

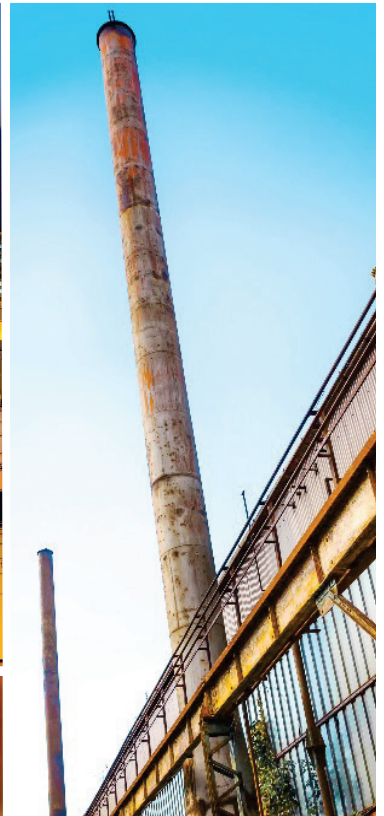


2020 City-Wide Stormwater Management Monitoring Program

Integrated Stormwater Management
Master Plan

Section A – Core Stormwater Management
Monitoring Program

City of Kitchener





Executive Summary

To provide the City of Kitchener (the City) with an approach and framework for future Stormwater Management (SWM) implementation, the Kitchener Stormwater Management Policy Development Study was completed in 2001 and a Stormwater Management Master Plan was developed. The intent of the master plan was to guide the location, design, and implementation of future SWM measures. As a result of the study, the Kitchener Stormwater Management Policy (#I-1135) was developed. This study also resulted in a report detailing the existing SWM infrastructure including SWM ponds (wet ponds, dry ponds, and wetlands), Oil-Grit Separators (OGS) and streams. The program assisted the City in outlining new policies to manage, monitor and improve SWM within the City.

As a result of the SWM policy, a city-wide monitoring program was developed and initiated by AECOM in 2002 in order to assess the implementation of the SWM policy. The primary focus of the original monitoring program was to establish baseline datasets and determine the impact of the SWM policy on the water quality of the City's watersheds and streams. Monitoring included surface water quality, benthic invertebrate, and fish community sampling (biological), as well as continuous temperature and flow monitoring.

The overall health of watersheds in Kitchener were recently evaluated in the *Integrated Stormwater Management Master Plan Municipal Class Environmental Assessment* (EA) completed by Aquafor Beech in 2016. This document replaced the 2001 SWM Policy (#I-1135) in 2016, as over time, the policy no longer aligned with changing industry practices and changes in federal, provincial, regional, and local policies. The purpose of the Integrated Stormwater Management Master Plan (ISWM-MP) is to address existing urban areas of the City and "*recommend remedial measures to improve overall environmental performance, increase efficiencies and reduce costs*" (Aquafor Beech, 2016). A few of the environmental issues identified in the ISWM-MP specific to surface water include the following:

- Degradation of surface water quality
- Increased sediment loads to surface water
- Thermal enrichment of surface water
- Loss and depredation of fish and wildlife habitat
- Increased erosion.

In the ISWM-MP, watersheds within the City were evaluated and prioritized with Priority 1 watersheds identified as having the greatest need of environment improvement while Priority 4 watersheds were identified as closest to natural conditions and therefore had the lowest need for environmental improvement.

Under the original 2001 SWM Policy and continued under the 2016 ISWM-MP, an annual stormwater monitoring program was mandated to monitor the performance of SWM works within the City, including annual summary reports. The SWM Monitoring Program has been an assessment tool to ensure that the best management practices (BMPs) for monitoring are used within the City.



The program is governed by a Steering Committee comprised of the selected Consultant, City staff, Grand River Conservation Authority (GRCA) staff and Region of Waterloo staff.

The GRCA has conducted pre-, during-, and post-development environmental monitoring in Blair Creek on behalf of the City since 2006, under a framework established by the *Upper Blair Creek Functional Drainage Study* (Stantec, 2009). The headwaters of Blair Creek are the most untouched watercourse with available data, and as a result, the Blair Creek monitoring results act as a reference station for the other monitoring efforts as part of the City's SWM Monitoring Program. Monitoring components include surface water quality (chemistry and temperature) and flows, fish, and benthic invertebrate communities, as well as groundwater quality and levels.

The 2020 SWM Monitoring Program included: grab sampling and auto-sampling for chemical analysis, benthic invertebrate and fish community surveys continuous depth and temperature monitoring, and flow monitoring. The use of Event Mean Concentration (EMC) monitoring in order to assess pollutant mass loadings into receiving watercourses for six select monitoring stations was conducted in 2020.

The 2020 SWM Monitoring Program also included the monitoring of stormwater management facility (SWMF) 6 located at Manchester Road as per Environmental Compliance Approval (ECA) number 3382-A8WQUM. This monitoring includes the collection of wet-weather samples and an inspection of the SWMF.

Physical Monitoring

Blair Creek

In 2020, thermal stability graphs were created by GHD for two stations based on the monitoring data collected by the GRCA. Based on the 2020 data, these stations are observed to be classified in the cold-coolwater to coolwater thermal regime. These results are similar to 2018 where Reichert Drive (Station 2414044) was classified as coolwater and New Dundee Road (Station 2414002) as cold-coolwater to coolwater.

In 2020, streamflow was monitored by GRCA at various permanent gauge stations. Only continuous data for New Dundee Road (Station 2414002) was provided by GRCA to be included in this report as part of the SWM Monitoring Program.

Core Stations - Temperature Monitoring

Stream temperature classification for the 2020 results has been broken down into biological temperature monitoring and physical temperature monitoring. For biological purposes, temperature categories are listed as warmwater, coolwater, and coldwater. Thermal stability graphs were created for stations where physical continuous temperature monitoring occurred during the 2020 monitoring period. At these three stations (SC1, SC9 and SB2) three additional thermal categories have been included: coolwater to cool-warmwater, cold-coolwater and cool-warmwater.

As a result, Lower Schneider Creek (SC1) was classified as coolwater to cool-warmwater, which in 2017 had been classified as coolwater. Upper Schneider Creek (SC9) was classified as cool-warmwater, which remains consistent with its classification in 2017. School Creek (SCH1), Voisin Creek (VS1), and Sandrock Greenway (SR2) were all classified as coolwater. Strasburg Creek (SB2) was classified as cold-coolwater, which is a slight change from 2019 when it was classified as



coldwater to cold-coolwater. Water temperature and thermal enrichment of the City's creek systems were identified as key environmental issues in the 2016 ISWM-MP and will continue to form a component of the City's annual SWM Monitoring Program into the future.

Core Stations - Flow Monitoring

Discrete flow measurements and flow depths were recorded at the flow-proportionate automated sampling locations (SC1, SC9, VS1, SR2, SB2, and SCH1) on a minimum of five separate occasions. The continuous level data collected at the automated sampling locations was converted to flow rates using a rating curve, which relates flow to depth. Continuous flow monitoring data was normalized using barometric pressure. The flow data at almost all sites indicate a short response time (i.e., within 24-hours) for observed peak flows in response to precipitation events while Strasburg Creek (SB2) showed less "peakiness" in response to precipitation events.

During the 2020 monitoring season, additional discrete flow measurements were conducted at Borden Creek (BD1), Middle Schneider Creek (MS1), and Melitzer Creek (MZ1) to allow for the creation of rating curves in advance of the 2021 automated sampler installation.

Water Quality Monitoring

Blair Creek

In 2020, grab samples were collected by GRCA at multiple stations along Blair Creek but for the purposes of the 2020 SWM Monitoring Program, only data from Dickie Settlement Road (Station 2414001), New Dundee Road (Station 2414002), and Reichert Drive (Station 2414044) were provided. The GRCA also operated ISCO automated samplers on Blair Creek in 2020 located at Reichert Drive (Station 2414044) and New Dundee Road (Station 2414002). In 2020, GRCA conducted eleven grab sampling events starting in March 2002; however, due to COVID-19, the remaining sampling events did not occur until September and concluded in December 2020. Event Mean Concentration samples collected using the automated samplers were collected during two events in November 2020.

Blair Creek did not have any chloride or nitrate exceedances of the CCME limits in 2020. Blair Creek at New Dundee Road (2414002) continued to exceed the PWQO limit for total phosphorous with the annual average value exceeding the guideline concentration. The maximum total phosphorus concentrations at the Dickie Settlement Road (2414001) and Reichert Drive (2414044) stations exceeded the PWQO but the average remained below the guideline. There were no metal exceedances observed at any of the Blair Creek locations in 2020.

Historically, chloride levels from the Dickie Settlement Road (2414001) and Reichert Drive (2414044) stations ranged from approximately 30 mg/L to 60 mg/L and over the past decade have remained consistent within this range. However, the 2019 and 2020 data appear to be on the higher end of this range at both stations and could be indicative of an overall increase in chloride levels in Blair Creek. At New Dundee Road (2414002), the 2019 and 2020 data fall within the 50 mg/L to 85 mg/L range. TSS levels have historically been greater during wet-weather events but overall have remained consistently below 15 mg/L at New Dundee Road. At Dickie Settlement Road, greater variation in wet-weather TSS levels was observed over the past decade, ranging from approximately 5 mg/L to 55 mg/L.



Compared to other creeks with long-term datasets, Blair Creek has the lowest historical chloride and TSS concentrations, which is to be expected as the stations monitored are located at the headwaters of the Blair Creek system where land is predominantly agricultural and urban development is low.



Table ES-1 Summary of 2020 SWM Water Quality Monitoring Results

Location	Chloride Limit: 120 mg/L (Long-Term)			TSS Limit: N/A			Total Phosphorus Limit: 0.03 mg/L			Nitrate (as N) Limit: 13 mg/L			Lead Limit: 0.005 mg/L			Copper Limit: 0.005 mg/L			Zinc Limit: 0.02 mg/L		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Blair Creek at New Dundee Road (Station 2414002)	73	86	39	5.3	32.0	ND	0.052	0.142	0.013	0.193	0.832	ND	0.001	0.001	0.001	0.001	0.002	ND	0.005	0.007	0.004
Blair Creek at Reichert Drive (Station 2414044)	68	79	45	4.3	9.4	ND	0.027	0.039	0.011	0.443	1.220	0.142	ND	ND	ND	0.002	0.003	0.001	0.005	0.005	0.004
Blair Creek at Dickie Settlement (Station 2414001)	55	60	34	8.1	43.2	1.0	0.013	0.064	0.000	2.770	3.750	1.320	NM	NM	NM	NM	NM	NM	NM	NM	NM
Sandrock Greenway (SR2)	254	571	84	33.8	104	ND	0.115	0.270	0.022	0.575	1.330	0.357	0.0011	0.0028	0.0001	0.009	0.018	0.002	0.025	0.078	0.004
Voisin Creek (VS1)	211	654	35	89.0	292	ND	0.229	0.776	0.088	0.324	0.516	0.036	0.0049	0.0151	0.0003	0.015	0.041	0.003	0.055	0.169	0.007
Upper Schneider Creek (SC9)	167	407	67	110.6	267	ND	0.154	0.367	0.019	0.443	1.240	0.123	0.0051	0.0149	0.0001	0.009	0.018	0.001	0.040	0.085	0.005
North Strasburg Creek (SB13a)	454	551	388	13.8	24.3	ND	0.044	0.092	0.016	0.533	0.540	0.520	0.0002	0.0003	0.0001	0.001	0.002	0.001	0.034	0.092	0.005
Strasburg Creek (SB2)	112	145	89	228	875	ND	0.222	0.951	0.005	0.920	1.600	0.483	0.0040	0.0183	0.0000	0.008	0.026	ND	0.045	0.147	ND
School Creek (SCH1)	153	307	43	49.0	94.2	8.0	0.134	0.341	0.021	0.867	1.810	0.026	0.0015	0.0068	0.0002	0.008	0.012	0.001	0.034	0.086	0.007
Lower Schneider Creek (SC1)	196	316	78	63.7	215	ND	0.103	0.253	0.010	0.755	1.170	0.360	0.0033	0.0101	0.0001	0.007	0.015	0.001	0.030	0.068	ND

Notes:

NM – Not Measured

ND – Non-Detect (value of zero assigned)

1. Red highlighted cells indicate the minimum concentration exceeds the CCME/PWQO guideline
2. Orange highlighted cells indicate the average concentration exceeds the CCME/PWQO guideline
3. Yellow cells indicate the maximum concentration exceeds the CCME/PWQO guideline



Core Stations

Water quality samples were collected by grab sample methodology at the 2020 SWM Monitoring Program stations. Three dry samples were collected at core stations, including Voisin Creek (VS1), Strasburg Creek (SB2), North Strasburg Creek (SB13a), Sandrock Greenway (SR2), School Creek (SCH1), Upper Schneider Creek (SC9), and Lower Schneider Creek (SC1). Dry-weather sampling was conducted seasonally, with one event in each season (spring, summer, and fall) at the core stations. Dry-weather sampling consists of grab samples which are analyzed to provide an indication of failing infrastructure or contamination due to spills upstream. ISCO automated sampling devices were installed at Lower Schneider Creek (SC1), Upper Schneider Creek (SC9), School Creek (SCH1), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2), which included continuous stage and temperature measurements.

Table ES-1 summarizes the water quality results of the 2020 SWM Monitoring Program. Similar to previous years, the average concentration of chloride at all locations exceeds the Long-Term Exposure Limit of 120 mg/L, with the exception of Strasburg Creek (SB2). The average concentration for total phosphorus exceeded the PWQO limit of 0.03 mg/L at all locations. Only Voisin Creek (VS1) had its minimum total phosphorus concentration above the PWQO limit.

As seen in previous years, nitrate concentrations continued to experience no exceedances at any of the locations. Unlike, 2019, the average lead concentration at Upper Schneider Creek (SC9) exceeded the PWQO limit of 0.005 mg/L while the maximum concentration for five locations exceeded the applicable limit. In 2020, exceedances in average and maximum copper and zinc concentrations were observed at almost all the core monitoring locations. Only North Strasburg Creek (SB13a) did not exceed the PWQO limit for copper.

Water Quality Trends

Water quality trends have been identified by comparing sites monitored in 2020 that had six or more years of historical water quality data. Sites with six or more years of water quality data included: Lower Schneider Creek (SC1), Sandrock Greenway (SR2) and Strasburg Creek (SB2).

General seasonal trends that remain consistent across all monitoring locations include chloride concentrations being higher during dry-weather grab samples collected throughout the summer period. This is likely caused by the concentrated effect in the waterbody due to the low water levels. Variations in chloride concentration can also be attributed to winter weather conditions during a specific year. If more freeze-thaw cycles are observed during a particular winter, high chloride concentrations can generally also be observed which may be related to increased road salt application required during those years. The maximum seasonal concentration for TSS is generally seen during the summer monitoring period when water levels are at their lowest, and intense precipitation events create flashy, turbid conditions. In some monitoring years, the maximum seasonal TSS concentration is seen during the spring melt when debris is flushed through the waterbodies, however, this trend is dependent on the annual precipitation regime.

An analysis summary is presented below for each monitoring location during 2020:

Lower Schneider Creek (SC1): Wet-weather chloride samples at Lower Schneider Creek (SC1) have typically been below the CCME Long-Term guideline of 120 mg/L. The maximum recorded wet-weather chloride concentration was observed in 2007 with a value of 507.0 mg/L. Dry-weather



chloride concentrations have generally remained consistent around the 200-400 mg/L range, with the majority of samples exceeding the CCME Long-Term guideline of 120 mg/L. The maximum recorded dry-weather chloride concentration was collected in 2014 with a value of 1,050 mg/L. The 2019 chloride concentrations ranged from 280 mg/L to 362 mg/L with an average of 344 mg/L. In comparison, the 2020 chloride concentrations ranged from 78.4 mg/L to 350.0 mg/L, with an average of 183.4 mg/L. Historical data has revealed that dry-weather concentrations of TSS have generally been below 25 mg/L, with the exception of three dry-weather grabs. It should be noted that no TSS samples were collected from 2013 to 2016. Historical wet-weather grab samples ranged from “Non-Detect” which was assigned a value of 0 mg/L to 980 mg/L. The 2019 TSS concentrations ranged from 2.1 mg/L to 15.2 mg/L with an average of 8.1 mg/L. In comparison, the 2020 TSS concentrations ranged from “Non-Detect” (0.0 mg/L) to 215.0 mg/L with an average of 70.4 mg/L. This range is much larger than the observed TSS range in 2019 due to the numerous wet-weather EMC samples collected in 2020.

Sandrock Greenway (SR2): The minimum chloride concentrations at Sandrock Greenway (SR2) were initially below the CCME long-term guideline of 120 mg/L; however, this limit has been exceeded in recent years (2017-2018). The majority of dry-weather concentrations have exceeded the CCME long-term guideline of 120 mg/L. The maximum chloride concentration observed at 2,090 mg/L during a dry-weather sampling event in 2012 also exceeded the CCME short-term limit of 640 mg/L. The chloride concentration values for 2019 ranged from 67 mg/L to 757 mg/L with an average of 249 mg/L. In comparison, the chloride concentration values for 2020 ranged from 84.4 mg/L to 571 mg/L with an average of 253.9 mg/L, showing a similar trend to what was observed in 2019. The majority of dry-weather samples have been below 25 mg/L for TSS. The maximum dry-weather grab sample concentration of TSS was observed in 2012 with a concentration of 237.0 mg/L. Wet-weather TSS measurements were consistently higher than dry-weather sample events, with the maximum value observed in 2012 with a value of 290.0 mg/L. The TSS concentration values for 2019 ranged from 2.5 mg/L to 112.0 mg/L with an average of 47.8 mg/L. In comparison, the TSS concentration values for 2020 ranged from 3.0 mg/L to 104.0 mg/L with an average of 34.1 mg/L, showing a similar trend to what was observed in 2019.

Strasburg Creek (SB2): The majority of chloride concentrations during wet-weather events and EMC sampling are below the CCME long-term guideline of 120 mg/L and no values exceeded the CCME short-term guideline of 640 mg/L. As a general trend, dry-weather sample events have higher chloride concentrations than wet-weather sample events. The maximum chloride concentration was observed in July 2005 with a value of 355 mg/L. The maximum annual chloride concentrations decreased in subsequent monitoring years; however, the annual average appears to be steadily increasing again from 2011 to 2020. The inclusion of the SW8 samples from the Battler Road SSDF Post-Construction Monitoring Program provide a more complete understanding of the full range of chloride concentrations year-round. During the winter months (January to March), chloride concentrations in 2019 and 2020 were between 125 mg/L and 425 mg/L at SW8. The chloride concentration values for 2019 ranged from 61.7 mg/L to 141.0 mg/L with an average of 97.6 mg/L. In comparison, the chloride concentration values for 2020 ranged from 88.2 mg/L to 145.0 mg/L with an average of 112.3 mg/L. The general trend observed is that TSS concentrations increase significantly during wet-weather sample events compared to dry-weather sample events. Over recent years, dry-weather concentrations of TSS have been below 25 mg/L, with the exception of one dry-weather event in 2003 with a value of 42 mg/L and a dry-weather event in 2013 with a value



of 28 mg/L. Wet-weather measurements in 2007 resulted in the maximum TSS concentration of 1,770 mg/L with the next highest concentration of 875.0 mg/L observed in 2020. The TSS concentration values for 2019 ranged from 2.1 mg/L to 59.9 mg/L with an average of 27.4 mg/L. In comparison, the TSS concentration values for 2020 ranged from 0.0 mg/L to 875.0 mg/L with an average of 223.5 mg/L.

Biological Monitoring

Blair Creek

As a result of the current ongoing COVID-19 pandemic, biological monitoring data was not collected by the GRCA in 2020 due to limited resources. As the biological monitoring data collected at Blair Creek is only compared to itself year over year, GHD acknowledges the impact will result in a data gap in the 2020 sampling year, with 2021 being presumably the next year for comparison. The scheduled monitoring in 2020 was intended to be a biomass (triple-pass) surveying year for the fish community, where higher catch rates would have typically been observed resulting in potentially a more complete depiction of the local fish community. GHD does not expect significant trends to be lost with a single-year data gap for the fish community and benthic invertebrate data sets. GRCA confirmed that in 2021, biomass (triple-pass) surveying will be conducted.

Core Stations - Benthic Invertebrate Monitoring

Benthic invertebrate monitoring was conducted at seven stations (SC1, SC9, VS1, SR2, SB2, SCH1, and SB13a). The results of these surveys and sampling were compared between watercourses. Additionally, the monitoring results of Strasburg Creek (SB2) and Sandrock Greenway (SR2) were also compared against the first and second Five Year Report Card values to help identify any changes in the aquatic communities over time.

The 2020 samples at all seven stations included a total of 80 taxa, which is fairly consistent with previous years where the same number of stations were sampled (seven stations sampled in 2018 resulting in 84 taxa). Seven new taxa were identified as part of the 2020 monitoring, including one species of Ephemeroptera (HBI tolerance value of 4). In general, the new taxa had mixed tolerance values ranging from 2 – 10 indicating low to high tolerance to organic pollution. Contrary to previous sampling years, Chironomidae (non-biting midges) was not the most abundant group and instead the Isopod genus *Caecidotea* was the most abundant. This resulted from extremely high counts at a few stations (specifically VS1). The next most abundant groups, in order of decreasing abundance, include Chironomidae (non-biting midges), caddisflies (family: *Hydropsychidae*), and black flies (genus: *Simulium*). In addition, two taxa of EPT, one individual of *Leuctra* and 29 *Dolophilodes* (stonefly and caddisfly, respectively), were reported at Strasburg Creek (SB2). Both of these taxa have an HBI tolerance value of zero, the lowest possible value for a taxon indicating good water quality. This represents both an increase in abundance and diversity of zero tolerance taxa at SB2 compared to 2019.

One station, Voisin Creek (VS1) had taxa richness lower than the expected range for an unimpaired gravel-bottom creek, although abundance fell within the expected range. This is due to the high abundance of the tolerant isopod *Caecidotea* sp. which dominated the species composition. The number of EPT families was low with only one family recorded, the caddisfly *Hydropsychidae*. This is likely an indication of impaired water quality at this station, reflected by the high HBI value and lowest Shannon's diversity index value of all stations monitored in 2020.



The historic benthic invertebrate results for Strasburg Creek (SB2) and Sandrock Greenway (SR2) were also compared. Strasburg Creek (SB2) displayed an overall improvement in water quality between 2015 – 2020. One negative trend observed was a gradual increase in HBI value from 2017 – 2020. Despite this gradual increase, all index scores within this timeframe represent good water quality with some organic pollution. Trends indicating improved diversity were also noted with consecutive improvement observed for Shannon Diversity Index, Taxa Richness, and EPT Taxa. Historically, Sandrock greenway (SR2) results largely indicate consistently impaired conditions, however various levels of water quality improvement trends were observed in 2020. A slight decrease in HBI Index was observed and represents the third consecutive year of metric improvement. The number of EPT taxa remained consistently low with previous years, however, a significant increase in EPT percentage was observed in 2020, suggesting there was an increase in abundance of previously established EPT taxa. Improvement to overall benthic diversity was also observed, reflected by an increase in Taxa Richness which also marks the highest taxa richness observed for this site.

Fish Community Monitoring

Fish community surveys were conducted at seven stations (SC1, SC9, VS1, SR2, SB2, SCH1, and SB13a), which resulted in a total of 14 species observed throughout the Study Area.

A new site to the City's monitoring program, School Creek (SCH1), was established in 2020. The reach was characteristically short due to close proximity to the confluence with Lower Schneider Creek, however, the high abundance of fish captured resulted in the highest density of fish captured per 100 m² across all sites. The fish community consisted of a mix between cool and warmwater species with tolerance ranging from tolerant to intermediate. Of the five species captured, brook stickleback dominated the community with 83 individuals out of the total 131 fish captured.

No fish were captured at Voisin Creek (VS1), which is a consistent result of the 2019 and 2018 sampling years. Seasonally low water levels were observed during fish sampling which likely limits the ability for fish to inhabit the reach.

Sandrock Greenway (SR2) scored the highest for number of fish captured across all sites with 202 fish captured. This also marks the highest fish abundance recorded for this site compared to all previous sampling years. The high fish abundance is due to pumpkinseed which dominated the fish community. The majority of pumpkinseed captured were of the young of year and small juvenile year classes which suggests this species had high spawning success in 2020. Fish community trends for this site indicate a consistent decrease in percent tolerant species since 2015 as more intermediate tolerant species such as pumpkinseed become more abundant. Species richness remains consistent between the years, ranging from four to six.

Strasburg Creek (SB2) was the only monitoring site to contain intolerant fish species and therefore scored the highest for percent intolerant species compared to all sites. However, when compared to previous years percent intolerant species at this site has slightly decreased since 2017. This is partly explained by brook trout being the only intolerant species observed, resulting in this metric depending on the relative abundance of brook trout, of which only one individual was captured in 2020. A change in dominant species was observed between 2019 and 2020 from pumpkinseed to creek chub. The respective tolerance for these species is intermediate and tolerant, which explains



the notable increase in percent tolerant species observed in 2020. Overall, a positive trend towards a more diverse and even species composition was observed for this reach.

SWMF 6 Performance Monitoring

As per the City's ECA #33882-A8WQM for SWMF 6, GHD conducted performance monitoring including the collection of wet-weather samples and annual inspection of the SWMF. TSS results in the wet-weather water quality samples ranged from 10.5 mg/L to 21.4 mg/L. Through inspection of the facility, only minor issues were noted including high turbidity which was likely attributed to the previous high precipitation event, as well as excessive vegetation. Further, it was noted that the outlet channel has minor sediment accumulation and active erosion and gully along the south edge of the access trail/path was observed immediately west of the north inlet (Inlet #1) during the heavy precipitation event in August 2020.

Recommendations for the 2021 Monitoring Program

Building on the recommendations as described in the *Integrated SWM-MP – Implementation Plan* (Aquafor Beech, 2016), the results of the 2016-2020 SWM Monitoring Programs, as well as feedback from the Steering Committee members, the following recommendations have been developed for the 2021 SWM Monitoring Program.

1. Prior to the start of the 2020 SWM Monitoring Program, confirm the current monitoring program schedule and locations as dictated by the *Integrated SWM-MP – Implementation Plan* remain correct. If changes to the SWM Monitoring Program are required, revise the schedule, and distribute to the City, GRCA, and Consultant.
 - a. Verify creek rehabilitation and SWMF retrofit projects for 2021 to determine if scheduled monitoring locations will be impacted.
2. Establish nine (9) flow proportionate monitoring sites in 2021, as soon as weather conditions allow, at the locations below listed using City-owned ISCO autosamplers:
 - a. 2021 SWM Monitoring Program: BD1, MS1, MZ1, SC1 (long-term), SC9 (long-term), VS1 (long-term), MG1 (long-term), SB2 (long-term), SR2 (long-term).
 - b. A minimum of eight wet-weather sampling events per year should be undertaken, with two events per season (i.e., Spring, Summer, Fall, Winter) to ensure the full range of seasonal variation is captured.
3. Establish five (5) flow monitoring sites (pre-EMC) in 2021 in anticipation of the installation of autosamplers in 2022 at the following locations:
 - a. 2021 SWM Monitoring Program: Laurel Creek (LC1), Detweiler Creek (DW1b), East Side Creek (ES1), Doon South (DS1), and Kolb Creek (KD1).
 - b. Undertake a minimum of five (5) discrete flow measurements and install a staff gauge at each site in order to develop a rating curve (i.e., depth versus flow relationship). Continuously recorded depth values are translated to flow rates per the relationship developed by the rating curve. Additional discrete flow measurements may be required to improve the accuracy of associated rating curves.



4. To improve the chloride datasets and allow for a more comprehensive understanding of the physical health of each watercourse, it is recommended that at stations where dry-weather samples are collected, an additional grab sample event be conducted in January/February/March to represent winter conditions when road salt application is in effect and chloride concentrations are highest. This could be focused to long-term monitoring stations only, if needed.
5. Continue to maintain and revise the SWM Monitoring Program SOP, as required, to ensure the consistency of data collection and analysis is maintained throughout the program.
 - a. A common maintenance schedule and SOP should be developed for GRCA, and Consultant operated autosamplers and included as part of the SWM Monitoring Program SOP.
6. The precipitation datasets collected by the City at the City Hall and KOF rain gauges do not undergo QA/QC procedures by the Consultant. It is recommended that since these datasets are utilized as part of the SWM Monitoring Program and other City-monitored programs, that they undergo a QA/QC process.
7. The GRCA operates a weather station at the mouth of the Blair Creek (Station 2414046). Precipitation data from this station would provide a more comprehensive program precipitation dataset to ensure variability from localized rainfall activity at the City's southern end is captured.
8. Blair Creek data is currently monitored by GRCA and provided to the City for inclusion in annual reports. To ensure consistency between the programs, it is recommended that the City and GRCA reassess the respective monitoring programs annually to ensure the data collected as part of GRCA's program is aligned with the goals of the City's monitoring program.
9. GHD identified beaver activity on multiple occasions while monitoring at School Creek (SCH1) and while conducting the fish community sampling at Strasburg Creek (SB2). It is recommended that the City follow up on this activity.
10. Brook trout have been documented within Strasburg Creek (SB2) in all monitoring events since 2014. Field observations of watercress, a groundwater upwelling indicator, suggests this reach may provide suitable brook trout spawning habitat. GHD recommends implementing fall brook trout spawning surveys to the 2021 SWM Monitoring Program to confirm and provide additional context to the productivity and function of North Strasburg Creek.
11. The fish community of Blair Creek is monitored by GRCA using a program which alternates biomass (three passes) and community (single pass) surveys on a yearly basis. Adoption of a similar methodology that includes fish biomass surveys to the rotation of core station monitoring can provide better resolution of community dynamics and trends that are not possible with single pass community surveys. Stations with a robust fish community that may be suitable for biomass surveys include SB2, SR2, and SC9.
12. During the August 2, 2020, annual inspection of SWMF 6, GHD noted minor sediment accumulation, as well as excessive vegetation growth in the main pond. Active erosion and gully along the south edge of the access trail/path was also observed immediately west of the north inlet (Inlet #1). GHD recommends that the City continue to monitor the above noted items that could potentially lead to long term maintenance and/or safety issues.



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1. Introduction

This annual report includes a review of monitoring activities undertaken in 2020 as part of the city-wide stormwater management monitoring program for the City of Kitchener (City). Historical data collected from 2002 through 2019 as part of previous monitoring programs was built upon by continuing to collect comparable data from the program's core monitoring sites.

The 2020 SWM Monitoring Program included: grab and auto-sampling for chemical analysis, benthic invertebrate and fish community surveys, continuous water depth and temperature monitoring, as well as flow monitoring. The 2020 monitoring program continued to use Event Mean Concentration (EMC) monitoring in order to assess pollutant mass loadings into receiving watercourses for select monitoring sites. As part of the 2020 monitoring program, six stations underwent EMC monitoring. The 2020 monitoring program also included the monitoring of stormwater management facility (SWMF) 6 located at Manchester Road as per Environmental Compliance Approval (ECA) number 3382-A8WQUM. This monitoring included an inspection of the SWMF and the collection of three wet-weather samples.

The current monitoring program was developed with considerations from the recommendation sections of previous SWM Monitoring Program reports (GHD, 2016, 2017, 2018 and 2019). Recommendations for ongoing monitoring were also made in the 2016 *Integrated Stormwater Management Master Plan* (ISWM-MP), specifically to the schedule of sites to be monitored each year and the nature of monitoring to be completed at each site. As identified in the ISWM-MP, the SWM Monitoring Program has now entered Phase 2, which includes a refined monitoring program with locations and protocols based on watershed prioritization (i.e., highest priority for watersheds with most needs and/or opportunity to improve conditions) and focused monitoring to establish long-term water quality data sets. The 2020 monitoring was conducted in accordance with the City's SWM Monitoring Program guidance document, which can be found in **Appendix A**.

2. Background

To provide the City with an approach and framework for future SWM implementation, the Kitchener Stormwater Management Policy Development Study was completed in 2001 and a Stormwater Management Master Plan was developed. The intent of the master plan was to guide the location, design, and implementation of future SWM measures. As a result of the study, the Kitchener Stormwater Management Policy (#I-1135) was developed. This study also resulted in a report detailing the existing SWM infrastructure including SWM ponds (wet ponds, dry ponds, and wetlands), Oil-Grit Separators (OGS) and streams. The program assisted the City in outlining new policies to manage, monitor and improve SWM within the City.

As a result of the SWM policy, a city-wide monitoring program was developed and initiated by AECOM in 2002 to assess the implementation of the SWM policy. The primary focus of the original monitoring program was to establish baseline datasets and determine the impact of the SWM policy on the water quality of the City's watersheds and streams. Monitoring included surface water quality, benthic invertebrate, and fish community sampling (biological), as well as continuous temperature and flow monitoring.



The overall health of watersheds in Kitchener were recently evaluated in the *Integrated Stormwater Management Master Plan Municipal Class Environmental Assessment* (EA) completed by Aquafor Beech in 2016. This document replaced the 2001 SWM Policy (#I-1135) in 2016, as over time, the policy no longer aligned with changing industry practices and changes in federal, provincial, regional, and local policies. The purpose of the ISWM-MP is to address existing urban areas of the City and “*recommend remedial measures to improve overall environmental performance, increase efficiencies and reduce costs*” (Aquafor Beech, 2016a). A few of the environmental issues identified in the ISWM-MP specific to surface water include the following.

- Degradation of surface water quality
- Increased sediment loads to surface water
- Thermal enrichment of surface water
- Loss and depredation of fish and wildlife habitat, and
- Increased erosion.

In the ISWM-MP, watersheds within the City were evaluated and prioritized with Priority 1 watersheds identified as having the greatest need of environment improvement while Priority 4 watersheds were identified as closest to natural conditions and therefore had the lowest need for environmental improvement.

Under the original 2001 SWM Policy and continued under the 2016 ISWM-MP, an annual stormwater monitoring program was mandated to monitor the performance of SWM works within the City, including annual summary reports. The SWM Monitoring Program has been an assessment tool to ensure that the best management practices for monitoring are used within the City. The program is governed by a Steering Committee comprised of the selected Consultant, City staff, Grand River Conservation Authority (GRCA) staff, and Region of Waterloo staff.

The GRCA has conducted pre-, during-, and post-development environmental monitoring in Blair Creek on behalf of the City since 2006, under a framework established by the *Upper Blair Creek Functional Drainage Study* (Stantec, 2009). The headwaters of Blair Creek are the most untouched watercourse within the city with available data, and as a result, the Blair Creek monitoring results act as a reference station for the other monitoring efforts as part of the City’s SWM Monitoring Program. Monitoring components include surface water quality (chemistry and temperature) and flows, fish and benthic invertebrate communities, as well as groundwater quality and levels. Monitoring data for all sites and all parameters are summarized in annual GRCA reports.

Figure 1 shows the locations of the 2020 monitoring sites. Individual maps of each monitoring location and type of monitoring conducted can be found in **Figure 2** to **Figure 10**. A photographic log of all of the 2020 monitoring stations is included in **Appendix B**.

3. Program Overview

Table 3-1 below provides a summary of the stations monitored as part of the 2020 SWM Monitoring Program.



Table 3-1 Overview of Monitoring Stations

Monitoring Station	Northing	Easting	Watershed
North Strasburg Creek (SB13a)	4805474.55	543106.78	North Strasburg Creek
Lower Schneider Creek (SC1)	4804722.55	547286.75	Lower Schneider Creek
Upper Schneider Creek (SC9)	4808636.15	542952.14	Upper Schneider Creek
Voisin Creek (VS1)	4808550.39	540489.12	Voisin Creek
School Creek (SCH1)	4804053.21	546721.92	School Creek
Strasburg Creek (SB2)	4804434.61	544024.66	Strasburg Creek
Sandrock Greenway (SR2)	4808729.67	538209.58	Sandrock Greenway
Melitzer Creek (MZ1)	4815383.01	542531.09	Melitzer Creek
Borden Creek (BD1)	4808547.95	540672.13	Borden Creek
Middle Schneider Creek (MS1)	4807851.93	543092.14	Middle Schneider Creek
Upper Balzer Creek (BZ2)	4807134.25	543744.91	Balzer Creek
Lower Balzer Creek (BZ3)	4807069.44	543374.21	Balzer Creek

3.1 COVID-19 Response

Throughout 2020, the COVID-19 pandemic prevented various challenges that resulted in numerous delays to the execution of the 2020 SWM Monitoring Program. Firstly, the pandemic resulted in equipment delays including delays on automatic sample enclosures. In order to minimize the effect this would have on the collection of monitoring data, GHD installed temporary plywood enclosures until steel enclosures were received. Additionally, the pandemic resulted in a delay to receive the License to Collect Fish for Scientific Purposes, thus the spring fish community survey at Balzer Creek could not be collected as the early June deadline was missed. With that being said, the summer fish community survey was conducted as planned. Additionally, the COVID-19 pandemic influenced the data collected in Blair Creek by the GRCA, with limited water quality data collected and no benthic invertebrate or fish community surveys undertaken.

4. Meteorological Data

Precipitation data was obtained from the City's rain gauges located at City Hall and the Kitchener Operations Facility (KOF). Both locations are monitored using rain gauges that are operated year-round with a heated tipping-bucket. Due to spatial differences between the two locations (approximately 6 kilometres), differing monthly precipitation values were observed due to localized precipitation activity. It should be noted that GHD does not perform quality accordance/quality control of the precipitation datasets. The precipitation data is collected at a 5-minute interval and is downloaded as needed by GHD via online portals. Hourly air temperature data was obtained from Environment Canada's weather station for Kitchener/Waterloo (Climate ID: 6144239). A summary of the monthly meteorological data for 2020 is provided in **Table 4-1**. The meteorological data is summarized on **Figure 11** and **Figure 12** summarizing the total monthly precipitation and average monthly temperature, respectively. Climate normal data presented in **Figure 11** and **Figure 12** were obtained from Environment Canada's 1981 to 2010 Waterloo Wellington A (Climate ID: 6149387) dataset.



Table 4-1 Meteorological Data

Month	Minimum Monthly Air Temperature ³ (°C)	Maximum Monthly Air Temperature ³ (°C)	Total Monthly Precipitation Kitchener/Waterloo ³ (mm)	Total Monthly Precipitation City Hall ¹ (mm)	Total Monthly Precipitation KOF ² (mm)
January 2020	-18.3	11.6	78.8	84.0	82.4
February 2020	-27.3	5.90	22.7	32.0	14.6
March 2020	-17.4	20.6	47.3	58.6	52.6
April 2020	-7.7	17.0	39.6	43.6	37.0
May 2020	-4.4	31.8	45.0	63.2	45.6
June 2020	3.1	31.4	36.4	77.8	45.6
July 2020	9.8	35.0	81.0	42.6	60.2
August 2020	5.7	31.7	95.0	51.2	57
September 2020	-2.6	28.7	70.6	54.6	71.8
October 2020	-8.7	24.6	64.2	54.2	65.5
November 2020	-7.2	23.1	58.6	46.8	42.4
December 2020	-13.1	9.3	50.0	45.0	50.2
2020 Total:	N/A	N/A	689.2	653.6	624.9

Notes:

1. Precipitation data collected from the Kitchener City Hall Rain Gauge.
2. Precipitation data collected from Kitchener Operations Facility Rain Gauge.
3. Precipitation and temperature data retrieved from the Environment Canada Kitchener/Waterloo station (Climate ID 6144239), formerly Region of Waterloo International Airport station.

At the start of 2020, January was a warmer than average month, setting a record as the 6th warmest January in almost over 100 years. A warm February followed with a few wide temperature swings during the month. By spring, temperatures were less variable and slightly warmer than average in March and below average in April and May. The months of June, July, August, and September saw slightly higher temperatures compared to the average. A slightly colder October was observed, however, warmer temperatures in November occurred. Throughout the month of December, the temperatures were slightly warmer than average.

For precipitation in 2020, January was a very wet month. Heavy rainfall occurred on January 11, 2020, almost doubling the total rainfall previously recorded in a single day in January. February followed with below average precipitation and a few large snowfalls pushing the total snowfall for the year to be above average for this time of the year. In March, precipitation totals were just below average values. April, May, June, and July were below average as recorded by all rain gauge stations. During the month of August, the KOF and City Hall rain gauge stations recorded lower than average rainfall amounts, however the Kitchener/Waterloo Environment Canada rain gauge recorded higher than the average due to a large, localized rainfall event on August 3rd. October experienced average to slightly lower rainfall amounts recorded by each station. The year ended with a drier than average November and December. Differences observed between each of the stations can be attributed to localized rainfall activity; however, equipment issues could also be the



source. Notable precipitation events in 2020 (i.e., greater than 20 mm) occurred on the following days summarized in **Table 4-2**.

Table 4-2 Meteorological Data – Significant Precipitation Events

Date	KOF (mm)	City Hall (mm)	Kitchener/Waterloo (mm)
January 11, 2020	50.8	56.8	46.6
June 10, 2020	20.2	32.8	16.5
July 10, 2020	34.0	7.2	34.8
August 2, 2020	35.2	28.0	37.3
August 3, 2020	7.4	12.0	31.7
September 9, 2020	24.2	16.8	0.0
September 28, 2020	27.6	19.2	27.9

Notes:

1. Precipitation data collected from the Kitchener City Hall and KOF Rain Gauges.
2. Precipitation data retrieved from the Environment Canada Kitchener/Waterloo station (Climate ID 6144239), formerly Region of Waterloo International Airport station.

The GRCA operates a weather station within the Blair Creek sub-watershed (Station 2414046 – Blair Creek Mouth); however, precipitation data from this station has not been included as part of the monitoring program's overall precipitation dataset. GHD recommends including this dataset in future reporting years, if possible, to help provide a more comprehensive understanding of the localized rainfall activity across the City.

5. Creek Rehabilitation and Retrofit Projects

Table 5-1 summarizes the retrofit and creek rehabilitation projects that the City undertook in 2020. Activities completed as part of these projects may have influenced the 2020 SWM Monitoring Program results.

Table 5-1 2020 Creek Rehabilitation and Retrofit Projects

Project Name	Watershed
Idlewood Creek Rehabilitation	Idlewood Creek
SWMF 65 Retrofit (McIntyre and Strasburg Road)	North Strasburg Creek
Field Sparrow Crescent Extension	Melitzer Creek
Hayward Avenue LRT Reconstruction	Middle Schneider Creek
Guerin Avenue Infiltration Gallery	Idlewood Creek
Florence Avenue Infiltration Gallery	Idlewood Creek
Fairmount Infiltration Gallery (Clive to Jackson)	Montgomery Creek
Fairmount Perforated Pipe (MH9 to MH10)	Montgomery Creek

6. Blair Creek

Blair Creek is a watercourse that runs through the southwestern portion of the City before discharging into the Grand River in the Village of Blair (approximately 9 kilometers south of the municipal City boundary). The portion of the creek located within the City boundary represents the



headwaters of the Blair Creek system where land is predominantly agricultural with increased urban areas at the southern end of the sub-watershed. SWM facilities are present and under construction within the rapidly urbanizing portions of the sub-watershed. Due to the fact that Blair Creek is monitored at the headwaters of the Blair Creek system, and is the most untouched watercourse with available data, the Blair Creek monitoring results act as a reference station for the other monitoring efforts as part of the City's SWM Monitoring Program.

All monitoring within the Blair Creek sub-watershed conducted as part of the annual monitoring program is completed by the GRCA. Locations monitored in 2020 included:

- Station 2414001 – Blair Creek Upstream Dickie Settlement Road (North Dumfries)
- Station 2414002 – Blair Creek Upstream Culvert at New Dundee Road (Kitchener)
- Station 2414044 – Blair Creek Downstream Reichert Drive (Kitchener).

6.1 Physical Monitoring

6.1.1 Temperature Monitoring

6.1.1.1 Temperature Monitoring Methodology

Continuous water temperature data was provided by the GRCA for two stations monitored as part of the 2020 SWM Monitoring Program. Temperature data was collected using HOBO U22 Water Temp Pro v2 temperature loggers set to collect data on a 15-minute interval. Temperature loggers are not removed seasonally to allow for data collection during the winter months; however, the temperature logger at Reichert Drive (Station 2414044) was removed on October 3, 2019, due to beaver activity at the station and reinstalled on January 15, 2020.

6.1.1.2 Temperature Monitoring Results

Blair Creek continuous temperature data is presented in **Figure 13**. At Reichert Drive (Station 2414044) the maximum water temperature recorded was 24.94°C on July 9, 2020. At New Dundee Road (Station 2414002) the maximum water temperature recorded was 28.69°C on July 9, 2020.

Stoneman and Jones (1996) revised by Chu (2009) was utilized to classify the stations into coldwater, coolwater, or warmwater areas based on their maximum air and water temperatures during the summer months (July 1st – September 7th). Daily water temperatures provided by the GRCA between 16:00 and 18:00 were plotted, coinciding to the air temperature at 16:00. **Figure 14** displays the thermal stability classification for both Blair Creek stations. Based on the 2020 monitoring data, both stations are observed to be classified in the cold-coolwater to coolwater thermal regime. These results are similar to 2019 when both stations were classified in the cold-coolwater to coolwater thermal regime.

6.1.2 Flow Monitoring

6.1.2.1 Flow Monitoring Methodology

In 2020, streamflow was monitored by GRCA at various permanent gauge stations. Only continuous data for New Dundee Road (Station 2414002) was provided by GRCA to be included in this report as part of the SWM Monitoring Program.



6.1.2.2 Flow Monitoring Results

Figure 15 displays the continuous streamflow data measured at New Dundee Road (Station 2414002). In 2020, the maximum flow of 0.68 cubic metres per second (m^3/s) was recorded on January 12, 2020, following the heavy rainfall event that occurred on January 11, 2020. Throughout the spring months, peak flows were observed in response to precipitation events and flow responses reduced into the summer and early fall months. From late August and into the winter months, flow response peaks were observed to be below $0.1 \text{ m}^3/\text{s}$, even during heavy rainfall events.

6.2 Water Quality Monitoring

6.2.1 Water Quality Monitoring Methodologies

6.2.1.1 Grab Sampling Methodology

In 2020, grab samples were collected by GRCA at multiple stations along Blair Creek but for the purposes of the 2020 SWM Monitoring Program, only data from Dickie Settlement Road (Station 2414001), New Dundee Road (Station 2414002), and Reichert Drive (Station 2414044) were provided. Samples are typically collected monthly and following significant rainfall events and analyzed for the following parameters: dissolved and total phosphorus, total suspended solids (TSS), chloride, and nitrite/nitrate. Discrete field parameters are also measured during each sampling event using an YSI 600XLM sonde.

6.2.1.2 Event Mean Concentration Methodology

The GRCA operated ISCO automated samplers on Blair Creek as part of their 2020 monitoring season; the analytical results from two automated sampler locations were reported as part of the 2020 SWM Monitoring Program report. The samplers were located at Reichert Drive (Station 2414044) and New Dundee Road (Station 2414002). The samplers were programmed to take sequential samples on a flow proportionate basis at New Dundee Road (Station 2414002) and at a fixed time interval at Reichert Drive (Station 2414044) (due to beaver activity at the site) during flow events. The sequential samples were pooled into composite samples, and this composite sample was submitted for laboratory analysis of the following parameters: dissolved and total phosphorus, TSS, chloride, nitrite/nitrate, and total metals (copper, lead, and zinc).

6.2.2 Water Quality Monitoring Results

The following Sections present the grab and EMC sample results for Blair Creek at Reichert Drive (241404), Dickie Settlement Road (2414001) and upstream of New Dundee Road (2414002) for chloride, total phosphorous, dissolved phosphorus, TSS, nitrate, and total metals (copper, lead and zinc). For the purpose of calculating station averages, results with a value of "Non-Detect" were assigned a value of zero. Grab sampling and ISCO water quality results provided by GRCA can be found in **Appendix C**. In 2020, GRCA conducted eleven grab sampling events starting in March 2002; however, due to COVID-19, the remaining sampling events did not occur until September and concluded in December 2020. Event Mean Concentration samples collected using the automated samplers were collected during two events in November 2020.



6.2.2.1 Chloride

Figure 16 displays the concentrations for chloride grab samples and EMC samples at Blair Creek stations for 2020. The annual average (from sampling locations along Blair Creek) was 65.50 mg/L, compared to the 2019 annual average of 46.84 mg/L. The average concentration for each sampling location (Reichert Drive – 67.94 mg/L, Dickie Settlement – 54.89 mg/L and New Dundee Road – 73.38 mg/L) were below the CCME Short-Term Concentration limit (640 mg/L) and Long-Term Concentration limit (120 mg/L). Sample results for chloride ranged from 34.0 mg/L to 86.4 mg/L with the minimum observed at Dickie Settlement Road (2414001) and the maximum observed at New Dundee Road (2414002). Chloride concentrations during both wet and dry-weather sampling events generally appeared steady throughout the monitoring period at Reichert Drive (Station 2414044) and Dickie Settlement Road (2414001). Higher chloride concentrations were observed at the upstream station at New Dundee Road (2414002) compared to Reichert Drive (Station 2414044). The Roseville Swamp is located between the two monitoring locations and is a known groundwater input. It should be noted that no grab samples were collected during the winter months when road de-icing activities may have occurred.

6.2.2.2 Nitrate

Figure 17 displays the grab and EMC sample results for nitrate at Blair Creek for 2020. Nitrate levels during the 2020 monitoring period ranged from “Non-Detect” (assigned a value of 0) to 3.75 mg/L compared to 0.021 mg/L to 3.71 mg/L in 2019. The annual average in 2020 was 0.778 mg/L compared to the annual average in 2019 of 0.957 mg/L. The annual average at Reichert Drive (Station 2414044) was 0.443 mg/L compared to 0.155 mg/L in 2019. The increase in annual average at this station is likely attributed to the absence of dry-weather grab samples collected in 2019 when only wet-weather EMC samples were collected. The annual average at New Dundee Road (Station 2414002) was 0.211 mg/L compared to 0.254 mg/L in 2019. In 2020, the annual average at Dickie Settlement Road (2414001) was 2.77 mg/L compared to an average of 2.17 mg/L in 2019. Similar to 2019, all results were below the nitrate guidelines set by the CCME (13 mg/L) with Dickie Settlement Road values below 4.0 mg/L and the values at Blair. Two samples resulted in a “Non-Detect” which were assigned a value of zero. In general, nitrate concentrations were higher during the dry-weather samples compared to the wet-weather samples. No significant seasonal trends could be identified for nitrate during the 2020 monitoring due to the limited datasets.

6.2.2.3 Phosphorus

Total Phosphorus

Error! Reference source not found.**18** displays the concentrations for total phosphorus grab samples and EMC samples at Blair Creek during 2020. The majority of sampling results at New Dundee Road (2414002) (upstream location), both dry-weather and wet-weather, were above the PWQO total phosphorus limit (0.03 mg/L) with the exception of two grab samples collected in late fall. One of the two EMC sample collected at Reichert Drive (Station 2414044) in 2020 was above the PWQO total phosphorous limit (0.03 mg/L). At Dickie Settlement Road (2414001), one of the grab sample results exceeded the PWQO total phosphorous limit, this sample was collected in the spring. At Reichert Drive (2414044) three grab samples exceeded the PWQO total Phosphorous limit with two of the three from fall sampling and the other from spring sampling. Therefore, the annual average concentration at all locations (New Dundee Road, Dickie Settlement and Reichert Drive) exceeded



the PWQO total phosphorus limit. The annual average concentration during 2020 is 0.032 mg/L compared to 0.068 mg/L in 2019. It should be noted that this reduction in annual average could be attributed to the lack of spring and summer data in 2020. Total phosphorus levels during 2020 ranged from “Non-Detect” (assigned a value of 0 mg/L) to 0.142 mg/L compared to 0.004 mg/L to 0.628 mg/L in 2019. Similar to 2019, higher EMC total phosphorus concentrations were observed at the upstream New Dundee Road (2414002) station compared to the downstream Reichert Drive (2414044) station. The Roseville Swamp is located between the two monitoring locations and is a known groundwater input. It should be noted that the surrounding land use of Blair Creek is predominantly agricultural, which could attribute to higher total phosphorus concentrations compared to the other more urbanized creeks.

Dissolved Phosphorus

Figure 19 displays the grab sample and EMC results for dissolved phosphorus at Blair Creek during 2020. dissolved phosphorus levels during 2020 ranged from “Non-Detect” (assigned a value of 0 mg/L) to 0.043 mg/L compared to 0.003 mg/L to 0.072 mg/L in 2019. The annual average for 2020 was 0.010 mg/L compared to 0.019 mg/L observed in 2019. The annual average specific to New Dundee Road (2414002) was 0.018 mg/L, 0.002 mg/L at Dickie Settlement Road (Station 2414001) and 0.010 mg/L at Reichert Drive (Station 2414044). This is compared to 2019 annual averages of 0.032 mg/L at New Dundee Road (2414002), 0.011 mg/L at Dickie Settlement Road (Station 2414001) and 0.014 mg/L at Reichert Drive (Station 2414044). There is no PWQO for dissolved phosphorus so values were compared to the PWQO total phosphorus limit of 0.03 mg/L where excessive plant growth in watercourses should be eliminated (MOEE, 1994). Zero exceedances of the PWQO total phosphorus level (0.03 mg/L) were noted at Reichert Drive (Station 2414044) and Dickie Settlement Road (Station 2414001). However, one exceedance of the PWQO total phosphorus level were noted for New Dundee Road (Station 2414002). Historically, seasonally, the trends at Blair Creek have revealed higher dissolved phosphorus levels during the summer months when aquatic life is most productive, and a decrease in concentration as the weather cools in the spring and fall. In 2020, no samples were collected during the summer months, thus no seasonal trends have been identified.

6.2.2.4 Total Metals

Copper

Figure 20 displays the EMC sample results for copper at Blair Creek during 2020 (grab samples were not analyzed for copper). A total of two EMC samples were collected during November 2020, representing fall water conditions in Blair Creek. Copper concentrations for the two monitoring locations at Blair Creek during 2020 ranged from “Non-Detect” to 2.9 µg/L in 2020 compared to “Non-Detect” to 8.7 µg/L in 2019. The 2020 annual average between both stations was 1.43 µg/L compared to the annual average of 2.85 µg/L in 2019. The annual average specific to Reichert Drive (Station 2414044) was 2.10 µg/L which is lower than 2019 (2.57 µg/L). The annual average for the station near New Dundee Road (2414002) was 0.75 µg/L which is lower than last years average of 3.02 µg/L. It is noted that the 2020 averages were based on only two EMC samples collected in 2020, both of which were collected in November 2020. This is the assumed reasoning for the reduction in annual averages between 2019 and 2020. All sample results were below the PWQO objective of 5 µg/L. One sample result (at New Dundee Road) resulted in a “Non-Detect” which was assigned a value of zero.



Lead

Figure 20 displays the EMC sample results for lead at Blair Creek during 2020. Lead concentrations from both monitoring locations at Blair Creek ranged from “Non-Detect” to 0.84 µg/L, compared to “Non-Detect” to 4.02 µg/L in 2019. The annual combined average in 2020 was 0.42 µg/L which was lower than last year’s average of 1.50 µg/L. The annual average specific to Reichert Drive (Station 2414044) was 0.000 µg/L due to all samples being identified as non-detects, compared to 0.12 µg/L in 2019. The annual average for New Dundee Road (2414002) was 0.84 µg/L which is lower than last year’s average of 1.77 µg/L. No sample results were found to be above the PWQO limit of 5 µg/L.

Zinc

Figure 20 displays the EMC sample results for zinc at Blair Creek during 2020. Zinc concentrations from both monitoring locations along Blair Creek ranged from 3.70 µg/L to 6.90 µg/L which is a smaller range compared to the 2019 range from “Non-Detect” to 25.6 µg/L. The 2020 combined annual average was 4.88 µg/L which is lower than the 2019 combined annual average of 7.63 µg/L, likely attributed to only two EMC samples being collected at each station in 2020. The annual average specific to Reichert Drive (Station 2414044) was 4.45 µg/L which is similar to that of 2019 (4.68 µg/L). The 2020 annual average at New Dundee Road (2414002) was 5.30 µg/L which is significantly lower than the 2019 average of 11.33 µg/L, which as previously mentioned may be attributed to a reduction in the number of samples, as well as a reduction in the seasonal period which samples were collected. No sample results exceeded the PWQO objective of 20 µg/L.

6.2.2.5 Total Suspended Solids

Figure 21 displays the TSS Concentrations for grab samples and EMC samples at Blair Creek during 2020. The CCME guidelines allow for a maximum increase of 25 mg/L (24-hr period) and 5 mg/L (24-hr 30-days period) from background levels. No CCME guideline is shown on **Figure 21** because no background level data was established as part of the 2020 SWM Monitoring Program. The average annual concentration for TSS for all stations was 6.0 mg/L compared to 12.2 mg/L in 2019. The TSS concentrations ranged from “Non-Detect” (assigned a value of zero) to 43.2 mg/L, compared to 0.50 mg/L to 136.0 mg/L in 2019. Unlike what was observed in 2019 where the minimum and maximum values were both observed at New Dundee Road (Station 2414002), in 2020 the minimum value was observed at Reichert Drive (Station 2414044) and the maximum at Dickie Settlement (Station 2414001). As a general trend and observed in 2020, TSS values tend to be highest during wet-weather and EMC sampling which is likely influenced to due to increased precipitation.

6.3 Biological Monitoring

As previously mentioned in Section 3, as a result of the COVID-19 pandemic, no biological monitoring data was collected by the GRCA in 2020.

6.4 Historical Water Quality Trends

Historical trends are identified by comparing the Blair Creek monitoring sites to historical data for the two indicator parameters of chloride and TSS. The historical trends presented remain consistent with the 2020 Monitoring Report with the annual results presented along the y-axis in a continuous but



irregularly scaled manner, using ordinal dates along the x-axis. The ordinal day is one on January 1, counting daily through 365 on December 31 (or 366 during leap years). Using the ordinal day for comparison of historical data aligns representative results from the same periods during the years. In historical figures the most recent data is given a solid colour. This colour fades as a gradient, with the oldest analytical result being shown as a lower density of points, outlier results stand out on their own, and emerging trends are given directional impact from the changing gradient.

Figure 22 to Figure 25 provide the historic measurements of chloride and TSS for Blair Creek at both the upstream station at New Dundee Road (Station 2414002) and most downstream station at Dickie Settlement Road (Station 2414001) for wet and dry-weather events. No data is available for Dickie Settlement Road (Station 2414001) in 2015 as seen in the historical summaries provided in **Table 6-1** and **Table 6-2**. The number of samples collected at both locations annually varied year over year, but generally increased from 2006 to 2020.

Table 6-1 Historical Chloride and TSS Summary – Blair Creek at New Dundee Road

Year	Chloride			TSS		
	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
2006	56	36	102 (dry)	1.8	ND	5 (dry)
2007	74	46	110 (wet)	1.8	ND	9 (wet)
2008	40	21	51 (dry)	2.8	ND	8 (dry)
2009	52	41	65 (wet)	4.1	2	13 (wet)
2010	39	30	49 (wet)	6.4	ND	35 (wet)
2011	46	32	81 (wet)	12.5	2	71 (wet)
2012	45	32	95 (wet)	0.4	ND	3 (dry)
2013	49	35	86 (wet)	18.3	ND	100 (wet)
2014	41	30	58 (wet)	3.8	ND	38 (wet)
2015	38	35	55 (wet)	1.9	1	9 (wet)
2016	53	31	72 (dry)	9.7	1	32 (wet)
2017	41	26	71 (wet)	20.6	ND	220 (wet)
2018	43	29	66 (dry)	6.4	ND	39 (wet)
2019	50	12	66 (dry)	17.0	ND	136 (wet)
2020	73	39	86 (wet)	2.2	ND	5.3 (dry)

Table 6-2 Historical Chloride and TSS Summary – Blair Creek at Dickie Settlement

Year	Chloride			TSS		
	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
2006	43	35	50 (dry)	2.6	0	9 (wet)
2007	46	43	50 (dry)	1.2	0	3 (wet)
2008	40	24	48 (dry)	3.8	0	10 (wet)
2009	43	36	48 (dry)	8.1	2	28 (wet)
2010	38	30	43 (dry)	20.9	2	100 (wet)



Year	Chloride			TSS		
	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)
2011	37	25	44 (dry)	14.2	2	52 (wet)
2012	40	37	42 (dry)	3.6	2	11 (wet)
2013	38	30	45 (dry)	9	1	48 (wet)
2014	40	34	46 (dry)	7.1	0	31 (wet)
2016	43	39	46 (dry)	7.1	0	37 (wet)
2017	41	26	49 (dry)	13.7	2	48 (wet)
2018	42	32	50 (dry)	11.9	1	38 (wet)
2019	44	0.66	57 (dry)	5.7	1	21 (wet)
2020	55	34	60 (dry)	8.1	1	43 (wet)

Historically, both wet and dry-weather chloride samples have been below the CCME Long-Term guideline of 120 mg/L at both the New Dundee Road and at the Dickie Settlement monitoring locations. The maximum recorded wet-weather chloride concentration was observed in 2007 with a value of 110 mg/L at New Dundee Road (Station 2414002), and the maximum recorded wet-weather chloride concentration at Dickie Settlement was observed in 2020 with a value of 58 mg/L. The maximum recorded dry-weather chloride concentration at New Dundee Road was observed in 2006 with a value of 102 mg/L, and the maximum recorded dry-weather chloride concentration at Dickie Settlement was observed in 2020 with a concentration of 60 mg/L. The 2020 dry-weather chloride grab samples at New Dundee Road ranged from 69 mg/L to 78 mg/L. The 2020 dry-weather chloride grab samples at Dickie Settlement ranged from 57 mg/L to 60 mg/L. Generally, chloride levels from both stations range from approximately 30 mg/L to 60 mg/L and over the past decade have remained consistent within this range. However, compared to historical data (**Figure 23** and **Figure 25**), the 2019 and 2020 data appears to be on the higher end of this range at both stations and could be indicative of an overall increase in chloride levels in Blair Creek. At New Dundee Road (Station 2414002), the 2019 and 2020 data fall within the 50 mg/L to 85 mg/L range.

Historical data has revealed that dry-weather concentrations of TSS have generally been below 15 mg/L at Dickie Settlement (consistent with the majority of the 2020 results), with the exception of two dry-weather grabs. Dry-weather concentrations of TSS have generally been below 10 mg/L at New Dundee Road, with the exception of one dry-weather grab. For wet-weather samples, TSS concentrations at New Dundee Road have historically been below 40 mg/L, with the exception of four samples. At Dickie Settlement, wet-weather samples have historically been below 50 mg/L, with the exception of two samples. The 2020 TSS dry-weather grab sample concentrations ranged from 0 mg/L (Non-Detect) to 5.3 mg/L at New Dundee Road and 1.0 mg/L to 2.8 mg/L at Dickie Settlement Road. Generally, TSS levels have historically been greater during wet-weather events but overall have remained consistently below 15 mg/L at New Dundee Road. At Dickie Settlement Road, greater variation in wet-weather TSS levels was observed over the past decade, ranging from approximately 5 mg/L to 55 mg/L.

Compared to other creeks with long term datasets (see **Section 89**), Blair Creek has the lowest historical chloride and TSS concentrations, which is to be expected as the two stations monitored are located at the headwaters of the Blair Creek system where land is predominantly agricultural, and development is minimal.



7. Physical Monitoring

Physical monitoring in 2020 included the collection of continuous water level and temperature, as well as discrete flow measurements. All physical monitoring took place between March and October 2020. **Table 7-1** summarizes the dates when discrete flow measurements were conducted at the 2020 EMC station School Creek (SCH1) to verify the existing rating curve. Flow monitoring was not conducted at the remaining 2020 EMC stations (Lower Schneider Creek (SC1), Upper Schneider Creek (SC9), Voisin Creek (VS1), Sandrock Greenway (SR2) and Strasburg Creek (SB2) due to extensive historic flow data and reliability in the existing rating curve for each station. In addition, discrete flow measurements were also conducted at the three stations to be monitored by automated samplers in 2021, which include Borden Creek (BD1), Middle Schneider Creek (MS1) and Melitzer Creek (MZ1).

Table 7-1 Dates of Discrete Flow Monitoring

Locations	Date of Flow Monitoring	Type of Event
BD1, MS1 & MZ1	8/10/2020	Dry
BD1, MS1, MZ1 & SCH1	9/2/2020	Wet
BD1, MS1, MZ1 & SCH1	9/17/2020	Dry
BD1, MS1, MZ1 & SCH1	9/29/2020	Wet
BD1, MS1, MZ1 & SCH1	10/13/2020	Wet

7.1 Temperature Monitoring

7.1.1 Temperature Monitoring Methodology

Continuous water temperature data was collected at all EMC stations monitored as part of the 2020 SWM Monitoring Program. Temperature data was collected using Solinst Leveloggers set to collect data on a 15-minute interval. Each logger was attached to a T-bar in the centre of the channel. Temperature loggers were operated seasonally (typically April to December) and therefore removed during the winter months to prevent damage to the loggers due to freezing conditions.

7.1.2 Temperature Monitoring Results

Figure 26 and **Figure 27** show the daily maximum and minimum water temperature at each site monitored for continuous temperature (SC1, SC9, SCH1, VS1, SB2 and SR2), as well as the daily average air temperature. The 2020 maximum, minimum, and average monthly water temperatures for each site are presented on **Figure 27B**. The five-year average maximum, minimum, and average monthly water temperatures for data collected from 2016 to 2020 are presented on **Figure 27C**. It should be noted that continuous data is not collected throughout the full year and data gaps were not interpolated/extrapolated. Daily average air temperature data was obtained from the Kitchener/Waterloo Environment Canada Weather Station. **Table 7-2** summarizes the minimum and maximum water temperatures recorded during the 2020 monitoring period at each site. Water temperatures were observed to generally follow the same trend as air temperature.

**Table 7-2 2020 Water Temperature Monitoring**

Location	Minimum Temperature (°C)	Maximum Temperature (°C)
Lower Schneider Creek (SC1)	0.24°C on 11/22/2020	27.78°C on 7/09/2020
Upper Schneider Creek (SC9)	0.12°C on 11/18/2020	31.09°C on 7/09/2020
School Creek (SCH1)	2.67°C on 12/08/2020	24.17°C on 7/08/2020
Voisin Creek (VS1)	-0.14°C on 12/08/2020	26.98°C on 7/08/2020
Strasburg Creek (SB2)	0.56°C on 12/08/2020	21.11°C on 7/09/2020
Sandrock Greenway (SR2)	0.46°C on 4/22/2020	27.75°C on 7/08/2020

Stoneman and Jones (1996) revised by Chu (2009) was utilized to classify sites into coldwater, coolwater, or warmwater areas based on their maximum air and water temperatures during the summer months (July 1st – September 7th, 2020). Daily water temperatures collected between 16:00 and 18:00 were plotted, coinciding with the air temperatures at 16:00. **Figure 28** and **Figure 29** show the thermal stability classifications for Lower Schneider Creek (SC1), Upper Schneider Creek (SC9), School Creek (SCH1), Voisin Creek (VS1), Strasburg Creek (SB2), and Sandrock Greenway (SR2), respectively. **Table 7-3** summarizes the thermal regimes for each station in 2020.

Table 7-3 2020 Thermal Stability Classifications

Location	2020 Thermal Stability Classification	2019 Thermal Stability Classification	2018 Thermal Stability Classification	2017 Thermal Stability Classification	2016 Thermal Stability Classification
Lower Schneider Creek (SC1)	Coolwater to Cool-Warmwater	-	-	Coolwater	-
Upper Schneider Creek (SC9)	Cool-Warmwater	-	-	Cool-Warmwater	-
School Creek (SCH1)	Coolwater	-	-	-	-
Voisin Creek (VS1)	Coolwater	Cold-Coolwater to Coolwater	Cool-Warmwater	-	-
Strasburg Creek (SB2)	Cold-Coolwater	Coldwater to Cold-Coolwater	-	-	-
Sandrock Greenway (SR2)	Coolwater	Coolwater	-	-	Cool-Warmwater to Warmwater

7.2 Flow Monitoring

7.2.1 Flow Monitoring Methodology

Discrete velocity measurements were collected using a handheld acoustic Doppler velocity meter (Sontek FlowTracker). A transect was established at each monitoring location perpendicular to the direction of flow. The width of the stream was divided into equal intervals where velocity readings were calculated. A forty second measurement time was used and averaged at each station along the transect. A total discharge calculation is conducted internally by the FlowTracker and used to



develop the associated rating curves for the automated samplers. QA/QC was conducted on all field-derived FlowTracker files, which can be found in **Appendix D**.

Continuous water level data was collected at a 15-minute interval using a Sigma low-profile submerged Area-Velocity (A/V) sensor at all auto sampler locations. The sensor was mounted to the bottom of each channel. Manual data downloads were conducted throughout the 2020 monitoring program. The ISCO 6712 samplers and A/V sensors were installed in April 2020 and removed from all stations in November 2020.

7.2.2 Flow Monitoring Results

Wet-weather discrete flow monitoring and corresponding manual water levels were recorded in 2020 at School Creek (SCH1) to verify the existing rating curve. The developed rating curve for School Creek (SCH1) along with rating curves for Lower Schneider Creek (SC1), Upper Schneider Creek (SC9), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2) are presented **Appendix D**.

The Strasburg Creek (SB2), Lower Schneider Creek (SC1) and Upper Schneider Creek (SC9) rating curves were developed from five discrete flow measurements, all of which were collected in 2018. The Sandrock Greenway (SR2) rating curve was developed based on six discrete flow measurements collected in 2016. The Voisin Creek (VS1) rating curve was developed based on six discrete flow measurements, four of which were collected in 2017, and two of which were collected in 2018. The School Creek (SCH1) rating curve was developed based on nine discrete flow measurements, five of which were collected in 2019 and four of which were collected in 2020. These discrete flow measurements were used in combination with water level data to develop a station-specific rating curve relationship equation(s).

Dry and wet-weather discrete flow monitoring for future EMC locations was conducted during the 2020 annual monitoring to develop the site-specific rating curves in advance of the 2021 monitoring seasons. Flow measurements were undertaken on five occasions at Borden Creek (BD1), Middle Schneider Creek (MS1), and Melitzer Creek (MZ1). The draft rating curves for Borden Creek (BD1), Middle Schneider Creek (MS1), and Melitzer Creek (MZ1) are presented within **Appendix D**.

The continuous water level data collected at all locations was used to calculate the continuous flow rates using the rating curve relationship equations. **Figure 30** through **Figure 35** displays the continuous flow data (i.e., hydrographs) measured at Lower Schneider Creek (SC1), Upper Schneider Creek (SC9), School Creek (SCH1), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2), respectively. Where data was available, the historical monthly average flow for the sites monitored in 2020 is presented on **Figure 35B**. The secondary axis plots daily precipitation data recorded at the rain gauge operated at the KOF to determine if flow peaks correspond with larger precipitation events.

The flow data at almost all stations indicate a short response time (i.e., within 24-hours) for observed peak flows in response to precipitation events while Strasburg Creek (SB2) showed less “peakiness” in response to precipitation events. **Table 7-4** summarizes the peak measured flows observed in 2020, associated sub-watershed drainage areas, and the total precipitation received within 24-hours of the maximum flow observed recorded from the KOF Rain Gauge.



Table 7-4 2020 Flow Monitoring Maximums

Location	Drainage Area (ha)	Peak Flow Measurement (m ³ /s)	Date of Event	24-hr Precipitation (mm)
Lower Schneider Creek (SC1)	809	15.35	6/11/2020	20.2
Upper Schneider Creek (SC9)	726	14.51	6/11/2020	20.2
School Creek (SCH1)	85	0.22	6/11/2020	20.2
Voisin Creek (VS1)	318	5.88	6/11/2020	20.2
Strasburg Creek (SB2)	461	0.46	8/02/2020	35.2
Sandrock Greenway (SR2)	401	7.61	7/10/2020	34.0

8. Water Quality Monitoring

Consistent with previous years of monitoring, water chemistry was analyzed as part of the 2020 SWM Monitoring Program. **Table 8-1** presents a list of the parameters analyzed during the 2020 SWM Monitoring Program, in addition, discrete field measurements of temperature, pH, dissolved oxygen (DO), specific conductivity, oxidation-reduction potential (ORP), total dissolved solids (TDS), and turbidity were collected using a Horiba U52 water quality unit during each grab sampling event. All water quality samples collected in 2020 were submitted to ALS Laboratories in Waterloo for chemical analysis. Original laboratory reports and chain of custodies are included in **Appendix E**. All 2020 laboratory analytical results were validated by a GHD chemist prior to report submission. A copy of the analytical validation memo is included in **Appendix F**. All samples as part of the 2020 SWM Monitoring Program were deemed acceptable with specific qualifications and exceptions for dissolved phosphorus and hardness, as indicated in the analytical validation memo.



Table 8-1 Water Quality Parameters and Sampling Procedure

Parameters	Location of Analysis	Sampling Procedure/Type
Chloride (mg/L)	Laboratory	Grab & Automated
Nitrate (as N)	Laboratory	Grab & Automated
Copper (mg/L)	Laboratory	Grab & Automated
Lead (mg/L)	Laboratory	Grab & Automated
Zinc(mg/L)	Laboratory	Grab & Automated
Total and Dissolved Phosphorus (mg/L)	Laboratory	Grab & Automated
Total Suspended Solids (TSS)	Laboratory	Grab & Automated
Hardness (as CaCO ₃)	Laboratory	Grab & Automated
pH	Field	Grab
Temperature (°C)	Field	Grab
Dissolved Oxygen (mg/L)	Field	Grab
Specific Conductivity (µS/cm)	Field	Grab
ORP (mV)	Field	Grab
TDS (g/L)	Field	Grab
Turbidity (NTU)	Field	Grab

As per the requirements of the 2020 SWM Monitoring Program, three dry-weather and eight wet-weather sampling events were conducted. The dates and weather conditions during the dry and wet-weather sample events are presented in **Table 8-2** and **Table 8-3**, respectively.

Table 8-2 Dry-Weather Grab Sampling Events

Location	Date	Daily Average Air Temperature	Last Precipitation Event	Precipitation (mm)
SB13a, SC1, SC9, VS1, SCH1, SB2, SR2	4/24/2020	4.8°C	4/21/2020	7.8
	7/14/2020	20.3°C	7/11/2020	3.4
	11/4/2020	10.4°C	11/1/2020	2.0

Notes:

1. Precipitation data collected from the Kitchener City Hall Rain Gauge.
2. Temperature data retrieved from the Environment Canada Kitchener/Waterloo station



Table 8-3 Wet-Weather Sampling Events

Location	Sample Submission Dates	Daily Average Air Temperature	Sampled Precipitation Event	Precipitation (mm)
Lower Schneider Creek (SC1)	4/17/2020	0.1°C	4/13/2020	8.0
	5/17/2020	10.4°C	5/15/2020	8.8
	5/20/2020	4.7°C	5/18/2020	20.6
	7/15/2020	22.2°C	7/10/2020	34.8
	9/9/2020	15.0°C	9/7/2020	5.8
	9/30/2020	11.1°C	9/28/2020	24.4
	10/7/2020	12.8°C	10/4/2020	9.4
Upper Schneider Creek (SC9)	10/19/2020	5.8°C	10/15/2020	12.6
	6/7/2020	14.8°C	6/6/2020	14.8
	7/15/2020	22.2°C	7/10/2020	10.6
	7/28/2020	22.0°C	7/23/2020	12
	9/9/2020	15.0°C	9/7/2020	5.8
	9/30/2020	11.1°C	9/28/2020	24.4
	10/7/2020	12.8°C	10/4/2020	9.4
School Creek (SCH1)	10/16/2020	5.6°C	10/15/2020	9.4
	11/16/2020	1.6°C	11/15/2020	16.8
	5/17/2020	10.4°C	5/15/2020	8.8
	5/20/2020	13.1°C	5/18/2020	20.6
	6/5/2020	21.1°C	6/3/2020	8.4
	6/7/2020	14.8°C	6/5/2020	14.6
	7/17/2020	23.2°C	7/10/2020	34.8
Voisin Creek (VS1)	9/30/2020	11.1°C	9/28/2020	24.4
	10/19/2020	5.8°C	10/15/2020	12.6
	11/17/2020	-1.3	11/15/2020	13.4
	4/19/2020	4.7°C	4/13/2020	8.0
	5/17/2020	10.4°C	5/15/2020	8.8
	5/21/2020	13.7°C	5/18/2020	20.6
	6/7/2020	14.8°C	6/5/2020	14.6
Strasburg Creek (SB2)	7/28/2020	22.0°C	7/23/2020	12
	10/7/2020	12.8°C	10/4/2020	7.2
	10/19/2020	5.8°C	10/15/2020	12.6
	11/16/2020	1.6°C	11/15/2020	16.8
	4/17/2020	0.1°C	4/13/2020	8.0
	5/20/2020	13.1°C	5/18/2020	20.6
	6/7/2020	14.8°C	6/5/2020	14.6
Sandrock Greenway (SR2)	6/16/2020	14.9°C	6/10/2020	32.8
	7/17/2020	18.05°C	7/10/2020	34.8
	9/30/2020	11.1°C	9/28/2020	24.4
	10/19/2020	5.8°C	10/15/2020	9.4
	11/16/2020	1.6°C	11/15/2020	16.8
	4/19/2020	4.7°C	4/13/2020	8.0
	5/7/2020	7.0°C	5/1/2020	6.8
	5/17/2020	10.4°C	5/15/2020	8.8
	5/21/2020	13.7°C	5/18/2020	20.6
	6/29/2020	22.5°C	6/27/2020	7.2
	10/7/2020	12.8°C	10/4/2020	7.2
	10/16/2020	5.6°C	10/15/2020	9.4
	11/16/2020	1.6°C	11/15/2020	16.8

Notes:

1. Precipitation data collected from the Kitchener City Hall Rain Gauge.
2. Temperature data retrieved from the Environment Canada Kitchener/Waterloo station.



8.1 Water Quality Monitoring Methodologies

8.1.1 Grab Sampling Methodology

Dry-weather sampling was conducted as part of the 2020 SWM Monitoring Program with a minimum of one event per season (spring, summer, and fall). Dry-weather sampling consists of collecting grab samples which are analyzed to provide an indication of failing infrastructure or contamination due to spills upstream. Grab sampling was conducted by dipping the sample container directly into the stream to collect surface water, unless the sample bottles contained preservatives. If the bottle contained preservatives, sterile unpreserved bottles were used to collect the sample. Samples were collected below the surface with the sample bottles completely submerged. This prevents floating debris from entering the sample bottles, which could result in unrepresentative analytical data. The water sample was then transferred to the appropriate preserved bottles.

The sample bottles were placed in a cooler with ice until the sample was delivered to the laboratory. The Chain-of-Custody (COC) form, which was supplied by the laboratory, was filled out with the sample, time, date, and location, and was signed by field staff before being relinquished to the receiving laboratory.

All samples collected by GHD were submitted to ALS Environmental in Waterloo, Ontario for analysis. ALS Environmental is accredited by the Canadian Association for Laboratory Accreditation (CALA). See **Appendix E** for original laboratory reports and COC forms.

8.1.2 Event Mean Concentration Methodology

To conduct wet-weather samples, ISCO 6712 automated samplers with Sigma 750 Low-Profile Submerged Area-Velocity flow modules (to measure water depth and velocity) and Solinst Leveloggers were installed at Lower Schneider Creek (SC1), Upper Schneider Creek (SC9), School Creek (SCH1), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2).

Table 8-4 presents a summary of equipment installation dates.

Table 8-4 Equipment Installation Dates

Location	Equipment	Installation Date
Lower Schneider Creek (SC1)	Solinst Levelogger	April 11, 2020
	ISCO Autosampler	April 3, 2020
Upper Schneider Creek (SC9)	Solinst Levelogger	May 6, 2020
	ISCO Autosampler	April 3, 2020 June 5, 2020
School Creek (SCH1)	Solinst Levelogger	May 6, 2020
	ISCO Autosampler	April 28, 2020
Voisin Creek (VS1)	Solinst Levelogger	April 1, 2020
	ISCO Autosampler	
Strasburg Creek (SB2)	Solinst Levelogger	April 11, 2020
	ISCO Autosampler	April 3, 2020
Sandrock Greenway (SR2)	Solinst Levelogger	April 1, 2020
	ISCO Autosampler	



Installation dates were weather-dependant and occurred as soon frozen ground conditions had thawed. The autosampler located at Upper Schneider Creek (SC9) was originally installed on April 3, 2020, with a temporary plywood enclosure; however, it was removed on April 24, 2020, after the enclosure was vandalized. The autosampler at this location was reinstalled on June 5, 2020, once the stainless-steel enclosure was received. All autosampler stations were dismantled and removed for the monitoring season in December 2020.

Continuously recorded water levels, obtained from the area-velocity flow module, were translated to flow rates utilizing the relationship equations developed by the corresponding rating curve. The rating curve equations were programmed into the ISCO 6712 samplers. These samplers use the rating curve equation to calculate the flow rate using the water level readings, thus triggering the sampler to begin sampling once a specified water level and flow rate condition are met. Once triggered, aliquot samples were collected throughout the wet event at a constant volume and flowrate. Following the wet event, GHD staff combined all aliquot samples into a composite sample and filled laboratory provided sample bottles to be submitted for analysis.

Continuous temperature monitoring was conducted at the autosampler locations to establish thermal baseline regimes. Data was recorded using a Solinst Levelogger set at 15-minute intervals. Temperature loggers were installed at all flow proportionate sites during autosampler installation and removed for the season in December 2020 (see **Section 7.1**).

As part of the 2020 monitoring program, GHD performed the required maintenance on all ISCO samplers. A full summary of all operation and maintenance events at the ISCO sampler is provided in **Table 1** attached.

8.2 Water Quality Monitoring Results

8.2.1 Grab Sampling Results

Three dry-weather grab samples were collected at the following stations: Voisin Creek (VS1), Strasburg Creek (SB2), North Strasburg Creek (SB13a), Sandrock Greenway (SR2), School Creek (SCH1), Upper Schneider Creek (SC9), and Lower Schneider Creek (SC1). Results for each sampling parameter have been compared to applicable guidelines, including the Provincial Water Quality Objectives (PWQO) and the Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life. These guideline comparisons have been made since the onset of the SWM monitoring program. Where applicable, the five-year annual average is provided for reference (i.e., results from 2016 to 2020). It should be noted that for dry-weather samples, Sandrock Greenway (SR2) is the only site with a consistent 5-year annual record. Strasburg Creek (SB2) and Lower Schneider Creek (SC1) have four years of data within the 2016 to 2020 period, and both Voisin Creek (VS1) and Upper Schneider Creek (SC9) have three years of data. Results for each water quality parameter are summarized in **Figure 36** to **Figure 38**.

Seasonally, trends and comparisons can be made across all monitoring locations for 2020. In general, chloride concentrations were found to be the highest at sites during the spring and fall sampling events, and the lowest during the summer period. This relationship is directly tied to road salt application during de-icing efforts. Alternatively, seasonal trends for all other parameters increased slightly during the summer monitoring period compared to spring and fall sampling results. This is likely caused by the dilution factor which occurs during the spring and fall periods when higher quantities of water are present in all watercourses, thus lowering concentration levels.



It is worth noting that no winter water quality samples (i.e., January to April) were collected as part of the 2020 SWM Monitoring Program due to equipment and program timing restrictions. This is consistent with past monitoring programs. Winter water quality grab sampling would provide a full water quality suite for analysis and allow for a more comprehensive understanding of the physical health of each watercourse. However, as part of the City's Battler Road Snow Storage and Disposal Post-Construction Monitoring Program (see *2020 City-Wide Stormwater Management Monitoring Program: Section B – Additional Stormwater Management Monitoring*), discrete grab sampling winter data was collected in 2020 at a location (SW8) approximately 30 metres (m) downstream of Strasburg Creek (SB2). As per the recommendation of the 2018 SWM Annual Monitoring Program, this data has been included as part of the grab sampling results analysis for this site.

In the results tables provided, the stations have been presented in descending order with the most upstream site at the top and the most downstream site at the bottom.

8.2.1.1 Chloride

The chloride concentrations for all dry-weather event surface water monitoring locations in 2020 are presented on **Figure 36**. The annual average, 5-year annual average, minimum and maximum chloride concentrations for 2020 are summarized in **Table 8-5**. The annual averages for all sites monitored in 2020 ranged from 112.5 mg/L at Strasburg Creek (SB2) to 471.3 mg/L at Sandrock Greenway (SR2).

The annual averages of all 2020 monitoring locations, except for Strasburg Creek (SB2), exceeded the CCME Long-Term Concentration Limit of 120 mg/L. No site's annual average exceeded the CCME Short-Term Concentration limit of 640 mg/L.

Table 8-5 2020 Dry-Weather Grab Sample Results – Chloride

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	431.1	471.3	372.0	571.0
VS1	439.1	424.3	223.0	654.0
SC9	316.2	322.7	269.0	407.0
SB13a	-	453.7	388.0	551.0
SB2	87.1	112.8	99.4	122.0
SCH1	-	238.3	210.0	268.0
SC1	306.1	289.0	242.0	350.0

A general trend between all sites showed that the highest chloride concentrations were recorded during the spring sampling event on April 24, 2020, except for School Creek (SCH1) which had the highest chloride concentration observed during the fall event on November 4, 2020. The high chloride concentrations observed in the spring are likely the result of snow melt and the flush of road salts following the spring freshet. Sites with close proximity to heavily developed catchment areas (SR2, VS1, SC9, and SB13a) demonstrated higher average chloride concentrations compared to sites in less developed areas.

Similar to what was observed throughout the 2019 monitoring program, chloride concentrations at Strasburg Creek (SB2) remained fairly consistent throughout the 2020 monitoring period, ranging



from 99.4 mg/L to 122.0 mg/L. The results from monitoring location SW8 (Battler Road SSDF Monitoring Program) are relatively consistent with the results observed at Strasburg Creek (SB2), this is consistent with what was seen during the 2019 monitoring program. Voisin Creek (VS1) had the highest maximum chloride concentration, and the third lowest minimum, thus resulting in the widest range in data collected. Strasburg Creek (SB2) had the lowest annual average concentration, consistent with what was observed in 2019.

8.2.1.2 Nitrate

Figure 36 displays the nitrate concentrations for all dry-weather event surface water monitoring locations in 2020. The annual average, 5-year annual average, minimum and maximum nitrate concentrations for 2020 are summarized in **Table 8-6**. The CCME Long Term Concentration guideline for nitrate in a freshwater watercourse is 13 mg/L.

Table 8-6 2020 Dry-Weather Grab Sample Results – Nitrate

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	0.63	0.48	0.41	0.57
VS1	0.47	0.28	0.12	0.39
SC9	0.97	0.85	0.60	1.24
SB13a	-	0.37	0.02	0.54
SB2	1.24	0.81	0.01	1.22
SCH1	-	1.44	0.92	1.81
SC1	0.95	0.93	0.80	1.17

The annual averages for all sites during the 2020 monitoring ranged from 0.28 mg/L at Voisin Creek (VS1) to 1.44 mg/L at School Creek (SCH1) compared to 0.42 mg/L to 1.29 mg/L in 2019. All annual averages are well below the CCME nitrate threshold. No seasonal trends for nitrate were observed during the 2020 monitoring year.

8.2.1.3 Phosphorus

Total Phosphorus

The total phosphorus concentrations for all dry-weather event surface water monitoring locations in 2020 are presented on **Figure 36**. The annual average, minimum and maximum total phosphorus concentrations for 2020 are summarized in **Table 8-7**. The PWQO of 0.03 mg/L was used as the threshold target for the watercourses. This concentration limit was selected as it is less likely for excessive vegetation growth to occur in waterbodies with total phosphorus results below this limit (MOEE, 1994).

**Table 8-7 2020 Dry-Weather Grab Sample Results – Total Phosphorus**

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	0.067	0.035	0.022	0.059
VS1	0.068	0.054	0.030	0.088
SC9	0.022	0.022	0.019	0.024
SB13a	-	0.044	0.016	0.092
SB2	0.016	0.014	0.005	0.029
SCH1	-	0.162	0.021	0.341
SC1	0.021	0.015	0.010	0.022

Similar to previous years, the majority of the monitoring locations fluctuated above and below the PWQO limit, with the exception of Lower Schneider Creek (SC1), Strasburg Creek (SB2) and Upper Schneider Creek (SC9), which did not exceed the PWQO guideline for any of the collected grab samples. The annual average concentrations ranged from 0.014 mg/L at Strasburg Creek (SB2) to 0.054 mg/L at Voisin Creek (VS1) compared to the 2019 range of 0.017 mg/L to 0.130 mg/L. The highest total phosphorus concentration was 0.341 mg/L at School Creek (SCH1) during the summer sampling event and the lowest total phosphorus concentration was 0.005 mg/L at Strasburg Creek (SB2) during the fall sampling event. As a general trend, total phosphorus concentrations were higher during the summer period and lower during the spring and fall periods.

Dissolved Phosphorus

Error! Reference source not found.36 displays the dissolved phosphorus concentrations for all dry-weather event surface water monitoring locations in 2020. The annual average, minimum and maximum dissolved phosphorus concentrations for 2020 are summarized in **Table 8-8**. The PWQO concentration limit of 0.03 mg/L for total phosphorus was used to compare the dissolved phosphorus results as no guideline for dissolved phosphorus currently exists.

Table 8-8 2020 Dry-Weather Grab Sample Results – Dissolved Phosphorus

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	0.039	0.017	0.006	0.033
VS1	0.038	0.025	0.011	0.043
SC9	0.009	0.006	0.004	0.009
SB13a	-	0.015	0.004	0.035
SB2	0.010	0.006	ND (0.000)	0.014
SCH1	-	0.015	0.004	0.031
SC1	0.009	0.006	0.004	0.009

Annual averages for all sites ranged from 0.006 mg/L to 0.025 mg/L compared to the 2019 range of 0.014 mg/L to 0.121 mg/L. Dissolved phosphorus concentrations for all sites were below the PWQO limits with the exception of Voisin Creek (VS1), Sandrock Greenway (SR2), School Creek (SCH1) and North Strasburg Creek (SB13a) during the summer sampling events. This is similar to what has been observed since 2017. The same general trend for total phosphorus concentrations was



observed for dissolved phosphorus where concentrations were higher during the summer sampling and lower during spring and fall sampling.

8.2.1.4 Metals

Zinc

The zinc concentrations for all dry-weather event surface water monitoring locations in 2020 are presented on Error! Reference source not found.37. The annual average, minimum and maximum zinc concentrations for 2020 are summarized in **Table 8-9**. Results were compared to the PWQO limit of 0.020 mg/L for zinc.

Table 8-9 2020 Dry-Weather Grab Sample Results – Zinc

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	0.000	0.005	0.004	0.007
VS1	0.010	0.010	0.007	0.017
SC9	0.010	0.012	0.005	0.024
SB13a	-	0.034	0.005	0.092
SB2	0.020	0.011	ND (0.000)	0.029
SCH1	-	0.034	0.007	0.086
SC1	0.000	0.003	0.000	0.004

The annual averages for zinc concentration by monitoring location ranged from 0.002 mg/L to 0.034 mg/L compared to the 2019 range of “Non-Detect” to 0.016 mg/L. All sample results fell below the PWQO except for the summer sample results at Strasburg Creek (SB2), School Creek (SCH1), North Strasburg Creek (SB13a) and Upper Schneider Creek (SC9). The lowest average zinc concentration of 0.002 mg/L was observed at Lower Schneider Creek (SC1). The 2020 zinc concentrations followed the same general trend as copper and lead, with the highest levels observed in the summer compared to spring and fall.

Copper

Error! Reference source not found.37 displays the copper concentrations for all dry-weather event surface water monitoring locations in 2020. The annual average, minimum and maximum copper concentrations for 2020 are summarized in **Table 8-10**. The PWQO standard of 0.005 mg/L was used for result comparison.

**Table 8-10 2020 Dry-Weather Grab Sample Results – Copper**

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	0.0024	0.0029	0.0020	0.0038
VS1	0.0043	0.0037	0.0027	0.0054
SC9	0.0020	0.0023	0.0018	0.0029
SB13a	-	0.0013	0.0011	0.0015
SB2	0.0010	0.0003	ND (0.0000)	0.0010
SCH1	-	0.0044	0.0014	0.0093
SC1	0.0017	0.0015	0.0014	0.0017

The annual average across all monitoring locations for copper concentrations ranged from 0.0003 mg/L to 0.0044 mg/L compared to the 2019 annual average ranges of “Non-Detect” to 0.005 mg/L. All samples fell below the PWQO limit for copper except for two samples collected during the July 14, 2020, sampling event, one at Voisin Creek (VS1) and the other at School Creek (SCH1). The maximum copper concentration of 0.0093 mg/L was collected at School Creek (SCH1). In both 2018 and 2019, the maximum copper concentration was observed at Voisin Creek (VS1). In 2020, Voisin Creek (VS1) had the second highest copper concentration, while School Creek (SCH1) which had not yet been monitored as part of the SWM monitoring program, has the highest. The 2020 copper concentrations followed the same general trend as zinc and lead, with the highest levels observed in the summer compared to spring and fall.

Lead

The lead concentrations for all dry-weather event surface water monitoring locations in 2020 are presented on Error! Reference source not found.37. The annual average, minimum and maximum lead concentrations for 2020 are summarized in **Table 8-11**. PWQO guidelines for lead concentrations range from 0.001 mg/L to 0.005 mg/L for various hardness levels. The upper limit of 0.005 mg/L (hardness above 80 mg/L) was used as the standard for the City surface water monitoring program.

Table 8-11 2020 Dry-Weather Grab Sample Results – Lead

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	0.0002	0.0002	0.0001	0.0003
VS1	0.0012	0.0012	0.0003	0.0026
SC9	0.0002	0.0002	0.0001	0.0004
SB13a	-	0.0002	0.0001	0.0003
SB2	0.0001	0.0001	0.0001	0.0003
SCH1	-	0.0017	0.0002	0.0047
SC1	0.0003	0.0002	0.0001	0.0002

All 2020 lead concentrations for dry-weather event samples were below the PWQO limit of 0.005 mg/L. The 2020 averages for lead concentrations ranged from 0.0001 mg/L to 0.0017 mg/L compared to the 2019 range from 0.0001 mg/L to 0.0012 mg/L. School Creek (SCH1) demonstrated



the highest annual average (0.0017 mg/L) while Strasburg Creek (SB2) had the lowest annual average concentration of 0.0001 mg/L. The maximum concentration during the 2020 monitoring program was collected at School Creek (SCH1) during the summer sampling event with a value of 0.0047 mg/L which is still below the PWQO limit. The 2020 lead concentrations followed the same general trend as zinc and copper, with the highest levels observed in the summer compared to spring and fall.

8.2.1.5 Total Suspended Solids

Error! Reference source not found.38 displays the TSS concentrations for all dry-weather event surface water monitoring locations in 2020. The annual average, minimum and maximum TSS concentrations for 2020 are summarized in **Table 8-12**. The CCME guidelines permit a threshold increases of 25 mg/L per 24-hr period, or a 5 mg/L increase per 24-hr over a 30-day period from background levels. The CCME guideline is not shown on **Figure 38** because no background level data was established as part of the 2020 SWM Monitoring Program.

Table 8-12 2020 Dry-Weather Grab Sample Results – TSS

Location	5-year Annual Average (mg/L)	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	4.80	5.40	ND (0.00)	10.50
VS1	23.07	43.43	ND (0.00)	121.00
SC9	4.32	3.60	ND (0.00)	6.90
SB13a	-	13.80	ND (0.00)	24.30
SB2	3.67	2.27	ND (0.00)	6.80
SCH1	-	65.50	8.00	123.00
SC1	4.54	0.83	ND (0.00)	2.50

Annual average TSS concentrations by location ranged from 0.83 mg/L to 65.5 mg/L compared to the 2019 concentration range of 2.2 mg/L to 11.0 mg/L. It should be noted that an extremely high TSS concentration of 4,040 mg/L from School Creek (SCH1) was removed from the dataset as it is expected a high amount of particulate matter entered the sample bottle as field staff noted a low water level at this location which likely resulted in the high TSS concentration. Regardless, School Creek (SCH1) still had the highest annual average TSS concentration of 65.5 mg/L due to a TSS concentration of 123 mg/L observed during the spring sampling event at this site. The lowest annual average TSS concentration was observed at Lower Schneider Creek (SC1) with a value of 0.83 mg/L where during the spring and fall events, a value of ND (0.0) mg/L was observed for TSS.

8.2.1.6 Dissolved Oxygen

Dissolved oxygen levels for all dry-weather event surface water monitoring locations in 2020 are presented on Error! Reference source not found.38. The annual average, minimum and maximum DO concentrations for 2020 are summarized in **Table 8-13**. The PWQO sets the minimum acceptable concentrations of DO to support aquatic life as 4 mg/L for warm-water systems and 5 mg/L for cold-water systems.

**Table 8-13 2020 Dry-Weather Grab Sample Results – Dissolved Oxygen**

Location	2020 Thermal Stability Classification	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	Coolwater	11.01	6.01	13.80
VS1	Coolwater	10.72	6.26	15.33
SC9	Cool-Warmwater	15.09	13.94	17.80
SB13a	Coldwater	12.08	7.87	14.90
SB2	Cold-Coolwater	10.49	6.93	14.05
SCH1	Coolwater	6.49	2.28	9.54
SC1	Coolwater to Cool-Warmwater	10.33	8.75	11.91

All DO results for 2020 were above both the warm-water and cold-water threshold (i.e., acceptable for supporting aquatic life), with the exception of a DO measurement of 2.28 mg/L at School Creek (SCH1). This measurement was observed during the summer sampling event when water levels and water velocities were very low. The annual average at each monitoring location ranged from 6.49 mg/L to 15.09 mg/L compared to the 2019 range of 7.31 mg/L to 10.27 mg/L. The relationship between DO and water temperature is consistent with the seasonal trends identified at each monitoring location. DO concentrations are typically higher in the spring and fall when water temperatures are lower and decrease in the summer months as water temperatures warm.

8.2.1.7 pH

Error! Reference source not found.38 displays the discrete field-measured pH results for all dry-weather event surface water monitoring locations in 2020. The annual average, minimum and maximum pH concentrations for 2020 are summarized in **Table 8-14**. The PWQO lower and upper pH limits (6.5 and 8.5) are plotted for comparison.

Table 8-14 2020 Dry-Weather Grab Sample Results – pH

Location	Annual Average (mg/L)	Minimum Concentration (mg/L)	Maximum Concentration (mg/L)
SR2	8.07	7.79	8.41
VS1	8.24	7.95	8.74
SC9	8.43	8.03	8.71
SB13a	7.69	6.78	8.26
SB2	7.98	7.55	8.36
SCH1	7.45	6.99	7.89
SC1	8.05	7.7	8.39

All samples fell between the PWQO limits of a maximum pH of 8.5 and a minimum pH of 6.5 with the exception of the spring sample at Voisin Creek (VS1) which had a value of 8.74 and both the spring and summer samples at Upper Schneider Creek (SC9) which had values of 8.55 and 8.71, respectively. The average annual pH values by sampling location ranged from 7.45 at School Creek (SCH1) to 8.43 at Upper Schneider Creek (SC9). A general observation for most monitoring locations was a decreasing trend in pH from spring into the fall.



8.2.1.8 Specific Conductivity

The discrete field-measured specific conductivity (conductivity normalized to 25°C) results for all dry-weather event surface water monitoring locations in 2020 are presented on Error! Reference source not found.38. The annual average, minimum and maximum specific conductivity results for 2020 are summarized in Table 8-15.

Table 8-15 2020 Dry-Weather Grab Sample Results – Specific Conductivity

Location	Annual Average (µS/cm)	Minimum Concentration (µS/cm)	Maximum Concentration (µS/cm)
SR2	1,870	1,390	2,310
VS1	1,640	1,040	2,450
SC9	1,660	1,340	2,040
SB13a	1,332	175	2,190
SB2	1,288	829	2,190
SCH1	1,370	1,310	1,410
SC1	1,318	884	1,760

The average annual specific conductivity by monitoring location in 2020 ranged from 1,288 µS/cm at Strasburg Creek (SB2) to 1,870 µS/cm at Sandrock Greenway (SR2) compared to the 2019 annual averages of 790 µS/cm to 3,127 µS/cm. Specific conductivity and chloride levels can be compared to one another on a bi-linear scale. The relationship is evident during dry-weather sampling events, where both specific conductivity and chloride concentration levels increase. All sites appear to follow the same trends for both specific conductivity and chloride.

8.2.2 Event Mean Concentration Results

Event Mean Concentrations for selected parameters are used to calculate the mass loadings of pollutants into receiving waterbodies. Mass loadings act as a true measure of the effectiveness of SWM measures currently in place. Mass loadings also assist in evaluating the performance of the Best Management Practices (BMPs) implemented within municipalities across the province of Ontario. Where applicable, the five-year annual average is provided for reference (i.e., results from 2016 to 2020). It should be noted that for wet-weather samples, Sandrock Greenway (SR2), Voisin Creek (VS1) and Lower Schneider Creek (SC1) have three years of data within the 2016 to 2020 period, and Upper Schneider Creek (SC9) and Strasburg Creek (SB2) both have two years of data.

Historical EMC studies have demonstrated considerable variation of constituent loading, both monthly and seasonally. Most studies have demonstrated that much of the annual loading (>50%) occurs between the months of March and May of a given year. However, most water quality studies occur between April and October.

8.2.2.1 School Creek (SCH1)

Based on the 2020 temperature monitoring data, School Creek (SCH1) is thermally classified as a coolwater creek and is located just South of Doon Village Road and Doon South Drive. The primary land use of the School Creek sub-watershed is residential and forested with some industrial properties.



EMC samples were collected at School Creek (SCH1) during wet-weather events. In addition, three dry-weather grab samples were collected in 2020. The following sections present the sampling results for the School Creek (SCH1) location with EMC and grab sample concentrations for each parameter displayed on **Figure 39** and **Figure 40** and summarized in **Table 8-16**.

Table 8-16 School Creek (SCH1) – Wet (EMC) and Dry Summary

Parameter	Wet (EMC)				Dry (Grab)			
	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)
Chloride	-	120.7	43.1	307.0	-	238.3	210.0	268.0
Nitrate	-	0.652	0.026	1.330	-	1.440	0.92	1.81
Total Phosphorus	-	0.123	0.033	0.230	-	0.162	0.021	0.341
Dissolved Phosphorus	-	0.0231	0.0037	0.0594	-	0.0149	0.0042	0.0312
Copper	-	0.0091	0.0041	0.0124	-	0.0044	0.0014	0.0093
Lead	-	0.0019	0.0005	0.0068	-	0.0017	0.0002	0.0047
Zinc	-	0.0337	0.0152	0.0700	-	0.0340	0.0073	0.0856
Total Suspended Solids	-	44.90	13.70	94.20	-	65.50	8.00	123.00

8.2.2.1.1 Chloride

Figure 39 presents the EMC and dry-weather grab results for chloride at School Creek (SCH1) for 2020. The annual station average (wet and dry-weather results) at this site was 152.8 mg/L, which is below the CCME Short Term Concentration limit (640 mg/L), but above the CCME Long Term Concentration limit (120 mg/L). All three dry-weather samples were above the CCME Long Term Concentration limit. Only two of the eight collected EMC samples were above the CCME Long Term Concentration limit. The average dry-weather chloride concentration of 238.2 mg/L at School Creek (SCH1) was higher compared to the average chloride EMC concentration of 120.7 mg/L for 2020. The highest recorded chloride concentration was seen in an EMC sample collected on May 17, 2020, at a concentration of 307 mg/L.

8.2.2.1.2 Nitrate

Error! Reference source not found. **39** displays the EMC and dry-weather grab results for nitrate at School Creek (SCH1). The average dry-weather nitrate concentration at School Creek (SCH1) was higher than the wet-weather EMC average. The overall nitrate average at School Creek (SCH1) (dry and wet-weather samples) was 0.867 mg/L which is well below the CCME limit. No significant seasonal trends were identified for nitrate during the 2020 monitoring.



8.2.2.1.3 Phosphorus

Total Phosphorus

Error! Reference source not found.**39** displays the EMC and dry-weather grab results for total phosphorus at School Creek (SCH1) for 2020. All EMC samples were above the PWQO limit of 0.03 mg/L for total phosphorus; however, the spring dry-weather grab sample result was below the PWQO limit. Both the EMC and dry-weather grab sample annual averages were above the PWQO limit of 0.03 mg/L. Seasonally, total phosphorus results during the summer were higher than in the spring and fall which could be attributed to the application of fertilizers and cleaners in urbanized areas during the spring and summer months, which could enter the creek during surface water runoff during precipitation events.

Dissolved Phosphorus

Error! Reference source not found.**39** displays the EMC and dry-weather grab results for dissolved phosphorus at School Creek (SCH1) for 2020. During 2020, two of the eight samples collected exceeded the PWQO for total phosphorus (0.03 mg/L) (there is currently no PWQO for dissolved phosphorus). Both the EMC and dry-weather grab sample annual averages for dissolved phosphorus are below the PWQO limit. Seasonally, there was no observable trend for dissolved phosphorus present.

8.2.2.1.4 Metals

Copper

Error! Reference source not found.**40** displays the EMC and dry-weather grab results for copper at School Creek (SCH1) during 2020. Only one EMC sample result for copper was below the PWQO limit of 0.005 mg/L at School Creek (SCH1). One dry-grab sample result was above the PWQO limit. The overall station average (both wet and dry samples) for School Creek (SCH1) was 0.008 mg/L, which is above the PWQO limit. Seasonally, copper at School Creek (SCH1) was lower in the early spring and increased into summer and fall. It is speculated that during the summer months, large rain events caused heavy metals and road debris to accumulate in the watercourse and appear at concentrated levels.

Lead

Error! Reference source not found.**40** displays the EMC and dry-weather grab results for lead at School Creek (SCH1) during 2020. Similar to what was observed for copper, one EMC sample exceeded the PWQO for lead (0.005 mg/L). All dry-weather samples were below the PWQO limit. Seasonally, the 2020 trends reveal that the highest lead concentrations occurred during late-spring and into the summer period.

Zinc

Error! Reference source not found.**40** displays the EMC and dry-weather grab results for zinc at School Creek (SCH1) during 2020. All EMC samples were above the PWQO limit of 0.02 mg/L for zinc with the exception of one sample collected on May 20, 2020. One of the three collected dry-grab samples exceeded the PWQO limit. Both the annual average for wet and dry weather samples exceeded the PWQO limit. Seasonally, the 2020 trends reveal the highest zinc concentrations



occurred during the late-spring and summer period when dilution from precipitation events decreases compared to the spring and fall months.

8.2.2.1.5 Total Suspended Solids

Error! Reference source not found. **40** displays the EMC and dry-weather grab results for TSS at School Creek (SCH1) during 2020. The CCME guidelines allow for a maximum increase of 25 mg/L (over a 24-hr period) and 5 mg/L (over a 30-day period) from background levels. The CCME guideline is not shown on **Figure 40** because no background level data was established as part of the 2020 SWM Monitoring Program.

The annual average dry-weather TSS concentration (65.5 mg/L) was higher compared to the annual average EMC concentration (44.90 mg/L). The higher dry-weather average TSS concentration is resultant of the spring grab sample that had a concentration of 123 mg/L. The summer value of 4,040 mg/L was removed from the dataset as it is expected a high amount of particulate matter entered the sample bottle when field staff noted low water levels at the time of sample collection. Seasonally, there are no obvious trends in the 2020 TSS data.

8.2.2.2 Voisin Creek (VS1)

Based on the 2020 temperature monitoring data, Voisin Creek (VS1) is thermally classified as a coolwater creek and is located within proximity to Highway 8 and other major roadways such as Homer Watson Boulevard and Fischer Hallman Road. The primary land use for Voisin Creek sub-watershed is a mixture of residential and industrial.

EMC samples were collected at Voisin Creek (VS1) during eight wet-weather events. Three dry-weather grab samples were also collected in 2020. EMC and grab sample results for each parameter analyzed at Voisin Creek (VS1) are displayed on **Figure 41** and **Figure 42** and summarized in **Table 8-17**.

**Table 8-17 Voisin Creek (VS1) – Wet (EMC) and Dry Summary**

Parameter	Wet (EMC)				Dry (Grab)			
	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)
Chloride	135.9	130.6	34.6	309.0	439.1	424.3	223.0	654.0
Nitrate	0.330	0.342	0.036	0.516	0.470	0.276	0.119	0.390
Total Phosphorus	0.266	0.295	0.130	0.776	0.679	0.054	0.030	0.088
Dissolved Phosphorus	0.0567	0.0584	0.0053	0.1590	0.0377	0.0254	0.0107	0.0433
Copper	0.0203	0.0197	0.0127	0.0412	0.0043	0.0037	0.0027	0.0054
Lead	0.0075	0.0063	0.0018	0.0151	0.0012	0.0012	0.0003	0.0026
Zinc	0.0801	0.0721	0.0336	0.1690	0.0103	0.0103	0.0067	0.0170
Total Suspended Solids	139.1	106.1	17.0	292.0	23.1	43.4	ND (0.00)	121.0

8.2.2.2.1 Chloride

Error! Reference source not found. displays the EMC and dry-weather grab results for chloride at Voisin Creek (VS1). Both the annual EMC average of 130.6 mg/L and dry-weather average of 424.3 mg/L for chloride at Voisin Creek (VS1) are above the CCME Long Term Limit (120 mg/L). The annual EMC average was above the 2019 average of 92.08 mg/L, but below the 2018 average of 185 mg/L. The annual dry-weather EMC average was slightly lower than the 2019 average of 451.33 mg/L. The highest chloride concentration was observed on April 24, 2020, at a concentration of 654.0 mg/L. This sample is believed to be affected by the impact of road salts on the creek following the spring freshet. In general, lower chloride concentrations were seen in wet samples which is attributed to dilution from precipitation. Seasonally, chloride concentrations were highest during the spring and decreased towards the fall months.

8.2.2.2.2 Nitrate

Error! Reference source not found.⁴¹ presents the EMC and dry-weather grab results for nitrate at Voisin Creek (VS1) during 2020. All EMC and dry-weather grab sample results were well below the PWQO for nitrate (13 mg/L). The annual average dry-weather nitrate concentration of 0.276 mg/L was lower in comparison to the EMC average concentration of 0.342 mg/L. This is different than what was seen during both 2019 and 2018 monitoring years at Voisin Creek (VS1) where the dry-weather average annual concentration was higher than the wet-weather average annual concentration.



8.2.2.2.3 Phosphorus

Total Phosphorus

Error! Reference source not found.**41** displays the EMC and dry-weather grab results for total phosphorus at Voisin Creek (VS1) during 2020. All sampling event results were above the PWQO for total phosphorus (0.03 mg/L) with the exception of one dry-weather sample collected in the spring. In comparison to total phosphorus concentrations at Voisin Creek (VS1) in 2019, a slight increase in average EMC concentration was observed. The annual average dry-weather concentration has decreased from 0.082 mg/L in 2019. Seasonally, total phosphorus was low during early spring with an increase into the summer months. This trend could be attributed to the application of fertilizers and cleaners in urbanized areas during the summer months which could enter the creek via surface water runoff during precipitation events.

Dissolved Phosphorus

Error! Reference source not found.**41** displays the EMC and dry-weather grab results for dissolved phosphorus at Voisin Creek (VS1) during 2020. The majority of sample results at Voisin Creek (VS1) were above the PWQO for total phosphorus (0.03 mg/L) (there is currently no PWQO for dissolved phosphorus). The annual average dry-weather concentration 0.0254 mg/L is below the PWQO limit, and lower than the annual average EMC of 0.0584 mg/L, which exceeds the PWQO limit. No seasonal trends were noted for dissolved phosphorus in 2020.

8.2.2.2.4 Metals

Copper

Error! Reference source not found.**42** displays the EMC and dry-weather grab results at Voisin Creek (VS1) during 2020. All samples collected at Voisin Creek (VS1) in 2020 were above the PWQO for copper (0.005 mg/L), with the exception of two dry-weather samples one of which was collected in the spring, and the other in the fall. The annual average dry-weather copper concentration of 0.0037 mg/L was lower compared to the annual average EMC concentration of 0.0197 mg/L in 2019. These trends are similar to those observed in both 2019 and 2018. Seasonally, copper concentrations peaked late-spring into the summer months. The 2020 copper concentrations followed the same general trend as lead, zinc and TSS, with the lowest levels observed in the early spring and highest in summer and decreasing into fall.

Lead

Error! Reference source not found.**42** displays the lead EMC and dry-weather grab results at Voisin Creek (VS1) during 2020. Three of the eight EMC samples exceeded the PWQO for lead (0.005 mg/L), while all dry-weather samples were below the PWQO. The annual average dry-weather lead concentration of 0.0012 mg/L was lower when compared to the annual average EMC concentration of 0.0063 mg/L. This is similar to what was observed for lead in Voisin Creek (VS1) in both 2019 and 2018. Similar to the seasonal trends observed for copper, lead concentrations were highest during the late spring into the summer months when water levels were at their lowest creating a concentrated effect in the watercourse.



Zinc

Error! Reference source not found. **42** displays the EMC and dry-weather grab results for zinc at Voisin Creek (VS1) during 2020. All EMC sample results were above the PWQO for zinc (0.02 mg/L). No dry sample results exceeded the PWQO for zinc. The annual average dry-weather zinc concentration of 0.0103 mg/L was lower compared to the annual EMC concentration of 0.0721 mg/L. Similar to the seasonal trends observed for both copper and lead, zinc concentrations were highest during the late spring and summer when water levels were at their lowest, creating a concentrated effect on the watercourse.

8.2.2.2.5 Total Suspended Solids

Error! Reference source not found. **42** displays the TSS EMC and dry-weather grab results at Voisin Creek (VS1) during 2020. The CCME guidelines allow for a maximum increase of 25 mg/L (over a 24-hr period) and 5 mg/L (over a 30-day period) from background levels. The CCME guidelines for TSS are not shown on **Figure 42** because no background level data was established as part of the 2020 SWM Monitoring Program.

The annual site average for TSS at Voisin Creek (VS1) was 89.03 mg/L. The annual average dry-weather TSS concentration of 43.4 mg/L was considerably lower compared to the annual EMC average concentration of 106.1 mg/L. Seasonal trends show TSS to be highest during wet-weather samples (EMC) which correlated to precipitation events with the highest TSS concentration observed in early June. This trend was also seen during the 2019 and 2018 monitoring at Voisin Creek (VS1).

8.2.2.3 Strasburg Creek (SB2)

Based on the 2020 temperature monitoring data, Strasburg Creek (SB2) is thermally classified as a cold-coolwater creek located in the southwest portion of the city. Strasburg Creek (SB2) ultimately feeds into Schneider Creek, which flows through the City's downtown core prior to discharging into the Grand River. The primary land use of the sub-watershed is residential, and recreational land, but the majority of the catchment does not receive stormwater treatment. In 2010, the Middle Branch of Strasburg Creek underwent significant improvements in aquatic environments as part of the Strasburg Creek Rehabilitation Brigadoon Pond.

EMC samples were collected at Strasburg Creek (SB2) during eight wet-weather events. Additionally, three dry-weather grab samples were collected. The following sections present the sample results for each parameter for Strasburg Creek (SB2). EMC and grab sample results for each parameter analyzed at Strasburg Creek (SB2) are displayed on **Figure 43** and **Figure 44** and summarized in **Table 8-18**.

**Table 8-18 Strasburg Creek (SB2) – Wet (EMC) and Dry Summary**

Parameter	Wet (EMC)				Dry (Grab)			
	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)
Chloride	105.3	112.1	89.2	145.0	87.1	112.8	99.4	122.0
Nitrate	0.668	0.761	0.483	1.190	1.2424	0.8116	0.0047	1.2200
Total Phosphorus	0.178	0.299	0.063	0.951	0.015	0.014	0.005	0.029
Dissolved Phosphorus	0.0127	0.0152	0.0044	0.0469	0.0104	0.0058	ND (0.000)	0.0143
Copper	0.0081	0.0111	0.0044	0.0256	0.0010	0.0003	ND (0.0000)	0.0010
Lead	0.0032	0.0054	0.0005	0.0183	0.00012	0.00008	ND (0.00000)	0.00018
Zinc	0.0363	0.0588	0.0127	0.1470	0.0162	0.0108	ND (0.0000)	0.0293
Total Suspended Solids	174.41	312.56	11.30	875.00	3.67	2.27	ND (0.00)	6.80

8.2.2.3.1 Chloride

Figure 43 displays the chloride EMC and dry-weather grab results at Strasburg Creek (SB2) for 2020. Chloride sample results for monitoring location SW8 as part of the Battler Road SSDF Monitoring Program are presented with the 2020 data to provide greater year-round context to the site.

All sample results for Strasburg Creek (SB2) were below the CCME Short Term Concentration Limit (640 mg/L) and only two EMC samples and one dry-weather sample exceeded the CCME Long Term Concentration Limit (120 mg/L). The annual average dry-weather chloride concentration 112.8 mg/L was comparable to the average EMC concentration of 112.1 mg/L. The results from monitoring location SW8 (Battler Road SSDF Monitoring Program) are consistent with the results observed at Strasburg Creek (SB2) and provides a comparable year-round view of the site. Seasonally, chloride concentrations were highest during the early spring and relatively steady over the remainder of the monitoring program.

8.2.2.3.2 Nitrate

Figure 43 displays the EMC and dry-weather grab results for nitrate at Strasburg Creek (SB2) during 2020. All sample results were well below the nitrate guideline set by the CCME (13 mg/L). The annual average dry-weather nitrate concentration of 1.343 mg/L was higher compared to the nitrate annual EMC average concentration of 0.761 mg/L. Seasonally, the nitrate concentrations are seen to be slightly higher in the spring and decrease in the fall. The higher concentrations of nitrate seen in the spring could be related to the application of fertilizers. In general, lower nitrate concentrations were noted during wet-weather sampling compared to dry-weather sampling events.



8.2.2.3.3 Phosphorus

Total Phosphorus

Figure 43 displays the EMC and dry-weather grab results for total phosphorus at Strasburg Creek (SB2) during 2020. All sample results were above the PWQO for total phosphorus (0.03 mg/L), with the exception of all three dry-weather grab samples. The annual average dry-weather concentration for total phosphorus of 0.014 mg/L was below the PWQO and lower when compared to the annual EMC average concentration of 0.299 mg/L. Seasonally, total phosphorus concentrations were higher in the late spring and summer and lower in the fall, with the exception of one sample collected late September. This seasonal relationship could be attributed to the application of fertilizers in the spring and summer months.

Dissolved Phosphorus

Figure 43 displays the EMC and dry-weather grab results for dissolved phosphorus at Strasburg Creek (SB2) during 2020. All sample results were below the PWQO for total phosphorus (0.03 mg/L) (there is currently no PWQO for dissolved phosphorus). The annual average dry-weather dissolved phosphorus concentration of 0.0058 mg/L was lower than the EMC average concentration of 0.0152 mg/L. No seasonal trends were observed for dissolved phosphorus in 2020.

8.2.2.3.4 Metals

Copper

Figure 44 displays the copper EMC and dry-weather grab results at Strasburg Creek (SB2) during 2020. Five of the eight EMC wet-weather samples were above the PWQO for copper (0.005 mg/L). Seasonally, copper concentrations were highest during the late spring and summer period, likely a direct influence of the spring melt flush effect, as well as low water levels in the summer resulting in a concentrated effect on the watercourse. The 2020 copper concentrations followed the same general trend as lead, zinc and TSS, with the lowest levels observed in the early spring and highest in summer and decreasing into fall.

Lead

Figure 44 displays the lead EMC and dry-weather grab results at Strasburg Creek (SB2) during 2020. All sample results were below the PWQO for lead (0.005 mg/L) with the exception of three wet-weather EMC samples. The annual average dry-weather lead concentration of 0.0001 mg/L was lower when compared to the annual average EMC concentration of 0.0054 mg/L. Seasonally, lead concentrations were highest during the spring and summer period when water levels were at their lowest, creating a concentrated effect on the watercourse. Similar to what was observed with the copper results, the wet-weather samples had higher concentrations of copper compared to the dry-weather samples.

Zinc

Figure 44 displays the zinc EMC and dry-weather grab results at Strasburg Creek (SB2) during 2020. All samples except one wet-weather EMC sample collected in the fall and two dry-weather grab samples exceeded the PWQO limit (0.02 mg/L). The annual dry-weather average of 0.0096 mg/L was lower compared to the annual average EMC concentration of 0.0588 mg/L. Similar to the



trends observed for copper and lead, the wet-weather samples had higher concentrations of zinc compared to the dry-weather samples.

8.2.2.3.5 Total Suspended Solids

Figure 44 displays the TSS EMC and dry-weather grab results at Strasburg Creek (SB2) during 2020. The CCME guidelines allow for a maximum increase of 25 mg/L (over a 24-hr period) and 5 mg/L (input over 24-hr over a 30-day period) from background levels. The CCME guidelines are not shown on **Figure 44** because no background data was established as part of the 2020 SWM Monitoring Program.

TSS concentrations for Strasburg Creek (SB2) ranged from “Non-Detect” which was assigned a value of 0 mg/L to 875 mg/L with an overall annual average of 227.94 mg/L. The annual average dry-weather TSS concentration of 2.27 mg/L was significantly lower compared to the annual EMC average concentration of 312.56 mg/L. Seasonally, TSS concentrations were highest during wet-weather events in the late spring and summer and decreased into the fall.

8.2.2.4 Sandrock Greenway (SR2)

Based on the 2020 temperature monitoring data, Sandrock Greenway (SR2) is thermally classified as a coolwater creek and is located just south of Highland Road West and west of Fisher Hallman Road. The primary land use of the sub-watershed is residential and recreational with minor commercial use.

EMC samples were collected at Sandrock Greenway (SR2) during eight wet-weather events. Additionally, three dry-weather grab samples were collected. The following sections present the sample results for each parameter for Sandrock Greenway (SR2). EMC and grab sample results for each parameter analyzed at Sandrock Greenway (SR2) are displayed on **Figure 45** and **Figure 46** and summarized in **Table 8-19**.

**Table 8-19 Sandrock Greenway (SR2) – Wet (EMC) and Dry Summary**

Parameter	Wet (EMC)				Dry (Grab)			
	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)
Chloride	137.9	172.3	84.4	307.0	431.1	471.3	372.0	571.0
Nitrate	0.622	0.610	0.357	1.330	0.632	0.483	0.410	0.570
Total Phosphorus	0.154	0.146	0.043	0.270	0.067	0.035	0.022	0.059
Dissolved Phosphorus	0.0489	0.0589	0.0123	0.1150	0.0389	0.0170	0.0055	0.0331
Copper	0.0143	0.0118	0.0075	0.0182	0.0024	0.0029	0.0020	0.0038
Lead	0.0021	0.0014	0.0005	0.0028	0.0002	0.0002	0.0001	0.0003
Zinc	0.0376	0.0322	0.0159	0.0775	0.0045	0.0054	0.0036	0.0071
Total Suspended Solids	67.3	44.5	10.3	104.0	4.8	5.4	ND (0.0)	10.5

8.2.2.4.1 Chloride

Figure 45 displays the chloride EMC and dry-weather grab results at Sandrock Greenway (SR2) for 2020. All sample results were below the CCME Short Term Limit (640 mg/L). All samples except one wet-weather sample exceeded the CCME Long Term Limit (120 mg/L). The annual average dry-weather chloride concentration of 471.3 mg/L was higher compared to the annual average EMC concentration of 172.3 mg/L due to the lack of dilution from precipitation events. Seasonally, chloride concentrations were the highest during the early spring and dry-weather samples were higher than wet-weather samples.

8.2.2.4.2 Nitrate

Figure 45 displays the EMC and dry-weather grab results for nitrate at Sandrock Greenway (SR2) during 2020. All results were well below the nitrate guideline set by the CCME (13 mg/L). The annual average dry-weather nitrate concentration of 0.483 mg/L was lower compared to the nitrate annual average EMC concentration of 0.610 mg/L. The maximum nitrate concentration during 2020 occurred during the June 29, 2020, wet-weather sampling event. No distinct seasonal trends were identified during the 2020 monitoring.

8.2.2.4.3 Phosphorus**Total Phosphorus**

Figure 45 displays the EMC and dry-weather grab results for total phosphorus at Sandrock Greenway (SR2) during 2020. All sample results were above the PWQO total phosphorus limit (0.03



mg/L) with the exception of two dry-weather grab samples, one of which was collected in the spring and the other in the fall. The annual average dry-weather total phosphorus concentration of 0.115 mg/L was slightly lower than the annual average EMC concentration of 0.146 mg/L. Seasonally, total phosphorus was higher during the spring and summer months. This seasonal trend could be attributed to the application of fertilizers during the spring and summer months.

Dissolved Phosphorus

Figure 45 displays the EMC and dry-weather grab results for dissolved phosphorus at Sandrock Greenway (SR2) during 2020. All sample results for dissolved phosphorus exceeded the PWQO for total phosphorus (0.03 mg/L) (there is currently no PWQO for dissolved phosphorus) with the exception of two EMC samples and two dry-weather samples. As a result, the annual average EMC concentration exceeded the PWQO for total phosphorus. The annual average dry-weather dissolved phosphorus concentration of 0.0170 mg/L was below the annual average EMC concentration of 0.0589 mg/L. Seasonally, dissolved phosphorus concentrations were elevated during the early spring months.

8.2.2.4.4 Metals

Copper

Figure 46 displays the copper EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2020. All wet-weather samples exceeded the PWQO for copper (0.005 mg/L) while all dry-weather samples were below the PWQO limit. The annual average dry-weather copper concentration of 0.0029 mg/L was lower compared to the annual average EMC concentration of 0.0029 mg/L. Seasonally, no trend was observed regarding copper concentrations.

Lead

Figure 46 displays the lead EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2020. All sample results were below the PWQO lead limit (0.005 mg/L). The annual average dry-weather lead concentration of 0.0002 mg/L was considerably lower compared to the annual average EMC concentration of 0.0014 mg/L. Seasonally, slightly elevated lead concentrations were seen during the spring.

Zinc

Figure 46 displays the zinc EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2020. All but one of the wet-weather sample results exceeded the PWQO limit (0.02 mg/L), whereas none of the dry-weather samples exceeded the PWQO limit. The annual average dry-weather zinc concentration of 0.0054 mg/L was lower when compared to the annual average EMC concentration of 0.0322 mg/L. Seasonally, zinc concentrations were higher during the spring and summer seasons.

8.2.2.4.5 Total Suspended Solids

Figure 46 displays the TSS EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2020. The CCME guidelines allow for a maximum increase of 25 mg/L (over a 24-hr period) and 5 mg/L (input over 24-hr over a 30-day period) from background levels. The CCME guidelines are not



shown on **Figure 46** because no background data was established as part of the 2020 SWM Monitoring Program.

The annual average dry-weather TSS concentration of 5.4 mg/L was considerably lower when compared to the annual average EMC concentration of 44.5 mg/L. The highest wet-weather TSS concentration was seen during the spring (May 29, 2020), with the lowest wet-weather TSS concentration seen during the fall (November 4, 2020). Generally, TSS concentrations were higher during wet-weather events compared to dry-weather events.

8.2.2.5 Lower Schneider Creek (SC1)

Based on the 2020 temperature monitoring data, Lower Schneider Creek (SC1) is thermally classified as a coolwater to cool-warmwater creek and is located near Old Mill Road between Pinnacle Drive and Mill Park Drive. The primary land use of the Lower Schneider Creek sub-watershed is residential and forested with some industrial and commercial properties.

EMC samples were collected at Lower Schneider Creek (SC1) during wet-weather events. In addition, three dry-weather grab samples were collected in 2020. The following sections present the sampling results for Lower Schneider Creek (SC1). EMC and grab sample concentrations for each parameter are displayed on **Figure 47** and **Figure 48** and summarized in **Table 8-20**.

Table 8-20 Lower Schneider Creek (SC1) – Wet (EMC) and Dry Summary

Parameter	Wet (EMC)				Dry (Grab)			
	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)
Chloride	175.7	161.4	78.4	316.0	306.1	289	242	350
Nitrate	0.71	0.69	0.36	1.06	0.95	0.93	0.80	1.17
Total Phosphorus	0.144	0.135	0.034	0.253	0.021	0.015	0.010	0.022
Dissolved Phosphorus	0.0212	0.0221	0.0040	0.1170	0.0087	0.0059	0.0040	0.0087
Copper	0.0114	0.0097	0.0049	0.0151	0.0017	0.0015	0.0014	0.0017
Lead	0.00577	0.00445	0.00085	0.01010	0.00026	0.00017	0.00013	0.00022
Zinc	0.0397	0.0299	0.0086	0.0682	0.0049	0.0025	ND (0.0000)	0.0040
Total Suspended Solids	115.44	87.28	14.90	215.00	4.54	0.83	ND (0.00)	2.50

8.2.2.5.1 Chloride

Error! Reference source not found. **47** presents the EMC and dry-weather grab results for chloride at Lower Schneider Creek (SC1) for 2020. The annual station average (wet and dry-weather results) at Lower Schneider Creek (SC1) was 196.2 mg/L, which is below the CCME Short Term Concentration



limit (640 mg/L), but above the CCME Long Term Concentration limit (120 mg/L). All three dry-weather grab samples were above the CCME Long Term Concentration limit, and five of the eight EMC samples were above the CCME Long Term Concentration limit. The average dry-weather chloride concentration of 238.3 mg/L was higher compared to the annual average EMC concentration of 161.4 mg/L. The highest recorded chloride sample was a wet-weather EMC sample collected on May 17, 2020. Lower chloride concentrations in wet-weather samples are attributed to dilution from precipitation events.

8.2.2.5.2 Nitrate

Error! Reference source not found.47 displays the EMC and dry-weather grab results for nitrate at Lower Schneider Creek (SC1). The average dry-weather nitrate concentration of 0.93 mg/L was higher than the annual average EMC concentration of 0.69 mg/L. The overall nitrate average for the site (dry and wet-weather samples) was 0.76 mg/L which is well below the CCME limit for nitrate of 13 mg/L. No significant seasonal trends were observed for nitrate at Lower Schneider Creek (SC1) during the 2020 monitoring as nitrate levels were observed to be approximately 1 mg/L throughout the year for both dry and wet-weather samples.

8.2.2.5.3 Phosphorus

Total Phosphorus

Figure 47 displays the EMC and dry-weather grab results for total phosphorus at Lower Schneider Creek (SC1) for 2020. All EMC samples were above the PWQO limit of 0.03 mg/L for total phosphorus; however, all dry-weather samples were below the PWQO limit. The annual average EMC total phosphorous concentration of 0.135 mg/L was significantly higher than the annual average dry-weather concentration of 0.015 mg/L. Seasonally, there were no observed total phosphorus trends throughout 2020.

Dissolved Phosphorus

Error! Reference source not found.47 displays the EMC and dry-weather grab results for dissolved phosphorus at Lower Schneider Creek (SC1) for 2020. During 2020, one of the eight EMC samples collected exceeded the PWQO limit for total phosphorus (0.03 mg/L) (there is currently no PWQO for dissolved phosphorus), the sample which exceeded the PWQO limit was collected in the spring. None of the dry grab samples collected in 2020 exceeded the PWQO limit. The annual average EMC dissolved phosphorus concentration of 0.0221 mg/L and the annual average dry concentration of 0.0059 mg/L are both below the PWQO limit. Seasonally, elevated dissolved phosphorus concentrations were seen early spring and mid summer.

8.2.2.5.4 Metals

Copper

Error! Reference source not found.48 displays the EMC and dry-weather grab results for copper at Lower Schneider Creek (SC1) during 2020. All EMC sample results for copper were above the PWQO limit (0.005 mg/L) with the exception of one sample collected in the spring. All dry-weather samples were below the PWQO. Seasonally, copper at Lower Schneider Creek (SC1) was highest in the summer and fall. It is assumed that the elevated copper concentrations seen during the summer and fall months are due to precipitation events causing heavy metals and road debris to



accumulate in the watercourse and appear at concentrated levels. The lead, zinc and TSS concentrations for Lower Schneider Creek (SC1) also followed this same general trend in 2020.

Lead

Error! Reference source not found. displays the EMC and dry-weather grab results for lead at Lower Schneider Creek (SC1) during 2020. Three out of the eight EMC samples collected exceeded the PWQO for lead (0.005 mg/L) while all dry-weather samples were well below the PWQO limit. Similar to what was observed for copper, seasonally, the highest lead concentrations were observed during the summer and fall sampling events.

Zinc

Error! Reference source not found.**48** displays the EMC and dry-weather grab results for zinc at Lower Schneider Creek (SC1) during 2020. Four of the eight collected samples exceeded the PWQO limit (0.02 mg/L) for zinc. The annual average dry-weather zinc concentration of 0.0025 mg/L was significantly below the PWQO limit, and the annual average EMC concentration of 0.0299 was slightly above the PWQO limit. Seasonally, the highest zinc concentration occurred during the summer when it is likely that dilution from precipitation events decreases the concentrations.

8.2.2.5.5 Total Suspended Solids

Error! Reference source not found.**48** displays the EMC and dry-weather grab results for TSS at Lower Schneider Creek (SC1) during 2020. The CCME guidelines allow for a maximum increase of 25 mg/L (over a 24-hr period) and 5 mg/L (over a 30-day period) from background levels. The CCME guideline is not shown on **Figure 48** because no background level data was established as part of the 2020 SWM Monitoring Program.

The annual average dry-weather TSS concentration of 0.83 mg/L was significantly lower when compared to the annual average EMC concentration of 87.28 mg/L. Higher TSS levels were observed during wet-weather sampling which is likely influenced by the resuspension of sediments during precipitation events. Seasonally, TSS concentrations were slightly elevated during the summer.

8.2.2.6 Upper Schneider Creek (SC9)

Based on the 2020 temperature monitoring data, Upper Schneider Creek (SC9) is thermally classified as a cool-warmwater creek and is located adjacent to Courland Avenue, just south of Highway 7. The primary land use of the Upper Schneider Creek sub-watershed is residential, recreational, commercial and some industrial properties.

EMC samples were collected at Upper Schneider Creek (SC9) during wet-weather events. In addition, three dry-weather grab samples were collected in 2020. The following sections present the sampling results for the Upper Schneider Creek (SC9). EMC and grab sample results for each parameter analyzed at Upper Schneider Creek (SC9) are displayed on **Figure 49** and **Figure 50** and summarized in **Table 8-21**.

**Table 8-21 Upper Schneider Creek (SC9) – Wet (EMC) and Dry Summary**

Parameter	Wet (EMC)				Dry (Grab)			
	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)	5-year Annual Average (mg/L)	Annual Average (mg/L)	Annual Minimum (mg/L)	Annual Maximum (mg/L)
Chloride	112.0	108.4	66.9	142.0	316.2	322.7	269.0	407.0
Nitrate	0.349	0.292	0.123	0.514	0.966	0.847	0.600	1.240
Total Phosphorus	0.256	0.204	0.073	0.367	0.022	0.022	0.019	0.024
Dissolved Phosphorus	0.0176	0.0131	ND (0.0000)	0.0594	0.0092	0.0060	0.0037	0.0086
Copper	0.0173	0.0119	0.0012	0.0181	0.0020	0.0023	0.0018	0.0029
Lead	0.0106	0.0069	0.0024	0.0149	0.0002	0.0002	0.0001	0.0004
Zinc	0.0789	0.0499	0.0067	0.0853	0.0076	0.0117	0.0054	0.0243
Total Suspended Solids	228.44	150.76	72.00	267.00	4.32	3.60	ND (0.00)	6.90

8.2.2.6.1 Chloride

Error! Reference source not found.**49** presents the EMC and dry-weather grab results for chloride at Upper Schneider Creek (SC9) for 2020. The annual station average (wet and dry-weather results) at the site was 166.7 mg/L, which is below the CCME Short Term Concentration limit (640 mg/L), but above the CCME Long Term Concentration limit (120 mg/L). All three dry-weather grab samples were above the CCME Long Term Concentration limit, and all EMC samples were above the CCME Long Term Concentration limit. The annual average dry-weather chloride concentration of 322.3 mg/L was higher compared to the annual average EMC concentration of 108.4 mg/L. The highest chloride concentrations were observed during dry-weather sampling events. Lower chloride concentrations in wet-weather samples are attributed to dilution from precipitation events. Seasonally, the highest chloride concentrations were observed during the spring sampling event which is likely a result of road salt from the spring freshet.

8.2.2.6.2 Nitrate

Error! Reference source not found.**49** displays the EMC and dry-weather grab results for nitrate at Upper Schneider Creek (SC9). All nitrate samples were significantly lower than the CCME Long Term Concentration guideline for nitrate of 13 mg/L. The annual average dry-weather nitrate concentration of 0.847 mg/L was higher than the annual average EMC concentration of 0.292 mg/L. The overall nitrate average for the Site (dry and wet-weather samples) was 0.443 mg/L which is well below the CCME limit. No significant seasonal trends were identified for nitrate during the 2020 monitoring.



8.2.2.6.3 Phosphorus

Total Phosphorus

Error! Reference source not found.**49** displays the EMC and dry-weather grab results for total phosphorus at Upper Schneider Creek (SC9) for 2020. All EMC samples were above the PWQO limit (0.03 mg/L) for total phosphorus; however, all dry-weather samples were below the PWQO limit. Due to this, the average annual EMC total phosphorus concentration of 0.204 mg/L was significantly higher than the average annual dry-weather concentration of 0.022 mg/L. Seasonally, total phosphorus results were elevated during the spring and summer months. This is likely attributed to the application of fertilizers and cleaners during the spring and summer months, which could enter the creek via surface water runoff during precipitation events.

Dissolved Phosphorus

Figure 49 displays the EMC and dry-weather grab results for dissolved phosphorus at Upper Schneider Creek (SC9) for 2020. During 2020, one of the eight EMC samples collected exceeded the PWQO limit for total phosphorus (0.03 mg/L) (there is currently no PWQO for dissolved phosphorus). None of the dry-weather grab samples exceeded the PWQO limit. The annual average EMC dissolved phosphorus concentration of 0.0131 mg/L is significantly higher than the annual dry sample average of 0.0060 mg/L. Seasonally, there was no observed trend for dissolved phosphorus present, with the exception of one spike in dissolved phosphorus observed during the November 17, 2020, sampling event.

8.2.2.6.4 Metals

Copper

Error! Reference source not found.**50** displays the EMC and dry-weather grab results for copper at Upper Schneider Creek (SC9) during 2020. All EMC sample results for copper at were above the PWQO limit (0.005 mg/L), with the exception of one sample collected on July 28, 2020. All dry-weather grab samples were below the PWQO limit. Seasonally, copper at Upper Schneider Creek (SC9) was elevated during the spring and summer months. During the spring and summer months, it is speculated that precipitation events caused heavy metals and road debris to accumulate in the watercourse and appear at concentrated levels.

Lead

Error! Reference source not found.**50** displays the EMC and dry-weather grab results for lead at Upper Schneider Creek (SC9) during 2020. Six of the eight collected EMC samples exceeded the PWQO for lead (0.005 mg/L). All of the dry-weather samples were well below the PWQO limit. Similar to what was observed for copper, seasonally, the 2020 trends reveal the highest lead concentrations occur during the spring and summer months.

Zinc

Error! Reference source not found.**50** displays the EMC and dry-weather grab results for zinc at Upper Schneider Creek (SC9) during 2020. All of the EMC samples were above the PWQO limit of 0.02 mg/L for zinc, with the exception of one sample collected on September 30, 2020. One of the three collected dry samples exceeded the PWQO limit. The annual average EMC concentration for zinc of 0.0499 mg/L was above the PWQO limit, while the annual average dry-weather concentration



of 0.0117 mg/L was below the PWQO limit. Similar to what was observed for both copper and zinc, the highest zinc concentrations occurred during the spring and summer months.

8.2.2.6.5 Total Suspended Solids

Error! Reference source not found. **50** displays the EMC and dry-weather grab results for TSS at Upper Schneider Creek (SC9) during 2020. The CCME guidelines allow for a maximum increase of 25 mg/L (over a 24-hr period) and 5 mg/L (over a 30-day period) from background levels. The CCME guideline is not shown on **Figure 50** because no background level data was established as part of the 2020 SWM Monitoring Program.

The annual average dry-weather TSS concentration of 3.60 mg/L was significantly lower compared to the annual average EMC concentration of 150.76 mg/L. Higher TSS levels were observed during wet-weather sampling, which is likely influenced by the resuspension of sediments during precipitation events. Seasonally, higher TSS concentrations were observed during the spring and summer of 2020.

9. Historical Trends

Historical trends have been identified by comparing sites monitored in 2020 that had six or more years of historical water quality data for two indicator parameters: chloride and TSS. Sites with six or more years of data are summarized in **Table 9-1**. As per the recommendation of the 2018 SWM Monitoring Program, Sandrock Greenway (SR2) and Strasburg Creek (SB2) have been established as long-term monitoring stations as of 2019 and will act as representative warmwater and coldwater stations for historical trend comparisons.

Table 9-1 Historical Sites

Location	Years of Available Data		
	Dry	Wet	EMC
Lower Schneider Creek (SC1)	16	14	2
Sandrock Greenway (SR2)	14	10	3
Strasburg Creek (SB2)	17	13	3

The historical trends presented in the 2020 SWM Monitoring Report remain consistent with the 2019, 2018 and 2017 Monitoring Reports with the annual results presented along the y-axis in a continuous but irregularly scaled manner, using ordinal dates along the x-axis. The ordinal day is one on January 1, counting daily through 365 on December 31 (or 366 during leap years). Using the ordinal day for comparison of historical data aligns representative results from the same periods during the years. In the historical figures the most recent data is given a solid colour. This colour fades as a gradient with the oldest analytical results being shown as the lightest colour. Seasonal patterns are visible as overlapping analytical results being shown as the lightest colour. Seasonal patterns are visible as overlapping annual trends, data gaps as a lower density of points, outlier results stand out on their own, and emerging trends are given directional impact from the changing gradient.



General seasonal trends that remain consistent across all monitoring locations include chloride concentrations being higher during dry-weather grab samples collected throughout the summer period. This is likely caused by the concentrated effect in the waterbody due to low water levels. However, it should be noted that winter samples when de-icing activities are in effect are not collected as part of the SWM monitoring program. Without this data, it is possible that the true annual peak chloride concentration for each monitoring site is not represented.

TSS values reveal wet-weather samples to have higher TSS concentrations than dry-weather sample events. The maximum seasonal concentration is generally seen during the summer monitoring period when water levels are at their lowest and intense precipitation events create flashy, turbid conditions. In some monitoring years, the maximum seasonal concentration is seen during the spring melt when debris is flushed through the waterbodies; however, this trend is dependent on the annual precipitation regime.

9.1 Lower Schneider Creek (SC1)

Error! Reference source not found.**51** and Error! Reference source not found.**53** provide ordinal scatter plots of the historical results for chloride and TSS at Lower Schneider Creek (SC1) during wet-weather, dry-weather, and EMC events. **Figure 52** and **Figure 54** provide the concentration statistic box and whisker plots for the historical chloride and TSS results displaying the minimum, maximum, and average concentrations per year along with the first and third quartiles. These plots provide greater context to the data with respect to annual average trends and range of results collected. Lower Schneider Creek (SC1) is the only monitoring location with 16 straight years of data (i.e., annual no data gaps), specifically for chloride.

In 2015, only one sample was collected while other years had over 15 samples collected per year. It should be noted that wet-weather grab sampling was removed from the SWM monitoring program in 2016. Wet-weather monitoring is now completed through EMC monitoring, therefore no wet-weather grab samples were collected from 2017 to 2020. Wet-weather sampling was completed through EMC monitoring in 2017 and in 2020. The Lower Schneider Creek (SC1) location has transitioned to a long-term monitoring station, therefore wet-weather EMC samples will be collected at this site for the foreseeable future.

Wet-weather chloride samples at Lower Schneider Creek (SC1) have typically been below the CCME Long-Term guideline of 120 mg/L. The maximum recorded wet-weather chloride concentration was observed in 2007 with a value of 507.0 mg/L. Dry-weather chloride concentrations have generally remained consistent around the 200-400 mg/L range, with the majority of samples exceeding the CCME Long-Term guideline of 120 mg/L. The maximum recorded dry-weather chloride concentration was collected in 2014 with a value of 1,050 mg/L. As shown in **Figure 52**, the 1,050 mg/L chloride concentration inflates the concentration average for 2014 above the third quartile. The 2019 chloride concentrations ranged from 280 mg/L to 362 mg/L with an average of 344 mg/L. In comparison, the 2020 chloride concentrations ranged from 78.4 mg/L to 350.0 mg/L, with an average of 183.4 mg/L.

Historical data has revealed that dry-weather concentrations of TSS have generally been below 25 mg/L, with the exception of three dry-weather grabs. It should be noted that no TSS samples were collected from 2013 to 2016. Historical wet-weather grab samples ranged from “Non-Detect” which was assigned a value of 0 mg/L to 980 mg/L. As shown in **Figure 54**, the 980 mg/L TSS



concentration inflates the concentration average for 2008 above the third quartile. The 2019 TSS concentrations ranged from 2.1 mg/L to 15.2 mg/L with an average of 8.1 mg/L. In comparison, the 2020 TSS concentrations ranged from “Non-Detect” (0.0 mg/L) to 215.0 mg/L with an average of 70.4 mg/L. This range is much larger than the observed TSS range in 2019 due to the numerous wet-weather EMC samples collected in 2020.

9.2 Sandrock Greenway (SR2)

Error! Reference source not found.55 and Error! Reference source not found.57 provide ordinal scatter plots of the historical results for chloride and TSS at Sandrock Greenway (SR2) during wet-weather, dry-weather, and EMC events. **Figure 56** and **Figure 58** provide the concentration statistic box and whisker plots for the historical chloride and TSS results displaying the minimum, maximum, and average concentrations per year along with the first and third quartiles. These plots provide greater context to the data with respect to annual average trends and range of results collected. No data is available from 2003 to 2007. In 2014, only two samples were collected while in other years (2002 to 2016) had a minimum of 5 samples collected per year. It should be noted that wet-weather grab sampling was removed from the SWM monitoring program in 2016. Wet-weather monitoring is now completed through EMC monitoring, therefore no wet-weather grab samples were collected in 2016 to 2020. In 2019, the Sandrock Greenway (SR2) site became a long-term monitoring station; therefore, wet-weather EMC samples will be collected at this site for the foreseeable future.

The minimum chloride concentrations at Sandrock Greenway (SR2) were initially below the CCME long-term guideline of 120 mg/L; however, this limit has been exceeded in recent years (2017-2018). The majority of dry-weather concentrations have exceeded the CCME long-term guideline of 120 mg/L. The maximum chloride concentration observed at 2,090 mg/L during a dry-weather sampling event in 2012 also exceeded the CCME short-term limit of 640 mg/L. As shown in **Figure 56**, the 2,090 mg/L concentration inflates the concentration average for 2012 above the third quartile. This was one of two samples in the historical dataset for Sandrock Greenway (SR2) that was collected during the winter months on January 23, 2012, and is the most representative of the effects of de-icing activities. The chloride concentration values for 2019 ranged from 67 mg/L to 757 mg/L with an average of 249 mg/L. In comparison, the chloride concentration values for 2020 ranged from 84.4 mg/L to 571 mg/L with an average of 253.9 mg/L, showing a similar trend to what was observed in 2019.

The majority of dry-weather samples have been below 25 mg/L for TSS. The maximum dry-weather grab sample concentration of TSS was observed in 2012 with a concentration of 237.0 mg/L. Wet-weather TSS measurements were consistently higher than dry-weather sample events, with the maximum value observed in 2012 with a value of 290.0 mg/L. In 2013, the majority of the dry and wet-weather samples were “Non-Detect”, thus those samples were assigned concentration values of 0.0 mg/L; however, two concentrations of 70.0 mg/L and 72.0 mg/L were observed during dry and wet-weather conditions, respectively. As shown in **Figure 58**, the 2013 statistics resulted in a first and third quartile of 0.0 mg/L, thus no box plot is displayed. The TSS concentration values for 2019 ranged from 2.5 mg/L to 112.0 mg/L with an average of 47.8 mg/L. In comparison, the TSS concentration values for 2020 ranged from 3.0 mg/L to 104.0 mg/L with an average of 34.1 mg/L, showing a similar trend to what was observed in 2019.



9.3 Strasburg Creek (SB2)

Error! Reference source not found.59 and Error! Reference source not found.61 provide ordinal scatter plots of the historical results for chloride and TSS at Strasburg Creek (SB2) during wet-weather, dry-weather, and EMC events. **Figure 60** and **Figure 62** provide the concentration statistic box and whisker plots for the historical chloride and TSS results displaying the minimum, maximum, and average concentrations per year along with the first and third quartiles. These plots provide greater context to the data with respect to annual average trends and range of results collected. Chloride and TSS data are not available for 2010 and 2018, as well as no TSS data for 2004. It should be noted that wet-weather grab sampling was removed from the SWM monitoring program in 2016. Wet-weather monitoring is now completed through EMC monitoring, therefore no wet-weather samples were collected from 2016 to 2020. In 2019, the Strasburg Creek (SB2) site became a long-term monitoring station therefore wet-weather EMC samples will be collected at this site for the foreseeable future.

It should be noted that no samples have been collected as part of the monitoring program during the winter and early spring months when road salt application is in effect and chloride concentrations are highest. However, winter samples are collected at monitoring location SW8 as part of the City's Battler Road SSDF Post-Construction Monitoring Program. This station is located approximately 30 m downstream of the Strasburg Creek (SB2) site. Winter chloride results for SW8 have been included on **Figure 59** for reference, as per the recommendation of the 2018 SWM Monitoring Program.

The majority of chloride concentrations during wet-weather events and EMC sampling are below the CCME long-term guideline of 120 mg/L and no values exceeded the CCME short-term guideline of 640 mg/L. As a general trend, dry-weather sample events have higher chloride concentrations than wet-weather sample events. The maximum chloride concentration was observed in July 2005 with a value of 355 mg/L. The maximum annual chloride concentrations decreased in subsequent monitoring years; however, the annual average appears to be steadily increasing again from 2011 to 2020. The inclusion of the SW8 samples from the Battler Road SSDF Post-Construction Monitoring Program provide a more complete understanding of the full range of chloride concentrations year-round. During the winter months (January to March), chloride concentrations in 2019 and 2020 were between 125 mg/L and 425 mg/L at SW8. As shown in **Figure 60**, the maximum chloride concentration of 154.0 mg/L in 2012 has inflated the concentration average above the third quartile. The chloride concentration values for 2019 ranged from 61.7 mg/L to 141.0 mg/L with an average of 97.6 mg/L. In comparison, the chloride concentration values for 2020 ranged from 88.2 mg/L to 145.0 mg/L with an average of 112.3 mg/L.

The general trend observed is that TSS concentrations increase significantly during wet-weather sample events compared to dry-weather sample events. Over recent years, dry-weather concentrations of TSS have been below 25 mg/L, with the exception of one dry-weather event in 2003 with a value of 42 mg/L and a dry-weather event in 2013 with a value of 28 mg/L. Wet-weather measurements in 2007 resulted in the maximum TSS concentration of 1,770 mg/L with the next highest concentration of 875.0 mg/L observed in 2020. As shown in **Figure 62**, in 2002, 2007, and 2013, the annual concentration average was inflated above their respective third quartiles. The TSS concentration values for 2019 ranged from 2.1 mg/L to 59.9 mg/L with an average of 27.4 mg/L. In comparison, the TSS concentration values for 2020 ranged from 0.0 mg/L to 875.0 mg/L with an average of 223.5 mg/L.



10. Biological Monitoring

As part of the 2020 SWM Monitoring Program, both fish and benthic invertebrate surveys were conducted. Benthic invertebrate and fish community monitoring occurred at a total of 7 stations (SB2, SC1, SR2, VS1 SC9, SCH1 and SB13a). The dates of the biological monitoring are presented in **Table 10-1**.

Table 10-1 Biological Monitoring Events

Location	Watercourse	Thermal Regime	Benthic Monitoring Date	Fish Monitoring Date
SB2	Strasburg Creek	Cold-Coolwater	July 14, 2020	July 28, 2020
SC1	Lower Schneider Creek	Coolwater to Cool-Warmwater	July 14, 2020	July 28, 2020
SR2	Sandrock Greenway	Coolwater	July 15, 2020	July 30, 2020
VS1	Voisin Creek	Coolwater	July 15, 2020	July 28, 2020
SC9	Upper Schneider Creek	Cool-Warmwater	July 15, 2020	July 29, 2020
SCH1	School Creek	Coolwater	July 15, 2020	July 28, 2020
SB13a	North Strasburg Creek	Coldwater	July 14, 2020	July 29, 2020

10.1 Site Identification

All biological monitoring sites were set-up following OSAP Section 1: Modules 1 and 2 - Defining Site Boundaries and Key Identifiers; Screening Level Site Documentation (Stanfield, 2013). Upstream and downstream site boundaries were documented at each site to ensure repeatability for future monitoring. The survey reach began at a cross-over point located at a riffle feature and flagged with a wood stake. Site location was thoroughly documented to ensure these boundaries can be found in future years, ensuring repeatability. The average stream width was measured using a metre tape at the downstream cross-over point. This point was multiplied by ten to obtain a minimum reach length of 60 metres (m), as per literature that states within stable low gradient streams, the spacing of cross-overs will be seven to ten times the bankfull stream width (Stanfield, 2013). The survey reach included a minimum of three riffle-pool sequences enabling local variances and different habitat types.

10.2 Benthic Invertebrate Monitoring

10.2.1 Benthic Invertebrate Monitoring Field Methodology

Seven monitoring sites were sampled semi-quantitatively using the Transect Travelling Kick-and-Sweep methodology following OSAP and the OBBN protocol (Stanfield, 2013; Jones *et al*, 2007). Cross-stream transects were continuously disturbed by vigorous kicking for three minutes while sweeping a 500-micron D-net downstream. This process was repeated for each of the three replicate stations; replicate stations were collected over a riffle-pool-riffle sequence within the identified sampling reach.

All samples were field processed to remove excess sediment and organic material using a 500-micron sieve. Any woody debris and larger detritus collected were scrubbed and/or picked over to ensure retention of organisms.



All sites were Global Positioning System (GPS) referenced in the Universal Transverse Mercator coordinate system UTM17 NAD83 coordinates using a Garmin® handheld GPS system. Supplemental field parameters were recorded including dominant substrate class, organic matter-aerial coverage, riparian vegetation community, aquatic macrophytes and algae. Discrete surface water quality field measurements were collected using a U-52 Horiba multi-parameter water quality meter for pH, DO, turbidity, specific conductivity, and temperature.

Benthic invertebrate samples were transferred into 1 litre (L) plastic sample containers, labelled, and field preserved in a 90 percent isopropanol solution. Benthic invertebrate samples were submitted to an experienced taxonomist for taxonomic enumeration and identification to the lowest practical level. Copies of the field data sheets are provided in **Appendix G**.

10.2.2 Benthic Invertebrate Analytical Methodology

Benthic invertebrate samples were processed by William B. Morton in Guelph, Ontario. The samples were processed in the same manner as previous year's studies following OBBN protocols. Before sorting, the samples were placed into a geological sieve with a 0.5-micron mesh to drain and save the field preservative, then rinsed with tap water. Small amounts of sediment were then placed into sorting trays and the invertebrate specimens were removed with the assistance of a 10x dissecting microscope. Extra sub-samples were processed until at least 100 organisms were removed. All the specimens in the last sub-sample were completely sorted. The blot dried wet weight of the sorted material versus that of the total sample's was used to calculate the percent sub-samples (sorted/total x 100 = %). The sorted sediments were discarded, and any unsorted material was returned to the original container with the reserved field preservative and re-preserved.

Prior to identification, the specimens were sorted into like groups then identified to the lowest practical level (species if possible). Identified specimens were placed into labelled shell vials with neoprene stoppers and preserved with 75 percent ethanol. Any taxa new to the study were added to the existing reference collection. The resulting data was entered into two Excel spreadsheets, one with the combined taxa list from 2016, 2017, 2018, 2019 and 2020 and a second with only the 2020 data.

Sub-sampling was completed only when samples were too large to be processed in a timely manner. Sub-sampling was completed using a Marchant sub-sampler following the procedures described by Marchant (1989). The Marchant box is divided into 100 equal cells; the entire sample is placed in the box, diluted with water, gently shaken to mix the sample and distribute it into the cells. Cells are then randomly selected using two 10-sided dice, and the selected cell is sorted and identified. This procedure continues until the targeted number of organisms is reached (in this case 100), when the data is entered into the database this count is extrapolated to the full 100 cell count, and this is the number recorded.

From the laboratory data, community metrics were calculated to better understand the composition and changes in the invertebrate communities over time. Species richness and species composition were calculated, in addition to the following functional feeding groups and habitat/behavioral characteristics:



- Taxa Richness
- % Dominant
- % Oligochaeta
- % Diptera
- % Chironomidae
- % EPT
- Number of EPT
- % Predators
- % Collector-Filterer
- % Collector-Gatherer
- % Scraper
- % Shredder
- % Clinger
- Shannon-Weiner Diversity Index
- Hilsenhoff Biotic Index (HBI)

10.2.2.1 Taxa Richness

Taxa richness refers to the number of distinct taxa represented in a sample, excluding immature specimens unless they are the sole representation of a particular taxon. In southern Ontario, the expected range for unimpaired gravel bottom creeks is 20-40 taxa per site (Griffiths, 1999) with higher values typically being representative of good stream health.

10.2.2.2 Percent Dominant

An assessment of dominance involves determination of the most numerous taxon in a sample. Where the dominant species constitute greater than 50 percent of a sampled community, they are considered to be the characterizing species and can act as a means to assess the cause of impairment (Griffiths, 1999). A high dominance percentage generally indicates a less diverse community, and therefore a potentially more impaired community.

10.2.2.3 Percent EPT

Percent EPT (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) is a community metric that measures the proportion of specific pollution intolerant orders within a sample to make inferences of stream health. It is calculated here as the total number of EPT individuals present as a proportion of the total number of individuals in the sample. Lower percentages of EPT are generally representative of poor water quality.

10.2.2.4 Number of EPT

The number of EPT metric is simply the sum of the number of all EPT taxa (family level) in a sample. **Table 10-2** illustrates the inferred water quality associated with the number of families of EPT (Mackie, 2004).

Table 10-2 EPT Value Index

EPT Value	Water Quality Assessment
>10	Non-impacted
6-9	Slightly Impacted
3-5	Moderately Impacted
0-2	Severely Impacted



10.2.2.5 Percent Feeding Class

To determine percent feeding class the total individuals of taxa classified by a particular feeding habit/group is divided by the total number of individuals in a sample and multiplied by 100. This metric aids in the determination of community structure. Feeding groups and habits represented in analyses include predator, collector-filterer, collector-gatherer, scraper, shredder, and clinger. Each of the feeding habits/groups is further detailed herein.

Predator

Organisms that are considered predators obtain food by consuming other organisms. Predators use various strategies to capture their prey, including modified mouth parts, legs, and behavior (Griffiths, 1999).

Collector-filterer

Organisms that are considered collector-filterers capture particles directly from the water column and typically have special adaptations (ability to construct nets or modified mouth parts) to filter feed (Griffiths, 1999).

Collector-gatherer

Collector-gatherers are organisms that use modified mouth parts to sieve or collect small particles from deposited sediment and debris (Griffiths, 1999).

Scraper

Scrapers are organism that feed on periphyton by grazing or scraping mineral and organic surfaces (Merritt et al., 2008).

Shredder

Shredders are detritivores that feed on decomposing plant tissue by chewing, and/or organisms that feed on wood by gouging and excavating (Merritt et al., 2008).

Clinger

Clingers are organisms that have adaptations which allow them to attach to surfaces in flowing water (Barbour et al., 1999).

10.2.2.6 Shannon-Weiner Diversity Index

The Shannon-Weiner Diversity (H') is commonly used to characterize species diversity in a community by using both abundance and evenness of the species present. H' is calculated using the following formula:

$$H' = - \sum p_i \log p_i$$
$$\text{where } p_i = \frac{n_i}{N}$$

Where:

p_i = the proportion of the total number of individuals occurring in species i



n_i = the number of individuals occurring in species i
 N = The total number of taxa in a sample

The number and distribution of taxa increase in relation to H' . **Table 10-3** illustrates the degree of organic pollution representative for different ranges of H' values (modified from Griffiths, 1999). This index provides equal weight to all species present in a sample.

Table 10-3 Shannon-Weiner Diversity Index

Shannon-Weiner Diversity Index (H')	Degree of Organic Pollution
3 - 5	Unpolluted
1 - 3	Moderate Pollution
<1	Substantial Pollution

10.2.2.7 Hilsenhoff Biotic Index (HBI)

This index was originally developed by Hilsenhoff (1982) to assign a single “tolerance value” to a community and indicate nutrient and organic pollution. This index provides an estimate of water quality for each site using established pollution tolerance values for each taxon. The single value is a mean of all the tolerance values of the taxa represented in a sample. Tolerance values, taken from Hilsenhoff (1987) are a measure of an organism’s tolerance to organic pollution and range from 0 (very intolerant) to 10 (highly tolerant). Based on the taxon level for this analysis, the equation for the HBI is:

$$HBI = \frac{\sum(n_i \times t_i)}{N}$$

Where:

n_i = the number of individuals of species i
 t_i = the tolerance value of species i
 N = the total number of individuals in the sample

The relative water quality scale developed by Hilsenhoff (1987) to interpret the results of this index is provided in **Table 10-4**.

Table 10-4 Hilsenhoff Biotic Index

Hilsenhoff Biotic Index (HBI)	Water Quality	Implied Degree of Organic Pollution
0.0 - 3.5	Excellent	No organic pollution
3.5 - 4.5	Very Good	Slight organic pollution
4.5 - 5.5	Good	Some organic pollution
5.5 - 6.5	Fair	Fairly substantial pollution
6.5 - 7.5	Fairly Poor	Significant organic pollution
7.5 - 8.5	Poor	Very significant organic pollution
8.5 - 10.0	Very Poor	Severe organic pollution



10.2.3 Benthic Invertebrate Monitoring Results

Benthic invertebrate monitoring results for 2020, as well as historical trends, are provided in the following sections.

10.2.3.1 Benthic Invertebrate Community

A multi-metric suite of analyses were conducted on the benthic invertebrate data sets of samples collected from the sampled reaches. These included abundance, species richness and community structure, in addition to functional feeding groups and habitat/behavioral characteristics.

Expected values have been developed for unimpaired gravel bottom creeks in southern Ontario. The 2020 results and historical results were compared where applicable to these expected values following the methodologies of Griffiths (1999). This method of comparison represents an industry standard, and these expected values can act as a baseline for comparison in the absence of habitat specific expected values. Similarly, it is established that larger values for Taxa Richness, percent EPT, number of EPT taxa, percent Scrapers, percent Shredders, percent Clingers and the Shannon-Weiner Diversity Index, imply a healthy biological community, and low values imply reduced ecosystem health (Jones, 2007; Barbour et al., 1999). Conversely, lower percent Diptera, percent Chironomidae, percent dominant and HBI values implies a healthier biological community (Jones, 2007; Barbour et al., 1999). In conjunction with comparisons to expected values for unimpaired creeks and established ranges for indices, the 2020 results were also compared to the other monitoring sites and for temporal trends within sites.

Indicator values have not been established for metrics such as percent Collector-filterer, percent Collector-gatherer, percent Predator and percent Oligochaeta (critical values lay at both extremes) (Jones, 2007; Barbour et al., 1999). Therefore, these metrics will not be used for water quality comparison between sites. These indices are presented to identify differences in habitat characteristics between the sample sites, and to provide insight into whether a community is changing over time as a result of either natural or anthropogenic impacts.

Table 2 presents a summary of the 2020 results of the calculated metrics used to analyze the benthic invertebrates collected at the sample sites.

The following paragraphs provide brief summaries of the benthic community recorded at the seven SWM monitoring program sites. A list of all identified taxa for the 2020 monitoring season is found in **Appendix H**.

Strasburg Creek (SB2)

SB2 had the highest taxa richness and number of EPT families of all the sites during the 2020 monitoring. The benthic community was diverse, with a low dominance percentage (16%). The most abundant taxon was the genus *Hydropsyche* within the order Trichoptera, similar to 2019. A second genus within the Trichoptera order, *Dolophilodes* also had a notably high abundance, together contributing to the high percentage of EPT species (34%) at this site. All functional feeding groups were represented within the benthic community with collector-gatherers (44%) and collector-filterers (32%) being the most abundant and scrapers (6%) and shredders (6%) being the least abundant groups. SB2 had the highest Shannon-Weiner Diversity Index (3.12) and lowest HBI (5.44) of all stations. The value for Shannon-Weiner Diversity index indicated a diverse community with unpolluted water while the HBI value suggest good water quality with some organic pollution. This



represents a slight improvement of the Shannon's Diversity Index and a slight decrease in HBI from 2019.

North Strasburg Creek (SB13a)

The benthic community of SB13a was fairly diverse with a taxa richness of 24. However, the percent dominance was on the higher end comparatively to other stations at 46% suggesting a lower species evenness. The taxon with the highest abundance was *Caecidotea*, a genus within the Isopoda order and second highest abundance (34%) was the genus *Simulium* within the Diptera order. Both of these taxa are part of the clinger behavioral group, contributing to the high percentage of clingers (82%) observed at this station. The functional feeding groups with the highest percentage include collector-gatherers and collector-filterers with 52% and 35%, respectively. No shredders were observed at this station and scrapers had the second lowest percentage composing of only 1% of the benthic community. Three EPT families were present and made up 2% of the overall community. The values for the Shannon-Weiner Diversity Index (1.57) falls within a moderate degree of organic pollution, while the HBI (6.72) indicates fairly poor water quality indicative of significant organic pollution. Together these results suggest a degree of water quality impairment for North Strasburg Creek.

Lower Schneider Creek (SC1)

The benthic community at SC1 was fairly diverse with a diverse taxa richness of 30. The percent dominance was fairly low (18%), implying a more even distribution across taxa. The most abundant taxon was the genus *Cheumatopsyche* within the order Trichoptera. A second genus within the Trichoptera order, *Hydropsyche*, also had a notably high abundance, together contributing to the high percentage of EPT species (55%), the highest value across all sites. The functional feeding groups with the highest percentage include collector-gatherers and collector-filterers with 47% and 35%, respectively, and the lowest include scraper (5%) and shredder (2%). The values for the Shannon-Weiner Diversity Index (2.63) falls within a moderate degree of organic pollution, while the HBI (5.90) indicates fair water quality indicative of fairly substantial organic pollution. These values both represent improvement for Lower Schneider Creek compared to 2019 and suggest moderate water quality impairment.

Upper Schneider Creek (SC9)

The benthic community of SC9 is comprised of a diverse taxa richness of 29, however has a percent dominance of 43%, suggesting a lower species evenness. The most abundant taxon was *Caecidotea*, an isopoda within the Asellidae family. Species within the family Asellidae are considered moderately tolerant to pollution and tend to increase in number under eutrophic conditions (Peckarsky et al. 1990). As *Caecidotea* is characterized as being a collector-gatherer and clinger for the functional feeding group and behavioral group, respectively, the high abundance of this taxon contributed to the high values observed for both the percentage collector-gathers (55%) and percent clingers (61%). Three EPT families were observed, whose total individuals represented 12% of the benthic community. The values for the Shannon-Weiner Diversity Index (2.22) indicate a moderate degree of organic pollution, while the HBI (7.11) suggests fairly poor water quality indicative of significant organic pollution. Together these results suggest a degree of water quality impairment for Upper Schneider Creek.



Sandrock Greenway (SR2)

The benthic community at SR2 had fairly high taxa richness (32) and low percent dominance (26%), which together are generally good community indications. However, a high Chironomidae percentage (61%) was observed which is greater than the upper limit of the expected values for an unimpaired system. This metric suggests that the bulk of the benthic community is comprised of taxa tolerant to impaired water conditions and is consistent with results from 2019 monitoring. Many members of the Chironomidae family are part of the collector-gatherer functional feeding group which also contributed to the high percentage of collector-gatherers (52%) observed. The predator functional feeding group also had a notable high percentage (33%) which was the highest value observed across all stations and represents an increase from 2019 for this station. Two EPT families were observed, which together represented 14% of the benthic community. The values for the Shannon-Weiner Diversity Index (2.47) falls within a moderate degree of organic pollution, while the HBI (7.16) indicates fairly poor water quality indicative of significant organic pollution. Together these results suggest a degree of water quality impairment for Sandrock Greenway.

Voisin Creek (VS1)

Station VS1 had by far the lowest taxa richness (10) and only one EPT family. The benthic community was dominated by the genus *Caecidotea* (73%), an isopoda within the Asellidae family. Species within the family Asellidae are considered moderately tolerant to pollution and tend to increase in number under eutrophic conditions (Peckarsky et al. 1990). As *Caecidotea* is characterized as being a collector-gatherer and clinger for the functional feeding group and behavioral group, respectively, the high abundance of this taxon contributed to the high values observed for both the percentage collector-gathers (97%) and percent clingers (74%). No shredders or scrapers were observed at this station and collector-filterers and EPT families both contributed to less than 1% of the overall benthic community. The values for both the Shannon-Weiner Diversity Index (0.96) and HBI (8.21) also indicate impaired water quality with ranks of substantial pollution and very poor water quality with severe organic pollution, respectively. This represents an increase in HBI, and similar Shannon-Weiner Diversity Index values compared to 2019. Together, these results suggest significant water quality impairment for Voisin Creek.

School Creek (SCH1)

This was the first year of monitoring School Creek. A total of 25 taxa were observed, of which only one was a member of an EPT order. *Stictochironomus*, a genus within the Chironomidae family was the dominant taxon, comprising of 27% of the benthic community. One other notably abundant taxon that was observed was *Pisidium*, a bivalve mollusc, which accounted for 21% of the benthic community. *Pisidium* has been observed at other stations but is generally only present in relatively low abundances. The most abundant functional feeding group was collector-gatherer (53%) followed by collector-filterer (27%); shredders and scrapers represented less than 1%. The value for the Shannon-Weiner Diversity Index was 2.21 which suggests the watercourse contains a moderate degree of organic pollution. The HBI value was 8.52 which is the highest HBI value observed across all stations. This is likely due to the abundance of highly tolerant *Stictochironomus*, which has a HBI tolerance value of 9. The HBI score for this station indicates very poor water quality with a severe amount of organic pollution. Together, the benthic community results suggest significant water quality impairment of School Creek.



10.2.3.2 Benthic Invertebrate Community Trends

Historical consecutive benthic invertebrate results from 2013 to 2020 are only available for SB2 and SR2; therefore, benthic invertebrate trends will only be compared between these two watercourses. Previous reports included historical trend discussion for Montgomery Creek (MG1); however, MG1 was not included as a monitoring station for the 2020 program. As such, a comparison of the trends between SB2 and SR2 over time is provided in **Table 3**.

Strasburg Creek (SB2)

Historically, Strasburg Creek (SB2) showed the poorest water quality in 2014. Since then, the water quality has gradually shown improvements between the 2015 – 2020 monitoring results. In 2020, the assessed metrics indicated consistent or slight improvements relative to the 2019 results. The HBI value in 2020 was 5.4 which represents a slight quality decline relative to the 2019 HBI value 5.0. Despite this increase, the HBI value still indicates good water quality with only some impacts and is consistent with 2017 – 2019. The Shannon-Weiner Diversity Index value for 2020 was 3.1 which falls within the range of an unpolluted watercourse. This result represents continual improvement from 2017 – 2020 and is the highest value observed historically for this station. Improvements in diversity are also indicated with an increase in Taxa Richness to 41 which is the same taxa richness as 2015 and is the highest value observed for this station. The number of EPT families for 2020 was 6, which also shows continual improvements from 2017 – 2020. There was a slight decrease observed in percent EPT (34% in 2020), however is still considered healthy and consistent with the percent EPT greater than 20% since 2015. Notable improvements since 2014 in metrics such as HBI and percent Chironomidae suggest that the dramatic decline in 2014 results were likely anomalous and may have been attributed to natural factors such as seasonal fluctuations, low sample abundance, change in sample collectors, and/or changes in the flow regime. In 2020, this watercourse continues to be considered having one of the healthiest biological communities of the stations examined as part of this study.

Sandrock Greenway (SR2)

Historically, the water quality of Sandrock Greenway (SR2) has remained fairly consistent from 2013 with only gradual metric changes throughout the years. In 2020, the HBI value was 7.2 which represents the third consecutive year of decreasing (improved quality) HBI values from 2018 – 2020. This trend may indicate some level of improvement in the last few years, however the current HBI value still suggests fairly poor water quality with significant organic pollution. In 2019 an increase in percent Chironomidae was observed well above the expected value for an unimpaired system. This value decreased in 2020 which may indicate that the abnormally high value observed in 2019 was an anomaly and not indicative of any true pattern. However, the 2020 metric results suggest that shows a level of impairment remains. The Shannon-Diversity Index value was consistent with that of the 2019 results and has remained fairly similar since 2014. There was an improvement observed for taxa richness, with the highest value observed historically for this station (richness of 32 taxa). The number of EPT taxa has remained fairly consistent with values from 2015 – 2019, however percent EPT showed a significant improvement despite being fairly low from 2015 – 2019. Overall, water quality metrics for Sandrock Greenway (SR2) generally indicate a level of impairment consistent with previous years, although minor improvements in 2020 may reveal a pattern of gradual water quality enhancement in following monitoring years.



10.3 Fish Community Monitoring

10.3.1 Fish Community Monitoring and Analysis Methodologies

The intent of the fish community surveys was to produce a comprehensive fish species inventory within the site, characterize the fish community and provide a qualitative assessment of species abundance to compare to historical monitoring efforts.

A Licence to Collect Fish for Scientific Purposes was obtained from the Ministry of Natural Resources and Forestry (MNRF) prior to study commencement (Licence #1095946). A copy can be found in **Appendix I**.

A single pass backpack electrofishing survey was conducted as per OSAP Section 3: Module 1 at seven monitoring sites along five creeks using a Halltech electrofisher, model HT-2000. No blocknets were installed during the fish community assessments of the stations, as this is an optional technique for single pass surveys and was deemed unnecessary for this survey. Fish were enumerated at the end of each pass.

Total number of fish, species, total lengths in millimetres (mm) and approximate weights in grams (g) were recorded for each the maximum and minimum fish of each species captured during the survey. Photographs of each species were taken for future reference. Fish survey field sheets are located in **Appendix J**.

In addition, discrete water quality field parameters were measured at each survey site using a Horiba U-52 multi-parameter water quality meter and included temperature, pH, specific conductivity, turbidity, DO, ORP, and TDS.

10.3.2 Fish Community Monitoring Results

Fish community monitoring results for 2020, as well as historical trends, are provided in the following sections.

10.3.2.1 Fish Community

The results of the 2020 fish community survey (presented in **Table 4**) indicate a fish community similar to that of past monitoring years. Historical fisheries data from 2014 to 2020 are presented in **Table 5**.

Strasburg Creek (SB2)

A total of nine species were identified within the study area in 2020. This is a slight decrease from 2019, which observed ten species. However, this diversity is overall higher than historic sampling events which captured eight and six species in 2017 and 2016, respectively. The two coldwater species, brook trout (*Salvelinus fontinalis*) and mottled sculpin (*Cottus bairdii*), that have been observed since 2014 were again recaptured in the 2020 monitoring. Abundance of brook trout were not as high as previously observed which led to a slight decrease in the intolerant species percentage. No new species were identified as part of the 2020 monitoring program.

In 2019, Strasburg Creek (SB2) scored the highest for total fish abundance, which was a large increase from previous events. The fish abundance in 2020, was again high, although not to the same magnitude as observed the previous year, with 102 individuals observed, compared to 214 in



2019. The species composition contained a mix of tolerant, intermediate, and intolerant species, with creek chub (*Semotilus atromaculatus*) being the most abundant for 2020 compared to pumpkinseed (*Lepomis gibbosus*) in 2019. Mottled sculpin also had a notably high abundance, which is consistent with previous years. The percent of tolerant species increased from 9.81% in 2019 to 32.35% in 2020. This is likely attributed to a decrease in pumpkinseed, an intermediate tolerance species, which saw a large population in 2019. Percent of intolerant species is largely determined by the presence of brook trout as this is the only intolerant species identified throughout the reach. One brook trout was observed in 2020 which is a decrease from seven observed in 2019. This resulted in a decrease in percent intolerant species and marks the third consecutive decrease of this metric since 2017, however this result is also influenced by the high overall fish abundances observed in 2020 and 2019.

The 2020 Thermal Stability Classifications (**Table 7-3**) characterized Strasburg Creek to support a cold-coolwater thermal regime. This was confirmed through the fish species captured within the study area in 2020. The most abundant fish found in all datasets were coolwater species which include five species (white sucker, creek chub, longnose dace, western blacknose dace, brook stickleback), totalling 59 individuals. All five of these species are native coolwater species. There were two native coldwater species (mottled sculpin and brook trout) captured totalling 25 individuals. Warmwater species included the capture of two species (pumpkinseed and fathead minnow) totalling 18 individuals. The percentage of fish attributed to cold, cool, and warm water designations includes 57.84% coolwater, 24.51% coldwater, and 17.65% warmwater.

Strasburg Creek was previously characterized to support coldwater to cold-coolwater thermal regime in 2019. However, this classification was not a reflection of fish species captured within the study area in 2019. The most abundant fish found in 2019 was coolwater species; with five species (white sucker, creek chub, longnose dace, western blacknose dace, and brook stickleback), totalling 52 individuals. The next abundant was warmwater species, with three species (pumpkinseed, fathead minnow, and bluntnose minnow) totalling 137 individuals. Coldwater species include the capture of two species (mottled sculpin and brook trout) totalling 25 individuals. The percentage of fish attributed to cold, cool, and warm water designations includes 64.02% warmwater, 24.3% coolwater and, 11.68% coldwater. Heavy rainfall events in January 2020 and above average snowfall in February 2020 may have contributed to the decrease in warmwater individuals observed in 2020 surveys.

North Strasburg Creek (SB13a)

North Strasburg Creek (SB13a) was added to the fish community monitoring program in 2020 after not being sampled since 2016. In total, two fish species were captured, namely pumpkinseed and creek chub with a total of 39 individuals captured. This is a decrease in the total number of species from 2016 but is consistent with results from 2015 and 2014. However, the species community that make up the various sampling years are slightly different, resulting in a total of six different species that have been observed in this reach, of which pumpkinseed represents a new species observed in this year's monitoring. The total abundance observed in 2020 was the highest of all previous monitoring years, however, was mainly dominated by creek chub, a tolerant species, and therefore resulted in a high percent tolerant species value.

North Strasburg Creek was not assessed for thermal stability classification, however, the study area observed one native coolwater species (creek chub) totalling 34 individuals, and one native



warmwater species (pumpkinseed), totalling five individuals during 2020 surveys (87.18% coolwater and 12.82% warmwater).

Sandrock Greenway (SR2)

Sandrock Greenway (SR2) had the highest total number of fish observed across all 2020 monitoring locations, with a total catch of 202. This also marks the highest fish abundance from all previous monitoring years. The fish community was made up of a mix between cool and warmwater species with tolerances ranging from tolerant to intermediate. The most dominant species was pumpkinseed with 117 individuals captured, the majority of which being young of year. There were no new species captured and the remaining species have all been frequently observed in previous monitoring years. Despite the large abundance of pumpkinseed, an intermediate tolerance species, the percent tolerant species value (42%) remained fairly consistent with 2019 but does show a trend of decreasing compared to previous monitoring years.

The 2020 Thermal Stability Classifications (**Table 7-3**) characterized Sandrock Greenway to support a coolwater thermal regime. This was not a reflection of fish species captured within the study area in 2020. The most abundant fish found in all datasets were warmwater species which included two species (pumpkinseed and fathead minnow), totalling 133 individuals. There were two coolwater species (white sucker and creek chub) totalling 69 individuals. The percentage of fish attributed to cold, cool, and warm water designations includes 65.84% warmwater and 34.16% coolwater.

In 2019, Sandrock Greenway was designated to support a coolwater thermal regime. This was also not a reflecting of fish species captured. The most abundant fish was warmwater species which included three species (pumpkinseed, fathead minnow, and bluntnose minnow), totalling 38 individuals followed by coolwater species resulting in the capture of two species (white sucker and creek chub), totalling 20 individuals. Similar to the findings in 2020 datasets, the percentage of fish attributed to cold, cool, and warm water designations includes 65.52% warmwater and 34.48% coolwater.

In 2016, Sandrock Greenway was characterized to support a cool-warmwater to warmwater thermal regime. Fish community monitoring was not completed for that year; however, the thermal stability classification seems to be appropriate given the fish species composition observed in 2019 and 2020.

Voisin Creek (VS1)

No fish were captured at Voisin Creek (VS1) in 2020, which is a consistent result from the previous two sampling years conducted in 2019 and 2018. This resulted in VS1 having the lowest scores for all categories. In all previous monitoring years seasonally low water levels were observed in this reach and it is anticipated that this is the likely reason for the absence of fish.

Voisin Creek was assessed for thermal stability classification in 2020, 2019, and 2018 (**Table 7-3**), however no fish were captured in any of the years.

Lower Schneider Creek (SC1)

Lower Schneider Creek (SC1) was added to the fish community monitoring program in 2020 after not being sampled since 2017. In total, five species were captured with longnose dace (*Rhinichthys obtusus*) being the most dominant species. This represents an increase in species diversity, however longnose dace was also the most dominant species in 2017. Fish abundance in 2020 was



also larger with 28 individuals captured compared to 14 in 2017. The community is made up of warm to coolwater species with tolerances ranging from intermediate to tolerant. Bluntnose minnow (*Pimephales notatus*) is the only species that was not recaptured since the 2017 monitoring event. The only tolerant species observed was one creek chub which resulted in a very low percent tolerance value of 3.6%. This is the lowest value of all other stations sampled in 2020, however as the 2017 monitoring did not capture any tolerant species this value was 0%.

The 2020 Thermal Stability Classifications (**Table 7-3**) characterized Lower Schneider Creek to support a coolwater to cool-warmwater thermal regime. This reflected fish species captured within the study area in 2020. The most abundance fish species includes the capture of four coolwater species (creek chub, longnose dace, western blacknose dace, and an unidentified young of year), totalling 26 individuals. Warmwater species were less common, with one species (pumpkinseed) captured totalling two individuals (92.86% coolwater and 7.14% warmwater).

Lower Schneider Creek was previously characterized to support a coolwater thermal regime in 2017. This was a reflection of the fish species captured within the study area in 2017. Coolwater species was the most abundant fish species resulting in capture of two species (longnose dace and an unidentified young of year), totalling 13 individuals. A single warmwater species (bluntnose minnow) were also captured. These findings were the same as 2020 results, with percentage of fish attributed to cold, cool, and warm water designations including 92.86% coolwater and 7.14% warmwater.

Upper Schneider Creek (SC9)

Upper Schneider Creek (SC9) was last sampled in 2017. A total of nine species were captured in 2020 which is an increase from the seven species captured in 2017. Species composition was fairly different with five new species captured, including common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), brook stickleback (*Culaea inconstans*), common shiner (*Luxilus comulus*), and rock bass (*Ambloplites rupestris*). Three species from 2017 sampling were not recaptured, including goldfish (*Carassius auratus*), longnose dace, and white sucker (*Catostomus commersonii*). Fish abundance was also higher in 2020 with 107 individuals captured compared to 71 in 2017. Species composition consisted of mainly coolwater species with intermediate tolerance. Percent tolerant species was 33.6% which is a slight decrease from 2017.

The 2020 Thermal Stability Classifications (**Table 7-3**) characterized Upper Schneider Creek to support a cool-warmwater thermal regime. This reflected the fish species captured within the study area in 2020. The most abundant fish species includes the capture of five coolwater species (creek chub, western blacknose dace, brook stickleback, common shiner, and rock bass), totalling 77 individuals. There was also the capture of four warmwater species (common carp, pumpkinseed, fathead minnow, and bluntnose minnow), totalling 30 individuals (71.96% coolwater and 28.04% warmwater).

Upper Schneider Creek was also characterized to support a cool-warm water thermal regime in 2017. This was also a reflection of the fish species captured within the study area in 2017. The most abundant fish species includes the capture of four coolwater species (white sucker, creek chub, longnose dace, and western blacknose dace), totalling 54 individuals. Additionally, three warmwater species (pumpkinseed, bluntnose minnow, and goldfish), totalling 17 individuals, were captured (76.06% coolwater and 23.94% warmwater).



School Creek (SCH1)

No previous fish community sampling was conducted for School Creek. A total of five species were captured. Brook stickleback, an intermediate coolwater species, dominated the species composition resulting in a relatively low percent tolerant species value of 28.2%. A total of 131 species were captured however, due to the short length and width of the reach (31 m and 2.1 m, respectively) the density of fish was the highest of all stations sampled in 2020 with number of fish collected/100m² being 198.4.

The 2020 Thermal Stability Classifications (**Table 7-3**) characterized School Creek to support a coolwater thermal regime. This reflected the fish species captured within the study area in 2020. The most abundant fish species captured was four coolwater species (white sucker, creek chub, and brook stickleback) totalling 129 individuals. Warmwater species was less abundant with one species (fathead minnow) captured totalling two individuals (98.47% coolwater and 1.53% warmwater).

10.3.2.2 Fish Community Trends

Consecutive historic fish community results are only available for Strasburg Creek (SB2) and Sandrock Greenway (SR2). **Table 6** displays the similarities and differences between the 2020 sampling results and those of previous years. Fish community surveys were not conducted at SR2 during the 2013 or 2016 monitoring programs, while no fish community sampling was conducted at SB2 in 2018.

Strasburg Creek (SB2)

During the 2020 monitoring, species richness decreased by one compared to 2019 but still represents a positive trend from previous monitoring years. A large increase in pumpkinseed abundance was observed in 2019 however this trend did not continue in 2020 and instead appears to be an isolated instance of abnormally high pumpkinseed survivorship in 2019. Fish abundance appears to fluctuate between sampling years without any clear trends. Despite a decrease in abundance observed in 2020 compared to 2019, values are still in line with previous sampling years. In addition to the high fish diversity observed in 2020, the species composition was notably more even with no specific species dominating the majority of the fish community. The two coldwater species that have been observed at all previous monitoring years, mottled sculpin, and brook trout, were again observed in 2020, however only one individual brook trout was observed. As brook trout is the only intolerant species identified at this site, the low abundance observed in 2020 resulted in a lower percent intolerant species value suggesting a potential decreasing trend between 2017 - 2020. Percent tolerant species increased in 2020 and was the highest of all previous sampling events. This increase may be attributed to a higher abundance of the tolerant creek chub and subsequent decrease in intolerant pumpkinseed from the previous year. Overall, a positive trend towards a more diverse and even species composition was observed, however, results from 2020 may indicate some level of change towards a more tolerant species composition.

Sandrock Greenway (SR2)

During the 2020 monitoring, species richness was low and resulted in four species being captured. This is fairly consistent with previous monitoring years where taxa richness has ranged between four and six. The percent tolerant species value is slightly lower than 2019 and indicates a consistent decreasing trend since 2015 monitoring. The main different from 2020 compared to any previous



monitoring year is the high fish abundance. A total of 202 fish were captured throughout the reach in 2020, whereas the next highest abundance was 95 individuals captured during 2018. The majority of the fish community in 2020 was comprised of pumpkinseed in the young-of-year and small juvenile year classes. Pumpkinseed were also found in high abundances in previous years but not to the same magnitude as observed in 2020. Sampling conducted in 2017 reveals the lowest fish abundance from all sampling years. This is likely explained by the observation that fish were not all being impacted by the electric field at the time of the survey and to avoid lethally harming any fish the voltage and frequency settings were not increased. Overall, the fish community at Sandrock Greenway appears to remain fairly consistent with previous years, however results do indicate that percent tolerant species may be trending downward as more intermediate tolerant species such as pumpkinseed become more abundant.

10.4 Biological Monitoring Trend Summary

This section provides a summary and comparative review of the data compiled for the *Five-Year Stormwater Report Card 2010 Technical Report* (AECOM, 2011) and the *Stormwater Management Audit 5 Year Report Card* (TSH, 2008) with the 2020 biological monitoring results. **Table 7** contrasts the 2020 biological indicators as compared to the first 5-years study (2002 – 2006) and the second 5-years study (2007 – 2011). To maintain consistency, only historical data from two replicate sites, Sandrock Greenway (SR2) and Strasburg Creek (SB2) are examined in this summary.

The results for both the first 5-years study and the second 5-years study for Sandrock Greenway (SR2) indicate a tolerant, impacted system with minor adjustments in metrics between the studies. The 2020 results indicate both minor improvement and consistencies with previous studies. The HBI value for the reach has improved but is still within the range of 'fairly poor' invertebrate-inferred water quality which is consistent with the second 5-years study. Species richness in 2020 is consistent with observations in the first 5-years study but fish indicator species present in 2020 show improvements to the species composition.

The results of both the first and second 5 years studies for Strasburg Creek (SB2) consistently indicate a somewhat impacted system capable of supporting intolerant fish species. The 2020 results indicate continued improvement across all biological indicators, with increased fish species richness, good benthic-invertebrate-inferred water quality, and maintenance of both brook trout and mottled sculpin populations.

Overall, the biological indicators suggest an equal or improved water quality of the respective watercourses in 2020 relative to that indicated by the results of the 5-year studies from the early 2000's.

11. SWMF Performance Monitoring

11.1 SWMF Performance Monitoring Methodology

The SWMF monitoring portion of the program focused on Pond 6, located at 641 Manchester Road. Monitoring was conducted in compliance to the issued Environmental Compliance Approval (ECA) #33882-A8WQUM. The performance monitoring included the collection of wet-weather grab samples and an annual inspection of the SWMF. As per the ECA, grab samples were collected from the 600 mm diameter outfall pipe during three wet-weather rainfall events. Further, two of the three events were required to occur between May and September. Wet-weather events were defined as receiving a minimum of 15 mm of rain in the 24-hours prior to sampling. An additional sample was collected in August 2020 due to the heavy rainfall event which received 34.6 mm within a 24-hour period. The water quality grab samples were tested for TSS at ALS Laboratories in Waterloo.



11.2 SWMF Performance Monitoring Results

The TSS concentrations observed during the sampling events are summarized in **Table 11-1**.

Table 11-1 Pond 6 2020 TSS Concentrations

Date	TSS (mg/L)	24-hour Precipitation (mm)
3/29/2020	21.4	21.8
5/18/2020	12.1	21.0
6/11/2020	14.0	32.8
8/2/2020	10.5	34.6

Notes:

1. Precipitation data collected from the Kitchener City Hall Rain Gauge, approximately 3.5 km from site.

The SWMF annual inspection was completed on August 2, 2020. The completed inspection checklist can be found in Appendix K along with a photo log of photographs taken during the inspection. The phot log also includes photographs taken during prior sampling events.

In general, the facility infrastructure and pond were deemed in acceptable condition. Items of note included the high turbidity of water in Forebay #1, Forebay #2, and the main pond, which was attributed to the precipitation preceding the inspection. In addition, excessive vegetation growth was observed in the main pond. The outlet channel was found to have significant vegetation and minor sediment accumulation. Erosion and gullyng along the south edge of the access trail/path was observed immediately west of Inlet #1 (north inlet). Turbid water from the active erosion was observed in Forebay #1. The approximate depth of the gullyng was 0.30 m.



GHD recommends that the City continue to monitor the above noted items that could potentially lead to long term maintenance and/or safety issues.

12. Overall Summary

12.1 Water Quality Monitoring

Table 12-1 summarizes the water quality results of the 2020 SWM Monitoring Program. For each parameter, the annual average, maximum and minimum concentration are shown. A severity scale has been applied to each parameter, where:

- Red highlighted cells indicate the minimum concentration exceeds the CCME/PWQO guideline
- Orange highlighted cells indicate the average concentration exceeds the CCME/PWQO guideline
- Yellow highlighted cells indicate the maximum concentration exceeds the CCME/PWQO guideline



Table 12-1 Summary of 2020 SWM Water Quality Monitoring Results

Location	Chloride Limit: 120 mg/L (Long-Term)			TSS Limit: N/A			Total Phosphorus Limit: 0.03 mg/L			Nitrate (as N) Limit: 13 mg/L			Lead Limit: 0.005 mg/L			Copper Limit: 0.005 mg/L			Zinc Limit: 0.02 mg/L		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
Blair Creek at New Dundee Road (Station 2414002)	73	86	39	5.3	32.0	ND	0.052	0.142	0.013	0.193	0.832	ND	0.001	0.001	0.001	0.001	0.002	ND	0.005	0.007	0.004
Blair Creek at Reichert Drive (Station 2414044)	68	79	45	4.3	9.4	ND	0.027	0.039	0.011	0.443	1.220	0.142	ND	ND	ND	0.002	0.003	0.001	0.005	0.005	0.004
Blair Creek at Dickie Settlement (Station 2414001)	55	60	34	8.1	43.2	1.0	0.013	0.064	0.000	2.770	3.750	1.320	NM	NM	NM	NM	NM	NM	NM	NM	NM
Sandrock Greenway (SR2)	254	571	84	33.8	104	ND	0.115	0.270	0.022	0.575	1.330	0.357	0.0011	0.0028	0.0001	0.009	0.018	0.002	0.025	0.078	0.004
Voisin Creek (VS1)	211	654	35	89.0	292	ND	0.229	0.776	0.088	0.324	0.516	0.036	0.0049	0.0151	0.0003	0.015	0.041	0.003	0.055	0.169	0.007
Upper Schneider Creek (SC9)	167	407	67	110.6	267	ND	0.154	0.367	0.019	0.443	1.240	0.123	0.0051	0.0149	0.0001	0.009	0.018	0.001	0.040	0.085	0.005
North Strasburg Creek (SB13a)	454	551	388	13.8	24.3	ND	0.044	0.092	0.016	0.533	0.540	0.520	0.0002	0.0003	0.0001	0.001	0.002	0.001	0.034	0.092	0.005
Strasburg Creek (SB2)	112	145	89	228	875	ND	0.222	0.951	0.005	0.920	1.600	0.483	0.0040	0.0183	0.0000	0.008	0.026	ND	0.045	0.147	ND
School Creek (SCH1)	153	307	43	49.0	94.2	8.0	0.134	0.341	0.021	0.867	1.810	0.026	0.0015	0.0068	0.0002	0.008	0.012	0.001	0.034	0.086	0.007
Lower Schneider Creek (SC1)	196	316	78	63.7	215	ND	0.103	0.253	0.010	0.755	1.170	0.360	0.0033	0.0101	0.0001	0.007	0.015	0.001	0.030	0.068	ND

Notes:

NM – Not Measured

ND – Non-Detect (value of zero assigned)

1. Red highlighted cells indicate the minimum concentration exceeds the CCME/PWQO guideline
2. Orange highlighted cells indicate the average concentration exceeds the CCME/PWQO guideline
3. Yellow cells indicate the maximum concentration exceeds the CCME/PWQO guideline



Similar to previous years, the average concentration of chloride at majority of locations exceeds the CCME Long-Term Exposure Limit of 120 mg/L, except at Strasburg Creek (SB2) and all Blair Creek locations. Of all the locations which exceeded the CCME Long-Term Exposure Limit for the average observed chloride concentration, only North Strasburg Creek (SB13a) also exceeded that location's minimum chloride concentration, identifying a negative water quality impact.

No limits for TSS concentrations have been set for long-term comparison, therefore exceedances at the monitoring locations during the 2020 monitoring program could not be determined.

The average concentration for total phosphorus exceeded the PWQO limit of 0.03 mg/L at all but two locations, Blair Creek at Reichert Drive (2414044) and Blair Creek at Dickie Settlement (2414001). Blair Creek at New Dundee Road (214002) continued to exceed the PWQO limit with the annual minimum value exceeding the guideline concentration. Only Voisin Creek (VS1) had its minimum total phosphorus concentration above the PWQO limit.

As seen in previous years, nitrate concentrations continued to experience no exceedances at any of the locations. Unlike 2019, the average lead concentration at Upper Schneider Creek (SC9) exceeded the PWQO limit of 0.005 mg/L while the maximum concentration for five locations exceeded the applicable limit. In 2020, exceedances in average and maximum copper and zinc concentrations were observed at almost all the core monitoring locations. Only North Strasburg Creek (SB13a) did not exceed the PWQO limit for copper.

To provide an alternate overall assessment of each sub-watershed based on the parameters monitored as part of the city-wide monitoring efforts, specific parameter plots are provided in **Figure 63** to **Figure 66**. These plots provide a breakdown for select parameters with respect to water quality for the sub-watersheds monitored in 2020 based on sub-watershed area and how water quality is improving or degrading, compared to the previous year and 5-year averages. For these plots, "good" water quality is defined as a parameter result being below applicable water quality objectives or guidelines (i.e., PWQO or long-term CCME). For parameters where the CCME guideline is applicable, "fair" water quality is defined as a parameter result that is between the long-term and short-term limit. For parameters where the PWQO is applicable, "fair" water quality is defined as a parameter result between the PWQO value and double the PWQO value. For parameters where the CCME guideline is applicable, "poor" water quality is defined as a parameter result that is above the short-term limit. For parameters where the PWQO is applicable, "poor" water quality is defined as a parameter result above double the PWQO value. **Table 12-2** provides a summary of the city-wide parameter assessments.

Table 12-2 City-wide Parameter Assessment Summary

Parameter	Good Water Quality (%)	Fair Water Quality (%)	Poor Water Quality (%)	Not Assessed (%)
Chloride	8.5	16.4	0.2	74.9
Nitrate/Phosphorus	16.8	1.9	6.4	74.9
Zinc/Lead/Copper	14.3	4.8	6.0	74.9

An overall city-wide multiparameter sub-watershed assessment is provided in **Figure 67**, where an average was calculated for each water quality category for each parameter presented in **Figure 63** to **Figure 66**. Based on these results, 13.1% of the of the sub-watershed areas monitored in 2020



has “good” water quality, 6.3% has “fair” water quality, and 5.8% has “poor” water quality. In 2020, 74.9% of the sub-watershed area was not assessment (i.e., not monitored).

12.2 Water Quality Historical Trends

Historical trends have been identified by comparing sites monitored in 2020 that had six or more years of historical water quality data. Sites with six or more years of water quality data included: Lower Schneider Creek (SC1), Sandrock Greenway (SR2) and Strasburg Creek (SB2). Time series are provided for TSS and chloride, shown using ordinal days along the x-axis. Metals and nutrients are generally correlated with TSS and follow the same pattern.

General seasonal trends that remain consistent across all monitoring locations include chloride concentrations being higher during dry-weather grab samples collected throughout the summer period. This is likely caused by the concentrated effect in the waterbody due to the low water levels. Variations in chloride concentration can also be attributed to winter weather conditions during a specific year. If more freeze-thaw cycles are observed during a particular winter, high chloride concentrations can generally also be observed which may be related to increased road salt application required during those years.

Chloride concentrations at Lower Schneider Creek (SC1) appear to be fluctuating within the 100 mg/L to 350 mg/L range with values in 2020 lower than 2018 and 2019. Similar to Lower Schneider Creek (SC1), Chloride concentration at Sandrock Greenway (SR2) appear to also be fluctuating within the 100 mg/L to 350 mg/L range with values in 2019 and 2020 lower than 2018. At Strasburg Creek (SB2), a steady increase in annual chloride concentration averages from 2011 to 2020 was observed.

TSS values reveal that wet-weather samples have higher TSS concentrations than dry-weather sample events. The maximum seasonal concentration is generally seen during the summer monitoring period when water levels are at their lowest, and intense precipitation events create flashy, turbid conditions. In some monitoring years, the maximum seasonal concentration is seen during the spring melt when debris is flushed through the waterbodies, however, this trend is dependent on the annual precipitation regime.

TSS concentrations at Lower Schneider Creek (SC1) appear to be fluctuating within the 0.0 mg/L to 140 mg/L range with values in 2020 within this range but higher than 2018 and 2019. The 2020 TSS concentrations were still below 2012 which historically had the highest TSS concentrations between 160 mg/L and 200 mg/L. TSS concentrations at Sandrock Greenway (SR2) appear to be fluctuating within the 0.0 mg/L to 75 mg/L range with values in 2020 lower than 2019 but higher than 2018. At Strasburg Creek (SB2), TSS concentrations historically fluctuated within the 0.0 mg/L to 30 mg/L range; however, in 2019 TSS concentrations increased to 40 mg/L while 2020 was observed to have the highest average (223 mg/L) and range of TSS concentrations in the long-term dataset.

12.3 Biological Monitoring

Fish community surveys and benthic invertebrate sampling was conducted at seven stations (SC1, SCH1, SB2, VS1, SB13a, SC9, and SR2). The results of these surveys and sampling were compared between watercourses. Additionally, the monitoring results of Strasburg Creek (SB2) and



Sandrock Greenway (SR2) were also compared against the first and second Five Year Report Card values to help identify any changes in the aquatic communities over time.

Blair Creek

As a result of the current on-going COVID-19 pandemic, biological monitoring data was not collected by the GRCA in 2020 due to limited resources. As the biological monitoring data collected at Blair Creek is only compared to itself year over year, GHD acknowledges the impact will result in a data gap in the 2020 sampling year, with 2021 being presumably the next year for comparison. The scheduled monitoring in 2020 was intended to be a biomass (triple pass) surveying year for fish community, where higher catch rates would have typically been observed resulting in potentially a more complete depiction of the local fish community. GRCA confirmed that 2021 sampling would be completed as a biomass (triple pass) surveying year. GHD does not expect significant trends to be lost with a single year data gap for the fish community and benthic invertebrate data sets.

Benthic Invertebrate Monitoring

The 2020 samples at all seven stations included a total of 80 taxa, which is fairly consistent with previous years where the same number of stations were sampled (seven stations sampled in 2018 resulting in 84 taxa). Seven new taxa were identified as part of the 2020 monitoring, including one species of Ephemeroptera (HBI tolerance value of 4). In general, the new taxa had mixed tolerance values ranging from 2 – 10 indicating low to high tolerance to organic pollution. Contrary to previous sampling years, Chironomidae (non-biting midges) was not the most abundant group and instead the Isopod genus *Caecidotea* was the most abundant. This resulted from extremely high counts at a few stations (specifically VS1). The next most abundant groups, in order of decreasing abundance include, Chironomidae (non-biting midges), caddisflies (family: *Hydropsychidae*), and black flies (genus: *Simulium*). In addition, two taxa of EPT, one individual of *Leuctra* and 29 *Dolophilodes* (stonefly and caddisfly, respectively), were reported at Strasburg Creek (SB2). Both of these taxa have an HBI tolerance value of zero, the lowest possible value for a taxon indicating good water quality. This represents both an increase in abundance and diversity of zero tolerance taxa at SB2 compared to 2019.

One station, Voisin Creek (VS1) had taxa richness lower than the expected range for an unimpaired gravel-bottom creek, although abundance fell within the expected range. This is due to the high abundance of the tolerant isopod *Caecidotea* sp. which dominated the species composition. The number of EPT families was low with only one family recorded, the caddisfly *Hydropsychidae*. This is likely an indication of impaired water quality at this station, reflected by the high HBI value and lowest Shannon's diversity index value of all stations monitored in 2020.

The historic benthic invertebrate results for Strasburg Creek (SB2) and Sandrock Greenway (SR2) were also compared (**Appendix L: Figure 1**). Strasburg Creek (SB2) displayed an overall improvement in water quality between 2015 – 2020. One negative trend observed was a gradual increase in HBI value from 2017 – 2020. Despite this gradual increase, all index scores within this timeframe represent good water quality with some organic pollution. Trends indicating improved diversity were also noted with consecutive improvement observed for Shannon Diversity Index, Taxa Richness (**Appendix L: Figure 2**), and EPT Taxa. Historically, Sandrock greenway (SR2) results largely indicate consistently impaired conditions, however various levels of water quality improvement trends were observed in 2020. A slight decrease in HBI Index was observed and



represents the third consecutive year of metric improvement (**Appendix L: Figure 3**). Number of EPT taxa remained consistently low with previous years, however, a significant increase in EPT percentage was observed in 2020, suggesting there was increase in abundance of previously established EPT taxa. Improvement to overall benthic diversity was also observed, reflected by an increase in Taxa Richness which also marks the highest taxa richness observed for this site.

Fish Community Monitoring

Seven sites were monitored in 2020, which resulted in a total of 14 species observed throughout the Study Area (**Appendix L: Figure 4**). In contrast, both 2019 and 2018 observed ten species at four and six sites, respectively.

A new site to the City's monitoring program, School Creek (SCH1), was established in 2020. The reach was characteristically short due to close proximity to the confluence with Lower Schneider Creek, however due to the high abundance of fish captured, resulted in the highest density of fish captured per 100 m² across all sites. Fish community consisted of a mix between cool and warmwater species with tolerance ranging from tolerant to intermediate. Of the five species captured, brook stickleback dominated the community with 83 individuals out of the total 131 fish captured.

No fish were captured at Voisin Creek (VS1), which is a consistent result to 2019 and 2018 sampling years. Seasonally low water levels were observed during fish sampling which likely limits the ability for fish to inhabit the reach.

Sandrock Greenway (SR2) scored the highest for number of fish captured across all sites with 202 fish captured. This also marks the highest fish abundance recorded for this site compared to all previous sampling years. The high fish abundance is due to pumpkinseed which dominated the fish community. The majority of pumpkinseed captured were of the young of year and small juvenile year classes which suggests this species had high spawning success in 2020. Fish community trends for this site indicate a consistent decrease in percent tolerant species since 2015 as more intermediate tolerant species such as pumpkinseed become more abundant. Species richness remains consistent between the years, ranging from four to six.

Strasburg Creek (SB2) was the only monitoring site to contain intolerant fish species and therefore scored the highest for percent intolerant species compared to all sites. However, when compared to previous years percent intolerant species at this site has slightly decreased since 2017. This is partly explained by brook trout being the only intolerant species observed, resulting in this metric depending on the relative abundance of brook trout, of which only one individual was captured in 2020. A change in dominant species was observed between 2019 and 2020 from pumpkinseed to creek chub. The respective tolerance for these species is intermediate and tolerant, which explains the notable increase in percent tolerant species observed in 2020. Overall, a positive trend towards a more diverse and even species composition was observed for this reach.

12.4 SWMF Performance Monitoring

As per the City's ECA #33882-A8WQM for SWMF 6, GHD conducted performance monitoring including the collection of wet-weather samples and annual inspection of the SWMF. TSS results in the wet-weather water quality samples ranged from 10.5 mg/L to 21.4 mg/L. Through inspection of the facility, only minor issues were noted including high turbidity which was likely attributed to the



previous high precipitation event, as well as excessive vegetation. Further, it was noted that the outlet channel has minor sediment accumulation and active erosion and gully along the south edge of the access trail/path was observed immediately west of the north inlet (Inlet #1) during the heavy precipitation event in August 2020.

13. Recommendations

Building on the recommendations as described in the *Integrated SWM-MP – Implementation Plan* (Aquafor Beech, 2016), the results of the 2016-2020 SWM Monitoring Programs, as well as feedback from the Steering Committee members, the following recommendations have been developed for the 2021 SWM Monitoring Program.

1. Prior to the start of the 2020 SWM Monitoring Program, confirm the current monitoring program schedule and locations as dictated by the *Integrated SWM-MP – Implementation Plan* remain correct. If changes to the SWM monitoring program are required, revise the schedule, and distribute to the City, GRCA, and Consultant.
 - a. Verify creek rehabilitation and SWMF retrofit projects for 2021 to determine if scheduled monitoring locations will be impacted.
2. Establish nine (9) flow proportionate monitoring sites in 2021, as soon as weather conditions allow, at the locations below listed using City-owned ISCO autosamplers:
 - a. 2021 SWM Monitoring Program: BD1, MS1, MZ1, SC1 (long-term), SC9 (long-term), VS1 (long-term), MG1 (long-term), SB2 (long-term), SR2 (long-term)
 - b. A minimum of eight wet-weather sampling events per year should be undertaken, with two events per season (i.e., Spring, Summer, Fall, Winter) to ensure the full range of seasonal variation is captured.
3. Establish five (5) flow monitoring sites (pre-EMC) in 2021 in anticipation of the installation of autosamplers in 2022 at the following locations:
 - a. 2021 SWM Monitoring Program: Laurel Creek (LC1), Detweiler Creek (DW1b), East Side Creek (ES1), Doon South (DS1), and Kolb Creek (KD1)
 - b. Undertake a minimum of five (5) discrete flow measurements and install a staff gauge at each site in order to develop a rating curve (i.e., depth versus flow relationship). Continuously recorded depth values are translated to flow rates per the relationship developed by the rating curve. Additional discrete flow measurements may be required to improve the accuracy of associated rating curves.
4. To improve the chloride datasets and allow for a more comprehensive understanding of the physical health of each watercourse, it is recommended that at stations where dry-weather samples are collected, an additional grab sample event be conducted in January/February/March to represent winter conditions when road salt application is in effect and chloride concentrations are highest. This could be focused to long-term monitoring stations only, if needed.



5. Continue to maintain and revise the SWM Monitoring Program SOP, as required, to ensure the consistency of data collection and analysis is maintained throughout the program.
 - a. A common maintenance schedule and SOP should be developed for GRCA, and Consultant operated autosamplers and included as part of the SWM Monitoring Program SOP.
6. The precipitation datasets collected by the City at the City Hall and KOF rain gauges do not undergo QA/QC procedures by the Consultant. It is recommended that since these datasets are utilized as part of the SWM monitoring program and other City-monitored programs, that they undergo a QA/QC process.
7. The GRCA operates a weather at the mouth of the Blair Creek (Station 2414046). Precipitation data from this station would provide a more comprehensive program precipitation dataset to ensure variability from localized rainfall activity at the City's southern end is captured.
8. Blair Creek data is currently monitored by GRCA and provided to the City for inclusion in annual reports. To ensure consistency between the programs, it is recommended that the City and GRCA reassess the respective monitoring programs annually to ensure the data collected as part of GRCA's program is aligned with the goals of the City's monitoring program.
9. GHD identified beaver activity on multiple occasions while monitoring at School Creek (SCH1) and while conducting the fish community sampling at Strasburg Creek (SB2). It is recommended that the City follow up on this activity.
10. Brook trout have been documented within Strasburg Creek (SB2) in all monitoring events since 2014. Field observations of watercress, a groundwater upwelling indicator, suggests this reach may provide suitable brook trout spawning habitat. GHD recommends implementing fall brook trout spawning surveys to the 2021 monitoring program to confirm and provide additional context to the productivity and function of North Strasburg Creek.
11. The fish community of Blair Creek is monitored by GRCA using a program which alternates biomass (three passes) and community (single pass) surveys on a yearly basis. Adoption of a similar methodology that includes fish biomass surveys to the rotation of core station monitoring can provide better resolution of community dynamics and trends that are not possible with single pass community surveys. Stations with a robust fish community that may be suitable for biomass surveys include SB2, SR2, and SC9.
12. During the August 2, 2020, annual inspection of SWMF 6, GHD noted minor sediment accumulation, as well as excessive vegetation growth in the main pond. Active erosion and gully along the south edge of the access trail/path was also observed immediately west of the north inlet (Inlet #1). GHD recommends that the City continue to monitor the above noted items that could potentially lead to long term maintenance and/or safety issues.



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All of Which is Respectfully Submitted,

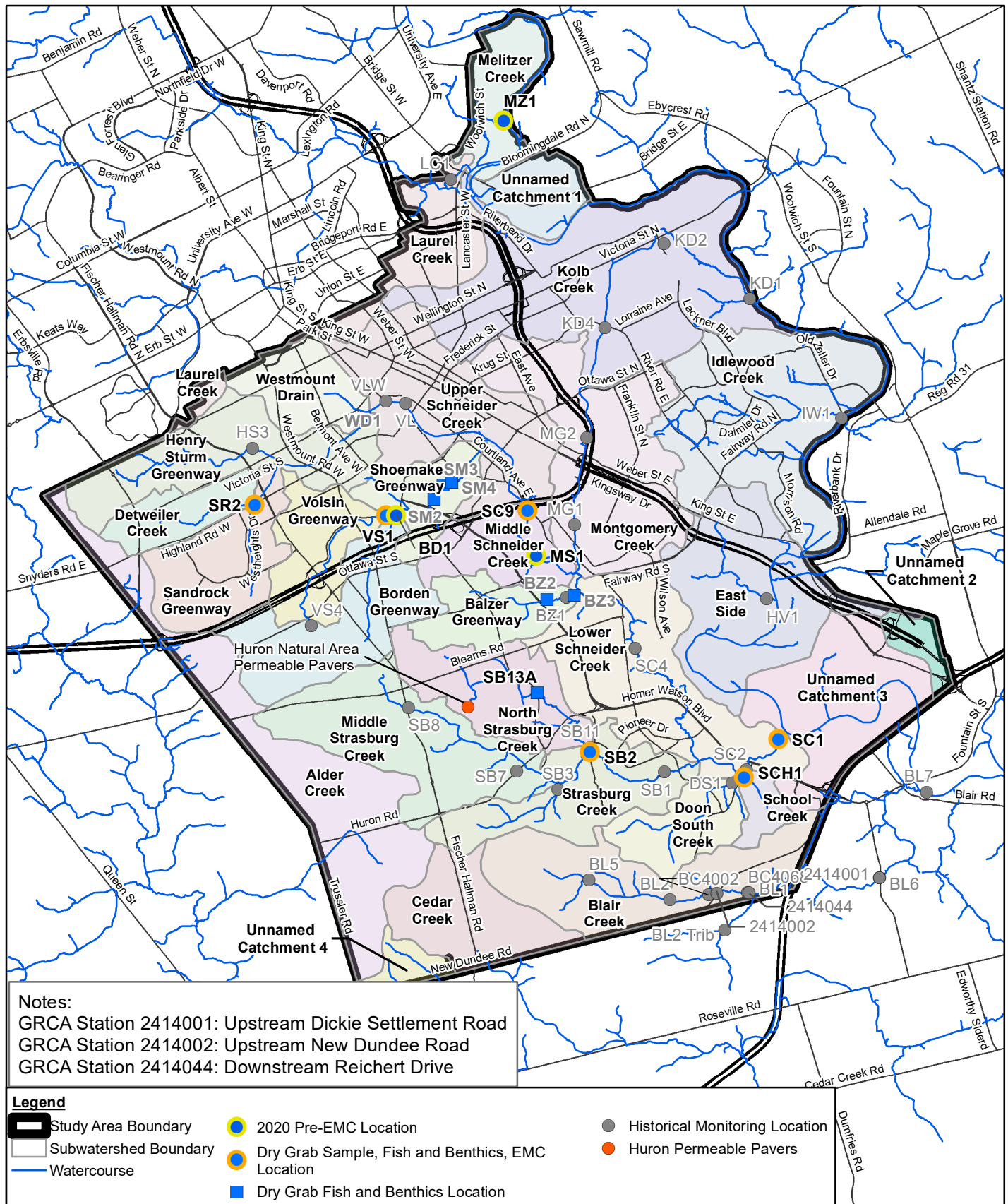
GHD

A handwritten signature in blue ink that reads 'Laura Lawlor'.

Laura Lawlor, M.Sc., C.S.E.
Principal, Senior Ecologist

A handwritten signature in blue ink that reads 'Sarah Andrew'.

Sarah Andrew, P.Eng.
Project Manager, Water Resources Engineer



Source: MNRF NRVS, 2014. City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021

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Meters
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NAD 1983 UTM Zone 17N

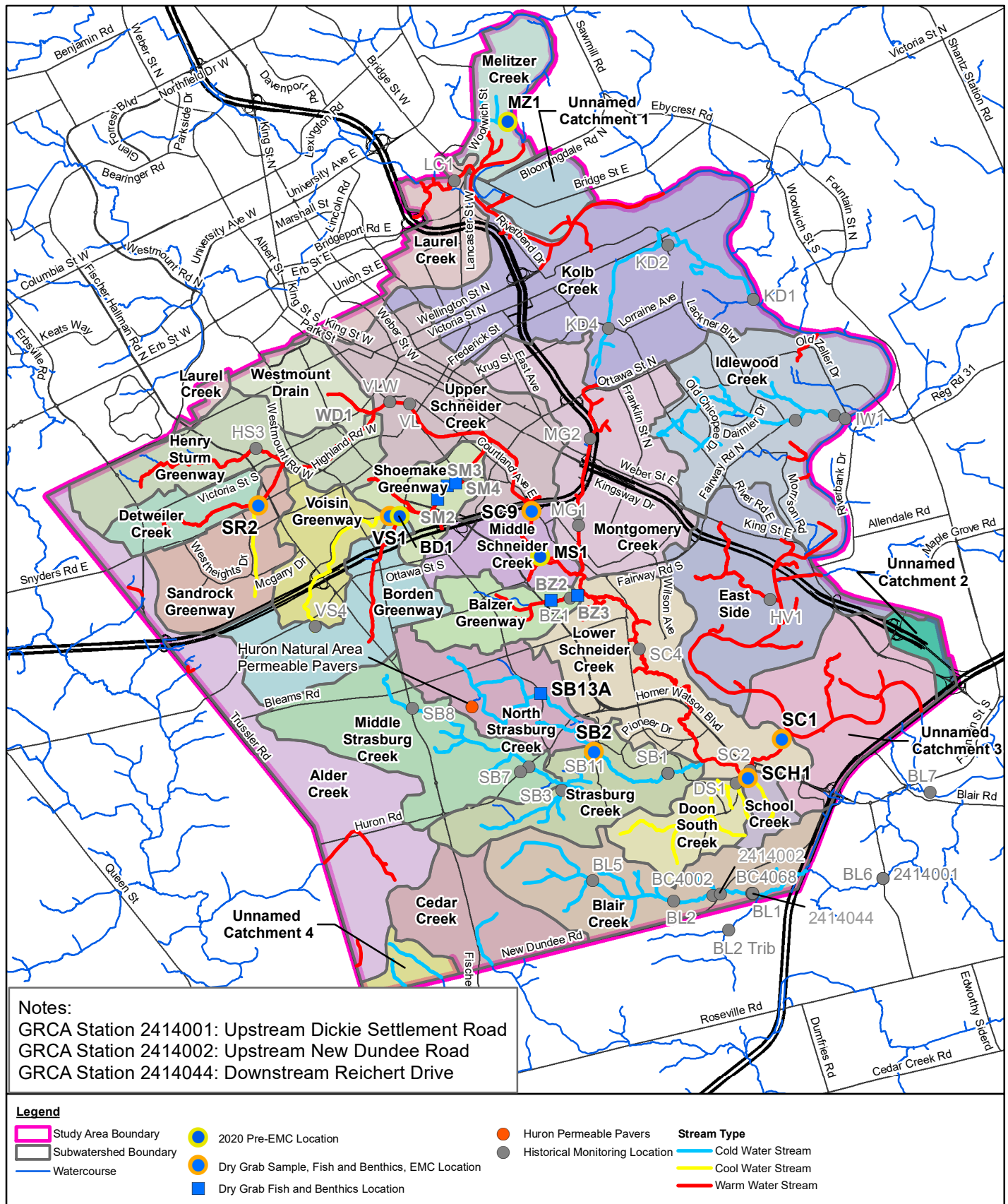


CITY OF KITCHENER
 KITCHENER, ONTARIO
 2020 STORMWATER MANAGEMENT MONITORING

11207597
 Feb 15, 2021

PROGRAM LOCATIONS

FIGURE 1



Source: MNRF NRVS, 2014. City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021

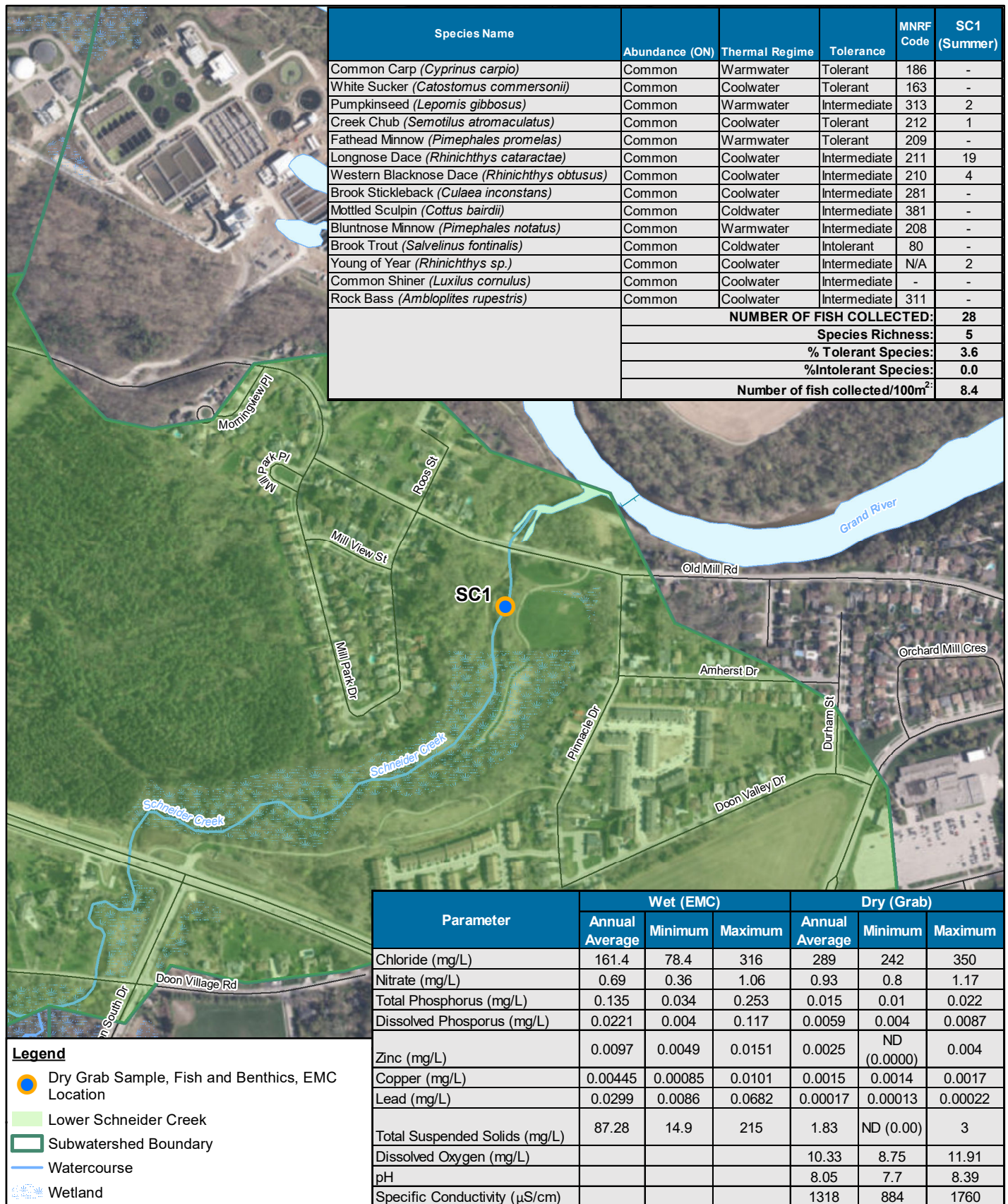
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NAD 1983 UTM Zone 17N



CITY OF KITCHENER
 KITCHENER, ONTARIO
 2020 STORMWATER MANAGEMENT MONITORING
 AQUATIC RESOURCES
 STREAM CLASSIFICATION

11207597
 Feb 15, 2021

FIGURE 2



Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2019

0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N

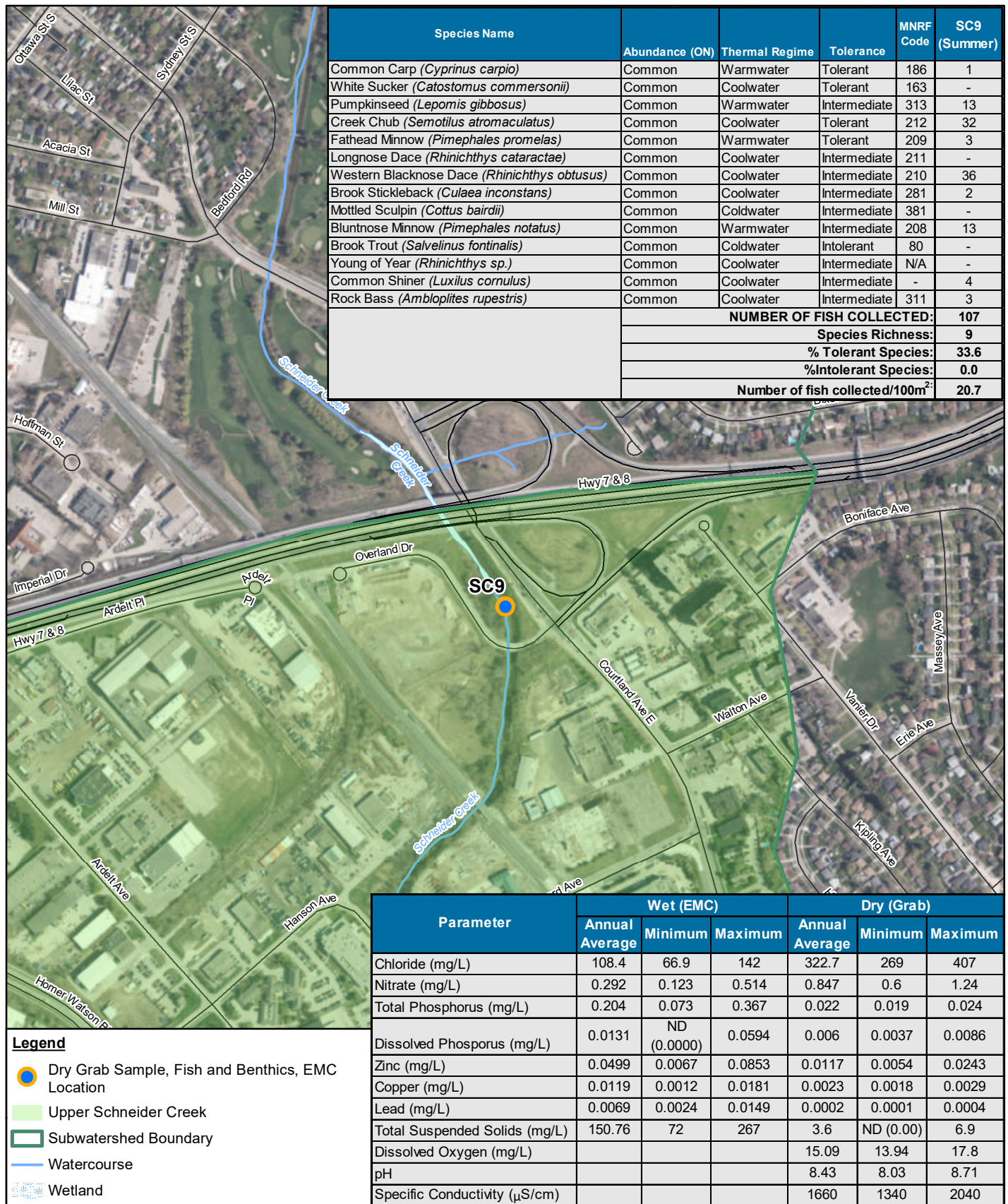


CITY OF KITCHENER
KITCHENER, ONTARIO

2020 SWM MONITORING LOCATIONS
LOWER SCHNEIDER CREEK(SC1)

11207597
Feb 15, 2021

FIGURE 3



Source:Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2019

0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N

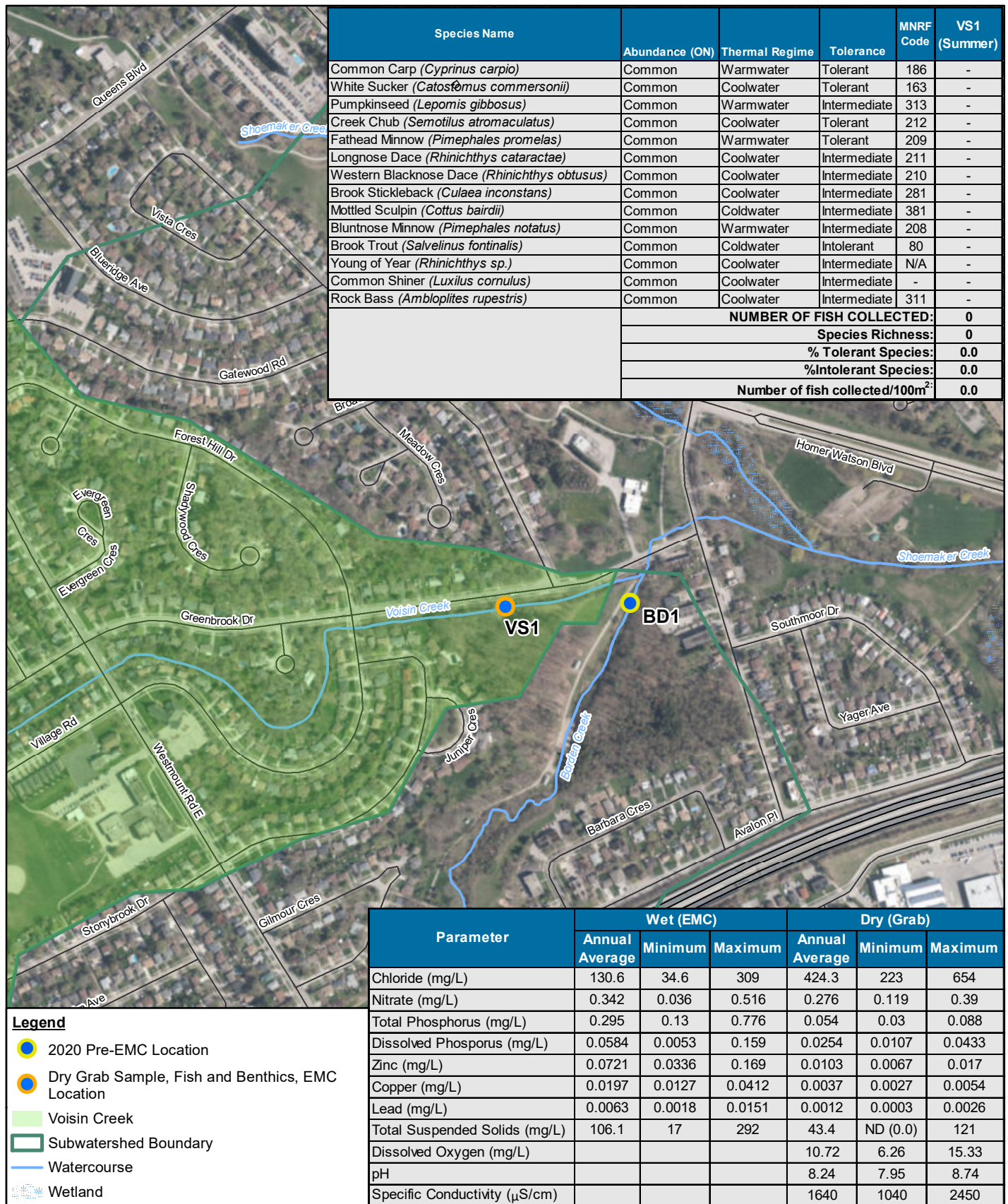


CITY OF KITCHENER
KITCHENER, ONTARIO

2020 SWM MONITORING LOCATIONS
UPPER SCHNEIDER CREEK(SC9)

11207597
Feb 13, 2021

FIGURE 4



Source:Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2019

0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N

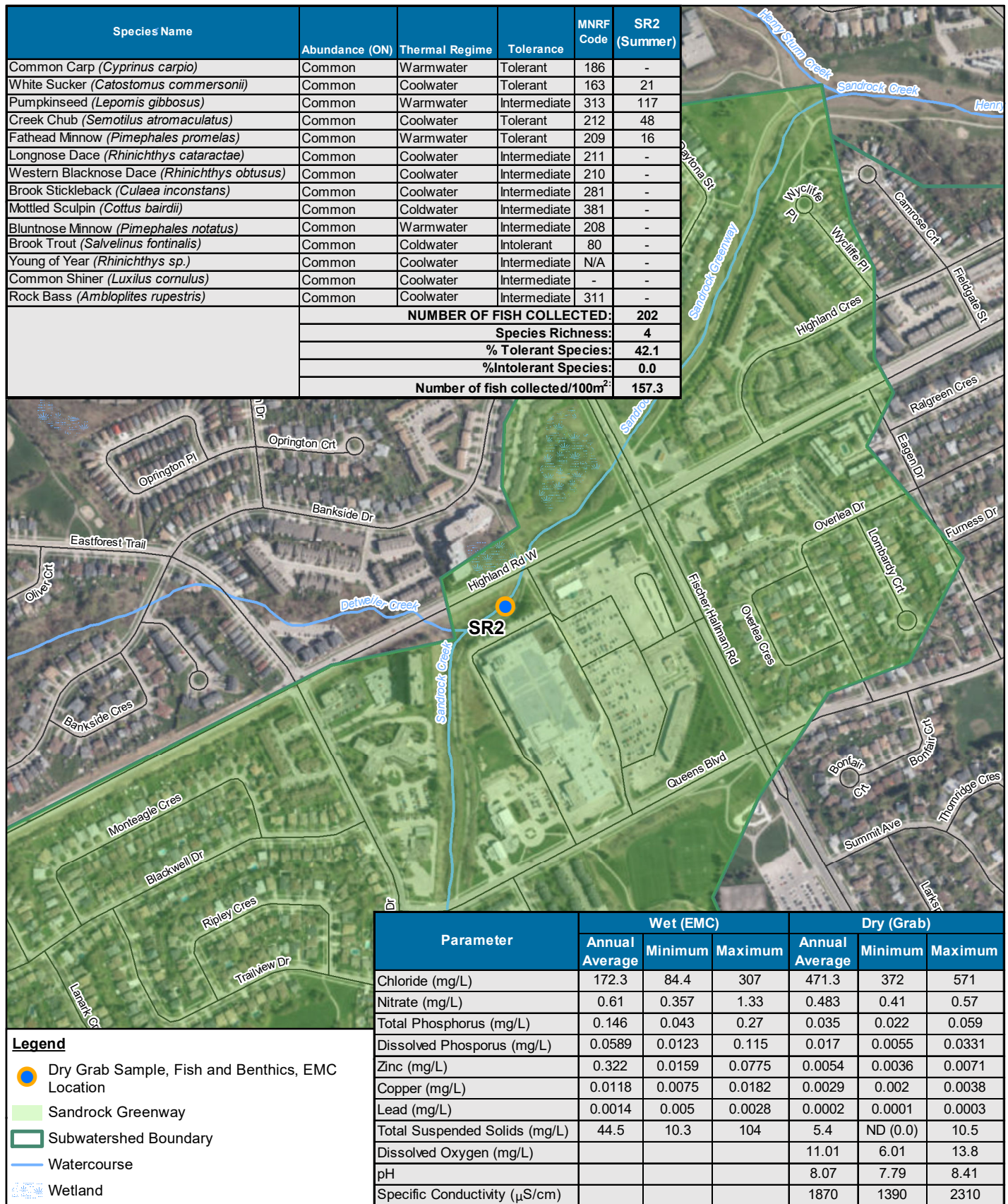


CITY OF KITCHENER
KITCHENER, ONTARIO

2020 SWM MONITORING LOCATIONS
VOISIN CREEK(VS1)

11207597
Feb 13, 2021

FIGURE 5



Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2019

0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N

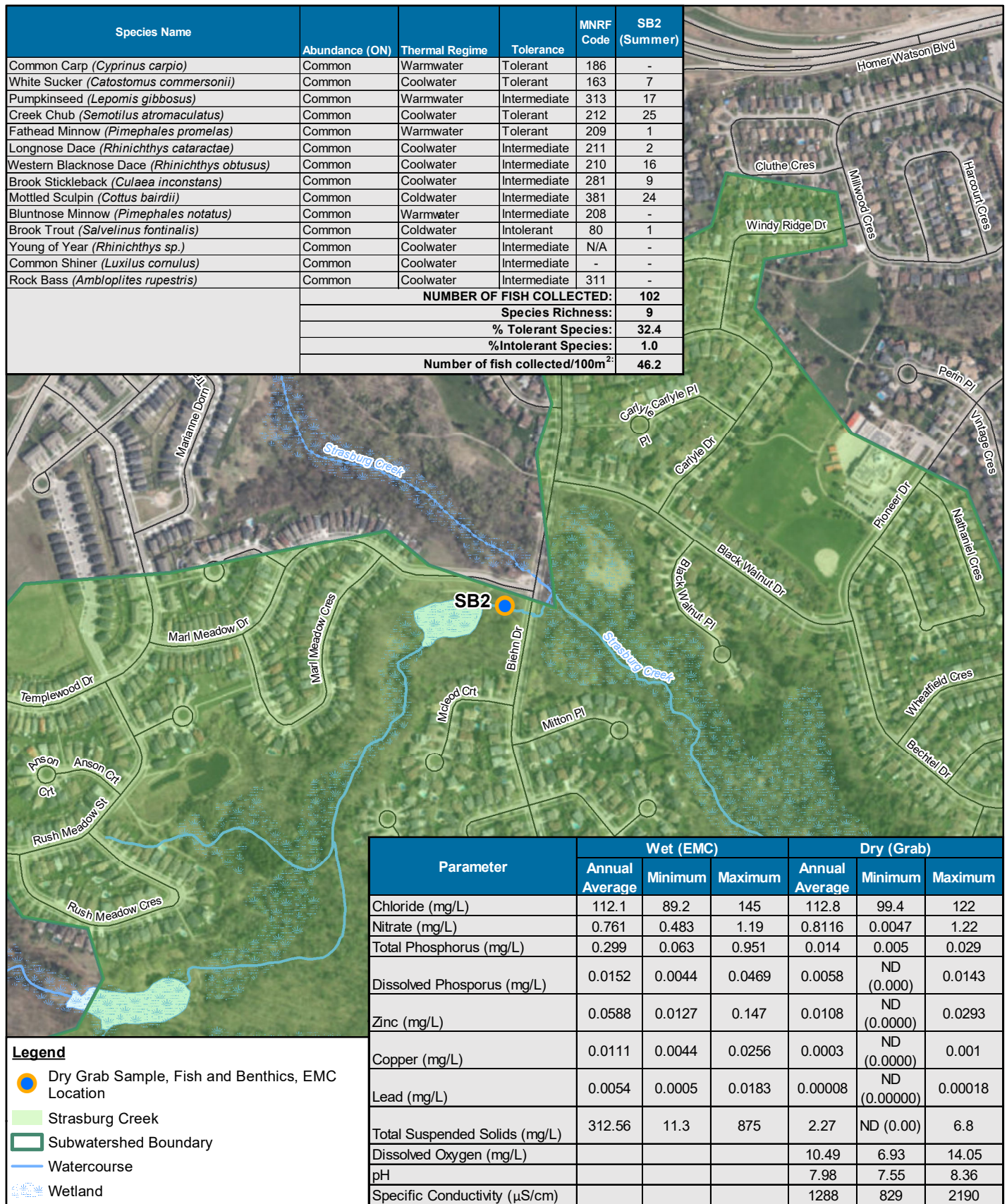


CITY OF KITCHENER
KITCHENER, ONTARIO

2020 SWM MONITORING LOCATIONS
SANDROCK GREENWAY(SR2)

11207597
Feb 13, 2021

FIGURE 6



Source:Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2019

0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N

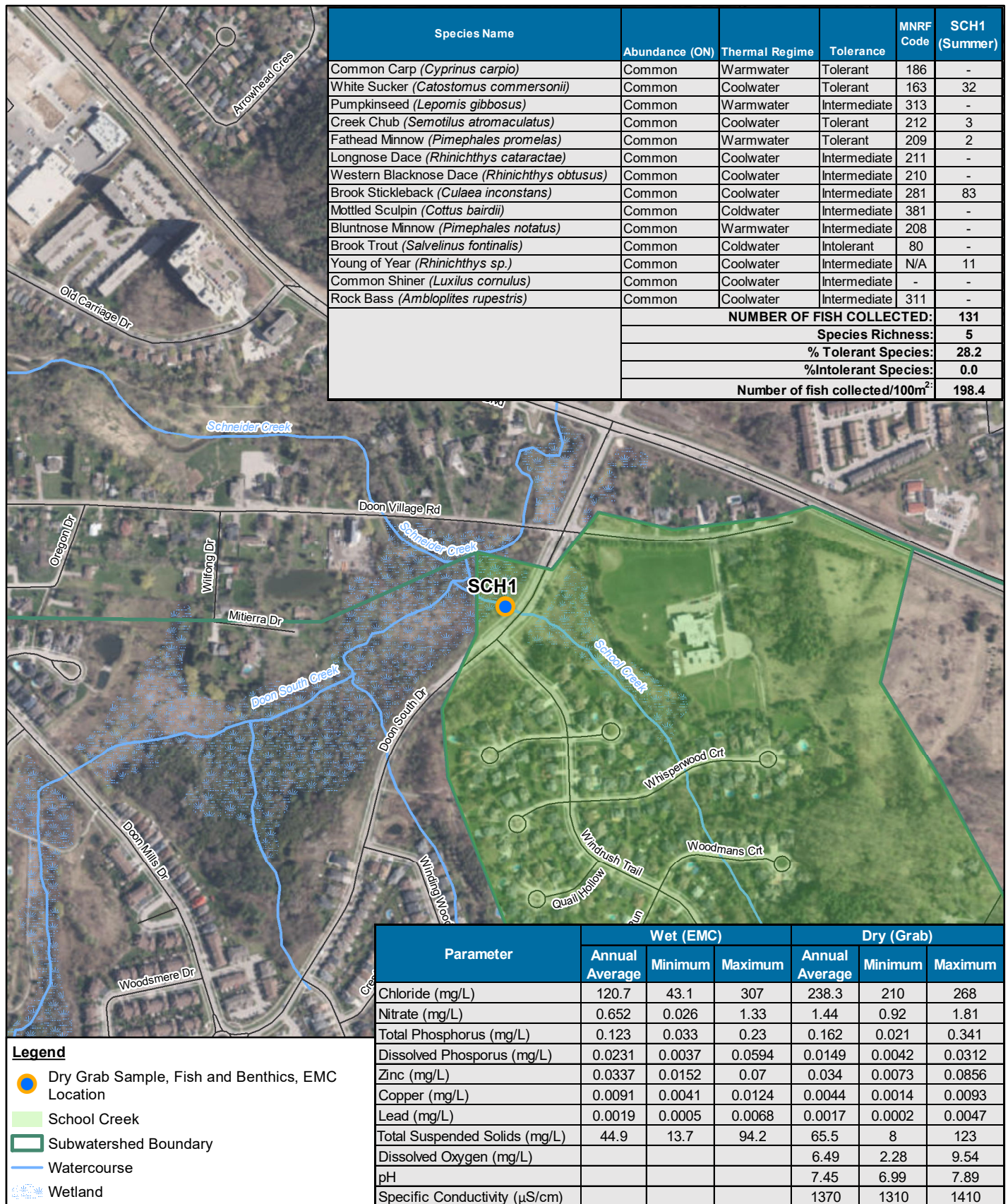


CITY OF KITCHENER
KITCHENER, ONTARIO

2020 SWM MONITORING LOCATIONS
STRASBURG CREEK(SB2)

11207597
Feb 15, 2021

FIGURE 7



Source:Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2019

0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N

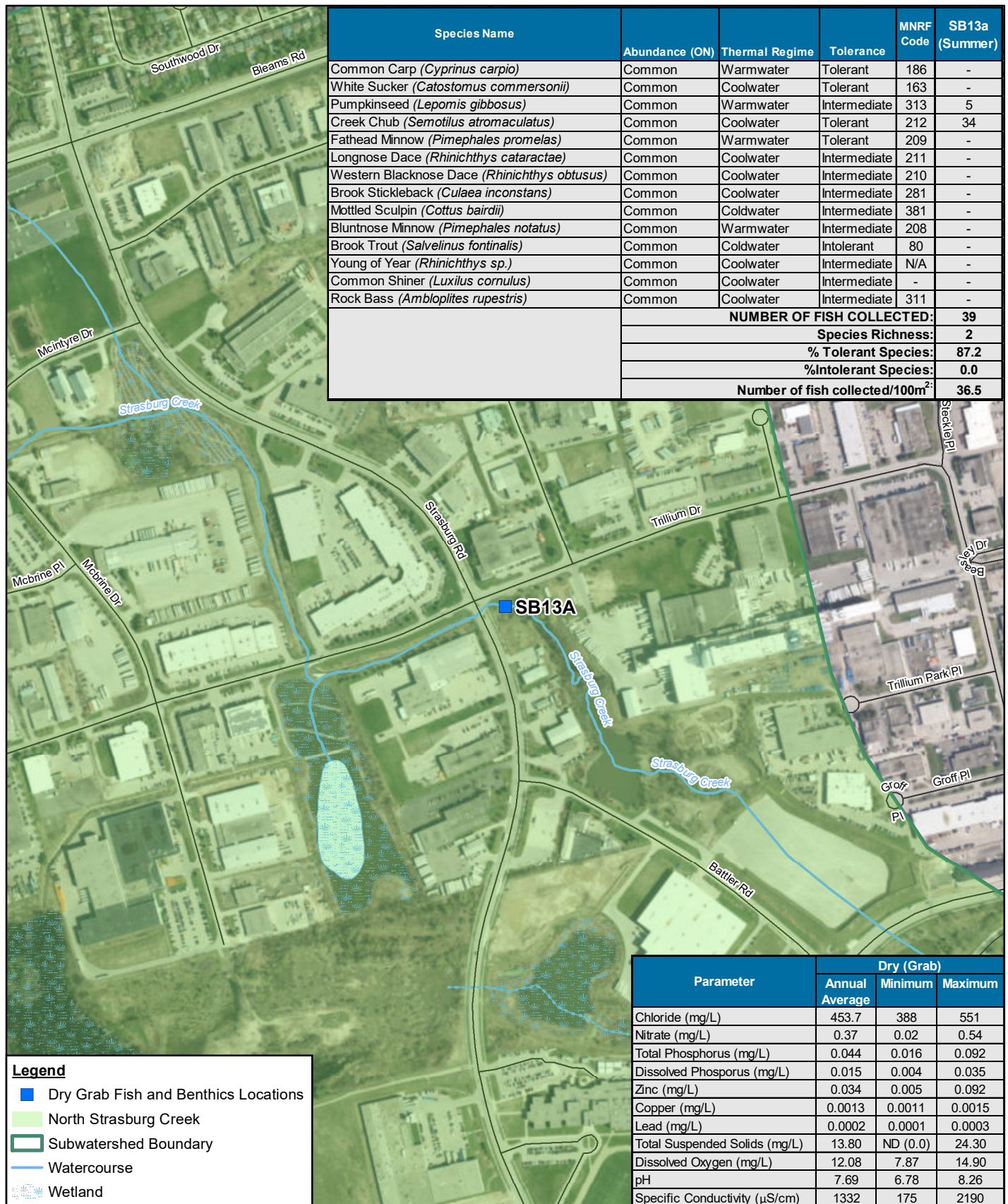


CITY OF KITCHENER
KITCHENER, ONTARIO

2020 SWM MONITORING LOCATIONS
SCHOOL CREEK(SCH1)

11207597
Feb 15, 2021

FIGURE 8



Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2019

0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N

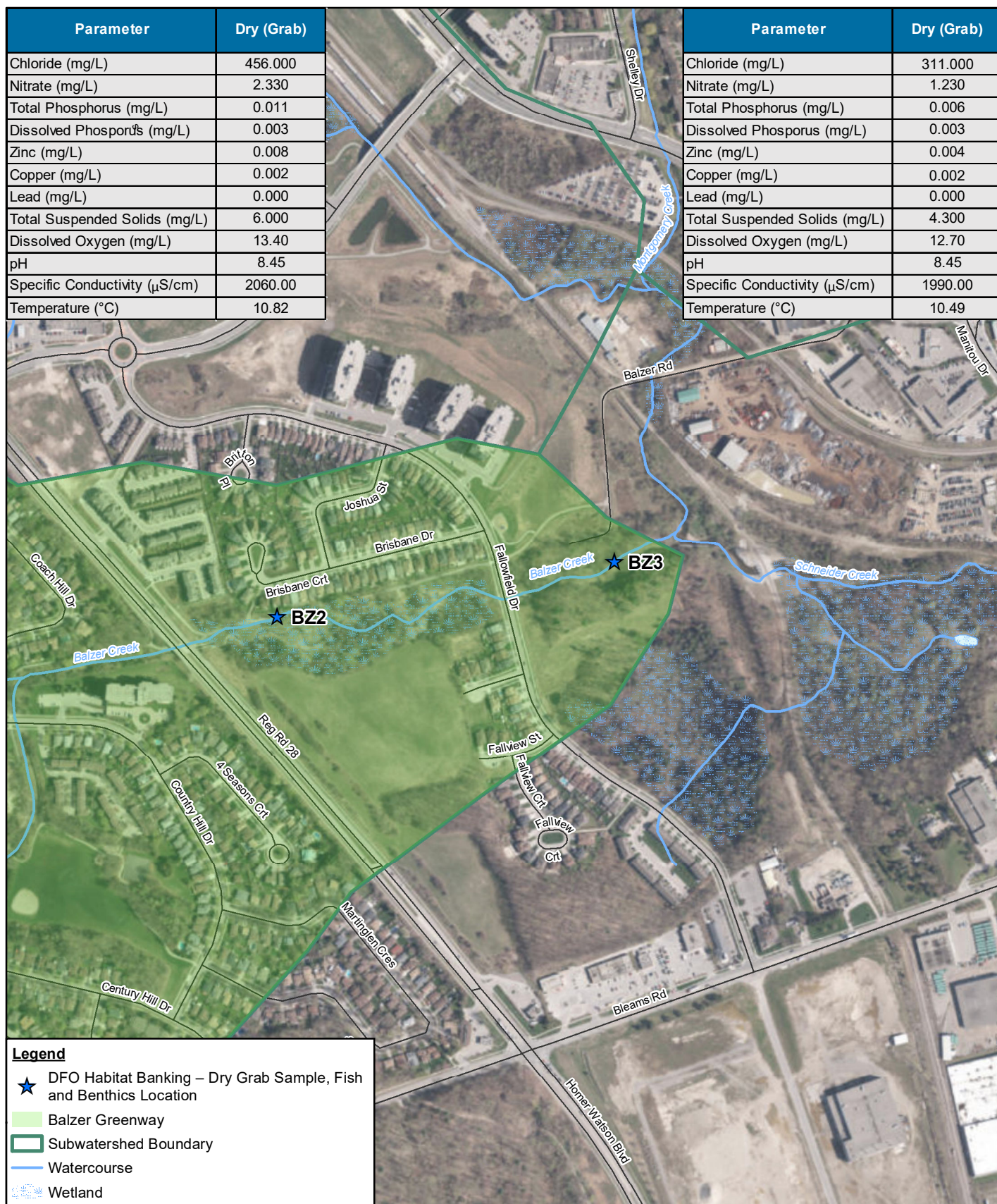


CITY OF KITCHENER
KITCHENER, ONTARIO

2020 SWM MONITORING LOCATIONS
NORTH STRASBURG CREEK(SB13A)

11207597
Feb 15, 2021

FIGURE 9



Source: Source: MNRF NRVIS, 2014, City of Kitchener, 2016. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021 Imagery City of Kitchener 2017

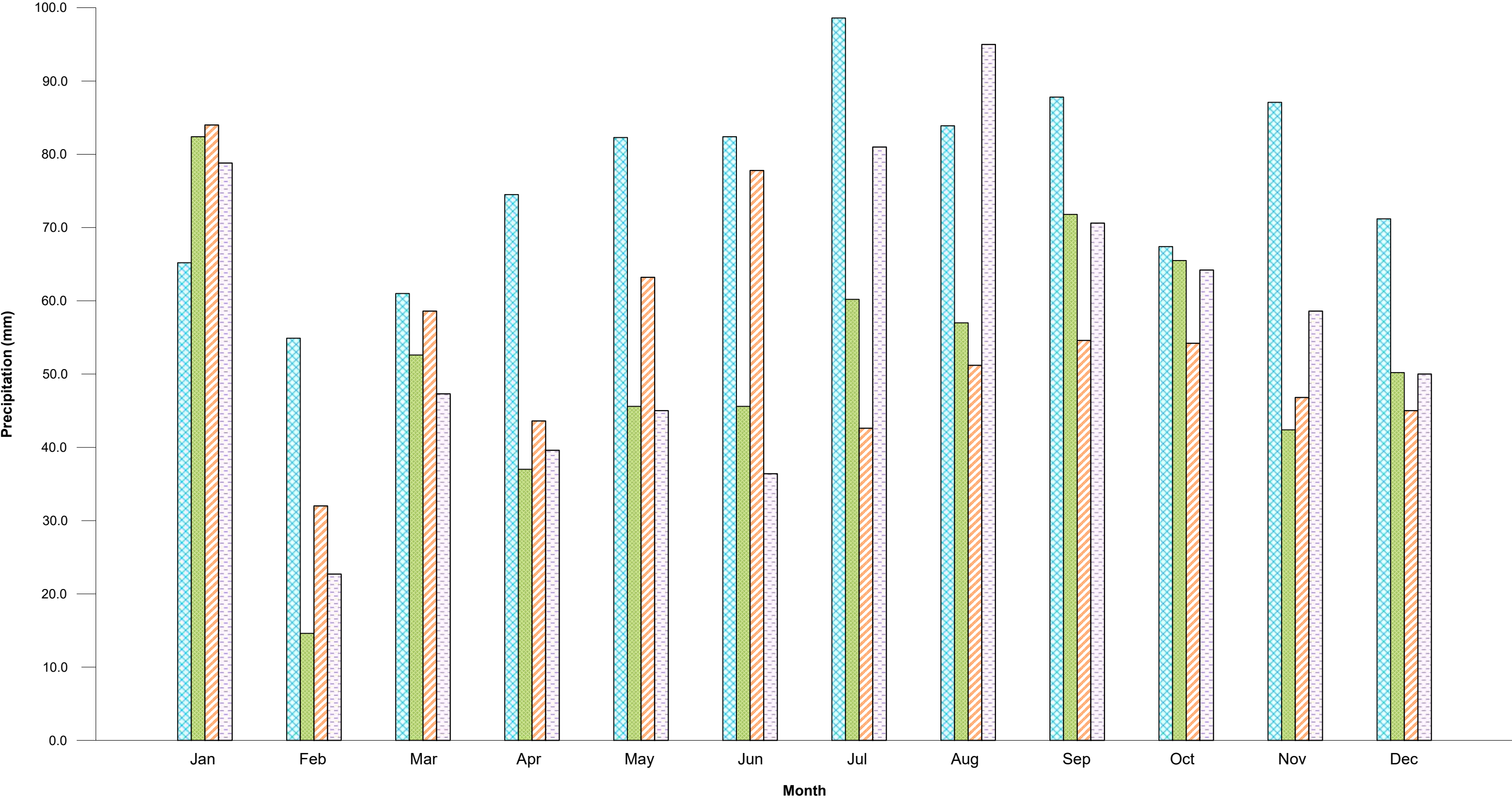
0 50 100 150
Meters
Coordinate System:
NAD 1983 UTM Zone 17N



CITYOFKITCHEN E
KITCHEN E ON TA IO

11207597
Feb 2, 2021

2020 DFO HABITAT BANK
BALZER CREEK POST CONSTRUCTION FIGURE 10



Note:
- Climate normal data was retrieved from the 1981 to 2010
Waterloo Wellington A Environment Canada Station.

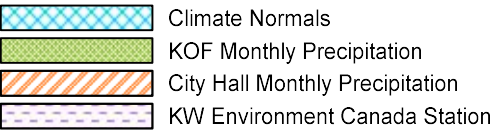
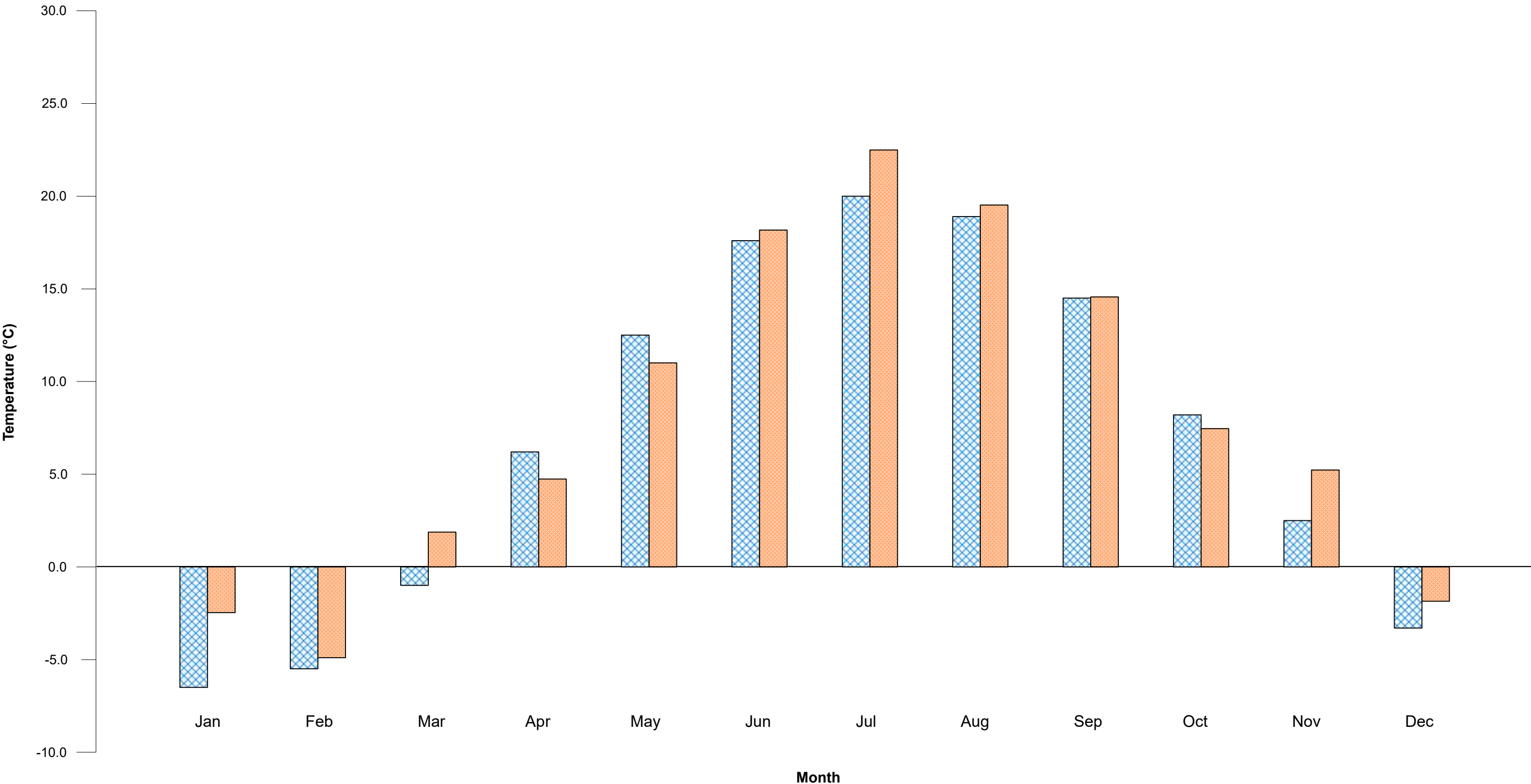


Figure 11
Monthly Precipitation
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Note:
- Climate normal data was retrieved from the 1981 to 2010
Waterloo Wellington A Environment Canada Station dataset.

Monthly Average Ambient Temperature
Climate Normals

Figure 12
Monthly Average Ambient Temperature
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario

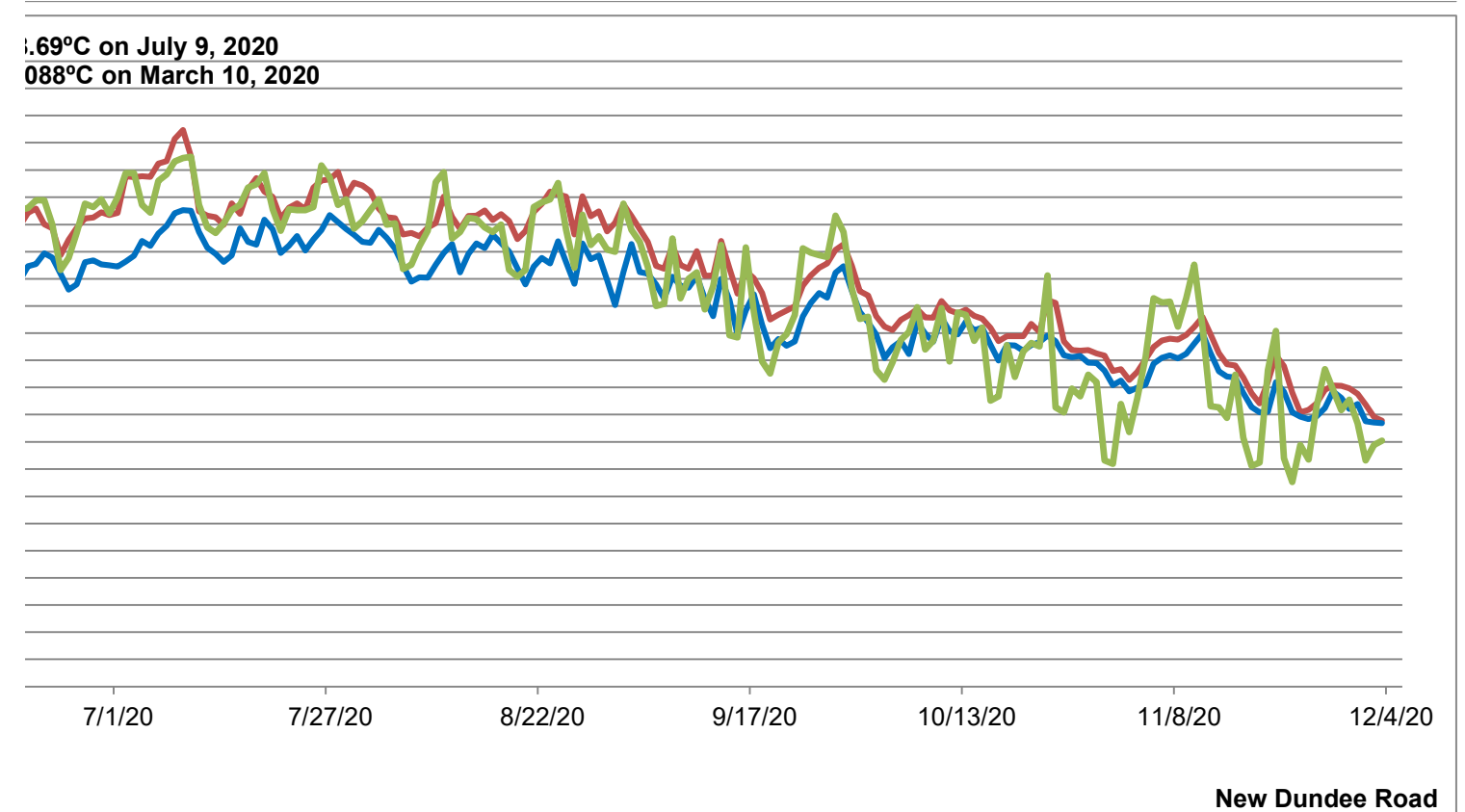
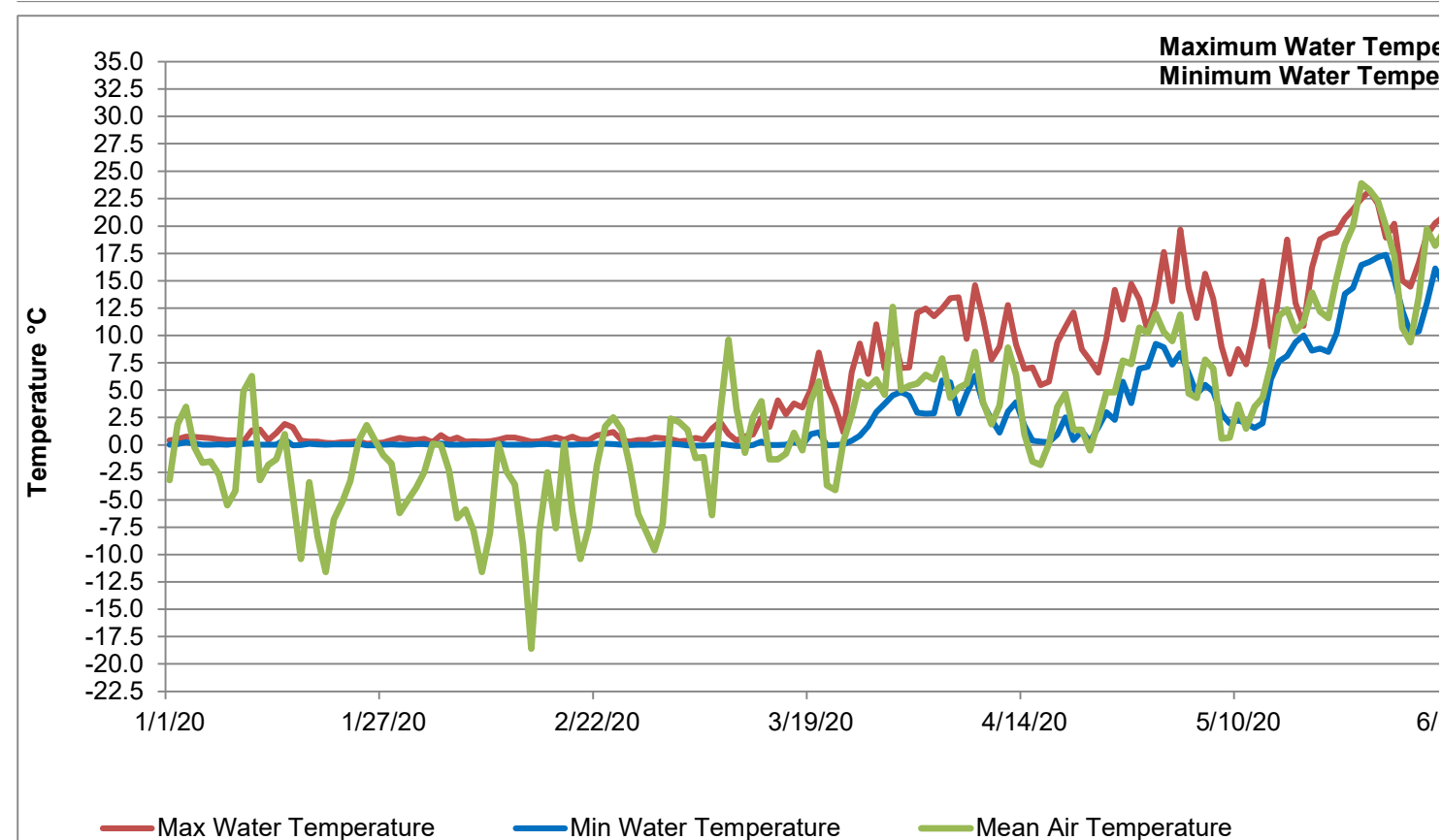
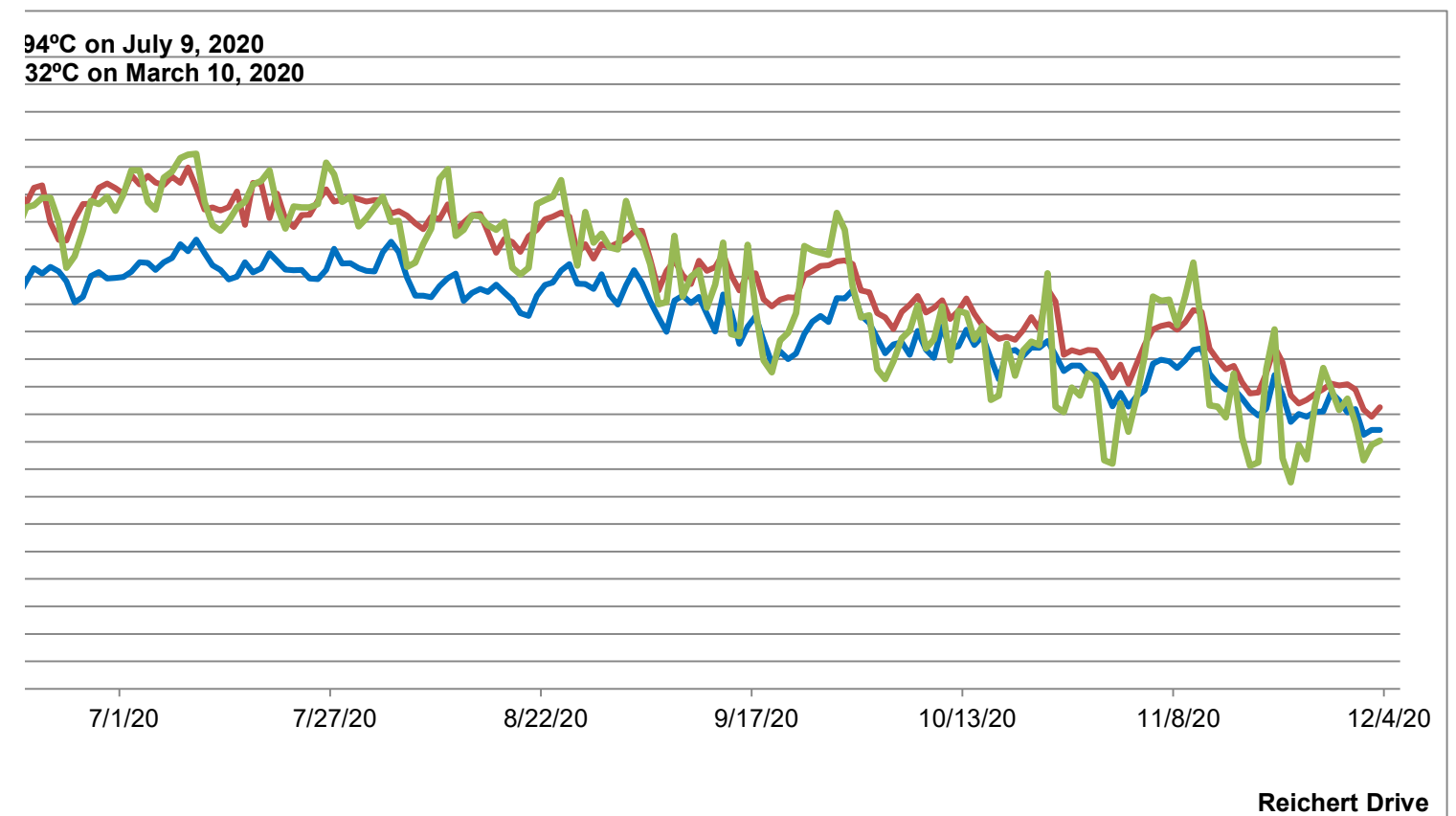
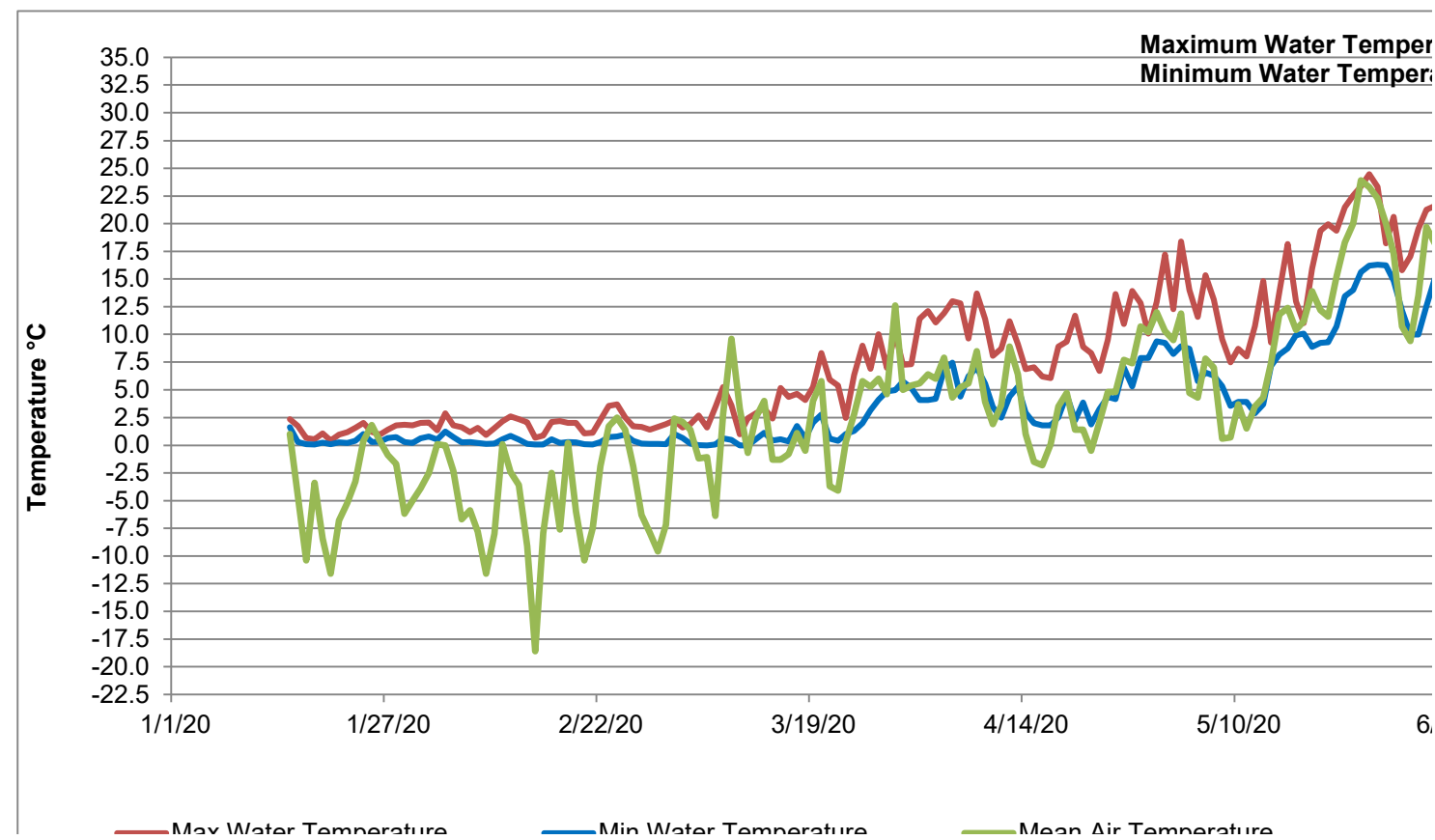


Figure 13
Continuous Water Temperature - Blair Creek at Reichert Drive and New Dundee Road
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario

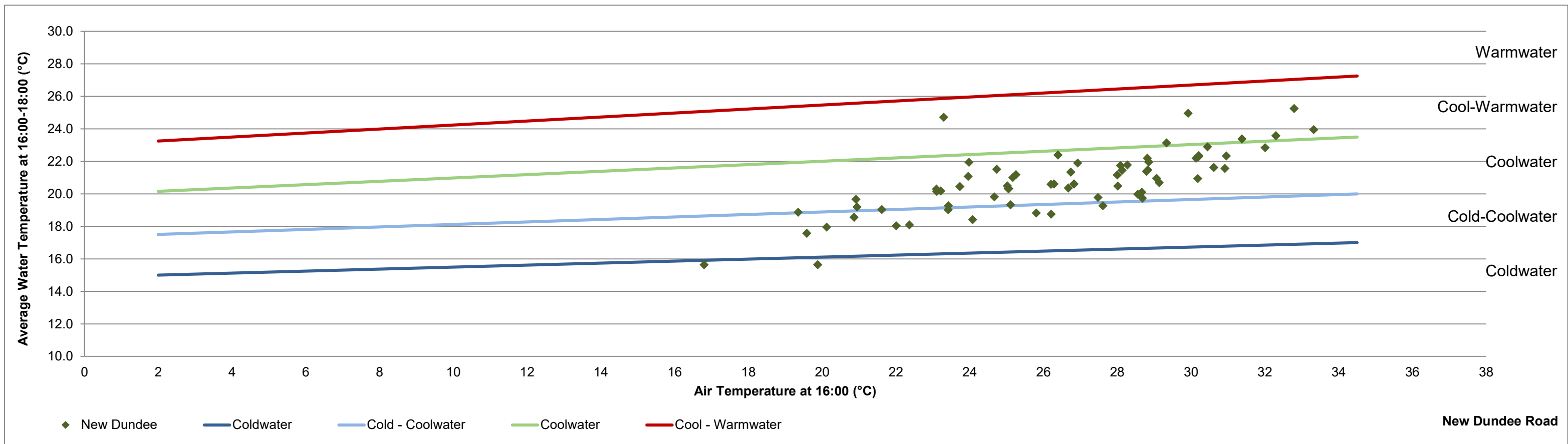
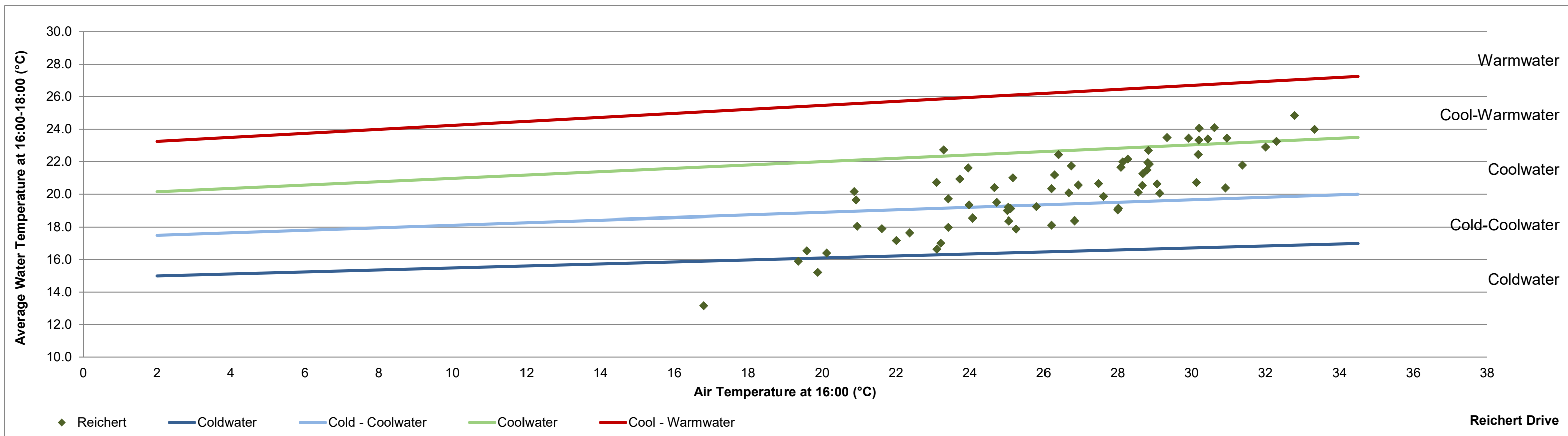
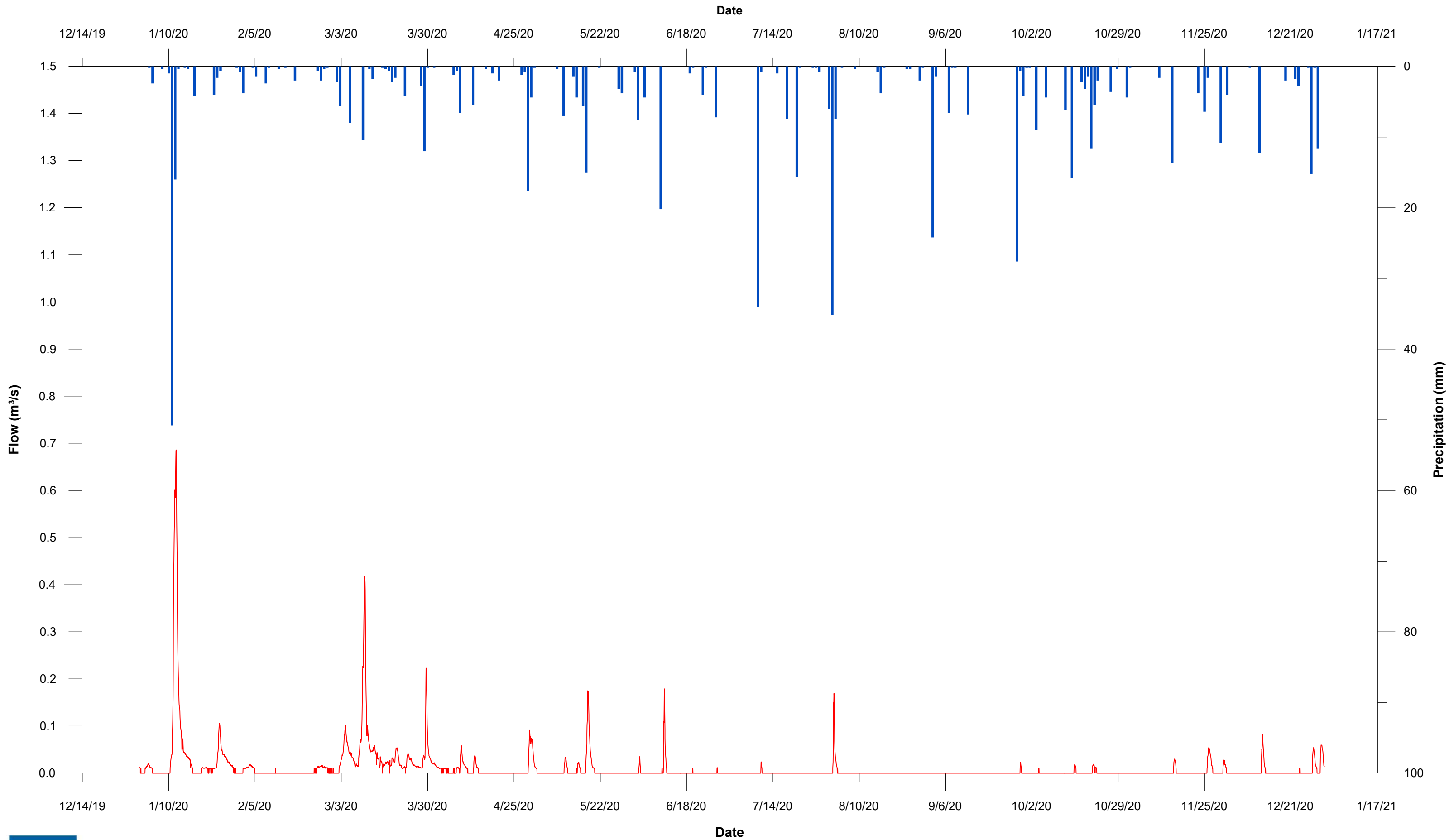


Figure 14
Thermal Stability Classification - Blair Creek at Reichert Drive and New Dundee Road
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Precipitation (KOH)
Continuous Streamflow

Figure 15
Blair Creek at New Dundee Road Hydrograph
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario

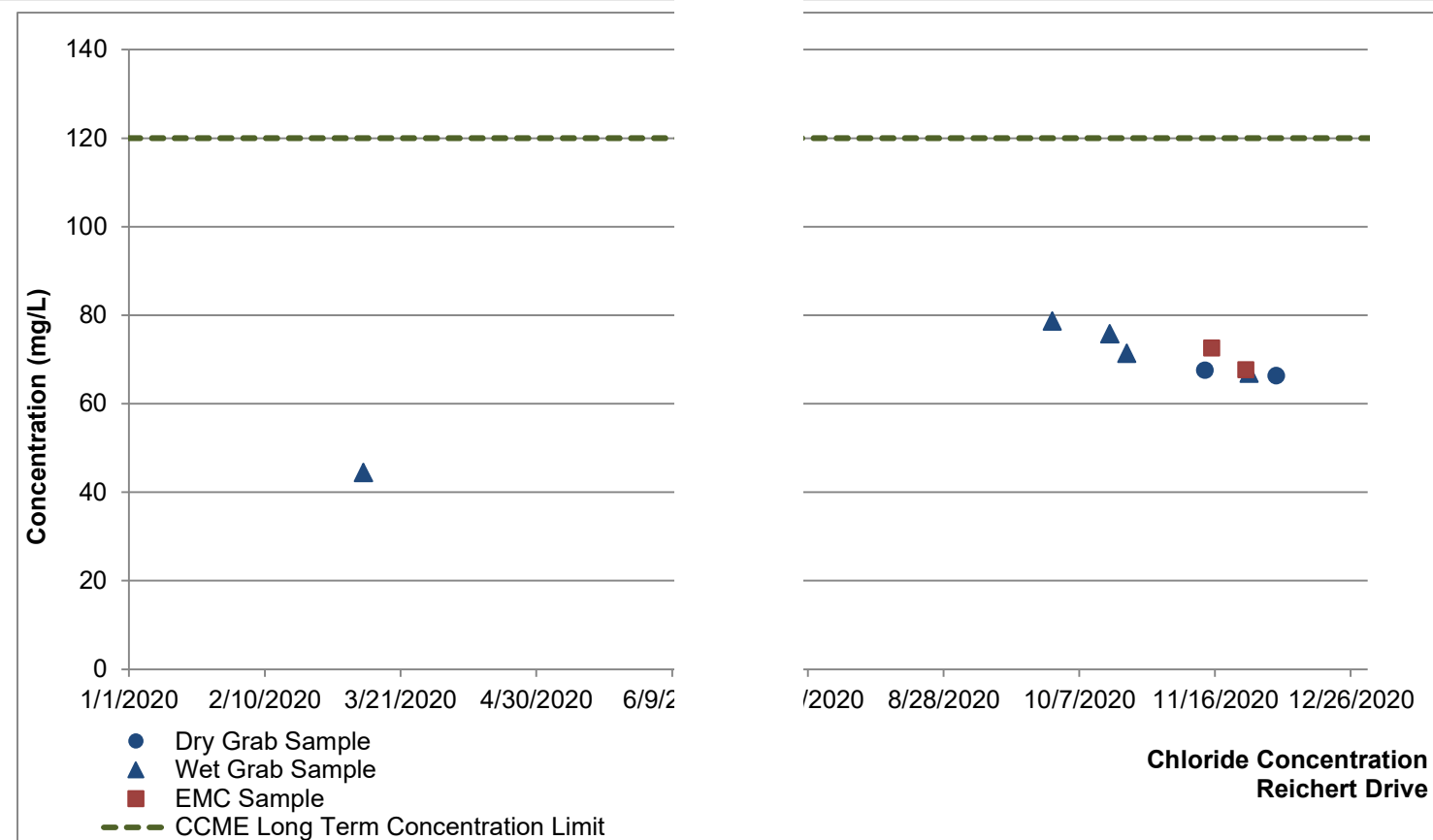
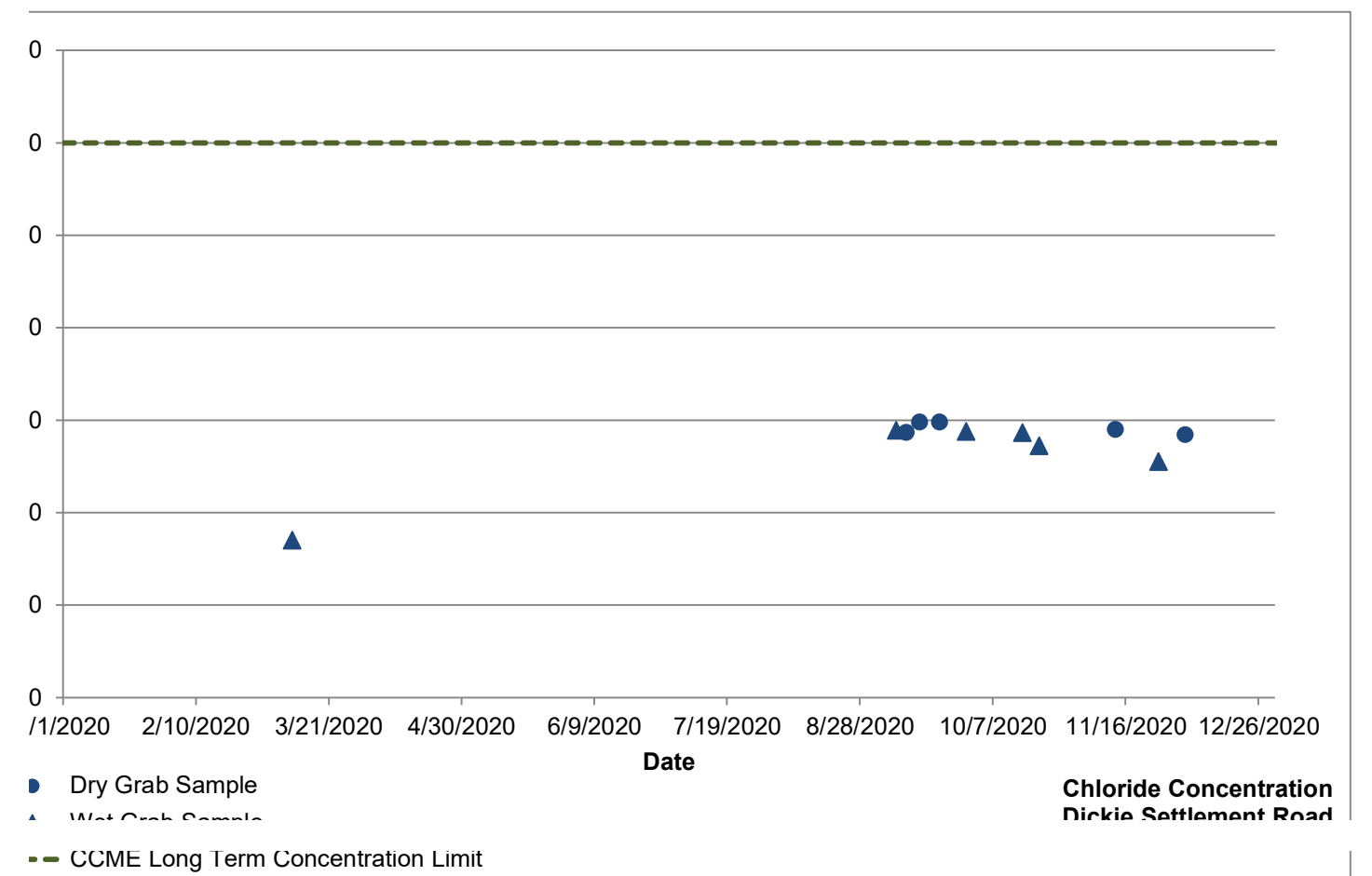
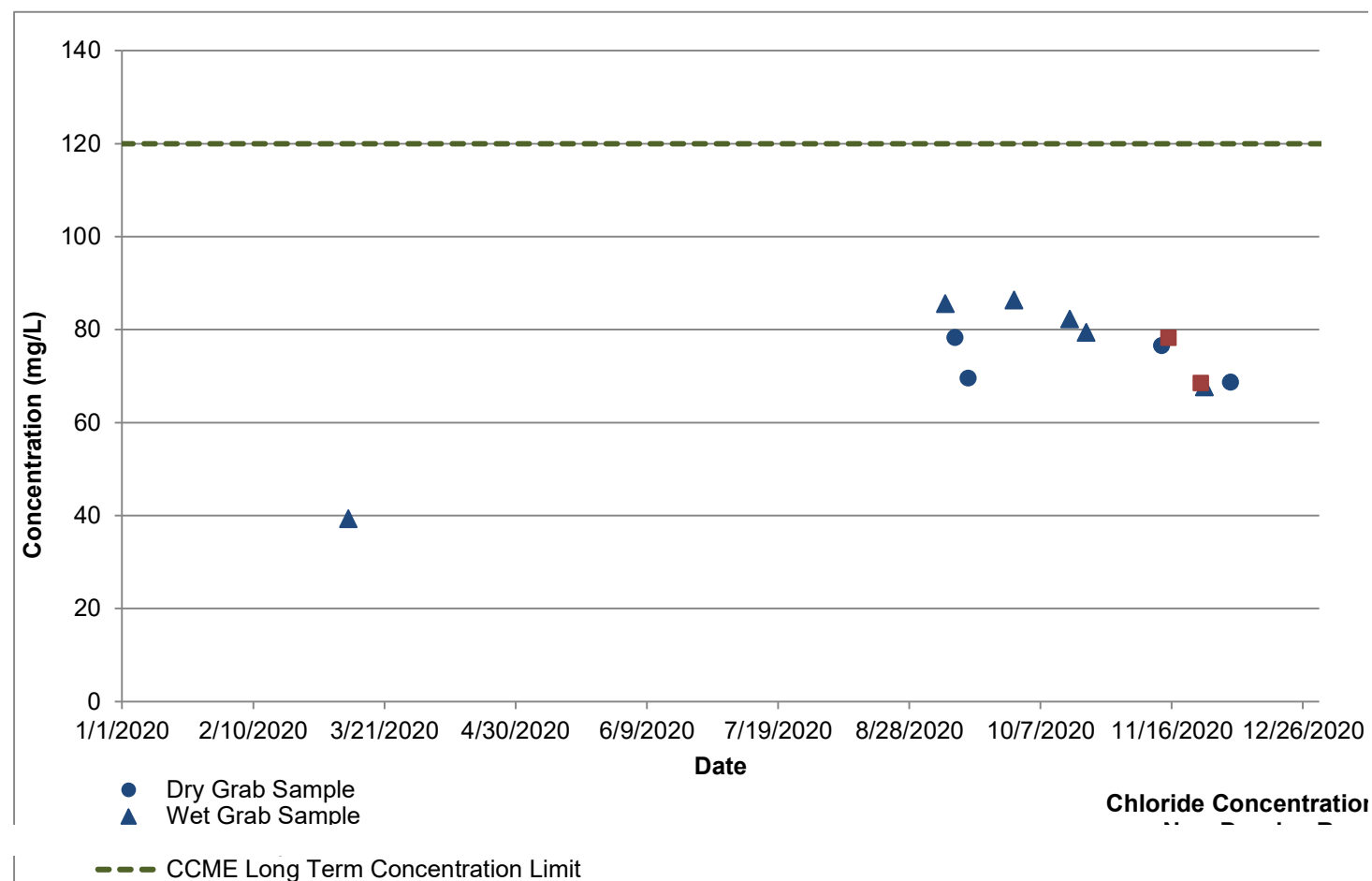


Figure 16
Chloride Concentrations - Blair Creek Locations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

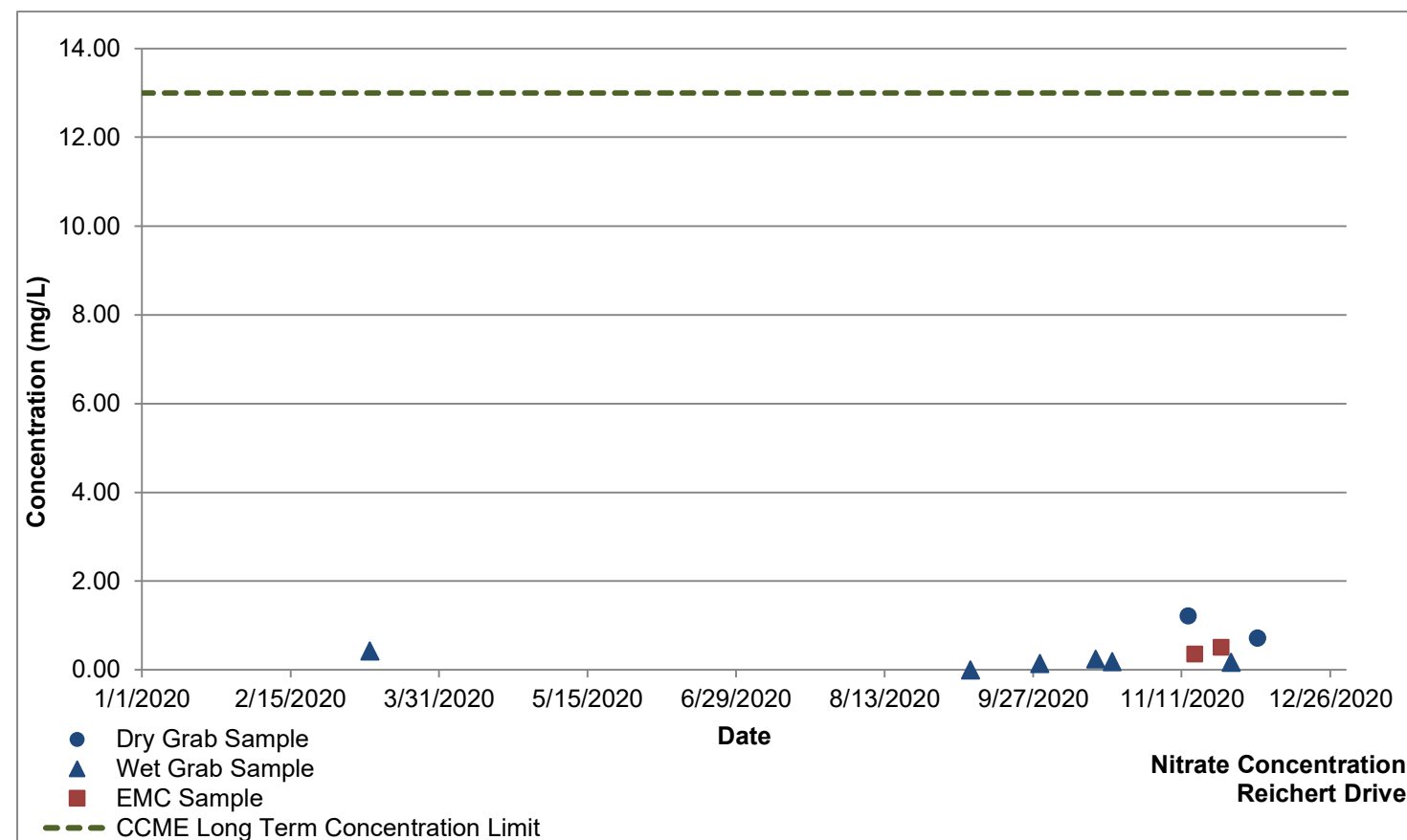
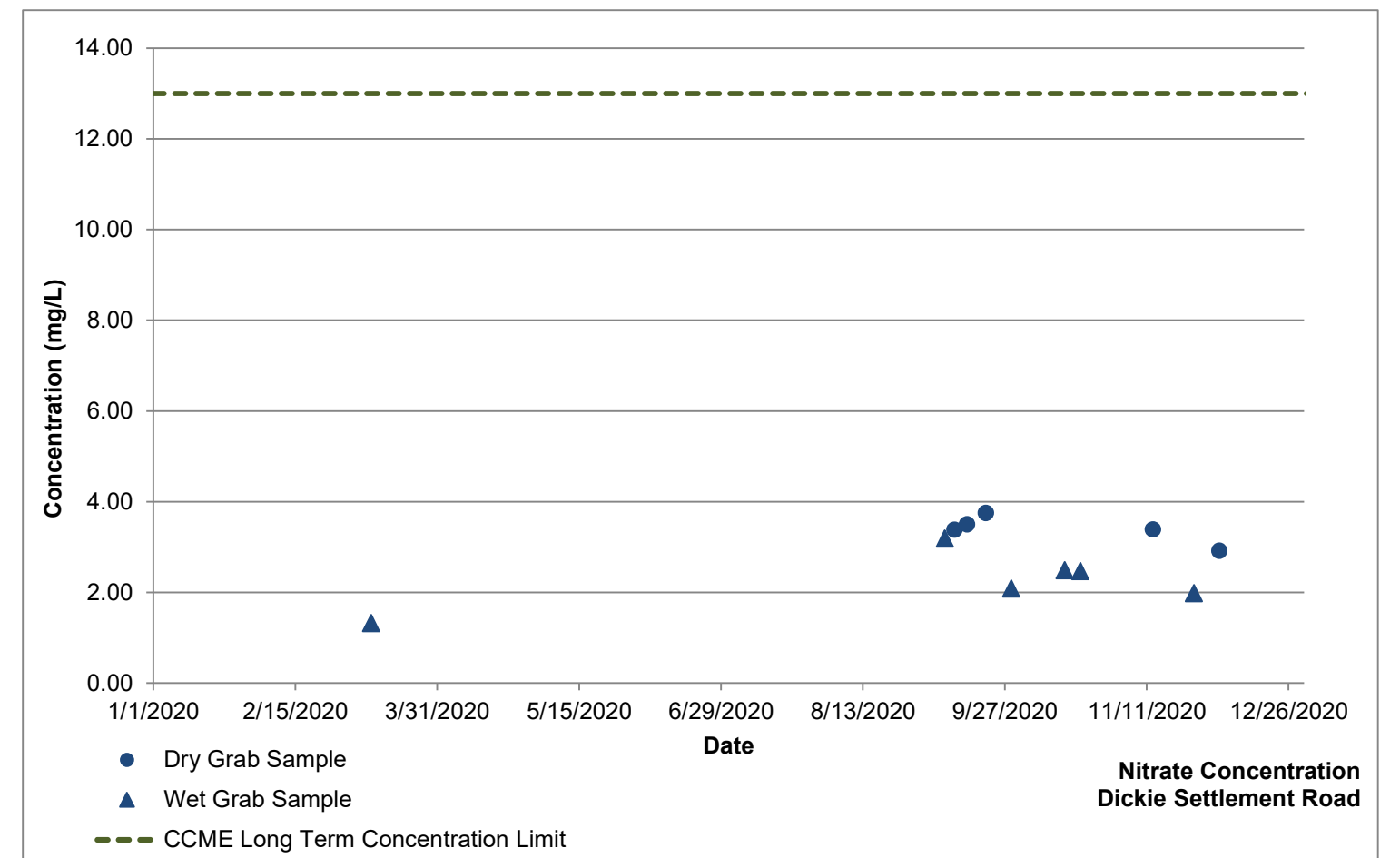
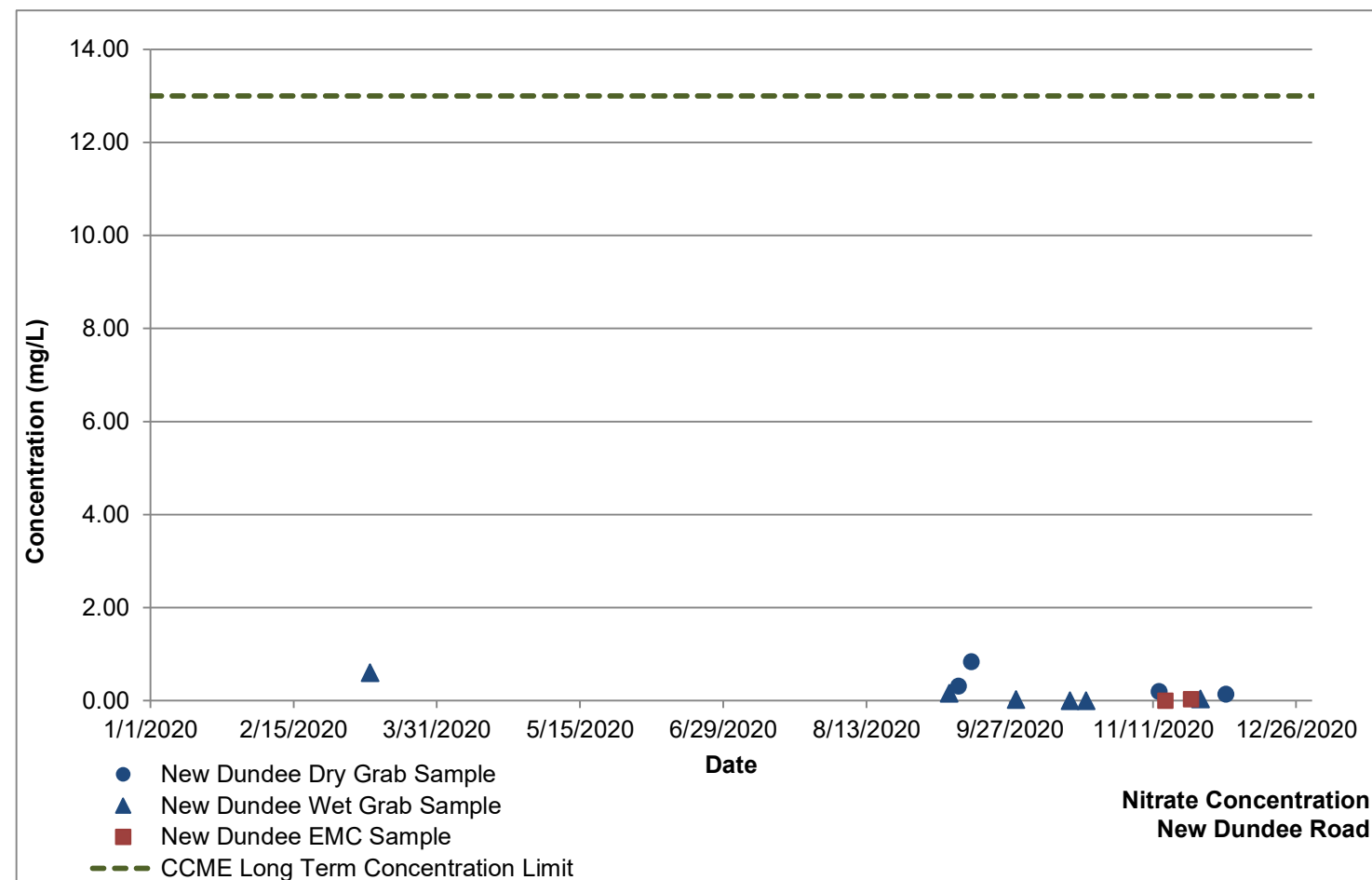


Figure 17
Nitrate Concentrations - Blair Creek Locations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

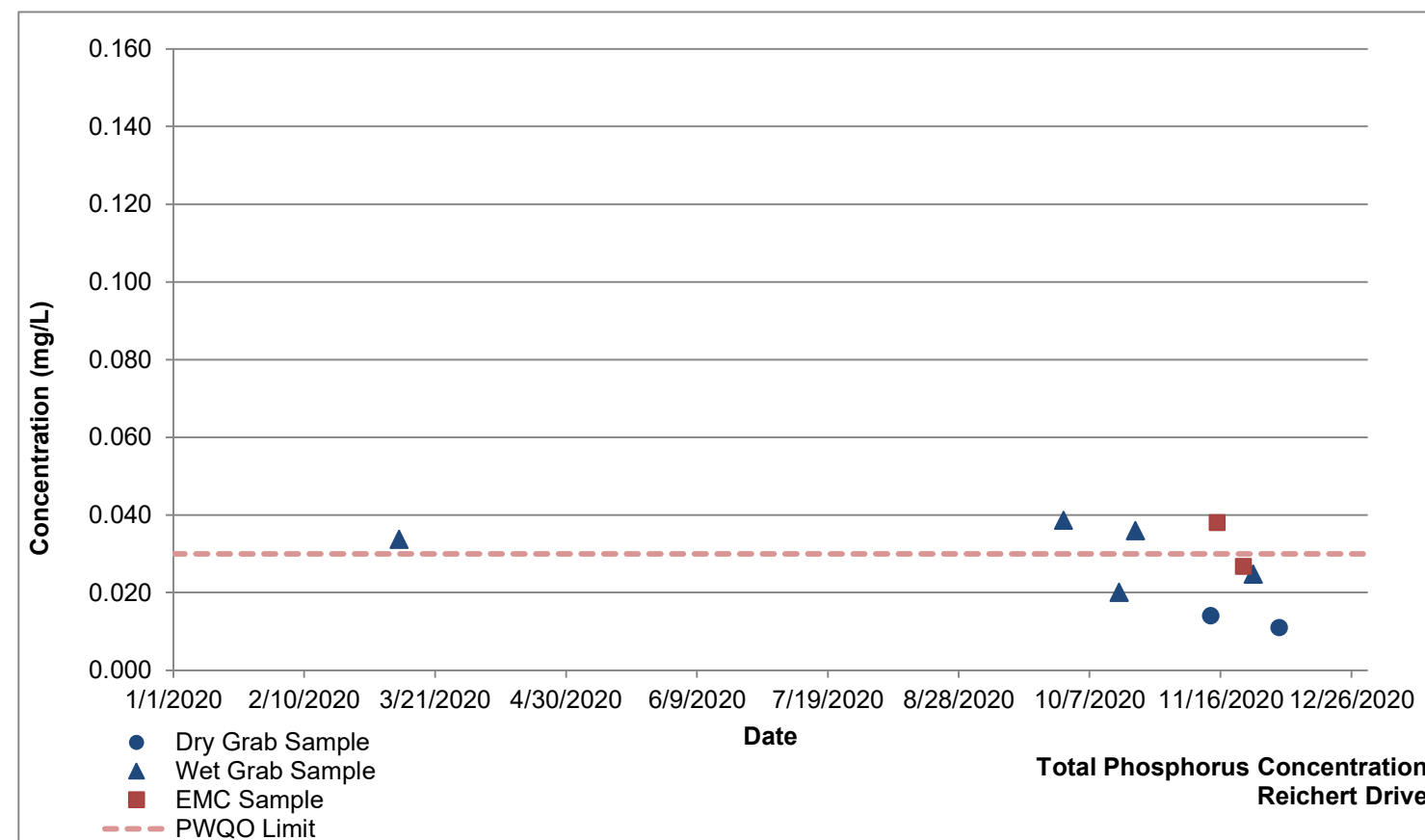
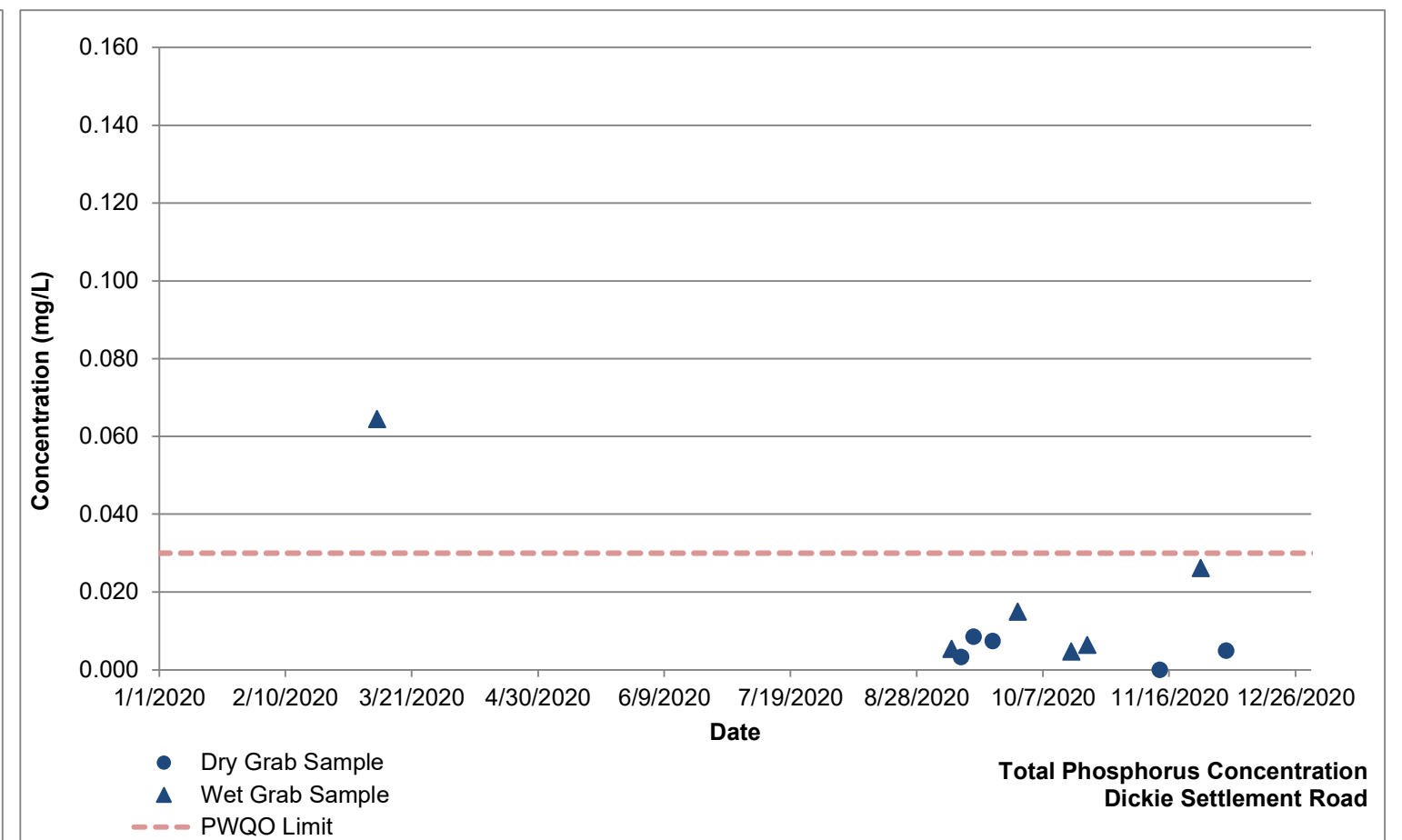
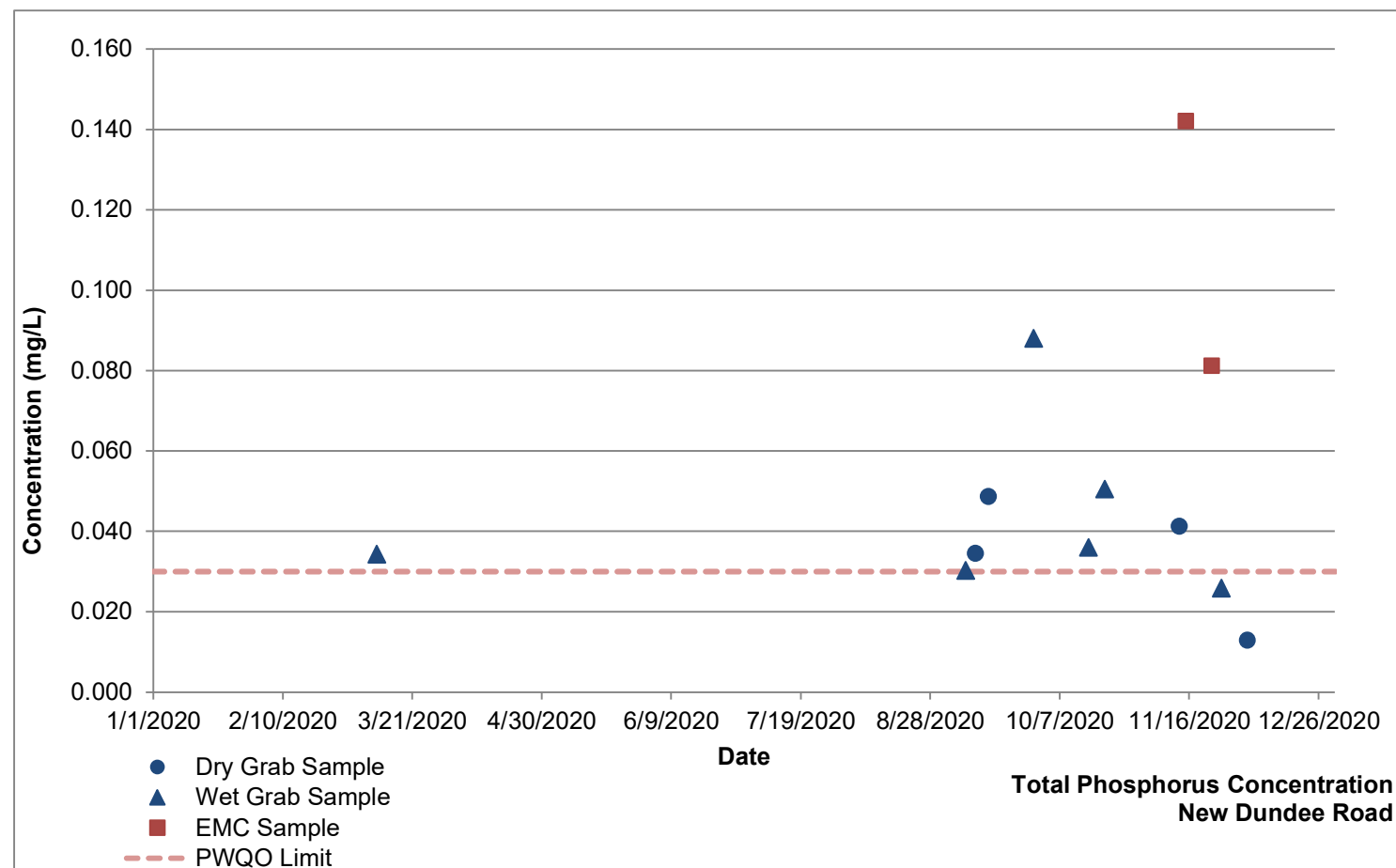


Figure 18
Total Phosphorous Concentrations - Blair Creek Locations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

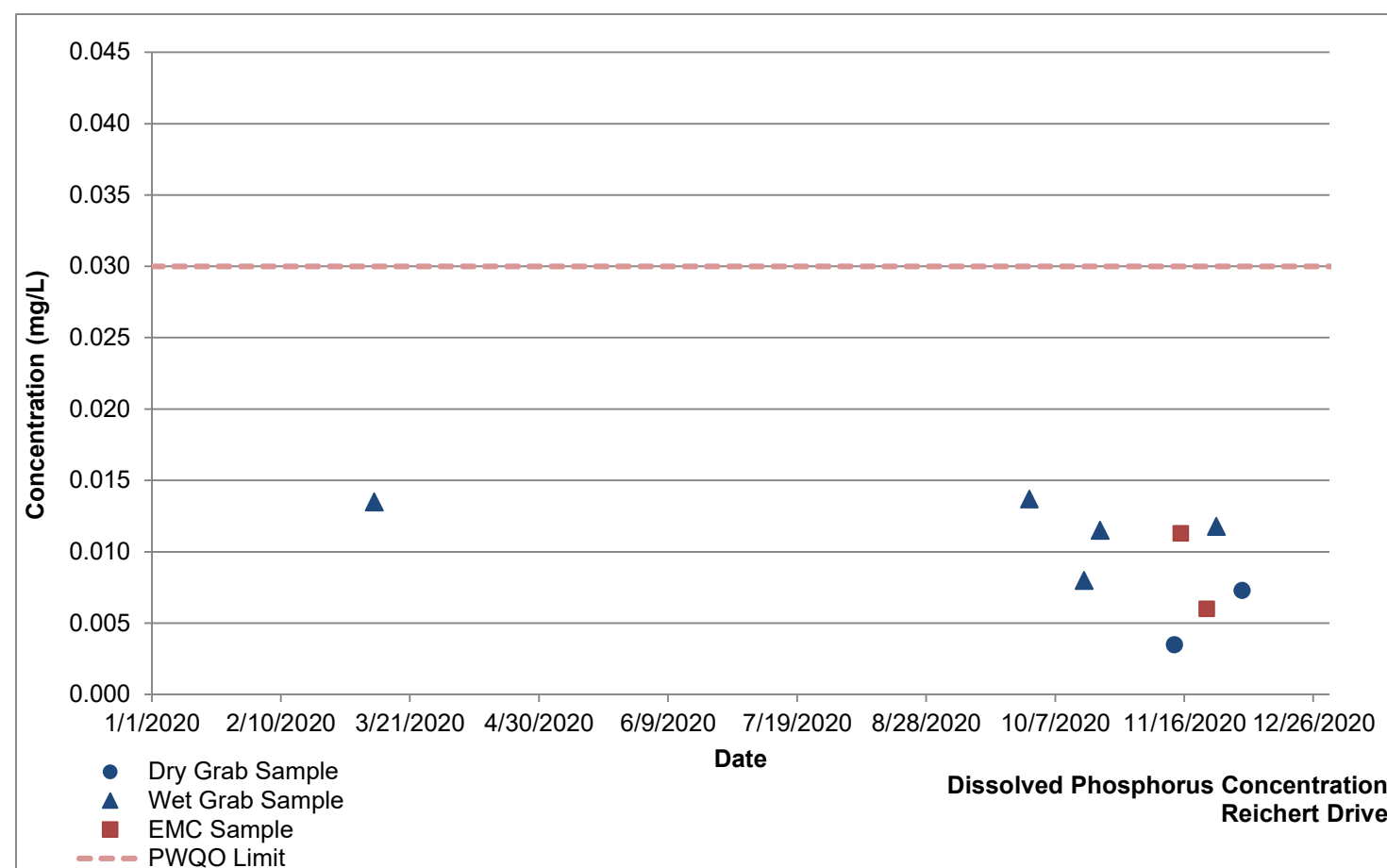
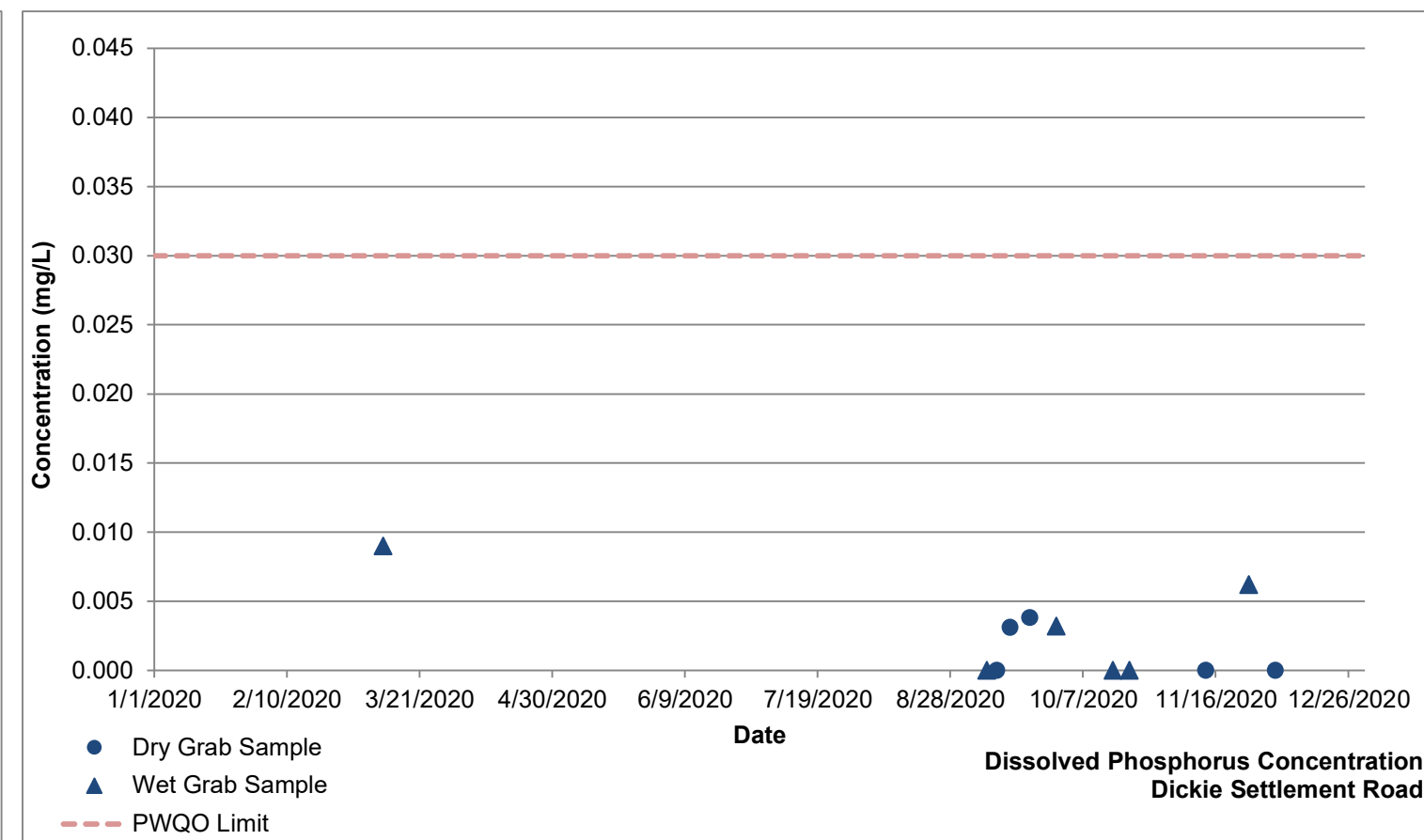
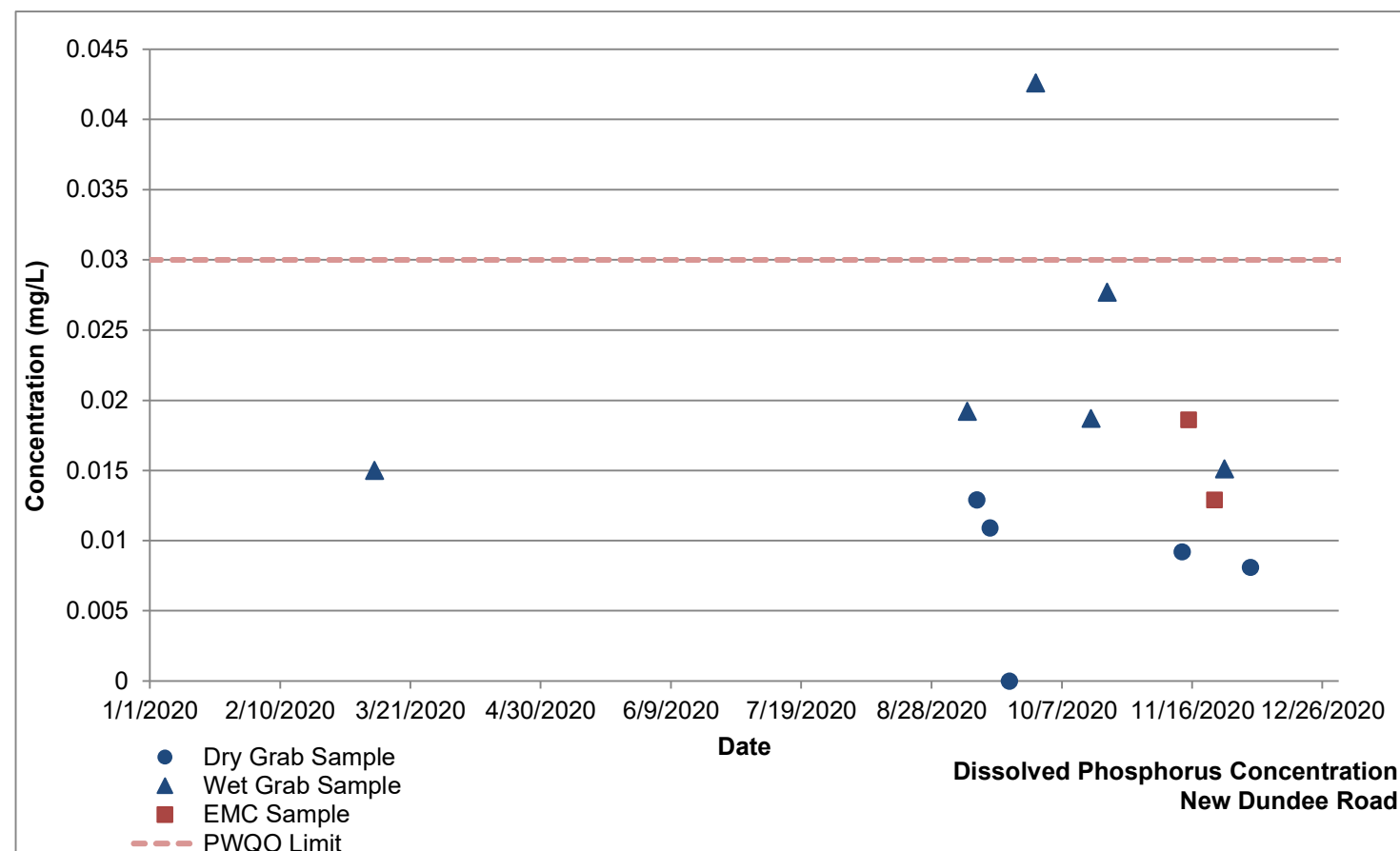


Figure 19
Dissolved Phosphorous Concentrations - Blair Creek Locations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

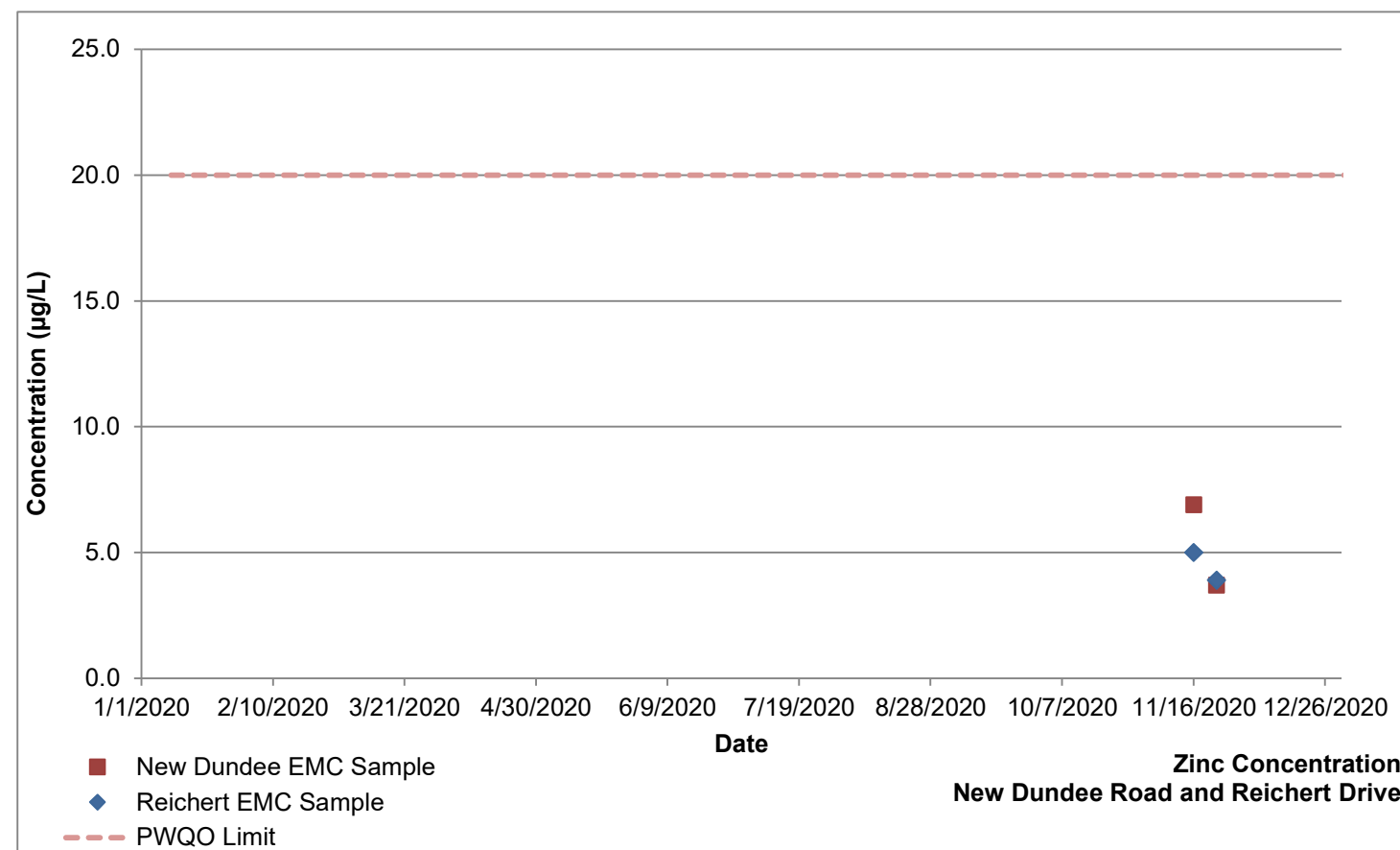
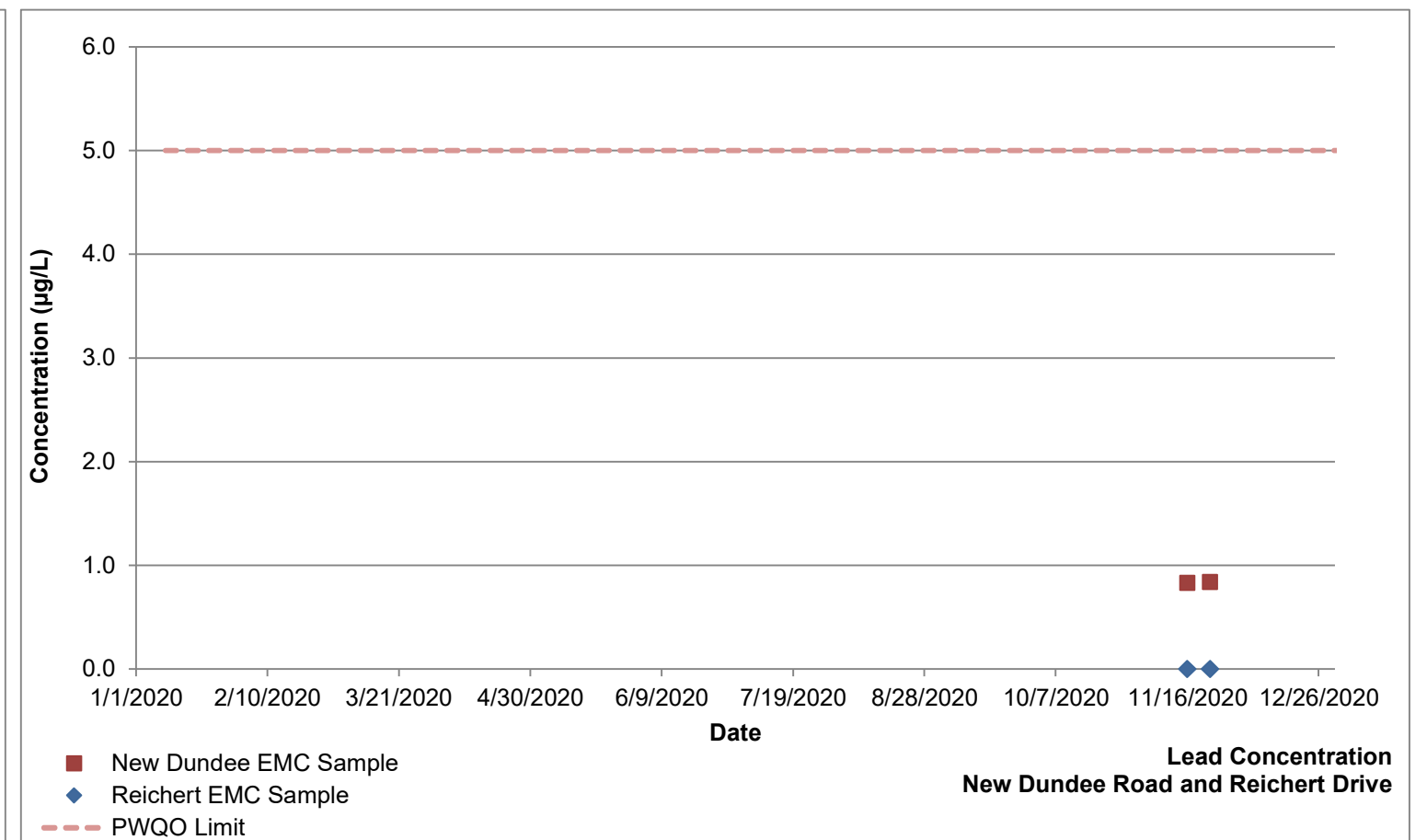
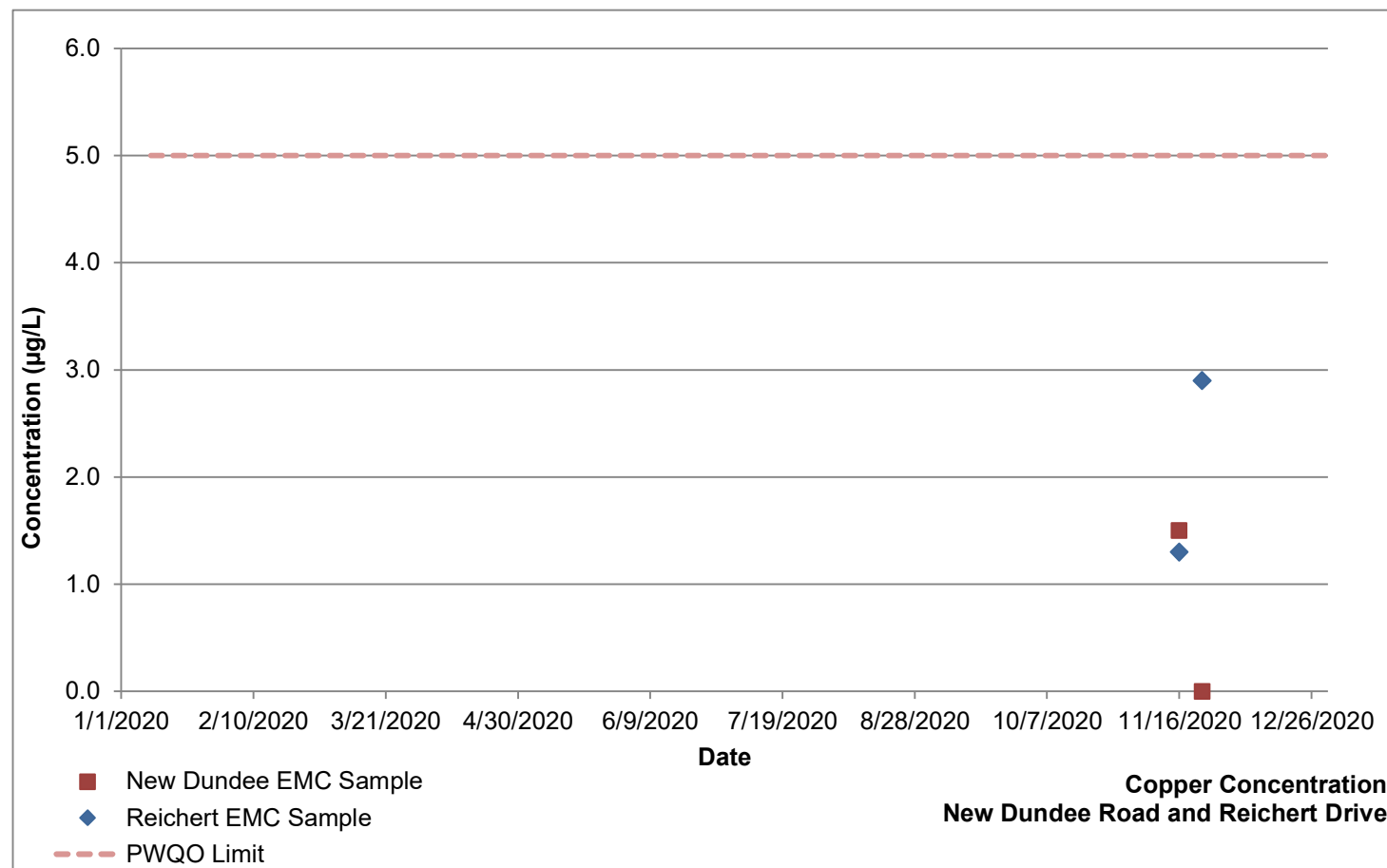
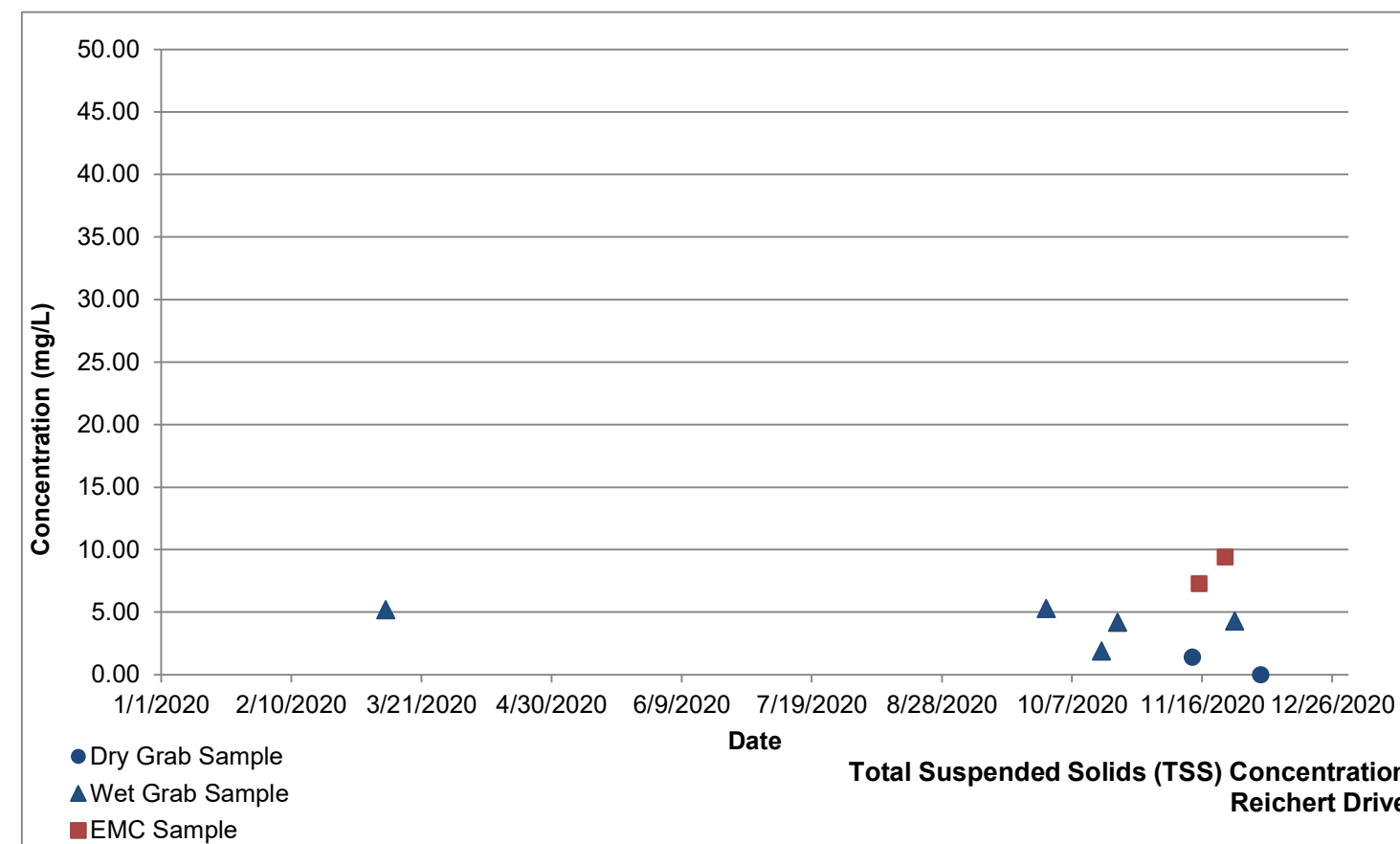
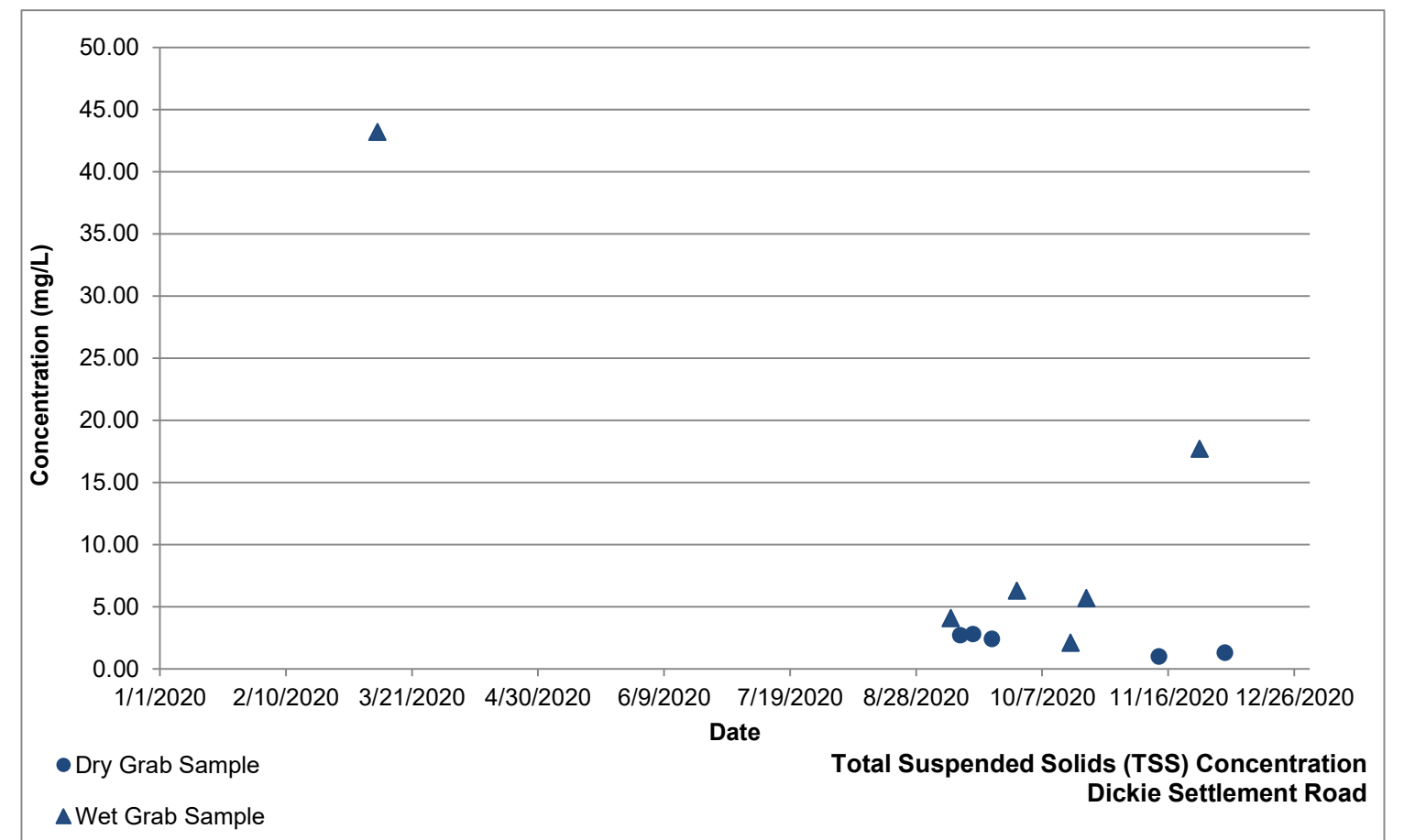
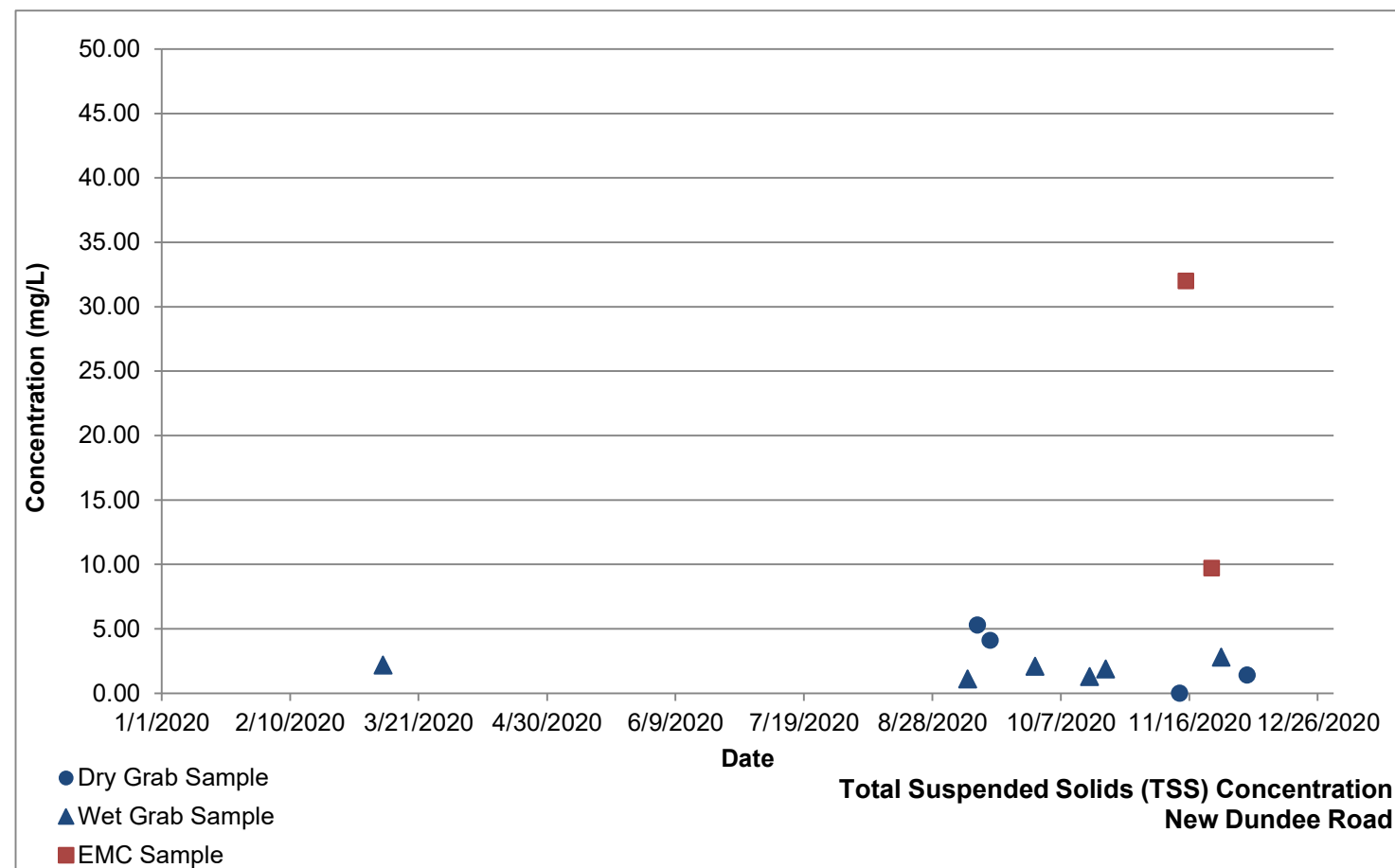
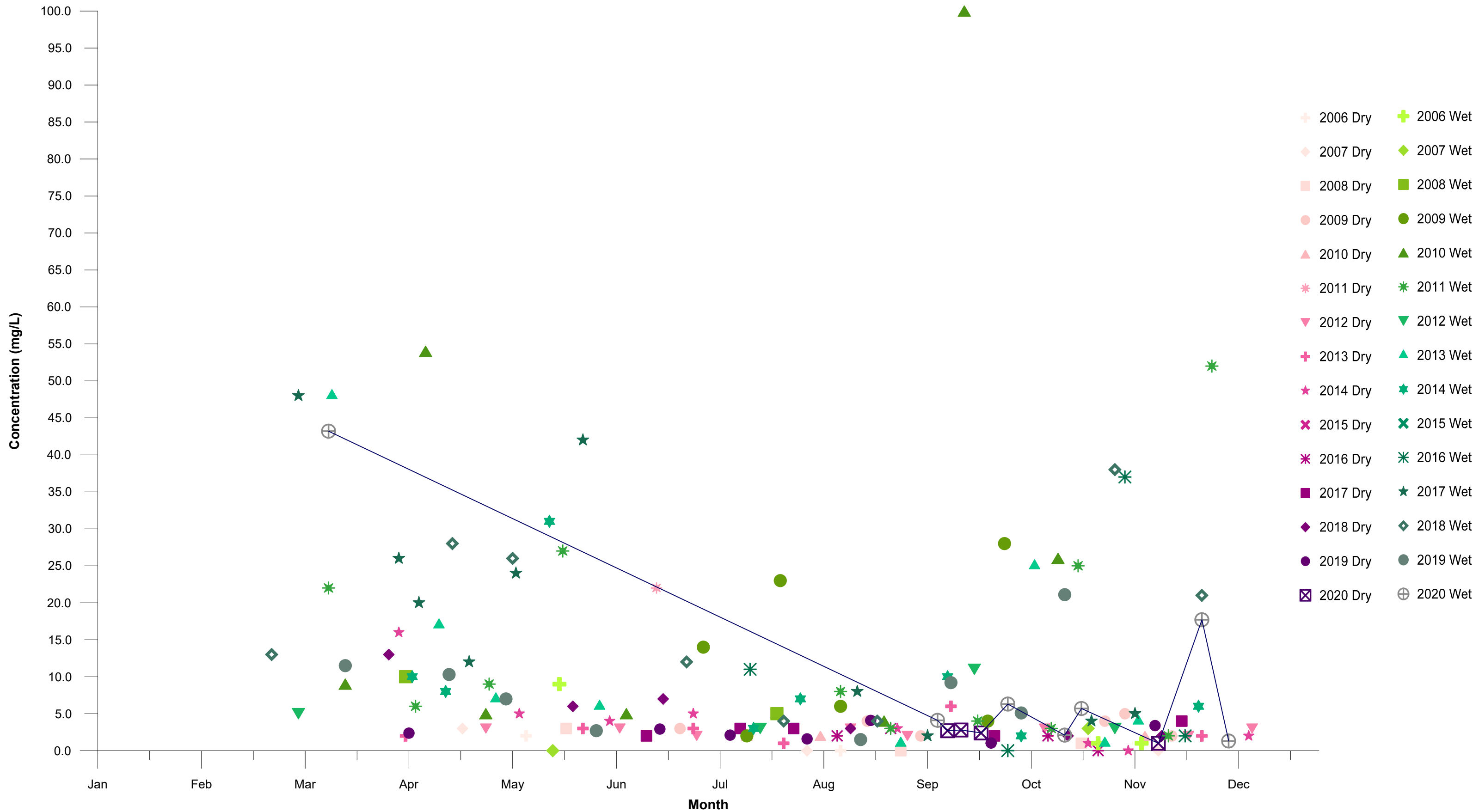


Figure 20
Copper, Lead, Zinc Concentrations - Blair Creek Locations
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario

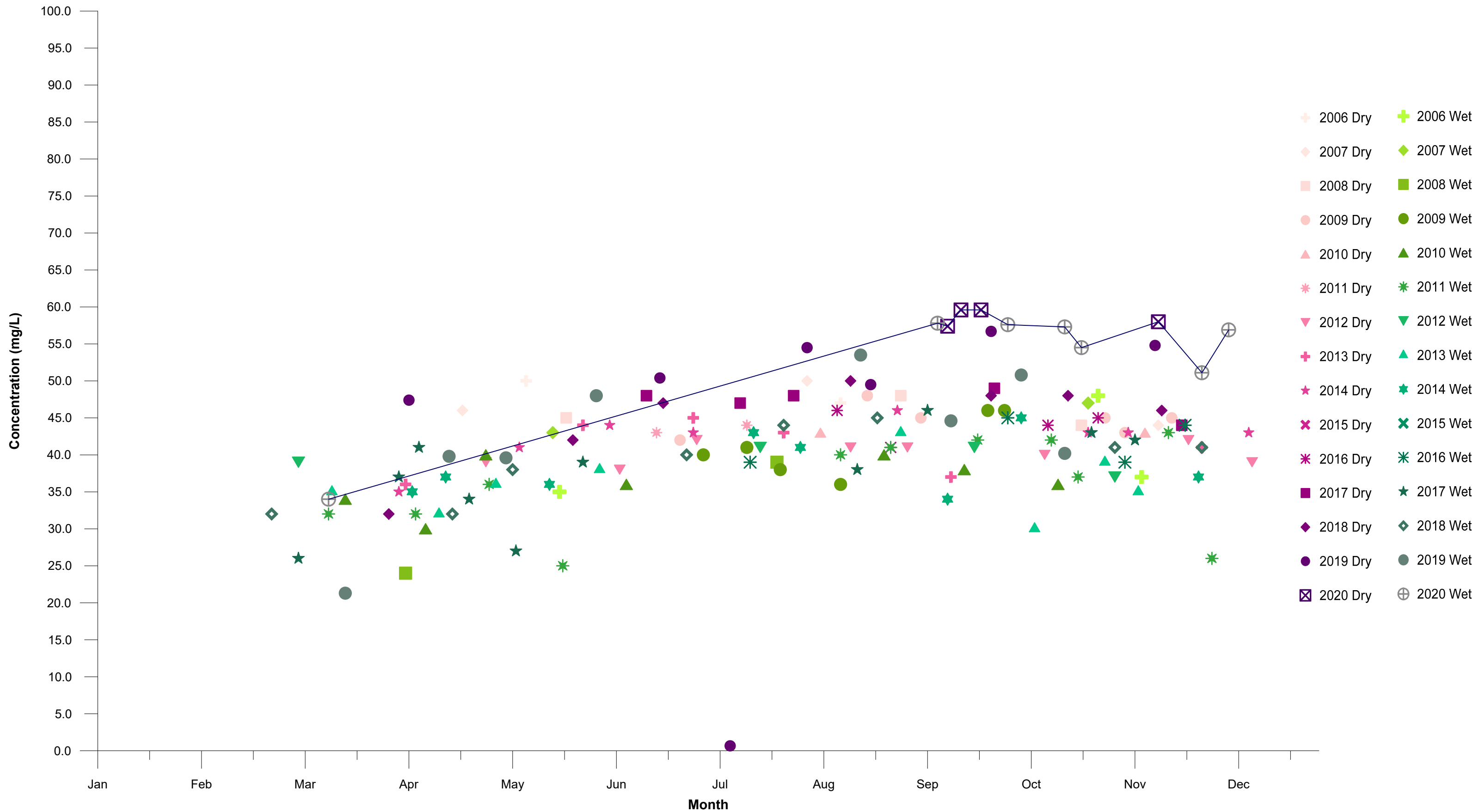




Note:

- The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

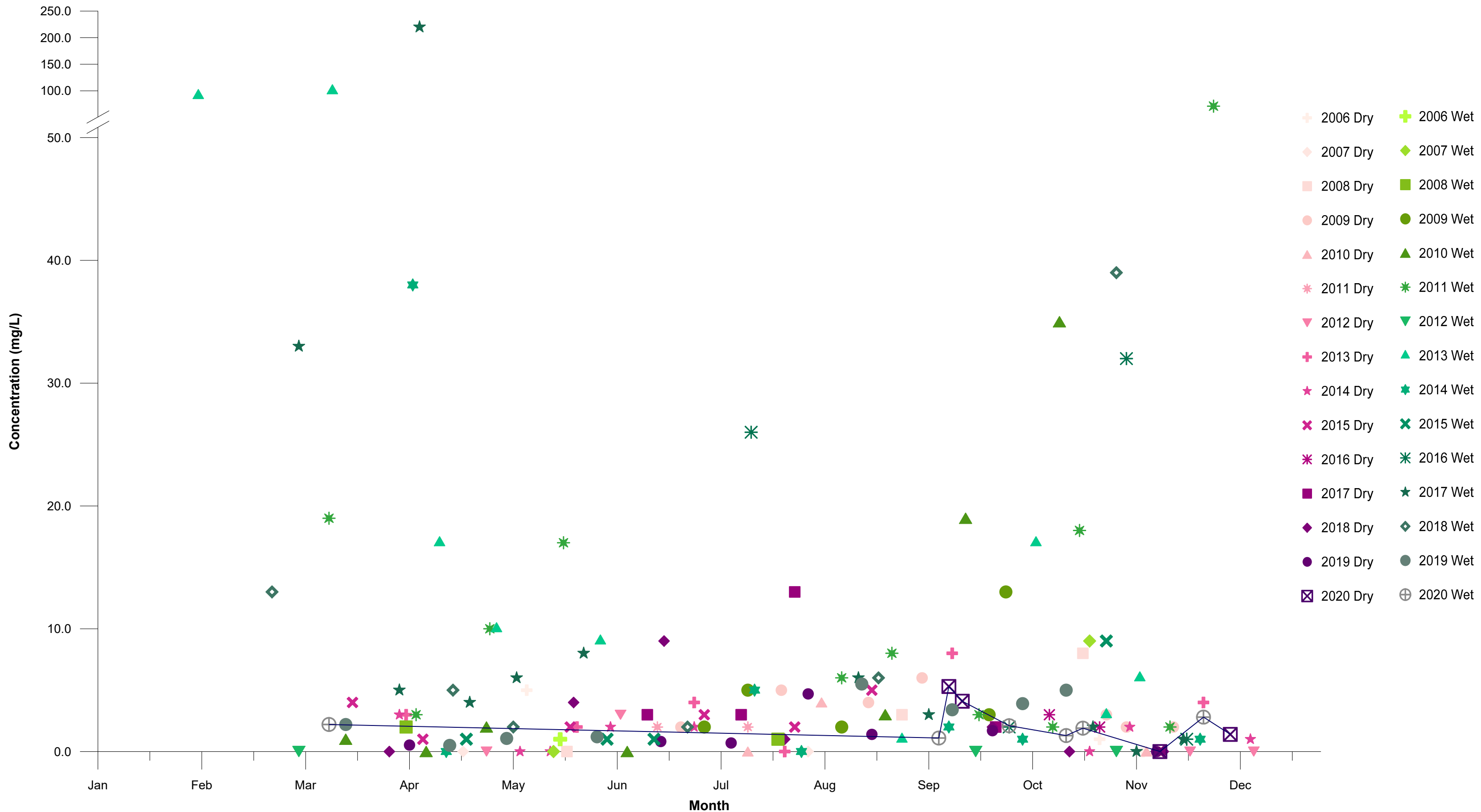
Figure 22
Total Suspended Solids Historical Trend Concentrations - Blair Creek - Dickie Settlement Road
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note:

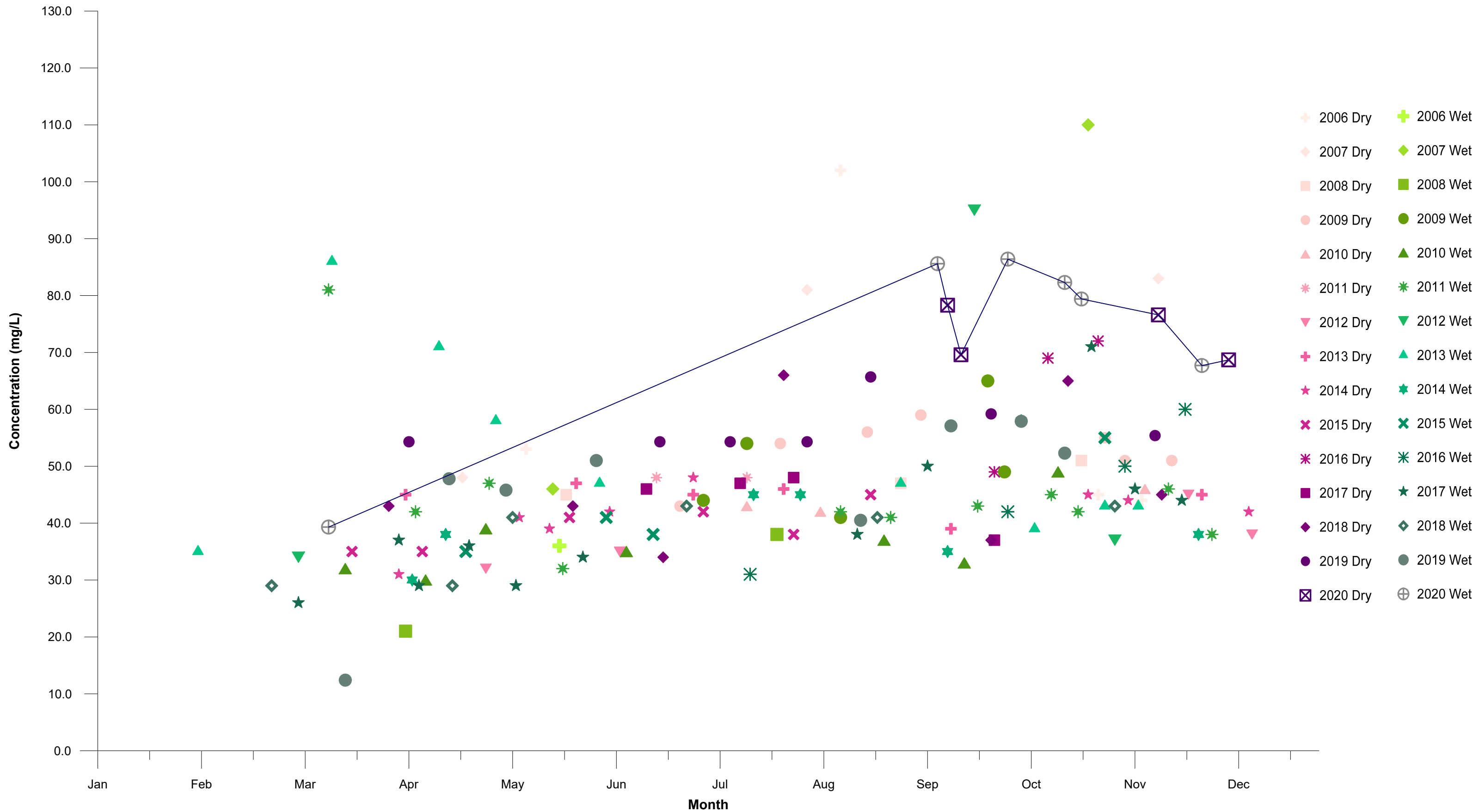
- The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 23
Chloride Historical Trend Concentrations - Blair Creek - Dickie Settlement Road
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note:
 - The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 24
Total Suspended Solids Historical Trend Concentrations - Blair Creek - New Dundee Road
 Stormwater Management Monitoring Program 2020
 2020 Kitchener Surface Water Monitoring
 Kitchener, Ontario



Note:

- The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 25
Chloride Historical Trend Concentrations - Blair Creek - New Dundee Road
 Stormwater Management Monitoring Program 2020
 2020 Kitchener Surface Water Monitoring
 Kitchener, Ontario

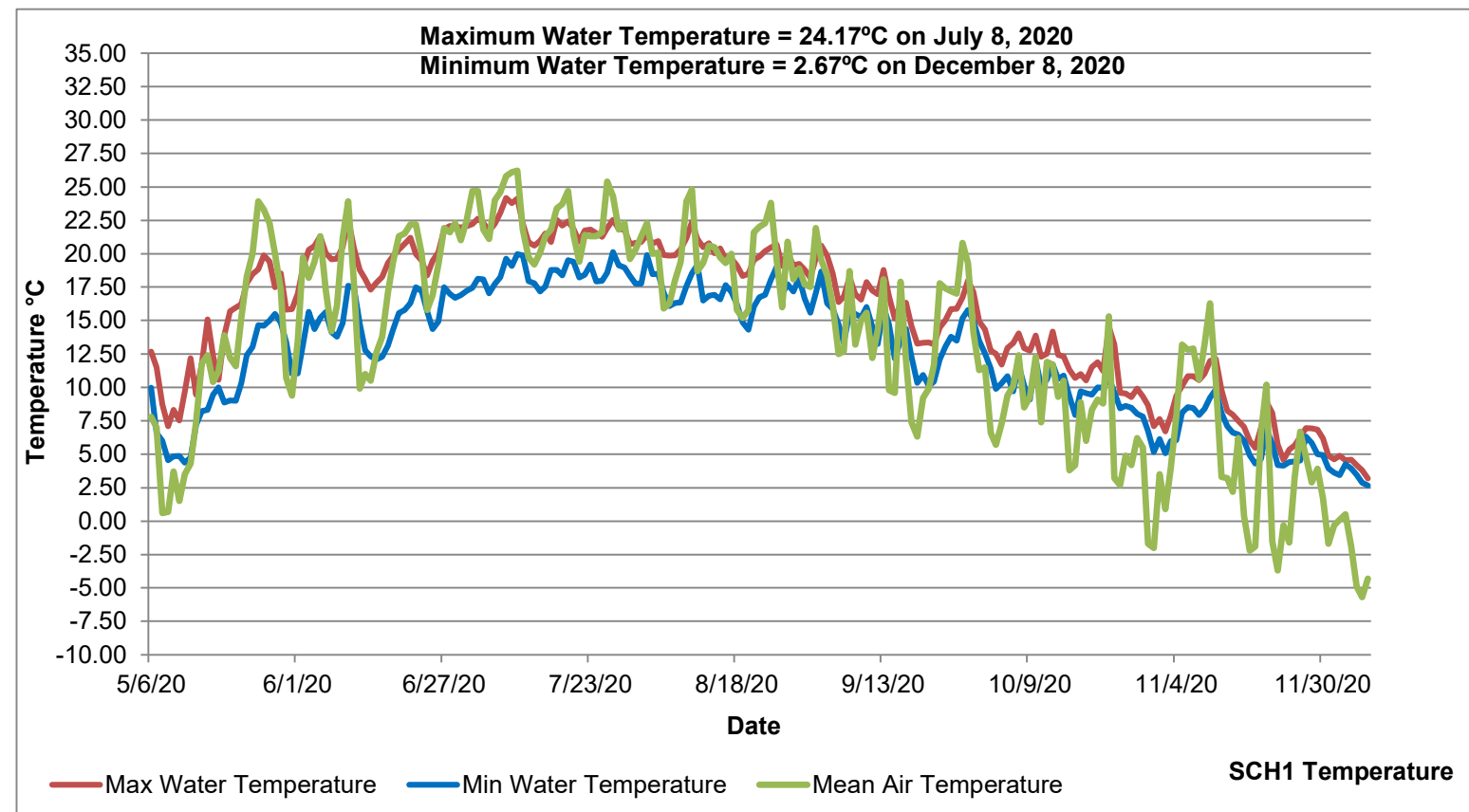
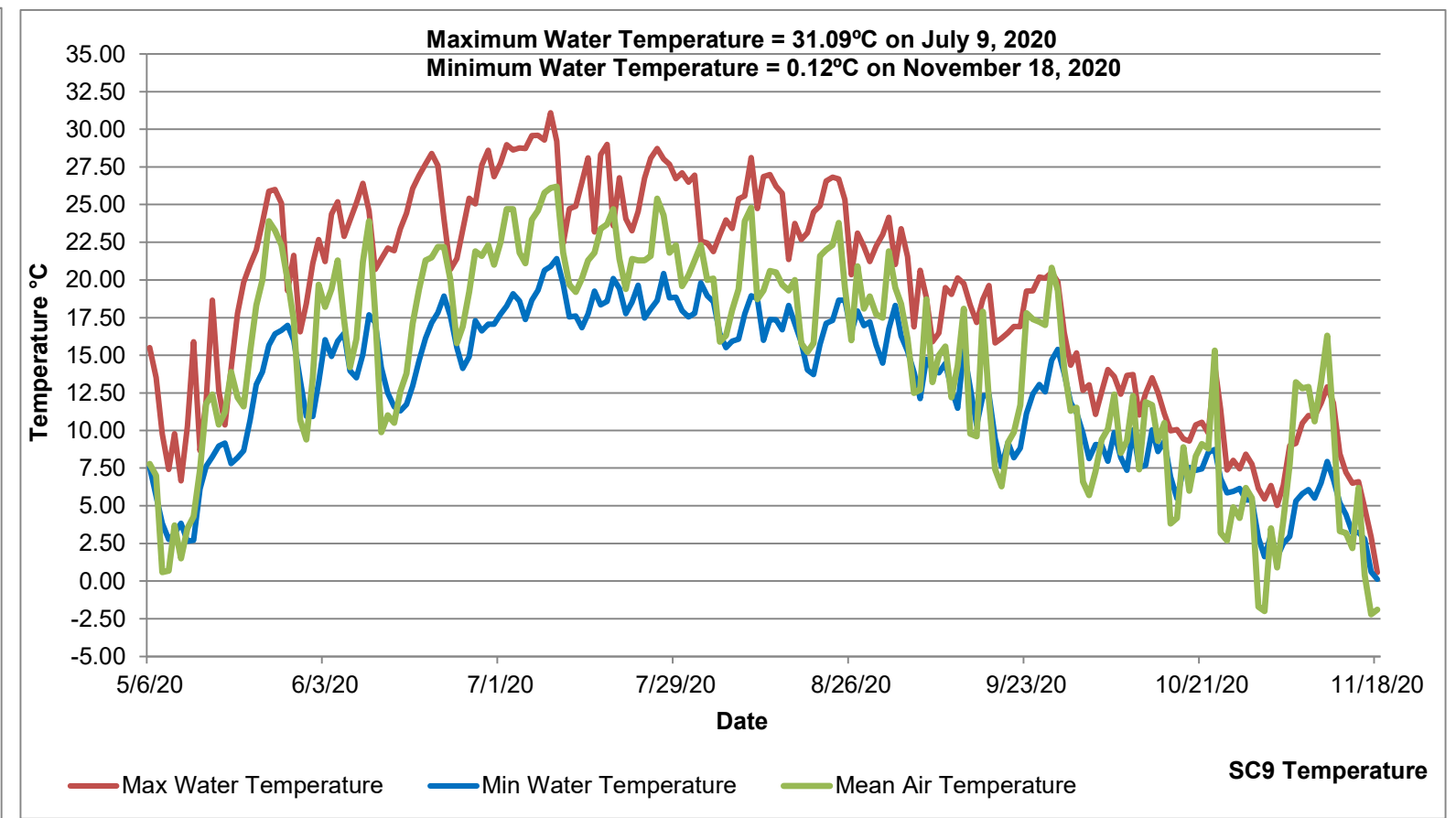
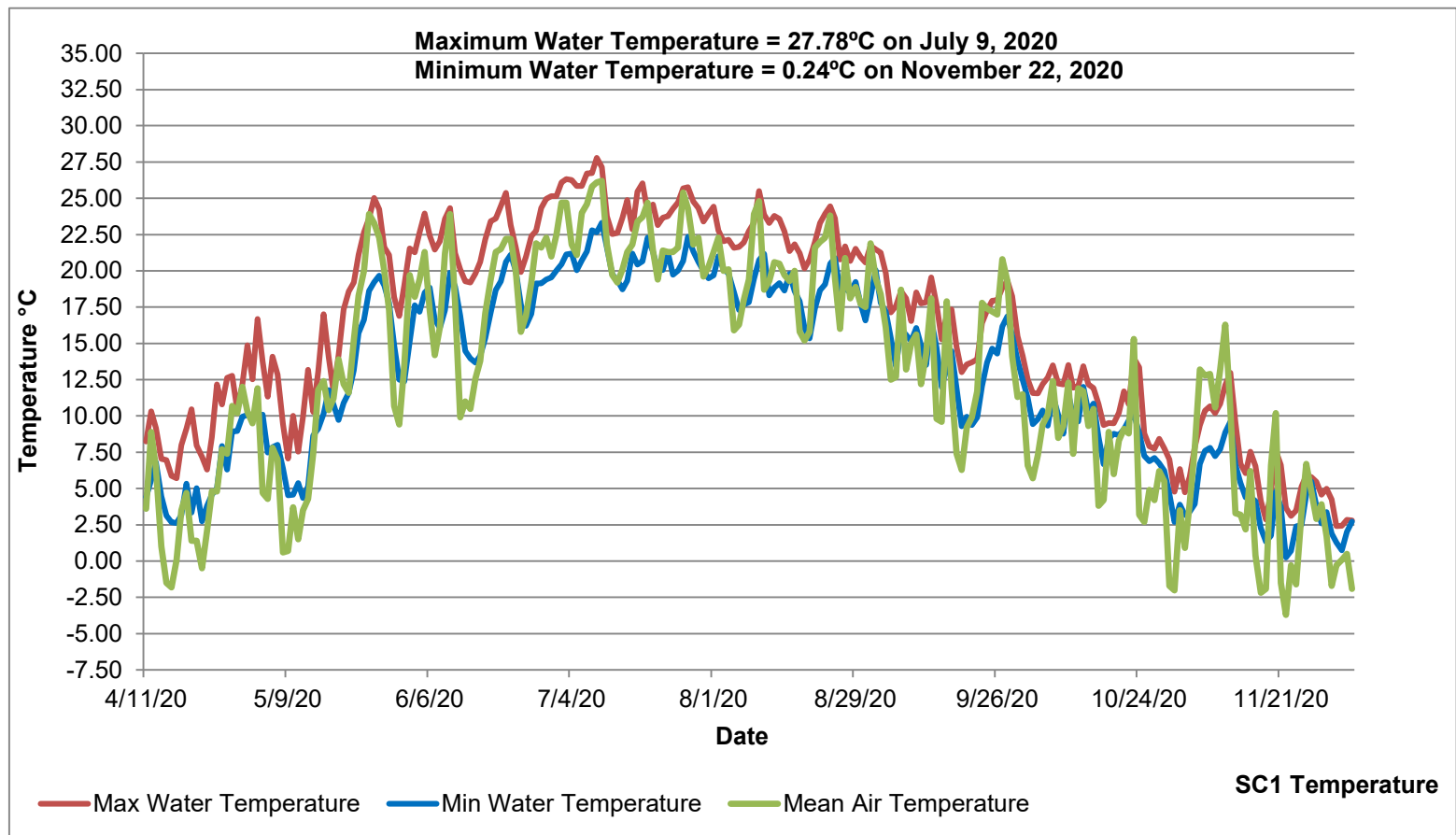
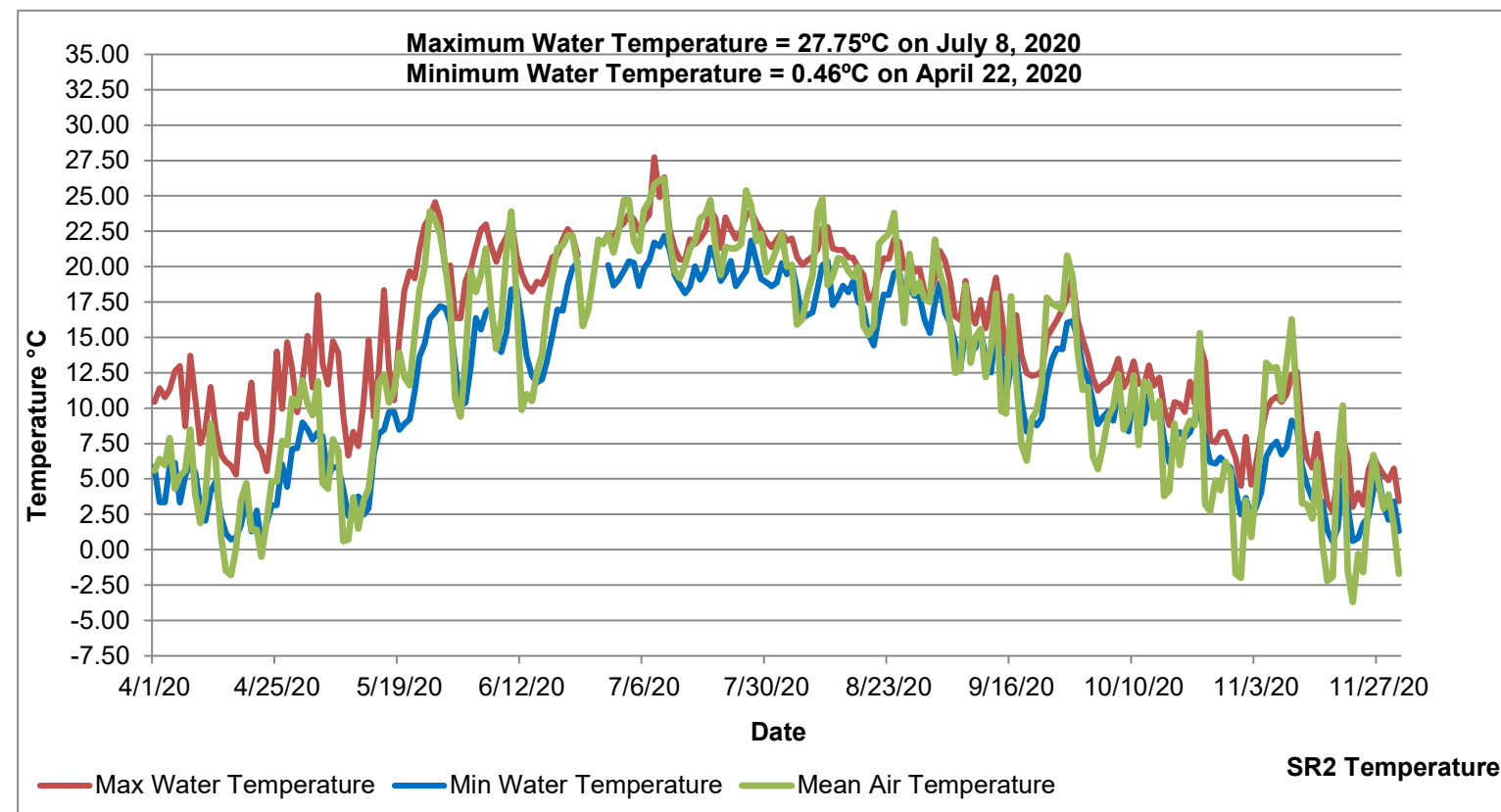
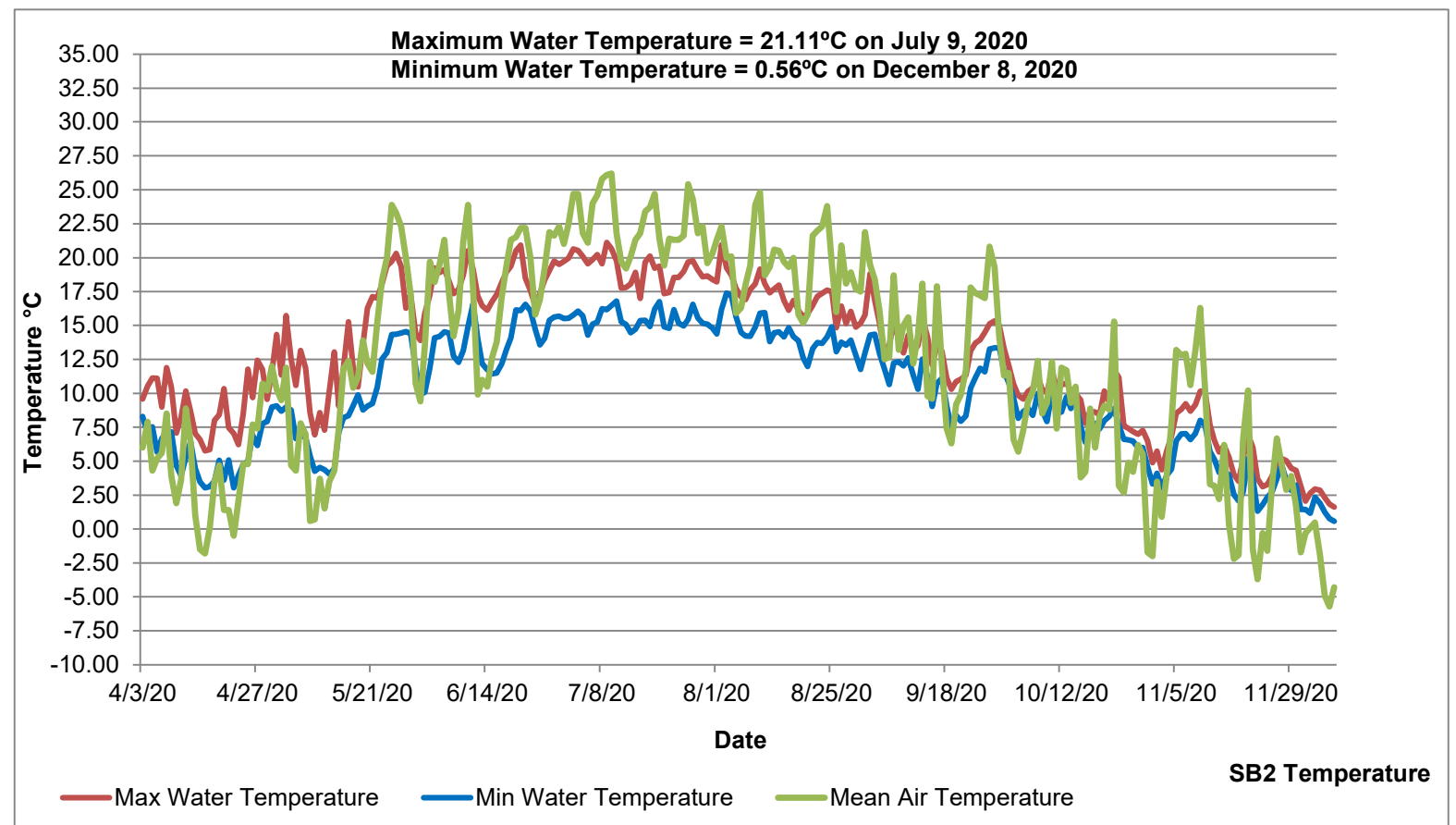
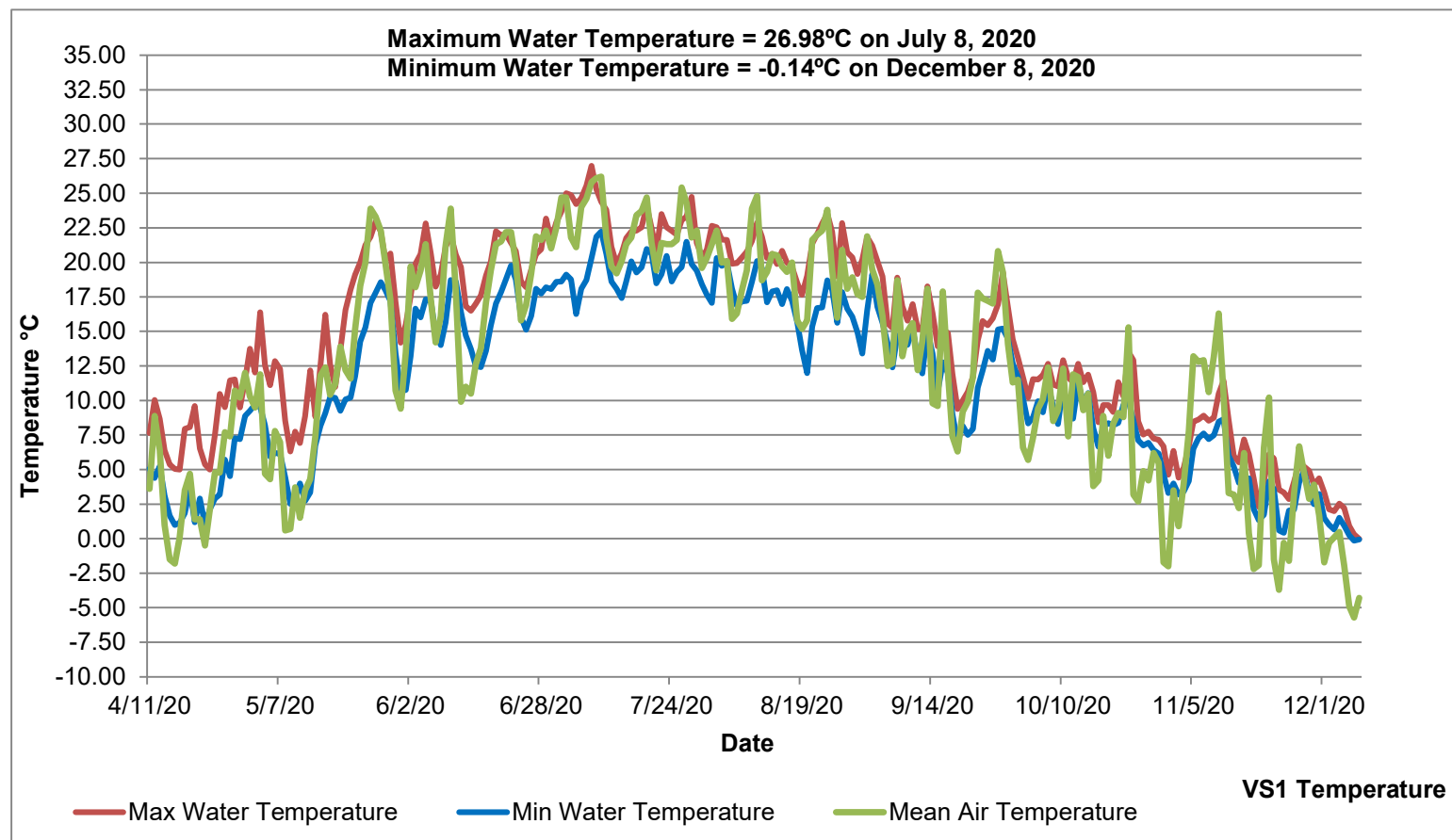


Figure 26
Continuous Water Temperature - SC1, SC9, SCH1
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



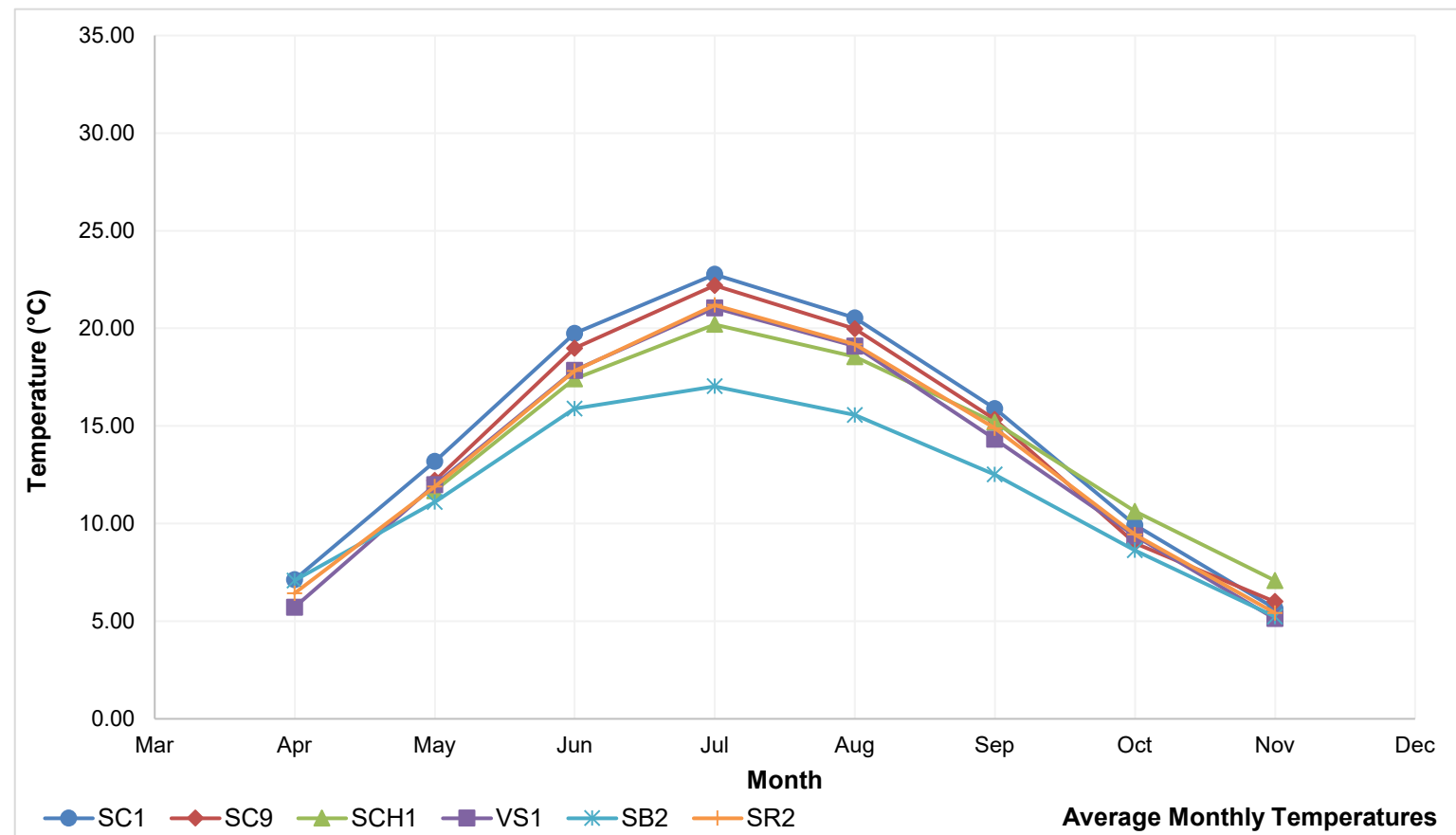
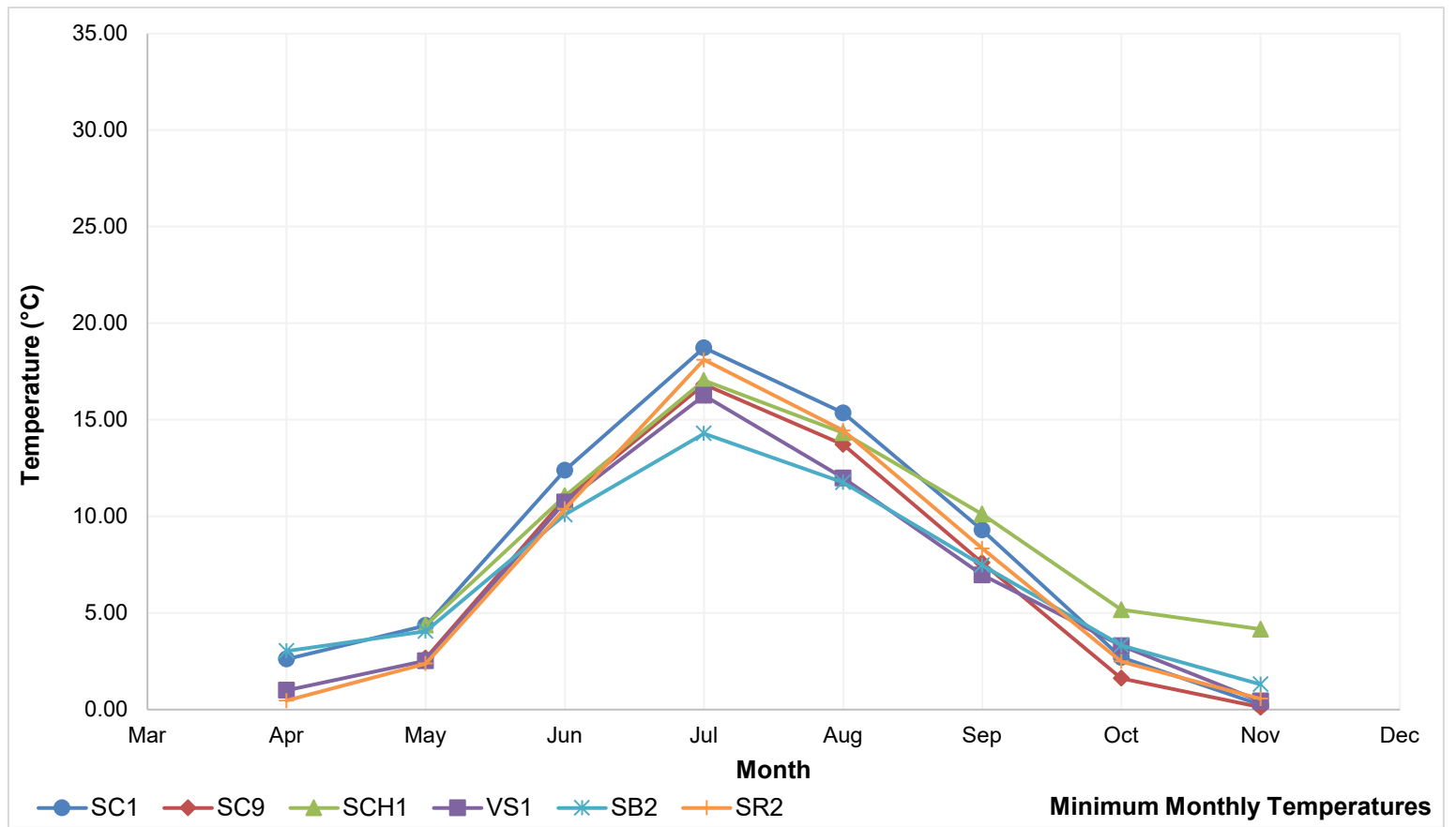
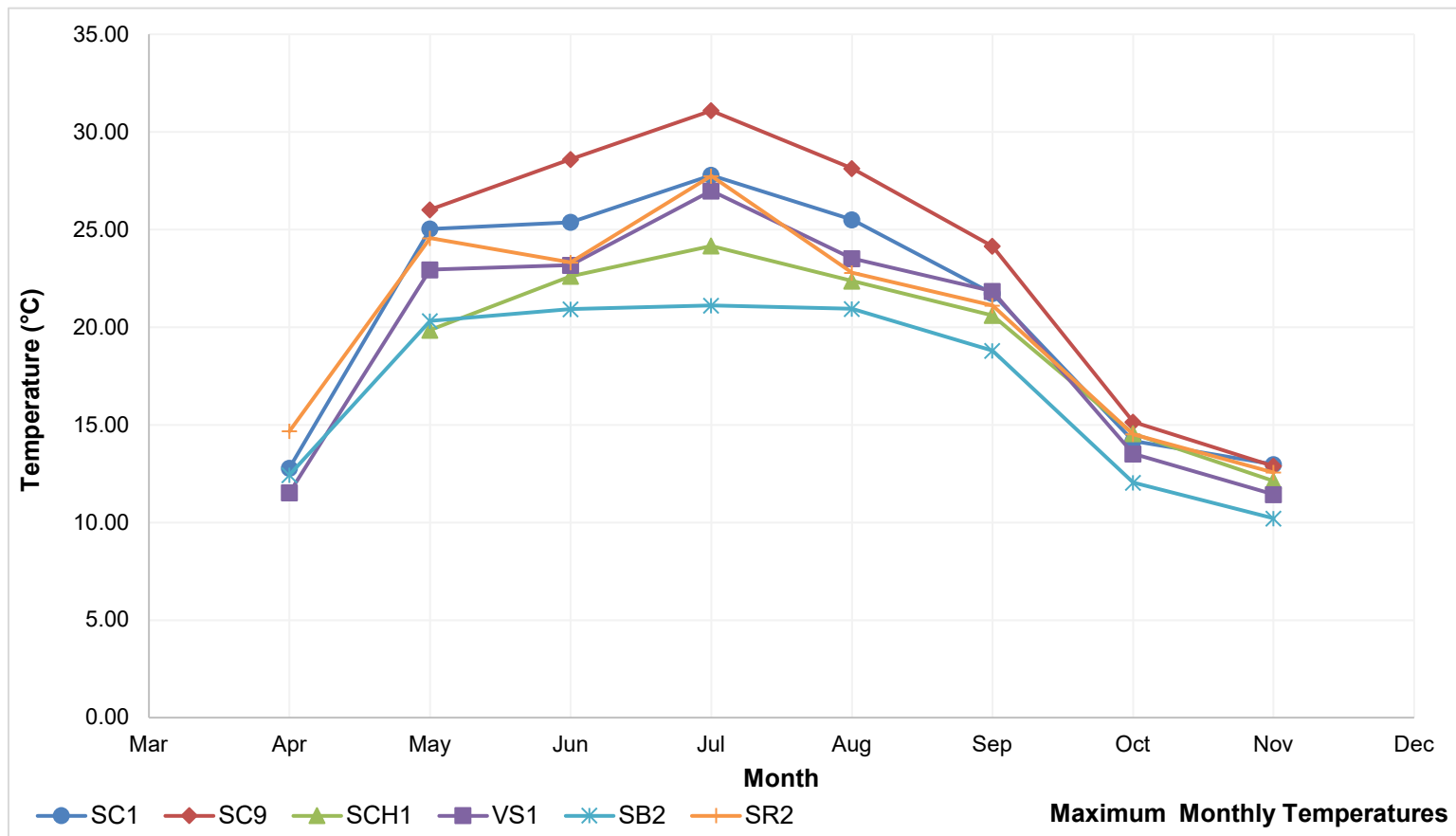
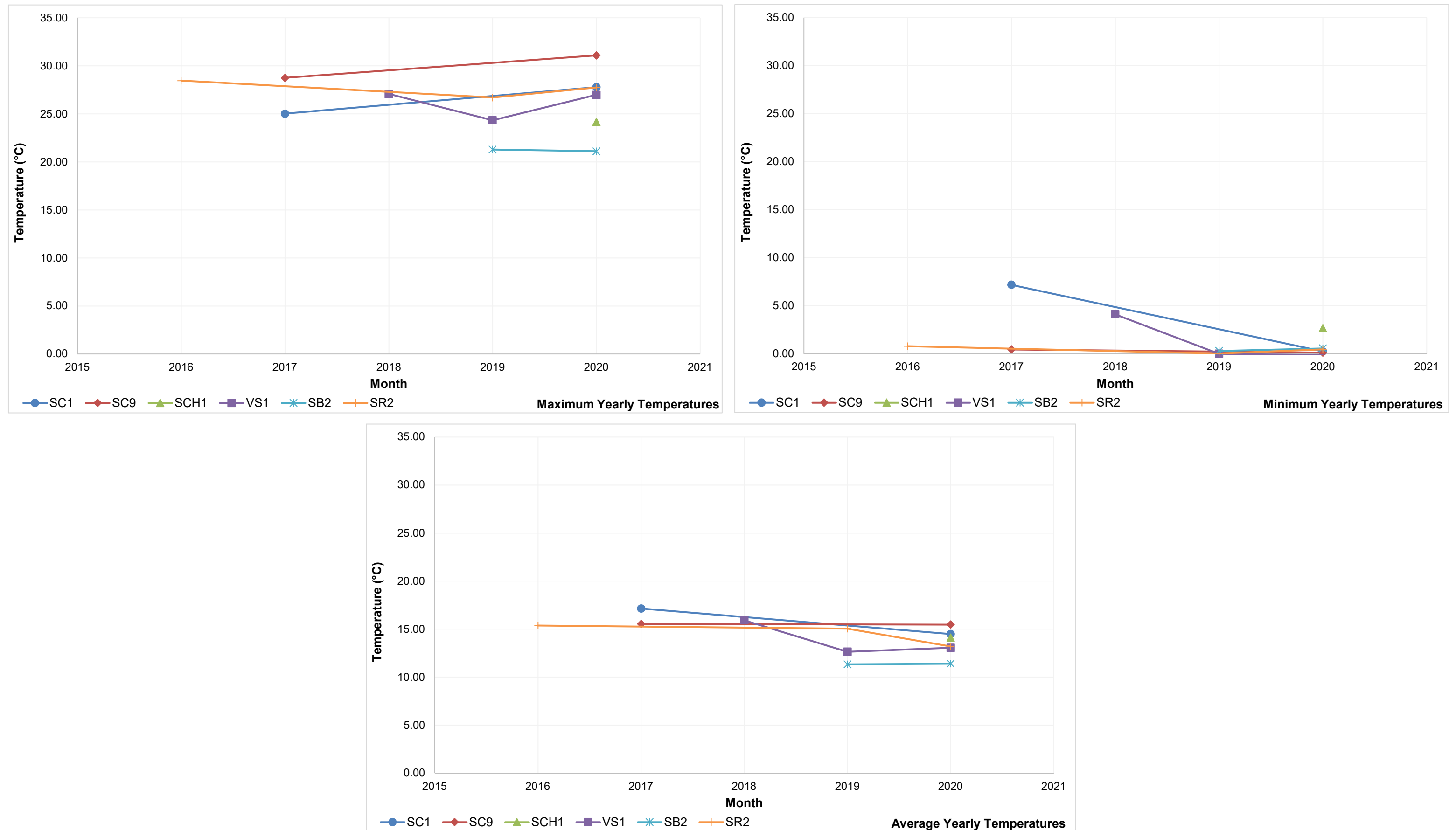


Figure 27B
2020 Monthly Water Temperatures
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Notes:

- SC1, SC9, and SCH1 was not monitored in 2019
- SC1, SC9, SCH1, SB2, and SR2 was not monitored in 2018
- SCH1, VS1, SB2, and SR2 was not monitored in 2017
- SC1, SC9, SCH1, VS1, and SB2 was not monitored in 2016
- Temperature monitoring was not conducted throughout a full calendar year, therefore the minimum and average temperatures may not be representative.
- Connecting lines are for visual presentation, and not intended to represent a trend.



Figure 27C
2016-2020 Water Temperatures
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

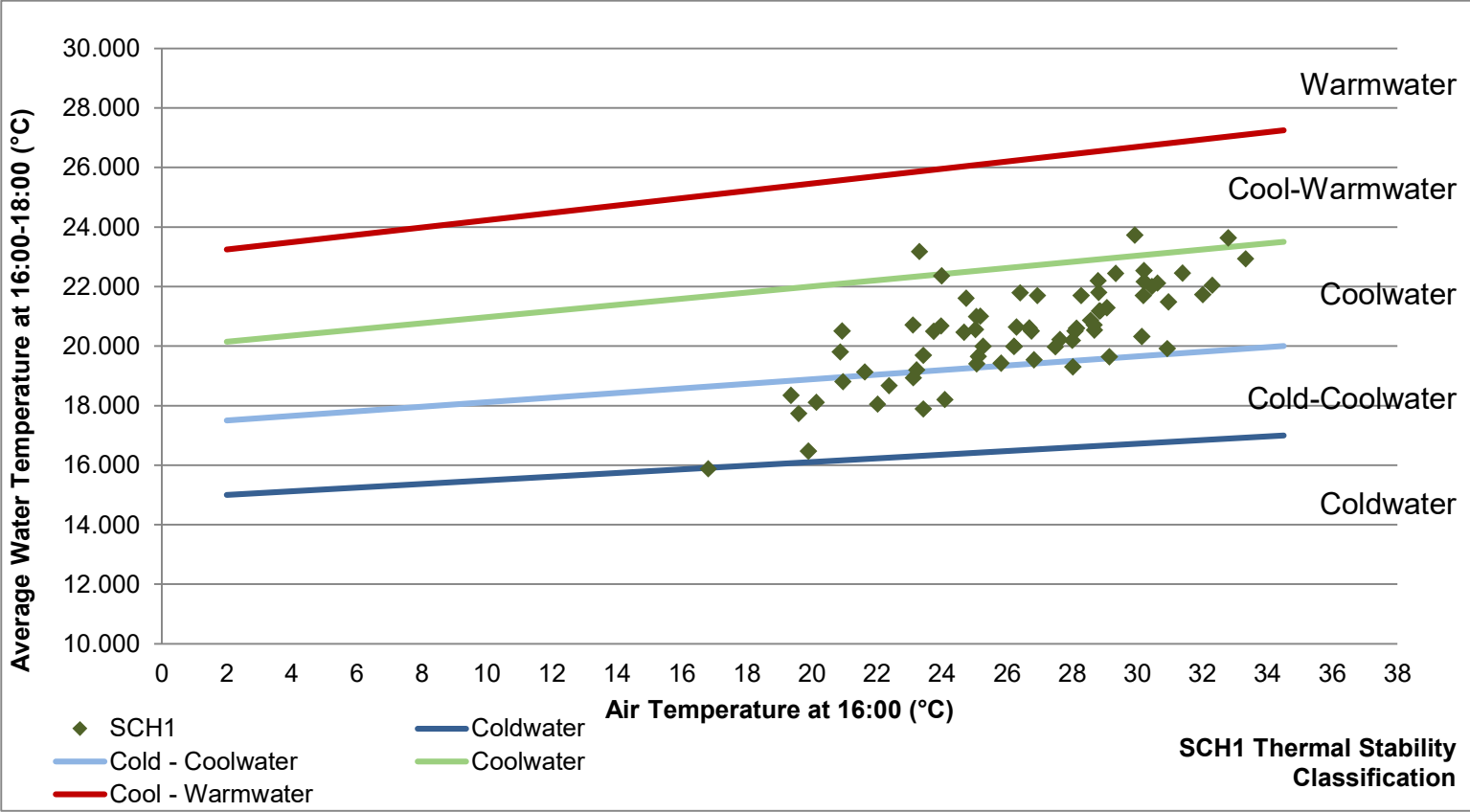
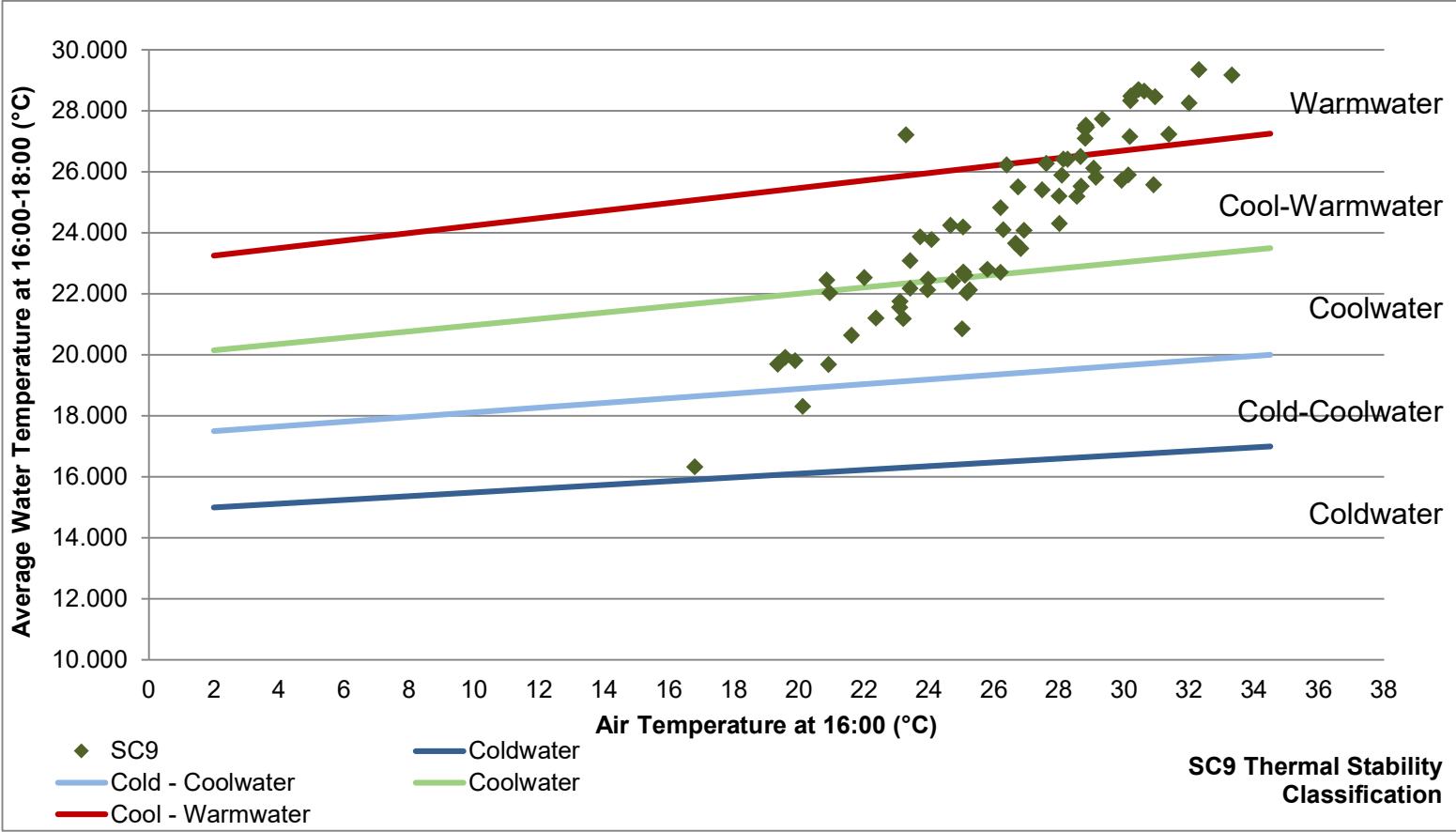
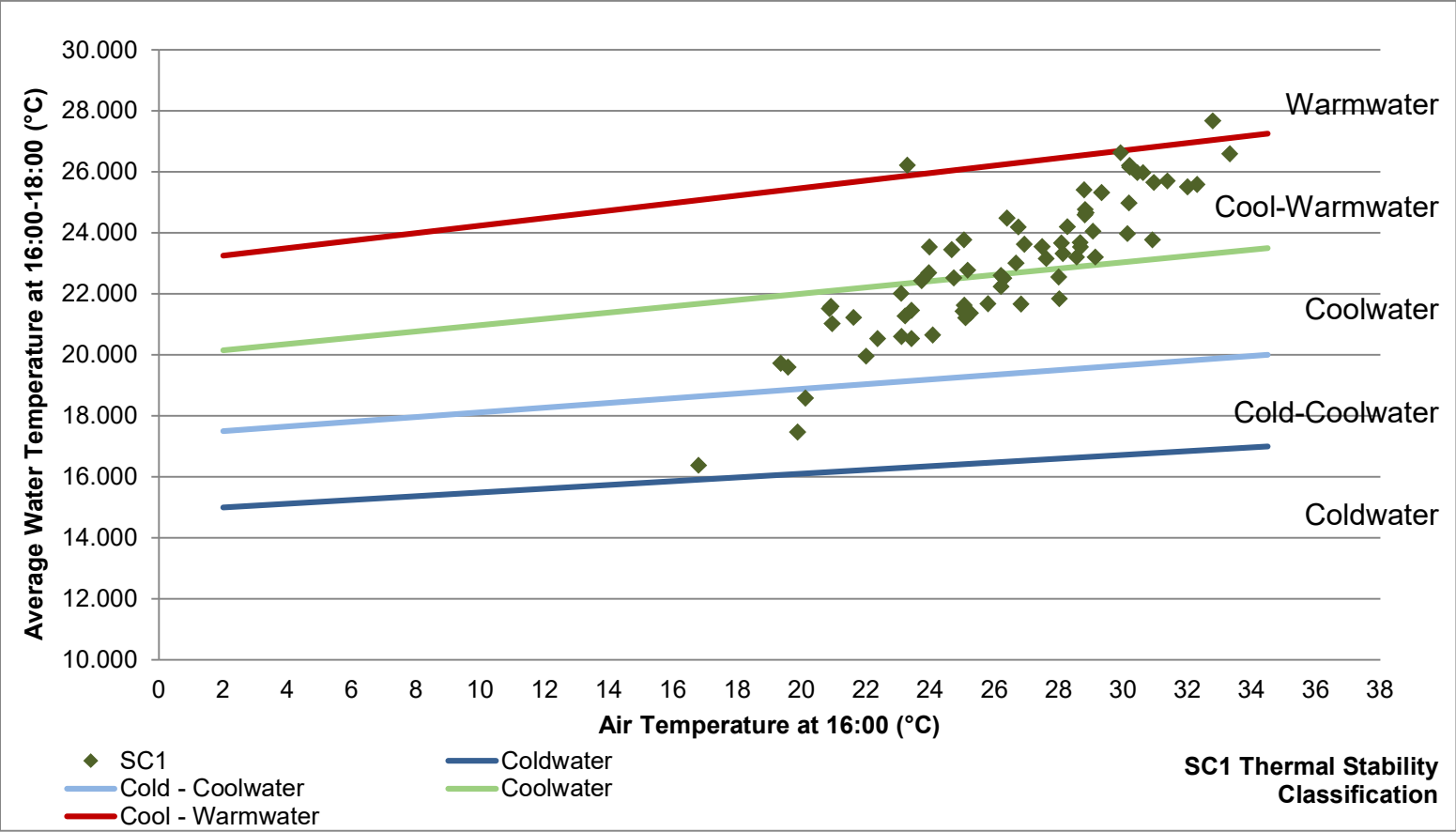
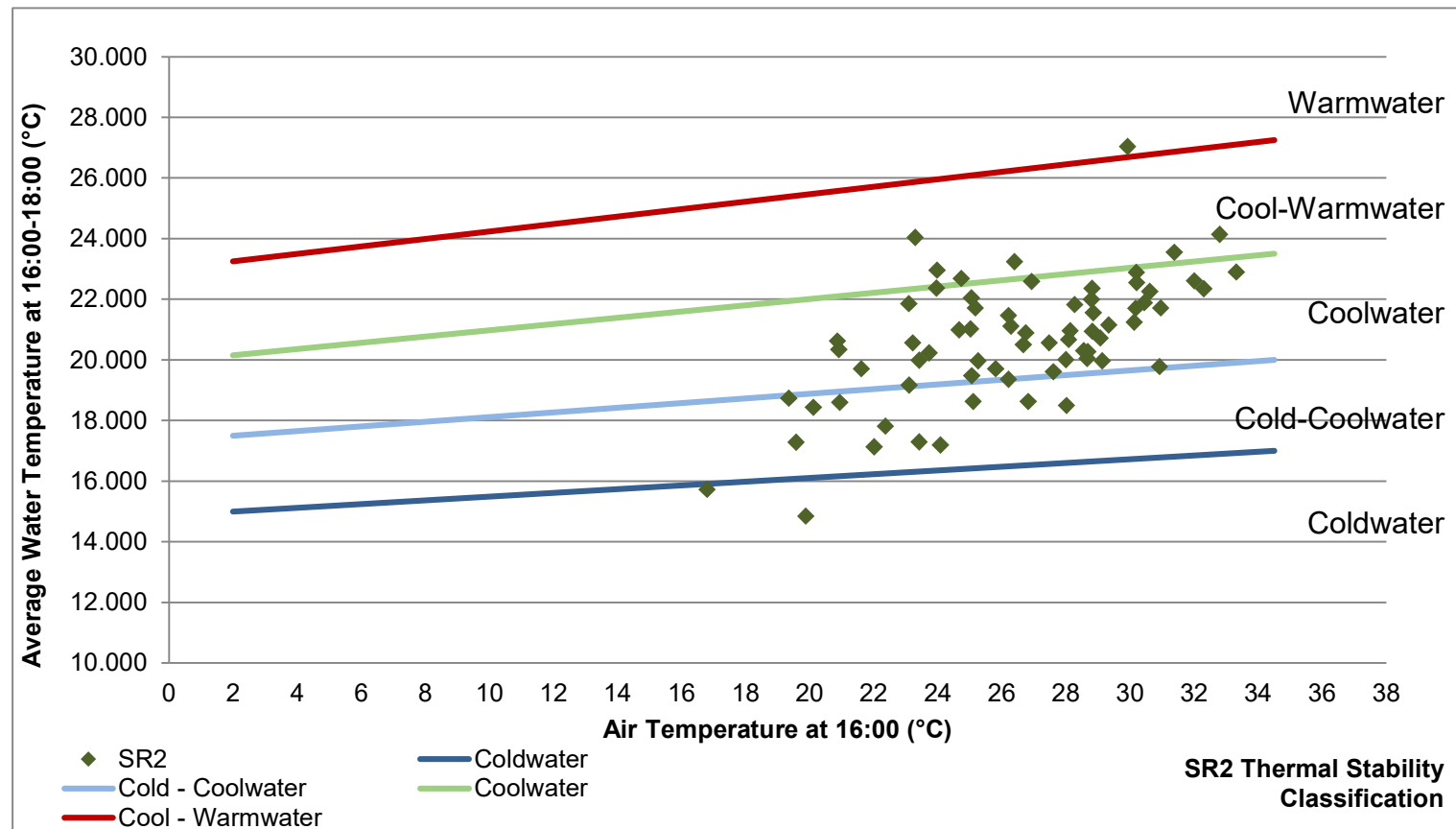
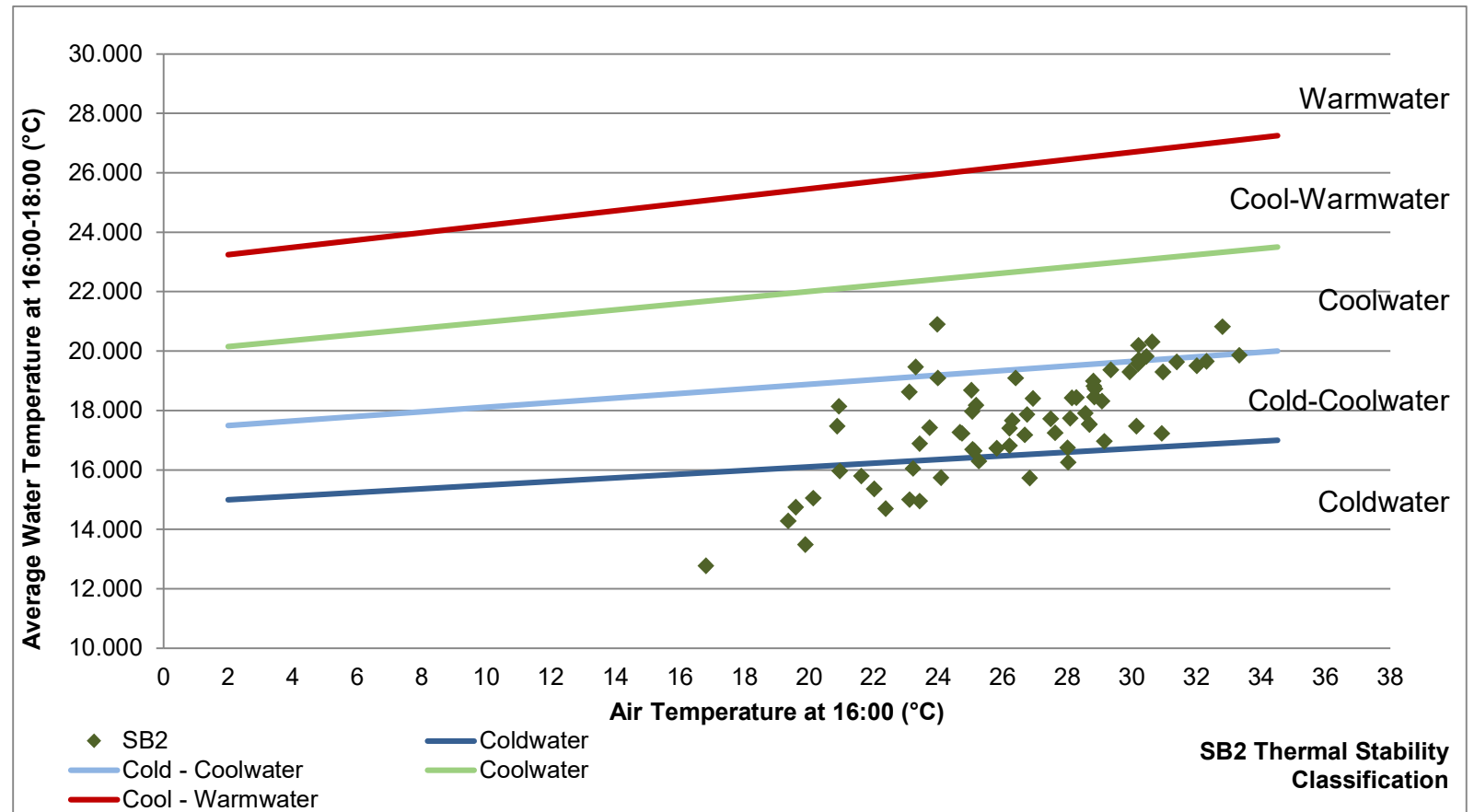
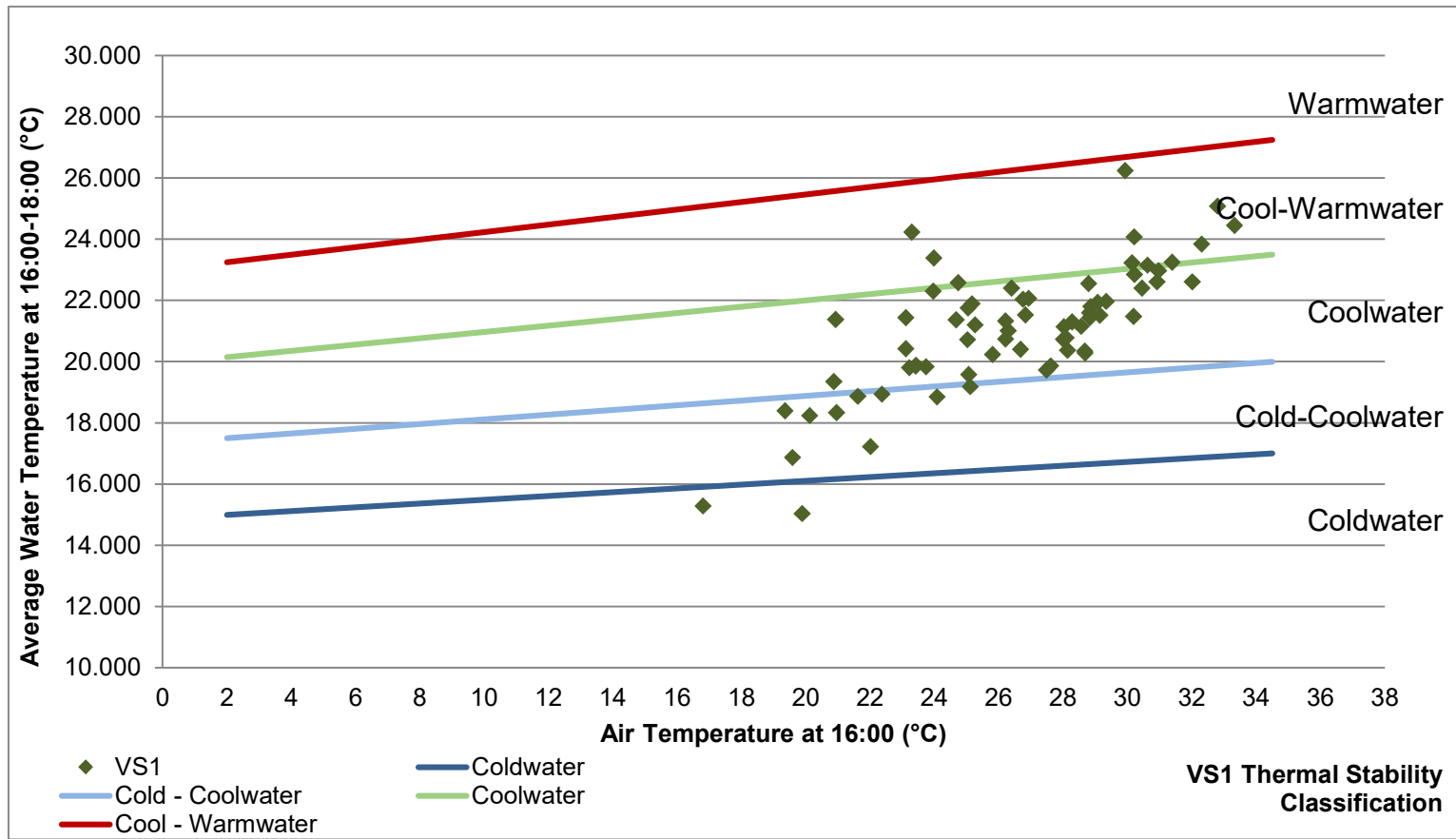
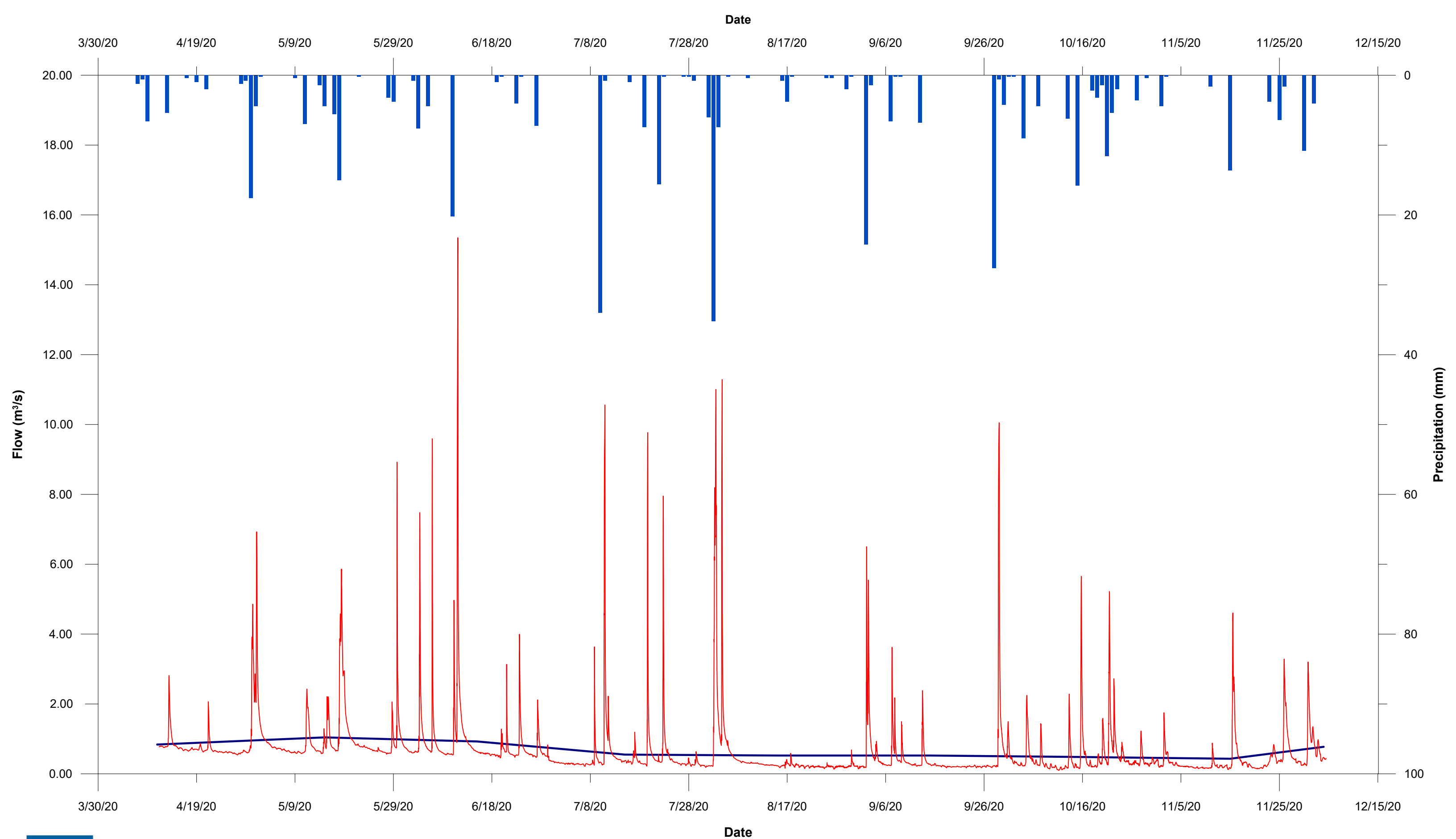


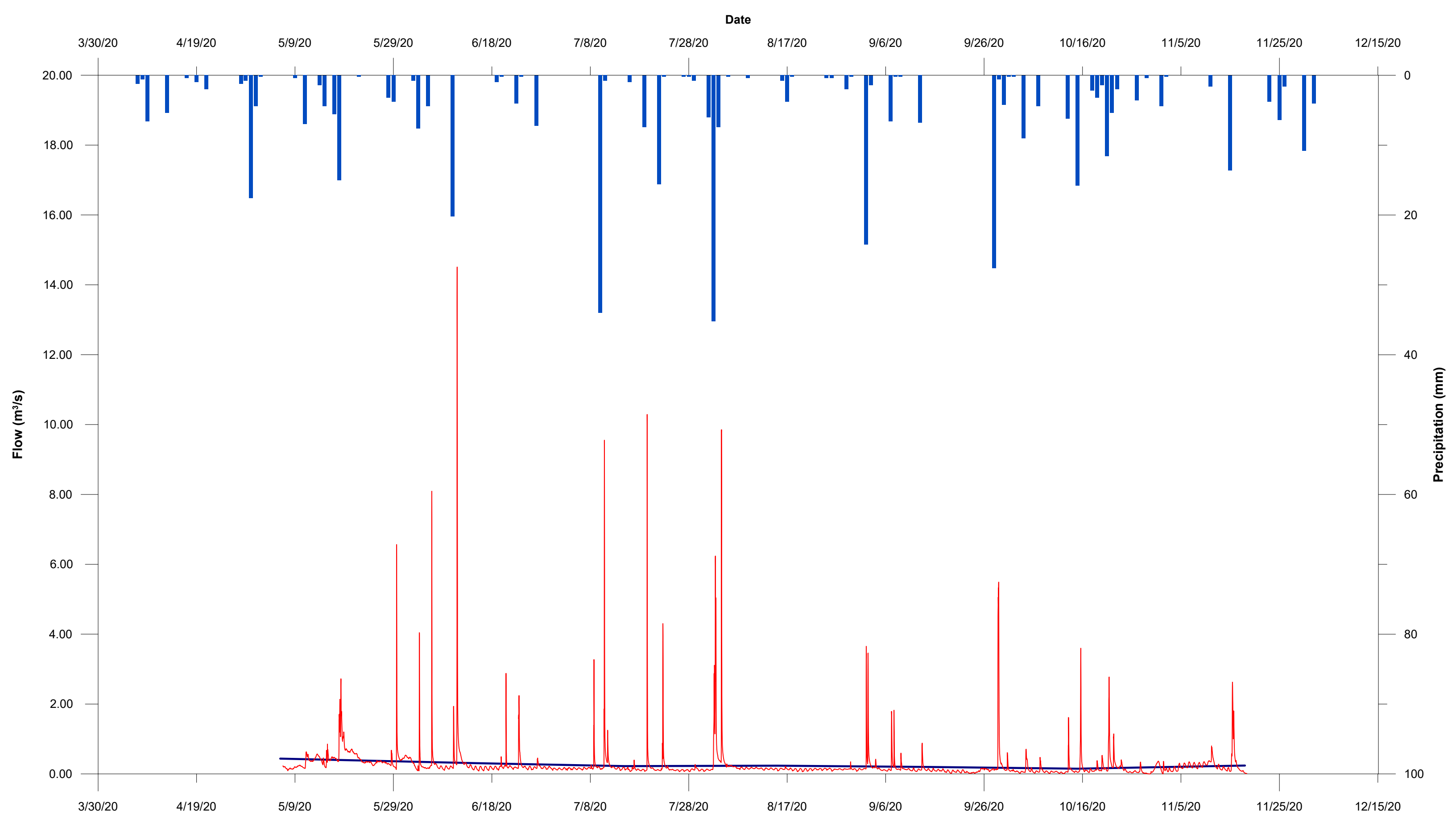
Figure 28
Thermal Stability Classification - SC1, SC9, SCH1
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario





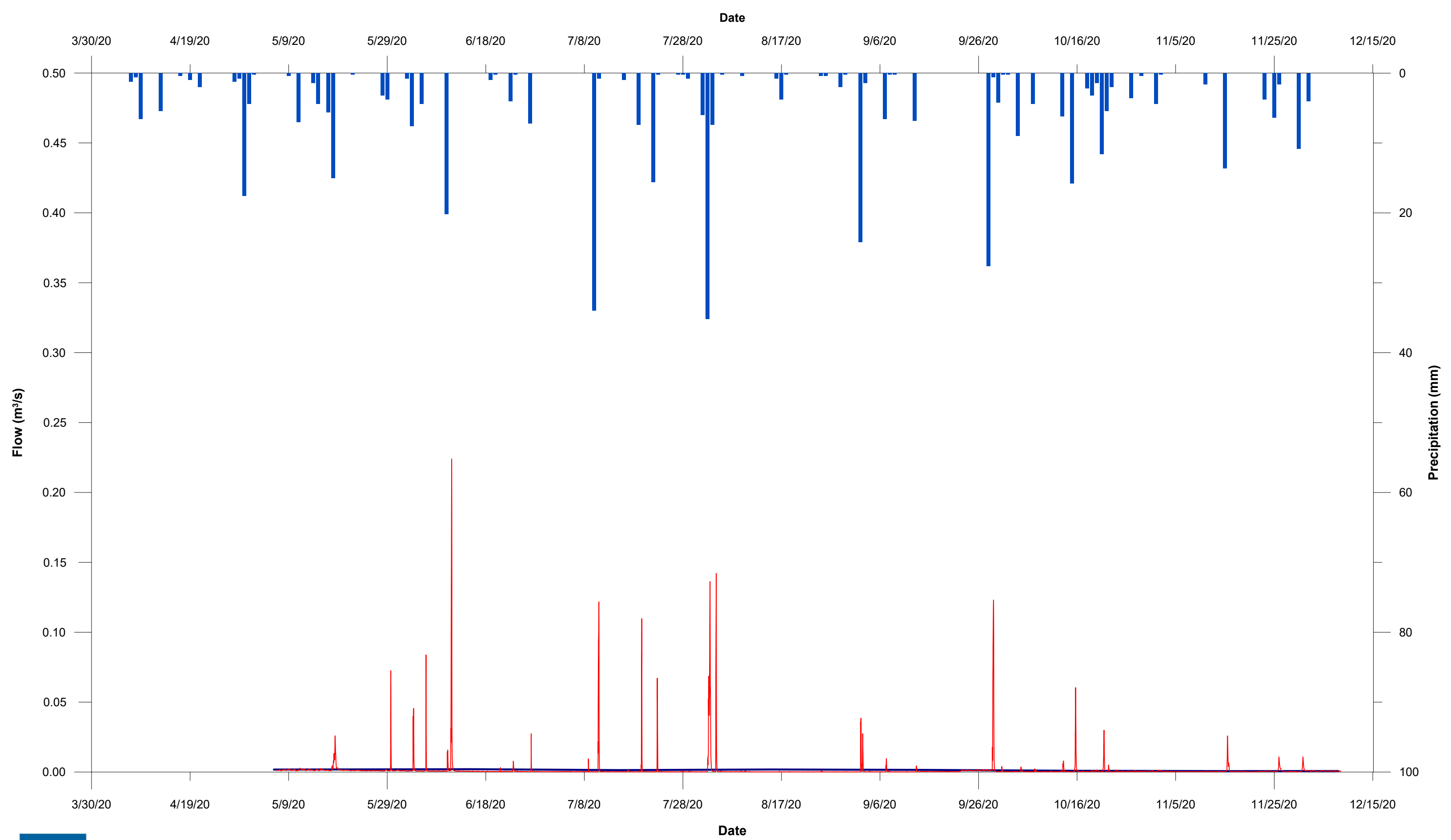
- Precipitation (KOF)
- Continuous Streamflow
- Monthly Average Streamflow

Figure 30
Lower Schneider Creek (SC1) Hydrograph
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Precipitation (KOF)
Continuous Streamflow
Monthly Average Streamflow

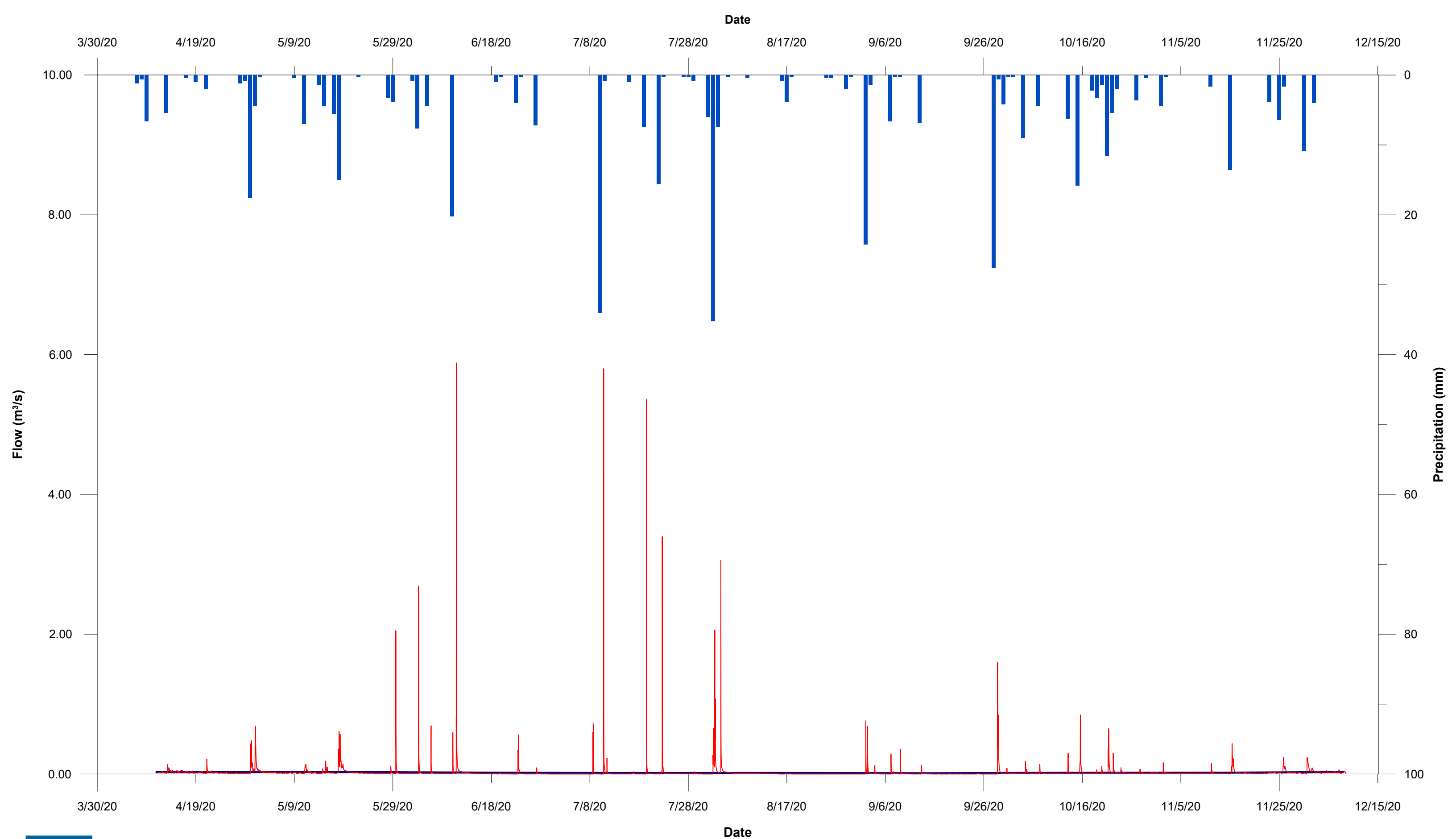
Figure 31
Upper Schneider Creek (SC9) Hydrograph
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Note:
- Various periods of low flow or stagnant water throughout the monitoring period.

- Precipitation (KOF)
- Continuous Streamflow
- Monthly Average Streamflow

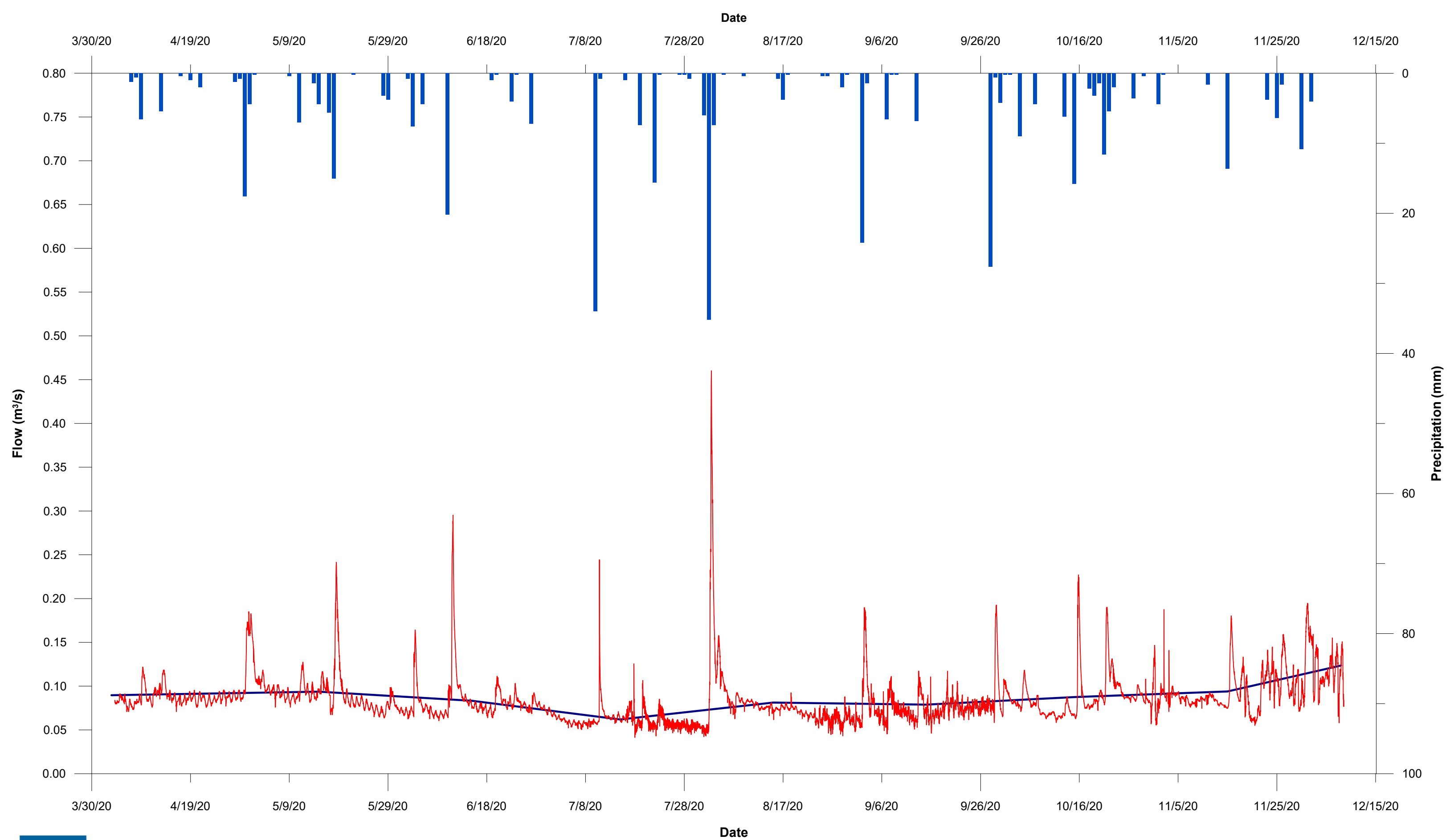
Figure 32
School Creek (SCH1) Hydrograph
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Note:
-Various dry periods throughout late spring and summer.

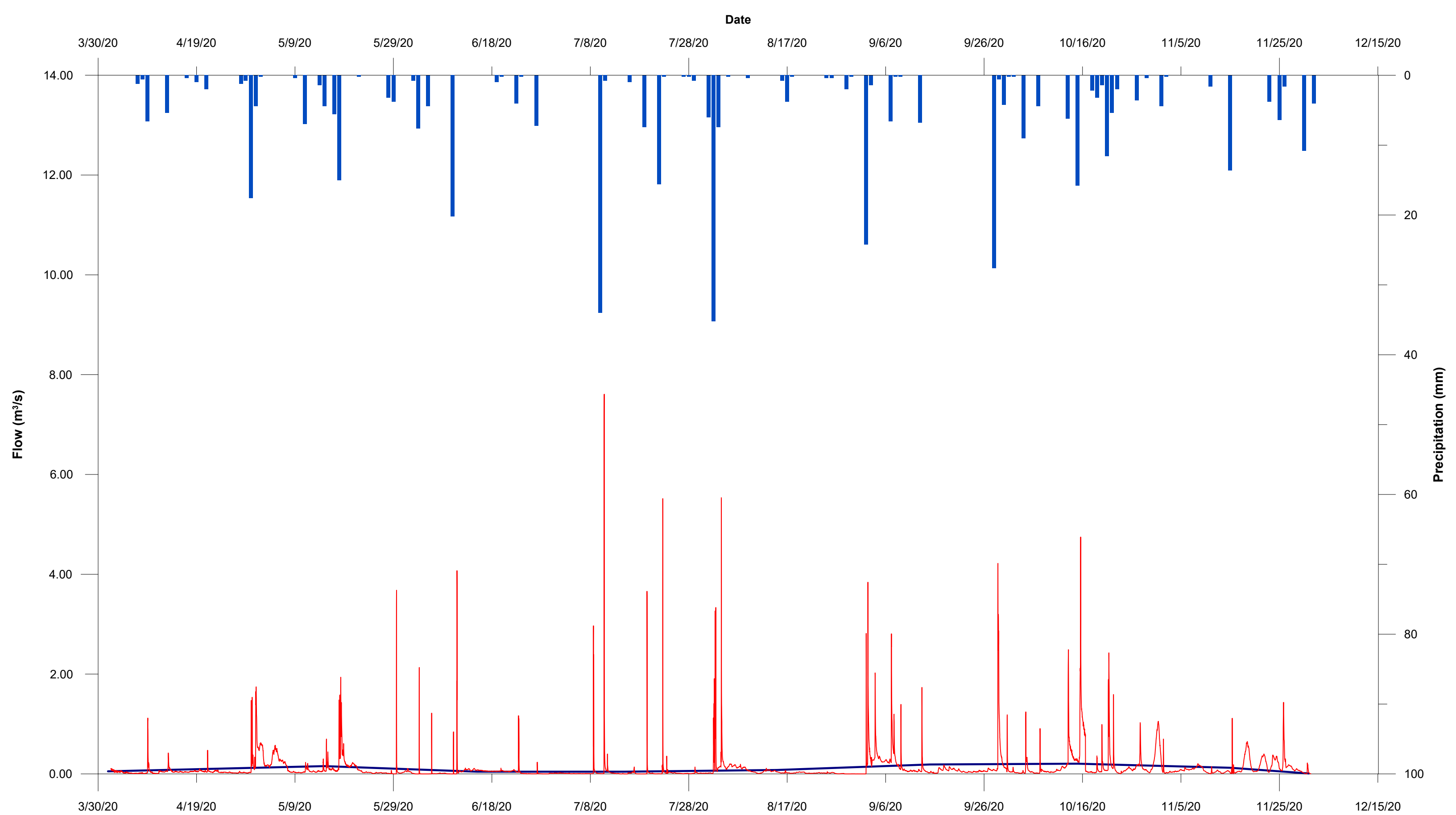
- Precipitation (KOF)
- Continuous Streamflow
- Monthly Average Streamflow

Figure 33
Voisin Creek (VS1) Hydrograph
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



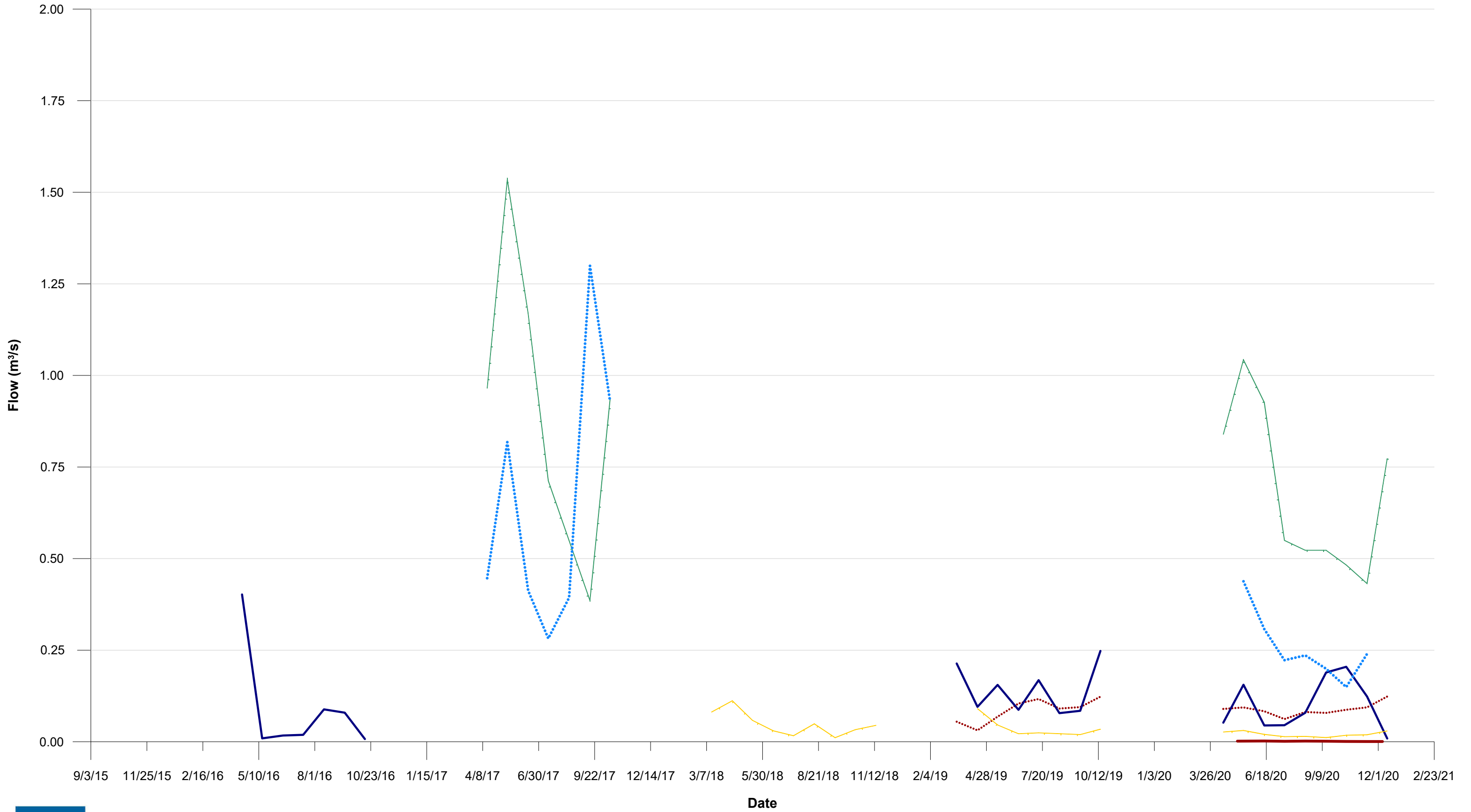
Precipitation (KOF)
Continuous Streamflow
Monthly Average Streamflow

Figure 34
Strasburg Creek (SB2) Hydrograph
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Precipitation (KOF)
Continuous Streamflow
Monthly Average Streamflow

Figure 35
Sandrock Greenway (SR2) Hydrograph
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



..... SB2 Monthly Average Flow — VS1 Monthly Average Flow
 — SC1 Monthly Average Flow — SCH1 Monthly Average Flow
 SC9 Monthly Average Flow — SR2 Monthly Average Flow

Figure 35B
Historical Monthly Average Flow
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

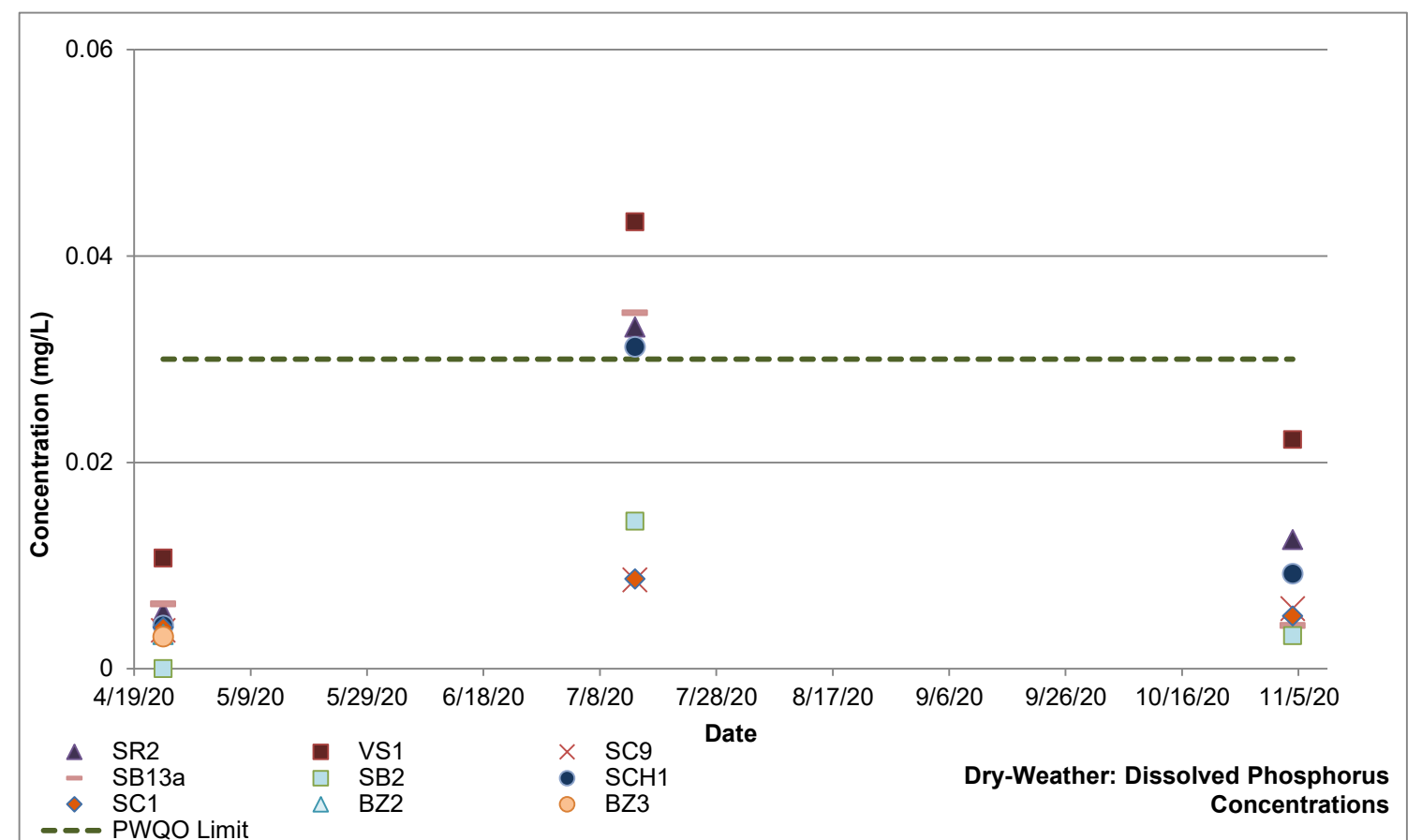
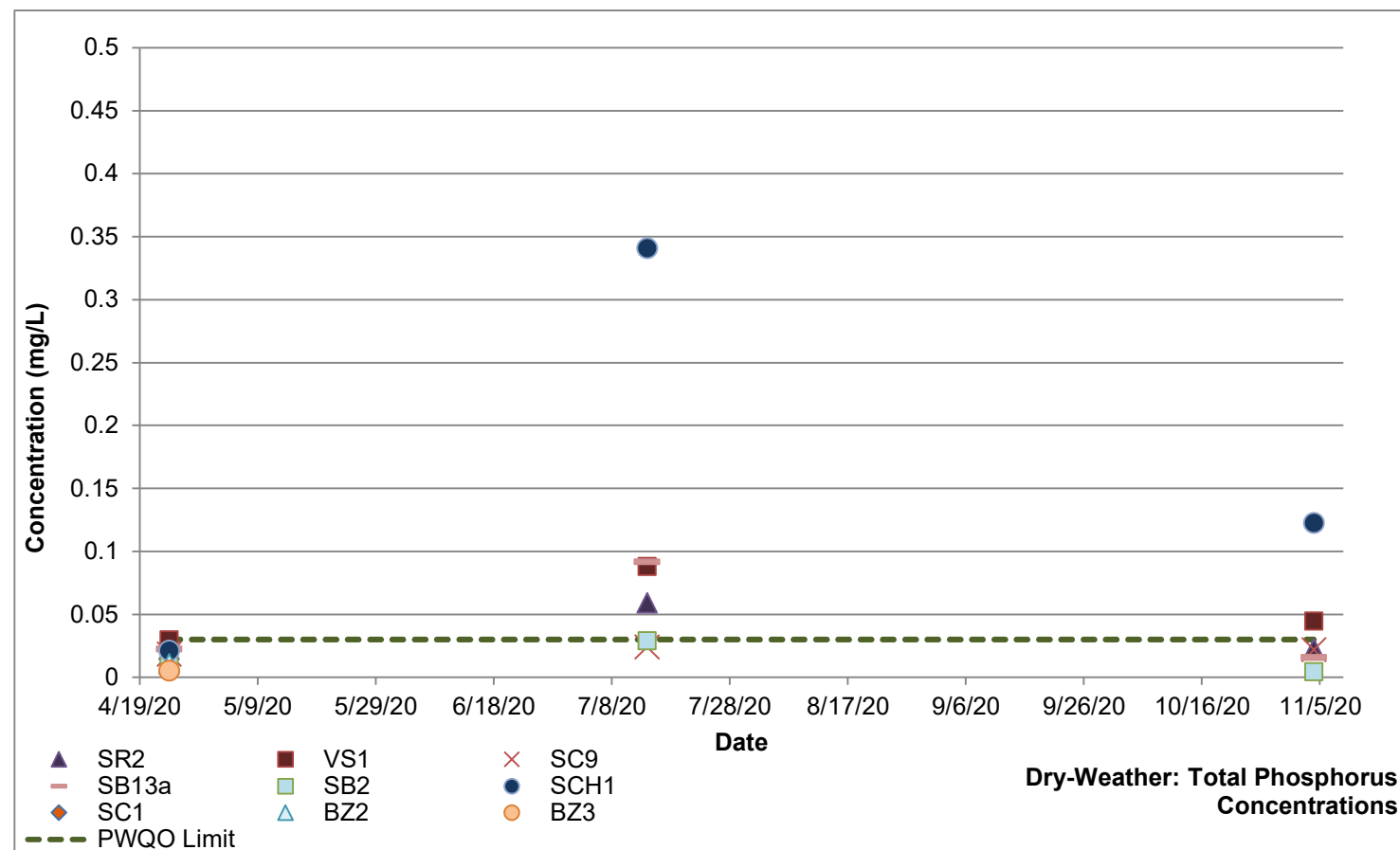
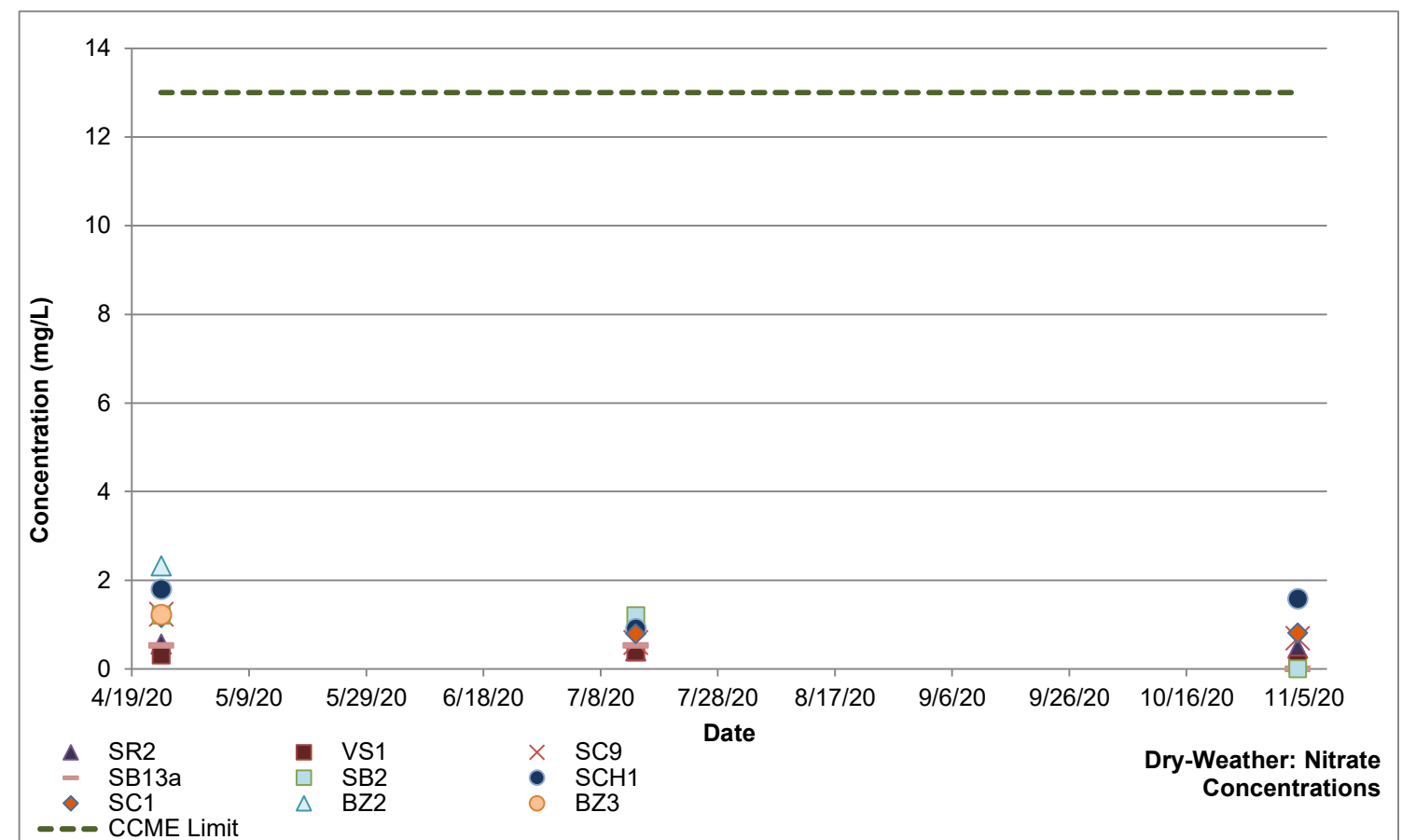
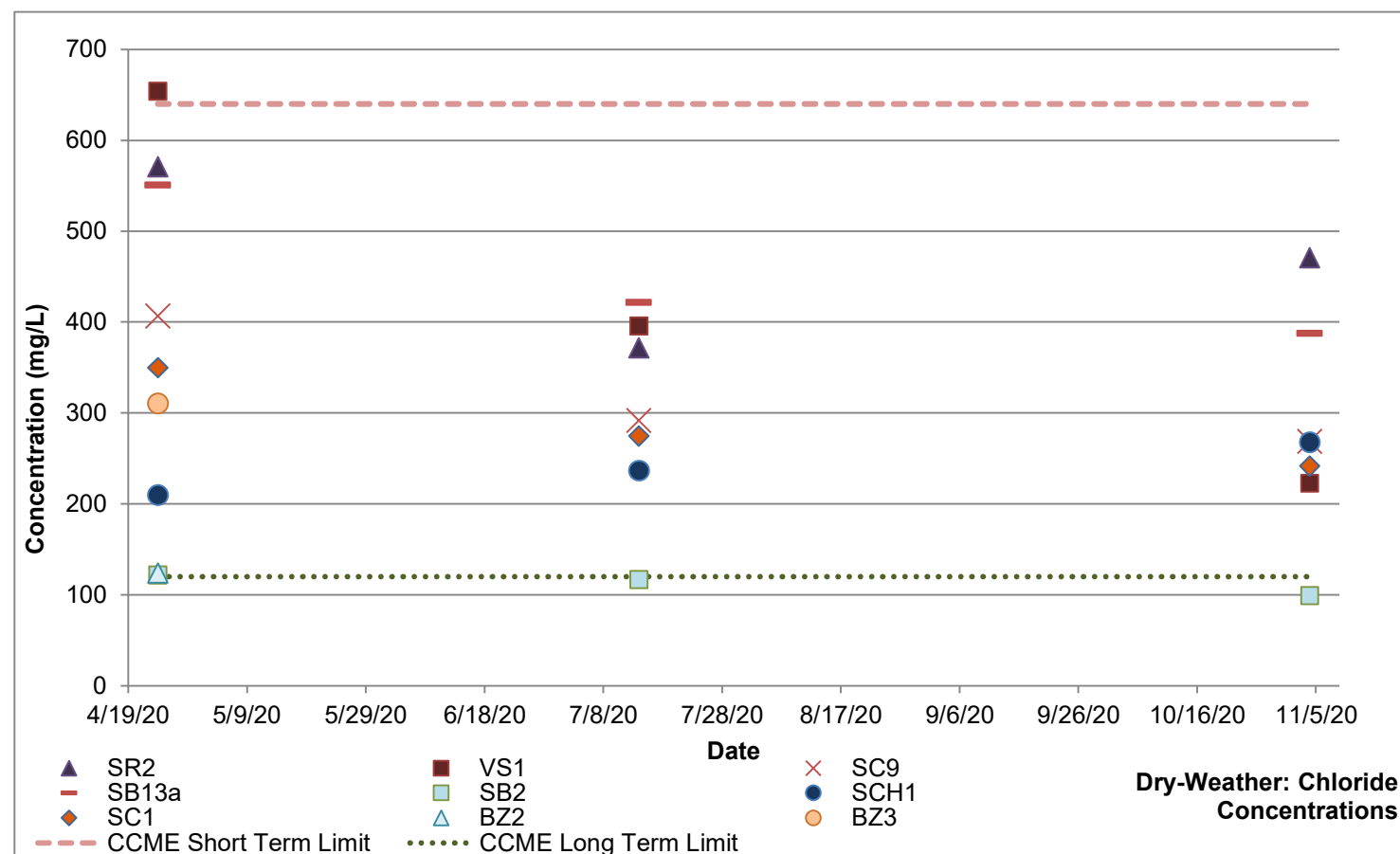


Figure 36
Dry-Weather: Chloride, Nitrate, Total and Dissolved Phosphorus Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

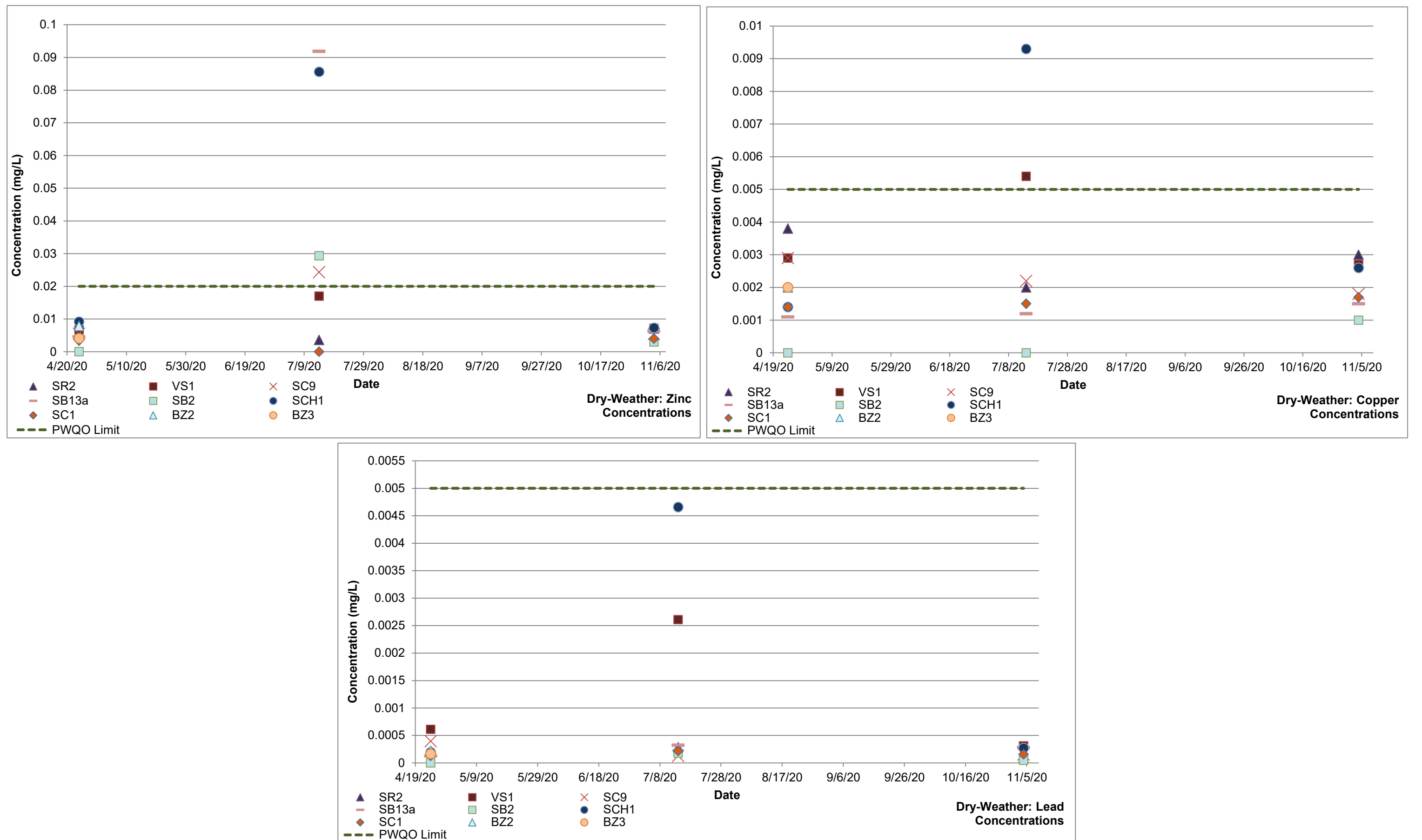
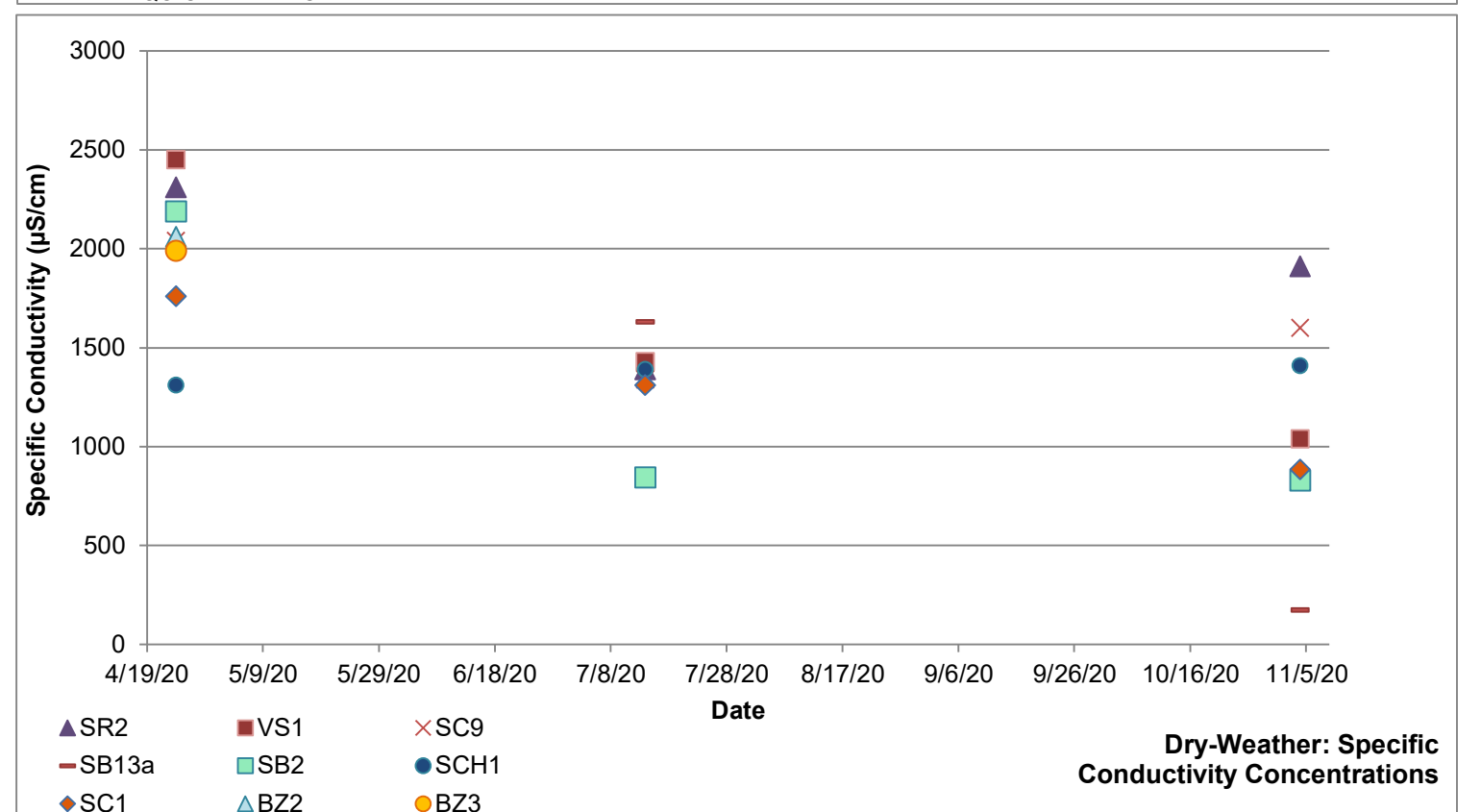
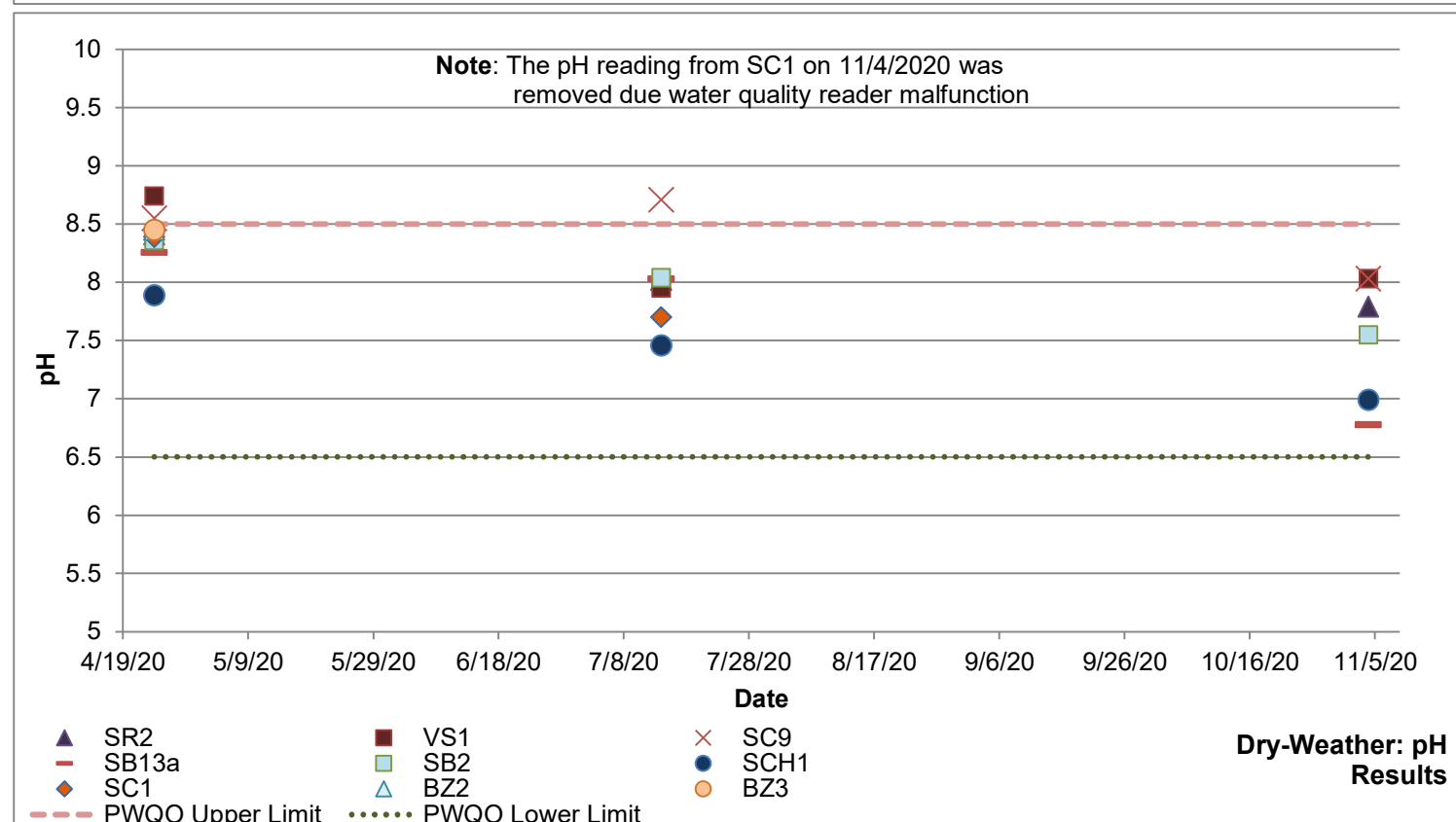
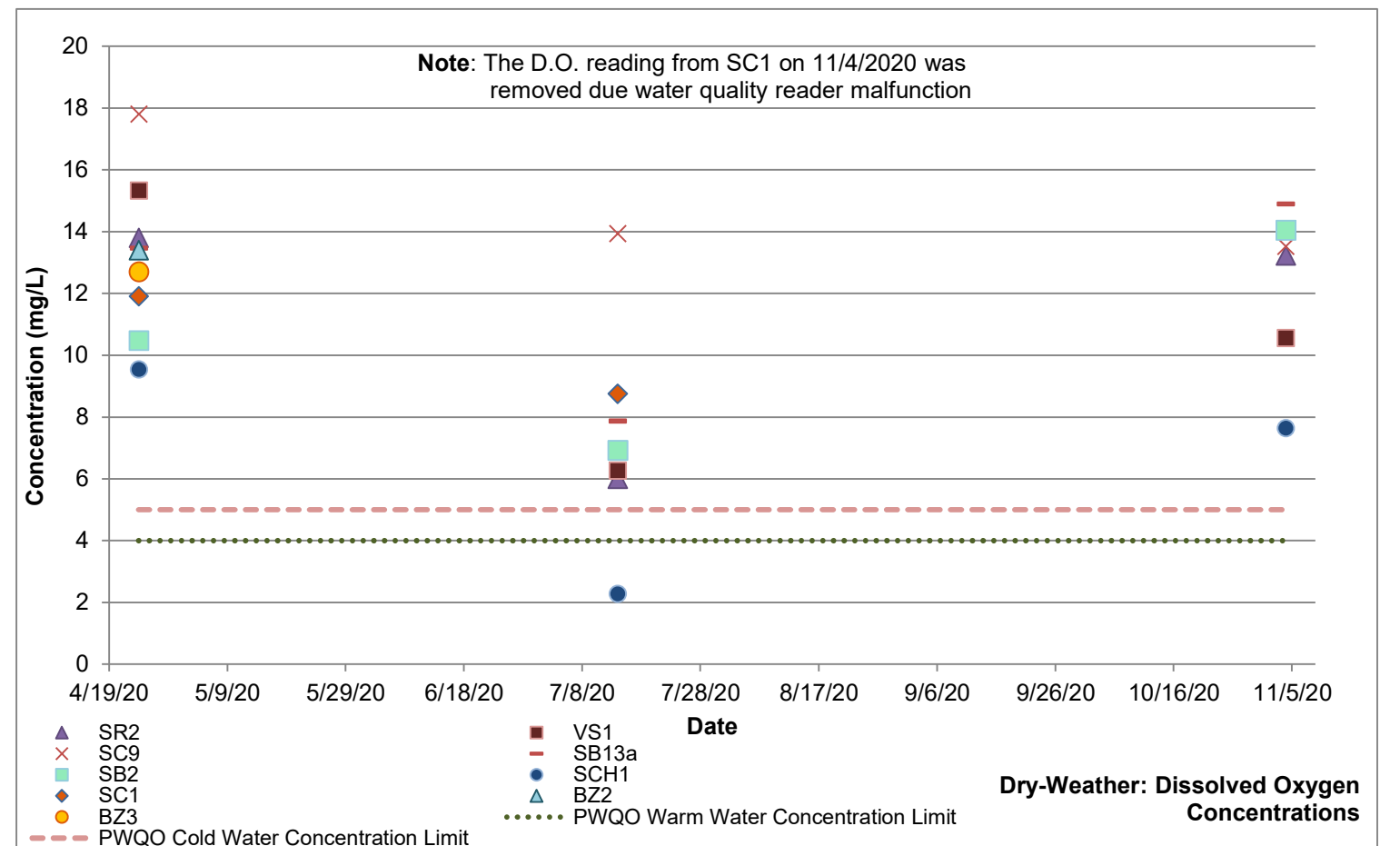
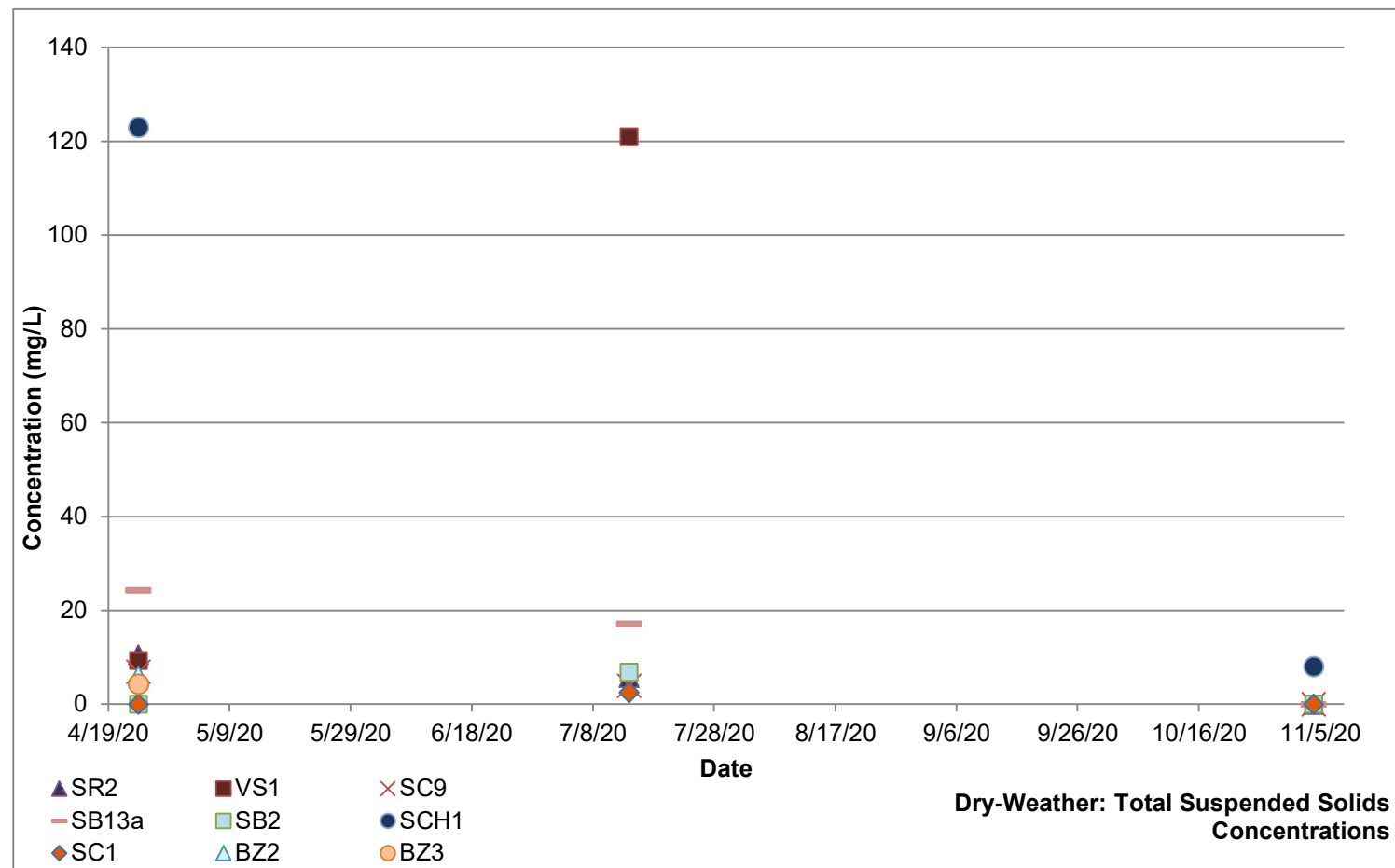
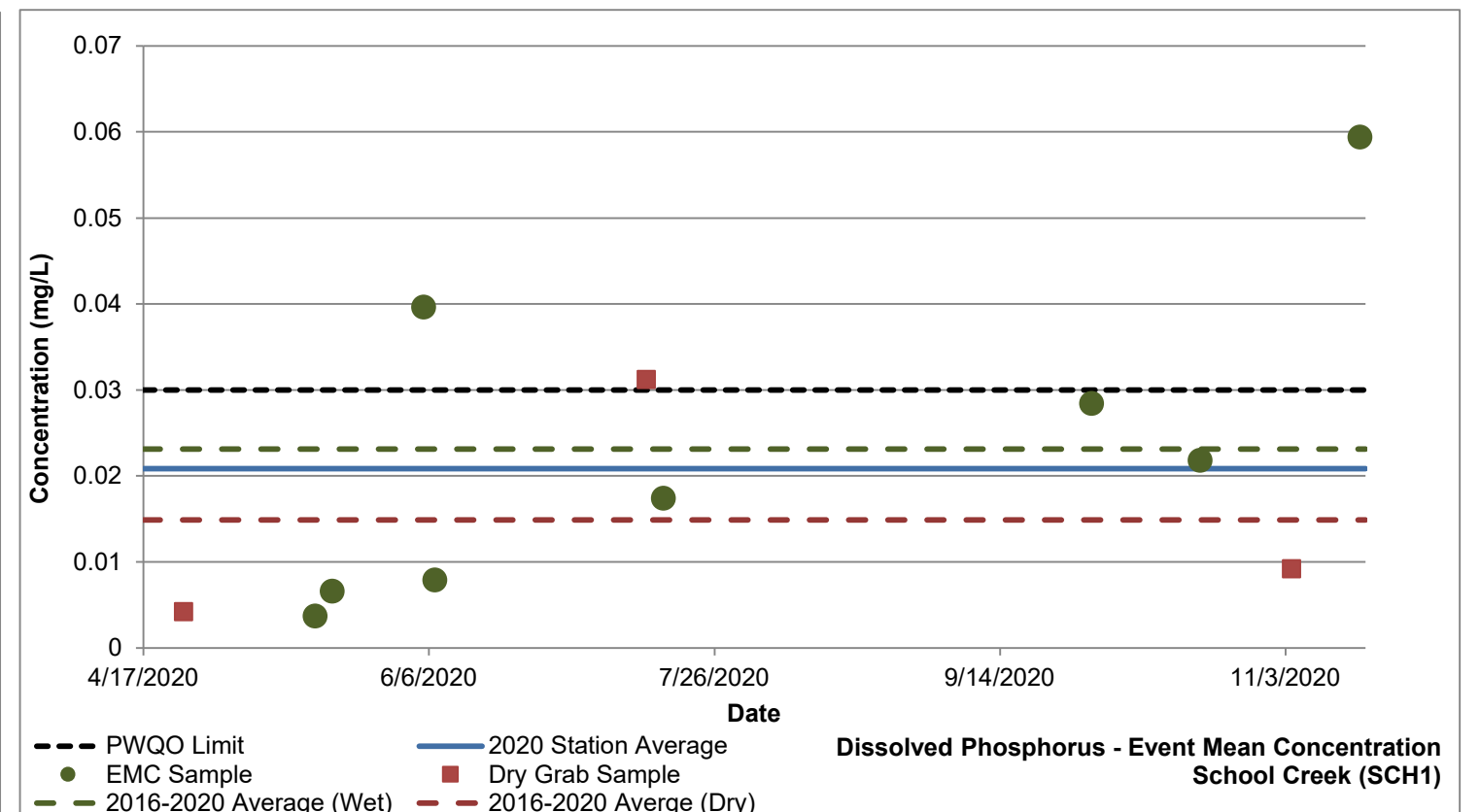
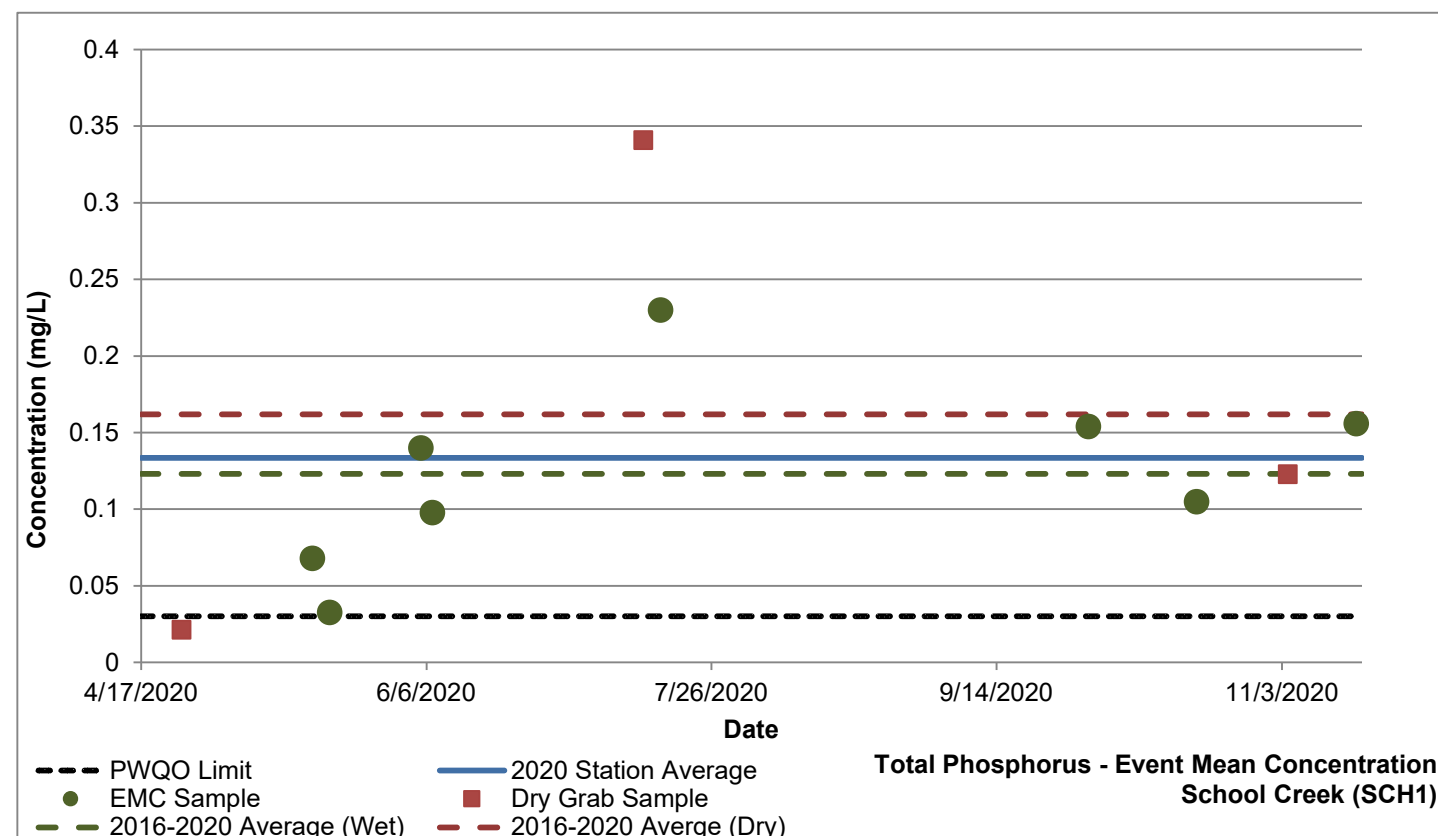
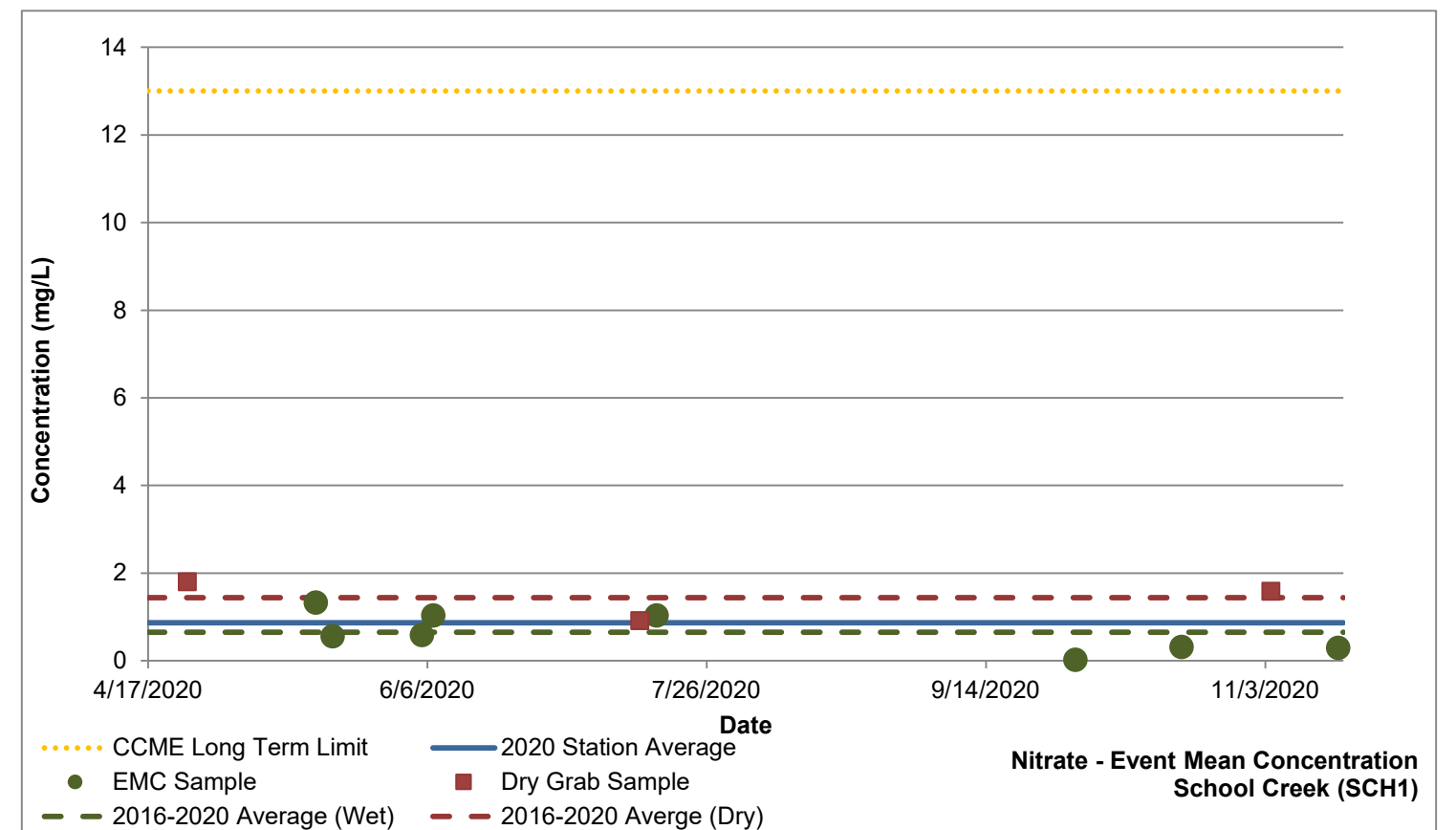
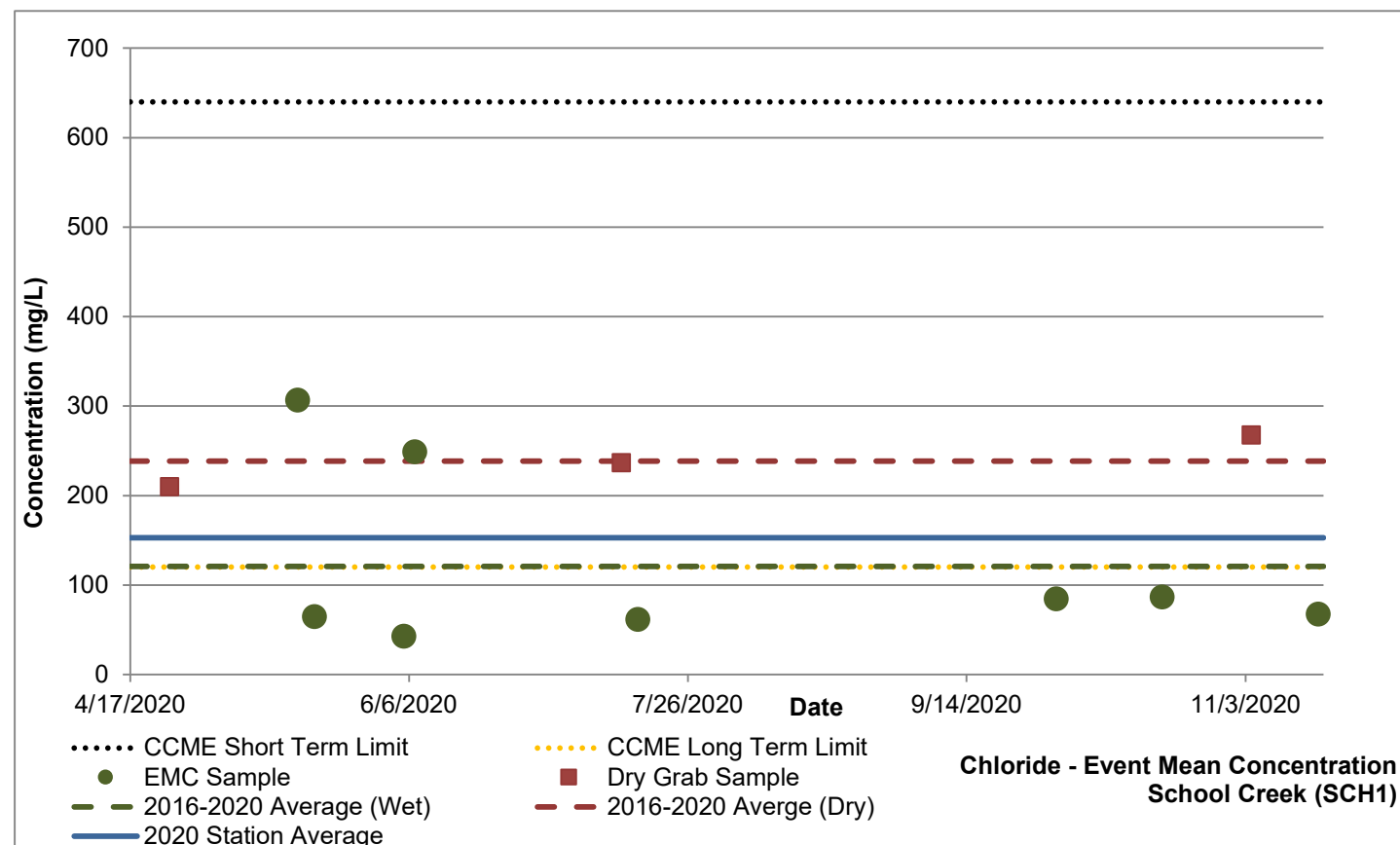


Figure 37
Dry-Weather: Zinc, Copper, Lead Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario

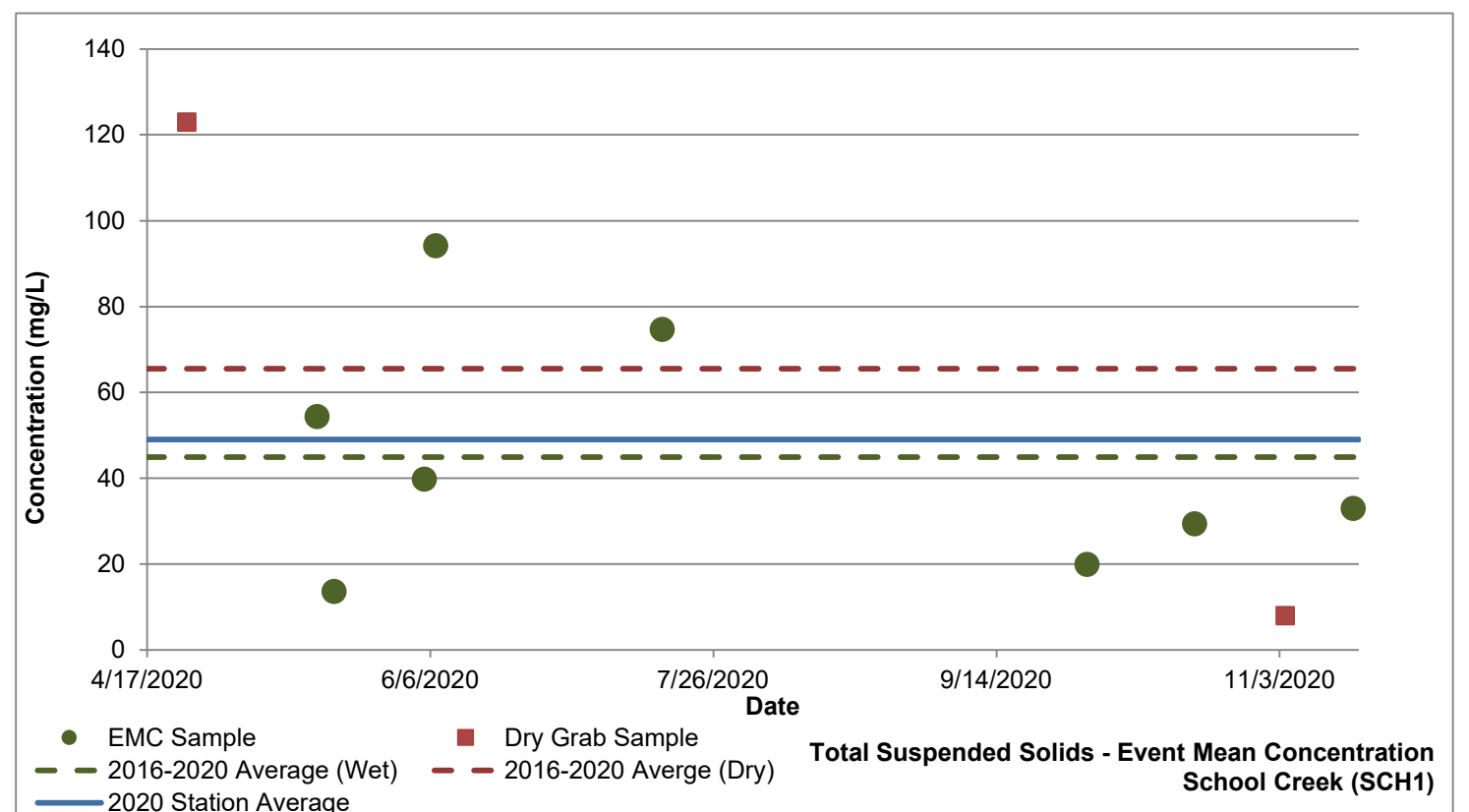
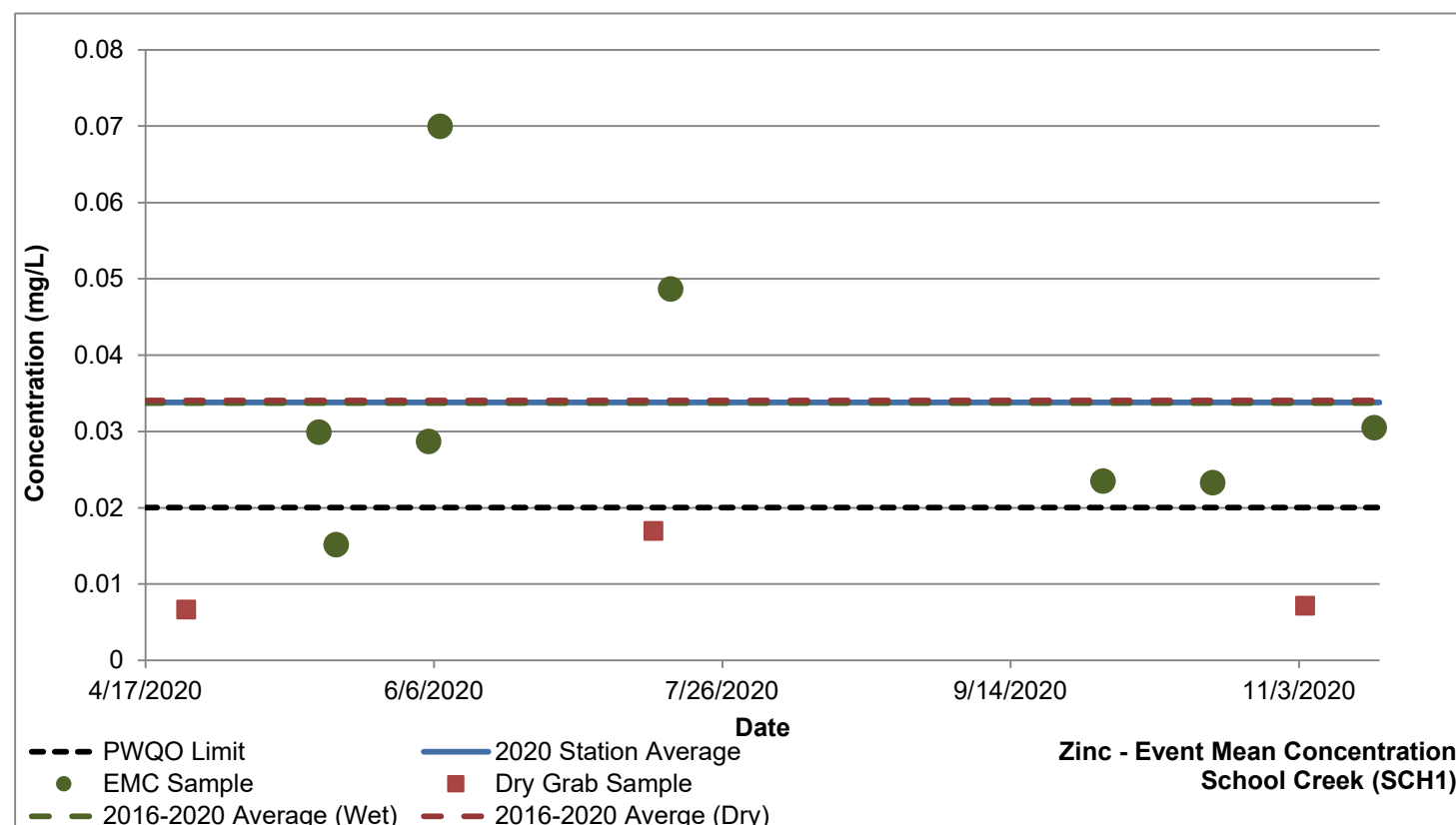
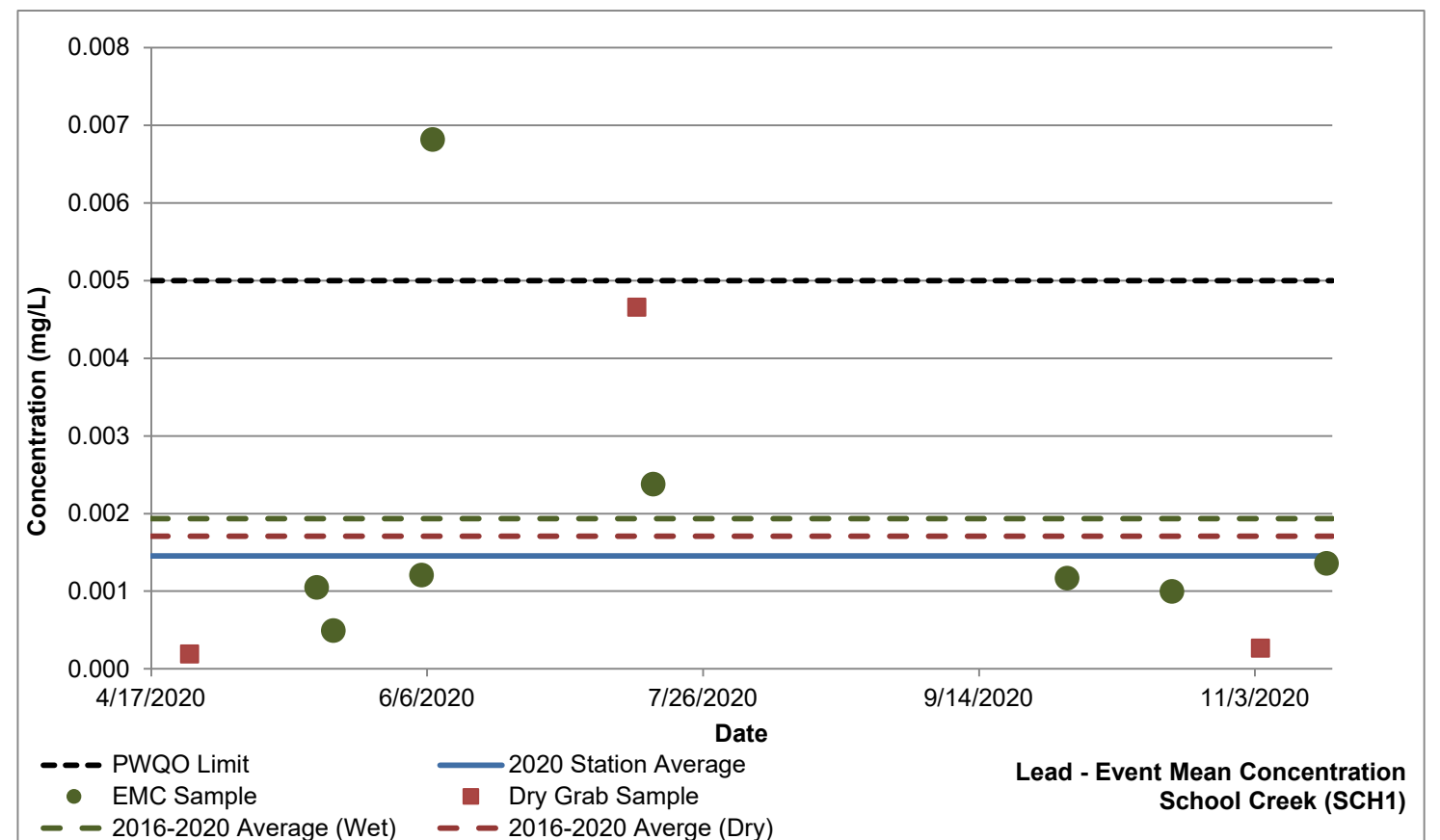
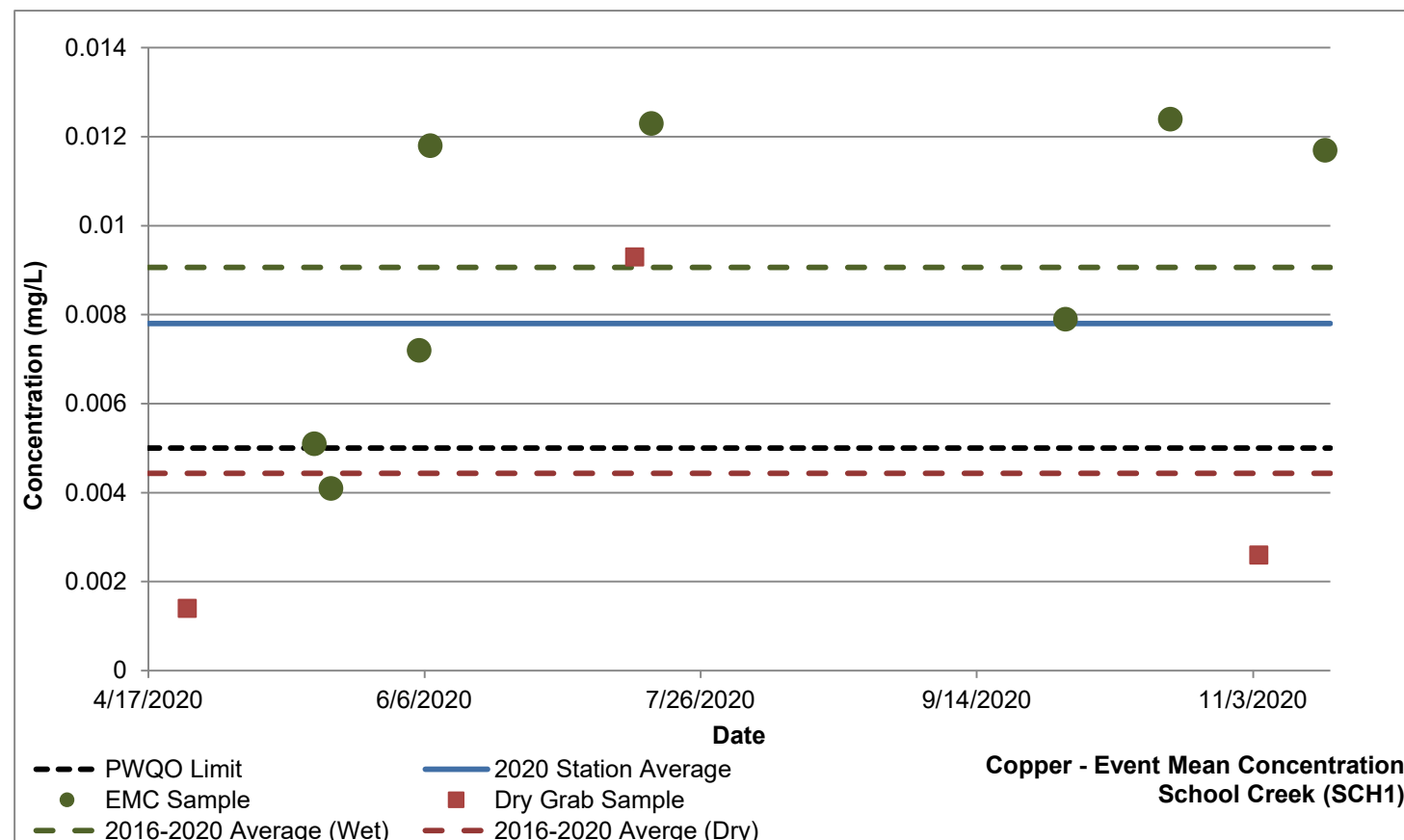




Note: No samples were collected at SCH1 from 2016 to 2019.



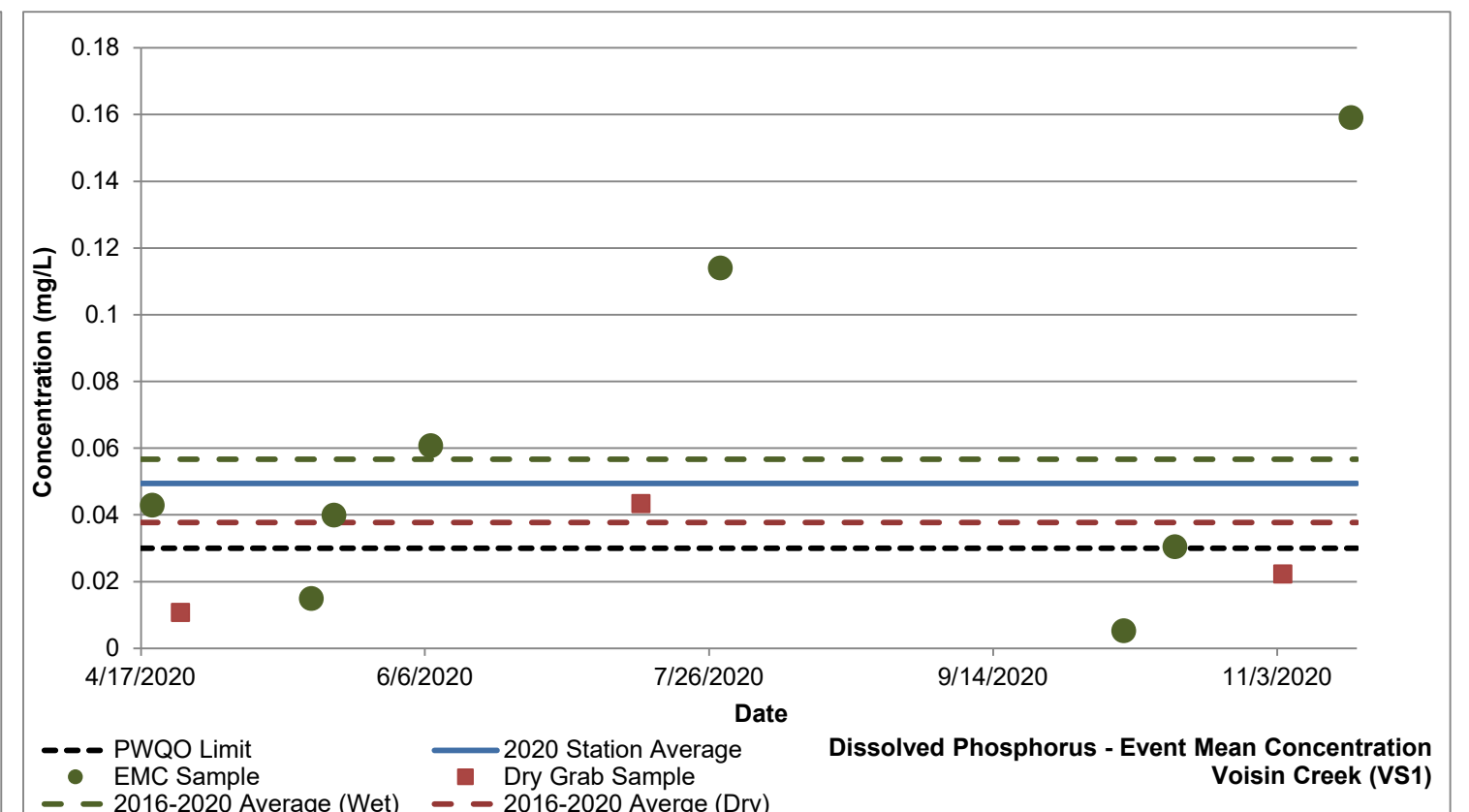
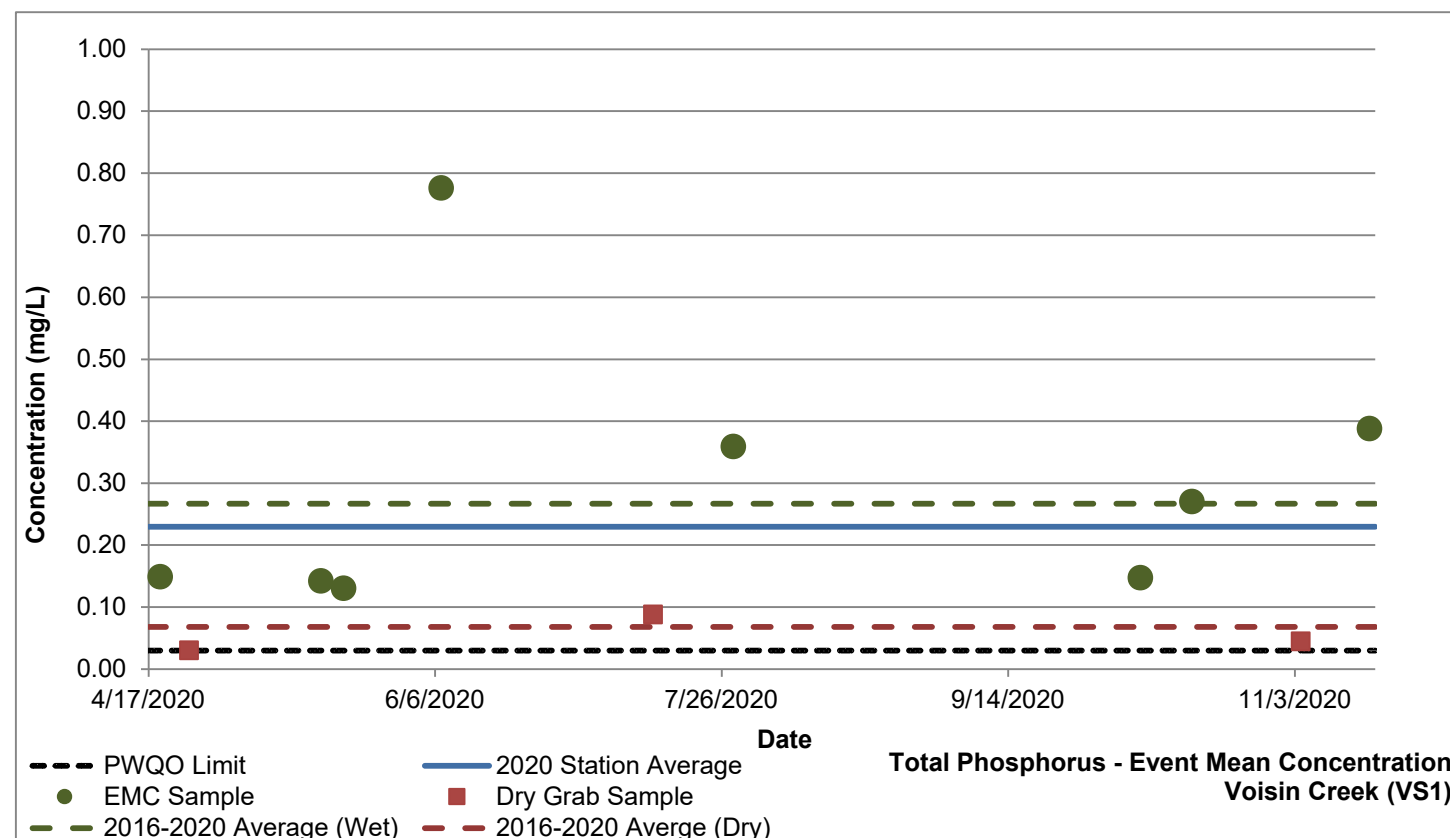
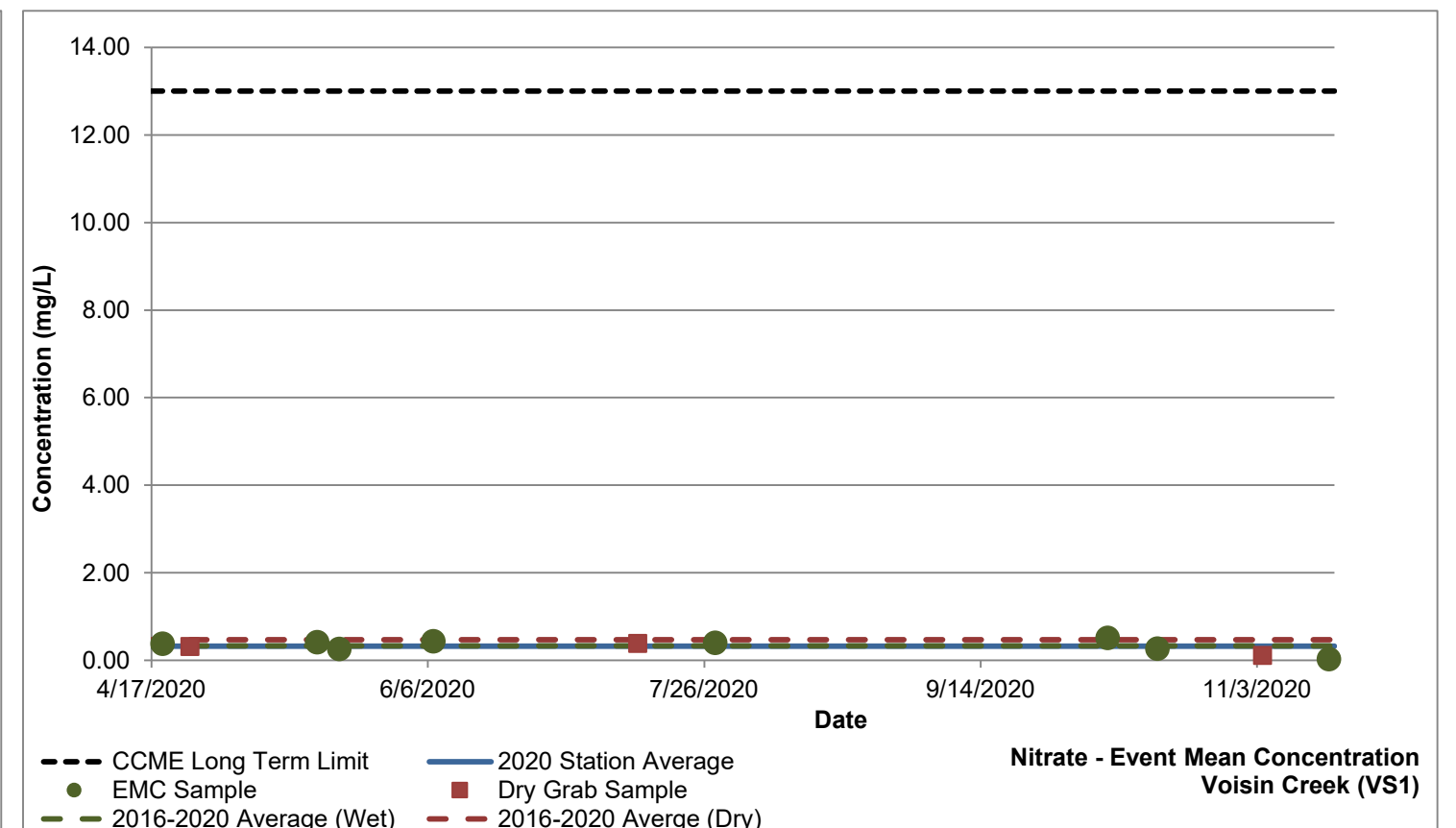
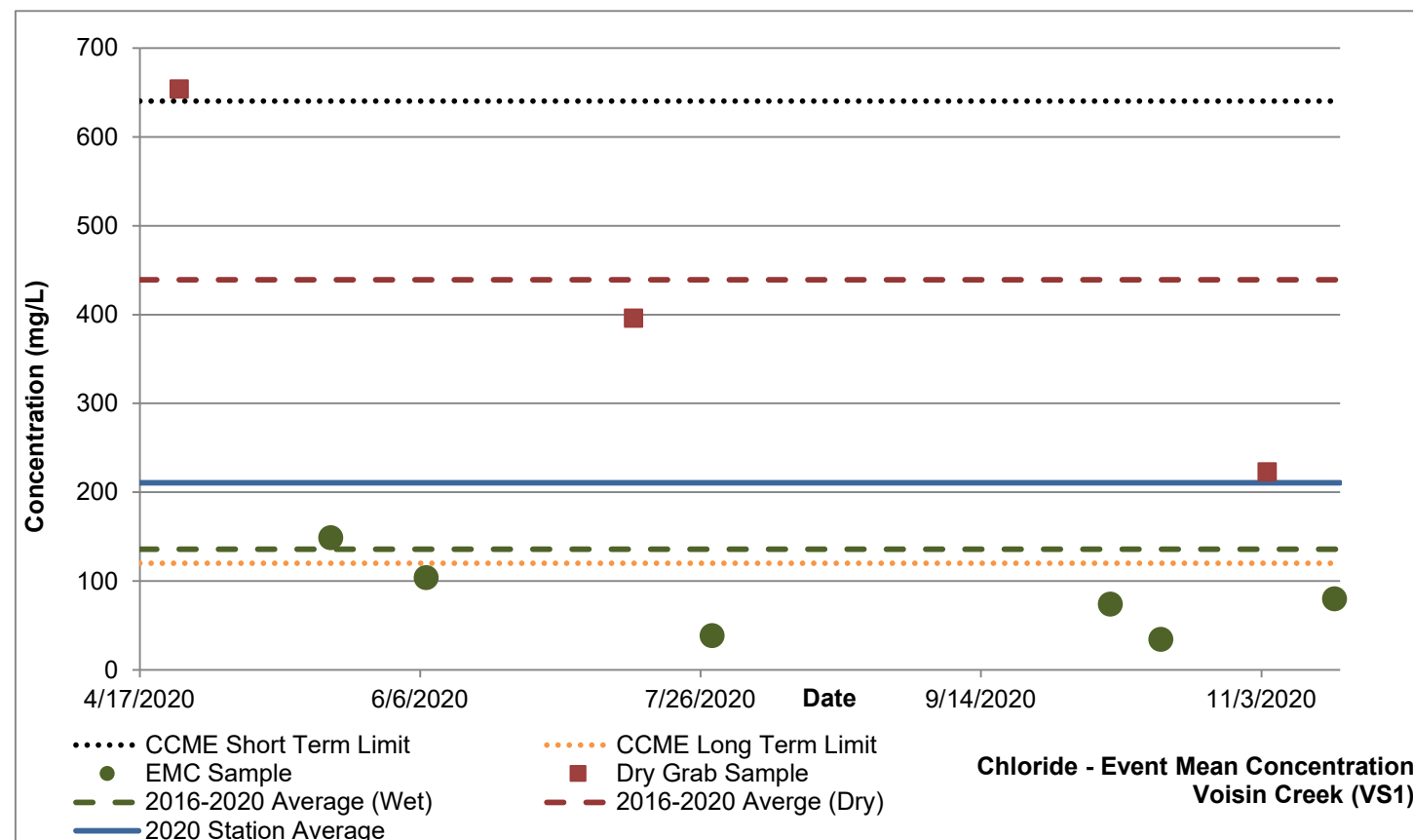
Figure 39
School Creek (SCH1) EMC: Chloride, Nitrate, Total and Dissolved Phosphorous Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No samples were collected at SCH1 from 2016 to 2019.



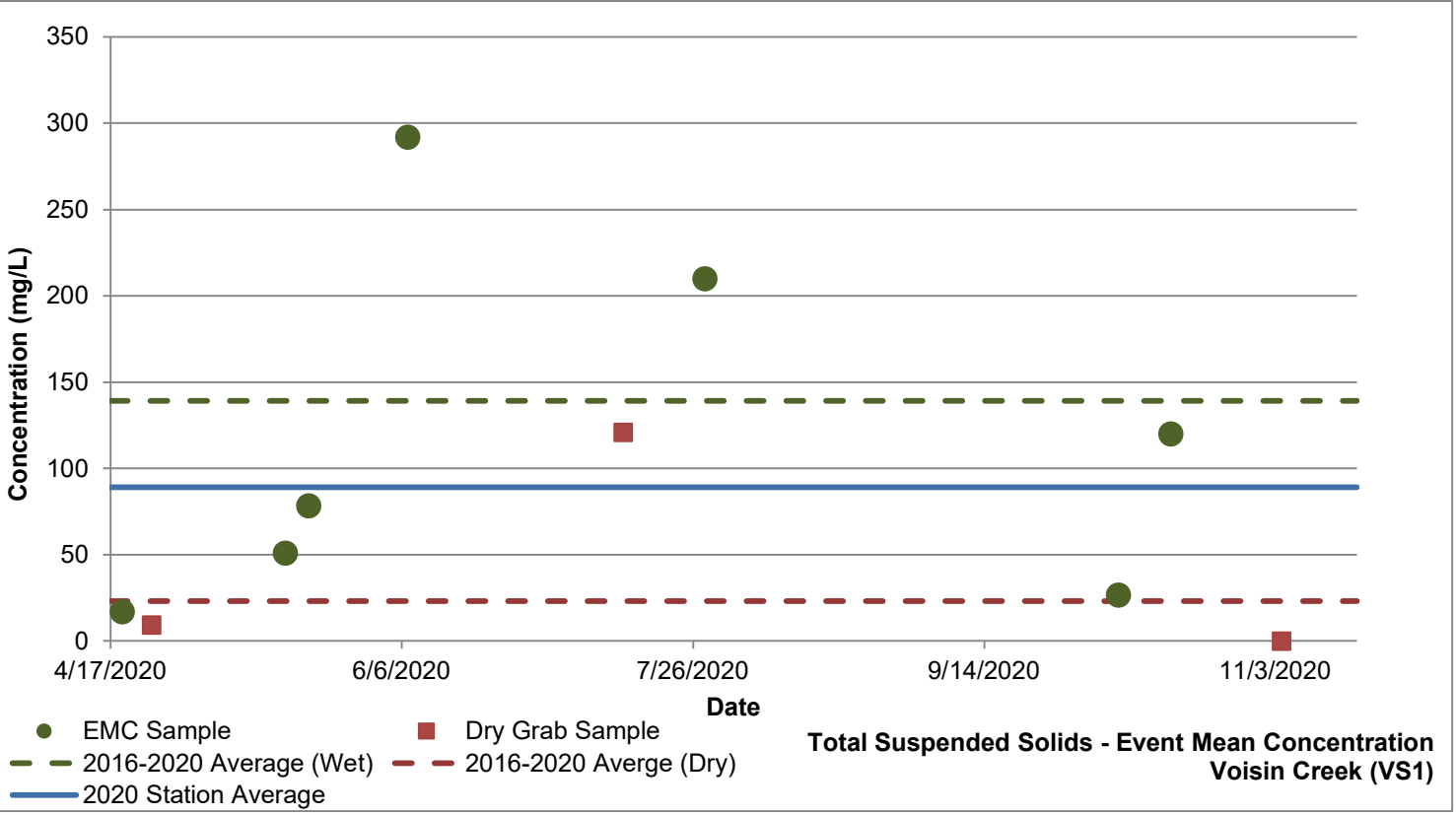
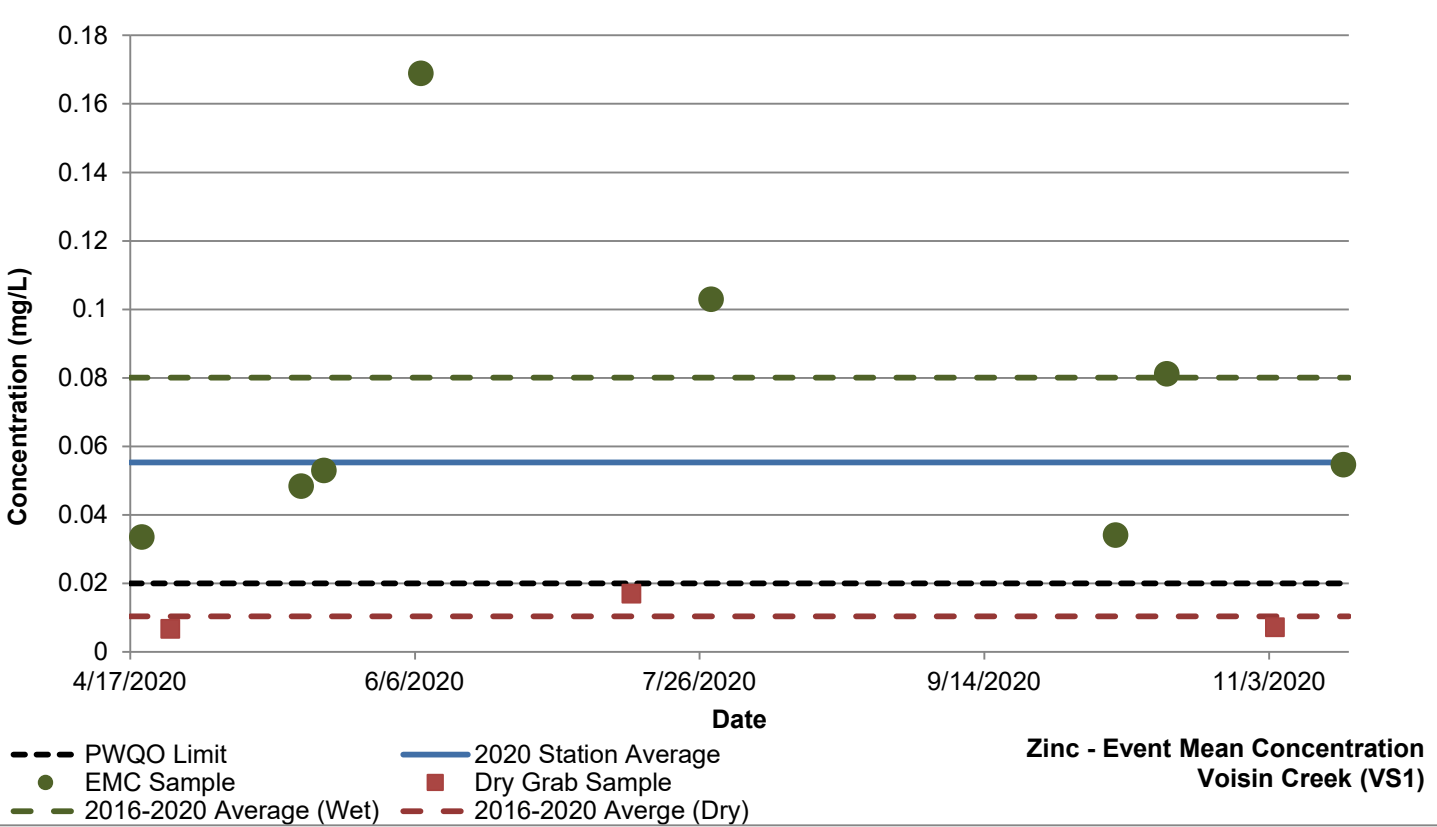
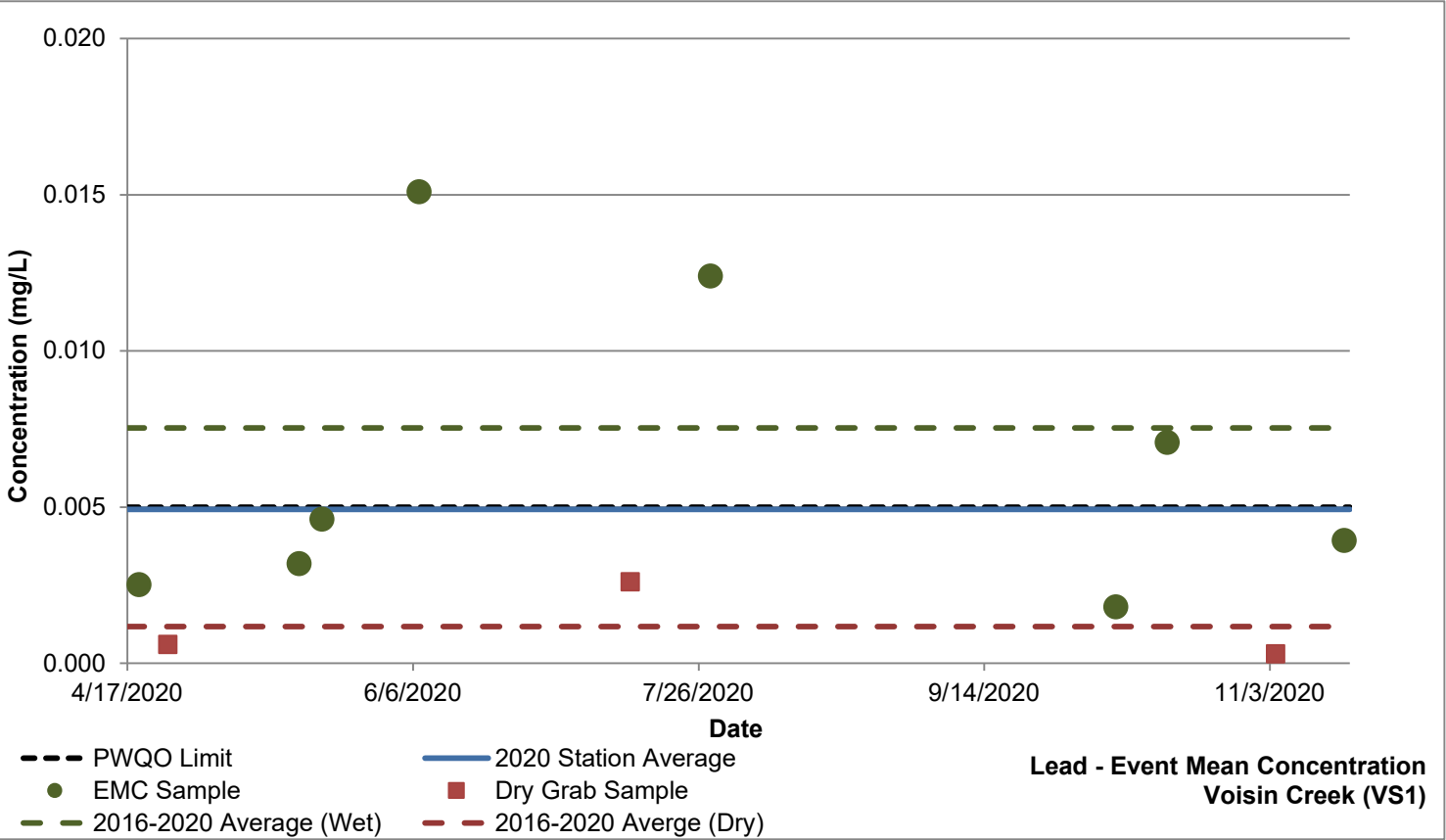
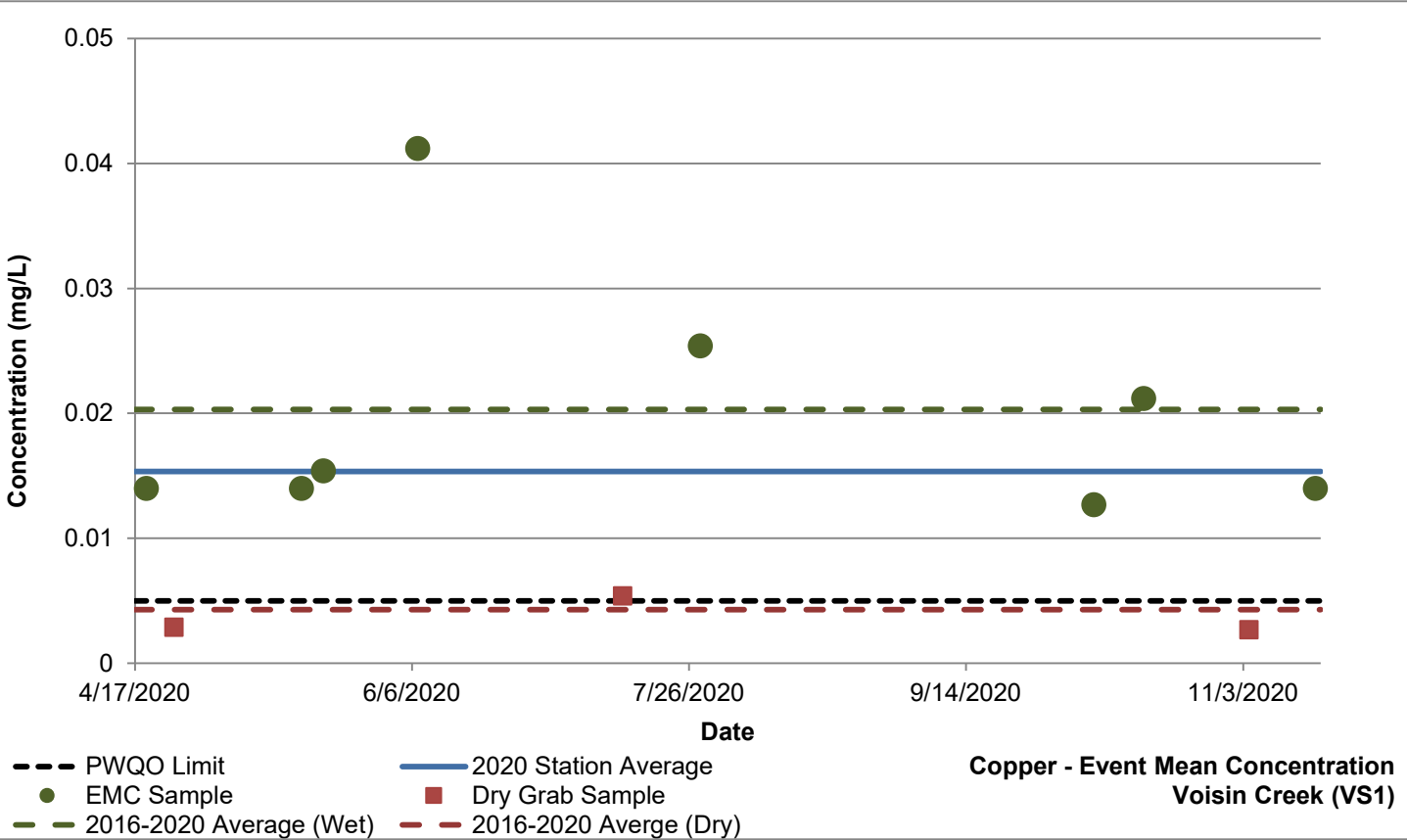
Figure 40
School Creek (SCH1) EMC: Copper, Lead, Zinc, Total Suspended Solids Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No samples were collected at VS1 from 2016 to 2017.



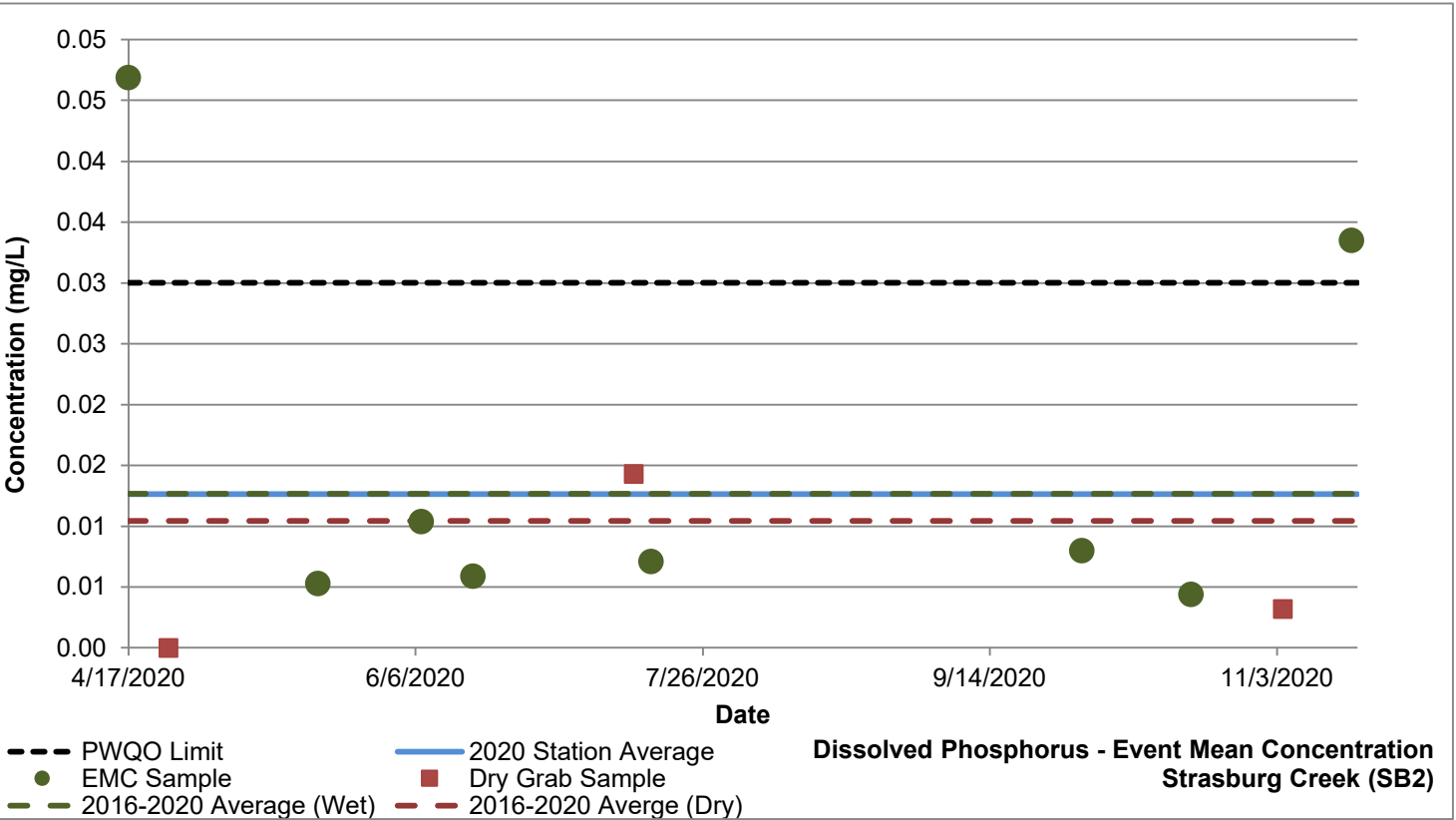
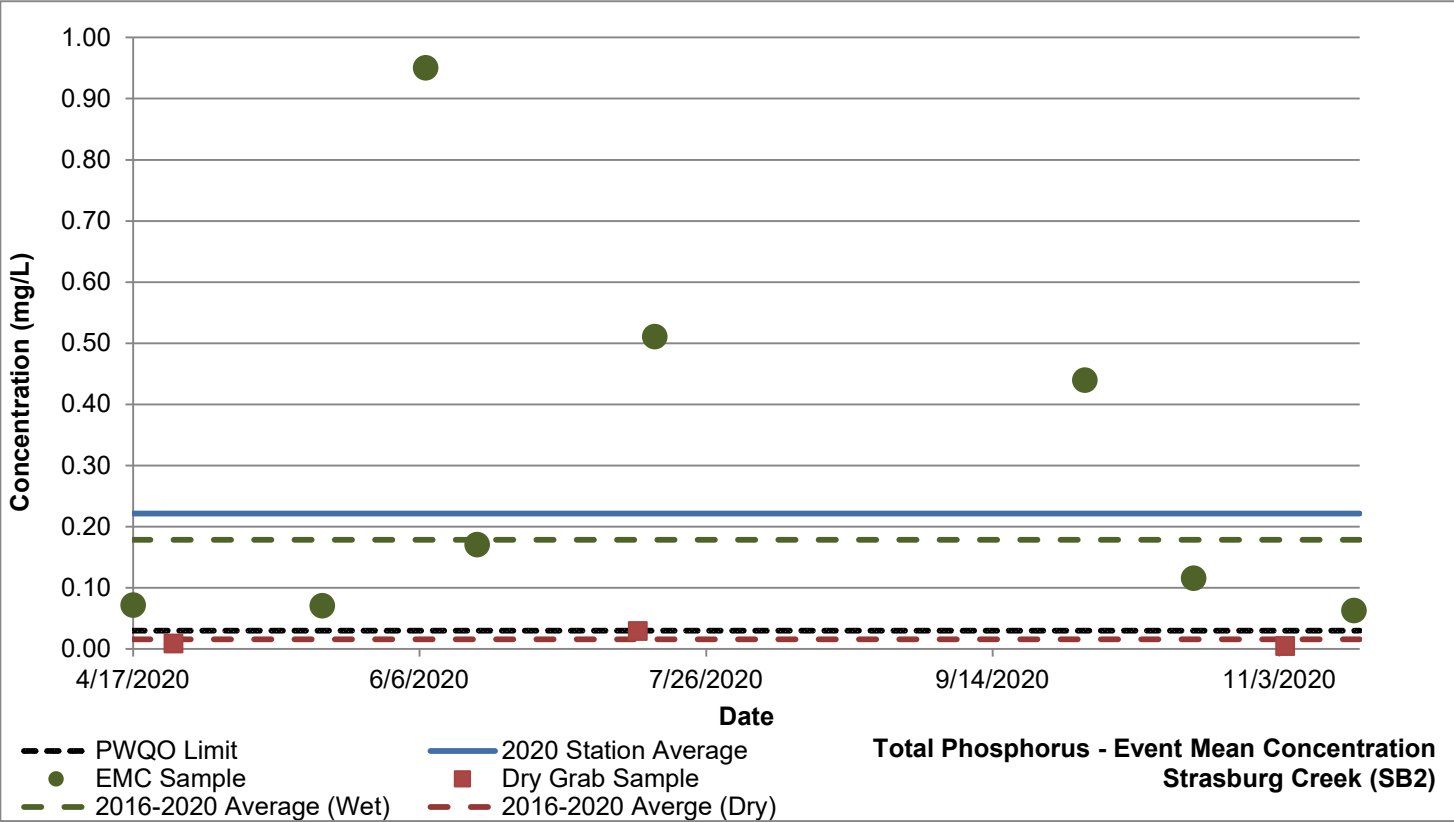
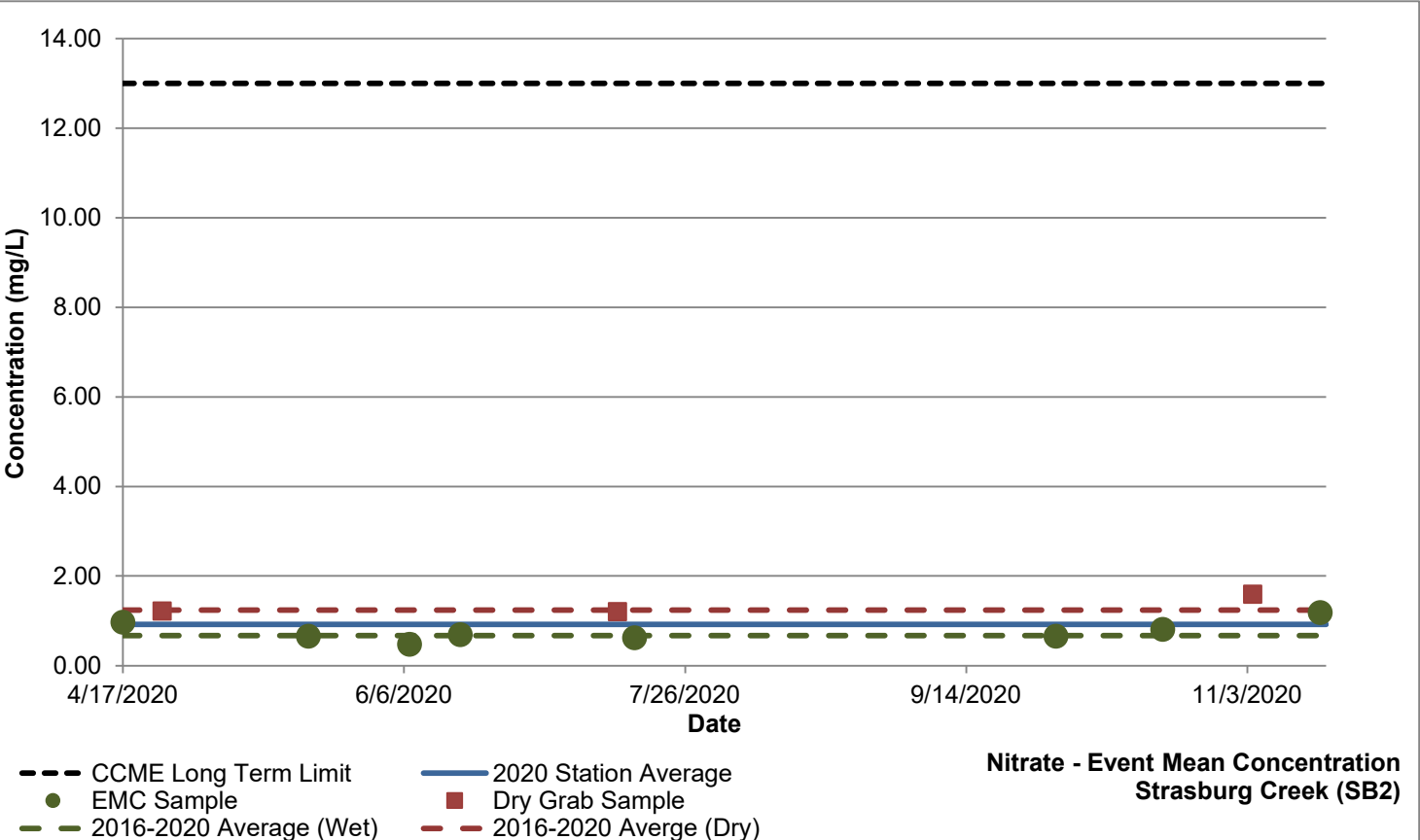
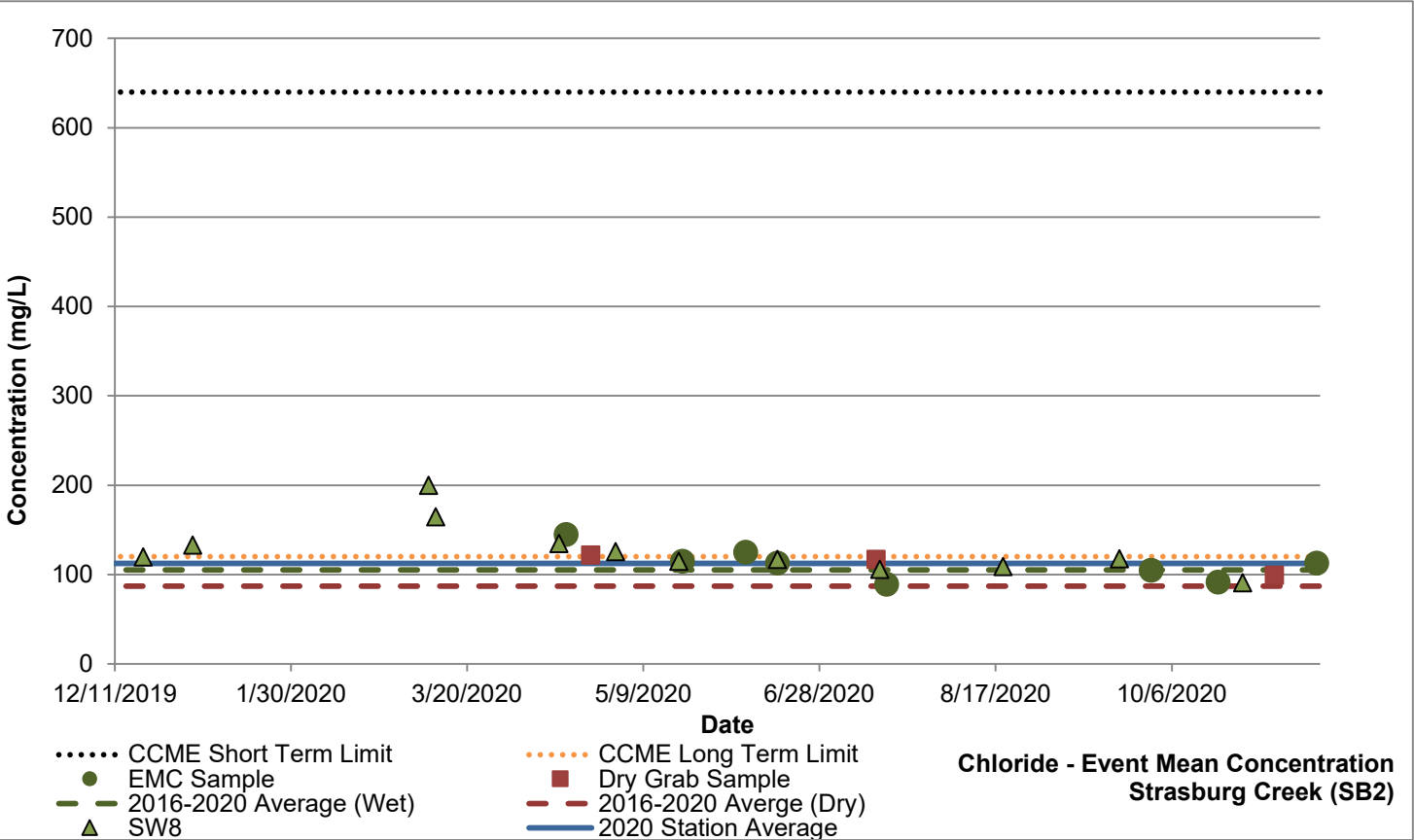
Figure 41
Voisin Creek (VS1) EMC: Chloride, Nitrate, Total and Dissolved Phosphorous Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No samples were collected at VS1 from 2016 to 2017.



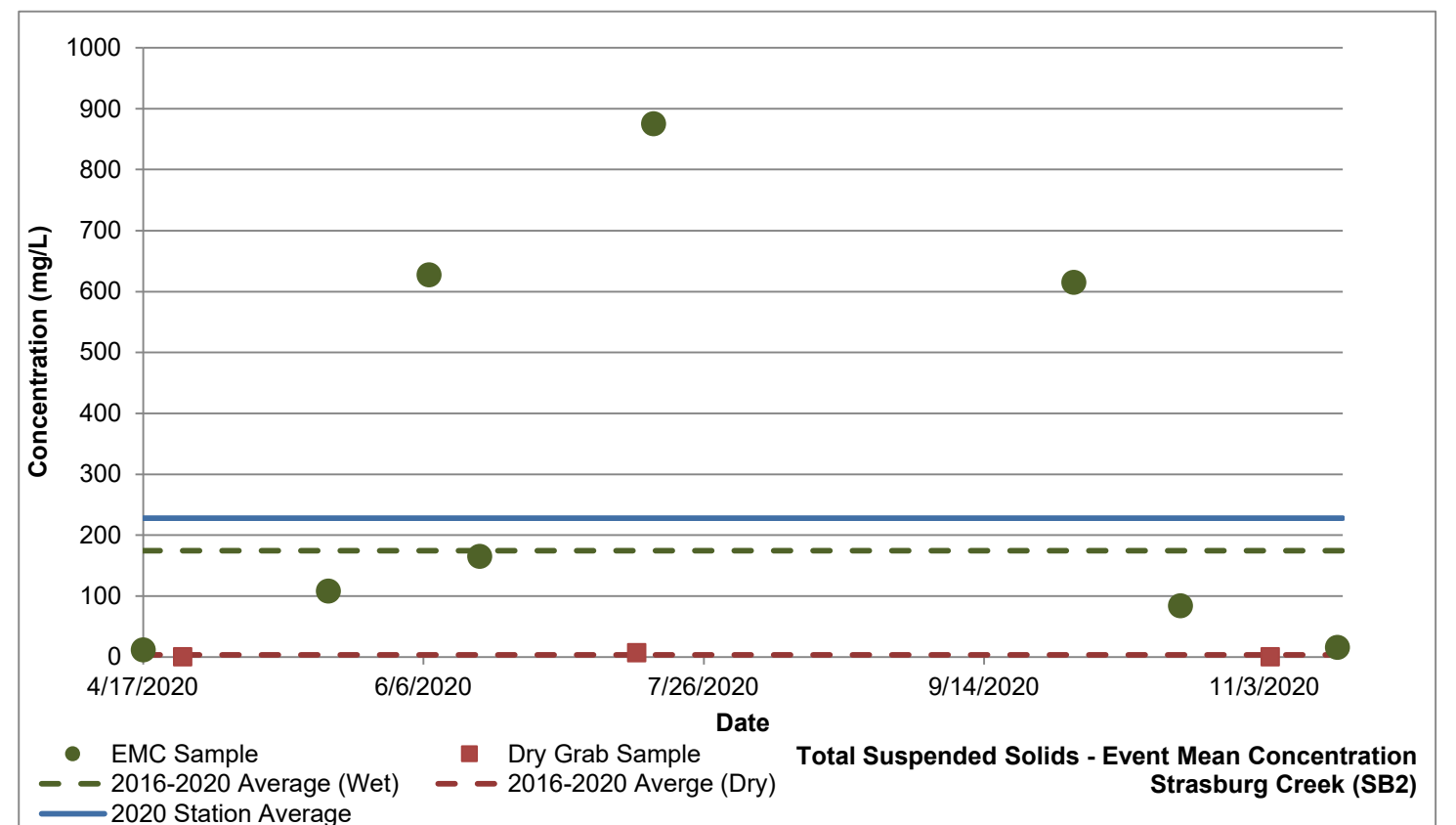
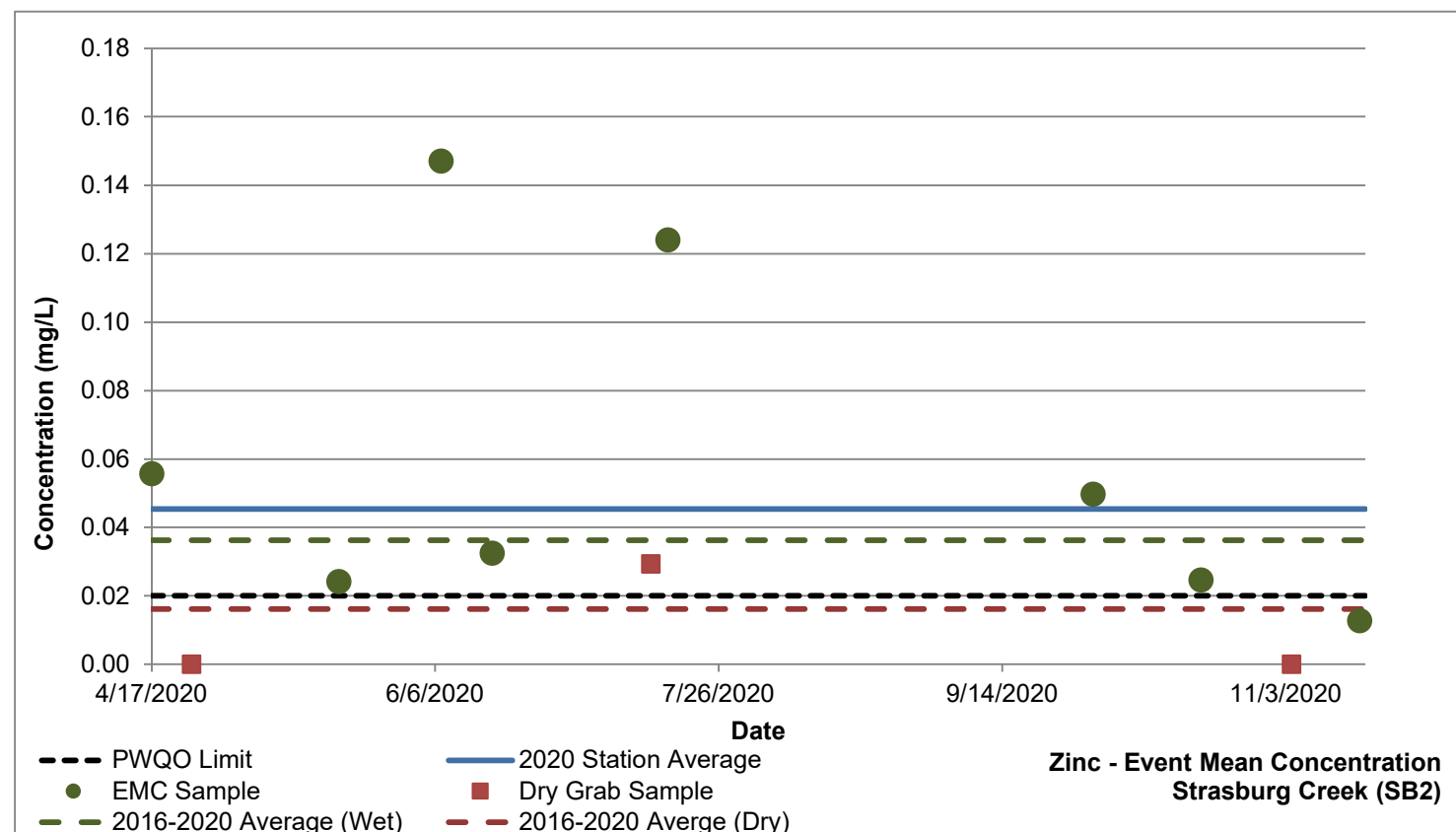
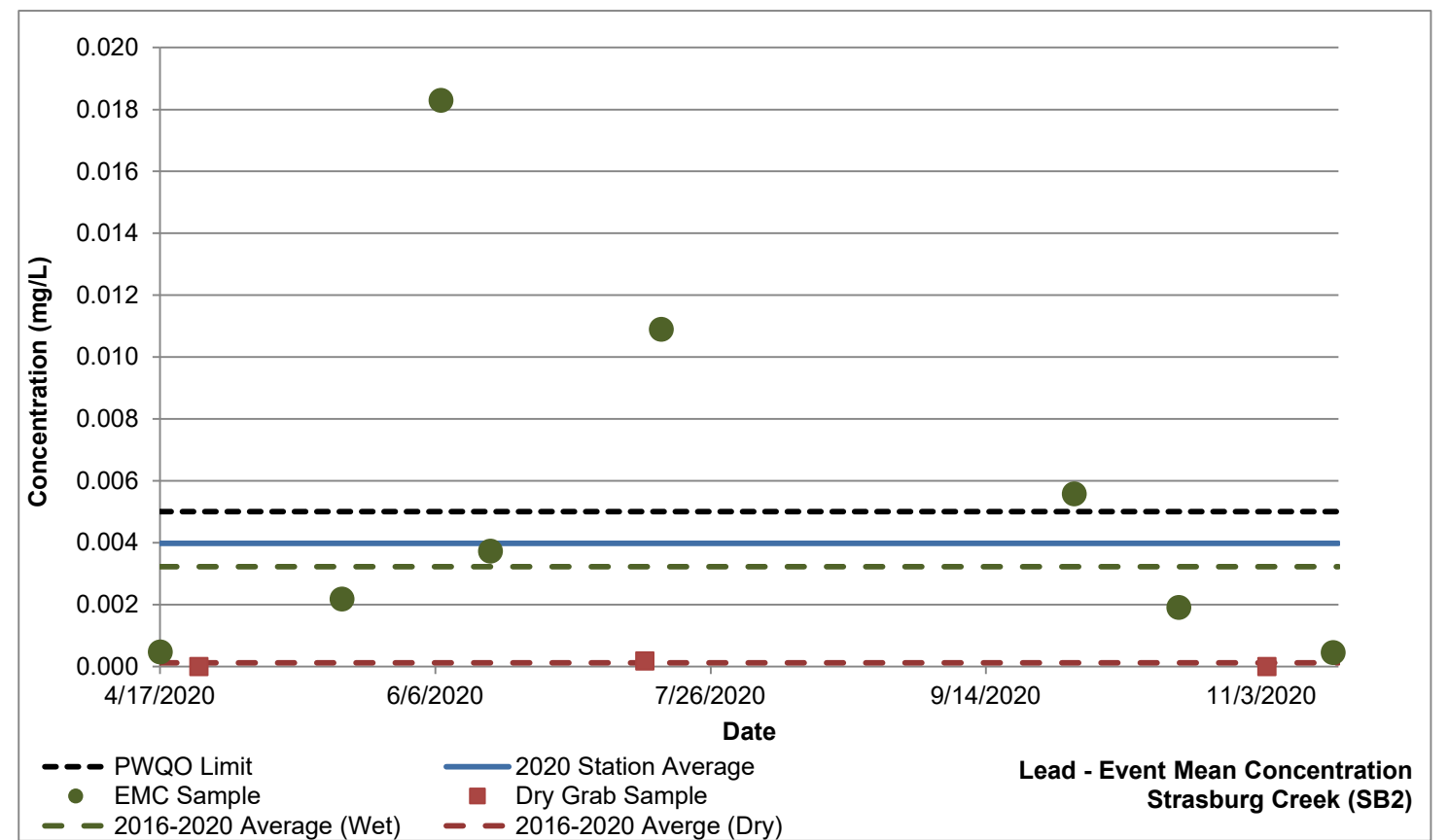
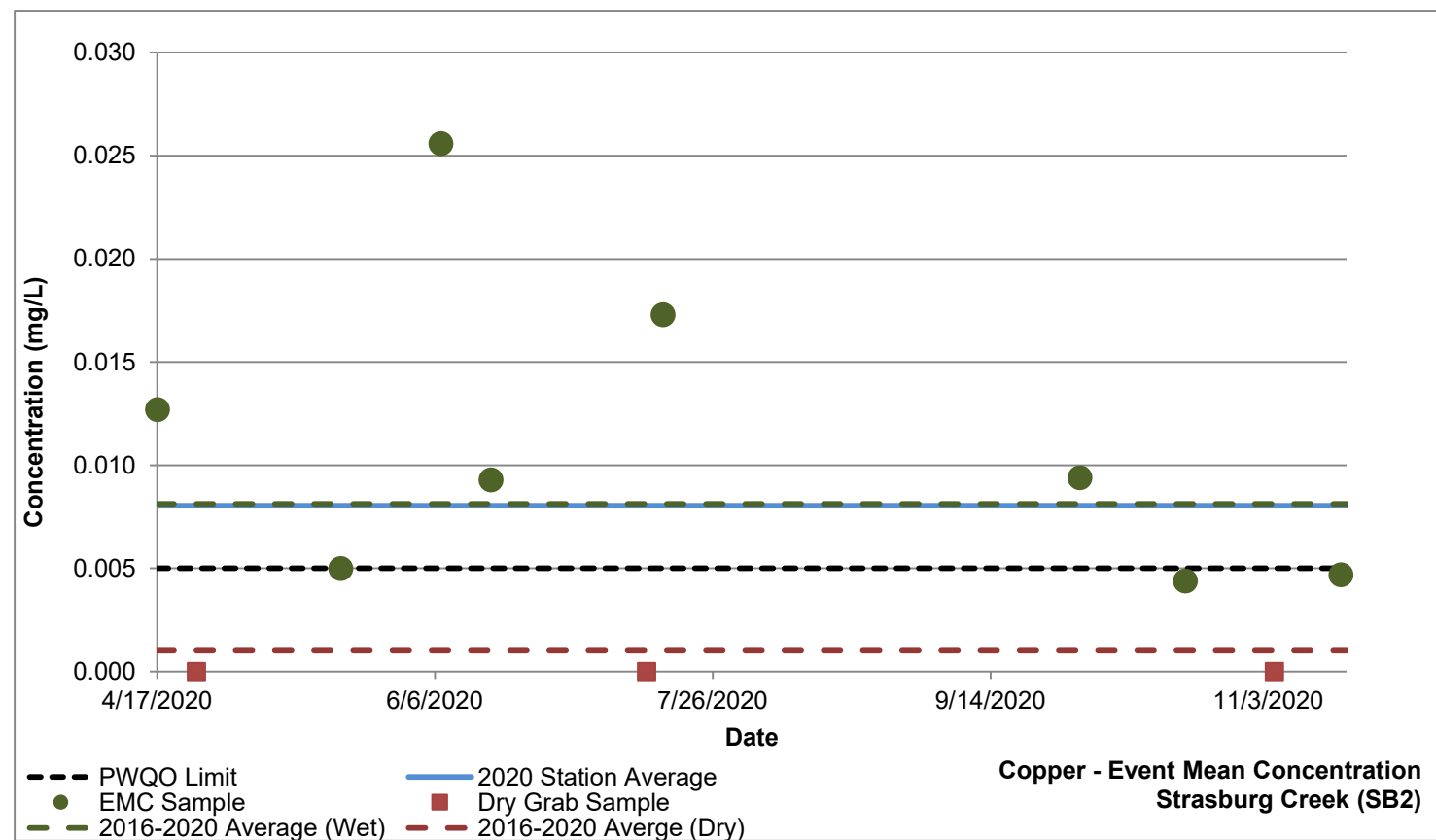
Figure 42
Voisin Creek (VS1) EMC: Copper, Lead, Zinc, Total Suspended Solids Concentrations
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Note: No samples were collected at SB2 in 2018. No wet samples were collected in 2016 and 2017.



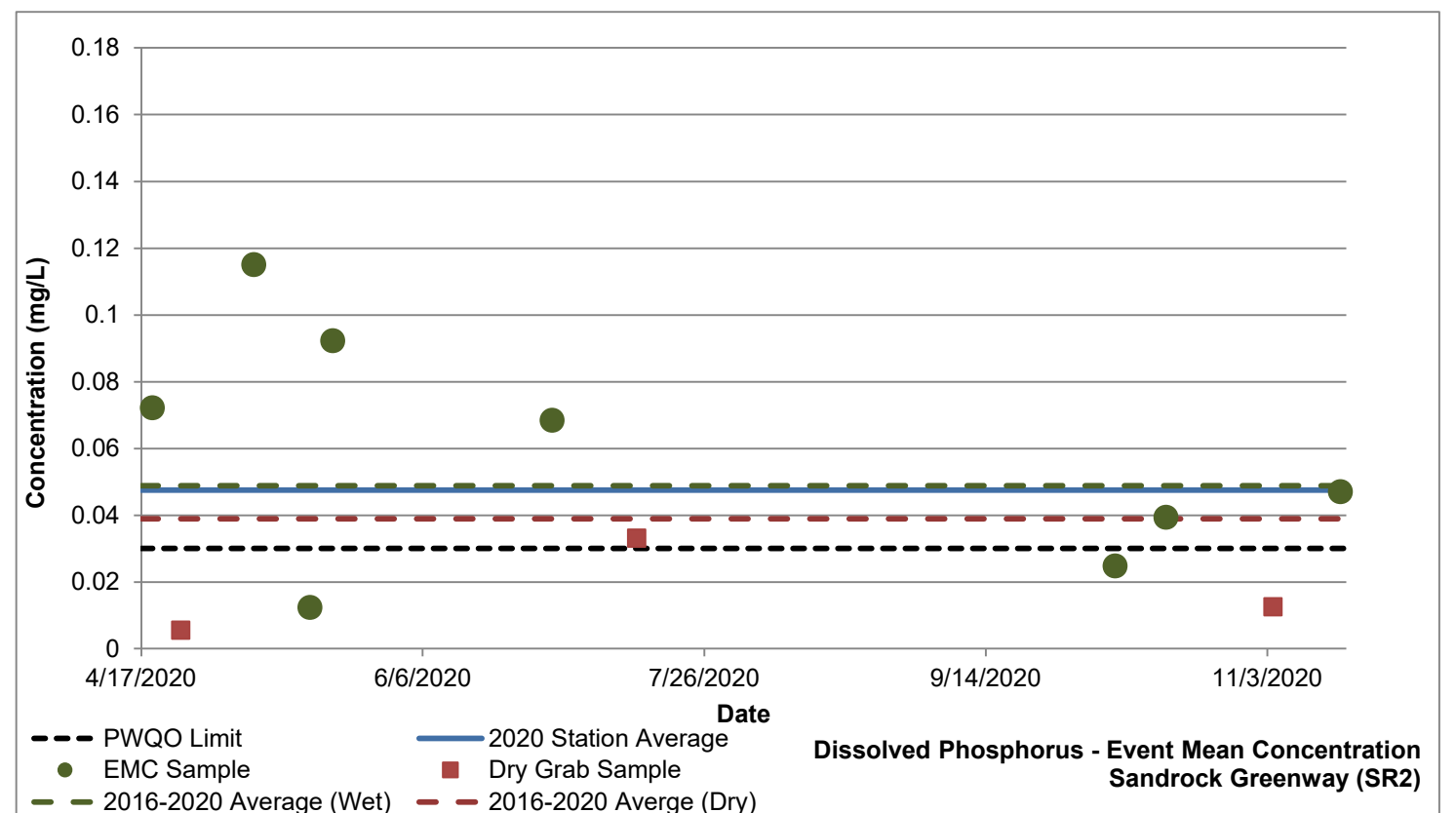
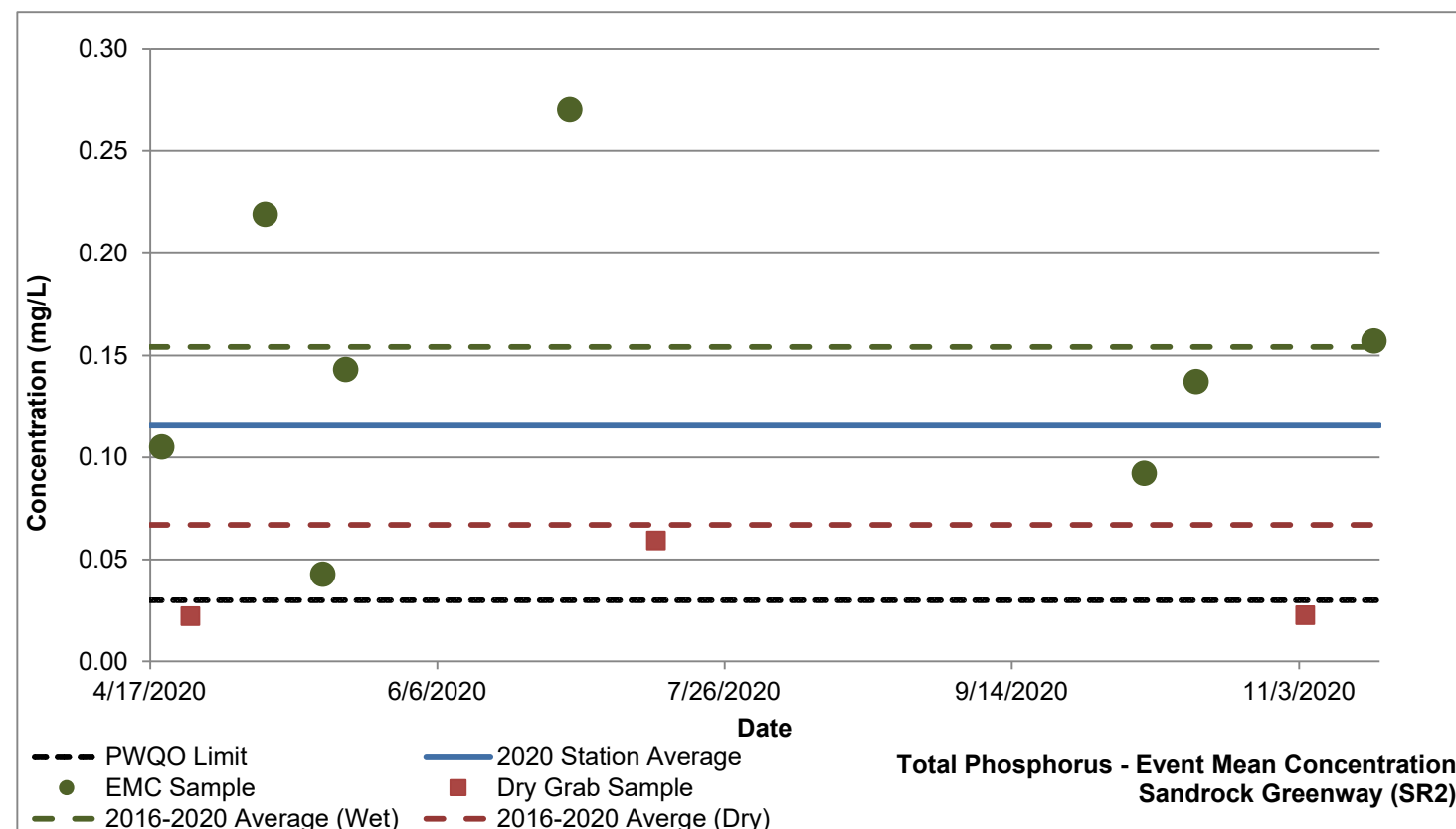
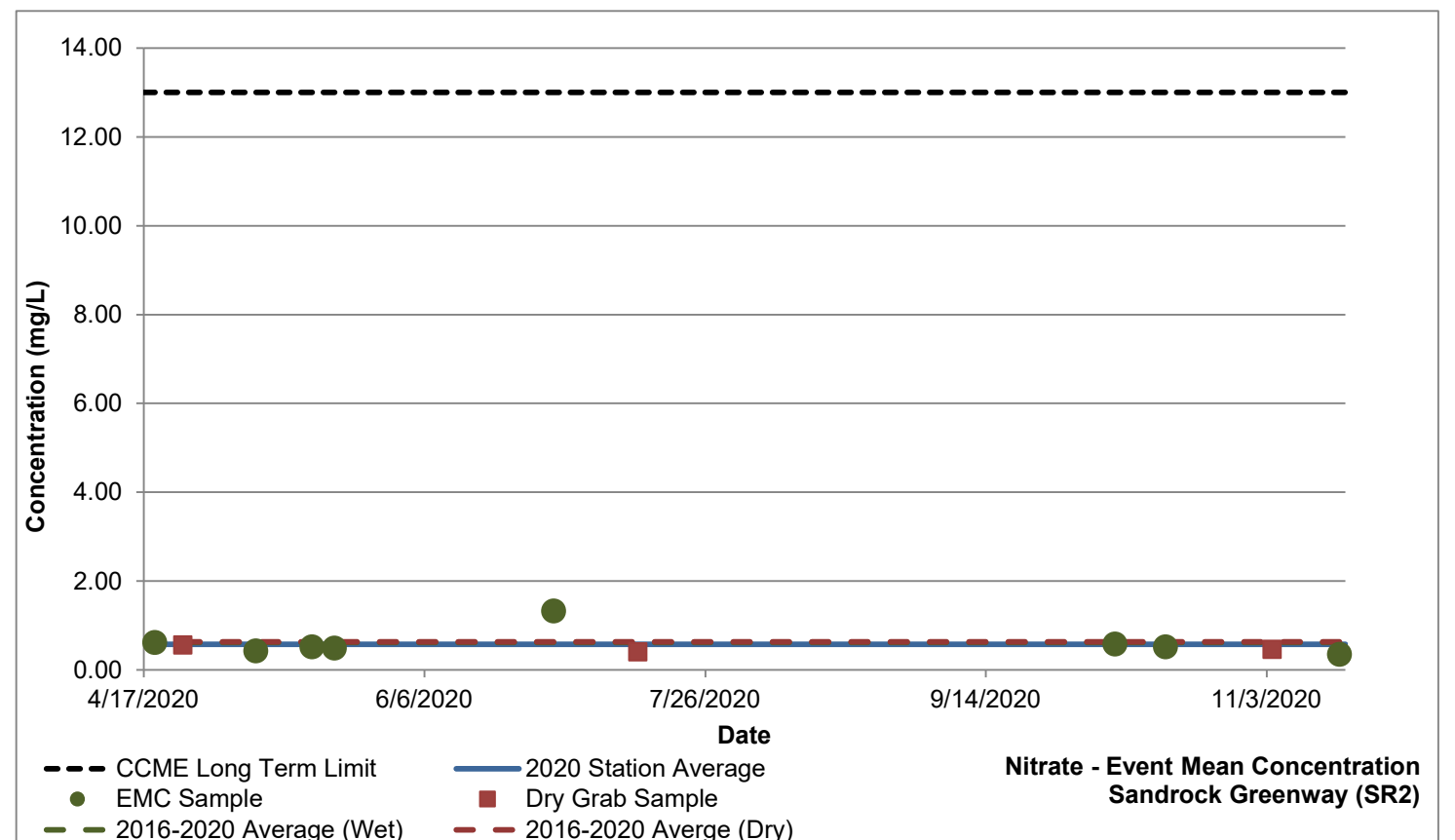
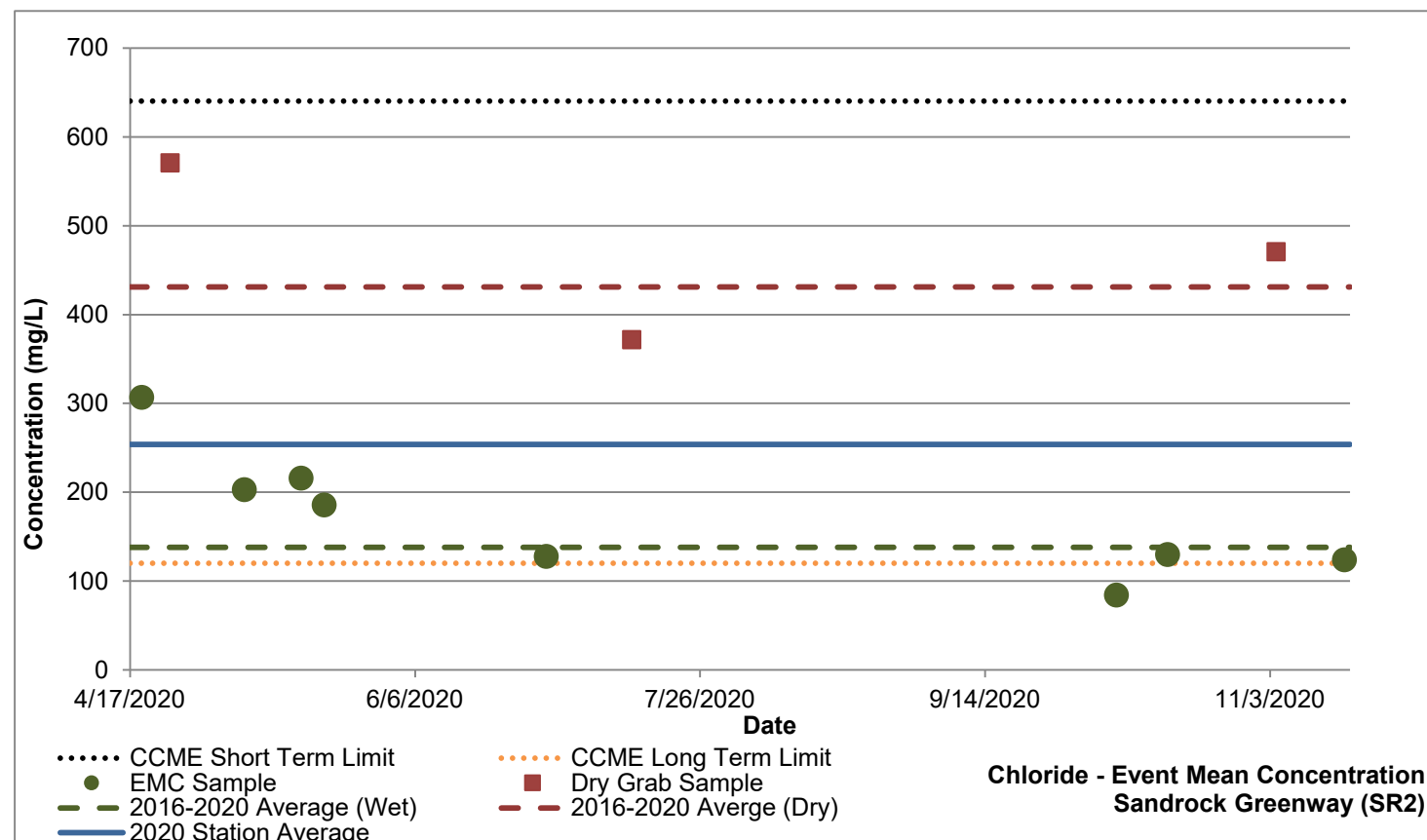
Figure 43
Strasburg Creek (SB2) EMC: Chloride, Nitrate, Total and Dissolved Phosphorous Concentrations
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Note: No samples were collected at SB2 in 2018. No wet samples were collected in 2016 and 2017.



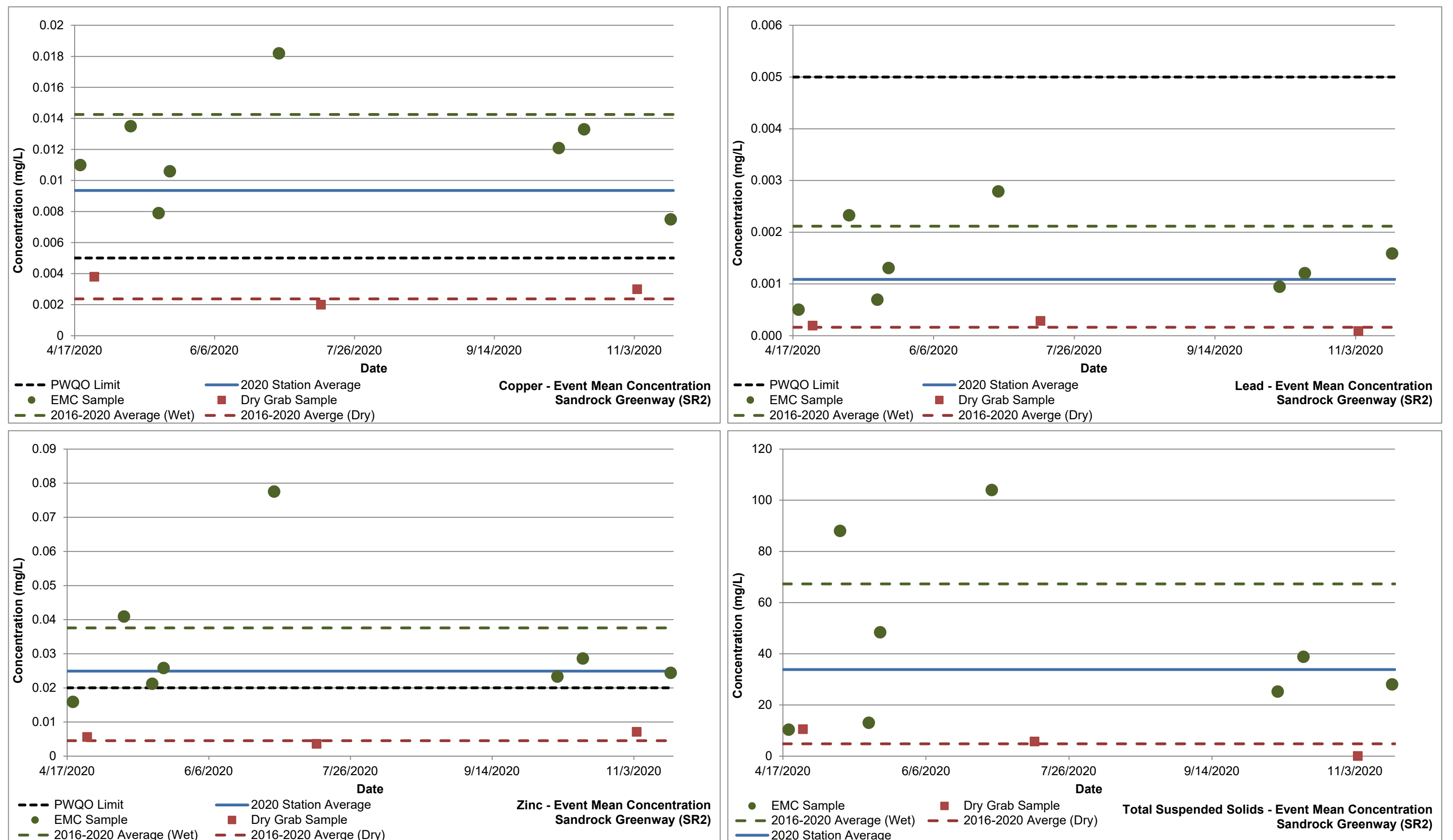
Figure 44
Strasburg Creek (SB2) EMC: Copper, Lead, Zinc, Total Suspended Solids Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No wet samples were collected in 2017 and 2018 at SR2.



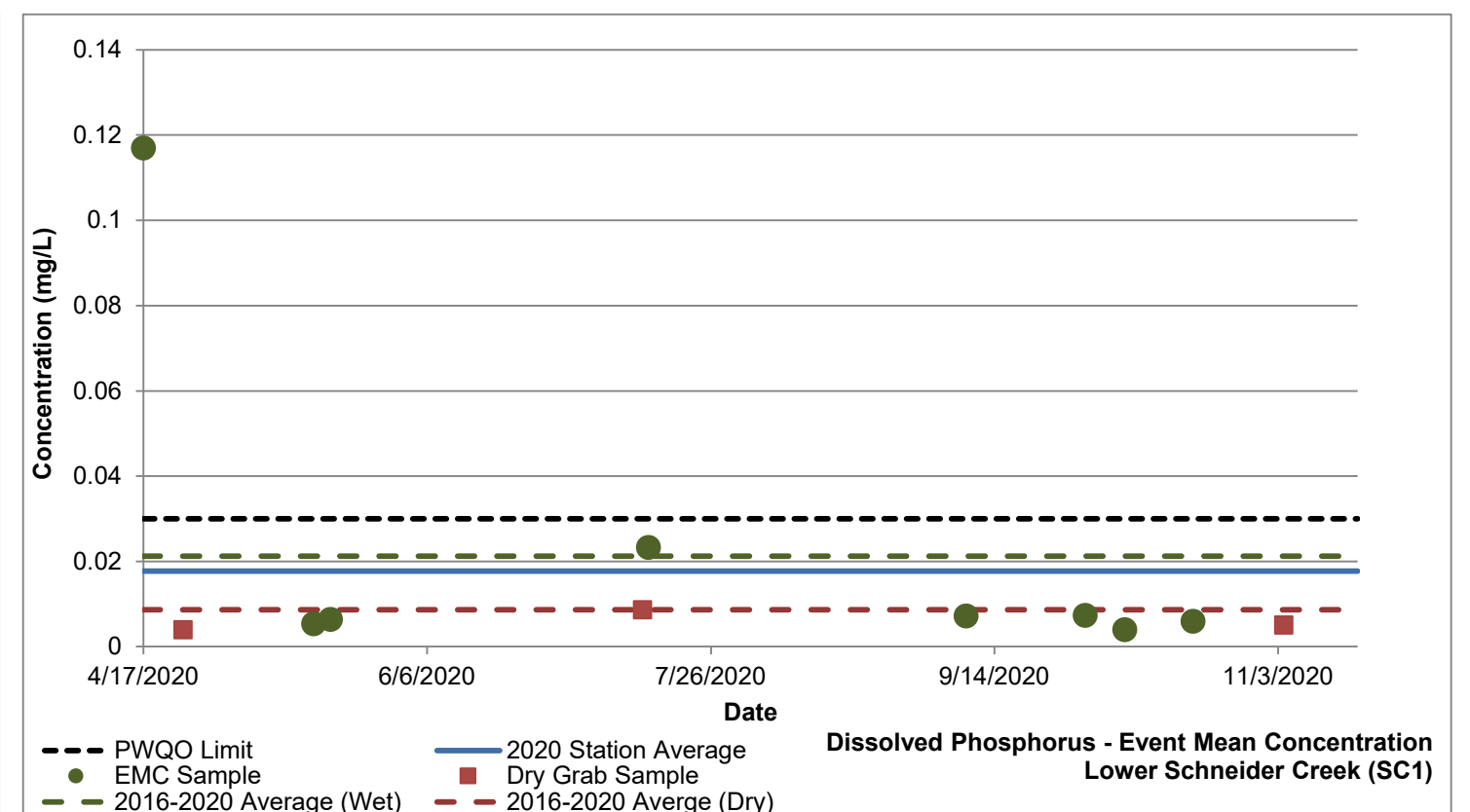
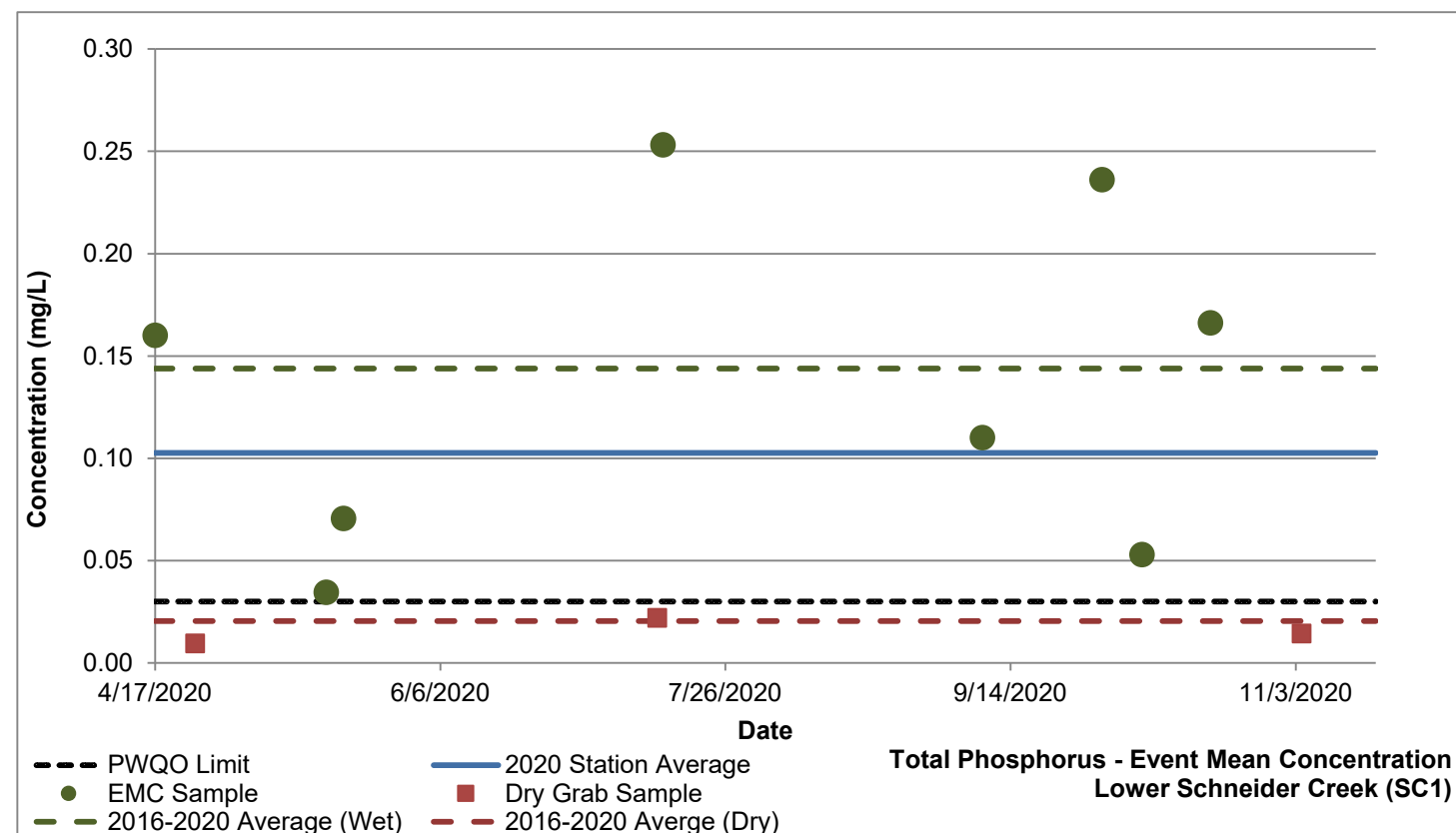
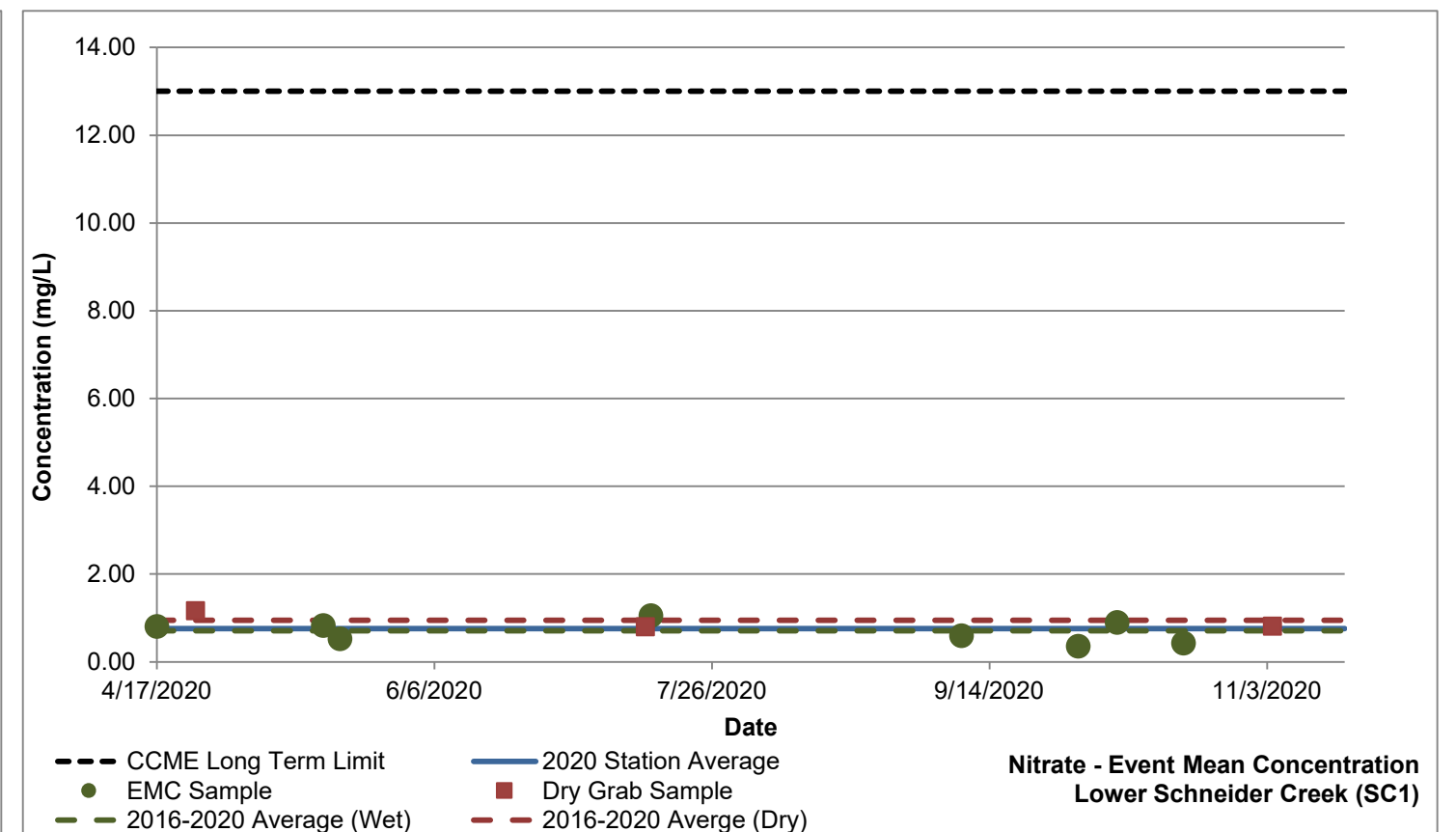
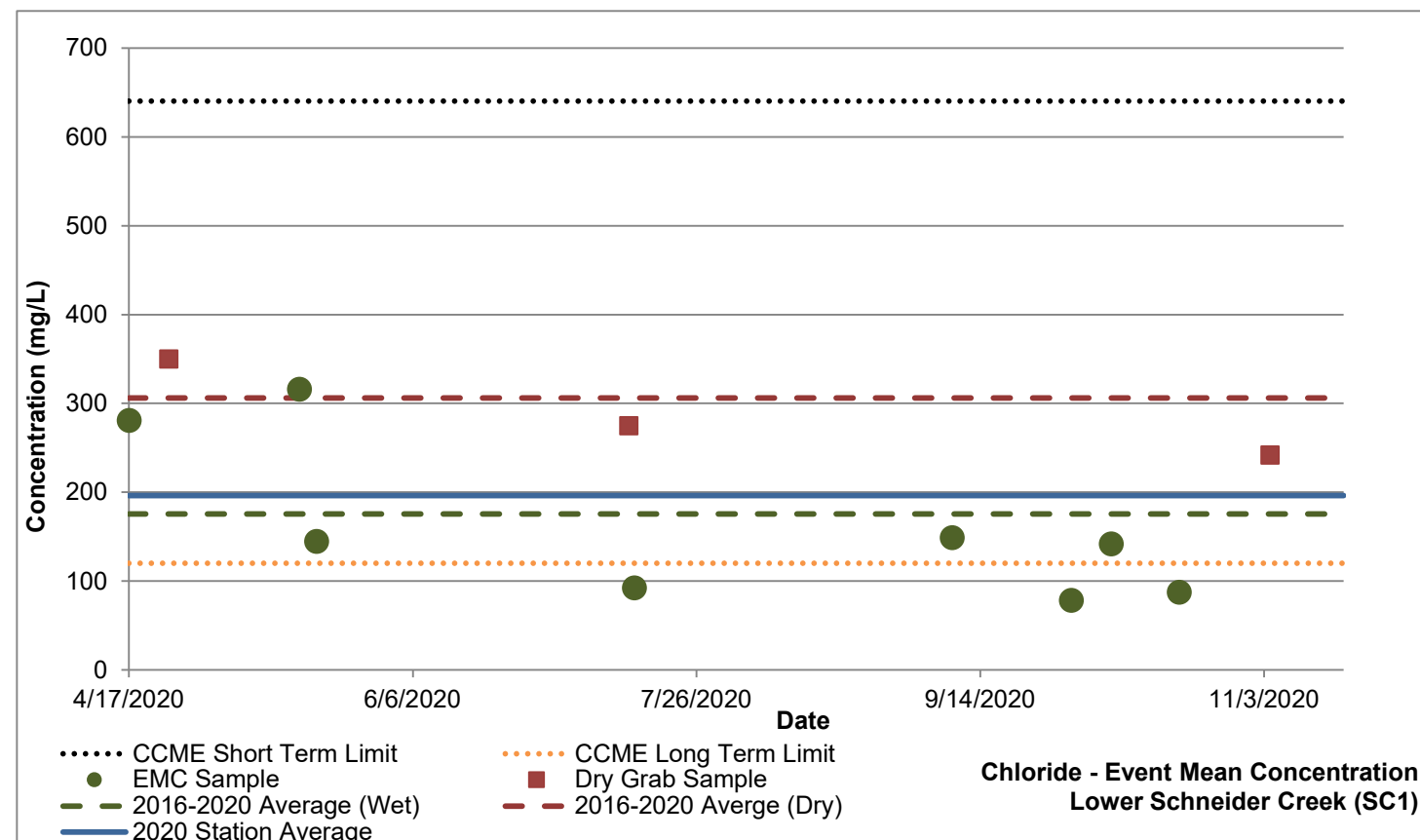
Figure 45
Sandrock Greenway (SR2) EMC: Chloride, Nitrate, Total and Dissolved Phosphorous Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No wet samples were collected in 2017 and 2018 at SR2.



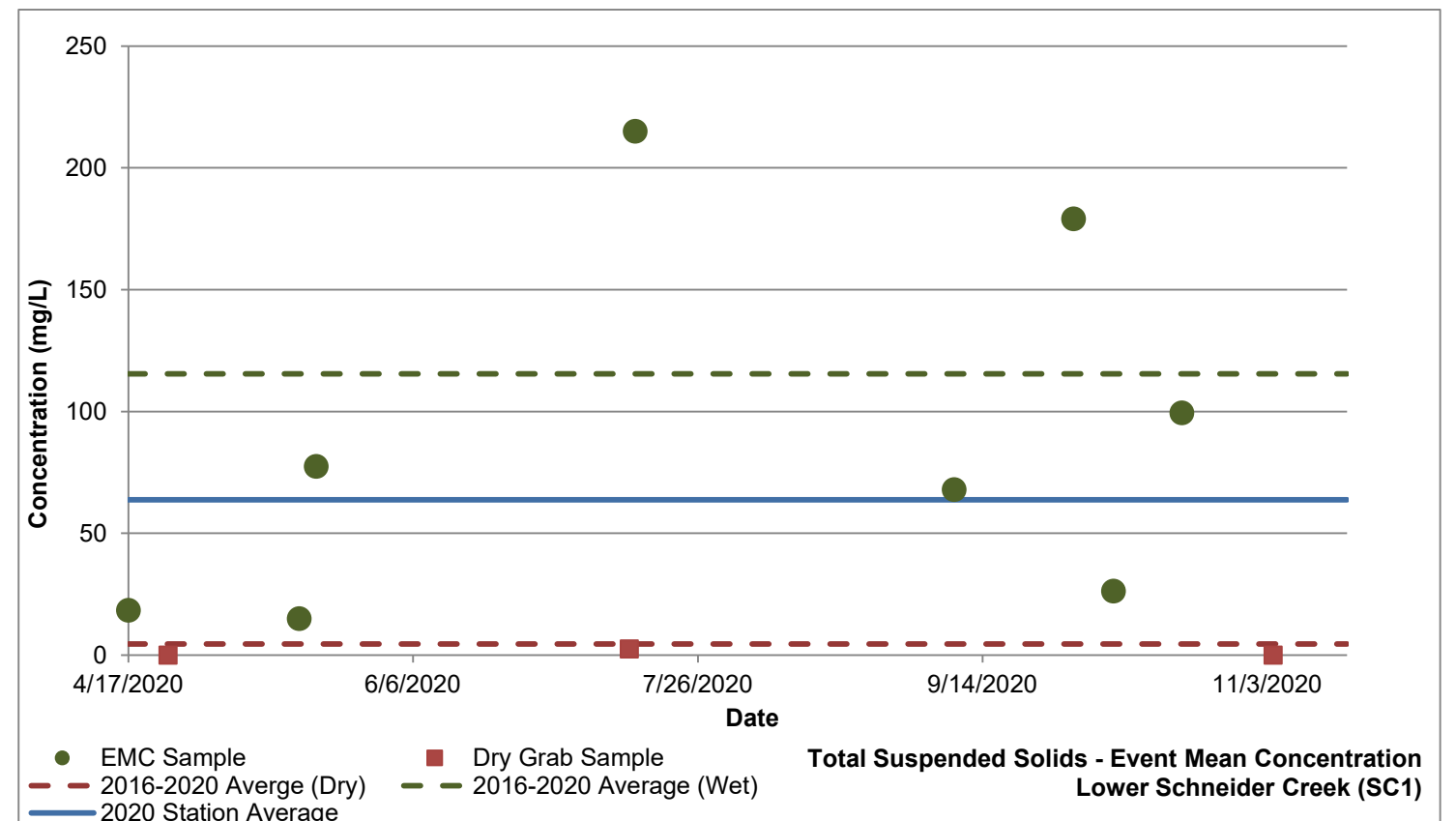
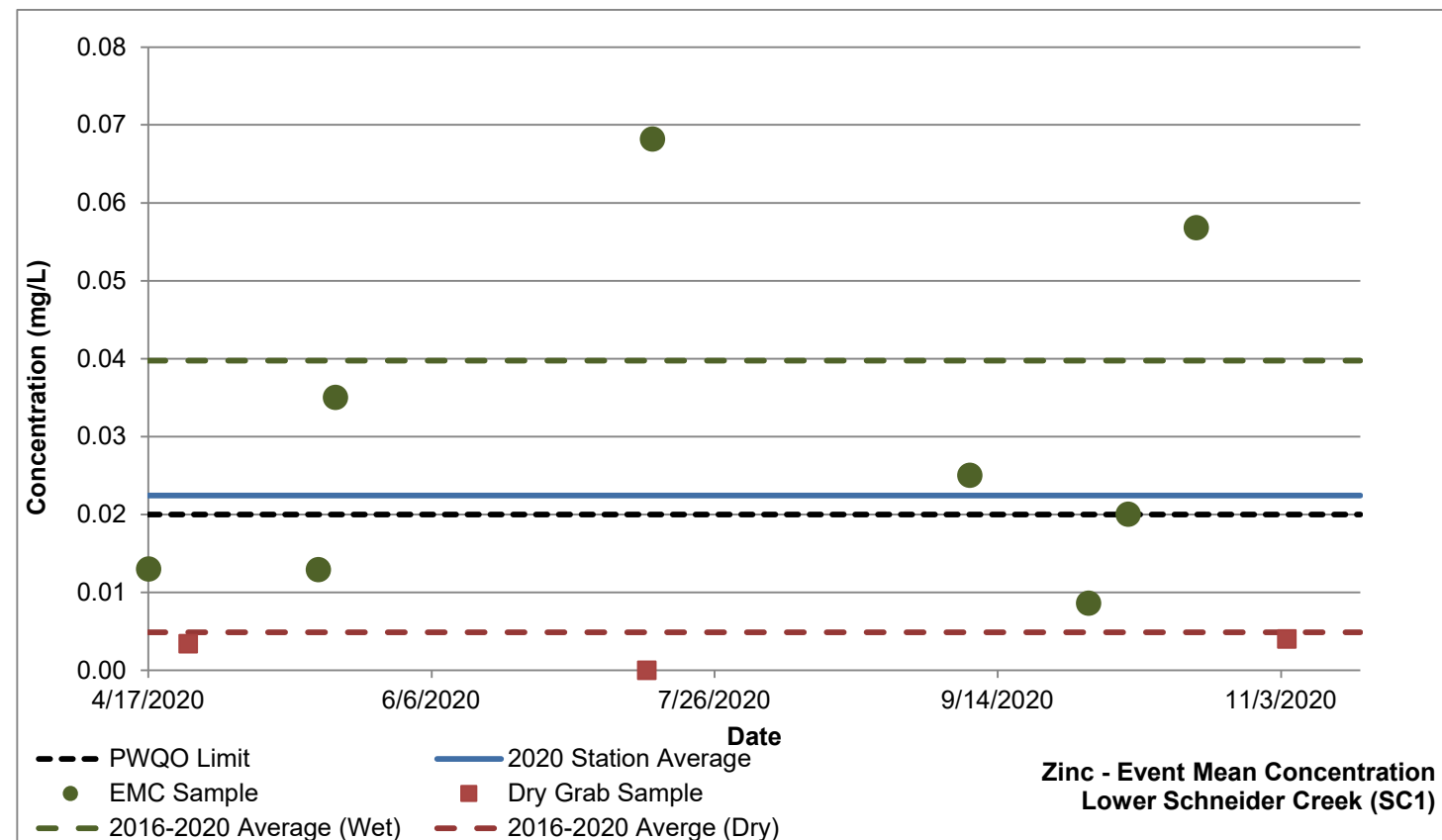
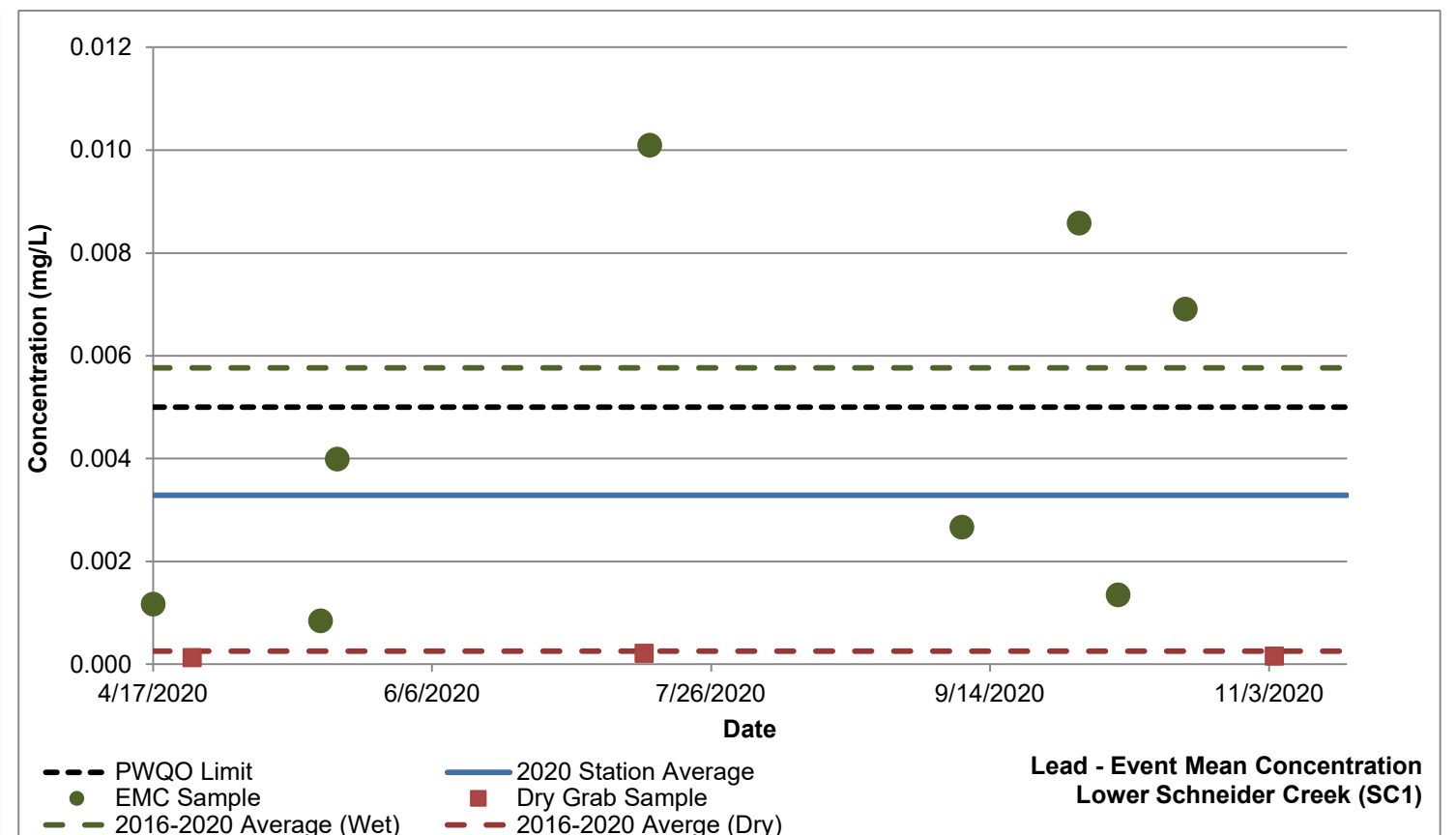
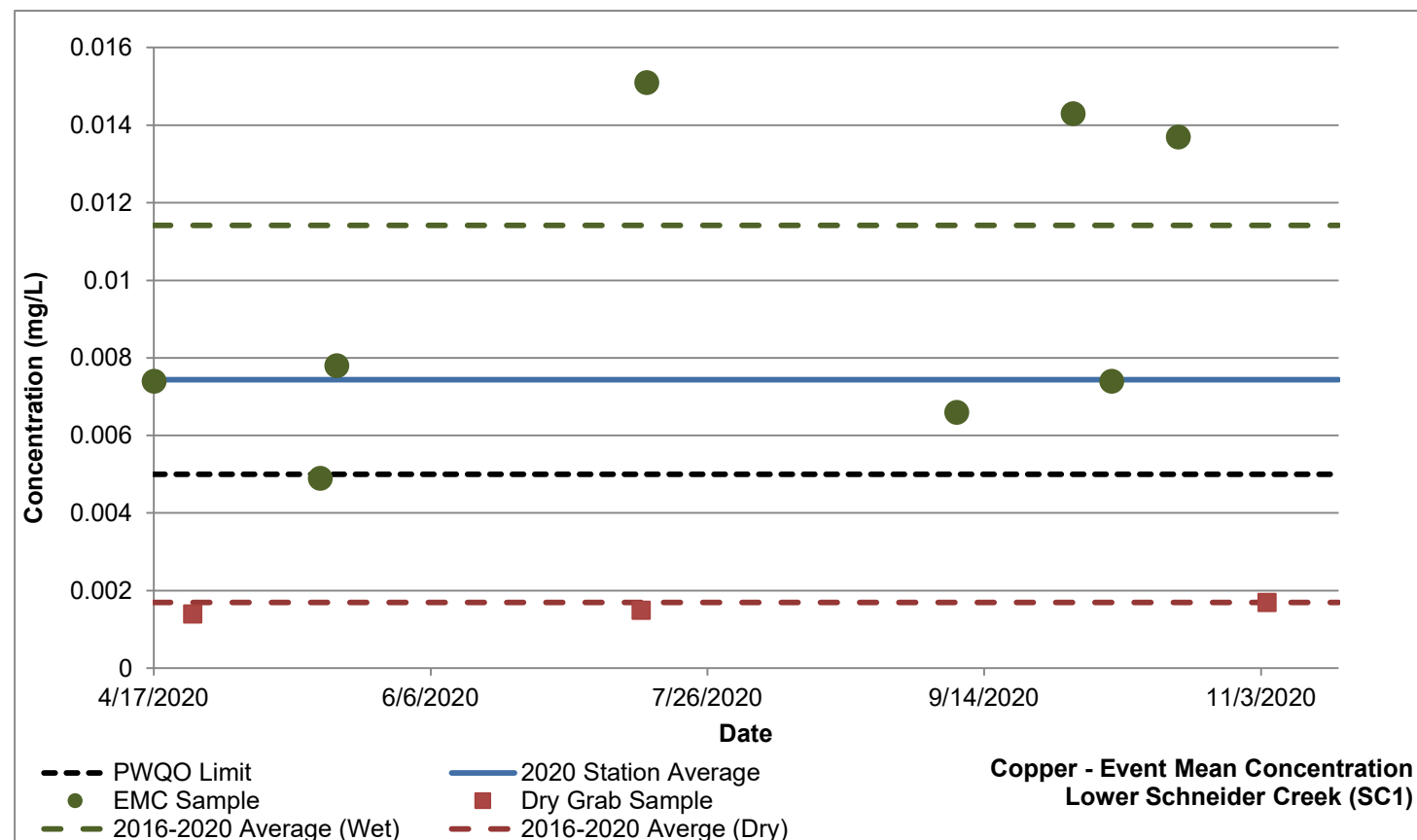
Figure 46
Sandrock Greenway (SR2) EMC: Copper, Lead, Zinc, Total Suspended Solids Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No samples were collected at SC1 in 2016. No wet samples were collected in 2018 and 2019.



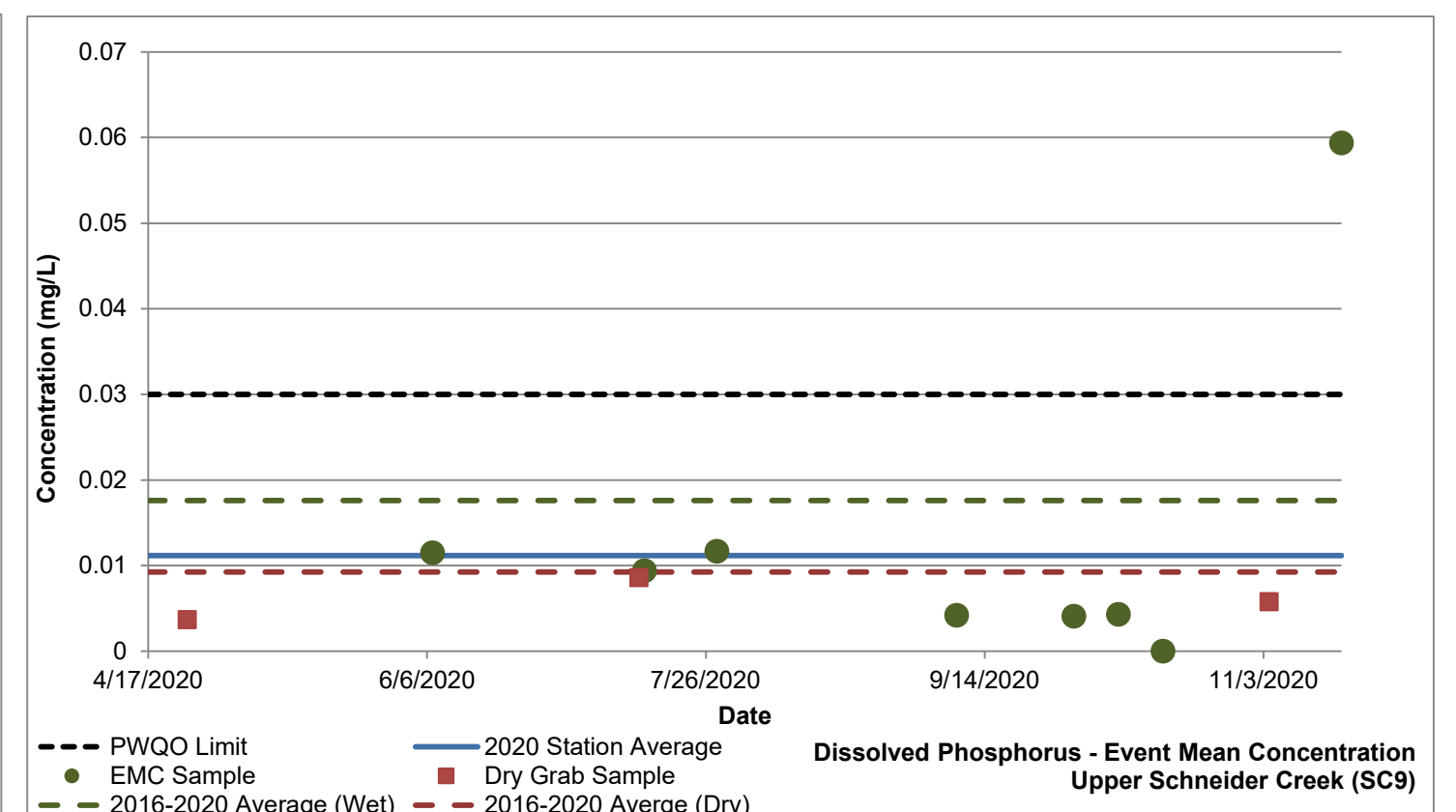
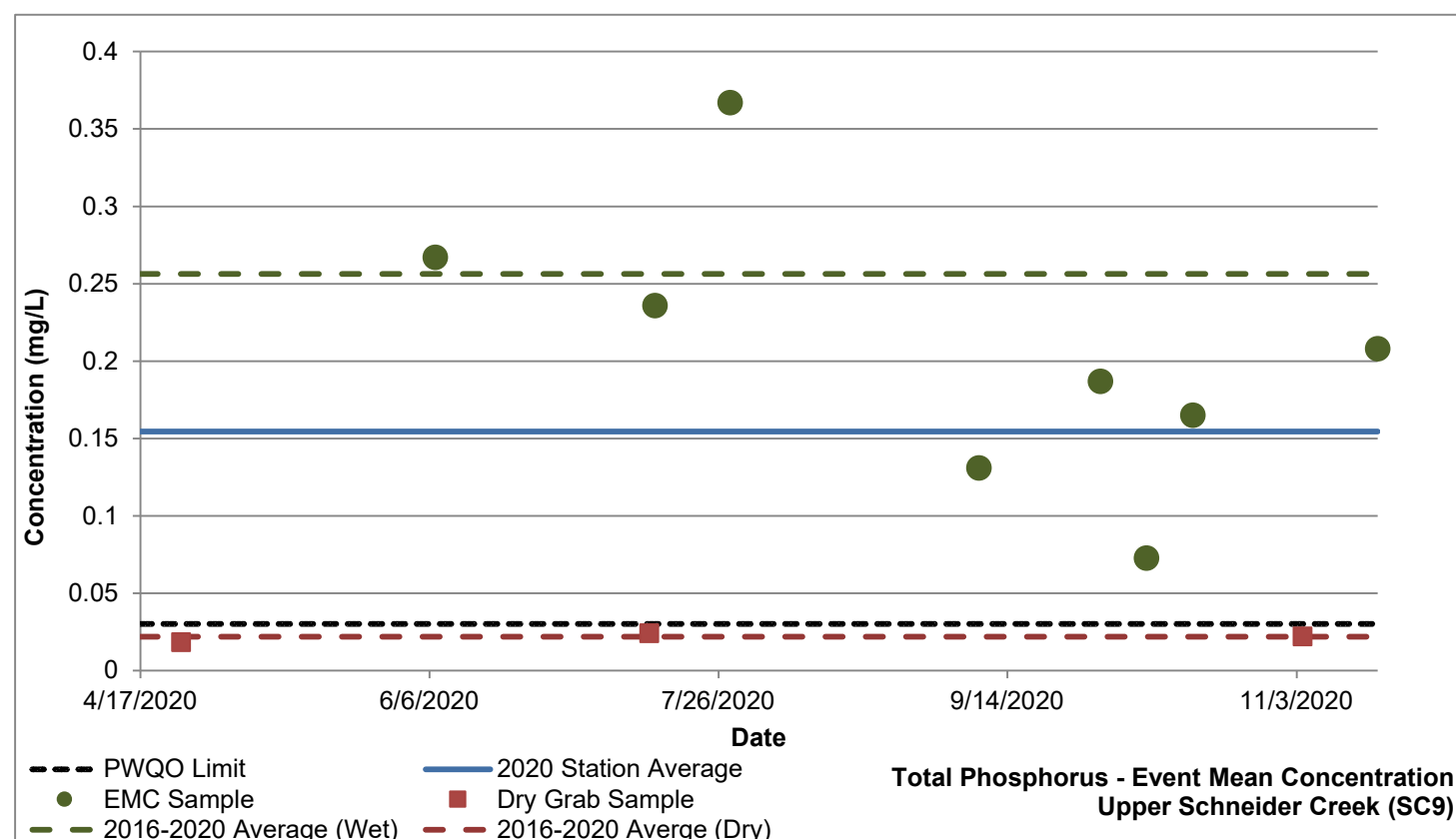
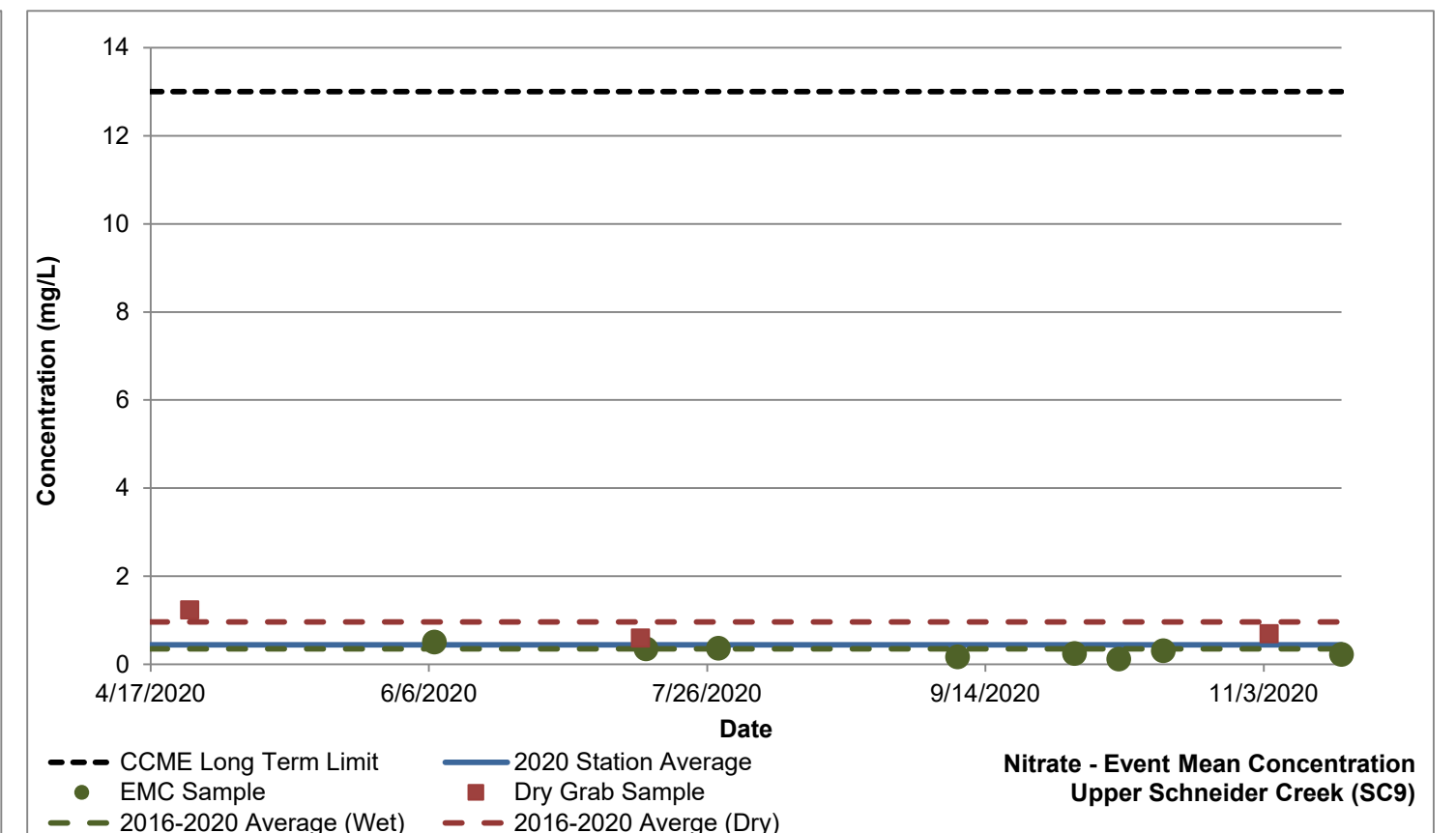
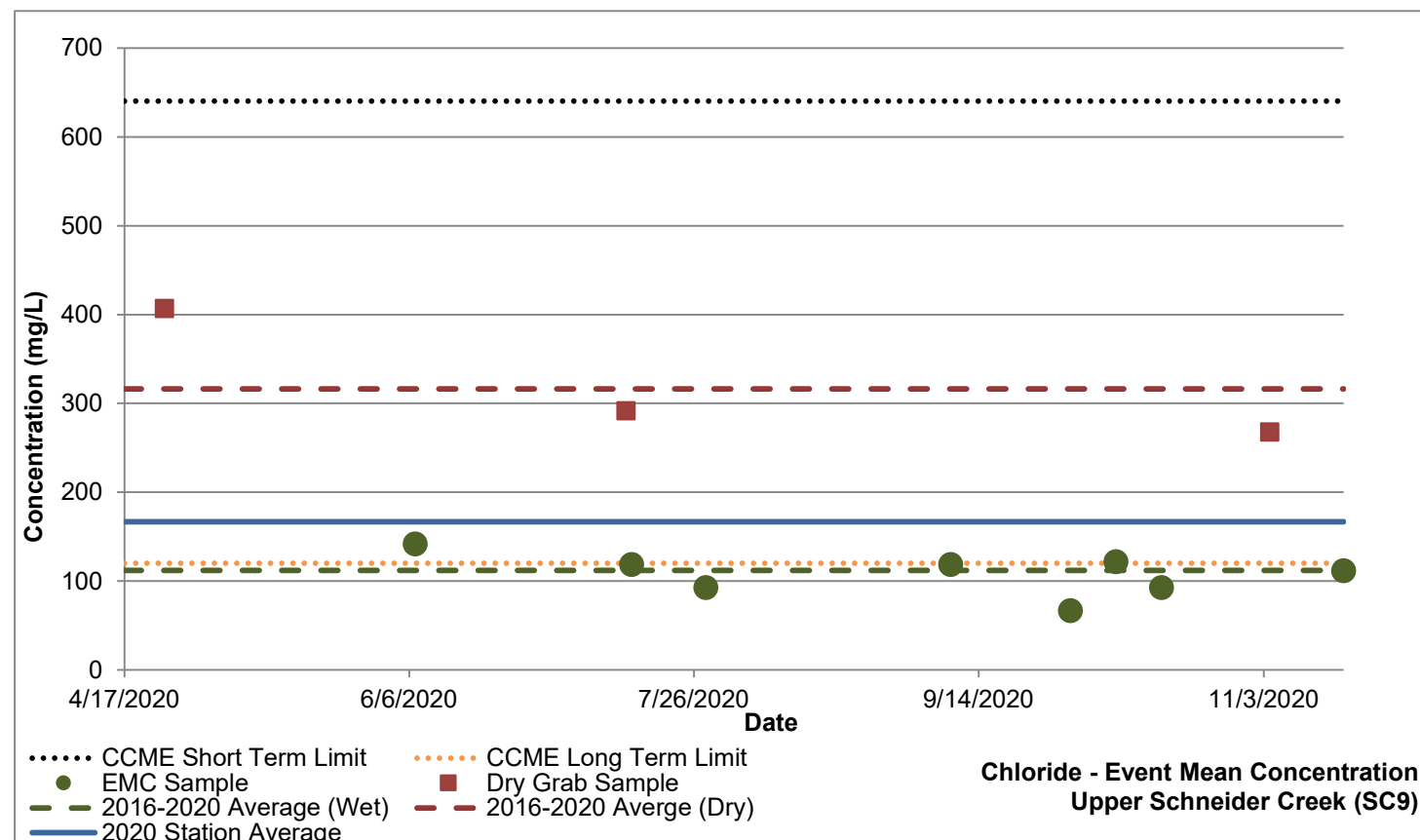
Figure 47
Lower Schneider Creek (SC1) EMC: Chloride, Nitrate, Total and Dissolved Phosphorous Concentrations
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario



Note: No samples were collected at SC1 in 2016. No wet samples were collected in 2018 and 2019.



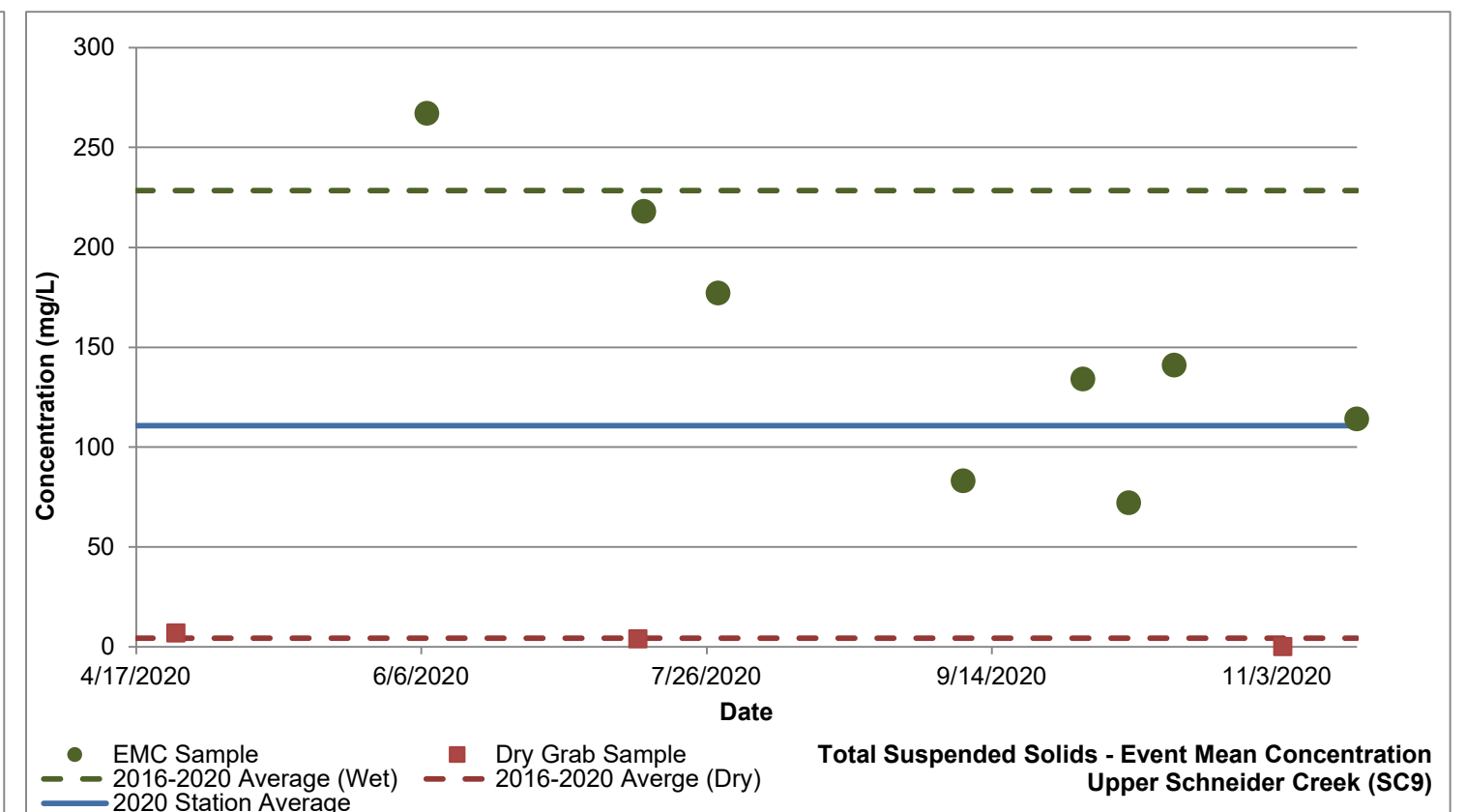
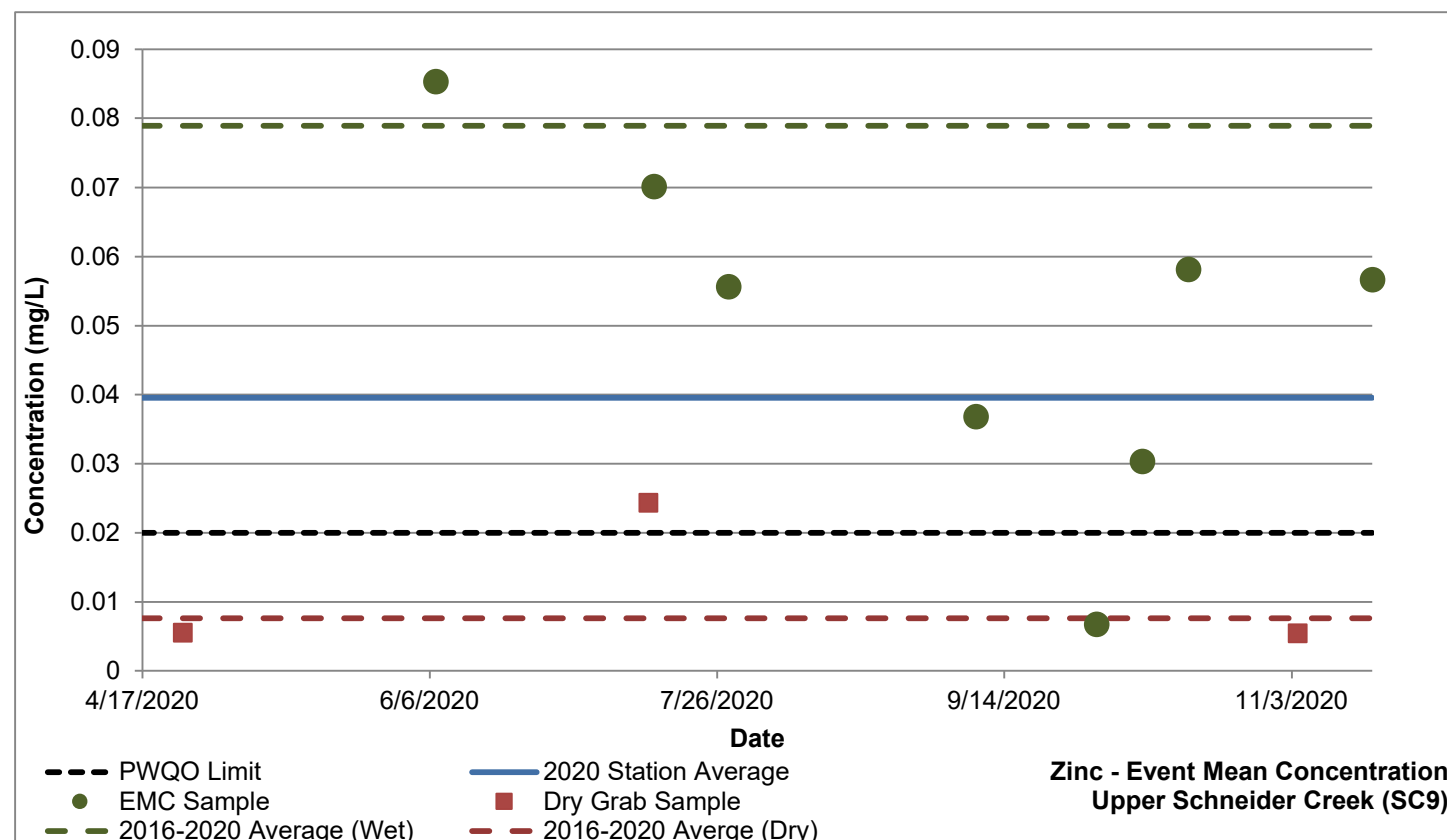
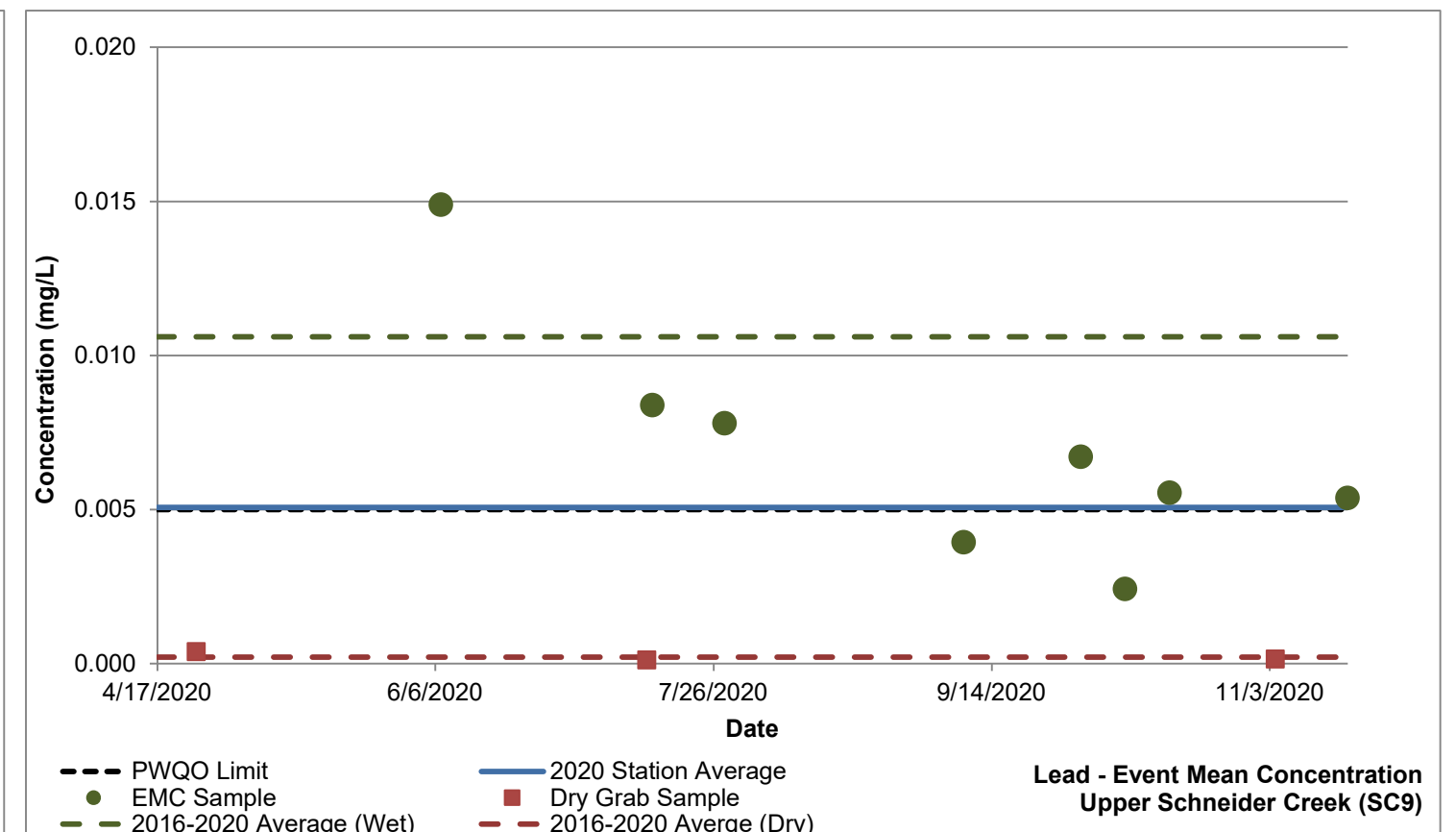
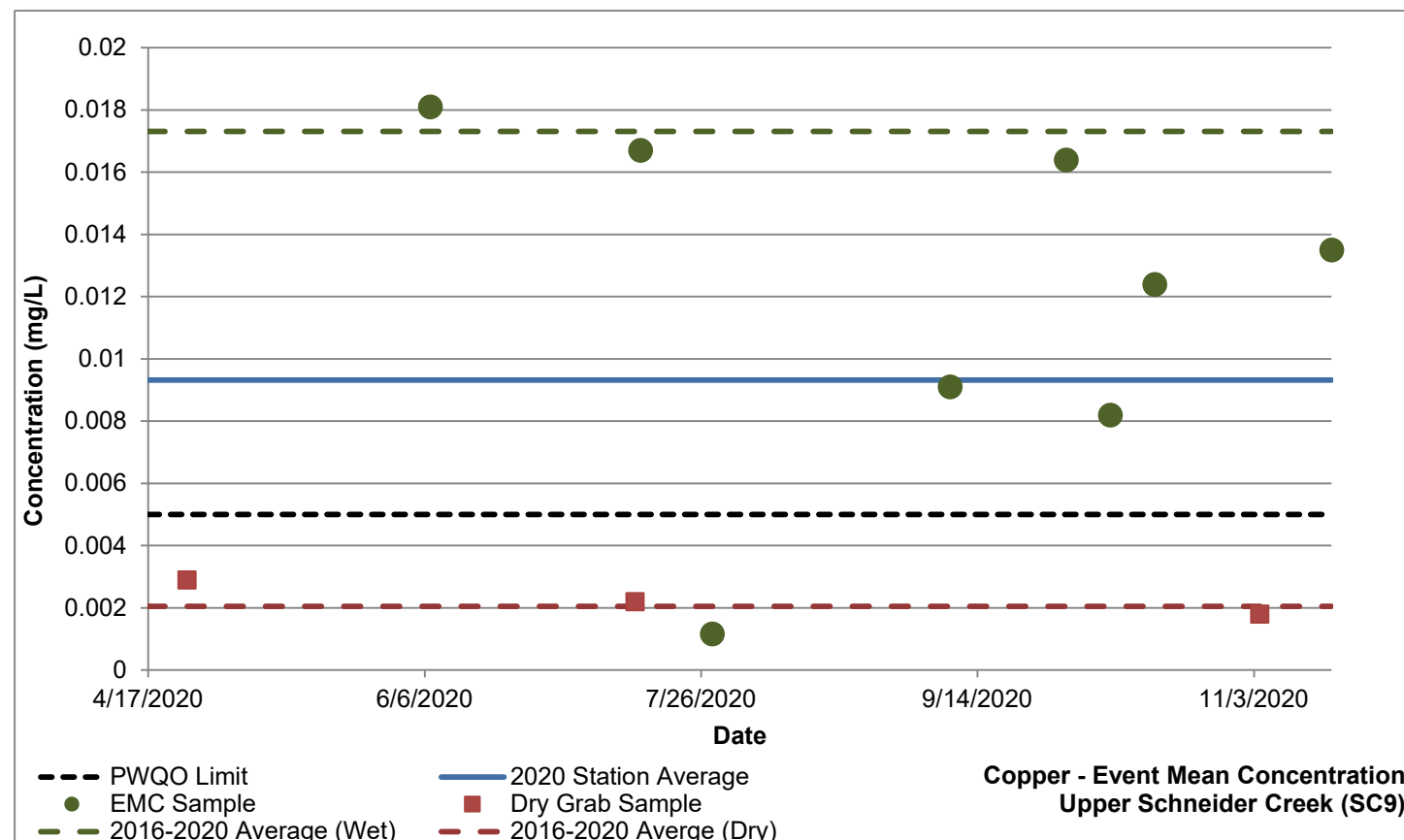
Figure 48
Lower Schneider Creek (SC1) EMC: Copper, Lead, Zinc, Total Suspended Solids Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No samples were collected at SC9 in 2016 and 2019. No wet samples were collected in 2018.



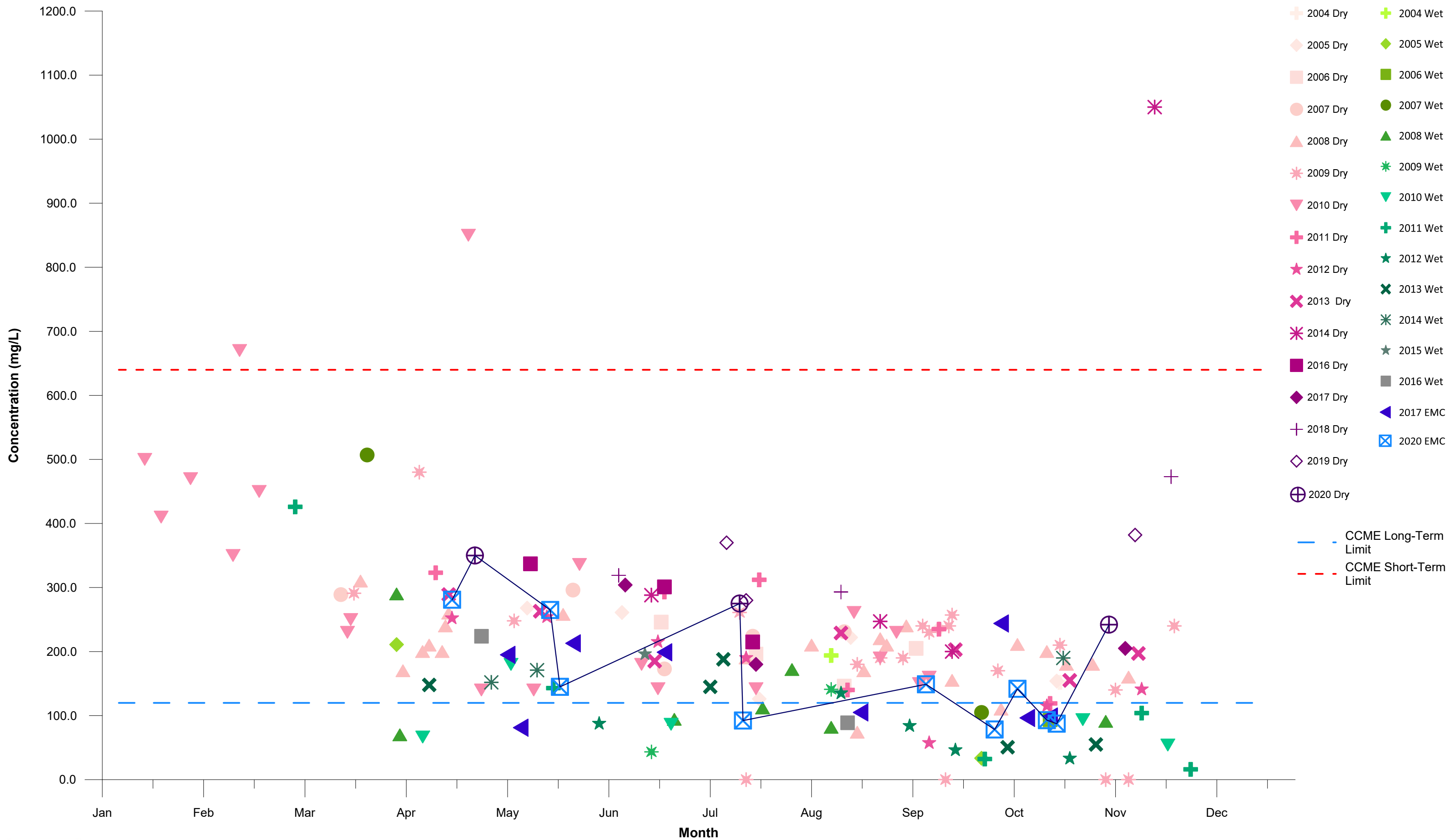
Figure 49
Upper Schneider Creek (SC9) EMC: Chloride, Nitrate, Total and Dissolved Phosphorous Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
 Kitchener, Ontario



Note: No samples were collected at SC9 in 2016 and 2019. No wet samples were collected in 2018.

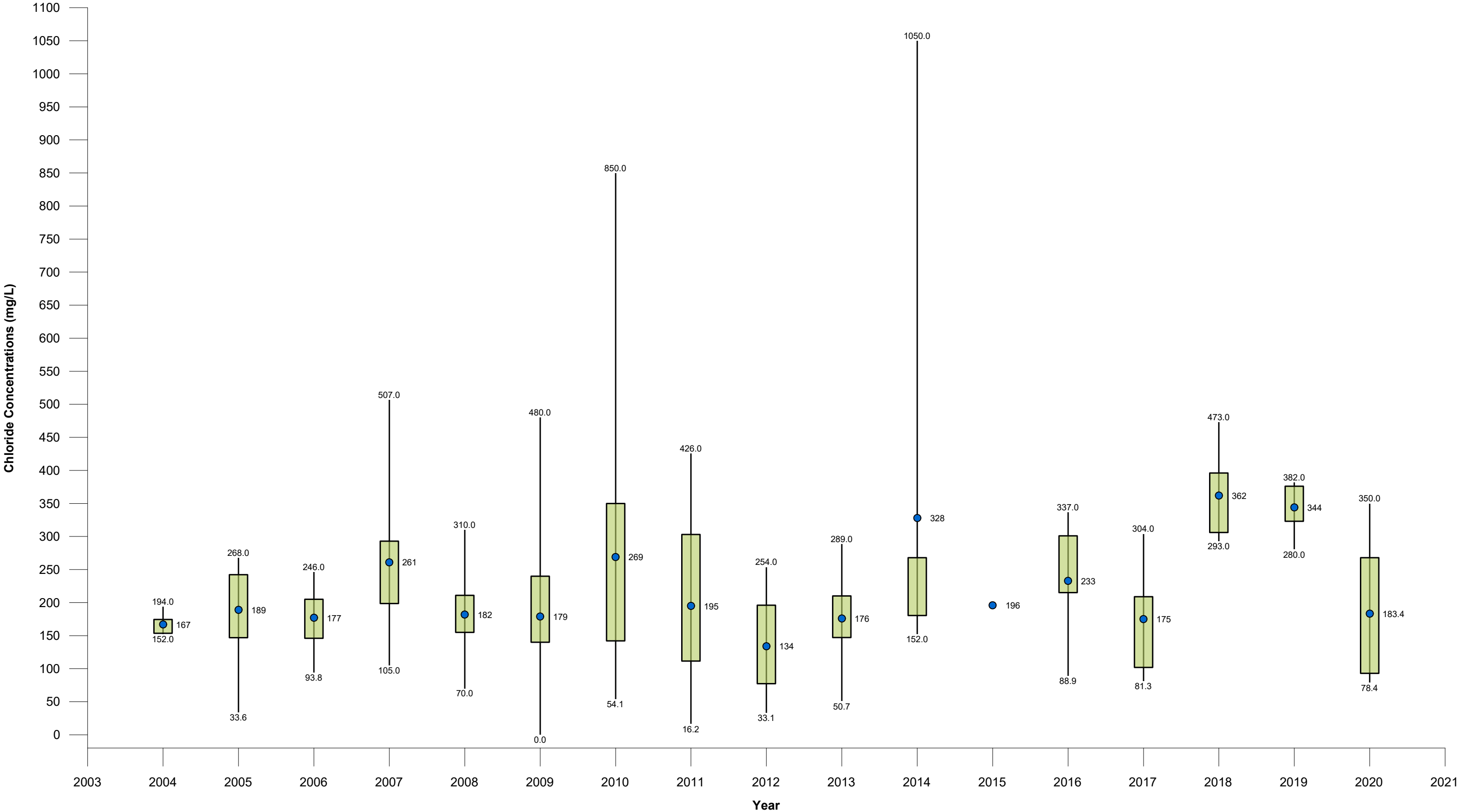


Figure 50
Upper Schneider Creek (SC9) EMC: Copper, Lead, Zinc, Total Suspended Solids Concentrations
 Stormwater Management Monitoring Program 2020
 Kitchener 2020 Surface Water Monitoring
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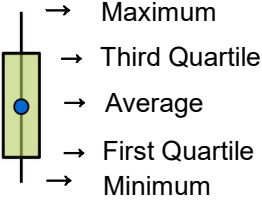


Note:
- The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 51
Lower Schneider Creek (SC1) Chloride Historical Trend Concentrations
Stormwater Management Monitoring Program 2020
2020 Kitchener Surface Water Monitoring
Kitchener, Ontario



Note:
-Only one sample was collected in 2015, thus the minimum, maximum, average, first quartile, and third quartile concentration values are equal

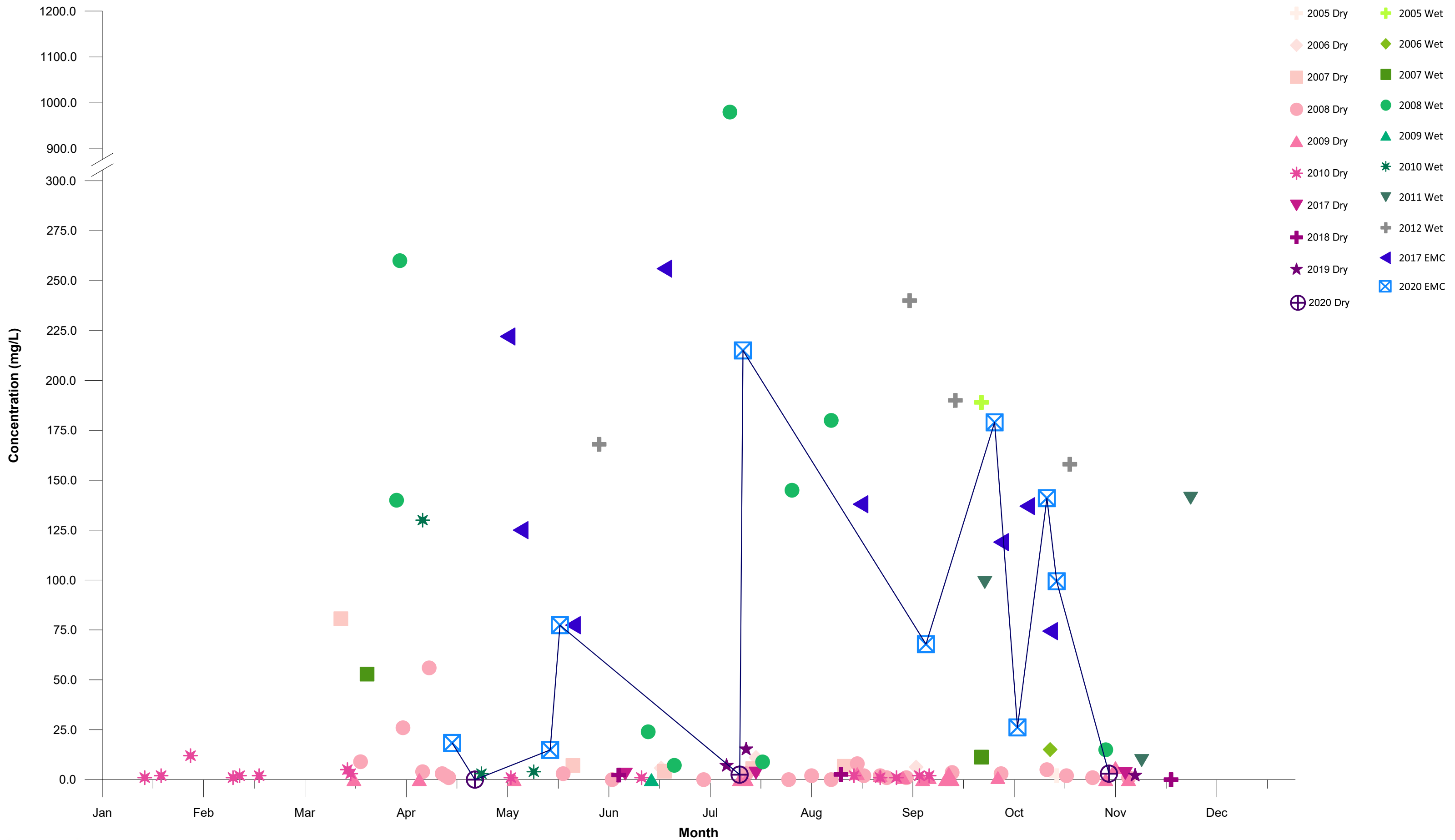


STORMWATER MANAGEMENT MONITORING PROGRAM 2020
KITCHENER 2020 SURFACE WATER MONITORING
KITCHENER, ONTARIO

SC1 Historical Chloride Concentration Statistics

11207597
February 2021

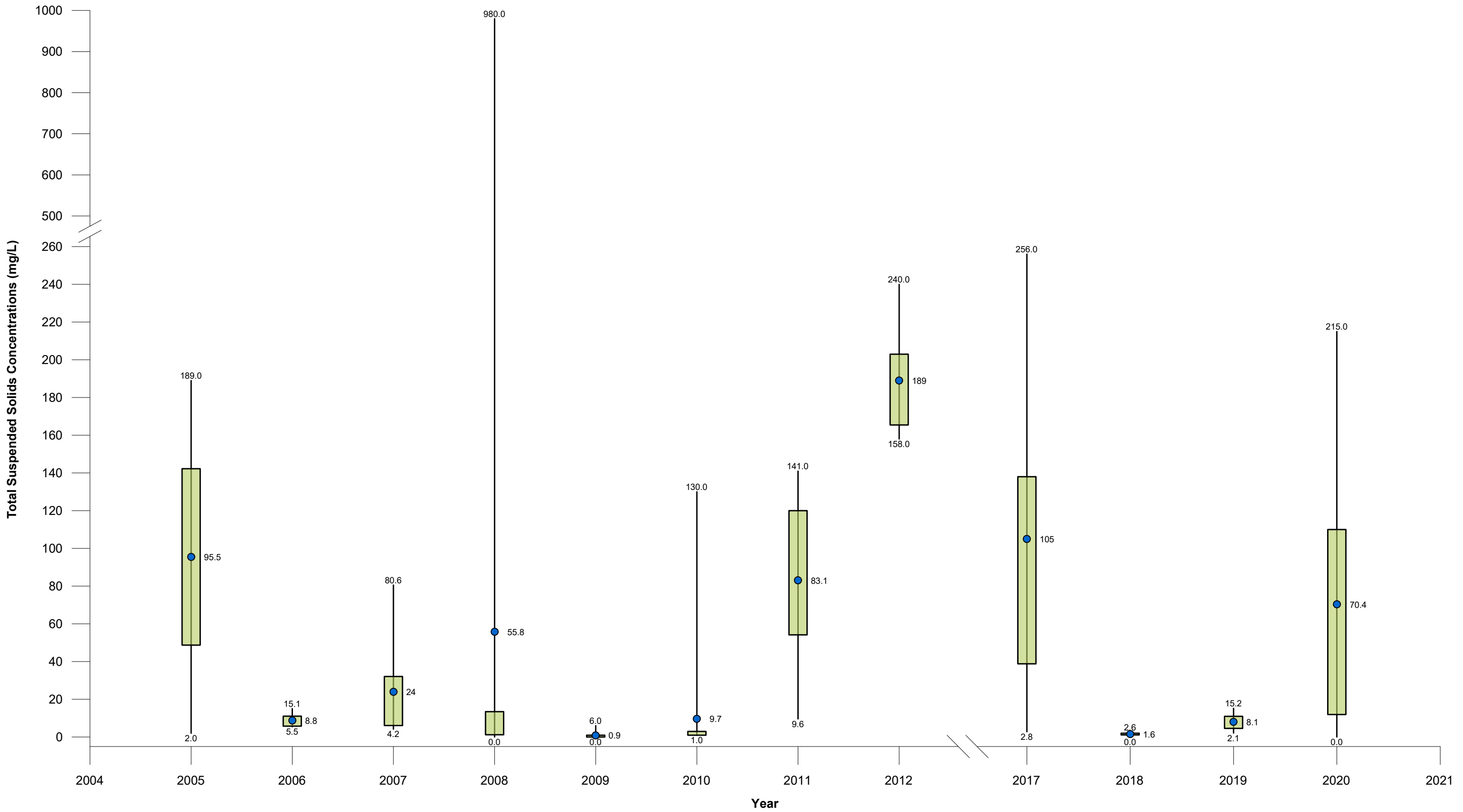
FIGURE 52



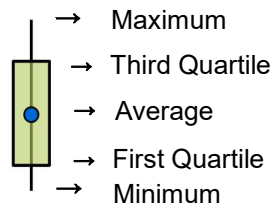
Note:

- The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 53
Lower Schneider Creek (SC1) TSS Historical Trend Concentrations
 Stormwater Management Monitoring Program 2020
 2020 Kitchener Surface Water Monitoring
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Note:
-No sampling conducted in 2013-2016.



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KITCHENER, ONTARIO

SC1 Historical TSS Concentration Statistics

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February 2021

FIGURE 54

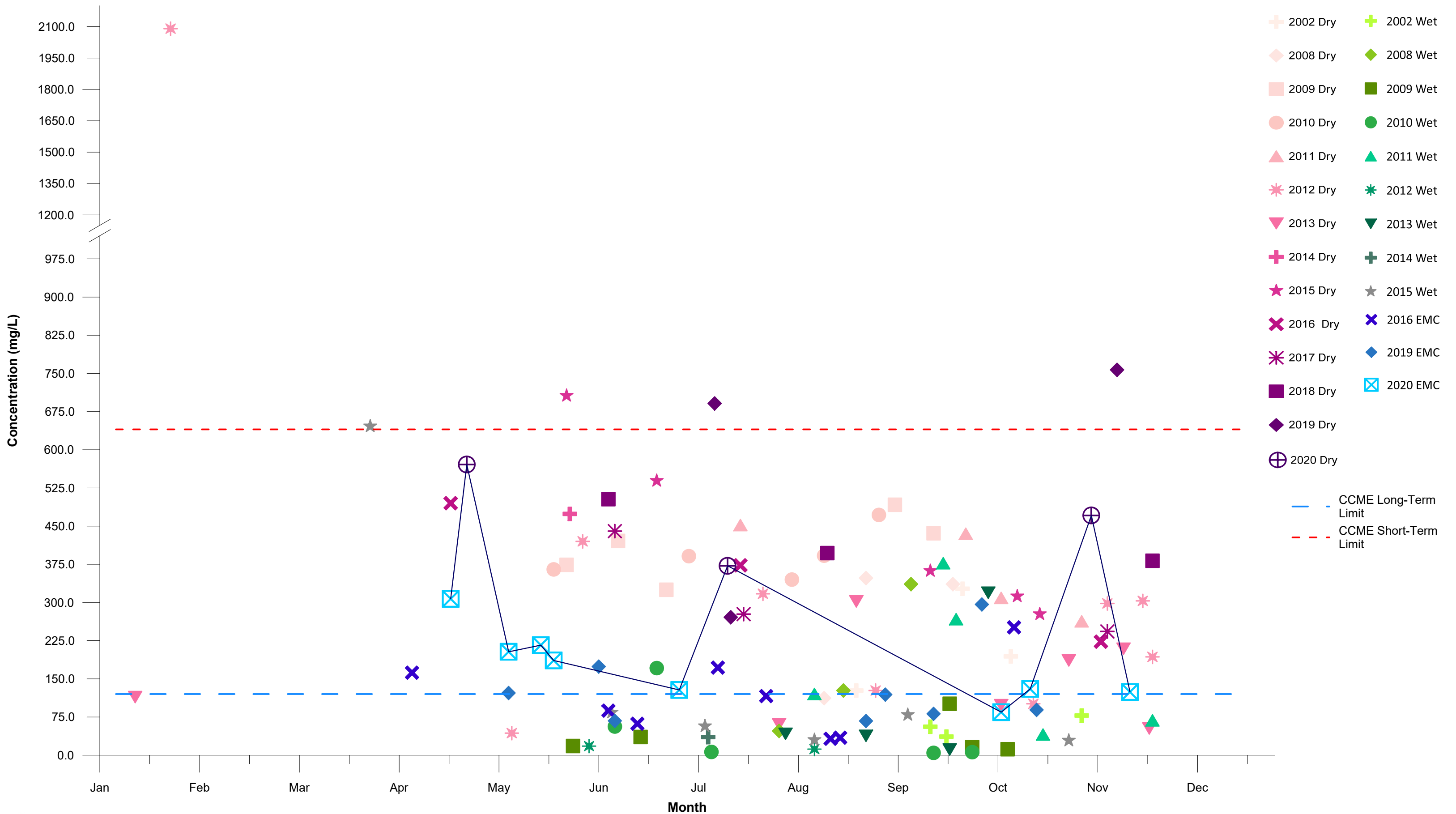
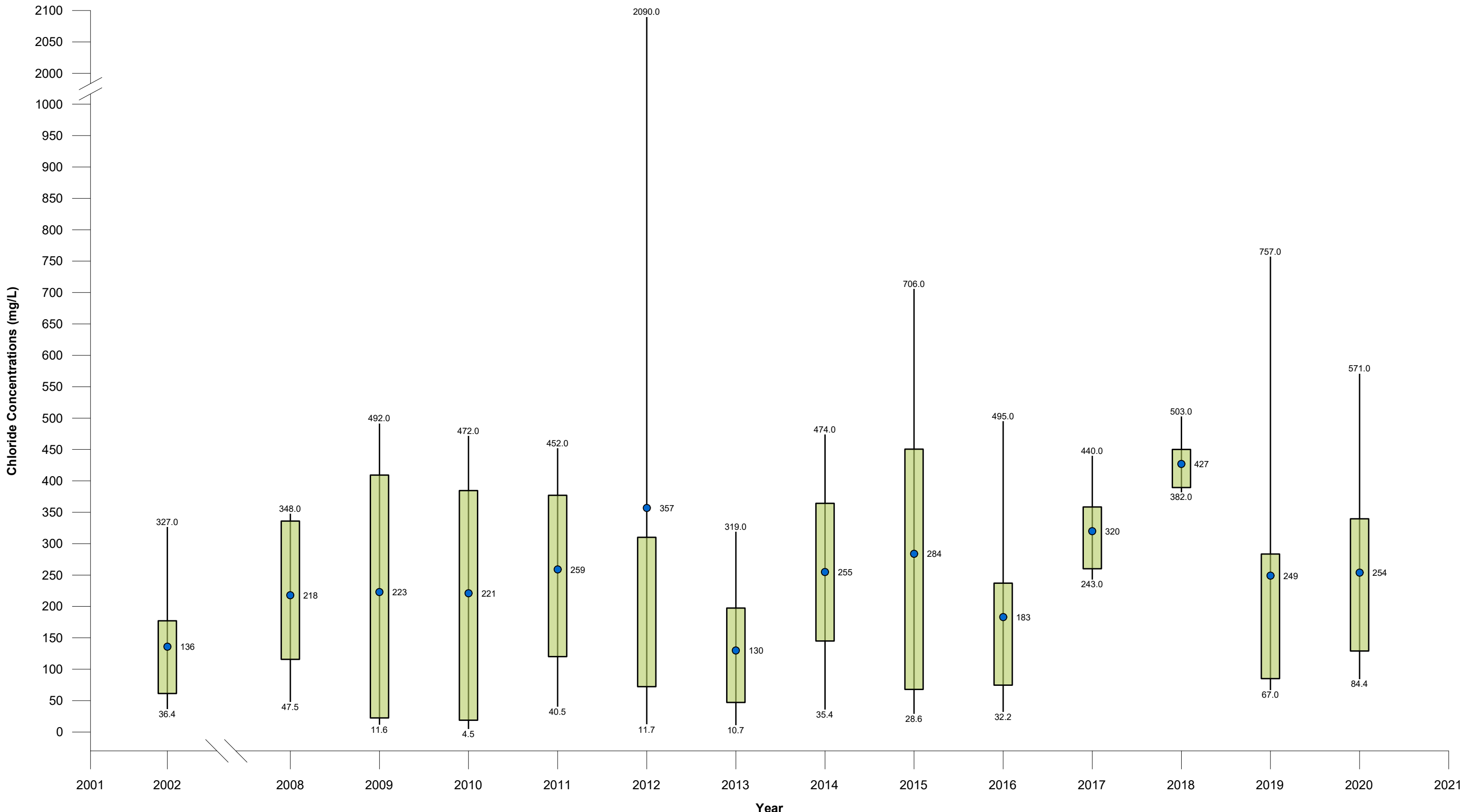


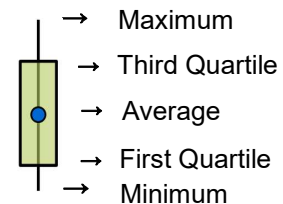
Figure 55
Sandrock Greenway (SR2) Chloride Historical Trend Concentrations
 Stormwater Management Monitoring Program 2020
 2020 Kitchener Surface Water Monitoring
 Kitchener, Ontario



Note:
 - The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.



Note:
-No sampling conducted in 2003-2007.

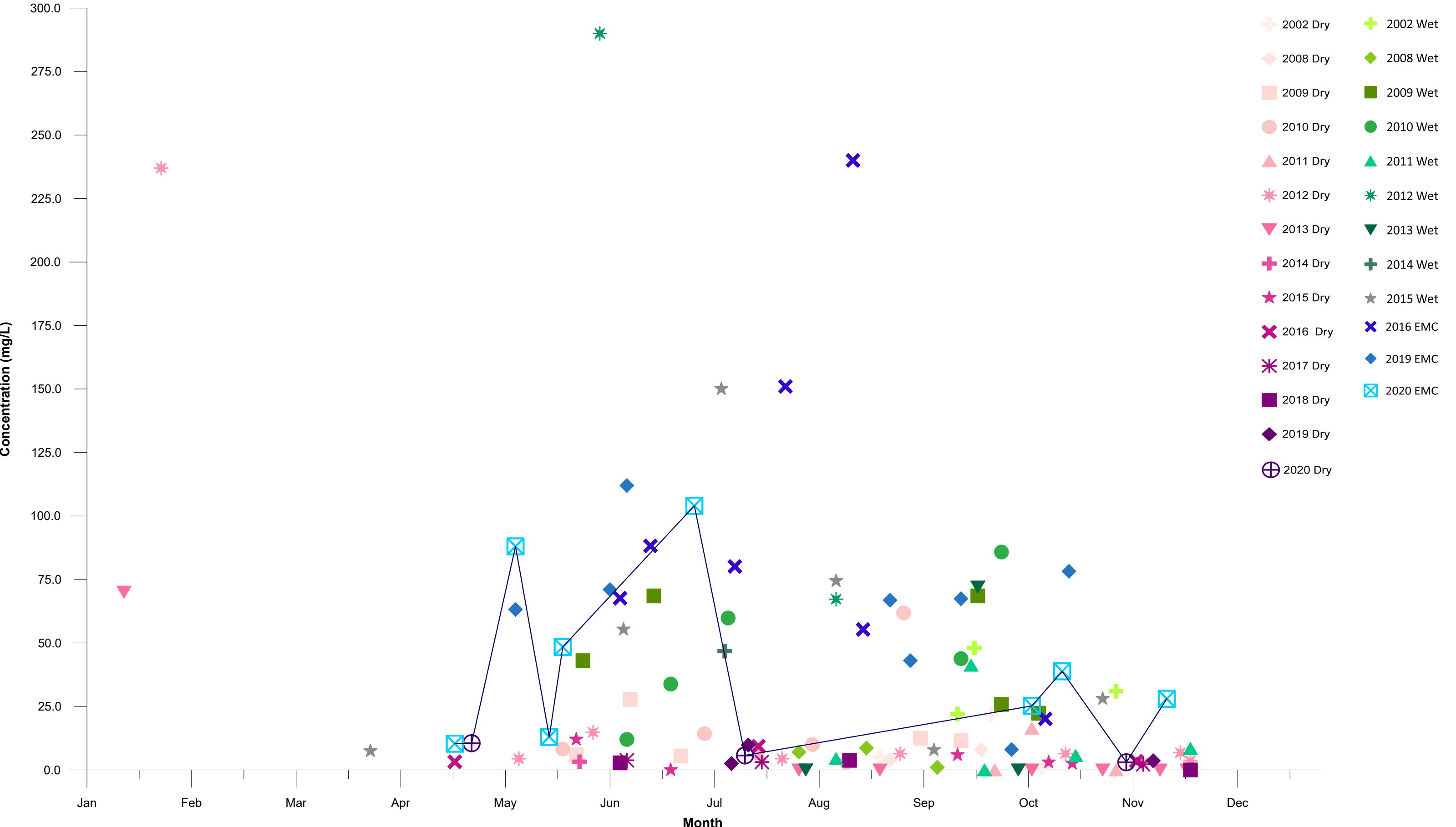


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11207597
February 2021

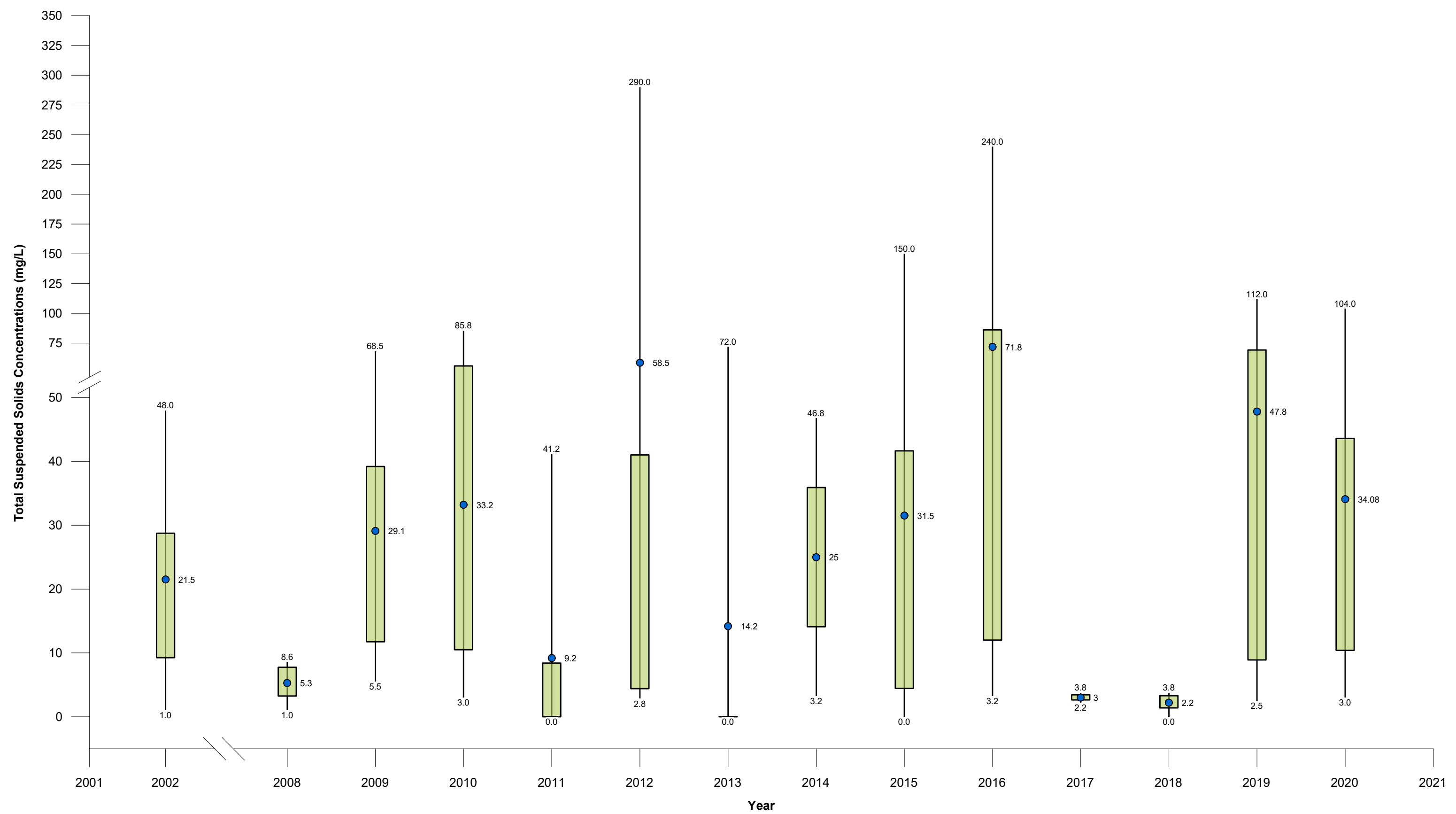
SR2 Historical Chloride Concentration Statistics

FIGURE 56

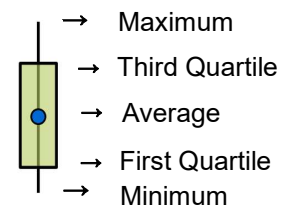


Note:
 - The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 57
Sandrock Greenway (SR2) TSS Historical Trend Concentrations
 Stormwater Management Monitoring Program 2020
 2020 Kitchener Surface Water Monitoring
 Kitchener, Ontario



Notes:
-In 2013, the first and third quartiles equalled zero, thus no box is displayed.
-No sampling conducted in 2003-2007.

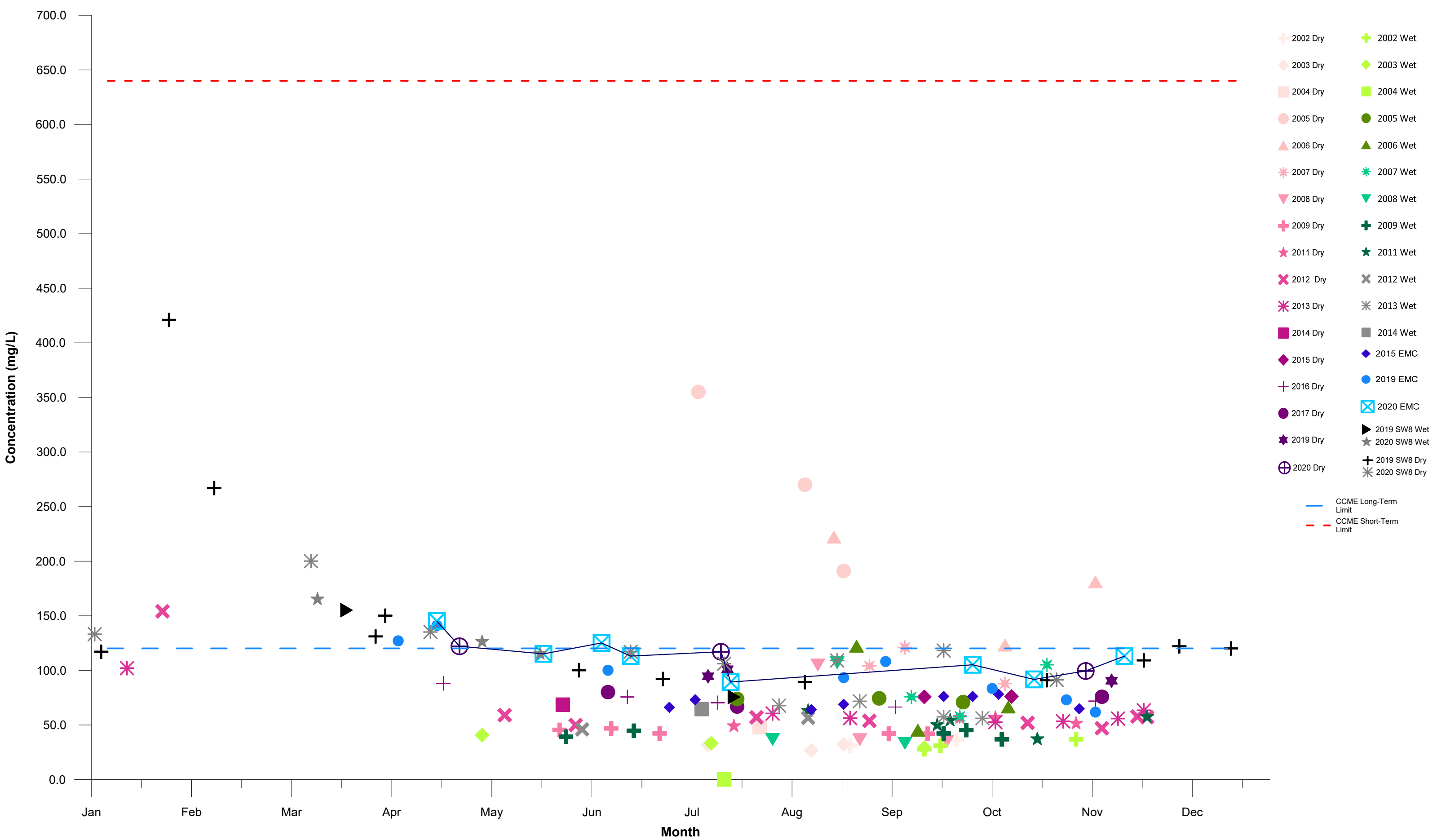


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SR2 Historical TSS Concentration Statistics

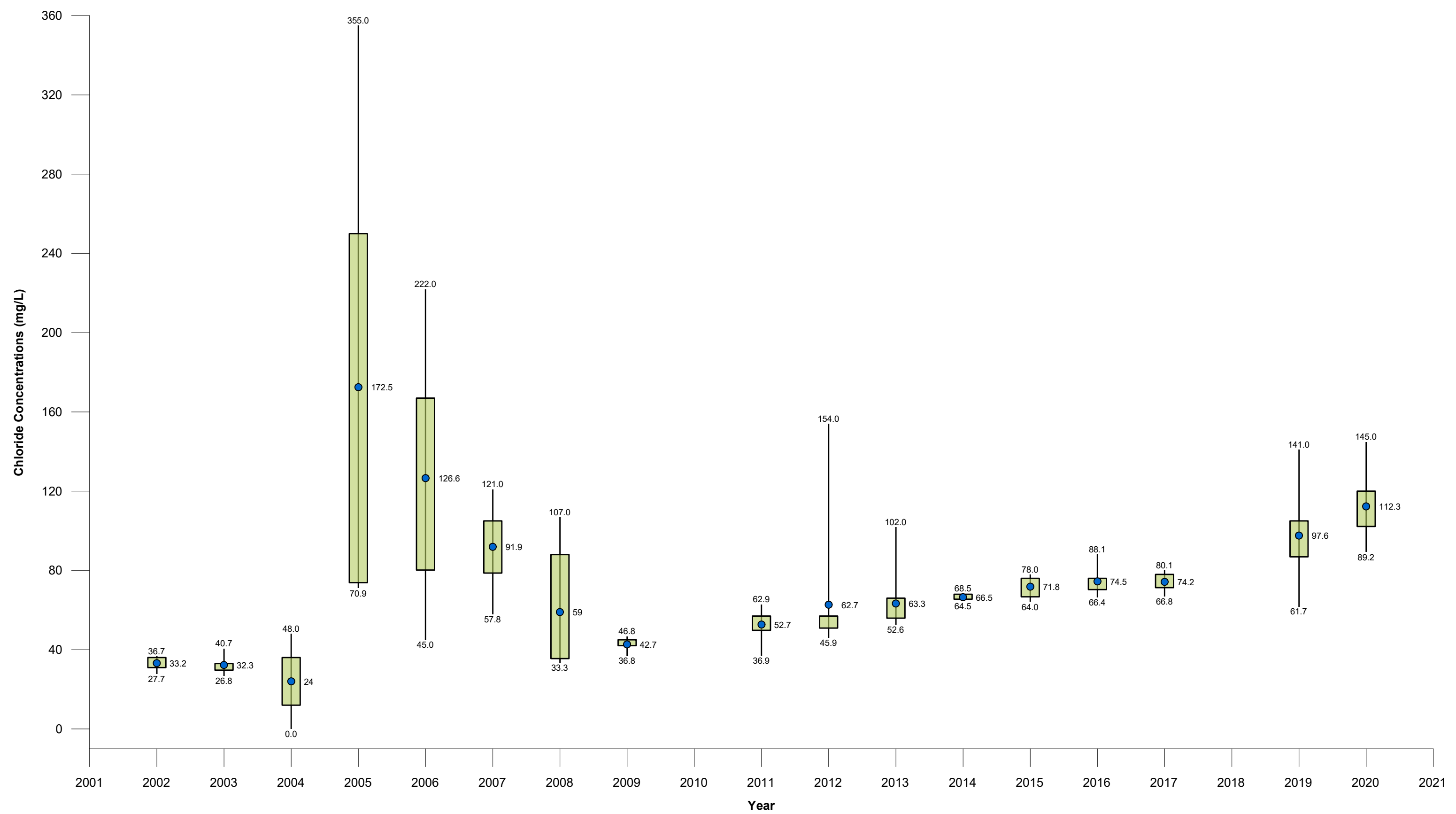
11207597
February 2021

FIGURE 58

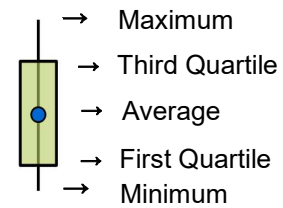


Note:
 - The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 59
Strasburg Creek (SB2) Chloride Historical Trend Concentrations
 Stormwater Management Monitoring Program 2020
 2020 Kitchener Surface Water Monitoring
 Kitchener, Ontario



Note:
-No sampling conducted in 2010 and 2018.

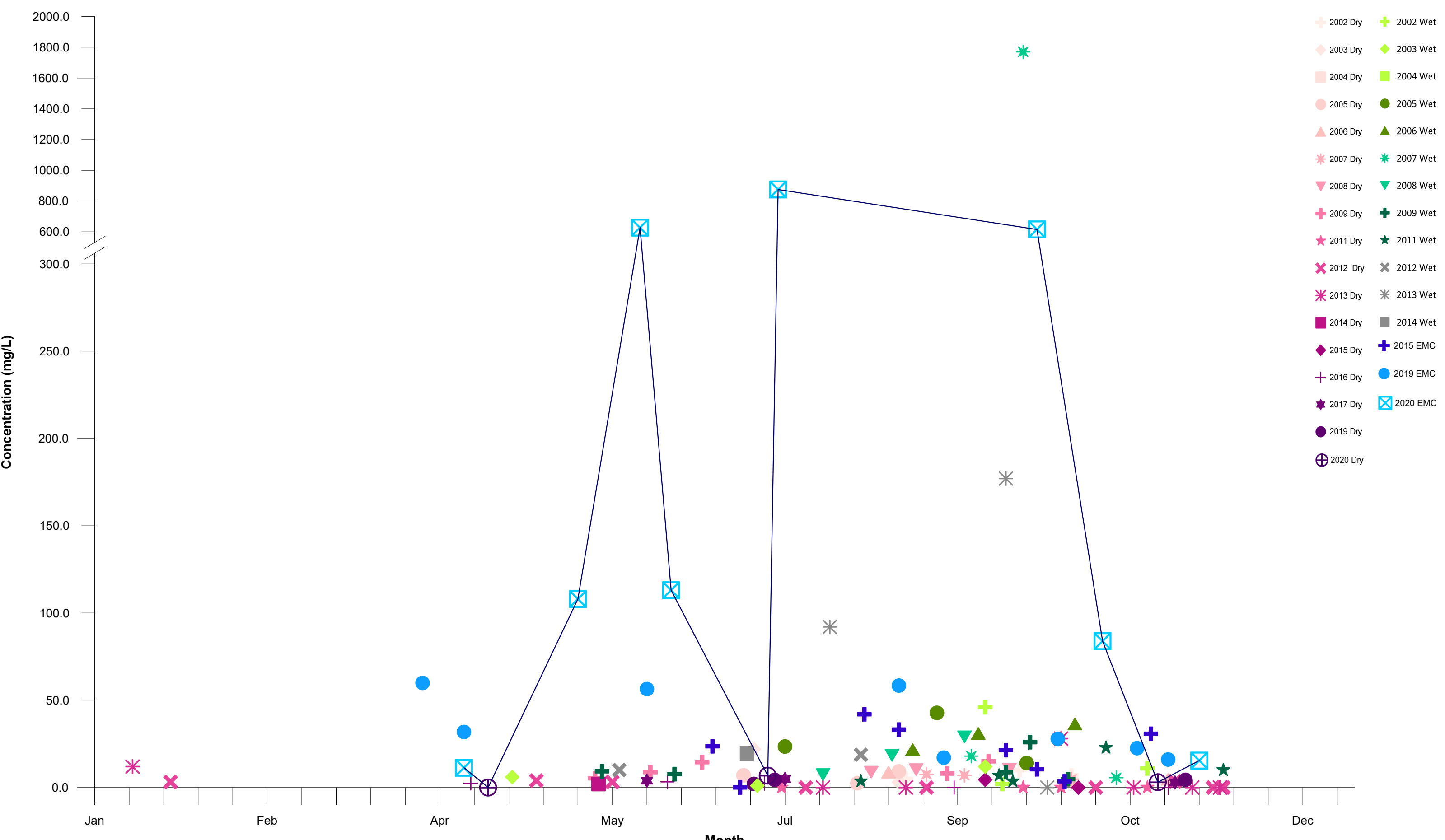


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KITCHENER 2020 SURFACE WATER MONITORING
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SB2 Historical Chloride Concentration Statistics

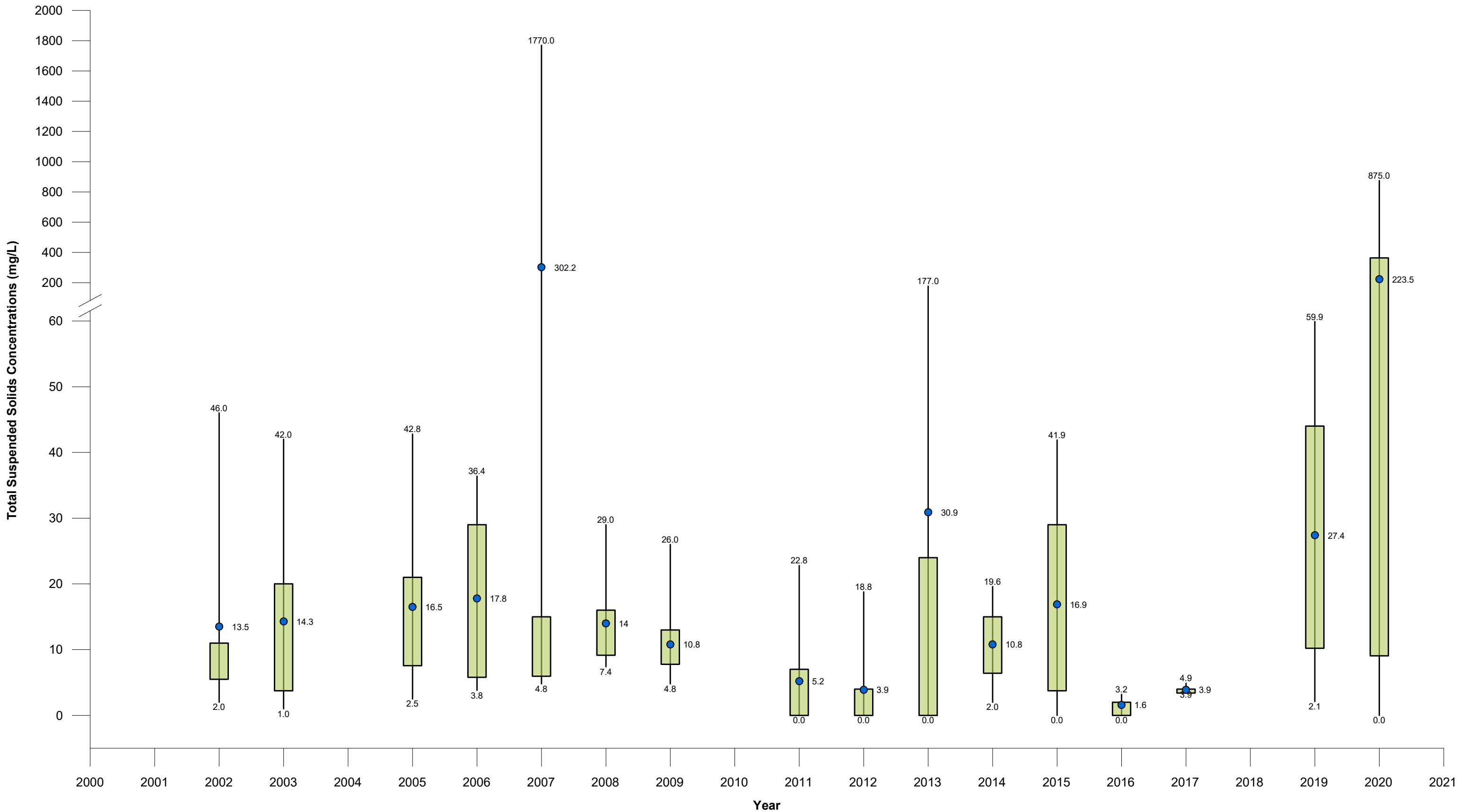
11207597
February 2021

FIGURE 60

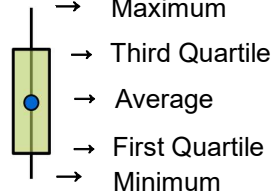


Note:
- The line that is connecting the discrete sampling results do not represent the full seasonal trend. The line is used as a visual aid.

Figure 61
Strasburg Creek (SB2) TSS Historical Trend Concentrations
Stormwater Management Monitoring Program 2020
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Note:
 -No TSS samples were collected in 2004, 2010, and 2018.

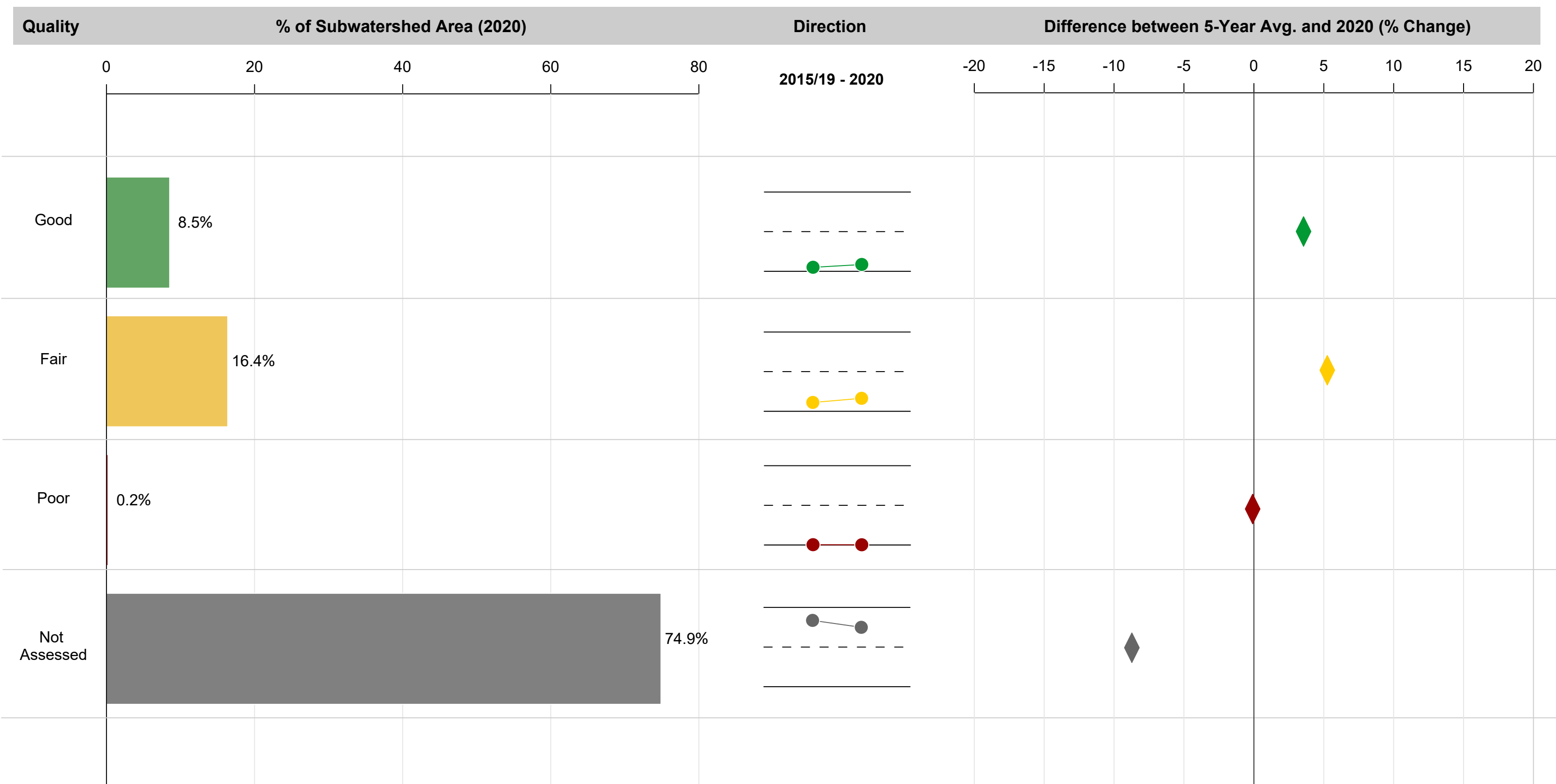


STORMWATER MANAGEMENT MONITORING PROGRAM 2020
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11207597
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SB2 Historical TSS Concentration Statistics

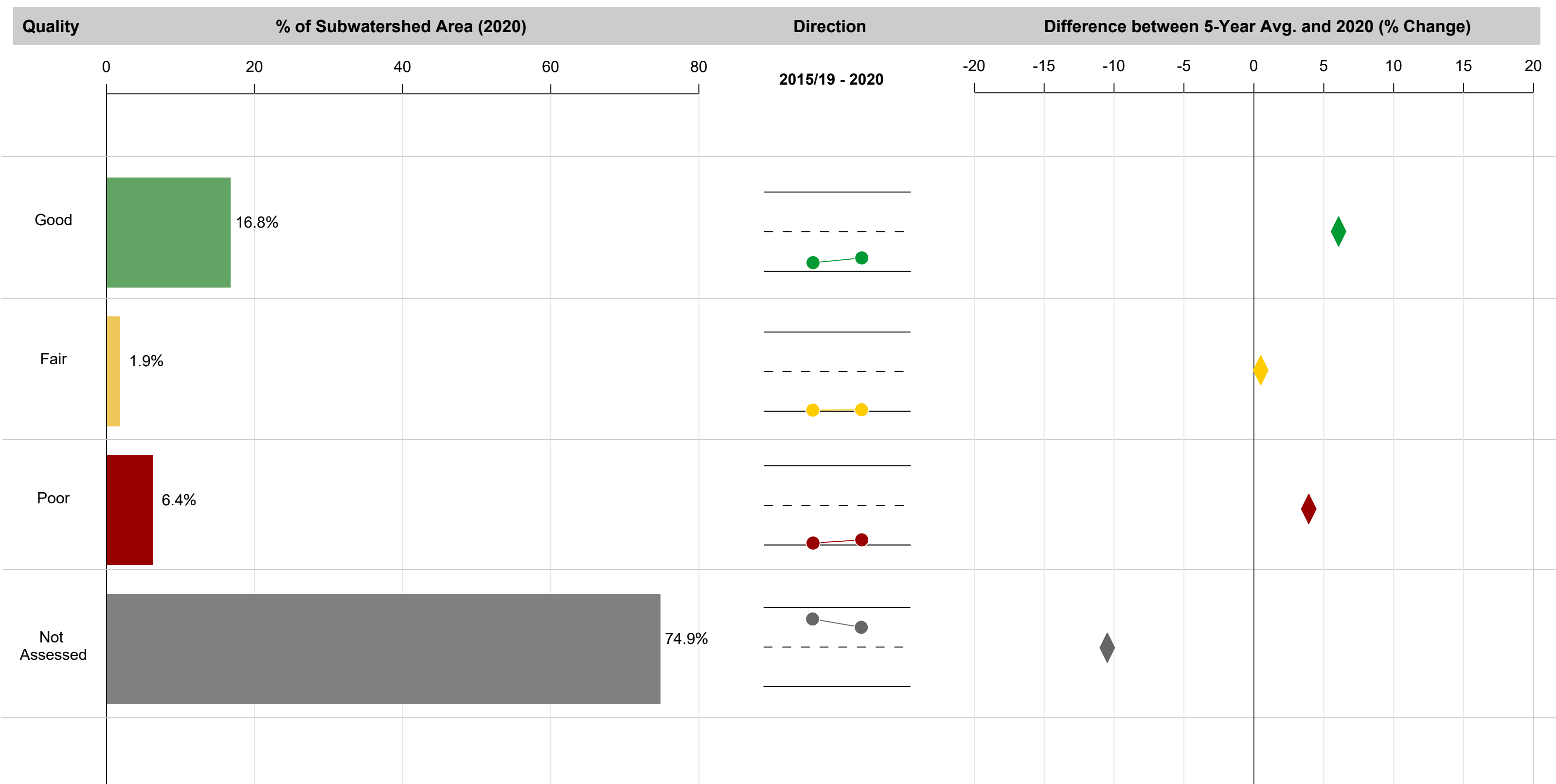
FIGURE 62



Notes:

- Good quality is based on chloride concentrations below the long-term CCME limit of 120 mg/L.
- Fair quality is based on chloride concentrations above the long-term CCME limit of 120 mg/L and below the short-term CCME limit of 640 mg/L.
- Poor quality is based on chloride concentrations above the short-term CCME limit of 640 mg/L.
- Not Assessed represents the remaining subwatershed areas that were not sampled.

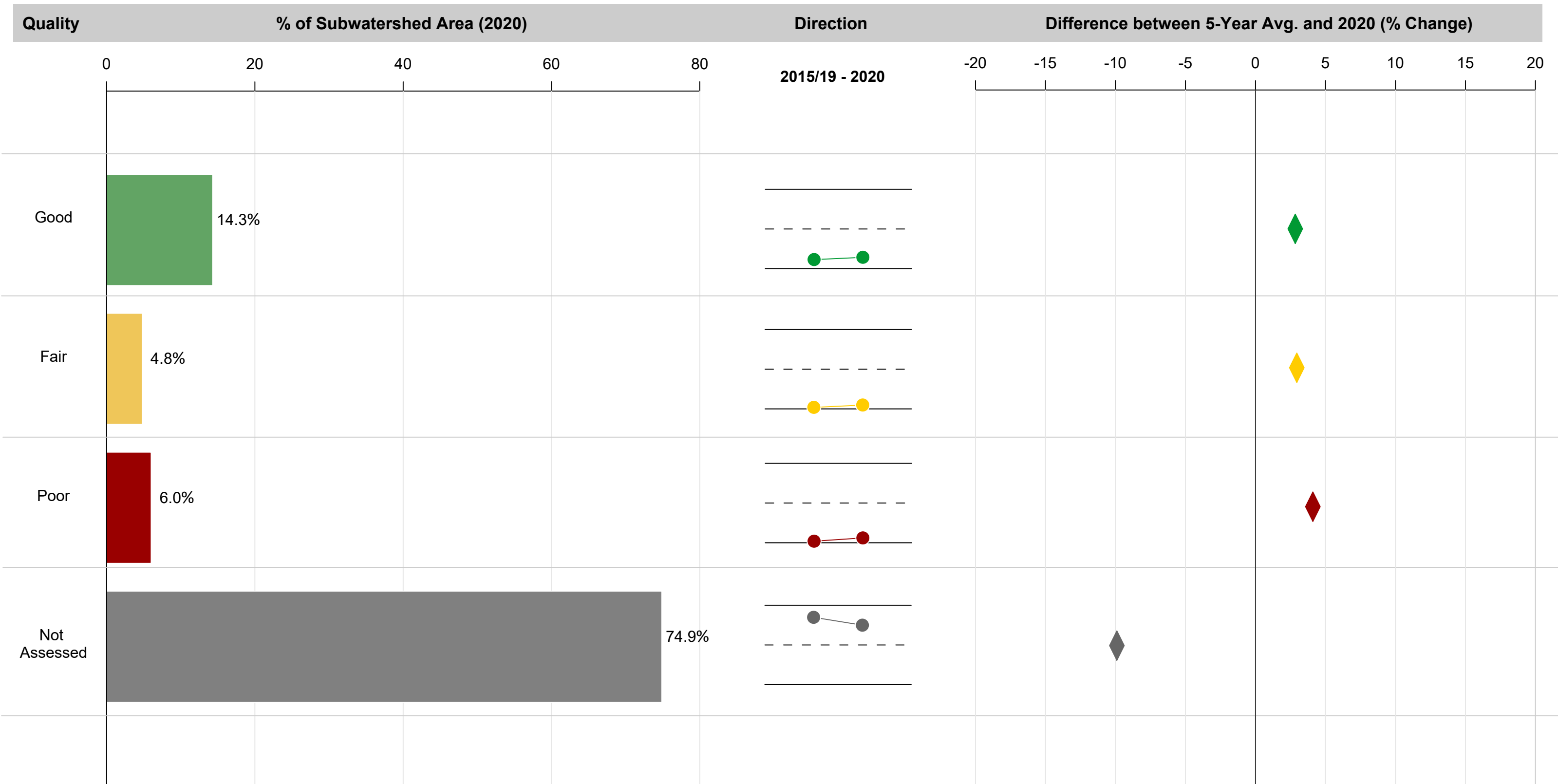
Figure 63
City-Wide Chloride Assessment
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario

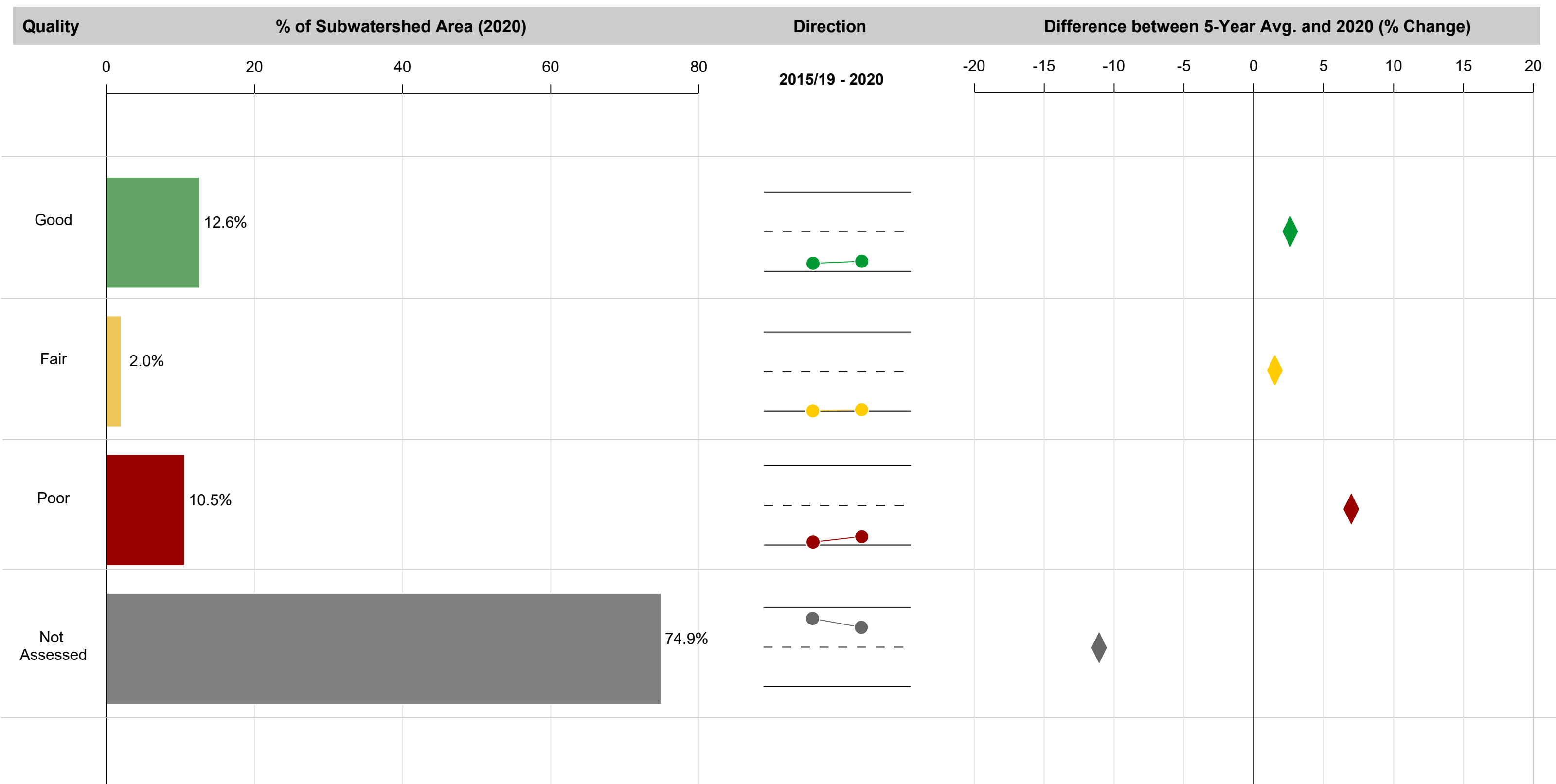


Notes:

- Good quality is based on concentrations below the CCME limit of 13 mg/L (Nitrate) and below the PWQO limit of 30 µg/L (Phosphorus).
- Fair quality for Nitrate is based on concentrations above the CCME limit of 13 mg/L and below 26 mg/L (double of the CCME limit).
- Fair quality for Phosphorus is based on concentrations above the PWQO limit of 30 µg/L and below 76 µg/L (<https://doi.org/10.1073/pnas.1903226116>).
- Poor quality is based on concentrations above 26 mg/L (Nitrate), and above 76 µg/L (Phosphorus).
- Not Assessed represents the remaining subwatershed areas that were not sampled.

Figure 64
City-Wide Nitrate and Phosphorus Assessment
Stormwater Management Monitoring Program 2020
Kitchener 2020 Surface Water Monitoring
Kitchener, Ontario





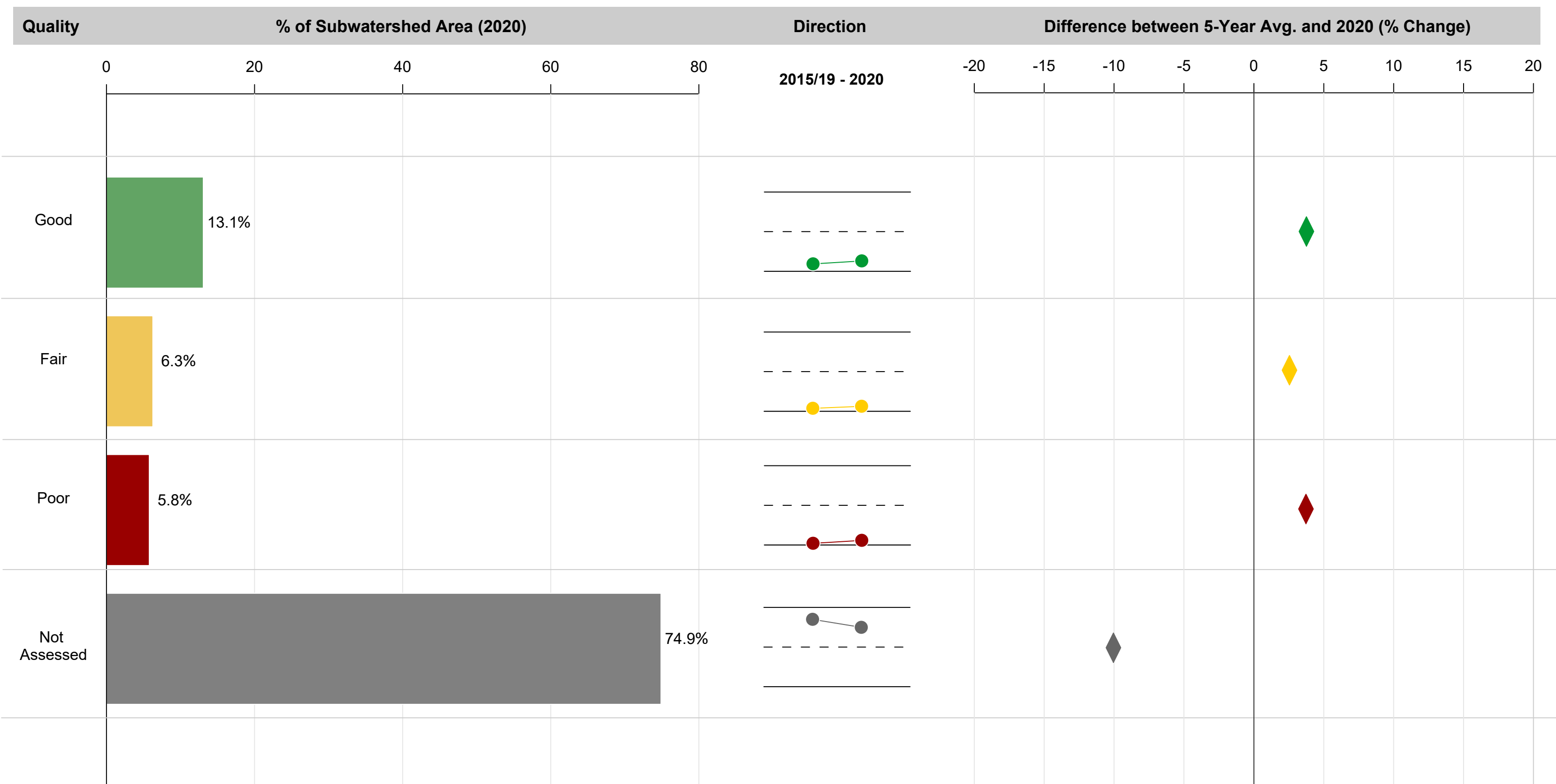


Table 1 ISCO Operation and Maintenance Events

Date	ISCO Location	Operations and Maintenance Summary
April 1, 2020	VS1	Solinst temperature/level logger and ISCO sampler installed.
	SR2	Solinst temperature/level logger and ISCO sampler installed.
April 3, 2020	SC1	ISCO sampler installed.
	SB2	ISCO sampler installed.
	SC9	Solinst temperature/level logger and ISCO sampler installed.
April 11, 2020	SB2	Strainer drilled into suction line; suction length = 7.0m. Solinst temperature/level logger installed.
	SC1	Sampler pacing changed to 400 m ³ ; that will provide 60 seconds at 1.0 m head. Solinst temperature/level logger installed.
	SR2	Some drift identified on sensor; readjusted to actual depth. Suction hose length = 6.0m.
	VS1	Fuse blown upon arrival; fuse replaced. Battery at 12.47 V; suction line = 8.1m; transducer (SN:2002612) installed. 15-minute intervals.
	SC9	Solinst temperature/level logger installed.
April 17, 2020	SC1	Successfully collected sample.
	SB2	Successfully collected sample.
April 19, 2020	VS1	Successfully collected sample.
	SR2	Successfully collected sample.
April 24, 2020	SC9	Solinst temperature/level logger and ISCO sampler removed from station due to vandalism.
April 28, 2020	SCH1	ISCO sampler installed. Strainer drilled into suction line; suction length = 7.0m.
May 6, 2020	SCH1	Transducer (SN:2074692) installed. 15-minute intervals.
May 7, 2020	SR2	Successfully collected sample. Battery dead on arrival, but full event captured. Some drift identified in logger - high 3-4 cm. Transducer (SN:1063527) downloaded on data grabber; replaced at 12:10pm.
May 10, 2020	SC1	Sample dumped; program completed before full sample collected.
	SCH1	Transducer (SN:2074692) installed. 15-minute intervals.
May 14, 2020	SCH1	Sampler pacing decreased.
	SC1	Blue band replaced.
	SB2	Blue band replaced.
	SR2	Pacing increased in anticipation of significant precipitation event in PM.
	VS1	Battery replaced.

Table 1 ISCO Operation and Maintenance Events

Date	ISCO Location	Operations and Maintenance Summary
May 17, 2020	SC1	Successfully collected sample. Pacing increased in anticipation of significant precipitation in PM (+75mm). Pump rollers cleaned of debris.
	VS1	Successfully collected sample. Blue band replaced. Pacing doubled in anticipation of significant precipitation event.
	SR2	Successfully collected sample. Pacing increased in anticipation of significant precipitation event (75mm) in PM. Blue band replaced.
	SCH1	Successfully collected sample.
	SB2	Sample dumped, insufficient peak during rain event on May 15, 2020. Pacing doubled in anticipation of significant precipitation event (+75mm).
	SC1	Successfully collected sample.
May 20, 2020	SB2	Successfully collected sample.
	SC1	Successfully collected sample.
	SCH1	Successfully collected sample.
May 21, 2020	SR2	Successfully collected sample.
	VS1	Successfully collected sample.
June 5, 2020	SC9	ISCO installed with new stainless-steel enclosure. Debris cleared at intake. Suction line length = 7.1m
	SCH1	Successfully collected sample. Pacing adjusted.
June 7, 2020	SC1	Sample dumped; full event not captured. Pacing increased to 1200.
	SC9	Successfully collected sample.
	SCH1	Successfully collected sample.
	SB2	Successfully collected sample. Pacing increased to 100 to get more aliquots.
	VS1	Successfully collected sample.
June 16, 2020	SC9	Fixed sampler positioning. Sampler tipped over in enclosure due to high water level in channel which flooded the enclosure.
	SB2	Successfully collected sample.
June 23, 2020	SR2	Sample dumped. Insufficient sample. Transducer (SN:1063527) downloaded on laptop. Transducer not replaced due to quickly increasing water level.
	SC9	Pump assembly malfunction, new parts ordered.
	VS1	Re-started program.
June 29, 2020	SR2	Successfully collected sample. Transducer replaced.
	SC1	Sample dumped. Insufficient sample. Transducer (SN:2002608) downloaded on laptop.
	VS1	Sample dumped. Insufficient sample. Transducer (SN:2002612) downloaded on laptop.
June 30, 2020	SR2	Sample dumped. Insufficient sample. Sampler reset.
	SC9	Repaired pump assembly malfunction.

Table 1 ISCO Operation and Maintenance Events

Date	ISCO Location	Operations and Maintenance Summary
July 15, 2020	SR2	Fixed sampler positioning. Sampler tipped over in enclosure due to high water level in channel which flooded the enclosure. Evidence of high flow on banks.
	SC1	Successfully collected sample.
	SC9	Successfully collected sample. Debris cleared at intake.
July 17, 2020	SB2	Successfully collected sample.
	SCH1	Successfully collected sample. Second transducer installed (installed on US side of weir)
July 28, 2020	SC9	Successfully collected sample. Debris cleared at intake. Transducer (SN:1063820) downloaded using data grabber. Pacing slightly reduced.
	VS1	Successfully collected sample. Transducer (SN:2002612) downloaded on laptop.
August 7, 2020	SB2	Successfully collected sample.
	SC9	Sample dumped. Insufficient sample. Battery dead upon arrival.
September 9, 2020	SC1	Successfully collected sample.
	SC9	Successfully collected sample.
	SCH1	Sample dumped. Insufficient sample.
September 28, 2020	SC9	Debris cleared at intake. Sensor cleaned. Tested pump.
September 30, 2020	SB2	Successfully collected sample. Intake cleared of sand.
	SC1	Successfully collected sample.
	SC9	Successfully collected sample. Battery replaced.
	SCH1	Successfully collected sample.
October 1, 2020	VS1	Sample dumped. Insufficient sample.
October 7, 2020	SR2	Successfully collected sample.
	SC1	Successfully collected sample.
	VS1	Successfully collected sample.
	SCH1	Sample dumped. Insufficient sample.
October 8, 2020	SC9	Successfully collected sample. Blue band replaced. Debris cleared from intake.
December 8, 2020	SC9	Removed ISCO sampler and Solinst temperature/level logger for winter season
	VS1	
	SC1	
	SR2	
	SB2	
	SCH1	

Table 2

2020 Benthic Community Sampling Results
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario

Index	Range of Expected	Lower Schneider Creek	Upper Schneider Creek	Strasburg Creek	North Strasburg Creek	School Creek	Voisin Creek	Sandrock Creek
	Values ¹	SC1	SC9	SB2	SB13a	SCH1	VS1	SR2
Abundance²	>300	325	321	334	370	335	357	304
Taxa Richness	20 - 40	30	29	41	24	25	10	32
% Dominant³	<50	18	43	16	46	27	73	26
# of EPT Families⁴	>10	5	3	6	3	1	1	2
% Oligochaeta	-	5	1	1	4	1	11	5
% Diptera	-	15	40	48	44	49	6	62
% Chironomidae	10 to 30	13	36	41	8	49	6	61
% EPT	-	55	12	34	2	1	0	14
% Predators	-	12	21	11	12	19	2	32
% Collector-Filterer	-	35	17	32	35	27	0	3
% Collector-Gatherer	-	47	55	44	52	53	97	52
% Scraper	-	5	2	6	1	0	0	12
% Shredder	20 - 40	2	5	6	0	1	0	0
% Clinger	-	52	61	46	82	14	74	21
Shannon's Diversity Index⁵	3.0 to 5	2.63	2.22	3.12	1.57	2.21	0.96	2.47
Hilsenhoff's Biotic Index (HBI)⁵	0.0 - 3.5	5.90	7.11	5.44	6.72	8.52	8.21	7.16

Notes

¹Range of expected values for unimpaired gravel-bottom creeks in southern Ontario. Values taken from Table 10-1 of BioMAP (Griffiths, 1999) unless otherwise noted

²Restricted by subsampling until 100 organisms are reached in each replicate (riffle, pool, riffle), or whole sample is enumerated

³50% or greater of one species is an indication of impaired water quality (Griffiths, 1999)

⁴>10 indicates a Non-impacted system (Mackie, 2004)

⁵These values indicate the range considered "Unpolluted" or "Excellent" water quality

Table 3

Benthic Invertebrate Community Trends 2013-2020
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario

Index	Sandrock Greenway (SR2)									Strasburg Creek (SB2)								
	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020		
Total Number of Organisms	340	315	308	No Data	181	316	362	304	314	234	384	318	223	No Data	339	334		
Taxa Richness	16	31	25		19	28	25	32	36	23	41	36	26		33	41		
% Oligochaeta	77	0	2		28	28	2	5	6	7	0	0	0		0	1		
% Diptera	22	56	76		36	49	88	62	81	72	45	60	37		50	48		
% Chironomidae	22	53	72		18	48	87	61	80	71	41	56	25		47	41		
% EPT	0	27	5		1	4	1	14	8	0	25	29	49		39	34		
EPT Taxa	1	8	3		2	3	2	2	7	0	12	8	4		4	6		
% CF	0	21	13		17	7	6	3	6	12	19	21	36		27	32		
%CG	97	75	77		56	79	70	52	83	77	69	69	53		54	44		
%SC	0	7	7		1	1	0	12	6	1	14	4	6		6	6		
%SH	19	37	11		1	3	13	0	53	7	31	3	4		10	6		
%CL	19	44	24		17	9	4	21	64	15	33	37	43		32	46		
Hilsonhoff Biotic Index	6.3	6.4	7.2		7.4	7.8	7.4	7.2	6.4	8.1	6.8	5.6	4.8		5.0	5.4		
Shannon Diversity Index	0.9	2.6	2.6		2.3	2.6	2.5	2.5	2.6	2.5	2.6	2.5	2.4		2.7	3.1		
<u>Thermal Classifications:</u> SR2- Warmwater; SB2 - Coolwater																		

Table 4

2020 Fish Community Sampling Results
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario

Species Name	Abundance (ON)	Thermal Regime	Tolerance	MNRF Code	SC1 (Summer)	SCH1 (Summer)	SB2 (Summer)	VS1 (Summer)
Common Carp (<i>Cyprinus carpio</i>)	Common	Warmwater	Tolerant	186	-	-	-	-
White Sucker (<i>Catostomus commersonii</i>)	Common	Coolwater	Tolerant	163	-	32	7	-
Pumpkinseed (<i>Lepomis gibbosus</i>)	Common	Warmwater	Intermediate	313	2	-	17	-
Creek Chub (<i>Semotilus atromaculatus</i>)	Common	Coolwater	Tolerant	212	1	3	25	-
Fathead Minnow (<i>Pimephales promelas</i>)	Common	Warmwater	Tolerant	209	-	2	1	-
Longnose Dace (<i>Rhinichthys cataractae</i>)	Common	Coolwater	Intermediate	211	19	-	2	-
Western Blacknose Dace (<i>Rhinichthys obtusus</i>)	Common	Coolwater	Intermediate	210	4	-	16	-
Brook Stickleback (<i>Culaea inconstans</i>)	Common	Coolwater	Intermediate	281	-	83	9	-
Mottled Sculpin (<i>Cottus bairdii</i>)	Common	Coldwater	Intermediate	381	-	-	24	-
Bluntnose Minnow (<i>Pimephales notatus</i>)	Common	Warmwater	Intermediate	208	-	-	-	-
Brook Trout (<i>Salvelinus fontinalis</i>)	Common	Coldwater	Intolerant	80	-	-	1	-
Young of Year (<i>Rhinichthys sp.</i>)	Common	Coolwater	Intermediate	N/A	2	11	-	-
Common Shiner (<i>Luxilus cornutus</i>)	Common	Coolwater	Intermediate	198	-	-	-	-
Rock Bass (<i>Ambloplites rupestris</i>)	Common	Coolwater	Intermediate	311	-	-	-	-
NUMBER OF FISH COLLECTED:					28	131	102	0

Table 5

Historical Fish Community Results
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario

Scientific Name	Common Name	Abundance (ON)	Thermal Regime	Tolerance	MNR Code	2020							2019				2018					
						SC1	SCH1	SB2	VS1	SB13a	SC9	SR2	VS1	WD1	SB2	SR2	HS4	HS1	SR2	SB1	SB7	VS1
<i>Cyprinus carpio</i>	Common Carp	Common	Warmwater	Tolerant	186	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
<i>Catostomus commersonii</i>	White Sucker	Common	Coolwater	Tolerant	163	-	32	7	-	-	-	21	-	4	8	10	48	6	8	1	6	-
<i>Lepomis gibbosus</i>	Pumpkinseed	Common	Warmwater	Intermediate	313	2	-	17	-	5	13	117	-	-	120	30	47	46	34	-	1	-
<i>Semotilus atromaculatus</i>	Creek Chub	Common	Coolwater	Tolerant	212	1	3	25	-	34	32	48	-	-	12	10	32	13	33	2	4	-
<i>Pimephales promelas</i>	Fathead Minnow	Common	Warmwater	Tolerant	209	-	2	1	-	-	3	16	-	-	1	7	5	13	10	-	-	-
<i>Rhinichthys cataractae</i>	Longnose Dace	Common	Coolwater	Intermediate	211	19	-	2	-	-	-	-	-	-	3	-	-	-	-	10	-	-
<i>Rhinichthys obtusus</i>	Western Blacknose Dace	Common	Coolwater	Intermediate	210	4	-	16	-	-	36	-	-	21	26	-	2	6	-	6	8	-
<i>Culaea inconstans</i>	Brook Stickleback	Common	Coolwater	Intermediate	281	-	83	9	-	-	2	-	-	-	3	-	-	-	-	-	16	-
<i>Cottus bairdii</i>	Mottled Sculpin	Common	Coldwater	Intermediate	381	-	-	24	-	-	-	-	-	-	18	-	-	4	-	-	-	-
<i>Pimephales notatus</i>	Bluntnose Minnow	Common	Warmwater	Intermediate	208	-	-	-	-	-	13	-	-	-	16	1	9	-	-	1	-	-
<i>Salvelinus fontinalis</i>	Brook Trout	Common	Coldwater	Intolerant	80	-	-	1	-	-	-	-	-	-	7	-	-	-	-	-	-	-
<i>Carassius auratus</i>	Goldfish	Common	Warmwater	Tolerant	181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rhinichthys sp.</i>	Young of Year	Common	Coolwater	Intermediate	N/A	2	11	-	-	-	-	-	-	-	-	-	73	1	10	6	37	-
<i>Ameiurus nebulosus</i>	Brown Bullhead	Common	Warmwater	Intermediate	233	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Luxilus cornutus</i>	Common Shiner	Common	Coolwater	Intermediate	198	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
<i>Ambloplites rupestris</i>	Rock Bass	Common	Coolwater	Intermediate	311	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
<i>Etheostoma nigrum</i>	Johnny Darter	Common	Coolwater	Tolerant	341	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	Unidentified	Common	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lepomis macrochirus</i>	Bluegill	Common	Warmwater	Intermediate	314	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Umbra limi</i>	Central Mudminnow	Common	Coolwater	Tolerant	141	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lepomis gibbosus x macrochirus</i>	Pumpkinseed/Bluegill Hybrid	Common	Warmwater	Intermediate	702	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NUMBER OF FISH COLLECTED:						28	131	102	0	39	107	202	0	25	214	58	217	89	95	26	72	0
Species Richness:						5	5	9	0	2	9	4	0	2	10	5	8	7	5	6	6	0
% Tolerant Species:						3.57	28.24	32.35	0	87.18	33.64	42.08	0	16.00	9.81	46.55	39.6	36.0	53.7	15.4	13.9	0.0
%Intolerant Species:						0	0	0.98	0	0	0	0	0	0.00	3.27	0.00	0	0	0	0	0	0
Number of fish collected/100m ² :						8.42	198.39	46.25	0	36.51	20.74	157.31	0	8.07	94.86	33.81	75.66	21.13	54.15	12.97	149.07	0.00

Table 5

Historical Fish Community Results
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario

Scientific Name	Common Name	Abundance (ON)	Thermal Regime	Tolerance	MNR Code	2017				2016				2015							
						SC1	SC9	SB2	SR2	KD1	MG1	SB2	SB13a	HS1	IW1	KD1	MG1	SB2	SB13a	SM1	SR2
<i>Cyprinus carpio</i>	Common Carp	Common	Warmwater	Tolerant	186	-	-	-	-	-	-	-	6	5	-	-	-	-	-	-	-
<i>Catostomus commersonii</i>	White Sucker	Common	Coolwater	Tolerant	163	-	7	5	1	4	1	-	-	2	2	4	-	-	-	-	4
<i>Lepomis gibbosus</i>	Pumpkinseed	Common	Warmwater	Intermediate	313	-	1	2	3	-	-	-	-	7	-	1	-	-	-	-	4
<i>Semotilus atromaculatus</i>	Creek Chub	Common	Coolwater	Tolerant	212	-	13	2	5	4	12	1	8	2	10	6	4	2	7	-	41
<i>Pimephales promelas</i>	Fathead Minnow	Common	Warmwater	Tolerant	209	-	-	1	6	-	-	-	5	-	-	-	-	-	-	-	9
<i>Rhinichthys cataractae</i>	Longnose Dace	Common	Coolwater	Intermediate	211	10	11	1	-	2	-	1	-	-	-	47	-	5	-	-	-
<i>Rhinichthys obtusus</i>	Western Blacknose Dace	Common	Coolwater	Intermediate	210	-	23	13	-	2	4	15	-	-	33	-	7	45	-	-	-
<i>Culaea inconstans</i>	Brook Stickleback	Common	Coolwater	Intermediate	281	-	-	-	-	-	11	1	-	-	4	-	37	15	-	-	-
<i>Cottus bairdii</i>	Mottled Sculpin	Common	Coldwater	Intermediate	381	-	-	28	-	-	-	144	-	-	-	-	-	26	-	-	-
<i>Pimephales notatus</i>	Bluntnose Minnow	Common	Warmwater	Intermediate	208	1	1	-	-	-	-	-	5	11	-	-	-	-	25	-	-
<i>Salvelinus fontinalis</i>	Brook Trout	Common	Coldwater	Intolerant	80	-	-	4	-	-	-	1	-	-	-	-	-	2	-	-	-
<i>Carassius auratus</i>	Goldfish	Common	Warmwater	Tolerant	181	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rhinichthys sp.</i>	Young of Year	Common	Coolwater	Intermediate	N/A	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ameiurus nebulosus</i>	Brown Bullhead	Common	Warmwater	Intermediate	233	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-
<i>Luxilus cornutus</i>	Common Shiner	Common	Coolwater	Intermediate	198	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ambloplites rupestris</i>	Rock Bass	Common	Coolwater	Intermediate	311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Etheostoma nigrum</i>	Johnny Darter	Common	Coolwater	Tolerant	341	-	-	-	-	-	-	-	-	-	-	25	-	-	-	-	-
-	Unidentified	Common	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lepomis macrochirus</i>	Bluegill	Common	Warmwater	Intermediate	314	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Umbra limi</i>	Central Mudminnow	Common	Coolwater	Tolerant	141	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<i>Lepomis gibbosus x macrochirus</i>	Pumpkinseed/Bluegill Hybrid	Common	Warmwater	Intermediate	702	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
NUMBER OF FISH COLLECTED:						14	71	56	15	12	28	163	24	36	49	84	48	95	32	0	63
Species Richness:						2	7	8	4	4	4	6	4	6	4	6	3	6	2	0	6
% Tolerant Species:						0.0	49.3	14.3	80.0	66.7	46.4	0.6	79.2	25.0	24.5	42.9	8.3	2.1	21.9	0.0	85.7
%Intolerant Species:						0	0	7.1	0	0	0	0.613	0	0	0	0	0	2.1	0	0	0
Number of fish collected/100m ² :						2.48	18.50	26.92	7.62	7.24	16.53	97.96	30.46	18	41	103	24	58	40	0	30

Table 5

Historical Fish Community Results
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario

Scientific Name	Common Name	Abundance (ON)	Thermal Regime	Tolerance	MNR Code	2014							
						BZ1	HV1	KD1	MG1	SB2	SB13a	SM1	SR2
<i>Cyprinus carpio</i>	Common Carp	Common	Warmwater	Tolerant	186	-	-	-	-	-	-	-	-
<i>Catostomus commersonii</i>	White Sucker	Common	Coolwater	Tolerant	163	-	-	21	1	-	-	-	-
<i>Lepomis gibbosus</i>	Pumpkinseed	Common	Warmwater	Intermediate	313	-	1	-	-	1	-	-	21
<i>Semotilus atromaculatus</i>	Creek Chub	Common	Coolwater	Tolerant	212	13	1	19	-	-	12	-	-
<i>Pimephales promelas</i>	Fathead Minnow	Common	Warmwater	Tolerant	209	-	-	-	-	-	-	-	3
<i>Rhinichthys cataractae</i>	Longnose Dace	Common	Coolwater	Intermediate	211	-	-	1	2	11	-	-	-
<i>Rhinichthys obtusus</i>	Western Blacknose Dace	Common	Coolwater	Intermediate	210	7	-	-	10	-	2	-	-
<i>Culaea inconstans</i>	Brook Stickleback	Common	Coolwater	Intermediate	281	-	-	-	15	-	-	-	-
<i>Cottus bairdii</i>	Mottled Sculpin	Common	Coldwater	Intermediate	381	-	-	-	-	25	-	-	-
<i>Pimephales notatus</i>	Bluntnose Minnow	Common	Warmwater	Intermediate	208	-	-	-	-	-	-	-	-
<i>Salvelinus fontinalis</i>	Brook Trout	Common	Coldwater	Intolerant	80	-	-	-	-	2	-	-	-
<i>Carassius auratus</i>	Goldfish	Common	Warmwater	Tolerant	181	-	-	-	-	-	-	-	-
<i>Rhinichthys sp.</i>	Young of Year	Common	Coolwater	Intermediate	N/A	-	-	-	-	-	-	-	-
<i>Ameiurus nebulosus</i>	Brown Bullhead	Common	Warmwater	Intermediate	233	-	-	-	-	-	-	-	6
<i>Luxilus cornutus</i>	Common Shiner	Common	Coolwater	Intermediate	198	-	-	-	-	-	-	-	1
<i>Ambloplites rupestris</i>	Rock Bass	Common	Coolwater	Intermediate	311	-	-	-	-	-	-	-	-
<i>Etheostoma nigrum</i>	Johnny Darter	Common	Coolwater	Tolerant	341	1	-	9	-	-	-	-	-
-	Unidentified	Common	-	-	-	2	-	-	-	-	-	-	1
<i>Lepomis macrochirus</i>	Bluegill	Common	Warmwater	Intermediate	314	-	-	-	-	-	-	-	-
<i>Umbra limi</i>	Central Mudminnow	Common	Coolwater	Tolerant	141	-	-	-	-	-	-	-	-
<i>Lepomis gibbosus x macrochirus</i>	Pumpkinseed/Bluegill Hybrid	Common	Warmwater	Intermediate	702	-	-	-	-	-	-	-	-
NUMBER OF FISH COLLECTED:						23	2	50	28	39	14	0	32
Species Richness:						4	2	4	4	4	2	0	5
% Tolerant Species:						60.9	50.0	98.0	3.6	0.0	85.7	0.0	9.4
%Intolerant Species:						0	0	0	0	5.13	0	0	0
Number of fish collected/100m²:						19	3	42	20	33	14	0	20

Table 6

Fish Community Trends 2013 to 2020
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario

Index	SB2 (Coldwater)							SR2 (Warmwater)								
	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020
Number of Fish Collected	31	39	95	163	56	No Data	214	102	No Data	32	63	No Data	15	95	58	202
Species Richness	7	4	6	6	8		10	9		5	6		4	5	5	4
% Tolerant Species	9.68	0.00	2.10	0.61	14.30		9.81	32.35		9.38	85.71		80.00	53.68	46.55	42.08
% Intolerant Species	12.90	5.12	2.10	0.61	7.10		3.27	0.98		0.00	0.00		0.00	0.00	0.00	0.00
Number of Fish Collected/100m ²	14.16	33.00	58.00	97.96	26.92		94.86	46.25		20.00	30.00		7.62	54.15	33.81	157.31

Table 7

**Biological Indicator Comparison
City of Kitchener Stormwater Management Monitoring Program
Kitchener, Ontario**

Biological Indicators	Sandrock Greenway (SR2)			Strasburg Creek (SB2)		
	First 5-yr Study	Second 5-yr Study	2020 Results	First 5-yr Study	Second 5-yr Study	2020 Results
Fish Species Richness	4	2.8	4	7	6	9
Fish Indicator Species	Goldfish, Brook Stickleback	Goldfish, Pumpkinseed	Pumpkinseed, Creek Chub, White Sucker	Mottled Sculpin	Brook Trout, Mottled Sculpin	Brook Trout, Pumpkinseed, Mottled Sculpin, Blacknose Dace
HBI Value Range	ND	ND	7.2	6.2 to 7.3	6.6 to 7.3	5.4
Benthic HBI 5-Year Mean	8.38	7.40	-	7.0	6.7	-
Benthic HBI Rating System (7 categories)	Poor	Fairly Poor	Fairly Poor	Fairly Poor	Fairly Poor	Good

First 5-year Study (2002 to 2006)

Second 5-year Study (2007 to 2011)

ND - No data available



about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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