Niagara Peninsula Conservation Authority

Water Quality Monitoring Program Summary Report 2023

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Acknowledgements

The Niagara Peninsula Conservation Authority would like to thank the City of Hamilton, Ontario Ministry of Environment, Conservation and Parks, Regional Municipality of Niagara, and Haldimand County for their support of the NPCA Water Quality Monitoring Program.

Land Acknowledgement

The Niagara Peninsula watershed is situated within the traditional territory of the Haudenosaunee, Attiwonderonk (Neutral), and the Anishinaabeg, including the Mississaugas of the Credit—many of whom continue to live and work here today. This territory is covered by the Upper Canada Treaties (No. 3, 4, and 381) and is within the land protected by the Dish with One Spoon Wampum agreement. Today, the watershed is home to many First Nations, Métis, and Inuit peoples.

Through the NPCA 10-year Strategic Plan, we re-confirm our commitment to shared stewardship of natural resources and deep appreciation of Indigenous culture and history in the watershed.

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Executive Summary

The Niagara Peninsula Conservation Authority's (NPCA) Water Quality Monitoring Program was implemented in 2001 and is operated in partnership with the Ontario Ministry of Environment, Conservation and Parks (MECP), Regional Municipality of Niagara, Haldimand County, and the City of Hamilton. Through these partnerships the NPCA collects water quality samples at 84 surface water stations and 46 groundwater wells located throughout the NPCA watershed. The NPCA utilizes both chemical and biological approaches to evaluate the surface water quality. Surface water quality samples are analysed for several indicators such as chloride, nutrients, *E. coli*, suspended solids, and metals. Surface water results are used to calculate the Canada Council of Ministers of Environment Water Quality Index. This index is a Canada-wide standard for reporting water quality information. The NPCA also evaluates water quality in the watershed by sampling the benthic macroinvertebrates (BMI) at most of the NPCA surface water quality stations using the Ontario Biological Benthos Monitoring (OBBN) protocol. The abundance and diversity of animals living in the watercourse provides a biological assessment of the water quality. Groundwater samples are evaluated by comparing monitoring results to the MECP's Drinking Water Standards (ODWS).

For surface water, the monitoring results indicate many of the NPCA's watersheds have marginal to poor water quality. Total phosphorus, *E. coli*, suspended solids, and chlorides from non-point sources (agricultural/livestock runoff, faulty septic systems) and point sources (combined sewer overflow, urban stormwater) continue to be the major causes of impairment in the NPCA watershed. Watercourses under the direct influence from the Great Lakes and Niagara River such as the Lower Welland River have higher water quality ratings. Watershed tributaries that are strongly influenced by groundwater discharge like the Upper Twelve Mile Creek Effingham portion and Upper Welland River as well as the tributaries found with substantial natural landscapes like Point Abino Drain and Beaver Creek (Fort Erie) continue to have the best water quality ratings in the NPCA watershed.

The ambient groundwater geochemistry in NPCA jurisdiction was found to have some health and aesthetic ODWS exceedances. Health ODWS exceedances have been investigated by MECP and are attributed to natural conditions of the groundwater but in the case of sodium exceedances, the local Health Units are periodically notifying local physicians of elevated sodium levels in the groundwater for them to advise their patients with sodium-restricted diets. The NPCA recommends that residents using groundwater regularly test their well water and use the appropriate water treatment.

The Water Quality Monitoring Program continues to provide valuable information about the health of the NPCA watershed. Often the way the land is managed is reflected in the health of our water resources. The fact that the water quality is generally poor in the NPCA watershed has been caused by decades of environmental degradation. However, water quality improvement programs that refine how nutrients are managed, increase riparian buffers, and expand forest cover can begin to address these impacts. It will likely take many years of implementing these programs before the water quality in the NPCA watershed improves to the point where it is able to meet federal and provincial water quality guidelines and objectives. As such, it is recommended that the NPCA continue to monitor both our surface water and groundwater to ensure that there is up-to-date current water quality information available, be able to quantify trends, and continue to identify sources of contamination within the NPCA watershed.

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Acronyms

AOC	Area of Concern
BMI	Benthic Macroinvertebrates
BMPs	Best Management Practices
CCME	Canadian Council of Ministers of the Environment
CWQG	Canadian Water Quality Guidelines
ECCC	Environment and Climate Change Canada
EMRB	Environmental Monitoring and Reporting Branch
HIA	Hamilton International Airport
HBI	Hilsenhoff Biotic Index
MECP	Ministry of Environment Conservation and Parks
NPCA	Niagara Peninsula Conservation Authority
PFC	Perfluorinated Compound
PGMN	Provincial Groundwater Monitoring Network
PWQMN	Provincial Water Quality Monitoring Network
PWQO	Provincial Water Quality Objective
OBBN	Ontario Benthos Biomonitoring Network
ODWS	Ontario Drinking Water Standards
OGS	Ontario Geologic Survey
OPG	Ontario Power Generation
RMN	Regional Municipality of Niagara
WQI	Water Quality Index for CCME

Niagara Peninsula Conservation Authority: Water Quality Monitoring Program Summary Report 2023

1.0 Introduction

The Niagara Peninsula Conservation Authority (NPCA) Water Quality Monitoring Program was initiated in 2001. Prior to the program initiation in 2001, the NPCA was involved in numerous water quality related initiatives but did not have a dedicated monitoring program. The NPCA has since established an extensive network of monitoring stations located throughout the watershed with the purpose of gathering long-term water quality data for both surface water and groundwater. This network represents the largest and most comprehensive water quality monitoring program in the Niagara Peninsula. The NPCA monitoring network is operated in partnership with the Ministry of Environment, Conservation and Parks (MECP), Regional Municipality of Niagara (RMN), Haldimand County and City of Hamilton. The main objective of the NPCA Water Quality Monitoring Program is to assess water quality in local watersheds using a network of chemical and biological monitoring stations. The purpose of this Annual Report is to summarize the water quality data collected from these monitoring stations and provide recommendations for future monitoring and stewardship initiatives.

2.0 Surface Water Quality Monitoring Program

2.1 Chemical Monitoring

In 2023, the NPCA water quality monitoring team monitored 84 stations covering 52 watersheds. Grab samples are collected monthly during the ice-free months and analyzed for several parameters including nutrients, metals, bacteria, suspended solids, and general chemistry. The chemical monitoring program is mainly funded through the municipal levy, however, the NPCA does receive additional support for lab analysis from the following partners: RMN, MECP, ECCC, and the City of Hamilton. These are described in detail below.

2.1.1 Provincial Water Quality Monitoring Network

In 2003, a partnership was established with the MECP through the Provincial Water Quality Monitoring Network (PWQMN) whereby NPCA staff collect monthly water samples at stations located within the NPCA watershed and the MECP provides laboratory services. The PWQMN was established in 1964 to collect surface water quality information from rivers and streams at strategic locations throughout Ontario. Over time, stations have been added and discontinued in response to changing MECP and program-specific needs. The NPCA has 13 PWQMN stations which are located on Black Creek (Fort Erie), Welland River (West Lincoln and Welland), Twenty Mile Creek (West Lincoln and Lincoln), Forty Mile Creek (Grimsby), Four Mile Creek (Niagara-on-the-Lake), and Twelve Mile Creek (Pelham and St. Catharines).

2.2 Biological Monitoring

The NPCA also monitors surface water quality using benthic macroinvertebrates (BMI) as indicators of stream health. Water quality monitoring has historically relied heavily upon chemical testing as a means of measuring the quality of water but the advantages of biological monitoring using BMIs as indicators of water quality are well documented (Griffiths 1999, Jones *et al.* 2005). Due to their restricted mobility and habitat preferences BMIs usually remain in a localized area. As a result, they are continuously subjected to the effects of all pollutants and environmental stream conditions over time, and as such can provide a broad overview of water quality related problems. They are abundant in all types of aquatic systems and can be easily collected and identified. The NPCA has been using BMI as indicators of water quality since 1995 and is a leader in the field of biological monitoring in the Niagara Peninsula. BMI samples are collected annually during the spring and fall seasons using the Ontario Benthos Biomonitoring Network (OBBN) protocol (Jones *et al*. 2005). The OBBN provides a standardized benthic invertebrate sampling protocol for the province of Ontario and provides a biological complement to the chemistry based PWQMN. The NPCA uses the Hilsenhoff Biotic Index, HBI (Hilsenhoff 1987 & 1988), to summarize biological monitoring data in this report.

3.0 Surface Water Quality Indicator Parameters

For this summary report, the NPCA uses 8 indicator parameters and one BMI community parameter. These parameters, and their water quality objectives, are summarized in **Table 1** below.

Table 1: Summary of surface water quality indicator parameters.

Indicator Parameter	Parameter objective / Goal	Reference
Chloride	120 mg/L (Chronic)	CWQG (CCME 2011)
Nitrate	2.93 mg/L	CWQG (CCME 2003)
Total Phosphorus	30 µg/L	PWQO (MOE 1994)
Total Suspended Solids	35 mg/L	CWQG (CCME 2002)
Copper	5 µg/L	PWQO (MOE 1994)
Lead	5 µg/L	PWQO (MOE 1994)
Zinc	20 µg/L	PWQO (MOE 1994)
Escherichia coli	100 count/100mL	PWQO (MOE 1994)
Benthic Macroinvertebrates	Fair water quality rating or higher	HBI (Hilsenhoff 1988)

3.1 Indicator Parameters Explained

3.1.1 Chloride

Chloride is a naturally occurring substance found in all waters. Chloride can be toxic to aquatic organisms with acute toxic effects at high concentrations and chronic effects on growth and reproduction at lower concentrations. Chloride is not susceptible to degradation in the aquatic environment and tends to remain in solution. Chloride is extensively used in the form of sodium chloride and calcium chloride for salting of roadways and ice removal during the winter season. Other anthropogenic or human-derived sources of chloride include sewage, animal waste, storm and irrigation drainage, fertilizers, and industrial effluent. The Canadian Water Quality Guidelines (CWQG) for the Protection of Aquatic Life recommend that long-term or chronic chloride concentrations should not exceed 120mg/L in surface water (CCME 2011).

3.1.2 Nitrate

Nitrate is the most common form of nitrogen that occurs in surface water. In aerobic or oxygen-rich water, bacteria convert ammonium and nitrite to nitrate through a process known as nitrification. In anaerobic or oxygen-depleted water, the process is reversed through denitrification. The nitrate ion is the most stable form of nitrogen in water and does not tend to combine with other ions in solution. Nitrate can be toxic to aquatic organisms and elevated concentrations contribute to excessive plant and algae growth in surface water. Anthropogenic sources of nitrate include sewage discharges, animal waste, fertilizers, and pesticides. The CWQG for the Protection of Aquatic Life recommend that nitrate-nitrogen concentrations should not exceed 2.93 mg/L in surface water (CCME 2003).

3.1.3 Total Phosphorus

Phosphorus is a natural element found in rocks, soils and organic material and is an essential nutrient for plant growth. Phosphorus clings tightly to soil particles and is often associated with suspended sediment. Excessive phosphorus concentrations stimulate the overgrowth and decomposition of plants and algae. The decomposition of organic matter in turn depletes dissolved oxygen concentrations and stresses aquatic organisms such as fish and benthic invertebrates. Total phosphorus is a measure of all forms of phosphorus in a water sample and includes biologically accessible phosphates. Anthropogenic sources of phosphorus include fertilizers, pesticides, and sewage discharges. The interim Ontario Provincial Water Quality Objective (PWQO) for total phosphorus in streams and rivers is 30 µg/L (MOE 1994).

3.1.4 Total Suspended Solids

Total suspended solids (TSS) are a measure of undissolved solid material in surface water and usually consist of silt, clay, plankton, and fine particles of organic and inorganic matter. Sources of suspended solids include soil erosion, stormwater, wastewater, and industrial effluent. Fine particles are significant carriers of phosphorus, metals and other contaminants. Concentrations of suspended solids vary seasonally and often peak during rain events. Due to natural variability in surface water, there is currently no water quality guideline for suspended solids in Ontario. High concentrations of suspended solids in surface water can negatively impact aquatic organisms. The Canadian Water Quality Guidelines provides a narrative guideline for TSS: the maximum increase of TSS should be no more than 25 mg/L from background concentrations (with NPCA using a background TSS concentration of 10 mg/L determined using data from the NPCA jurisdiction; CCME 2002). Therefore, a concentration of 35 mg/L was used as the NPCA's guideline.

3.1.5 Copper

Copper is an essential trace element that is toxic to aquatic organisms at elevated concentrations. In surface water copper tends to bind with organic matter and accumulate in streambed sediment. Natural sources are wind-blown dust, decaying vegetation and from forest fires. Anthropogenic sources of copper include industrial wastewater, sewage discharges and pesticides. The interim PWQO for copper is 5 µg/L based on >20 mg/L Hardness as $CaCO_3$ (MOE 1994).

3.1.6 Lead

Lead is a non-essential trace element that is toxic to aquatic organisms at elevated concentrations. Lead tends to bioaccumulate and can affect the central nervous system. Lead occurs naturally in the environment. However, most lead concentrations that are found in the environment are a result of human activities. Anthropogenic sources of lead include industrial wastewater, sewage discharges, municipal waste incineration, fertilizers, and pesticides. The interim PWQO for lead is 5 µg/L based on >80 mg/L Hardness as $CaCO_3$ (MOE 1994).

3.1.7 Zinc

Zinc is an essential trace element that is toxic to aquatic organisms at elevated concentrations. In surface water zinc tends to bind with organic matter and accumulate in streambed sediment. Zinc occurs naturally in air, water, and soil. Anthropogenic sources of zinc include industrial wastewater, sewage discharges and stormwater runoff. The interim PWQO for zinc is 20 µg/L (MOE 1994).

3.1.8 Escherichia coli

Escherichia coli (*E. coli*) is a type of fecal coliform bacteria that is commonly found in the intestines of warm-blooded animals and humans. *E. coli* is used as an indicator for the presence of sewage or animal waste in surface water, and the possible presence of pathogens (Tchobanoglous & Schroeder 1987). The PWQO for *E. coli* is 100 counts per 100 mL (MOE 1994).

3.2 Biological Assessment: Benthic Macroinvertebrates

Benthic macroinvertebrates are the larger organisms inhabiting the substrate of watercourses for at least part of their life cycle. As a rule, BMI includes those species whose body width exceeds 500 microns. Examples of benthic invertebrate species that are commonly found in the NPCA watershed include clams, snails, leeches, worms, and the larval stages of dragonflies, stoneflies, caddisflies, mayflies, and beetles.

The NPCA collects benthic samples during the spring and summer each year at approximately 20 monitoring sites, with sites visited once every 3-5 years. Once collected, counted, and preserved, the BMIs are identified to family level and various statistics were calculated. For this 2023 Report the Hilsenhoff Biotic Index (HBI) was calculated for each sample site. The HBI estimates the overall tolerance of the community in a sampled area, weighted by the relative abundance of each family taxonomic group. Organisms are assigned a modified Hilsenhoff tolerance value based on New York State Department of Environmental Conservation (Smith *et al*. 2009). Water quality is classified as gradient from excellent to very poor in to recognize the occurrence of organisms whose environmental requirements and tolerances match those which would be expected at the site without the input of environmental stresses to those with the organisms found are less sensitive. Therefore, more tolerant to environmental stresses than organisms which would have historically occurred. The benthic population at an impaired site would typically be dominated by these more tolerant species, and as a result biodiversity at the site would be quite low.

Table 2: Hilsenhoff Family Biotic Index water quality classifications (Hilsenhoff 1988).

Family Biotic Index	Water Quality Rating
0.00-3.75	Excellent
3.76-4.25	Very Good
4.26-5.00	Good
5.01-5.75	Fair
5.76-6.50	Fairly Poor
6.51-7.25	Poor
7.26-10.00	Very Poor

4.0 Surface Water Quality Monitoring Results

The Canadian Council of Ministers of the Environment (CCME) Water Quality Index (WQI) was used to summarize the indicator parameter data collected from NPCA surface water quality monitoring stations between 2019 and 2023. This approach reduces the overall sample size of water quality monitoring stations, but it allows for the partitioning of the water quality dataset to determine if CCME WQI ratings are changing over time. This approach is consistent with Conservation Ontario's recommendation for comparing water quality data in watershed reporting (Conservation Ontario 2011). Using the five-year blocks of data minimizes seasonal variation and provides sufficient data (n=40 to 50) for reliable statistics in surface water analysis.

The WQI was developed by a sub-committee established under the Canadian Council for Ministers of the Environment (CCME) Water Quality Guidelines Task Group to provide a convenient means of summarizing complex water quality information and communicating it to the public (CCME 2001). The WQI incorporates the number of parameters where water quality objectives have been exceeded, the frequency of exceedances within each parameter, and the amplitude of each exceedance. The index produces a number between 0 and 100 which represents the worst and best water quality, respectively. These numbers are divided into five descriptive categories that range from *poor* to *excellent* (**Table 2**). The CCME WQI has been used extensively by other agencies, including conservation authorities and provincial ministries, as a means of reporting water quality data.

Table 3: CCME Water Quality Index categories (CCME 2001).

Category	Water Quality Index	Description
Excellent	95-100	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
Good	80-94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	65-79	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45-64	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

The calculation of the WQI is dependent on the water quality parameters and objectives selected for analysis. The indicator parameters and objectives summarized in **Table 1** were used to determine the WQI for NPCA monitoring stations. BMI data is not included in the WQI and is presented separately. It is important to note that the water quality information presented in this report is limited by the size of the dataset which represents 1 to 5 years of data, depending on the station. The reliability of the WQI rating improves over time (> 3 years) as more data is collected and a wider range of water quality conditions are captured in the dataset. In addition, water quality indicator parameters were summarized using boxplots which allow for comparison of the data distributions and basic statistical attributes such as median, percentiles, overall range, and outliers (**Figure 1**).

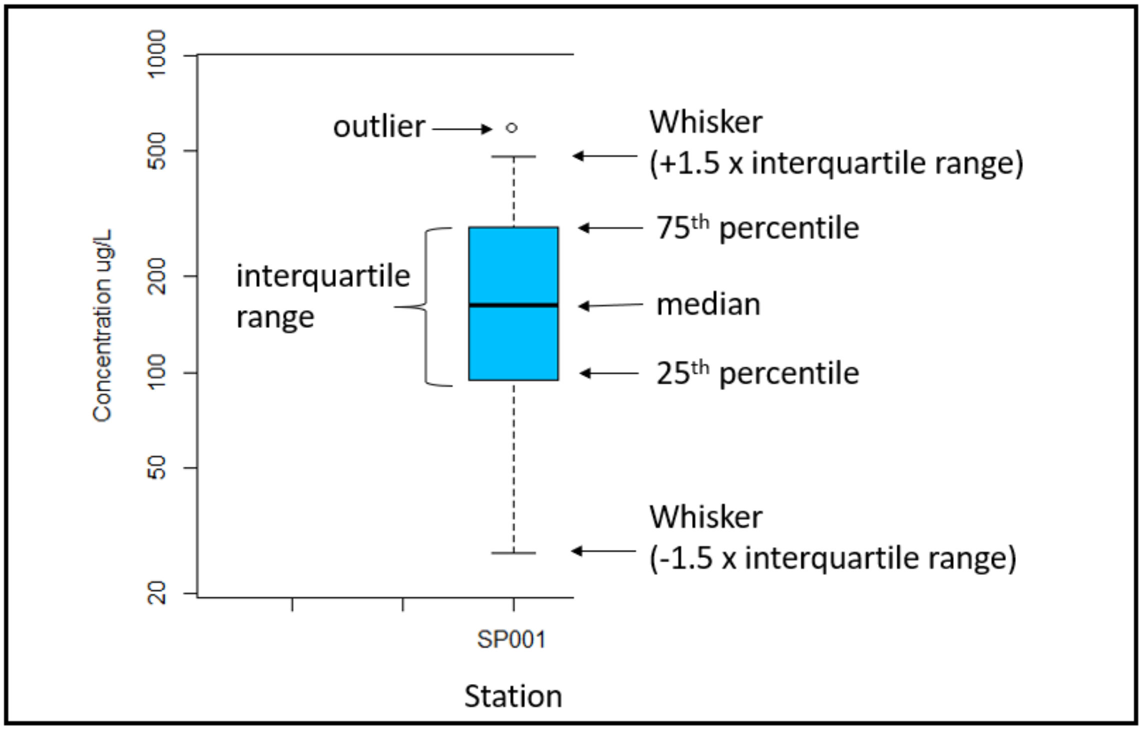

Figure 1: Description of a boxplot.

4.1 Trend Analysis

The NPCA surface water quality database has reached a sufficient size for trend analysis to be conducted. Trend analyses are very useful for determining if water quality parameter concentrations are increasing, decreasing, or remaining unchanged over time. If the concentration of a water quality parameter is found to be increasing or remaining in an impaired status, then appropriate corrective action can be taken. Trend analysis is also useful for evaluating the performance of stewardship or remediation efforts.

The data on many water quality parameters for the NPCA are not normally distributed and it is not appropriate to use parametric statistical methods to test for trends. Non-parametric statistical methods can deal effectively with non-normally distributed data and are flexible enough to account for seasonal variability. The Seasonal Mann-Kendall Test is often used to determine trends in water quality data (Helsel and Hirsch 1992). The Seasonal Mann-Kendall Test modified from the Mann-Kendall Test (Helsel and Hirsch 1992), compares relative ranks of data values from the same season. This means the water quality parameter concentrations of May would be compared with concentrations of May in other years. Similarly, June concentrations would be compared with June concentrations and so forth. The null hypothesis (H_0) is that the concentration of a water quality parameter is independent of time, or, in other words, the datasets show no distinct trend. The alternative hypothesis (H_A) means that a significant increasing or decreasing trend is found over time. The Seasonal Mann-Kendall uses alpha (α) to quantify the probability that a trend exists. For this report, the alpha level for statistical significance was set at $\alpha = 0.05$. This alpha level is commonly used in statistical methods to test for statistical significance. It should be noted that a value of $\alpha = 0.05$ means there is a 5 percent possibility of falsely rejecting the null hypothesis that no trend exists. Probability values of less than 0.05 mean there was statistically significant trend (increasing or decreasing). Trend analysis using the Seasonal Mann-Kendall Test was conducted on chloride, *E. coli*, total phosphorus and total suspended solids concentrations at all stations with 5 or more years of data using software provided by the U.S. Geological Survey (Helsel *et al.*, 2005). Trend analysis for copper, lead, nitrate, and zinc parameters could only be conducted on a small number of stations because many concentrations found were below the laboratory detections limits. These were reported as “non-detect” or a “less than” the laboratory detection limit. Trend analysis with many non-detections or less than values was not favourable for analysis and therefore was excluded from most stations.

4.2 Welland River Watershed

The Welland River is the largest watershed in the NPCA jurisdiction with a total drainage area of 1,023 km^2. The watershed covers eleven local municipalities, originating in the Town of Ancaster and spanning the center of the Niagara Peninsula to its physical outlet in the City of Niagara Falls at the Niagara River (**Figure 2**). Over 70% of the watershed is classified as rural. The Welland River is part of the Niagara River Area of Concern (AOC). As shown in **Appendix A**, 30 of the 84 surface water quality monitoring stations are in the Welland River watershed, and 14 of these 30 stations are located on the main Welland River channel.

4.2.1 Welland River: Canadian Water Quality Index

The calculated WQI for the Welland River ranges from *poor* to *fair*. Based on the 2019 to 2023 data collected, six of fourteen Welland River stations have *poor* water quality, six stations were rated as *marginal*, and two stations were rated as fair. WQI results are illustrated in **Appendix A**. Mapping showing the spatial distribution and boxplots of the eight indicator parameters from 2019 to 2023 are found in **Appendix B and C**. In 2022, a new site was added (WR003A) on Harrison Road, however, there is insufficient data to include it in this report. Highlights of the water quality monitoring in the Welland River are summarized in **Table 4**.

Figure 2: Welland River watershed.

Table 4: Summary of NPCA water quality data for the Welland River (2019-2023).

Site	WQI Rating ↔ Stable ↓ Declining ↑ Improving	Hilsenhoff Family Biotic Index Rating	Factors Affecting Water Quality (% percentage reported if >50)	Indicator Parameter Trends (2019-2023)
WR00A	Marginal ↔	Fairly Poor	• Exceedances in copper, E. coli, lead, total phosphorus (95%), total suspended solids, and zinc • Potential stressors include agricultural and roadway run-off • Groundwater discharge sustains baseflow	• Decreasing total phosphorus and total suspended solids • Stable E. coli • Increasing chloride
WR000	Good ↑	Very Poor	• Exceedances in E. coli and total phosphorus (67%) • Potential stressors include agricultural and roadway run-off • Groundwater discharge provides intermittent baseflow but the watercourse will dry up in the summer when groundwater levels drop	• Decreasing phosphorus and E.coli concentrations • Stable total suspended solids and chloride
WR001	Marginal ↔	Poor	• Exceedances in chloride, copper, E. coli (58%), total phosphorus (77%), total suspended solids, and zinc • Potential stressors include agricultural, airport and roadway run-off	• Indicator parameters remain stable
WR002	Poor ↔	Fairly Poor	• Exceedances of chloride (93%), copper (55%), E. coli, lead, total phosphorus, total suspended solids, and zinc (90%) • Potential stressors include agricultural, airport and roadway run-off	• Indicator parameters remain stable
WR020	Marginal ↔	Insufficient Data	• Exceedances in chloride (73%), copper, E. coli, total phosphorus (95%), and total suspended solids • Potential stressors include agricultural and roadway run-off	• Indicator parameters remain stable

WR003	Marginal ↑	Poor	• Exceedances of chloride (56%), coper, E. coli, nitrate, total phosphorus (97%), total suspended solids and zinc • Potential stressors include: agricultural and roadway run-off	• Decreasing total suspended solid • Stable E. coli and total phosphorus • Increasing chloride
WR004	Fair ↔	Very Poor	• Exceedances of E. coli, total phosphorus (81%) and total suspended solids • Potential stressors include agricultural and roadway run-off • Lake Niapenco is improving the water quality the Welland River at this site	• Decreasing E.coli, total phosphorus and total suspended solids • Stable chloride
WR003A	Insufficient Data	Fairly Poor	• Potential stressors include agricultural and roadway run-off. Development occurring upstream	• Insufficient data
WR005	Poor ↔	Fairly Poor	• Exceedances of chloride, copper, E. coli (57%), nitrate, total phosphorus (100%), suspended solids (54%) and zinc. • Potential stressors include agricultural and roadway run-off	• Indicator parameters remain stable
WR006	Marginal ↔	Poor	• Exceedances of copper, E. coli, nitrate, total phosphorus (100%), suspended solids and zinc • Potential stressors include agricultural and roadway run-off • Algae and duckweed observed during summer months	• Indicator parameters remain stable
WR007	Poor ↔	Very Poor	• Exceedances of copper, E. coli, nitrate, total phosphorus (100%), total suspended solids and zinc • Potential stressors include agricultural, roadway run-off • Algae and duckweed observed during summer months • Non-native Zebra Mussels present	• Stable chloride and total phosphorus • Increasing E. coli and total suspended solids

WR009B	Marginal ↔	Insufficient Data	• Exceedances of copper, E. coli (51%), total phosphorus (95%), total suspended solid and zinc • Potential stressors include sewage treatment plant effluent and agricultural and urban run-off • Site strongly influenced by Niagara River backwater which has the potential to improve water quality	• Decreasing chloride • Stable E. coli, total phosphorus and total suspended solid
WR010	Marginal ↔	Insufficient Data	• Exceedances of copper, E. coli, total phosphorus (93%), total suspended solids and zinc • Potential stressors include sewage treatment plant effluent and agricultural and urban run-off • Site strongly influenced by Niagara River backwater which has the potential to improve water quality	• Indicator parameters remain stable
WR011	Fair ↑	Insufficient Data	• Exceedances of copper, E. coli, total phosphorus (79%) and total suspended solids • Potential stressors include sewage treatment plant effluent and agricultural and urban run-off • Site strongly influenced by Niagara River backwater which has the potential to improve water quality	• Decreasing E. coli • Stable total phosphorus and total suspended solids • Increasing chloride concentrations
WR012	Fair ↔	Insufficient Data	• Exceedances of E. coli, total phosphorus and total suspended solids • Potential stressors include urban run-off • Site strongly influenced by Niagara River backwater which has the potential to improve water quality	• Indicator parameters remain stable

4.2.2 Welland River: Hilsenhoff Biotic Index Results

Hilsenhoff Biotic Index (HBI) results indicate that water quality at most stations in the Welland River ranged from *Very Poor* to *Fairly Poor* (**Table 4**). Results from Hilsenhoff Biotic Index assessments completed between 2019 and 2023 are illustrated in **Appendix B**.

Low HBI scores observed in the Welland River mainly are due to road salts and metals in stormwater, sediment loading, lack of in-stream habitat, and nutrient enrichment. A biological assessment was not completed for WR009B, WR010, WR011 and WR012 due to high water depth and channel morphology. These stations are located at the siphon where the Welland River flows beneath the Welland Canal and would require boat access for sample collection.

4.2.3 Welland River: Key Findings

Based on the 2019-2023 data, elevated concentrations of total phosphorus are a widespread cause of water quality impairment in the Welland River. Greater than 95% of samples collected in the main Welland River exceeded the PWQO with some concentrations greater than 20 times the PWQO. High phosphorus in the Welland River has stimulated the overgrowth of algae and duckweed throughout the watershed. When these plants transpire, and decompose they deplete dissolved oxygen in the water and this in turn stresses aquatic organisms such as fish and benthic invertebrates. Manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides are sources of total phosphorus in the Welland River.

Figure 3: Excessive algae growth in the Central Welland River

Generally, the overall water quality of the Welland River downstream of the City of Welland is less stressed than the water upstream of the City of Welland. This is caused by the redirection of the Niagara River water down the Welland River in Chippawa for Ontario Power Generation (OPG). This results in a dilution effect that reduces the concentrations of water quality parameters. This effect is observed to the east side of the City of Welland. However, upstream of the City of Welland, the river flow pattern caused by OPG operations and canal siphons are likely restricting the natural flushing of sediment, nutrients and other contaminates from the central Welland River watershed and exacerbating water quality conditions in this watershed.

Water quality stations in the vicinity of Hamilton Airport (HIA) continue to have water quality designated as *poor* due to elevated concentrations of chloride and zinc. Chloride concentrations are stable at WR001 but increasing at WR002 despite the recent removal of the road salt storage pad. Zinc concentrations found at these stations consistently exceed the PWQO and are the highest observed in the NPCA water quality network. The current information that the HIA has suggests that zinc is coming off the brake system of the airplanes. It should be noted that zinc concentrations have been decreasing at both stations. The NPCA also has not observed any propylene glycol discharge in WR001 or WR002 this year. In 2011, the HIA expanded its facilities and upgraded its water quality safeguards to WR001 and WR002. Continued monitoring by the NPCA will track water quality changes at these tributaries. The NPCA does not monitor the water quality of the Hamilton Airport tributary identified as the potential source of Per- and polyfluoroalkyl substances (PFAS) that has been found in turtle/fish tissue sampled at Binbrook Conservation Area. PFAS are a man-made compound belonging to a large family of compounds known as perfluorinated chemicals. These compounds do not readily breakdown and have the potential to bioaccumulate in animal tissue. MECP continues to provide fish consumption guidelines based on fish samples they have collected for this area and information is found on (https://www.ontario.ca/page/guide-eating-ontario-fish). The NPCA continues to notify Binbrook Conservation Area Park users about the new fish consumption guidelines and information regarding PFAS has been posted on the NPCA website: https://npca.ca/parks-recreation/conservation-areas/binbrook. Since 2015, Transport Canada and Procurement Canada have retained Arcadis Canada Inc. to conduct a risk assessment to investigate presence and distribution of PFAS in the Welland River downstream of the HIA. Through this assessment process Arcadis has released project updates to property owners and other groups with an interest in the risk assessment area. The final report is still pending. The NPCA Watershed Monitoring and Reporting division has added PFAS sampling in 2012 as part of special project monitoring program at Binbrook Reservoir and this information can be found in Section 6.5.

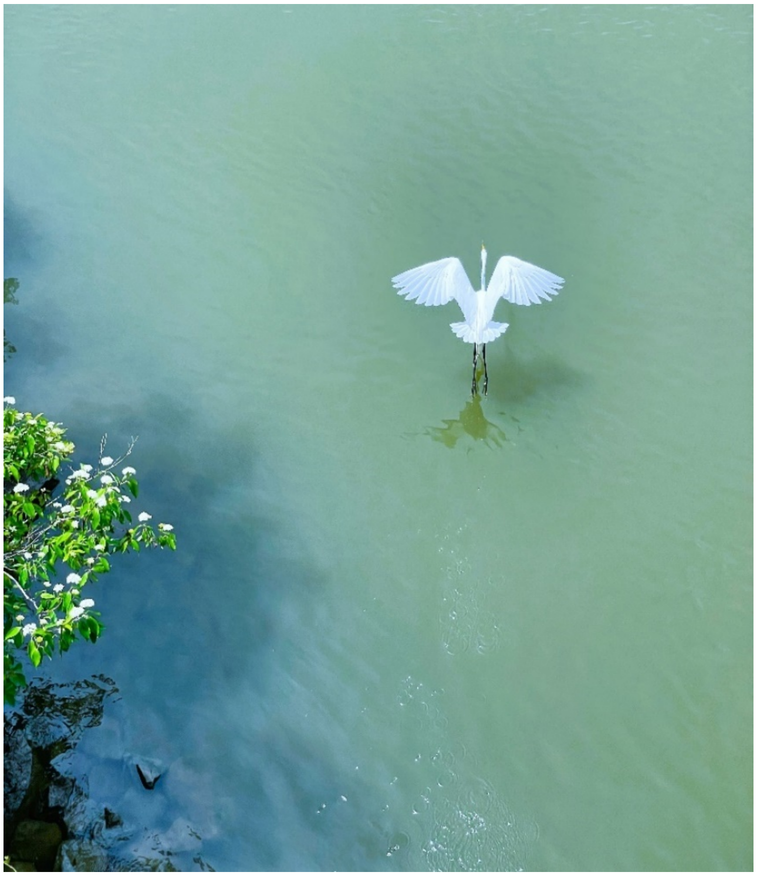

Figure 4: An egret takes flight in the Welland River.

4.3 Welland River Tributaries

Fifteen tributaries of the Welland River are monitored through the NPCA Water Quality Monitoring Program. These tributaries include Buckhorn Creek, Elsie Creek, Mill Creek, Oswego Creek, Beaver Creek, Big Forks Creek, Coyle Creek, Drapers Creek, Feeder Canal, Mill Race Creek, Grassy Brook, Tee Creek, Thompson Creek, Power Canal, and Lyons Creek (**Figure 2**). Tributaries were selected based on drainage area, land use, restoration projects, and watershed plans.

4.3.1 Welland River Tributaries: Water Quality Index

Based on the results of the WQI twelve of sixteen Welland River tributary stations have water quality that is rated as *poor* and four are rated as marginal (**Table 5**). WQI results are illustrated in **Appendix A.** Mapping showing the spatial distribution and boxplots of the eight indicator parameters from 2019-2023 are found in **Appendix B** and **Appendix D.**

Table 5: Summary of NPCA water quality data for Welland River Tributaries (2019-2023).

Site	WQI Rating ↔ Stable ↓ Declining ↑ Improving	Hilsenhoff Family Biotic Index Rating	Factors Affecting Water Quality (% percentage reported if >50)	Indicator Parameter Trends (2019-2023)
BF001 **Big Forks Creek**	Poor ↔	Very Poor	• Exceedances in chloride, copper, E. coli, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Significant algae and duckweed growth in summer • Prone to zero baseflow during summer	• Increase in total phosphorus • E. coli, total suspended solids, and chloride remain stable
BU001 **Buckhorn Creek**	Poor ↔	Fairly Poor	• Exceedances in chloride (51%), copper, E. coli (64%), lead, nitrate, total phosphorus (95%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Prone to zero baseflow in summer	• Indicator parameters remain stable
BV001 **Beaver Creek**	Poor ↔	Poor	• Exceedances in copper, E. coli, lead, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Significant algae growth in summer	• Indicator parameters remain stable
CO001 **Coyle Creek**	Marginal ↑	Fairly Poor	• Exceedances in chloride, copper, E. coli, nitrate, total phosphorus (97%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Invasive zebra mussels present	• Decrease in total suspended solids • Increase in chloride • Total phosphorus and E. coli remain stable
DR001 **Drapers Creek**	Marginal ↑	Fairly Poor	• Exceedances in chloride, copper, E. coli (92%), total phosphorus (100%), and zinc • Potential stressors include agricultural and road run-off • Significant algae in summer months	• Increase in E. coli and chloride • Total phosphorus and total suspended solids remain stable

EL001 **Elsie Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli, lead, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Prone to zero baseflow in summer	• Indicator parameters remain stable
GR001 **Grassy Brook**	Poor ↔	Fairly Poor	• Exceedances in chloride, copper, E. coli (53%), lead, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Significant algae growth and zero baseflow in summer	• Decrease in total suspended solids • Total phosphorus, E. coli, and chloride remain stable
TE001 **Tee Creek**	Poor ↔	Very Poor	• Exceedances in chloride, copper, E. coli (54%), nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Prone to algae and zero baseflow in summer	• Indicator parameters remain stable
LY003 **Lyons Creek**	Marginal ↔	Poor	• Exceedances in copper, E. coli, lead, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Site is influenced by back flow from the Niagara River	• Decrease in chloride and total phosphorus • E. coli and total suspended solids remain stable
MI001 **Mill Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli, lead, nitrate, total phosphorus (97%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Significant algae and duckweed growth in summer	• Decrease in total phosphorus and total suspended solids • Increase in chloride • E. coli remains stable
OS001 **Oswego Creek**	Poor ↔	Poor	• Exceedances in copper, E. coli (58%), nitrate, total phosphorus (100%), total suspended solids (62%), and zinc • Potential stressors include agricultural and road run-off • Significant algae and duckweed growth during summer	• Increase in total phosphorus • E. coli, total suspended solids, and chloride remains stable

OS002 **Oswego Creek**	Poor ↔	Poor	• Exceedances in chloride, copper (51%), E. coli (66%), lead, nitrate, total phosphorus (100%), total suspended solids (62%), and zinc • Potential stressors include agricultural and road run-off • Significant algae and duckweed growth in summer	• Increase in chloride • Total phosphorus, E. coli, and total suspended solids remain stable
TC001 **Thompson Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli (65%), lead, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off	• Increase in chloride • Total phosphorus, E. coli, and total suspended solids remain stable
PR001 **Power Canal**	Marginal ↔	Insufficient Data	• Exceedances in E. Coli, total phosphorus, total suspended solids, and zinc • Potential stressors include urban run-off and Niagara Falls wastewater treatment plant • Water source is from Niagara River potentially improving water quality at this site	• Decrease in E. coli • Total phosphorus, total suspended solids, and chloride remain stable
MR001 **Mill Race Creek**	Poor ↔	Insufficient Data	• Exceedances in copper, E. coli (66%), lead, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off	• Indicator parameters remains stable
FC001 **Feeder Canal**	Poor ↔	Insufficient Data	• Exceedances in chloride, copper, E. coli, lead, total phosphorus (88%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off	• Decrease in E. coli and chloride • Total phosphorus and total suspended solids remain stable

4.3.2 Welland River Tributaries: Hilsenhoff Biotic Index Results

HBI results indicate that water quality is ranged from *very poor* to *fairly poor* at all Welland River tributary stations currently monitored (**Table 5**). Results from biological assessments completed between 2019-2023 are illustrated in **Appendix B**. Sediment loading, lack of in-stream habitat, and nutrient enrichment are the primary causes of impairment at all stations.

4.3.3 Welland River Tributaries: Key Findings

Based on the 2019-2023 data, elevated concentrations of total phosphorus are a widespread cause of water quality impairment in the Welland River tributaries. Approximately 95% of samples collected from the Welland River tributaries exceeded the PWQO with some concentrations greater than 30 times the PWQO. Concentrations of total phosphorus are very high in Beaver Creek, Big Forks Creek, Oswego Creek, and Tee Creek. It is recommended that these subwatersheds be prioritized by Best Management Practice programs such as those provided by the NPCA to reduce phosphorus loads. Sources of phosphorus include manure from livestock operations, sewage discharges, soil erosion, fertilizers, and pesticides.

E. coli concentrations frequently exceed the PWQO in Buckhorn Creek, Big Forks Creek, Beaver Creek, Coyle Creek, Drapers Creek, Elsie Creek, Mill Creek, and Oswego Creek.

Decreasing total phosphorus concentrations in Mill Creek are now being observed with the NPCA's long-term data. Mill Creek watersheds have been targeted by the NPCA's restoration program over the last twenty years to reduced non-point pollution such as nutrients and sediment. This data provides some evidence that this program is reducing nutrient runoff. 2019-2023 data also shows decreased in TP in the headwaters of the Welland River.

4.4 Twenty Mile Creek Watershed

The Twenty Mile Creek watershed is the second largest watershed in the NPCA jurisdiction with a total drainage area of 302 km^2. Ten of 84 NPCA surface water quality monitoring stations are located within the Twenty Mile Creek watershed. There are six stations on the main channel. There are also monitoring stations for each of the subwatersheds which include Sinkhole Creek, Spring Creek, North Creek and Gavora Ditch (**Figure 5**).

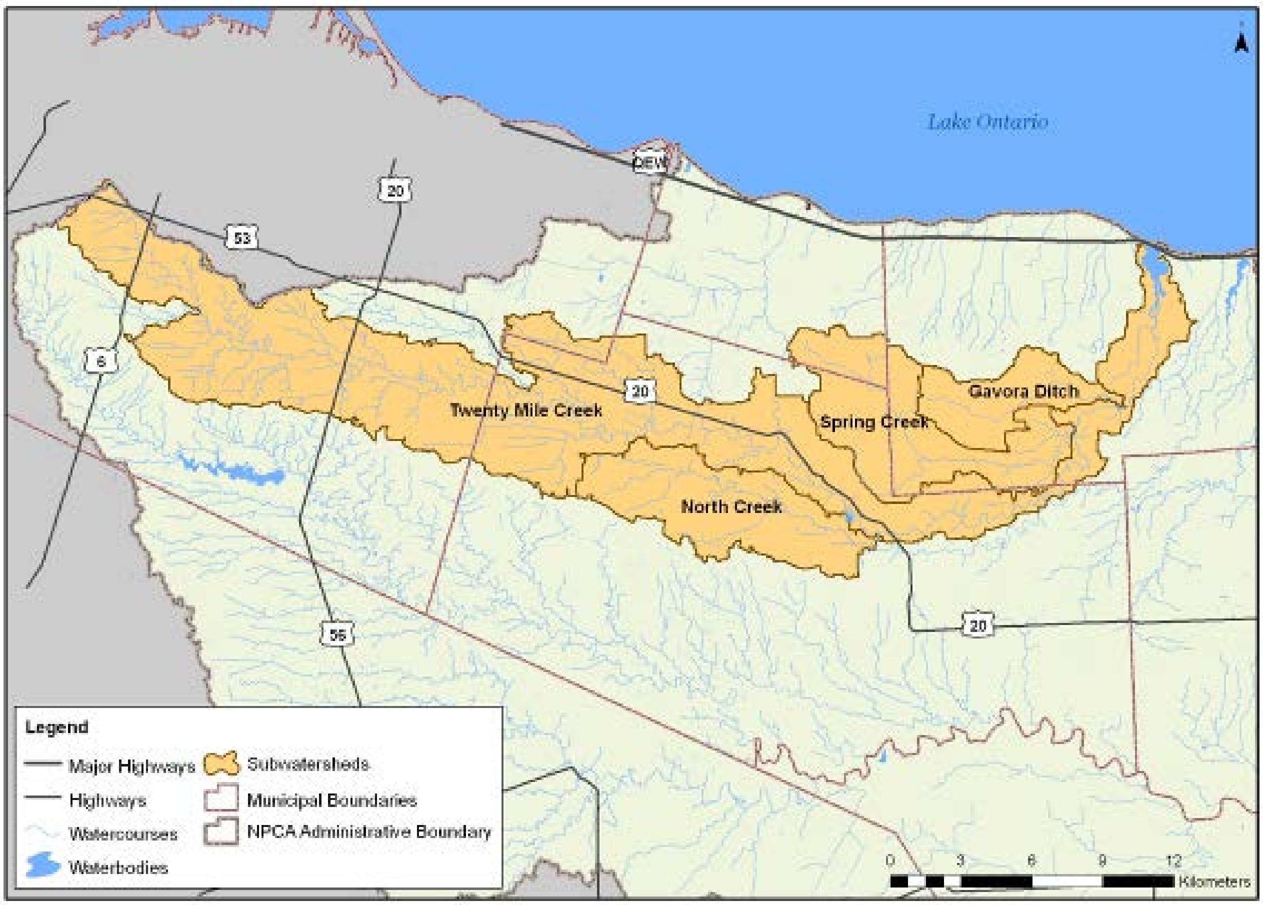

Figure 5: Map of Twenty Mile Creek watershed

4.4.1 Twenty Mile Creek Watershed: Canadian Water Quality Index

Based on the results of the WQI five of nine Twenty Mile Creek watershed stations have water quality that is rated as *marginal*. WQI results are illustrated in **Appendix A**. Mapping showing the spatial distribution and boxplots of the eight indicator parameters from 2019 to 2023 are found in **Appendix B** and **Appendix E**. Sinkhole Creek was added in 2022 and therefore has insufficient data for this report. Highlights of the water quality monitoring in the Twenty Mile Creek are summarized in **Table 6.**

Table 6: Summary of NPCA water quality data for Twenty Mile Creek watershed (2019-2023).

Site	WQI Rating ↔ Stable ↓ Declining ↑ Improving	Hilsenhoff Family Biotic Index Rating	Factors Affecting Water Quality (% percentage reported if >50)	Indicator Parameter Trends (2019-2023)
TN001	Marginal ↑	Poor	• Exceedances in chloride, copper, E. coli (54%), lead, total phosphorus (92%), total suspended solids, and zinc • Potential stressors include agricultural and urban run-off • Invasive Chinese Mystery Snails present • Excessive algae growth in summer	• Decrease in total phosphorus • E. coli, total suspended solids, and chloride remain stable
TN002	Fair ↑	Good	• Exceedances in chloride, copper, E. coli, total phosphorus (90%), and total suspended solids • Potential stressors include agricultural and urban run-off • Prone to zero baseflow in summer	• Decrease in total phosphorus • E. coli, total suspended solids, and chloride remain stable
TN003	Marginal ↔	Fairly Poor	• Exceedances in chloride, copper, E. coli, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and urban run-off • Significant algae growth during summer	• Decrease in total suspended solids • Total phosphorus, E. coli, and chloride remain stable
TN003A	Marginal ↑	Fairly Poor	• Exceedances in chloride, copper, E. coli (50%), nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and urban run-off • Significant algae growth during summer	• Indicator parameters remain stable
TN004	Poor ↔	Fairly Poor	• Exceedances in chloride, copper, E. coli (68%), nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and urban run-off • Significant algae growth during summer	• Increase in chloride • Total phosphorus, E. coli, and total suspended solids remain stable

TN006	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Significant algae growth in summer	• Indicator parameters remain stable
NC001 **North Creek**	Poor ↔	Fairly Poor	• Exceedances in chloride, copper, E. coli (74%), nitrate, total phosphorus (97%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off • Prone to excessive algae growth and zero baseflow in summer	• Decrease in total suspended solids • Increase in chloride • Total phosphorus and E. coli remain stable
SP001 **Spring Creek**	Marginal ↔	Fairly Poor	• Exceedances in chloride, copper, E. coli (65%), lead, total phosphorus (100%), and zinc • Potential stressors include agricultural and road run-off • Prone to excessive algae growth and zero baseflow in summer	• Decrease in total suspended solids • Increase in chloride • Total phosphorus and E. coli remain stable
GV001 **Gavora Ditch**	Marginal ↔	Fairly Poor	• Exceedances in copper, E. coli (54%), and total phosphorus (100%) • Potential stressors include agricultural and road run-off • Prone to zero baseflow during summer	• Decrease in total suspended solids • Total phosphorus, E. coli, and chloride remain stable
SK001 **Sinkhole Creek**	Insufficient Data	Poor	• Potential stressors include urban and agricultural run-off • Prone to zero baseflow during summer	• Insufficient data

4.4.2 Twenty Mile Creek Watershed: Hilsenhoff Biotic Index Results

HBI results indicate that water quality is ranged from *poor* to *fairly poor* at most Twenty Mile Creek monitoring stations (**Table 6**). Results from biological assessments completed between 2019 and 2023 are illustrated in **Appendix B.** Reduced baseflow, high sediment loading due to erosion, lack of in-stream habitat, and nutrient enrichment are primary causes of impairment at these stations.

4.4.3 Twenty Mile Creek Watershed: Key Findings

Based on the 2019-2023 data, elevated concentrations of total phosphorus are a widespread cause of water quality impairment in the Twenty Mile watershed. Approximately 95% of samples collected from the Twenty Mile watershed exceeded the PWQO with some concentrations greater than 30 times the PWQO.

Figure 6: Longnose Gar in Twenty Mile Creek.

E. coli and total suspended solid concentrations frequently exceed the provincial objective in Twenty Mile Creek watershed. It is recommended that this subwatershed be prioritized by Best Management Practice programs such as those provided by the NPCA to reduce sources of *E. coli* in this watershed.

4.5 Lake Ontario Tributaries

Nineteen tributaries discharging into Lake Ontario are monitored through the NPCA Water Quality Monitoring Program. These tributaries include: Forty Mile Creek, Thirty Mile Creek, Eighteen Mile Creek, Sixteen Mile Creek, Fifteen Mile Creek, Twelve Mile Creek (see Section 4.6), Francis Creek, Richardson Creek, Walker's Creek, Eight Mile Creek, Six Mile Creek, Four Mile Creek, Two Mile Creek, One Mile Creek, Bartlett Creek, Prudhommes Drain, Welland Canal, Shriners Creek, and Beaver Dam Creek (**Figure 7**). Twelve Mile Creek and Twenty Mile Creek are also tributaries of Lake Ontario but are presented separately due to the expansion of monitoring in each watershed.

4.5.1 Lake Ontario Tributaries: Canadian Water Quality index

Based on the results of the WQI, fourteen of eighteen Lake Ontario tributary stations have water quality that is rated as *poor*. Four stations were rated as *marginal*. WQI results are illustrated in **Appendix A**. Mapping showing the spatial distribution and boxplots of the eight indicator parameters from 2019 and 2023 are found in **Appendix B** and **Appendix F**. Highlights of the water quality monitoring in the Lake Ontario tributaries are summarized in **Table 7**.

Figure 7: Map of the subwatersheds draining to Lake Ontario.

Table 7: Summary of the NPCA water quality data for Lake Ontario Tributaries (2019-2023).

Site	WQI Rating ↔ Stable ↓ Declining ↑ Improving	Hilsenhoff Family Biotic Index Rating	Factors Affecting Water Quality (% percentage reported if >50)	Indicator Parameter Trends (2019-2023)
FM001 **Forty Mile Creek**	Poor ↔	Poor	• Exceedances in chloride (60%), copper, E. coli (85%), total phosphorus (98%), total suspended solids, and zinc • Potential stressors include road salt storage compound, quarry dewatering, agricultural and urban run-off • Significant algae growth seen in summer months	• Indicator parameters remain stable
ET001 **Eighteen Mile Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli (64%), nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include greenhouse wastewater, agricultural run-off • Frequent copper exceedances warrant further investigation	• Indicator parameters remain stable
FF001 **Fifteen Mile Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli (54%), lead, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural run-off • Significant algae growth in summer	• Decrease in total suspended solids • Phosphorus, E. coli, and chloride remain stable
SX001 **Sixteen Mile Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli (72%), lead, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural run-off	• Indicator parameters remain stable
EI001 **Eight Mile Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli (84%), nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off	• Increase in total phosphorus and chloride • E. coli and total suspended solids remain stable

FA001 **Francis Creek**	Poor ↓	Very Poor	• Exceedances in chloride (79%), copper, E. coli (71%), total phosphorus (68%), and total suspended solids • Potential stressors include agricultural and road run-off	• Increasing chloride concentrations • Total phosphorus, E. coli, and total suspended solids remain stable
RC001 **Richardson Creek**	Poor ↔	Very Poor	• Exceedances in chloride (77%), copper (65%), E. coli (56%), nitrate (100%), total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off, greenhouse wastewater	• Increasing chloride and total phosphorus • E. coli and total suspended solids remain stable
SI001 **Six Mile Creek**	Poor ↔	Poor	• Exceedances in chloride (59%), copper, E. coli (72%), nitrate, total phosphorus (79%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off	• Indicator parameters remain stable
FU004 **Four Mile Creek**	Poor ↔	Very Poor	• Exceedances in chloride, copper, E. coli (69%), nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off	• Decrease in E. coli and total suspended solids • Increase in total phosphorus • Chloride remains stable
TM001 **Two Mile Creek**	Poor ↔	Very Poor	• Exceedances in chloride, copper, E. coli (87%), nitrate, total phosphorus (100%), and total suspended solids • Potential stressors include agricultural and urban run-off • High E. coli concentrations warrant further investigation	• Decreasing total suspended solids and chloride • Total phosphorus and E. coli remain stable
OM001 **One Mile Creek**	Poor ↔	Poor	• Exceedances in chloride (56%), copper, E. coli (94%), nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include urban run-off • Prone to zero baseflow in summer	• Increase in total phosphorus and chloride • E. coli and total suspended solids remain stable

TH001 **Thirty Mile Creek**	Marginal ↔	Fairly Poor	• Exceedances in chloride (56%), copper, E. coli (77%), nitrate, total phosphorus (92%), and zinc • Potential stressors include agricultural run-off	• Indicator parameters remain stable
WC001 **Walkers Creek**	Poor ↔	Very Poor	• Exceedances in chloride (68%), coppers, E. coli (84%), lead, nitrate, total phosphorus (95%), total suspended solids, and zinc • Potential stressors include urban run-off	• Indicator parameters remain stable
SH002 **Shriners Creek**	Marginal ↑	Poor	• Exceedances in chloride (69%), copper, E. coli, total phosphorus (100%), and total suspended solids • Potential stressors include urban run-off • Excessive algae growth in summer	• Decrease in total suspended solids • Increase in total phosphorus and chloride • E. coli remains stable
BE004 **Beaver Dam Creek**	Marginal ↔	Poor	• Exceedances in chloride, E. coli, total phosphorus (84%), total suspended solids, and zinc • Potential stressors include industrial and urban run-off	• Decrease in total phosphorus and E. coli • Increase in total suspended solids and chloride
WE001 **Welland Canal**	Marginal ↔	Insufficient Data	• Exceedances in chloride, E. coli, total phosphorus, total suspended solids, and zinc • Water source at this site is predominately Lake Erie	• Increasing chloride • Total phosphorus, E. coli, and total suspended solids remain stable
PD001 **Prudhommes Drain**	Poor ↔	Very Poor	• Exceedances in chloride (80%), copper, E. coli (83%), nitrate, total phosphorus (93%), total suspended solids, and zinc • Potential stressors include urban run-off • Significant algae and duckweed growth during summer	• Decrease in total phosphorus and total suspended solids • Increase in chloride • E. coli remains stable
BT001 **Bartlett Creek**	Poor ↔	Very Poor	• Exceedances in chloride (61%), copper, E. coli, nitrate, total phosphorus (96%), total suspended solids, and zinc • Potential stressors include agricultural and QEW run-off	• Increasing chloride • Total phosphorus, E. coli, total suspended solids remain stable

4.5.2 Lake Ontario Tributaries: Hilsenhoff Biotic Index Results

HBI results indicate that water quality is ranged from *very poor to fairly poor* at Lake Ontario tributary stations (**Table 7**). Results from biological assessments completed between 2019 and 2023 are illustrated in **Appendix B**. Sediment loading, nutrient enrichment, and the lack of in-stream habitat are the primary causes of impairment at these stations.

4.5.3 Lake Ontario Tributaries: Key Findings

Based on the 2019-2023 data, all the Lake Ontario tributaries have total phosphorus exceedances. The most impacted of these tributaries include Fifteen Mile Creek, Sixteen Mile Creek and Eighteen Mile Creek which had median concentrations nearly 7 times the PWQO. The upper portions of these watersheds need to be prioritized for BMPs to reduce phosphorus loads.

Two Mile Creek (TM001) has the highest concentrations of *E. coli* in the NPCA watershed and continues to suggest that there may be sewage entering the Two Mile Creek. The NPCA sampled the stormwater outfalls of Two Mile Creek Conservation Area and found a source of the bacteria and are currently working with the Town of NOTL and MECP to solve this issue. Elevated *E.coli* concentrations for Walkers Creek (St. Catharines) and Prudhommes Drain (Lincoln) were also observed.

Copper and zinc concentrations in Eighteen Mile Creek consistently exceed PWQOs. Within the NPCA water quality monitoring network regular metal exceedances are uncommon but based on the land use in this watershed there may be pesticides entering the watercourse. The NPCA will investigate these exceedances further.

Richardson Creek consistently exceeds CCME for nitrate and a significant upstream source exists that requires further investigation.

4.6 Twelve Mile Creek Watershed

Twelve Mile Creek (**Figure 7**) is split into the Upper and Lower watersheds. Upper Twelve Mile Creek is a unique groundwater fed coldwater stream that springs from a glacial sand deposit known as the Fonthill Kame Delta. The Upper Twelve Mile Creek is monitored at 8 locations by the NPCA. Lower Twelve Mile Creek begins in Thorold where Ontario Power Generation (OPG) operations and man-made reservoirs for drinking water divert water from the Welland Canal and influence Twelve Mile Creek (Durley, 2006). Lower Twelve Mile Creek is monitored in 2 locations by the NPCA, with only 1 site with enough data to be analyzed in this report.

4.6.1 Twelve Mile Creek Watershed: Canadian Water Quality Index

Based on the results of the WQI, Twelve Mile Creek ranges from marginal to fair (**Table 8**). Based on the 2019-2023 data, three locations are rated as *fair.* No Twelve Mile Creek sites were rated as poor. WQI results are illustrated in **Appendix A.** Mapping showing the spatial distribution and boxplots of the eight indicator parameters from 2019 to 2023 are found in **Appendix B** and **Appendix G.** TW011 was added in 2021 and therefore has insufficient data for this report. Highlights of water quality monitoring in Twelve Mile Creek are summarized in **Table 8** below.

Table 8: Summary of the NPCA water quality data for the Twelve Mile Creek Watershed (2019-2023).

Site	WQI Rating ↔ Stable ↓ Declining ↑ Improving	Hilsenhoff Family Biotic Index Rating	Factors Affecting Water Quality (% percentage reported if >50)	Indicator Parameter Trends (2019-2023)
TW001	Marginal ↔	Fairly Poor	• Exceedances in chloride, copper, E. coli (56%), total phosphorus (61%), and total suspended solids • Potential stressors include agricultural and urban run-off	• Decrease in E. coli and total suspended solids • Increase in chloride • Total phosphorus remains stable
TW002	Fair ↔	Fairly Poor	• Exceedances in copper, E. coli, total phosphorus, and total suspended solids • Potential stressors include agricultural run-off	• Decrease in total phosphorus and total suspended solids • E. coli and chloride remain stable
TW003	Marginal ↔	Fairly Poor	• Exceedances in chloride, copper, E. coli (62%), total phosphorus (89%), total suspended solids, and zinc • Potential stressors include agricultural run-off and decommissioned landfill	• Increase in chloride • Total phosphorus, E. coli, and total suspended solids remain stable
TW004	Marginal ↔	Fairly Poor	• Exceedances in copper, E. coli, nitrate (97%), total phosphorus, and total suspended solids • Potential stressors include agricultural and golf course run-off	• Decrease in total phosphorus • Increase in chloride • E. coli and total suspended solids remain stable
TW005	Marginal ↔	Fairly Poor	• Exceedances in E. coli (59%), total phosphorus (73%), and total suspended solids • Potential stressors include agricultural run-off	• Decrease in E. coli and total suspended solids • Increase in chloride • Total phosphorus remains stable

TW006	Fair ↔	Fair	• Exceedances in E. coli (54%), total phosphorus (64%), and total suspended solids • Potential stressors include agricultural and urban run-off	• Decrease in E. coli and chloride • Total phosphorus and total suspended solids remain stable
TW007	Marginal ↔	Fairly Poor	• Exceedances in chloride, E. coli (67%), nitrate, total phosphorus (81%), and total suspended solids • Potential stressors include agricultural runoff	• Increase in total phosphorus • E. coli, total suspended solids, and chloride remain stable
TW008	Marginal ↔	Poor	• Exceedances in chloride (79%), E. coli (59%), nitrate, and total phosphorus (100%) • Potential stressors include agricultural and highway run-off	• Increase in total phosphorus • E. coli, total suspended solids, and chloride remain stable
TW009	Fair ↑	Insufficient Data	• Exceedances in chloride, E. coli (50%), total phosphorus and total suspended solids • Potentials stressors include urban run-off and industrial wastewater	• Decrease in chloride • Increase in E. coli • Total phosphorus and total suspended solids remain stable
TW011	Insufficient Data	Insufficient Data	• Potential stressors include urban run-off	• Insufficient data

4.6.2 Twelve Mile Creek: Hilsenhoff Biotic Index Results

Most upper Twelve Mile Creek sites are rated as f*airly poor*. Site TW006 is rated as *fair*. Some upper Twelve Mile Creek tributaries can support several sensitive taxa such as mayflies and stoneflies due to cooler water temperatures, excellent riparian buffer and in-stream habitat, and suitable water quality.

4.6.3 Twelve Mile Creek: Key Findings

The Upper Twelve Mile Creek watershed represents some of the best water quality in the Niagara Peninsula. The upper portion of Twelve Mile Creek supports brook trout and a rich macroinvertebrate community that is unique in Niagara. The main stresses to the aquatic community include exceedances of total phosphorus and *E. coli*. Nitrate contamination has been identified as a stressor at TW004 and it may be sourced to a local business. Efforts to minimize these stressors through BMP initiatives will allow this watershed to remain in its current state.

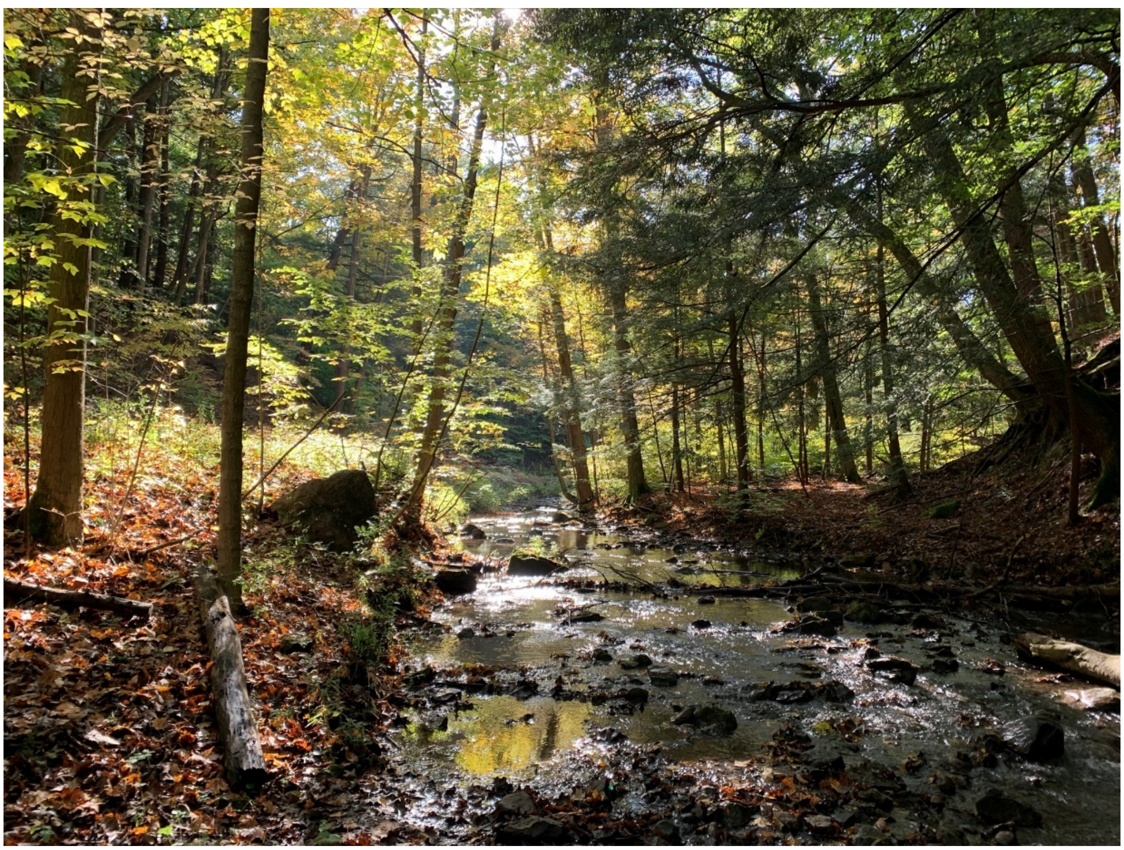

Figure 8: Twelve Mile Creek in Pelham, Ontario.

4.7 Niagara River Tributaries

Four tributaries discharging to the Niagara River are monitored through the NPCA Water Quality Monitoring Program. These tributaries include: Bayer Creek, Black Creek (including Beaver Creek), Frenchman's Creek, and Usshers Creek (**Figure 9**).

4.7.1 Niagara River Tributaries: Canadian Water Quality Index

Based on the data from 2019-2023, Black Creek (BL003), Frenchman's Creek (FR003), and Beaver Creek (BR001) sites are rated as *marginal*. WQI results are illustrated in **Appendix A**. Mapping showing the spatial distribution and boxplots of the eight indicator parameters from 2019 to 2023 are found in **Appendix B** and **Appendix H**. Highlights of the water quality monitoring in the Niagara River Tributaries are summarized in **Table 9.**

Figure 9: Map of subwatersheds that drain into Niagara River.

Table 9: Summary of the NPCA water quality data for the Niagara River tributaries (2019-2023).

Site	WQI Rating ↔ Stable ↓ Declining ↑ Improving	Hilsenhoff Family Biotic Index Rating	Factors Affecting Water Quality (% percentage reported if >50)	Indicator Parameter Trends (2019-2023)
BA001 **Bayer Creek**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli (62%), lead, nitrate, total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural run-off	• Indicator parameters remain stable
BL003 **Black Creek**	Marginal ↔	Insufficient data	• Exceedances in copper, E. coli (53%), total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural and road run-off	• Increase in E. coli and total suspended solids • Total phosphorus and chloride remain stable
BR001 **Beaver Creek**	Marginal ↓	Poor	• Exceedances in E. coli, total phosphorus (97%), and total suspended solids • Potential stressors include agricultural run-off	• Decrease in total suspended solids • Total phosphorus, E. coli, and chloride remain stable
FR003 **Frenchman Creek**	Marginal ↑	Poor	• Exceedances in chloride, copper, E. coli (59%), total phosphorus (78%), total suspended solids, and zinc • Potential stressors include agricultural run-off	• Decrease in total phosphorus and chloride • E. coli and total suspended solids remain stable
US001 **Usshers Creek**	Poor ↔	Very Poor	• Exceedances in chloride, copper, E. coli, total phosphorus (97%), total suspended solids, and zinc • Potential stressors include agricultural run-off • Prone to zero baseflow and algae growth in summer	• Indicator parameters remain stable

4.7.2 Niagara River Tributaries: Hilsenhoff Biotic Index

HBI ratings ranged from *very poor* to *poor* at three Niagara River tributary stations (**Table 9**). Results from biological assessments completed between 2019 and 2023 are illustrated in **Appendix B**. Sediment loading, reduced baseflow, lack of in-stream habitat, and nutrient enrichment are primary causes of impairment at these stations. Samples have not been collected from station BL003 due to high water depth, channel morphology, and access restrictions.

4.7.3 Niagara River Tributaries: Key Findings

Three of five Niagara River tributaries monitored were found to have higher WQI than other NPCA watersheds. The degree of land use impacts from urban and rural pressures are significantly less in this watershed.

Based on the 2019-2023 data, all the Niagara River tributaries had total phosphorus exceedances. The most impacted of these tributaries was Usshers Creek which had median concentrations 6 times the PWQO. Total phosphorus concentrations were found to be much lower in Frenchman Creek with median concentrations only 2 times the PWQO. Nonetheless these watersheds would benefit by BMP works to reduce phosphorus loads.

4.8 Lake Erie Tributaries

Eight tributaries discharging to Lake Erie are monitored through the NPCA Water Quality Monitoring Program. These tributaries include: Beaver Dam Creek, Casey Drain, Eagle Marsh Drain, Kraft Drain, Low Banks Drain, Point Abino Drain, Six Mile Creek, and Wignell Drain (**Figure 10**). In addition, the Welland Canal monitoring point in Port Colborne is also included with the Lake Erie tributaries. Water at this site enters the Welland Canal and outlets in Lake Ontario.

4.8.1 Lake Erie Tributaries: Canadian Water Quality Index

Based on the results of the WQI four of nine Lake Erie tributary stations are rated as having *poor* water quality three stations are rated as *marginal*, one station (PA001) rated as fair and one station (WE000) rated as *good* (**Table 10**). WQI results are illustrated in **Appendix A**. Mapping showing the spatial distribution and boxplots of the eight indicator parameters from 2019 to 2023 are found in **Appendix B** and **Appendix I**. Highlights of the water quality monitoring in the Lake Erie Tributaries are summarized in **Table 10.**

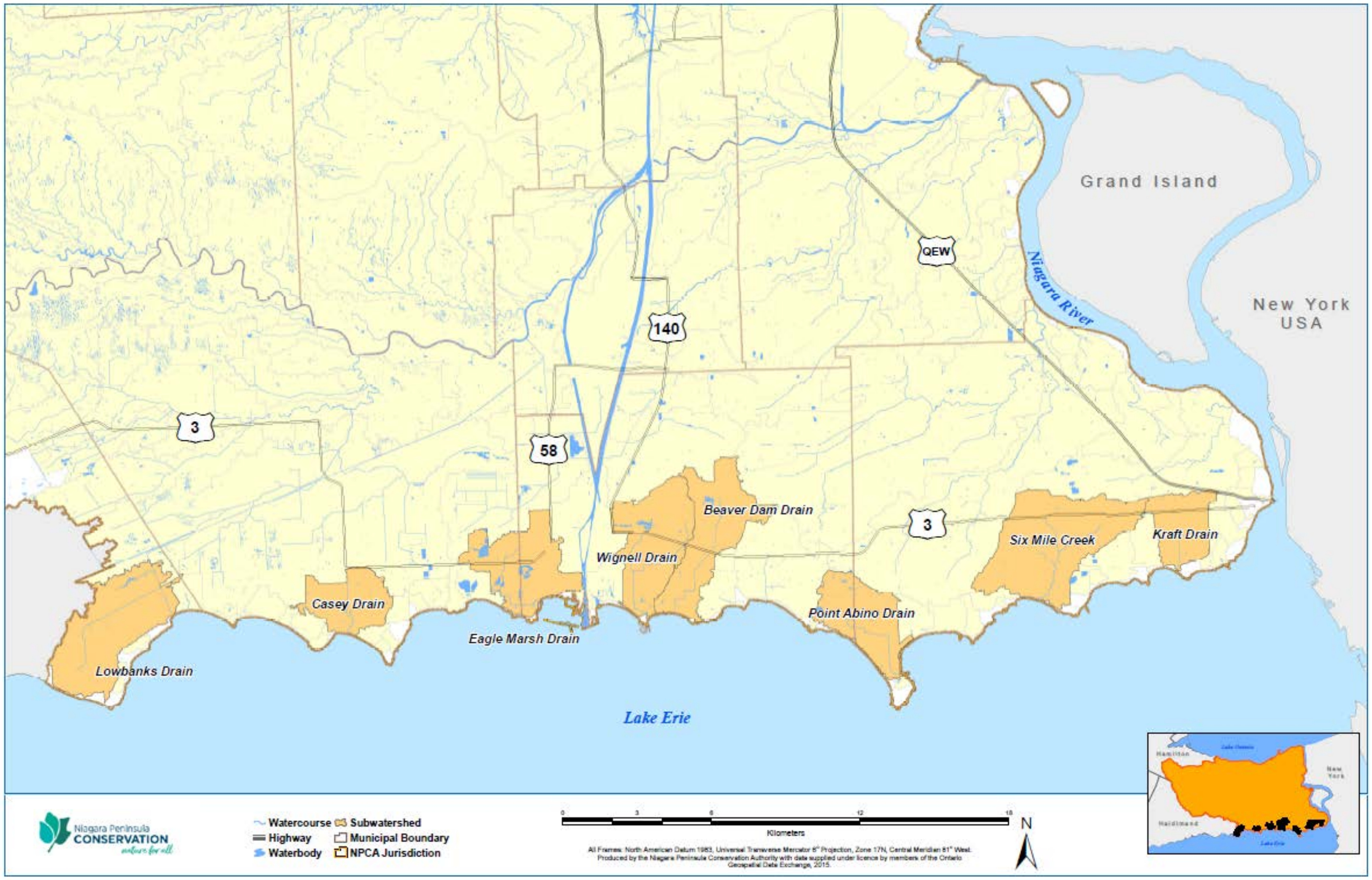

Figure 10: Map of monitored watersheds that drain into Lake Erie

Table 10: Summary of the NPCA water quality data for the Lake Erie North Shore tributaries (2019-2023).

Site	WQI Rating ↔ Stable ↓ Declining ↑ Improving	Hilsenhoff Family Biotic Index Rating	Factors Affecting Water Quality (% percentage reported if >50)	Indicator Parameter Trends (2019-2023)
BD001 **Beaver Dam Drain**	Marginal ↑	Very Poor	• Exceedances in chloride, copper, E. coli (56%), total phosphorus (100%), total suspended solids, and zinc • Potential stressors include historic industrial pollution and agricultural run-off	• Indicator parameters remain stable
CD001 **Casey Drain**	Poor ↔	Very Poor	• Exceedances in chloride, copper, E. coli (68%), nitrate, total phosphorus (97%), total suspended solids, and zinc • Potential stressors include agricultural run-off	• Decrease in chloride • Increase in total phosphorus • E. coli and total suspended solids remain stable
EM001 **Eagle Marsh Drain**	Poor ↓	Very Poor	• Exceedances in chloride, E. coli (56%), total phosphorus (85%), total suspended solids, and zinc (51%) • Potential stressors include quarry dewatering and agricultural run-off	• Decreasing total suspended solids and chloride • Increasing total phosphorus • E. coli remains stable
KD001 **Kraft Drain**	Poor ↔	Poor	• Exceedances in chloride, copper, E. coli (79%), total phosphorus (95%), total suspended solids, and zinc • Potential stressors include agricultural and urban run-off	• Decrease in total suspended solids • Increase in total phosphorus • E. coli and chloride remain stable
LB001 **Lowbanks Drain**	Marginal ↑	Poor	• Exceedances in copper, E. coli, nitrate, total phosphorus (92%), total suspended solids, and zinc • Potential stressors include agricultural run-off	• Indicator parameters remain stable

PA001 **Point Abino Drain**	Fair ↔	Poor	• Exceedances in copper, E. coli (55%), and total phosphorus (82%) • Potential stressors include agricultural run-off • Back flow from Lake Erie	• Decrease in total suspended solids • Increase in chloride • Total phosphorus and E. coli remain stable
SM001 **Six Mile Creek**	Marginal ↑	Poor	• Exceedances in chloride, copper, E. coli (54%), total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural run-off	• Decrease in total suspended solids and chloride • Increase in total phosphorus • E. coli remains stable
WD001 Wignell Drain	Poor ↔	Very Poor	• Exceedances in chloride, copper, E. coli (64%), total phosphorus (100%), total suspended solids, and zinc • Potential stressors include agricultural run-off • Excessive algae and duck weed growth in summer	• Decrease in total suspended solids • Increase in total phosphorus • E. coli and chloride remain stable
WE000 **Welland Canal**	Good ↔	Insufficient Data	• Exceedances in total phosphorus • Lake Erie is the main water source at this location	• Decrease in chloride • Total phosphorus, E. coli, and total suspended solids remain stable

4.8.2 Lake Erie Tributaries: Hilsenhoff Biotic Index

HBI results ranged from *very poor* to *poor* at Lake Erie tributaries monitored (**Table 10**). Results from biological assessments for these stations are illustrated in **Appendix B**. Sediment loading, reduced baseflow, lack of in-stream habitat, and nutrient enrichment are primary causes of impairment at these stations.

4.8.3 Lake Erie Tributaries: Key Findings

Based on the 2019 to 2023 data, all the Lake Erie tributaries have total phosphorus exceedances. The most impacted of these tributaries is Wignell Drain which had median concentrations 10 times the Provincial Water Quality Objective. Wignell Drain watershed needs to be prioritized for Best Management Practice (BMPs) works to reduce phosphorus loads to Lake Erie.

Nickel is not included in the WQI calculation; however, nickel concentrations were found to frequently exceed the PWQO at Beaver Dam Creek station BD001 and Wignell Drain station WD001. These nickel exceedances are likely from previous industrial land use.

Figure 11: A drain to Lake Erie with excessive duckweed growth.

5.0 Groundwater Quality Monitoring Program

5.1 NPCA Groundwater Monitoring Network

The NPCA Groundwater Monitoring Network (**Figure 12**) is comprised of two components. The first component is the Provincial Groundwater Monitoring Network (PGMN) which is a partnership between the MECP and the Conservation Authorities of Ontario. The PGMN was initiated in 2001 and is a province-wide groundwater monitoring program designed to collect long-term baseline data on groundwater quantity and quality in special areas of interest. There are currently 470 ambient groundwater monitoring wells in the program. Groundwater is monitored through a network of 15 monitoring wells located throughout the NPCA watershed in locally significant hydrogeological areas. Most PGMN monitoring wells are sampled yearly for water geochemistry and all wells are instrumented with datalogging equipment which records hourly groundwater levels. In 2023, a subset of PGMN wells were also sampled in the Spring in addition to the regular fall sampling.

The second component of the NPCA Groundwater Monitoring Network is a network of 31 monitoring wells installed at 23 different locations across the NPCA watershed through a project between the NPCA and the Ontario Geological Survey (OGS). Each of the 23 locations has a groundwater monitoring well installed at the top of bedrock in an aquifer zone commonly known as the Contact-Zone Aquifer. Three (3) of 23 locations have a set of nested monitoring wells installed at various depths within the overburden sediments. These wells were initially installed to investigate regional groundwater flow of five distinct features within the NPCA jurisdiction, which include: three (3) buried bedrock valleys (Erigan Channel, Chippawa-Niagara Falls Channel and Crystal Beach Channel) and their groundwater relationships to Lake Erie, Lake Ontario and the Niagara River; The Fonthill-Kame Delta Complex/Twelve Mile Creek watershed area; and The Upper Welland River watershed.

The NPCA samples water geochemistry yearly, in the fall, and all these wells are instrumented with datalogging equipment which records hourly groundwater levels to provide a better understanding of ambient groundwater conditions across the NPCA watershed.

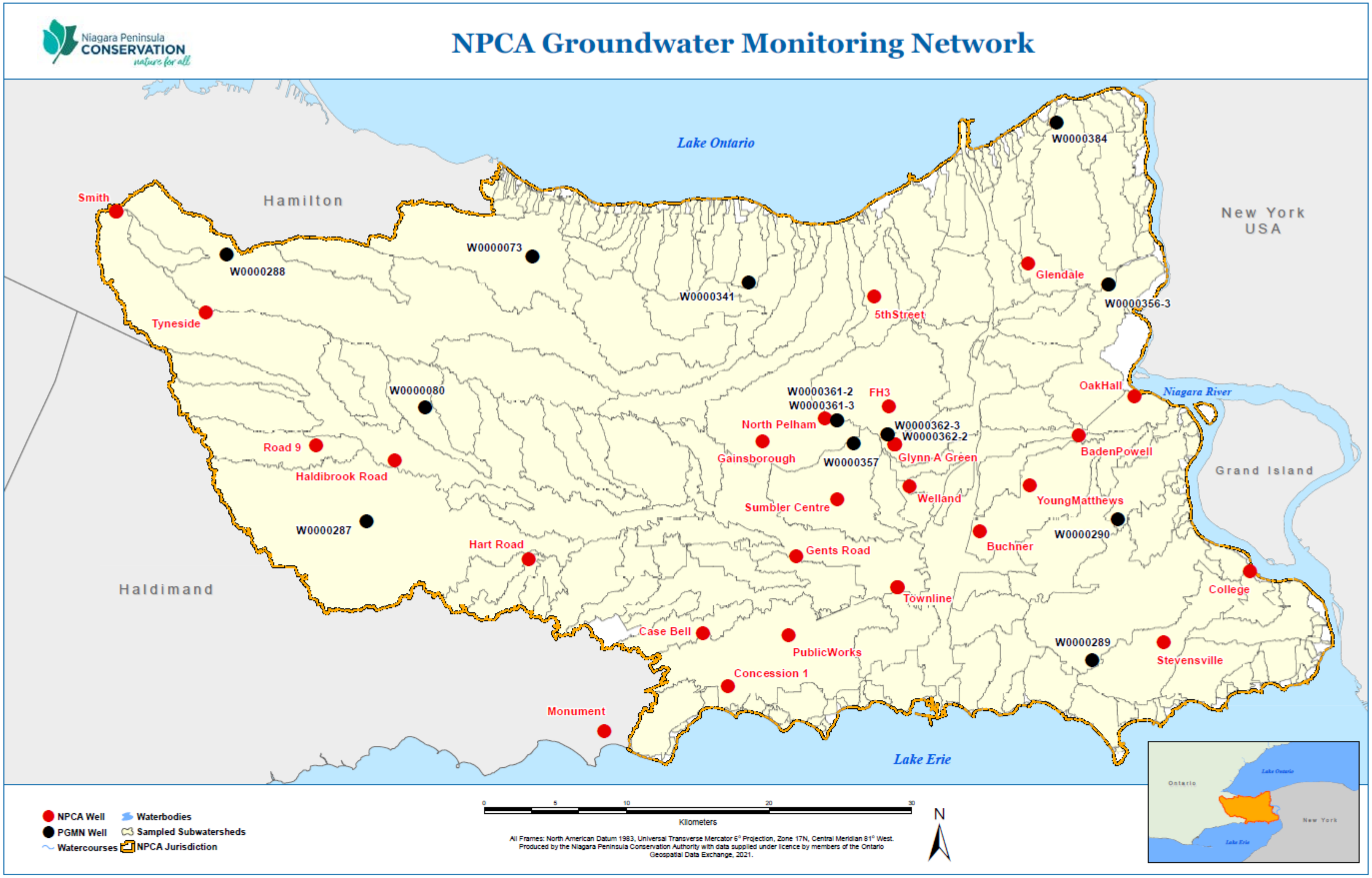

Figure 12: NPCA Groundwater monitoring network.

5.1.1 Groundwater Levels

The NPCA has been monitoring water levels at all PGMN wells since 2003 and other NPCA wells since 2014. Groundwater levels are typically at their highest during the late-winter and spring but begin to drop during the dry summer months and are lowest in the fall. There is also yearly variation in the groundwater levels which is dependent on precipitation. In dry years (such as 2016), water levels can drop substantially from their seasonal highs; and conversely the water level drops in wet years (2009) are not as substantial. PGMN monitoring wells each have water levels that are seasonally and yearly variable due to several factors (geologic formation the well is installed in, soils, precipitation, etc.). The groundwater level data from the NPCA groundwater monitoring network will be used to help better understand the impacts of local/provincial scale drought events and its connection to climate change. Groundwater level data for 2023 is unavailable for this report, and will be reported on in the future.

Figure 13: NPCA staff performing routine monitoring on a groundwater well.

5.1.2 Groundwater Geochemistry Results

Groundwater quality samples are analyzed for general chemistry, nutrients, metals, and project specific parameters. Groundwater chemistry results are compared to the Ontario Drinking Water Standards (ODWS, MOE 2003) to provide an indication of overall groundwater quality across the NPCA. **Table 11** summarizes the health-related exceedances of the ODWS from 2019-2023 for the NPCA Groundwater Monitoring Network. All health related ODWS exceedances in PGMN wells are flagged by the MECP and are reported to the NPCA, Region of Niagara Public Health Department and local municipalities. Wells with reported exceedances are subsequently re-sampled by the MECP to confirm the initial exceedance. Based on the type and source of the exceedance these agencies formulate an action plan to protect human health. In the case of the non-PGMN wells, exceedances were reviewed through the OGS Ambient Geochemistry program (Colgrove, L.M. and Hamilton, S. M., 2018).

Table 11: NPCA Groundwater Monitoring Network stations. Provincial Groundwater Monitoring Network stations are highlighted in blue. The remainder are NPCA wells. Health-related exceedances (ODWS) are listed for 2019-2023. Red text indicates human influence.

Well ID **Location**	**Well Type**	**Formation**	Year				
			2019	2020	2021	2022	2023
W0000073 (Grimsby)	Bedrock	Guelph-Lockport	Sodium	Sodium	Sodium	Sodium	Sodium
W0000080 (West Lincoln)	Bedrock	Guelph-Lockport	Sodium Fluoride Uranium	Sodium Fluoride Uranium	Sodium Fluoride Uranium	Sodium Fluoride Uranium	Sodium Fluoride Uranium
W0000288 (Hamilton)	Bedrock	Guelph-Lockport	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Gainsborough (West Lincoln)	Bedrock	Guelph	No Exceedance	No Exceedance	Fluoride	Fluoride	Fluoride
Welland (Welland)	Bedrock	Guelph	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Smith Road (Hamilton)	Bedrock	Guelph	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Tyneside (Hamilton)	Bedrock	Guelph	No Exceedance	No Exceedance	No Exceedance	No Exceedance	Sodium
Oak Hall (Niagara Falls)	Bedrock	Guelph	Sodium	Sodium	Sodium	Sodium	Sodium
Glynn A Green (Pelham)	Bedrock	Lockport	Fluoride	Fluoride	Fluoride Arsenic	Fluoride Arsenic	Fluoride Arsenic

Well ID Location	Well Type	Formation	Year				
			2019	2020	2021	2022	2023
W0000289 (Port Colborne)	Bedrock	Onondaga	No Exceedance	No Exceedance	No Exceedance	No Exceedance	Sodium
W0000341 (Lincoln)	Bedrock	Clinton	Sodium	Sodium	Sodium	Sodium	Sodium
W0000357 (Pelham)	Overburden	Fonthill Kame	No Exceedance	Unable to sample	Unable to sample	Sodium	Unable to sample
W0000361-2 (Pelham)	Overburden	Fonthill Kame	Nitrate	Sodium	Sodium	Sodium Nitrate	Sodium Nitrate
W0000361-3 (Pelham)	Overburden	Fonthill Kame	Sodium	Sodium	Sodium	Sodium	Sodium
W0000362-2 (Pelham)	Overburden	Fonthill Kame	Sodium	Sodium	Sodium	Sodium	Sodium
W0000362-3 (Pelham)	Overburden	Fonthill Kame	Sodium	Sodium	Sodium	Sodium	Sodium
W0000384 (NOTL)	Overburden	Iroquois Sandplain	Sodium Nitrate	Sodium	Sodium	Sodium	Sodium

Well ID Location	Well Type	Formation	Year				
			2019	2020	2021	2022	2023
Concession 1 (Wainfleet)	Bedrock	Bertie	Sodium	Sodium	Sodium	Sodium	Fluoride Sodium
Stevensville (Fort Erie)	Bedrock	Bertie	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Monument (Haldimand County)	Bedrock	Bois Blanc	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
North Pelham (Pelham)	Bedrock	Eramosa	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
5th Street (St.Catharines)	Bedrock	Queenston	No Exceedance	Sodium	Sodium	Sodium	Sodium
Baden Powell (Niagara Falls)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium
Townline (Port Colborne)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium
Young Matthews (Niagara Falls)	Bedrock	Salina	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Buchner (Welland)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium

Well ID Location	Well Type	Formation	Year				
			2019	2020	2021	2022	2023
College (Fort Erie)	Bedrock	Salina	Sodium Boron	Sodium Boron	Sodium Boron	Sodium Boron	Sodium Boron
Gents Road (Wainfleet)	Bedrock	Salina	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Sumbler Centre (Pelham)	Bedrock	Salina	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Public Works (Wainfleet)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium
Road 9 (Haldimand County)	Bedrock	Salina	No Exceedance	No Exceedance	No Exceedance	No Exceedance	No Exceedance
Haldibrook Road (Haldimand County)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium
Hart Road (Haldimand County)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium
Case Bell (Wainfleet)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium

Well ID **Location**	**Well Type**	**Formation**	Year				
			2019	2020	2021	2022	2023
W0000287 (Haldimand County)	Bedrock	Salina	Sodium	Sodium	Sodium	Sodium	Sodium
W0000290 (Niagara Falls)	Bedrock	Salina	Sodium Boron	Sodium Boron	Sodium Boron	Sodium Boron	Sodium Boron

5.1.3 Key Groundwater Findings

Exceedances of ODWS of arsenic (Glynn A Green), boron (W290-1 & College), fluoride (W080-1, Glynn A Green, and Concession 1) and uranium (W080-1) were observed in the NPCA sampling program, and these exceedances (except the Smith Road arsenic exceedance) have been attributed to natural groundwater conditions by the MECP Environmental Monitoring and Reporting Branch (EMRB) staff and by OGS Ambient Geochemistry program (Colgrove, L.M. and Hamilton, S. M., 2018). These elements occur naturally in the groundwater due to the dissolution of minerals from the bedrock formations. No anthropogenic activities or potential sites were identified. This appears to be an aquifer wide issue that will likely be present when this water is extracted for use. Regular water testing and treatment is recommended when using these aquifer sources for drinking. The new arsenic exceedance at the Smith Road well will be verified by additional NPCA confirmatory sampling.

Most NPCA Groundwater Monitoring Network wells have sodium concentrations which exceed the 20 mg/L concentration. This is a health related ODWS exceedance where MECP has informed the Medical Officer of Health for the Health units so that this information could be communicated to local physicians for their use with patients on sodium restricted diets. MECP, EMRB and OGS Ambient Geochemistry program (Colgrove, L.M. and Hamilton, S. M., 2018) have attributed these exceedances to natural groundwater conditions and possibility from road salt in the shallow overburden wells. Regular water testing and treatment is recommended when using these aquifer sources for drinking.

Elevated nitrate concentrations observed at monitoring wells W384-1 and W361-2 from 2003-2019 and 2022-2023 (W361-2 only) were attributed to agricultural land use and/or faulty septic systems. In response to these exceedances, additional groundwater sampling of local private wells was completed by the NPCA in partnership with the Region of Niagara Public Health Unit in October 2008 and November 2009. The purpose of the additional sampling was to determine the extent of nitrate contamination near PGMN wells (W384-1 and W361-2) and to notify affected residents of potential health concerns related to elevated nitrate concentrations in drinking water. Sampling results indicated that none of the private wells tested exceeded the Ontario Drinking Water Standard (ODWS) for nitrate (MOE 2003) near W384-1 and one private well was found to exceed the ODWS near W361-2. The well exceeding the ODWS was determined to be a shallow dug well with poor construction and is likely not related to the nitrate exceedance at PGMN well W361-2. From 2018 to 2021 nitrate ODWS exceedances were not detected in both wells, and these reductions may be attributed to changes of local land uses and allowed for attenuation of nitrate. However, as of 2022, nitrate concentrations have increased over Ontario Drinking Water Standards again at W361-2 and suggests a continue local source of nitrate.

In general, ambient groundwater geochemistry across the NPCA was found to have elevated levels of chloride, iron, manganese sodium, and sulfate that exceed the Aesthetic Objectives within the ODWS (MOE 2003). The parameters which have Aesthetic Objectives may not be the source of any health-related issues, but these exceedances typically make the groundwater unpalatable or otherwise unpleasant for normal use (i.e., build-up/staining). Regular water testing and treatment is recommended when using these aquifer sources for drinking and other uses.

5.2 Water Well Decommissioning Program

In 2023, the NPCA continued to provide grants to watershed residents interested in properly decommissioning abandoned water wells on their property through the NPCA Water Well Decommissioning Program. The grant program offers an 80% subsidy for water well decommissioning to a maximum of $1000 per well. Grant applications are prioritized in areas designated as highly susceptible to groundwater contamination in the NPCA Groundwater Study (Waterloo Hydrogeologic Inc. 2005), areas where there is a high density of private wells used for domestic purposes, and areas where a watershed plan has been completed or is underway. Numerous improperly abandoned water wells are known to exist in the NPCA watershed, and these wells can serve as a direct pathway between potential contaminants at ground surface and deeper aquifers. The implementation of this program will reduce the risk of groundwater contamination and fulfills a recommendation made in the Groundwater Management Strategy of the NPCA Groundwater Study (Waterloo Hydrogeologic Inc. 2005). To date, 114 water wells have been decommissioned with the NPCA water well decommissioning program. An example of a water well decommissioning project is shown in **Figure 14**.

Figure 14: Before and after photos from a water well decommissioning project.

6.0 Additional Water Quality Monitoring Projects

6.1 Hamilton International Airport Monitoring

Since 1998, the NPCA has been commissioned and funded by the Hamilton International Airport (HIA) to complete annual biological assessments of water quality near their property. The goal of the annual assessment is to determine if stormwater runoff and de-icing fluids such as propylene glycol are impacting surface water quality in two headwater tributaries of the Welland River. The NPCA generates this separate report for the HIA for their exclusive information and use.

6.2 Glanbrook Landfill Monitoring

Since 1998, the NPCA has been commissioned and funded by the City of Hamilton to complete biennial biological assessments of water quality for the Glanbrook Landfill. The Glanbrook Landfill is owned and operated by the City of Hamilton, and is designed to receive domestic, commercial, and non-hazardous solid industrial waste. The purpose of the biennial assessments is to determine if stormwater runoff and leachate from the landfill are negatively impacting water quality and aquatic biota in the Welland River and Buckhorn Creek. The NPCA generates this separate report for the City of Hamilton for their exclusive information and use.

6.3 Upper Twelve Mile Creek Temperature Monitoring

The upper Twevle Mile Creek watershed encompasses the only identified cold water streams in the Niagara Region. These coldwater streams are groundwater fed and maintain cold water temperatures, approximately <19 ℃ year-round. These streams will flow during dry periods of the year because they are not dependant upon precipitaion or other surface water influences. Water temperature is an essential factor in determing the composition of aquatic communities. Coldwater sensitive species (Trout, Sculpins, specific Mayflies and Stoneflies) require cold, well oxygentaed water. Therefore, these streams support a unique aquatic community that relies on cold water temperatures, and any significant changes to the temperatures could harm these species.There are several threats to the condition of coldwater streams and they include climate change, land use changes leading to habitat degradation, and overuse of groundwater resources. In 2013, the NPCA reinitiatied temperature monitoring in the upper Twelve Mile Creek watershed to (1) identify and classify the thermal regime at the surface water sampling stations and (2) to identify any changes that have occurred to the thermal stability of Twelve Mile Creek.

The NPCA monitored stream temperature at ten sites in 2023 **(Figure 15)**. These sites were chosen due to the availabilty of background data, including water chemistry, benthic macroinvertebrate data, fisheries, stream morphology, hydrology data and stream temperature data. At seven of the locations, Onset HOBO Water Temperature dataloggers were deployed to capture stream temperature data. At the three remaining sites, the stream temperature data was collected from NPCA stream flow gauge stations. The HOBO temperature dataloggers were deployed June 15th 2023, set to record every 15 minutes and extracted December 8th 2023.

The methodology used by the NPCA, and many other conservation authorities to classify stream thermal stability was developed by Stoneman and Jones (1996). The approach uses daily maximum air temperature and water temperature at 16:00 from July 1st to September 10th. This method was determined to be monitoring the warmest period of the year. To analyse the stream temperature data, the NPCA uses modified nomograms (Stoneman and Jones 1996) to determine the stream thermal stability and to estimate the thermal regime of each stream site. This method classifies a stream to be coldwater, coolwater, or warmwater. Stoneman and Jones (1996) define the following 1) coldwater sites which support a large population of coldwater species; 2) coolwater sites that support a mix of coldwater-coolwater-warmwater; and 3) warmwater sites support few or no coldwater species.

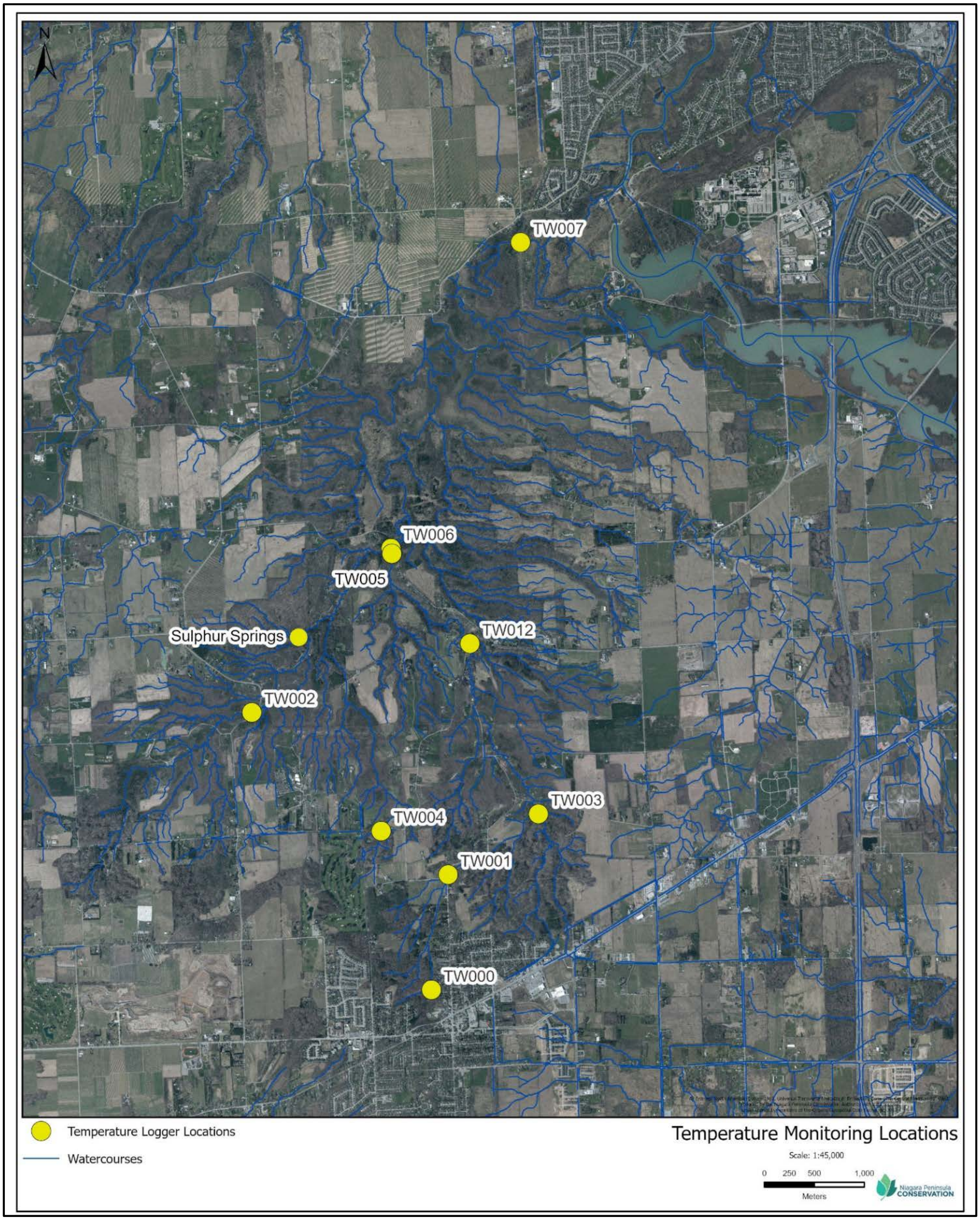

Figure 15: Temperature monitoring locations in the Upper Twelve Mile Creek watershed.

Nomograms (**Figures 16 and 17**) were created for the Effingham and St Johns Tributaries of the Upper Twelve Mile Creek with the stream temperature data collected from July 1st to September 10th 2023. The findings of these nomograms classify sites TW000 and TW003 as coldwater. Sites TW001, TW004, TW006, TW007 and TW012 were classified as coolwater. Sites TW002, TW005 and Sulphur Springs encountered logger failure and did not have sufficient temperature data to determine a classification. No sites were classified as warmwater.

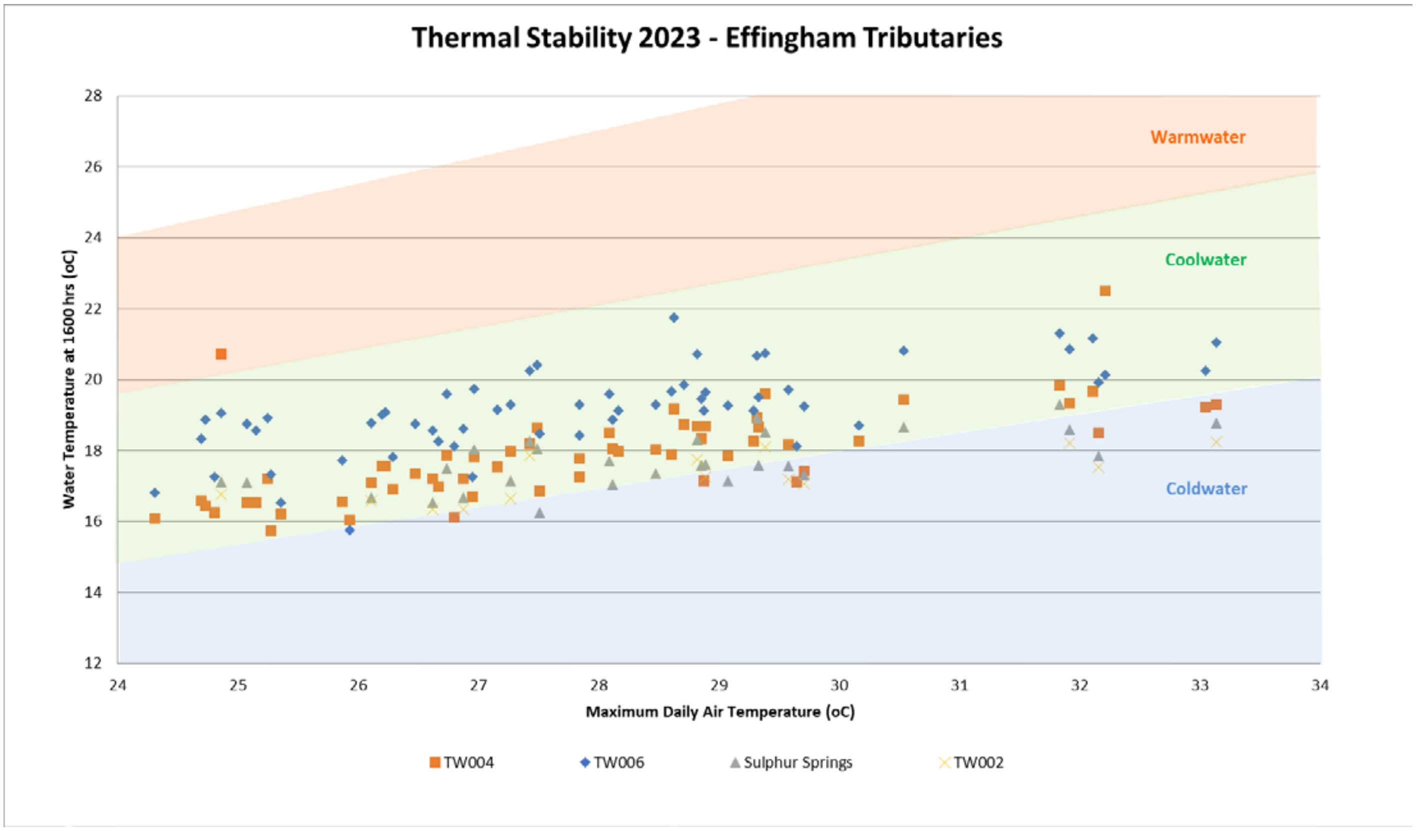

Figure 16: Thermal stability nomogram for Effingham Tributaries of Upper Twelve Mile Creek.

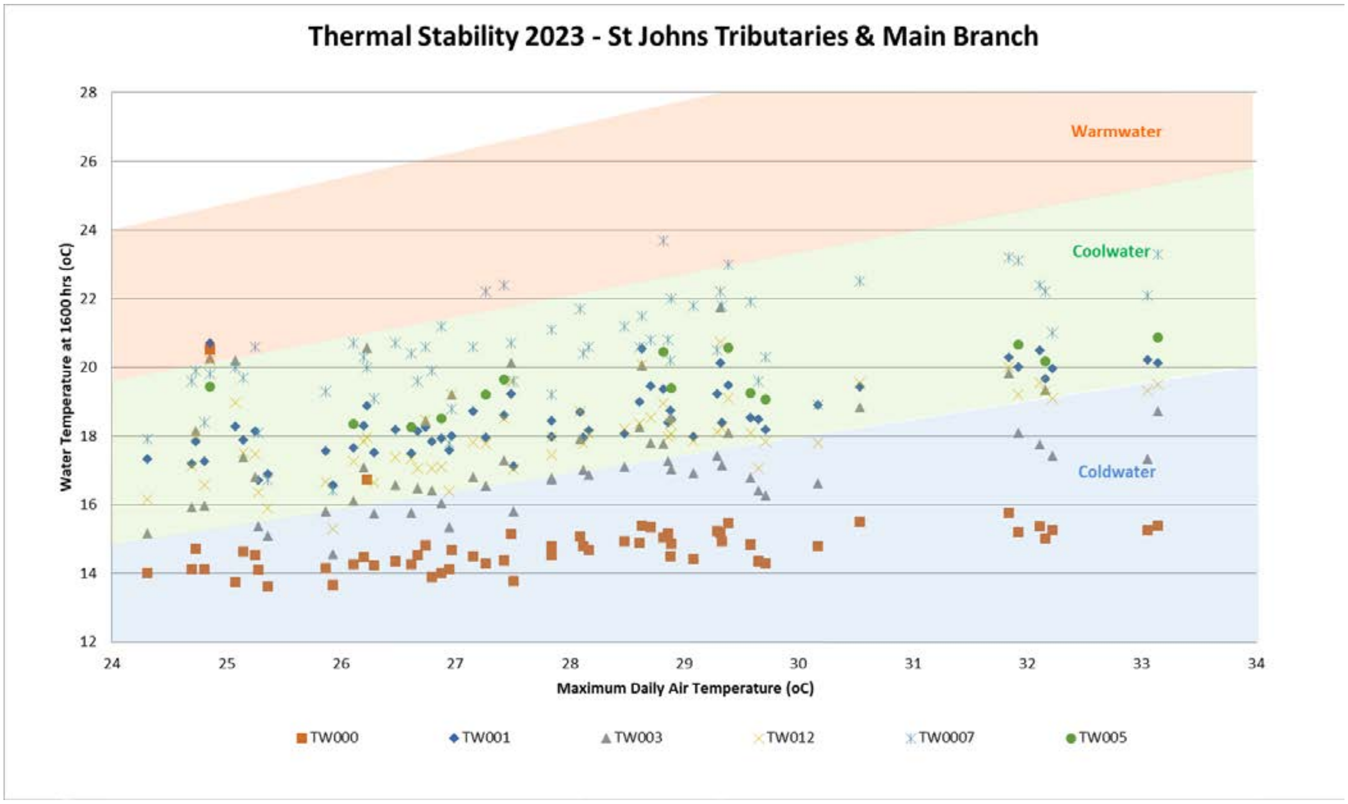

Figure 17: Thermal stability nomogram for St Johns tributary and the main branch of Upper Twelve Mile Creek.

The headwaters of the St. Johns tributary have continued to maintain a coldwater classification from 2011-2023 (**Table 13**). Site TW004 shifted from coldwater in 2022 to coolwater in 2023. Site TW012 was added to the list of monitoring sites in 2023 and will continue to be monitored in future years. In general, the classification of the monitoring sites has remained stable with previous assessments. In 2023, equipment failures at sites TW002, Sulphur Springs, and TW005 meant that data was missing during the summer and therefore these streams have not been classified in 2023.

Table 12: Stream classification summary 2011-2023.

Monitoring Site	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TW000	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water	Cold Water
TW001	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water
TW002	Cool Water	Cool Water	Cold Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cold Water	Cool Water	Cold Water	
Sulphur Springs					Cool Water	Cool Water	Cool Water	Cool Water	Cold Water	Cool Water	Cold Water	
TW003	Cool Water	Cold Water	Cold Water	Cold Water	Cool Water	Cool Water	Cool Water	Cold Water	Cold Water	Cool Water	Cold Water	Cold Water
TW004	Cool Water	Cool Water	Cold Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cold Water	Cool Water
TW005	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	
TW006	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water	Cool Water
TW007	Cool Water	Warm Water			Warm Water	Cool Water		Warm Water	Warm Water	Warm Water	Cool Water	Cool Water
TW012												Cool Water

The NPCA will continue to monitor stream temperature as an additional method to evaluate the health and status of watershed communities in the significant coldwater streams of the upper Twelve Mile Creek. It is recommended that monitoring continue to ensure that these tributaries do not warm up enough to threaten the coldwater species that thrive here.

6.4 Water Quality Sensor Deployment

The NPCA water quality monitoring program deploys various sensors to monitor parameters over time. Table 12 below outlines the sensors deployed in 2023.

Water quality sensor deployment allows the NPCA to monitor continuous water quality information during the ice-free months. Sensor deployment provides important data for different studies and ambient water quality data.

Table 13: Water quality sensors deployed in 2023.

Sensor	Location	Parameters
HOBO U26 Dissolved Oxygen Data Logger	Big Forks Creek	Water temperature, dissolved oxygen
HOBO U26 Dissolved Oxygen Data Logger	Wignell Drain	Water temperature, dissolved oxygen
HOBO U26 Dissolved Oxygen Data Logger	Beaver Dam Drain	Water temperature, dissolved oxygen
YSI EXO 2 Multiparameter Sonde	O'Reilly's Bridge, Welland River	Water temperature, pH, conductivity, dissolved oxygen, turbidity
YSI EXO 2 Multiparameter Sonde	Lake Niapenco, Binbrook Conservation Area	Water temperature, pH, conductivity, dissolved oxygen, turbidity, total algae
YSI EXO 3 Multiparameter Sonde	Twelve Mile Creek downstream of Short Hills Provincial Park	Water temperature, pH, conductivity, dissolved oxygen, turbidity
YSI EXO 3 Multiparameter Sonde	Welland River, Caistorville	Water temperature, pH, conductivity, dissolved oxygen, turbidity
YSI EXO 3 Multiparameter Sonde	Twenty Mile Creek, Woodburn	Water temperature, pH, conductivity, dissolved oxygen, turbidity

Figure 18: NPCA staff installing an EXO multiparameter sonde in a buoy.

Figure 19: NPCA staff installing a dissolved oxygen logger in a creek.

6.5 Lake Niapenco Perfluorinated Compound Monitoring

Since 2012, the NPCA has been monitoring for Per- and polyfluoroalkyl substances (PFAS) in Lake Niapenco at Binbrook Conservation Area. PFAS were found in the plasma of snapping turtles at Lake Niapenco in 2009 and 2010 by an Environment Canada (EC) scientist as part of an organic toxins' accumulation study (de Solla et al. 2012). PFAS trackdown studies by MECP confirmed the presence of PFAS in Lake Niapenco and identified John C. Munro International Airport as the source of the contamination (Fowler 2011). Since 2015, Transport Canada and Procurement Canada have retained Arcadis Canada Inc. to conduct a risk assessment to investigate presence and distribution of PFAS in the Welland River downstream of the HIA.

NPCA collected a water sample at Lake Niapenco on June 10, 2023. **Figure 20** shows the sample location in the Conservation Area. The sampling protocol was as follows: 1) Lake Niapenco samples were collected in waist-deep water at the beach (**Figure 21**); and 2) Samples were collected and placed in a cooler with ice and shipped the next day for PFAS analysis.

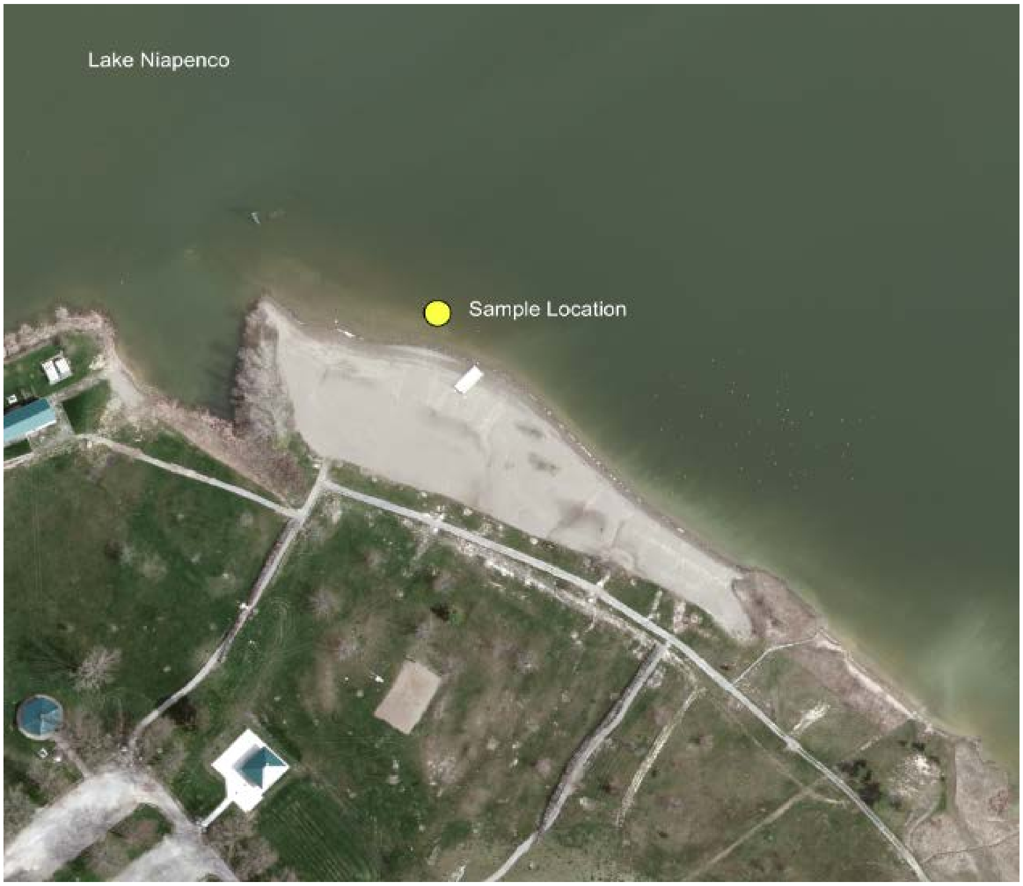

Figure 20: Lake Niapenco sampling location for PFAS.

Figure 21: Beach sampling for PFAS in Lake Niapenco.

The water chemistry results from Lake Niapenco indicated the present of PFOS at concentrations below Health Canada Provisional Drinking Water Guidelines (**Figure 22**). The concentration of PFOS generally matched the PFOS concentrations observed in previous NPCA sampling events. Several other PFCs were detected in the Lake Niapenco. These included Perfluorooctanoic acid (PFOA), Perfluorohexane Sulfonate (PFHxS), Perfluorohexanoic Acid (PFHxA) and Perfluoropentanoic Acid (PFPeA). These concentrations generally matched previous sampling event concentrations. The concentration of PFOA in Lake Niapenco was below Health Canada Provisional Drinking Water Guidelines. The other PFCs (PFHxS, PFHxA and PFPeA) have no drinking water guidelines.

Lake Niapenco was contaminated by historic PFAS usage from Hamilton International Airport (de Solla 2012 and Fowler 2011). The NPCA's monitoring at Binbrook Conservation Area continues to support the evidence that PFAS and specifically PFOS are present in Lake Niapenco but not at concentrations above Health Canada drinking water guidelines. It is expected that PFAS will continue to be present in Lake Niapenco due the persistence of PFAS in the environment. It should be noted that Hamilton Public Health has evaluated previous PFAS water quality data at Binbrook Conservation Area and determined that the PFAS concentrations detected would not adversely affect the park users. In addition, the NPCA will continue to work with Transport Canada and the Risk Assessment Team to fully understand the presence and distribution of PFAS in the Welland River downstream o the HIA.

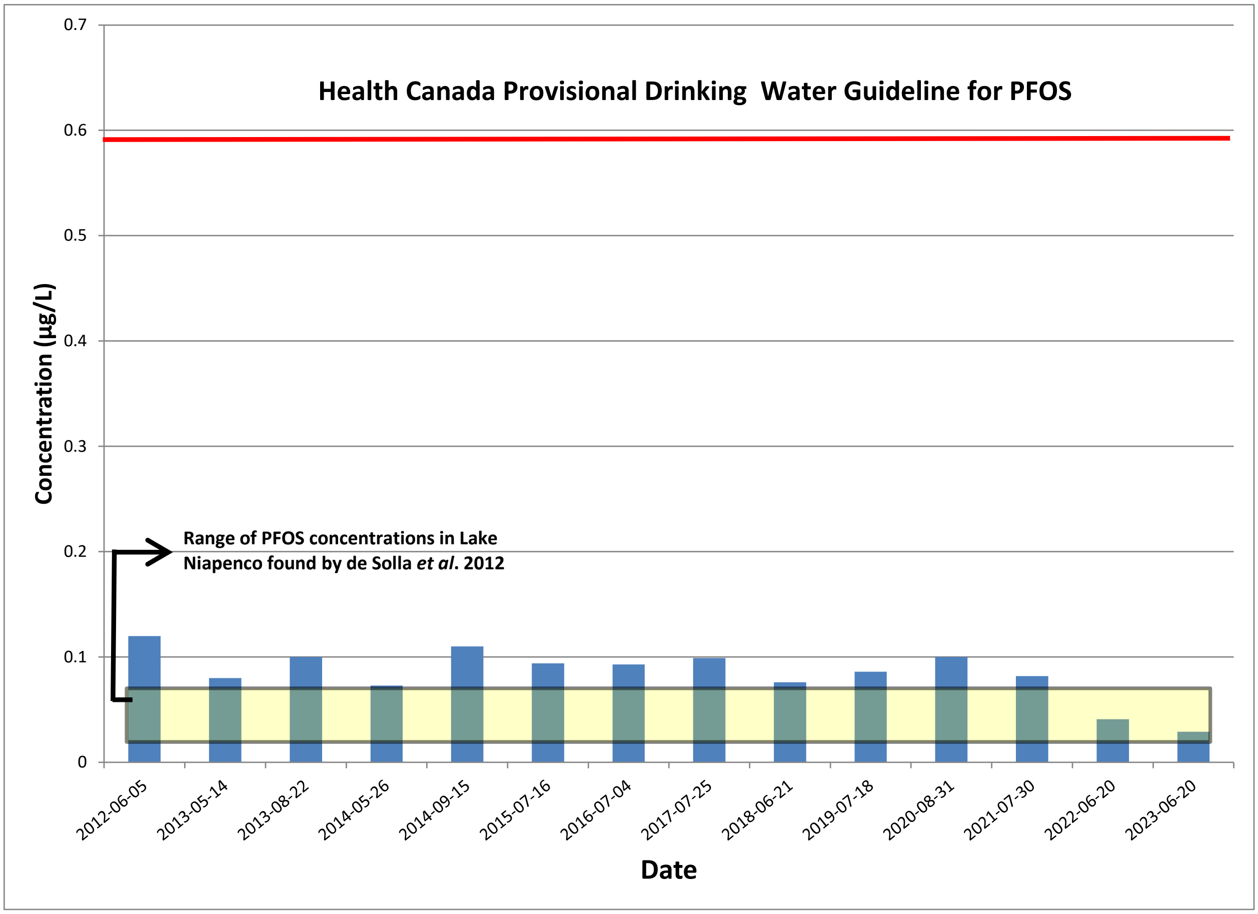

Figure 22: PFOS sampling results 2012-2023.

6.6 Canada Ontario Agreement Climate Change Monitoring Networks Review Project

A climate change sensitivity assessment completed by the MECP in 2009 identified the NPCA watershed as one of several southern Ontario watersheds that are highly vulnerable to the impacts of climate change. Indicators used in their analysis were related to water quality and quantity for both surface and groundwater resources. These indicators included frequency of low water levels, water use, water quality at active PWQMN stations, shallow well vulnerability, and baseflow. As a follow-up to this assessment, the NPCA conducted a detailed assessment in 2009-2010 of their existing monitoring networks and made specific recommendations for climate change detection and adaptation monitoring. Based on the NPCA and MECP assessments the existing monitoring station at Balls Falls Conservation Area was upgraded to an integrated monitoring site in 2015 which includes a rain gauge, soil moisture sensors and extended laboratory analysis for event sampling. The NPCA took 16 samples at this location in 2023.

6.7 Conservation Area Water Quality Monitoring

The NPCA Water Quality Monitoring Program was expanded in 2017 to include the waterbodies of the Conservation Areas: Dils Lake, Jordan Harbour, Lake Niapenco, Mud Lake, St. John's Pond, Virgil Reservoir, Wainfleet Wetlands and Wainfleet Bog. Water samples are collected quarterly or seasonally during the year and analyzed for general chemistry, nutrients, metals, and bacteria.

The water quality results for the NPCA Conservation Area locations are shown in **Appendix J**. Generally, the water quality observed in the Conservation Areas met environmental threshold values, but some exceedances were found. Total phosphorus exceeded the PWQO at most Conservation Areas, but Virgil Reservoir, Mud Lake and Wainfleet Bog had notably higher observed concentrations. The lentic Conservation Area environments (St. Johns, Binbrook, Mud Lake, Dils Lake and Virgil Reservoir) which have higher water temperatures, greater sunlight exposure, and reduced water flow are particularly vulnerable to excessive phosphorus concentrations which can stimulate the overgrowth and decomposition of plants and algae causing water quality concerns. There were chloride, copper, total suspended solids, and nitrate exceedances observed in Virgil Reservoir and these are likely due to the rural land uses, the proximity to Four Mile Creek Road and an abundance of carp in the reservoir. The pH of Wainfleet Bog also exceeded the lower threshold of the PWQO however this type of wetland is naturally acidic. This acidity is a by-product of microbial decay processes, cation exchange of the Sphagnum moss vegetation and input of additional acids from the atmosphere. Copper and zinc exceedances were observed at Wainfleet Bog main drainage ditch. This may be due past levels of atmospheric metal depositions that have accumulated in the peat soils and now being released in the surface water of the drainage ditch. The NPCA will continue to investigate the source of these metal exceedances.

6.8 Lower Twelve Mile Creek Total PCBs Monitoring

In 2020, MECP and City of St. Catharines had been investigating potential offsite impacts on surface water of Twelve Mile Creek from the former GM industrial area. To support agency partners, the NPCA has provided monthly samples (beginning September 2020) upstream and downstream of the former GM plant on 12 Mile Creek. This project included enhanced monitoring at the PWQMN station at Lakeport Road (TW009) and the reactivating a former monitoring site (TW011) at Welland Vale Road (See **Figure 23**). Samples collected are being analyzed for general chemistry, metals, nutrients, bacteria, and total PCBs.

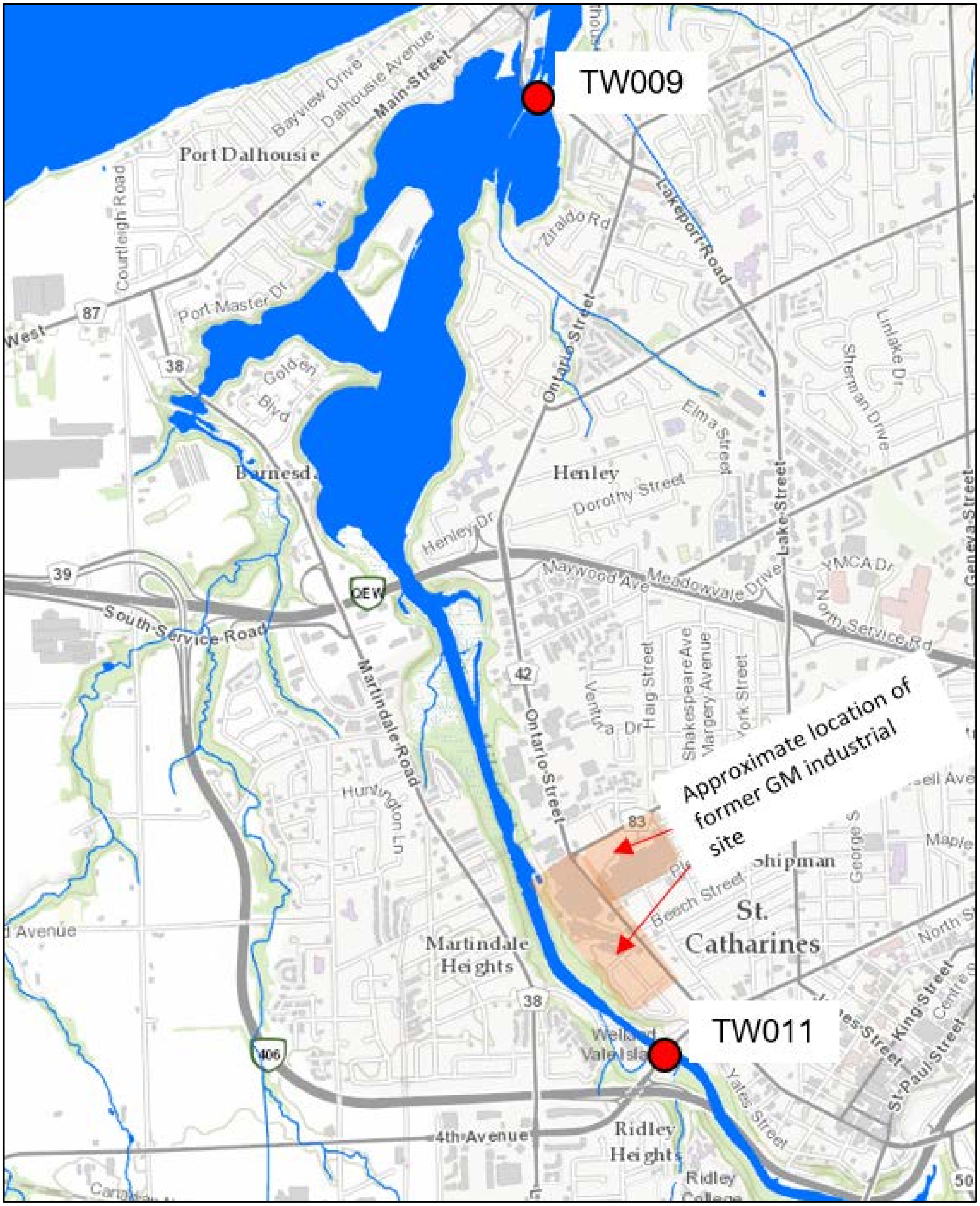

Figure 23: PCBs sampling locations in the Lower Twelve Mile Creek watershed.

Table 14: Twelve Mile Creek surface water quality laboratory results (2023) from upstream (TW011) and downstream (TW009) of the former GM industrial area.

NPCA Site ID	Date	Total PCBs ug/L	Aluminum mg/L	Alkalinity mg/L	Barium mg/L	Beryllium mg/L	Cadmium mg/L	Chloride mg/L	Cobalt mg/L	Conductivity uS/cm	Chromium mg/L	Copper mg/L	Escherichia Coli ct/100mL	Iron mg/L	Lithium mg/L	Magnesium mg/L	Manganese mg/L	Molybdenum mg/L	Sodium mg/L	Nickel mg/L	Nitrite mg/L	Nitrate mg/L	Total Phosphorus mg/L	Lead mg/L	pH	Silver mg/L	Titanium mg/L	Total Suspended Solids mg/L	Uranium mg/L	Vanadium mg/L	Zinc mg/L
PWQO/CWQG		**0**	**0.08**			**1.1**	**0.0002**	**120**				**0.01**	**100**	**0.3**				**0.04**		**0.025**	**0.06**	**2.93**	**0.03**	**0.01**	**6.5-8.5**			**30**	**0.005**	**0.006**	**0.03**
TW011	17-Jan-23	<0.060	0.108	103	0.025	<0.000020	0.0000059	21.2	<0.00010	310	5E-04	1E-03	450	0.14	0.001	9.47	0.004	0.001	13.2	1E-03	<0.010	0.126	0.0138	1E-04	8.12	<0.000010	0.002	<3.0	4E-04	<0.00050	<0.0030
TW009	17-Jan-23	<0.060	0.257	101	0.025	<0.0001	<0.0009	21.1	<0.0001	306	<0.0001	0.001		0.15	<0.005	8.58	0.004	<0.002	13.8	<0.002	0.004	0.21	0.017	<0.007	7.96	<0.0009	0.008	4.71	<0.003	<0.0005	0.007
TW011	13-Feb-23	<0.060	0.273	103	0.026	<0.000020	0.0000087	19.3	0.00014	312	5E-04	0.001	166	0.309	0.002	9.73	0.007	0.001	12	0.001	<0.010	0.228	0.0204	2E-04	8.35	<0.000010	0.006	5.3	4E-04	7E-04	0.004
TW009	13-Feb-23	<0.060	0.289	99.8	0.028	<0.0001	<0.0009	24.3	<0.0001	312	<0.0001	0.002		0.19	<0.005	9.02	0.007	<0.002	13.3	<0.002	0.005	0.31	0.025	<0.007	8.09	<0.0009	0.008	9.44	<0.003	6E-04	0.012
TW011	24-Apr-23	<0.1	0.13	113	0.02	<0.0005	<0.0001	20	<0.0002	249	<0.001	0.001	97	0.15	0.002	9	<0.01	<0.005	12	<0.005	<0.10	0.46	0.019	<0.001	8.1	<0.0001	<0.01	11	<0.001	<0.001	<0.01
TW009	24-Apr-23	<0.1	0.25	102.4	0.027	<0.0001	<0.0009	21.3	<0.0001	321	<0.001	0.001	81	0.12	0.009	9.34	0.01	<0.002	14.2	<0.002	0.007	0.54	0.0273	<0.007	8.1	<0.0009	0.006	12.5	<0.003	<0.0005	0.008
TW011	29-May-23	<0.1	0.07	105	0.02	<0.0005	<0.0001	17	<0.0002	238	<0.001	0.001	110	0.11	0.002	9	<0.01	<0.005	12	<0.005	<0.10	0.26	0.011	<0.001	8.21	<0.0001	<0.01	10	<0.001	<0.001	<0.01
TW009	29-May-23	<0.1	0.087	95.4	0.026	<0.0001	<0.0009	17.9	<0.0001	298	<0.001	0.002	114	0.126	0.009	8.92	0.01	<0.002	11.6	<0.002	0.004	0.32	0.0099	<0.007	8.25	<0.0009	0.002	14.2	<0.003	<0.0005	0.003
TW011	26-Jun-23	<0.1	0.116	92.1	0.024	<0.0001	<0.0009	17.3	<0.0001	283	<0.001	0.002	74	0.196	0.008	8.6	0.014	<0.002	11.6	<0.002	0.006	0.17	0.0248	<0.007	8.24	<0.0009	0.002	16.3	<0.003	<0.0005	0.005
TW009	26-Jun-23	<0.1	0.11	111	0.021	<0.0005	<0.0001	17.5	0.0002	224	<0.001	0.002		0.24	0.002	9	0.02	<0.005	11	<0.005	<0.1	0.15	0.018	0.001	8.12	<0.0001	<0.01	26	<0.001	0.001	0.01
TW011	24-Jul-23	<0.1	0.07	115	0.024	<0.0005	<0.0001	17.1	<0.0002	226	<0.001	0.001	230	0.1	0.002	9	0.01	<0.005	11	<0.005	<0.1	<0.1	0.017	<0.001	8.11	<0.0001	<0.01	11	<0.001	<0.001	<0.01
TW009	24-Jul-23	<0.1	0.105	93.2	0.025	<0.0001	<0.0009	16.6	<0.0001	282	<0.001	0.002	236	0.148	0.007	8.53	0.014	<0.002	11.4	<0.002	0.006	0.05	0.0457	<0.007	8.33	<0.0009	0.002	17.8	<0.003	<0.0005	0.005
TW011	30-Aug-23	<0.1	0.08	104	0.025	<0.0005	<0.0001	17.7	<0.0002	231	<0.001	0.001	67	0.13	0.002	8	0.01	<0.005	11	<0.005	<0.1	0.14	0.015	<0.001	8.14	<0.0001	<0.01	21	<0.001	<0.001	<0.01
TW009	30-Aug-23	<0.1	0.057	96.2	0.024	<0.0001	<0.0009	17.5	<0.0001	291	<0.001	0.002	98	0.103	<0.005	8.63	0.008	<0.002	11.4	<0.002	0.005	0.12	0.0181	<0.007	8.26	<0.0009	0.001	8.51	<0.003	<0.0005	0.006
TW011	13-Sep-23	<0.1	0.05	107	0.025	<0.0005	<0.0001	18.8	<0.0002	242	<0.001	<0.001	90	0.05	0.003	9	<0.01	<0.005	13	<0.005	<0.1	0.11	0.012	<0.001	8.01	<0.0001	<0.01	59	0.002	0.001	0.01
TW009	13-Sep-23	<0.1	0.036	97.1	0.024	<0.0001	<0.0009	18.7	<0.0001	291	<0.001	0.002	377	0.052	<0.005	8.71	0.008	<0.002	12.6	<0.002	0.005	0.12	0.0163	<0.007	8.21	<0.0009	0.001	4.72	<0.003	<0.0005	0.005
TW011	30-Oct-23	<0.1	0.06	107	0.024	<0.0005	<0.0001	17.6	<0.0002	237	<0.001	<0.001	230	0.08	0.002	8	<0.01	<0.005	11	<0.005	<0.1	<0.1	0.011	<0.001	8.14	<0.0001	<0.01	4	<0.001	<0.001	<0.01
TW009	30-Oct-23	<0.1	0.052	114.2	0.023	<0.0001	<0.0009	17.1	<0.0001	295	<0.001	5E-04	322	0.063	<0.005	8.32	0.008	<0.002	11.4	<0.002	0.005	0.15	0.0159	<0.007	8.17	<0.0009	0.001	5.16	<0.003	<0.0005	0.004
TW011	27-Nov-23	<0.1	0.11	109	0.024	<0.0005	<0.0001	17.6	<0.0002	241	<0.001	<0.001	140	0.09	0.002	9	<0.01	<0.005	12	<0.005	<0.1	0.18	0.011	<0.001	8.1	<0.0001	<0.01	3	<0.001	<0.001	<0.01
TW009	27-Nov-23	<0.1	0.13	112	0.025	<0.0005	<0.0001	17.5	<0.0002	241	<0.001	<0.001	50	0.16	0.002	9	0.01	<0.005	12	<0.005	<0.1	0.17	0.018	<0.001	8.03	<0.0001	<0.01	11	<0.001	<0.001	<0.01
TW011	06-Dec-23	<0.1	0.09	109	0.022	<0.0005	<0.0001	18.5	<0.0002	246	<0.001	0.001	90	0.13	0.002	9	0.01	<0.005	13	<0.005	<0.1	0.22	0.017	<0.001	8.02	<0.0001	<0.01	6	<0.001	<0.001	<0.01
TW009	06-Dec-23	<0.1	0.164	102.8	0.025	<0.0001	<0.0009	19.3	<0.0001	311	<0.001	0.002	n/a	0.262	<0.005	8.97	0.015	<0.002	12.3	<0.002	0.005	0.3	0.035	<0.007	8.22	<0.0009	0.002	17.2	<0.003	<0.0005	0.007

In 2023, most water quality observed met environmental thresholds. Exceedances were found in *E. coli* which could be due to human or animal sources. Exceedances in some metals and total phosphorus were observed which are from a combination of natural and anthropogenic sources. Aluminum routinely exceeded the PWQO which is likely due to the contribution of naturally elevated levels of aluminum found in the soils of the watershed. All total PCBs results for both sites were less than the laboratory detection in 2023. Based on the NPCA data there is not sufficient information to conclude that runoff from the former GM industrial area is impacting Twelve Mile Creek at Lakeport Road. The NPCA will continue to conduct water quality sampling at these stations in 2024 and provide data to support the investigation of potential offsite impacts of surface water of Twelve Mile Creek from the former GM industrial area.

6.9 NPCA Data Request

The NPCA Water Quality Monitoring Program generates a large wealth of scientific data that is a valuable resource to several clients. In 2023 the NPCA water quality monitoring program received 37 data requests from a variety of agencies and the public. These include:

- Ontario Ministry of the Environment Conservation and Parks
- Ontario Ministry of Natural Resources
- Academia (Brock University, University of Guelph, Niagara College)
- Environment and Climate Change Canada
- Municipalities (Upper and Lower Tier)
- Consultants
- Non-Governmental Agencies
- Public

7.0 NPCA Water Quality Monitoring Program 2023 in Review

7.1 Summary of findings

Canadian Water Quality Index Rating Summary

In 2023, 84 surface water stations were monitored, and 730 surface water samples were collected. Benthic macroinvertebrates were collected at 17 sites in 2023. Forty-one groundwater samples were collected. Seventeen water quality sensors were deployed by the NPCA.

Based on the Canadian Water Quality index for data from 2019-2023,

- 47.5% of sites are poor. This is down from 59% (2018-2022).
- 40% of sites are marginal. This is up from 31% (2018-2022).
- 10% of sites are fair. This is up from 9% (2018-2022).
- 2.5% of sites are good. This is up from 1% (2018-2022).
- 0% sites are rated excellent the same as in (2018-2022).

In general, WQI ratings remained relatively stable for the analysis of 2019-2023 compared to the pervious analysis of 2018-2022. Fifteen sites had improved WQI ratings while 3 sites decreased in WQI rating compared to 2018-2022.

Hilsenhoff Biotic Index Summary

Based on the Hilsenhoff Biotic Index (HBI),

- 25.7% of sites are very poor, down from 27.9% in (2018-2022).
- 42.9% of sites are poor, down from 45.6% in (2018-2022).
- 28.6% of sites are fairly poor, up from 23.5% in (2018-2022).
- 1.4% of sites are fair, down from 2.9% in (2018-2022).
- 1.4% of sites are good, up from 0% in (2018-2022).
- 0% sites are very good or excellent, the same as in (2018-2022).

Hilsenhoff Biotic Index ratings typically show significant impairment in the NPCA watershed. WQI and HBI do not always agree entirely in the impairment levels at each creek. This could be due in part to data set size, in-stream habitat availability, and taxonomic resolution.

Water Quality Parameter Summary

Total phosphorus exceedances are found at most NPCA water quality stations due to significant agricultural land use. Total phosphorus is the most common exceedance, and the magnitude of exceedances are the largest cause of impaired water quality ratings. Improvements in WQI ratings were seen in the Upper Welland River and Twenty Mile Creek watersheds largely due to decreased in total phosphorus and total suspended solids.

Exceedances in *E. coli* also contribute greatly to poor water quality ratings in Niagara. Approximately 60% of stations have a median concentration of *E. coli* greater than the PWQO. The NPCA has initiated DNA track down investigations in watercourses with high magnitude *E. coli* exceedances. Two Mile Creek, in the town of Niagara-on-the-Lake, was found to have high concentrations of human source *E. coli*. The Town is working to implement infrastructure upgrades to eliminate the source. The NPCA will continue to work with municipalities to identify *E. coli* sources.

Increases in chloride concentrations were found in several Lake Ontario tributaries including Twelve Mile Creek. Chloride exceedances are mainly related to road salt impacts to surface water from urban runoff as the main source.

Exceedances for metals (copper, lead, and zinc), nitrate, and total suspended solids were uncommon in the NPCA watershed. Elevated copper exceedances in Richardsons Creek (St. Catharines) and Eighteen Mile Creek (Lincoln) warrants further investigation. Nitrate exceedances in the Richardson Creek and the upper Twelve Mile Creek may be related nearby commercial operations in the area. Total suspended solids are mainly related wet weather events and inadequate riparian buffers along watercourses.

Groundwater Quality Summary

Most NPCA groundwater monitoring wells exceeded 20 mg/L ODWS for sodium which is a health-related concern for individuals with sodium restricted diets. A small number of wells were found to have ODWS exceedances in arsenic, boron, fluoride, nitrate, and uranium. In addition, ambient groundwater geochemistry across the NPCA was found to have elevated levels of sulfate, iron, manganese, and chloride that exceed the Aesthetic ODWS. ODWS exceedances have been investigated by MECP and Public Health Units and are attributed to natural conditions of the groundwater or in the case of nitrate a local source. It is recommended that watershed residents using groundwater test their water regularly and treat water appropriately.

Data Users

The NPCA Water Quality Monitoring Program continues to generate a large wealth of scientific data that is a valuable resource to the public, environmental consultants, community groups, educational institutions, and other governmental agencies. In 2023, the NPCA processed 39 data requests for a variety of environmental monitoring data to assist its partners.

7.2 Recommendations

The following recommendations are based on the NPCA Water Quality Monitoring Report for 2023:

1. It is recommended that the NPCA continue to monitor water quality to collect up-to-date and reliable water quality data. The NPCA should continue to make this information freely accessible to the public.

2. It is recommended that the NPCA analyze water quality data collected to identify significant trends and abnormalities. This includes following up and investigating anomalies in water quality results.

3. It is recommended that the NPCA continue to work with our partner municipalities and the MECP to identify and mitigate abnormally high sources of water pollution as they are identified through the Water Quality Monitoring field sampling program.

4. It is recommended that the NPCA continue to monitor summer water temperatures for the upper Twelve Mile Creek sampling stations to classify their thermal regimes and to identify any changes to the thermal stability of this watershed.

5. It is recommended that the NPCA continue to undertake annual water quality assessments for the Hamilton International Airport and the City of Hamilton’s Glanbrook Landfill (both presently commissioned and funded by the City of Hamilton). The NPCA will pursue additional fee-for-service environmental monitoring for its partners.
6. It is recommended that the NPCA continue to offer the ‘Water Well Decommissioning Program’ to the public to help reduce the risk of groundwater contamination by removing old and abandoned wells.

7. As it is no longer typical to have watercourses completely frozen from December to March, it is recommended that the NPCA continue to pursue opportunities to expand the surface water quality monitoring program outside of the months of April to November to address water quality data gaps which presently exist for the winter months.

8. It is recommended that the NPCA continue to monitor Per- and polyfluoroalkyl substances in Lake Niapenco to provide the public with annual reporting information. Yearly surveillance is an appropriate time interval for monitoring based on lab analysis costs and contaminant variability and concentrations. It is also recommended that NPCA continue to partner and share information with Transport Canada and the Risk Assessment Team to fully understand the presence and distribution of PFAS in the Welland River downstream of the HIA.

9. It is recommended that the NPCA continue to support and MECP Climate Change project for Twenty Mile Creek at Balls Falls Conservation Area by continuing to operate and maintain this enhanced monitoring station.

10. NPCA Water Quality Monitoring Program will monitor to support internal corporate programs such as Conservation Area Management Plans. This includes, but is not limited to, surface water and benthic surveys within NPCA Conservation Areas.

11. NPCA should transition to an integrated monitoring program. An integrated monitoring program would measure a variety of environmental conditions, such as hydrometric, groundwater, terrestrial in addition to water quality monitoring. This would further serve the strategic priorities set out by the NPCA in the Strategic Plan (2021-2031). Specifically, these include Healthy and Climate Resilient Watersheds, and Supporting Sustainable Growth.

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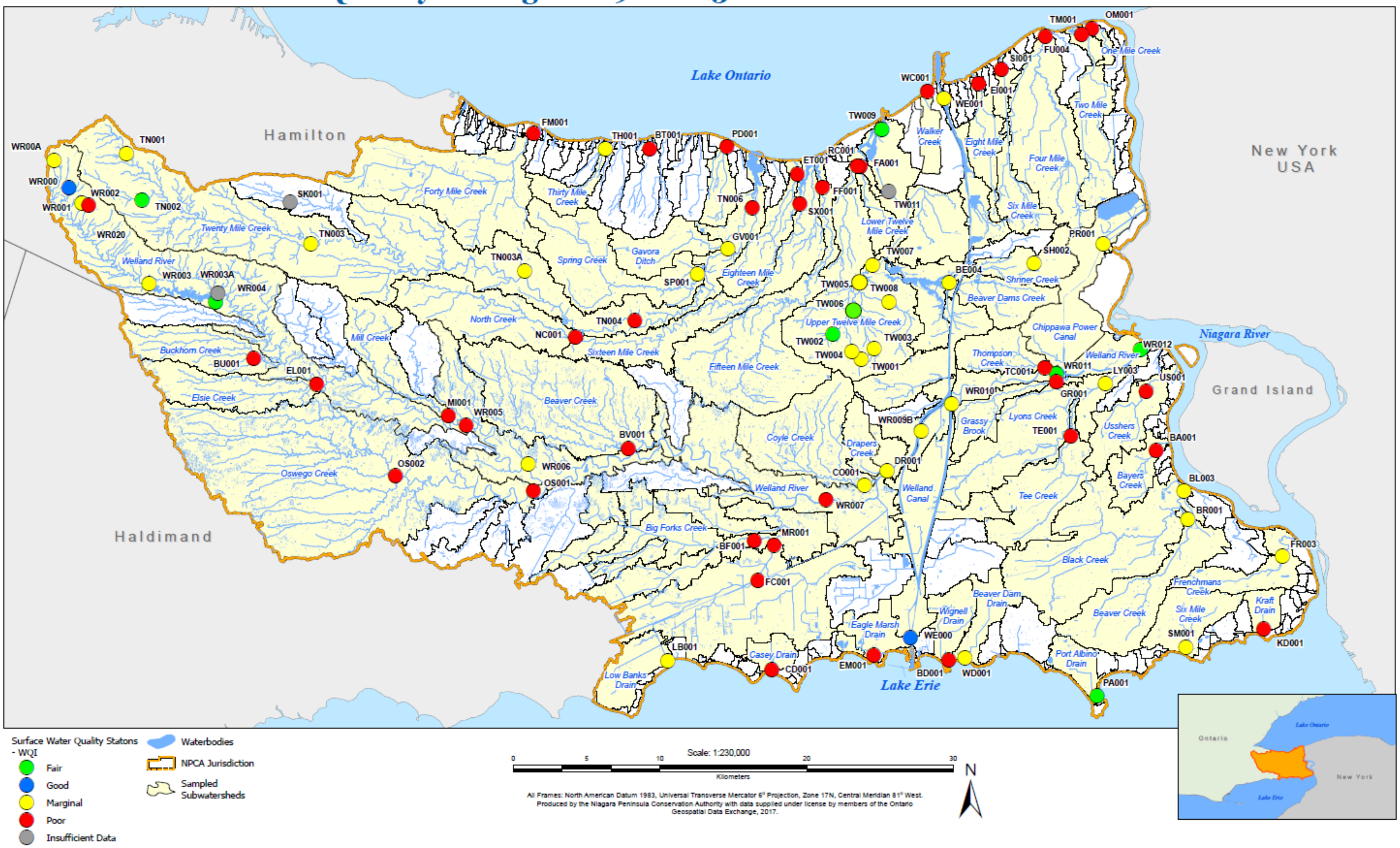
Appendix A

Water Quality Index Ratings 2019-2023

Niagara Peninsula CONSERVATION nature for all

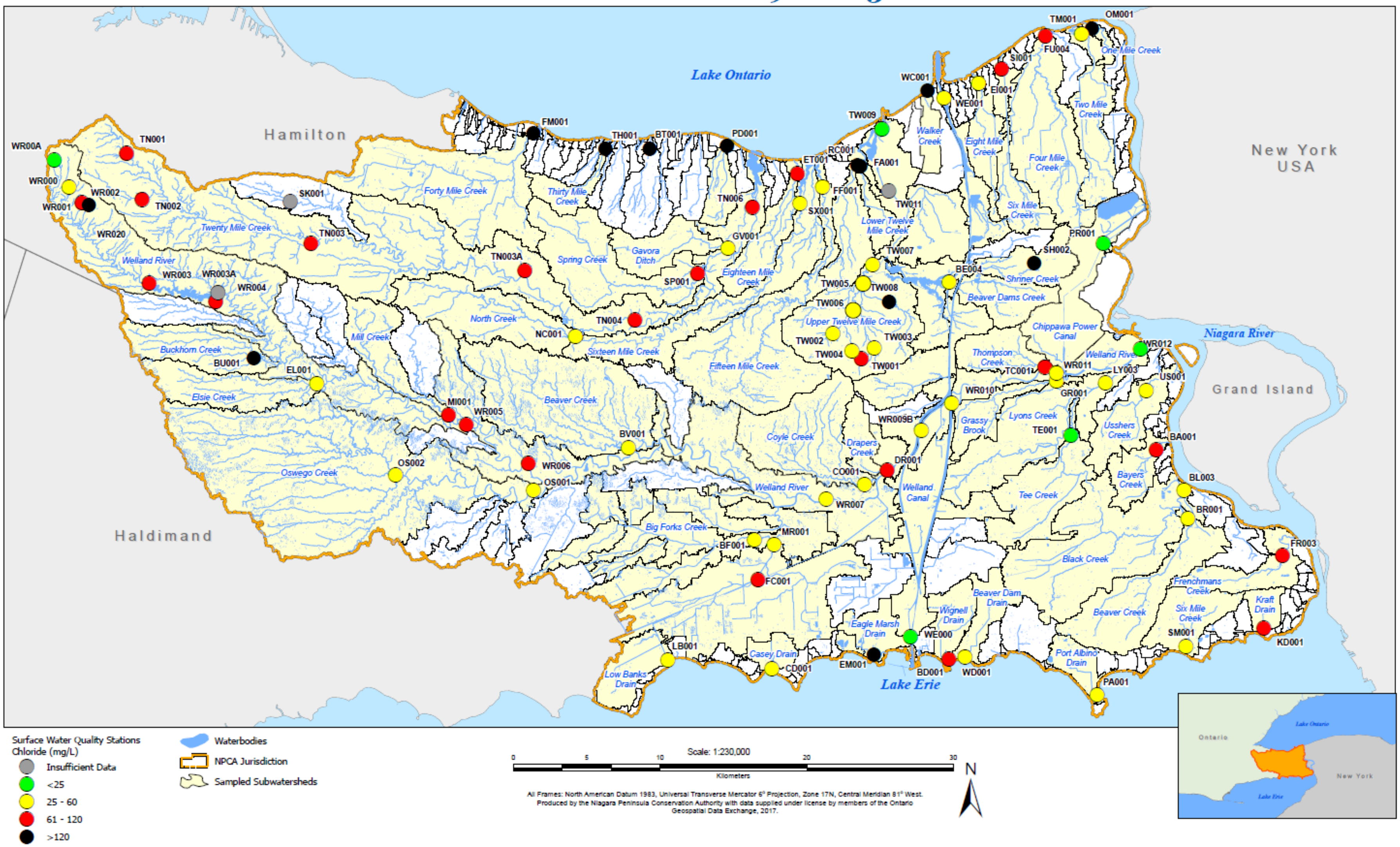
Niagara Peninsula Conservation Authority
Water Quality Ratings 2019 - 2023



Appendix B

Water Quality Indicator Median Concentrations Maps 2019-2023

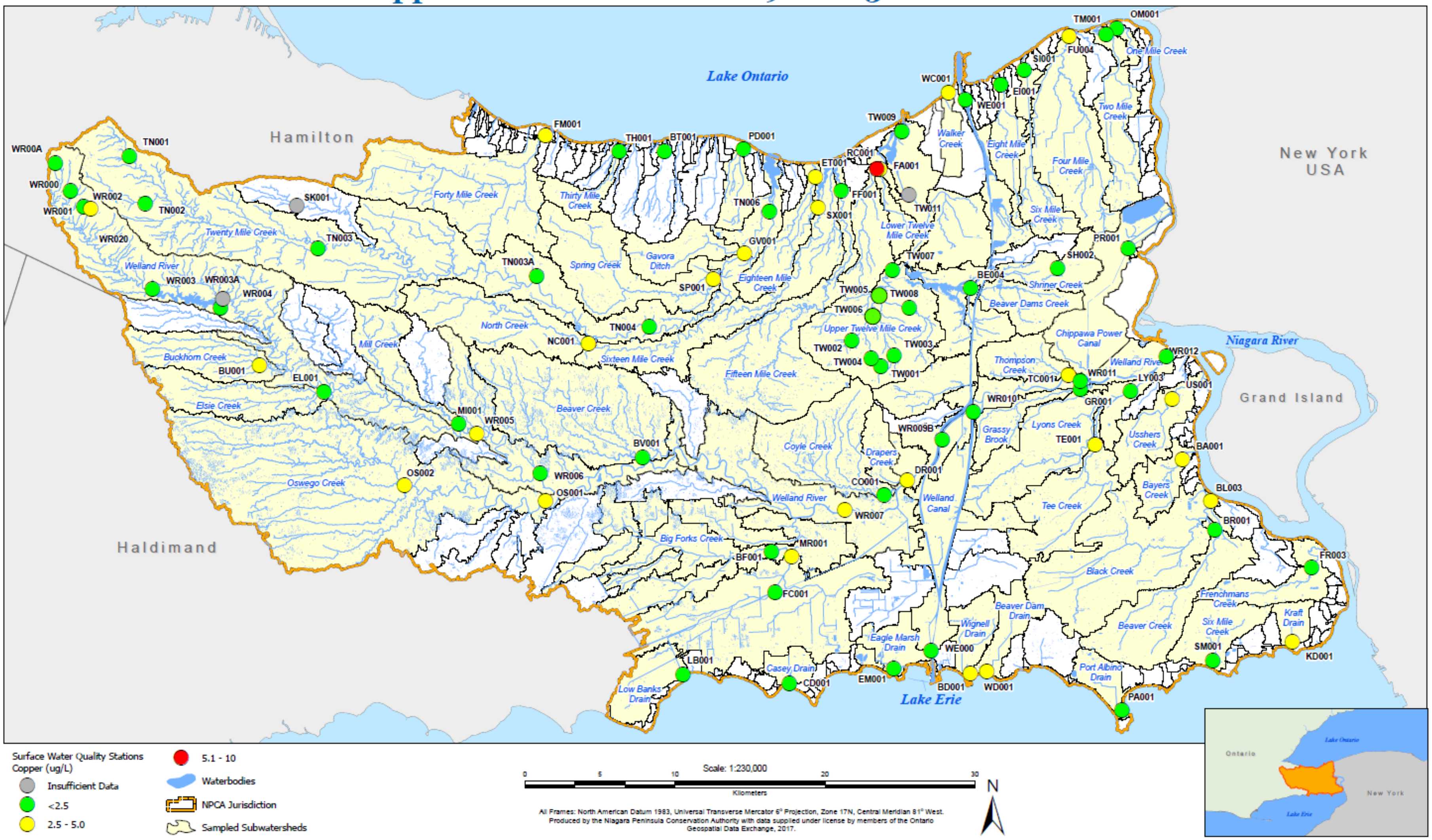
Niagara Peninsula Conservation Authority
Median Chloride Concentrations 2019 - 2023



All Frames: North American Datum 1983, Universal Transverse Mercator 6° Projection, Zone 17N, Central Meridian 81° West. Produced by the Niagara Peninsula Conservation Authority with data supplied under license by members of the Ontario Geospatial Data Exchange, 2017.

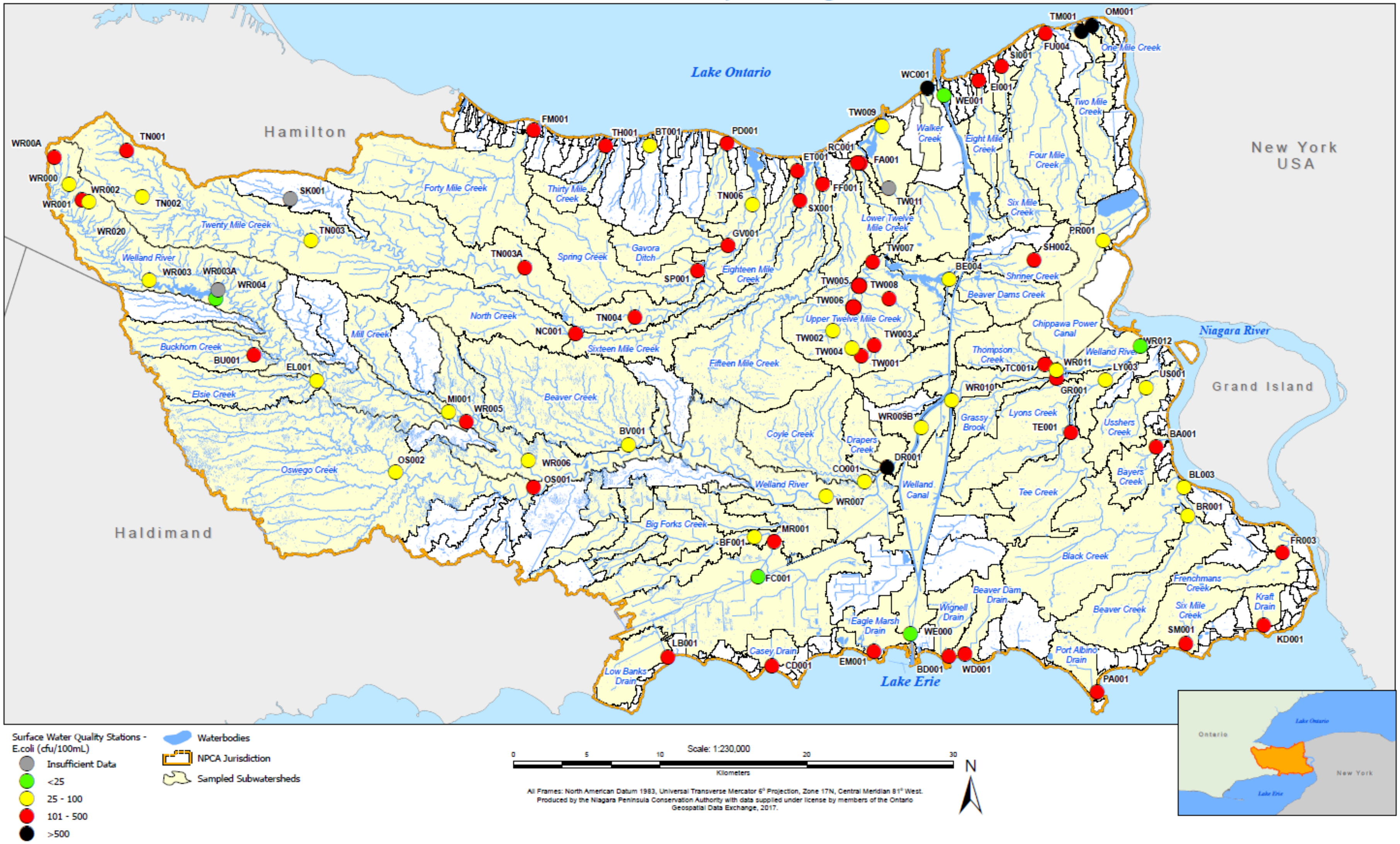
Niagara Peninsula CONSERVATION nature for all

Niagara Peninsula Conservation Authority
Median Copper Concentrations 2019 - 2023

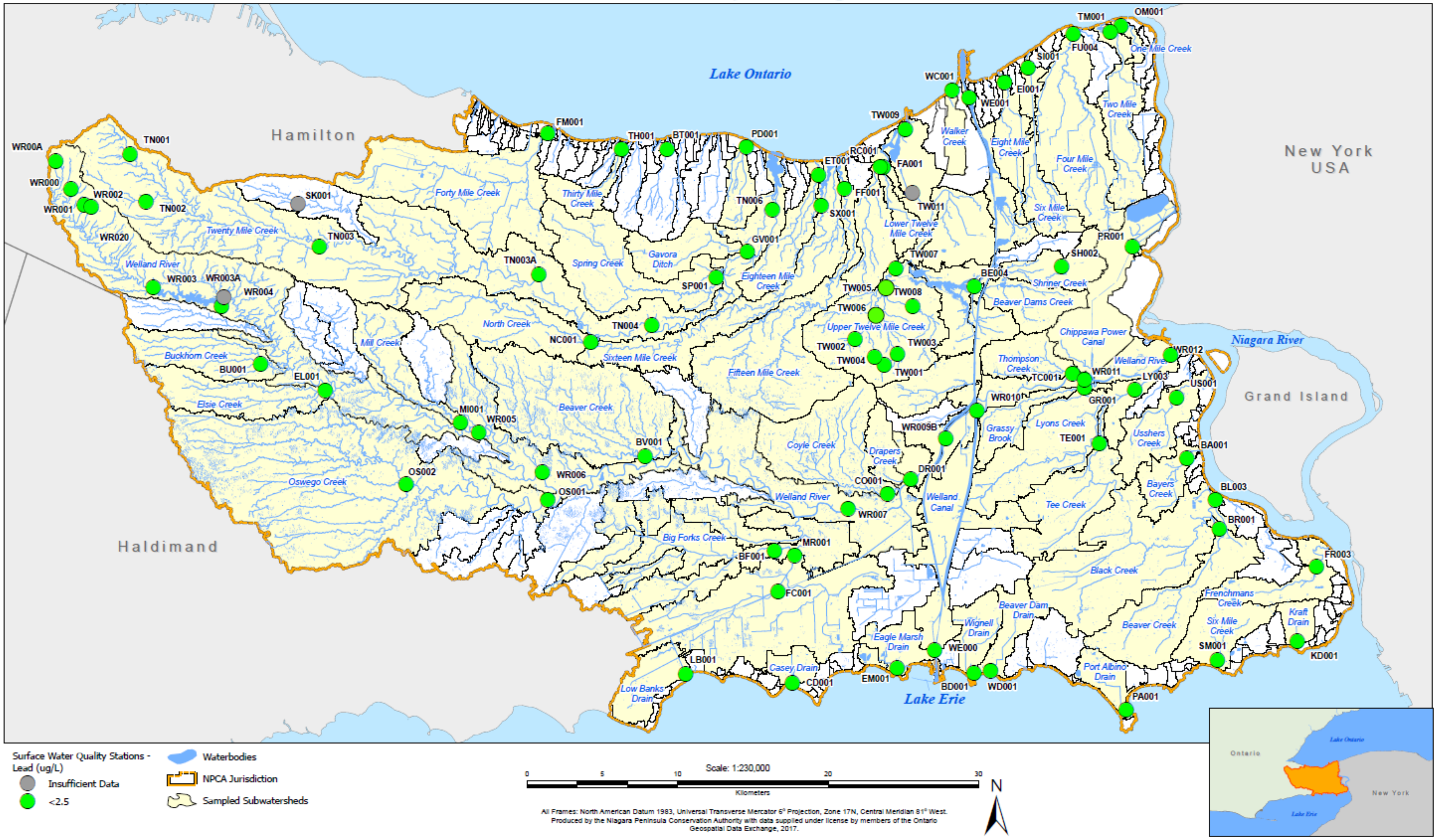


Niagara Peninsula CONSERVATION nature for all

Niagara Peninsula Conservation Authority
Median E.coli Concentrations 2019 - 2023

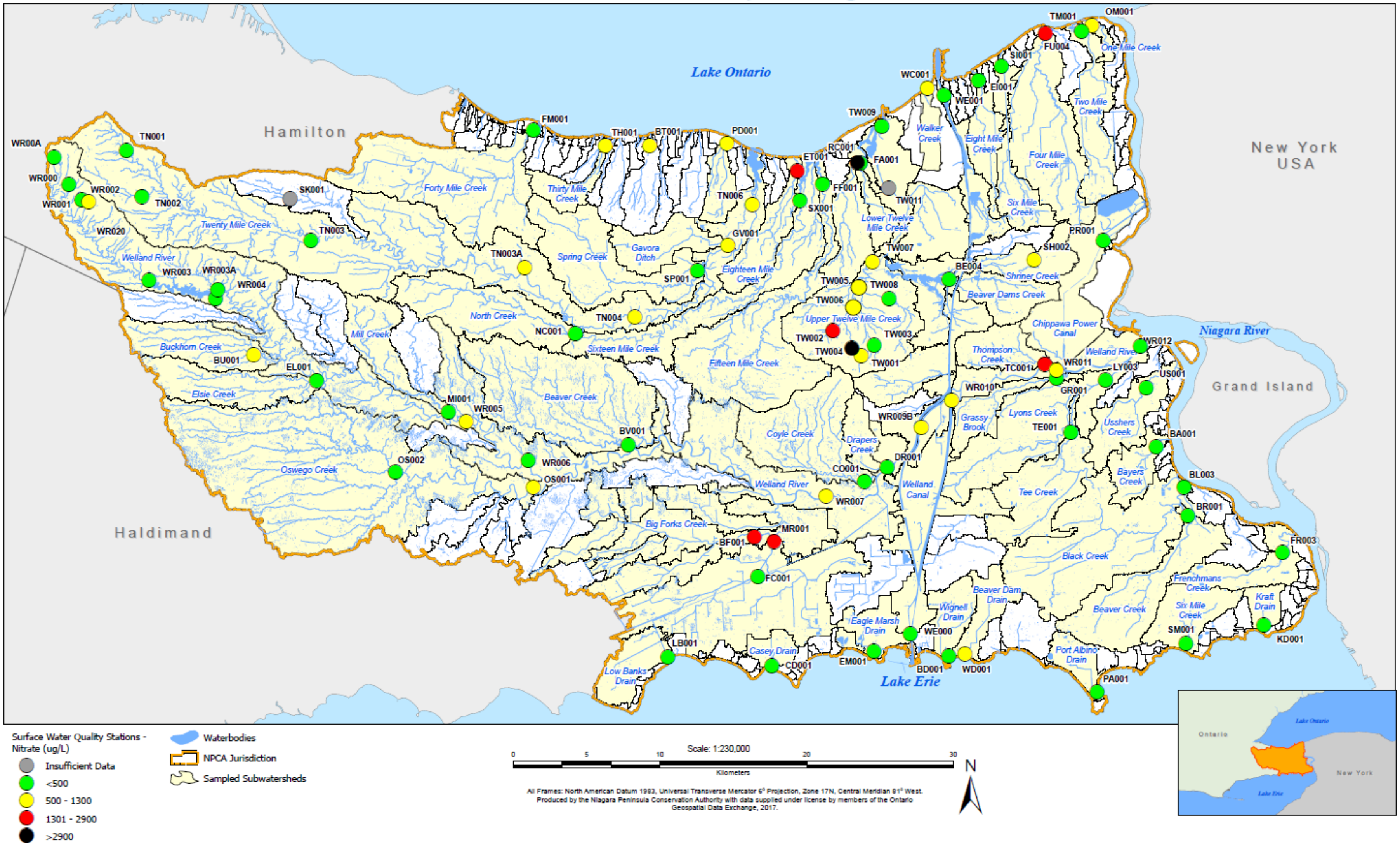


Niagara Peninsula Conservation Authority
Median Lead Concentrations 2019 - 2023

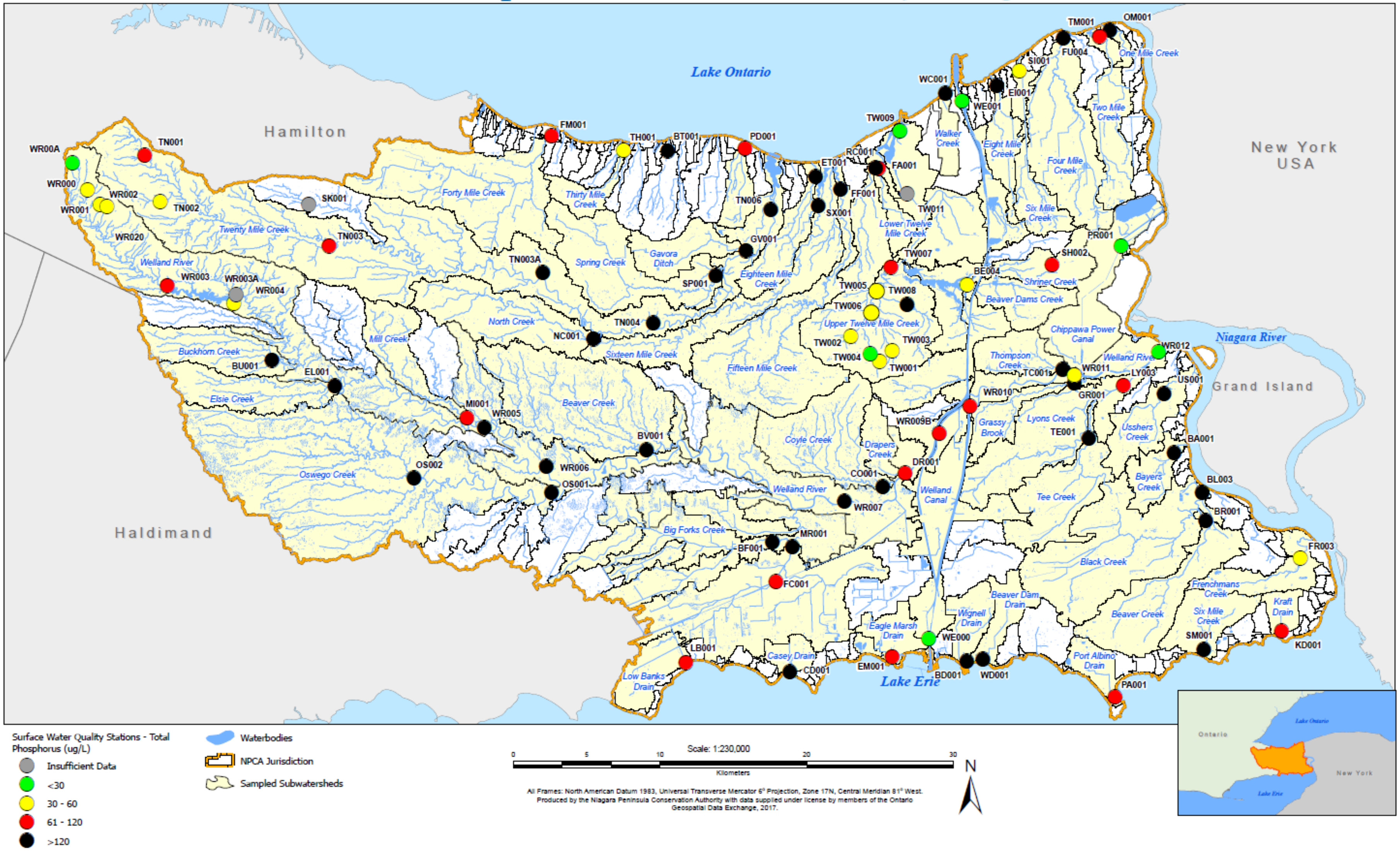


Niagara Peninsula CONSERVATION nature for all

Niagara Peninsula Conservation Authority
Median Nitrate Concentrations 2019 - 2023

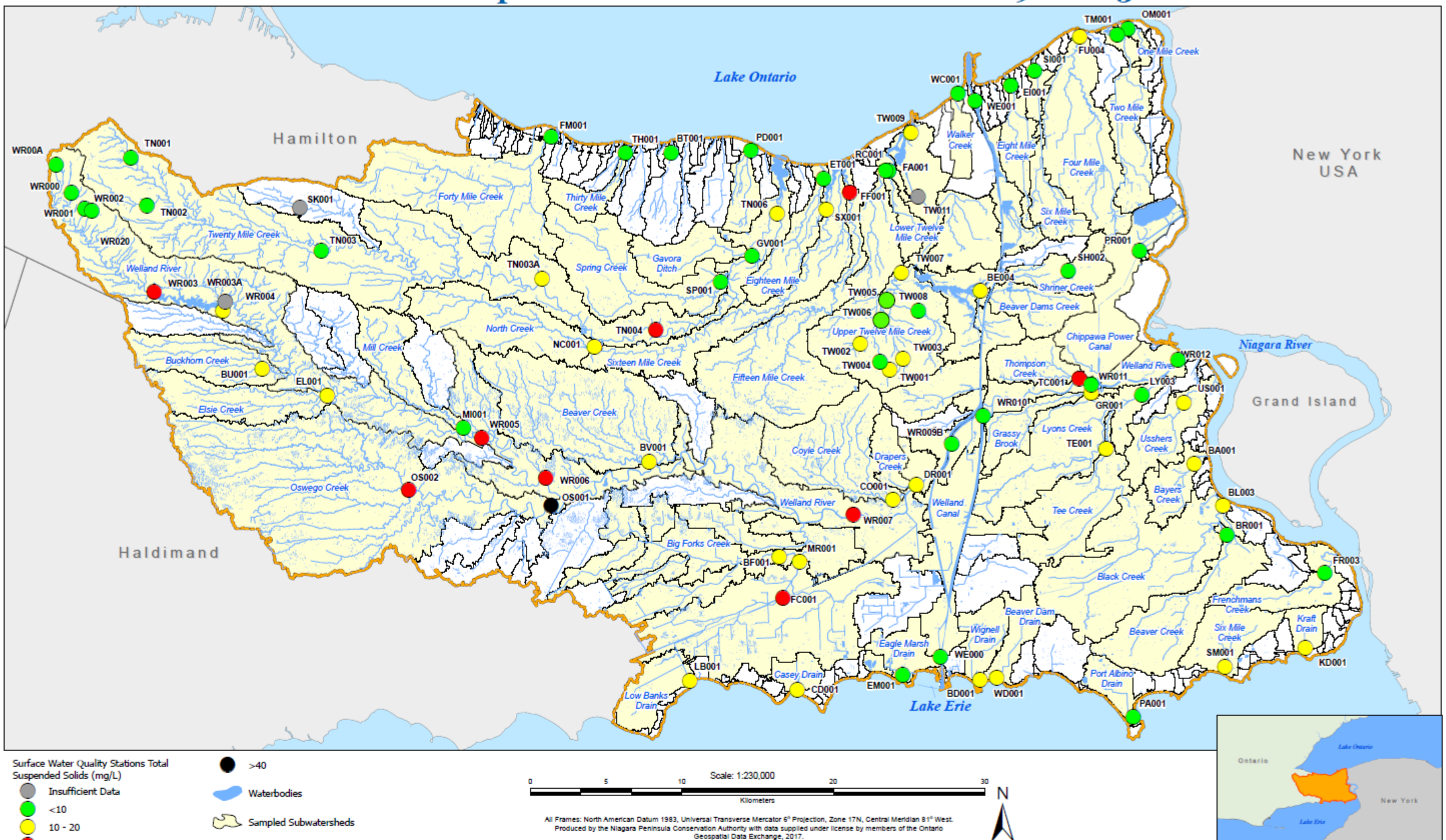


Niagara Peninsula Conservation Authority
Median Total Phosphorus Concentrations 2019 - 2023

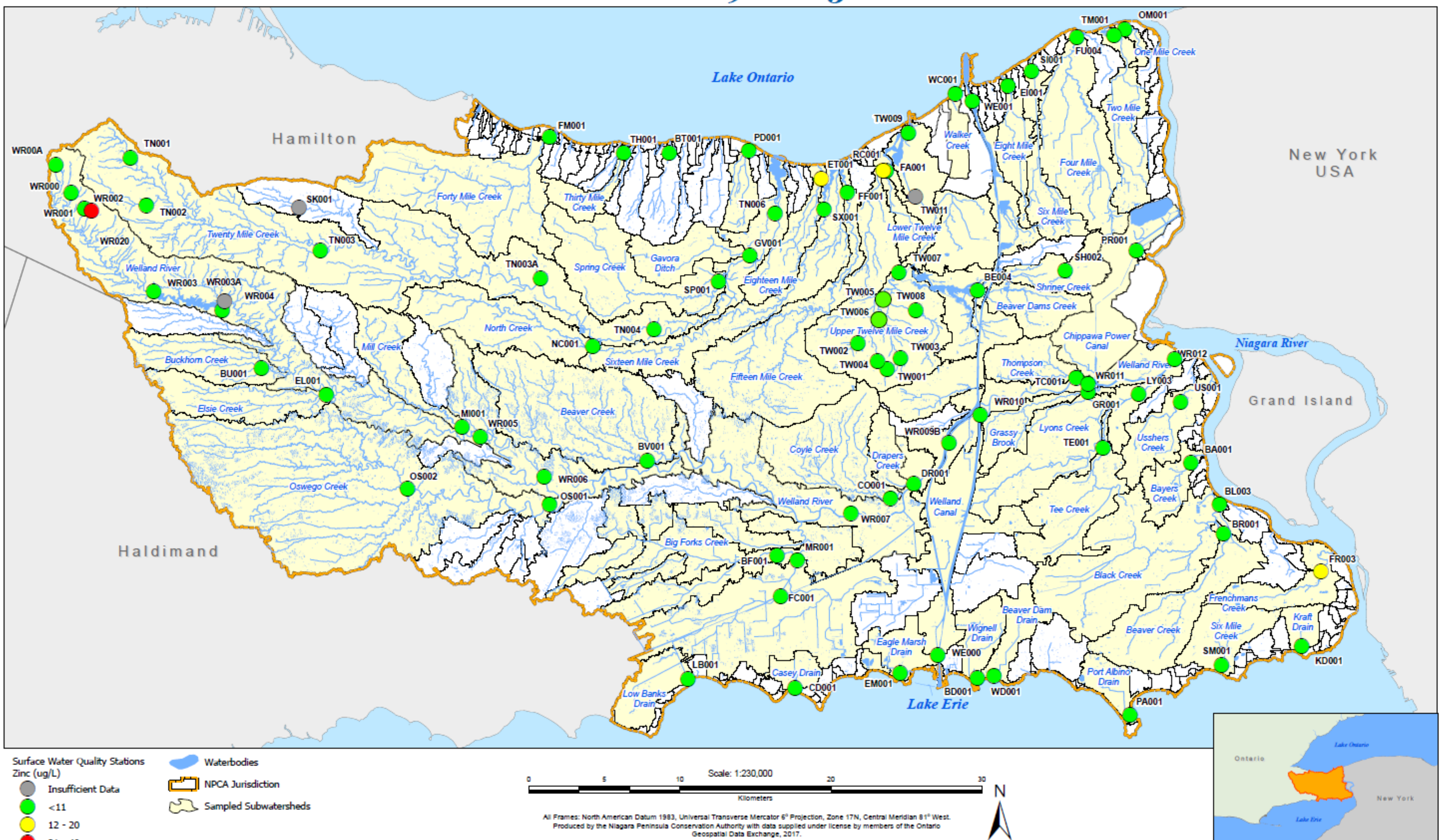


Niagara Peninsula CONSERVATION nature for all

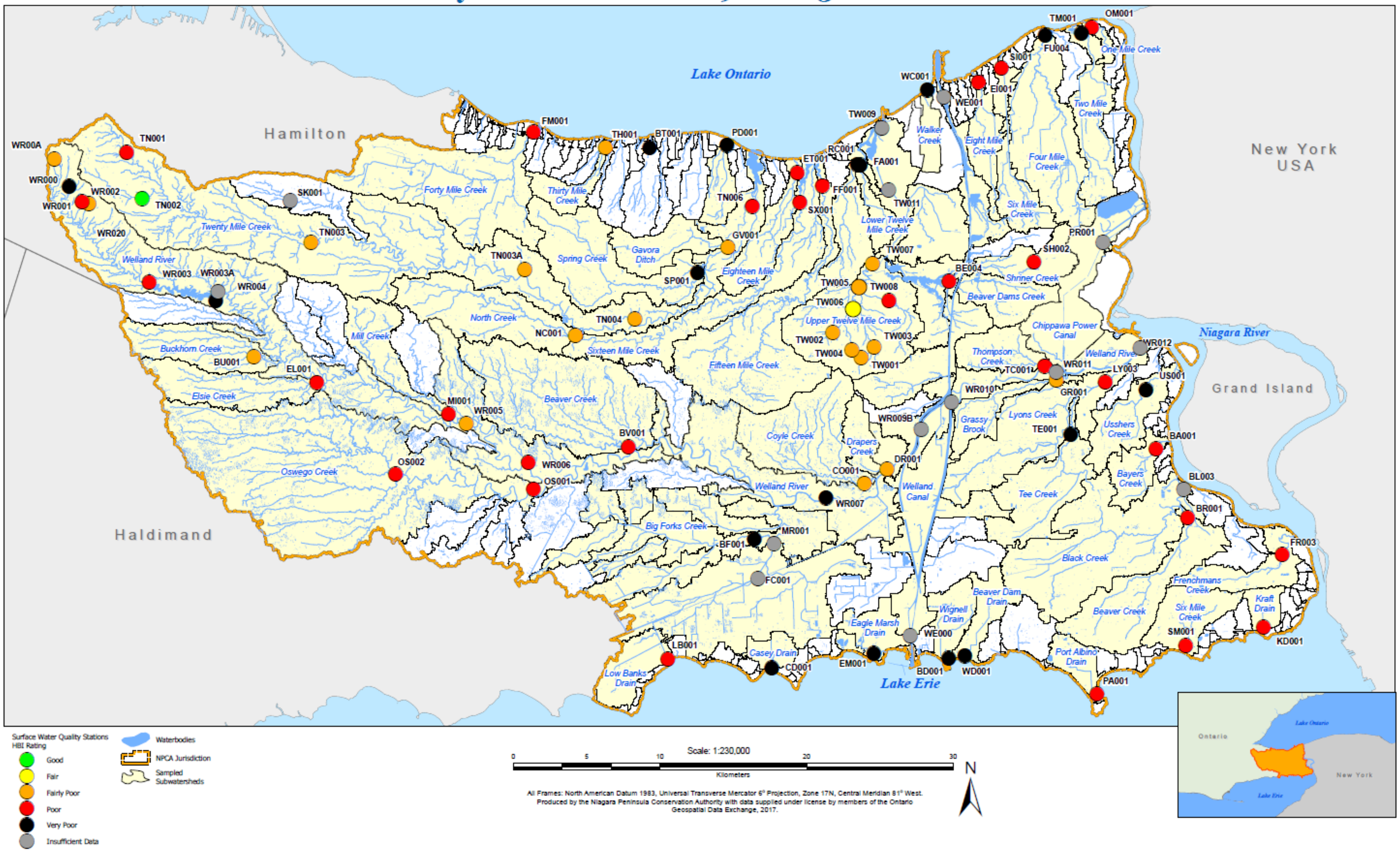
Niagara Peninsula Conservation Authority
Median Total Suspended Solids Concentrations 2019 - 2023



Niagara Peninsula Conservation Authority
Median Zinc Concentrations 2019 - 2023

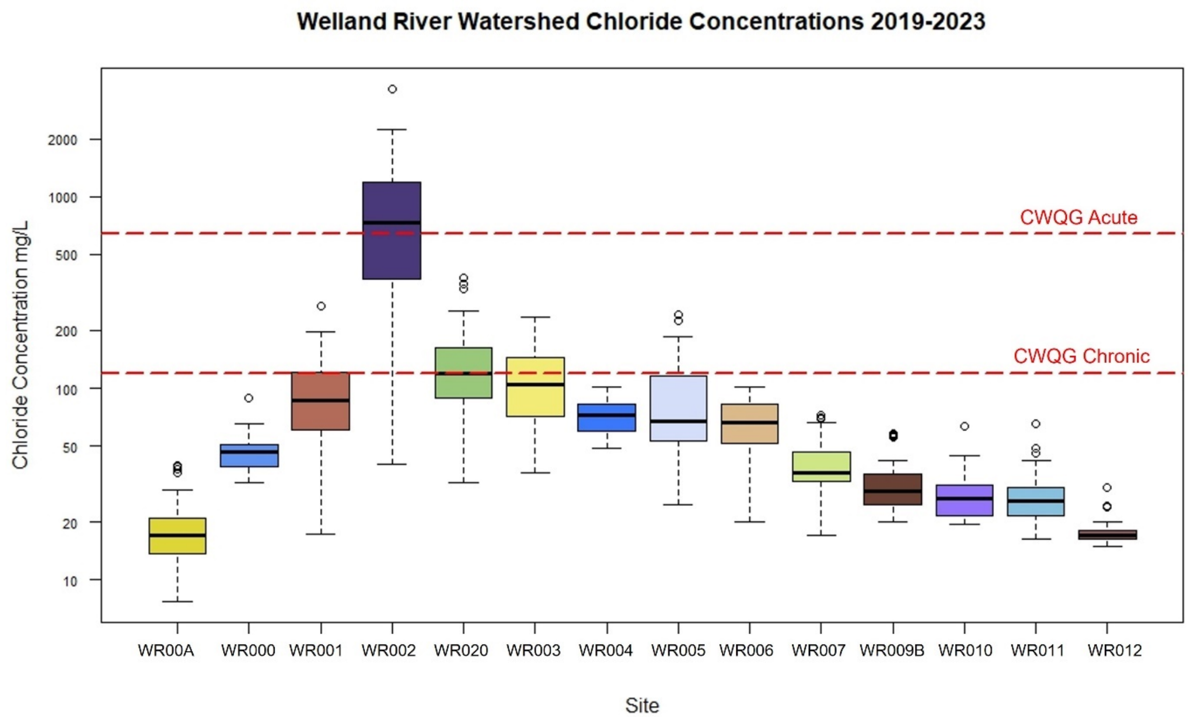


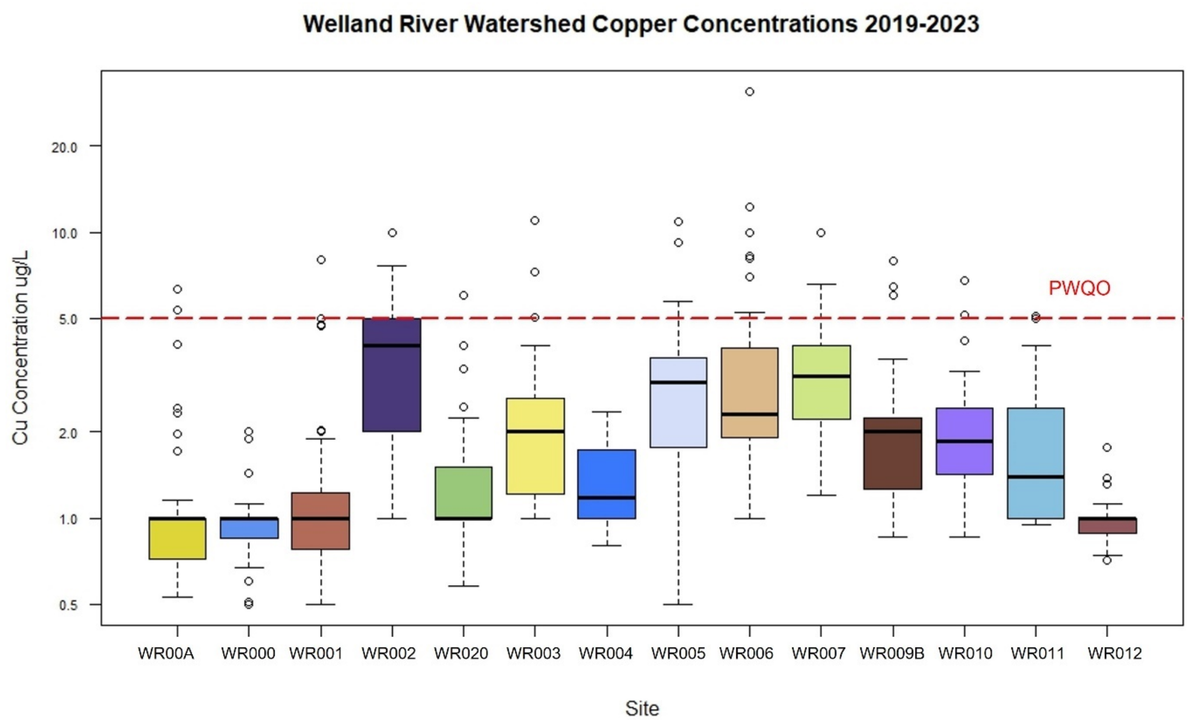
Niagara Peninsula Conservation Authority
Hilsenoff Family Biotic Index 2019 - 2023

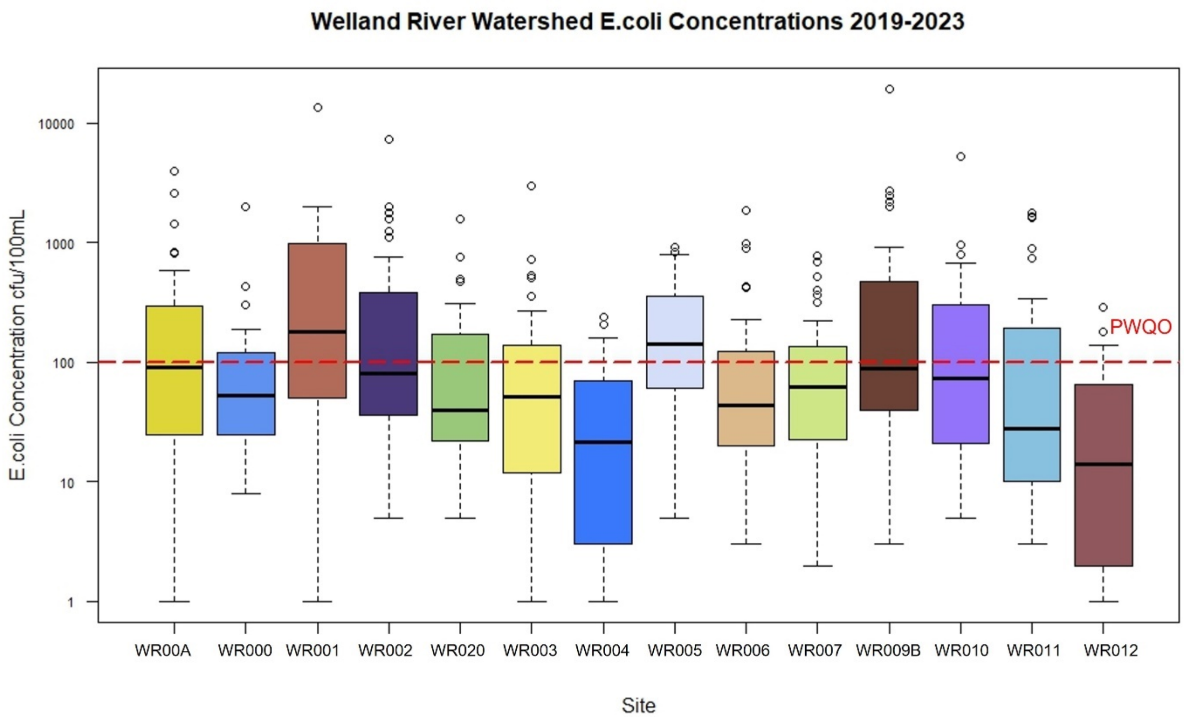


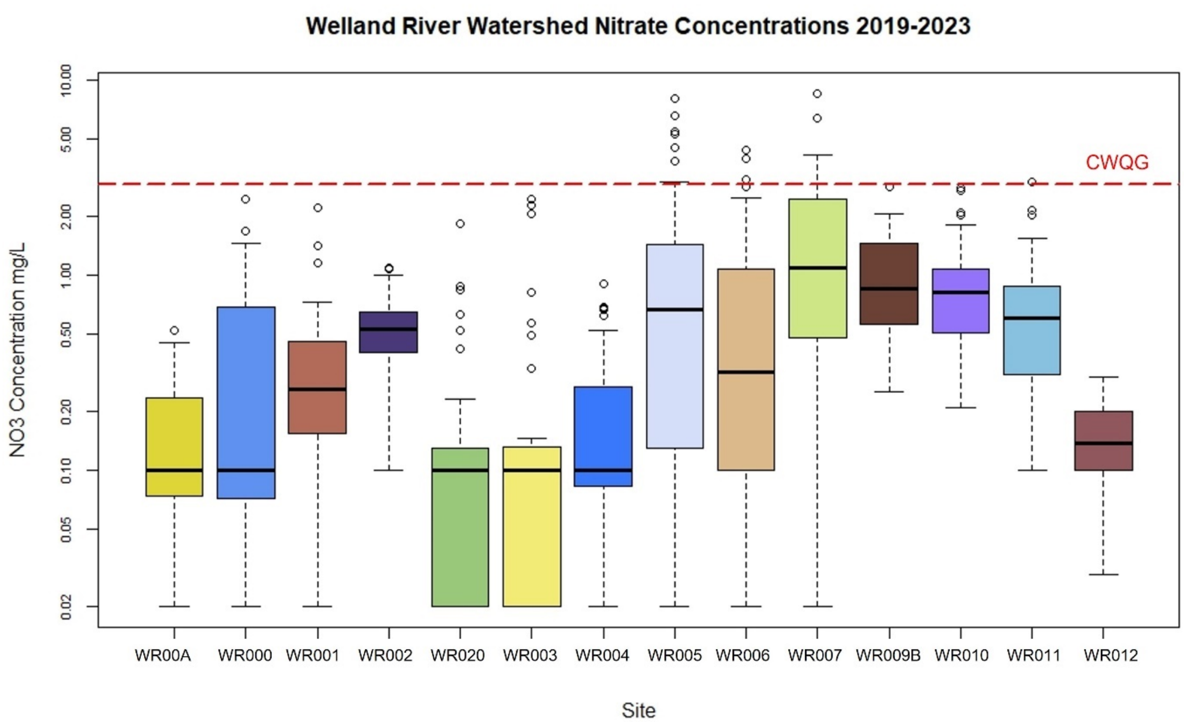
Appendix C

Welland River Watershed Indicator Parameter Boxplot Summaries 2019-2023

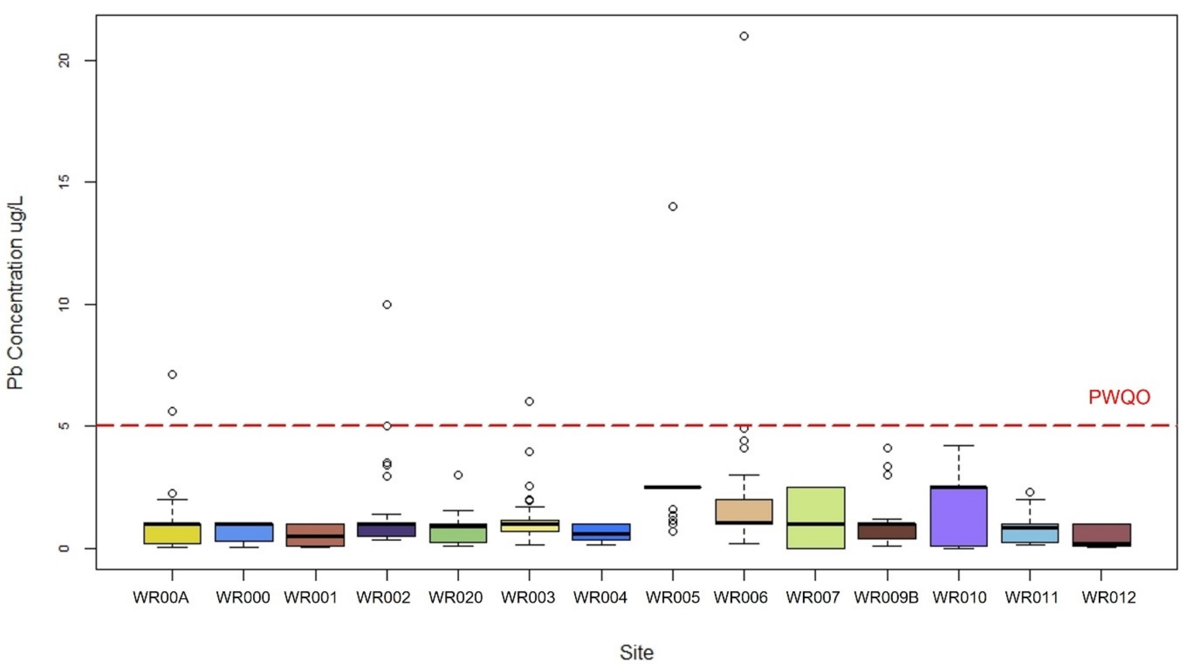

Welland River Watershed Chloride Concentrations 2019-2023
Chloride Concentration mg/L
2000
1000
500
200
100
50
20
10
CWQG Acute
CWQG Chronic
WR00A WR000 WR001 WR002 WR020 WR003 WR004 WR005 WR006 WR007 WR009B WR010 WR011 WR012
Site


Welland River Watershed Copper Concentrations 2019-2023
Cu Concentration ug/L
20.0
10.0
5.0
2.0
1.0
0.5
PWQO
WR00A WR000 WR001 WR002 WR020 WR003 WR004 WR005 WR006 WR007 WR009B WR010 WR011 WR012
Site

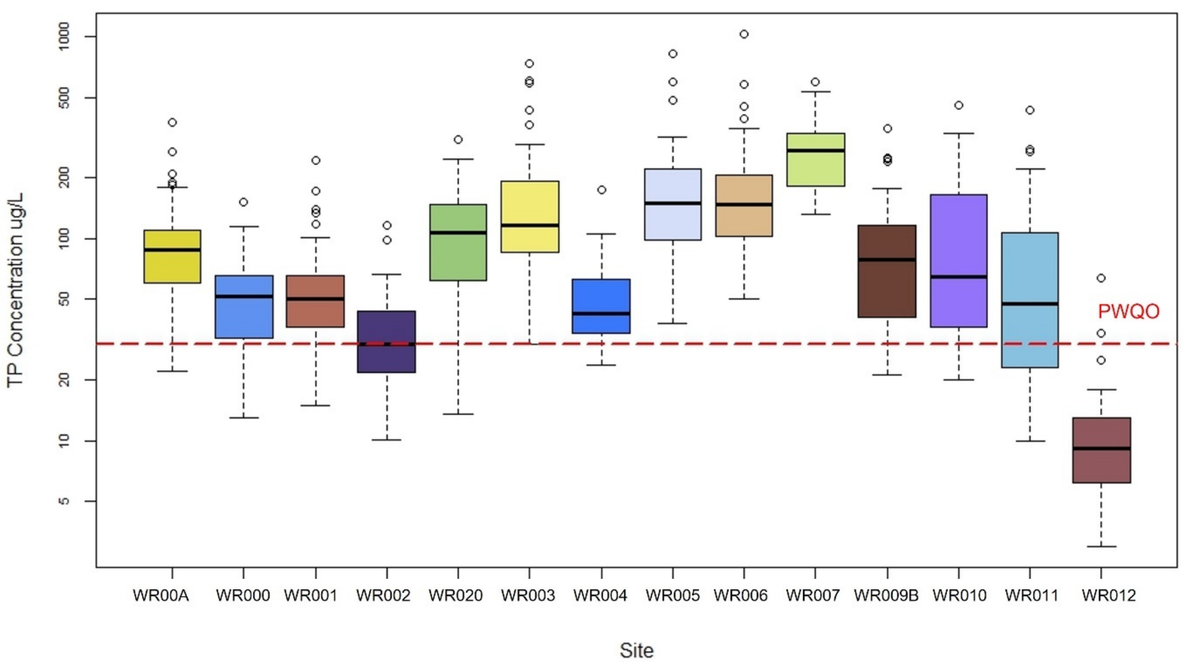

Welland River Watershed E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
10000
1000
100
10
1
PWQO
WR00A
WR000
WR001
WR002
WR020
WR003
WR004
WR005
WR006
WR007
WR009B
WR010
WR011
WR012
Site

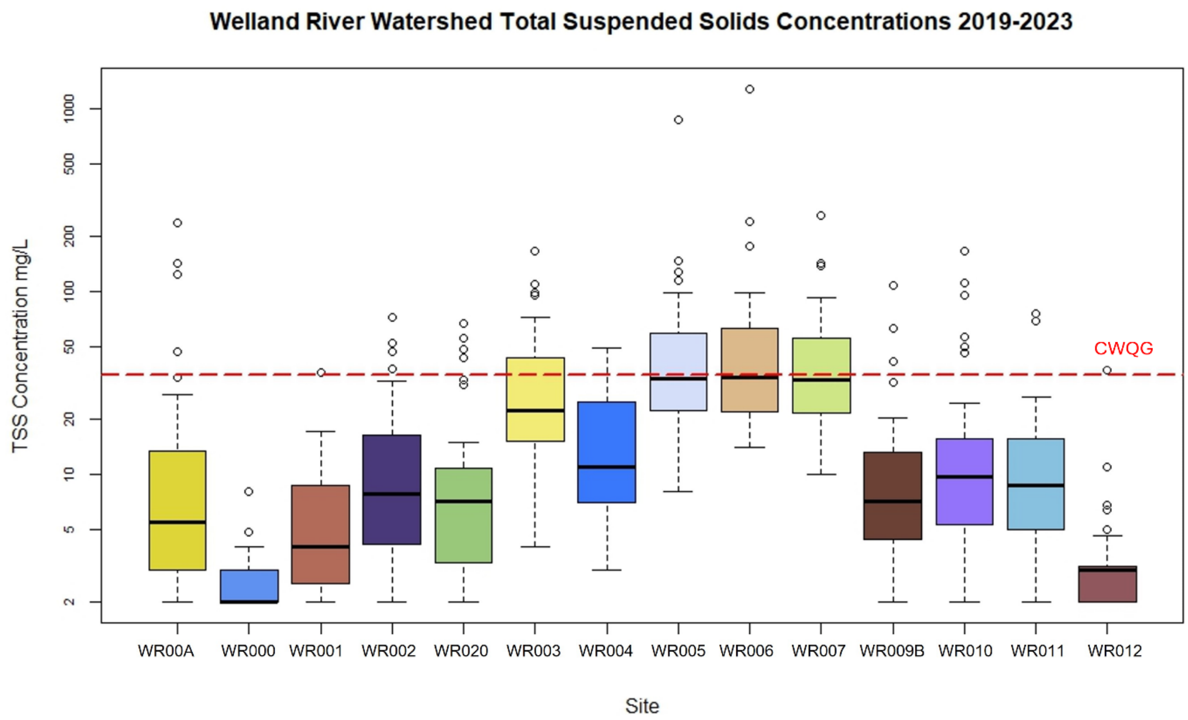

Welland River Watershed Nitrate Concentrations 2019-2023
NO3 Concentration mg/L
10.00
5.00
2.00
1.00
0.50
0.20
0.10
0.05
0.02
CWQG
WR00A
WR000
WR001
WR002
WR020
WR003
WR004
WR005
WR006
WR007
WR009B
WR010
WR011
WR012
Site

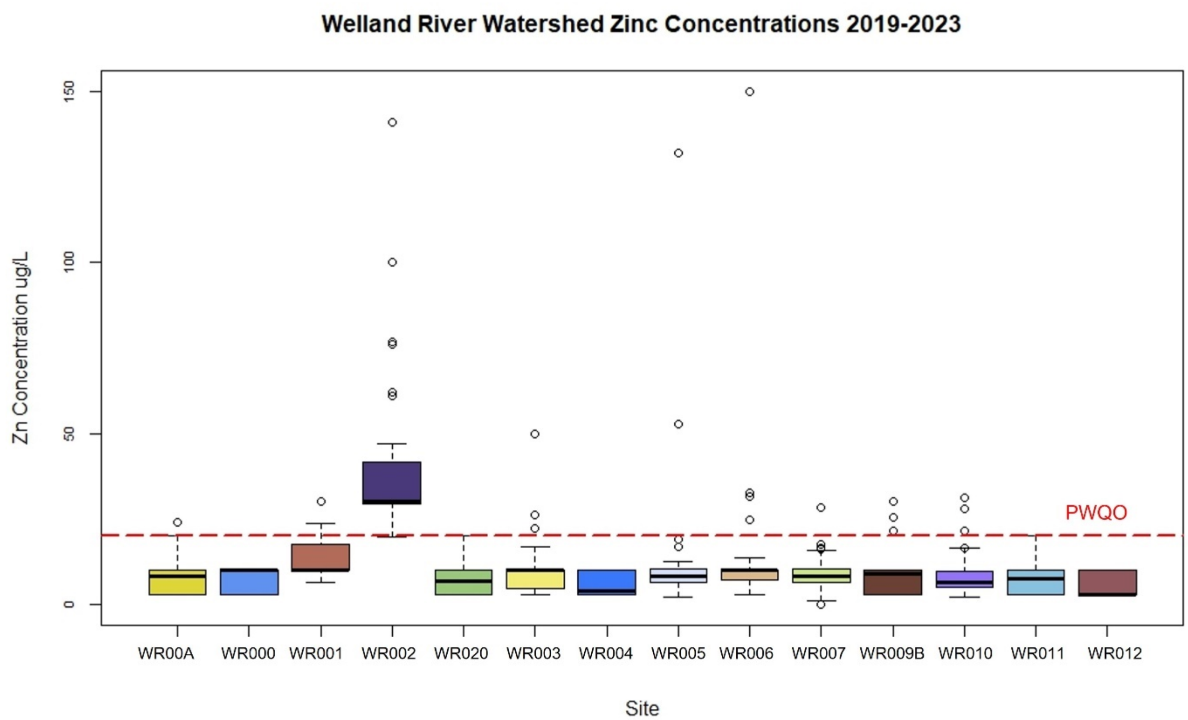
Welland River Watershed Lead Concentrations 2019-2023



Welland River Watershed Total Phosphorus Concentrations 2019-2023



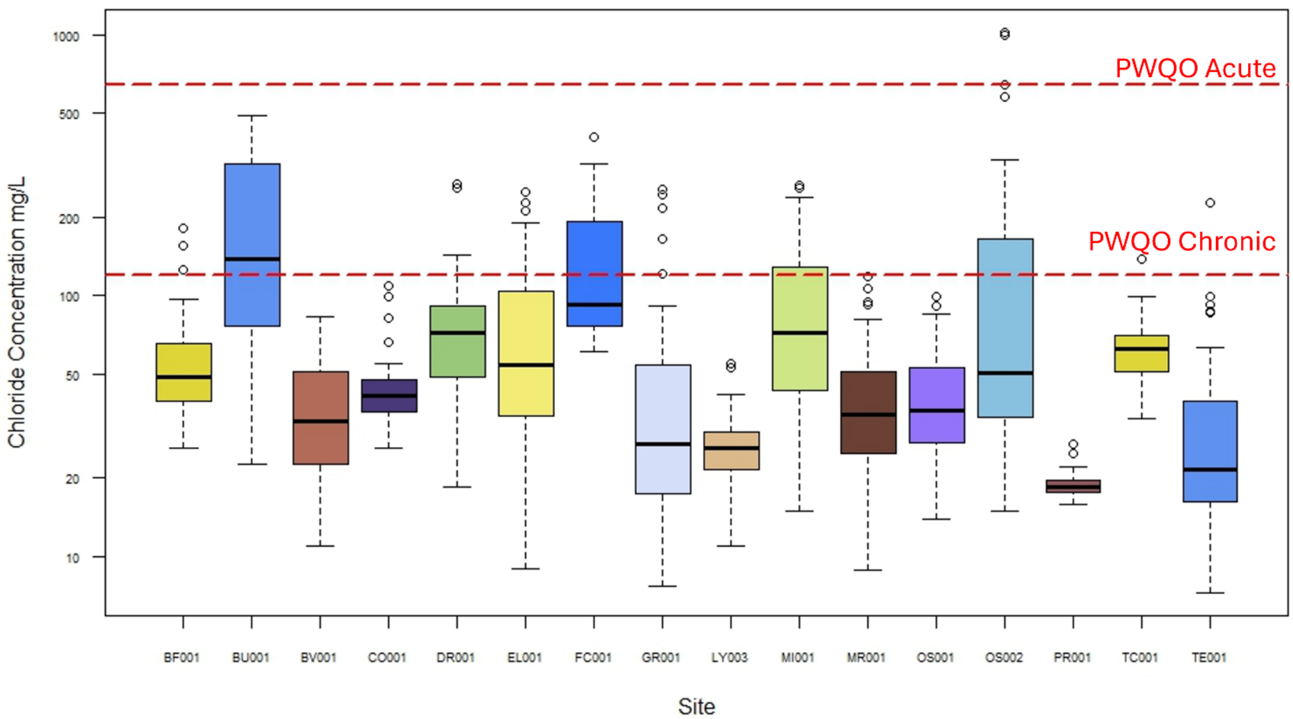

Welland River Watershed Total Suspended Solids Concentrations 2019-2023
TSS Concentration mg/L
1000
500
200
100
50
20
10
5
2
CWQG
WR00A
WR000
WR001
WR002
WR020
WR003
WR004
WR005
WR006
WR007
WR009B
WR010
WR011
WR012
Site


Welland River Watershed Zinc Concentrations 2019-2023
Zn Concentration ug/L
150
100
50
0
PWQO
WR00A
WR000
WR001
WR002
WR020
WR003
WR004
WR005
WR006
WR007
WR009B
WR010
WR011
WR012
Site

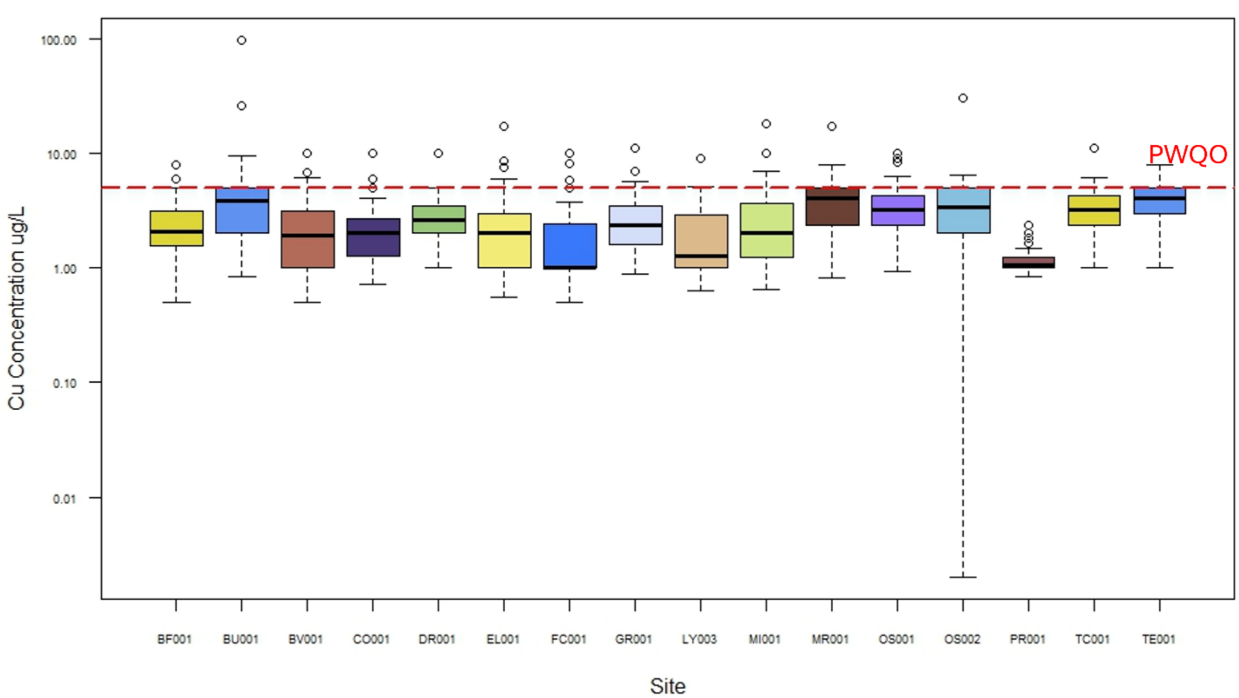
Appendix D

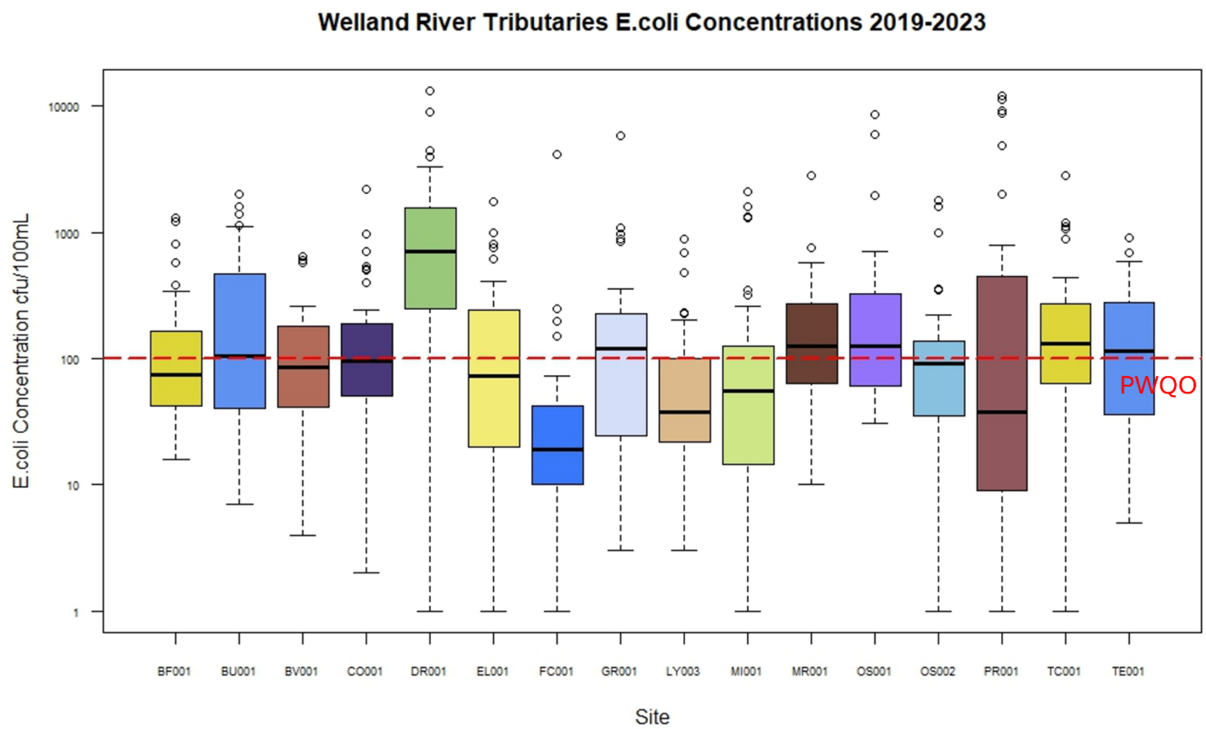
Welland River Tributaries Indicator Parameter Boxplot Summaries 2019-2023

Welland River Tributaries Chloride Concentrations 2019-2023

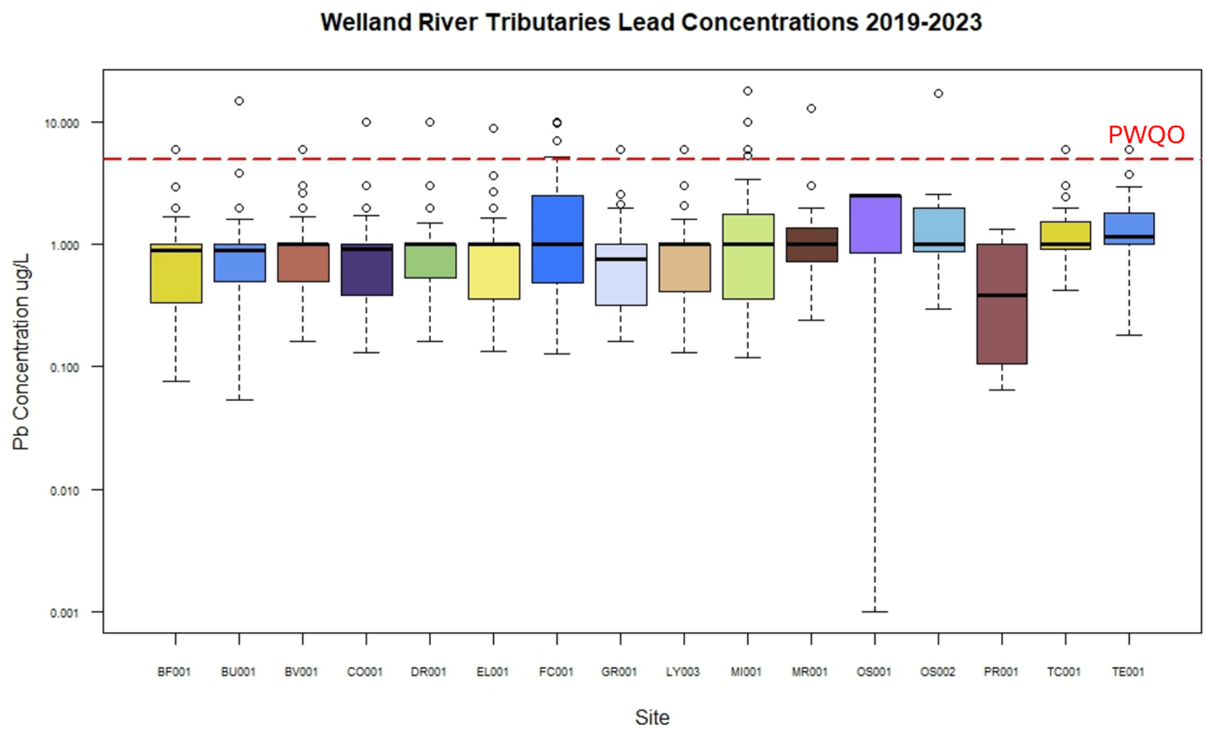


Welland River Tributaries Copper Concentrations 2019-2023



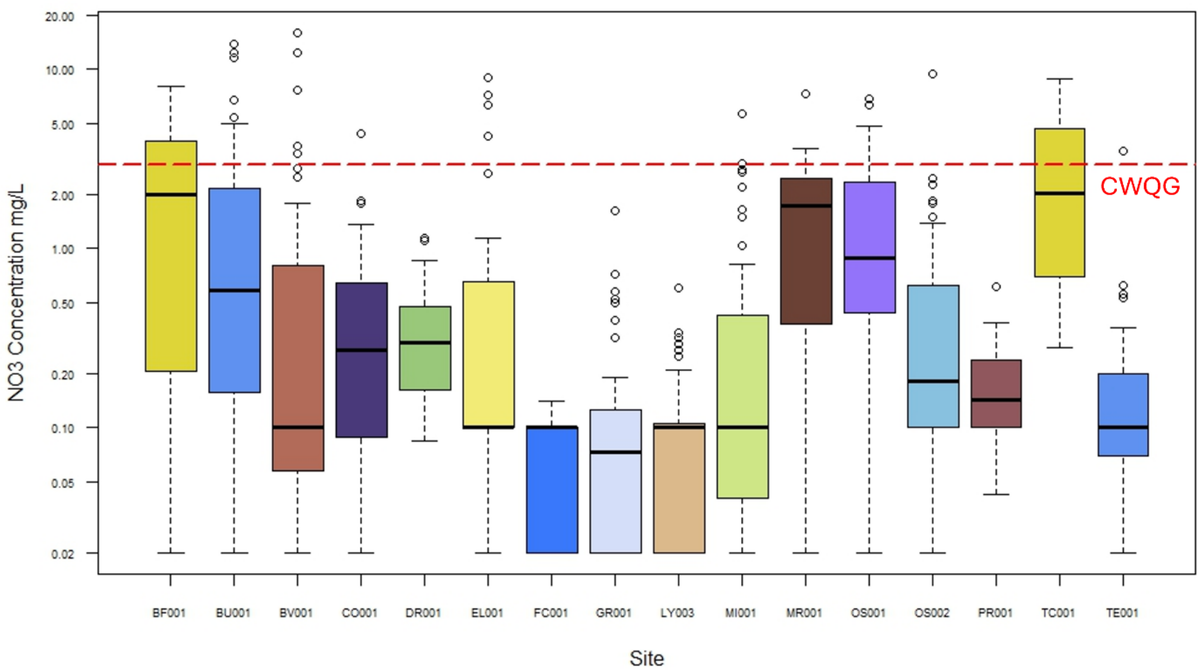


Welland River Tributaries E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
10000
1000
100
10
1
PWQO
BF001
BU001
BV001
CO001
DR001
EL001
FC001
GR001
LY003
MI001
MR001
OS001
OS002
PR001
TC001
TE001
Site

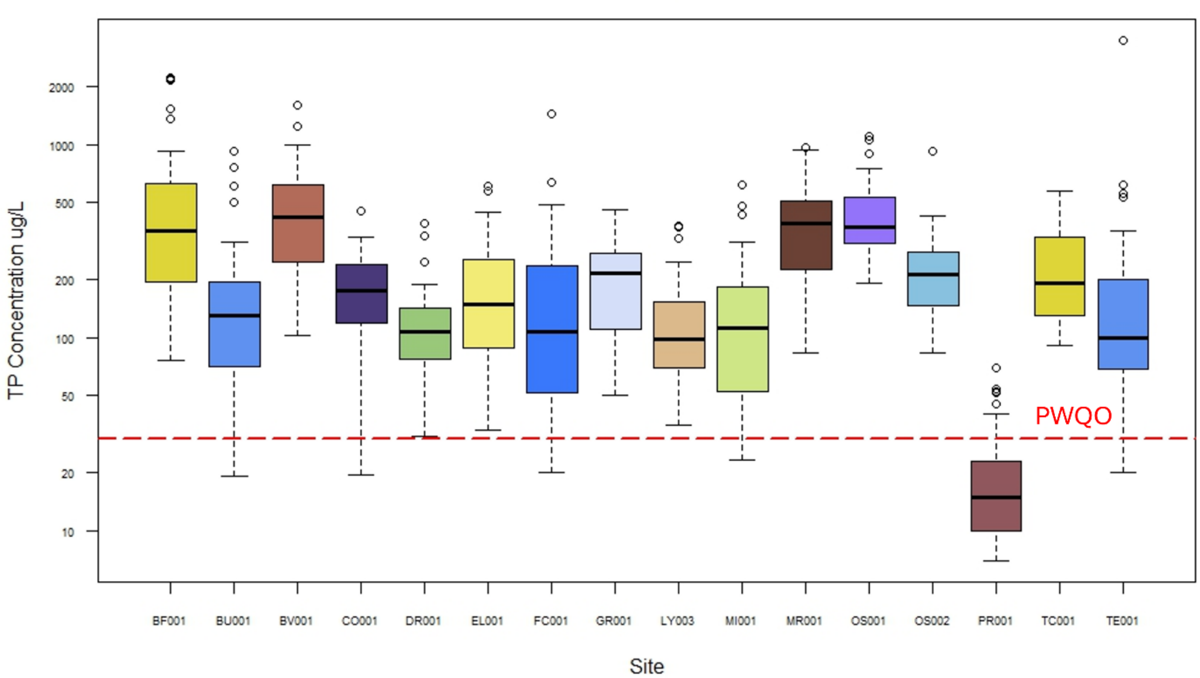


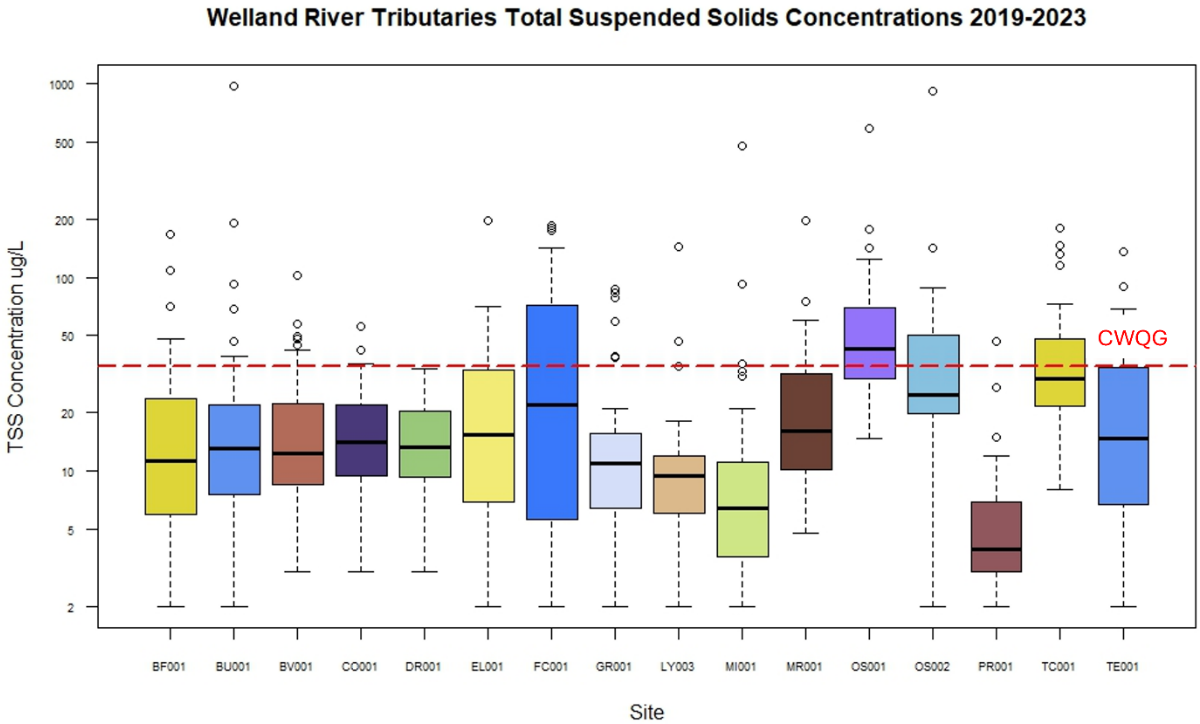
Welland River Tributaries Lead Concentrations 2019-2023
Pb Concentration ug/L
10.000
1.000
0.100
0.010
0.001
PWQO
BF001
BU001
BV001
CO001
DR001
EL001
FC001
GR001
LY003
MI001
MR001
OS001
OS002
PR001
TC001
TE001
Site

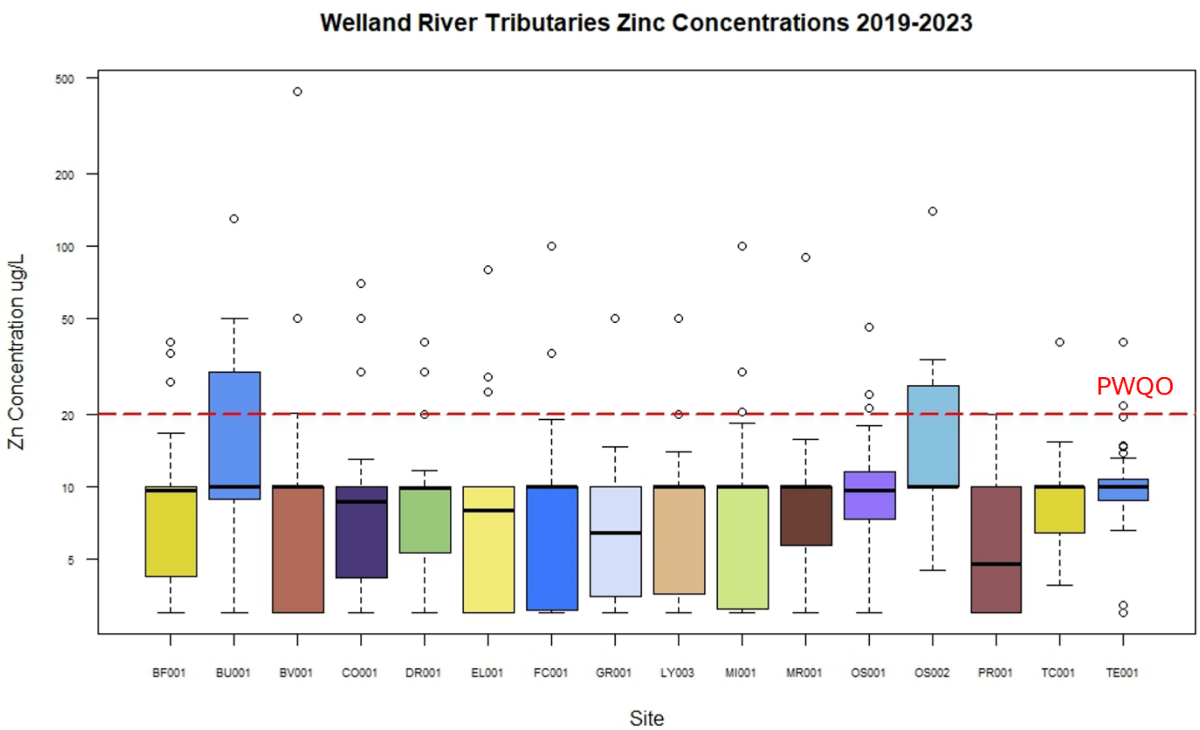
Welland River Tributaries Nitrate Concentrations 2019-2023



Welland River Tributaries Total Phosphorus Concentrations 2019-2023

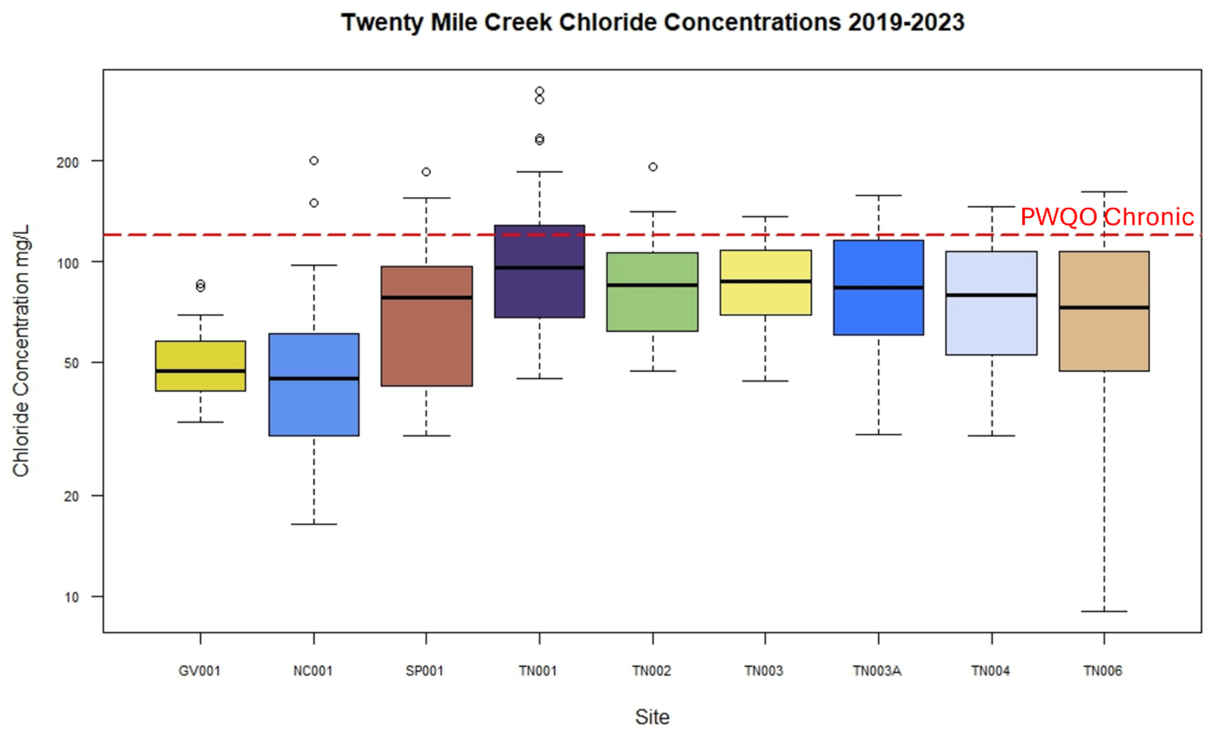


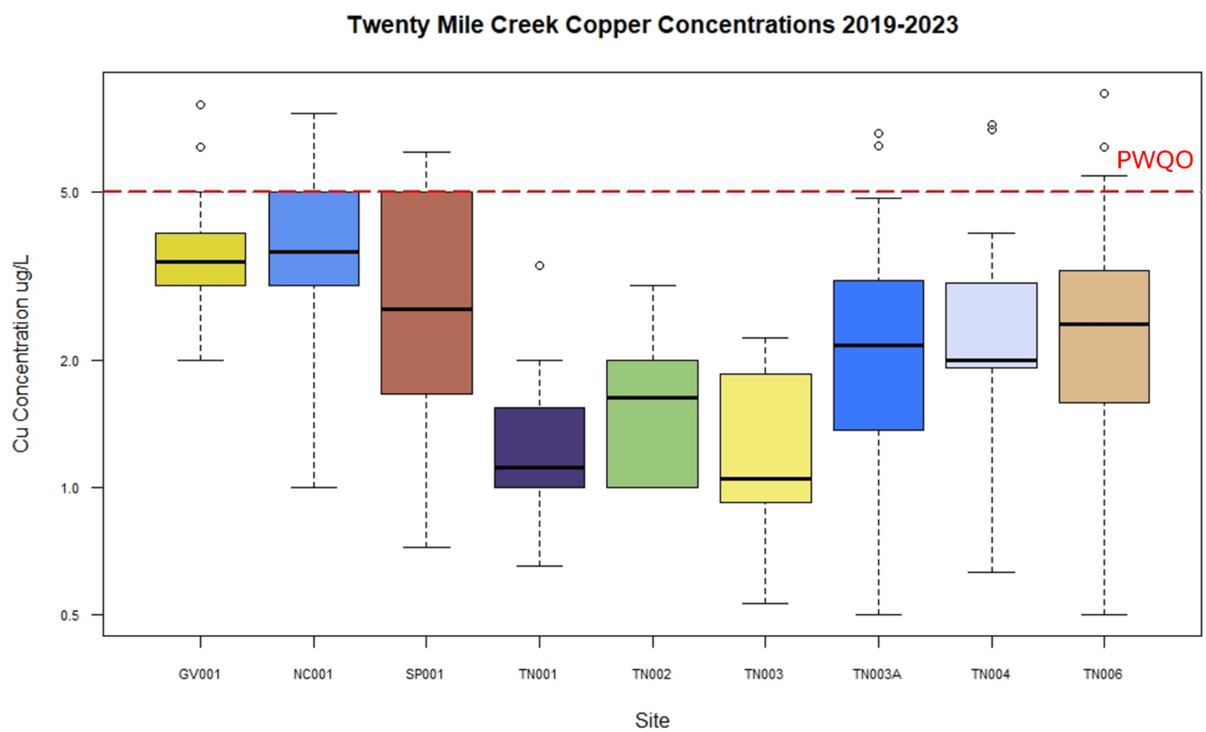

Welland River Tributaries Total Suspended Solids Concentrations 2019-2023
TSS Concentration ug/L
1000
500
200
100
50
20
10
5
2
CWQG
BF001
BU001
BV001
CO001
DR001
EL001
FC001
GR001
LY003
MI001
MR001
OS001
OS002
PR001
TC001
TE001
Site

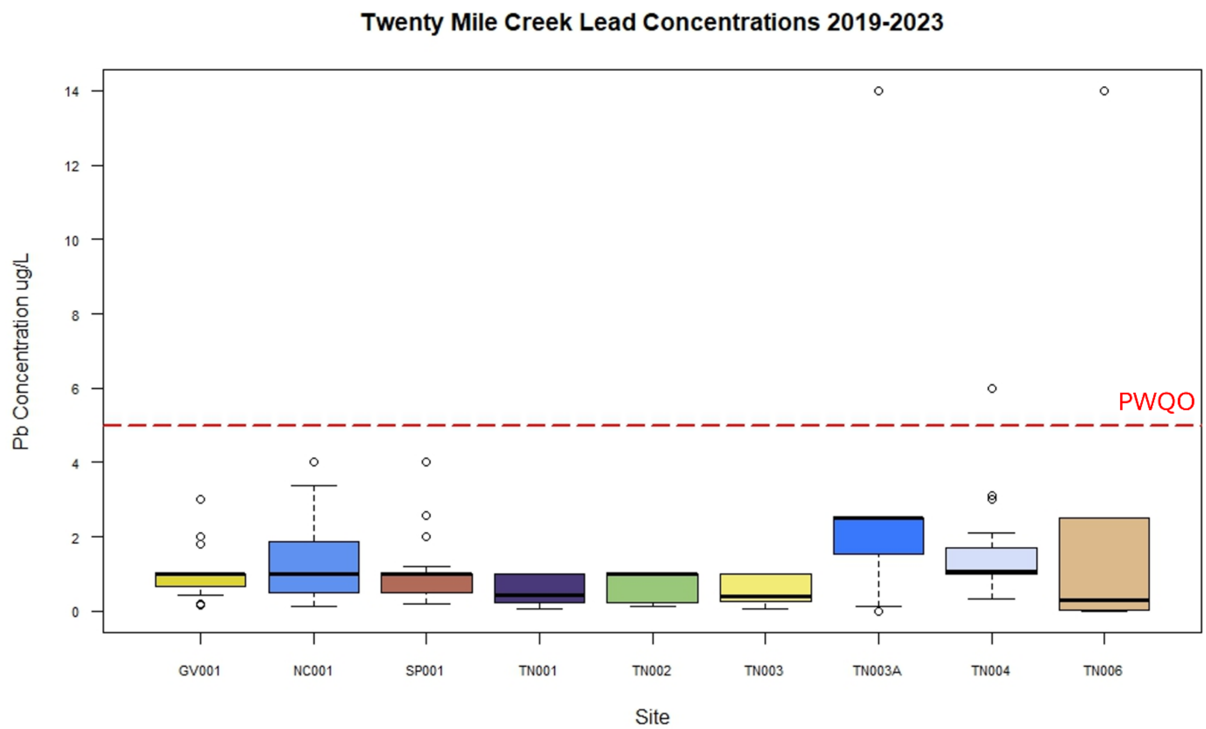

Welland River Tributaries Zinc Concentrations 2019-2023
Zn Concentration ug/L
500
200
100
50
20
10
5
PWQO
BF001
BU001
BV001
CO001
DR001
EL001
FC001
GR001
LY003
MI001
MR001
OS001
OS002
PR001
TC001
TE001
Site

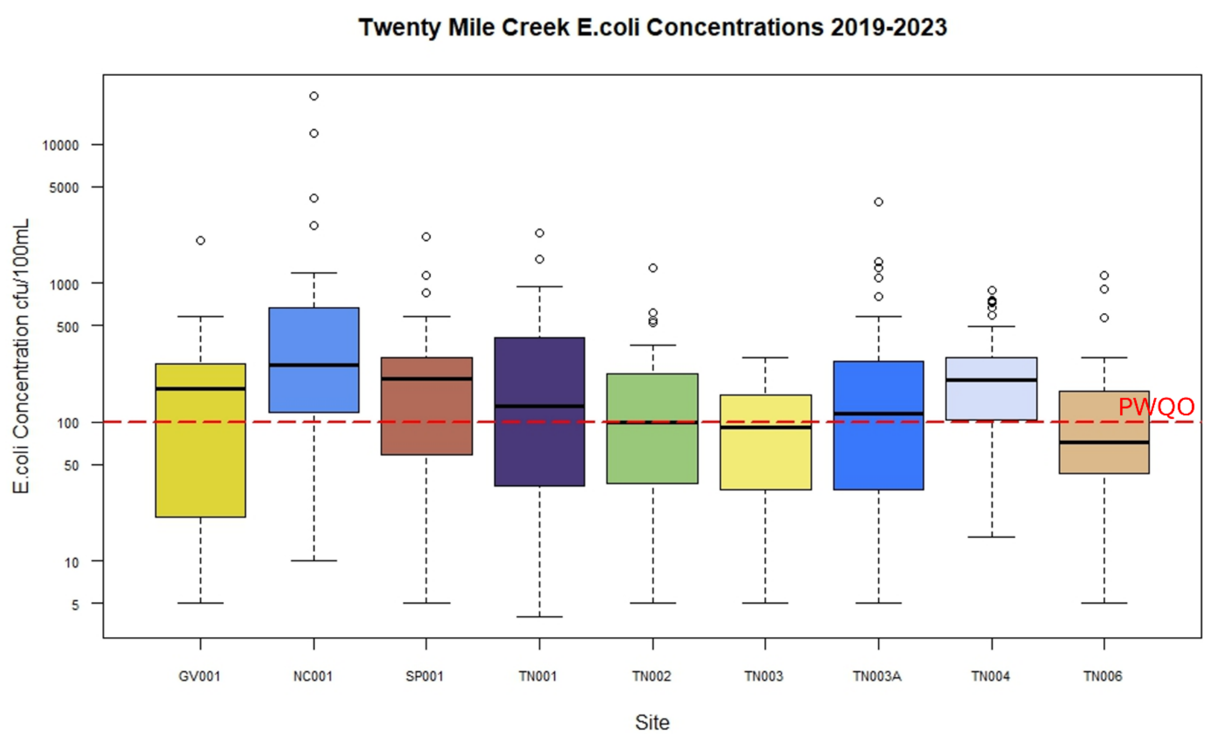
Appendix E

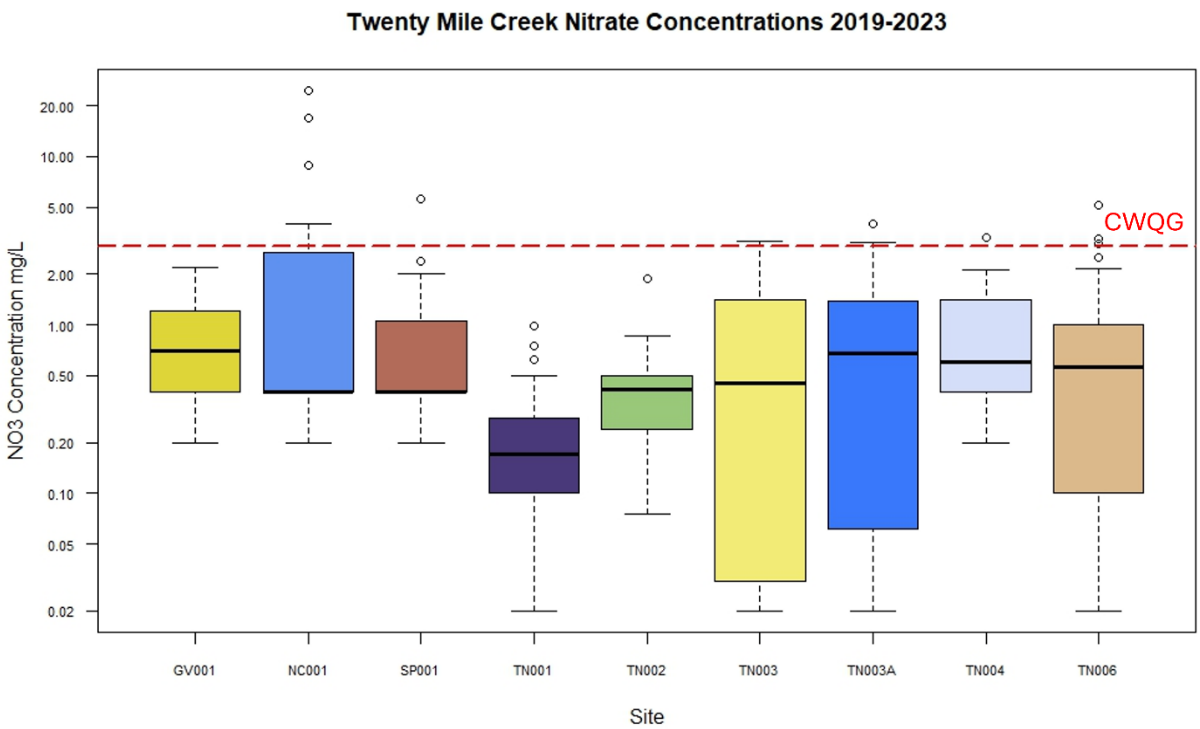
Twenty Mile Creek Watershed Indicator Parameter Boxplot Summaries 2019-2023

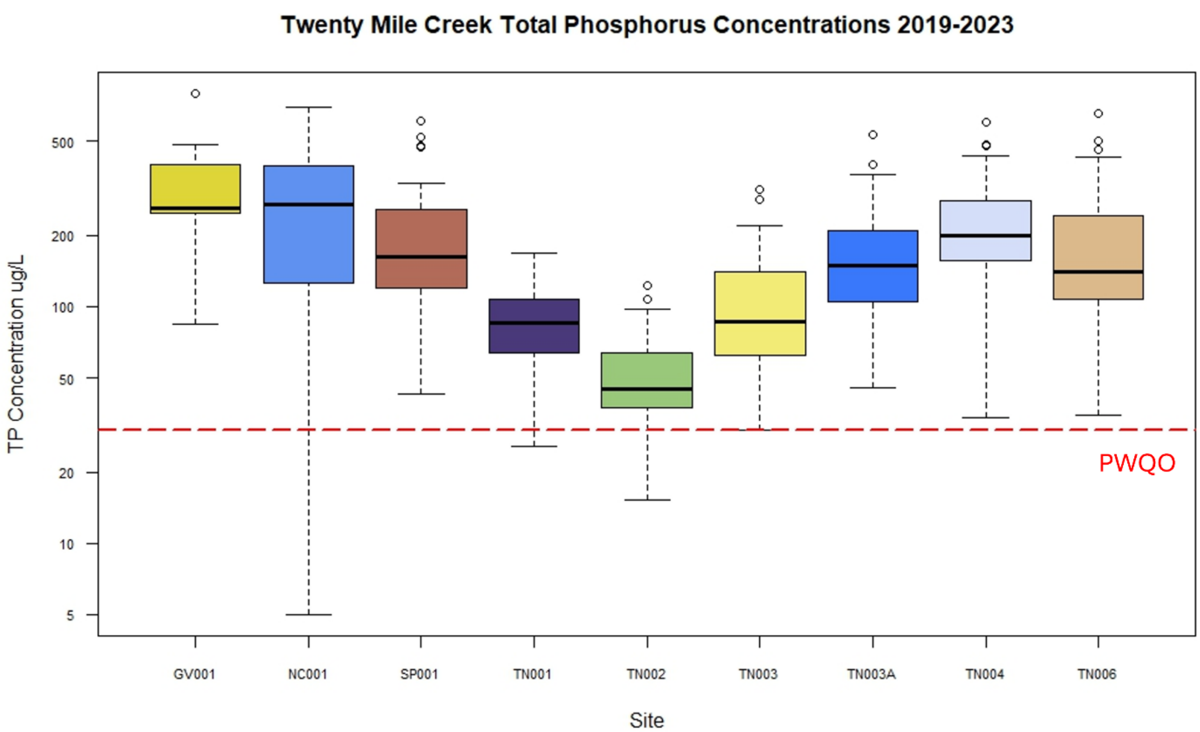

Twenty Mile Creek Chloride Concentrations 2019-2023
Chloride Concentration mg/L
200
100
50
20
10
PWQO Chronic
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site

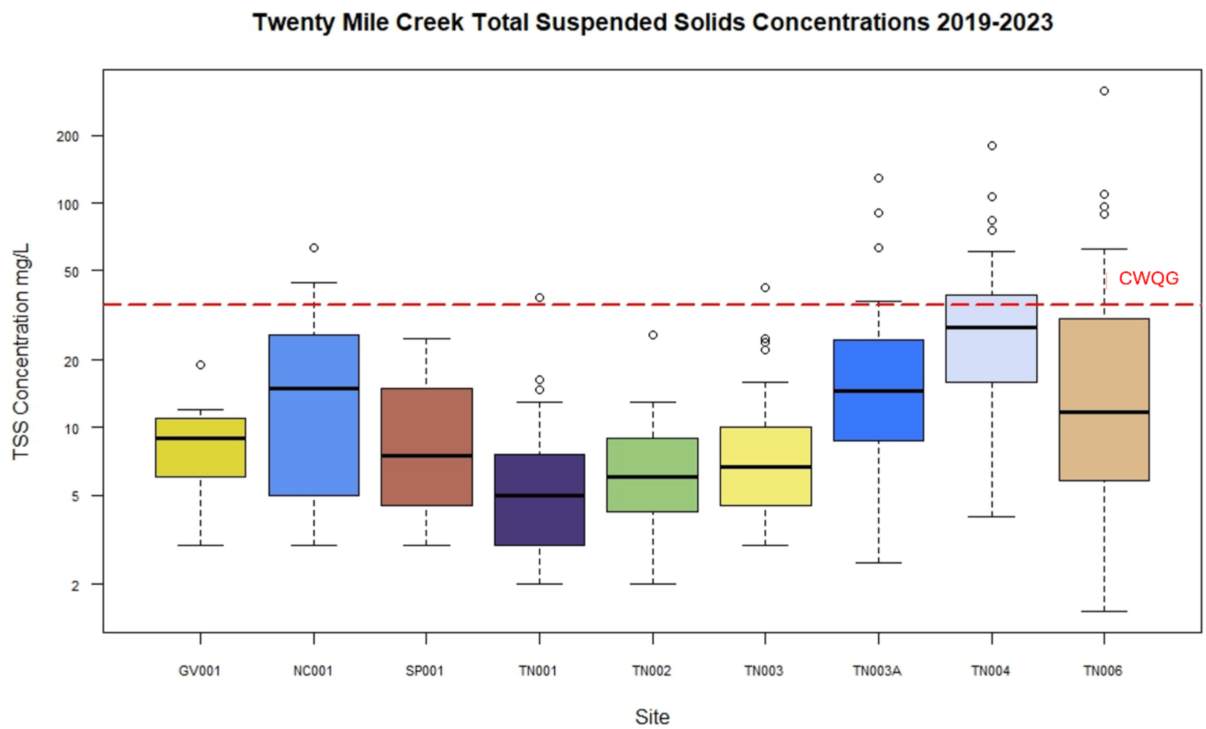

Twenty Mile Creek Copper Concentrations 2019-2023
Cu Concentration ug/L
5.0
2.0
1.0
0.5
PWQO
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site

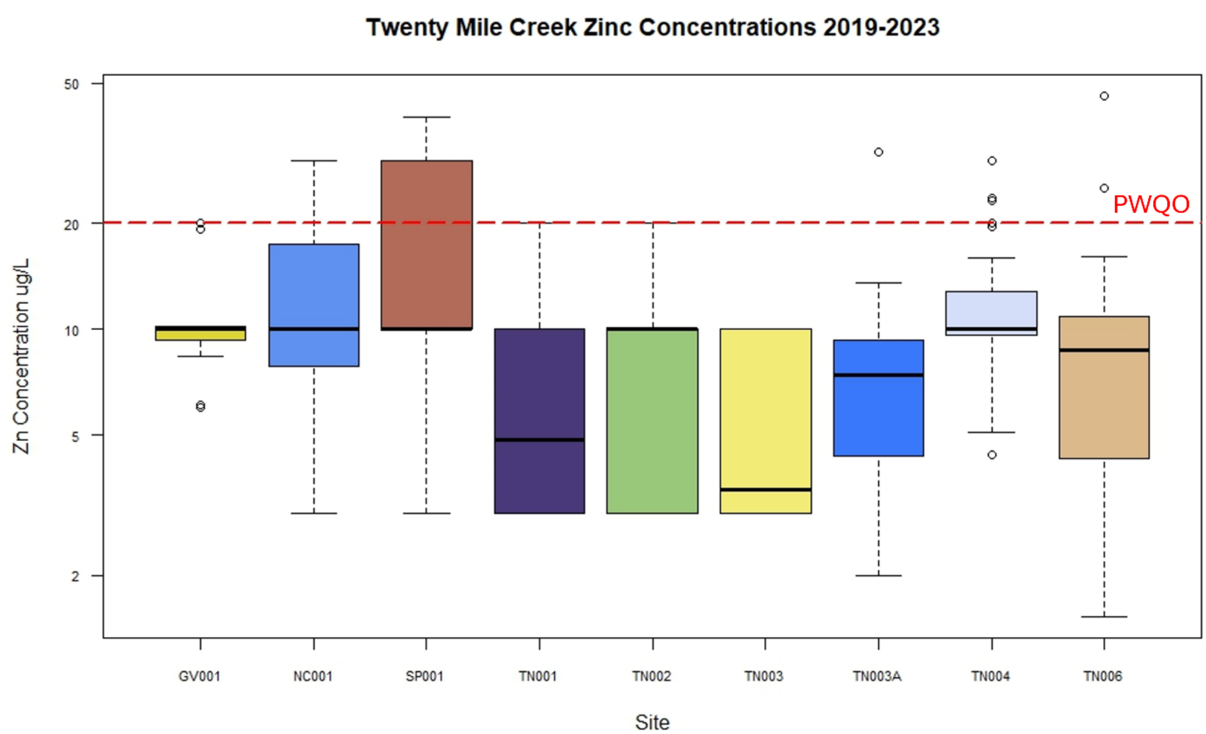

Twenty Mile Creek Lead Concentrations 2019-2023
Pb Concentration ug/L
14
12
10
8
6
4
2
0
PWQO
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site


Twenty Mile Creek E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
10000
5000
1000
500
100
50
10
5
PWQO
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site


Twenty Mile Creek Nitrate Concentrations 2019-2023
NO3 Concentration mg/L
20.00
10.00
5.00
2.00
1.00
0.50
0.20
0.10
0.05
0.02
CWQG
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site

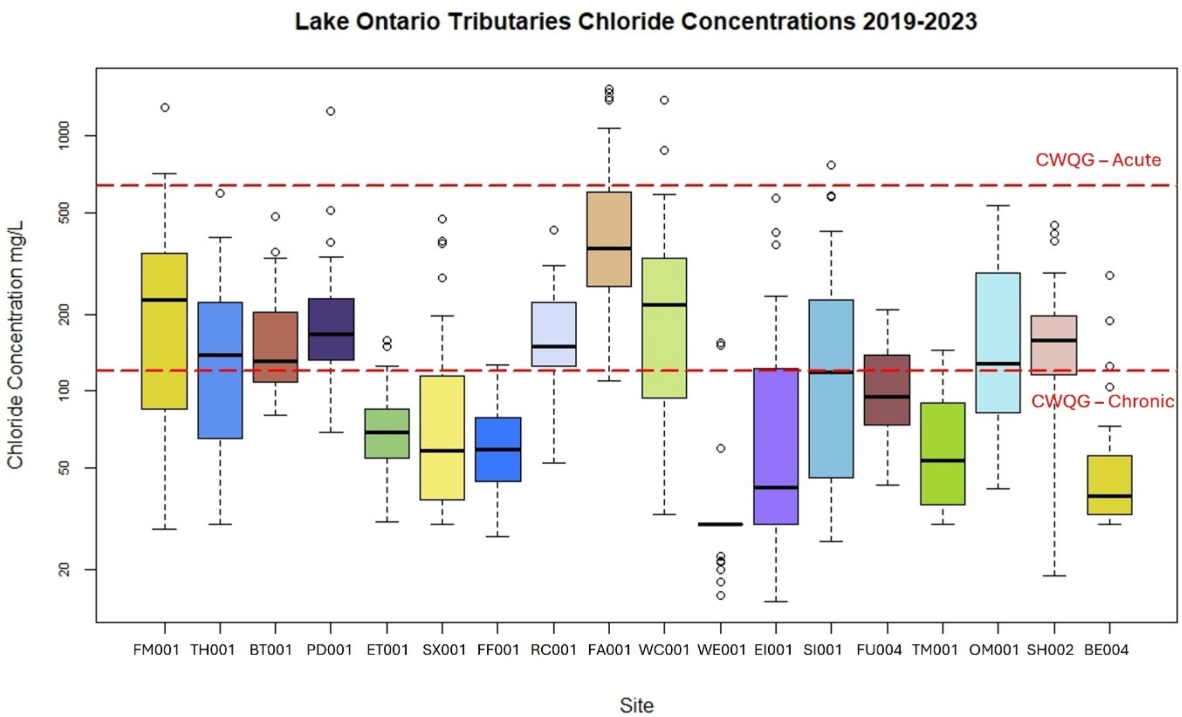

Twenty Mile Creek Total Phosphorus Concentrations 2019-2023
TP Concentration ug/L
500
200
100
50
20
10
5
PWQO
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site

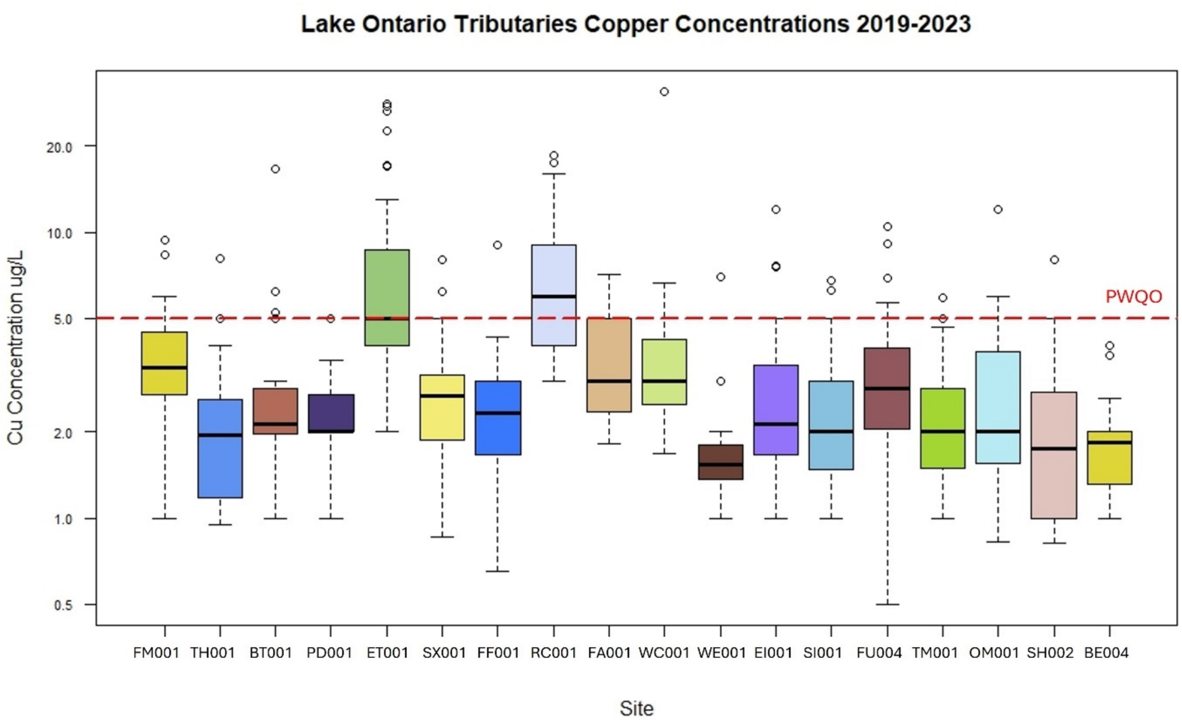

Twenty Mile Creek Total Suspended Solids Concentrations 2019-2023
TSS Concentration mg/L
200
100
50
20
10
5
2
CWQG
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site

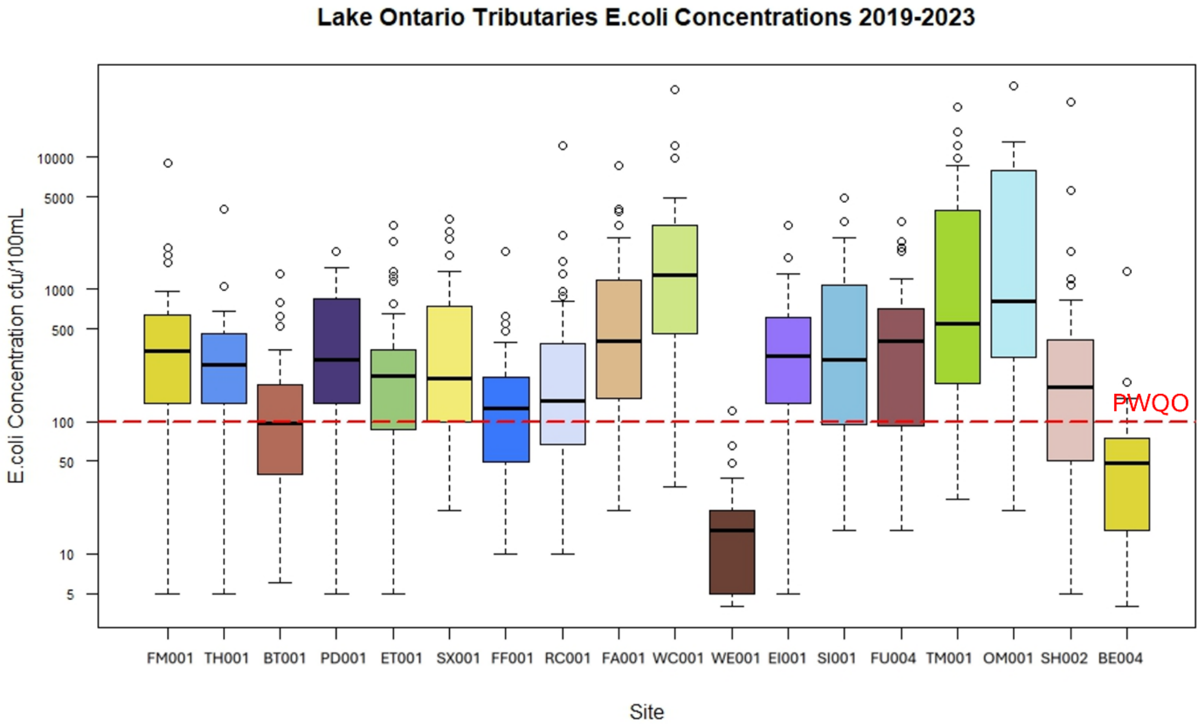

Twenty Mile Creek Zinc Concentrations 2019-2023
Zn Concentration ug/L
50
20
10
5
2
PWQO
GV001
NC001
SP001
TN001
TN002
TN003
TN003A
TN004
TN006
Site

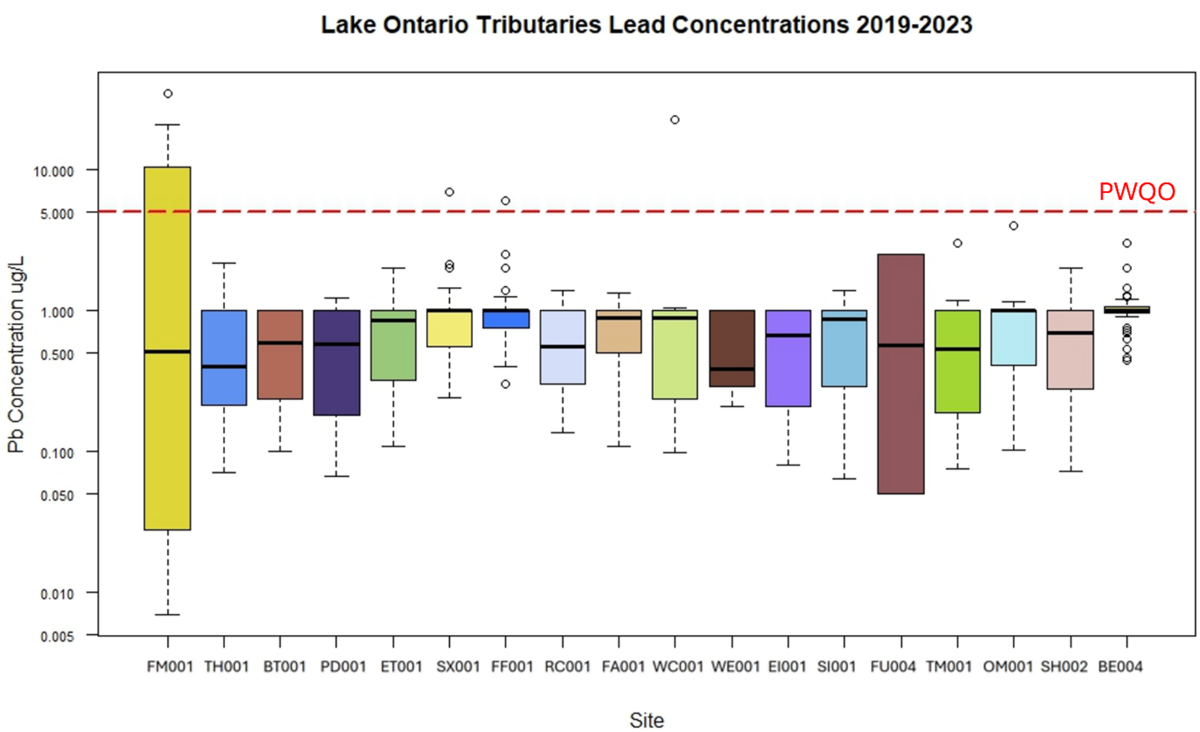
Appendix F

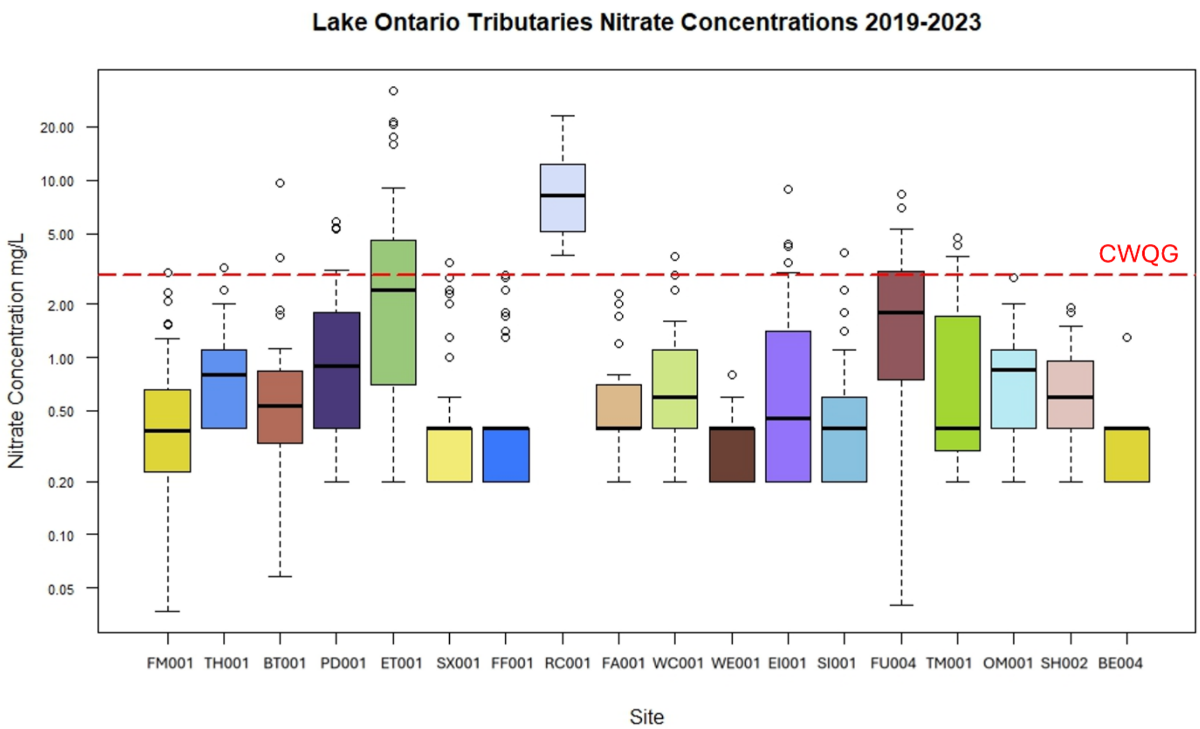
Lake Ontario South Shore Tributaries Indicator Parameter Boxplot Summaries 2019-2023

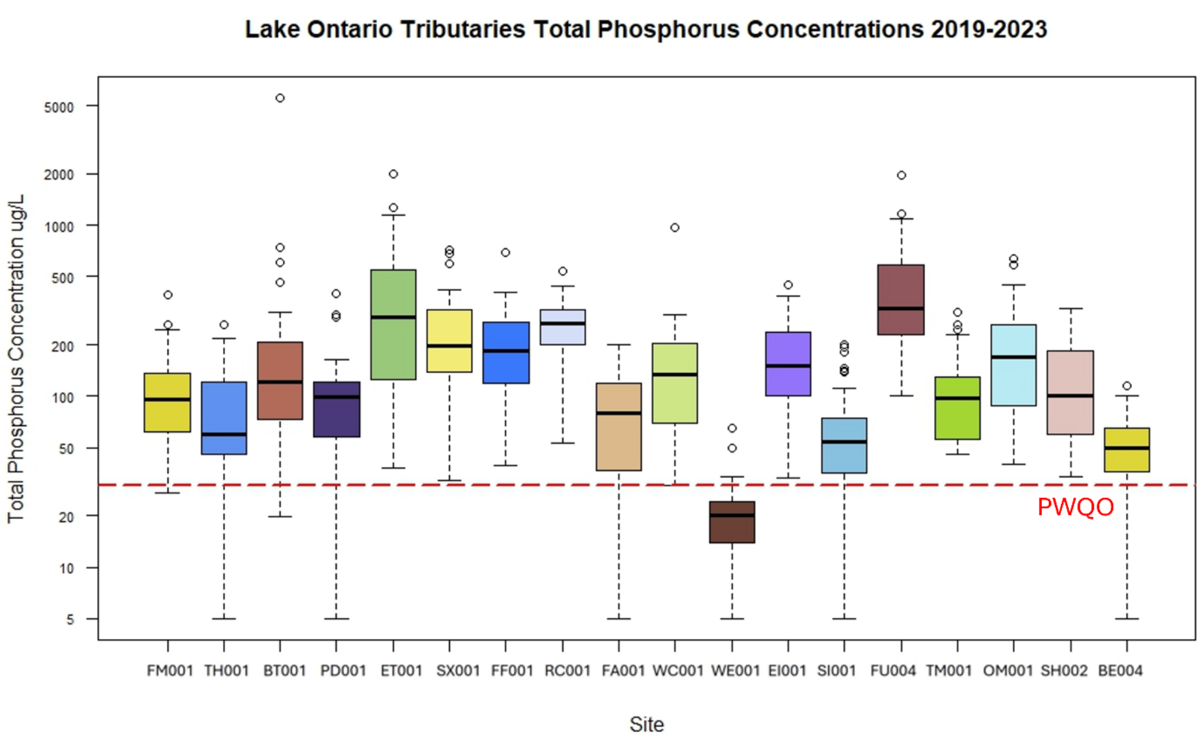

Lake Ontario Tributaries Chloride Concentrations 2019-2023
Chloride Concentration mg/L
CWQG – Acute
CWQG – Chronic
20
50
100
200
500
1000
FM001 TH001 BT001 PD001 ET001 SX001 FF001 RC001 FA001 WC001 WE001 EI001 SI001 FU004 TM001 OM001 SH002 BE004
Site

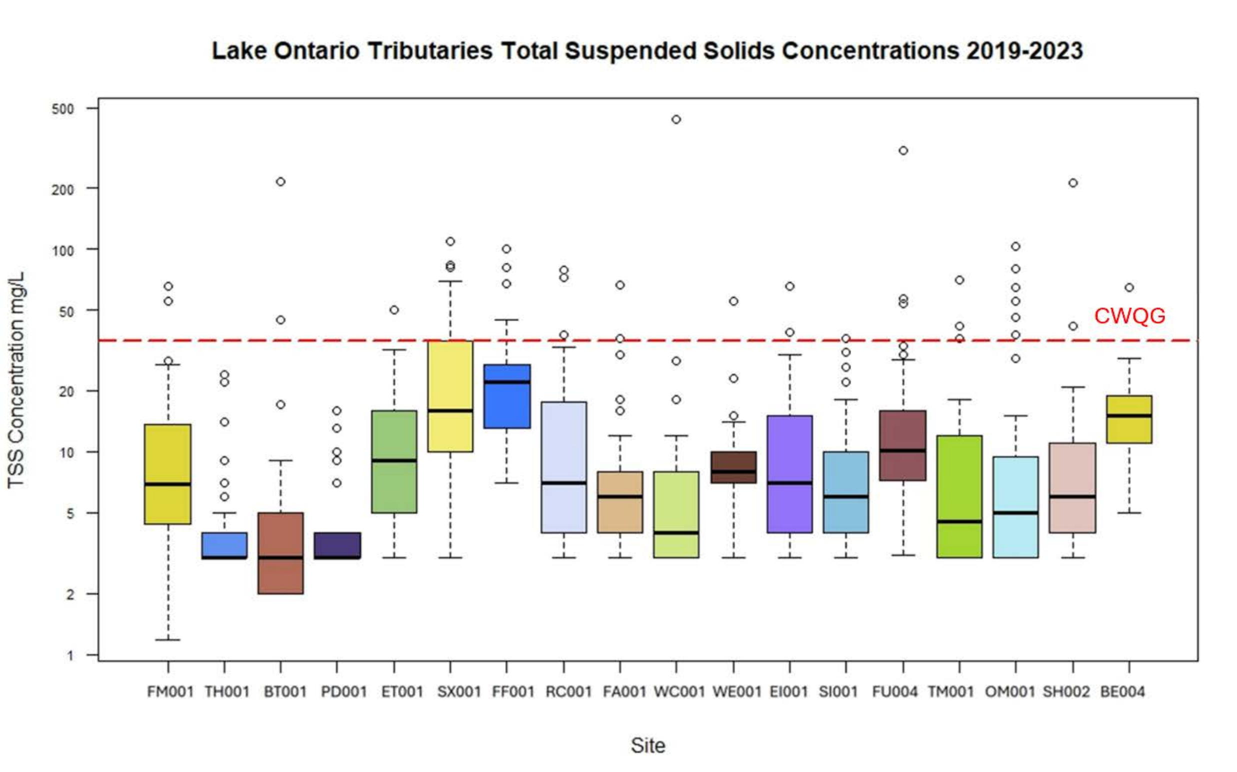

Lake Ontario Tributaries Copper Concentrations 2019-2023
Cu Concentration ug/L
PWQO
0.5
1.0
2.0
5.0
10.0
20.0
FM001 TH001 BT001 PD001 ET001 SX001 FF001 RC001 FA001 WC001 WE001 EI001 SI001 FU004 TM001 OM001 SH002 BE004
Site

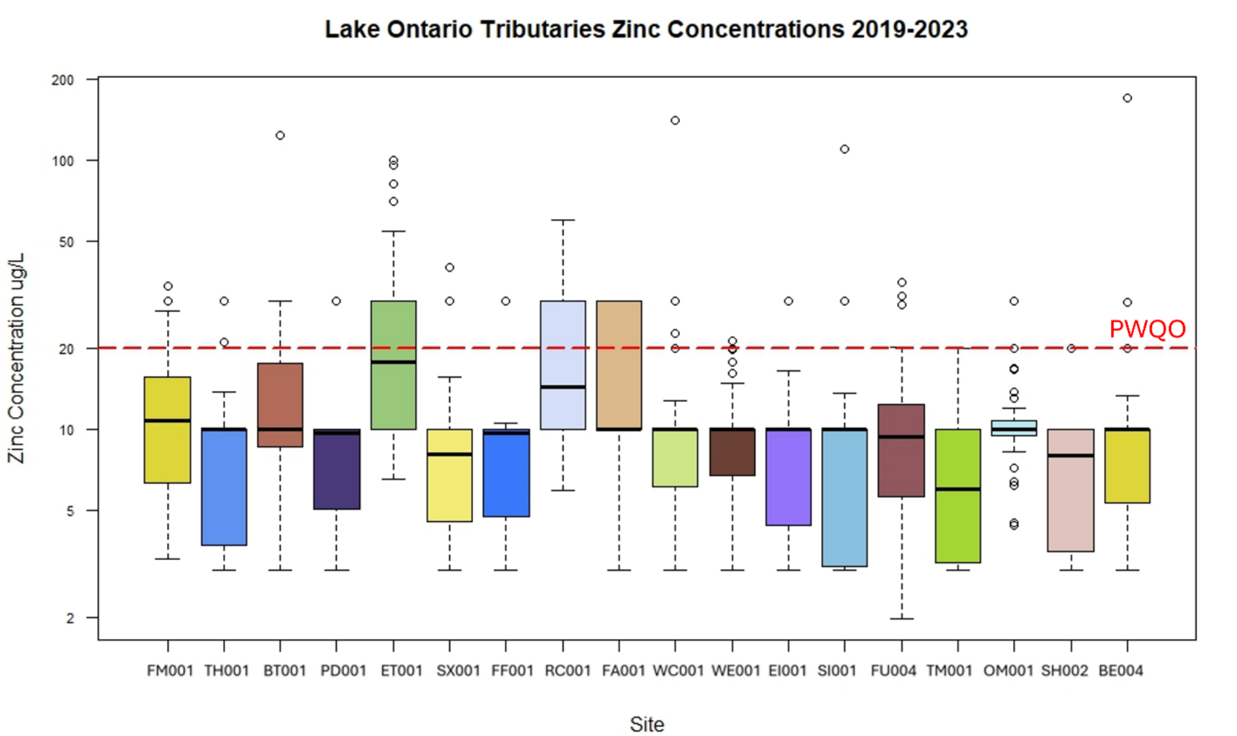

Lake Ontario Tributaries E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
10000
5000
1000
500
100
50
10
5
PWQO
FM001
TH001
BT001
PD001
ET001
SX001
FF001
RC001
FA001
WC001
WE001
EI001
SI001
FU004
TM001
OM001
SH002
BE004
Site


Lake Ontario Tributaries Lead Concentrations 2019-2023
Pb Concentration ug/L
10.000
5.000
1.000
0.500
0.100
0.050
0.010
0.005
PWQO
FM001
TH001
BT001
PD001
ET001
SX001
FF001
RC001
FA001
WC001
WE001
EI001
SI001
FU004
TM001
OM001
SH002
BE004
Site


Lake Ontario Tributaries Nitrate Concentrations 2019-2023
Nitrate Concentration mg/L
20.00
10.00
5.00
2.00
1.00
0.50
0.20
0.10
0.05
CWQG
FM001 TH001 BT001 PD001 ET001 SX001 FF001 RC001 FA001 WC001 WE001 EI001 SI001 FU004 TM001 OM001 SH002 BE004
Site


Lake Ontario Tributaries Total Phosphorus Concentrations 2019-2023
Total Phosphorus Concentration ug/L
5000
2000
1000
500
200
100
50
20
10
5
PWQO
FM001 TH001 BT001 PD001 ET001 SX001 FF001 RC001 FA001 WC001 WE001 EI001 SI001 FU004 TM001 OM001 SH002 BE004
Site

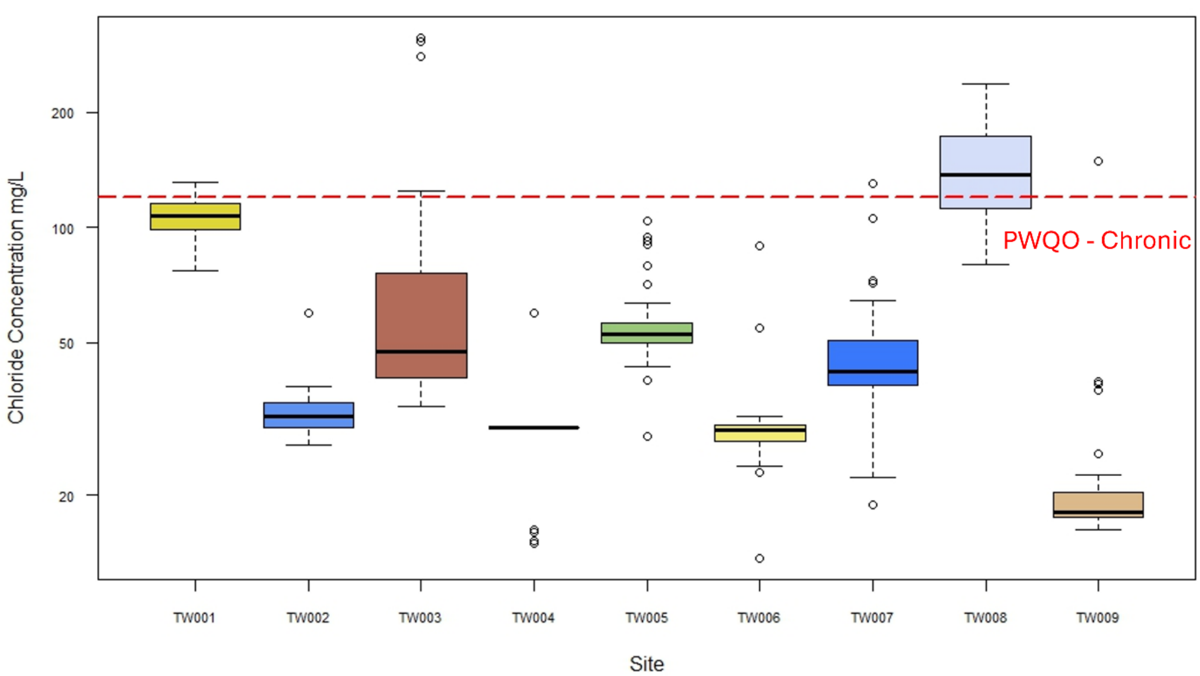

Lake Ontario Tributaries Total Suspended Solids Concentrations 2019-2023
TSS Concentration mg/L
500
200
100
50
20
10
5
2
1
CWQG
FM001 TH001 BT001 PD001 ET001 SX001 FF001 RC001 FA001 WC001 WE001 EI001 SI001 FU004 TM001 OM001 SH002 BE004
Site


Lake Ontario Tributaries Zinc Concentrations 2019-2023
Zinc Concentration ug/L
200
100
50
20
10
5
2
PWQO
FM001 TH001 BT001 PD001 ET001 SX001 FF001 RC001 FA001 WC001 WE001 EI001 SI001 FU004 TM001 OM001 SH002 BE004
Site

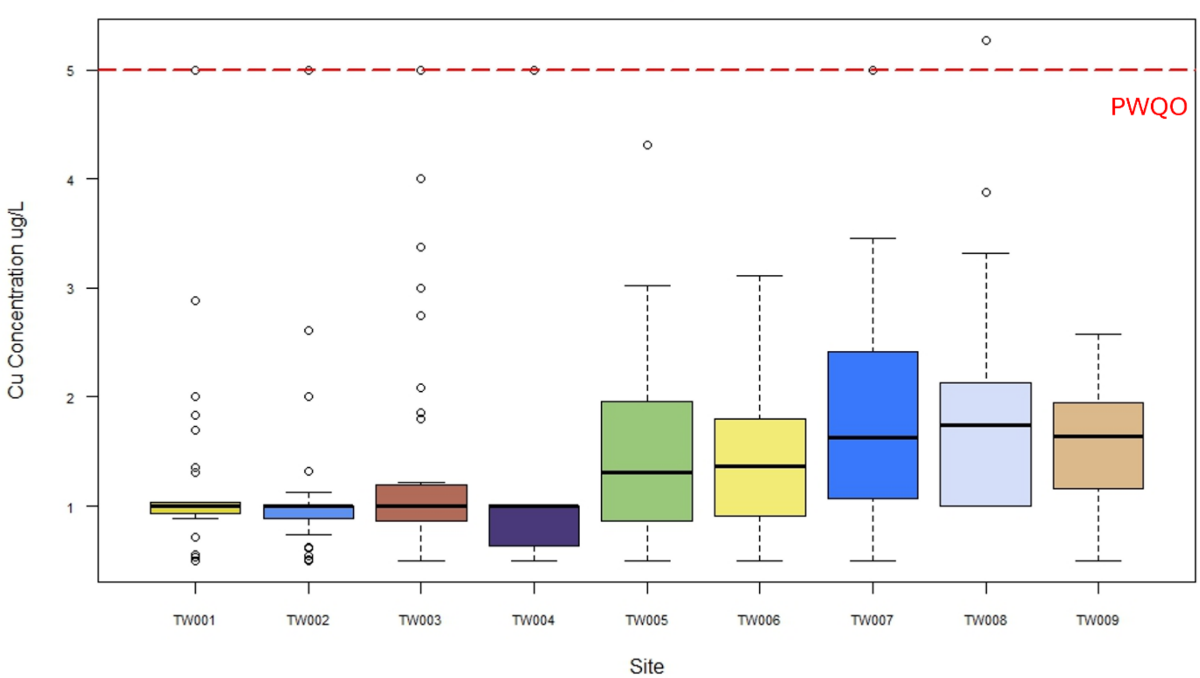
Appendix G

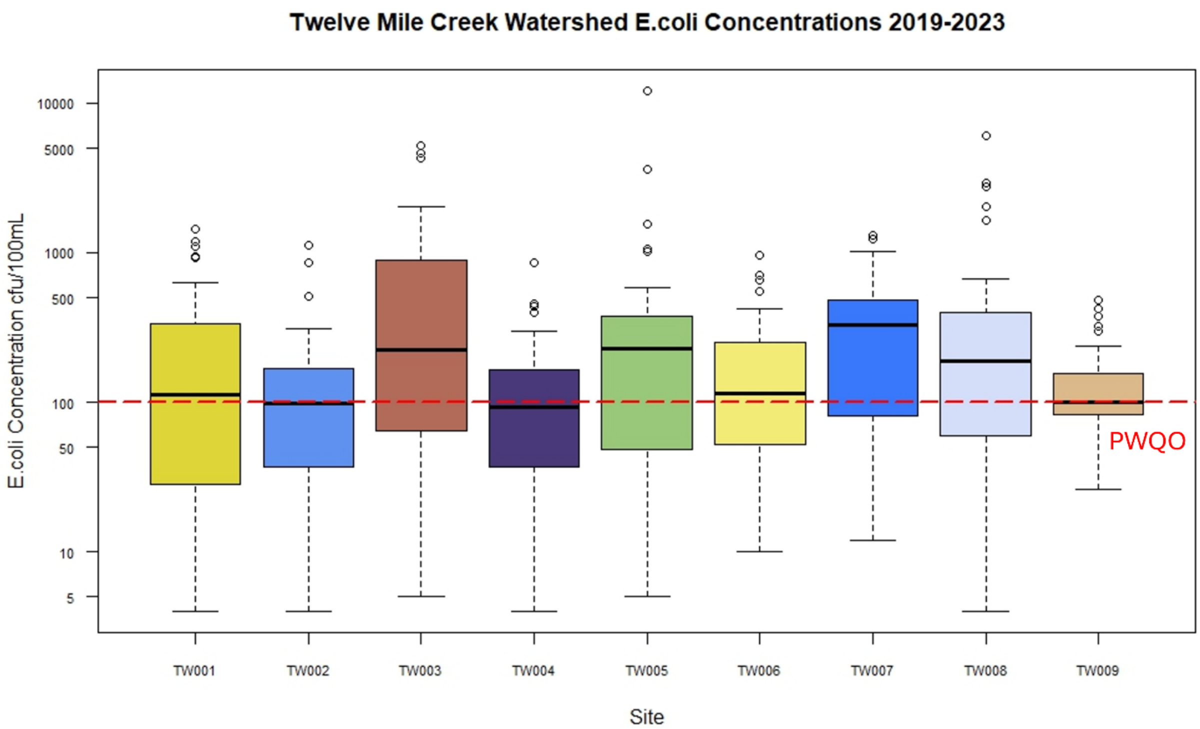
Twelve Mile Creek Watershed Indicator Parameter Boxplot Summaries 2019-2023

Twelve Mile Creek Watershed Chloride Concentrations 2019-2023

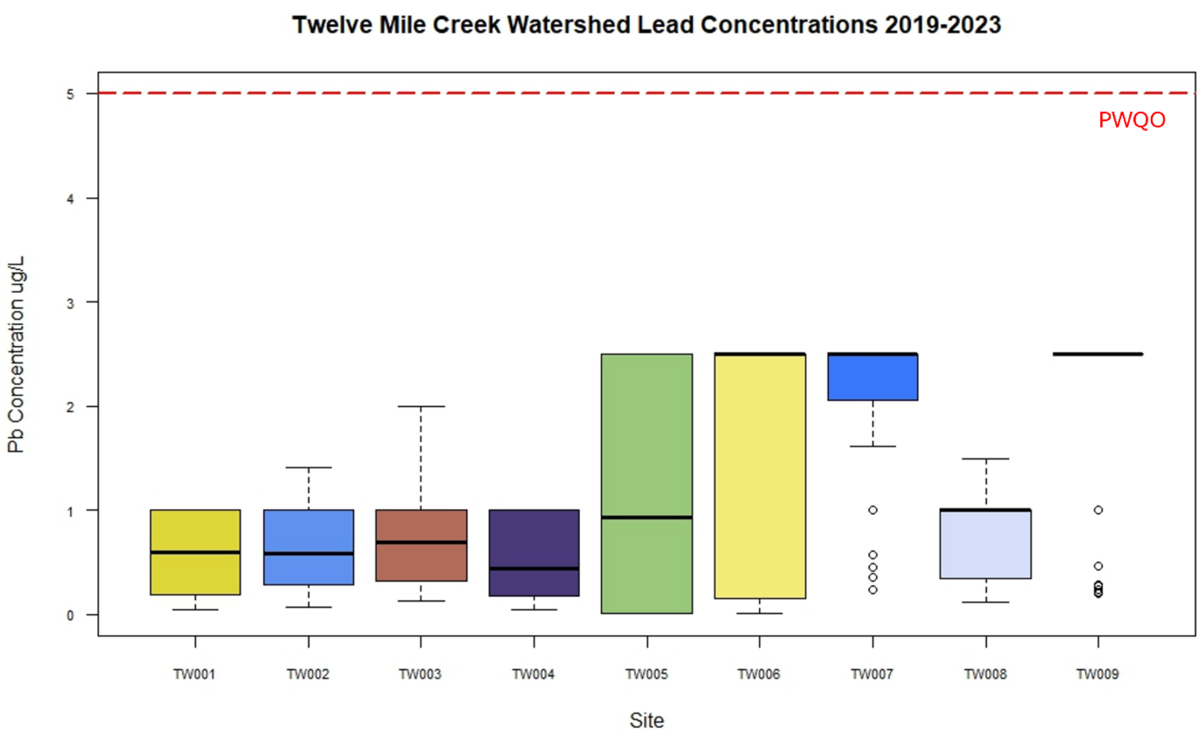


Twelve Mile Creek Watershed Copper Concentrations 2019-2023

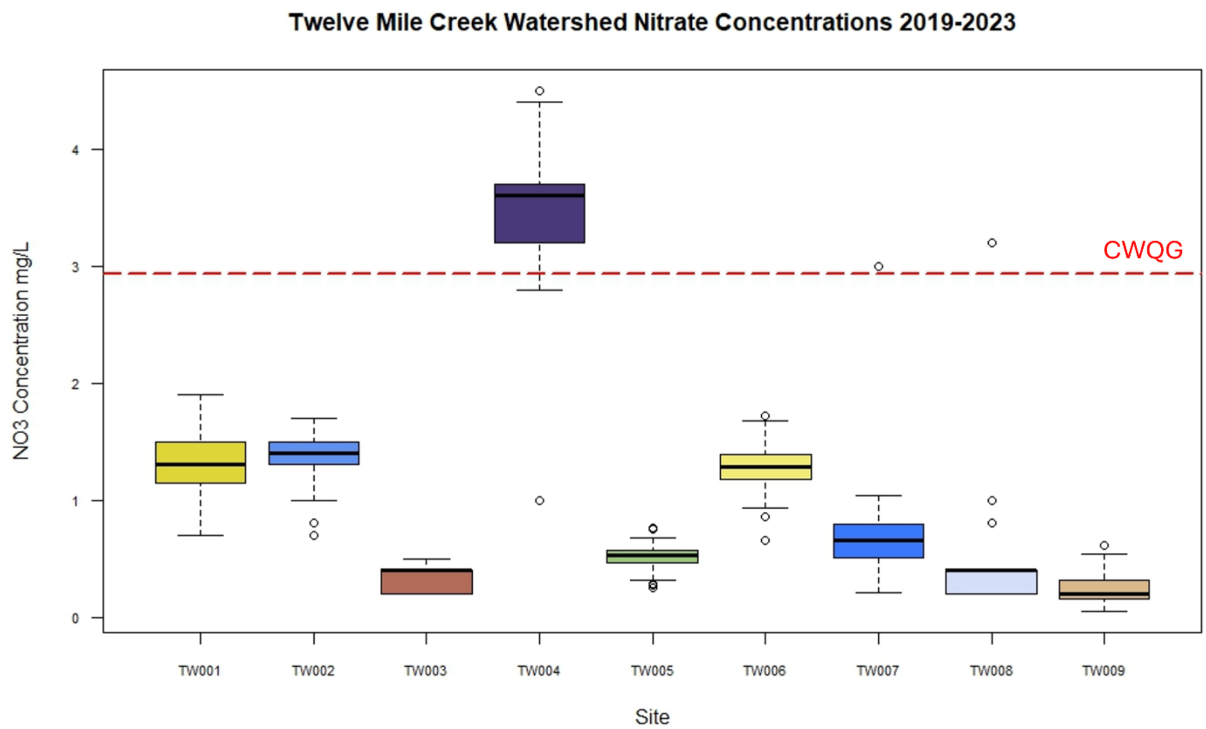


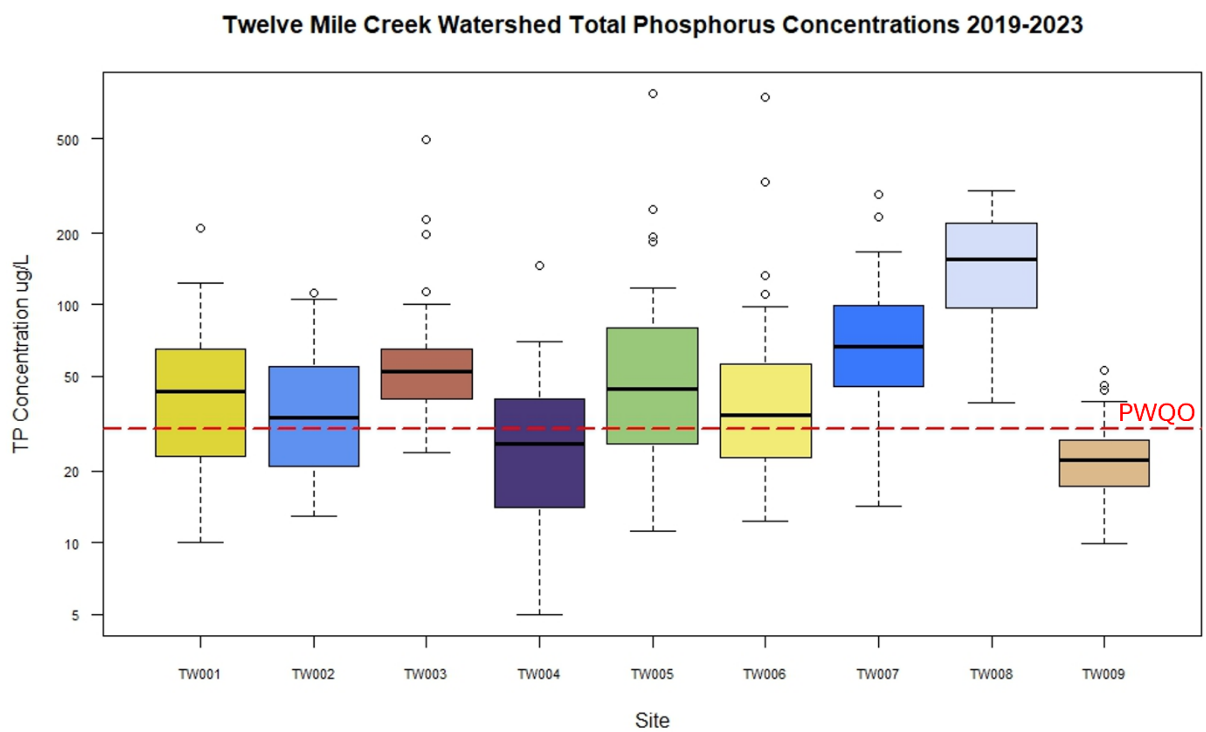


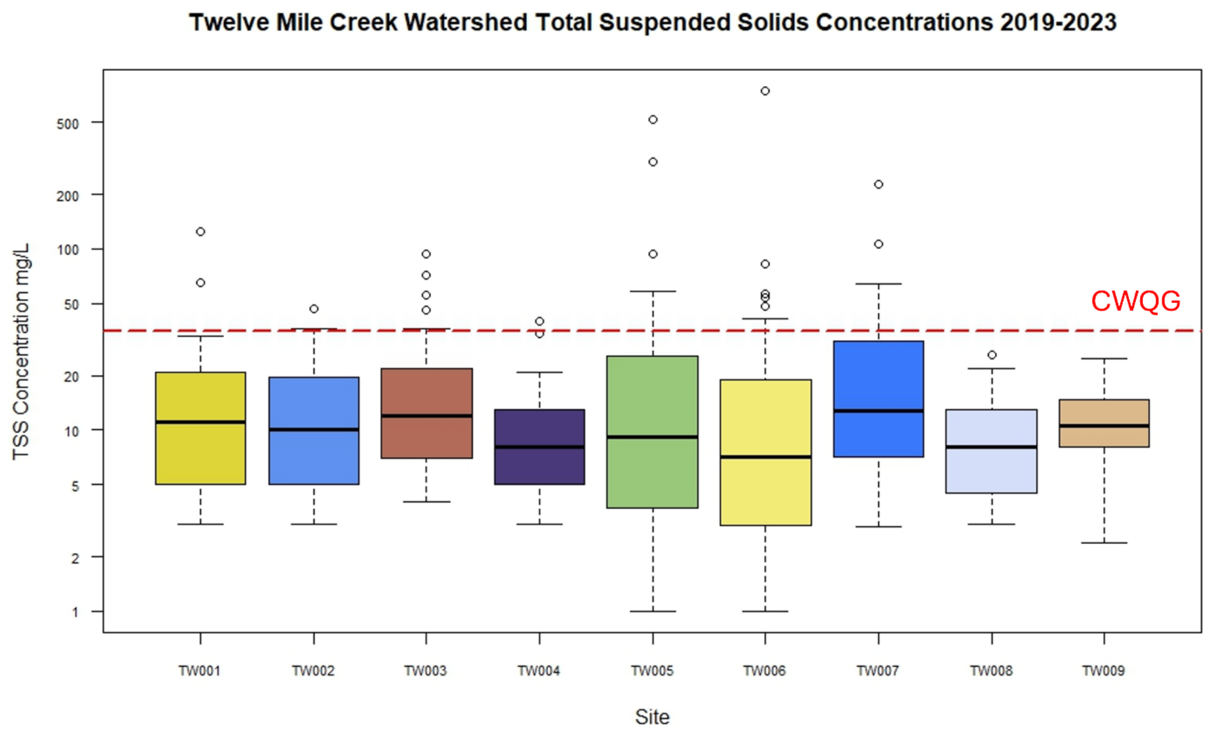
Twelve Mile Creek Watershed E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
10000
5000
1000
500
100
50
10
5
PWQO
TW001
TW002
TW003
TW004
TW005
TW006
TW007
TW008
TW009
Site



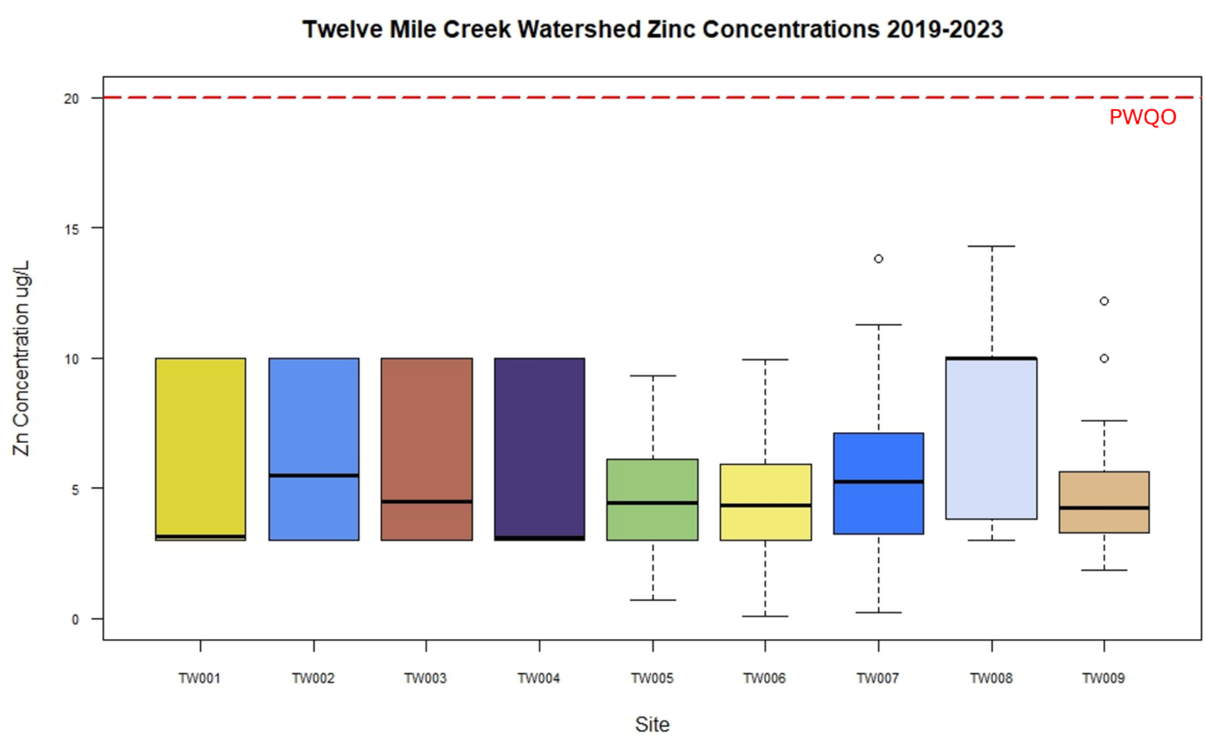
Twelve Mile Creek Watershed Lead Concentrations 2019-2023
Pb Concentration ug/L
5
4
3
2
1
0
PWQO
TW001
TW002
TW003
TW004
TW005
TW006
TW007
TW008
TW009
Site


Twelve Mile Creek Watershed Nitrate Concentrations 2019-2023
NO3 Concentration mg/L
0
1
2
3
4
CWQG
TW001
TW002
TW003
TW004
TW005
TW006
TW007
TW008
TW009
Site


Twelve Mile Creek Watershed Total Phosphorus Concentrations 2019-2023
TP Concentration ug/L
5
10
20
50
100
200
500
PWQO
TW001
TW002
TW003
TW004
TW005
TW006
TW007
TW008
TW009
Site



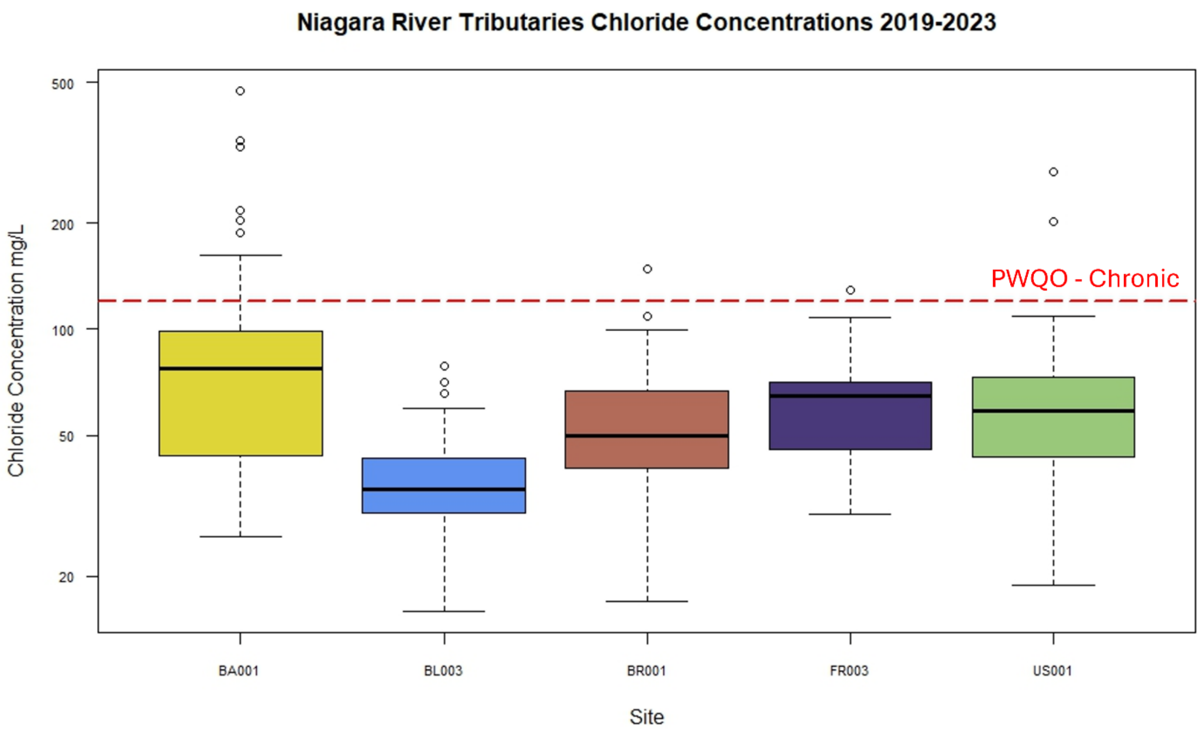
Twelve Mile Creek Watershed Total Suspended Solids Concentrations 2019-2023
TSS Concentration mg/L
CWQG
TW001
TW002
TW003
TW004
TW005
TW006
TW007
TW008
TW009
Site

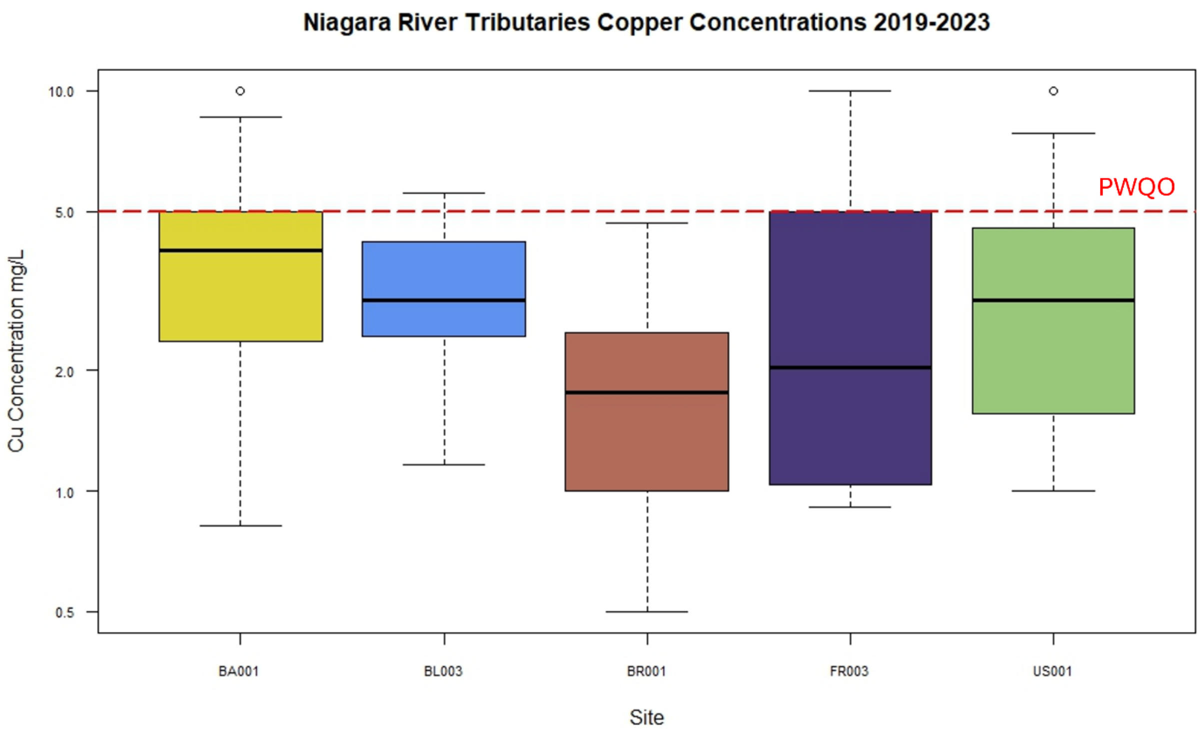


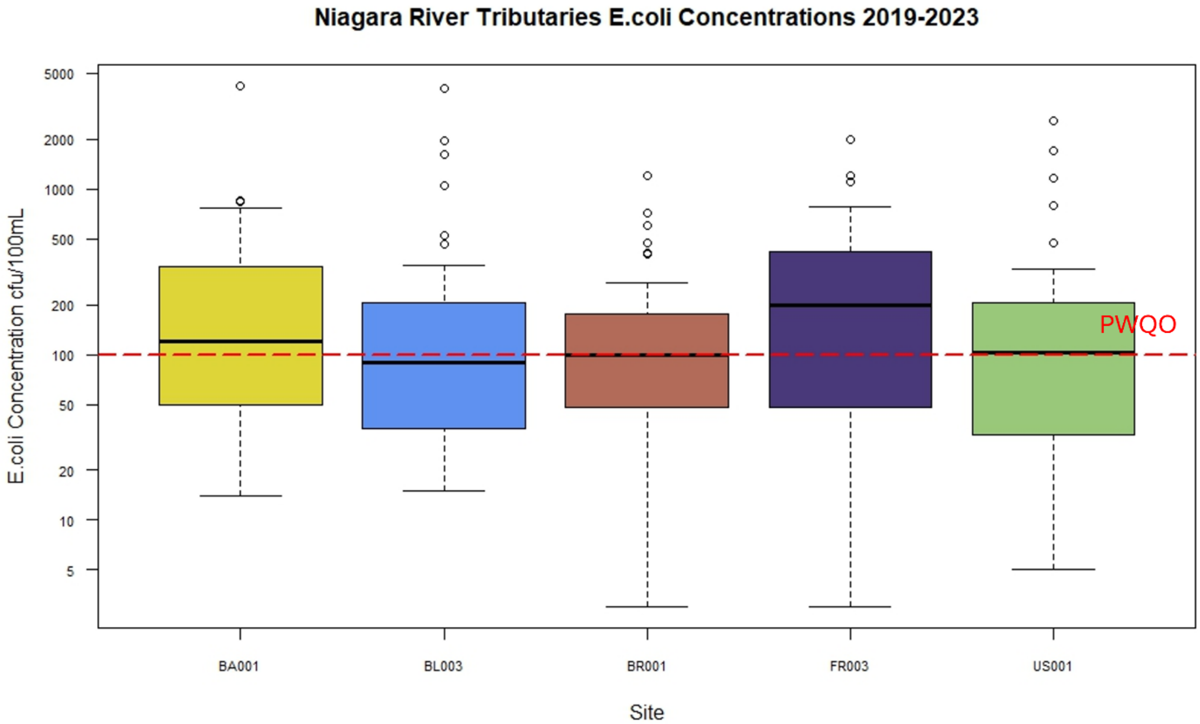
Twelve Mile Creek Watershed Zinc Concentrations 2019-2023
Zn Concentration ug/L
PWQO
TW001
TW002
TW003
TW004
TW005
TW006
TW007
TW008
TW009
Site

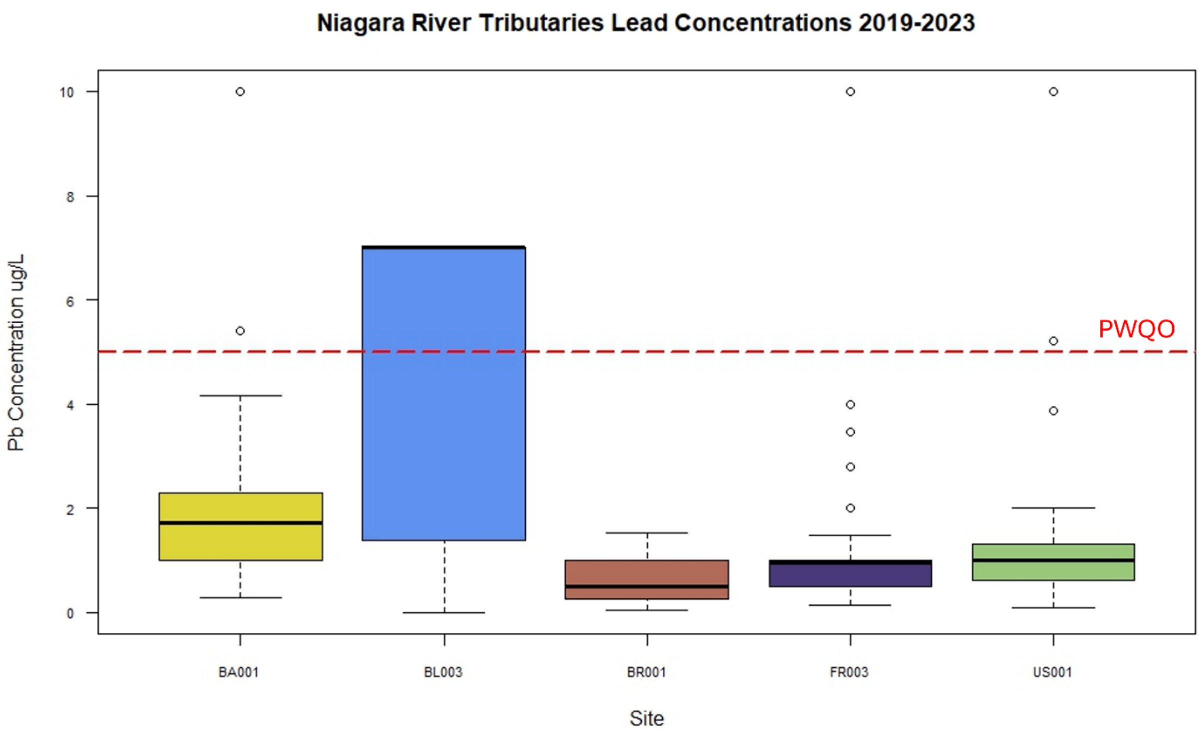
Appendix H

Niagara River Tributaries Indicator Parameter Boxplot Summaries 2019-2023

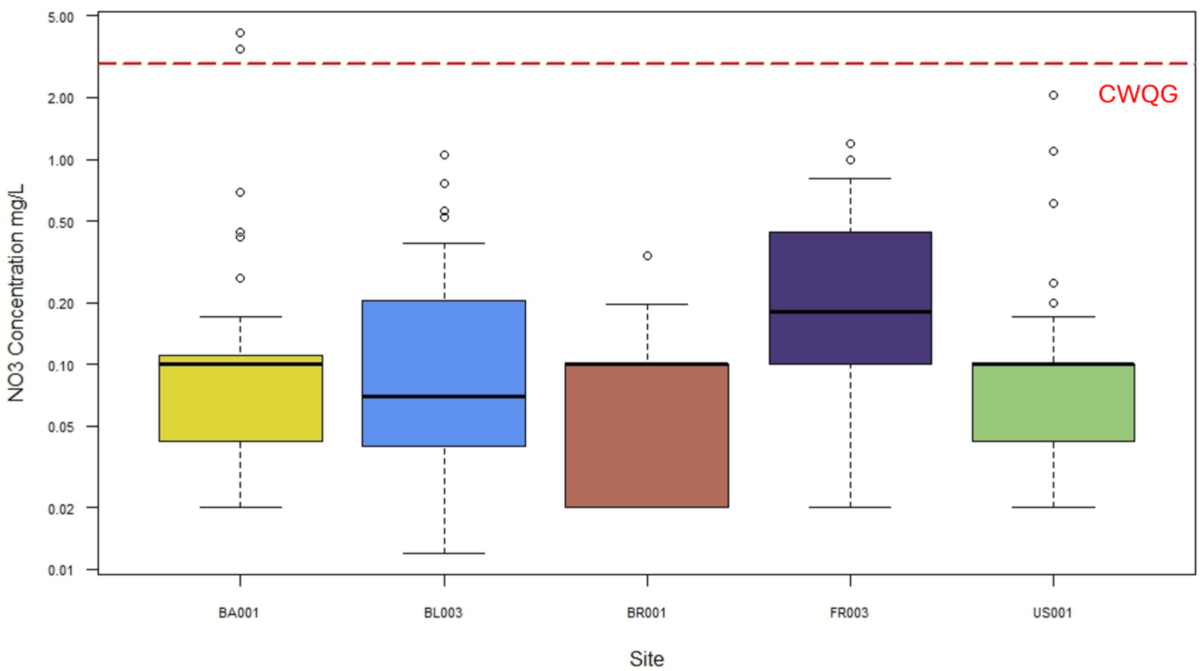

Niagara River Tributaries Chloride Concentrations 2019-2023
500
200
100
50
20
Chloride Concentration mg/L
PWQO - Chronic
BA001
BL003
BR001
FR003
US001
Site


Niagara River Tributaries Copper Concentrations 2019-2023
10.0
5.0
2.0
1.0
0.5
Cu Concentration mg/L
PWQO
BA001
BL003
BR001
FR003
US001
Site

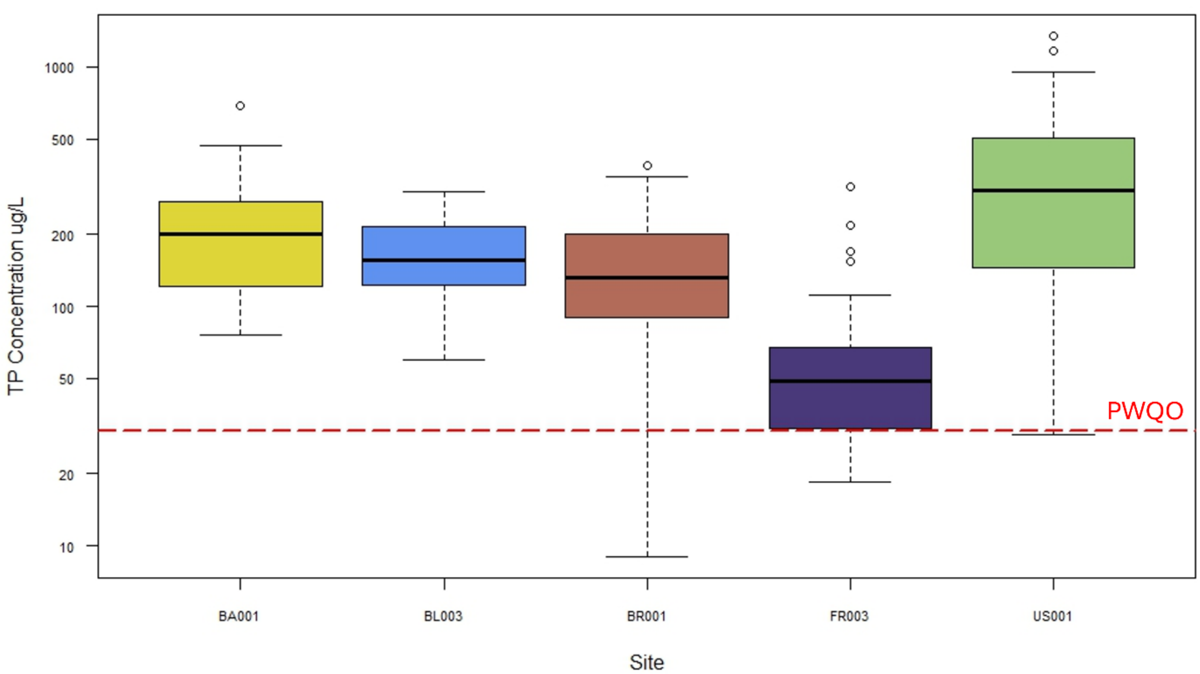

Niagara River Tributaries E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
5000
2000
1000
500
200
100
50
20
10
5
PWQO
BA001
BL003
BR001
FR003
US001
Site


Niagara River Tributaries Lead Concentrations 2019-2023
Pb Concentration ug/L
10
8
6
4
2
0
PWQO
BA001
BL003
BR001
FR003
US001
Site

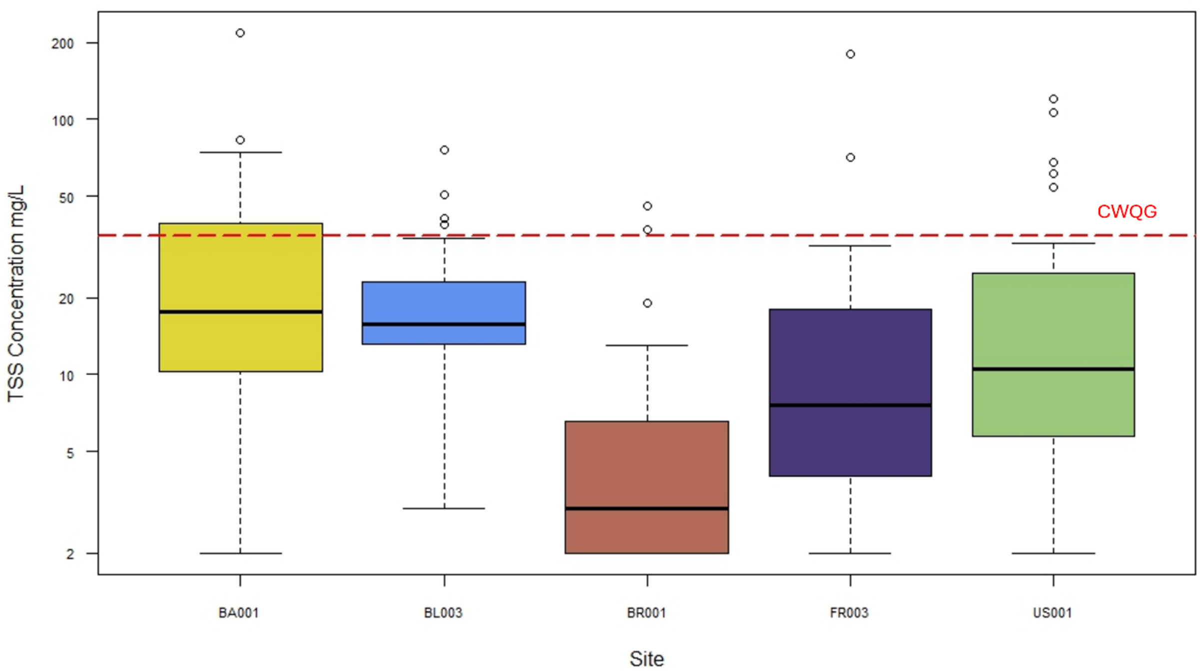
Niagara River Tributaries Nitrate Concentrations 2019-2023



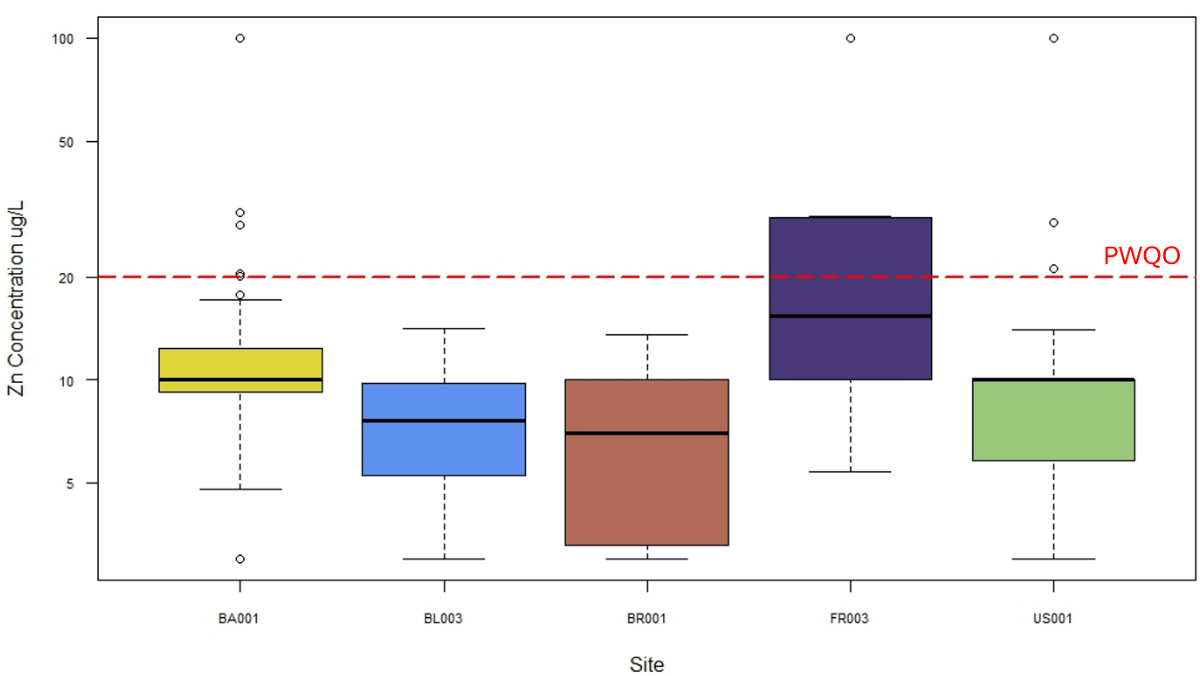
Niagara River Tributaries Total Phosphorus Concentrations 2019-2023



Niagara River Tributaries Total Suspended Solids Concentrations 2019-2023

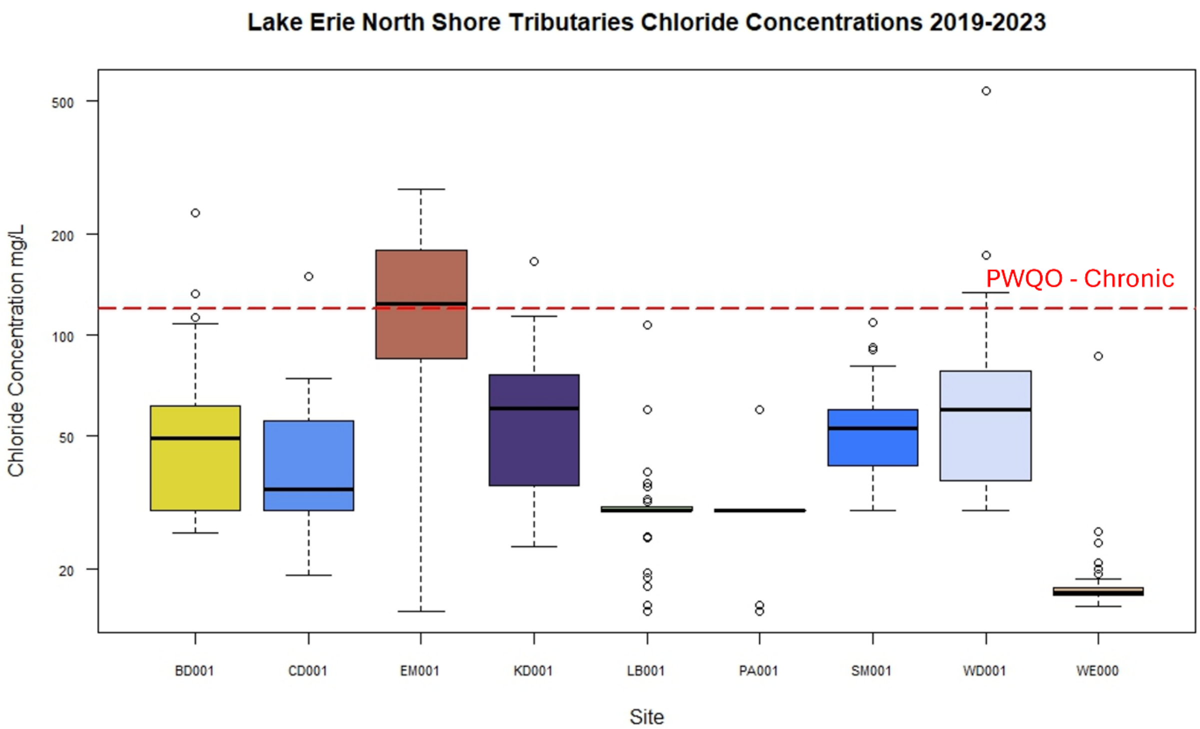


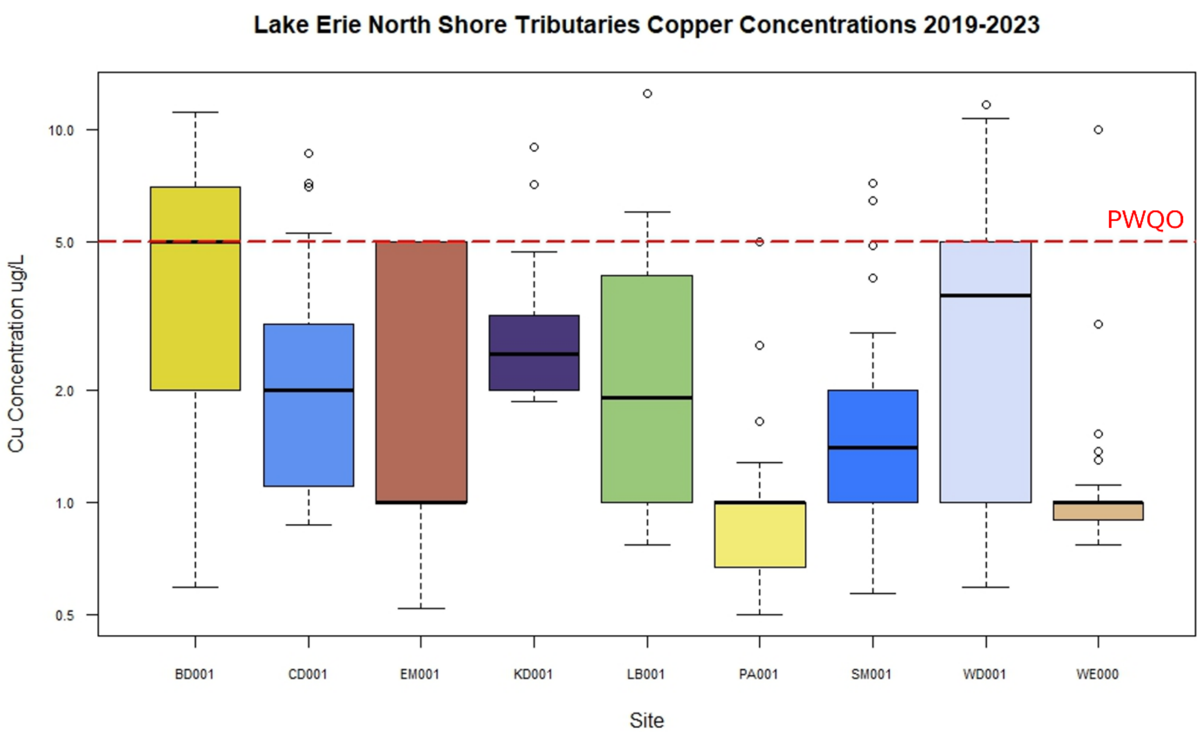
Niagara River Tributaries Zinc Concentrations 2019-2023

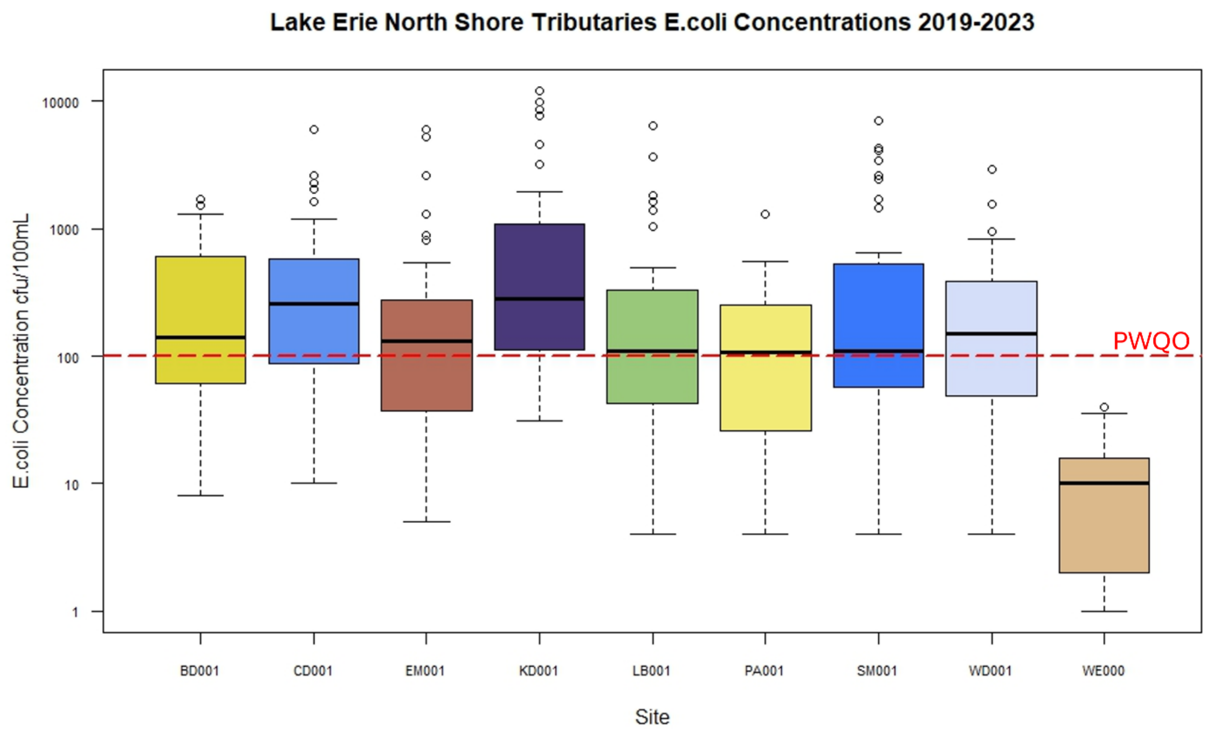


Appendix I

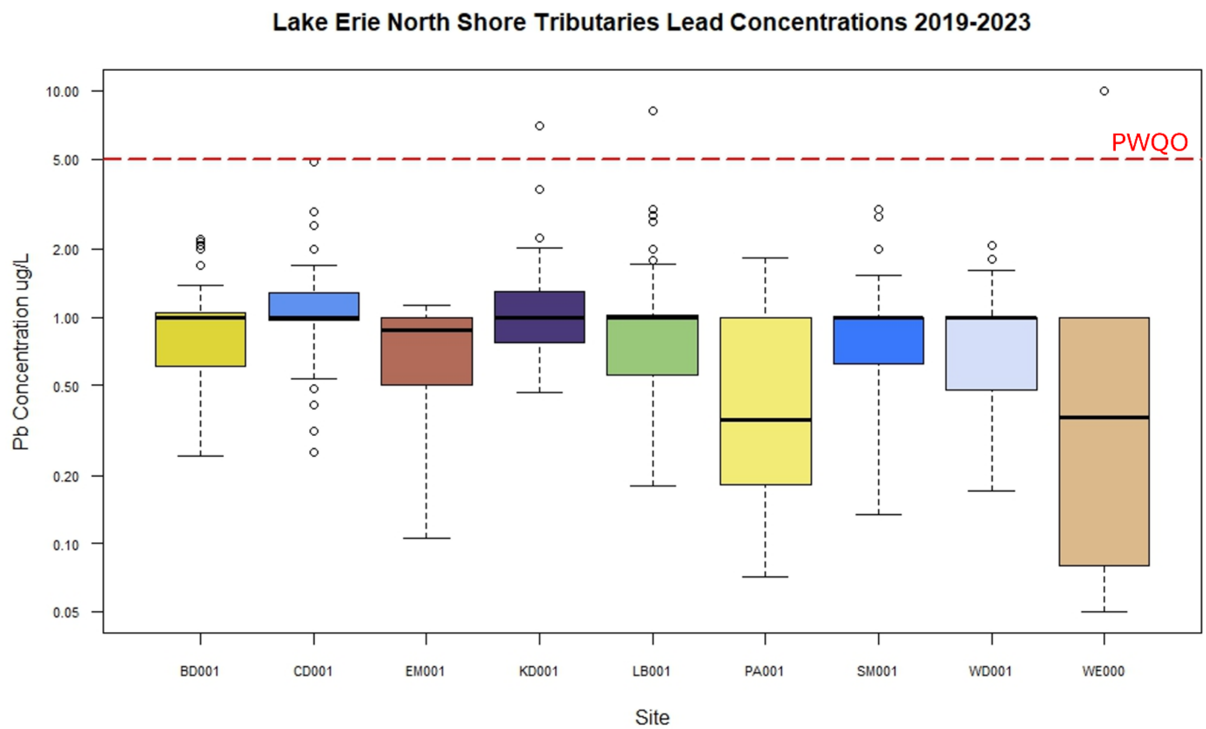
Lake Erie North Shore Tributaries Indicator Parameter Boxplot Summaries 2019-2023


Lake Erie North Shore Tributaries Chloride Concentrations 2019-2023
Chloride Concentration mg/L
500
200
100
50
20
PWQO - Chronic
BD001
CD001
EM001
KD001
LB001
PA001
SM001
WD001
WE000
Site


Lake Erie North Shore Tributaries Copper Concentrations 2019-2023
Cu Concentration ug/L
10.0
5.0
2.0
1.0
0.5
PWQO
BD001
CD001
EM001
KD001
LB001
PA001
SM001
WD001
WE000
Site

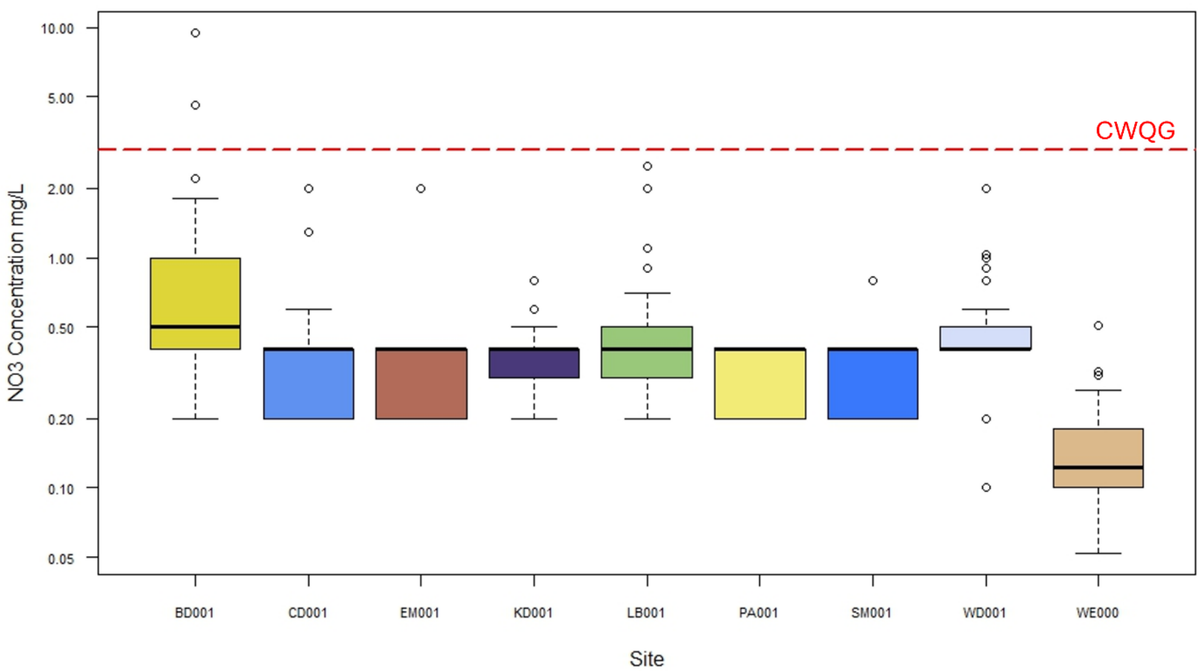


Lake Erie North Shore Tributaries E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
10000
1000
100
10
1
PWQO
BD001
CD001
EM001
KD001
LB001
PA001
SM001
WD001
WE000
Site

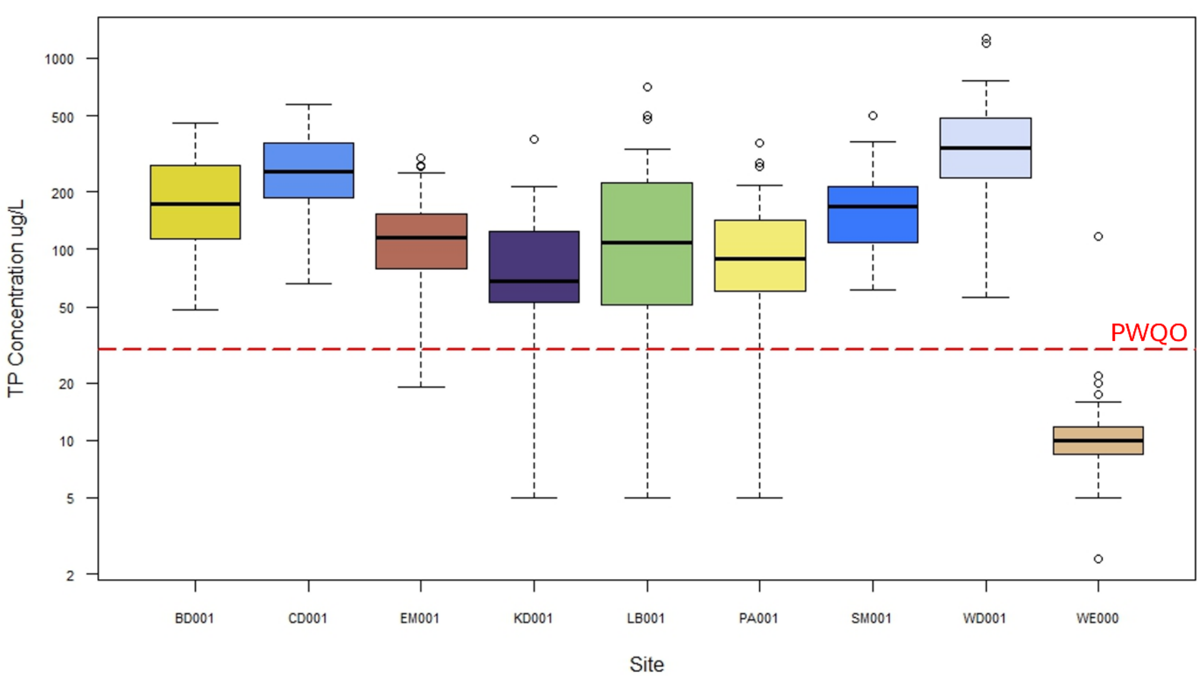


Lake Erie North Shore Tributaries Lead Concentrations 2019-2023
Pb Concentration ug/L
10.00
5.00
2.00
1.00
0.50
0.20
0.10
0.05
PWQO
BD001
CD001
EM001
KD001
LB001
PA001
SM001
WD001
WE000
Site

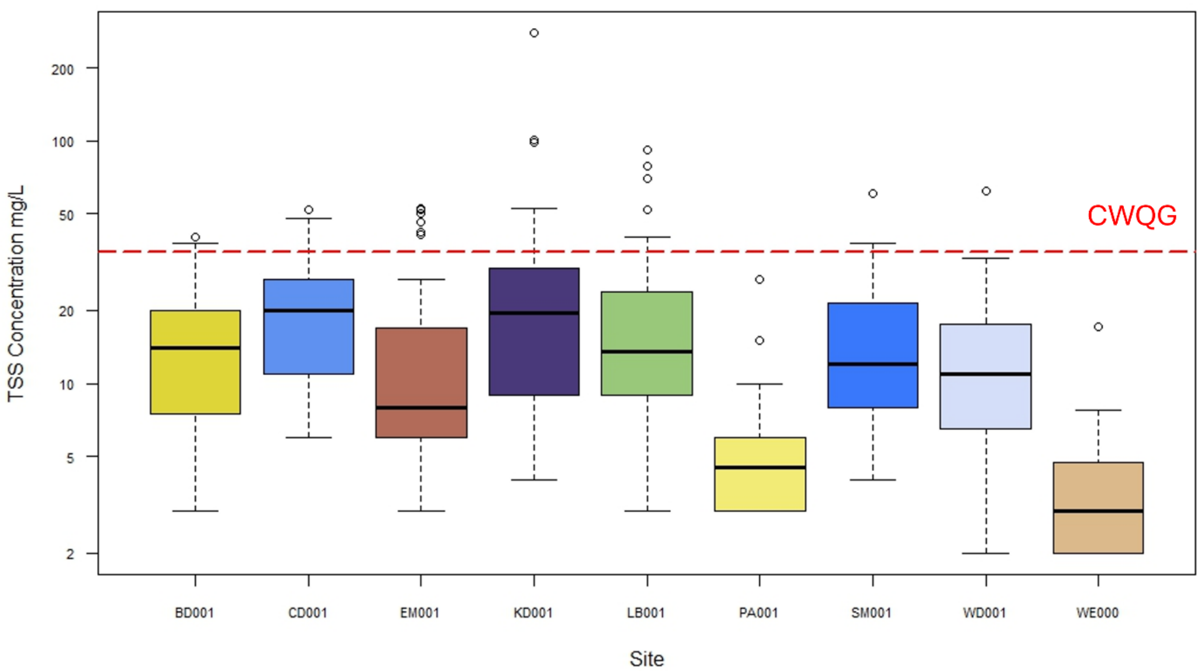
Lake Erie North Shore Tributaries Nitrate Concentrations 2019-2023



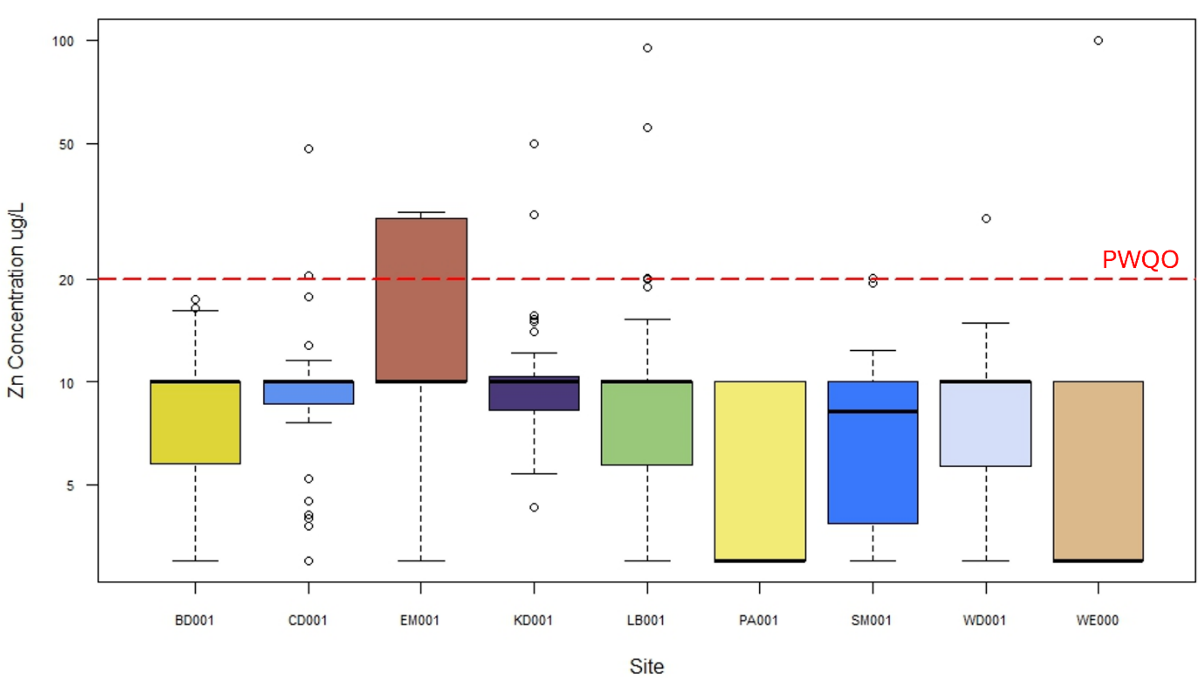
Lake Erie North Shore Tributaries Total Phosphorus Concentrations 2019-2023



Lake Erie North Shore Tributaries Total Suspended Solids Concentrations 2019-2023

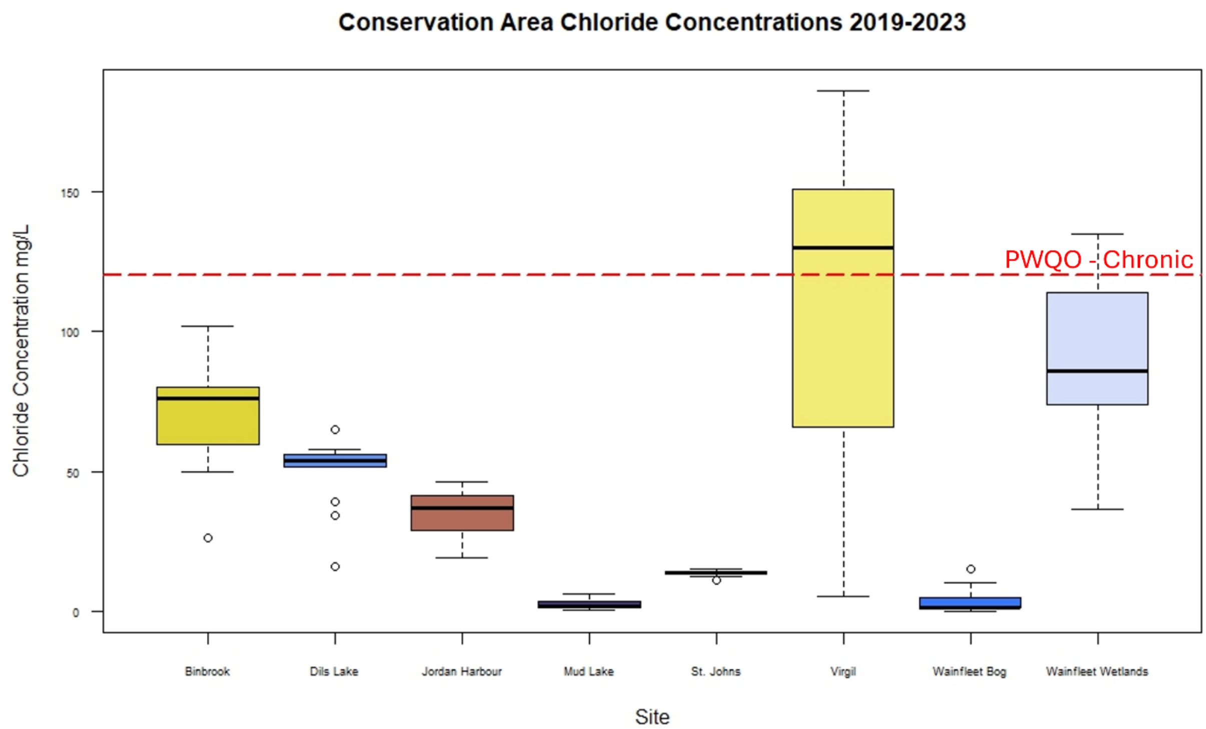


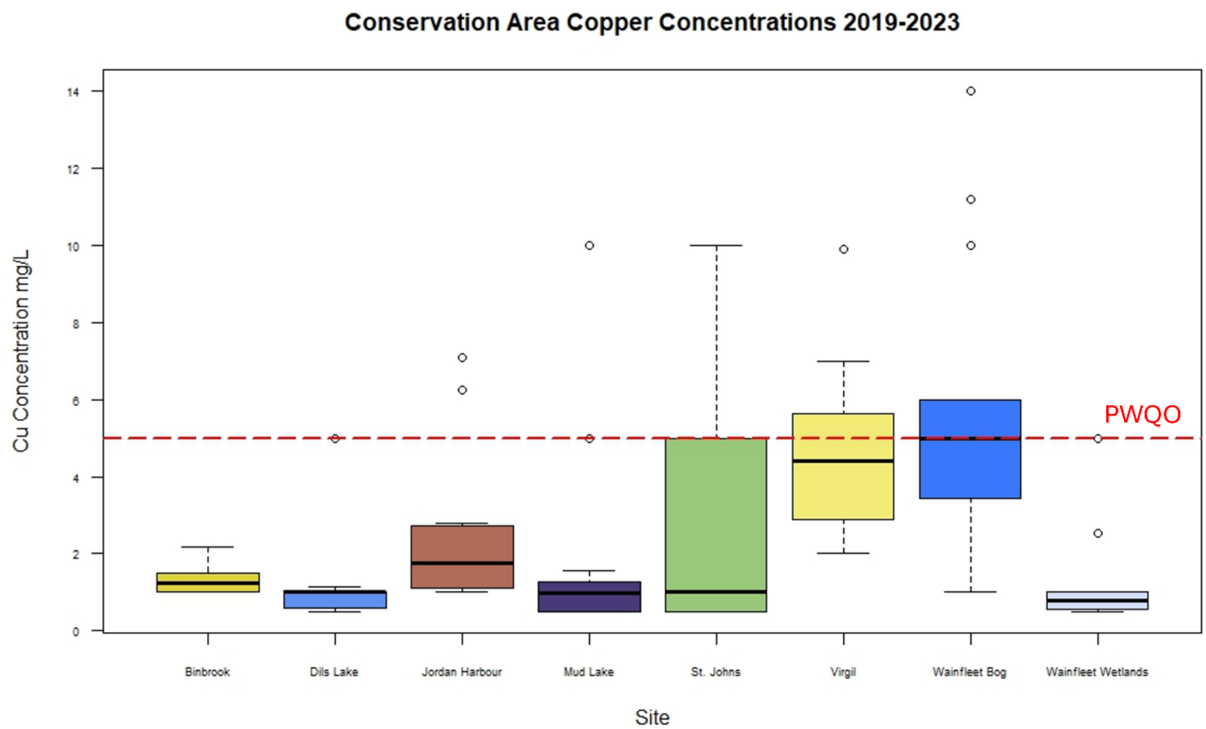
Lake Erie North Shore Tributaries Zinc Concentrations 2019-2023

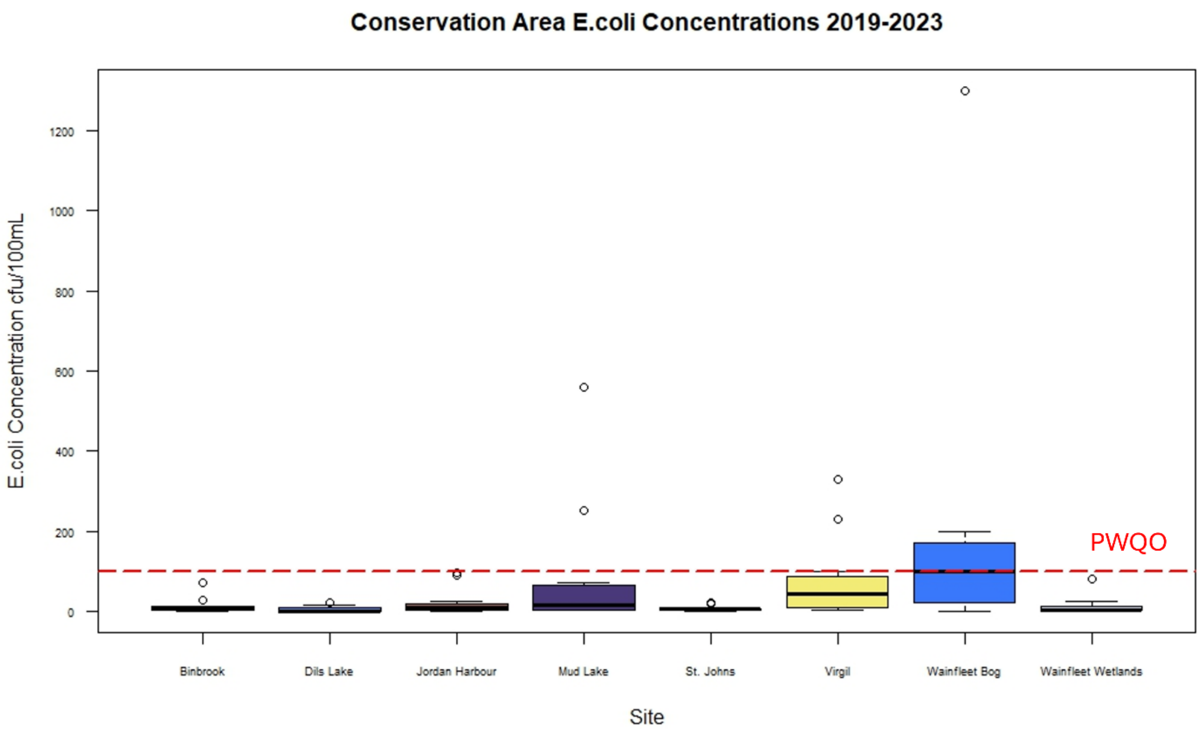


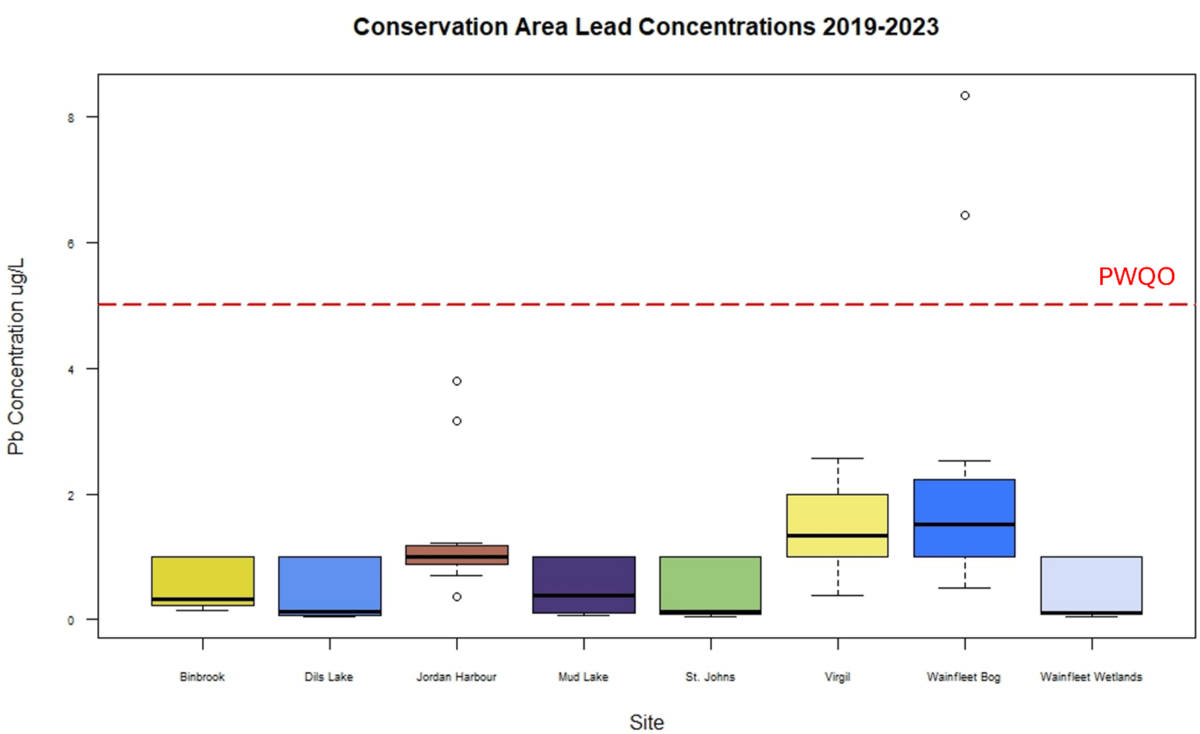
Appendix J

Conservation Area Indicator Parameter Boxplot Summaries 2019-2023

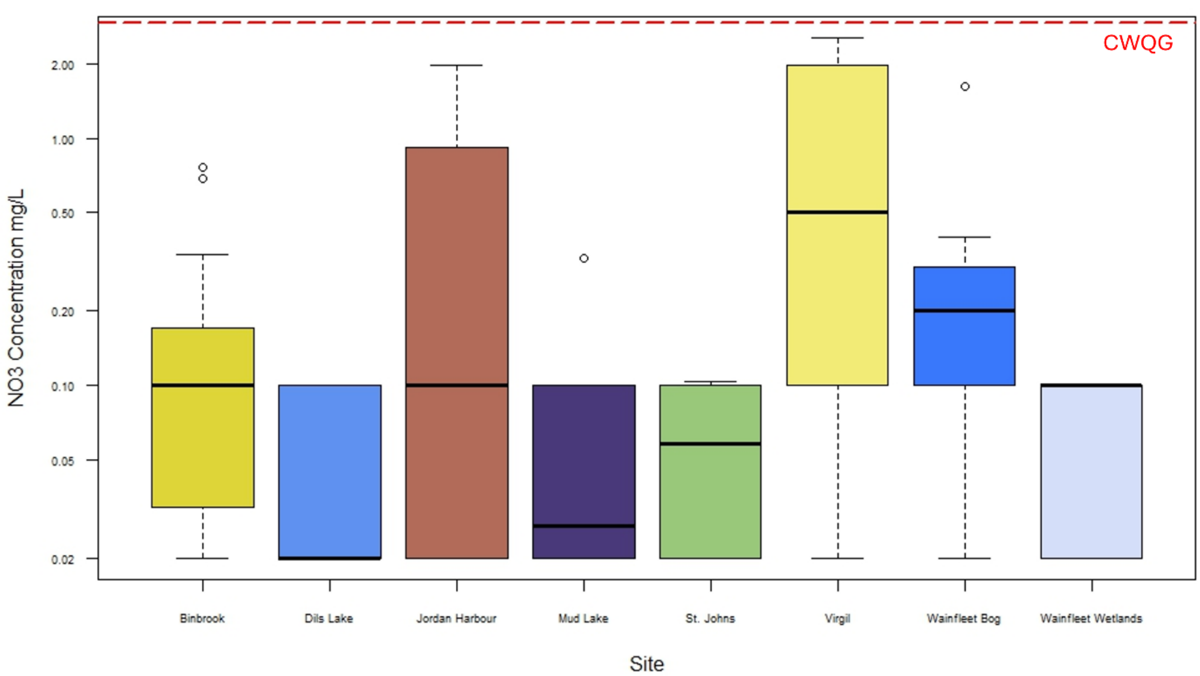

Conservation Area Chloride Concentrations 2019-2023
Chloride Concentration mg/L
0
50
100
150
PWQO - Chronic
Binbrook
Dils Lake
Jordan Harbour
Mud Lake
St. Johns
Virgil
Wainfleet Bog
Wainfleet Wetlands
Site


Conservation Area Copper Concentrations 2019-2023
Cu Concentration mg/L
0
2
4
6
8
10
12
14
PWQO
Binbrook
Dils Lake
Jordan Harbour
Mud Lake
St. Johns
Virgil
Wainfleet Bog
Wainfleet Wetlands
Site

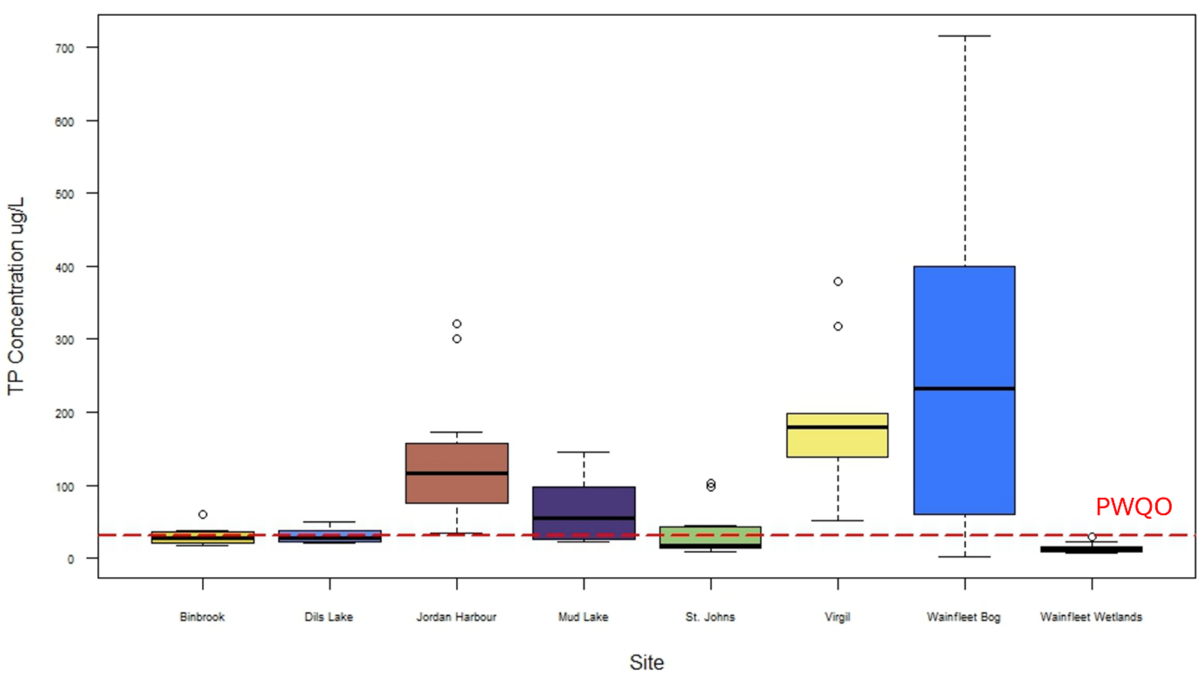

Conservation Area E.coli Concentrations 2019-2023
E.coli Concentration cfu/100mL
0
200
400
600
800
1000
1200
PWQO
Binbrook
Dils Lake
Jordan Harbour
Mud Lake
St. Johns
Virgil
Wainfleet Bog
Wainfleet Wetlands
Site

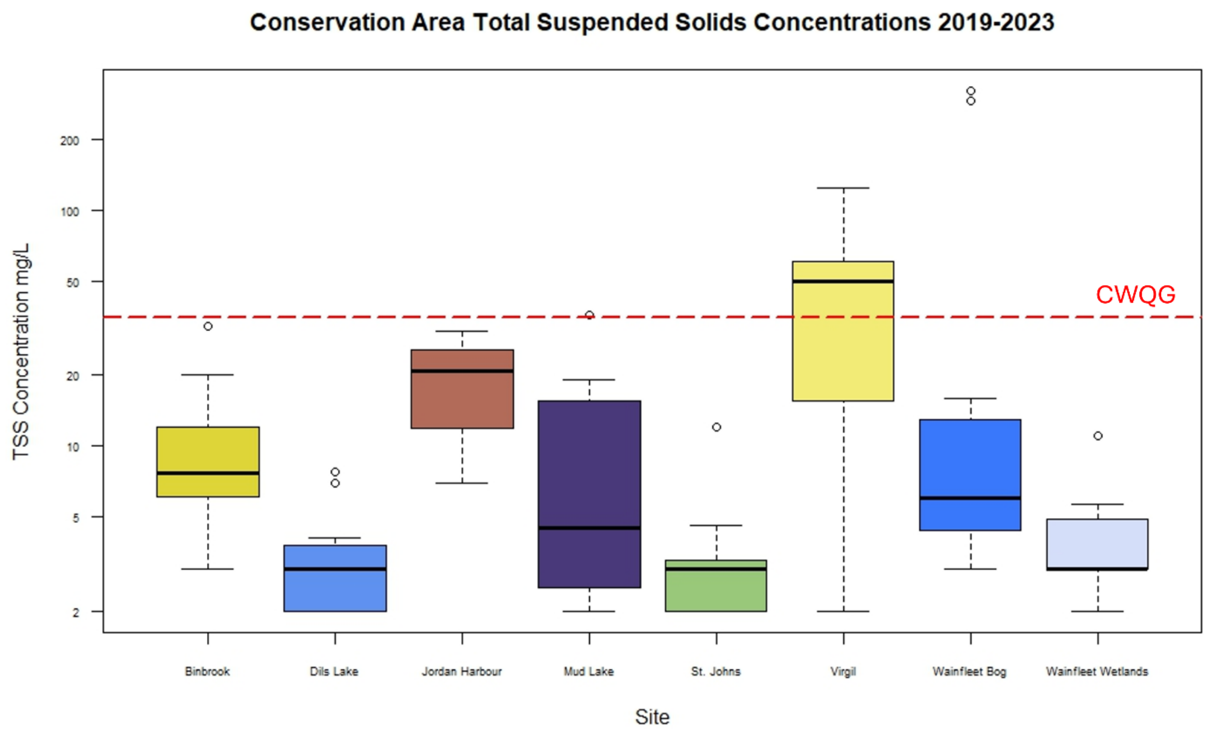

Conservation Area Lead Concentrations 2019-2023
Pb Concentration ug/L
0
2
4
6
8
PWQO
Binbrook
Dils Lake
Jordan Harbour
Mud Lake
St. Johns
Virgil
Wainfleet Bog
Wainfleet Wetlands
Site

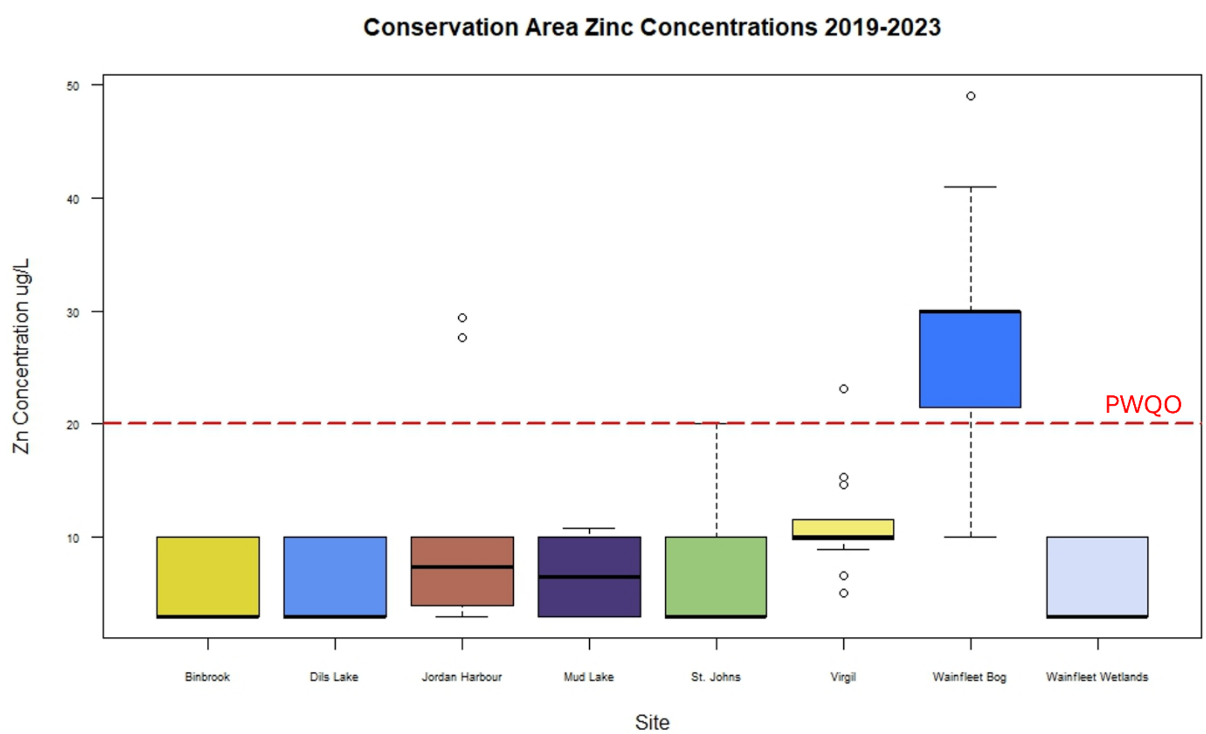
Conservation Area Nitrate Concentrations 2019-2023



Conservation Area Total Phosphorus Concentrations 2019-2023




Conservation Area Total Suspended Solids Concentrations 2019-2023
TSS Concentration mg/L
200
100
50
20
10
5
2
CWQG
Binbrook
Dils Lake
Jordan Harbour
Mud Lake
St. Johns
Virgil
Wainfleet Bog
Wainfleet Wetlands
Site


Conservation Area Zinc Concentrations 2019-2023
Zn Concentration ug/L
50
40
30
20
10
PWQO
Binbrook
Dils Lake
Jordan Harbour
Mud Lake
St. Johns
Virgil
Wainfleet Bog
Wainfleet Wetlands
Site