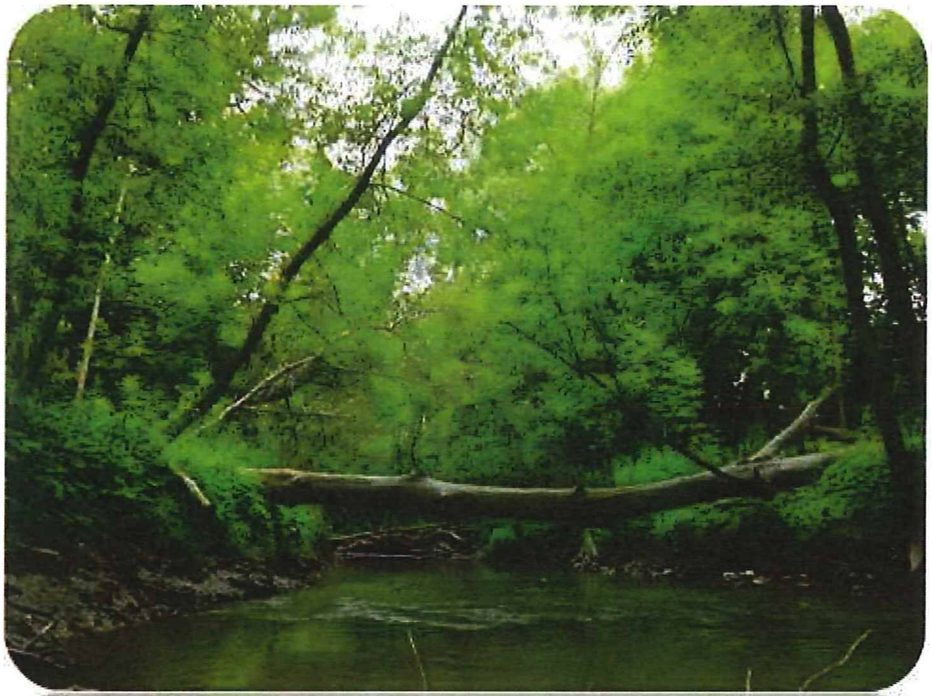

WATERSHED PLANNING & ENGINEERING

May 31, 2017

Hamilton Conservation Authority

Healthy Streams...Healthy Communities!

2016/2017 TRIBUTARY MONITORING FOR COOTES PARADISE

To support the Hamilton Harbour Remedial Action Plan

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Background

This monitoring program aims to understand water quality contributions from creeks flowing into Cootes Paradise Marsh and ultimately, Hamilton Harbour. Establishing non-point sources of water quality inputs to the marsh, such as contributions from creeks and tributaries, is an important step in reaching the delisting objectives for site CP1 located in the marsh. Once the relative sources of inputs are assessed, any needed remedial efforts in these tributaries that support delisting Hamilton Harbour can be determined.

The Hamilton Conservation Authority has been involved with this water quality monitoring program in partnership with the Hamilton Harbour Remedial Action Plan (HHRAP), Ministry of Environment and Climate Change, and the City of Hamilton since spring of 2014. The monitoring program has been adapted from a previous sampling program undertaken by the Royal Botanical Gardens (RBG).

This program aims to explore water quality conditions in the sub-watersheds of Lower Spencer Creek, Chedoke Creek, Borers Creek, Ancaster Creek and Sulphur Creek; their drainage areas can be seen on Figure 1. HCA assumed sampling responsibilities from RBG for the Lower Spencer Creek, Chedoke Creek and Borers Creek sampling sites, to continue long term data analysis for these locations. These sites are known as CP-7, CP-11 and CP-18.1 (See Figure 2) and are located immediately upstream of the locations where they drain into the Cootes Paradise Marsh.

In addition, in 2014 the monitoring program was expanded to include four new sites to help characterize the water quality contributions coming from the Ancaster Creek sub-watershed (AC-1, AC-2, AC-3 and AC-4), which has relatively little water quality and flow data near the lower reaches of the sub-watershed boundaries.

In 2015, the monitoring program was further expanded in that storm event samples were taken at site AC-1 using an ISCO automated composite sampler.

Changes to Water Quality Monitoring Program in 2016

In 2016 the sampling period was lengthened to be year-round at all seven stations. Year round monitoring will allow us to develop an all-encompassing view of water quality conditions throughout a wide variety of climate conditions.

However, storm event sampling at AC-1 was not undertaken in the winter months. Furthermore, equipment for the installation of two new storm event sampling locations arrived in October 2016, and was installed by April 2017 in Spencer Creek at Highway 5 and Spencer Creek at Market Street. These sites will capture storm event samples during the 2017 program. Expanding storm event sampling will deepen our understanding of how land uses and conditions affect water quality during heavy wet events.

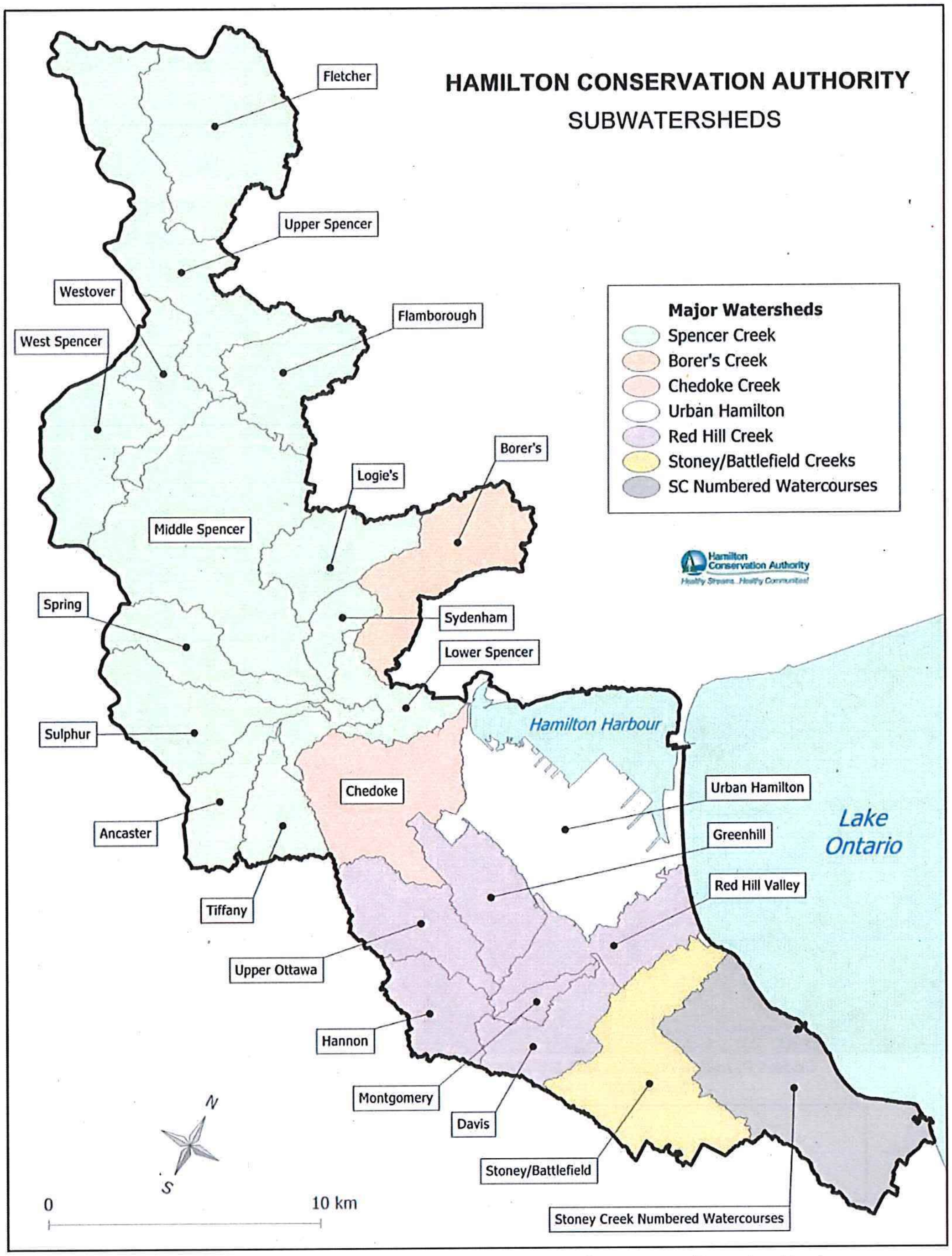

Figure 1: Hamilton subwatersheds surrounding the Harbour

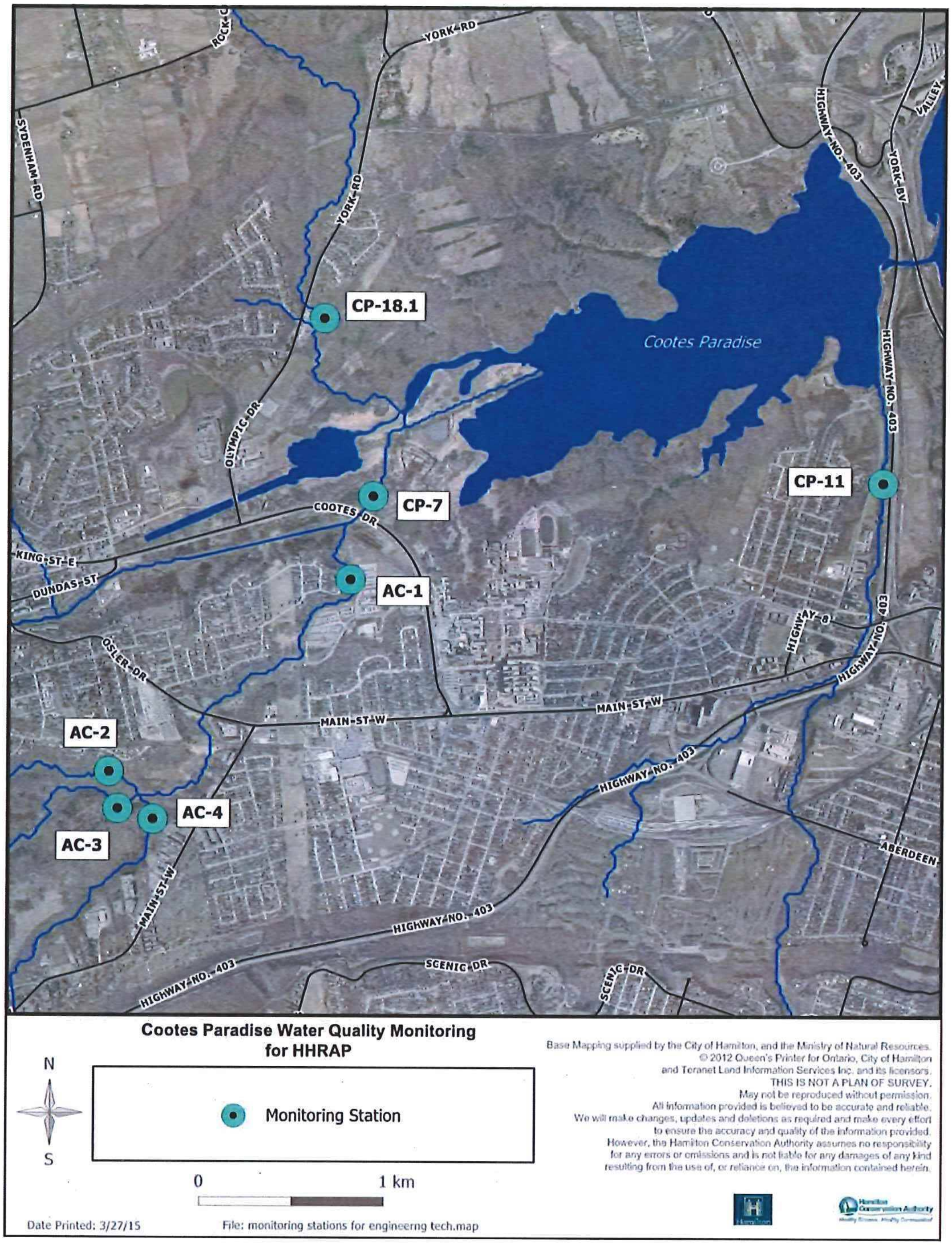

Figure 2: Water Quality Sampling Locations

Project Objective

The project objective is to identify important contributions to Cootes Paradise water quality from the creeks discharging to the marsh. This will also provide information to support where mitigation activities can best be applied to benefit the overall water quality within Cootes Paradise. As well, as part of a separate project for the Hamilton Harbour Remedial Action Plan (HHRAP), a nutrient loadings model is being developed for Cootes Paradise by the University of Toronto. This model could benefit from data collected by this monitoring program. The data will be shared with the Hamilton Harbour Remedial Action Plan office and/or one of the technical committees associated with the HHRAP.

Sample Locations

Site AC-1 is on the main branch of Ancaster Creek just upstream of the confluence with Spencer Creek. This location is ideal to capture the nutrient and sediment contributions from the Ancaster Creek subwatershed and its tributaries before entering Spencer Creek. Predominant land uses for the Ancaster Creek subwatershed are residential, woodland with some light agricultural in the headwaters.

Site AC-2 is located on Sulphur Creek before the confluence with Ancaster Creek. Main land uses for the Sulphur Creek subwatershed are woodland and residential with some agricultural in the upper headwaters.

Site AC-3 is located on the main branch of Ancaster Creek upstream of the confluence with Sulphur Creek.

Site AC-4 is located on an unnamed watercourse just upstream of the confluence with Ancaster Creek and has a relatively small drainage area which is mainly residential.

Site CP-7 located on Lower Spencer Creek and is aimed at capturing inputs from the entire Spencer Creek Watershed and its tributaries including Ancaster Creek. Its dominant land uses are agricultural in the upper and middle reaches and residential in the lower reach below the escarpment.

Site CP-11 is located on Chedoke Creek before it drains in to Cootes Paradise marsh. Chedoke Creek subwatershed is mostly residential land use with some industrial and a municipal golf course. Long reaches of the creek are piped and culverted with virtually no naturalized habitat.

Site CP-18.1 is located on Borers Creek just downstream of York Road in Dundas upstream of the confluence with Spencer Creek. Borers Creek subwatershed dominant land uses are agricultural and residential.

Sampling Methodology

The 2016 water quality monitoring program occurred on alternate weeks from April 2016 to March, 2017. Surface grab samples were taken during daylight hours with same day drop off for analysis at the City of Hamilton Regional Environmental Lab. Levels of phosphorus, e.coli, various nitrogen compounds, and suspended solids were measured. In addition, temperature, pH, conductivity, turbidity and dissolved oxygen are measured on site by HCA staff for each sample site using a YSI 6600.

Chlorophyll-a is measured in an accredited laboratory once every three years (samples in 2013 were analyzed for Chlorophyll-a, thus sampling was undertaken as part of the 2016 program).

It was determined if samples were impacted by storm water conditions (wet events) by confirming rain data recorded at the Environment Canada precipitation monitoring station at Hamilton Airport Climate ID 6153193. If more than 4 mm rainfall had occurred within the 24 hours prior to sampling it is considered that the samples are storm water impacted. A visual inspection of storm water outfalls in the area will also be completed if storm water conditions are suspected.

In order to estimate loadings from Ancaster Creek into Spencer Creek and the Harbour, the HCA has set-up a temporary flow monitoring and remote sample collection station on Ancaster Creek just upstream of the confluence with Spencer Creek to sample storm events starting in 2015. The ISCO automated sampler will be triggered prior to an incoming storm event to take a 1 L sample every hour from the time of initiation. With 24 sample bottles in the ISCO carousel, it will be possible to capture a 24 hour time period of the storm and its effect on the creek. A level weighted composite sample was made using a depth logger attached to the intake of the ISCO sampler. At various points throughout the sample season, flows were manually measured at site AC-1 using a Marsh McBirney flow meter in order to establish a rating curve to estimate flows and thus loadings coming from Ancaster Creek before the confluence with Spencer Creek.

Spencer Creek has three upstream Provincial Water Quality Monitoring Network sample locations that have been undertaken since 2002 and three Water Survey of Canada hydrometric gauging stations, the closest being less than 3 kilometers upstream. This will make it possible to compare relative input contributions of Ancaster Creek to Spencer Creek and provide an understanding of relative inputs to Cootes Paradise and the Hamilton Harbour from the individual tributaries. It is projected that several years of measurements will be required to establish trends and determine baseline, dry weather and event conditions.

2016 Sampling Program Details

The sampling period reported in this document covers April 2016 – March 2017. A total of 26 biweekly samples were taken at each location. Due to the unusually dry year experienced in 2016, 8 out of 26 samples (30%) were taken during wet conditions, and four heavy rain events were captured with the automated sampler at AC-1. Table 1 displays the 2016/2017 routine sample days, the previous 24 hour rainfall amounts and whether or not the sample day was classified as wet or dry. Table 2 shows the rainfall totals for the four heavy rain events captured in 2016 at the automated sampler at AC-1.

Rainfall Data

Table 1: Rainfall totals on routine sample dates at all sampling locations in 2016/17

Date	Previous 24 Hour Rainfall (mm)	Classification
April-12-16	3.8	Dry
April-28-16	0	Dry
May-11-16	0	Dry
May-25-16	0	Dry
June-16-16	10.4	Wet
June-22-16	0.8	Dry
July-06-16	0	Dry
July-19-16	0	Dry
August-04-16	0	Dry
August-17-16	16	Wet
August-31-16	4.6	Dry
September-14-16	1.2	Dry
September-28-16	3.2	Dry
October-12-16	0.8	Dry
October-26-16	8	Dry
November-09-16	3	Dry
November-24-16	6.4	Wet
December-07-16	3	Dry
December-21-16	1.8	Dry
January-04-17	12.4	Wet
January-18-17	14.2	Wet
February-01-17	2.6	Dry
February-15-17	0	Dry
March-01-17	29	Wet
March-15-17	25.9	Wet
March-29-17	12.6	Wet

Table 2: Rainfall totals on storm event sample dates at the AC-1 automated sampler

Date	Previous 24 Hour Rainfall (mm)
August-17-16	16
August-25-16	23.8
September-10-16	10.6
November-03-16	21

Flow Monitoring at AC-1

In order to estimate nutrient and sediment loading coming from the Ancaster Creek watershed, a rating curve is maintained along with a water level meter during non-ice periods. Capturing high flow days was difficult in 2016, as baseflow was observed for most of the year. Results from flow monitoring can be seem below.

Table 3: Flow measuring results

Date	Discharge (m^3/s)	Depth (m)
May-25-16	0.20841	0.45
June-22-16	0.14219	0.41
July-06-16	0.10797	0.40
August-17-16	0.20151	0.43

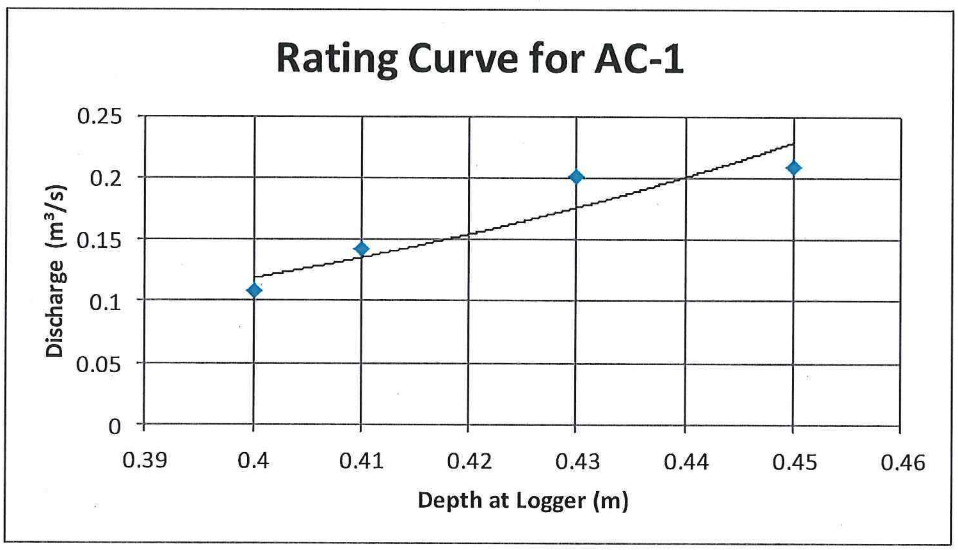

Figure 3: 2016 Rating Curve

Difficulties obtaining reliable data from the ISCO Bubbler Flow Module prevented the continuous monitoring of flows throughout the sample period, however a depth logger was installed at the intake in place of the bubbler. Maintenance will be conducted to the intake and Bubbler unit in 2017 in order to ensure the quality and accuracy of data and samples collected.

Water Quality Objectives

Samples were analyzed for the parameters listed in Table 4. Objectives to ensure that water quality is satisfactory for aquatic life were based on Provincial Water Quality Objectives (MOE 1999), federal guidelines outlined by the Canadian Council of Ministers of the Environment (2001) and Cootes – Grindstone Water Quality Targets (RAP office 2012). A description of each parameter is provided below.

Table 4: Water quality parameters and their desired objective

Parameter	Units	Target/Objective	Reference
Unionized Ammonia	mg/L	0.02 mg/L	HHRAP
Nitrate as N	mg/L	3 mg/L	HHRAP
Nitrite as N	mg/L	0.06 mg/L	CWQG
o-Phosphate as P	mg/L	n/a	
Total Phosphorous	mg/L	0.03 mg/L	PWQO
Total Suspended Solids	mg/L	25 mg/L	HHRAP
Volatile Suspended Solids	mg/L	n/a	
Escherichia coli	CFU/100mL	100 CFU/100mL	PWQO

Total Phosphorous

Total Phosphorous (TP) is commonly found in fertilizers, manure and organic wastes in sewage and industrial effluent. It is an essential nutrient to aquatic life, but in excess can cause eutrophication and algae blooms. Soil erosion is a main contributor of TP in surface waters, as phosphorous particles tend to attach to soil particles.

Unionized Ammonia

Ammonia is the preferred nitrogen containing nutrient for plant growth, yet it can also cause algal blooms and stress to fish in high concentrations. In water, ammonia occurs in two forms; ionized and unionized ammonia. This difference is important to know because NH_3, un-ionized ammonia, is the form more toxic to fish. Both water temperature and pH affect which form of ammonia is predominant at any given time in an aquatic system.

Nitrate

Nitrates are an essential nutrient for regulating plant life but can cause degraded water quality in excess concentrations. The target concentration for nitrates in this study is based on the Canadian Water Quality Guideline (CWQG) of 3.0mg/L. Typically nitrate concentrations tend to be low during base-flow conditions; however runoff from fertilizer, waste water treatment plants and storm sewer outfalls can bring the concentration of nitrates up to and beyond the target for water quality.

Nitrite

For this study, we've adopted the Canadian Water Quality Guideline (CWQG) target of 0.06mg/L as N.

Total Suspended Solids

Targeted concentrations of Total Suspended Solids (TSS) vary depending on the system being monitored. TSS thresholds are established by understanding the underlying background levels of a site which may or may not have clear flow during base-flow conditions. Storm events move sediment downstream and therefore TSS values are expected to be much higher during these events. Since background levels of TSS is unavailable for the majority of the sites sampled, the Hamilton Harbour Remedial Action Plan interim target of 25 mg/L was used as the target for TSS (RAP office 2012). This target is derived from the Canadian Water Quality Guideline (CWQG) for total suspended sediment.

Volatile Suspended Solids

Volatile Suspended Solids represent the organic portion of Total Suspended Solids. There is no current target set for Volatile Suspended Solids for the HHRAP or PWQO's. However understanding the make-up of solids (organic vs. inorganic) can help us in understanding the individual stresses occurring.

Escherichia coli

E.coli is well known to have harmful effects on human health when found in the environment at certain concentrations. There are strict guidelines for E.*coli* targets for drinking and recreational purposes. Since there is little to no background data for the majority of the sites, we will be comparing the geometric mean concentrations from each site to the PWQO of 100CFU/100mL (MOE 1999), the target for recreational purposes.

Results and Discussion

Total Phosphorous

Table 5: Results for Total Phosphorous in mg/L

Date	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	0.386	0.047	0.024	0.063	0.059	0.026	0.04	DRY
28-Apr-16	0.518	0.016	0.023	0.015	0.014	0.012	0.018	DRY
11-May-16	0.62	0.012	0.012	0.012	0.014	0.018	0.013	DRY
25-May-16	0.762	<0.01	0.028	0.018	0.015	0.026	0.027	DRY
16-Jun-16	0.716	0.057	0.039	0.064	0.076	0.053	0.041	WET
22-Jun-16	0.521	0.078	0.03	0.034	0.029	0.058	0.039	DRY
06-Jul-16	0.632	0.05	0.037	0.039	0.023	0.024	0.05	DRY
19-Jul-16	0.421	0.045	0.044	0.038	0.012	0.026	0.029	DRY
04-Aug-16	1.04	0.258	0.044	0.037	0.016	0.035	0.039	DRY
17-Aug-16	0.433	0.031	0.042	0.024	0.01	0.019	0.05	WET
31-Aug-16	0.36	0.03	0.044	0.049	0.033	0.034	0.054	DRY
14-Sep-16	0.828	0.027	0.046	0.025	0.029	0.022	0.044	DRY
28-Sep-16	0.375	0.03	0.024	0.018	<0.01	<0.01	0.025	DRY
12-Oct-16	0.232	0.043	0.038	0.014	<0.01	0.013	0.051	DRY
26-Oct-16	0.232	0.017	0.012	<0.01	<0.01	<0.01	0.039	DRY
09-Nov-16	0.506	0.02	0.025	0.017	0.012	0.02	0.05	DRY
24-Nov-16	0.393	0.012	0.025	0.016	0.011	0.022	0.054	WET
07-Dec-16	0.226	0.017	0.019	0.011	<0.01	0.017	0.031	DRY
21-Dec-16	0.237	<0.01	0.013	<0.01	0.011	<0.01	0.042	DRY
04-Jan-17	0.189	0.12	0.066	0.051	0.058	0.039	0.051	WET
18-Jan-17	0.171	0.183	0.241	0.078	0.099	0.073	0.061	WET
01-Feb-17	0.158	0.023	0.025	0.018	0.027	0.021	0.03	DRY
15-Feb-17	0.137	0.025	0.024	0.021	0.027	0.018	0.032	DRY
01-Mar-17	0.713	0.755	0.303	0.67	1.04	0.216	---	WET
15-Mar-17	0.109	0.017	0.022	0.017	0.048	0.021	0.028	WET
29-Mar-17	0.162	0.025	0.028	0.021	0.024	0.027	0.018	WET

Mean	0.426	0.075	0.049	0.053	0.065	0.032	0.038	
Dry Events (mean)	0.455	0.041	0.028	0.024	0.018	0.021	0.036	
Wet Events (mean)	0.361	0.150	0.096	0.118	0.171	0.059	0.043	

Table 6

Site	Total Exceedances	Dry Exceedances	Wet Exceedances
AC-1	38%	33%	50%
AC-2	27%	11%	63%
AC-3	27%	17%	67%
AC-4	73%	67%	88%
CP-7	42%	33%	63%
CP-11	100%	100%	100%
CP-18.1	42%	33%	63%

Table 7

Classification	Samples	Exceedances	Percent
Dry	126	54	43%
Wet	56	37	66%

Total Phosphorous (TP) results for routine sample days in the 2016/17 season can be seen in Table 5. Results in red text indicate an exceedance of the water quality objective of 0.03mg/L. Table 6 lists the sites and their exceedances by percent and Table 7 lists exceedances on wet vs. dry sampling days.

Elevated TP values were observed at all sites, indicating TP impairment throughout the watershed. Also, exceedances occurred throughout the sampling year, however the majority of exceedances occurred during the summer months. In addition, exceedances were strongly related to wet sample events with 66% of all samples collected during wet conditions exceeded the water quality objective. In comparison, 43% of all samples collected during dry conditions exceeded the objective.

Site CP-11 in Chedoke Creek stands out as a location experiencing high TP concentrations. Site CP-11 exceeded the target objective on every sample event. Site AC-4, which has far less flow than other locations, routinely exceeds the objective. AC-1 in Ancaster Creek, CP-7 in Spencer Creek and CP-18.1 in Borers Creek experienced similar total exceedances, with approximately 40% of samples exceeding the TP objective at each of these sampling sites. Sites AC-2 in Sulphur Creek and AC-3 in Ancaster Creek has the best water quality out of all locations. These sample locations happen to be located within a vegetated floodplain.

Figure 4 further illustrates the relationship between wet event sample days and higher concentrations of TP. Most locations experience concentrations near the water quality objective of 0.03 mg/L for dry sample days, however annual averages for wet events are well above the desired objective at nearly all locations. All locations are susceptible to high TP concentrations during wet events. In addition, although AC-2 has the lowest number of total exceedances (27%), the mean values for the sampling period were among the highest of all the sites. This indicates that this location is susceptible to high increases of TP during storm runoff events. Furthermore, site AC-4 exceeded the water quality objective for 73% of sample events, with a large amount of exceedances occurring on dry events, and with a similar average wet and dry event concentration. AC-4 has a relatively small drainage area compared to AC-2 and AC-3 that originates about 2.5 kilometers upstream of the sample location and the land use is mostly urban residential. Lastly, CP-18.1 had a relatively large mean concentration and average wet event concentration, due largely to two sampling dates with significant elevated values (January 18 and March 1), compared to other sampling dates.

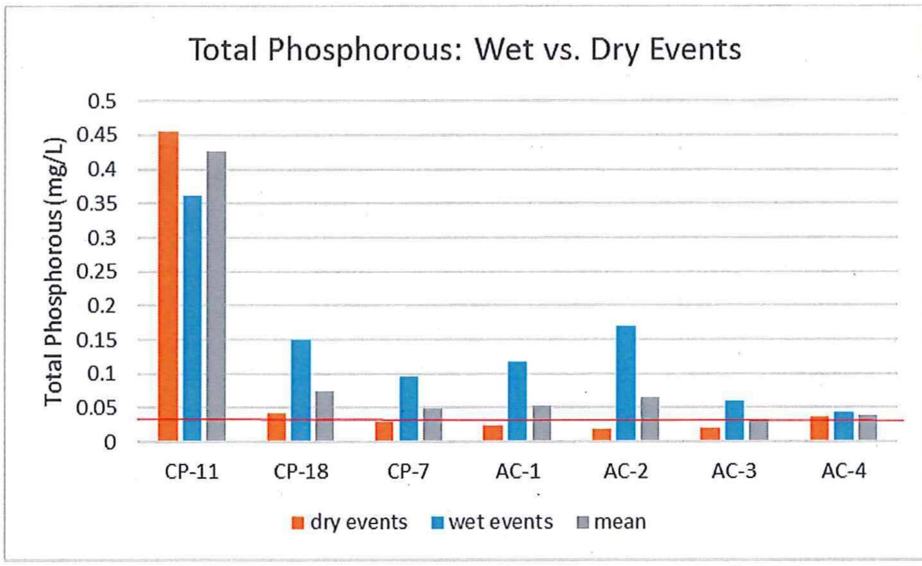

Figure 4: Total Phosphorous at each site wet vs. dry events.

Figure 5 shows the distribution of TP throughout the four seasons. In the first full year of sampling, it appears that winter experienced heavy TP contributions to the marsh, although this is at least partially the result of the number high proportion of wet events sampled during this season. Also, it should be noted that the samples taken on March 1, 2017 were remarkably high in TP, and corresponded with a significant storm event.

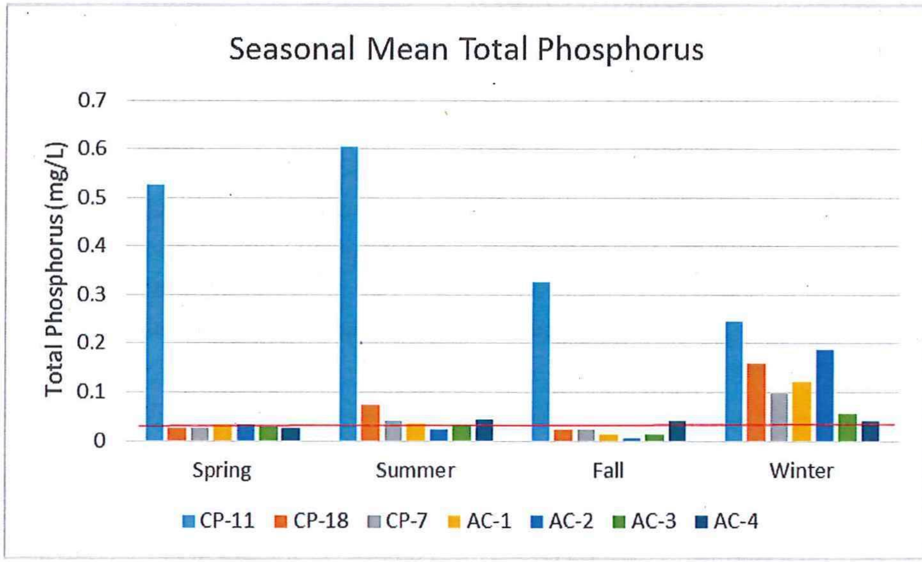

Figure 5: Total Phosphorous shown in seasonal averages

Total Suspended Solids

Total Suspended Solids (TSS) results for routine sample days in the 2016/17 season can be seen in Table 8. Results in red text indicate an exceedance of the objective of 25 mg/L. Table 9 lists the sites and their exceedances by percent.

Exceedances were relatively uncommon throughout the sample year, as 2016 was relatively dry throughout. It is of interest to note that 62% (15/24) of TSS exceedances occurred on wet sample days. The highest exceedances occurred during the March 1 wet sampling event in the spring, and corresponded with a significant storm event.

The Ancaster Creek locations AC-1 and AC-2 had some of the highest exceedances in 2016. These Ancaster Creek sites seem to be more susceptible to increased sediment loading during storm events.

Site CP-11 experiences exceedances at the same rate whether it was dry or wet conditions while sampling. All other sites had a very low exceedance rate during dry conditions. AC-3 in Ancaster Creek and CP-18.1 in Borers Creek experience similar exceedance rates in wet conditions, however it is low at 13%. Site AC-1 in Ancaster Creek experienced slightly higher exceedances during wet conditions than site CP-7 in Spencer Creek. Site AC-4 had no TSS exceedances during the annual sampling program.

Table 8: Results for Total Suspended Solids in mg/L

Date	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	10.4	7	10.6	40.2	59.8	16.8	14.2	DRY
28-Apr-16	9.4	<2	2.8	<2	2.8	4	2.6	DRY
11-May-16	47.2	<2	2.2	2.8	4.6	12	3	DRY
25-May-16	70	2.2	5.6	4.4	5.2	11.6	6.7	DRY
16-Jun-16	29.8	11.8	8.9	31	48	18	10	WET
22-Jun-16	18.8	6.2	9	10.8	14.2	22.6	10	DRY
6-Jul-16	57.5	16.8	10	11.8	8.8	12.2	13.4	DRY
19-Jul-16	33.2	7.2	11.4	8.4	5.6	6.6	4.8	DRY
4-Aug-16	104	59.8	11.3	4	4.2	10.6	9.7	DRY
17-Aug-16	3.8	3.6	20	9.6	9.8	7.4	15	WET
31-Aug-16	19.6	<2	12.4	3	7	6.1	2.4	DRY
14-Sep-16	38	<2	15.2	<2	2.2	7.4	4.2	DRY
28-Sep-16	3.4	<2	4.2	<2	4.6	<2	<2	DRY
12-Oct-16	4.4	<2	16	<2	<2	2.2	8.2	DRY
26-Oct-16	3.8	<2	1.8	<2	<2	<2	3.4	DRY
9-Nov-16	11.1	<2	2	<2	<2	<2	<2	DRY
24-Nov-16	17.8	<2	3.5	<2	<2	2.5	2	WET
7-Dec-16	8.9	2.2	2.8	<2	3	2.7	2	DRY
21-Dec-16	4.8	<2	<2	<2	<2	1.6	9.8	DRY
4-Jan-17	15.5	9.5	13.8	19.3	35.7	6.9	8.9	WET
18-Jan-17	11.6	20	35.6	34.5	76.4	23.2	18.8	WET
1-Feb-17	<4	<4	<4	5.5	21.5	8	<4	DRY
15-Feb-17	8	<2	5.7	8.1	19	6.7	8.8	DRY
1-Mar-17	52	359	214	703	1160	191	---	WET
15-Mar-17	<3	<3	3.6	7.4	35.6	8.8	6.4	WET
29-Mar-17	4.2	3.3	5.3	10.7	14.5	18	6	WET
Mean	23.49	20.98	16.45	35.17	59.32	15.65	6.81	

Dry Events (mean)	25.13	6.51	6.83	5.5	9.03	7.28	5.73	
Wet Events (mean)	19.24	58.17	38.09	101.93	172.5	34.48	9.59	

Table 9

Site	Total Exceedances	Dry Exceedances	Wet Exceedances
AC-1	15%	6%	38%
AC-2	23%	6%	63%
AC-3	4%	0%	13%
AC-4	0%	0%	0%
CP-7	8%	0%	25%
CP-11	27%	22%	25%
CP-18.1	8%	6%	13%

Figure 6 shows the relationship between wet event sample days and higher concentrations of TSS experienced at most locations. Most locations experience concentrations below the water quality objective of 25 mg/L for dry sample days, however annual averages for wet events are higher than the desired objective at nearly all locations. All locations are susceptible to high TSS concentrations during wet events.

Figure 7 shows the distribution of TP throughout the four seasons. In the first full year of sampling, it appears that winter experiences heavy TSS contributions to the marsh, or this could be due to the occurrence of four wet events in winter. It should be noted that the samples taken on March 1, 2017 were noticeably high in TSS, and corresponded with a significant storm event and sampling during intense rain.

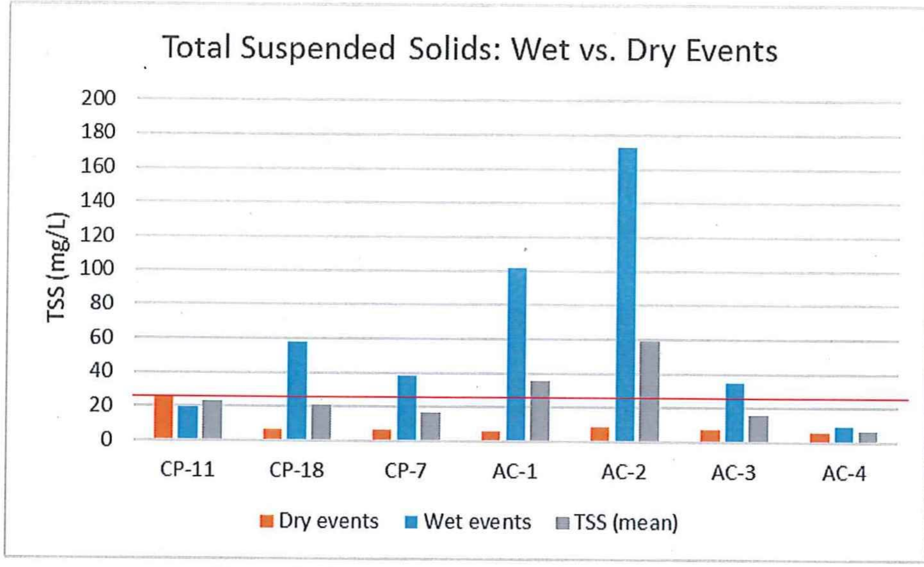

Figure 6: Total Suspended Solids at each site wet vs. dry events

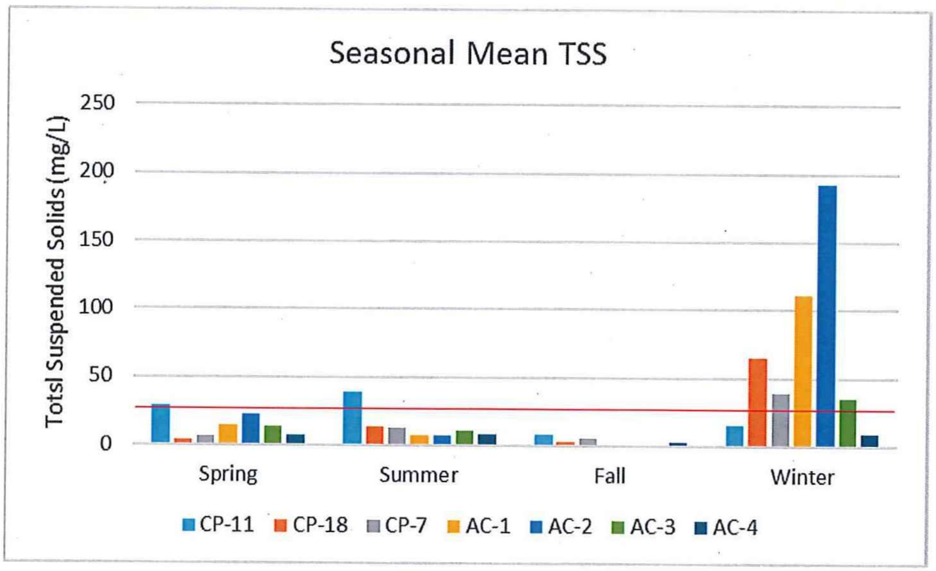

Figure 7: Total Suspended Solids in seasonal averages

Volatile Suspended Solids

Volatile Suspended Solids (VSS) results from routine sample days in the 2016/17 season can be seen in Table 10. VSS represents the organic portion of TSS, such as plant matter and animal waste. Volatile suspended solids do not have a target objective outlined for this report.

Table 10: Results for Volatile Suspended Solids in mg/L

Dates	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	6.2	1.6	1.8	3.2	4.2	2.2	1.6	DRY
28-Apr-16	6.6	<2	1.6	<2	0.8	4	<2	DRY
11-May-16	35.2	<2	1.6	1.8	1.6	2.8	1.6	DRY
25-May-16	45	0.8	1.8	1.1	1.4	1.6	1.8	DRY
16-Jun-16	22.2	3.2	2.2	4	5.7	2.8	2.7	WET
22-Jun-16	12	1.6	1.8	2	2	2.6	2.2	DRY
6-Jul-16	45.5	4.6	2.8	2.4	2	2.2	2.8	DRY
19-Jul-16	25.6	1.6	1.4	1.2	1.6	1.8	1	DRY
4-Aug-16	89.6	28.4	2.6	1.2	1.2	1.4	2	DRY
17-Aug-16	2.6	1.2	2.8	1.6	1.6	1.2	2.2	WET
31-Aug-16	10.6	<2	2.2	0.8	1.2	1.2	1.2	DRY
14-Sep-16	38	<2	2.8	<2	1	1.4	1.6	DRY
28-Sep-16	2.8	<2	1	<2	1	<2	<2	DRY
12-Oct-16	1.6	3.4	2.8	<2	<2	<2	1.2	DRY
26-Oct-16	1.8	1	1.4	<2	<2	<2	1.2	DRY
9-Nov-16	4.7	<2	0.9	<2	<2	<2	<2	DRY
24-Nov-16	4.8	<2	2.5	<2	<2	1.5	2	WET
7-Dec-16	3.3	1.6	1.1	<2	1.4	1.1	1.3	DRY
21-Dec-16	0.8	<2	<2	<2	<2	<2	1.2	DRY
4-Jan-17	5.9	2.5	4.2	2.3	3.4	1.4	2.3	WET
18-Jan-17	3.6	3.6	7.2	5	6.4	2.8	2	WET
1-Feb-17	<4	<4	<4	2.5	3.5	2.5	<4	DRY

15-Feb-17	3.5	<4	2.4	2.4	3.4	1.9	3.4	DRY
1-Mar-17	19	37	21	41	64	14	---	WET
15-Mar-17	<3	<3	1.3	1.3	2.5	1.3	1.6	WET
29-Mar-17	2.7	1.6	2.3	2	1.9	2.3	2.5	WET
Mean	17	6.58	3.1	4.61	5.5	2.59	1.85	
Dry Events (mean)	19.58	4.96	1.88	1.86	1.88	2.05	1.72	
Wet Events (mean)	8.68	8.18	5.44	8.17	12.21	3.41	2.19	

As seen in Figure 8, all locations except CP-11 consist of mostly fixed suspended solids, which are inorganic materials. Site CP-11 is made up of mostly volatile suspended solids, meaning that the majority of suspended material is organic. This is consistent with the high nutrient values we are seeing in site CP-11.

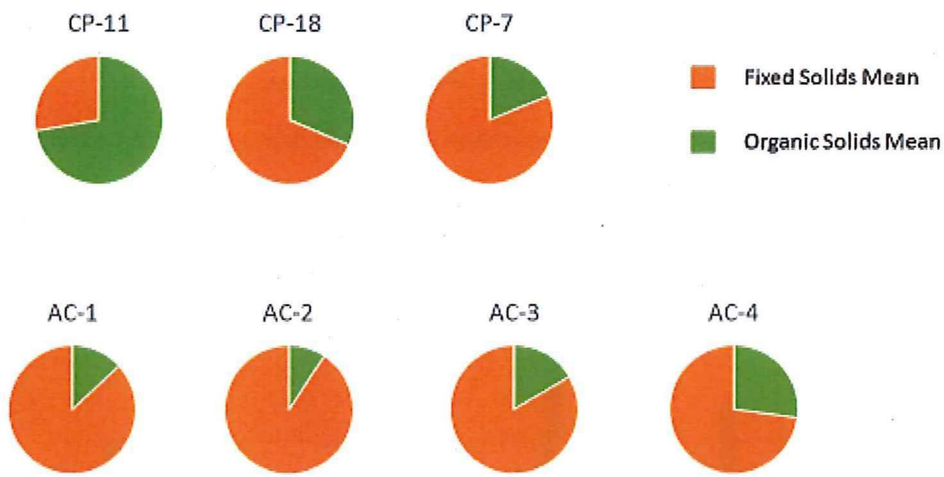

Figure 8: TSS breakdown at each sample site

Figure 9 shows the relationship between wet event sample days and higher concentrations of VSS experienced at most locations. All locations are susceptible to higher VSS concentrations during wet events except CP-11, which has higher VSS concentrations during dry events. Site CP-11 had higher concentrations during spring and summer seasons and there does not appear to be a strong correlation between wet sample days and higher concentrations of VSS at this site.

Figure 10 shows the distribution of VSS throughout the four seasons. In the first full year of sampling, it appears that winter experiences heavy VSS contributions to the marsh, this could be due to the fact that 4/7 sample days in winter were classified as wet events – a much higher ratio than other seasons. It should be noted that the samples taken on March 1, 2017 were much higher in VSS. and corresponded with a significant storm event.

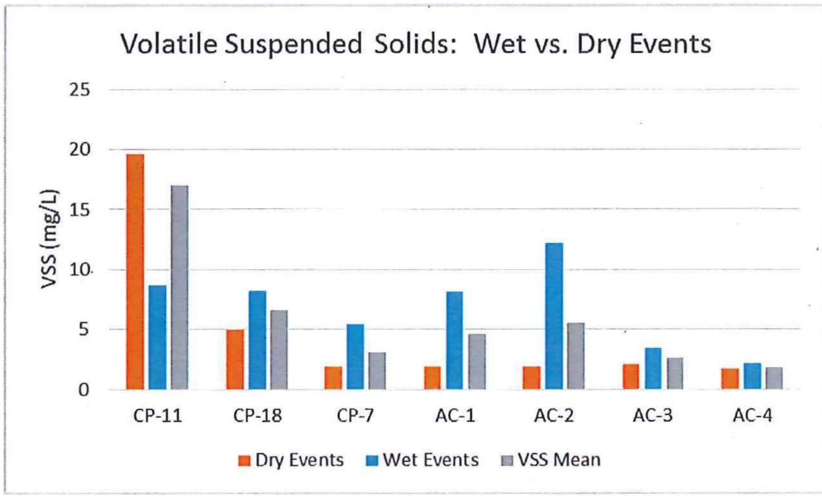

Figure 9: Volatile Suspended Solids at each site wet vs. dry events

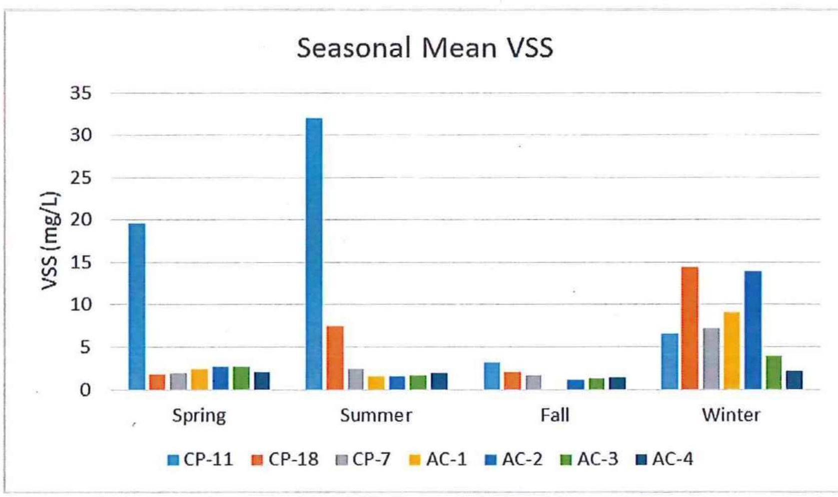

Figure 10: Volatile Suspended Solids seasonal averages

Unionized Ammonia

The results in Table 11 were found by using a formula to derive unionized ammonia using temperature, pH and total ammonia concentration. The only exceedances that occurred during the sample season were at CP-11. 8/24 (or 33%) of samples exceeded the objective of 0.02 mg/L at this location. All other locations are consistently below the objective. Based on the results consistently reporting below the target objective, unionized ammonia does not appear to be a contaminant of concern at most locations.

Table 11: Results for Unionized Ammonia in mg/L

Dates	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	0	0	0	0	0	0	0	DRY
28-Apr-16	0.0262	0.0010	0.0010	0.0002	0.0003	0.0000	0.0003	DRY
11-May-16	0	0	0	0	0	0	0	DRY
25-May-16	0.0022	0.0000	0.0011	0.0007	0.0004	0.0005	0.0004	DRY
16-Jun-16	0.0257	0.0010	0.0027	0.0022	0.0023	0.0016	0.0013	WET
22-Jun-16	0.0583	0.0003	0.0031	0.0034	0.0024	0.0020	0.0031	DRY
6-Jul-16	0.0117	0.0002	0.0017	0.0013	0.0006	0.0006	0.0010	DRY
19-Jul-16	0.0328	0.0001	0.0010	0.0008	0.0005	0.0004	0.0004	DRY
4-Aug-16	0.0072	0	0.0014	0.0008	0.0003	0.0005	0.0002	DRY
17-Aug-16	0.0489	0.0019	0.0030	0.0015	0.0018	0.0007	0.0015	WET
31-Aug-16	0.0203	0	0.0014	0.0006	0.0003	0.0003	0.0008	DRY
14-Sep-16	0.0240	0.0003	0.0022	0.0007	0	0	0.0005	DRY
28-Sep-16	0.0187	0	0.0013	0.0005	0	0	0.0002	DRY
12-Oct-16	0.0085	0.0001	0.0004	0.0001	0	0	0.0003	DRY
26-Oct-16	0.0026	0	0.0003	0	0	0	0	DRY
9-Nov-16	0.0126	0	0.0004	0	0	0	0	DRY
24-Nov-16	0.0124	0	0.0003	0.0001	0	0	0.0003	WET
7-Dec-16	0.0023	0	0.0004	0	0	0	0.0003	DRY
21-Dec-16	0.0006	0	0.0007	0.0001	0.0001	0	0.0006	DRY
4-Jan-17	0.0015	0.0002	0.0004	0.0003	0.0003	0.0000	0.0006	WET
18-Jan-17	0.0029	0.0003	0.0006	0.0003	0.0002	0.0001	0.0007	WET

1-Feb-17	0.0007	0.0000	0.0004	0.0002	0.0002	0.0000	0.0011	DRY
15-Feb-17	0.0006	0.0000	0.0000	0.0002	0.0001	0.0000	0.0010	DRY
1-Mar-17	0.0342	0.0007	0.0006	0.0005	0.0005	0.0005	---	WET
15-Mar-17	0.0005	0	0.000376	0.000244	0.000069	0.00016968	0.000658	WET
29-Mar-17	0.00219	0	0.000406	0.000184	0	0.000084	0.000292	WET
Mean	0.014	0.000243	0.000991	0.000592	0.000426	0.000295	0.000618	
Dry Events (mean)	0.0127	0.0001	0.0009	0.0005	0.0003	0.0002	0.0006	
Wet Events (mean)	0.016	0.0005	0.001	0.0007	0.0007	0.0004	0.0007	

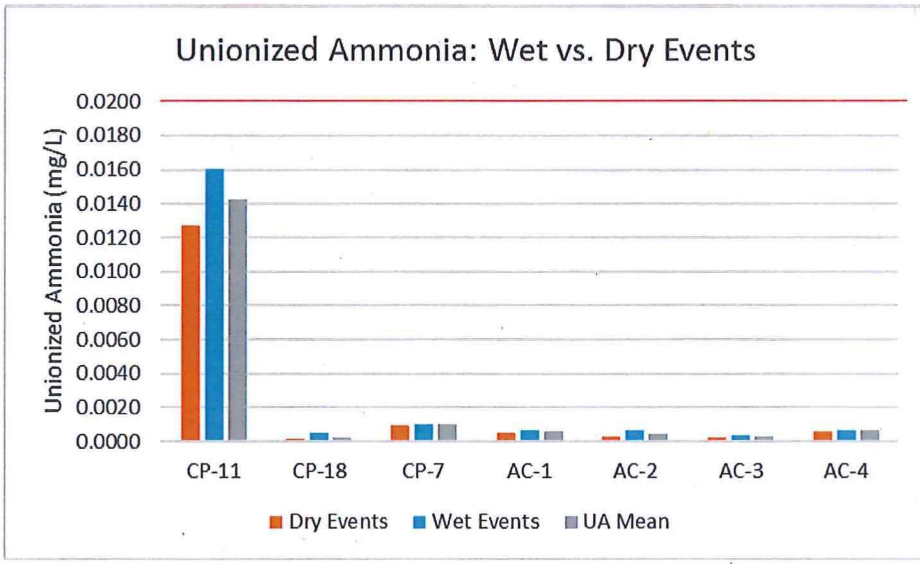

Figure 11: Unionized Ammonia at each site wet vs. dry events

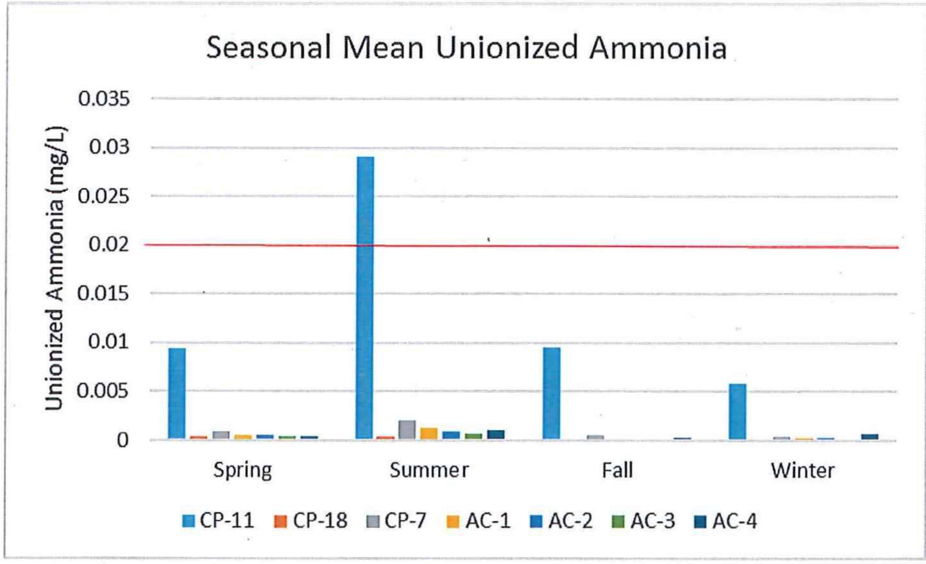

Figure 12: Unionized Ammonia seasonal averages

Total Ammonia

Table 12: Total ammonia concentrations

Dates	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4
12-Apr-16	2.33	0.03	0.02	<0.01	<0.01	<0.01	0.03
28-Apr-16	4.45	0.02	0.02	0.01	0.01	<0.01	0.01
11-May-16	0.02	<0.01	0.02	0.01	<0.01	0.01	0.02
25-May-16	0.02	<0.01	0.02	0.02	0.01	0.02	0.01
16-Jun-16	4.06	0.02	0.07	0.06	0.05	0.04	0.03
22-Jun-16	1.98	0.01	0.05	0.07	0.04	0.04	0.07
6-Jul-16	0.16	0.01	0.06	0.04	0.02	0.02	0.03
19-Jul-16	0.43	0.01	0.04	0.03	0.02	0.02	0.02
4-Aug-16	0.04	<0.01	0.06	0.03	0.01	0.02	0.01
17-Aug-16	3.20	0.02	0.04	0.02	0.02	0.01	0.02
31-Aug-16	0.75	<0.01	0.04	0.02	0.01	0.01	0.03
14-Sep-16	0.83	0.01	0.04	0.02	<0.01	<0.01	0.02

28-Sep-16	2.14	<0.01	0.04	0.02	<0.01	<0.01	0.01
12-Oct-16	0.81	0.01	0.03	0.01	<0.01	<0.01	0.04
26-Oct-16	0.50	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
9-Nov-16	2.48	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
24-Nov-16	1.21	<0.01	0.02	0.01	<0.01	<0.01	0.04
7-Dec-16	0.23	<0.01	0.02	<0.01	<0.01	<0.01	0.03
21-Dec-16	0.15	<0.01	0.05	0.02	0.01	<0.01	0.13
4-Jan-17	0.17	0.02	0.03	0.03	0.02	<0.01	0.06
18-Jan-17	0.47	0.03	0.06	0.04	0.04	0.01	0.07
1-Feb-17	0.12	<0.01	0.02	0.02	0.02	<0.01	0.11
15-Feb-17	0.24	<0.01	<0.01	0.02	0.01	<0.01	0.10
1-Mar-17	2.82	0.04	0.03	0.04	0.04	0.03	---
15-Mar-17	0.07	<0.01	0.02	0.02	0.01	0.02	0.08
29-Mar-17	0.37	<0.01	0.02	0.02	<0.01	0.01	0.03

Ortho-Phosphate

Table 13: ortho-phosphate concentrations

Dates	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
28-Apr-16	0.20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
11-May-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
25-May-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
16-Jun-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	WET
22-Jun-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
6-Jul-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY

19-Jul-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
4-Aug-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
17-Aug-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	WET
31-Aug-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
14-Sep-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
28-Sep-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
12-Oct-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
26-Oct-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
9-Nov-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
24-Nov-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	WET
7-Dec-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
21-Dec-16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
4-Jan-17	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	WET
18-Jan-17	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	WET
1-Feb-17	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
15-Feb-17	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	DRY
1-Mar-17	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	---	WET
15-Mar-17	0.10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
29-Mar-17	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET

Nitrate

Nitrate results for routine sample days can be seen in Table 14. Results in red text indicate an exceedance of the objective of 3 mg/L. There were only 4 exceedances during the sampling year, and they all fell upon wet days at various locations. All locations consistently reported under the target objective throughout all four seasons. Based on the lack of exceedances and test results routinely below the target objective, nitrate does not appear to be a parameter of concern at this point.

Table 14: Results for Nitrate in mg/L

Dates	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	2.68	0.82	0.91	0.58	0.57	0.57	0.75	DRY
28-Apr-16	1.37	0.25	0.5	0.41	0.31	0.56	0.24	DRY
11-May-16	1.46	0	0.51	0.36	0.25	0.47	0.16	DRY
25-May-16	0.59	0	0.38	0.41	0.28	0.63	0.14	DRY
16-Jun-16	0.8	0.14	0.57	0.6	0.49	4.03	0.42	WET
22-Jun-16	0.28	0.08	0.53	0.56	0.51	0.7	0.41	DRY
6-Jul-16	0.59	0	0.48	0.42	0.42	0.5	0.24	DRY
19-Jul-16	0.79	0.1	0.45	0.4	0.44	0.5	0.25	DRY
4-Aug-16	0.67	0	0.46	0.4	0.4	0.51	0.2	DRY
17-Aug-16	0.9	0.22	0.5	0.44	0.36	0.47	0.37	WET
31-Aug-16	1.67	0.1	0.72	0.48	0.43	0.57	0.61	DRY
14-Sep-16	1.41	0	0.67	0.41	0.38	0.62	0.43	DRY
28-Sep-16	1.66	0.16	0.63	0.52	0.44	0.71	0.36	DRY
12-Oct-16	2.49	0	0.71	0.45	0.36	0.72	0.26	DRY
26-Oct-16	2.37	0	0.5	0.27	0.18	0.59	0.32	DRY
9-Nov-16	2.01	0	0.39	0.26	0.18	0.39	0.23	DRY
24-Nov-16	1.61	0	0.4	0.46	0.42	0.41	0.65	WET
7-Dec-16	1.82	0.25	0.45	0.43	0.44	0.56	0.56	DRY
21-Dec-16	2.83	0.31	0.89	0.69	0.63	0.79	0.52	DRY
4-Jan-17	3.36	3.67	1.88	0.99	0.87	1.13	1.13	WET

18-Jan-17	2.84	1.3	1.12	0.75	0.76	0.77	1.02	WET
1-Feb-17	2.22	1.77	1.26	0.78	0.71	0.89	0.79	DRY
15-Feb-17	2.2	1.49	1.36	0.75	0.67	0.82	0.75	DRY
1-Mar-17	3.28	1.45	1.27	0.75	0.71	0.78	---	WET
15-Mar-17	2.47	1.16	1.15	0.79	0.65	0.95	0.85	WET
29-Mar-17	3.06	0.8	1.13	0.58	0.41	0.72	0.79	WET
Mean	1.77	0.53	0.75	0.53	0.47	0.79	0.47	
Dry Events (mean)	1.62	0.30	0.66	0.48	0.42	0.62	0.40	
Wet Events (mean)	2.29	1.09	1.00	0.67	0.58	1.16	0.75	

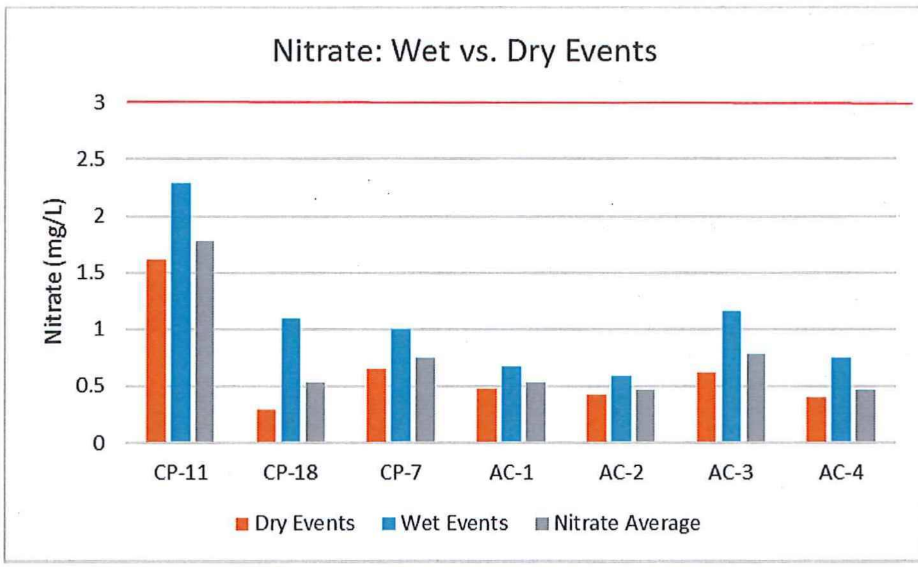

Figure 13: Nitrate at each site wet vs. dry events

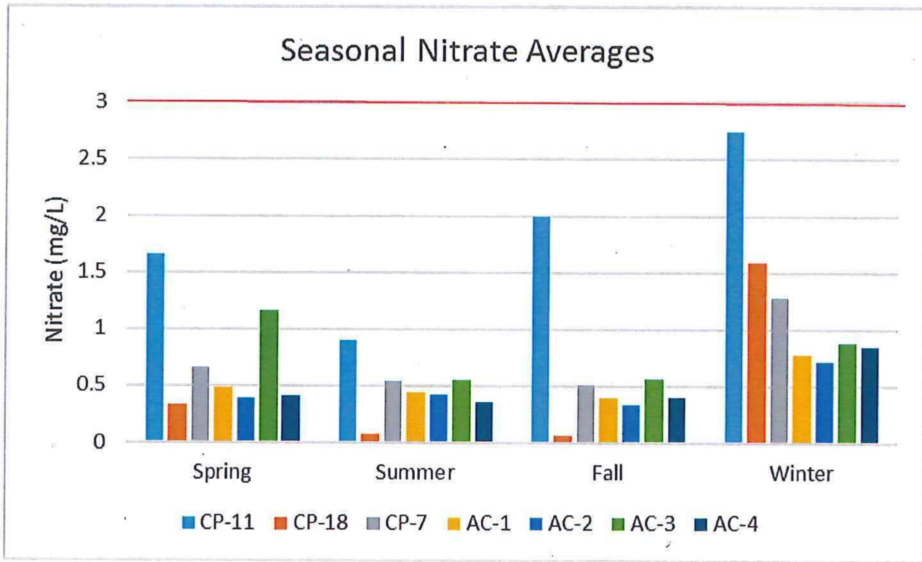

Figure 14: Nitrate Seasonal Averages

Nitrite

Table 15: Results for Nitrite in mg/L

Dates	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
28-Apr-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
11-May-16	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
25-May-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
16-Jun-16	0.28	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
22-Jun-16	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
6-Jul-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
19-Jul-16	0.17	<0.05	0.1	<0.05	<0.05	<0.05	<0.05	DRY
4-Aug-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
17-Aug-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
31-Aug-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
14-Sep-16	0.2	<0.05	<0.05	0.07	<0.05	0.12	0.39	DRY
28-Sep-16	0.06	<0.05	<0.05	0.1	0.09	0.23	<0.05	DRY
12-Oct-16	0.19	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY

26-Oct-16	<0.05	<0.05	<0.05	<0.05	<0.05	0.11	<0.05	WET
9-Nov-16	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
24-Nov-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
7-Dec-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
21-Dec-16	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
4-Jan-17	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
18-Jan-17	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
1-Feb-17	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
15-Feb-17	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY
1-Mar-17	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
15-Mar-17	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET
29-Mar-17	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	WET

Nitrite results for routine sample days can be seen in Table 15. Results in red text indicate an exceedance of the objective of 0.06 mg/L. There were fourteen exceedances during the sampling year, falling upon dry days mostly. Six of the fourteen exceedances were in CP-11. All locations routinely reported under the detection limits of equipment used at the Woodward Laboratory. Nitrite does not appear to be a parameter of concern at any location.

Escherichia coli

E.coli results from routine sample days can be seen in Table 16. Results in red text indicate an exceedance of the objective of 100 CFU/100mL. Exceedances were common throughout the sample year. Wet events experienced much higher concentrations at all locations. Site CP-11 once again stands out as the highest contributor of e.coli.

Table 16: results for e.coli in CFU/100mL

Dates	CP-11	CP-18.1	CP-7	AC-1	AC-2	AC-3	AC-4	
12-Apr-16	80000	70	10	100	40	160	370	DRY
28-Apr-16	162000	40	20	60	80	50	120	DRY
11-May-16	150	20	390	110	20	100	80	DRY

25-May-16	10	130	240	110	60	80	90	DRY
16-Jun-16	1350000	170	1800	3100	3300	2100	880	WET
22-Jun-16	12300	320	280	600	370	320	410	DRY
6-Jul-16	150	480	440	560	220	110	410	DRY
19-Jul-16	510	170	430	820	210	180	430	DRY
4-Aug-16	130	550	740	1300	790	140	110	DRY
17-Aug-16	34000	110	1200	790	710	520	430	WET
31-Aug-16	2200	120	260	420	440	90	560	DRY
14-Sep-16	3400	30	500	390	190	180	1400	DRY
28-Sep-16	39000	210	1270	890	680	350	660	DRY
12-Oct-16	600	<10	210	230	60	570	270	DRY
26-Oct-16	3500	70	580	140	240	180	50	DRY
9-Nov-16	640000	10	380	140	70	30	220	DRY
24-Nov-16	132000	20	330	240	390	80	100	WET
7-Dec-16	21600	60	50	90	30	120	60	DRY
21-Dec-16	1100	<10	1100	170	10	370	320	DRY
4-Jan-17	5100	1900	510	220	120	300	670	WET
18-Jan-17	13000	770	230	260	170	340	540	WET
1-Feb-17	600	<10	40	60	<10	60	1610	DRY
15-Feb-17	7000	<10	50	90	40	30	<10	DRY
1-Mar-17	480000	410	510	520	910	480	---	WET
15-Mar-17	80	<10	40	20	<10	40	120	WET
29-Mar-17	1500	<10	20	10	10	30	<10	WET
Mean	5324	56	252	244	131	160	222	
Dry Events (mean)	3227	34	228	227	85	141	189	
Wet Events (mean)	19748	246	276	207	289	218	344	

Figure 15 attempts to show the relationship between wet event sample days and e.coli concentrations. Most locations experience concentrations above the water quality objective of 100 CFU/100mL for dry and wet sample days. Sites CP-7 in Spencer Creek and AC-1 in Ancaster Creek don't seem to experience much of a difference in concentration between wet and dry events. Sites AC-2, AC-3, AC-4 and CP-18.1 all experience notably higher e.coli concentrations during wet events. Site CP-11 is not shown on figures 15 and 16 due to its much higher concentrations; however it experiences much higher concentrations during wet events. Figure 16 shows the distribution of e.coli throughout the four seasons. Summer appears to be when e.coli concentrations are at their highest at all locations.

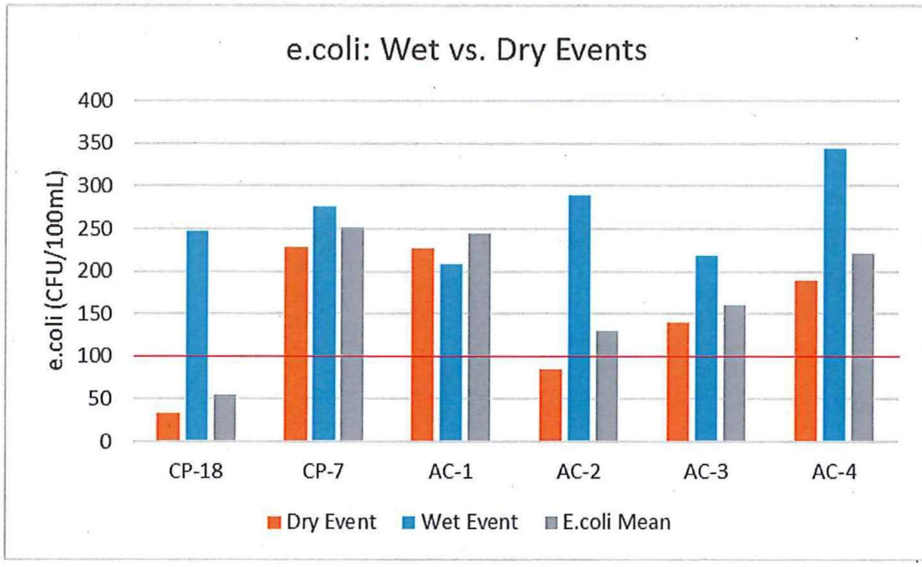

Figure 15: e.coli at each site wet vs. dry events

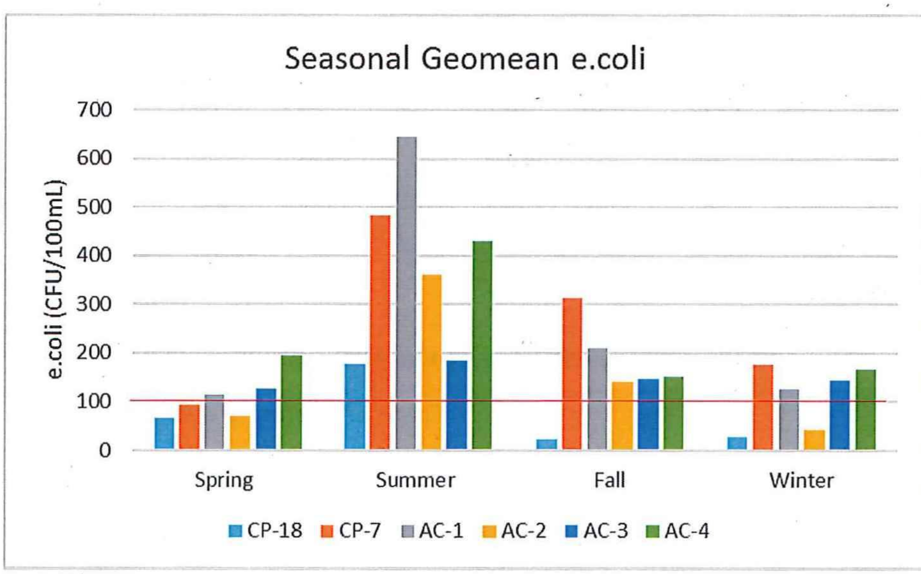

Figure 16: E.coli seasonal average (geomean)

Historical Trends at Locations with Long Term Data Records

Site CP-7 in Spencer Creek

Using a historical record of data obtained from the RBG for sites CP-7, CP-11 and CP-18.1 we are able to plot long-term data to see how TP, TSS and e.coli are trending. Site CP-7 in Spencer Creek is seeing a general downward trend in the three parameters. From 1989 – 2014 the sample season was May – September. In 2015 it was expanded to cover April – November and in 2016, year-round sampling began. The flux in sampling seasons will have an effect on the yearly averages; however it is still beneficial to compare the data in order to determine whether or not we are seeing an overall improvement towards water quality objectives. In the coming years of year-round data recording, we will be able to define with greater confidence which direction the trend is moving. Based on the data available to us today, Figure 17, Figure 18, and Figure 19 indicate that the trend for TP, TSS and e.coli are moving towards objectives.

Total Phosphorous

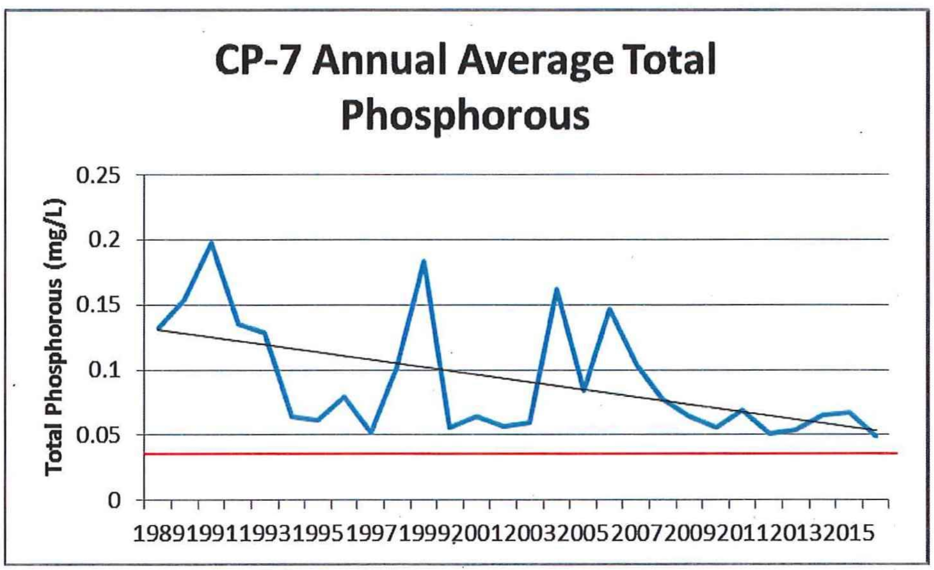

Figure 17: Historical averages for CP-7

Total Suspended Solids

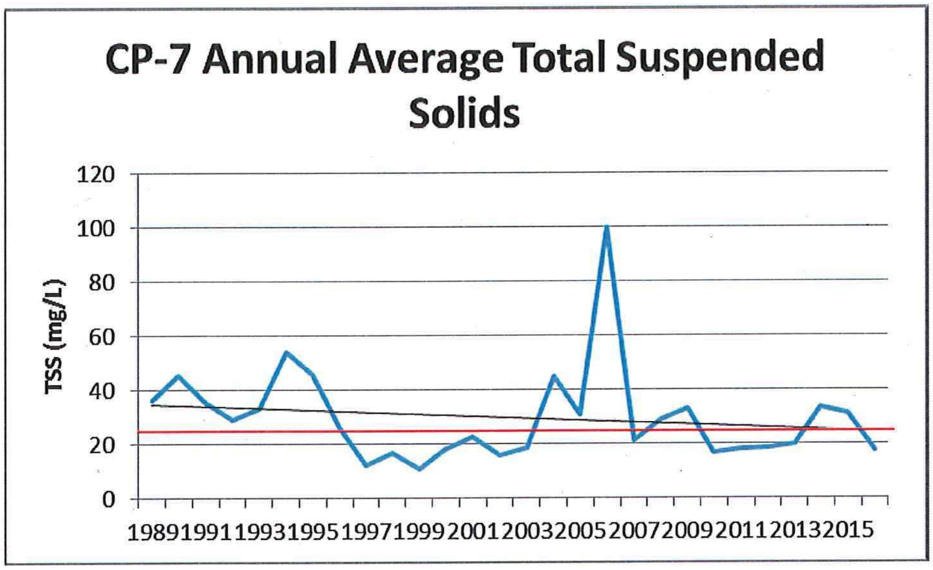

Figure 18: Historical average TSS for CP-7

Escherichia coli

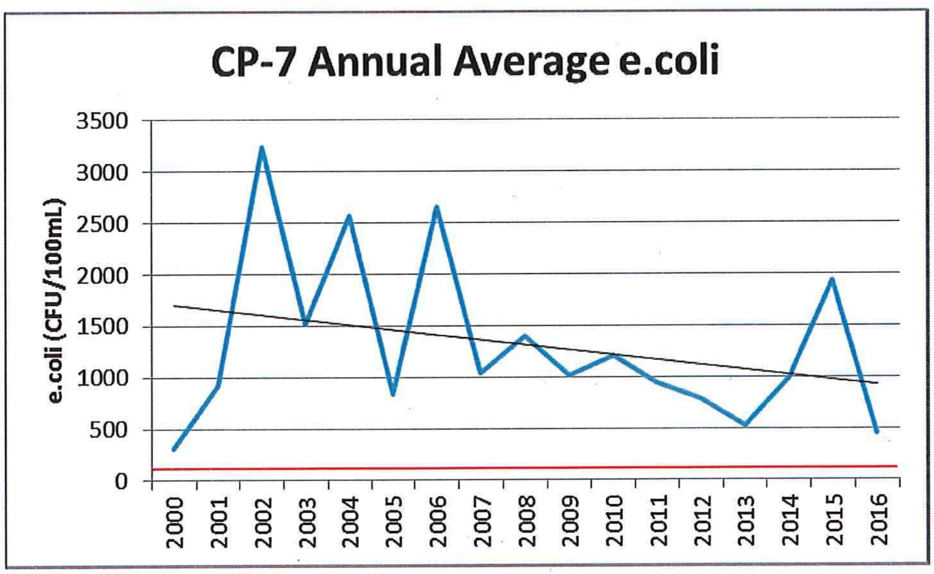

Figure 19: historical average e.coli for CP-7

Site CP-11 in Chedoke Creek

The historical record in site CP-11 in Chedoke Creek for TP and e.coli in Figure 20 and Figure 22 indicate that it is trending further away from the desired objectives. Concentrations of TP and e.coli appear to have risen in 2014, which coincides with the year HCA took over sampling duties for CP-11. Consultation with RBG field staff to confirm sample protocol symmetry will be completed in 2017 to ensure consistency throughout the years. TSS at CP-11 has been trending downwards since 1999, approaching the water quality target of 25 mg/L. TSS at this location are mostly composed of organic solids. The decrease of TSS at CP-11 will contribute to reducing unwanted organic matter entering Cootes Paradise Marsh from Chedoke Creek.

TOTAL PHOSPHOROUS

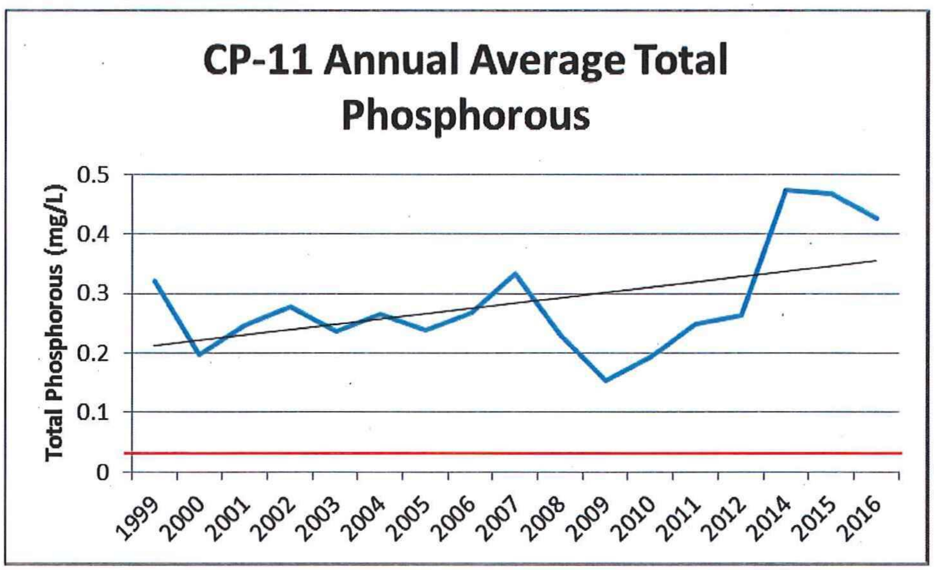

Figure 20: historical average TP for CP-11

TOTAL SUSPENDED SOLIDS

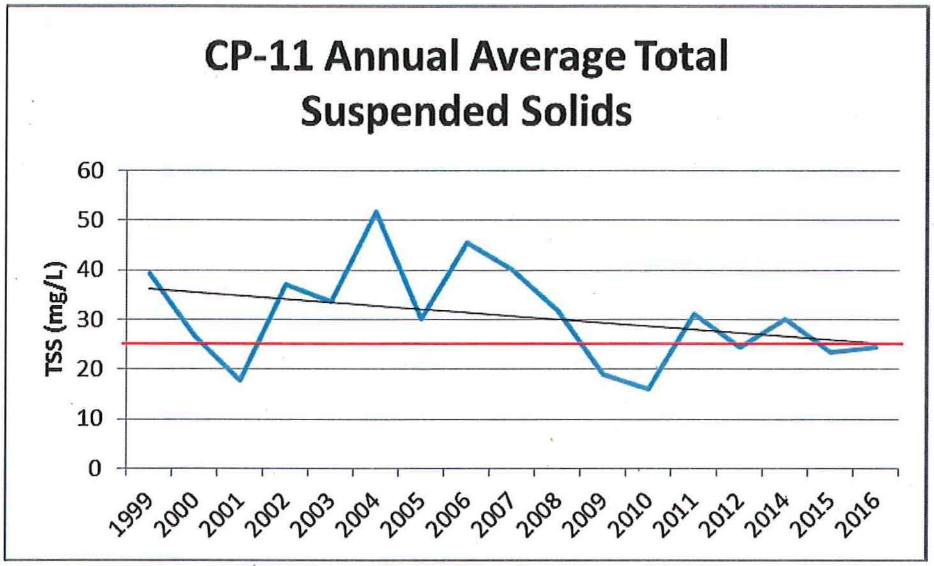

Figure 21: historical average TSS for CP-11

ESCHERICHIA COLI

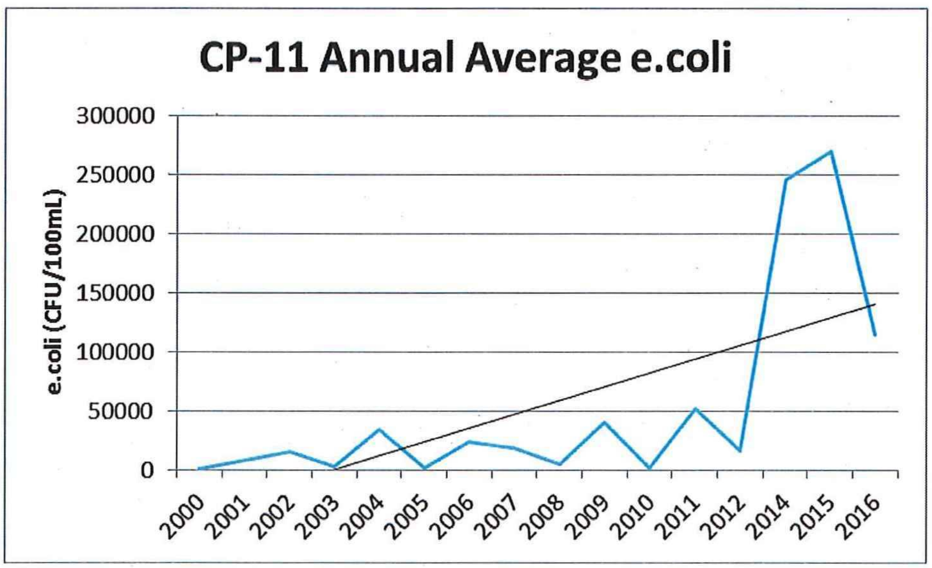

Figure 22: historical average e.coli for CP-11

Site CP-18.1 in Borers Creek

There is a general downward trend for TP, TSS and e.coli at site CP-18.1 in Borers Creek. TP and TSS have risen since sampling season expansion began in 2014, which reflects the higher winter/wet event concentrations discussed earlier in this report. Additional years of sampling through four seasons will give more accurate annual average concentration for TP, TSS and e.coli in Borers Creek.

TOTAL PHOSPHOROUS

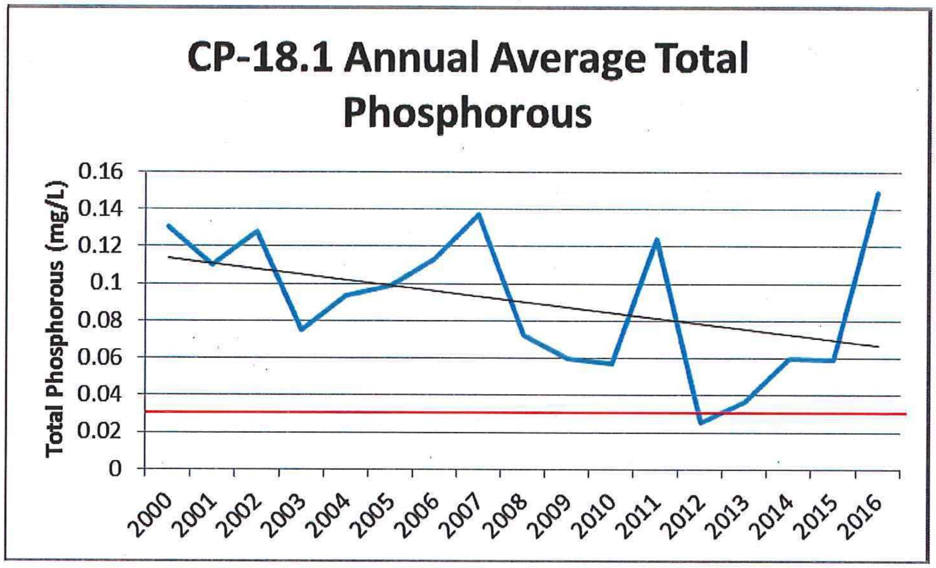

Figure 23: historical average TP in CP-18.1

Total Suspended Solids

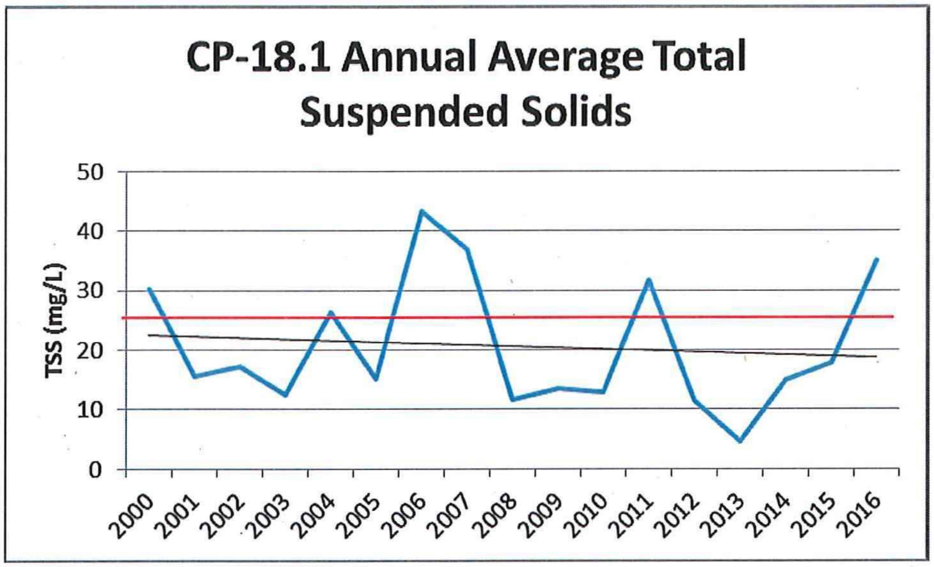

Figure 24: historical average TSS in CP-18.1

Escherichia coli

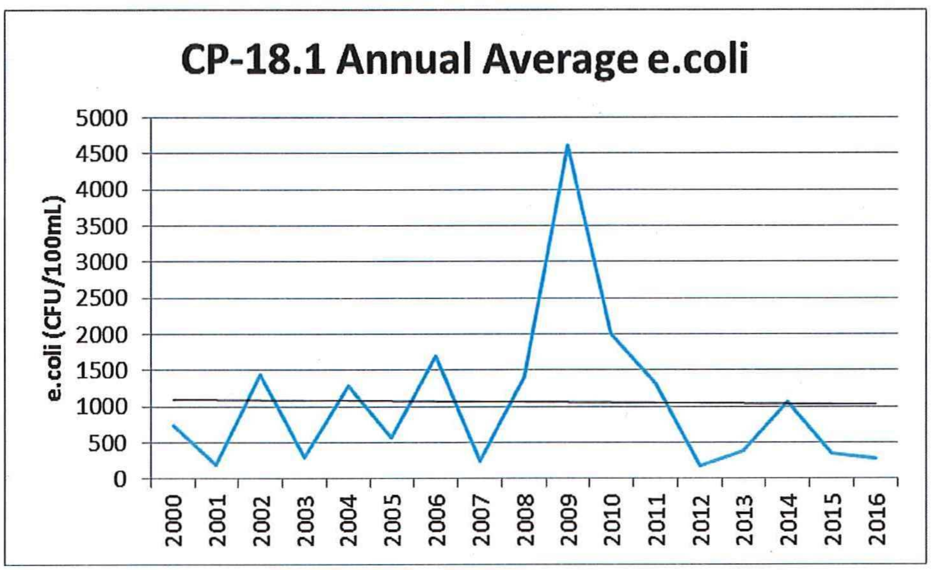

Figure 25: historical average e.coli for CP-18.1

Storm Sample Events

In addition to the routine grab samples detailed above, the sampling program also includes automatic sampling (using an ISCO sampler) of additional significant storm events to get an idea of the impairment to water quality during these events. In 2016, such storm events were sampled at site AC-1.

Most parameters saw a significant increase in average concentrations during the four storm events compared to the annual average; Nitrate is the only parameter to have decreased during storm events. Even when compared to the averages for wet sample days, storm sample events show much higher concentrations in all but Nitrate.

Table 17: Storm event concentrations

Parameter	8/17/16	8/25/16	9/10/16	11/03/16	Storm Event Average	Annual Average (All Samples)	Annual Average (Wet Events)
Escherichia coli CFU/100mL	9200	12900	---	1980	6170.89	244.20	207.95
Nitrate as N mg/L	0.53	0.53	0.55	0.37	0.495	0.534	0.67
Phosphorus Total mg/L	0.276	0.573	0.24	0.136	0.306	0.053	0.118
Total Suspended Solids mg/L	212	506	228	114	265	35.17	101.94
Volatile Suspended Solids mg/L	20.9	51.3	22	9.6	25.95	4.61	8.17

Discussion Summary

Data collected for this report in the 2016/2017 year-round sampling program has provided more insight into the overall water quality contributions entering Cootes Paradise. Expanding the sampling season to year-round has shown that sediment, e.coli and nutrient loading during winter and wet events is possibly quite elevated compared to other seasons and dry events.

Site CP-11 in Chedoke Creek is still the most impaired site. Interestingly, wet events at CP-11 seemed to have a dilution effect to TP, TSS and VSS. Background concentrations during normal, dry conditions are above target objectives for all parameters except for Nitrogen compounds.

All sample locations had an overall mean TP concentration higher than the target of 0.03mg/L. Apart from CP-11, all sample locations experienced higher TP during wet events. This correlates with higher TSS concentrations at these locations during wet events. Sites AC-1 and AC-2 in Ancaster and Sulphur Creek have substantially higher concentrations of TSS than the other locations. AC-1 and AC-2 experience a lot of sediment displacement during wet events. During dry conditions, the AC sites are in generally good water quality in terms of nutrients, sediment and bacteria.

Site CP-7 in Spencer Creek has fairly good water quality during dry conditions with all parameters except e.coli reporting below target objectives. This site shows significant impairment to TP and TSS during wet events. E.coli is above the target objective, yet is not high enough to be concerned with sewage contamination at this location.

Site CP-18.1 in Borers Creek was similar to CP-7 in terms of seeing the same exceedances during wet and dry events. Under dry conditions, this location is regularly reports under target objectives for all parameters sampled.

Unionized ammonia, nitrate, nitrite and ortho-phosphate were all found to have a low impact on water quality at all sample locations. Site CP-11 did experience a 33% exceedance rate for unionized ammonia, however mean concentrations for wet and dry events are below the target objective of 0.02 mg/L.

Site CP-11 in Chedoke Creek is by far the most impacted of the sample locations. The downstream proximity to a combined sewer overflow location, which discharges raw sewage into the creek during some high flow events, as well as the concrete and culverted nature of the creek are likely reasons that this location is experiencing poor water quality. E.coli, total phosphorous, unionized ammonia and nitrite were much higher at CP-11 than at all other locations.

Total phosphorous at the AC locations in the Ancaster Creek watershed have been at or just below the target objective of 0.03 mg/L during dry events since sampling began in 2014. Site AC-4 experiences some higher concentrations, however the discharge compared to all other locations is much smaller. These locations have shown to be more susceptible to high TP and TSS concentrations during wet events since sampling began.

Site AC-1 has a higher average TP and TSS concentrations than CP-7 for dry and wet event days, and is about 500 meters upstream. This may imply that the TP concentration coming from Ancaster Creek is being diluted once it merges with Spencer Creek. Data from 2014 & 2015 supports this finding as well.

Some wet events had a greater impact on water quality than others, and storm events had an even greater impact than most wet events. This seems to indicate that storm intensity can greatly affect the amount of sediments and nutrients being transported downstream. The sample event on March 1, 2017 took place during heavy rain and results seem to indicate that water quality is most affected during the higher intensity periods of a storm.

Historical data depicted in Figures 17 – 25 seem to indicate we are headed in the right direction to obtaining our target objectives at CP-7 and CP-18.1. More year-round sampling and delineation between wet and dry sample events will give a better idea as to where and when the water quality os most affected.

An important change in sampling protocol made in 2016 was to expand the sampling season from April – November (as it was in 2015) to year-round sampling, covering from April 2016 – March 2017. This allowed for a full year spectrum of water quality data to be obtained for the first time, as well as have a look at how winter conditions can affect the marsh. Winter sampling ended up resulting in more wet sample days, which came along with elevated concentrations of all water quality parameters tested (except CP-11 as mentioned earlier).

2016 was a drought year with very little rainfall during spring, summer and fall. This made capturing storm events difficult. The automated sampler at AC-1 only captured four storm event samples successfully. Problems with suction in the early stages of the sample season negated some sampling attempts. The four storm event samples collected at this location indicate that Total Phosphorous, Total Suspended Solids and e.coli concentrations are much higher during storm events. More data is essential to be able to analyze the magnitude in which Ancaster Creek is being impaired and the amount of sediments and nutrients that are being displaced during storm events.

Changes in sampling period over the past 3 years could account for some of the changes we are seeing in water quality. It is clear that wet sample days are higher in concentration at most locations (CP-11 aside), and samples taken during wet events has steadily gone up over the years (one in 2014, five in 2015 and eight in 2016/17). It is important to distinguish between wet and dry sample events, as wet conditions impairs water quality to a much higher degree than dry conditions. More year-round data and comparison of wet vs. wet and dry vs. dry events over the years will give a better idea as to how the overall water quality is doing, and which way it is actually trending.

Table 18 depicts the average concentrations for dry, wet and annual average concentration for TP, TSS, Nitrate and e.coli at all locations. This is comparing data on defined wet and dry events is an important comparison, giving better insight to the overall water quality and impacts of wet conditions to different locations.

Table 18: Dry, wet, and annual average concentrations at all locations

Parameter	Dry or Wet Event	Average Concentration						
		CP-11	CP-18	CP-7	AC-1	AC-2	AC-3	AC-4
TP (mg/L)	Dry (18 events)	0.455	0.041	0.028	0.024	0.018	0.021	0.036
	Wet (8 events)	0.361	0.15	0.096	0.118	0.171	0.059	0.043
	Total (26 Events)	0.426	0.075	0.049	0.053	0.065	0.032	0.038
TSS (mg/L)	Dry (18 events)	25.14	6.51	6.83	5.5	9.03	7.28	5.73
	Wet (8 events)	19.24	58.17	38.09	101.94	172.5	34.48	9.59
	Total (26 Events)	23.49	20.98	16.45	35.17	59.33	15.65	6.81
Nitrate (mg/L)	Dry (18 events)	1.62	0.296	0.656	0.477	0.422	0.617	0.401
	Wet (8 events)	2.29	1.09	1.00	0.670	0.584	1.16	0.747
	Total (26 Events)	1.77	0.531	0.748	0.534	0.467	0.786	0.470

E Coli (CFU / 100mL)	Dry (18 events)	3226.73	33.64	228.34	227.46	85.33	140.54	188.78
	Wet (8 events)	19748.78	246.50	276.45	207.95	289.31	218.17	343.51
	Total (26 Events)	5324.47	55.55	251.70	244.20	130.59	160.43	221.68

Future Planned Monitoring Activities

For the 2017/2018 sample season, year-round monitoring is to continue as well as storm event sampling. Two new storm event sampling station have been installed for 2017/18 on Spencer Creek. ISCO automated samplers have been set-up on Spencer Creek at Highway 5 in Greensville and further downstream on Market Street in Dundas. These locations will operate in the same way that the AC-1 sample location operated in 2015, with the added benefit of being located close to Water Survey of Canada hydrological monitoring stations. The samplers being located in proximity to these gauging stations will make it easier to prepare flow-weighted composite samples using the data obtained from the loggers within the gauge. The HCA will attempt to capture ten storm events this upcoming sample season at each of the three storm sampling locations. The data obtained from these storm events will provide insight to the storm event contributions coming from Spencer Creek in different land use areas. Spencer Creek at Highway 5 is mostly agricultural land use, whereas Spencer Creek at Market Street is residential. Further to these locations, the HCA expects to install a fourth storm event sampling location further upstream on Ancaster Creek at Rosseaux Street. This location is upstream of the floodplain/valley lands in which AC-2, AC-3 and AC-4 are located. This will provide valuable insight as to the water quality conditions before Ancaster Creek flows down the escarpment and into the forested floodplain. The area is mostly residential land use, with some agricultural in the head waters as well as a golf course. It will be interesting to see if the water quality is improved or impaired by the floodplain and the erosion that happens therein.

Further breakdown of analysis on wet and dry days is to be completed for the 2017/2018 report. Categorizing historical data into wet and dry days, then comparing those days to one another over the years will give a better idea of water quality during different conditions. Data suggests that water quality on dry days and wet days is quite different, therefore it would be beneficial to separate the two event classification for better comparison and understanding of historical trends. In addition to this, wet event and storm event intensity will be defined to better understand how higher intensity events affect water quality impairment. A 5 mm rainfall event vs. a 50 mm rainfall event may have very different outcomes on water quality, and understanding how rainfall intensity/duration may affect different watercourses will give better insight as to when and how sediments and nutrients are being transported through the creeks and tributaries into Cootes Paradise Marsh.