BOWMANVILLE/SOPER CREEK WATERSHED EXISTING CONDITIONS REPORT CHAPTER 11 – SURFACE WATER QUALITY

FINAL – December 2011

Central Lake Ontario Conservation

DURHAM REGION

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1.0 INTRODUCTION

Water is a valued public resource; streams with unimpaired water quality satisfy a wide variety of needs, such as fisheries and wildlife habitat, human consumption, recreation, and industry. Streams with impaired water quality can pose health risks for local residents, livestock, or wildlife. In order to provide effective management recommendations, it is imperative that the watershed's water quality is well understood.

Surface water quality is generally described using measures of chemical, physical and biological characteristics. These measured values can then be compared with established standards. The water quality can assist in determining the level at which existing conditions in the watershed are able to sustain and promote wildlife diversity and fish populations, to support vegetation, and to ensure adequate safe water supplies for human consumption, agriculture, and recreational uses. Degradation of water quality can diminish the aesthetic value of water resources, adversely affect terrestrial and aquatic species, and/or create health hazards for humans.

Considerable changes in water quality may be attributed to both natural and human-related causes. Natural causes such as physical and geochemical rock weathering often result in an increase in turbidity and concentrations of some constituents in stream waters. These natural causes, however, have been surpassed by water quality changes brought about by human activities that are mostly related to changes in land use, behavioural changes and other developments. Pollution brought about by these changes adversely affect the physical, chemical and/or biological conditions in both surface and groundwater environments. The general and most common types of pollution, among others, include toxic, organic, nutrient, bacterial and sediment (turbidity). Thermal impairment from land use alteration also impacts water quality and is described in detail in Chapter 10 Water Temperature. Stormwater management facilities assist in the reduction of sediment transport to creek systems (see Chapter 12 for more detail). CLOCA requires an 80% reduction of sediment in runoff from proposed development, in accordance with the Ministry of Environment (MOE) guidelines for Enhanced Protection.


Soper Creek subwatershed

Toxic pollution is caused by the addition of elements such as heavy metals and inorganic and organic compounds, which can be toxic to all life forms.
Organic pollution is caused by the addition of biomass, which requires chemical breakdown, thus resulting in oxygen depletion. Primary sources are industrial waste and sewage.
Nutrient pollution is caused by the introduction of excessive concentrations of plant nutrients such as nitrogen and Phosphorous from agricultural runoff, lawn fertilizers, domestic wastewater, sewage and industrial discharges. Depletion of dissolved oxygen levels results from increased bio-production.
Bacterial (Pathogenic) pollution results from coliform (e.g., *E. coli*) and/or disease-carrying organisms from mammals. Sources are generally domestic sewage and livestock wastes.
Sediment pollution is caused by the excessive suspension of soil materials that may be eroded from development sites, agricultural areas or streambanks in the watercourses. Concentration of solids or high turbidity may reduce biological activity, deplete oxygen levels and eventually result in stream sterilization.

Aside from pollution types, it is also essential to determine whether the contaminants came from point or non-point sources. Point source pollutants are those originating from industries, storage structures and certain processing plants while non-point sources are widespread and generally mobile. Non-point sources include acid rain, road salting, fertilizer and pesticide applications, and accidental chemical spills from moving vehicles.

Applicable Legislation and Policies

Surface water quality monitoring activities in the Bowmanville/Soper Creek watershed and all watersheds within CLOCA are governed by principles, regulations and guidelines embodied in federal and provincial legislations on water resources management and protection. The Environmental Protection Act, 1990 and Ontario Water Resources Act, 1990 are just two pieces of legislation related to the protection and management of water resources. The Ontario Water Resources Act has provisions that prescribe and regulate standards of quality for water supplies, sewage and industrial waste effluents discharging to streams and water courses. The Environmental Protection Act pertains specifically to on site standards and exceedances brought about by construction developments. The Safe Drinking Water Act 2002 focuses on the protection of human health through the control and regulation of drinking-water systems and drinking-water testing, including the treatment and testing requirements for all categories of regulated water systems. The Nutrient Management Act 2002, deals with nutrient load management mostly originating from agricultural lands and septic sources. The focus of the Clean Water Act 2006 is to ensure the safety of municipal drinking water by identifying potential risks to local sources. CLOCA is currently engaged in developing source water protection strategies to meet the requirements of the Clean Water Act.

In line with the above-mentioned legislative and regulatory instruments, a surface water quality monitoring strategy was developed to generate tools that will assist managers, decision-makers and implementers to properly address water contamination concerns and immediately mitigate if not totally eliminate its adverse effects during the early stage of detection.

2.0 STUDY AREA AND SCOPE

The Bowmanville/Soper Creek watershed is situated entirely within the Regional Municipality of Durham and covers an area of approximately 170 km^2 (Figure 1). The watershed drains southerly towards Lake Ontario from its headwaters in the Oak Ridges Moraine. The Bowmanville/Soper Creek watershed consists of 2 primary subwatersheds: Bowmanville Creek and Soper Creek, whose tributaries join together prior to outletting to Lake Ontario.

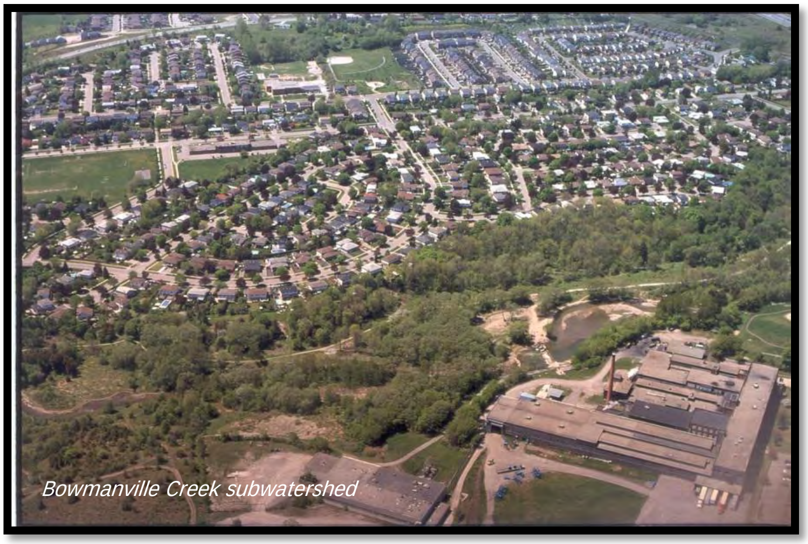
Surface water quality information is collected by CLOCA at sites throughout the watershed. This information is used to identify trends in the quality of the water using various indicators. This chapter reports on these indicators and the state of the surface water quality within the Bowmanville and Soper creeks.

3.0 METHODOLOGY

3.1 Water Quality Index

The Water Quality Index (WQI) is a collection of chemical water quality parameters that assist in determining the surface water quality conditions. The WQI parameters were chosen based on the monitoring programs in place, historical studies, and their significance as a water quality indicator. Table 1 presents the WQI parameters, their descriptions, method of calculation and significance as an indicator of watershed condition.

Both parametric and non-parametric tests were used for statistical trend analyses. Parametric tests are hypothesis tests for probability, which assume that data has a particular distribution (usually a normal distribution). Non-parametric tests (also called distribution-free) are hypothesis tests for probability not requiring the assumption that data follow a particular distribution (Helsel, D.R., et.al., 2002). Water quality data, including the parameters that are not in the WQI list, were statistically analyzed using Microsoft Excel for most parametric analysis and AquaChem was used for both parametric and non-parametric analysis. AquaChem is a software package developed by Waterloo Hydrogeologic Inc. that assists in performing graphical and numerical analysis and modelling of water quality data.



Bowmanville Creek subwatershed

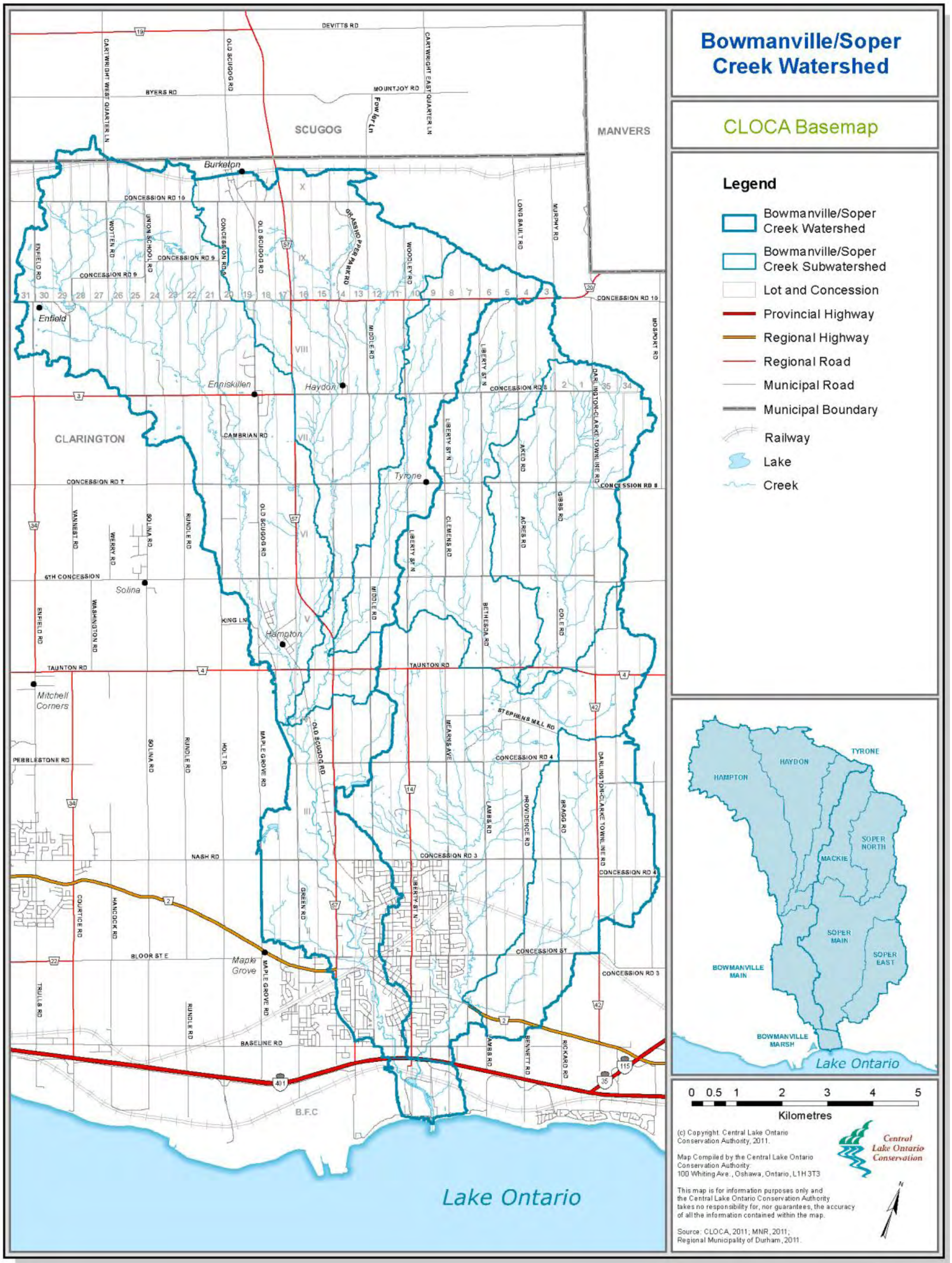
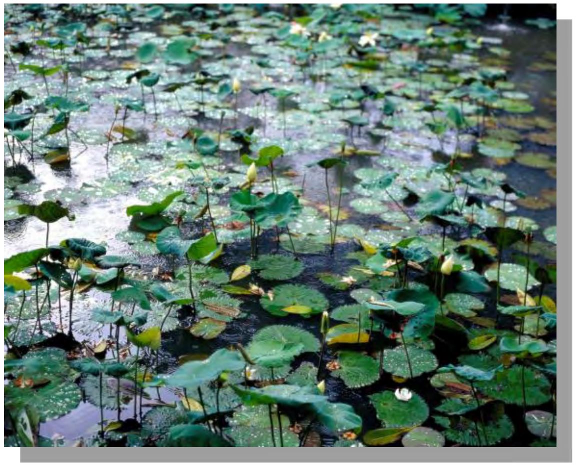


Figure 1: Bowmanville/Soper Creek watershed

Table 1: Description of Parameters in the Surface Water Quality Index

Indicator	What it Measures	Why it is important
Chloride	The concentration of Chloride in the water	Once Chloride is dissolved in a solution it tends to remain there. Chloride is present in road salt, fertilizers and industrial wastewater. In high concentrations chloride can be toxic to aquatic organisms.
Phosphorous	The concentration of Phosphorous in the water	Phosphorous binds to soil particles and thus is an indicator of soil delivery to streams. Phosphorous is present in soaps, fertilizers and pesticides. Increased concentrations in water can cause algae blooms.
Nitrogen Compounds	The concentration of the various compounds of Nitrogen (i.e. Nitrate and Nitrite)	Nitrogen, in the form of Nitrate, is a nutrient with sources and effects similar to Phosphorous. It is also potentially toxic in aquatic systems when in the form of ammonia or nitrite the latter of which is a very transient stage in the nitrification process converting ammonia to nitrite.)
Copper	The concentration of Copper in water	The toxicity of copper to marine organisms is difficult to generalize and the level of tolerance varies among marine organisms. Aquatic invertebrates are thought to be slightly more sensitive to copper than fish. Copper has an existing limit of 5 ug/L under the Provincial Water Quality Objective (PWQO). An interim objective of 1 ug/L (hardness dependent) is currently under development pending MOE approval.
Biological Oxygen Demand (BOD) and Dissolved Oxygen (DO)	BOD and DO in mg/L	The BOD of water corresponds to the amount of oxygen required for aerobic microorganisms to oxidize organic matter into a stable inorganic form. High BOD level corresponds to low Dissolved Oxygen concentrations which could lead to stress responses in aquatic organisms. No official guideline for BOD level exists. BOD levels above 2 mg/L (or 5 mg/L during exclusively dry weather) indicate the presence of a persistent organic load to the system. The Canadian water quality objective for DO ranges from 5.0 – 6.0 mg/L for warm water biota and 6.5 – 9.5 mg/L for cold water biota depending on life stages.(1)
Benthic	The benthic invertebrate organisms living in the stream sediments	Benthic organisms generally: • have limited mobility, making them vulnerable to many stresses in the creek; • have short life cycles; • are easily collected and identified; and, • exists in almost all aquatic habitats.

Note: (1) Toronto and Region Conservation Authority, 2002



3.2 Water Quality Collection

Different types of water quality information have been collected by CLOCA and MOE through the Provincial Water Quality Monitoring Network Program since 1964. Biological water quality is based on aquatic life, while chemical water quality is assessed by analyzing the concentrations of various chemicals in the water.

Hampton Monitoring Station

3.2.1 Chemical Water Quality

CLOCA has two chemical water quality sampling programs in place, the Provincial Water Quality Monitoring Network (PWQMN) and CLOCA's own water quality monitoring program. In Bowmanville and Soper creeks, the list of the chemical quality monitoring stations is presented in Table 2 and their site locations are shown in Figure 2.

Table 2: Chemical quality monitoring stations (Bowmanville and Soepr Creeks)

CLOCA ID	Watershed	Location	Program	First	Last	Re-started	PWQMN ID
SWQ4	Bowmanville Creek	West Beach Rd, Bowmanville	PWQMN	1964	1997	2003	6011600102
SWQ15	Bowmanville Creek	Hampton Conservation Area	PWQMN	2003			6011600502
SWQ16	Bowmanville Creek	Taunton Rd, Clarington	CLOCA	2004			
SWQ17	Bowmanville Creek	Long Sault Conservation Area	PWQMN	2003			6011600602
SWQ5	Soper Creek	West Beach Rd, Bowmanville	CLOCA/HISTORIC PWQMN	1967	1994	2003	6011600202
SWQ18	Soper Creek (west branch)	Taunton Rd, Clarington	CLOCA	2004			
SWQ19	Soper Creek (east branch)	Taunton Rd, Clarington	CLOCA	2004			
SWQ20	Soper Creek (east branch)	Gibbs Rd north Conc. 7	CLOCA	2004			
SWQ21	Soper Creek (east branch)	Lambs Road, Clarington	CLOCA	2005			

The PWQMN was designed to collect surface water quality information province wide. The objectives of the PWQMN are to collect, document and assess long term water quality. The Ministry of Environment operates the program across the province while CLOCA assists in collecting samples from nine sites, three that are located within the Bowmanville/Soper Creek watershed, on monthly intervals from April through November. The samples collected under the PWQMN program are sent to the Ministry of Environment (MOE) laboratory and tested for 40 parameters (see APPENDIX A-1: Chemical Parameters Analyzed (York-Durham Environmental Laboratory).

Supplemental to the PWQMN water quality sampling, CLOCA independently conducts water quality sampling at 10 stations across our jurisdiction, six of which are located within Bowmanville/Soper Creek watershed. The samples from these stations are collected twice during the summer months on the same day that the PWQMN sampling occurs. The samples collected under this program are submitted to the Durham-York Region Environmental Laboratory for analysis of 46 physical-chemical parameters (Appendix A-2).

3.2.2 Biological Water Quality

Biological water quality has been collected under three programs within CLOCA: the Biological Monitoring and Assessment Protocol (BioMAP), Hilsenhoff scores derived from invertebrate sampling data collected under the Ontario Stream Assessment Protocol (OSAP), and the Ontario Benthos Biomonitoring Network (OBBN).

Using the BioMAP protocol (Griffiths, 1999), 18 sites within the Bowmanville/Soper watershed were assessed in 1998 and 11 sites were sampled between 2003 and 2004. Through this program, invertebrates were collected from each site and identified generally to the species level. Certain aquatic invertebrates are known to be tolerant of poor water quality conditions, while others are more sensitive (i.e. intolerant) and are only found in areas of good water quality. The numbers of tolerant/intolerant individuals at each site were used to evaluate whether or not the water quality was impaired.

Hilsenhoff scores were calculated from benthic invertebrate sampling conducted as part of the OSAP protocol (Stanfield *et al.* 1998). Hilsenhoff scores are a qualitative measure of water quality and organic pollution using tolerance values from benthic invertebrate families. Using this protocol, over 90 sites were sampled within the Bowmanville/Soper watershed between 1995-2004. This information has also been reported on in the Central Lake Ontario Fisheries Management Plan (CLOCA/MNR 2007) and the Aquatic Resource Management Plan for the Bowmanville/Soper Creek Watershed (CLOCA 2000).

The OBBN (Jones, et al., 2005) protocol also involves the sampling and identification of benthic microinvertebrates to serve as indicators of environmental quality. Through this program, test sites are compared to minimally impacted "reference" sites to determine the level of degradation. Using the OBBN protocol, 13 different sites were sampled a total of 25 times within the Bowmanville/Soper watershed from 2005-2010. Preliminary results from this assessment are presented within this chapter.

It would be worthy to note that the BioMAP and Hilsenhoff information is historical and these methodologies have not been used by CLOCA since 2004. The only benthic sampling procedure that CLOCA currently use is the OBBN methodology.

While every effort has been made to accurately present the findings reported in this chapter, factors such as significant digits and rounding, and processes such as computer digitizing and data interpretation may influence results. For instance, in data tables, no relationship between significant digits and level of accuracy is implied, and values may not always sum to the expected total.


OBBN Sampling

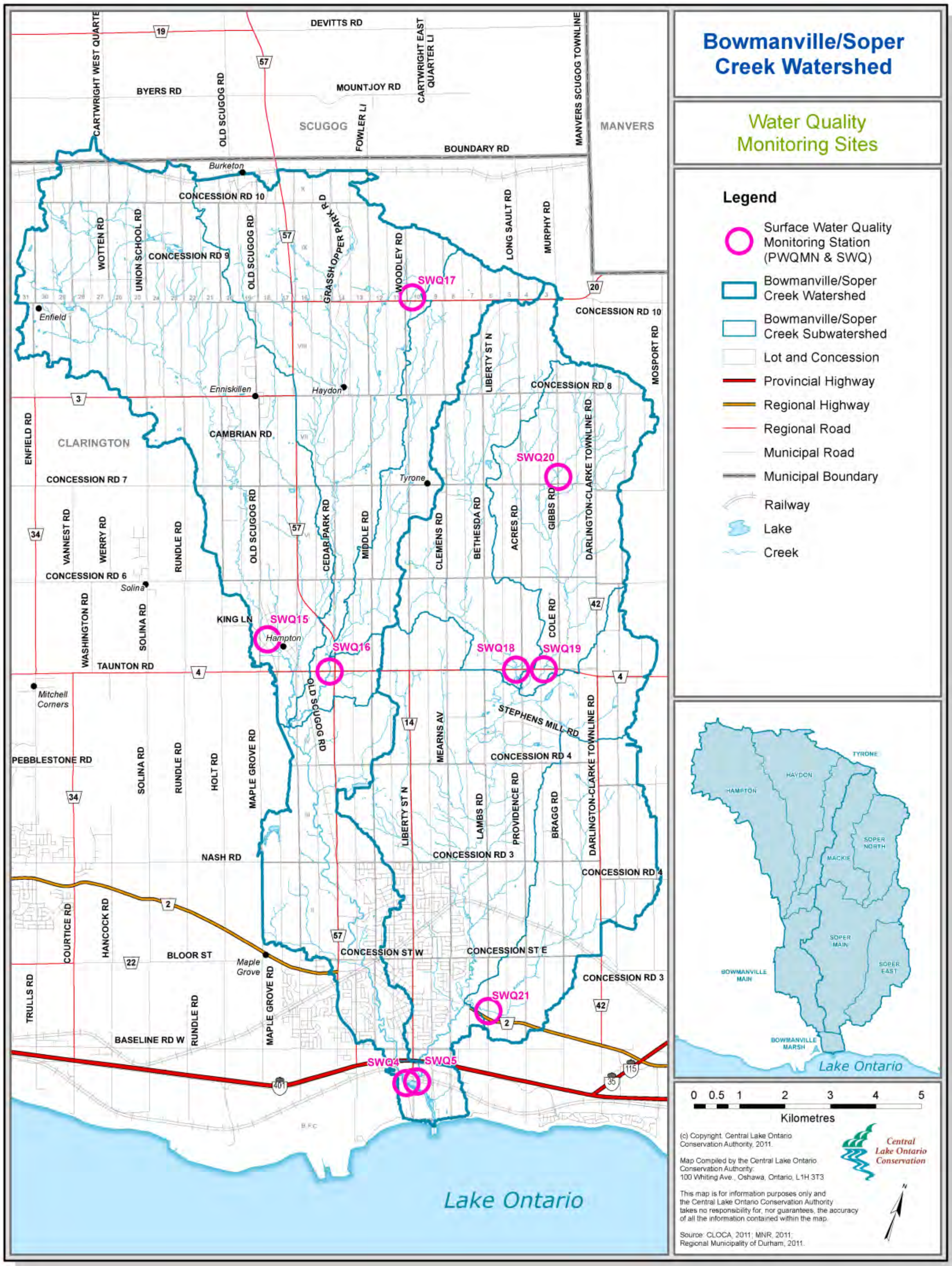


Figure 2: Water quality monitoring stations in the Bowmanville/Soper Creek watershed

4.0 FINDINGS

4.1 Bowmanville/Soper Creek Watershed

4.1.1 Chemical Water Quality

Statistical tests (trend analyses) were performed for the WQI parameters that have sufficient data to process. Trend analysis results either show downward or upward trends are indicative of improving or deteriorating water quality, respectively. This is not the case for dissolved oxygen (DO) where the condition improves proportional with increase in concentration. In the Bowmanville/Soper Creek watershed, statistical trend analysis was performed on chloride, Phosphorous, nitrogen compound (nitrate), copper, biochemical oxygen demand (BOD) and dissolved oxygen. Although statistical and parametric trend analyses that include mean, standard deviation and simple linear regression may be used to graphically show trends, the variability of water quality data, as influenced by changes in season, streamflow and other environmental factors, render parametric trend analysis unreliable. In view of this, the non-parametric trend analysis, specifically the Mann-Kendall Test trend estimator included in the AquaChem[1] water quality management software, was utilized instead. This statistical tool determines whether chemical concentrations are significantly increasing or diminishing over time in a more complex and reliable method. Non-parametric trend analysis is considered to be more reliable because it is not restricted by distributional assumptions, nor grossly affected by data errors, outliers or non-detects, missing data, and irregularly spaced measurement periods. In this test, non-detects are assigned the smallest measured value such that all samples are taken into consideration in the analysis.

For the purposes of determining the relationship between DO and BOD parameters linear regression analysis was performed on all DO and BOD values tested in all four stations. The data show poor linear distribution and this variability is normal in most hydrologic records (Figure 3). The graph, however, is conclusive on the inversely proportional relationship between the two parameters.

4.1.2 Water Quality Exceedances

There are 55 chemical and physical water quality parameters tested, which include the water quality index (WQI) parameters, for each sample collected. All other parameters were chosen as standard Ministry of Environment requirements as well as parameters related to the predominant activities and natural features characterizing the watershed. Parameters excluded in the WQI are monitored with respect to existing provincial and federal water quality standards. Exceedances are regularly noted and monitored for trends and potential adverse effects in the aquatic environment. The list of all water quality parameters tested in the laboratory is presented in Appendix A-1 and A-2.

[1] *Aquachem* is a software package developed by Waterloo Hydrogeologic, Inc. for graphical and numerical modeling of water quality data.

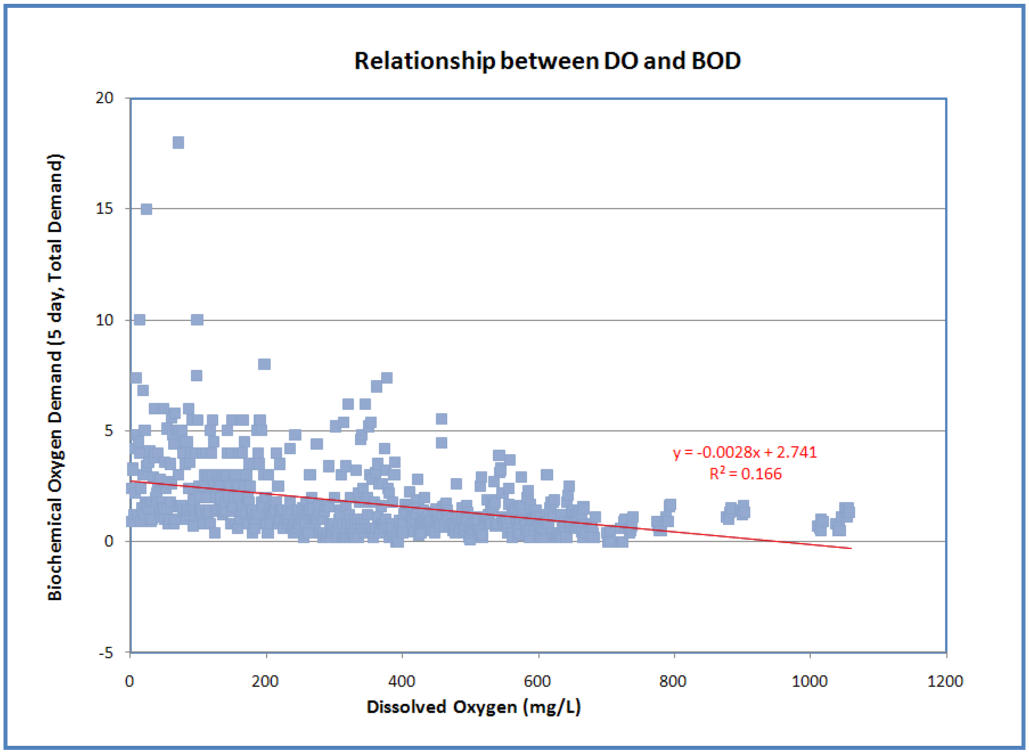


Figure 3: Relationship between DO and BOD at SWQ4, SWQ5, SWQ16, SWQ17, SWQ18, SWQ19, SWQ20 and SWQ21

4.1.3 Biological Water Quality

Biological water quality was assessed historically using BioMAP in 1998 and 2001, 2003-2004 at 31 sites throughout the watershed. Of the 31 sites sampled for biological water quality only one site was considered impaired and two were considered in the "grey area" between impaired and unimpaired. These sites were located in the older urban areas of Bowmanville where stormwater management is lacking or in agricultural areas with insufficient riparian buffers, or where cattle have access to the creek.

Biological water quality (i.e. macroinvertebrates) was also assessed from 1998-2004 while conducting fish community sampling at over 90 sites using the Ontario Stream Assessment Protocol (Stanfield *et al*. 1998). Like BioMAP, the Hilsenhoff scores showed that water quality throughout the watershed was predominantly fair to good. The Main branch in Soper subwatershed did show evidence of degraded conditions where urban and agricultural pressures were high with many sites scoring "fair". In the upper urban areas where stormwater management has been implemented in recent years or there is abundant natural cover or riparian areas, scores were mostly "good". There are situations where intensive agriculture influenced the results through additional nutrients and scores dropped to "fairly poor" or "fair".

Results from the 2005-2010 OBBN data, at 13 sites throughout the watershed, have yet to be thoroughly analyzed. Preliminary results; however, do show a response to human disturbance. Taxa richness and % EPT (the percent of sensitive taxa in the overall catch, including **E**phemeroptera (Mayflies), **P**lecoptera (Stoneflies) and **T**richoptera (Caddisflies)) were calculated. With both of these indices, large values imply a healthy biological community, while low values imply reduced health or impaired water quality (Jones *et al*. 2005). Percent EPT ranged from low to high throughout the watershed. The low sites where located in the older urban areas of Bowmanville or near intensive agriculture areas. It should be noted, however, that %EPT often decreases to zero within the high-order urbanized sections of creek whereas Bowmanville/Soper showed evidence of relatively healthy conditions. This can likely be attributed to the higher amounts of riparian cover and natural cover throughout the watershed. Taxa richness at each site ranged from 4 to 13. The greatest richness typically occurred within larger stream orders or within the Oak Ridges Moraine.

4.2 Subwatershed Findings

This section is organized such that summaries on the concentration and distribution of each index parameter are shown, where applicable, at all stations. Long-term data records were only available from stations SWQ4, SWQ5, and SWQ15 whereas stations SWQ16, SWQ17, SWQ18, SWQ19, SWQ20, and SWQ21 have records after the Provincial Water Quality Monitoring Network (PWQMN) was revived in 2003. As statistical trend analyses rely heavily on the quantity of data processed, and reported trends were based on longer term datasets,there are instances where excessive concentrations were determined, and after careful evaluation, disregarded in some trend analyses. The extremely high concentrations, also known as outliers, are not entirely disregarded but rather subjected to investigation for validity. A number of valid reasons for these occurrences may include, accidental spill immediately before sampling or extreme rainfall event after extended dry spell. The invalid results, however, may be due to errors in sampling procedure or laboratory analysis.

4.2.1 Bowmanville Creek Subwatershed

4.2.1.1 Chemical Water Quality

Bowmanville Creek subwatershed drains an area of 9,205 hectares (ha). Lands situated north of Boundary Road (Clarington-Scugog Townline) to Bowmanville/Westside Marshes Conservation Area on Lake Ontario are drained by Bowmanville Creek and it's tributaries (Figure 4). The built-up area covers about 11% mostly on the southern portions of the subwatershed. The surface water quality monitoring stations within Bowmanville Creek subwatershed include SWQ4, SWQ15, SWQ16 and SWQ17 (Figure 4). SWQ4 and SWQ15 have monitoring records since 1964 but these records are not continuous as there are some data gaps indicating monitoring activities had been stopped or suspended.

Only SWQ4 is located in heavily built-out area on the southern portion of the watershed while SWQ15 is located in the hamlet of Hampton. The rest of the monitoring stations in this subwatershed are located within rural areas close to farmlands and major thoroughfares.

Statistical analysis of WQI parameters in Bowmanville Creek subwatershed is presented in Table 3.

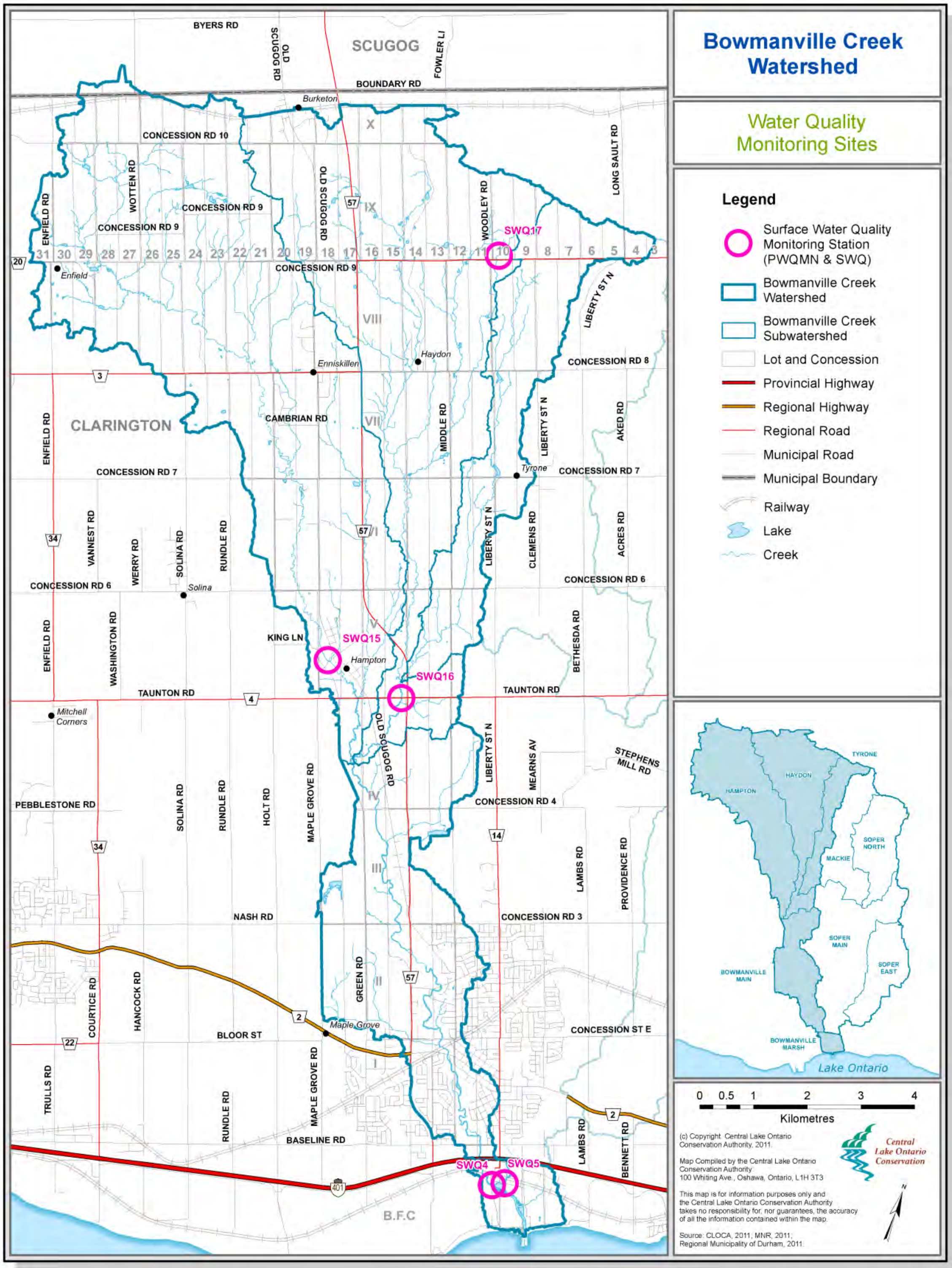


Figure 4: Water quality monitoring stations in the Bowmanville Creek subwatershed

Table 3: Statistical analysis of WQI parameters in Bowmanville Creek chemical quality monitoring stations

Parameter	Sampling Period	Number of Samples	Min	Max	Mean	Standard Deviation	Linear Regression	25th Percentile	Median 50th Percentile	75th Percentile	MKS (1) (S)	MKS (2) (Z)	MKS (3)
Bowmanville Creek - SWQ4	**1964-97, 2003-08**												
Chloride (mg/L)		407	1.3	791	19.36	42.24	0.214	9.28	14	20.3	32629	11.9	increasing trend
Phosphorous, Total (ug/L)		413	1	2484	95.4	0.244	-0.567	16	30	60	-32268	-11.51	decreasing trend
Nitrate, total, filtered (mg/L)		149	0.165	2.71	0.81	0.516	-0.258	0.37	0.635	1.1	-215	-0.351	no trend
Nitrate, total, unfiltered (mg/L)		29	0.05	2.13	0.834	0.504	-0.267	0.52	0.675	0.995	34	0.619	no trend
Nitrate as N (mg/L)		46	0.4	3.97	0.986	0.678	N/A	0.543	0.66	1.345	-112	-1.05	N/A
Copper (ug/L)		234	0.0262	6600	32.1	431.3	-0.167	0.83	1.3	3	-13741	-11.48	decreasing trend
BOD, 5 day, total demand		345	0.01	10	1.37	1.314	-0.596	0.6	1	1.6	-16446	-7.68	decreasing trend
Dissolved Oxygen (mg/L)		407	1.36	17.2	10.66	2.71	-0.146	9	11	12.32	7021	2.56	no trend
Bowmanville Creek - SWQ15	**1964-94, 1996-97, 2003-08**												
Chloride (mg/L)		69	8	20	12.2	3.34	0.698	9.4	11.2	15.4	473	2.445	no trend
Phosphorous, Total (ug/L)		69	5	20.97	17.22	0.01722	0.155	12	17	24	-390	-2.015	no trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate, total, unfiltered (mg/L)		22	0.465	1.3	0.632	0.1946	0.855	0.537	0.556	0.612	33	0.902	no trend
Nitrate as N (mg/L)		47	0.44	1.78	0.776	0.372	N/A	0.528	0.6	0.92	-325	-2.97	N/A
Copper (ug/L)		49	0.0531	1.8	0.395	0.287	0.511	0.2	0.3	0.5	182	1.56	no trend
BOD, 5 day, total demand		2	0.4	0.7	0.55	0.212	N/A	N/A	N/A	N/A	-1	0	N/A
Dissolved Oxygen (mg/L)		65	1.31	38	10.86	5.48	0.372	6.71	11.9	13.5	593	3.35	no trend
Bowmanville Creek - SQW17	**2003-08**												
Chloride (mg/L)		35	0.9	1.3	1.071	0.1073	-0.229	1	1.1	1.1	-15	-0.199	no trend
Phosphorous, Total (ug/L)		35	5	39	19.06	8.2	-0.54	12.5	18	24	-116	-1.633	no trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate, total, unfiltered (mg/L)		22	0.122	0.191	0.1658	0.01733	-0.893	0.1573	0.1675	0.1785	-108	-3.02	no trend
Nitrate as N (mg/L)		13	0.132	0.201	0.1617	0.0222	N/A	0.148	0.158	0.179	9	0.488	N/A
Copper (ug/L)		12	0.113	0.564	0.3025	0.1612	0.906	0.1728	0.2725	0.426	30	1.99	increasing trend
BOD, 5 day, total demand		2	0.2	0.2	0.2	0	N/A	N/A	N/A	N/A	0	0	N/A
Dissolved Oxygen (mg/L)		39	1.25	16.48	9.57	4.36	0.407	6.1	11.1	12.58	167	2.01	no trend
Bowmanville Creek - SWQ16	**2004-08**												
Chloride (mg/L)		44	11	22.8	15.43	3.51	0.94	12.6	14.15	17.03	216	2.175	increasing trend
Phosphorous, Total (ug/L)		44	6	128	21.14	25.13	0.952	6.83	11.5	22.5	-13	-0.1214	increasing trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate, total, unfiltered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N (mg/L)		44	0.03	1.62	0.772	0.329	0.629	0.568	0.655	0.878	-148	-1.487	no trend
Copper (ug/L)		44	0.1	1.5	0.434	0.295	0.296	0.2	0.35	0.6	76	0.759	no trend
BOD, 5 day, total demand		10	0.4	1.5	0.91	0.3604	0.846	0.625	0.85	1.1	27	2.344	no trend
Dissolved Oxygen (mg/L)		26	3.79	16	11.52	3.74	N/A	10.9	12.66	14.22	87	1.896	N/A

(1) Mann Kendall Statistics (MKS) S (trend statistic) indicating increasing or decreasing trends
(2) Mann Kendall Statistics (MKS) Z (test statistics) approximated Z-value for calculating probability
(3) Mann Kendall Statistics (MKS) results 95% significance

Chloride

The mean and median chloride concentrations on all stations within Bowmanville Creek are below the provincial limit of 150 mg/L to protect aquatic life (CESI report 2010). The highest chloride concentration of 791 mg/L was recorded at SWQ4 on February 8, 1971. On the 3rd of December 2007, the provincial limit was exceeded for the second time when the water sample from the same station was tested to contain 282 mg/L of chloride. No chloride exceedence was recorded on other monitoring stations within Bowmanville Creek.

The trend analysis using Mann-Kendall statistical method showed increasing trend of chloride concentrations at SWQ4 and SWQ16 in Bowmanville Creek (Figure 5). SWQ15 and SWQ17 did not show any trend.

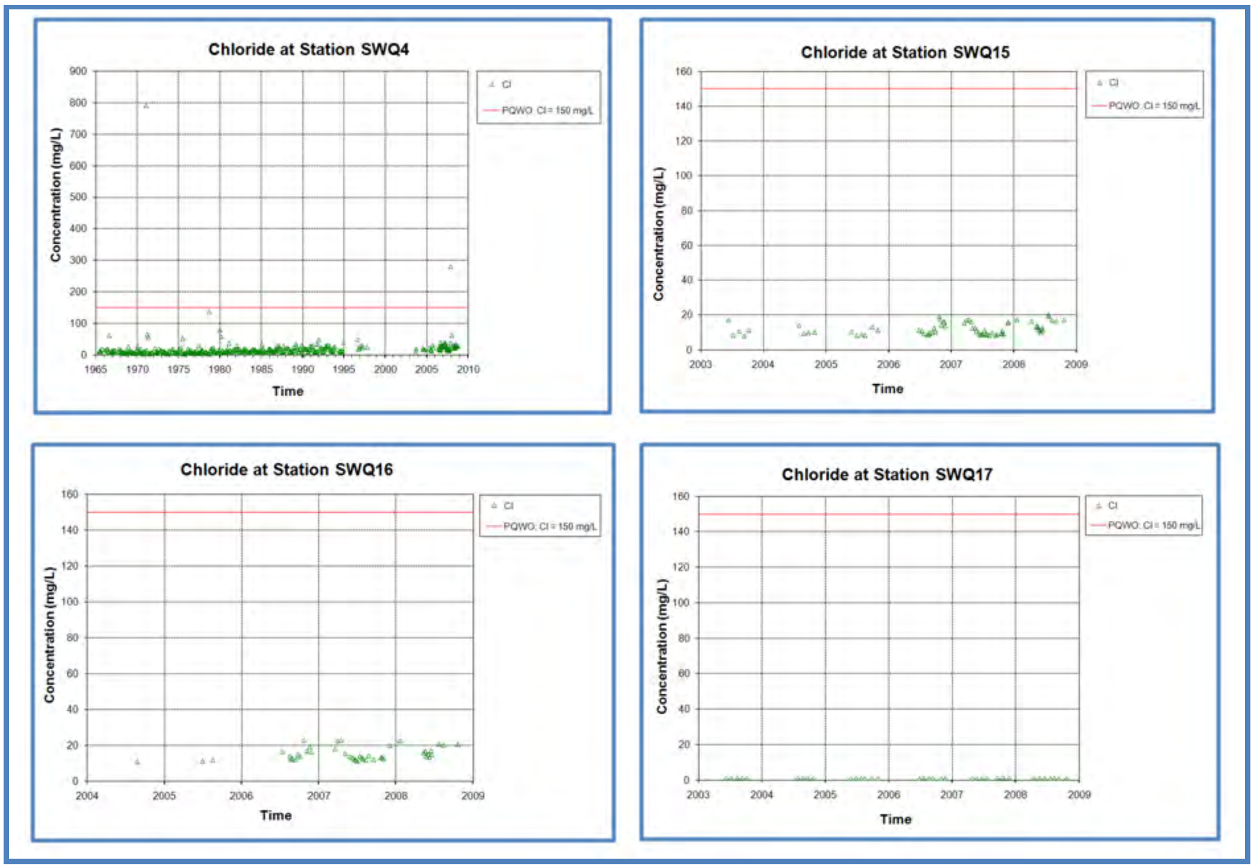


Figure 5: Chloride concentrations at Bowmanville Creek water quality monitoring stations

Phosphorous

Phosphorous is one of the most frequently exceeded WQI parameters. The maximum recorded Phosphorous concentration of 2,484 ug/L was detected on the sample collected at SWQ4 on November 4, 1968. Mean and median concentrations remains within the 30 ug/L concentration limit prescribed by the province. One hundred ninety-six out of 413 or 47% percent of samples obtained from SWQ4 have concentrations exceeding the prescribed limit. In comparison, SWQ15, SWQ16 and SWQ17 have percentage exceedances of 17%, 20% and 9%, respectively; which were represented by fewer samples as the monitoring period for these three stations only started in 2003.

Statistical trend analysis, using the Mann-Kendall method, showed decreasing concentrations at SWQ4 while increasing trend was observed in SWQ16 (Figure 6). Although no obvious trends were observed at SWQ15 and SWQ17, the graph shows that higher nitrate concentrations are being recorded later in the observation periods.

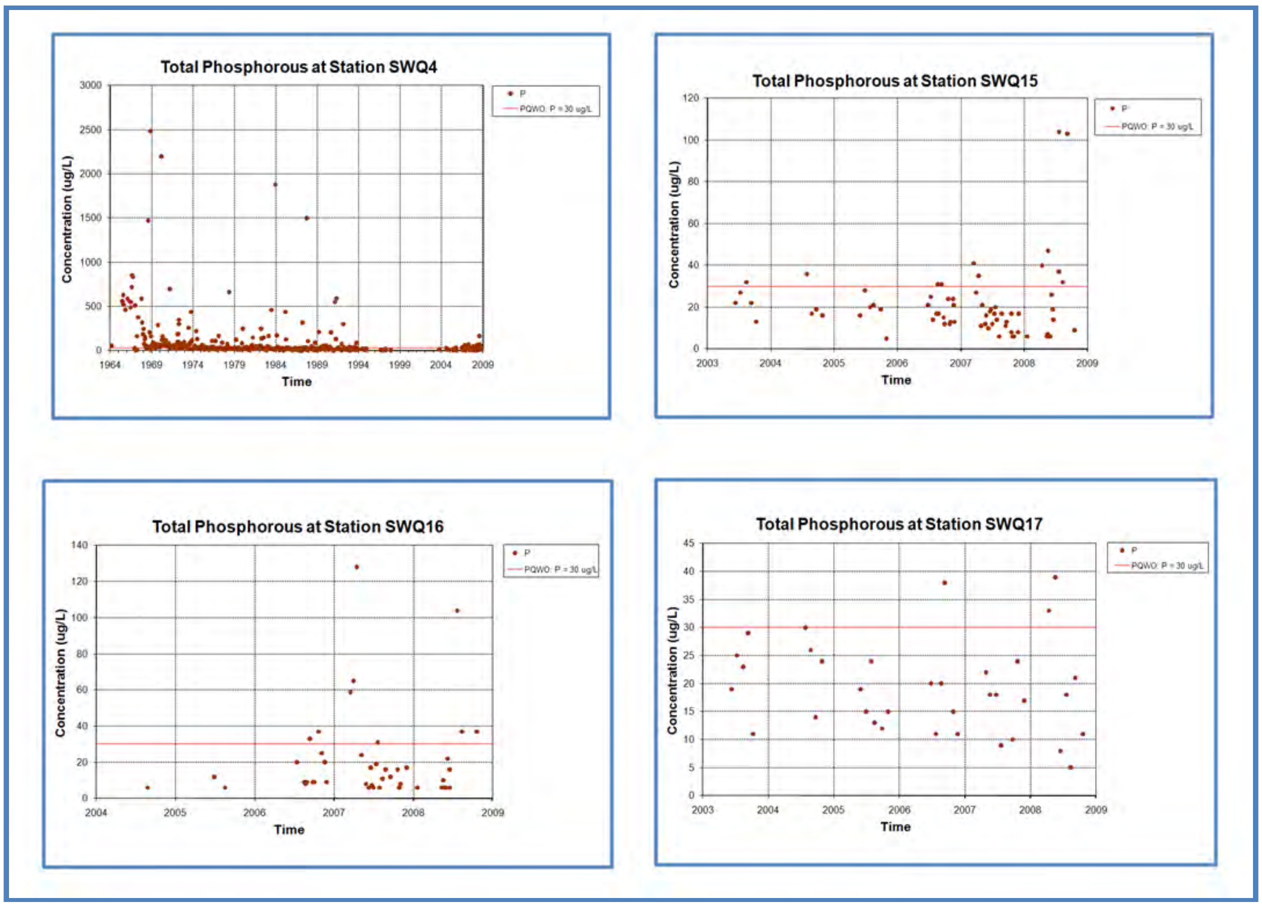


Figure 6: Phosphorous concentrations at Bowmanville Creek water quality monitoring stations

Nitrate

Over the years, there have been significant changes in the methods for testing nutrient species, which includes nitrate. Although the United States Geological Survey (USGS) evaluation suggested "the analytical values reported for pairs of unfiltered and filtered concentrations for identified nutrient species are statistically indistinguishable", the MOE suggested retaining the distinction between varying laboratory methodologies when interpreting results.

The analysis of the water samples on all stations show that nitrate concentrations are generally below the provincially prescribed limit of 2.93 mg/L. The only exceedance of 3.97 mg/L was detected on January 21, 2008 at SWQ4 (Table 3). This observation is statistically not significant but will be monitored closely to determine future trends. Nitrate concentrations over time are presented in Figure 7.

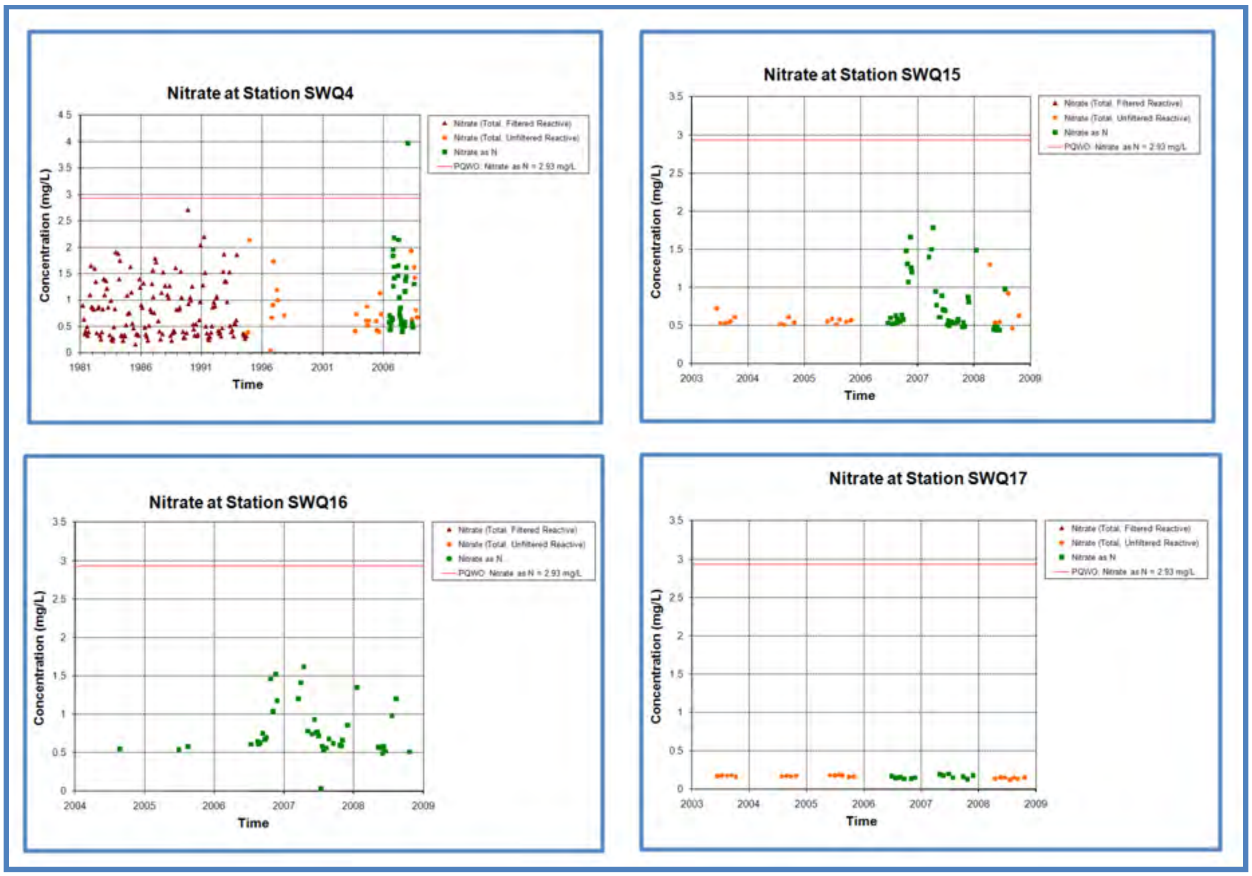


Figure 7: Nitrate concentrations at Bowmanville Creek water quality monitoring stations

Copper (Cu)

Copper concentrations across monitoring stations within Bowmanville Creek show a number of spikes and outliers. The mean and median concentrations however remain within the PWQO limit of 5 ug/L except in SWQ4 where the mean concentration reached 32.1 ug/L (Table 3). Non-parametric statistical trend analysis however showed decreasing trend of copper concentrations in this station. No apparent trends were observed in the other stations.

Figure 8 shows the distribution of copper concentrations over time at SWQ4, SWQ15, SWQ16 and SWQ17. This cluster of graphs suggests that the distribution of copper in Bowmanville Creek increases with the level of development in the areas within the immediate vicinity of the monitoring station.

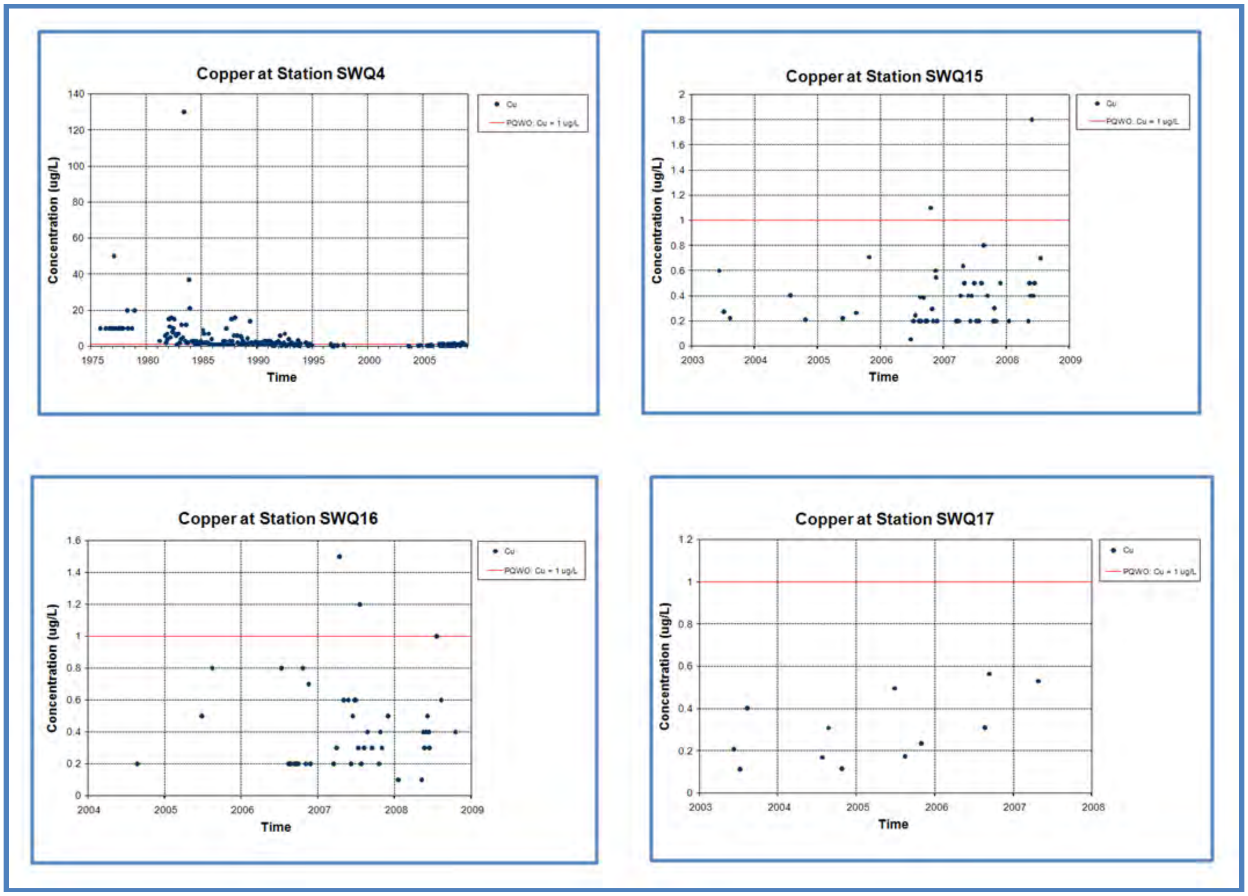


Figure 8: Copper concentrations at Bowmanville Creek subwatershed

Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO)

In principle, an increase in biochemical oxygen demand (BOD) tends to deplete the amount of dissolved oxygen (DO) in the natural water environment. This relationship, however, may be direct or indirect considering that there are factors other than BOD that could cause the decrease of DO concentration in the waterbodies. Some of these factors include temperature and variability and severity of weather conditions.

With the BOD and DO relationship established earlier in Figure 3, discussions will focus on DO in this section. The mean and median concentrations of DO are generally above the provincial requirements of 5 to 8 mg/L for cold water biota and 4 to 7 mg/L for warm water biota (Figure 9). Occasionally, DO concentrations drop below PWQO criteria but no report of adverse effect on aquatic life due to prolonged exposure has been recorded.

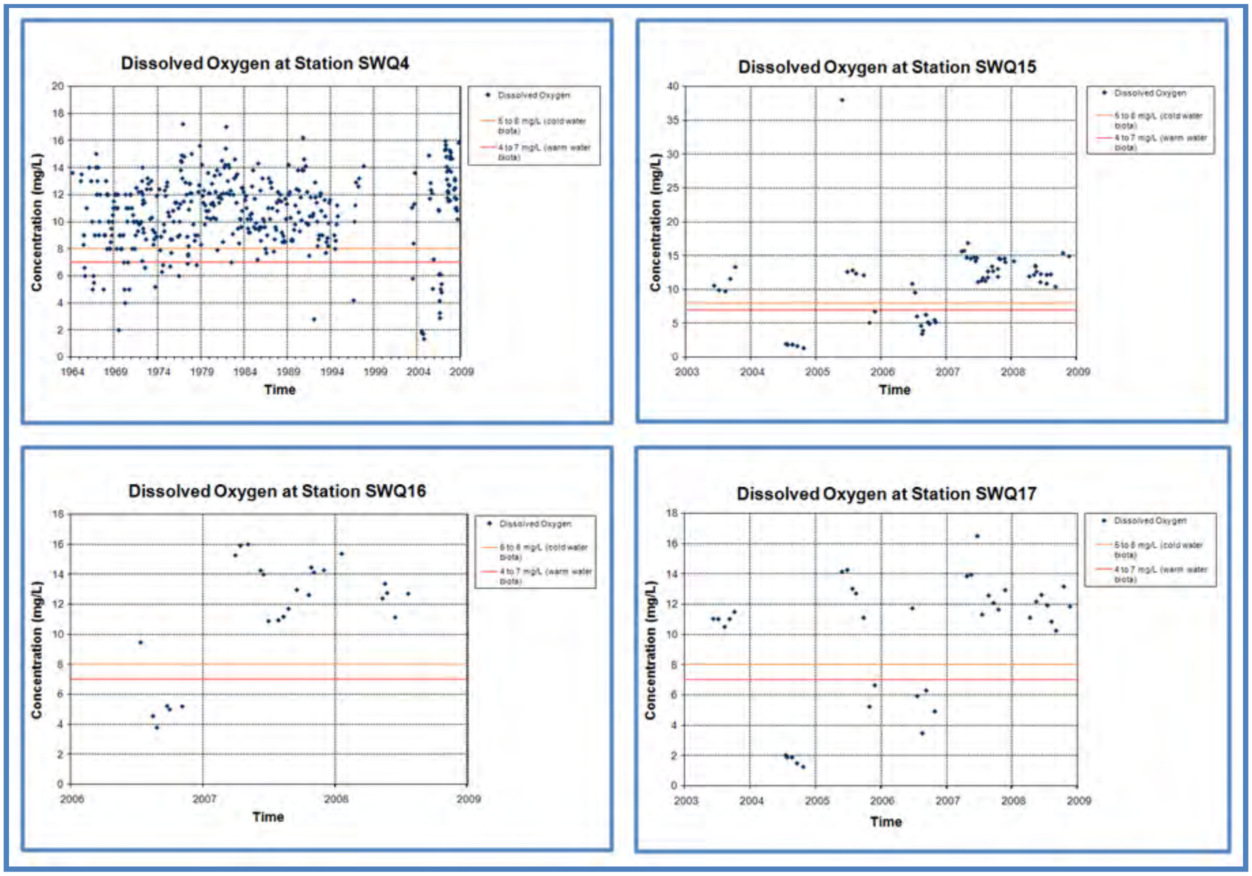


Figure 9: Dissolved oxygen (DO) concentrations at Bowmanville Creek subwatershed water quality monitoring stations

Exceedances

Some analyzed chemical parameters excluded in the WQI were also found to have exceeded PWQO concentration criteria. These parameters are arsenic (As), Cadmium (Cd), Cobalt (Co) Chromium (Cr), Iron (Fe), Lead (Pb), Mercury (Hg) and Zinc (Zn). One hundred eleven (111) of 257 samples were detected to have exceeded the provincial lead concentration limit of 5 ug/L though majority of these are from samples taken before 1992. One hundred six (106) or 32% of the 328 samples have iron concentration above the 0.3 mg/L limit. Aside from cadmium, which has an exceedance percentage of 29%, exceedances of other chemical parameters did not go beyond 15%. More than 75% of the exceedances were from samples collected at SWQ4.

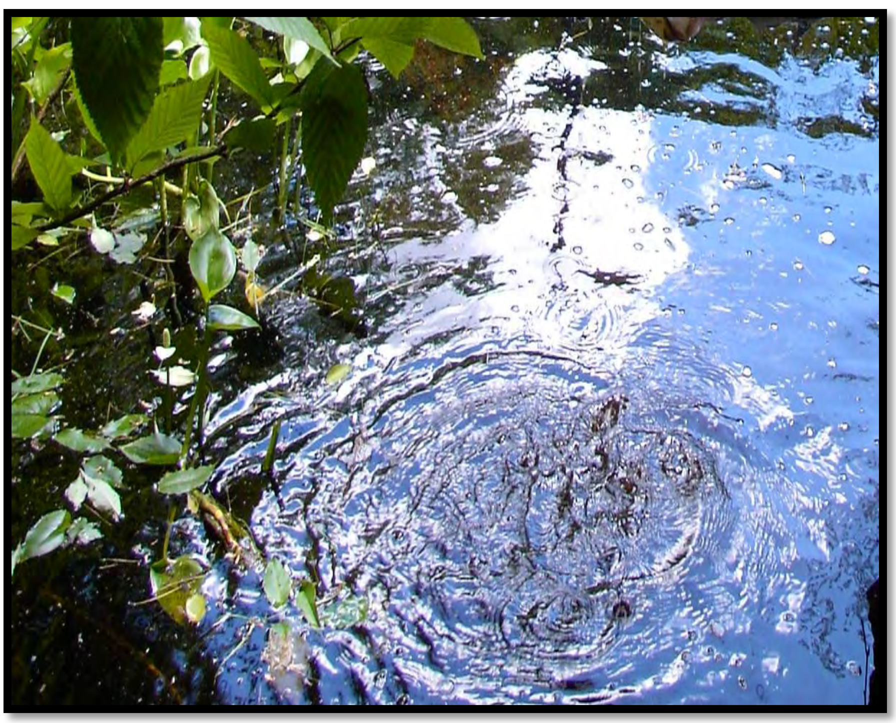
4.2.1.2 Biological Water Quality

Biological water quality in Bowmanville Creek was assessed at 18 sites throughout the subwatershed from 1998 to 2004 using BioMAP. Of the 18 sites sampled for biological water quality, zero sites were considered impaired (Table 4). In addition, biological water quality data (Hilsenhoff scores) was collected at 39 sites during stream fisheries assessment sampling in 1998-2004. Results from this assessment ranged from poor to good. More recently, biological water quality was assessed at 7 sites from 2005-2010 using the OBBN protocol. Preliminary results from this assessment show low to moderate proportions of sensitive stoneflies, caddisflies and mayflies in the sample which implies reduced health. These sites have yet to be compared to reference conditions. Overall, %EPT ranged from 10 to 69% and taxa richness ranged from 8-12. The Bowmanville subwatershed has good water quality assessed though biological indicators in comparison to the other watersheds within CLOCA jurisdiction.

Table 4: Biological water quality monitoring in the Bowmanville Creek subwatershed between 2002 and 2008

Site	Year	Method	Status
BOW 04/98	1998	BioMAP	Unimparied
BOW 05/98	1998	BioMAP	Unimparied
BOW 06/98	1998	BioMAP	Unimparied
BOW BP04	2004	BioMAP	Unimparied
BOW 07/98	1998	BioMAP	Unimparied
BOW 08/98	1998	BioMAP	Unimparied
BOW 09/98	1998	BioMAP	Unimparied
BOW BP13	2004	BioMAP	Unimparied
BOW 10/98	1998	BioMAP	Unimparied
BOW 11/98	1998	BioMAP	Unimparied
BOW 01/98	1998	BioMAP	Unimparied
BOW 02/98	1998	BioMAP	Unimparied
BOW 03/98	1998	BioMAP	Unimparied
BOW BP01	2004	BioMAP	Unimparied
BOW 01/03	2003	BioMAP	Unimparied
BOW 12/03	2003	BioMAP	Unimparied
BOW DJ03	2003	BioMAP	Unimparied
BOW DH01	2001	BioMAP	Gray Zone
BA01	1998	OSAP/Hilsenhoff	Good
BA02	1999	OSAP/Hilsenhoff	Fairly Poor
BA03	1998	OSAP/Hilsenhoff	Good
BA04	1999	OSAP/Hilsenhoff	Fair
BA05	1998	OSAP/Hilsenhoff	Good
BA06	1998	OSAP/Hilsenhoff	Good
BA07	1998	OSAP/Hilsenhoff	Good
BA08	1999	OSAP/Hilsenhoff	Fair
BA09	1999	OSAP/Hilsenhoff	Good
BA10	1998	OSAP/Hilsenhoff	Good
BA11	1998	OSAP/Hilsenhoff	Good
BA12	1998	OSAP/Hilsenhoff	Good
BB01	1998	OSAP/Hilsenhoff	Poor
BB02	1999	OSAP/Hilsenhoff	Fair
BB03	1998	OSAP/Hilsenhoff	Fairly Poor
BB04	1999	OSAP/Hilsenhoff	Good
BB05	1998	OSAP/Hilsenhoff	Fair
BB06	1999	OSAP/Hilsenhoff	Good
BB07	1998	OSAP/Hilsenhoff	Fair

Site	Year	Method	Status
BC01	1999	OSAP/Hilsenhoff	Fair
BC02	1998	OSAP/Hilsenhoff	Good
BC03	1999	OSAP/Hilsenhoff	Fairly Poor
BC04	1999	OSAP/Hilsenhoff	Fairly Poor
BC05	1998	OSAP/Hilsenhoff	Fair
BC06	1999	OSAP/Hilsenhoff	Good
BD01	1998	OSAP/Hilsenhoff	Good
BD02	1999	OSAP/Hilsenhoff	Fair
BD04	1999	OSAP/Hilsenhoff	Good
BWDJ	1996	OSAP/Hilsenhoff	Fair
BWDJ	1997	OSAP/Hilsenhoff	Good
BWDJ	1998	OSAP/Hilsenhoff	Fair
BWDJ	1999	OSAP/Hilsenhoff	Good
BWDJ	2000	OSAP/Hilsenhoff	Fair
BWDJ	2001	OSAP/Hilsenhoff	Good
BWDJ	2002	OSAP/Hilsenhoff	Good
LMP1	2002	OSAP/Hilsenhoff	Good
LMP2	2002	OSAP/Hilsenhoff	Poor
LMP3	2002	OSAP/Hilsenhoff	Good
BOWOB01	2005	OBBN	%EPT = 26.6, Taxa Richness = 9
BOWOB01	2006	OBBN	%EPT = 13.9, Taxa Richness = 11
BOWOB02	2005	OBBN	%EPT = 18.9, Taxa Richness = 10
BOWOB03	2005	OBBN	%EPT = 24.0, Taxa Richness = 9
BOWOB03	2006	OBBN	%EPT = 44.1, Taxa Richness = 10
BOWOB03	2007	OBBN	%EPT = 40.9, Taxa Richness = 11
BOWOB03	2008	OBBN	%EPT = 29.9, Taxa Richness = 10
BOWOB03	2009	OBBN	%EPT = 28.6, Taxa Richness = 10
BOWOB03	2010	OBBN	%EPT = 40.9, Taxa Richness = 12
BOWOB04	2005	OBBN	%EPT = 23.3, Taxa Richness = 10
BOWOB04	2008	OBBN	%EPT = 37.1, Taxa Richness = 11
BOWOB05	2006	OBBN	%EPT = 10.0, Taxa Richness = 8
BOWOB06	2006	OBBN	%EPT = 30.9, Taxa Richness = 10
BOWOB06	2008	OBBN	%EPT = 69.0, Taxa Richness = 9
BOWOB07	2008	OBBN	%EPT = 49.0, Taxa Richness = 9



4.2.2 Soper Creek Subwatershed

4.2.2.1 Chemical Water Quality

Soper Creek subwatershed is the easternmost catchment basin of CLOCA. It drains approximately 7,729 ha from the intersection of Regional Road 20 and Liberty Road, south to where it converges with Bowmanville Creek in the Bowmanville Marsh. Approximately 17% of the entire subwatershed area is built-up, consisting of residential, commercial and industrial land uses. These built-up areas are mostly concentrated in the southern portion of the subwatershed between Concession Road 3 and Highway 401.

Soper Creek subwatershed has five surface water monitoring stations (Figure 10). SWQ5, which is located at the West Beach Road in Bowmanville, used to be one of the PWQMN stations until MOE ceased using it in 1994. CLOCA continued the water quality monitoring at this station starting in 2003. This monitoring station has the longest water quality data record in this subwatershed dating back in 1967, albeit not without gap. The remaining water quality stations were established in 2004. All chemical water quality monitoring stations in Soper Creek subwatershed are being operated by CLOCA.

Statistical analysis of WQI parameters in Soper Creek subwatershed is presented in Table 5.

Soper Creek subwatershed

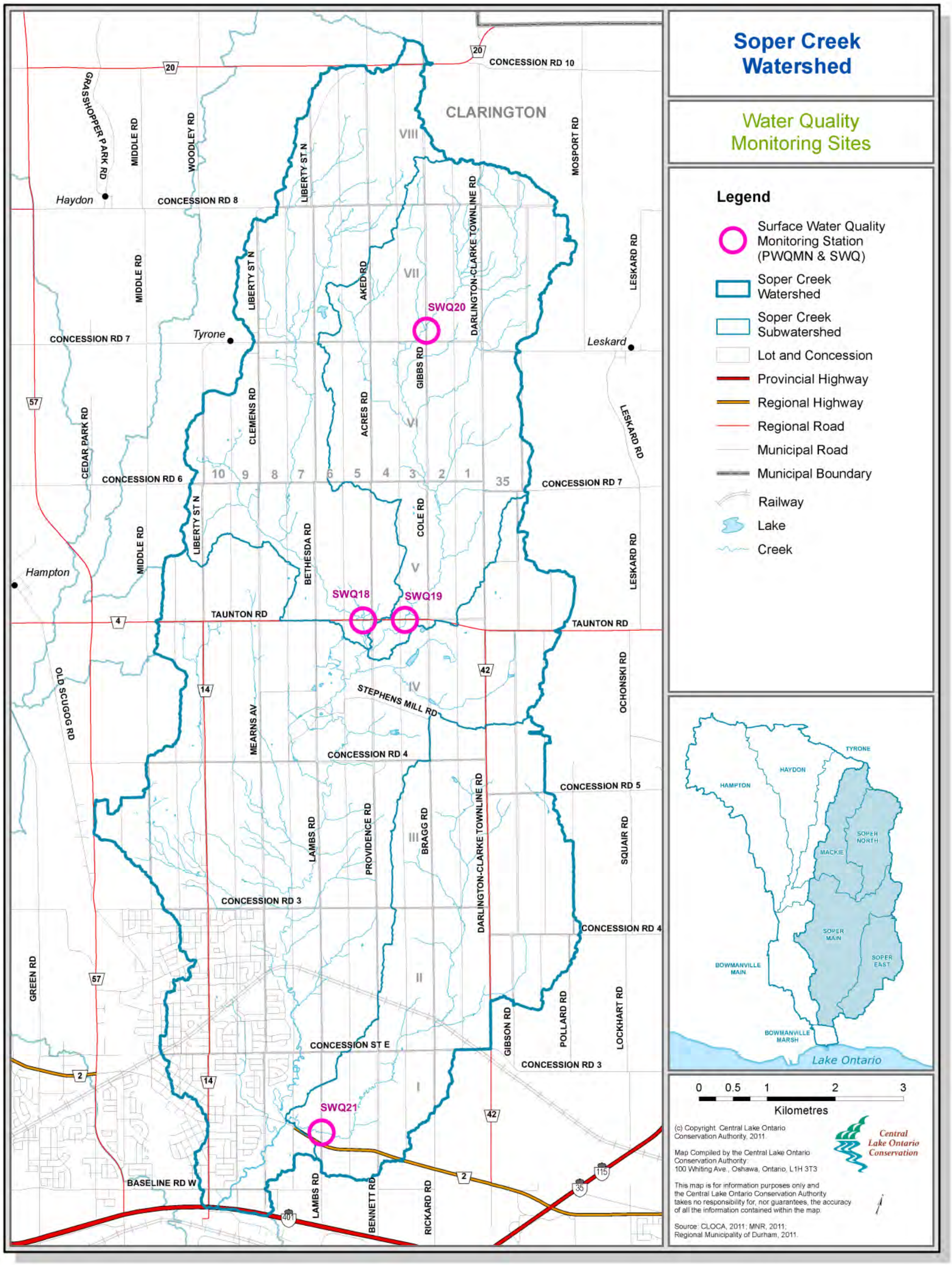


Figure 10: Water quality monitoring stations in the Soper Creek subwatershed

Table 5: Statisical analysis of WQI parameters in Soper Creek chemical quality monitoring stations

Parameter	Sampling Period	Number of Samples	Min	Max	Mean	Standard Deviation	Linear Regression	25th Percentile	Median 50th Percentile	75th Percentile	MKS (1) (S)	MKS (2) (Z)	MKS (3)
Soper Creek - SWQ5	**1967-94, 2003-08**												
Chloride (mg/L)		358	1.3	292	26.2	27.6	0.303	16	21.5	28.9	11616	5.13	increasing trend
Phosphorous, Total (ug/L)		365	6	2300	237.6	306.4	-0.792	28.1	96	340	-39041	-16.76	decreasing trend
Nitrate, total, filtered (mg/L)		149	0.265	5.95	1.952	1.057	-0.468	1.12	1.64	2.55	-733	-1.201	no trend
Nitrate, total, unfiltered (mg/L)		5	0.987	2.75	1.59	0.696	N/A	1.2	1.33	1.68	0	0	N/A
Nitrate as N (mg/L)		45	0.81	3.95	1.66	0.793	0.709	1.15	1.36	1.72	7	0.0587	no trend
Copper (ug/L)		193	0.2	140	4.91	13.52	-0.629	1	1.7	3	-9896	-11.03	decreasing trend
BOD, 5 day, total demand		327	0.04	18	2.12	1.953	-0.721	0.9	1.4	3	-20709	-10.48	decreasing trend
Dissolved Oxygen (mg/L)		337	3.3	20.4	10.25	2.593	0.157	8.4	10.2	11.9	6808	3.294	no trend
Soper Creek (east branch) - SWQ19	**2004-08**												
Chloride (mg/L)		44	8.18	62.8	12.08	8.42	0.712	9.05	9.95	11.23	101	1.011	no trend
Phosphorous, Total (ug/L)		44	6	62	16.58	14.56	0.968	6	10.5	17.75	-1	0	increasing trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate, total, unfiltered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N (mg/L)		44	0.79	2.28	1.41	0.2927	0.955	1.24	1.355	1.48	40	0.3945	increasing trend
Copper (ug/L)		44	0.1	2.6	0.3705	0.387	0.782	0.2	0.2	0.4	154	1.548	no trend
BOD, 5 day, total demand		10	0.2	1.5	0.743	0.402	0.887	0.5	0.55	0.975	25	2.155	increasing trend
Dissolved Oxygen (mg/L)		27	3.86	16.5	11.45	3.67	N/A	11.08	12.32	14.04	78	1.605	N/A
Soper Creek (east branch) - SWQ20	**2004-05, 2008**												
Chloride (mg/L)		6	6.01	9.8	7.54	1.688	N/A	6.22	6.93	8.94	7	1.127	N/A
Phosphorous, Total (ug/L)		6	6	14	7.67	3.204	N/A	6	6	7.5	-5	-0.765	N/A
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate, total, unfiltered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N (mg/L)		6	0.75	1.08	0.93	0.138	N/A	0.823	0.945	1.045	-15	-2.63	N/A
Copper (ug/L)		6	0.2	1.2	0.533	0.388	N/A	0.3	0.35	0.7	-4	-0.574	N/A
BOD, 5 day, total demand		6	0.2	1.1	0.6	0.2966	N/A	0.5	0.55	0.675	12	2.067	N/A
Dissolved Oxygen (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	N/A

(1) Mann Kendall Statistics (MKS) S (trend statistic) indicating increasing or decreasing trends
(2) Mann Kendall Statistics (MKS) Z (test statistics) approximated Z-value for calculating probability
(3) Mann Kendall Statistics (MKS) results 95% significance

Table 5. Statistical analysis of WQI parameters in Soper Creek chemical quality monitoring stations cont.

Parameter	Sampling Period	Number of Samples	Min	Max	Mean	Standard Deviation	Linear Regression	25th Percentile	Median 50th Percentile	75th Percentile	MKS (1) (S)	MKS (2) (Z)	MKS (3)
Soper Creek (east branch) - SWQ21	**2005-08**												
Chloride (mg/L)		9	27.6	37.1	33.9	2.826	0.843	33.1	34.4	35.5	18	1.772	no trend
Phosphorous, Total (ug/L)		9	20	100	54.3	25.87	-0.553	41	53	70	-12	-1.147	no trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate, total, unfiltered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N (mg/L)		9	3.06	5.96	4.34	0.959	0.867	3.9	4.27	4.64	20	1.98	no trend
Copper (ug/L)		9	0.2	1.1	0.678	0.303	0.164	0.6	0.8	0.8	5	0.419	no trend
BOD, 5 day, total demand		9	0.5	1.6	1.067	0.45	0.449	0.7	1	1.5	4	0.313	no trend
Dissolved Oxygen (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Soper Creek (west branch) - SWQ18	**2004-08**												
Chloride (mg/L)		44	8.6	23.9	19.2	3.286	0.268	18.88	19.65	20.9	366	3.69	no trend
Phosphorous, Total (ug/L)		44	6	72	16.4	13.8	0.857	6.75	10.5	23.25	-55	-0.546	no trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate, total, unfiltered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nitrate as N (mg/L)		44	0.81	2.2	1.225	0.247	0.412	1.06	1.17	1.333	-283	-2.85	no trend
Copper (ug/L)		44	0.1	1	0.3455	0.197	0.243	0.2	0.3	0.4	126	1.265	no trend
BOD, 5 day, total demand		10	0.2	1.4	0.76	0.4006	0.99	0.5	0.65	1.05	22	1.88	increasing trend
Dissolved Oxygen (mg/L)		27	3.93	15.95	11.52	3.61	N/A	10.94	12.16	14.13	89	1.835	N/A

(1) Mann Kendall Statistics (MKS) S (trend statistic) indicating increasing or decreasing trends
(2) Mann Kendall Statistics (MKS) Z (test statistics) approximated Z-value for calculating probability
(3) Mann Kendall Statistics (MKS) results 95% significance

Chloride

The mean and median concentrations of chloride at the five water quality monitoring stations in Soper Creek subwatershed are below the 150 mg/L provincially prescribed limit (Table 5). Exceedance was only observed at SWQ5 with the highest concentration recorded at 292 mg/L from a sample collected on February 21, 1989. The most recent record of high chloride concentration of 246 mg/L was analyzed from a sample taken on December 3, 2007. Except at SWQ5 where an increasing trend has been statistically detected, no clear trends were seen in the remaining four stations. Chloride distribution over time is presented in Figure 11.

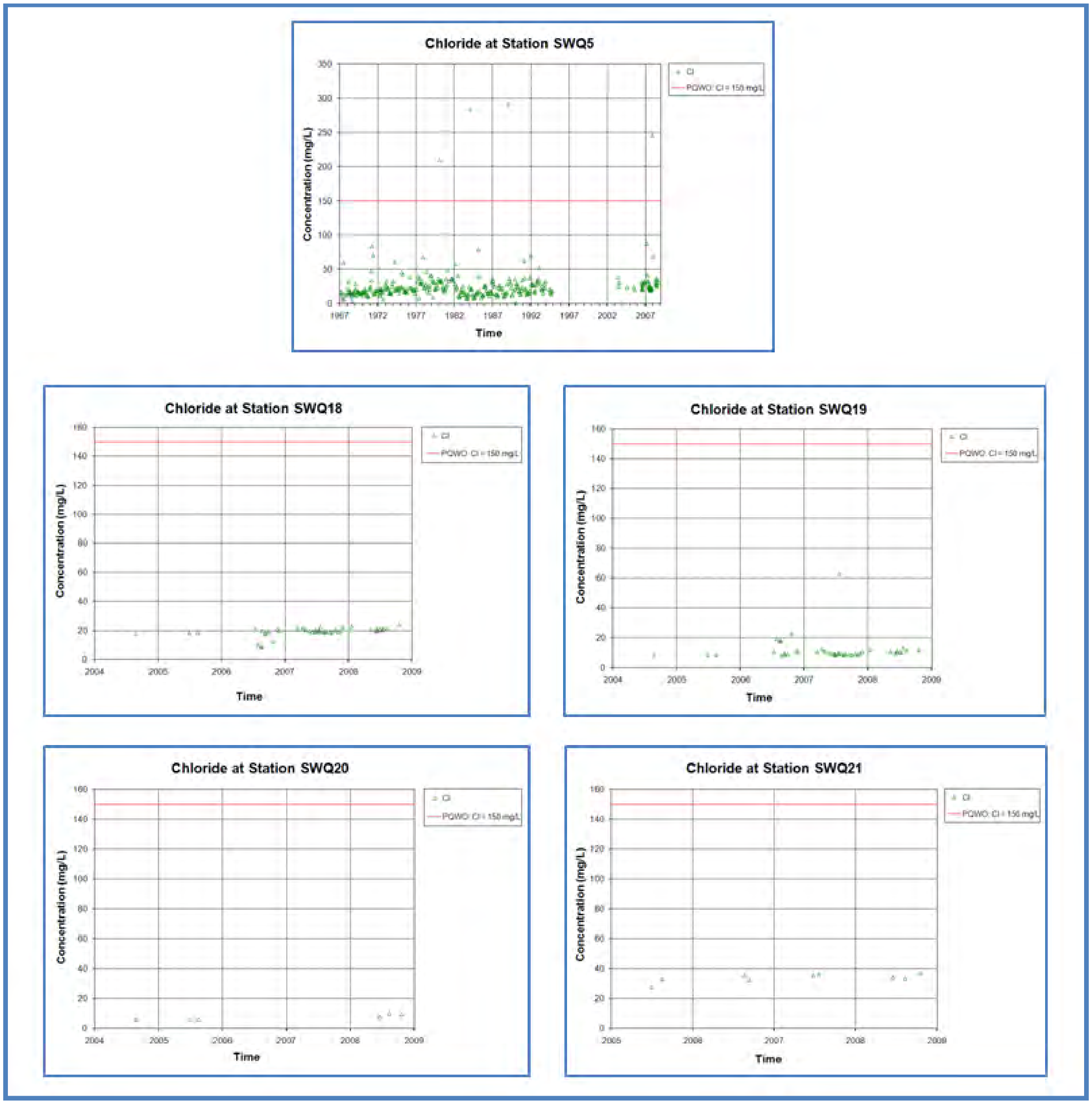


Figure 11: Chloride concentrations at Soper Creek subwatershed

Phosphorous

Relative to Bowmanville Creek subwatershed, Phosphorous similarly has the most number of exceedances among the WQI parameters. Two hundred ninety four (294) or 63% of the 468 water samples collected at all stations within this subwatershed exceeded the 30 ug/L provincial limit. Ninety three percent of the exceedances were detected in SWQ5 while the concentration of phosphorous at SWQ20 fellmostly below the detection limit.

Relatively high median values were recorded at SWQ5 (96 mg/L) and SWQ21 (53 mg/L) while the rest of the stations have median concentration values ranging from 6 to 11 mg/L (Table 5). Statistical analysis shows a decreasing trend at SWQ5, an increasing trend at SWQ19, and the rest did not manifest any trend at all. The distribution of Phosphorous concentrations in each monitoring station over the observation period is shown in Figure 12.

Nitrate

Most mean and median concentrations of nitrate are within the recently adopted provincial objective of 2.93 mg/L with the exception of SWQ21 having 4.34 mg/L and 4.27 mg/L mean and median concentrations, respectively (Table 5).

Figure 13 shows that exceedances were observed on stations situated in the southern portion of the subwatershed. The highest recorded concentration of 2.96 mg/L was recorded on the August 14, 2008 water sample collected at SWQ21. Mann-Kendall trend analysis was able to detect an increasing nitrate concentration at SWQ19 while no apparent trends were observed on the samples from the other stations.

Copper (Cu)

About 12 percent of samples analyzed for copper showed concentrations exceeding the 5 ug/L PWQO limit. All exceedances were detected at SWQ5. The highest concentration of 140 ug/L was analyzed in the sample collected on September 9, 1983. Although most of the concentration values of water samples collected after 2004 on all Soper Creek stations are below the provincially prescribed limit, it is worthy to note that a stricter limit of 1 ug/L (hardness dependent) for copper is currently under development. Once approved, the new concentration limit will increase the number of exceedance occurrences in practically all monitoring stations. Using the current provincial criteria, the mean and median values at all stations are well within required standard (Table 5).

Time-series distribution of copper concentrations and the respective existing and interim provincial limits are shown in Figure 14.

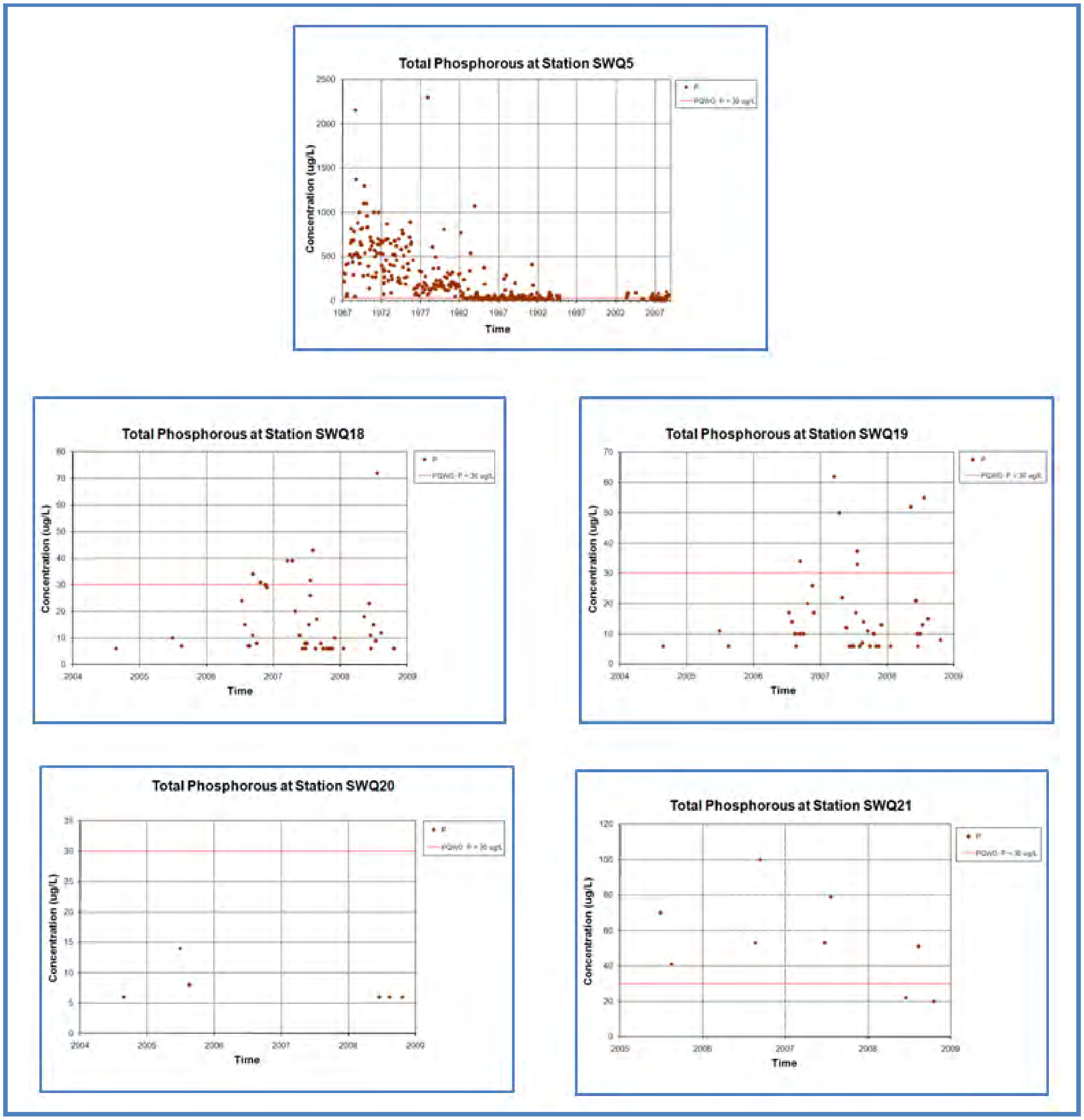


Figure 12: Phosphorous concentrations at Soper Creek subwatershed

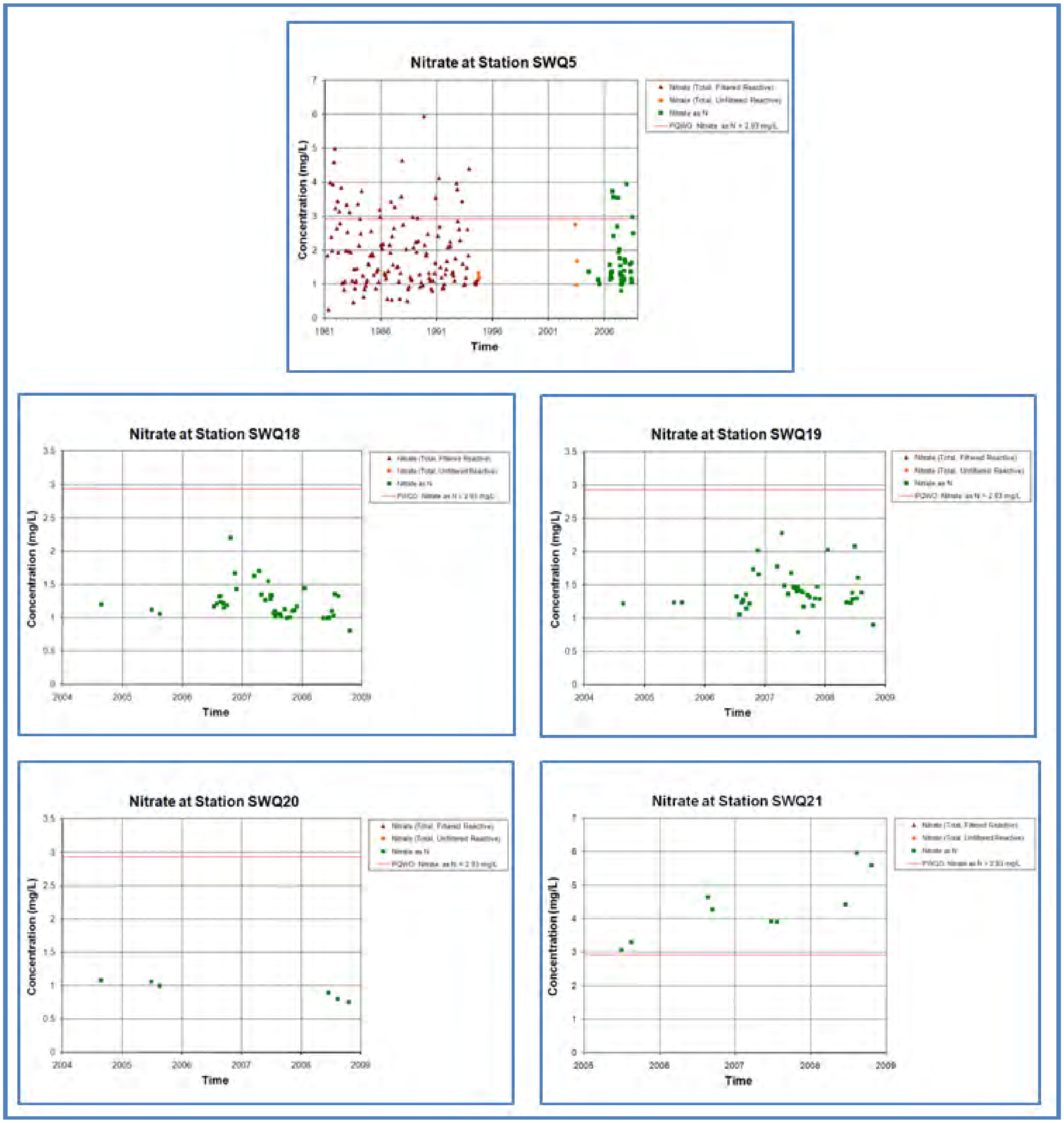


Figure 13: Nitrate concentrations at Soper Creek subwatershed

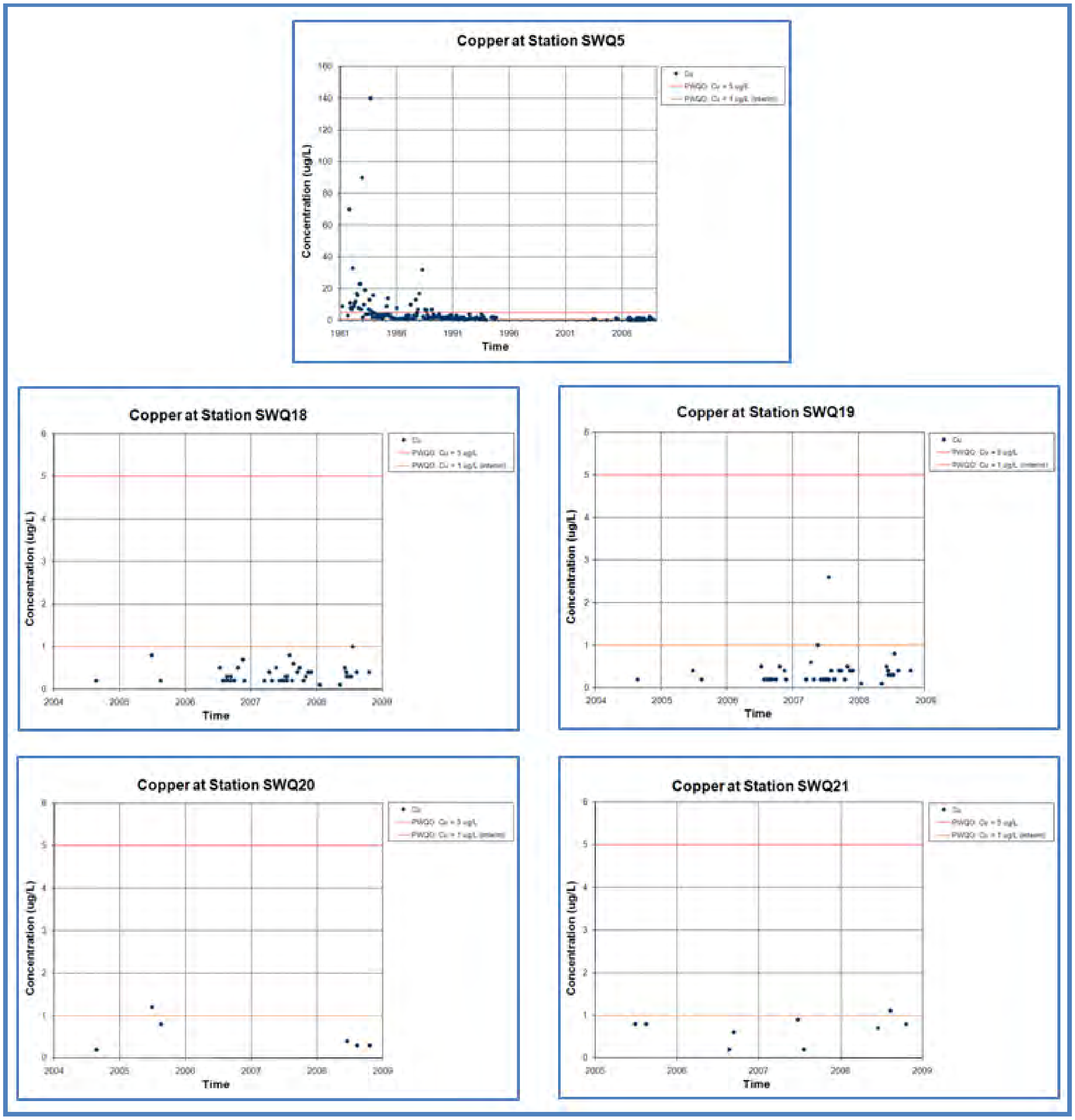


Figure 14: Copper concentrations at Soper Creek subwatershed

Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO)

Eighty six percent of the 381 samples collected at all chemical water quality stations within Soper Creek subwatershed have dissolved oxygen (DO) concentration above the desired limit of 8 mg/L. Analyzed samples were obtain from SWQ5, SWQ18 and SWQ19, while no record of DO concentration analysis were obtained from SWQ20 and SWQ21. As well, median concentrations of DO in the three stations are above 10 mg/L (Table 4). Although no trend was seen on DO concentrations, the decreasing trend in BOD observed at SWQ5 suggests improving water quality condition. Conversely, increasing BOD were detected at SWQ18 and SWQ19.

Figure 15 suggests that, for the most part, DO concentrations at the various water quality monitoring stations within Soper Creek subwatershed remains above the desirable limits for the protection of both warm and cold water biota.

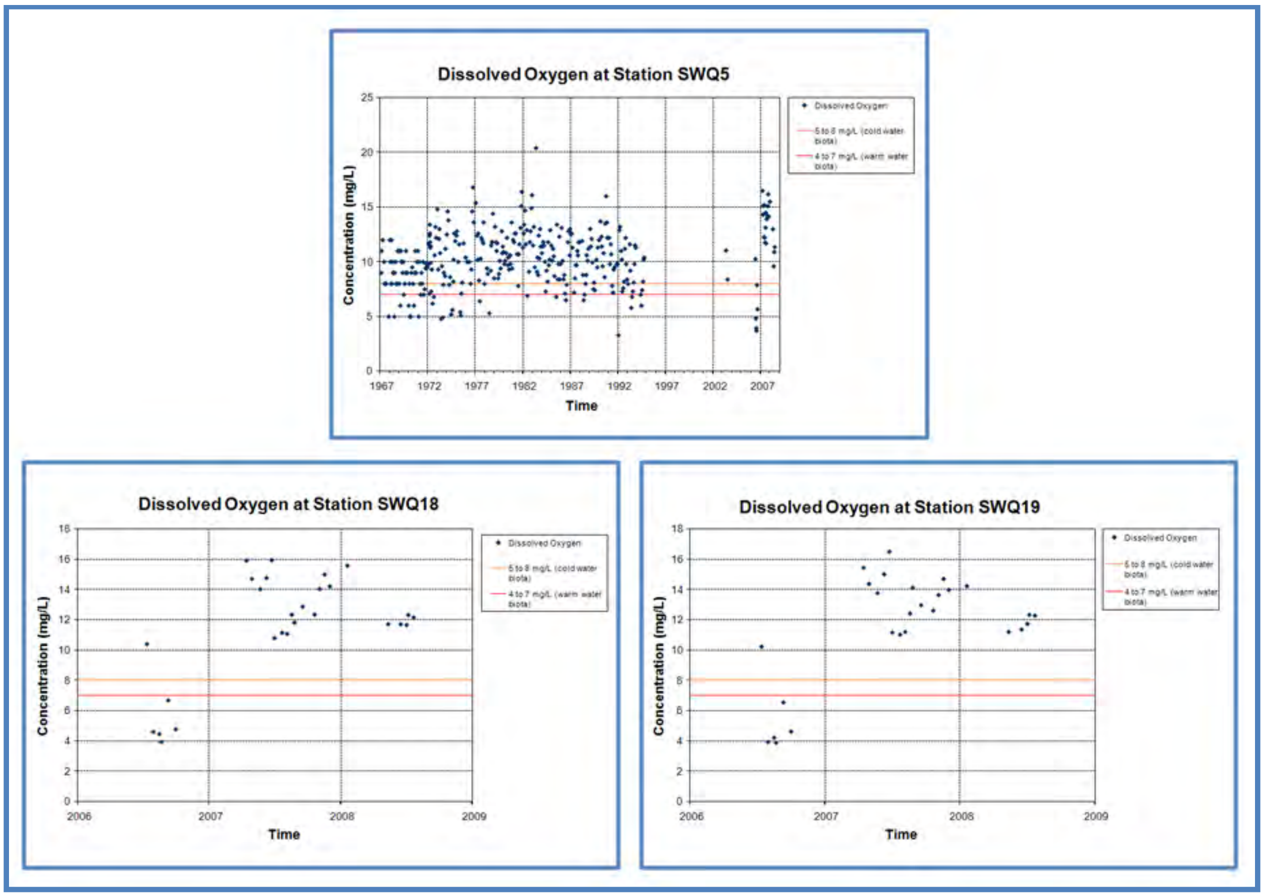


Figure 15: Dissolved oxygen (DO) concentrations at Soper Creek subwatershed

Exceedances

Among the analyzed chemical parameters excluded in the WQI, the following chemicals were tested to have exceeded the PWQO prescribed limits: cadmium (Cd), Chromium (Cr), Iron (Fe), Lead (Pb) and Zinc(Zn). Forty five percent of the samples, mostly from SWQ5, have lead concentration above the prescribed limit of 5 ug/L. Also from the same station, over 35% of the samples have iron concentrations that exceed 0.3 mg/L (PWQO). Other exceedances that have relatively fewer occurrences may be considered as spikes or outliers and close monitoring of these parameters is encouraged to determine possible sources and future trending.

4.2.2.2 Biological Water Quality

Biological water quality in Soper Creek was assessed at 11 sites throughout the subwatershed in 1998, 2003 and 2004 using BioMAP. Of the 11 sites sampled for biological water quality, one site was considered impaired (Table 6) and one of the sites was undetermined (Gray Zone between Impaired and Unimpaired). In addition, biological water quality data (Hilsenhoff scores) was collected at 27 sites during stream fisheries assessment sampling in 1998, 2003 and 2004. Results from this assessment typically ranged from very good to poor. More recently, biological water quality was assessed at 11 sites from 2005-2009 using the OBBN protocol. Preliminary results from this assessment show a wide range of proportions of sensitive stoneflies, caddisflies and mayflies in the sample which implies some water quality degradation in some areas and high water quality in others. These sites have yet to be compared to reference conditions. Overall, the Soper Creek subwatershed showed some impairment in agricultural areas or downstream of urban areas but was generally healthy in areas dominated by natural cover. Sites showing impairment were typically related to the cumulative effects of nutrient enrichment from urban or agricultural sources.

Table 6: Biological water quality monitoring in the Soper Creek subwatershed between 2001 and 2008

Site	Year	Method	Status
SOP 01/98	1998	BioMAP	Unimpaired
SOP 02/98	1998	BioMAP	Unimpaired
SOP 03/98	1998	BioMAP	Imparied
SOP 04/98	1998	BioMAP	Unimpaired
SOP 05/98	1998	BioMAP	Unimpaired
SOP 06/98	1998	BioMAP	Unimpaired
SOP 07/98	1998	BioMAP	Unimpaired
SOP 08/03	2003	BioMAP	Grey Zone
SOP 09/03	2003	BioMAP	Unimpaired
SOP BP10	2003	BioMAP	Unimpaired
SOP BP11	2004	BioMAP	Unimpaired
SA01	1998	OSAP/Hilsenhoff	Poor
SA02	1999	OSAP/Hilsenhoff	Fair
SA03	1998	OSAP/Hilsenhoff	Fairly Poor
SA04	1999	OSAP/Hilsenhoff	Poor
SB01	1999	OSAP/Hilsenhoff	Fair
SB02	1998	OSAP/Hilsenhoff	Fair
SB03	1999	OSAP/Hilsenhoff	Fair
SB04	1998	OSAP/Hilsenhoff	Fair
SB05	1998	OSAP/Hilsenhoff	Fair
SB06	1999	OSAP/Hilsenhoff	Fairly Poor
SB07	1999	OSAP/Hilsenhoff	Fairly Poor
SB08	1999	OSAP/Hilsenhoff	Fairly Poor
SB09	1999	OSAP/Hilsenhoff	Fair
SB10	1998	OSAP/Hilsenhoff	Fair
SB11	1998	OSAP/Hilsenhoff	Fair
SB12	1999	OSAP/Hilsenhoff	Fair
SB13	1998	OSAP/Hilsenhoff	Fair
SB14	1998	OSAP/Hilsenhoff	Fair
SB15	1999	OSAP/Hilsenhoff	Fair
SC01	1998	OSAP/Hilsenhoff	Good
SC02	1998	OSAP/Hilsenhoff	Good

Site	Year	Method	Status
SC03	1999	OSAP/Hilsenhoff	Good
SC04	1998	OSAP/Hilsenhoff	Good
SD01	1999	OSAP/Hilsenhoff	Good
SD02	1999	OSAP/Hilsenhoff	Poor
SD03	1998	OSAP/Hilsenhoff	Fair
SD04	1998	OSAP/Hilsenhoff	Poor
SOPOB01	2005	OBBN	%EPT =7.6, Taxa Richness = 9
SOPOB01	2006	OBBN	%EPT = 6.8, Taxa Richness =9
SOPOB02	2005	OBBN	%EPT = 66.0, Taxa Richness = 9
SOPOB02	2006	OBBN	%EPT = 21.3, Taxa Richness = 9
SOPOB02	2009	OBBN	%EPT = 54.7, Taxa Richness = 10
SOPOB03	2005	OBBN	%EPT = 75.0, Taxa Richness = 10
SOPOB03	2006	OBBN	%EPT = 64.1, Taxa Richness = 10
SOPOB04	2005	OBBN	%EPT = 14.3, Taxa Richness = 6
SOPOB04	2006	OBBN	%EPT = 4.3, Taxa Richness = 9
SOPOB05	2009	OBBN	%EPT = 18.9, Taxa Richness = 13
SOPOB06	2009	OBBN	%EPT = 10.3, Taxa Richness = 13


Soper East Subwatershed

5.0 CONCLUSIONS

Water is critical for all living things on this planet, but quantities of water can be polluted by minute amounts of harmful substances. In addition, substances that are considered useful to humans, such as fertilizers, pesticides and metals, can make their way into surface water through runoff from roads, lawns, agricultural fields, industrial sites, etc. The contaminants can accumulate to levels that may be harmful to humans or wildlife. While the results reported in this chapter are specific to a few parameters that have been measured over the long term, other contaminants have been measured since 1964 (see Appendix A-1 and A-2).

Evaluation of the tested chemical parameters within the Bowmanville/Soper Creek watershed resulted in the following conclusions:

- Chlorides are natural constituents in the hydrologic environments. This chemical can be present due to natural or anthropogenic sources including rocks containing salt, road salting, agricultural runoff and wastewater. Ontario recently adopted the 150 mg/L limit (under CESI 2010 report) for the protection of aquatic life. This prescribed limit is just occasionally exceeded only at SWQ4 and SWQ5.

- Although phosphorous has very little adverse effects on human health, excessive concentrations of this chemical in an aquatic environment could lead to a number of adverse effects including, increase in algae and plant growth, decrease in biodiversity and an increase in turbidity. Human activities related to land disturbance, industrial, domestic and livestock wastes may contribute to increased levels of phosphorous.

  Over 40% of the water samples collected at the monitoring stations in Bowmanville Creek subwatershed have Phosphorous concentrations exceeding the prescribed limit of 30 ug/L. Moreover, increasing trend in concentration was observed at SWQ16. Higher exceedance rate of 63% was observed in Soper Creek subwatershed primarily at southernmost station (SWQ5). Increasing Phosphorous concentration trend was observed at SWQ19.

- Nitrate concentrations in water environments generally originate from decaying plants and animals, agricultural fertilizers, domestic sewage and wastewater. Similar to phosphorous, excessive concentration of nitrate in surface waters encourages excessive growth of algae causing algal blooms and euthrophication[2]. Nitrate concentration exceedance in Bowmanville Creek subwatershed is uncommon, but was more frequently observed at SWQ5. All samples collected at SWQ21 have nitrate concentration above the provincial limit of 2.93 mg/L.

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[2] Eutrophication is a natural process of excessive algae growth taking nutrients, mainly phosphorous and nitrogen (nitrate) that commonly adversely affect bio-diversity.

- Copper is introduced in the environment from industrial and domestic wastes, mining and mineral leaching. In the aquatic environment, copper is toxic to plants and algae at moderate levels. In ionic form (free metal), copper becomes toxic towards aquatic organisms and may result to inhibited growth, decreased production and offspring survival rates, increased mortality, deformities and abnormalities.

  Copper concentrations exceeding the 5 ug/L PWQO limit were observed at SWQ4 (Bowmanville Creek) and SWQ5 (Soper Creek) but excessive concentrations were most notable before 1990. Samples taken after the monitoring network was revived in 2003 showed occasional spikes in concentration that may not be statistically significant but would require close observation in anticipation of stricter future regulation.

- Higher concentrations of dissolved oxygen in water suggest better quality. The solubility of oxygen in water is basically influenced by temperature and organic content. As dissolved oxygen is required by microorganisms to decompose organic wastes in water, biochemical oxygen demand (BOD), which is the index used to qualify this parameter, is inversely proportional to DO.

  DO concentrations, for the most part, are above the interim standard, some concentrations occasionally dropped below suggested limit at all stations but no observation of adverse effect due to prolonged exposures were recorded.

- Aside from the closely evaluated WQI parameters, an initial evaluation was also made to determine which parameters exceeded prescribed water quality standards. Provincial Water Quality Objective (PWQO,1999) and recently adopted limits under the CESI 2010 report are being used as standard reference for raw water with multiple uses. Among the 55 analyzed chemical parameters, eight parameters excluded in the WQI were determined to have exceeded provincially set standards. With the exception of iron, lead and cadmium, most exceedances were isolated spikes and outliers that are common in most non-linear datasets. Iron, lead and cadmium, on the other hand, will be closely monitored for frequency, intensity and indication of adverse effects.

- Biological water quality results typically showed some impairment in areas dominated by intensive agriculture which lack sufficient riparian buffers, and urban areas, especially southern reaches where cumulative effects can be seen and development is old and lacking stormwater management. Water quality was not as impaired in newer developments which could be a result of improved stormwater management, or simply that upstream areas are still somewhat natural and therefore cumulative effects are not as apparent. The healthiest areas of the watershed were typically located within areas dominated by natural land cover, including well vegetated valley sections or within areas protected by the Provincially Significant Wetland.

WHAT WE DO ON THE LAND IS MIRRORED IN THE WATER

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APPENDIX A-1: Chemical Parameters Analyzed (York-Durham Environmental Laboratory)

ANALYTE	Transfer Code	Unit	MDL
Alkalinity as $CaCO_3$	ALK	mg/L	10.0
Aluminum as Al	Al	mg/L	0.0007
Ammonia+Ammonium as N	NH_3	mg/L	0.03
Antimony as Sb	Sb	mg/L	0.003
Arsenic as As	As	mg/L	0.0007
Barium as Ba	Ba	mg/L	0.0001
Beryllium as Be	Be	mg/L	0.0002
BOD (5 day)	BOD	mg/L	0.2
Cadmium as Cd	Cd	mg/L	0.0001
Calcium as Ca	Ca	mg/L	0.13
Calculated Conductivity	CCD	µmho/cm	0.01
Calculated Dissolved Solids	CDS	mg/L	20
Chloride as Cl	CHL	mg/L	0.1
Chromium as Cr	Cr	mg/L	0.0003
Cobalt as Co	Co	mg/L	0.0002
Colour	COL	TCU	1
Conductivity	CON	µmho/cm	0.01
Copper as Cu	Cu	mg/L	0.0002
Flouride as F	FLU	mg/L	0.04
Hardness as $CaCO_3$	HAR	mg/L	1.0
Ionic Balance	ION	%	0.01
Iron as Fe	Fe	mg/L	0.0002
Langelier Index	LIX		-2.0
Lead as Pb	Pb	mg/L	0.0007
Magnesium as Mg	Mg	mg/L	0.04
Manganese as Mn	Mn	mg/L	0.0001
Molybdenum as Mo	Mo	mg/L	0.0002
Nickel as Ni	Ni	mg/L	0.0001
Nitrate as N	NO_3	mg/L	0.03
Nitrite as N	NO_2	mg/L	0.05
pH (units)	pH	Units	0.01
Phosphate as P	PHO	mg/L	0.1
Potassium as K	K	mg/L	0.02
Selenium as Se	Se	mg/L	0.002
Sodium as Na	Na	mg/L	0.2
Strontium as Sr	Sr	mg/L	0.0001
Sulphate as SO_4	SO_4	mg/L	0.2
Suspended Solids	SUS	mg/L	0.9
Titanium as Ti	Ti	mg/L	0.0001
Total Anions	TAN	meq/L	0.01
Total Cations	CAT	meq/L	0.01
Total Kjeldhal Nitrogen	TKN	mg/L	0.05
Total Phosphorous as P	P	mg/L	0.006
Turbidity (NTU)	TUR	NTU	0.05
Vanadium as V	V	mg/L	0.0003
Zinc as Zn	Zn	mg/L	0.0002

Appendix A-2: Chemical Parameters Analyzed (Ministry of Environment Laboratory)

PARAMETER DESCRIPTION	UNITS
ALKALINITY, TOTAL	mg/L
ALUMINUM, UNFILTERED TOTAL	µg/L
AMMONIUM, TOTAL UNFILTERED REACTIVE	mg/L
BARIUM, UNFILTERED TOTAL	µg/L
BERYLLIUM, UNFILTERED TOTAL	µg/L
CADMIUM, UNFILTERED TOTAL	µg/L
CALCIUM, UNFILTERED TOTAL	mg/L
CHLORIDE, UNFILTERED TOTAL	mg/L
CHROMIUM, UNFILTERED TOTAL	µg/L
COBALT, UNFILTERED TOTAL	µg/L
CONDUCTIVITY, 25C	µg/L
CONDUCTIVITY, AMBIENT	µg/L
COPPER, UNFILTERED TOTAL	µg/L
DISSOLVED OXYGEN	mg/L
HARDNESS, TOTAL	mg/L
IRON, UNFILTERED TOTAL	µg/L
LEAD, UNFILTERED TOTAL	µg/L
MAGNESIUM, UNFILTERED TOTAL	mg/L
MALATHION	nanogram/L
MANGANESE, UNFILTERED TOTAL	µg/L
METHOPRENE	nanogram/L
METHOPRENE ACID	nanogram/L
METHOXYCITONELLAL	nanogram/L
MOLYBDENUM, UNFILTERED TOTAL	µg/L
NICKEL, UNFILTERED TOTAL	µg/L
NITRATES TOTAL, UNFILTERED REACTIVE	mg/L
NITRITE, UNFILTERED REACTIVE	mg/L
NITROGEN, TOTAL, KJELDAHL REACTIVE	mg/L
PH (-LOGH+CONCENTRATION)	none
PH FIELD	none
PHOSPHATE, FILTERED REACTIVE	mg/L
PHOSPHOROUS, UNFILTERED TOTAL	mg/L
POTASSIUM, UNFILTERED TOTAL	mg/L
RESIDUE, PARTICULATE	mg/L
SODIUM, UNFILTERED TOTAL	mg/L
STROTIUM, UNFILTERED TOTAL	µg/L
TEMPERATURE, WATER	Deg. C
TITANIUM, UNFILTERED TOTAL	µg/L
TURBIDITY	Forman
VANADIUM, UNFILTERED TOTAL	µg/L
ZINC, UNFILTERED TOTAL	µg/L