# 2019 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 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 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 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 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 is 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 2019 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 Event Mean Concentration (EMC) monitoring in order to assess pollutant mass loadings into receiving watercourses for four select monitoring stations was conducted in 2019.

The 2019 monitoring program also included the monitoring of stormwater management facility (SWMF) 6 located at Manchester Road and Rothsay Avenue 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 2019, thermal stability graphs were created for two stations based on the monitoring data collected by the GRCA. 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 2019, 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.

#### Temperature Monitoring

Stream temperature classification for the 2019 results have 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 2019 monitoring period. At these four stations (WD1, VS1, SB2 and SR2) two additional thermal categories have been included: warm-coolwater and cool-coldwater.

As a result, Westmount Drain (WD1) was classified as a cold-coolwater creek, Voisin Creek (VS1) as a cold-coolwater to coolwater (in 2018 classified as cool-warmwater) and Sandrock Greenway (SR2) as a coolwater creek based on the thermal stability graphs developed through continuous water temperature monitoring. North Strasburg Creek (SB2) was classified as a coldwater to cold-coolwater creek based on the 2019 thermal stability graph. Water temperature and thermal enrichment of the City's creek systems was identified as a key environmental issue in the 2016

ISWM-MP, and will continue to form a component of the City's annual SWM Monitoring Program into the future.

### *Flow Monitoring*

Discrete flow measurements and flow depths were recorded at the flow-proportionate automated sampling locations (WD1, VS1, SB2 and SR2) 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 the Westmount Drain (WD1), Voisin Creek (VS1) and Sandrock Greenway (SR2) sites indicate a short response time for observed peak flows in response to precipitation events while North Strasburg Creek (SB2) showed less "peakiness" in response to precipitation events.

During the 2019 monitoring season, additional discrete flow measurements were conducted at Lower Schneider Creek (SC1), Upper Schneider Creek (SC9) and School Creek (SCH1) to allow for the creation of rating curves in advance of the 2020 automated sampler installation.

## ***Water Quality Monitoring***

### *Blair Creek*

In 2019, grab samples were collected by GRCA at multiple stations along Blair Creek but for the purposes of the 2019 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 2019 located at Reichert Drive (Station 2414044) and New Dundee Road (Station 2414002), and 3 other sites.

Blair Creek did not have any Chloride or Nitrate exceedances of the CCME limits in 2019. The average concentration for Total Phosphorus exceeded the PWQO limit of 0.03 mg/L at Blair Creek at Reichert Drive (2414044) and Blair Creek at New Dundee Road (214002). Blair Creek at New Dundee Road (214002) continued to exceed the PWQO limit for Total Phosphorous with the annual minimum value exceeding the guideline concentration. Copper and Zinc both had exceedances for maximum concentrations at Blair Creek at New Dundee Road (214002). No exceedances for Lead were observed in 2019.

Historically, 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. Compared to historical data, the 2019 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. 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 two stations monitored are located at the headwaters of the Blair Creek system where land is predominantly agricultural and urban development is still low and ongoing.

## Table ES-1 Summary of 2019 SWM Water Quality Monitoring Results

| Station | 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** |
| Lower Schneider Creek (SC1) | 344 | 382 | 280 | 8.1 | 15.2 | 2.1 | 0.026 | 0.050 | 0.009 | 0.942 | 1.170 | 0.664 | 0.000 | 0.001 | 0.000 | 0.002 | 0.003 | 0.002 | 0.005 | 0.007 | 0.003 |
| Westmount Creek (WD1) | 586 | 1430 | 162 | 11.0 | 25.3 | 0.0 | 0.029 | 0.057 | 0.014 | 0.424 | 0.440 | 0.403 | 0.001 | 0.004 | 0.000 | 0.000 | 0.001 | 0.000 | 0.016 | 0.041 | 0.000 |
| Voisin Creek (VS1) | 451 | 651 | 200 | 7.7 | 14.5 | 3.6 | 0.082 | 0.168 | 0.026 | 0.629 | 0.860 | 0.376 | 0.001 | 0.003 | 0.000 | 0.005 | 0.011 | 0.000 | 0.010 | 0.024 | 0.000 |
| North Strasburg Creek (SB2) | 95 | 101 | 91 | 2.2 | 4.4 | 0.0 | 0.017 | 0.026 | 0.009 | 1.293 | 1.390 | 1.200 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sandrock Greenway (SR2) | 573 | 757 | 271 | 5.3 | 9.8 | 2.5 | 0.130 | 0.273 | 0.025 | 0.378 | 0.890 | 0.044 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.000 | 0.002 | 0.005 | 0.000 |
| Blair Creek at Reichert Dr. | 46 | 51 | 39 | 8.7 | 16.8 | 3.8 | 0.055 | 0.080 | 0.024 | 0.155 | 0.235 | 0.075 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.002 | 0.005 | 0.006 | 0.004 |
| Blair Creek at New Dundee Rd. | 47 | 62 | 21 | 51.3 | 136.0 | 4.4 | 0.268 | 0.628 | 0.039 | 0.076 | 0.180 | 0.021 | 0.002 | 0.004 | 0.000 | 0.003 | 0.009 | 0.001 | 0.011 | 0.026 | 0.004 |

***Notes:***

1. Chloride values for Blair Creek are dissolved Chloride
2. Red highlighted cells indicate the minimum concentration exceeds the CCME/PWQO guideline
3. Orange highlighted cells indicate the average concentration exceeds the CCME/PWQO guideline
4. Yellow cells indicate the maximum concentration exceeds the CCME/PWQO guideline

### *Core Stations*

Water quality samples were collected by grab sample methodology at the 2019 SWM Monitoring Program stations. Three dry samples were collected at core stations including: Westmount Drain (WD1), Lower Schneider Creek (SC1), Sandrock Greenway (SR2), Voisin Creek (VS1), and North Strasburg Creek (SB2). 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 Westmount Drain (WD1), Sandrock Greenway (SR2), Voisin Creek (VS1), and North Strasburg Creek (SB2), which included continuous stage and temperature measurements.

**Table ES-1** summarizes the water quality results of the 2019 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 North Strasburg Creek (SB2). The average concentration for Total Phosphorus exceeded the PWQO limit of 0.03 mg/L at Voisin Creek (VS1) and Sandrock Greenway (SR2).

As seen in previous years, Nitrate concentrations continued to experience no exceedances at any of the locations. Unlike 2018, Lead experienced no exceedances at any of the monitoring locations. Copper and Zinc both had exceedances for maximum concentrations at Voisin Creek (VS1) and the average Zinc concentration at Westmount Creek (WD1) exceeded the limit.

### *Water Quality Trends*

Water quality trends have been identified by comparing sites monitored in 2019 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 North 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. 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.

An analysis summary is presented below for each monitoring location during 2019:

**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 2014 with a value of 1050 mg/L. Dry-weather Chloride concentrations have generally remained consistent around the 300-400 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 2010 with a value of 850 mg/L. In 2019, Chloride dry-weather grab sample concentrations ranges from 280 mg/L to 382 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. 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 dry-weather grab sample concentrations ranged from 2.1 mg/L to 15.2 mg/L.

**Sandrock Greenway (SR2):** The minimum Chloride concentrations at Sandrock Greenway (SR2) were historically below the CCME long-term guideline of 120 mg/L; however, this limit has been exceeded in recent years (2018 and 2019). 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. This was one of two samples in the historical dataset for Sandrock Greenway (SR2) that was collected during the winter months. The 2019 dry-weather grab concentrations ranged from 271 mg/L to 757 mg/L, which are slightly elevated compared to the 2018 results. 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 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 mg/L. The EMC (wet-weather) data collected in 2019 ranged from 8 mg/L to 112 mg/L which is lower than what was observed during the previous EMC monitoring year in 2016.

**North Strasburg Creek (SB2):** The majority of Chloride concentrations during wet-weather events and EMC sampling at North Strasburg Creek (SB2) are below the CCME long-term guideline of 120 mg/L and no values exceeded the CCME short-term guideline of 640 mg/L. The maximum Chloride concentration was observed in 2005 with a value of 355 mg/L. The maximum Chloride value has continued to decrease in subsequent monitoring years. The 2019 dry-weather grab sample Chloride concentrations ranged from 90.5 mg/L to 101 mg/L, this is higher when compared to the dry-weather sampling results in 2017 (no samples collected in 2018). TSS concentrations generally 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 2013 with a value of 28 mg/L. Wet-weather measurements in 2007 resulted in the maximum TSS concentration of 1,770 mg/L. The 2019 dry-weather grab TSS concentrations ranged from 2.1 mg/L to 4.4 mg/L.

### *Biological Monitoring*

#### *Blair Creek*

The benthic invertebrate metrics for Blair Creek infer it to be an unimpaired system that has good water quality with slight pollution. The fish community within Blair Creek remained similar in 2019 to previous years and ultimately supports an intolerant and intermediately tolerant fish community. Six brook trout, a sensitive, coldwater species were identified during the 2019 monitoring. Overall, the 2019 results of the Blair Creek monitoring continue to indicate a healthy, relatively unimpaired system with a diverse community structure and composition.

#### *Benthic Invertebrate Monitoring*

Fish community surveys were conducted at four stations (SB2, SR2, VS1 and WD1). Benthic invertebrate sampling was conducted at the aforementioned stations, as well as SC1. The results of these surveys and sampling were compared between watercourses. Additionally, the monitoring results of North 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 2019 samples at all stations included a total of 67 taxa, which is a decrease from the total number collected in 2018, however this is most likely due to the reduced number of sampling stations (seven stations in 2018 vs. five stations in 2019). Three of these taxa were new to the monitoring program, one of which has moderate tolerance and two of which have moderately-high tolerance to organic pollution. Also worth noting is that eight individuals of a species with a tolerance value of zero, the lowest possible value for a taxon, were identified which indicates good water quality at North Strasburg Creek (SB2).

Two stations, Voisin Creek (VS1) and Westmount Drain (WD1) had taxa richness lower than the expected range for an unimpaired gravel-bottom creek even though abundance fell within the expected range. This is likely an indication of impaired water quality at these stations and is reflected in the dominance of certain tolerant species. The number of EPT families and percent shredders was low across all stations which may indicate a lack of detritus within the creeks for them to feed on.

The historical data for North Strasburg Creek (SB2) and Sandrock Greenway (SR2) were compared to the 2019 data. North Strasburg Creek (SB2) displayed an overall improvement in water quality since 2015 with metrics showing improvement or stability from the 2018 results. Overall the Sandrock Greenway (SR2) results indicate a continued trend of water quality improvement since 2013.

### *Fish Community Monitoring*

The 2019 fish community sampling revealed similar results as previous monitoring years. Strasburg Creek (SB2) scored the highest on total number of fish and consisted of a mix of intermediate, intolerant and tolerant species. Seven brook trout, a sensitive, coldwater species were identified during the 2019 monitoring. To date, this is the highest abundance of brook trout caught at North Strasburg Creek (SB2).

Sandrock Greenway (SR2) scored second highest on total number of fish caught, with a total catch of 58 fish. Similar to 2018, a total of five species were identified at this station. Once again, this watercourse consisted of tolerant and intermediately tolerant species (absent any intolerant species), with a mix of species that prefer coolwater and warmwater thermal regimes. Of all stations monitored, Sandrock Greenway (SR2) had the highest percentage of tolerant species (46.5%), indicating community lacking diversity and dominated almost solely by tolerant species. However, this percentage has decreased from 54% during the 2018 monitoring program.

Westmount Drain (WD1) is a new station introduced as part of the 2019 monitoring program. This watercourse was composed of intermediate and tolerant species that prefer coolwater environments. Westmount Drain (WD1) had a relatively low percentage of tolerant species (16%) and no intolerant species.

Voisin Creek (VS1) scored the lowest for all categories, as similar to during the 2018 monitoring, zero fish were caught at this station during 2019. Similar to 2018, the 2019 Voisin Creek results could have been influenced by the seasonally low water levels present during the summer when the field surveys were conducted.

Annual fish community trends were identified for North Strasburg Creek (SB2) and Sandrock Greenway (SR2). At SB2 the total number of fish captured and species richness have been increasing year to year, and the percentage of tolerant species have decrease. Overall, a positive trend is occurring at this monitoring station. At SR2, the 2019 fish community results compared closely to those of previous years, producing high percentages of tolerant species, a steady taxa richness of 5 species and identified zero intolerant species.

### *Recommendations for the 2020 Monitoring Program*

Building on the recommendations as described in the *Integrated SWM-MP – Implementation Plan* (Aquafor Beech, 2016), the results of the 2016-2018 SWM Monitoring Programs, as well as feedback from the Steering Committee members, the following recommendations have been developed for the 2020 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 2020 to determine if scheduled monitoring locations will be impacted.
2. Establish six (6) flow proportionate monitoring sites in 2020, as soon as weather conditions allow, at the locations below listed using City-owned ISCO autosamplers:
    a. 2020 SWM Monitoring Program: SCH1, SC1 (long-term), SC9 (long-term), VS1 (long-term), SB2 (long-term), SR2 (long-term)
    b. A minimum of wet-weather eight 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 three (3) flow monitoring sites (pre-EMC) in 2020 in anticipation of the installation of autosamplers in 2021 at the following locations:
    a. 2020 SWM Monitoring Program: Borden Creek (BD1), Middle Schneider (MS1), and Melitzer Creek (MZ1)
    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 to represent winter conditions when road salt application is in effect and Chloride concentrations are highest.
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.

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# 1. Introduction

This annual report includes a review of monitoring activities undertaken in 2019 as part of the city-wide stormwater management monitoring program for the City of Kitchener (City). Historical data collected from 2002 through 2018 as part of previous monitoring programs was built upon, continuing to collect comparable data from the program's core monitoring sites. The 2019 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 2019 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 2019 monitoring program, four stations underwent EMC monitoring.

The 2019 monitoring program also included the monitoring of stormwater management facility (SWMF) 6 located at Manchester Road and Rothsay Avenue as per Environmental Compliance Approval (ECA) number 3382-A8WQUM. This monitoring includes the collection of three wet-weather samples per year, two of which are to occur between May and September, and an inspection of the SWMF.

The current monitoring program was developed with considerations from the recommendations sections of previous SWM Monitoring Program Reports (GHD, 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 2019 monitoring was conducted in accordance with the City's Stormwater Management 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.

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- Degradation of surface water quality
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**Figure 1** shows the locations of the 2019 monitoring sites. Individual maps of each monitoring location and type of monitoring conducted can be found in **Figure 2** to **Figure 6**. A photo log of all of the 2019 monitoring stations is included in **Appendix B**.

# 3. 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 observe 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 dedicated websites. 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 2019 is provided in **Table 3-1** below. The meteorological data is summarized on **Figure 7** and **Figure 8** summarizing the total monthly precipitation and average monthly temperature, respectively.

Table 3-1 Meteorological Data

| Month | Minimum | Maximum | Total Monthly | Total Monthly | Total Monthly |
|---|---|---|---|---|---|
| January 2019 | -24.5 | 8.6 | 28.5 | 11.0 | 19.8 |
| February 2019 | -25.7 | 11.0 | 38.6 | 53.6 | 35.6 |
| March 2019 | -21.1 | 10.4 | 60.3 | 101.2 | 43.6 |
| April 2019 | -4.1 | 19.2 | 93.3 | 99.0 | 75.2 |
| May 2019 | 0.5 | 28.2 | 79.4 | 68.4 | 94.2 |
| June 2019 | 3.7 | 28.9 | 53.2 | 63.6 | 62.4 |
| July 2019 | 8.2 | 31.9 | 50.6 | 28.2 | 47.8 |
| August 2019 | 6.9 | 29.5 | 59.1 | 41.0 | 48.6 |
| September 2019 | 3.7 | 28.7 | 30.1 | 31.8 | 39.6 |
| October 2019 | -3.8 | 29.2 | 132.5 | 126.8 | 124.8 |
| November 2019 | -15.3 | 10.0 | 34.4 | 23.4 | 23.4 |
| December 2019 | -17.9 | 10.2 | 44.1 | 33.6 | 9.0 |
| **2019 Total:** | **N/A** | **N/A** | **704.1** | **681.6** | **624.0** |

***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 2019, January saw great variation in temperatures with multiple freeze-thaw cycles throughout the month and while this trend continued in February 2019, more dramatic temperature swings were observed. By spring, temperatures were less variable and slightly warmer than average in March and average in April. The remainder of the year was overall average with the exception of July, a few days in September, and the start to October which saw seasonally warmer than average temperatures. November was considerably colder than normal while the year ended with an average December.

For precipitation in 2019, January received a below average amount while February was average according to the City Hall Rain Gauge but below average as recorded at the KOF Rain Gauge. In March, below average precipitation was recorded at the KOF Rain Gauge while considerably above average precipitation was recorded at the City Hall Rain Gauge. This difference between the two locations could be attributed to localized activity; however an equipment issue could also be the source. April was average as recorded by the KOF Rain Gauge but above average at the City Hall Rain Gauge while May was above average at the KOF Rain Gauge and below average at the City Hall Rain Gauge. Less variation between the two locations was observed from June to the end of the year. The summer months (June, July, August, and September) were much drier than normal followed by a significantly wetter than average October. The year ended with a drier than average November and December. Notable precipitation events in 2019 (i.e., greater than 20 mm) occurred on the following days summarized in **Table 3-2**.

Table 3-2 Meteorological Data – Significant Precipitation Events

| Date | KOF (mm) | City Hall (mm) | Kitchener/Waterloo (mm) |
|---|---|---|---|
| March 30, 2019 | 22.4 | 36.4 | 33.6 |
| April 19, 2019 | 15.4 | 27 | 20.3 |
| April 26, 2019 | 16.8 | 24.6 | 21.4 |
| May 25, 2019 | 31 | 26 | 15.6 |
| July 17, 2019 | 23.4 | 16.8 | 37.7 |
| October 2, 2019 | 20.2 | 25.2 | 17.4 |
| October 27, 2019 | 20.6 | 11.4 | 11.5 |
| October 31, 2019 | 16.6 | 22.2 | 12.4 |

***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.

# 4. Creek Rehabilitation and Retrofit Projects

**Table 4-1** summarizes the retrofit and creek rehabilitation projects that the City undertook in 2019. Activities completed as part of these projects may have influenced the 2019 SWM Monitoring Program results.

Table 4-1 2019 Creek Rehabilitation and Retrofit Projects

| Project Name | Duration of Project |
|---|---|
| Idlewood Creek Rehabilitation | 2018-2029 |
| Victoria Park Lake (SWMF 144) Sediment Removal | 2019 |
| Sterling Avenue South Reconstruction | 2018 |
| Weber Street East Reconstruction | 2018 |
| King Street East Reconstruction | 2018-2019 |
| Adelaide Street Reconstruction | 2018-2019 |
| Fairmount Road Reconstruction | 2019 |
| Florence Avenue Reconstruction | 2019 |
| Guerin Avenue Reconstruction | 2019 |
| Vanier Avenue Reconstruction | 2019 |
| Walker Street Reconstruction | 2019 |
| Huber Street Reconstruction | 2019 |
| Rock Avenue Reconstruction | 2019 |
| Sandra Avenue Reconstruction | 2019 |
| Third Avenue Reconstruction | 2019 |
| Jansen Avenue Reconstruction | 2019 |
| Centreville Street Reconstruction | 2019 |
| Dunham Avenue Reconstruction | 2019 |
| Earl Street Reconstruction | 2019 |
| Franklin Street North Reconstruction | 2019 |
| Ahrens Street West Reconstruction | 2019 |
| Sheldon Avenue North Reconstruction | 2019 |

# 5. 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. SWM facilities are present and under construction within the rapidly urbanizing portions of the 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 subwatershed conducted as part of the annual monitoring program is completed by the Grand River Conservation Authority (GRCA). Locations monitored in 2019 included:

- Station 2414001 – Blair Creek Upstream Dickie Settlement Road
- Station 2414002 – Blair Creek Upstream Culvert at New Dundee Road

- Station 2414044 – Blair Creek Downstream Reichert Drive
- Station 2414047 – Blair Creek Upstream of Highway 401

## 5.1 Physical Monitoring

### 5.1.1 Temperature Monitoring

#### 5.1.1.1 Temperature Monitoring Methodology

Continuous water temperature data was provided by the GRCA for the two stations monitored as part of the 2019 SWM Monitoring Program. Temperature data was collected use 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.

#### 5.1.1.2 Temperature Monitoring Results

Blair Creek continuous temperature data is presented in **Figure 9** and **Figure 10**. At Reichert Drive (Station 2414044) the maximum water temperature recorded was 24.9°C on July 20, 2019. At New Dundee Road (Station 2414002) the maximum water temperature recorded was 23.6°C on July 20, 2019.

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 2019). Daily water temperatures provided by the GRCA between 16:00 and 18:00 were plotted, coinciding to the air temperature at 16:00. **Figure 11a** and **Figure 11b** show the thermal stability classification for both Blair Creek stations. Based on the 2019 monitoring data, both 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.

### 5.1.2 Flow Monitoring

#### 5.1.2.1 Flow Monitoring Methodology

In 2019, 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.

#### 5.1.2.2 Flow Monitoring Results

**Figure 12** displays the continuous streamflow data measured at New Dundee Road (Station 2414002).

## 5.2 Water Quality Monitoring

### 5.2.1 Water Quality Monitoring Methodologies

#### 5.2.1.1 Grab Sampling Methodology

In 2019, grab samples were collected by GRCA at multiple stations along Blair Creek but for the purposes of the 2019 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), Dissolved Chloride, and nitrite/nitrate. Discrete field parameters are also measured during each sampling event using an YSI 600XLM sonde.

#### 5.2.1.2 Event Mean Concentration Methodology

The GRCA operated ISCO automated samplers on Blair Creek as part of their 2019 monitoring season; the analytical results from two automated sampler locations were reported as part of the 2019 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, Total Suspended Solids (TSS), Dissolved Chloride, Nitrite/Nitrate, and Total Metals (Copper, Lead, and Zinc).

### 5.2.2 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 Dissolved 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.

#### 5.2.2.1 Dissolved Chloride

**Figure 13** and **Figure 14** display the concentrations for Dissolved Chloride grab samples and EMC samples at Blair Creek stations for 2019. The annual average (from sampling locations along Blair Creek) was 46.84 mg/L compared to the 2018 annual average of 42.03 mg/L. The average concentration for each sampling location (Reichert Drive – 45.52 mg/L, Dickie Settlement – 43.45 mg/L and New Dundee Road – 49.64 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 0.66 mg/L to 65.70 mg/L with the minimum observed at Dickie Settlement Road (2414001) and the maximum observed at New Dundee Road (2414002). Seasonally, Chloride concentrations during both wet and dry-weather sampling events generally appeared steady throughout the monitoring period. It should be noted that no grab samples were collected during the winter months when road de-icing activities may have occurred.

#### 5.2.2.2 Nitrate

**Figure 15** and **Figure 16** display the grab and EMC sample results for Nitrate at Blair Creek for 2019. Nitrate levels during the 2019 monitoring period ranged from 0.021 mg/L to 3.71 mg/L compared to “Non-Detect” (assigned a value of zero) to 2.64 mg/L in 2018. The annual average in 2019 was 0.957 mg/L compared to the annual average in 2018 of 0.331 mg/L. The annual average at Reichert Drive (Station 2414044) was 0.155 mg/L compared to 0.259 mg/L in 2018 and 0.254 mg/L at New Dundee Road (2414002) compared to 0.385 mg/L in 2018. In 2019, the annual average at Dickie Settlement Road (2414001) was 2.168 mg/L. All results were below the Nitrate guidelines set by the CCME (13 mg/L). Two samples resulted in a “Non-Detect” which were assigned a value of zero. No significant seasonal trends were identified for Nitrate during the 2019 monitoring.

#### 5.2.2.3 Phosphorus

***Total Phosphorus***

**Figure 17** and **Figure 18** display the concentrations for Total Phosphorus grab samples and EMC samples at Blair Creek during 2019. The majority of sampling results at New Dundee Road (2414002) (upstream location) were above the PWQO Total Phosphorus limit (0.03 mg/L) with the exception of three grab samples collected in the spring, and one collected in the fall. All EMC sample results were above the PWQO Total Phosphorus limit (0.03 mg/L). Only two of the six EMC samples collected at Reichert Drive (Station 2414044) were below the PWQO limit. At Dickie Settlement Road (2414001), three of the grab sample results exceeded the PWQO Total Phosphorus limit. 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 2019 is 0.068 mg/L compared to 0.048 mg/L in 2018. Total Phosphorus levels during 2019 ranged from 0.004 mg/L to 0.628 mg/L compared to 0.010 mg/L to 0.230 mg/L in 2018. 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** and **Figure 20** display the grab sample and EMC results for Dissolved Phosphorus at Blair Creek during 2019. Dissolved Phosphorus levels during 2019 ranged from 0.003 mg/L to 0.072 mg/L compared to 0.005 mg/L to 0.046 mg/L in 2018. The annual average for 2019 was 0.019 mg/L which is the same as the average observed in 2018. The annual average specific to New Dundee Road (2414002) was 0.032 mg/L, 0.011 mg/L at Dickie Settlement Road (Station 2414001) and 0.014 mg/L at Reichert Drive (Station 2414044). This is compared to 2018 annual averages of 0.022 mg/L at New Dundee Road (2414002) and 0.005 mg/L at Dickie Settlement Road (Station 2414001). Zero exceedances of the PWQO Total Phosphorus level (0.03 mg/L) were noted for Reichert Drive (Station 2414044) however, six exceedances of the PWQO Total Phosphorus level were noted for New Dundee Road (2414002) and one exceedance at Dickie Settlement Road (Station 2414001). Seasonally, the trends at Blair Creek reveal 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.

### 5.2.2.4 Total Metals

#### *Copper*

**Figure 21** and **Figure 22** display the EMC sample results for Copper at Blair Creek during 2019 (grab samples were not analyzed for Copper). Copper concentrations for the two monitoring locations at Blair Creek during 2019 ranged from “Non-Detect” to 8.7 µg/L in 2019 compared to “Non-Detect” to 10 µg/L in 2018. The 2019 annual average between both stations was 2.85 µg/L compared to the annual average in 2018 of 3.29 µg/L. The annual average specific to Reichert Drive (Station 2414044) was 2.57 µg/L which was higher than 2018 (1.30 µg/L). The annual average for the station near New Dundee Road (2414002) was 3.02 µg/L which is higher than last year’s average of 4.28 µg/L. One sampling event was observed to be above the PWQO objective of 5 µg/L at New Dundee Road (2414002); however, all samples collected at Reichert Drive (Station 2414044) were below the PWQO objective. Three samples resulted in a “Non-Detect” which was assigned a value of zero. The highest concentration of Copper was observed during the early October sampling event.

#### *Lead*

**Figure 23** and **Figure 24** display the EMC sample results for Lead at Blair Creek during 2019. Lead concentrations from both monitoring locations at Blair Creek ranged from “Non-Detect” to 4.02 µg/L, compared to from “Non-Detect” to 3.1 µg/L in 2018. The annual combined average in 2019 was 1.50 µg/L which was higher than last year’s average of 0.94 µg/L. The annual average specific to Reichert Drive (Station 2414044) was 0.12 µg/L, compared to 0.00 µg/L in 2018 due to all samples being identified as non-detects. The annual average for New Dundee Road (2414002) was 1.77 µg/L which is higher than last year’s average of 1.42 µg/L. No sample results were found to be above the PWQO of 5 µg/L. A total of six samples from both stations resulted in “Non-Detect”. The highest lead concentrations were observed during a period of high precipitation from early to mid-October. The only lead sample that returned a value greater than zero (Non-Detect) at Reichert Drive (Station 2414044) corresponds to a precipitation event exceeding 20 mm.

#### *Zinc*

**Figure 25** and **Figure 26** display the EMC sample results for Zinc at Blair Creek during 2019. Zinc concentrations from both monitoring locations along Blair Creek ranged from “Non-Detect” to 25.6 µg/L which is a slightly wider range compared to “Non-Detect” to 23.0 µg/ in 2018. The 2019 combined annual average was 7.63 µg/L, which is lower than the 2018 average of 9.23 µg/L. The annual average specific to Reichert Drive (Station 2414044) was 4.68 µg/L which is similar to that of 2018 (4.87 µg/L). The 2019 annual average at New Dundee Road (2414002) was 11.33 µg/L which is slightly lower than the 2018 average of 11.42 µg/L. One sample result at New Dundee Road (2414002) exceeded the PWQO objective of 20 µg/L. The highest concentration of Zinc is associated with the early October sampling event.

#### 5.2.2.5 Total Suspended Solids

**Figure 27** and **Figure 28** display the TSS Concentrations for grab samples and EMC samples at Blair Creek during 2019. 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 27** and **Figure 28** because no background level data was established as part of the 2019 SWM Monitoring Program. The average annual concentration for TSS was 12.2 mg/L compared to 12.0 mg/L in 2018. The TSS concentrations ranged from 0.50 mg/L to 136.00 mg/L, compared to 0 mg/L to 71 mg/L in 2018. Similar to what was observed in 2018, the 2019 minimum and maximum values were both observed at New Dundee Road (Station 2414002). As a general trend, TSS values tend to be highest during wet-weather sampling in summer and fall, which are likely influenced due to a combination of increased precipitation during this period and runoff of sediment from active construction sites.

## 5.3 Biological Monitoring

The following sections summarize the Blair Creek biological monitoring data collected by the GRCA in 2019. A full list of benthic invertebrate and fish monitoring results is available in **Appendix C**. The GRCA have many monitoring sites along Blair Creek, but for the purposes of this analysis the station located on Blair Creek upstream of Highway 401 (Station 2414047), has been identified as the representative monitoring site for the City-wide Stormwater Management Monitoring Program.

### 5.3.1 Benthic Invertebrate Monitoring

#### 5.3.1.1 Benthic Invertebrate Monitoring Methodology

In spring 2019, the GRCA conducted benthic invertebrate monitoring (May 22, 2019). All monitoring was conducted in accordance with the Ontario Benthos Biomonitoring Network (OBBN) protocol using the travelling-kick-and-sweep method. A total of three replicates were collected at the station, preserved in isopropyl alcohol and sent to Craig Logan in Cambridge, Ontario for identification and enumeration and QA/QC was completed by BIOTAX for re-picking and re-identification.

#### 5.3.1.2 Benthic Invertebrate Monitoring Results

Results for the 2019 benthic invertebrate monitoring conducted by GRCA were provided to GHD for inclusion in this report. The calculated benthic invertebrate metrics used to characterize the water quality in Blair Creek are presented in **Table 5-1.** All data sets (2014-2019) have been collected and provided by the GRCA.

Table 5-1 Benthic Invertebrate Metrics for Blair Creek (Station 2414047)

| Index | Range of Expected Values[1] | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| Total Number of Organisms[2] | >300 | 1419 | 40444 | 12378 | 6803 | 24580 | 12060 |
| Taxa Richness | 20-40 | 43 | 56 | 59 | 61 | 62 | 73 |
| % Oligochaeta | - | <1 | 4 | 4 | 8 | 5 | 12 |
| % Diptera | - | 42 | 53 | 39 | 51 | 54 | 48 |
| % Chironomidae | 10-30 | 2 | 46 | 34 | 48 | 49 | 43 |
| EPT Taxa[3] | >10 | 12 | 14 | 10 | 7 | 9 | 13 |
| % EPT | - | 35 | 29 | 42 | 16 | 26 | 18 |
| % Collector-Filterer | - | 2 | 9 | 2 | 4 | 5 | 7 |
| % Collector-Gatherer | - | 39 | 34 | 41 | 47 | 33 | 50 |
| % Scraper | - | 25 | 10 | 10 | 24 | 31 | 23 |
| % Shredder | 20-40 | 23 | 13 | 1 | 6 | 12 | 9 |
| % Clinger | - | 23 | 18 | 13 | 26 | 24 | 32 |
| Shannon-Weiner Diversity Index[4] | 3-5 | 2.5 | 3.3 | 3.4 | 3.5 | 3.4 | 3.3 |
| Hilsenhoff Biotic Index[4] | 0.0-3.5 | 3.03 | 4.30 | 3.43 | 4.45 | 4.61 | 5.08 |

**Notes**

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

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

[3] >10 indicates a Non-impacted system (Mackie, 2004)

[4] These values indicate the range considered “Unpolluted” or “Excellent” water quality, as per Hilsenhoff (1987)

Benthic invertebrate metrics have been relatively consistently between 2017 and 2019. Taxa richness falls above the range of expected values for unimpaired creeks; percent Oligochaeta has increased to 12 percent, which is the highest over the years, and percent Chironomidae consistently falls outside the expected range within unimpaired creeks of 10-30 percent (Griffiths, 1999). Percent EPT is slightly lower than 2018 but similar to 2017. The number of EPT taxa increased to values similar to values observed between 2014 and 2016. While the calculated percent EPT is still low for a healthy system, the 2019 number of EPT families is consistent with expected values for an un-impacted creek system, and overall indicates an increase in the diversity and abundance of these sensitive species.

The Shannon-Weiner Diversity Index for Blair Creek remains greater than 3, at 3.3 in 2019, a value consistent with an unimpaired system and the results since 2015. The HBI value in slightly increased in 2019, however still indicates good water quality with slight pollution (Griffiths, 1999). Overall, the metrics for Blair Creek from 2019 continue to indicate a healthy, relatively unimpaired system with a diverse community structure and composition.

### 5.3.2 Fish Community Monitoring

Though multiple survey locations along Blair Creek are monitored by GRCA as part of the fish community survey, the station of focus from 2014 to 2019 for the purposes of this report is Blair Creek upstream of Highway 401 (Station 2414047). It is important to note that the GRCA alternates between fish community monitoring (a single pass method) and fish biomass monitoring (a 3 pass method) every other year at this Blair Creek survey location; fish community monitoring in odd-numbered years (e.g. 2019) and biomass monitoring in even-numbered years (e.g. 2018).

#### 5.3.2.1 Fish Community Monitoring Methodology

In 2019, the GRCA conducted fish community monitoring along a 50 m reach of Blair Creek on August 7, 2019. The fish community monitoring was conducted using a single pass method with a Halltech HT2000B backpack electrofisher.

#### 5.3.2.2 Fish Community Monitoring Results

**Table 1** summarizes the results from the 2019 Blair Creek fish community monitoring completed by the GRCA. This fish community data set displayed similar results to those of previous years with single pass surveys (i.e. odd-numbered monitoring years). As expected, the total number of fish collected was less than in 2018 due to the lower effort monitoring (single pass method), but overall similar to other single pass survey years (i.e., 2015 and 2017). Species richness remained comparable from 2014 – 2019, with a value of seven. This is a one species increase compared to the last two monitoring years. Previous monitoring suggested that the Blair Creek fish community consisted of a mix of tolerant, intermediately tolerant and intolerant species. In 2019, the percentage of tolerant species continued to represent a small proportion (<10%) of the fish community. The intolerant species present in 2019 included four brown trout (*Salmo trutta*) and six brook trout (*Salvelinus fontinalis*). This data validates that the system is able to support intolerant and intermediately tolerant fish communities. However, the percent of the fish community comprised of intolerant species has declined in 2018 and 2019 to less than or equal to 67% of the community proportion occupied by intolerant species in 2014 – 2016.

## 5.4 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 2018 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 29** to **Figure 32** provide the historic measurements of Chloride and TSS for Blair Creek at both New Dundee Road (Station 2414002) and 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 5-2** and **Table 5-3**. The number of samples collected at both locations annually varied year over year, but generally increased from 2006 to 2019.

Table 5-2 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) |

Table 5-3 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) |
| 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) |

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, and the maximum recorded wet-weather Chloride concentration at Dickie Settlement was observed in 2006 with a value of 48 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 both 2006 and 2007 with a concentration of 50 mg/L. The 2019 dry-weather Chloride grab samples at New Dundee road ranged from 54 mg/L to 66 mg/L. The 2019 dry-weather Chloride grab samples at Dickie Settlement ranged from 1 mg/L to 57 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. Compared to historical data, the 2019 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.

Historical data has revealed that dry-weather concentrations of TSS have generally been below 15 mg/L at Dickie Settlement, 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 2019 TSS dry-weather grab sample concentrations ranged from 0 mg/L (non-detect) to 136 mg/L at New Dundee Road and 1 mg/L to 21 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 8**), 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.

# 6. Physical Monitoring

Physical monitoring in 2019 included the collection of continuous water level and temperature, as well as discrete flow measurements. All physical monitoring took place between March and October 2019. **Table 6-1** summarizes the dates when discrete flow measurements were conducted at the 2019 EMC stations of Voisin Creek (VS1) and North Strasburg Creek (SB2) to verify existing rating curves. Flow monitoring was not conducted at the 2019 EMC stations of Westmount Drain (WD1) and Sandrock Greenway (SR2) 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 2020, which include School Creek (SCH1), Lower Schneider Creek (SC1) and Upper Schneider Creek (SC9).

### Table 6-1 Dates of Discrete Flow Monitoring

| Site | Date of Flow Monitoring | Type of Event |
|---|---|---|
| SCH1, SC1, SC9 | March 29, 2019 | Dry |
| SCH1, SC1, SC9 | April 15, 2019 | Wet |
| SCH1, VS1 | April 19, 2019 | Wet |
| SCH1, SB2 | April 26, 2019 | Wet |
| SC9 | October 2, 2019 | Wet |
| SC1 | October 4, 2019 | Wet |
| SCH1 | October 16, 2019 | Wet |

## 6.1 Temperature Monitoring

### 6.1.1 Temperature Monitoring Methodology

Continuous water temperature data was collected at all EMC stations monitored as part of the 2019 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 November) and therefore removed during the winter months to prevent damage to the loggers due to freezing conditions.

### 6.1.2 Temperature Monitoring Results

**Figure 33** to **Figure 36** show the daily maximum and minimum water temperature at each site monitored for continuous temperature (WD1, VS1, SB2 and SR2), as well as the daily average air temperature. Daily average air temperature data was obtained from the Kitchener/Waterloo Environment Canada Weather Station. **Table 6-2** summarizes the minimum and maximum temperatures recorded during the 2019 monitoring period at each site. Water temperatures were observed to generally follow the same trend as air temperature, with the exception of Westmount Drain (WD1) where in the fall months (October and November 2019) water temperatures were slow to respond to the decrease in air temperatures.

### Table 6-2 2019 Temperature Monitoring

| Site | Minimum Temperature (°C) | Maximum Temperature (°C) |
|---|---|---|
| Westmount Drain (WD1) | 6.47°C on April 20, 2019 | 24.44°C on August 18, 2019 |
| Voisin Creek (VS1) | 0.00°C on November 8, 2019 | 24.34°C on July 20, 2019 |
| North Strasburg Creek (SB2) | 0.30°C on April 1, 2019 | 21.29°C on July 20, 2019 |
| Sandrock Greenway (SR2) | 0.03°C on April 1, 2019 | 26.70°C on July 20, 2019 |

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 2019). Daily water temperatures collected between 16:00 and 18:00 were plotted, coinciding with the air temperatures at 16:00. **Figure 37** to **Figure 40** show the thermal stability classifications for Westmount Drain (WD1), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2), respectively. **Table 6-3** summarizes the thermal regimes for each station in 2019.

Table 6-3 Thermal Stability Classifications

| Site | 2019 Thermal | 2018 Thermal | 2016 Thermal |
|---|---|---|---|
| Westmount Drain (WD1) | Cold-Coolwater | - | - |
| Voisin Creek (VS1) | Cold-Coolwater to Coolwater | Cool-warmwater | - |
| North Strasburg Creek (SB2) | Coldwater to Cold-Coolwater | - | Coldwater |
| Sandrock Greenway (SR2) | Coolwater | - | - |

## 6.2 Flow Monitoring

### 6.2.1 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 2019 monitoring program. The ISCO 6712 samplers and A/V sensors were installed in April 2019 and removed from all stations in December 2019. After installation of the A/V sensor at Westmount Drain (WD1) in May 2019, a sensor issue was observed which resulted in replacement with a new sensor in June 2019.

### 6.2.2 Flow Monitoring Results

Wet-weather discrete flow monitoring and corresponding manual water levels were recorded in April 2019 at Voisin Creek (VS1) and Strasburg Creek (SB2) to verify the existing rating curves. The developed rating curves for Voisin Creek (VS1) and North Strasburg Creek (SB2) are presented on **Figure 41** and **Figure 42.** Existing rating curves of high regression quality were used for Westmount Drain (WD1) and Sandrock Greenway (SR2) and are provided in **Figure 43** and **Figure 44.**

Dry and wet-weather discrete flow monitoring for future EMC locations was conducted during the 2019 annual monitoring in order to develop the site-specific rating curves in advance of the 2020 monitoring seasons. Flow measurements were undertaken on three occasions at Lower Schneider Creek (SC1) and Upper Schneider Creek (SC9) and five occasions at School Creek (SCH1). Evidence of beaver activity and damming was noted during two of the fall events along School Creek (SCH1). The rating curves for Lower Schneider Creek (SC1), Upper Schneider Creek (SC9) and School Creek (SCH1) are presented on **Figure 45** to **Figure 47.**

The continuous water level data collected at Westmount Drain (WD1), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2) was used to calculate flow rates using the relative flow versus water level relationship. **Figure 48** through **Figure 51** displays the continuous flow data (i.e., hydrographs) measured at Westmount Drain (WD1), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2). The secondary axis plots daily precipitation data recorded at the rain gauge operated at the Kitchener City Hall.

The flow data at the Westmount Drain (WD1), Voisin Creek (VS1) and Sandrock Greenway (SR2) sites indicate a short response time for observed peak flows in response to precipitation events while North Strasburg Creek (SB2) showed less “peakiness” in response to precipitation events. **Table 6-4** summarizes the maximum flows observed in 2019 and associated subwatershed drainage areas and total precipitation received within 24-hours.

Table 6-4 2019 Flow Monitoring Maximums

| Site | Drainage | Maximum Flow ($m^3/s$) | 24-hr Precipitation |
|---|---|---|---|
| Westmount Drain (WD1) | 256 | 42.5<br>(October 2, 2019) | 25.2 (City Hall)<br>20.2 (KOF) |
| Voisin Creek (VS1) | 318 | 14.3<br>(September 13, 2019) | 8.8 (City Hall)<br>16.2 (KOF) |
| North Strasburg Creek (SB2) | 416 | 2.9<br>(July 17, 2019) | 16.8 (City Hall)<br>23.4 (KOF) |
| Sandrock Greenway (SR2) | 401 | 35.8<br>(September 13, 2019) | 8.8 (City Hall)<br>16.2 (KOF) |

# 7. Water Quality Monitoring

Consistent with previous years of monitoring, water chemistry was analyzed as part of the 2019 SWM Monitoring Program. **Table 7-1** presents a list of the parameters analyzed during the 2019 SWM Monitoring Program, in addition, discrete field measurements of temperature, pH, dissolved oxygen (DO), conductivity oxidation-reduction potential (ORP), Total Dissolved Solids (TDS) and turbidity were collected when grab sampling occurred using a Horiba U52 water quality unit. All water quality samples collected in 2019 were submitted to ALS Laboratories in Waterloo for chemical analysis. Original laboratory reports and chain of custodies are included in **Appendix E.** All 2019 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**. The following locations, which were monitored as part of the 2019 monitoring program were also monitored during the prior monitoring year (2018): Schneider Creek (SC1), Sandrock Greenway (SR2) and Voisin Creek (VS1).

## Table 7-1 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 |
| Conductivity (µS/cm) | Field | Grab |
| ORP (mV) | Field | Grab |
| TDS (g/L) | Field | Grab |
| Turbidity (NTU) | Field | Grab |

As per the requirements of the 2019 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 7-2** and **Table 7-3**, respectively.

## Table 7-2 Dry-Weather Grab Sampling Events

| Location(s) | Date | Daily Average Air | Last Precipitation | Precipitation |
|---|---|---|---|---|
| WD1, SB2, SR2, SC1 | 7/10/2019 | 22.21 | 7/6/2019 | 0.2 |
| VS1, SR2 | 7/15/2019 | 20.09 | 7/10/2019 | 1 |
| WD1, SB2, SC1 | 7/16/2019 | 23.27 | 7/10/2019 | 1 |
| VS1 | 9/19/2019 | 19.27 | 9/15/2019 | 1.8 |
| SC1, WD1, VS1, SB2, SR2 | 11/12/2019 | -8.77 | 11/10/2019 | 0.2 |

***Notes:***

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

## Table 7-3 Wet-Weather Sampling Events

| Location(s) | Dates | Daily Average Air Temparature | Last Precipitation Event | Precipitation (mm) |
|---|---|---|---|---|
| Westmount Drain (WD1) | 6/26/2019 | 20.5 | 6/25/2019 | 0.6 |
| | 7/1/2019 | 18.8 | 6/28/2019 | 11.4 |
| | 8/21/2019 | 23.0 | 8/21/2019 | 1.8 |
| | 9/1/2019 | 14.8 | 9/1/2019 | 0.8 |
| | 9/16/2019 | 15.8 | 9/15/2019 | 1.8 |
| | 9/16/2019 | 15.8 | 9/15/2019 | 1.8 |
| | 10/8/2019 | 9.4 | 10/6/2019 | 1.6 |
| | 10/17/2019 | 4.2 | 10/16/2019 | 11.2 |
| Voisin Creek (VS1) | 4/17/2019 | 5.5 | 4/16/2019 | 2.4 |
| | 4/29/2019 | 1.3 | 4/29/2019 | 1.2 |
| | 6/9/2019 | 18.2 | 6/5/2019 | 13.4 |
| | 7/1/2019 | 18.8 | 6/28/2019 | 11.4 |
| | 8/21/2019 | 23.0 | 8/21/2019 | 1.8 |
| | 9/3/2019 | 16.1 | 9/2/2019 | 0.2 |
| | 10/6/2019 | 13.9 | 10/6/2019 | 1.6 |
| | 10/17/2019 | 4.2 | 10/16/2019 | 11.2 |
| North Strasburg Creek (SB2) | 4/5/2019 | 1.6 | 3/31/2019 | 0.6 |
| | 4/17/2019 | 5.5 | 4/16/2019 | 2.4 |
| | 6/9/2019 | 18.2 | 6/5/2019 | 13.4 |
| | 8/21/2019 | 23.0 | 8/21/2019 | 1.8 |
| | 9/3/2019 | 16.1 | 9/2/2019 | 0.2 |
| | 10/6/2019 | 13.9 | 10/6/2019 | 1.6 |
| | 10/29/2019 | 7.3 | 10/27/2019 | 11.4 |
| | 11/7/2019 | -2.1 | 11/7/2019 | 2.6 |
| Sandrock Greenway (SR2) | 5/7/2019 | 8.6 | 5/7/2019 | 3.2 |
| | 6/4/2019 | 12.7 | 6/2/2019 | 1.2 |
| | 6/9/2019 | 18.2 | 6/5/2019 | 13.4 |
| | 8/26/2019 | 17.9 | 8/21/2019 | 1.8 |
| | 9/1/2019 | 14.8 | 9/1/2019 | 0.8 |
| | 9/16/2019 | 15.8 | 9/15/2019 | 1.8 |
| | 10/1/2019 | 21.5 | 10/1/2019 | 11.4 |
| | 10/18/2019 | 4.7 | 10/17/2019 | 0.4 |

***Notes:***

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

## 7.1 Water Quality Monitoring Methodologies

### 7.1.1 Grab Sampling Methodology

Dry-weather sampling was conducted as part of the 2019 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 place 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 in addition to the sample bottles 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.

### 7.1.2 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 Westmount Drain (WD1), Voisin Creek (VS1), Strasburg Creek (SB2) and Sandrock Greenway (SR2). **Table 7-4** presents a summary of equipment installation dates.

Table 7-4 Equipment Installation Dates

| Location(s) | Equipment | Installation Date |
|---|---|---|
| Westmount Drain (WD1) | Solinst Levelogger | 4/18/2019 |
| | ISCO Autosampler | 4/24/2019 |
| Voisin Creek (VS1) | ISCO Autosampler<br>Solinst Levelogger | 4/10/2019 |
| North Strasburg Creek (SB2) | ISCO Autosampler<br>Solinst Levelogger | 3/27/2019 |
| Sandrock Greenway (SR2) | Solinst Levelogger | 4/18/2019 |
| | ISCO Autosampler | 4/24/2019 |

***Notes:***

1. A/V sensor issues noted at Westmount Drain (WD1) in April/May 2019, new sensor installed June 1, 2019.

All autosampler stations were dismantled and removed for the monitoring season in December 2019. The Strasburg Creek (SB2) and Westmount Drain (WD1) 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. These discrete flow measurements were used in combination with water level data to develop a station-specific rating curve (depth versus flow relationship).

Continuously recorded water levels obtained from the area-velocity flow module are translated to flow rates utilizing the relationship developed by the corresponding rating curve. Once calculated, the rating curve equations were programmed into the ISCO 6712 samplers. These samplers use the rating curve equation to estimate the flow, thus triggering the sampler to begin sampling once specified water level and flow rate conditions were met. Once triggered, aliquot samples were collected throughout the rain event at a constant volume and flowrate. Following the rainfall 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 in order 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 remove for the season in December 2019 (see **Section 6.1**).

As part of the 2019 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 2** attached.

## 7.2 Water Quality Monitoring Results

### 7.2.1 Grab Sampling Results

Three dry-weather grab samples were collected at the following stations: Westmount Drain (WD1), Voisin Creek (VS1), Strasburg Creek (SB2), Sandrock Greenway (SR2) 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 guidelines. These guideline comparisons have been made since the onset of the SWM Monitoring Program. Results for each water quality parameter are summarized in **Figure 52** to **Figure 62.**

Seasonally, trends and comparisons can be made across all of the monitoring sites for 2019. 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 2019 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 *2019 City-Wide Stormwater Management Monitoring Program: Section B – Additional Stormwater Management Monitoring*), discrete grab sampling winter data was collected in 2019 at a location (SW8) approximately 30 m downstream of North 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.

#### 7.2.1.1 Chloride

The Chloride concentrations for all dry-weather event surface water monitoring locations in 2019 are presented on **Figure 52**. The annual average, minimum and maximum Chloride concentrations for 2019 are summarized in **Table 7-5**. The annual averages for all sites monitored in 2019 ranged from 90.5 mg/L at North Strasburg Creek (SB2) to 1,430 mg/L at Westmount Drain (WD1). The maximum concentration at Westmount Drain (WD1) was observed on November 12, 2019. This chloride concentration is nearly ten times greater than previous concentrations observed at this location. During this field visit, it was noted that there was a pipe discharging water of an unknown source upstream of the monitoring station.

The annual averages of all 2019 monitoring locations with the exception of North 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 7-5 2019 Dry-Weather Grab Sample Results – Chloride

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SR2 | 573 | 271 | 757 |
| WD1 | 586.33 | 162 | 1,430 |
| VS1 | 451.33 | 200 | 651 |
| SB2 | 95.33 | 90.5 | 101 |
| SC1 | 344 | 280 | 382 |

A general trend between all sites showed that the highest chloride concentrations were recorded during the fall sampling event with the exception of North Strasburg Creek (SB2) and Lower Schneider Creek (SC1) where the chloride concentrations in the spring and fall were generally consistent. The high chloride concentrations observed during the fall are likely the result of the road de-icing efforts. The fall sample event occurred on November 12, 2019. Prior to this sampling event, in early November, significant snowfall occurred which resulted in the application of road salts. Sites with close proximity to heavily developed catchment areas (WD1, VS1 and SR2) demonstrated higher average chloride concentrations compared to sites in less developed areas.

It should be noted that the chloride concentrations at North Strasburg Creek (SB2) remained fairly consistent throughout the 2019 monitoring period, ranging from 90.5 mg/L to 101.0 mg/L. The results from monitoring location SW8 (Battler Road SSDF Monitoring Program) are consistent with the results observed at North Strasburg Creek (SB2) and provides a comparable year-round view of the site. Both Voisin Creek (VS1) and Lower Schneider Creek (SC1) were also monitored in 2018, and 2019 results show comparable annual average concentrations. Westmount Drain (WD1) had the highest maximum Chloride concentration, and the second lowest minimum, thus resulting in the widest range in data collected. North Strasburg Creek (SB2) had the lowest annual average concentration.

### 7.2.1.2 Nitrate

**Figure 53** displays the Nitrate concentrations for all dry-weather event surface water monitoring locations in 2019. The annual average, minimum and maximum Nitrate concentrations for 2019 are summarized in **Table 7-6**. The CCME Long Term Concentration guideline for Nitrate in a freshwater watercourse is 13 mg/L. The annual averages for all sites during the 2019 monitoring ranged from 0.42 mg/L at WD1 to 1.29 at SB2 compared to 0.44 mg/L to 2.95 mg/L in 2018. All annual averages are well below the CCME Nitrate threshold.

Table 7-6 2019 Dry-Weather Grab Sample Results – Nitrate

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SR2 | 0.38 | 0.0440 | 0.8900 |
| WD1 | 0.42 | 0.4030 | 0.4400 |
| VS1 | 0.63 | 0.3760 | 0.8600 |
| SB2 | 1.29 | 1.200 | 1.390 |
| SC1 | 0.94 | 0.664 | 1.170 |

No seasonal trends for Nitrate were observed, with the exception of a minor increase from spring to fall observed at Voisin Creek (VS1).

### 7.2.1.3 Phosphorus

#### *Total Phosphorus*

The Total Phosphorus concentrations for all dry-weather event surface water monitoring locations in 2019 are presented on **Figure 54**. The annual average, minimum and maximum Total Phosphorus concentrations for 2019 are summarized in **Table 7-7**. 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.

Table 7-7 2019 Dry-Weather Grab Sample Results – Total Phosphorus

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SR2 | 0.130 | 0.025 | 0.2730 |
| WD1 | 0.029 | 0.014 | 0.057 |
| VS1 | 0.082 | 0.026 | 0.1680 |
| SB2 | 0.017 | 0.009 | 0.0255 |
| SC1 | 0.026 | 0.009 | 0.050 |

Similar to previous years, the monitoring sites fluctuated above and below the PWQO limit, with the exception of North Strasburg Creek (SB2), which did not exceed the PWQO guideline for any of the collected grab samples. The annual average concentrations ranged from 0.017 mg/L to 0.130 mg/L compared to the 2018 range of 0.015 mg/L to 0.067 mg/L. The highest Total Phosphorus concentration was at Sandrock Greenway (SR2) (0.273 mg/L) and the lowest Total Phosphorus concentration was at Lower Schneider Creek (SC1) and North Strasburg (SB2) with a value of 0.009 mg/L. As a general trend, Total Phosphorus concentrations were higher during the spring and summer periods and lower during the fall periods.

### *Dissolved Phosphorus*

**Figure 55** displays the Dissolved Phosphorus concentrations for all dry-weather event surface water monitoring locations in 2019. The annual average, minimum and maximum Dissolved Phosphorus concentrations for 2019 are summarized in **Table 7-8**. 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 7-8 2019 Dry-Weather Grab Sample Results – Dissolved Phosphorus

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SR2 | 0.1209 | 0.0113 | 0.273 |
| WD1 | 0.0085 | 0.005 | 0.0139 |
| VS1 | 0.0713 | 0.0205 | 0.168 |
| SB2 | 0.0140 | 0.0042 | 0.0255 |
| SC1 | 0.0220 | 0.0071 | 0.0502 |

Annual averages for all sites ranged from 0.014 mg/L to 0.121 mg/L compared to the 2018 range of 0.007 mg/L to 0.042 mg/L. Average annual Dissolved Phosphorus concentrations for all sites were below the PWQO limits with the exception of Voisin Creek (VS1), Sandrock Greenway (SR2) and Schneider Creek (SC1) during the summer sample events. This is similar to what was observed in 2017 and 2018 when the maximum Dissolved Phosphorus concentration was observed at Voisin Creek (VS1) and Sandrock Greenway (SR2). The same general trend for Total Phosphorus concentrations was observed for Dissolved Phosphorus where concentrations were higher during the spring and summer periods and lower during the fall periods.

### 7.2.1.4 Metals

### *Zinc*

The Zinc concentrations for all dry-weather event surface water monitoring locations in 2019 are presented on **Figure 56**. The annual average, minimum and maximum Zinc concentrations for 2019 are summarized in **Table 7-9**. Results were compared to the PWQO limit of 0.020 mg/L for Zinc.

Table 7-9 2019 Dry-Weather Grab Sample Results – Zinc

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SR2 | 0.0017 | ND | 0.0052 |
| WD1 | 0.0155 | ND | 0.0410 |
| VS1 | 0.0100 | ND | 0.0239 |
| SB2 | ND | ND | ND |
| SC1 | 0.0052 | 0.0034 | 0.0068 |

The annual averages for Zinc concentration by monitoring location ranged from “Non-Detect” to 0.016 mg/L compared to the 2018 range of “Non-Detect” to 0.013 mg/L. All sampled results fell below the PWQO limit with the exception of Westmount Drain (WD1) which had one exceedance of 0.041 mg/L on November 12, 2019 and Voisin Creek (VS1) which had one exceedance of 0.0239 mg/L on July 15, 2019. With the exception of these events, the next highest concentration was collected at Lower Schneider Creek (SC1) on July 16, 2019 with a value of 0.0068 mg/L. North Strasburg Creek (SB2) had all Zinc samples return with a value of “Non-Detect” thus having the lowest average Zinc concentration.

### *Copper*

**Figure 57** displays the Copper concentrations for all dry-weather event surface water monitoring locations in 2019. The annual average, minimum and maximum Copper concentrations for 2019 are summarized in **Table 7-10**. The PWQO standard of 0.005 mg/L was used for result comparison.

Table 7-10 2019 Dry-Weather Grab Sample Results – Copper

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SC1 | 0.0019 | 0.0015 | 0.0027 |
| WD1 | 0.0004 | ND | 0.0011 |
| VS1 | 0.0047 | ND | 0.0108 |
| SB2 | ND | ND | ND |
| SR2 | 0.0009 | ND | 0.0028 |

The annual average across all monitoring locations for Copper concentrations ranged from “Non-Detect” to 0.005 mg/L compared to the 2018 annual average range of “Non-Detect” to 0.002 mg/L. All monitoring locations fell below the PWQO limit for Copper (0.005 mg/L) with the exception of one sample collected on July 15, 2019 at Voisin Creek (VS1). This is similar to what was seen during the 2018 monitoring program, where the maximum Copper concentration was also collected at Voisin Creek (VS1) during the summer sampling period.

### *Lead*

The Lead concentrations for all dry-weather event surface water monitoring locations in 2019 are presented on **Figure 58**. The annual average, minimum and maximum Lead concentrations for 2019 are summarized in **Table 7-11**. 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 7-11 2019 Dry-Weather Grab Sample Results – Lead

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SR2 | 0.00006 | ND | 0.00019 |
| WD1 | 0.00124 | ND | 0.00350 |
| VS1 | 0.00124 | ND | 0.00296 |
| SB2 | 0.00010 | 0.00007 | 0.00016 |
| SC1 | 0.00038 | 0.00020 | 0.00072 |

All 2019 Lead concentrations for dry-weather event samples were below the PWQO limit of 0.005 mg/L. The 2019 annual average for Lead concentrations ranged from 0.00006 mg/L to 0.00124 mg/L compared to the 2018 concentration range from 0.0001 mg/L to 0.0004 mg/L. Westmount Drain (WD1) demonstrated the highest annual average (0.00124 mg/L) while Sandrock Greenway (SR2) demonstrated the lowest annual average concentration of 0.00006 mg/L. The maximum concentration during the 2019 monitoring program was collected at Westmount Drain (WD1) during the fall sampling event with a value of 0.0035 mg/L which is still below the PWQO limit.

#### 7.2.1.5 Total Suspended Solids

**Figure 59** displays the TSS concentrations for all dry-weather event surface water monitoring locations in 2019. The annual average, minimum and maximum TSS concentrations for 2019 are summarized in **Table 7-12**. 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. No monitoring locations exhibited such significant increases in TSS during 2019.

Table 7-12 2019 Dry-Weather Grab Sample Results – TSS

| Site | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| SR2 | 5.3 | 2.5 | 9.8 |
| WD1 | 11.0 | ND | 25.3 |
| VS1 | 7.7 | 3.6 | 14.5 |
| SB2 | 2.2 | ND | 4.4 |
| SC1 | 8.1 | 2.1 | 15.2 |

Annual average TSS concentrations by location ranged from 2.2 mg/L to 11.0 mg/L compared to the 2018 concentration range of 1.6 mg/L to 14.9 mg/L during dry-weather sample events. The site with the highest annual average concentration was Westmount Drain (WD1) which demonstrated an average concentration of 11.0 mg/L. The overall maximum TSS concentration (25.3 mg/L) during 2019 was also identified at Westmount Drain (WD1). The lowest annual TSS average was at North Strasburg Creek (SB2) with a value of 2.2 mg/L.

#### 7.2.1.6 Dissolved Oxygen

Dissolved Oxygen levels for all dry-weather event surface water monitoring locations in 2019 are presented on **Figure 60.** The annual average, minimum and maximum DO concentrations for 2019 are summarized in **Table 7-13**. 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 7-13 2019 Dry-Weather Grab Sample Results – Dissolved Oxygen

| Site | Thermal Stream Classification | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|---|
| SR2 | Coolwater | 8.13 | 3.79 | 14.34 |
| WD1 | Cold-Coolwater | 7.31 | 6.09 | 8.08 |
| VS1 | Cold-Coolwater | 7.60 | 3.31 | 13.54 |
| SB2 | Coldwater | 9.72 | 6.49 | 13.61 |
| SC1 | Warmwater | 10.27 | 5.39 | 14.59 |

All DO results for 2019 were above both the warmwater and coldwater threshold (i.e., acceptable for supporting aquatic life), with the exception of a summer sample collected at Voisin Creek (VS1) and at Sandrock Greenway (SR2). The annual average at each monitoring location ranged from 7.31 mg/L to 10.27 mg/L compared to the 2018 range of 6.88 mg/L to 10.35 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.

#### 7.2.1.7 pH

**Figure 61** displays the discrete field-measured pH results for all dry-weather event surface water monitoring locations in 2019. The annual average, minimum and maximum pH concentrations for 2019 are summarized in **Table 7-14**. The PWQO lower and upper pH limits (6.5 and 8.5) are plotted for comparison.

Table 7-14 2019 Dry-Weather Grab Sample Results – pH

| Site | Thermal Stream Classification | Annual Average | Minimum Result | Maximum Result |
|---|---|---|---|---|
| SR2 | Coolwater | 7.70 | 7.42 | 7.94 |
| WD1 | Cold-Coolwater | 7.69 | 7.45 | 7.83 |
| VS1 | Cold-Coolwater | 8.02 | 7.89 | 8.26 |
| SB2 | Coldwater | 7.97 | 7.78 | 8.12 |
| SC1 | Warmwater | 8.09 | 7.99 | 8.27 |

All samples fell between the PWQO limits of a maximum pH of 8.5 and a minimum pH of 6.5. The average annual pH values by sampling location ranged from 7.69 at Westmount Drain (WD1) to 8.09 at Lower Schneider Creek (SC1)

#### 7.2.1.8 Specific Conductivity

The discrete field-measured Specific Conductivity (conductivity normalized to 25ºC) results for all dry-weather event surface water monitoring locations in 2019 are presented on **Figure 62**. The annual average, minimum and maximum Specific Conductivity results for 2019 are summarized in **Table 7-15**.

Table 7-15 2019 Dry-Weather Grab Sample Results – Specific Conductivity

| Site | Annual Average (µS/cm) | Minimum Concentration (µS/cm) | Maximum Concentration (µS/cm) |
|---|---|---|---|
| SR2 | 2114 | 872 | 2890 |
| WD1 | 3127 | 1900 | 5580 |
| VS1 | 1688 | 953 | 2260 |
| SB2 | 790 | 778 | 799 |
| SC1 | 1600 | 1350 | 1800 |

The average annual Specific Conductivity by monitoring location in 2019 ranged from 790 µS/cm at North Strasburg Creek (SB2) to 3127 µS/cm at Westmount Drain (WD1) compared to the 2018 annual averages of 984 µS/cm to 2493 µS/cm. Specific Conductivity and Chloride levels can be compared to one another on a bi-linear scale. This relationship is evident during dry-weather sampling events, where both Specific Conductivity and Chloride concentration levels increase. All sites appear to be following the same trend for both Specific Conductivity and Chloride.

### 7.2.2 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.

Historical EMC studies have demonstrated considerable variation of constituent loading, both monthly and seasonally. Most studies have demonstrated that the majority 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.

#### 7.2.2.1 Westmount Drain (WD1)

Westmount Drain (WD1) is part of a cold-coolwater creek located just North of Victoria Street South, in close proximity to the City's Victoria Park Lake. The primary land use of the Westmount Drain subwatershed is residential, with some industrial properties.

EMC samples were collected at Westmount Drain (WD1) during wet-weather events. In addition, three dry-weather grab samples were collected in 2019. The following sections present the sampling results for the Westmount Drain (WD1) location with EMC and grab sample concentrations for each parameter displayed on **Figure 63** to **Figure 70.**

#### *7.2.2.1.1 Chloride*

**Figure 63** presents the EMC and dry-weather grab results for Chloride at Westmount Drain (WD1) for 2019 while **Table 7-16** summarizes the annual average, minimum and maximum concentrations.

Table 7-16 Westmount Drain (WD1) – Chloride Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 44.26 | 17.2 | 70 |
| Dry (Grab) | 586.33 | 162 | 1430 |

The annual station average (wet and dry-weather results) at this site was 192.1 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 below the CCME Long Term Concentration limit. The average dry-weather Chloride concentration (586.33 mg/L) at Westmount Drain (WD1) was higher compared to the average Chloride EMC concentration of 44.26 mg/L for 2019. The highest recorded Chloride sample was a dry-weather sample collected on November 12, 2019 at a concentration of 1,430 mg/L. It is noted that during this time, field staff observed a pipe discharging unknown water upstream of the sample location. This sample was collected following a large snowfall event, thus the value could be attributed to the effects of road de-icing as the City's winter maintenance program commenced shortly prior to this sampling event. Lower chloride concentrations in wet-weather samples are attributed to dilution from precipitation events.

#### *7.2.2.1.2 Nitrate*

**Figure 64** displays the EMC and dry-weather grab results for Nitrate at Westmount Drain (WD1) while **Table 7-17** summarizes the annual average, minimum and maximum concentrations. All results were below the CCME Long Term Concentration guideline for Nitrate (13 mg/L).

Table 7-17 Westmount Drain (WD1) – Nitrate Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.322 | 0.230 | 0.441 |
| Dry (Grab) | 0.424 | 0.403 | 0.440 |

The average dry-weather Nitrate concentration at Westmount Drain (WD1) was slightly higher than the average wet-weather EMC. The overall Nitrate average for the site (dry and wet-weather samples) was 0.350 mg/L which is well below the CCME limit. No significant seasonal trends were identified for Nitrate during the 2019 monitoring.

#### *7.2.2.1.3 Phosphorus*

##### *Total Phosphorus*

**Figure 65** displays the EMC and dry-weather grab results for Total Phosphorus at Westmount Drain (WD1) for 2019 while **Table 7-18** summarizes the annual average, minimum and maximum concentrations.

Table 7-18 Westmount Drain (WD1) – Total Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.271 | 0.165 | 0.418 |
| Dry (Grab) | 0.029 | 0.014 | 0.057 |

All EMC samples were above the PWQO limit of 0.03 mg/L for Total Phosphorus, however the average dry-weather concentration (0.029 mg/L) is below the PWQO limit. Seasonally, Total Phosphorus results during the spring and summer months were higher than the 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 via surface water runoff during precipitation events.

##### *Dissolved Phosphorus*

**Figure 66** displays the EMC and dry-weather grab results for Dissolved Phosphorus at Westmount Drain (WD1) for 2019 while **Table 7-19** summarizes the annual average, minimum and maximum concentrations.

Table 7-19 Westmount Drain (WD1) – Dissolved Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.042 | 0.008 | 0.084 |
| Dry (Grab) | 0.0085 | 0.0050 | 0.0139 |

During 2019, five of the eight samples collected exceeded the PWQO limit for Dissolved Phosphorus (0.03 mg/L). The average EMC and site average (0.033 mg/L) for Dissolved Phosphorus are both above the PWQO while the dry-weather average is below the PWQO. Seasonally, there was no obvious trend for Dissolved Phosphorus present.

#### *7.2.2.1.4 Metals*

##### *Copper*

**Figure 67** displays the EMC and dry-weather grab results for Copper at Westmount Drain (WD1) during 2019 while **Table 7-20** summarizes the annual average, minimum and maximum concentrations.

### Table 7-20 Westmount Drain (WD1) – Copper Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0238 | 0.0153 | 0.0310 |
| Dry (Grab) | 0.0004 | ND | 0.0011 |

All EMC sample results for Copper were above the PWQO limit of 0.005 mg/L at Westmount Drain (WD1) while all dry-weather grab samples were below the PWQO, ranging from “Non-Detect” to 0.0011 mg/L. Seasonally, Copper at Westmount Drain (WD1) was highest in the spring and summer decreased slightly into the fall. During the spring and summer months, precipitation events cause heavy metals and road debris to accumulate in the watercourse and appear at concentrated levels.

#### *Lead*

**Figure 68** displays the EMC and dry-weather grab results for Lead at Westmount Drain (WD1) during 2019 and **Table 7-21** summarizes the annual average, minimum and maximum concentrations.

### Table 7-21 Westmount Drain (WD1) – Lead Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0087 | 0.0051 | 0.0149 |
| Dry (Grab) | 0.0012 | ND | 0.0035 |

Similar to what was observed for copper, all EMC samples collected exceeded the PWQO for Lead (0.005 mg/L) while all dry-weather samples were well below the PWQO limit. Seasonally, the 2019 trends reveal that the highest Lead concentrations occurred during the summer period.

#### *Zinc*

**Figure 69** displays the EMC and dry-weather grab results for Zinc at Westmount Drain (WD1) during 2019 and **Table 7-22** summarizes the annual average, minimum and maximum concentrations.

### Table 7-22 Westmount Drain (WD1) – Zinc Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.084 | 0.060 | 0.117 |
| Dry (Grab) | 0.016 | ND | 0.041 |

Similar to what was observed with both Copper and Lead, all EMC samples were above the PWQO limit of 0.02 mg/L for Zinc. The annual average dry-weather Zinc Concentration (0.016 mg/L) was slightly below the PWQO limit due to a fall sample where the maximum concentration of 0.041 mg/L was observed. Seasonally, the 2019 trends reveal that the highest Zinc concentrations occurred during the summer period when dilution from precipitation events decreases compared to the spring and fall months.

##### *7.2.2.1.5 Total Suspended Solids*

**Figure 70** displays the EMC and dry-weather grab results for TSS at Westmount Drain (WD1) during 2019 and **Table 7-23** summarizes the annual average, minimum and maximum concentrations. 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 70** because no background level data was established as part of the 2019 SWM Monitoring Program.

Table 7-23 Westmount Drain (WD1) – TSS Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 187.33 | 97.60 | 391.00 |
| Dry (Grab) | 11.00 | ND | 25.30 |

The annual average dry-weather TSS concentration (11.00 mg/L) was significantly lower compared to the annual average EMC concentration (187.33 mg/L). Higher TSS levels were observed during wet-weather sampling which is likely influenced by the resuspension of sediments during precipitation events. Seasonally, there are no obvious trends in the 2019 TSS data.

#### 7.2.2.2 Voisin Creek (VS1)

Based on the 2019 temperature monitoring data, Voisin Creek (VS1) is currently classified as a cold-coolwater to coolwater creek 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 subwatershed 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 2019. EMC and grab sample results for each parameter analyzed at Voisin Creek (VS1) are displayed in **Figure 71** to **Figure 78**.

##### *7.2.2.2.1 Chloride*

**Figure 71** displays the EMC and dry-weather grab results for Chloride at Voisin Creek (VS1) while **Table 7-24** summarizes the annual average, minimum and maximum concentrations.

Table 7-24 Voisin Creek (VS1) – Chloride Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 92.08 | 42.60 | 220 |
| Dry (Grab) | 451.33 | 200 | 651 |

The annual EMC average for Chloride (92.08 mg/L) is below the CCME Long Term Limit (120 mg/L) and below the 2018 EMC average for Chloride (185 mg/L). The annual average dry-weather Chloride concentration (451.33 mg/L) was greater than the CCME Long Term Limit, as well as the EMC average concentration, and slightly higher than the 2018 dry-weather concentration (442 mg/L). The highest Chloride level was observed on November 12, 2019 at a concentration of 651 mg/L. This sample was collected following a large snowfall event, thus the value could be attributed to the effects of road de-icing as the City's winter maintenance program commenced shortly prior to this sampling event. Generally, lower Chloride concentrations in wet-weather samples are attributed to dilution from precipitation events. Seasonally, Chloride concentrations were highest during the early summer and decreased into the fall months. However, due to the lack of winter data, this trend may not be accurate if additional winter data was available.

#### *7.2.2.2.2 Nitrate*

**Figure 72** presents the EMC and dry-weather grab results for Nitrate at Voisin Creek (VS1) during 2019 while **Table 7-25** summarizes the annual average, minimum and maximum concentrations.

Table 7-25 Voisin Creek (VS1) – Nitrate Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.252 | 0.116 | 0.391 |
| Dry (Grab) | 0.629 | 0.376 | 0.860 |

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 (0.629 mg/L) was below the PWQO but higher when compared to the EMC average concentration (0.252 mg/L). When compared to the 2018 Nitrate concentrations at Voisin Creek, a similar trend is seen between the wet-weather and dry-weather average concentrations. Nitrate concentrations from the EMC samples (i.e., wet-weather samples) were lower than dry-weather samples likely due to dilution during precipitation events.

#### *7.2.2.2.3 Phosphorus*

##### *Total Phosphorus*

**Figure 73** displays the EMC and dry-weather grab results for Total Phosphorus at Voisin Creek (VS1) during 2019 while **Table 7-26** summarizes the annual average, minimum and maximum concentrations.

Table 7-26 Voisin Creek (VS1) – Total Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.289 | 0.092 | 0.507 |
| Dry (Grab) | 0.082 | 0.026 | 0.168 |

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 fall. In comparison to Total Phosphorus concentrations at Voisin Creek (VS1) in 2018, 2019 results showed comparable values, with a slight increase in average EMC concentration in 2019 (from 0.216 mg/L in 2018) as well as a slight increase in dry-weather average (from 0.067 mg/L in 2018). Seasonally, Total Phosphorus was low during early spring, with an increase into the summer months, with a few minor sporadic decreases during late summer/early fall. 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*

**Figure 74** displays the EMC and dry-weather grab results for Dissolved Phosphorus at Voisin Creek (VS1) during 2019 while **Table 7-27** summarizes the annual average, minimum and maximum concentrations.

Table 7-27 Voisin Creek (VS1) – Dissolved Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.061 | 0.008 | 0.118 |
| Dry (Grab) | 0.071 | 0.021 | 0.168 |

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 (0.071 mg/L) is above the PWQO and above the annual EMC average of 0.061 mg/L for 2019. This is contrary to what was observed for Dissolved Phosphorus in 2018 where the EMC average concentration was higher than the dry-weather average concentration. Seasonally, the trends at Voisin Creek (VS1) reveal higher Dissolved Phosphorus levels during the summer and early fall months when aquatic life is most productive.

### *7.2.2.2.4 Metals*

#### *Copper*

**Figure 75** displays the EMC and dry-weather grab results at Voisin Creek (VS1) during 2019 while **Table 7-28** summarizes the annual average, minimum and maximum concentrations.

Table 7-28 Voisin Creek (VS1) – Copper Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.021 | 0.013 | 0.033 |
| Dry (Grab) | 0.005 | ND | 0.011 |

All samples collected at Voisin Creek (VS1) in 2019 were above the PWQO for Copper (0.005 mg/L), with the exception of two dry-weather samples collected in the fall. The annual average dry-weather Copper concentration (0.005 mg/L) was lower compared to the annual EMC concentration of 0.021 mg/L in 2019. These trends are similar to those observed in 2018. Seasonally, Copper concentrations experienced a peak during the summer months and lower levels during the spring and fall.

### *Lead*

**Figure 76** displays the Lead EMC and dry-weather grab results at Voisin Creek (VS1) during 2019 while **Table 7-29** summarizes the annual average, minimum and maximum concentrations.

Table 7-29 Voisin Creek (VS1) – Lead Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0091 | 0.0033 | 0.0154 |
| Dry (Grab) | 0.0012 | ND | 0.0030 |

All of the EMC samples exceeded the PWQO for Lead (0.005 mg/L) with the exception of one spring sample, while all dry-weather samples were below the PWQO. The annual average dry-weather Lead concentration (0.0012 mg/L) was lower when compared to the annual average EMC concentration of 0.0091 mg/L in 2019. This is similar to what was observed for Lead at Voisin Creek (VS1) in 2018. Similar to the seasonal trend observed for Copper, Lead concentrations were highest during the summer months when water levels were at their lowest creating a concentrated effect on the watercourse.

### *Zinc*

**Figure 77** displays the EMC and dry-weather grab results for Zinc at Voisin Creek (VS1) during 2019 and **Table 7-30** summarizes the annual average, minimum and maximum concentrations.

Table 7-30 Voisin Creek (VS1) – Zinc Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.096 | 0.052 | 0.152 |
| Dry (Grab) | 0.010 | ND | 0.024 |

All sample results, with the exception of two dry-weather grab samples in the fall, were above the PWQO for Zinc (0.02 mg/L). The annual average dry-weather Zinc concentration (0.010 mg/L) was lower compared to the annual EMC concentration of 0.096 mg/L in 2019, as well as below the PWQO limit. Similar to the seasonal trends observed for both Copper and Lead, Zinc concentrations were highest throughout the summer when water levels were at their lowest, creating a concentrated effect on the watercourse.

### *7.2.2.2.5 Total Suspended Solids*

**Figure 78** displays the TSS EMC and dry-weather grab results at Voisin Creek (VS1) during 2019 and **Table 7-31** summarizes the annual average, minimum and maximum concentrations. 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 78** because no background level data was established as part of the 2019 SWM Monitoring Program.

Table 7-31 Voisin Creek (VS1) – TSS Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 185.2 | 93.6 | 388.0 |
| Dry (Grab) | 7.7 | 3.6 | 14.5 |

The annual site average for TSS at Voisin Creek (VS1) was 136.8 mg/L. The annual average dry-weather TSS concentration (7.7 mg/L) was considerably lower compared to the annual EMC average concentration of 185.2 mg/L. Seasonal trends show TSS to be highest during the 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 2018 TSS monitoring at Voisin Creek (VS1).

#### 7.2.2.3 North Strasburg Creek (SB2)

Based on the 2019 temperature monitoring data, North Strasburg Creek is currently classified as a cold to cold-coolwater creek located in the southwest portion of the City. North 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 subwatershed is residential, and recreational land, but majority of the catchment does not receive stormwater treatment. In 2010, the North Branch of Strasburg Creek underwent significant improvements in aquatic environments as part of the Strasburg Creek Rehabilitation Brigadoon Pond.

EMC samples were collected at North Strasburg Creek (SB2) during eight wet-weather events. Additionally, three dry-weather grab samples were collected. As mentioned in **Section 7.2.1**, Chloride sample results for monitoring location SW8 as part of the Battler Road SSDF Monitoring Program are presented with the 2019 data to provide greater year-round context to the site. The following sections present the sample results for each parameter for Strasburg Creek (SB2).

##### *7.2.2.3.1 Chloride*

**Figure 79** displays the Chloride EMC and dry-weather grab results at North Strasburg Creek (SB2) for 2019 and **Table 7-32** summarizes the annual average, minimum and maximum concentrations.

Table 7-32 Strasburg Creek (SB2) – Chloride Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 98.40 | 61.70 | 141.00 |
| Dry (Grab) | 95.33 | 90.50 | 101.00 |

All sample results for North Strasburg Creek (SB2) were below the Short Term (640 mg/L) and only two EMC samples exceeded the Long Term Concentration Limit (120 mg/L) set by the CCME. The annual average dry-weather Chloride concentration (95.33 mg/L) was comparable to the average EMC concentration of 98.40 mg/L. The results from monitoring location SW8 (Battler Road SSDF Monitoring Program) are consistent with the results observed at North Strasburg Creek (SB2) and provides a comparable year-round view of the site. Seasonally, Chloride concentrations were highest during the early spring and decreased over the summer and fall months when no road de-icing activities occur.

#### *7.2.2.3.2 Nitrate*

**Figure 80** displays the EMC and dry-weather grab results for Nitrate at North Strasburg Creek (SB2) during 2019 and **Table 7-33** summarizes the annual average, minimum and maximum concentrations.

Table 7-33 Strasburg Creek (SB2) – Nitrate Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.575 | 0.374 | 0.754 |
| Dry (Grab) | 1.293 | 1.200 | 1.390 |

All sample results were well below the Nitrate guideline set by the CCME (13 mg/L). The annual average dry-weather Nitrate concentration (1.293 mg/L) was higher compared to the Nitrate annual EMC average concentration of 0.575 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 events.

#### *7.2.2.3.3 Phosphorus*

##### *Total Phosphorus*

**Figure 81** displays the EMC and dry-weather grab results for Total Phosphorus at North Strasburg Creek (SB2) during 2019 and **Table 7-34** summarizes the annual average, minimum and maximum concentrations.

Table 7-34 Strasburg Creek (SB2) – Total Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.058 | 0.035 | 0.097 |
| Dry (Grab) | 0.017 | 0.009 | 0.026 |

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 (0.017 mg/L) was below the PWQO and lower when compared to the annual EMC average concentration of 0.058 mg/L in 2019. Seasonally, Total Phosphorus concentrations were higher in the spring and summer and lower in the fall, with the exception of one sample collected in early October. This seasonal relationship could be attributed to the application of fertilizers in the spring and summer months.

### *Dissolved Phosphorus*

**Figure 82** displays the EMC and dry-weather grab results for Dissolved Phosphorus at North Strasburg Creek (SB2) during 2019 and **Table 7-35** summarizes the annual average, minimum and maximum concentrations.

Table 7-35 Strasburg Creek (SB2) – Dissolved Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.010 | 0.006 | 0.027 |
| Dry (Grab) | 0.014 | 0.004 | 0.026 |

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 (0.014 mg/L) was comparable to the EMC average concentration of 0.010 mg/L in 2019. No seasonal trends were observed for Dissolved Phosphorus in 2019.

### *7.2.2.3.4 Metals*

### *Copper*

**Figure 83** displays the Copper EMC and dry-weather grab results at North Strasburg Creek (SB2) during 2019 and **Table 7-36** summarizes the annual average, minimum and maximum concentrations.

Table 7-36 Strasburg Creek (SB2) – Copper Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.005 | 0.003 | 0.011 |
| Dry (Grab) | ND | ND | ND |

All sample results were below the PWQO for Copper (0.005 mg/L), with the exception of two samples collected in early spring and early fall. Seasonally, Copper concentrations were highest during the spring period which is likely influenced by the spring melt flush effect, as well as during the summer period when lower water levels create a concentrated effect on the watercourse.

### *Lead*

**Figure 84** displays the Lead EMC and dry-weather grab results at North Strasburg Creek (SB2) during 2019 and **Table 7-37** summarizes the annual average, minimum and maximum concentrations.

### Table 7-37 Strasburg Creek (SB2) – Lead Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0010 | 0.0006 | 0.0017 |
| Dry (Grab) | 0.0001 | 0.0001 | 0.0002 |

All sample results were well below the PWQO for Lead (0.005 mg/L). The annual average dry-weather Lead concentration (0.0001 mg/L) was lower compared to the annual EMC average concentration of 0.0010 mg/L in 2019. Seasonally, Lead concentrations were generally highest during the summer period when water levels were at their lowest, creating a concentrated effect on the watercourse. The maximum lead concentration in 2019 was on August 21, 2019 which coincides with a precipitation event. Similarly observed with the Copper results, the wet-weather samples had higher concentrations of Copper compared to the dry-weather samples.

#### *Zinc*

**Figure 85** displays the Zinc EMC and dry-weather grab results at North Strasburg Creek (SB2) during 2019 and **Table 7-38** summarizes the annual average, minimum and maximum concentrations.

### Table 7-38 Strasburg Creek (SB2) – Zinc Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0138 | 0.0089 | 0.0184 |
| Dry (Grab) | ND | ND | ND |

None of the sample results exceeded the PWQO of 0.02 mg/L at North Strasburg Creek (SB2). The annual dry-weather average ("Non-Detect") was lower compared to the annual EMC concentration of 0.0138 mg/L in 2019. Similar to the trends observed for Copper and Lead, the wet-weather samples had higher concentrations of Zinc compared to the dry-weather samples.

#### *7.2.2.3.5 Total Suspended Solids*

**Figure 86** displays the TSS EMC and dry-weather grab results at North Strasburg Creek (SB2) during 2019 and **Table 7-39** summarizes the annual average, minimum and maximum concentrations. 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 86** because no background data was established as part of the 2019 SWM Monitoring Program.

Table 7-39 Strasburg Creek (SB2) – TSS Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 36.25 | 16.00 | 59.90 |
| Dry (Grab) | 2.17 | ND | 4.40 |

TSS concentrations for North Strasburg Creek (SB2) ranged from "Non-Detect" which was assigned a value of 0 mg/L to 59.9 mg/L with an annual average of 26.95 mg/L for 2019. The annual average dry-weather TSS concentration (2.17 mg/L) was significantly lower compared to the annual EMC average concentration of 36.25 mg/L in 2019. Seasonally, TSS concentrations were highest during wet-weather events in the spring and summer and decreased during the fall.

### 7.2.2.4 Sandrock Greenway (SR2)

Sandrock Greenway (SR2) is a coolwater creek (confirmed with 2019 temperature monitoring) located just south of Highland Road West and west of Fisher Hallman Road. The primary land use of the subwatershed 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).

#### *7.2.2.4.1 Chloride*

**Figure 87** displays the Chloride EMC and dry-weather grab results at Sandrock Greenway (SR2) for 2019 and **Table 7-40** summarizes the annual average, minimum and maximum concentrations.

Table 7-40 Sandrock Greenway (SR2) – Chloride Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 126.9 | 67.1 | 296.0 |
| Dry (Grab) | 573.0 | 271.0 | 757.0 |

All sample results were below the CCME Short Term Limit (640 mg/L) with the exception of two out of three of the dry-weather samples. Three wet-weather samples and all dry-weather samples exceeded the CCME Long Term Limit (120 mg/L). The annual average dry-weather Chloride concentration (573 mg/L) was higher compared to the average EMC concentration of 126.9 mg/L in 2019 due to the lack of dilution from precipitation events. Seasonally, Chloride concentrations were the highest during the early spring season, with the exception of two dry-weather samples, one in July and one in November, and one wet-weather samples in early October.

#### *7.2.2.4.2 Nitrate*

**Figure 88** displays the EMC and dry-weather grab results for Nitrate at Sandrock Greenway (SR2) during 2019 and **Table 7-41** summarizes the annual average, minimum and maximum concentrations.

Table 7-41 Sandrock Greenway (SR2) – Nitrate Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.68 | 0.27 | 2.11 |
| Dry (Grab) | 0.38 | 0.04 | 0.89 |

All results were well below the Nitrate guideline set by the CCME (13 mg/L). The annual average dry-weather Nitrate concentration (0.38 mg/L) was lower compared to the Nitrate annual EMC concentration of 0.68 mg/L in 2019. The maximum Nitrate concentration during 2019 occurred during the October 1, 2019 wet-weather sampling event. No distinct seasonal trends were identified during the 2019 monitoring.

#### *7.2.2.4.3 Phosphorus*

##### *Total Phosphorus*

**Figure 89** displays the EMC and dry-weather grab results for Total Phosphorus at Sandrock Greenway (SR2) during 2019 and **Table 7-42** summarizes the annual average, minimum and maximum concentrations.

Table 7-42 Sandrock Greenway (SR2) – Total Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.138 | 0.072 | 0.211 |
| Dry (Grab) | 0.130 | 0.025 | 0.273 |

All sample results were above the PWQO Total Phosphorus limit (0.03 mg/L) with the exception of one dry-weather grab collected in November. The annual average dry-weather Total phosphorus concentration (0.130 mg/L) was comparable to the annual EMC concentration of 0.138 mg/L in 2019. Seasonally, no trend for Total Phosphorus was apparent.

##### *Dissolved Phosphorus*

**Figure 90** displays the EMC and dry-weather grab results for Dissolved Phosphorus at Sandrock Greenway (SR2) during 2019 and **Table 7-43** summarizes the annual average, minimum and maximum concentrations.

Table 7-43 Sandrock Greenway (SR2) – Dissolved Phosphorus Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.046 | 0.008 | 0.106 |
| Dry (Grab) | 0.121 | 0.011 | 0.273 |

All sample results for Dissolved Phosphorus exceeded the PWQO for Total Phosphorous (0.03 mg/L), with the exception of three EMC samples and one dry-weather sample. As a result, both the dry-weather and EMC average concentrations exceeded the PWQO for Total Phosphorus. The annual average dry-weather Dissolved Phosphorus concentration (0.121 mg/L) was above the annual EMC average concentration of 0.046 mg/L in 2019. Seasonally, Dissolved Phosphorus concentrations were elevated during the spring and fall and lower during the summer.

#### *7.2.2.4.4 Metals*

##### *Copper*

**Figure 91** displays the Copper EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2019 and **Table 7-44** summarizes the annual average, minimum and maximum concentrations.

Table 7-44 Sandrock Greenway (SR2) – Copper Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0117 | 0.0083 | 0.0154 |
| Dry (Grab) | 0.0009 | ND | 0.0028 |

All wet-weather samples exceeded the PWQO for Copper (0.005 mg/L) while all dry-weather samples were below the PWQO. The annual average dry-weather Copper concentration (0.0009 mg/L) was lower compared to the annual EMC average concentration of 0.0117 mg/L in 2019. Seasonally, no trend was observed regarding Copper concentrations.

##### *Lead*

**Figure 92** displays the Lead EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2019 and **Table 7-45** summarizes the annual average, minimum and maximum concentrations.

Table 7-45 Sandrock Greenway (SR2) – Lead Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0018 | 0.00038 | 0.0028 |
| Dry (Grab) | 0.0001 | ND | 0.0002 |

All sample results were below the PWQO Lead limit (0.005 mg/L). The annual average dry-weather Lead concentration (0.0001 mg/L) was considerably lower compared to the EMC average concentration of 0.0018 mg/L in 2019. Similar to Copper, there was no notable seasonal trend in Lead concentrations at Sandrock Greenway (SR2).

##### *Zinc*

**Figure 93** displays the Zinc EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2019 and **Table 7-46** summarizes the annual average, minimum and maximum concentrations.

Table 7-46 Sandrock Greenway (SR2) – Zinc Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 0.0322 | 0.0169 | 0.0441 |
| Dry (Grab) | 0.0017 | ND | 0.0052 |

All but one of the wet-weather sample results exceeded the PWQO of 0.02 mg/L at Sandrock Greenway (SR2). None of the dry-weather samples exceeded the PWQO. The annual dry-weather average (0.0017 mg/L) was lower compared to the annual EMC average concentration of 0.0322 mg/L in 2019. Similar to Copper and Lead, no seasonal trend was obvious for Zinc concentrations in the watercourse.

#### *7.2.2.4.5 Total Suspended Solids*

**Figure 94** displays the TSS EMC and dry-weather grab results at Sandrock Greenway (SR2) during 2019 and **Table 7-47** summarizes the annual average, minimum and maximum concentrations. 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 94** because no background data was established as part of the 2019 SWM Monitoring Program.

Table 7-47 Sandrock Greenway (SR2) – TSS Summary

| Sample Type | Annual Average (mg/L) | Minimum Concentration (mg/L) | Maximum Concentration (mg/L) |
|---|---|---|---|
| Wet (EMC) | 63.7 | 8.0 | 112.0 |
| Dry (Grab) | 5.3 | 2.5 | 9.8 |

The annual average dry-weather TSS concentration (5.3 mg/L) was considerably lower when compared to the annual EMC average concentration of 63.7 mg/L in 2019. The highest wet-weather TSS concentration was seen during the spring (June 6, 2019), with the lowest wet-weather TSS concentration seen during the fall (October 1, 2019). There was no overall seasonal trend for TSS at Sandrock Greenway (SR2). Generally, TSS concentrations were higher during wet-weather results compared to dry-weather results.

# 8. Historical Trends

Historical trends have been identified by comparing sites monitored in 2019 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 8-1**. As per the recommendation of the 2018 SWM Monitoring Program, Sandrock Greenway (SR2) and North Strasburg Creek (SB2) have been established as long-term monitoring stations in 2019 and will act as representative warmwater and coldwater stations for historical trend comparisons.

## Table 8-1 Historical Sites

| Station | Years of Available Data | | |
|---|---|---|---|
| | Dry | Wet | EMC |
| Lower Schneider Creek (SC1) | 15 | 13 | 1 |
| Sandrock Greenway (SR2) | 13 | 9 | 2 |
| North Strasburg Creek (SB2) | 16 | 12 | 2 |

The historical trends presented in the 2019 SWM Monitoring Report remain consistent with the 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.

## 8.1 Lower Schneider Creek (SC1)

**Figure 95** and **Figure 96** display the historic measurements of Chloride and TSS at Lower Schneider Creek (SC1) for wet and dry-weather events, as well as Event Mean Concentration data collected at this site. Lower Schneider Creek (SC1) is the only monitoring location with 15 straight years of data (i.e., annual no data gaps), as seen in the historical summary provided in **Table 8-2**. In 2014, only two samples were collected while other years (2010 to 2016) had a minimum of 10 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 samples were collected from in 2018 and 2019 when only three dry-weather samples were collected per year. Wet-weather sampling was completed through

EMC monitoring in 2017 and is scheduled for monitoring in 2020 as the Lower Schneider Creek (SC1) site will become a long-term monitoring station, therefore wet-weather EMC samples will be collected at this site for the foreseeable future.

Table 8-2 Historical Summary – Lower Schneider Creek (SC1)

| Year | Chloride | | | TSS | | |
|---|---|---|---|---|---|---|
| | Average (mg/L) | Minimum (mg/L) | Maximum (mg/L) | Average (mg/L) | Minimum (mg/L) | Maximum (mg/L) |
| 2004 | 167 | 152 | 194 (wet) | - | - | - |
| 2005 | 189 | 33.6 | 268 (dry) | 95.5 | 2 | 189 (wet) |
| 2006 | 177 | 93.8 | 246 (dry) | 8.8 | 5.5 | 15.1 (wet) |
| 2007 | 261 | 105 | 507 (wet) | 24 | 4.2 | 80.6 (dry) |
| 2008 | 182 | 70 | 310 (dry) | 55.8 | ND | 980 (wet) |
| 2009 | 179 | ND | 480 (dry) | 0.9 | ND | 6 (dry) |
| 2010 | 269 | 54.1 | 850 (dry) | 9.7 | 1 | 130 (wet) |
| 2011 | 195 | 16.2 | 426 (wet) | 83.1 | 9.6 | 141 (wet) |
| 2012 | 134 | 33.1 | 254 (dry) | 189 | 158 | 240 (wet) |
| 2013 | 176 | 50.7 | 289 (dry) | - | - | - |
| 2014 | 328 | 152 | 1050 (dry) | - | - | - |
| 2015 | 196 | 196 | 196 (wet) | - | - | - |
| 2016 | 233 | 88.9 | 337 (dry) | - | - | - |
| 2017 | 175 | 81.3 | 304 (dry) | 105 | 2.8 | 256 (EMC) |
| 2018 | 362 | 293 | 473 (dry) | 1.6 | ND | 2.6 (dry) |
| 2019 | 344 | 280 | 382 (dry) | 8.1 | 2.1 | 15.2 (dry) |

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 2014 with a value of 1050 mg/L. Dry-weather Chloride concentrations have generally remained consistent around the 300-400 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 2010 with a value of 850 mg/L. The 2018 Chloride dry-weather grab sample concentrations ranges from 293 mg/L to 473 mg/L. Similarly, the 2019 Chloride dry-weather grab sample concentrations ranges from 280 mg/L to 382 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. Historical wet-weather grab samples ranged from “Not-Detect” which was assigned a value of 0 mg/L to 980 mg/L. The 2018 TSS dry-weather grab sample concentrations ranged from “Not-Detect” which was assigned a value of 0 mg/L to 2.6 mg/L. The 2019 TSS dry-weather grab sample concentrations ranged from 2.1 mg/L to 15.2 mg/L. This range is much larger than the observed TSS range in 2018. It should be noted that no wet-weather grab samples have been collected from Lower Schneider Creek (SC1) since 2012.

## 8.2 Sandrock Greenway (SR2)

**Figure 97** and **Figure 98** provide the historical measurements of Chloride and TSS at Sandrock Greenway (SR2) for wet-weather, dry-weather and EMC (2016 and 2019) events. No data is available from 2003 to 2007, as seen in the historical summary provided in **Table 8-3**. 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 samples were collected in 2017 and 2018 when only three dry-weather samples were collected. 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.

Table 8-3 Historical Summary – Sandrock Greenway (SR2)

| Year | Chloride | | | TSS | | |
|---|---|---|---|---|---|---|
| | Average (mg/L) | Minimum (mg/L) | Maximum (mg/L) | Average (mg/L) | Minimum (mg/L) | Maximum (mg/L) |
| 2002 | 136 | 36.4 | 327 (dry) | 21.5 | 1 | 48 (wet) |
| 2008 | 218 | 47.5 | 348 (dry) | 5.3 | 1 | 8.6 (wet) |
| 2009 | 223 | 11.6 | 492 (dry) | 29.1 | 5.5 | 68.5 (wet) |
| 2010 | 221 | 4.5 | 472 (dry) | 33.2 | 3 | 85.8 (wet) |
| 2011 | 259 | 40.5 | 452 (dry) | 9.2 | ND | 41.2 (wet) |
| 2012 | 357 | 11.7 | 2090 (dry) | 58.5 | 2.8 | 290 (wet) |
| 2013 | 130 | 10.7 | 319 (wet) | 14.2 | ND | 72 (wet) |
| 2014 | 255 | 35.4 | 474 (dry) | 25 | 3.2 | 46.8 (wet) |
| 2015 | 284 | 28.6 | 706 (dry) | 31.5 | ND | 150 (wet) |
| 2016 | 183 | 32.2 | 495 (dry) | 71.8 | 3.2 | 240 (EMC) |
| 2017 | 320 | 243 | 440 (dry) | 3 | 2.2 | 3.8 (dry) |
| 2018 | 427 | 382 | 503 (dry) | 2.2 | ND | 3.8 (dry) |
| 2019 | 249 | 67 | 757 (dry) | 47.8 | 2.5 | 112 (EMC) |

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 (2018 and 2019). 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. 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 therefore the most representative of the effects of de-icing activities. The second winter sample was collected on January 11, 2013 with a Chloride concentration of 114 mg/L. The EMC values for 2016 ranged from 32 mg/L to 251 mg/L. The EMC values for 2019 ranged from 67.1 mg/L to 296 mg/L, showing a similar trend to what was observed in 2016. The 2019 dry-weather grab concentrations ranged from 271 mg/L to 757 mg/L, which are slightly elevated compared to the 2018 grab sample results (382 mg/L to 503 mg/L).

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 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 mg/L. The EMC data collected in 2016 ranged from 20 mg/L to 240 mg/L. The EMC data collected in 2019 ranged from 8 mg/L to 112 mg/L which is lower than what was observed during the 2016 monitoring.

## 8.3 North Strasburg Creek (SB2)

**Figure 99** and **Figure 100** display the historic measurements of Chloride and TSS at North Strasburg Creek (SB2) for wet and dry-weather events, as well as EMC data (2015 and 2019) collected at this site. No data is available for 2018, as seen in the historical summary provided in **Table 8-4**. 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 in 2016 and 2017 when only three dry-weather samples were collected. In 2019, the North 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.

Table 8-4 Historical Summary – North Strasburg Creek (SB2)

| Year | Chloride | | | TSS | | |
|---|---|---|---|---|---|---|
| | Average (mg/L) | Minimum (mg/L) | Maximum (mg/L) | Average (mg/L) | Minimum (mg/L) | Maximum (mg/L) |
| 2002 | 33.2 | 27.7 | 36.7 (wet) | 13.5 | 2.0 | 46 (wet) |
| 2003 | 32.3 | 26.8 | 40.7 (wet) | 14.3 | 1.0 | 42 (dry) |
| 2004 | 24 | ND | 48 (dry) | - | - | - |
| 2005 | 172.5 | 70.9 | 355 (dry) | 16.5 | 2.5 | 42.8 (wet) |
| 2006 | 126.6 | 45.0 | 222 (dry) | 17.8 | 3.8 | 36.4 (wet) |
| 2007 | 91.9 | 57.8 | 121 (dry) | 302.2 | 4.8 | 1770 (wet) |
| 2008 | 59.0 | 33.3 | 107 (wet) | 14.0 | 7.4 | 29 (wet) |
| 2009 | 42.7 | 36.8 | 46.8 (dry) | 10.8 | 4.8 | 26 (wet) |
| 2011 | 52.7 | 36.9 | 62.9 (wet) | 5.2 | ND | 22.8 (wet) |
| 2012 | 62.7 | 45.9 | 154 (dry) | 3.9 | ND | 18.8 (wet) |
| 2013 | 63.3 | 52.6 | 102 (dry) | 30.9 | ND | 177 (wet) |
| 2014 | 66.5 | 64.5 | 68.5 (dry) | 10.8 | 2 | 19.6 (wet) |
| 2015 | 71.8 | 64.0 | 78 (EMC) | 16.9 | ND | 41.9 (EMC) |
| 2016 | 74.5 | 66.4 | 88.1 (dry) | 1.6 | ND | 3.2 (dry) |
| 2017 | 74.2 | 66.8 | 80.1 (dry) | 3.9 | 3.9 | 4.9 (dry) |
| 2019 | 97.6 | 61.7 | 141 (EMC) | 27.4 | 2.1 | 59.9 (EMC) |

As presented on **Figure 99**, 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 2005 with a value of 355 mg/L. The maximum Chloride value has continued to decrease in subsequent monitoring years. The 2019 dry-weather grab sample Chloride concentrations ranged from 90.5 mg/L to 101 mg/L, this is higher when compared to the dry-weather sampling results in 2017 which ranged from 66.8 mg/L to 80.1 mg/L but still below the CCME long-term guideline of 120 mg/L. 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 North Strasburg Creek (SB2) site. Winter results for SW8 have been included on **Figure 99** for reference, as per the recommendation of the 2018 SWM Monitoring Program.

**Figure 100** displays the general trend 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 2013 with a value of 28 mg/L. Wet-weather measurements in 2007 resulted in the maximum TSS concentration of 1,770 mg/L (not shown on figure), with the next highest concentration of 177 mg/L observed in 2013. The 2019 dry-weather grab TSS concentrations ranged from 2.1 mg/L to 4.4 mg/L. This range is similar to what was observed in 2017 (2.9 mg/L to 4.9 mg/L). The 2019 wet-weather TSS concentrations ranged from 16.0 mg/L to 59.9 mg/L.

# 9. Biological Monitoring

As part of the 2019 SWM Monitoring Program, both fish and benthic invertebrate surveys were conducted. Benthic invertebrate monitoring occurred at a total of 5 stations (SB2, SC1, SR2, VS1 and WD1) while fish community monitoring occurred at four stations (SB2, SR2, VS1 and WD1). The dates of the biological monitoring are presented in **Table 9-1**.

Also included in the analysis was the data from a Blair Creek station (Station 2414047 – Blair Creek Upstream of Highway 401) sampled by GRCA. As noted previously (in **Section 5**), the headwaters of Blair Creek systems is the most untouched local 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.

Table 9-1 Biological Monitoring Events

| Station | Watercourse | Thermal Regime | Benthic Monitoring Date | Fish Monitoring Date |
|---|---|---|---|---|
| SB2 | North Strasburg Creek | Cold-Coolwater | July 16, 2019 | July 22, 2019 |
| SC1 | Lower Schneider Creek | Warmwater | July 16, 2019 | n/a |
| SR2 | Sandrock Greenway | Coolwater | July 15, 2019 | July 22, 2019 |
| VS1 | Voisin Creek | Coolwater | July 15, 2019 | July 22, 2019 |
| WD1 | Westmont Creek | Cold-Coolwater | July 16, 2019 | July 24, 2019 |

***Note:***

1. Lower Schneider Creek (SC1) was designated as a “dry-weather sampling and benthic” station in 2019; therefore no fish monitoring was conducted in 2019.

## 9.1 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 7 to 10 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.

## 9.2 Benthic Invertebrate Monitoring

### 9.2.1 Benthic Invertebrate Monitoring Field Methodology

The five core 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 all 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, 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 then 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**.

The Blair Creek benthic invertebrate samples, as per **Section 5**, were field processed, preserved, and analyzed by an experienced taxonomist in a similar manner.

### 9.2.2 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, and 2019 and a second with only the 2019 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, 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)

#### 9.2.2.1 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.

#### 9.2.2.2 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.

#### 9.2.2.3 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.

#### 9.2.2.4 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 9-2** illustrates the inferred water quality associated with the number of families of EPT (Mackie, 2004).

Table 9-2 EPT Value Index

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

#### 9.2.2.5 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).

### 9.2.2.6 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:

$$H' = -\sum p_i \log p_i$$

$$where\ \ p_i = \frac{n_i}{N}$$

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 9-3** 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 9-3 Shannon-Weiner Diversity Index

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

### 9.2.2.7 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 9-4.**

Table 9-4 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 |

### 9.2.3 Benthic Invertebrate Monitoring Results

Benthic invertebrate monitoring results for 2019, as well as historical trends, are provided in the following sections.

#### 9.2.3.1 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 2019 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 2019 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 3** presents a summary of the 2019 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 five SWM Monitoring Program sites. A list of all identified taxa for the 2019 monitoring season is found in **Appendix H**.

### *North Strasburg Creek (SB2)*

SB2 had the highest taxa richness and the second highest number of EPT families of all sites during the 2019 monitoring. The benthic community was diverse, with a low dominance percentage (19%). The most abundant species was Hydropsyche within the order Trichoptera. The large proportion of Hydropsyche is reflected in the high percentage of EPT species (39%) at the site. Functional feeding groups within SB2 are also diverse, with collector-gatherers being the most dominant (54%) and scrapers being the least abundant (6%). The values for both the Shannon-Weiner Diversity Index (2.73) and HBI (5.00) also indicate a diverse habitat with water quality that ranks of moderate pollution and good water quality with some organic pollution, respectively. Together, these results imply slight water quality impairment of Strasburg Creek.

### *Lower Schneider Creek (SC1)*

The benthic community at SC1 was fairly diverse, with a percentage dominant value of 30%, which is within the range of expected values for a healthy system. The most dominant species is an Isopoda from the family Asellidae. The large proportion of Asellidae is reflected in the even larger proportion of collector-gatherers (50%), as Asellidae species are characteristic collector-gatherers. Species within the family Asellidae are considered moderately tolerant to pollution and tend to increase in number under eutrophic conditions (Peckarsky et al. 1990). Percent EPT at SC1 is higher than expected, typically an indication of good water quality; however, the EPT species present are moderately tolerant of disturbance. The values for the Shannon-Weiner Diversity Index (2.46) fall within a moderate degree of organic pollution, while the HBI (6.44) indicates fair water quality indicative of fairly substantial pollution. Together, these results imply moderate water quality impairment of Lower Schneider Creek (SC1).

### *Sandrock Greenway (SR2)*

Percent Chironomidae well exceeded the upper limit of the expected value for an unimpaired system. SR2 was also highly dominated by Diptera (88%) influencing the high percentage of collector-gatherers within the community. SR2 is one of the lowest stations for percent EPT with those EPT species present considered moderately tolerant of pollution. The values for both the Shannon-Weiner Diversity Index (2.46) and HBI (7.41) also indicate impaired water quality with ranks of moderately polluted and fairly poor water quality with significant organic pollution, respectively. These results imply water quality impairment of Sandrock Greenway.

### *Voisin Creek (VS1)*

Station VS1 had the second lowest score for taxa richness, and the lowest number of EPT families. The community at VS1 was dominated with an Isopod within the family Asellidae. With an 80 percent relative abundance, *Caecidotea* sp. is the characterizing species of this low diversity benthic community, and may be considered an indicator of impairment. The large proportion of the Asellidae family is reflected in the even larger proportion of collector-gatherers, as species within Asellidae family are characterized by this feeding group. Species within the family Asellidae are considered moderately tolerant to pollution and tend to increase in number under eutrophic conditions (Peckarsky et al. 1990). The values for both the Shannon-Weiner Diversity Index (0.95) and HBI (7.88) also indicate impaired water quality with ranks of substantial pollution and poor water quality respectively. Together, these results imply water quality impairment of Voisin Creek.

### *Westmount Drain (WD1)*

WD1 had the highest total abundance of all sites, however the lowest score for taxa richness, as well as a low number of EPT. The community was dominated with an Isopod within the family Asellidae, accounting for 52 percent of the community. As mentioned previously, species within the Asellidae family are considered moderately tolerant to pollution and tend to increase in number under eutrophic conditions (Peckarsky et al. 1990). The large proportion Asellidae individuals is also reflected in the even larger proportion of collector-gatherers feeding group. A high percentage of Oligochaeta (35%) was also noted within the benthic community. The values for both the Shannon-Weiner Diversity Index (1.35) and HBI (8.43) also indicate impaired water quality with ranks of moderate pollution and poor water quality respectively. Together, these results imply water quality impairment of Westmount Drain.

#### 9.2.3.2 Benthic Invertebrate Community Trends

Historical consecutive benthic invertebrate results from 2013 to 2019 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 2019 program. As such, a comparison of the trends between SB2 and SR2 over time is provided in **Table 4**.

### *North Strasburg Creek (SB2)*

Overall water quality within North Strasburg Creek (SB2) decreased in 2014 from its 2013 conditions, but results revealed an improvement versus the 2015 – 2019 monitoring results. The 2019 values remained similar to those of previous years in SB2 for Shannon Diversity Index, indicating moderate levels of pollution. However a marked improvement in HBI is noted every year from 2015 to 2017 with 2017 values indicating good water quality with only some impact. The HBI value for 2019 increased slightly, but still signifies good water quality with some organic pollution. The percent EPT continued to increase from 2014-2018 implying an improvement in water quality and habitat. A minor decrease in percent EPT was noted in 2019, however percentages are still considered healthy. 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. This watercourse is once again considered to have one of the healthiest biological communities of the stations examined as part of this study.

***Sandrock Greenway (SR2)***

Overall water quality in Sandrock Greenway (SR2) appears consistent from 2013 conditions to the present. Compared to 2013 there has been an improvement in Shannon-Weiner Diversity Index; however, scores for HBI have slightly increased consistently from 2013 implying an increase in the presence of organic pollution and a decline in sensitive species which are typically an indication of good water quality. Percent Chironomidae are once again well above the expected values for an unimpaired system, with the 2019 percentage of Chironomidae at the highest proportion relative to all years of monitoring. As a result, the community continues to be dominated by one feeding group, collector-gatherers. Overall the monitoring consistently shows impaired water quality at Sandrock Greenway (SR2).

## 9.3 Fish Community Monitoring

### 9.3.1 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 #1092969). A copy can be found in **Appendix I**.

A single pass backpack electrofishing survey was conducted as per OSAP Section 3: Module 1 at four core monitoring sites along four creeks using a Halltech electrofisher, model HT-2000. No blocknets were installed during the fish community assessments of the core 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, conductivity, turbidity, DO, ORP, and TDS.

### 9.3.2 Fish Community Monitoring Results

Fish community monitoring results for 2019, as well as historical trends, are provided in the following sections.

#### 9.3.2.1 Fish Community

The results of the 2019 fish community survey (presented in **Table 5**), indicate a fish community similar to that of past monitoring years. Historical fisheries data from 2014 to 2019 are presented in **Table 6**.

##### *North Strasburg Creek (SB2)*

A total of ten species were identified within the study area in 2019 compared to eight species in 2017 and six species in 2016. It should be noted that in 2018, North Strasburg Creek (SB2) was not monitored for fish community. During 2016, 2017 and 2019 surveys, two coldwater species, brook trout (*Salvelinus fontinalis)* and mottled sculpin (*Cottus bairdii)* were identified at SB2, thus influencing the total species count, and increasing intolerant species percentages. No new species were identified as part of the 2019 monitoring program.

During the summer fish surveys, Strasburg Creek (SB2) scored the highest on total number of fish with 214 fish caught. This watercourse consists of a mix of intermediate, intolerant and tolerant species. Similar to previous years, this creek had high numbers of western blacknose dace (*Rhinichthys obtusus*) and mottled sculpin (*Cottus bairdii*). However, unlike previous years the most abundant species was pumpkinseed (*Lepomis gibbosus*). The total number of fish caught in 2019 was significantly higher than previous years, and the total numbers of species increased by two since 2017. The percentage of tolerant species decreased from 2017 to 2019, however the percentage of intolerant species also slightly decreased. This decrease was negatively influenced by the significantly higher total number of fish caught in 2019 compared to 2017. Seven brook trout (*Salvelinus fontinalis*), a sensitive, coldwater species were identified during the 2019 monitoring. To date, this is the highest abundance of brook trout caught at Strasburg Creek (SB2) in a single survey event.

##### *Sandrock Greenway (SR2)*

Sandrock Greenway (SR2) scored second highest on total number of fish caught of the 2019 monitoring locations, with a total catch of 58 fish. Similar to 2018, a total of five species were identified at SR2. Once again, this watercourse consisted of tolerant and intermediate tolerant species, with a mix of species that prefer coolwater and warmwater thermal regimes. Creek chub (*Semotilus atromaculatus*), white sucker (*Catostomus commersonii*) and pumpkinseed were the three most abundant species identified at Sandrock Greenway (SR2). Of all stations monitored in 2019, Sandrock Greenway (SR2) had the highest percentage of tolerant species (46.5%), indicating a fish community lacking diversity and dominated almost solely by tolerant species. However, this percentages has decreased from 54% during the 2018 monitoring program.

##### *Voisin Creek (VS1)*

Voisin Creek (VS1) scored the lowest for all categories, similar to during the 2018 monitoring, with zero fish caught at this station during the 2019 survey. Similar to 2018, the 2019 Voisin Creek results could have been influenced by the seasonally low water levels present during the summer when the field surveys were conducted.

#### *Westmount Drain (WD1)*

Westmount Drain (WD1) is a new station introduced as part of the 2019 monitoring program. A total of 25 fish were caught at WD1. This watercourse was composed of intermediate and tolerant species that prefer coolwater environments. A total of two species, namely western blacknose dace and white sucker were present within the reach. Westmount Drain had a relatively low percentage of tolerant species (16%) and no intolerant species.

### 9.3.2.2 Fish Community Trends

Consecutive historic fish community results are only available for North Strasburg Creek (SB2) and Sandrock Greenway (SR2). **Table 7** displays the similarities and differences between the 2019 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.

#### *North Strasburg Creek (SB2)*

During the 2019 monitoring, species richness at SB2 increased to a value of ten. Total number of fish caught has been increasing from year-to-year, as well as species richness. The percentage of tolerant species has decreased compared to the 2017 value. The percentage of intolerant species, namely brook trout has varied slightly over the years, however has always remained above zero. The 2019 fish survey was composed of the following species: white sucker, pumpkinseed, creek chub, fathead minnow (*Pimephales promelas),* longnose dace (*Rhinichthys cataractae*), western blacknose dace, brook stickleback (*Culaea inconstans*), mottled sculpin, bluntnose minnow (*Pimephales notatus)* and brook trout. Brook stickleback were last caught within the reach in 2015 and bluntnose minnow have never been historically recorded within North Strasburg Creek (SB2). Overall, a positive trend toward a more diverse and abundant fish community is occurring over the years within the watercourse.

#### *Sandrock Greenway (SR2)*

During the 2019 monitoring, species richness at Sandrock Greenway (SR2) remained similar to previous monitoring years with a low total value of five species. Overall, the 2019 fish community results compared closely to those of previous years, producing high percentages of tolerant species and identified zero intolerant species. The 2019 fish survey was composed of the following species: white sucker, pumpkinseed, creek chub, fathead minnow and bluntnose minnow. All species caught in 2019 were also noted in the 2018 surveys with the exception of bluntnose minnow (of which only one was caught). The total number of fish caught in 2019 was lower than 2018 but higher than 2017. Abundance values were most comparable to 2015 numbers. It should be noted that during the 2017 survey some fish were not impacted by the electric field; however, to avoid lethally harming any fish the voltage and frequency were not increased. This may have contributed to the lower numbers caught in 2017.

## 9.4 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 2019 biological monitoring results. **Table 8** contrasts the 2019 biological indicators as compared to the first 5-years study (2002 – 2006) and the second 5-years study (2007 – 2011). Maintain consistency, only historical data from two replicate sites, Sandrock Greenway (SR2) and North 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 2019 results indicate minor improvement in the results of both studies, with consistent benthic invertebrate-inferred water quality but improved fish species richness and fish community composition.

The results of both the first and second 5 years studies for North Strasburg Creek (SB2) consistently indicate a somewhat impacted system capable of supporting intolerant fish species. The 2019 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 2019 relative to that indicated by the results of the 5 year studies from the early 2000's.

# 10. SWMF Performance Monitoring

## 10.1 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 inspections of the SWMF. As per the ECA, grab samples were collected from the 600 mm diameter outfall pipe during three wet-weather rainfall events. Wet-weather events were defined as receiving a minimum of 15 mm of rain in the 24-hours prior to sampling. Further, two of the three events were required to occur between May and September. The water quality grab samples were tested for Total Suspended Solids (TSS) at ALS Laboratories in Waterloo.

## 10.2 SWMF Performance Monitoring Results

The TSS concentrations observed during the sampling events are summarized in **Table 10-1** below.

### Table 10-1 Pond 6 2019 TSS Concentrations

| Date | TSS (mg/L) | 24-hour Precipitation (mm) |
|---|---|---|
| 4/19/2019 | 14.5 | 27 |
| 8/19/2019 | 9.7 | 17.8 |
| 10/2/2019 | 21.9 | 30.2 |

***Notes:***

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

The SWMF underwent an annual inspection on October 2, 2019. The completed inspection checklist can be found in **Appendix K** along with a photo log taken during the inspection. Majority of inspected facility infrastructure were deemed in acceptable condition, along with the pond being overall in acceptable condition. Items of note included the high turbidity of water in Forebay 1, Forebay 2 and the main pond which was likely due to the precipitation event prior to inspection. In addition, excessive vegetation growth was observed in Forebay 1, Forebay 2 and the main pond. The SWMF's outlet channel was found to have excessive sediment accumulation (approximately 0.07 m inside the culvert) as well as cattail growth within the discharge channel (Photo 15). GHD recommends that the City continue to monitor the above noted items that could potentially lead to long term issues.

# 11. Overall Summary

## 11.1 Water Quality Monitoring

**Table 11-1** summarizes the water quality results of the 2019 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 11-1 Summary of 2019 SWM Water Quality Monitoring Results

| Station | 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** |
| Lower Schneider Creek (SC1) | 344 | 382 | 280 | 8.1 | 15.2 | 2.1 | 0.026 | 0.050 | 0.009 | 0.942 | 1.170 | 0.664 | 0.000 | 0.001 | 0.000 | 0.002 | 0.003 | 0.002 | 0.005 | 0.007 | 0.003 |
| Westmount Creek (WD1) | 586 | 1430 | 162 | 11.0 | 25.3 | 0.0 | 0.029 | 0.057 | 0.014 | 0.424 | 0.440 | 0.403 | 0.001 | 0.004 | 0.000 | 0.000 | 0.001 | 0.000 | 0.016 | 0.041 | 0.000 |
| Voisin Creek (VS1) | 451 | 651 | 200 | 7.7 | 14.5 | 3.6 | 0.082 | 0.168 | 0.026 | 0.629 | 0.860 | 0.376 | 0.001 | 0.003 | 0.000 | 0.005 | 0.011 | 0.000 | 0.010 | 0.024 | 0.000 |
| North Strasburg Creek (SB2) | 95 | 101 | 91 | 2.2 | 4.4 | 0.0 | 0.017 | 0.026 | 0.009 | 1.293 | 1.390 | 1.200 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sandrock Greenway (SR2) | 573 | 757 | 271 | 5.3 | 9.8 | 2.5 | 0.130 | 0.273 | 0.025 | 0.378 | 0.890 | 0.044 | 0.000 | 0.000 | 0.000 | 0.001 | 0.003 | 0.000 | 0.002 | 0.005 | 0.000 |
| Blair Creek at Reichert Dr. | 46 | 51 | 39 | 8.7 | 16.8 | 3.8 | 0.055 | 0.080 | 0.024 | 0.155 | 0.235 | 0.075 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.002 | 0.005 | 0.006 | 0.004 |
| Blair Creek at New Dundee Rd. | 47 | 62 | 21 | 51.3 | 136.0 | 4.4 | 0.268 | 0.628 | 0.039 | 0.076 | 0.180 | 0.021 | 0.002 | 0.004 | 0.000 | 0.003 | 0.009 | 0.001 | 0.011 | 0.026 | 0.004 |

***Notes:***

1. Chloride values for Blair Creek are dissolved Chloride
2. Red highlighted cells indicate the minimum concentration exceeds the CCME/PWQO guideline
3. Orange highlighted cells indicate the average concentration exceeds the CCME/PWQO guideline
4. 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 North Strasburg Creek (SB2) and Blair Creek. However, it must be noted that at Blair Creek, dissolved Chloride was analyzed by GRCA, not Total Chloride. All locations which exceeded the CCME Long-Term Exposure Limit for the average observed Chloride concentration, also exceeded for the locations 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 2019 monitoring program could not be determined.

The average concentration for Total Phosphorus exceeded the PWQO limit of 0.03 mg/L at four locations, including Blair Creek at Reichert Drive (2414044), Blair Creek at New Dundee Road (214002), Voisin Creek (VS1) and Sandrock Greenway (SR2). Blair Creek at New Dundee Road (214002) continued to exceed the PWQO limit with the annual minimum value exceeding the guideline concentration.

As seen in previous years, Nitrate concentrations continued to experience no exceedances at any of the locations. Unlike 2018, Lead experienced no exceedances at any of the monitoring locations. Copper and Zinc both had exceedances for maximum concentrations at Voisin Creek (VS1) and Blair Creek at New Dundee Road (214002). Additionally, the average Zinc concentration at Westmount Creek (WD1) exceeded the limit.

## 11.2 Water Quality Historical Trends

Historical trends have been identified by comparing sites monitored in 2019 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 North 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. 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.

## 11.3 Biological Monitoring

Fish community surveys were conducted at four stations (SB2, SR2, VS1 and WD1). Benthic invertebrate sampling was conducted at the aforementioned stations, as well as SC1. The results of these surveys and sampling were compared between watercourses. Additionally, the monitoring results of North 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*

The benthic invertebrate metrics for Blair Creek infer it to be an unimpaired system that has good water quality with slight pollution. The fish community within Blair Creek remained similar in 2019 to previous years and ultimately supports an intolerant and intermediately tolerant fish community. Overall, the 2019 results of the Blair Creek monitoring continue to indicate a healthy, relatively unimpaired system with a diverse community structure and composition.

### *Benthic Invertebrate Monitoring*

The 2019 samples at all five stations included a total of 67 taxa, which is a decrease from the total number collected in 2018 (84), however this is most likely due to the reduced number of sampling stations (seven stations in 2018 vs. five stations in 2019). Three of these taxa were new to the monitoring program, one of which has moderate tolerance and two of which have moderately-high tolerance to organic pollution. Consistent with past findings, the Chironomidae (non-biting midges) were the most abundant and diverse group. Oligochaetes (worms), Isopods (*Caecidotea*), Chironomids (commonly, *Polypedilum*, *Cricotopus*, *Conchapelopia*) and Caddisflies (Hydropsychid) were the most abundant groups in the 2019 samples. Also worth noting is that eight individuals of Dolophilodes, a caddisfly and EPT taxon, were reported at North Strasburg Creek (SB2). This species has a tolerance value of zero, the lowest possible value for a taxon indicating good water quality at North Strasburg Creek (SB2).

Two stations, Voisin Creek (VS1) and Westmount Drain (WD1) had taxa richness lower than the expected range for an unimpaired gravel-bottom creek even though abundance fell within the expected range. This is likely an indication of impaired water quality at these stations and is reflected in the dominance of the tolerant isopod *Caecidotea* sp. The number of EPT families was low, with a range of 1 to 7 families per station. Percent Shredders was also very low across all stations, and may indicate a lack of detritus within the creeks for them to feed on.

The historical benthic invertebrate results for North Strasburg Creek (SB2) and Sandrock Greenway (SR2) were also compared. North Strasburg Creek (SB2) displayed an overall improvement in water quality since 2015 with metrics showing improvement or stability from the 2018 results. At North Strasburg Creek (SB2) there was a slight decrease in the number of EPT taxa and percent EPT and a gradual improvement in Shannon-Weiner Diversity Index and HBI values. The 2019 results of Sandrock Greenway (SR2) show an increase in pollution tolerant taxa (percent Diptera and percent Chironomidae) are noted from 2018, and the number of EPT taxa and percent EPT remain very low at this location. However, overall the Sandrock Greenway (SR2) results indicate a continued trend of water quality improvement since 2013, as reflected in the Shannon-Weiner Diversity Index and HBI.

### *Fish Community Monitoring*

A total of ten species were identified within the study area compared to nine species in 2018 and eleven species during the 2016 and 2017 surveys. It should be noted that North Strasburg Creek (SB2) was once again included in the core stations during the 2019 sampling program, unlike during 2018.

North Strasburg Creek (SB2) scored the highest total number of fish with 214 fish caught as part of the 2019 survey. This watercourse consisted of a mix of intermediate, intolerant and tolerant species. The percentage of tolerant species decreased from 2017 to 2019, however the percentage of intolerant species also slightly decreased. This decrease was negatively influenced by the significantly higher total number of fish caught in 2019 compared to 2017. Seven brook trout, a sensitive, coldwater species were identified during the 2019 monitoring. To date, this is the highest abundance of brook trout caught at North Strasburg Creek (SB2).

During 2016, 2017 and 2019 surveys, coldwater brook trout and mottled sculpin were identified at North Strasburg Creek (SB2). The continued record of these species influences the total species count, increases intolerant species relative abundance in the fish community, and indicates a suitable habitat for survival of intolerant fish species. No new species were identified as part of the 2019 monitoring program.

Sandrock Greenway (SR2) scored second highest on total number of fish caught, with a total catch of 58 fish. Similar to 2018, a total of five species were identified at this station. Once again, this watercourse consisted of tolerant and intermediately tolerant species (absent any intolerant species), with a mix of species that prefer coolwater and warmwater thermal regimes. Of all stations monitored, Sandrock Greenway (SR2) had the highest percentage of tolerant species (46.5%), down from 54% during the 2018 monitoring program. This indicates an impaired system with a fish community of low diversity nearly dominated by tolerant species.

Voisin Creek (VS1) scored the lowest for all categories, as similar to during the 2018 monitoring, zero fish were caught at this station during the 2019 survey. Similar to 2018, the 2019 Voisin Creek results could have been influenced by the seasonally low water levels present during the summer when the field surveys were conducted.

Westmount Drain (WD1) is a new station introduced as part of the 2019 monitoring program. A total of 25 fish were caught within WD1. This watercourse was composed of intermediate and tolerant species that prefer coolwater environments. A total of two species, namely western blacknose dace and white sucker, were identified within the reach. Westmount Drain had a relatively low percentage of tolerant species (16%) and no intolerant species.

Annual fish community trends were identified for North Strasburg Creek (SB2) and Sandrock Greenway (SR2). At SB2 the total number of fish captured and species richness have been increasing year to year, and the percentage of tolerant species have decrease. Overall, a positive trend is occurring at this monitoring station. At SR2, the 2019 fish community results compared closely to those of previous years, producing high percentages of tolerant species, a steady taxa richness of 5 species and identified zero intolerant species.

## 11.4 SWMF Performance Monitoring

As per the City’s ECA #33882-A8WQM for Pond 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 9.7 mg/L to 21.9 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 excessive sediment accumulation.

# 12. Recommendations

Building on the recommendations as described in the *Integrated SWM-MP – Implementation Plan* (Aquafor Beech, 2016), the results of the 2016-2018 SWM Monitoring Programs, as well as feedback from the Steering Committee members, the following recommendations have been developed for the 2020 SWM Monitoring Program.

7. 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 2020 to determine if scheduled monitoring locations will be impacted.
8. Establish six (6) flow proportionate monitoring sites in 2020, as soon as weather conditions allow, at the locations below listed using City-owned ISCO autosamplers:
   a. 2020 SWM Monitoring Program: SCH1, SC1 (long-term), SC9 (long-term), VS1 (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.
9. Establish three (3) flow monitoring sites (pre-EMC) in 2020 in anticipation of the installation of autosamplers in 2021 at the following locations:
   a. 2020 SWM Monitoring Program: Borden Creek (BD1), Middle Schneider (MS1), and Melitzer Creek (MZ1)
   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.
10. 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 to represent winter conditions when road salt application is in effect and Chloride concentrations are highest.
11. 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.
12. 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.

13. GHD identified beaver activity on multiple occasions while monitoring at School Creek (SCH1). It is recommended that the City follow up on this activity.
14. During the November 12, 2019 monitoring event at Westmount Drain (WD1), GHD identified a pie discharging water of an unknown source upstream of the monitoring location. GHD recommends that the City should follow up on this and determine the source of discharge water. A sample to be collected in November 2020 may be warranted to verify chloride concentrations, however this location is no longer monitored as part of the city-wide monitoring program after 2019.
15. During the October 2, 2019 annual inspection of SWMF Pond 6, GHD noted excessive sediment accumulation as well as cattail growth in the discharge channel. GHD recommends that the City continue to monitor this as it could lead to long term issues.

# 13. References

AECOM. 2011. Five-Year Stormwater Report Card 2010 Technical Report. Prepared for the City of Kitchener. February 18, 2011.

Aquafor Beech Limited. 2016. Integrated Stormwater Management Master Plan (ISWM-MP) Municipal Class Environmental Assessment (EA). Prepared for the City of Kitchener. May 2016.

Aquafor Beech Limited. 2016. Integrated Stormwater Management Master Plan (ISWM-MP) Implementation Plan. Prepared for the City of Kitchener. October27, 2016.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Chu, C., N.E. Jones, A. R. Piggott, and J.M. Buttle. 2009. Evaluation of a Simple Method to Classify the Thermal Characteristics of Streams Using a Nomogram of Daily Maximum Air and Water Temperatures. North American Journal of Fisheries Management 29:1605-1619.

GHD Limited. 2017. 2016 Stormwater Management Monitoring Program. Prepared for the City of Kitchener. May 2, 2017.

GHD Limited. 2018. Five-Year Stormwater Report Card (2011 to 2015) – 2015 Technical Report. Prepared for the City of Kitchener. February 26, 2018.

GHD Limited. 2018. Integrated Stormwater Management Master Plan: 2017 Monitoring Program. Prepared for the City of Kitchener. May 9, 2018.

GHD Limited. 2019. Integrated Stormwater Management Master Plan: 2018 Monitoring Program. Prepared for the City of Kitchener. April 17, 2019.

GHD Limited. 2020. Draft Annual Post-Development Monitoring Summary Report – Year 3: Battler Road Snow Storage and Disposal Facility. Prepared for the City of Kitchener. February 21, 2020.

Griffiths, R.W. 1999. BioMAP: Bioassessment of Water Quality. The Centre for Environmental Training, Niagara College, Niagara-on-the-Lake, Canada, pp. 58, 78, 109, 110.

Hilsenhoff, W.L. 1982. Using a biotic index to evaluate water quality in streams. Tech. Bull. Wisconsin Dept. Nat. Resour. 132. 22 pp.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist. 20(1) 31-40.

Jones, C., K. M. Somers, B. Craig, and T. B. Reynoldson. 2007. Ontario Benthos Biomonitoring Network Protocol Manual. Ontario Ministry of Environment, Queen's Printer for Ontario, Toronto.

Mackie, G. 2004. Applied Aquatic Ecosystem Concepts. 2nd Edition. Kendall/Hunt Publishing Company. 784 pp.

Marchant, R., 1989. A subsampler for samples of benthic invertebrates. Bulletin of the Australian Society of Limnology. 12. Pp 49-52.

Merritt, R.W., K.W. Cummins, and M.B. Berg. 2008. An introduction to the aquatic insects of North America. 4th ed., Kendall/Hunt Publishing Company, Dubuque, Iowa. 1158 p.

Peckarsky, B.L., M.A. Fraissinet, M.A. Penton, and D.J. Conklin, Jr. 1990. Freshwater macroinvertebrates of Northeastern North America. Cornell Univ. Press, New York.

Stanfield, L. (ed.). 2013. Ontario Stream Assessment Protocol. Version 9.0. Fisheries Policy Section. Ontario Ministry of Natural Resources. Peterborough, Ontario. 505 Pages.

Stantec Consulting Ltd. 2009. Upper Blair Creek Functional Drainage Study. March 2009.

Stoneman, C.L., and M.L. Jones. 1996. A Simple Method to Classify Stream Thermal Stability with Singe Observations of Daily Maximum Water and Air Temperature. North American Journal of Fisheries Management 16:728-737.

TSH. 2008. Stormwater Management Audit 5 Year Report Card. Prepared for the City of Kitchener. June 2008.

All of Which is Respectfully Submitted,

GHD

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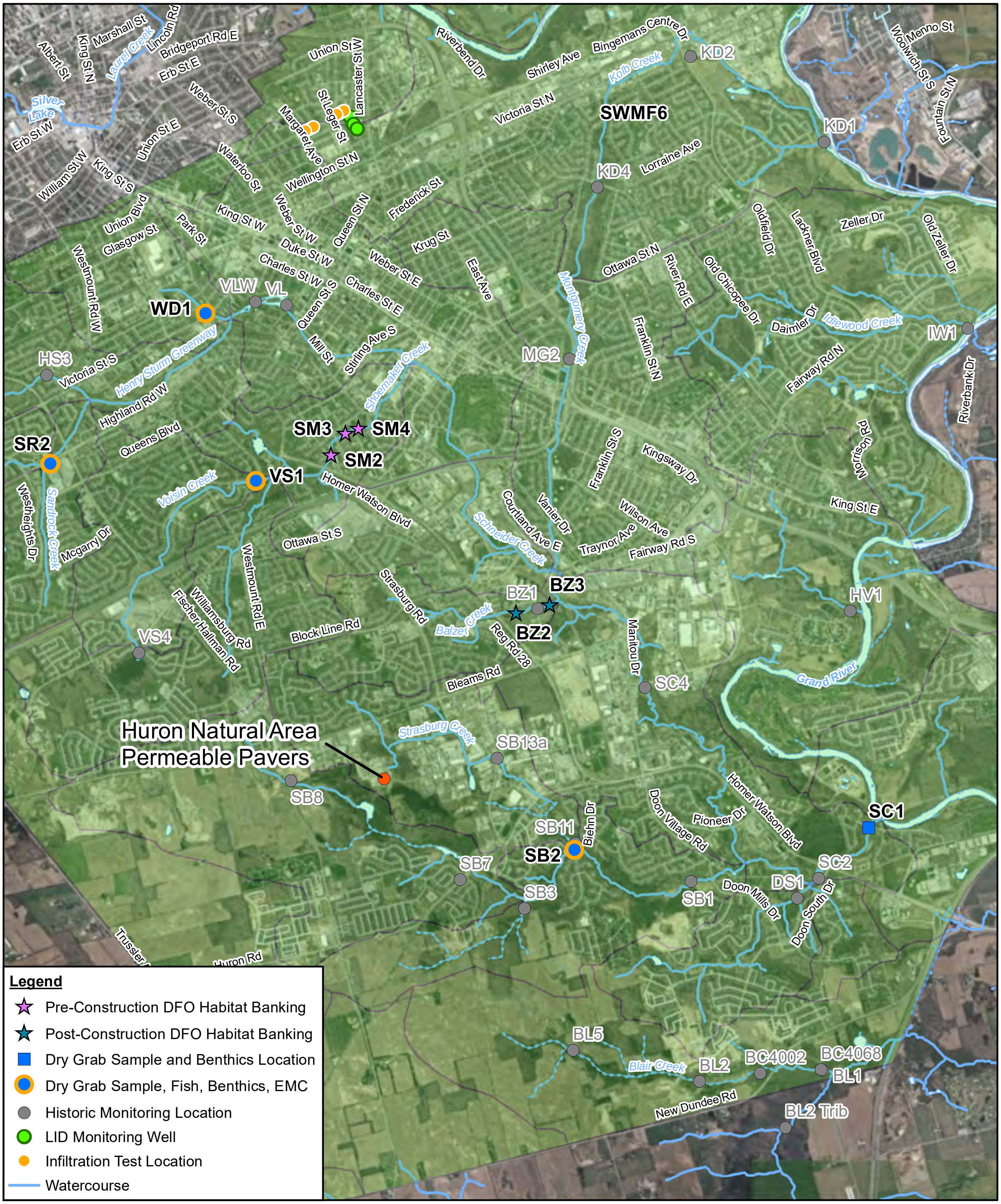
Principal, Senior Ecologist

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



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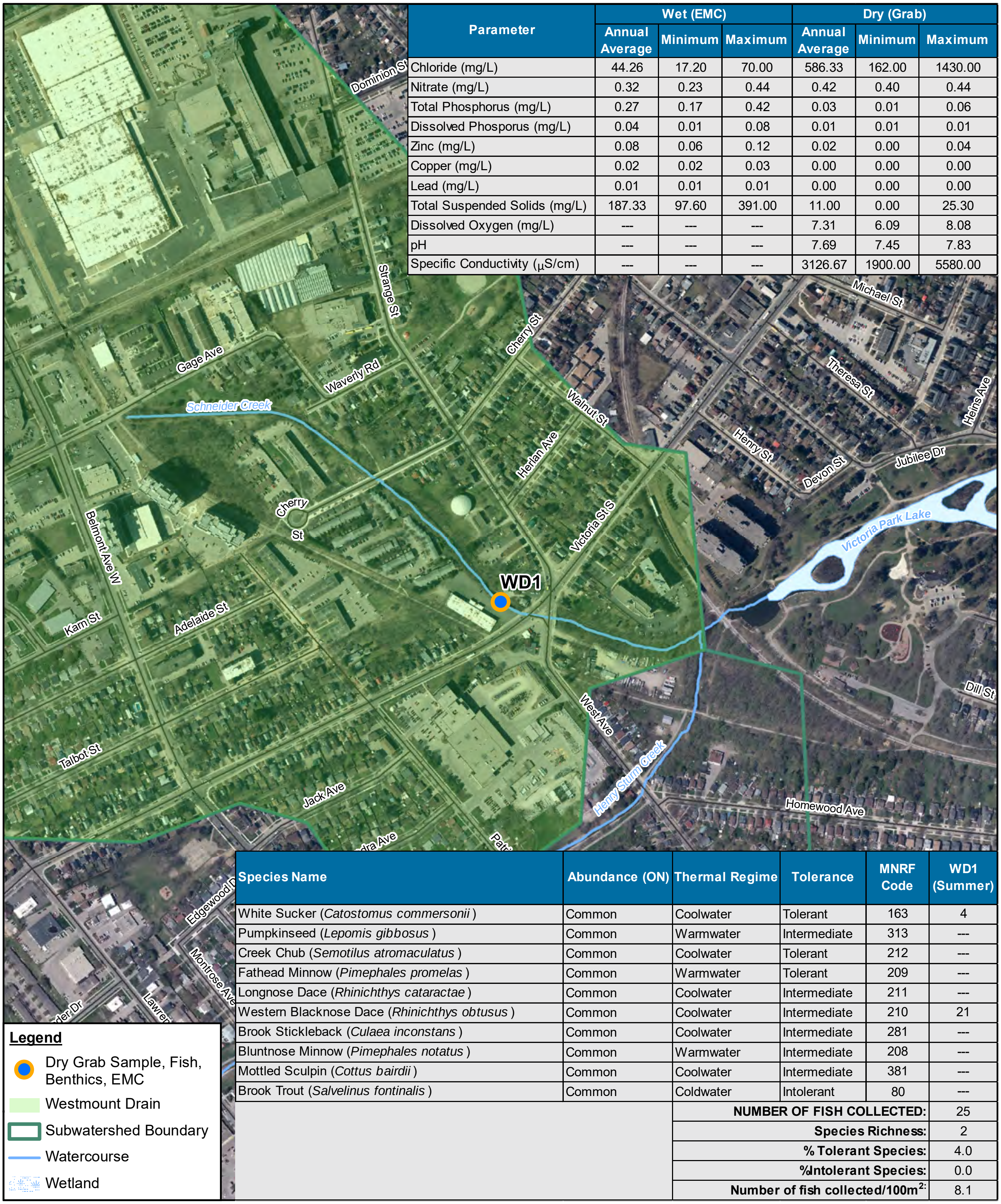
Coordinate System:
NAD 1983 UTM Zone 17N

CITY OF KITCHENER
KITCHENER, ONTARIO
2019 SWM MONITORING LOCATIONS

11193719
Jan 14, 2020

FIGURE 1

GIS File: Q:\GIS\PROJECTS\11193000s\11193719\Layouts\003\11193719-100(003)GIS-WA001.mxd



| Parameter | Wet (EMC) | | | Dry (Grab) | | |
|---|---|---|---|---|---|---|
| | Annual Average | Minimum | Maximum | Annual Average | Minimum | Maximum |
| Chloride (mg/L) | 44.26 | 17.20 | 70.00 | 586.33 | 162.00 | 1430.00 |
| Nitrate (mg/L) | 0.32 | 0.23 | 0.44 | 0.42 | 0.40 | 0.44 |
| Total Phosphorus (mg/L) | 0.27 | 0.17 | 0.42 | 0.03 | 0.01 | 0.06 |
| Dissolved Phosporus (mg/L) | 0.04 | 0.01 | 0.08 | 0.01 | 0.01 | 0.01 |
| Zinc (mg/L) | 0.08 | 0.06 | 0.12 | 0.02 | 0.00 | 0.04 |
| Copper (mg/L) | 0.02 | 0.02 | 0.03 | 0.00 | 0.00 | 0.00 |
| Lead (mg/L) | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Total Suspended Solids (mg/L) | 187.33 | 97.60 | 391.00 | 11.00 | 0.00 | 25.30 |
| Dissolved Oxygen (mg/L) | --- | --- | --- | 7.31 | 6.09 | 8.08 |
| pH | --- | --- | --- | 7.69 | 7.45 | 7.83 |
| Specific Conductivity ($\mu$S/cm) | --- | --- | --- | 3126.67 | 1900.00 | 5580.00 |

| Species Name | Abundance (ON) | Thermal Regime | Tolerance | MNRF Code | WD1 (Summer) |
|---|---|---|---|---|---|
| White Sucker (*Catostomus commersonii* ) | Common | Coolwater | Tolerant | 163 | 4 |
| Pumpkinseed (*Lepomis gibbosus* ) | Common | Warmwater | Intermediate | 313 | --- |
| Creek Chub (*Semotilus atromaculatus* ) | Common | Coolwater | Tolerant | 212 | --- |
| Fathead Minnow (*Pimephales promelas* ) | Common | Warmwater | Tolerant | 209 | --- |
| Longnose Dace (*Rhinichthys cataractae* ) | Common | Coolwater | Intermediate | 211 | --- |
| Western Blacknose Dace (*Rhinichthys obtusus* ) | Common | Coolwater | Intermediate | 210 | 21 |
| Brook Stickleback (*Culaea inconstans* ) | Common | Coolwater | Intermediate | 281 | --- |
| Bluntnose Minnow (*Pimephales notatus* ) | Common | Warmwater | Intermediate | 208 | --- |
| Mottled Sculpin (*Cottus bairdii* ) | Common | Coolwater | Intermediate | 381 | --- |
| Brook Trout (*Salvelinus fontinalis* ) | Common | Coldwater | Intolerant | 80 | --- |
| | | **NUMBER OF FISH COLLECTED:** | | | 25 |
| | | **Species Richness:** | | | 2 |
| | | **% Tolerant Species:** | | | 4.0 |
| | | **%Intolerant Species:** | | | 0.0 |
| | | **Number of fish collected/100m$^{2}$:** | | | 8.1 |

**Legend**

| | |
|---|---|
| ● | Dry Grab Sample, Fish, Benthics, EMC |
| 🟩 | Westmount Drain |
| ▭ | Subwatershed Boundary |
| — | Watercourse |
| ▨ | Wetland |

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 2020 Imagery City of Kitchener 2018

0 50 100 150
Meters

Coordinate System:
NAD 1983 UTM Zone 17N

CITY OF KITCHENER
KITCHENER, ONTARIO
2019 SWM MONITORING LOCATIONS

WESTMOUNT DRAIN
(WD1)

11193719
Jan 28, 2020

FIGURE 2

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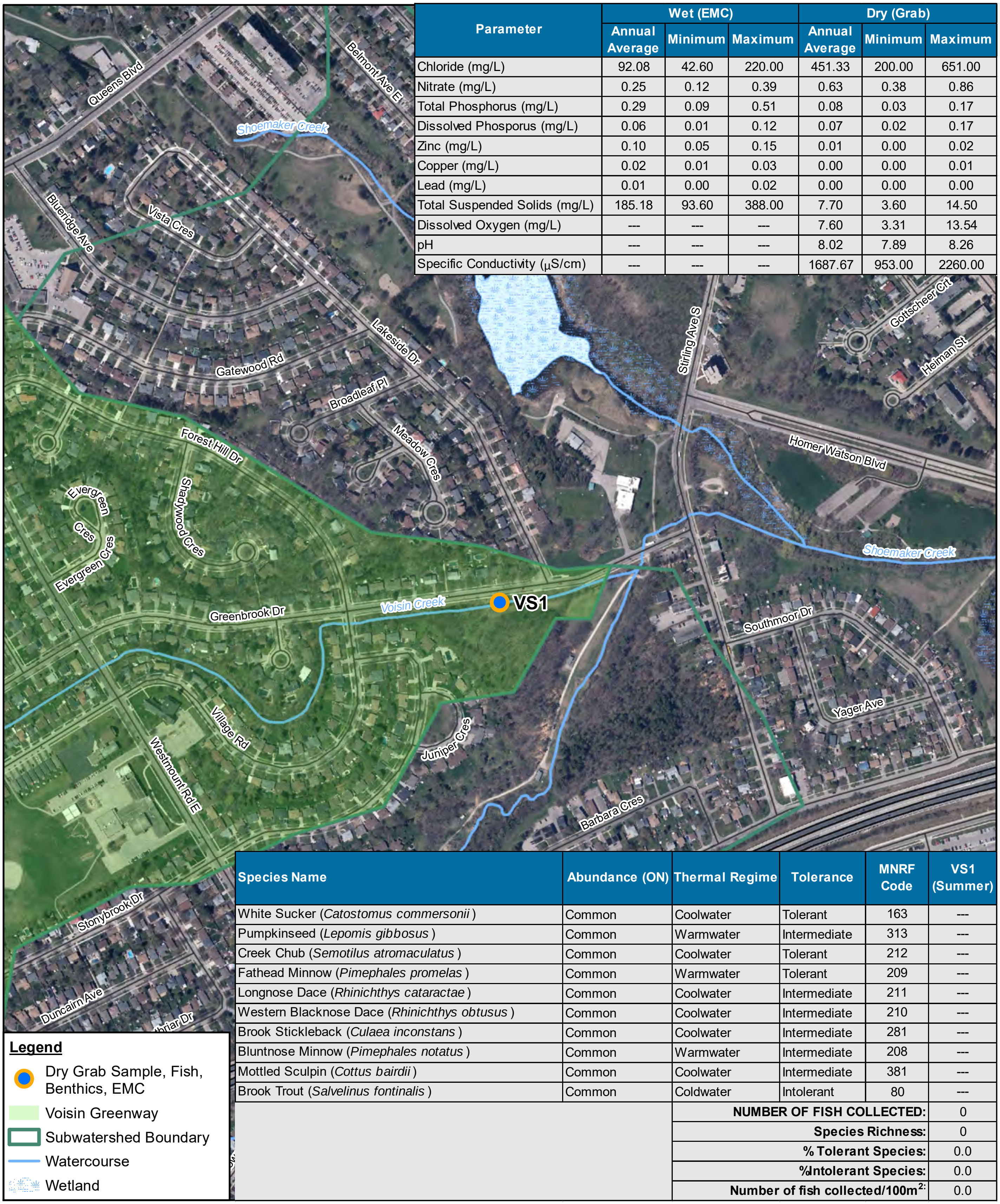

| Parameter | Wet (EMC) | | | Dry (Grab) | | |
|---|---|---|---|---|---|---|
| | Annual Average | Minimum | Maximum | Annual Average | Minimum | Maximum |
| Chloride (mg/L) | 92.08 | 42.60 | 220.00 | 451.33 | 200.00 | 651.00 |
| Nitrate (mg/L) | 0.25 | 0.12 | 0.39 | 0.63 | 0.38 | 0.86 |
| Total Phosphorus (mg/L) | 0.29 | 0.09 | 0.51 | 0.08 | 0.03 | 0.17 |
| Dissolved Phosporus (mg/L) | 0.06 | 0.01 | 0.12 | 0.07 | 0.02 | 0.17 |
| Zinc (mg/L) | 0.10 | 0.05 | 0.15 | 0.01 | 0.00 | 0.02 |
| Copper (mg/L) | 0.02 | 0.01 | 0.03 | 0.00 | 0.00 | 0.01 |
| Lead (mg/L) | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| Total Suspended Solids (mg/L) | 185.18 | 93.60 | 388.00 | 7.70 | 3.60 | 14.50 |
| Dissolved Oxygen (mg/L) | --- | --- | --- | 7.60 | 3.31 | 13.54 |
| pH | --- | --- | --- | 8.02 | 7.89 | 8.26 |
| Specific Conductivity ($\mu$S/cm) | --- | --- | --- | 1687.67 | 953.00 | 2260.00 |

| Species Name | Abundance (ON) | Thermal Regime | Tolerance | MNRF Code | VS1 (Summer) |
|---|---|---|---|---|---|
| White Sucker (*Catostomus commersonii*) | Common | Coolwater | Tolerant | 163 | --- |
| Pumpkinseed (*Lepomis gibbosus*) | Common | Warmwater | Intermediate | 313 | --- |
| Creek Chub (*Semotilus atromaculatus*) | Common | Coolwater | Tolerant | 212 | --- |
| Fathead Minnow (*Pimephales promelas*) | Common | Warmwater | Tolerant | 209 | --- |
| Longnose Dace (*Rhinichthys cataractae*) | Common | Coolwater | Intermediate | 211 | --- |
| Western Blacknose Dace (*Rhinichthys obtusus*) | Common | Coolwater | Intermediate | 210 | --- |
| Brook Stickleback (*Culaea inconstans*) | Common | Coolwater | Intermediate | 281 | --- |
| Bluntnose Minnow (*Pimephales notatus*) | Common | Warmwater | Intermediate | 208 | --- |
| Mottled Sculpin (*Cottus bairdii*) | Common | Coolwater | Intermediate | 381 | --- |
| Brook Trout (*Salvelinus fontinalis*) | Common | Coldwater | Intolerant | 80 | --- |
| | | **NUMBER OF FISH COLLECTED:** | | | 0 |
| | | **Species Richness:** | | | 0 |
| | | **% Tolerant Species:** | | | 0.0 |
| | | **%Intolerant Species:** | | | 0.0 |
| | | **Number of fish collected/100m$^2$:** | | | 0.0 |

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 2020 Imagery City of Kitchener 2018

0 50 100 150
Meters

Coordinate System:
NAD 1983 UTM Zone 17N

N

GHD

CITY OF KITCHENER
KITCHENER, ONTARIO
2019 SWM MONITORING LOCATIONS
VOISIN CREEK
(VS1)

11193719
Jan 28, 2020

FIGURE 3

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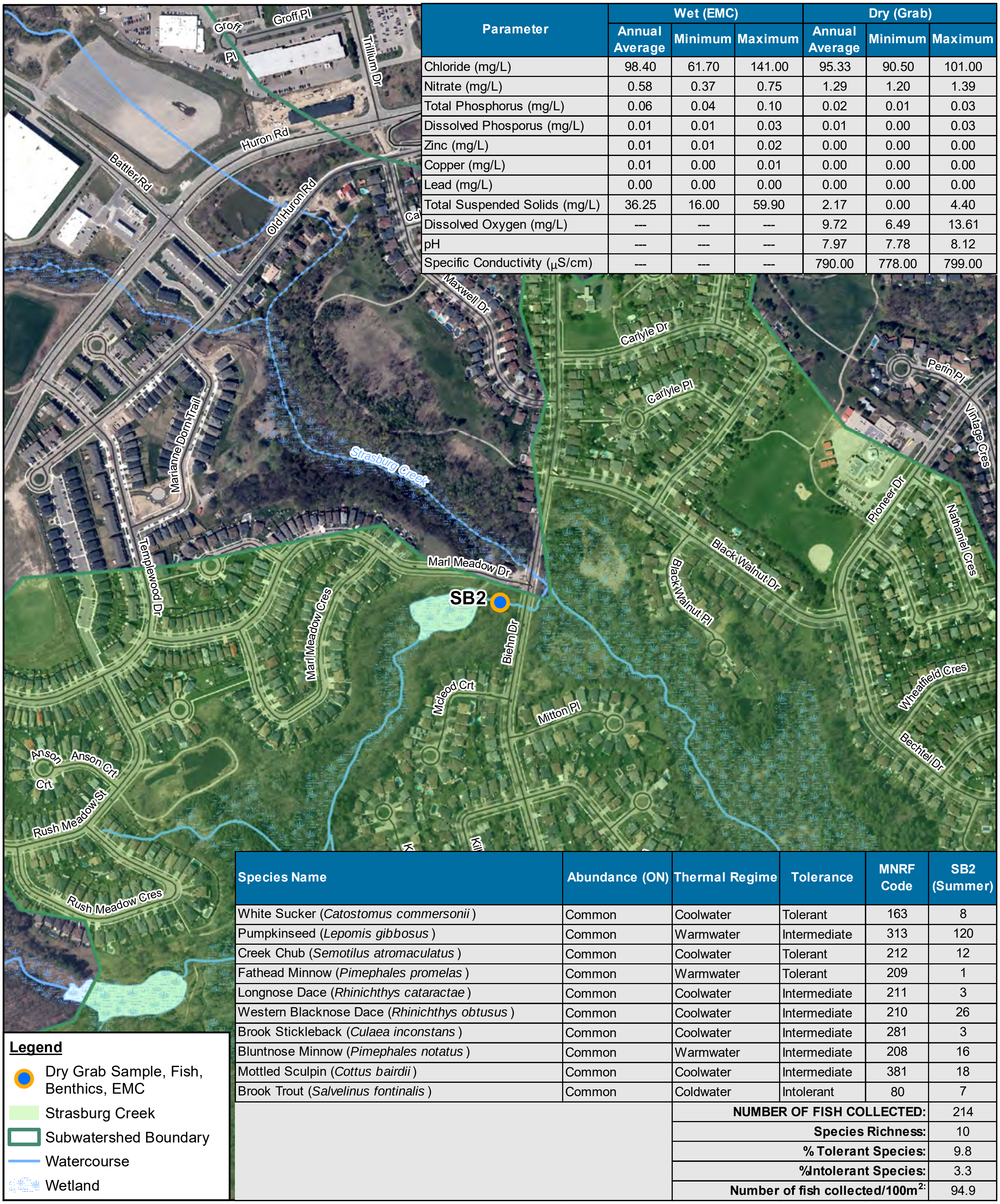


| Parameter | Wet (EMC) | | | Dry (Grab) | | |
|---|---|---|---|---|---|---|
| | Annual Average | Minimum | Maximum | Annual Average | Minimum | Maximum |
| Chloride (mg/L) | 98.40 | 61.70 | 141.00 | 95.33 | 90.50 | 101.00 |
| Nitrate (mg/L) | 0.58 | 0.37 | 0.75 | 1.29 | 1.20 | 1.39 |
| Total Phosphorus (mg/L) | 0.06 | 0.04 | 0.10 | 0.02 | 0.01 | 0.03 |
| Dissolved Phosporus (mg/L) | 0.01 | 0.01 | 0.03 | 0.01 | 0.00 | 0.03 |
| Zinc (mg/L) | 0.01 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| Copper (mg/L) | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Lead (mg/L) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Suspended Solids (mg/L) | 36.25 | 16.00 | 59.90 | 2.17 | 0.00 | 4.40 |
| Dissolved Oxygen (mg/L) | --- | --- | --- | 9.72 | 6.49 | 13.61 |
| pH | --- | --- | --- | 7.97 | 7.78 | 8.12 |
| Specific Conductivity ($\mu$S/cm) | --- | --- | --- | 790.00 | 778.00 | 799.00 |

| Species Name | Abundance (ON) | Thermal Regime | Tolerance | MNRF Code | SB2 (Summer) |
|---|---|---|---|---|---|
| White Sucker (*Catostomus commersonii*) | Common | Coolwater | Tolerant | 163 | 8 |
| Pumpkinseed (*Lepomis gibbosus*) | Common | Warmwater | Intermediate | 313 | 120 |
| Creek Chub (*Semotilus atromaculatus*) | Common | Coolwater | Tolerant | 212 | 12 |
| Fathead Minnow (*Pimephales promelas*) | Common | Warmwater | Tolerant | 209 | 1 |
| Longnose Dace (*Rhinichthys cataractae*) | Common | Coolwater | Intermediate | 211 | 3 |
| Western Blacknose Dace (*Rhinichthys obtusus*) | Common | Coolwater | Intermediate | 210 | 26 |
| Brook Stickleback (*Culaea inconstans*) | Common | Coolwater | Intermediate | 281 | 3 |
| Bluntnose Minnow (*Pimephales notatus*) | Common | Warmwater | Intermediate | 208 | 16 |
| Mottled Sculpin (*Cottus bairdii*) | Common | Coolwater | Intermediate | 381 | 18 |
| Brook Trout (*Salvelinus fontinalis*) | Common | Coldwater | Intolerant | 80 | 7 |
| | | | | **NUMBER OF FISH COLLECTED:** | 214 |
| | | | | **Species Richness:** | 10 |
| | | | | **% Tolerant Species:** | 9.8 |
| | | | | **%Intolerant Species:** | 3.3 |
| | | | | **Number of fish collected/100m$^{2}$:** | 94.9 |

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 2020 Imagery City of Kitchener 2018

0 50 100 150
Meters

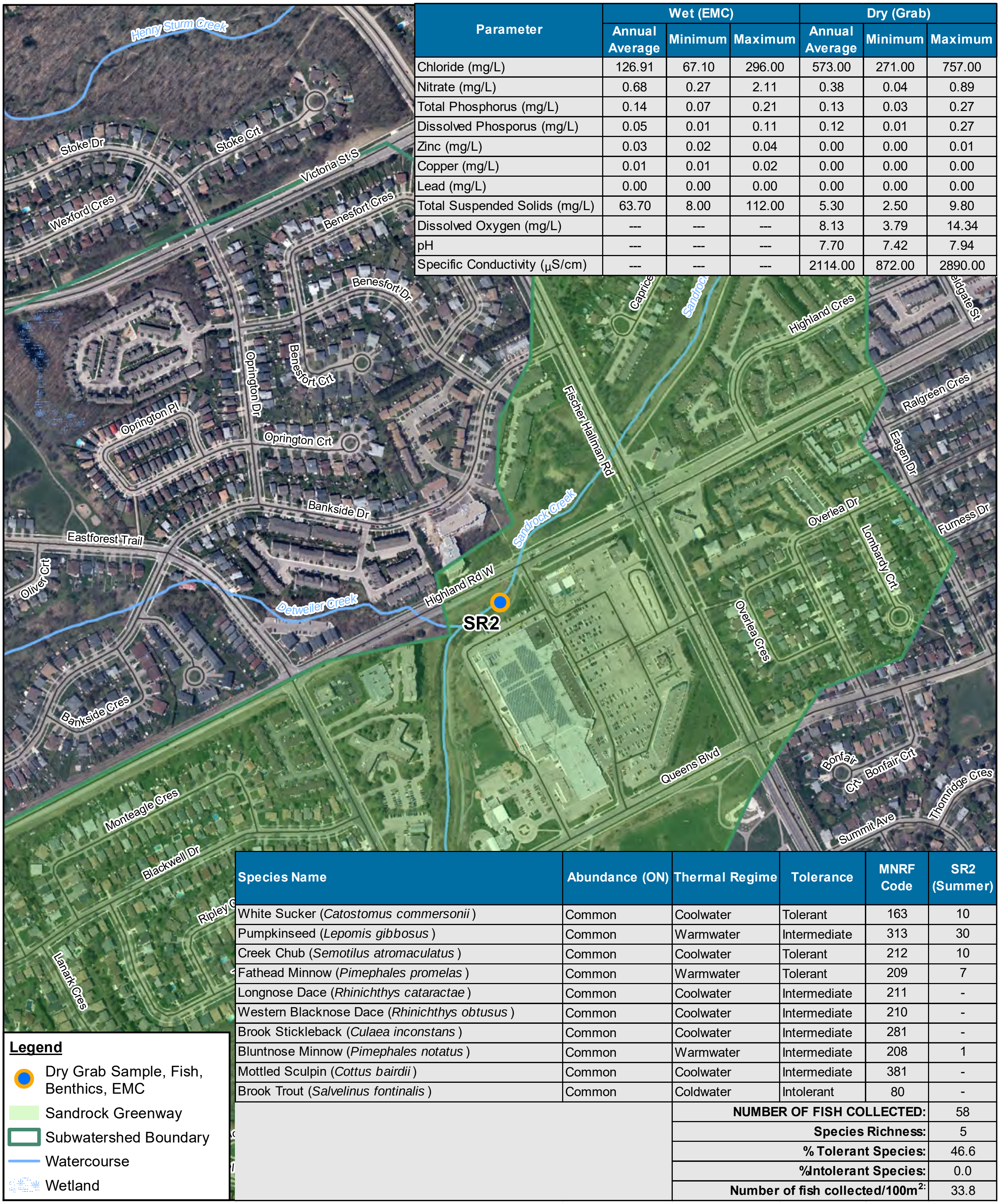
Coordinate System:
NAD 1983 UTM Zone 17N

CITY OF KITCHENER
KITCHENER, ONTARIO
2019 SWM MONITORING LOCATIONS
STRASBURG CREEK
(SB2)

11193719
Jan 28, 2020

FIGURE 4

GIS File: Q:\GIS\PROJECTS\11193000s\11193719\Layouts\003\11193719-100(003)GIS-WA006.mxd



| Parameter | Wet (EMC) | | | Dry (Grab) | | |
|---|---|---|---|---|---|---|
| | Annual Average | Minimum | Maximum | Annual Average | Minimum | Maximum |
| Chloride (mg/L) | 126.91 | 67.10 | 296.00 | 573.00 | 271.00 | 757.00 |
| Nitrate (mg/L) | 0.68 | 0.27 | 2.11 | 0.38 | 0.04 | 0.89 |
| Total Phosphorus (mg/L) | 0.14 | 0.07 | 0.21 | 0.13 | 0.03 | 0.27 |
| Dissolved Phosporus (mg/L) | 0.05 | 0.01 | 0.11 | 0.12 | 0.01 | 0.27 |
| Zinc (mg/L) | 0.03 | 0.02 | 0.04 | 0.00 | 0.00 | 0.01 |
| Copper (mg/L) | 0.01 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| Lead (mg/L) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Suspended Solids (mg/L) | 63.70 | 8.00 | 112.00 | 5.30 | 2.50 | 9.80 |
| Dissolved Oxygen (mg/L) | --- | --- | --- | 8.13 | 3.79 | 14.34 |
| pH | --- | --- | --- | 7.70 | 7.42 | 7.94 |
| Specific Conductivity ($\mu$S/cm) | --- | --- | --- | 2114.00 | 872.00 | 2890.00 |

| Species Name | Abundance (ON) | Thermal Regime | Tolerance | MNRF Code | SR2 (Summer) |
|---|---|---|---|---|---|
| White Sucker (*Catostomus commersonii* ) | Common | Coolwater | Tolerant | 163 | 10 |
| Pumpkinseed (*Lepomis gibbosus* ) | Common | Warmwater | Intermediate | 313 | 30 |
| Creek Chub (*Semotilus atromaculatus* ) | Common | Coolwater | Tolerant | 212 | 10 |
| Fathead Minnow (*Pimephales promelas* ) | Common | Warmwater | Tolerant | 209 | 7 |
| Longnose Dace (*Rhinichthys cataractae* ) | Common | Coolwater | Intermediate | 211 | - |
| Western Blacknose Dace (*Rhinichthys obtusus* ) | Common | Coolwater | Intermediate | 210 | - |
| Brook Stickleback (*Culaea inconstans* ) | Common | Coolwater | Intermediate | 281 | - |
| Bluntnose Minnow (*Pimephales notatus* ) | Common | Warmwater | Intermediate | 208 | 1 |
| Mottled Sculpin (*Cottus bairdii* ) | Common | Coolwater | Intermediate | 381 | - |
| Brook Trout (*Salvelinus fontinalis* ) | Common | Coldwater | Intolerant | 80 | - |
| | | **NUMBER OF FISH COLLECTED:** | | | 58 |
| | | **Species Richness:** | | | 5 |
| | | **% Tolerant Species:** | | | 46.6 |
| | | **%Intolerant Species:** | | | 0.0 |
| | | **Number of fish collected/100m$^{2}$:** | | | 33.8 |

**Legend**

● Dry Grab Sample, Fish, Benthics, EMC

🟩 Sandrock Greenway

▭ Subwatershed Boundary

— Watercourse

Wetland

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 2020 Imagery City of Kitchener 2018

0 50 100 150
Meters

Coordinate System:
NAD 1983 UTM Zone 17N

N

GHD

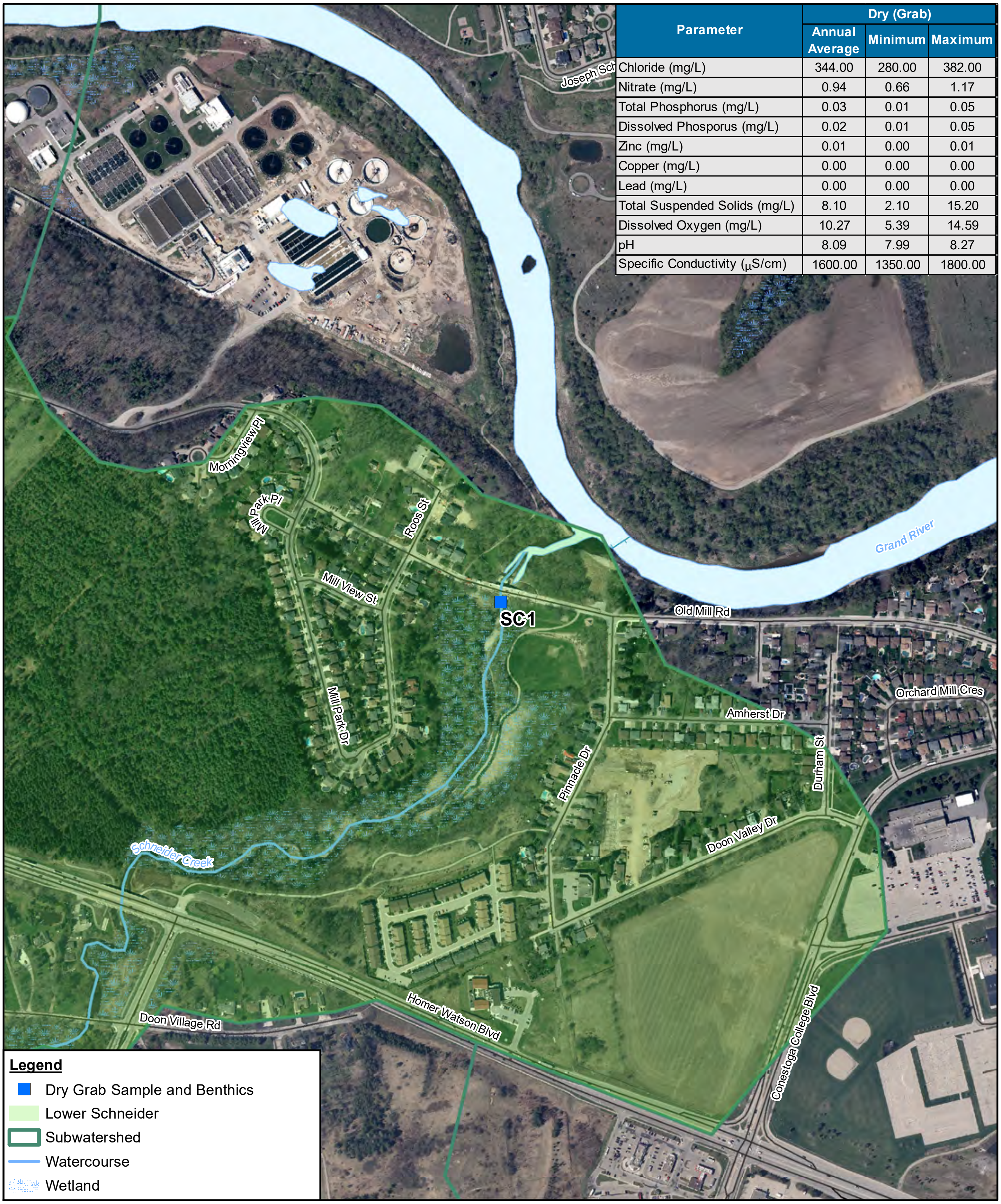
CITY OF KITCHENER
KITCHENER, ONTARIO
2019 SWM MONITORING LOCATIONS

SANDROCK GREENWAY
(SR2)

11193719
Jan 28, 2020

FIGURE 5

GIS File: Q:\GIS\PROJECTS\11193000s\11193719\Layouts\003\11193719-100(003)GIS-WA007.mxd



| Parameter | Dry (Grab) | | |
|---|---|---|---|
| | Annual Average | Minimum | Maximum |
| Chloride (mg/L) | 344.00 | 280.00 | 382.00 |
| Nitrate (mg/L) | 0.94 | 0.66 | 1.17 |
| Total Phosphorus (mg/L) | 0.03 | 0.01 | 0.05 |
| Dissolved Phosporus (mg/L) | 0.02 | 0.01 | 0.05 |
| Zinc (mg/L) | 0.01 | 0.00 | 0.01 |
| Copper (mg/L) | 0.00 | 0.00 | 0.00 |
| Lead (mg/L) | 0.00 | 0.00 | 0.00 |
| Total Suspended Solids (mg/L) | 8.10 | 2.10 | 15.20 |
| Dissolved Oxygen (mg/L) | 10.27 | 5.39 | 14.59 |
| pH | 8.09 | 7.99 | 8.27 |
| Specific Conductivity (μS/cm) | 1600.00 | 1350.00 | 1800.00 |

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 2020 Imagery City of Kitchener 2018

0 50 100 150
Meters

Coordinate System:
NAD 1983 UTM Zone 17N

N

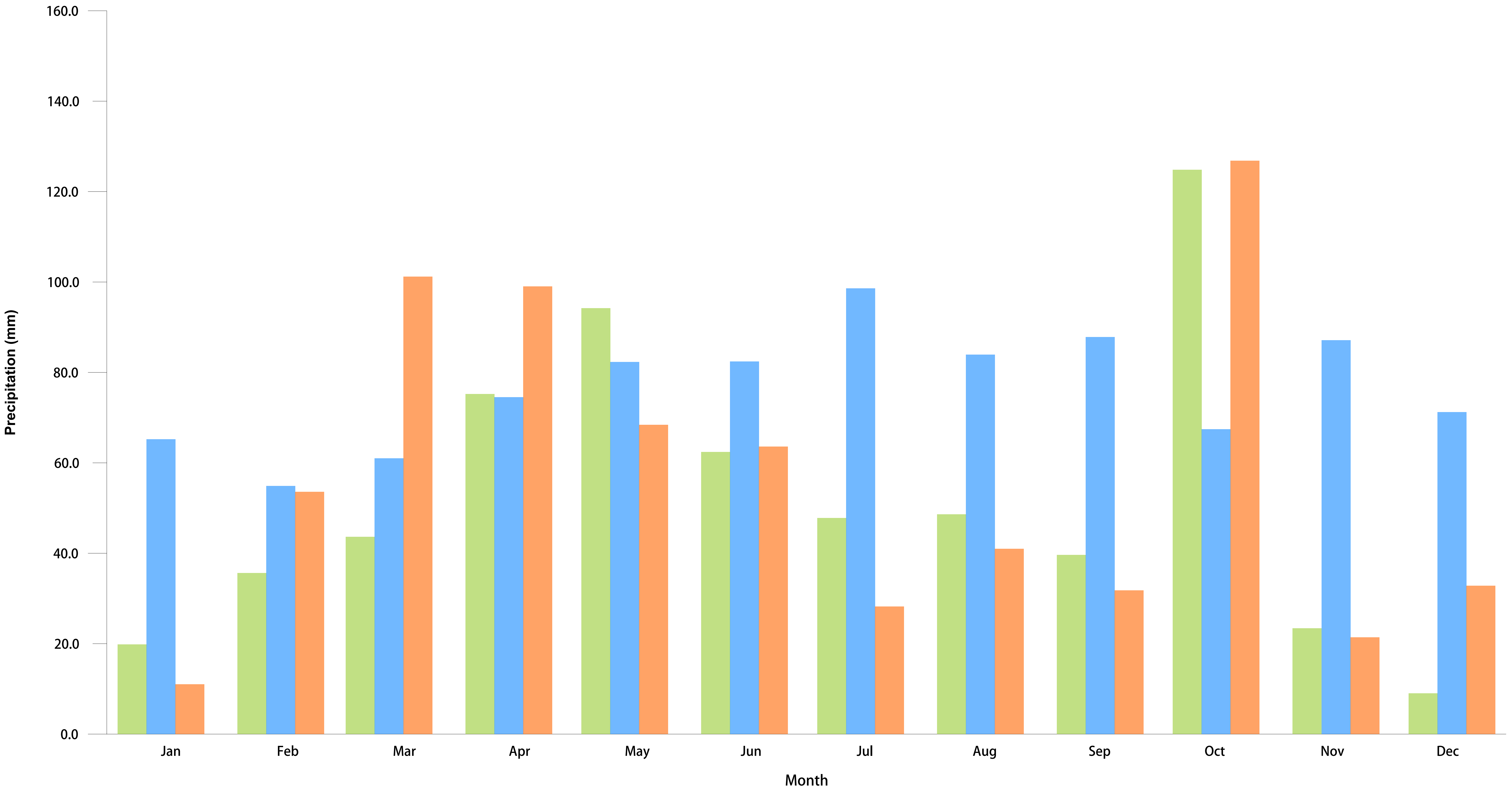
GHD

CITY OF KITCHENER
KITCHENER, ONTARIO
2019 SWM MONITORING LOCATIONS
SCHNEIDER CREEK
(SC1)

11193719
Jan 28, 2020

FIGURE 6

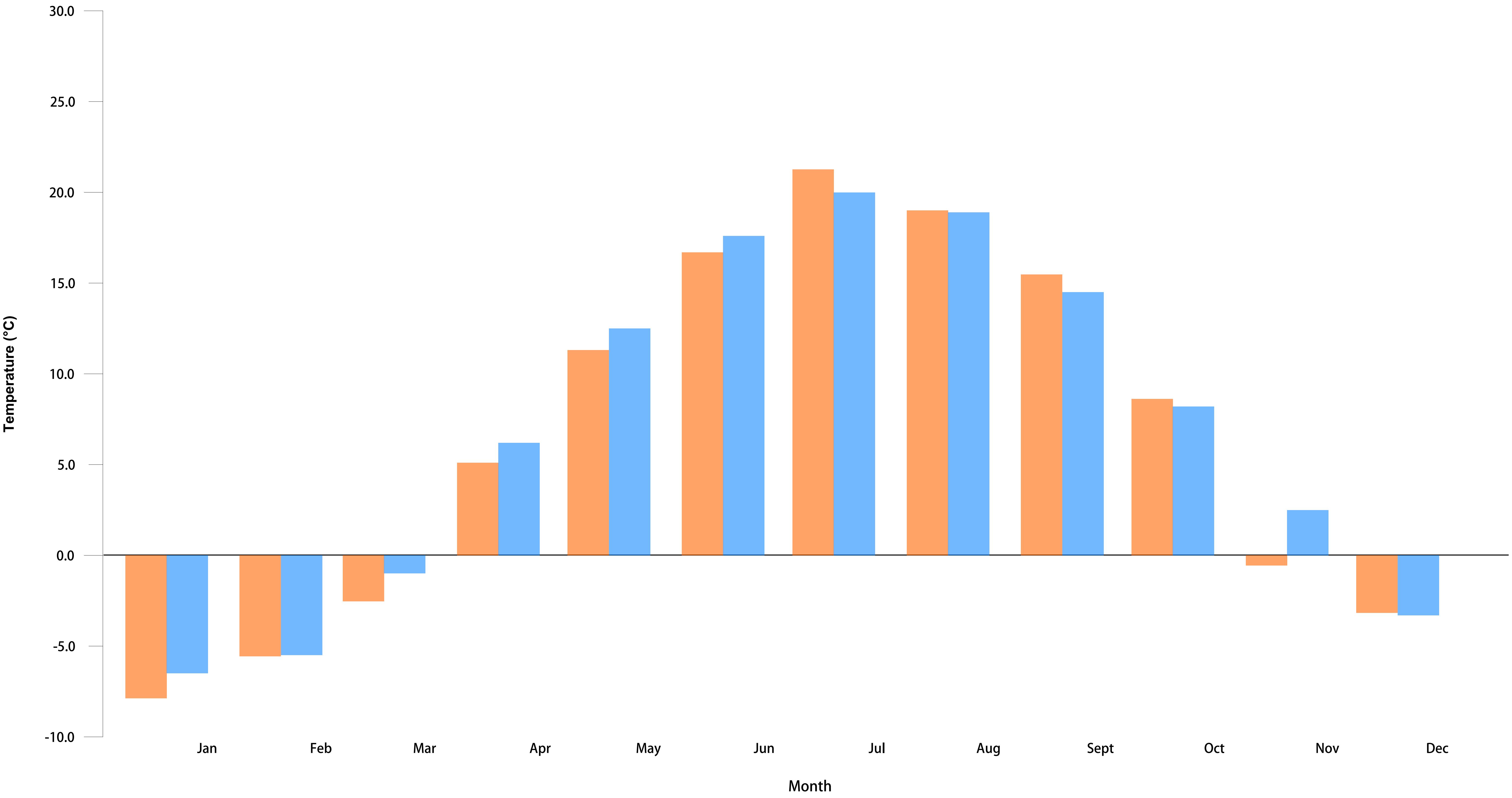
GIS File: Q:\GIS\PROJECTS\11193000s\11193719\Layouts\003\11193719-100(003)GIS-WA008.mxd



**Notes:**
- Climate normal data obtained between 1981 and 2010 at Waterloo Wellington A

🟦 Climate Normals
🟩 KOF Monthly Precipitation
🟧 City Hall Monthly Precipitation

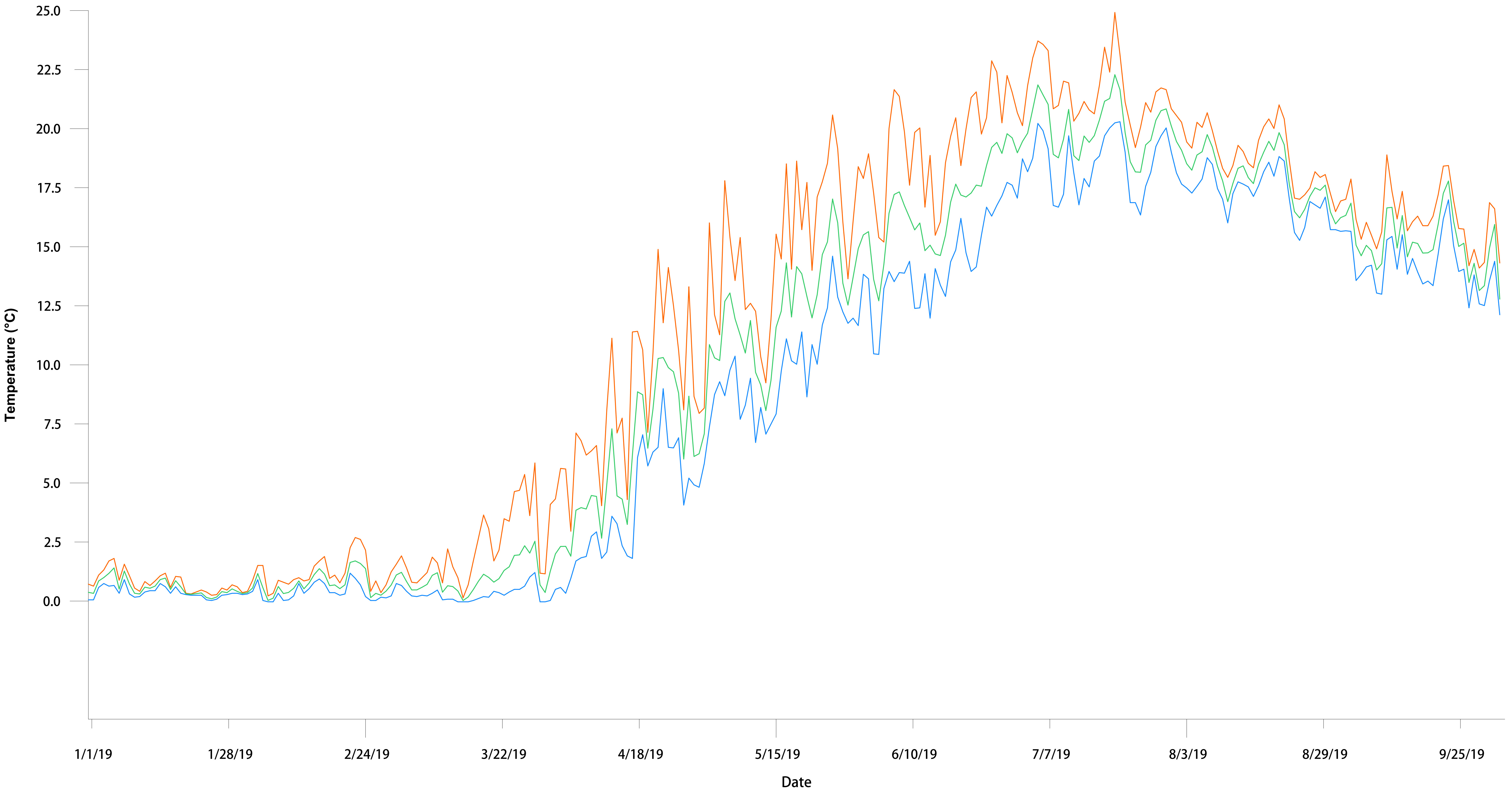
**Figure 7**
**TOTAL MONTHLY PRECIPITATION**
STORMWATER MANAGEMENT MONITORING PROGRAM 2019
CITY OF KITCHENER
KITCHENER, ONTARIO



**Notes:**
- Climate normal data obtained between 1981 and 2010 at Waterloo Wellington A

🟧 Monthly Average Air Temperature
🟦 Climate Normals

Figure 8
**AVERAGE MONTHLY TEMPERATURE**
STORMWATER MANAGEMENT MONITORING PROGRAM 2019
CITY OF KITCHENER
KITCHENER, ONTARIO



**MAXIMUM WATER TEMPERATURE** = 24.9°C ON JULY 20, 2019
**MINIMUM WATER TEMPERATURE** = -0.0°C
ON VARIOUS DATES IN FEBRUARY & MARCH

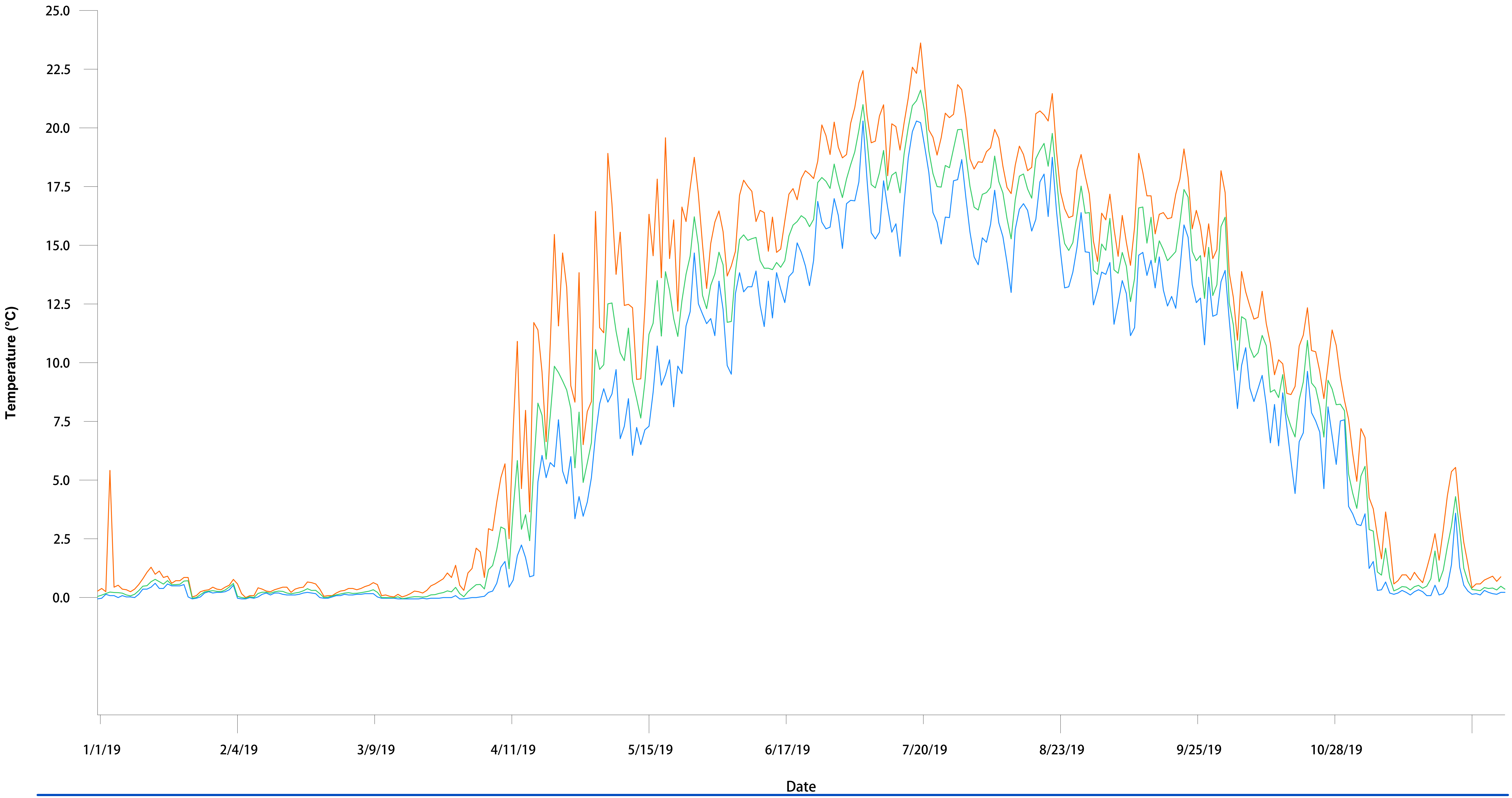
🟩 Average Daily Water Temperature
🟧 Maximum Daily Water Temperature
🟦 Minimum Daily Water Temperature

**CITY OF KITCHENER**
STORMWATER MANAGEMENT MONITORING PROGRAM 2019
KITCHENER, ONTARIO

**BLAIR CREEK (REICHERT DRIVE)**
CONTINUOUS WATER TEMPERATURE

Project 11193719
December 9, 2019

**FIGURE 9**



**MAXIMUM WATER TEMPERATURE** = 23.6°C ON JULY 20, 2019
**MINIMUM WATER TEMPERATURE** = 0°C ON VARIOUS DATES

**CITY OF KITCHENER**
STORMWATER MANAGEMENT MONITORING PROGRAM 2019
KITCHENER, ONTARIO

**BLAIR CREEK (NEW DUNDEE ROAD)**
CONTINUOUS WATER TEMPERATURE

**FIGURE 10**

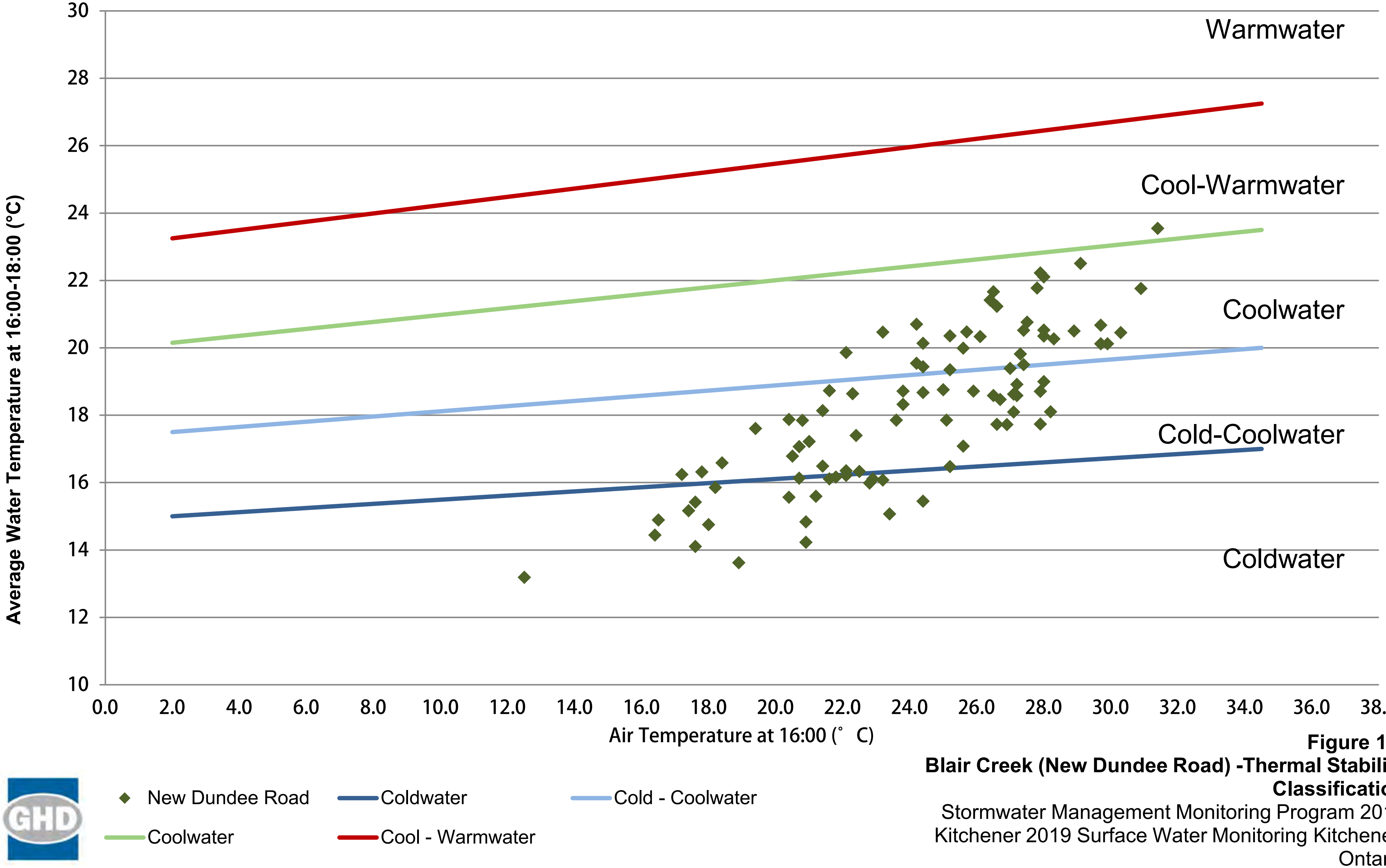


**Figure 11a**
**Blair Creek (New Dundee Road) -Thermal Stability Classification**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring Kitchener, Ontario

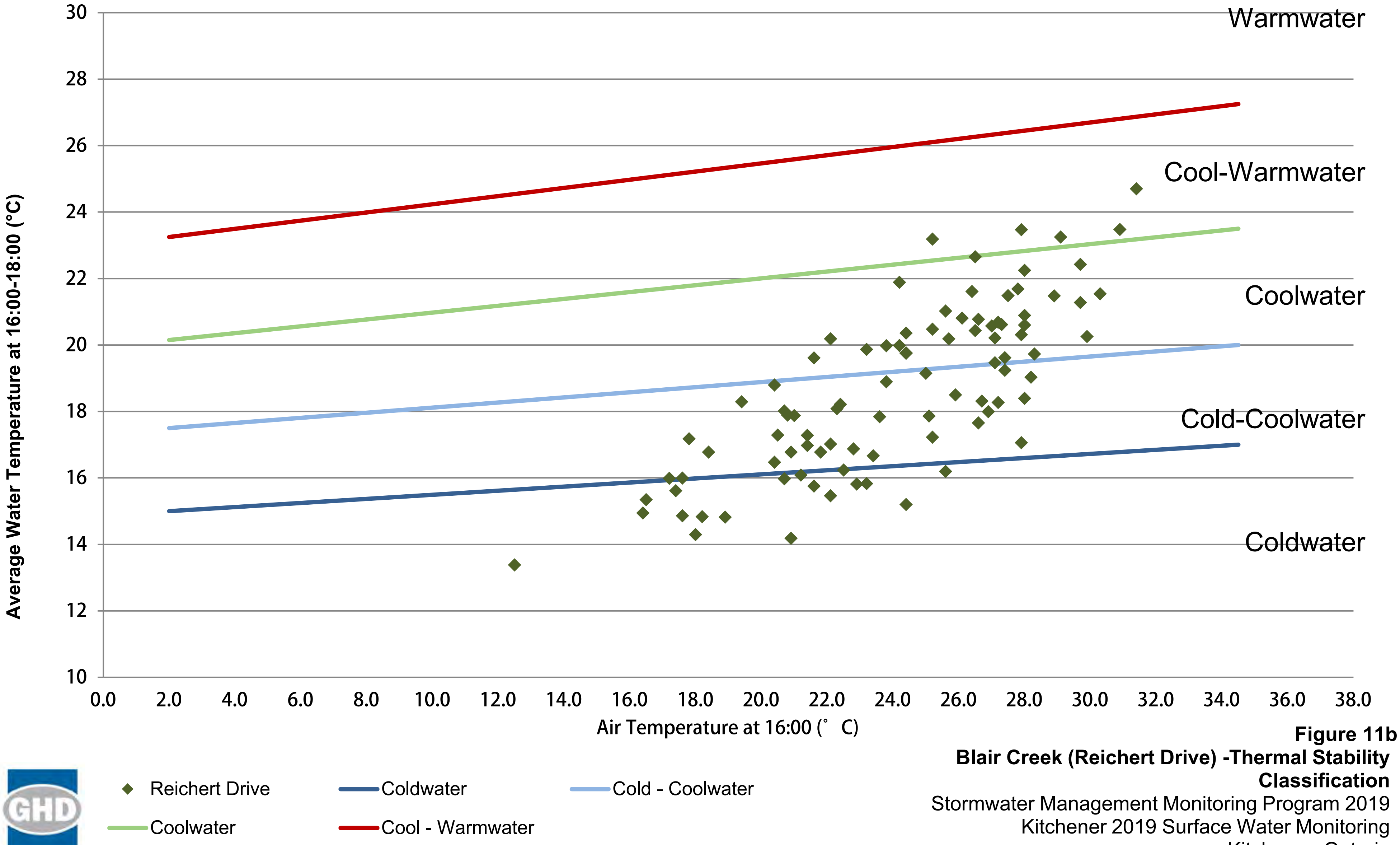


**Figure 11b**
**Blair Creek (Reichert Drive) -Thermal Stability Classification**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

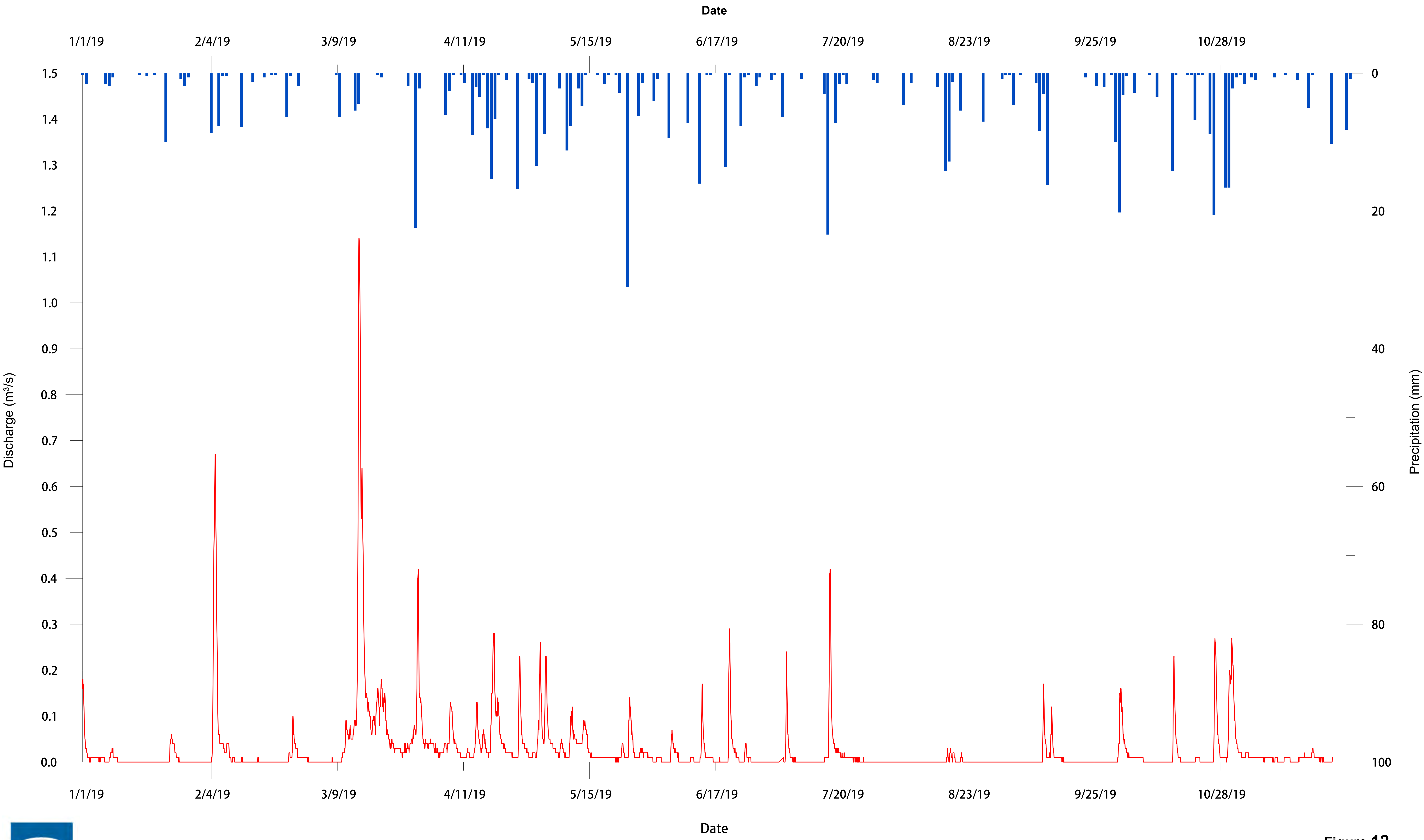


**Figure 12**

**Blair Creek at New Dundee Road Hydrograph**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

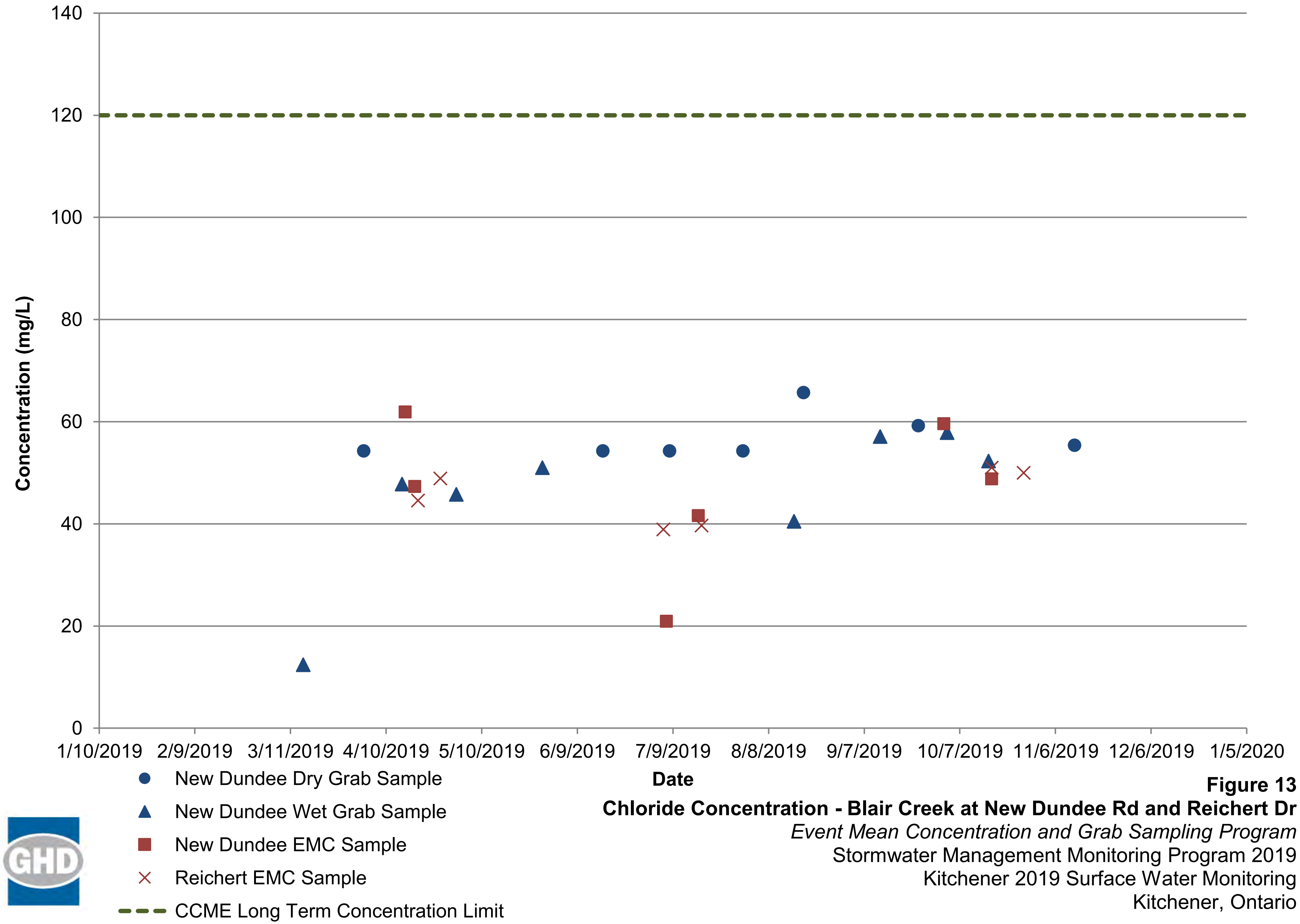


**Figure 13**
**Chloride Concentration - Blair Creek at New Dundee Rd and Reichert Dr**
*Event Mean Concentration and Grab Sampling Program*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

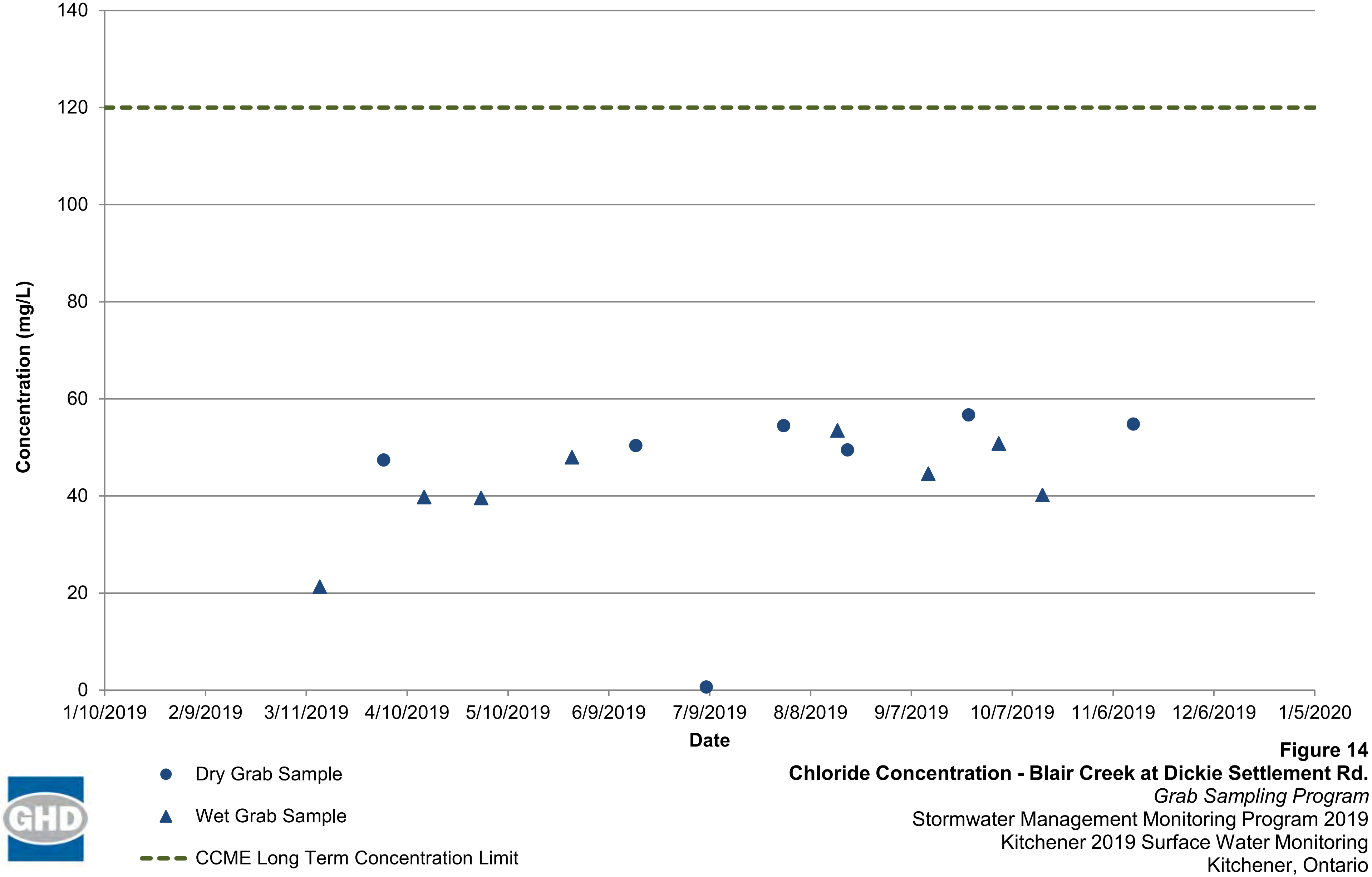


**Figure 14**

**Chloride Concentration - Blair Creek at Dickie Settlement Rd.**

*Grab Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

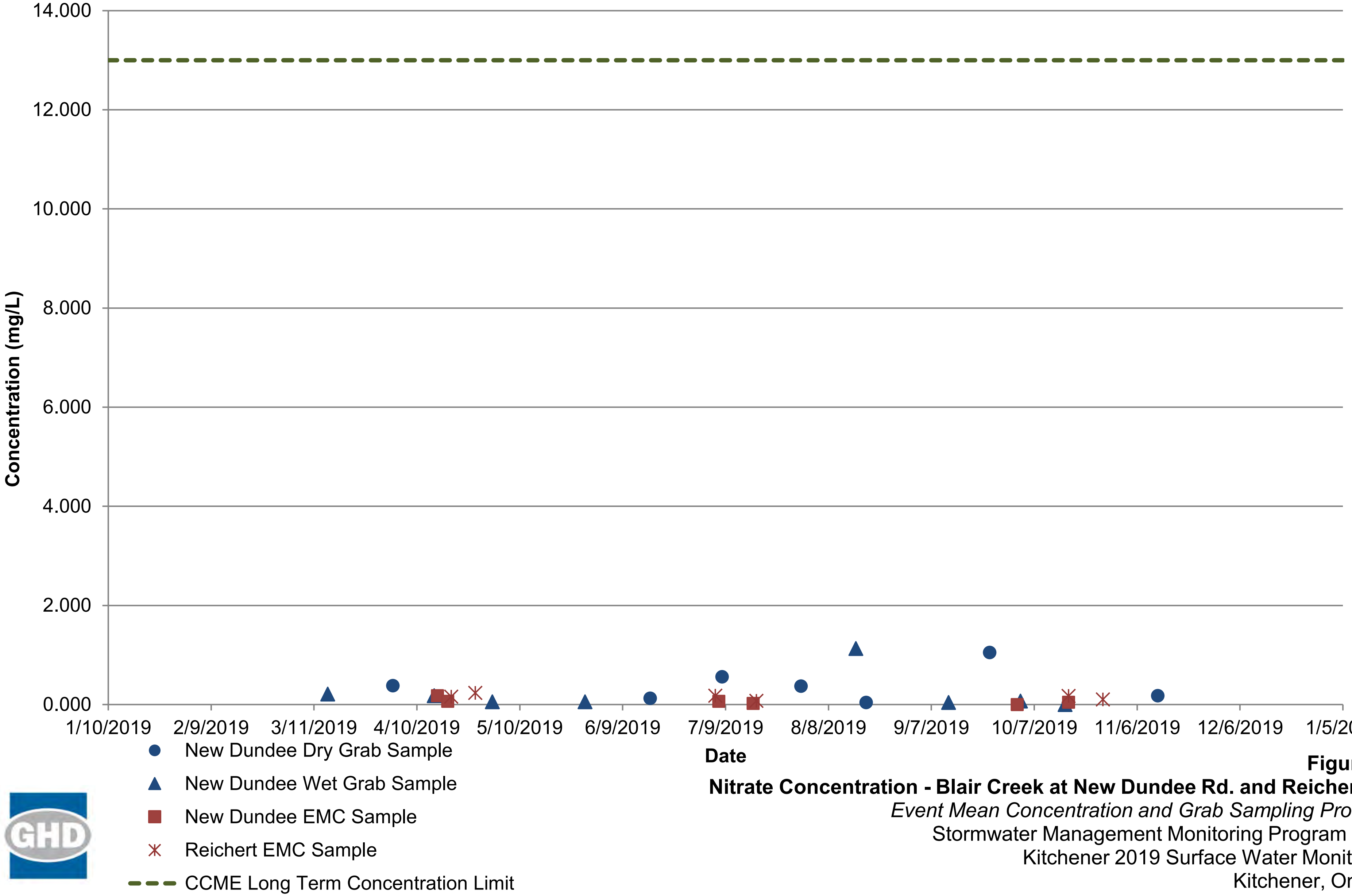


**Figure 15**

**Nitrate Concentration - Blair Creek at New Dundee Rd. and Reichert Dr.**

*Event Mean Concentration and Grab Sampling Program*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

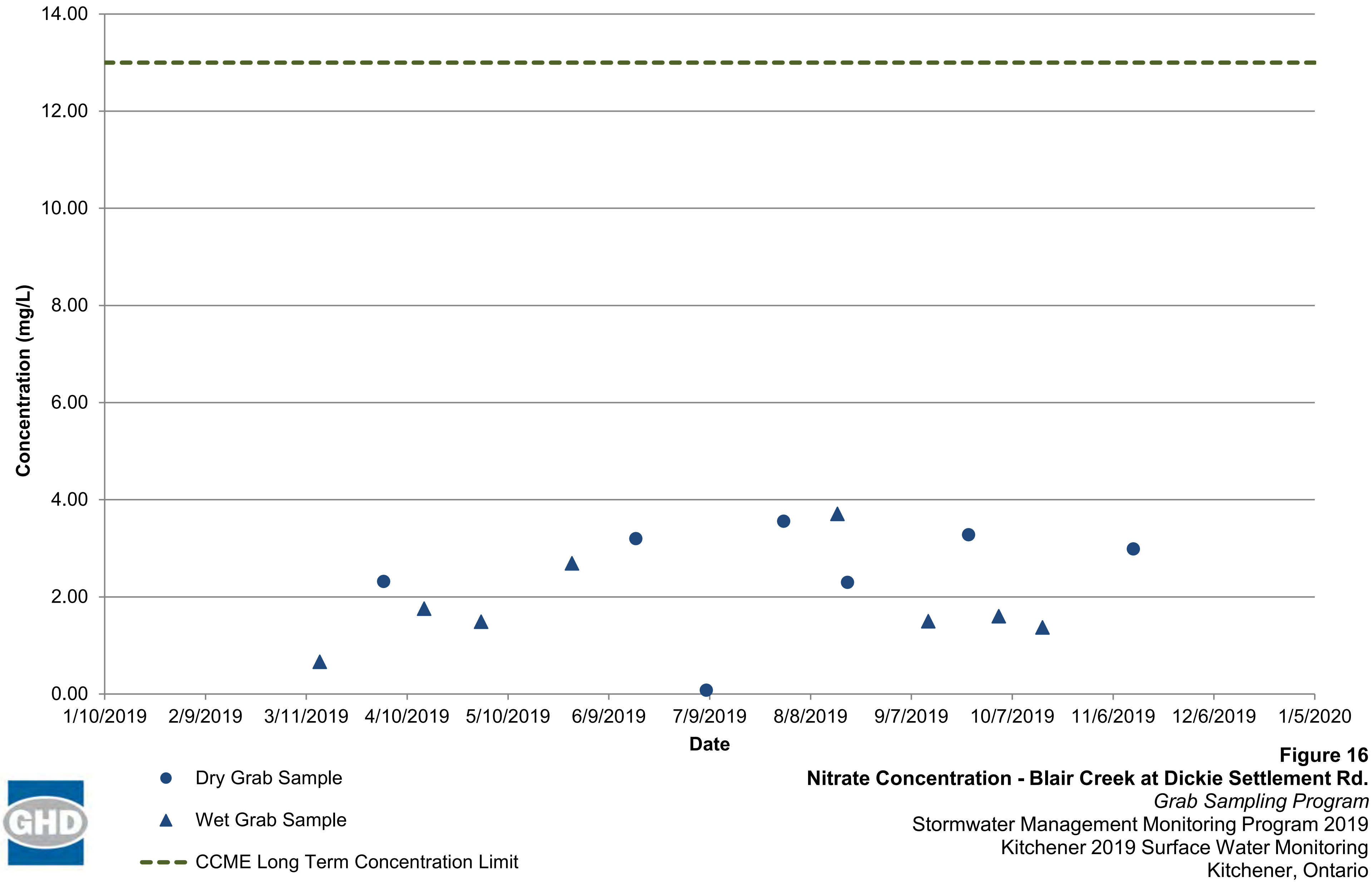


**Figure 16**

**Nitrate Concentration - Blair Creek at Dickie Settlement Rd.**

*Grab Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

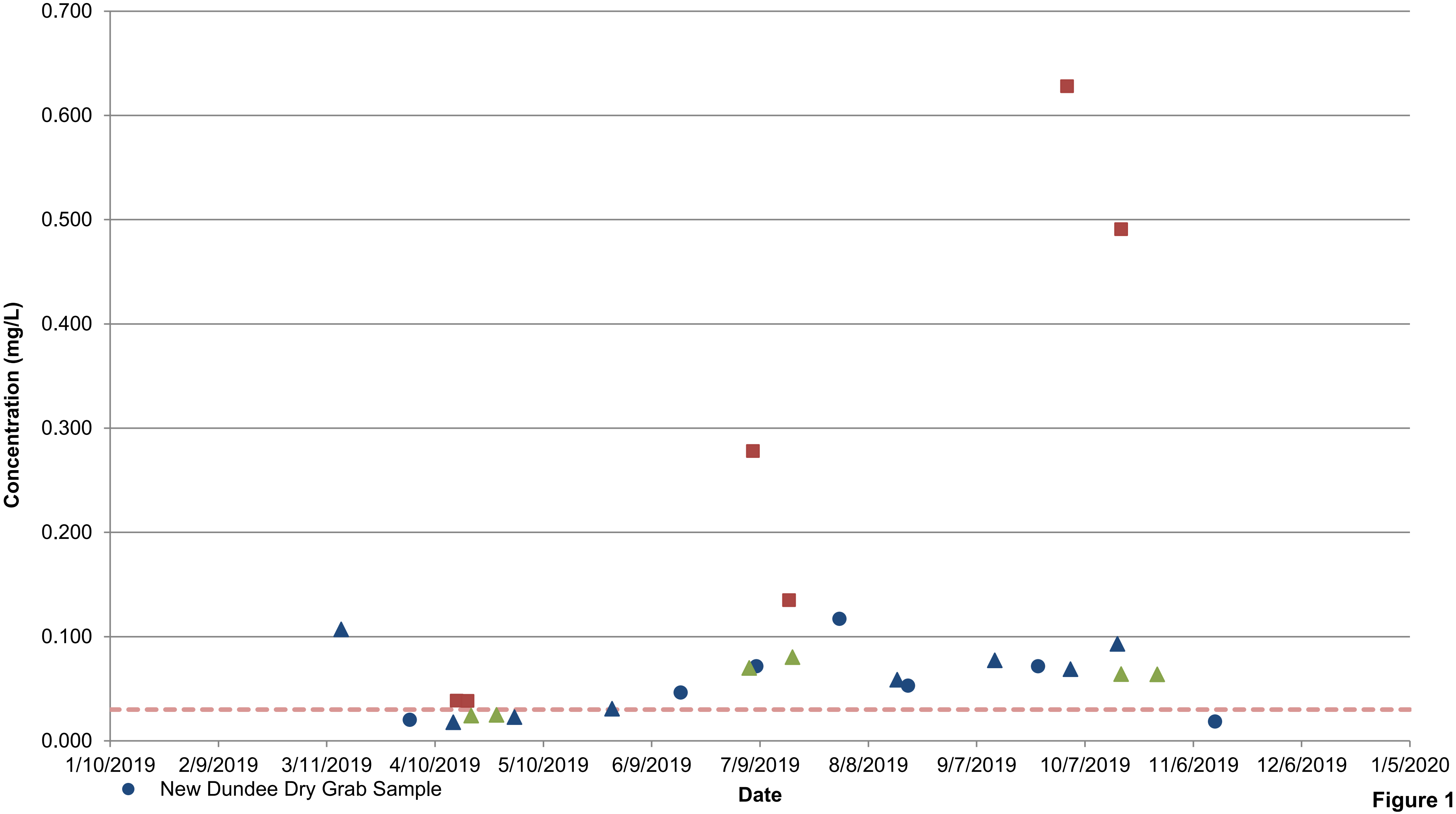


**Figure 17**

**Total Phosphorus Concentration - Blair Creek at New Dundee Rd. and Reichert Dr.**

*Event Mean Concentration and Grab Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

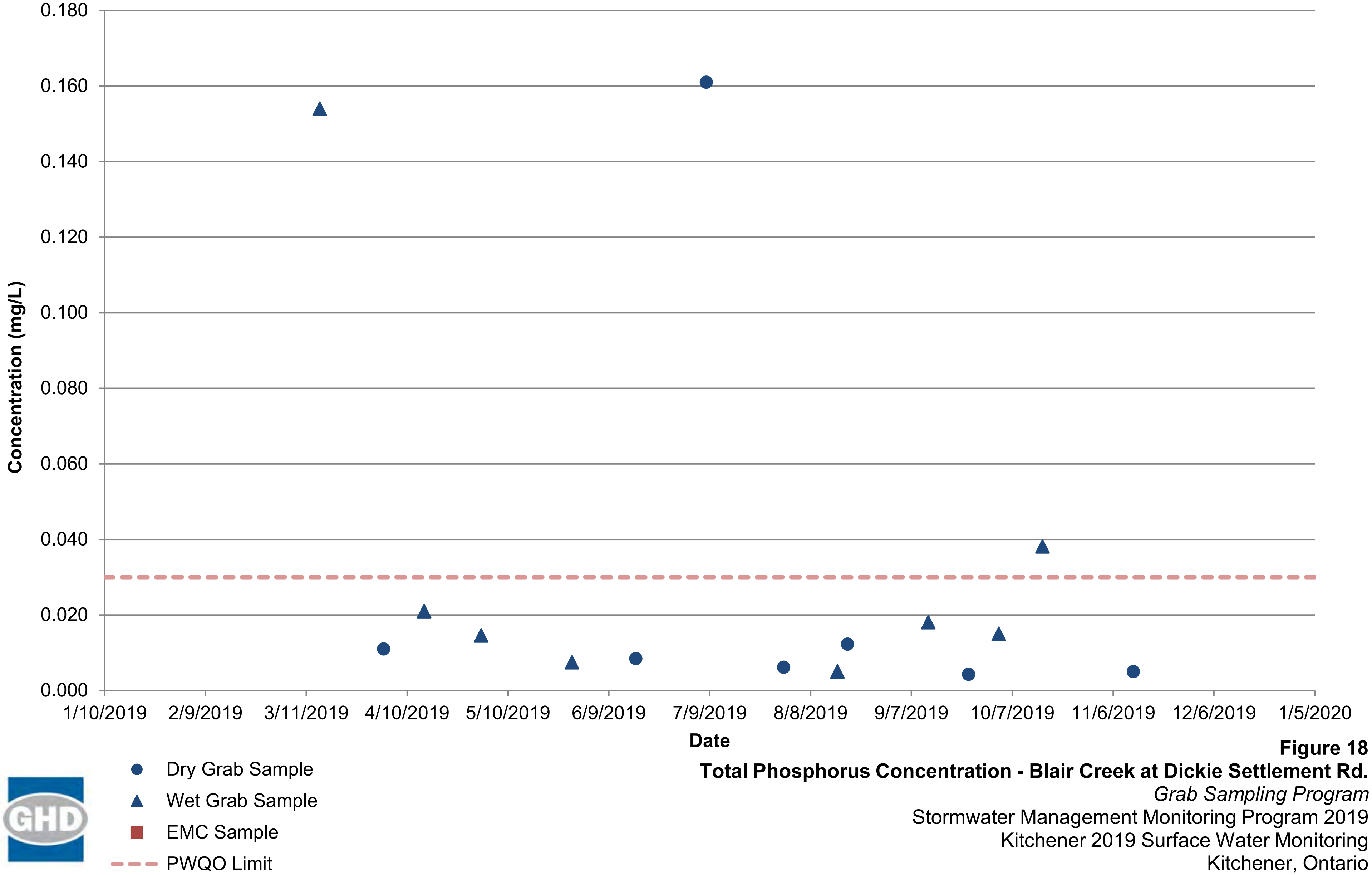


**Figure 18**

**Total Phosphorus Concentration - Blair Creek at Dickie Settlement Rd.**

*Grab Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

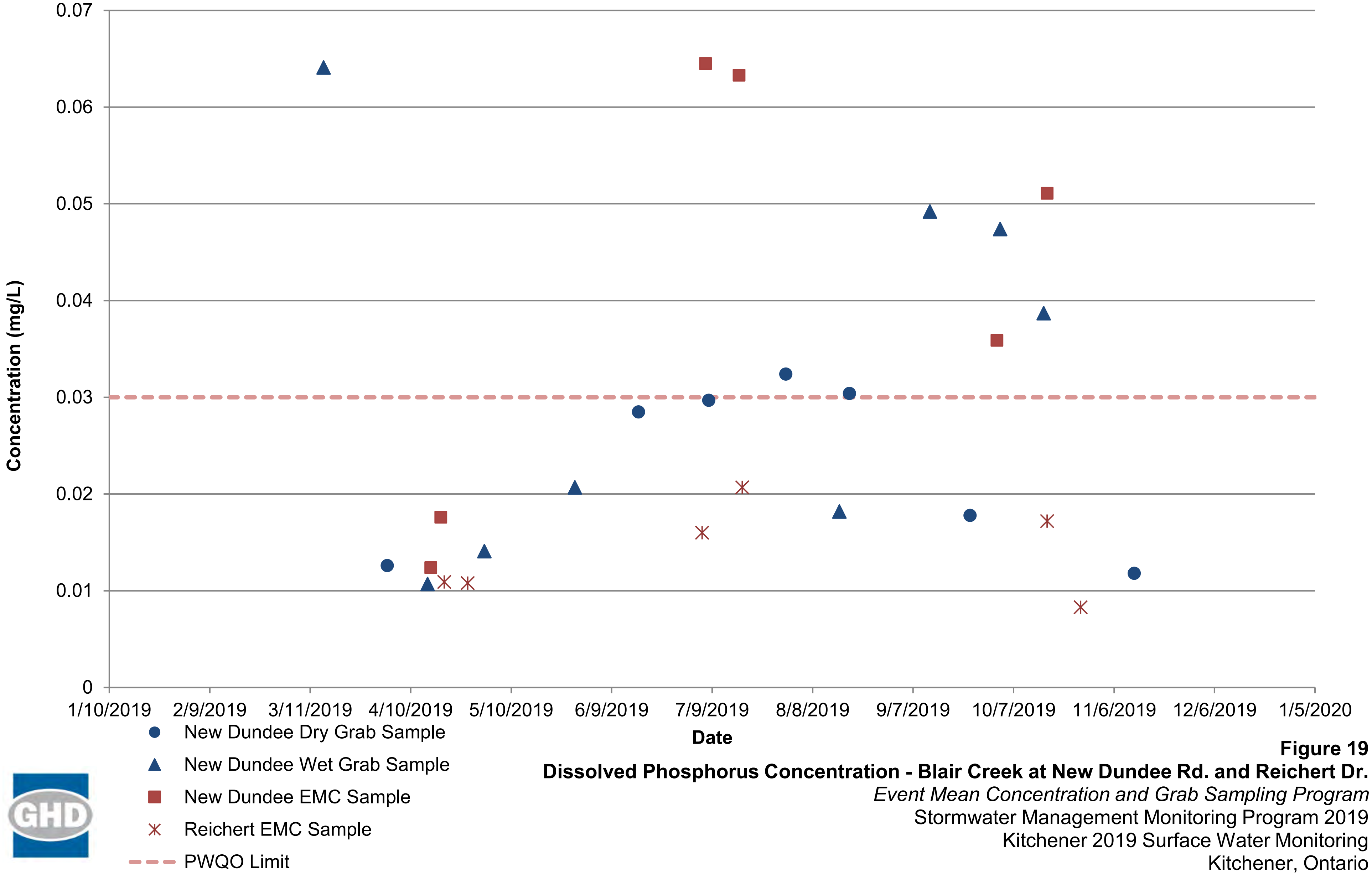


**Figure 19**

**Dissolved Phosphorus Concentration - Blair Creek at New Dundee Rd. and Reichert Dr.**

*Event Mean Concentration and Grab Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

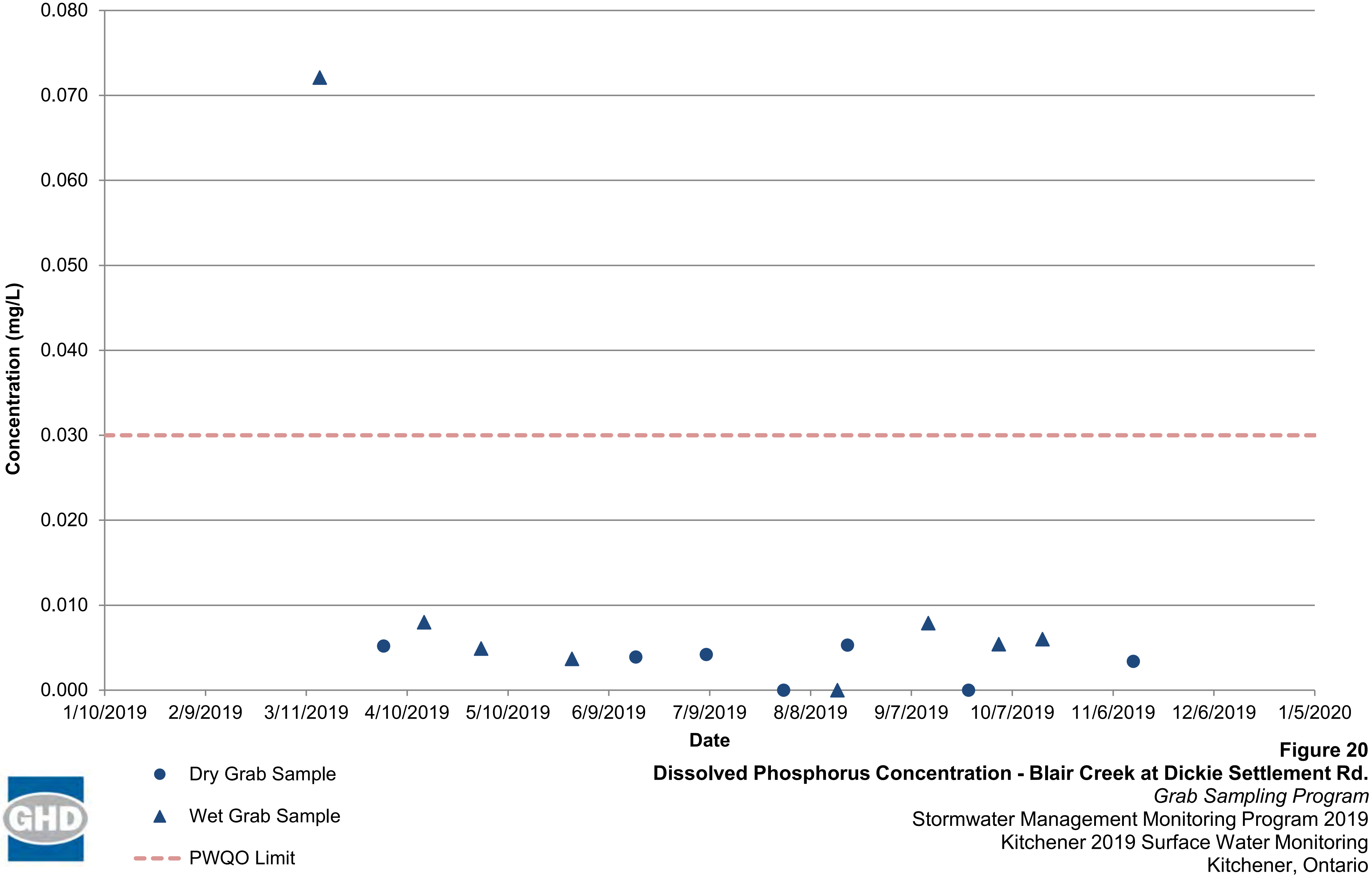


**Figure 20**

**Dissolved Phosphorus Concentration - Blair Creek at Dickie Settlement Rd.**

*Grab Sampling Program*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

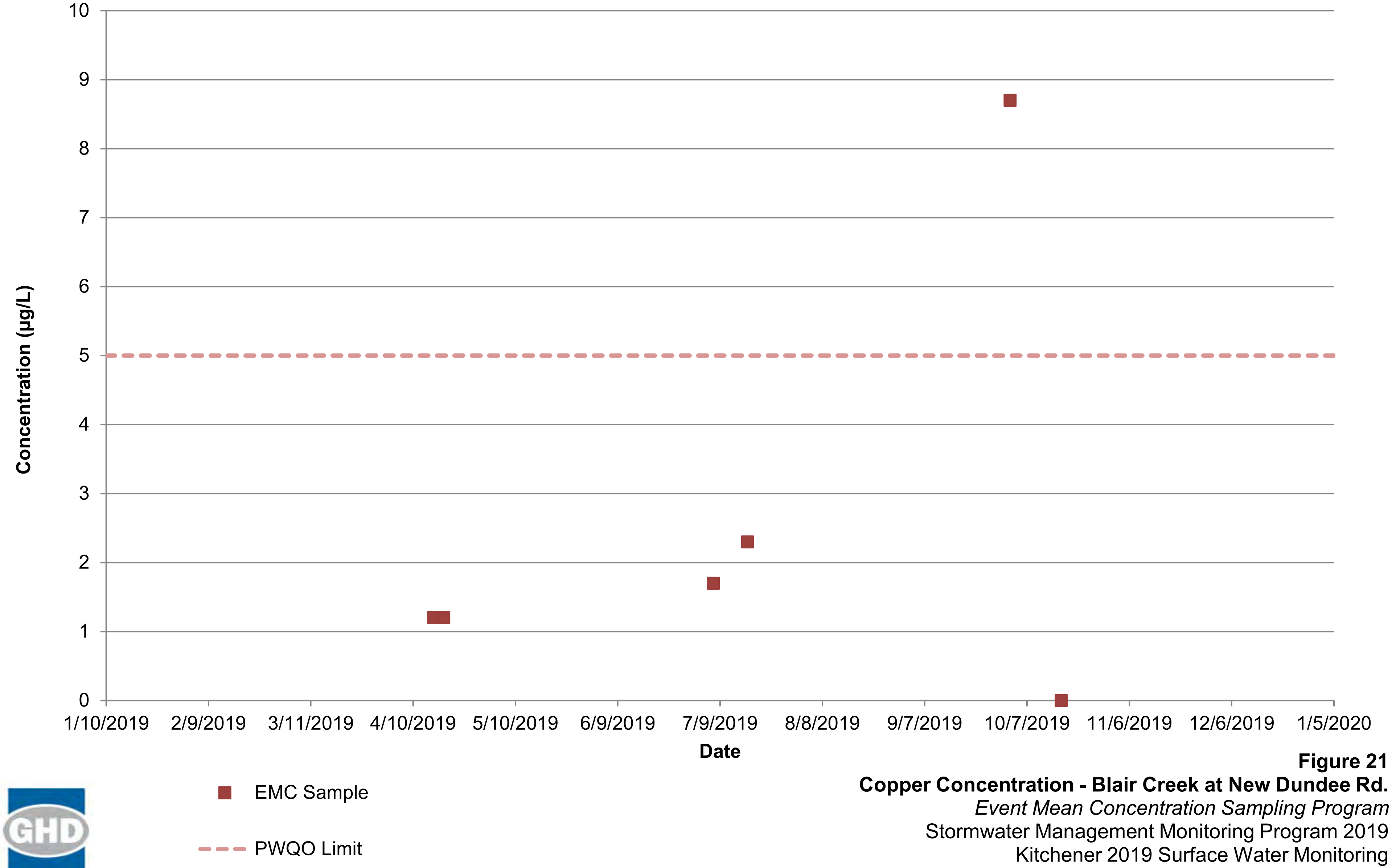


**Figure 21**

**Copper Concentration - Blair Creek at New Dundee Rd.**

*Event Mean Concentration Sampling Program*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

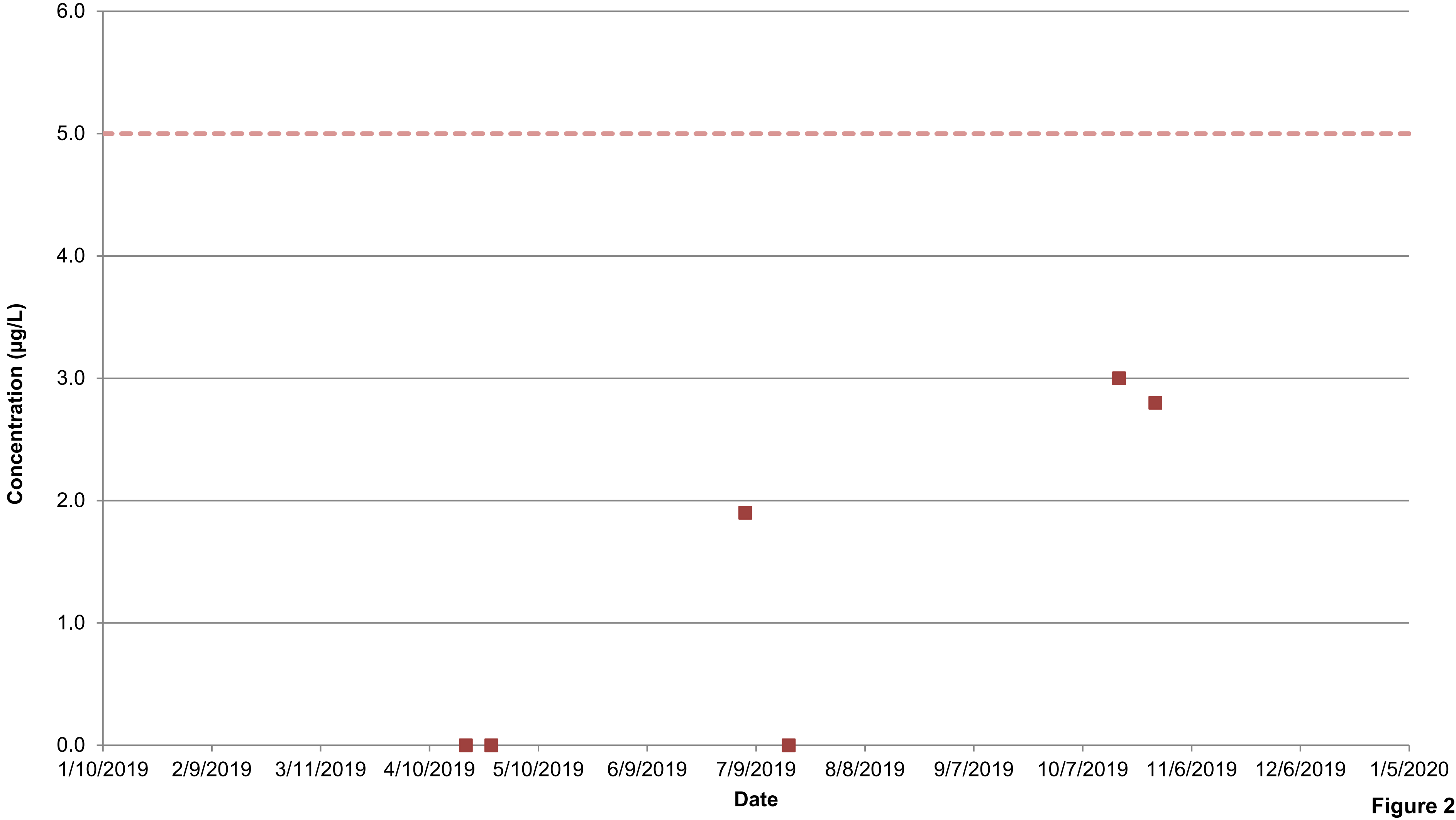


**Figure 22**
**Copper Concentration - Blair Creek at Reichert Dr.**
*Event Mean Concentration Sampling Program*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

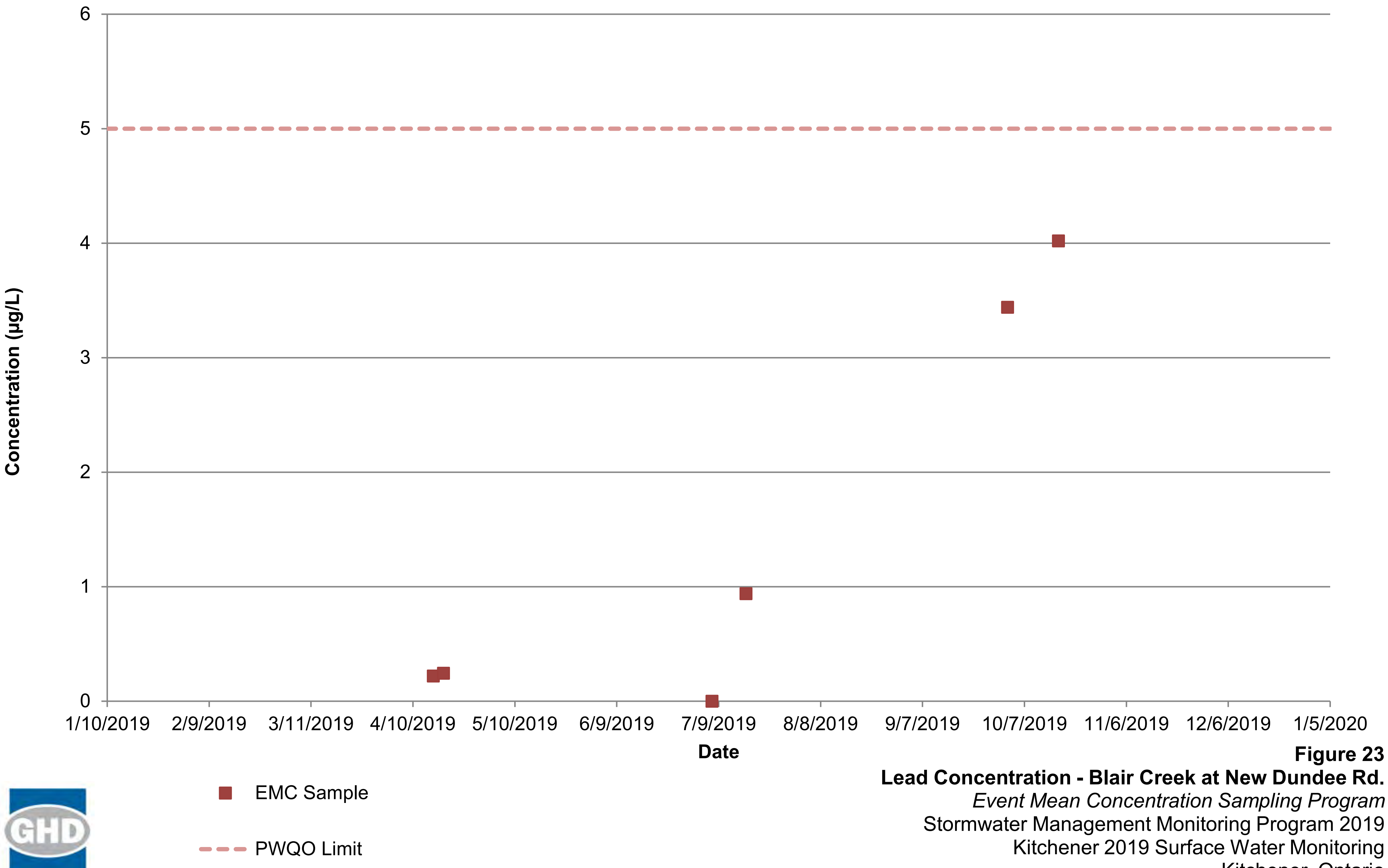


**Figure 23**
**Lead Concentration - Blair Creek at New Dundee Rd.**
*Event Mean Concentration Sampling Program*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

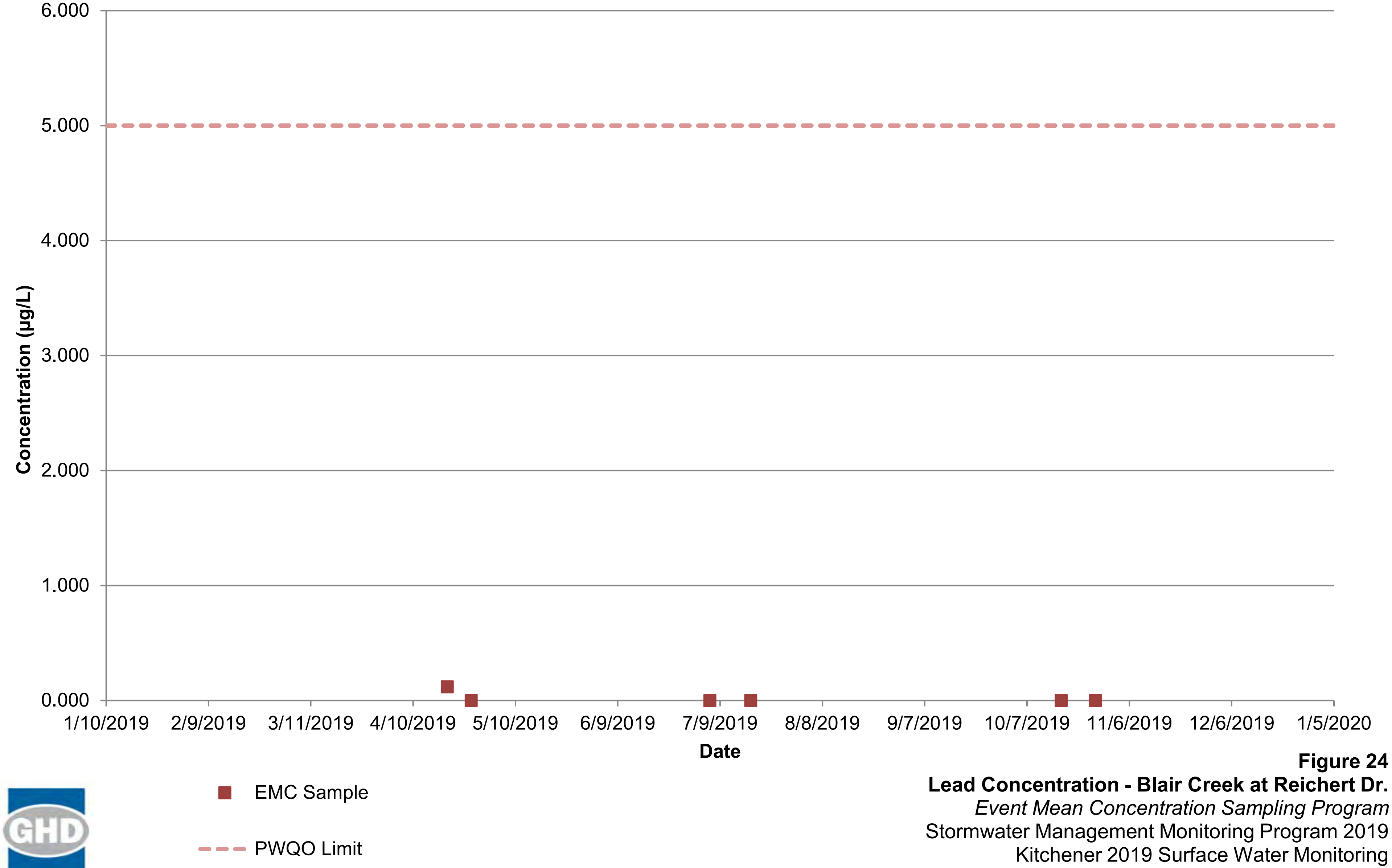


**Figure 24**

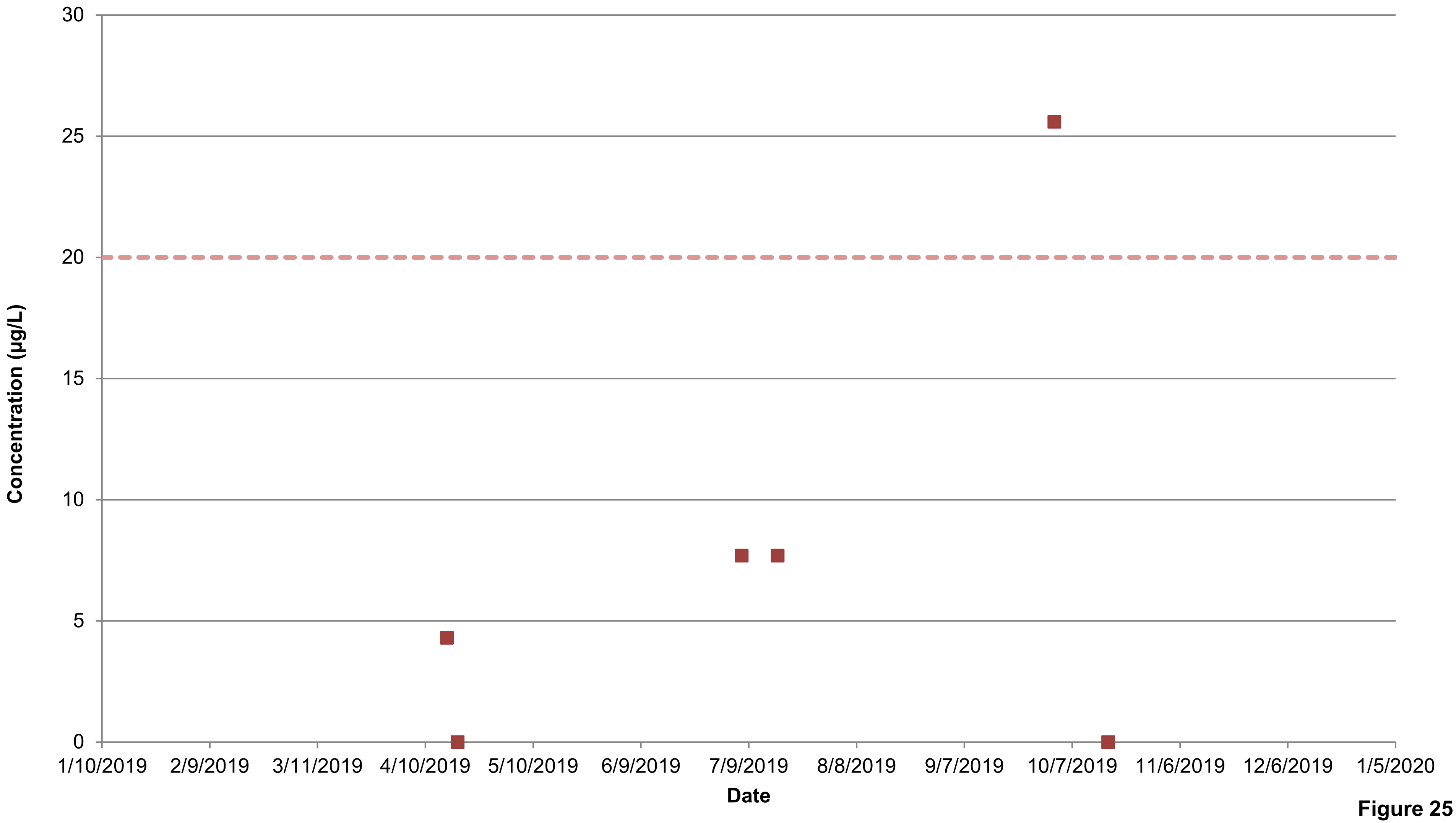
**Lead Concentration - Blair Creek at Reichert Dr.**

*Event Mean Concentration Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario



■ EMC Sample

– – – PWQO Limit

**Figure 25**

**Zinc Concentration - Blair Creek at New Dundee Rd.**

*Event Mean Concentration Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

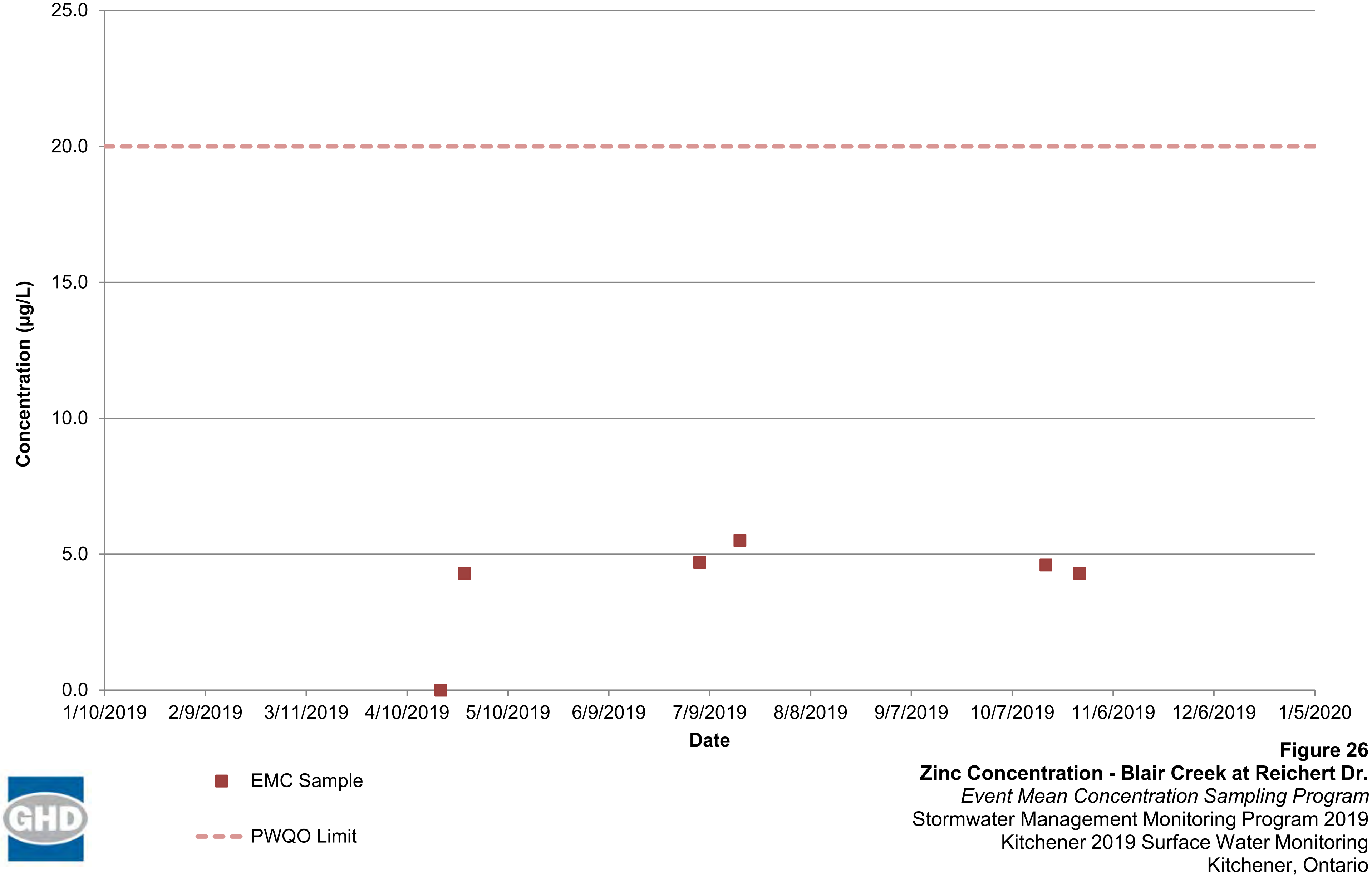


**Figure 26**
**Zinc Concentration - Blair Creek at Reichert Dr.**
*Event Mean Concentration Sampling Program*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

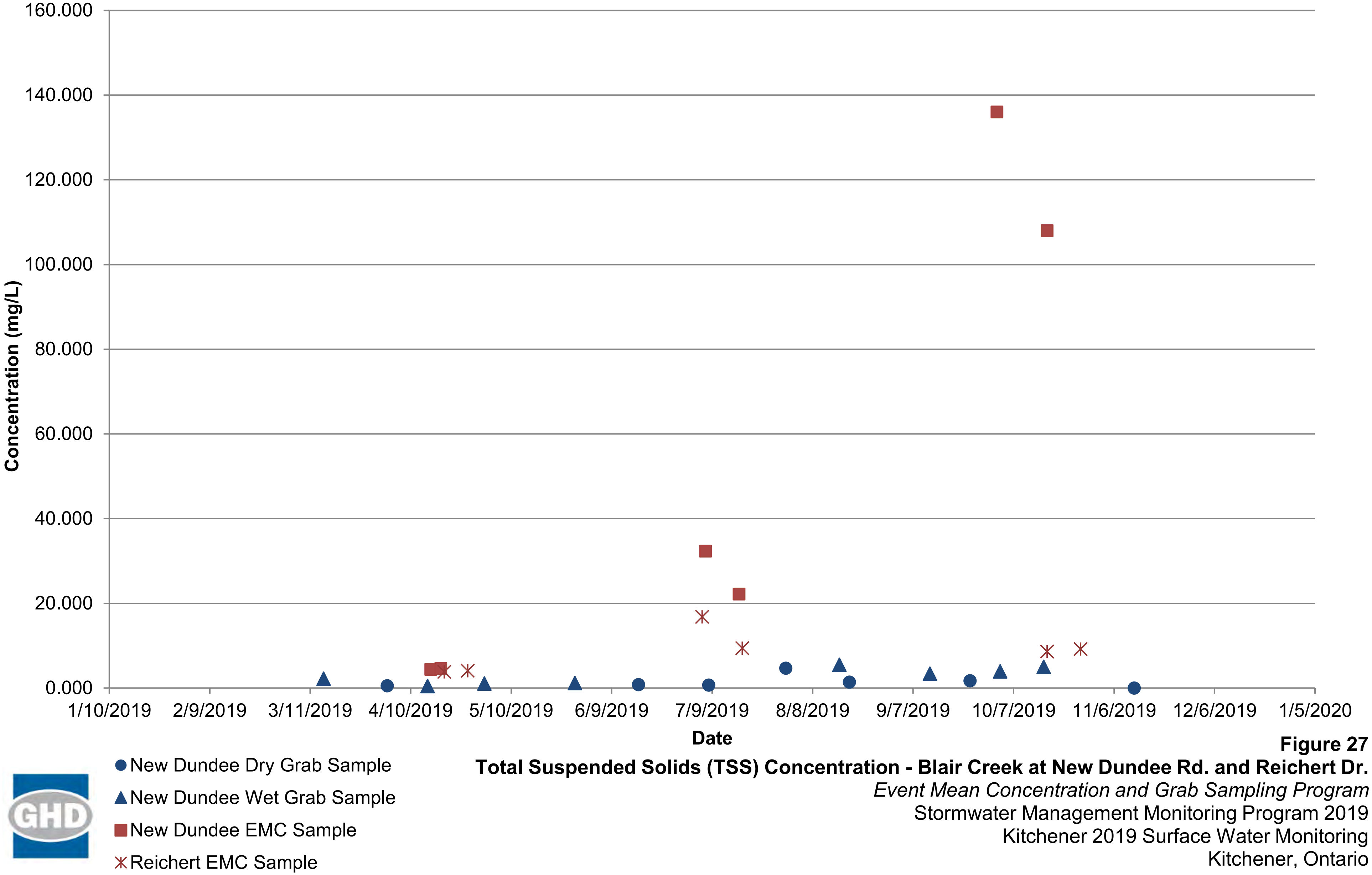


**Figure 27**

**Total Suspended Solids (TSS) Concentration - Blair Creek at New Dundee Rd. and Reichert Dr.**

*Event Mean Concentration and Grab Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

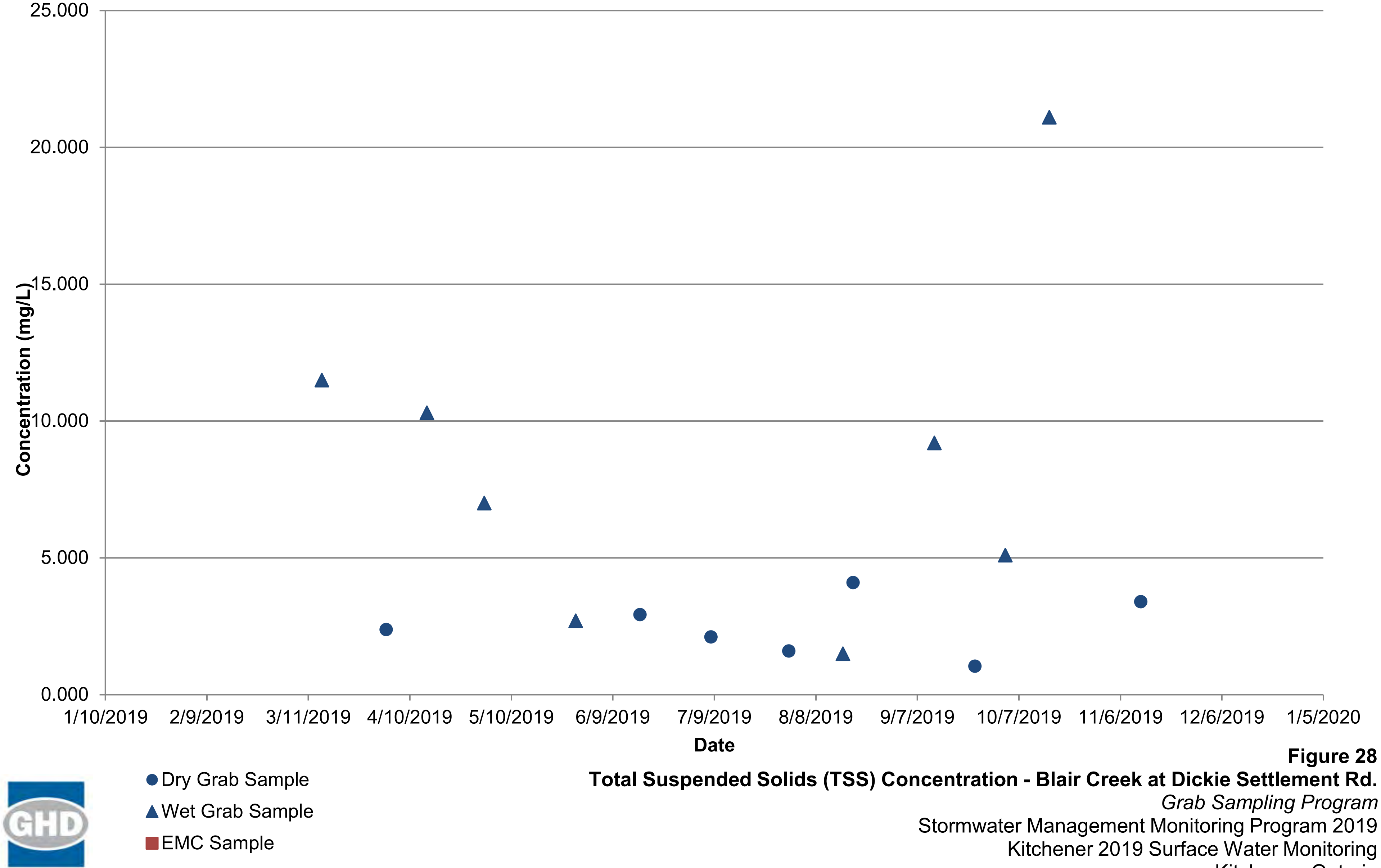


**Figure 28**

**Total Suspended Solids (TSS) Concentration - Blair Creek at Dickie Settlement Rd.**

*Grab Sampling Program*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

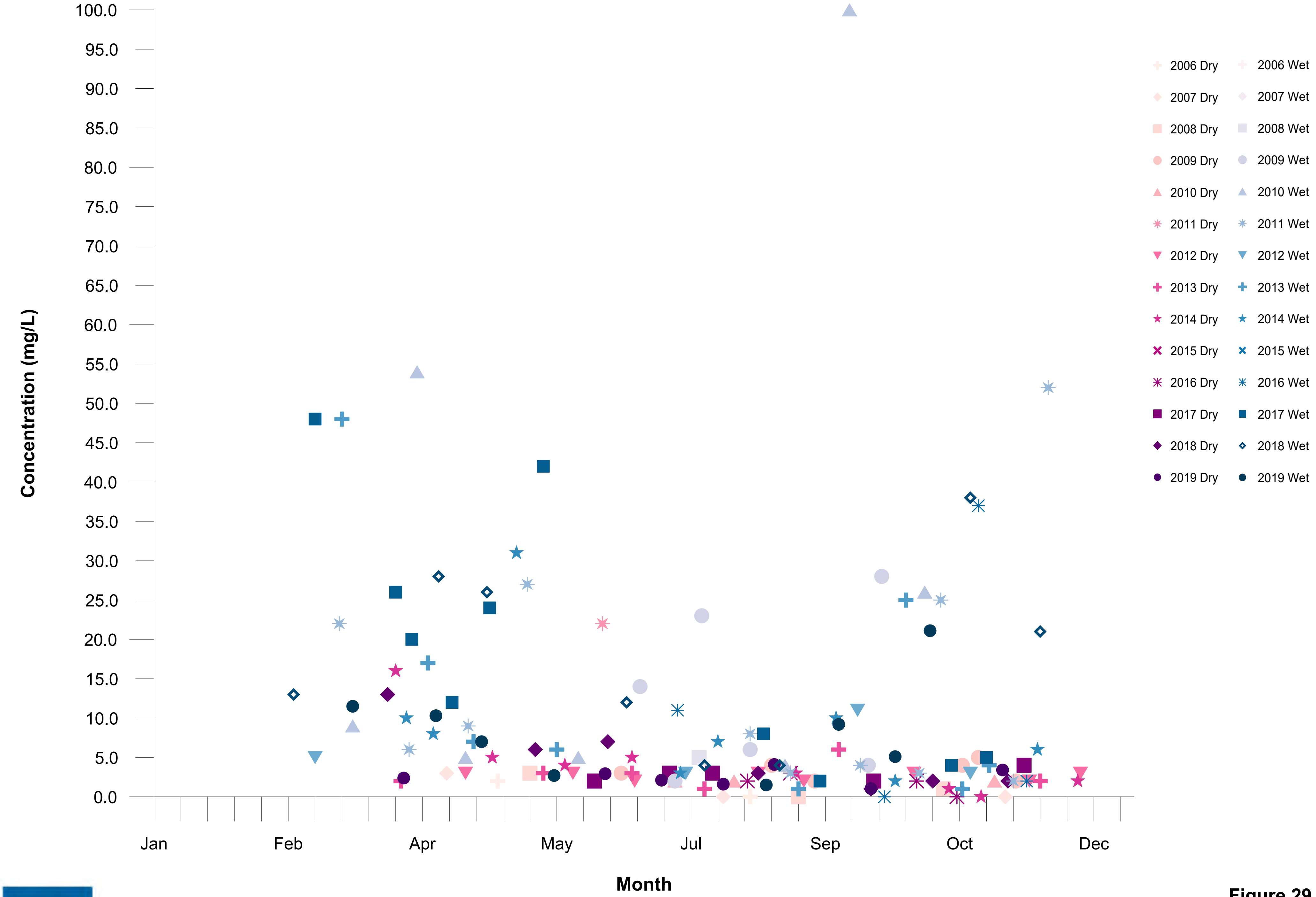


**Figure 29**
**TSS Historical Trend Concentrations**
Blair Creek - Dickie Settlement Rd.
Stormwater Management Monitoring Program 2019
Kitchener, Ontario

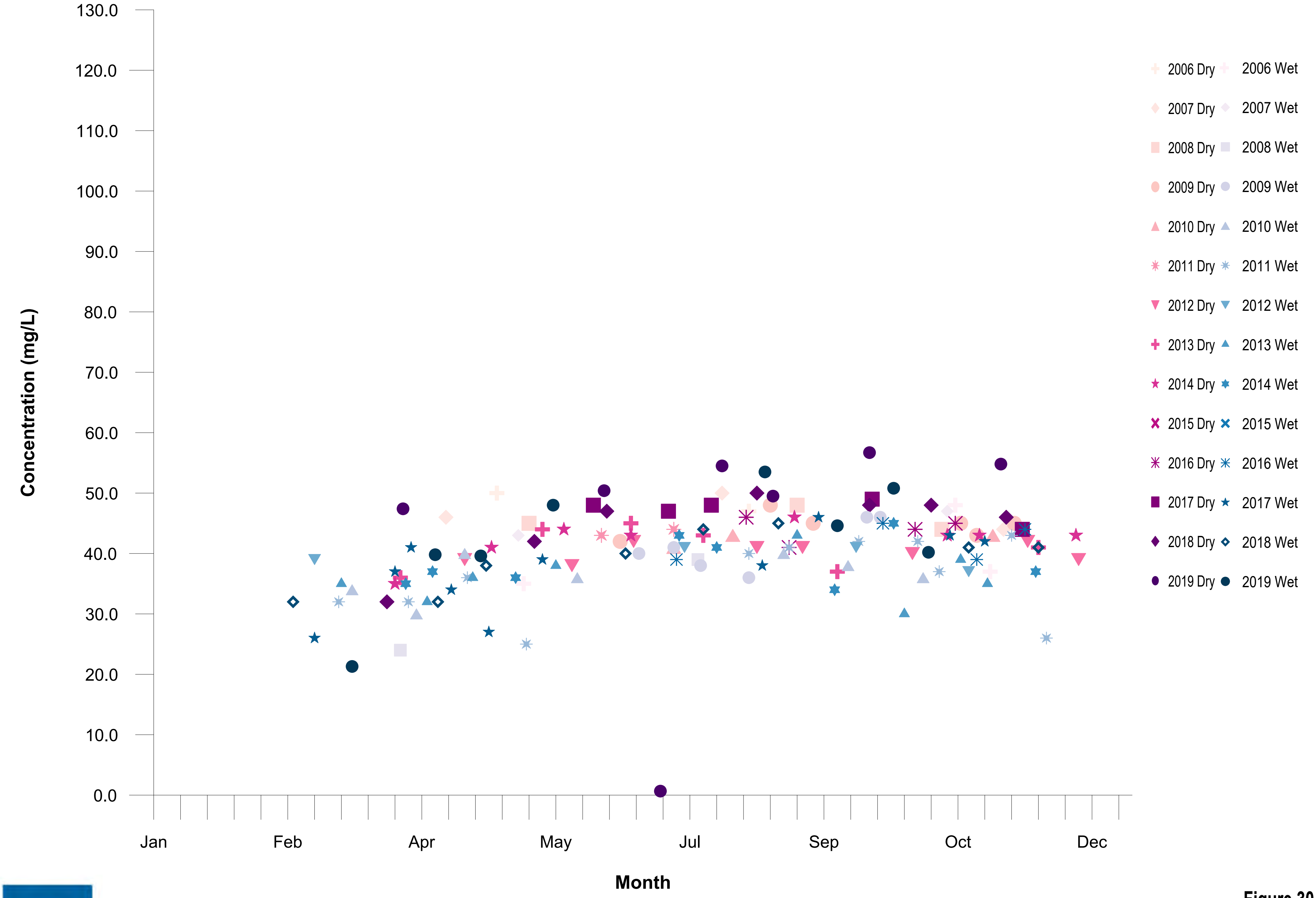


**Figure 30**
**Chloride Historical Trend Concentrations Blair**
Creek - Dickie Settlement Rd.
Stormwater Management Monitoring Program 2019
Kitchener, Ontario

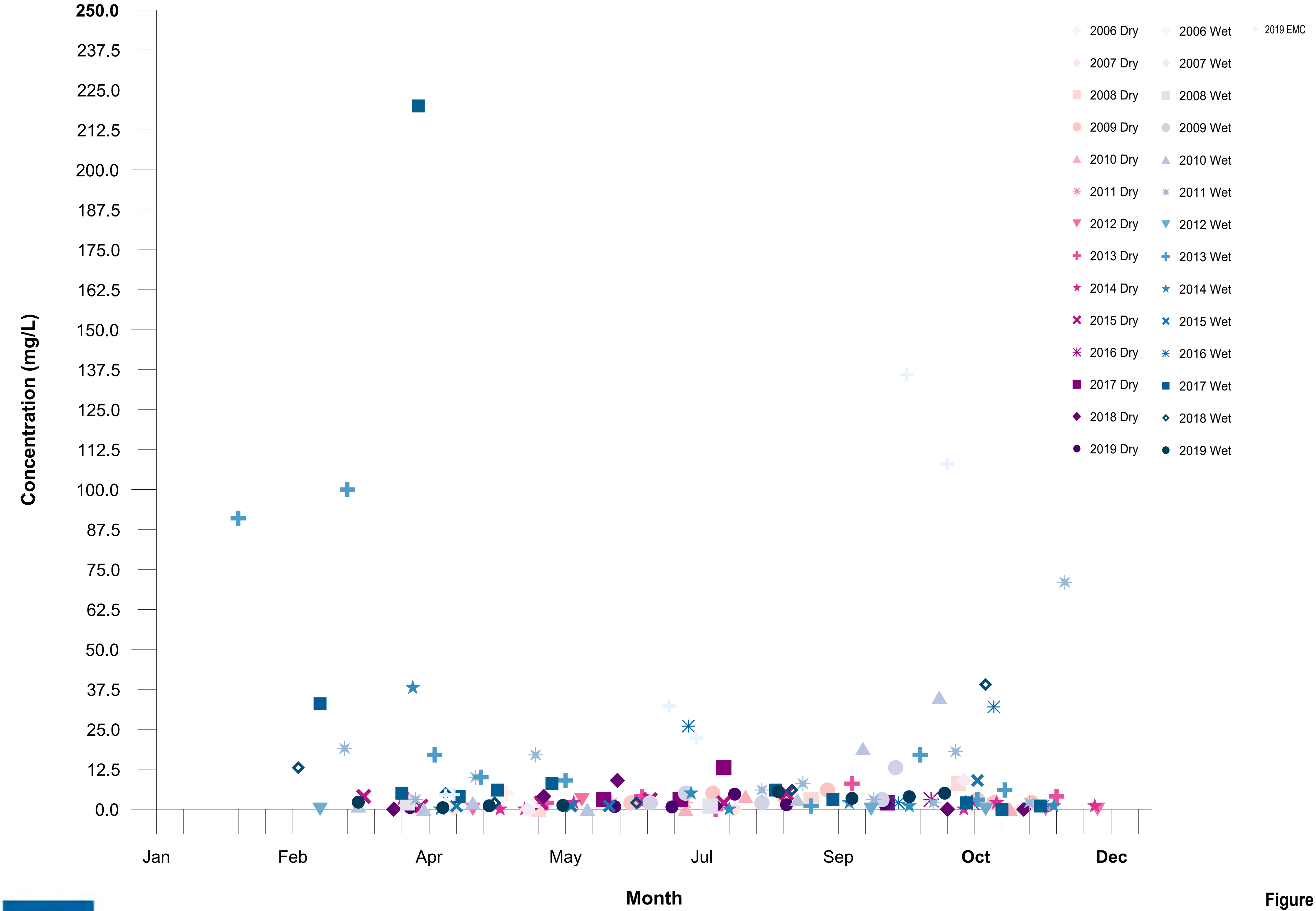


**Figure 31**

**TSS Historical Trend Concentrations**

Blair Creek - New Dundee Rd.

Stormwater Management Monitoring Program 2019

Kitchener, Ontario

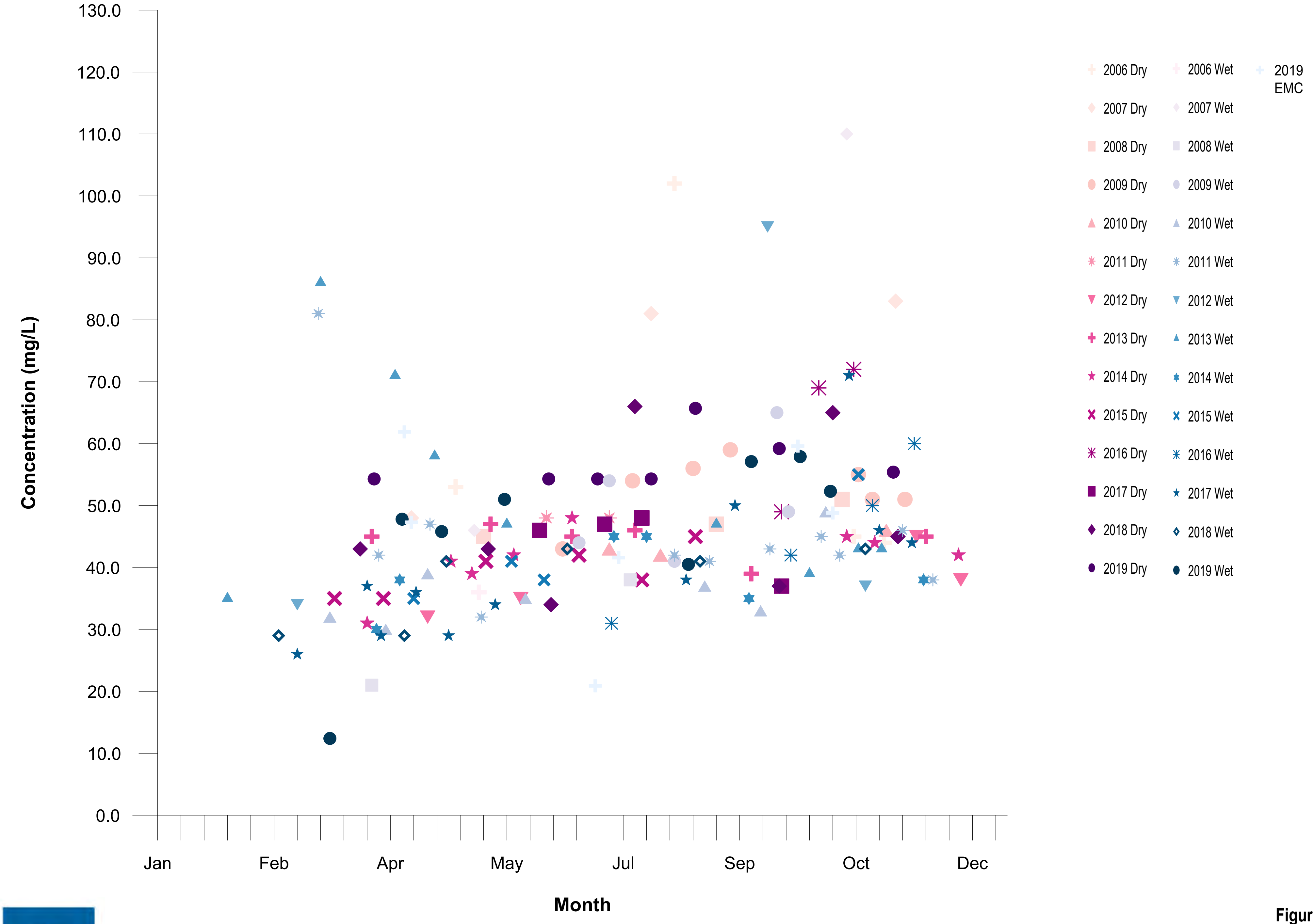
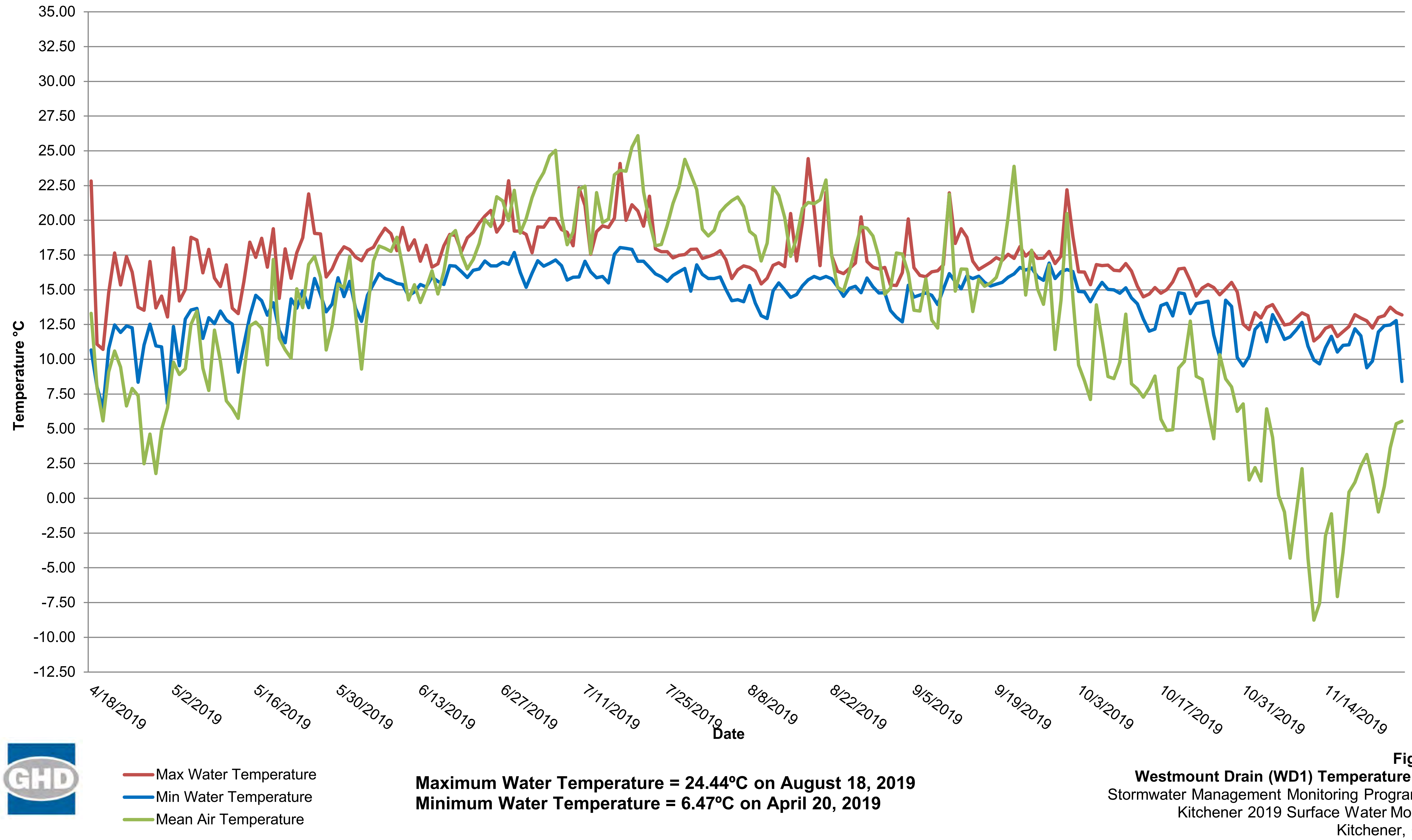


**Figure 32**

**Chloride Historical Trend Concentrations Blair Creek - New Dundee Rd.**

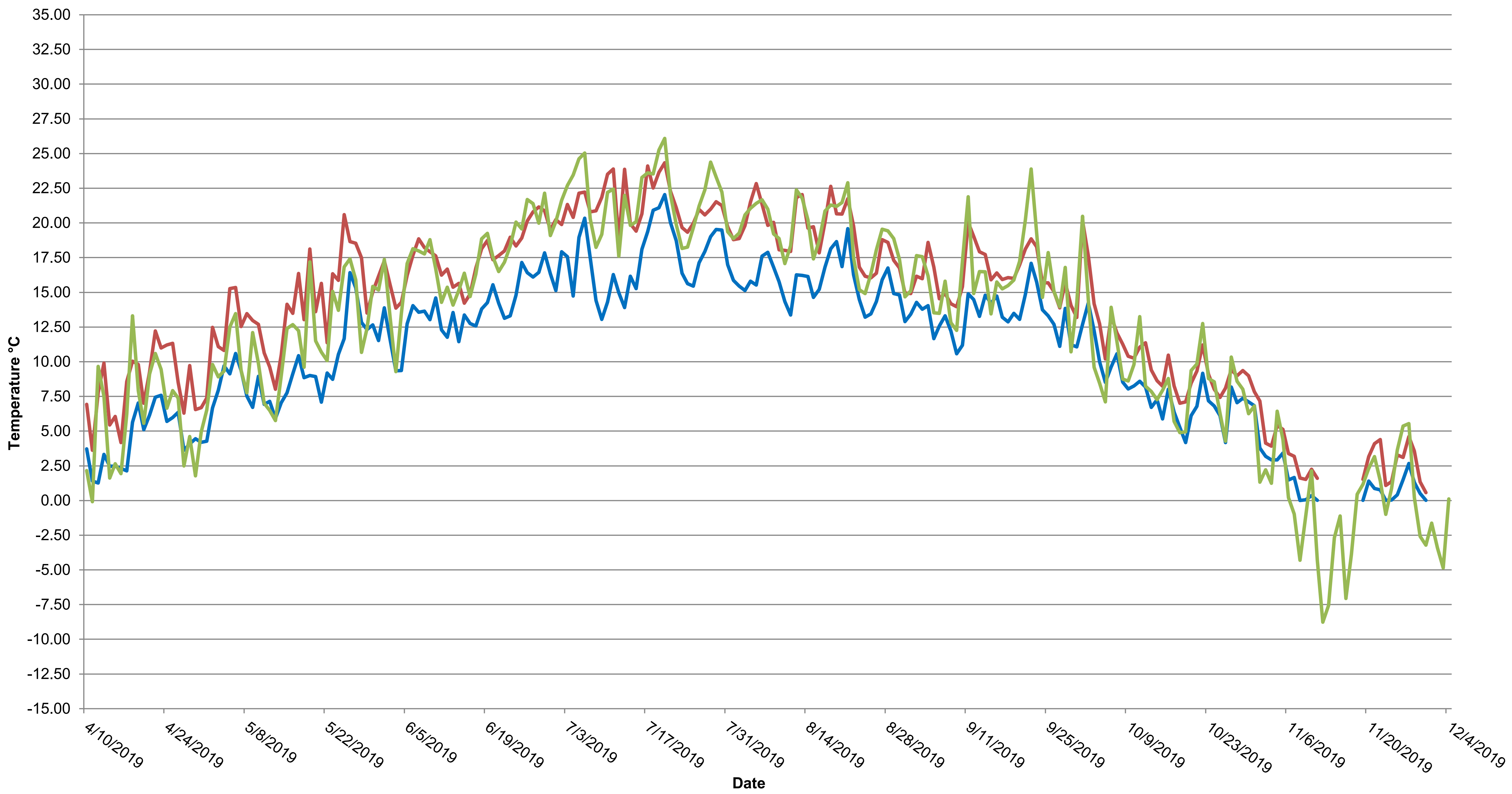
Stormwater Management Monitoring Program 2019

Kitchener, Ontario



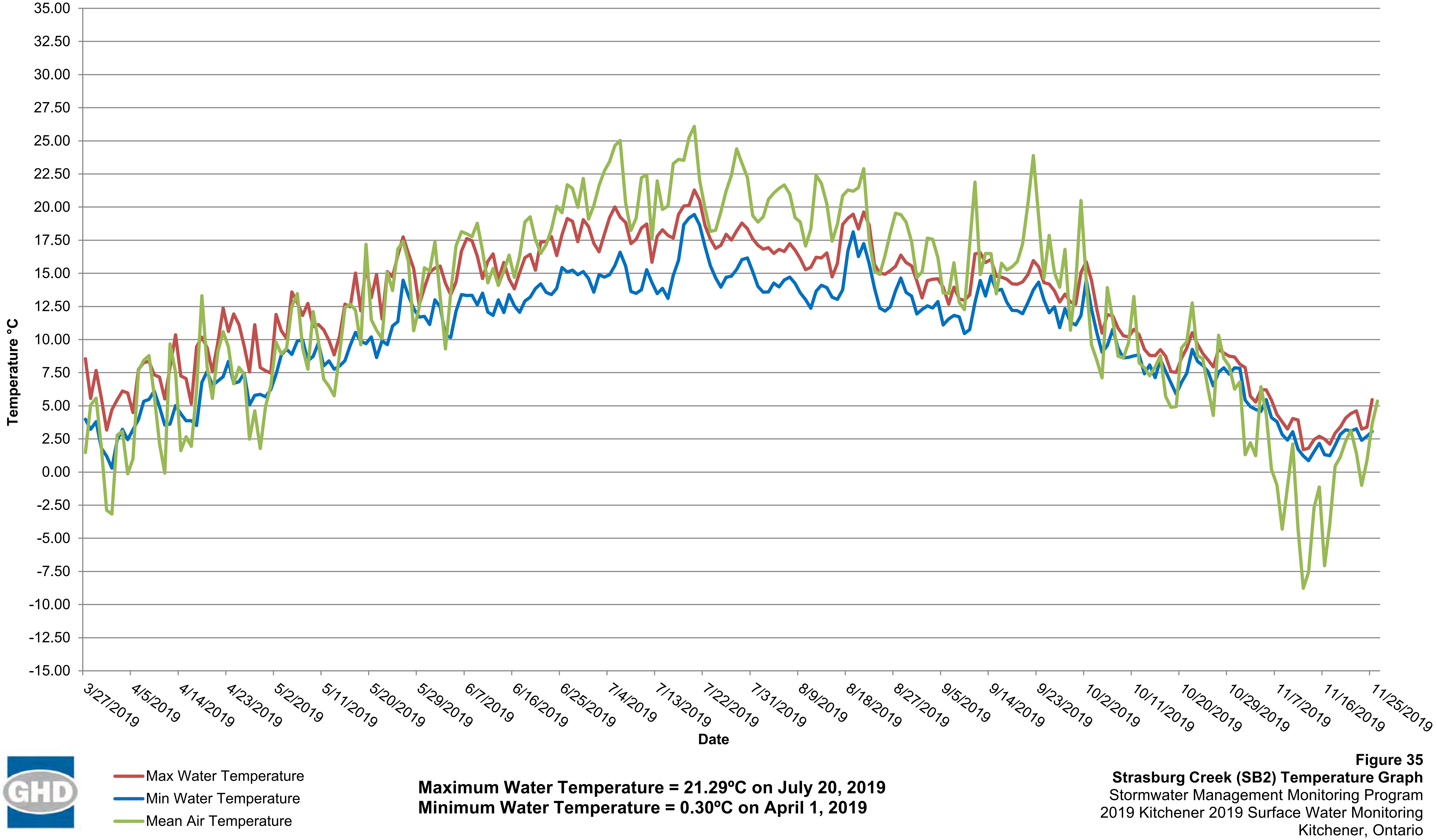
**Maximum Water Temperature = 24.44ºC on August 18, 2019**
**Minimum Water Temperature = 6.47ºC on April 20, 2019**

**Figure 33**
**Westmount Drain (WD1) Temperature Graph**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



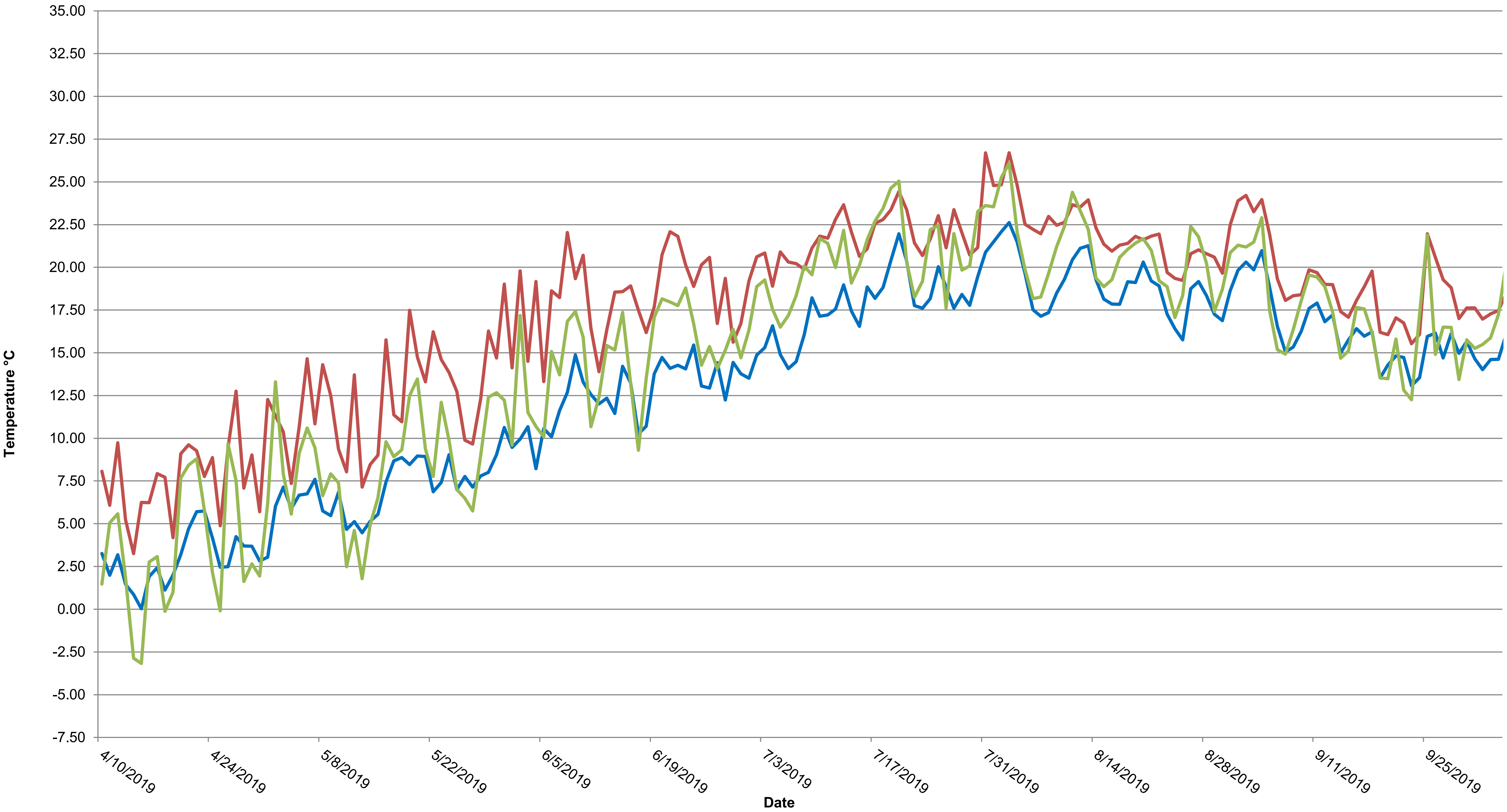
**Maximum Water Temperature = 24.34ºC on July 20, 2019**
**Minimum Water Temperature = 0.003 on November 8, 2019**

**Figure 34**
**Voisin Creek (VS1) Temperature Graph**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



**Maximum Water Temperature = 21.29ºC on July 20, 2019**
**Minimum Water Temperature = 0.30ºC on April 1, 2019**

**Figure 35**
**Strasburg Creek (SB2) Temperature Graph**
Stormwater Management Monitoring Program
2019 Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



Max Water Temperature
Min Water Temperature
Mean Air Temperature

**Maximum Water Temperature = 26.70ºC on July 20, 2019**
**Minimum Water Temperature = 0.026ºC on April 1, 2019**

**Figure 36**
**Sandrock Greenway (SR2) Temperature Graph**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

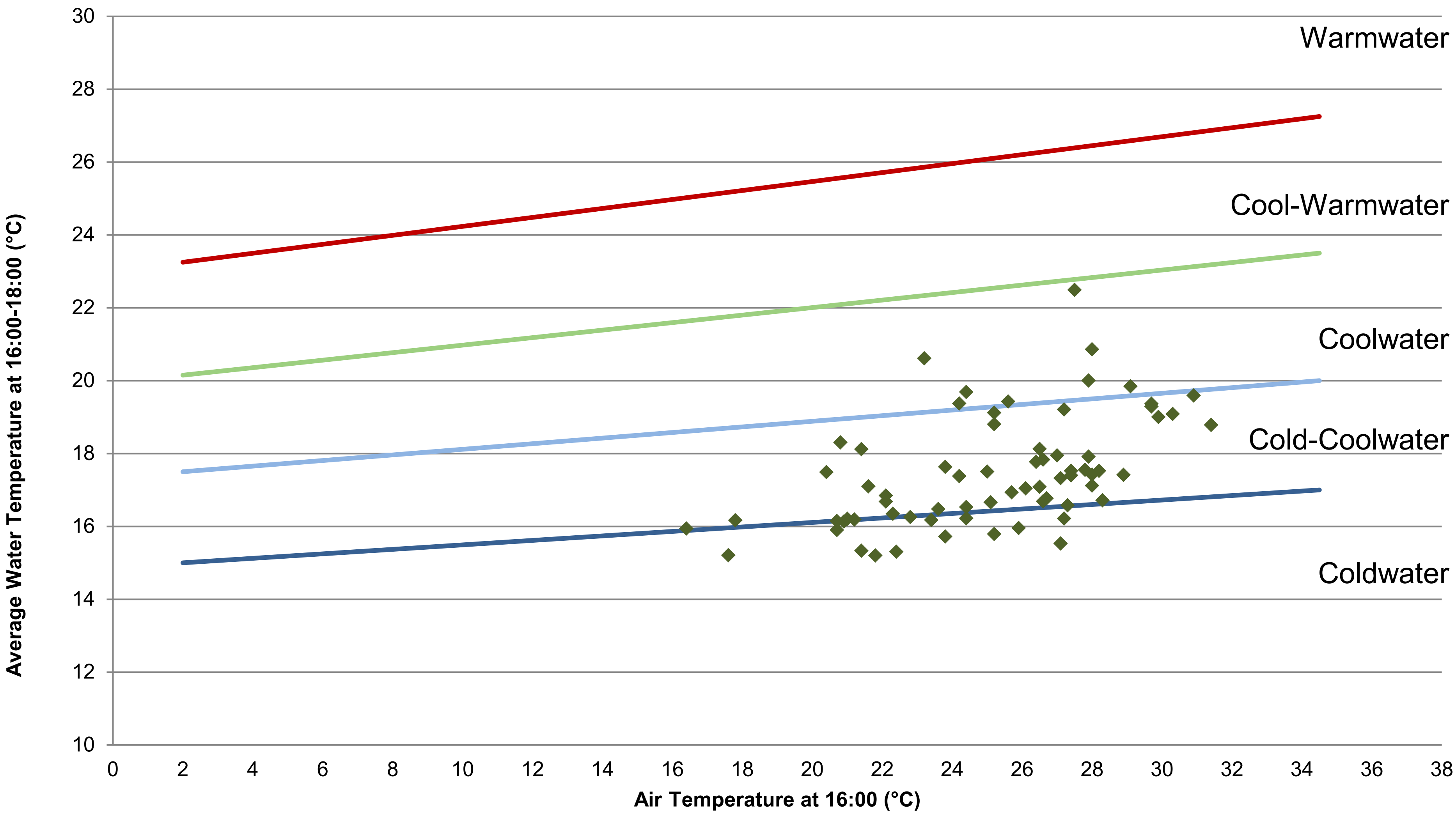


**Figure 37**
**WD1 Thermal Stability Classification**
Stormwater Management Monitoring Program
2019 Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

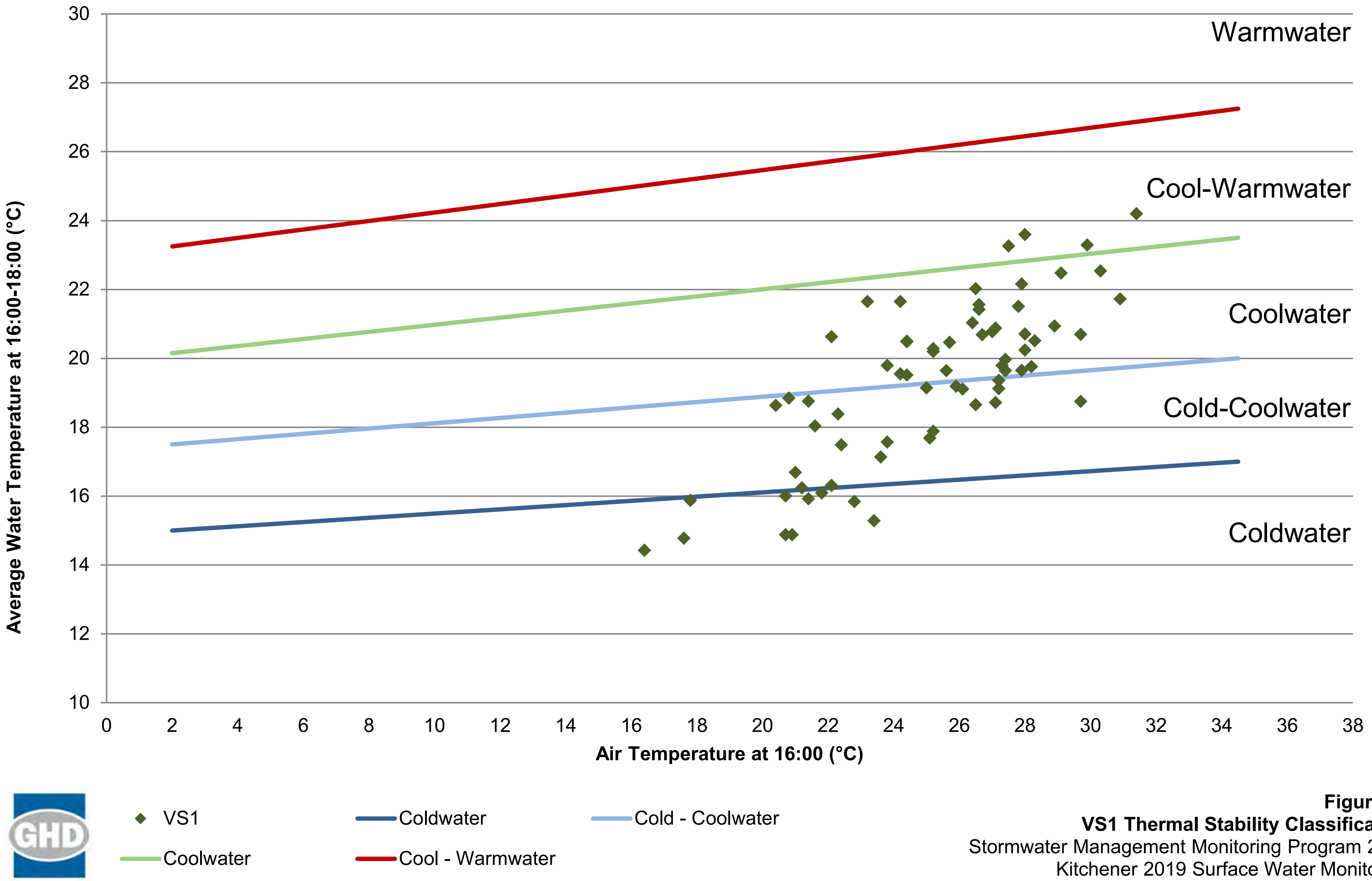


**Figure 38**
**VS1 Thermal Stability Classification**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

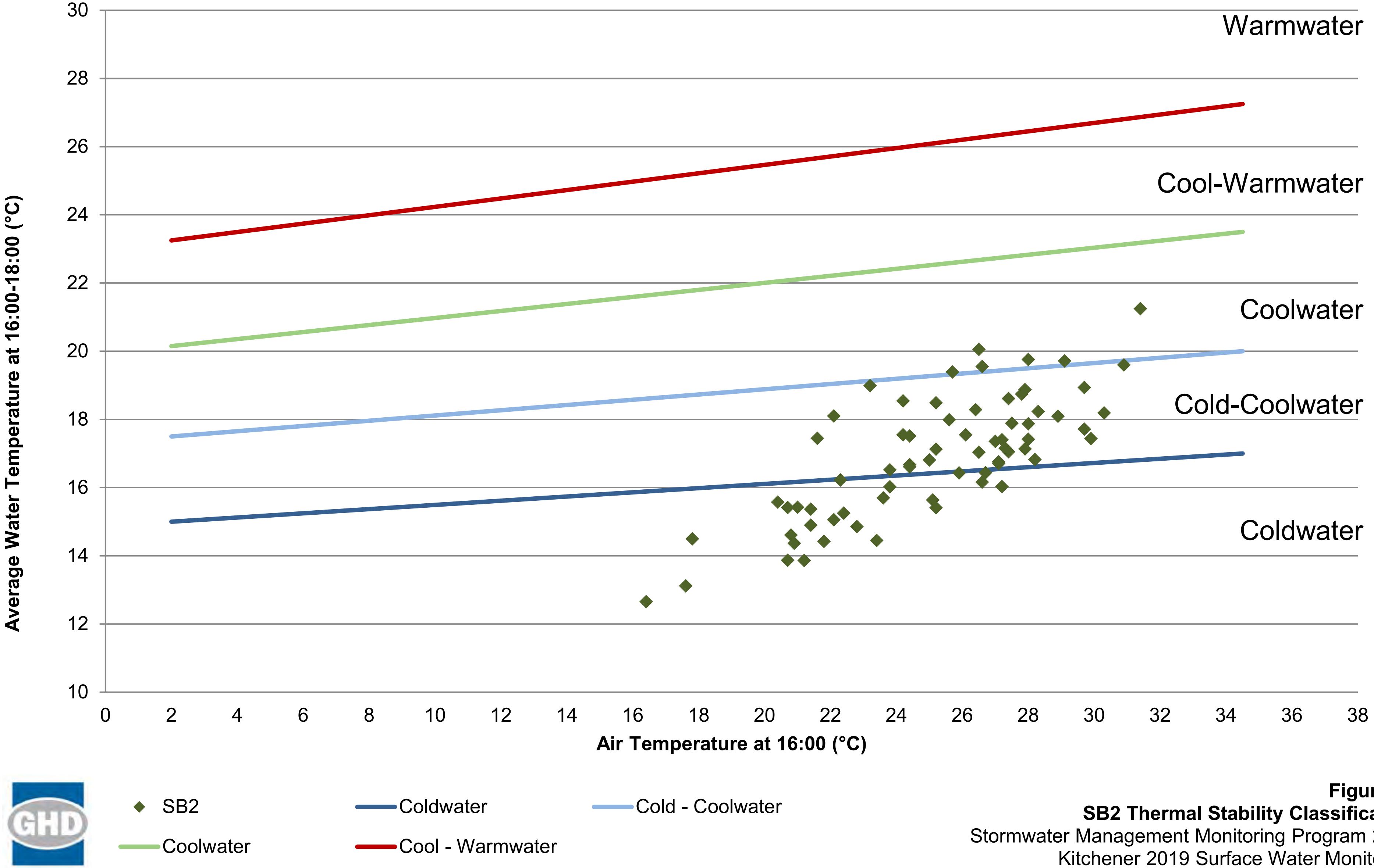


**Figure 39**

**SB2 Thermal Stability Classification**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

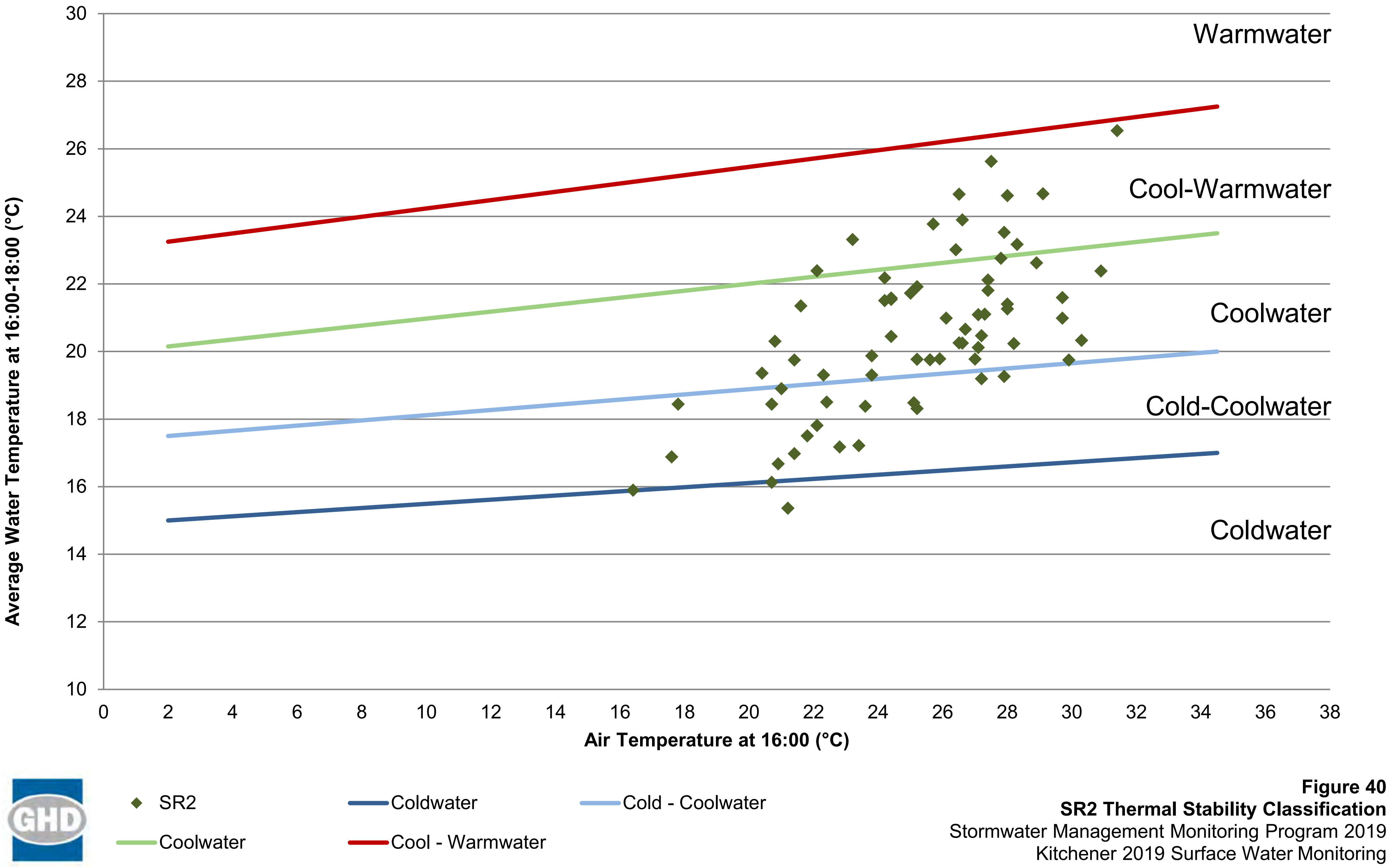


**Figure 40**

**SR2 Thermal Stability Classification**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

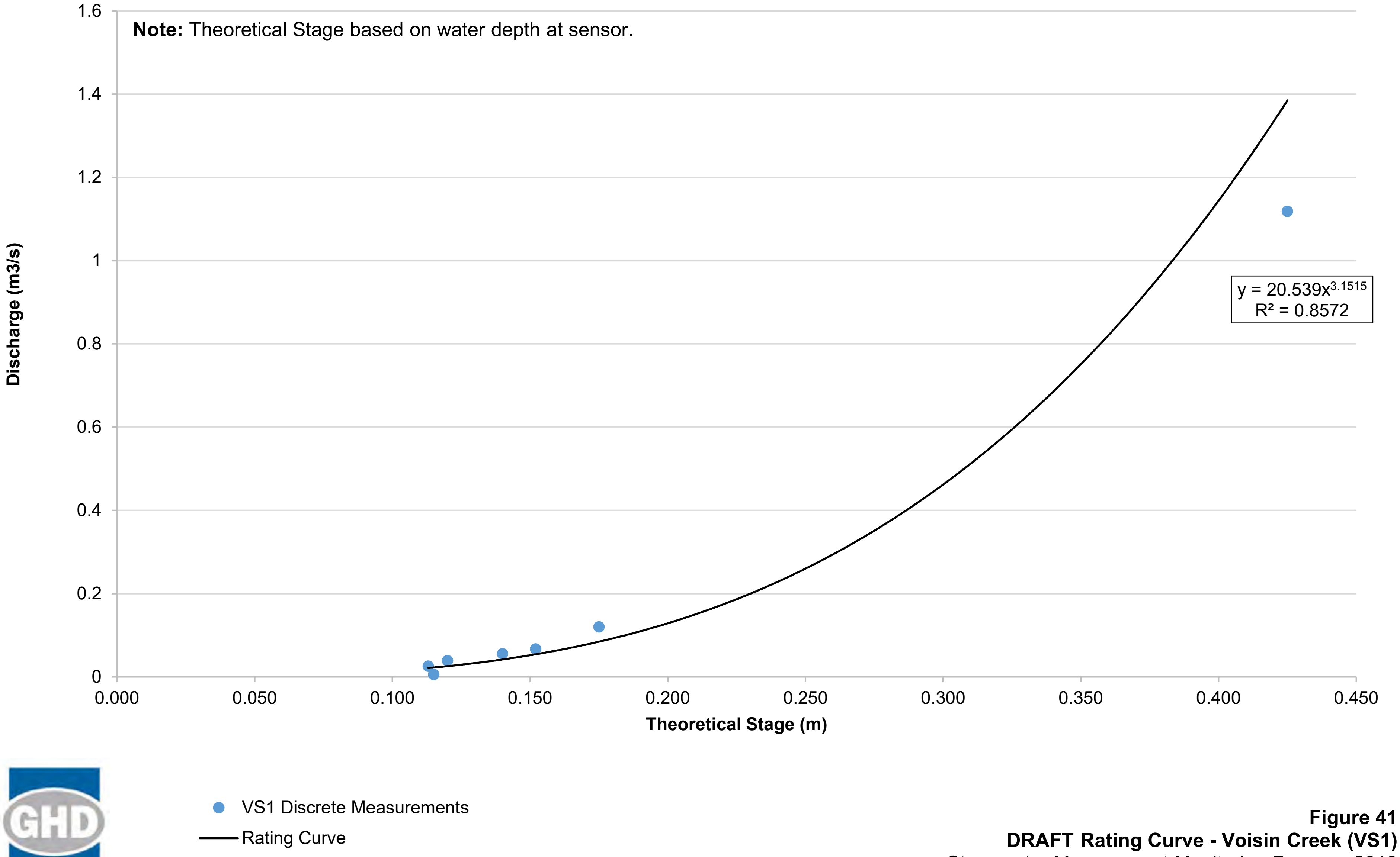


**Figure 41**

**DRAFT Rating Curve - Voisin Creek (VS1)**

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

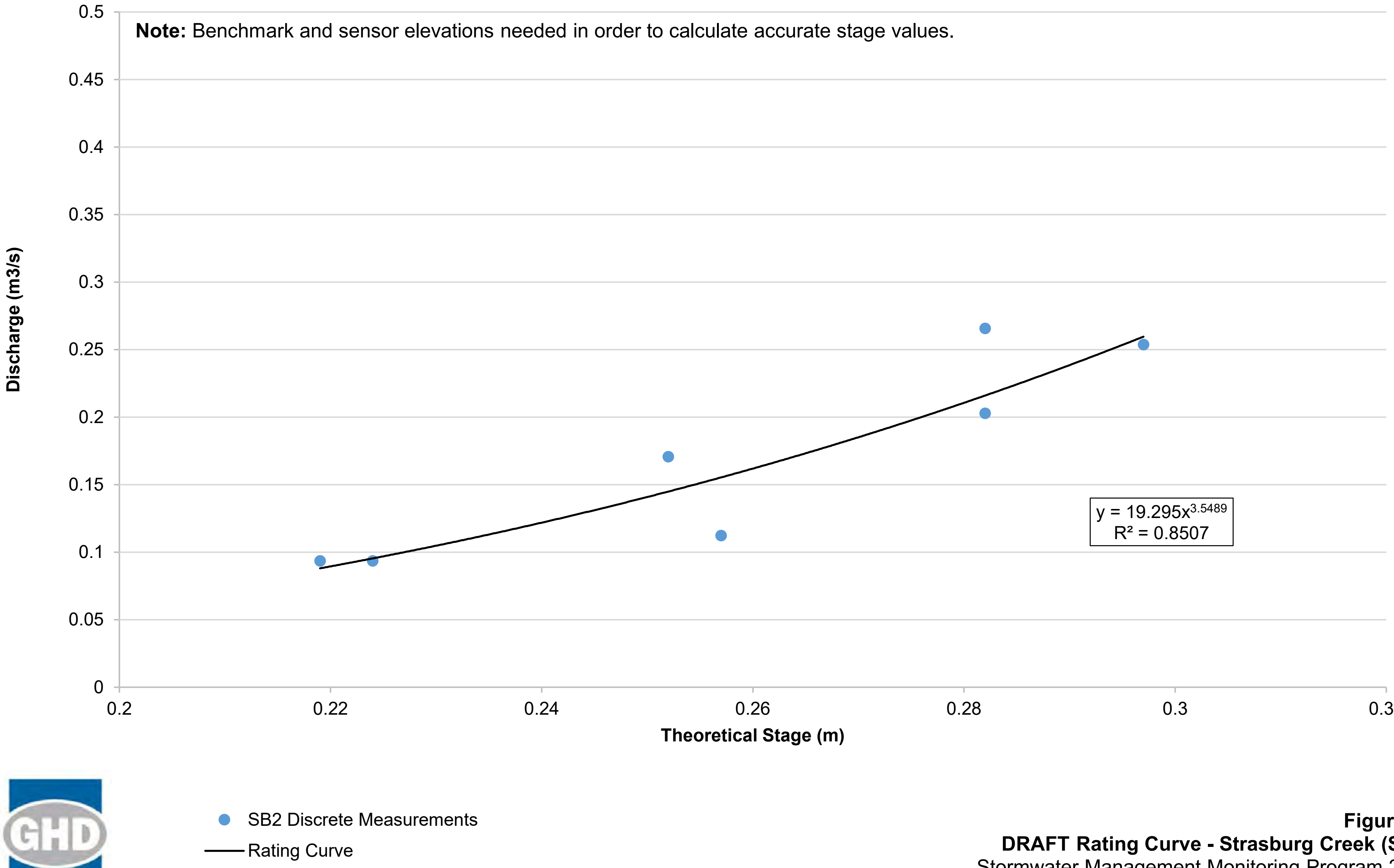
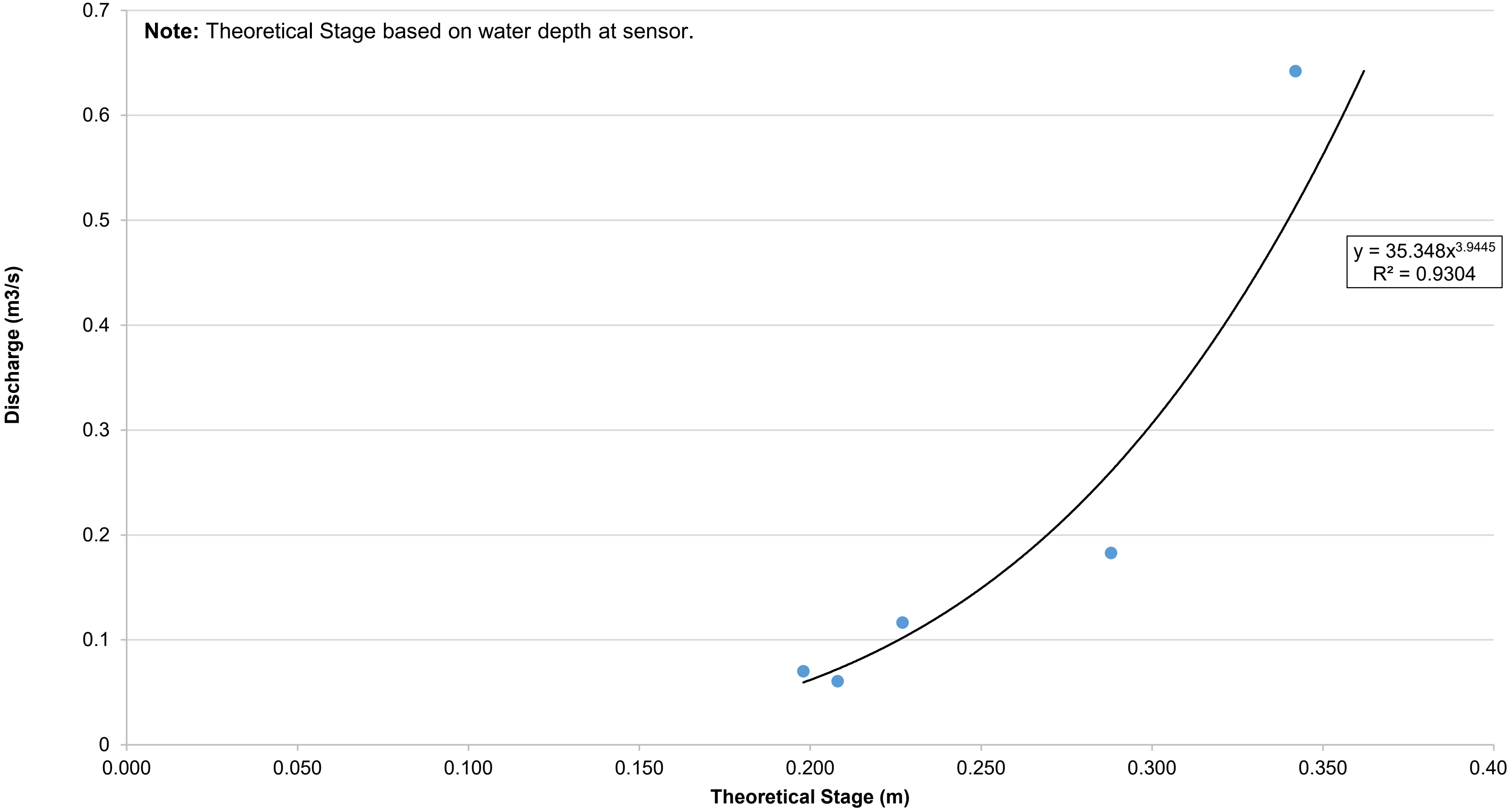


**Figure 42**
**DRAFT Rating Curve - Strasburg Creek (SB2)**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



**Note:** Theoretical Stage based on water depth at sensor.

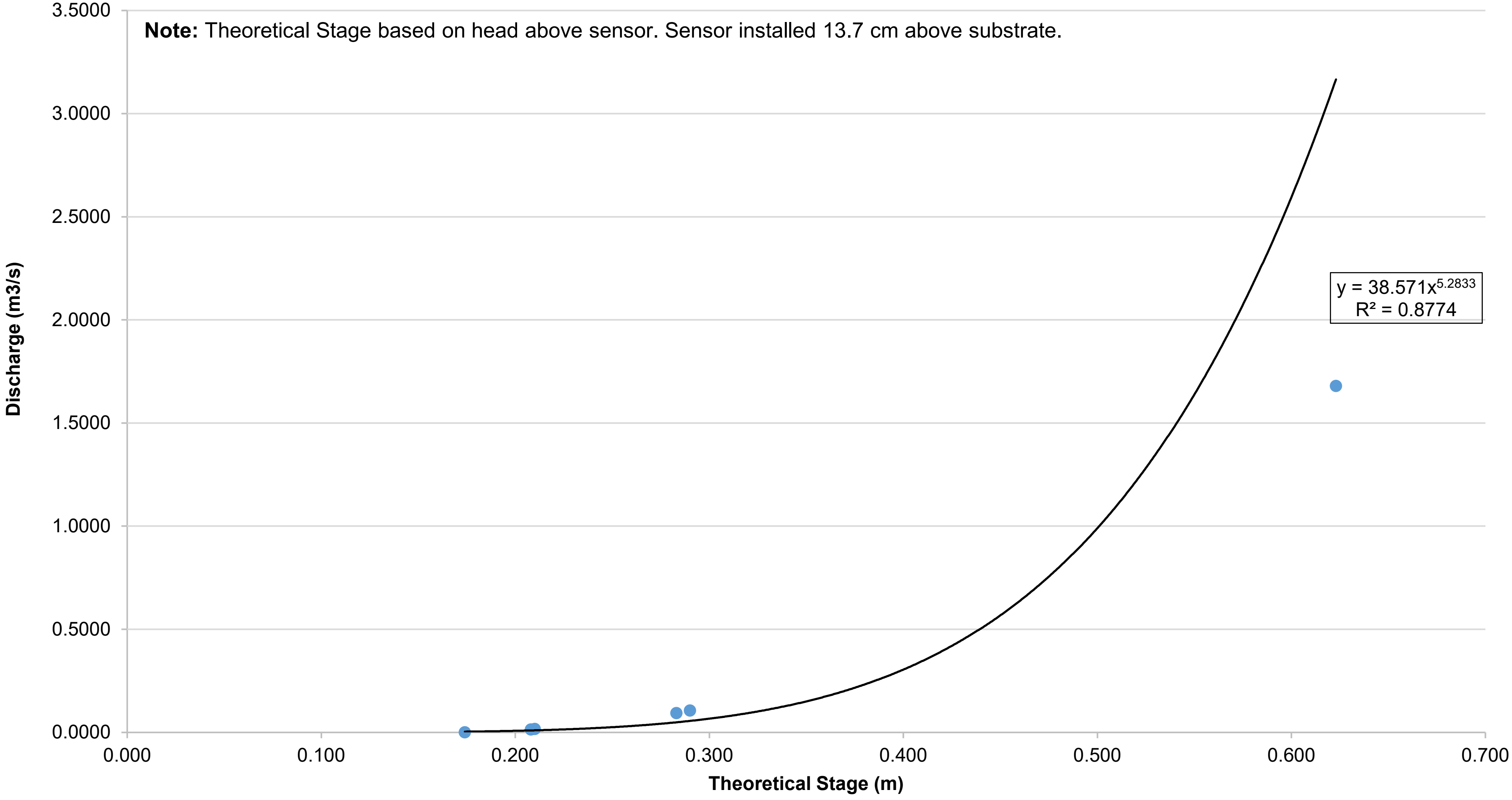
● WD1 Discrete Measurements

— Rating Curve

**Figure 43**

**DRAFT Rating Curve - Westmount Drain (WD1)**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



● SR2 Discrete Measurements

— Rating Curve

**Figure 44**

**DRAFT Rating Curve - Sandrock Greenway (SR2)**

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

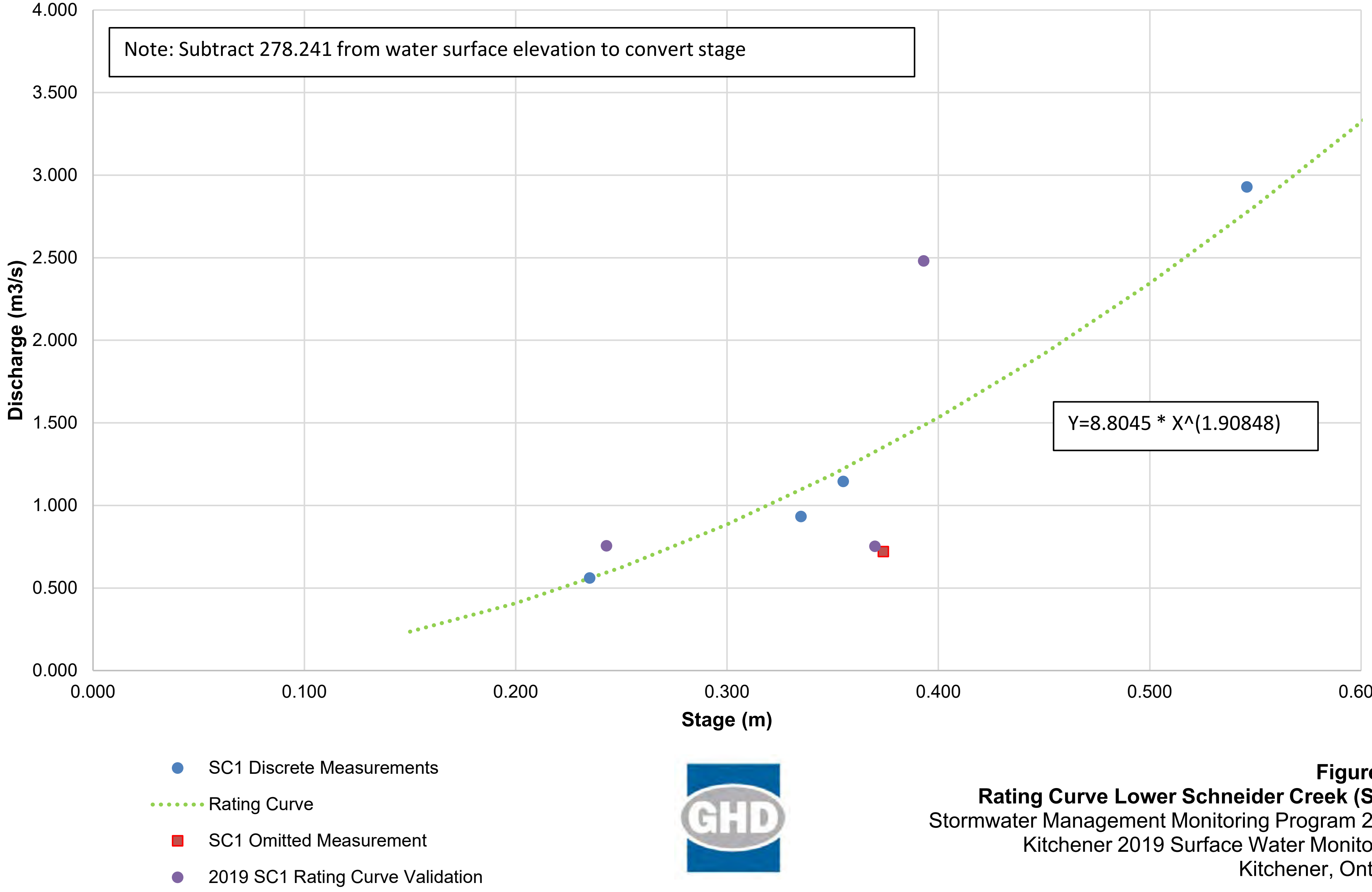


**Figure 45**
**Rating Curve Lower Schneider Creek (SC1)**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

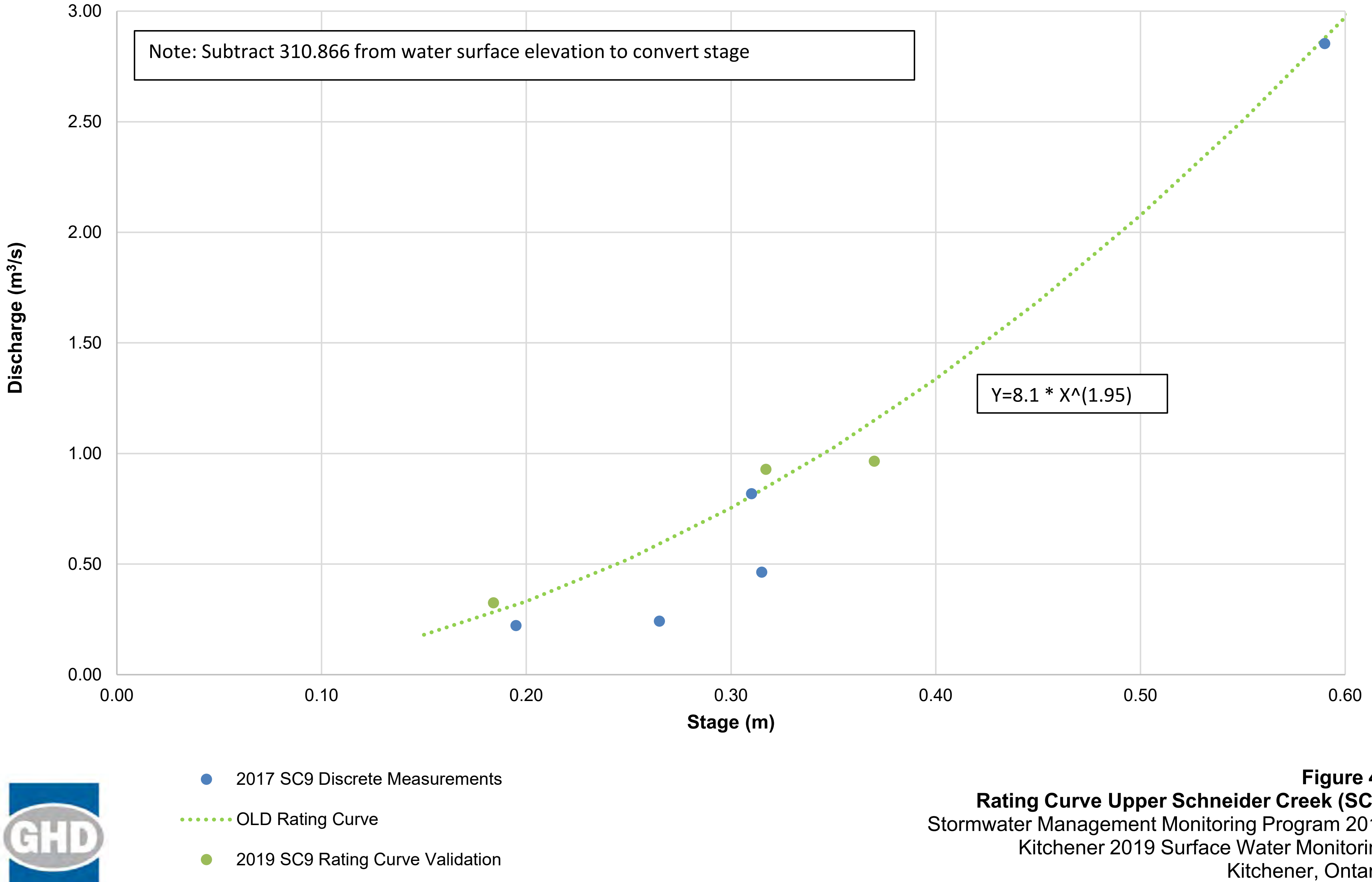


**Figure 46**

**Rating Curve Upper Schneider Creek (SC9)**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

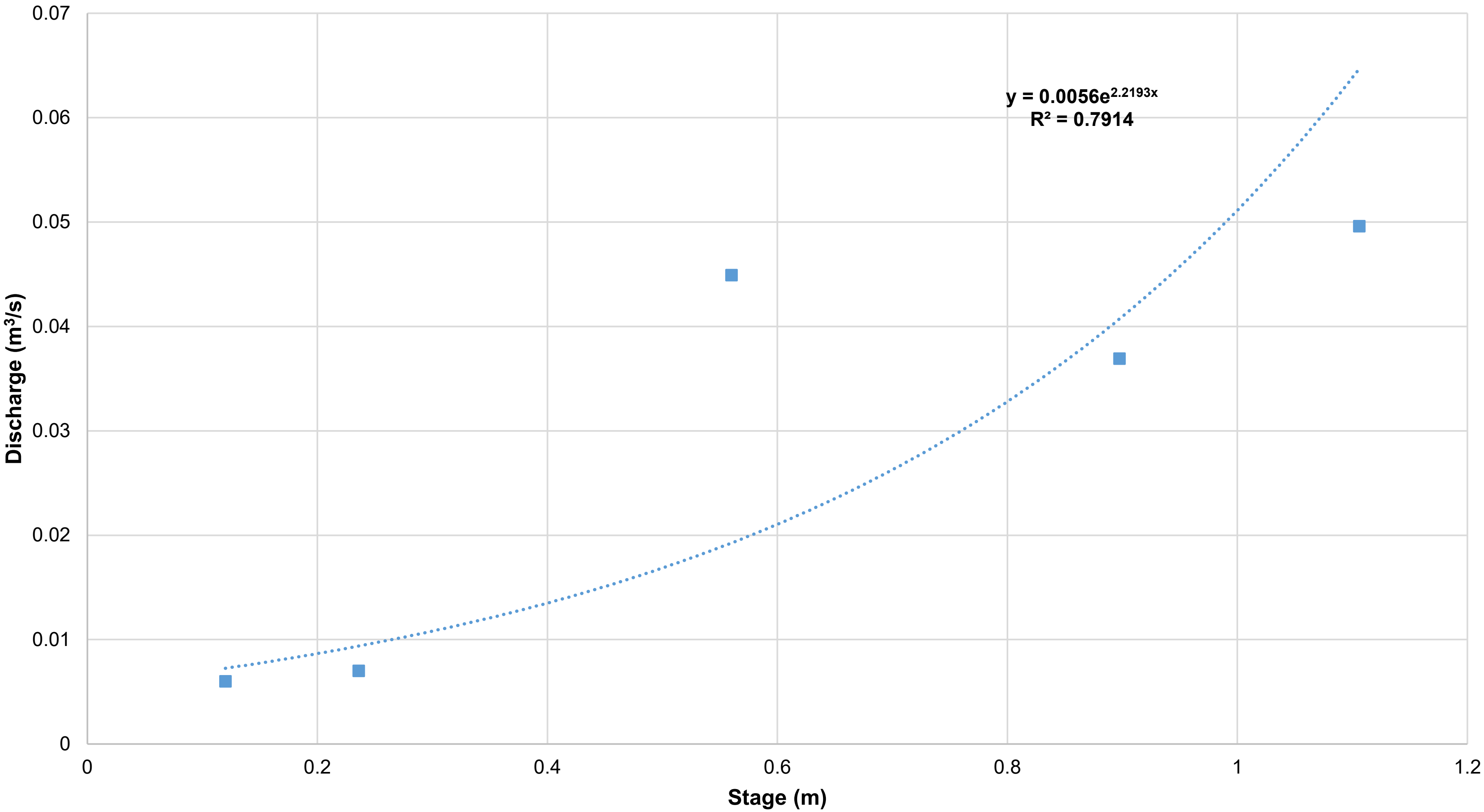


**Figure 47**

**Rating Curve School Creek (SCH1)**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

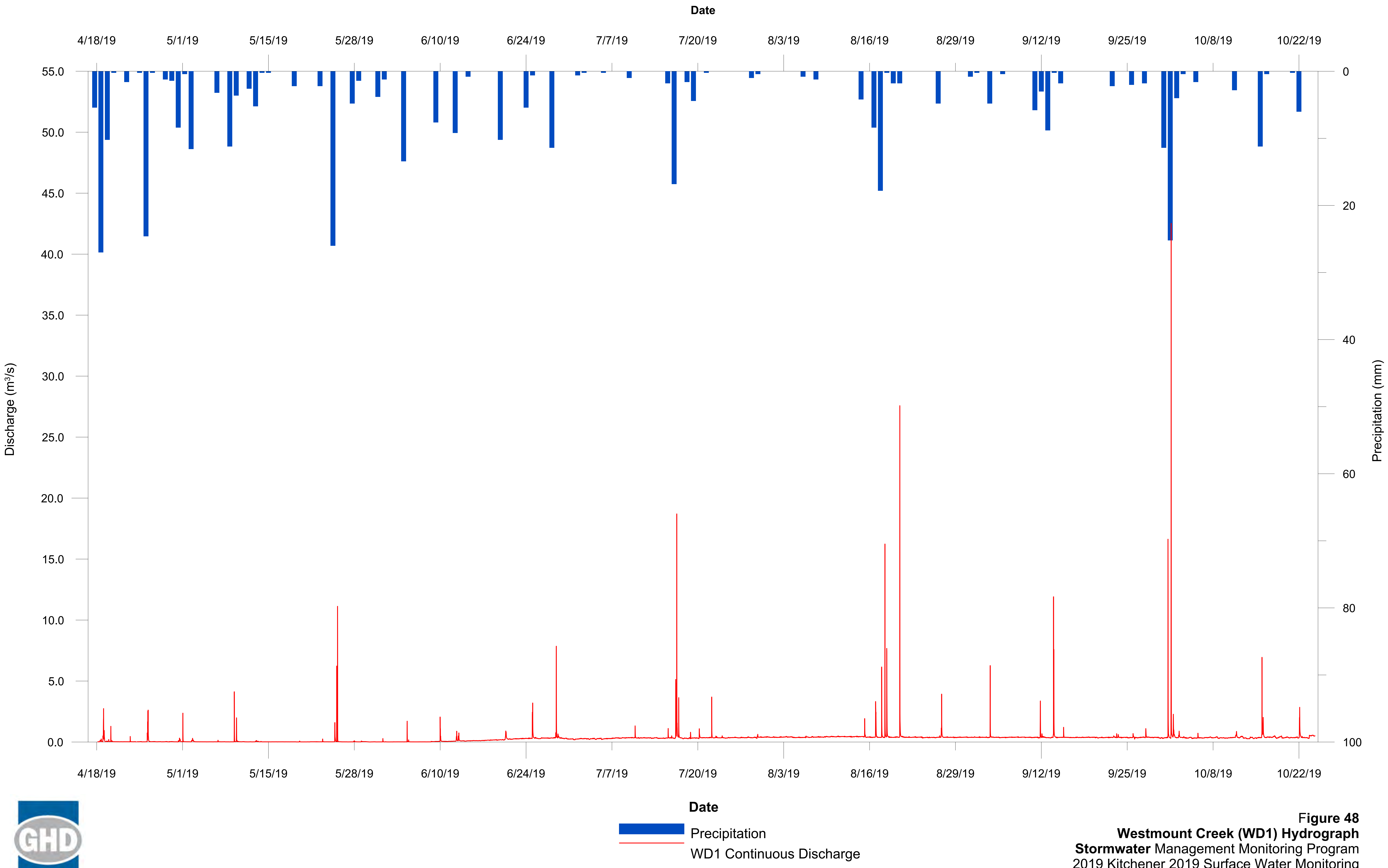


**Figure 48**
**Westmount Creek (WD1) Hydrograph**
**Stormwater** Management Monitoring Program
2019 Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

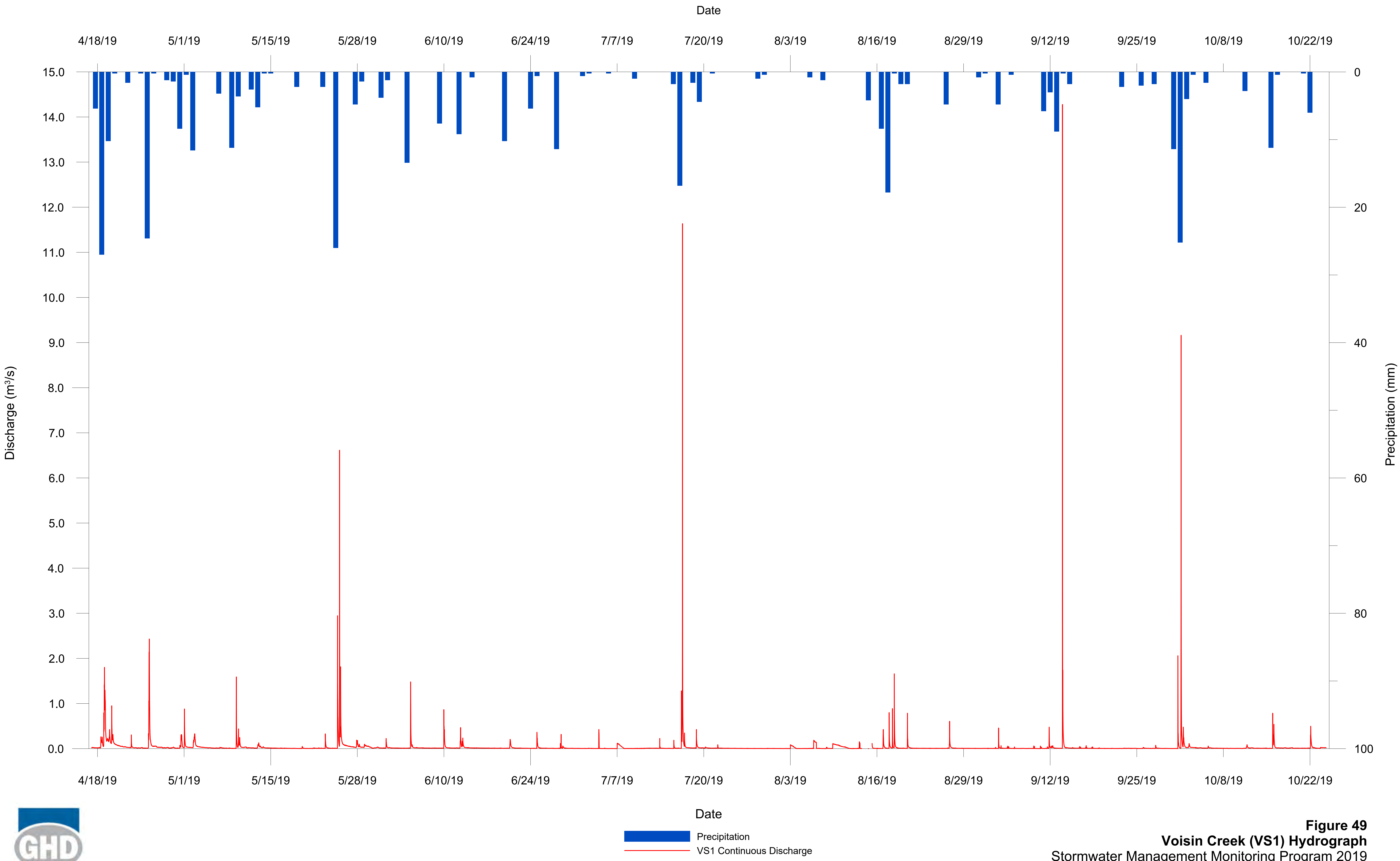
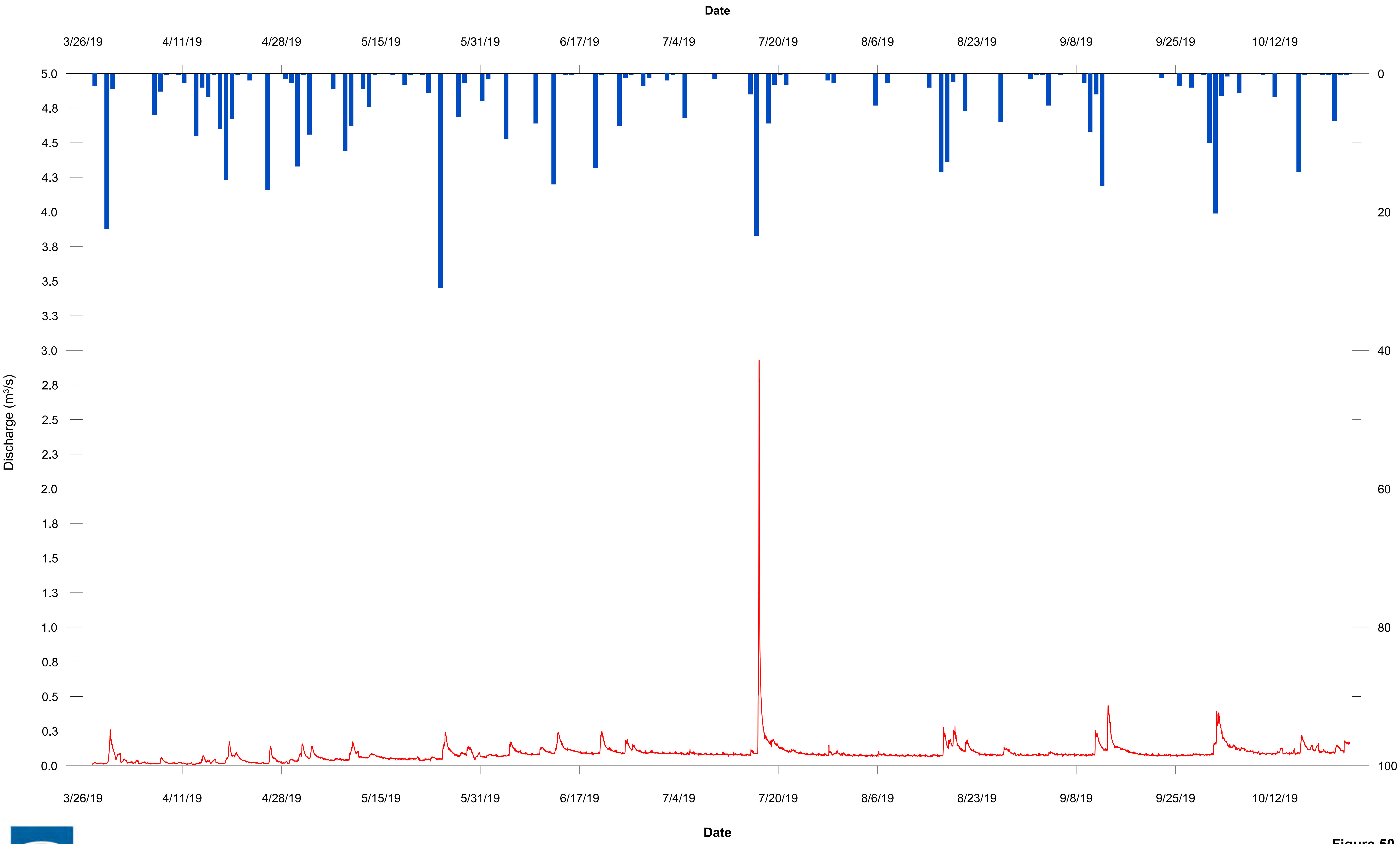


**Figure 49**

**Voisin Creek (VS1) Hydrograph**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



Notes:
- On July 17, 2019 when a peak in flow was observed Kitchener/Waterloo Airport reported 37.7 mm of rain

**Figure 50**

**Strasburg Creek (SB2) Hydrograph Stormwater**
Management Monitoring Program 2019 Kitchener
2019 Surface Water Monitoring Kitchener, Ontario

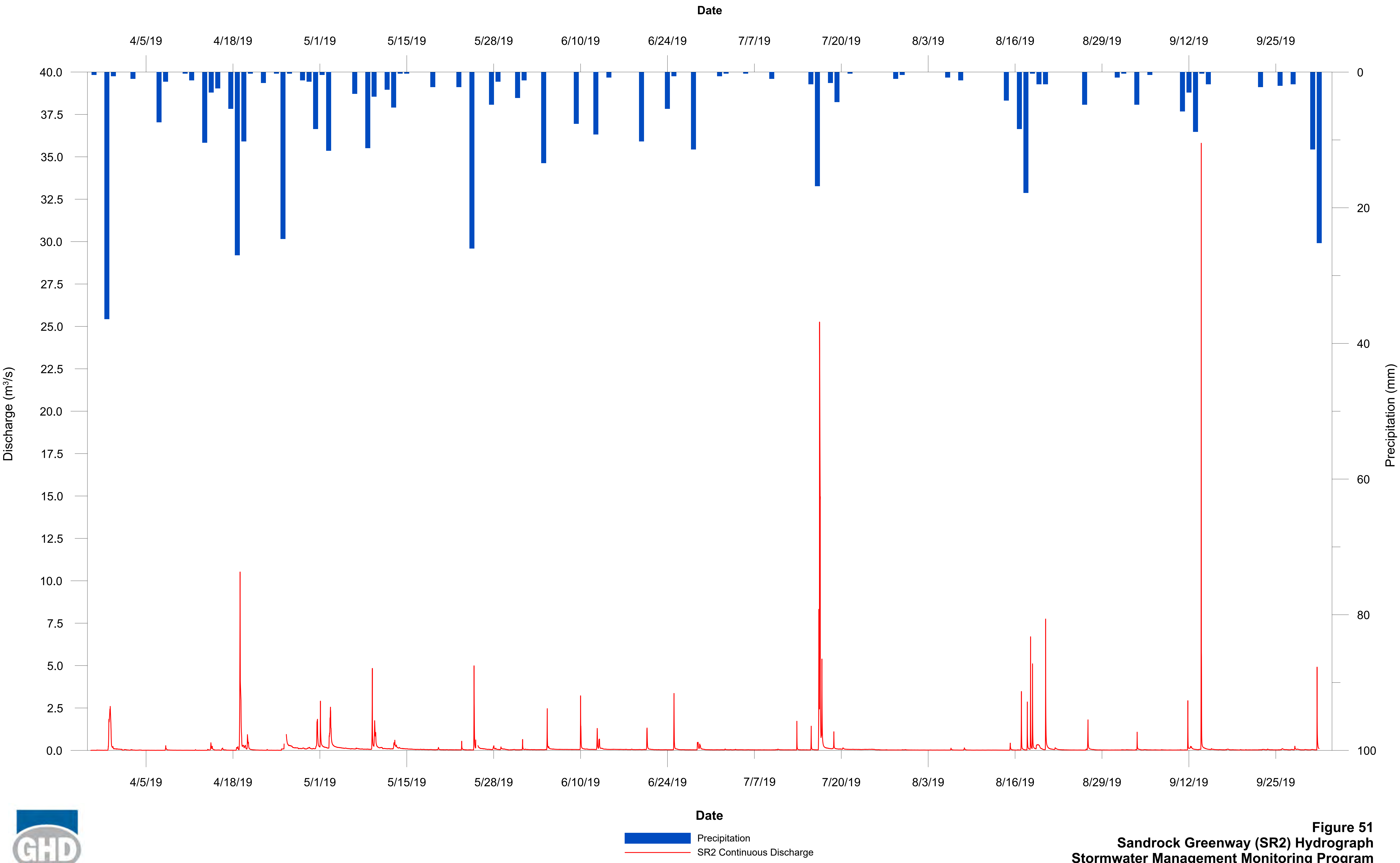


**Figure 51**
**Sandrock Greenway (SR2) Hydrograph**
**Stormwater Management Monitoring Program**
2019 Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

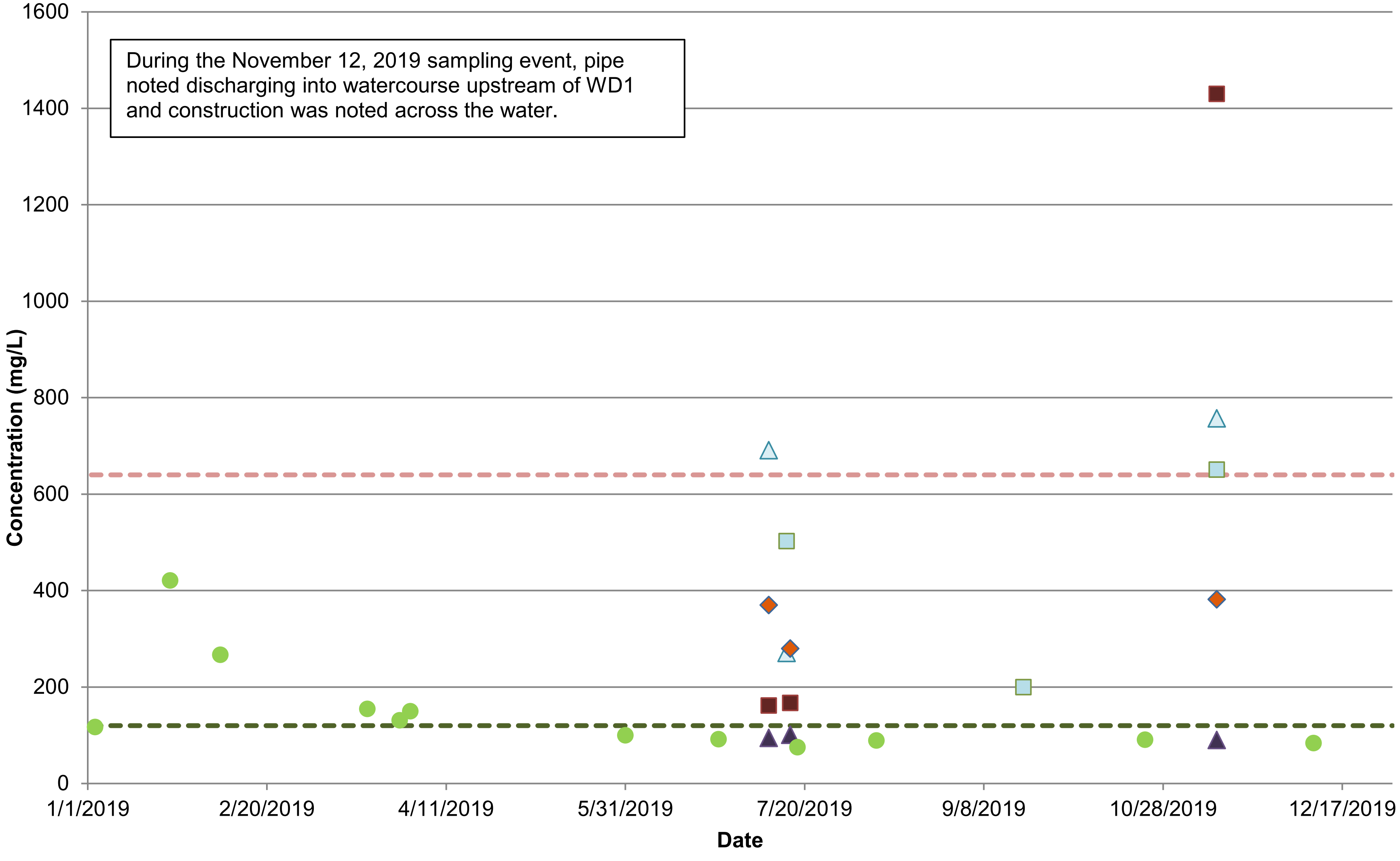
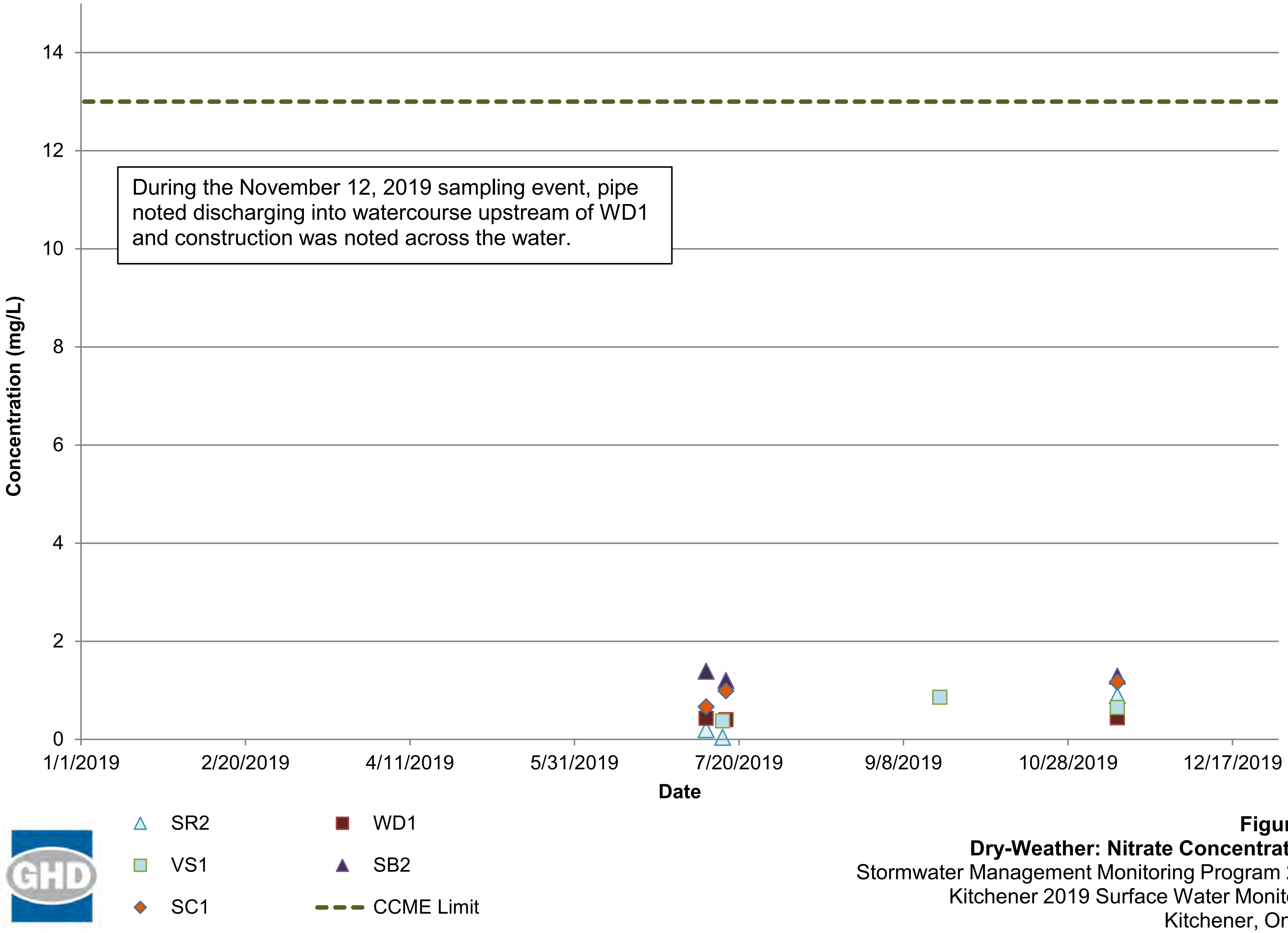


**Figure 52**

**Dry-Weather: Chloride Concentrations**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

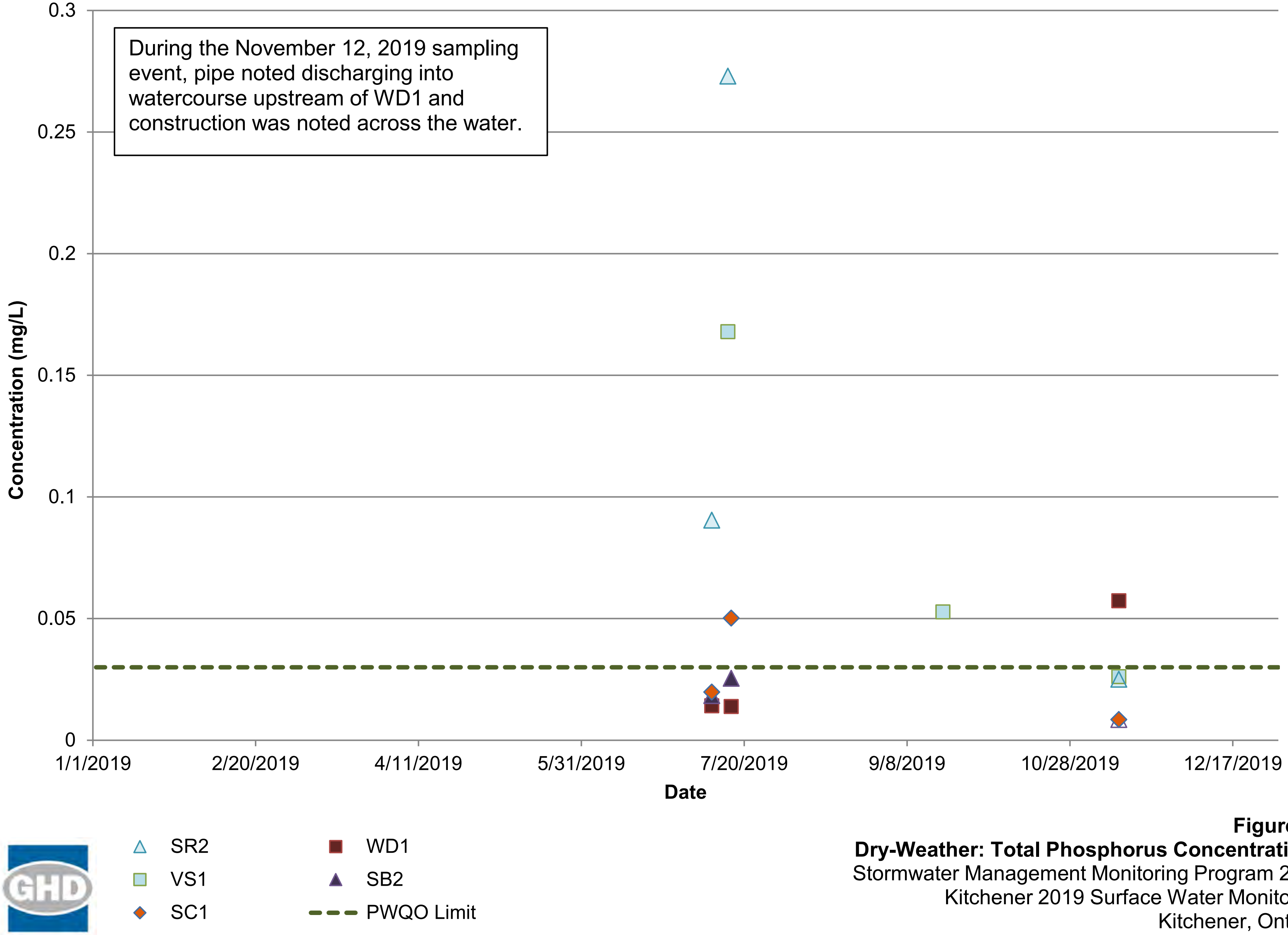


During the November 12, 2019 sampling event, pipe noted discharging into watercourse upstream of WD1 and construction was noted across the water.

**Figure 53**

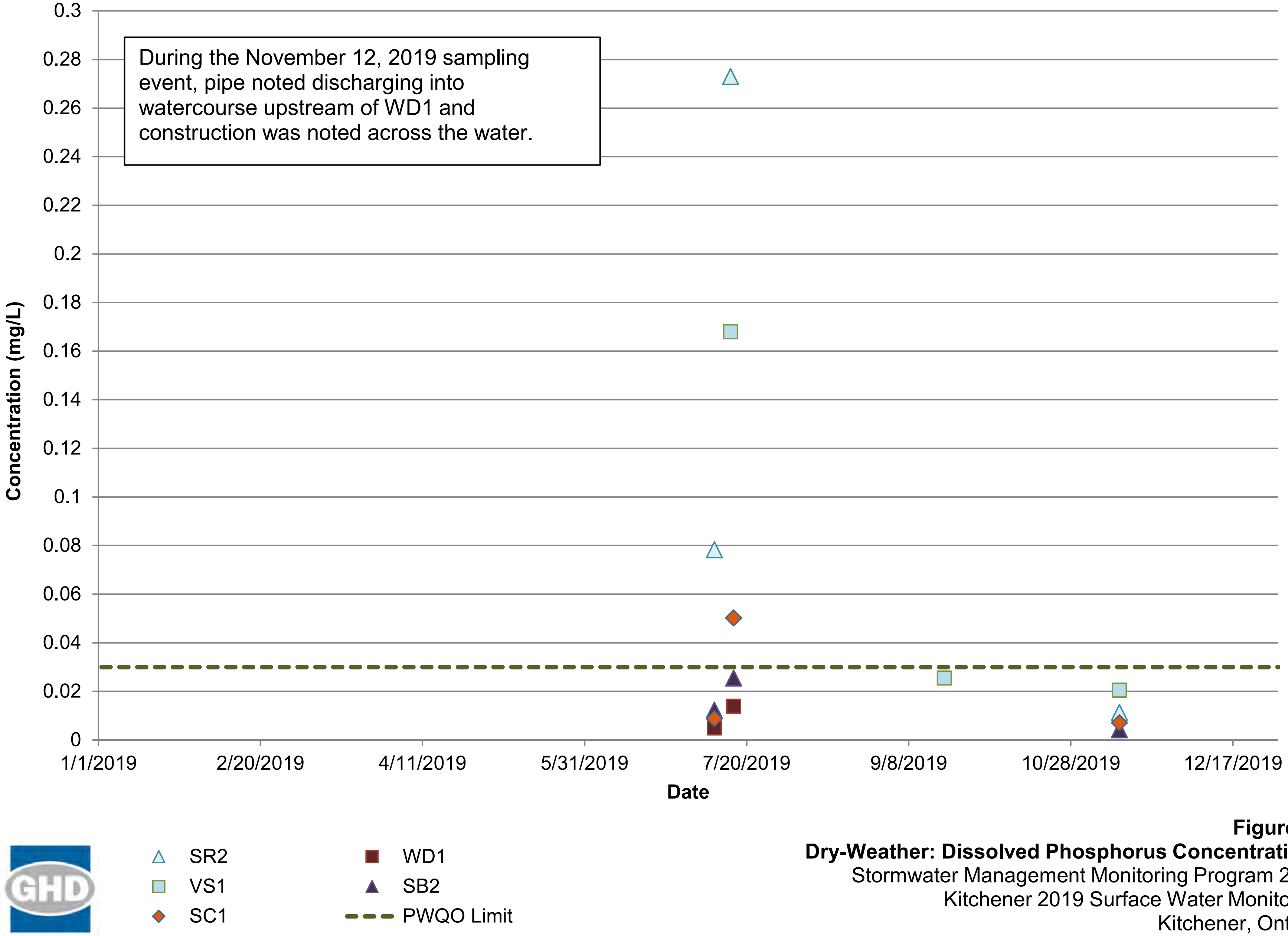
**Dry-Weather: Nitrate Concentrations**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



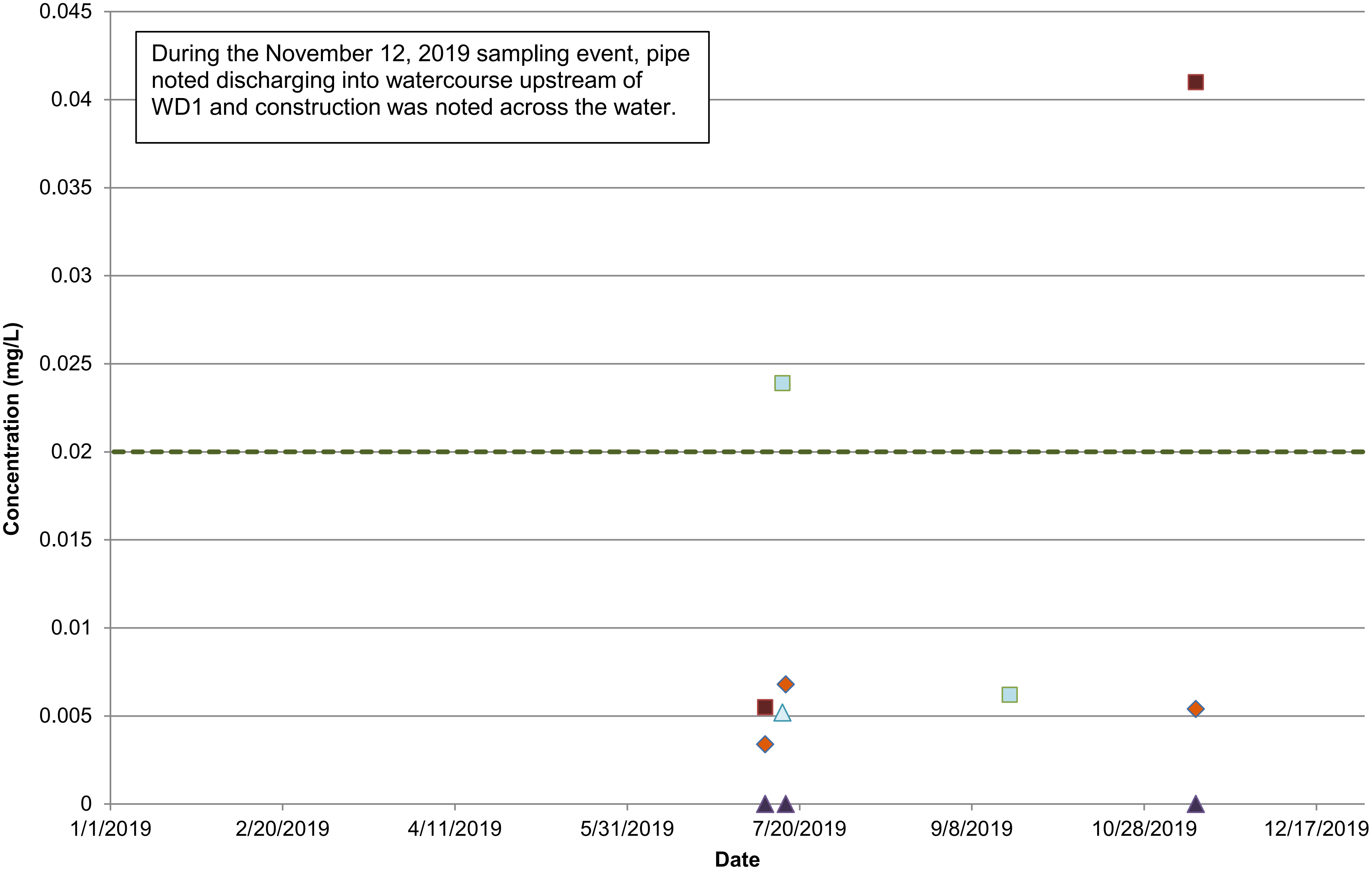
During the November 12, 2019 sampling event, pipe noted discharging into watercourse upstream of WD1 and construction was noted across the water.

**Figure 54**
**Dry-Weather: Total Phosphorus Concentrations**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



During the November 12, 2019 sampling event, pipe noted discharging into watercourse upstream of WD1 and construction was noted across the water.

**Figure 55**
**Dry-Weather: Dissolved Phosphorus Concentrations**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



△ SR2
🟩 VS1
◆ SC1
■ WD1
▲ SB2
– – – PWQO Limit

**Figure 56**
**Dry-Weather: Zinc Concentrations**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

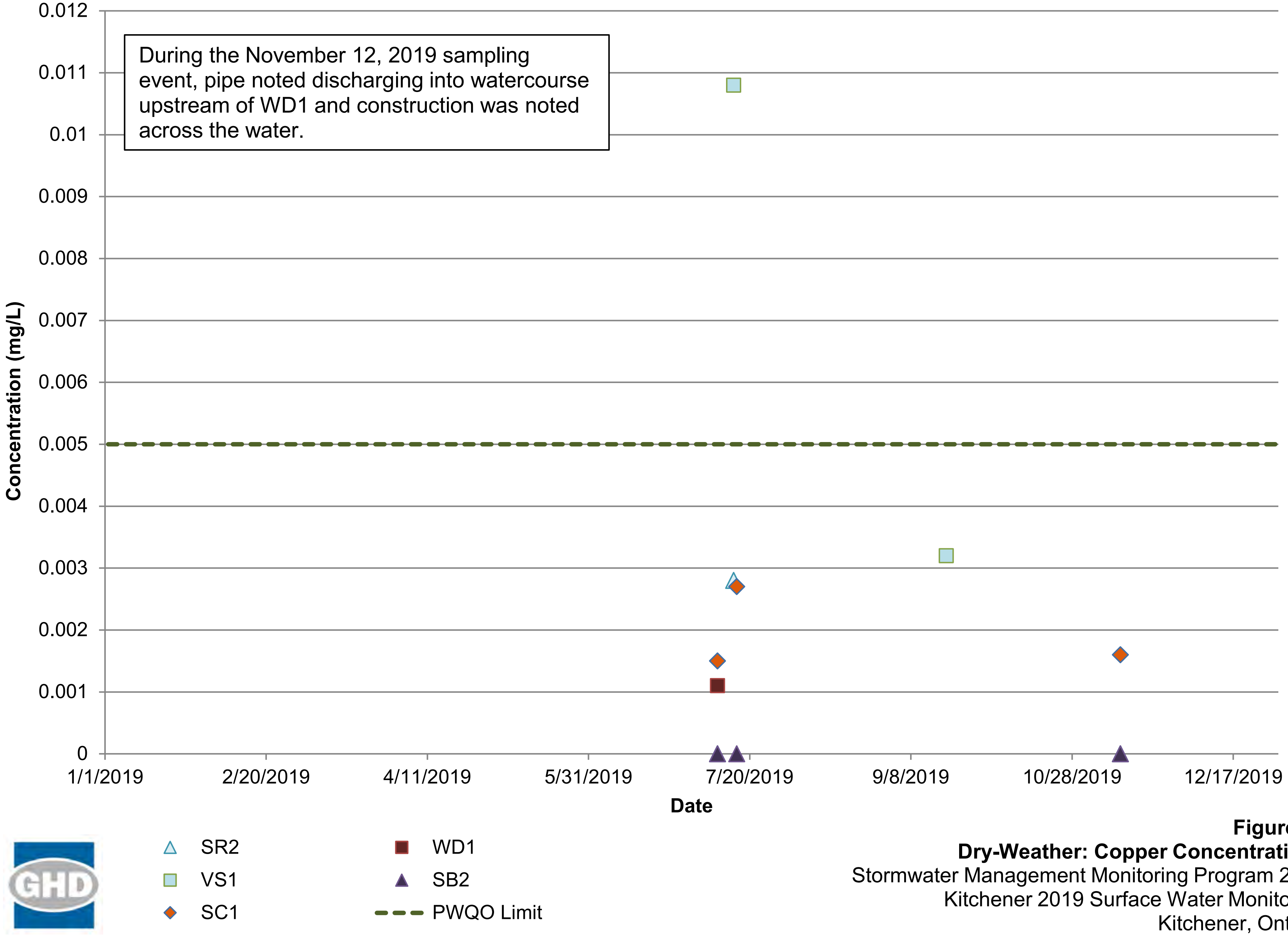
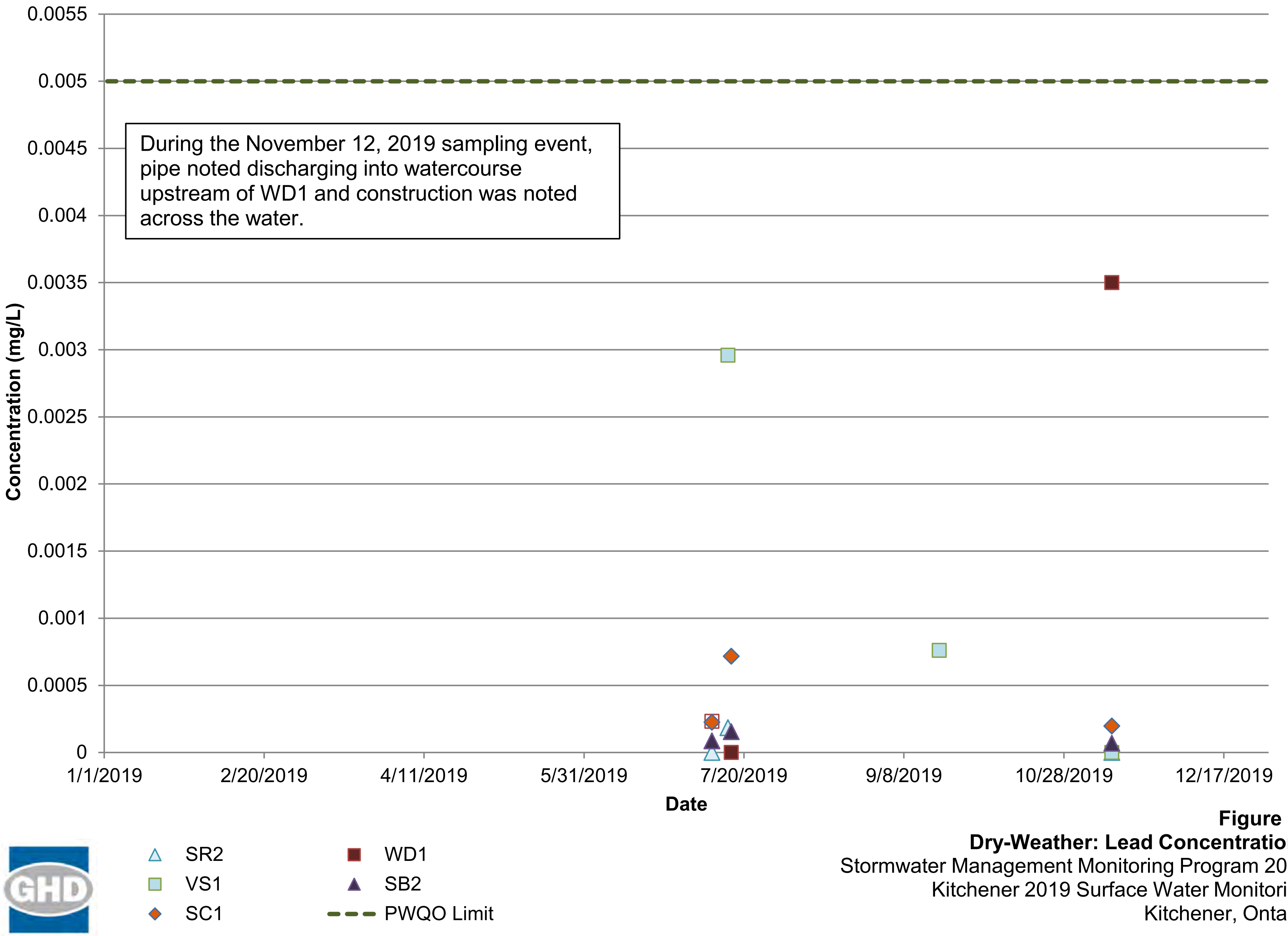


**Figure 57**

**Dry-Weather: Copper Concentrations**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

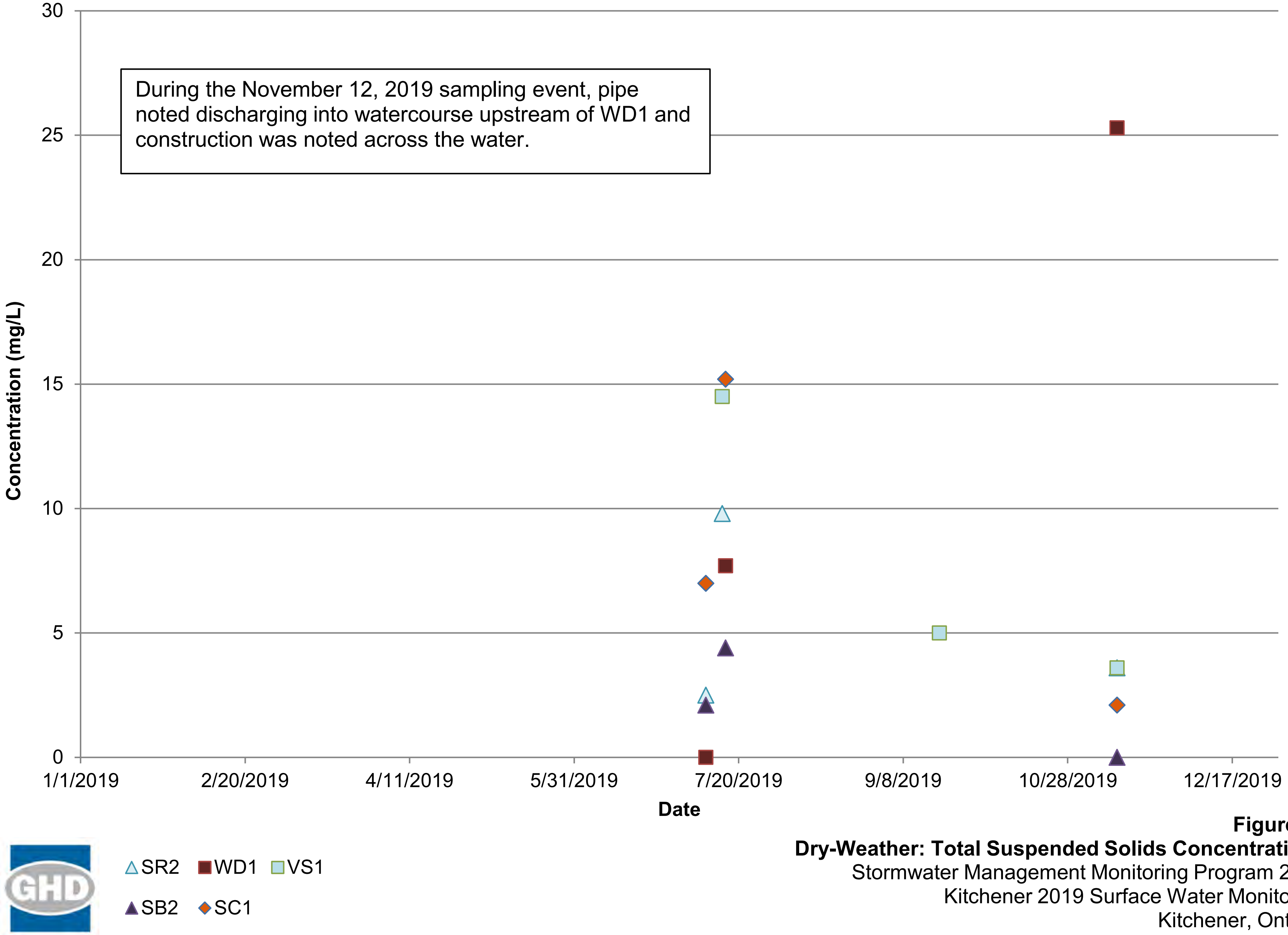


During the November 12, 2019 sampling event, pipe noted discharging into watercourse upstream of WD1 and construction was noted across the water.

**Figure 58**

**Dry-Weather: Lead Concentrations**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

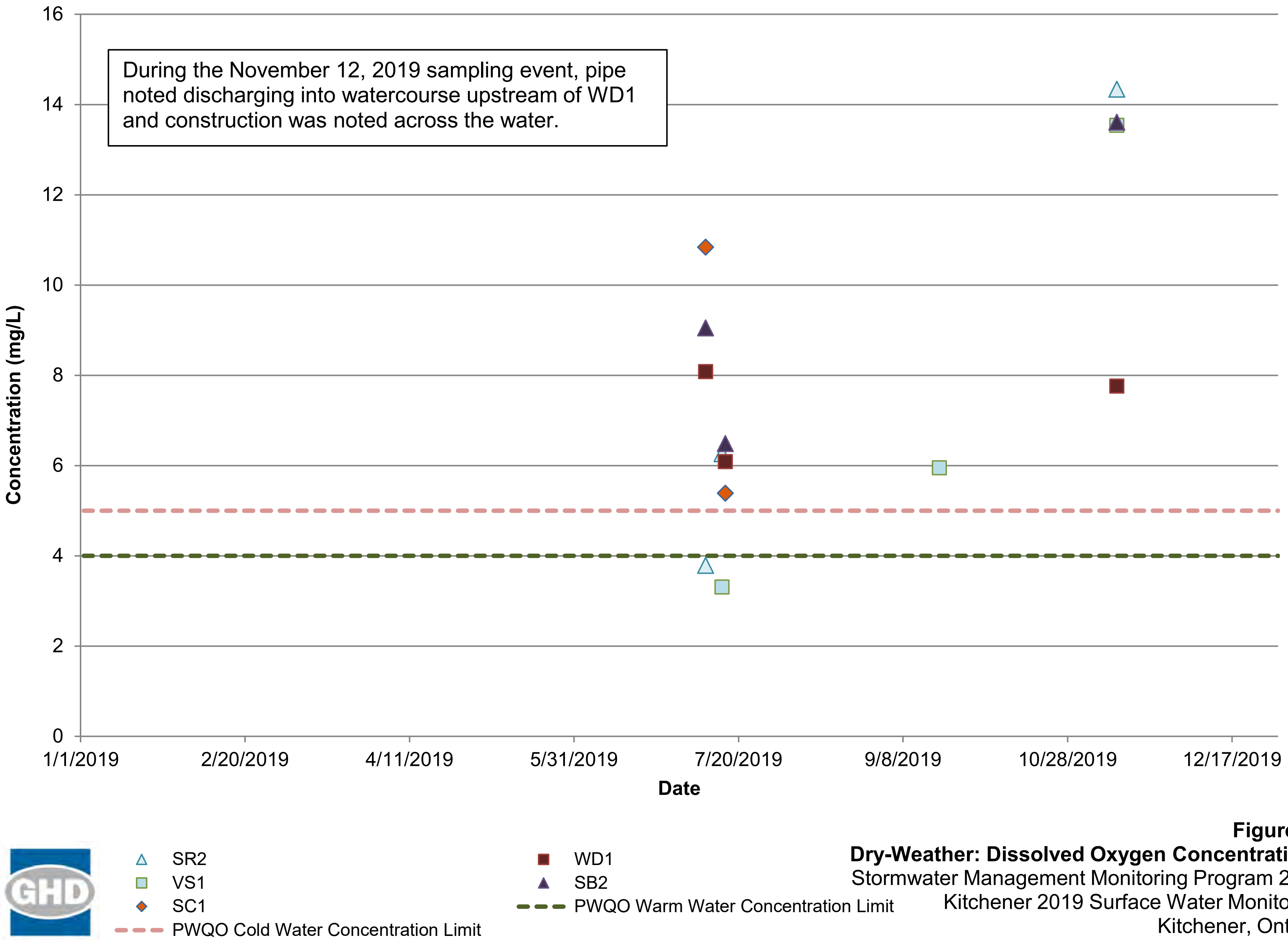


During the November 12, 2019 sampling event, pipe noted discharging into watercourse upstream of WD1 and construction was noted across the water.

**Figure 59**

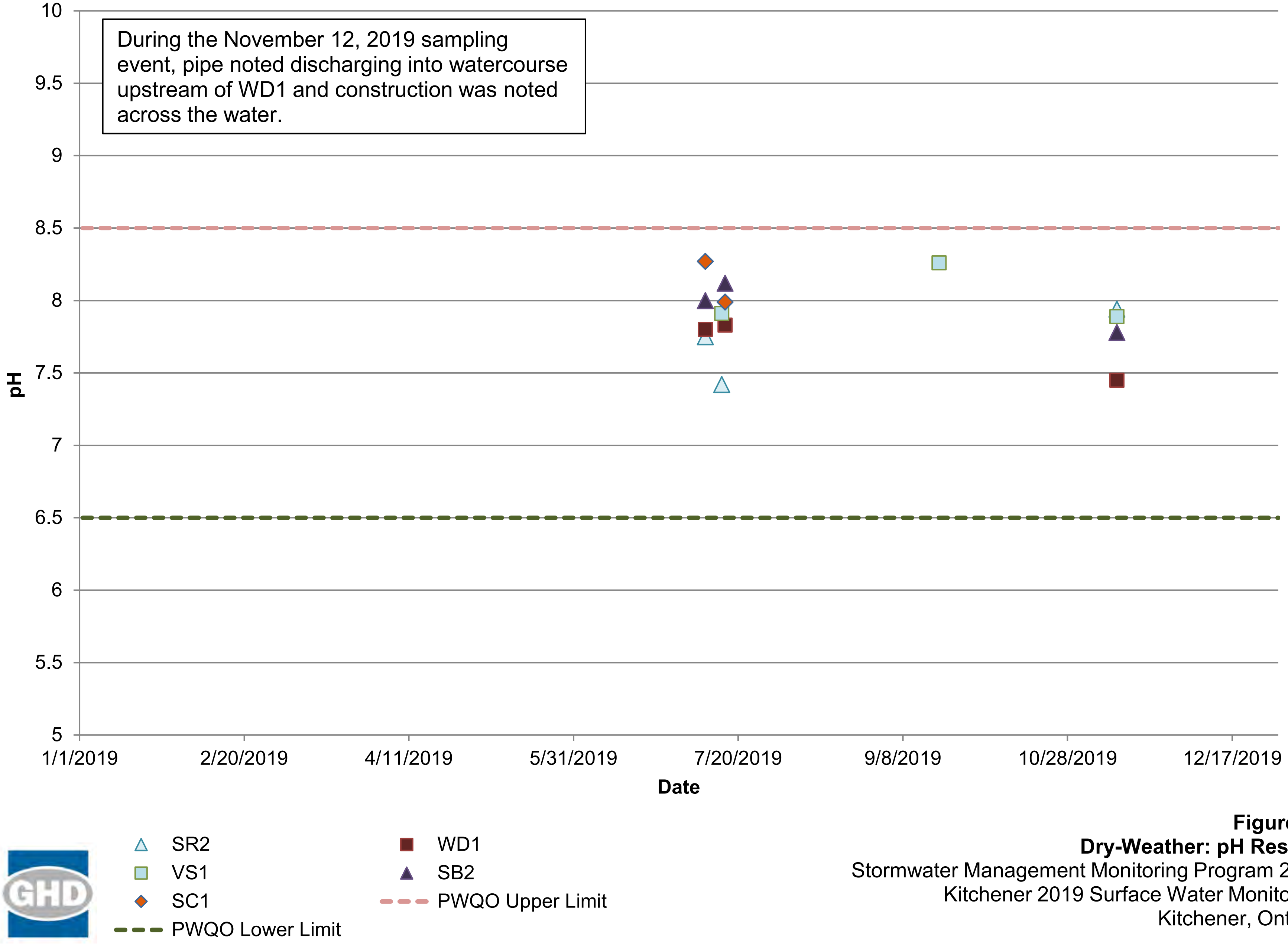
**Dry-Weather: Total Suspended Solids Concentrations**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



During the November 12, 2019 sampling event, pipe noted discharging into watercourse upstream of WD1 and construction was noted across the water.

**Figure 60**
**Dry-Weather: Dissolved Oxygen Concentrations**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



During the November 12, 2019 sampling event, pipe noted discharging into watercourse upstream of WD1 and construction was noted across the water.

**Figure 61**

**Dry-Weather: pH Results**

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

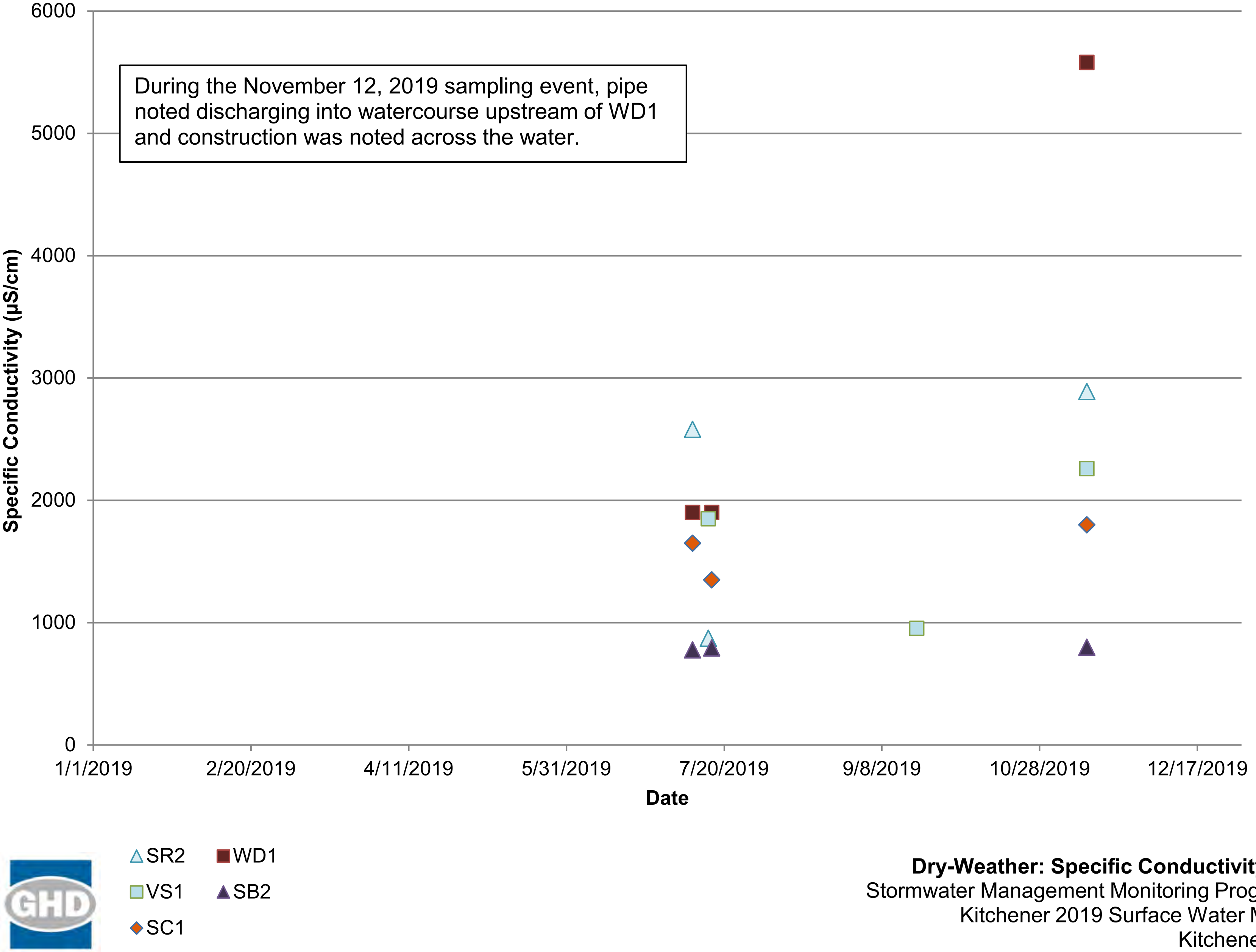


**Figure 62**
**Dry-Weather: Specific Conductivity Results**
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

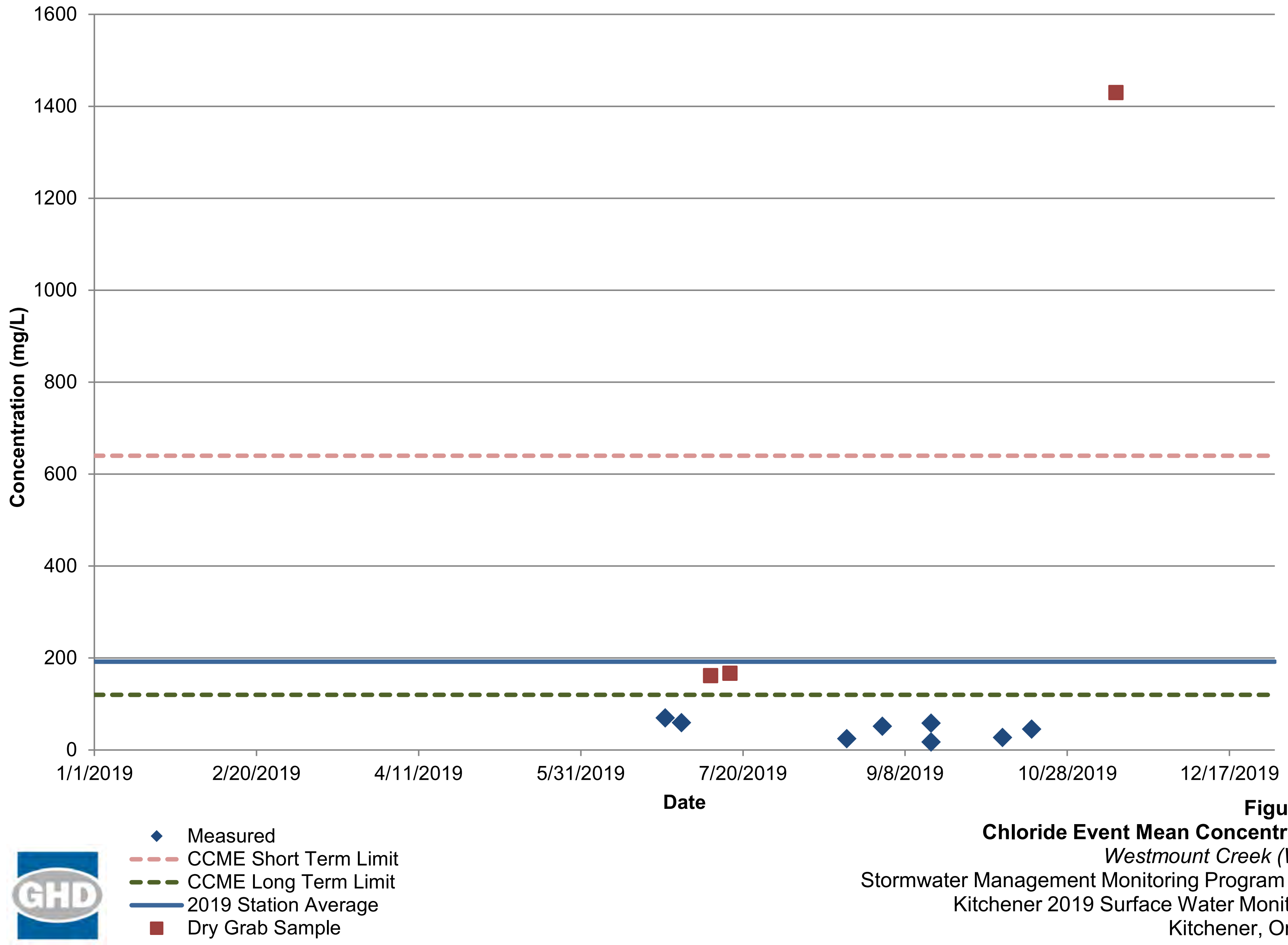


**Figure 63**

**Chloride Event Mean Concentration**

*Westmount Creek (WD1)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

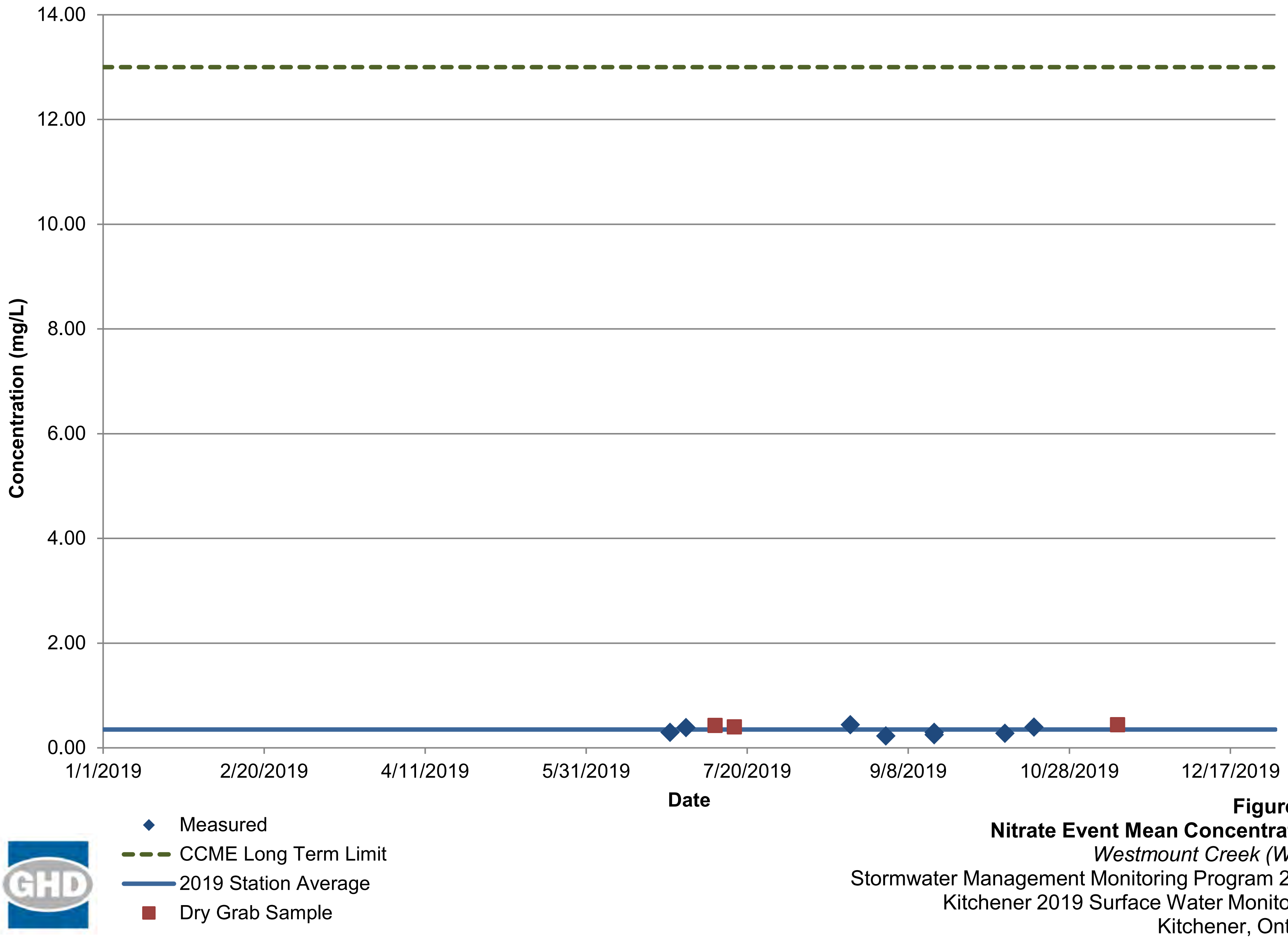


**Figure 64**

**Nitrate Event Mean Concentration**

*Westmount Creek (WD1)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

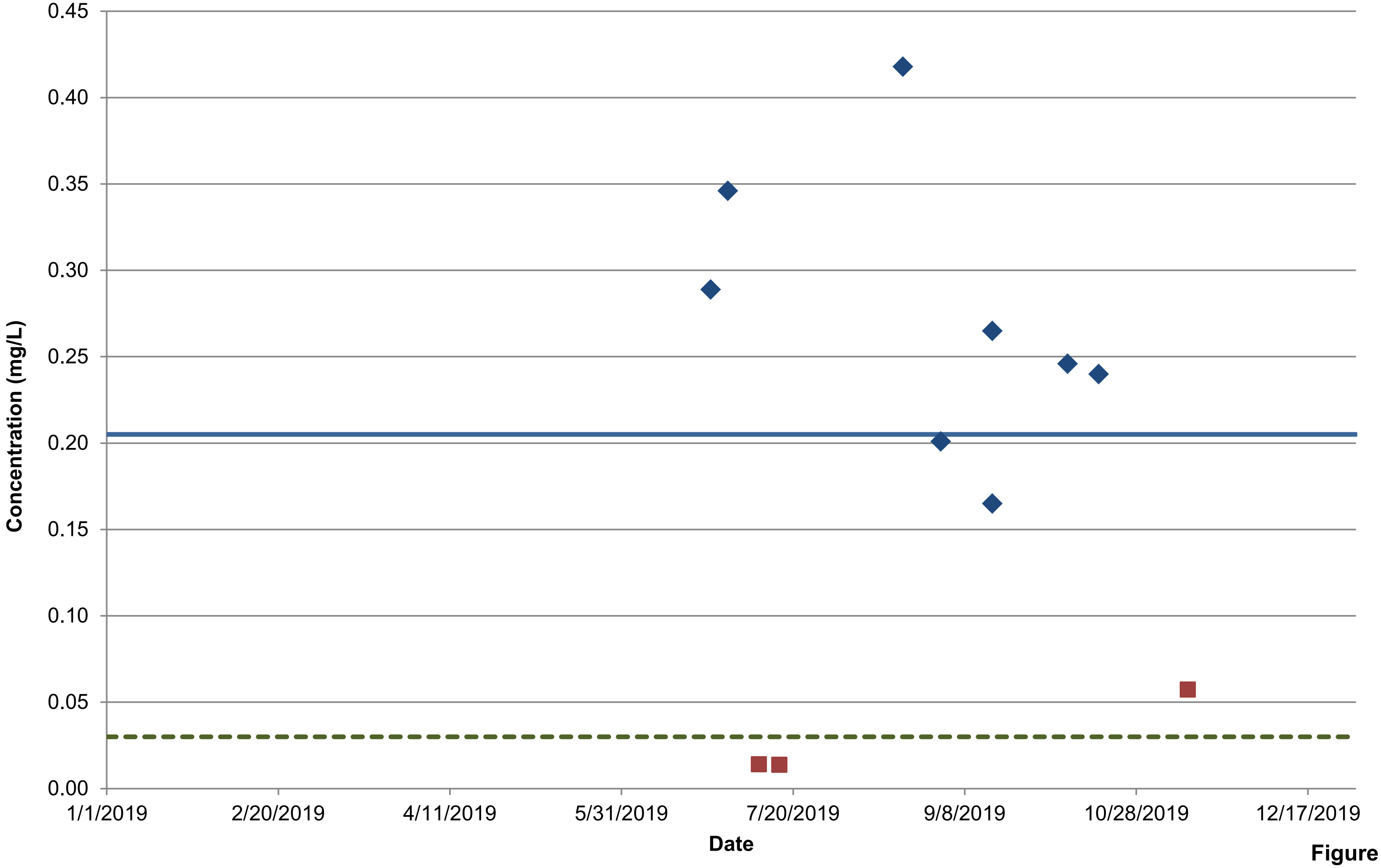
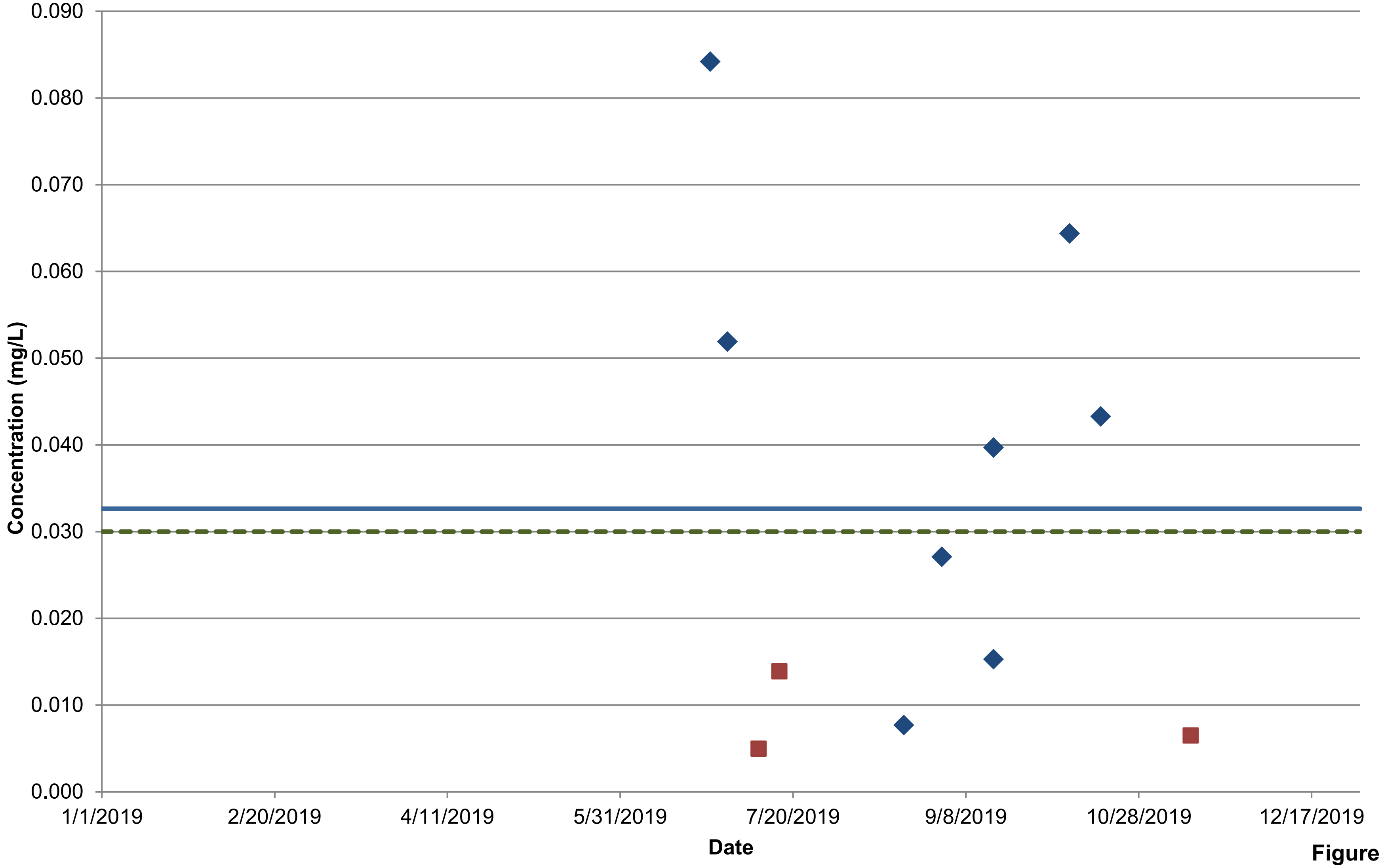


**Figure 65**
**Total Phosphorus Event Mean Concentration**
*Westmount Creek (WD1)*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



◆ Measured
PWQO Limit
2019 Station Average
■ Dry Grab Sample

**NOTE:** Two EMC samples collected on 9/16/2019 represent two seperate precipitation events.

**Figure 66**

**Dissolved Phosphorus Event Mean Concentration**

*Westmount Creek (WD1)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

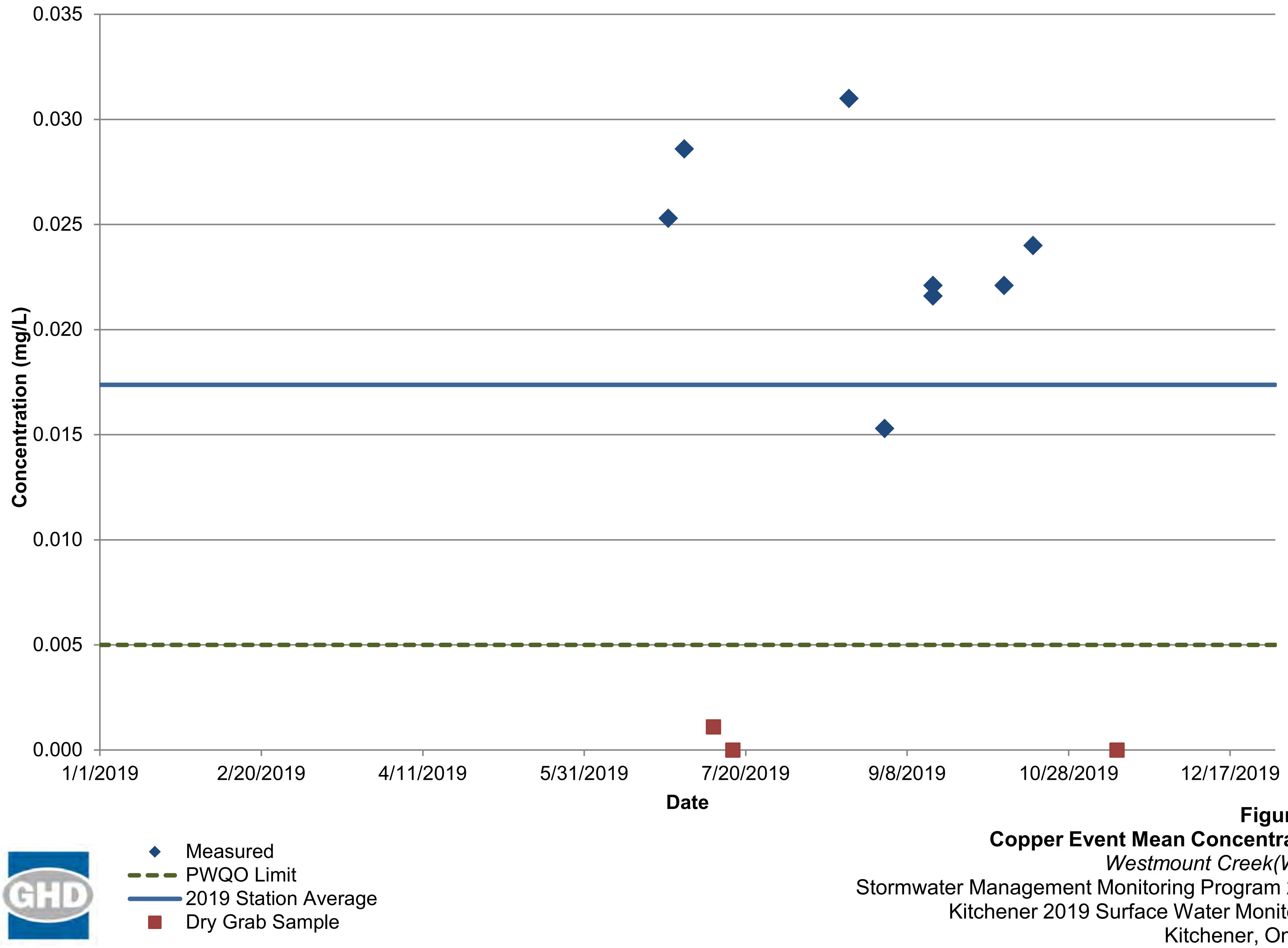


**Figure 67**

**Copper Event Mean Concentration**

*Westmount Creek(WD1)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

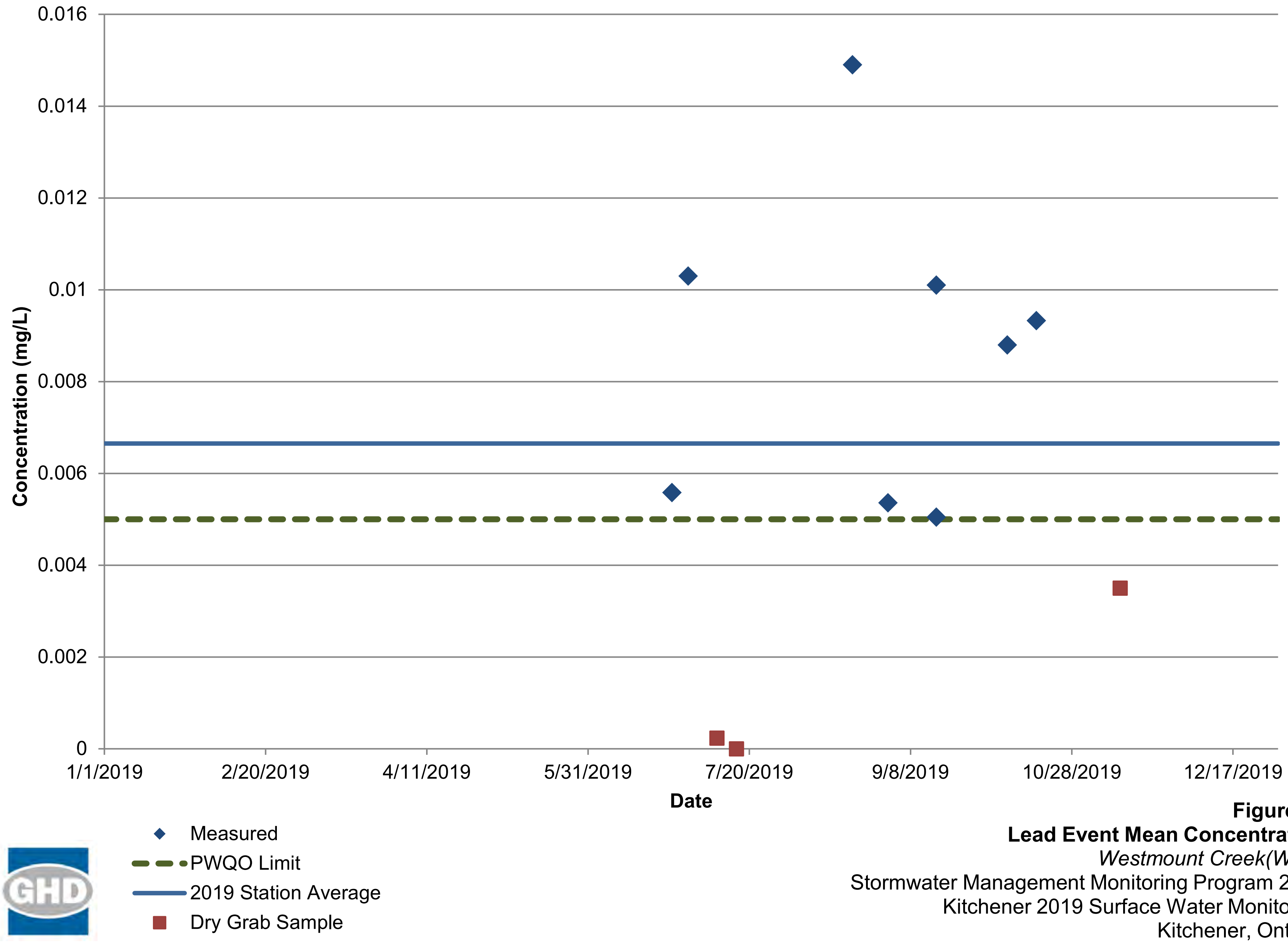


**Figure 68**

**Lead Event Mean Concentration**

*Westmount Creek(WD1)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

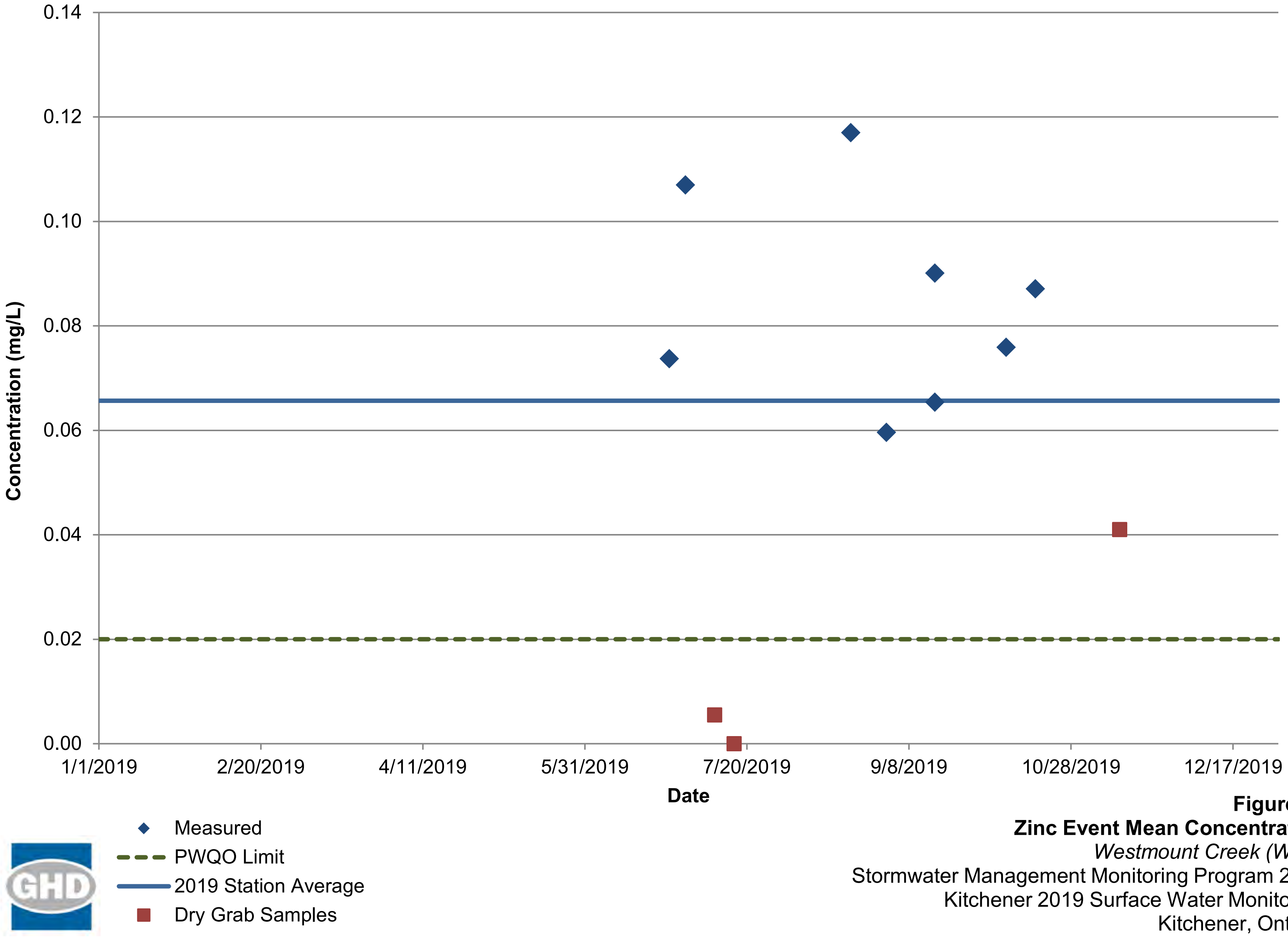


**Figure 69**

**Zinc Event Mean Concentration**

*Westmount Creek (WD1)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

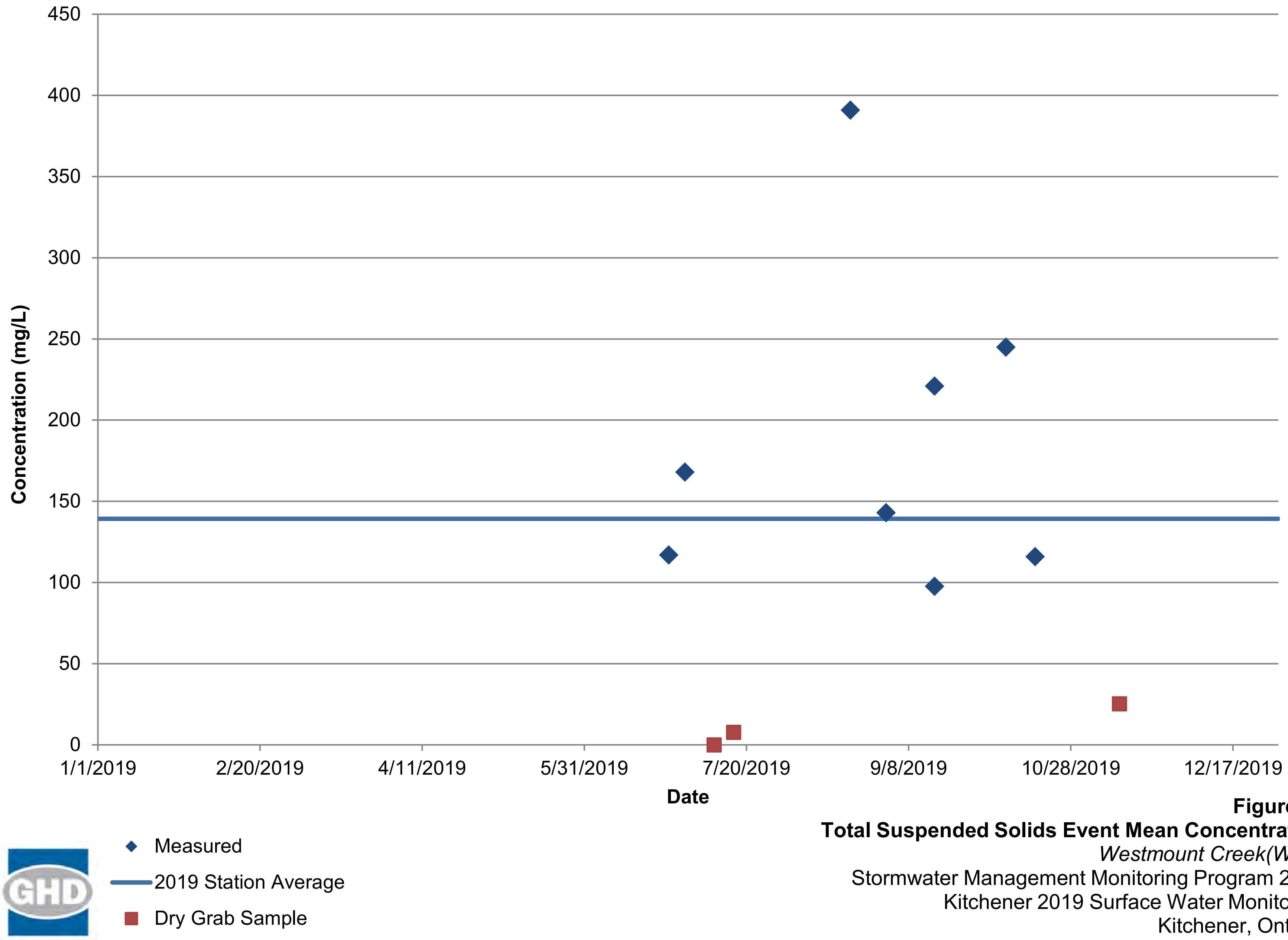


**Figure 70**

**Total Suspended Solids Event Mean Concentration**

*Westmount Creek(WD1)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

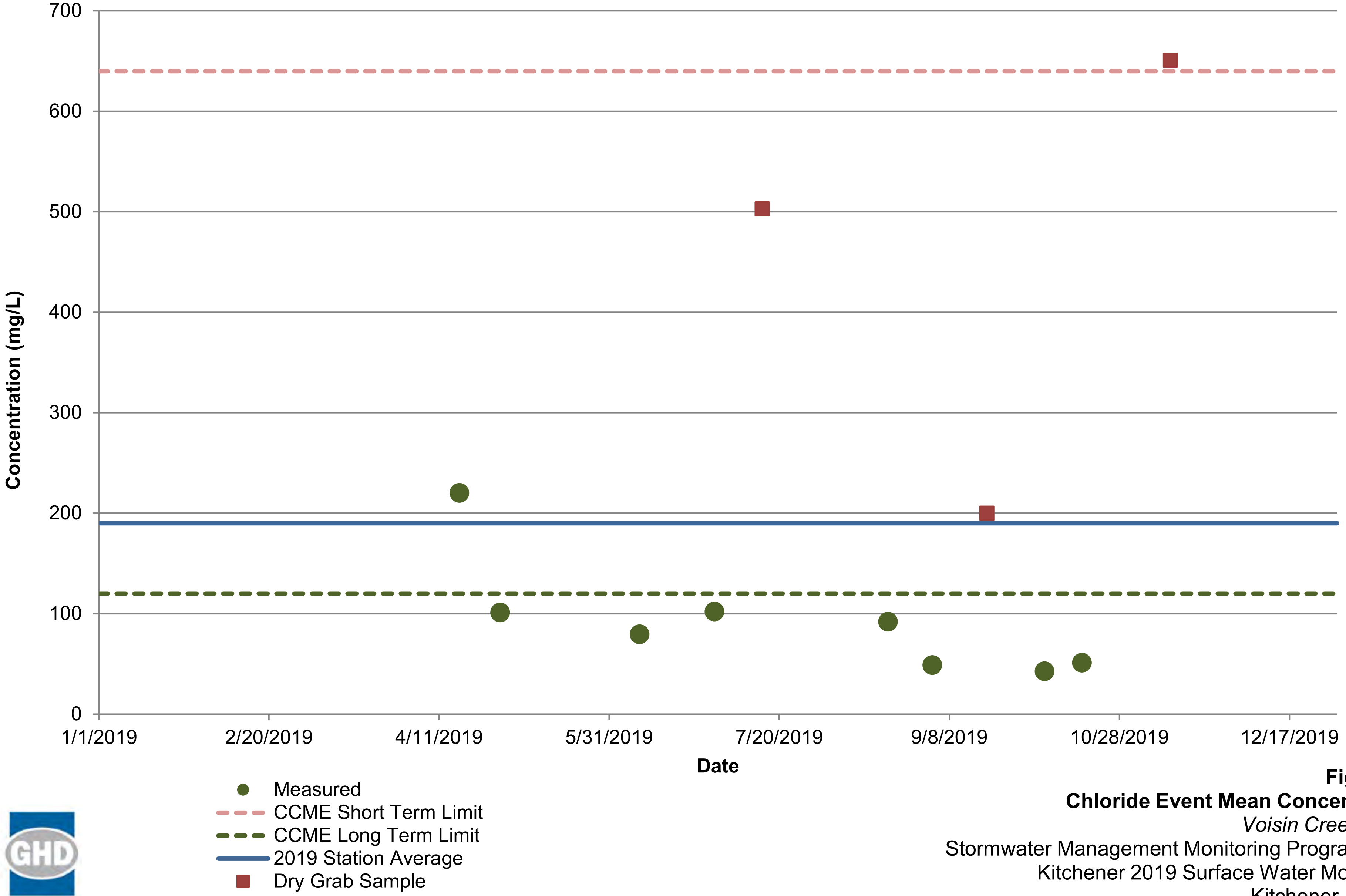


**Figure 71**

**Chloride Event Mean Concentration**

*Voisin Creek (VS1)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

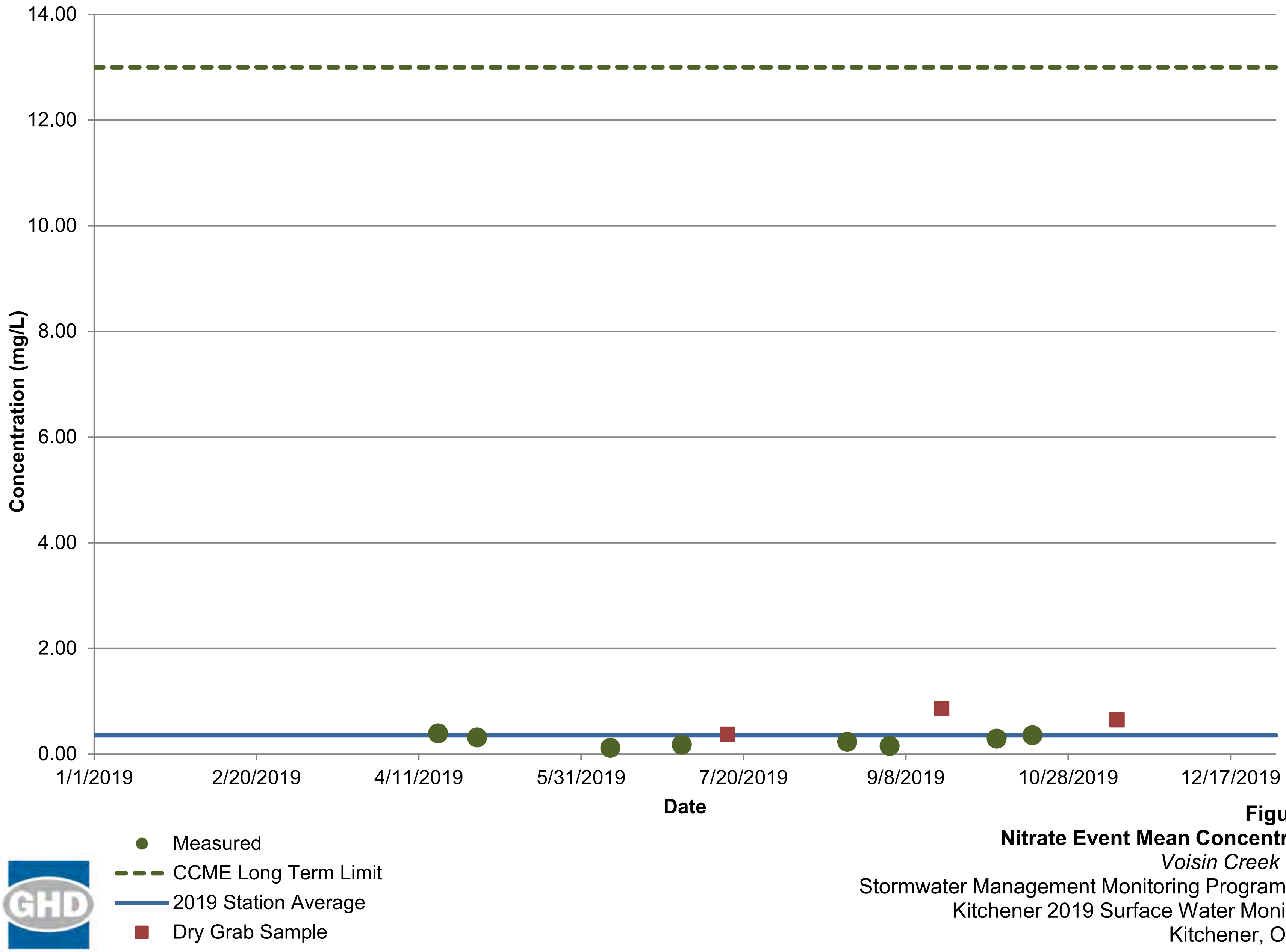


**Figure 72**
**Nitrate Event Mean Concentration**
*Voisin Creek (VS1)*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

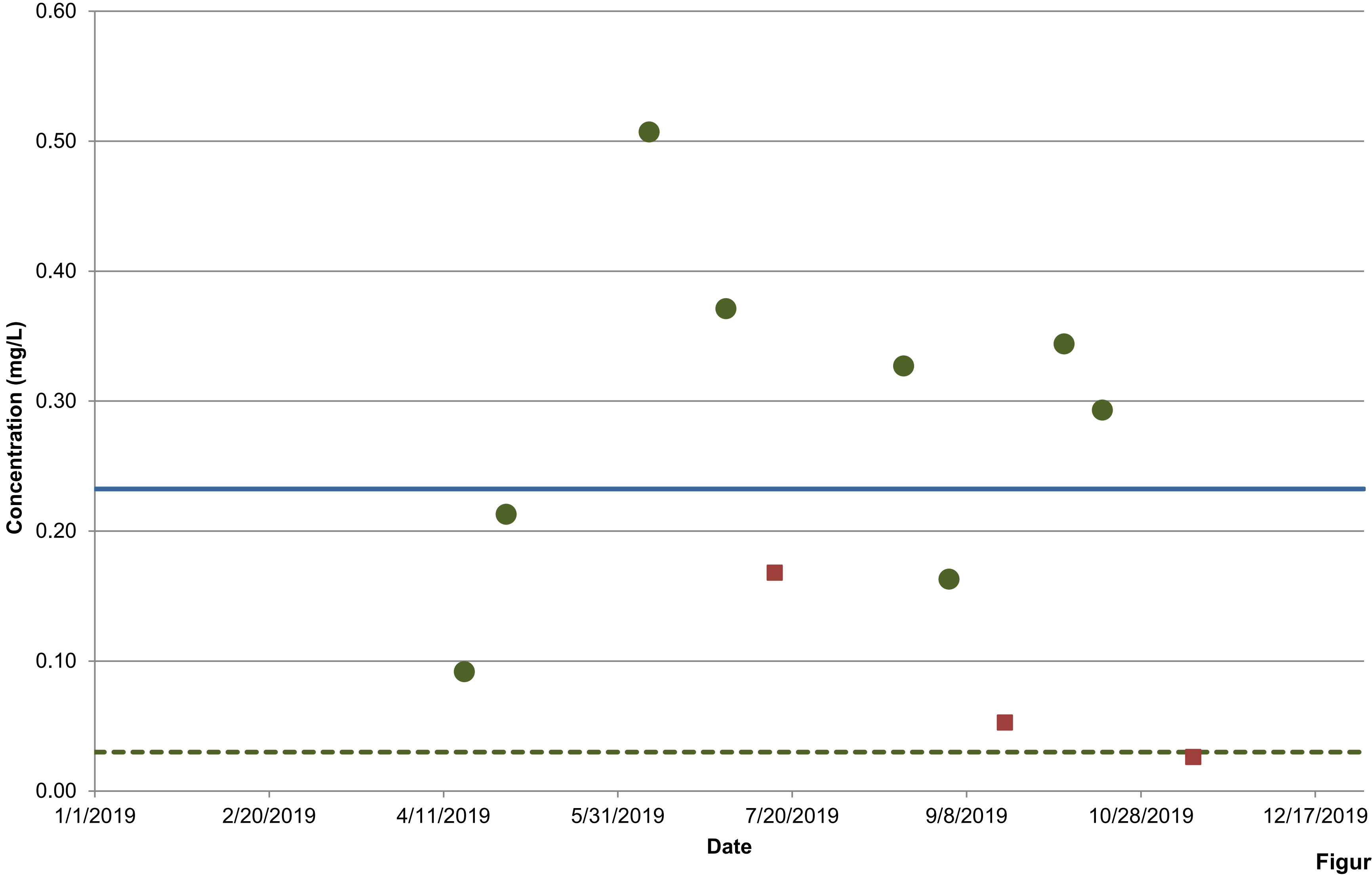


**Figure 73**

**Total Phosphorus Event Mean Concentration**

*Voisin Creek (VS1)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

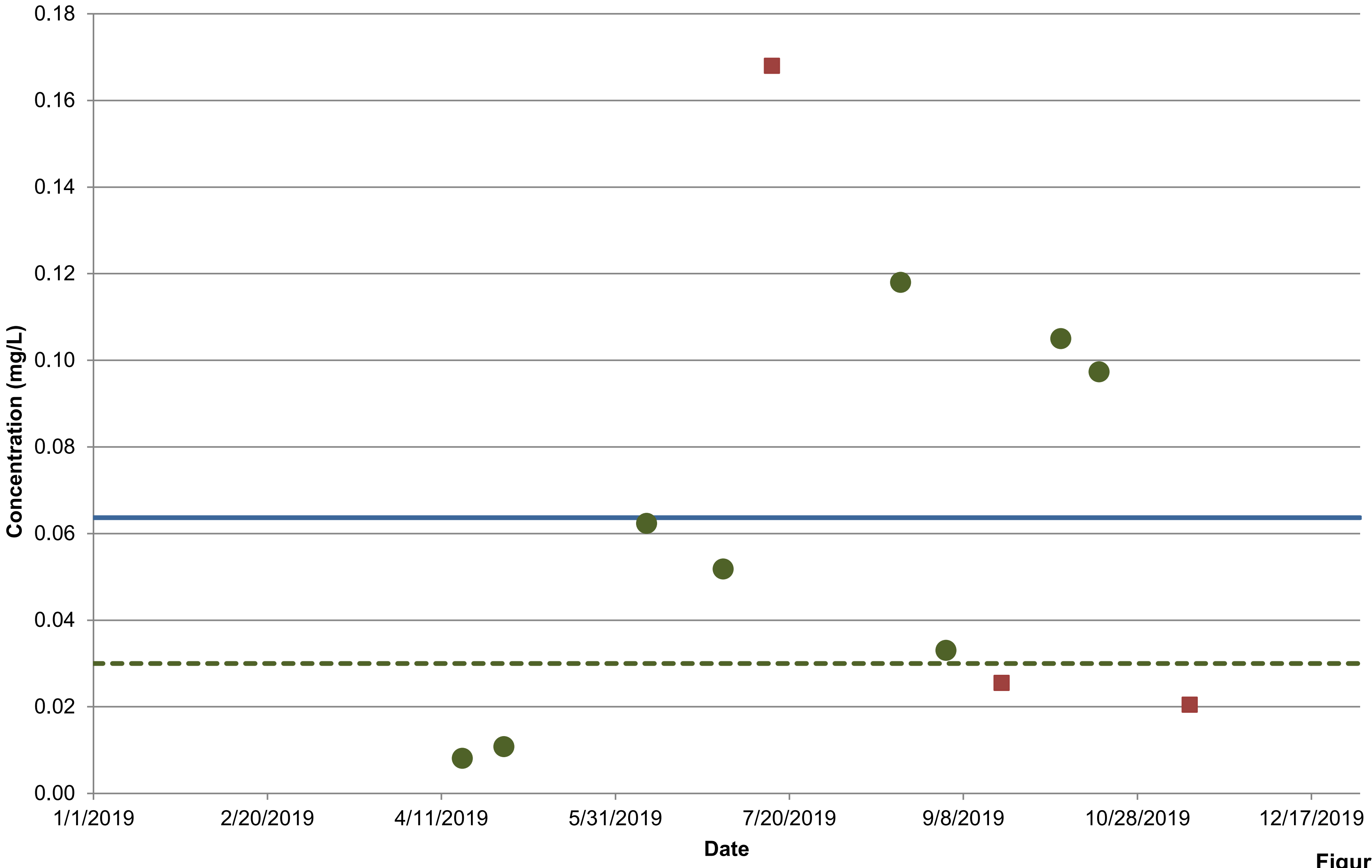


**Figure 74**

**Dissolved Phosphorus Event Mean Concentration**

*Voisin Creek (VS1)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

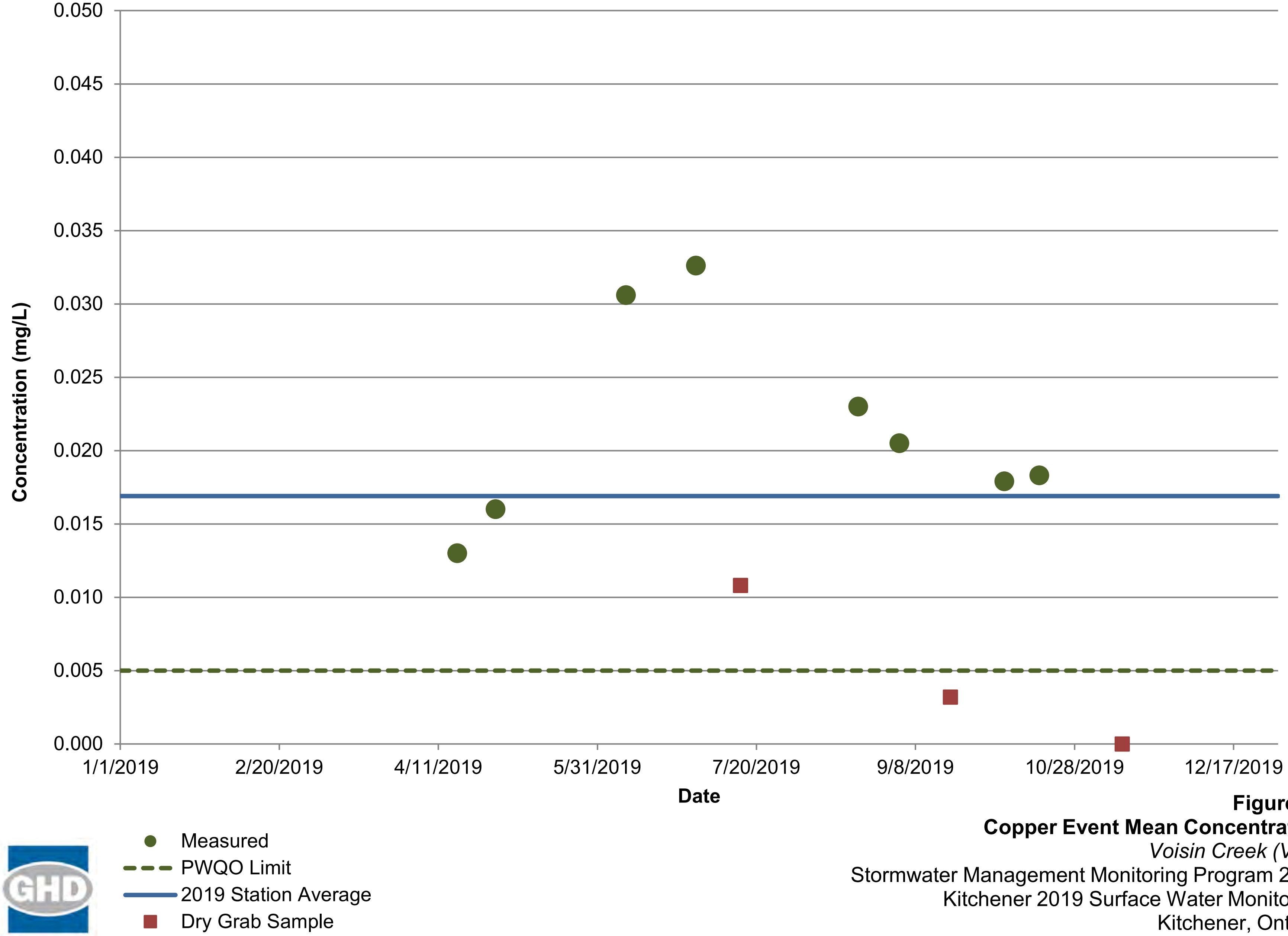


**Figure 75**

**Copper Event Mean Concentration**

*Voisin Creek (VS1)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

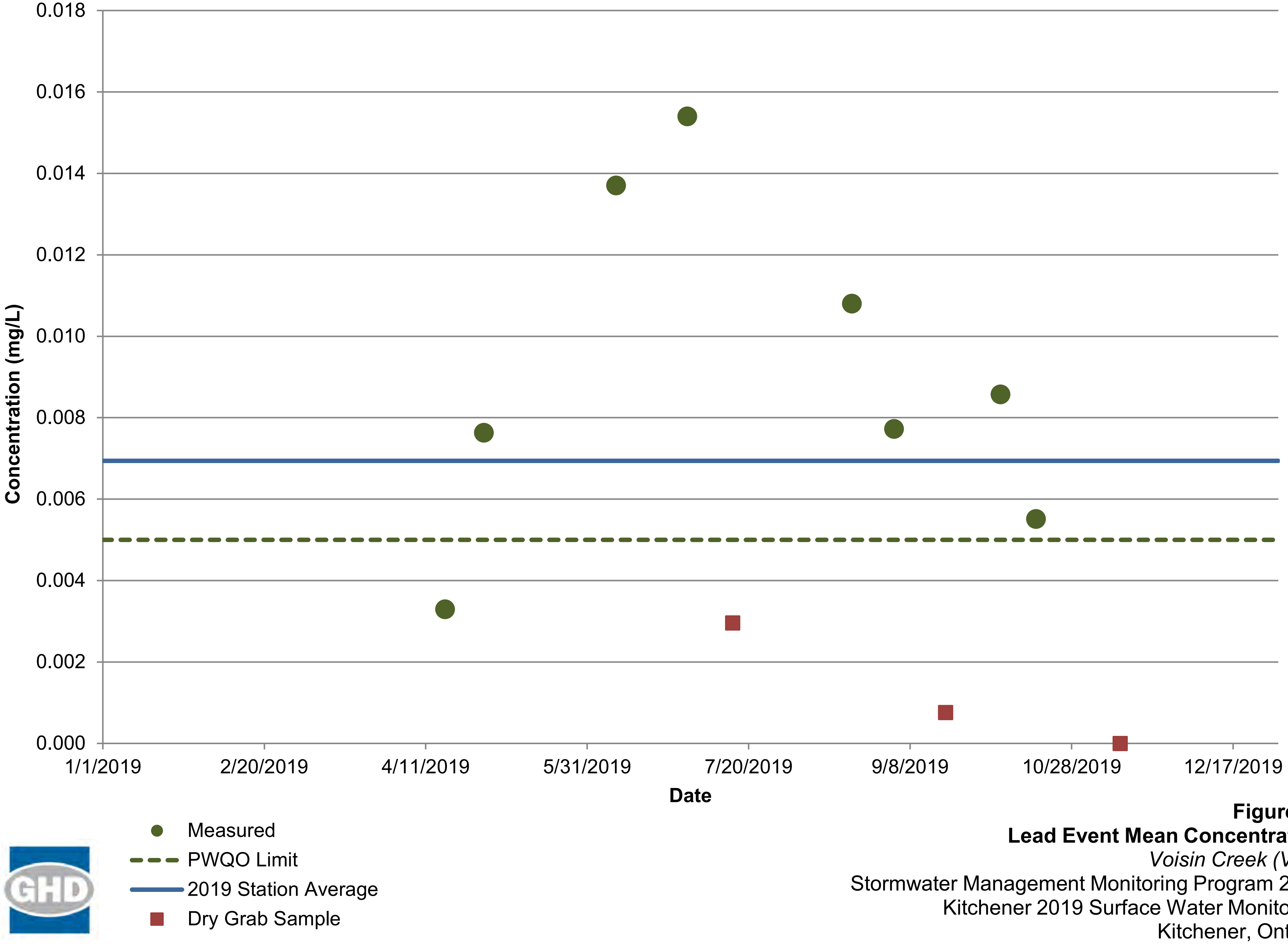


**Figure 76**

**Lead Event Mean Concentration**

*Voisin Creek (VS1)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

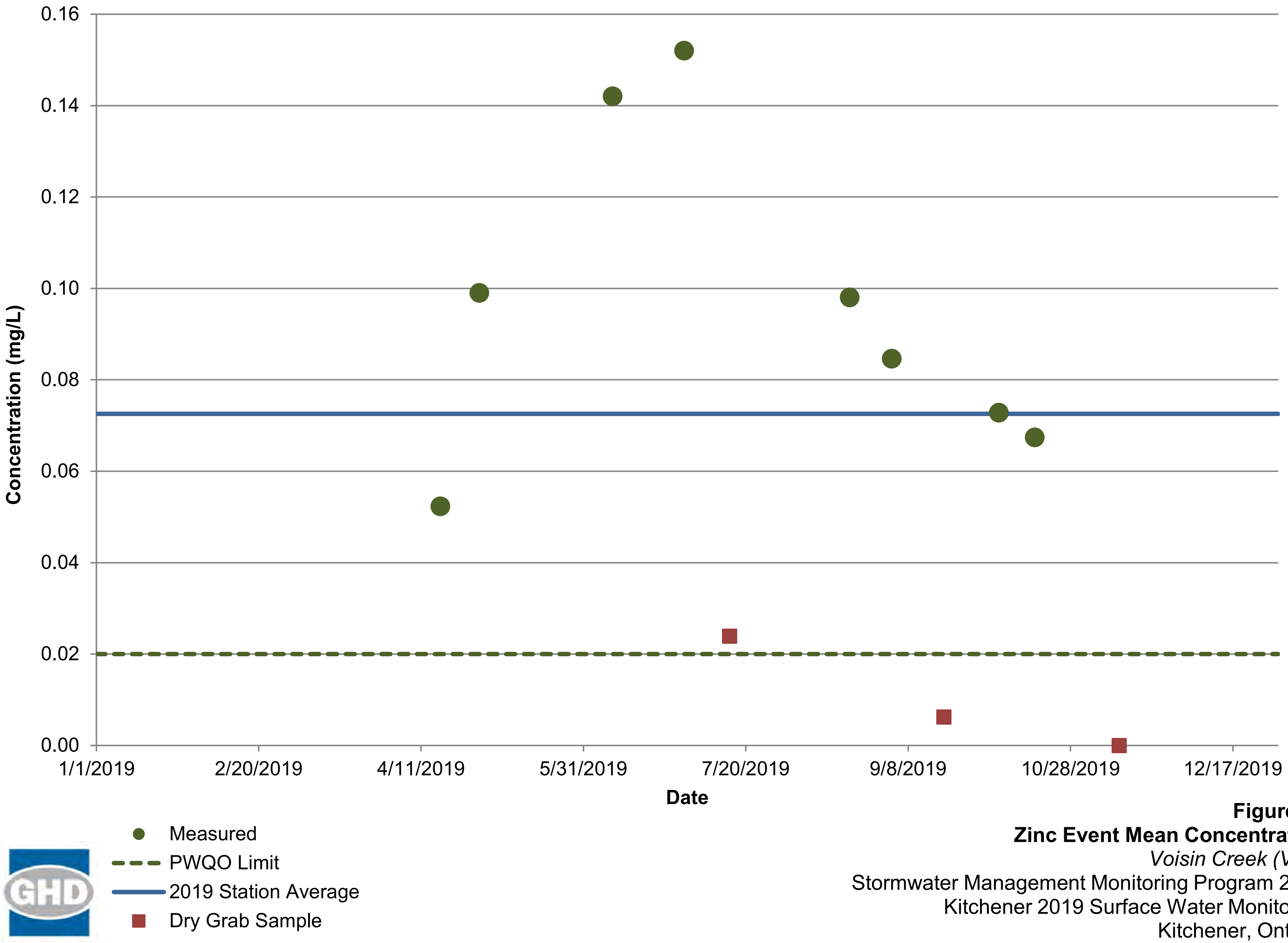
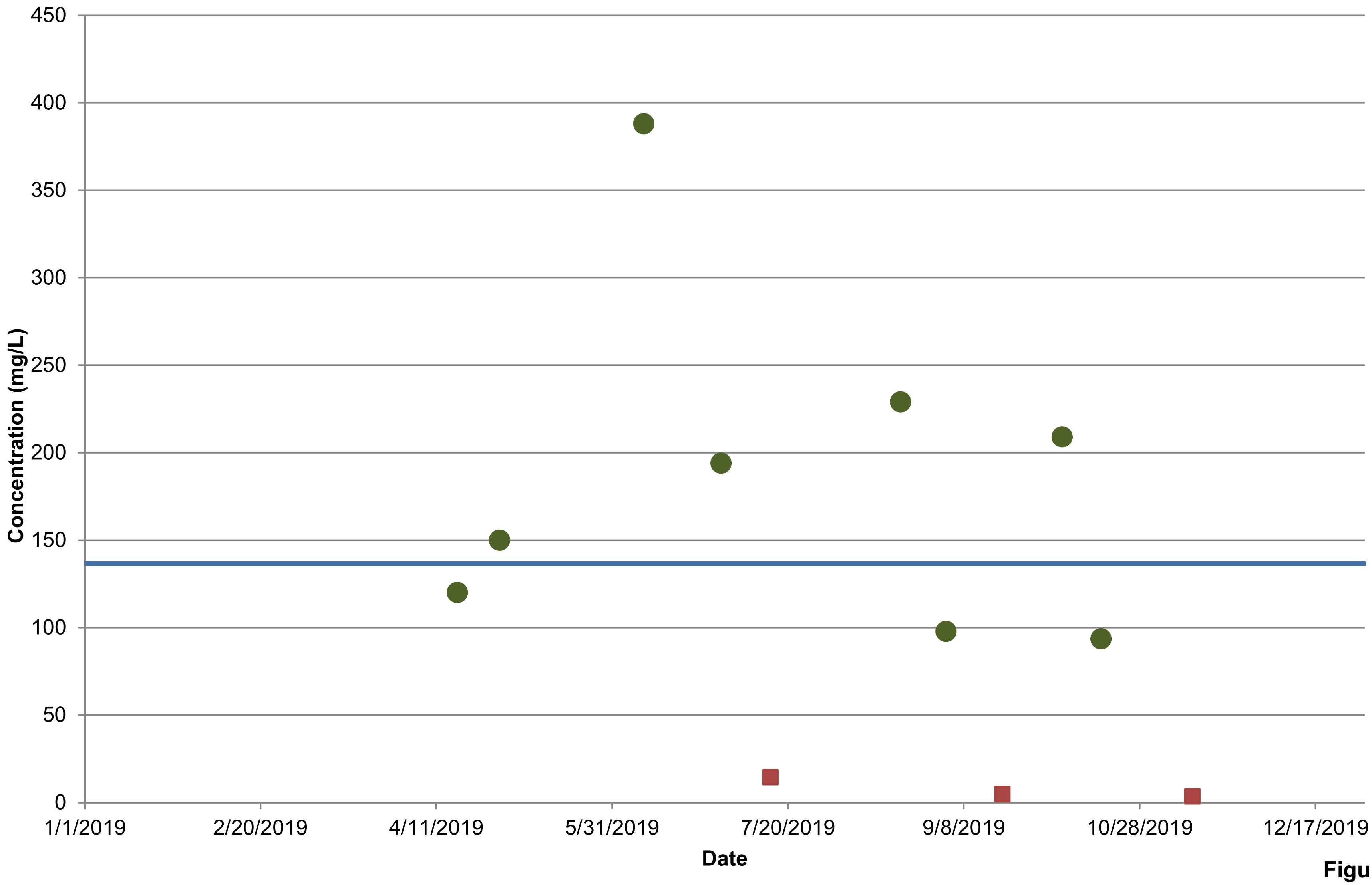


**Figure 77**

**Zinc Event Mean Concentration**

*Voisin Creek (VS1)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario



● Measured
2019 Station Average
🟥 Dry Grab Sample

**Figure 78**
**Total Suspended Solids Event Mean Concentration**
*Voisin Creek (VS1)*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

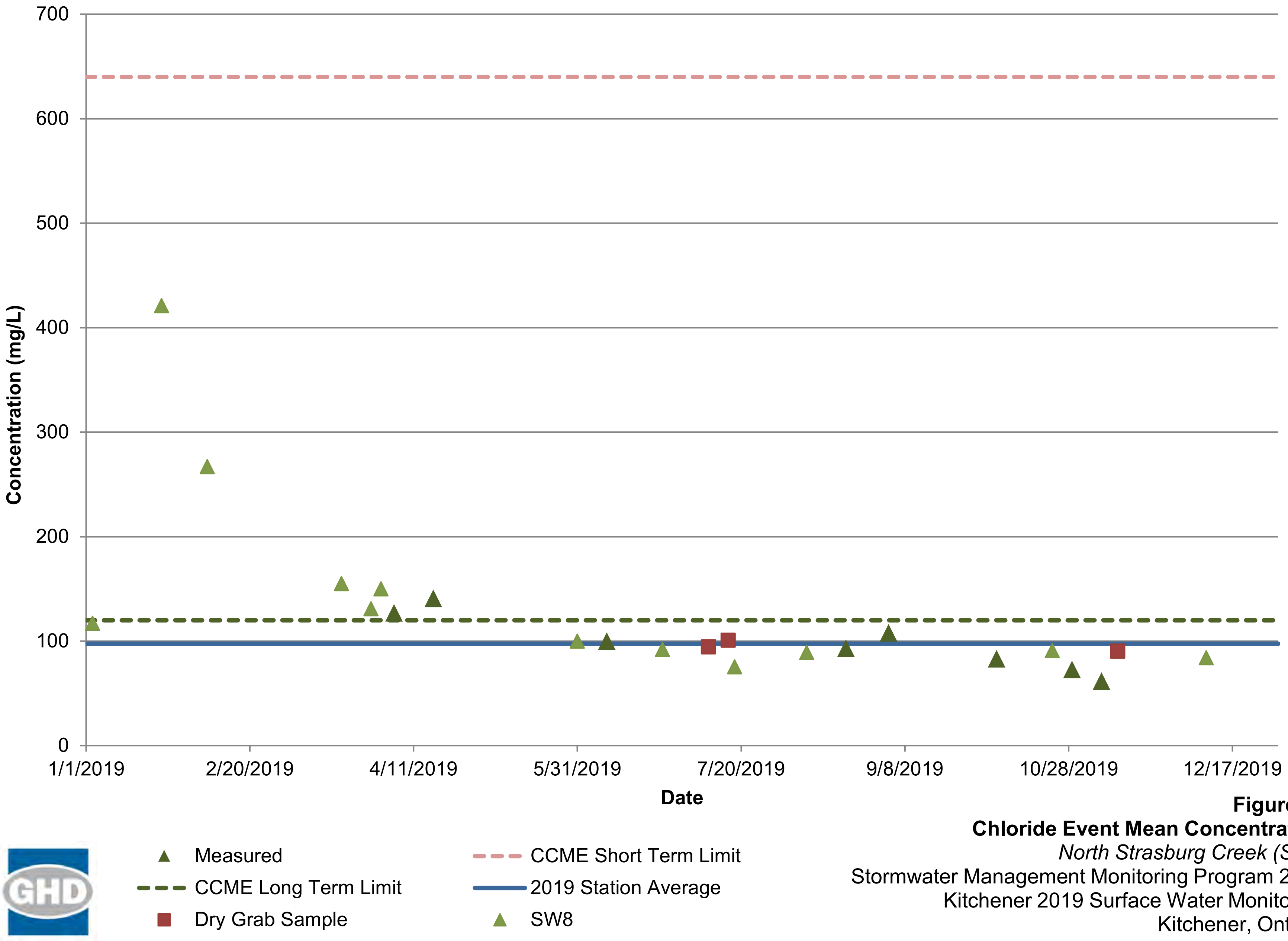


**Figure 79**

**Chloride Event Mean Concentration**

*North Strasburg Creek (SB2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

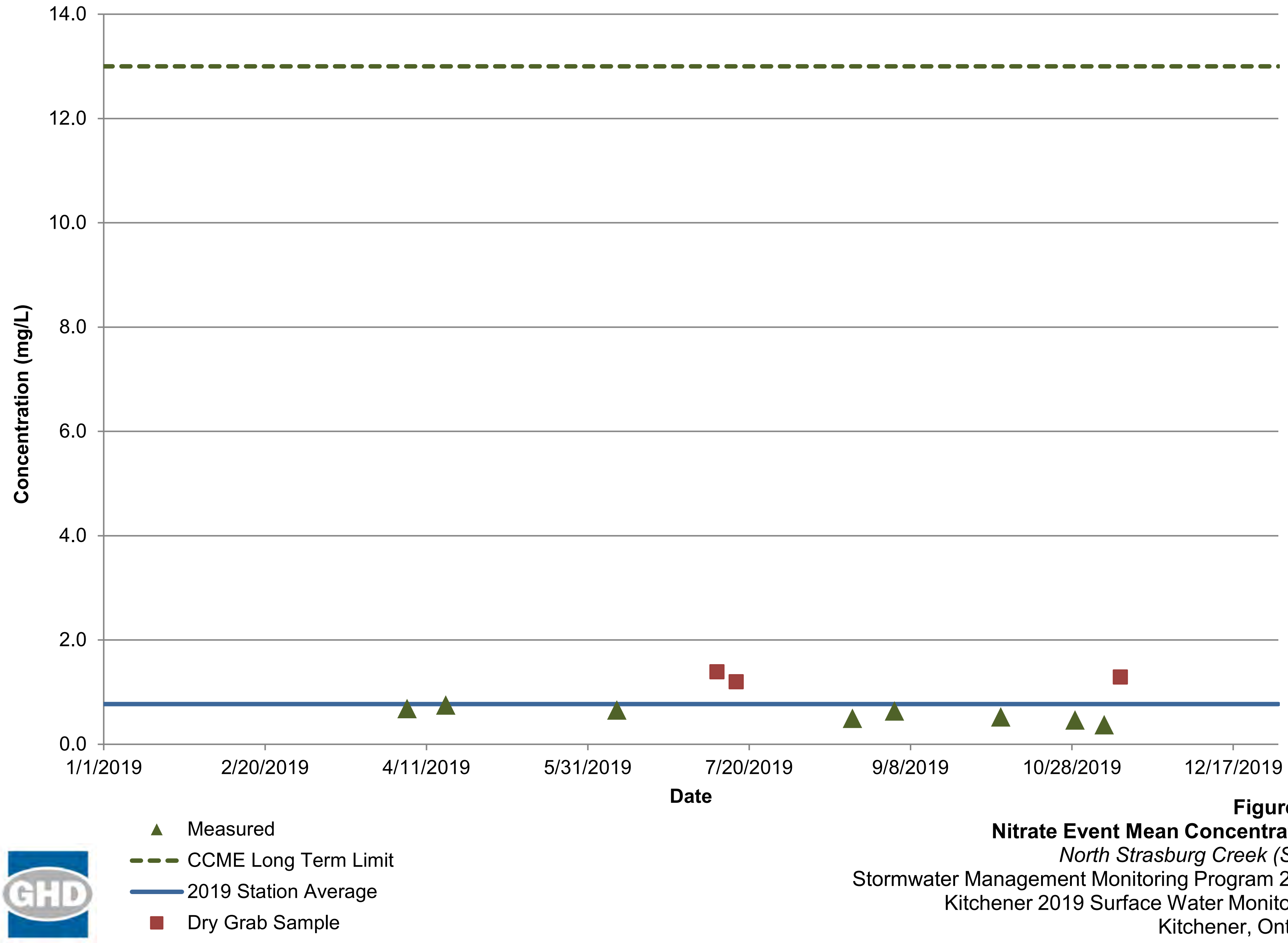


**Figure 80**

**Nitrate Event Mean Concentration**

*North Strasburg Creek (SB2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

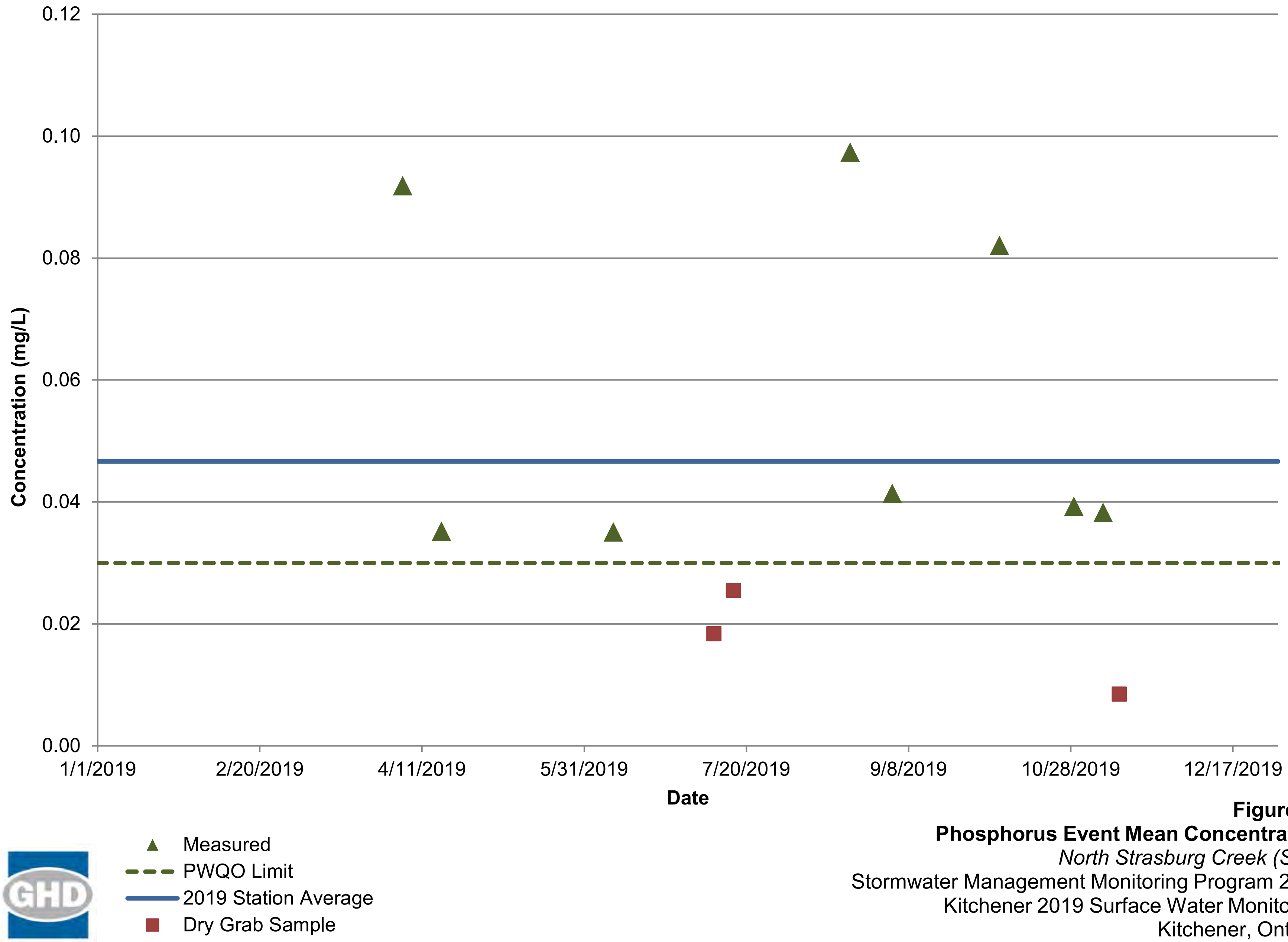


**Figure 81**
**Phosphorus Event Mean Concentration**
*North Strasburg Creek (SB2)*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

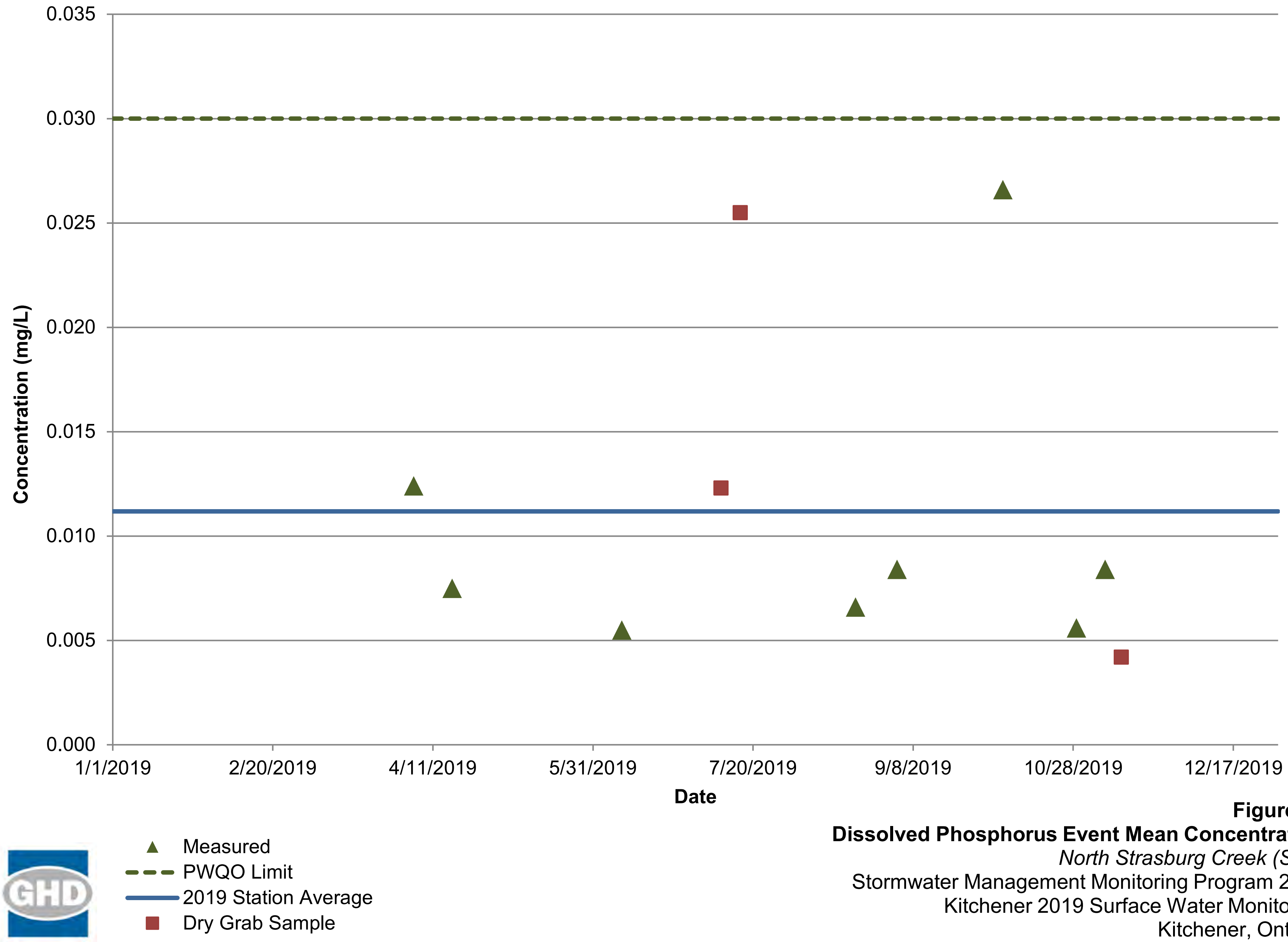


**Figure 82**

**Dissolved Phosphorus Event Mean Concentration**

*North Strasburg Creek (SB2)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

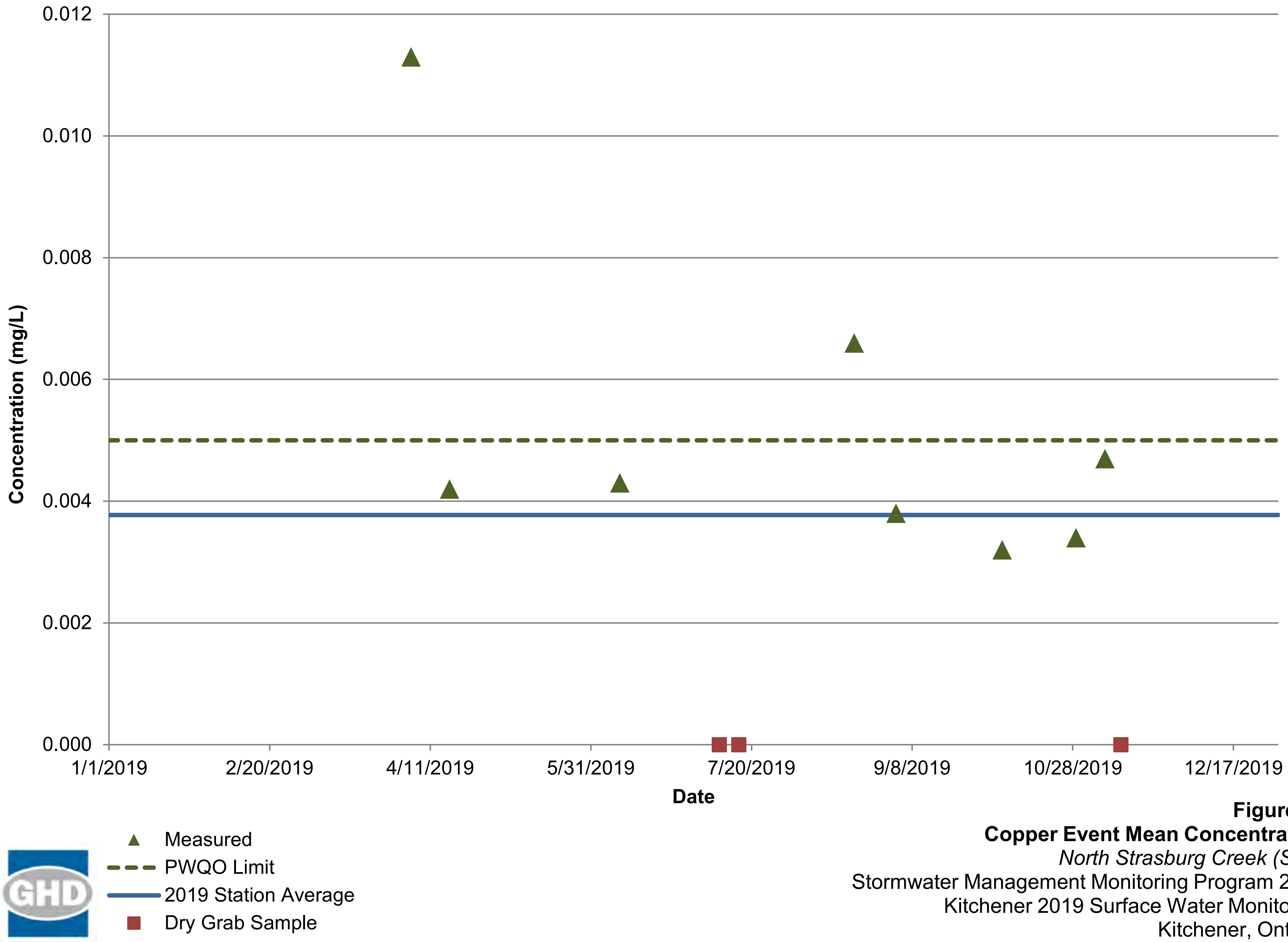


**Figure 83**

**Copper Event Mean Concentration**

*North Strasburg Creek (SB2)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

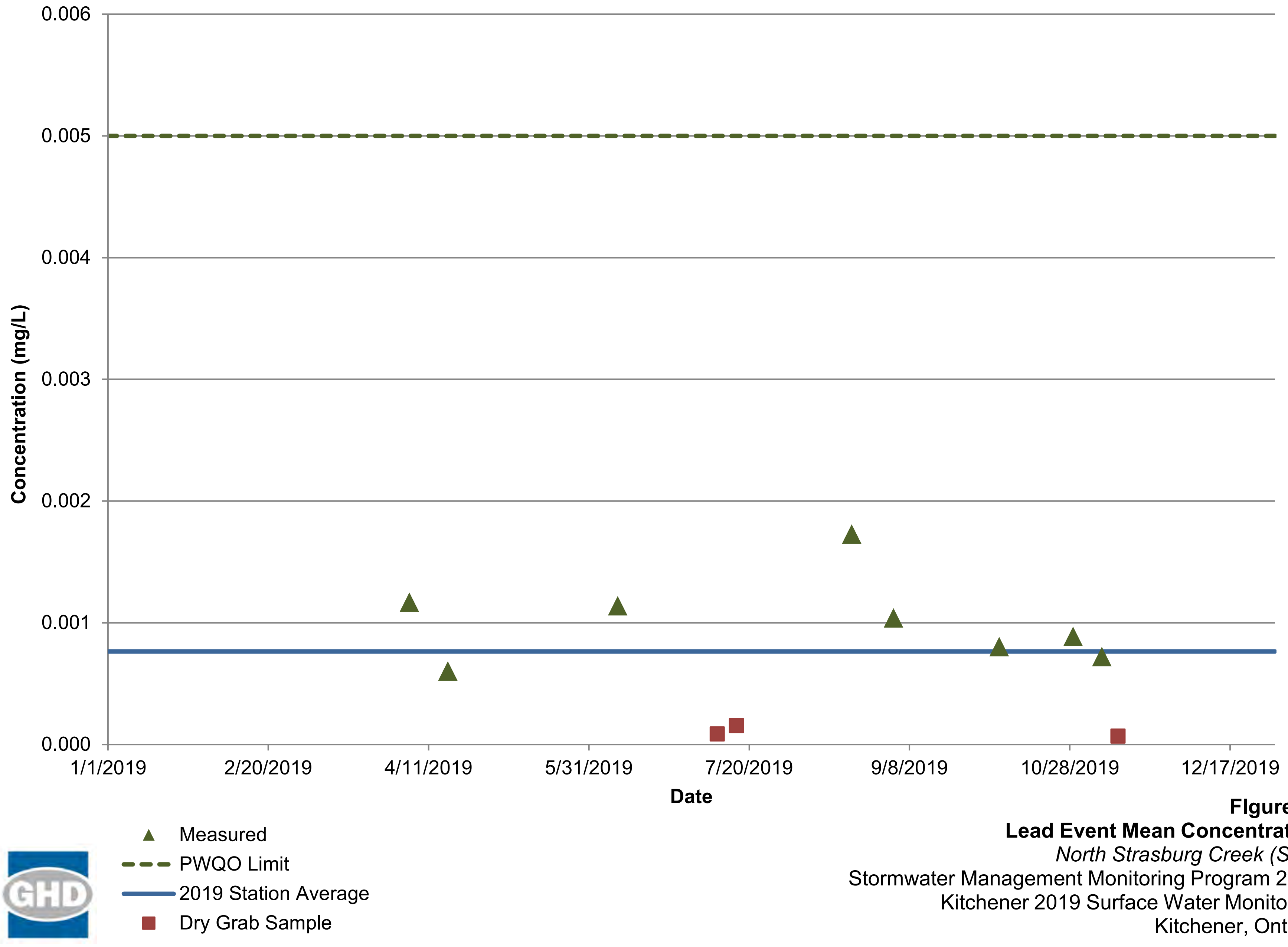


**FIgure 84**
**Lead Event Mean Concentration**
*North Strasburg Creek (SB2)*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

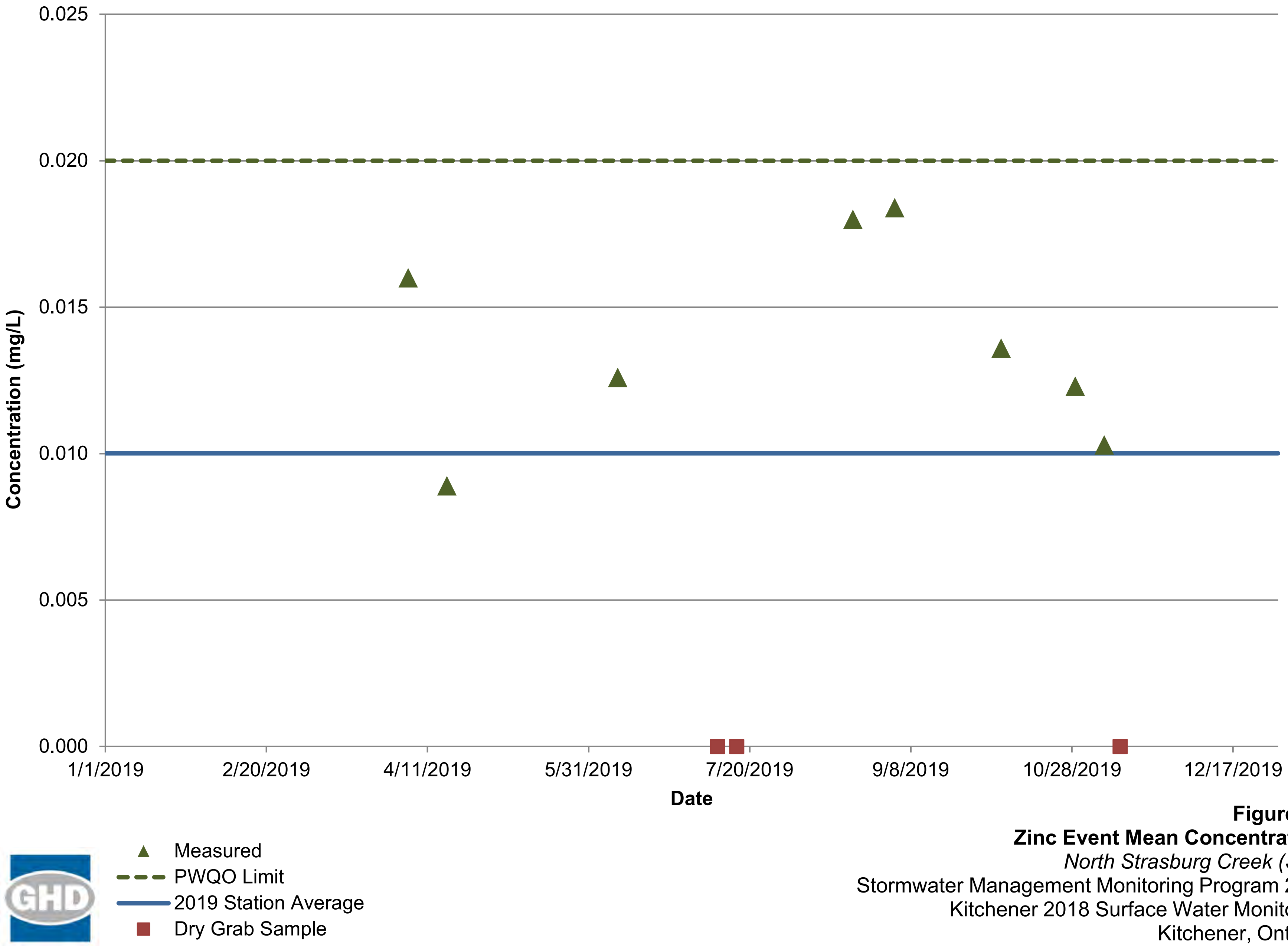


**Figure 85**

**Zinc Event Mean Concentration**

*North Strasburg Creek (SB2)*

Stormwater Management Monitoring Program 2019
Kitchener 2018 Surface Water Monitoring
Kitchener, Ontario

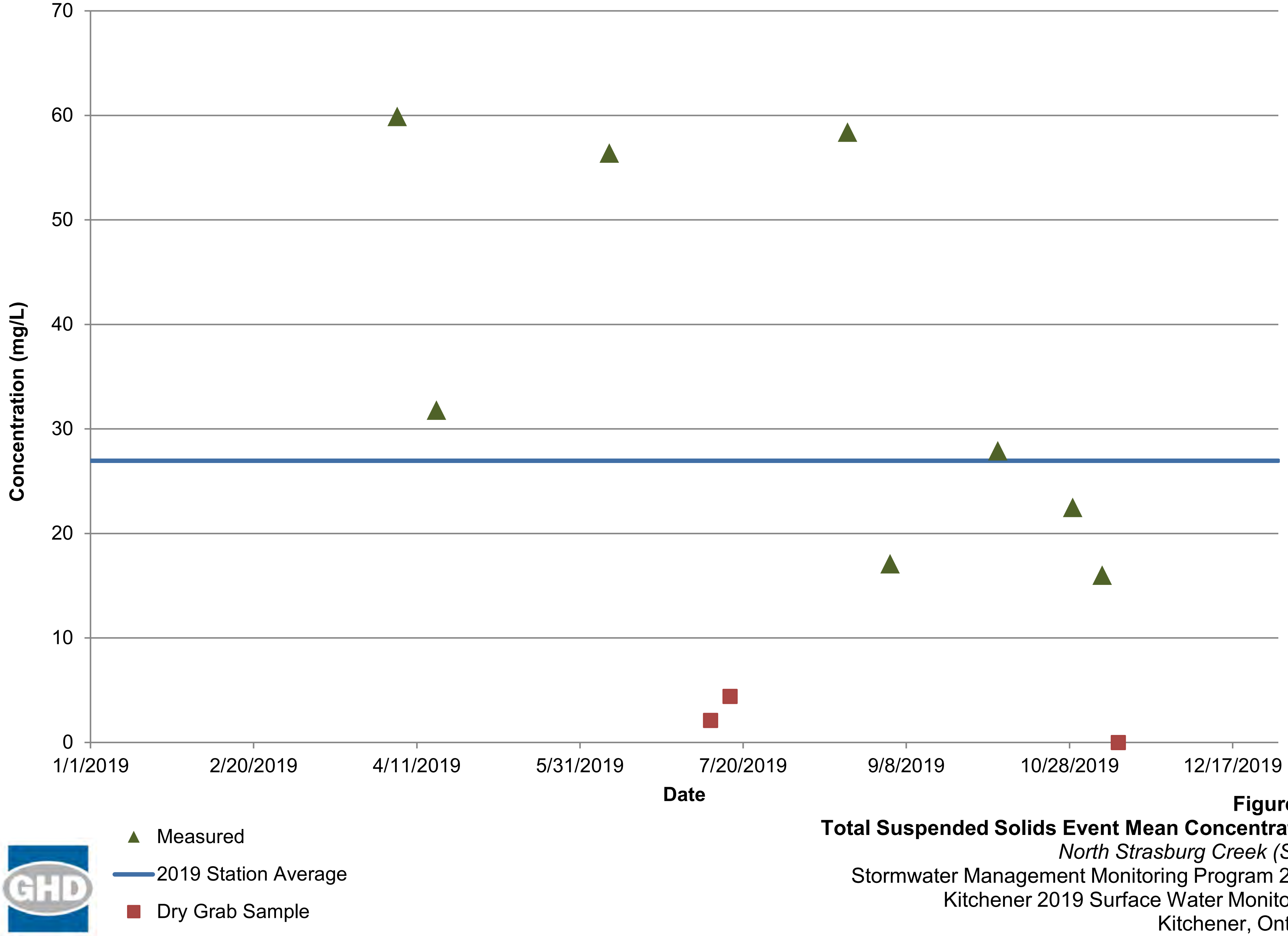


**Figure 86**

**Total Suspended Solids Event Mean Concentration**

*North Strasburg Creek (SB2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

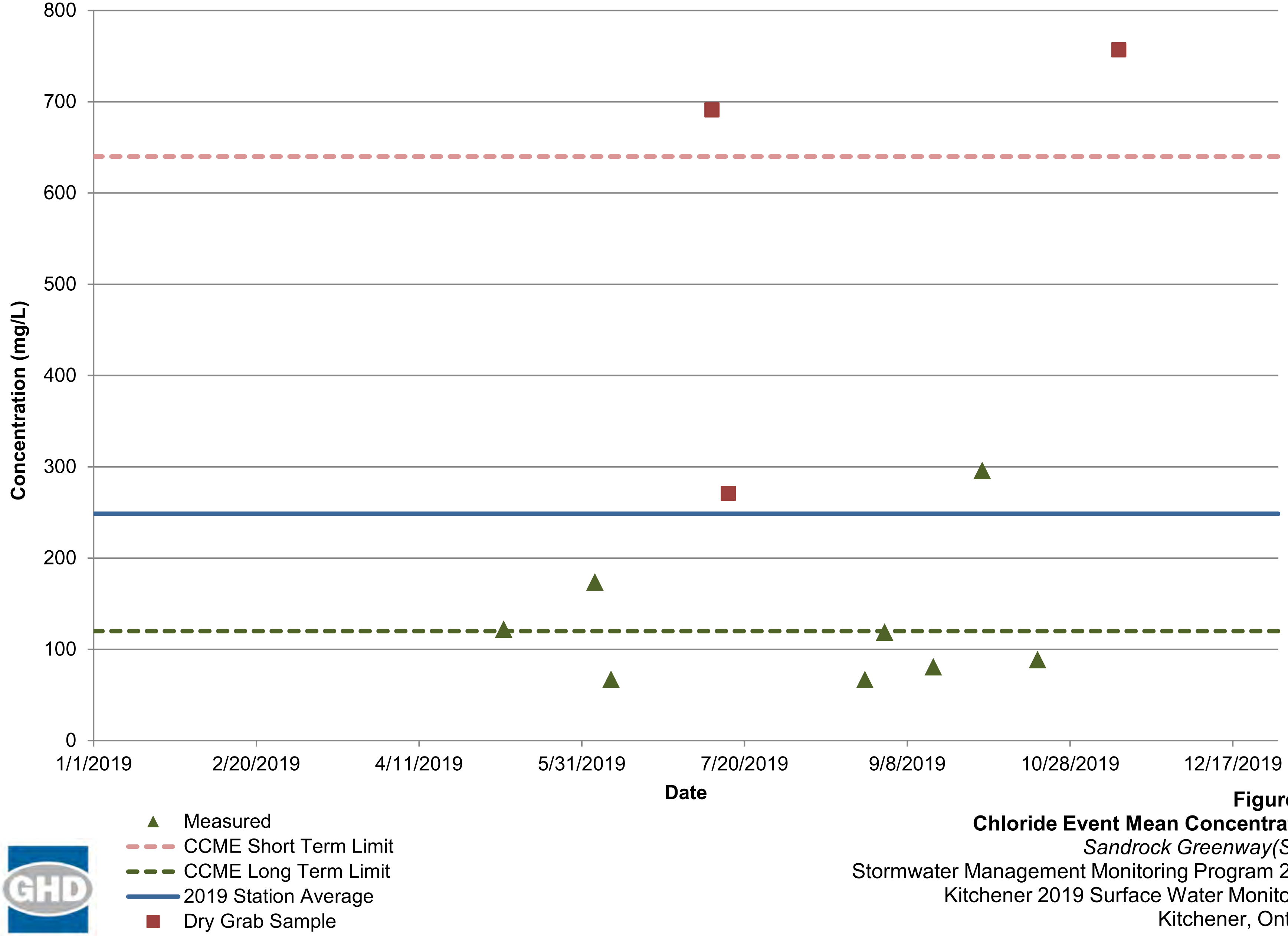


**Figure 87**

**Chloride Event Mean Concentration**

*Sandrock Greenway(SR2)*

Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

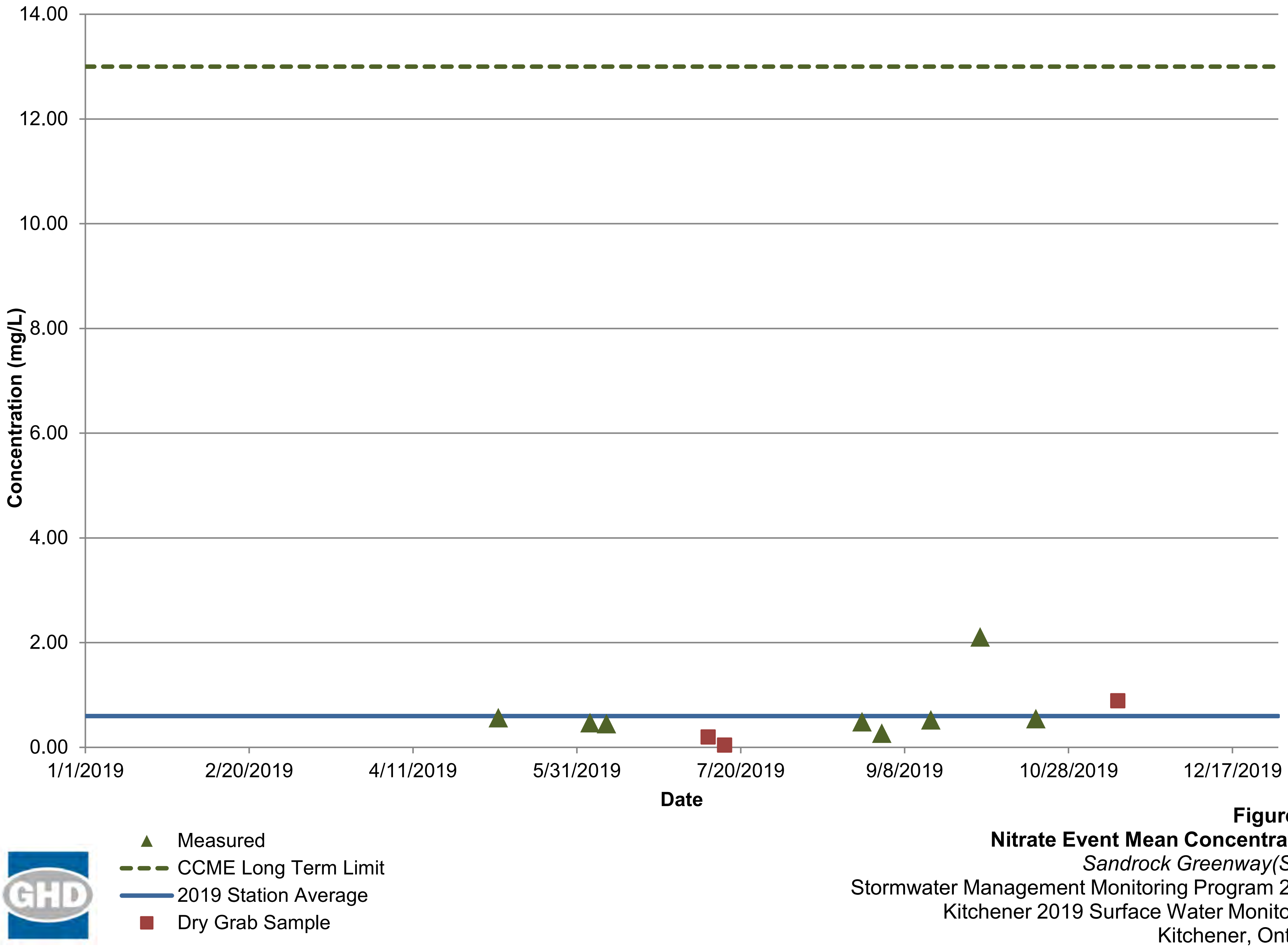


**Figure 88**

**Nitrate Event Mean Concentration**

*Sandrock Greenway(SR2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

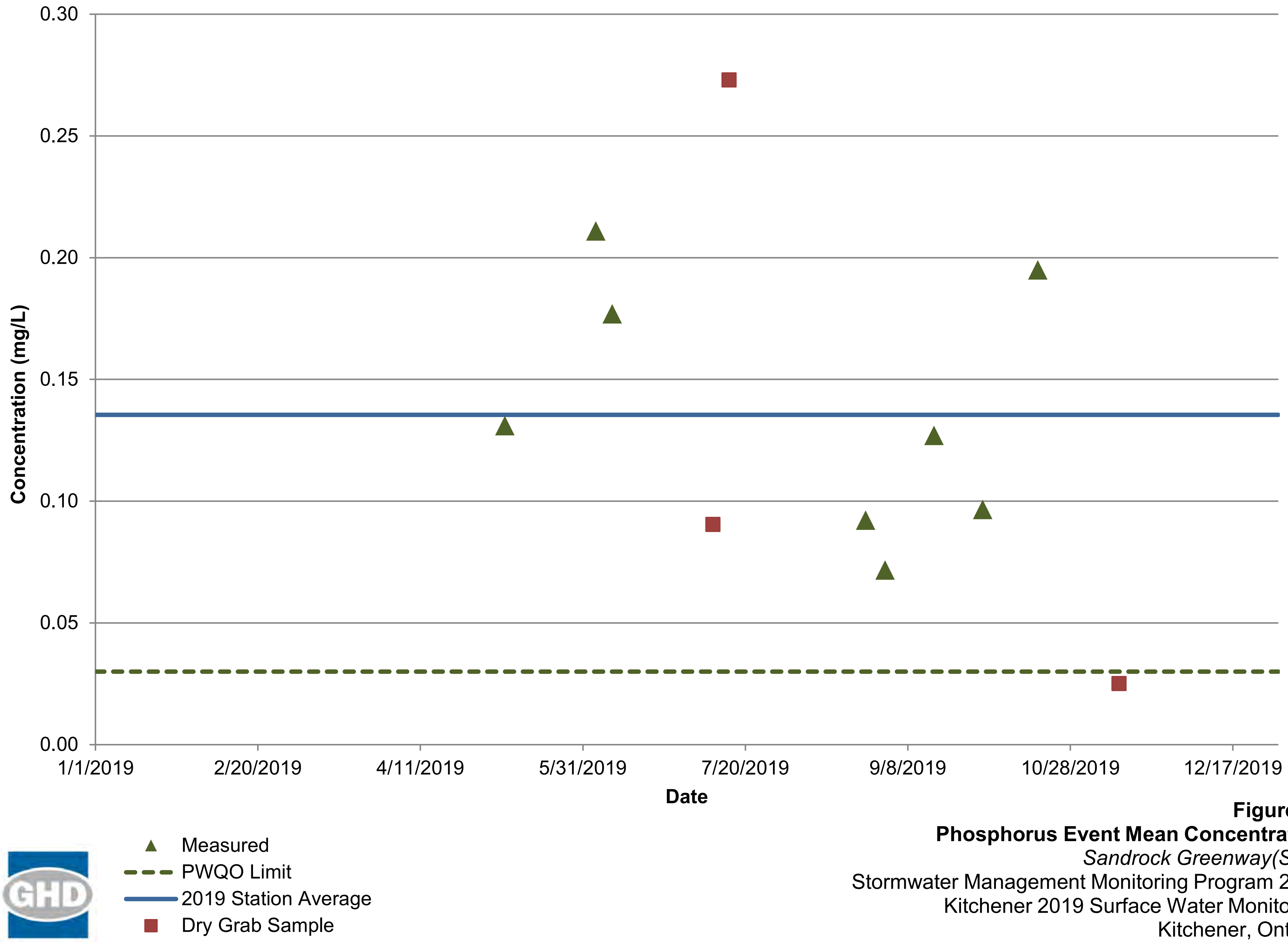


**Figure 89**

**Phosphorus Event Mean Concentration**

*Sandrock Greenway(SR2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

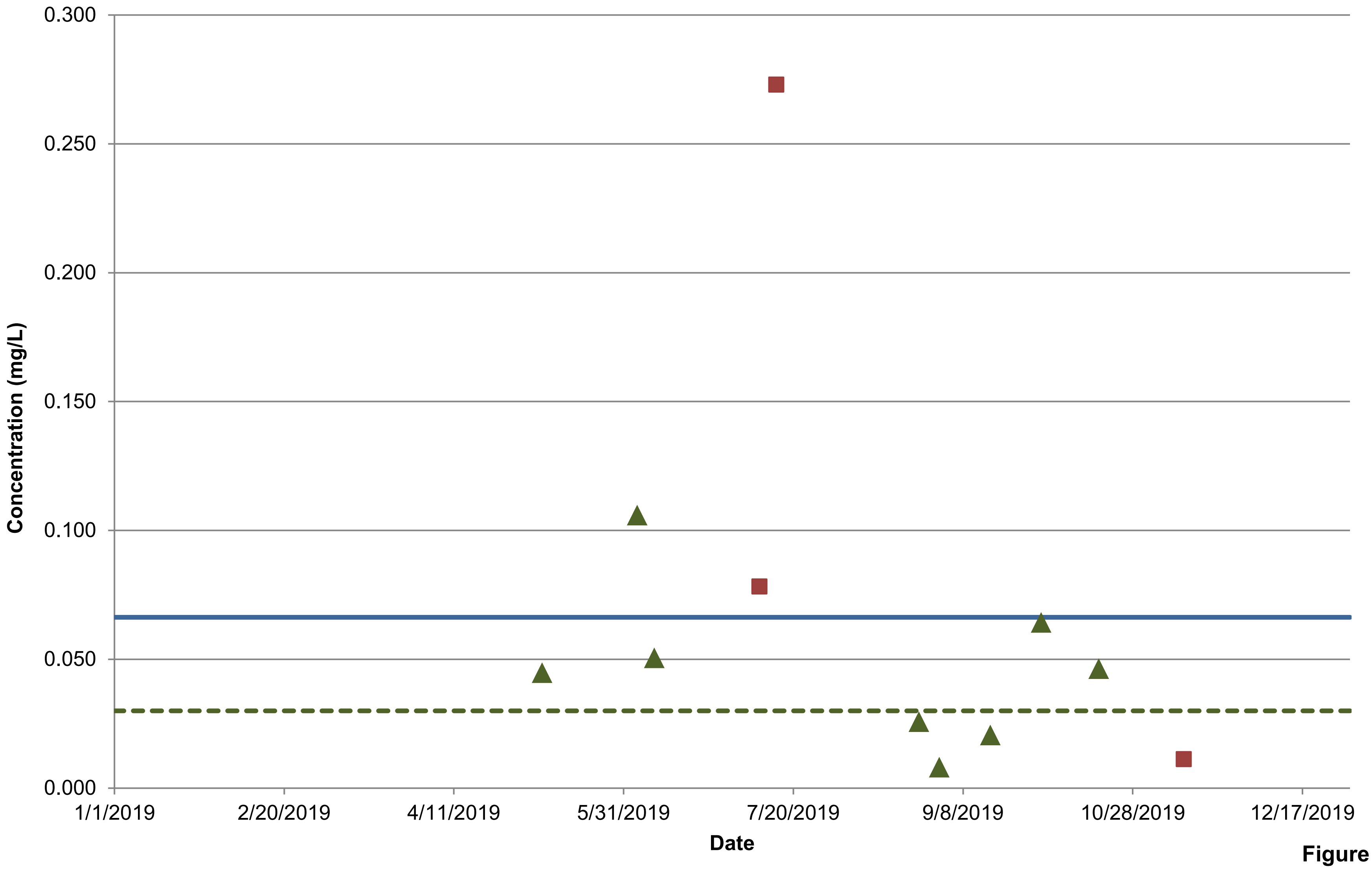


**Figure 90**

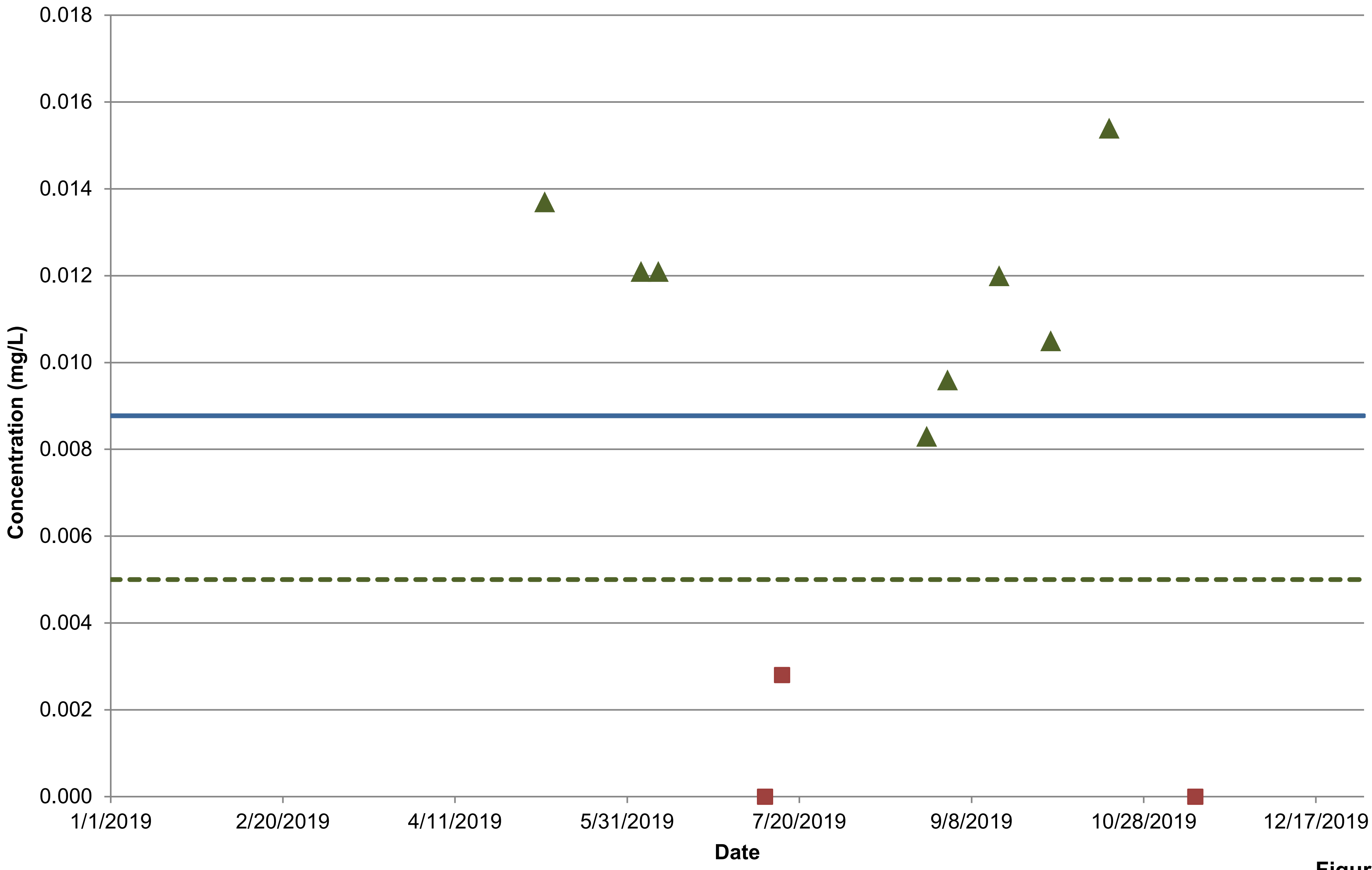
**Dissolved Phosphorus Event Mean Concentration**

*Sandrock Greenway(SR2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario



▲ Measured

- - - PWQO Limit

— 2019 Station Average

■ Dry Grab Sample

**Figure 91**

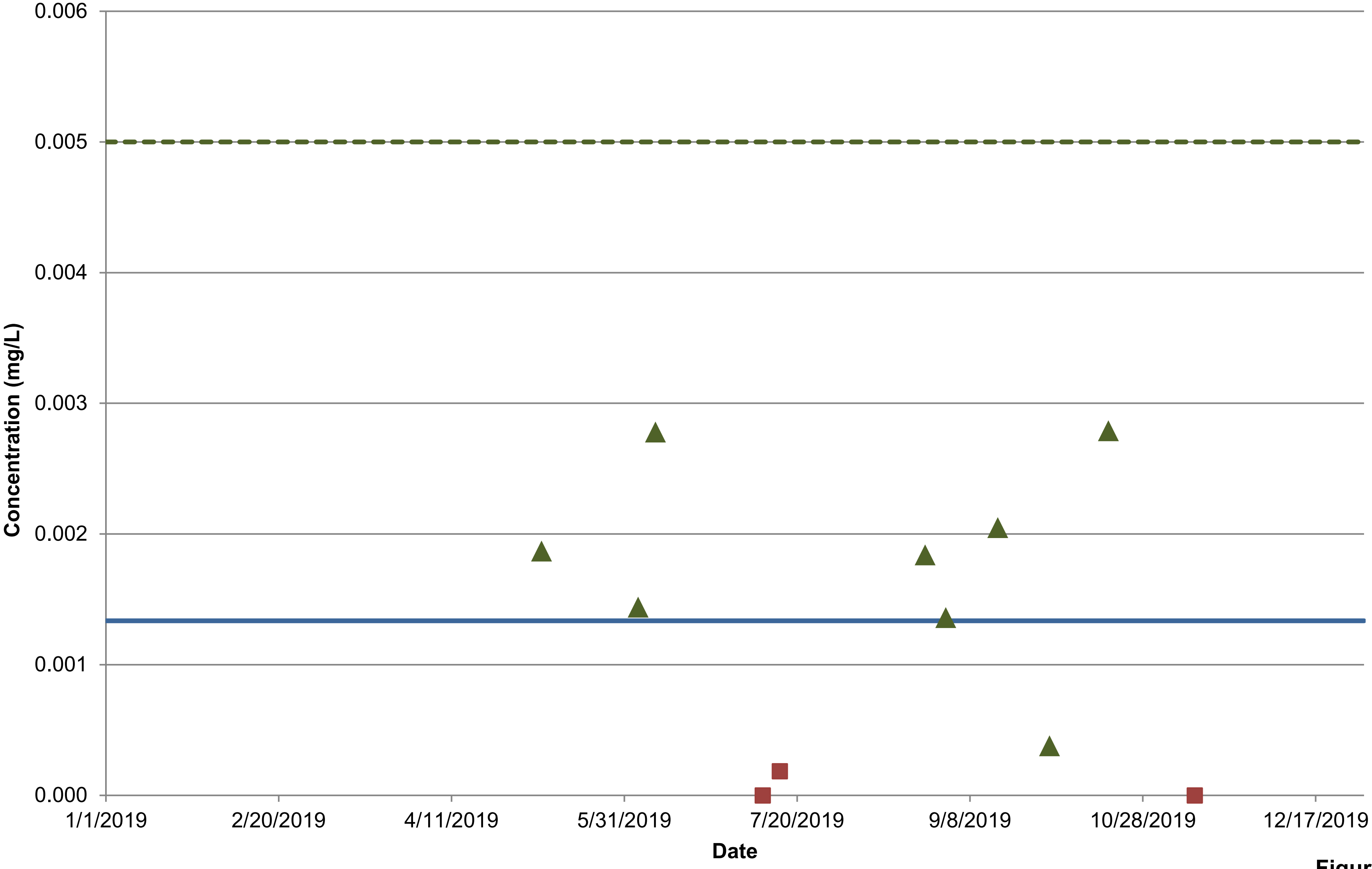
**Copper Event Mean Concentration**

*Sandrock Greenway (SR2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario



▲ Measured
PWQO Limit
2019 Station Average
■ Dry Grab Sample

**Figure 92**
**Lead Event Mean Concentration**
*Sandrock Greenway(SR2)*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

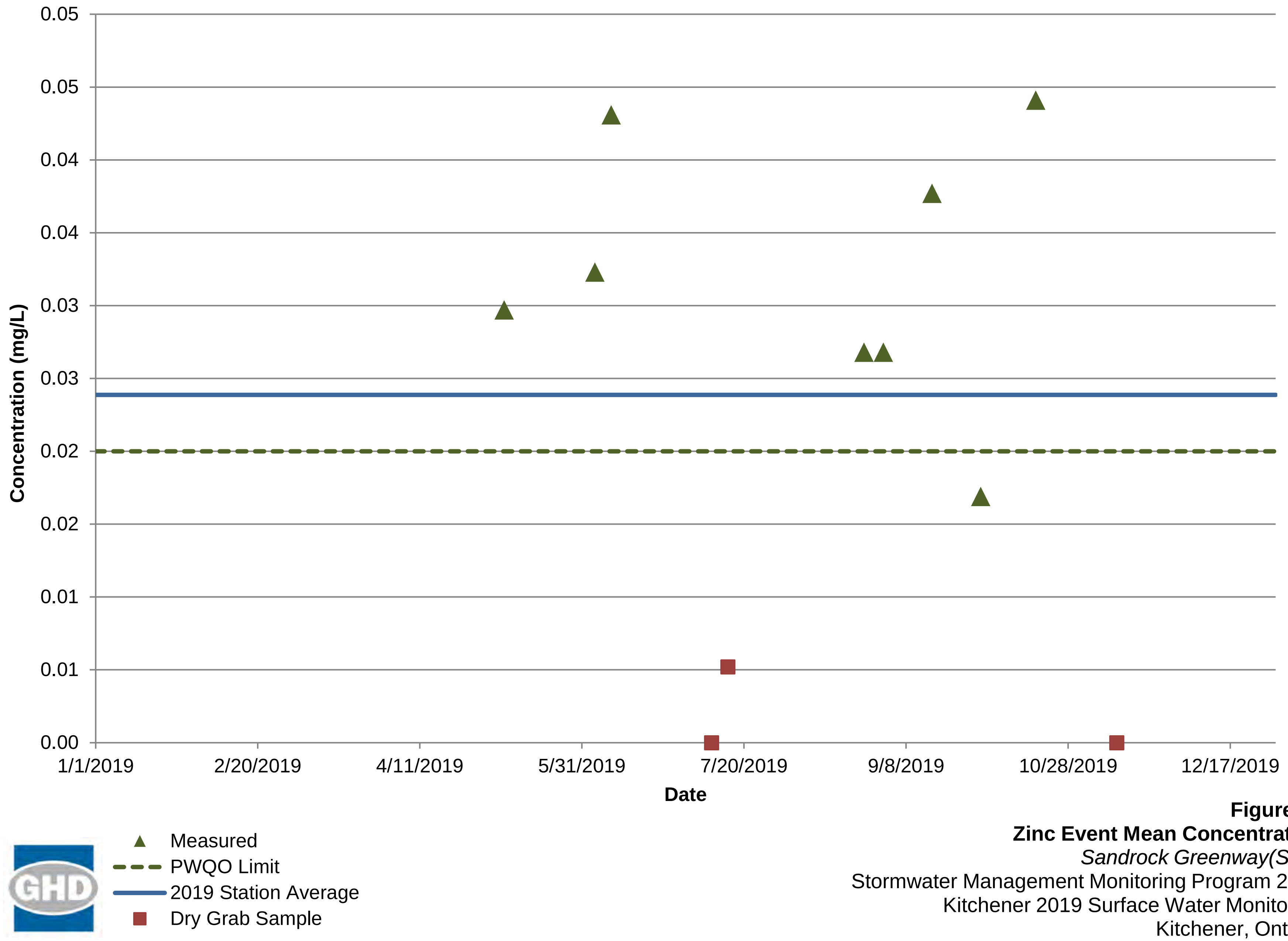


**Figure 93**

**Zinc Event Mean Concentration**

*Sandrock Greenway(SR2)*

Stormwater Management Monitoring Program 2019

Kitchener 2019 Surface Water Monitoring

Kitchener, Ontario

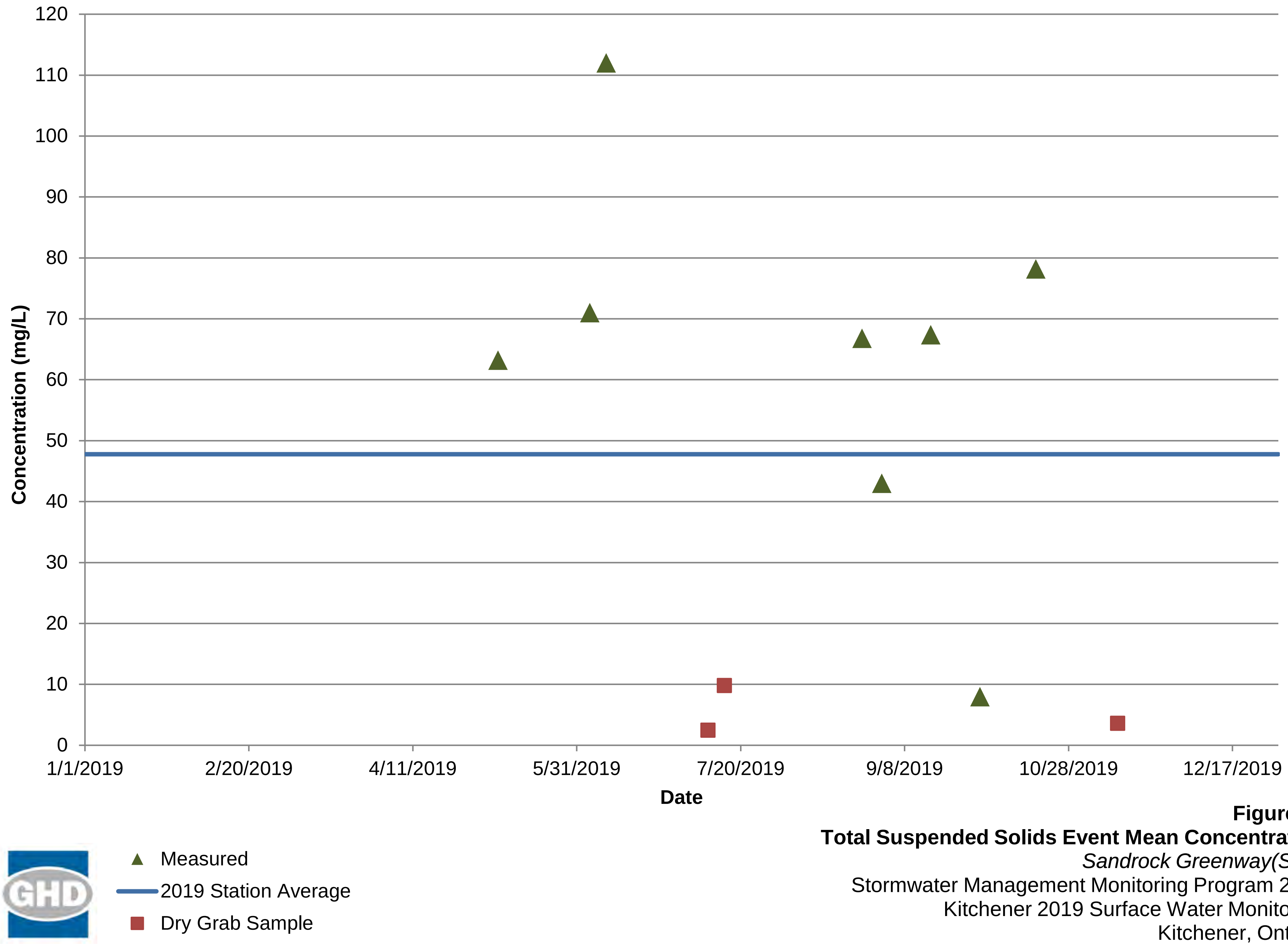


**Figure 94**
**Total Suspended Solids Event Mean Concentration**
*Sandrock Greenway(SR2)*
Stormwater Management Monitoring Program 2019
Kitchener 2019 Surface Water Monitoring
Kitchener, Ontario

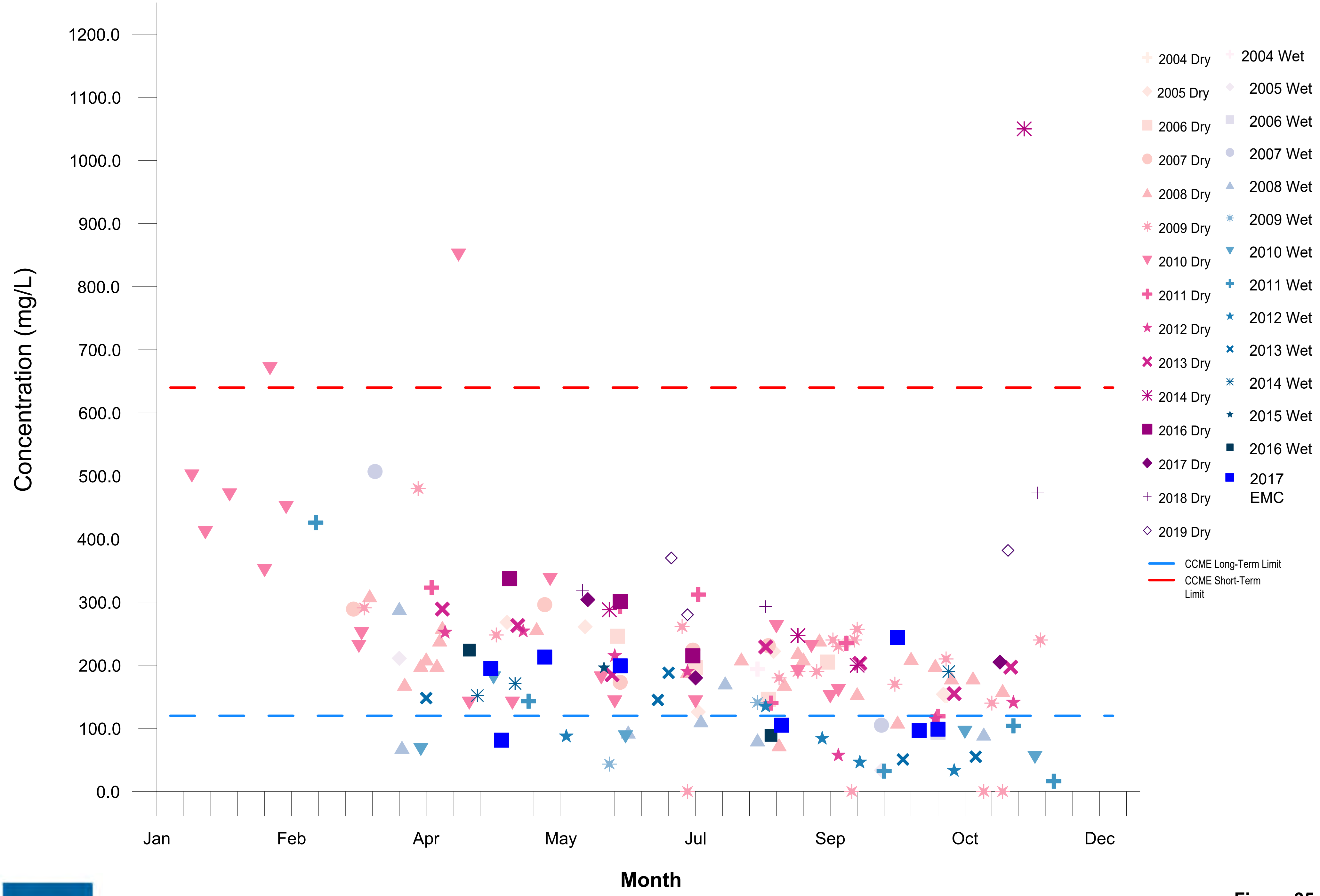


**Figure 95**
**Chloride Historical Trend Concentrations Lower**
Schneider Creek (SC1)
Stormwater Management Monitoring Program 2019
Kitchener, Ontario

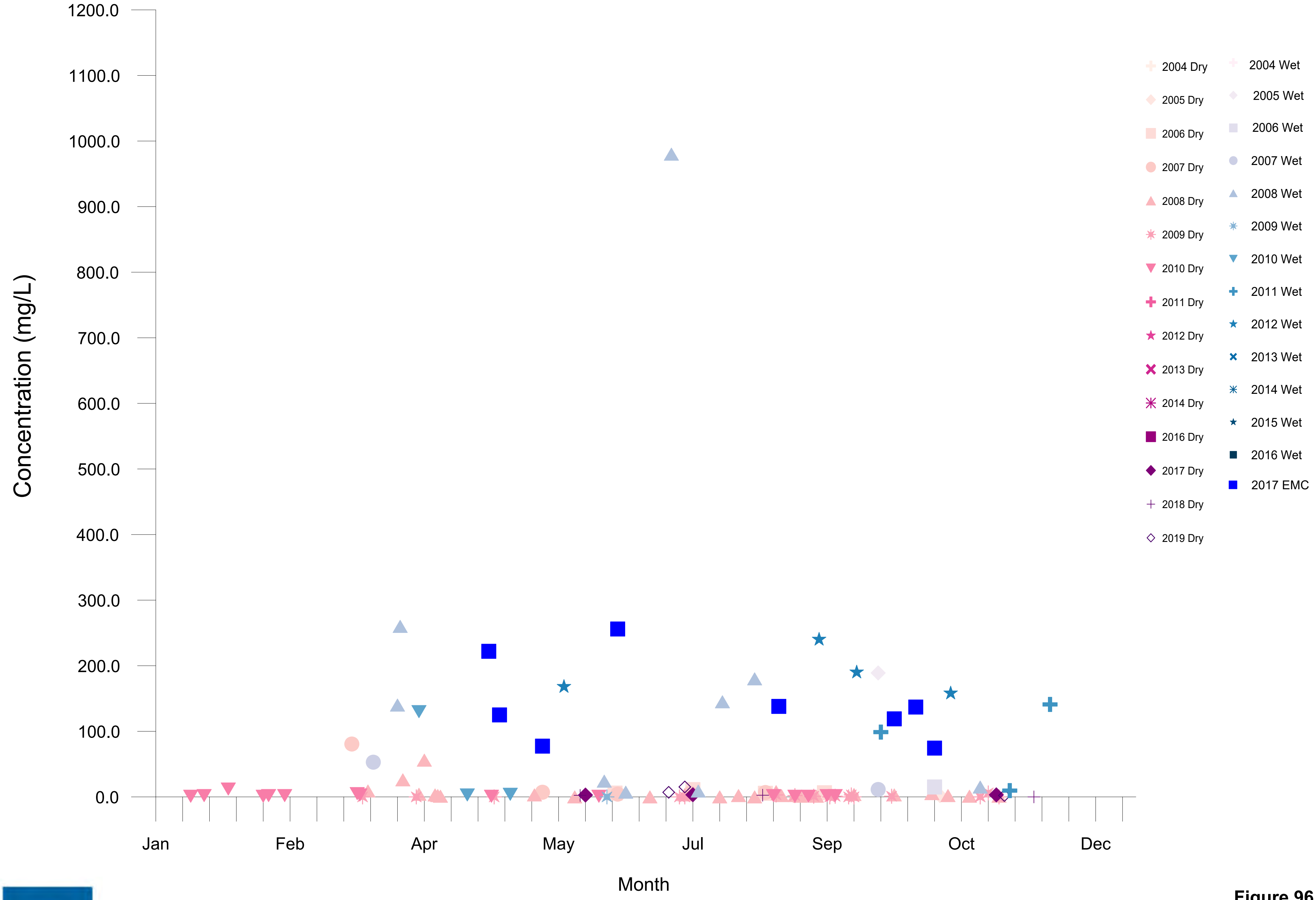


**Figure 96**
**TSS Historical Trend Concentrations**

Lower Schneider Creek (SC1)
Stormwater Management Monitoring Program
2019 Kitchener, Ontario

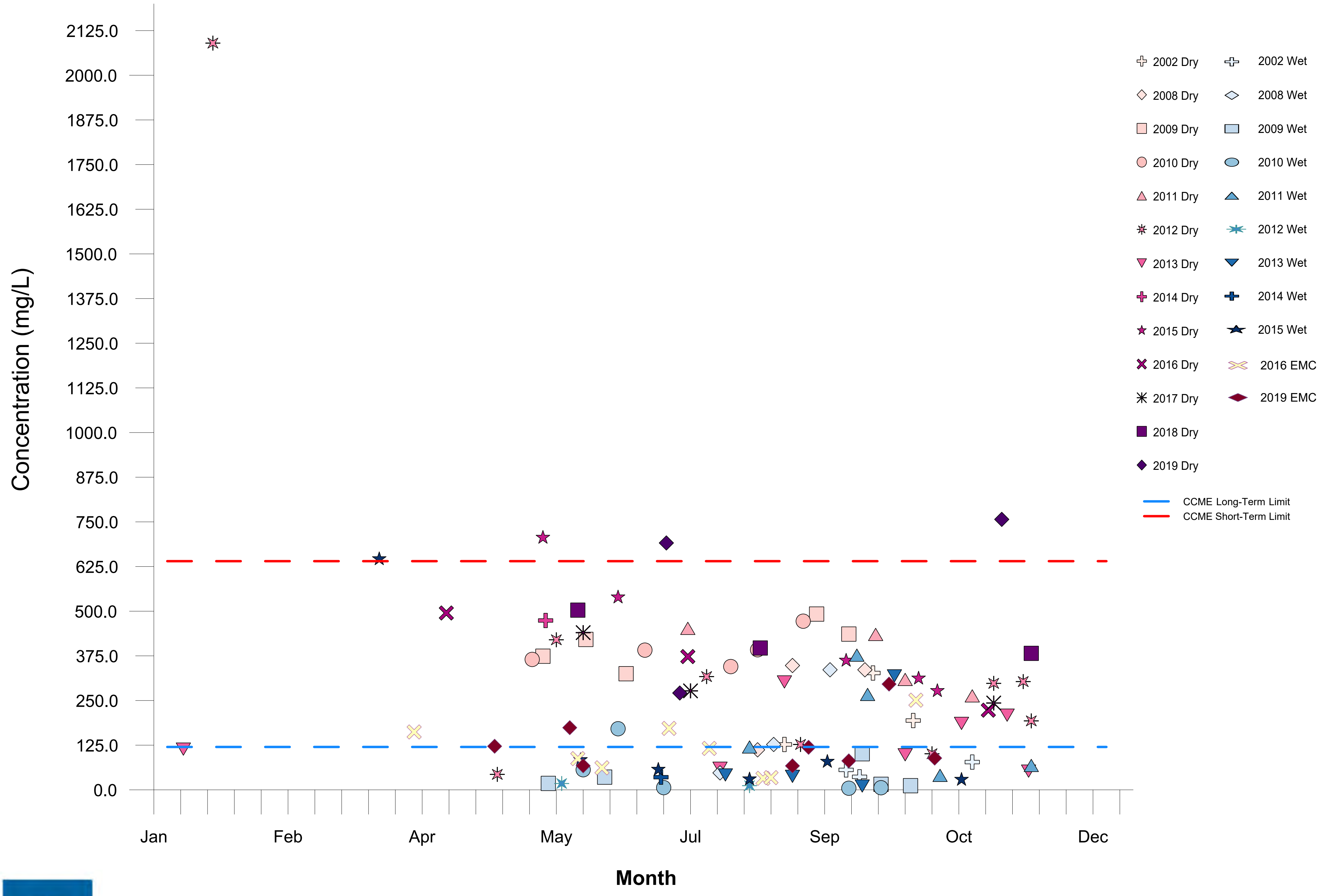


**Figure 97**

**Chloride Historical Trend Concentrations Sandrock Greenway (SR2)**

Stormwater Management Monitoring Program 2019

Kitchener, Ontario

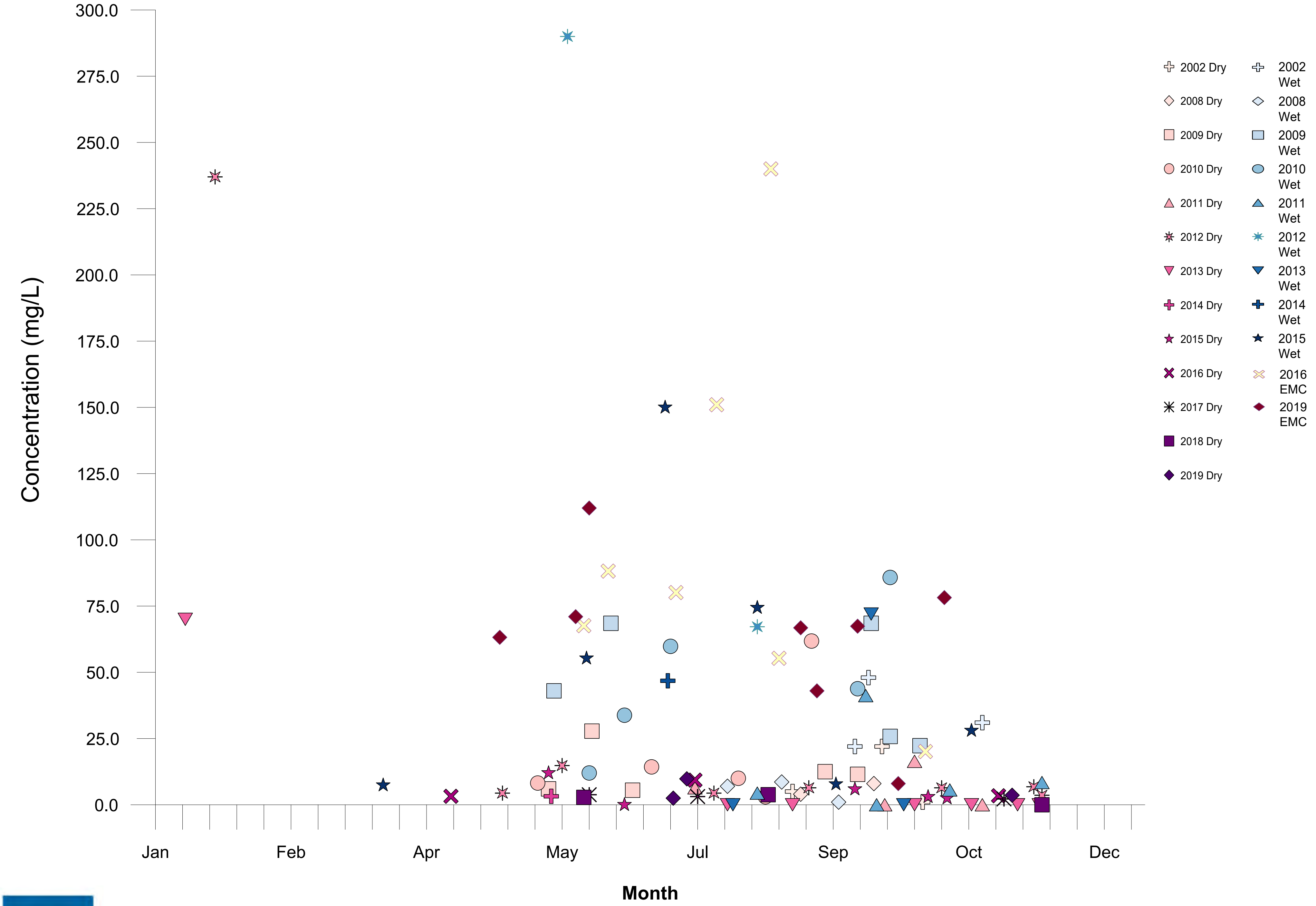


**Figure 98**
**TSS Historical Trend Concentrations**
Sandrock Greenway (SR2)
Stormwater Management Monitoring Program 2019
Kitchener, Ontario

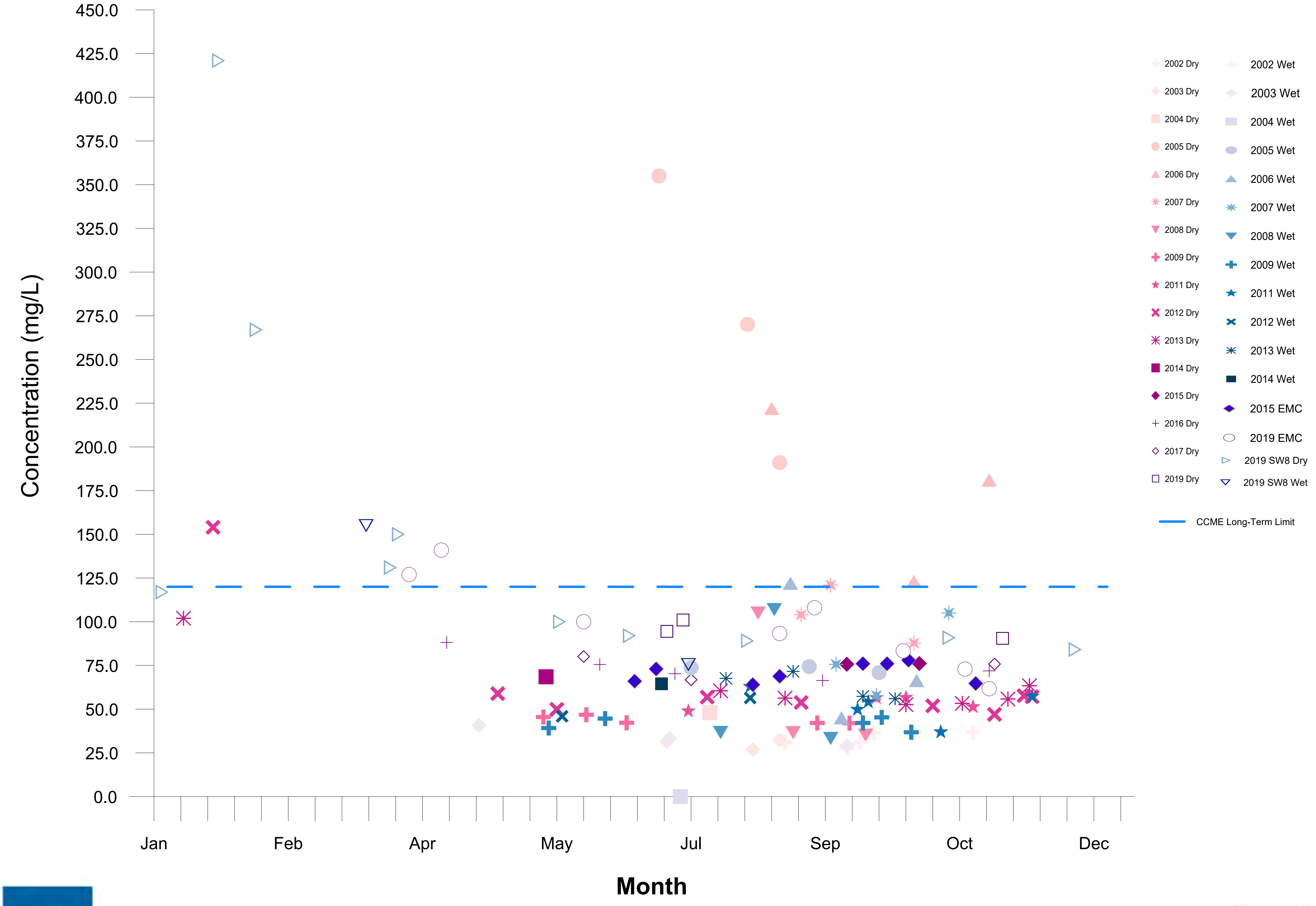
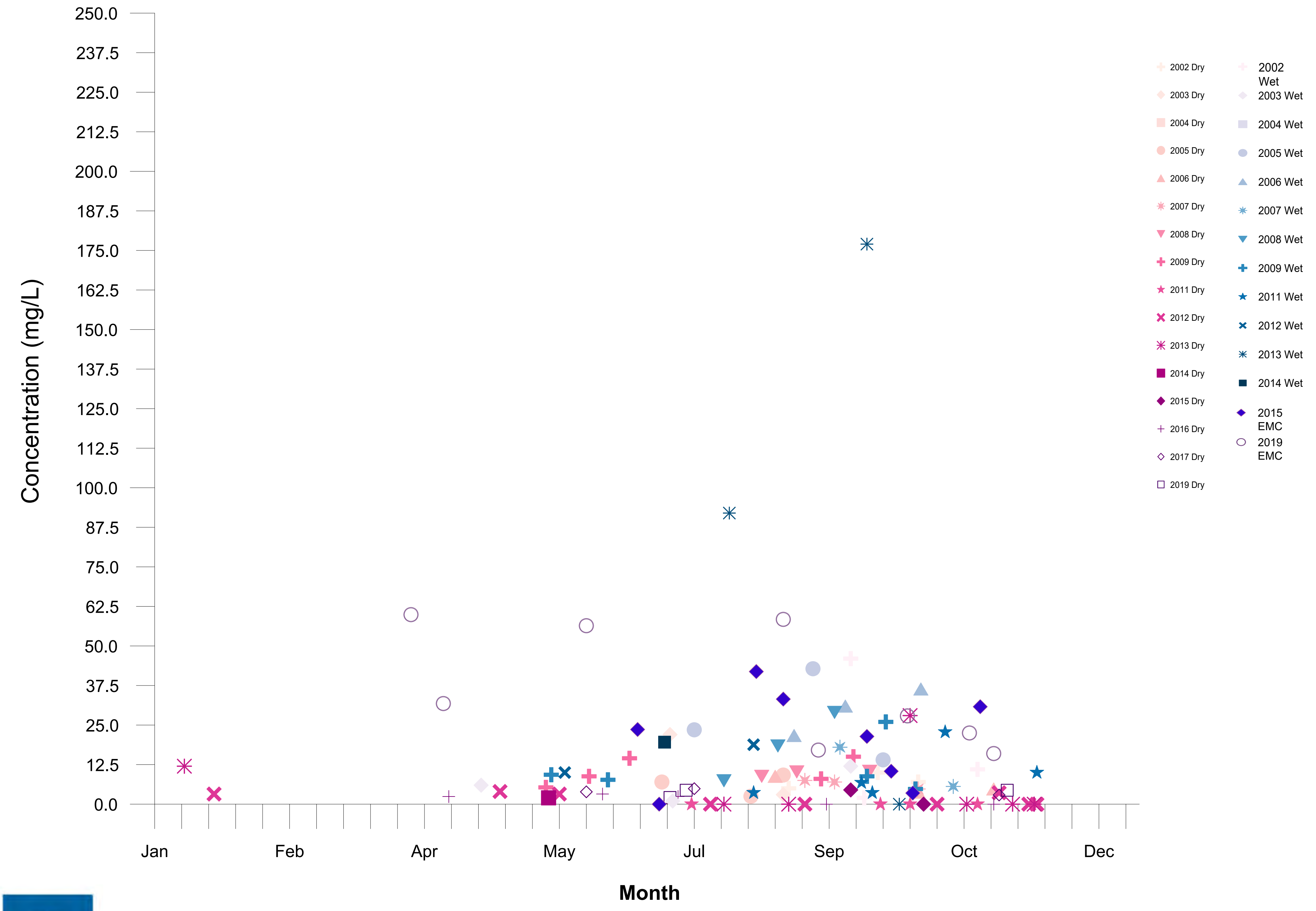


**Figure 99**
**Chloride Historical Trend Concentrations North**
Strasburg Creek (SB2)
Stormwater Management Monitoring Program 2019
Kitchener, Ontario



Note:
- Wet weather measurements in 2007 resulted in the maximum TSS concentration of 1770 mg/L (not shown on Figure)

**Figure 100**
**TSS Historical Trend Concentrations**
North Strasburg Creek (SB2)
Stormwater Management Monitoring Program 2019
Kitchener, Ontario

## Table 1

### 2019 Blair Creek Fish Community Results
### City of Kitchener Stormwater Management Monitoring Program
### Kitchener, Ontario

| | | | | | | GRCA Station 2414047 (Upstream 401) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Abundance (ON)** | **Thermal Regime** | **Tolerance** | **MNRF Code** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
| *Salmo trutta* | Brown Trout | Common | Cold | Intolerant | 78 | 4 | 1 | 12 | 4 | 7 | 4 |
| *Salvelinus fontinalis* | Brook Trout | Common | Cold | Intolerant | 80 | 32 | 13 | 12 | 7 | 15 | 6 |
| *Umbra limi* | Central Mudminnow | Common | Cool | Tolerant | 141 | 1 | - | - | - | 1 | - |
| *Catostomus commersonii* | White Sucker | Common | Cool | Tolerant | 163 | 2 | 2 | - | 1 | 2 | 3 |
| *Semotilus atromaculatus* | Creek Chub | Common | Cool | Tolerant | 212 | 5 | - | - | 2 | - | 1 |
| *Lepomis gibbosus* | Pumpkinseed | Common | Warm | Intermediate | 313 | - | 2 | 2 | - | - | 1 |
| *Lepomis macrochirus* | Bluegill | Common | Warm | Intermediate | 314 | 1 | - | - | - | - | - |
| *Cottus bairdii* | Mottled Sculpin | Common | Cold | Intermediate | 381 | 35 | 7 | 31 | 16 | 33 | 24 |
| *Rhinichthys obtusus* | Western Blacknose Dace | Common | Cool | Intermediate | 210 | 41 | 17 | 15 | 11 | 42 | 12 |
| | | | | | | | | | | | |
| Thermal Classification:<br>Coolwater-Coldwater | | | | | **NUMBER OF FISH COLLECTED:** | 61 | 42 | 72 | 41 | 100 | 51 |
| | | | | | **Species Richness:** | 5 | 6 | 5 | 6 | 6 | 7 |
| | | | | | **% Tolerant Species:** | 8.2 | 4.8 | 0 | 7.3 | 3.0 | 7.8 |
| | | | | | **%Intolerant Species:** | 34.4 | 33.3 | 33.3 | 26.8 | 22.0 | 19.6 |
| **Note:** GRCA alternates community sampling (a single pass survey) and biomass sampling (a 3 pass survey) every other year at this Blair Creek survey location. | | | | | | | | | | | |
| Community (single pass) Survey years: 2015, 2017, 2019 | | | | | | | | | | | |
| Biomass (triple pass) Survey years: 2014, 2016, 2018 | | | | | | | | | | | |
| *2014 and 2015 data taken from the 'City of Kitchener, 2015 Stormwater Management Monitoring Program' (AECOM)* | | | | | | | | | | | |

## Table 2 ISCO Operation and Maintenance Events

| Date | ISCO Location | Operations and Maintenance Summary |
|---|---|---|
| March 27, 2019 | SB2 | Solinst temperature/level logger and ISCO sampler installed |
| | SR2 | Attempted to install ISCO sampler, ground still frozen |
| April 5, 2019 | SB2 | Sample collected |
| April 10, 2019 | VS1 | Solinst temperature/level logger and ISCO sampler installed |
| April 17, 2019 | SB2, VS1 | Sample collected, manual water level |
| April 18, 2019 | WD1, SR2 | Solinst temperature/level logger installed |
| April 29, 2019 | VS1 | Sample collected, manual water level |
| | SB2 | Manual water level |
| April 24, 2019 | WD1, SR2 | ISCO sampler installed |
| April 25, 2019 | SR2 | Manual water level, replaced tubing with longer length |
| May 1, 2019 | WD1 | AV sensor not working, ordered new sensor |
| May 7, 2019 | SR2 | Sample collected, two-peak event (95% captured) |
| May 30, 2019 | SB2 | Sample dumped, pacing error, manual water level, blue band replaced |
| | SR2 | Manual water level |
| | VS1 | Sample dumped, infested with ants, ant nest cleared, manual water level |
| June 1, 2019 | WD1 | New AV sensor installed |
| June 4, 2019 | SR2 | Sample collected |
| June 9, 2019 | SB2, SR2 | Sample collected |
| | VS1 | Sample collected, manual water level, ants in enclosure |
| | WD1 | Water level sensor not measuring, re-initialized sampler |
| June 24, 2019 | SB2, VS1 | Manual water level |
| | SR2 | Manual water level, debris cleared from tbar |
| | WD1 | Flow module removed and desiccant checked, cleared of debris, reinstalled flow module and AV sensor now working |
| June 26, 2019 | WD1 | Sample collected |
| July 1, 2019 | WD1, VS1 | Sample collected |
| August 21, 2019 | WD1, VS1, SB2 | Sample collected, manual water level |
| August 26, 2019 | SR2 | Sample collected |
| September 1, 2019 | SR2, WD1 | Sample collected, manual water level |
| September 3, 2019 | SB2, VS1 | Sample collected, manual water level |
| September 16, 2019 | SR2, WD1 | Sample collected |
| October 1, 2019 | SR2 | Sample collected, manual water level |
| October 6, 2019 | SB2, VS1 | Sample collected, manual water level |
| October 8, 2019 | WD1 | Sample collected, manual water level |
| October 17, 2019 | WD1, VS1 | Sample collected |
| October 18, 2019 | SR2 | Sample collected |
| October 29, 2019 | SB2 | Sample collected |
| November 7, 2019 | SB2 | Sample collected |
| November 26, 2019 | SB2 | Solinst temperature/level logger and ISCO sampler removed |
| December 18, 2019 | WD1, VS1, SR2 | Solinst temperature/level logger and ISCO sampler removed |

## Table 3

## 2019 Benthic Community Sampling Results
## City of Kitchener Stormwater Management Monitoring Program
## Kitchener, Ontario

| Index | Range of Expected Values[1] | Strasburg Creek SB2 | Schneider Creek SC1 | Sandrock Greenway SR2 | Voisin Creek VS1 | Westmount Drain WD1 |
|---|---|---|---|---|---|---|
| **Abundance[2]** | >300 | 339 | 332 | 362 | 322 | 373 |
| **Taxa Richness** | 20 - 40 | 33 | 32 | 25 | 15 | 14 |
| **% Dominant[3]** | <50 | 19 | 30 | 19 | 80 | 52 |
| **# of EPT Families[4]** | >10 | 4 | 7 | 2 | 1 | 2 |
| **% Oligochaeta** | - | 0 | 1 | 2 | 4 | 35 |
| **% Diptera** | - | 50 | 22 | 88 | 14 | 6 |
| **% Chironomidae** | 10 to 30 | 47 | 19 | 87 | 14 | 2 |
| **% EPT** | - | 39 | 35 | 1 | 0 | 1 |
| **% Predators** | - | 4 | 10 | 11 | 8 | 4 |
| **% Collector-Filterer** | - | 27 | 31 | 6 | 2 | 5 |
| **% Collector-Gatherer** | - | 54 | 50 | 70 | 86 | 89 |
| **% Scraper** | - | 6 | 6 | 0 | 0 | 1 |
| **% Shredder** | 20 - 40 | 10 | 3 | 13 | 4 | 0 |
| **% Clinger** | - | 32 | 35 | 4 | 0 | 7 |
| | | | | | | |
| **Shannon's Diversity Index[5]** | 3.0 to 5 | 2.73 | 2.46 | 2.46 | 0.95 | 1.35 |
| **Hilsenhoff's Biotic Index (HBI)[5]** | 0.0 - 3.5 | 5.00 | 6.44 | 7.41 | 7.88 | 8.43 |

Notes

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

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

[3] 50% or greater of one species is an indication of impaired water quality (Griffiths, 1999)

[4] >10 indicates a Non-impacted system (Mackie, 2004) further assessments found in full table in Section 9.1

[5] These values indicate the range considered "Unpolluted" or "Excellent" water quality, complete tables are in Section 9.1

# Table 4

## Benthic Invertebrate Community Trends 2013-2019
## City of Kitchener Stormwater Management Monitoring Program
## Kitchener, Ontario

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

*Thermal Classifications:*
SR2- Warmwater; SB2 - Coolwater

# Table 5

## 2019 Fish Community Sampling Results
## City of Kitchener Stormwater Management Monitoring Program
## Kitchener, Ontario

| Species Name | Abundance (ON) | Thermal Regime | Tolerance | MNRF Code | SB2 (Summer) | SR2 (Summer) | VS1 (Summer) | WD1 (Summer) |
|---|---|---|---|---|---|---|---|---|
| White Sucker (*Catostomus commersonii*) | Common | Coolwater | Tolerant | 163 | 8 | 10 | - | 4 |
| Pumpkinseed (*Lepomis gibbosus*) | Common | Warmwater | Intermediate | 313 | 120 | 30 | - | - |
| Creek Chub (*Semotilus atromaculatus*) | Common | Coolwater | Tolerant | 212 | 12 | 10 | - | - |
| Fathead Minnow (*Pimephales promelas*) | Common | Warmwater | Tolerant | 209 | 1 | 7 | - | - |
| Longnose Dace (*Rhinichthys cataractae*) | Common | Coolwater | Intermediate | 211 | 3 | - | - | - |
| Western Blacknose Dace (*Rhinichthys obtusus*) | Common | Coolwater | Intermediate | 210 | 26 | - | - | 21 |
| Brook Stickleback (*Culaea inconstans*) | Common | Coolwater | Intermediate | 281 | 3 | - | - | - |
| Bluntnose Minnow (*Pimephales notatus*) | Common | Warmwater | Intermediate | 208 | 16 | 1 | - | - |
| Mottled Sculpin (*Cottus bairdii*) | Common | Coolwater | Intermediate | 381 | 18 | - | - | - |
| Brook Trout (*Salvelinus fontinalis*) | Common | Coldwater | Intolerant | 80 | 7 | - | - | - |
| | | **NUMBER OF FISH COLLECTED:** | | | **214** | **58** | **0** | **25** |
| | | **Species Richness:** | | | **10** | **5** | **0** | **2** |
| | | **% Tolerant Species:** | | | **9.8** | **46.6** | **0.0** | **4.0** |
| | | **%Intolerant Species:** | | | **3.3** | **0.0** | **0.0** | **0.0** |
| | | **Number of fish collected/100m$^{2:}$** | | | **94.9** | **33.8** | **0.0** | **8.1** |

# Table 6

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

| | | | | | | 2019 | | | | 2018 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Abundance (ON)** | **Thermal Regime** | **Tolerance** | **MNRF Code** | **VS1** | **WD1** | **SB2** | **SR2** | **HS4** | **HS1** | **SR2** | **SB1** | **SB7** | **VS1** |
| *Cyprinus carpio* | Common Carp | Common | Warmwater | Tolerant | 186 | - | - | | - | 1 | - | - | - | - | - |
| *Catostomus commersonii* | White Sucker | Common | Coolwater | Tolerant | 163 | - | 4 | 8 | 10 | 48 | 6 | 8 | 1 | 6 | - |
| *Lepomis gibbosus* | Pumpkinseed | Common | Warmwater | Intermediate | 313 | - | - | 120 | 30 | 47 | 46 | 34 | - | 1 | - |
| *Semotilus atromaculatus* | Creek Chub | Common | Coolwater | Tolerant | 212 | - | - | 12 | 10 | 32 | 13 | 33 | 2 | 4 | - |
| *Pimephales promelas* | Fathead Minnow | Common | Warmwater | Tolerant | 209 | - | - | 1 | 7 | 5 | 13 | 10 | - | - | - |
| *Rhinichthys cataractae* | Longnose Dace | Common | Coolwater | Intermediate | 211 | - | - | 3 | - | - | - | - | 10 | - | - |
| *Rhinichthys obtusus* | Western Blacknose Dace | Common | Coolwater | Intermediate | 210 | - | 21 | 26 | - | 2 | 6 | - | 6 | 8 | - |
| *Culaea inconstans* | Brook Stickleback | Common | Coolwater | Intermediate | 281 | - | - | 3 | - | - | - | - | - | 16 | - |
| *Cottus bairdii* | Mottled Sculpin | Common | Coldwater | Intermediate | 381 | - | - | 18 | - | - | 4 | - | - | - | - |
| *Pimephales notatus* | Bluntnose Minnow | Common | Warmwater | Intermediate | 208 | - | - | 16 | 1 | 9 | - | - | 1 | - | - |
| *Salvelinus fontinalis* | Brook Trout | Common | Coldwater | Intolerant | 80 | - | - | 7 | - | - | - | - | - | - | - |
| *Carassius auratus* | Goldfish | Common | Warmwater | Tolerant | 181 | - | - | - | - | - | - | - | - | - | - |
| *Rhinichthys sp.* | Young of Year | Common | Coolwater | Intermediate | N/A | - | - | - | - | 73 | 1 | 10 | 6 | 37 | |
| *Ameiurus nebulosus* | Brown Bullhead | Common | Warmwater | Intermediate | - | - | - | - | - | - | - | - | - | - | - |
| *Luxilus cornulus* | Common Shiner | Common | Coolwater | Intermediate | - | - | - | - | - | - | - | - | - | - | - |
| *Etheostoma nigrum* | Johnny Darter | Common | Coolwater | Tolerant | - | - | - | - | - | - | - | - | - | - | - |
| - | Unidentified | Common | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Lepomis macrochirus* | Bluegill | Common | Warmwater | Intermediate | 314 | - | - | - | - | - | - | - | - | - | - |
| *Umbra limi* | Central Mudminnow | Common | Coolwater | Tolerant | 141 | - | - | - | - | - | - | - | - | - | - |
| *Lepomis gibbosus x macrochirus* | Pumpkinseed/Bluegill Hybrid | Common | Warmwater | Intermediate | 702 | - | - | - | - | - | - | - | - | - | - |
| | | **NUMBER OF FISH COLLECTED:** | | | | **0** | **25** | **214** | **58** | **217** | **89** | **95** | **26** | **72** | **0** |
| | | **Species Richness:** | | | | **0** | **2** | **10** | **5** | **8** | **7** | **5** | **6** | **6** | **0** |
| | | **% Tolerant Species:** | | | | **0** | **16.00** | **9.81** | **46.55** | **39.6** | **36.0** | **53.7** | **15.4** | **13.9** | **0.0** |
| | | **%Intolerant Species:** | | | | **0** | **0.00** | **3.27** | **0.00** | **0** | **0** | **0** | **0** | **0** | **0** |
| | | **Number of fish collected/100m$^{2:}$** | | | | **0** | **8.07** | **94.86** | **33.81** | **75.66** | **21.13** | **54.15** | **12.97** | **149.07** | **0.00** |

## Table 6

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

| | | | | | | 2017 | | | | 2016 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Abundance (ON)** | **Thermal Regime** | **Tolerance** | **MNRF Code** | **SC1** | **SC9** | **SB2** | **SR2** | **KD1** | **MG1** | **SB2** | **SB13a** |
| *Cyprinus carpio* | Common Carp | Common | Warmwater | Tolerant | 186 | - | - | - | - | - | - | - | 6 |
| *Catostomus commersonii* | White Sucker | Common | Coolwater | Tolerant | 163 | - | 7 | 5 | 1 | 4 | 1 | - | - |
| *Lepomis gibbosus* | Pumpkinseed | Common | Warmwater | Intermediate | 313 | - | 1 | 2 | 3 | - | - | - | - |
| *Semotilus atromaculatus* | Creek Chub | Common | Coolwater | Tolerant | 212 | - | 13 | 2 | 5 | 4 | 12 | 1 | 8 |
| *Pimephales promelas* | Fathead Minnow | Common | Warmwater | Tolerant | 209 | - | - | 1 | 6 | - | - | - | 5 |
| *Rhinichthys cataractae* | Longnose Dace | Common | Coolwater | Intermediate | 211 | 10 | 11 | 1 | - | 2 | - | 1 | - |
| *Rhinichthys obtusus* | Western Blacknose Dace | Common | Coolwater | Intermediate | 210 | - | 23 | 13 | - | 2 | 4 | 15 | - |
| *Culaea inconstans* | Brook Stickleback | Common | Coolwater | Intermediate | 281 | - | - | - | - | - | 11 | 1 | - |
| *Cottus bairdii* | Mottled Sculpin | Common | Coldwater | Intermediate | 381 | - | - | 28 | - | - | - | 144 | - |
| *Pimephales notatus* | Bluntnose Minnow | Common | Warmwater | Intermediate | 208 | 1 | 1 | - | - | - | - | - | 5 |
| *Salvelinus fontinalis* | Brook Trout | Common | Coldwater | Intolerant | 80 | - | - | 4 | - | - | - | 1 | - |
| *Carassius auratus* | Goldfish | Common | Warmwater | Tolerant | 181 | - | 15 | - | - | - | - | - | - |
| *Rhinichthys sp.* | Young of Year | Common | Coolwater | Intermediate | N/A | 3 | - | - | - | - | - | - | - |
| *Ameiurus nebulosus* | Brown Bullhead | Common | Warmwater | Intermediate | - | - | - | - | - | - | - | - | - |
| *Luxilus cornulus* | Common Shiner | Common | Coolwater | Intermediate | - | - | - | - | - | - | - | - | - |
| *Etheostoma nigrum* | Johnny Darter | Common | Coolwater | Tolerant | - | - | - | - | - | - | - | - | - |
| - | Unidentified | Common | - | - | - | - | - | - | - | - | - | - | - |
| *Lepomis macrochirus* | Bluegill | Common | Warmwater | Intermediate | 314 | - | - | - | - | - | - | - | - |
| *Umbra limi* | Central Mudminnow | Common | Coolwater | Tolerant | 141 | - | - | - | - | - | - | - | - |
| *Lepomis gibbosus x macrochirus* | Pumpkinseed/Bluegill Hybrid | Common | Warmwater | Intermediate | 702 | - | - | - | - | - | - | - | - |
| | | **NUMBER OF FISH COLLECTED:** | | | | **14** | **71** | **56** | **15** | **12** | **28** | **163** | **24** |
| | | **Species Richness:** | | | | **2** | **7** | **8** | **4** | **4** | **4** | **6** | **4** |
| | | **% Tolerant Species:** | | | | **0.0** | **49.3** | **14.3** | **80.0** | **66.7** | **46.4** | **0.6** | **79.2** |
| | | **%Intolerant Species:** | | | | **0** | **0** | **7.1** | **0** | **0** | **0** | **0.613** | **0** |
| | | **Number of fish collected/100m$^{2}$:** | | | | **2.48** | **18.50** | **26.92** | **7.62** | **7.24** | **16.53** | **97.96** | **30.46** |

## Table 6

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

| | | | | | | 2015 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Abundance (ON)** | **Thermal Regime** | **Tolerance** | **MNRF Code** | **HS1** | **IW1** | **KD1** | **MG1** | **SB2** | **SB13a** | **SM1** | **SR2** |
| *Cyprinus carpio* | Common Carp | Common | Warmwater | Tolerant | 186 | 5 | - | - | - | - | - | - | - |
| *Catostomus commersonii* | White Sucker | Common | Coolwater | Tolerant | 163 | 2 | 2 | 4 | - | - | - | - | 4 |
| *Lepomis gibbosus* | Pumpkinseed | Common | Warmwater | Intermediate | 313 | 7 | - | 1 | - | - | - | - | 4 |
| *Semotilus atromaculatus* | Creek Chub | Common | Coolwater | Tolerant | 212 | 2 | 10 | 6 | 4 | 2 | 7 | - | 41 |
| *Pimephales promelas* | Fathead Minnow | Common | Warmwater | Tolerant | 209 | - | - | - | - | - | - | - | 9 |
| *Rhinichthys cataractae* | Longnose Dace | Common | Coolwater | Intermediate | 211 | - | - | 47 | - | 5 | - | - | - |
| *Rhinichthys obtusus* | Western Blacknose Dace | Common | Coolwater | Intermediate | 210 | - | 33 | - | 7 | 45 | - | - | - |
| *Culaea inconstans* | Brook Stickleback | Common | Coolwater | Intermediate | 281 | - | 4 | - | 37 | 15 | - | - | - |
| *Cottus bairdii* | Mottled Sculpin | Common | Coldwater | Intermediate | 381 | - | - | - | - | 26 | - | - | - |
| *Pimephales notatus* | Bluntnose Minnow | Common | Warmwater | Intermediate | 208 | 11 | - | - | - | - | 25 | - | - |
| *Salvelinus fontinalis* | Brook Trout | Common | Coldwater | Intolerant | 80 | - | - | - | - | 2 | - | - | - |
| *Carassius auratus* | Goldfish | Common | Warmwater | Tolerant | 181 | - | - | - | - | - | - | - | - |
| *Rhinichthys sp.* | Young of Year | Common | Coolwater | Intermediate | N/A | - | - | - | - | - | - | - | - |
| *Ameiurus nebulosus* | Brown Bullhead | Common | Warmwater | Intermediate | - | 9 | - | - | - | - | - | - | - |
| *Luxilus cornulus* | Common Shiner | Common | Coolwater | Intermediate | - | - | - | - | - | - | - | - | - |
| *Etheostoma nigrum* | Johnny Darter | Common | Coolwater | Tolerant | - | - | - | 25 | - | - | - | - | - |
| - | Unidentified | Common | - | - | - | - | - | - | - | - | - | - | - |
| *Lepomis macrochirus* | Bluegill | Common | Warmwater | Intermediate | 314 | - | - | - | - | - | - | - | 1 |
| *Umbra limi* | Central Mudminnow | Common | Coolwater | Tolerant | 141 | - | - | 1 | - | - | - | - | - |
| *Lepomis gibbosus x macrochirus* | Pumpkinseed/Bluegill Hybrid | Common | Warmwater | Intermediate | 702 | - | - | - | - | - | - | - | 4 |
| | | **NUMBER OF FISH COLLECTED:** | | | | **36** | **49** | **84** | **48** | **95** | **32** | **0** | **63** |
| | | **Species Richness:** | | | | **6** | **4** | **6** | **3** | **6** | **2** | **0** | **6** |
| | | **% Tolerant Species:** | | | | **25.0** | **24.5** | **42.9** | **8.3** | **2.1** | **21.9** | **0.0** | **85.7** |
| | | **%Intolerant Species:** | | | | **0** | **0** | **0** | **0** | **2.1** | **0** | **0** | **0** |
| | | **Number of fish collected/100m$^{2:}$** | | | | **18** | **41** | **103** | **24** | **58** | **40** | **0** | **30** |

## Table 6

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

| | | | | | | 2014 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Abundance (ON)** | **Thermal Regime** | **Tolerance** | **MNRF Code** | **BZ1** | **HV1** | **KD1** | **MG1** | **SB2** | **SB13a** | **SM1** | **SR2** |
| *Cyprinus carpio* | Common Carp | Common | Warmwater | Tolerant | 186 | - | - | - | - | - | - | - | - |
| *Catostomus commersonii* | White Sucker | Common | Coolwater | Tolerant | 163 | - | - | 21 | 1 | - | - | - | - |
| *Lepomis gibbosus* | Pumpkinseed | Common | Warmwater | Intermediate | 313 | - | 1 | - | - | 1 | - | - | 21 |
| *Semotilus atromaculatus* | Creek Chub | Common | Coolwater | Tolerant | 212 | 13 | 1 | 19 | - | - | 12 | - | |
| *Pimephales promelas* | Fathead Minnow | Common | Warmwater | Tolerant | 209 | - | - | - | - | - | - | - | 3 |
| *Rhinichthys cataractae* | Longnose Dace | Common | Coolwater | Intermediate | 211 | - | - | 1 | 2 | 11 | - | - | - |
| *Rhinichthys obtusus* | Western Blacknose Dace | Common | Coolwater | Intermediate | 210 | 7 | - | - | 10 | - | 2 | - | - |
| *Culaea inconstans* | Brook Stickleback | Common | Coolwater | Intermediate | 281 | - | - | - | 15 | - | - | - | - |
| *Cottus bairdii* | Mottled Sculpin | Common | Coldwater | Intermediate | 381 | - | - | - | - | 25 | - | - | - |
| *Pimephales notatus* | Bluntnose Minnow | Common | Warmwater | Intermediate | 208 | - | - | - | - | - | - | - | - |
| *Salvelinus fontinalis* | Brook Trout | Common | Coldwater | Intolerant | 80 | - | - | - | - | 2 | - | - | - |
| *Carassius auratus* | Goldfish | Common | Warmwater | Tolerant | 181 | - | - | - | - | - | - | - | - |
| *Rhinichthys sp.* | Young of Year | Common | Coolwater | Intermediate | N/A | - | - | - | - | - | - | - | - |
| *Ameiurus nebulosus* | Brown Bullhead | Common | Warmwater | Intermediate | - | - | - | - | - | - | - | - | 6 |
| *Luxilus cornulus* | Common Shiner | Common | Coolwater | Intermediate | - | - | - | - | - | - | - | - | 1 |
| *Etheostoma nigrum* | Johnny Darter | Common | Coolwater | Tolerant | - | 1 | - | 9 | | - | - | - | - |
| - | Unidentified | Common | - | - | - | 2 | - | - | - | - | - | - | 1 |
| *Lepomis macrochirus* | Bluegill | Common | Warmwater | Intermediate | 314 | - | - | - | - | - | - | - | - |
| *Umbra limi* | Central Mudminnow | Common | Coolwater | Tolerant | 141 | - | - | - | - | - | - | - | - |
| *Lepomis gibbosus x macrochirus* | 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/100m$^{2:}$** | | | | **19** | **3** | **42** | **20** | **33** | **14** | **0** | **20** |

# Table 7

## Fish Community Trends 2013 to 2019
## City of Kitchener Stormwater Management Monitoring Program
## Kitchener, Ontario

| Index | SB2 (Coldwater) | | | | | | | SR2 (Warmwater) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Number of Fish Collected | 31 | 39 | 95 | 163 | 56 | No Data | 214 | No Data | 32 | 63 | No Data | 15 | 95 | 58 |
| Species Richness | 7 | 4 | 6 | 6 | 8 | | 10 | | 5 | 6 | | 4 | 5 | 5 |
| % Tolerant Species | 9.68 | 0.00 | 2.10 | 0.61 | 14.30 | | 9.81 | | 9.38 | 85.71 | | 80.00 | 53.68 | 46.55 |
| % Intolerant Species | 12.90 | 5.12 | 2.10 | 0.61 | 7.10 | | 3.27 | | 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 | | 20.00 | 30.00 | | 7.62 | 54.15 | 33.81 |

# Table 8

## 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 | 2019 Results | First 5-yr Study | Second 5-yr Study | 2019 Results |
| Fish Species Richness | 4 | 2.8 | 5 | 7 | 6 | 10 |
| Fish Indicator Species | Goldfish,<br>Brook Stickleback | Goldfish,<br>Pumpkinseed | Pumkinseed,<br>Creek Chub,<br>White Sucker | Mottled Sculpin | Brook Trout,<br>Mottled Sculpin | Brook Trout,<br>Pumpkinseed,<br>Mottled Sculpin,<br>Blacknose Dace |
| HBI Value Range | ND | ND | 7.4 | 6.2 to 7.3 | 6.6 to 7.3 | 5.0 |
| 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*

# Appendices

# Appendix A

# Stormwater Management Monitoring Program Guidance Document

# Stormwater Management Monitoring Program Guidance Document

## City of Kitchener

Prepared by:

**GHD Limited**

455 Phillip Street

Waterloo, Ontario N2L 3X2

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# Table Index

# List of Abbreviations

| | |
|---|---|
| AV | area velocity |
| CCME | Canadian Council of Ministers of the Environment |
| City | City of Kitchener |
| cm | centimeter |
| DFO | Department of Fisheries and Oceans Canada |
| EDD | electronic data-deliverables |
| EMC | event mean concentration |
| ft | feet |
| g | grams |
| GRCA | Grand River Conservation Authority |
| GHD | GHD Limited |
| HBI | Hilsenhoff Biotic Index |
| ICL | Issue Contributing Area |
| ISWM-MP | Integrated Stormwater Management Master Plan |
| L | liter |
| LID | Low Impact Development |
| m | meter |
| mm | millimeter |
| mL | milliliter |
| OSAP | Ontario Stream Assessment Protocol |
| PWQO | Provincial Water Quality Objectives |
| RMOW | Region Municipality of Waterloo |
| SWM | stormwater management |
| SWMF | stormwater management facility |
| SOP | Standard Operating Procedure |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| USGS Standard | United States Geological Survey's Discharge Measurements at Gaging Stations |
| WSC | Water Survey of Canada |
| WSC Standard | Water Survey of Canada's Principles of Discharge Measurement |

# Revision History

| Latest Issue | Date | Description of Changes | Project Manager Approval | Manager Approval |
|---|---|---|---|---|
| Issue 01 | September 20, 2018 | Initial Release | | |
| | | | | |
| | | | | |
| | | | | |

# 1. Introduction

Since 2002, the City of Kitchener (City) has been committed to the improvement of stormwater management (SWM), infrastructure assessment and tracking water quality through the SWM Monitoring Program (Program). Over the years, the Program has refocused to address new goals and objectives, while maintaining long-term data sets. In order to respond to the growing complexity of the Program for future years, the City and its agents have developed the methodologies outlined within this guidance document to aid staff and Consultants and ensure consistency with water monitoring, field sampling and documentation, project reporting, data management and storage procedures.

This guidance document is a living document that is to be updated at the end of each annual monitoring period to reflect any changes in scope or to include new methodologies as new goals and objectives of the Program are introduced. This document is not a comprehensive health and safety resource. Due to the inherent risks of conducting fieldwork in and around water, it is the responsibility of the Consultant to provide a health and safety plan that covers all aspects of fieldwork and monitoring completed as part of the Program.

In addition to the annual Program, the City also monitors Fisheries and Oceans Canada (DFO) Habitat Banking sites at Filsinger Park and Henry Sturm and on Balzer and Idlewood Creeks. These DFO Habitat Banking monitoring sites follow site-specific Annex B reports, as per the City's Municipal Fisheries Habitat Bank agreements with DFO. For DFO Habitat Bank monitoring, it is the responsibility of the Consultant to review the applicable methodology as described in the site-specific Annex B report. For consistency, the results of the DFO Habitat Banking sites will be detailed in separate site-specific reports and a summary of results and conclusions will be incorporated into the annual SWM monitoring report.

# 2. Background

The City implemented the Program in 2002 to establish baseline data, which would allow for water quality characterization of the City's watercourses, as well as assist in the identification of SWM issues that may occur, such as erosion, sedimentation, SWM facility failures, etc. The Program currently includes the collection of comparable data from a set of core stations through grab sampling and/or automatic sampling for chemical analysis, benthic and fish sampling, continuous depth and temperature monitoring, and discrete flow monitoring.

The Program has been part of a continuous improvement process, governed by a Steering Committee comprised of the selected Consultant, City staff, Grand River Conservation Authority (GRCA) staff and Region of Waterloo staff, to ensure that the best management practices for monitoring are utilized.

Completed in 2016, the Integrated Stormwater Management Master Plan (ISWM-MP) provided recommendations for the Program to ensure that the objectives of the ISWM-MP are accomplished over time. The following paragraphs from the ISWM-MP Report are available on the City's webpage: https://www.kitchener.ca/en/resourcesGeneral/Documents/DSD_ENG_StormwaterMasterPlan_Implementation-Plan.pdf

*Over the near future, the proposed stormwater management monitoring program has two (2) distinct phases. Monitoring has been phased to permit City staff to build capacity with the municipality, vet the proposed monitoring program with partner agencies (specifically the GRCA and RMOW) and permit the alignment of future budgets with the revised program needs. The two (2) distinct phases include:*

*Phase 1 - Continuation of a refined SWM Audit monitoring (2017-2018) – to establish baseline monitoring results (existing conditions) for previously established historical monitoring locations throughout the City using the City's existing three (3) autosamplers. Monitoring efforts are focused on previously identified core stations with the addition of Priority 1 and Priority 4 subwatersheds.*

*Phase 2 - Updated Water Quality and Flow Monitoring (2019 - ongoing) – refined monitoring locations and protocols to align with the implementation approach of prioritizing works based on the watersheds in the most need and where there are opportunities to improve conditions but also recognizes the need to protect existing watershed health. Phase 2 monitoring also focuses on the collection of data within subwatersheds that were determined to have insufficient data during the subwatershed prioritization analysis and established long-term monitoring sites for the collection of water quality data within Priority 1 subwatersheds.*

Currently, the City is in Phase 2 of implementing the transition noted above. During Phase 1 of the transition, the following data gaps were identified:

- Winter data – due to the schedule of the Program, sample collection does not occur during the winter months therefore year-long trends for certain parameters of concern, such as chloride, are incomplete.
- Flow data prior to installation of autosampler at EMC locations – flow data is essential to programing the autosamplers. Therefore, it is recommended that autosampler locations be identified two (2) years prior to installation. This allows for flow monitoring to be conducted and rating curves to be developed one (1) year in advance of installation. A minimum of five (5) discrete flow measurements be collected and a staff gauge installed at each location 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.
- Standardized water quality and biological sampling protocols – in previous years the sampling methodology was at the discretion of the Consultant. With different Consultants conducting the Program, it is recommended that a standardized methodology be developed to ensure consistency throughout the Program.

# 3. Program Overview

In general, the Program will be executed in a similar manner as to previous years and follow the same schedule. The Program milestones are summarized in Table 3.1 below.

Table 3.1 Monitoring Program Milestones

| Milestones | Action Item |
|---|---|
| February of Monitoring Year | Kick-off meeting |
| Early March of Monitoring Year | Obtain City equipment and preform inspection of equipment. Purchase of additional equipment if necessary. |

Table 3.1 Monitoring Program Milestones

| Milestones | Action Item |
|---|---|
| End of March of Monitoring Year | Installation of Equipment & Start of Monitoring Season |
| As Required | Interim Reporting |
| November of Monitoring Year | Completion of Monitoring Season |
| December of Monitoring Year | Submit Draft Monitoring Reports (City-Wide and DFO) |
|  | Presentation to Steering Committee |
| January of Year Following Monitoring | Submit Final City-Wide Monitoring Report |
|  | Report and Presentation to Environmental Committee |
|  | Submit Final Department of Fisheries Habitat Banking Reports |

## 3.1 Monitoring Site Selection

Prior to conducting monitoring, the first consideration should be the selection of monitoring locations. As part of the Program, surface water monitoring sites have been established throughout the City of Kitchener (see Table 3.2 below). These locations include core sites (Priority 1 and 4 subwatersheds and select Priority 2), non-core sites (Priority 2 and 3 subwatersheds), and locations included as part of the City's Municipal Fisheries Habitat Bank agreement with DFO sites.

Prior to the start of field activities each year, monitoring sites (i.e., specific creeks and watersheds) are established in consultation with the City. Justification of each site location should also be documented. The Consultant is responsible for establishing the exact sampling location at the selected monitoring sites and providing GPS coordinates (NAD83 Zone 17) in the annual report.

Table 3.2 Established Monitoring Locations

| Location Name | Location ID | Description | Subwatershed Priority |
|---|---|---|---|
| Henry Sturm 1 | HS1 | Core | Priority 2 |
| Kolb Creek 1 | KD1 | Core | Priority 2 |
| Montgomery 1 | MG1 | Core | Priority 1 |
| North Strasburg 2 | SB2 | Core | Priority 2 |
| Lower Schneider 1 | SC1 | Core | Priority 2 |
| Sandrock 2 | SR2 | Core | Priority 1 |
| Shoemaker 1 | SM1 | Core | Priority 1 |
| Upper Schneider | SC-9 | Core | Priority 1 |
| Voisin Creek | VS-1 | Core | Priority 1 |
| Middle Strasburg | SB7 | Core | Priority 4 |
| Strasburg | SB1 | Core | Priority 4 |
| Blair Creek | BBB-F6 | Core | Priority 4 |
| Idlewood 1 | IW1 | Non-Core | Priority 2 |
| Idlewood Downstream (Reach 1b) | IW2 | DFO | Priority 2 |
| Idlewood Upstream (Reach 5b) | IW3 | DFO | Priority 2 |
| Henry Sturm 4 | HS4 | Non-Core, DFO | Priority 2 |

Table 3.2 Established Monitoring Locations

| Location Name | Location ID | Description | Subwatershed Priority |
|---|---|---|---|
| Balzer Creek | BZ1 | Non-Core | Priority 2 |
| Balzer Creek Upstream | BZ2 | DFO | Priority 2 |
| Balzer Creek Downstream | BZ3 | DFO | Priority 2 |
| Laurel Creek | LC-1 | Non-Core | Priority 2 |
| Borden Creek | BD-1 | Non-Core | Priority 2 |
| Unnamed Catchment 1 | - | Non-Core | Priority 2 |
| Middle Schneider | MS-1 | Non-Core | Priority 2 |
| Detweiler Creek | DW-1(b) | Non-Core | Priority 2 |
| Westmount Creek | WD1 | Non-Core | Priority 2 |
| East Side Creek | ES-1 | Non-Core | Priority 2 |
| North Strasburg 13a | SB13a | Non-Core | Priority 2 |
| School Creek | SCH-1 | Non-Core | Priority 3 |
| Melitzer Creek | MZ-1 | Non-Core | Priority 3 |
| Doon South | DS-1 | Non-Core | Priority 3 |
| Unnamed Catchment 3 | - | Non-Core | Priority 3 |
| Cedar Creek | CC-1 | Non-Core | N/A |
| Alder Creek | AC-1 | Non-Core | Priority 2 |
| Unnamed Catchment 2 | - | Non-Core | N/A |
| Unnamed Catchment 4 | - | Non-Core | N/A |

# 4. Field Monitoring

## 4.1 Surface Water Quality Grab Sampling

Surface water sampling is performed to obtain samples of surface water bodies that are representative of existing surface water conditions.

Surface water samples collected must be free of particulate matter with no suspended sediments, therefore it is crucial to limit re-suspension of sediments to the extent practical. Surface water samples should be collected commencing at the furthest downstream location and working upstream to avoid sediment interference at upstream locations. Samples are generally collected in areas of surface water bodies that are representative of the surface water body conditions. Representative surface water samples should be collected in a section of the watercourse that has a uniform cross-section and flow rate. Mixing is influenced by turbulence and water velocity, therefore the selection of a surface water sampling location immediately downstream of a riffle area (i.e., fast flow zone) will ensure good vertical mixing.

When collecting surface water samples, direct dipping of the sample container into the stream or water is acceptable unless the sample container contains preservatives. If preserved, a pre-cleaned unpreserved sample container should be used to collect the surface water sample. The surface water sample is then decanted to the appropriate preserved sample container. When collecting surface water samples, submerse the inverted bottle to the desired sample depth and tilt the opening of the sample container upstream to fill. During surface water sample collection, wading or movement may cause sediment deposits to be re-suspended and can result in biased samples. Wading is acceptable if the stream has a noticeable current and the samples are collected directly in the sample container when faced upstream. Surface water samples should be collected about 6 inches (15 centimeter [cm]) below the surface, with the sample bottles being completely submerged. Taking the surface water sample at this depth eliminates the collection of floating debris in the sample container.

Surface water sample collection where the flow depth is less than 1 inch (< 2.5 cm) requires the use of special equipment to eliminate sediment disturbance. Surface water sampling may be conducted with a container then transferred to the appropriate sample container, or collection may be performed using a peristaltic pump. A small excavation in the stream bed to create a sump for sample collection can also be considered but should be prepared in advance to allow for any sediment to settle prior to conducting surface water sampling activities. Glass beakers or stainless steel cups may also be used to collect surface water samples if parameter interference does not occur. The beaker or cup must be rinsed at least three (3) times with the surface water sample prior to sample collection.

Field parameters should also be collected using a multi-parameter surface water quality meter when a discrete surface water sample is collected. At a minimum, field parameters to be collected should include: temperature, pH, conductivity, turbidity, and dissolved oxygen.

## 4.2 Groundwater Quality Grab Sampling

Groundwater sampling is conducted to obtain samples that are representative of existing groundwater conditions, or that retain the physical and chemical properties of groundwater in the hydrostratigraphic unit. Currently, there is no groundwater monitoring component of the Program. Upon future implementation of a groundwater monitoring aspect, variation may be made to these monitoring guidelines at the discretion of the City and the Consultant, on a case-by-case basis. If existing groundwater well logs are available, they should be reviewed prior to conducting monitoring and copies brought into the field during monitoring.

Prior to removing a well cap, breathing space above the well should be measured with a photoionization detector to establish a background level of undifferentiated organic vapor. Once the well cap is removed, another measurement should be conducted to determine if an air-purifying respirator is required.

To collect a representative sample, well purging must initially take place to eliminate any stagnant water. Before commencing well purging, a static water level measurement should be taken. This water level measurement is required to determine the typical well volume. Watertight caps may cause a vacuum affect in the well. Once the cap has been removed, it is recommended that the Consultant wait at minimum thirty (30) minutes for the pressure to stabilize. The device used to measure the water level can be chosen at the discretion of the Consultant. Typical devices include, but are not limited to, battery-operated water level indicators, battery-operated oil/water interface probes and electronic transducers.

According to the Association of Professional Geoscientists of Ontario, well stabilization is typically achieved by removing three (3) to five (5) times the calculated well volume. As an alternative, purging requirements can be met through the continuous monitoring of field measured parameters (i.e., pH, temperature, turbidity, dissolved oxygen, oxidation-reduction potential, and specific conductance) until stable conditions have been met. Any agitation of the water within the well will increase turbidity. Thus, purging should be complete, where possible, from the top of the water column. This will move water from the formation through the well screen and into the well casing. Field parameter measurements are to be recorded during purging activities at a maximum of 5-minute intervals, until readings indicate that stabilization has occurred. Prior to collecting a sample, the well should be allowed to recover after purging.

Upon completion of purging, groundwater samples can be collected. Where possible samples should be collected directly from the purging pump. If new sampling equipment is installed, the first few volumes should be discarded (due to disturbing the water column upon install). The interior bottle or cap must not be contaminated, and thus gloves should be worn, at best changing gloves for each sample. Groundwater samples are to be transferred directly into the sample container for laboratory submittal. On occasion, samples may need to be transferred from larger containers to smaller containers, when the sample requires field filtering prior to laboratory submittal. Choice of preferred purging and sampling equipment can be made at the discretion of the Consultant however when possible, low-flow purging and sampling are preferred, particularly when sampling volatile contaminants of concern (i.e., VOCs) or when high turbidity is observed in a well. Typical devices include, but are not limited to, peristaltic pumps, suction pumps, submersible pumps, airlift pumps, bladder pumps, inertial pumps, bailers, and passive diffusion bags.

## 4.3 Flow Proportionate Water Quality Sampling

### 4.3.1 Equipment

A comprehensive equipment list for a typical event mean concentration (EMC) sampling station in the City of Kitchener follows:

- ISCO 6712 portable sampler (refer to Installation and Operation Guide for details)
- Secure housing unit capable of storing the ISCO sampler. An ideal housing unit should be made of metal and have an enclosed lid to protect against weather and pests, prevent vandalism of the automated sampler, and allow access to the sampler for sample collection and maintenance tasks
- ISCO 750 Area Velocity (AV) Module
- 12 Volt Direct-Current, deep-cycle marine battery (typically Class-24) (two per sampler)
- Minimum 20 feet (ft) of 3/8th inch vinyl tubing and a 3/8th inch stainless steel tubing coupler
- Stainless steel strainer on the suction line to reduce debris uptake
- Replacement pumping tubes (replace every 1,000,000 pump counts, which is approximately 912 standard samples [standard sample is 200 ml at 5 ft suction head using a 10 ft vinyl suction line], typically one year for current monitoring program)
- Interrogator for communicating with the ISCO sampler
- 1000 milliliter (mL) polypropylene bottles for storage of samples (24 bottles per unit)
- Reinforced T-bar used for attaching the AV sensor and the strainer or sensor mounting plate for solid bottom installations
- Zip-ties for securing the sensors
- Staff gauge/meter stick to attach to the T-bar for easy-to-read water level reference

- Desiccant beads

### 4.3.2 Installation Considerations

The following should be considered during the pre-EMC phase (year prior or prior to establishment of an EMC location):

- Safety of technicians: is the location known for violence or mischief, is there regular flooding that could cause accessibility issues, is there good lighting when the technicians are performing tasks (time of day), etc.
- Stability of the sampler unit: ensure samplers and housing units are level and set away from potential hazards such as eroded or unstable soil, falling trees, unstable rocks, areas prone to flooding
- Accessibility of the unit: steep slopes, dense bushes, private property, significant hike etc.
- Security of housing unit: potential for vandalism, ability to secure the housing unit to a permanent or difficult-to-remove structure with a chain or enclosed bolts.
- Historical data: continuation of the historical data record for existing or past monitoring locations.

### 4.3.3 Installation Instructions

Once the sampler location is established, the housing unit can be installed securely. Prior to installing any sensors, it is recommended that a semi-permanent T-bar (or similar post) be installed within the stream to secure the sensors to. In a solid/concrete structure, a mounting plate should be used to secure the sensor and sample strainer.

When determining the T-bar location, it is important to consider the geomorphological structure of the stream, as well as where the watercourse meanders as the depth and velocity will vary throughout. An ideal location is away from banks where silt can accumulate and in an area where there is constant flow. The sensors require a minimum depth to reliably detect water level or velocity, so installing the sensors in an area with low flow will increase the risk of no water levels recorded during base flow conditions. Furthermore, ensure the T-bar is secure and will not be effected by oncoming flow by bracing the vertical T-bar with a second T-bar installed at an angle. A survey of the top of T-bar or to a fixed structure (i.e., culvert) will allow depth data to be converted to a surface water elevation.

Install a meter stick onto the T-bar or staff-gauge at a nearby location to act as a reference point to compare the depth value readout from the ISCO samplers to the actual stream depth. Estimate the minimum depth for the AV sensor based on previously developed hydrographs or known diurnal changes and patterns observed in the stream. The depth should be measured at the upstream end of the sensor with the AV sensor itself oriented to face upstream. The sample strainer should be oriented facing downstream to reduce the quantity of sediments collected by the sampler. Connect the AV sensor (recommended 30 ft line) to the ISCO sampler and adjust to site conditions. Store any excess AV cable within the housing unit to avoid damaged.

Attach the suction line to the pump tubing through the stainless steel coupler. Measure the distance of the tubing from the coupler attachment to where the strainer begins; record this distance as it will be needed when programing the ISCO sampler. Attach the strainer either at a height that will experience flow with higher discharge rates or keep the strainer submerged. Placing the strainer above the normal flow conditions reduces the chance of pumping a sample prematurely, or when not necessary. Once the AV sensor and the strainer have been installed, secure both cables together with zip-ties. To avoid vandalism, bury or install in conduit tubing.

Once the ISCO sampler is installed, it is ready to be programmed. It is important to note that once the sampling period is complete, ensure all tubing is above ground prior to ground-freezing conditions. If the tubing is to remain below ground, removal of the tubing and AV sensor will be problematic.

#### 4.3.4 Sample Pacing

The volume and frequency at which water samples are collected during a storm event is ideally determined based on historic hydrographs. These hydrographs act as a reference point to how the stream behaves under different storm events, and can be used to program the ISCO pacing. When historic hydrographs are not available, the initial pacing can be determined by evaluating historic precipitation and catchment area.

The pacing is the rate at which the sampler collects samples. Depending on the type of pacing selected (uniform time paced, event paced, non-uniform paced or flow paced which is to be used for the City sampling program) the rate is controlled by the sampler's internal clock or by intervals received from connected instruments and sensors. The sampler works by collecting sample aliquots at a frequency based on the programmed pacing parameters. The ISCO can be programmed to collect a known aliquot volume if the water depth exceeds the base flow set point. The sampler can also collect water samples based on a timed interval (i.e., every 20 minutes) during high flow conditions. When the ISCO sampler is collecting aliquots, a total sample volume of at least 2 liters (L) should be collected to represent the storm event but not more than 24 L.

The sample sizes collected by the ISCO sampler will vary per storm event. To meet the requirements of a 2 L sample and to remain under the 24 L limit, the operator must adjust the aliquot sizes to match the storm size and obtain the most accurate representation of the water quality during the event. For instance, if a large amount of precipitation was expected during a rain event in a short amount of time, the aliquot size would have to be larger than for a large rain event that is expected to continue for an extended period of time (i.e., multi-day event). The ISCO's pacing can be adjusted to smaller aliquots to better represent the amount of water passing through the stream and not run out of the maximum sample collection space (24 L). Similarly, the pacing may need to be adjusted for monitoring sites with a "peaky" stream response to rain events. At these sites during peak flow, an aliquot could be triggered at a rate too rapid for the ISCO unit to keep pace, where completion of the first collection cycle is not completed before another collection/rinse cycle is triggered. This will trigger a sampler error and although sampling will continue, it would be less representative of the event mean concentration due to missed aliquot cycles during the peak.

Adjusting the aliquot size and pacing for expected storm events will lead to a more successful representation of water quality in the stream. Furthermore, as the base flow changes seasonally, water level will also vary. Base flow conditions during spring (March to April) are higher than the base flow conditions expected during the summer (July to August). The operator must alter the sampler's trigger depth to accommodate these changing conditions.

For example, if the pacing is set to start collecting samples when the watercourse reaches a depth of 400 millimeters (mm) during the spring, it is less likely that rain events during the summer (when water levels are lower) will reach the same water level within the same response period. Ideally, samples should be triggered when water levels exceed the base flow.

Paying attention to the weather in advance and comparing the amount of expected rain to previous years, as well as the current level-hydrograph, can inform the user in programming the sampler's pacing. Through developing an understanding of the hydrology of the stream, relating the amount of precipitation and historic discharge rates, the user is able to adjust the pacing and aliquot parameters accordingly and improve sampling successes.

### 4.3.5 Rating Curve Development

Natural, irregular waterways do not always accommodate the use of automatic velocity-area measurements, as the location of the average velocity within the watercourse may be unknown or may not be at a location where a sensor can be installed. Also, it is unlikely that the cross-sectional area of an irregular watercourse is represented in the programmable options of an automatic velocity-area sensor. However, this type of equipment would work well in typical storm sewers.

Engineered flow structures, such as weirs, are located throughout the City but are not always available near the desired monitoring location.

For natural waterways, it is more typical to rely on a stage (water depth) to discharge relationship. Stage-discharge relationships are also commonly referred to as rating curves and allow for the interpretation of a flow from a more readily recordable water depth. Rating curves programmed into the ISCO loggers generally require 10 or more points in a rating table to allow interpolation between different flow conditions accurately. The stage-discharge relationship may be calculated using theoretical equations and/or field measurements such as the timed volume method or the velocity area method. The rating curve should be validated on a regular basis based on measured field data (e.g., seasonally), and adjusted accordingly if channel conditions change over time.

It is recognized that an engineered control structure has several advantages over the use of a stream cross-section since a natural section's rating curve may "shift" due to channel scour, bank slumping, or backwater impacts from the buildup of ice, vegetation, sediment, debris, or downstream ponding – all of which may vary seasonally. The main advantage of an engineered control section is accuracy and reliability of the monitoring data.

## 4.4 Stream Flow Monitoring

In the context of flow monitoring, flow systems are typically differentiated into two categories: open systems and closed systems. Closed systems are characterized by closed conduits which are flowing completely filled and pressurized (e.g., potable water lines and industrial process lines). Although measurement of flow through a closed system shares some of the fundamentals with open system flow measurement, the methods and equipment are significantly different (i.e., flow in closed systems is typically measured by a device inserted into the conduit such as flow nozzles, venturi meters, orifice meters, and pitot tube flow meters).

Open flow may be defined as flow in which the water flows with a free surface. Examples are rivers, ditches, streams, creeks, etc. Some closed channels, such as sewers and culverts when flowing partially full and not under pressure, may be classified as an open flow system. The City SWM monitoring program is for open flow systems. To implement the flow monitoring portion of the SWM program, the following criteria should be planned and developed:

- Monitoring location(s)
- Events: discrete event or continuous monitoring, dry-weather base flow or wet-weather storm flow events

- Method: wading-rod velocity-area method, hydraulic structure method etc., automated versus manual
- Equipment: suitable for specified methods, accuracy for water depth.

The accuracy of flow measurements are very sensitive to the care and judgment exercised when completing the measurements. It is important for the practitioner to understand the program needs and select the measurement technique and equipment that best suits the accuracy required for the studies undertaken. It should be noted that efficiency and repeatability of the field data collection must also be considered when determining the desired level of accuracy of the results.

Regardless of the flow measurement method selected, it is important for the practitioner to understand the limitations of the measurement technique and equipment, and the range of accuracy possible. For example, instantaneous remotely collected flow measurements utilizing a velocity probe and area measurements at best can provide results with an accuracy of ±10 percent, whereas the installation of a temporary weir or flume (i.e., primary measuring device) will greatly improve the accuracy of results (i.e., ±2 percent).

Guidelines and standards are available to assist in determining the most appropriate flow measurement method for the desired accuracy, efficiency, and repeatability. The Water Survey of Canada's (WSC) Principles of Discharge Measurement (WSC Standard), the United States Geological Survey's (USGS) Discharge Measurements at Gaging Stations (USGS Standard), and the Ontario Stream Assessment Protocol (OSAP) provide general guidelines on measurement techniques.

The practitioner must also know the channel size and understand its hydrology to select an appropriate measuring range, method (e.g., timed volume for small flows, hydraulic structure for medium flows, or velocity-area for a large stream or river), equipment type (flume versus weir, V-Notch weir versus broad crested weir), sizing (e.g., weir opening size), and to predict instream impacts.

### 4.4.1 Monitoring Locations

Surface water monitoring sites have been established across the City of Kitchener throughout the SWM monitoring program. The selected monitoring locations are established prior to any field activities in consultation with the City. However, the Consultant is held responsible for establishing the flow monitoring cross-sections at the selected locations.

The following should be considered prior to conducting stream flow monitoring:

1. Develop an understanding of the land use (snow storage and disposal sites, industrial areas, construction zones, etc.) upstream of the monitoring location(s).
2. Inquire about field conditions (e.g., average depth of water, velocity of water, possible sampling points, etc.) at the monitoring location.
3. Obtain appropriate mapping and understand flow regime of the monitoring location.
4. Check recent precipitation events, snow melts, or reservoir discharges that may have an impact on the flow at the monitoring location.
5. The measuring location should have a smooth bottom and a fairly uniform depth.

6. The velocity should be well distributed across the stream and the flow perpendicular to the section. Avoid areas of turbulence (e.g., bends, obstructions in stream or culvert, invert drop sections).
7. Use existing hydraulic structures (culverts, dam weirs) when possible.
8. Select areas to verify upstream results (i.e., redundancy).
9. In wetlands and broad streams it may be difficult to find a cross-section with a clear, measurable cross-sectional area or which has a flow velocity that is higher than meter sensitivity. In heavily vegetated areas and riprap, it may even be difficult to find water.
10. Be aware of the location of point source inflows.
11. Account for vandalism and theft potential of unattended equipment and cross-section and/or survey point markers.
12. Be aware of power and/or phone lines in the vicinity.
13. The humidity of the monitoring location (e.g., steam in a culvert or sewer) can affect the probe desiccant life.
14. Dry-weather and wet-weather access: Can vehicles get close to the location? Locations accessible in the winter and spring may become too overgrown in summer to access. The station must be accessible for data downloading even when wet or inundated.
15. Ensure safe conditions (e.g., fast deep water, steep channel banks, deep sediment, etc.).

Demarcate monitoring locations in the field with T-bars or survey stakes so they can be surveyed. Demarcate cross-sections utilized for discrete monitoring events (by the velocity-area method) with a T-bar or stake on each bank to ensure that the cross-section is measured at the same location with the same station coordinates each time, to allow development of a rating curve and to assess if the cross-section has vertically or horizontally shifted. Stakes should be installed on the channel banks at a sufficient distance from the active channel so there is less likelihood of them being washed away during high flow events. A location (e.g., tree branch, fence line, hydro pole, etc.) on the bank should be clearly marked with flagging tape (or some sort of marker) so that in the event that the stakes installed on each bank are missing, a new cross-section can be set-up in the same general area.

### 4.4.2 Events

Prior to selecting the monitoring method and equipment, the type of event to be measured should first be defined. Surface water flow measurements will be required for dry-weather (base flow) events (e.g., to characterize groundwater discharges or for aquatic habitat impact analysis/assimilative capacity studies) and wet-weather (storm flow and spring thaw) events (e.g., for flood line mapping studies or SWM design). The required frequency (once, daily, weekly, monthly, seasonally/quarterly, yearly, etc.) of monitoring will be defined in consultation with City.

Discrete instantaneous monitoring events are typically measured using manual (e.g., velocity-area) methods. Continuous monitoring is typically measured using a permanent water level pressure transducer and converted to a flow using a rating curve, as described in Section 2.2.5 and below.

### 4.4.3 Methods

The following section outlines the most common methods to determine the rate of flow in open channels. Although there are many methods used to determine the rate of flow, the City prefers the velocity-area method or the use of hydraulic structures, as these methods are the most accurate for the locations in the SWM monitoring program.

#### 1. *Timed Volume*

In this method, the entire contents of the flow stream (usually perched culvert discharge) are collected in a container for a fixed length of time. The weight or volume of the water is then determined and the mean flow rate calculated. The flow rate over the period of the collection must be relatively uniform for this method to be appropriate. A field application of this technique is the "bucket and stopwatch" method. This method is limited to low flow rates and is not suited for continuous measurement. However, this method is well suited to calibration applications or developing a stage/flow curve for a hydraulic structure. The mean flow rate should be based on the average of the mean flow rate calculated from at least three (3) timed volume measurements that are collected one after the other (to identify potential errors in any of the measurements and to have greater confidence in the data collected). Significant figures used in the average should reflect the confidence in the time measurements.

#### 2. *Dilution*

Flow is calculated in this method by measuring the amount of dilution of an added tracer. Historically, brine tracers have been used. Recently, radioactive and fluorescent dye tracers are more common. The dilution technique produces no pressure loss, requires no drop in hydraulic grade line, creates no obstruction to the flow, does not require flow through a hydraulic structure with a known stage/ discharge relationship, and provides an estimate of flow rate directly by simple formulas. Vertical and lateral mixing at the measurement site is essential. The main disadvantages of dilution techniques are the need to introduce a foreign chemical into the water and that the time, labor, amount of training, site access, type/amount of equipment, and overall cost limit the usefulness of this method. It is generally not suited to continuous, automated monitoring, and better suited where other methods that may be hazardous to the field technician or equipment (i.e. high velocity, hazardous atmosphere in confined space entry etc.).

#### 3. *Velocity-Area*

Flow rate is calculated by determining the flow velocity through a cross section and then multiplying the measured velocity by the flow area. This method is suitable for manual, discrete monitoring events by using a portable velocity meter and a surveyed cross section.

A complication in this simple procedure is that the velocity profile of a section varies throughout its depth and width and, therefore, numerous measurements must be taken. Some velocity meters (e.g., Doppler technology) will take hundreds of readings throughout the cross section and average them. Other technologies will provide the velocity only in the immediate vicinity of the probe. For these technologies, numerous readings must be taken. An ideal cross-section consists of a uniform bottom free from obstructions (large rocks, fallen logs, vegetation, undercut banks) at the section as well as immediately upstream and downstream of the section; no bends immediately upstream or downstream; a fairly uniform depth; and a uniform velocity distribution perpendicular to the cross section should be selected. Exceptions must be made at each section for site access, geomorphology, etc.

Each specific measurement component for the discharge calculation has associated sources of uncertainty contributing to the overall discharge uncertainty. The primary sources of uncertainty associated with the velocity-area method are derived from the velocity measurement and water depth measurements. There is also some uncertainty associated with the equipment used to collect the velocity measurements; this value is normally specified by the manufacturer and assumes that the equipment is calibrated, functioning properly, and is being used within its limitations. Another consideration, since all measurements for the flow calculation are not taken simultaneously, is the amount of discharge and profile of a cross-section can change during measurements (i.e. a blockage is cleared upstream of the section, or the streambed scouring from natural causes or by the technician conducting the measurements, precipitation), which will affect the overall uncertainty of the discharge. For all depth measurements, it is important that the practitioner be aware of the channel bottom (i.e., ensure the meter stick does not sink into soft substrate or have all depth measurements collected from atop boulders scattered across the cross-section, as well as to be cautious of water rise on the meter stick in channels with higher velocities.

For shallow or narrow cross-sections, the (vertical) average velocity should be measured approximately every horizontal 0.10 meters (m), which is the minimum spacing between verticals based on WSC Standard. For wider sections a maximum panel width of 1.0 m can be used. The individual velocity at horizontal and vertical increments may be measured and flow calculated for each grid point or panel, which is then summed for the section. The selection of an appropriate grid is governed by the stream width and depth. The WSC Standard and USGS Standard both recommend a duration of least 40 seconds for a velocity measurement to be collected. Spacing should be adjusted, or additional panels added to target no more than 10% flow in anyone panel in the resultant calculation.

The following are some of the more common methods of selecting a grid and measuring velocity for the velocity-area method:

- Two-point method
- Six-tenths depth method
- Vertical velocity curve method
- Integration method
- Surface method

The two-point method consists of measuring the velocity at 0.2 and then at 0.8 of the depth from the water surface and using the average of the two measurements to represent the flow velocity of the vertical where measurements were collected. The accuracy obtainable with this method is reasonably high and its use is recommended. This method should be employed when the water depth is more than 0.75 m.

The six-tenths depth method consists of measuring the velocity at 0.6 of the depth from the water surface (0.4 of the depth from the bed). This method can be employed for depths up to 0.75 m.

The vertical, and integration methods are specialized data collection methods and will not typically be used for the City methods. The best example of flow monitoring equipment using these methods are acoustic-Doppler current profilers (ADCPs), which are capable of combining both methods in a single instrument. However, equipment costs, field time constraints, and depth of flow makes them unsuitable for most current City measurements. The use of ADCPs would be ideal in unwaddable river applications (i.e. the Grand River).

The surface method should not be used due to low accuracy; however, it can be used as a basic check for other methods (i.e., identifying safe wadding velocities).

A comparison of the Kitchener SOP preferred method to the USGS and WSC Standards is provided below for each of the measurement procedures described.

Table 4.1 Single Discharge Measurement Standards Summary

| Measurement Standards | Kitchener SOP | USGS Standard | WSC Standard |
|---|---|---|---|
| Discharge Equation Used | Mid-Section | Mid-Section | Mid-Section |
| Minimum Panel Number | Not Specified | 25 | 20 |
| Minimum Panel Width | 0.10 m | Not Specified | 0.10 m |
| Maximum Percentage of Flow per Panel | 10% | 10% (goal is 5%) | 10% |
| Spacing of Panels | More in main flow | More in main flow | Not Specified |
| Precision for Depth Measurements | 0.005 m | 0.003 m | 0.02 m |
| Minimum Depth for Velocity Measurement | Determined by instrument used | 0.09 m | Not Specified |
| Depth for 0.6D Velocity Measurement | <0.75 m | <0.45 cm (<1.5 ft) | <0.75 m |
| Depth for 0.2D/0.8D Velocity Measurement | >0.75 m | >0.45 cm (<1.5 ft) | >0.75 m |
| Precision for Velocity Measurements | Not Specified | Not Specified | 0.001m/s |
| Minimum Time for Velocity Measurement | 40 seconds | 40 seconds | 40 seconds |
| Uncertainty Calculation | None | USGS | Not Specified |

Once all of the field measurements have been collected, the discharge through the channel can be calculated. It is important that the field data is processed correctly (i.e., data entered into spreadsheets correctly and proper calculations are performed) to ensure that the results are representative of the channels monitored.

### *4. Hydraulic Structure*

This is the most widely used method of continuous open channel flow measurement for creeks and sewers. In this method, the depth of water is measured upstream of a hydraulic structure (primary measuring device). The hydraulic structure is typically a weir. Flumes and orifices may be appropriate for some applications. The hydraulic drop across culverts and bridges may also be used, but are generally not as accurate as a weir, flume, or orifice. The stage (i.e., depth of water) is converted to a flow by a known relationship between the stage upstream of the structure and the flow through the structure. The stage may be measured by an automated measuring device (secondary measuring device) typically attached to a datalogger or by visual inspection of a staff gage. Care must be taken to ensure that the stage-discharge relationship does not become altered over time due to debris (e.g., leaves, ice), maintenance (damaged weir) or backwater impacts (e.g., beaver dams, vegetation, sediments). The need for calibration and cost of secondary measuring devices should also be considered. If a structure is available, this method should be selected for continuous flow measurements.

### *5. Slope-Hydraulic Radius*

In this method, flow may be calculated using Manning's equation (or an equivalent) if the depth of water is measured over a length of uniform channel section, and the channel/sewer slope and cross-sectional area corresponding to the measured depth are known. The Manning equation also requires a roughness factor dependent on the character of the channel. This method is not as accurate as the hydraulic structures method, but may be suited to sewer flow in some cases, or may be used to predict a rating table where pre-EMC flow measurements have not be collected, or to assist in identifying peak flow conditions beyond the wadable water depth. Its advantage is that only depth is required to be measured and it does not require the installation of a hydraulic structure. In natural channels, the inaccuracies may be introduced over time due to channel erosion, sedimentation, vegetation, ice, etc. In general, this method is suitable for data-gap filling, but not for long-term use.

## 4.5 Field Notes

Field notes regarding equipment installation conditions and location must be recorded for each site visit. Photographs should also be taken for documentation purposes. Documentation regarding weather conditions (i.e., dry-weather, wet-weather, snowmelt vs. rainfall, etc.) is very important to interpreting the measurement data. For monitoring stations using the hydraulic structure method for flow monitoring, flow measurements at different water levels (wet-weather and dry-weather) must be taken to calibrate the rating curve. Observations should include:

- Date and time that monitoring and observations were performed
- Equipment that was used
- Degree of meandering of stream, if any
- Presence of fish and/or wildlife
- Presence of debris at the cross-section or upstream/downstream of the cross-section (e.g. beaver dam, garbage, etc.)
- Water and air temperature
- Floodplain or bank soil saturation
- Physical description of flow: flowing clear or turbid, turbulent, slow, etc.
- Measurement from a known benchmark location to the water surface
- Description of stream banks: steep or sloping
- Amount of vegetation in the stream channel and on the banks
- Condition of the floodplain: developed, agricultural, or type of vegetation
- Signs of erosion, such as cut banks
- Stream bank and stream bed material: silt, clay, sand, gravel, etc.
- Signs of overbank flow: flattened vegetation, high water marks, etc.
- Visual flow observation: are measured flows realistic? Does the water surface appear the same as previous visits? Etc.

## 4.6 List of City-Owned Equipment

A summary of the list of equipment currently owned by the City is presented in Table 4.2. At the end of each monitoring year, this table should be updated by the Consultant.

Table 4.2 List of City-Owned Equipment

| Equipment | Manufacturer | Year of Purchase | # of Units |
|---|---|---|---|
| ISCO 6712 Automated Samplers | Teledyne | 2013<br>2014 | 3 |
| Sigma 750 Low-Profile Area-Velocity Flow Modules | Teledyne | 2013<br>2014 | 3 |
| Metal Enclosure for ISCO Automated Samplers | Forest Technology Systems (FTS) | 2013<br>2014<br>2018 | 4 |
| Solinst 3001 Levelogger Edge (M5) | Solinst | 2018 | 6 |

## 4.7 Biological Monitoring

Biological monitoring is required to evaluate the benthic invertebrate and fish communities across multiple SWM monitoring sites. All biological monitoring sites will be required to follow OSAP Section 1: Modules 1 and 2 (Defining Site Boundaries and Key Identifiers; Screening Level Site Documentation). Upstream and downstream site boundaries need to be documented at each site to ensure repeatability for future monitoring.

### 4.7.1 Benthic Invertebrate Sampling

The current benthic invertebrate sampling method agreed upon by the City for the SWM monitoring program is the Kick and Sweep Method; however, the Surber Method is another benthic invertebrate sampling option that is used in the DFO Habitat Bank monitoring. The Kick and Sweep Method is qualitative while the Surber Method is quantitative. It is the responsibility of the Consultant to verify with the City at the start of each annual monitoring program that the Kick and Sweep Method is still preferred or if a specific portion of the Program requires the Surber Method. For DFO Habitat Bank monitoring, it is the responsibility of the Consultant to review the applicable methodology as described in the site-specific Annex B reports.

**1. *Kick and Sweep Method***

The Transect Travelling Kick and Sweep methodology must follow the OSAP and the OBBN protocol (Stanfield, 2017; Jones et al, 2007). Cross-stream transects should be continuously disturbed by vigorous kicking for three (3) minutes while sweeping a 500 micron D net downstream. This process should be repeated for each of the three (3) replicate stations; replicate stations include collection over a riffle, pool, riffle sequence within the identified sampling reach.

All samples must be field processed to remove excess sediment and organic material using a 500 micron sieve. Any woody debris and larger detritus collected must be scrubbed and/or picked over to ensure retention of all organisms. Supplemental field parameters should be recorded including dominant substrate class, organic matter-aerial coverage, riparian vegetation community, aquatic macrophytes and algae. Discrete surface water quality field measurements are recommended for pH, dissolved oxygen, turbidity, conductivity, and temperature.

Benthic macroinvertebrate samples should then be transferred into 1 L plastic sample containers, labelled, and field preserved in a >70 percent isopropanol solution.

**2. Surber Method**

The Surber method must be sampled quantitatively using a 500 micron Surber sampler following the OBBN protocol (Jones et al, 2007). At each sampling location, the Surber sampler must be placed at a representative location (to reduce habitat variability) and the substrate within the area (0.093 $m^2$) of the Surber sampler must be continuously disturbed for three (3) minutes.

All samples must be field processed to remove excess sediment and organic material using a 500 micron sieve. Any woody debris and larger detritus collected must be scrubbed and/or picked over to ensure retention of all organisms. Supplemental field parameters should be recorded including dominant substrate class, organic matter-aerial coverage, riparian vegetation community, aquatic macrophytes and algae. Discrete surface water quality field measurements are recommended for pH, dissolved oxygen, turbidity, conductivity, and temperature.

Benthic macroinvertebrate samples should then be transferred into 1 L plastic sample containers, labelled, and field preserved in a >70 percent isopropanol solution.

### 4.7.2 Fish Community Surveys

The intent of the fish community surveys is 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 single pass backpack electrofishing survey should be utilized and conducted as per OSAP Section 3: Module 1. For DFO Habitat Bank monitoring, it is the responsibility of the Consultant to review the applicable methodology as described in the site-specific Annex B reports.

A Licence to Collect Fish for Scientific Purposes must be obtained from the Ministry of Natural Resources and Forestry (MNRF) prior to study commencement of any fish community surveys. Each survey site should be delineated using OSAP procedures, Section 1, Module 1. The survey reach should be a minimum of 40 m in length and must begin and end at a cross-over point. A wood stake is to be installed and flagged at the upstream and downstream site limits. Site location should be thoroughly documented to ensure these boundaries can be found in future years, ensuring repeatability. For reference, within stable low gradient streams the spacing of cross-overs will be approximately 7 to 10 times the bankfull stream width and are typically associated with a riffle (Stanfield, 2017). The survey reach should include a minimum of three (3) riffles and two (2) pools, enabling local variances and different habitat types.

The total number of fish, species, total lengths in millimeters and approximate weights in grams (g) need to be recorded for each the maximum and minimum fish of each species captured during the survey. Photographs of each species should be taken for future reference. In addition, discrete water quality field parameters are recommended for pH, dissolved oxygen, turbidity, conductivity, and temperature.

## 4.8 Summer Terrestrial Vegetation Assessment

Terrestrial vegetation surveys are not currently conducted as part of the annual SWM monitoring program. These surveys have been completed in the past as part of the of the DFO Habitat Bank monitoring, where terrestrial vegetation surveys are completed annually to provide an assessment of riparian vegetation both before and after restoration activities along the reaches. For consistency, methods used in establishing the monitoring are continued with and can be divided into projects started before 2017 and projects started after 2017. The following methods are established for the different sites; however, it is the responsibility of the Consultant to review the applicable methodology as described in the site-specific Annex B reports.

### 4.8.1 Projects Started Before 2017 - Henry Sturm

A qualitative assessment of vegetation cover and survivorship of shrubs and herbaceous species is completed annually in the growing season. Dominant cover types and non-native species establishment is also documented. Planted trees are compared to as-built construction drawings to assess survivorship and presence of natural recruitment.

### 4.8.2 Projects Started In or After 2017 - Balzer and Idlewood

Typically, both a qualitative and quantitative assessment are completed at these sites during the growing season following standard methodologies laid out in each site-specific Annex B report. Streambank vegetation is visually assessed to determine percentage of healthy riparian vegetation, excluding point bars which are naturally low in plant cover. Floodplain vegetation is assessed using established quadrats to count the number of woody stems both planted and naturally recruited. These quadrats represent no less than 2% of the restored area. As previously mentioned, it is the responsibility of the Consultant to review the applicable methodology as described in the site-specific Annex B report.

## 4.9 LID Monitoring

As part of the Program, the monitoring of specific LID initiative projects may be included as part of the annual Program. In previous years, the City has implemented LID measures such as permeable surfaces, bio-retention planters, and exfiltration pipes. If an additional LID measure is implemented, this guidance document should be revised to include monitoring and performance analysis of the LID measure.

### 4.9.1 Permeable Surfaces

The purpose of permeable surface monitoring is to evaluate the response to various storm events, and analyze how performance varies over time (seasonally and annually). This monitoring consists of infiltration testing of the surface and continuous subsurface water level monitoring using monitoring wells.

The infiltration test should be conducted in accordance to ASTM C1781/C1781M-13-Standard Test Method for Surface Infiltration Rate of Permeable Unity Pavement Systems. A minimum of five (5) infiltration tests should be conducted to develop the mean and median infiltration rates. Having a median and average rate allows for comparison of current infiltration capacity to previous years.

Continuous water level monitoring is to be conducted in a monitoring well. A pressure transducer and barologger must be provided by the Consultant and installed inside of the monitoring well. The barologger can be clipped to the top of the well cap, and the pressure transducer should be suspended to an elevation just above the bottom of the well above any sediment accumulation. Intervals should be set to five (5) minutes to capture the quick response of the system. As the infiltration capacity degrades over time, the rate may be reduced.

Continuous water level monitoring allows for comparison of the surface elevation to the groundwater level, and to the precipitation events that resulted in this water level. This relationship determines whether the permeable surface can successfully contain all of the rainfall.

### 4.9.2 Bio-Retention Planters

To ensure continuous optimal operation of bio-retention planters, annual and seasonal maintenance practices should be performed for the planters to thrive from both a stormwater control and plant irrigation perspective. Annually, the following are recommended to be conducted:

- Vegetation replaced, as needed.
- Fertilization of vegetation, as needed.
- Topsoil replacement, as needed.

Once in the spring and once in the fall (at a minimum) inlet grates need to be cleared of debris and leaves. Prior to snowfall, the inlet gates must be placed to ensure salt intense snow is diverted from the planters. After snowmelt, these gates must be removed to use the bio-retention planters.

Currently, monitoring of bio-retention planters is not part of the Program. Upon future addition to the Program, the following is recommended for monitoring. Ultimately, the selected monitoring technique will be made at the discretion of the Consultant.

Continuous water level monitoring should be conducted inside of monitoring wells in each of the bio-retention planters. A pressure transducer and barologger must be provided by the Consultant and installed inside the existing monitoring well. The barologger can be clipped to the top of the well cap, and the pressure transducer should be suspended to an elevation just above the bottom of the bio-retention planter. Intervals should be set to five (5) minutes to capture the quick response of the system.

Continuous water level data can be used to evaluate the planter performance through comparison with precipitation events. The planters were designed to fill up during rainfall events, and slowly drain during the following 24-hours. Response of the bio-retention planters to a variety of rainfall events can be compared year over year, to determine whether planter performance is depleting over time.

Soil quality monitoring can be conducted in the bio-retention planters. The purpose of soil quality monitoring would be to determine whether high chloride meltwater is altering the soil composition and could consequently damage vegetation. Based on a 2017 study, the electrical conductivity in existing planters has increased substantially from 2010, and may be damaging herbaceous and juvenile plants (Spraakman & Drake, 2018). Electrical conductivity is a measure of the soils ability to conduct electrical current, and thus is an excellent indicator of salt content. Soil samples from bio-retention planters should be collected and tested for electrical conductivity annually. Development of a representative sampling program is at the discretion of the Consultant.

### 4.9.3 Exfiltration Pipes

The City does not currently have any standards for performance monitoring of exfiltration pipes, and at this time, it is not part of the Program. In the future should exfiltration pipe monitoring become part of the Program, the Consultant should develop a standardized process of monitoring such systems within the City.

# 5. Project Reporting

## 5.1 Monitoring Event Details

To interpret fully the results of the SWM monitoring program, it is crucial to report details of the sample collection conditions. Location and time of monitoring and sampling should be summarized, as well as background information that can strengthen understanding of the results. GPS coordinates of the sampling locations should be provided. At a minimum, the following are to be reported during each monitoring event.

- **Grab & Auto Samples:** time of sampling, type of sample (melt grab, dry grab, wet grab), average air temperature (from Kitchener/Waterloo weather station), total daily precipitation (from one of the two City-operated rain gauges - KOF or City Hall)
- **Biological:** thermal regime of the subject stream, whether fish sampling occurred
- **Physical Measurements**: type of event monitored (wet, dry, low-flow, high-flow)

## 5.2 Water Quality Results

Discrete water quality results and field measurements for each parameter at every location monitored are to be plotted, and where applicable, compared to existing water quality guidelines or limits (i.e., Canadian Council of Ministers of the Environment [CCME], Provincial Water Quality Objectives [PWQO]).

Consistent with previous years, the average EMC for each location and contaminant are to be compared to discrete measurements and grab sample results. Furthermore, automated sampler results are to be compared to EMC averages and any water quality guidelines or limits applicable to the parameter.

## 5.3 Groundwater Results

Currently, groundwater monitoring is not in the scope of the Program. Upon the addition of groundwater monitoring, reporting is to be consistent with surface water quality results. Discrete groundwater levels and results for each parameter at every location monitored should be plotted, and where applicable, compared to existing water quality guidelines or limits (i.e., Canadian Council of Ministers of the Environment [CCME], Provincial Water Quality Objectives [PWQO]).

## 5.4 Historical Data

Historical data for sites with a minimum of eight (8) years of chloride and total suspended solids data should be presented on an ordinal date scale. The ordinal day is one on January 1, counting daily through 365 on December 31 (or 366 for leap years). This allows for historical data to naturally align seasonally to compare results for the same period of each year.  Historical chloride trends should be compared to CCME guidelines.

## 5.5 Physical Monitoring Results

### 5.5.1 Temperature

It is recommended to plot the daily maximum, minimum and average water temperature for each location with continuous water temperature monitoring. This allows for evaluation of daily fluctuations.

Consistent with recommendations by Stoneman and Jones (1996) revised by Chu (2006), maximum air temperatures are to be plotted against maximum water temperatures between summer months (July 1st to September 7th) in order to classify the watercourse into cold-water, cool-water, or warm-water. Air temperature data should be taken from the Kitchener/Waterloo Airport weather station.

### 5.5.2 Flow Monitoring

For each monitoring location, discrete flow results can be used to develop a best-fit rating curve. A rating curve is the relation between measured water level (stage) and flow rate (discharge) during various monitoring events (high flow, low flow). Development of the rating curve allows for interpolation of stream flow at a location given water level. Personal discretion or statistical methods can be used in evaluating data outliers.

Continuous flow monitoring data should be plotted alongside daily total precipitation for a given location. A maximum of 15-minute intervals or better for continuous flow data measurements is recommended. This allows for relation of high flow events to high precipitation events and the contrary.

## 5.6 Biological Results

Annual benthic macroinvertebrate results for each location should be compared against one another and rated in terms of best and worst water quality. Where historic benthic macroinvertebrate results are available, results are to be compared to report whether results have improved or declined from the previous monitor year. Metrics to be calculated for comparison include: taxa richness, % dominant, % oligochaete, % diptera, % chironomidae, % EPT, number of EPT, % predators, % collector-filterer, % collector-gatherer, % scraper, % shredder, % clinger, Shannon’s Diversity Index and Hilsenhoff Biotic Index (HBI).

A list of identified fish species, and their presence at each monitoring location should be provided. A summary of fish findings including species richness and % tolerant species is to be provided. These key parameters are to be compared to previous year’s fish community sampling results for consistency.

Results for the DFO Habitat Bank monitoring sites (i.e., Filsinger Park and Henry Sturm, Balzer Creek and Idlewood Creek) will be detailed in site-specific reports and analyzed using the metrics set out in the City’s Municipal Fisheries Habitat Bank agreement with DFO and identified in the site-specific Annex B reports. Results from these site-specific monitoring reports will be incorporated into the annual SWM monitoring report.

## 5.7 LID Monitoring Results

### 5.7.1 Permeable Surfaces

Infiltration results should be summarized in tabular form, including a minimum of five (5) tests to determine a median and mean infiltration rate. Comparison to historic rates allows for classification of performance of the surface.

An annual hydrograph is to be developed comparing the water level to permeable surface elevation. Water level data should be plotted at a maximum of five (5) minute intervals or better. It is important to ensure that these plots include precipitation data (from KOF or City Hall gauge) to correlate how well the surface is responding to rain events. For closer analysis of a particular rain event (i.e., high flow), additional hydrographs can be developed to show the period of focus. This allows for closer analysis of response of the water level to the specific precipitation event.

### 5.7.2 Bio-Retention Planters

Bio-retention planter monitoring is currently not part of the Program. Upon addition to the Program, the following are recommended to be included in reporting.

Electrical conductivity results can be summarized in tabular form, along with the location sampled. Annual electrical conductivity values should be compared to historic rates to classify whether electrical conductivity continues to increase from road salt exposure.

An annual hydrograph can be developed showing the continuous water level in relation to precipitation data (from KOF or City Hall gauge). Water level data should be plotted at a maximum of five (5) minute intervals or better. For closer analysis of a particular rainfall event, additional hydrographs may be developed to further analyze the bio-retention planter's response.

### 5.7.3 Exfiltration Pipes

As previous mentioned no monitoring is currently in place for exfiltration systems. At this time there are no performance results being collected that require reporting.

# 6. Data Management and Integrity

Data management and integrity of the historical data record are the responsibility of the Consultant for the duration of the project. This includes maintaining the historical data record along with the on-going work. At the start of the contract, the Consultant will be provided existing raw data in a CSV, Microsoft Excel, or other demonstrably standard software format requested by the City of Kitchener.

As part of the Consultant's data integrity responsibility, the Consultant should also take efforts to prevent data loss. This could include copies emailed to Kitchener at regular intervals following sampling, cloud storage, drive backups, or part of the Consultant's enterprise backup plans.

Hydrologic data standards vary through the industry. Software packages such as Kisters' WISKI and Aquatic Infomatic's$^{TM}$ Aquarius software packages can improve the efficiency of data management standards for the Consultant; however, proprietary data packages must be capable of exporting continuous and discrete measurements into the standard file formats outlined above.

Hydrologic data at a minimum should include the raw measurement data, and calculated flow (including formulas) used for hydrographs. Flow calculations should be carefully transcribed from field files and data entry peer reviewed for transcription errors. Files should be organized by monitoring site and year, discrete flow measurements and work documenting rating curves should be provided per monitoring station. Event mean concentration sampling records recording aliquot volume and pacing settings per sample should also be kept with the other monitoring site files in a separate Excel tab or file.

Chemical data management will benefit from integration of data management and QA principles. Use of electronic data-deliverables (EDD) from the selected laboratory will reduce human transcription errors for lab analyses results. Field parameters will likely require some method of data entry and peer review is to be prescribed, prior to combining the field data set with laboratory. Field and laboratory data should be available in a single table, organized by the location, date, and sample identifiers.

Proprietary data management software (WISKI, Aquarius, MSSQL, Oracle, MS ACCESS, EQUIS etc.) are allowed to be used by the Consultant for the project duration for laboratory data, however a single flat file in a format setout above is to be provided at the end of the project or at intervals requested by Kitchener. Flat files should include the entire historical data record in addition to the Consultant’s collected data.

# 7. References

Aquafor Beech Ltd. 2016. Integrated Stormwater Management Master Plan (ISWM-MP) Implementation Plan. Prepared for the City of Kitchener. October 27, 2016.

ASTM C1781 Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems

ASTM D5640 Guide for Selection of Weirs and Flumes for Open-Channel Flow Measurement of Water

ASTM D5541 Practice for Developing a Stage-Discharge Relation for Open-Channel Flow

Association of Professional Geoscientists of Ontario. 2011. Guidance for Environmental Site Assessments under Ontario Regulation 153/04 (as amended) – April 2011.

Chu, C., N. E. Jones, A. R. Piggott, and J. M. Buttle. 2009. Evaluation of a simple method to classify the thermal characteristics of streams using a nomogram of daily maximum air and water temperatures. North American Journal of Fisheries Management 29:1605-1619.

Geological Survey Techniques and Methods book 3, chap. A8

Grant, D.M., ISCO Open Channel Flow Measurement Handbook - Third Edition 1992.

Lane, R. 1999., Principles of Discharge Measurement. Fredericton, N.B.: Environment Canada

Sontek/YSI, 2007. Flow Tracker Technical Manual (2007).

Spraakman, S., and Drake, J., 2018. Kitchener Bioretention Planters Study.

Stanfield, L. (editor). 2017. Ontario Stream Assessment Protocol. Version 10. Fisheries Policy Section. Ontario Ministry of Natural Resources. Peterborough, Ontario. Stoneman, C. L., and M. L. Jones. 1996. A simple method to classify stream thermal stability with single observations of daily maximum water and air temperature. North American Journal of Fisheries Management 16:728–737.

Terzi, R.A., Hydrometric Field Manual - Measurement of Streamflow, Environment Canada, 1981.

Turnipseed, D.P., and Sauer, V.B., 2010. Discharge measurements at gaging stations: U.S.

USEPA, N.D., Standard Operating Procedure for the Standard/Well-Volume Method for Collecting a Ground-water Sample from Monitoring Wells for Site Characterization.

# Appendix B

# 2019 Photo Log

Photo 1 - Downstream of SC1 (03/29/2019)

Photo 2 - Upstream of SC1 (03/29/2019)

## Site Photographs

Photo 3 - Downstream of SC9 (03/29/2019)

Photo 4 - Upstream of SC9 (03/29/2019)

## Site Photographs

Photo 5 - SCH1 Upstream Culvert (03/29/2019)

Photo 6 - Downstrem of SCH1 (03/29/2019)

## Site Photographs

Photo 7 - WD1 ISCO (24/04/2019)

Photo 8 - SB2 (26/04/2019)

Photo 9 - Upstream of SM4 (06/05/2019)

Photo 10 - Downtream of SM2 (06/05/2019)

Photo 11 - Upstream of SM2 (06/05/2019)

Photo 12 - Downstream of SM4 (06/05/2019)

## Site Photographs

Photo 13 - Downstream of SM3 (15/07/2019)

Photo 14 - Upstream of SM3 (15/07/2019)

## Site Photographs

Photo 15 - Upstream of SR2 (07/15/2019)

Photo 16 - Downstream of SR2 (07/15/2019)

## Site Photographs

Photo 17 - Upstream of VS1 (07/15/2019)

# Appendix C

# 2019 Blair Creek Data

| | | |
|---|---|---|
| **Project: Blair Creek 2019** | | |
| **Site code: 2414047-1** | | |
| **Date: 22/05/2019** | | |
| **No. Cells processed: 5** | | |
| **Taxa** | **Raw counts** | **Total counts** |
| **P: Annelida** | | |
| **Cl: Oligochaeta** | | |
| **O: Haplotaxida** | | |
| F: Enchytraeidae | | 20 |
| Enchytraeus | 1 | 20 |
| F: Naididae | | 500 |
| Tubificinae immatures with cheatal hairs | 2 | 40 |
| Tubificinae immatures without cheatal hairs | 9 | 180 |
| Nais | 1 | 20 |
| Nais behningi | 1 | 20 |
| Nais bretscheri | 4 | 80 |
| Nais variabilis | 7 | 140 |
| | | |
| **P: Mollusca** | | |
| **Cl: Bivalvia** | | |
| **O: Veneroida** | | |
| F: Sphaeriidae | | 20 |
| Pisidium nitidum | 1 | 20 |
| | | |
| **Cl: Gastropoda** | | |
| **O: Basommatophora** | | |
| F: Physidae | | 20 |
| Physa | 1 | 20 |
| | | |
| **P: Arthropoda** | | |
| **Cl: Insecta** | | |
| **O: Ephemeroptera** | | |
| F: Baetidae | | 20 |
| Baetis | 1 | 20 |
| Baetis tricaudatus | 1 | 20 |
| **O: Plecoptera** | | |
| F: Leuctridae | | 60 |
| Unknown specimens | 2 | 40 |
| Paraleuctra sara | 1 | 20 |
| F: Nemouridae | | 60 |
| Amphinemoura delosa | 3 | 60 |
| **O: Trichoptera** | | |
| F: Hydropsychidae | | 140 |
| Hydropsyche betteni | 2 | 40 |
| Hydropsyche slossonae | 5 | 100 |
| F: Hydroptilidae | | 20 |
| Hydroptila | 1 | 20 |
| F: Rhyacophilidae | | 20 |
| Rhyacophila fuuscula | 1 | 20 |
| **O: Coleoptera** | | |
| F: Elmidae | | 360 |
| Optioservus | 16 | 320 |
| Optioservus fastiditus | 2 | 40 |

| | | |
|---|---|---|
| **O: Diptera** | | |
| F: Ceratopogonidae | | 20 |
| Culicoides | 1 | 20 |
| F: Chironomidae | | 1500 |
| Cladotanytarsus | 4 | 80 |
| Conchapelopia | 3 | 60 |
| Corynoneura | 1 | 20 |
| Cricotopus | 2 | 40 |
| Eukiefferiella claripennis group | 2 | 40 |
| Larsia | 1 | 20 |
| Micropsectra (1 pupa in vial) | 2 | 40 |
| Nilotanypus fimbriatus | 2 | 40 |
| Orthocladius | 6 | 120 |
| Orthocladius obumbratus (2 pupae in vial) | 38 | 760 |
| Parametriocnemus (1 pupa in vial) | 5 | 100 |
| Paratanytarsus longistilus | 1 | 20 |
| Paratendipes albimanus | 2 | 40 |
| Polypedilum scalaenum group | 1 | 20 |
| Rheotanytarsus | 1 | 20 |
| Stempellinella fimbriata (1 pupa in vial) | 2 | 40 |
| Thienemanniella xena | 1 | 20 |
| F: Empididae | | 40 |
| Hemerodromia | 2 | 40 |
| F: Simuliidae | | 100 |
| Simulium tuberosum complex | 5 | 100 |
| F: Tipulidae | | 80 |
| Antocha | 4 | 80 |
| | | |
| **Cl: Malacostraca** | | |
| **O: Isopoda** | | |
| F: Trichoniscidae | | 20 |
| Trichoniscus pusillus | 1 | 20 |
| | | |
| **Cl: Arachnida** | | |
| **O: Trombidiformes** | | |
| F: Hygrobatidae | | 20 |
| Hygrobates | 1 | 20 |
| F: Lebertiidae | | 40 |
| Lebertia | 2 | 40 |
| | | |
| **TOTAL** | 152 | 3040 |
| | | |
| **P: Nemata** | 26 | 520 |

| **Project:  Blair Creek 2019** | | |
|---|---|---|
| **Site code: 2414047-2** | | |
| **Date: 22/05/2019** | | |
| **No. Cells processed:  10** | | |
| **Taxa** | **Raw counts** | **Total counts** |
| **P: Cnidaria** | | |
| **Cl: Hydrozoa** | | |
| **O: Antnoathecatae** | | |
| F: Hydridae | | 10 |
| Hydra | 1 | 10 |
| | | |
| **P: Annelida** | | |
| **Cl: Oligochaeta** | | |
| **O: Haplotaxida** | | |
| F: Naididae | | 190 |
| Tubificinae immatures with cheatal hairs | 1 | 10 |
| Aulodrilus pluriseta | 2 | 20 |
| Chaetogaster diastrophus | 4 | 40 |
| Nais | 3 | 30 |
| Nais alpine | 7 | 70 |
| Nais bretscheri | 2 | 20 |
| | | |
| **P: Nemertea** | | |
| **Cl: Enopla** | | |
| **O: Haplonemertea** | | |
| F: Tetrastemmatidae | | 10 |
| Prostoma | 1 | 10 |
| | | |
| **P: Mollusca** | | |
| **Cl: Bivalvia** | | |
| **O: Veneroida** | | |
| F: Sphaeriidae | | 10 |
| Pisidium | 1 | 10 |
| | | |
| **P: Arthropoda** | | |
| **Cl: Insecta** | | |
| **O: Plecoptera** | | |
| F: Leuctridae | | 70 |
| Paraleuctra sara | 7 | 70 |
| F: Perlodidae | | 10 |
| Unknown specimens | 1 | 10 |
| **O: Trichoptera** | | |
| F: Limnophilidae | | 10 |
| Pycnopsyche | 1 | 10 |
| **O: Coleoptera** | | |
| F: Elmidae | | 310 |
| Dubiraphia | 2 | 20 |
| Optioservus | 29 | 290 |
| **O: Diptera** | | |
| F: Ceratopogonidae | | 20 |
| Bezzia | 2 | 20 |
| F:  Chironomidae | | 310 |
| Orthocladiinae | 2 | 20 |

| | | |
|---|---|---|
| Conchapelopia | 4 | 40 |
| Natarsia baltimorea | 2 | 20 |
| Orthocladius | 5 | 50 |
| Orthocladius obumbratus | 3 | 30 |
| Paracladopelma undine | 1 | 10 |
| Parakiefferiella | 2 | 20 |
| Stempellinella (1 pupa in vial) | 6 | 60 |
| Stempellinella fimbriata | 3 | 30 |
| Tanytarsus | 5 | 50 |
| F: Empididae | | 30 |
| Hemerodromia | 3 | 30 |
| F: Tipulidae | | 10 |
| Antocha | 1 | 10 |
| | | |
| **Cl: Arachnida** | | |
| **O: Trombidiformes** | | |
| F: Aturidae | | 10 |
| Aturus | 1 | 10 |
| F: Lebertiidae | | 10 |
| Lebertia | 1 | 10 |
| **O: Sarcoptiformes** | | |
| F: Phthiropacaridae | | 10 |
| Atropacarus | 1 | 10 |
| | | |
| **TOTAL** | 104 | 1040 |
| | | |
| **P: Nemata** | 5 | 50 |
| | | |
| **P: Arthropoda** | | |
| **Cl: Ostracoda** | | |
| **O: Podocopida** | | |
| F: Candonidae | | 10 |
| Candona | 1 | 10 |

| | | |
|---|---|---|
| **Project:  Blair Creek 2019** | | |
| **Site code: 2414047-3** | | |
| **Date: 22/05/2019** | | |
| **No. Cells processed:  5** | | |
| **Taxa** | **Raw counts** | **Total counts** |
| **P: Annelida** | | |
| **Cl: Oligochaeta** | | |
| **O: Haplotaxida** | | |
| F: Enchytraeidae | | 20 |
| Enchytraeus | 1 | 20 |
| F: Naididae | | 720 |
| Tubificinae immarues with cheatal hairs | 2 | 40 |
| Amphicheata leydigi | 1 | 20 |
| Chaetogaster diastrophus | 6 | 120 |
| Nais behningi | 15 | 300 |
| Nais bretscheri | 6 | 120 |
| Nais communis | 1 | 20 |
| Nais elinguis | 2 | 40 |
| Nais pardalis | 3 | 60 |
| | | |
| **P: Arthropoda** | | |
| **Cl: Insecta** | | |
| **O: Ephemeroptera** | | |
| F: Baetidae | | 120 |
| Baetis tricaudatus | 6 | 120 |
| F: Heptageniidae | | 140 |
| Maccaffertium luteum | 3 | 60 |
| Stenonema femoratum | 4 | 80 |
| **O: Plecoptera** | | |
| F: Leuctridae | | 500 |
| Paraleuctra sara | 25 | 500 |
| F: Nemouridae | | 320 |
| Amphinemoura delosa | 16 | 320 |
| **O: Trichoptera** | | |
| F: Hydropsychidae | | 560 |
| Cheumatopsyche | 15 | 300 |
| Hydropsyche | 3 | 60 |
| Hydropsyche betteni | 3 | 60 |
| Hydropsyche slossonae | 7 | 140 |
| F: Rhyacophilidae | | 60 |
| Rhyacophila carolina | 2 | 40 |
| Rhyacophila fuscula | 1 | 20 |
| **O: Coleoptera** | | |
| F: Elmidae | | 1720 |
| Optioservus | 70 | 1400 |
| Optioservus fastiditus | 8 | 160 |
| Optioservus trivittata | 3 | 60 |
| Stenelmis | 2 | 40 |
| Stenelmis crenata | 3 | 60 |
| **O: Diptera** | | |
| F: Ceratopogonidae | | 60 |
| Bezzia | 1 | 20 |
| Dasyhelea | 1 | 20 |

|  |  |  |
|---|---|---|
| Palpomyia | 1 | 20` |
| F:  Chironomidae |  | 3340 |
| Orthocladiinae | 4 | 80 |
| Conchapelopia | 4 | 80 |
| Cricotopus annulator complex | 7 | 140 |
| Cricotopus bicinctus | 7 | 140 |
| Diamesa | 1 | 20 |
| Eukiefferiella brevicalar group | 3 | 60 |
| Eukiefferiella claripennis group | 13 | 260 |
| Nilotanypus fimbriatus | 2 | 40 |
| Orthocladius | 3 | 60 |
| Orthocladius obumbratus (5 pupae in vial) | 101 | 2020 |
| Pagastia | 4 | 80 |
| Pagastia orthogonia | 2 | 40 |
| Parakifferiella | 1 | 20 |
| Parametriocnemus | 6 | 120 |
| Stenpellinella | 1 | 20 |
| Stempellinella fimbriata | 7 | 140 |
| Tanytarsus | 5 | 100 |
| F: Empididae |  | 40 |
| Hemerodromia | 1 | 20 |
| Neoplasta | 1 | 20 |
| F: Simuliidae |  | 40 |
| Simulium tuberosum complex | 2 | 40 |
| F: Tipulidae |  | 160 |
| Antocha | 7 | 140 |
| Dicranota | 1 | 20 |
|  |  |  |
| **Cl: Arachnida** |  |  |
| **O: Trombidiformes** |  |  |
| F: Hygrobatidae |  | 40 |
| Atractides | 1 | 20 |
| Hygrobates | 1 | 20 |
| F: Lebertiidae |  | 40 |
| Lebertia | 2 | 40 |
| F: Torrenticolidae |  | 20 |
| Testudacarus | 1 | 20 |
|  |  |  |
| **TOTAL** | 399 | 7980 |
|  |  |  |
| **P: Nemata** | 3 | 60 |
|  |  |  |
| **P: Platyhelminthes** |  |  |
| **Cl: Trepaxonemata** |  |  |
| **O: Neoophora** |  |  |
| F: Dugsiidae |  | 20 |
| Cura formanii | 1 | 20 |
|  |  |  |
| **P: Arthropoda** |  |  |
| **Cl: Copepoda** |  |  |
| **O: Harpacticoida** | 2 | 40 |

**Blair Creek Electrofish Survey Results, 2019.**

| Species Code | Scientific Name | Species | Preferred Thermal Regime | Upstream 401 (2414047) |
|---|---|---|---|---|
| 78 | *Salmo trutta* | brown trout | coldwater | 4 |
| 80 | *Salvelinus fontinalis* | brook trout | coldwater | 6 |
| 141 | *Umbra limi* | central mudminnow | coolwater | |
| 163 | *Catostomus commersonii* | white sucker | coolwater | 3 |
| 212 | *Semotilus atromaculatus* | creek chub | coolwater | 1 |
| 281 | *Culaea inconstantans* | brook stickleback | coolwater | |
| 313 | *Lepomis gibbosus* | pumpkinseed | warmwater | 1 |
| 381 | *Cottus bairdii* | mottled sculpin | coldwater | 24 |
| 630 | *Rhinichthys obtusus* | Western blacknose dace | coolwater | 12 |

| | |
|---|---|
| Total individuals: | 51 |
| No. species: | 7 |
| Date: | Aug-7-19 |
| Electrofish seconds: | 2192 |
| Site length: | 49.6 |
| Air temperature ($^oC$): | 22.0 |
| Water temperature ($^oC$): | 13.0 |

* Note: 2019 fish community surveys used single pass electrofish method.

# Appendix D
# Flow Tracker Summary Sheets

4/9/2019 10:35:46 AM

# Discharge Measurement Summary

**File Information**

| | |
|---|---|
| File name | SC1_20190329.ft |
| Start date and time | 3/29/2019 11:41 AM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

**Discharge Summary**

| | | | | | |
|---|---|---|---|---|---|
| Start time | 3/29/2019 11:41:59 AM | | End time | 3/29/2019 12:09:58 PM | |
| # Stations | 15 | | Avg interval | 40 | |
| Mean depth | 0.243 | m | | | |
| Mean velocity | 0.314 | m/s | Total width | 9.900 | m |
| Mean SNR | 42.690 | dB | Total area | 2.406 | m² |
| Mean temp | 6.442 | °C | Total discharge | 0.756 | m³/s |

**System Information**

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

**Site Details**

| | |
|---|---|
| Site name | Sc1 |
| Site number | |
| Operator(s) | Dk |
| Comment | |

**Discharge Uncertainty**

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0 % | 1.0 % |
| Depth | 0.4 % | 4.9 % |
| Velocity | 1.0 % | 6.7 % |
| Width | 0.2 % | 0.2 % |
| Method | 2.6 % | |
| # Stations | 3.3 % | |
| Overall | 4.5 % | 8.3 % |

**Discharge Settings**

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

**Station Warning Settings**

| | | |
|---|---|---|
| Maximum station discharge | 15.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

**Summary overview**

One or more quality control settings were changed
Quality control warnings

**Data Collection Settings**

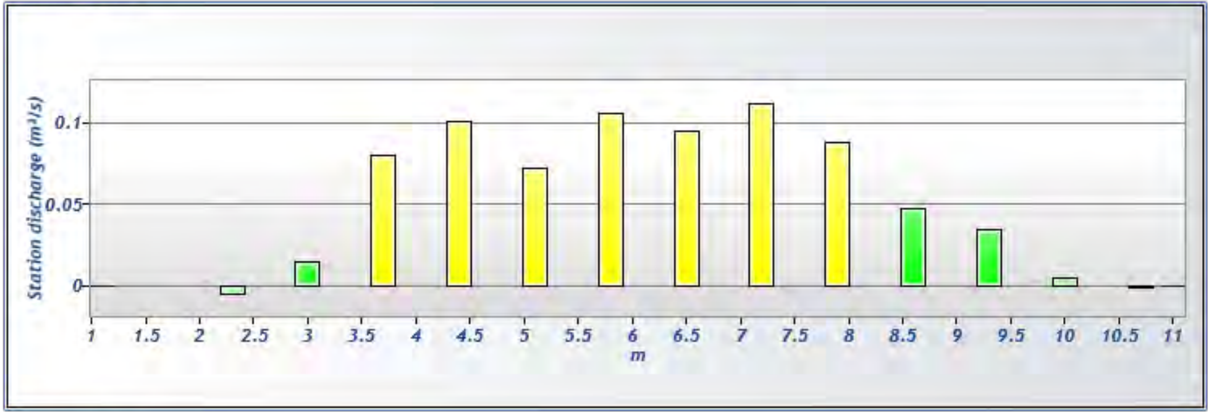
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

**Quality Control Settings**

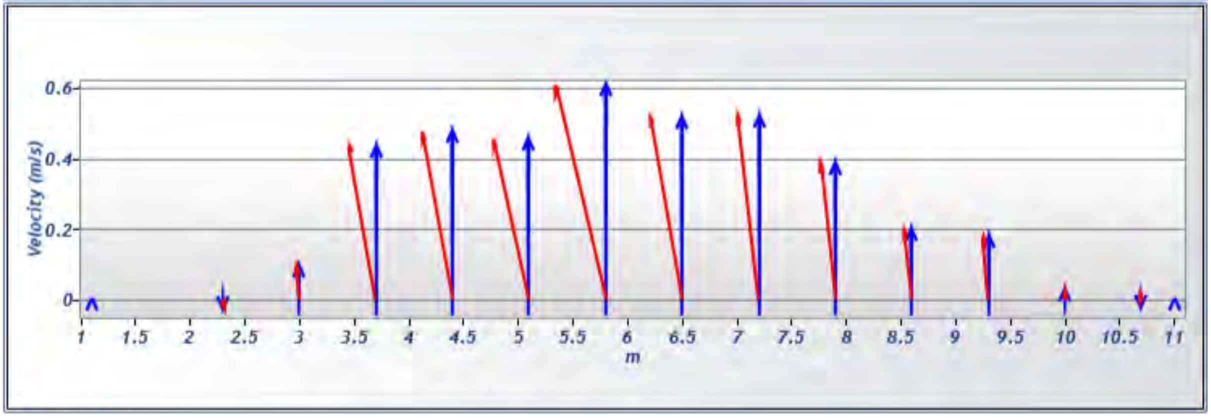
| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |

4/9/2019 10:35:46 AM

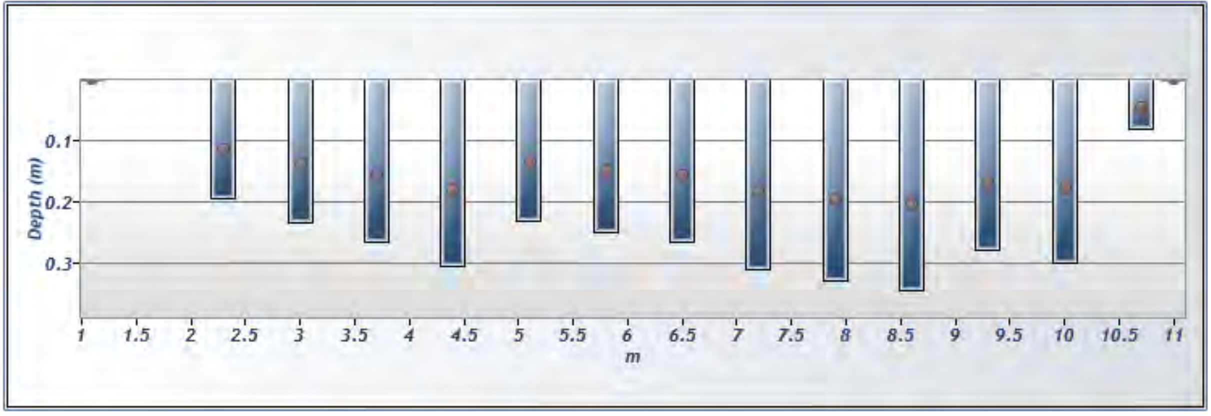
**Discharge chart**

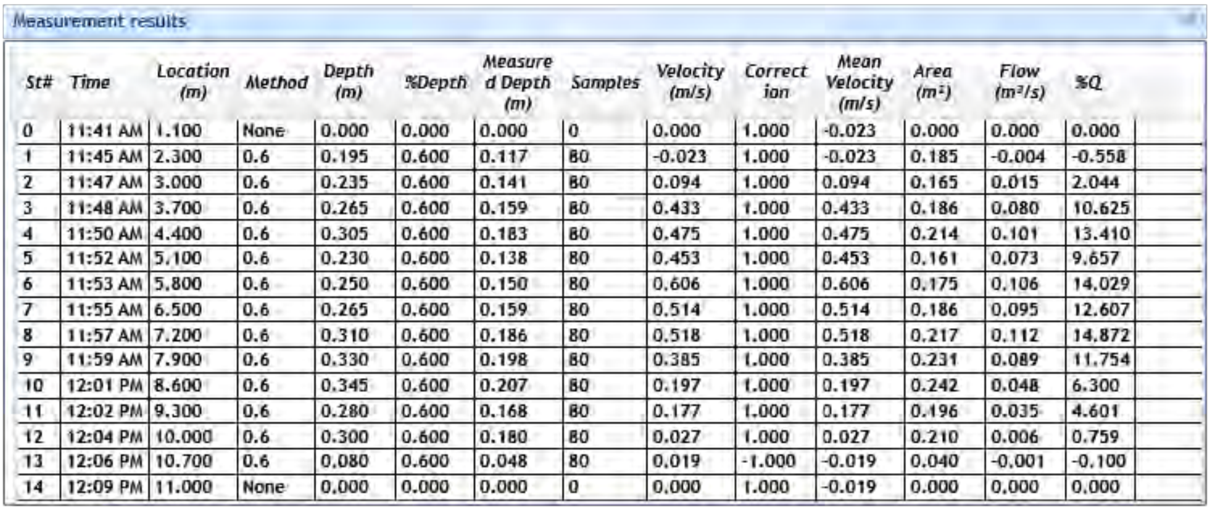


**Velocity chart**



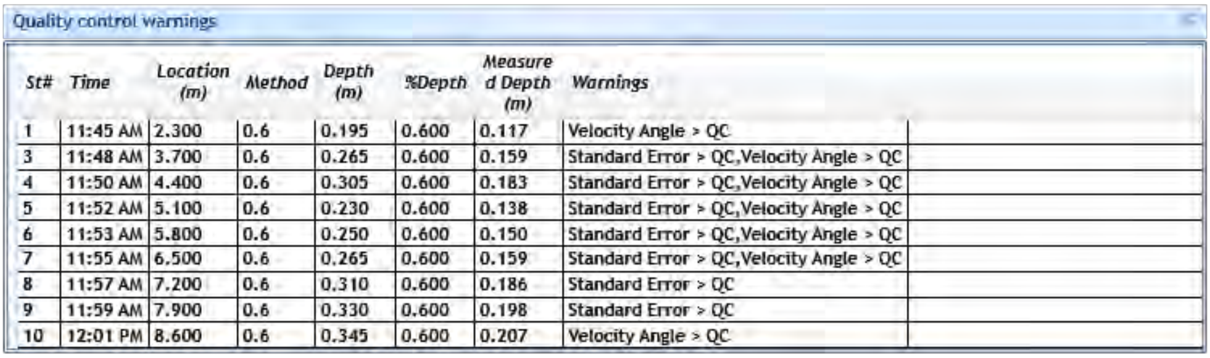
**Depth chart**





Measurement results

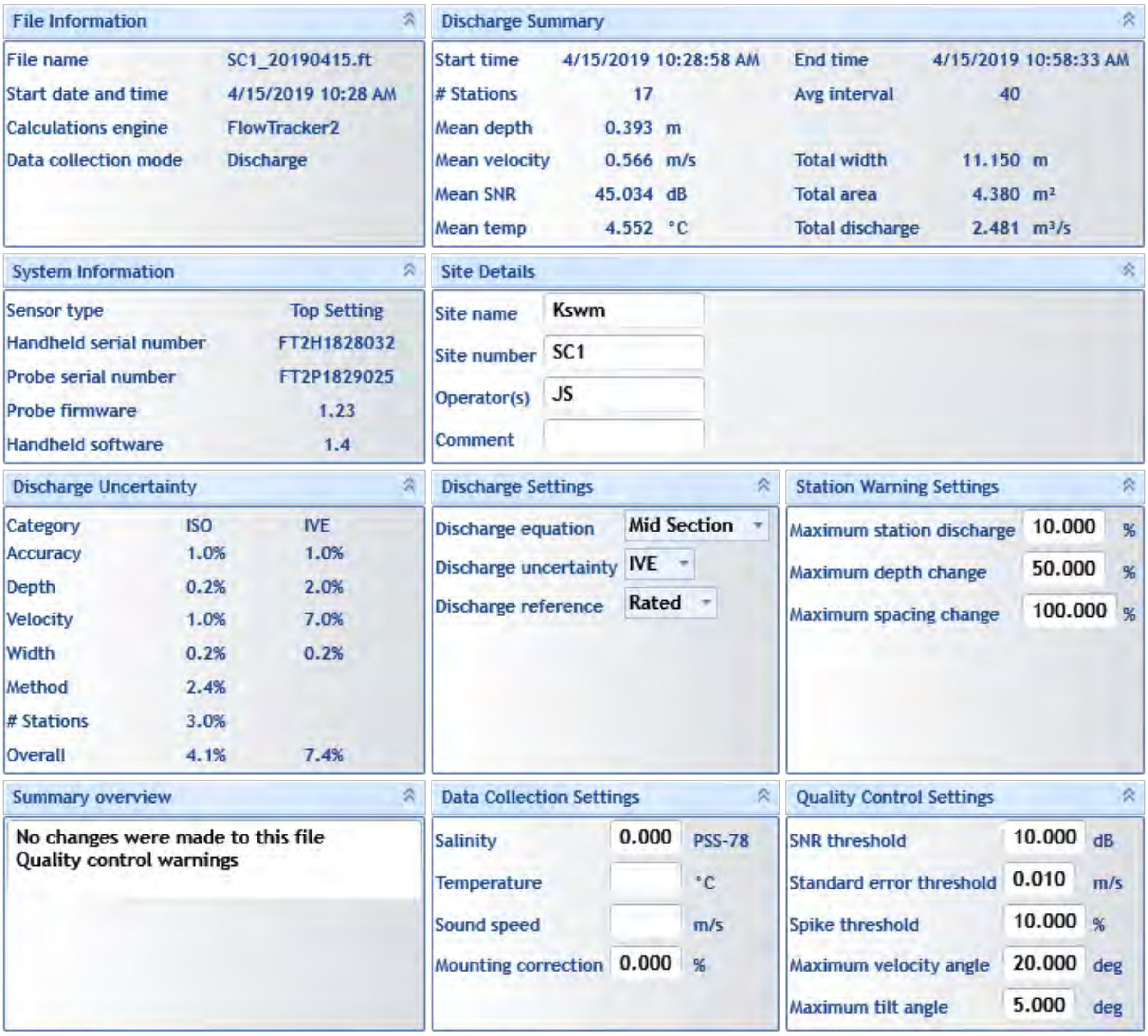
| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area ($m^2$) | Flow ($m^3/s$) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 11:41 AM | 1.100 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | -0.023 | 0.000 | 0.000 | 0.000 |
| 1 | 11:45 AM | 2.300 | 0.6 | 0.195 | 0.600 | 0.117 | 80 | -0.023 | 1.000 | -0.023 | 0.185 | -0.004 | -0.558 |
| 2 | 11:47 AM | 3.000 | 0.6 | 0.235 | 0.600 | 0.141 | 80 | 0.094 | 1.000 | 0.094 | 0.165 | 0.015 | 2.044 |
| 3 | 11:48 AM | 3.700 | 0.6 | 0.265 | 0.600 | 0.159 | 80 | 0.433 | 1.000 | 0.433 | 0.186 | 0.080 | 10.625 |
| 4 | 11:50 AM | 4.400 | 0.6 | 0.305 | 0.600 | 0.183 | 80 | 0.475 | 1.000 | 0.475 | 0.214 | 0.101 | 13.410 |
| 5 | 11:52 AM | 5.100 | 0.6 | 0.230 | 0.600 | 0.138 | 80 | 0.453 | 1.000 | 0.453 | 0.161 | 0.073 | 9.657 |
| 6 | 11:53 AM | 5.800 | 0.6 | 0.250 | 0.600 | 0.150 | 80 | 0.606 | 1.000 | 0.606 | 0.175 | 0.106 | 14.029 |
| 7 | 11:55 AM | 6.500 | 0.6 | 0.265 | 0.600 | 0.159 | 80 | 0.514 | 1.000 | 0.514 | 0.186 | 0.095 | 12.607 |
| 8 | 11:57 AM | 7.200 | 0.6 | 0.310 | 0.600 | 0.186 | 80 | 0.518 | 1.000 | 0.518 | 0.217 | 0.112 | 14.872 |
| 9 | 11:59 AM | 7.900 | 0.6 | 0.330 | 0.600 | 0.198 | 80 | 0.385 | 1.000 | 0.385 | 0.231 | 0.089 | 11.754 |
| 10 | 12:01 PM | 8.600 | 0.6 | 0.345 | 0.600 | 0.207 | 80 | 0.197 | 1.000 | 0.197 | 0.242 | 0.048 | 6.300 |
| 11 | 12:02 PM | 9.300 | 0.6 | 0.280 | 0.600 | 0.168 | 80 | 0.177 | 1.000 | 0.177 | 0.196 | 0.035 | 4.601 |
| 12 | 12:04 PM | 10.000 | 0.6 | 0.300 | 0.600 | 0.180 | 80 | 0.027 | 1.000 | 0.027 | 0.210 | 0.006 | 0.759 |
| 13 | 12:06 PM | 10.700 | 0.6 | 0.080 | 0.600 | 0.048 | 80 | 0.019 | -1.000 | -0.019 | 0.040 | -0.001 | -0.100 |
| 14 | 12:09 PM | 11.000 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | -0.019 | 0.000 | 0.000 | 0.000 |



Quality control warnings

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 1 | 11:45 AM | 2.300 | 0.6 | 0.195 | 0.600 | 0.117 | Velocity Angle > QC |
| 3 | 11:48 AM | 3.700 | 0.6 | 0.265 | 0.600 | 0.159 | Standard Error > QC,Velocity Angle > QC |
| 4 | 11:50 AM | 4.400 | 0.6 | 0.305 | 0.600 | 0.183 | Standard Error > QC,Velocity Angle > QC |
| 5 | 11:52 AM | 5.100 | 0.6 | 0.230 | 0.600 | 0.138 | Standard Error > QC,Velocity Angle > QC |
| 6 | 11:53 AM | 5.800 | 0.6 | 0.250 | 0.600 | 0.150 | Standard Error > QC,Velocity Angle > QC |
| 7 | 11:55 AM | 6.500 | 0.6 | 0.265 | 0.600 | 0.159 | Standard Error > QC,Velocity Angle > QC |
| 8 | 11:57 AM | 7.200 | 0.6 | 0.310 | 0.600 | 0.186 | Standard Error > QC |
| 9 | 11:59 AM | 7.900 | 0.6 | 0.330 | 0.600 | 0.198 | Standard Error > QC |
| 10 | 12:01 PM | 8.600 | 0.6 | 0.345 | 0.600 | 0.207 | Velocity Angle > QC |

# Discharge Measurement Summary



## File Information

| | |
|---|---|
| File name | SC1_20190415.ft |
| Start date and time | 4/15/2019 10:28 AM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

## Discharge Summary

| | | | |
|---|---|---|---|
| Start time | 4/15/2019 10:28:58 AM | End time | 4/15/2019 10:58:33 AM |
| # Stations | 17 | Avg interval | 40 |
| Mean depth | 0.393 m | | |
| Mean velocity | 0.566 m/s | Total width | 11.150 m |
| Mean SNR | 45.034 dB | Total area | 4.380 m² |
| Mean temp | 4.552 °C | Total discharge | 2.481 m³/s |

## System Information

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

## Site Details

| | |
|---|---|
| Site name | Kswm |
| Site number | SC1 |
| Operator(s) | JS |
| Comment | |

## Discharge Uncertainty

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0% | 1.0% |
| Depth | 0.2% | 2.0% |
| Velocity | 1.0% | 7.0% |
| Width | 0.2% | 0.2% |
| Method | 2.4% | |
| # Stations | 3.0% | |
| Overall | 4.1% | 7.4% |

## Discharge Settings

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

## Station Warning Settings

| | | |
|---|---|---|
| Maximum station discharge | 10.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

## Summary overview

No changes were made to this file
Quality control warnings

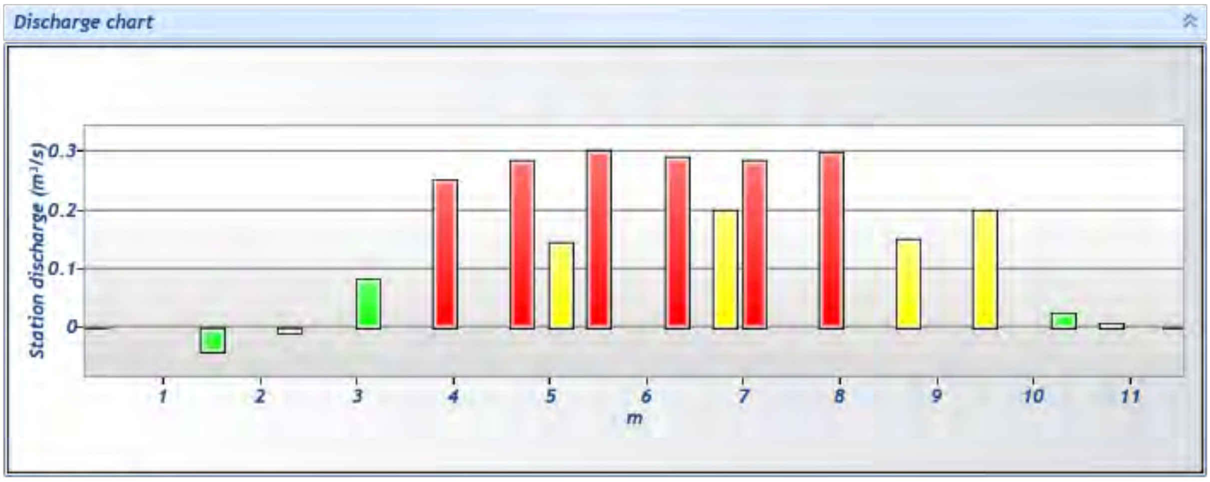
## Data Collection Settings

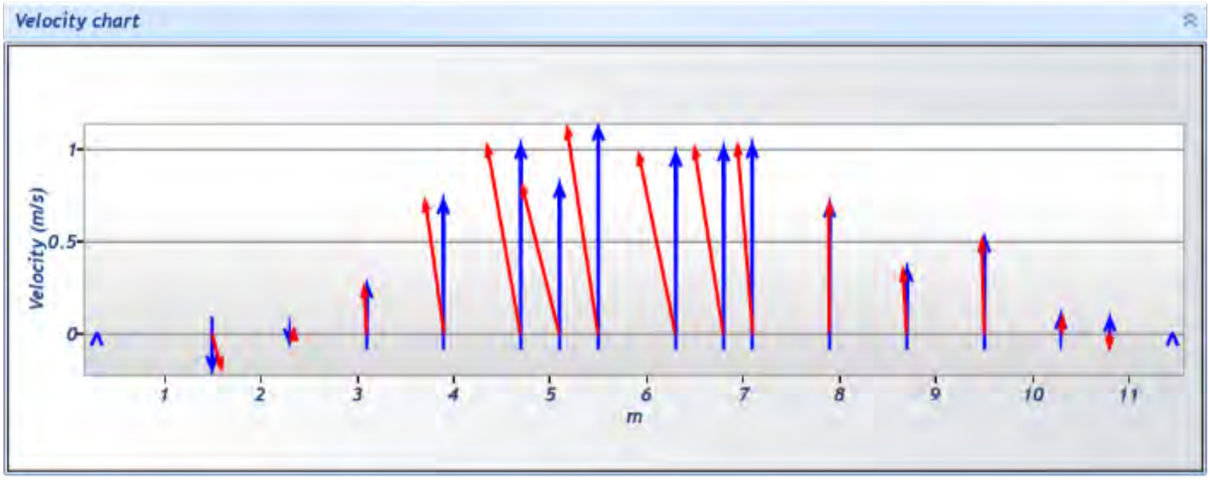
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

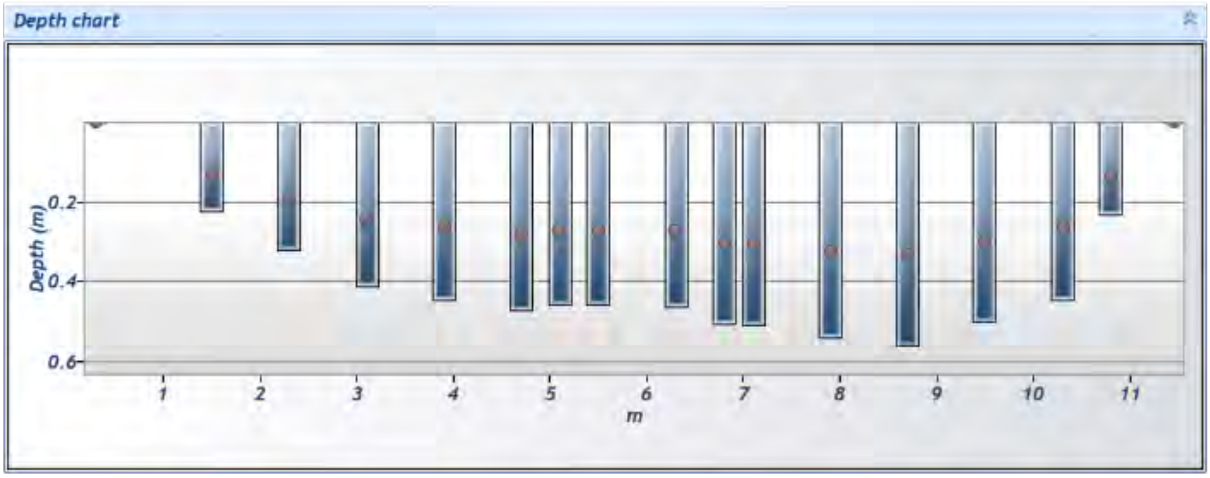
## Quality Control Settings

| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |

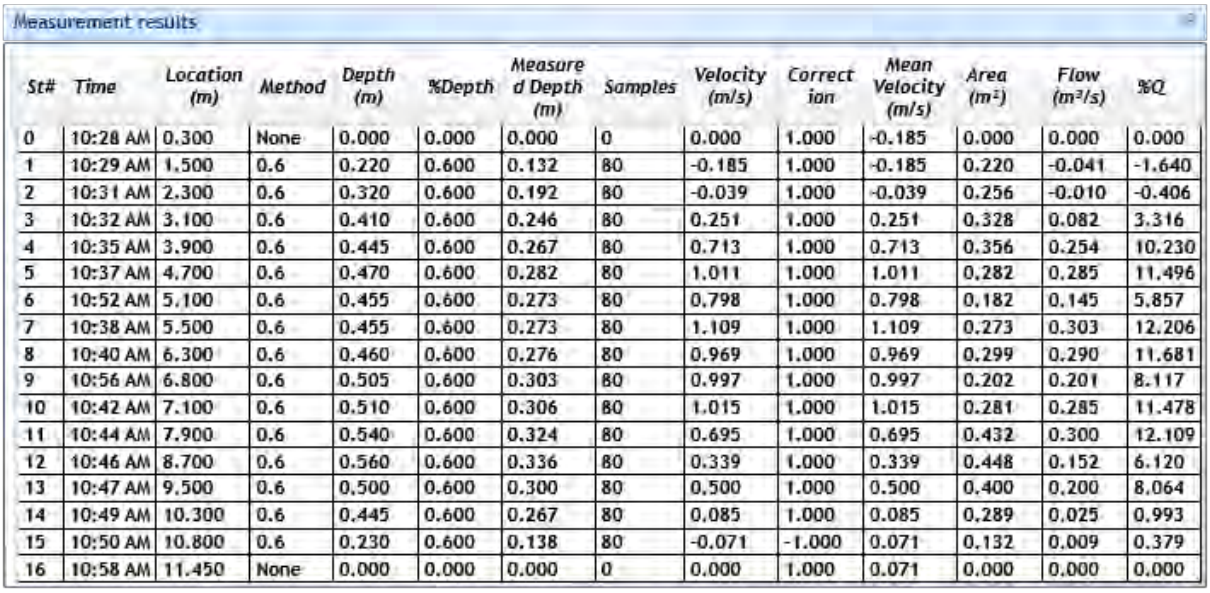
3/23/2020 10:02:03 AM



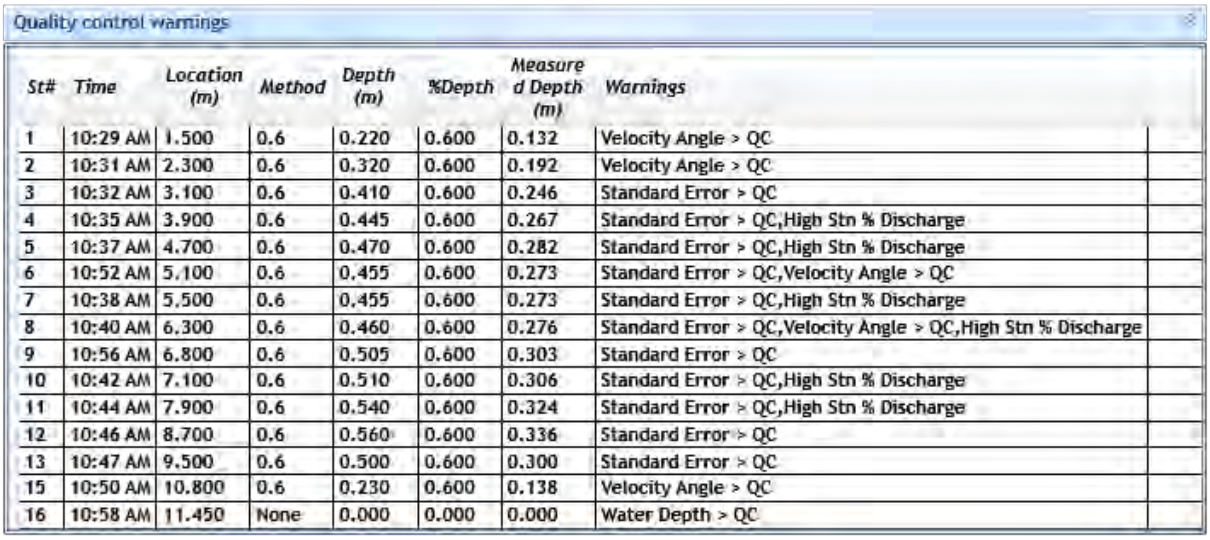




3/23/2020 10:02:03 AM


Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area ($m^2$) | Flow ($m^3/s$) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 10:28 AM | 0.300 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | -0.185 | 0.000 | 0.000 | 0.000 |
| 1 | 10:29 AM | 1.500 | 0.6 | 0.220 | 0.600 | 0.132 | 80 | -0.185 | 1.000 | -0.185 | 0.220 | -0.041 | -1.640 |
| 2 | 10:31 AM | 2.300 | 0.6 | 0.320 | 0.600 | 0.192 | 80 | -0.039 | 1.000 | -0.039 | 0.256 | -0.010 | -0.406 |
| 3 | 10:32 AM | 3.100 | 0.6 | 0.410 | 0.600 | 0.246 | 80 | 0.251 | 1.000 | 0.251 | 0.328 | 0.082 | 3.316 |
| 4 | 10:35 AM | 3.900 | 0.6 | 0.445 | 0.600 | 0.267 | 80 | 0.713 | 1.000 | 0.713 | 0.356 | 0.254 | 10.230 |
| 5 | 10:37 AM | 4.700 | 0.6 | 0.470 | 0.600 | 0.282 | 80 | 1.011 | 1.000 | 1.011 | 0.282 | 0.285 | 11.496 |
| 6 | 10:52 AM | 5.100 | 0.6 | 0.455 | 0.600 | 0.273 | 80 | 0.798 | 1.000 | 0.798 | 0.182 | 0.145 | 5.857 |
| 7 | 10:38 AM | 5.500 | 0.6 | 0.455 | 0.600 | 0.273 | 80 | 1.109 | 1.000 | 1.109 | 0.273 | 0.303 | 12.206 |
| 8 | 10:40 AM | 6.300 | 0.6 | 0.460 | 0.600 | 0.276 | 80 | 0.969 | 1.000 | 0.969 | 0.299 | 0.290 | 11.681 |
| 9 | 10:56 AM | 6.800 | 0.6 | 0.505 | 0.600 | 0.303 | 80 | 0.997 | 1.000 | 0.997 | 0.202 | 0.201 | 8.117 |
| 10 | 10:42 AM | 7.100 | 0.6 | 0.510 | 0.600 | 0.306 | 80 | 1.015 | 1.000 | 1.015 | 0.281 | 0.285 | 11.478 |
| 11 | 10:44 AM | 7.900 | 0.6 | 0.540 | 0.600 | 0.324 | 80 | 0.695 | 1.000 | 0.695 | 0.432 | 0.300 | 12.109 |
| 12 | 10:46 AM | 8.700 | 0.6 | 0.560 | 0.600 | 0.336 | 80 | 0.339 | 1.000 | 0.339 | 0.448 | 0.152 | 6.120 |
| 13 | 10:47 AM | 9.500 | 0.6 | 0.500 | 0.600 | 0.300 | 80 | 0.500 | 1.000 | 0.500 | 0.400 | 0.200 | 8.064 |
| 14 | 10:49 AM | 10.300 | 0.6 | 0.445 | 0.600 | 0.267 | 80 | 0.085 | 1.000 | 0.085 | 0.289 | 0.025 | 0.993 |
| 15 | 10:50 AM | 10.800 | 0.6 | 0.230 | 0.600 | 0.138 | 80 | -0.071 | -1.000 | 0.071 | 0.132 | 0.009 | 0.379 |
| 16 | 10:58 AM | 11.450 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.071 | 0.000 | 0.000 | 0.000 |



| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 1 | 10:29 AM | 1.500 | 0.6 | 0.220 | 0.600 | 0.132 | Velocity Angle > QC |
| 2 | 10:31 AM | 2.300 | 0.6 | 0.320 | 0.600 | 0.192 | Velocity Angle > QC |
| 3 | 10:32 AM | 3.100 | 0.6 | 0.410 | 0.600 | 0.246 | Standard Error > QC |
| 4 | 10:35 AM | 3.900 | 0.6 | 0.445 | 0.600 | 0.267 | Standard Error > QC,High Stn % Discharge |
| 5 | 10:37 AM | 4.700 | 0.6 | 0.470 | 0.600 | 0.282 | Standard Error > QC,High Stn % Discharge |
| 6 | 10:52 AM | 5.100 | 0.6 | 0.455 | 0.600 | 0.273 | Standard Error > QC,Velocity Angle > QC |
| 7 | 10:38 AM | 5.500 | 0.6 | 0.455 | 0.600 | 0.273 | Standard Error > QC,High Stn % Discharge |
| 8 | 10:40 AM | 6.300 | 0.6 | 0.460 | 0.600 | 0.276 | Standard Error > QC,Velocity Angle > QC,High Stn % Discharge |
| 9 | 10:56 AM | 6.800 | 0.6 | 0.505 | 0.600 | 0.303 | Standard Error > QC |
| 10 | 10:42 AM | 7.100 | 0.6 | 0.510 | 0.600 | 0.306 | Standard Error > QC,High Stn % Discharge |
| 11 | 10:44 AM | 7.900 | 0.6 | 0.540 | 0.600 | 0.324 | Standard Error > QC,High Stn % Discharge |
| 12 | 10:46 AM | 8.700 | 0.6 | 0.560 | 0.600 | 0.336 | Standard Error > QC |
| 13 | 10:47 AM | 9.500 | 0.6 | 0.500 | 0.600 | 0.300 | Standard Error > QC |
| 15 | 10:50 AM | 10.800 | 0.6 | 0.230 | 0.600 | 0.138 | Velocity Angle > QC |
| 16 | 10:58 AM | 11.450 | None | 0.000 | 0.000 | 0.000 | Water Depth > QC |

# Discharge Measurement Summary

### File Information

| | |
|---|---|
| File name | SC1_20191004.ft |
| Start date and time | 10/4/2019 2:18 PM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

### Discharge Summary

| | | | |
|---|---|---|---|
| Start time | 10/4/2019 2:19:27 PM | End time | 10/4/2019 2:46:17 PM |
| # Stations | 18 | Avg interval | 40 |
| Mean depth | 0.240 m | | |
| Mean velocity | 0.326 m/s | Total width | 9.600 m |
| Mean SNR | 43.240 dB | Total area | 2.308 m² |
| Mean temp | 13.747 °C | Total discharge | 0.752 m³/s |

### System Information

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

### Site Details

| | |
|---|---|
| Site name | Sc1 |
| Site number | |
| Operator(s) | Lj |
| Comment | |

### Discharge Uncertainty

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0% | 1.0% |
| Depth | 0.4% | 2.4% |
| Velocity | 0.8% | 6.7% |
| Width | 0.1% | 0.1% |
| Method | 2.2% | |
| # Stations | 2.8% | |
| Overall | 3.8% | 7.2% |

### Discharge Settings

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

### Station Warning Settings

| | | |
|---|---|---|
| Maximum station discharge | 10.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

### Summary overview

No changes were made to this file
Quality control warnings

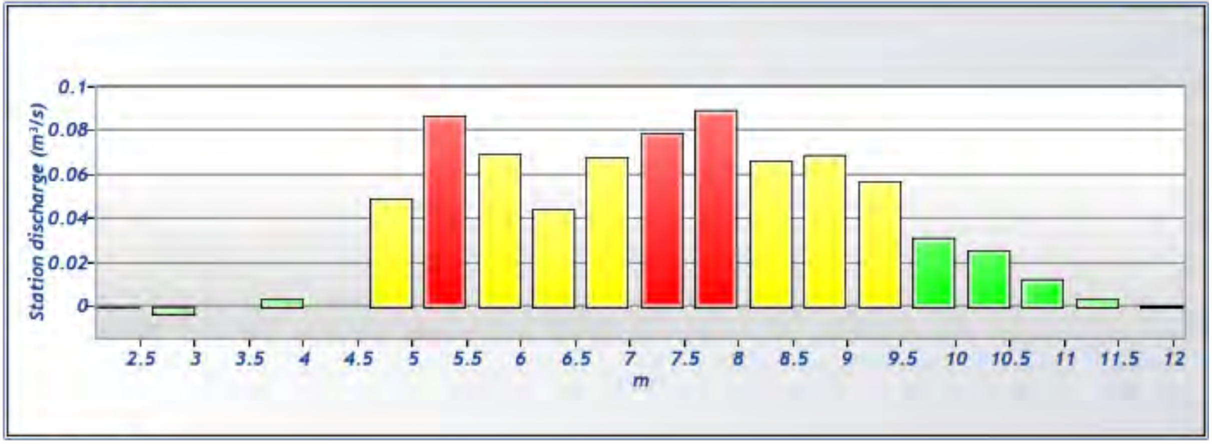
### Data Collection Settings

| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

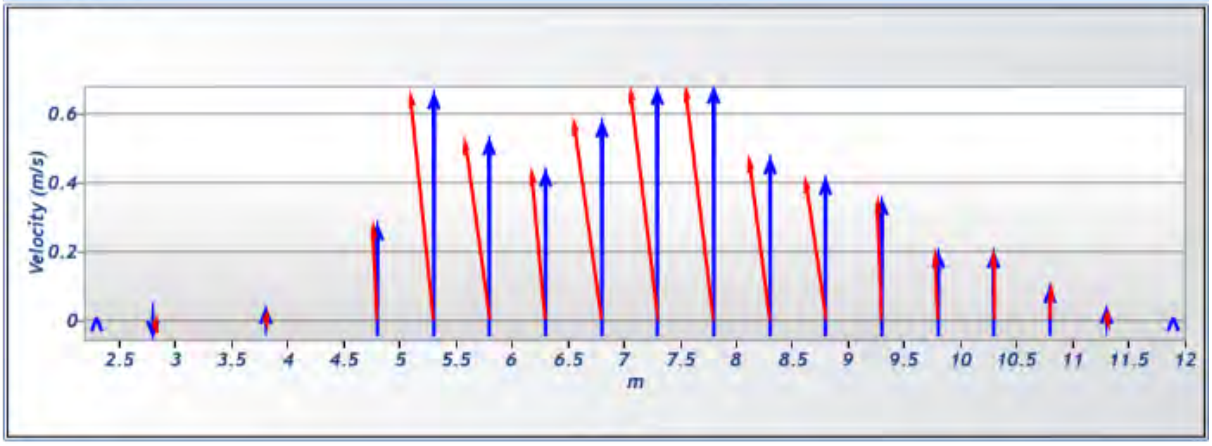
### Quality Control Settings

| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |

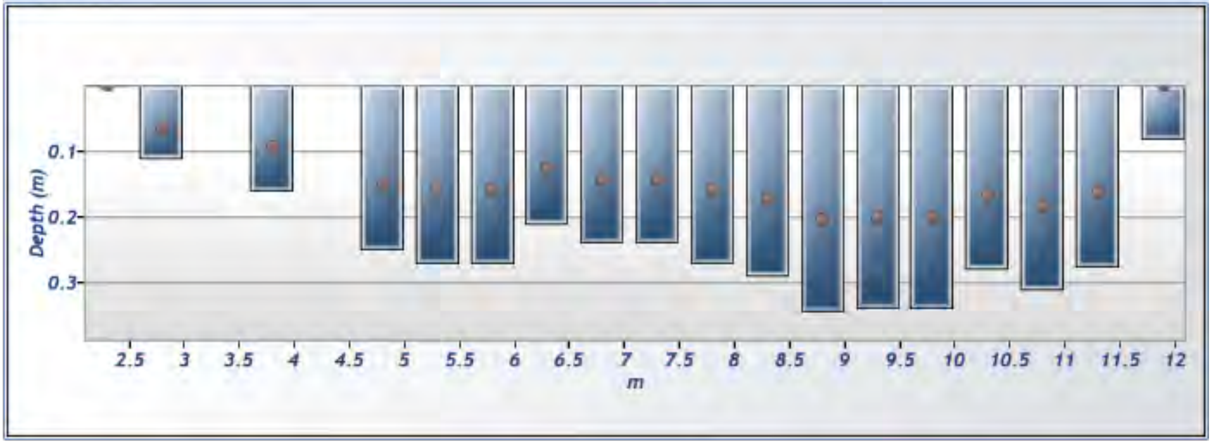
**Discharge chart**



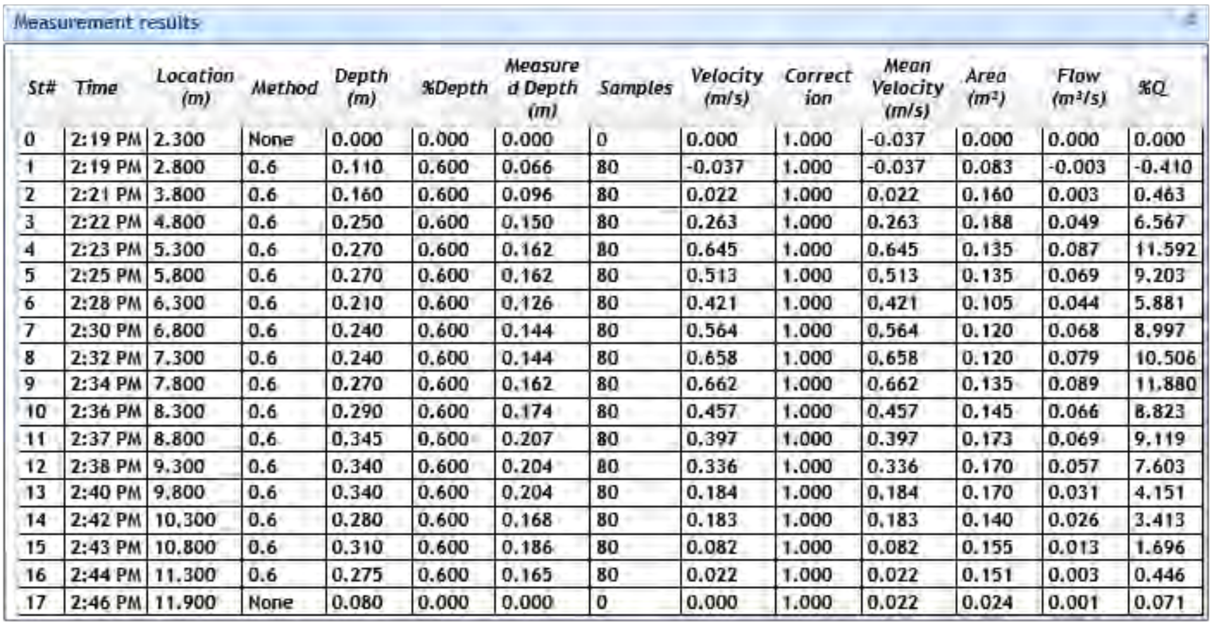
**Velocity chart**



**Depth chart**

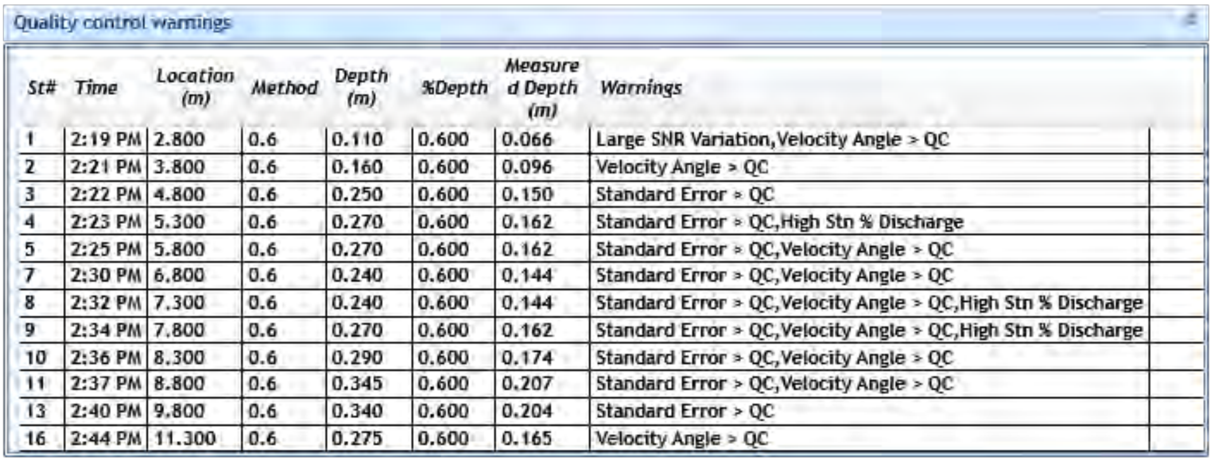


3/23/2020 10:22:22 AM



Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measure d Depth (m) | Samples | Velocity (m/s) | Correct ion | Mean Velocity (m/s) | Area ($m^2$) | Flow ($m^3/s$) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 2:19 PM | 2.300 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | -0.037 | 0.000 | 0.000 | 0.000 |
| 1 | 2:19 PM | 2.800 | 0.6 | 0.110 | 0.600 | 0.066 | 80 | -0.037 | 1.000 | -0.037 | 0.083 | -0.003 | -0.410 |
| 2 | 2:21 PM | 3.800 | 0.6 | 0.160 | 0.600 | 0.096 | 80 | 0.022 | 1.000 | 0.022 | 0.160 | 0.003 | 0.463 |
| 3 | 2:22 PM | 4.800 | 0.6 | 0.250 | 0.600 | 0.150 | 80 | 0.263 | 1.000 | 0.263 | 0.188 | 0.049 | 6.567 |
| 4 | 2:23 PM | 5.300 | 0.6 | 0.270 | 0.600 | 0.162 | 80 | 0.645 | 1.000 | 0.645 | 0.135 | 0.087 | 11.592 |
| 5 | 2:25 PM | 5.800 | 0.6 | 0.270 | 0.600 | 0.162 | 80 | 0.513 | 1.000 | 0.513 | 0.135 | 0.069 | 9.203 |
| 6 | 2:28 PM | 6.300 | 0.6 | 0.210 | 0.600 | 0.126 | 80 | 0.421 | 1.000 | 0.421 | 0.105 | 0.044 | 5.881 |
| 7 | 2:30 PM | 6.800 | 0.6 | 0.240 | 0.600 | 0.144 | 80 | 0.564 | 1.000 | 0.564 | 0.120 | 0.068 | 8.997 |
| 8 | 2:32 PM | 7.300 | 0.6 | 0.240 | 0.600 | 0.144 | 80 | 0.658 | 1.000 | 0.658 | 0.120 | 0.079 | 10.506 |
| 9 | 2:34 PM | 7.800 | 0.6 | 0.270 | 0.600 | 0.162 | 80 | 0.662 | 1.000 | 0.662 | 0.135 | 0.089 | 11.880 |
| 10 | 2:36 PM | 8.300 | 0.6 | 0.290 | 0.600 | 0.174 | 80 | 0.457 | 1.000 | 0.457 | 0.145 | 0.066 | 8.823 |
| 11 | 2:37 PM | 8.800 | 0.6 | 0.345 | 0.600 | 0.207 | 80 | 0.397 | 1.000 | 0.397 | 0.173 | 0.069 | 9.119 |
| 12 | 2:38 PM | 9.300 | 0.6 | 0.340 | 0.600 | 0.204 | 80 | 0.336 | 1.000 | 0.336 | 0.170 | 0.057 | 7.603 |
| 13 | 2:40 PM | 9.800 | 0.6 | 0.340 | 0.600 | 0.204 | 80 | 0.184 | 1.000 | 0.184 | 0.170 | 0.031 | 4.151 |
| 14 | 2:42 PM | 10.300 | 0.6 | 0.280 | 0.600 | 0.168 | 80 | 0.183 | 1.000 | 0.183 | 0.140 | 0.026 | 3.413 |
| 15 | 2:43 PM | 10.800 | 0.6 | 0.310 | 0.600 | 0.186 | 80 | 0.082 | 1.000 | 0.082 | 0.155 | 0.013 | 1.696 |
| 16 | 2:44 PM | 11.300 | 0.6 | 0.275 | 0.600 | 0.165 | 80 | 0.022 | 1.000 | 0.022 | 0.151 | 0.003 | 0.446 |
| 17 | 2:46 PM | 11.900 | None | 0.080 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.022 | 0.024 | 0.001 | 0.071 |



Quality control warnings

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 1 | 2:19 PM | 2.800 | 0.6 | 0.110 | 0.600 | 0.066 | Large SNR Variation,Velocity Angle > QC |
| 2 | 2:21 PM | 3.800 | 0.6 | 0.160 | 0.600 | 0.096 | Velocity Angle > QC |
| 3 | 2:22 PM | 4.800 | 0.6 | 0.250 | 0.600 | 0.150 | Standard Error > QC |
| 4 | 2:23 PM | 5.300 | 0.6 | 0.270 | 0.600 | 0.162 | Standard Error > QC,High Stn % Discharge |
| 5 | 2:25 PM | 5.800 | 0.6 | 0.270 | 0.600 | 0.162 | Standard Error > QC,Velocity Angle > QC |
| 7 | 2:30 PM | 6.800 | 0.6 | 0.240 | 0.600 | 0.144 | Standard Error > QC,Velocity Angle > QC |
| 8 | 2:32 PM | 7.300 | 0.6 | 0.240 | 0.600 | 0.144 | Standard Error > QC,Velocity Angle > QC,High Stn % Discharge |
| 9 | 2:34 PM | 7.800 | 0.6 | 0.270 | 0.600 | 0.162 | Standard Error > QC,Velocity Angle > QC,High Stn % Discharge |
| 10 | 2:36 PM | 8.300 | 0.6 | 0.290 | 0.600 | 0.174 | Standard Error > QC,Velocity Angle > QC |
| 11 | 2:37 PM | 8.800 | 0.6 | 0.345 | 0.600 | 0.207 | Standard Error > QC,Velocity Angle > QC |
| 13 | 2:40 PM | 9.800 | 0.6 | 0.340 | 0.600 | 0.204 | Standard Error > QC |
| 16 | 2:44 PM | 11.300 | 0.6 | 0.275 | 0.600 | 0.165 | Velocity Angle > QC |

4/9/2019 10:36:22 AM

# Discharge Measurement Summary

**File Information**

| | |
|---|---|
| File name | SC9_20190329.ft |
| Start date and time | 3/29/2019 10:34 AM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

**Discharge Summary**

| | | | |
|---|---|---|---|
| Start time | 3/29/2019 10:36:34 AM | End time | 3/29/2019 11:01:26 AM |
| # Stations | 14 | Avg interval | 40 |
| Mean depth | 0.184 m | | |
| Mean velocity | 0.231 m/s | Total width | 7.680 m |
| Mean SNR | 31.091 dB | Total area | 1.411 m² |
| Mean temp | 6.724 °C | Total discharge | 0.325 m³/s |

**System Information**

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

**Site Details**

| | |
|---|---|
| Site name | |
| Site number | SC9 |
| Operator(s) | JS |
| Comment | |

**Discharge Uncertainty**

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0 % | 1.0 % |
| Depth | 0.5 % | 3.2 % |
| Velocity | 0.6 % | 3.9 % |
| Width | 0.2 % | 0.2 % |
| Method | 2.4 % | |
| # Stations | 3.6 % | |
| Overall | 4.5 % | 5.2 % |

**Discharge Settings**

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

**Station Warning Settings**

| | | |
|---|---|---|
| Maximum station discharge | 15.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

**Summary overview**

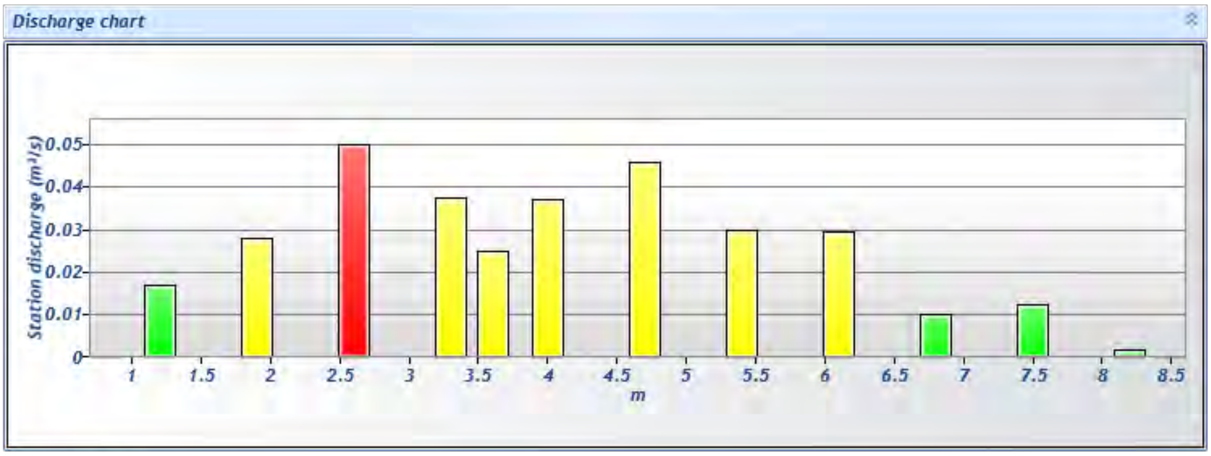
One or more quality control settings were changed
Quality control warnings

**Data Collection Settings**

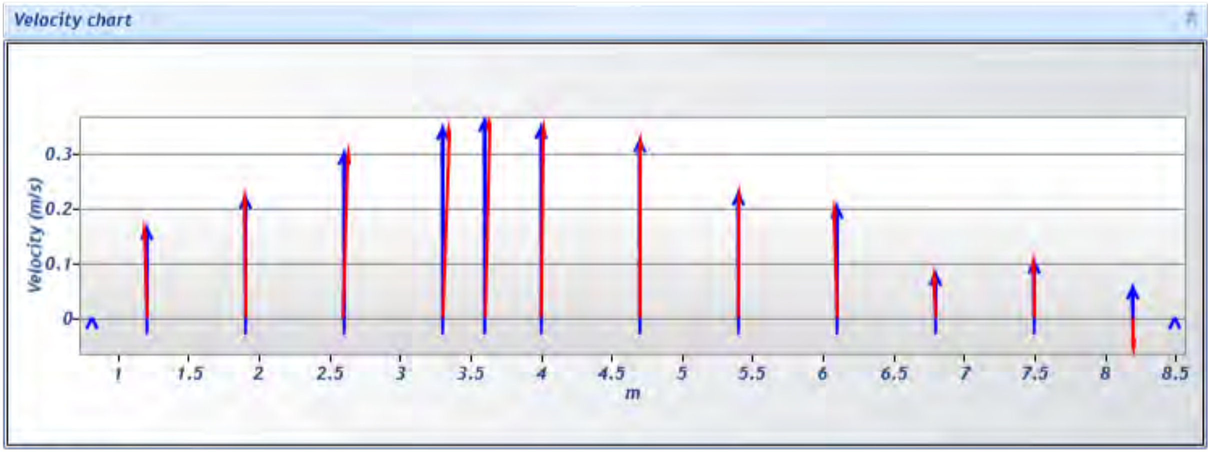
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

**Quality Control Settings**

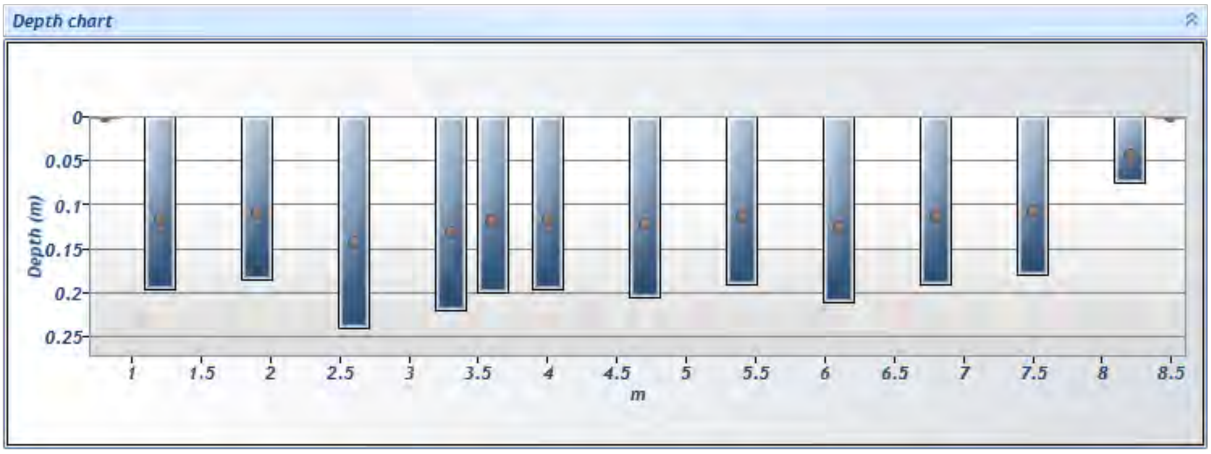
| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |



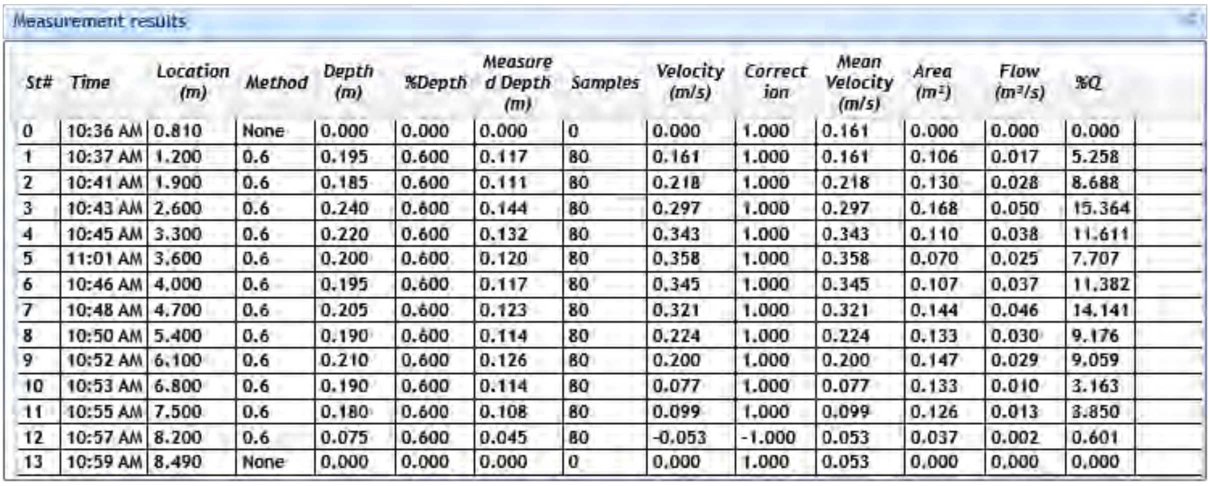
Discharge chart



Velocity chart

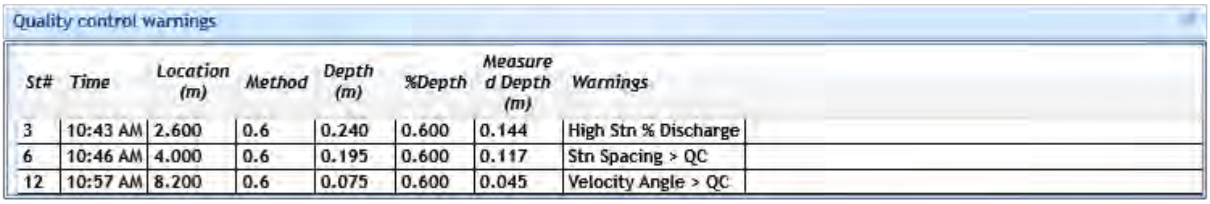


Depth chart



Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area ($m^2$) | Flow ($m^3/s$) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 10:36 AM | 0.810 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.161 | 0.000 | 0.000 | 0.000 |
| 1 | 10:37 AM | 1.200 | 0.6 | 0.195 | 0.600 | 0.117 | 80 | 0.161 | 1.000 | 0.161 | 0.106 | 0.017 | 5.258 |
| 2 | 10:41 AM | 1.900 | 0.6 | 0.185 | 0.600 | 0.111 | 80 | 0.218 | 1.000 | 0.218 | 0.130 | 0.028 | 8.688 |
| 3 | 10:43 AM | 2.600 | 0.6 | 0.240 | 0.600 | 0.144 | 80 | 0.297 | 1.000 | 0.297 | 0.168 | 0.050 | 15.364 |
| 4 | 10:45 AM | 3.300 | 0.6 | 0.220 | 0.600 | 0.132 | 80 | 0.343 | 1.000 | 0.343 | 0.110 | 0.038 | 11.611 |
| 5 | 11:01 AM | 3.600 | 0.6 | 0.200 | 0.600 | 0.120 | 80 | 0.358 | 1.000 | 0.358 | 0.070 | 0.025 | 7.707 |
| 6 | 10:46 AM | 4.000 | 0.6 | 0.195 | 0.600 | 0.117 | 80 | 0.345 | 1.000 | 0.345 | 0.107 | 0.037 | 11.382 |
| 7 | 10:48 AM | 4.700 | 0.6 | 0.205 | 0.600 | 0.123 | 80 | 0.321 | 1.000 | 0.321 | 0.144 | 0.046 | 14.141 |
| 8 | 10:50 AM | 5.400 | 0.6 | 0.190 | 0.600 | 0.114 | 80 | 0.224 | 1.000 | 0.224 | 0.133 | 0.030 | 9.176 |
| 9 | 10:52 AM | 6.100 | 0.6 | 0.210 | 0.600 | 0.126 | 80 | 0.200 | 1.000 | 0.200 | 0.147 | 0.029 | 9.059 |
| 10 | 10:53 AM | 6.800 | 0.6 | 0.190 | 0.600 | 0.114 | 80 | 0.077 | 1.000 | 0.077 | 0.133 | 0.010 | 3.163 |
| 11 | 10:55 AM | 7.500 | 0.6 | 0.180 | 0.600 | 0.108 | 80 | 0.099 | 1.000 | 0.099 | 0.126 | 0.013 | 3.850 |
| 12 | 10:57 AM | 8.200 | 0.6 | 0.075 | 0.600 | 0.045 | 80 | -0.053 | -1.000 | 0.053 | 0.037 | 0.002 | 0.601 |
| 13 | 10:59 AM | 8.490 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.053 | 0.000 | 0.000 | 0.000 |

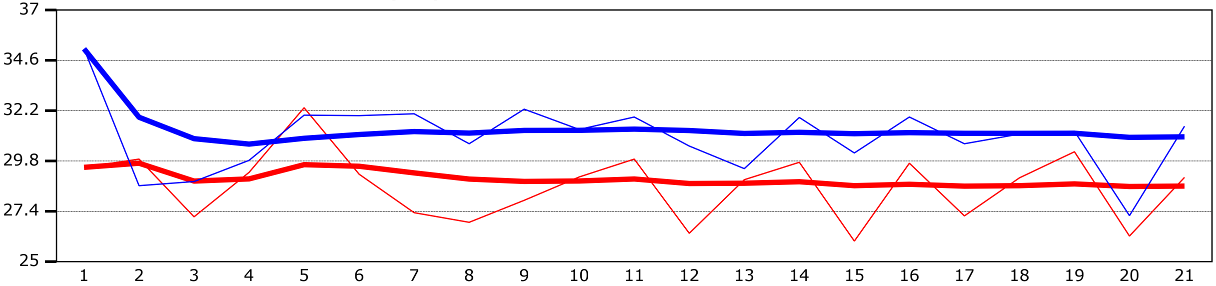


| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 3 | 10:43 AM | 2.600 | 0.6 | 0.240 | 0.600 | 0.144 | High Stn % Discharge |
| 6 | 10:46 AM | 4.000 | 0.6 | 0.195 | 0.600 | 0.117 | Stn Spacing > QC |
| 12 | 10:57 AM | 8.200 | 0.6 | 0.075 | 0.600 | 0.045 | Velocity Angle > QC |

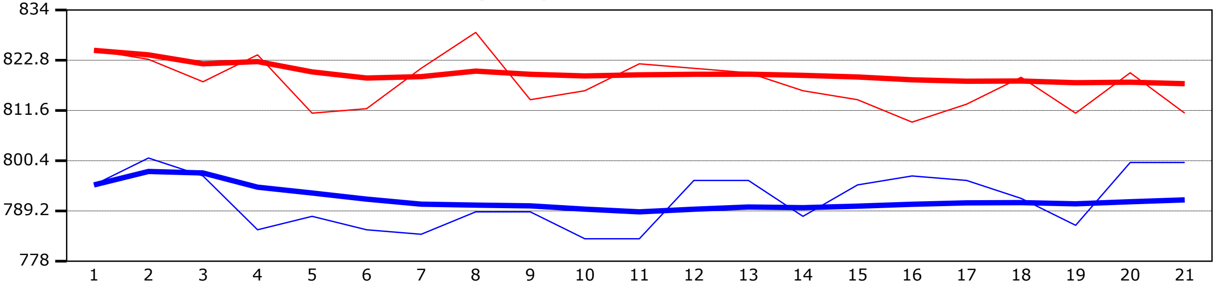
4/9/2019 10:36:22 AM

Automated beam check Start time 3/29/2019 10:36:08 AM

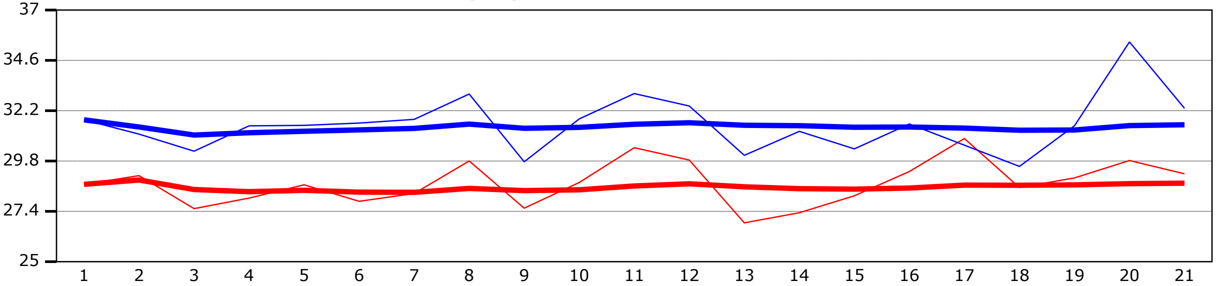
Automated beam check SNR(dB)



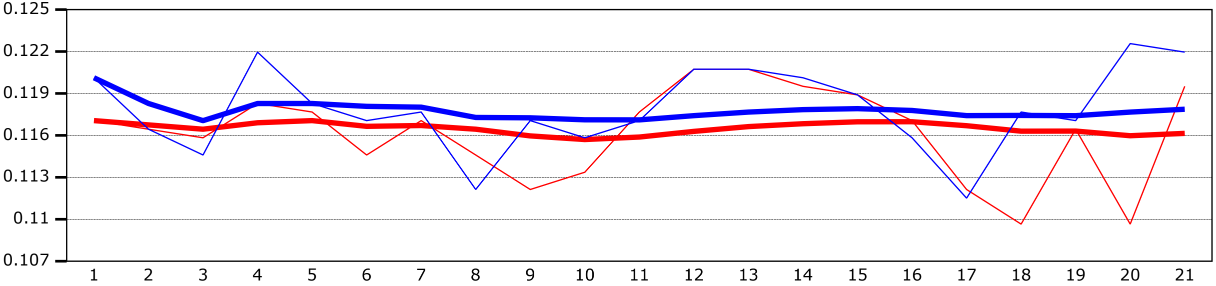
Automated beam check Noise level(cnts)



Automated beam check Peak level(dB)



Automated beam check Peak position(m)



Automated beam check Quality control warnings

No quality control warnings

# Discharge Measurement Summary

### File Information

| | |
|---|---|
| File name | SC9_20190415.ft |
| Start date and time | 4/15/2019 9:34 AM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

### Discharge Summary

| | | | | | |
|---|---|---|---|---|---|
| Start time | 4/15/2019 9:35:28 AM | | End time | 4/15/2019 9:53:29 AM | |
| # Stations | 14 | | Avg interval | 40 | |
| Mean depth | 0.317 | m | | | |
| Mean velocity | 0.378 | m/s | Total width | 7.750 | m |
| Mean SNR | 33.211 | dB | Total area | 2.457 | m² |
| Mean temp | 4.906 | °C | Total discharge | 0.928 | m³/s |

### System Information

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

### Site Details

| | |
|---|---|
| Site name | Kswm |
| Site number | SC9 |
| Operator(s) | JS |
| Comment | |

### Discharge Uncertainty

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0% | 1.0% |
| Depth | 0.2% | 2.6% |
| Velocity | 0.5% | 2.7% |
| Width | 0.2% | 0.2% |
| Method | 2.3% | |
| # Stations | 3.6% | |
| Overall | 4.4% | 3.8% |

### Discharge Settings

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

### Station Warning Settings

| | | |
|---|---|---|
| Maximum station discharge | 10.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

### Summary overview

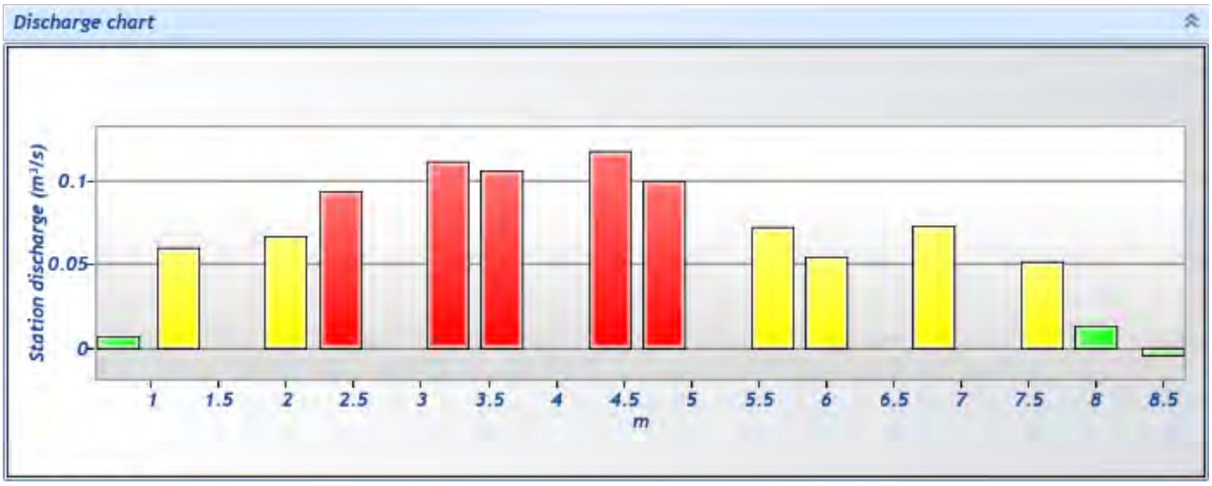
No changes were made to this file
Quality control warnings

### Data Collection Settings

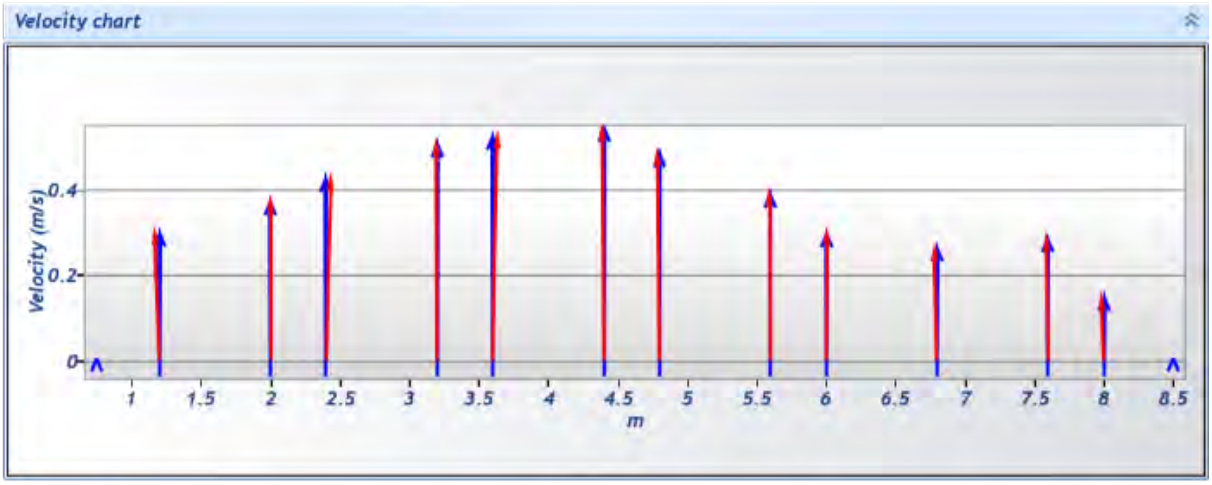
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

### Quality Control Settings

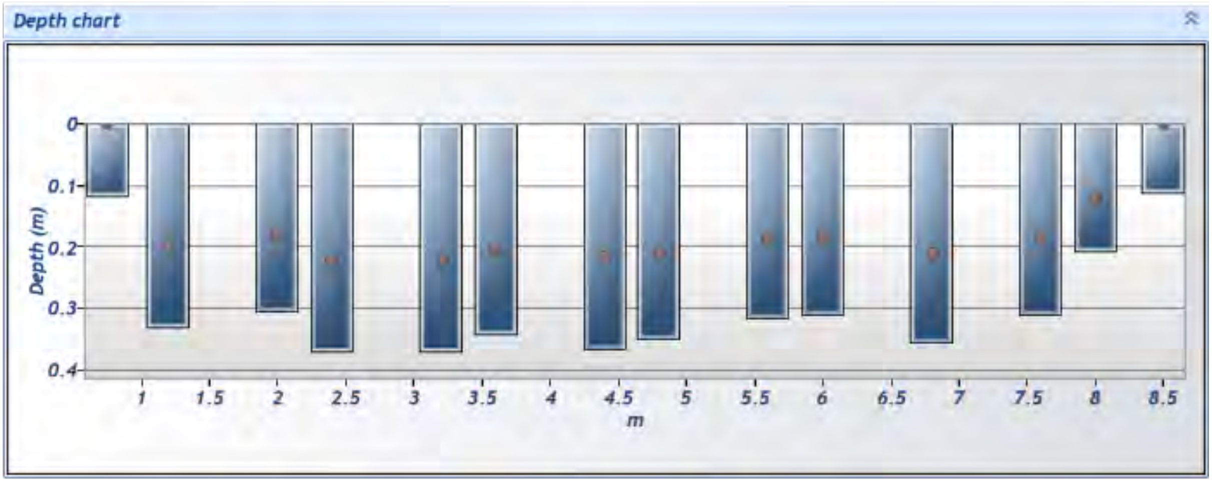
| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |



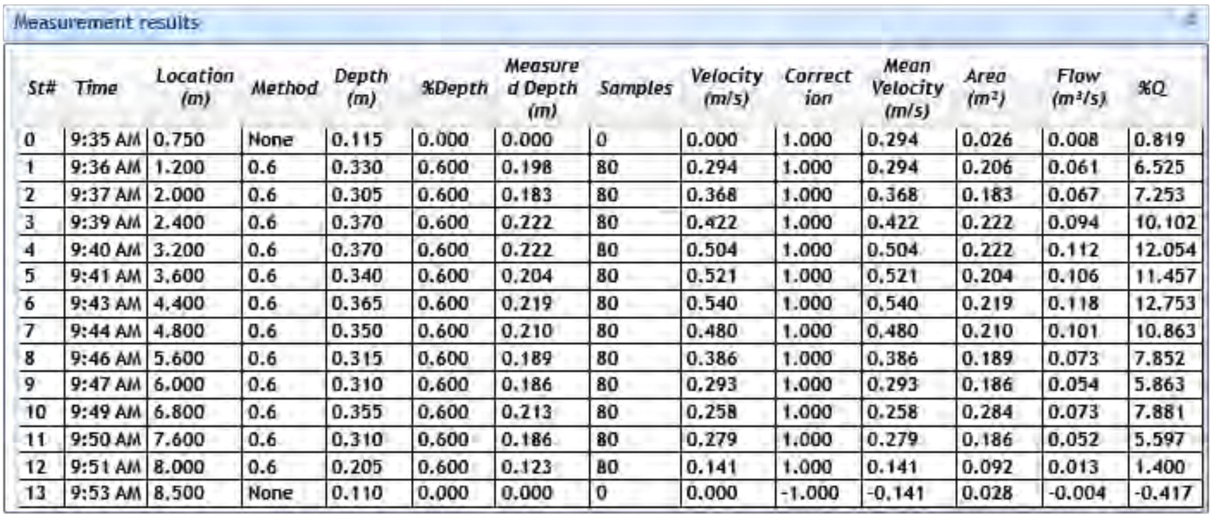
Discharge chart



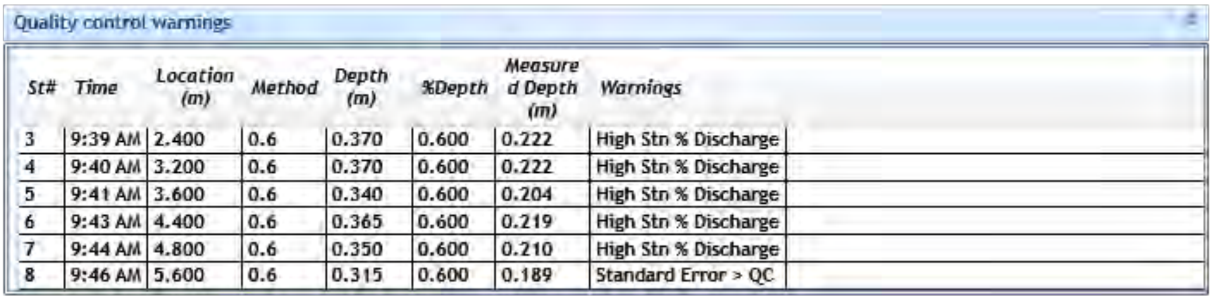
Velocity chart



Depth chart



| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area (m²) | Flow (m³/s) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 9:35 AM | 0.750 | None | 0.115 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.294 | 0.026 | 0.008 | 0.819 |
| 1 | 9:36 AM | 1.200 | 0.6 | 0.330 | 0.600 | 0.198 | 80 | 0.294 | 1.000 | 0.294 | 0.206 | 0.061 | 6.525 |
| 2 | 9:37 AM | 2.000 | 0.6 | 0.305 | 0.600 | 0.183 | 80 | 0.368 | 1.000 | 0.368 | 0.183 | 0.067 | 7.253 |
| 3 | 9:39 AM | 2.400 | 0.6 | 0.370 | 0.600 | 0.222 | 80 | 0.422 | 1.000 | 0.422 | 0.222 | 0.094 | 10.102 |
| 4 | 9:40 AM | 3.200 | 0.6 | 0.370 | 0.600 | 0.222 | 80 | 0.504 | 1.000 | 0.504 | 0.222 | 0.112 | 12.054 |
| 5 | 9:41 AM | 3.600 | 0.6 | 0.340 | 0.600 | 0.204 | 80 | 0.521 | 1.000 | 0.521 | 0.204 | 0.106 | 11.457 |
| 6 | 9:43 AM | 4.400 | 0.6 | 0.365 | 0.600 | 0.219 | 80 | 0.540 | 1.000 | 0.540 | 0.219 | 0.118 | 12.753 |
| 7 | 9:44 AM | 4.800 | 0.6 | 0.350 | 0.600 | 0.210 | 80 | 0.480 | 1.000 | 0.480 | 0.210 | 0.101 | 10.863 |
| 8 | 9:46 AM | 5.600 | 0.6 | 0.315 | 0.600 | 0.189 | 80 | 0.386 | 1.000 | 0.386 | 0.189 | 0.073 | 7.852 |
| 9 | 9:47 AM | 6.000 | 0.6 | 0.310 | 0.600 | 0.186 | 80 | 0.293 | 1.000 | 0.293 | 0.186 | 0.054 | 5.863 |
| 10 | 9:49 AM | 6.800 | 0.6 | 0.355 | 0.600 | 0.213 | 80 | 0.258 | 1.000 | 0.258 | 0.284 | 0.073 | 7.881 |
| 11 | 9:50 AM | 7.600 | 0.6 | 0.310 | 0.600 | 0.186 | 80 | 0.279 | 1.000 | 0.279 | 0.186 | 0.052 | 5.597 |
| 12 | 9:51 AM | 8.000 | 0.6 | 0.205 | 0.600 | 0.123 | 80 | 0.141 | 1.000 | 0.141 | 0.092 | 0.013 | 1.400 |
| 13 | 9:53 AM | 8.500 | None | 0.110 | 0.000 | 0.000 | 0 | 0.000 | -1.000 | -0.141 | 0.028 | -0.004 | -0.417 |



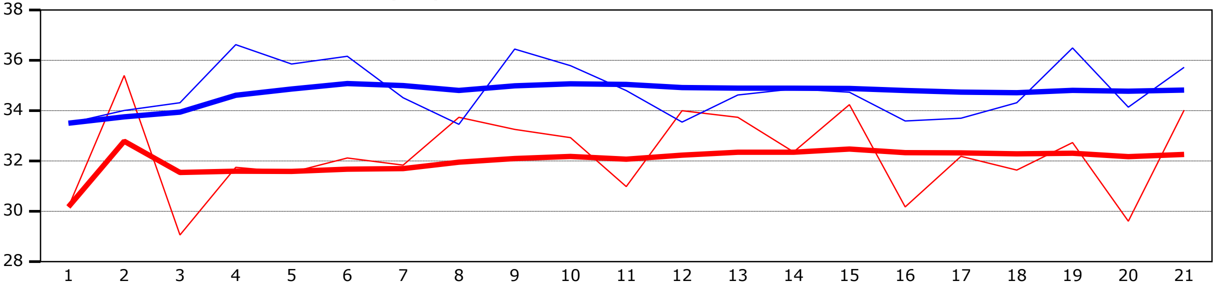
Quality control warnings

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 3 | 9:39 AM | 2.400 | 0.6 | 0.370 | 0.600 | 0.222 | High Stn % Discharge |
| 4 | 9:40 AM | 3.200 | 0.6 | 0.370 | 0.600 | 0.222 | High Stn % Discharge |
| 5 | 9:41 AM | 3.600 | 0.6 | 0.340 | 0.600 | 0.204 | High Stn % Discharge |
| 6 | 9:43 AM | 4.400 | 0.6 | 0.365 | 0.600 | 0.219 | High Stn % Discharge |
| 7 | 9:44 AM | 4.800 | 0.6 | 0.350 | 0.600 | 0.210 | High Stn % Discharge |
| 8 | 9:46 AM | 5.600 | 0.6 | 0.315 | 0.600 | 0.189 | Standard Error > QC |

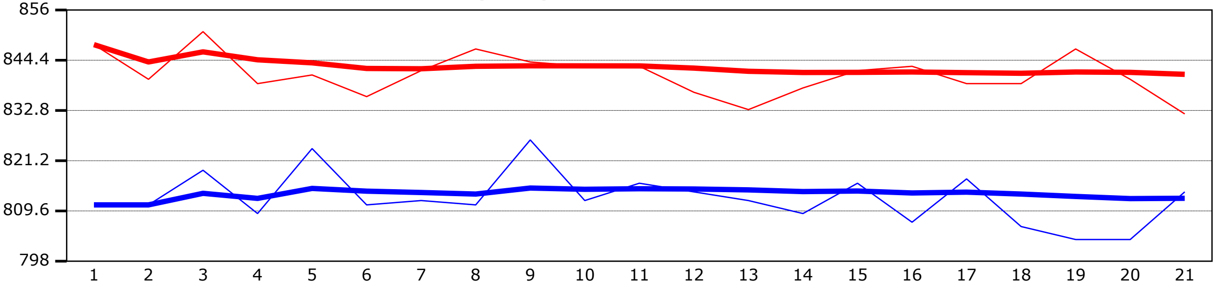
3/23/2020 10:03:32 AM

Automated beam check Start time 4/15/2019 9:35:02 AM

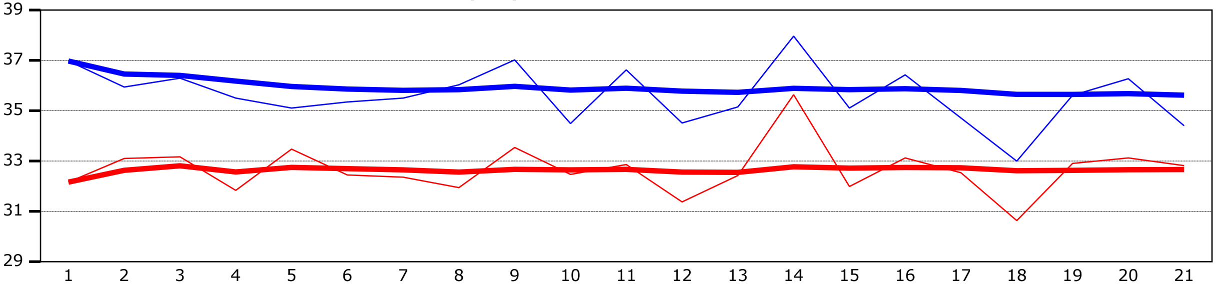
Automated beam check SNR(dB)



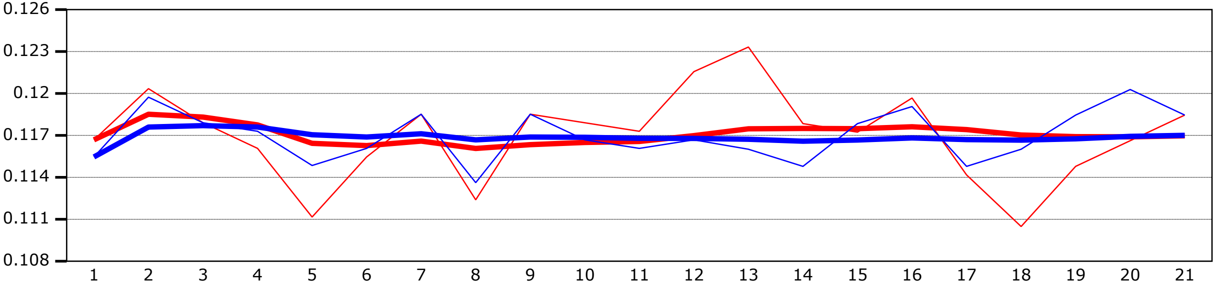
Automated beam check Noise level(cnts)



Automated beam check Peak level(dB)



Automated beam check Peak position(m)

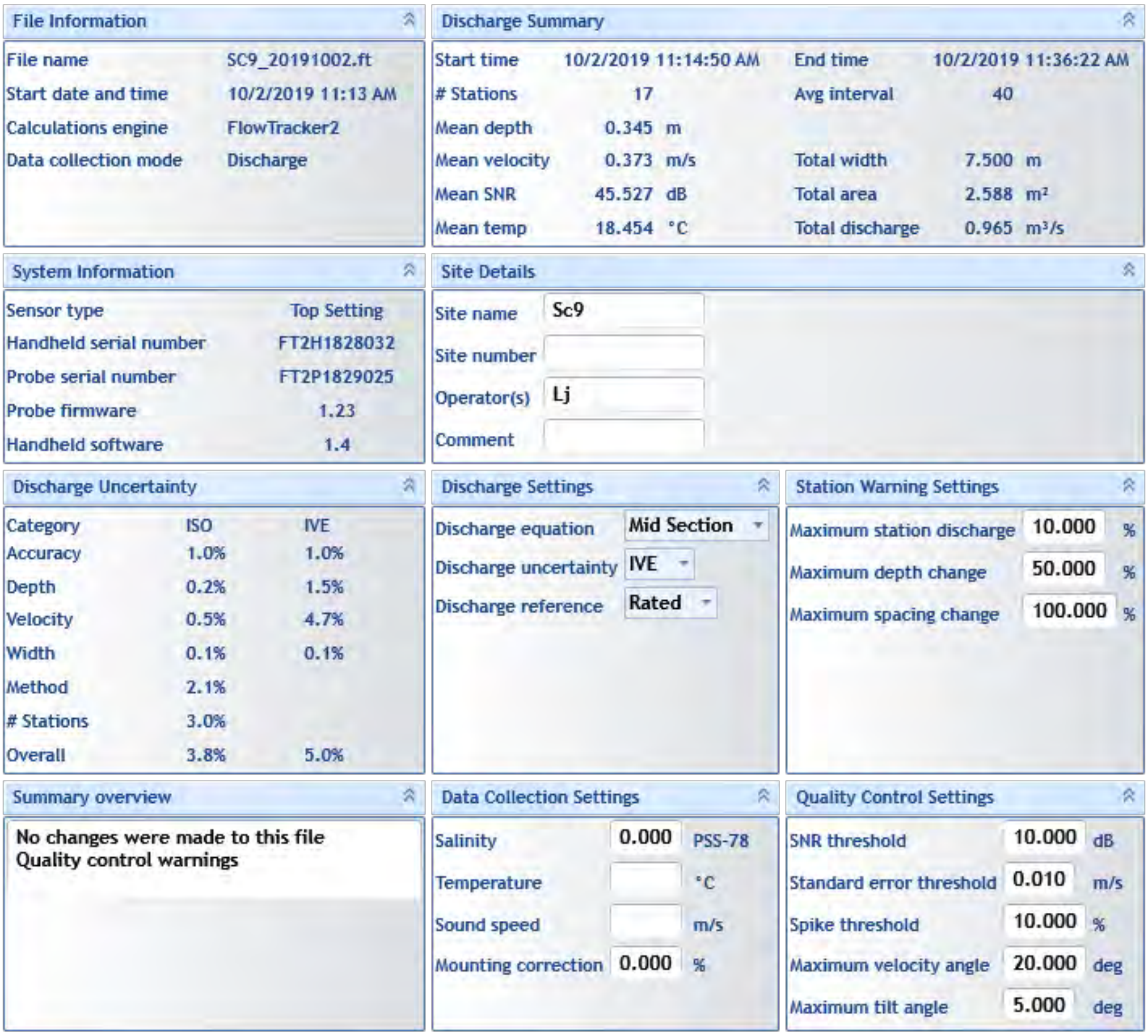


Automated beam check Quality control warnings

No quality control warnings

FlowTracker2

# Discharge Measurement Summary



**File Information**

| | |
|---|---|
| File name | SC9_20191002.ft |
| Start date and time | 10/2/2019 11:13 AM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

**Discharge Summary**

| | | | |
|---|---|---|---|
| Start time | 10/2/2019 11:14:50 AM | End time | 10/2/2019 11:36:22 AM |
| # Stations | 17 | Avg interval | 40 |
| Mean depth | 0.345 m | | |
| Mean velocity | 0.373 m/s | Total width | 7.500 m |
| Mean SNR | 45.527 dB | Total area | 2.588 m² |
| Mean temp | 18.454 °C | Total discharge | 0.965 m³/s |

**System Information**

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

**Site Details**

| | |
|---|---|
| Site name | Sc9 |
| Site number | |
| Operator(s) | Lj |
| Comment | |

**Discharge Uncertainty**

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0% | 1.0% |
| Depth | 0.2% | 1.5% |
| Velocity | 0.5% | 4.7% |
| Width | 0.1% | 0.1% |
| Method | 2.1% | |
| # Stations | 3.0% | |
| Overall | 3.8% | 5.0% |

**Discharge Settings**

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

**Station Warning Settings**

| | | |
|---|---|---|
| Maximum station discharge | 10.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

**Summary overview**

No changes were made to this file
Quality control warnings

**Data Collection Settings**

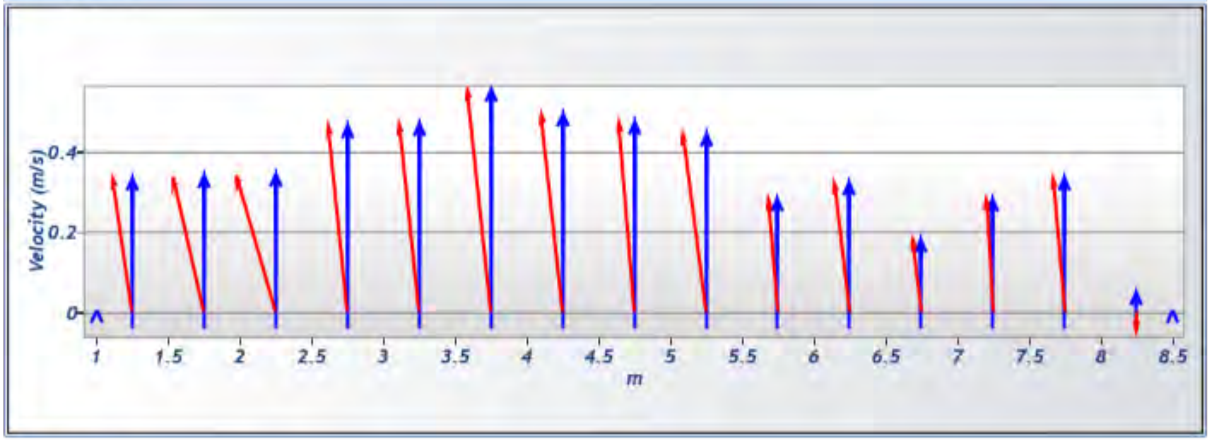
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

**Quality Control Settings**

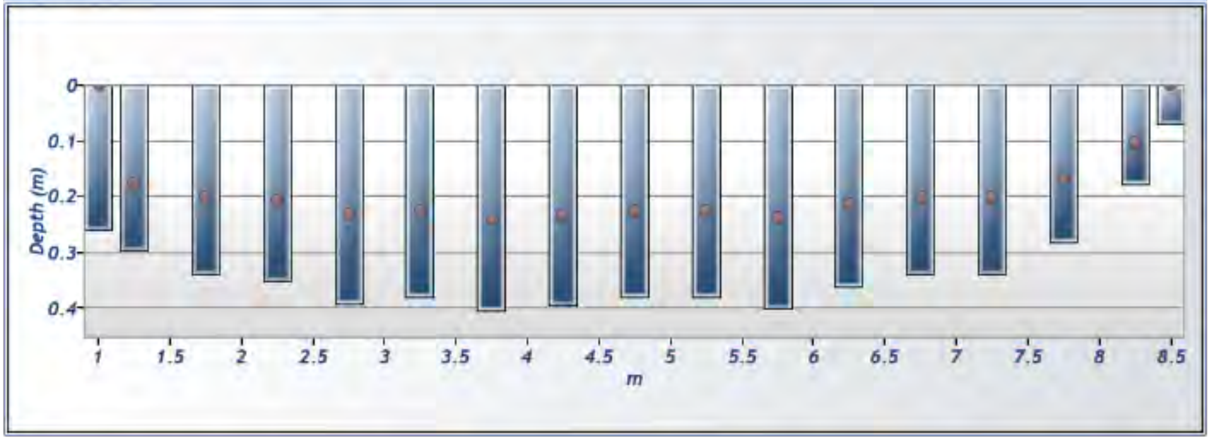
| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |

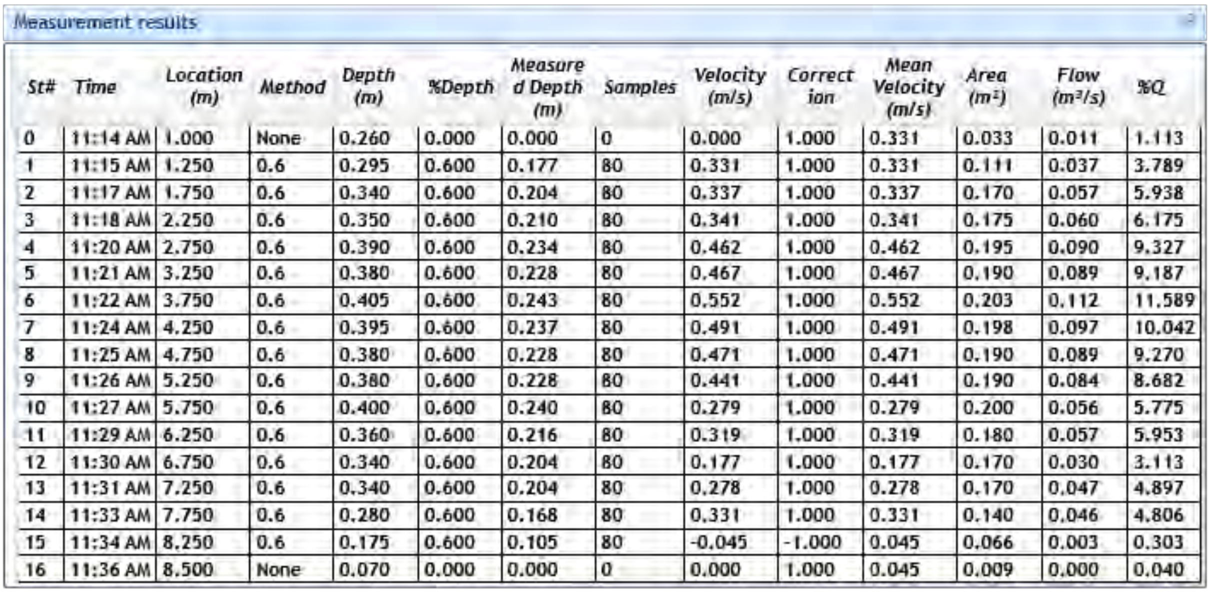
**Discharge chart**

**Velocity chart**



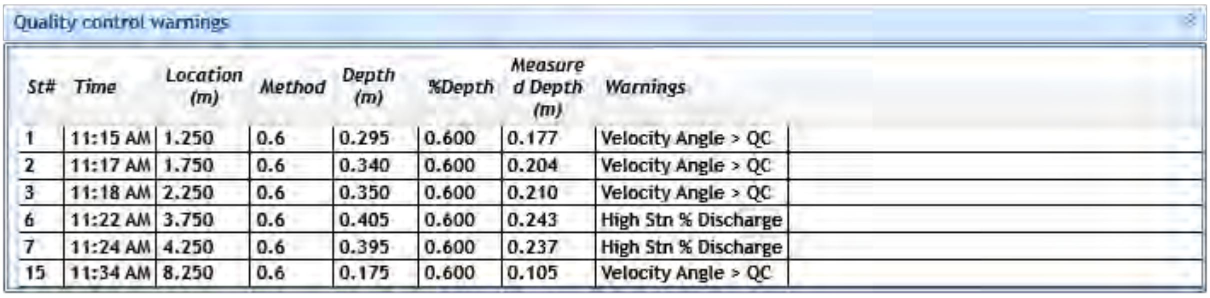
**Depth chart**





Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area $(m^2)$ | Flow $(m^3/s)$ | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 11:14 AM | 1.000 | None | 0.260 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.331 | 0.033 | 0.011 | 1.113 |
| 1 | 11:15 AM | 1.250 | 0.6 | 0.295 | 0.600 | 0.177 | 80 | 0.331 | 1.000 | 0.331 | 0.111 | 0.037 | 3.789 |
| 2 | 11:17 AM | 1.750 | 0.6 | 0.340 | 0.600 | 0.204 | 80 | 0.337 | 1.000 | 0.337 | 0.170 | 0.057 | 5.938 |
| 3 | 11:18 AM | 2.250 | 0.6 | 0.350 | 0.600 | 0.210 | 80 | 0.341 | 1.000 | 0.341 | 0.175 | 0.060 | 6.175 |
| 4 | 11:20 AM | 2.750 | 0.6 | 0.390 | 0.600 | 0.234 | 80 | 0.462 | 1.000 | 0.462 | 0.195 | 0.090 | 9.327 |
| 5 | 11:21 AM | 3.250 | 0.6 | 0.380 | 0.600 | 0.228 | 80 | 0.467 | 1.000 | 0.467 | 0.190 | 0.089 | 9.187 |
| 6 | 11:22 AM | 3.750 | 0.6 | 0.405 | 0.600 | 0.243 | 80 | 0.552 | 1.000 | 0.552 | 0.203 | 0.112 | 11.589 |
| 7 | 11:24 AM | 4.250 | 0.6 | 0.395 | 0.600 | 0.237 | 80 | 0.491 | 1.000 | 0.491 | 0.198 | 0.097 | 10.042 |
| 8 | 11:25 AM | 4.750 | 0.6 | 0.380 | 0.600 | 0.228 | 80 | 0.471 | 1.000 | 0.471 | 0.190 | 0.089 | 9.270 |
| 9 | 11:26 AM | 5.250 | 0.6 | 0.380 | 0.600 | 0.228 | 80 | 0.441 | 1.000 | 0.441 | 0.190 | 0.084 | 8.682 |
| 10 | 11:27 AM | 5.750 | 0.6 | 0.400 | 0.600 | 0.240 | 80 | 0.279 | 1.000 | 0.279 | 0.200 | 0.056 | 5.775 |
| 11 | 11:29 AM | 6.250 | 0.6 | 0.360 | 0.600 | 0.216 | 80 | 0.319 | 1.000 | 0.319 | 0.180 | 0.057 | 5.953 |
| 12 | 11:30 AM | 6.750 | 0.6 | 0.340 | 0.600 | 0.204 | 80 | 0.177 | 1.000 | 0.177 | 0.170 | 0.030 | 3.113 |
| 13 | 11:31 AM | 7.250 | 0.6 | 0.340 | 0.600 | 0.204 | 80 | 0.278 | 1.000 | 0.278 | 0.170 | 0.047 | 4.897 |
| 14 | 11:33 AM | 7.750 | 0.6 | 0.280 | 0.600 | 0.168 | 80 | 0.331 | 1.000 | 0.331 | 0.140 | 0.046 | 4.806 |
| 15 | 11:34 AM | 8.250 | 0.6 | 0.175 | 0.600 | 0.105 | 80 | -0.045 | -1.000 | 0.045 | 0.066 | 0.003 | 0.303 |
| 16 | 11:36 AM | 8.500 | None | 0.070 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.045 | 0.009 | 0.000 | 0.040 |

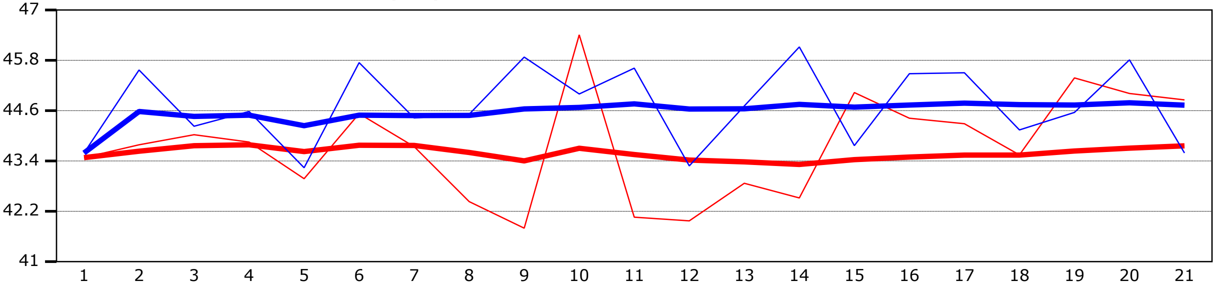


| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 1 | 11:15 AM | 1.250 | 0.6 | 0.295 | 0.600 | 0.177 | Velocity Angle > QC |
| 2 | 11:17 AM | 1.750 | 0.6 | 0.340 | 0.600 | 0.204 | Velocity Angle > QC |
| 3 | 11:18 AM | 2.250 | 0.6 | 0.350 | 0.600 | 0.210 | Velocity Angle > QC |
| 6 | 11:22 AM | 3.750 | 0.6 | 0.405 | 0.600 | 0.243 | High Stn % Discharge |
| 7 | 11:24 AM | 4.250 | 0.6 | 0.395 | 0.600 | 0.237 | High Stn % Discharge |
| 15 | 11:34 AM | 8.250 | 0.6 | 0.175 | 0.600 | 0.105 | Velocity Angle > QC |

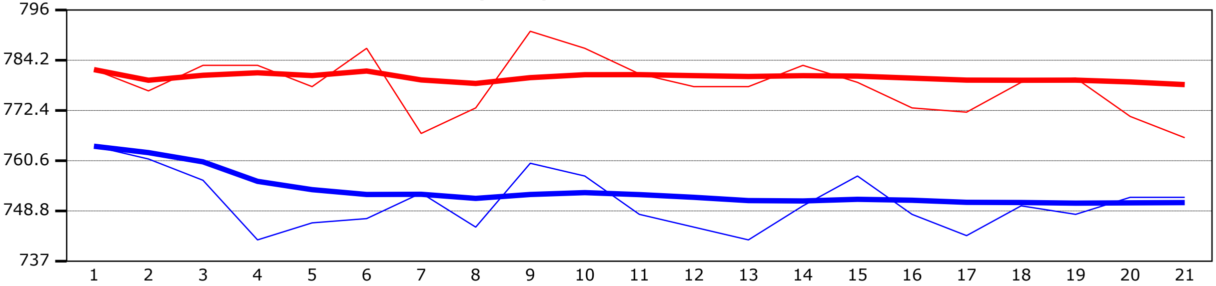
3/23/2020 10:20:29 AM

Automated beam check Start time 10/2/2019 11:14:16 AM

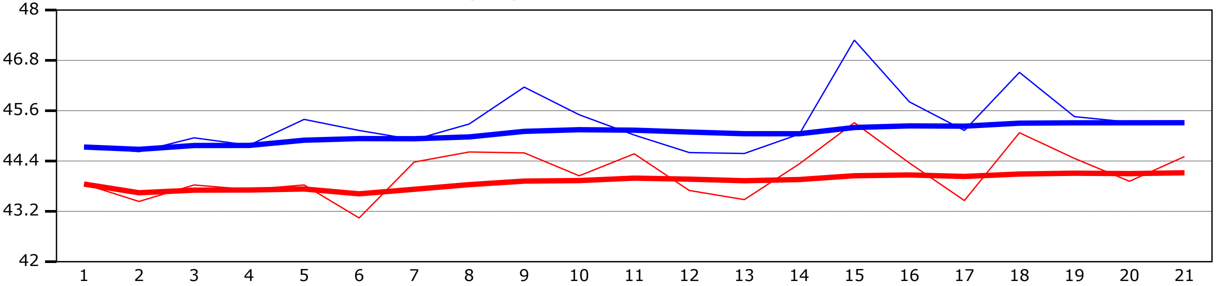
Automated beam check SNR(dB)



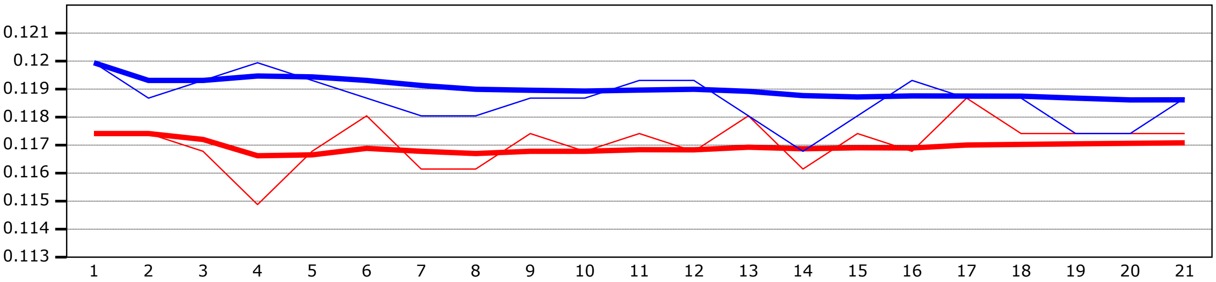
Automated beam check Noise level(cnts)



Automated beam check Peak level(dB)



Automated beam check Peak position(m)

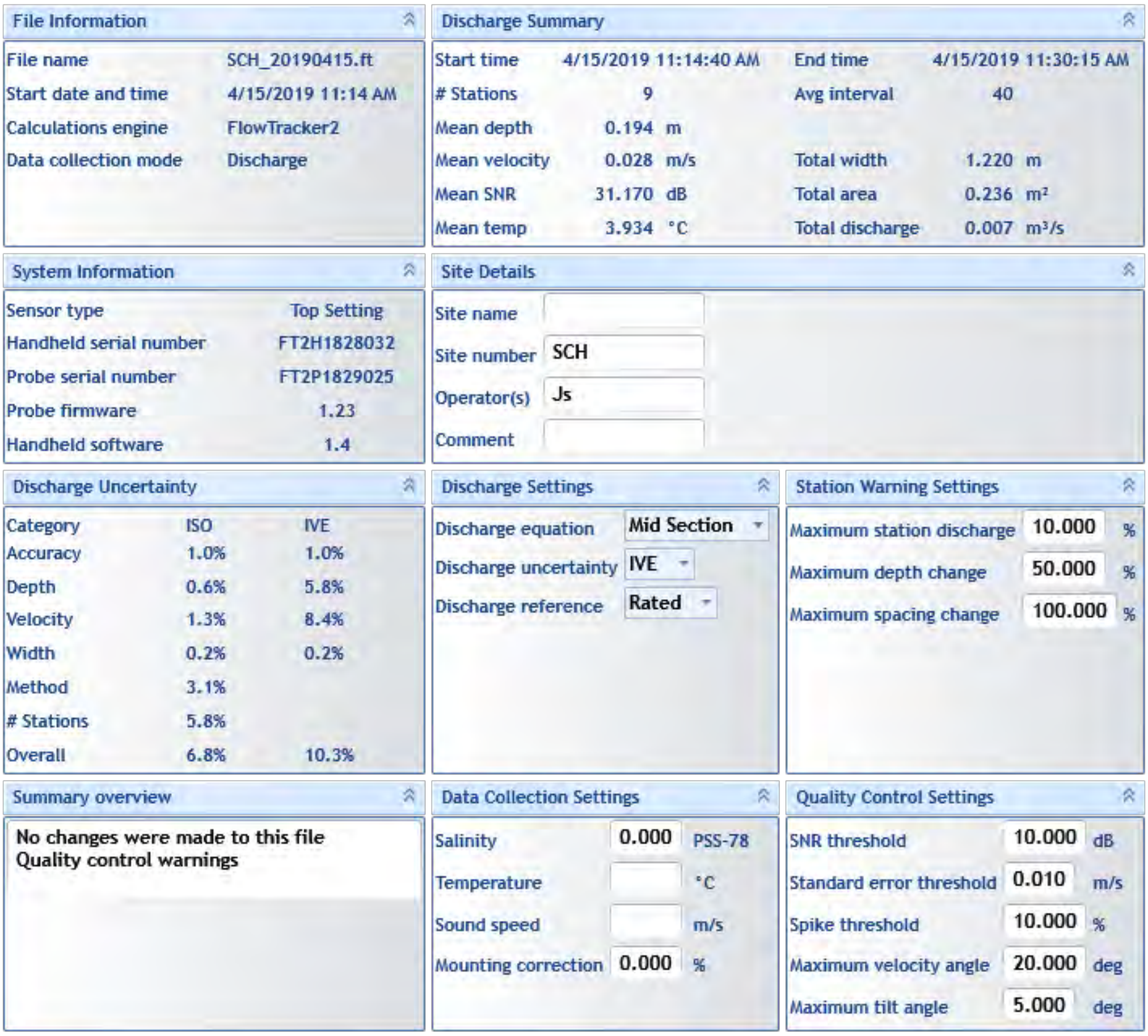


Automated beam check Quality control warnings

No quality control warnings

3/23/2020 10:04:18 AM

# Discharge Measurement Summary



**File Information**

| | |
|---|---|
| File name | SCH_20190415.ft |
| Start date and time | 4/15/2019 11:14 AM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

**Discharge Summary**

| | | | | | |
|---|---|---|---|---|---|
| Start time | 4/15/2019 11:14:40 AM | | End time | 4/15/2019 11:30:15 AM | |
| # Stations | 9 | | Avg interval | 40 | |
| Mean depth | 0.194 | m | | | |
| Mean velocity | 0.028 | m/s | Total width | 1.220 | m |
| Mean SNR | 31.170 | dB | Total area | 0.236 | m² |
| Mean temp | 3.934 | °C | Total discharge | 0.007 | m³/s |

**System Information**

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

**Site Details**

| | |
|---|---|
| Site name | |
| Site number | SCH |
| Operator(s) | Js |
| Comment | |

**Discharge Uncertainty**

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0% | 1.0% |
| Depth | 0.6% | 5.8% |
| Velocity | 1.3% | 8.4% |
| Width | 0.2% | 0.2% |
| Method | 3.1% | |
| # Stations | 5.8% | |
| Overall | 6.8% | 10.3% |

**Discharge Settings**

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

**Station Warning Settings**

| | | |
|---|---|---|
| Maximum station discharge | 10.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

**Summary overview**

No changes were made to this file
Quality control warnings

**Data Collection Settings**

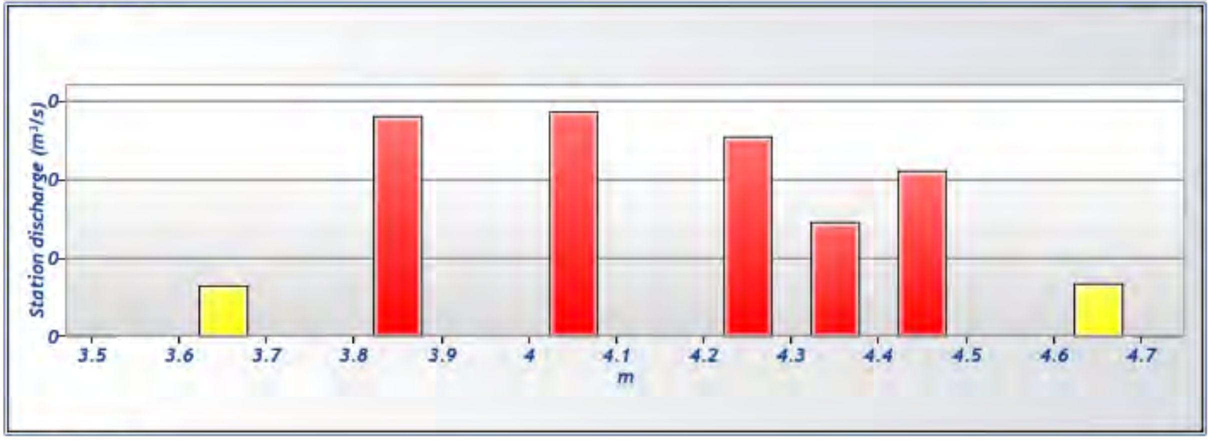
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

**Quality Control Settings**

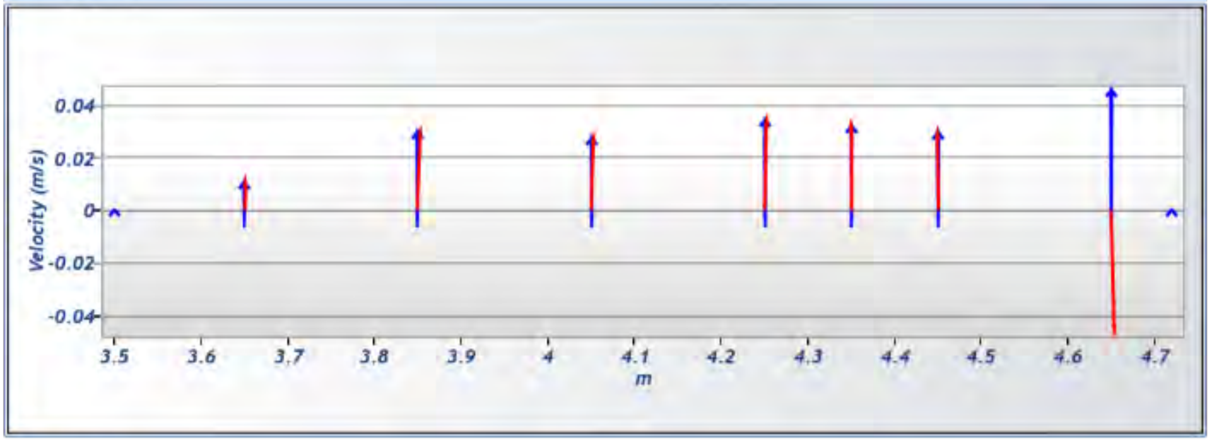
| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |

3/23/2020 10:04:18 AM

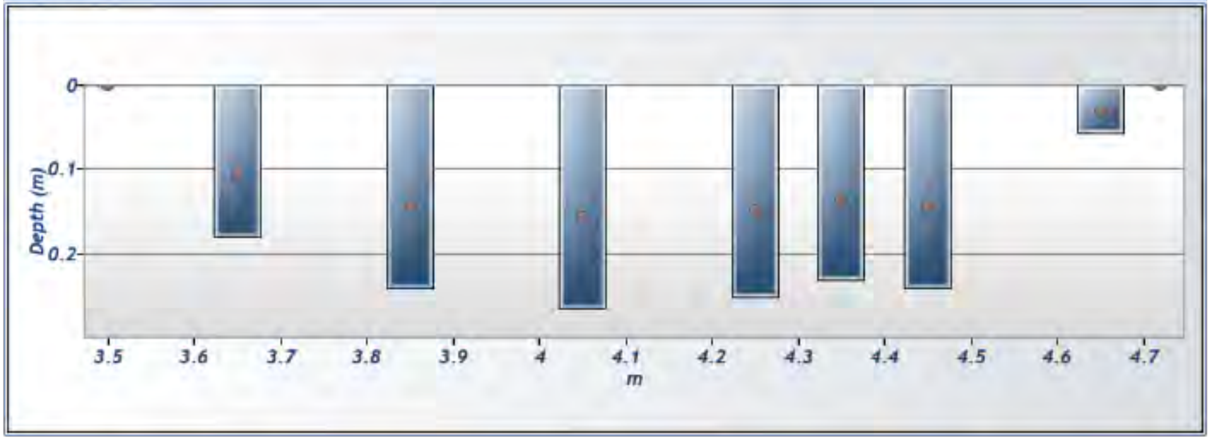
Discharge chart



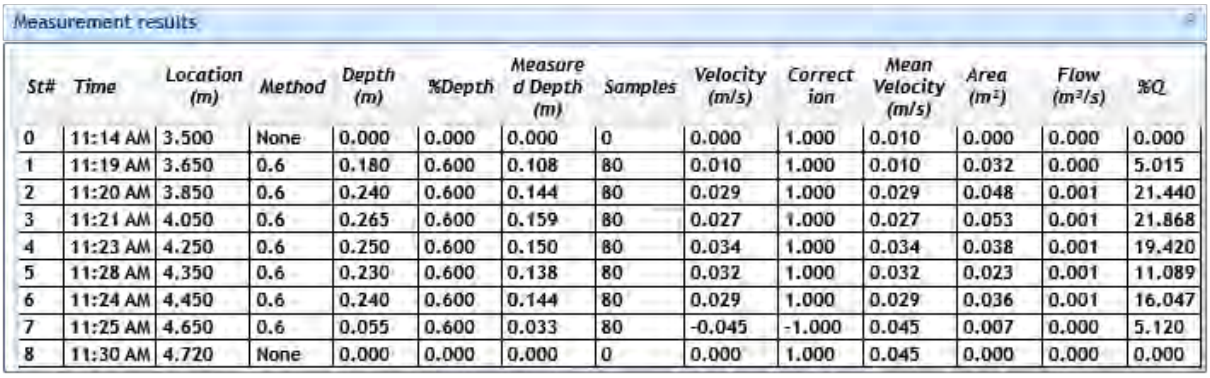
Velocity chart



Depth chart



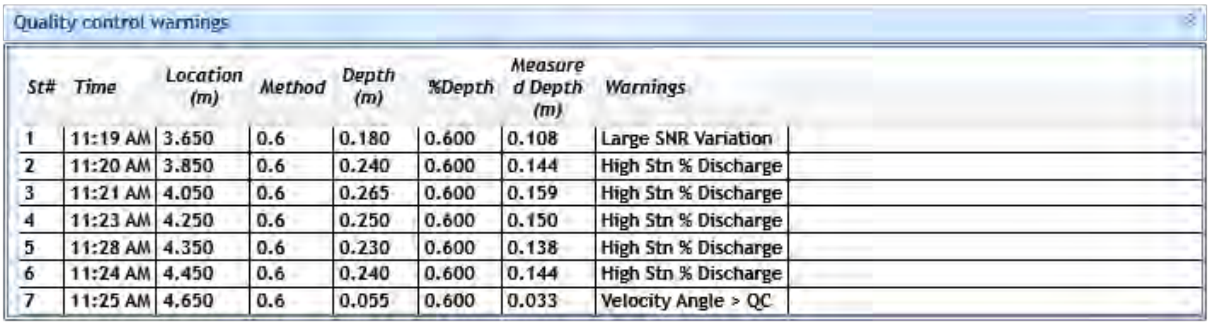
3/23/2020 10:04:18 AM



Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area ($m^2$) | Flow ($m^3/s$) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 11:14 AM | 3.500 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.010 | 0.000 | 0.000 | 0.000 |
| 1 | 11:19 AM | 3.650 | 0.6 | 0.180 | 0.600 | 0.108 | 80 | 0.010 | 1.000 | 0.010 | 0.032 | 0.000 | 5.015 |
| 2 | 11:20 AM | 3.850 | 0.6 | 0.240 | 0.600 | 0.144 | 80 | 0.029 | 1.000 | 0.029 | 0.048 | 0.001 | 21.440 |
| 3 | 11:21 AM | 4.050 | 0.6 | 0.265 | 0.600 | 0.159 | 80 | 0.027 | 1.000 | 0.027 | 0.053 | 0.001 | 21.868 |
| 4 | 11:23 AM | 4.250 | 0.6 | 0.250 | 0.600 | 0.150 | 80 | 0.034 | 1.000 | 0.034 | 0.038 | 0.001 | 19.420 |
| 5 | 11:28 AM | 4.350 | 0.6 | 0.230 | 0.600 | 0.138 | 80 | 0.032 | 1.000 | 0.032 | 0.023 | 0.001 | 11.089 |
| 6 | 11:24 AM | 4.450 | 0.6 | 0.240 | 0.600 | 0.144 | 80 | 0.029 | 1.000 | 0.029 | 0.036 | 0.001 | 16.047 |
| 7 | 11:25 AM | 4.650 | 0.6 | 0.055 | 0.600 | 0.033 | 80 | -0.045 | -1.000 | 0.045 | 0.007 | 0.000 | 5.120 |
| 8 | 11:30 AM | 4.720 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.045 | 0.000 | 0.000 | 0.000 |

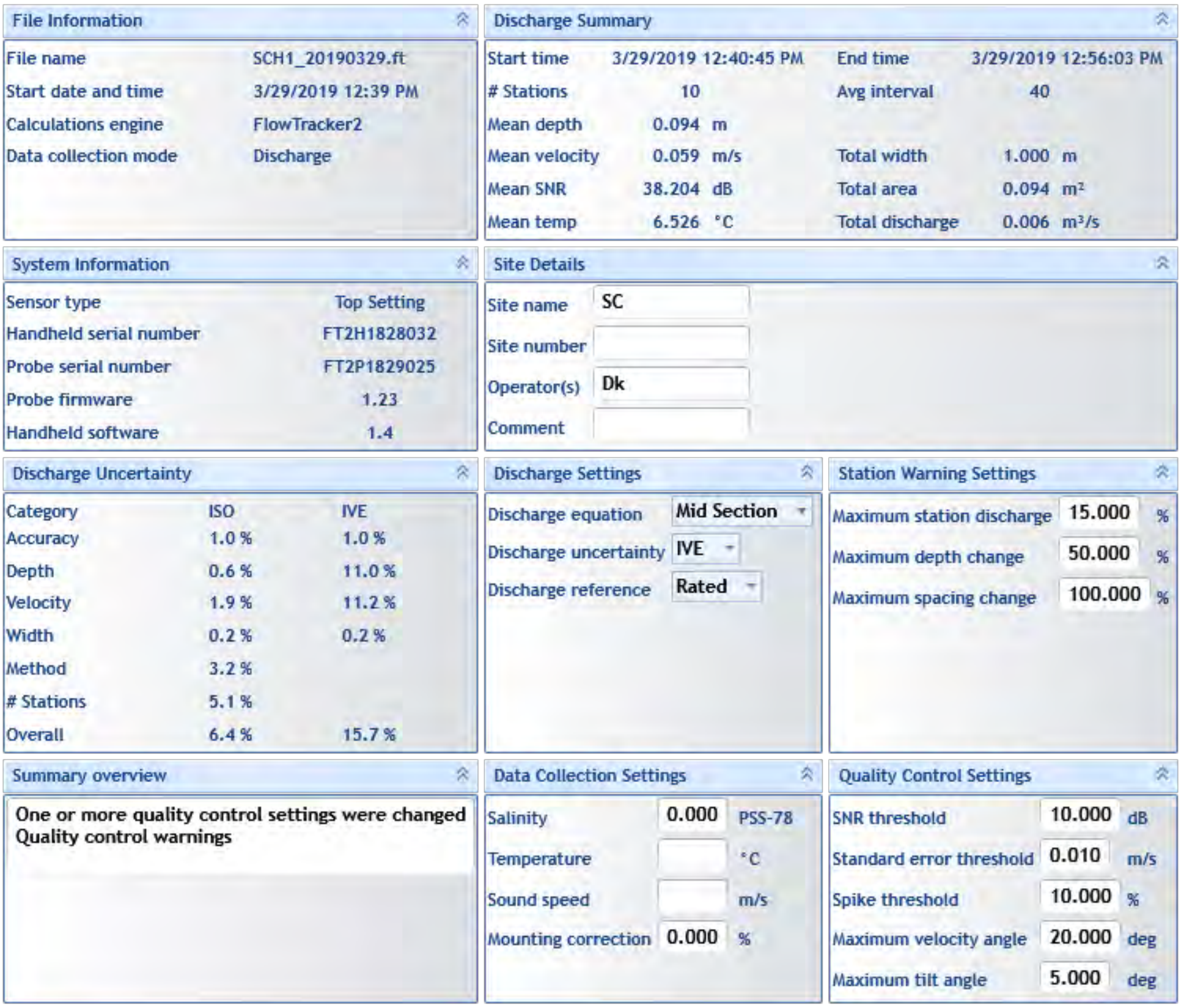
3/23/2020 10:04:18 AM



| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 1 | 11:19 AM | 3.650 | 0.6 | 0.180 | 0.600 | 0.108 | Large SNR Variation |
| 2 | 11:20 AM | 3.850 | 0.6 | 0.240 | 0.600 | 0.144 | High Stn % Discharge |
| 3 | 11:21 AM | 4.050 | 0.6 | 0.265 | 0.600 | 0.159 | High Stn % Discharge |
| 4 | 11:23 AM | 4.250 | 0.6 | 0.250 | 0.600 | 0.150 | High Stn % Discharge |
| 5 | 11:28 AM | 4.350 | 0.6 | 0.230 | 0.600 | 0.138 | High Stn % Discharge |
| 6 | 11:24 AM | 4.450 | 0.6 | 0.240 | 0.600 | 0.144 | High Stn % Discharge |
| 7 | 11:25 AM | 4.650 | 0.6 | 0.055 | 0.600 | 0.033 | Velocity Angle > QC |

4/9/2019 10:38:50 AM

# Discharge Measurement Summary



## File Information

| | |
|---|---|
| File name | SCH1_20190329.ft |
| Start date and time | 3/29/2019 12:39 PM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

## Discharge Summary

| | | | | | |
|---|---|---|---|---|---|
| Start time | 3/29/2019 12:40:45 PM | | End time | 3/29/2019 12:56:03 PM | |
| # Stations | 10 | | Avg interval | 40 | |
| Mean depth | 0.094 | m | | | |
| Mean velocity | 0.059 | m/s | Total width | 1.000 | m |
| Mean SNR | 38.204 | dB | Total area | 0.094 | m² |
| Mean temp | 6.526 | °C | Total discharge | 0.006 | m³/s |

## System Information

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

## Site Details

| | |
|---|---|
| Site name | SC |
| Site number | |
| Operator(s) | Dk |
| Comment | |

## Discharge Uncertainty

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0 % | 1.0 % |
| Depth | 0.6 % | 11.0 % |
| Velocity | 1.9 % | 11.2 % |
| Width | 0.2 % | 0.2 % |
| Method | 3.2 % | |
| # Stations | 5.1 % | |
| Overall | 6.4 % | 15.7 % |

## Discharge Settings

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

## Station Warning Settings

| | | |
|---|---|---|
| Maximum station discharge | 15.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

## Summary overview

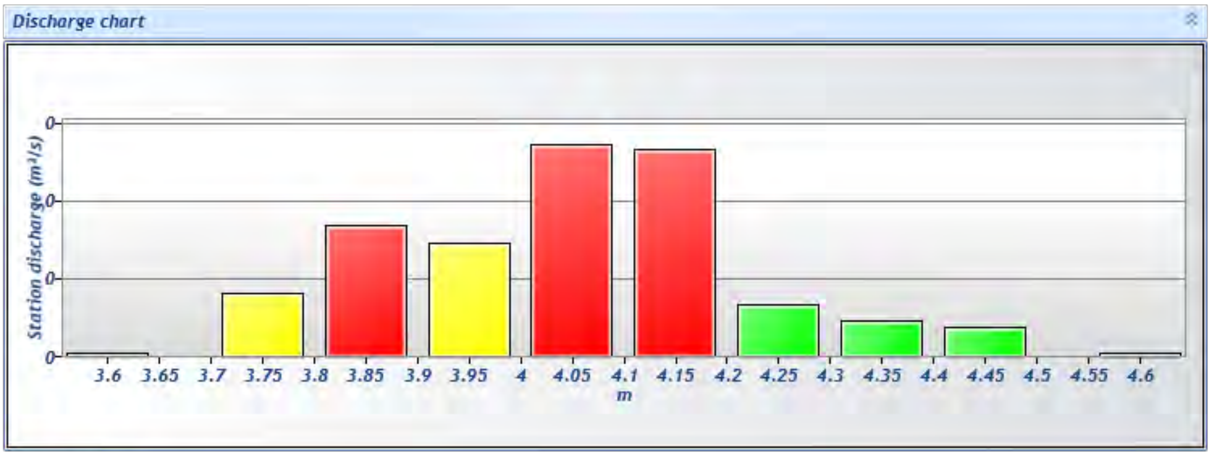
One or more quality control settings were changed
Quality control warnings

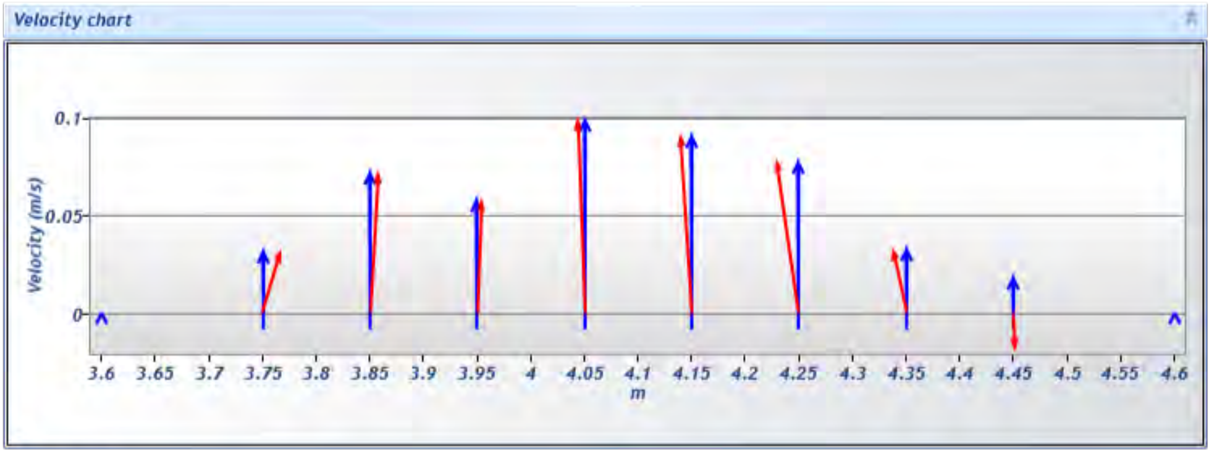
## Data Collection Settings

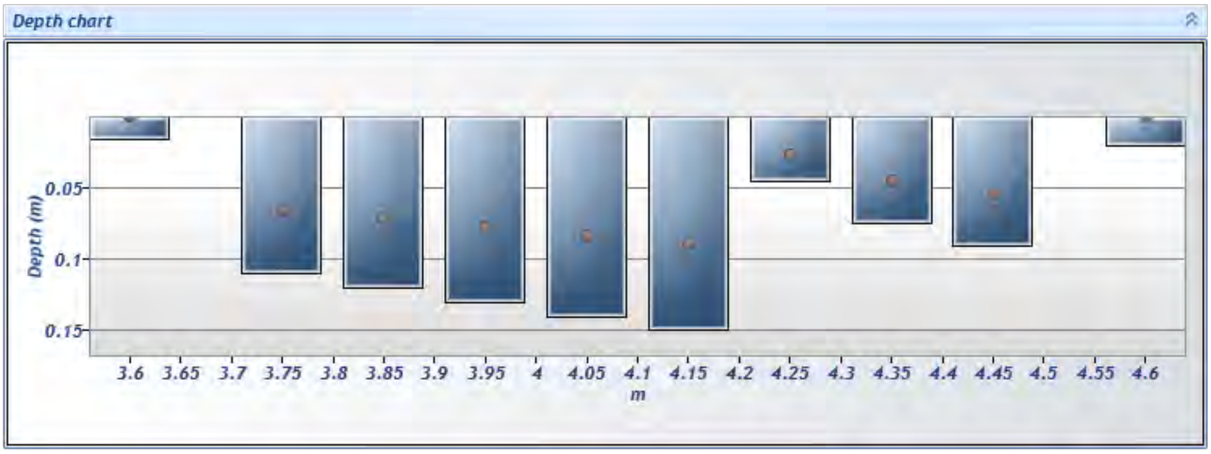
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

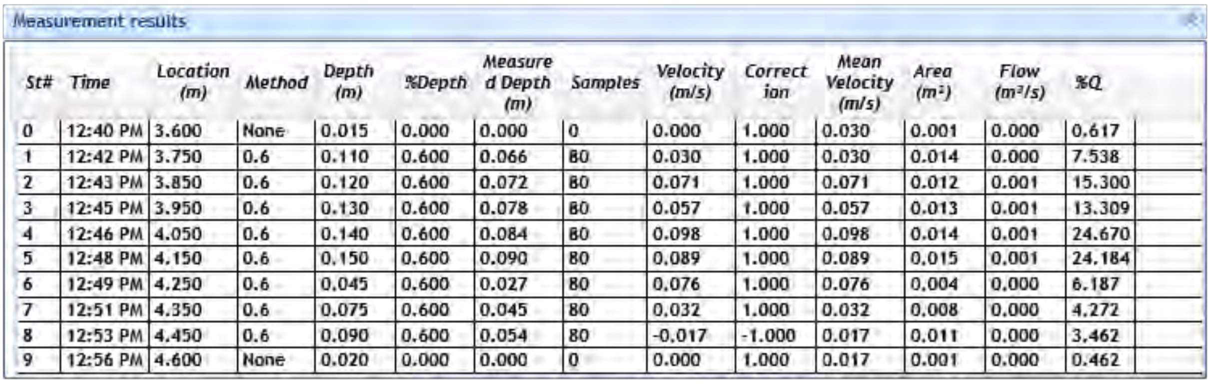
## Quality Control Settings

| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |


Discharge chart
Station discharge (m³/s)
0
0
0
0
3.6
3.65
3.7
3.75
3.8
3.85
3.9
3.95
4
4.05
4.1
4.15
4.2
4.25
4.3
4.35
4.4
4.45
4.5
4.55
4.6
m

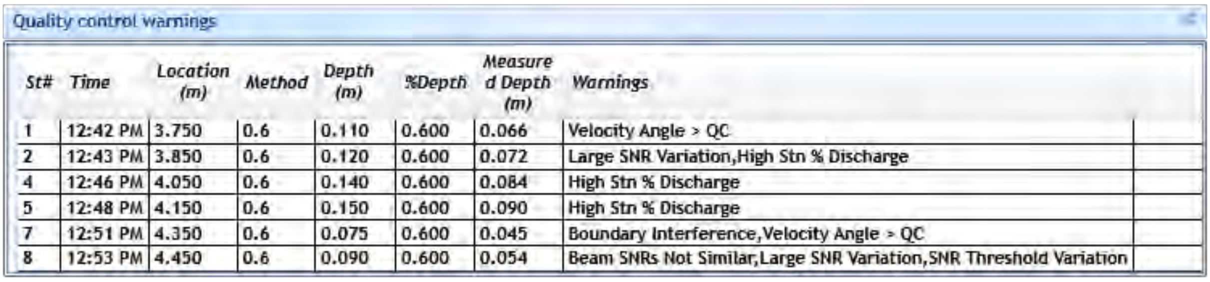

Velocity chart
Velocity (m/s)
0.1
0.05
0
3.6
3.65
3.7
3.75
3.8
3.85
3.9
3.95
4
4.05
4.1
4.15
4.2
4.25
4.3
4.35
4.4
4.45
4.5
4.55
4.6
m


Depth chart
Depth (m)
0.05
0.1
0.15
3.6
3.65
3.7
3.75
3.8
3.85
3.9
3.95
4
4.05
4.1
4.15
4.2
4.25
4.3
4.35
4.4
4.45
4.5
4.55
4.6
m



Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area (m$^2$) | Flow (m$^3$/s) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 12:40 PM | 3.600 | None | 0.015 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.030 | 0.001 | 0.000 | 0.617 |
| 1 | 12:42 PM | 3.750 | 0.6 | 0.110 | 0.600 | 0.066 | 80 | 0.030 | 1.000 | 0.030 | 0.014 | 0.000 | 7.538 |
| 2 | 12:43 PM | 3.850 | 0.6 | 0.120 | 0.600 | 0.072 | 80 | 0.071 | 1.000 | 0.071 | 0.012 | 0.001 | 15.300 |
| 3 | 12:45 PM | 3.950 | 0.6 | 0.130 | 0.600 | 0.078 | 80 | 0.057 | 1.000 | 0.057 | 0.013 | 0.001 | 13.309 |
| 4 | 12:46 PM | 4.050 | 0.6 | 0.140 | 0.600 | 0.084 | 80 | 0.098 | 1.000 | 0.098 | 0.014 | 0.001 | 24.670 |
| 5 | 12:48 PM | 4.150 | 0.6 | 0.150 | 0.600 | 0.090 | 80 | 0.089 | 1.000 | 0.089 | 0.015 | 0.001 | 24.184 |
| 6 | 12:49 PM | 4.250 | 0.6 | 0.045 | 0.600 | 0.027 | 80 | 0.076 | 1.000 | 0.076 | 0.004 | 0.000 | 6.187 |
| 7 | 12:51 PM | 4.350 | 0.6 | 0.075 | 0.600 | 0.045 | 80 | 0.032 | 1.000 | 0.032 | 0.008 | 0.000 | 4.272 |
| 8 | 12:53 PM | 4.450 | 0.6 | 0.090 | 0.600 | 0.054 | 80 | -0.017 | -1.000 | 0.017 | 0.011 | 0.000 | 3.462 |
| 9 | 12:56 PM | 4.600 | None | 0.020 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.017 | 0.001 | 0.000 | 0.462 |



Quality control warnings

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 1 | 12:42 PM | 3.750 | 0.6 | 0.110 | 0.600 | 0.066 | Velocity Angle > QC |
| 2 | 12:43 PM | 3.850 | 0.6 | 0.120 | 0.600 | 0.072 | Large SNR Variation,High Stn % Discharge |
| 4 | 12:46 PM | 4.050 | 0.6 | 0.140 | 0.600 | 0.084 | High Stn % Discharge |
| 5 | 12:48 PM | 4.150 | 0.6 | 0.150 | 0.600 | 0.090 | High Stn % Discharge |
| 7 | 12:51 PM | 4.350 | 0.6 | 0.075 | 0.600 | 0.045 | Boundary Interference,Velocity Angle > QC |
| 8 | 12:53 PM | 4.450 | 0.6 | 0.090 | 0.600 | 0.054 | Beam SNRs Not Similar,Large SNR Variation,SNR Threshold Variation |

10/8/2019 4:35:00 PM

# Discharge Measurement Summary

### File Information

| | |
|---|---|
| File name | —_20191004_2.ft |
| Start date and time | 10/4/2019 1:23 PM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

### Discharge Summary

| | | | |
|---|---|---|---|
| Start time | 10/4/2019 1:24:06 PM | End time | 10/4/2019 1:43:47 PM |
| # Stations | 13 | Avg interval | 40 |
| Mean depth | 0.215 m | | |
| Mean velocity | -0.003 m/s | Total width | 3.650 m |
| Mean SNR | 56.383 dB | Total area | 0.784 m² |
| Mean temp | 13.104 °C | Total discharge | -0.002 m³/s |

### System Information

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

### Site Details

| | |
|---|---|
| Site name | Sch1 |
| Site number | |
| Operator(s) | Lj |
| Comment | |

### Discharge Uncertainty

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0 % | 1.0 % |
| Depth | 0.6 % | 6.7 % |
| Velocity | 6.3 % | 51.7 % |
| Width | 0.4 % | 0.4 % |
| Method | 5.3 % | |
| # Stations | 3.9 % | |
| Overall | 9.1 % | 52.1 % |

### Discharge Settings

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

### Station Warning Settings

| | | |
|---|---|---|
| Maximum station discharge | 15.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

### Summary overview

One or more quality control settings were changed
Quality control warnings

### Data Collection Settings

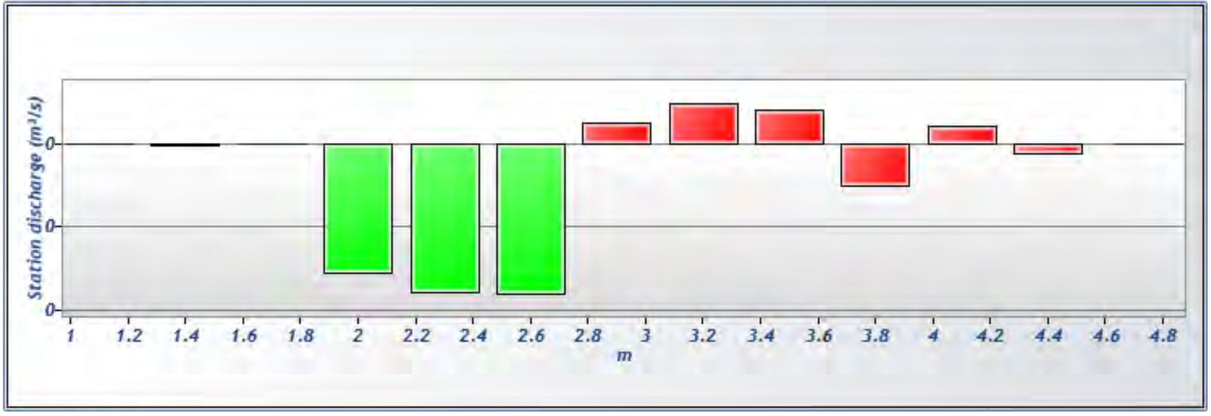
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

### Quality Control Settings

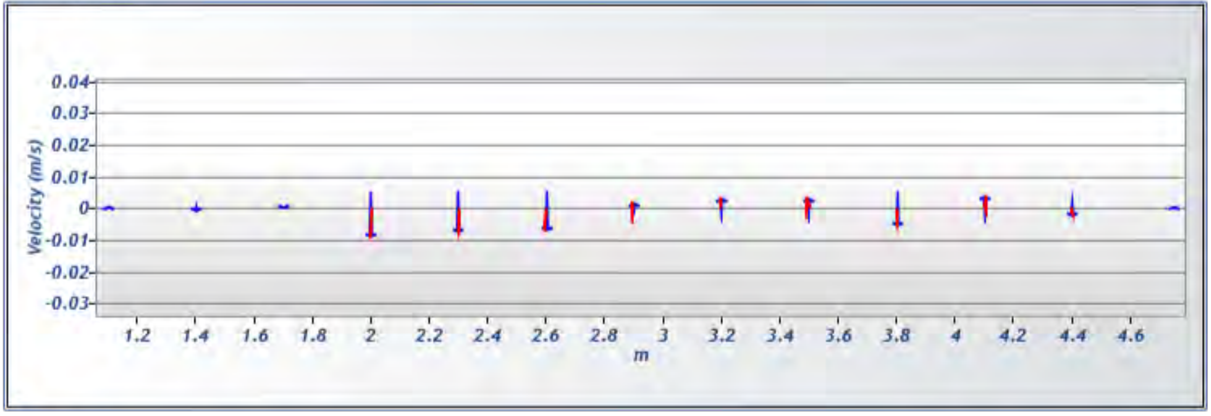
| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |

10/8/2019 4:35:00 PM

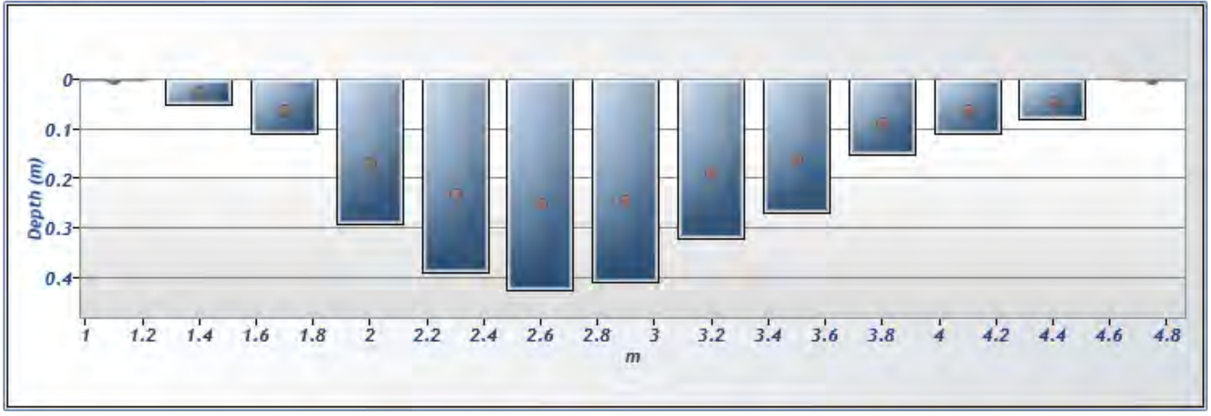
Discharge chart



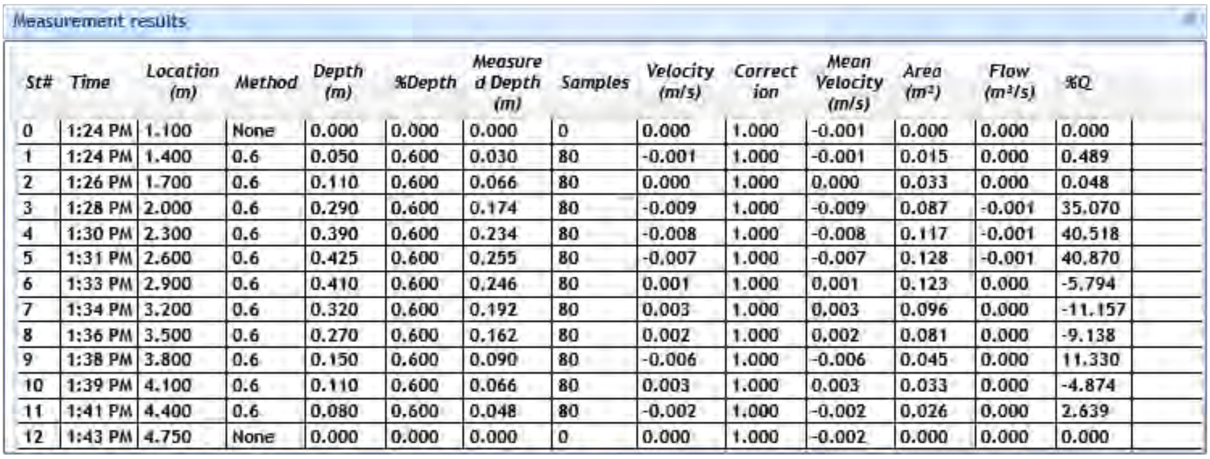
Velocity chart



Depth chart

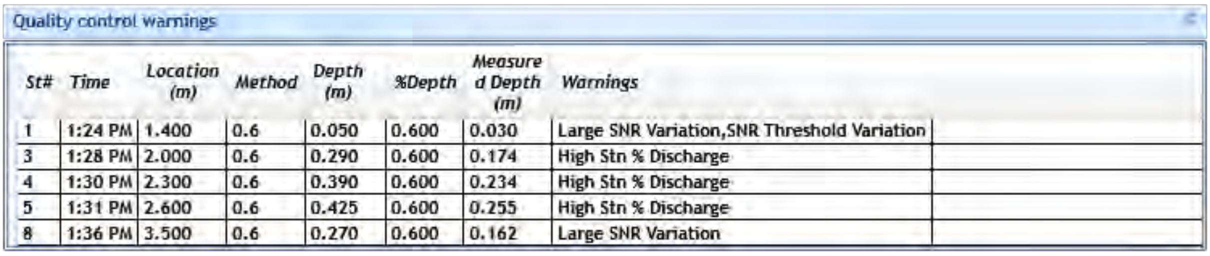


10/8/2019 4:35:00 PM



Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area ($m^2$) | Flow ($m^3/s$) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1:24 PM | 1.100 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | -0.001 | 0.000 | 0.000 | 0.000 |
| 1 | 1:24 PM | 1.400 | 0.6 | 0.050 | 0.600 | 0.030 | 80 | -0.001 | 1.000 | -0.001 | 0.015 | 0.000 | 0.489 |
| 2 | 1:26 PM | 1.700 | 0.6 | 0.110 | 0.600 | 0.066 | 80 | 0.000 | 1.000 | 0.000 | 0.033 | 0.000 | 0.048 |
| 3 | 1:28 PM | 2.000 | 0.6 | 0.290 | 0.600 | 0.174 | 80 | -0.009 | 1.000 | -0.009 | 0.087 | -0.001 | 35.070 |
| 4 | 1:30 PM | 2.300 | 0.6 | 0.390 | 0.600 | 0.234 | 80 | -0.008 | 1.000 | -0.008 | 0.117 | -0.001 | 40.518 |
| 5 | 1:31 PM | 2.600 | 0.6 | 0.425 | 0.600 | 0.255 | 80 | -0.007 | 1.000 | -0.007 | 0.128 | -0.001 | 40.870 |
| 6 | 1:33 PM | 2.900 | 0.6 | 0.410 | 0.600 | 0.246 | 80 | 0.001 | 1.000 | 0.001 | 0.123 | 0.000 | -5.794 |
| 7 | 1:34 PM | 3.200 | 0.6 | 0.320 | 0.600 | 0.192 | 80 | 0.003 | 1.000 | 0.003 | 0.096 | 0.000 | -11.157 |
| 8 | 1:36 PM | 3.500 | 0.6 | 0.270 | 0.600 | 0.162 | 80 | 0.002 | 1.000 | 0.002 | 0.081 | 0.000 | -9.138 |
| 9 | 1:38 PM | 3.800 | 0.6 | 0.150 | 0.600 | 0.090 | 80 | -0.006 | 1.000 | -0.006 | 0.045 | 0.000 | 11.330 |
| 10 | 1:39 PM | 4.100 | 0.6 | 0.110 | 0.600 | 0.066 | 80 | 0.003 | 1.000 | 0.003 | 0.033 | 0.000 | -4.874 |
| 11 | 1:41 PM | 4.400 | 0.6 | 0.080 | 0.600 | 0.048 | 80 | -0.002 | 1.000 | -0.002 | 0.026 | 0.000 | 2.639 |
| 12 | 1:43 PM | 4.750 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | -0.002 | 0.000 | 0.000 | 0.000 |

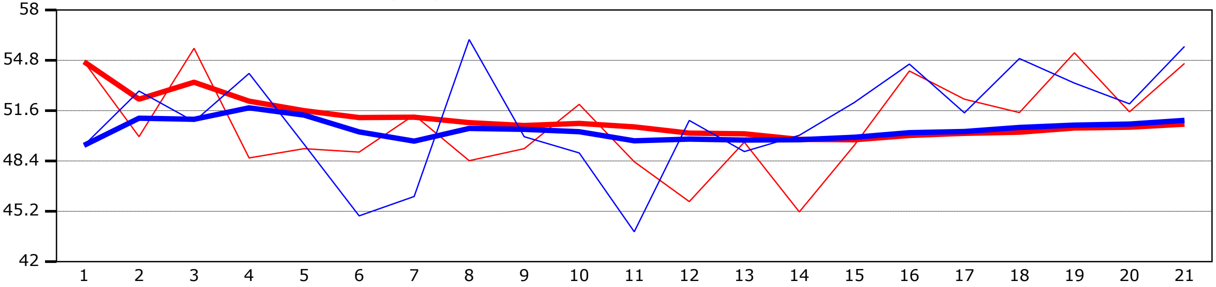


Quality control warnings

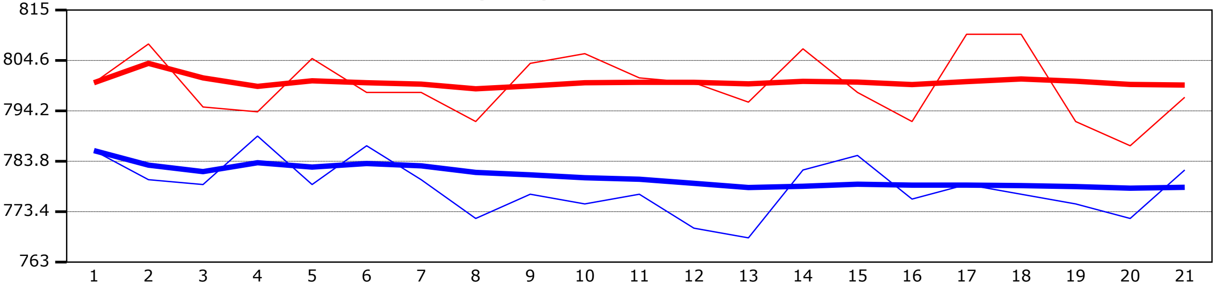
| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 1 | 1:24 PM | 1.400 | 0.6 | 0.050 | 0.600 | 0.030 | Large SNR Variation,SNR Threshold Variation |
| 3 | 1:28 PM | 2.000 | 0.6 | 0.290 | 0.600 | 0.174 | High Stn % Discharge |
| 4 | 1:30 PM | 2.300 | 0.6 | 0.390 | 0.600 | 0.234 | High Stn % Discharge |
| 5 | 1:31 PM | 2.600 | 0.6 | 0.425 | 0.600 | 0.255 | High Stn % Discharge |
| 8 | 1:36 PM | 3.500 | 0.6 | 0.270 | 0.600 | 0.162 | Large SNR Variation |

Automated beam check Start time 10/4/2019 1:23:42 PM

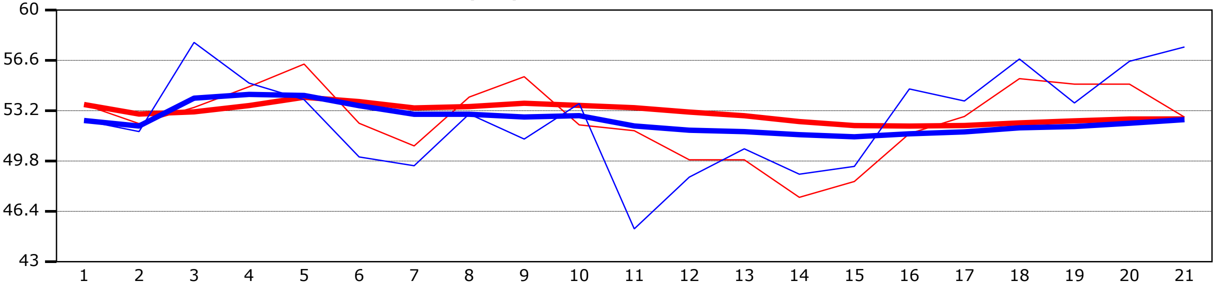
Automated beam check SNR(dB)



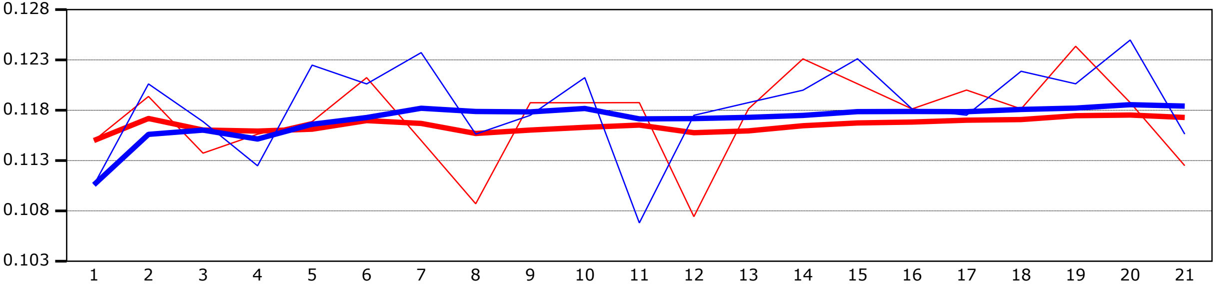
Automated beam check Noise level(cnts)



Automated beam check Peak level(dB)



Automated beam check Peak position(m)

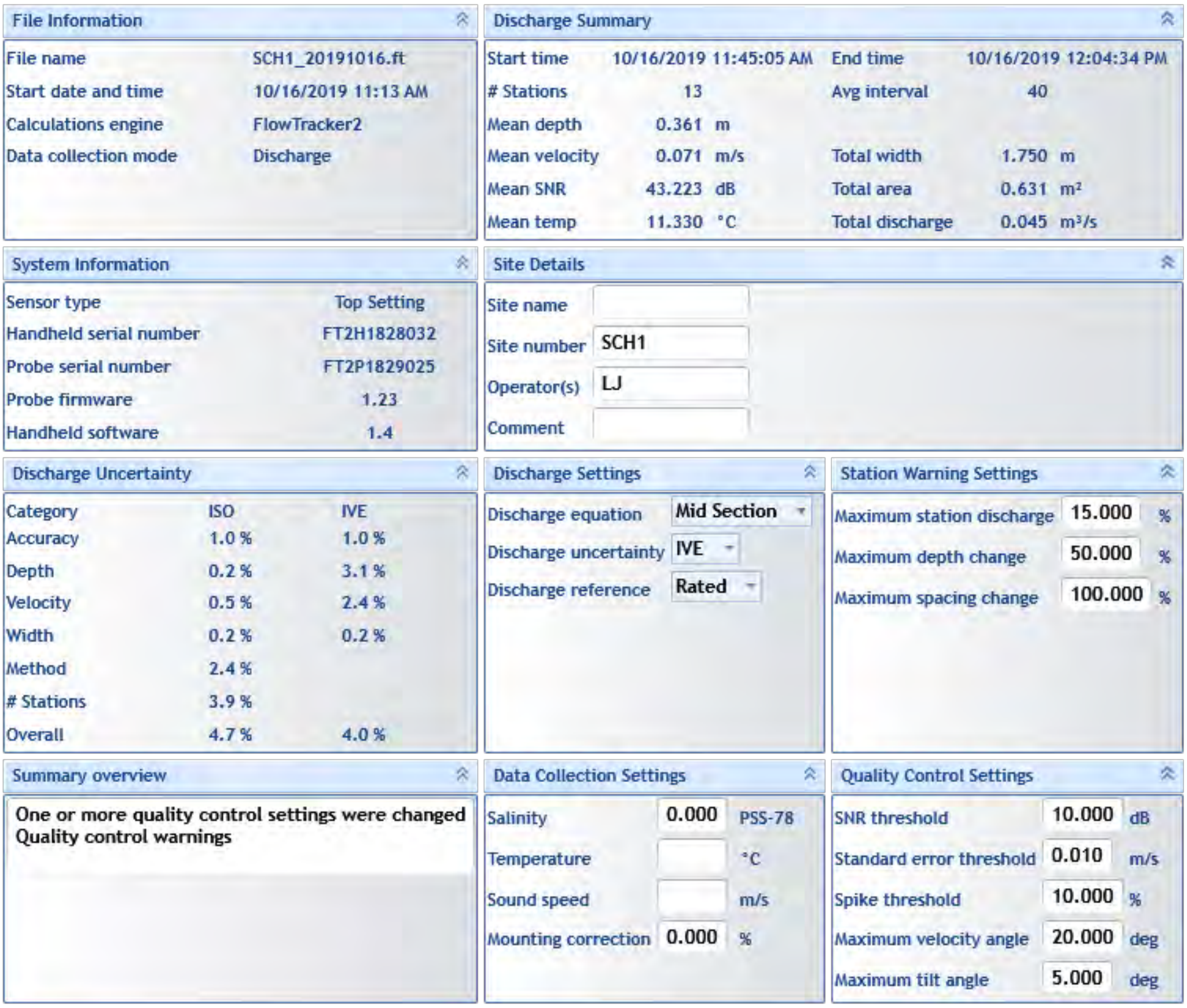


Automated beam check Quality control warnings

No quality control warnings

10/17/2019 4:33:25 PM

# Discharge Measurement Summary



### File Information

| | |
|---|---|
| File name | SCH1_20191016.ft |
| Start date and time | 10/16/2019 11:13 AM |
| Calculations engine | FlowTracker2 |
| Data collection mode | Discharge |

### Discharge Summary

| | | | | | |
|---|---|---|---|---|---|
| Start time | 10/16/2019 11:45:05 AM | | End time | 10/16/2019 12:04:34 PM | |
| # Stations | 13 | | Avg interval | 40 | |
| Mean depth | 0.361 | m | | | |
| Mean velocity | 0.071 | m/s | Total width | 1.750 | m |
| Mean SNR | 43.223 | dB | Total area | 0.631 | m² |
| Mean temp | 11.330 | °C | Total discharge | 0.045 | m³/s |

### System Information

| | |
|---|---|
| Sensor type | Top Setting |
| Handheld serial number | FT2H1828032 |
| Probe serial number | FT2P1829025 |
| Probe firmware | 1.23 |
| Handheld software | 1.4 |

### Site Details

| | |
|---|---|
| Site name | |
| Site number | SCH1 |
| Operator(s) | LJ |
| Comment | |

### Discharge Uncertainty

| Category | ISO | IVE |
|---|---|---|
| Accuracy | 1.0 % | 1.0 % |
| Depth | 0.2 % | 3.1 % |
| Velocity | 0.5 % | 2.4 % |
| Width | 0.2 % | 0.2 % |
| Method | 2.4 % | |
| # Stations | 3.9 % | |
| Overall | 4.7 % | 4.0 % |

### Discharge Settings

| | |
|---|---|
| Discharge equation | Mid Section |
| Discharge uncertainty | IVE |
| Discharge reference | Rated |

### Station Warning Settings

| | | |
|---|---|---|
| Maximum station discharge | 15.000 | % |
| Maximum depth change | 50.000 | % |
| Maximum spacing change | 100.000 | % |

### Summary overview

One or more quality control settings were changed
Quality control warnings

### Data Collection Settings

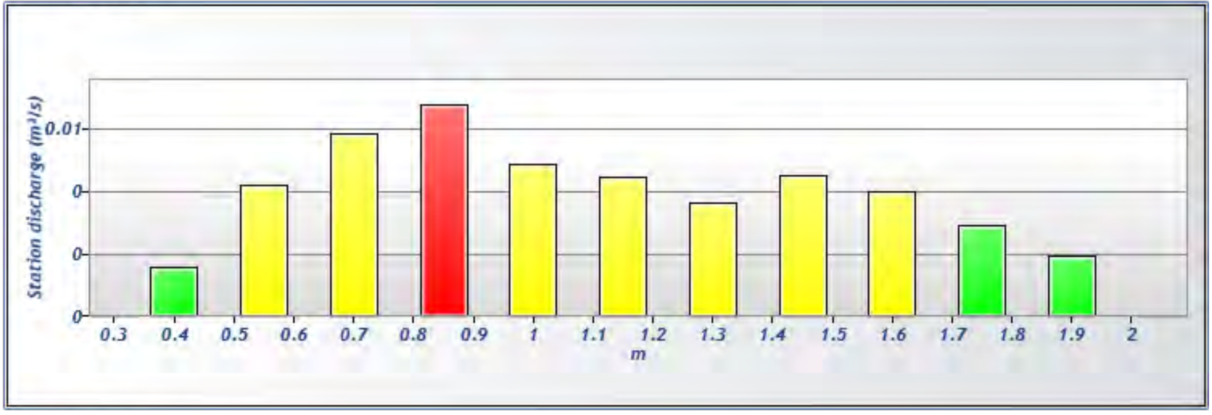
| | | |
|---|---|---|
| Salinity | 0.000 | PSS-78 |
| Temperature | | °C |
| Sound speed | | m/s |
| Mounting correction | 0.000 | % |

### Quality Control Settings

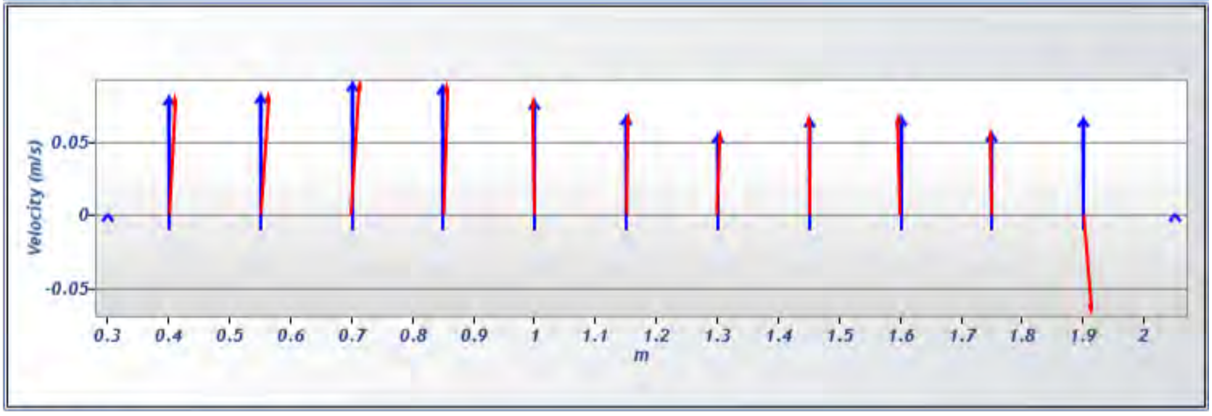
| | | |
|---|---|---|
| SNR threshold | 10.000 | dB |
| Standard error threshold | 0.010 | m/s |
| Spike threshold | 10.000 | % |
| Maximum velocity angle | 20.000 | deg |
| Maximum tilt angle | 5.000 | deg |

10/17/2019 4:33:25 PM

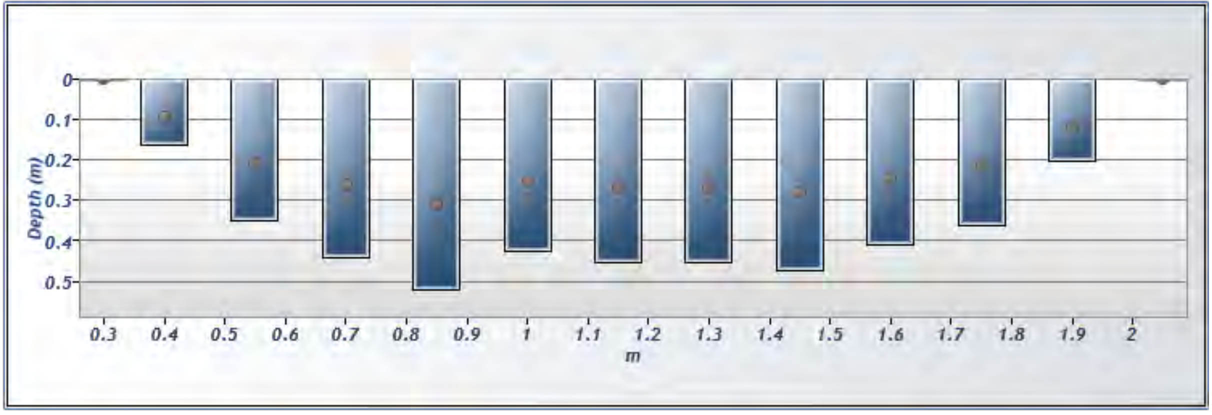
**Discharge chart**

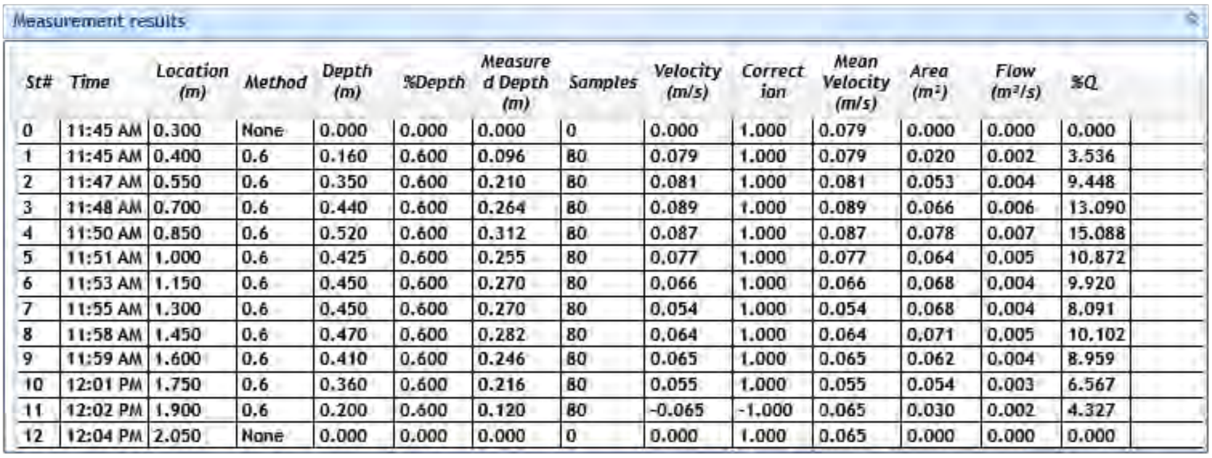


**Velocity chart**



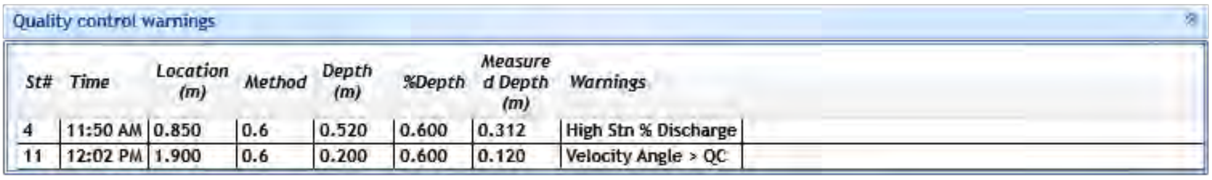
**Depth chart**





Measurement results

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Samples | Velocity (m/s) | Correction | Mean Velocity (m/s) | Area ($m^2$) | Flow ($m^3/s$) | %Q |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 11:45 AM | 0.300 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.079 | 0.000 | 0.000 | 0.000 |
| 1 | 11:45 AM | 0.400 | 0.6 | 0.160 | 0.600 | 0.096 | 80 | 0.079 | 1.000 | 0.079 | 0.020 | 0.002 | 3.536 |
| 2 | 11:47 AM | 0.550 | 0.6 | 0.350 | 0.600 | 0.210 | 80 | 0.081 | 1.000 | 0.081 | 0.053 | 0.004 | 9.448 |
| 3 | 11:48 AM | 0.700 | 0.6 | 0.440 | 0.600 | 0.264 | 80 | 0.089 | 1.000 | 0.089 | 0.066 | 0.006 | 13.090 |
| 4 | 11:50 AM | 0.850 | 0.6 | 0.520 | 0.600 | 0.312 | 80 | 0.087 | 1.000 | 0.087 | 0.078 | 0.007 | 15.088 |
| 5 | 11:51 AM | 1.000 | 0.6 | 0.425 | 0.600 | 0.255 | 80 | 0.077 | 1.000 | 0.077 | 0.064 | 0.005 | 10.872 |
| 6 | 11:53 AM | 1.150 | 0.6 | 0.450 | 0.600 | 0.270 | 80 | 0.066 | 1.000 | 0.066 | 0.068 | 0.004 | 9.920 |
| 7 | 11:55 AM | 1.300 | 0.6 | 0.450 | 0.600 | 0.270 | 80 | 0.054 | 1.000 | 0.054 | 0.068 | 0.004 | 8.091 |
| 8 | 11:58 AM | 1.450 | 0.6 | 0.470 | 0.600 | 0.282 | 80 | 0.064 | 1.000 | 0.064 | 0.071 | 0.005 | 10.102 |
| 9 | 11:59 AM | 1.600 | 0.6 | 0.410 | 0.600 | 0.246 | 80 | 0.065 | 1.000 | 0.065 | 0.062 | 0.004 | 8.959 |
| 10 | 12:01 PM | 1.750 | 0.6 | 0.360 | 0.600 | 0.216 | 80 | 0.055 | 1.000 | 0.055 | 0.054 | 0.003 | 6.567 |
| 11 | 12:02 PM | 1.900 | 0.6 | 0.200 | 0.600 | 0.120 | 80 | -0.065 | -1.000 | 0.065 | 0.030 | 0.002 | 4.327 |
| 12 | 12:04 PM | 2.050 | None | 0.000 | 0.000 | 0.000 | 0 | 0.000 | 1.000 | 0.065 | 0.000 | 0.000 | 0.000 |



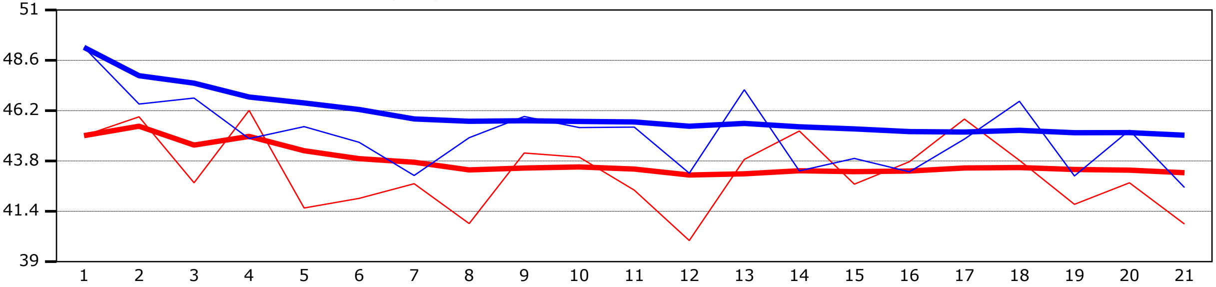
Quality control warnings

| St# | Time | Location (m) | Method | Depth (m) | %Depth | Measured Depth (m) | Warnings |
|---|---|---|---|---|---|---|---|
| 4 | 11:50 AM | 0.850 | 0.6 | 0.520 | 0.600 | 0.312 | High Stn % Discharge |
| 11 | 12:02 PM | 1.900 | 0.6 | 0.200 | 0.600 | 0.120 | Velocity Angle > QC |

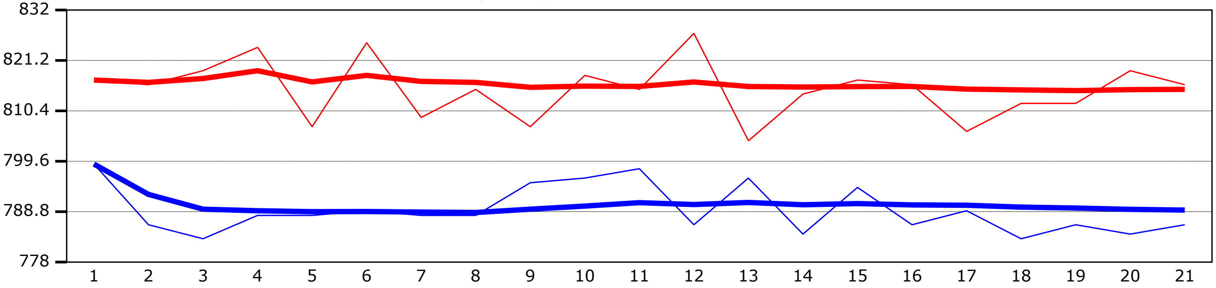
10/17/2019 4:33:25 PM

Automated beam check Start time 10/16/2019 11:44:45 AM

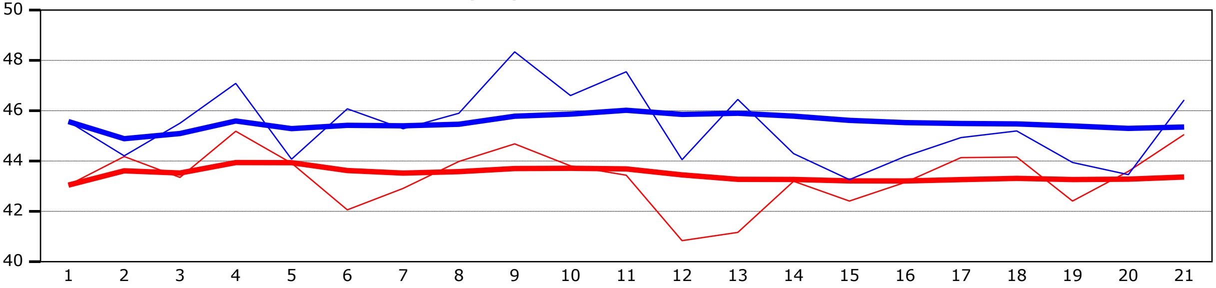
Automated beam check SNR(dB)



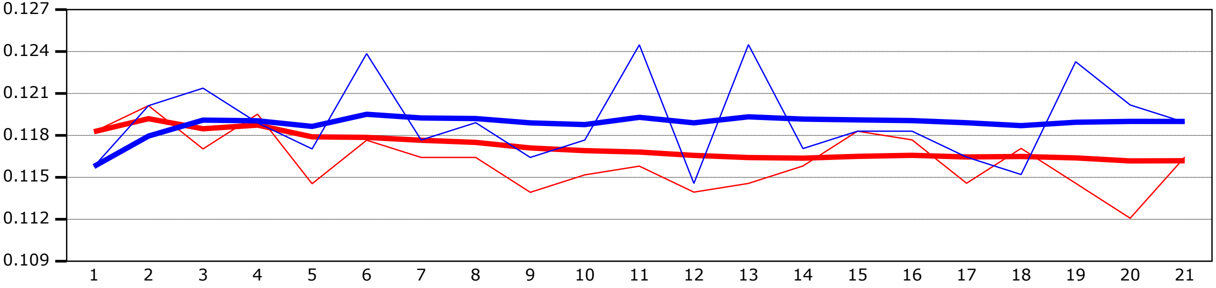
Automated beam check Noise level(cnts)



Automated beam check Peak level(dB)



Automated beam check Peak position(m)



Automated beam check Quality control warnings

No quality control warnings

# Appendix E
# Laboratory Analytical Reports

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

| | |
|---|---|
| Date Received: | 05-APR-19 |
| Report Date: | 11-APR-19 13:31 (MT) |
| Version: | FINAL |

Client Phone: 519-884-0510

# Certificate of Analysis

| | |
|---|---|
| **Lab Work Order #:** | **L2254436** |
| Project P.O. #: | 211265 |
| Job Reference: | 11193719 |
| C of C Numbers: | |
| Legal Site Desc: | |

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2254436-1 SW-11193719-040519-DK-SB2<br>Sampled By: DK on 05-APR-19 @ 15:10<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 185 | HTC | 1.3 | mg/L | | 08-APR-19 | |
| Total Suspended Solids | 59.9 | | 2.0 | mg/L | 10-APR-19 | 11-APR-19 | R4595886 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 127 | | 0.50 | mg/L | | 10-APR-19 | R4596200 |
| Nitrate (as N) | 0.685 | | 0.020 | mg/L | | 10-APR-19 | R4596200 |
| Phosphorus (P)-Total Dissolved | 0.0124 | | 0.0030 | mg/L | 08-APR-19 | 08-APR-19 | R4592252 |
| Phosphorus, Total | 0.0919 | | 0.0030 | mg/L | 09-APR-19 | 10-APR-19 | R4593498 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 54.6 | | 0.50 | mg/L | 08-APR-19 | 08-APR-19 | R4592122 |
| Copper (Cu)-Total | 0.0113 | | 0.0010 | mg/L | 08-APR-19 | 08-APR-19 | R4592122 |
| Lead (Pb)-Total | 0.00117 | | 0.000050 | mg/L | 08-APR-19 | 08-APR-19 | R4592122 |
| Magnesium (Mg)-Total | 11.8 | | 0.050 | mg/L | 08-APR-19 | 08-APR-19 | R4592122 |
| Zinc (Zn)-Total | 0.0160 | | 0.0030 | mg/L | 08-APR-19 | 08-APR-19 | R4592122 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2254436-1 |
| Matrix Spike | Zinc (Zn)-Total | MS-B | L2254436-1 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

**Chain of Custody Numbers:**

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2254436 Report Date: 11-APR-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4596200** | | | | | | | | |
| **WG3024788-9 DUP** | | **WG3024788-8** | | | | | | |
| Chloride (Cl) | | 75.5 | 75.5 | | mg/L | 0.0 | 20 | 10-APR-19 |
| **WG3024788-7 LCS** | | | | | | | | |
| Chloride (Cl) | | | 100.6 | | % | | 90-110 | 10-APR-19 |
| **WG3024788-6 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 10-APR-19 |
| **WG3024788-10 MS** | | **WG3024788-8** | | | | | | |
| Chloride (Cl) | | | 95.8 | | % | | 75-125 | 10-APR-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4592122** | | | | | | | | |
| **WG3022806-4 DUP** | | **WG3022806-3** | | | | | | |
| Calcium (Ca)-Total | | 161 | 154 | | mg/L | 4.5 | 20 | 08-APR-19 |
| Copper (Cu)-Total | | <0.010 | <0.010 | RPD-NA | mg/L | N/A | 20 | 08-APR-19 |
| Lead (Pb)-Total | | <0.00050 | <0.00050 | RPD-NA | mg/L | N/A | 20 | 08-APR-19 |
| Magnesium (Mg)-Total | | 30.5 | 31.4 | | mg/L | 3.0 | 20 | 08-APR-19 |
| Zinc (Zn)-Total | | <0.030 | <0.030 | RPD-NA | mg/L | N/A | 20 | 08-APR-19 |
| **WG3022806-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 97.4 | | % | | 80-120 | 08-APR-19 |
| Copper (Cu)-Total | | | 99.5 | | % | | 80-120 | 08-APR-19 |
| Lead (Pb)-Total | | | 104.9 | | % | | 80-120 | 08-APR-19 |
| Magnesium (Mg)-Total | | | 108.4 | | % | | 80-120 | 08-APR-19 |
| Zinc (Zn)-Total | | | 96.8 | | % | | 80-120 | 08-APR-19 |
| **WG3022806-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 08-APR-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 08-APR-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 08-APR-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 08-APR-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 08-APR-19 |
| **WG3022806-5 MS** | | **WG3022806-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 08-APR-19 |
| Copper (Cu)-Total | | | 97.2 | | % | | 70-130 | 08-APR-19 |
| Lead (Pb)-Total | | | 91.1 | | % | | 70-130 | 08-APR-19 |
| Magnesium (Mg)-Total | | | 92.3 | | % | | 70-130 | 08-APR-19 |
| Zinc (Zn)-Total | | | N/A | MS-B | % | | - | 08-APR-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2254436 Report Date: 11-APR-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4596200** | | | | | | | | |
| **WG3024788-9 DUP** | | **WG3024788-8** | | | | | | |
| Nitrate (as N) | | 1.31 | 1.31 | | mg/L | 0.1 | 20 | 10-APR-19 |
| **WG3024788-7 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.4 | | % | | 90-110 | 10-APR-19 |
| **WG3024788-6 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 10-APR-19 |
| **WG3024788-10 MS** | | **WG3024788-8** | | | | | | |
| Nitrate (as N) | | | 95.3 | | % | | 75-125 | 10-APR-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4593498** | | | | | | | | |
| **WG3024099-3 DUP** | | **L2254457-1** | | | | | | |
| Phosphorus, Total | | 0.0193 | 0.0203 | | mg/L | 5.3 | 20 | 10-APR-19 |
| **WG3024099-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 100.6 | | % | | 80-120 | 10-APR-19 |
| **WG3024099-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 10-APR-19 |
| **WG3024099-4 MS** | | **L2254457-1** | | | | | | |
| Phosphorus, Total | | | 94.8 | | % | | 70-130 | 10-APR-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4592252** | | | | | | | | |
| **WG3022919-3 DUP** | | **L2254436-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0124 | 0.0140 | | mg/L | 12 | 20 | 08-APR-19 |
| **WG3022919-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 102.3 | | % | | 80-120 | 08-APR-19 |
| **WG3022919-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 08-APR-19 |
| **WG3022919-4 MS** | | **L2254436-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 95.0 | | % | | 70-130 | 08-APR-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4595886** | | | | | | | | |
| **WG3025066-3 DUP** | | **L2254714-2** | | | | | | |
| Total Suspended Solids | | 9590 | 8480 | | mg/L | 12 | 20 | 11-APR-19 |
| **WG3025066-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 101.8 | | % | | 85-115 | 11-APR-19 |
| **WG3025066-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 11-APR-19 |

# Quality Control Report

Workorder: L2254436 Report Date: 11-APR-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

---

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

# Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2254436-COFC

COC Number: 17 -

Page of

| | |
|---|---|
| **Report To** | Contact and company name below will appear on the final report |
| Company: | GHD LIMITED - ACCT #13791 |
| Contact: | Laura Ermeta |
| Phone: | 519-884-0510 |
| | Company address below will appear on the final report |
| Street: | 455 Phillip St |
| City/Province: | Waterloo,Ontario |
| Postal Code: | N2L 3X2 |
| **Invoice To** | Same as Report To ☑ YES ☐ NO |
| | Copy of Invoice with Report ☐ YES ☑ NO |
| Company: | GHD Limited |
| Contact: | Laura Ermeta |

**Report Format**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2 See PO

Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2

✓ - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY
- 1 Business day [E - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Oil and Gas Required Fields (client use)**

| | |
|---|---|
| AFE/Cost Center: | PO# |
| Major/Minor Code: | Routing Code: |
| Requisitioner: | |
| Location: | |

ALS Lab Work Order # (lab use only): L2254436

ALS Contact: Rick H

Sampler: Don Krivenko

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | | | | | | | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-0405K-DK-SR2 | 04-05-19 | 3:10 | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human consumption/ use? ☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | 6.3 | | | |

**SHIPMENT RELEASE (client use)**

Released by: Dan Krivenko Date: 04/05/19 Time: 3:52

**INITIAL SHIPMENT RECEPTION (lab use only)**

Received by: Date: Time:

**FINAL SHIPMENT RECEPTION (lab use only)**

Received by: Date: Apr 5/19 Time: 15:55

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

| | |
|---|---|
| Date Received: | 17-APR-19 |
| Report Date: | 22-APR-19 13:07 (MT) |
| Version: | FINAL |

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2259478**

| | |
|---|---|
| Project P.O. #: | 211265 |
| Job Reference: | 11193719 |
| C of C Numbers: | |
| Legal Site Desc: | |

Rick Hawthorne

Rick Hawthorne
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2259478-1 SW-11193719-041719-DK-VS1<br>Sampled By: DK on 17-APR-19 @ 10:05<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 123 | HTC | 1.3 | mg/L | | 18-APR-19 | |
| Total Suspended Solids | 120 | DLHC | 4.0 | mg/L | 20-APR-19 | 22-APR-19 | R4606692 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 220 | | 0.50 | mg/L | | 18-APR-19 | R4606014 |
| Nitrate (as N) | 0.391 | | 0.020 | mg/L | | 18-APR-19 | R4606014 |
| Phosphorus (P)-Total Dissolved | 0.0081 | | 0.0030 | mg/L | 18-APR-19 | 22-APR-19 | R4606809 |
| Phosphorus, Total | 0.0918 | | 0.0030 | mg/L | 18-APR-19 | 22-APR-19 | R4606818 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 37.7 | | 0.50 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Copper (Cu)-Total | 0.0130 | | 0.0010 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Lead (Pb)-Total | 0.00329 | | 0.000050 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Magnesium (Mg)-Total | 6.95 | | 0.050 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Zinc (Zn)-Total | 0.0523 | | 0.0030 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| L2259478-2 SW-11193719-041719-DK-SB2<br>Sampled By: DK on 17-APR-19 @ 10:35<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 241 | HTC | 1.3 | mg/L | | 18-APR-19 | |
| Total Suspended Solids | 31.8 | | 2.0 | mg/L | 20-APR-19 | 22-APR-19 | R4606692 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 141 | | 0.50 | mg/L | | 18-APR-19 | R4606014 |
| Nitrate (as N) | 0.754 | | 0.020 | mg/L | | 18-APR-19 | R4606014 |
| Phosphorus (P)-Total Dissolved | 0.0075 | | 0.0030 | mg/L | 18-APR-19 | 22-APR-19 | R4606809 |
| Phosphorus, Total | 0.0352 | | 0.0030 | mg/L | 18-APR-19 | 22-APR-19 | R4606818 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 70.3 | | 0.50 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Copper (Cu)-Total | 0.0042 | | 0.0010 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Lead (Pb)-Total | 0.000604 | | 0.000050 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Magnesium (Mg)-Total | 15.8 | | 0.050 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |
| Zinc (Zn)-Total | 0.0089 | | 0.0030 | mg/L | 18-APR-19 | 18-APR-19 | R4605618 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2259478-1, -2 |
| Matrix Spike | Copper (Cu)-Total | MS-B | L2259478-1, -2 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2259478-1, -2 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.<br>Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). | | | |
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |
| Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation. | | | |
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |
| Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.<br>Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.<br>Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). | | | |
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |
| This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample. | | | |
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |
| This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter. | | | |
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |
| A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved. | | | |

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2259478 Report Date: 22-APR-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4606014** | | | | | | | | |
| **WG3030580-10 DUP** | | **WG3030580-8** | | | | | | |
| Chloride (Cl) | | 63.8 | 64.1 | | mg/L | 0.6 | 20 | 18-APR-19 |
| **WG3030580-7 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.7 | | % | | 90-110 | 18-APR-19 |
| **WG3030580-6 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 18-APR-19 |
| **WG3030580-9 MS** | | **WG3030580-8** | | | | | | |
| Chloride (Cl) | | | 100.8 | | % | | 75-125 | 18-APR-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4605618** | | | | | | | | |
| **WG3030009-4 DUP** | | **WG3030009-3** | | | | | | |
| Calcium (Ca)-Total | | 39.8 | 38.6 | | mg/L | 3.0 | 20 | 18-APR-19 |
| Copper (Cu)-Total | | 0.0298 | 0.0300 | | mg/L | 0.6 | 20 | 18-APR-19 |
| Lead (Pb)-Total | | 0.000348 | 0.000351 | | mg/L | 0.9 | 20 | 18-APR-19 |
| Magnesium (Mg)-Total | | 3.83 | 3.90 | | mg/L | 1.9 | 20 | 18-APR-19 |
| Zinc (Zn)-Total | | 0.0165 | 0.0169 | | mg/L | 2.5 | 20 | 18-APR-19 |
| **WG3030009-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 102.0 | | % | | 80-120 | 18-APR-19 |
| Copper (Cu)-Total | | | 99.8 | | % | | 80-120 | 18-APR-19 |
| Lead (Pb)-Total | | | 103.9 | | % | | 80-120 | 18-APR-19 |
| Magnesium (Mg)-Total | | | 104.2 | | % | | 80-120 | 18-APR-19 |
| Zinc (Zn)-Total | | | 98.1 | | % | | 80-120 | 18-APR-19 |
| **WG3030009-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 18-APR-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 18-APR-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 18-APR-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 18-APR-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 18-APR-19 |
| **WG3030009-5 MS** | | **WG3030009-3** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 18-APR-19 |
| Copper (Cu)-Total | | | N/A | MS-B | % | | - | 18-APR-19 |
| Lead (Pb)-Total | | | 98.7 | | % | | 70-130 | 18-APR-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 18-APR-19 |
| Zinc (Zn)-Total | | | 88.5 | | % | | 70-130 | 18-APR-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2259478 Report Date: 22-APR-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4606014** | | | | | | | | |
| **WG3030580-10 DUP** | | **WG3030580-8** | | | | | | |
| Nitrate (as N) | | 0.356 | 0.358 | | mg/L | 0.6 | 20 | 18-APR-19 |
| **WG3030580-7 LCS** | | | | | | | | |
| Nitrate (as N) | | | 102.3 | | % | | 90-110 | 18-APR-19 |
| **WG3030580-6 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 18-APR-19 |
| **WG3030580-9 MS** | | **WG3030580-8** | | | | | | |
| Nitrate (as N) | | | 103.5 | | % | | 75-125 | 18-APR-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4606818** | | | | | | | | |
| **WG3030857-3 DUP** | | **L2259478-1** | | | | | | |
| Phosphorus, Total | | 0.0918 | 0.0941 | | mg/L | 2.5 | 20 | 22-APR-19 |
| **WG3030895-3 DUP** | | **L2259478-2** | | | | | | |
| Phosphorus, Total | | 0.0352 | 0.0342 | | mg/L | 2.9 | 20 | 22-APR-19 |
| **WG3030857-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 102.0 | | % | | 80-120 | 22-APR-19 |
| **WG3030895-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 100.3 | | % | | 80-120 | 22-APR-19 |
| **WG3030857-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 22-APR-19 |
| **WG3030895-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 22-APR-19 |
| **WG3030857-4 MS** | | **L2259478-1** | | | | | | |
| Phosphorus, Total | | | 104.4 | | % | | 70-130 | 22-APR-19 |
| **WG3030895-4 MS** | | **L2259478-2** | | | | | | |
| Phosphorus, Total | | | 83.1 | | % | | 70-130 | 22-APR-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4606809** | | | | | | | | |
| **WG3030859-3 DUP** | | **L2259478-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0081 | 0.0083 | | mg/L | 2.7 | 20 | 22-APR-19 |
| **WG3030859-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 102.1 | | % | | 80-120 | 22-APR-19 |
| **WG3030859-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 22-APR-19 |
| **WG3030859-4 MS** | | **L2259478-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 96.0 | | % | | 70-130 | 22-APR-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2259478 Report Date: 22-APR-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4606692** | | | | | | | | |
| **WG3031316-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 99.6 | | % | | 85-115 | 22-APR-19 |
| **WG3031316-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 22-APR-19 |

# Quality Control Report

Workorder: L2259478 Report Date: 22-APR-19

**Client:** GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2

**Contact:** LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2259478-COFC

COC Number: 17 -

Page of

| | | | |
|---|---|---|---|
| **Report To** | Contact and company name below will appear on the final report | **Report Format / Distribution** | |
| Company: | GHD LIMITED - ACCT #13791 | Select Report Format: | ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL) |
| Contact: | Laura Ermeta | Quality Control (QC) Report with Report | ☑ YES ☐ NO |
| Phone: | 519-884-0510 | ☐ Compare Results to Criteria on Report - provide details below if box checked | |
| | Company address below will appear on the final report | Select Distribution: | ☑ EMAIL ☐ MAIL ☐ FAX |
| Street: | 455 Phillip St | Email 1 or Fax | laura.ermeta@ghd.com |
| City/Province: | Waterloo,Ontario | Email 2 | See PO |
| Postal Code: | N2L 3X2 | Email 3 | |
| **Invoice To** | Same as Report To ☑ YES ☐ NO | **Invoice Distribution** | |
| | Copy of Invoice with Report ☐ YES ☑ NO | Select Invoice Distribution: | ☐ EMAIL ☐ MAIL ☐ FAX |
| Company: | GHD Limited | Email 1 or Fax | laura.ermeta@ghd.com |
| Contact: | Laura Ermeta | Email 2 | |

| | | | |
|---|---|---|---|
| **Project Information** | | **Oil and Gas Required Fields (client use)** | |
| ALS Account # / Quote #: | 13791, Q51918 | AFE/Cost Center: | PO# |
| Job #: | 11193719 | Major/Minor Code: | Routing Code: |
| PO / AFE: | 211265 | Requisitioner: | |
| LSD: | | Location: | |
| **ALS Lab Work Order # (lab use only):** | L2259478 | **ALS Contact:** Rick H | Sampler: DAN KRWENKO |

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

| | | | | |
|---|---|---|---|---|
| PRIORITY (Business Days) | 4 day [P4-20%] ☐ | EMERGENCY | 1 Business day [E - 100%] | ☐ |
| | 3 day [P3-25%] ☐ | | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] | ☐ |
| | 2 day [P2-50%] ☐ | | | |

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Analysis Request**

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below | | | | | | | | | | | | | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | | | | | | | | | |
| | SW-11193719-041719 DK-VS1 | 17-04-19 | 10:05 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-041719-DK-SB2 | 17-04-19 | 10:35 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |
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| | | | | Water | | | | | | | | | | | | | | | | | |
| | | | | Water | | | | | | | | | | | | | | | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☒ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | 4.9 | | | |

| **SHIPMENT RELEASE (client use)** | | | **INITIAL SHIPMENT RECEPTION (lab use only)** | | | **FINAL SHIPMENT RECEPTION (lab use only)** | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: 04-17-19 | Time: 1115 | Received by: | Date: | Time: | Received by: | Date: April 17/19 | Time: 1145 |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

Date Received: 23-APR-19
Report Date: 26-APR-19 09:20 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2261392**

Project P.O. #: 211265
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|---|
| L2261392-1 | SW-11193719-041919-JPF-001 | | | | | | | |
| Sampled By: | J-P.FLERAS on 19-APR-19 @ 11:10 | | | | | | | |
| Matrix: | WATER | | | | | | | |
| **Physical Tests** | | | | | | | | |
| Total Suspended Solids | | 14.5 | | 2.0 | mg/L | 25-APR-19 | 26-APR-19 | R4613003 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104-1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

ALS Environmental

# Quality Control Report

Workorder: L2261392 Report Date: 26-APR-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4613003** | | | | | | | | |
| **WG3034352-3 DUP** | | **L2261547-1** | | | | | | |
| Total Suspended Solids | | 99 | 104 | | mg/L | 4.9 | 20 | 26-APR-19 |
| **WG3034352-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 99.9 | | % | | 85-115 | 26-APR-19 |
| **WG3034352-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 26-APR-19 |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2261392-COFC

COC Number: 17 -

Page of

| | | |
|---|---|---|
| **Report To** | Contact and company name below will appear on the final report | |
| Company: | GHD LIMITED - ACCT #13791 | |
| Contact: | Laura Ermeta | |
| Phone: | 519-884-0510 | |
| | Company address below will appear on the final report | |
| Street: | 455 Phillip St | |
| City/Province: | Waterloo,Ontario | |
| Postal Code: | N2L 3X2 | |
| **Invoice To** | Same as Report To | ☑ YES ☐ NO |
| | Copy of Invoice with Report | ☐ YES ☑ NO |
| Company: | GHD Limited | |
| Contact: | Laura Ermeta | |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days):
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐

EMERGENCY:
1 Business day [E - 100%] ☐
Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only): L2261392

ALS Contact: Rick H

Sampler: J-P FLERAS

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | SOLIDS-TSS-WT | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|
| | SW-11193719-041919-JPF-001 | 19/04/19 | 11:10 | Water | 4 | R | | |
| | SW-11193719-_______-_____-_______ | | | Water | | R | | |
| | SW-11193719-_______-_____-_______ | | | Water | | R | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO
Are samples for human consumption/ use?
☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-SWMF TSS

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐
SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐
Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INIITIAL COOLER TEMPERATURES °C

FINAL COOLER TEMPERATURES °C 12.2

**SHIPMENT RELEASE (client use)**

Released by: DAN KRIVENKO
Date: 04-23-2019
Time: 1235

**INITIAL SHIPMENT RECEPTION (lab use only)**

Received by:
Date:
Time:

**FINAL SHIPMENT RECEPTION (lab use only)**

Received by: TM
Date: 04/23/19
Time: 12:35

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

Date Received: 01-MAY-19
Report Date: 07-MAY-19 13:03 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2266208**

Project P.O. #: 211265
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2266208-1 SW-11193719-042919-JPF-001<br>Sampled By: JPF on 29-APR-19 @ 16:15<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 129 | HTC | 1.3 | mg/L | | 03-MAY-19 | |
| Total Suspended Solids | 150 | DLHC | 4.0 | mg/L | 03-MAY-19 | 04-MAY-19 | R4622794 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 101 | | 0.50 | mg/L | | 06-MAY-19 | R4625622 |
| Nitrate (as N) | 0.311 | | 0.020 | mg/L | | 06-MAY-19 | R4625622 |
| Phosphorus (P)-Total Dissolved | 0.0108 | | 0.0030 | mg/L | 06-MAY-19 | 07-MAY-19 | R4625567 |
| Phosphorus, Total | 0.213 | | 0.0030 | mg/L | 06-MAY-19 | 07-MAY-19 | R4625558 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 37.4 | DLHC | 0.50 | mg/L | 02-MAY-19 | 02-MAY-19 | R4620610 |
| Copper (Cu)-Total | 0.016 | DLHC | 0.010 | mg/L | 02-MAY-19 | 02-MAY-19 | R4620610 |
| Lead (Pb)-Total | 0.00763 | DLHC | 0.00050 | mg/L | 02-MAY-19 | 02-MAY-19 | R4620610 |
| Magnesium (Mg)-Total | 8.56 | DLHC | 0.050 | mg/L | 02-MAY-19 | 02-MAY-19 | R4620610 |
| Zinc (Zn)-Total | 0.099 | DLHC | 0.030 | mg/L | 02-MAY-19 | 03-MAY-19 | R4620610 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Tzpe Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2266208-1 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2266208-1 |

## Sample Parameter Qualifier kez listed:

| Qualifier | Description |
|---|---|
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using proced dapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| Suspended solids | | APHA 2540 D-Gravimetric | |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratorz Definition Code | Laboratorz Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custodz Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*

*mg/kg wwt - milligrams per kilogram based on wet weight of sample*

*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*

*mg/L - unit of concentration based on volume, parts per million.*

*< - Less than.*

*D.L. - The reporting limit.*

*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*

*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*

*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

ALS Environmental

# Quality Control Report

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4625622** | | | | | | | | |
| **WG3042653-9 DUP** | | **WG3042653-8** | | | | | | |
| Chloride (Cl) | | 7.86 | 7.84 | | mg/L | 0.2 | 20 | 06-MAY-19 |
| **WG3042653-7 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.6 | | % | | 90-110 | 06-MAY-19 |
| **WG3042653-6 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 06-MAY-19 |
| **WG3042653-10 MS** | | **WG3042653-8** | | | | | | |
| Chloride (Cl) | | | 104.2 | | % | | 75-125 | 06-MAY-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4620610** | | | | | | | | |
| **WG3039578-4 DUP** | | **WG3039578-3** | | | | | | |
| Calcium (Ca)-Total | | 44.1 | 43.7 | | mg/L | 1.0 | 20 | 02-MAY-19 |
| Copper (Cu)-Total | | <0.0010 | <0.0010 | RPD-NA | mg/L | N/A | 20 | 02-MAY-19 |
| Lead (Pb)-Total | | 0.000097 | 0.000096 | | mg/L | 1.7 | 20 | 02-MAY-19 |
| Magnesium (Mg)-Total | | 14.3 | 14.4 | | mg/L | 0.6 | 20 | 02-MAY-19 |
| Zinc (Zn)-Total | | 0.0033 | 0.0036 | | mg/L | 7.5 | 20 | 02-MAY-19 |
| **WG3039578-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 97.1 | | % | | 80-120 | 02-MAY-19 |
| Copper (Cu)-Total | | | 97.7 | | % | | 80-120 | 02-MAY-19 |
| Lead (Pb)-Total | | | 96.8 | | % | | 80-120 | 02-MAY-19 |
| Magnesium (Mg)-Total | | | 102.1 | | % | | 80-120 | 02-MAY-19 |
| Zinc (Zn)-Total | | | 101.2 | | % | | 80-120 | 02-MAY-19 |
| **WG3039578-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 02-MAY-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 02-MAY-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 02-MAY-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 02-MAY-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 03-MAY-19 |
| **WG3039578-5 MS** | | **WG3039578-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 02-MAY-19 |
| Copper (Cu)-Total | | | 91.4 | | % | | 70-130 | 02-MAY-19 |
| Lead (Pb)-Total | | | 91.4 | | % | | 70-130 | 02-MAY-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 02-MAY-19 |
| Zinc (Zn)-Total | | | 90.1 | | % | | 70-130 | 02-MAY-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

ALS Environmental

# Quality Control Report

Workorder: L2266208 Report Date: 07-MAY-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4625622** | | | | | | | | |
| **WG3042653-9 DUP** | | **WG3042653-8** | | | | | | |
| Nitrate (as N) | | <0.020 | <0.020 | RPD-NA | mg/L | N/A | 20 | 06-MAY-19 |
| **WG3042653-7 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.8 | | % | | 90-110 | 06-MAY-19 |
| **WG3042653-6 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 06-MAY-19 |
| **WG3042653-10 MS** | | **WG3042653-8** | | | | | | |
| Nitrate (as N) | | | 99.7 | | % | | 75-125 | 06-MAY-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4625558** | | | | | | | | |
| **WG3042711-3 DUP** | | **L2266184-22** | | | | | | |
| Phosphorus, Total | | 0.0729 | 0.0722 | | mg/L | 1.0 | 20 | 07-MAY-19 |
| **WG3042711-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 101.5 | | % | | 80-120 | 07-MAY-19 |
| **WG3042711-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 07-MAY-19 |
| **WG3042711-4 MS** | | **L2266184-22** | | | | | | |
| Phosphorus, Total | | | 90.1 | | % | | 70-130 | 07-MAY-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4625567** | | | | | | | | |
| **WG3042713-3 DUP** | | **L2266311-6** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0073 | 0.0084 | | mg/L | 15 | 20 | 07-MAY-19 |
| **WG3042713-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 101.9 | | % | | 80-120 | 07-MAY-19 |
| **WG3042713-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 07-MAY-19 |
| **WG3042713-4 MS** | | **L2266311-6** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 95.8 | | % | | 70-130 | 07-MAY-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4622794** | | | | | | | | |
| **WG3040739-3 DUP** | | **L2266800-2** | | | | | | |
| Total Suspended Solids | | 3140 | 3120 | | mg/L | 0.4 | 20 | 04-MAY-19 |
| **WG3040739-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 100.5 | | % | | 85-115 | 04-MAY-19 |
| **WG3040739-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 04-MAY-19 |

# Quality Control Report

Workorder: L2266208 Report Date: 07-MAY-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental

www.alsglobal.com

# Chain of Custody (COC) / Analyti
# Request Form

Canada Toll Free: 1 800 668 9878

L2266208-COFC

COC Number: 17 -

Page of

| | |
|---|---|
| **Report To** | Contact and company name below will appear on the final report |
| Company: | GHD LIMITED - ACCT #13791 |
| Contact: | Laura Ermeta |
| Phone: | 519-884-0510 |
| | Company address below will appear on the final report |
| Street: | 455 Phillip St |
| City/Province: | Waterloo,Ontario |
| Postal Code: | N2L 3X2 |
| **Invoice To** | Same as Report To ☑ YES ☐ NO |
| | Copy of Invoice with Report ☐ YES ☑ NO |
| Company: | GHD Limited |
| Contact: | Laura Ermeta |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2 See PO

Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY
- 1 Business day [E - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918

Job #: 11193719

PO / AFE: 211265

LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center: | PO#

Major/Minor Code: | Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only): L2266208 LS 01D

ALS Contact: Rick H

Sampler: J-P FLERAS

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW-11193719-042919-JPF-001 | 04/29/2019 | 16:15 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-___-___-___ | | | Water | | R | R | R | R | R | R | R | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☒ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C

FINAL COOLER TEMPERATURES °C: 8°C

**SHIPMENT RELEASE (client use)**

Released by: Date: 05/01/2019 Time: 848

**INITIAL SHIPMENT RECEPTION (lab use only)**

Received by: Date: Time:

**FINAL SHIPMENT RECEPTION (lab use only)**

Received by: Date: 01/May/2019 Time: 17:47

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

Date Received: 06-MAY-19
Report Date: 10-MAY-19 12:22 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2268196**

Project P.O. #: 211265
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2268196-1 SW-11193719-050619-LJ-001 | | | | | | | |
| Sampled By: L. JEFFERSON on 06-MAY-19 @ 14:19 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Phzsical Tests** | | | | | | | |
| Hardness (as CaCO3) | 400 | HTC | 1.3 | mg/L | | 08-MAY-19 | |
| Total Suspended Solids | <2.0 | | 2.0 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630209 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 446 | | 0.50 | mg/L | | 08-MAY-19 | R4629187 |
| Nitrate (as N) | 2.22 | | 0.020 | mg/L | | 08-MAY-19 | R4629187 |
| Phosphorus (P)-Total Dissolved | 0.0054 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630445 |
| Phosphorus, Total | 0.0105 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630440 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 119 | | 0.50 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Copper (Cu)-Total | 0.0023 | | 0.0010 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Lead (Pb)-Total | 0.000077 | | 0.000050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Magnesium (Mg)-Total | 25.1 | | 0.050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Zinc (Zn)-Total | 0.0048 | | 0.0030 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| L2268196-2 SW-11193719-050619-LJ-002 | | | | | | | |
| Sampled By: L. JEFFERSON on 06-MAY-19 @ 15:50 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Phzsical Tests** | | | | | | | |
| Hardness (as CaCO3) | 407 | HTC | 1.3 | mg/L | | 08-MAY-19 | |
| Total Suspended Solids | 2.0 | | 2.0 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630209 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 474 | | 0.50 | mg/L | | 08-MAY-19 | R4629187 |
| Nitrate (as N) | 2.80 | | 0.020 | mg/L | | 08-MAY-19 | R4629187 |
| Phosphorus (P)-Total Dissolved | 0.0071 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630445 |
| Phosphorus, Total | 0.0121 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630440 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 121 | DLHC | 0.50 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Copper (Cu)-Total | <0.010 | DLHC | 0.010 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Lead (Pb)-Total | <0.00050 | DLHC | 0.00050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Magnesium (Mg)-Total | 25.5 | DLHC | 0.050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Zinc (Zn)-Total | <0.030 | DLHC | 0.030 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| L2268196-3 SW-11193719-050619-LJ-003 | | | | | | | |
| Sampled By: L. JEFFERSON on 06-MAY-19 @ 17:07 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Phzsical Tests** | | | | | | | |
| Hardness (as CaCO3) | 241 | HTC | 1.3 | mg/L | | 08-MAY-19 | |
| Total Suspended Solids | 3.8 | | 2.0 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630209 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 343 | | 0.50 | mg/L | | 08-MAY-19 | R4629187 |
| Nitrate (as N) | 0.436 | | 0.020 | mg/L | | 08-MAY-19 | R4629187 |
| Phosphorus (P)-Total Dissolved | 0.0119 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630445 |
| Phosphorus, Total | 0.0231 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630440 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 69.7 | | 0.50 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2268196-3 SW-11193719-050619-LJ-003 | | | | | | | |
| Sampled By: L. JEFFERSON on 06-MAY-19 @ 17:07 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals** | | | | | | | |
| Copper (Cu)-Total | 0.0029 | | 0.0010 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Lead (Pb)-Total | 0.000260 | | 0.000050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Magnesium (Mg)-Total | 16.2 | | 0.050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Zinc (Zn)-Total | 0.0052 | | 0.0030 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| L2268196-4 SW-11193719-050619-LJ-004 | | | | | | | |
| Sampled By: L. JEFFERSON on 06-MAY-19 @ 17:20 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Phzsical Tests** | | | | | | | |
| Hardness (as CaCO3) | 236 | HTC | 1.3 | mg/L | | 08-MAY-19 | |
| Total Suspended Solids | 2.5 | | 2.0 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630209 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 343 | | 0.50 | mg/L | | 08-MAY-19 | R4629187 |
| Nitrate (as N) | 0.404 | | 0.020 | mg/L | | 08-MAY-19 | R4629187 |
| Phosphorus (P)-Total Dissolved | 0.0119 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630445 |
| Phosphorus, Total | 0.0235 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630440 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 67.8 | | 0.50 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Copper (Cu)-Total | 0.0024 | | 0.0010 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Lead (Pb)-Total | 0.000252 | | 0.000050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Magnesium (Mg)-Total | 16.1 | | 0.050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Zinc (Zn)-Total | 0.0051 | | 0.0030 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| L2268196-5 SW-11193719-050619-LJ-005 | | | | | | | |
| Sampled By: L. JEFFERSON on 06-MAY-19 @ 17:38 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Phzsical Tests** | | | | | | | |
| Hardness (as CaCO3) | 222 | HTC | 1.3 | mg/L | | 08-MAY-19 | |
| Total Suspended Solids | 4.8 | | 2.0 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630209 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 342 | | 0.50 | mg/L | | 08-MAY-19 | R4629187 |
| Nitrate (as N) | 0.280 | | 0.020 | mg/L | | 08-MAY-19 | R4629187 |
| Phosphorus (P)-Total Dissolved | 0.0118 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630445 |
| Phosphorus, Total | 0.0252 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630440 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 63.9 | | 0.50 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Copper (Cu)-Total | 0.0024 | | 0.0010 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Lead (Pb)-Total | 0.000289 | | 0.000050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Magnesium (Mg)-Total | 15.1 | | 0.050 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |
| Zinc (Zn)-Total | 0.0059 | | 0.0030 | mg/L | 07-MAY-19 | 07-MAY-19 | R4625748 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Tzpe Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2268196-1, -2, -3, -4, -5 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2268196-1, -2, -3, -4, -5 |
| Matrix Spike | Zinc (Zn)-Total | MS-B | L2268196-1, -2, -3, -4, -5 |

## Sample Parameter Qualifier kez listed:

| Qualifier | Description |
|---|---|
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratorz Definition Code | Laboratorz Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custodz Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2268196 Report Date: 10-MAY-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4629187** | | | | | | | | |
| **WG3044240-4 DUP** | | **WG3044240-3** | | | | | | |
| Chloride (Cl) | | 58.0 | 57.9 | | mg/L | 0.2 | 20 | 08-MAY-19 |
| **WG3044240-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.6 | | % | | 90-110 | 08-MAY-19 |
| **WG3044240-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 08-MAY-19 |
| **WG3044240-5 MS** | | **WG3044240-3** | | | | | | |
| Chloride (Cl) | | | 104.7 | | % | | 75-125 | 08-MAY-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4625748** | | | | | | | | |
| **WG3042882-4 DUP** | | **WG3042882-3** | | | | | | |
| Calcium (Ca)-Total | | 88.9 | 90.6 | | mg/L | 1.9 | 20 | 07-MAY-19 |
| Copper (Cu)-Total | | 0.0026 | 0.0028 | | mg/L | 8.0 | 20 | 07-MAY-19 |
| Lead (Pb)-Total | | 0.00334 | 0.00349 | | mg/L | 4.5 | 20 | 07-MAY-19 |
| Magnesium (Mg)-Total | | 49.2 | 49.0 | | mg/L | 0.2 | 20 | 07-MAY-19 |
| Zinc (Zn)-Total | | 0.201 | 0.200 | | mg/L | 0.2 | 20 | 07-MAY-19 |
| **WG3042882-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 102.0 | | % | | 80-120 | 07-MAY-19 |
| Copper (Cu)-Total | | | 100.9 | | % | | 80-120 | 07-MAY-19 |
| Lead (Pb)-Total | | | 102.2 | | % | | 80-120 | 07-MAY-19 |
| Magnesium (Mg)-Total | | | 103.4 | | % | | 80-120 | 07-MAY-19 |
| Zinc (Zn)-Total | | | 99.5 | | % | | 80-120 | 07-MAY-19 |
| **WG3042882-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 07-MAY-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 07-MAY-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 07-MAY-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 07-MAY-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 07-MAY-19 |
| **WG3042882-5 MS** | | **WG3042882-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 07-MAY-19 |
| Copper (Cu)-Total | | | 91.3 | | % | | 70-130 | 07-MAY-19 |
| Lead (Pb)-Total | | | 90.7 | | % | | 70-130 | 07-MAY-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 07-MAY-19 |
| Zinc (Zn)-Total | | | N/A | MS-B | % | | - | 07-MAY-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4629187** | | | | | | | | |
| **WG3044240-4 DUP** | | **WG3044240-3** | | | | | | |
| Nitrate (as N) | | <0.020 | <0.020 | RPD-NA | mg/L | N/A | 20 | 08-MAY-19 |
| **WG3044240-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.6 | | % | | 90-110 | 08-MAY-19 |
| **WG3044240-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 08-MAY-19 |
| **WG3044240-5 MS** | | **WG3044240-3** | | | | | | |
| Nitrate (as N) | | | 103.1 | | % | | 75-125 | 08-MAY-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4630440** | | | | | | | | |
| **WG3045445-3 DUP** | | **L2268196-5** | | | | | | |
| Phosphorus, Total | | 0.0252 | 0.0252 | | mg/L | 0.0 | 20 | 10-MAY-19 |
| **WG3045453-3 DUP** | | **L2268196-3** | | | | | | |
| Phosphorus, Total | | 0.0231 | 0.0258 | | mg/L | 11 | 20 | 10-MAY-19 |
| **WG3045445-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 103.6 | | % | | 80-120 | 10-MAY-19 |
| **WG3045453-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 103.8 | | % | | 80-120 | 10-MAY-19 |
| **WG3045445-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 10-MAY-19 |
| **WG3045453-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 10-MAY-19 |
| **WG3045445-4 MS** | | **L2268196-5** | | | | | | |
| Phosphorus, Total | | | 90.3 | | % | | 70-130 | 10-MAY-19 |
| **WG3045453-4 MS** | | **L2268196-3** | | | | | | |
| Phosphorus, Total | | | 92.3 | | % | | 70-130 | 10-MAY-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4630445** | | | | | | | | |
| **WG3045457-3 DUP** | | **L2268196-5** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0118 | 0.0104 | | mg/L | 13 | 20 | 10-MAY-19 |
| **WG3045457-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 103.5 | | % | | 80-120 | 10-MAY-19 |
| **WG3045457-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 10-MAY-19 |
| **WG3045457-4 MS** | | **L2268196-5** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 97.4 | | % | | 70-130 | 10-MAY-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2268196 Report Date: 10-MAY-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4630209** | | | | | | | | |
| **WG3045136-3 DUP** | | **L2268797-2** | | | | | | |
| Total Suspended Solids | | 2670 | 2490 | | mg/L | 7.1 | 20 | 10-MAY-19 |
| **WG3045136-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 101.2 | | % | | 85-115 | 10-MAY-19 |
| **WG3045136-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 10-MAY-19 |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental

www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2268196-COFC

COC Number: 17 -

Page 1 of 1

| | |
|---|---|
| **Report To** | Contact and company name below will appear on the final report |
| Company: | GHD LIMITED - ACCT #13791 |
| Contact: | Laura Ermeta |
| Phone: | 519-884-0510 |
| | Company address below will appear on the final report |
| Street: | 455 Phillip St |
| City/Province: | Waterloo,Ontario |
| Postal Code: | N2L 3X2 |
| **Invoice To** | Same as Report To ☑ YES ☐ NO |
| | Copy of Invoice with Report ☐ YES ☑ NO |
| Company: | GHD Limited |
| Contact: | Laura Ermeta |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2 See PO

Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY
- 1 Business day [E - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918

Job #: 11193719

PO / AFE: 211265

LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center:

PO#

Major/Minor Code:

Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only): L2268196

ALS Contact: Rick H

Sampler: L. Jefferson

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-050619-LJ-001 | 06-May-19 | 2:19pm | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-050619-LJ-002 | ↓ | 3:50pm | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-050619-LJ-003 | | 5:07pm | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-050619-LJ-004 | | 5:20pm | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-080619-LJ-005 | | 5:38pm | Water | 4 | R | R | R | R | R | R | R | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-GRAB

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | FINAL COOLER TEMPERATURES °C | | |
|---|---|---|---|---|---|
| | | | 10.8 | | |

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: Jefferson | Date: May 6/19 | Time: 18:22 | Received by: | Date: | Time: | Received by: | Date: May 6/19 | Time: 18:20 |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2016 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

| | |
|---|---|
| Date Received: | 07-MAY-19 |
| Report Date: | 10-MAY-19 12:23 (MT) |
| Version: | FINAL |

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2268231**

| | |
|---|---|
| Project P.O. #: | 211265 |
| Job Reference: | 11193719 |
| C of C Numbers: | |
| Legal Site Desc: | |

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2268231-1 SW-11193719-050719-JPF-001<br>Sampled By: JPF on 07-MAY-19 @ 07:00<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 149 | HTC | 1.3 | mg/L | | 08-MAY-19 | |
| Total Suspended Solids | 63.2 | | 2.0 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630210 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 122 | | 0.50 | mg/L | | 07-MAY-19 | R4628221 |
| Nitrate (as N) | 0.568 | | 0.020 | mg/L | | 07-MAY-19 | R4628221 |
| Phosphorus (P)-Total Dissolved | 0.0448 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630445 |
| Phosphorus, Total | 0.131 | | 0.0030 | mg/L | 09-MAY-19 | 10-MAY-19 | R4630440 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 45.3 | | 0.50 | mg/L | 08-MAY-19 | 08-MAY-19 | R4627931 |
| Copper (Cu)-Total | 0.0137 | | 0.0010 | mg/L | 08-MAY-19 | 08-MAY-19 | R4627931 |
| Lead (Pb)-Total | 0.00187 | | 0.000050 | mg/L | 08-MAY-19 | 08-MAY-19 | R4627931 |
| Magnesium (Mg)-Total | 8.82 | | 0.050 | mg/L | 08-MAY-19 | 08-MAY-19 | R4627931 |
| Zinc (Zn)-Total | 0.0297 | | 0.0030 | mg/L | 08-MAY-19 | 08-MAY-19 | R4627931 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2268231-1 |
| Matrix Spike | Copper (Cu)-Total | MS-B | L2268231-1 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2268231-1 |
| Matrix Spike | Zinc (Zn)-Total | MS-B | L2268231-1 |
| Matrix Spike | Nitrate (as N) | MS-B | L2268231-1 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

<table>
<tr><th>ALS Test Code</th><th>Matrix</th><th>Test Description</th><th>Method Reference**</th></tr>
<tr><td>CL-IC-N-WT</td><td>Water</td><td>Chloride by IC</td><td>EPA 300.1 (mod)</td></tr>
<tr><td colspan="4">Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.<br><br>Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).</td></tr>
<tr><td>HARDNESS-CALC-WT</td><td>Water</td><td>Hardness</td><td>APHA 2340 B</td></tr>
<tr><td colspan="4">Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.</td></tr>
<tr><td>MET-T-CCMS-WT</td><td>Water</td><td>Total Metals in Water by CRC ICPMS</td><td>EPA 200.2/6020A (mod)</td></tr>
<tr><td colspan="4">Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.<br><br>Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.<br><br>Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).</td></tr>
<tr><td>NO3-IC-WT</td><td>Water</td><td>Nitrate in Water by IC</td><td>EPA 300.1 (mod)</td></tr>
<tr><td colspan="4">Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.</td></tr>
<tr><td>P-T-COL-WT</td><td>Water</td><td>Total P in Water by Colour</td><td>APHA 4500-P PHOSPHORUS</td></tr>
<tr><td colspan="4">This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.</td></tr>
<tr><td>P-TD-COL-WT</td><td>Water</td><td>Total Dissolved P in Water by Colour</td><td>APHA 4500-P PHOSPHORUS</td></tr>
<tr><td colspan="4">This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.</td></tr>
<tr><td>SOLIDS-TSS-WT</td><td>Water</td><td>Suspended solids</td><td>APHA 2540 D-Gravimetric</td></tr>
<tr><td colspan="4">A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.</td></tr>
</table>

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSART OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

# Quality Control Report

Workorder: L2268231 Report Date: 10-MAY-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4628221** | | | | | | | | |
| **WG3043259-19 DUP** | | **WG3043259-18** | | | | | | |
| Chloride (Cl) | | 83.3 | 83.3 | | mg/L | 0.0 | 20 | 07-MAY-19 |
| **WG3043259-17 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.6 | | % | | 90-110 | 07-MAY-19 |
| **WG3043259-16 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 07-MAY-19 |
| **WG3043259-20 MS** | | **WG3043259-18** | | | | | | |
| Chloride (Cl) | | | 99.1 | | % | | 75-125 | 07-MAY-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4627931** | | | | | | | | |
| **WG3043896-4 DUP** | | **WG3043896-3** | | | | | | |
| Calcium (Ca)-Total | | 45.4 | 44.8 | | mg/L | 1.5 | 20 | 08-MAY-19 |
| Copper (Cu)-Total | | <0.0010 | <0.0010 | RPD-NA | mg/L | N/A | 20 | 08-MAY-19 |
| Lead (Pb)-Total | | 0.000083 | 0.000079 | | mg/L | 5.2 | 20 | 08-MAY-19 |
| Magnesium (Mg)-Total | | 16.0 | 16.0 | | mg/L | 0.5 | 20 | 08-MAY-19 |
| Zinc (Zn)-Total | | <0.0030 | <0.0030 | RPD-NA | mg/L | N/A | 20 | 08-MAY-19 |
| **WG3043896-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 97.4 | | % | | 80-120 | 08-MAY-19 |
| Copper (Cu)-Total | | | 99.8 | | % | | 80-120 | 08-MAY-19 |
| Lead (Pb)-Total | | | 99.5 | | % | | 80-120 | 08-MAY-19 |
| Magnesium (Mg)-Total | | | 105.7 | | % | | 80-120 | 08-MAY-19 |
| Zinc (Zn)-Total | | | 100.5 | | % | | 80-120 | 08-MAY-19 |
| **WG3043896-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 08-MAY-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 08-MAY-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 08-MAY-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 08-MAY-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 08-MAY-19 |
| **WG3043896-5 MS** | | **WG3043896-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 08-MAY-19 |
| Copper (Cu)-Total | | | N/A | MS-B | % | | - | 08-MAY-19 |
| Lead (Pb)-Total | | | 93.9 | | % | | 70-130 | 08-MAY-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 08-MAY-19 |
| Zinc (Zn)-Total | | | N/A | MS-B | % | | - | 08-MAY-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4628221** | | | | | | | | |
| **WG3043259-19 DUP** | | **WG3043259-18** | | | | | | |
| Nitrate (as N) | | 2.65 | 2.61 | | mg/L | 1.3 | 20 | 07-MAY-19 |
| **WG3043259-17 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.9 | | % | | 90-110 | 07-MAY-19 |
| **WG3043259-16 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 07-MAY-19 |
| **WG3043259-20 MS** | | **WG3043259-18** | | | | | | |
| Nitrate (as N) | | | N/A | MS-B | % | | - | 07-MAY-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4630440** | | | | | | | | |
| **WG3045453-3 DUP** | | **L2268196-3** | | | | | | |
| Phosphorus, Total | | 0.0231 | 0.0258 | | mg/L | 11 | 20 | 10-MAY-19 |
| **WG3045453-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 103.8 | | % | | 80-120 | 10-MAY-19 |
| **WG3045453-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 10-MAY-19 |
| **WG3045453-4 MS** | | **L2268196-3** | | | | | | |
| Phosphorus, Total | | | 92.3 | | % | | 70-130 | 10-MAY-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4630445** | | | | | | | | |
| **WG3045457-3 DUP** | | **L2268196-5** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0118 | 0.0104 | | mg/L | 13 | 20 | 10-MAY-19 |
| **WG3045457-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 103.5 | | % | | 80-120 | 10-MAY-19 |
| **WG3045457-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 10-MAY-19 |
| **WG3045457-4 MS** | | **L2268196-5** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 97.4 | | % | | 70-130 | 10-MAY-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4630210** | | | | | | | | |
| **WG3045131-3 DUP** | | **L2268777-2** | | | | | | |
| Total Suspended Solids | | 2670 | 2860 | | mg/L | 6.9 | 20 | 10-MAY-19 |
| **WG3045131-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 100.4 | | % | | 85-115 | 10-MAY-19 |
| **WG3045131-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 10-MAY-19 |

# Quality Control Report

Workorder: L2268231 Report Date: 10-MAY-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2268231-COFC

COC Number: 17 -

Page of

| | |
|---|---|
| **Report To** | Contact and company name below will appear on the final report |
| Company: | GHD LIMITED - ACCT #13791 |
| Contact: | Laura Ermeta |
| Phone: | 519-884-0510 |
| | Company address below will appear on the final report |
| Street: | 455 Phillip St |
| City/Province: | Waterloo,Ontario |
| Postal Code: | N2L 3X2 |
| **Invoice To** | Same as Report To ☑ YES ☐ NO |
| | Copy of Invoice with Report ☐ YES ☑ NO |
| Company: | GHD Limited |
| Contact: | Laura Ermeta |

**Report Format**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2

…w - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐

EMERGENCY
1 Business day [E - 100%] ☐
Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only): L2268231

ALS Contact: Rick H

Sampler: JPFleal

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | | | | | | | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-050719-JPF-001 | 07-May-19 | 07:00 A | Water | 4 | R | R | R | R | R | R | R | | | | | | | | — | — |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☑ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | FINAL COOLER TEMPERATURES °C | | |
|---|---|---|---|---|---|
| | | | 4.2 | | |

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: JPFleal | Date: May 7 2019 | Time: 0815 | Received by: | Date: | Time: | Received by: | Date: May 7/2019 | Time: 815 AM |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

| | |
|---|---|
| Date Received: | 05-JUN-19 |
| Report Date: | 13-JUN-19 14:24 (MT) |
| Version: | FINAL |

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2286119**

| | |
|---|---|
| Project P.O. #: | 211265 |
| Job Reference: | 11193719 |
| C of C Numbers: | |
| Legal Site Desc: | |

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2286119-1 SW-11193719-060419-DK-001<br>Sampled By: DK on 04-JUN-19 @ 09:30<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 136 | HTC | 1.3 | mg/L | | 07-JUN-19 | |
| Total Suspended Solids | 71 | DLHC | 20 | mg/L | 10-JUN-19 | 11-JUN-19 | R4663232 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 174 | DLDS | 0.50 | mg/L | | 06-JUN-19 | R4661315 |
| Nitrate (as N) | 0.472 | DLDS | 0.020 | mg/L | | 06-JUN-19 | R4661315 |
| Phosphorus (P)-Total Dissolved | 0.106 | | 0.0030 | mg/L | 12-JUN-19 | 13-JUN-19 | R4668516 |
| Phosphorus, Total | 0.211 | | 0.0030 | mg/L | 12-JUN-19 | 13-JUN-19 | R4668512 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 42.0 | | 0.50 | mg/L | 06-JUN-19 | 06-JUN-19 | R4659849 |
| Copper (Cu)-Total | 0.0121 | | 0.0010 | mg/L | 06-JUN-19 | 06-JUN-19 | R4659849 |
| Lead (Pb)-Total | 0.00144 | | 0.000050 | mg/L | 06-JUN-19 | 06-JUN-19 | R4659849 |
| Magnesium (Mg)-Total | 7.54 | | 0.050 | mg/L | 06-JUN-19 | 06-JUN-19 | R4659849 |
| Zinc (Zn)-Total | 0.0323 | | 0.0030 | mg/L | 06-JUN-19 | 06-JUN-19 | R4659849 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Chloride (Cl) | MS-B | L2286119-1 |
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2286119-1 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2286119-1 |
| Matrix Spike | Nitrate (as N) | MS-B | L2286119-1 |
| Matrix Spike | Phosphorus, Total | MS-B | L2286119-1 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| DLDS | Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity. |
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| EC-SCREEN-WT | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

**ALS Environmental**

# Quality Control Report

Workorder: L2286119 Report Date: 13-JUN-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4661315** | | | | | | | | |
| **WG3069823-14 DUP** | | **WG3069823-13** | | | | | | |
| Chloride (Cl) | | 126 | 126 | | mg/L | 0.1 | 20 | 06-JUN-19 |
| **WG3069823-12 LCS** | | | | | | | | |
| Chloride (Cl) | | | 102.7 | | % | | 90-110 | 06-JUN-19 |
| **WG3069823-11 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 06-JUN-19 |
| **WG3069823-15 MS** | | **WG3069823-13** | | | | | | |
| Chloride (Cl) | | | N/A | MS-B | % | | - | 06-JUN-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4659849** | | | | | | | | |
| **WG3068892-4 DUP** | | **WG3068892-3** | | | | | | |
| Calcium (Ca)-Total | | 508 | 515 | | mg/L | 1.4 | 20 | 06-JUN-19 |
| Copper (Cu)-Total | | <0.010 | <0.010 | RPD-NA | mg/L | N/A | 20 | 06-JUN-19 |
| Lead (Pb)-Total | | <0.00050 | <0.00050 | RPD-NA | mg/L | N/A | 20 | 06-JUN-19 |
| Magnesium (Mg)-Total | | 177 | 176 | | mg/L | 0.1 | 20 | 06-JUN-19 |
| Zinc (Zn)-Total | | <0.030 | <0.030 | RPD-NA | mg/L | N/A | 20 | 06-JUN-19 |
| **WG3068892-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 92.8 | | % | | 80-120 | 06-JUN-19 |
| Copper (Cu)-Total | | | 89.5 | | % | | 80-120 | 06-JUN-19 |
| Lead (Pb)-Total | | | 98.6 | | % | | 80-120 | 06-JUN-19 |
| Magnesium (Mg)-Total | | | 93.2 | | % | | 80-120 | 06-JUN-19 |
| Zinc (Zn)-Total | | | 94.6 | | % | | 80-120 | 06-JUN-19 |
| **WG3068892-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 06-JUN-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 06-JUN-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 06-JUN-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 06-JUN-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 06-JUN-19 |
| **WG3068892-5 MS** | | **WG3068892-3** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 06-JUN-19 |
| Copper (Cu)-Total | | | 86.1 | | % | | 70-130 | 06-JUN-19 |
| Lead (Pb)-Total | | | 84.3 | | % | | 70-130 | 06-JUN-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 06-JUN-19 |
| Zinc (Zn)-Total | | | 83.3 | | % | | 70-130 | 06-JUN-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2286119 Report Date: 13-JUN-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4661315** | | | | | | | | |
| **WG3069823-14 DUP** | | **WG3069823-13** | | | | | | |
| Nitrate (as N) | | 3.39 | 3.39 | | mg/L | 0.0 | 20 | 06-JUN-19 |
| **WG3069823-12 LCS** | | | | | | | | |
| Nitrate (as N) | | | 102.5 | | % | | 90-110 | 06-JUN-19 |
| **WG3069823-11 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 06-JUN-19 |
| **WG3069823-15 MS** | | **WG3069823-13** | | | | | | |
| Nitrate (as N) | | | N/A | MS-B | % | | - | 06-JUN-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4668512** | | | | | | | | |
| **WG3075299-3 DUP** | | **L2286119-1** | | | | | | |
| Phosphorus, Total | | 0.211 | 0.194 | | mg/L | 8.7 | 20 | 13-JUN-19 |
| **WG3075299-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 97.1 | | % | | 80-120 | 13-JUN-19 |
| **WG3075299-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 13-JUN-19 |
| **WG3075299-4 MS** | | **L2286119-1** | | | | | | |
| Phosphorus, Total | | | N/A | MS-B | % | | - | 13-JUN-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4668516** | | | | | | | | |
| **WG3075306-3 DUP** | | **L2287106-4** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0068 | 0.0069 | | mg/L | 2.3 | 20 | 13-JUN-19 |
| **WG3075306-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 99.2 | | % | | 80-120 | 13-JUN-19 |
| **WG3075306-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 13-JUN-19 |
| **WG3075306-4 MS** | | **L2287106-4** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 114.1 | | % | | 70-130 | 13-JUN-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4663232** | | | | | | | | |
| **WG3072250-3 DUP** | | **L2285554-3** | | | | | | |
| Total Suspended Solids | | 650 | 710 | | mg/L | 8.1 | 20 | 11-JUN-19 |
| **WG3072250-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 100.1 | | % | | 85-115 | 11-JUN-19 |
| **WG3072250-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 11-JUN-19 |

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

# Chain of Custody (COC) / Analytical Request Form

**ALS Environmental**
www.alsglobal.com

**Canada Toll Free: 1 800 668 9878**

L2286119-COFC

COC Number: 17 -

Page of

UB.

| **Report To** | Contact and company name below will appear on the final report |
|---|---|
| Company: | **GHD LIMITED - ACCT #13791** |
| Contact: | Laura Ermeta |
| Phone: | 519-884-0510 |
| | Company address below will appear on the final report |
| Street: | 455 Phillip St |
| City/Province: | Waterloo,Ontario |
| Postal Code: | N2L 3X2 |
| **Invoice To** | Same as Report To ☐ YES ☑ NO |
| | Copy of Invoice with Report ☐ YES ☑ NO |
| Company: | City of Kitchener |
| Contact: | Chris Nechacov |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2 See PO

Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax Chris.Nechacov@kitchener.ca

Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

**Regular [R]** ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- **4 day [P4-20%]** ☐
- **3 day [P3-25%]** ☐
- **2 day [P2-50%]** ☐

EMERGENCY
- **1 Business day [E - 100%]** ☐
- **Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ]** ☐

**Date and Time Required for all E&P TATs:** dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

**ALS Account # / Quote #:** 13791, Q51918

Job #: 11193719

PO / AFE: 211265

LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

**ALS Lab Work Order # (lab use only):** L2286119 28. 050.

**ALS Contact:** Rick H

**Sampler:** Dan Krivenko

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| **ALS Sample # (lab use only)** | **Sample Identification and/or Coordinates** (This description will appear on the report) | **Date** (dd-mmm-yy) | **Time** (hh:mm) | **Sample Type** | **NUMBER OF CONTAINERS** | **NO3, CL (ANIONS-IC-2-WT)** | **Total Select Metals (MET-T-CCMS-WT)** | **REP: Cu, Pb, Zn, Ca, Mg** | **Hardness (HARDNESS-CALC-WT)** | **Diss. Phosphorus LL (P-TD-COL-WT)** | **Total Phosphorus LL (P-T-COL-WT)** | **TSS (SOLIDS-TSS-WT)** | | | | | | | | **SAMPLES ON HOLD** | **SUSPECTED HAZARD (see Special Instructions)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | SW-11193719-060419-DK-001 | 04/06/2019 | 9:30 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-____-____-____ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |

**Drinking Water (DW) Samples[1] (client use)**

**Are samples taken from a Regulated DW System?**

☐ YES ☑ NO

**Are samples for human consumption/ use?**

☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-GRAB

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☒ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☒

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | 7.6° | | | |

**SHIPMENT RELEASE (client use)**

Released by: Daniel Krivenko

Date: ~~FS~~ 06/05/19

Time: 5:02

**INITIAL SHIPMENT RECEPTION (lab use only)**

Received by:

Date:

Time:

**FINAL SHIPMENT RECEPTION (lab use only)**

Received by: UB

Date: June 5

Time: 17:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

Date Received: 10-JUN-19
Report Date: 18-JUN-19 11:51 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2288189**

Project P.O. #: 211265
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2288189-1 SW-11193719-060919-JPF-001<br>Sampled By: J-P FLERAS on 09-JUN-19 @ 06:15<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 97.7 | HTC | 1.3 | mg/L | | 11-JUN-19 | |
| Total Suspended Solids | 112 | | 2.0 | mg/L | 13-JUN-19 | 14-JUN-19 | R4669881 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 67.3 | | 0.50 | mg/L | | 11-JUN-19 | R4664225 |
| Nitrate (as N) | 0.455 | | 0.020 | mg/L | | 11-JUN-19 | R4664225 |
| Phosphorus (P)-Total Dissolved | 0.0506 | | 0.0030 | mg/L | 17-JUN-19 | 18-JUN-19 | R4672411 |
| Phosphorus, Total | 0.177 | | 0.0030 | mg/L | 17-JUN-19 | 18-JUN-19 | R4672402 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 29.4 | | 0.50 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Copper (Cu)-Total | 0.0121 | | 0.0010 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Lead (Pb)-Total | 0.00278 | | 0.000050 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Magnesium (Mg)-Total | 5.90 | | 0.050 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Zinc (Zn)-Total | 0.0431 | | 0.0030 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| L2288189-2 SW-11193719-060919-JPF-002<br>Sampled By: J-P FLERAS on 09-JUN-19 @ 07:05<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 139 | HTC | 1.3 | mg/L | | 11-JUN-19 | |
| Total Suspended Solids | 388 | | 2.0 | mg/L | 13-JUN-19 | 14-JUN-19 | R4669881 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 79.3 | | 0.50 | mg/L | | 11-JUN-19 | R4664225 |
| Nitrate (as N) | 0.116 | | 0.020 | mg/L | | 11-JUN-19 | R4664225 |
| Phosphorus (P)-Total Dissolved | 0.0623 | | 0.0030 | mg/L | 17-JUN-19 | 18-JUN-19 | R4672411 |
| Phosphorus, Total | 0.507 | | 0.0030 | mg/L | 17-JUN-19 | 18-JUN-19 | R4672402 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 39.4 | | 0.50 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Copper (Cu)-Total | 0.0306 | | 0.0010 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Lead (Pb)-Total | 0.0137 | | 0.000050 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Magnesium (Mg)-Total | 9.91 | | 0.050 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Zinc (Zn)-Total | 0.142 | | 0.0030 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| L2288189-3 SW-11193719-060919-JPF-003<br>Sampled By: J-P FLERAS on 09-JUN-19 @ 07:40<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 261 | HTC | 1.3 | mg/L | | 11-JUN-19 | |
| Total Suspended Solids | 56.4 | | 2.0 | mg/L | 13-JUN-19 | 14-JUN-19 | R4669881 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 100 | | 0.50 | mg/L | | 11-JUN-19 | R4664225 |
| Nitrate (as N) | 0.660 | | 0.020 | mg/L | | 11-JUN-19 | R4664225 |
| Phosphorus (P)-Total Dissolved | 0.0055 | | 0.0030 | mg/L | 17-JUN-19 | 18-JUN-19 | R4672411 |
| Phosphorus, Total | 0.0351 | | 0.0030 | mg/L | 17-JUN-19 | 18-JUN-19 | R4672402 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 73.7 | | 0.50 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2288189-3 SW-11193719-060919-JPF-003<br>Sampled By: J-P FLERAS on 09-JUN-19 @ 07:40<br>Matrix: WATER | | | | | | | |
| **Total Metals** | | | | | | | |
| Copper (Cu)-Total | 0.0043 | | 0.0010 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Lead (Pb)-Total | 0.00114 | | 0.000050 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Magnesium (Mg)-Total | 18.6 | | 0.050 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |
| Zinc (Zn)-Total | 0.0126 | | 0.0030 | mg/L | 11-JUN-19 | 11-JUN-19 | R4663292 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2288189-1, -2, -3 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2288189-1, -2, -3 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| EC-SCREEN-WT | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2288189 Report Date: 18-JUN-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4664225** | | | | | | | | |
| **WG3073775-4 DUP** | | **WG3073775-3** | | | | | | |
| Chloride (Cl) | | 8.22 | 8.23 | | mg/L | 0.1 | 20 | 11-JUN-19 |
| **WG3073775-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.1 | | % | | 90-110 | 11-JUN-19 |
| **WG3073775-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 11-JUN-19 |
| **WG3073775-5 MS** | | **WG3073775-3** | | | | | | |
| Chloride (Cl) | | | 101.6 | | % | | 75-125 | 11-JUN-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4663292** | | | | | | | | |
| **WG3073224-4 DUP** | | **WG3073224-3** | | | | | | |
| Calcium (Ca)-Total | | 209 | 219 | | mg/L | 4.8 | 20 | 11-JUN-19 |
| Copper (Cu)-Total | | <0.010 | <0.010 | RPD-NA | mg/L | N/A | 20 | 11-JUN-19 |
| Lead (Pb)-Total | | <0.00050 | <0.00050 | RPD-NA | mg/L | N/A | 20 | 11-JUN-19 |
| Magnesium (Mg)-Total | | 34.3 | 33.5 | | mg/L | 2.4 | 20 | 11-JUN-19 |
| Zinc (Zn)-Total | | <0.030 | <0.030 | RPD-NA | mg/L | N/A | 20 | 11-JUN-19 |
| **WG3073224-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 102.5 | | % | | 80-120 | 11-JUN-19 |
| Copper (Cu)-Total | | | 98.9 | | % | | 80-120 | 11-JUN-19 |
| Lead (Pb)-Total | | | 100.6 | | % | | 80-120 | 11-JUN-19 |
| Magnesium (Mg)-Total | | | 108.3 | | % | | 80-120 | 11-JUN-19 |
| Zinc (Zn)-Total | | | 96.8 | | % | | 80-120 | 11-JUN-19 |
| **WG3073224-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 11-JUN-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 11-JUN-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 11-JUN-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 11-JUN-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 11-JUN-19 |
| **WG3073224-5 MS** | | **WG3073224-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 11-JUN-19 |
| Copper (Cu)-Total | | | 94.4 | | % | | 70-130 | 11-JUN-19 |
| Lead (Pb)-Total | | | 94.2 | | % | | 70-130 | 11-JUN-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 11-JUN-19 |
| Zinc (Zn)-Total | | | 91.4 | | % | | 70-130 | 11-JUN-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2288189 Report Date: 18-JUN-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4664225** | | | | | | | | |
| **WG3073775-4 DUP** | | **WG3073775-3** | | | | | | |
| Nitrate (as N) | | 0.428 | 0.428 | | mg/L | 0.0 | 20 | 11-JUN-19 |
| **WG3073775-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.6 | | % | | 90-110 | 11-JUN-19 |
| **WG3073775-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 11-JUN-19 |
| **WG3073775-5 MS** | | **WG3073775-3** | | | | | | |
| Nitrate (as N) | | | 100.4 | | % | | 75-125 | 11-JUN-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4672402** | | | | | | | | |
| **WG3079455-3 DUP** | | **L2288154-5** | | | | | | |
| Phosphorus, Total | | 0.0170 | 0.0151 | | mg/L | 12 | 20 | 18-JUN-19 |
| **WG3079455-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 92.8 | | % | | 80-120 | 18-JUN-19 |
| **WG3079455-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 18-JUN-19 |
| **WG3079455-4 MS** | | **L2288154-5** | | | | | | |
| Phosphorus, Total | | | 89.1 | | % | | 70-130 | 18-JUN-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4672411** | | | | | | | | |
| **WG3079464-3 DUP** | | **L2288189-3** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0055 | 0.0060 | | mg/L | 9.6 | 20 | 18-JUN-19 |
| **WG3079464-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 90.2 | | % | | 80-120 | 18-JUN-19 |
| **WG3079464-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 18-JUN-19 |
| **WG3079464-4 MS** | | **L2288189-3** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 98.1 | | % | | 70-130 | 18-JUN-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4669881** | | | | | | | | |
| **WG3076492-3 DUP** | | **L2288343-1** | | | | | | |
| Total Suspended Solids | | 23.5 | 23.5 | | mg/L | 0.2 | 20 | 14-JUN-19 |
| **WG3076492-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 101.8 | | % | | 85-115 | 14-JUN-19 |
| **WG3076492-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 14-JUN-19 |

# Quality Control Report

Workorder: L2288189 Report Date: 18-JUN-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

# Chain of Custody (COC) / Analytical Request Form

ALS
www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L2288189-COFC

COC Number: 17 -

Page 1 of 1

**Report To** Contact and company name below will appear on the final report

Company: GHD LIMITED - ACCT #13791
Contact: Laura Ermeta
Phone: 519-884-0510
Company address below will appear on the final report
Street: 455 Phillip St
City/Province: Waterloo,Ontario
Postal Code: N2L 3X2

**Invoice To** Same as Report To ☑ YES ☐ NO
Copy of Invoice with Report ☐ YES ☑ NO
Company: GHD Limited
Contact: Laura Ermeta

**Project Information**
ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

ALS Lab Work Order # (lab use only): L2288189

**Report Format / Distribution**
Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Invoice Distribution**
Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2

**Oil and Gas Required Fields (client use)**
AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

ALS Contact: Rick H
Sampler: JP Fleras

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**
Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply
PRIORITY (Business Days)
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐
EMERGENCY
1 Business day [E - 100%] ☐
Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐
Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
For tests that can not be performed according to the service level selected, you will be contacted.

**Analysis Request**
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (Anions-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | Rep: Cu, Pb, ZN, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (Solids-TSS-WT) | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-060919-JPF-001 | 09-JUN-19 | 0615 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-060919-JPF-002 | 09-JUN-19 | 0705 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-060919-JPF-003 | 09-JUN-19 | 0740 | Water | 4 | R | R | R | R | R | R | R | | |
| | | | | | | | | | | | | | | |
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**Drinking Water (DW) Samples[1] (client use)**
Are samples taken from a Regulated DW System?
☐ YES ☑ NO
Are samples for human consumption/ use?
☐ YES ☑ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**
11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**
Frozen ☐
Ice Packs ☐ Ice Cubes ☒
Cooling Initiated ☐
SIF Observations Yes ☐ No ☐
Custody seal intact Yes ☐ No ☐
INITIAL COOLER TEMPERATURES °C
FINAL COOLER TEMPERATURES °C 8.2

**SHIPMENT RELEASE (client use)**
Released by: L Chiarello
Date: 06/10/19
Time: 11:05

**INITIAL SHIPMENT RECEPTION (lab use only)**
Received by:
Date:
Time:

**FINAL SHIPMENT RECEPTION (lab use only)**
Received by:
Date: 10 JUN 19
Time: 1105

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

| | |
|---|---|
| Date Received: | 27-JUN-19 |
| Report Date: | 08-JUL-19 13:37 (MT) |
| Version: | FINAL |

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2300245**

| | |
|---|---|
| Project P.O. #: | 211265 |
| Job Reference: | 11193719 |
| C of C Numbers: | |
| Legal Site Desc: | |

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2300245-1 SW-11193719-062619-JPF-001<br>Sampled By: CLIENT on 26-JUN-19 @ 16:20<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 290 | HTC | 1.3 | mg/L | | 28-JUN-19 | |
| Total Suspended Solids | 117 | DLHC | 4.0 | mg/L | 03-JUL-19 | 04-JUL-19 | R4693626 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 70.0 | | 0.50 | mg/L | | 02-JUL-19 | R4691920 |
| Nitrate (as N) | 0.296 | | 0.020 | mg/L | | 02-JUL-19 | R4691920 |
| Phosphorus (P)-Total Dissolved | 0.0842 | | 0.0030 | mg/L | 05-JUL-19 | 08-JUL-19 | R4696275 |
| Phosphorus, Total | 0.289 | | 0.0030 | mg/L | 05-JUL-19 | 08-JUL-19 | R4696282 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 83.5 | | 0.50 | mg/L | 28-JUN-19 | 28-JUN-19 | R4689952 |
| Copper (Cu)-Total | 0.0253 | | 0.0010 | mg/L | 28-JUN-19 | 28-JUN-19 | R4689952 |
| Lead (Pb)-Total | 0.00558 | | 0.000050 | mg/L | 28-JUN-19 | 28-JUN-19 | R4689952 |
| Magnesium (Mg)-Total | 19.7 | | 0.050 | mg/L | 28-JUN-19 | 28-JUN-19 | R4689952 |
| Zinc (Zn)-Total | 0.0737 | | 0.0030 | mg/L | 28-JUN-19 | 28-JUN-19 | R4689952 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Chloride (Cl) | MS-B | L2300245-1 |
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2300245-1 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2300245-1 |
| Matrix Spike | Zinc (Zn)-Total | MS-B | L2300245-1 |
| Matrix Spike | Nitrate (as N) | MS-B | L2300245-1 |
| Matrix Spike | Phosphorus, Total | MS-B | L2300245-1 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| EC-SCREEN-WT | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2300245 Report Date: 08-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4691920** | | | | | | | | |
| **WG3093467-10 DUP** | | **WG3093467-8** | | | | | | |
| Chloride (Cl) | | 155 | 155 | | mg/L | 0.1 | 20 | 02-JUL-19 |
| **WG3093467-7 LCS** | | | | | | | | |
| Chloride (Cl) | | | 100.4 | | % | | 90-110 | 02-JUL-19 |
| **WG3093467-6 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 02-JUL-19 |
| **WG3093467-9 MS** | | **WG3093467-8** | | | | | | |
| Chloride (Cl) | | | N/A | MS-B | % | | - | 02-JUL-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4689952** | | | | | | | | |
| **WG3090854-4 DUP** | | **WG3090854-3** | | | | | | |
| Calcium (Ca)-Total | | 114 | 115 | | mg/L | 1.4 | 20 | 28-JUN-19 |
| Copper (Cu)-Total | | <0.010 | <0.010 | RPD-NA | mg/L | N/A | 20 | 28-JUN-19 |
| Lead (Pb)-Total | | 0.00080 | 0.00078 | | mg/L | 2.7 | 20 | 28-JUN-19 |
| Magnesium (Mg)-Total | | 60.6 | 61.7 | | mg/L | 1.7 | 20 | 28-JUN-19 |
| Zinc (Zn)-Total | | <0.030 | <0.030 | RPD-NA | mg/L | N/A | 20 | 28-JUN-19 |
| **WG3090854-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 100.1 | | % | | 80-120 | 28-JUN-19 |
| Copper (Cu)-Total | | | 97.9 | | % | | 80-120 | 28-JUN-19 |
| Lead (Pb)-Total | | | 98.1 | | % | | 80-120 | 28-JUN-19 |
| Magnesium (Mg)-Total | | | 99.9 | | % | | 80-120 | 28-JUN-19 |
| Zinc (Zn)-Total | | | 95.7 | | % | | 80-120 | 28-JUN-19 |
| **WG3090854-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 28-JUN-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 28-JUN-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 28-JUN-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 28-JUN-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 28-JUN-19 |
| **WG3090854-5 MS** | | **WG3090854-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 28-JUN-19 |
| Copper (Cu)-Total | | | 86.0 | | % | | 70-130 | 28-JUN-19 |
| Lead (Pb)-Total | | | 84.1 | | % | | 70-130 | 28-JUN-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 28-JUN-19 |
| Zinc (Zn)-Total | | | N/A | MS-B | % | | - | 28-JUN-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2300245 Report Date: 08-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4691920** | | | | | | | | |
| **WG3093467-10 DUP** | | **WG3093467-8** | | | | | | |
| Nitrate (as N) | | 4.46 | 4.46 | | mg/L | 0.0 | 20 | 02-JUL-19 |
| **WG3093467-7 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.1 | | % | | 90-110 | 02-JUL-19 |
| **WG3093467-6 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 02-JUL-19 |
| **WG3093467-9 MS** | | **WG3093467-8** | | | | | | |
| Nitrate (as N) | | | N/A | MS-B | % | | - | 02-JUL-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4696282** | | | | | | | | |
| **WG3097055-7 DUP** | | **L2300245-1** | | | | | | |
| Phosphorus, Total | | 0.289 | 0.276 | | mg/L | 4.5 | 20 | 08-JUL-19 |
| **WG3097055-6 LCS** | | | | | | | | |
| Phosphorus, Total | | | 99.1 | | % | | 80-120 | 08-JUL-19 |
| **WG3097055-5 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 08-JUL-19 |
| **WG3097055-8 MS** | | **L2300245-1** | | | | | | |
| Phosphorus, Total | | | N/A | MS-B | % | | - | 08-JUL-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4696275** | | | | | | | | |
| **WG3097063-3 DUP** | | **L2300245-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0842 | 0.0866 | | mg/L | 2.8 | 20 | 08-JUL-19 |
| **WG3097063-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 99.0 | | % | | 80-120 | 08-JUL-19 |
| **WG3097063-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 08-JUL-19 |
| **WG3097063-4 MS** | | **L2300245-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 94.7 | | % | | 70-130 | 08-JUL-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4693626** | | | | | | | | |
| **WG3094138-3 DUP** | | **L2300279-10** | | | | | | |
| Total Suspended Solids | | 396 | 404 | | mg/L | 2.0 | 20 | 04-JUL-19 |
| **WG3094138-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 98.3 | | % | | 85-115 | 04-JUL-19 |
| **WG3094138-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 04-JUL-19 |

# Quality Control Report

Workorder: L2300245 Report Date: 08-JUL-19

| | |
|---|---|
| Client: | GHD Limited (Waterloo)<br>455 PHILLIP ST<br>WATERLOO ON N2L 3X2 |
| Contact: | LAURA ERMETA |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2300245-COFC

COC Number: 17 -

Page 1 of 1

**Report To** Contact and company name below will appear on the final report
Company: GHD LIMITED - ACCT #13791
Contact: Laura Ermeta
Phone: 519-884-0510
Company address below will appear on the final report
Street: 455 Phillip St
City/Province: Waterloo,Ontario
Postal Code: N2L 3X2

**Report Format / Distribution**
Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**
Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply
PRIORITY (Business Days): 4 day [P4-20%] ☐ 3 day [P3-25%] ☐ 2 day [P2-50%] ☐
EMERGENCY: 1 Business day [E - 100%] ☐ Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐
Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
For tests that can not be performed according to the service level selected, you will be contacted.

**Invoice To**
Same as Report To ☐ YES ☑ NO
Copy of Invoice with Report ☐ YES ☑ NO
Company: City of Kitchener
Contact: Chris Nechacov

**Invoice Distribution**
Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax Chris.Nechacov@kitchener.ca
Email 2

**Project Information**
ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Oil and Gas Required Fields (client use)**
AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only): L2300245
ALS Contact: Rick H
Sampler: JP Fleas

**Analysis Request**
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | | | | | | | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-062019-JPF-001 | 20-JUN-19 | 1620 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-8-_-_ | 8 | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-_-_-_ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |

**Drinking Water (DW) Samples[1] (client use)**
Are samples taken from a Regulated DW System?
☐ YES ☑ NO
Are samples for human consumption/ use?
☐ YES ☑ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**
11193719-ISCO
WO1

**SAMPLE CONDITION AS RECEIVED (lab use only)**
Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☑ Ice Cubes ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑
INITIAL COOLER TEMPERATURES °C:
FINAL COOLER TEMPERATURES °C: 6.1

**SHIPMENT RELEASE (client use)**
Released by: JP Fleas Date: June 27 2019 Time: 1515

**INITIAL SHIPMENT RECEPTION (lab use only)**
Received by: Date: Time:

**FINAL SHIPMENT RECEPTION (lab use only)**
Received by: MG Date: June 27, 2019 Time: 15:15

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

| | |
|---|---|
| Date Received: | 02-JUL-19 |
| Report Date: | 09-JUL-19 12:51 (MT) |
| Version: | FINAL |

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2301649**

| | |
|---|---|
| Project P.O. #: | 211265 |
| Job Reference: | 11193719 |
| C of C Numbers: | |
| Legal Site Desc: | |

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2301649-1 SW-11193719-070119-JF-001<br>Sampled By: CLIENT on 01-JUL-19 @ 07:45<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 294 | HTC | 1.3 | mg/L | | 04-JUL-19 | |
| Total Suspended Solids | 168 | | 2.0 | mg/L | 05-JUL-19 | 06-JUL-19 | R4695968 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 59.3 | | 0.50 | mg/L | | 04-JUL-19 | R4694695 |
| Nitrate (as N) | 0.388 | | 0.020 | mg/L | | 04-JUL-19 | R4694695 |
| Phosphorus (P)-Total Dissolved | 0.0519 | | 0.0030 | mg/L | 08-JUL-19 | 09-JUL-19 | R4698890 |
| Phosphorus, Total | 0.346 | | 0.0030 | mg/L | 08-JUL-19 | 09-JUL-19 | R4698888 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 84.3 | | 0.50 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Copper (Cu)-Total | 0.0286 | | 0.0010 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Lead (Pb)-Total | 0.0103 | | 0.000050 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Magnesium (Mg)-Total | 20.4 | | 0.050 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Zinc (Zn)-Total | 0.107 | | 0.0030 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| L2301649-2 SW-11193719-070119-JF-002<br>Sampled By: CLIENT on 01-JUL-19 @ 08:15<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 141 | HTC | 1.3 | mg/L | | 04-JUL-19 | |
| Total Suspended Solids | 194 | | 2.0 | mg/L | 05-JUL-19 | 06-JUL-19 | R4695968 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 102 | | 0.50 | mg/L | | 04-JUL-19 | R4694695 |
| Nitrate (as N) | 0.177 | | 0.020 | mg/L | | 04-JUL-19 | R4694695 |
| Phosphorus (P)-Total Dissolved | 0.0518 | | 0.0030 | mg/L | 08-JUL-19 | 09-JUL-19 | R4698890 |
| Phosphorus, Total | 0.371 | | 0.0030 | mg/L | 08-JUL-19 | 09-JUL-19 | R4698888 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 40.4 | | 0.50 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Copper (Cu)-Total | 0.0326 | | 0.0010 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Lead (Pb)-Total | 0.0154 | | 0.000050 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Magnesium (Mg)-Total | 9.77 | | 0.050 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |
| Zinc (Zn)-Total | 0.152 | | 0.0030 | mg/L | 03-JUL-19 | 03-JUL-19 | R4693335 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Method Blank | Magnesium (Mg)-Total | MB-LOR | L2301649-1, -2 |
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2301649-1, -2 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2301649-1, -2 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MB-LOR | Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

**ALS Test Code** | **Matrix** | **Test Description** | **Method Reference****

CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

EC-SCREEN-WT | Water | Conductivity Screen (Internal Use Only) | APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2301649 Report Date: 09-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4694695** | | | | | | | | |
| **WG3095722-4 DUP** | | **WG3095722-3** | | | | | | |
| Chloride (Cl) | | 0.76 | 0.75 | | mg/L | 1.3 | 20 | 04-JUL-19 |
| **WG3095722-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 100.4 | | % | | 90-110 | 04-JUL-19 |
| **WG3095722-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 04-JUL-19 |
| **WG3095722-5 MS** | | **WG3095722-3** | | | | | | |
| Chloride (Cl) | | | 103.7 | | % | | 75-125 | 04-JUL-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4693335** | | | | | | | | |
| **WG3093926-4 DUP** | | **WG3093926-3** | | | | | | |
| Calcium (Ca)-Total | | 84.9 | 87.6 | | mg/L | 3.0 | 20 | 03-JUL-19 |
| Copper (Cu)-Total | | 0.0010 | <0.0010 | RPD-NA | mg/L | N/A | 20 | 03-JUL-19 |
| Lead (Pb)-Total | | 0.000079 | 0.000071 | | mg/L | 11 | 20 | 03-JUL-19 |
| Magnesium (Mg)-Total | | 16.3 | 16.0 | | mg/L | 1.6 | 20 | 03-JUL-19 |
| Zinc (Zn)-Total | | <0.0030 | <0.0030 | RPD-NA | mg/L | N/A | 20 | 03-JUL-19 |
| **WG3093926-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 97.5 | | % | | 80-120 | 03-JUL-19 |
| Copper (Cu)-Total | | | 95.6 | | % | | 80-120 | 03-JUL-19 |
| Lead (Pb)-Total | | | 97.6 | | % | | 80-120 | 03-JUL-19 |
| Magnesium (Mg)-Total | | | 100.9 | | % | | 80-120 | 03-JUL-19 |
| Zinc (Zn)-Total | | | 93.5 | | % | | 80-120 | 03-JUL-19 |
| **WG3093926-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 03-JUL-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 03-JUL-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 03-JUL-19 |
| Magnesium (Mg)-Total | | | 0.0090 | MB-LOR | mg/L | | 0.005 | 03-JUL-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 03-JUL-19 |
| **WG3093926-5 MS** | | **WG3093926-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 03-JUL-19 |
| Copper (Cu)-Total | | | 93.1 | | % | | 70-130 | 03-JUL-19 |
| Lead (Pb)-Total | | | 94.4 | | % | | 70-130 | 03-JUL-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 03-JUL-19 |
| Zinc (Zn)-Total | | | 92.7 | | % | | 70-130 | 03-JUL-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2301649 Report Date: 09-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4694695** | | | | | | | | |
| **WG3095722-4 DUP** | | **WG3095722-3** | | | | | | |
| Nitrate (as N) | | <0.020 | <0.020 | RPD-NA | mg/L | N/A | 20 | 04-JUL-19 |
| **WG3095722-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.1 | | % | | 90-110 | 04-JUL-19 |
| **WG3095722-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 04-JUL-19 |
| **WG3095722-5 MS** | | **WG3095722-3** | | | | | | |
| Nitrate (as N) | | | 102.4 | | % | | 75-125 | 04-JUL-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4698888** | | | | | | | | |
| **WG3098752-3 DUP** | | **L2301342-8** | | | | | | |
| Phosphorus, Total | | 0.0059 | 0.0053 | | mg/L | 11 | 20 | 09-JUL-19 |
| **WG3098752-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 102.2 | | % | | 80-120 | 09-JUL-19 |
| **WG3098752-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 09-JUL-19 |
| **WG3098752-4 MS** | | **L2301342-8** | | | | | | |
| Phosphorus, Total | | | 85.5 | | % | | 70-130 | 09-JUL-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4698890** | | | | | | | | |
| **WG3098758-3 DUP** | | **L2301649-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0519 | 0.0518 | | mg/L | 0.2 | 20 | 09-JUL-19 |
| **WG3098758-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 102.4 | | % | | 80-120 | 09-JUL-19 |
| **WG3098758-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 09-JUL-19 |
| **WG3098758-4 MS** | | **L2301649-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 94.2 | | % | | 70-130 | 09-JUL-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4695968** | | | | | | | | |
| **WG3096463-3 DUP** | | **L2303136-1** | | | | | | |
| Total Suspended Solids | | 402 | 404 | | mg/L | 0.5 | 20 | 06-JUL-19 |
| **WG3096463-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 99.9 | | % | | 85-115 | 06-JUL-19 |
| **WG3096463-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 06-JUL-19 |

# Quality Control Report

Workorder: L2301649 Report Date: 09-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MB-LOR | Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

---

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

L2301649-COFC

COC Number: 17 - /

Page 1 of 1

**Report To** Contact and company name below will appear on the final report

Company: GHD LIMITED - ACCT #13791
Contact: Laura Ermeta
Phone: 519-884-0510

Company address below will appear on the final report

Street: 455 Phillip St
City/Province: Waterloo,Ontario
Postal Code: N2L 3X2

**Invoice To** Same as Report To ☑ YES ☐ NO
Copy of Invoice with Report ☐ YES ☑ NO
Company: GHD Limited
Contact: Laura Ermeta

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐

EMERGENCY
1 Business day [E - 100%] ☐
Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only): L2301649 MJ

ALS Contact: Rick H

Sampler: J-P Fly

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW-11193719-070119-JPF-001 | 01-Jul-19 | 07:45 | Water | 4 | R | R | R | R | R | R | R | | |
| 2 | SW-11193719-070119-JPF-002 | 01-JUL19 | 08.15 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☑ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐
SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☒ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | 5.6 | | | |

**SHIPMENT RELEASE (client use)**

Released by:
Date: 07/02/19
Time: 9:35

**INITIAL SHIPMENT RECEPTION (lab use only)**

Received by:
Date:
Time:

**FINAL SHIPMENT RECEPTION (lab use only)**

Received by:
Date: 2-JUL-19
Time: 940

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

Date Received: 10-JUL-19
Report Date: 17-JUL-19 11:40 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2307296**

Project P.O. #: 211265
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2307296-1 SW-11193719-071019-LC-001<br>Sampled By: LUCAS C on 10-JUL-19 @ 12:15<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 389 | HTC | 1.3 | mg/L | | 11-JUL-19 | |
| Total Suspended Solids | 7.0 | | 2.0 | mg/L | 12-JUL-19 | 12-JUL-19 | R4709299 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 370 | DLDS | 1.0 | mg/L | | 11-JUL-19 | R4708638 |
| Nitrate (as N) | 0.664 | DLDS | 0.040 | mg/L | | 11-JUL-19 | R4708638 |
| Phosphorus (P)-Total Dissolved | 0.0088 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713543 |
| Phosphorus, Total | 0.0198 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713534 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 102 | | 0.50 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Copper (Cu)-Total | 0.0015 | | 0.0010 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Lead (Pb)-Total | 0.000226 | | 0.000050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Magnesium (Mg)-Total | 32.9 | | 0.050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Zinc (Zn)-Total | 0.0034 | | 0.0030 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| L2307296-2 SW-11193719-071019-LC-002<br>Sampled By: LUCAS C on 10-JUL-19 @ 12:35<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 325 | HTC | 1.3 | mg/L | | 11-JUL-19 | |
| Total Suspended Solids | 2.1 | | 2.0 | mg/L | 12-JUL-19 | 12-JUL-19 | R4709299 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 94.5 | | 0.50 | mg/L | | 11-JUL-19 | R4708638 |
| Nitrate (as N) | 1.39 | | 0.020 | mg/L | | 11-JUL-19 | R4708638 |
| Phosphorus (P)-Total Dissolved | 0.0123 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713543 |
| Phosphorus, Total | 0.0184 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713534 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 89.7 | | 0.50 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Copper (Cu)-Total | <0.0010 | | 0.0010 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Lead (Pb)-Total | 0.000087 | | 0.000050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Magnesium (Mg)-Total | 24.6 | | 0.050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Zinc (Zn)-Total | <0.0030 | | 0.0030 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| L2307296-3 SW-11193719-071019-LC-003<br>Sampled By: LUCAS C on 10-JUL-19 @ 13:15<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 386 | HTC | 1.3 | mg/L | | 11-JUL-19 | |
| Total Suspended Solids | 2.5 | | 2.0 | mg/L | 12-JUL-19 | 12-JUL-19 | R4709299 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 691 | DLDS | 2.5 | mg/L | | 11-JUL-19 | R4708638 |
| Nitrate (as N) | 0.20 | DLDS | 0.10 | mg/L | | 11-JUL-19 | R4708638 |
| Phosphorus (P)-Total Dissolved | 0.0783 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713543 |
| Phosphorus, Total | 0.0905 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713534 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 109 | DLHC | 0.50 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2307296-3 SW-11193719-071019-LC-003<br>Sampled By: LUCAS C on 10-JUL-19 @ 13:15<br>Matrix: WATER | | | | | | | |
| **Total Metals** | | | | | | | |
| Copper (Cu)-Total | <0.010 | DLHC | 0.010 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Lead (Pb)-Total | <0.00050 | DLHC | 0.00050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Magnesium (Mg)-Total | 27.7 | DLHC | 0.050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Zinc (Zn)-Total | <0.030 | DLHC | 0.030 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| L2307296-4 SW-11193719-071019-LC-004<br>Sampled By: LUCAS C on 10-JUL-19 @ 13:40<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 946 | HTC | 1.3 | mg/L | | 11-JUL-19 | |
| Total Suspended Solids | <2.0 | | 2.0 | mg/L | 12-JUL-19 | 12-JUL-19 | R4709299 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 162 | DLDS | 2.5 | mg/L | | 11-JUL-19 | R4708638 |
| Nitrate (as N) | 0.43 | DLDS | 0.10 | mg/L | | 11-JUL-19 | R4708638 |
| Phosphorus (P)-Total Dissolved | 0.0050 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713543 |
| Phosphorus, Total | 0.0142 | | 0.0030 | mg/L | 16-JUL-19 | 17-JUL-19 | R4713534 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 277 | | 0.50 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Copper (Cu)-Total | 0.0011 | | 0.0010 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Lead (Pb)-Total | 0.000233 | | 0.000050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Magnesium (Mg)-Total | 61.6 | | 0.050 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |
| Zinc (Zn)-Total | 0.0055 | | 0.0030 | mg/L | 11-JUL-19 | 11-JUL-19 | R4707792 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2307296-1, -2, -3, -4 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2307296-1, -2, -3, -4 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| DLDS | Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity. |
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| EC-SCREEN-WT | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratorz that performed analztical analzsis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analzte(s), but that do not normallz occur in environmental samples. For applicable tests, surrogates are added to samples prior to analzsis as a check on recoverz. In reports that displaz the D.L. column, laboratorz objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on drz weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate onlz to the samples as received bz the laboratorz.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analztical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2307296 Report Date: 17-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4708638** | | | | | | | | |
| **WG3102326-14 DUP** | | **WG3102326-13** | | | | | | |
| Chloride (Cl) | | 94.3 | 94.4 | | mg/L | 0.0 | 20 | 11-JUL-19 |
| **WG3102326-12 LCS** | | | | | | | | |
| Chloride (Cl) | | | 103.6 | | % | | 90-110 | 11-JUL-19 |
| **WG3102326-11 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 11-JUL-19 |
| **WG3102326-15 MS** | | **WG3102326-13** | | | | | | |
| Chloride (Cl) | | | 99.1 | | % | | 75-125 | 11-JUL-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4707792** | | | | | | | | |
| **WG3101681-4 DUP** | | **WG3101681-3** | | | | | | |
| Calcium (Ca)-Total | | 102 | 104 | | mg/L | 2.3 | 20 | 11-JUL-19 |
| Copper (Cu)-Total | | 0.0015 | 0.0015 | | mg/L | 1.7 | 20 | 11-JUL-19 |
| Lead (Pb)-Total | | 0.000226 | 0.000245 | | mg/L | 7.8 | 20 | 11-JUL-19 |
| Magnesium (Mg)-Total | | 32.9 | 32.5 | | mg/L | 1.2 | 20 | 11-JUL-19 |
| Zinc (Zn)-Total | | 0.0034 | <0.0030 | RPD-NA | mg/L | N/A | 20 | 11-JUL-19 |
| **WG3101681-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 98.2 | | % | | 80-120 | 11-JUL-19 |
| Copper (Cu)-Total | | | 97.6 | | % | | 80-120 | 11-JUL-19 |
| Lead (Pb)-Total | | | 98.8 | | % | | 80-120 | 11-JUL-19 |
| Magnesium (Mg)-Total | | | 107.0 | | % | | 80-120 | 11-JUL-19 |
| Zinc (Zn)-Total | | | 99.7 | | % | | 80-120 | 11-JUL-19 |
| **WG3101681-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 11-JUL-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 11-JUL-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 11-JUL-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 11-JUL-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 11-JUL-19 |
| **WG3101681-5 MS** | | **WG3101681-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 11-JUL-19 |
| Copper (Cu)-Total | | | 87.1 | | % | | 70-130 | 11-JUL-19 |
| Lead (Pb)-Total | | | 90.5 | | % | | 70-130 | 11-JUL-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 11-JUL-19 |
| Zinc (Zn)-Total | | | 87.5 | | % | | 70-130 | 11-JUL-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4708638** | | | | | | | | |
| **WG3102326-14 DUP** | | **WG3102326-13** | | | | | | |
| Nitrate (as N) | | 1.38 | 1.38 | | mg/L | 0.1 | 20 | 11-JUL-19 |
| **WG3102326-12 LCS** | | | | | | | | |
| Nitrate (as N) | | | 104.3 | | % | | 90-110 | 11-JUL-19 |
| **WG3102326-11 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 11-JUL-19 |
| **WG3102326-15 MS** | | **WG3102326-13** | | | | | | |
| Nitrate (as N) | | | 98.7 | | % | | 75-125 | 11-JUL-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4713534** | | | | | | | | |
| **WG3106568-3 DUP** | | **L2301342-100** | | | | | | |
| Phosphorus, Total | | 0.0039 | 0.0037 | | mg/L | 6.6 | 20 | 17-JUL-19 |
| **WG3106568-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 117.4 | | % | | 80-120 | 17-JUL-19 |
| **WG3106568-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 17-JUL-19 |
| **WG3106568-4 MS** | | **L2301342-100** | | | | | | |
| Phosphorus, Total | | | 89.8 | | % | | 70-130 | 17-JUL-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4713543** | | | | | | | | |
| **WG3106573-3 DUP** | | **L2307296-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0088 | 0.0092 | | mg/L | 3.9 | 20 | 17-JUL-19 |
| **WG3106576-3 DUP** | | **L2307296-4** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0050 | 0.0052 | | mg/L | 4.3 | 20 | 17-JUL-19 |
| **WG3106573-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 103.2 | | % | | 80-120 | 17-JUL-19 |
| **WG3106576-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 101.7 | | % | | 80-120 | 17-JUL-19 |
| **WG3106573-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 17-JUL-19 |
| **WG3106576-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 17-JUL-19 |
| **WG3106573-4 MS** | | **L2307296-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 103.5 | | % | | 70-130 | 17-JUL-19 |
| **WG3106576-4 MS** | | **L2307296-4** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 99.2 | | % | | 70-130 | 17-JUL-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |

# Quality Control Report

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4709299** | | | | | | | | |
| **WG3103572-3 DUP** | | **L2307105-9** | | | | | | |
| Total Suspended Solids | | 2420 | 2620 | | mg/L | 7.9 | 20 | 12-JUL-19 |
| **WG3103572-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 98.0 | | % | | 85-115 | 12-JUL-19 |
| **WG3103572-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 12-JUL-19 |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

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The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2307296-COFC

COC Number: 17 - 10

Page 1 of 1

| | | |
|---|---|---|
| **Report To** | Contact and company name below will appear on the final report | |
| Company: | GHD LIMITED - ACCT #13791 | |
| Contact: | Laura Ermeta | |
| Phone: | 519-884-0510 | |
| | Company address below will appear on the final report | |
| Street: | 455 Phillip St | |
| City/Province: | Waterloo,Ontario | |
| Postal Code: | N2L 3X2 | |
| **Invoice To** | Same as Report To | ☑ YES ☐ NO |
| | Copy of Invoice with Report | ☐ YES ☑ NO |
| Company: | GHD Limited | |
| Contact: | Laura Ermeta | |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐

EMERGENCY
1 Business day [E - 100%] ☐
Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only): L2307296
ALS Contact: Rick H
Sampler: Lucas Chiarello

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-071019-LC-001 | 10-Jul-19 | 12:15 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-071019-LC-002 | 10-Jul-19 | 12:35 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-071019-LC-003 | 10-Jul-19 | 13:15 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-071019-LC-004 | 10-Jul-19 | 13:40 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-____-___-____ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-____-___-____ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-____-___-____ | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719-____-___-____ | | | Water | | R | R | R | R | R | R | R | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO
Are samples for human consumption/ use?
☐ YES ☑ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-GRAB

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☑ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C:
FINAL COOLER TEMPERATURES °C: 6-9°

**SHIPMENT RELEASE (client use)**

Released by: LChiarello Date: July 10/19 Time: 2:10

**INITIAL SHIPMENT RECEPTION (lab use only)**

Received by: Date: Time:

**FINAL SHIPMENT RECEPTION (lab use only)**

Received by: Date: July 10/19 Time: 210

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1 If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

| | |
|---|---|
| Date Received: | 16-JUL-19 |
| Report Date: | 23-JUL-19 10:20 (MT) |
| Version: | FINAL |

Client Phone: 519-884-0510

# Certificate of Analysis

| | |
|---|---|
| **Lab Work Order #:** | **L2310800** |
| Project P.O. #: | 211647 |
| Job Reference: | 11193719 |
| C of C Numbers: | |
| Legal Site Desc: | |

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2310800-1 SW-11193719-071519-LJ-001<br>Sampled By: CLIENT on 15-JUL-19 @ 12:00<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 500 | HTC | 1.3 | mg/L | | 17-JUL-19 | |
| Total Suspended Solids | 6.4 | | 2.0 | mg/L | 18-JUL-19 | 19-JUL-19 | R4717268 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 395 | DLDS | 1.0 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 1.76 | DLDS | 0.040 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.0170 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.0299 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 142 | | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Copper (Cu)-Total | 0.0021 | | 0.0010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Lead (Pb)-Total | 0.000408 | | 0.000050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 35.2 | | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | 0.0090 | | 0.0030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| L2310800-2 SW-11193719-071519-LJ-002<br>Sampled By: CLIENT on 15-JUL-19 @ 12:55<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 459 | HTC | 1.3 | mg/L | | 17-JUL-19 | |
| Total Suspended Solids | 3.5 | | 2.0 | mg/L | 18-JUL-19 | 19-JUL-19 | R4717268 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 404 | DLDS | 1.0 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 1.60 | DLDS | 0.040 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.0094 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.0239 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 129 | | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Copper (Cu)-Total | 0.0021 | | 0.0010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Lead (Pb)-Total | 0.000163 | | 0.000050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 33.1 | | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | 0.0082 | | 0.0030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| L2310800-3 SW-11193719-071519-LJ-003<br>Sampled By: CLIENT on 15-JUL-19 @ 13:40<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 431 | HTC | 1.3 | mg/L | | 17-JUL-19 | |
| Total Suspended Solids | 5.4 | | 2.0 | mg/L | 19-JUL-19 | 20-JUL-19 | R4719543 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 437 | DLDS | 1.0 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 0.321 | DLDS | 0.040 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.0159 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.0453 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 120 | | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2310800-3 SW-11193719-071519-LJ-003 | | | | | | | |
| Sampled By: CLIENT on 15-JUL-19 @ 13:40 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Total Metals** | | | | | | | |
| Copper (Cu)-Total | 0.0026 | | 0.0010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Lead (Pb)-Total | 0.000243 | | 0.000050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 31.6 | | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | 0.0127 | | 0.0030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| L2310800-4 SW-11193719-071519-LJ-004 | | | | | | | |
| Sampled By: CLIENT on 15-JUL-19 @ 14:35 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 212 | HTC | 1.3 | mg/L | | 17-JUL-19 | |
| Total Suspended Solids | 14.5 | | 2.0 | mg/L | 19-JUL-19 | 20-JUL-19 | R4719543 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 503 | DLDS | 1.0 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 0.376 | DLDS | 0.040 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.0911 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.168 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 63.9 | | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Copper (Cu)-Total | 0.0108 | | 0.0010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Lead (Pb)-Total | 0.00296 | | 0.000050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 12.9 | | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | 0.0239 | | 0.0030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| L2310800-5 SW-11193719-071519-LJ-005 | | | | | | | |
| Sampled By: CLIENT on 15-JUL-19 @ 16:43 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 199 | HTC | 1.3 | mg/L | | 17-JUL-19 | |
| Total Suspended Solids | 9.8 | | 2.0 | mg/L | 19-JUL-19 | 20-JUL-19 | R4719543 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 271 | DLDS | 1.0 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 0.044 | DLDS | 0.040 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.146 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.273 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 60.5 | | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Copper (Cu)-Total | 0.0028 | | 0.0010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Lead (Pb)-Total | 0.000185 | | 0.000050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 11.6 | | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | 0.0052 | | 0.0030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| L2310800-6 SW-11193719-071619-LJ-006 | | | | | | | |
| Sampled By: CLIENT on 16-JUL-19 @ 09:10 | | | | | | | |
| Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 335 | HTC | 1.3 | mg/L | | 17-JUL-19 | |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2310800-6 SW-11193719-071619-LJ-006<br>Sampled By: CLIENT on 16-JUL-19 @ 09:10<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Total Suspended Solids | 15.2 | | 2.0 | mg/L | 19-JUL-19 | 20-JUL-19 | R4719543 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 280 | DLDS | 1.0 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 0.991 | DLDS | 0.040 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.0082 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.0502 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 91.5 | | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Copper (Cu)-Total | 0.0027 | | 0.0010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Lead (Pb)-Total | 0.000718 | | 0.000050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 25.9 | | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | 0.0068 | | 0.0030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| L2310800-7 SW-11193719-071619-LJ-007<br>Sampled By: CLIENT on 16-JUL-19 @ 11:01<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 305 | HTC | 1.3 | mg/L | | 17-JUL-19 | |
| Total Suspended Solids | 4.4 | | 2.0 | mg/L | 19-JUL-19 | 20-JUL-19 | R4719543 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 101 | | 0.50 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 1.20 | | 0.020 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.0160 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.0255 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 83.8 | | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Copper (Cu)-Total | <0.0010 | | 0.0010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Lead (Pb)-Total | 0.000156 | | 0.000050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 23.2 | | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | <0.0030 | | 0.0030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| L2310800-8 SW-11193719-071619-LJ-008<br>Sampled By: CLIENT on 16-JUL-19 @ 13:10<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 877 | HTC | 1.3 | mg/L | | 17-JUL-19 | |
| Total Suspended Solids | 7.7 | | 2.0 | mg/L | 19-JUL-19 | 20-JUL-19 | R4719543 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 167 | DLDS | 1.0 | mg/L | | 18-JUL-19 | R4716109 |
| Nitrate (as N) | 0.403 | DLDS | 0.040 | mg/L | | 18-JUL-19 | R4716109 |
| Phosphorus (P)-Total Dissolved | 0.0067 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720567 |
| Phosphorus, Total | 0.0139 | | 0.0030 | mg/L | 22-JUL-19 | 23-JUL-19 | R4720556 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 251 | DLHC | 0.50 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Copper (Cu)-Total | <0.010 | DLHC | 0.010 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2310800-8 SW-11193719-071619-LJ-008<br>Sampled By: CLIENT on 16-JUL-19 @ 13:10<br>Matrix: WATER | | | | | | | |
| **Total Metals** | | | | | | | |
| Lead (Pb)-Total | <0.00050 | DLHC | 0.00050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Magnesium (Mg)-Total | 60.7 | DLHC | 0.050 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |
| Zinc (Zn)-Total | <0.030 | DLHC | 0.030 | mg/L | 17-JUL-19 | 17-JUL-19 | R4713288 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2310800-1, -2, -3, -4, -5, -6, -7, -8 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2310800-1, -2, -3, -4, -5, -6, -7, -8 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| DLDS | Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity. |
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| EC-SCREEN-WT | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2310800 Report Date: 23-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4716109** | | | | | | | | |
| **WG3109163-14 DUP** | | **WG3109163-13** | | | | | | |
| Chloride (Cl) | | 63.5 | 63.4 | | mg/L | 0.3 | 20 | 18-JUL-19 |
| **WG3109163-12 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.4 | | % | | 90-110 | 18-JUL-19 |
| **WG3109163-11 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 18-JUL-19 |
| **WG3109163-15 MS** | | **WG3109163-13** | | | | | | |
| Chloride (Cl) | | | 102.2 | | % | | 75-125 | 18-JUL-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4713288** | | | | | | | | |
| **WG3107054-4 DUP** | | **WG3107054-3** | | | | | | |
| Calcium (Ca)-Total | | 142 | 141 | | mg/L | 1.2 | 20 | 17-JUL-19 |
| Copper (Cu)-Total | | 0.0021 | 0.0021 | | mg/L | 0.1 | 20 | 17-JUL-19 |
| Lead (Pb)-Total | | 0.000408 | 0.000400 | | mg/L | 1.8 | 20 | 17-JUL-19 |
| Magnesium (Mg)-Total | | 35.2 | 35.0 | | mg/L | 0.5 | 20 | 17-JUL-19 |
| Zinc (Zn)-Total | | 0.0090 | 0.0090 | | mg/L | 0.1 | 20 | 17-JUL-19 |
| **WG3107054-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 96.6 | | % | | 80-120 | 17-JUL-19 |
| Copper (Cu)-Total | | | 93.8 | | % | | 80-120 | 17-JUL-19 |
| Lead (Pb)-Total | | | 95.6 | | % | | 80-120 | 17-JUL-19 |
| Magnesium (Mg)-Total | | | 98.2 | | % | | 80-120 | 17-JUL-19 |
| Zinc (Zn)-Total | | | 94.3 | | % | | 80-120 | 17-JUL-19 |
| **WG3107054-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 17-JUL-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 17-JUL-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 17-JUL-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 17-JUL-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 17-JUL-19 |
| **WG3107054-5 MS** | | **WG3107054-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 17-JUL-19 |
| Copper (Cu)-Total | | | 85.6 | | % | | 70-130 | 17-JUL-19 |
| Lead (Pb)-Total | | | 87.8 | | % | | 70-130 | 17-JUL-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 17-JUL-19 |
| Zinc (Zn)-Total | | | 80.8 | | % | | 70-130 | 17-JUL-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2310800 Report Date: 23-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4716109** | | | | | | | | |
| **WG3109163-14 DUP** | | **WG3109163-13** | | | | | | |
| Nitrate (as N) | | 2.07 | 2.06 | | mg/L | 0.4 | 20 | 18-JUL-19 |
| **WG3109163-12 LCS** | | | | | | | | |
| Nitrate (as N) | | | 101.6 | | % | | 90-110 | 18-JUL-19 |
| **WG3109163-11 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 18-JUL-19 |
| **WG3109163-15 MS** | | **WG3109163-13** | | | | | | |
| Nitrate (as N) | | | 103.0 | | % | | 75-125 | 18-JUL-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4720556** | | | | | | | | |
| **WG3111776-3 DUP** | | **L2310800-1** | | | | | | |
| Phosphorus, Total | | 0.0299 | 0.0312 | | mg/L | 4.5 | 20 | 23-JUL-19 |
| **WG3111776-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 96.1 | | % | | 80-120 | 23-JUL-19 |
| **WG3111776-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 23-JUL-19 |
| **WG3111776-4 MS** | | **L2310800-1** | | | | | | |
| Phosphorus, Total | | | 118.5 | | % | | 70-130 | 23-JUL-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4720567** | | | | | | | | |
| **WG3111781-3 DUP** | | **L2310800-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0170 | 0.0130 | J | mg/L | 0.0040 | 0.006 | 23-JUL-19 |
| **WG3111781-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 96.6 | | % | | 80-120 | 23-JUL-19 |
| **WG3111781-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 23-JUL-19 |
| **WG3111781-4 MS** | | **L2310800-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 92.2 | | % | | 70-130 | 23-JUL-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4717268** | | | | | | | | |
| **WG3108806-3 DUP** | | **L2311061-4** | | | | | | |
| Total Suspended Solids | | 11500 | 11000 | | mg/L | 4.1 | 20 | 19-JUL-19 |
| **WG3108806-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 98.9 | | % | | 85-115 | 19-JUL-19 |
| **WG3108806-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 19-JUL-19 |

# Quality Control Report

Workorder: L2310800 Report Date: 23-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4719543** | | | | | | | | |
| **WG3109639-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 100.7 | | % | | 85-115 | 20-JUL-19 |
| **WG3109639-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 20-JUL-19 |

# Quality Control Report

Workorder: L2310800 Report Date: 23-JUL-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| J | Duplicate results and limits are expressed in terms of absolute difference. |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

# Chain of Custody (COC) / Analytical Request Form

ALS Environmental

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

L2310800-COFC

COC Number: 17 -

Page 1 of 1

**Report To** Contact and company name below will appear on the final report

Company: GHD LIMITED - ACCT #13791
Contact: Laura Ermeta
Phone: 519-884-0510

Company address below will appear on the final report

Street: 455 Phillip St
City/Province: Waterloo,Ontario
Postal Code: N2L 3X2

**Invoice To** Same as Report To ☑ YES ☐ NO
Copy of Invoice with Report ☐ YES ☑ NO
Company: GHD Limited
Contact: Laura Ermeta

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐

EMERGENCY
1 Business day [E - 100%] ☐
Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only): L2310800

ALS Contact: Rick H

Sampler: L Jefferson

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | | | | | | | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SW-11193719-071519-LJ-001 | 15-Jul-19 | 12:00 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| 2 | SW-11193719-071519-LJ-002 | ↓ | 12:55 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| 3 | SW-11193719-071519-LJ-003 | | 13:40 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| 4 | SW-11193719-071519-LJ-004 | | 14:35 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| 5 | SW-11193719-071519-LJ-005 | | 16:43 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| 6 | SW-11193719-071619-LJ-006 | 16-Jul-19 | 9:10 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| 7 | SW-11193719-071619-LJ-007 | ↓ | 11.01 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| 8 | SW-11193719-071619-LJ-008 | | 13:10 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| | ~~SW-11193719-___-___-009~~ | | | Water | | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | | | | | | | | | |
| | ~~SW-11193719-___-___-010~~ | | | Water | | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | ~~R~~ | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☐ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-GRAB

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐
Ice Packs ☑ Ice Cubes ☑
Cooling Initiated ☐
SIF Observations Yes ☐ No ☐
Custody seal intact Yes ☐ No ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1.8 | | | |

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: Leah Jefferson | Date: July 16/19 | Time: 15:10 | Received by: | Date: | Time: | Received by: | Date: July 16/19 | Time: 15:10 |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

---

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

Date Received: 19-AUG-19
Report Date: 23-AUG-19 11:19 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2331276**

Project P.O. #: 211647
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2331276-1 SW-11193719-081919-JPF-001<br>Sampled By: JP.FLERAS on 19-AUG-19 @ 08:45<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Total Suspended Solids | 9.7 | | 2.0 | mg/L | 22-AUG-19 | 23-AUG-19 | R4766089 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## Qualifiers for Sample Submission Listed:

| Qualifier | Description |
|---|---|
| CINT | Cooling initiated. Samples were received packed with ice or ice packs and were sampled the same day as received. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*

*mg/kg wwt - milligrams per kilogram based on wet weight of sample*

*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*

*mg/L - unit of concentration based on volume, parts per million.*

*< - Less than.*

*D.L. - The reporting limit.*

*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*

*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*

*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2331276 Report Date: 23-AUG-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4766089** | | | | | | | | |
| **WG3140791-3 DUP** | | **L2331267-1** | | | | | | |
| Total Suspended Solids | | 2260 | 2550 | | mg/L | 12 | 20 | 23-AUG-19 |
| **WG3140791-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 98.4 | | % | | 85-115 | 23-AUG-19 |
| **WG3140791-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 23-AUG-19 |

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2331276-COFC

COC Number: 17 -

Page 1 of 1

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| | | | |
|---|---|---|---|
| **Report To** | Contact and company name below will appear on the final report | **Report Format / Distribution** | |
| Company: | GHD LIMITED - ACCT #13791 | Select Report Format: | ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL) |
| Contact: | Laura Ermeta | Quality Control (QC) Report with Report | ☑ YES ☐ NO |
| Phone: | 519-884-0510 | ☐ Compare Results to Criteria on Report - provide details below if box checked | |
| | Company address below will appear on the final report | Select Distribution: | ☑ EMAIL ☐ MAIL ☐ FAX |
| Street: | 455 Phillip St | Email 1 or Fax | laura.ermeta@ghd.com |
| City/Province: | Waterloo,Ontario | Email 2 | See PO |
| Postal Code: | N2L 3X2 | Email 3 | |
| **Invoice To** | Same as Report To ☑ YES ☐ NO | **Invoice Distribution** | |
| | Copy of Invoice with Report ☐ YES ☑ NO | Select Invoice Distribution: | ☐ EMAIL ☐ MAIL ☐ FAX |
| Company: | GHD Limited | Email 1 or Fax | laura.ermeta@ghd.com |
| Contact: | Laura Ermeta | Email 2 | |

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days):
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY:
- 1 Business day [E - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

| **Project Information** | | **Oil and Gas Required Fields (client use)** | |
|---|---|---|---|
| ALS Account # / Quote #: | 13791, Q51918 | AFE/Cost Center: | PO# |
| Job #: | 11193719 | Major/Minor Code: | Routing Code: |
| PO / AFE: | 211265 | Requisitioner: | |
| LSD: | | Location: | |
| ALS Lab Work Order # (lab use only): | L2331276 | ALS Contact: Rick H | Sampler: |

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | ~~NO3, Cl (ANIONS-IC-2-WT)~~ | ~~Total Select Metals (MET-T-CCMS-WT)~~ | ~~REP: Cu, Pb, Zn, Ca, Mg~~ | Hardness (HARDNESS-CALC-WT) | ~~Diss. Phosphorus LL (P-TD-COL-WT)~~ | ~~Total Phosphorus LL (P-T-COL-WT)~~ | TSS (SOLIDS-TSS-WT) | | | | | | | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-081919-JPF-001 | 19-AUG-19 | 0845 | Water | 2 | R | R | R | R | R | R | R | ← | TSS | only | | | | | — | — |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |

88

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO

Are samples for human consumption/ use?
☐ YES ☑ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

TSS only

~~11193719-GRAB~~

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice Packs ☐ Ice Cubes ☒ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☒

INIITIAL COOLER TEMPERATURES °C

FINAL COOLER TEMPERATURES °C: 14.6

| **SHIPMENT RELEASE (client use)** | | | **INITIAL SHIPMENT RECEPTION (lab use only)** | | | **FINAL SHIPMENT RECEPTION (lab use only)** | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: Augst 19/19 | Time: 1354 | Received by: | Date: | Time: | Received by: | Date: Aug 19/2019 | Time: 256 |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO ON N2L 3X2

Date Received: 22-AUG-19
Report Date: 29-AUG-19 09:35 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2334339**

Project P.O. #: 211647
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2334339-1 SW-11193719-082119-JPF-001<br>Sampled By: JP FLERAS on 21-AUG-19 @ 13:20<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 240 | HTC | 1.3 | mg/L | | 23-AUG-19 | |
| Total Suspended Solids | 58.4 | | 2.0 | mg/L | 28-AUG-19 | 28-AUG-19 | R4774971 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 93.3 | | 0.50 | mg/L | | 26-AUG-19 | R4768847 |
| Nitrate (as N) | 0.498 | | 0.020 | mg/L | | 26-AUG-19 | R4768847 |
| Phosphorus (P)-Total Dissolved | 0.0066 | | 0.0030 | mg/L | 27-AUG-19 | 28-AUG-19 | R4771930 |
| Phosphorus, Total | 0.0974 | | 0.0030 | mg/L | 27-AUG-19 | 28-AUG-19 | R4771928 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 68.2 | | 0.50 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Copper (Cu)-Total | 0.0066 | | 0.0010 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Lead (Pb)-Total | 0.00173 | | 0.000050 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Magnesium (Mg)-Total | 16.9 | | 0.050 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Zinc (Zn)-Total | 0.0180 | | 0.0030 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| L2334339-2 SW-11193719-082119-JPF-002<br>Sampled By: JP FLERAS on 21-AUG-19 @ 13:55<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 105 | HTC | 1.3 | mg/L | | 23-AUG-19 | |
| Total Suspended Solids | 229 | | 2.0 | mg/L | 28-AUG-19 | 28-AUG-19 | R4774971 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 91.9 | | 0.50 | mg/L | | 26-AUG-19 | R4768847 |
| Nitrate (as N) | 0.229 | | 0.020 | mg/L | | 26-AUG-19 | R4768847 |
| Phosphorus (P)-Total Dissolved | 0.118 | | 0.0030 | mg/L | 27-AUG-19 | 28-AUG-19 | R4771930 |
| Phosphorus, Total | 0.327 | | 0.0030 | mg/L | 27-AUG-19 | 28-AUG-19 | R4771928 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 30.1 | DLHC | 0.50 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Copper (Cu)-Total | 0.023 | DLHC | 0.010 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Lead (Pb)-Total | 0.0108 | DLHC | 0.00050 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Magnesium (Mg)-Total | 7.33 | DLHC | 0.050 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Zinc (Zn)-Total | 0.098 | DLHC | 0.030 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| L2334339-3 SW-11193719-082119-JPF-003<br>Sampled By: JP FLERAS on 21-AUG-19 @ 14:20<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 262 | HTC | 1.3 | mg/L | | 23-AUG-19 | |
| Total Suspended Solids | 391 | DLHC | 4.0 | mg/L | 28-AUG-19 | 28-AUG-19 | R4774971 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 24.5 | | 0.50 | mg/L | | 26-AUG-19 | R4768847 |
| Nitrate (as N) | 0.441 | | 0.020 | mg/L | | 26-AUG-19 | R4768847 |
| Phosphorus (P)-Total Dissolved | 0.0077 | | 0.0030 | mg/L | 27-AUG-19 | 28-AUG-19 | R4771930 |
| Phosphorus, Total | 0.418 | | 0.0030 | mg/L | 27-AUG-19 | 28-AUG-19 | R4771928 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 76.4 | DLHC | 0.50 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2334339-3 SW-11193719-082119-JPF-003<br>Sampled By: JP FLERAS on 21-AUG-19 @ 14:20<br>Matrix: WATER | | | | | | | |
| **Total Metals** | | | | | | | |
| Copper (Cu)-Total | 0.031 | DLHC | 0.010 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Lead (Pb)-Total | 0.0149 | DLHC | 0.00050 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Magnesium (Mg)-Total | 17.2 | DLHC | 0.050 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |
| Zinc (Zn)-Total | 0.117 | DLHC | 0.030 | mg/L | 23-AUG-19 | 23-AUG-19 | R4765749 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2334339-1, -2, -3 |
| Matrix Spike | Copper (Cu)-Total | MS-B | L2334339-1, -2, -3 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2334339-1, -2, -3 |
| Matrix Spike | Zinc (Zn)-Total | MS-B | L2334339-1, -2, -3 |
| Matrix Spike | Phosphorus, Total | MS-B | L2334339-1, -2, -3 |
| Matrix Spike | Phosphorus (P)-Total Dissolved | MS-B | L2334339-1, -2, -3 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| DLHC | Detection Limit Raised: Dilution required due to high concentration of test analyte(s). |
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

<table>
<tr><th>ALS Test Code</th><th>Matrix</th><th>Test Description</th><th>Method Reference**</th></tr>
<tr><td>CL-IC-N-WT</td><td>Water</td><td>Chloride by IC</td><td>EPA 300.1 (mod)</td></tr>
<tr><td colspan="4">Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.<br>Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).</td></tr>
<tr><td>EC-SCREEN-WT</td><td>Water</td><td>Conductivity Screen (Internal Use Only)</td><td>APHA 2510</td></tr>
<tr><td colspan="4">Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.</td></tr>
<tr><td>HARDNESS-CALC-WT</td><td>Water</td><td>Hardness</td><td>APHA 2340 B</td></tr>
<tr><td colspan="4">Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.</td></tr>
<tr><td>MET-T-CCMS-WT</td><td>Water</td><td>Total Metals in Water by CRC ICPMS</td><td>EPA 200.2/6020A (mod)</td></tr>
<tr><td colspan="4">Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.<br>Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.<br>Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).</td></tr>
<tr><td>NO3-IC-WT</td><td>Water</td><td>Nitrate in Water by IC</td><td>EPA 300.1 (mod)</td></tr>
<tr><td colspan="4">Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.</td></tr>
<tr><td>P-T-COL-WT</td><td>Water</td><td>Total P in Water by Colour</td><td>APHA 4500-P PHOSPHORUS</td></tr>
<tr><td colspan="4">This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.</td></tr>
<tr><td>P-TD-COL-WT</td><td>Water</td><td>Total Dissolved P in Water by Colour</td><td>APHA 4500-P PHOSPHORUS</td></tr>
<tr><td colspan="4">This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.</td></tr>
<tr><td>SOLIDS-TSS-WT</td><td>Water</td><td>Suspended solids</td><td>APHA 2540 D-Gravimetric</td></tr>
<tr><td colspan="4">A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.</td></tr>
</table>

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*

*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2334339 Report Date: 29-AUG-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4768847** | | | | | | | | |
| **WG3143220-10 DUP** | | **WG3143220-8** | | | | | | |
| Chloride (Cl) | | 12.3 | 12.3 | | mg/L | 0.1 | 20 | 26-AUG-19 |
| **WG3143220-7 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.4 | | % | | 90-110 | 26-AUG-19 |
| **WG3143220-6 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 26-AUG-19 |
| **WG3143220-9 MS** | | **WG3143220-8** | | | | | | |
| Chloride (Cl) | | | 103.1 | | % | | 75-125 | 26-AUG-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4765749** | | | | | | | | |
| **WG3141084-4 DUP** | | **WG3141084-3** | | | | | | |
| Calcium (Ca)-Total | | 74.4 | 75.6 | | mg/L | 1.7 | 20 | 23-AUG-19 |
| Copper (Cu)-Total | | <0.010 | <0.010 | RPD-NA | mg/L | N/A | 20 | 23-AUG-19 |
| Lead (Pb)-Total | | <0.00050 | <0.00050 | RPD-NA | mg/L | N/A | 20 | 23-AUG-19 |
| Magnesium (Mg)-Total | | 18.5 | 18.2 | | mg/L | 1.8 | 20 | 23-AUG-19 |
| Zinc (Zn)-Total | | <0.030 | <0.030 | RPD-NA | mg/L | N/A | 20 | 23-AUG-19 |
| **WG3141084-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 97.6 | | % | | 80-120 | 23-AUG-19 |
| Copper (Cu)-Total | | | 96.5 | | % | | 80-120 | 23-AUG-19 |
| Lead (Pb)-Total | | | 97.7 | | % | | 80-120 | 23-AUG-19 |
| Magnesium (Mg)-Total | | | 98.8 | | % | | 80-120 | 23-AUG-19 |
| Zinc (Zn)-Total | | | 98.0 | | % | | 80-120 | 23-AUG-19 |
| **WG3141084-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 23-AUG-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 23-AUG-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 23-AUG-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 23-AUG-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 23-AUG-19 |
| **WG3141084-5 MS** | | **WG3141084-6** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 23-AUG-19 |
| Copper (Cu)-Total | | | N/A | MS-B | % | | - | 23-AUG-19 |
| Lead (Pb)-Total | | | 94.2 | | % | | 70-130 | 23-AUG-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 23-AUG-19 |
| Zinc (Zn)-Total | | | N/A | MS-B | % | | - | 23-AUG-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2334339 Report Date: 29-AUG-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4768847** | | | | | | | | |
| **WG3143220-10 DUP** | | **WG3143220-8** | | | | | | |
| Nitrate (as N) | | 0.059 | 0.059 | | mg/L | 0.9 | 20 | 26-AUG-19 |
| **WG3143220-7 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.8 | | % | | 90-110 | 26-AUG-19 |
| **WG3143220-6 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 26-AUG-19 |
| **WG3143220-9 MS** | | **WG3143220-8** | | | | | | |
| Nitrate (as N) | | | 101.8 | | % | | 75-125 | 26-AUG-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4771928** | | | | | | | | |
| **WG3144593-3 DUP** | | **L2334399-1** | | | | | | |
| Phosphorus, Total | | 10.9 | 11.4 | | mg/L | 5.0 | 20 | 28-AUG-19 |
| **WG3144593-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 100.4 | | % | | 80-120 | 28-AUG-19 |
| **WG3144593-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 28-AUG-19 |
| **WG3144593-4 MS** | | **L2334399-1** | | | | | | |
| Phosphorus, Total | | | N/A | MS-B | % | | - | 28-AUG-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4771930** | | | | | | | | |
| **WG3144594-3 DUP** | | **L2333556-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.994 | 1.08 | | mg/L | 7.8 | 20 | 28-AUG-19 |
| **WG3144594-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 100.8 | | % | | 80-120 | 28-AUG-19 |
| **WG3144594-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 28-AUG-19 |
| **WG3144594-4 MS** | | **L2333556-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | N/A | MS-B | % | | - | 28-AUG-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4774971** | | | | | | | | |
| **WG3145380-3 DUP** | | **L2336763-5** | | | | | | |
| Total Suspended Solids | | 6300 | 6270 | | mg/L | 0.5 | 20 | 28-AUG-19 |
| **WG3145380-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 99.8 | | % | | 85-115 | 28-AUG-19 |
| **WG3145380-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 28-AUG-19 |

# Quality Control Report

Workorder: L2334339 Report Date: 29-AUG-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

---

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental

www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2334339-COFC

COC Number: 17 -

Page ___ of ___

| Report To | Contact and company name below will appear on the final report |
|---|---|
| Company: | GHD LIMITED - ACCT #13791 |
| Contact: | Laura Ermeta |
| Phone: | 519-884-0510 |
| | Company address below will appear on the final report |
| Street: | 455 Phillip St |
| City/Province: | Waterloo,Ontario |
| Postal Code: | N2L 3X2 |

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)

Quality Control (QC) Report with Report ☑ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax laura.ermeta@ghd.com

Email 2 See PO

Email 3

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- 4 day [P4-20%] ☐
- 3 day [P3-25%] ☐
- 2 day [P2-50%] ☐

EMERGENCY
- 1 Business day [E - 100%] ☐
- Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

| Invoice To | |
|---|---|
| Same as Report To | ☐ YES ☑ NO |
| Copy of Invoice with Report | ☐ YES ☑ NO |
| Company: | City of Kitchener |
| Contact: | Chris Nechacov |

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax Chris.Nechacov@kitchener.ca

Email 2

**Project Information**

| | |
|---|---|
| ALS Account # / Quote #: | 13791, Q51918 |
| Job #: | 11193719 |
| PO / AFE: | 211265 |
| LSD: | |

ALS Lab Work Order # (lab use only): L2334339 VE

**Oil and Gas Required Fields (client use)**

| | |
|---|---|
| AFE/Cost Center: | PO# |
| Major/Minor Code: | Routing Code: |
| Requisitioner: | |
| Location: | |

ALS Contact: Rick H

Sampler: J-P Flers

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-082119-JPF-001 | 21-AUG-19 | 13:20 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-082119-JPF-002 | ↓ | 13:55 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719-082119-JPF-003 | | 14:20 | Water | 4 | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |
| | SW-11193719- - - | | | Water | | R | R | R | R | R | R | R | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System? ☐ YES ☑ NO

Are samples for human consumption/ use? ☐ YES ☑ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice Packs ☐ Ice Cubes ☑ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | 3.5 | | | |

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: Aug 22/2019 | Time: 1420 | Received by: | Date: | Time: | Received by: AP | Date: 22-8-19 | Time: 16:20 |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

[1] If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

GHD Limited (Waterloo)
ATTN: LAURA ERMETA
455 PHILLIP ST
WATERLOO  ON  N2L 3X2

Date Received: 27-AUG-19
Report Date: 03-SEP-19 15:49 (MT)
Version: FINAL

Client Phone: 519-884-0510

# Certificate of Analysis

**Lab Work Order #: L2336314**

Project P.O. #: 211647
Job Reference: 11193719
C of C Numbers:
Legal Site Desc:

Rick Hawthorne

Rick Hawthorne
Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2336314-1 SW-11193719-082619-JPF-001<br>Sampled By: JP.FLERAS on 26-AUG-19 @ 18:05<br>Matrix: WATER | | | | | | | |
| **Physical Tests** | | | | | | | |
| Hardness (as CaCO3) | 78.5 | HTC | 1.3 | mg/L | | 29-AUG-19 | |
| Total Suspended Solids | 66.8 | | 2.0 | mg/L | 30-AUG-19 | 03-SEP-19 | R4780470 |
| **Anions and Nutrients** | | | | | | | |
| Chloride (Cl) | 67.1 | | 0.50 | mg/L | | 28-AUG-19 | R4777541 |
| Nitrate (as N) | 0.490 | | 0.020 | mg/L | | 28-AUG-19 | R4777541 |
| Phosphorus (P)-Total Dissolved | 0.0258 | | 0.0030 | mg/L | 28-AUG-19 | 29-AUG-19 | R4775875 |
| Phosphorus, Total | 0.0922 | | 0.0030 | mg/L | 28-AUG-19 | 29-AUG-19 | R4775873 |
| **Total Metals** | | | | | | | |
| Calcium (Ca)-Total | 23.7 | | 0.50 | mg/L | 28-AUG-19 | 28-AUG-19 | R4771069 |
| Copper (Cu)-Total | 0.0083 | | 0.0010 | mg/L | 28-AUG-19 | 28-AUG-19 | R4771069 |
| Lead (Pb)-Total | 0.00184 | | 0.000050 | mg/L | 28-AUG-19 | 28-AUG-19 | R4771069 |
| Magnesium (Mg)-Total | 4.70 | | 0.050 | mg/L | 28-AUG-19 | 28-AUG-19 | R4771069 |
| Zinc (Zn)-Total | 0.0268 | | 0.0030 | mg/L | 28-AUG-19 | 28-AUG-19 | R4771069 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## QC Samples with Qualifiers & Comments:

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Calcium (Ca)-Total | MS-B | L2336314-1 |
| Matrix Spike | Magnesium (Mg)-Total | MS-B | L2336314-1 |

## Sample Parameter Qualifier key listed:

| Qualifier | Description |
|---|---|
| HTC | Hardness was calculated from Total Ca and/or Mg concentrations and may be biased high (dissolved Ca/Mg results unavailable). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| CL-IC-N-WT | Water | Chloride by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| EC-SCREEN-WT | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| HARDNESS-CALC-WT | Water | Hardness | APHA 2340 B |

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| MET-T-CCMS-WT | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod) |

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-WT | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-T-COL-WT | Water | Total P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is deteremined colourimetrically after persulphate digestion of the sample.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| P-TD-COL-WT | Water | Total Dissolved P in Water by Colour | APHA 4500-P PHOSPHORUS |

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| SOLIDS-TSS-WT | Water | Suspended solids | APHA 2540 D-Gravimetric |

A well-mixed sample is filtered through a weighed standard glass fibre filter and the residue retained is dried in an oven at 104_1 C for a minimum of four hours or until a constant weight is achieved.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WT | ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA |

## Chain of Custody Numbers:

# Reference Information

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid weight of sample*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report

Workorder: L2336314 Report Date: 03-SEP-19

**Client:** GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
**Contact:** LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **CL-IC-N-WT** | **Water** | | | | | | | |
| **Batch R4777541** | | | | | | | | |
| **WG3145484-4 DUP** | | **L2336003-2** | | | | | | |
| Chloride (Cl) | | 19.1 | 19.1 | | mg/L | 0.0 | 20 | 28-AUG-19 |
| **WG3145484-2 LCS** | | | | | | | | |
| Chloride (Cl) | | | 101.4 | | % | | 90-110 | 28-AUG-19 |
| **WG3145484-1 MB** | | | | | | | | |
| Chloride (Cl) | | | <0.50 | | mg/L | | 0.5 | 28-AUG-19 |
| **WG3145484-5 MS** | | **L2336003-2** | | | | | | |
| Chloride (Cl) | | | 103.0 | | % | | 75-125 | 28-AUG-19 |
| **MET-T-CCMS-WT** | **Water** | | | | | | | |
| **Batch R4771069** | | | | | | | | |
| **WG3145266-4 DUP** | | **WG3145266-3** | | | | | | |
| Calcium (Ca)-Total | | 61.1 | 61.4 | | mg/L | 0.5 | 20 | 28-AUG-19 |
| Copper (Cu)-Total | | 0.0022 | 0.0022 | | mg/L | 2.3 | 20 | 28-AUG-19 |
| Lead (Pb)-Total | | 0.000171 | 0.000164 | | mg/L | 3.7 | 20 | 28-AUG-19 |
| Magnesium (Mg)-Total | | 19.3 | 18.6 | | mg/L | 3.9 | 20 | 28-AUG-19 |
| Zinc (Zn)-Total | | 0.0062 | 0.0061 | | mg/L | 2.7 | 20 | 28-AUG-19 |
| **WG3145266-2 LCS** | | | | | | | | |
| Calcium (Ca)-Total | | | 96.0 | | % | | 80-120 | 28-AUG-19 |
| Copper (Cu)-Total | | | 93.7 | | % | | 80-120 | 28-AUG-19 |
| Lead (Pb)-Total | | | 96.1 | | % | | 80-120 | 28-AUG-19 |
| Magnesium (Mg)-Total | | | 96.7 | | % | | 80-120 | 28-AUG-19 |
| Zinc (Zn)-Total | | | 91.3 | | % | | 80-120 | 28-AUG-19 |
| **WG3145266-1 MB** | | | | | | | | |
| Calcium (Ca)-Total | | | <0.050 | | mg/L | | 0.05 | 28-AUG-19 |
| Copper (Cu)-Total | | | <0.0010 | | mg/L | | 0.001 | 28-AUG-19 |
| Lead (Pb)-Total | | | <0.000050 | | mg/L | | 0.00005 | 28-AUG-19 |
| Magnesium (Mg)-Total | | | <0.0050 | | mg/L | | 0.005 | 28-AUG-19 |
| Zinc (Zn)-Total | | | <0.0030 | | mg/L | | 0.003 | 28-AUG-19 |
| **WG3145266-5 MS** | | **WG3145266-3** | | | | | | |
| Calcium (Ca)-Total | | | N/A | MS-B | % | | - | 28-AUG-19 |
| Copper (Cu)-Total | | | 88.3 | | % | | 70-130 | 28-AUG-19 |
| Lead (Pb)-Total | | | 88.3 | | % | | 70-130 | 28-AUG-19 |
| Magnesium (Mg)-Total | | | N/A | MS-B | % | | - | 28-AUG-19 |
| Zinc (Zn)-Total | | | 81.7 | | % | | 70-130 | 28-AUG-19 |
| **NO3-IC-WT** | **Water** | | | | | | | |

# Quality Control Report

Workorder: L2336314 Report Date: 03-SEP-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-WT** | **Water** | | | | | | | |
| **Batch R4777541** | | | | | | | | |
| **WG3145484-4 DUP** | | **L2336003-2** | | | | | | |
| Nitrate (as N) | | <0.020 | <0.020 | RPD-NA | mg/L | N/A | 20 | 28-AUG-19 |
| **WG3145484-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.9 | | % | | 90-110 | 28-AUG-19 |
| **WG3145484-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 28-AUG-19 |
| **WG3145484-5 MS** | | **L2336003-2** | | | | | | |
| Nitrate (as N) | | | 102.7 | | % | | 75-125 | 28-AUG-19 |
| **P-T-COL-WT** | **Water** | | | | | | | |
| **Batch R4775873** | | | | | | | | |
| **WG3146320-3 DUP** | | **L2334510-5** | | | | | | |
| Phosphorus, Total | | 0.0034 | 0.0033 | | mg/L | 4.2 | 20 | 29-AUG-19 |
| **WG3146320-2 LCS** | | | | | | | | |
| Phosphorus, Total | | | 96.5 | | % | | 80-120 | 29-AUG-19 |
| **WG3146320-1 MB** | | | | | | | | |
| Phosphorus, Total | | | <0.0030 | | mg/L | | 0.003 | 29-AUG-19 |
| **WG3146320-4 MS** | | **L2334510-5** | | | | | | |
| Phosphorus, Total | | | 94.3 | | % | | 70-130 | 29-AUG-19 |
| **P-TD-COL-WT** | **Water** | | | | | | | |
| **Batch R4775875** | | | | | | | | |
| **WG3146324-3 DUP** | | **L2336314-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | 0.0258 | 0.0277 | | mg/L | 7.0 | 20 | 29-AUG-19 |
| **WG3146324-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 96.0 | | % | | 80-120 | 29-AUG-19 |
| **WG3146324-1 MB** | | | | | | | | |
| Phosphorus (P)-Total Dissolved | | | <0.0030 | | mg/L | | 0.003 | 29-AUG-19 |
| **WG3146324-4 MS** | | **L2336314-1** | | | | | | |
| Phosphorus (P)-Total Dissolved | | | 96.5 | | % | | 70-130 | 29-AUG-19 |
| **SOLIDS-TSS-WT** | **Water** | | | | | | | |
| **Batch R4780470** | | | | | | | | |
| **WG3148062-3 DUP** | | **L2337956-1** | | | | | | |
| Total Suspended Solids | | 6120 | 5960 | | mg/L | 2.6 | 20 | 03-SEP-19 |
| **WG3148062-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 99.9 | | % | | 85-115 | 03-SEP-19 |
| **WG3148062-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <2.0 | | mg/L | | 2 | 03-SEP-19 |

# Quality Control Report

Workorder: L2336314 Report Date: 03-SEP-19

Client: GHD Limited (Waterloo)
455 PHILLIP ST
WATERLOO ON N2L 3X2
Contact: LAURA ERMETA

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |
| RPD-NA | Relative Percent Difference Not Available due to result(s) being less than detection limit. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2336314-COFC

COC Number: 17 -

84

Page 1 of 1

| | | |
|---|---|---|
| **Report To** | Contact and company name below will appear on the final report | |
| Company: | GHD LIMITED - ACCT #13791 | |
| Contact: | Laura Ermeta | |
| Phone: | 519-884-0510 | |
| | Company address below will appear on the final report | |
| Street: | 455 Phillip St | |
| City/Province: | Waterloo,Ontario | |
| Postal Code: | N2L 3X2 | |
| **Invoice To** | Same as Report To | ☐ YES ☑ NO |
| | Copy of Invoice with Report | ☐ YES ☑ NO |
| Company: | City of Kitchener | |
| Contact: | Chris Nechacov | |

**Project Information**

ALS Account # / Quote #: 13791, Q51918
Job #: 11193719
PO / AFE: 211265
LSD:

**Report Format / Distribution**

Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ YES ☐ NO
☐ Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax laura.ermeta@ghd.com
Email 2 See PO
Email 3

**Invoice Distribution**

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax Chris.Nechacov@kitchener.ca
Email 2

**Oil and Gas Required Fields (client use)**

AFE/Cost Center:
PO#
Major/Minor Code:
Routing Code:
Requisitioner:
Location:

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] ☑ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
4 day [P4-20%] ☐
3 day [P3-25%] ☐
2 day [P2-50%] ☐

EMERGENCY
1 Business day [E - 100%] ☐
Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply) ] ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

ALS Lab Work Order # (lab use only): L2336314 84

ALS Contact: Rick H

Sampler: JP Fleas

**Analysis Request**

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | NO3, CL (ANIONS-IC-2-WT) | Total Select Metals (MET-T-CCMS-WT) | REP: Cu, Pb, Zn, Ca, Mg | Hardness (HARDNESS-CALC-WT) | Diss. Phosphorus LL (P-TD-COL-WT) | Total Phosphorus LL (P-T-COL-WT) | TSS (SOLIDS-TSS-WT) | | | | | | | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SW-11193719-082619-JPF-001 | 26-AUG-19 | 1805 | Water | 4 | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |
| | SW-11193719-__-__-__ | | | Water | | R | R | R | R | R | R | R | | | | | | | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System?
☐ YES ☑ NO
Are samples for human consumption/ use?
☐ YES ☑ NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

11193719-ISCO

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen ☐
Ice Packs ☒ Ice Cubes ☐
Cooling Initiated ☐
SIF Observations Yes ☐ No ☐
Custody seal intact Yes ☐ No ☐

| INITIAL COOLER TEMPERATURES °C | | | | FINAL COOLER TEMPERATURES °C | | | |
|---|---|---|---|---|---|---|---|
| | | | | 6.1 | | | |

**SHIPMENT RELEASE (client use)**

Released by: JP Fleas
Date: Aug 27 2019
Time: 1027A

**INITIAL SHIPMENT RECEPTION (lab use only)**

Received by:
Date:
Time:

**FINAL SHIPMENT RECEPTION (lab use only)**

~~Received by:~~
Date: Aug 27 2019
Time: 1030

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

# Appendix F
# Analytical Data Validation Memo

# Memorandum

December 5, 2019

To: Sarah Andrew; Leah Jefferson; Stephanie Vella    Ref. No.: 11193719-100

LE

From: Laura Ermeta/ev/1

**Subject:** **Analytical Data Verification**
**Surface Water Monitoring - Year 1**
**City of Kitchener**
**Kitchener, Ontario**
**April 2019 to November 2019**

## 1. Introduction

The following document details an analytical data verification of results for surface water samples collected in support of the Surface Water Monitoring Event at the Battler Road Site during April 2019 to November 2019. Samples were submitted to ALS Canada Ltd. (ALS) located in Waterloo, Ontario. A sample collection and analysis summary is presented in Table 1. A summary of the analytical methodology is presented in Table 2.

Standard GHD Limited (GHD) report deliverables were submitted by the laboratory. The final results and supporting quality assurance/quality control (QA/QC) data were assessed. Evaluation of the data was based on information obtained from the chain of custody forms, finished report forms, method blank data, duplicate data, recovery data from laboratory control samples (LCS), and matrix spikes (MS).

The QA/QC criteria by which these data have been assessed are outlined in the analytical methods referenced in Table 2 and applicable guidance from the documents entitled:

i) "National Functional Guidelines for Inorganic Superfund Methods Data Review", United States Environmental Protection Agency (USEPA) 540-R-2016-001, September 2016

ii) "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act", Laboratory Services Branch, Ministry of the Environment. March 9, 2004, amended as of July 1, 2011

Item i) will subsequently be referred to as the "Guidelines" in this Memorandum. Item ii) will subsequently be referred to as the "O. Reg. 153 Analytical Protocols".

## 2. Sample Holding Time and Preservation

The sample holding time criteria for the analyses are summarized in Table 2. Sample chain of custody documents and analytical reports were used to determine sample holding times. Most samples were prepared and analyzed within the required holding times. Sample data that were obtained past the recommended holding time have been qualified as estimated (see Table 3).

Most samples were properly preserved, delivered on ice, and stored by the laboratory at the required temperature (<10°C). The sample collected on April 19, 2019 was qualified due to high temperature upon arrival at the laboratory (see Table 4). Samples collected on May 6, August 19, September 16, September 19, October 2, and October 17, 2019 arrived at the laboratory on the day of sampling and had not had time to achieve a temperature of <10°C. This is acceptable since the cooling process had been initiated.

## 3. Laboratory Method Blank Analyses

Method blanks are prepared from a purified matrix and analyzed with investigative samples to determine the existence and magnitude of sample contamination introduced during the analytical procedures.

For this study, laboratory method blanks were analyzed at a minimum frequency of 1 per 20 investigative samples and/or 1 per analytical batch.

Most method blank results were non-detect, indicating that laboratory contamination was not a factor for this investigation. Magnesium was detected in one method blank. Associated sample concentrations were greater than 10 times the blank value and were not qualified.

## 4. Laboratory Control Sample Analyses

LCS are prepared and analyzed as samples to assess the analytical efficiencies of the methods employed, independent of sample matrix effects.

For this study, LCS were analyzed at a minimum frequency of 1 per 20 investigative samples and/or 1 per analytical batch.

The LCS contained all analytes of interest. LCS recoveries were assessed per the "Guidelines". All LCS recoveries were within the control limits, demonstrating acceptable analytical accuracy.

## 5. Matrix Spike Analyses

To evaluate the effects of sample matrices on the extraction or digestion process, measurement procedures, and accuracy of a particular analysis, samples are spiked with a known concentration of the analyte of concern and analyzed as MS samples. If the original sample concentration is significantly greater than the spike concentration, the recovery is not assessed.

The MS samples were spiked with the analytes of interest, and the results were evaluated using the "Guidelines". All percent recoveries were within the control limits, demonstrating acceptable analytical accuracy.

## 6. Duplicate Sample Analyses

Analytical precision is evaluated based on the analysis of laboratory duplicate samples. For this study, duplicate samples were prepared and analyzed by the laboratory. The laboratory performed additional site-specific duplicate analyses internally. The relative percent differences (RPDs) associated with these duplicate samples must be less than 20 percent for water samples. If the reported concentration in either the investigative sample or its duplicate is less than five times the reporting limit (RL), then the evaluation criteria is based on the RL. In water samples, the difference between the two results must not be greater than one times the RL. Most duplicate analyses performed were acceptable, demonstrating acceptable analytical precision. One dissolved total phosphorus result displayed variability. Associated sample results were qualified as estimated (see Table 5).

## 7. Total Calcium and Magnesium Data Used For Hardness Calculation

Hardness results were flagged by the laboratory because the values were calculated using total calcium and magnesium concentrations. The associated sample results have been qualified as estimated as the results may be biased high (see Table 6).

## 8. Conclusion

Based on the assessment detailed in the foregoing, the data are acceptable with the specific qualifications noted herein.

# Table 1

## Sample Collection and Analysis Summary
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| | | | | | | Analysis/Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Report # | Sample Identification | Location | Matrix | Collection Date (mm/dd/yyyy) | Collection Time (hr:min:sec) | Chloride | Nitrate (as N) | Total Suspended Solids | Total Phosphorus | Total Dissolved Phosphorus | Total Metals | Hardness |
| L2254436 | SW-11193719-040519-DK-SB2 | SB2 | Surface Water | 04/05/2019 | 15:10:00 | X | X | X | X | X | X | X |
| L2259478 | SW-11193719-041719-DK-SB2 | SB2 | Surface Water | 04/17/2019 | 10:35:00 | X | X | X | X | X | X | X |
| L2259478 | SW-11193719-041719-DK-VS1 | VS1 | Surface Water | 04/17/2019 | 10:05:00 | X | X | X | X | X | X | X |
| L2261392 | SW-11193719-041919-JPF-001 | SWMF6 | Surface Water | 04/19/2019 | 11:10:00 | - | - | X | - | - | - | - |
| L2266208 | SW-11193719-042919-JPF-001 | VS1 | Surface Water | 04/29/2019 | 16:15:00 | X | X | X | X | X | X | X |
| L2268196 | SW-11193719-050619-LJ-002 | BZ2 | Surface Water | 05/06/2019 | 15:50:00 | X | X | X | X | X | X | X |
| L2268196 | SW-11193719-050619-LJ-001 | BZ3 | Surface Water | 05/06/2019 | 14:19:00 | X | X | X | X | X | X | X |
| L2268196 | SW-11193719-050619-LJ-005 | SM2 | Surface Water | 05/06/2019 | 17:38:00 | X | X | X | X | X | X | X |
| L2268196 | SW-11193719-050619-LJ-004 | SM3 | Surface Water | 05/06/2019 | 17:20:00 | X | X | X | X | X | X | X |
| L2268196 | SW-11193719-050619-LJ-003 | SM4 | Surface Water | 05/06/2019 | 17:07:00 | X | X | X | X | X | X | X |
| L2268231 | SW-11193719-050719-JPF-001 | SR2 | Surface Water | 05/07/2019 | 07:00:00 | X | X | X | X | X | X | X |
| L2286119 | SW-11193719-060419-DK-001 | SR2 | Surface Water | 06/04/2019 | 09:30:00 | X | X | X | X | X | X | X |

# Table 1

## Sample Collection and Analysis Summary
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Sample Identification | Location | Matrix | Collection Date (mm/dd/yyyy) | Collection Time (hr:min:sec) | Analysis/Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Chloride | Nitrate (as N) | Total Suspended Solids | Total Phosphorus | Total Dissolved Phosphorus | Total Metals | Hardness |
| L2288189 | SW-11193719-060919-JPF-003 | SB2 | Surface Water | 06/09/2019 | 07:40:00 | X | X | X | X | X | X | X |
| L2288189 | SW-11193719-060919-JPF-001 | SR2 | Surface Water | 06/09/2019 | 06:15:00 | X | X | X | X | X | X | X |
| L2288189 | SW-11193719-060919-JPF-002 | VS1 | Surface Water | 06/09/2019 | 07:05:00 | X | X | X | X | X | X | X |
| L2300245 | SW-11193719-062619-JPF-001 | WD1 | Surface Water | 06/26/2019 | 16:20:00 | X | X | X | X | X | X | X |
| L2301649 | SW-11193719-070119-JPF-002 | VS1 | Surface Water | 07/01/2019 | 08:15:00 | X | X | X | X | X | X | X |
| L2301649 | SW-11193719-070119-JPF-001 | WD1 | Surface Water | 07/01/2019 | 07:45:00 | X | X | X | X | X | X | X |
| L2307296 | SW-11193719-071019-LC-002 | SB2 | Surface Water | 07/10/2019 | 12:35:00 | X | X | X | X | X | X | X |
| L2307296 | SW-11193719-071019-LC-001 | SC1 | Surface Water | 07/10/2019 | 12:15:00 | X | X | X | X | X | X | X |
| L2307296 | SW-11193719-071019-LC-003 | SR2 | Surface Water | 07/10/2019 | 13:15:00 | X | X | X | X | X | X | X |
| L2307296 | SW-11193719-071019-LC-004 | WD1 | Surface Water | 07/10/2019 | 13:40:00 | X | X | X | X | X | X | X |
| L2310800 | SW-11193719-071619-LJ-007 | SB2 | Surface Water | 07/16/2019 | 11:01:00 | X | X | X | X | X | X | X |
| L2310800 | SW-11193719-071619-LJ-006 | SC1 | Surface Water | 07/16/2019 | 09:10:00 | X | X | X | X | X | X | X |
| L2310800 | SW-11193719-071519-LJ-003 | SM2 | Surface Water | 07/15/2019 | 13:40:00 | X | X | X | X | X | X | X |
| L2310800 | SW-11193719-071519-LJ-002 | SM3 | Surface Water | 07/15/2019 | 12:55:00 | X | X | X | X | X | X | X |
| L2310800 | SW-11193719-071519-LJ-001 | SM4 | Surface Water | 07/15/2019 | 12:00:00 | X | X | X | X | X | X | X |
| L2310800 | SW-11193719-071519-LJ-005 | SR2 | Surface Water | 07/15/2019 | 16:43:00 | X | X | X | X | X | X | X |

## Table 1

## Sample Collection and Analysis Summary
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| | | | | | | Analysis/Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab Report # | Sample Identification | Location | Matrix | Collection Date (mm/dd/yyyy) | Collection Time (hr:min:sec) | Chloride | Nitrate (as N) | Total Suspended Solids | Total Phosphorus | Total Dissolved Phosphorus | Total Metals | Hardness |
| L2310800 | SW-11193719-071519-LJ-004 | VS1 | Surface Water | 07/15/2019 | 14:35:00 | X | X | X | X | X | X | X |
| L2310800 | SW-11193719-071619-LJ-008 | WD1 | Surface Water | 07/16/2019 | 13:10:00 | X | X | X | X | X | X | X |
| L2331276 | SW-11193719-081919-JPF-001 | SWMF6 | Surface Water | 08/19/2019 | 08:45:00 | - | - | X | - | - | - | - |
| L2334339 | SW-11193719-082119-JPF-001 | SB2 | Surface Water | 08/21/2019 | 13:20:00 | X | X | X | X | X | X | X |
| L2334339 | SW-11193719-082119-JPF-002 | VS1 | Surface Water | 08/21/2019 | 13:55:00 | X | X | X | X | X | X | X |
| L2334339 | SW-11193719-082119-JPF-003 | WD1 | Surface Water | 08/21/2019 | 14:20:00 | X | X | X | X | X | X | X |
| L2336314 | SW-11193719-082619-JPF-001 | SR2 | Surface Water | 08/26/2019 | 18:05:00 | X | X | X | X | X | X | X |
| L2339794 | SW-11193719-090319-JPF-001 | SB2 | Surface Water | 09/03/2019 | 06:55:00 | X | X | X | X | X | X | X |
| L2339794 | SW-11193719-090119-JPF-001 | SR2 | Surface Water | 09/01/2019 | 11:20:00 | X | X | X | X | X | X | X |
| L2339794 | SW-11193719-090319-JPF-002 | VS1 | Surface Water | 09/03/2019 | 07:20:00 | X | X | X | X | X | X | X |
| L2339794 | SW-11193719-090119-JPF-002 | WD1 | Surface Water | 09/01/2019 | 11:40:00 | X | X | X | X | X | X | X |
| L2347960 | SW-11193719-091619-JPF-001 | SR2 | Surface Water | 09/16/2019 | 13:15:00 | X | X | X | X | X | X | X |
| L2347960 | SW-11193719-091619-JPF-002 | WD1 | Surface Water | 09/16/2019 | 13:40:00 | X | X | X | X | X | X | X |
| L2347960 | SW-11193719-091619-JPF-003 | WD1 | Surface Water | 09/16/2019 | 13:50:00 | X | X | X | X | X | X | X |

# Table 1

## Sample Collection and Analysis Summary
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Sample Identification | Location | Matrix | Collection Date (mm/dd/yyyy) | Collection Time (hr:min:sec) | Analysis/Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Chloride | Nitrate (as N) | Total Suspended Solids | Total Phosphorus | Total Dissolved Phosphorus | Total Metals | Hardness |
| L2350765 | SW-11193719-091919-LJ-001 | VS1 | Surface Water | 09/19/2019 | 14:20:00 | X | X | X | X | X | X | X |
| L2357170 | SW-11193719-100119-JPF-001 | SR2 | Surface Water | 10/01/2019 | 09:50:00 | X | X | X | X | X | X | X |
| L2358178 | SW-11193719-100219-001 | SWMF6 | Surface Water | 10/02/2019 | 09:30:00 | - | - | X | - | - | - | - |
| L2361557 | SW-11193719-100619-JPF-001 | SB2 | Surface Water | 10/06/2019 | 06:00:00 | X | X | X | X | X | X | X |
| L2361557 | SW-11193719-100619-JPF-002 | VS1 | Surface Water | 10/06/2019 | 06:40:00 | X | X | X | X | X | X | X |
| L2363104 | SW-11193719-100819-JPF-001 | WD1 | Surface Water | 10/08/2019 | 17:20:00 | X | X | X | X | X | X | X |
| L2367357 | SW-11193719-101719-JPF-001 | VS1 | Surface Water | 10/17/2019 | 13:55:00 | X | X | X | X | X | X | X |
| L2367357 | SW-11193719-101719-JPF-002 | WD1 | Surface Water | 10/17/2019 | 14:20:00 | X | X | X | X | X | X | X |
| L2368053 | SW-11193719-101819-JPF-001 | SR2 | Surface Water | 10/18/2019 | 05:30:00 | X | X | X | X | X | X | X |
| L2374579 | SW-11193719-102919-JPF-001 | SB2 | Surface Water | 10/29/2019 | 16:15:00 | X | X | X | X | X | X | X |
| L2379913 | SW-11193719-110719-JPF-001 | SB2 | Surface Water | 11/07/2019 | 16:20:00 | X | X | X | X | X | X | X |

# Table 1

## Sample Collection and Analysis Summary
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Sample Identification | Location | Matrix | Collection Date (mm/dd/yyyy) | Collection Time (hr:min:sec) | Analysis/Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Chloride | Nitrate (as N) | Total Suspended Solids | Total Phosphorus | Total Dissolved Phosphorus | Total Metals | Hardness |
| L2380936 | SW-11193719-111219-LJ-002 | SB2 | Surface Water | 11/12/2019 | 14:45:00 | X | X | X | X | X | X | X |
| L2380936 | SW-11193719-111219-LJ-001 | SC1 | Surface Water | 11/12/2019 | 14:15:00 | X | X | X | X | X | X | X |
| L2380936 | SW-11193719-111219-LJ-004 | SR2 | Surface Water | 11/12/2019 | 15:45:00 | X | X | X | X | X | X | X |
| L2380936 | SW-11193719-111219-LJ-003 | VS1 | Surface Water | 11/12/2019 | 15:20:00 | X | X | X | X | X | X | X |
| L2380936 | SW-11193719-111219-LJ-005 | WD1 | Surface Water | 11/12/2019 | 16:00:00 | X | X | X | X | X | X | X |

Notes:

"-" - Not applicable
N - Nitrogen

# Table 2

## Analytical Method and Holding Time Criteria
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| | Methodology (1) | Holding Time Criteria(2) |
|---|---|---|
| **Parameters** | **Water** | **Water** |
| Chloride | EPA 300.1 | 28 days |
| Nitrate (as N) | EPA 300.1 | 7 days |
| Total Suspended Solids | APHA 2540 D-Gravimetric | 7 days |
| Total Phosphorus | APHA 4500-P | 28 days |
| Total Dissolved Phosphorus - Lab Filtered | APHA 4500-P | 3 days |
| Total Metals | EPA 200.2/6020A | 60 days |
| Hardness | APHA 2340 B (Calculation) | 60 days |

Notes:

(1) Methods referenced from the following:
EPA - U.S. Environmental protection Agency. Analytical Methodology (October, 2007)
APHA - "Standard Methods for the Examination of Water and Wastewater", 19th Ed., APHA, 1995

(2) Holding times differing from those defined in the indicated methodology were obtained from the O. Reg. 153 Analytical Protocols

N - Nitrogen

# Table 3

## Qualified Sample Results Due to Holding Time Exceedance
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Holding Time (days) | Holding Time Criteria (days) | Analyte | Qualified Sample Results | Units |
|---|---|---|---|---|---|---|---|
| L2266208 | Gen Chem | SW-11193719-042919-JPF-001 | 7 days | 3 days | Phosphorus (dissolved) | 0.0108 J- | mg/L |
| L2286119 | Gen Chem | SW-11193719-060419-DK-001 | 8 days | 3 days | Phosphorus (dissolved) | 0.106 J- | mg/L |
| L2288189 | Gen Chem | SW-11193719-060919-JPF-001 | 8 days | 3 days | Phosphorus (dissolved) | 0.0506 J- | mg/L |
| L2288189 | Gen Chem | SW-11193719-060919-JPF-002 | 8 days | 3 days | Phosphorus (dissolved) | 0.0623 J- | mg/L |
| L2288189 | Gen Chem | SW-11193719-060919-JPF-003 | 8 days | 3 days | Phosphorus (dissolved) | 0.0055 J- | mg/L |
| L2300245 | Gen Chem | SW-11193719-062619-JPF-001 | 9 days | 3 days | Phosphorus (dissolved) | 0.0842 J- | mg/L |
| L2301649 | Gen Chem | SW-11193719-070119-JPF-001 | 7 days | 3 days | Phosphorus (dissolved) | 0.0519 J- | mg/L |
| L2301649 | Gen Chem | SW-11193719-070119-JPF-002 | 7 days | 3 days | Phosphorus (dissolved) | 0.0518 J- | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-001 | 6 days | 3 days | Phosphorus (dissolved) | 0.0088 J- | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-002 | 6 days | 3 days | Phosphorus (dissolved) | 0.0123 J- | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-003 | 6 days | 3 days | Phosphorus (dissolved) | 0.0783 J- | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-004 | 6 days | 3 days | Phosphorus (dissolved) | 0.0050 J- | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-001 | 7 days | 3 days | Phosphorus (dissolved) | 0.0170 J- | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-002 | 7 days | 3 days | Phosphorus (dissolved) | 0.0094 J- | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-003 | 7 days | 3 days | Phosphorus (dissolved) | 0.0159 J- | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-004 | 7 days | 3 days | Phosphorus (dissolved) | 0.0911 J- | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-005 | 7 days | 3 days | Phosphorus (dissolved) | 0.146 J- | mg/L |
| L2310800 | Gen Chem | SW-11193719-071619-LJ-006 | 6 days | 3 days | Phosphorus (dissolved) | 0.0082 J- | mg/L |

## Table 3

## Qualified Sample Results Due to Holding Time Exceedance
Surface Water Monitoring - Year 1
City of Kitchener
Kitchener, Ontario
April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Holding Time (days) | Holding Time Criteria (days) | Analyte | Qualified Sample Results | Units |
|---|---|---|---|---|---|---|---|
| L2310800 | Gen Chem | SW-11193719-071619-LJ-007 | 6 days | 3 days | Phosphorus (dissolved) | 0.0160 J- | mg/L |
| L2310800 | Gen Chem | SW-11193719-071619-LJ-008 | 6 days | 3 days | Phosphorus (dissolved) | 0.0067 J- | mg/L |
| L2334339 | Gen Chem | SW-11193719-082119-JPF-001 | 6 days | 3 days | Phosphorus (dissolved) | 0.0066 J- | mg/L |
| L2334339 | Gen Chem | SW-11193719-082119-JPF-002 | 6 days | 3 days | Phosphorus (dissolved) | 0.118 J- | mg/L |
| L2334339 | Gen Chem | SW-11193719-082119-JPF-003 | 6 days | 3 days | Phosphorus (dissolved) | 0.0077 J- | mg/L |
| L2339794 | Gen Chem | SW-11193719-090119-JPF-001 | 5 days | 3 days | Phosphorus (dissolved) | 0.0082 J- | mg/L |
| L2339794 | Gen Chem | SW-11193719-090119-JPF-002 | 5 days | 3 days | Phosphorus (dissolved) | 0.0271 J- | mg/L |
| L2347960 | Gen Chem | SW-11193719-091619-JPF-001 | 7 days | 3 days | Phosphorus (dissolved) | 0.0206 J- | mg/L |
| L2347960 | Gen Chem | SW-11193719-091619-JPF-002 | 7 days | 3 days | Phosphorus (dissolved) | 0.0153 J- | mg/L |
| L2347960 | Gen Chem | SW-11193719-091619-JPF-003 | 7 days | 3 days | Phosphorus (dissolved) | 0.0397 J- | mg/L |
| L2350765 | Gen Chem | SW-11193719-091919-LJ-001 | 7 days | 3 days | Phosphorus (dissolved) | 0.0255 J- | mg/L |
| L2361557 | Gen Chem | SW-11193719-100619-JPF-001 | 9 days | 3 days | Phosphorus (dissolved) | 0.0266 J- | mg/L |
| L2361557 | Gen Chem | SW-11193719-100619-JPF-002 | 9 days | 3 days | Phosphorus (dissolved) | 0.105 J- | mg/L |
| L2363104 | Gen Chem | SW-11193719-100819-JPF-001 | 8 days | 3 days | Phosphorus (dissolved) | 0.0644 J- | mg/L |
| L2367357 | Gen Chem | SW-11193719-101719-JPF-001 | 7 days | 3 days | Phosphorus (dissolved) | 0.0973 J- | mg/L |
| L2367357 | Gen Chem | SW-11193719-101719-JPF-002 | 7 days | 3 days | Phosphorus (dissolved) | 0.0433 J- | mg/L |

## Table 3

## Qualified Sample Results Due to Holding Time Exceedance
### Surface Water Monitoring - Year 1
### City of Kitchener
### Kitchener, Ontario
### April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Holding Time (days) | Holding Time Criteria (days) | Analyte | Qualified Sample Results | Units |
|---|---|---|---|---|---|---|---|
| L2368053 | Gen Chem | SW-11193719-101819-JPF-001 | 7 days | 3 days | Phosphorus (dissolved) | 0.0464 J- | mg/L |
| L2374579 | Gen Chem | SW-11193719-102919-JPF-001 | 8 days | 3 days | Phosphorus (dissolved) | 0.0056 J- | mg/L |
| L2379913 | Gen Chem | SW-11193719-110719-JPF-001 | 6 days | 3 days | Phosphorus (dissolved) | 0.0084 J- | mg/L |

Notes:

| | |
|---|---|
| J- | - Estimated concentration, the result may be biased low |
| Gen Chem | - General chemistry |

# Table 4

## Qualified Sample Data Due to Insufficient Sample Preservation - Temperature
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Temp. Upon Receipt at Laboratory (°C) | Required Temperature (°C) | Analyte | Qualified Result | | Units |
|---|---|---|---|---|---|---|---|---|
| L2261392 | Gen Chem | SW-11193719-041919-JPF-001 | 12.2 | 10 | Total suspended solids (TSS) | 14.5 | J- | mg/L |

Notes:

| | |
|---|---|
| J- | - Estimated concentration, the result may be biased low |
| Gen Chem | - General chemistry |

# Table 5

## Qualified Sample Data Due To Outlying Laboratory Duplicate Results
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Analyte | Diff | Associated Sample IDs | Qualified Result | Units |
|---|---|---|---|---|---|---|---|
| L2310800 | Gen Chem | SW-11193719-071519-LJ-001 | Phosphorus (dissolved) | >1XRL | SW-11193719-071519-LJ-001 | 0.0170 J | mg/L |
| | | | | | SW-11193719-071519-LJ-002 | 0.0094 J | mg/L |
| | | | | | SW-11193719-071519-LJ-003 | 0.0159 J | mg/L |
| | | | | | SW-11193719-071519-LJ-004 | 0.0911 J | mg/L |
| | | | | | SW-11193719-071519-LJ-005 | 0.146 J | mg/L |
| | | | | | SW-11193719-071619-LJ-006 | 0.0082 J | mg/L |
| | | | | | SW-11193719-071619-LJ-007 | 0.0160 J | mg/L |
| | | | | | SW-11193719-071619-LJ-008 | 0.0067 J | mg/L |

Notes:

| | |
|---|---|
| Diff | - Difference (i.e., >1XRL for water samples) |
| RL | - Reporting Limit |
| J | - Estimated concentration |
| Gen Chem | - General chemistry |

## Table 6

## Qualified Sample Results Due to Total Calcium and Magnesium Data Use For Hardness Calculation
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Analyte | Qualified Sample Results | Units |
|---|---|---|---|---|---|
| L2254436 | Gen Chem | SW-11193719-040519-DK-SB2 | Hardness | 185 J+ | mg/L |
| L2259478 | Gen Chem | SW-11193719-041719-DK-VS1 | Hardness | 123 J+ | mg/L |
| L2259478 | Gen Chem | SW-11193719-041719-DK-SB2 | Hardness | 241 J+ | mg/L |
| L2266208 | Gen Chem | SW-11193719-042919-JPF-001 | Hardness | 129 J+ | mg/L |
| L2268196 | Gen Chem | SW-11193719-050619-LJ-001 | Hardness | 400 J+ | mg/L |
| L2268196 | Gen Chem | SW-11193719-050619-LJ-002 | Hardness | 407 J+ | mg/L |
| L2268196 | Gen Chem | SW-11193719-050619-LJ-003 | Hardness | 241 J+ | mg/L |
| L2268196 | Gen Chem | SW-11193719-050619-LJ-004 | Hardness | 236 J+ | mg/L |
| L2268196 | Gen Chem | SW-11193719-050619-LJ-005 | Hardness | 222 J+ | mg/L |
| L2268231 | Gen Chem | SW-11193719-050719-JPF-001 | Hardness | 149 J+ | mg/L |
| L2286119 | Gen Chem | SW-11193719-060419-DK-001 | Hardness | 136 J+ | mg/L |
| L2288189 | Gen Chem | SW-11193719-060919-JPF-001 | Hardness | 97.7 J+ | mg/L |
| L2288189 | Gen Chem | SW-11193719-060919-JPF-002 | Hardness | 139 J+ | mg/L |
| L2288189 | Gen Chem | SW-11193719-060919-JPF-003 | Hardness | 261 J+ | mg/L |
| L2300245 | Gen Chem | SW-11193719-062619-JPF-001 | Hardness | 290 J+ | mg/L |
| L2301649 | Gen Chem | SW-11193719-070119-JPF-001 | Hardness | 294 J+ | mg/L |
| L2301649 | Gen Chem | SW-11193719-070119-JPF-002 | Hardness | 141 J+ | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-001 | Hardness | 389 J+ | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-002 | Hardness | 325 J+ | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-003 | Hardness | 386 J+ | mg/L |
| L2307296 | Gen Chem | SW-11193719-071019-LC-004 | Hardness | 946 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-001 | Hardness | 500 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-002 | Hardness | 459 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-003 | Hardness | 431 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-004 | Hardness | 212 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071519-LJ-005 | Hardness | 199 J+ | mg/L |

## Table 6

## Qualified Sample Results Due to Total Calcium and Magnesium Data Use For Hardness Calculation
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Analyte | Qualified Sample Results | Units |
|---|---|---|---|---|---|
| L2254436 | Gen Chem | SW-11193719-040519-DK-SB2 | Hardness | 185 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071619-LJ-006 | Hardness | 335 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071619-LJ-007 | Hardness | 305 J+ | mg/L |
| L2310800 | Gen Chem | SW-11193719-071619-LJ-008 | Hardness | 877 J+ | mg/L |
| L2334339 | Gen Chem | SW-11193719-082119-JPF-001 | Hardness | 240 J+ | mg/L |
| L2334339 | Gen Chem | SW-11193719-082119-JPF-002 | Hardness | 105 J+ | mg/L |
| L2334339 | Gen Chem | SW-11193719-082119-JPF-003 | Hardness | 262 J+ | mg/L |
| L2336314 | Gen Chem | SW-11193719-082619-JPF-001 | Hardness | 78.5 J+ | mg/L |
| L2339794 | Gen Chem | SW-11193719-090119-JPF-001 | Hardness | 101 J+ | mg/L |
| L2339794 | Gen Chem | SW-11193719-090119-JPF-002 | Hardness | 319 J+ | mg/L |
| L2339794 | Gen Chem | SW-11193719-090319-JPF-001 | Hardness | 297 J+ | mg/L |
| L2339794 | Gen Chem | SW-11193719-090319-JPF-002 | Hardness | 81.4 J+ | mg/L |
| L2347960 | Gen Chem | SW-11193719-091619-JPF-001 | Hardness | 92.2 J+ | mg/L |
| L2347960 | Gen Chem | SW-11193719-091619-JPF-002 | Hardness | 350 J+ | mg/L |
| L2347960 | Gen Chem | SW-11193719-091619-JPF-003 | Hardness | 191 J+ | mg/L |
| L2350765 | Gen Chem | SW-11193719-091919-LJ-001 | Hardness | 208 J+ | mg/L |
| L2357170 | Gen Chem | SW-11193719-100119-JPF-001 | Hardness | 177 J+ | mg/L |
| L2361557 | Gen Chem | SW-11193719-100619-JPF-001 | Hardness | 232 J+ | mg/L |
| L2361557 | Gen Chem | SW-11193719-100619-JPF-002 | Hardness | 81.9 J+ | mg/L |
| L2363104 | Gen Chem | SW-11193719-100819-JPF-001 | Hardness | 209 J+ | mg/L |
| L2367357 | Gen Chem | SW-11193719-101719-JPF-001 | Hardness | 68.1 J+ | mg/L |
| L2367357 | Gen Chem | SW-11193719-101719-JPF-002 | Hardness | 253 J+ | mg/L |
| L2368053 | Gen Chem | SW-11193719-101819-JPF-001 | Hardness | 102 J+ | mg/L |
| L2374579 | Gen Chem | SW-11193719-102919-JPF-001 | Hardness | 234 J+ | mg/L |

## Table 6

## Qualified Sample Results Due to Total Calcium and Magnesium Data Use For Hardness Calculation
## Surface Water Monitoring - Year 1
## City of Kitchener
## Kitchener, Ontario
## April 2019 to November 2019

| Lab Report # | Parameter | Sample ID | Analyte | Qualified Sample Results | | Units |
|---|---|---|---|---|---|---|
| L2254436 | Gen Chem | SW-11193719-040519-DK-SB2 | Hardness | 185 | J+ | mg/L |
| L2379913 | Gen Chem | SW-11193719-110719-JPF-001 | Hardness | 196 | J+ | mg/L |
| L2380936 | Gen Chem | SW-11193719-111219-LJ-001 | Hardness | 394 | J+ | mg/L |
| L2380936 | Gen Chem | SW-11193719-111219-LJ-002 | Hardness | 296 | J+ | mg/L |
| L2380936 | Gen Chem | SW-11193719-111219-LJ-003 | Hardness | 207 | J+ | mg/L |
| L2380936 | Gen Chem | SW-11193719-111219-LJ-004 | Hardness | 304 | J+ | mg/L |
| L2380936 | Gen Chem | SW-11193719-111219-LJ-005 | Hardness | 916 | J+ | mg/L |

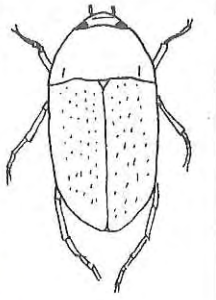
Notes:

| | |
|---|---|
| J+ | - Estimated concentration, the result may be biased high |
| Gen Chem | - General chemistry |

# Appendix G
# OBBN Field Sheets

Onsite @ 16:00
Offsite @ 17:10

## Ontario Benthos Biomonitoring Network Field Sheet: STREAMS



Date: July 15/2019

Time 16:00

Agency: GHD Ltd

Investigators: LJ/ND

Stream name: Sandrock Creek

Site #: SR2

Location: centroid of 3 replicates; Lat/Long or UTM

Photos: US/DS

Elevation (m asl):

Datum/zone:

**Water Quality**

Water Temperature (°C): 20.86

Conductivity (~~µ~~mS/cm): 0.972

pH: 7.42

DO (mg/l): 6.76

~~Alkalinity (mg/l as CaCO$_3$):~~ Turb: 63.1 NTU

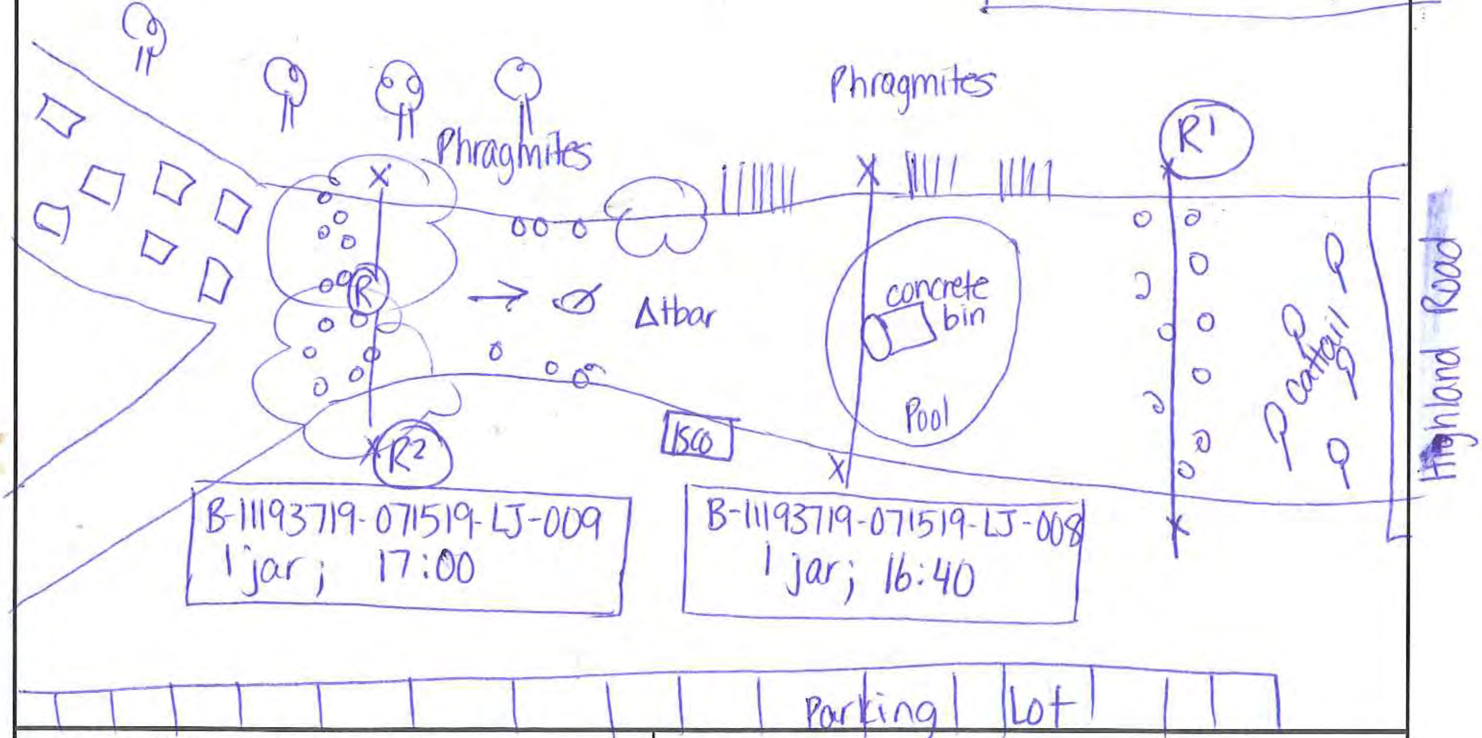
ORP: -181mV

TDS: 0.622g/L

**Site Description and Map**

*Draw a map of the site (with landmarks) and indicate areas sampled. Attach photograph (optional)*
*Show north arrow.*

B-11193719-071519-LJ-007
1 jar 16:15



B-11193719-071519-LJ-009
1 jar; 17:00

B-11193719-071519-LJ-008
1 jar; 16:40

**Benthos Collection Method** (circle one):

- [✓ Traveling Kick & Sweep]
- Grab Sample
- Other (specify):

**Gear Type** (circle one)

- [✓ D-net]
- Ponar
- Other (*specify*):
- Ekman
- Rock Baskets

**Mesh Size:** [✓ 500 micron] (or specify)

| Sub-samples | Sampling distance covered (m) | Time (min.) | Max. Depth (m) | Wetted Width (m) | Max. Hydraulic Head (mm) | # Grabs pooled per sample |
|---|---|---|---|---|---|---|
| Sample 1: Riffle (cross-over) | 11.1 | 3 | 0.170 | 3.7 | 0 | 1 |
| Sample 2: Pool | 12.3 | 3 | 0.490 | 4.1 | 0 | 1 |
| Sample 3: Riffle (cross-over) | 12.0 | 3 | 0.190 | 3.0 | 0 | 1 |

| | | |
|---|---|---|
| Riffle #1 | 17T 0538211<br>4808742 | #WP43 |
| Pool | 17T 0538208<br>4808733 | #WP44 |
| Riffle #2 | 17T 0538160<br>4808707 | #WP45 |

SW-11193719-071519-LJ-005
4 jars filled @ 16:43
Clear, colourless, earthy odour, minor particulate.

**Substrate**

*Enter dominant substrate class and second dominant class for each sub-sample*

|  | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Dominant | 5 | 3 | 3 |
| 2nd Dominant | 3 | 5 | 5 |

| Class | Description |
|---|---|
| 1 | Clay (hard pan) |
| 2 | Silt (gritty, < 0.06 mm particle diameter) |
| 3 | Sand (grainy, 0.06 - 2 mm) |
| 4 | Gravel (2 - 65 mm) |
| 5 | Cobble (65 - 250 mm) |
| 6 | Boulder (> 250 mm) |
| 7 | Bed Rock |

**Substrate Notes**

Coarse sand with cobble deposits. Minor gravel.

**Organic Matter-Areal Coverage**

Use 1: Abundant, 2: Present, 3: Absent

|  | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Woody Debris | 3 | 3 | 3 |
| Detritus | 1 | 1 | 2 (minimal) |

**Riparian Vegetative Community**

Use: 1 (None), 2 (cultivated), 3 (meadow), 4 (scrubland), 5 (forest, mainly coniferous), 6 (forest, mainly deciduous)

| Zone (dist. From water's edge) | Left Bank | Right Bank (facing downstream) |
|---|---|---|
| 1.5-10 m | 3 | 3 |
| 10-30 m | 2 | 2 |
| 30-100 m | 2 | 2 |

% Canopy Cover (circle one)

0-24 25-49 [✓ 50-74] 75-100

If instrument used, record type:

**Aquatic Macrophytes and Algae** (Use: 1 (Abundant), 2 (Present), 3 (Absent). Circle dominant type.

| Macrophytes | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Emergent | 2 | 3 | 2 |
| Rooted Floating | 3 | 3 | 3 |
| Submergent | 3 | 3 | 3 |
| Free Floating | 3 | 3 | 3 |

| Algae | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Floating Algae | 3 | 3 | 3 |
| Filaments | 3 | 3 | 3 |
| Attached Algae | 2 | 2 | 2 |
| Slimes or Crusts | 3 | 3 | 3 |

**Stream Size/Flow**

Bank Full Width (m): N/M Discharge ($m^3/s$, optional, indicate method): N/A

**River Characterisation** (*circle one*) [✓ Perennial] Intermittent Unknown

*Notes (esp. related to land-use, habitat, obvious stressors)*

Low flow, barely moving.
Brown-green colour.

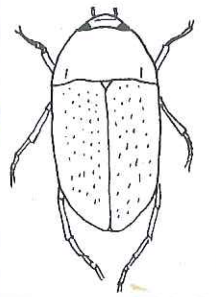
**Candidate reference Site** - Minimally Impacted? (circle one) Yes [✓ No]

**General Comments**

Urbanized channel heavily dominated by phragmites along REW. Shopping cart in channel upstream of R2.

Onsite @ 8:40am
Offsite @ 10:05am

# Ontario Benthos Biomonitoring Network Field Sheet: STREAMS



Date: July 16/2019
Time 8:50am
Agency: GHD Ltd
Investigators: LJ/ND

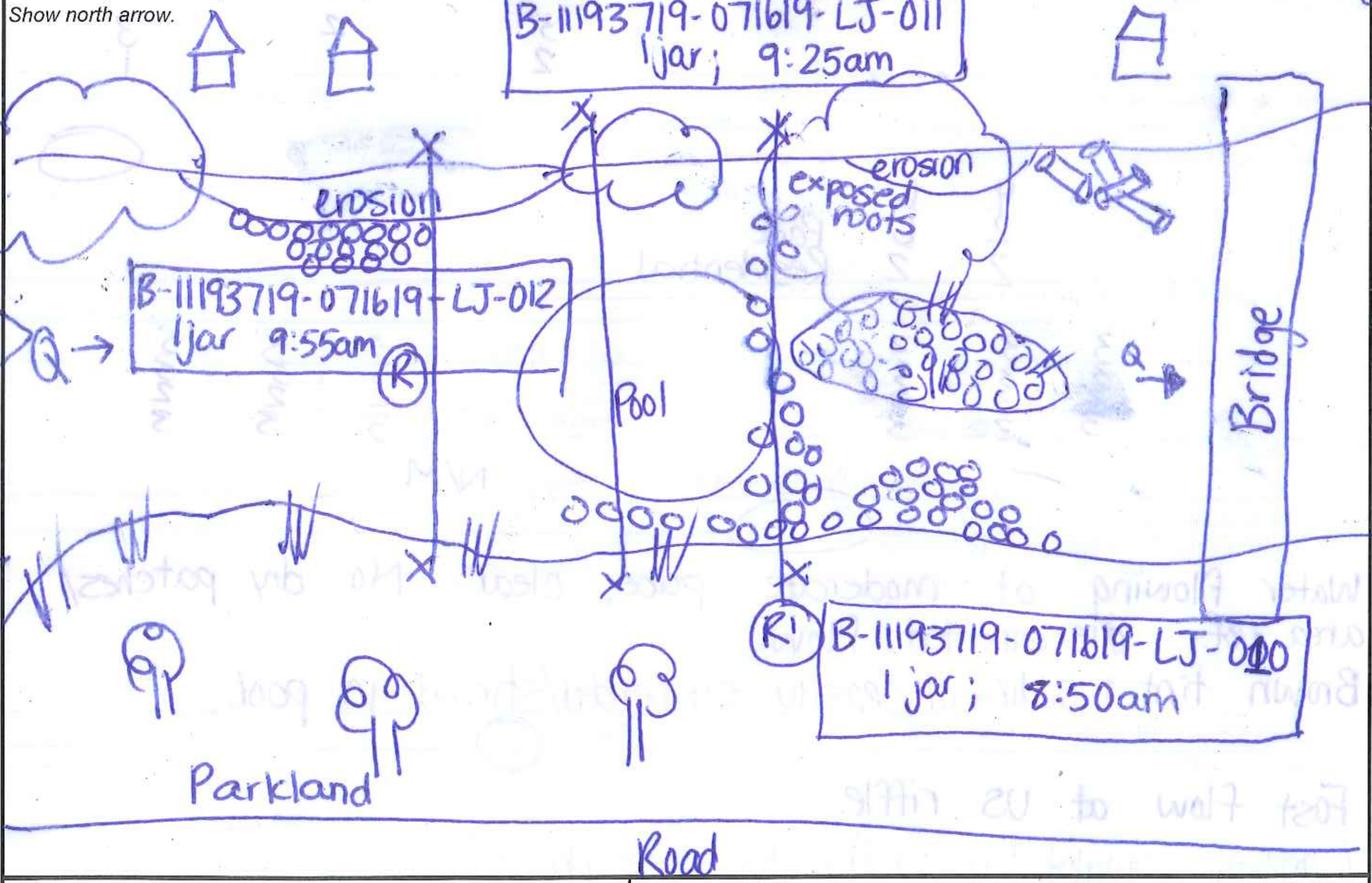
Stream name: Schneider Creek
Site #: SC1
Location: centroid of 3 replicates; Lat/Long or UTM
Photos: US/DS
Elevation (m asl): (See Below)
Datum/zone:

**Water Quality**

Water Temperature (°C): 20.62
DO (mg/l): 5.39
Conductivity (~~µ~~mS/cm): 1.35
pH: 7.99
~~Alkalinity (mg/l as CaCO3):~~ Turb: 19.4 NTU
ORP: -47mV
TDS: 0.862g/L

**Site Description and Map**

*Draw a map of the site (with landmarks) and indicate areas sampled. Attach photograph (optional)*
*Show north arrow.*



| **Benthos Collection Method** (circle one): | | **Gear Type** (circle one) | | |
|---|---|---|---|---|
| [✓ ◆ Traveling Kick & Sweep] | ◆ Grab Sample | [✓ ◆ D-net] | ◆ Ponar | ◆ Other (*specify*): |
| ◆ Other (specify): | | ◆ Ekman | ◆ Rock Baskets | |
| | | **Mesh Size**: [✓ 500 micron] (or specify) | | |

| Sub-samples | Sampling distance covered (m) | Time (min.) | Max. Depth (m) | Wetted Width (m) | Max. Hydraulic Head (mm) | # Grabs pooled per sample |
|---|---|---|---|---|---|---|
| Sample 1: Riffle (cross-over) | 13.9 | 3 | 0.11 | 13.9 | 5 | 1 |
| Sample 2: Pool | 16.6 | 3 | 0.62 | 8.3 | 0 | 1 |
| Sample 3: Riffle (cross-over) | 16.4 | 3 | 0.32 | 8.2 | 10 | 1 |

| | | |
|---|---|---|
| Riffle #1 | 17T 0547283<br>4804663 | WP #46 |
| Pool | 17T 0547275<br>4804657 | WP #47 |
| Riffle #2 | 17T 0547268<br>4804590 | WP # 48 |

SW-11193719-071619-LJ-006
4 bottles @ 9:10am
Clear, colourless, odourless, no visible particulate

**Substrate**

*Enter dominant substrate class and second dominant class for each sub-sample*

| | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Dominant | 5 | 2 | 5 |
| 2nd Dominant | 4 | 4 | 4 |

| Class | Description |
|---|---|
| 1 | Clay (hard pan) |
| 2 | Silt (gritty, < 0.06 mm particle diameter) |
| 3 | Sand (grainy, 0.06 - 2 mm) |
| 4 | Gravel (2 - 65 mm) |
| 5 | Cobble (65 - 250 mm) |
| 6 | Boulder (> 250 mm) |
| 7 | Bed Rock |

**Substrate Notes**

Cobble + gravel in riffles.
Silt deposition in pool.

**Organic Matter-Areal Coverage**

Use 1: Abundant, 2: Present, 3: Absent

| | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Woody Debris | 3 | 2 | 3 |
| Detritus | 2 | 1 | 1 |

**Riparian Vegetative Community**

Use: 1 (None), 2 (cultivated), 3 (meadow), 4 (scrubland), 5 (forest, mainly coniferous), 6 (forest, mainly deciduous)

| Zone (dist. From water's edge) | Left Bank | Right Bank (facing downstream) | |
|---|---|---|---|
| 1.5-10 m | 4 | 6 | |
| 10-30 m | 2 | 6 | Park |
| 30-100 m | 2 | 2 | Residential |

% Canopy Cover (circle one)

0-24 [✓ 25-49]
50-74 75-100

If instrument used, record type:

**Aquatic Macrophytes and Algae** (Use: 1 (Abundant), 2 (Present), 3 (Absent). Circle dominant type.

| Macrophytes | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Emergent | 3 | 3 | 3 |
| Rooted Floating | 3 | 3 | 3 |
| Submergent | 3 | 3 | 3 |
| Free Floating | 3 | 3 | 3 |

| Algae | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Floating Algae | 3 | 3 | 3 |
| Filaments | 3 | 3 | 3 |
| Attached Algae | 2 | 2 | 2 |
| Slimes or Crusts | 3 | 3 | 3 |

**Stream Size/Flow**

Bank Full Width (m): —

Discharge ($m^3/s$, optional, indicate method): N/M

**River Characterisation** (*circle one*) [✓ Perennial] Intermittent Unknown

*Notes (esp. related to land-use, habitat, obvious stressors)*

Water flowing at moderate pace, clear. No dry patches/area of disconnected flow.
Brown tint + sediment easily suspended/stirred in pool.

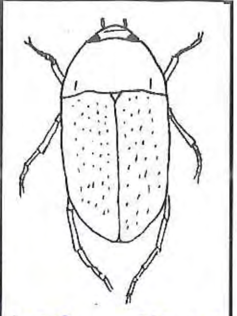
**Candidate reference Site** - Minimally Impacted? (circle one) Yes [✓ No]

**General Comments**

Fast flow at US riffle.
Crayfish caught in riffle #2 (see photos).

Onsite @ 10:40am
Offsite @ 12:05pm

## Ontario Benthos Biomonitoring Network Field Sheet: STREAMS



Date: July 16/2019
Time: 10:40am
Agency: GHD Ltd
Investigators: LJ / ND

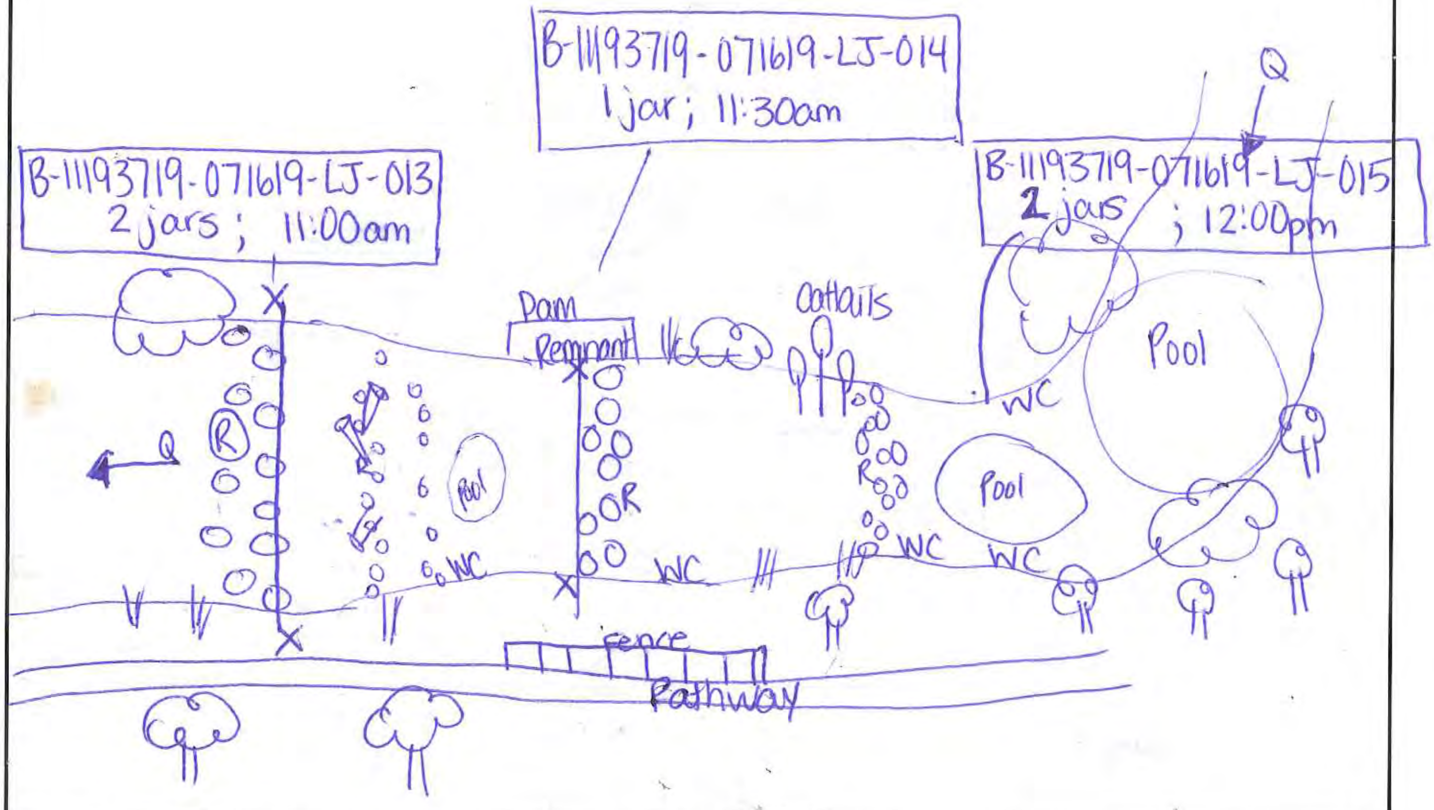
Stream name: Strasburg Creek
Site #: SB2
Location: centroid of 3 replicates; Lat/Long or UTM
Photos: US/DS
Elevation (m asl): See
Datum/zone: Below

**Water Quality**

Water Temperature (°C): 17.07
DO (mg/l): 6.49
Conductivity (~~µ~~mS/cm): 0.793
pH: 8.12
~~Alkalinity (mg/l as CaCO3):~~ Turb: 6.3 NTU
ORP: -24mV
TDS: 0.508g/L

**Site Description and Map**

*Draw a map of the site (with landmarks) and indicate areas sampled. Attach photograph (optional)*
*Show north arrow.*



**Benthos Collection Method** (circle one):

[✓ Traveling Kick & Sweep] • Grab Sample • Other (specify):

**Gear Type** (circle one)

[✓ D-net] • Ponar • Other (*specify*): • Ekman • Rock Baskets

**Mesh Size**: [✓ 500 micron] (or specify)

| Sub-samples | Sampling distance covered (m) | Time (min.) | Max. Depth (m) | Wetted Width (m) | Max. Hydraulic Head (mm) | # Grabs pooled per sample |
|---|---|---|---|---|---|---|
| Sample 1: Riffle (cross-over) | 9.9 | 3 | 0.07 | 3.3 | 20 | 1 |
| Sample 2: ~~Pool~~ Riffle #2 | 11.7 | 3 | 0.16 | 3.9 | 20 | 1 |
| Sample 3: ~~Riffle (cross-over)~~ Pool | 10.0 | 3 | 0.590 | 2.5 | 0 | 1 |

| | | |
|---|---|---|
| Riffle #1 | 0544010 17T<br>4804453 | WP #49 |
| Pool | 17T 0543995<br>4804461 | WP #50 |
| Riffle #2 | 17T 0543948<br>4804458 | WP #51 |

SW-11193719-071619-LJ-007
4 bottles filled @ 11:01
Clear, colourless, odourless, no visible particulates.

**Substrate**

*Enter dominant substrate class and second dominant class for each sub-sample*

| | Riffle<br>Sample 1 | Riffle<br>Sample 2 | Pool<br>Sample 3 |
|---|---|---|---|
| Dominant | 5 | 5 | 2 |
| 2nd Dominant | 4 | 4 (minor boulder) | 5 (cobble on edges) |

| Class | Description |
|---|---|
| 1 | Clay (hard pan) |
| 2 | Silt (gritty, < 0.06 mm particle diameter) |
| 3 | Sand (grainy, 0.06 - 2 mm) |
| 4 | Gravel (2 - 65 mm) |
| 5 | Cobble (65 - 250 mm) |
| 6 | Boulder (> 250 mm) |
| 7 | Bed Rock |

**Substrate Notes**

cobble/gravel (algae cover on large cobble) in riffles
Sticky silt/muck in pool.

**Organic Matter-Areal Coverage**

Use 1: Abundant, 2: Present, 3: Absent

| | Riffle #1<br>Sample 1 | Riffle #2<br>Sample 2 | Pool<br>Sample 3 |
|---|---|---|---|
| Woody Debris | 3 | 3 | 2 |
| Detritus | 2 | 2 | 2 |

**Riparian Vegetative Community**

Use: 1 (None), 2 (cultivated), 3 (meadow), 4 (scrubland), 5 (forest, mainly coniferous), 6 (forest, mainly deciduous)

| Zone (dist. From water's edge) | Left Bank | Right Bank [✓ (facing downstream)] |
|---|---|---|
| 1.5-10 m | 3 | 3 |
| 10-30 m | 6 | 6 |
| 30-100 m | 1 | 1 |

Residential/Parkland trails

% Canopy Cover (circle one)

0-24 [✓ 25-49]
50-74 75-100

If instrument used, record type:

**Aquatic Macrophytes and Algae** (Use: 1 (Abundant), 2 (Present), 3 (Absent). Circle dominant type.

| <u>Macrophytes</u> | Sample 1 | riffle<br>Sample 2 | Pool<br>Sample 3 |
|---|---|---|---|
| Emergent | 3 | 2 | 3 |
| Rooted Floating | 3 | 3 | 3 |
| Submergent | 2 | 2 | 3 |
| Free Floating | 3 | 3 | 3 |

| <u>Algae</u> | Riffle<br>Sample 1 | Riffle<br>Sample 2 | Pool<br>Sample 3 |
|---|---|---|---|
| Floating Algae | 3 | 3 | 3 |
| Filaments | 1 | 1 | 1 |
| Attached Algae | 1 | 1 | 1 |
| Slimes or Crusts | 3 | 3 | 3 |

**Stream Size/Flow**

Bank Full Width (m): /

Discharge ($m^3/s$, optional, indicate method): N/M

**River Characterisation** (*circle one*) [✓ Perennial] Intermittent Unknown

*Notes (esp. related to land-use, habitat, obvious stressors)*

Water flowing quickly, clear, cool.
Lots of detritus + algae in all samples.

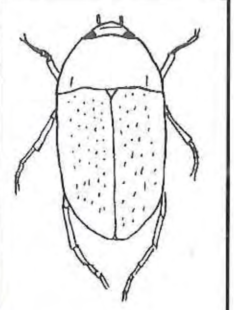
**Candidate reference Site** - Minimally Impacted? (circle one) [✓ Yes] No

**General Comments**

Crayfish caught in pool.
↳ Rusty crayfish preserved with sample.
↳ Mottled Sculpin caught in pool, released.

Onsite @ 14:30.
Offsite @ 15:50.

## Ontario Benthos Biomonitoring Network Field Sheet: STREAMS



Date: July 15 /2019
Time 14:30
Agency: GHD Ltd.
Investigators: LJ / ND

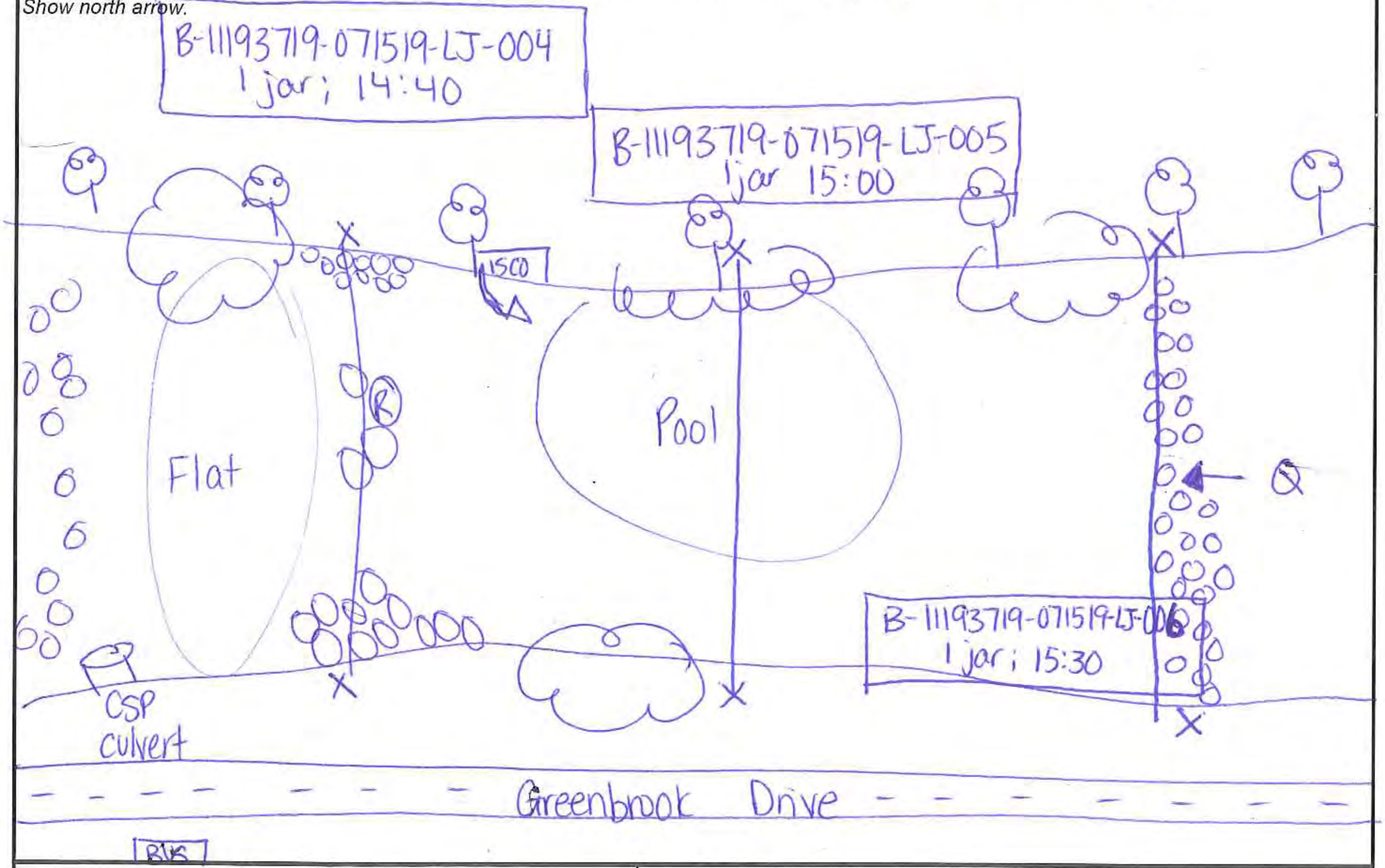
Stream name: Voisin Creek
Site #: VS.1
Location: centroid of 3 replicates; Lat/Long or UTM
Photos: US/DS
Elevation (m asl):
Datum/zone:

**Water Quality**

Water Temperature (°C): 20.70
Conductivity (mS/cm): 1.85
pH: 7.91
DO (mg/l): 3.31
~~Alkalinity (mg/l as CaCO$_3$):~~ Turb: 9.3 NTU
ORP: -69mV
TDS: 1.19 g/L

**Site Description and Map**

*Draw a map of the site (with landmarks) and indicate areas sampled. Attach photograph (optional) Show north arrow.*



**Benthos Collection Method** (circle one):
[✓ Traveling Kick & Sweep] ◆ Grab Sample
◆ Other (specify):

**Gear Type** (circle one)
[✓ D-net] ◆ Ponar ◆ Other (*specify*):
◆ Ekman ◆ Rock Baskets
**Mesh Size**: [✓ 500 micron] (or specify)

| Sub-samples | Sampling distance covered (m) | Time (min.) | Max. Depth (m) | Wetted Width (m) | Max. Hydraulic Head (mm) | # Grabs pooled per sample |
|---|---|---|---|---|---|---|
| Sample 1: Riffle (cross-over) | 13.2 | 3 | 0.09 | 3.3 | 0 | 1 |
| Sample 2: Pool | 10.2 | 3 | 0.11 | 3.4 | 0 | 1 |
| Sample 3: Riffle (cross-over) | 12.8 | 3 | 0.07 | 3.2 | 0 | 1 |

| | | | |
|---|---|---|---|
| #1 Riffle → 17T | 0540529<br>4808548 | WP #40 | |
| Pool → 17T | 0540521<br>4808548 | WP#41 | |
| #2 Riffle → 17T | 0540504<br>4808547 | WP#42 | |

SW-11193719-071519-LJ-004
→ 4 bottles filled at 14:35
→ Clear, colourless, odourless, minor visible particulate.

**Substrate**

*Enter dominant substrate class and second dominant class for each sub-sample*

| | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Dominant | 4 | 4 | 4 |
| 2nd Dominant | 4 | 2 | 5 |

| Class | Description |
|---|---|
| 1 | Clay (hard pan) |
| 2 | Silt (gritty, < 0.06 mm particle diameter) |
| 3 | Sand (grainy, 0.06 - 2 mm) |
| 4 | Gravel (2 - 65 mm) |
| 5 | Cobble (65 - 250 mm) |
| 6 | Boulder (> 250 mm) |
| 7 | Bed Rock |

**Substrate Notes**

Gravel + cobble substrate. Silt accumulating in deeper pools.

**Organic Matter-Areal Coverage**

Use 1: Abundant, 2: Present, 3: Absent

| | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Woody Debris | 3 | 3 | 3 |
| Detritus | 1 | 2 | 2 |

**Riparian Vegetative Community**

Use: 1 (None), 2 (cultivated), 3 (meadow), 4 (scrubland), 5 (forest, mainly coniferous), 6 (forest, mainly deciduous)

| Zone (dist. From water's edge) | Left Bank | Right Bank (facing downstream) |
|---|---|---|
| 1.5-10 m | 6 | 6 |
| 10-30 m | 6 | 2 Residential + roadway |
| 30-100 m | 2 | 2 |

% Canopy Cover (circle one)

0-24 25-49

50-74 [✓ 75-100]

If instrument used, record type:

**Aquatic Macrophytes and Algae** (Use: 1 (Abundant), 2 (Present), 3 (Absent). Circle dominant type.

| Macrophytes | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Emergent | 3 | 3 | 3 |
| Rooted Floating | 3 | 3 | 3 |
| Submergent | 3 | 3 | 3 |
| Free Floating | 3 | 3 | 3 |

| Algae | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|
| Floating Algae | 3 | 3 | 3 |
| Filaments | 3 | 3 | 3 |
| Attached Algae | 3 | 3 | 3 |
| Slimes or Crusts | 3 | 3 | 3 |

**Stream Size/Flow**

Bank Full Width (m): —

Discharge ($m^3/s$, optional, indicate method): N/A

**River Characterisation** (*circle one*) Perennial [✓ Intermittent] Unknown

*Notes (esp. related to land-use, habitat, obvious stressors)*

Known to go dry during the summer.

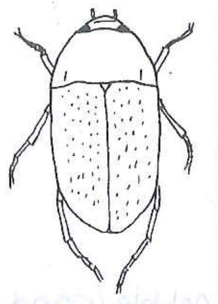
Very low water levels, slow flow. Clear.
No discharge actively occurring @ culverts.
Heavy veg/riparian growth.

**Candidate reference Site** - Minimally Impacted? (circle one) Yes [✓ No]

**General Comments**

Onsite @ 12:45 pm
Offsite @ 14:00

# Ontario Benthos Biomonitoring Network Field Sheet: STREAMS



Date: July 16 2019
Time: 12:50 pm
Agency: GHD Ltd.
Investigators: LJ / ND

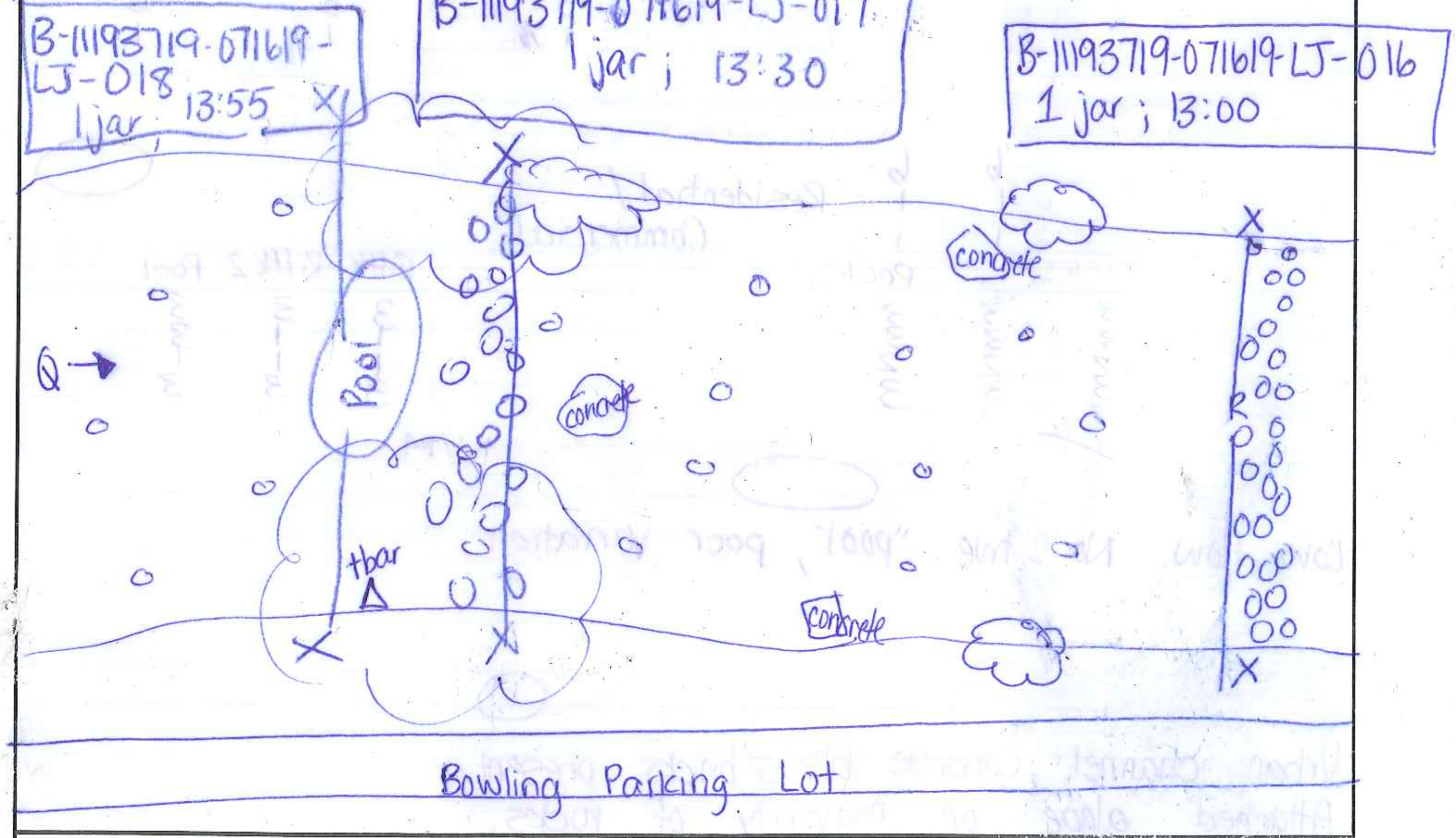
Stream name: Westmount Drain
Site #: WD1
Location: centroid of 3 replicates; Lat/Long or UTM
Photos: US/DS
Elevation (m asl):
Datum/zone:

**Water Quality**

Water Temperature (°C): 19.90
Conductivity (~~µ~~MS/cm): 1.90
pH: 7.83
DO (mg/l): 6.09 mg/L
~~Alkalinity (mg/l as $CaCO_3$):~~ Turb: 0.0NTU
ORP: -15mV
TDS: 1.22 g/L

**Site Description and Map**

*Draw a map of the site (with landmarks) and indicate areas sampled. Attach photograph (optional)*
*Show north arrow.*



B-11193719-071619-LJ-018
1 jar, 13:55

B-11193719-071619-LJ-017
1 jar ; 13:30

B-11193719-071619-LJ-016
1 jar ; 13:00

**Benthos Collection Method** (circle one):
[✓ ◆ Traveling Kick & Sweep] ◆ Grab Sample
◆ Other (specify):

**Gear Type** (circle one)
[✓ ◆ D-net] ◆ Ponar ◆ Other (specify)
◆ Ekman ◆ Rock Baskets
**Mesh Size**: [✓ 500 micron (or specify)]

| Sub-samples | Sampling distance covered (m) | Time (min.) | Max. Depth (m) | Wetted Width (m) | Max. Hydraulic Head (mm) | # [illegible] pooled per sample |
|---|---|---|---|---|---|---|
| Sample 1: Riffle (cross-over) | 11.8 | 3 | 0.11 | 5.9 | 0 | 1 |
| Sample 2: ~~Pool~~ Riffle | 10.0 | 3 | 0.13 | 5.0 | 0 | 1 |
| Sample 3: ~~Riffle (cross-over)~~ Pool | 10.0 | 3 | 0.25 | 5.0 | 0 | 1 |

| | | |
|---|---|---|
| Riffle #1 | 17T 0539913<br>4810418 | WP#52 |
| Pool | 17T 0539888<br>4810455 | WP#53 |
| Riffle #2 | 17T 0539888<br>4810460 | WP#54 |

SW-11193719-071619-LJ-008
4 bottles filled @ 13:10
Clear, colourless, odourless
no vis particulate

**Substrate**

*Enter dominant substrate class and second dominant class for each sub-sample*

|  | Sample 1 | Sample 2<br>Riffle | Sample 3<br>Pool |
|---|---|---|---|
| Dominant | 5 | 5 | 3 |
| 2nd Dominant | 3 | 3 | 4 |

| Class | Description |
|---|---|
| 1 | Clay (hard pan) |
| 2 | Silt (gritty, < 0.06 mm particle diameter) |
| 3 | Sand (grainy, 0.06 - 2 mm) |
| 4 | Gravel (2 - 65 mm) |
| 5 | Cobble (65 - 250 mm) |
| 6 | Boulder (> 250 mm) |
| 7 | Bed Rock |

**Substrate Notes**

cobble/sand/

**Organic Matter-Areal Coverage**

Use 1: Abundant, 2: Present, 3: Absent

|  | Sample 1 | Sample 2<br>Riffle #2 | Sample 3<br>Pool |
|---|---|---|---|
| Woody Debris | 3 | 3 | 3 |
| Detritus | 1 | 1 | 1 |

**Riparian Vegetative Community**

Use: 1 (None), 2 (cultivated), 3 (meadow), 4 (scrubland), 5 (forest, mainly coniferous), 6 (forest, mainly deciduous)

| Zone (dist. From water's edge) | Left Bank | Right Bank (facing downstream) |
|---|---|---|
| 1.5-10 m | 6 | 6 |
| 10-30 m | 1 | 1 |
| 30-100 m | 1 | 1 |

Residential / Commercial

% Canopy Cover (circle one)

0-24 25-49 50-74 [✓ 75-100]

If instrument used, record type:

**Aquatic Macrophytes and Algae** (Use: 1 (Abundant), 2 (Present), 3 (Absent). Circle dominant type.

| Macrophytes | Sample 1 | Sample 2 | Sample 3<br>Pool |
|---|---|---|---|
| Emergent | 3 | 3 | 3 |
| Rooted Floating | 3 | 3 | 3 |
| Submergent | 2 | 2 | 2 |
| Free Floating | 3 | 3 | 3 |

| Algae | Sample 1<br>Riffle | Sample 2<br>Riffle 2 | Sample 3<br>Pool |
|---|---|---|---|
| Floating Algae | 3 | 3 | 3 |
| Filaments | 1 | 1 | 3 |
| Attached Algae | 1 | 1 | 1 |
| Slimes or Crusts | 3 | 3 | 3 |

**Stream Size/Flow**

Bank Full Width (m): —

Discharge ($m^3/s$, optional, indicate method): NVM

**River Characterisation** (*circle one*) [✓ Perennial] Intermittent Unknown

*Notes (esp. related to land-use, habitat, obvious stressors)*

Low flow. No true "pool", poor variation.

**Candidate reference Site** - Minimally Impacted? (circle one) Yes [✓ No]

**General Comments**

Urban channel. Concrete blocks/bricks present.
Attached algae on majority of rocks.
Rain during last 2 samples.

# Appendix H
# 2019 Benthic

| STATION | Kitchener | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REPLICATE | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | |
| DATE | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | | HBI |
| TAXA LIST | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **ANNELIDA:HIRUDINEA** | | | | | | | | | | | | | | | | | |
| ERPOBDELLIDAE: | | | | | | | | | | | | | | | | | |
| *Erpobdella (juveniles)* | | | 1 | | | | | | | | | | | | | 1 | 6 |
| GLOSSIPHIONIIDAE: | | | | | | | | | | | | | | | | | |
| *Helobdella stagnalis* | | | | | | 2 | | | | | | | | | | 1 | 6 |
| **ANNELIDA:OLIGOCHAETA** | | | | | | | | | | | | | | | | | |
| ENCHYTRAEIDAE: | | | | | | | | | | | | | | | | 0 | 10 |
| LUMBRICIDAE: | | | | | | | | | | | | | | | | | |
| *Eiseniella tetraedra* | | | | | | | | | | | | | | | | 0 | 8 |
| *Lumbricus rubellus* | 3 | 3 | 1 | | | | | 1 | | | | | | | | 4 | 8 |
| NAIDIDAE: | | | | | | | | | | | | | | | | | |
| *Nais* | | | | | | | | | | | | | | | | 0 | 8 |
| TUBIFICIDAE: | | | | | | | | | | | | | | | | | |
| Immature With Hairs | | 3 | | 3 | | | | | | | | | | | 22 | 3 | 10 |
| Immature Without Hairs | 1 | | 3 | 2 | 2 | 2 | | | | | | | 47 | 7 | 56 | 8 | 10 |
| *Branchiura sowerbyi* | | | | | | | | 1 | | | | 1 | | | | 2 | 10 |
| | | | | | | | | | | | | | | | | | |
| **CRUSTACEA: AMPHIPODA:** | | | | | | | | | | | | | | | | | |
| CRANGONYCTIDAE: | | | | | | | | | | | | | | | | | |
| *Crangonyx* | | | | | | 2 | 2 | 8 | 6 | 1 | | | 1 | 1 | 1 | 8 | 8 |
| **CRUSTACEA: DECAPODA:** | | | | | | | | | | | | | | | | | |
| CAMBARIDAE: | | | | | | | | | | | | | | | | | |
| *Orconectes obscurus* | | | | | | | | | | | | 1 | | | | 1 | 6 |
| **CRUSTACEA: ISOPODA:** | | | | | | | | | | | | | | | | | |
| ASELLIDAE: | | | | | | | | | | | | | | | | | |
| *Caecidotea* | 78 | 85 | 94 | 6 | 1 | 4 | 71 | 21 | 8 | 4 | 1 | 4 | 66 | 83 | 45 | 15 | 8 |
| | | | | | | | | | | | | | | | | | |
| **INSECTA:** | | | | | | | | | | | | | | | | | |
| **COLEOPTERA:** | | | | | | | | | | | | | | | | | |
| ELMIDAE: | | | | | | | | | | | | | | | | | |
| *Dubiraphia* | | | | | | | | | | | | 2 | | | | 1 | 6 |
| *Optioservus fastiditus* | | | | | | 1 | | | 2 | 9 | 9 | | | | | 4 | 4 |
| *Stenelmis crenata* | | | | | | | 8 | 4 | 3 | 1 | 1 | | | | | 5 | 5 |
| HYDROPHILIDAE: | | | | | | | | | | | | | | | | | |
| *Helophorus* | | | | 1 | | | | | | | | | | | | 1 | 5 |
| *Paracymus* | | | | | | | | 1 | | | | | | | | 1 | 5 |
| | | | | | | | | | | | | | | | | | |
| **DIPTERA:** | | | | | | | | | | | | | | | | | |
| CHIRONOMIDAE: CHIRONOMINAE: | | | | | | | | | | | | | | | | | |
| *Chironomus* | | | | 11 | 5 | 1 | | 1 | | | | | | | | 4 | 10 |
| *Cladopelma* | | | | | | | | | | | | 1 | | | | 1 | 9 |
| *Cryptochironomus* | 10 | 7 | 1 | | 6 | 5 | | 3 | | | | 4 | | | | 7 | 8 |
| *Dicrotendipes* | | | | 27 | 28 | 7 | | 7 | | | | 2 | | | | 5 | 8 |
| *Microtendipes* | | | | | | | 2 | 2 | 1 | | | | | | | 3 | 6 |
| *Paratanytarsus* | 2 | | | 13 | 16 | 41 | | 4 | | | | | | | | 5 | 6 |
| *Paratendipes* | | | | 3 | 3 | | | 2 | | | | 1 | | | | 4 | 8 |
| *Polypedilum* | 4 | 8 | 1 | 5 | 30 | 10 | 2 | 3 | 2 | 11 | 2 | 18 | | | 1 | 13 | 6 |
| *Stictochironomus* | 2 | 1 | 1 | 20 | 35 | 8 | | | | | | 32 | | | | 7 | 9 |
| *Tanytarsus* | 1 | 2 | | 3 | 4 | 2 | | 9 | | 2 | | 9 | 1 | | | 9 | 6 |
| CHIRONOMIDAE: DIAMESINAE: | | | | | | | | | | | | | | | | | |
| *Diamesa* | | | | | | | | | | | | | | | | 0 | 5 |

| STATION | Kitchener | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REPLICATE | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | |
| DATE | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | | HBI |
| TAXA LIST | | | | | | | | | | | | | | | | | |
| *Pagastia* | | | | | | | | | | 13 | 14 | 1 | | | | 3 | 1 |
| CHIRONOMIDAE: ORTHOCLADIINAE: | | | | | | | | | | | | | | | | | |
| *Brillia* | | | | | | | | | | | | | | | | 0 | 5 |
| *Cricotopus/Orthocladius* | | | | 2 | 1 | 6 | | | | | 2 | | 1 | 1 | 1 | 7 | 7 |
| *Parametriocnemus* | | | | | | | 2 | | | 1 | | 1 | 1 | | | 4 | 5 |
| *Tvetenia* | | | | | | | 1 | | | | 6 | | | | | 2 | 5 |
| CHIRONOMIDAE: PRODIAMESINAE: | | | | | | | | | | | | | | | | | |
| *Odontomesa fulva* | | | | | | | | | | | | 2 | | | | 1 | 4 |
| *Prodiamesa* | | | | | | | | | | | | 33 | | | | 1 | 3 |
| CHIRONOMIDAE: TANYPODINAE: | | | | | | | | | | | | | | | | | |
| *Ablabesmyia* | | | | | | | | | | | | | | | | 0 | 8 |
| *Conchapelopia* | 3 | 1 | 1 | | 4 | 16 | 2 | 15 | 3 | | 3 | 1 | | | | 10 | 6 |
| *Paramerina* | | | | | | | | | | | | | | | | 0 | 6 |
| *Procladius* | | | | 3 | | | | 1 | | | | | | | | 2 | 9 |
| CULICIDAE: | | | | | | | | | | | | | | | | | |
| *Aedes* | | | | 4 | | | | | | | | | | | | 1 | 8 |
| EMPIDIDAE: | | | | | | | | | | | | | | | | | |
| *Hemerodromia* | | | | | | | | | | | | | | | | 0 | 6 |
| MUSCIDAE: | | | | | | | | | | | | | | | | | |
| *Limnophora* | | | 1 | | | | | | | | | | | | | 1 | 6 |
| SIMULIIDAE: | | | | | | | | | | | | | | | | | |
| *Simulium* | | | | | | 1 | | | 1 | 3 | 1 | | 7 | 9 | 1 | 7 | 5 |
| TIPULIDAE: | | | | | | | | | | | | | | | | | |
| *Antocha* | | | | | | | | 7 | | 1 | 3 | | | | | 3 | 3 |
| *Dicranota* | | | | | | | | | | 2 | | | | | | 1 | 3 |
| *Tipula* | | | | | | | 2 | | | 1 | 1 | | | | | 3 | 4 |
| | | | | | | | | | | | | | | | | | |
| **EPHEMEROPTERA:** | | | | | | | | | | | | | | | | | |
| BAETIDAE: | | | | | | | | | | | | | | | | | |
| *Baetis brunneicolor* | | | | | | | | | | 6 | 31 | | | | | 2 | 4 |
| *Baetis flavistriga* | | | | | | | 1 | | 16 | 15 | 2 | 1 | | | | 5 | 4 |
| *Baetis tricaudatus* | | | | | | | 1 | | 1 | | | | | | | 2 | 6 |
| *Callibaetis* | | | | | | 2 | | | | | | | | | | 1 | 9 |
| CAENIDAE: | | | | | | | | | | | | | | | | | |
| *Caenis* | | | | | | | 1 | 1 | | | | | | | | 2 | 7 |
| LEPTOHYPHIDAE: | | | | | | | | | | | | | | | | | |
| *Tricorythodes* | | | | | | | 1 | 1 | | | | 1 | | | | 3 | 4 |
| | | | | | | | | | | | | | | | | | |
| **HEMIPTERA:** | | | | | | | | | | | | | | | | | |
| CORIXIDAE:(nymphs) | | | | | | 4 | | | | | | | | | | 1 | 5 |
| *Sigara* | | | | 1 | | | | | | | | | | | | 1 | 5 |
| **MEGALOPTERA:** | | | | | | | | | | | | | | | | | |
| SIALIDAE: | | | | | | | | | | | | | | | | | |
| *Sialis* | 1 | | | | | | | 6 | 2 | | | 2 | | | | 4 | 4 |
| **ODONATA:** | | | | | | | | | | | | | | | | | |
| AESHNIDAE: | | | | | | | | | | | | | | | | | |
| *Aeshna* | | | | | | | | | | | | | | | 1 | 1 | 5 |
| **TRICHOPTERA:** | | | | | | | | | | | | | | | | | |
| HYDROPSYCHIDAE: | | | | | | | | | | | | | | | | | |
| *Cheumatopsyche* | | | 1 | | | 2 | 5 | 1 | 15 | | 1 | | | 1 | | 7 | 5 |
| *Hydropsyche* | | | | | | | 14 | 1 | 53 | 35 | 31 | | | 1 | | 6 | 6 |
| HYDROPTILIDAE: | | | | | | | | | | | | | | | | | |

William B. Morton
2019.09.18

| STATION | Kitchener | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REPLICATE | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | |
| DATE | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.15 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | 19.07.16 | | HBI |
| TAXA LIST | | | | | | | | | | | | | | | | | |
| *Hydroptila* | | | | | | | 1 | 1 | | | | | 2 | | 1 | 4 | 6 |
| LEPTOCERIDAE: | | | | | | | | | | | | | | | | | |
| *Mystacides sepulchralis* | | | | | | | | 1 | | | | | | | | 1 | 4 |
| PHILOPOTAMIDAE: | | | | | | | | | | | | | | | | | |
| *Dolophilodes* | | | | | | | | | | 3 | 4 | 1 | | | | 3 | 0 |
| POLYCENTROPODIDAE: | | | | | | | | | | | | | | | | | |
| *Polycentropus* | | | | | | | | 1 | | | | | | | | 1 | 6 |
| | | | | | | | | | | | | | | | | | |
| **MOLLUSCA:BIVALVIA** | | | | | | | | | | | | | | | | | |
| SPHAERIIDAE: | | | | | | | | | | | | | | | | | |
| *Pisidium* | 1 | | 1 | | | 6 | | | | 1 | | | | | | 4 | 8 |
| **MOLLUSCA:GASTROPODA:** | | | | | | | | | | | | | | | | | |
| PHYSIDAE: | | | | | | | | | | | | | | | | | |
| *Aplexa hypnorum* | | | | 1 | | | | | | | | | | | | 1 | 8 |
| *Physella gyrina* | | | | | | | | | | | | | | | | 0 | 8 |
| PLANORBIDAE: | | | | | | | | | | | | | | | | | |
| *Gyraulus circumstriatus* | | | | | | | | | | | | | | | | 0 | 8 |
| | | | | | | | | | | | | | | | | | |
| **PLATYHELMINTHES:** | | | | | | | | | | | | | | | | | |
| PLANARIIDAE: | | | | | | | | | | | | | 3 | 10 | 2 | 3 | 6 |
| | | | | | | | | | | | | | | | | | |
| TOTAL NUMBERS | 106 | 110 | 106 | 105 | 135 | 122 | 116 | 103 | 113 | 109 | 112 | 118 | 129 | 113 | 131 | | |
| TOTAL TAXA (richness) | 11 | 8 | 11 | 16 | 12 | 19 | 16 | 25 | 13 | 17 | 16 | 20 | 9 | 8 | 10 | 67 | |
| | | | | | | | | | | | | | | | | | |
| % of sample sorted for min.100 | 20 | 50 | 25 | 56 | 19 | 14 | 1 | 21.6 | 1 | 1 | 1 | 5 | 31.4 | 31.1 | 14.7 | | |
| Taxa in red are new additions for July 2018 | | | | | | | | | | | | | | | | | |

# Appendix I

# License to Collect Fish for Scientific Purposes

**Ministry of Natural Resources and Forestry**

Guelph District
1 Stone Road West
Guelph, Ontario
N1G 4Y2

**Ministère des Richesses naturelles et des Forêts**

Telephone: (519) 826-4955
Facsimile: (519) 826-4929

Ontario

---

May 6, 2019

Robyn Leppington
455 Phillip Street
Waterloo, ON N2L 3X2

Dear Robyn:

Re: License to Collect Fish No. 1092969

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Attached is the above Licence to Collect. The expiry date is October 31st, 2019.

Please ensure you and your assistants read and adhere to all conditions on the attached Schedule A **(there have been some important changes)** and have this documentation with you when you are on site at all times.

Viral Hemorrhagic Septicemia (VHS) continues to cause concerns with the capture and transport of fish. VHS has been confirmed in the lower Great Lakes, some inland tributaries and Lake Simcoe. In order to address concerns with the spread of aquatic invasive species and diseases, a condition has been included in all fish collection licenses stating that all collections and sampling must be in compliance with the best management practices identified in the enclosed technical bulletin titled '*BMP for Collection of Fish for Scientific Purposes'*.

Please note the conditions of this licence require a report to be submitted to scp.guelph@ontario.ca, using the accompanying Site Collection Report Form within 30 days of the termination date but in no case later than January 31st of the following year.

**Also note, as of April 1st, 2019, all responsibilities under the ESA now reside with Ministry of Environment, Conservation and Parks (MECP). All correspondence and enquiries related to the ESA or SAR should be sent to SAROntario@ontario.ca to reach MECP directly.**

**Should you capture an endangered or threatened species while conducting activities under this authorization, please notify Ministry of Environment, Conservation and Parks immediately by emailing SAROntario@ontario.ca.**

Please return the *signed* licence and Schedule A by email to scp.guelph@ontario.ca before commencement of any work.

If you have any questions or need to amend your licence at any time please send your request to scp.guelph@ontario.ca.

Kind regards,

M Bonaldo

Michelle Bonaldo
Resources Management Clerk
Ministry of Natural Resources
Guelph District
Telephone: (519) 826-4909
Email: michelle.bonaldo@ontario.ca

Ontario

Ministry of Natural Resources

Ministère des Richesses naturelles

# Licence to Collect Fish for Scientific Purposes

# Permis pour faire la collecte de poissons à des fins scientifiques

Licence No. / N° de permis: 1092969

Local Reference No. / N° de référence local: GL2019-1155

Issuer Account No. / N° de compte du délivreur de permis: 10001664

**This licence is issued under Part I of the Fish Licensing Regulation made under the Fish and Wildlife Conservation Act, 1997 to:**

**Ce permis est délivré en vertu de la Partie I du règlement sur la délivrance de permis de pêche formulé conformément à la Loi sur la protection du poisson et de la faune de 1997 à:**

***Name of Licencee / Nom du titulaire du permis***

Last Name / Nom de famille: Mrs. Leppington

First Name / Prénom: Robyn

Middle Name / Second Prénom:

Name of Business/Organization/Affiliation ( if applicable) / Nom de l'entreprise/de l'organisme/de l'affiliation (le cas échéant): GHD Ltd.

***Mailing address of Licencee / Adresse postale du titulaire du permis***

Street Name & No./PO Box/RR#/Gen. Del./ N° rue/C.P./R.R./poste restante: 455 Phillip Street

City/Town/Municipality / Ville/village/municipalité: Waterloo

Province/State / Province/État: ON

Postal Code/Zip Code / Code Postal/Zip: N2L 3X2

**to collect the species, size and quantites of fish from the waters as set out below.**

**Pour faire la collecte des espèces suivantes (stade et nombre indiqués ci-dessous):**

| Species<br>Espèces | Eggs<br>Oeuf<br>X | Juvenile<br>Fretin<br>X | Adults<br>Adulte<br>X | Numbers<br>Nombre | Name of Waterbody<br>Nom de l'étendue d'eau |
|---|---|---|---|---|---|
| All fish encountered | X | X | X | | Voison Creek VS1, Balzer Creek BZ2, BZ3 |
| All fish encountered | | | | | Shoemaker Creek SM1, SM3, SM4 |
| All fish encountered | | | | | Montgomery Creek MG1, MG2, |
| All fish encountered | | | | | Westmount Creek WD1, Strasburg Creek SB2 |
| All fish encountered | | | | | Sandrock Greenway SR2 |

Yes/Oui ☐ Additional species/Waterbody list attached / Liste d'espèces/d'étendue d'eau additionnelles ci-jointe

***Purpose of collection / But de la collecte***: conducting spring and summer community inventories which are required as part of the ongoing monitoring program for the City of Kitchener

***Licence Dates / Dates du permis***

Effective Date / Date d'entrée en vigueur (YYYY-MM-DD): 2019-05-06

Expiry Date / Date d'expiration (YYYY-MM-DD): 2019-10-31

***Licence conditions / Conditions du permis***

This licence is subject to the conditions contained in Schedule A if included. / Ce permis doit respecter les conditions de l'annexe A si celle-ci est jointe.

Yes/Oui ☒ No/Non ☐ Schedule A included. / Annexe A ci-jointe

Issued by (please print) / Délivré par (veuillez écrire en caractères d'imprimerie): Ian Thornton, Resource Operations Supervisor

Signature of issuer / Signature du délivreur:

Date of Issue/Date de délivrance (YYYY-MM-DD): 2019-05-06

Signature of Licencee / Signature du titulaire du permis: Robyn Leppington

Date (YYYY-MM-DD): 2019-05-06

Personal information contained on this form is collected under the authority of the Fish and Wildlife Conservation Act, 1997 and will be used for the purpose of licencing, identification, enforcement, resource management and customer service surveys. Please direct further inquiries to the District Manager of the MNR issuing district.

Les renseignements personnels dans ce formulaire sont recueillis conformément à la Loi sur la protection du poisson de la faune, 1997, et ils seront utilisés aux fins de délivrance de permis, d'identification, d'application des règlements, de gestion des ressources et de sondage sur les services à la clientèle. Veuillez communiquer avec le chef du district du MRN qui délivré le permis si vous avez des questions.

FW0032 (04/00)

# License to Collect Fish for Scientific Purposes
# Permis pour faire la collecte de poissons à des fins scientifiques
## Schedule A - Licence Conditions
## Annexe A – Conditions du permis

License No. 1092969

**This license is subject to the conditions listed below.**

1. This License is valid only for the persons, species, numbers, areas and calendar year indicated. A written report covering the operation of the preceding year must be submitted to the license issuer within 30 days of the termination date, but in no case later than January 31 following the year of issue. The report shall contain a statement outlining the objectives of the operations, the methods used, the number and species of fish caught and their fate as well as a map indicating where the collections took place. An analysis is not required. The submission of a satisfactory report is a prerequisite to any subsequent renewals. **Year-end mandatory reports are to be sent by email to scp.guelph@ontario.ca.**
2. Before carrying out any operation under the licence in any area the licensed person shall inform the Resources Management Supervisor or District/Lake Manager of his or her intentions at least a week before commencing work and include information as to the type of operation, location, duration, and the name or names of personnel involved.
3. A copy of the original license must be carried by the licensed person when working at the designated sites. An assistant of the licensed person who is carrying out activities under this license during the absence of the licensed person shall carry a copy of the license on his or her person.
4. This license is not valid in Provincial Parks, Park Reserves, or National Parks without the written permission from the authorized person in charge of the area concerned.
5. Capture gear shall be inspected regularly and live holding traps must be inspected at least once daily.
6. All unattended collection gear shall be clearly marked with the licensed person's and organization's name.
7. This license does not allow access to any property without permission of the landowner.
8. **Names of assistants covered under this authorization are as follows:** Stacey Litwiller-Koebel, Natalie Doerr, Leah Jefferson and Christine Pritchard
   ***Any changes to assistants must be confirmed in writing.**
9. **Gear permitted under this authorization is as follows:** Backpack electro-fisher, minnow traps, nets, aerators, buckets and minnow traps.
10. Unless otherwise specified, all captured fish will be released alive at the capture site except for voucher specimens, approved permanent collections and/or when further examination is necessary in the laboratory. Voucher specimens shall be deposited in the Royal Ontario Museum collection for taxonomic verification and voucher retention.
11. Dead fish and offal not required for study purposes must be buried ashore above the high water mark (Section 33(1) Fisheries Act). Where large amounts of fish/offal must be disposed of, it is advisable that a special area be designated. (Section 43, Fisheries Act).
12. The licensee shall follow the Best Management Practices for the collection, handling, transportation and holding of fish identified in FS Bulletin 2011 included with the license in order to minimize the risk of spreading aquatic invasive species and diseases.
13. Due to potential spawning activity by resident or migratory fish species, visual inspection of all sampling areas should be done prior to sampling with the electro-fisher or seine nets. Should spawning activity or Redds be observed, all sampling must be stopped in order to prevent disturbance to the fish and habitats.

**Ce permis doit se conformer aux conditions ci-dessous.**

1. Ce permis n'est valide que pour les personnes, espèces, nombres, zones et année civile indiqués. Un rapport écrit portant sur les activités de l'année précédente doit être soumis au délivreur du permis dans les 30 jours suivant la date d'expiration et jamais plus tard que le 31 janvier qui suit la date de délivrance. Le rapport devra comprendre une déclaration décrivant les objectifs des activités, les méthodes utilisées, le nombre et les espèces de poissons capturés et leur destination finale ainsi qu'une carte montrant l'emplacement des collectes. Une analyse n'est pas requise. La présentation d'un rapport satisfaisant est une condition préalable pour obtenir un renouvellement de permis.
2. Avant de réaliser toute activité visée par le permis dans toute zone, le titulaire du permis doit aviser le superviseur de la zone ou le gestionnaire du lac de ses intentions au moins une semaine avant de commencer ses activités et il doit fournir des renseignements sur le type d'activité, l'emplacement, la durée et le nom de toutes les personnes impliquées.
3. Le titulaire du permis doit avoir en sa possession un exemplaire du permis original lorsqu'il travaille dans les endroits désignés. Si un adjoint du titulaire du permis réalise des activités visées par le permis en l'absence du titulaire du permis, il devra avoir un exemplaire du permis en sa possession.
4. Ce permis n'est pas valide dans les parcs provinciaux, les réserves de parcs et les parcs nationaux sans la permission écrite de la personne autorisée qui est responsable de la zone en question.
5. Tout le matériel de collecte doit être inspecté régulièrement et les viviers doivent être inspectés au moins une fois par jour.
6. Ce permis ne permet pas au titulaire d'avoir accès à une propriété privée sans la permission du propriétaire foncier.

**Signature of Licencee / Signature du titulaire du permis**

Robyn Leppington

**Date**

May 6, 2018

# License to Collect Fish for Scientific Purposes
# Permis pour faire la collecte de poissons à des fins scientifiques
## Schedule A - Licence Conditions
## Annexe A – Conditions du permis

License No. 1092989

14. Invasive species sampled beyond their known range must be reported immediately a Management Biologist at the MNRF office responsible for the area in which the collection site is situated. Any such specimens captured outside of their established range (not already naturalized) **shall be euthanized**, not returned to the water and kept for identification purposes.
15. Unless specifically authorized by a separate Endangered Species Act (ESA) authorization (i.e. Registry or permit) and/or Federal Species at Risk Act (SARA) permit, no person shall attempt to catch a Species at Risk.
16. Unless specifically authorized by a separate Endangered Species Act (ESA) authorization (i.e. Registry or permit) and/or Federal Species at Risk Act (SARA) permit, any Species at Risk that are incidentally captured (including, but not limited to: redside dace, black redhorse, river redhorse, eastern sand darter, and brook lamprey (Northern or American)) must be photographed and immediately released alive at the point of capture. The photographs, including capture coordinates and date caught, must be forwarded to SAROntario@ontario.ca
17. Unless specifically authorized by a separate Endangered Species Act (ESA) authorization (i.e. Registry or permit) and/or Federal Species at Risk Act (SARA) permit, sampling must cease immediately in an area when a Species at Risk is caught.
18. All aquatic SAR must also be reported to the Ministry of Natural Resources and Forestry Natural Heritage Information Centre on the appropriate form at: **https://www.ontario.ca/environment-and-energy/natural-heritage-information-centre**

**Signature of Licencee / Signature du titulaire du permis**

Robyn Leppington

**Date**

May 6, 2019

# Appendix J
# OSAP Electrofishing Field Notes

Onsite @ 13:00

Offsite @ 14:30

# Fish Sampling

**Mandatory Fields In Grey**
**Must be filled out for processing**

WQ
Temp: 18.19°C
pH: 7.94
ORP: -31mV
Cond: 1.75mS/cm

turb: 0.3NTU
DO: 6.12mg/L
TDS: 1.12g/L

Stream Name: WESTMOUNT DRAIN

Date (yyyy-mm-dd): 2019-07-24

Stream Code: WD1

Sample: 01

Run No.: 01 of 01

Site Code:

Science Collect. No.:

Start Time (24hr): 13:18

Stop Time (24hr): 13:43

Elapsed Min.: 25

Shocker Sec.: 626

Model No.: HT2000

Anod. Voltage: 100

Frequency: 100

Pulse:

Channel Morphology Available? ☐ Yes ☑ No

If no, measure the station length and 10 widths.

Length (m): 61.6

Widths (m)

| | | | |
|---|---|---|---|
| 1 | 5.7 | 6 | 4.5 |
| 2 | 5.6 | 7 | 4.7 |
| 3 | 5.7 | 8 | 4.8 |
| 4 | 4.7 | 9 | 5.4 |
| 5 | 4.4 | 10 | 4.8 |

Depths (mm)
1. 90
2. 170
3. 130
4. 130
5. 135
6. 130
7. 110
8. 200
9. 130
10. 250

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

**Individual Fish**

☑ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

| ID | Species | Length (mm) | Weight (g) | B/O | P/S | Sp Name/Remarks |
|---|---|---|---|---|---|---|
| 1 | | 38 | — | ☐ ☐ | ☐ ☐ | White Sucker |
| 2 | | 43 | — | ☐ ☐ | ☐ ☐ | " " |
| 3 | | 40 | — | ☐ ☐ | ☐ ☐ | " " |
| 4 | | 85 | | ☐ ☐ | ☐ ☐ | Blacknose Dace |
| 5 | | 75 | | ☐ ☐ | ☐ ☐ | " |
| 6 | | 68 | | ☐ ☐ | ☐ ☐ | " |
| 7 | | 77 | | ☐ ☐ | ☐ ☐ | " |
| 8 | | 72 | | ☐ ☐ | ☐ ☐ | " |
| 9 | | 80 | | ☐ ☐ | ☐ ☐ | " |
| 10 | | 77 | | ☐ ☐ | ☐ ☐ | " |
| 11 | | 66 | | ☐ ☐ | ☐ ☐ | " |
| 12 | | 40 | | ☐ ☐ | ☐ ☐ | " (YOY) |
| 13 | | 74 | | ☐ ☐ | ☐ ☐ | " |
| 14 | | 80 | | ☐ ☐ | ☐ ☐ | " |
| 15 | | 68 | | ☐ ☐ | ☐ ☐ | " |
| 16 | | 80 | | ☐ ☐ | ☐ ☐ | " |
| 17 | | 78 | | ☐ ☐ | ☐ ☐ | " |
| 18 | | 80 | | ☐ ☐ | ☐ ☐ | " |
| 19 | | 85 | | ☐ ☐ | ☐ ☐ | " |
| 20 | | 76 | | ☐ ☐ | ☐ ☐ | " |

Comments
US extent: 17T 0539876, 4810467 WP#58
DS extent: 17T 0539918, 4810420 WP#57

**Bulk Fish**

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

Bulk Weights

| Batch | ~~Species~~ (length) | Grp # | Fish Total | Bulk Weight (g) | Presvd | Bag # | Sp Name/Remarks |
|---|---|---|---|---|---|---|---|
| 1 | | | 4 | 4 | | | White Sucker |
| 2 | | | 21 | 9 | | | Blacknose Dace |
| ~~3~~ | | | | | | | |
| 4 | | | | | | | TOTAL: 25 |
| 5 | | | | | | | |
| 6 | 74 | | | | | | Blacknose Dace (cont.) |
| 7 | 80 | | | | | | " |
| 8 | 81 | | | | | | " |
| 9 | 76 | | | | | | " |
| 10 | 30 | | | | | | White Sucker (YOY) |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |

Crew Leader (init. & last name): R LEPPINGTON

Crew: RL/LJ

Recorder: LJ

Field ID (init. & last name): L JEFFERSON

Cert. Level:

Lab ID (init. & last name):

Cert. Level:

Entered/Scanned:

Verified:

Corrected:

Pg 1 of 1

Onsite at 14:30
Offsite at 15:20

Temp: 22.50°C turb: 9.7 NTU
pH: 8.46
ORP: -30mV
Cond: 1.10 mS/cm
DO: 7.22 mg/L
TDS: 0.706 g/L

Pg 1 of 1

# Fish Sampling

**Mandatory Fields In Grey**
**Must be filled out for processing**

Stream Name: VOISIN CREEK

Stream Code: VS1

Sample: 01

Run No.: 01 of 01

Site Code:

Science Collect. No.: 1092969

Start Time (24hr): 14:42

Stop Time (24hr): 14:52

Elapsed Min.: 10

Shocker Sec.:

Model No.: HT2000

Anod. Voltage: 150

Frequency: 20

Pulse:

Date (yyyy-mm-dd): 2019-07-22

Channel Morphology Available? ☐ Yes ☑ No

If no, measure the station length and 10 widths.

Length (m): 74.

| Widths (m) | | | |
|---|---|---|---|
| 1 | 2.6 | 6 | 3.3 |
| 2 | 3.4 | 7 | 3.4 |
| 3 | 3.4 | 8 | 3.2 |
| 4 | 3.9 | 9 | 3.3 |
| 5 | 3.3 | 10 | 3.6 |

Depths
1. 80mm
2. 70mm
3. 130mm
4. 65mm
5. 150mm
6. 110mm
7. 105mm
8. 150mm
9. 40mm
10. 90mm

Deviations *(Check all that apply)*
☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

**Individual Fish**

☐ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

| ID | Species | Length (mm) | Weight (g) | B/O | P/S | Sp Name/Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | ☐☐ | ☐☐ | |
| 2 | | | | ☐☐ | ☐☐ | |
| 3 | | | | ☐☐ | ☐☐ | No fish |
| 4 | | | | ☐☐ | ☐☐ | caught. |
| 5 | | | | ☐☐ | ☐☐ | |
| 6 | | | | ☐☐ | ☐☐ | |
| 7 | | | | ☐☐ | ☐☐ | |
| 8 | | | | ☐☐ | ☐☐ | |
| 9 | | | | ☐☐ | ☐☐ | |
| 10 | | | | ☐☐ | ☐☐ | No visual |
| 11 | | | | ☐☐ | ☐☐ | sightings of fish |
| 12 | | | | ☐☐ | ☐☐ | @ site. |
| 13 | | | | ☐☐ | ☐☐ | |
| 14 | | | | ☐☐ | ☐☐ | |
| 15 | | | | ☐☐ | ☐☐ | |
| 16 | | | | ☐☐ | ☐☐ | |
| 17 | | | | ☐☐ | ☐☐ | |
| 18 | | | | ☐☐ | ☐☐ | |
| 19 | | | | ☐☐ | ☐☐ | |
| 20 | | | | ☐☐ | ☐☐ | |

Comments
Downstream - 17T 0540581, 4808553 (WP54)
Upstream - 17T 0540494, 4808547 (WP55)

**Bulk Fish**

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

| Batch | Species | Grp # | Fish Total | Bulk Weight (g) | Presvd | Bag # | Sp Name/Remarks |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | Low water levels |
| 6 | | | | | | | Evidence of brush |
| 7 | | | | | | | clearing on left |
| 8 | | | | | | | bank (facing US). |
| 9 | | | | | | | |
| 10 | | | | | | | |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |

Crew Leader (init. & last name): R LEPPINGTON

Crew: LJ/RL

Recorder: LJ

Field ID (init. & last name): L JEFFERSON

Cert. Level:

Lab ID (init. & last name):

Cert. Level:

Entered/Scanned:

Verified:

Corrected:

WDJ -jumping heigh 400 mm
-substrate to top 670 mm

HOR-W19-021
Cal Sol'n Lot 9GA501 exp Jan 2020
Calibration pH 3.98
cond 4.47 mS/cm
turb 0.0 NTU
DO 8.31 mg/L

p 1 of 1

# Fish Sampling

**Mandatory Fields In Grey**
**Must be filled out for processing**

Stream Name: STRAZBURG CREEK

Date (yyyy-mm-dd): 2019-07-22

Stream Code: SB2

Sample:

Run No. of

Site Code:

Science Collect. No.: 1092969

Start Time (24hr): 9:32

Stop Time (24hr): 10:07

Elapsed Min.: 35

Shocker Sec.: 1600

Model No.: HT2000

Anod. Voltage: 150

Frequency: 60

Pulse: —

Channel Morphology Available? ☐ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m): 80.0

Widths (m)

| | | | |
|---|---|---|---|
| 1 | 2.6 | 6 | 2.3 |
| 2 | 3.2 | 7 | 2.6 |
| 3 | 2.5 | 8 | 2.4 |
| 4 | 3.2 | 9 | 3.5 |
| 5 | 2.8 | 10 | 3.1 |

depths mm

1. 400
2. 460
3. 200
4. 240
5. 320
6. 605
7. 310
8. 240
9. 160
10. 130

Deviations *(Check all that apply)*

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

**Individual Fish**

☑ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

Pic

| ID | Species | Length (mm) | Weight (g) | B/O | P/S | Sp Name/Remarks |
|---|---|---|---|---|---|---|
| 1 | | 170 | 31 | ☐☐ | ☐☐ | Brook Trout x2 |
| 2 | | 160 | 36 | ☐☐ | ☐☐ | " " |
| 3 | | 165 | 27 | ☐☐ | ☐☐ | " " |
| 4 | | 230 | 62 | ☐☐ | ☐☐ | " " |
| 5 | | 57 | 8 | ☐☐ | ☐☐ | " " |
| 6 | | 163 | 32 | ☐☐ | ☐☐ | " " |
| 7 | | 171 | 40 | ☐☐ | ☐☐ | " " |
| 8 | | 150 | 11 | ☐☐ | ☐☐ | White Sucker |
| 9 | | 101 | 8 | ☐☐ | ☐☐ | " " |
| 10 | | 98 | — | ☐☐ | ☐☐ | Mottled Sculpin x3 |
| 11 | | 38 | — | ☐☐ | ☐☐ | " " |
| 12 | | 113 | — | ☐☐ | ☐☐ | Longnose Dace x2 |
| 13 | | 84 | — | ☐☐ | ☐☐ | " " |
| 14 | | 20 | — | ☐☐ | ☐☐ | Blacknose Dace |
| 15 | | 96 | — | ☐☐ | ☐☐ | " " x3 |
| 16 | | 96 | — | ☐☐ | ☐☐ | Pumpkinseed x2 |
| 17 | | 40 | — | ☐☐ | ☐☐ | " " |
| 18 | | 42 | — 4 | ☐☐ | ☐☐ | Brookstickle back x3 |
| 19 | | 35 | — 4 | ☐☐ | ☐☐ | " " |
| 20 | | 42 | — | ☐☐ | ☐☐ | " " |

**Bulk Fish**

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

| Batch | Species | Grp # | Fish Total | Bulk Weight (g) | Presvd | Bag # | Sp Name/Remarks |
|---|---|---|---|---|---|---|---|
| 1 | — | — | 8 | 42 | — | — | White Sucker |
| 2 | — | — | 18 | 42 | — | — | Mottled Sculpin |
| 3 | — | — | 3 | 16 | — | — | Longnose Dace |
| 4 | — | — | 26 | 64 | — | — | Blacknose Dace |
| 5 | — | — | 120 | 108 | — | — | Pumpkinseed |
| 6 | — | | 3 | 6 | — | — | Brookstickleback |
| 7 | — | — | 12 | 42 | — | — | Creek Chub |
| 8 | | | | | | | ~~YOY Cyprinids~~ |
| 9 | | | 16 | 10 | | | Bluntnose |
| 10 | | | | | | | |
| 11 | | | Length (mm) | weight | | | |
| 12 | | | 65 | 3 | | | Bluntnose x2 |
| 13 | | | 52 | 2 | | | " " |
| 14 | | | 41 | 2 | | | ~~Chreek~~ Creek Chub |
| 15 | | | 168 | 24 | | | Creek Chub x3 |
| | | | 70 | 3 | | | Fathead Minnow x1 |

Crew Leader (init. & last name): R LEPPINGTON

Crew: RL / LJ

Recorder: RL

Field ID (init. & last name): L JEFFERSON

Cert. Level:

Lab ID (init. & last name):

Cert. Level:

Entered/Scanned:

Verified:

Corrected:

*Bulk weight all sp. except Brook Trout & Fathead

Comments

WQ → temp 17.79°C / pH - 7.91 / ORP - 16mV / cond - 0.738 mS/cm
turb 5.3 NTU / DO 6.62 mg/L / TDS - 0.472 g/L

lots of watercress along bank edges

*scale not working for small/individual but does for bulk weight p1 of 1

# Fish Sampling

**Mandatory Fields In Grey**
**Must be filled out for processing**

Stream Name: SANDROCK CREEK

Stream Code: SR2

Sample:

Run No: of

Site Code:

Science Collect. No.: 109 2969

Start Time (24hr): 12:55

Stop Time (24hr): 13:15

*second counter not working

Elapsed Min.: 20 ~ Shocker Sec.: 900

Model No.: HT2000

Anod. Voltage: 100 Frequency: 80 Pulse: —

Date (yyyy-mm-dd): 2019-07-22

Channel Morphology Available? ☐ Yes ☐ No

If no, measure the station length and 10 widths.

Length (m): 43.0

Widths (m)

| | | | |
|---|---|---|---|
| 1 | 3.6 | 6 | 4.6 |
| 2 | 3.2 | 7 | 4.7 |
| 3 | 2.9 | 8 | 4.3 |
| 4 | 4.0 | 9 | 4.6 |
| 5 | 4.4 | 10 | 3.6 |

Depths (mm)

| | |
|---|---|
| 1. | 75 |
| 2. | 230 |
| 3. | 180 |
| 4. | 300 |
| 5. | 440 |
| 6. | 510 |
| 7. | 580 |
| 8. | 600 |
| 9. | 550 |
| 10. | 90 |

Deviations (*Check all that apply*)

☐ Inexperienced Sampler ☐ Upstream Blocknet Used ☐ All Habitats not Sampled ☐ Imprecise Weigh Scale

**Individual Fish**

☒ Total Length
☐ Fork Length

B = Bulk P = Preserved O = Otolith S = Scale

| ID | Species | Length (mm) | Weight (g)* | B P / O S | Sp Name/Remarks Photo |
|---|---|---|---|---|---|
| 1 | | 40 | 1 | | Creek Chub |
| 2 | | 86 | 3 | | " " |
| 3 | | 70 | 3 | | Fathead minnow |
| 4 | | 76 | 4 | | " " x2 |
| 5 | | 88 | 5 | | White Sucker |
| 6 | | 143 | 33 | | " " |
| 7 | | 56 | 1 | | Pumpkinseed |
| 8 | | 93 | 12 | | " " |
| 9 | | 61 | 2 | | Bluntnose |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |
| 17 | | | | | |
| 18 | | | | | |
| 19 | | | | | |
| 20 | | | | | |

**Bulk Fish**

Grp #
0 = unsorted or mixed sizes/ages
1 = YOY salmonines with total length < 100mm
2 = salmonines with total length > 100mm

| Batch | Species | Grp # | Fish Total | Bulk Weight (g) | Presvd | Bag # | Sp Name/Remarks |
|---|---|---|---|---|---|---|---|
| 1 | — | — | 10 | 33 | — | — | Creek Chub |
| 2 | — | — | 7 | 48 | — | — | Fathead minnow |
| 3 | — | — | 10 | 138 | — | | White Sucker |
| 4 | | | 30 | 142 | | | Pumpkindseed |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 13 | | | | | | | |
| 14 | | | | | | | |
| 15 | | | | | | | |

Crew Leader (init. & last name): R LEPPINGTON

Crew: RL/LJ

Recorder: RL

Field ID (init. & last name): L JEFFERSON

Cert. Level:

Lab ID (init. & last name):

Cert. Level:

Entered/Scanned:

Verified:

Corrected:

Comments

WQ- pH-8.00 / ORP = -58mV / cond - 1.19 mS/cm / turb 4.4 NTU
temp: 21.71°C / DO - 5.05 mg/L / TDS - 0.758 g/L

* high conductivity for efishing had to adjust settings accordingly due to frequent overloading

*scale not working ~~fell~~ for individual fish

# Appendix K

# SWMF 6 Inspection Sheets & Photo Log

## Storm Water Management Pond Inspection Checklist

### Manchester Road in Forfar Park & Rothsay Avenue

**Facility Address:** Manchester Road & Rothsay Avenue, Kitchener, ON
**Type of Facility:** Forfar Park
**Certificate of Approval No.:** 3382-A8WQUM

**Inspection Date:** Oct 2nd/2019

**Weather:** Light rain, 16°C

**Collection of surface water sample:** Conducted ☑ Not Conducted ☐
**Sample Identification:** SW-11193719-100219-LJ-001
**No. of bottles filled:** 2 Time: 9:30
**Sample Notes:** Clear, brown tint earthy odour, no visible particulate Fast flow, turbid.

**Photos:** Multiple of SWMF/sample outfall/sampe/creek

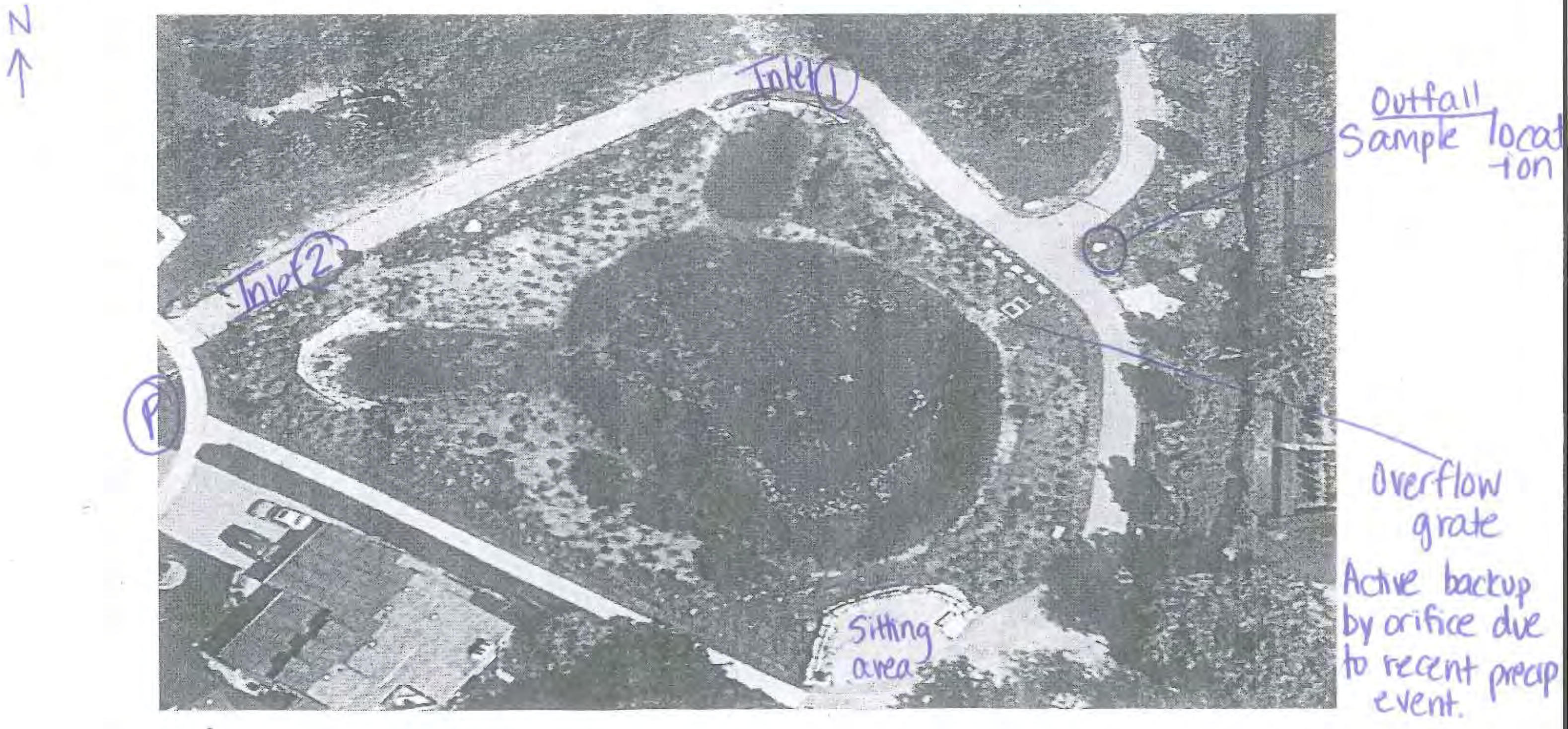
**Discrete Water Quality**

Temp: 19.59°C
pH: 7.14
Conductivity: 0.342mS/cm
Turbidity: 63.1NTU
DO: 0.11 mg/L ⊛error
TDS: 0.222g/L
ORP: 153mV

**Additional Comments:**

HOR-W19-03

Calibration: Lot #9GA501 exp: Jan 2020
pH: 4.00 turb: 0.0 NTU
Cond: 4.48mS/cm DO: 8.97mg/L



# Storm Water Management Pond Inspection Checklist

## Scoring Breakdown

**N/A** - Not Applicable
**N/I** - Not Investigated
**0** - Not a Problem/Not Present
**1** - Monitor (potential for future problem exists)
**2** - Routine Maintenance Required
**3** - Immediate Repair/Attention Necessary

| **Inlet 1** | | | | | | |
|---|---|---|---|---|---|---|
| Inflow Pipe Direction: N E [✓ S] W | | | | | | |
| Endwalls, headwalls, end sections | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Inlet pipes | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Condition of safety guardrail ✓ excellent signage | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Discharge undercutting inlet | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Discharge water causing inlet erosion | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Sediment accumulation Gravel (no silt/sed) | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Sediment depth @ inlet (2 pts): | 1. 0 mm | | | 2. 0 mm | | |
| BM to water surface (obvert to WS): | 0.600m | | WQ | Temp: 18.62°C | | cond: 0.362mS/cm |
| Water depth in box culvert ~~pipe~~: | 0.305m | | | pH: 7.52 | | turb: 37.8 |

ORP: 125mV
DO: 0.0 ①
TDS: 0.233g/L

No flow
Cleared
leaf
litter.

| **Inlet 2** | | | | | | |
|---|---|---|---|---|---|---|
| Inflow Pipe Direction: N [✓ E] S W | | | | | | |
| Endwalls, headwalls, end sections | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Inlet pipes | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Condition of safety guardrail (working) | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Discharge undercutting inlet Rocky "mini forebay" | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Discharge water causing inlet erosion to prevent | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Sediment accumulation erosion | N/A | N/I | 0 | 1 | 2 | 3 |
| Sediment depth @ inlet (2 pts): | 1. 0 mm | | | 2. 0 mm | | gravel/cobble |
| BM to water surface (obvert to WS): | 0.605m | | WQ | Temp: 18.27C | | cond: 0.434mS/cm |
| Water depth in culvert pipe: | ~~Dry~~/trickle flow | | | pH: 7.19 | | turb: 9.0NTU |

ORP: 131mV
DO: 0.0 ①
TDS: 0.290g/L

**Forebay 1 & 2**

| | | | | | | |
|---|---|---|---|---|---|---|
| Visible Sheen (hydrocarbon presence) | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Turbidity of water recent rain | N/A | N/I | 0 | [✓ 1] | 2 | 3 |
| Scum/Algae growth | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Odour | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Mosquitoes | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Aquatic bench inadequately vegetated | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Excessive wetland vegetation (e.g. cattails) | N/A | N/I | 0 | [✓ 1] | 2 | 3 |
| Abnormally high/low pool water levels | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Sediment/debris accumulation | N/A | N/I | 0 | 1 | 2 | 3 |
| Sediment depth @ forebay #1 (2pts): | 1. 40 mm | | | 2. 80 mm | | |
| Sediment depth @ forebay #2 (2pts): | 1. 300 mm | | | 2. 150 mm | | |
| Animal Burrows | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Nesting Geese | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Bank Erosion and/or loss of material | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Bathymetric study recommended | YES | | | [✓ NO] | | |
| Other: Blue Heron/ducks present | N/A | N/I | 0 | 1 | 2 | 3 |

## Scoring Breakdown

**N/A** - Not Applicable
**N/I** - Not Investigated
**0** - Not a Problem/Not Present
**1** - Monitor (potential for future problem exists)
**2** - Routine Maintenance Required
**3** - Immediate Repair/Attention Necessary

**Main Pond**

| | | | | | | |
|---|---|---|---|---|---|---|
| Visible Sheen (hydrocarbon presence) | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Turbidity of water recent rain | N/A | N/I | 0 | [✓ 1] | 2 | 3 |
| Scum/Algae growth | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Odour | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Mosquitoes | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Aquatic bench inadequately vegetated | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Excessive wetland vegetation (e.g. cattails) | N/A | N/I | 0 | [✓ 1] | 2 | 3 |
| Abnormally high/low pool water levels | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Sediment/debris accumulation | N/A | N/I | 0 | 1 | 2 | 3 |
| Sediment depth @ forebay (2pts): | 1._____mm | | 2._____mm | | | |
| Animal Burrows | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Nesting Geese | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Bank Erosion and/or loss of material | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Bathymetric study recommended | YES | | | [✓ NO] | | |
| Other: Ducks | N/A | N/I | 0 | 1 | 2 | 3 |

**Vegetation Surrounding Pond and Pond Bank Conditions**

| | | | | | | |
|---|---|---|---|---|---|---|
| Invasive plants | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| % cover 15% | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Vegetation matches landscape space | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Planting needed | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Shore erosion | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Coverage needs improvement | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Predominant vegetation types: | Forested ☐ | Shrubs ☐ | Meadow ☑ | Grass ☐ | | |

**Outlet Points/Outlet pipes**

Number of Outlet points 1

**Outlet 1**

| | | | | | | |
|---|---|---|---|---|---|---|
| Outlet Pipe Direction: [✓ NE] E S W | | | | | | |
| Condition of Outlet Structure | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Clogging of outlet structure | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Condition of safety guardrail | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Outlet Orifice (if accessible) | N/A | [✓ N/I] | 0 | 1 | 2 | 3 |

BM to WS (Downstream outfall obvert to WS): 0.265 m Active flow

WL inside culv → 0.260m
~ sediment accumulation = 0.330 - 0.260 = 0.070m

## Scoring Breakdown

**N/A** - Not Applicable
**N/I** - Not Investigated
**0** - Not a Problem/Not Present
**1** - Monitor (potential for future problem exists)
**2** - Routine Maintenance Required
**3** - Immediate Repair/Attention Necessary

**Emergency Spillway**

| | | | | | | |
|---|---|---|---|---|---|---|
| Woody growth/unauthorized plantings | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Erosion or back cutting | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Soft or boggy areas | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Obstructions/debris | N/A | N/I | [✓ 0] | 1 | 2 | 3 |

**Outfall Channel from Pond**

| | | | | | | |
|---|---|---|---|---|---|---|
| Outfall Channel Functioning | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| ~~Manholes~~, Frames, Covers Grate on culv. | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Erosion | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Released water undercutting outlet | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Displaced rip rap | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Excessive sediment deposits accumulation present | N/A | N/I | 0 | [✓ 1] | 2 | 3 |
| Excessive vegetation | N/A | N/I | 0 | [✓ 1] | 2 | 3 |
| Other: cattail growth in discharge channel | N/A | N/I | 0 | 1 | 2 | 3 |

**Special Structures**

| | | | | | | |
|---|---|---|---|---|---|---|
| Manhole access (steps, ladders, etc.) | [✓ N/A] | N/I | 0 | 1 | 2 | 3 |
| Vehicular access | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Concrete/masonry condition | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Trash racks | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Elbows | [✓ N/A] | N/I | 0 | 1 | 2 | 3 |
| Sediment/trash removal | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Excessive grass clippings (clogging potential) | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Fence/lock condition | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Safety signs ✓ | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Grafiti | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Public hazards | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Dust/debris in surrounding paved areas | N/A | N/I | [✓ 0] | 1 | 2 | 3 |
| Presence of standing water in inappropriate areas | Y | | [✓ N] | | | |

**Overall Condition of Facility (check one)**

✓ **Acceptable**
☐ **Unacceptable**

**Comments:** DO sensor malfunctioning.

**Inspection by:**

Leah Jefferson
Authorized Representative

SW Technician
Title

Oct 2/2019
Date

Photo 1 - Inlet #1 facing north.

Photo 2 - City issued health and safety signage at inlet #1.

# SWMF6 Site Inspection Photographs

Photo 3 - Natural environment signage posted near inlet #1.

Photo 4 - View of inlet #1 forebay facing north.

Photo 5 - Great Blue Heron and ducks present at inlet #1 forebay and main pond.

Photo 6 - Inlet #2 forebay looking west.

# SWMF6 Site Inspection Photographs

Photo 7 - Inlet #2 forebay looking east toward main pond.

Photo 8 - Debris cover at inlet #2 culvert.

## SWMF6 Site Inspection Photographs

Photo 9 - Debris removed from inlet #2 culvert.

Photo 10 - Rock displacement at base of inlet #2 culvert.

# SWMF6 Site Inspection Photographs

Photo 11 - View of main pond looking southeast.

Photo 12 - View of main pond looking east from inlet #2.

## SWMF6 Site Inspection Photographs

Photo 53 - Pond outfall grate structure.

Photo 14 - Orifice plate on pond outlet.

## SWMF6 Site Inspection Photographs

Photo 15 - Pond outfall toward Kolb Creek.

Photo 16 - Outfall culvert and sampling location.

## SWMF6 Site Inspection Photographs

Photo 17 - Kolb Creek upstream of outfall location.

Photo 18 - Kolb Creek downstream of outfall location.

## SWMF6 Site Inspection Photographs

# 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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