w/ light sprinkles
~60°F

Spruce: Snow pile almost completely melted, <3 cy dirty snow left. Pond water turbid.

Spruce Outfall Pipe* ~3:40pm
Temp: 15.73°C pH: 5.56
Cond: 0.083 mS/cm
69 uS/cm Turb: 46.6 ntu
Sal: 0.04 Blank: 0.10 ntu
* Outfall pipe plugged/not discharging, sample grabbed from 2nd pond

Spruce Wetland
Temp: 13.65°C pH: 4.16
Cond: 0.052 mS/cm
40 uS/cm Turb: 1.84 ntu
Sal 0.02

Snow Storage 2018 5/31/18
Visit #18 KBC
p2of2

Tudor: Channel flow + pond @ most turbid so far this year

Tudor Channel ~4:30
Temp: 11.82°C pH: 6.04
Cond: 0.129 mS/cm
97 uS/cm Turb: 286 ntu
Sal: 0.06 Blank: 0.19 ntu
Flow: W=1.7' D=0.3' Vel=0.35

Tudor Pond
Temp: 12.73° pH: ~~6.86~~ 6.9
Cond: 0.145 mS/cm
111 uS/cm Turb: 78.1
Sal: 0.07

Tudor Stream ~4:55
Temp: 5.75°C pH: 5.04
Cond: 0.138 mS/cm
88 uS/cm Turb: 1.46
Sal: 0.07

Rite in the Rain

Snow Storage 2018 — 6/8/18
~~Visit #19~~ KBC
Weather: Sunny ~64°F p1 of 2

Spruce: ~3:10pm
Snow pile now completely melted
2nd pond is significantly less turbid
2nd discharge to wetland downstream
a trickle

Spruce Outfall ~~Pond~~*
Temp: 22.43°C pH: ~~7.58~~ 7.24
Cond: 0.063 mS/cm
60 µS/cm Turb: 6.57 ntu
Sal: 0.03 Blank, 0.43 ntu
* No discharge from outfall pipe.
Grab sample taken from 2nd pond

Spruce Wetland:
temp: 14.75°C pH: 4.85
Cond: 0.006 mS/cm
53 µS/cm Turb: 2.37 ntu
Sal: 0.03

YSI Cal ck
Cond @ 1.0 mS/cm = 0.999 mS/cm
pH @ 7.0 = 7.05

Snow Storage 2018 — 6/8/18
~~Visit #19~~ KBC
p 2 of 2

Tudor: ~3:50 pm
Channel flow very turbid, pond most turbid it has been.

Tudor Channel:
Temp: 19.9°C pH: 6.89
Cond: 0.187 mS/cm
169 µS/cm Turb: 725 ntu
Sal: 0.09 Blank: 0.21 ntu

Tudor Pond:
Temp: 19.95°C pH: 7.08
Cond: 0.198 mS/cm
178 µS Turb: 209 ntu
Sal: 0.09

Tudor Stream:
No sample: short on time

Rite in the Rain

42 Snow Storage 2018 6/18/18
Visit #20 p 1 of 2
Weather: Overcast + windy

Spruce: No discharge from outfall pipe from pond + no discharge from 2nd pond to wetland. Lots of evap/infiltration since last observation. Water will likely be gone w/in 1-2 wks.

Snow Storage 2018 6/18/18 43
Visit #20 p 2 of 2

Tudor: Flow is down, but still very turbid.

Tudor Channel:
Temp: 17.31°C pH: 7.14
Cond: 0.248 mS/cm
217 uS/cm Turb: 212 ntu
Sal: 0.12 Blank: 0.28 ntu

Tudor Pond
Temp: 15.12°C pH: 7.21
Cond: 0.259 mS/cm
208 uS/cm Turb: 49.6 ntu
Sal: 0.12

Tudor Stream
Temp: 6.21°C pH: 5.56
Cond: 0.141 mS/cm
90.0 uS/cm Turb: 1.61 ntu
Sal: 0.07 Blank: 0.19 ntu

Rite in the Rain

Snow Storage 2018 6/29/18
Visit 21 KBC

Tudor: Overcast ~3:30pm 1 of 1

Decent sized pile still left but flow is down to a trickle & less turbid. Pond almost completely evaporated

Tudor Channel

Temp: 18.76°C pH: 7.07
Cond: 0.197mS/cm
173 mS/cm Turb: 57.7ntu
Sal 0.09 Blank: 0.30ntu

Tudor Pond

Temp: 18.9°C pH: 6.98
Cond: 0.185mS/cm
163 mS/cm Turb: 40.6ntu
Sal 0.09

Tudor Stream

Temp: 6.47°C pH: 5.88
Cond: 0.133mS/cm
86 mS/cm Turb: 1.02ntu
Sal: 0.06