BLACK/HARMONY/FAREWELL CREEK WATERSHED
EXISTING CONDITIONS REPORT
CHAPTER 11 – SURFACE WATER QUALITY

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 water quality of the watershed is well understood.

Surface water quality is generally described with 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. It was observed through the years that these changes generally generate more and more pollution which adversely affects 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.

'water quality is generally described with measures of chemical, physical and biological characteristics'

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 phosphorus 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.

'the Environmental Protection Act, 1990 and Ontario Water Resources Act, 1990 are two of the prominent legislations related to the protection and management of water resources'

Applicable Legislation and Policies

Surface water quality monitoring activities in the Black/Harmony/Farewell Creek watershed and all watersheds within CLOCA jurisdiction 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 two of the prominent legislations related to the protection and management of water resources. These legislations have been subjected to numerous amendments to keep up with changes and developments. 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 recently enacted Clean Water Act 2006 is aimed to ensure the safety of drinking water by identifying potential risks to local sources. The source water protection strategies developed in CLOCA as well as in each of the other Conservation Authorities are directed towards attaining the Clean Water Act's objectives at the community level.

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 Black/Harmony/Farewell Creek watershed is situated entirely within the Regional Municipality of Durham and covers an area of approximately 108 km^2 (Figure 1). The watershed drains southerly towards Lake Ontario from its headwaters which originate in the south slope till plain of the Oak Ridges Moraine. The Black/Harmony/Farewell Creek watershed is divided into three primary subwatersheds: Black Creek, Harmony Creek and Farewell Creek.

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 Black, Harmony, and Farewell creeks.

'water quality information is collected by CLOCA across the jurisdiction'


Farewell Creek subwatershed


Harmony Creek subwatershed

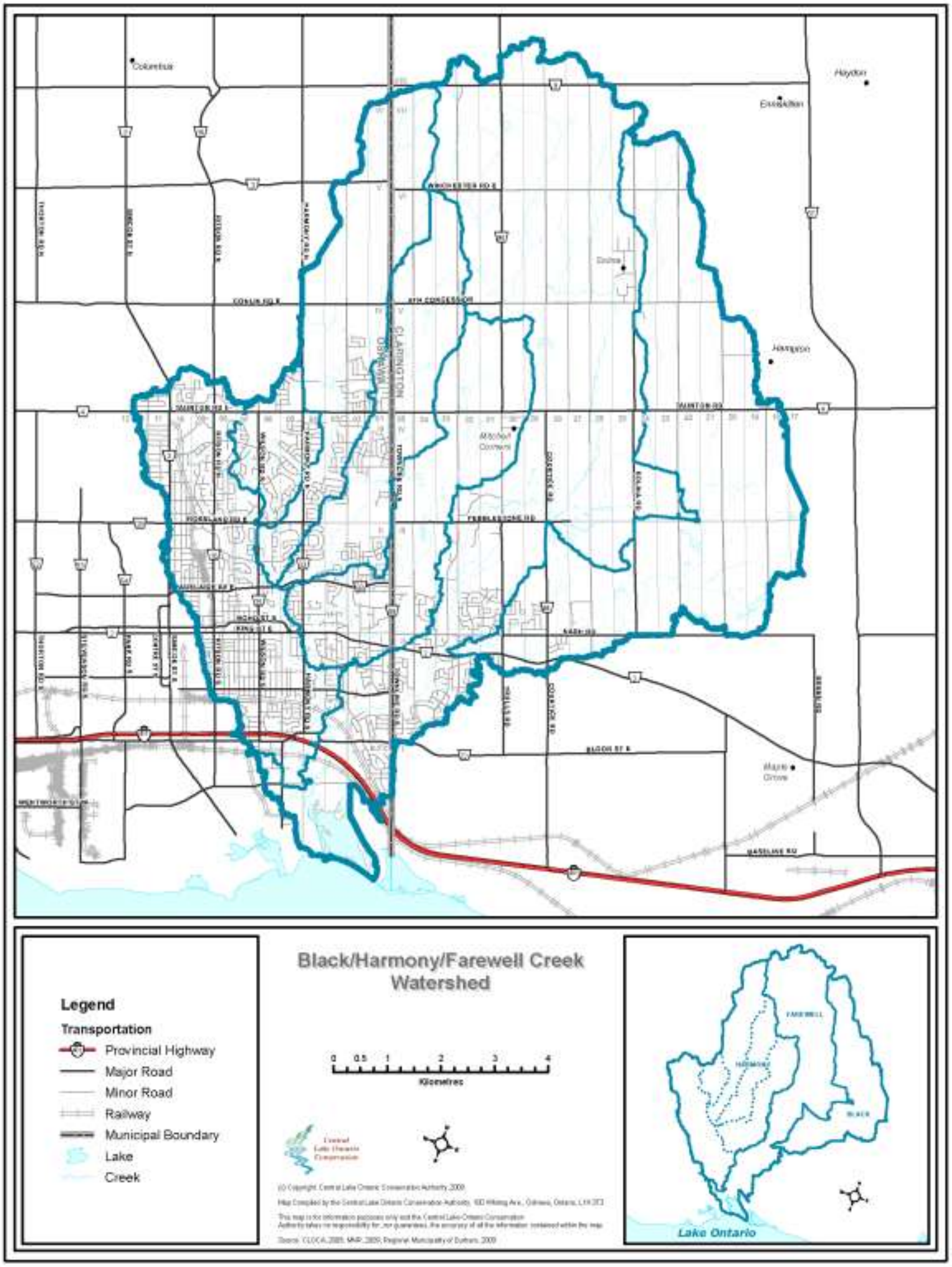

Figure 1: Black/Harmony/Farewell Creek watershed.

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.

'WQI parameters were chosen based on the monitoring programs in place, historical studies, and their significance as a water quality indicator'

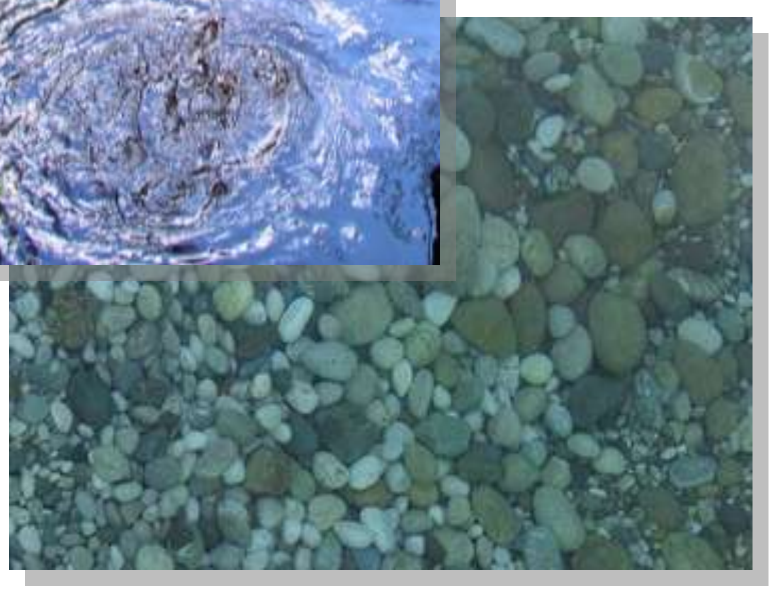

Table 1: Description of Parameters in the Surface Water Quality Index

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.
Phosphorus	The concentration of Phosphorus in the water	Phosphorus binds to soil particles and thus is an indicator of soil delivery to streams. Phosphorus 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 Phosphorus. 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. A firm Provincial Water Quality Objectives (PWQO) does not exist for nitrate at this time, however sustained high levels (e.g. 1-10 mg/L) are suspected to stress aquatic life.(1)
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 a limit of 1 mg/L under the Ontario Drinking Water Standard (ODWS) while the PWQO set a lower limit 5 µg/L limit in drinking water.
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.(2)
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)This table was taken in part from the Upper Thames River Watershed Report Cards 2001.
(2) 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.

Monitoring Station SWQ12 - Harmony Creek and Bloor Street intersection

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. The location of the chemical water quality sites within the Black/Harmony/Farewell Creek watershed is shown in Figure 2.

'CLOCA has 2 chemical water quality sampling programs in place, the Provincial Water Quality Monitoring Network (PWQMN) and CLOCA's own water quality monitoring program'

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, two that are located within the Black/Harmony/Farewell 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, two of which are located within Black/Harmony/Farewell 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) (see Figure 2).

Using the BioMAP protocol (Griffiths, 1999), 14 sites within the Black/Harmony/Farewell Creek watershed were assessed in 2002 and 2003. 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.

'The OBBN protocol also involves the sampling and identification of benthic microinvertebrates to serve as indicators of environmental quality.

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, 57 sites were sampled within the Black/Harmony/Farewell watershed during 2002. 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 Black, Harmony and Farewell Creeks Watershed (CLOCA 2008).

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, 10 sites were sampled within the Black/Harmony/Farewell Creek watershed during 2008. 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.

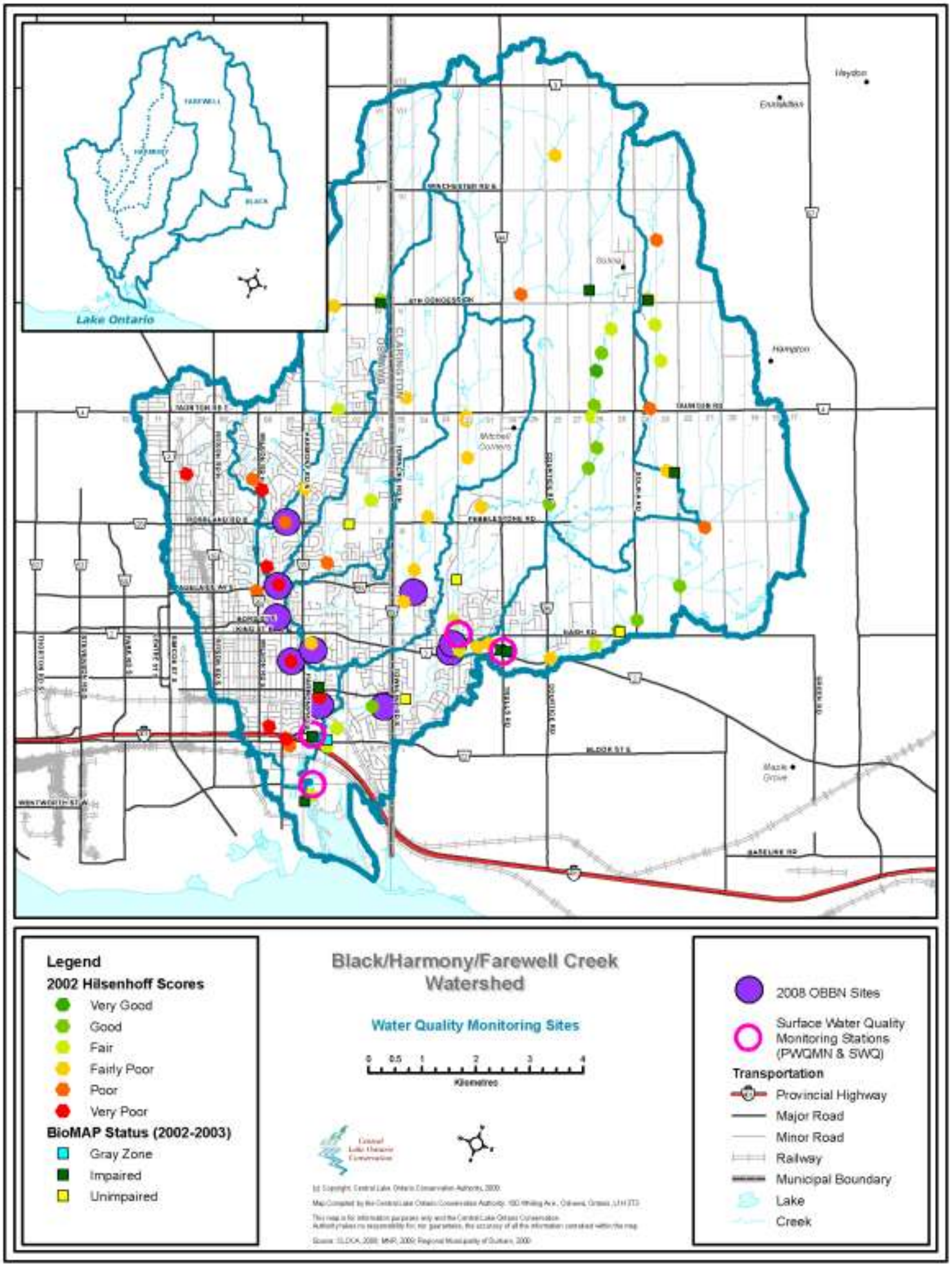

Figure 2: Water quality monitoring stations in the Black/Harmony/Farewell Creek watershed.

4.0 FINDINGS

4.1 Black/Harmony/Farewell 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 in exception of dissolved oxygen (DO) where the condition improves proportional with increase in concentration. In the Black/Harmony/Farewell Creek watershed, statistical trend analysis was performed on chloride, phosphorus, nitrogen compounds, 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.

'statistical trend analysis was performed on chloride, phosphorus, nitrogen compounds, copper, biological oxygen demand (BOD) and dissolved oxygen'

The results of statistical analyses and parametric and non-parametric tests are presented in Table 2.

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.

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

Table 2 (1/2): Summary statistics and trends in surface water quality parameters from two sites in the Farewell, and one site in each of the Black and Harmony Creek watersheds, analyzed using parametric and non-parametric statistical tests.

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)
Harmony Creek – SWQ 12	**1964-81, 2005-08**												
Chloride (mg/L)		172	0.153	351	89.3	63.3	0.557	46.6	89.3	131.9	6223	8.2	increasing trend
Phosphorus, Total (ug/L)		179	7	230	60.6	51.9	-0.1899	25.6	60.6	95.6	-2021	-2.52	decreasing trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	-0.0478	N/A	N/A	N/A	0	0	no trend
Nitrate, total, unfiltered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	no trend
Nitrate as N (mg/L)		9	0.75	2.28	1.17	0.484	0.2779	0.84	1.17	1.96	-4	-0.313	no trend
Copper (ug/L)		9	1	4.1	2.06	0.88	N/A	1.46	2.06	2.65	3	0.21	no trend
BOD, 5 day, total demand		191	0.1	10	1.75	1.37	-0.1445	0.825	1.75	2.67	-3222	-3.65	decreasing trend
Dissolved Oxygen (mg/L)		180	5	17.6	10.5	2.36	0.0483	8.9	10.5	12.1	348	0.43	no trend
Farewell Creek – SWQ 3	**1980-97, 2003-08**												
Chloride (mg/L)		226	0.7	594	87.5	60.3	0.5373	46.8	87.5	128.1	8817	7.76	increasing trend
Phosphorus, Total (ug/L)		207	6	147	36.8	26.7	-0,044	18.8	36.8	54.9	-605	-0.606	no trend
Nitrate, total, filtered (mg/L)		143	0.045	4.25	1.26	0.66	0.1386	0.81	1.26	1.7	860	1.5	no trend
Nitrate, total, unfiltered (mg/L)		18	0.62	1.82	1.28	0.41	0.312	1	1.28	1.55	13	0.455	no trend
Nitrate as N (mg/L)		52	0.66	3.4	1.5	0.6	-0.2764	1.1	1.5	2.5	-275	-2.16	decreasing trend
Copper (ug/L)		200	0.0005	14	3.2	2.8	-0.447	1.3	3.2	5.1	-6941	-7.3	decreasing trend
BOD, 5 day, total demand (mg/L)		158	0.04	6.6	1.45	1.19	0.0784	0.645	1.45	2.25	1080	1.62	no trend
Dissolved Oxygen (mg/L)		184	1.23	17	10.2	2.8	-0.2787	8.36	10.2	12.1	-2993	-3.58	decreasing trend
Farewell Creek – SWQ 13	**2005-2008**												
Chloride (mg/L)		34	18.2	63.3	29.7	10.4	0.0662	22.7	29.7	36.7	4	0.0445	no trend
Phosphorus, Total (ug/L)		30	6	25	12.5	5.1	0.1694	9.05	12.5	16	-5	-0.0714	no trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	no trend
Nitrate, total, unfiltered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	no trend
Nitrate as N (mg/L)		34	0.74	2.7	1.82	0.394	0.1001	1.55	1.82	2.47	-90	-1.32	no trend
Copper (ug/L)		34	0.2	3	0.71	0.605	0.2328	0.303	0.71	1.12	115	1.69	no trend
BOD, 5 day, total demand (mg/L)		2	0.6	0.7	0.65	0.071	-1.00	0.6	0.65	0.7	-1	0	no trend
Dissolved Oxygen (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	no trend

(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 2 (2/2): Summary statistics and trends in surface water quality parameters from two sites in the Farewell, and one site in each of the Black and Harmony Creek watersheds, analyzed using parametric and non-parametric statistical tests.

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)
Black Creek – SWQ 14	**2003-2008**												
Chloride (mg/L)		66	21.6	151	71.5	29.4	-0.2427	51.7	71.5	91.3	-191	-1.05	no trend
Phosphorus, Total (ug/L)		66	14	318	74.7	55.3	0.051	37.4	74.7	112	-46	-0.25	no trend
Nitrate, total, filtered (mg/L)		0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	no trend
Nitrate, total, unfiltered (mg/L)		14	0.7	1.56	0.96	0.246	0.0426	0.8	0.96	1.13	-1	0	no trend
Nitrate as N (mg/L)		52	0.2	1.82	0.93	0.42	0.0501	0.64	0.93	1.62	-395	-3.1	no trend
Copper (ug/L)		53	0.109	6.3	1.13	1.15	0.273	0.35	1.13	1.9	257	1.96	increasing trend
BOD, 5 day, total demand (mg/L)		2	0.9	1	0.95	0.071	1.00	0.9	0.95	1	1	0	no trend
Dissolved Oxygen (mg/L)		32	1.3	15	8.9	3.85	0.3426	6.3	8.9	11.5	93	1.49	no trend

(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

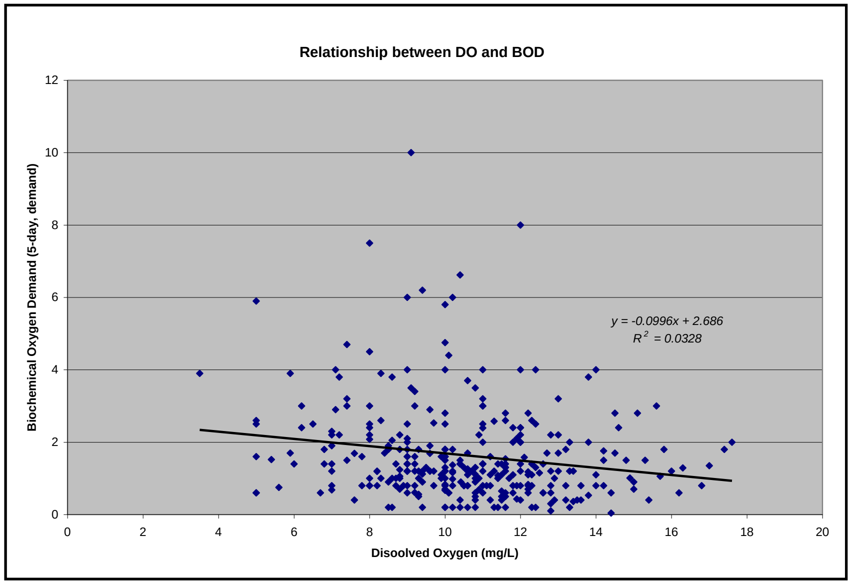

Figure 3: Relationship between DO and BOD at SWQ3, SWQ12, SWQ13, and SWQ14

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.

4.1.3 Biological Water Quality

Biological quality was assessed historically using BioMAP in 2002 and 2003 at 14 sites throughout the watershed (Figure 2). Of the 14 sites sampled for biological water quality, 9 sites were considered impaired. These sites were typically located in the older urban areas of Oshawa 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 in 2002 while conducting fish community sampling at 57 sites using the Ontario Stream Assessment Protocol (Stanfield *et al*. 1998). Like BioMAP, the Hilsenhoff scores showed a contrast from poor in the older urban areas of Oshawa and some agricultural areas, to fair in the upper urban areas where stormwater management has been implemented in recent years, to good in areas where natural cover is abundant or riparian corridors are still intact (CLOCA/MNR 2007).

'differences in water quality were observed between water quality sites dominated by urban and agricultural land uses'

Results from the 2008 OBBN data, at 10 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 or even zero in the older urban areas of Oshawa to moderate in the newer urban areas of Harmony Creek, or in close proximity to the confluence of Farewell and Black Creeks. Taxa richness at each site ranged from 6 to 11. The greatest richness typically occurred within larger stream orders or within the PSW. It should be noted that no OBBN sites were sampled in areas dominated by agricultural land uses so the impacts of this land use could not be determined.

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 SWQ3 and SWQ12 whereas stations SWQ13 and SWQ14 have records that were started when the Provincial Water Quality Monitoring Network (PWQMN) was revived in 2003. As statistical trend analyses rely heavily on the quantity of data processed, and the 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 its occurrence include, among others, accidental spill immediately before sampling or extreme rainfall after extended dry spell. The invalid results, however, may include, but are not limited to, errors in sampling procedure or laboratory analysis.

4.2.1 Harmony Creek Subwatershed

4.2.1.1 Chemical Water Quality

Harmony Creek subwatershed drains an area of 4,667 hectares (ha). Its main channel stretches from just south of Regional Road No. 3 near Townline Road N down to its confluence with Farewell Creek at Wentworth Street (Figure 4). The built-up area covers about 65 percent of this subwatershed. The only surface water quality monitoring station (SWQ12) in this subwatershed is located along Harmony Creek close to the bridge crossing at Bloor Street in Oshawa. The areas in the immediate vicinity of the station is not densely populated, because it is within a floodplain. However, development intensifies outside of the floodplain, especially to the north. . This station has 17 years of continuous historical record (1964 to 1981).

'statistical analysis at SWQ12 showed increasing trend of chloride concentration in Harmony Creek'

Chloride

The Mann-Kendall statistical analysis at SWQ12 showed an increasing trend of the chloride concentrations in Harmony Creek (Table 2). Historically, the recorded chloride concentrations at this station went as high as 950 mg/L in early 1980s. Throughout the sampling events, chloride concentrations occasionally exceeded the 250 mg/L limit set under the Ontario Drinking Water Standard (ODWS). The province has no firm guideline on the concentration of chloride to protect aquatic life. However, the US EPA, has determined that the acute threshold for chloride for aquatic life is 860 mg/L and the chronic threshold is 230 mg/L.

The provincial monitoring activity at this station was discontinued after 1986, but was revived by CLOCA in 2005. This data gap, between 1985 and 2005, is illustrated in Figure 5.

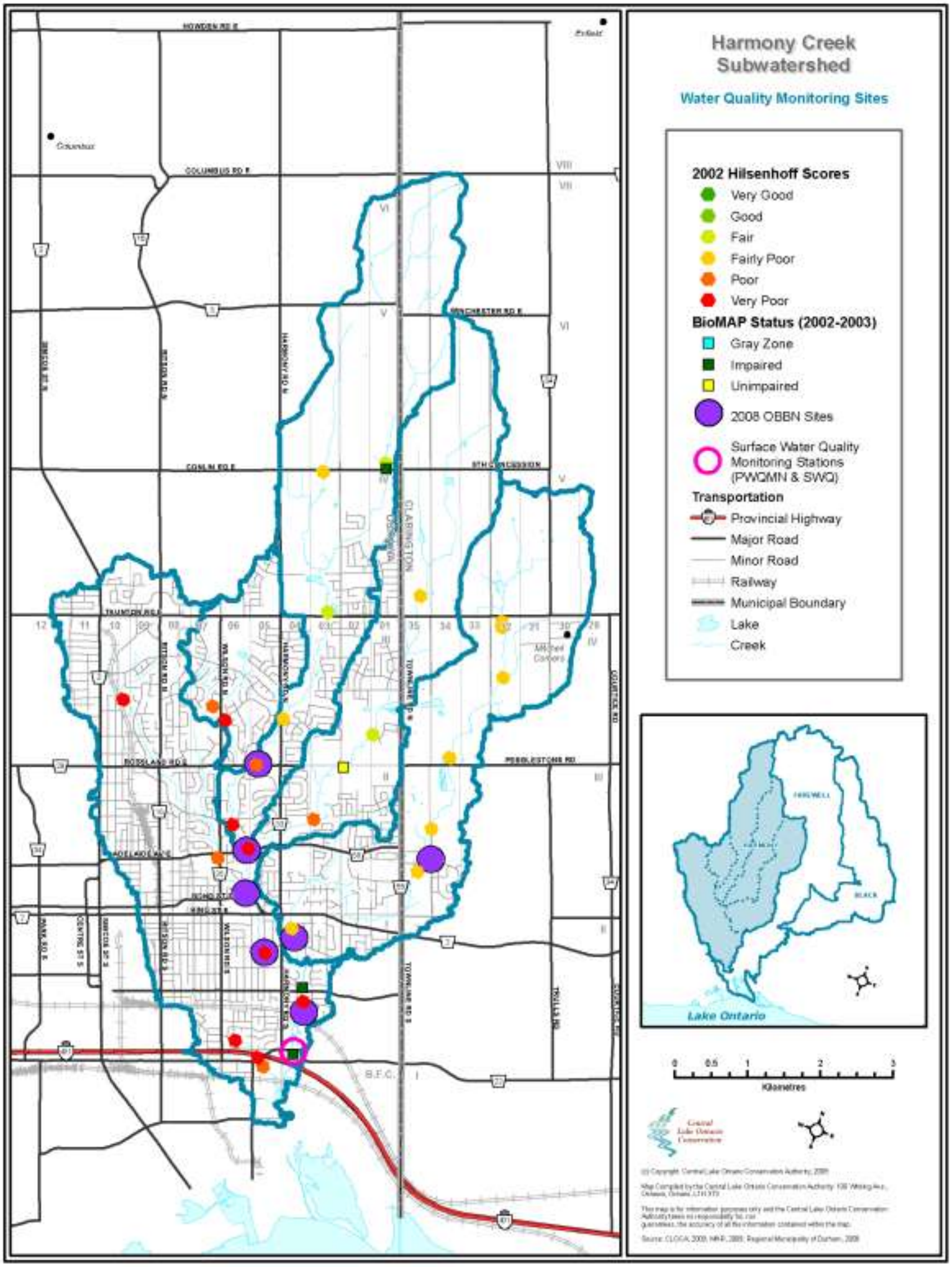

Figure 4: Water quality monitoring stations in the Harmony Creek subwatershed

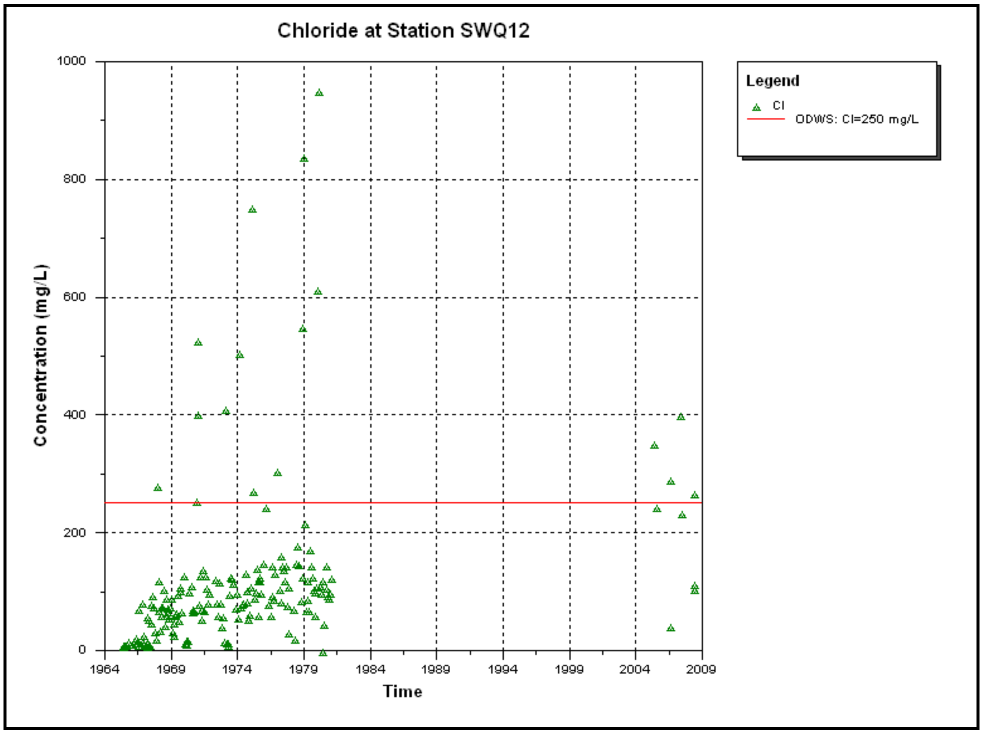

Figure 5: Chloride concentrations at SWQ12.

Analysis of the seasonal distribution of chloride shows that the median concentration of chloride is approximately 90 mg/L (Figure 6). Concentration exceeding the 250 mg/L ODWS limit occasionally occurred during all seasons of the year, while relatively higher concentrations (greater than 100 mg/L) were observed during the summer and winter.

'seasonal distribution shows that median concentration of chloride borders around 90 mg/L'

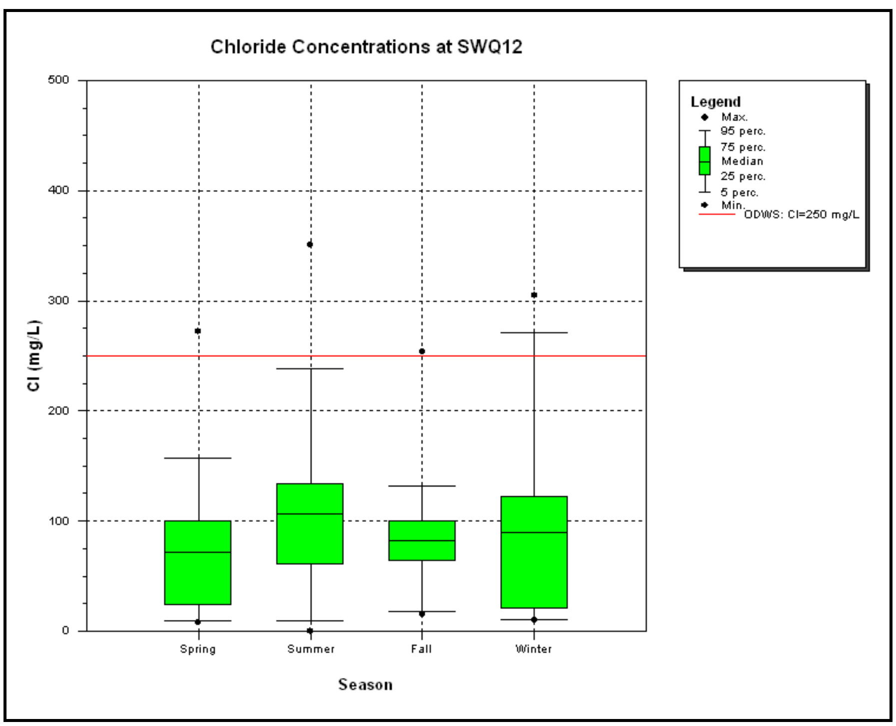

Figure 6: Seasonal chloride concentrations at SWQ12

Phosphorus

A statistical analysis of phosphorous showed a decreasing trend in concentrations at SWQ12. Chemical analysis records show that phosphorus concentrations at this station are historically high and generally exceed the provincial interim limit of 30 ug/L (Figure 7).

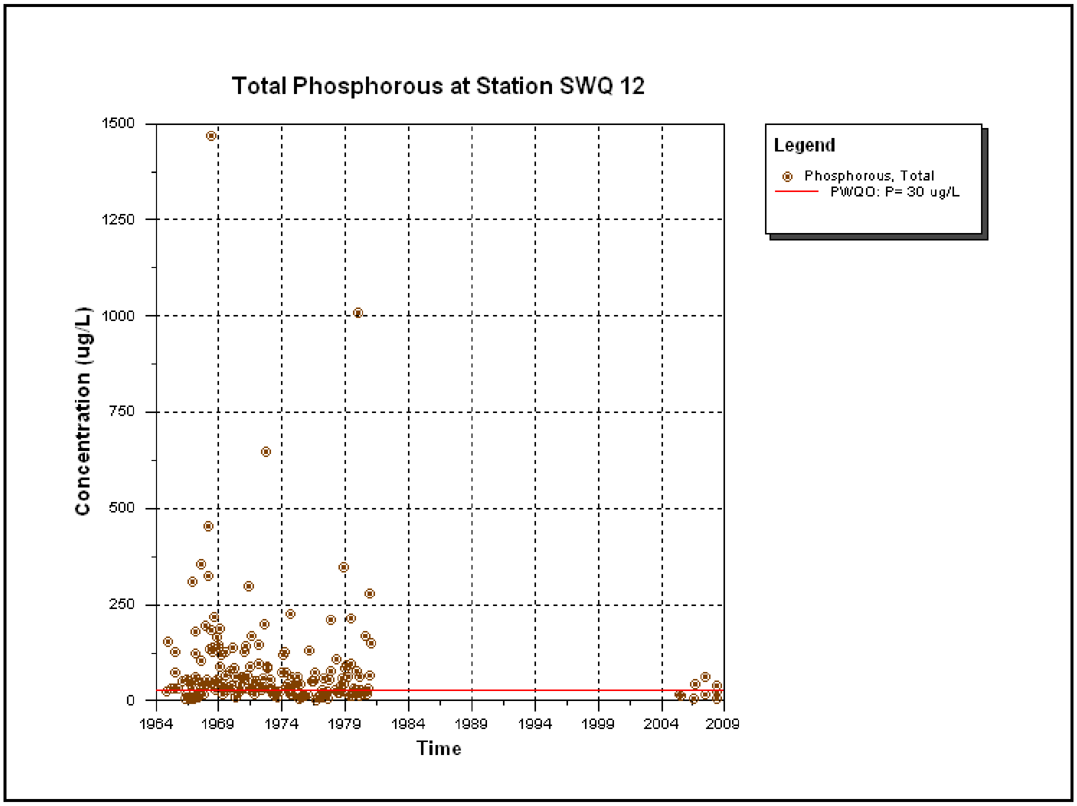

Figure 7: Phosphorous concentrations at SWQ 12.

Analysis of the seasonal distribution of phosphorus at SWQ12 revealed that the median concentrations, as well as 75% of all analyzed samples, are generally higher than the interim provincial limit throughout the observation period (Figure 8). Similar to chloride, median concentrations of phosphorous were higher during the winter. However, a trend analysis revealed that phosphorous concentration at this station are decreasing with time.

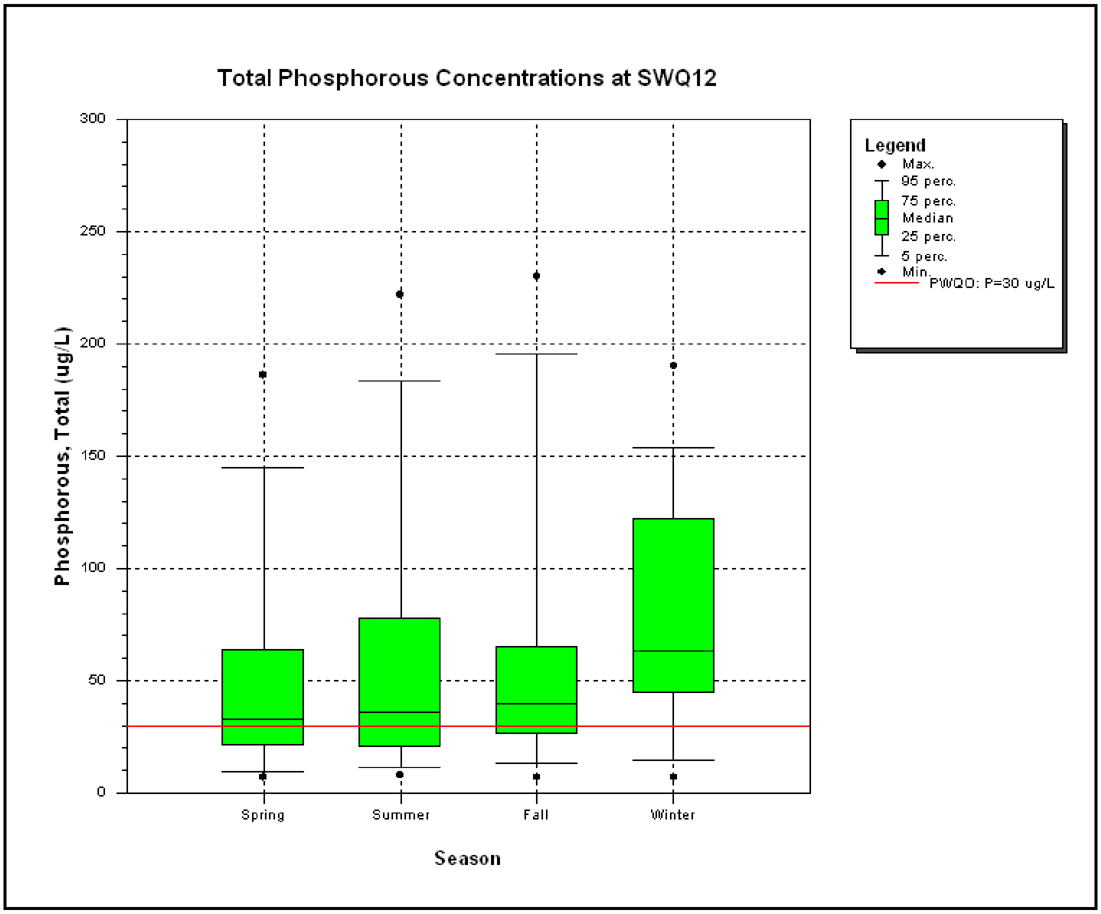

Figure 8: Seasonal phosphorus concentrations at SWQ12

'trend analysis revealed that phosphorous concentration at SWQ12 is decreasing in time'

Nitrate

Over the years, there have been significant changes in the methods for testing nitrate. These changes have enabled only partial statistical analysis of laboratory results using different methods at different sampling durations. The earlier method (1964-1981) required water samples to be filtered before testing Results from filtered samples indicated increasing trends at SWQ12, while lower concentrations were observed in 2005, when samples were unfiltered (Figure 9). The current procedure for testing nitrate in unfiltered samples has an inadequate number of test results to allow for a valid statistical analysis. Available test results, however, did not show any sample exceeding the 13 mg/L prescribed by Environment Canada for the protection of aquatic life.

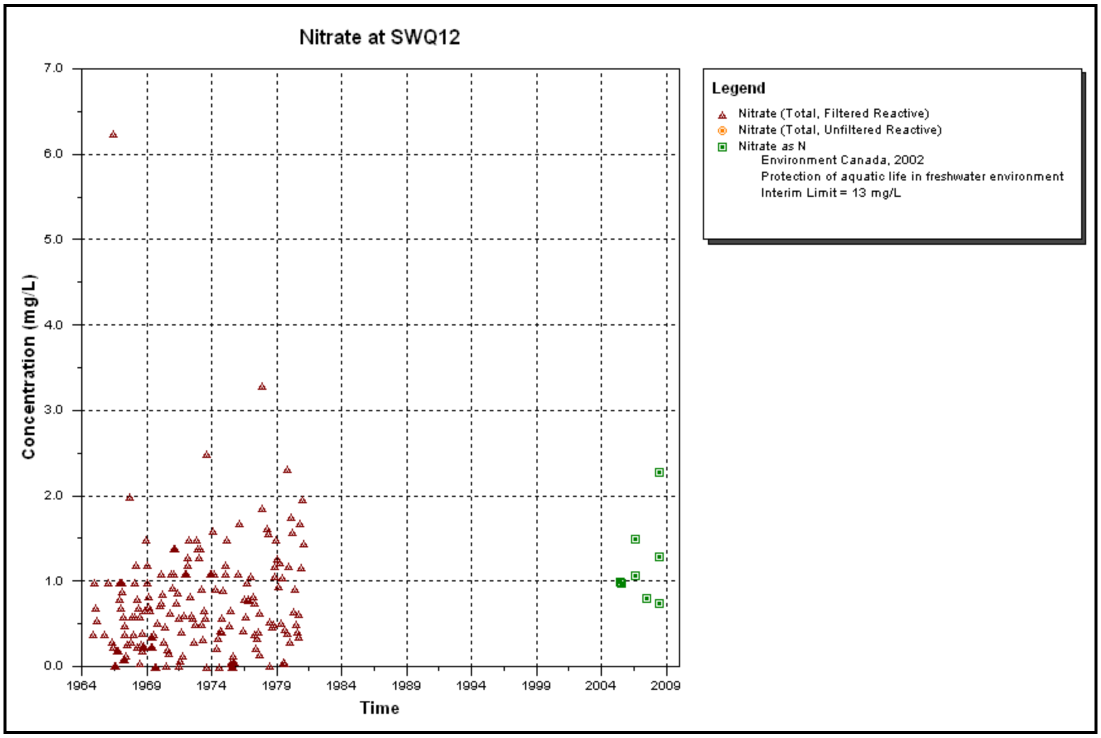

Figure 9: Nitrate concentrations at SWQ12

Copper (Cu)

Laboratory analysis on copper concentration at SWQ12 was not performed until the monitoring activity was revived in 2005. The very limited number of laboratory test results for this metal showed that its concentration has never exceeded the 5 ug/L limit set under the PWQO (Figure 10).

'Available test results, however, did not show any sample exceeding the 13 mg/L (Nitrate standard limit) prescribed by Environment Canada for the protection of aquatic life'

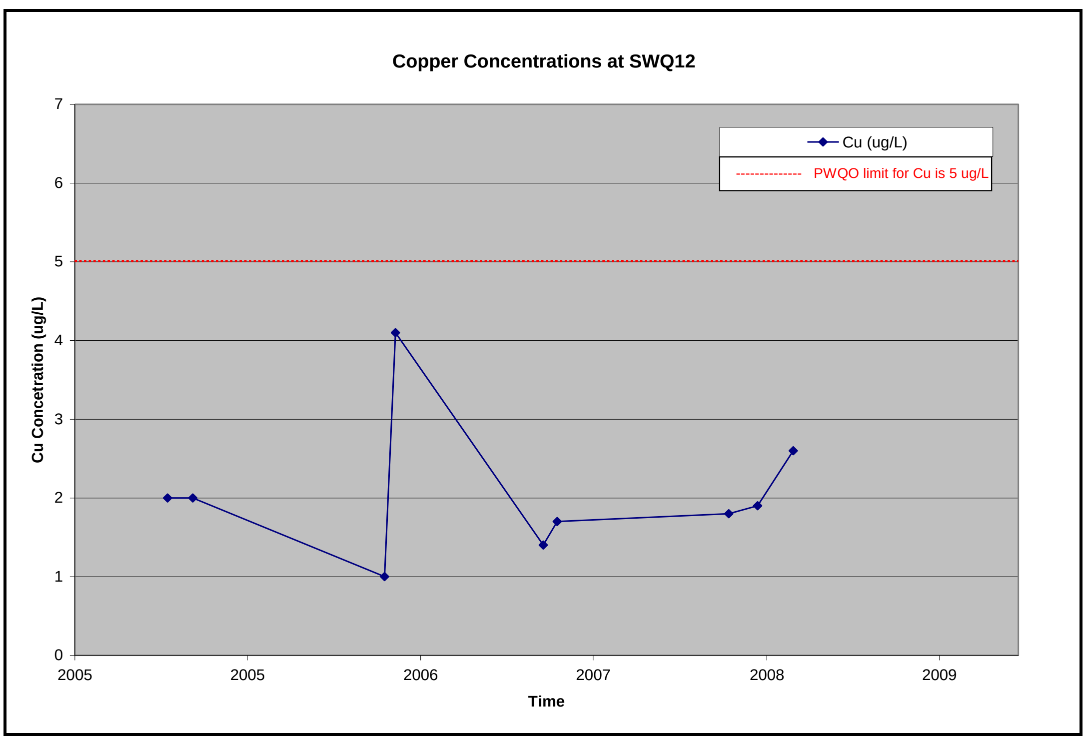

Figure 10: Copper concentrations at SWQ12

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. Figure 11 exhibits the historical relationship of BOD and DO (1964-1981). It would be worthy to note that the absence of DO concentrations in the graphs after 1981 denotes missing data rather than non-detects.

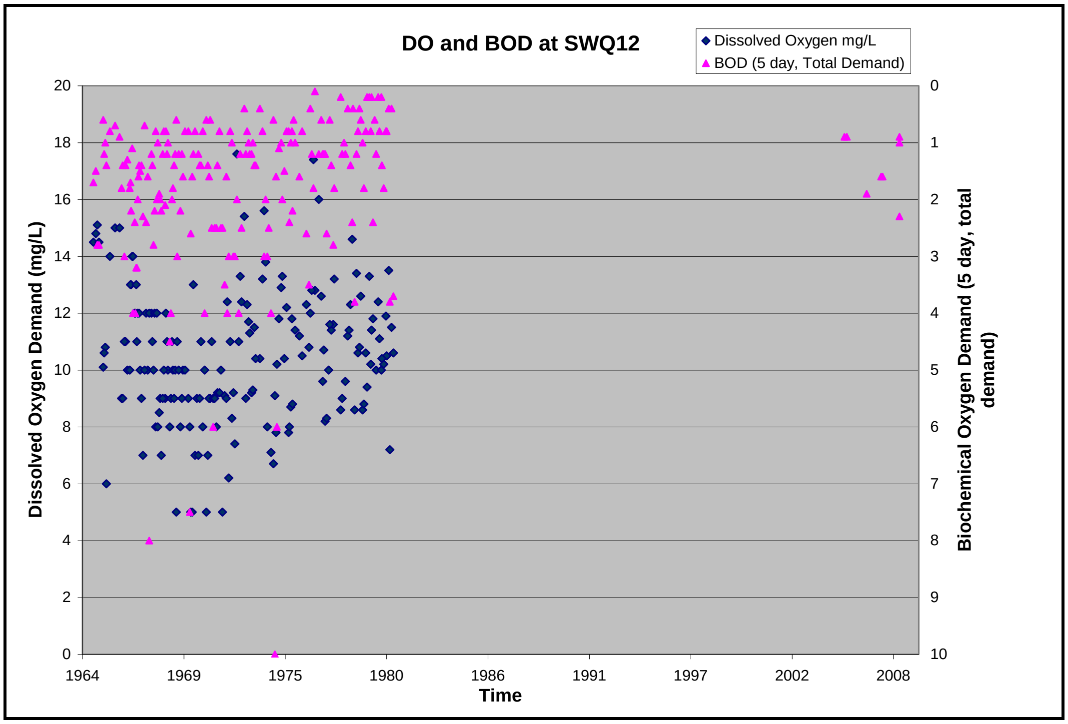

Figure 11: BOD and DO at SWQ12

Recent water quality analysis shows that the BOD remained relatively low, this had an adverse affect on DO concentrations in the natural water environment of the subwatershed. In view of this, it would be safe to assume that present DO concentrations at this station are not critical despite the fact that historic concentrations occasionally dipped below the level critical to support aquatic life (Figure 11 and Figure 12).

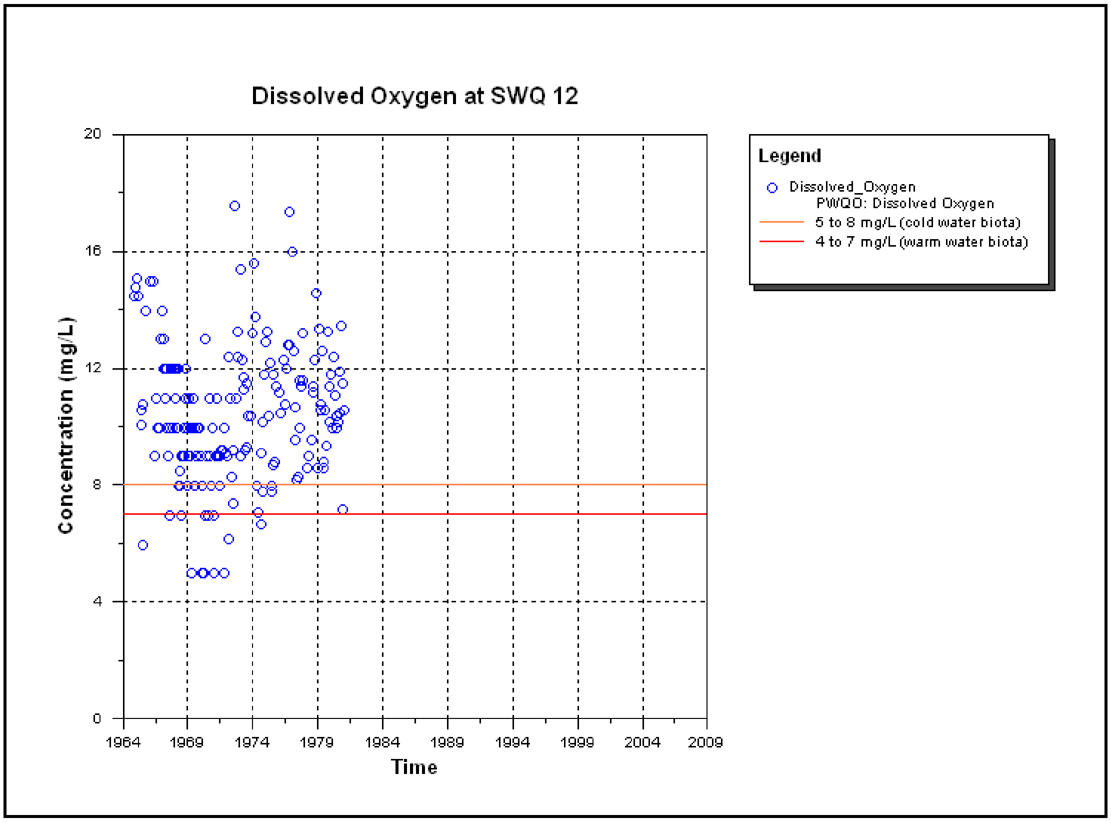

Figure 12: Dissolved Oxygen (DO) concentrations at SWQ12

'recent water quality analysis shows that the BOD remained relatively low to adversely affect DO concentration levels'

Exceedances

Twenty-six of the 191 samples taken at SWQ12 have iron concentrations exceeding the 0.3 mg/L limit set under the PWQO. The limit for iron is an aesthetic objective, which means that excessive amount of this metal discolours the water. In domestic water supplies, the presence of excessive iron may cause staining of laundry and plumbing fixtures as well as affect the clarity of water. It can also promote the growth of iron bacteria whose precipitate may damage watermain and service pipes.

4.2.1.2 Biological Water Quality

Biological water quality in Harmony Creek was assessed at 4 sites throughout the subwatershed in 2002 and 2003 using BioMAP (Figure 4). Of the 4 sites sampled for biological water quality, 3 sites were considered impaired (**Table 3**). In addition, biological water quality data (Hilsenhoff scores) was collected at 26 sites during stream fisheries assessment sampling in 2002. Results from this assessment ranged from fair to very poor. More recently, biological water quality was assessed in at 7 sites in 2008 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, the Harmony Creek subwatershed had the greatest water quality degradation compared to the Black and Farewell Creek subwatersheds. The cumulative effects of nutrient enrichment from urban or agricultural sources are thought to result in the impairment of these sites.

Table 3: Biological water quality monitoring in the Harmony Creek subwatershed between 2002 and 2008

Site	Year	Method	Status
HAR3	2002	BioMAP	Impaired
HAR2	2002	BioMAP	Unimpaired
HAR1	2002	BioMAP	Impaired
Harmony/03	2003	BioMAP	Impaired
H101	2002	OSAP/Hilsenhoff	Very Poor
H102	2002	OSAP/Hilsenhoff	Poor
H103	2002	OSAP/Hilsenhoff	Very Poor
H201	2002	OSAP/Hilsenhoff	Very Poor
H202	2002	OSAP/Hilsenhoff	Very Poor
H203	2002	OSAP/Hilsenhoff	Poor
H301	2002	OSAP/Hilsenhoff	Poor
H302	2002	OSAP/Hilsenhoff	Fairly Poor
H303	2002	OSAP/Hilsenhoff	Fair
H304	2002	OSAP/Hilsenhoff	Fairly Poor
H305	2002	OSAP/Hilsenhoff	Fair
H401	2002	OSAP/Hilsenhoff	Very Poor
H402	2002	OSAP/Hilsenhoff	Poor
H403	2002	OSAP/Hilsenhoff	Fair
H404	2002	OSAP/Hilsenhoff	Fairly Poor
H501	2002	OSAP/Hilsenhoff	Fairly Poor
H502	2002	OSAP/Hilsenhoff	Fairly Poor
H503	2002	OSAP/Hilsenhoff	Fairly Poor
H504	2002	OSAP/Hilsenhoff	Fairly Poor
H505	2002	OSAP/Hilsenhoff	Fairly Poor
H506	2002	OSAP/Hilsenhoff	Fairly Poor
H507	2002	OSAP/Hilsenhoff	Fairly Poor
H601	2002	OSAP/Hilsenhoff	Poor
H602	2002	OSAP/Hilsenhoff	Very Poor
HYS1	2002	OSAP/Hilsenhoff	Very Poor
HYS2	2002	OSAP/Hilsenhoff	Very Poor
HYOB01	2008	OBBN	%EPT = 2.7, Taxa Richness = 9
HYOB02	2008	OBBN	%EPT = 3.1, Taxa Richness = 7
HYOB03	2008	OBBN	%EPT = 3.7, Taxa Richness = 6
HYOB04	2008	OBBN	%EPT = 8.7, Taxa Richness = 7
HYOB05	2008	OBBN	%EPT = 15.9, Taxa Richness = 10
HYOB06	2008	OBBN	%EPT = 35.6, Taxa Richness = 8
HYOB07	2008	OBBN	%EPT = 7.1, Taxa Richness = 11

4.2.2 Farewell Creek Subwatershed

4.2.2.1 Chemical Water Quality

Farewell Creek subwatershed serves as the main system among the three watersheds since it is the only stream with the main channel directly discharging to Lake Ontario. The main channels of Harmony and Black Creeks, connect with the Farewell Creek main channel approximately 1.2 and 5.5 kilometres from Lake Ontario, respectively.

The headwaters of Farewell Creek begin around the Regional Road No. 3 and Enfield Rd intersection, and feeds into a drainage subwatershed area of approximately 3771 ha. Approximately 20 percent of the entire subwatershed area is highly developed. These built-up areas are mostly concentrated in the southern portions between Pebblestone Road and Bloor Street.

Farewell Creek subwatershed has two surface water monitoring stations. SWQ3 is located at the Coronel Sam Drive bridge crossing with the main channel in Oshawa immediately north of the Second Marsh Wildlife Area. The second monitoring station, SWQ13, is located in highly built-up area of Courtice at the Farewell channel crossing at Nash Road (Figure 13).

'among the three watersheds, …Farewell creek is the only stream with the main channel directly discharging to Lake Ontario'

Farewell Creek subwatershed

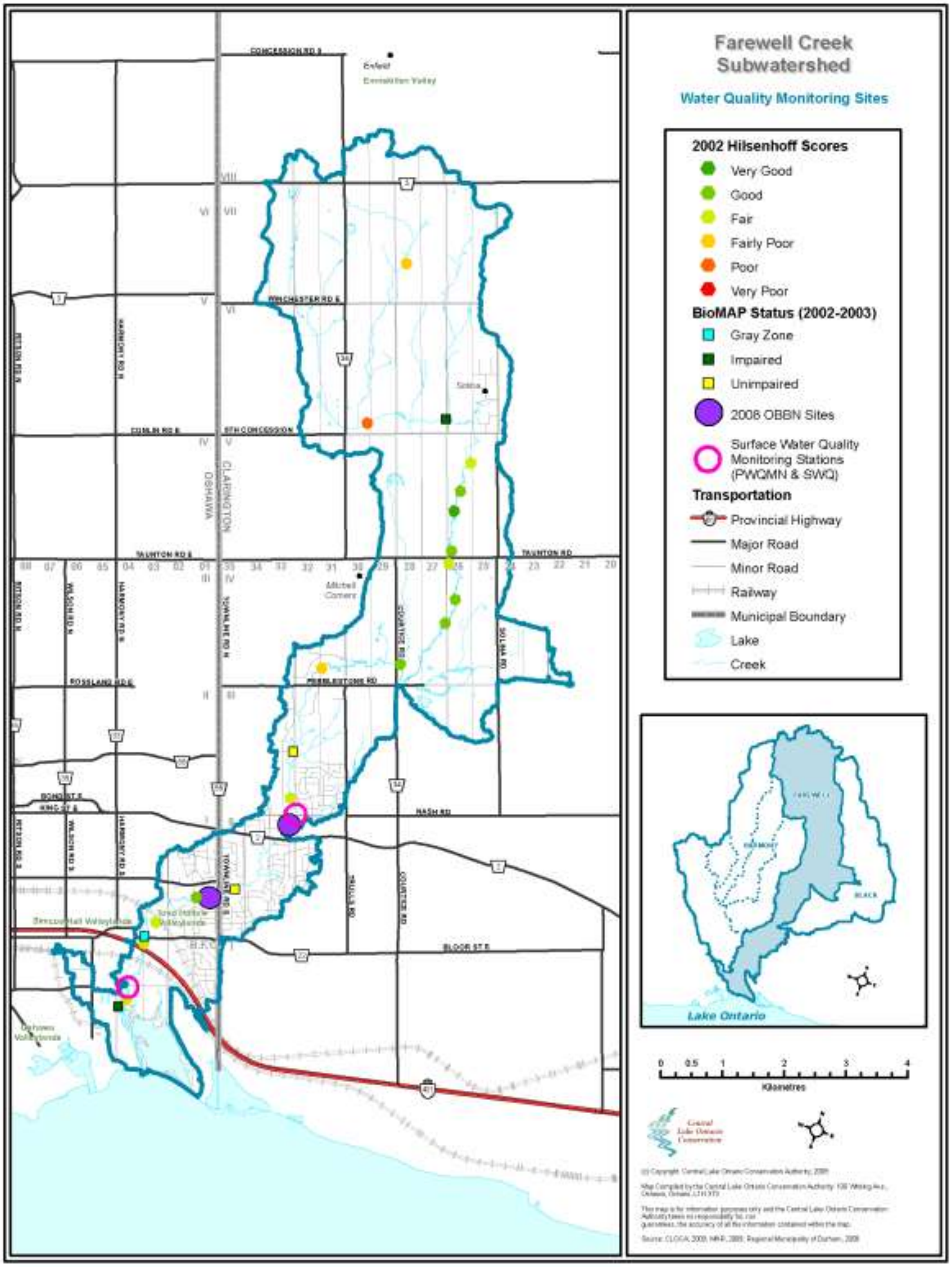

Figure 13: Water quality monitoring stations in the Farewell Creek subwatershed

Chloride

Chloride concentrations at SWQ3 are relatively higher than those at SWQ13 (Figure 14). A statistical analysis (Table 2) shows that SWQ3 has a mean chloride concentration that is three times greater than at SWQ13. Few of the samples collected after the program revival in 2003 have chloride content exceeding the 250 mg/L limit set under the ODWS.

A Mann-Kendall test also revealed that chloride concentrations at SWQ3 have an increasing trend. SWQ13 has an insufficient quantity of data required to complete a non-parametric trend analysis.

'chloride concentration at SWQ3 has an increasing trend'

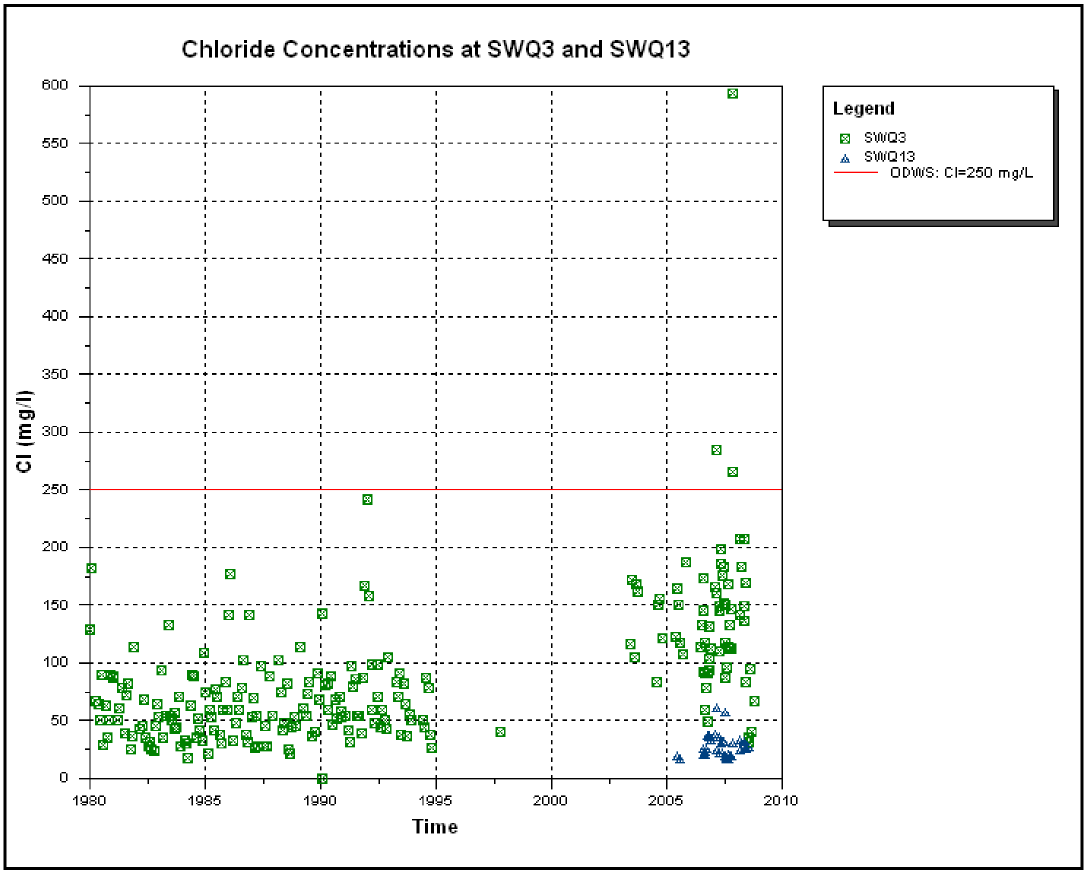

Figure 14: Distributions of chloride concentrations at Stations SWQ3 and SWQ13.

Seasonal distribution at both stations shows mean chloride concentrations that are generally higher in the winter (Figure 15 and Figure 16). However, the median concentrations in the spring and fall are not in agreement in these two stations. Based on the longer observation period, it is expected that SWQ3 would provide a more statistically valid representation of the seasonal distribution of chloride in the locality of the station.

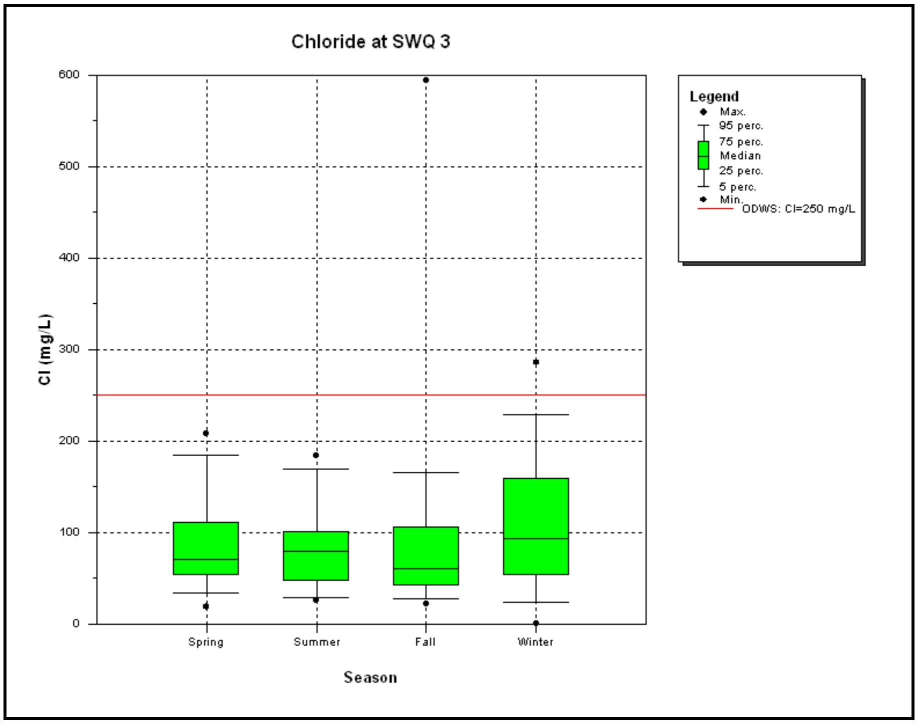

Figure 15: Seasonal chloride concentrations at SWQ3

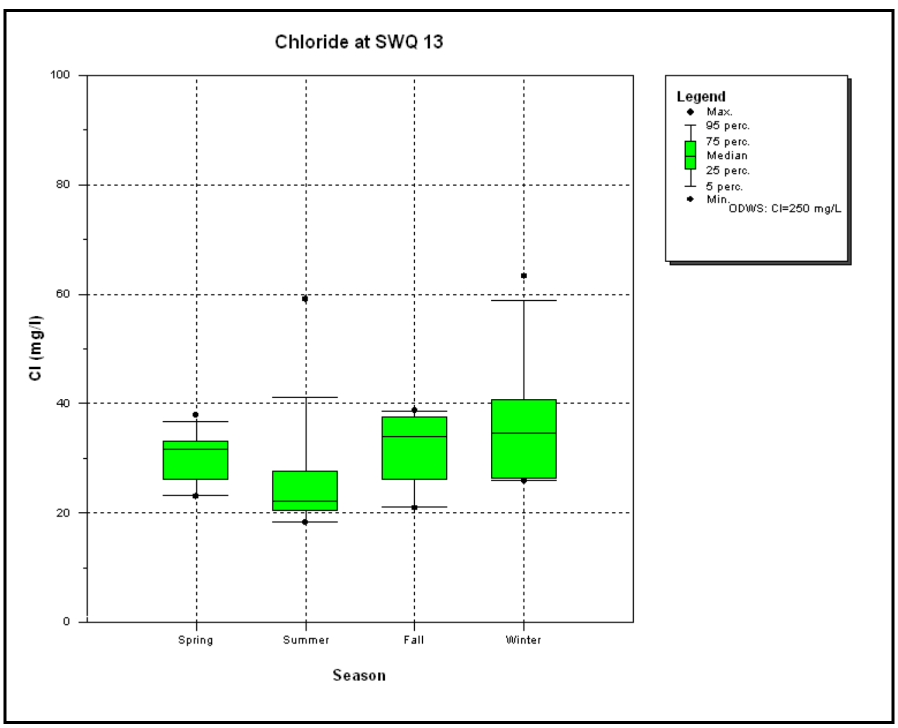

Figure 16: Seasonal chloride concentrations at SWQ13

Phosphorous

Phosphorous concentrations showed no definitive trends at the SWQ3 monitoring station, despite the long-term data used in the non-parametric statistical analysis. SWQ13 has insufficient data to complete a trend analysis, (Table 2).

Nearly 50 percent of the 207 samples analyzed for phosphorous at SWQ3 exceeded the 30 ug/L interim provincial limit (Figure 17). All water samples at SWQ13 have phosphorous concentrations within the prescribed standard.

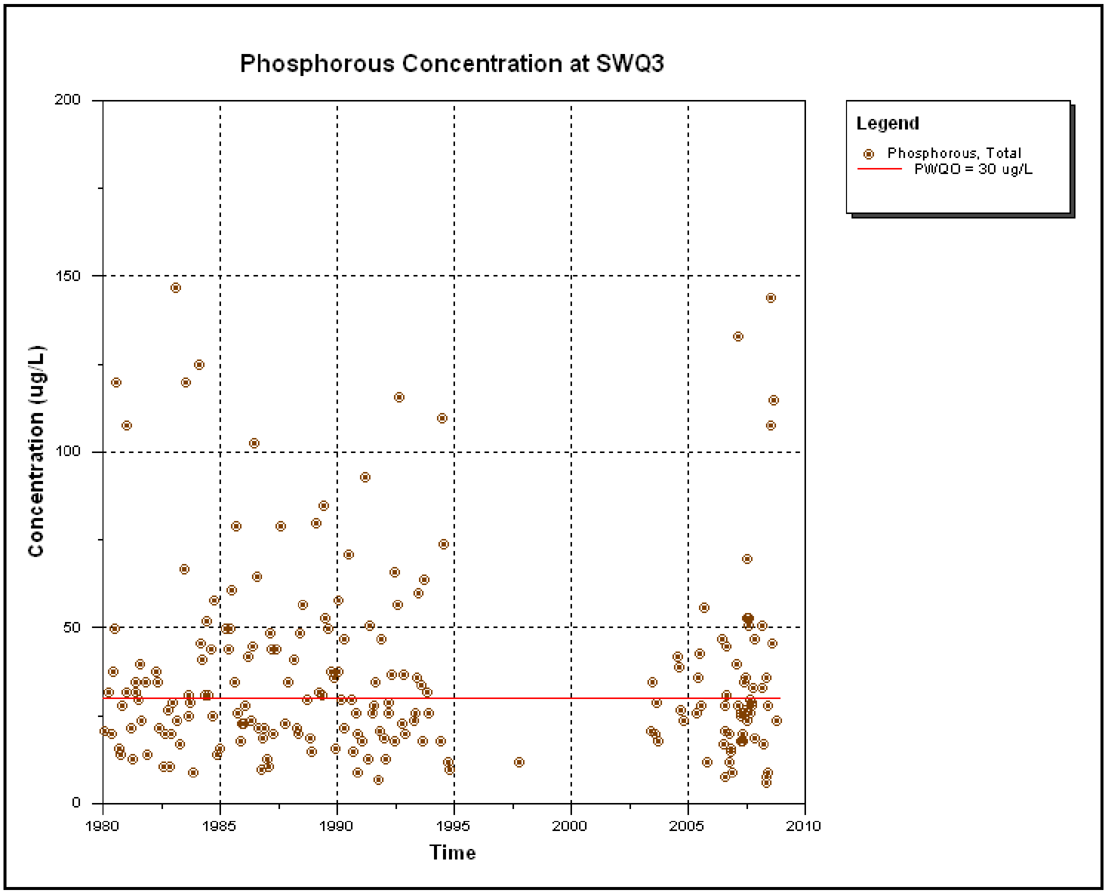

Figure 17: Phosphorus concentrations at SWQ3.

'Nearly 50 percent of the 207 samples analyzed for phosphorous at SWQ3 exceeded the 30 ug/L interim provincial limit

The comparison of phosphorous concentrations at SWQ3 and SWQ13 is shown in Figure 18.

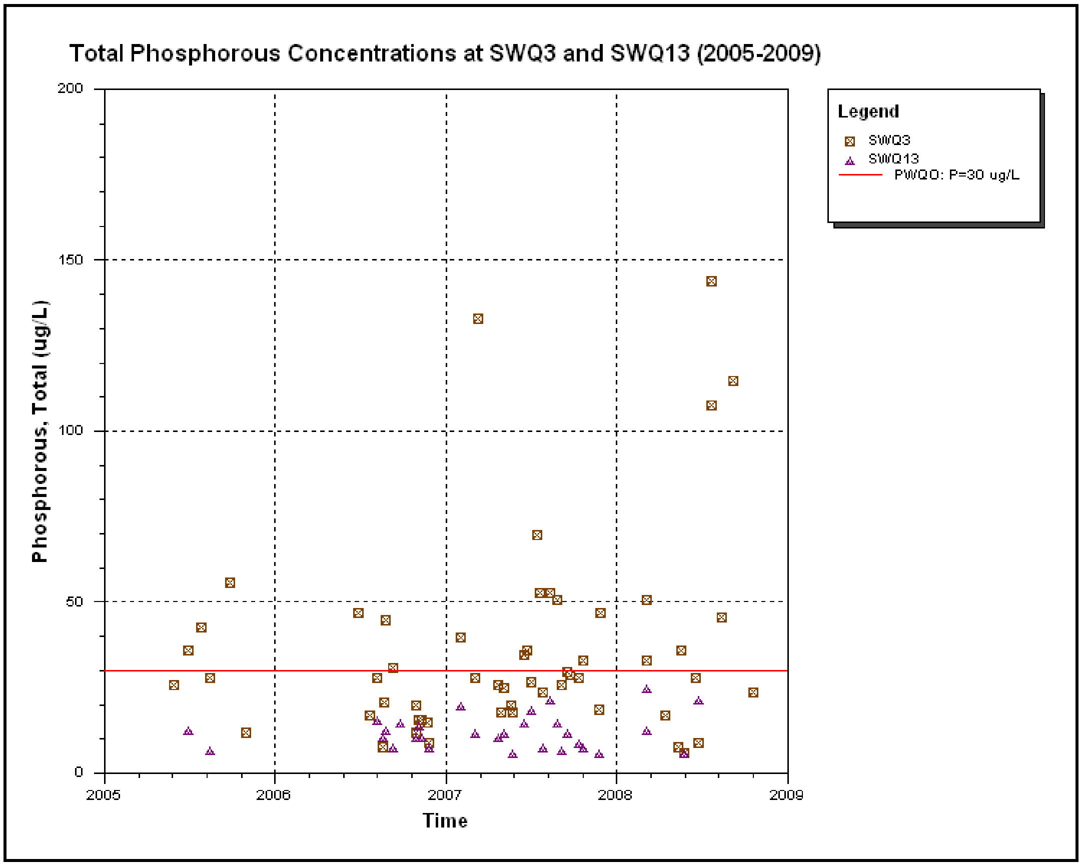

Figure 18: Phosphorus concentrations at SWQ3 and SWQ13 (2005-2009)

Seasonal distribution of phosphorous at SWQ13 showed that median values of concentration are highest in the summer and lowest in the fall (Figure 19). Median concentrations in the winter and spring are close to the provincial interim limit (30 ug/L) while almost 75% of the samples collected in the summer have phosphorous concentrations exceeding the provincial interim limit.

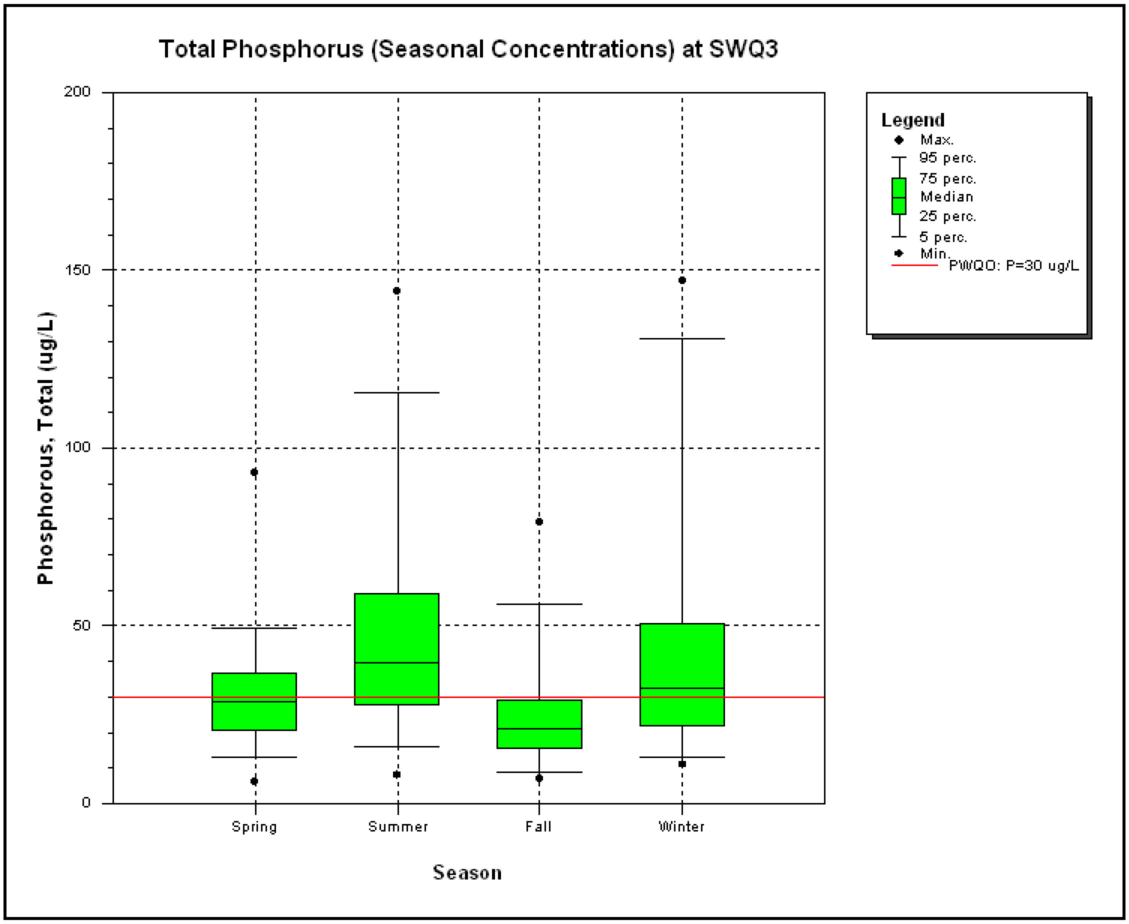

Figure 19: Seasonal phosphorus concentrations at SWQ3

'all test results for nitrate concentrate ion at SWQ3 are below the 13 mg/L limit set by Environment Canada (2002) for the protection of aquatic life'

Nitrate

The nitrate concentrations are presented in Figure 20. The graph clearly indicates the differences in the methodologies in laboratory analysis for nitrate over the duration of observation.. The graph indicated that all test results for nitrate concentration are below the 13 mg/L limit set by Environment Canada (2002) for the protection of aquatic life.

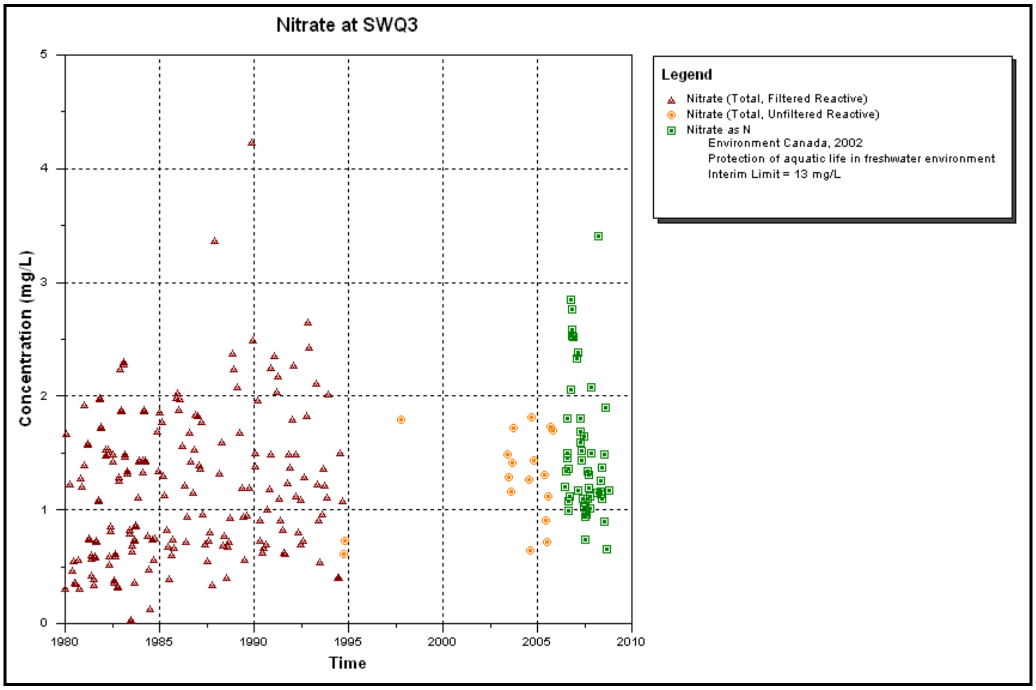

Figure 20: Nitrate concentrations at SWQ3

The shorter term data available at SWQ13 similarly shows that nitrate concentrations are below the prescribed limit (Figure 21).

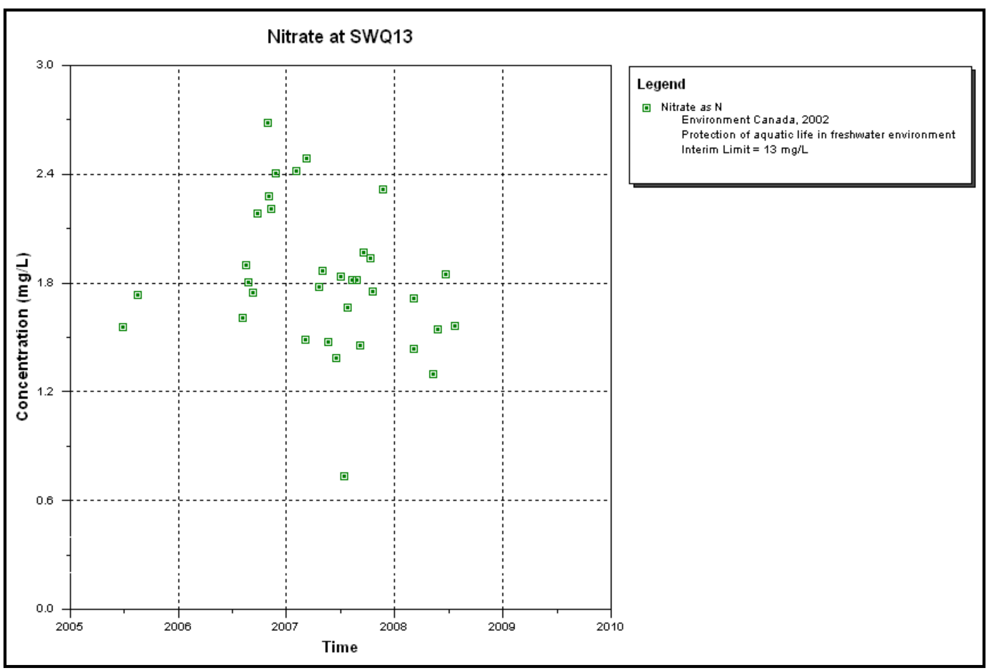

Figure 21: Nitrate concentrations at SWQ13

Copper (Cu)
Approximately 25 percent of the samples at SWQ3 have concentrations exceeding the 5 ug/L copper concentration limit (PWQO, 1999). Figure 22 illustrates that most of the exceedances were observed between 1980 and 1997. Several samples with extremely high concentrations, with one sample having 68 ug/L, were collected in the fall of 2006. These unusually high values, relative to mean concentration of copper, were tested and determined to be outlierstherefore they were excluded in the statistical analysis. These outliers will still be subjected to closer observation and investigation, because copper, is known to be toxic to plants and algae at moderate levels, and may affect aquatic organisms.

None of the analyzed samples at SWQ13 have copper concentrations that exceed the provincially prescribed limit (Figure 23). Figure 24 shows the comparison of copper concentrations at SWQ3 and SWQ13 between 2005 and 2009.

'copper, which is known to be toxic to plants and algae at moderate levels, may also adversely affect aquatic organisms specifically in its ionic or free metal form'

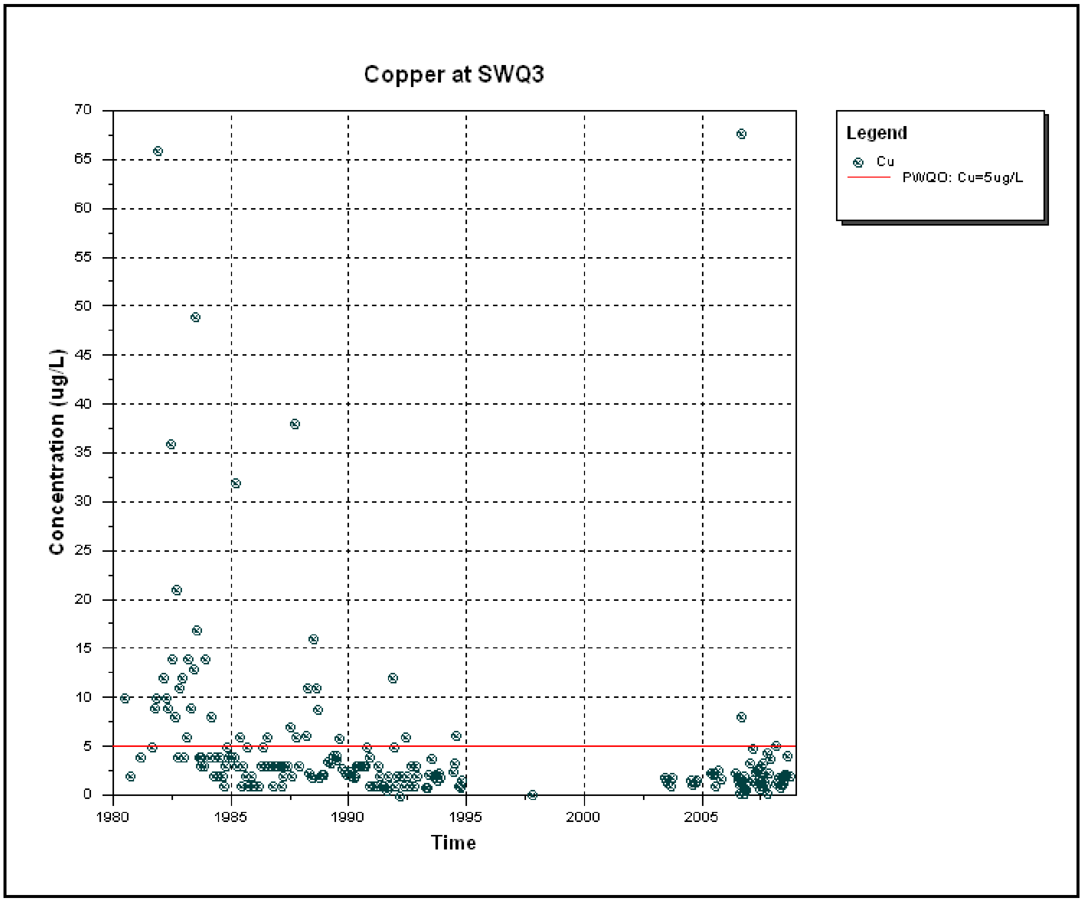

Figure 22: Copper concentrations at SWQ3

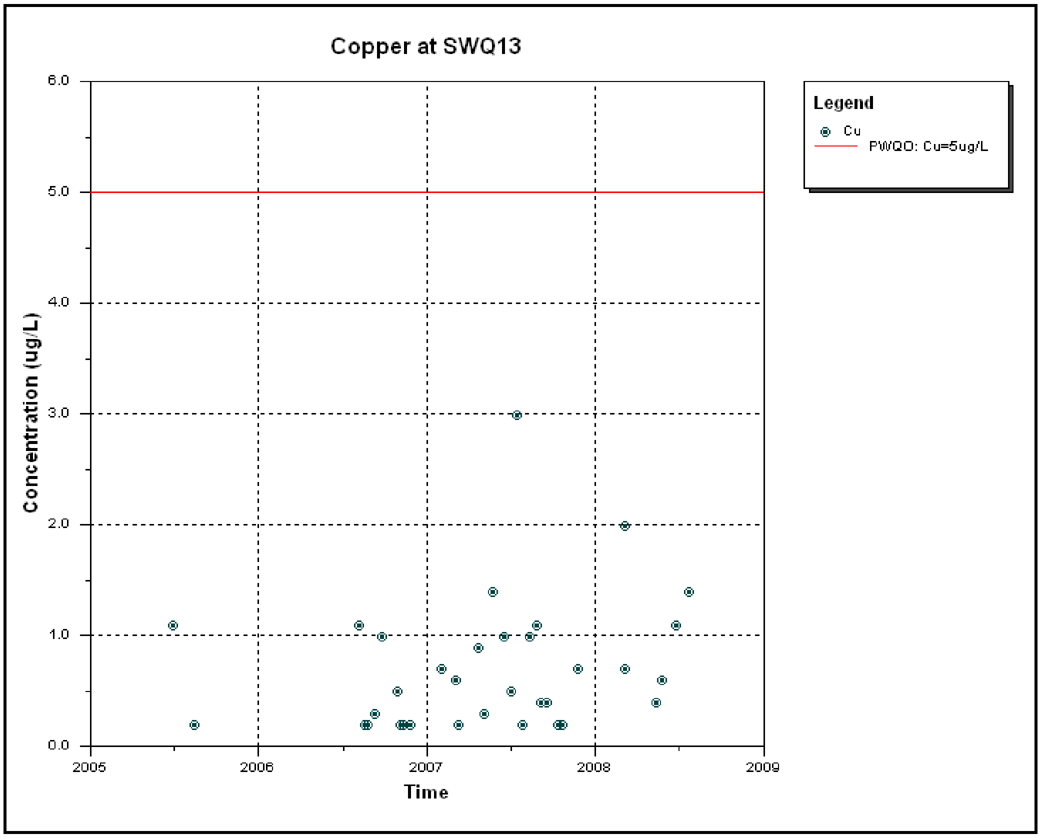

Figure 23: Copper concentrations at SWQ13

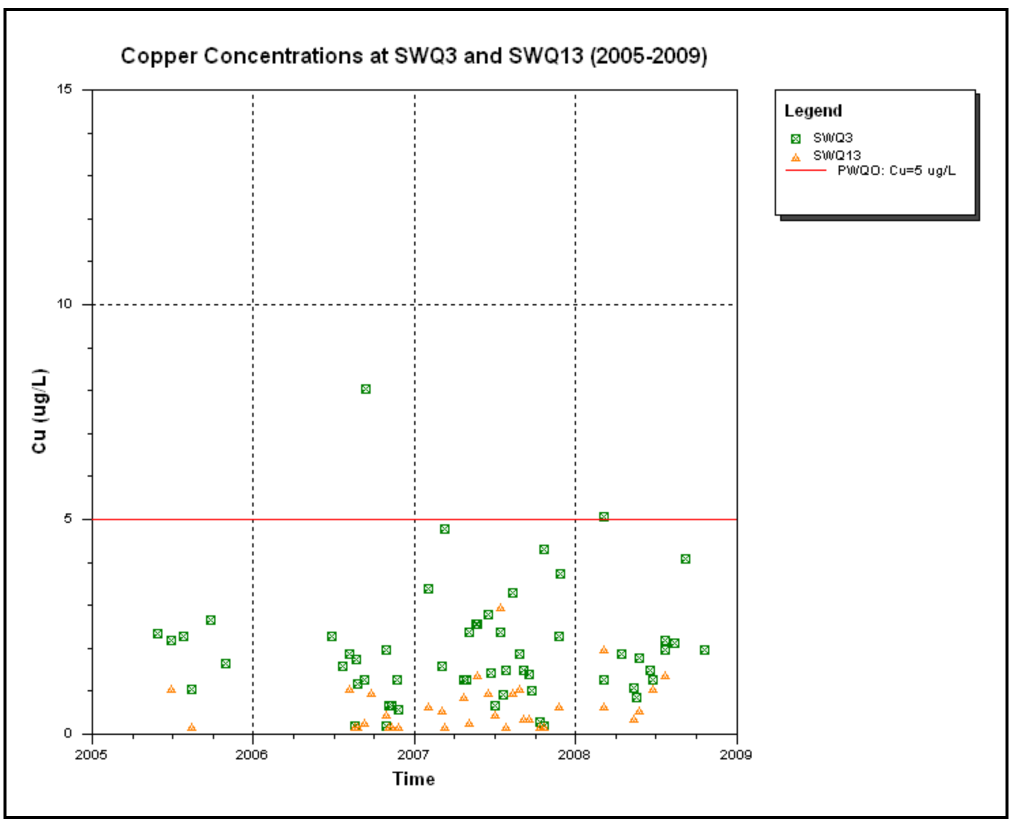

Figure 24: Copper concentrations at SWQ3 and SWQ13 (2005-2009)

'none of the analyzed samples at SWQ13 has copper concentration exceeding the provincially prescribed limit'

Analysis of the seasonal distribution of copper concentrations at SWQ3 shows that median values are not close to the 5 ug/L provincial limit (Figure 25). Samples with higher concentrations of copper were observed in the winter but extreme values were recorded during the fall and summer.

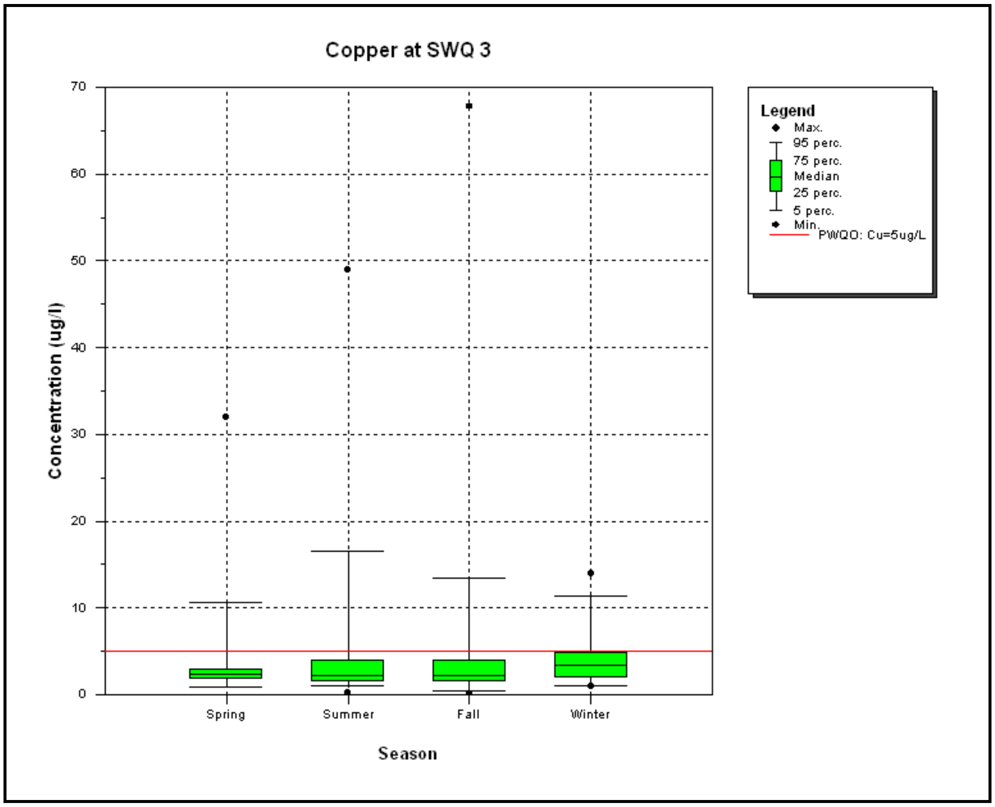

Figure 25: Seasonal distribution of copper concentrations at SWQ3

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

Dissolved oxygen (DO) with desirable concentrations, of above 8 mg/L, comprise about 80% of the analyzed samples at SWQ3. In addition these samples had notably lower BOD, suggesting that a lower amount of organic wastes is present. Figure 26 presents the historical BOD and DO concentrations at SWQ3. The tested BOD at SWQ13 are significantly lower relative to SWQ3. The available data for SWQ3 is inadequate to merit a statistical analysis.

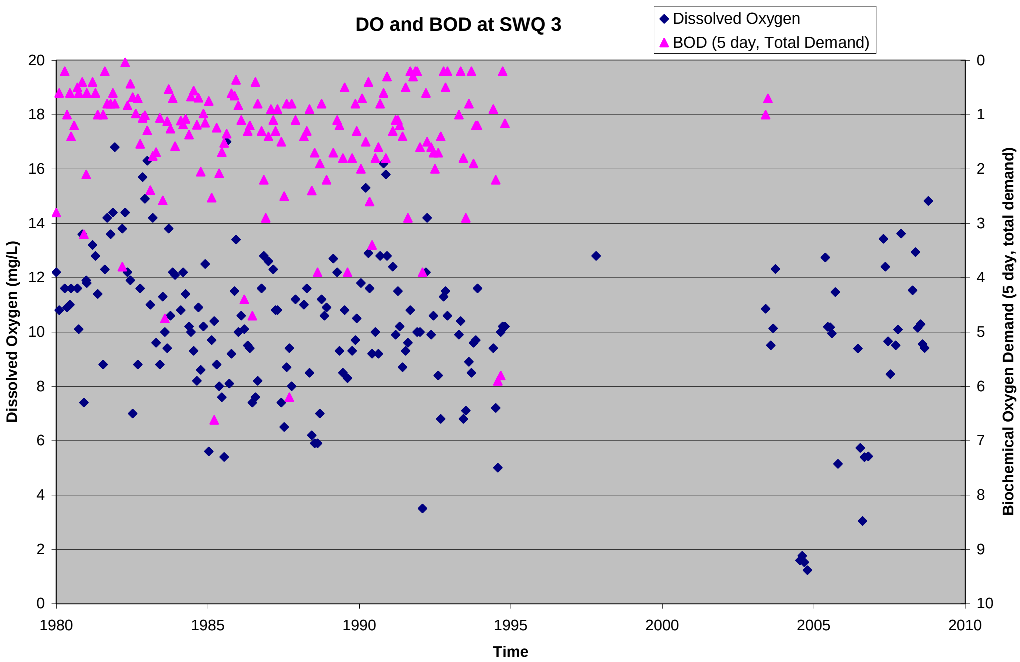

Figure 26: BOD and DO concentrations at SWQ3

Seasonal distribution of DO at SWQ3 shows that median concentration values are highest in the winter and lowest in the summer (Figure 27). Extreme values and a greater concentration range were observed in the fall while the opposite is observed in the spring.

Station SWQ13 has an inadequate quantity of test results to perform a seasonal distribution analysis.

'tested BOD at SWQ13 are significantly lower relative to SWQ3'

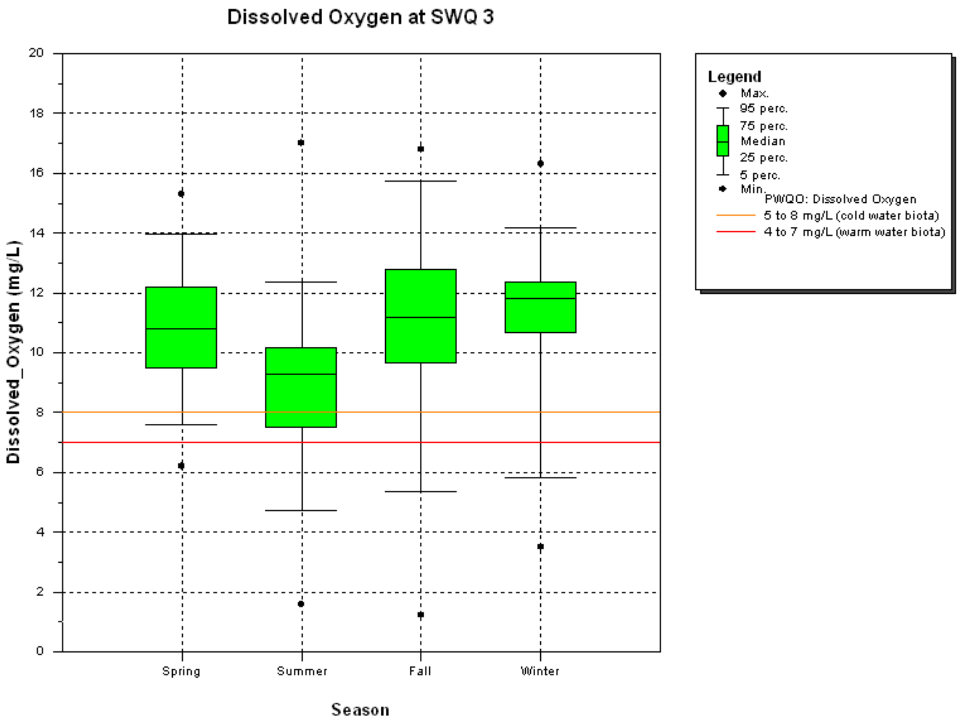

Figure 27: Seasonal distribution of Dissolved Oxygen (DO) concentrations at SWQ3

"cadmium, cobalt, cyanide and compounds, iron, nickel and lead, observed to have exceeded provincially prescribed concentration limits'

Exceedances

The 28 years monitoring record at SWQ3, excluding the six years between 1997 and 2003, identified six chemical parameters that have exceeded the provincial limit. The parameters that exceeded the limits are: cadmium, cobalt, cyanide and compounds, iron, nickel and lead.

Cadmium was analyzed to have exceeded the 0.2 ug/L concentration limit in 23 of the 72 samples tested. Eight of the 66 samples tested for cobalt exceeded the 0.3 ug/L concentration limit. Cyanide and compound concentrations of 10 ug/L, which exceeded the provincial limit of 5 ug/L, were obtained from samples collected three days apart in 1980. The excessive cyanide and compound concentrations were not repeated in later analyses.

Eighty-three of the 208 samples were analyzed to have iron concentrations exceeding the PWQO limit of 0.3 mg/L. Similarly, lead exceeded the provincially prescribed limit of 5 ug/L in 99 of the 202 analyzed samples. A nickel concentration of 50 ug/L was detected in a sample collected on September 25, 2006,, which was the only sample exceeding the provinciallimit of25 ug/L.

Information on the possible sources and potential adverse effects of these chemicals is presented in Appendix B.

4.2.2.2 Biological Water Quality

Biological water quality in Farewell Creek was assessed at 5 sites throughout the subwatershed in 2002 and 2003 using BioMAP (Figure 13). Of the 5 sites sampled for biological water quality, 2 sites were considered impaired (Table 4) and one of the sites was undetermined (Gray Zone between Impaired and Unimpaired). In addition, biological water quality data (Hilsenhoff scores) was collected at 16 sites during stream fisheries assessment sampling in 2002. Results from this assessment typically ranged from very good to poor. More recently, biological water quality was assessed at 2 sites in 2008 using the OBBN protocol. Preliminary results from this assessment show moderate proportions of sensitive stoneflies, caddisflies and mayflies in the sample which implies some water quality degradation. These sites have yet to be compared to reference conditions. Overall, the Farewell Creek subwatershed showed some impairment in agricultural areas or downstream of urban areas but was generally healthy in areas dominated by natural cover (close proximity to the Harmony Farewell Iroquois Beach PSW). Sites showing impairment was typically related to the cumulative effects of nutrient enrichment from urban or agricultural sources.

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

Site	Year	Method	Status
FAR4	2002	BioMAP	Impaired
FAR3	2002	BioMAP	Unimpaired
FAR2	2002	BioMAP	Unimpaired
FAR1	2002	BioMAP	Impaired
Farewell/03	2003	BioMAP	Gray Zone
FA01	2002	OSAP/Hilsenhoff	Fair
FA02	2002	OSAP/Hilsenhoff	Fair
FA03	2002	OSAP/Hilsenhoff	Good
FA04	2002	OSAP/Hilsenhoff	Fair
FA05	2002	OSAP/Hilsenhoff	Fairly Poor
FA06	2002	OSAP/Hilsenhoff	Good
FA07	2002	OSAP/Hilsenhoff	Good
FA08	2002	OSAP/Hilsenhoff	Good
FA09	2002	OSAP/Hilsenhoff	Very Good
FA10	2002	OSAP/Hilsenhoff	Good
FA11	2002	OSAP/Hilsenhoff	Poor
FAS1	2002	OSAP/Hilsenhoff	Fair
FAS2	2002	OSAP/Hilsenhoff	Good
FAS3	2002	OSAP/Hilsenhoff	Fair
FAS4	2002	OSAP/Hilsenhoff	Fair
FAS5	2002	OSAP/Hilsenhoff	Fairly Poor
FLOB01	2008	OBBN	%EPT = 11.0, Taxa Richness = 10
FLOB02	2008	OBBN	%EPT = 37.2, Taxa Richness = 9

'Overall, the Farewell Creek subwatershed showed some impairment in agricultural areas or downstream of urban areas but was generally healthy in areas dominated by natural cover'

4.2.3 Black Creek Subwatershed

4.2.3.1 Chemical Water Quality

The 23.56 hectare Black Creek subwatershed is drained by a 37. 9 kilometer main channel that begins between Regional Road 3 and Concession Road 7 and drains south to Nash Road (Figure 29). The subwatershed is predominantly agricultural and open fields with approximately 10 percent being built-up. The built up area is concentrated within the extreme southern portion of the subwatershed.

SWQ14 is the only surface water quality monitoring station in this subwatershed. It is located at Trulls Road approximately a kilometer upstream of its confluence with Farewell Creek. The monitoring station is notably situated in the more developed area of the subwatershed.

Chloride

The majority of the chloride concentrations observed at SWQ14 are within the range between 40 and 120 mg/L (Figure 28). The maximum recorded concentration is 151 mg/L, which was collected on September 10, 2003. This value is far below the 250 mg/L provincial limit for drinking water.

'monitoring station SWQ14 is situated in the more developed area of the subwatershed'

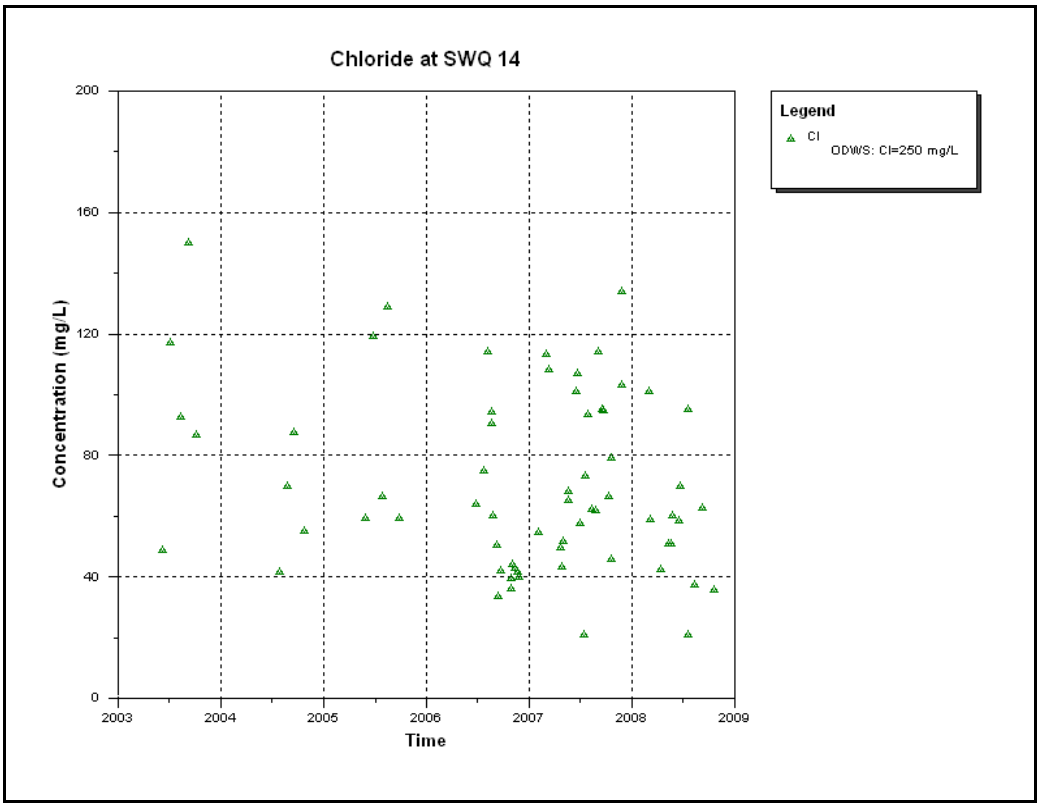

Figure 28: Distributions of chloride concentrations at SWQ12

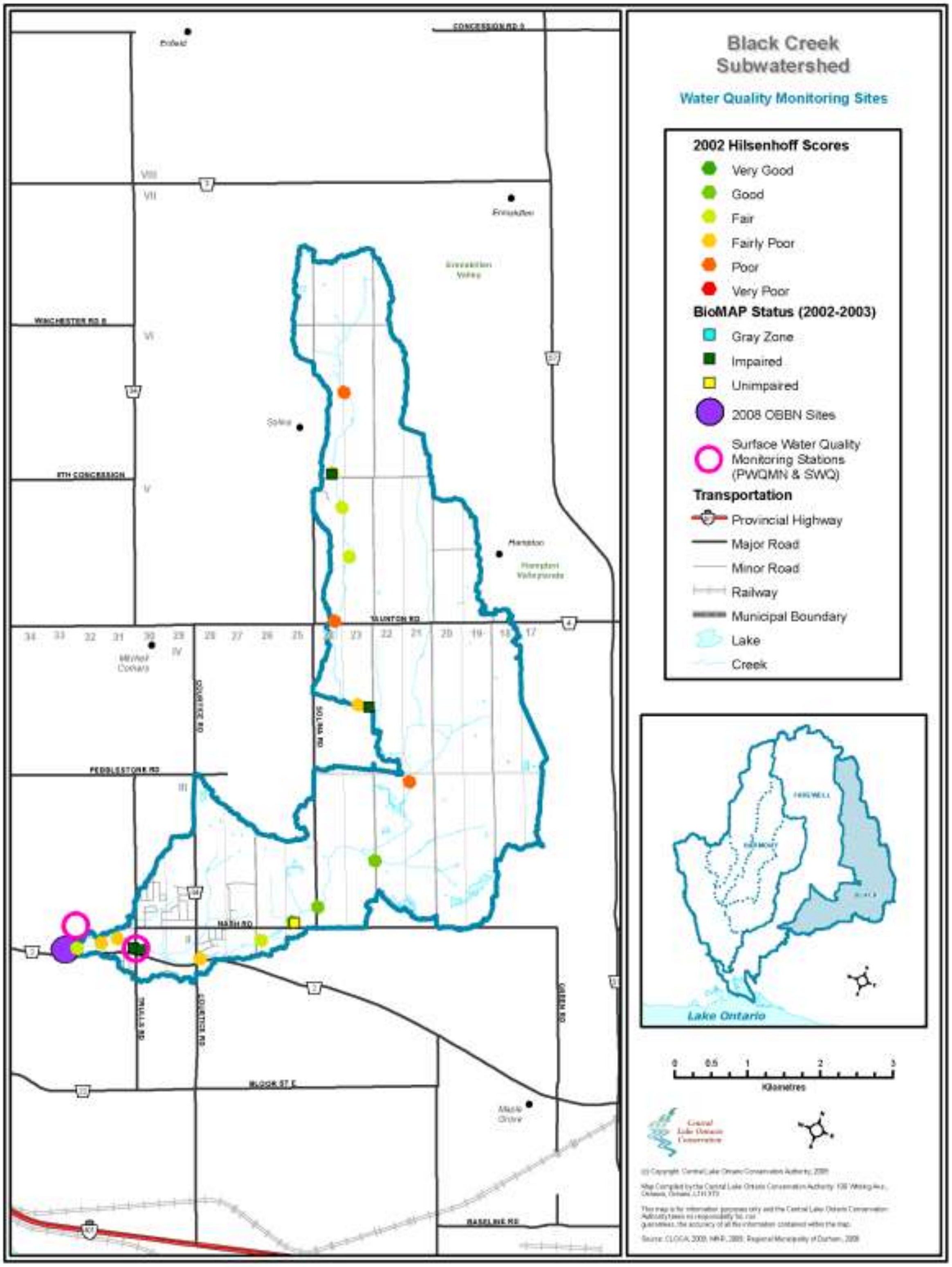

Figure 29: Water quality monitoring stations in the Black Creek subwatershed

Seasonal median values, as shown in Figure 30, are higher during the winter while relatively lower concentrations were observed in the fall. Extreme concentration values are common during the summer. No trend on chloride concentration was established during the five-year observation period.

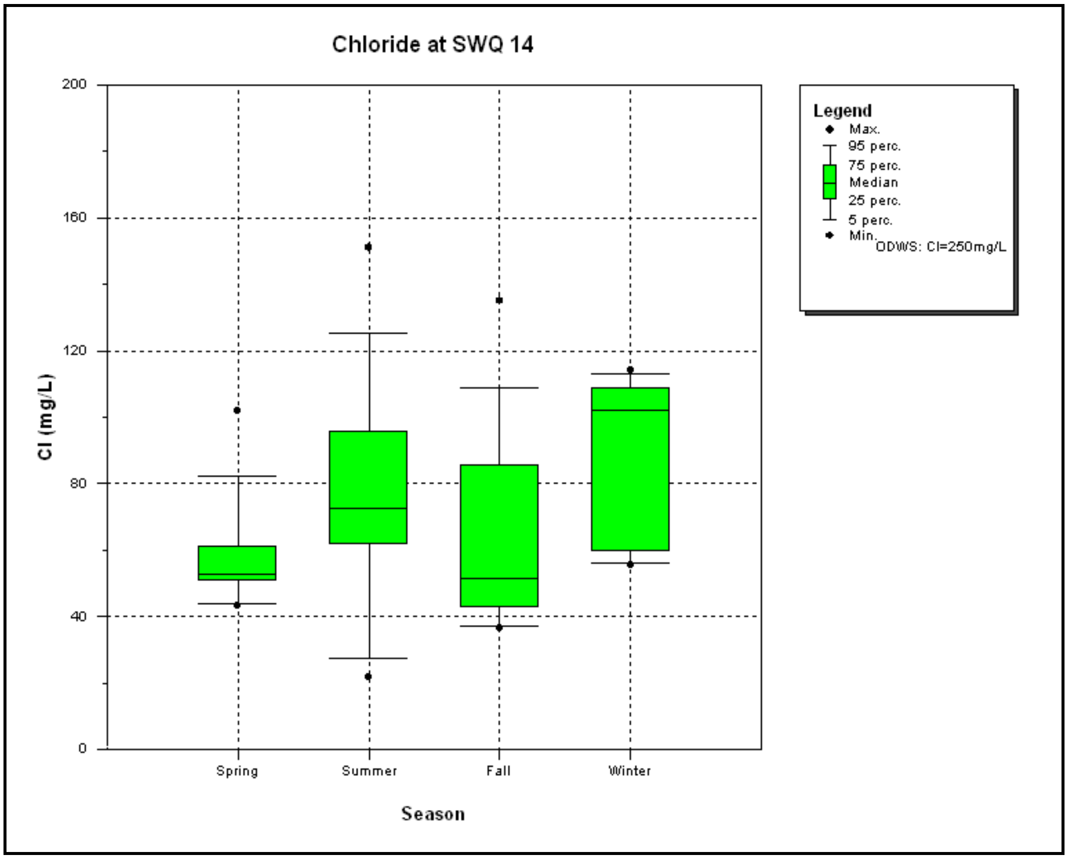

Figure 30: Seasonal chloride concentrations at SWQ14

Phosphorus

A statistical analysis at SWQ14 indicated that over 75% of the samples have phosphorous concentrations that exceed the PWQO interim limit,30 ug/L (Figure 31). Concentration mean value is at 75 ug/L while the maximum tested value,318 ug/L, was measured on September 7, 2007.

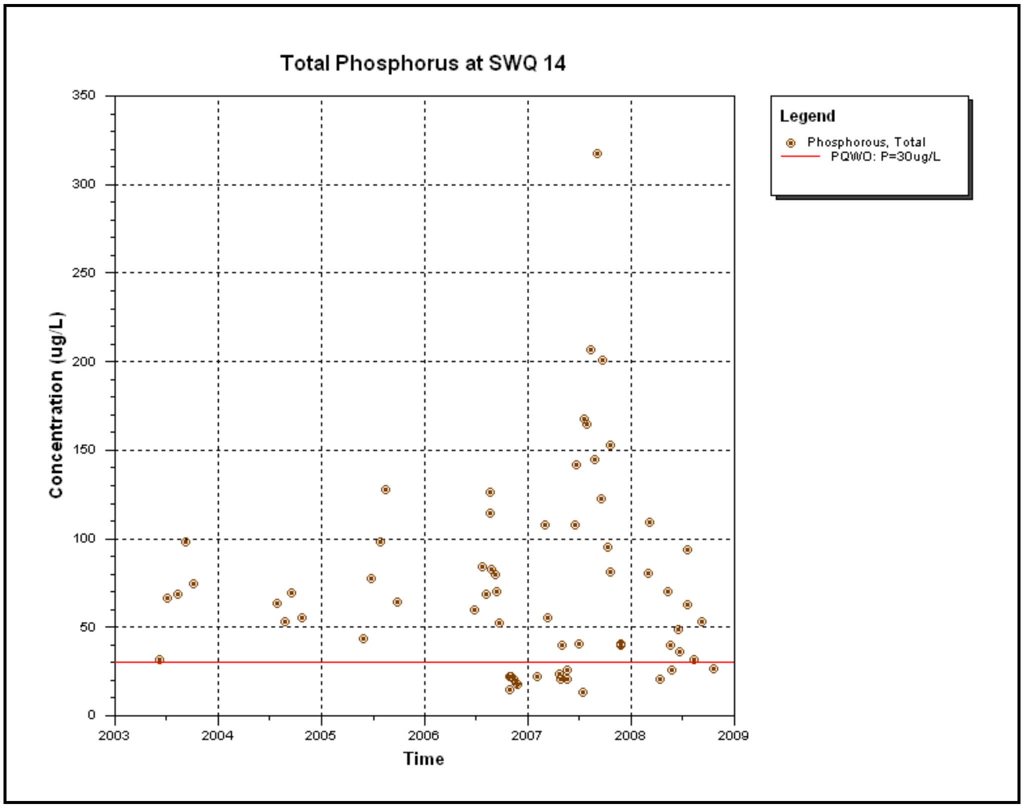

Figure 31: Phosphorous concentration at SWQ14

'statistical analysis at SWQ14 indicated that over 75% of the samples have phosphorous concentrations exceeding the PWQO interim limit'

The median concentrations of phosphorous at SWQ14 were observed to have exceeded the interim provincial limit through all seasons of the year (Figure 32). A seasonal analysis also showed relatively higher concentrations as well as extreme measured values in the summer. Most of the samples collected in the spring showed relatively lower phosphorous concentrations.

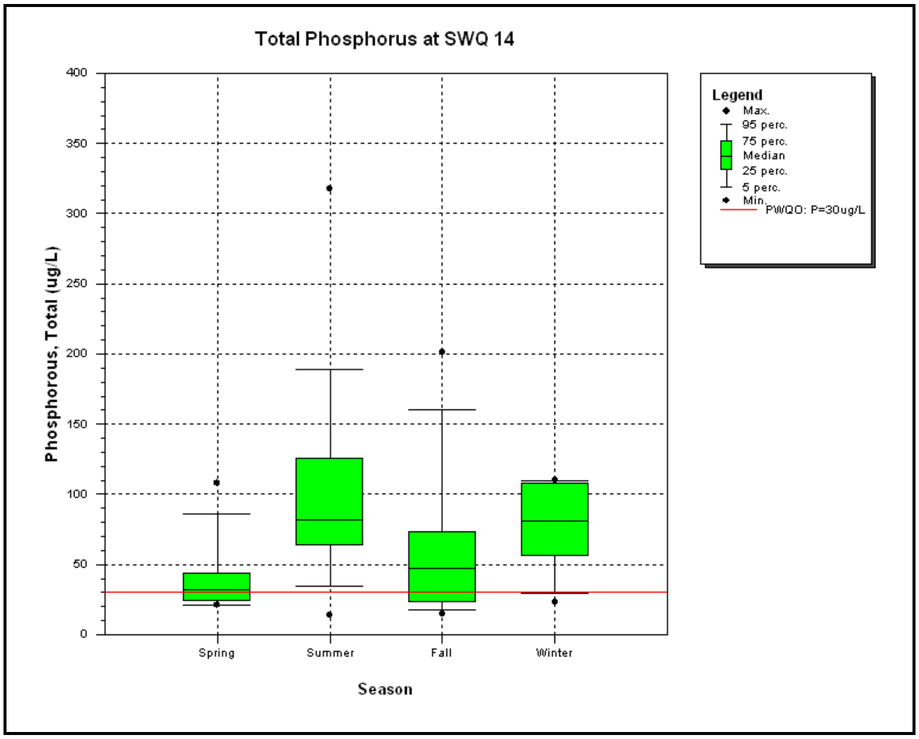

Figure 32: Seasonal phosphorus concentrations at SWQ14

'most of the samples collected in spring showed relatively lower phosphorous concentrations'

Nitrate

All samples collected at SWQ14 had nitrate concentrations below 2 mg/L. These concentrations are far below the 13 mg/L interim limit recommended by Environment Canada (2002) to protect aquatic life (Figure 33).

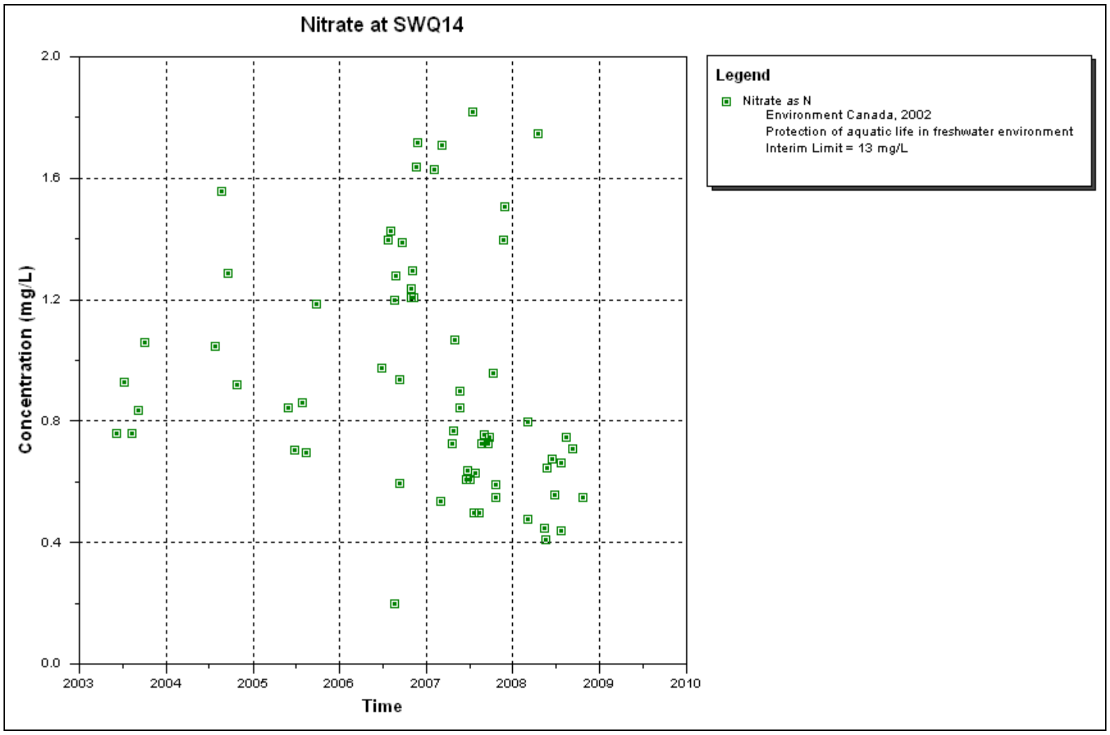

Figure 33: Nitrate concentration at SWQ14

Copper (Cu)

The five year period of monitoring SWQ14 yielded two samples having copper concentration that exceeded the 5 ug/L provincial limit for natural waterbodies (Figure 34). The highest concentration of 6.3 ug/L was obtained from sample collected on July 9, 2007.

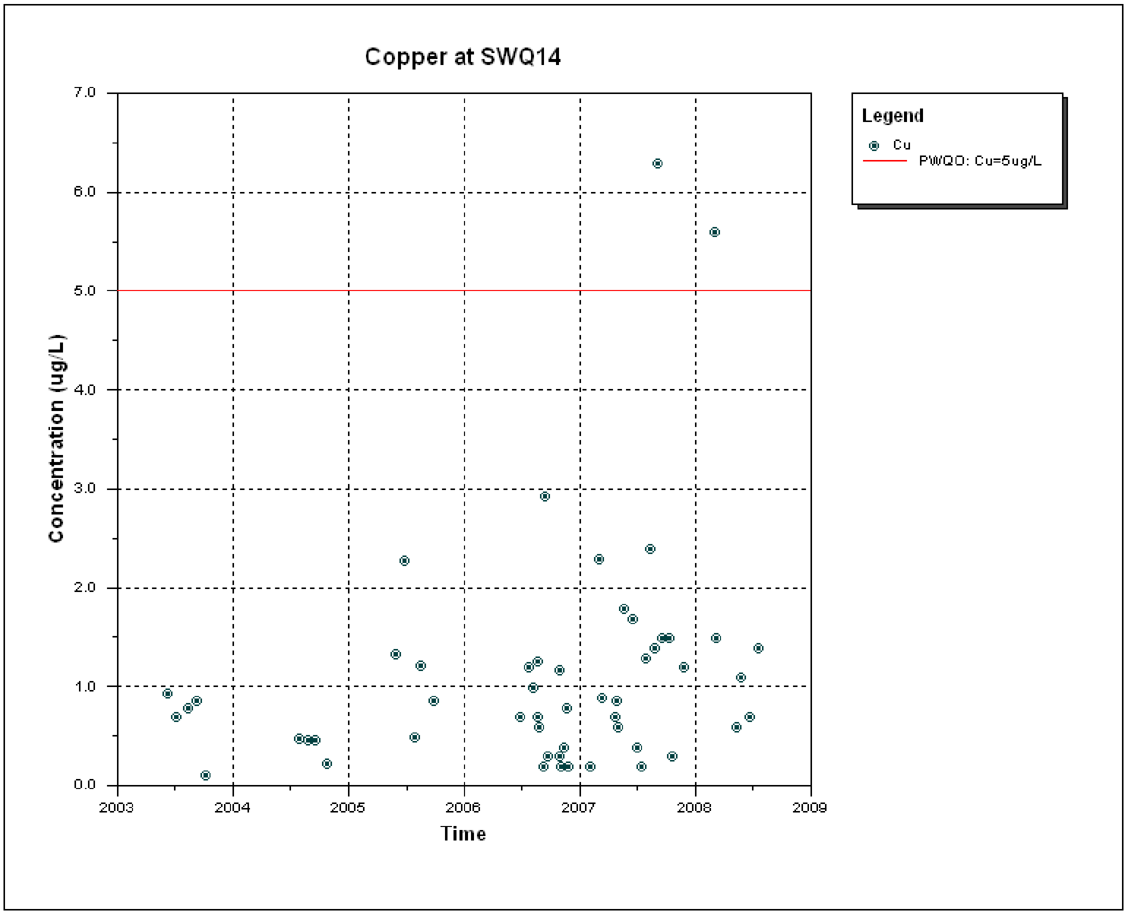

Figure 34: Copper concentrations at SWQ14

'five year period of monitoring SWQ14 yielded two samples having copper concentration exceeding the 5 ug/L provincial limit'

Median concentrations of copper at this station are generally below the 1 ug/L, (Figure 35). Relatively higher concentrations were observed in the winter while extreme values are more apparent in the winter and summer months. Lower copper concentrations prevail during the fall seasons.

Although visual observation of Figure 34 may suggest an increasing copper concentration over time, the limited quantity of data made for inconclusive results using the robust non-parametric trend analysis.

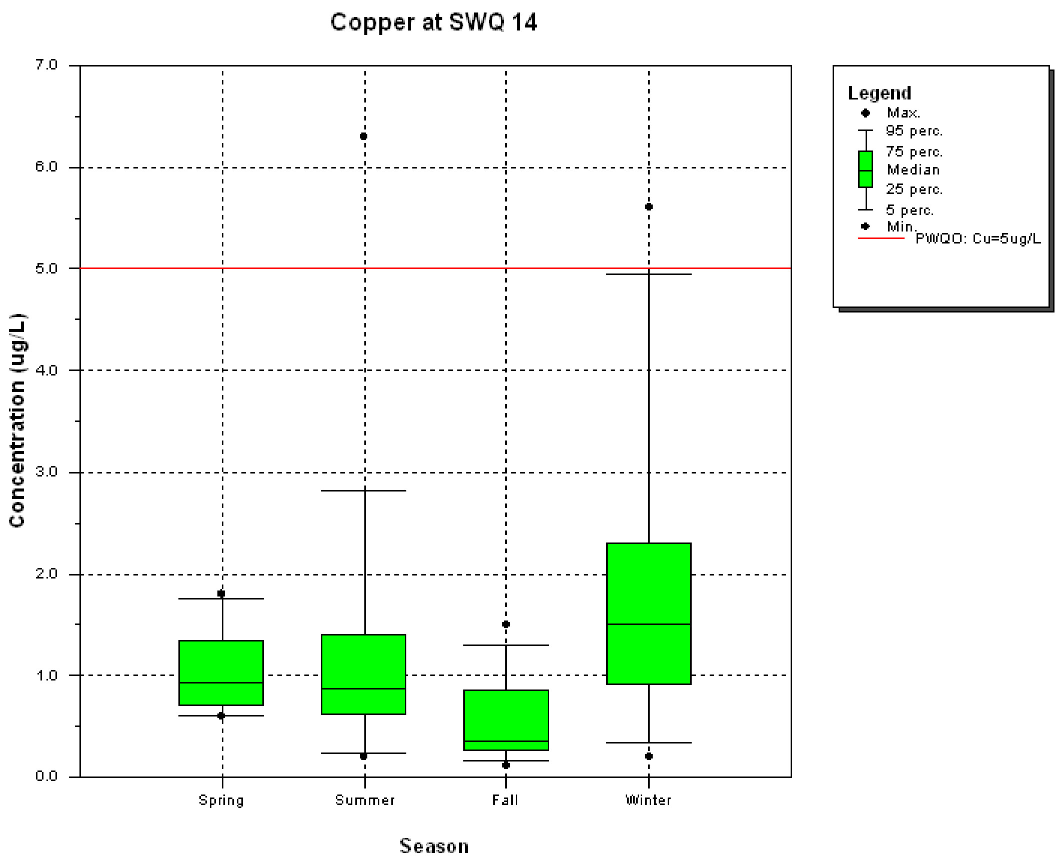

Figure 35: Seasonal copper concentrations at SWQ14

'lower copper concentrations prevail during fall seasons'

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

The limited data available for the determination of biochemical oxygen demand (BOD) and Dissolved Oxygen (DO) during the observation period between 2003 and 2009 at SWQ14, makes it difficult to draw conclusions as to the relationship between these two WQI parameters.

Dissolved oxygen (DO) concentrations at SWQ14 are generally above the prescribed limit to sustain aquatic life. In 2004, DO concentrations dropped below 2 mg/L in the months between July and October (Figure 36). Relatively lower DO concentrations ranging from 2.85 to 5.49 mg/L were also observed in the summer of 2006. The remainder of DO concentrations are above the PWQO prescribed limit.

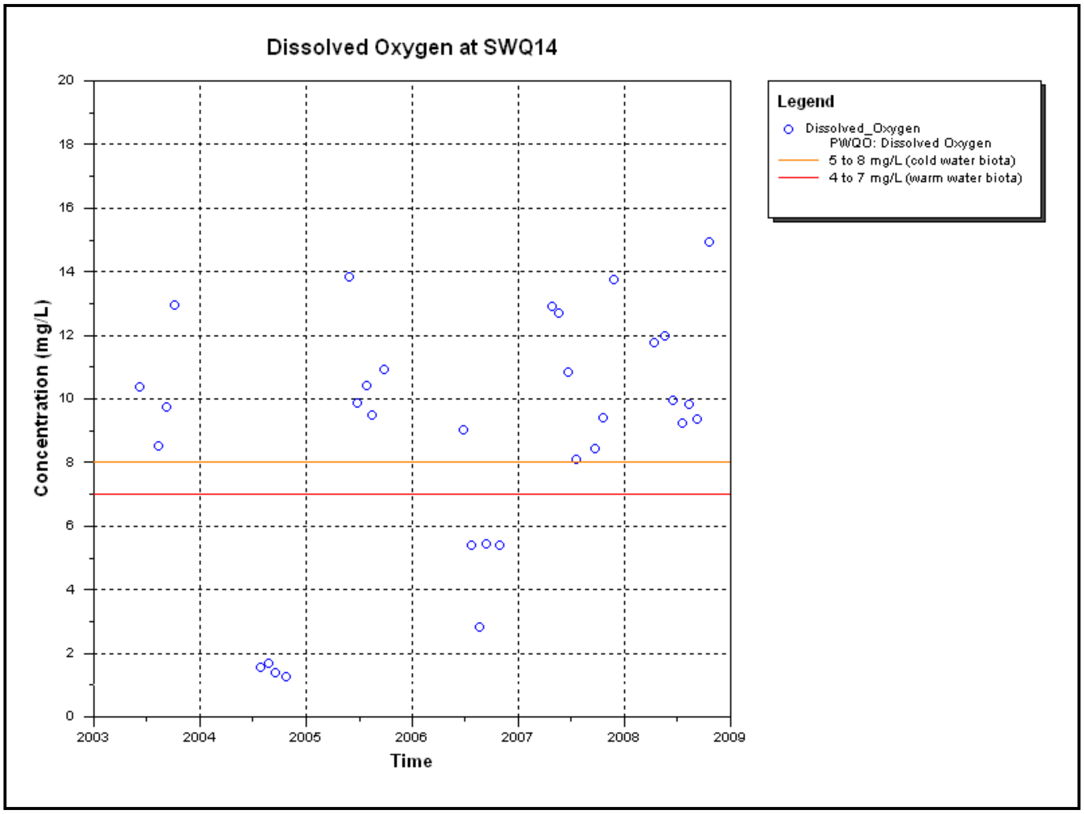

Figure 36: DO concentrations at SWQ12

'dissolved oxygen concentrations at SWQ14 are generally above the prescribed limit to sustain aquatic life'

Exceedances

Four of the 55 chemical parameters analyzed showed exceedances on the provincially prescribed limits. These parameters include copper, cadmium, cobalt and iron. Copper is a WQI parameter that was earlier discussed in the section.

Seven of the 66 samples taken between 2004 and 2006 have cadmium concentrations above the provincial limit of 0.2 ug/L. Cobalt concentrations exceeding the 0.9 ug/L provincial limit were detected in two of the 66 tested samples. The 0.3 mg/L iron concentration prescribed limit was exceeded in seven samples on the same set of water samples tested.

4.2.3.2 Biological Water Quality

Biological water quality in Black Creek was assessed at 5 sites throughout the subwatershed in 2002 and 2003 using BioMAP. Of the 5 sites sampled for biological water quality, 4 sites were considered impaired (Table 5). In addition, biological water quality data (Hilsenhoff scores) was collected at 15 sites during stream fisheries assessment sampling in 2002. Results from this assessment ranged from good to poor. More recently, biological water quality was assessed at 1 site upstream of the Farewell Creek confluence in 2008 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 some water quality degradation. These sites have yet to be compared to reference conditions. Overall, the Black Creek subwatershed showed some impairment in agricultural areas or downstream of urban areas but was generally healthy in areas dominated by natural cover (close proximity to the Harmony Farewell Iroquois Beach PSW). Sites showing impairment was typically related to the cumulative effects of nutrient enrichment from urban or agricultural sources.

'the Black Creek subwatershed showed some impairment in agricultural areas or downstream of urban areas but was generally healthy in areas dominated by natural cover'

Table 5: Biological water quality monitoring in the Black Creek subwatershed between 2002 and 2008.

Site	Year	Method	Status
BLA4	2002	BioMAP	Impaired
BLA3	2002	BioMAP	Impaired
BLA2	2002	BioMAP	Unimpaired
BLA1	2002	BioMAP	Impaired
Black/03	2003	BioMAP	Impaired
BL01	2002	OSAP/Hilsenhoff	Fair
BL02	2002	OSAP/Hilsenhoff	Fairly Poor
BL03	2002	OSAP/Hilsenhoff	Fairly Poor
BL04	2002	OSAP/Hilsenhoff	Fairly Poor
BL05	2002	OSAP/Hilsenhoff	Good
BL06	2002	OSAP/Hilsenhoff	Fairly Poor
BL07	2002	OSAP/Hilsenhoff	Poor
BL08	2002	OSAP/Hilsenhoff	Fair
BL09	2002	OSAP/Hilsenhoff	Fair
BL10	2002	OSAP/Hilsenhoff	Fairly Poor
BLS1	2002	OSAP/Hilsenhoff	Fair
BLS2	2002	OSAP/Hilsenhoff	Good
BLS3	2002	OSAP/Hilsenhoff	Poor
BLS4	2002	OSAP/Hilsenhoff	Poor
BLSP	2002	OSAP/Hilsenhoff	Good
BKOB01	2008	OBBN	%EPT = 12.7, Taxa Richness = 11

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 Black/Harmony/Farewell 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. Chloride has a prescribed limit of 250 mg/L (ODWS) which was exceeded occasionally in stations SWQ3 (Farewell Creek) and SWQ12 (Harmony Creek). Extremely high concentrations were observed prior to 1981 at SWQ12. An increasing trend in chloride concentrations were observed in both stations. Seasonal concentrations are usually higher in the winter at all stations.

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

- Phosphorus concentrations were observed to have exceeded the 30 ug/L PWQO at all monitoring stations except SWQ13 (Farewell Creek). Seasonal distribution of phosphorus showed higher concentrations in the winter at SWQ12 (Harmony Creek) while increased concentrations were observed during the summer at SWQ3 (Farewell Creek) and SWQ14 (Black Creek). SWQ13 has an inadequate quantity of data to enable a seasonal distribution analysis. Trend analysis revealed a decreasing trend at SWQ12 while the voluminous data record at SWQ3 did not yield any distinct trend in phosphorous concentration at this station.

- 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

'human activities related to land disturbance and industrial, domestic and livestock wastes may contribute to increase phosphorous in aquatic environment'

and euthrophication[2].There were no PWQO exceedances of the 13mg/L interim limit at any of the stations. Trend analysis showed a decreasing trend in nitrate concentration at SWQ3 (Farewell Creek).

- 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 SWQ3 (Farewell Creek) and SWQ14 (Black Creek) but excessive concentrations were most notable at SWQ3 in early 1980's as well as in the fall of 2006. Median copper concentrations at SWQ3 and SWQ14 (Harmony Creek) were higher in the winter while extreme values were seen in the summer. A trend analysis showed a decreasing trend at SWQ13 while an increasing trend was observed at SWQ14.

- Higher concentrations of dissolved oxygen in water suggests 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 stations SWQ12 (Harmony Creek), SWQ3 (Farewell Creek) and SWQ14 (Black Creek). PWQO suggests DO concentration greater than 5 mg/L (interim) is generally required for the survival of fish and other aquatic organisms.

'PWQO suggests DO concentration greater than 5 mg/L (interim) is generally required for the survival of fish and other aquatic organisms'

- Aside from the closely evaluated WQI parameters, an initial evaluation was also made to determine which parameters exceeded prescribed water quality standards. Whenever applicable, the Provincial Water Quality Objective (PWQO,1999) is being used as standard reference for raw water with multiple uses. Among the 55 analyzed chemical parameters, six parameters excluded in the WQI were determined to have exceeded provincially set standards. One hundred seventeen samples were tested to contain iron exceeding the provincial limit of 0.3 mg/L. Cadmium in excess of 0.2 ug/L concentrations were detected in 31 samples at stations SWQ3 (Farewell Creek), SWQ13 (Farewell Creek) and SWQ14 (Black Creek). At stations SWQ 3 and SWQ14, cobalt concentrations above the 0.3 ug/L concentration limit were detected in 10 samples also at SWQ3 and SWQ14.

  Cyanide and compounds, lead, and nickel with concentrations above the prescribed standards were all detected at SWQ3.

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

- 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.

- Fish community monitoring results suggest that there has been an improvement in aquatic health in recent years (see Chapter 16 – Fisheries and Aquatic Habitat). This is suggested by the increased distribution and abundance of sensitive coldwater fish species like rainbow trout (present in 4 of the 5 Harmony Creek subwatersheds in 2008, compared to 1 of the 5 Harmony Creek subwatersheds in 2002). These results are not as apparent in the biological water quality monitoring results; however, it should be noted that different sampling methodologies have been used to assess water quality over the years and additional analyses comparing 2008 monitoring data to reference conditions has yet to be completed. Future results of this work may provide further insight into watershed health.


Black Creek subwatershed


Harmony Creek subwatershed

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 Phosphorus 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
PHOSPHORUS, 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