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Item No. 1
North West Community Council
December 12, 2016

TO: Chair and Members of North West Community Council

ORIGINAL SIGNED

SUBMITTED BY:

Bob Bjerke, Chief Planner & Director, Planning & Development

DATE: November 28, 2016

SUBJECT: Bedford West Water Quality Status Update

INFORMATION REPORT

ORIGIN

Bedford Municipal Planning Strategy, Bedford West Secondary Planning Strategy, Policies BW-3, BW-4, and BW-5.

Development Agreements between Halifax Regional Municipality and West Bedford Holdings Ltd, and between Halifax Regional Municipality and Cresco Ltd.

LEGISLATIVE AUTHORITY

The Halifax Regional Municipality Charter, Part VIII, Planning and Development, Section 240, Development Agreements.

BACKGROUND

The Bedford West Secondary Planning Strategy, Policy BW-3, requires that a water quality monitoring program be undertaken for the Paper Mill Lake watershed to track the eutrophication process. Eutrophication is the process by which lakes naturally accumulate nutrients and biological material. This process is typically accelerated through the impacts of human activities, resulting in relatively rapid changes in trophic state, from lower states (fewer nutrients) to higher states (more nutrients), with corresponding changes in appearance, functional uses, and amenity values. The monitoring program was identified as a requirement in the Secondary Planning Strategy in response to the Municipality's stated desire to "stem the decline of lakes from the accelerated process of eutrophication, and sedimentation and inputs from other urban runoff", as published in the former Regional Municipal Planning Strategy.[1]

The terms of the monitoring program are specified within Development Agreements that have been negotiated in consultation with the Bedford Watershed Advisory Board1[2] until its dissolution in 2013, and the Regional Watersheds Advisory Board since 2013. All such agreements have identified the value of 10 micrograms per Litre (µg/L) of Total Phosphorus (TP) as a "trigger value", representing the transition point between the second-lowest trophic state (oligotrophic) to the next-highest trophic state (mesotrophic) according to Environment Canada criteria (see Table 1).

Trophic Status	TP (µg/L)
Ultra-oligotrophic	< 4
Oligotrophic	4-10
Mesotrophic	10-20
Meso-eutrophic	20-35
Eutrophic	35-100
Hypereutrophic	> 100

Table 1. Summary of Canadian trophic state trigger ranges. From Environment Canada (2004).

The Municipality is required to submit test results to the Developer, the Community Council, and BWAB (now RWAB) within three months of being received from the consultant, or immediately, if TP or bacterial results exceed management thresholds identified therein. Furthermore, in spring 2015, staff reviewed historic contractor reports submitted from spring 2012 through fall 2014 and realized that a high proportion of water quality samples had TP results exceeding the trigger value of 10µg/L This trend consequently initiated a three-phase assessment process to better understand the TP occurrences and to help devise a future approach to watershed management as follows:

Phase 1:
Report and discuss 2012-2014 TP exceedance findings with the developer and conduct a detailed assessment of existing water quality data from the Paper Mill Lake watershed to identify trends in TP measurements, considering CCME Guidelines.

Phase 2:
Investigate cause(s) of high Total Phosphorus measurements, considering all significant land uses and activities that have occurred in the Paper Mill Lake watershed since the inception of the monitoring program.

Phase 3:
Determine a course of action respecting watershed management and future land use development in the area.

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[1] The current Regional Municipal Planning Strategy states this objective as follows: "This Plan will seek to … maintain the existing trophic status of our lakes and waterways to the extent possible".

[2] RWAB assumed the functions previously performed by BWAB respecting Bedford West SPS once it began conducting meetings in July 2013.

DISCUSSION

This report presents an update to Council on the status of the assessment process regarding TP and water quality monitoring for Bedford West and the findings of the August 2016 monitoring event. Phase 1 was initiated in June 2015 and concluded in October of that year. The results of that phase are documented in Attachment A.

To undertake Phase 2, staff engaged Dalhousie University's Centre for Water Resource Studies (CWRS) to undertake a study of the Paper Mill Lake Watershed to answer the following questions:

1. What are the largest sources of Phosphorus (P) to Kearney Lake and Paper Mill Lake?
2. What role does internal loading have on TP concentrations in Kearney Lake and Paper Mill Lake?
3. What type of monitoring program would be required to track P loading over time from the Bedford West subdivision? How can P export coefficients for the Paper Mill Lake watershed be validated?
4. How should the trophic state of Kearney Lake and Paper Mill Lake be monitored?
5. What are the consequences of adopting alternative water quality thresholds for regulating activities within the Paper Mill Lake watershed?

CWRS began their work in April 2016 and submitted the final report (Attachment B) to the Municipality on October 7, concluding their contract and the second phase of the assessment process. At the request of North West Community Council (NWCC), CWRS presented an overview of their work and conclusions at the NWCC meeting on November 15, 2016. With the receipt of the final report from CWRS, the second phase of the assessment process has now concluded and will help inform Phase III of the assessment process.

August TP Monitoring Event Summary

The monitoring event held during August 2016 found that total phosphorus concentrations exceeded the trigger value of 10 micrograms per Litre (10ug/L) at six of eleven stations monitored in August 2016.

A summary of TP results observed at all stations during the August 2016 monitoring event is presented below in Table 2. These results only represent water quality at the time that the samples were collected, and as such have little significance on their own. Their value may be realized in the determination of whether or not water quality is trending towards a mesotrophic (or higher) trophic state, and in indicating possible sources of excess nutrient contributions.

Sample Station	Concentration (µg/L)	Exceedance
KL1	5	No
KL2	16	Yes
KL3	5	No
KL4	4	No
KL5	4	No
HWY 102-1	38	Yes
HWY 102-2	34	Yes
LSD	23	Yes
LU	11	Yes
PML1	104	Yes
PML2	3	No

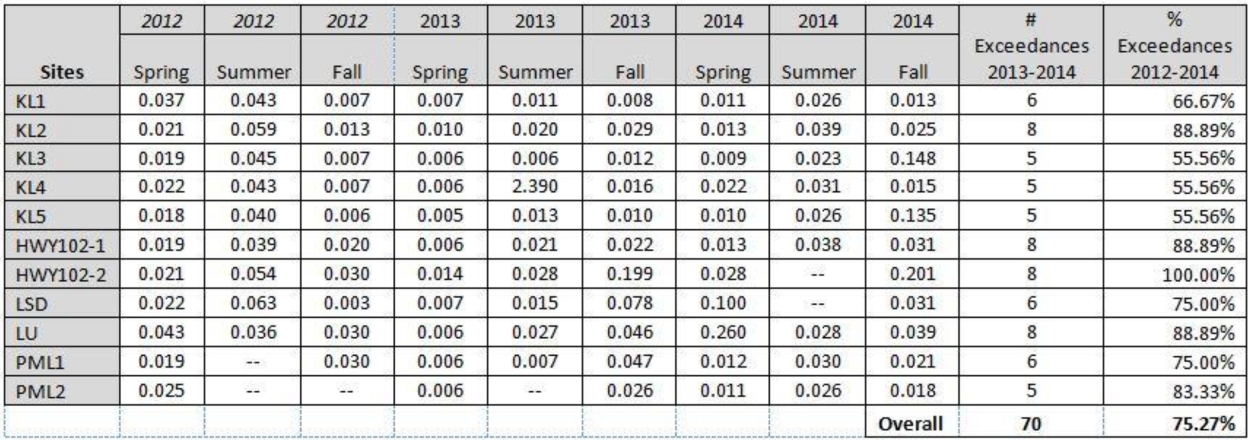
Table 2. Summary of TP results and exceedances August 2016.

Development Agreements in effect for sub-areas now undergoing development authorize the Municipality to direct the selected water quality monitoring consultant (i.e., contractor) to undertake follow-up testing in the event that threshold levels are exceeded.

As noted above in Table 2, six sample stations yielded exceedances of the TP trigger value in August 2016. On this occasion, a follow-up assessment process is already underway in reference to previous test results exceeding the 10µg/L trigger value (Table 3). Reports documenting the results of the May and August 2016 sampling events are provided as attachments C and D. Sample station locations are presented within each report in Figure 1.

Next Steps

Staff will now embark on the third and final phase of the process, determining a course of action respecting watershed management and future land use development in the area. The scope, timeline, participants and associated reporting for this final phase of the assessment process has not been determined at this time.



Sites	2012 Spring	2012 Summer	2012 Fall	2013 Spring	2013 Summer	2013 Fall	2014 Spring	2014 Summer	2014 Fall	# Exceedances 2013-2014	% Exceedances 2012-2014
KL1	0.037	0.043	0.007	0.007	0.011	0.008	0.011	0.026	0.013	6	66.67%
KL2	0.021	0.059	0.013	0.010	0.020	0.029	0.013	0.039	0.025	8	88.89%
KL3	0.019	0.045	0.007	0.006	0.006	0.012	0.009	0.023	0.148	5	55.56%
KL4	0.022	0.043	0.007	0.006	2.390	0.016	0.022	0.031	0.015	5	55.56%
KL5	0.018	0.040	0.006	0.005	0.013	0.010	0.010	0.026	0.135	5	55.56%
HWY102-1	0.019	0.039	0.020	0.006	0.021	0.022	0.013	0.038	0.031	8	88.89%
HWY102-2	0.021	0.054	0.030	0.014	0.028	0.199	0.028	--	0.201	8	100.00%
LSD	0.022	0.063	0.003	0.007	0.015	0.078	0.100	--	0.031	6	75.00%
LU	0.043	0.036	0.030	0.006	0.027	0.046	0.260	0.028	0.039	8	88.89%
PML1	0.019	--	0.030	0.006	0.007	0.047	0.012	0.030	0.021	6	75.00%
PML2	0.025	--	--	0.006	--	0.026	0.011	0.026	0.018	5	83.33%
									Overall	**70**	**75.27%**

Table 3. Summary of Total Phosphorus results and exceedances from Spring 2012 through Fall 2014

FINANCIAL IMPLICATIONS

There are no financial implications for this report.

COMMUNITY ENGAGEMENT

No community engagement was required for this report.

ATTACHMENTS

Attachment A. Paper Mill Lake Watershed Total Phosphorus Characterization Project Final Report
Attachment B. Final Report: Paper Mill Lake Watershed Assessment
Attachment C. Water Quality Monitoring Program, Bedford West Spring 2016 Sampling Event
Attachment D. Water Quality Monitoring Program, Bedford West Summer 2016 Sampling Event

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A copy of this report can be obtained online at http://www.halifax.ca/commcoun/index.php then choose the appropriate Community Council and meeting date, or by contacting the Office of the Municipal Clerk at 902.490.4210, or Fax 902.490.4208.

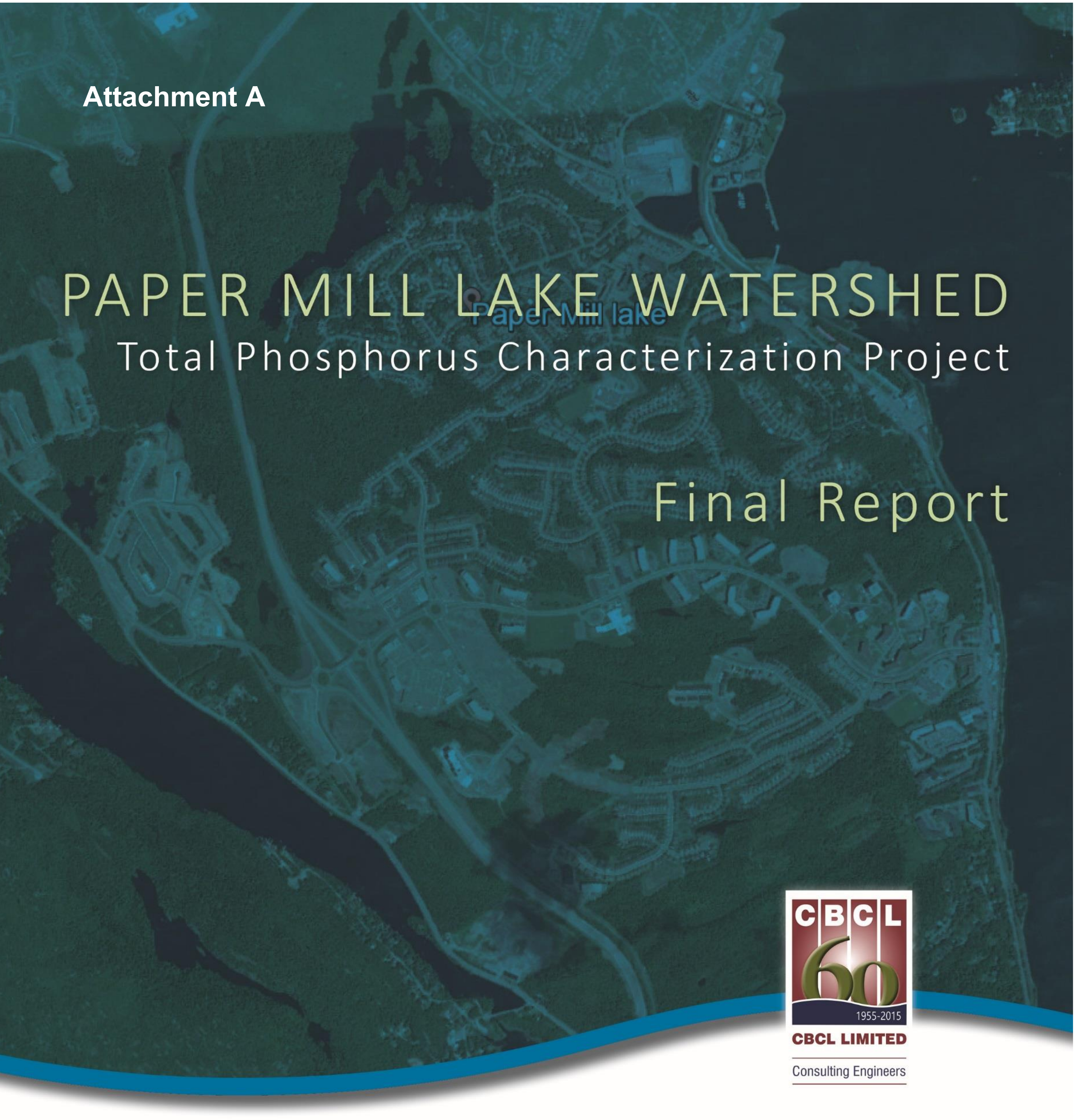
Report Prepared by: Cameron Deacoff, Environmental Performance Officer, 902.490.1926

ORIGINAL SIGNED

Report Approved by:

Holly Richardson, Acting Program Manager, Energy & Environment, 902.490.3665.

Attachment A



PAPER MILL LAKE WATERSHED

Total Phosphorus Characterization Project

Final Report

CBCL
1955-2015
CBCL LIMITED
Consulting Engineers

Prepared for

HALIFAX

151033.00 • Final Report • September 2015

Final Report	Original Signed	09/18/2015	Original Signed
Draft Report	A. Wilson	09/14/2015	L. Braschi
Issue or Revision	***Reviewed By:***	***Date***	***Issued By:***

CBCL

CBCL LIMITED

Consulting Engineers

Original Stamped

EXECUTIVE SUMMARY

In spring of 2009, monitoring was initiated in Bedford West according to a plan jointly developed by the Bedford Watershed Advisory Board and the Halifax Regional Municipality (HRM) staff. It was determined that, if water quality levels for Paper Mill Lake reached a total phosphorus (TP) threshold of 0.010 mg/L, the municipality should conduct an assessment. Recent indications suggest that TP concentrations in the Kearney and Paper Mill Lakes rose above the established threshold several times since at least 2012 (they have exceeded the “early warning” threshold). HRM has therefore commissioned CBCL to characterize these recent increases in TP levels.

The purpose of this Phase I study is to identify when and where the TP threshold has been exceeded in the Kearney and Paper Mill Lakes and adjacent watercourses. In this report, the 2006-2011 conditions are first established based on a statistical analysis of HRM’s former Water Quality Monitoring Program. Then, the variation in TP measurements from those conditions is visually and statistically compared based on the Bedford West Monitoring Plan (2009-2014).

- Measured TP levels in both lakes during the 2006-2011 period displayed little variation, with levels in the oligotrophic range (<0.010 mg/L).
- There are indications that TP is increasing in Kearney and Paper Mill Lakes.
    - Average TP values from the 2009-2014 data set are higher than averages from the 2006-2011 data set.
    - For three sites, there were statistically significant linear increases in TP over time.
    - The “early warning” threshold of 0.010 mg/L was exceeded several times in the 2009-2014 data set, with levels moving into the mesotrophic range, and on some occasions, into the eutrophic range (> 0.035 mg/L).
- TP displayed increased variation during the 2009-2014 phase. A pattern of higher variation in TP is to be expected in oligotrophic lakes such as Kearney and Paper Mill Lakes, as they become initially more enriched. This is particularly the case in lakes that are in transition from oligotrophic to mesotrophic, and where levels are close to the limits of analytical detection. The variation could also be explained by a chance in sampling methodology.

However, the two data sets are not directly comparable because they were obtained from samples taken at different locations; this discrepancy is evident from the period of overlap (2009-2011) between the two sampling programs, because they yield different results. Also, duration of sampling and sample size is insufficient to statistically characterize spatial and temporal variability in TP measurements. In order to more closely compare 2006-2011 conditions to 2009-2014 conditions, it may be worthwhile to consider renewed sampling at the 2006-2011 data set sampling locations.

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CHAPTER 1 INTRODUCTION

In spring of 2009, monitoring was initiated in Bedford West according to a plan jointly developed by the Bedford Watershed Advisory Board and the Halifax Regional Municipality (HRM) staff. It was determined that, if water quality levels for Paper Mill Lake reached a total phosphorus (TP) threshold of 0.010 mg/L, the municipality should conduct an assessment. Recent indications suggest that TP concentrations in the Kearney and Paper Mill Lakes rose above the established threshold several times since at least 2012 (they have exceeded the "early warning" threshold). HRM has therefore commissioned CBCL Limited to characterize these recent increases in TP levels.

Elevated TP concentrations in waterbodies can contribute to an increase in primary productivity, which can lead to plant growth and depleted oxygen levels (when decaying organic material decomposes). This may also cause a decrease in biodiversity and changes in the dominant biota. Excessive plant growth can also include certain species of cyanobacteria that cause increased risk to human health (CCME 2004). TP is the main predictor of trophic status recommended by the Canadian Environmental Quality Guidelines (Table 1.1; CCME 2004). TP concentrations are particularly critical for Kearney and Paper Mill Lakes, because both lakes are strongly limited in phosphorus (AECOM 2013).

Table 1.1: Trophic Statuses Based on TP, According to the Canadian Environmental Quality Guidelines (CCME 2004)

Trophic Status	Total Phosphorus
Ultra-oligotrophic	<4 µg/L
Oligotrophic	4 – 10 µg/L
Mesotrophic	10 – 20 µg/L
Meso-eutrophic	20 – 35 µg/L
Eutrophic	35 – 100 µg/L
Hyper-eutrophic	>100 µg/L

The purpose of this Phase I study is to identify when and where the TP threshold is exceeded in the Kearney and Paper Mill Lakes and adjacent watercourses. In this report, the 2006-2011 conditions are first established based on a statistical analysis of HRM's former Water Quality Monitoring Program. Then, the variation in TP measurements from those conditions is visually and statistically compared based on the Bedford West Monitoring Plan (2009-2014). Both monitoring programs were ongoing during 2009-2011; thus, there is a period of overlap of two years. The HRM Water Quality Monitoring Program includes two measurement locations in each of the Kearney and Paper Mill Lakes, monitored three times annually (Appendix A). The Bedford West Monitoring Plan started with nine stations and expanded to eleven stations in 2012, also monitored three times annually (Appendix A). These two data sets will be hereinafter referred to as “2006-2011 Data Set” and “2009-2014 Data Set” respectively. Phase II of the project will investigate potential causes of the TP observations and trends.

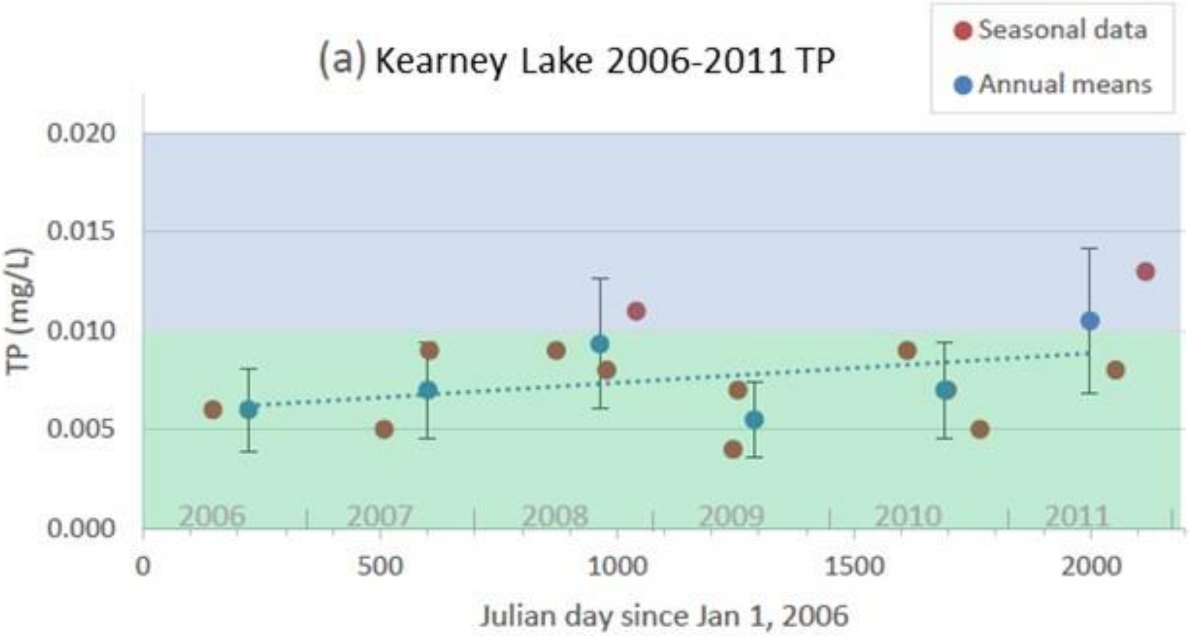
1.1 2006-2011 Data Set

Average conditions were first quantified for the 2006-2011 data set. This data set provides up to three measurements in both Kearney and Paper Mill Lakes for each year, annual means were calculated for each lake and identified the corresponding annual trophic statuses (Table 1.2). Annual means are a good statistic for this data set in the sense that there are no apparent patterns in seasonal variability that would have been lost by the averaging process (Appendix B). However, for a sampling regime of only three samples, missing values render annual means statistically meaningless (e.g., only one measurement available). Table 1.2 shows that TP in both Kearney and Paper Mill Lakes during 2006-2011 was generally < 0.010 mg/L, and that the lakes were therefore oligotrophic for much of the 2006-2011 time period. Individual TP measurements and annual TP means are shown together in Figure 1.1. Three-year running means are discussed and reported in Appendix F.

Table 1.2: Kearney and Paper Mill Lakes 2006-2011 TP Annual Means and Trophic Statuses

	Kearney Lake 2006-2011		Paper Mill Lake 2006-2011	
	Mean TP (mg/L)	**Trophic status**	**Mean TP (mg/L)**	**Trophic Status**
2006	0.006 ± 0.002 (1 σ)	Oligotrophic	0.007 ± 0.002 (1 σ)	Oligotrophic
2007	0.007 ± 0.002 (1 σ)	Oligotrophic	0.004 ± 0.001 (1 σ)	Oligotrophic
2008	0.009 ± 0.003 (1 σ)	Oligotrophic	0.009 ± 0.003 (1 σ)	Oligotrophic
2009	0.006 ± 0.002 (1 σ)	Oligotrophic	0.008 ± 0.003 (1 σ)	Oligotrophic
2010	0.007 ± 0.002 (1 σ)	Oligotrophic	0.010 ± 0.004 (1 σ)	Oligo- Mesotrophic
2011	0.011 ± 0.004 (1 σ)	Oligo-Mesotrophic	0.008 ± 0.003 (1 σ)	Oligotrophic

In both Table 1.2 and Figure 1.1, the error on each annual mean is the standard deviation (σ), as reported by AGAT laboratories (35%). The standard deviation is a measure used to quantify the amount of variation or dispersion of measurements compared to the mean. This uncertainty results from natural TP variability of as well as measurement error (due to limits on instrumental precision).



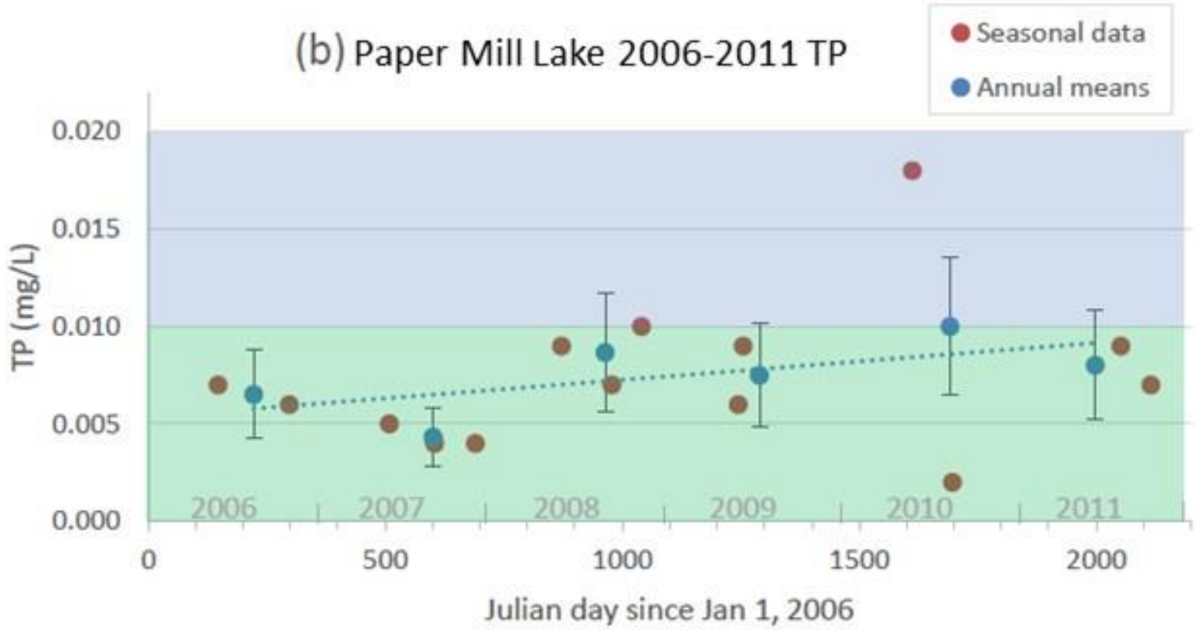


Figure 1.1: Kearney and Paper Mill 2006-2011 Time Series of TP Measurements

A slight trend is visually apparent in the 2006-2011 data of both lakes (Figure 1.1). However, based on regression analysis (Appendix C), the trend is not statistically significant. This confirms the Stantec (2012) and AECOM (2013) preliminary results (based on visual analyses) that the TP was stable in both Kearney and Paper Mill Lakes from 2006-2011. Hence, it can be considered that TP was unchanged in both lakes throughout the 2006-2011 time period. The means of the TP measurements from each lake were therefore calculated, thus obtaining an average TP value representative of the entire sampling period from 2006-2011 (Table 1.3). The standard deviation (σ) provides a measure of the variability from this 2006-2011 average.

Table 1.3: Kearney and Paper Mill Lakes 2006-2011 TP Means and Trophic Statuses for the Entire Sampling Period

	Kearney Lake 2006-2011		Paper Mill Lake 2006-2011	
	Mean TP (mg/L)	**Trophic Status**	**Mean TP (mg/L)**	**Trophic Status**
2006-2011	0.008 ± 0.003 (1 σ)	Oligotrophic	0.007 ± 0.004 (1 σ)	Oligotrophic

The standard deviation (1 σ error) includes variability within years, between years, and due to measurement error.

Next, it was necessary to determine whether the difference in the TP averages between the two lakes was significant. Using a 2-sample t-test, it was found that the two means are statistically indistinguishable (Appendix D). Therefore, the TP measurements for both lakes can be pooled. In other words, the 2006-2011 data set shows no statistically significant spatial differences in TP. The pooled average and pooled error is reported in Table 1.4.

Table 1.4: Pooled Kearney and Paper Mill Lakes 2006-2011 TP and Trophic Status. The Pooled Standard Deviation is from the Analysis of Variance (ANOVA; Appendix D)

	Pooled Kearney and Paper Mill Lakes 2006-2011	
	Mean TP (mg/L)	**Trophic status**
2006-2011	0.008 ± 0.003 (1 σ)	Oligotrophic

In summary, there are no apparent seasonal patterns in the TP measurements during the 2006-2011 period, the TP measurements did not change significantly over time, and the TP levels between Kearney and Paper Mill Lakes cannot be statistically distinguished. A 2006-2011 average was obtained as well as a measure of the variability in TP (the amount by which measurements tend to vary from the average). The trophic status classification of both lakes during the 2006-2011 period was oligotrophic.

In both Table 1.2 and Figure 1.1, the error on each annual mean is the standard deviation (σ; 35%). This uncertainty on the mean value results from natural TP variability of as well as measurement error (due to limits on instrumental precision). The Julian day convention is explained in Appendix A. The oligotrophic range is shown in green and the mesotrophic range is shown in blue.

1.2 2009-2014 Data Set

This section describes and characterizes TP during 2009-2014, in comparison to the established 2006-2011. The 2009-2014 TP data set shows two main differences from the 2006-2011 data set. Firstly, there are occasional, abnormally high TP measurements, which are considerably higher than other measurements. This type of observation was absent from the 2006-2011 data set. Secondly, there is a statistically significant linear increase over time in TP measurements at certain locations. This contrasts with the demonstrated stability of the 2006-2011 TP measurements.

The abnormally high TP measurements (Figure 1.2), which only occur at one to three stations on any given sampling date, cannot be definitively attributed to measurement error, seasonal conditions, weather events, or concerns with particular sampling locations. Each of these potential factors is addressed in Appendix E. The investigations were therefore focused on the bulk of the measurements (see Appendix E for excluded data points). Regressions which include the abnormally high measurements were found to be less meaningful because of the disproportionate influence of single measurements, due to small sample sizes (Appendix E). This is apparent in Figure 1.2, where a linear regression is shown through annual averages, but this is skewed by abnormally high values.

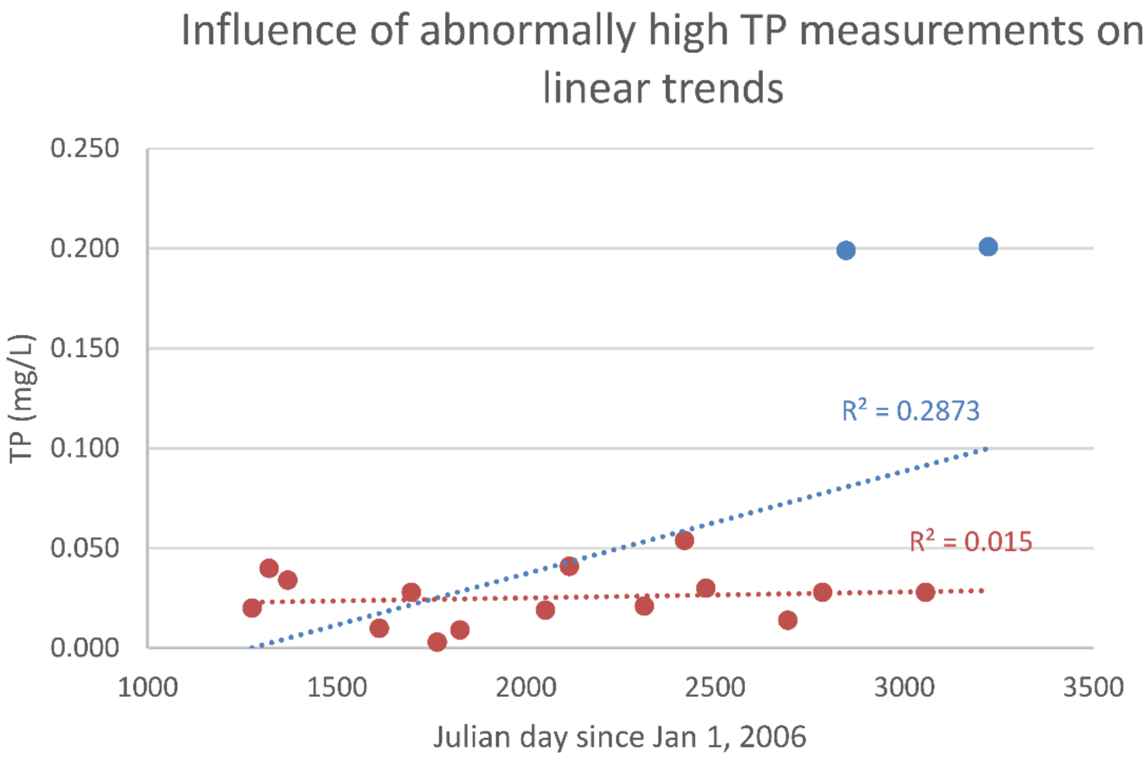


Figure 1.2: **2009-2014 TP at Highway-102 Site 2**

The blue measurements represent abnormally high values. The blue trend line is calculated on all measurements, including the abnormally high values (both the red and blue points). The red trend line is calculated without the abnormally high values (only the red points).

The remaining 2009-2014 data set shows increasing TP over time in some locations; in some locations, the TP measurements cross from the oligotrophic range (green) into the mesotrophic range (blue; Figure 1.3). According to a regression analysis (Appendix C), these linear trends are statistically significant at three sites: the Highway 102 Site 1 (HWY 102-01, Figure 1.3b), Paper Mill Lake Site 2 (PML2, Figure 1.3f), and Kearny Lake Site 3 (KL3, Figure 1.3i).

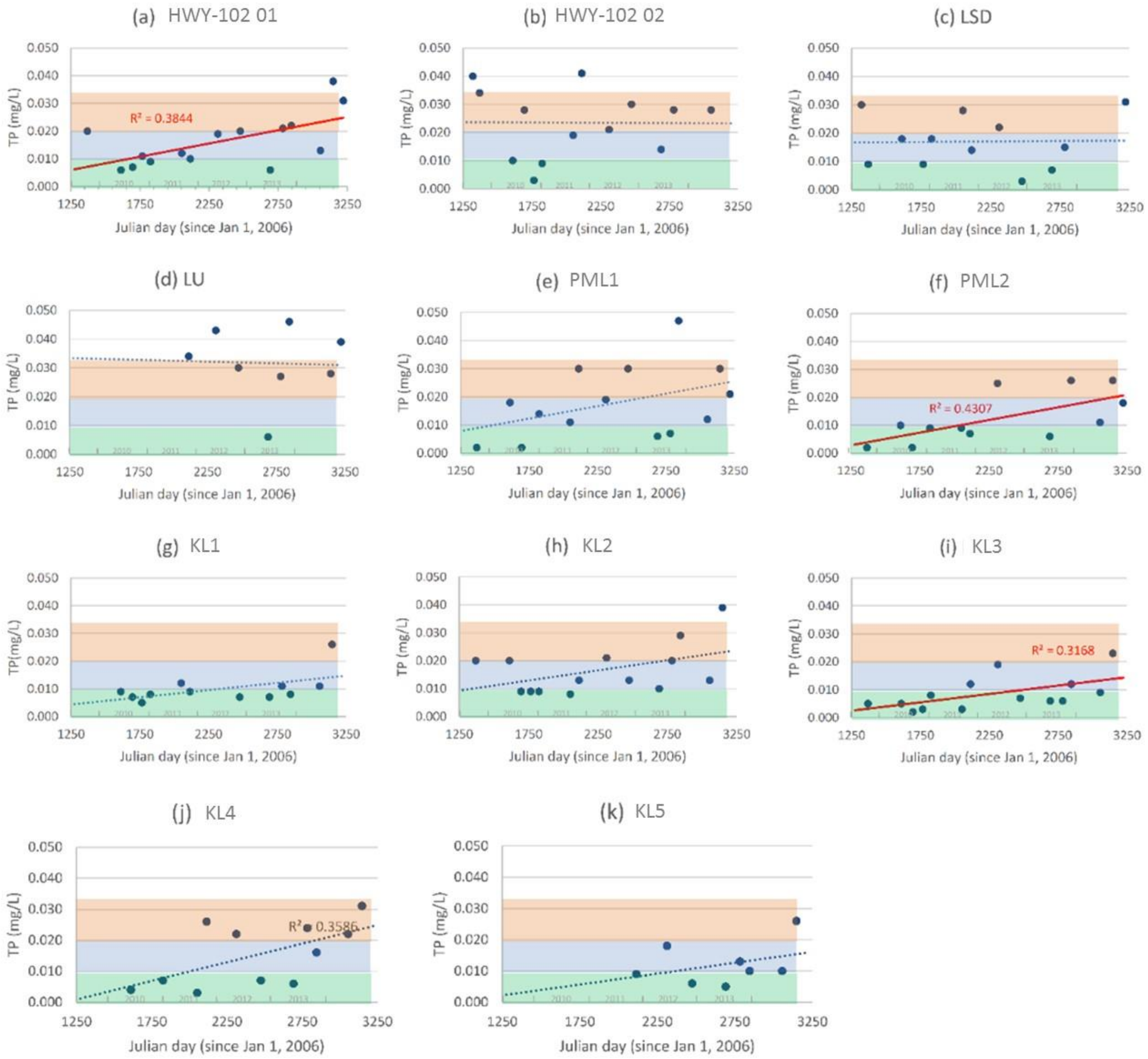


Figure 1.3: Bedford West 2009-2014 TP Background Trends

Statistically significant trend lines are shown in red. The oligotrophic range is shown in green, the mesotrophic in blue, and meso-eutrophic in orange.

For the sampling locations without statistically significant trends (all locations except Highway-102 Site 01, Paper Mill Lake Site 2, and Kearney Lake Site 2), means of the TP measurements were calculated and average TP values representative of the entire sampling period from 2009-2014 were obtained (Table 1.5). The Kearney Lake measurements were pooled, since they were not statistically different based on an ANOVA analysis (Appendix D). AECOM (2013) came to the same conclusion during the Birch Cove Lake Study and suggested that the TP measurements for KL1, KL3 and KL4 should be pooled.

Table 1.5: 2009-2014 TP Values for Sampling Locations without Linear Trends

Sampling Station	TP and Trophic Status (2009-2011)	
	Mean TP (mg/L)	Trophic Status
HWY 102-02	0.023 ± 0.012 (1 σ)	Meso-eutrophic
LSD	0.017 ± 0.009 (1 σ)	Mesotrophic
LU	0.032 ± 0.012 (1 σ)	Meso-eutrophic
PML1	0.018 ± 0.013 (1 σ)	Meso-eutrophic
KL1	0.010 ± 0.005 (1 σ)	Mesotrophic
KL2	0.017 ± 0.009 (1 σ)	Mesotrophic
KL4	0.015 ± 0.010 (1 σ)	Mesotrophic
KL5	0.012 ± 0.007 (1 σ)	Mesotrophic
KL1, KL2, KL4, KL5 average	0.018 ± 0.008 (1 σ)	Mesotrophic

The 2009-2014 TP means are generally higher than the 2006-2011 TP mean, and they correspond to mesotrophic or meso-eutrophic rather than oligotrophic conditions. However, the interpretation of this result requires a careful comparison of the 2006-2011 and 2009-2014 data sets where they overlap (2009-2011). Figure 1.4 shows that the 2009-2014 data has more variability and a higher average than the 2006-2011 data set during those two years. Regardless of the reason for this discrepancy, comparison of 2009-2014 data to 2006-2011 data overestimates the change in TP over time, since the 2009-2014 data set has higher TP values.

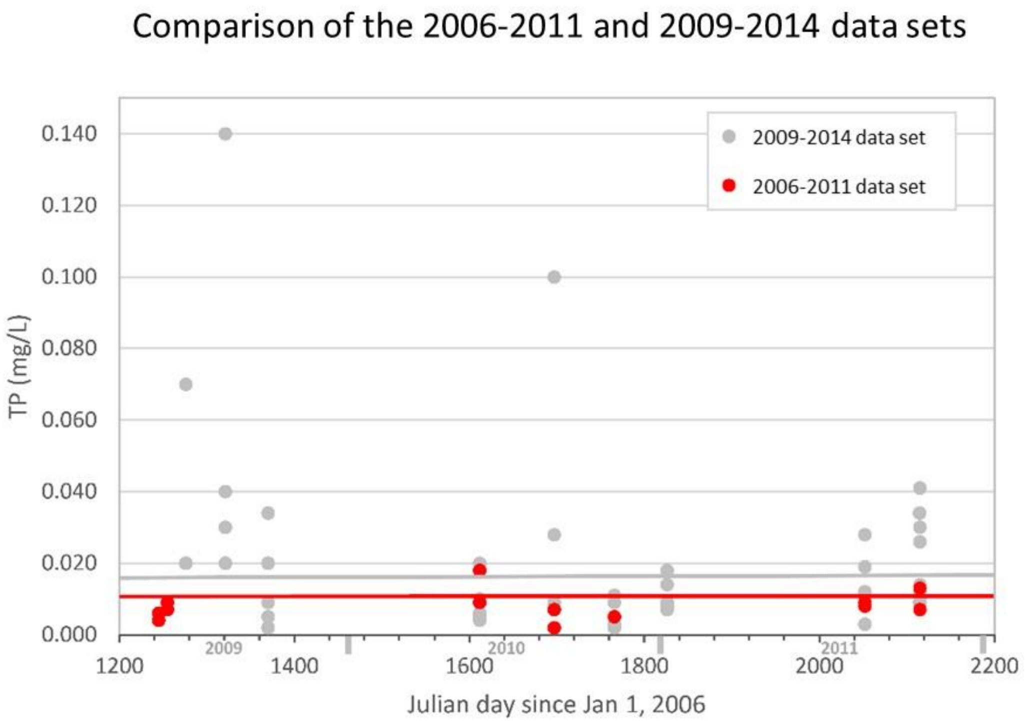


Figure 1.4: Comparison of 2006-2011 and 2009-2014 TP Data Sets

The 2006-2011 data set is shown in red and the 2009-2014 data set is shown in grey. Average values are shown in the solid lines (in red and grey respectively).

The discrepancy may be caused by a difference in the sampling locations. The 2006-2011 data were obtained from the outlet of Kearney and Paper Mill Lakes, unlike the 2009-2014 samples (see discussion Appendix E). Both sampling programs obtained samples at 1 m depth whenever possible and analysed TP using spectrophotometry.

It is important to note that some of the sampling locations had fewer TP measurements. These small sample sizes were further reduced by the removal of abnormally high values. Small sample sizes reduce the statistical power of tests such as linear regressions and ANOVAs. The statistical term ‘power’ is the probability of rejecting the null hypothesis (hypothesis of no difference) when it is false. A small sample size makes it much harder to detect differences (trends in the case of regression, and differences between groups in the case of ANOVA): the power is low. This is particularly applicable if natural variability is high. Thus, data limitations may be part of the reason why distinct trends over time and patterns over space could not be discerned from the data.

CHAPTER 2 COMPARISON TO MODEL RESULTS

AECOM (2013) investigated the potential effects of future land use changes on the trophic state and phosphorus concentrations in various lakes using two models: a Lake Capacity Model (LCM) and a stormwater management model (SWMM). Four scenarios were tested:

1. Modelling Scenario 1: Existing Conditions.
2. Modelling Scenario 2: Approved and Planned Development Commitments (build-out of Bedford West and Bedford South).
3. Modelling Scenario 3: Scenario 2 plus full build-out of the Highway 102 West Corridor Lands.
4. Modelling Scenario 4: Scenario 3 minus Highway 102 West Corridor Lands within the Conceptual Park.

For Paper Mill Lake, both LCM and SWMM predicted that Modelling Scenario 1 (existing conditions) would not result in any changes in the lake's trophic status. However, Scenarios 2-4 would result in a shift to mesotrophic conditions. Modelling results were the same for Kearney Lake, except that the SWMM model predicted no change in the trophic status for Scenario 2.

CWRS (2004) used a refined version of the Dillon-Rigler (1975) phosphorus loading model to predict that future development would cause TP concentrations to increase by 0.0035 mg/L in Kearney Lake and 0.0063 mg/L in Paper Mill Lake. The observed changes in TP measurements (identified from comparison of the 2006-2011 and 2009-2014 data sets) from oligotrophic to mesotrophic concentrations agree with the modelled predictions of AECOM (2013) and CWRS (2004).

CHAPTER 3 CONCLUSIONS AND RECOMMENDATIONS

The 2006-2011 and 2009-2014 data sets are not directly comparable because different sites were used for sampling; this discrepancy is evident from the period of overlap (2009-2011) between the two sampling programs. Also, sample size is insufficient to properly characterize potential spatial variability in TP measurements. Nonetheless, the following conclusions can be made:

- Measured TP levels in Kearney and Paper Mill Lakes during the 2006-2011 period displayed little variation, with levels within the oligotrophic range (<0.10 mg/L);
- TP does appear to be increasing in Kearney and Paper Mill Lakes. Average TP values from the 2009-2014 data set are higher than those of the 2006-2011 data set. The “early warning” threshold of 0.010 mg/L was exceeded several times in the 2009-2014 data set, with TP levels therefore moving into the mesotrophic range. On some occasions, TP levels in the eutrophic range (>0.35mg/L) were recorded. For some sites there was an indication of a linear increase in TP over time;
- TP levels during the 2009-2014 phase displayed an increased variation in both lakes. In particular, there is an occurrence of abnormally high values in this data set; and
- A pattern of higher variation in TP levels is to be expected in oligotrophic lakes such as Kearney and Paper Mill Lakes as they become initially more enriched. This is particularly the case in lakes that are in transition from oligotrophic to mesotrophic, and where levels are close to the limits of analytical detection.

CHAPTER 4 REFERENCES

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Original Signed

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APPENDIX A

Data Used

Two data sets were relevant for this study (Table A1). The first data set was the HRM Lakes Water Quality Monitoring Program (2006-2011), which has one sampling location in each of Kearney and Paper Mill Lakes. The only missing data are for summer 2006 and fall 2009 in both locations, in addition to fall 2006 and 2007 in Kearney Lake. AECOM (2013) conducted a watershed study on behalf of HRM entitled "Birch Cove Lakes Watershed Study", which used the HRM Lakes Water Quality Monitoring Program (2006-2011) data set. AECOM supplemented the HRM data by collecting data on four occasions during 2011-2012. Since these additional locations were geographically removed from the Kearney and Paper Mill Lakes, they were not analysed in this study. The AECOM data compilation also includes data collected by the Nova Scotia Department of Environment and the Nova Scotia Department of Fisheries and Aquaculture as a part of the Nova Scotia Lakes Inventory Program (initiated in 1940). The more recent HRM Lakes Water Quality Monitoring Program Data was deemed more representative of pre-development conditions in Bedford West, and was therefore the focus of these analyses. This HRM Lakes Water Quality Monitoring Program Data is referred to as the "2006-2011" data set in this report.

The second data set was the Bedford West Monitoring Program. The data referenced are from Spring 2009 onward, collected 3 times each year. During 2009-2012, nine stations were monitored, and during 2012-2014, an additional 2 stations (11 in total) were monitored. Sampling could not be consistently conducted in Paper Mill Lake in 2012 and 2013 due to safety considerations (AECOM 2013). This data set is referred to as the "2009-2014" data set in this report.

In the spreadsheets obtained by CBCL from HRM, data points below the detection limits were indicated by the "<" sign and the detection limit. Any data point presented as < 0.02 mg/L was removed, since the actual TP concentration could be an order of magnitude less than the detection limit. These data points were found to be overly influential on the regression analyses. It is noted that a detection limit of 0.02 mg/L is not suitable for determining whether a lake is changing from oligotrophic to mesotrophic conditions. Deep water TP could not be used in the regression analysis due to the scarcity of the data (see Appendix H)

In order for the date of sampling to be analysed as a continuous variable (and thus to enable regression analyses), the sampling dates needed to be converted from calendar dates to Julian dates. Although Julian days are usually calculated since January 1, 4713 BCE, for the purpose of this study, January 1, 2006 was selected as a simplified starting date.

Table A1: TP Data Used in this Report. Abbreviations: HWY 102-01 (Highway 102 Site 1), HWY 102-02 (Highway-102 Site 2), LSD (Lake Shore Drive), LU (Larry Uteck), PM (Paper Mill Lake), KL (Kearney Lake)

	2006-2011 Data Set			2009-2014 Data Set											
	Julian day	Kearney	Paper Mill	Julian Day	HWY 102-01	HWY 102-02	LSD	LU	PML1	PML2	KL1	KL2	KL3	KL4	KL5
Spring 2006	147	0.006	0.007												
Fall 2006	298	ND	0.006												
Spring 2007	509	0.005	0.005												
Summer 2007	604	0.009	0.004												
Fall 2007	690	ND	0.004												
Spring 2008	872	0.009	0.009												
Summer 2008	978	0.008	0.007												
Fall 2008	1041	0.011	0.010												
Spring 2009	1245	0.004	0.006	1276	0.070	<0.020	ND		<0.020	<0.020	<0.02	0.020	<0.020	<0.020	
Summer 2009	1255	0.007	0.009	1321	0.140	0.040	0.030		<0.020	<0.020	<0.02	0.020	<0.020	<0.020	
Fall 2009	1370	ND	ND	1370	0.020	0.034	0.009		0.002	0.002	<0.002	0.020	0.005	<0.002	
Spring 2010	1612	0.009	0.018	1612	0.006	0.010	0.018		0.018	0.010	0.009	0.020	0.005	0.004	
Summer 2010	1697	0.007	0.002	1697	0.007	0.028	0.100		0.002	0.002	0.007	0.009	<0.002	<0.002	
Fall 2010	1766	0.005		1766	0.011	0.003	0.009		<0.002	<0.002	0.005	0.009	0.003	<0.002	
Spring 2011	1826	ND	ND	1826	0.009	0.009	0.018		0.014	0.009	0.008	0.009	0.008	0.007	
Summer 2011	2052	0.008	0.009	2052	0.012	0.019	0.028		0.011	0.009	0.012	0.008	0.003	0.003	
Fall 2011	2115	0.013	0.007	2115	0.010	0.041	0.014	0.034	0.030	0.007	0.009	0.013	0.012	0.026	0.009
Spring 2012				2313	0.019	0.021	0.022	0.043	0.019	0.025	0.037	0.021	0.019	0.022	0.018
Summer 2012				2419	0.039	0.054	0.063	0.036	ND	ND	0.043	0.059	0.045	0.043	0.040
Fall 2012				2476	0.020	0.030	0.003	0.030	0.030	ND	0.007	0.013	0.007	0.007	0.006
Spring 2013				2692	0.006	0.014	0.007	0.006	0.006	0.006	0.007	0.010	0.006	0.006	0.005
Summer 2013				2784	0.021	0.028	0.015	0.027	0.007	ND	0.011	0.020	0.006	0.024	0.013
Fall 2013				2846	0.022	0.199	0.078	0.046	0.047	0.026	0.008	0.029	0.012	0.016	0.010
Spring 2014				3056	0.013	0.028	0.100	0.260	0.012	0.011	0.011	0.013	0.009	0.022	0.010
Summer 2014				3148	0.038			0.028	0.030	0.026	0.026	0.039	0.023	0.031	0.026
Fall 2014				3222	0.031	0.201	0.031	0.039	0.021	0.018	0.013	0.025	0.148	0.015	0.135

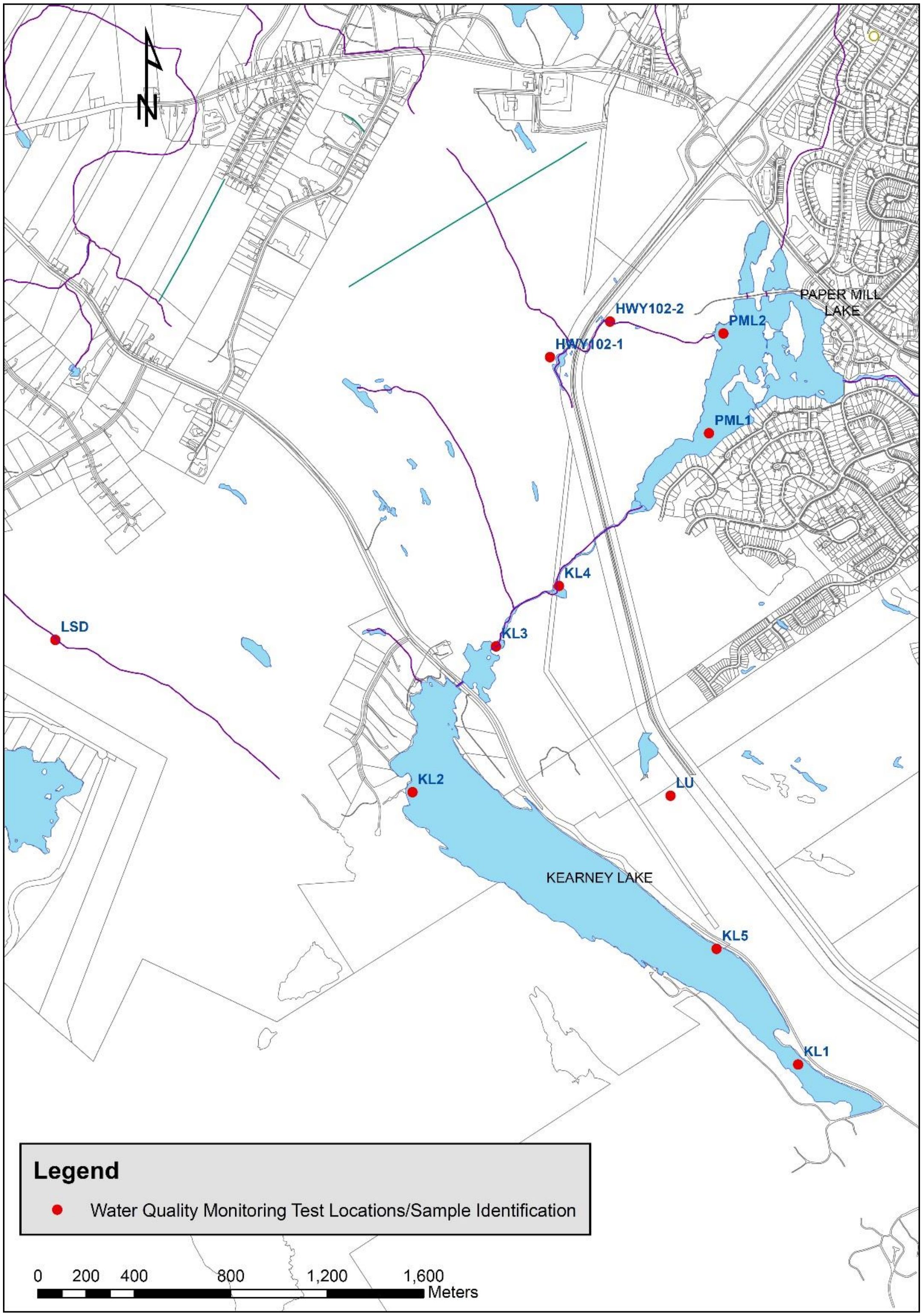


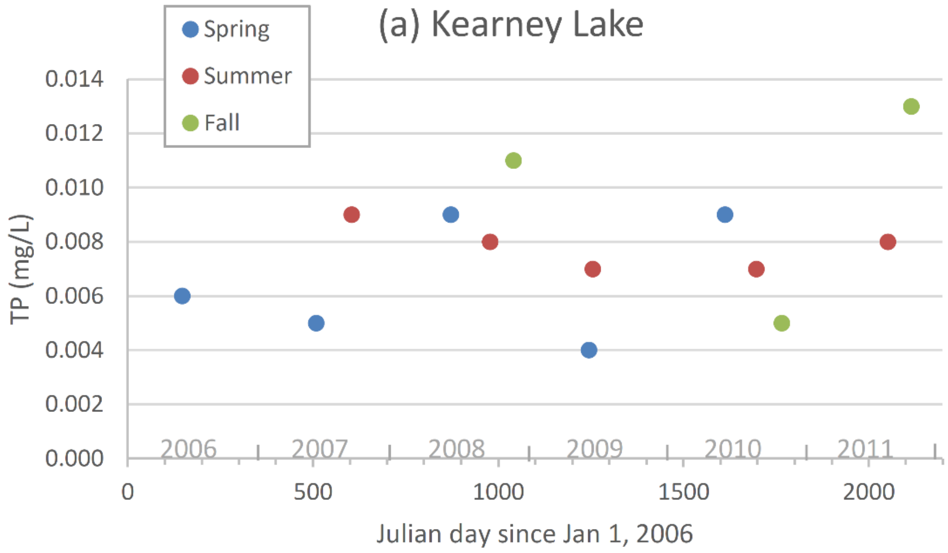
Figure A1: Map of Sampling Locations for the Bedford West Water Quality Monitoring Program. Map Modified from SNC Lavalin (2014).

APPENDIX B

Seasonal Patterns in 2006-2011 TP

It was of interest to investigate whether there were any consistent differences in the TP measured in the spring, summer, and fall, since these would have been lost by the annual averaging. TP can display seasonal variation due to the annual cycle of growth and biological production in lakes, and due to the thermal stratification of most deep lakes. For example, the TP measured in spring may differ from the ice-free season average by being influenced by the contribution of TP accumulated under ice and the resuspension of sediment at spring turnover (Dillon et al. 1986). Phosphorus is commonly lost during stratification due to the settling of algal cells (Dillon et al. 1986).

It appears from Figure A1 that there are no patterns in seasonal variation. The absence of seasonal patterns in TP measurements suggests that Kearney and Paper Mill Lakes may not show significant stratification during the ice-free season (perhaps because of their small size). Annual standard deviations of TP were also calculated and plotted, but no patterns could be discerned. This is concordant with the finding by AECOM (2013) that “differences in spring, summer and fall epilimnetic [surface] phosphorus concentrations were negligible”. Furthermore, samples collected 1 m below the thermocline for TP were relatively low and comparable to epilimnetic (surface) TP measurements.



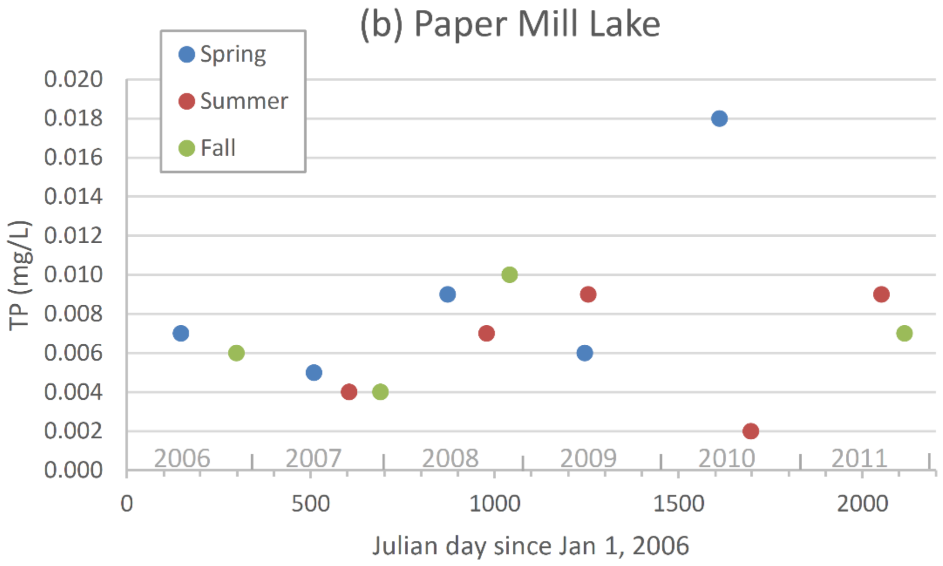


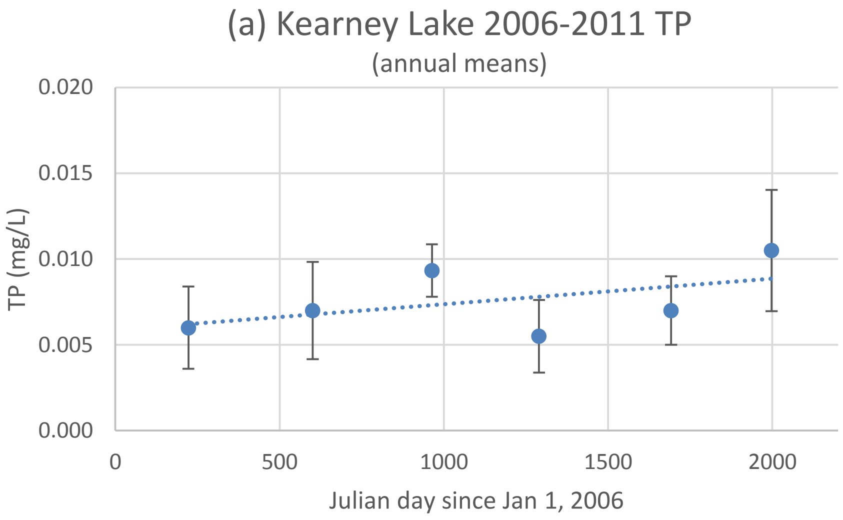
Figure B1: **Effect of Seasonal Variation on 2006-2011 TP Measurements**

APPENDIX C

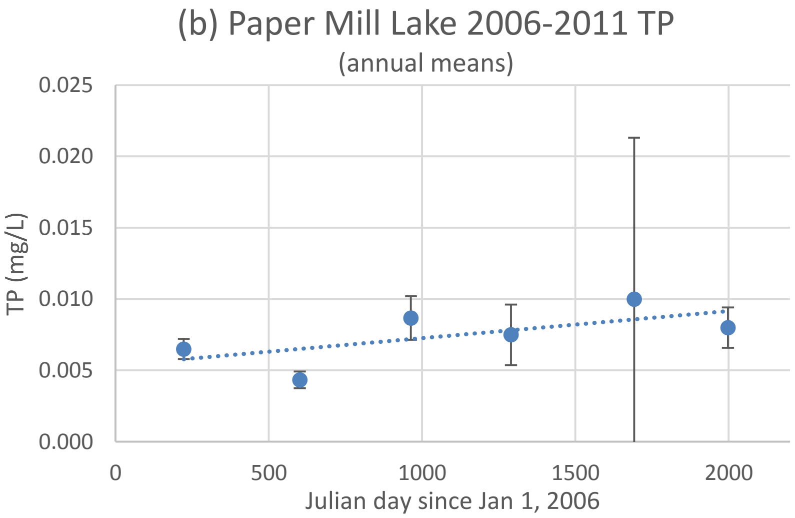
Regression Analyses

i. 2006-2011 Data Set: Kearney and Paper Mill Lake

Kearney and Paper Mill Lakes appear to have increasing trends of TP over time (Figure C1). However, using α = 0.05, regression analysis reveals that neither lake's trend is statistically significant. This means that the null hypothesis that the measurements were produced by random variability cannot be rejected. The regression was repeated using both geometric means and 3-year running averages, and the same result was obtained. The regression was also performed on all data points (without taking annual means first), but the trend was also insignificant. This regression analysis does not factor the error on the measurements (which would make the trend even more likely to be caused by random variation).


(a) Kearney Lake 2006-2011 TP

(annual means)


(b) Paper Mill Lake 2006-2011 TP

(annual means)

Figure C1: Kearney and Paper Mill Lake 2006-2011 TP Linear Trends. The error on each annual mean is the standard deviation (σ) of the three measurements obtained during that year.

Minitab regression analysis results for Kearney Lake:

```
The regression equation is: Kearney_TP = 0.006276 + 0.000001*Julian_day

S = 0.00251735   R-Sq = 8.6%   R-Sq(adj) = 0.3%

Analysis of Variance:
Source      DF         SS         MS     F      P
Regression   1  0.0000066  0.0000066  1.04  0.329
Error       11  0.0000697  0.0000063
Total       12  0.0000763
```

Minitab regression analysis results for Paper Mill Lake:

```
The regression equation is: Paper Mill_TP = 0.005430 + 0.000002*Julian_day

S = 0.00380081   R-Sq = 8.4%   R-Sq(adj) = 0.7%

Analysis of Variance:
Source      DF         SS         MS     F      P
Regression   1  0.0000159  0.0000159  1.10  0.315
Error       12  0.0001734  0.0000144
Total       13  0.0001892
```

ii. 2009-2014 Data Set: TP Time Series at Each Sampling Location

The 2009-2014 TP time series for each location was tested for trends (α = 0.05), following removal of abnormally high measurements (Appendix E). Samples sizes (n = 8-15) were not large enough to provide a very precise estimate of the strength of the relationship.

Table C1: Linear Regression Results for 2009-2014 Sampling Locations

Sampling Location	Is Linear Regression Significant at α = 0.05?	p	% of the Variation can be Explained by Linear Regression	R
HWY102-01	Yes	0.014	38.44	0.62
HWY102-02	No	0.974		
LSD	No	0.948		
LU	No	0.929		
PML1	No	0.138		
PML2	Yes	0.020	43.07%	0.66
KL1	No	0.074		
KL2	No	0.094		
KL3	Yes	0.036	31.68%	0.56
KL4	No	0.052		
KL5	No	0.383		

APPENDIX D

Analyses of Variance (ANOVAs)

i. 2006-2011 Data Set: Kearney vs. Paper Mill Lake

A 2-sample t-test was performed to identify whether a statistical difference between the two lakes can be discerned. A 2-sample t-test is equivalent to a one-way ANOVA with only 2 groups. Both lakes passed the test for normality (Ryan-Joiner/ Shapiro-Wilk test; p >0.1 for both lakes) as well as for test for homogeneity of variance (Levenes test; p=0.394). This is consistent with visual analysis of the data sets. The t-test was then performed, and the null hypothesis of no difference could not be rejected (α = 0.05). The 2006-2011 data sets for both lakes were therefore pooled to create a regional 2006-2011 average (see main text).

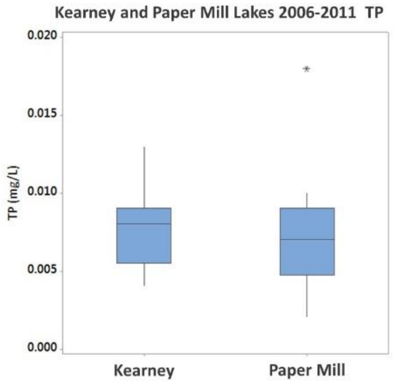


Figure D1: **Boxplot of the Kearney and Paper Mill 2006-2011 TP data sets. The boxes show the distribution of values for each sampling location. The horizontal black line in each box is the median TP for that location. The upper and lower limits of the box represent the first and third quartiles. The first quartile splits the lowest 25% of the data, whereas the third quartile splits the upper 75% of the data. The vertical lines (or “whiskers”) extend to the minimum and maximum data points (excluding outliers). The asterisk represents an outlier in the Paper Mill Lake data set.**

Minitab two-sample equivalence test:

```
Test mean of Paper Mill = mean of Kearney
Equal variances were not assumed for the analysis.

Descriptive Statistics:

Variable    N       Mean      StDev     SE Mean
Kearney    13  0.0077692  0.0025217  0.00069939
Paper Mill  14  0.0073571  0.0038151   0.0010196


Difference: Mean (Kearney) - Mean (Paper Mill)
Difference         SE 95% Lower Bound Lower Limit
0.00041209 0.0012364       -0.0017111           0

Lower bound is not greater than 0. Cannot claim Mean (Kearney) > Mean (Paper
Mill).

Test
```

```
Null hypothesis:         Mean (Kearney) - Mean (Paper Mill) ≤ 0
Alternative hypothesis:  Mean (Kearney) - Mean (Paper Mill) > 0
α level:                 0.05

DF  T-Value  P-Value
22  0.33329    0.371

P-Value > 0.05. Cannot claim Mean (Kearney) > Mean (Paper Mill).
```

ii. 2009-2014 Data Set: Sampling Locations without Statistically Significant Trends

A 1-way ANOVA was performed to test whether a statistical difference between the Kearney 2009-2014 data sets which do not have statistically significant trends (KL1, KL2, KL4, KL5) can be discerned. All Kearney sampling locations passed the test for normality (Ryan-Joiner/ Shapiro-Wilk). However, the test for homogeneity of variance (Levenes) failed. Figure D2 shows that the KL1 sampling location has much lower variance in TP measurements. The consequence of heterogeneity of variance is to reduce the power of the ANOVA (lower likelihood of rejecting the null hypothesis if it is false). An ANOVA was conducted and the null hypothesis was not rejected (α = 0.05). However, heterogeneity of variance could have weakened the test and contributed to the rejection of the null hypothesis.

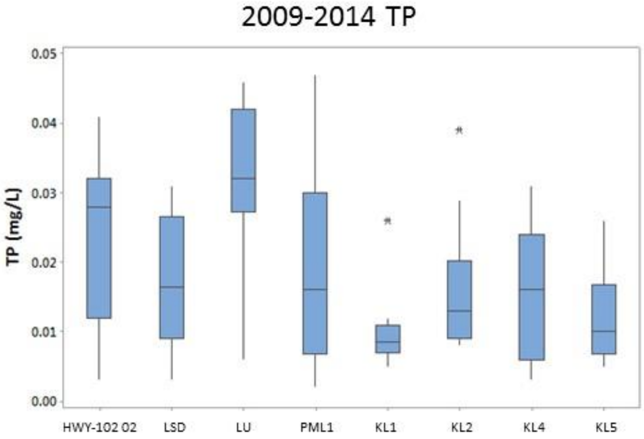


Figure D2: **Boxplot for the sampling locations of the 2009-2014 TP data set which show no linear trends. The boxes show the distribution of values for each sampling location. The horizontal black line in each box is the median TP for that location. The upper and lower limits of the box represent the first and third quartiles. The first quartile splits the lowest 25% of the data, whereas the third quartile splits the upper 75% of the data. The vertical lines (or "whiskers") extend to the minimum and maximum data points (excluding outliers). The asterisks represents outliers.**

Minitab ANOVA results:

```
Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05
Rows unused             27

Factor Information:
Factor  Levels  Values
Factor       4  KL1, KL2, KL4, KL5

Analysis of Variance:
Source   DF    Adj SS    Adj MS  F-Value  P-Value
Factor   3  0.000332  0.000111     1.67    0.189
```

```
Error    41  0.002727  0.000067
Total    44  0.003059

Model Summary
        S     R-sq  R-sq(adj)  R-sq(pred)
0.0081548   10.86%      4.34%       0.00%

Means
Factor   N     Mean    StDev        95% CI
KL1      12  0.01000  0.00543  (0.00525, 0.01475)
KL2      14  0.01664  0.00894  (0.01224, 0.02104)
KL4      11  0.01526  0.01014  (0.01030, 0.02023)
KL5       8  0.01212  0.00692  (0.00630, 0.01795)

Pooled StDev = 0.00815481
```

iii. 2009-2014 data set: Event of Summer 2012

Figure D3 shows that Summer 2012 has higher measurements of TP than do other events. It would have been ideal to determine whether this is a statistically distinct event by performing an ANOVA (to determine whether the Summer 2012 TP measurements are part of the same population as TP measurements on other days). However, an ANOVA could not be performed because of the disparate variances (even if the outliers are removed, the variances are still too heterogeneous). Therefore, it was not possible to confirm whether Summer 2012 is a statistically distinct "event".

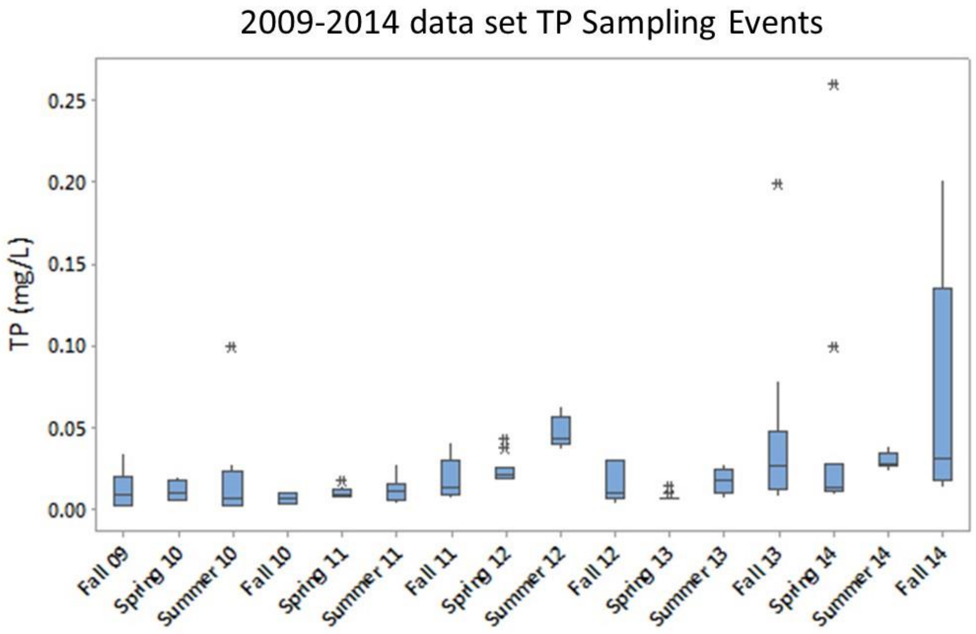


Figure D3: **Boxplot of 2009-2014 TP Sampling Events. The horizontal black line in each box is the median TP for that location. The upper and lower limits of the box represent the first and third quartiles. The first quartile splits the lowest 25% of the data, whereas the third quartile splits the upper 75% of the data. The vertical lines (or "whiskers") extend to the minimum and maximum data points (excluding outliers). The asterisk represents an outlier in the Paper Mill Lake data set.**

APPENDIX E

Abnormally High TP Measurements

The 2009-2014 data set contains high, isolated measurements, some of which are statistical outliers (> 2 σ from the mean; Figure 2). This means that the oligotrophic-mesotrophic threshold is exceeded more in the 2009-2014 data set than in the 2006-2011 data set (Table E1).

Table E1: Percentage of Measurements that Exceed the Oligotrophic-mesotrophic Threshold of 0.010 mg/L (CCME 2004)

Monitoring Program	Year	Total Number of Measurements	Number of Times that the Threshold is Exceeded	Percentage of Measurements that Exceed the Threshold
HRM Water Quality Monitoring Program	2006-2011	27	3	11
Bedford West Monitoring Plan	2009	12	8	67
	2010	23	6	26
	2011	29	14	48
	2012	30	25	83
	2013	32	18	56
	2014	31	29	94

Some of the hypothesised causes of these abnormally high measurements include:

- **Problematic locations?** Abnormally high measurements do not always occur at the same sampling stations, and therefore are harder to attribute to point sources, edge effects, or other spatial considerations;
- **Problematic sampling days?** During some sampling events, the abnormally high measurements occur only in one location. During other events, they are present in up to 3 locations. Usually, the sampling locations without the abnormality(ies) are not particularly elevated in TP. Therefore, it was not possible to isolate unusual “events” (e.g., caused by problematic weather conditions). AECOM (2013) reports that the high TP concentration measured on October 16, 2011, followed a 21.6 mm rain event on October 14, 2011 and wet weather the first two weeks in October. However, high TP measurements were only observed at one location on this date (Highway-102 Site 02). Summer 2012 was the only sampling date where TP measurements were elevated across several sampling locations, ANOVA could not be used to show that the difference in TP measurements was statistically significant (Appendix C);
- **Problematic seasonal variation?** Although TP is known to vary with seasonal conditions (e.g., snowmelt, low flow conditions in waterways, lake stratification), there is no correspondence in the 2009-2014 data set of abnormally high values with the time of year. This is consistent with the lack of seasonality in the 2006-2011 data set (Appendix B); and
- **Measurement errors?** The abnormally high values consistently fall within a certain range, suggesting that they cannot be data entry errors. Some measurements are > 0.1 mg/L, but others are only > 0.06 mg/L. There is no basis for excluding the abnormal measurements based on measurement error.

> Nothing atypical was recorded in field reports, and both sampling programs use spectrophotometry to analyse for TP in the laboratory. Problems can arise during the transfer of sample from the sampling container to the analytical vessel, as bacteria containing phosphorous and algae adhere strongly to the container wall. However, the result is a consistent underestimate of the TP in the sample. Could this have been a problem with the 2006-2011 data set? Although AECOM (2013) report that surface water samples were collected and placed in clean laboratory-supplied jars and stored in a chilled container, it is unclear whether this sampling protocol was used for both data sets.

As mentioned in the main text of this report, there is a discrepancy when the 2006-2011 and 2009-2014 data sets overlap (2009-2011). This may be because the 2006-2011 and 2009-2014 data set TP measurements were not obtained at the same locations. In particular, the 2006-2011 TP measurements for Kearney Lake were obtained from the center of the lake, whereas KL1 is from near the inflow, KL2 is from the northwestern portion of the lake in Black Duck Brook, and KL3 and KL4 are from the outflow of Kearney Lake into Paper Mill Lake. Similarly, the 2006-2011 TP measurements for Paper Mill Lake were obtained from the outlet, whereas the 2009-2014 TP measurements were sampled from the inflow (PML1) and the northwestern basin of the lake (PML2). Nearshore areas or isolated embayments may not display values that are typical of whole lake values even though the lake is considered 'theoretically' to be mixed. In any case, the 2006-2011 and 2009-2014 data sets are difficult to compare because the sampling locations are different.

Note that this discrepancy between the data sets is likely the cause for the apparent shift in variability. A shift to higher TP values, from the 2006-2011 TP, seems to have occurred around late 2011, but since this coincides with a shift in the data set, it cannot be ruled out that the change in variability is due to a change in methodology (e.g., location). It is also possible that the overall range (or variability) of concentrations during recent years has increased compared to during 2006-2011. Increases in TP are accompanied by increases in TP variability, since TP often enters waterbodies at point sources; however, this cannot be determined with the available data.

Table E2: Abnormally high TP Values in the 2009-2014 data set. The Bolded values were excluded from analysis. Measurements > 0.1 mg/L are highlighted in pink.

Sampling Date	HWY 102-01	HWY 102-02	LSD	LU	PML1	PML2	KL1	KL2	KL3	KL4	KL5
29/06/2009	**0.070**	0.020									
13/08/2009	**0.140**	0.040	0.030								
01/10/2009	0.020	0.034	0.009		0.002	0.002		0.020	0.005		
31/05/2010	0.006	0.010	0.018		0.018	0.010	0.009	0.020	0.005	0.004	
24/08/2010	0.007	0.028	**0.100**		0.002	0.002	0.007	0.009	0.002		
01/11/2010	0.011	0.003	0.009				0.005	0.009	0.003		
13/05/2011	0.009	0.009	0.018		0.014	0.009	0.008	0.009	0.008	0.007	
14/08/2011	0.012	0.019	0.028		0.011	0.009	0.012	0.008	0.003	0.003	
16/10/2011	0.010	0.041	0.014	0.034	0.030	0.007	0.009	0.013	0.012	0.026	0.009
01/05/2012	0.019	0.021	0.022	0.043	0.019	0.025	**0.037**	0.021	0.019	0.022	0.018
15/08/2012	0.039	0.054	**0.063**	0.036			**0.043**	**0.059**	**0.045**	0.043	**0.040**
11/10/2012	0.020	0.030	0.003	0.030	0.030		0.007	0.013	0.007	0.007	0.006
15/05/2013	0.006	0.014	0.007	0.006	0.006	0.006	0.007	0.010	0.006	0.006	0.005
15/08/2013	0.021	0.028	0.015	0.027	0.007		0.011	0.020	0.006	0.024	0.013
16/10/2013	0.022	**0.199**	**0.078**	0.046	0.047	0.026	0.008	0.029	0.012	0.016	0.010
14/05/2014	0.013	0.028	**0.100**	**0.260**	0.012	0.011	0.011	0.013	0.009	0.022	0.010
14/08/2014	**0.038**			0.028	0.030	0.026	0.026	0.039	0.023	0.031	0.026
27/10/2014	0.031	**0.201**	0.031	0.039	0.021	0.018	0.013	0.025	**0.148**	0.015	**0.135**

APPENDIX F

Three-year Running Means

Three-year running means were calculated for both 2006-2011 and 2009-2014 data sets and are reported in Table F1 and Figure F1. The error reported in Table F1 is at one standard deviation (1 σ), and represents the variation between all measurements taken during the three-year periods. The averages in Figure F1 are plotted according to the middle year of the three-year average. These results show a TP increase in some locations, as well as an increase in the overall variability of TP, as reported and discussed in the main text.

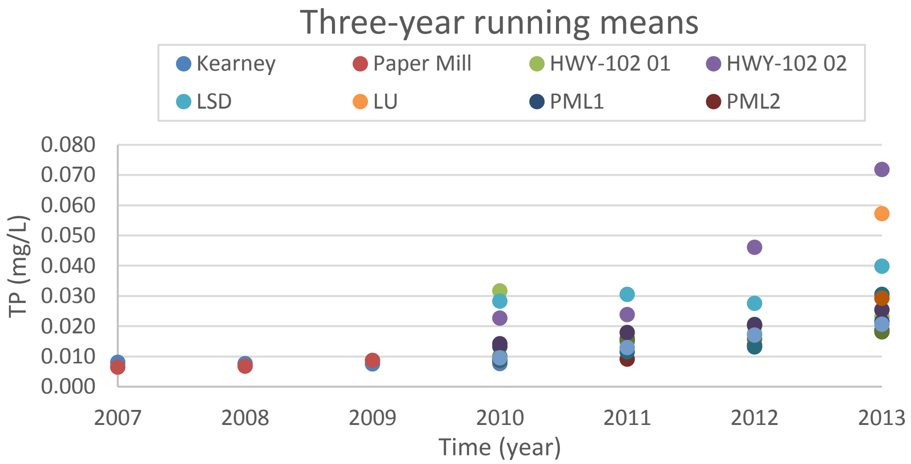


Figure F1: **Three-year Running Means**

Table F1: Three-year Running Means

	2006-2011 Data Set		2009-2014 Data Set										
	Kearney	Paper Mill	HWY 102-01	HWY 102-02	LSD	LU	PML1	PML2	KL1	KL2	KL3	KL4	KL5
2006-2008	0.008±0.002	0.007 ±0.002											
2007-2009	0.008±0.002	0.007 ±0.002											
2008-2010	0.008±0.002	0.009 ±0.005											
2009-2011	0.008±0.003	0.009 ±0.005	0.032 ±0.045	0.023 ±0.014	0.028 ±0.030		0.013 ±0.010	0.009 ±0.007	0.010 ±0.006	0.014 ±0.006	0.009 ±0.007	0.010 ±0.010	
2010-2012			0.015 ±0.010	0.024 ±0.016	0.031 ±0.031		0.016 ±0.011	0.009 ±0.008	0.015 ±0.014	0.018 ±0.016	0.012 ±0.014	0.013 ±0.014	
2011-2013			0.018 ±0.010	0.046 ±0.059	0.028 ±0.026		0.021 ±0.014	0.014 ±0.009	0.016 ±0.014	0.020 ±0.016	0.013 ±0.013	0.017 ±0.013	
2012-2014			0.023 ±0.011	0.072 ±0.080	0.040 ±0.036	0.057 ±0.077	0.022 ±0.014	0.019 ±0.009	0.018 ±0.014	0.025 ±0.015	0.031 ±0.043	0.021 ±0.010	0.029 ±0.041

APPENDIX G

Comparison of TP to Rainfall

One characteristic of the 2009-2014 data set is the occurrence of occasional, abnormally high TP measurements, which are considerably higher than other measurements. Figure 4 illustrates how these measurements are more prevalent in the post-development data set, and Figure 2 shows how they strongly influence linear trends. The measurements considered to be abnormally high are summarized in Table E1. Refer to Appendix E for a list of their possible causes.

One plausible cause is the flushing of nutrients into the lake during high rainfall events. This possibility was explored by plotting measured TP measurements against Environment Canada daily rainfall data (Figure G.1; rainfall data available until 2012). No correlation between TP and rainfall could be identified.

The abnormally high measurements are not associated with a strong temporal pattern. During some sampling events, the abnormally high measurements occur only in one location. During other events, they are present in up to 3 locations. Usually, the sampling locations without the abnormality(ies) are not particularly elevated in TP. For example, although AECOM (2013) report that the high TP concentration measured on October 16, 2011 followed a 21.6 mm rain event on October 14, 2011 and wet weather the first two weeks in October, high TP measurements were only observed at one location on this date (Highway-102 Site 02). August 15, 2012 was the only sampling date where TP measurements were elevated across several sampling locations (Figure G.1), but ANOVA could not be used to show that the difference in TP measurements was statistically significant (Appendix D).

The discrepancy between the 2006-2011 and 2009-2014 data sets during the period of overlap (2009-2011) may provide clues as to the cause of the abnormally high measurements. During 2009-2011, unusually high measurements occur in the 2009-2014 data set but are generally absent from the 2006-2011 data set (Figure 4). Hence, what is causing the abnormally high measurements is affecting the 2009-2014 data set but not the 2006-2011 data set. For example, differences in location or methodology could be causing the occurrence of abnormally high measurements in one sampling program but not the other (see discussion in Appendix E).

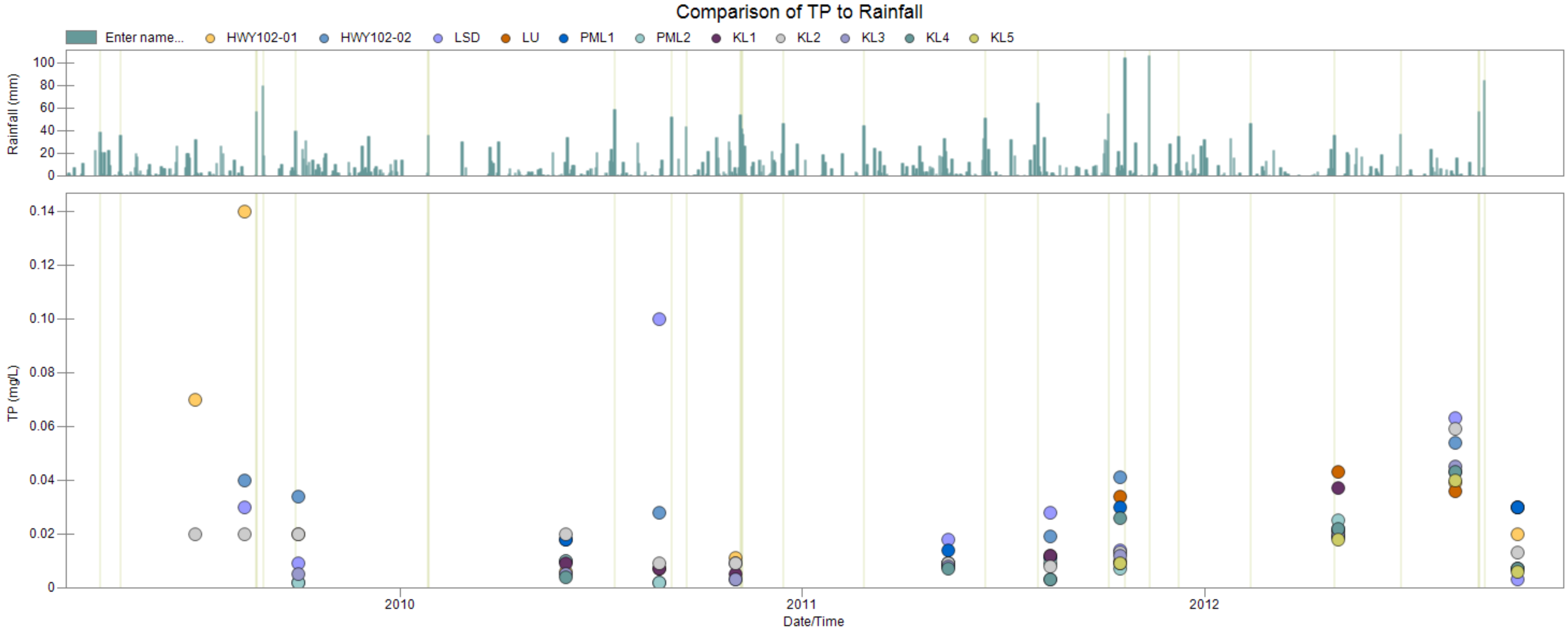


Figure G1: **Comparison of TP to Rainfall. Rainfall data obtained from Environment Canada.**

APPENDIX H

Considerations for trophic status monitoring

The type and resolution of monitoring should be designed to address the water quality management objectives. This appendix presents several considerations for sampling which must be viewed in light of management objectives. These sampling considerations also require careful evaluation of site-specific characteristics.

i. Sampling locations: management goals

Water quality management objectives have an important bearing on sampling location. Lake-based and inflow-based sampling programs are two approaches which meet different water monitoring objectives. If the objective is to establish the state of the lake and the health of the ecosystem, a lake-based approach is more appropriate. Sampling within the lake shows how the lake is responding to nutrient inputs. However, if the objective is to monitor inflows into the lake, an inflow-based approach is more appropriate. Sampling at the inflows into the lake (e.g., outflows from development areas) will help identify causes of lake enrichment. Whereas sampling within the lake gives an indication of average conditions, sampling at the inflows is more likely to capture spikes in concentrations. The disadvantage of an inflow-based approach is that it does not show how the lake system is responding as a whole (i.e., through increased biological productivity, decreased oxygen levels, etc.).

ii. Sampling locations: long-term consistency

Long-term monitoring enables a better characterization of inter-annual variability. Therefore, it is important for earlier data to be comparable to more recent data. In this report, it was identified that the 2006-2011 and 2009-2014 data set TP measurements were not obtained at the same locations. In particular, the 2006-2011 TP measurements for Paper Mill Lake were obtained from the outlet, whereas the 2009-2014 TP measurements were sampled from the inflow (PML1) and the northwestern basin of the lake (PML2). The 2006-2011 TP measurements for Kearney Lake were obtained from the center of the lake, whereas KL1 is from near the inflow, KL2 is from the northwestern portion of the lake in Black Duck Brook, and KL3 and KL4 are from the outflow of Kearney Lake into Paper Mill Lake.

Figure H2 shows these differences in station location in Kearney Lake in context of the location of outfalls into the lake. For instance, the figure shows that KL2 is at the outlet of Black Duck Brook. It it therefore likely highly influenced by the brook and less representative of average lake conditions. KL1, near the inflow, is in the narrow southeastern portion of the lake. Nearshore areas or isolated embayments may not display values that are typical of whole lake values even though the lake is considered 'theoretically' to be mixed.

For these reasons, the 2006-2011 and 2009-2014 data sets are difficult to compare because the sampling locations are different. It the goal is to compare new measurements to the 2006-2011 data set, it is highly recommended that the original 2006-2011 station locations be re-instated in the future (and supplemented by other station locations).

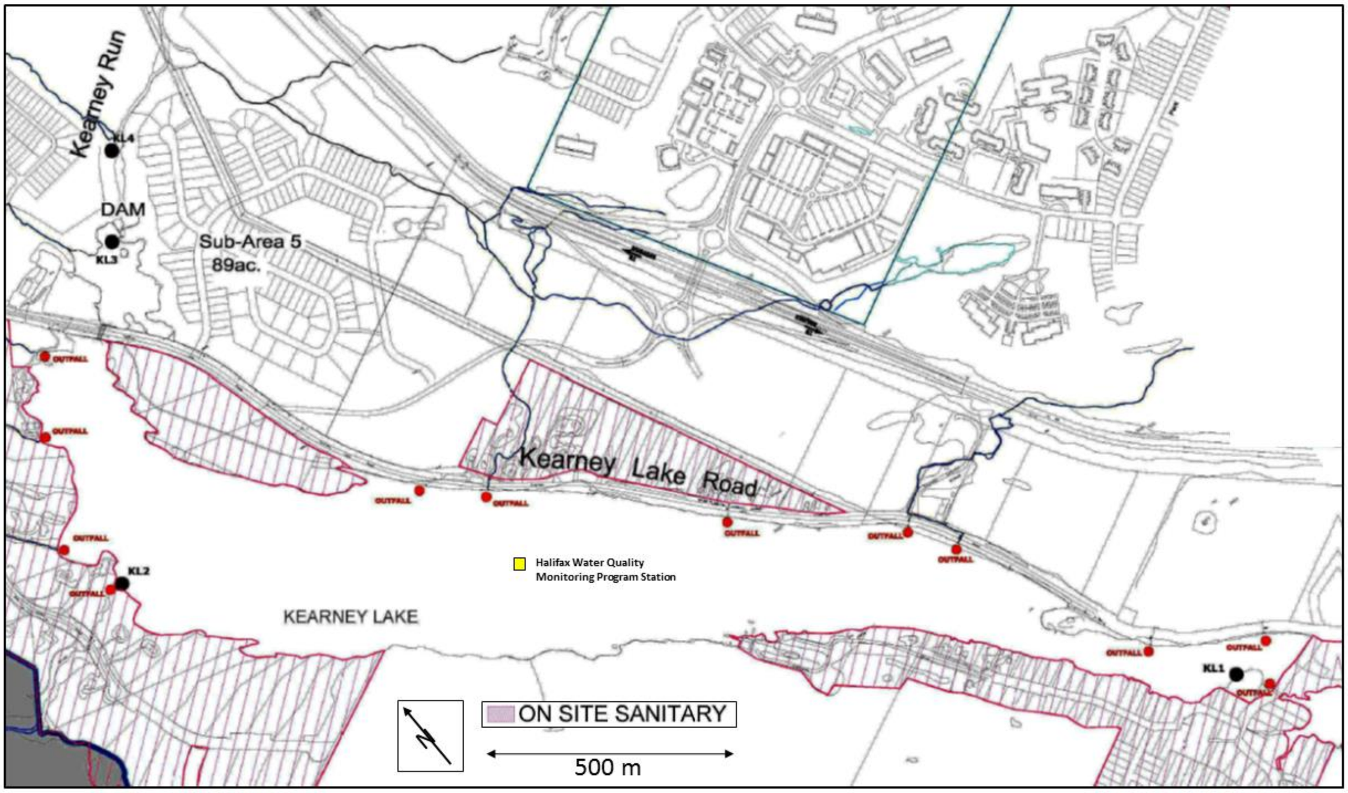


Figure H1: **Change of sampling station locations (map modified from Stantec, 2015).**

iii. Choosing trophic status indicators

Although TP is the most commonly measured indicator for monitoring changes in trophic status, several other water quality indicators are also habitually used. Indicators of eutrophication can either be biological (measures of biomass) or chemical (measures of compounds essential to the growth and survival of living organisms). For instance, chlorophyll a, bottom water oxygen, and nitrogen are three indicators of eutrophication (Table H1). Chlorophyll a is a measure of phytoplankton production in the lake. The maximum chlorophyll value, which occurs during spring turnover, reflects the biological phytoplankton response of the lake to nutrient enrichment. The deficit in bottom water oxygen shows how the lake's chemistry is responding to biological productivity. Total Nitrogen indicates whether there are inputs of fertilizer or sewage to the lake.

The relevance of different water quality indicators for assessing trends in the eutrophication of a given lake depends on the local characteristics of the site. For example, a lake rich in pondweed, which tends to be abundant in lakes dominated by shallow water, will likely show increases in pondweed when exposed to increases in nutrient loading. Changes in pondweed in such a lake are therefore a good indicator of changes in eutrophication. In contrast, a lake poor in pondweed is likely to show greater changes in the concentration of chlorophyll a, because the nutrients are primarily being used for algae growth.

Since several water quality parameters have been monitored as part of the Halifax Water Quality Monitoring Program, it could be useful to consider them in addition to TP when assessing trends in the eutrophication of Kearney and Paper Mill Lakes. Several indices have been developed to combine different water quality indicators and provide a more comprehensive reflection of the lake system (e.g., Carlson 1977, Cheng and Li 2006). Carlson's index is one of the more commonly used trophic indices and is used by the US Environmental Protection Agency.

Table H1: Trophic status indicators.

Indicator	Sampling Requirements	Usefulness
Maximum chlorophyll	Must be sampled during lake turnover	Reflects biological phytoplankton response of the lake to enrichment in addition to any potential water quality problems.
Mean chlorophyll		Gives an average response of the lake to enrichment.
Bottom water oxygen deficit	Deep sampling	Shows how the lake's chemistry is responding to biological productivity. Gives a measure of the health of the lake as an ecosystem.
Secchi depth	-	Measures the water transparency and is only a very rough indicator of the trophic status of the lake.
Nitrogen (NO_3^- or Total Nitrogen)	-	Gives insight as to whether there are inputs of fertilizer and/or sewage. Provides a measure of an important nutrient for plant growth, in addition to phosphorus.
Conductivity	-	Indicates increased mineralization and only provides limited information about trophic status.

The relevance of different water quality indicators for assessing trends in the eutrophication of a given lake depends on the local characteristics of the site. For example, a lake rich in pondweed, which tends to dominate in lakes with lots of shallow water, will likely show increases in pondweed when exposed to increases in nutrient loading. Changes in pondweed in such a lake are therefore a good indicator of changes in eutrophication. In contrast, a lake poor in pondweed is likely to show greater changes in the concentration of chlorophyll a, because the nutrients are primarily being used for algae growth.

Since several water quality parameters have been monitored as part of the Halifax Water Quality Monitoring Program, it could be useful to consider them in addition to TP when assessing trends in the eutrophication of Kearney and Paper Mill Lakes. Several indices have been developed to combine different water quality indicators and provide a more comprehensive reflection of the lake system (e.g., Carlson 1977, Cheng and Li 2006). Carlson's index is one of the more commonly used trophic indices and is used by the US Environmental Protection Agency.

iv. Sampling at different depths and during different seasons

The stratification cycle of lakes has a major influence on nutrient concentrations. As the sun warms the surface of deeper lakes, the temperature difference between the upper and lower layers increases (Figure H1). The temperature difference eventually creates a physical force (i.e., difference in density) strong enough to resist the mixing force of the wind. The stratification continues until fall when surface waters cool and begin to sink. The surface waters can cut off the exchange of oxygen with the atmosphere from deeper layers, which in turn affects the solubility of nutrients from the bottom sediments (e.g., phosphorus is more soluble in anoxic bottom water).

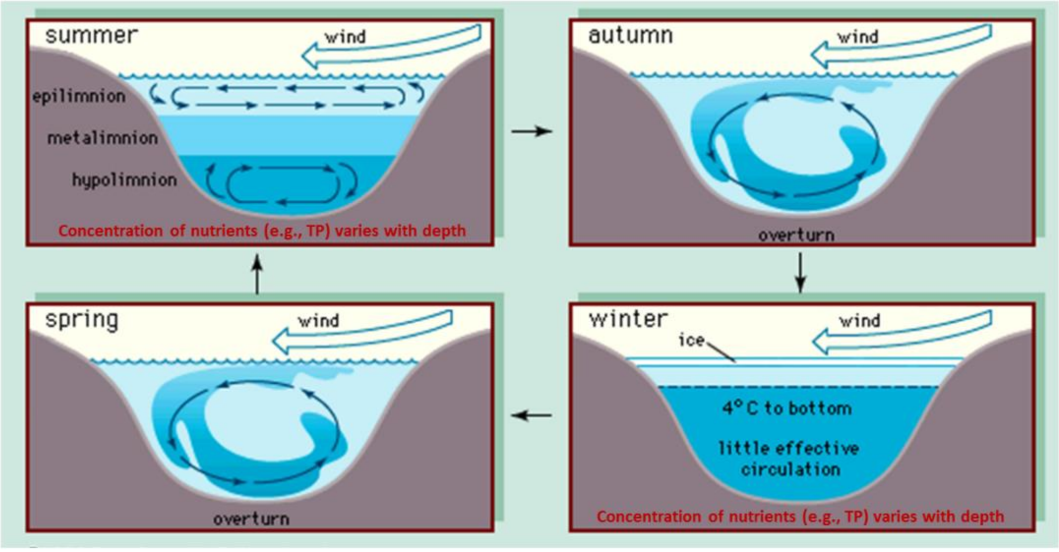


Figure H2: **Seasonal lake stratification (image from Encyclopedia Britannica, Inc., 1996).**

Therefore, the timing of sampling (i.e., degree of stratification) dictates whether the measurement represents average lake conditions or the conditions of a sublayer. For example, sampling a stratified lake during spring overturning conditions will capture the peak in TP. A good strategy is to focus monitoring efforts at this time, and to track maximum TP concentrations. However, the stability of stratification varies from lake to lake, depending on factors such as the lake's depth, shape, size, orientation to the wind, and inflows and outflows. Thus, Kearney and Paper Mill Lakes may not stratify to the same extent, or at the same time. Hence, the selection of how TP (and other water quality indicators) should be monitored in Kearney and Paper Mill Lakes requires careful consideration of the respective local characteristics of these lakes. Seasonality was investigated for Kearney and Paper Mill Lakes in Appendix B, but no strong patterns were identified (possibly due to insufficient data paired with high variability).

The Halifax Water Quality Monitoring Program (2006-2011) had "deep water TP" sampling stations (Table H2). However, as stated in Stantec's 2012 review of the program, "data from deep water TP stations were not consistently available". Stantec identified this as one of several limitations with the water quality data. Over the course of 2006-2011, only 19% of measurements for deep water TP in Kearney Lake were successful (1 in the spring and 3 in the fall, and therefore none during potentially stratified summer conditions). No deep TP data was recorded for Paper Mill Lake. This may be because both lakes are shallow, Paper Mill Lake being more shallow than Kearney Lake. However, data from other lakes in the sampling program is also sparse. The lack of data may thus be due to challenges associated with obtaining deep measurements. The cause for missing data should be investigated.

Table H2: **Kearney and Paper Mill Lakes Deep Phosphorus Data.**

		2006			2007			2008			2009			2010			2011		
		Sumer	Fall	Fall	Spring	Sumer	Fall	Spring	Sumer	Fall	Spring	Sumer	Fall	Spring	Sumer	Fall	Spring	Sumer	Fall
Kearney	1m depth	0.006	--	ND	0.005	0.009	ND	0.009	0.008	0.011	0.004	0.007	--	0.009	0.007	0.005	--	0.008	0.013
	deep		--			0.008			0.01			0.003					--	N/A	
Paper Mill	1m depth	0.007	--	0.006	0.005	0.004	0.004	0.009	0.007	0.01	0.006	0.009	--	0.018	0.002	ND	--	0.009	0.007
	deep		--			N/A			--			N/A			--		--	N/A	

v. Sampling resolution

Lastly, water quality management objectives also determine the level of uncertainty that is acceptable. For example, if a given trend must be statistically significant at α=0.05 in order for a action to be taken, then the temporal resolution, spatial resolution, consistency of monitoring, and total time of monitoring must be sufficient to characterize the trend at that level of significance (this will also depend on how much natural and human-induced variability is present).

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Attachment B

Final Report:
Paper Mill Lake Watershed Assessment

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List of Abbreviations

%	Percent
<	Less Than
$\mu g\ L^{-1}$	Micrograms per litre
BMP	Best Management Practice
BW-SPS	Bedford West Secondary Planning Strategy
CABIN	Canadian Aquatic Biomonitoring Network
$CaCO_3$	Calcium Carbonate
CBCL	Canadian British Consultants Limited
CCME	Canadian Council of the Ministers of the Environment
Chl *a*	Chlorophyll *a*
CWRS	Centre for Water Resources Studies
d	Day
DNR	Department of Natural Resources
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EU	European Union
Fe	Iron
g	Gram
GIS	Geographic Information Systems
ha	Hectare
HPCL	High Performance Liquid Chromatography
hr	Hour
HRM	Halifax Regional Municipality
JWL	Jacques Whitford Limited

kg	Kilogram
KL	Kearney Lake
km	Kilometre
m^2	Metre Squared
mg	Milligram
mL	Millilitre
N	Nitrogen
NSE	Nova Scotia Environment
NSTDB	Nova Scotia Topographic Data Base
NTU	Nephelometric Turbidity Units
^{o}C	Degrees Celsius
OECD	Organization for Economic Cooperation and Development
ORP	Oxidation-Reduction potential
P	Phosphorus
PML	Paper Mill Lake
q_s	Hydraulic Load
RUSLE	Revised Universal Soil Loss Equation
SD	Secchi Depth
TN	Total Nitrogen
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total suspended solids
WFD	Water Framework Directive
WQI	Water quality index
WRT	Water retention time

yr	Year
$z_{eu}/\overline{z}$	Euphotic Zone Depth/Mean Depth

Executive Summary

This report documents the findings from a desktop assessment of the Paper Mill Lake (PML) Watershed, with a specific focus on characterizing sources of phosphorus (P) loading and approaches for monitoring trophic state drivers and indicators within the watershed. This study was initiated in response to recent data generated from a regulatory water quality monitoring program which indicated that total phosphorus (TP) concentrations in Kearney Lake (KL) and PML were exceeding the regulatory threshold of 10 µg L^{-1}. This study focused on developing answers to five questions:

1. What are the largest sources of P to KL and PML?
2. What role does internal loading have on TP concentrations in KL and PML?
3. What type of monitoring program would be required to track P loading over time from the Bedford West Subdivision? How can P export coefficients for the PML Watershed be validated?
4. How should the trophic state of KL and PML be monitored?
5. What are the consequences of adopting alternative water quality thresholds for regulating activities within the PML Watershed?

Question 1: What are the largest sources of P to KL and PML?

The relative influence of a suite of potential P sources were assessed using an updated P loading model originally developed for the PML Watershed by Scott & Hart (2004). The relative influence, uncertainty and sensitivity of existing, continuous sources within the watershed, as well as intermittent P loading from construction activities, were evaluated with respect to their potential to increase average annual TP concentrations in KL and PML. Key findings from this component of the study are summarized in the following list.

- When examining the sources of P to KL, upstream sources account for approximately 31 % of the total P load, with KL sub-watershed sources contributing 69 % of the total load. When examining the sources of P to PML, upstream sources account for 78% of the total P load, with PML sub-watershed sources contributing 22% of the load. This illustrates that the TP concentration in PML is heavily influenced by P sources that originate upstream of the PML sub-watershed.
- Within the KL sub-watershed, the three largest sources of P, in decreasing load, were determined to be septic systems, and runoff export from residential and industrial developments. Within the PML sub-watershed, the three largest sources of P, in

decreasing load, were determined to be runoff export from residential and industrial developments, and runoff export from forested landscapes.

- When accounting for all potential sources of P to KL (upstream and sub-watershed) the sources that had a significant effect (> 3 µg L^{-1}) on in-lake mean TP concentrations are septic systems, upstream sources and runoff export from residential development within the sub-watershed.
- When accounting for all potential sources of P to PML (upstream and sub-watershed) the sources that had a significant effect (> 3 µg L^{-1}) on in-lake mean TP concentrations are upstream sources, septic systems and runoff export from residential development within the sub-watershed.
- The repeated draining of PML during the summers of 2012, 2013, and 2014 could have caused short-term increases in the concentrations of TP after the lake was allowed to refill in the fall upon completion of works for each year. There are both biological and chemical mechanisms that could have mobilized P from sediments during the draining/refilling process. It is not possible to quantify the magnitude of this impact due to the fact that the necessary data was not collected prior to and after draining PML.
- The P loading assessment was based on the use of literature-derived phosphorus export coefficients. The largest sources of uncertainty were found to be in: (i) estimating export coefficients from residential land-use, (ii) estimating the water quality performance of stormwater best management practices (BMP)s, and (iii) estimating the retention of phosphorus in on-site wastewater treatment systems. A sensitivity analysis demonstrated that predicted equilibrium TP concentrations in KL and PML could change by >+/- 100% depending on the selection of P export coefficients and septic system P retention coefficients.
- The primary conclusion that can be made from the loading assessment is that there are several different sources of P within the PML watershed that can influence the TP concentration in KL and PML. Given the level of uncertainty associated with characterizing the magnitude of these sources, and quality/quantity of monitoring data available for the watershed, it is not possible to identify any one source as the primary cause of recent TP increases.

Question 2: What role does internal loading have on TP concentrations in KL and PML?

Internal loading of P refers to the release of P from lake bed sediments into the water column. This process is primarily driven by the development of anoxic conditions at the sediment-water interface. To assess the potential for this to occur, historical monitoring data from 2005 was used to delineate the spatial extent and duration of anoxia within KL and PML. Data collected in July of 2016 suggest that anoxic conditions at specific locations in both lakes may occur annually. Key findings from this component of the study are listed as follows.

- The internal load of P associated with anoxic conditions was predicted to have a negligible effect on TP concentrations in both lakes. This was due to the fact that the duration and delineated spatial extent of anoxia was relatively small.
- The potential for internal loading could be tracked in future monitoring programs through the collection of vertical profiles of temperature, dissolved oxygen and TP concentrations throughout the ice-free season (minimum monthly sampling frequency).

Question 3: What type of monitoring program would be required to track P loading over time from the Bedford West development? How can P export coefficients for the PML Watershed be validated?

The current regulatory monitoring program for the Bedford West Development is based on TP concentrations measured in the receiving water bodies. As these water bodies are influenced by several other sources of P in addition to Bedford West, it is thought that directly measuring the P load leaving the Bedford West site would be a more appropriate monitoring approach. The type of monitoring program required to adequately capture P loading from the Bedford West site was assessed. Key findings from this component of the study are summarized below.

- Measurement of annual P loads originating from the Bedford West development would require intensive sampling of both flow and water quality during all runoff events throughout the year. This would necessitate the installation of equipment for continuous flow measurement and automated water quality sample collection, due to the quick hydrologic response of these urbanized catchments. This would not be practical to implement on the entire Bedford West site as there are approximately 27 individual stormwater discharge locations that would need to be monitored.
- A practical approach for evaluating P loading from the Bedford West site would be to select a sub-set of catchments that represent the dominant types of land-uses and BMPs within the site. These catchments would be intensively monitored over a 2-4 year period. This data could be used to develop validated P export coefficients and BMP performance estimates that could be applied to the remainder of the site. This dataset and information could also be used to evaluate P loading from other current and proposed developments throughout the Halifax regional municipality (the Municipality).

Question 4: How should the trophic state of KL and PML be monitored?

Total P is currently used as the indicator of trophic state within KL and PML. TP is not a direct indicator of biological productivity (trophic state), but rather is a key driver of trophic state, along with several other factors. The use of TP as a trophic state indicator is based on an assumed relationship with chlorophyll *a* values that was developed by the Organization for Economic Cooperation and Development (OECD) several decades ago. An analysis of available data for HRM lakes generated from the HRM corporate monitoring program from 2006-2011 showed that the OECD relationship was generally applicable to HRM lakes, but that some lakes did not appear to conform to the OECD relationship. The original OECD reports also provided a list of lake characteristics that should be examined when determining if their TP:chlorophyll *a* relationship is applicable. It was determined that PML, and to a lesser extent KL, did not fit some of these key criteria. This component of the study recommended a two-fold monitoring approach described as follows.

- Chlorophyll *a*, using the trophic state classification system as proposed by Vollenweider & Kerekes (1982), is recommended as the trophic state indicator for both KL and PML. The recommended sampling program involves biweekly sampling of the euphotic zone during the ice-free period at 2 deep stations within each lake.

- TP should continue to be a component of all future monitoring programs and should remain as a key parameter within any regulatory framework for watershed management as P loading is a key, local anthropogenic driver of trophic state change in HRM watersheds.

Question 5: What are the consequences of adopting alternative water quality thresholds for regulating activities within the PML Watershed?

The current water quality threshold used in management of trophic state in the PML watershed is 10 µg L^{-1} TP, which corresponds with an assumed transition from oligotrophy to mesotrophy. A suite of alternative thresholds was reviewed with respect to their strengths and weaknesses. As well, a literature review was conducted to assess the potential consequences of either lake transitioning to a mesotrophic state. Key findings from this component of the study are listed as follows.

- Potential thresholds for regulating activities and maintaining desired water use objectives in the PML watershed could be based on chlorophyll *a*, TP, or both. It is recommended that both chlorophyll *a* and TP be used within any future regulatory monitoring programs. The strength of this approach is that chlorophyll *a* is a direct indicator of trophic state and P is the key local, anthropogenic driver of trophic state change.

- The current threshold of 10 µg L^{-1} TP is based on maintaining an oligotrophic trophic state. Adjusting the TP threshold to a value that is greater than 10 µg L^{-1} would mean that TP concentrations would already be in the mesotrophic range at the time at which a management review would be initiated. Several previous modeling studies have predicted that the equilibrium concentration of TP in KL and PML would be approximately 20 µg L^{-1} given the current level of development. However, due to the uncertainties currently associated with many of the parameters within P loading models, it is not recommended that a model-based baseline concentration be used as a threshold. An alternative approach would involve establishing a measured baseline concentration of TP in the two lakes prior to the development of Bedford West, and establishing a threshold based on a percentage increase (e.g. 25 or 50%) over this value.

- A transition to mesotrophy within KL and/or PML would result in higher levels of phytoplankton growth, and an increased risk of experiencing a bloom of phytoplankton that produce toxins (cyanobacteria) that could be harmful to both humans and animals.

Additional Conclusions and Recommendations

In addition to the core questions that drove this study, a few additional findings were observed, which are summarized in the following points.

- A meta-analysis of water quality data from the HRM corporate lake monitoring program from 2006-2011 showed that TP is a strong predictor of trophic state, as measured by chlorophyll *a*. This indicates that TP could continue to be used as a general indicator of eutrophication pressure on lakes in HRM. It was also found however, that some lakes did not appear to fit the OECD chlorophyll *a*/TP relationship, and that caution should be used in using TP as the only trophic state indicator within regulatory frameworks.

- It was also noted that there are challenges associated with regulating individual development activities in a watershed based on measurement of trophic state indicators in a receiving water body. Trophic state can be influenced by many factors beyond the nutrient load originating from one specific development. As is the case with the PML watershed, there are several potential P sources, and it is extremely challenging to quantify individual loads with any certainty. As well, there are other factors, such as climate change, that can influence biological productivity and trophic state, which are not associated with watershed activities.

- Any future monitoring program should include sampling of in-lake deep stations in both KL and PML. The evaluation of mean concentrations of trophic state indicators or drivers, either chlorophyll *a* or TP, should be based on computation of volume-weighted concentrations with adequate sampling resolution in the vertical profile.

1.0 Introduction

This report presents results from a desktop assessment of the Paper Mill Lake (PML) Watershed, with a particular focus on sources of phosphorus (P) and monitoring of trophic state in Kearney Lake (KL) and PML. This study was initiated in response to recent data generated from a regulatory water quality monitoring program which indicated that total phosphorus (TP) concentrations in KL and PML were exceeding the regulatory threshold of 10 µg L^{-1}. The primary objective of this study is to provide Halifax Regional Municipality (the Municipality) staff with guidance to respond to the objective of the Bedford West Secondary Planning Strategy, Policy BW-5:

> *"In the event that water quality threshold levels, as specified under clause (c) of policy BW-3, for Paper Mill Lake or Kearney Lake are reached, the Municipality shall undertake an assessment and determine an appropriate course of action respecting watershed management and future land use development in the area. An assessment shall consider the CCME guidelines. Water quality thresholds and any assessment reports shall be made available to the public."*

In support of this primary objective, secondary project objectives are outlined in the following list.

- Identify known and likely sources of P to KL and PML, and the relative magnitudes of these sources where possible.
    - Recommend practical means of validating estimates for the P loading coefficients or annual loads.
- Given available information, assess if P loading is predominately driven by external or internal loading. Recommend any additional studies required to validate the outcomes of the assessment.
- Recommend a water quality monitoring program designed to determine if P loading from the Bedford West development is increasing over time, both over the entire subdivision, and on a sub-area by sub-area basis.
- Recommend an appropriate, reliable, and conventional methodology that the Municipality should adopt to determine the current trophic state of KL and PML, which may or may not necessarily be limited to the use of TP concentrations.

- Outline the potential consequences of adopting alternative water quality management thresholds. Identify factors that may impact trophic status and body contact recreation opportunities.

The Regional Watershed Advisory Board (RWAB) provided direction on project scope and presentation of the study findings. On April 13, 2016 a presentation of the project objectives was made by Dalhousie University to the Municipality's RWAB. A follow up presentation of the study's preliminary findings was provided to the RWAB on August 10, 2016. Comments received during this meeting were incorporated into a draft report, which was provided to the RWAB on September 7, 2016. Dalhousie University attended a meeting with the RWAB on September 14th, 2016, to receive feedback on the draft report. This feedback was incorporated into the final report.

1.1 The Paper Mill Lake Watershed

The PML Watershed is located within the boundaries of the Municipality, north of Timberlea and the Bayers Lake Business Park, and west of peninsular Halifax. Overlying a significant portion of the downstream area of this watershed is the Bedford West subdivision, which is currently under development. Most of this subdivision falls within the PML Watershed, although a small portion drains to the Sackville River Watershed. The latter watershed is not under consideration here. Also within the PML Watershed is a residential and commercial development known as "Bedford South". A delineation of the PML Watershed, including major sub-watersheds, is provided in Figure 1. The Bedford West and Bedford South developments are shown in Figure 2.

A considerable amount of development has taken place within the PML Watershed within the last decade. Aerial photos from 2005 and 2016 are provided (Figure 3) to illustrate how the watershed has changed during this time period. A more detailed depiction of the progression of land development from 2009 to 2015 is illustrated in Figure 4 and Figure 5. Shown are areas within both the Bedford West and Bedford South developments where construction began as of the year indicated. Some years are missing due to lack of easily accessible aerial photos.

Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 1. PML Watershed with major sub-watersheds.

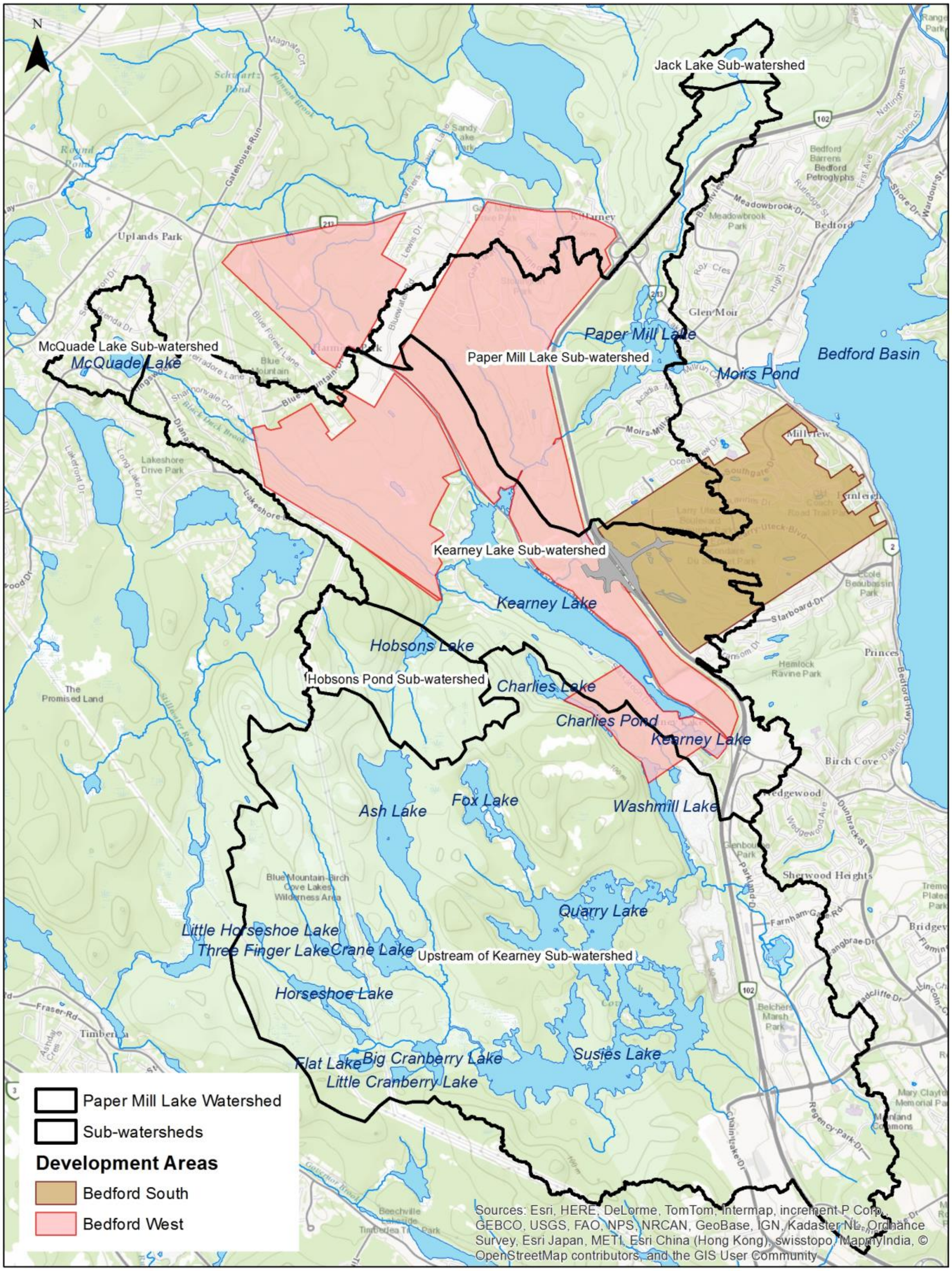


Figure 2. Locations of the Bedford West and Bedford South development areas within the PML Watershed.

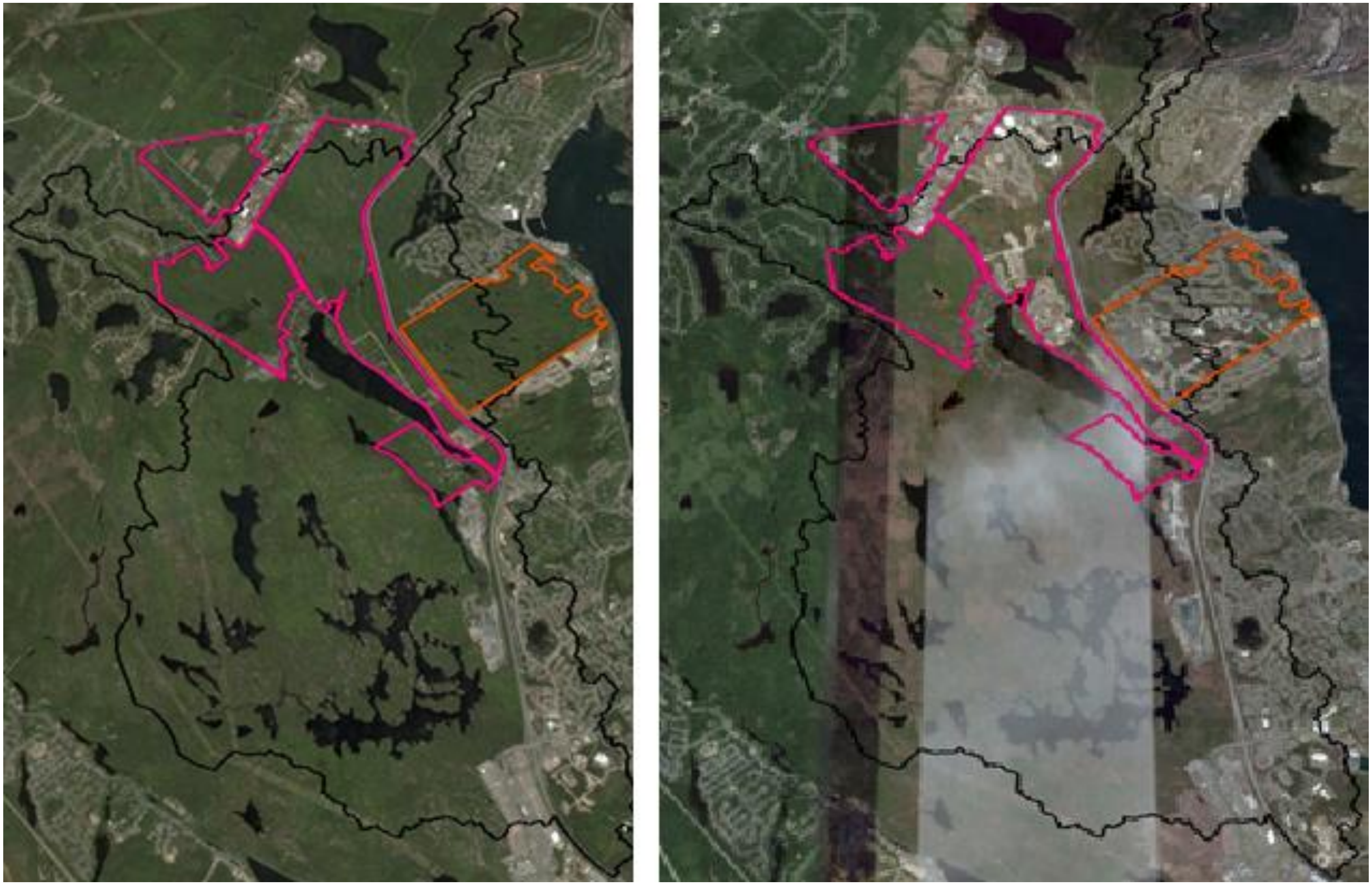


Figure 3. Aerial photographs depicting land-use change in the PML Watershed between 2005 (left) and 2016 (right).

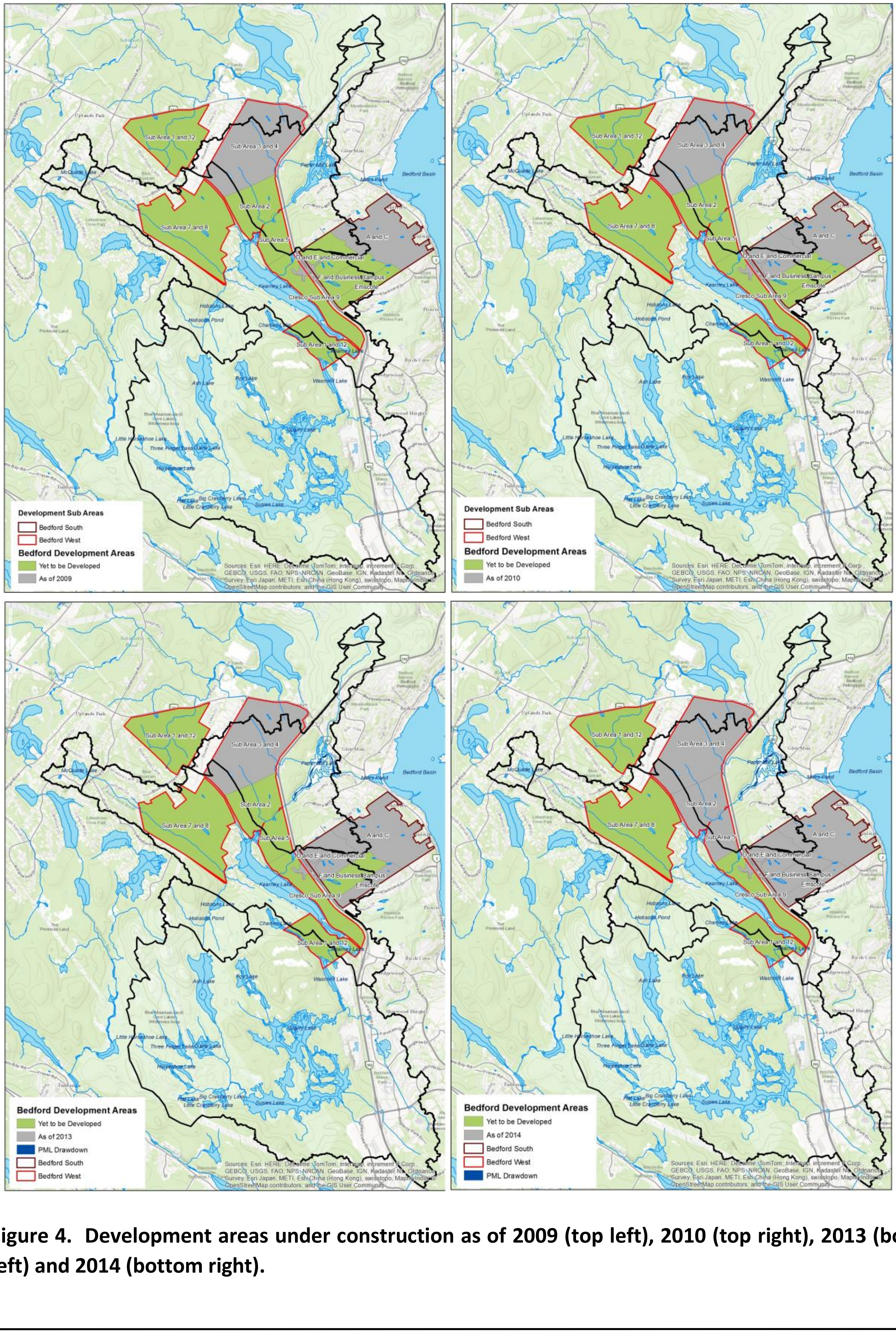


Figure 4. Development areas under construction as of 2009 (top left), 2010 (top right), 2013 (bottom left) and 2014 (bottom right).

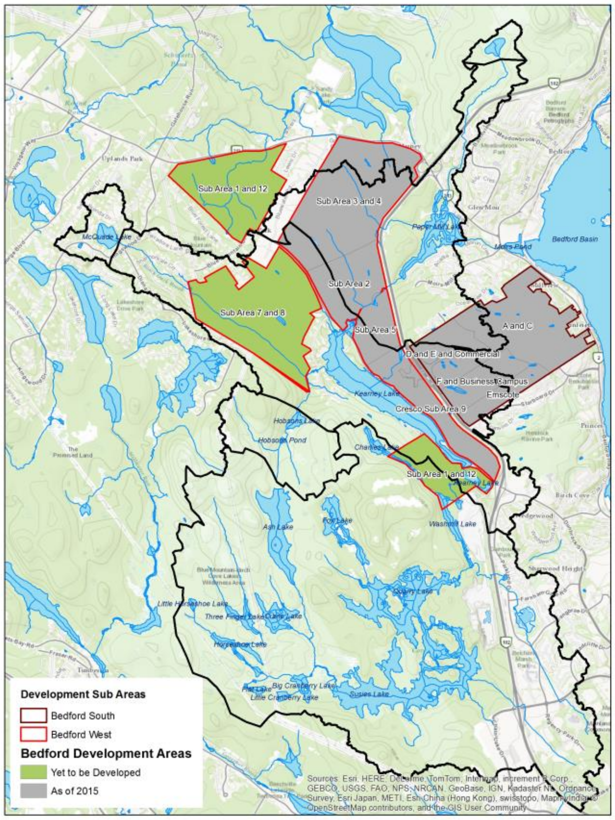


Figure 5. Development areas under construction as of 2015.

1.1.1 Recent Watershed Monitoring Programs

An on-going watershed monitoring program has focused on collection of water quality grab samples from several surface water features within the PML Watershed. Samples are collected from several tributaries to KL and PML, and from the shoreline of both lakes. Several previous consultant reports (SNC Lavalin, 2009-2016; Stantec, 2015; CBCL, 2015) have assessed trends in TP concentrations, and noted that TP concentrations have been frequently exceeding the 10 µg L^{-1} threshold set in Policy BW-3, and that TP concentrations have increased over time.

The data used in this assessment was from HRM's *Seasonal Water Quality Sampling program* (2006-2011) and the Bedford West sampling program conducted by SNC Lavalin (2009-2015). The number of sampling events in any one year was generally 3 (spring, summer, fall) and within the HRM sampling program only a single sample was collected from each lake. The sampling procedures employed within the two programs were also different. Within the HRM program samples were collected from a boat near the deepest part of the lake, while the SNC Lavalin protocol has involved collection of shoreline samples. High intra-annual variability present in TP concentrations observed between 2011-2015, has created considerable uncertainty in mean annual TP concentrations in KL and PML.

Available water quality data for PML was compiled and plotted to illustrate the observed key trends (Figure 6 and Figure 7). Included in the plots are data collected from the HRM corporate lake monitoring program, and data collected as part of the on-going regulatory watershed monitoring program conducted by SNC Lavalin. It should be noted however, that the HRM corporate program involved the collection of in-lake samples at deep stations, while the recent on-going watershed monitoring involves collection of samples from the lake shoreline only. Using this dataset an increasing trend in TP concentrations is evident (Figure 6). Samples collected from 2012 onward suggest that the lake possessed TP concentrations that would be characteristic of a mesotrophic state, with some recent concentrations exceeding 35 ug L^{-1}.

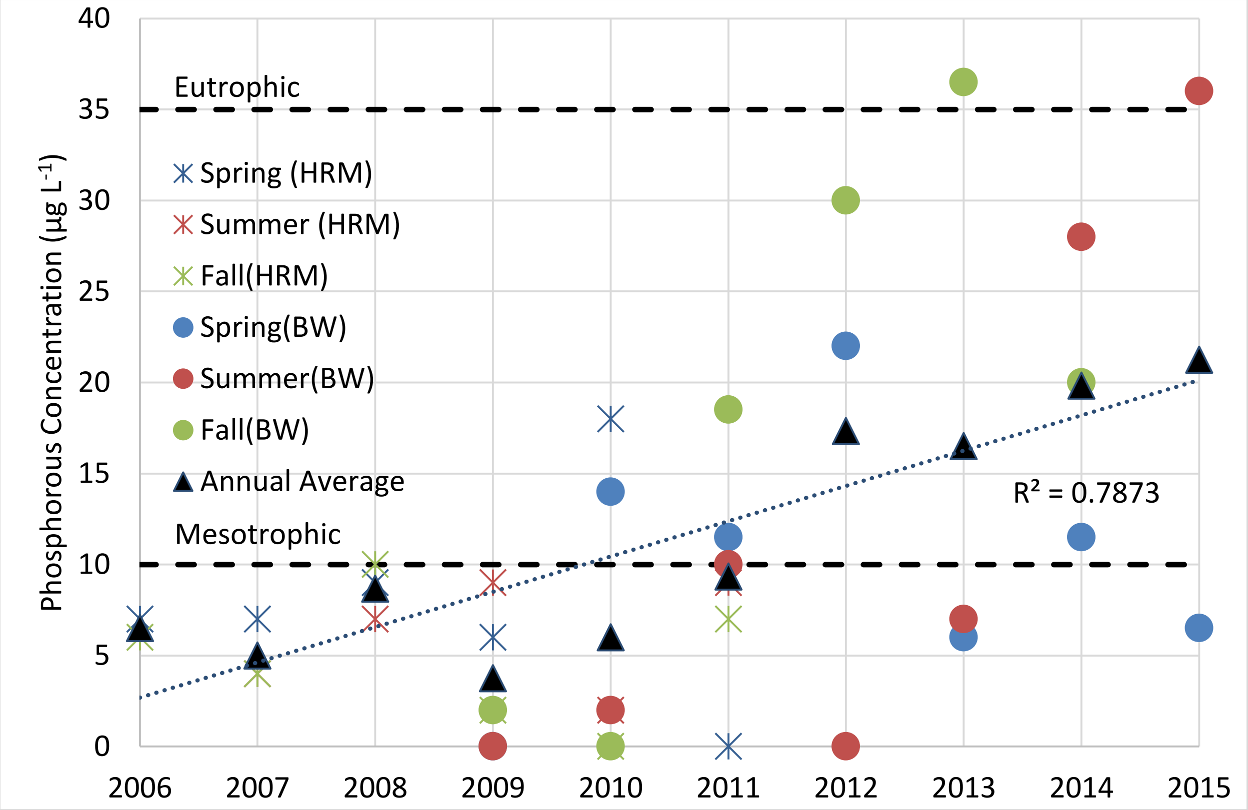


Figure 6. Seasonal and annual TP concentrations in PML 2006-2015. Mesotrophic (0.01 – 0.035 µg L^{-1}) and eutrophic ranges (> 0.035 µg L^{-1}) from CCME (2004) are illustrated. Linear regression is of the annual average TP concentration (error bars removed due to large confidence intervals caused by low sampling frequency).

Observed chlorophyll *a* concentrations in PML have not followed the same trend as TP. Between 2006 and 2014, mean annual concentrations fell in the oligotrophic category, while that for 2015 was considered mesotrophic (Figure 7). It is the opinion of the authors that the current practice of collecting samples for chlorophyll *a* analysis from the shoreline area of the lakes is not appropriate for assessing trophic state; samples should instead be collected from the pelagic zone (free open water).

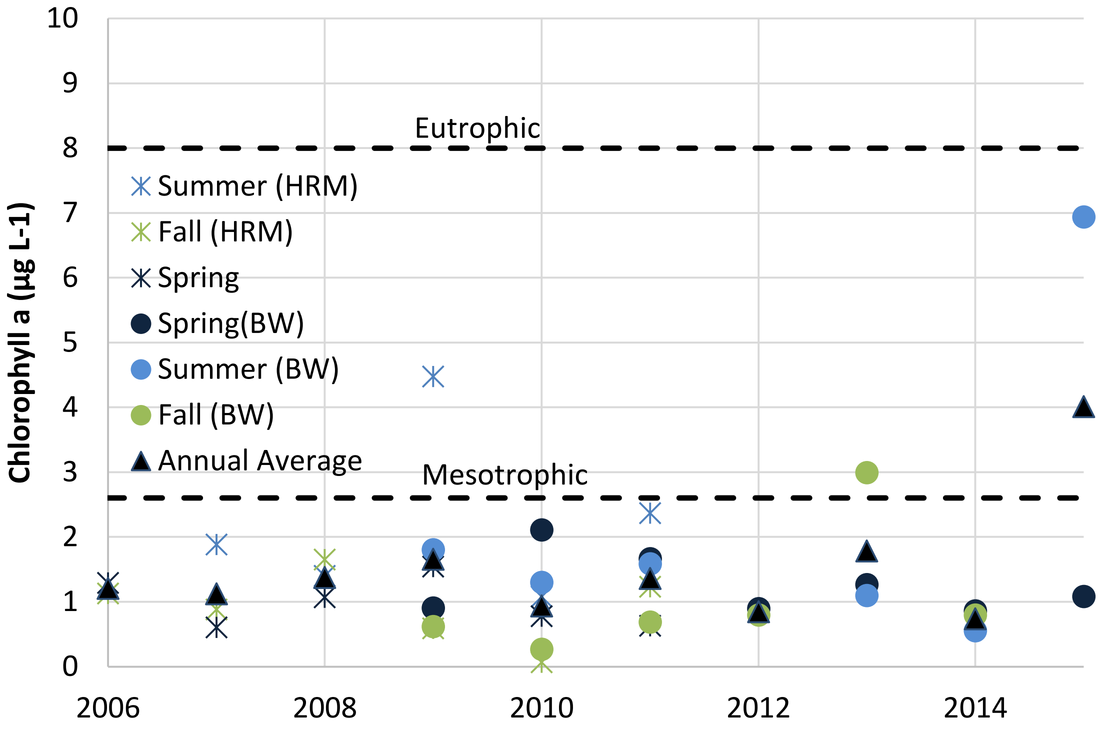


Figure 7. Seasonal and annual chlorophyll *a* concentrations in PML 2006-2015. Mesotrophic and eutrophic category boundaries are based on mean values (Vollenweider & Kerekes, 1982).

1.2 Previous Watershed Assessment and Planning Reports

Available reports regarding the PML watershed, and more broadly the Birch Cove Lakes area, date back to 1996. These reports range in topics from preliminary resource mapping, to watershed scale P loading modeling, to stormwater management planning for specific proposed developments. A list of reviewed reports and data sets are provided in Table 1.

Of specific significance to this study were the four reports which provided results from P loading modeling for the PML Watershed (Porter Dillon, 1996; Scott & Hart, 2004; Watt, 2009; AECOM, 2013). All reports used a similar P loading modeling methodology. While each report examined slightly different land-use scenarios, they generally predicted that KL should be oligotrophic (Porter Dillion, 1996; AECOM, 2013), or mesotrophic (Scott & Hart, 2004), and PML oligotrophic (Porter Dillion, 1996; Scott & Hart; 2004; AECOM, 2013), under baseline conditions. The models also predicted that both lakes experience a shift into the mesotrophic TP range under potential future development scenarios that generally represent the present day state of development in the watershed.

Table 1. Technical reports and datasets reviewed.

Date (M/D/Y)	Report Title	Author(s)	Prepared For
05/01/1996	Birch Cove Lakes Area Environmental Study Task 2 Report	Porter Dillon, The Eastern Group Limited, CWRS, R.H.Loucks and Avens Isle Limited	The Municipality
05/01/1996	Birch Coves Lakes Area Environmental Study - Issues and Opportunities	Porter Dillon, The Eastern Group Limited, CWRS, R.H.Loucks and Avens Isle Limited	The Municipality
03/21/2003	Selection of P Loading Model for Nova Scotia Environment (NSE) Phase 1	CWRS, Soil and Water Conservation Society of Metro Halifax and Acadia University	NSE
04/28/2004	Water Quality Impact Assessment of Water Bodies Contained in the Bedford West Planning Area using a Phosphorus Loading Model Approach	CWRS (Scott and Hart)	Annapolis Group
05/01/2004	Bedford West Planning Area Subwatershed Management Plan	JWL	Annapolis Group
02/01/2009	Outline of a Model of Total Phosphorus Levels in the Lakes of the PML Watershed	Walton D. Watt	Bedford Waters Advisory Board
03/06/2013	Birch Cove Lakes Watershed Study	AECOM	The Municipality
11/04/2014	Bedford West Lake Monitoring Program	The Municipality	The Municipality
08/12/2015	Memo: Phosphorous Levels in the PML Watershed	Stantec	The Municipality
09/01/2015	PML Watershed - Total Phosphorus Characterization Project, Final Report.	CBCL	The Municipality
2009 - Present	Water Quality Monitoring Program Bedford West.	SNC Lavalin, SLR Consulting	The Municipality
2006-2011	HRM Lake Sampling Program	The Municipality	The Municipality

2.0 Phosphorus Assessment of Kearney and Paper Mill Lakes

The steady-state P loading model applied by Scott and Hart (2004) for TP levels in lakes in the PML Watershed, was used to generate estimates of individual P loads for each of the various land uses within the KL and PML watersheds, based on existing (2016) conditions. Predicted in-lake mean annual TP concentrations were also generated. This particular version of the model, or slight variation of it, has been applied by others for this particular watershed (Porter Dillon, 1996; Watt, 2009; AECOM, 2013). The Scott & Hart (2004) version of the model is the product of several refinements to the Dillon & Rigler (1975) P loading model. Many of the refinements resulting from research conducted in Nova Scotia (Waller, 1977; Hart et al., 1978; Waller & Hart, 1985; Scott et al., 2000). This version is unofficially referred to as the Nova Scotia P Loading Model. This terminology was first adopted following a collaborative review by a group of Nova Scotia modelers (Scott et al., 2003) and subsequent model refinement by Brylinsky (2004).

2.1 Update of Phosphorus Loading Model

The P loading model applied to the PML Watershed is a mass balance steady-state model which combines various sub-watersheds and lake characteristics to estimate or predict in-lake values of P. The model has its limitations and relies on several assumptions to enable a user to assess the effects of existing land uses, as well as the potential water quality impacts of future watershed development. The assumptions and limitations of this model are detailed in the following list (in no particular order).

- Export coefficients incorporated in the model are assumed to be accurate representations of the various land uses found within the drainage basin (land use export coefficients are mean values developed from a series of data sets representing a specific category).
- Runoff coefficients applied to the various land uses are reasonable.
- 50% of P entering an on-site wastewater disposal system that is located within 300 m of a lake or tributary stream will eventually make its way to that waterbody.
- The time for the septic system phosphorus load to reach a watercourse or lake is uncertain and could be in the order of decades.
- The main function of the model is to predict steady-state conditions (what phosphorus levels will be once the system has reached equilibrium following a change in land use).
- The model assumes that regardless of the positioning of entry points of land and watercourse P loads to a lake, 100% of these various loads are seen to contribute to the predicted mean annual P concentration. For example, KL receives inflow from Black Duck Brook, which is located at the downstream end of the lake. It is highly unlikely that the entire input from this brook is fully mixed throughout the lake prior to reaching to outflow.
- The model was not intended for application to shallow lakes. (shallow is defined as a lake in which sufficient light (1% of ambient light) is able to penetrate the water column to the

bottom sediments throughout the lake to support photosynthesis of higher aquatic plants (Wetzel, 2001).

- The model predicts average lake phosphorus concentration and is not capable of addressing temporal and/or spatially variability.
- The contribution of P from precipitation may be outdated and no longer applies, as the model relies on information in 1984 (Underwood, 1984).
- Examples of potential phosphorus sources/sinks which are not accommodated by the model include: waterfowl, aquatic plants, etc.
- In-lake P response time-lags will vary with respect to the type of activity and hydraulic connection to receiving waters (i.e., septic system impacts) and will play a role in the agreement between predicted and observed phosphorus concentrations.
- Over- or under-estimation of in-lake phosphorus retention can occur. The retention factor used applies to lakes which experience anoxic conditions. However, areas affected in the two lakes with empirical confirmation (KL and PML) are extremely small and may not qualify the lakes as truly anoxic in the intended application.

Without adequate data to calibrate and validate the model it can only be responsibly used to assess a lakes sensitivity to changes within the watershed, or to compare the relative contributions from different sources of P. This constraint is consistent with how the model was used through this report.

The input data of the Scott & Hart (2004) P loading model was updated to reflect current land uses. Descriptions of current land uses and other anthropogenic activities are outlined later within the report. The updated inputs were generated using a geographic information systems (GIS) analysis. Specific GIS data sets used are summarized in Table 2..

Updating the land use of the Scott & Hart (2004) model generally resulted in an increase of 324 and 162 hectares (ha) of residential land-use, within the KL and PML sub-watersheds, respectively. Within the sub-watershed of KL, the area of commercial land use increased by 27 ha (Figure 8). Refer to Appendix I for updated model results.

Table 2. Summary of GIS data sets used to update land use.

Data Name	Source	Use
Parcels 2016	HRM	Land use classification
Forestry Layer	DNR[1]	Land use classification
DEM_5m[2]	HRM Open Data	Watershed Delineation
Lakes/Streams/Wetlands	NSTDB:10,000[3]	Watershed Delineation

[1] Department of Natural Resources (DNR), [2]Digital Elevation Model, [3] Nova Scotia Topographic Data Base (NSTDB).

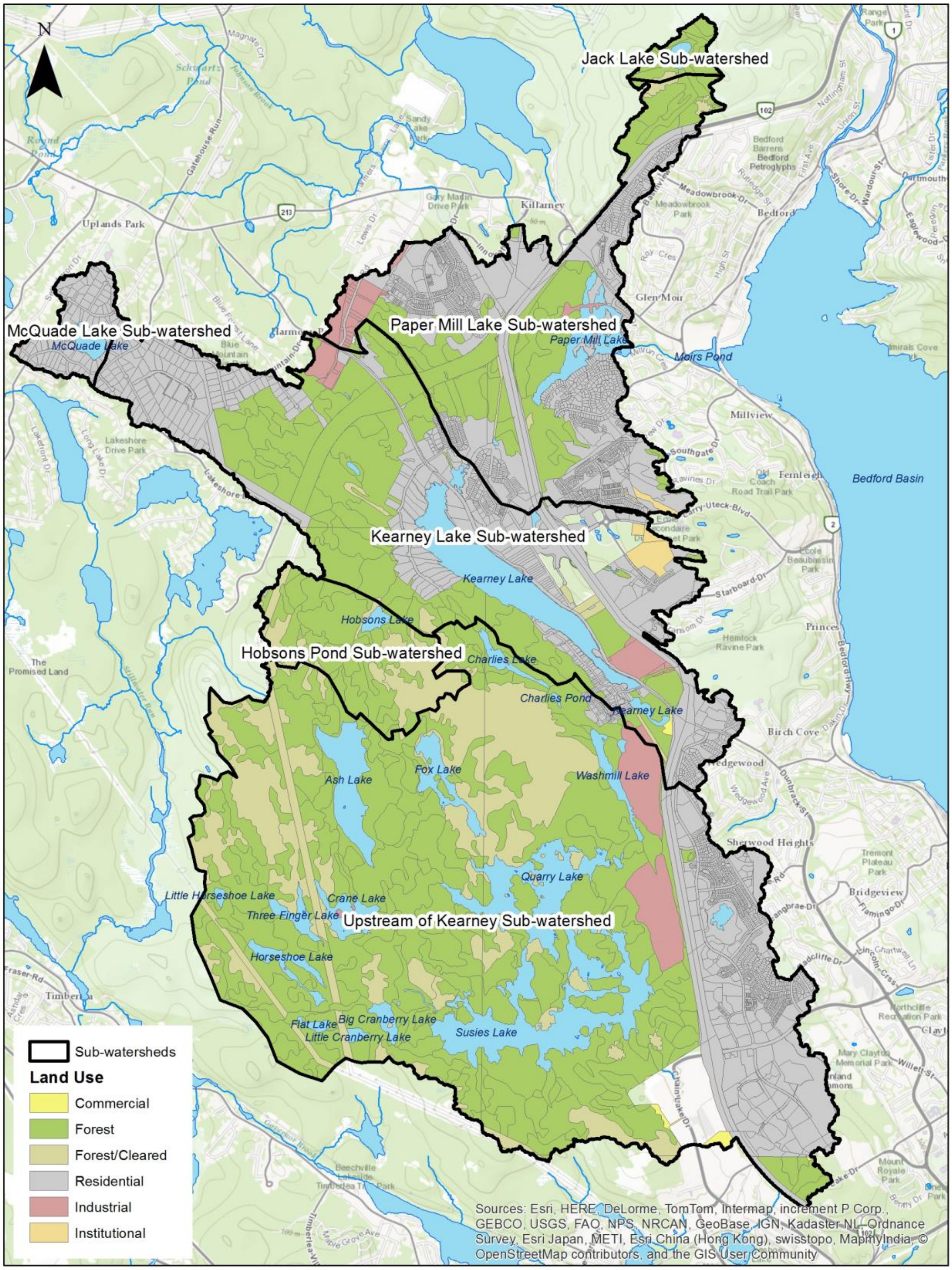


Figure 8. PML Watershed land use (2016) with major sub-watersheds.

2.1.1 *Primary Sources of Phosphorus to Kearney and Paper Mill Lakes*

In this section the general breakdown of sources of P to both lakes are provided. In Section 2.3 the relative influence of specific developments and activities will be discussed.

The results of the updated model show that 31% of the total P load to KL comes from upstream sources. The remaining 69% of the total P load originates from within the KL sub-watershed. For PML the situation is quite different with 78% of the total P load coming from sources upstream of the PML sub-watershed and 22% from within the PML sub-watershed (Table 3). From these results it can be concluded that sources of P upstream of the PML sub-watershed heavily influence the PML TP concentration.

The breakdown of sub-watershed P loads to KL and PML are presented in Figure 9 and Figure 10, respectively. The concentration and percentage of in-lake TP associated with each P source is presented in Table 3.

Within the KL sub-watershed, the three largest sources of phosphorus were determined to be septic systems (32%), followed by runoff export from residential land use (24%) and industrial land use (6%). Within the PML sub-watershed, the three largest sources of P were determined to be runoff export from residential (16%) and industrial developments (5%), and runoff export from forested landscapes (1%).

The updated version of the model predicts mean annual TP concentrations in KL and PML of 20.3 μg L^{-1} and 19.8 μg L^{-1}, respectively.

Table 3. Summary of in-lake TP concentrations for each contributing source for KL and PML.

Sub-Watershed	P Sources	KL		PML	
		μg L^{-1}	%	μg L^{-1}	%
Upstream	Upstream	6.2	31	15.8	78
Within Sub-watershed	Septic Systems	6.3	32	0*	0
	Residential	4.8	24	3.2	16
	Industrial	1.2	6	0.9	5
	Forest	0.6	3	0.2	1
	Atmospheric	0.3	1	0.1	1
	Commercial	0.3	1	0	0
	Institutional	0.1	1	0	0
	Total	**19.8**	**100**	**20.1**	**100**

*Please note that there are no known septic systems within the PML sub-watershed, therefore the septic system P contribution to PML is included within upstream sources. The contribution from all septic systems within the PML watershed to KL and PML are detailed in section 2.2.5.

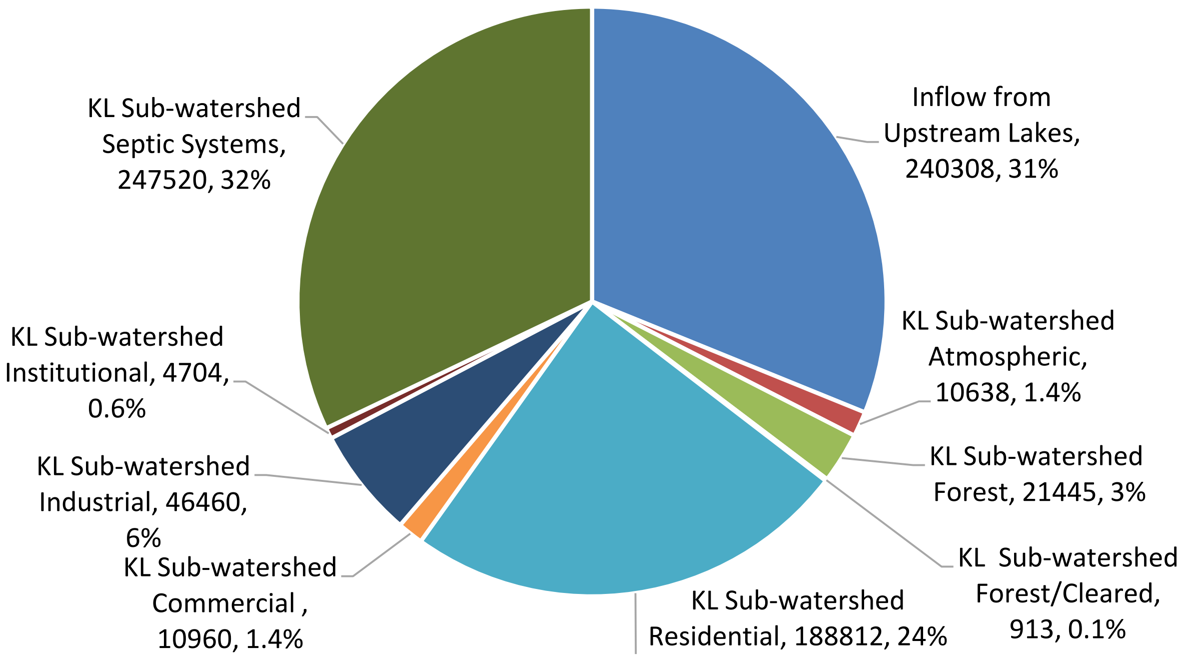


Figure 9. P inputs to KL (g yr^{-1}, %).

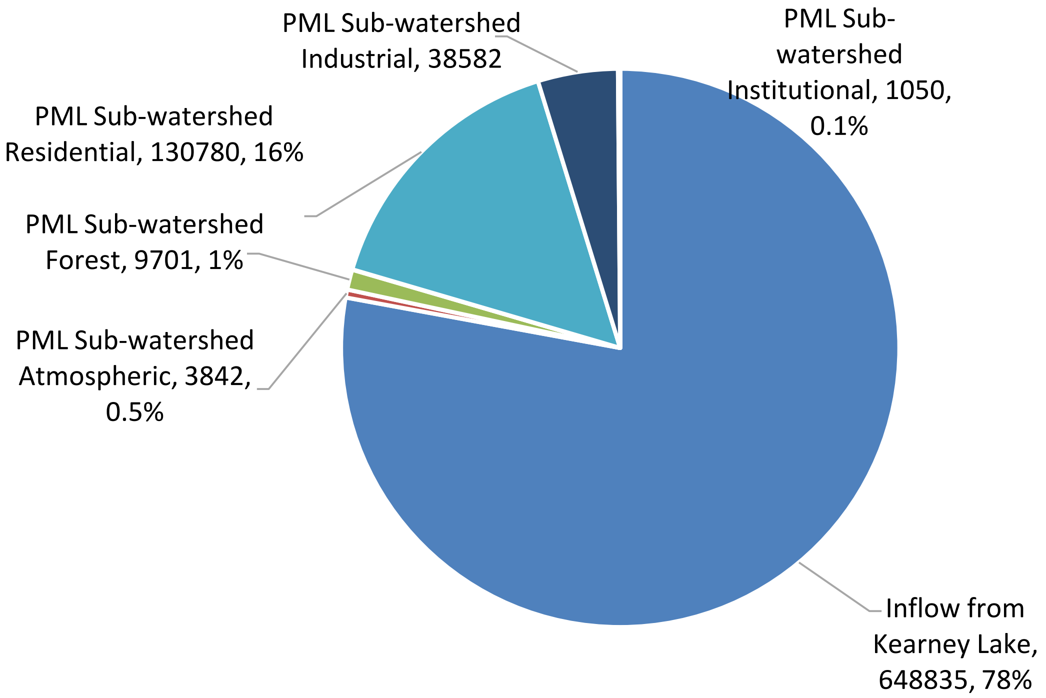


Figure 10. P input to PML (g yr^{-1}, %).

2.1.2 Sensitivity of Model Results to Export Coefficients

Of all of the input variables contained in the Nova Scotia P Loading Model, the most uncertainty to the model results comes from literature-based export coefficients. For example, Table 4 provides a comparison of the various P export coefficients (mg m^{-2} yr^{-1}) applied by AECOM (2013) and CWRS (2004), when examining the potential land use impacts in the PML Watershed on in-lake TP concentrations. Although individual coefficients applied in both studies fall within ranges provided in the literature (AECOM, 2013; Reckhow, 1980; Scott et al. 2003), the commercial and residential export coefficients used by the two studies differed significantly. This in part could be due to the lack of definition of residential or commercial land use. Residential land use can range from dense urban settings to rural settings. Selection of a specific coefficient is somewhat subjective, as a range of coefficients are available for specific land use categories. Additionally, many of the P export values in the AECOM literature survey, and in both the AECOM and CWRS P models, originate from studies conducted in Ontario (Waller & Hart, 1985; HESL & MOE, 2011).

The high variability in literature export values, as well as the use of export coefficients measured in Ontario, adds uncertainty as to whether such values would be appropriate for Nova Scotia. P export depends on the climate, and soil and bedrock characteristics present within the watershed area of a lake. Using export coefficients derived for one region does not mean they are applicable in regions with dissimilar climate, soil, and bedrock. There is a gap in locally, validated P export coefficients from industrial, commercial, and residential land uses. Further research is recommended to validate export coefficients for these land use types in Nova Scotia's climate and geology.

Using the updated P model, a sensitivity analysis was conducted to illustrate how choice of P export coefficient can influence the model output (in-lake P in KL and PML). The export coefficients used in the updated version of the model are presented in Table 5, as well as the minimum and maximum values of the coefficient ranges reported in the literature. The model was re-run varying the P export coefficient between the minimum and maximum value for each land use shown in Table 5. The change in predicted TP concentration in KL and PML was then assessed. Recall that the model produced in-lake TP concentrations of 19.8 and 20.1 µg L^{-1} for KL and PML respectively. Varying the residential export coefficient produced the greatest changes to in-lake TP concentrations, which ranged from 13.2 to 41.7 and 11.5 to 48.8 µg L^{-1} for KL and PML respectively. The second greatest change was seen due to the range of the industrial export coefficient, which produced in-lake TP concentrations ranging from 19.2 to 31.1, and 19.2 to 31.4 µg L^{-1} in KL and PML respectively. Since the model currently uses the low end value for the commercial export coefficient, only an increase of in-lake TP concentration was observed; whereby, KL increased to 26.5 µg L^{-1} and PML increased to 25.4 µg L^{-1}.

Table 4. Variability in applied P export coefficients (mg m^{-2} yr^{-1}).

Land Use	AECOM (2013)		(Scott & Hart, 2004)		Literature Ranges	
	Land Use	Coefficient	Land Use	AECOM (2013)	Reckhow (1980)	Coefficient
Atmospheric Deposition	Water	17	Precipitation	17-25	--	17
Forest	Forest Forest-meadow	6.9 8.3	Forest Forest + >15% cleared	2.0-20	1.0-830	6.9 8.3
Wetland	Wetland	8.3	--	16-25	--	--
Industrial	Industrial	202	Industrial	149-535	75-417	202
Institutional	Institutional	42	Institutional	42	--	42
Commercial	Commercial Commercial and residential	202 167	Commercial	40-398	66-485	40
Residential	High density Medium density Low density Open space	132 52 13 13	Urban (residential)	0.5-221	19-220	52
Quarry	Quarry	8.0	--	0.4-11	--	--
Roadway	Roadway	202	--	83-350	--	--

Table 5. Export coefficient sensitivity analysis.

Land Use	Exp Coef (Updated Scott and Hart 2004) (µg m^{-2} yr^{-1})		Exp Coef low (µg m^{-2} yr^{-1})		Exp Coef high (µg m^{-2} yr^{-1})		
Industrial	202		75		535		
Commercial	40		40		485		
Residential	52		0.5		220		
	In-Lake P Concentrations (µg L^{-1})						
	KL	PML	KL	PML	KL	PML	Percent Change
Industrial	19.8	20.1	19.2	19.2	31.1	30.4	-5 to 57
Commercial	19.8	20.1	19.8	20.1	26.5	25.4	33
Residential	19.8	20.1	13.2	11.5	41.7	48.8	-43 to 140

In order to reduce the uncertainty in the modeling outputs, it is recommended that representative land uses with large export coefficient variability be validated. Validating the residential, industrial, and commercial land uses within the KL and PML sub-watersheds could greatly increase the confidence in modeling predictions, not only for this study but for other modeling studies within similar areas. Section 4.2.2 of this report presents the details of a monitoring program which could be used to validate phosphorus export coefficients for the land uses discussed.

2.2 Phosphorus Loading from Specific Sub-Watershed Activities

In this section an analysis of potential P loading from specific sub-watershed activities and developments is presented. Some of the activities represent continuous, on-going sources of P that have been included in the P model results presented in Section 2.1.1 (e.g. runoff export from Bedford West and Bedford South sub-divisions, P loading from septic systems). Other activities represent limited duration activities (e.g. construction, sewer overflows) that have not been represented in the model results presented in Section 2.1.1. For each activity, a brief description of the methodology used to quantify the source is provided. This is followed by a summary of the results including an estimate the percent increase the source may contribute to the TP concentration in both KL and PML.

2.2.1 Sewer Overflows

In the original scope of work an inquiry was made regarding the potential P loading from *"Occasional temporary overflows from the former Halifax Water pumping station located east of KL, west of Parkland Drive and downstream of the Gateway Material quarry"*. Halifax Water has identified that there is one pumping station within the PML sub-watershed and that there was one in the KL sub-watershed until it was decommissioned in 2015. During the time period spanning from 2008 to 2015, the only known overflow occurrence was from the pumping station in the KL sub-watershed on March 22, 2012. The duration of the overflow was estimated to have been approximately 3 hours (Halifax Water, personal comm.). Halifax Water reports that there have been no overflows from the pumping station within the PML sub-watershed.

In order to estimate the loading from this single pumping station overflow, the P loading was estimated based on the breakdown of development tributary to the pumping station (Table 6) (Halifax Water, personal comm.).

Adding this estimated P load (412 mg) to the updated P model, the concentration increase in both KL and PML was predicted (Table 7).

Sewer overflows throughout the PML watershed have been estimated to increase the annual in-lake TP concentration in KL, in 2012, by 0.1 µg L^{-1} or by 0.5%. This loading may have caused a greater increase for a short duration immediately after the overflow, but generally is considered insignificant. There was no predicted impact on PML.

Table 6. Summary of pumping station over flow specification.

Residential	Number of Units	People unit^{-1a}	L day^{-1}
6 Multi-Residential (with 50 units each)	300	2.25	276,750
Individual Homes	111	3.35	152,459
4 Strip Malls (Assume 50 parking spaces each and no food service)	200	4	800
1 Hotel (with 150 Units)	150	136	20,400
Assume hotel has 30 employees	25	36	900
		Total Daily Wastewater Flow (L day^{-1})	451,310
		Total Wastewater Flow for Overflow Event (L 3 hours^{-1})	56,414
		Total Phosphorus (g)^{c}	412

[a]Halifax Water, 2015, [b]NSE, 2013, [c]TP concentration in raw wastewater, 7.3 mg L^{-1} (Sinclair, 2014).

Table 7. P increase to KL and PML from sewer overflow (µg L^{-1}).

Source of Phosphorus	P (µg L^{-1}) increase in KL	P (µg L^{-1}) increase in PML
Overflow in KL Sub-watershed	0.1	0

2.2.2 Gateway Materials Quarry

The Gateway Materials Quarry is located on Crusher Road, off of Kearney Lake Road. The extent of the quarry was delineated using aerial photos in Google Earth (Figure 11). The quarry is located within the Washmill and KL sub-watersheds and was included within the updated P loading model presented in Section 2.1.1. Water quality monitoring reports regarding the quarry were obtained from NSE, however TP observations accompanied with flow estimates were not included. Without these observations, it is not possible to calculate a mass load of P due to the quarry operations.

The P loading from the quarry was estimated using its area and an export coefficient, and is summarized in Table 8.

The updated P loading model was used to determine the quarry's contribution to the TP concentration in KL and PML. In order to estimate the increase, the land use area assigned to the quarry was reverted back to forested and the model re-run. For both KL and PML, the Gateway Materials Quarry was estimated to contribute <0.2 µg L^{-1} TP and is considered insignificant.

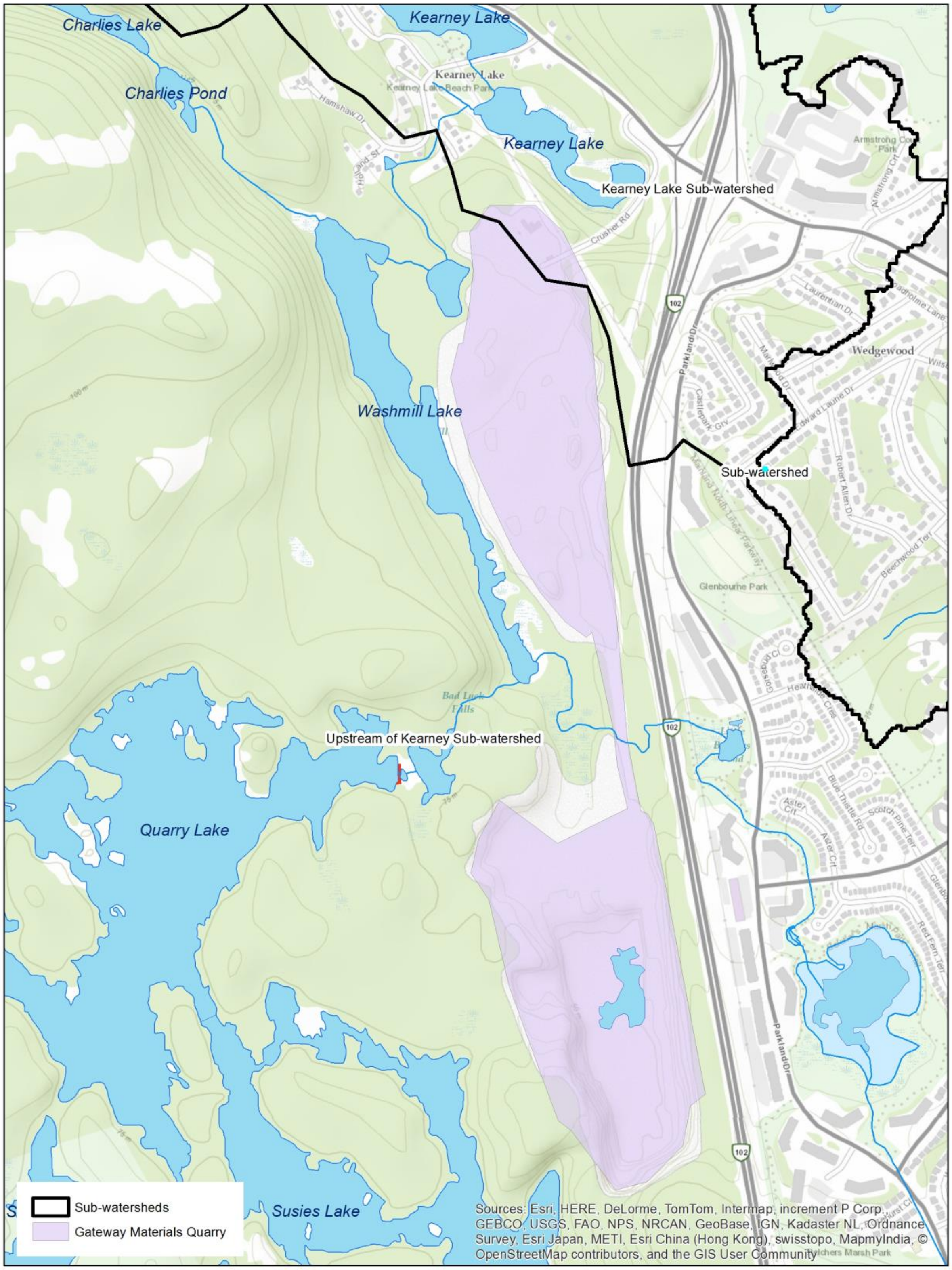


Figure 11. Gateway Materials Quarry footprint.

Table 8. Gateway Materials Quarry characteristics and P loading.

Land Use	Gateway Materials Quarry within:	
	Washmill Lake Sub-Watershed	KL Sub-Watershed
Area (ha)	42	7.5
Exp Coefficient, mg m^{-2} yr^{-1}	8	8
TP concentration contribution in KL (µg L^{-1})		0.2
TP concentration contribution in PML (µg L^{-1})		0.1

2.2.3 Operation of Bedford South

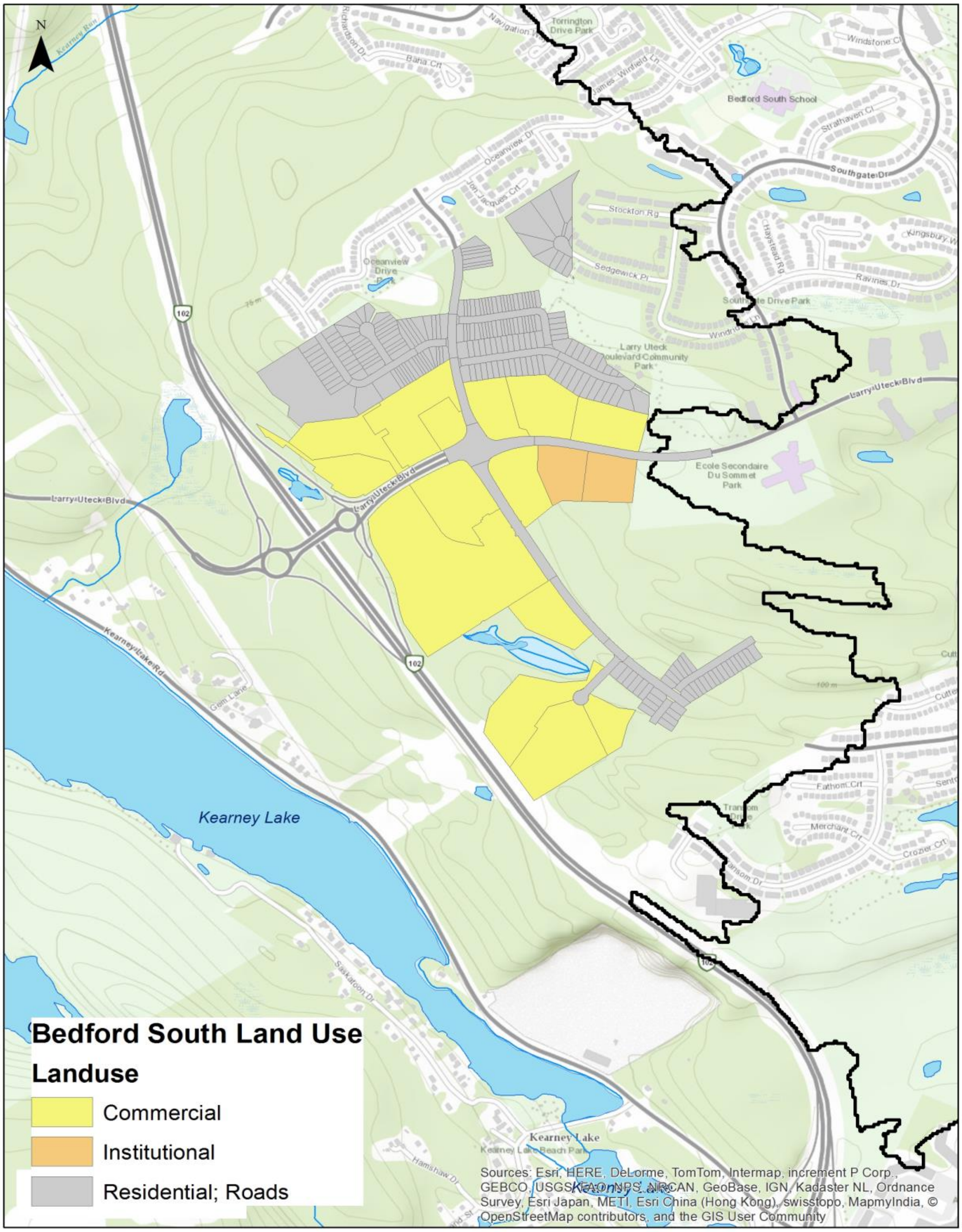
As with the Gateway Materials Quarry, P loading from the on-going operation of the Bedford South development was estimated using an export coefficient approach within the updated P loading model. The breakdown of Bedford South land uses was determined based on the feature codes within the Parcels layer supplied by HRM, which allowed for the identification of roads and non-roads. Then it was assumed that all parcels greater than 5,000 m^2 were commercial/institutional, and verified using aerial photos as shown in Figure 12, and summarized in Table 9.

The P loading model was used to estimate the contribution of Bedford South to the TP concentration in KL and PML. To do this the land use area assigned to the Bedford South was reverted back to forested and the model was re-run.

For both KL and PML, Bedford South is estimated to be a minor contributor (<0.6 µg L^{-1}) to the mean annual TP concentration.

Table 9. Summary of Bedford South land uses and contribution to TP concentrations in KL and PML.

Land use	Area (ha)	Export Coefficient, (mg m^{-2} yr^{-1})
Commercial	39.6	40
Residential	12.2	52
Roads (assumed to be Residential)	6.4	52
Institutional	2.2	42
TP concentration contribution in KL (µg L^{-1})		0.6
TP concentration contribution in PML (µg L^{-1})		0.5



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 12. Bedford South land use (2016).

2.2.4 *Operation of Bedford West*

P loading from the completed portion of Bedford West was also calculated using an export coefficient approach. The breakdown of land uses was determined based on the features codes within the Parcels layer supplied by HRM in combination with aerial photos, as summarized in Table 10 and shown in Figure 13. The Parcels layer is from 2016 and was assumed to represent the current extent of Bedford West development.

Table 10. Summary of Bedford West land uses (as of 2016) and contributions in P concentration to KL and PML.

Land use	Area (ha)	Export Coefficient (mg m^{-2} yr^{-1})
Commercial	9.0	40
Residential	141.6	52
Industrial	12.3	202
Institutional	2.5	42
TP concentration contribution in KL (µg L^{-1})		1.5
TP concentration contribution in PML (µg L^{-1})		1.9

The P loading model was used to estimate the contribution of Bedford West to the TP concentration in KL and PML. To do this the land use area assigned to the Bedford West was reverted back to forested and the model was re-run. Using this approach, it was estimated that the development of Bedford West to date may be contributing 1.5 and 1.9 µg L^{-1} to the average annual in-lake TP concentration in KL and PML, respectively.

2.2.5 *Septic systems in KL and McQuade Lake watersheds*

There are approximately 238 septic systems within the KL sub-watershed and 89 within the McQuade Lake sub-watershed (Scott & Hart, 2004). The approximate locations are shown in Figure 14. P loading from septic systems is calculated based on an estimate of P loading to the septic systems and the ability of both imported and natural soils to retain P. Two mechanisms are responsible for P treatment or retention. The primary mechanism is P sorption to soil particles, and a secondary mechanism involves the precipitation of P. Phosphorus loading from septic systems is a dynamic source of P within the watershed. Dynamic means that the impact can change over time. This is due to the fact that as sorption sites within a disposal field become occupied with P, the P treatment performance of the system progressively decreases. This was observed in a series of on-site wastewater systems studied by CWRS, where treatment efficiency decreased on average by 58% during the first 7 years of operation (Sinclair, 2014).

A retention coefficient of 0.5 was used, meaning that half of the phosphorus is retained within the septic system and any imported and natural soils. The P loading model was run with and without the septic systems in order to determine the lake phosphorus concentration attributable to the septic systems. The septic systems are predicted to contribute 7.3 and 5.7 µg L^{-1} to the TP concentration in KL and PML, respectively

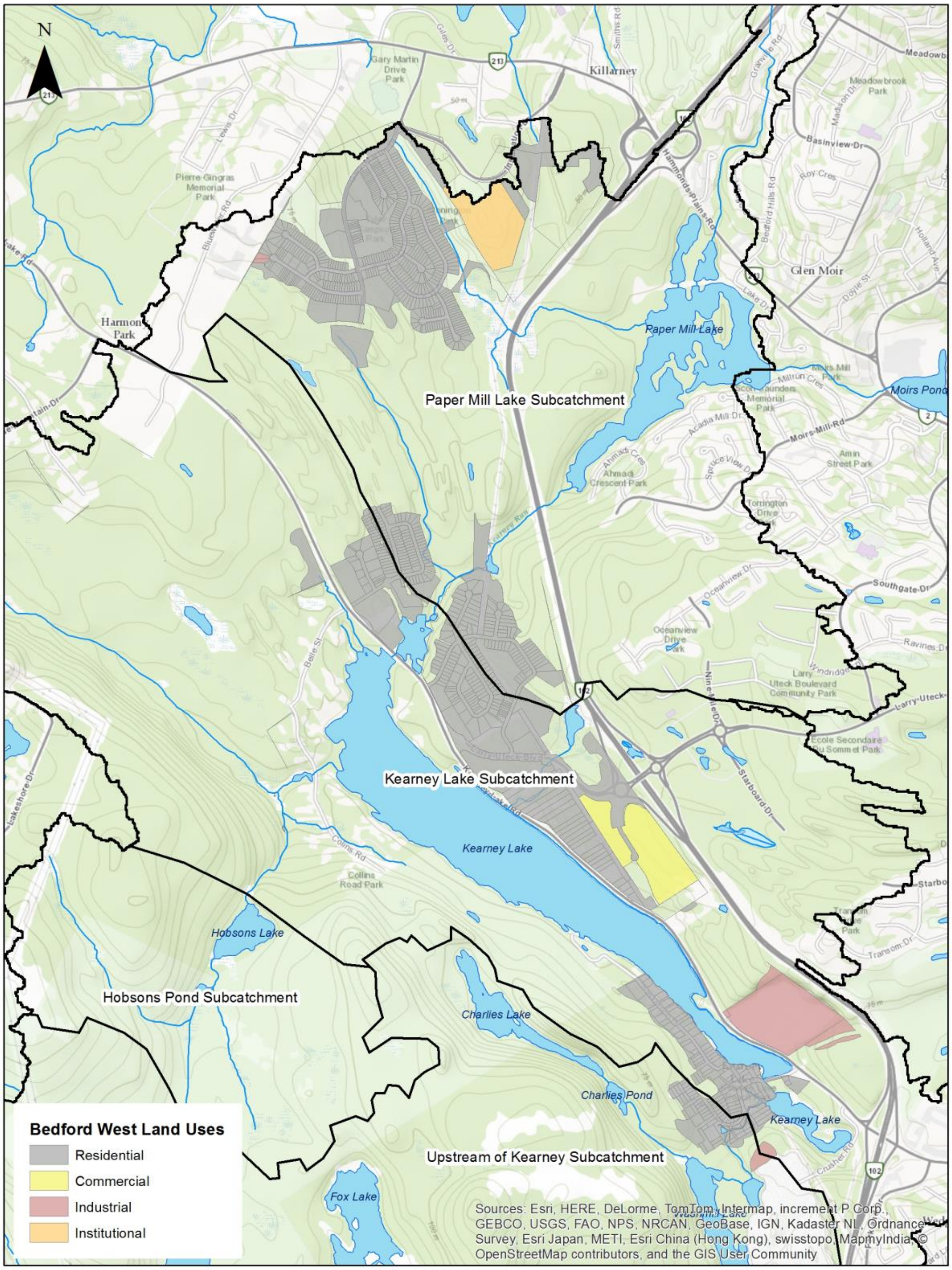


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Figure 13. Bedford West land use (2016).

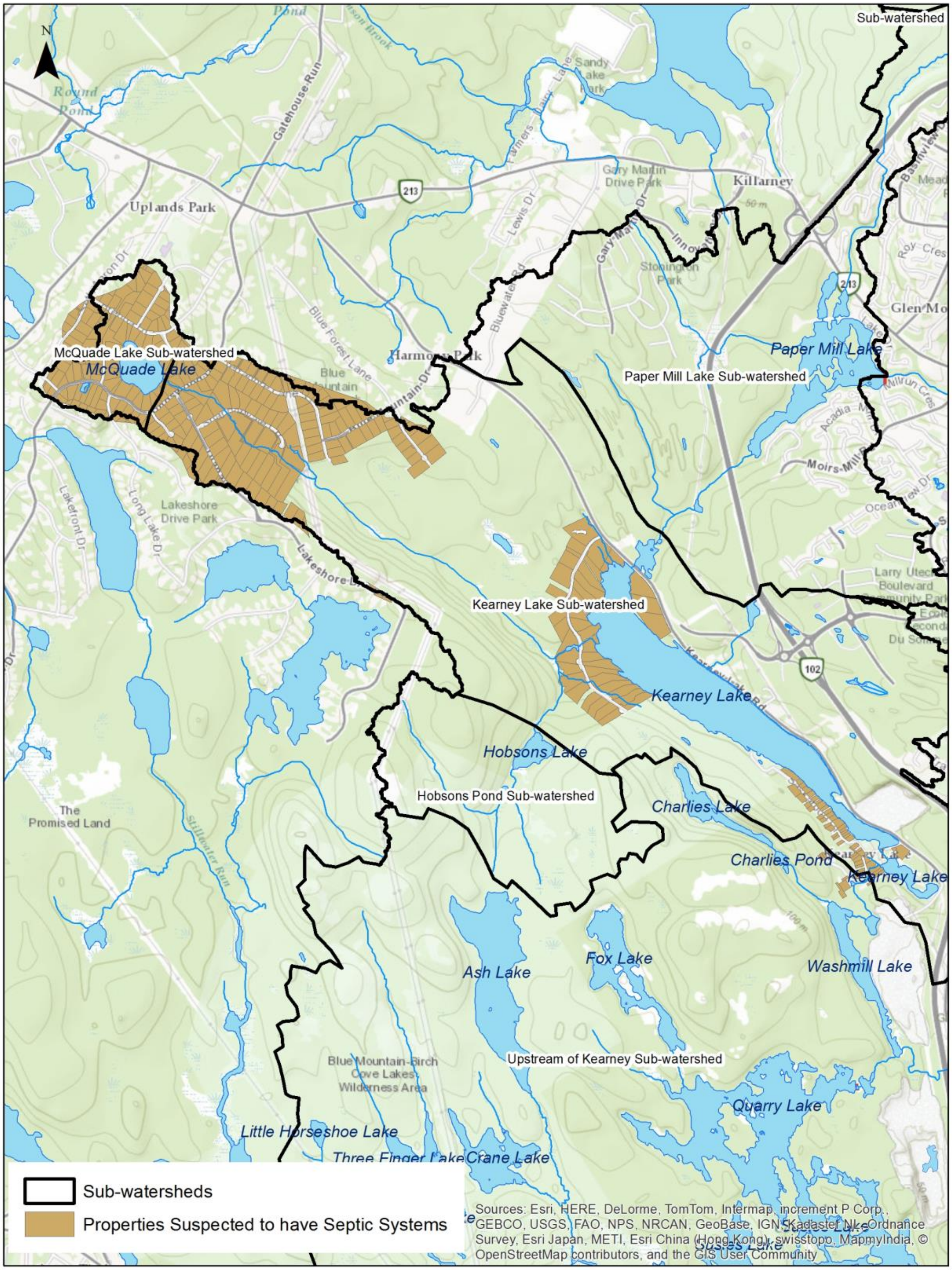

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Figure 14. Properties serviced with septic systems.

The assumptions regarding P loading from septic systems have been carried forward from past studies and are summarized in Table 11.

Table 11. Septic system P loading assumptions.

Septic Systems in KL Sub-watershed	238
Septic Systems in McQuade Lake Sub-watershed	89
P load (g capita^{-1} year^{-1}) (Scott & Hart, 2004)	800
Persons per dwelling (Scott & Hart, 2004)	2.6
P retention coefficient	0.5

Recalling that P sources upstream of the KL and PML sub-watersheds (Table 3) included P contributions from septic systems, it was deemed necessary to determine the portion of upstream sources that originate from septic systems. For PML, the total contribution of upstream sources of P was 15.8 µg L^{-1}. Using the model, it was determined that the septic systems in KL and McQuade sub-watersheds contributes 5.7 µg L^{-1} P to PML, and therefore 10.1 µg L^{-1} P is from upstream sources other than septic systems. For KL, 6.3 µg L^{-1} P comes from septic systems within the KL sub-watershed, however it was determined that of the 6.2 µg L^{-1} P from upstream sources, 1 µg L^{-1} originates from the septic systems in the McQuade Lake sub-watershed (refer to Table 12 for a complete breakdown of sources).

It is not expected that residences serviced with a central water supply and a septic system, would generate a greater mass of P than those serviced by wells. While the amount of water used by the centrally serviced homes may be greater due to the nature of the supply, the P concentration within the wastewater stream would most likely be less when compared to the residences serviced by wells. However, residences serviced by a central water supply may experience a greater rate of septic system hydraulic failure, due to the potential increase in water volume being treated by the system, and this could contribute to larger P loading to surface water systems.

The updated P loading modeling is predicting TP concentrations of 19.8 and 20.3 µg L^{-1} in KL and PML, respectively, therefore septic systems represent approximately 25% of the TP in both lakes. It should be noted that this analysis is based on an assumed retention coefficient of 0.5. To better understand the uncertainty associated with the retention coefficient, a sensitivity analysis was conducted, where the coefficient was varied from 0.2 to 0.8. The results are presented in Table 13.

Table 12. P loading from septic systems and upstream sources to KL and PML.

PML		**KL**		
Upstream Sources (Table 3) (µg L^{-1})		Upstream Sources (Table 3) (µg L^{-1})		KL Sub-Watershed **Septic Systems** (µg L^{-1})
15.8		6.2		6.3
Septic Systems in KL and McQuade Lake Sub-watersheds	Other Upstream Sources	**Septic Systems** in McQuade Lake Sub-watershed	Other Upstream Sources	--
5.7	10.1	1	5.2	
Total P from Septic Systems 5.7		**Total P from Septic Systems = 6.3 + 1 = 7.3**		

Table 13. Sensitivity analysis of septic system P retention coefficient.

Retention Coefficient	0.2	0.5	0.8
P increase in KL (µg L^{-1})	11.9	7.4	3.0
P increase in PML (µg L^{-1})	9.1	5.7	2.2

Varying the retention coefficient from 0.2 to 0.8, caused the septic system contribution to vary from 11.9 to 3.0 µg L^{-1} in KL, and from 9.1 to 2.2 µg L^{-1} in PML. These ranges suggest that the model is quite sensitive to the retention coefficient used, which is a considerable source of uncertainty within the model.

2.2.6 Construction Activities

The Revised Universal Soil Loss Equation (RUSLE) was used to estimate the potential soil loss from construction activities within the KL and PML sub-watersheds. Four specific activities were identified for consideration:

- Construction of the Larry Uteck Boulevard interchange at Highway 102;
- Linear road work along Kearney Lake Road associated with the Pockwock Water Transmission Main Replacement Project, and the installation of the KL Trunk Sewer;
- Construction associated with the development of the Bedford South lands; and
- Construction associated with the development of Bedford West.

Using the potential soil erosion rate and an assumed concentration of P within the soil, the amount of P potentially transported to receiving lakes was estimated. In order to do so, the following assumptions were made:

- Larry Uteck interchange construction took place in the KL Sub-watershed over the course of one year;
- Linear road work activities took place along the entire length of Kearney Lake Road within the KL Sub-watershed (4.5 km length, 10 m width), and took place over the course of one year;
- Bedford South development construction occurred over the entire Bedford South area within the KL Sub-watershed, and took place over the course of one year;
- Bedford West development construction took place over an area of 49 ha within the PML Sub-watershed over the course of one year; and
- The average P concentration in the prevailing soil type, the Halifax Soil Series, was estimated to be 12 mg kg^{-1} of soil (MacDougall, Cann and Hilchey, 1963).

While it is strongly suspected that many of the construction activities took place for longer than one year, it has been assumed that the entire area of the activity was exposed for one year in order to produce a worst case estimate of P loading. For example, it was assumed that all of Bedford South within the KL sub-watershed was under construction in one year, while in reality a smaller area would have been under construction in any one year. The area of impact associated with each construction activity are presented in Figure 15 and Figure 16. Table 14 presents the parameter values used to evaluate the potential soil erosion rate.

From Figure 15 and Table 14 it can be seen that the linear road work and the Larry Uteck interchanges did not contribute significant masses of P to KL, 13,000 and 1,500 g P yr^{-1}, respectively, and that the construction of Bedford West and Bedford South, if they had taken place over the course of one year, are estimated to produce approximately 68,000 g of P each.

Adding these P loads to the updated P loading model, the predicted concentration increase in both KL and PML associated with these activities is summarized in Table 15.

Of these construction activities, Bedford West was estimated to have caused the greatest predicted increase in the P concentration in PML (1.6 µg L^{-1}) followed by Bedford South (1.3 µg L^{-1}). However, it is suspected that Bedford South and Bedford West were developed over multiple years and that the effects per year are less than those presented in Table 15. It should also be noted that the use of sediment and erosion control measures on site during construction could have reduced this theoretical loading. These calculated loads represent an estimate of worst case P loading, in the absence of sediment and erosion control measures. It is therefore likely that construction activities would have had a small to moderate impact on TP concentrations in KL and PML during the time period of 2008-2015.

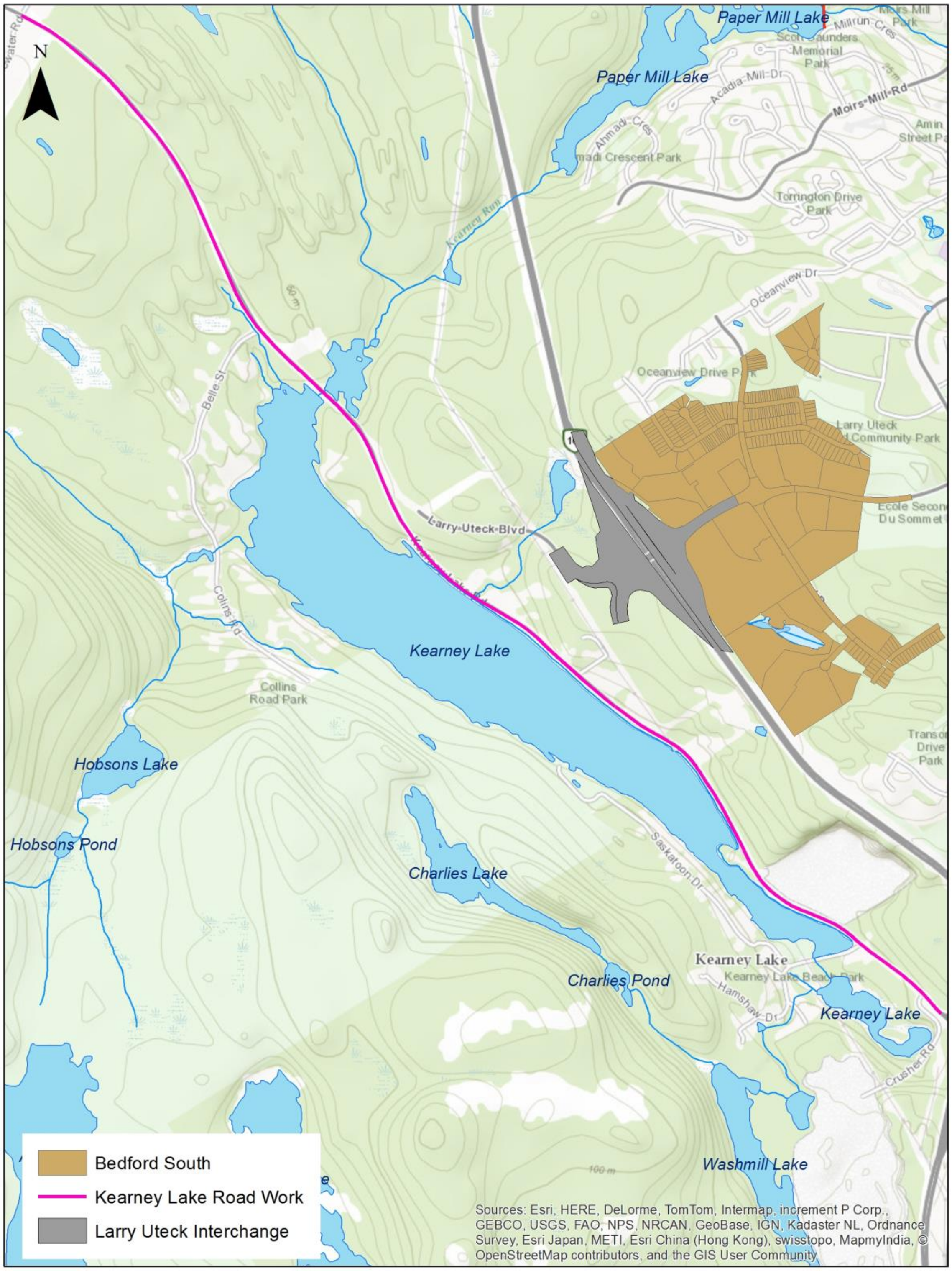

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Figure 15. Areas of Construction Activities with the KL Sub-Watershed.

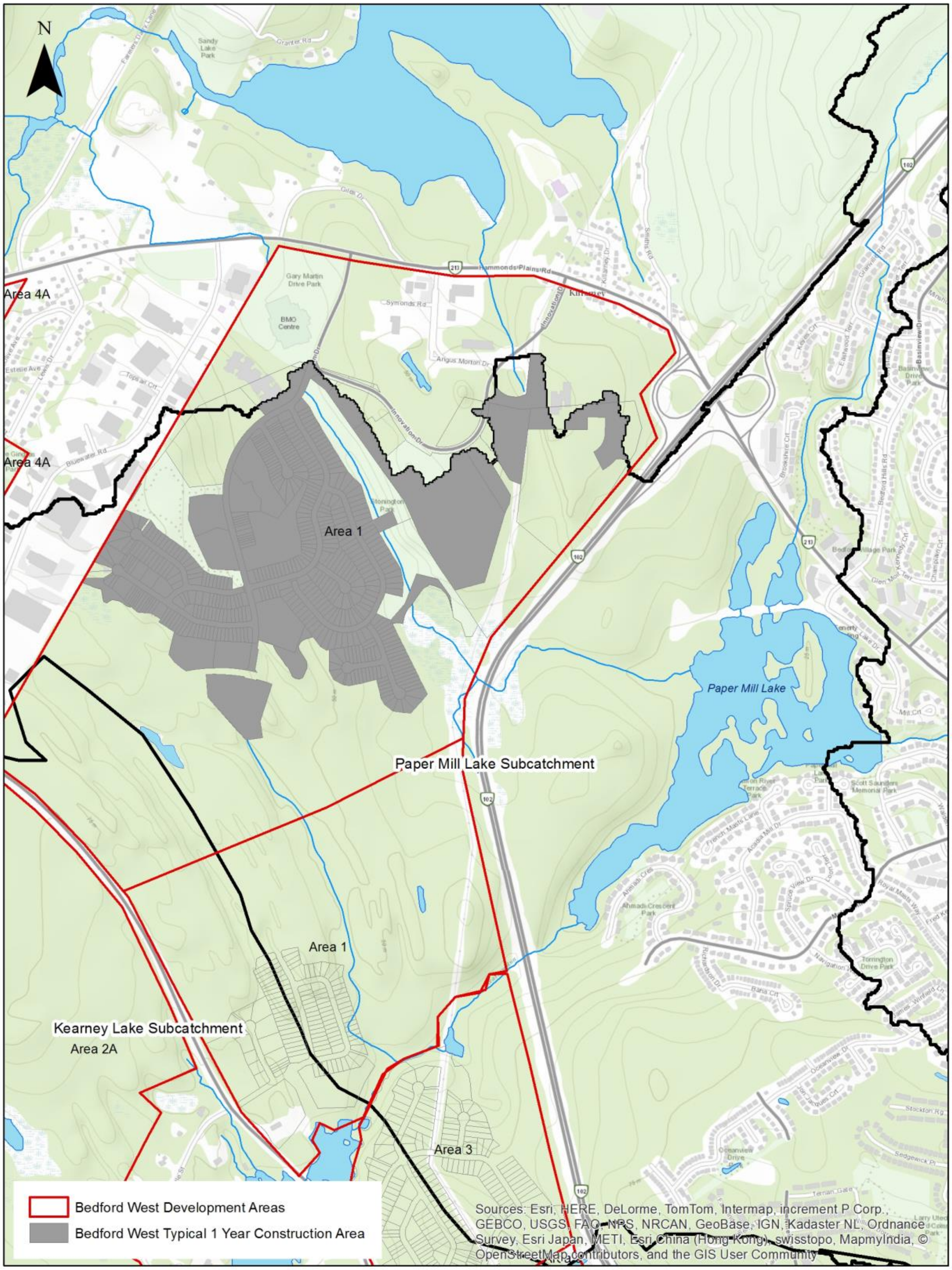

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Figure 16. Areas of Construction Activities with the PML sub-watershed.

Table 14. Summary of parameters used in the RUSLE for construction activities.

Potential Sources of Phosphorus	Larry Uteck Boulevard interchanges	Kearney Lake Road Work	Construction Bedford South	Construction Bedford West	Notes
Area (ha)	13.08	4.50	58.20	49.0	Refer to Figures 15 and 16.
R - Rainfall factor	2,500	2,500	2,500	2,500	From Isoerodent Map showing R1 values for the Maritime Region.
K - Soil erodibility factor	0.02	0.02	0.02	0.02	From soil erodibility values (K): brown sandy loam over yellowish sandy loam (Nova Scotia, Soil Survey Report No. 13).
LS - Slope Length Factor	1.95	0.65	2.30	2.74	Simple slopes for high ratio of rill:inter-rill erosion, applicable to freshly prepared construction sites, mean values used.
C - Crop Factor	1.00	1.00	1.00	1.00	For construction sites under worst case scenario.
P - Support Practice Factor	1.00	1.00	1.00	1.00	No support practice in place, worst case scenario.
Tonnes Soil (tonnes ha^{-1} yr^{-1})	83	28	98	116	--
Tonnes Soil (yr^{-1})	1,084	124	5,689	5,706	--
P in soil (mg kg^{-1})	12.00	12.00	12.00	12.00	From Table 18 - Available Nutrients in Pounds per Acre (MacDougall et al., 1963).
P Loading (g yr^{-1})	13,000	1,500	68,300	68,500	

Table 15. Potential increase in P concentration in KL and PML due to construction activities.

Source of P	P increase in KL (µg L^{-1})	P increase in PML (µg L^{-1})
Larry Uteck Boulevard interchanges	0.4	0.2
Kearney Lake Road Work	0.1	0.0
Construction Bedford South	1.8	1.3
Construction Bedford West	0	1.6
All Sources in the Same Year	2.2	3.1

2.2.7 Drawdown of PML for Dam Upgrades

The PML dam structure, owned and maintained by the Annapolis Group, underwent a reconstruction over three consecutive summers between 2012 and 2014. During this period, lake water levels were lowered to accommodate the various phases of the reconstruction activity. The estimated maximum extent to which water levels were lowered is shown in Figure 17.

Of particular interest to this review is the potential role played by the annual lowering and subsequent refilling of the lake on observed TP levels. Normal physical, chemical, and biological processes occurring within the lake would have been affected.

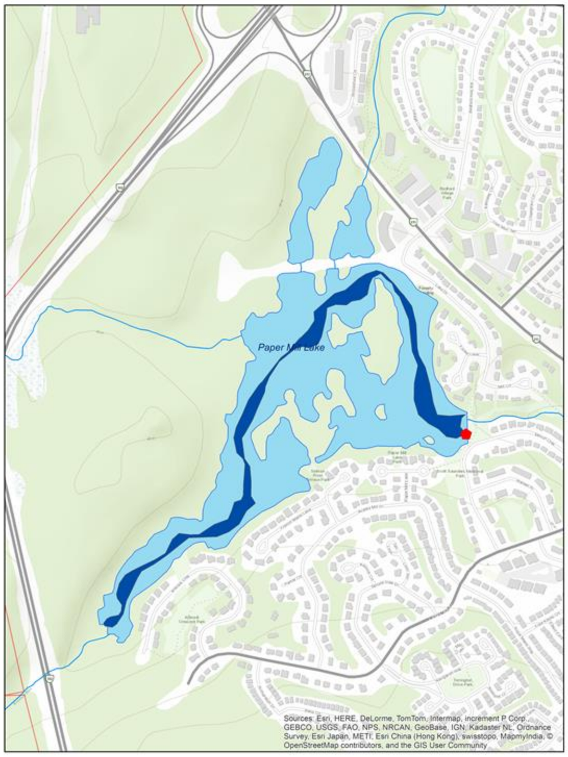

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Figure 17. Outline of PML water level when full (light blue), and after drawdown (dark blue) during 2012-2014 summer reconstruction periods, and the location of dam structure (red dot).

As the lake's water periphery migrated away from hydraulically weathered shoreline discharge areas as lake level was lowered, less stable lake sediment would have been exposed and subject to channeling and resuspension effects resulting from higher velocity tributary stream runoff. Besides the potential physical re-introduction of P from lake sediments into the lake, is the re-introduction via chemical and biological processes. McComb & Qiu (1998) have developed a conceptual model that describes the impacts of exposing lake sediments to air and subsequent availability of P to surface waters following the lake refilling phase (Figure 18). On the chemical side, bonds between P and iron oxyhydroxides gradually weaken during the drying process. During the refilling phase the loosely bound P is released into the overlying water body. On the biological side, the drying process of lake sediments culminates with the release of P contained in dead plankton and bacteria cells into rising water.

It is unclear what the net impact of the above processes may have been on TP concentrations in PML between dam reconstruction seasons. Monitoring data required to provide specific information as to the impact of draining and refilling PML on P levels was not collected, and therefore cannot be used to help determine the impact on the lake. However, based on theoretical knowledge it is suspected that as exposed sediments were again submerged with the refilling of the lake, any released P would have immediately been available to chemical and biological processes associated with P influx, and potentially removed from the water column. From Figure 6, it is obvious that whatever the potential impact, recovery had occurred by the time the lake was sampled the following Spring.

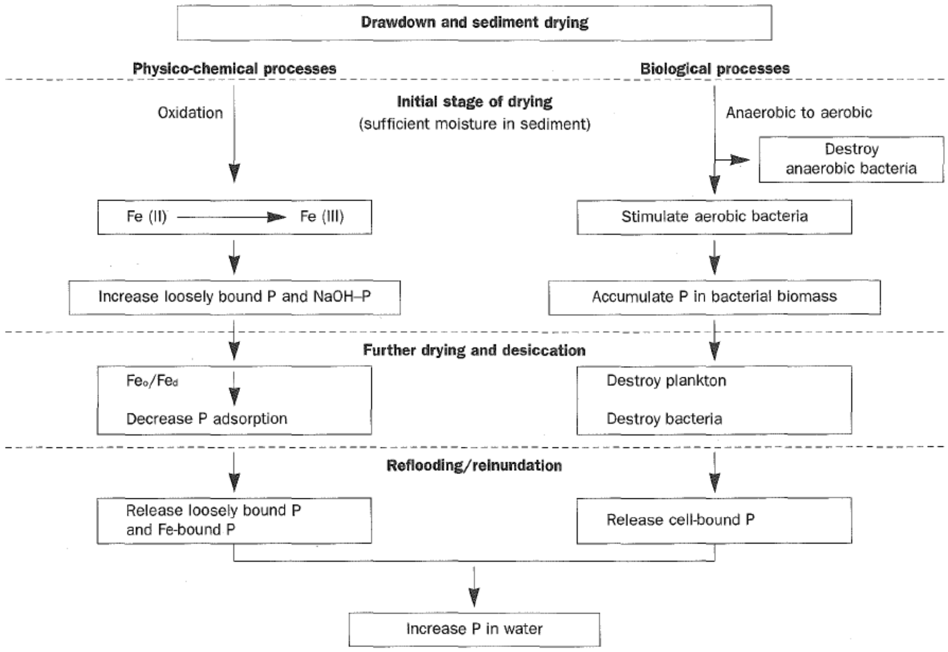


Figure 18. Physio-chemical and biological processes responsible for phosphorus release after lake refilling (McComb & Qiu, 1998).

2.3 Summary of Modeling Results

The purpose of using the P loading model was to determine the theoretical relative P contributions of developments and activities within the PML watershed to in-lake TP concentrations of KL and PML. Table 16 provides a summary and ranking of P contribution to both lakes. An evaluation of the significance of each source as well as the uncertainty associated with each source is also provided. When accounting for all of the contributing sources of P to KL (upstream and sub-watershed) listed in Table 16, those having a potentially significant effect (> 3 μg L^{-1}) on in-lake mean TP concentrations are septic systems, upstream sources and runoff from residential development. The significance range were defined by: > 3 ug L^{-1} would be approximately 50% of the pre-2009 TP concentrations in PML, 1 – 3 ug L^{-1} is approximately 10 – 50 % of pre-2009 TP concentrations, and < 1 ug L^{-1} is approximately less than 10% of pre-2009 TP concentrations.

Table 16. Summary of P loading assessment.

Activity (yearly)	Relative Contribution to KL (μg L^{-1})	Relative Contribution to PML (μg L^{-1})	Significance[a]/ Uncertainty[b]
Upstream Sources	5.2	10.1	High/Med
Septic Systems	7.3	5.7	High/Med
Residential	4.8	3.2	High/High
Construction of Bedford West	2.2	1.6	Med/Med
Construction of Bedford South	1.8	1.3	Med/Med
Bedford West	1.5	1.9	Med/Med
Industrial	1.2	0.9	Low/High
Bedford South	0.6	0.5	Low/Med
Forest	0.6	0.2	Low/Med
Construction of Larry Uteck Interchange	0.4	0.2	Low/High
Atmospheric	0.3	0.1	Low/Med
Commercial	0.3	0.0	Low/High
Operation of Gateway Materials Quarry	0.1	0.2	Low/High
Institutional	0.1	0.0	Low/High
Kearney Lake Road Linear Road Work	0.1	0.0	Low/Med
Sewer Overflows	0.1	0.0	Low/Med

[a] Significance of relative contribution to KL and PML defined as P < 1 μg L^{-1} = Low, 1-3 μg L^{-1} = Medium and > 3 μg L^{-1} = Highly significant.

[b] Uncertainty in the relative contribution estimate to both KL and PML.

For PML (upstream and sub-watershed) sources with a similar potential impact include upstream sources, septic systems, and residential development. P loading from septic systems are of particular concern as they change with time, becoming progressively worse, as soil adsorption sites becomes filled.

Sources of medium significance include the construction of Bedford West and South (as described within the text), and the ultimate predicted P loading from Bedford West once completed, and runoff export from industrial land use for PML. The remaining listed P sources were considered to be of low significance: the ultimate predicted P loading from Bedford South; export from forested land use; construction of Larry Uteck Interchange; atmospheric deposition; export from commercial land use; operation of Gateway Materials Quarry; Kearney Lake Road linear road work; and sewer overflows.

3.0 Internal Loading

Seasonal P releases (P efflux) from lake sediments is commonly associated with the onset of anoxia (absence of oxygen) at the sediment-water interface. The migration of P from sediment to the overlying water column has been linked to redox conditions, which are effectively controlled by the presence of dissolved oxygen (DO) (Mortimer, 1941). With the onset of anoxic conditions and resultant decrease in redox potential, a reduction in Fe(III) occurs, through microbial reduction releasing phosphate bound in hydrous oxides and gels at the sediment surface (Carlton & Wetzel, 1988). In addition to oxygen, other factors affecting the rate of P efflux are pH, temperature, bioturbation, epipelic algal (flora growing on sediments) photosynthesis, microbial metabolism (Wetzel, 2001; Carlton & Wetzel, 1988), redox-sensitive uptake and release of P by benthic communities (Gächter et al., 1988), and apatite (calcium phosphate) precipitation (Golterman, 2001).

When the waters overlying lake sediments are oxidized, binding of phosphate to Fe(III) oxyhydroxides limits P efflux into the water column (Katsev, 2006), with a predominance of P influx occurring (Nürnberg, 1984; Beutel et al., 2008). However, P efflux has been documented to occur in shallow hardwater lakes (125 mg L^{-1} as calcium carbonate ($CaCO_3$) range) with elevated pH levels (7.7 to 10.6; mean 8.8) (Hoverson, 2008). According to water quality summaries for 2010 and 2011 of HRM's water quality monitoring program, both KL and PML are considered soft (hardness less than 30 mg L^{-1} as $CaCO_3$), and near pH neutral (6.0-7.0), and are not likely to respond in similar fashion.

Historical (June-October 2005) (CWRS, 2006) and more recent (July 2016) water column temperature and DO profiles, accompanied by stratum P concentrations, indicate that the formation of anoxic zones in separate basins of both KL and PML is seasonal, occurring during periods of summer thermal stratification. The magnitude of P being released from the sediments during this period into the over-lying water column in terms of the overall P budgets of both lakes, however, is considered to be insignificant at between 0.001 and 0.003 percent of total lake P load. Although it is possible that similar anoxic zones exist during the winter stratification, the absence of suitable water quality data representing the period of ice-cover restricts comment. The fate of P contained in the anoxic zones of both KL and PML is discussed in Section 3.3.

3.1 Kearney Lake

Summertime temperature and DO profiles reported by Porter Dillon (1996) and CWRS (2006) indicate that at no time during the 1994 and 2005 summer stratification periods, and the 1995 winter stratification, did the main lake basin at Station 1 exhibit signs of oxygen depletion in the hypolimnion. However, a thin 1.5m thick anoxic layer overlying the lake bottom was observed to develop at Station 2 in the lake's outlet basin. The maximum basin depth is 7.4m. Refer to Figure 19 for station locations.

The reverse internal loading approach applied to PML was also carried for the smaller KL basin (Table II-1, Appendix II). Application of the NS P Loading Model (Scott & Hart, 2004) to water bodies in the PML drainage basin did not treat the KL outlet pond as a separate entity. Therefore, in order to gain an appreciation of the magnitude of the P load contained in the anoxic zone of this particular body of water, information from the Scott & Hart (2004) report was used to apply the model and generate estimates of the various P sources listed in Table II-2, Appendix II.

As with the upper basin of PML, the data suggests that P contained in the anoxic bottom layer of the KL outlet pond constitutes an insignificant portion of the total pond P load at roughly 0.001 percent. Assuming that a portion of the P mass found in the anoxic zone does not originate from the lake sediments; the resulting net load percentage from P efflux alone would presumably be lower. It was decided that given the scale of the percent load estimate, there was no reasonable justification to similarly apply the release rates from Geolimnos Consulting (1983) and Nürnberg (1984) to this basin as was carried out for PML.

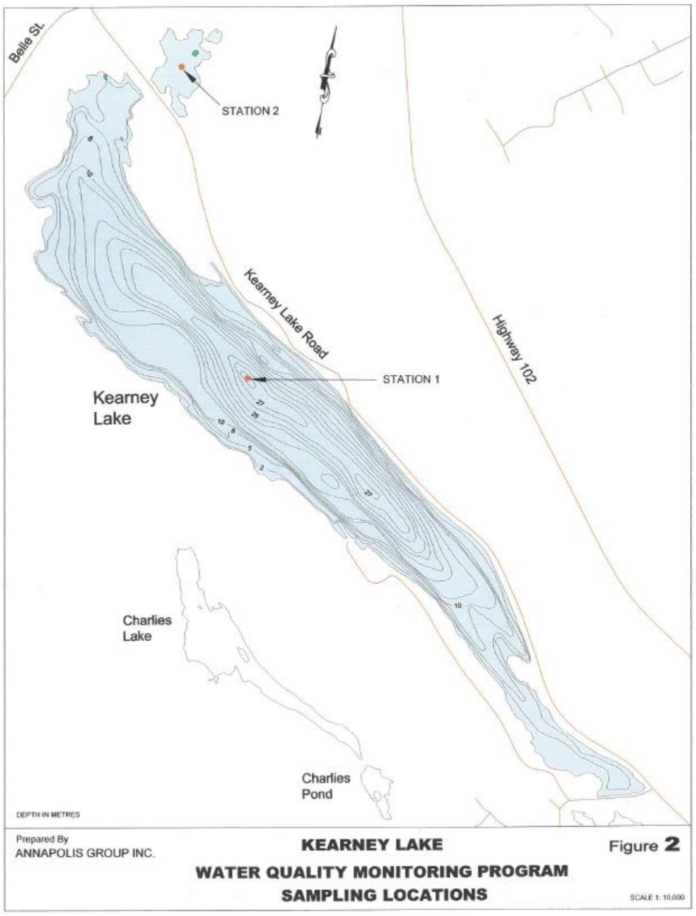


Figure 19. KL deep-station locations (CWRS, 2006).

3.2 Paper Mill Lake

The potential existence and magnitude of sediment P efflux in PML was examined using DO profiles and P data generated between May and December in 2005 (CWRS, 2006). By late-June, water columns in the upper (Station 1) and lower (Station 2) basins of the lake had thermally stratified. Refer to Figure 20 for station locations. By late-July, the existence of an anoxic layer (<0.5 mg L^{-1} DO) at Station 1 at a depth of 10m (lake maximum depth 10.8m) affecting an area of approximately 100m^2 of lake bottom was observed. At no time during the 2005 summer stratification did DO levels near the lake bottom at Station 2 (maximum depth 6.5m) exhibit signs of anoxia.

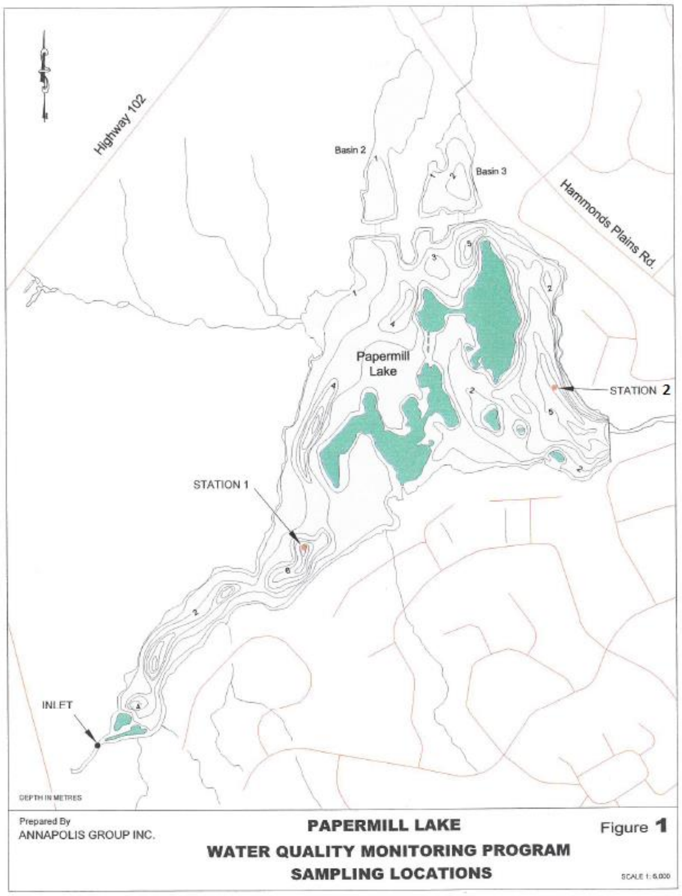


Figure 20. Paper Mill Lake deep-station locations (CWRS, 2006).

Lake-bottom DO concentrations at this location remained at or above 2.7 mg L^{-1} throughout the stratified period. By the end of September, the water column at Station 1 below a depth of 7 m became anoxic, affecting an area of lake-bottom of roughly 1,500 m^2 in size. TP at the 10 m depth had risen from a pre-anoxia onset concentration of 0.0056 mg L^{-1} in June to a September peak of 0.0116 mg L^{-1}. By the middle of October, the water column at both lake stations had thermally mixed and DO rose to saturation or near saturation levels through the water column, and TP concentrations returned to pre-onset levels. The net increase in the P mass in the volume of hypolimnion affected over the July through September period of anoxia was approximately 17,455 mg (Table II-1, Appendix II). Although P efflux from lake sediments may account for the majority of the P mass, other possible contributors include P contained in sedimentation and P re-cycling and re-deposition through chemical adsorptive processes.

Regardless of the weight distribution of net P contained in the anoxic zone by source, when compared with predictive P model outputs for various P loads reported in Scott & Hart (2004), the anoxic zone mass made up approximately 0.003% of the total annual P load of PML.

In addition to the reverse internal loading approach used above to estimate the role of internal loading when considering the total P budget for PML, release rates of 0.045 and 0.230 mg m^{-2} d^{-1} from Beaverskin Lake located in Kejimkujik National Park (Geolimnos Consulting, 1983), and a mean rate of 14 mg m^{-2} d^{-1} for a set of 15 North American and European lakes (Nürnberg, 1984), were considered for comparison (Table II-2, Appendix II). The set of Nürnberg lakes had long histories of anthropogenic pollution (i.e., anoxic lakes, lakes which are extremely productive, and may not necessarily be reflective of pristine lakes with natural anoxia due to, for example, morphometry) (Nürnberg, 1984). Application of these P efflux rates generated loads of between 2 and 658 g yr^{-1} and percentages of total annual lake loads ranging from 0.0003 to 0.1 percent.

There is no empirical data available to suggest that the water column at Station 1 experiences similar anoxia trends during the winter stratification period. However, if a zone of anoxic conditions was to occur, it is likely that the magnitude of P efflux would be less than that of the summer stratification; this would be due to the limiting effects of the direct relationship between water temperature and the rate of microbial oxygen consumption in lake sediments (Kelderman, 1984).

3.3 Fate of Phosphorus Contained in Anoxic Zone

When lakes become thermally stratified, the movement of phosphorus from the hypolimnion to the trophogenic zone (area in the water column where photosynthetic production predominates (Wetzel, 2001)), including the P portion released from lake sediments during periods of anoxia, is restricted by the presence of a dramatic temperature-density gradient ($>1^{o}$C change per metre), known as the thermocline. Maximum observed thicknesses of this zone during the 2005 summer stratification for KL and PML were 4m and 3m, respectively. With the thinning of the thermocline and at turnover, hypolimnetic P is allowed to mix throughout the water column. Nürnberg (1984) estimated that in the presence of high iron, roughly 30% of hypolimnetic P settles to lake sediments as iron precipitates, 30% is taken up by plankton, 38% stays in solution, with the fate of the remaining 2% unknown.

Evidence that hypolimnetic P has influenced epilimnetic waters during or following turnover is reflected in P increases in either epilimnetic or thermocline water, or in the volume-weighted water column mean concentration, following turnover. This correlates with P contained in the anoxic layer prior to mixing, and/or an increase in phytoplankton production (reflected in chlorophyll a levels), due to the injection of additional P into the trophogenic zone. In the case of KL and PML lakes, neither type of response was observed in 2005.

3.4 Internal Loading Monitoring Program

Based on the reviewed data and literature, internal loading is not currently a significant source of P to either KL or PML. Therefore, the pursuit of in-lake data for the sole purpose of monitoring this source is not warranted.

At some point in the future TP concentrations in KL and PML may increase above desired levels, triggering the need to re-visit the subject of internal loading. If this was to occur, it is recommended that any monitoring program intended to address the question consider the following. The focus of the program should be structured in such a way that ultimately the surface area and volume of anoxic zones along with a sense of duration are characterized. Anoxic zones tend to form in the deepest part of lakes and therefore vertical profiles of DO, temperature, pH, and TP/soluble reactive phosphorus (SRP) at the deep lake stations should be monitored. It would be important to consider SRP as an analyte because it would provide additional insight into the flux of P from lake sediments to overlying waters during periods of seasonal anoxia.

Historical thermal profiling information (CWRS, 2006) suggests that the onset of the summer stratification in KL and PML occurs in late-May. The first signs of anoxia come about in mid- to late-July and persist until mid-October. In order to track the emergence and maturation of anoxic zones in these lakes, it is recommended that a monitoring program operate between early July and mid-October. Table 17 presents monitoring program details.

Table 17. Internal loading monitoring details.

Sampling Season	July - September
Vertical profiling	DO, TP, SRP, pH, Temperature
KL	2 in Lake Stations
PML	2 in Lake Stations

4.0 Monitoring Program

Development in the Bedford West subdivision is regulated by the Municipality through the Halifax regional Planning Strategy (the "Regional Plan") and a number of subsidiary plans including the Bedford West Secondary Planning Strategy (BW-SPS). The Municipality's overriding policy objective for watersheds includes the goal of maintaining the existing trophic status for lakes and waterways to the greatest extent possible.

This process entails the determination of pre-development trophic status in subject watercourses and the development and execution of water quality monitoring programs to track changes in key indicators of trophic status, among other parameters.

Specific to the BW-SPS, Policy BW-3 requires that a water quality monitoring program be undertaken for the PML watershed to track the eutrophication process. The terms of the program are specified within Development Agreements that have been negotiated in consultation with the Bedford Watershed Advisory Board, until its dissolution in 2013, and the RWAB since 2013.

As the trophic state of a receiving water body is influenced by other factors beyond the activities associated with any individual development, directly measuring the P load at the development level is a more appropriate monitoring approach. The type of monitoring program required to adequately capture P loading from the Bedford West site was assessed.

4.1 Phosphorous Mass Loading

The calculation of loading of P from any contributing area requires quantification of: (i) concentration and (ii) flow. The real concern with respect to P being loaded into a lake is not the concentration (mass/volume) of the phosphorus but the mass of the phosphorus being exported to the lake (mass/volume * volume). It is this mass, then dispersed in the lake, that is responsible for the concentration in the lake (mass P in lake/volume lake).

Accurate quantification of mass loading is challenging as both P concentrations and surface runoff flow rates exhibit large temporal variability. P concentrations in runoff are seasonally variable, influenced by changes in hydrological and soil characteristics (Gelbretch et al. 2005; Macrae et al. 2007). P concentrations are also variable over the length of a storm event because of changing flows and reduced availability of P for export as the storm progresses (Macrae et al. 2007). As a result, representative sampling strategies must involve intensive sampling during storm event in all seasons.

4.1.1 Flow

Flow can be continuously measured using logging depth sensors (pressure transducers) that are installed in channels or hydraulic control structures. The measured water depth is converted to a flow rate using a depth-discharge relationship. Flow rate through the channel/structure must be manually gauged over a range of flows in order to develop the depth-discharge relationship.

If a control structure such as a weir or flume is used, the stage-discharge relationship can be developed using standard hydraulic relationships.

4.1.2 Phosphorus Concentration

Phosphorus concentrations in the runoff from a sub-watershed is correlated with rainfall events in a non-linear relationship (Macrae et al., 2007). The export of P from an area during a storm depends on factors such as rainfall duration and intensity, and antecedent watershed conditions, and for impervious areas, the time since the last runoff event. Sediment and P export is highly variable and can vary by more than an order of magnitude during a storm event (Macrae et al. 2007; Scott & Waller 2002). The variability in P export is attributed to the association of P with sediment and the changes in availability of sediment as a rainfall event progresses. This temporal variability is problematic for quantification of P loading as low sampling frequency can under or overestimate the P export from an area.

Figure 21 illustrates an example of a rainfall hydrograph superimposed with Total Suspended Solids (TSS) concentrations, which emphasizes the high temporal variability in TSS during a storm event. Examining data generated from Scott & Waller (2002), it was estimated that approximately 8 samples per a storm event are required to characterize P loading. Assuming an average of 13 runoff producing events per year for the HRM (Dillon Consulting, 2006), 104 samples outfall^{-1} yr^{-1} would be required to quantify P loading from a given catchment area. This is in agreement with Rekolainen et al. (1991), who assessed different sampling strategies for quantifying annual P loading, and found that using a flow-proportional (sample collected at a set interval of volumetric throughput) sampling strategy, with a threshold flow trigger (sample collected when a specified flow is exceeded), 100 samples produce an accurate estimate of annual P load.

4.1.3 Stormwater Outfalls

Ideally, all stormwater infrastructure that terminates in the PML sub-watershed would be instrumented and monitored. Parameters that would be monitored would include TP, Total Nitrogen (TN), and TSS.

The approximate cost of monitoring one stormwater outfall for one year is estimated to be in the range of $15,000. The estimate of $15,000 includes the initial capital cost of the equipment, which is estimated to be approximately $7,000, refer to Table 18 for a breakdown of the cost estimate.

The stormwater plans presented within the Bedford West Development Agreements for sub areas 2, 3 and 4, 5, 9, 7, and 8 were combined and are shown in Figure 22. Under full build out, it was estimated that there would approximately 27 outfalls, of various specified and unspecified types. They include outfalls from a variety of BMPs, including retention ponds, and vegetated swales. Implementing a P loading monitoring program across all stormwater discharge points and the estimated cost would therefore be impractical.

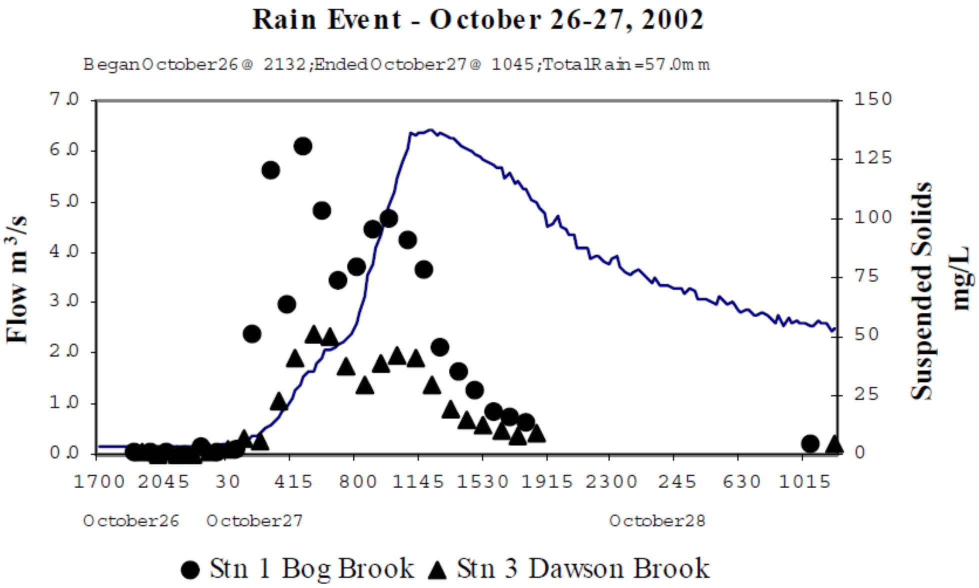
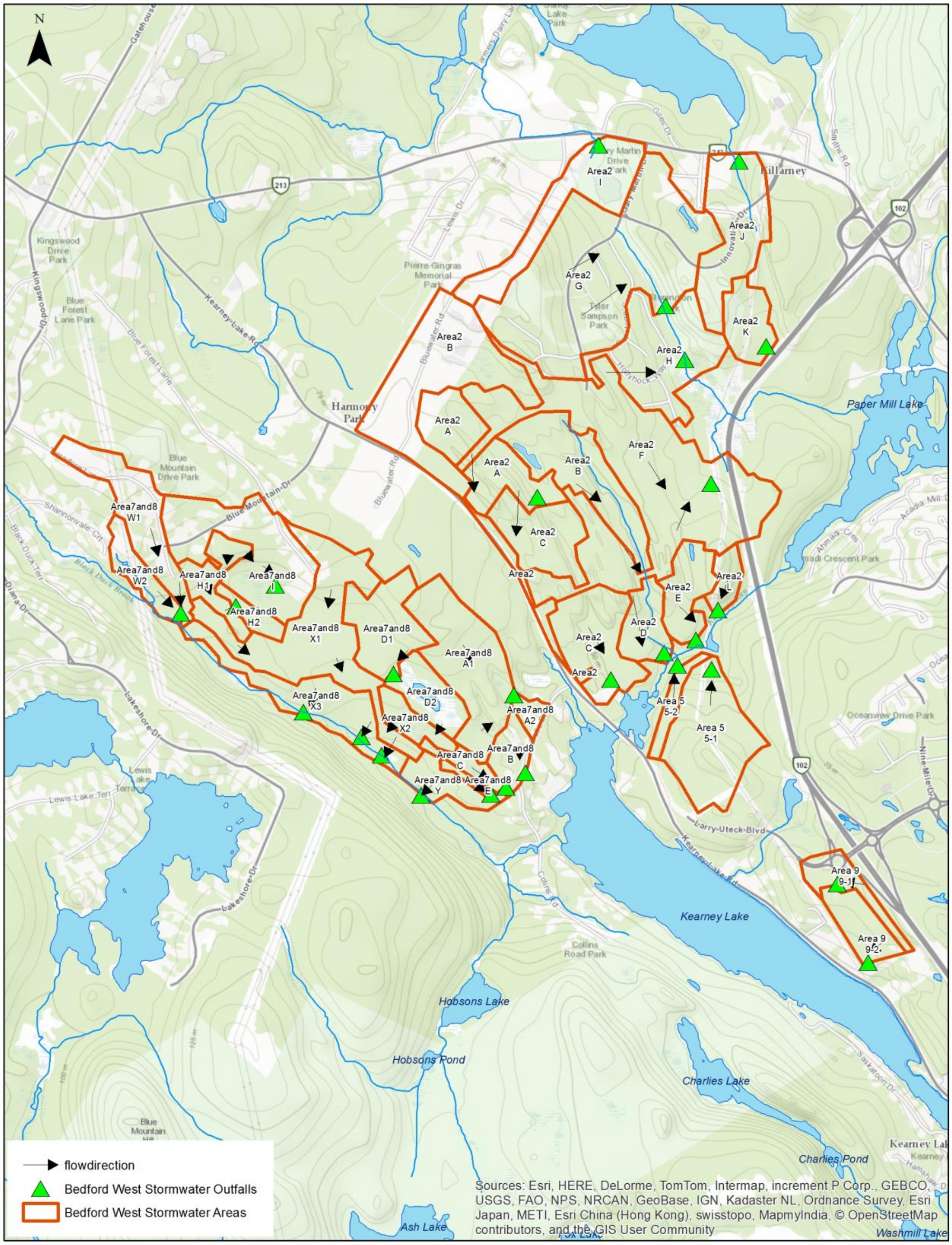


Figure 21 Characteristic hydrograph with suspended solids concentration during a large rain event. Demonstrates the high sediment export during the rising limb of the hydrograph that quickly tapers off as easily mobilized (eroded) sediment becomes less available.

Table 18. Annual cost estimate to monitor one outfall.

Cost Breakdown	
Events Per Year	13
Samples Per events	8
Analytical Cost Per Sample	$45
Analytical Cost Per Year	$4,700
Labour Cost Per Year (if part of larger program)	$3,300
Instrumentation Cost in First Year	$7,000
Total Cost Per Year/Outfall	$15,000



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 22. An approximation of Bedford West stormwater areas and outfall locations.

4.2 Alternative Monitoring Approach for Bedford West

It is recognized that the proposed monitoring program that is necessary to fully quantify P export from the Bedford West development is impractical. Below is a list of potential monitoring program alterations that could be employed to reduce the monitoring program to a more manageable level.

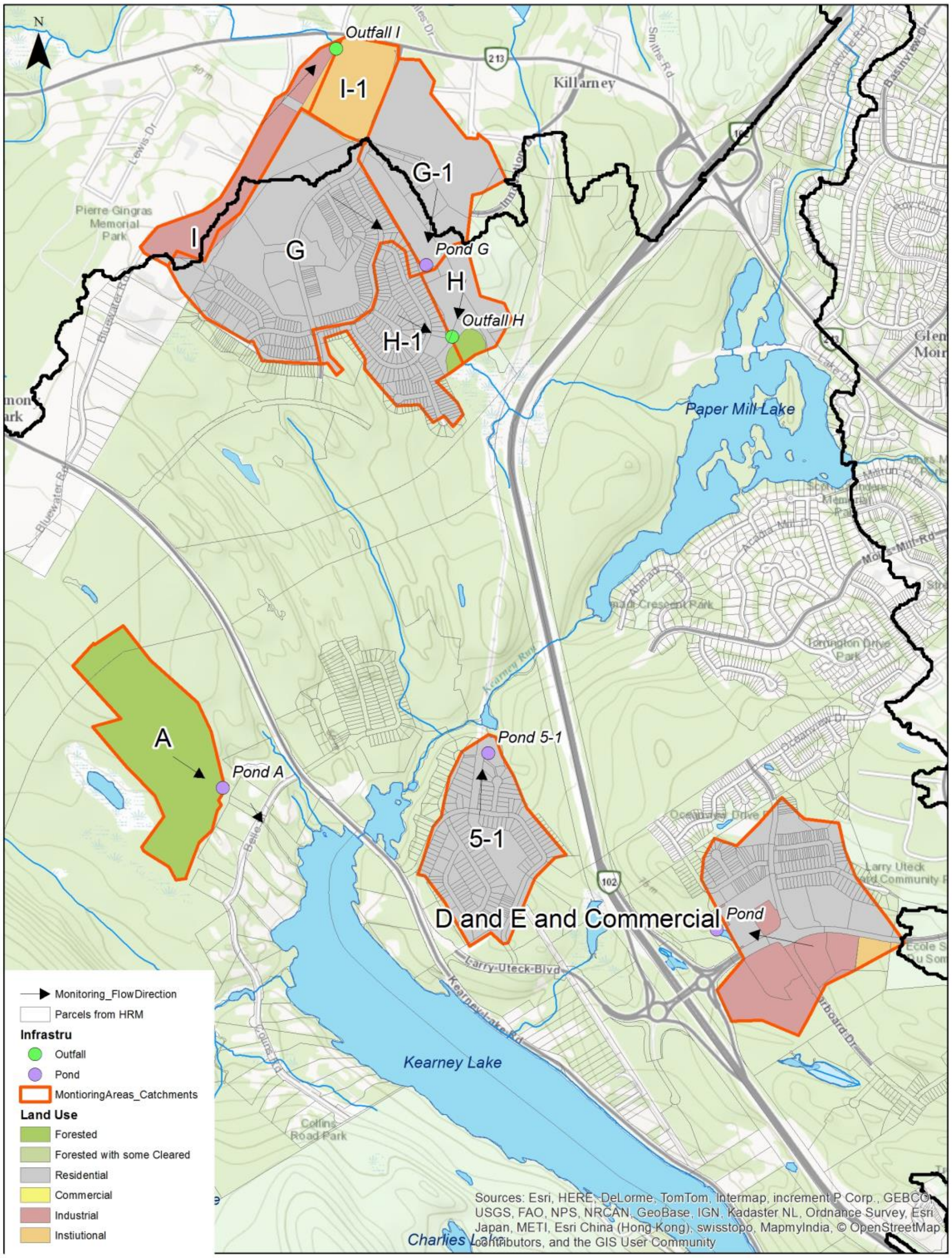
- Modify existing and planned storm water infrastructure and future planning to bring together multiple outfalls at the same location to reduce number of monitoring locations.
- Use a network of catchment areas with representative land-use characteristics (residential, commercial, industrial) in the watershed to validate export coefficients that are consistently used in P models for development approval. Use the validated export coefficients to estimate P export from other sub-watersheds based on land use to quantify the overall impact of Bedford West.
- Focus on monitoring a representative sub-set of implemented BMPs to determine their P retention performance.

From an initial review of the Bedford West development a scaled back monitoring program, focused on a sub-set of representative catchment areas, has been designed to illustrate what this type of program would look like and is not intended to be final. Details are provided in Figure 23 and summarized in Table 19. A well designed monitoring program for the Bedford West site could also provide opportunities to perform critical research that can be applied to future development in the Municipality. There is an apparent need to: (i) locally validate P export coefficients and (ii) assess the effectiveness of implemented BMPs in a local context.

4.2.1 Effectiveness of Best Management Practices

The Bedford West Master Stormwater Management Plan for Area 7 & 8 (LVM Maritime Testing, 2013) assumes TP removal rates ranging from 30% for extended dry detention ponds and 70% for infiltration basins and trenches. These removal rates are referenced from the HRM Stormwater Guidelines (Dillon Consulting, 2006) which were adopted from other regions. It is unknown whether BMPs in Nova Scotia would perform to the same standard. The available literature suggests that these BMPs can be highly variable in performance Hussain et al. (2005). Therefore, it is recommended that the pollutant removal capacity of BMPs be assessed in the local environment and based on governing design standards and specifications to which they have been built and are operating.

To assess the effectiveness of BMPs, water flow and concentration would need to be monitored continuously at the designated inlet and outlet of the structure. Over a period of 2-3 years a mass balance of the P entering and leaving the system would be performed, allowing for the quantification of a percent removal. In order to perform this assessment, it is important that an easily accessible and well defined influent and effluent location of the system be available.



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 23. Example of scaled back monitoring program to validate export coefficients and BMP removal efficiencies.

4.2.2 Phosphorus Export Coefficient Validation

As previously mentioned, it is generally not practical to physically measure P loading from a large residential development that possesses numerous stormwater discharge locations. However, an accurate estimate of P loading can be determined using a P loading model with validated phosphorus export coefficients. P export coefficients are a key component of the watershed modeling studies currently used to support planning policies. However, the ranges reported for these export coefficients for a given land use is large, and export coefficients have not been formally evaluated for the HRM (Section 2.1.2). The validation of export coefficients is predicated on the ability to identify easily monitored catchment areas with homogeneous land uses. Specific to the Bedford West development the following are examples of representative catchment areas for consideration in the development of a validation study; refer to Figure 23 and Table 19.

Table 19. Scaled back monitoring program example areas.

Area	Land use	Validation Target
For Bedford West		
5-1	Medium Residential (100%)	Validation of medium density residential export coefficient. Stormwater P removal efficiency to be determined.
A	Forest (100%)	Baseline data collection from accessible and un-impacted catchment and export coefficient validation for forested areas.
G-1	Dense Residential (apartments)	Validate export coefficients for high density residential. Areas G-1 and G flow to established stormwater pond for which the P removal efficiency to be determined.
H-1	Forest (2%) Residential (98%)	Validate medium density residential export coefficients and assess swale treatment effectiveness.
For Surrounding Area		
I, Blue Water Road	Residential (4%) Commercial/Industrial (91%) Industrial (5)	Validate export coefficients from primarily Commercial/Industrial land use.
D & E	Residential (19%) Commercial/Industrial (34%) Institutional (3%)	Validate export coefficient – potentially both residential and commercial land uses, and assess pond treatment.

Note that 2 sub-watersheds outside the Bedford West area have been recommended because of the limited developed commercial space in the Bedford West site to date. The desktop study identified catchment area I, Blue Water Road, and D&E in Bedford South as the closest areas to examine an industrial and commercial area respectively. However, a physical survey may indicate that the catchment is not suitable, and in this case another catchment within the Municipality with primarily commercial land use could be monitored alternatively.

5.0 Trophic State Monitoring

5.1 Definition of Trophic State

The trophic state of a water body generally refers to the amount of biomass that a water body can support. The biomass is most often quantified in terms of primary production in the form of phytoplankton, periphyton or macrophytes (aquatic plants). The classification of trophic state spans from oligotrophic (low biomass production, low nutrient levels, high biodiversity) to eutrophic (high biomass production, high nutrient levels, low biodiversity). Water bodies are typically grouped into three categories; oligotrophic, mesotrophic (moderate nutrient levels and biomass production) and eutrophic; however, in reality trophic state is a continuum. The trophic state may affect residential, industrial, and recreational uses. Of particular concern is when a water body becomes increasingly eutrophic resulting in excessive plant and algae growth. In this state the aquatic system may have: taste and odour issues, anoxic conditions in the hypolimnion, harmful toxins associated blue-green algae (cyanobacteria) blooms, poor visual esthetics, and/or the ability to clog water intakes or other infrastructure.

Eutrophication means “well fed”, and denotes that a lake has high concentrations of critical nutrients needed for primary production such as P and Nitrogen (N). Natural eutrophication occurs over a span of hundreds to thousands of years as nutrients and biomass accumulate in a water body. However, human activity such as agriculture, sewage disposal, water diversion, urbanization, etc., may disrupt the natural flow of nutrients and biomass in watersheds resulting in rapid progression in trophic state. This is termed “cultural” or “accelerated” eutrophication.

5.2 Trophic State Monitoring Approaches

5.2.1 Biological

Since trophic state is a description of ecosystem characteristics, it is best assessed by characterization of the presence and abundance of flora and fauna. There is a considerable body of research relating biological indicators to eutrophication and trophic state. However, the primary challenge with the use of biological indicators is that species are endemic (native, to a water body or area), and as a result, biological trophic indices are regionally specific. Additionally, monitoring trophic state via biological indicator species is time consuming and requires significant expertise. The advantage of biological indicators is that they change less rapidly and, with effective protocols and monitoring programs, can be monitored on a less frequent basis as compared to chemical indicators.

All countries within the European Union (EU) are now required to implement biological monitoring systems for freshwater systems. The European Union Water Framework Directive (WFD) Common Implementation Strategy (2003) specifically states:

“The use of non-biological indicators for estimating the condition of a biological quality element may complement the use of biological indicators but it cannot replace it. Without comprehensive knowledge of all the pressures on a water body and their combined biological effects, direct measures of the condition of the biological quality elements using biological indicators will always be necessary to validate any biological impacts suggested by non-biological indicators.”

The implementation of the EU WFD has resulted in a considerable research effort to develop biological indices of ecosystem health and trophic state. Typically, biological indicators in a lake of interest are compared to relatively pristine reference lakes in the same geographic area. The greatest benefit, and main reason for the advocacy of the use of biological indicators, is they are a direct measure of the impact of eutrophication (Cairns & Pratt, 1993). Biological indicators of trophic state that have been developed include the abundance, diversity, and distribution of species of phytoplankton (Rakocevic-Nedovic & Hollert, 2005), macrophytes (Dudley et al., 2013), benthic invertebrates (Pilotto et al., 2011) and/or fish (Argillier et al., 2013).

The agreement on the best trophic status biological indicators is still contentious as there are almost 100 biological assessment methods being applied to European lakes alone (Brucet et al., 2013). However, there has been a concerted effort through the WFD to standardize the data of member countries through intercalibration of metrics. Lyche-Solheim et al. (2013) conducted a meta-analysis of indicators being used to meet the WFD, ranking a total of 11 metrics with respect to their ability to detect changes in eutrophication pressure and hydromodification. The top ranked indicators for tracking eutrophication pressure were related to phytoplankton (chlorophyll *a*, taxonomic composition index, functional traits index). With respect to Canada, national protocols for biological assessment of aquatic systems exists through the Canadian Aquatic Biomonitoring Network (CABIN). CABIN is the core monitoring tool in the assessment of biological indicators in some larger watersheds (Great Lake Basin, St. Lawrence River, and Lake Winnipeg Basin). However, the CABIN program does not specifically focus on monitoring of trophic state.

5.2.2 Trophic State Surrogates

Common surrogate measures of trophic state include Secchi depth (transparency) and chlorophyll *a*. Secchi depth is an empirical measure that is based on the visual disappearance/reappearance of a physical disk as it is lowered/raised in the water column. It has been shown to be well correlated to water clarity and trophic state in clear water lakes (through the increased absorption of light with increasing phytoplankton population). However, measurement of Secchi depth is operator dependent and subjective, and it is influenced by water colour. For these reasons, it is not recommended as a reliable trophic state indicator for the Municipality’s lakes.

Chlorophyll *a*, a primary photosynthetic pigment, is a widely used trophic state indicator, as it has been shown that chlorophyll *a* levels can provide an adequate characterization of algal biomass (Lyche-Solheim, 2013). Primary disadvantages associated with the use of chlorophyll *a* as a trophic state indicator are the sampling and analytical requirements. Characterizing the mean chlorophyll *a* concentration in a lake requires a high sampling frequency, both temporally and spatially, as phytoplankton populations vary both in space and time. The EU WFD recommends the collection of at least 6-12 sampling events per year, and during each sampling event, samples must be collected at different depths throughout the euphotic zone, as phytoplankton have the ability to move throughout the water column. In general, strong relationships have been developed between chlorophyll *a* concentrations and phytoplankton populations. However, it should be noted that chlorophyll *a* production per unit mass of phytoplankton can vary as a function of phytoplankton species and environmental conditions, such as nutrient levels (Kasprzak et al., 2008).

The analytical requirements for chlorophyll *a* must also be carefully considered. There are three principle analytical methods used to measure chlorophyll *a* concentration – spectrophotometric, fluorometric, and high performance liquid chromatography (HPLC). The fluorometric and HPLC methods provide greater detection sensitivity than the spectrophotometric method and depending on the source, may also require less sample volume.

In Nova Scotia, two prominent research groups, the Canadian Wildlife Service (Dr. J. Kerekes) and the Centre for Water Resources Studies (CWRS, Dalhousie University), have routinely employed a fluorometric method, correcting for pheophytin with acidification, in all of their lake studies since the mid-1970's and early 1980's, respectively. Local commercial laboratories providing fluorometric analysis include: Queen Elizabeth II Environmental Services, Maxxam Analytics and AGAT. Given the extensive analytical histories of these groups, it is presumed that the majority of chlorophyll *a* data available in the province was generated using fluorometry. Another issue associated with the measurement of chlorophyll *a* is possible interferences with chlorophyll *b* and chlorophyll *c* if they are present in appreciable quantities within the samples. The use of narrow-bandpass filters within the flourometric technique can help mitigate this issue if it exists.

Of most importance is that analytical methods remain consistent within long term monitoring programs. Application of a common analytical methodology promotes the consistency of data being produced and facilitates any subsequent use of these data, especially when data is pooled. For example, the Kings County Volunteer Monitoring Program encountered a dramatic shift after seven years of chlorophyll *a* testing when the fluorometric analytical method being used during that period was replaced by a spectrophotometric method (Brylinsky, 2008). A subsequent paired-test study revealed that the spectrophotometric method produced consistently higher values compared to those generated by the fluorometric method. Consequently, the volunteer group was left with the dilemma of deciding what to do with the three years of data generated using the replacement method. It is extremely important that all individuals conducting water quality monitoring programs be aware that when chlorophyll *a* data based on different analytical methods is pooled, further evaluation may be necessary to establish the comparability of results.

5.2.3 Trophic State Drivers (Nutrients)

P has become intimately associated with trophic state and eutrophication ever since its presence in detergents was discovered as the leading contributor of eutrophication in the 1960s. P is typically the limiting nutrient for primary production in fresh water systems, where there is a strong relationship between P concentrations and chlorophyll *a*, which is an indicator of primary production and eutrophication. Typically, N is much more readily available for plant growth, resulting in N not being limited in freshwater systems. Additionally, blue-green algae (responsible for many bloom events) are able to fix (incorporate) N from the air, and as a result are rarely N limited; however, they may be limited by other micronutrients.

The OECD, conducted a large scale research program in the 1960s related to eutrophication, with a specific focus on the role of nutrients. The OECD research team produced a set of five reports; four initial reports, and one supplementary report focused on Canadian freshwater systems. These reports are summarized in “Eutrophication of waters. Monitoring, assessment and control” (Vollenweider & Kerekes, 1982). The reports covered lakes and reservoirs in Europe and North America. The focus was on quantifying the relationships between chlorophyll *a*, TP, TN, and Secchi depth in lakes of varying trophic status. The Canadian supplementary report (Janus & Vollenweider, 1982) compared data collected from a suite of Canadian lakes to relationships developed in the original OECD studies. The Canadian supplementary report found that for the 58 lakes examined, the relationship between TP and chlorophyll *a* was similar to those created from the original OECD dataset of 110 lakes. This led to the development of trophic state trigger ranges based on TP concentrations.

The P-based trophic state classification scheme developed by the OECD has been widely adopted in Canada (CCME, 2004), and elsewhere, despite the fact that the OECD stressed that these relationships may not apply to all lakes. The list of situations where the relationships may not be applicable—that were outlined in the Canadian OECD supplementary report—include situations when:

a) $z_{eu}/\overline{z}$ (euphotic zone depth/mean depth) is substantially greater than one;

b) Hydraulic load is high ($q_s > 50$ m y^{-1}), flushing rate is more than twice/year (Water retention time (WRT) < 0.5 yr) and/or lakes with irregular flushing regimes either seasonally or over consecutive years;

c) High mineral turbidity or a high degree of humic staining exists;

d) N/P ratios are ≤ 5 and/or P exceeds 100 mg m^{-3};

e) P is relatively inert (e.g. as apatite) or internal loading is substantial; and

f) Dynamic equilibrium has not been attained as in the case of increasing or decreasing nutrient loads.

The general relationships between TP and chlorophyll *a* have been validated in several studies involving multi-lake datasets in a broad range of geographies. However, it has also been shown that these relationships are not valid for every lake, and that other factors besides TP concentrations may control the level of productivity in a lake ecosystem (Kalff, 2002; Spears et al., 2013). Other factors that could influence the relationship between phosphorus and chlorophyll *a* are N:P ratios, flushing rates, water colour, alkalinity, temperature, and stratification regimes.

5.3 Trophic State Classification Systems

Trophic state trigger ranges, based on concentrations of both TP and chlorophyll *a*, have been developed by several agencies and jurisdictions. Examples of a suite of trophic state classification systems are presented in Table 20. The classification systems are generally similar, with mean annual TP and chlorophyll *a* concentrations of 10 ug L^{-1}, and 2.5 - 3 ug L^{-1}, respectively, designated as the threshold for a transition from oligotrophy to mesotrophy by Environment Canada (2004). The Canadian criteria (CCME, 2004) have been adapted from the original OECD trigger ranges, with an additional sub-division for TP concentrations identifying a meso-eutrophic trophic state.

More recently, an updated ecological classification system for lakes has been developed for Europe as part of the EU WFD (Carvalho et al., 2006). The classification system is again based on chlorophyll *a* as the primary metric of trophic state, and P as the primary driver of the eutrophication process. Relationships between chlorophyll *a* and TP concentrations were assessed in a total of 540 lakes, resulting in the establishment of new thresholds for chlorophyll *a* and TP based on lake type. Lakes were categorized according to several parameters including alkalinity, mean depth, and colour. An ecological classification system based on deviation from a reference condition was developed. A classification system was developed for Europe as a whole, and a separate system was also developed specifically for the United Kingdom. Within this classification system, lakes are classified into one of 5 ecological status categories: High/Good/Moderate/Poor/Bad. Provided in Table 21 are the upper boundaries for the "High" and "Good" ecological status categories for both mean annual chlorophyll *a* and TP concentrations in the United Kingdom as an example.

5.3.1 Carlson Index

The Carlson index relates three easily measured parameters, TP, Secchi depth, and chlorophyll *a*, to trophic state (Equations 1-3) (Carlson, 1983). These three parameters were chosen because P is generally the limiting nutrient in freshwater systems, and Secchi depth and chlorophyll *a* are surrogates of primary production. The Trophic State Index (TSI) is a continuous scale from 0 to 100 and is determined separately for each parameter; the trophic state is identified by an assessment of the 3 TSI values. The TSI values are not intended to be averaged. There is generally good agreement between the calculated TSI of these three parameters. However, the TSI values do not always agree nor are they indicative of trophic state in all water bodies. Lakes with unique morphology, nutrient limitations, and/or high color may have TSI values not reflective of the trophic state. Carlson (1983) provided guidance on how to interpret disagreements between calculated TSI values (Table 22). There are many regionally modified versions of the Carlson index that may include other parameters or modifications of the TSI to improve the local predictive capacity.

Table 20. Summary of trophic state trigger ranges (Adapted from Galvez et al., 2007).

Trophic status	TP (µg L^{-1})	chlorophyll *a* (µg L^{-1})	
		Mean	Maximum
OECD criteria[a]			
Ultra-oligotrophic	< 4	< 1	< 2.5
Oligotrophic	< 10	< 2.5	< 8
Mesotrophic	10-35	2.5-8	8-25
Eutrophic	35-100	8-25	25-75
Hypereutrophic	> 100	> 25	> 75
Canadian criteria[b]			
Ultra-oligotrophic	< 4	< 1.0	< 2.5
Oligotrophic	4-10	< 2.5	< 8
Mesotrophic	10-20	2.5-8	8-25
Meso-eutrophic	20-35	--	--
Eutrophic	30-100	8-25	25-75
Hypereutrophic	> 100	> 25	> 75
Nurnberg criteria[c]			
Oligotrophic	< 10	< 3.5	--
Mesotrophic	10-30	3.5-9	--
Eutrophic	31-100	9.1-25	--
Hypereutrophic	> 100	> 25	--
Quebec criteria[d]			
Oligotrophic	4-10	1-3	--
Mesotrophic	10-30	3-8	--
Eutrophic	30-100	8-25	--
Hypereutrophic	--	--	--
Swedish criteria[e]			
Oligotrophic	< 15	< 3	--
Mesotrophic	15-25	3-7	--
Eutrophic	25-100	7-40	--
Hypereutrophic	> 100	> 40	--

[a]Ryding and Rast (1994), [b]Environment Canada (2004), [c]Nurnberg (2001), [d]MDDEP (2007), [e]University of Florida (1983).

Table 21. EU WFD lake type ecological status boundaries for annual mean TP and chl *a*. Provided are 2 values (separated by a semicolon) representing the boundaries between the "High/Good" and "Good/Moderate" ecological status categories (Spears et al., 2013).

	High alkalinity very shallow	High alkalinity shallow	Moderate alkalinity deep	Moderate alkalinity very shallow	Moderate alkalinity shallow	Low alkalinity shallow	Low alkalinity very shallow	Low alkalinity deep
Annual mean TP (ug L^{-1})	23; 32	17; 23	8; 13	16; 23	11; 16	7; 10	9; 14	5; 9
Chla (ug L^{-1})	8.6; 16.5	4.6; 7.5	4.4; 6.7	8.3; 15.3	4.7; 7.2	3.2; 5.5	4.1; 7.9	3.2; 4.8

Equations 1-3 Carlson's (1976) Trophic State Index (TSI) equations. Calculations result in a value from 0 – 100.

$$TSI(SD) = 10(6 - \frac{ln(SD)}{ln(2)}) \quad \text{Equation 1}$$

$$TSI(Chl) = 10(6 - \left(2.04 - 0.68\frac{ln(Chl)}{ln(2)}\right)) \quad \text{Equation 2}$$

$$TSI(TP) = 10(6 - \frac{ln(\frac{48}{TP})}{ln(2)}) \quad \text{Equation 3}$$

Table 22. The interpretation of disagreements in TSI values calculated from chlorophyll *a*, total phosphorus and secchi depth (Carlson, 1983).

Relationship between TSI	Carlson's Interpretation
TSI(Chl) = TSI(TP) = TSI(SD)	Algae dominate light attenuation
TN/TP ~ 33:1 TSI(Chl) > TSI(SD)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(SD) > TSI(CHl)	Non-algal particulates or color dominate light attenuation
TSI(SD) = TSI(Chl) > TSI(TP)	Phosphorus limits algal biomass (TN/TP >33:1)
TSI(TP) > TSI(Chl) = TSI(SD)	Algae dominate light attenuation, but some factor such as nitrogen limitation, zooplankton grazing or toxics limit algal biomass

5.3.2 CCME Water Quality Index

A water quality index (WQI) has been suggested by the CCME as a convenient tool to communicate water quality results. A WQI considers the scope (number of failed tests), frequency, and amplitude (amount) of water quality criteria exceedances. The CCME does not have a list of recommended parameters or objective levels, and as a result a substantial investment in each jurisdiction in the development of a regional WQI is required. Additionally, the CCME's user manual explicitly states that objectives are dependent on the nature of the waterbody (stream, river, lake). A WQI has not been developed for the HRM, or Nova Scotia. Required for the application of a WQI to HRM lakes is the:

1. Determination of individual waterbody use objectives;
2. Determination of applicable parameters to the aforementioned objectives;
3. Determination of acceptable parameter ranges (guided by CCME and regional water quality monitoring); and
4. Establishment of a routine monitoring program with standard procedures.

Although a WQI is certainly useful for characterizing the general health of a waterbody, it would not appear to be relevant as an indicator for monitoring specific water quality impairments, such as trophic state.

5.4 Other Key Factors

Although P has become the most widely used indicator for trophic state in Canada, recent literature suggests that other factors can significantly affect the water quality and biological productivity in lakes, and in some cases, more so than P levels.

5.4.1 Flushing Rates (Water Retention Time)

The flushing rate of a lake, which is related to water retention time (WRT), has a strong influence on both nutrient levels and growth of algae (Jones and Elliott, 2007). There is a general consensus in the literature that as flushing rates increase (and WRTs decrease) lakes are less vulnerable to trophic state changes as a result of nutrient loading. Early work conducted by Kerekes (1975) on a set of lakes in southwestern Nova Scotia demonstrated the influence of flushing rates on nutrient levels, showing that lakes with high flushing rates ($> 7\ yr^{-1}$) were less vulnerable to pollution than lakes with low flushing rates. Higher flushing rates also shorten the time that P is available to be assimilated by algae, and the time that algae have to establish communities. High flushing rates (shorter WRTs) are also negatively correlated with algal blooms (Kalff, 2002; Londe et al., 2016). Several researchers have empirically observed a relationship between decreased algal growth and high flushing rates (Dickman, 1969; Reynolds & Lund, 1988; Maberly et al. 2002). Jones & Elliott (2007) specifically examined the influence of WRT on phytoplankton growth and mean chlorophyll *a* levels using a calibrated process based modeling approach. They observed a four-fold decrease in mean chlorophyll *a* concentrations moving from a WRT of 338 to 8 days. Chlorophyll *a* still shows positive correlations with P concentrations but the relative influence of P levels appears to diminish, and the response of algae populations to P increases is dampened, as flushing rate increases. It should be emphasized that a high flushing rate cannot entirely prevent algal blooms from occurring, although it is certainly an important factor that can affect trophic state.

5.4.2 Climate Change and Acidification Effects

Climate change is slowly increasing global air temperatures and water temperature of freshwater lakes are also increasing; surface water temperatures in seasonally ice-covered lakes are increasing by 0.72°C per decade (O'Reilly et al. 2015). There has been considerable interest in assessing how algae populations, and in particular harmful cyanobacteria, may be responding to climate change. Increasing temperatures can directly influence the growth of algae, and can alter the strength and duration of stratification phenomena, which also affects the population size and species distribution of algae. Several researchers have found that increasing water temperatures favours the dominance of cyanobacteria (Paerl & Husiman, 2008; Elliott, 2010). Rigosi et al. (2015) demonstrated through a modeling study that a small water temperature increase (by 0.08°C from 24°C) can increase the risk of harmful cyanobacteria blooms by 5%; the same increase in bloom risk was found for a P increase from 10 μg L^{-1} to 20 μg L^{-1}. In general, their study indicated that rising temperatures may be a more important factor influencing lake trophic state than P levels.

Another global process that appears to have had a significant effect on the trophic structure of lakes in many parts of North America and Europe is acidification. In particular, recent work conducted on Nova Scotia lakes has indicated that decreases in calcium concentrations in lakes, a result of acidification, has caused a shift in dominant zooplankton species that feed on algae (Korosi et al., 2012). This shift to less effective grazers of algae can have a pronounced effect on aquatic food webs, and it has been observed that chlorophyll *a* concentrations have increased in some lakes without an increase in nutrient levels.

5.4.3 Colour and Dissolved Organic Carbon

Another factor that has been shown to influence trophic state is water colour, also measured by the surrogate parameter Dissolved Organic Carbon (DOC). The main contributor of colour, and the main component of DOC, is humic matter, which absorbs light and limits its penetration into the water column, thus having a negative relationship with Secchi depth (Webster et al., 2008). Humic matter is also a carbon source for heterotrophic organisms and can affect lake metabolism and levels of other nutrients. By its absorption of light, high colour can potentially limit algal and macrophyte growth. Contrastingly, colour has been shown to have a positive relationship with chlorophyll *a* in some studies, such as Webster et al. (2008). The authors hypothesized that this could be due to higher numbers of motile algae, and higher concentrations of chlorophyll *a* produced by individual algal cells. Due to its strong effects on chlorophyll *a* and Secchi depth, two widely used trophic state indicators, as well as on overall dynamics such as lake metabolism, colour is an important parameter to consider when evaluating lake trophic state.

5.5 Monitoring Recommendations for Paper Mill Lake Watershed

Theoretically, trophic state is best assessed through the measurement of a suite of biological indicator species, however the use of biological monitoring approaches within a regulatory process would not currently be practical for lakes in the HRM. The use of biological approaches would first require a considerable effort to identify and characterize reference conditions and develop standard statistical approaches for comparing monitored lakes to these reference conditions. The choice of appropriate biological method would also be influenced by the characteristics of the lake and the types of pressures (eutrophication, hydromodication) placed on the lake. Finally, the majority of the biological approaches would require specific technical expertise for sample collection and analysis, and for interpretation of the data, which may not be consistently available. Therefore, biological monitoring approaches are not currently recommended for compliance monitoring of lakes within the PML watershed. However, HRM is encouraged to initiate some form of biological monitoring within the PML watershed, and other pressured lakes, to start to develop the database necessary to possibly use this approach in the future.

In the absence of a biological indicator of trophic state, the best available chemical indicators are chlorophyll *a* and TP. TP has been widely used as the trophic state indicator in HRM, and other regions of Canada. As discussed in Section 5.2.3, P is typically the limiting nutrient in freshwater systems, and strong relationships have been developed between mean TP and chlorophyll *a* concentrations. Mean TP concentrations can typically be quantified in a lake with less sampling effort than chlorophyll *a*, and most commercial laboratories can perform low-level detection of P.

A meta-analysis of available water quality data from HRM lakes was conducted to assess the applicability of the TP trigger ranges developed by the OECD, and largely applied in the CCME (2004) guidelines (Figure 24 and Figure 25). It was found that the OECD TP:chlorophyll *a* relationships are generally applicable to the region. The strength of the relationship was only evident when several years of data were used to characterize the mean TP and chlorophyll *a* levels for each lake (Figure 24). When the dataset was analyzed on a yearly basis (i.e., TP and chlorophyll *a* values for each year were plotted separately, resulting in 5-6 data pairs for each lake) the relationship was much weaker (Figure 25). However, there are lakes that deviate from this relationship, and a further survey of the peer reviewed literature (Section 5.2.2 and Section 5.4) has shown that there are several factors which may influence the response of a lake to increasing nutrient levels.

With respect to PML, the high flushing rate (76 times yr^{-1}), would indicate that the biological response of this system to P concentrations could deviate significantly from the OECD TP:chlorophyll *a* relationship. For this reason, it is recommended that chlorophyll *a* be included as the primary determinant of trophic state in future monitoring programs. As noted earlier, sampling and analysis of chlorophyll *a* is more challenging than TP; however, it is our opinion that the uncertainty associated with the use of TP as the sole trophic state indicator for PML warrants this extra monitoring effort. It was also noted that the recent water quality data collected from PML has shown an increasing concentration in TP, moving towards the eutrophic range, while mean chlorophyll *a* concentrations have largely remained in the oligotrophic range. However the fact that these recent samples were not collected from the pelagic zone of the lake limits their ability to be used for trophic state assessment.

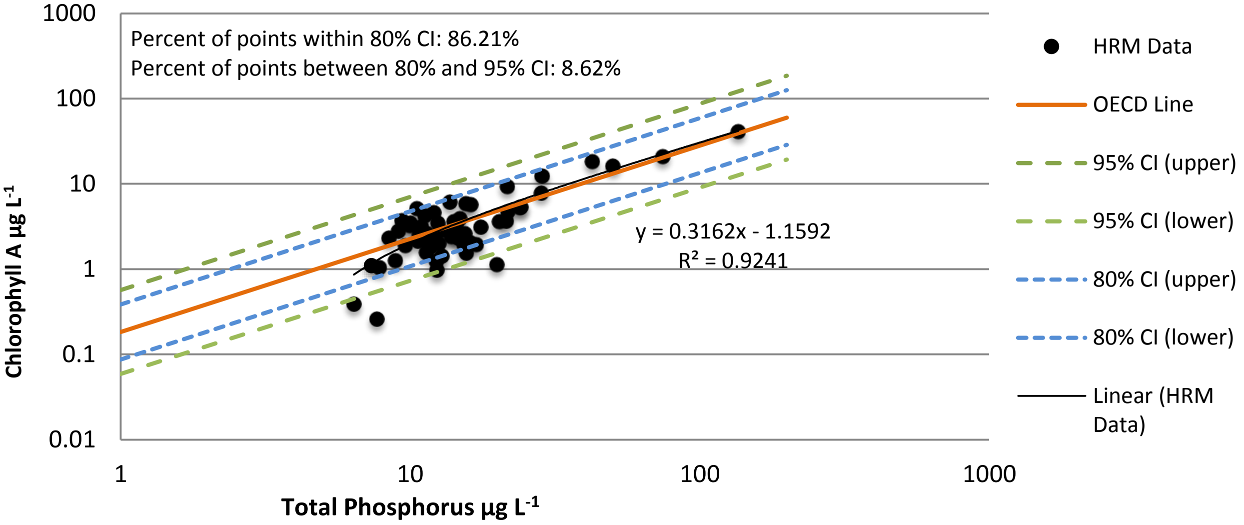


Figure 24. Mean TP and corresponding chlorophyll *a* values based on average TP:Chla relationship for 58 lakes in the Halifax Regional Municipality. Data was collected from 2006-2011.

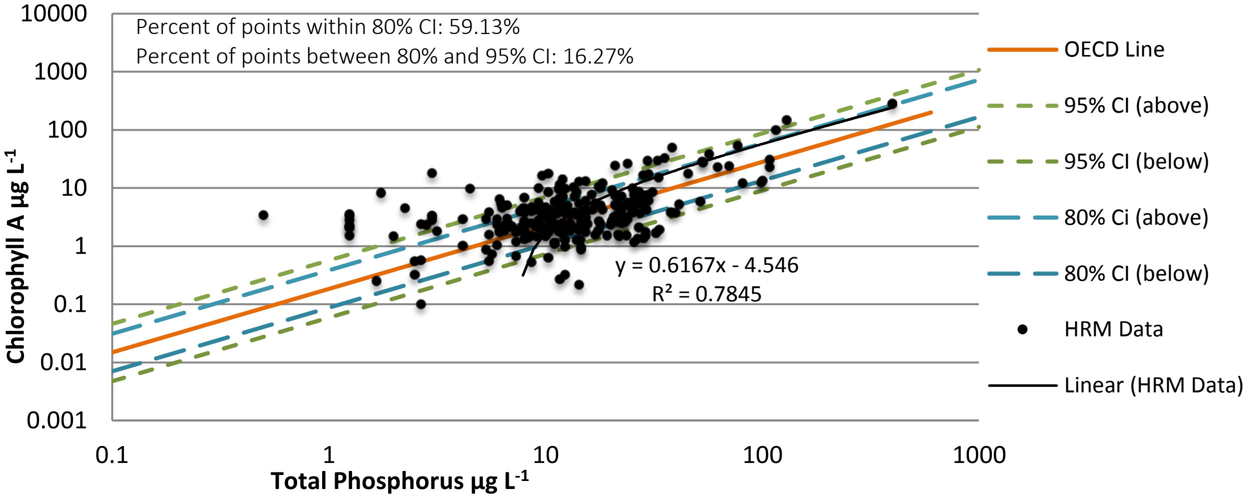


Figure 25. Annual mean TP and annual mean chlorophyll *a* for 58 lakes in the Municipality. Data was collected from 2006-2011.

The characteristics of KL are more aligned with the original suite of lakes included in the development of the OECD TP trigger ranges, however the flushing rate is still greater than 2 times yr^{-1}. As it would be preferable to have consistent monitoring regimes for both lakes, it is therefore recommended that chlorophyll *a* be included as the primary determinant of trophic state in KL in future monitoring programs. It is also important to maintain a consistent monitoring program for both lakes as PML is strongly influenced by the outflow of KL. It is recommended that the annual mean of chlorophyll *a* concentrations during the ice-free period be used as the indicator of trophic state. The mean chlorophyll a trophic state trigger ranges provided by Vollenweider & Kerekes (1983) should be used to determine trophic state (Table 23).

Table 23. Chlorophyll a trophic state trigger ranges based on annual mean concentrations.

Trophic status OECD criteria	Mean[a]
Ultra-oligotrophic	< 1
Oligotrophic	< 2.5
Mesotrophic	2.5-8
Eutrophic	8-25
Hypereutrophic	> 25

[a] Vollenweider & Kerekes (1982).

The recommended sampling strategy for PML and KL is outlined in Table 24. TP would still be included in the suite of measured parameters, and could still be a component of the regulatory monitoring program; however, chlorophyll *a* levels would be the primary parameter used to classify trophic state. Additional parameters that should be included in the monitoring program, at a minimum, are TP, TN, TSS, turbidity, colour, alkalinity, pH, and DO. An example of implementation of this sampling strategy is detailed in Section 7.0. Volume-weighted concentrations of chlorophyll a and other nutrients (P,N) should be computed when determining average concentrations of these constituents in the lakes.

A permanent discharge measurement station should be installed at the outlet of PML. Continuous measurement of discharge would allow for an assessment of the intra-annual variability in WRT within PML. On average, PML has a flushing rate of 76 times yr^{-1} but flushing rates could be much longer (e.g. during the summer), or shorter (e.g. during the spring), depending on the time of year due to variability in hydrologic inputs.

Table 24. Recommended sampling strategy for monitoring trophic state via chlorophyll *a* in KL and PML.

Sample	Strategy
Season	Ice free to fall turn over
Frequency	Bi-weekly
Location	2 deep stations in each lake
per Station	3 minimum (top, middle and bottom of euphotic zone)

6.0 Consequences of Adopting Different Thresholds

6.1 Alternative Trophic State Thresholds for Paper Mill Lake Watershed

The current water quality threshold that is used within the regulatory framework for the management of KL and PML is a TP concentration of 10 µg L^{-1}. This concentration corresponds with the upper level of the oligotrophic trophic state in the CCME guidelines. Concerns have been raised regarding the appropriateness of this threshold due to two primary reasons:

1. Given the existing (pre-Bedford West) potential sources of P within the watershed, the baseline concentration of P in these lakes may be higher once an equilibrium condition is reached (i.e. all sources, including septic systems, are fully contributing their P load); and

2. P may not be an appropriate indicator of trophic state within these lakes.

A suite of alternate thresholds that could be applied within a regulatory monitoring framework for management of KL and PML was therefore compiled (Table 25). The strengths and weaknesses of each threshold have also been provided. Based on our review of available water quality indicators, the two parameters that could be used within a regulatory framework are TP and chlorophyll *a*. As discussed in Section 5.5, chlorophyll *a* would be the recommended trophic state indicator for these lakes, however TP concentrations could still be used within a regulatory monitoring framework, as P is the primary driver of trophic state change that is influenced by anthropogenic activities in the watershed.

In general, the primary weakness of using a TP concentration as the sole regulatory threshold is that TP is not a direct indicator of trophic state. The main strength of using a TP concentration as the regulatory threshold is that the sampling and analytical requirements are reduced.

Chlorophyll *a* concentrations could also be the sole metric used within a regulatory framework. For example, the upper value of the oligotrophic trophic state ranges (both annual mean and maximum values) could be used as the regulatory thresholds. The primary advantage of using chlorophyll *a* is that it is a direct indicator of trophic state. The primary disadvantage of using chlorophyll *a* is that the sampling requirements are increased. As well, the use of this type of threshold would not focus on controlling the primary anthropogenic driver of trophic state change (P loading). The optimal regulatory monitoring model would involve the use of the dual-threshold approach; whereby chlorophyll *a* is used to ensure the desired trophic state is maintained, and TP is used to ensure that nutrient levels are maintained within an acceptable range.

The choice of specific TP or chlorophyll *a* threshold to adopt as the threshold is dependent on the level of risk that the municipality wants to accept, and the level of confidence in the P loading models that have been used to predict the equilibrium concentration of P in these lakes. Obviously, selection of a higher TP or chlorophyll *a* threshold (e.g. in the mesotrophic range) mean that the concentrations would be in the mesotrophic range at the point at which a management review would be initiated.

An alternative to using a set TP concentration as the threshold is to implement a percentage increase over baseline conditions as the threshold. As an example the CCME guidelines recommends a 50% increase over baseline TP concentrations as a second trigger for possible intervention. The challenge with this approach is in identifying what an appropriate baseline concentration is. The baseline concentration could be established based on water quality data from a specific time period prior to a development (e.g. the mean phosphorus concentration from 2005-2008). The baseline concentration could also be established through a model backcasting exercise (e.g. predict the phosphorus concentration in each lake for a specific stage of watershed development). Given the uncertainties associated with the parameterization of steady state phosphorus loading models for this watershed, discussed previously, it would not be advised to use a modeled baseline concentration for regulatory purposes.

In essence, raising the threshold value(s) corresponds to an acceptance of a higher level of pollution, and associated environmental change, because these pollution sources already exist in the watershed. An analogy would be raising the speed limit because too many people are already speeding. However, maintaining and enforcing the current threshold, or speed limit, will require an intervention program that addresses all major P sources in the watershed, not just Bedford West. This will require a considerable effort on the part of the municipality to develop and implement mechanisms, both regulatory and non-regulatory, to address other P sources (e.g. septic systems).

The authors would like to note that regulating the activities of a specific development based on compliance with water quality thresholds in a receiving water body is challenged for several reasons. The PML watershed, in particular, possesses numerous types of activities that could influence the water quality of KL and PML. Linking a change in water quality to an individual activity would require a monitoring effort that is simply not practical. In addition, there are other external factors, such as climate change, that can potentially influence water quality, and trophic state, in an aquatic system. Therefore, if a water quality threshold, either chlorophyll *a* or TP, was exceeded it would not be possible to identify any one watershed activity as the cause of the change. Considerable resources would need to be invested in a monitoring program in order to identify the source, and it is possible that the cause of the water quality shift would never be conclusively identified. These resources would be more effectively allocated to a watershed-wide intervention program that targets all primary sources of P in the watershed.

Table 25. Alternative thresholds that could be used within PML/KL regulatory monitoring program.

Trigger ***Phosphorus-Based***	**Strengths**	**Weaknesses**
10 µg L^{-1} (Status Quo)	- Conservative - Less intensive monitoring program - Focused on anthropogenic driver of trophic state change	- Not a direct measurement of trophic state - Baseline conditions could be > 10 µg L^{-1} - Possibly overly conservative if KL and PML can handle higher concentration without change in trophic state
20 µg L^{-1}	- Realistic target if model projections are correct - Less intensive monitoring program - Focused on anthropogenic driver of trophic state change	- Assumes models are correct - Not a direct measure of trophic state - Higher risk of allowing transition to different trophic state with associated waterbody use impacts - Already transitioned to a different trophic state if TP trophic state ranges are applicable
15 µg L^{-1}	- Realistic target if model projections are correct - Less intensive monitoring program - Focused on anthropogenic driver of trophic state change - Proactive if goal is to prevent a transition to 20 µg L^{-1} TP	- Assumes models are correct - Not a direct measure of trophic state - Higher risk of allowing transition to different trophic state with associated waterbody use impacts
% increase over baseline (e.g. 25%, 50%)	- Possibly less risk of transition to different trophic state as compared to other triggers if pre-2008 monitoring data used to define baseline condition - Less intensive monitoring program - Focused on anthropogenic driver of trophic state change	- Need to define the baseline condition and statistical approach to assess if 25 or 50% increase has occurred - Baseline condition may be greater than this value if system is not currently in equilibrium - Not a direct measure of trophic state - Moderate risk of ecosystem change compared to status quo trigger
Chlorophyll-based		
Mean chl a > 2.5 µg L^{-1}	- Direct measure of trophic state - Conservative	- Does not focus on potential anthropogenic causes of ecosystem change - More intensive sampling program with potential analytical challenges/variability

Trigger	Strengths	Weaknesses
Max chl a > 8 $\mu g\ L^{-1}$		
Mean chl a > 8 $\mu g\ L^{-1}$ **Max chl a > 25 $\mu g\ L^{-1}$**	- Direct measure of trophic state - Takes into account potential state of ecosystem if P loading models are correct and TP/chl a relationship follows OECD statistical model	- Does not focus on potential anthropogenic causes of ecosystem change - More intensive sampling program with potential analytical challenges/variability - Allows for a change in trophic state and associated adverse water use impacts
Dual Trigger Approach (Example)		
25 or 50% TP increase **or** **Mean chl a > 2.5 $\mu g\ L^{-1}$** **Max chl a > 8 $\mu g\ L^{-1}$**	- Direct measurement of trophic state - Tracks potential anthropogenic drivers of trophic state change	- Need to define the baseline condition and statistical approach to assess if 50% TP increase has occurred - Baseline TP values may be greater than this value if system is not currently in equilibrium - More intensive sampling program with potential analytical challenges/variability

6.2 Consequences of a Shift from Oligotrophy to Mesotrophy

The alternative thresholds that are presented in Table 25 are largely linked to either an oligotrophic or mesotrophic trophic state condition. The selection of a higher threshold would mean that there is a greater risk of a change in the trophic state of the system. The trophic state of the system will have an impact on the use of the lake for recreational purposes, and on the aquatic organisms which inhabit the lake. Keith et al. (2012) state that mesotrophic lakes typically have *"moderate biological productivity, intermittent blooms of algae and/or small areas of macrophyte beds"* in comparison to oligotrophic lakes, which "*contain relatively few plants, diversity, and/or biomass"*.

From the perspective of recreational use of the water body, the potential for harmful algal blooms (HABS) is the most important consideration. Cyanobacteria growth and dominance within freshwater lakes is influenced by many factors including nutrient levels, temperature, flushing rates, colour, alkalinity, and stratification dynamics (Elliott, 2010; Carvallho et al., 2011). P levels have been shown to have a large influence of cyanobacteria dominance. Downing et al. (2001) specifically examined the relationship between cyanobacteria dominance and TP concentrations in temperate zone lakes. They found that the risk of cyanobacteria dominance was <10% when TP concentrations were less than 30 µg L^{-1}. Rigosi et al. (2015) also examined cyanobacterial bloom risk as a function of trophic state, as characterized by P concentrations, in a modeling study. Lake systems at the upper limit of the OECD oligotrophic range (10 µg L^{-1} P) were modelled and compared to systems at the upper limit of the mesotrophic range (20 µg L^{-1} P). A mesotrophic system had a 5% increase in harmful cyanobacterial bloom risk (a bloom being defined as $>1x10^5$ cells mL^{-1}) compared to oligotrophic systems. They also examined the additional factor of increasing temperature and found that mesotrophic systems experienced a 27% increase in probability for harmful cyanobacterial blooms in response to a temperature increase of 4°C, compared with bloom probability increases of 3.9% and 5% for oligotrophic and eutrophic systems, respectively (Rigosi et al., 2015).

It has been hypothesized that other factors, such as flushing rates (or WRT), have an important impact on cyanobacteria dominance in lakes. Cyanobacteria growth rates are lower than other phytoplankton species (Kalff, 2002), and therefore are challenged to proliferate in lakes with high flushing rates. Elliott (2010) specifically examined the influence of flushing rate on algae communities and found that as flushing rate increased cyanobacteria dominance decreased. Carvalho et al. (2011) observed that water colour and alkalinity were more important drivers of cyanobacterial bloom risk in 134 lakes in the United Kingdom.

Another ecosystem characteristic that can be associated with trophic state is the growth of aquatic plants such as macrophytes. Macrophytes can impact the aesthetics and recreational uses of a lake; one local example is the growth of aquatic plants in Lake Banook which has impacted the use of the lake for rowing and kayaking activities. Macrophyte growth is primarily limited to the littoral zone of a lake due to light limitations with greater water depths

(Grzybowski, 2014), and therefore potential for macrophyte proliferation is more dependent on lake bathymetry and water levels, as opposed to nutrient levels. Zhu et al. (2008) examined the relative effects of nutrient concentrations and light availability on macrophyte growth in temperature lake environments, and found that light, as opposed to phosphorus concentrations, controlled macrophyte growth. Therefore, it is expected that changes in water levels, as opposed to nutrient loading, would be the main driver of macrophyte proliferation.

In general, mesotrophic lakes are still commonly used recreationally, and tend to support healthy sport fisheries (Keith et al., 2012). Mesotrophic lakes, however, tend to possess lower concentrations of DO in the hypoliminion due to increased decomposition of settled algae biomass. In lakes within HRM this may place stresses on cold water salomonid species such as trout. If the morphology of the lake allows for trout to find cool water with sufficient DO, they may be able to survive, and even thrive due to the increase in nutrients within mesotrophic and eutrophic lakes. However, if this is not possible salmonids may be replaced by other species such as yellow perch or small mouth bass, if they have been introduced to the system (Rutherford, B; Personnal Communication). These local observations are generally consistent with the findings of Persson et al. (1991), who observed a tendency for Salmoniformes (e.g. salmon, trout) to be replaced by percids (e.g. perch, walleye), which in turn were replaced by cyprinids (e.g. carp, minnows) with increasing chlorophyll levels in Swedish lakes. It should also be noted that the PML dam, and others in the watershed, do not have fish passage, which likely has more of an effect on fish populations then the trophic status of the lakes.

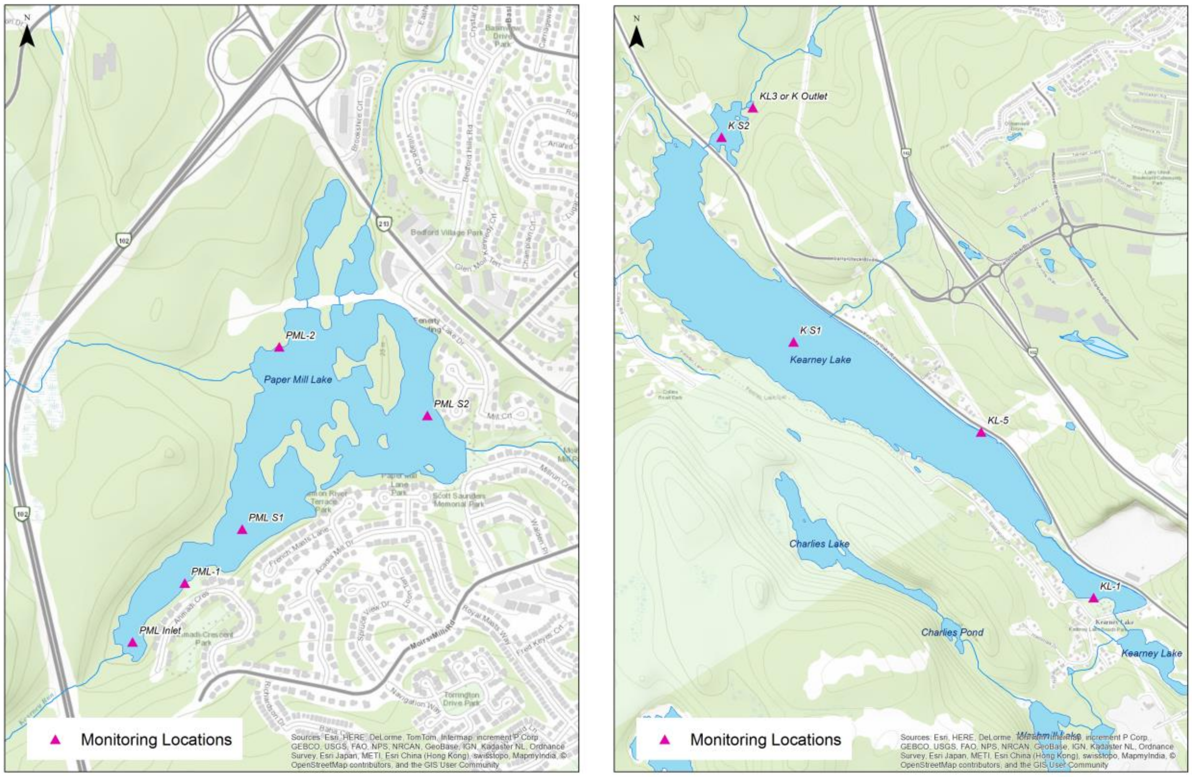
7.0 CWRS Water Quality Monitoring Results

Although not within the original scope of work CWRS conducted a one-time sampling event on July 18, 2016, focusing on TP and chlorophyll *a* levels in KL and PML at in-lake deep-stations and shoreline locations. During the document and data review it was noted that the recent water quality monitoring program had consisted of collection of shoreline samples from both KL and PML, as opposed to samples collected from deep lake stations. This made it challenging to draw conclusions regarding trends in water quality as samples collected through the HRM corporate monitoring program prior to 2011 were from deep stations.

7.1 Methods

7.1.1 Deep-Stations

Deep-station water quality sample collection was performed using a 2.2L PVC Kemmerer sampler lowered from a stationary 12-foot aluminum boat to designated sampling depths through the water column at PML S1, PML S2, K S1 and K S2 (Figure 26). Specific water quality sampling depths were selected base on temperature and DO profiles. These data were collected using a YSI Model 600 sonde equipped with a 15m cable. A YSI Model 6600 sonde with internal logging capabilities was used for depths exceeding 15m (KL Station 1 only). Grab samples were collected from stations PML Inlet and K Outlet (Figure 26).



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 26. CWRS monitoring locations in PML (left) and KL (right).

7.1.2 Shoreline

Shoreline samples were collected at stations PML 1 and PML 2 and KL 1 and KL 5, (Figure 26), as specified in the SNC Lavalin Spring 2016 sampling report. Care was taken by sampling staff to prevent resuspension of sediments. In-*situ* measurements of water temperature, pH, dissolved oxygen, conductivity, and oxidation-reduction potential (ORP) were taken with a handheld YSI sonde (Yellow Springs, OH, USA).

7.1.3 Sample Handling and Laboratory Analysis

All water samples (deep-station and shoreline) were placed in a series of new distilled water/sample water rinsed polyethylene bottles and stored in a cooler chilled with ice. The coolers were transported to a laboratory at Dalhousie University within 3 hours after collection for processing. Upon arrival at the Dalhousie laboratory, samples for chlorophyll *a* analysis were filtered immediately through Whatman GF/C glass fibre filters in subdued light then stored frozen. Sample filters were subsequently analyzed within two weeks of the date of sample collection. The fluorometric method of Yentsch & Menzel (1963) as modified by Holm-Hansen et al. (1965) and recommended by Strickland & Parsons (1968) was applied using a Model 110 Turner fluorometer. TSS were measured according to Standard Method 2540 D, turbidity was measured as per Standard Method 2130 B, and true colour (on filtered samples) was measured as per Standard Method 2120 C (APHA, 1998). Samples measured for TP were first digested with persulfate, then measured as per the ascorbic acid method with a 100mm pathlength cell (Murphy & Riley, 1962). Samples were analyzed for TOC and TN on a TOC-V_{CPH} Total Organic Carbon Analyzer by Shimadzu (Shimadzu, Boston, MA, USA).

7.2 Summary of Results

A water quality summary is presented in Tables 26 and 27. A complete listing of all data gathered is contained in Appendix II.

Of particular interest to the current review are the observed TP and chlorophyll *a* concentrations. For deep-station locations, mean TP concentrations at both KL sites were 3.4 ug L^{-1}. Mean TP concentrations at PML 1 and PML 2 were 5.3 and 5.4 ug L^{-1}, respectively. All of these TP mean values are reflective of oligotrophic conditions. TP concentrations observed at the two shoreline sampling locations in each of the two lakes also fell in the oligotrophic range (KL1 6.6 and KL5 4.4 ug L^{-1}; PML1 5.0 and PML2 5.7 ug L^{-1}).

Mean deep-station euphotic zone chlorophyll *a* values for K S1 and K S2 were 0.81 and 1.41 ug L^{-1}, respectively, and 1.19 and 1.51 ug L^{-1} for PML S1 and PML S2, respectively. Shoreline concentrations in KL were KL1 1.88 and KL5 1.40 ug L^{-1}, and in PML, PML1 1.70 and PML2 2.15 ug L^{-1}. All results are also indicative of oligotrophic conditions.

When comparing these data with those gathered from PML for the summer periods of 2014 and 2015, the current values are markedly lower, especially TP concentrations (2014 summertime value 30 ug L^{-1}; 2015 summertime value 60 ug L^{-1}). The 2016 summer period CWRS TP data is more consistent with same period data gathered in previous years as part of the HRM and SNC Lavalin water quality monitoring programs. In terms of chlorophyll *a*, 2016 CWRS PML data are consistent with all previous summertime chlorophyll *a* data gathered through the HRM/SNC Lavalin monitoring programs, with one exception. In 2015, the summertime PML chlorophyll *a* concentration report by SNC Lavalin was roughly 3 times higher than all previously reported values, including the 2016 CWRS measurements. Exact reasons for the deviations between the CWRS data and the HRM/SNC Lavalin dataset are unknown. Normal season to season variability is assumed to play only a minor role. More likely factors include: potential water quality differences between shoreline and open water areas, lake level and wave action at the time of shoreline sample collection (these lake conditions would be especially critical during the 2012-2014 dam reconstruction period when at times lake levels were lowered exposing lake sediments), and potential differences between sampling and analytical protocols.

Table 26. Water Quality Data for samples collected from deep-stations and inlet/oulets in PML and KL outlet. Values for basin locations PML-S1, PML-S2, KS1, and KS2 are volume-weighted means of values measured throughout the water column.

Sampling Site	TSS (mg L^{-1})	Turbidity (NTU)	TP (µg L^{-1})	TOC (mg L^{-1})	TN (mg L^{-1})	Colour (Pt Co)	Chl *a* (µg L^{-1})
PML-S1	0.7	1.49	5.3	3.4	0.22	15	1.19
PML-S2	0.7	0.74	5.4	3.4	0.15	13	1.51
KS1	<0.1	0.44	3.4	3.6	0.19	22	0.81
KS2	0.2	0.57	3.4	3.4	0.17	17	1.44
PML-Inlet	0.5	1.13	5.3	3.4	0.18	14	--
KL-Outlet	<0.1	0.48	3.5	3.4	0.17	17	--

Table 27. Water quality data for shoreline samples.

Sampling Site (Shoreline)	TSS (mg L^{-1})	Turbidity (NTU)	TP (µg L^{-1})	TOC (mg L^{-1})	TN (mg L^{-1})	Colour (Pt Co)	Chl *a* (µg L^{-1})
KL1	0.5	0.921	6.6	3.4	0.18	16	1.88
KL5	ND	0.538	4.4	3.4	0.18	17	1.40
PML1	0.9	0.664	5.0	3.4	0.23	17	1.70
PML2	0.4	0.765	5.7	3.5	0.20	12	2.15

8.0 Conclusions and Recommendations

Question 1: What are the largest sources of phosphorus to KL and PML?

- When examining the sources of P to KL, upstream sources account for approximately 31 % of the total P load, with KL sub-watershed sources contributing 69 % of the total load. When examining the sources of P to PML, upstream sources account for 78% of the total P load, with PML sub-watershed sources contributing 22% of the load. This illustrates that the TP concentration in PML is heavily influenced by P sources that originate upstream of the PML sub-watershed.

- Within the KL sub-watershed, the three largest sources of P were determined to be septic systems, and runoff export from residential and industrial developments. Within the PML sub-watershed the three largest sources of P were determined to be runoff export from residential and industrial developments, and runoff export from forested landscapes.

- When accounting for all potential sources of P to KL (upstream and sub-watershed) the sources that had a significant effect (> 3 µg L^{-1}) on in-lake mean TP concentrations are septic systems, upstream sources and runoff export from residential development within the sub-watershed.

- When accounting for all potential sources of P to PML (upstream and sub-watershed) the sources that had a significant effect (> 3 µg L^{-1}) on in-lake mean TP concentrations are upstream sources, septic systems and runoff export from residential development within the sub-watershed.

- The repeated draining of PML during the summers of 2012, 2013, and 2014 could have caused short-term increases in the concentrations of TP after the lake was allowed to refill in the fall upon completion of works for each year. There are both biological and chemical mechanisms that could have mobilized P from sediments during the draining/refilling process. It is not possible to quantify the magnitude of this impact due to the fact that applicable data was not collected prior to and after draining PML.

- The P loading assessment was based on the use of literature-derived P export coefficients. The largest sources of uncertainty were found to be in: (i) estimating export coefficients from residential land-use, (ii) estimating the water quality performance of stormwater BMPs, and (iii) estimating the retention of phosphorus in on-site wastewater treatment systems. A sensitivity analysis demonstrated that predicted equilibrium TP concentrations in KL and PML could change by >+/- 100% depending on the selection of P export coefficients and septic system P retention coefficients.

- The primary conclusion that can be made from the loading assessment is that there are several different sources of P within the PML that can influence the TP concentration in KL and PML. Given the level of uncertainty associated with characterizing the magnitude of these sources, and quality/quantity of monitoring data available for the watershed, it is not possible to identify any one source as the primary cause of recent TP increases.

Question 2: What role does internal loading have on TP concentrations in KL and PML?

- The internal load of P associated with anoxic conditions was predicted to have a negligible effect on TP concentrations in both lakes. This was due to the fact that the delineated spatial extent of anoxia was relatively small.
- The potential for internal loading could be tracked in future monitoring programs through the collection of vertical profiles of temperature, DO and TP concentrations throughout the ice-free season (minimum monthly sampling frequency).

Question 3: What type of monitoring program would be required to track P loading over time from the Bedford West Development? How can P export coefficients for the PML Watershed be validated?

- Measurement of annual P loads originating from the Bedford West development would require intensive sampling of both flow and water quality during all runoff events throughout the year. This would necessitate the installation of equipment for continuous flow measurement and automated water quality sample collection, due to the quick hydrologic response of these urbanized catchments. This would not be practical to implement on the entire Bedford West site as there are approximately 27 individual stormwater discharge locations that would need to be monitored.
- A practical approach for evaluating P loading from the Bedford West site would be to select a sub-set of catchments that represent the dominant types of land-uses and BMPs within the site. These sub-watersheds would be intensively monitored over a 2-4 year period. This data could be used to develop validated P export coefficients and BMP performance estimates that could be applied to the remainder of the site. This dataset and information could also be used to evaluate P loading from other current and proposed developments throughout the HRM.

Question 4: How should the trophic state of KL and PML be monitored?

- Chlorophyll *a*, using the trophic state classification system as proposed by Vollenweider and Kerekes (1982), is recommended as the trophic state indicator for both KL and PML. The recommended sampling program involves bi-weekly sampling of the euphotic zone during the ice-free period at 2 deep stations within each lake.

- Total P should continue to be a component of all future monitoring programs and should remain as a key parameter within any regulatory framework for watershed management as P loading is a key, local anthropogenic driver of trophic state change in HRM watersheds.

Question 5: What are the consequences of adopting alternative water quality thresholds for regulating activities within the PML Watershed?

- Potential thresholds for regulating activities and maintaining desired water use objectives in the PML watershed could be based on chlorophyll *a*, TP, or both. It is recommended that both chlorophyll *a* and TP be used within any future regulatory monitoring programs. The strength of this approach is that chlorophyll *a* is a direct indicator of trophic state and P is the key local, anthropogenic driver of trophic state change.

- The current threshold of 10 μg L^{-1} TP is based on maintaining an oligotrophic trophic state. Adjusting the TP threshold to a value that is greater than 10 μg L^{-1} would mean that TP concentrations would be in the mesotrophic range at the point at which a management review would be initiated. Several previous modeling studies have predicted that the equilibrium concentration of TP in KL and PML should be approximately 20 μg L^{-1} given current development. However, due to the uncertainties currently associated with many of the parameters within P loading models, it is not recommended that a model-based baseline concentration be used as a threshold. An alternative approach would involve establishing a measured baseline concentration of TP in the two lakes prior to the development of Bedford West, and establishing a threshold based on a percentage increase (e.g. 25 or 50%) over this value.

- A transition to mesotrophy within KL and/or PML would result in higher levels of phytoplankton growth, and an increased risk of experiencing a bloom of phytoplankton that produce toxins (cyanobacteria) that could be harmful to both humans and animals.

Additional Conclusions and Recommendations

- A meta-analysis of water quality data from the HRM corporate lake monitoring program from 2006-2011 showed that TP is a strong predictor of trophic state, as measured by chlorophyll *a*. This indicates that TP could continue to be used as a general indicator of eutrophication pressure on lakes in HRM. It was also found however, that some lakes did not appear to follow the chlorophyll *a*/TP relationship developed by the OECD, and that caution should be used in using TP as the only trophic state indicator within regulatory frameworks.

- It was also noted that there are challenges associated with regulating individual development activities in a watershed based on measurement of trophic state indicators in a receiving water body. Trophic state can be influenced by many factors beyond the nutrient load originating from one specific development. As is the case with the PML watershed, there are several potential P sources, and it is extremely challenging to quantify individual loads with any certainty. As well, there are other factors, such as climate change, that can influence biological productivity and trophic state, which are not associated with watershed activities.

- Any future monitoring program should include sampling of in-lake deep stations in both KL and PML. The evaluation of mean concentrations of trophic state indicators or drivers, either chlorophyll *a* or TP, should be based on computation of volume weighted concentrations with adequate sampling resolution in the vertical profile.

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Appendix I: Updated P Loading Model Results

Little Horseshoe Lake (Area 12A) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	50.0	ha
Area Land Use Category 1 (Forest)	Ad1	50.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	1.0	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Pp_{ti}	14780	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	4580	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	510000	m^3 yr^{-1}
Total Hydraulic Input	Qt	524780	m^3 yr^{-1}
Areal Hydraulic Load	q_s	52.02	m yr^{-1}
Total Hydraulic Outflow	Qo	520200	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	173	gm yr^{-1}
Total Overland Run Off P Input	Je	3450	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	3623	gm yr^{-1}
Lake P Retention Factor	Rp	0.19	n/a
Lake Phosphorus Retention	Ps	688	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0056**	mg L^{-1}
Lake Phosphorus Outflow	Jo	2935	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets		
Hydraulic Budget (m^{-3})		
		% Total
Upstream Inflow	0	0
Precipitation	14780	2.82
Surface Run Off	510000	97.18
Evaporation	-4580	0.87
Total Outflow	520200	99.13
Total Check		100.00
Phosphorus Budget (gm yr^{-1})		
		% Total
Upstream Inflow	0	0
Atmosphere	173	4.78
Land Run Off	3450	95.22
Development	0	0.00
Sedimentation	-688	18.99
Total Outflow	2935	81.01
Total Check		100.00
Model Validation		
Pedicted P (mg L^{-1})		0.0056
Measured P (mg L^{-1})		0.0070
% Difference		-20.0

Three Finger Lake (Area 11) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	117.5	ha
Area Land Use Category 1 (Forest)	Ad1	117.5	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	6.5	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt_i	96070	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	29770	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	1198500	m^3 yr^{-1}
Total Hydraulic Input	Qt	1294570	m^3 yr^{-1}
Areal Hydraulic Load	q_s	19.46	m yr^{-1}
Total Hydraulic Outflow	Qo	1264800	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	1125	gm yr^{-1}
Total Overland Run Off P Input	Je	8108	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	9233	gm yr^{-1}
Lake P Retention Factor	Rp	0.39	n/a
Lake Phosphorus Retention	Ps	3601	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0045**	mg L^{-1}
Lake Phosphorus Outflow	Jo	5632	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	0	0
Precipitation	96070	7.42
Surface Run Off	1198500	92.58
Evaporation	-29770	2.3
Total Outflow	1264800	97.7
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	0	0
Atmosphere	1125	12.18
Land Run Off	8108	87.82
Development	0	0.00
Sedimentation	-3601	39.00
Total Outflow	5632	61.00
Total Check		100.00

Model Validation

Pedicted P (mg L^{-1})	0.0045
Measured P (mg L^{-1})	0.0042
% Difference	7.1

Big Horseshoe Lake (Area 12B) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	73.0	ha
Area Land Use Category 1 (Forest)	Ad1	73.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	7.0	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	1785000	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	8567	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	Nd	0	#
Average number of Persons per Dwelling	Nu	2.60	n/a
Average Fraction of Year Dwellings Occupied	Npc	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppti	103460	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	32060	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	744600	m^3 yr^{-1}
Total Hydraulic Input	Qt	2633060	m^3 yr^{-1}
Areal Hydraulic Load	q_s	37.16	m yr^{-1}
Total Hydraulic Outflow	Qo	2601000	m^3 yr^{-1}
Upstream P Input	Ju	8567	gm yr^{-1}
Total Atmospheric P Input	Jd	1211	gm yr^{-1}
Total Overland Run Off P Input	Je	5037	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	14815	gm yr^{-1}
Lake P Retention Factor	Rp	0.25	n/a
Lake Phosphorus Retention	Ps	3704	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0043**	mg L^{-1}
Lake Phosphorus Outflow	Jo	11111	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	1785000	67.79
Precipitation	103460	3.93
Surface Run Off	744600	28.28
Evaporation	-32060	1.22
Total Outflow	2601000	98.78
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	8567	57.83
Atmosphere	1211	8.17
Land Run Off	5037	34.00
Development	0	0.00
Sedimentation	-3704	25.00
Total Outflow	11111	75.00
Total Check		100.00

Model Validation

Pedicted P (mg L^{-1})	0.0043
Measured P (mg L^{-1})	0.0069
% Difference	-37.7

Flat Lake (Area 13) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	52.0	ha
Area Land Use Category 1 (Forest)	Ad1	52.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	2.0	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N$_d$	0	#
Average number of Persons per Dwelling	N$_u$	2.60	n/a
Average Fraction of Year Dwellings Occupied	N$_{pc}$	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt$_i$	29560	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	9160	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	530400	m^3 yr^{-1}
Total Hydraulic Input	Qt	559960	m^3 yr^{-1}
Areal Hydraulic Load	q_s	27.54	m yr^{-1}
Total Hydraulic Outflow	Qo	550800	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	346	gm yr^{-1}
Total Overland Run Off P Input	Je	3588	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	3934	gm yr^{-1}
Lake P Retention Factor	Rp	0.31	n/a
Lake Phosphorus Retention	Ps	1220	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0049**	mg L^{-1}
Lake Phosphorus Outflow	Jo	2714	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets		
Hydraulic Budget (m^{-3})		
		% Total
Upstream Inflow	0	0
Precipitation	29560	5.28
Surface Run Off	530400	94.72
Evaporation	-9160	1.64
Total Outflow	550800	98.36
Total Check		100.00
Phosphorus Budget (gm yr^{-1})		
		% Total
Upstream Inflow	0	0
Atmosphere	346	8.80
Land Run Off	3588	91.20
Development	0	0.00
Sedimentation	-1220	31.01
Total Outflow	2714	68.99
Total Check		100.00
Model Validation		
Pedicted P (mg L^{-1})		0.0049
Measured P (mg L^{-1})		0.0070
% Difference		-30.0

Little Cranberry Lake (Area 14A) - 1

Input Parameters	Symbol	Value	Units	Budgets		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	20.4	ha			
Area Land Use Category 1 (Forest)	Ad1	20.4	ha			**% Total**
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha	Precipitation	23648	10.21
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha	Surface Run Off	208080	89.79
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha	Evaporation	-7328	3.16
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha	Total Outflow	224400	96.84
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha			
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha			
Lake Surface Area	Ao	1.6	ha			**% Total**
Lake Volume	V	0.00	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	277	16.43
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	1408	83.56
Annual Unit Precipitation	Pr	1.478	m yr^{-1}	Development	0	0.00
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}	Sedimentation	-792	47.00
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}			
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}	Total Outflow	893	53.00
P Loading				Total Check		99.99
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}	**Model Validation**		
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}			
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}	Pedicted P (mg L^{-1})		0.0040
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}	Measured P (mg L^{-1})		0.0066
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}	% Difference		-39.4
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}			
Number of Dwellings	N$_d$	0	#			
Average number of Persons per Dwelling	N$_u$	2.60	n/a			
Average Fraction of Year Dwellings Occupied	N$_{pc}$	1	yr^{-1}			
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	12.4	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt$_i$	23648	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	7328	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	208080	m^3 yr^{-1}			
Total Hydraulic Input	Qt	231728	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	14.03	m yr^{-1}			
Total Hydraulic Outflow	Qo	224400	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	277	gm yr^{-1}			
Total Overland Run Off P Input	Je	1408	gm yr^{-1}			
Total Development P Input	Jd	0	gm yr^{-1}			
Total P Input	Jt	1685	gm yr^{-1}			
Lake P Retention Factor	Rp	0.47	n/a			
Lake Phosphorus Retention	Ps	792	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0040**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	893	gm yr^{-1}			
Lake Mean Depth	z	0	m			
Lake Turnover Time	TT	0	yr			
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}			
Lake Response Time	RT	#DIV/0!	yr			

Big Cranberry Lake (Area 14B) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	22.6	ha
Area Land Use Category 1 (Forest)	Ad1	22.6	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	4.4	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	3376200	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	14718	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt_i	65032	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	20152	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	230520	m^3 yr^{-1}
Total Hydraulic Input	Qt	3671752	m^3 yr^{-1}
Areal Hydraulic Load	q_s	82.99	m yr^{-1}
Total Hydraulic Outflow	Qo	3651600	m^3 yr^{-1}
Upstream P Input	Ju	14718	gm yr^{-1}
Total Atmospheric P Input	Jd	761	gm yr^{-1}
Total Overland Run Off P Input	Je	1559	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	17038	gm yr^{-1}
Lake P Retention Factor	Rp	0.13	n/a
Lake Phosphorus Retention	Ps	2215	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0041**	mg L^{-1}
Lake Phosphorus Outflow	Jo	14823	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets		
Hydraulic Budget (m^{-3})		
		% Total
Upstream Inflow	3376200	91.95
Precipitation	65032	1.77
Surface Run Off	230520	6.28
Evaporation	-20152	0.55
Total Outflow	3651600	99.45
Total Check		100.00
Phosphorus Budget (gm yr^{-1})		
		% Total
Upstream Inflow	14718	86.38
Atmosphere	761	4.47
Land Run Off	1559	9.15
Development	0	0.00
Sedimentation	-2215	13.00
Total Outflow	14823	87.00
Total Check		100.00
Model Validation		
Pedicted P (mg L^{-1})		0.0041
Measured P (mg L^{-1})		0.0086
% Difference		-52.3

Crane Lake (Area 15) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	36.0	ha
Area Land Use Category 1 (Forest)	Ad1	36.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	12.0	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N$_d$	0	#
Average number of Persons per Dwelling	N$_u$	2.60	n/a
Average Fraction of Year Dwellings Occupied	N$_{pc}$	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt$_i$	177360	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	54960	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	367200	m^3 yr^{-1}
Total Hydraulic Input	Qt	544560	m^3 yr^{-1}
Areal Hydraulic Load	q_s	4.08	m yr^{-1}
Total Hydraulic Outflow	Qo	489600	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	2076	gm yr^{-1}
Total Overland Run Off P Input	Je	2484	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	4560	gm yr^{-1}
Lake P Retention Factor	Rp	0.75	n/a
Lake Phosphorus Retention	Ps	3420	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0023**	mg L^{-1}
Lake Phosphorus Outflow	Jo	1140	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	0	0
Precipitation	177360	32.57
Surface Run Off	367200	67.43
Evaporation	-54960	10.09
Total Outflow	489600	89.91
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	0	0
Atmosphere	2076	45.53
Land Run Off	2484	54.47
Development	0	0.00
Sedimentation	-3420	75.00
Total Outflow	1140	25.00
Total Check		100.00

Model Validation

Pedicted P (mg L^{-1})	0.0023
Measured P (mg L^{-1})	0.0034
% Difference	-32.4

Ash Lake (Area 16) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	118.0	ha
Area Land Use Category 1 (Forest)	Ad1	118.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	30.0	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	Nd	0	#
Average number of Persons per Dwelling	Nu	2.60	n/a
Average Fraction of Year Dwellings Occupied	Npc	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppti	443400	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	137400	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	1203600	m^3 yr^{-1}
Total Hydraulic Input	Qt	1647000	m^3 yr^{-1}
Areal Hydraulic Load	q_s	5.03	m yr^{-1}
Total Hydraulic Outflow	Qo	1509600	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	5190	gm yr^{-1}
Total Overland Run Off P Input	Je	8142	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	13332	gm yr^{-1}
Lake P Retention Factor	Rp	0.71	n/a
Lake Phosphorus Retention	Ps	9466	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0026**	mg L^{-1}
Lake Phosphorus Outflow	Jo	3866	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	0	0
Precipitation	443400	26.92
Surface Run Off	1203600	73.08
Evaporation	-137400	8.34
Total Outflow	1509600	91.66
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	0	0
Atmosphere	5190	38.93
Land Run Off	8142	61.07
Development	0	0.00
Sedimentation	-9466	71.00
Total Outflow	3866	29.00
Total Check		100.00

Model Validation

Pedicted P (mg L^{-1})	0.0026
Measured P (mg L^{-1})	0.0022
% Difference	18.2

Fox Lake (Area 17) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	77.0	ha
Area Land Use Category 1 (Forest)	Ad1	77.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	16.0	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	Nd	0	#
Average number of Persons per Dwelling	Nu	2.60	n/a
Average Fraction of Year Dwellings Occupied	Npc	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppti	236480	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	73280	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	785400	m^3 yr^{-1}
Total Hydraulic Input	Qt	1021880	m^3 yr^{-1}
Areal Hydraulic Load	q_s	5.93	m yr^{-1}
Total Hydraulic Outflow	Qo	948600	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	2768	gm yr^{-1}
Total Overland Run Off P Input	Je	5313	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	8081	gm yr^{-1}
Lake P Retention Factor	Rp	0.68	n/a
Lake Phosphorus Retention	Ps	5495	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0027**	mg L^{-1}
Lake Phosphorus Outflow	Jo	2586	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	0	0
Precipitation	236480	23.14
Surface Run Off	785400	76.86
Evaporation	-73280	7.17
Total Outflow	948600	92.83
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	0	0
Atmosphere	2768	34.25
Land Run Off	5313	65.75
Development	0	0.00
Sedimentation	-5495	68.00
Total Outflow	2586	32.00
Total Check		100.00

Model Validation

Pedicted P (mg L^{-1})		0.0027
Measured P (mg L^{-1})		0.0031
% Difference		-12.9

Susies Lake (Area 18A) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	539.4	ha
Area Land Use Category 1 (Forest)	Ad1	393.4	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	81.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	65.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	80.6	ha
Lake Volume	V	2.61	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	5650800	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	19829	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt_i	1191268	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	369148	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	5954480	m^3 yr^{-1}
Total Hydraulic Input	Qt	12796548	m^3 yr^{-1}
Areal Hydraulic Load	q_s	15.42	m yr^{-1}
Total Hydraulic Outflow	Qo	12427400	m^3 yr^{-1}
Upstream P Input	Ju	19829	gm yr^{-1}
Total Atmospheric P Input	Jd	13944	gm yr^{-1}
Total Overland Run Off P Input	Je	190845	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	224618	gm yr^{-1}
Lake P Retention Factor	Rp	0.45	n/a
Lake Phosphorus Retention	Ps	101078	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0099**	mg L^{-1}
Lake Phosphorus Outflow	Jo	123540	gm yr^{-1}
Lake Mean Depth	z	3.2	m
Lake Turnover Time	TT	0.21	yr
Lake Flushing Rate	FR	4.77	times yr^{-1}
Lake Response Time	RT	0.09	yr

Budgets		
Hydraulic Budget (m^{-3})		
		% Total
Upstream Inflow	5650800	44.16
Precipitation	1191268	9.31
Surface Run Off	5954480	46.53
Evaporation	-369148	2.88
Total Outflow	12427400	97.12
Total Check		100.00
Phosphorus Budget (gm yr^{-1})		
		% Total
Upstream Inflow	19829	8.83
Atmosphere	13944	6.21
Land Run Off	190845	84.96
Development	0	0.00
Sedimentation	-101078	45.00
Total Outflow	123540	55.00
Total Check		100.00
Model Validation		
Pedicted P (mg L^{-1})		0.0099
Measured P (mg L^{-1})		0.0072
% Difference		37.5

Quarry Lake (Area 18B) - 1

Input Parameters	Symbol	Value	Units	Budgets		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	137.9	ha			
Area Land Use Category 1 (Forest)	Ad1	137.9	ha			**% Total**
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha	Upstream Inflow	13376000	86.58
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha	Precipitation	666578	4.31
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha	Surface Run Off	1406580	9.1
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha	Evaporation	-206558	1.34
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha	Total Outflow	15242600	98.66
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha	Total Check		99.99
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha			
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha			
Lake Surface Area	Ao	45.1	ha			**% Total**
Lake Volume	V	1.60	10^6 m^3	Upstream Inflow	126126	87.93
Hydrology				Atmosphere	7802	5.44
Upstream Hydraulic Inputs	Qi	13376000	m^3 yr^{-1}	Land Run Off	9515	6.63
Annual Unit Precipitation	Pr	1.478	m yr^{-1}	Development	0	0.00
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}	Sedimentation	-38730	27.00
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}			
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}	Total Outflow	104713	73.00
P Loading				Total Check		100.00
Upstream P Input	Pi	126126	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}	**Model Validation**		
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}			
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}	Pedicted P (mg L^{-1})		0.0069
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}	Measured P (mg L^{-1})		0.0056
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}	% Difference		23.2
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}			
Number of Dwellings	N_d	0	#			
Average number of Persons per Dwelling	N_u	2.60	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	12.4	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	666578	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	206558	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	1406580	m^3 yr^{-1}			
Total Hydraulic Input	Qt	15449158	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	33.8	m yr^{-1}			
Total Hydraulic Outflow	Qo	15242600	m^3 yr^{-1}			
Upstream P Input	Ju	126126	gm yr^{-1}			
Total Atmospheric P Input	Jd	7802	gm yr^{-1}			
Total Overland Run Off P Input	Je	9515	gm yr^{-1}			
Total Development P Input	Jd	0	gm yr^{-1}			
Total P Input	Jt	143443	gm yr^{-1}			
Lake P Retention Factor	Rp	0.27	n/a			
Lake Phosphorus Retention	Ps	38730	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0069**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	104713	gm yr^{-1}			
Lake Mean Depth	z	3.5	m			
Lake Turnover Time	TT	0.1	yr			
Lake Flushing Rate	FR	9.56	times yr^{-1}			
Lake Response Time	RT	0.06	yr			

Belchers Pond (Area 21) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	90.5	ha
Area Land Use Category 1 (Forest)	Ad1	1.5	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	89.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	2.5	ha
Lake Volume	V	0.00	$10^6\ m^3$
Hydrology			
Upstream Hydraulic Inputs	Qi	0	$m^3\ yr^{-1}$
Annual Unit Precipitation	Pr	1.478	$m\ yr^{-1}$
Annual Unit Lake Evaporation	Ev	0.458	$m\ yr^{-1}$
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	$m\ yr^{-1}$
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	$m\ yr^{-1}$
P Loading			
Upstream P Input	Pi	0	$gm\ P\ yr^{-1}$
Annual Unit Atmospheric P Deposition	Da	0.0173	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 1 P Export Coefficient	E1	0.0069	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 2 P Export Coefficient	E2	0.0083	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 3 P Export Coefficient	E3	0.0520	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 4 P Export Coefficient	E4	0.0400	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 5 P Export Coefficient	E5	0.2020	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 6 P Export Coefficient	E6	0.0420	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 7 P Export Coefficient	E7	0.0520	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 8 P Export Coefficient	E8	0.0400	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 9 P Export Coefficient	E9	0.2020	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 10 P Export Coefficient	E10	0.0420	$gm\ P\ m^{-2}\ yr^{-1}$
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	$gm\ P\ cap^{-1}\ yr^{-1}$
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt_i	36950	$m^3\ yr^{-1}$
Total Evaporation Hydraulic Loss	Eo	11450	$m^3\ yr^{-1}$
Total Hydraulic Surface Run Off	Ql	1199000	$m^3\ yr^{-1}$
Total Hydraulic Input	Qt	1235950	$m^3\ yr^{-1}$
Areal Hydraulic Load	q_s	48.98	$m\ yr^{-1}$
Total Hydraulic Outflow	Qo	1224500	$m^3\ yr^{-1}$
Upstream P Input	Ju	0	$gm\ yr^{-1}$
Total Atmospheric P Input	Jd	433	$gm\ yr^{-1}$
Total Overland Run Off P Input	Je	46384	$gm\ yr^{-1}$
Total Development P Input	Jd	0	$gm\ yr^{-1}$
Total P Input	Jt	46817	$gm\ yr^{-1}$
Lake P Retention Factor	Rp	0.2	n/a
Lake Phosphorus Retention	Ps	9363	$gm\ yr^{-1}$
Predicted Lake Phosphorus Concentration	[P]	**0.0306**	$mg\ L^{-1}$
Lake Phosphorus Outflow	Jo	37454	$gm\ yr^{-1}$
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	$times\ yr^{-1}$
Lake Response Time	RT	#DIV/0!	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	0	0
Precipitation	36950	2.99
Surface Run Off	1199000	97.01
Evaporation	-11450	0.93
Total Outflow	1224500	99.07
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	0	0
Atmosphere	433	0.92
Land Run Off	46384	99.08
Development	0	0.00
Sedimentation	-9363	20.00
Total Outflow	37454	80.00
Total Check		100.00

Model Validation

Pedicted P (mg L^{-1})	0.0306
Measured P (mg L^{-1})	0.0076
% Difference	302.6

Charlies Lake (Area 22) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	39.0	ha
Area Land Use Category 1 (Forest)	Ad1	39.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	6.0	ha
Lake Volume	V	0.00	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N$_d$	0	#
Average number of Persons per Dwelling	N$_u$	2.60	n/a
Average Fraction of Year Dwellings Occupied	N$_{pc}$	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt$_i$	88680	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	27480	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	397800	m^3 yr^{-1}
Total Hydraulic Input	Qt	486480	m^3 yr^{-1}
Areal Hydraulic Load	q_s	7.65	m yr^{-1}
Total Hydraulic Outflow	Qo	459000	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	1038	gm yr^{-1}
Total Overland Run Off P Input	Je	2691	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	3729	gm yr^{-1}
Lake P Retention Factor	Rp	0.62	n/a
Lake Phosphorus Retention	Ps	2312	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0031**	mg L^{-1}
Lake Phosphorus Outflow	Jo	1417	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	0	0
Precipitation	88680	18.23
Surface Run Off	397800	81.77
Evaporation	-27480	5.65
Total Outflow	459000	94.35
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	0	0
Atmosphere	1038	27.84
Land Run Off	2691	72.16
Development	0	0.00
Sedimentation	-2312	62.00
Total Outflow	1417	38.00
Total Check		100.00

Model Validation

Pedicted P (mg L^{-1})	0.0031
Measured P (mg L^{-1})	0.0035
% Difference	-11.4

Washmill Lake (Area 23) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	231.8	ha
Area Land Use Category 1 (Forest)	Ad1	122.6	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	54.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	55.2	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	8.2	ha
Lake Volume	V	0.2025	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	16926100	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	143584	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.0080	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N$_d$	0	#
Average number of Persons per Dwelling	N$_u$	2.60	n/a
Average Fraction of Year Dwellings Occupied	N$_{pc}$	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt$_i$	121196	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	37556	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	2702880	m^3 yr^{-1}
Total Hydraulic Input	Qt	19750176	m^3 yr^{-1}
Areal Hydraulic Load	q_s	240.4	m yr^{-1}
Total Hydraulic Outflow	Qo	19712620	m^3 yr^{-1}
Upstream P Input	Ju	143584	gm yr^{-1}
Total Atmospheric P Input	Jd	1419	gm yr^{-1}
Total Overland Run Off P Input	Je	40955	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	185958	gm yr^{-1}
Lake P Retention Factor	Rp	0.05	n/a
Lake Phosphorus Retention	Ps	9298	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0090**	mg L^{-1}
Lake Phosphorus Outflow	Jo	176660	gm yr^{-1}
Lake Mean Depth	z	2.5	m
Lake Turnover Time	TT	0.01	yr
Lake Flushing Rate	FR	97.35	times yr^{-1}
Lake Response Time	RT	0.01	yr

Budgets		
Hydraulic Budget (m^{-3})		
		% Total
Upstream Inflow	16926100	85.7
Precipitation	121196	0.61
Surface Run Off	2702880	13.69
Evaporation	-37556	0.19
Total Outflow	19712620	99.81
Total Check		100.00
Phosphorus Budget (gm yr^{-1})		
		% Total
Upstream Inflow	143584	77.21
Atmosphere	1419	0.76
Land Run Off	40955	22.02
Development	0	0.00
Sedimentation	-9298	5.00
Total Outflow	176660	95.00
Total Check		99.99
Model Validation		
Pedicted P (mg L^{-1})		0.0090
Measured P (mg L^{-1})		0.0051
% Difference		76.5

McQuade Lake (Area 25) - 1

Input Parameters	Symbol	Value	Units	Budgets		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	50.0	ha			
Area Land Use Category 1 (Forest)	Ad1	0.0	ha			**% Total**
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Urban Exist)	Ad3	49.6	ha	Precipitation	103460	13.46
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha	Surface Run Off	665000	86.54
Area Land Use Category 5 (Industrial Exist)	Ad5	0.4	ha	Evaporation	-32060	4.17
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha	Total Outflow	736400	95.83
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha			
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha			
Lake Surface Area	Ao	7.0	ha			**% Total**
Lake Volume	V	0.0000	$10^6\ m^3$	Upstream Inflow	0	0
Hydrology				Atmosphere	1211	1.01
Upstream Hydraulic Inputs	Qi	0	$m^3\ yr^{-1}$	Land Run Off	26600	22.10
Annual Unit Precipitation	Pr	1.478	$m\ yr^{-1}$	Development	92560	76.90
Annual Unit Lake Evaporation	Ev	0.458	$m\ yr^{-1}$	Sedimentation	-65000	54.00
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	$m\ yr^{-1}$			
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	$m\ yr^{-1}$	Total Outflow	55371	46.00
P Loading				Total Check		100.01
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P $m^{-2}\ yr^{-1}$			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P $m^{-2}\ yr^{-1}$	**Model Validation**		
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P $m^{-2}\ yr^{-1}$			
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P $m^{-2}\ yr^{-1}$			
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P $m^{-2}\ yr^{-1}$	Pedicted P (mg L^{-1})		0.0752
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P $m^{-2}\ yr^{-1}$	Measured P (mg L^{-1})		0.0102
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P $m^{-2}\ yr^{-1}$	% Difference		637.3
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P $m^{-2}\ yr^{-1}$			
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P $m^{-2}\ yr^{-1}$			
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P $m^{-2}\ yr^{-1}$			
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P $m^{-2}\ yr^{-1}$			
Number of Dwellings + Approved Lots	N_d	89	#			
Average number of Persons per Dwelling	N_u	2.60	n/a			
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}			
Phosphorus Load per Capita per Year	Sl	800	gm P $cap^{-1}\ yr^{-1}$			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	12.4	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppt_i	103460	$m^3\ yr^{-1}$			
Total Evaporation Hydraulic Loss	Eo	32060	$m^3\ yr^{-1}$			
Total Hydraulic Surface Run Off	Ql	665000	$m^3\ yr^{-1}$			
Total Hydraulic Input	Qt	768460	$m^3\ yr^{-1}$			
Areal Hydraulic Load	q_s	10.52	$m\ yr^{-1}$			
Total Hydraulic Outflow	Qo	736400	$m^3\ yr^{-1}$			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	1211	gm yr^{-1}			
Total Overland Run Off P Input	Je	26600	gm yr^{-1}			
Total Development P Input	Jd	92560	gm yr^{-1}			
Total P Input	Jt	120371	gm yr^{-1}			
Lake P Retention Factor	Rp	0.54	n/a			
Lake Phosphorus Retention	Ps	65000	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0752**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	55371	gm yr^{-1}			
Lake Mean Depth	z	0	m			
Lake Turnover Time	TT	0	yr			
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}			
Lake Response Time	RT	#DIV/0!	yr			

Hobsons Lake (Area 24) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	149.0	ha
Area Land Use Category 1 (Forest)	Ad1	95.8	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	47.2	ha
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	4.0	ha
Lake Volume	V	0.0000	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	Nd	0	#
Average number of Persons per Dwelling	Nu	2.60	n/a
Average Fraction of Year Dwellings Occupied	Npc	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppti	59120	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	18320	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	1458600	m^3 yr^{-1}
Total Hydraulic Input	Qt	1517720	m^3 yr^{-1}
Areal Hydraulic Load	q_s	37.49	m yr^{-1}
Total Hydraulic Outflow	Qo	1499400	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	692	gm yr^{-1}
Total Overland Run Off P Input	Je	10528	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	11220	gm yr^{-1}
Lake P Retention Factor	Rp	0.25	n/a
Lake Phosphorus Retention	Ps	2805	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0056**	mg L^{-1}
Lake Phosphorus Outflow	Jo	8415	gm yr^{-1}
Lake Mean Depth	z	0	m
Lake Turnover Time	TT	0	yr
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}
Lake Response Time	RT	#DIV/0!	yr

Budgets		
Hydraulic Budget (m^{-3})		
		% Total
Upstream Inflow	0	0
Precipitation	59120	3.9
Surface Run Off	1458600	96.1
Evaporation	-18320	1.21
Total Outflow	1499400	98.79
Total Check		100.00
Phosphorus Budget (gm yr^{-1})		
		% Total
Upstream Inflow	0	0
Atmosphere	692	6.17
Land Run Off	10528	93.83
Development	0	0.00
Sedimentation	-2805	25.00
Total Outflow	8415	75.00
Total Check		100.00
Model Validation		
Pedicted P (mg L^{-1})		0.0056
Measured P (mg L^{-1})		0.0072
% Difference		-22.2

Kearney Lake (Areas 26 and 27) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	746.0	ha
Area Land Use Category 1 (Forest)	Ad1	310.8	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	11.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	363.1	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	27.4	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	23.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	11.2	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	61.5	ha
Lake Volume	V	6.9779	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	21948420	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	240446	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N_d	238	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt_i	908822.2	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	281624.2	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	8930870	m^3 yr^{-1}
Total Hydraulic Input	Qt	31788112	m^3 yr^{-1}
Areal Hydraulic Load	q_s	51.24	m yr^{-1}
Total Hydraulic Outflow	Qo	31506488	m^3 yr^{-1}
Upstream P Input	Ju	240446	gm yr^{-1}
Total Atmospheric P Input	Jd	10638	gm yr^{-1}
Total Overland Run Off P Input	Je	273294	gm yr^{-1}
Total Development P Input	Jd	247520	gm yr^{-1}
Total P Input	Jt	771898	gm yr^{-1}
Lake P Retention Factor	Rp	0.19	n/a
Lake Phosphorus Retention	Ps	146661	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0198**	mg L^{-1}
Lake Phosphorus Outflow	Jo	625237	gm yr^{-1}
Lake Mean Depth	z	11.3	m
Lake Turnover Time	TT	0.22	yr
Lake Flushing Rate	FR	4.52	times yr^{-1}
Lake Response Time	RT	0.13	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	21948420	69.05
Precipitation	908822.2	2.86
Surface Run Off	8930870	28.09
Evaporation	-281624.2	0.89
Total Outflow	31506488	99.11
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	240446	31.15
Atmosphere	10638	1.38
Land Run Off	273294	35.41
Development	247520	32.07
Sedimentation	-146661	19.00
Total Outflow	625237	81.00
Total Check		100.01

Model Validation

Pedicted P (mg L^{-1})		0.0198
Measured P (mg L^{-1})		0.0067
% Difference		195.5

Papermill Lake Basin 2 (Area 33) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	18.2	ha
Area Land Use Category 1 (Forest)	Ad1	8.0	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	0.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	9.9	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.3	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	1.8	ha
Lake Volume	V	0.0113	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	0	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt_i	26456.2	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	8198.2	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	217260	m^3 yr^{-1}
Total Hydraulic Input	Qt	243716	m^3 yr^{-1}
Areal Hydraulic Load	q_s	13.16	m yr^{-1}
Total Hydraulic Outflow	Qo	235518	m^3 yr^{-1}
Upstream P Input	Ju	0	gm yr^{-1}
Total Atmospheric P Input	Jd	310	gm yr^{-1}
Total Overland Run Off P Input	Je	6306	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	6616	gm yr^{-1}
Lake P Retention Factor	Rp	0.49	n/a
Lake Phosphorus Retention	Ps	3242	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0143**	mg L^{-1}
Lake Phosphorus Outflow	Jo	3374	gm yr^{-1}
Lake Mean Depth	z	0.6	m
Lake Turnover Time	TT	0.05	yr
Lake Flushing Rate	FR	20.84	times yr^{-1}
Lake Response Time	RT	0.02	yr

Budgets

Hydraulic Budget (m^{-3})

		% Total
Upstream Inflow	0	0
Precipitation	26456.2	10.86
Surface Run Off	217260	89.14
Evaporation	-8198.2	3.36
Total Outflow	235518	96.64
Total Check		100.00

Phosphorus Budget (gm yr^{-1})

		% Total
Upstream Inflow	0	0
Atmosphere	310	4.68
Land Run Off	6306	95.31
Development	0	0.00
Sedimentation	-3242	49.00
Total Outflow	3374	51.00
Total Check		99.99

Model Validation

Pedicted P (mg L^{-1})	0.0143
Measured P (mg L^{-1})	0.0000
% Difference	#DIV/0!

Jack Lake (Area 34) - 1

Input Parameters	Symbol	Value	Units	Budgets		
Morphology				**Hydraulic Budget (m^{-3})**		
Drainage Basin Area (Excl. of Lake Area)	Ad	21.2	ha			
Area Land Use Category 1 (Forest)	Ad1	20.0	ha			**% Total**
Area Land Use Category 2 (Forest/Cleared)	Ad2	1.1	ha	Upstream Inflow	0	0
Area Land Use Category 3 (Urban Exist)	Ad3	0.0	ha	Precipitation	56164	20.7
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha	Surface Run Off	215220	79.3
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha	Evaporation	-17404	6.41
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha	Total Outflow	253980	93.59
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha	Total Check		100.00
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha			
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha	**Phosphorus Budget (gm yr^{-1})**		
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha			
Lake Surface Area	Ao	3.8	ha			**% Total**
Lake Volume	V	0.0000	10^6 m^3	Upstream Inflow	0	0
Hydrology				Atmosphere	657	30.89
Upstream Hydraulic Inputs	Qi	0	m^3 yr^{-1}	Land Run Off	1471	69.13
Annual Unit Precipitation	Pr	1.478	m yr^{-1}	Development	0	0.00
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}	Sedimentation	-1383	64.99
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}			
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}	Total Outflow	745	35.01
P Loading				Total Check		100.02
Upstream P Input	Pi	0	gm P yr^{-1}			
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}			
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}	**Model Validation**		
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}			
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}			
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}	Pedicted P (mg L^{-1})		0.0029
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}	Measured P (mg L^{-1})		0.0036
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}	% Difference		-19.4
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}			
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}			
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}			
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}			
Number of Dwellings	Nd	0	#			
Average number of Persons per Dwelling	Nu	2.60	n/a			
Average Fraction of Year Dwellings Occupied	Npc	1	yr^{-1}			
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}			
Septic System Retention Coefficient	Rsp	0.5	n/a			
Point Source Input 1	PS1	0				
Point Source Input 2	PS2	0				
Point Source Input 3	PS3	0				
Point Source Input 4	PS4	0				
Point Source Input 5	PS5	0				
Phosphorus Retention Coefficient	v	12.4	n/a			
Model Outputs						
Total Precipitation Hydraulic Input	Ppti	56164	m^3 yr^{-1}			
Total Evaporation Hydraulic Loss	Eo	17404	m^3 yr^{-1}			
Total Hydraulic Surface Run Off	Ql	215220	m^3 yr^{-1}			
Total Hydraulic Input	Qt	271384	m^3 yr^{-1}			
Areal Hydraulic Load	q_s	6.68	m yr^{-1}			
Total Hydraulic Outflow	Qo	253980	m^3 yr^{-1}			
Upstream P Input	Ju	0	gm yr^{-1}			
Total Atmospheric P Input	Jd	657	gm yr^{-1}			
Total Overland Run Off P Input	Je	1471	gm yr^{-1}			
Total Development P Input	Jd	0	gm yr^{-1}			
Total P Input	Jt	2128	gm yr^{-1}			
Lake P Retention Factor	Rp	0.65	n/a			
Lake Phosphorus Retention	Ps	1383	gm yr^{-1}			
Predicted Lake Phosphorus Concentration	[P]	**0.0029**	mg L^{-1}			
Lake Phosphorus Outflow	Jo	745	gm yr^{-1}			
Lake Mean Depth	z	0	m			
Lake Turnover Time	TT	0	yr			
Lake Flushing Rate	FR	#DIV/0!	times yr^{-1}			
Lake Response Time	RT	#DIV/0!	yr			

Papermill Lake Basin 3 (Area 35) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	73.7	ha
Area Land Use Category 1 (Forest)	Ad1	33.2	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	4.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	36.5	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	0.0	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	0.0	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	1.2	ha
Lake Volume	V	0.0147	$10^6\ m^3$
Hydrology			
Upstream Hydraulic Inputs	Qi	253980	$m^3\ yr^{-1}$
Annual Unit Precipitation	Pr	1.478	$m\ yr^{-1}$
Annual Unit Lake Evaporation	Ev	0.458	$m\ yr^{-1}$
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	$m\ yr^{-1}$
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	$m\ yr^{-1}$
P Loading			
Upstream P Input	Pi	745	$gm\ P\ yr^{-1}$
Annual Unit Atmospheric P Deposition	Da	0.0173	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 1 P Export Coefficient	E1	0.0069	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 2 P Export Coefficient	E2	0.0083	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 3 P Export Coefficient	E3	0.0520	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 4 P Export Coefficient	E4	0.0400	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 5 P Export Coefficient	E5	0.2020	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 6 P Export Coefficient	E6	0.0420	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 7 P Export Coefficient	E7	0.0520	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 8 P Export Coefficient	E8	0.0400	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 9 P Export Coefficient	E9	0.2020	$gm\ P\ m^{-2}\ yr^{-1}$
Land Use Category 10 P Export Coefficient	E10	0.0420	$gm\ P\ m^{-2}\ yr^{-1}$
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	$gm\ P\ cap^{-1}\ yr^{-1}$
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Ppt_i	17736	$m^3\ yr^{-1}$
Total Evaporation Hydraulic Loss	Eo	5496	$m^3\ yr^{-1}$
Total Hydraulic Surface Run Off	Ql	864890	$m^3\ yr^{-1}$
Total Hydraulic Input	Qt	1136606	$m^3\ yr^{-1}$
Areal Hydraulic Load	q_s	94.26	$m\ yr^{-1}$
Total Hydraulic Outflow	Qo	1131110	$m^3\ yr^{-1}$
Upstream P Input	Ju	745	$gm\ yr^{-1}$
Total Atmospheric P Input	Jd	208	$gm\ yr^{-1}$
Total Overland Run Off P Input	Je	21603	$gm\ yr^{-1}$
Total Development P Input	Jd	0	$gm\ yr^{-1}$
Total P Input	Jt	22556	$gm\ yr^{-1}$
Lake P Retention Factor	Rp	0.12	n/a
Lake Phosphorus Retention	Ps	2707	$gm\ yr^{-1}$
Predicted Lake Phosphorus Concentration	[P]	**0.0175**	$mg\ L^{-1}$
Lake Phosphorus Outflow	Jo	19849	$gm\ yr^{-1}$
Lake Mean Depth	z	1.2	m
Lake Turnover Time	TT	0.01	yr
Lake Flushing Rate	FR	76.95	$times\ yr^{-1}$
Lake Response Time	RT	0.01	yr

Budgets

Hydraulic Budget (m^{-3})		% Total
Upstream Inflow	253980	22.35
Precipitation	17736	1.56
Surface Run Off	864890	76.09
Evaporation	-5496	0.48
Total Outflow	1131110	99.52
Total Check		100.00

Phosphorus Budget ($gm\ yr^{-1}$)		% Total
Upstream Inflow	745	3.3
Atmosphere	208	0.92
Land Run Off	21603	95.77
Development	0	0.00
Sedimentation	-2707	12.00
Total Outflow	19849	88.00
Total Check		99.99

Model Validation		
Pedicted P ($mg\ L^{-1}$)		0.0175
Measured P ($mg\ L^{-1}$)		0.0000
% Difference		#DIV/0!

Papermill Lake (Areas 28, 31, 32, 36 and 37) - 1

Input Parameters	Symbol	Value	Units
Morphology			
Drainage Basin Area (Excl. of Lake Area)	Ad	436.0	ha
Area Land Use Category 1 (Forest)	Ad1	140.6	ha
Area Land Use Category 2 (Forest/Cleared)	Ad2	2.0	ha
Area Land Use Category 3 (Urban Exist)	Ad3	251.5	ha
Area Land Use Category 4 (Commercial Exist)	Ad4	0.0	ha
Area Land Use Category 5 (Industrial Exist)	Ad5	19.1	ha
Area Land Use Category 6 (Institutional Exist)	Ad6	2.5	ha
Area Land Use Category 7 (Urban BW)	Ad7	0.0	ha
Area Land Use Category 8 (Commercial BW)	Ad8	0.0	ha
Area Land Use Category 9 (Industrial BW)	Ad9	0.0	ha
Area Land Use Category 10 (Institutional BW)	Ad10	0.0	ha
Lake Surface Area	Ao	22.2	ha
Lake Volume	V	0.4906	10^6 m^3
Hydrology			
Upstream Hydraulic Inputs	Qi	32873116	m^3 yr^{-1}
Annual Unit Precipitation	Pr	1.478	m yr^{-1}
Annual Unit Lake Evaporation	Ev	0.458	m yr^{-1}
Annual Unit Hydraulic Runoff - Veg. Surfaces	Ru	1.020	m yr^{-1}
Annual Unit Hydraulic Runoff - Urban	Ru	1.330	m yr^{-1}
P Loading			
Upstream P Input	Pi	648460	gm P yr^{-1}
Annual Unit Atmospheric P Deposition	Da	0.0173	gm P m^{-2} yr^{-1}
Land Use Category 1 P Export Coefficient	E1	0.0069	gm P m^{-2} yr^{-1}
Land Use Category 2 P Export Coefficient	E2	0.0083	gm P m^{-2} yr^{-1}
Land Use Category 3 P Export Coefficient	E3	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 4 P Export Coefficient	E4	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 5 P Export Coefficient	E5	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 6 P Export Coefficient	E6	0.0420	gm P m^{-2} yr^{-1}
Land Use Category 7 P Export Coefficient	E7	0.0520	gm P m^{-2} yr^{-1}
Land Use Category 8 P Export Coefficient	E8	0.0400	gm P m^{-2} yr^{-1}
Land Use Category 9 P Export Coefficient	E9	0.2020	gm P m^{-2} yr^{-1}
Land Use Category 10 P Export Coefficient	E10	0.0420	gm P m^{-2} yr^{-1}
Number of Dwellings	N_d	0	#
Average number of Persons per Dwelling	N_u	2.60	n/a
Average Fraction of Year Dwellings Occupied	N_{pc}	1	yr^{-1}
Phosphorus Load per Capita per Year	Sl	800	gm P cap^{-1} yr^{-1}
Septic System Retention Coefficient	Rsp	0.5	n/a
Point Source Input 1	PS1	0	
Point Source Input 2	PS2	0	
Point Source Input 3	PS3	0	
Point Source Input 4	PS4	0	
Point Source Input 5	PS5	0	
Phosphorus Retention Coefficient	v	12.4	n/a
Model Outputs			
Total Precipitation Hydraulic Input	Pp_{ti}	328263.8	m^3 yr^{-1}
Total Evaporation Hydraulic Loss	Eo	101721.8	m^3 yr^{-1}
Total Hydraulic Surface Run Off	Ql	5086750	m^3 yr^{-1}
Total Hydraulic Input	Qt	38288130	m^3 yr^{-1}
Areal Hydraulic Load	q_s	171.93	m yr^{-1}
Total Hydraulic Outflow	Qo	38186408	m^3 yr^{-1}
Upstream P Input	Ju	648460	gm yr^{-1}
Total Atmospheric P Input	Jd	3842	gm yr^{-1}
Total Overland Run Off P Input	Je	180279	gm yr^{-1}
Total Development P Input	Jd	0	gm yr^{-1}
Total P Input	Jt	832581	gm yr^{-1}
Lake P Retention Factor	Rp	0.07	n/a
Lake Phosphorus Retention	Ps	58281	gm yr^{-1}
Predicted Lake Phosphorus Concentration	[P]	**0.0203**	mg L^{-1}
Lake Phosphorus Outflow	Jo	774300	gm yr^{-1}
Lake Mean Depth	z	2.2	m
Lake Turnover Time	TT	0.01	yr
Lake Flushing Rate	FR	77.84	times yr^{-1}
Lake Response Time	RT	0.01	yr

Budgets		
Hydraulic Budget (m^{-3})		
		% Total
Upstream Inflow	32873116	85.86
Precipitation	328263.8	0.86
Surface Run Off	5086750	13.29
Evaporation	-101721.8	0.27
Total Outflow	38186408	99.73
Total Check		100.01
Phosphorus Budget (gm yr^{-1})		
		% Total
Upstream Inflow	648460	77.89
Atmosphere	3842	0.46
Land Run Off	180279	21.65
Development	0	0.00
Sedimentation	-58281	7.00
Total Outflow	774300	93.00
Total Check		100.00
Model Validation		
Pedicted P (mg L^{-1})		0.0203
Measured P (mg L^{-1})		0.0088
% Difference		130.7

Appendix II: Internal Loading Calculations

Table II-1. Phosphorus accumulation in zones of deep-station anoxia and estimates of P efflux from lake sediments in anoxic zones following the application of published release rates in KL and PML.

	Thermally Mixed	Lake Composite mg L^{-1}	Cumulative Days	TP at Depth 10m	6m	ΔTP	Anoxic Area m^2	Stratum Volume m^3	Mass of P in Stratum mg	P Efflux mg m^{-2} day^{-1}
				----------------	mg L^{-1}	----------------				
Kearney Lake Stn 2 (CWRS, 2006)										
20-Jun-05	yes	0.0040	0	0.0049			0			
28-Jul-05	no	0.0037	29	0.0056	0.0041	0.0007	630	200	140	
25-Aug-05	no	0.0037	61	0.0139	0.0031	0.0083	1090	1000	7980	
26-Sep-05	no	0.0043	84	0.0106	0.0039	-0.0033	1090	1000	5340	
19-Oct-05	yes	0.0052	107	0.0078	0.0054		0			
Paper Mill Stn 1 (CWRS, 2006)										
20-Jun-05	yes	0.0048	0	0.0056	0.0048		0			
28-Jul-05	no	0.0041	29	0.0062	0.0046	0.0006	100	40	24	
25-Aug-05	no	0.0031	61	0.0066	0.004	0.0010	300	355	646	
26-Sep-05	no	0.0031	84	0.0116	0.0032	0.0060	1500	1755	17455	
19-Oct-05	yes	0.0049	107	0.0048	0.0048		0			
			By Period							
Geolimnos (1983)			29				100		130	0.045
			32				300		432	0.045
			23				1500		1552	0.045
								Total	2114	
			29				100		667	0.230
			32				300		2208	0.230
			23				1500		7935	0.230
								Total	10810	
Nurnberg (1984)			29				100		40600	14
			32				300		134400	14
			23				1500		483000	14
								Total	658000	

Table II-2. Estimates of phosphorus loading (Scott & Hart, 2004) versus phosphorus efflux estimates expressed as percent of total load.

	Sources of Phosphorus						
	Upstream	Atmospheric	Land	Urban	Industrial	P Efflux	Total
Paper Mill Lake							
g yr^{-1}	490885	3842	25792	46540	37370	17.4	604446
% of Total	81.2	0.6	4.3	7.7	6.2	0.003	
Geolimnos (1983)							
g yr^{-1}	490885	3842	25792	46540	37370	2.1/10.8	604435
% of Total	81.2	0.6	4.3	7.7	6.2	0.0003/0.002	
Nurnberg (1984)							
g yr^{-1}	490885	3842	25792	46540	37370	658	605087
% of Total	81.1	0.6	4.3	7.7	6.2	0.1	
Kearney Basin 2							
g yr^{-1}	462764	337	3671	0	16564	5	483341
% of Total	95.7	0.1	0.8	0.0	3.4	0.001	

Appendix III: CWRS 2016 Field Data

Table III-1. KL and PML field measurements from July 18, 2016.

Depth	Temperature		Conductivity		Dissolved Oxygen				pH		Secchi Depth	
m	°C		us cm^{-1}		mg L^{-1}		%				m	
	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2
PML Deep-Stations												
0	23.8	24.2	258	266	8.9	9.1	105	108.6	6.3	6.4	5.0	4.6
1	23.6	24.0	257	260	8.9	9.1	105	108.9	6.3	6.5		
2	22.5	22.7	252	265	8.7	9.3	100	108.1	6.2	6.4		
3	19.4	20.0	250	265	9.3	9.3	100	101.8	6.2	6.3		
4	17.9	17.1	249	252	8.9	6.7	94	68.8	6.1	5.8		
5	14.4	13.2	238	269	5.7	2.6	66	25.1	5.8	5.6		
6	10.3	12.2	247	271	4.6	1.1	41	10.4	5.6	5.6		
7	8.9		252		3.4		29		5.6			
8	8.3		255		3.1		26		5.6			
9	7.9		261		1.6		14		5.8			
10	7.8		267		0.3		2		5.9			
PML Inlet (from KL)	22.3		244		9.1		104		6.1			
Shore Line Samples												
PML-1	23.2		258		9.4		110		6.8			
PML-2	23.6		266		9.6		113		6.8			

Table III-1, continued.

Depth	Temperature		Conductivity		Dissolved Oxygen				pH		Secchi Depth	
m	C		us cm^{-1}		mg L^{-1}		%				m	
	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2	Stn 1	Stn 2
KL Deep-Stations												
0	23.7	23.8	235	231	8.6	9.0	101	99	7.5	7.3	6.0	5.3
1	23.7	23.6	235	231	8.6	8.9	101	98	7.3	7.2		
2	22.4	22.9	235	230	8.7	9.2	100	98	7.1	7.1		
3	20.9	20.0	233	227	8.9	8.2	100	94	7.0	7.0		
4	19.6	15.5	233	227	8.8	8.0	95	83	6.8	6.7		
5	18.3	11.8	232	227	8.5	6.0	91	57	6.6	6.6		
6	16.0	10.0	229	230	8.5	2.5	86	22	6.4	6.6		
7	13.4	9.2	231	240	8.6	<0.5	83	4	6.1	6.4		
8	11.6		233		9.0		83		5.9			
9	9.8		234		9.4		83		5.9			
10	8.8		235		9.5		82		5.8			
11	8.3		236		9.3		79		5.8			
12	8.0		236		9.2		78		5.8			
13	7.8		236		9.1		77		5.8			
14	7.8		236		9.1		76		5.8			
15	7.6		237		9.1		76		5.8			
20	7.5		237		9.0		75		5.8			
25	7.3		237		8.5		70		5.8			
28	7.3		237		8.1		67		5.8			
Outlet	23.7		231		9.0		101		7.2			
Shore Line Samples												
KL1	22.5		234		10.1		116		7.1			
KL5	23.3		233		9.8		115		7.0			

Table III-2. KL and PML water quality data, July 18, 2016

Location		TSS		Turbidity		TP		Chla	Euphotic Zone$_2$	TOC		TN		Colour	
	Depth, m	mg L^{-1}	VWM$_1$	NTU	VWM$_1$	ug L^{-1}	VWM$_1$	ug L^{-1}	VWM$_1$	mg L^{-1}	VWM$_1$	mg L^{-1}	VWM$_1$	Pt Co	VWM$_1$
PML Stn 1 (Basin 1)															
	0	0.7	0.7	1.07	1.49	5.4	5.3	0.85	1.19	3.4	3.4	0.23	0.22	14	15
	3			2.21		4.9		1.73		3.2		0.20			
	6			0.89		5.7		1.38		3.3		0.23		21	
	10	1.0		7.06		8.8		0.61		3.6		0.41			
PML Stn 2 (Basin 2)															
	0	0.7	0.7	0.69	0.74	5.1	5.4	0.87	1.51	3.4	3.4	0.16	0.15	13	13
	3			0.77		5.4		2.01		3.5		0.13			
	6	0.9		0.92		8.0		2.91		3.2		0.13		13	
PML Whole-Lake					1.13		5.3		1.32		3.4		0.18		
PML Inlet (from Kearney)		0.5		0.64		3.7		0.15		3.0		0.23		14	14
Shore Line Samples															
PML-1		0.9		0.66		5.0		1.70		3.4		0.23		17	
PML-2		0.4		0.76		5.7		2.15		3.5		0.20		12	

VWM$_1$ - Volume-weighted Mean.

Euphotic Zone$_2$ - Based on 2 times Secchi depth, the euphotic zone extends to the bottom at PML Stn 1, PML Stn 2, and KL Stn 2. For KL Stn 1, the euphotic zone depth is approximately 12 metres.

Table III-2, continued.

Location	TSS		Turbidity		TP		Chla	Euphotic Zone$_2$	TOC		TN		Colour	
Depth, m	mg L^{-1}	VWM$_1$	NTU	VWM$_1$	ug L^{-1}	VWM$_1$	ug L^{-1}	VWM$_1$	mg L^{-1}	VWM$_1$	mg L^{-1}	VWM$_1$	Pt Co	VWM$_1$
KL Stn 1														
0	<0.1	<0.1$_3$	0.41	0.44	3.0	3.4	0.96	0.81	3.4	3.6	0.17	0.19	17	22
3			0.49		3.2		1.61		3.4		0.18			
5			0.50		3.0		0.81		3.4		0.16		18	
8			0.40		3.4		0.33		3.7		0.19			
10	0.1		0.38		3.5		0.15		3.8		0.19		28	
15			0.44		3.7		0.11		3.8		0.21			
20			0.40		4.2		0.08		3.8		0.21		27	
28	0.3		0.55		5.5		0.14		3.8		0.25			
KL Stn 2														
0	0.1	0.2	0.53	0.57	3.4	3.4	1.51	1.44	3.5	3.4	0.16	0.17	17	17
3			0.56		3.5		1.42		3.4		0.16			
5			0.58		3.4		1.15		3.4		0.19		18	
7	0.6		1.65		5.8		0.95		3.2		0.31			
K Outlet	<0.1		0.48		3.5		2.32		3.4		0.17		17	
Shore Line Samples														
KL1	0.5		0.92		6.6		1.88		3.4		0.18		16	
KL5	<0.1		0.54		4.4		1.40		3.4		0.18		17	

VWM$_1$ - Volume-weighted Mean.

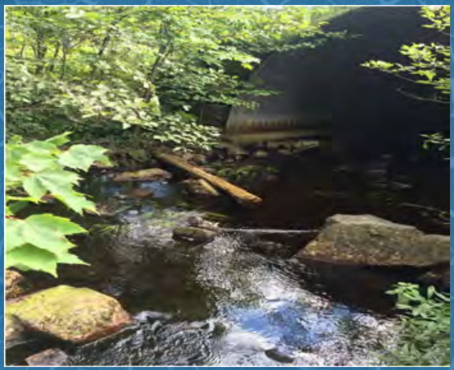
Euphotic Zone$_2$ - Based on 2 times Secchi depth, the euphotic zone extends to the bottom at PML Stn 1, PML Stn 2, and KL Stn 2. For KL Stn 1, the euphotic zone depth is approximately 12 metres.

<0.1$_3$ - A value of 0.5 times the detection limit was applied to VWM calculation.

Attachment C

Water Quality Monitoring Program
Bedford West, Bedford, NS

Spring 2016 Sampling Event



15 | 06 | 2016 Final Report

Water Quality Monitoring - Spring 2016

Rev. C01 > SLI ref. 631477-0001-T-4E-REP-000-0004

SNC·LAVALIN

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June 15, 2016

Halifax Regional Municipality
Energy and Environment
PO Box 1749
Halifax, Nova Scotia
B3J 3A5

Attention: Mr. Cameron Deacoff

Dear Mr. Deacoff:

RE: Final Report: Water Quality Monitoring Program. Spring 2016 Sampling Event Bedford West, Bedford, Nova Scotia

SNC-Lavalin Inc. (SLI) is pleased to submit one electronic copy of the final report presenting the results of the spring 2016 surface water quality sampling event for the Bedford West Water Quality Monitoring Program in Bedford, Nova Scotia.

If you have any questions or require clarification, please contact the undersigned at 902-492-4544.

Yours truly,

SNC♦LAVALIN INC.

Original Signed

Crysta Cumming, P. Eng
Environmental Department Manager

CC/jm/mg

631477-0001-T-4E-REP-000-0004_C01.docx

EXECUTIVE SUMMARY

On May 16th and 17th, 2016 SNC-Lavalin (Inc.) completed the Bedford West spring 2016 water quality monitoring sampling event on behalf of Halifax Regional Municipality (HRM). The sampling program consisted of collecting surface water samples from eleven (11) water quality sampling stations, recording field parameters and laboratory analyses of inorganic, calculated parameters, standard elements, additional metals, and microbiological.

Applicable water quality criteria included:

- Canadian Council of Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life – Freshwater (PAL-F).
- Health Canada guidelines for Canadian Recreational Water Quality (2012, Third Edition).
- Nova Scotia Environment (NSE) Environmental Quality Standards (EQS) for Surface Water (EQS for Contaminated Sites (NSE 2014) Table A2, Reference for Pathway Specific Standards for Surface Water – Fresh Water.

During the spring 2016 water quality monitoring, the following parameters exceeded the recommended water quality criteria. Detail information such as station ID(s) and analytical results are outlined in the report.

1. Dissolved Oxygen
2. Turbidity
3. Total Phosphorous (1m depth)
4. pH (in Situ and Laboratory)
5. Metals as follows:
    - Total Aluminium
    - Total Cadmium
    - Total Chromium
    - Total Iron
    - Total Lead
    - Total Zinc
    - Total Manganese
    - Total Vanadium

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1 INTRODUCTION AND BACKGROUND

SNC-Lavalin Inc. (SNCL) has prepared this report to provide Halifax Regional Municipality (HRM) with water quality data for eleven (11) surface water stations throughout the Bedford West development area.

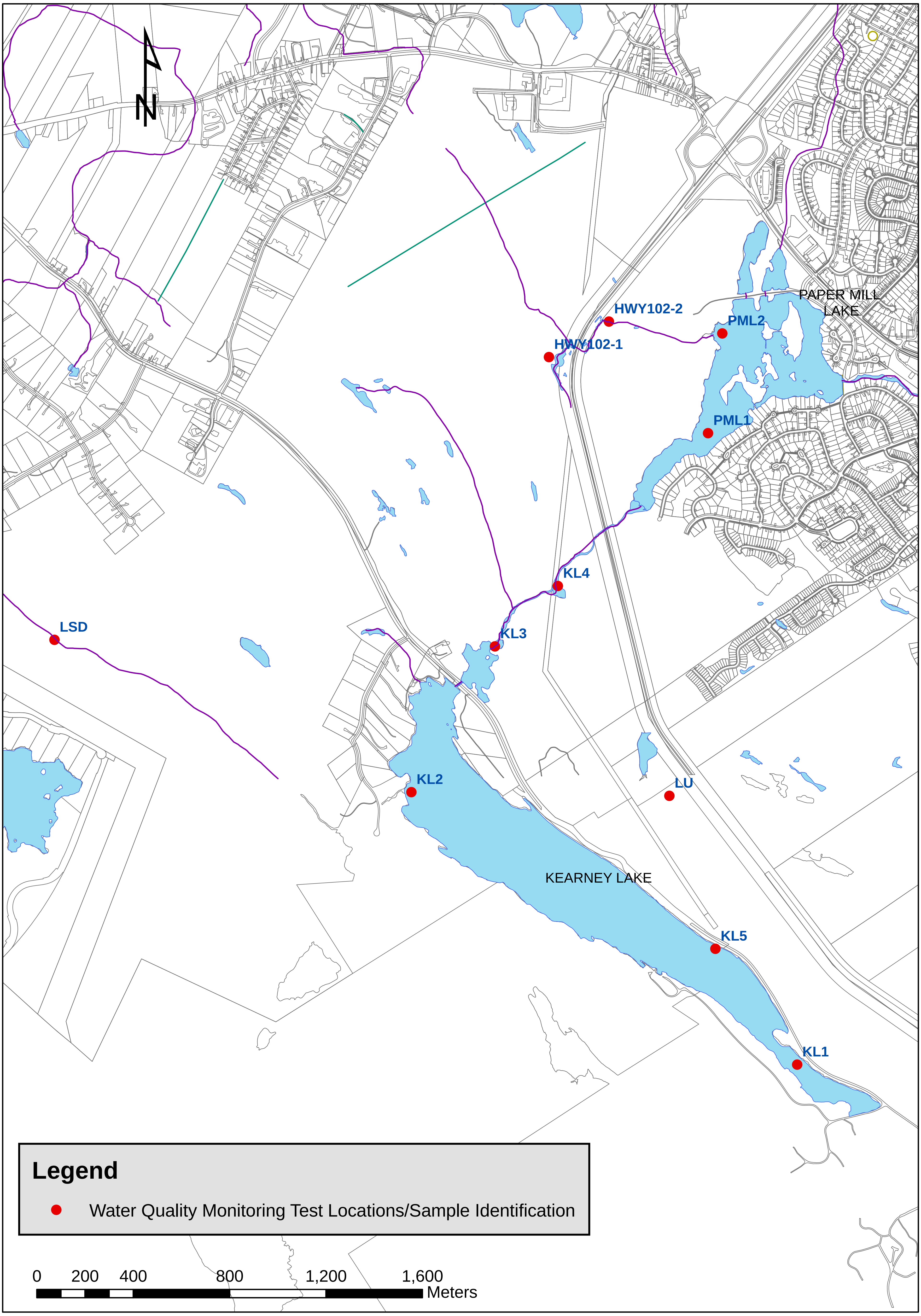
Water quality monitoring at the Bedford West development area has been ongoing since 2009. SNCL was retained by HRM to complete water quality monitoring program each spring, summer and fall for two years beginning in 2015. The results of the spring 2016 monitoring program are detailed herein.

The overall purpose of the program is to conduct water quality sampling and testing prior to and during construction activities of the development project in order to detect any impacts on and/or changes to water quality. The spring 2016 sampling stations are summarized in Table 1 and shown in Figure 1.

Table 1: Bedford West Water Quality Sampling Stations

Water Course	Sample Location Name	Updated Coordinates (UTM NAD 83)	
		Easting	Northing
Kearney Lake	KL-1	20T445718E	4948496N
Kearney Lake	KL-2	20T0443859	4949738N
Kearney Run	KL-3	20T444390E	4950406N
Kearney Run	KL-4	20T444463E	4950571N
Kearney Lake	KL-5	20T4949142E	445280N
Creek Above Highway	HWY 102-1	20T444708E	4951644N
Creek Below Highway	HWY 102-2	20T444829E	4951778N
Lake Shore Drive	LSD	20T442583E	4950431N
Larry Uteck Off-Ramp	LU	20T444954E	4949891N
Paper Mill Lake	PML-1	20T445129E	4951154N
Paper Mill Lake	PML-2	20T445363E	4951740N

Figure 1: Bedford West Water Quality Sampling Stations



SNC•LAVALIN SNC•LAVALIN Inc. Halifax, Nova Scotia, Canada Telephone: (902) 492-4544 Fax: (902) 492-4540 Certified ISO 9001 Member of the SNC•LAVALIN Group	HALIFAX	PROJECT: WATER QUALITY MONITORING WITHIN BEDFORD WEST	DESIGNED: CH	DATE: 21-09-2015
		TITLE: WATER QUALITY MONITORING TEST LOCATIONS	DRAWN: CH CHECKED: DH SCALE: AS SHOWN	PROJECT #: 631477-0001 DRAWING #: 1

2 METHODOLOGY

The spring 2016 water quality sampling event included collection of Field Parameters (Group A) and surface water for laboratory analysis of:

- Inorganic (Group B)
- Calculated Parameters (Group C)
- Standard Metals (Group D)
- Microbiological (Group E)
- Additional Metals (Group F)

Table 2 below summarizes the water quality parameters measured in the field or analyzed by the laboratory.

Table 2: Analytical Parameter Groups

Field Parameters (A)	Inorganic (B)	Calculated Parameters (C)	Standard Metals (D)	Microbiological (E)	Additional Metals (F)
· pH · TDS · Dissolved Oxygen · Temperature · Secchi Depth · Conductance · Air Temperature · Cloud Cover · Incidental Wildlife Sightings	· Total Alkalinity (as CaCO$_3$) · Dissolved Chloride · Colour · Total Kjeldahl Nitrogen · Nitrate + Nitrite · Nitrate · Nitrite · Nitrogen (as NH4) · Total Organic Carbon · Orthophosphate (P) · pH · Low Total Phosphorus · Reactive Silica · Total Suspended Solids · Dissolved Sulphate · Turbidity · Conductivity	· Anion Sum · Cation Sum · Ion Balance · Bicarbonate Alkalinity(as CaCO$_3$) · Carbonate Alkalinity (as CaCO$_3$) · Hardness · Total Dissolved Solids · Saturation pH (@4°C & 20°C) · Langelier Index (@4°C & 20°C)	· Calcium · Copper · Iron · Magnesium · Manganese · Potassium · Sodium · Zinc	· Chlorophyll A · E. coli · Most Probable Number (MPN) or CFU per 100 mL	· Aluminum · Antimony · Arsenic · Barium · Boron · Cadmium · Chromium · Cobalt · Lead · Molybdenum · Nickel · Selenium · Nickel · Selenium · Silver · Strontium · Thallium · Tin · Titanium · Uranium · Vanadium

All water samples and associated field parameters were collected on May 16th, 2016. In addition, Secchi depth measurements were collected on May 17th, 2016.

Field measurements of pH, dissolved oxygen, specific conductivity, water temperature and air temperature were taken at each station using an YSI Professional Plus (YSI serial 21276 and hand set serial 20102). The probe measures temperature, conductivity, DO, pH, ORP. The instrument is calibrated annually by the manufacturer, and a pre-calibration was conducted by the provider (Pine Environmental) prior to conduct the water quality sampling event.

Site conditions (i.e. weather, air temperature, cloud cover, site accessibility and wildlife sightings) and field parameters for each sampling location were recorded on a field report sheet. Each sample station was photographed during the sample event.

The water samples and field parameter readings were collected within a depth of 1.0 m below surface. Water samples were collected from the shore at all sample locations. Surface water sampling followed SNCL's Standard Operating Procedures (SOP) for surface water sampling. A new pair of nitrile gloves was used at each sample location.

Surface water samples were collected and placed in clean laboratory-supplied jars and stored in a chilled container together with a chain of custody record for transport to the laboratory. All surface water samples were submitted to AGAT Laboratories in Dartmouth, NS.

3 ASSESSMENT STANDARDS

- There is currently no national environmental quality guideline for phosphorus in freshwater aquatic environments. In the Canadian framework, trigger ranges are based on the trophic classification of the baseline condition. A trigger range is a desired concentration range for phosphorus; if the upper limit of the range is exceeded, it indicates potential for quality environmental issues, which "triggers" the need for further investigation. According to Canadian Council of Ministers of the Environment (CCME) 10µg/L of total phosphorous is the threshold between oligotrophic and mesotrophic trophic classifications. For this water quality monitoring program, HRM defined a Total Phosphorous management threshold value of 10µg/L or 0.01mg/L.
- The Canadian Council of Ministers of the Environment (CCME) Guidelines for the Protection of Aquatic Life – Freshwater (PAL-F) were used for parameter such as Dissolved Oxygen, pH (in Situ and Laboratory analysis), Dissolved Chloride, Nitrate, Nitrate, Nitrogen, as well as for total metals (i.e. Aluminum, Arsenic, Boron, Cadmium, Cooper, Iron, Lead, Molybdenum, Nickel, Selenium, Silver, Thallium, Uranium, and Zinc).
- For Total Suspended Solids (TSS), the CCME (2002) Water Quality Guidelines for the Protection of Aquatic Life at high flow conditions were applied. For TSS, the guideline value is equal to a maximum increase of 25mg/L from background levels at any time when background levels are between 25 and 250 mg/L. When background is greater than 250 mg/L, the concentration should not increase more than 10% of background levels.

- The Health Canada guidelines for Canadian Recreational Water Quality (2012, Third Edition) were used for parameters such as Secchi Depth (i.e. the guidelines indicate that the clarity of the water should be sufficiently clear such that a Secchi disk is visible at a minimum of 1.2 metres); pH (guideline of 5.0-9.0 pH); Turbidity (limit of 50 Nephelometric Turbidity Units); E. coli (400 MPN/100mL) and Fecal Coliform (400 MPN/mL).
- The Nova Scotia Environment (NSE) Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2, Reference for Pathway Specific Standards for Surface Water (µg/L) for Fresh Water were used for assessment of total metals (i.e. Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Cooper, Iron, Lead, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Uranium, Vanadium and Zinc).

4 WATER QUALITY RESULTS

4.1 FIELD OBSERVATIONS

Site conditions were recorded for all water quality monitoring stations and are included in the field data sheets in **Appendix B**.

Site condition observations include weather, cloud cover, air temperature, wildlife sightings and site accessibility. In addition, site photographs are included in **Appendix C**.

4.2 FIELD MEASUREMENTS

Field measurements included collection of parameters such as in Situ pH, dissolved Oxygen, water temperature, conductivity and Secchi depth where applicable. Field measurements were recorded on field data sheets which are enclosed in Appendix B.

Field measurements are also summarized in **Table 3** attached at the end of this section.

pH (in Situ)

Ph reading were outside the CCME-PAL-F guideline of 6.5-9.0 at water quality monitoring stations KL5 (5.75 pH) and HWY102-2 (5.86 pH)

Dissolved oxygen

Readings in nine (9) of eleven (11) water quality sampling stations were within the range of 5.5-9.5 mg/L recommended in the CCME PAL-F guidelines. Exceedances were recorded at stations KL1 (14.02 mg/L of Oxygen) and KL5 (10.47 mg/L of Oxygen)

4.3 LABORATORY ANALYTICAL RESULTS

Laboratory (AGAT) Certificates of Analysis for the spring 2016 event are enclosed in **Appendix A**. Analytical results are summarized in **Table 3** attached at the end of this section.

4.3.1 TOTAL PHOSPHOROUS

Total Phosphorus concentrations that exceeded the management threshold criteria of 10 µg/L (0.01 mg/L) listed in the HRM RFP 14-338 were reported at six (6) of the water quality monitoring stations as follows. NOTE: results are also presented in mg/L for comparison with Table 3.

♦ KL1	24 µg/L	(0.024 mg/L)
♦ HWY-102-2	222 µg/L	(0.222 mg/L)
♦ LSD	1250 µg/L	(1.25 mg/L)
♦ LU	29 µg/L	(0.029 mg/L)
♦ PLM-1	173 µg/L	(0.173 mg/L)
♦ PLM-2	12 µg/L	(0.012 mg/L)

4.3.2 GENERAL CHEMISTRY

pH was outside the CCME-PAL-F guideline of 6.5-9.0 at water quality monitoring station KL-2 (6.35 pH)

Turbidity was outside the Health Canada Guideline of 50 NTU for Recreational Water Quality at water quality monitoring stations HWY2012-2 (131 NTU), LSD (65.3 NTU) and PML1 (199.0 NTU).

4.3.3 METALS

Total Aluminium exceeded the applicable NSE EQS guideline of 5 µg/L at the following ten (10) water quality monitoring stations. It should also be noted that the CCME Guideline PAL-F limit is 5 - 100 µg/L.

♦ KL-1	206 µg/L
♦ KL-2	187 µg/L
♦ KL-3	163 µg/L
♦ KL-4	172 µg/L
♦ KL-5	163 µg/L
♦ HWY-102-2	3880 µg/L
♦ LSD	2150 µg/L
♦ LU	1420 µg/L
♦ PML1	7690 µg/L
♦ PML2	610 µg/L

Total Cadmium exceeded the applicable NSE EQS guideline of 0.01 µg/L at the following nine (9) water quality monitoring stations. Note that the CCME Guideline PAL-F is 0.017 µg/L.

KL-1	0.029 µg/L
KL-3	0.021 µg/L
KL-4	0.024 µg/L
KL-5	0.024 µg/L
HWY-102-2	0.778 µg/L
LSD	0.120 µg/L
LU	0.426 µg/L
PML1	0.227 µg/L
PML2	0.042 µg/L

Total Chromium exceeded the CCME Guideline PAL-F of 1 µg/L at the following four (4) water quality monitoring stations. Note there is not a NSE EQS guideline for Chromium.

HWY-102-2	8 µg/L
LSD	2 µg/L
LU	3 µg/L
PML1	6 µg/L

Total Iron exceeded the applicable NSE EQS guideline of 300 µg/L at the following five (5) water quality monitoring stations. Note that the CCME Guideline PAL-F is also 300 µg/L.

HWY102-2	21300 µg/L
LSD	2790 µg/L
LU	1940 µg/L
PML1	13600 µg/L
PML2	647 µg/L

Total Lead exceeded the applicable NSE EQS guideline of 1 µg/L at the following five (5) water quality monitoring stations. Note that the CCME Guideline PAL-F is 1.0-7.0 µg/L.

HWY102-2	39.7 µg/L
LSD	4.3 µg/L
LU	3.4 µg/L
PML1	13.9 µg/L
PML2	1.1 µg/L

Total Zinc exceeded the applicable NSE EQS guideline of 30 µg/L at the following three (3) stations. Note that the CCME Guideline PAL-F is also 30 µg/L.

HWY102-2	170 µg/L
LU	64 µg/L
PML1	34 µg/L

Total Manganese exceeded the applicable NSE EQS guideline of 820µg/L at the following station. Note there is no CCME guideline for total manganese.

LSD	921 µg/L

Total Vanadium exceeded the applicable NSE EQS guideline of 6µg/L at the following station. Note there is no CCME guideline for total vanadium.

PML1	16 µg/L
HWY102-2	18 µg/L

4.3.4 MICROBIOLOGICAL

Eleven (11) *E.coli* samples were collected during the spring 2016 sampling program. *E.coli* did not exceed the Heath Canada Guidelines of 400 CFU /100 mL in any of the samples collected.

Table 3: Surface Water Quality Monitoring Results

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Applied)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Kearney Lake																					
Sample Sites							KL1																					
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/14	2012/10/10	2013/05/15	2013/08/16	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					08:00	11:45	08:30	11:00	13:10	12:00	11:00	14:30	14:00	8:30	11:20	9:50	10:20	11:10	13:30	10:30	14:15	14:55	08:30	14:54	12:30	9:30
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		4.1	4.2	5.0	N/A	5.0	4.9	2.4	3.2	2.4	2.35	5.36	N/A	2.50	2.03	2.90	2.36	2.70	2.54	NCC	N/A	2.21	1.8 (on bottom)
Water Temp	Celsius	0.1	--	--	--		14.0	22.2	16.7	12.9	23.3	8.8	11.5	25.6	15.9	8.9	23.3	15.4	13.2	22.2	14.1	12.7	23.2	12.2	14.12	26.1	9.4	12.8
Dissolved Oxygen	mg/L	0.01	--	--	5.5 - 9.5		10.77	8.20	7.00	9.13	7.86	10.48	10.69	8.22	9.22	8.98	7.93	8.72	9.76	8.57	8.30	15.29	7.22	8.12	9.55	8.13	7.38	**14.02**
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.20	6.76	6.67	7.23	7.32	6.61	6.60	6.16	6.04	8.67	6.91	6.32	6.32	8.24	6.35	6.74	7.46	6.44	8.33	6.95	7.02	8.29
Specific Conductance	uS/cm	1	--	--	--		263	299	261	248	242	219	288	179	146	277	279	198.1	243	216.5	217.9	547.0	341.0	223.0	0.182	298.3	238.5	239
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		6	8	8	7	8	6	<5	9	7	24	7	<5	<5	<5	8	30	14	<5	5.2	6	7	5
Dissolved Chloride (Cl)	mg/L	1	--	--	120		81	74	64	62	60	55	73	45	33	66	70	50	66	59	48	80	76	46	60	62	58	55
Colour	TCU	5	--	--	--		18	18	16	26	8	21	28	40	45	50	11	20	11	37	20	13	8	23	37	8	22	31
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.18	0.09	0.12	0.21	0.16	0.23	0.2	0.11	0.13	0.20	0.09	0.10	0.18	0.14	0.19	0.11	0.11	0.08	0.15	0.15	0.17	0.10
Nitrate (N)	mg/L	0.05	--	--	13000		0.18	--	--	0.21	0.16	--	0.2	--	--	0.20	0.09	0.10	0.18	0.14	0.19	0.11	0.11	0.08	0.15	0.15	0.17	0.10
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.04	0.03	<0.03	0.03	0.03	<0.03	<0.03	<0.03	<0.03	<0.050	<0.03	<0.03	0.05
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	0.9	3.1	0.4	--	0.7	<0.4	1.1	<0.4	0.4	0.22	4.5	0.4	0.7
Total Organic Carbon	mg/L	0.5	--	--	--		2.4	2.9	4.7	3.3	3.2	3.1	3.4	5.9	5.5	5.4	2.9	5.2	4.4	4.1	4.3	4.6	2.4	4.4	3.0	5.3	5.5	4.3
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01
pH (Lab)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.94	6.65	6.68	6.91	7.00	6.79	6.52	6.51	6.52	6.7	7.2	6.9	6.78	6.93	6.85	6.72	7.06	6.35	6.62	6.95	6.99	6.64
Total Calcium (Ca)	mg/L	0.1	--	--	--		9.2	8.5	7.2	7.72	8.66	8.30	7.65	4.82	5.31	6.8	8.4	6.3	7.5	6.6	6.5	8.1	11	6.0	6400	7.9	6.1	6.8
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.5	1.4	1.2	1.42	1.36	1.30	1.29	0.86	1.06	1.1	1.5	1.5	1.1	1.2	1.2	1.6	1.6	0.9	920	1.3	0.9	1.1
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	<0.02	<0.02	<0.002	0.009	0.007	0.005	0.008	0.012	0.009	0.037	0.043	0.007	0.007	0.011	0.008	0.011	0.026	0.01	0.008	0.002	0.011	**0.024**
Total Potassium (K)	mg/L	0.1	--	--	--		1.1	0.9	1.3	0.876	0.888	0.901	0.788	0.773	0.871	0.7	0.9	0.9	0.8	0.7	1.1	0.9	1.6	0.7	680	0.9	0.7	0.7
Total Sodium (Na)	mg/L	0.1	--	--	--		51	46	37	31.8	35.2	33.8	43.7	22.8	19.8	40.1	42.0	29.8	35.8	26.2	31.6	50.2	54.2	37.6	33	43.3	39.8	35.5
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.6	2.2	2.3	2.9	2.7	2.9	2.8	1.9	2.3	2.4	1.3	2.2	2.5	1.8	2.2	2.0	1.5	1.8	2.5	1.8	2.7	2.8
Total Suspended Solids	mg/L	5	--	--	--		1	1	<1	4	17	3	2	2	3	<5	<5	<5	<5	<5	5	<5	<5	<5	<1.0	<5	<5	38
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		14	13	12	11	11	11	12	10	8	8	9	9	11	9	9	12	11	7	8.7	10	8	10
Turbidity (NTU)	NTU	0.1	--	50	--		0.7	0.8	1.0	1.3	0.6	1	1	1	0.9	2.4	0.8	1.3	1.6	3.3	0.5	2.9	0.7	1.9	0.81	1.9	1.1	10.6
Conductivity (uS/cm)	µS/cm	1	--	--	--		310	290	250	240	240	230	290	180	140	246	274	196	259	241	212	290	339	235	220	257	244	212
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		2.72	2.52	2.23	2.12	2.08	1.91	2.33	1.66	1.27	2.52	2.31	1.60	2.10	1.86	1.71	3.11	2.66	1.45	1.98	2.09	1.95	1.87
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		6	8	8	7	8	6	<1	9	7	24	7	<5	<5	<5	8	30	14.00	<5	5.2	6	7	5
Calculated TDS	mg/L	1	--	--	--		166	151	131	123	125	118	143	92	77	139	137	98	124	104	103	172	165.00	99	120	130	119	113
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		2.85	2.57	2.12	1.92	2.10	2.02	2.42	1.33	1.25	2.24	2.41	1.79	2.08	1.61	1.84	2.77	3.09	2.05	1.84	2.43	2.14	2.03
Hardness (CaCO3)	mg/L	N/A	--	--	--		29	27	23	25	27	26	24	16	18	21.5	27.2	21.9	23.3	21.4	21.2	26.8	34.10	18.7	20.0	25.1	18.9	21.5
Ion Balance (% Difference)	%	N/A	--	--	--		2.33	0.98	2.53	4.95	0.48	2.80	1.89	11.00	0.79	5.9	2.1	5.3	0.7	7.3	3.4	5.8	7.50	17.2	3.66	7.5	4.5	4.1
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-2.68	-2.87	-2.94	-2.72	-2.51	-2.87	NC	-3.18	-3.21	-2.69	-2.63	-3.19	-3.24	-3.14	-3.02	-2.51	-2.36	-3.76	-3.21	-2.97	-2.97	-3.42
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-2.93	-3.12	-3.19	-2.97	-2.76	-3.12	NC	-3.43	-3.46	-3.01	-2.95	-3.51	-3.56	-3.46	-3.34	-2.83	-2.68	-4.08	-3.46	-3.29	-3.29	-3.74
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.62	9.52	9.62	9.63	9.51	9.66	NC	9.69	9.73	9.39	9.83	10.10	10.0	10.1	9.87	9.23	9.42	10.1	9.83	9.92	9.96	10.1
Saturation pH (@ 4C)	N/A	N/A	--	--	--		9.87	9.77	9.87	9.88	9.76	9.91	NC	9.94	9.98	9.71	10.2	10.4	10.3	10.4	10.2	9.55	9.74	10.4	10.1	10.2	10.3	10.4
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		230	--	--	289	47.8	--	338	--	--	321	43	168	191	120	56	229	42	155		--	88	**206**
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Barium (Ba)	µg/L	5	1000	--	--		16	--	--	18.5	15.9	--	13	--	--	12	15	9	12	7	16	14	20	9	16	--	17	14
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		8	--	--	11.4	9.1	--	<50	--	--	<5	11	33	6	10	9	7	22	10	<50	--	<5	8
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	0.053	<0.017	--	0.056	--	--	0.032	0.027	0.021	0.020	<0.017	0.017	0.037	<0.017	0.025		--	0.187	**0.029**
Total Chromium (Cr)	µg/L	1	---	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	6	<1	<1	<1.0	--	<1	<1
Total Cobalt (Co)	µg/L	1	10	--	--		1	--	--	0.54	<0.40	--	0.79	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	<1
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2	--	--	5.8	<2.0	<2.0	<2.0	<2.0	<2.0	<2	<2	<2	<2	<1	1	1	<1	1	<2.0	<1	2	<1
Total Iron (Fe)	µg/L	50	300	--	300		130	--	--	313	62	125	177	162	384	229	137	195	207	132	92	147	124	168	110	157	81	149
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	--	--	10.3	<0.50	--	<0.50	--	--	<0.5	<0.5	1.9	<0.5	<0.5	<0.5	5.1	<0.5	<0.5	<0.50	--	<0.5	<0.5
Total Manganese (Mn)	µg/L	2	820	--	--		100	--	--	79.2	57.1	59	78.4	52.3	55.8	48	65	68	73	48	24	48	115	42	39	41	22	47
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		5	--	--	3.2	<2.0	--	3.2	--	--	<2	<2	2	2	<2	<2	3	<2	3	<2.0	--	<2	3
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	--	<1	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		46	--	--	39.1	37.7	--	36	--	--	32	41	32	37	33	30	40	45	26	29	--	19	30
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		11	--	--	6.4	<2.0	--	5.4	--	--	8	<2	3	4	2	<2	2	<2	5	2.3	--	<2	2
Total Uranium (U)	µg/L	0.1	300	--	15		0.1	--	--	0.11	<0.10	--	0.12	--	--	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.10	--	<0.1	0.1
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Zinc (Zn)	µg/L	5	30	--	30		27	--	--	14.4	7.5	11.1	12.1	13.3	9.7	5	<5	11	11	6	5	14	<5	9	13	8	<5	11
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		200	65	--	>250	63	>250	91	>250	--	2420	>2420	1120	1200	866	488	525	1550	>2420	---	980	122	866
E. coli	MPN/100mL	1	--	400	--		39	24	--	9	15	37	8	>250	<100	41	11	17	48	2	7	<1	15	28	60	24	6	4
Fecal Coliform	MPN/ml	--	--	400	--		--	--	<1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.53	0.79	1.11	1.73	1.47	0.99	0.76	1.44	1.36	0.62	2.3	1.54	1.22	1.40	1.19	0.40	0.41	0.84	0.64	1.14	1.79	2.76
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.48	0.69	1.17	1.61	1.42	0.81	0.69	1.15	1.14	0.63	2.3	2.16	1.40	1.40	1.19	1.32	0.36	0.8	0.62	1.11	0.95	3.48

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded)	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded	= Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Applied)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Kearney Lake																					
Sample Sites							KL2																					
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/14	2012/10/10	2013/05/15	2013/08/15	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					11:00	10:30	10:45	10:15	12:25	10:50	09:30	14:00	13:15	9:50	10:30	10:20	09:10	16:10	14:30	10:45	9:20	14:04	09:15	13:29	13:05	10:30
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	1.3	2.11 (on bottom)
Water Temp	Celsius	0.1	--	--	--		16.8	18.2	15.4	13.5	20.4	8.0	9.9	19.1	14.1	7.6	21.8	12.3	10.1	22.9	9.7	11.7	21.1	10.8	13.13	24.7	8.1	10.73
Dissolved Oxygen	mg/L	0.01	--	--	5.5 - 9.5		10.16	8.50	5.70	6.28	4.66	9.58	9.66	7.06	8.43	6.47	5.82	7.63	9.37	6.38	7.40	14.90	6.95	7.7	8.41	7.28	7.14	7.88
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.33	6.35	6.19	6.61	6.96	6.25	6.77	5.90	5.62	7.72	6.41	6.29	5.75	7.47	5.57	6.60	7.22	5.79	6.36	5.88	6.43	7.64
Specific Conductance	uS/cm	1	--	--	--		46	106	89	199	104	75	80	67	54	58	96.6	61.1	77.9	65.3	64.5	188.0	266.0	63.0	0.053	107.9	73.6	82
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		8	8	8	8	7	<5	<5	7	<5	20	<5	8	<5	<5	<5	29	7	28	<5.0	7	<5	<5
Dissolved Chloride (Cl)	mg/L	1	--	--	120		48	48	48	48	25	17	19	14	10	16	20	12	19	21	14	20	17	12	15	14	12	17
Colour	TCU	5	--	--	--		20	20	20	20	63	95	80	110	120	52	60	94	37	90	71	25	44	168	50	63	61	47
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.19	0.19	0.19	0.19	0.07	0.06	0.12	0.07	<0.05	0.11	0.08	<0.05	0.12	<0.05	<0.05	0.08	<0.05	<0.05	0.059	0.08	<0.05	<0.05
Nitrate (N)	mg/L	0.05	--	--	13000		0.19	0.19	0.19	0.19	0.07	--	0.12	--	--	0.11	0.08	<0.05	0.12	<0.05	<0.05	0.08	<0.05	<0.05	0.059	0.08	<0.05	<0.05
Nitrite (N)	mg/L	0.05	--	--	60		<0.05	<0.05	<0.05	<0.05	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.03	<0.03	<0.03	<0.03	<0.05	<0.05	<0.05	<0.05	<0.05	<0.03	<0.03	<0.03	<0.03	0.04	<0.03	<0.03	0.04	<0.03	<0.050	<0.03	<0.03	0.05
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	<0.4	2.2	0.7	--	1.1	<0.4	<0.4	0.4	<0.4	0.4	0.8	0.8	0.4
Total Organic Carbon	mg/L	0.5	--	--	--		4.3	4.3	4.3	4.3	6.6	9.7	6.5	10	12	8.1	7.1	10.9	7.5	11.1	10.9	6.2	6.6	12.9	4.0	13.3	14.0	6.2
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01
pH (Lab)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.85	6.85	6.85	6.85	6.78	6.11	6.27	6.4	6.05	6.5	6.7	6.5	6.37	6.62	6.34	6.53	6.87	6.06	6.32	6.99	6.28	**6.35**
Total Calcium (Ca)	mg/L	0.1	--	--	--		6.5	6.5	6.5	6.5	4.08	3.55	2.51	2.48	2.21	2.4	3.6	2.9	2.7	2.5	2.4	3.4	4.0	2.4	2600	3.4	1.1	2.9
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.2	1.2	1.2	1.2	0.98	0.84	0.63	0.64	0.36	0.7	1.0	1.0	0.7	0.5	0.8	1.1	1.0	0.6	640	0.9	0.7	0.7
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	0.02	0.02	0.02	0.02	0.009	0.009	0.009	0.008	0.013	0.021	0.059	0.013	0.010	0.020	0.029	0.013	0.039	0.03	0.008	0.012	0.008	0.009
Total Potassium (K)	mg/L	0.1	--	--	--		1.1	1.1	1.1	1.1	0.634	0.826	0.534	0.497	0.734	0.5	0.7	0.8	0.5	0.5	0.7	0.7	0.9	0.7	540	0.7	0.6	0.9
Total Sodium (Na)	mg/L	0.1	--	--	--		31.6	31.6	31.6	31.6	14.7	10.6	11.1	7.8	6.9	9.8	14.2	9.5	8.9	7.0	7.9	17.5	14.0	7.6	8.4	11.5	6.6	11.5
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.2	2.2	2.2	2.2	4.2	4.7	2.7	4.3	4	2.6	4.0	4.9	2.8	4.4	4.9	2.4	3.3	4.6	2.0	3.7	5.1	2.0
Total Suspended Solids	mg/L	5	--	--	--		103	103	103	103	7	<1	<1	<2	<1	<5	<5	<5	<5	135	<5	<5	<5	<5	<1.0	<5	17	<5
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		9	9	9	9	<2	<2	<2	<2	<2	3	3	2	4	5	4	4	2	3	2.8	<2	3	4
Turbidity (NTU)	NTU	0.1	--	50	--		0.5	0.5	0.5	0.5	1.0	1.0	0.4	0.7	0.6	0.5	1.1	1.0	1.9	2.2	1.0	0.9	0.8	1.2	<1.0	1.6	6.2	0.7
Conductivity (uS/cm)	µS/cm	1	--	--	--		212	212	212	212	100	97	79	66	54	71	91	61	83	69	62	87	94	66	64	81	73	79
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		0.49	0.82	0.45	0.77	0.85	0.49	0.53	0.53	0.28	0.92	0.63	0.54	0.63	0.70	0.48	1.23	0.66	0.96	0.48	0.54	0.40	0.56
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		<1	8	<1	5	7	<1	<1	7	<1	20	<5	8	<5	<5	<5	29	7	28	<1.0	7	<5	<5
Calculated TDS	mg/L	1	--	--	--		36	55	35	46	55	38	37	34	25	45	44	34	37	37	31	65	44	44	32	36	25	38
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		0.71	0.99	0.67	0.74	0.95	0.74	0.68	0.55	0.49	0.65	0.94	0.73	0.63	0.54	0.60	1.07	0.97	0.57	0.57	0.82	0.47	0.76
Hardness (CaCO3)	mg/L	N/A	--	--	--		10	15	10	12	14	12	9	9	8	8.9	13.1	11.4	9.6	8.3	9.3	13.0	14.1	8.5	9.1	12.2	5.6	10.1
Ion Balance (% Difference)	%	N/A	--	--	--		18.30	9.39	19.60	1.99	5.56	20.30	12.40	1.85	27.30	17.6	19.7	15.1	0.3	12.9	11.0	7.1	19.1	25.7	8.57	20.5	7.5	14.9
Langelier Index (@ 20C)	N/A	N/A	--	--	--		NC	-3.20	NC	-3.44	-3.05	NC	NC	-3.66	NC	-3.37	-3.60	-3.68	-4.05	-3.83	-4.12	-3.04	-3.23	-3.66	NC	-3.18	-4.51	-4.04
Langelier Index (@ 4C)	N/A	N/A	--	--	--		NC	-3.45	NC	-3.70	-3.30	NC	NC	-3.91	NC	-3.69	-3.92	-4.00	-4.37	-4.15	-4.44	-3.36	-3.55	-3.98	NC	-3.50	-4.83	-4.36
Saturation pH (@ 20C)	N/A	N/A	--	--	--		NC	9.78	NC	10.00	9.83	NC	NC	10.10	NC	9.87	10.3	10.2	10.4	10.5	10.5	9.57	10.1	9.72	NC	10.20	10.8	10.4
Saturation pH (@ 4C)	N/A	N/A	--	--	--		NC	10.00	NC	10.30	10.10	NC	NC	10.30	NC	10.2	10.6	10.5	10.7	10.8	10.8	9.89	10.4	10.0	NC	10.5	11.1	10.7
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		290	--	--	175	151	--	271	--	--	209	205	338	256	270	259	205	236	340	180	--	284	**187**
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Barium (Ba)	µg/L	5	1000	--	--		9	--	--	11.7	14.3	--	9.5	--	--	9	11	10	8	<5	13	13	18	9	9.2	--	9	10
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		8	--	--	14.7	12.7	--	<50	--	--	6	14	22	6	11	9	11	12	12	<50	--	<5	9
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	0.018	<0.017	--	<0.017	--	--	<0.017	<0.017	<0.017	<0.017	<0.017	0.019	<0.017	<0.017	0.018	0.014	--	0.176	<0.017
Total Chromium (Cr)	µg/L	1	---	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	9	<1	<1	<1.0	--	<1	1
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	<0.40	<0.40	--	<0.40	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	<1
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2	--	--	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2	<2	<2	<2	<1	2	<1	<1	4	<2.0	<1	<1	<1
Total Iron (Fe)	µg/L	50	300	--	300		250	--	--	227	403	238	202	418	358	154	541	813	269	528	523	174	723	305	250	641	478	232
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	--	--	1.01	<0.50	--	<0.50	--	--	<0.5	<0.5	1.1	<0.5	0.5	<0.5	5.8	<0.5	0.5	<0.50	--	0.6	<0.5
Total Manganese (Mn)	µg/L	2	820	--	--		26	--	--	43.2	83.3	34.7	12.1	68.4	22.6	17	90	114	24	67	53	33	146	25	47	120	57	21
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	1	<1	<1	<1	<1	<1	<1	<1.0	--	<1	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	0.42	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		14	--	--	17.8	19.5	--	11.9	--	--	10	18	15	12	9	12	16	17	12	12	--	8	12
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	3	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		2	--	--	<2.0	<2.0	--	2.8	--	--	<2	2	3	4	<2	2	2	<2	3	2.5	--	<2	<2
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Zinc (Zn)	µg/L	5	30	--	30		8	--	--	5.4	5.3	6.5	<5.0	<5.0	<5.0	<5	<5	7	<5	<5	<5	<5	<5	<5	<5.0	<5	<5	<5
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		1800	170	--	>250	11	>250	59	>250	--	>2420	1986	>2420	>2420	>2420	>2420	525	>2420	>2420	---	>2420	>2420	>2420
E. coli	MPN/100mL	1	--	400	--		1500	100	--	>250	6	6	2	>250	<100	3	7	3	12	6	2	<1	18	11	30	11	5	4
Fecal Coliform	MPN/ml	--	--	400	--		--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.82	6.05	1.97	0.73	0.55	0.22	0.44	0.89	0.97	0.53	2.2	0.07	0.62	1.00	0.73	0.13	0.83	0.41	0.34	0.96	0.46	0.30
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.87	5.97	1.95	0.66	0.54	0.21	0.42	0.73	0.82	0.56	2.2	0.12	0.72	1.00	0.74	0.14	0.86	0.41	---	1.26	0.26	0.43

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009) (Referenced)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded)	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded	= Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Applied)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Kearney Lake																					
Sample Sites							KL3																					
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/14	2012/10/10	2013/05/15	2013/08/16	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					09:00	11:00	09:30	11:30	14:12	11:40	10:30	12:20	12:00	10:26	12:20	11:20	9:50	10:00	14:00	11:00	11:50	14:25	10:35	11:45	10:40	11:00
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		14.0	21.6	17.3	14.7	23.1	9.9	10.3	21.1	15.5	9	24.5	15.6	11.7	21.5	13.6	11.0	22.7	12.8	14.73	25.0	8.4	12.07
Dissolved Oxygen	mg/L	0.01	--	--	5.5 - 9.5		**10.79**	8.00	8.00	9.26	7.83	**10.35**	**11.06**	8.42	**9.60**	8.89	8.17	7.72	**10.20**	9.20	8.90	5.90	7.87	8.12	8.02	**9.91**	8.65	9.34
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		7.27	6.74	6.97	7.27	7.33	6.76	6.83	6.96	6.30	7.68	6.85	6.51	5.86	7.25	6.49	6.55	7.37	6.67	6.84	6.87	7.17	7.4
Specific Conductance	uS/cm	1	--	--	--		95	282	246	220	228	199	220	175	161	204	225	177.2	207.3	194.4	210.6	405.0	252.0	208.0	0.185	245.1	236.6	213
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		<5	7	7	6	7	7	6	7	7	23	6	5	<5	5	7	15	5	6	<5.0	6	6	<5
Dissolved Chloride (Cl)	mg/L	1	--	--	120		66	63	60	55	55	53	56	43	37	50	57	46	54	40	46	58	46	45	60	56	56	54
Colour	TCU	5	--	--	--		22	20	20	28	12	20	31	38	40	57	15	31	19	23	20	16	13	20	34	13	14	29
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.14	0.12	0.14	0.24	0.15	0.22	0.24	0.15	0.16	0.19	0.09	0.09	0.21	0.11	<0.05	0.17	0.13	0.13	0.16	0.12	0.21	0.14
Nitrate (N)	mg/L	0.05	--	--	13000		0.14	--	--	0.24	0.15	--	0.24	--	--	0.19	0.09	0.09	0.21	0.11	<0.05	0.17	0.13	0.13	0.16	0.12	0.21	0.14
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.03	0.04	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.050	<0.03	<0.03	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	<0.4	2.8	<0.4	--	1.3	<0.4	0.6	0.4	0.4	0.15	1.2	0.9	<0.4
Total Organic Carbon	mg/L	0.5	--	--	--		2.6	3.9	4.3	3.6	3.1	3.3	3.8	5.1	5	5.9	3.4	4.9	4.3	4.4	4.6	4.6	2.8	4.5	3.4	5.7	5.8	4.3
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01
pH (Lab)	pH	N/A	--	5.0-9.0	6.5 - 9.0		**6.38**	6.67	6.82	6.82	6.99	6.87	6.52	6.5	**6.38**	6.7	7.1	6.9	6.68	6.96	6.86	6.68	6.87	6.59	6.54	6.92	6.94	6.69
Total Calcium (Ca)	mg/L	0.1	--	--	--		6.7	7.1	6.8	6.81	7.98	8.29	7.09	4.73	5.63	5.7	6.9	6.0	7.0	5.3	6.8	6.4	7.9	6.8	6600	7.8	5.2	6.2
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.2	1.2	1.11	1.22	1.28	1.27	1.21	0.83	1.01	1.0	1.2	1.3	1.0	0.9	1.3	1.4	1.2	1.0	940	1.2	0.9	1.0
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**<0.02**	**<0.02**	0.005	0.005	<0.002	0.003	0.008	0.003	**0.012**	**0.019**	**0.045**	0.007	0.006	0.006	**0.012**	0.009	**0.023**	**0.15**	0.004	0.004	0.002	0.008
Total Potassium (K)	mg/L	0.1	--	--	--		0.9	1.1	0.9	0.791	0.837	0.990	0.879	0.681	0.921	0.7	0.9	0.9	0.8	0.6	1.2	0.8	1.1	0.9	770	0.9	0.7	0.7
Total Sodium (Na)	mg/L	0.1	--	--	--		38	38	35	28.3	33.1	33.0	33.0	20.8	21.3	31.2	34.5	26.37	35.1	20.1	32.1	36.4	39.0	35.3	34	40.0	27.1	32.1
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.7	2.6	2.6	3.2	2.9	3.2	2.9	2.5	2.6	2.7	2.0	2.6	2.9	2.6	2.7	2.6	1.9	2.4	2.5	2.4	2.6	2.6
Total Suspended Solids	mg/L	5	--	--	--		<1	1	1	2	<2	<1	<1	<1	<1	<5	<5	<5	<5	<5	<5	<5	<5	<5	2.8	<5	<5	<5
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		11	12	12	10	10	10	9	10	8	7	8	7	7	7	8	9	7	7	7.9	9	8	10
Turbidity (NTU)	NTU	0.1	--	50	--		0.7	1.4	0.6	0.3	0.5	0.6	0.6	0.6	0.4	0.8	0.7	1	0.7	2.4	0.4	0.4	0.3	0.9	0.7	0.5	0.7	1.1
Conductivity (uS/cm)	µS/cm	1	--	--	--		250	250	240	220	220	220	220	170	160	197	222	182	219	216	204	218	243	216	220	242	238	206
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		2.11	2.17	2.08	1.90	1.93	1.87	1.90	1.58	1.36	2.03	1.90	1.55	1.68	1.38	1.60	2.14	1.55	1.54	1.87	1.90	1.88	1.74
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		<1	7	7	6	7	7	6	7	7	23	6	5	<5	5	7	15	5	6	<1.0	6.0	6	<5
Calculated TDS	mg/L	1	--	--	--		128	130	123	110	117	116	115	88	82	111	113	91	106	78	100	122	106	100	110	119	103	105
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		2.12	2.16	1.99	1.69	1.97	1.98	1.92	1.23	1.32	1.77	1.98	1.60	2.00	1.24	1.89	2.07	2.23	2.00	1.89	2.27	1.55	1.83
Hardness (CaCO3)	mg/L	N/A	--	--	--		22	23	22	22	25	26	23	15	18	18.4	22.2	20.3	21.6	16.9	22.3	21.7	24.7	21.1	20	24.4	16.7	19.6
Ion Balance (% Difference)	%	N/A	--	--	--		0.24	0.23	2.21	5.85	1.03	2.86	0.52	12.50	1.49	6.8	2.1	1.6	8.6	5.5	8.3	1.5	17.9	12.8	0.53	9.0	9.8	2.6
Langelier Index (@ 20C)	N/A	N/A	--	--	--		NC	-3.00	-2.89	-2.92	-2.60	-2.73	-3.23	-3.33	-3.35	-2.77	-2.88	-3.21	-3.37	-3.19	-3.05	-2.93	-3.12	-3.39	NC	-3.00	-3.15	-3.41
Langelier Index (@ 4C)	N/A	N/A	--	--	--		NC	-3.25	-3.14	-3.17	-2.85	-2.99	-3.49	-3.58	-3.60	-3.09	-3.20	-3.53	-3.69	-3.51	-3.37	-3.25	-3.44	-3.71	NC	-3.32	-3.47	-3.73
Saturation pH (@ 20C)	N/A	N/A	--	--	--		NC	9.67	9.71	9.74	9.59	9.60	9.75	9.83	9.73	9.47	9.98	10.10	10.0	10.2	9.91	9.61	9.99	9.98	NC	9.92	10.1	10.1
Saturation pH (@ 4C)	N/A	N/A	--	--	--		NC	9.92	9.96	9.99	9.84	9.86	10.00	10.10	9.98	9.79	10.3	10.4	10.4	10.5	10.2	9.93	10.3	10.3	NC	10.2	10.4	10.4
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		**259**	**259**	--	**124**	53.5	--	**266**	--	--	**199**	54	**153**	**140**	65	100	**260**	52	**105**	**180**	--	90	**163**
Total Antimony (Sb)	µg/L	2	20	--	--		<2	<2	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	<2	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Barium (Ba)	µg/L	5	1000	--	--		13	13	--	15.7	13.2	--	19.1	--	--	18	17	15	19	9	18	17	17	16	19	--	19	15
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	<2	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	<2	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		9	9	--	7.8	8.7	--	<50	--	--	5	9	17	7	7	10	8	10	12	<50	--	<5	8
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		0.019	0.019	--	**0.030**	<0.017	--	**0.046**	--	--	**0.019**	**0.021**	**0.027**	**0.028**	<0.017	<0.017	**0.038**	<0.017	0.017	**0.033**	--	<0.017	**0.021**
Total Chromium (Cr)	µg/L	1	---	--	1		<1	<1	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	**7**	<1	<1	<1.0	--	<1	<1
Total Cobalt (Co)	µg/L	1	10	--	--		<1	<1	--	<0.40	<0.40	--	<0.40	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	<1
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2	2	--	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2	<2	<2	<2	<1	1	1	<1	2	<2.0	1.0	<1	2
Total Iron (Fe)	µg/L	50	300	--	300		**523**	**523**	--	73	133	58	136	104	154	137	136	119	131	71	172	137	96	118	120	165	115	112
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	<0.5	--	0.60	<0.50	--	<0.50	--	--	<0.5	<0.5	0.7	<0.5	<0.5	0.9	3.6	<0.5	<0.5	<0.50	--	<0.5	<0.5
Total Manganese (Mn)	µg/L	2	820	--	--		53	53	--	36.8	67.1	32.1	41.5	33.1	32.5	25	47	46	37	20	92	41	45	27	36	48	24	31
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	<2	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	<2	--	2.0	<2.0	--	2.3	--	--	<2	<2	<2	<2	<2	<2	2	<2	<2	<2.0	--	<2	2
Total Selenium (Se)	µg/L	1	1.0	--	1		<1	<1	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	--	<1	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.1	<0.1	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		12	12	--	33.5	35.9	--	33.2	--	--	25	33	29	33	18	32	31	32	29	29	--	21	28
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	<0.1	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		<2	<2	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		2	2	--	<2.0	<2.0	--	4.9	--	--	<2	<2	<2	<2	<2	2	3	<2	2	2.7	--	<2	<2
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	<0.1	--	<0.10	<0.10	--	0.11	--	--	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	--	0.1	<0.1
Total Vanadium (V)	µg/L	2	6	--	--		<2	<2	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Zinc (Zn)	µg/L	5	30	--	30		<5	<5	--	9.7	6.9	6.4	9.3	6.6	9.2	<5	<5	8	10	5	7	10	<5	6	8.7	7	8	8
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		120	24	--	190	16	58	72	110	--	291	1553	178	345	2420	1300	86	1730	>2420	---	2420	285	548
E. coli	MPN/100mL	1	--	400	--		1	17	--	2	<1	8	5	37	<100	2	<1	3	8	21	<1	<1	<1	13	<0.10	7	6	2
Fecal Coliform	MPN/ml	--	--	400	--		--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		1.04	1.11	1.18	1.30	1.14	0.51	0.78	1.26	1.24	0.52	1.3	0.81	1.44	2.00	0.65	0.76	0.59	1.23	0.72	1.27	1.34	1.63
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.94	0.97	1.21	1.09	1.19	0.42	0.67	0.98	1.01	0.55	1.2	1.14	1.62	2.30	0.61	0.69	0.51	1.12	0.68	1.34	0.69	2.00

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009) (Referenced)
Nova Scotia Environment Environmental Quality Standards for Surface Water (Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2
Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water
Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Applied)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Kearney Lake																					
Sample Sites							KL4																					
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/14	2012/10/10	2013/05/15	2013/08/16	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					10:00	11:30	10:00	11:20	13:50	11:15	10:10	11:40	11:40	10:16	12:00	11:40	9:41	10:30	14:20	11:15	11:35	14:35	10:25	11:02	11:15	11:30
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		13.4	21.9	17.3	14.5	21.9	9.8	10.1	21.2	15.3	9.0	24.4	15.7	11.7	20.4	13.5	11.0	21.8	12.5	14.75	24.7	9.5	12.23
Dissolved Oxygen	mg/L	0.01	--	--	5.5 - 9.5		**10.87**	8.10	8.30	9.01	6.27	**10.89**	**10.99**	**8.55**	**9.65**	8.70	7.32	8.87	**10.09**	8.89	**9.60**	**14.50**	5.92	7.52	**9.81**	9.09	8.8	8.27
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		8.00	6.71	6.94	7.19	6.98	6.07	6.49	6.43	6.02	9.0	6.71	6.77	5.72	7.08	6.41	6.30	7.25	6.55	6.64	6.81	7.09	7.32
Specific Conductance	uS/cm	1	--	--	--		771	262	247	224	226	215	218	172	126	206	225	185.9	207.1	196.2	209.0	273.0	251.0	208.0	0.188	243.5	232.4	215
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		5	7	7	6	8	7	5	8	7	22	8	<5	<5	<5	<5	30	5	29	<5.0	6	7	<5
Dissolved Chloride (Cl)	mg/L	1	--	--	120		67	65	60	56	56	53	56	44	37	51	57	46	54	41	47	59	47	48	61	56	55	54
Colour	TCU	5	--	--	--		22	18	20	27	11	20	32	38	43	48	11	20	17	21	20	13	11	28	33	10	12	25
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.15	0.12	0.14	0.23	0.19	0.21	0.23	0.15	0.17	0.19	0.11	0.09	0.20	0.11	0.17	0.25	0.17	0.16	0.16	0.14	0.21	0.15
Nitrate (N)	mg/L	0.05	--	--	13000		0.15	--	--	0.23	0.19	--	0.23	--	--	0.19	0.11	0.09	0.20	0.11	0.17	0.25	0.17	0.16	0.16	0.14	0.21	0.15
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	0.05	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.1	<0.03	0.04	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	0.5	<0.4	0.7	--	1.8	1.1	<0.4	<0.4	<0.4	0.21	0.4	1.0	<0.4
Total Organic Carbon	mg/L	0.5	--	--	--		2.5	2.6	4.0	3.3	2.6	3.1	3.7	6	5.4	7.5	3.2	4.8	4.2	4.5	4.3	4.4	2.1	4.4	2.8	5.2	5.7	4.3
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01
pH (Lab)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.61	6.75	6.83	6.83	6.93	6.83	6.57	6.57	**6.46**	6.7	7.0	6.9	6.69	6.96	6.85	6.69	6.91	6.85	6.59	6.94	6.97	6.70
Total Calcium (Ca)	mg/L	0.1	--	--	--		6.8	7.7	7.0	6.81	8.00	8.45	6.84	4.93	5.24	5.7	6.8	5.8	6.8	5.1	6.8	6.4	7.9	6.8	6500	7.9	3.7	6.5
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.2	1.3	1.2	1.22	1.24	1.31	1.19	0.86	0.99	1.0	1.2	1.2	1.0	0.8	1.2	1.3	1.2	1.0	920	1.3	1.0	1.0
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**<0.02**	**<0.02**	<0.002	0.004	<0.002	<0.002	0.007	0.003	**0.026**	**0.022**	**0.043**	0.007	0.006	**2.39**	**0.016**	**0.022**	**0.031**	**0.015**	0.006	0.007	0.003	0.007
Total Potassium (K)	mg/L	0.1	--	--	--		1	1	1	0.807	0.905	0.968	0.826	0.733	1.130	0.7	1.0	0.9	0.8	0.6	1.2	0.8	1.1	0.9	760	0.9	0.7	0.7
Total Sodium (Na)	mg/L	0.1	--	--	--		39	41	37	28.5	34.3	33.9	32.1	21.5	21.1	31.5	34.5	25.2	31.6	20.1	30.7	35.9	38.6	34.1	34	40.0	28.2	32.4
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.7	2.6	2.6	3.1	2.9	3.1	2.9	2.5	2.7	2.7	2.2	2.6	3.0	2.6	2.5	2.6	2.1	2.5	2.5	2.6	3.0	2.6
Total Suspended Solids	mg/L	5	--	--	--		<1	1	<1	<2	<2	<1	2	<1	<2	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1.0	7.0	<5	7
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		11	12	11	10	10	10	9	10	8	7	8	7	7	7	9	9	8	8	7.7	9.0	8	10
Turbidity (NTU)	NTU	0.1	--	50	--		0.5	1.0	0.3	0.3	0.2	0.8	0.7	0.7	0.4	0.7	0.4	0.8	0.7	2.6	2.1	1.1	0.6	0.8	0.61	0.7	1.2	1.2
Conductivity (uS/cm)	µS/cm	1	--	--	--		260	250	230	220	230	250	210	170	160	200	224	183	218	218	204	219	241	218	220	241	235	206
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		2.23	2.22	2.09	1.91	1.94	1.85	1.88	1.62	1.36	2.04	1.94	1.45	1.68	1.31	1.53	2.47	1.60	2.11	1.88	1.90	1.87	1.74
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		5	7	7	6	8	7	5	8	7	22	8	<5	<5	<5	<5	30	5	29	<1.0	6.0	7	<5
Calculated TDS	mg/L	1	--	--	--		132	135	125	111	118	116	113	90	81	111	114	87	103	75	97	132	108	117	110	121	102	106
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		2.16	2.32	2.07	1.70	2.02	2.03	1.86	1.28	1.3	1.78	1.97	1.53	1.84	1.23	1.84	2.04	2.21	1.94	1.91	2.35	1.53	1.86
Hardness (CaCO3)	mg/L	N/A	--	--	--		22	25	22	22	25	27	22	16	17	18.4	21.9	19.4	21.1	16.0	21.9	21.3	24.7	21.1	20	25.1	13.4	20.3
Ion Balance (% Difference)	%	N/A	--	--	--		1.59	2.20	0.48	5.82	2.02	4.64	0.53	11.70	2.26	6.6	0.8	2.8	4.5	3.2	9.2	9.5	15.8	4.2	0.79	10.7	10.1	3.4
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-3.21	-2.89	-2.84	-2.92	-2.64	-2.75	-3.22	-3.18	-3.31	-2.79	-2.86	-3.22	-3.37	-3.21	-3.21	-2.63	-3.08	-2.45	NC	-2.98	-3.20	-3.38
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.46	-3.14	-3.09	-3.17	-2.89	-3.00	-3.47	-3.43	-3.56	-3.11	-3.18	-3.54	-3.69	-3.53	-3.53	-2.95	-3.40	-2.77	NC	-3.30	-3.52	-3.70
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.82	9.64	9.67	9.75	9.57	9.58	9.79	9.75	9.77	9.49	9.86	10.10	10.1	10.2	10.1	9.32	9.99	9.30	NC	9.92	10.2	10.1
Saturation pH (@ 4C)	N/A	N/A	--	--	--		10.1	9.9	9.9	10.0	9.8	9.8	10.0	10.0	10.0	9.8	10.2	10.4	10.4	10.5	10.4	9.64	10.3	9.62	NC	10.2	10.5	10.4
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		**150**	--	--	**125**	29.2	--	**231**	--	--	**188**	48	**149**	**141**	**106**	**159**	**236**	46	93	**160**	--	84	**172**
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Barium (Ba)	µg/L	5	1000	--	--		16	--	--	16.6	17.8	--	18.2	--	--	18	17	16	18	10	19	17	19	16	20	--	17	16
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		6	--	--	8.6	9.1	--	<50	--	--	6	9	16	7	6	9	8	11	11	<50	--	<5	7
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	**0.031**	<0.017	--	**0.035**	--	--	**0.021**	<0.017	**0.027**	**0.027**	0.017	**0.050**	**0.027**	<0.017	<0.017	**0.033**	--	<0.017	**0.024**
Total Chromium (Cr)	µg/L	1	---	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	6	<1	<1	<1	**6**	<1	<1	<1.0	--	<1	<1
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	<0.40	<0.40	--	<0.40	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	<1
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2	--	--	<2.0	2.4	<2.0	2.3	<2.0	<2.0	<2	<2	4	**9**	<1	1	<1	<1	2	**6.8**	1	1	1
Total Iron (Fe)	µg/L	50	300	--	300		86	--	--	82	51	55	119	109	138	129	118	133	213	144	248	129	55	104	100	217	83	122
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	--	--	3.23	<0.50	--	<0.50	--	--	<0.5	<0.5	0.8	0.9	<0.5	<0.5	2.6	<0.5	<0.5	<0.50	--	<0.5	<0.5
Total Manganese (Mn)	µg/L	2	820	--	--		51	--	--	34.5	63.5	29.4	38.5	27.2	29.7	23	34	38	34	77	130	34	29	24	25	78	34	34
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		3	--	--	2.0	<2.0	--	<2.0	--	--	<2	<2	5	<2	<2	<2	<2	<2	<2	<2.0	--	<2	2
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	--	**3**	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		34	--	--	33.1	36.7	--	32.7	--	--	25	32	28	32	17	31	31	31	29	30	--	20	28
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	5	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	4.2	--	--	<2	<2	<2	<2	<2	3	2	<2	<2	<2.0	--	<2	<2
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	0.1	--	--	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	0.1
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Zinc (Zn)	µg/L	5	30	--	30		14	--	--	10.4	6.9	7	11.3	7.4	7	<5	<5	**68**	21	<5	9	9	<5	<5	9.6	8	12	7
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		28	58	--	100	16	75	83	95	--	345	>2420	921	548	>2420	770	308	1550	>2420	---	>2420	281	488
E. coli	MPN/100mL	1	--	400	--		4	33	--	1	<1	2	5	39	<100	4	<1	4	6	38	<1	<1	1	8	<10	5	1	2
Fecal Coliform	MPN/ml	--	--	400	--		--	--	<1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.78	1.11	1.06	0.92	0.07	0.50	0.60	1.04	1.31	0.52	0.7	0.55	1.34	1.50	0.40	0.44	0.50	1.03	0.55	0.26	1.09	1.62
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.69	0.96	1.11	0.77	0.07	0.41	0.55	0.82	1.07	0.55	0.7	0.74	1.48	1.70	0.39	0.40	0.57	0.95	0.51	0.31	0.55	2.09

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009) (Referenced)
Nova Scotia Environment Environmental Quality Standards for Surface Water (Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water
Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Applied)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Kearney Lake													
Sample Sites							KL5													
Sampling Date	yyyy-mm-dd	--					2011/10/17	2012/05/01	2012/08/14	2012/10/10	2013/05/15	2013/08/16	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					9:40	10:52	13:10	12:10	10:03	10:50	13:45	11:30	13:55	10:45	09:00	12:04	12:00	10:00
FIELD DATA																				
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	2.74	2.1
Water Temp	Celsius	0.1	--	--	--		14.7	10.5	26.1	16.6	13.3	22.7	14.7	13.7	22.9	12.8	14.06	25.4	9.4	12.22
Dissolved Oxygen	mg/L	0.01	--	--	5.5 - 9.5		9.38	7.88	7.90	8.16	**9.67**	8.89	8.60	**15.83**	7.64	7.91	8.32	8.75	7.63	**10.47**
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.52	7.76	6.69	6.72	6.20	8.57	6.51	6.79	7.86	6.60	7.82	6.77	7.05	**5.75**
Specific Conductance	uS/cm	1	--	--	--		112	230	229	189.0	219.5	202.1	212.9	472.0	251.0	211.0	0.184	249.8	240.8	209
INORGANICS																				
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		9	21	8	<5	<5	6	5	32	<5	<5	5.4	6	7	<5
Dissolved Chloride (Cl)	mg/L	1	--	--	120		37	55	57	48	58	44	46	61	47	47	59	58	58	54
Colour	TCU	5	--	--	--		35	43	10	27	10	22	18	14	11	22	35	8	19	27
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.17	0.19	0.15	0.83	0.21	0.21	0.25	0.16	0.10	0.16	0.16	0.12	0.19	0.14
Nitrate (N)	mg/L	0.05	--	--	13000		--	0.19	0.15	0.83	0.21	0.21	0.20	0.16	0.10	0.16	0.16	0.12	0.19	0.14
Nitrite (N)	mg/L	0.05	--	--	60		--	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	<0.03	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.06	<0.050	<0.03	0.04	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	<0.4	2.3	1.0	--	0.6	1.1	<0.4	0.5	1.1	0.31	<0.4	1.8	0.5
Total Organic Carbon	mg/L	0.5	--	--	--		4.8	5.8	3.4	4.7	4.0	4.6	7.0	4.3	2.7	4.5	3.1	5.3	5.7	4.4
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01
pH (Lab)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.57	6.7	7.1	6.5	6.71	6.93	6.89	6.64	6.84	6.63	6.56	6.90	6.94	6.66
Total Calcium (Ca)	mg/L	0.1	--	--	--		5.79	6.1	6.6	5.9	7.1	5.7	6.4	6.5	7.6	7.0	6500	8.0	4.7	6.3
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.05	1.0	1.1	1.2	1.0	1.0	1.1	1.4	1.2	1.0	930	1.3	0.9	1.0
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	0.009	**0.018**	**0.040**	0.006	0.005	**0.013**	**0.010**	**0.010**	**0.026**	**0.14**	0.005	0.005	0.005	0.004
Total Potassium (K)	mg/L	0.1	--	--	--		0.858	0.7	0.9	0.8	0.8	0.7	1.1	0.8	1.1	0.9	720	0.09	0.7	0.7
Total Sodium (Na)	mg/L	0.1	--	--	--		22.0	34.6	32.0	27.7	33.6	19.2	31.3	37.5	40.3	38.3	33	42.6	28.3	32.5
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.5	2.7	2.0	2.4	2.7	2.5	2.5	2.7	2.1	2.5	3.3	1.9	2.2	2.7
Total Suspended Solids	mg/L	5	--	--	--		1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<1.0	<5	<5	<5
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		9	7	8	8	8	7	8	9	8	8	8	9	8	10
Turbidity (NTU)	NTU	0.1	--	50	--		0.9	1.1	0.7	0.9	0.7	0.8	0.4	1.1	0.4	0.8	0.71	1.0	1.0	0.7
Conductivity (uS/cm)	µS/cm	1	--	--	--		160	215	226	189	232	223	204	228	246	225	220	248	244	208
Calculated Parameters																				
Anion Sum	me/L	N/A	--	--	--		1.42	2.13	1.95	1.58	1.82	1.52	1.58	2.56	1.50	1.50	1.94	1.95	1.96	1.74
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		9	21	8	<5	<5	6	5	32	<5	<5	5.4	6	7	<5
Calculated TDS	mg/L	1	--	--	--		84	118	111	96	110	82	98	136	106	103	120	124	106	105
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		1.36	1.94	1.85	1.64	1.94	1.23	1.81	2.12	2.27	2.14	1.87	2.40	1.58	1.86
Hardness (CaCO3)	mg/L	N/A	--	--	--		19	19.3	21.0	19.7	21.8	18.4	20.5	22.0	23.9	21.6	20.0	25.3	15.4	19.8
Ion Balance (% Difference)	%	N/A	--	--	--		2.16	4.7	2.6	2.0	3.2	10.6	6.7	9.4	20.3	17.5	1.8	10.2	10.8	3.2
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-3.06	-2.79	-2.77	-3.62	-3.33	-3.11	-3.19	-2.64	-3.17	-3.42	-3.24	-3.20	-3.13	-3.43
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.31	-3.11	-3.09	-3.94	-3.65	-3.43	-3.51	-2.96	-3.49	-3.74	-3.50	-3.34	-3.45	-3.75
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.63	9.49	9.87	10.1	10.0	10.0	10.1	9.28	10.0	10.0	9.8	9.9	10.1	10.1
Saturation pH (@ 4C)	N/A	N/A	--	--	--		9.88	9.81	10.2	10.4	10.4	10.4	10.4	9.60	10.3	10.4	10.1	10.2	10.4	10.4
Metals (ICP-MS)																				
Total Aluminum (Al)	µg/L	5	5	--	5-100		--	**222**	52	**154**	**136**	58	61	**224**	53	**108**	**180**	---	79	**<u>163</u>**
Total Antimony (Sb)	µg/L	2	20	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	---	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	---	<2	<2
Total Barium (Ba)	µg/L	5	1000	--	--		--	18	16	15	19	9	16	16	17	17	17	---	19	14
Total Beryllium (Be)	µg/L	2	5.3	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	---	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	---	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		--	6	9	15	7	7	9	7	6	10	<50	---	<5	7
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		--	**0.022**	**0.027**	**0.029**	**0.024**	<0.017	**0.034**	**0.036**	<0.017	**0.024**	**0.035**	---	**0.332**	**<u>0.024</u>**
Total Chromium (Cr)	µg/L	1	---	--	1		--	<1	<1	5	<1	<1	<1	**6**	<1	<1	<1.0	---	**7**	<1
Total Cobalt (Co)	µg/L	1	10	--	--		--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.40	---	<1	<1
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2.0	<2	<2	<2	<2	<1	1	<1	<1	5	<2.0	1	<1	<1
Total Iron (Fe)	µg/L	50	300	--	300		175	160	78	120	111	70	79	111	<50	119	100	123	158	96
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		--	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	1.9	<0.5	0.5	<0.5	---	<0.5	<0.5
Total Manganese (Mn)	µg/L	2	820	--	--		35.9	30	14	37	35	13	12	40	18	25	34	24	35	23
Total Molybdenum (Mo)	µg/L	2	73	--	73		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	---	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		--	<2	<2	5	<2	<2	<2	2	<2	<2	<2.0	---	3	3
Total Selenium (Se)	µg/L	1	1.0	--	1		--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	---	<1	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	---	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		--	27	31	29	31	18	31	31	30	30	29	---	23	28
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	---	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	---	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		--	3	<2	<2	<2	<2	<2	<2	<2	2	2.3	---	<2	<2
Total Uranium (U)	µg/L	0.1	300	--	15		--	0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	---	0.1	0.1
Total Vanadium (V)	µg/L	2	6	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	---	<2	<2
Total Zinc (Zn)	µg/L	5	30	--	30		9.3	5	<5	**64**	11	7	5	10	<5	10	14	6	12	10
MICROBIOLOGICAL																				
Total Coliform	MPN/100mL	1	--	--	--		--	461	613	93	461	308	461	42	629	>2470	---	356	163	179
E. coli	MPN/100mL	1	--	400	--		100	14	2	6	6	6	4	<1	1	17	<10	1	2	<1
Fecal Coliform	MPN/ml	--	--	400	--		--	--	--	--	--	--	--	--	--	--	---	---	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.91	0.30	1.2	1.09	1.44	2.20	0.64	0.20	0.61	0.9	0.48	1.22	2.71	1.52
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.85	0.33	1.0	1.41	1.59	2.40	0.62	0.20	0.54	0.84	---	1.26	1.44	1.86

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009) (Referenced)
Nova Scotia Environment Environmental Quality Standards for Surface Water (Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
<u>Underlined (black shaded)</u>	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded	= Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Highway 102									
Sample Sites							HWY102-1									
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01
Sampling Time	hh:mm	--					07:00	12:45	08:00	13:00	10:20	09:00	13:40	11:00	11:00	14:50
FIELD DATA																
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		11.8	18.8	15.7	14.9	19.6	7.4	11.4	17.8	14.6	10.7
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		11.44	5.80	4.34	8.18	4.25	6.05	8.15	3.88	5.34	5.65
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		7.98	5.35	5.25	6.31	5.26	5.62	5.75	5.77	5.99	8.76
Specific Conductance	uS/cm	1	--	--	--		194	153	104	135	106	109	114	108	89	288
INORGANICS																
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		<5	<5	<5	<5	<5	<5	5	11	8	22
Dissolved Chloride (Cl)	mg/L	1	--	--	120		24	38	24	32	25	22	24	19	12	58
Colour	TCU	5	--	--	--		67	68	57	37	89	53	39	65	79	24
Nitrite + Nitrate	mg/L	0.05	--	--	--		<0.05	<0.05	<0.05	0.69	<0.05	1.2	0.69	0.25	1.2	2.61
Nitrate (N)	mg/L	0.05	--	--	13000		<0.05	--	--	0.69	<0.05	--	0.69	--	--	2.61
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.29	<0.05	<0.05	<0.05	<0.05	0.05	0.1	0.07	0.31
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	1.1
Total Organic Carbon	mg/L	0.5	--	--	--		6.5	10	7.7	4.7	11	6.3	4.5	7.2	7.4	5.5
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		4.54	5.24	5.40	5.48	6.24	5.31	6.42	6.55	6.28	6.4
Total Calcium (Ca)	mg/L	0.1	--	--	--		1.7	1.8	1.6	4.93	3.34	5.09	4.9	5.21	5.55	12.5
Total Magnesium (Mg)	mg/L	0.1	--	--	--		0.3	0.5	0.5	1.08	0.79	1.09	0.91	0.92	1.19	1.7
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	**0.01**	0.07	0.14	0.020	0.006	0.007	0.011	0.009	0.012	0.010	0.019
Total Potassium (K)	mg/L	0.1	--	--	--		0.5	1.2	0.7	1.140	1.630	1.310	1.100	1.500	1.880	1.6
Total Sodium (Na)	mg/L	0.1	--	--	--		15	25	13	15.9	14.5	14.6	14.8	10.2	8.26	36.3
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.5	2.2	2.0	1.1	3.8	5.1	2.8	5.2	4.6	4.1
Total Suspended Solids	mg/L	5	--	--	--		7	80	2	<2	11	<2	<1	1	<1	9
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		5	3	3	8	<2	8	10	8	10	14
Turbidity (NTU)	NTU	0.1	--	50	--		14.0	35	0.9	1.4	1.2	0.6	0.4	0.6	1.1	0.9
Conductivity (uS/cm)	µS/cm	1	--	--	--		100	140	92	130	100	110	110	100	88	263
Calculated Parameters																
Anion Sum	me/L	N/A	--	--	--		0.77	1.12	0.73	1.11	0.71	0.88	1.03	0.95	0.80	2.55
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		<1	<1	<1	<1	<1	<1	5	11	8	22
Calculated TDS	mg/L	1	--	--	--		50	73	45	67	50	63	65	58	54	150
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10
Cation Sum	me/L	N/A	--	--	--		0.84	1.32	0.74	1.06	0.93	1.02	1.00	0.83	0.80	2.43
Hardness (CaCO3)	mg/L	N/A	--	--	--		6	6	6	17	12	17	16	17	19	38.2
Ion Balance (% Difference)	%	N/A	--	--	--		4.35	8.20	0.68	2.30	13.40	7.37	1.48	6.74	0.00	2.6
Langelier Index (@ 20C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	-3.50	-2.99	-3.36	-2.77
Langelier Index (@ 4C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	-3.75	-3.25	-3.61	-3.09
Saturation pH (@ 20C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	9.92	9.54	9.64	9.17
Saturation pH (@ 4C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	10.20	9.80	9.89	9.49
Metals (ICP-MS)																
Total Aluminum (Al)	µg/L	5	5	--	5-100		510	--	--	169	192	--	205	--	--	134
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2
Total Barium (Ba)	µg/L	5	1000	--	--		22	--	--	52.9	36.9	--	37.3	--	--	58
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2
Total Boron (B)	µg/L	5	1200	--	1500		<5	--	--	11.4	10.9	--	<50	--	--	12
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	0.043	<0.017	--	0.023	--	--	0.034
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	0.50	0.46	--	<0.40	--	--	<1
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2	--	--	3.4	<2.0	<2.0	<2.0	<2.0	<2.0	<2
Total Iron (Fe)	µg/L	50	300	--	300		720	--	--	146	637	150	107	209	219	102
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		1.6	--	--	2.37	0.56	--	<0.50	--	--	<0.5
Total Manganese (Mn)	µg/L	2	820	--	--		40	--	--	55.3	39.0	67.0	28.1	21.0	31.3	34
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		11	--	--	29.1	19.7	--	24.3	--	--	48
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2
Total Titanium (Ti)	µg/L	2	--	--	--		6	--	--	<2.0	<2.0	--	3.5	--	--	<2
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2
Total Zinc (Zn)	µg/L	5	30	--	30		21	--	--	16.4	6.9	6.9	<5.0	<5.0	6.9	<5
MICROBIOLOGICAL																
Total Coliform	MPN/100mL	1	--	--	--		84	>250	--	>250	>250	180	120	180	--	687
E. coli	MPN/100mL	1	--	400	--		54	>250	--	12	17	5	1	78	<100	3
Fecal Coliform	MPN/ml	--	--	400	--		--	--	<1	--	--	--	--	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		15.40	19.29	0.70	18.12	1.61	8.45	0.93	0.58	0.69	0.53
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		17.50	19.60	0.84	17.62	1.68	7.52	0.84	0.56	0.65	0.59

Spring 2016	Highway 102											
Sample Sites	HWY102-1											
Sampling Date	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	11:00	9:50	14:15	12:22	12:30	12:00	10:10	9:30	13:15	09:20	9:40	14:30
FIELD DATA												
Secchi Depth	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Temp	21.8	13.6	11.7	19.5	8.9	12.1	19.6	10.2	14.29	20.70	5.40	13.42
Dissolved Oxygen	1.03	3.83	7.55	3.32	3.10	12.03	2.09	4.54	4.27	3.82	5.03	8.18
pH (in Situ)	5.73	6.38	6.19	7.10	6.79	6.02	6.63	5.12	6.35	6.24	6.92	7.34
Specific Conductance	225	155.5	226	173.2	234.0	880.0	337	109	0.393	335.8	251.2	289
INORGANICS												
Total Alkalinity (as CaCO3)	25	15	9	23	20	31	28	30	16	21	12	14
Dissolved Chloride (Cl)	48	28	53	31	40	65	57	19	130	67	49	71
Colour	65	40	9	65	25	11	31	93	22	27	29	23
Nitrite + Nitrate	0.06	0.43	0.51	<0.05	<0.05	<0.05	<0.05	0.53	<0.050	<0.05	0.17	0.05
Nitrate (N)	0.06	0.43	0.51	<0.05	<0.05	<0.05	<0.05	0.53	<0.050	<0.05	0.17	0.05
Nitrite (N)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	0.19	0.04	<0.03	0.05	0.06	<0.03	0.04	0.03	<0.050	<0.03	0.04	0.06
Total Kjeldahl Nitrogen as N	1.3	0.6	--	0.6	0.6	0.7	0.6	<0.4	0.34	0.50	0.6	0.7
Total Organic Carbon	10.0	7.0	5.1	10.1	17.7	4.1	7.7	9.0	2.7	14.6	8.4	4.5
Orthophosphate (as P)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01
pH (units)	6.9	6.8	6.86	6.87	6.73	6.56	7.49	5.90	6.61	7.46	6.80	6.87
Total Calcium (Ca)	11.7	7.5	11.1	10.5	13.9	7.2	23.3	2.2	18000	18.0	12.4	12.9
Total Magnesium (Mg)	2.0	1.4	1.4	1.5	2.3	1.6	3.2	0.6	2400	2.7	2.3	1.7
Total Phosphorus (1M depth)	0.039	0.02	0.006	0.021	0.022	0.013	0.038	0.03	0.007	0.020	0.002	0.005
Total Potassium (K)	2.5	1.5	1.3	1.7	2.4	1.2	2.5	0.7	2000	2.1	1.5	1.4
Total Sodium (Na)	27.7	14.6	30.8	15.0	20.5	39.1	38.7	18.6	64	37.7	28.8	45.4
Reactive Silica (SiO2)	6.1	5.1	3.1	5.1	5.8	1.7	7.1	4.7	2.1	4.9	4.8	1.4
Total Suspended Solids	6	<5	<5	<5	<5	6	<5	<5	<1.0	<5	<5	<5
Dissolved Sulphate (SO4)	8	9	12	8	12	10	7	6	13	9	14	14
Turbidity (NTU)	1.9	0.9	0.5	1.6	0.5	0.7	1.6	0.9	0.59	0.9	0.8	1.0
Conductivity (uS/cm)	231	143	243	188	218	252	338	112	470	324	244	289
Calculated Parameters												
Anion Sum	2.02	1.31	1.96	1.50	1.78	2.66	2.31	1.30	4.20	2.50	1.93	2.58
Bicarb. Alkalinity (calc. as CaCO3)	25	15	9	23	20	31	28	30	16	21	12	14
Calculated TDS	117	73	117	83	104	143	150	68	240	151	116	155
Carb. Alkalinity (calc. as CaCO3)	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10
Cation Sum	6.04	1.19	2.06	1.40	1.87	2.25	3.22	1.04	3.94	2.88	2.11	2.81
Hardness (CaCO3)	37.5	24.5	33.5	32.4	44.2	24.6	71.4	8.0	55.0	56.1	40.4	39.2
Ion Balance (% Difference)	1.9	4.6	2.4	3.5	2.6	8.4	16.4	11.2	3.19	7.1	4.7	4.4
Langelier Index (@ 20C)	-2.23	-2.72	-2.73	-2.33	-2.41	-2.69	-1.30	-3.85	-2.32	-1.57	-2.62	-2.48
Langelier Index (@ 4C)	-2.55	-3.04	-3.05	-2.65	-2.73	-3.01	-1.62	-4.17	-2.57	-1.89	-2.94	-2.80
Saturation pH (@ 20C)	9.13	9.52	9.59	9.20	9.14	9.25	8.79	9.75	8.93	9.03	9.42	9.35
Saturation pH (@ 4C)	9.45	9.84	9.91	9.52	9.46	9.57	9.11	10.1	9.18	9.35	9.74	9.67
Metals (ICP-MS)												
Total Aluminum (Al)	183	146	86	145	150	187	83	310	51	--	52	81
Total Antimony (Sb)	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Arsenic (As)	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Barium (Ba)	284	42	57	57	80	46	142	17	130	--	86	79
Total Beryllium (Be)	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Boron (B)	18	13	10	10	11	9	14	11	<50	--	<5	10
Total Cadmium (Cd)	0.021	<0.017	<0.017	<0.017	0.040	0.022	<0.017	0.022	0.024	--	<0.017	<0.017
Total Chromium (Cr)	<1	<1	<1	<1	<1	8	<1	<1	<1.0	--	<1	<1
Total Cobalt (Co)	<1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	<1
Total Copper (Cu)	<2	3	<2	<1	2	<1	<1	2	<2.0	<1	1	<1
Total Iron (Fe)	1380	255	111	938	446	147	820	290	140	1280	138	144
Total Lead (Pb)	0.7	<0.5	<0.5	<0.5	0.6	2.6	<0.5	0.6	<0.50	--	<0.5	<0.5
Total Manganese (Mn)	79	28	23	45	31	56	122	61	28	95	22	19
Total Molybdenum (Mo)	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Nickel (Ni)	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Selenium (Se)	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	--	<1	<1
Total Silver (Ag)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	58	36	52	47	62	38	103	13	85	--	39	58
Total Thallium (Tl)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Titanium (Ti)	3	<2	<2	<2	4	2	<2	<2	<2.0	--	<2	<2
Total Uranium (U)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Vanadium (V)	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2
Total Zinc (Zn)	6	<5	<5	<5	10	10	<5	7	11	<5	<5	<5
MICROBIOLOGICAL												
Total Coliform	>2420	>2420	1550	>2420	1553	120	>2420	>2420	---	>2420	659	>2420
E. coli	68	145	4	9	5	3	179	3	20	25	2	<1
Fecal Coliform	--	--	--	--	--	--	--	--	---	--	--	--
Chlorophyll A - Acidification method	2.59	0.81	1.27	14.70	1.99	0.25	1.10	1.22	0.5	7.27	0.36	0.94
Chlorophyll A - Welschmeyer method	2.89	1.05	1.45	15.80	2.20	0.82	1.11	1.38	0.55	6.79	0.23	1.30

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Highway 102																					
Sample Sites							HWY102-2																					
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					12:30	12:15	12:30	12:40	09:30	12:30	11:20	15:00	15:30	11:20	12:20	10:35	10:40	10:00	10:22	12:15	14:25	10:07	11:00	12:58	14:30	12:50
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	N/A	NCC	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		16.7	19.2	16.4	17.2	17.0	8.7	10.8	24.2	15.1	7.8	23.7	14.3	11.5	22.0	10.7	11.4	--	10.4	12.7	23.7	9.3	13.41
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**10.01**	5.90	**4.80**	**4.91**	**2.45**	**2.99**	6.92	7.03	**5.09**	**3.73**	**13.1**	**3.28**	6.30	**1.57**	**4.20**	**10.50**	--	9.25	**4.24**	6.11	5.28	6.77
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.57	5.71	5.40	6.33	5.86	5.64	6.22	5.89	5.29	7.3	6.37	6.72	6.01	6.92	5.40	5.40	--	5.85	6.45	6.04	5.96	**5.86**
Specific Conductance	uS/cm	1	--	--	--		37	457	162	415	167	101.2	92.2	123.1	96	225	226	159.1	288	188.5	204.4	204.4	--	174	0.411	699	197.6	968
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		<5	<5	7	6	5	<5	<5	5	<5	17	7	<5	6	14	7	30	--	8	7.5	5	<5	13
Dissolved Chloride (Cl)	mg/L	1	--	--	120		21	82	83	**170**	41	18	21	21	17	63	109	45	71	50	52	113	--	34	**260**	**178**	78	236
Colour	TCU	5	--	--	--		120	190	91	96	160	68	65	98	77	32	100	70	11	61	36	13	--	85	17	9	8	14
Nitrite + Nitrate	mg/L	0.05	--	--	--		<0.05	<0.05	<0.05	0.10	<0.05	0.62	0.26	1.8	3.2	1.54	<0.05	0.14	0.17	<0.05	<0.05	<0.05	--	0.12	<0.050	<0.05	0.15	0.21
Nitrate (N)	mg/L	0.05	--	--	13000		<0.05	--	--	0.10	<0.05	--	0.26	--	--	1.54	<0.05	0.14	0.17	<0.05	<0.05	<0.05	--	0.12	<0.050	<0.05	0.15	<0.05
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.010	<0.05	<0.05	0.21
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.06	<0.05	<0.05	0.20	<0.05	<0.05	0.30	0.08	0.09	<0.03	<0.03	<0.03	0.17	0.09	<0.03	--	<0.03	0.056	0.19	0.05	0.14
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	0.6	1.1	0.5	--	0.7	2.0	15.3	--	<0.4	0.33	62.6	2.0	24.3
Total Organic Carbon	mg/L	0.5	--	--	--		8.5	13	13	7.2	14	7.4	5.7	9.2	8.4	7.0	15.8	11.2	6.1	10.6	5.1	17.4	--	8.0	3.0	29.0	9.9	79.3
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01	<0.010	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		**5.43**	**5.96**	**6.30**	**6.05**	**6.32**	**5.47**	**5.93**	**6.18**	**5.92**	**5.9**	6.7	6.8	6.61	6.59	**6.34**	7.20	--	**6.40**	**6.12**	6.64	**6.18**	6.46
Total Calcium (Ca)	mg/L	0.1	--	--	--		1.6	4.0	4.8	7.44	3.84	4.01	3.07	2.22	3.80	7.0	8.4	5.6	7.6	8.5	8.2	14.1	--	9.5	20000	33.3	9.8	23.9
Total Magnesium (Mg)	mg/L	0.1	--	--	--		0.4	0.7	0.9	0.96	0.59	1.00	0.68	0.68	1.38	1.2	1.4	1.2	1.2	1.3	2.2	3.1	--	1.8	2500	32.7	2.2	3.2
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	**0.01**	**<0.02**	**0.04**	**0.034**	**0.010**	**0.028**	0.003	0.009	**0.019**	**0.041**	**0.021**	**0.054**	**0.03**	**0.014**	**0.028**	**0.199**	**0.028**	--	**0.20**	**0.01**	**1.56**	**0.012**	**0.222**
Total Potassium (K)	mg/L	0.1	--	--	--		0.5	0.8	1.1	0.984	0.956	1.390	0.844	1.310	1.880	1.2	1.7	1.6	1.3	1.5	2.5	2.9	--	1.7	1900	12.5	1.1	4.0
Total Sodium (Na)	mg/L	0.1	--	--	--		15	51	55	83.7	32.0	12.1	13.3	13.1	13.3	41.5	63.6	20.4	39.0	19.1	34.5	69.6	--	24.0	150	124	36.8	149.0
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.2	4.4	4.0	3.0	6.4	5.4	2.5	6.5	6.7	4.1	6.9	5.8	1.6	6.2	6.6	1.6	--	5.9	2.3	7.2	5.6	2.8
Total Suspended Solids	mg/L	5	--	--	--		<2	58	62	34	27	3	<1	10	14	<5	39	<5	<5	<5	194	34	--	<5	2	3000	15	342
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		<2	3	8	11	<2	7	5	5	8	12	6	10	10	9	10	12	--	8	15	7	8	22
Turbidity (NTU)	NTU	0.1	--	50	--		0.7	3.8	4.2	2.6	3.1	0.5	0.4	1.2 (1)	3.9	0.6	10.8	2	1.5	3.3	**144**	1.1	--	1.1	1.2	**1490**	9.9	**131**
Conductivity (uS/cm)	µS/cm	1	--	--	--		85	290	310	590	160	94	91	100	110	263	403	179	295	203	223	433	--	194	920	662	315	817
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		0.60	2.37	2.62	5.13	1.27	0.70	0.73	0.91	0.86	2.48	3.34	1.49	2.34	1.88	1.81	4.04	--	1.29	7.88	5.27	2.38	7.39
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		<1	<1	7	6	5	<1	<1	5	<1	17	7	<5	6	14	7	30	--	8	7.5	5	<5	13
Calculated TDS	mg/L	1	--	--	--		42	150	165	282	93	52	48	62	67	143	200	86	135	100	145	235	--	85	460	712	138	473
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	--	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		0.81	2.65	2.89	4.17	1.81	0.86	0.82	0.83	0.97	2.32	2.10	1.40	2.24	1.50	3.50	4.17	--	1.76	7.87	29.1	2.35	9.27
Hardness (CaCO3)	mg/L	N/A	--	--	--		6	13	16	23	12	14	11	8	15	22.4	26.7	18.9	23.9	26.6	29.5	48.0	--	31.1	59.0	218	33.5	72.9
Ion Balance (% Difference)	%	N/A	--	--	--		14.90	5.58	4.90	10.30	17.50	10.30	5.81	4.60	6.01	3.3	3.6	3.1	2.3	11.3	31.7	1.6	--	15.1	0.0600	69.4	0.5	11.3
Langelier Index (@ 20C)	N/A	N/A	--	--	--		NC	NC	-3.57	-3.72	-3.70	NC	NC	-4.07	NC	-3.63	-3.15	-3.34	-3.33	-2.92	-3.50	-1.80	--	-3.30	-3.18	-2.81	-3.73	-2.70
Langelier Index (@ 4C)	N/A	N/A	--	--	--		NC	NC	-3.82	-3.97	-3.95	NC	NC	-4.32	NC	-3.95	-3.47	-3.66	-3.65	-3.24	-3.82	-2.12	--	-3.62	-3.42	-3.13	-4.05	-3.02
Saturation pH (@ 20C)	N/A	N/A	--	--	--		NC	NC	9.87	9.77	10.00	NC	NC	10.30	NC	9.53	9.85	10.10	9.94	9.51	9.84	9.00	--	9.70	9.29	9.45	9.91	9.16
Saturation pH (@ 4C)	N/A	N/A	--	--	--		NC	NC	10.10	10.00	10.30	NC	NC	10.50	NC	9.85	10.2	10.5	10.3	9.83	10.2	9.32	--	10.0	9.54	9.77	10.2	9.5
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		270	--	--	189	368	--	260	--	--	145	**466**	**259**	**130**	**138**	**2760**	**400**	--	**216**	**100**	--	**129**	**3880**
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	2.1	--	<1.0	--	--	<2	<2	<2	<2	<2	6	<2	--	<2	<1.0	--	<2	3
Total Barium (Ba)	µg/L	5	1000	--	--		20	--	--	53.1	27.7	--	26.6	--	--	49	74	33	44	43	213	381	--	63	140	--	147	762
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		<5	--	--	7.9	7.8	--	<50	--	--	10	17	15	9	10	13	11	--	12	<50	--	<5	9
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	0.051	<0.017	--	<0.017	--	--	0.037	**0.031**	**0.032**	**0.019**	<0.017	**0.096**	**0.051**	--	**0.019**	**0.100**	--	<0.017	**0.778**
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	1.0	--	<1.0	--	--	<1	<1	<1	<1	1	**9**	**2**	--	<1	<1.0	--	<1	**8**
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	0.66	0.77	--	<0.40	--	--	<1	1	1	<1	1	3	1	--	<1	1.8	--	3	4
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2	--	--	2.0	<2.0	<2.0	<2.0	2.5	2.8	<2	3	3	<2	1	**12**	4	--	2	<2.0	**404**	2	13
Total Iron (Fe)	µg/L	50	300	--	300		**880**	--	--	**1380**	**3850**	**303**	229	**897**	**1110**	214	**5210**	**1550**	**383**	**1720**	**28400**	**1660**	--	**485**	**960**	**217000**	**714**	**21300**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		1.9	--	--	1.61	2.70	--	0.59	--	--	<0.5	5.2	2.1	0.6	0.7	19.4	3.5	--	1.0	<0.50	--	0.6	**39.7**
Total Manganese (Mn)	µg/L	2	820	--	--		110	--	--	387	135	52.9	40.5	106	176	78	219	207	83	173	327	212	--	93	470	**2800**	303	586
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	4	2	--	<2	<2.0	--	<2	8
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	<1	--	<1	<1.0	--	<1	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		11	--	--	37.4	21.1	--	16.9	--	--	33	45	31	39	40	45	75	--	43	96	--	38	96
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		4	--	--	<2.0	6.4	--	4.9	--	--	<2	10	4	4	<2	60	9	--	6	<2.0	--	<2	41
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	--	<0.1	<0.10	--	<0.1	0.2
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	2	<2	<2	<2	11	<2	--	<2	<2.0	--	<2	**18**
Total Zinc (Zn)	µg/L	5	30	--	30		12	--	--	13.6	12.3	9.3	5.5	9	12.5	<5	7	12	12	<5	**46**	**36**	--	17	27	**1210**	10	**170**
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		28	>250	--	>250	75	41	110	>250	--	1553	>2420	>2420	2420	1990	>2420	687	--	>2420	---	>2420	328	>2420
E. coli	MPN/100mL	1	--	400	--		4	230	--	9	5	<1	7	**>250**	<100	<1	16	50	111	9	4	<1	--	<1	<10	201	2	1
Fecal Coliform	MPN/ml	--	--	400	--		--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.90	82.63	48.17	0.85	16.36	0.25	0.97	4.91	1.9	2.07	21.03	0.33	2.41	1.10	21.62	10.34	--	0.46	0.53	119.14	6.24	539.78
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.91	81.20	52.50	0.85	17.35	0.23	0.87	4.49	2.15	2.27	17.26	0.50	3.02	1.30	27.02	11.09	--	0.55	0.58	129.77	2.23	793.90

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
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CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded)	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded	= Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Lake Shore Drive																					
Sample Sites							LSD																					
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/17	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					12:00	09:30	11:45	09:00	11:28	10:00	08:45	13:20	9:00	9:15	13:00	9:10	08:40	15:30	11:55	9:30	12:45	13:30	09:50	16:02	13:40	15:00
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	N/A	NCC	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		13.1	16.7	15.3	13.4	21.3	7.3	10.2	21.0	12.0	5.7	25.7	13.4	7.7	20.2	8.8	8.9	--	10.48	12.52	24.3	5.8	13.17
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**10.84**	5.70	5.50	8.60	**5.41**	8.47	9.44	7.87	8.16	**4.06**	**2.69**	7.58	8.77	7.26	7.60	**14.78**	--	7.22	6.26	7.25	7.21	8.22
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		7.88	6.74	6.34	6.42	6.64	6.17	7.09	6.88	6.63	8.22	7.16	6.92	5.19	7.28	6.23	7.02	--	6.31	6.88	6.34	6.48	6.63
Specific Conductance	uS/cm	1	--	--	--		723	210	168	218	203	110	146	126	112	62	177.5	116.7	123.6	132.5	147.8	180.0	--	111	0.119	155.3	132.3	162
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		13	16	12	13	21	9	9	15	12	21	14	11	8	20	11	35	--	10	11	7	9	11
Dissolved Chloride (Cl)	mg/L	1	--	--	120		41	34	31	49	45	25	38	27	22	22	33	23	39	32	23	29	--	23	32	27	26	39
Colour	TCU	5	--	--	--		32	27	37	20	26	33	32	41	49	13	20	40	10	21	25	9	--	31	20	11	26	25
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.14	0.14	0.06	0.23	0.10	0.12	0.25	0.17	0.09	0.13	0.80	<0.05	0.18	0.20	<0.05	0.09	--	0.11	0.15	0.25	0.30	0.08
Nitrate (N)	mg/L	0.05	--	--	13000		0.14	--	--	0.23	0.10	--	0.25	--	--	0.13	0.80	<0.05	0.18	0.20	<0.05	0.09	--	0.11	0.15	0.16	0.30	0.08
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.010	0.09	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.06	0.03	<0.03	<0.03	<0.03	0.03	0.03	0.04	--	<0.03	<0.050	0.11	<0.03	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	0.5	3.5	0.5	--	0.7	3.0	1.0	--	<0.4	0.29	77.4	2.8	2.2
Total Organic Carbon	mg/L	0.5	--	--	--		5.0	3.8	6.8	3.7	6.0	5.3	4.7	7.1	7.5	3.1	8.0	7.7	4.7	6.3	6.9	5.2	--	8.1	3.2	14.1	9.9	5.5
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01	<0.010	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.69	6.69	6.93	7.10	7.30	6.67	6.72	6.79	6.49	6.2	6.9	6.9	6.94	6.95	**6.49**	**6.47**	--	6.72	7.02	6.59	6.68	6.65
Total Calcium (Ca)	mg/L	0.1	--	--	--		6.5	6.9	5.4	7.99	10.5	5.29	5.9	5.14	5.04	2.6	18.1	5.1	6.4	6.0	5.6	5.4	--	5.1	6100	52.2	5.4	6.6
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.4	1.6	1.3	1.99	2.14	1.15	1.25	1.19	1.23	0.7	3.3	1.4	1.2	1.4	1.6	1.5	--	1.1	1300	23.0	1.5	1.4
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	**0.01**	**<0.02**	**0.03**	0.009	**0.018**	**0.100**	0.009	**0.018**	**0.028**	**0.014**	**0.022**	**0.063**	0.003	0.007	**0.015**	**0.078**	**0.100**	--	**0.03**	**0.011**	**0.501**	**0.095**	**1.25**
Total Potassium (K)	mg/L	0.1	--	--	--		1.2	1.1	1.3	1.180	1.210	1.030	1.070	0.960	1.240	0.6	1.9	1.3	1.2	1.1	1.4	1.1	--	1.1	1100	9.7	1.0	1.2
Total Sodium (Na)	mg/L	0.1	--	--	--		24	21	18	24.8	26.9	15.2	23.2	14.3	13.8	11.3	18.6	15.2	21.9	26.6	14.6	23.4	--	18.1	19	24.4	13.4	25.1
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		3.1	4.2	4.0	3.2	3.4	4.3	2.6	3.9	3.8	3.1	2.9	4.9	2.6	3.9	5.0	2.9	--	4.2	2.4	4.2	4.4	1.6
Total Suspended Solids	mg/L	5	--	--	--		16	98	5	6	110	7	4	77	5	<5	16	19	<5	17	9	51	--	8	4.6	719	69	93
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		6	4	5	7	3	4	6	4	4	5	5	5	6	7	5	5	--	4	4.8	<2	3	5
Turbidity (NTU)	NTU	0.1	--	50	--		0.6	12	2.5	12	6.2	1	0.6	2.5	1.7	6.7	**283**	2.1	1.1	31.6	**82.6**	6.6	--	1.4	1.2	**4430**	5.4	**65.3**
Conductivity (uS/cm)	µS/cm	1	--	--	--		170	150	140	200	200	110	150	130	110	96	161	110	168	136	105	122	--	125	140	129	136	160
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		1.56	0.82	1.22	1.80	1.77	0.97	1.39	1.14	0.96	1.15	1.37	0.97	1.40	1.46	0.97	1.63	--	0.94	1.22	0.92	1.00	1.43
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		13	8	12	13	21	9	9	15	12	21	14	11	8	20	11	35	--	10	11	7	9	11
Calculated TDS	mg/L	1	--	--	--		92	55	74	104	107	62	84	66	60	56	163	58	82	87	66	88	--	59	74	498	65	91
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	--	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		1.53	0.99	1.20	1.69	1.94	1.05	1.44	1.02	1.00	0.76	3.59	1.10	1.43	1.62	1.62	1.52	--	1.19	1.28	31.0	1.42	1.94
Hardness (CaCO3)	mg/L	N/A	--	--	--		22	15	19	28	35	18	20	18	18	9.4	58.8	18.5	20.9	20.7	20.6	19.7	--	17.3	21.0	225	19.7	22.2
Ion Balance (% Difference)	%	N/A	--	--	--		0.97	9.39	0.83	3.15	4.58	3.96	1.77	5.56	2.04	20.7	63.0	6.1	1.0	5.2	25.0	3.4	--	11.8	2.4	94.2	17.5	15.2
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-2.74	-3.20	-2.60	-2.22	-1.71	-2.99	-2.88	-2.64	-3.05	-3.62	-2.30	-2.91	-2.93	-2.55	-3.29	-2.84	--	-3.14	-2.50	-2.50	-3.20	-2.97
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-2.99	-3.45	-2.85	-2.47	-1.96	-3.24	-3.13	-2.89	-3.31	-3.94	-2.62	-3.23	-3.25	-2.87	-3.61	-3.16	--	-3.46	-2.75	-2.82	-3.52	-3.29
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.43	9.78	9.53	9.32	9.01	9.66	9.60	9.43	9.54	9.82	9.20	9.81	9.87	9.50	9.78	9.31	--	9.86	9.51	9.09	9.88	9.72
Saturation pH (@ 4C)	N/A	N/A	--	--	--		9.68	10.00	9.78	9.57	9.26	9.91	9.85	9.68	9.80	10.10	9.52	10.10	10.20	9.82	10.1	9.63	--	10.2	9.77	9.41	10.2	10.0
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		99	--	--	349	189	--	217	--	--	490	**19200**	**186**	**131**	93	**3420**	**487**	--	**141**	**120**	--	**1960**	**2150**
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	**8**	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2
Total Barium (Ba)	µg/L	5	1000	--	--		14	--	--	15.3	19.2	--	13.9	--	--	11	86	12	12	7	24	15	--	11	12	--	27	34
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		13	--	--	41.4	21.6	--	<50	--	--	6	24	16	10	15	15	14	--	16	<50	--	<5	12
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	0.018	<0.017	--	<0.017	--	--	0.029	**1.050**	**0.023**	<0.017	<0.017	**0.073**	**0.032**	--	<0.017	**0.011**	--	<0.017	**0.120**
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	**11**	<1	<1	<1	**2**	<1	--	<1	<1.0	--	**3**	**2**
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	<0.40	0.88	--	<0.40	--	--	<1	34	<1	<1	<1	1	<1	--	<1	<0.40	--	4	4
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2	--	--	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2	**22**	2	<2	1	**12**	2	--	3	<2.0	**183**	**6**	3
Total Iron (Fe)	µg/L	50	300	--	300		180	--	--	**554**	**965**	120	211	**388**	**384**	161	**38900**	**312**	236	254	**4200**	**593**	--	**363**	230	**176000**	**4570**	**2790**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	--	--	3.02	0.54	--	<0.50	--	--	0.6	**82.4**	<0.5	<0.5	<0.5	5.2	0.5	--	<0.5	<0.50	--	5.9	**4.3**
Total Manganese (Mn)	µg/L	2	820	--	--		51	--	--	113	632	22.8	30.2	53.4	38.5	26	**13200**	67	71	81	124	140	--	60	130	**13800**	**985**	921
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	13	<2	<2	<2	2	<2	--	<2	<2.0	--	5	2
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	**2**	<1	<1	<1	<1	<1	--	<1	<1.0	--	<1	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		30	--	--	36.3	42.1	--	24.4	--	--	12	82	22	24	24	25	26	--	19	25	--	16	29
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		<2	--	--	7.2	4.1	--	5.3	--	--	3	405	4	<2	2	36	6	--	3	3.3	--	41	30
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	1.6	<0.1	<0.1	<0.1	0.1	<0.1	--	<0.1	<0.10	--	0.2	0.2
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	30	<2	<2	<2	2	<2	--	<2	<2.0	--	6	4
Total Zinc (Zn)	µg/L	5	30	--	30		7	--	--	7.2	6.7	<5.0	<5.0	<5.0	5	<5	**110**	7	6	<5	15	<5	--	<5	<5.0	**799**	11	17
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		53	>250	--	>250	>250	280	85	>250	--	1414	>2420	>2420	1990	>2420	>2420	1203	--	8	---	>2420	>2420	>2420
E. coli	MPN/100mL	1	--	400	--		22	24	--	4	45	6	10	**>250**	<100	2	26	10	10	20	2	<1	--	>2420	<10	16	17	9
Fecal Coliform	MPN/ml	--	--	400	--		--	--	<1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		1.46	10.70	4.68	1.21	6.64	0.21	1.19	1.93	1.41	1.88	6.62	0.13	<0.50	1.6	2.02	1.91	--	0.32	1.02	90.33	5.12	8.22
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		1.85	11.10	5.62	1.32	7.71	0.19	1.07	1.73	1.18	2.28	7.58	0.22	<0.50	2	2.98	1.91	--	0.33	1.07	121.83	4.62	13.77

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
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Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded)	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
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TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Larry Uteck Blvd																					
Sample Sites							LU																					
Sampling Date	yyyy-mm-dd	--					2011/10/17	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14
Sampling Time	hh:mm	--					10:30	15:20	11:30	10:10	14:30	14:30	13:00	11:45	10:45	9:54	13:45	10:23	10:05	12:20	13:45	13:00	13:00	13:35	15:15	13:00	13:00	16:50
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	N/A	N/A	3.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		11.3	12.8	27.3	14.6	13.9	18.3	10.9	15.0	22.8	10.2	16.06	23.40	8.20	13.32	15.7	17.1	16.2	13.2	22.7	9.1	10.3	22.1
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**4.24**	6.17	8.2	9.04	**10.15**	8.29	**4.50**	**11.96**	8.08	7.55	7.28	9.49	8.50	8.75	**10.56**	8.10	6.90	8.76	7.83	**10.43**	**10.39**	8.17
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.07	7.82	6.65	6.78	6.39	7.49	5.45	6.50	7.23	6.17	6.57	6.80	6.99	7.17	7.39	6.57	6.64	7.06	7.35	5.89	6.28	6.20
Specific Conductance	uS/cm	1	--	--	--		203	955	480	262	670	320	845.0	999.0	611.0	371.0	0.646	569	436.2	588.0	561	279	223	265	234	125	177	174
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		12	14	14	14	6	22	7	30	21	<5	13	16	13	13	6	7	7	7	9	5	6	7
Dissolved Chloride (Cl)	mg/L	1	--	--	120		34	**224**	116	52	**190**	99	**258**	**243**	104	70	**210**	**132**	93	154	39	64	58	67	61	24	44	43
Colour	TCU	5	--	--	--		94	18	14	18	7	7	19	6	8	18	8.4	8	6	17	54	15	21	19	12	57	32	38
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.61	1.00	0.64	1.89	1.11	2.57	0.34	1.22	0.47	1.97	0.53	0.59	1.63	1.01	0.49	0.10	0.17	0.42	0.27	0.66	0.55	0.15
Nitrate (N)	mg/L	0.05	--	--	13000		--	1.00	0.64	1.89	1.11	2.57	0.34	1.22	0.47	1.97	0.53	0.59	1.63	1.01	0.49	--	--	0.42	0.27	--	0.55	--
Nitrite (N)	mg/L	0.05	--	--	60		--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05	<0.01	--	--	<0.01	<0.01	--	<0.01	--
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		0.06	0.04	0.16	<0.03	<0.03	0.04	0.04	0.05	<0.03	<0.03	<0.050	0.05	<0.03	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	0.4	4.2	0.7	--	0.5	<0.4	1.2	1.7	<0.4	0.3	8.0	0.7	1.2	--	--	--	--	--	--	--	--
Total Organic Carbon	mg/L	0.5	--	--	--		11.0	3.7	22.8	4.8	3.1	4.5	2.9	6.9	4.7	4.7	2.2	7.6	6.5	3.9	6.5	3.6	4.7	0.7	3.3	6.7	4.6	5
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		**6.43**	6.7	7.2	7.2	6.92	7.11	**6.49**	**6.42**	7.42	**6.41**	6.95	7.30	7.15	6.94	**6.36**	6.75	6.79	6.63	7.04	6.58	6.54	6.83
Total Calcium (Ca)	mg/L	0.1	--	--	--		7.63	30.7	22.1	14.5	22.0	17.6	21.8	23.9	27.6	12.6	27000	20.3	15.9	20.6	4.5	6.9	6.4	8.37	9.02	5.90	6.02	4.99
Total Magnesium (Mg)	mg/L	0.1	--	--	--		2.34	4.2	3.6	2.2	2.8	2.7	4.0	4.2	3.8	2.2	3800	3.4	1.9	2.9	0.6	1.1	1.0	1.25	1.22	0.82	0.98	0.89
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	**0.01**	**0.034**	**0.043**	**0.036**	**0.030**	0.006	**0.027**	**0.046**	**0.260**	**0.028**	**0.04**	0.007	0.009	**0.011**	**0.029**	**<0.02**	**<0.02**	0.002	**0.018**	0.002	<0.002	**0.014**	**0.011**
Total Potassium (K)	mg/L	0.1	--	--	--		2.110	3.2	3.6	2.5	2.6	2.8	2.9	3.1	3.7	3.0	3300	2.8	1.6	2.8	0.9	0.9	0.9	1.160	1.060	1.340	1.230	0.771
Total Sodium (Na)	mg/L	0.1	--	--	--		22.7	124	62.2	32.3	95.1	51.7	170	147	88.1	62.7	110	102	57.8	96.4	25	38	34	35.2	40.2	18.4	26.8	22.8
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		6.9	4.9	0.7	6.3	5.1	8.6	7.0	2.1	2.5	6.9	3.6	4.9	6.9	4.2	4.5	2.6	2.8	3.8	3.4	5.9	3.7	2.6
Total Suspended Solids	mg/L	5	--	--	--		13	5	165	<5	<5	<5	<5	626	<5	<5	<1.0	<5	6	29	<2	3	9	7	<2	<1	1	<2
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		21	26	25	23	26	29	33	29	20	27	27	31	30	28	13	11	11	13	12	12	12	10
Turbidity (NTU)	NTU	0.1	--	50	--		3.3	4.1	23.0	2.3	1.8	1.6	0.7	42.7	10.1	1.6	0.3	2.8	2.4	15.8	0.4	0.5	0.6	8.2	0.9	0.5	0.6	1
Conductivity (uS/cm)	µS/cm	1	--	--	--		190	813	482	255	732	433	840	819	605	394	790	575	462	582	170	250	230	260	250	130	180	170
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		1.69	7.21	4.12	2.36	6.10	4.02	8.13	8.15	3.80	2.68	6.77	4.73	3.62	5.26	1.51	2.18	1.99	2.34	2.15	1.09	1.62	1.56
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		12	14	14	14	6	22	7	30	21	<5	13	16	13	13	6	7	7	7	9	5	6	7
Calculated TDS	mg/L	1	--	--	--		109	426	246	144	347	229	496	477	262	187	400	305	216	321	93	129	118	137	134	75	100	90
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10	<1	<1	<1	<1	<1	<1	<1	<1
Cation Sum	me/L	N/A	--	--	--		1.70	7.40	4.30	2.43	5.55	3.51	8.90	8.24	5.64	3.64	6.69	5.86	3.52	5.78	1.40	2.11	1.89	2.11	2.33	1.20	1.58	1.35
Hardness (CaCO3)	mg/L	N/A	--	--	--		29	94.0	70.0	45.3	66.5	55.1	70.9	77.0	84.6	40.5	84	64.7	47.5	63.4	14	22	20	26	28	18	19	16
Ion Balance (% Difference)	%	N/A	--	--	--		0.29	1.3	2.2	1.4	4.7	6.8	4.5	0.6	19.4	15.2	0.59	10.6	1.4	4.7	3.78	1.63	2.58	5.17	4.02	4.80	1.25	7.22
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-2.95	-2.32	-1.94	-2.10	-2.60	-1.93	-2.98	-2.38	-1.45	-3.41	-1.95	-1.82	-2.16	-2.27	-3.57	-2.90	-2.94	-2.96	-2.43	-3.25	-3.27	-2.94
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.20	-2.64	-2.26	-2.42	-2.92	-2.25	-3.30	-2.70	-1.77	-3.73	-2.20	-2.14	-2.48	-2.59	-3.82	-3.15	-3.19	-3.21	-2.68	-3.50	-3.53	-3.19
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.38	9.02	9.14	9.30	9.52	9.04	9.47	8.80	8.87	9.82	8.90	9.12	9.31	9.21	9.93	9.65	9.73	9.59	9.47	9.83	9.81	9.77
Saturation pH (@ 4C)	N/A	N/A	--	--	--		9.63	9.34	9.46	9.62	9.84	9.36	9.79	9.12	9.19	10.1	9.15	9.44	9.63	9.53	10.20	9.90	9.98	9.84	9.72	10.10	10.10	10.00
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		--	218	**227**	**252**	**107**	**447**	31	**1400**	46	**109**	**59**	--	66	**1420**	**260**	--	--	**665**	45.9	--	**233**	--
Total Antimony (Sb)	µg/L	2	20	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Arsenic (As)	µg/L	2	5.0	--	5		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Barium (Ba)	µg/L	5	1000	--	--		--	225	201	116	133	134	119	185	157	80	150	--	111	127	23	--	--	35.3	24.4	--	26.6	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Bismuth (Bi)	µg/L	2	--	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Boron (B)	µg/L	5	1200	--	1500		--	11	17	22	10	22	18	22	20	21	<50	--	9	14	8	--	--	11.3	8.6	--	<50	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		--	0.538	**0.171**	**0.168**	**0.300**	**0.236**	**0.148**	**0.171**	**0.031**	**0.079**	**0.150**	--	**0.176**	**0.426**	<0.3	--	--	**0.032**	<0.017	--	<0.017	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		--	<1	<1	<1	<1	1	<1	<1	<1	<1	<1.0	--	<1	**3**	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Cobalt (Co)	µg/L	1	10	--	--		--	<1	1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	2	<1	--	--	0.96	<0.40	--	<0.40	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2.9	<2	3	16	2	**6**	2	2	<1	4	**2.1**	3	3	10	<2	--	--	2.0	<2.0	<2.0	4.0	<2.0
Total Iron (Fe)	µg/L	50	300	--	300		**2150**	**347**	**1320**	**500**	194	**890**	157	**2000**	207	229	170	**671**	171	**1940**	140	--	--	**837**	89	161	141	**315**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		--	0.8	0.7	1.0	<0.5	1.4	<0.5	1.8	<0.5	<0.5	<0.50	--	<0.5	**3.4**	<0.5	--	--	1.73	<0.50	--	<0.50	--
Total Manganese (Mn)	µg/L	2	820	--	--		129	182	485	120	87	89	26	71	182	36	110	371	61	444	17	--	--	142	68.9	41.3	14.4	128
Total Molybdenum (Mo)	µg/L	2	73	--	73		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		--	<2	<2	<2	<2	<2	<2	3	<2	<2	<2.0	--	<2	3	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Selenium (Se)	µg/L	1	1.0	--	1		--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	--	<1	<1	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	<0.5	--	--	<0.10	<0.10	--	<0.10	--
Total Strontium (Sr)	µg/L	5	21000	--	--		--	112	94	60	93	90	96	116	111	54	120	--	43	89	18	--	--	36.3	37.1	--	25	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	<0.1	--	--	<0.10	<0.10	--	<0.10	--
Total Tin (Sn)	µg/L	2	--	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Titanium (Ti)	µg/L	2	--	--	--		--	4	3	7	3	11	2	22	<2	3	<2.0	--	<2	31	<2	--	--	7.8	<2.0	--	3.9	--
Total Uranium (U)	µg/L	0.1	300	--	15		--	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	0.2	<0.1	--	--	<0.10	<0.10	--	<0.10	--
Total Vanadium (V)	µg/L	2	6	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	4	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Zinc (Zn)	µg/L	5	30	--	30		9	**79**	**92**	**39**	**57**	**49**	26	17	8	23	27	17	16	**64**	8	--	--	10.0	5.4	5.7	6.3	6.2
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		--	>2420	>2420	2420	866	>2420	866	>2420	961	>2420	---	>2420	>2420	>2420	200	73	--	>250	>250	>250	85	>250
E. coli	MPN/100mL	1	--	400	--		<100	<1	2	19	3	86	<1	<1	7	**1730**	<10	19	6	<1	33	45	--	19	**>250**	2	2	34
Fecal Coliform	MPN/ml	--	--	400	--		--	--	--	--	--	--	--	--	--	--	---	--	--	--	--	--	<1	--	--	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		1.99	2.44	32.52	1.80	1.54	2.30	0.12	99.13	2.54	0.96	0.69	3.14	4.94	5.43	0.62	2.31	0.57	0.82	1.12	0.07	2.85	0.86
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		2.08	2.71	31.31	2.15	1.77	2.50	0.11	98.00	2.51	0.96	0.68	3.10	2.71	6.73	0.64	2.21	0.64	0.74	1.04	0.06	2.75	0.76

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME FWAL calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Paper Mill Lake																					
Sample Sites							PML1																					
Sampling Date	yyyy-mm-dd	--					2011/10/16	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14
Sampling Time	hh:mm	--					17:00	12:50	--	10:55	10:51	11:35	10:45	10:30	14:45	12:35	12:45	08:45	8:20	13:15	13:15	13:40	13:45	14:30	16:20	13:00	12:40	16:20
FIELD DATA																												
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	2.91	2.65	2.8	2.2	2.3	N/A	3.0	2.0	2.2	2.3
Water Temp	Celsius	0.1	--	--	--		13.6	8.3	--	14.9	11.6	22.5	12.3	12.1	23.6	12.4	15.13	24.0	9.3	12.8	14.8	24.2	19.7	17.8	25.3	10.1	10.9	23.1
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		9.54	8.41	--	8.60	9.98	7.65	9.90	12.08	7.49	8.06	7.16	8.04	8.63	8.84	10.20	8.30	8.40	8.78	8.09	10.58	9.88	8.7
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.11	7.58	--	6.63	6.39	7.20	6.32	6.60	7.42	6.60	6.90	6.34	7.98	7.57	6.36	6.82	6.84	7.09	7.39	6.53	6.31	6.67
Specific Conductance	uS/cm	1	--	--	--		106	366	--	186.4	215.1	199.0	250.5	431.0	263.0	210.0	0.197	432.1	289.1	231.0	267	264	241	237	234	201	159	173
INORGANICS																												
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		7	20	--	<5	<5	6	7	31	7	7	5.2	6	6	<5	5	7	7	6	8	7	<5	8
Dissolved Chloride (Cl)	mg/L	1	--	--	120		18	55	--	45	57	57	48	63	50	46	65	57	56	59	63	63	58	62	58	50	44	43
Colour	TCU	5	--	--	--		65	38	--	29	8	15	11	17	10	30	31	7	15	18	22	17	19	20	13	23	35	38
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.62	0.22	--	0.14	0.21	0.18	0.18	0.22	0.24	0.18	0.18	0.14	0.24	0.19	0.14	0.07	0.09	0.19	0.11	0.23	0.33	0.14
Nitrate (N)	mg/L	0.05	--	--	13000		--	0.22	--	0.14	0.21	0.18	0.18	0.22	0.24	0.18	0.18	0.14	0.24	0.19	0.14	--	--	0.19	0.11	--	0.33	--
Nitrite (N)	mg/L	0.05	--	--	60		--	<0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05	<0.01	--	--	<0.01	<0.01	--	<0.01	--
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.06	--	<0.03	<0.03	0.04	<0.03	0.04	<0.03	<0.03	<0.050	<0.03	0.03	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	<0.4	--	0.4	--	0.4	0.8	0.4	0.4	<5	0.49	1.20	6.0	2.6	--	--	--	--	--	--	--	--
Total Organic Carbon	mg/L	0.5	--	--	--		8.3	5.7	--	5.3	4.2	4.1	5.1	4.0	2.0	4.4	2.7	5.4	5.8	7.1	3.6	2.6	4.5	3.2	3.4	3.6	4	6
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.67	6.6	--	6.8	6.71	6.92	6.88	6.66	7.00	6.64	6.67	6.95	6.84	6.36	6.50	6.81	6.82	6.66	7.02	6.83	6.37	6.60
Total Calcium (Ca)	mg/L	0.1	--	--	--		4.64	6.0	--	6.0	6.8	6.6	6.9	6.9	9.1	7.0	6900	7.8	4.8	7.9	6.1	7.1	6.1	7.17	7.69	7.96	5.30	4.76
Total Magnesium (Mg)	mg/L	0.1	--	--	--		0.85	1.0	--	1.1	1.0	0.9	1.5	1.3	1.4	1.0	970	1.4	0.9	1.5	1.1	1.1	1.1	1.25	1.17	1.20	0.93	0.86
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	0.030	0.019	--	0.03	0.006	0.007	0.047	0.012	0.030	0.02	0.005	0.060	0.018	0.173	<0.02	<0.02	0.002	0.010	0.002	<0.002	0.009	0.009
Total Potassium (K)	mg/L	0.1	--	--	--		1.430	0.8	--	1.0	0.8	1.0	1.5	0.9	1.3	0.9	800	1.0	0.6	1.0	0.9	1.0	0.9	0.984	0.900	1.020	0.861	0.801
Total Sodium (Na)	mg/L	0.1	--	--	--		13.7	33.6	--	29.8	35.3	28.5	32.2	38.1	41.6	33.7	35	38.6	25.6	37.6	35	40	34	31.1	35.1	30.8	25.7	21.3
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		5.4	2.9	--	3.2	2.8	2.6	2.6	2.5	2.3	2.7	2.4	2.4	2.5	2.5	2.6	2.5	2.3	2.6	2.3	3.3	2.9	2.5
Total Suspended Solids	mg/L	5	--	--	--		5	9	--	6	<5	<5	23	6	<5	<5	1	149	6	531	2	3	<1	15	<2	11	<1	8
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		12	7	--	10	8	10	10	10	8	8	7.8	9	8	11	11	11	11	10	10	10	9	10
Turbidity (NTU)	NTU	0.1	--	50	--		1.2	0.7	--	1	0.7	1.1	19.2	1.4	0.9	1.5	0.45	3.8	24.2	199.0	0.8	0.7	0.6	1.0	0.8	0.4	0.4	3.4
Conductivity (uS/cm)	µS/cm	1	--	--	--		100	214	--	179	227	218	209	230	261	224	240	246	241	224	240	250	230	230	230	210	170	170
Calculated Parameters																												
Anion Sum	me/L	N/A	--	--	--		0.92	2.11	--	1.49	1.79	1.95	1.71	2.62	1.73	1.62	2.11	1.93	1.88	1.91	2.11	2.17	1.99	2.07	2.01	1.77	1.46	1.58
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		7	20	--	<5	<5	6	7	31	7	7	5.2	6	6	<5	5	7	7	6	8	7	<1	8
Calculated TDS	mg/L	1	--	--	--		63	117	--	95	110	109	115	140	117	102	120	126	109	141	123	131	117	120	120	110	91	89
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<10	--	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10	<1	<1	<1	<1	<1	<1	<1	<1
Cation Sum	me/L	N/A	--	--	--		0.95	1.89	--	1.78	2.00	1.69	2.56	2.18	2.45	1.94	1.98	2.61	1.93	3.54	1.94	2.23	1.88	1.88	2.03	1.86	1.48	1.28
Hardness (CaCO3)	mg/L	N/A	--	--	--		15	19.1	--	19.5	21.1	20.2	23.4	22.6	28.5	21.6	21.0	25.2	15.7	25.9	20	22	20	23	24	25	17	15
Ion Balance (% Difference)	%	N/A	--	--	--		1.60	5.5	--	9.0	5.5	7.0	19.8	9.2	17.0	9.2	3.2	15.2	1.2	30.0	4.20	1.36	2.84	4.81	0.50	2.48	0.68	10.50
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-3.13	-2.91	--	-3.31	-3.35	-3.07	-3.03	-2.61	-2.79	-3.26	-3.13	-2.98	-3.29	-3.65	-3.33	-2.83	-2.93	-3.06	-2.55	-2.80	NC	-3.18
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.38	-3.23	--	-3.63	-3.67	-3.39	-3.35	-2.93	-3.11	-3.58	-3.38	-3.30	-3.61	-3.97	-3.59	-3.08	-3.18	-3.31	-2.80	-3.05	NC	-3.43
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.80	9.51	--	10.10	10.1	9.99	9.91	9.27	9.79	9.90	9.80	9.93	10.1	10.0	9.83	9.64	9.75	9.72	9.57	9.63	NC	9.78
Saturation pH (@ 4C)	N/A	N/A	--	--	--		10.10	9.83	--	10.40	10.4	10.3	10.2	9.59	10.1	10.2	10.1	10.2	10.5	10.3	10.10	9.89	10.00	9.97	9.82	9.88	NC	10.00
Metals (ICP-MS)																												
Total Aluminum (Al)	µg/L	5	5	--	5-100		--	177	--	306	141	103	3920	305	129	142	140	--	2320	7690	130	--	--	1030	55.8	--	202	--
Total Antimony (Sb)	µg/L	2	20	--	--		--	<2	--	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Arsenic (As)	µg/L	2	5.0	--	5		--	<2	--	<2	<2	<2	2	<2	<2	<2	<1.0	--	<2	4	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Barium (Ba)	µg/L	5	1000	--	--		--	22	--	19	20	12	40	23	23	18	21	--	34	60	16	--	--	23.0	12.2	--	23	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		--	<2	--	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Bismuth (Bi)	µg/L	2	--	--	--		--	<2	--	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Boron (B)	µg/L	5	1200	--	1500		--	6	--	9	6	8	9	8	13	11	<50	--	<5	10	5	--	--	8.2	8.8	--	<50	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		--	<0.017	--	0.066	0.021	0.018	0.430	<0.017	0.020	<0.017	0.025	--	0.146	0.227	<0.3	--	--	0.037	<0.017	--	0.028	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		--	<1	--	<1	<1	<1	3	<1	<1	<1	<1.0	--	2	6	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Cobalt (Co)	µg/L	1	10	--	--		--	<1	--	2	<1	<1	9	<1	<1	<1	<0.40	--	3	6	<1	--	--	0.65	<0.40	--	<0.40	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2.3	<2	--	<2	<2	1	6	1	<1	2	<2.0	3	4	10	<2	--	--	3.3	<2.0	<2.0	<2.0	<2.0
Total Iron (Fe)	µg/L	50	300	--	300		528	137	--	742	130	205	5300	239	296	182	93	4460	6020	13600	100	--	--	1090	151	76	143	699
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		--	<0.5	--	0.9	<0.5	<0.5	13.5	0.9	<0.5	<0.5	<0.50	--	6.3	13.9	<0.5	--	--	2.39	<0.50	--	<0.50	--
Total Manganese (Mn)	µg/L	2	820	--	--		62.4	48	--	214	33	58	693	54	260	49	34	296	278	424	58	--	--	159	81.0	28.0	33.8	88.6
Total Molybdenum (Mo)	µg/L	2	73	--	73		--	<2	--	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		--	<2	--	2	<2	<2	9	<2	<2	<2	<2.0	--	5	7	2	--	--	2.2	<2.0	--	<2.0	--
Total Selenium (Se)	µg/L	1	1.0	--	1		--	<1	--	<1	<1	<1	<1	<1	<1	<1	<1.0	--	1	1	<2	--	--	<1.0	<1.0	--	<1.0	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	<0.5	--	--	<0.10	<0.10	--	<0.10	--
Total Strontium (Sr)	µg/L	5	21000	--	--		--	26	--	30	31	25	34	35	37	30	32	--	22	40	30	--	--	34.7	32.8	--	25.7	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	<0.1	--	--	<0.10	<0.10	--	<0.10	--
Total Tin (Sn)	µg/L	2	--	--	--		--	<2	--	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Titanium (Ti)	µg/L	2	--	--	--		--	<2	--	4	<2	<2	65	4	<2	3	<2.0	--	25	106	<2	--	--	21.3	<2.0	--	3.6	--
Total Uranium (U)	µg/L	0.1	300	--	15		--	0.1	--	<0.1	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.10	--	0.6	0.9	<0.1	--	--	0.10	<0.10	--	<0.10	--
Total Vanadium (V)	µg/L	2	6	--	--		--	<2	--	<2	<2	<2	10	<2	<2	<2	<2.0	--	7	16	<2	--	--	<2.0	<2.0	--	<2.0	--
Total Zinc (Zn)	µg/L	5	30	--	30		5.4	<5	--	13	8	<5	62	<5	<5	6	11	13	12	34	12	--	--	18.3	<5.0	5.8	6.6	7.5
MICROBIOLOGICAL																												
Total Coliform	MPN/100mL	1	--	--	--		--	411	--	2420	866	1730	1011	613	2420	>2420	---	>2420	>2420	>2420	49	40	--	>250	46	97	64	>250
E. coli	MPN/100mL	1	--	400	--		<100	2	--	20	12	4	6	6	10	10	<10	3	6	>2420	10	31	--	69	<1	6	17	>250
Fecal Coliform	MPN/ml	--	--	400	--		--	--	--	--	--	--	--	--	--	--	---	--			--	--	12	--	--	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.15	1.03	--	0.69	1.17	1.10	5.07	0.67	0.64	0.91	0.57	8.84	4.67	8.00	1.15	1.36	0.59	3.50	1.54	0.53	0.55	2.48
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.15	1.10	--	0.91	1.37	1.10	6.39	0.65	0.65	0.87	0.54	9.54	3.69	12.31	1.22	1.33	0.66	3.39	1.51	0.42	0.51	2.26

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME FWAL calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009) (Referenced)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded)	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded	= Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Spring 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Paper Mill Lake													
Sample Sites							PML2													
Sampling Date	yyyy-mm-dd	--					2011/10/16	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16
Sampling Time	hh:mm	--					16:15	13:16	--	--	13:40	10:45	11:20	11:00	9:20	8:30	11:30	13:45	9:08	13:45
FIELD DATA																				
Secchi Depth	Meters	--	--	1.2	--		2.2	2.35	--	--	3.20	--	N/A	N/A	N/A	3.1	NCC	N/A	2.41	2.7
Water Temp	Celsius	0.1	--	--	--		15.2	11.6	--	--	14.8	--	12.6	14.4	21.1	12.1	15.09	27.0	9.0	13.8
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		8.94	7.75	--	--	9.26	--	8.90	**12.44**	6.95	7.92	8.06	**9.76**	8.28	8.55
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.13	8.61	--	--	6.49	--	6.13	6.50	7.22	5.92	6.56	6.76	7.25	7.57
Specific Conductance	uS/cm	1	--	--	--		156	231	--	--	234	--	250.5	966.0	266.0	215.0	0.214	255.6	454.9	264
INORGANICS																				
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		7	21	--	--	<5	--	8	32	10	26	<5.0	5	7	7
Dissolved Chloride (Cl)	mg/L	1	--	--	120		34	55	--	--	63	--	64	**245**	50	42	69	59	57	67
Colour	TCU	5	--	--	--		48	39	--	--	18	--	8	6	7	31	26	10	9	22
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.22	0.24	--	--	0.22	--	<0.05	0.13	0.18	0.18	0.11	0.32	0.23	0.10
Nitrate (N)	mg/L	0.05	--	--	13000		--	0.24	--	--	0.22	--	<0.05	0.13	0.18	0.18	0.11	0.17	0.23	0.10
Nitrite (N)	mg/L	0.05	--	--	60		--	<0.05	--	--	<0.05	--	<0.05	<0.05	<0.05	<0.05	<0.010	0.15	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	<0.03	--	--	0.03	--	0.23	0.05	0.03	<0.03	<0.050	<0.03	<0.03	0.05
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	<0.4	--	--	--	--	1.7	<0.4	0.4	<5	0.23	1.20	3.0	0.6
Total Organic Carbon	mg/L	0.5	--	--	--		5.6	5.9	--	--	4.4	--	4.0	2.7	2.4	5.8	2.8	6.0	6.1	4.0
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	--	--	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.60	6.6	--	--	6.68	--	6.73	7.13	7.04	6.77	6.64	6.98	6.98	6.83
Total Calcium (Ca)	mg/L	0.1	--	--	--		5.04	6.1	--	--	6.7	--	7.7	19.2	8.8	6.9	7300	8.2	6.2	8.9
Total Magnesium (Mg)	mg/L	0.1	--	--	--		0.90	1.0	--	--	1.0	--	1.4	1.7	1.4	1.0	1000	1.3	1.2	1.2
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	**0.01**	0.007	**0.025**	--	--	0.006	--	**0.026**	**0.011**	**0.026**	**0.02**	0.008	**0.012**	0.008	**0.012**
Total Potassium (K)	mg/L	0.1	--	--	--		0.968	0.8	--	--	0.8	--	1.3	1.4	1.2	1.1	830	1.0	0.9	1.0
Total Sodium (Na)	mg/L	0.1	--	--	--		20.9	34.6	--	--	37.5	--	42.0	133	42.6	33.9	38	43.3	31.3	42.9
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		3	2.8	--	--	2.7	--	4.2	2.4	2.3	2.9	1.9	1.8	2.8	2.3
Total Suspended Solids	mg/L	5	--	--	--		<1	<5	--	--	<5	--	<5	16	<5	<5	1	<5	<5	45
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		9	7	--	--	9	--	11	27	7	7	8	9	9	12
Turbidity (NTU)	NTU	0.1	--	50	--		0.5	0.7	--	--	1	--	3.3	2.6	0.7	1	0.88	1.9	1.3	9.4
Conductivity (uS/cm)	µS/cm	1	--	--	--		150	213	--	--	254	--	277	777	273	212	260	251	246	263
Calculated Parameters																				
Anion Sum	me/L	N/A	--	--	--		1.30	2.13	--	--	1.98	--	2.19	8.12	1.77	1.86	2.13	1.97	1.95	2.29
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		7	21	--	--	<5	--	8	32	10	26	<1.0	5	7	7
Calculated TDS	mg/L	1	--	--	--		79	119	--	--	119	--	137	448	118	109	130	127	112	139
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<10	--	--	<10	--	<10	<10	<10	<10	<1.0	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		1.27	1.94	--	--	2.09	--	2.55	6.96	2.47	1.95	2.14	2.44	1.84	2.53
Hardness (CaCO3)	mg/L	N/A	--	--	--		16	19.3	--	--	20.8	--	25.0	54.9	27.7	21.3	23.0	25.8	20.4	27.2
Ion Balance (% Difference)	%	N/A	--	--	--		1.17	4.8	--	--	2.8	--	7.5	7.7	16.5	2.2	0.23	10.6	3.0	5.1
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-3.17	-2.89	--	--	-3.39	--	-3.08	-1.73	-2.61	-2.57	NC	-3.00	-2.97	-2.98
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.42	-3.21	--	--	-3.71	--	-3.40	-2.05	-2.93	-2.89	NC	-3.32	-3.29	-3.30
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.77	9.49	--	--	10.1	--	9.81	8.86	9.65	9.34	NC	9.98	9.95	9.81
Saturation pH (@ 4C)	N/A	N/A	--	--	--		10.00	9.81	--	--	10.4	--	10.1	9.18	9.97	9.66	NC	10.3	10.3	10.1
Metals (ICP-MS)																				
Total Aluminum (Al)	µg/L	5	5	--	5-100		--	**189**	--	--	**131**	--	**107**	**181**	52	**122**	**130**	--	**278**	**610**
Total Antimony (Sb)	µg/L	2	20	--	--		--	<2	--	--	<2	--	<2	<2	<2	<2	<1.0	--	<2	<2
Total Arsenic (As)	µg/L	2	5.0	--	5		--	<2	--	--	<2	--	<2	<2	<2	<2	<1.0	--	<2	<2
Total Barium (Ba)	µg/L	5	1000	--	--		--	22	--	--	22	--	37	50	27	19	25	--	24	35
Total Beryllium (Be)	µg/L	2	5.3	--	--		--	<2	--	--	<2	--	<2	<2	<2	<2	<1.0	--	<2	<2
Total Bismuth (Bi)	µg/L	2	--	--	--		--	<2	--	--	<2	--	<2	<2	<2	<2	<2.0	--	<2	<2
Total Boron (B)	µg/L	5	1200	--	1500		--	6	--	--	6	--	9	7	13	11	<50	--	<5	8
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		--	**0.023**	--	--	**0.039**	--	**0.060**	**0.062**	**0.019**	**0.018**	**0.023**	--	**0.145**	**0.042**
Total Chromium (Cr)	µg/L	1	1.0	--	1		--	<1	--	--	<1	--	<1	<1	<1	<1	<1.0	--	<1	<1
Total Cobalt (Co)	µg/L	1	10	--	--		--	<1	--	--	<1	--	2	<1	<1	<1	<0.40	--	<1	<1
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2.0	<2	--	--	<2	--	**1380**	1	<1	2	<2.0	2	2	<1
Total Iron (Fe)	µg/L	50	300	--	300		181	178	--	--	181	--	**1760**	264	**316**	134	170	**334**	**368**	**647**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		--	<0.5	--	--	<0.5	--	**49.7**	0.7	<0.5	<0.5	<0.50	--	0.5	**1.1**
Total Manganese (Mn)	µg/L	2	820	--	--		30.6	22	--	--	87	--	866	206	278	24	43	67	61	109
Total Molybdenum (Mo)	µg/L	2	73	--	73		--	<2	--	--	<2	--	<2	<2	<2	<2	<2.0	--	<2	<2
Total Nickel (Ni)	µg/L	2	25	--	25-150		--	<2	--	--	<2	--	3	<2	<2	<2	<2.0	--	2	<2
Total Selenium (Se)	µg/L	1	1.0	--	1		--	<1	--	--	<1	--	<1	<1	<1	<1	<1.0	--	<1	<1
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		--	<0.1	--	--	<0.1	--	0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Strontium (Sr)	µg/L	5	21000	--	--		--	27	--	--	31	--	35	68	37	29	34	--	21	38
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		--	<0.1	--	--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Tin (Sn)	µg/L	2	--	--	--		--	<2	--	--	<2	--	3	<2	<2	<2	<2.0	--	<2	<2
Total Titanium (Ti)	µg/L	2	--	--	--		--	<2	--	--	<2	--	2	3	<2	<2	2.1	--	4	7
Total Uranium (U)	µg/L	0.1	300	--	15		--	0.1	--	--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1
Total Vanadium (V)	µg/L	2	6	--	--		--	<2	--	--	<2	--	<2	<2	<2	<2	<2.0	--	<2	<2
Total Zinc (Zn)	µg/L	5	30	--	30		10	8	--	--	11	--	**762**	<5	<5	5	14	<5	8	7
MICROBIOLOGICAL																				
Total Coliform	MPN/100mL	1	--	--	--		--	261	--	--	1410	--	411	291	517	>2420	---	>2420	1120	687
E. coli	MPN/100mL	1	--	400	--		<100	1	--	--	12	--	2	<1	3	16	<0.10	5	2	4
Fecal Coliform	MPN/ml	--	--	400	--		--	--	--	--	--	--	--	--	--	--	---	--		
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		1.33	0.76	--	--	1.18	--	0.25	0.99	0.48	0.72	1.67	4.79	1.50	3.82
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		1.13	0.76	--	--	1.34	--	0.27	1.13	0.44	0.7	1.56	4.59	0.74	5.04

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME FWAL calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

5 STATISTICAL PRESENTATION

Table 4 attached at the end of this section, provides the seasonal statistics of the eleven (11) water quality sampling stations representing water quality data from 2009 to 2016 for six (6) key water quality parameters as follows:

a. Total Phosphorous
b. Chloride
c. Laboratory measured pH
d. Total Suspended Solids
e. Conductivity
f. Chlorophyll-A

Table 4: Statistical Presentation of Key Water Quality Parameters

TABLE 4: Spring 2016 Statistical Presentation of Key Water Quality Parameters - Bedford West Water Quality Sampling Program

Station 1

KL-1	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	24	7	37	10	14
Chloride (mg/L)	55	55	81	66	68
Lab pH	6.64	6.52	6.94	6.71	6.73
Total Suspended Solids (mg/L)	38	0.5	4	2.5	2.14
Conductivity (uS/cm)	212	212	310	253	258
Chloropylla-A (µg/L)	2.76	0.4	1.73	0.64	0.84

Station 2

KL-2	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	9	8	21	12	14
Chloride (mg/L)	17	15	48	19	25.3
Lab pH	6.35	6.27	6.85	6.44	6.51
Total Suspended Solids (mg/L)	2.5	0.5	103	2.5	27.1
Conductivity (uS/cm)	79	64	212	81	111
Chloropylla-A (µg/L)	0.3	0.13	0.82	0.49	0.49

Station 3

KL-3	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	8	4	10	8	7
Chloride (mg/L)	54	50	66	55.5	56.6
Lab pH	6.69	6.38	6.82	6.68	6.63
Total Suspended Solids (mg/L)	2.5	0.5	2.8	2.5	1.9
Conductivity (uS/cm)	206	197	250	220	219
Chloropylla-A (µg/L)	1.63	0.52	1.63	0.91	1.02

Station 4

KL-4	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	7	4	22	22	11
Chloride (mg/L)	54	51	67	56	57
Lab pH	6.7	6.57	6.83	6.69	6.67
Total Suspended Solids (mg/L)	7	0.5	7	2.25	2.31
Conductivity (uS/cm)	206	200	260	219	219
Chloropylla-A (µg/L)	1.62	0.44	1.62	0.69	0.85

Note: The analytical results for Total Phosphorus (TP) and Total Suspended Solids (TSS) included values less than the laboratory RDL. When calculating the median and average, SNC-Lavalin Inc sets the "<RDL" values to the RDL. This allowed the median and average to take into account all data points, and resulted in a conservative approach to statistical averages.

Station 5

KL-5	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	4	4	18	5	8
Chloride (mg/L)	54	54	61	58	57
Lab pH	6.66	6.56	6.71	6.66	6.65
Total Suspended Solids (mg/L)	2.5	0.5	2.5	2.5	2.1
Conductivity (uS/cm)	208	208	232	220	221
Chloropylla-A (µg/L)	1.52	0.2	1.52	0.87	0.87

Station 6

HWY102-1	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	5	5	70	8	17
Chloride (mg/L)	71	24	130	55.5	57.1
Lab pH	6.87	4.54	6.87	6.49	6.22
Total Suspended Solids (mg/L)	2.5	0.5	9	2.5	3.63
Conductivity (uS/cm)	289	100	470	248	232
Chloropylla-A (µg/L)	0.94	0.25	18.1	0.94	5.35

Station 7

HWY102-2	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	222	9	222	12	41
Chloride (mg/L)	236	21	260	92	119
Lab pH	6.46	5.43	7.2	6.09	6.21
Total Suspended Solids (mg/L)	342	0.5	342	2.5	52.3
Conductivity (uS/cm)	817	85	920	364	437
Chloropylla-A (µg/L)	539.78	0.53	539.78	1.52	69.7

Station 8

LSD	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	1250	7	1250	18	180
Chloride (mg/L)	39	22	49	39	36
Lab pH	6.75	6.2	7.1	6.74	6.74
Total Suspended Solids (mg/L)	93	2.5	93	5.3	22.5
Conductivity (uS/cm)	160	96	200	155	151
Chloropylla-A (µg/L)	8.22	0.25	8.22	1.34	2.14

Note: The analytical results for Total Phosphorus (TP) and Total Suspended Solids (TSS) included values less than the laboratory RDL. When calculating the median and average we set the "<RDL" values to the RDL. This allowed the median and average to take into account all data points, and resulted in a conservative approach to statistical averages.

Station 9

LU	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	29	6	260	26	69
Chloride (mg/L)	154	154	243	210	204
Lab pH	6.94	6.42	6.95	6.92	6.79
Total Suspended Solids (mg/L)	29	0.5	626	5	133
Conductivity (uS/cm)	582	582	819	790	747
Chloropylla-A (µg/L)	5.43	0.69	99.1	2.44	21.8

Station 10

PML1	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	173	5	173	13	32
Chloride (mg/L)	59	39	67	58	56.1
Lab pH	6.36	6.36	6.71	6.62	6.57
Total Suspended Solids (mg/L)	531	1	531	4.25	69.8
Conductivity (uS/cm)	224	170	260	226	218
Chloropylla-A (µg/L)	8	0.57	8	0.93	1.97

Station 11

PML2	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	12	6	25	10	11
Chloride (mg/L)	67	44	245	63	83.5
Lab pH	6.83	6.37	7.13	6.65	6.68
Total Suspended Solids (mg/L)	45	0.5	45	2.5	10.6
Conductivity (uS/cm)	263	170	777	247	301
Chloropylla-A (µg/L)	3.82	0.55	3.82	1.17	1.7

Note: The analytical results for Total Phosphorus (TP) and Total Suspended Solids (TSS) included values less than the laboratory RDL. When calculating the median and average we set the “<RDL” values to the RDL. This allowed the median and average to take into account all data points, and resulted in a conservative approach to statistical averages.

6 GRAPHS

Appendix D includes seasonal (i.e. spring in this case) and yearly graphs that illustrate concentrations from 2009 to 2016 of the six (6) key water quality parameters including: dissolved chloride (mg/L), pH, total phosphorus (mg/L), total suspended solids (mg/L), conductivity (µS/cm) and chlorophyll A (µg/L) at each of the eleven (11) water quality monitoring sites. Graphs allow for comparison between water quality sampling stations and identification of concentration increases (i.e. above applicable CCME guidelines).

As many parameters show seasonal concentration fluctuations, the data was also graphed showing only the concentrations for a given season (i.e. spring events in this case). Where results were found to be less than the recordable detection limit (<RDL), they were graphed as half the recordable detection limit (1/2 RDL).

7 CONCLUSIONS

The spring 2016 water quality monitoring program included collection of surface water samples at eleven (11) water quality sampling stations for the analysis of general chemistry, total metals, total phosphorus, total suspended solids, *E.coli*, and chlorophyll-A. Additionally, field parameters collected at each station included in Situ pH, water temperature, dissolved oxygen, conductivity, Secchi depth (where applicable), air temperature, cloud cover and wildlife sightings.

Based on the spring 2016 water quality monitoring results and their comparison with applicable guidelines, the following list summarizes the results:

Field Parameters

pH (in Situ) was below the CCME-PAL-F guideline of 6.5-9.0 at water quality stations KL5 (5.75pH) and HWY102-2 (5.86pH)

Dissolved Oxygen was above the recommended CCME PAL-F guideline of 5.5-9.5 mg/L at stations KL1 (14.02 mg/L of Oxygen) and KL5 (10.47 mg/L of Oxygen)

General Chemistry

pH was below the CCME-PAL-F guideline of 6.5 - 9 at water quality station KL-2 (6.35 pH).

Turbidity was above the Health Canada Guideline of 50 NTU for Recreational Water Quality at three water quality monitoring stations as follows: HWY2012-2 (131 NTU), LSD (65.3 NTU) and PML1 (199.0 NTU).

Total Phosphorous

Total Phosphorous was above the management threshold criteria of 10µg/L at six water quality sampling stations as follows: KL1 (24µg/L), HWY-102-2 (222µg/L), LSD (1250µg/L), LU (29µg/L), PLM-1 (173µg/L) and PLM-2 (12µg/L).

Metals

Aluminium exceeded the applicable NSE EQS guideline of 5µg/L at the following ten water quality sampling stations: KL-1 (206µg/L), KL-2 (187µg/L), KL-3 (163µg/L), KL-4 (172µg/L), KL-5 (163µg/L), HWY-102-2 (3880µg/L), LSD (2150µg/L), LU (1420µg/L), PML1 (7690µg/L), and PML2 (610µg/L).

Cadmium exceeded the applicable NSE EQS guideline of 0.01µg/L at the following nine water quality sampling stations: KL-3 (0.021µg/L), KL-4 (0.024µg/L), KL-5 (0.024µg/L), HWY-102-2 (0.778µg/L), LSD (0.120µg/L), LU (0.426µg/L), PML1 (0.227µg/L), and PML2 (0.042µg/L).

Chromium exceeded the applicable CCME Guideline PAL-F of 1 µg/L of 1µg/L at following four stations: HWY-102-2 (8µg/L), LSD (2µg/L), LU (3µg/L), and PML1 (6µg/L).

Iron exceeded the applicable NSE EQS guideline of 300 µg/L at the following five water quality sampling stations: HWY102-2 (21300µg/L), LSD (2790µg/L), LU (1940µg/L), PML1 (13600µg/L), and PML2 (647µg/L).

Lead exceeded the applicable NSE EQS guideline of 1 µg/L at the following five water quality sampling stations: HWY102-2 (39.7µg/L), LSD (4.3µg/L), LU (3.4µg/L), PML1 (13.9 µg/L), and PML2 (1.1µg/L).

Zinc exceeded the applicable NSE EQS guideline of 30 µg/L at the following three water quality sampling stations: HWY102-2 (170µg/L), LU (64 µg/L), and PML1 (34µg/L).

Manganese exceeded the applicable NSE EQS guideline of 820µg/L at station LSD (921µg/L).

Vanadium exceeded the applicable NSE EQS guideline of 6µg/L at stations PLM1 (16µg/L) and HWY102-2 (18 µg/L).

Microbiological

E.coli analytical results did not report exceedances of the Heath Canada Guideline of 400CFU/100mL in any of the eleven (11) water quality sampling stations.

8 REFERENCES

Canadian Environmental Quality Guidelines for the Protection of Aquatic Life, 2004, "Phosphorous: Canadian Guidance Framework for the Management of Freshwater Systems".

Canadian Council of Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life – Freshwater (FWAL). For TSS and turbidity, the CCME Narrative Total Particulate Matter – Table 1 Suspended Sediments and Turbidity, High Flow Conditions, updated 2002 were used.

Environment Canada (EC), 2005, The Inspector's field sampling manual. Second Edition. Retrieved on March 6, 2015 from http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf

Health Canada guidelines for Canadian Recreational Water Quality (2012, Third Edition). For turbidity, the guidelines indicate a limit of 50 Nephelometric Turbidity Units (NTU).

Nova Scotia Environment (NSE), Environmental Quality Standards for Surface Water (Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (µg/L) – Fresh Water

9 LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by SNC-Lavalin Inc (SNCL) for Halifax Regional Municipality (HRM), hereafter referred to as the “Client”. It is intended for the sole and exclusive use of Halifax Regional Municipality.

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Appendix A

Laboratory Certificate of Analysis

AGAT Laboratories

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME:	SNC Lavalin Inc. 5657 SPRING GARDEN RD, SUITE 200 HALIFAX , NS B3J3R4 (902) 492-4544
ATTENTION TO:	Crysta Cumming
PROJECT:	631477
AGAT WORK ORDER:	16X095138
WATER ANALYSIS REVIEWED BY:	Laura Baker, Inorganics Data Reporter
DATE REPORTED:	May 26, 2016
PAGES (INCLUDING COVER):	12
VERSION*:	1

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 16X095138
PROJECT: 631477

CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:

ATTENTION TO: Crysta Cumming
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-05-16

DATE REPORTED: 2016-05-26

			SAMPLE DESCRIPTION:	KL-1	KL-2	KL-3	KL-4	KL-5	HWY 102-1		HWY 102-2
			SAMPLE TYPE:	Water	Water	Water	Water	Water	Water		Water
			DATE SAMPLED:	5/16/2016	5/16/2016	5/16/2016	5/16/2016	5/16/2016	5/16/2016		5/16/2016
Parameter	Unit	G / S	RDL	7558541	7558546	7558554	7558562	7558580	7558589	RDL	7558600
Alkalinity	mg/L		5	5	<5	<5	<5	<5	14	5	13
Chloride	mg/L		1	55	17	54	54	54	71	1	236
True Color	TCU		5	31	47	29	25	27	23	5	14
Nitrate + Nitrite as N	mg/L		0.05	0.10	<0.05	0.14	0.15	0.14	0.05	0.05	0.21
Nitrate as N	mg/L		0.05	0.10	<0.05	0.14	0.15	0.14	0.05	0.05	<0.05
Nitrite as N	mg/L		0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.21
Ammonia as N	mg/L		0.03	0.05	0.05	0.06	0.06	0.06	0.06	0.03	0.14
Total Organic Carbon	mg/L		0.5	4.3	6.2	4.3	4.3	4.4	4.5	0.5	79.3
Ortho-Phosphate as P	mg/L		0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
pH				6.64	6.35	6.69	6.70	6.66	6.87		6.46
Total Calcium	mg/L		0.1	6.8	2.9	6.2	6.5	6.3	12.9	0.1	23.9
Total Magnesium	mg/L		0.1	1.1	0.7	1.0	1.0	1.0	1.7	0.1	3.2
Total Phosphorus	mg/L		0.002	0.024	0.009	0.008	0.007	0.004	0.005	0.004	0.222
Total Potassium	mg/L		0.1	0.7	0.9	0.7	0.7	0.7	1.4	0.1	4.0
Total Sodium	mg/L		0.1	35.5	11.5	32.1	32.4	32.5	45.4	0.1	149
Reactive Silica as SiO2	mg/L		0.5	2.8	2.0	2.6	2.6	2.7	1.4	0.5	2.8
Total Suspended Solids	mg/L		5	38	<5	<5	7	<5	<5	5	342
Sulphate	mg/L		2	10	4	10	10	10	14	2	22
Turbidity	NTU		0.1	10.6	0.7	1.1	1.2	0.7	1.0	0.1	131
Electrical Conductivity	umho/cm		1	212	79	206	206	208	289	1	817
Anion Sum	me/L			1.87	0.56	1.74	1.74	1.74	2.58		7.39
Bicarb. Alkalinity (as CaCO3)	mg/L		5	5	<5	<5	<5	<5	14	5	13
Calculated TDS	mg/L		1	113	38	105	106	105	155	1	473
Carb. Alkalinity (as CaCO3)	mg/L		10	<10	<10	<10	<10	<10	<10	10	<10
Cation sum	me/L			2.03	0.76	1.83	1.86	1.86	2.81		9.27
Hardness	mg/L			21.5	10.1	19.6	20.3	19.8	39.2		72.9
% Difference/ Ion Balance (NS)	%			4.1	14.9	2.6	3.4	3.2	4.4		11.3
Langelier Index (@20C)	NA			-3.42	-4.04	-3.41	-3.38	-3.43	-2.48		-2.70
Langelier Index (@ 4C)	NA			-3.74	-4.36	-3.73	-3.70	-3.75	-2.80		-3.02
Saturation pH (@ 20C)	NA			10.1	10.4	10.1	10.1	10.1	9.35		9.16

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AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 16X095138
PROJECT: 631477

CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:

ATTENTION TO: Crysta Cumming
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-05-16

DATE REPORTED: 2016-05-26

			SAMPLE DESCRIPTION:	KL-1	KL-2	KL-3	KL-4	KL-5	HWY 102-1		HWY 102-2
			SAMPLE TYPE:	Water	Water	Water	Water	Water	Water		Water
			DATE SAMPLED:	5/16/2016	5/16/2016	5/16/2016	5/16/2016	5/16/2016	5/16/2016		5/16/2016
Parameter	Unit	G / S	RDL	7558541	7558546	7558554	7558562	7558580	7558589	RDL	7558600
Saturation pH (@ 4C)	NA			10.4	10.7	10.4	10.4	10.4	9.67		9.48
Total Aluminum	ug/L		5	206	187	163	172	163	81	5	3880
Total Antimony	ug/L		2	<2	<2	<2	<2	<2	<2	2	<2
Total Arsenic	ug/L		2	<2	<2	<2	<2	<2	<2	2	3
Total Barium	ug/L		5	14	10	15	16	14	79	5	762
Total Beryllium	ug/L		2	<2	<2	<2	<2	<2	<2	2	<2
Total Bismuth	ug/L		2	<2	<2	<2	<2	<2	<2	2	<2
Total Boron	ug/L		5	8	9	8	7	7	10	5	9
Total Cadmium	ug/L		0.017	0.029	<0.017	0.021	0.024	0.024	<0.017	0.017	0.778
Total Chromium	ug/L		1	<1	1	<1	<1	<1	<1	1	8
Total Cobalt	ug/L		1	<1	<1	<1	<1	<1	<1	1	4
Total Copper	ug/L		1	<1	<1	2	1	<1	<1	1	13
Total Iron	ug/L		50	149	232	112	122	96	144	50	21300
Total Lead	ug/L		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	39.7
Total Manganese	ug/L		2	47	21	31	34	23	19	2	586
Total Molybdenum	ug/L		2	<2	<2	<2	<2	<2	<2	2	<2
Total Nickel	ug/L		2	3	<2	2	2	3	<2	2	8
Total Selenium	ug/L		1	<1	<1	<1	<1	<1	<1	1	<1
Total Silver	ug/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
Total Strontium	ug/L		5	30	12	28	28	28	58	5	96
Total Thallium	ug/L		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
Total Tin	ug/L		2	<2	<2	<2	<2	<2	<2	2	<2
Total Titanium	ug/L		2	2	<2	<2	<2	<2	<2	2	41
Total Uranium	ug/L		0.1	0.1	<0.1	<0.1	0.1	0.1	<0.1	0.1	0.2
Total Vanadium	ug/L		2	<2	<2	<2	<2	<2	<2	2	18
Total Zinc	ug/L		5	11	<5	7	7	10	<5	5	170
Total Coliforms (MPN)	MPN/100 mL		1	866	>2420	548	488	179	>2420	1	>2420
E. Coli (MPN)	MPN/100 mL		1	4	4	2	2	<1	<1	1	1
Chlorophyll A - Acidification Method	ug/L		0.05	2.76	0.30	1.63	1.62	1.52	0.94	0.05	539.78

Certified By: ORIGINAL SIGNED

Certificate of Analysis

AGAT WORK ORDER: 16X095138
PROJECT: 631477

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Dartmouth, Nova Scotia
CANADA B3B 1M2
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FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:
ATTENTION TO: Crysta Cumming
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-05-16
DATE REPORTED: 2016-05-26

			SAMPLE DESCRIPTION:	KL-1	KL-2	KL-3	KL-4	KL-5	HWY 102-1		HWY 102-2
			SAMPLE TYPE:	Water	Water	Water	Water	Water	Water		Water
			DATE SAMPLED:	5/16/2016	5/16/2016	5/16/2016	5/16/2016	5/16/2016	5/16/2016		5/16/2016
Parameter	Unit	G / S	RDL	7558541	7558546	7558554	7558562	7558580	7558589	RDL	7558600
Chlorophyll A - Welschmeyer Method	ug/L		0.05	3.48	0.43	2.00	2.09	1.86	1.30	0.05	793.90
Total Kjeldahl Nitrogen as N	mg/L		0.4	0.7	0.4	<0.4	<0.4	0.5	0.7	0.4	24.3

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Certificate of Analysis

AGAT WORK ORDER: 16X095138
PROJECT: 631477

CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:

ATTENTION TO: Crysta Cumming
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-05-16

DATE REPORTED: 2016-05-26

		SAMPLE DESCRIPTION:		LSD		LU		PML-1		PML-2
		SAMPLE TYPE:		Water		Water		Water		Water
		DATE SAMPLED:		5/16/2016		5/16/2016		5/16/2016		5/16/2016
Parameter	Unit	G / S	RDL	7558610	RDL	7558618	RDL	7558626	RDL	7558634
Alkalinity	mg/L		5	11	5	13	5	<5	5	7
Chloride	mg/L		1	39	1	154	1	59	1	67
True Color	TCU		5	25	5	17	5	18	5	22
Nitrate + Nitrite as N	mg/L		0.05	0.08	0.05	1.01	0.05	0.19	0.05	0.10
Nitrate as N	mg/L		0.05	0.08	0.05	1.01	0.05	0.19	0.05	0.10
Nitrite as N	mg/L		0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05
Ammonia as N	mg/L		0.03	0.06	0.03	0.05	0.03	0.06	0.03	0.05
Total Organic Carbon	mg/L		0.5	5.5	0.5	3.9	0.5	7.1	0.5	4.0
Ortho-Phosphate as P	mg/L		0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
pH				6.75		6.94		6.36		6.83
Total Calcium	mg/L		0.1	6.6	0.1	20.6	0.1	7.9	0.1	8.9
Total Magnesium	mg/L		0.1	1.4	0.1	2.9	0.1	1.5	0.1	1.2
Total Phosphorus	mg/L		0.02	1.25	0.002	0.029	0.004	0.173	0.002	0.012
Total Potassium	mg/L		0.1	1.2	0.1	2.8	0.1	1.0	0.1	1.0
Total Sodium	mg/L		0.1	25.1	0.1	96.4	0.1	37.6	0.1	42.9
Reactive Silica as SiO2	mg/L		0.5	1.6	0.5	4.2	0.5	2.5	0.5	2.3
Total Suspended Solids	mg/L		5	93	5	29	5	531	5	45
Sulphate	mg/L		2	5	2	28	2	11	2	12
Turbidity	NTU		0.1	65.3	0.1	15.8	0.1	199	0.1	9.4
Electrical Conductivity	umho/cm		1	160	1	582	1	224	1	263
Anion Sum	me/L			1.43		5.26		1.91		2.29
Bicarb. Alkalinity (as CaCO3)	mg/L		5	11	5	13	5	<5	5	7
Calculated TDS	mg/L		1	91	1	321	1	141	1	139
Carb. Alkalinity (as CaCO3)	mg/L		10	<10	10	<10	10	<10	10	<10
Cation sum	me/L			1.94		5.78		3.54		2.53
Hardness	mg/L			22.2		63.4		25.9		27.2
% Difference/ Ion Balance (NS)	%			15.2		4.7		30.0		5.1
Langelier Index (@20C)	NA			-2.97		-2.27		-3.65		-2.98
Langelier Index (@ 4C)	NA			-3.29		-2.59		-3.97		-3.30
Saturation pH (@ 20C)	NA			9.72		9.21		10.0		9.81

Certified By: ORIGINAL SIGNED

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Certificate of Analysis

AGAT WORK ORDER: 16X095138
PROJECT: 631477

CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:

ATTENTION TO: Crysta Cumming
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-05-16

DATE REPORTED: 2016-05-26

			SAMPLE DESCRIPTION:	LSD		LU		PML-1		PML-2
			SAMPLE TYPE:	Water		Water		Water		Water
			DATE SAMPLED:	5/16/2016		5/16/2016		5/16/2016		5/16/2016
Parameter	Unit	G / S	RDL	7558610	RDL	7558618	RDL	7558626	RDL	7558634
Saturation pH (@ 4C)	NA			10.0		9.53		10.3		10.1
Total Aluminum	ug/L		5	2150	5	1420	5	7690	5	610
Total Antimony	ug/L		2	<2	2	<2	2	<2	2	<2
Total Arsenic	ug/L		2	<2	2	<2	2	4	2	<2
Total Barium	ug/L		5	34	5	127	5	60	5	35
Total Beryllium	ug/L		2	<2	2	<2	2	<2	2	<2
Total Bismuth	ug/L		2	<2	2	<2	2	<2	2	<2
Total Boron	ug/L		5	12	5	14	5	10	5	8
Total Cadmium	ug/L		0.017	0.120	0.017	0.426	0.017	0.227	0.017	0.042
Total Chromium	ug/L		1	2	1	3	1	6	1	<1
Total Cobalt	ug/L		1	4	1	2	1	6	1	<1
Total Copper	ug/L		1	3	1	10	1	10	1	<1
Total Iron	ug/L		50	2790	50	1940	50	13600	50	647
Total Lead	ug/L		0.5	4.3	0.5	3.4	0.5	13.9	0.5	1.1
Total Manganese	ug/L		2	921	2	444	2	424	2	109
Total Molybdenum	ug/L		2	<2	2	<2	2	<2	2	<2
Total Nickel	ug/L		2	2	2	3	2	7	2	<2
Total Selenium	ug/L		1	<1	1	<1	1	1	1	<1
Total Silver	ug/L		0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1
Total Strontium	ug/L		5	29	5	89	5	40	5	38
Total Thallium	ug/L		0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1
Total Tin	ug/L		2	<2	2	<2	2	<2	2	<2
Total Titanium	ug/L		2	30	2	31	2	106	2	7
Total Uranium	ug/L		0.1	0.2	0.1	0.2	0.1	0.9	0.1	<0.1
Total Vanadium	ug/L		2	4	2	4	2	16	2	<2
Total Zinc	ug/L		5	17	5	64	5	34	5	7
Total Coliforms (MPN)	MPN/100 mL		1	>2420	1	>2420	1	>2420	1	687
E. Coli (MPN)	MPN/100 mL		1	9	1	<1	1	>2420	1	4
Chlorophyll A - Acidification Method	ug/L		0.05	8.22	0.05	5.43	0.05	8.00	0.05	3.82

Certified By: ORIGINAL SIGNED

Certificate of Analysis

AGAT WORK ORDER: 16X095138
PROJECT: 631477

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CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:

ATTENTION TO: Crysta Cumming
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-05-16

DATE REPORTED: 2016-05-26

			SAMPLE DESCRIPTION:	LSD		LU		PML-1		PML-2
			SAMPLE TYPE:	Water		Water		Water		Water
			DATE SAMPLED:	5/16/2016		5/16/2016		5/16/2016		5/16/2016
Parameter	Unit	G / S	RDL	7558610	RDL	7558618	RDL	7558626	RDL	7558634
Chlorophyll A - Welschmeyer Method	ug/L		0.05	13.77	0.05	6.73	0.05	12.31	0.05	5.04
Total Kjeldahl Nitrogen as N	mg/L		0.4	2.2	0.4	1.2	0.4	2.6	0.4	0.6

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

7558541-7558634 Total Phosphorus was analysed at AGAT Mississauga.
Chlorophyll A was analysed by a sub-contracted laboratory.
TOC was analysed at AGAT Montreal.

Certified By: Original Signed

Quality Assurance

CLIENT NAME: SNC Lavalin Inc.
PROJECT: 631477
SAMPLING SITE:

AGAT WORK ORDER: 16X095138
ATTENTION TO: Crysta Cumming
SAMPLED BY:

Water Analysis

RPT Date: May 26, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
SNC-Lavalin Bedford West Custom Inorganics Package															
Alkalinity	7557780		9	8	NA	< 5	103%	80%	120%	NA	80%	120%	NA	80%	120%
Chloride	7558900		26	27	4.3%	< 1	97%	80%	120%	NA	80%	120%	NA	80%	120%
True Color	1	7559740	25	23	NA	< 5	100%	80%	120%		80%	120%		80%	120%
Nitrate + Nitrite as N	1					< 0.05		80%	120%		80%	120%		80%	120%
Nitrate as N	7558900		0.64	0.66	3.5%	< 0.05	90%	80%	120%	NA	80%	120%	NA	80%	120%
Nitrite as N	7558900		<0.05	<0.05	NA	< 0.05	95%	80%	120%	NA	80%	120%	105%	80%	120%
Ammonia as N	1	7559601	0.07	0.07	NA	< 0.03	104%	80%	120%		80%	120%	106%	80%	120%
Total Organic Carbon	7558541	7558541	4.3	4.3	0.0%	< 0.5	97%	80%	120%	96%	80%	120%	98%	80%	120%
Ortho-Phosphate as P	1	7559688	<0.01	<0.01	NA	< 0.01	99%	80%	120%		80%	120%	103%	80%	120%
pH	7557780		6.34	6.26	1.3%	<	101%	80%	120%	NA	80%	120%	NA	80%	120%
Total Calcium	5172016		21.9	22.8	4.0%	< 0.1	103%	80%	120%	100%	80%	120%	102%	70%	130%
Total Magnesium	5172016		3.02	3.15	4.2%	< 0.1	100%	80%	120%	99%	80%	120%	107%	80%	120%
Total Phosphorus	7559134		0.017	0.018	5.7%	< 0.002	106%	90%	110%	102%	90%	110%	103%	80%	120%
Total Potassium	5172016		1.3	1.3	0.0%	< 0.1	100%	80%	120%	96%	80%	120%	98%	70%	130%
Total Sodium	5172016		14.2	14.8	4.1%	< 0.1	101%	80%	120%	101%	80%	120%	102%	70%	130%
Reactive Silica as SiO2	1	7559688	2.6	2.3	NA	< 0.5	112%	80%	120%		80%	120%	98%	80%	120%
Total Suspended Solids	1	7556067	<5	<5	0.0%	< 5	96%	80%	120%		120%	120%	96%	80%	120%
Sulphate	7558900		26	27	3.7%	< 2	108%	80%	120%	NA	80%	120%	NA	80%	120%
Turbidity	1	7559734	0.8	0.8	0.0%	< 0.1	102%	80%	120%		80%	120%		80%	120%
Electrical Conductivity	7557780		97	96	0.6%	< 1	99%	80%	120%	NA	80%	120%	NA	80%	120%
Anion Sum	1					<									
Bicarb. Alkalinity (as CaCO3)	7557780		9	8	NA	< 5	NA	80%	120%	NA	80%	120%	NA	80%	120%
Calculated TDS	1					< 1									
Carb. Alkalinity (as CaCO3)	7557780		<10	<10	NA	< 10	NA	80%	120%	NA	80%	120%	NA	80%	120%
Cation sum	1					<									
Hardness	1					<		100%	100%		100%	100%		100%	100%
% Difference/ Ion Balance (NS)	1					<									
Langelier Index (@20C)	1					<									
Langelier Index (@ 4C)	1					<									
Saturation pH (@ 20C)	1					<									
Saturation pH (@ 4C)	1					<									
Total Aluminum	5172016		11	13	16.7%	< 5	103%	80%	120%	101%	80%	120%	104%	70%	130%
Total Antimony	5172016		< 2	< 2	0.0%	< 2	81%	80%	120%	103%	80%	120%	97%	70%	130%
Total Arsenic	5172016		3	3	0.0%	< 2	98%	80%	120%	98%	80%	120%	98%	70%	130%
Total Barium	5172016		37	37	0.0%	< 5	99%	80%	120%	94%	80%	120%	93%	70%	130%
Total Beryllium	5172016		< 2	< 2	0.0%	< 2	110%	80%	120%	107%	80%	120%	105%	70%	130%
Total Bismuth	5172016		< 2	< 2	0.0%	< 2	98%	80%	120%	94%	80%	120%	96%	70%	130%
Total Boron	5172016		48	48	0.0%	< 5	111%	80%	120%	105%	80%	120%	109%	70%	130%
Total Cadmium	5172016		< 0.017	< 0.017	0.0%	< 0.017	100%	80%	120%	98%	80%	120%	96%	70%	130%

Quality Assurance

CLIENT NAME: SNC Lavalin Inc.
PROJECT: 631477
SAMPLING SITE:

AGAT WORK ORDER: 16X095138
ATTENTION TO: Crysta Cumming
SAMPLED BY:

Water Analysis (Continued)

RPT Date: May 26, 2016			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Total Chromium	5172016		< 1	< 1	0.0%	< 1	82%	80%	120%	81%	80%	120%	79%	70%	130%
Total Cobalt	5172016		< 1	< 1	0.0%	< 1	88%	80%	120%	84%	80%	120%	85%	70%	130%
Total Copper	5172016		17	20	16.2%	< 1	86%	80%	120%	88%	80%	120%	114%	70%	130%
Total Iron	5172016		64	53	18.8%	< 50	83%	80%	120%	88%	80%	120%	81%	70%	130%
Total Lead	5172016		1.70	1.75	2.9%	< 0.5	97%	80%	120%	95%	80%	120%	96%	70%	130%
Total Manganese	5172016		18	18	0.0%	< 2	109%	80%	120%	108%	80%	120%	117%	70%	130%
Total Molybdenum	5172016		< 2	< 2	0.0%	< 2	93%	80%	120%	92%	80%	120%	97%	70%	130%
Total Nickel	5172016		< 2	< 2	0.0%	< 2	90%	80%	120%	85%	80%	120%	85%	70%	130%
Total Selenium	5172016		< 1	< 1	0.0%	< 1	98%	80%	120%	101%	80%	120%	98%	70%	130%
Total Silver	5172016		< 0.1	< 0.1	0.0%	< 0.1	103%	80%	120%	100%	80%	120%	100%	70%	130%
Total Strontium	5172016		111	112	0.9%	< 5	93%	80%	120%	91%	80%	120%	109%	70%	130%
Total Thallium	5172016		< 0.1	< 0.1	0.0%	< 0.1	100%	80%	120%	97%	80%	120%	97%	70%	130%
Total Tin	5172016		< 2	< 2	0.0%	< 2	95%	80%	120%	98%	80%	120%	100%	70%	130%
Total Titanium	5172016		< 2	< 2	0.0%	< 2	102%	80%	120%	101%	80%	120%	106%	70%	130%
Total Uranium	5172016		1.6	1.6	0.0%	< 0.1	97%	80%	120%	94%	80%	120%	100%	70%	130%
Total Vanadium	5172016		< 2	< 2	0.0%	< 2	83%	80%	120%	80%	80%	120%	82%	70%	130%
Total Zinc	5172016		10	9	10.5%	< 5	91%	80%	120%	86%	80%	120%	84%	70%	130%
Total Coliforms (MPN)	1					< 1									
E. Coli (MPN)	1					< 1									
Chlorophyll A - Acidification Method	1					< 0.05		100%	100%		100%	100%		100%	100%
Chlorophyll A - Welschmeyer Method	1					< 0.05		100%	100%		100%	100%		100%	100%
Total Kjeldahl Nitrogen as N	1	7559212	0.6	0.6	NA	< 0.4	99%	80%	120%		80%	120%	108%	80%	120%

Comments: If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

SNC-Lavalin Bedford West Custom Inorganics Package

PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Lower	Upper	Recovery	Lower	Upper	Recovery	Lower	Upper
Alkalinity	7558610	7558610	11	11	NA	< 5	104%	80%	120%	NA	80%	120%	NA	80%	120%
pH	7558610	7558610	6.75	6.75	0%	<	101%	80%	120%	NA	80%	120%	NA	80%	120%
Electrical Conductivity	7558610	7558610	160	161	0.2%	< 1	97%	80%	120%	NA	80%	120%	NA	80%	120%
Bicarb. Alkalinity (as CaCO3)	7558610	7558610	11	11	NA	< 5	NA	80%	120%	NA	80%	120%	NA	80%	120%
Carb. Alkalinity (as CaCO3)	7558610	7558610	<10	<10	NA	< 10	NA	80%	120%	NA	80%	120%	NA	80%	120%

Comments: If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By: original Signed

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

Method Summary

CLIENT NAME: SNC Lavalin Inc.
PROJECT: 631477
SAMPLING SITE:

AGAT WORK ORDER: 16X095138
ATTENTION TO: Crysta Cumming
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Alkalinity	INORG-121-6001	SM 2320 B	PC-TITRATE
Chloride	INORG-121-6005	SM 4110 B	IC
True Color	INORG-121-6014	EPA 110.2	NEPHELOMETER
Nitrate + Nitrite as N	INORG-121-6005	SM 4110 B	CALCULATION
Nitrate as N	INORG-121-6005	SM 4110 B	IC
Nitrite as N	INORG-121-6005	SM 4110 B	IC
Ammonia as N	INORG-121-6003	SM 4500-NH3 G	COLORIMETER
Total Organic Carbon	INORG-121-6026	SM 5310 B	TOC ANALYZER
Ortho-Phosphate as P	INORG-121-6005	SM 4110 B	COLORIMETER
pH	INOR-121-6001	SM 4500 H+B	PC-TITRATE
Total Calcium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Magnesium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Phosphorus	INOR-93-1022	SM 4500-P B & E	SPECTROPHOTOMETER
Total Potassium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Sodium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Reactive Silica as SiO2	INORG-121-6028	SM 4110 B	COLORIMETER
Total Suspended Solids	INOR-121-6024, 6025	SM 2540C, D	GRAVIMETRIC
Sulphate	INORG-121-6005	SM 4110 B	IC
Turbidity	INORG-121-6022	SM 2130 B	NEPHELOMETER
Electrical Conductivity	INOR-121-6001	SM 2510 B	PC-TITRATE
Anion Sum	CALCULATION	SM 1030E	CALCULATION
Bicarb. Alkalinity (as CaCO3)	INORG-121-6001	SM 2320 B	PC-TITRATE
Calculated TDS		SM 1030E	CALCULATION
Carb. Alkalinity (as CaCO3)	INORG-121-6001	SM 2320 B	PC-TITRATE
Cation sum	CALCULATION	SM 1030E	CALCULATION
Hardness	CALCULATION	SM 2340B	CALCULATION
% Difference/ Ion Balance (NS)	CALCULATION	SM 1030E	CALCULATION
Langelier Index (@20C)	CALCULATION	CALCULATION	CALCULATION
Langelier Index (@ 4C)	CALCULATION	CALCULATION	CALCULATION
Saturation pH (@ 20C)	CALCULATION	CALCULATION	CALCULATION
Saturation pH (@ 4C)	CALCULATION	CALCULATION	CALCULATION
Total Aluminum	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Antimony	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Arsenic	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Barium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Beryllium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Bismuth	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Boron	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Cadmium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS

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Method Summary

CLIENT NAME: SNC Lavalin Inc.
AGAT WORK ORDER: 16X095138
PROJECT: 631477
ATTENTION TO: Crysta Cumming
SAMPLING SITE:
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Total Chromium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Cobalt	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Copper	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Iron	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Lead	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Manganese	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Molybdenum	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Nickel	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Selenium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Silver	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Strontium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Thallium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Tin	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Titanium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Uranium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Vanadium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Zinc	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Coliforms (MPN)	MIC-121-7000	Based on SM 9223B	INCUBATOR
E. Coli (MPN)	MIC-121-7000	Based on SM 9223B	INCUBATOR
Chlorophyll A - Acidification Method	Subcontracted	Subcontracted	
Chlorophyll A - Welschmeyer Method	Subcontracted	Subcontracted	ICP-MS
Total Kjeldahl Nitrogen as N	INOR-121-6020	SM 4500 NORG D	COLORIMETER

Dalhousie University
Department of Oceanography
Halifax, N.S.
B3H 4R2

19-May-16 AGAT Laboratories, 11 Morris Dr. Unit 122, Dartmouth, NS, B3B 1M2

Attention: Janetta Fraser
Re: Determination of chlorophyll a in algae by fluorescence

AGAT Job#: 16X095138
PO#: 98250

Acidification Technique:

Sample ID	Chl a (µg/L)
KL-1	2.76
KL-2	0.30
KL-3	1.63
KL-4	1.62
KL-5	1.52
HWY 102-1	0.94
HWY 102-2	539.78
LSD	8.22
LU	5.43
PML-1	8.00
PML-2	3.82

Welschmeyer Technique:

Sample ID	Chl a (µg/L)
KL-1	3.48
KL-2	0.43
KL-3	2.00
KL-4	2.09
KL-5	1.86
HWY 102-1	1.30
HWY 102-2	793.90

LSD	13.77
LU	6.73
PML-1	12.31
PML-2	5.04

- **CHl a = chlorophyll a**
- **An underestimation of chl a occurs by the fluorescence acidification technique in the presence of Chl b. Since chl b containing chlorophytes are often present in freshwater ecosystems another technique (welschmeyer) was also employed.**
- **Reference for Welschmeyer technique Limnol. Oceanogr., 39(8) 1994, 1985-1992**

Received: 17-May-16
Completed: 18-May-16

Original Signed

Shannah Rastin

AGAT Laboratories

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www.agatlabs.com

Laboratory use Only
Arrival Condition: ☐ Good ☐ Poor (complete 'notes')
Arrival Temperature: 13°
AGAT Job Number: 16X095138
Notes:

Drinking Water Sample (y/n): Reg. No.
Waterworks Number:

Report To:
Company: SNC Lavalin
Contact: Crysta Cumming
Address: 5657 Spring Garden Road
Halifax, NS B3J 3R4
Phone: 902-492-4544 FAX:
PO#:
AGAT Quotation: 15-1718
Client Project #: 631477

Invoice to: Same (Y/N) - Circle
Company: SNC Lavalin
Contact: payables@snclavalin.com
Address:
Phone: Fax:
PO#/Credit Card #:

Report Information
1. Name: Crysta Cumming
Email:
2. Name: Ryan Flinn/Maria Gutierrez
Email:

Report Format
☐ Single PDF sample per page
☐ Multiple PDF samples per page
☐ Excel Format Included

Turnaround Time (TAT) Business Days
Regular TAT:
■ 5 - 7 days
Rush TAT:
☐ 1 day ☐ 2 days
☐ 3 - 4 days
Date Required:
Time Required:

Regulatory Requirements (Check):
☐ List Guidelines on Report ☐ Do Not List Guidelines on Report
☐ PIRI
☐ Teir 1 ☐ Res.
☐ Teir 2 ☐ Com
☐ Gas ☐ Fuel ☐ Lube
Site Info (check all that apply):
☐ Pot ☐ Coarse
☐ N/Pot. ☐ Fine
☐ CCME ☐ CDWQ
☐ Ind ☐ NSDFOSP
☐ Com ☐ HRM 101
☐ Res/P Storm Water
☐ Ag ☐ HRM 101
☐ FWAL Waste Water
☐ Sediment
☐ Other

SAMPLE IDENTIFICATION	DATE / TIME SAMPLED	SAMPLE MATRIX	# OF CONTAINERS	COMMENTS - Site/Sample Info, Sample Containment	Field Filtered/ Preserved	Bedford West Inorganics	Metals (Spring Quarter Only)	(Circle-Total, Diss or Available)	Mercury	BOD	pH	TSS	TP (Low Level) - Mississauga	Anions	Total Phosphorus	Phenols	TPH/BTEX (PIRI) Teir 1	TPH/BTEX-Fractionation Teir 2	VOC	THM	PAH	Chlorophyll A- Dal	E. coli by MPN	Hazardous (Y/N)	Lab Sample #
KL-1	May 16/16 9:30	water	7			X	X					X	X									X	X		
KL-2 10:30 →	May 16/16 [illegible]	water	7			X	X					X	X									X	X		
KL-3	May 16/16 11:10	water	7			X	X					X	X									X	X		
KL-4	May 16/16 11:20	water	7			X	X					X	X									X	X		
KL-5	May 16/16 10:10	water	7			X	X					X	X									X	X		
HWY 102-1 2:30 →	May 16/16 0945	water	7			X	X					X	X									X	X		
HWY 102-2	May 16/16 12:50	water	7			X	X					X	X									X	X		
LSD	May 16/16 3:10	water	7			X	X					X	X									X	X		
LU	May 16/16 12:40	water	7			X	X					X	X									X	X		
PML-1	May 16/16 1:15	water	7			X	X					X	X									X	X		
PML-2	May 16/16 1:35	water	7			X	X					X	X									X	X		

SURFACE WATER

Sample Relinquished By (print name & sign): RYAN FLINN
Date/Time: May 16/16
Samples Received By (print name and sign): [redacted]
Date/Time: May 16/16

Sample Relinquished By (print name & sign): [redacted]
Date/Time: 15:55
Samples Received By (print name and sign): [redacted]
Date/Time: 18:35

Special Instructions
SNC Lavalin-Bedford West Spring Package
Page of

Appendix B

Field Reports Spring 2016

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Kearney Lake	**Site ID: KL1**	
Watercourse: Kearney Lake	**Location:** Kearney Lake Road	

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0445718E, 4948496N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	10
Cloud Cover :	50%
Wildlife Sightings:	Birds
Site Accessibility: Yes, Accessible	Off Kearney Lake Road
Site Access Detail:	Sample taken off the end of dock at Kearney Lake beach. Parked in public parking of Hamshaw Dr. and walked down to beach area.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	9:30
Sample Depth (m):	0.5m
pH:	8.29
Dissolved Oxygen (mg/L):	14.02
Secchi Depth (m):	1.8m – Could see disk on bottom (17.05.2016)
Water Temperature (degrees Celsius):	12.8
Conductivity (µs/cm):	239

Additional Comments / Notes

ORP: 125
NTU: 0.0
Calm water

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Kearney Lake	**Site ID: KL2**	
Watercourse: Kearney Lake	**Location:** Kearney Lake Road	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0443942E, 4949803N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	6
Cloud Cover:	50%
Wildlife Sightings:	Birds
Site Accessibility: Yes, Accessible	Off Colin’s Rd.
Site Access Detail:	Sample taken on the lake side of the culvert between residential buildings 20 and 28. Walked down rock to left of culvert. Note: Sample when standing downstream of bottle.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	10:30
Sample Depth (m):	0.4m
pH:	7.64
Dissolved Oxygen (mg/L):	7.88
Secchi Depth (m):	2.11m – Could see disk on bottom (17.05.2016)
Water Temperature (degrees Celsius):	10.73
Conductivity (µs/cm):	82

Additional Comments / Notes

ORP: 169
NTU: 0.0
Lots of downstream debris – sticks, branches, logs, part of an old wooden walkway

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Kearney Lake Run		**Site ID: KL3**
Watercourse: Kearney Lake Run		**Location:** Kearney Lake Road
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0444390E, 4950406N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	6
Cloud Cover:	40%
Wildlife Sightings:	Birds
Site Accessibility: Yes, Accessible	Off walking trail from Amesbury Gate Rd.
Site Access Detail:	Access to site is via a walking path clearly evident off of Amesbury Gate Rd. (off Larry Uteck Blvd.) roughly 205m down road on left. Walk down path, follow gravel walkway down hill and take sample at the low point facing the dam. Look for large rock outcrop on right.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	11:00
Sample Depth (m):	0.35m
pH:	7.4
Dissolved Oxygen (mg/L):	9.34
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	12.07
Conductivity (µs/cm):	213

Additional Comments / Notes

Increase in the amount of residential development
Calm water
ORP: 169
NTU: 20.5

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Kearney Lake Run	**Site ID: KL4**	
Watercourse: Kearney Lake Run	**Location:** Kearney Lake Road	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0444463E, 4950571N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	7
Cloud Cover:	40%
Wildlife Sightings:	Birds
Site Accessibility: Yes, Accessible	Via the extended road at the end of Weybridge Ln.
Site Access Detail:	If Weybridge, go to end of extended road on right and walk and take sample above the rocky area at the base of the wider, slow moving section of the river.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	11:30
Sample Depth (m):	0.4m
pH:	7.32
Dissolved Oxygen (mg/L):	8.27
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	12.23
Conductivity (µs/cm):	215

Additional Comments / Notes

ORP: 174
NTU: 20.1
Clear water

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 9
Client:	Halifax Regional Municipality	
Site: Kearney Lake		**Site ID: KL5**
Watercourse: Kearney Lake		**Location:** Kearney Lake Road

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 4949142E, 445280N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Cloudy with light showers
Air Temperature:	9 degrees
Cloud Cover:	100%
Wildlife Sightings:	Birds
Site Accessibility: Yes, Accessible	Along Kearney Lake Road
Site Access Detail:	Easily accessible, sample location is directly off the Kearney Lake Road on a rocky outcrop supporting a power line pole (two pole structure). Slow truck down carefully, turn hazard lights on. Samples were taken on left front of outcrop facing lake.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	10:00
Sample Depth (m):	0.4m
pH:	5.75
Dissolved Oxygen (mg/L):	10.47
Secchi Depth (m):	2.1m (17.05.2016)
Water Temperature (degrees Celsius):	12.22
Conductivity (µs/cm):	209

Additional Comments / Notes

ORP: 157
NTU: 16.7

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Highway 102	**Site ID: HWY 102-1**	
Watercourse: Marsh area	**Location:** Highway 102, south of exit 3	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0444708E, 4951644N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	10
Cloud Cover:	70%
Wildlife Sightings:	Birds/Waterbugs
Site Accessibility: Yes, Accessible	Off Highway 102 Park before guardrail.
Site Access Detail:	Carefully slow truck down while pulling off highway 102. Park truck with hazard lights on before the start of the guardrail. Walk along outside of guardrail (for approximately 150m). Site is on right fed by a swampy bog area. Samples were taken in front of culvert. There is a concrete pad to step on to take samples. Sample while standing downstream.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	14:30
Sample Depth (m):	0.4m
pH:	7.34
Dissolved Oxygen (mg/L):	8.18
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	13.82
Conductivity (µs/cm):	289

Additional Comments / Notes

A lot of garbage was observed surrounding the water quality sampling location.
Limited water flow.
ORP: 153
NTU: 19.7

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Highway 102	**Site ID: HWY 102-2**	
Watercourse: Marsh area	**Location:** HWY 102, south of exit 3	

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0444829E, 4951778N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	11
Cloud Cover:	20%
Wildlife Sightings:	Birds/waterbugs
Site Accessibility: Yes, Accessible	Off Highway 102 (Small gravel drive way- *Back in)
Site Access Detail:	Travel along Highway 102 toward Bedford NS. Site is on right easily to identify based on swamp/bog. Carefully slow truck down with hazard lights flashing. There is a small driveway to park truck. Pull a head of driveway and when lanes are clear back truck down into spot. Take samples in water body in front of culvert.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	12:50
Sample Depth (m):	0.35m
pH:	6.77
Dissolved Oxygen (mg/L):	5.86
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	13.41
Conductivity (µs/cm):	968

Additional Comments / Notes

ORP: 13
NTU: 231
No water flow observed.
Murky, algae covered water within the water quality sampling station.

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Lake Shore Drive		**Site ID: LSD**
Watercourse: Marsh @ Lakeshore Dr.		**Location:** Kingswood Subdivision

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0442583E, 4950431N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	11
Cloud Cover:	65%
Wildlife Sightings:	Birds/Fish
Site Accessibility: Yes, Accessible	Via Lakeshore Drive in Kingswood Subdivision
Site Access Detail:	Take Kingswood Drive off Hammonds Plains Road. Travel down to Diana Drive on left go to end and take a left on Lakeshore drive. Travel approximately 1.0 km. There will be a clearing on left down to power lines. Drive truck (4X4) down until larger clearing is reached and park. Continue (walk) down hill to ATV pathway on left. Follow pathway for approximately 250m. Sample location is on right (river with a lot of vegetation throughout)

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	15:00
Sample Depth (m):	0.35m
pH:	6.63
Dissolved Oxygen (mg/L):	8.22
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	13.17
Conductivity (µs/cm):	162

Additional Comments / Notes

NTU: 162
ORP: 69
Murky water with a lot of decomposition on the river bottom (leaves, sticks)
Limited water flow

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 9
Client:	Halifax Regional Municipality	
Site: Larry Uteck Blvd.		**Site ID: LU**
Watercourse: Pond		**Location:** Larry Uteck off-ramp

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0444954E, 4949891N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	10
Cloud Cover:	30%
Wildlife Sightings:	Birds/Waterbugs
Site Accessibility: Yes, Accessible	From Larry Uteck Blvd.
Site Access Detail:	Take Larry Uteck off ramp and continue down Larry Uteck Blvd. for approximately 320m. Park truck safely on grassy clearing on left. Sample location is at shore line of lake across road. Take walking pathway to wooded area and travel approximately 80m to lake shore. Avoid walking through the bog area on right.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	12:20
Sample Depth (m):	0.35m
pH:	7.17
Dissolved Oxygen (mg/L):	8.75
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	13.32
Conductivity (µs/cm):	588

Additional Comments / Notes

ORP: 168
Murky water
Small skim of algae in spots

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	

Site: Paper Mill Lake	**Site ID: PML1**
Watercourse: Paper Mill Lake	**Location:** Moirs Mill Subdivision

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0445129E, 4951154N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	10
Cloud Cover:	50%
Wildlife Sightings:	Birds/Waterbugs
Site Accessibility: Yes, Accessible	Via Ahmadi Crescent in Moirs Mill Subdivision

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	13:15
Sample Depth (m):	0.5m
pH:	7.57
Dissolved Oxygen (mg/L):	8.84
Secchi Depth (m):	2.65m (17.05.2016)
Water Temperature (degrees Celsius):	12.83
Conductivity (µs/cm):	231

Additional Comments / Notes

ORP: 102
NTU: 31.1
Windy conditions
Clear water

FIELD REPORT – MAY 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Paper Mill Lake	**Site ID: PML2**	
Watercourse: Paper Mill Lake	**Location:** Moirs Mill Subdivision	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0445363E, 4951740N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sun/cloud
Air Temperature:	11
Cloud Cover:	60%
Wildlife Sightings:	Birds
Site Accessibility: Yes, Accessible	Via Lake Dr., off Hammonds Plains Rd.

Field Parameter Data

	Remarks
Date (d.m.y):	16.05.2016
Time (hh:mm):	13:45
Sample Depth (m):	0.5m
pH:	7.57
Dissolved Oxygen (mg/L):	8.55
Secchi Depth (m):	2.7m (17.05.2016)
Water Temperature (degrees Celsius):	13.84
Conductivity (µs/cm):	264

Additional Comments / Notes

ORP: 125
NTU: 20.2
Clear water

Appendix C

Site Photographs Spring 2016

Photo 1: PML-1 Paper Mill Lake Sample Location

Photo 2: HWY 102-1 Sample Location

Photo 3: LU Larry Uteck Sample Location

Photo 4: KL4 Kearney Lake Sample Location

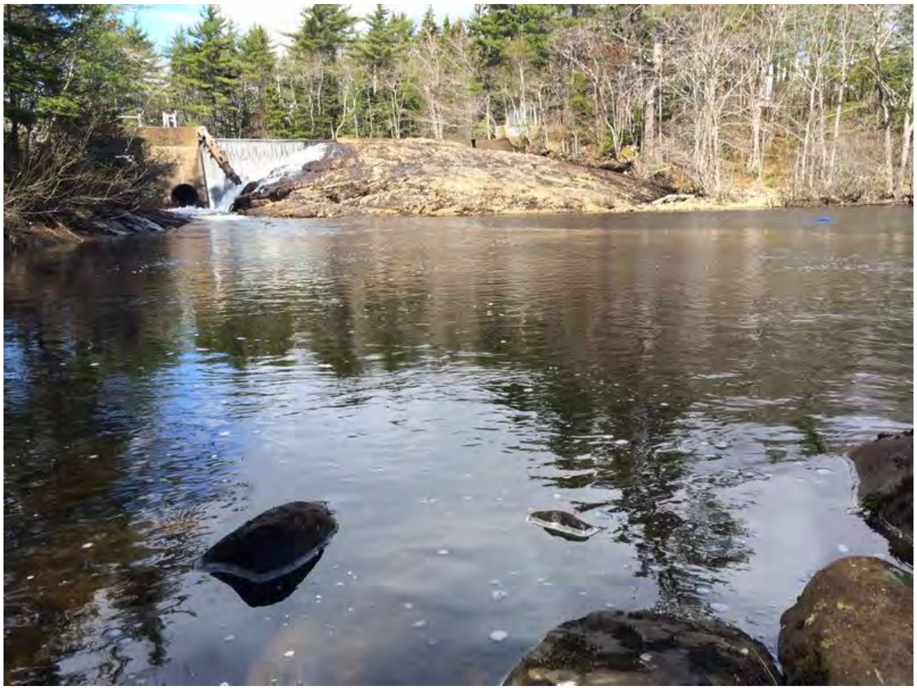


Photo 5: KL3 Kearney Lake Sample Location

Photo 6: KL5 Kearney Lake Sample Location

Photo 7: HWY102-2 Sample Location

Photo 8: KL1 Kearney Lake Sample Location

Photo 9: KL2 Kearney Lake Sample Location (lake side of culvert)

Photo 10: LSD Lake Shore Drive Sample Location

Photo 11: PML-2 Paper Mill Lake Sample Location

Appendix D

Graphs Spring 2016

Graphs were created showing concentrations from 2009 to 2016 for six (6) water quality parameters; dissolved chloride (mg/L), pH, total phosphorus (mg/L), total suspended solids (mg/L), conductivity (µS/cm) and chlorophyll A (µg/L) at each of the standard eleven (11) water quality sampling stations. This was done to allow for comparison between sites and identification of concentration increases.

As many parameters show seasonal concentration fluctuations, the data was also graphed showing only the concentrations for the current sampling season (i.e. spring sampling events). Where results were found to be less than the recordable detection limit (<RDL), they were graphed as half the recordable detection limit (1/2 RDL).

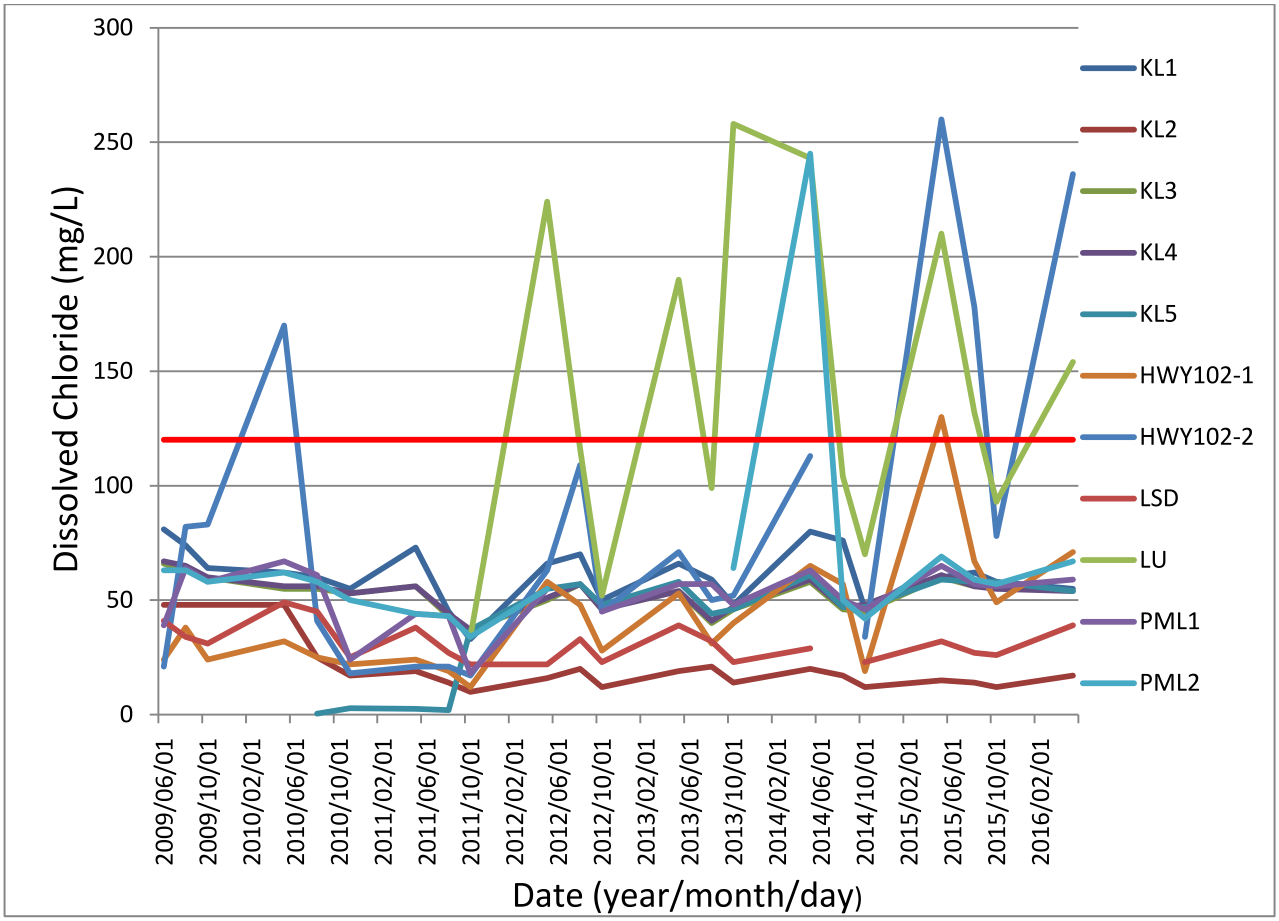


Figure 1 - Dissolved chloride concentrations

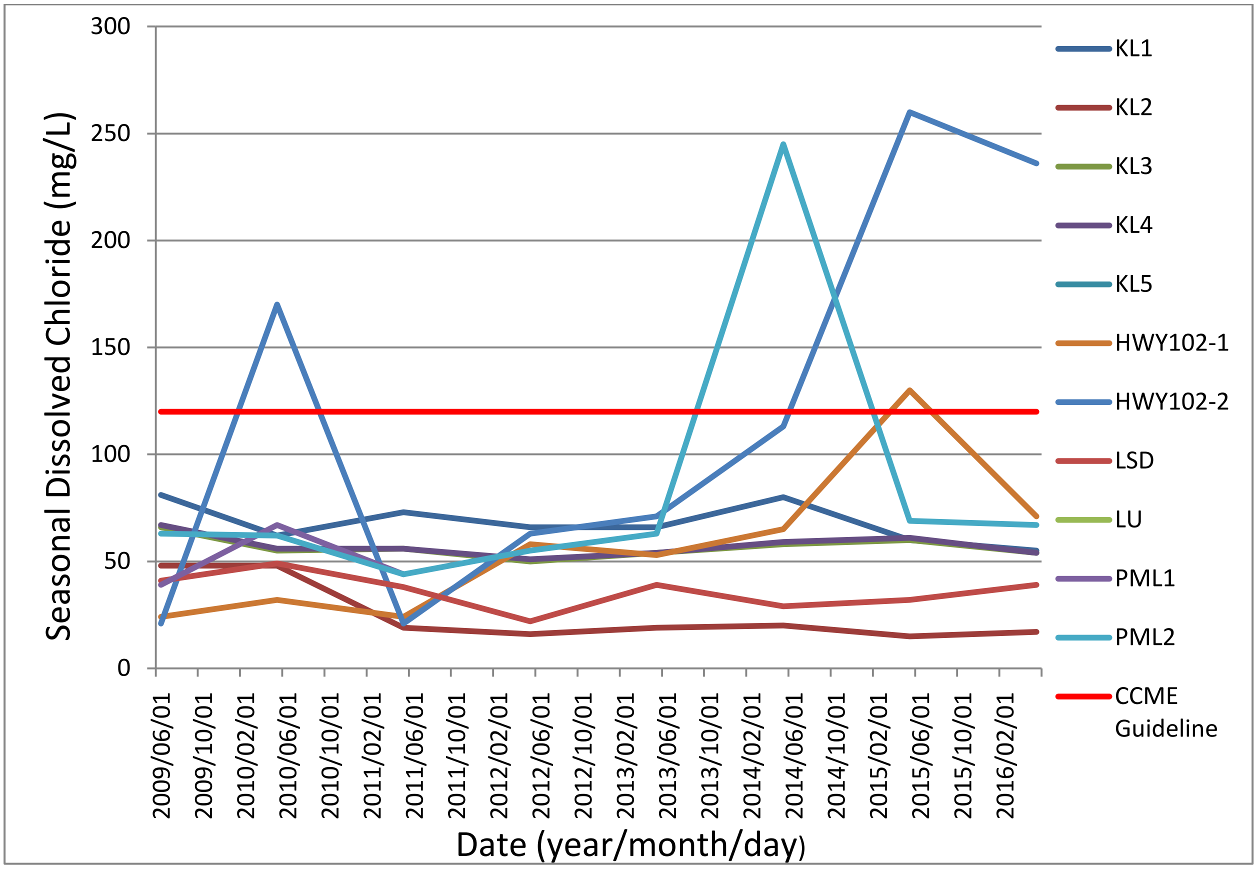


Figure 2 – Seasonal dissolved chloride concentrations

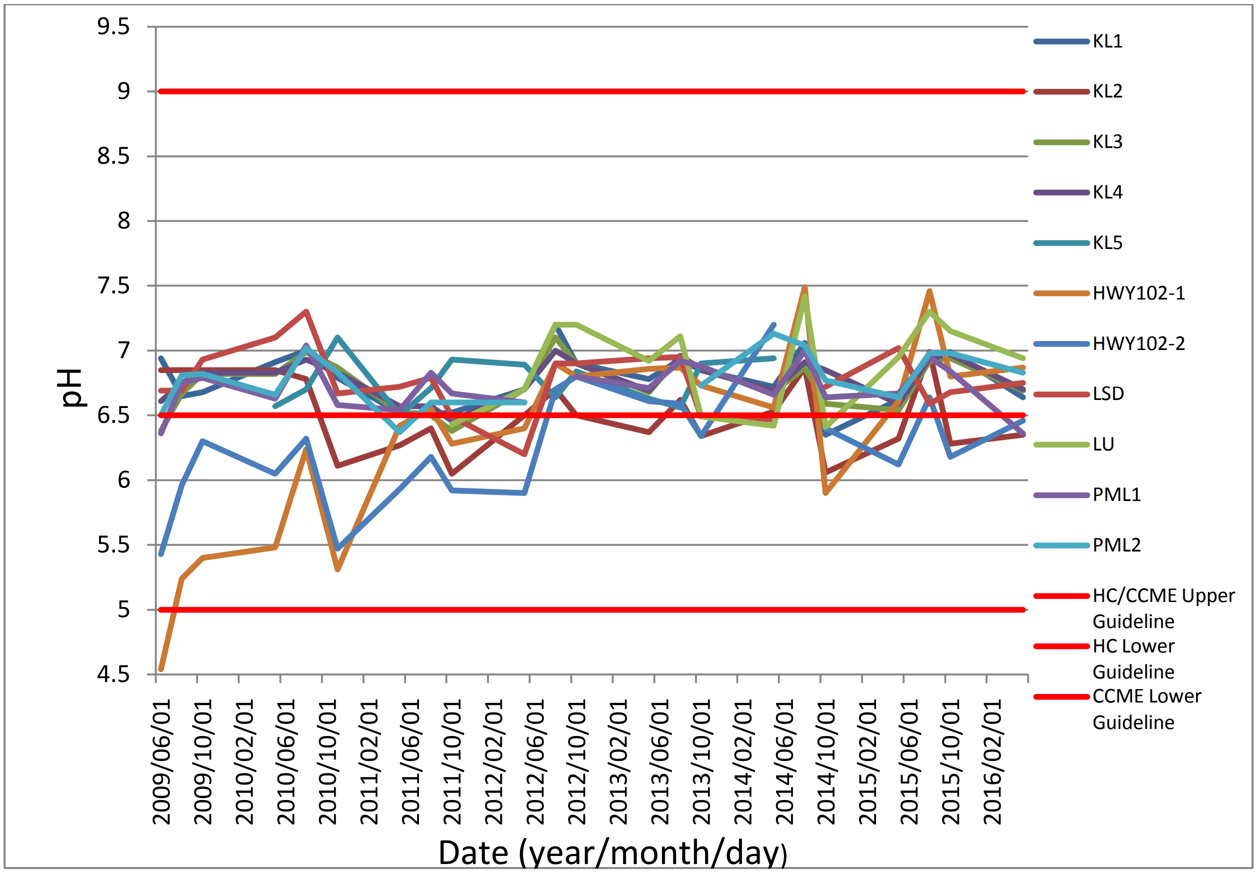

9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
pH
2009/06/01
2009/10/01
2010/02/01
2010/06/01
2010/10/01
2011/02/01
2011/06/01
2011/10/01
2012/02/01
2012/06/01
2012/10/01
2013/02/01
2013/06/01
2013/10/01
2014/02/01
2014/06/01
2014/10/01
2015/02/01
2015/06/01
2015/10/01
2016/02/01
Date (year/month/day)
KL1
KL2
KL3
KL4
KL5
HWY102-1
HWY102-2
LSD
LU
PML1
PML2
HC/CCME Upper Guideline
HC Lower Guideline
CCME Lower Guideline

Figure 3 – pH

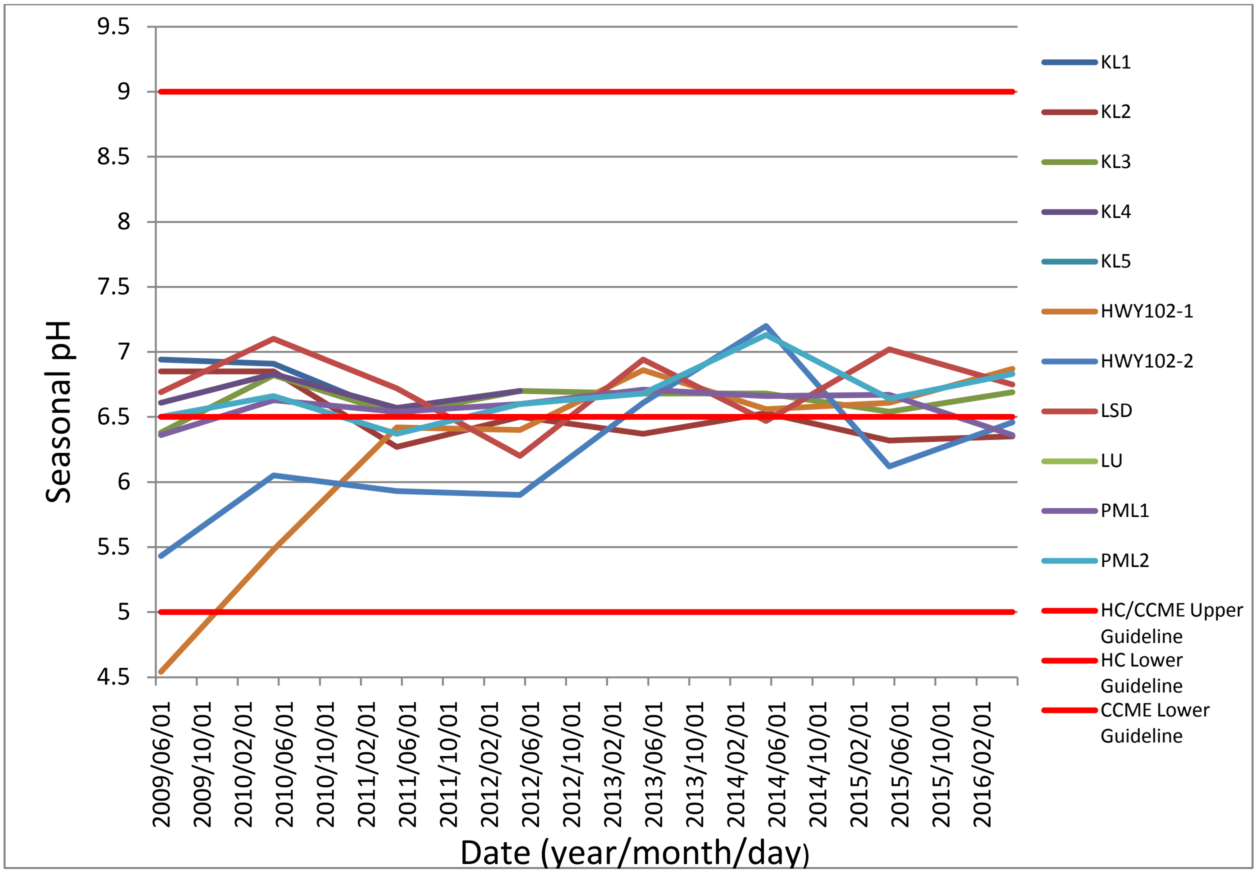


Figure 4 – Seasonal pH

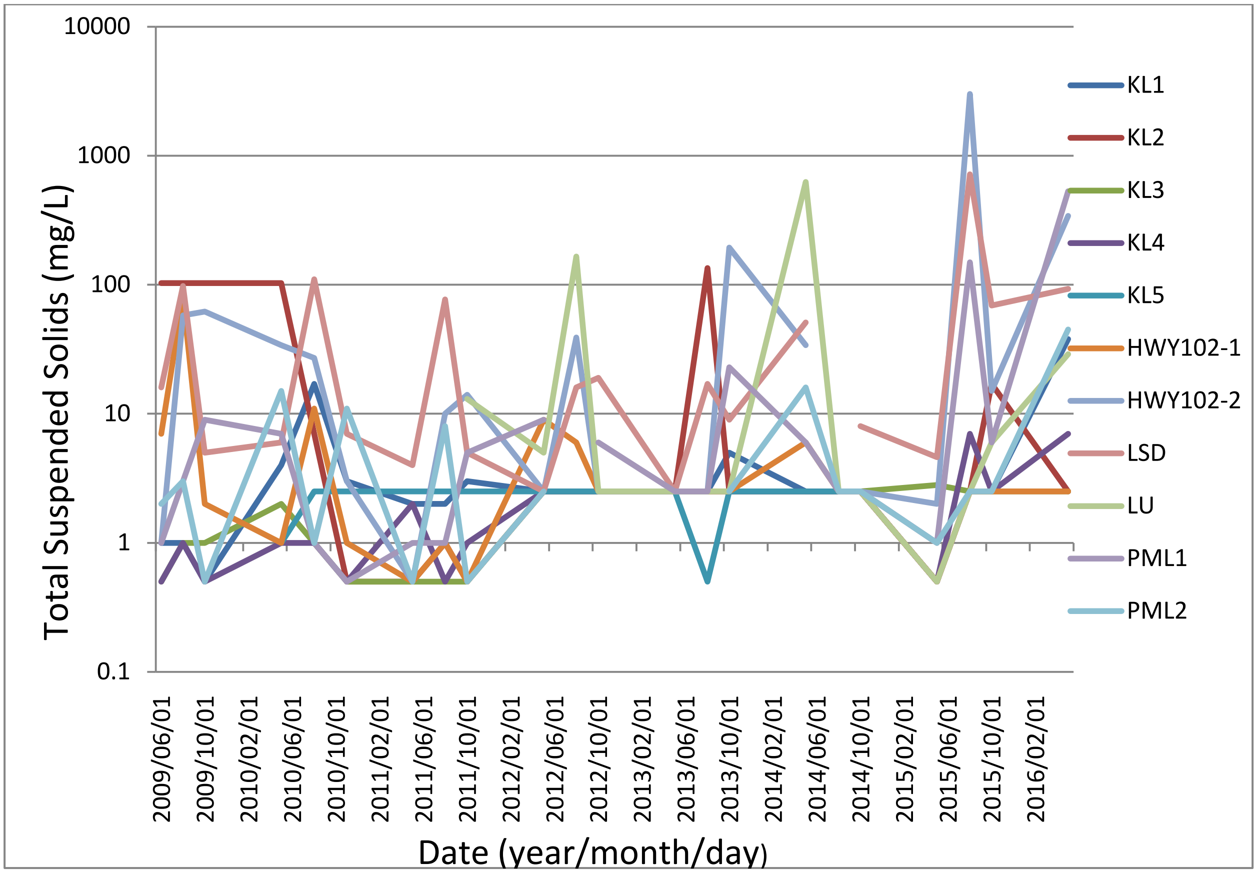


Figure 5 – Total suspended solids concentrations

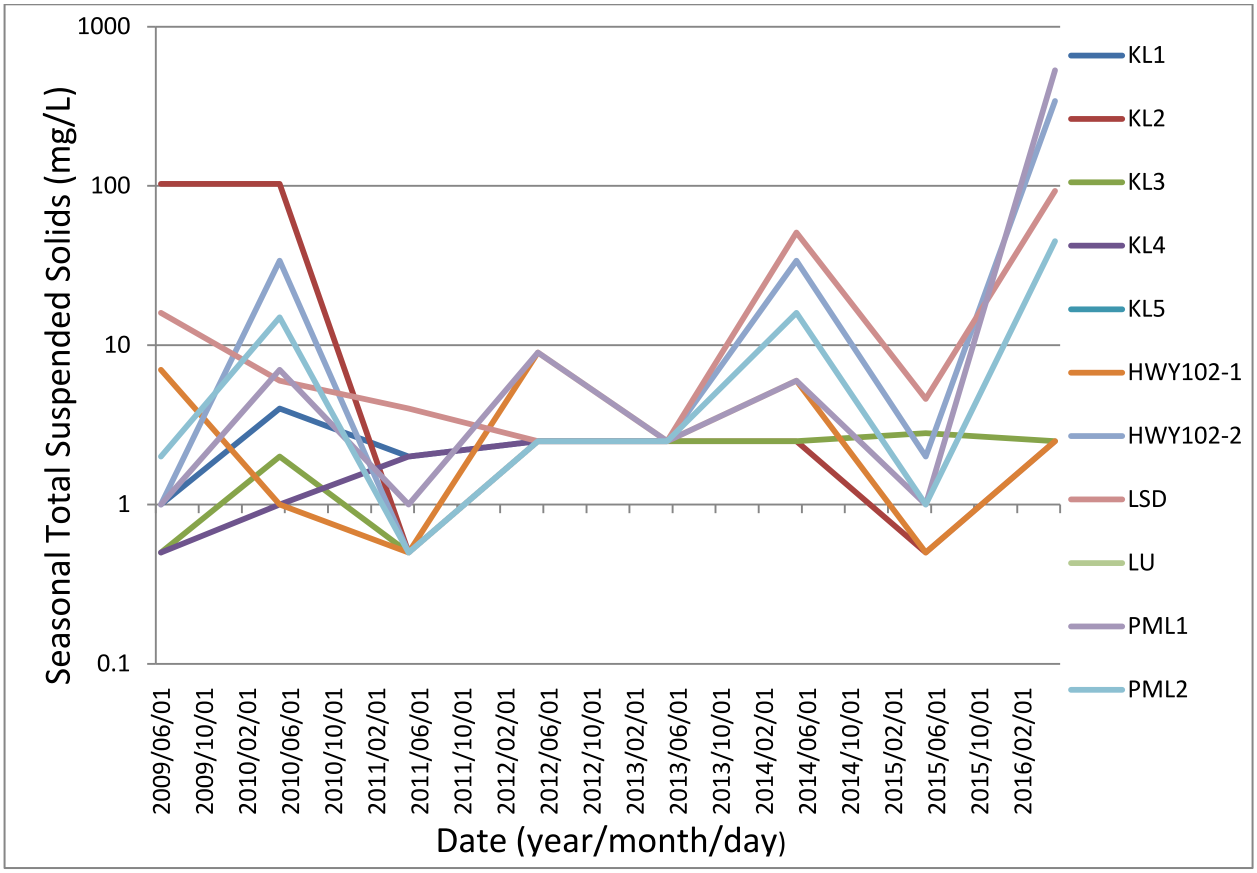


Figure 6 – Seasonal total suspended solids concentrations

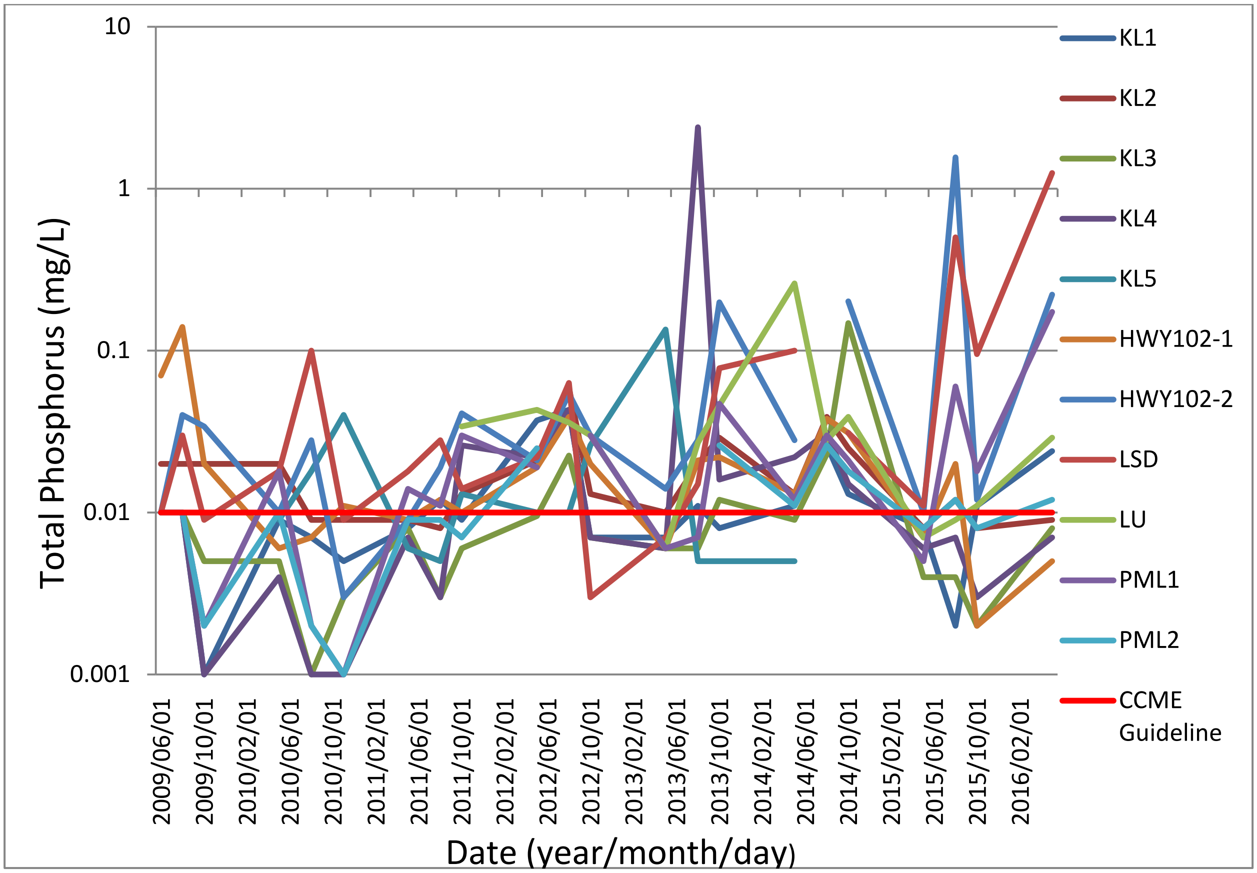


Figure 7 – Total phosphorus concentrations

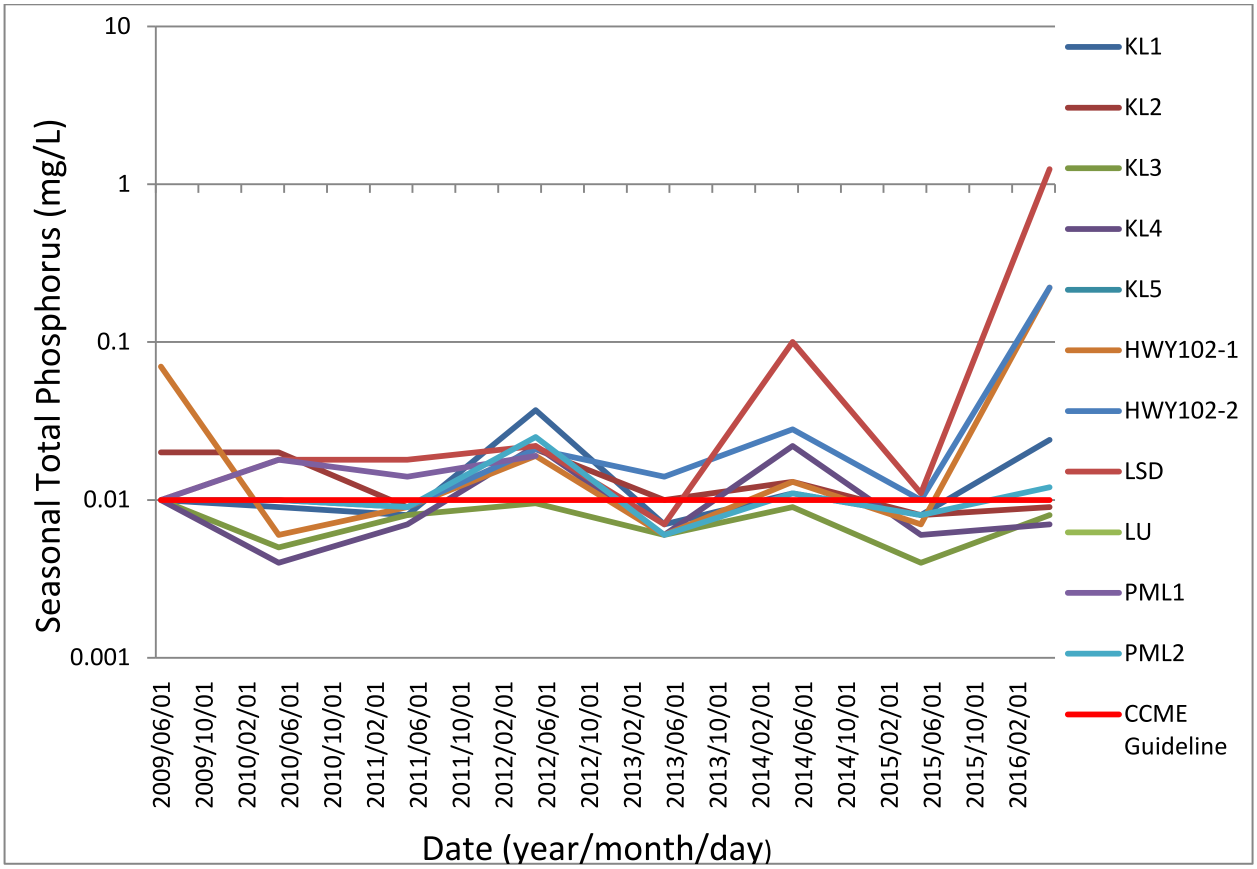


Figure 8 – Seasonal total phosphorus concentrations

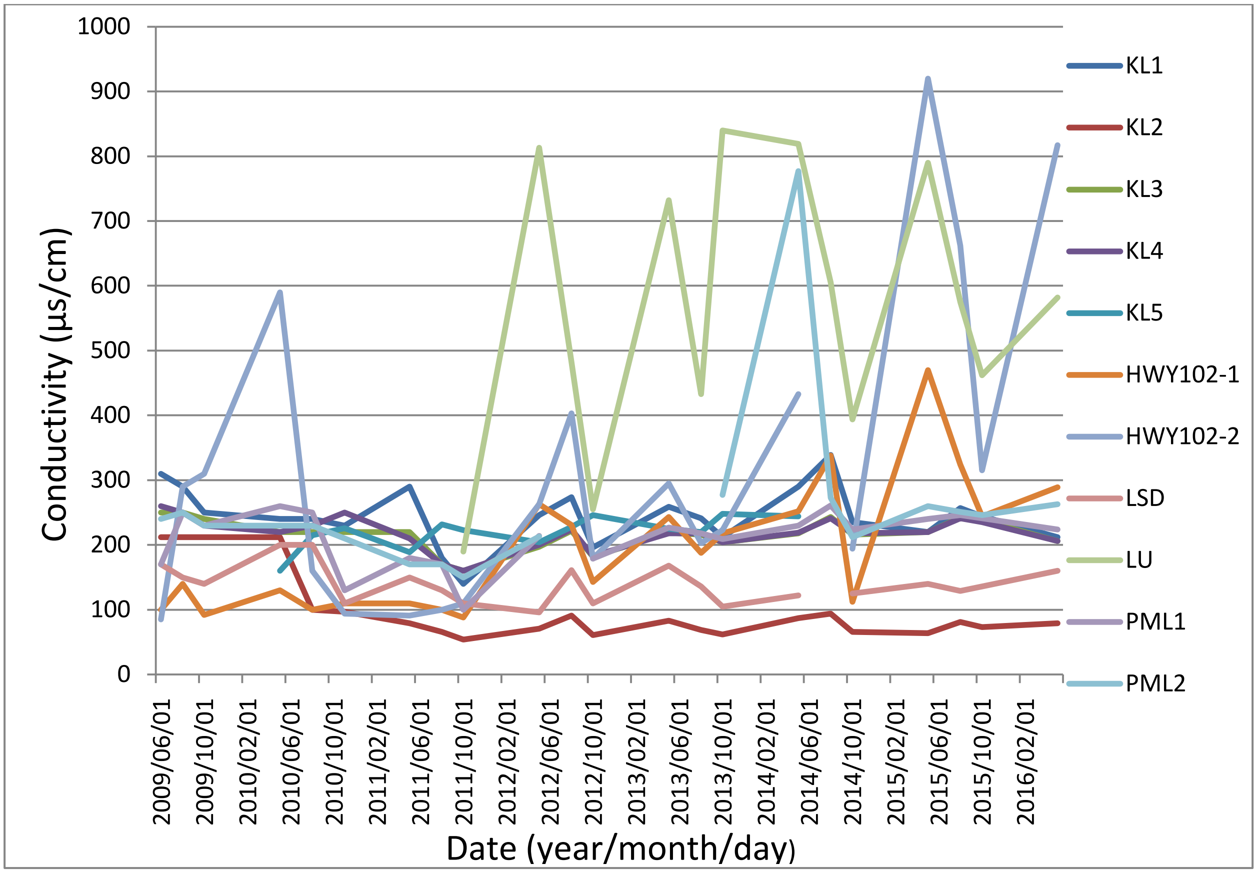


Figure 9 – Conductivity

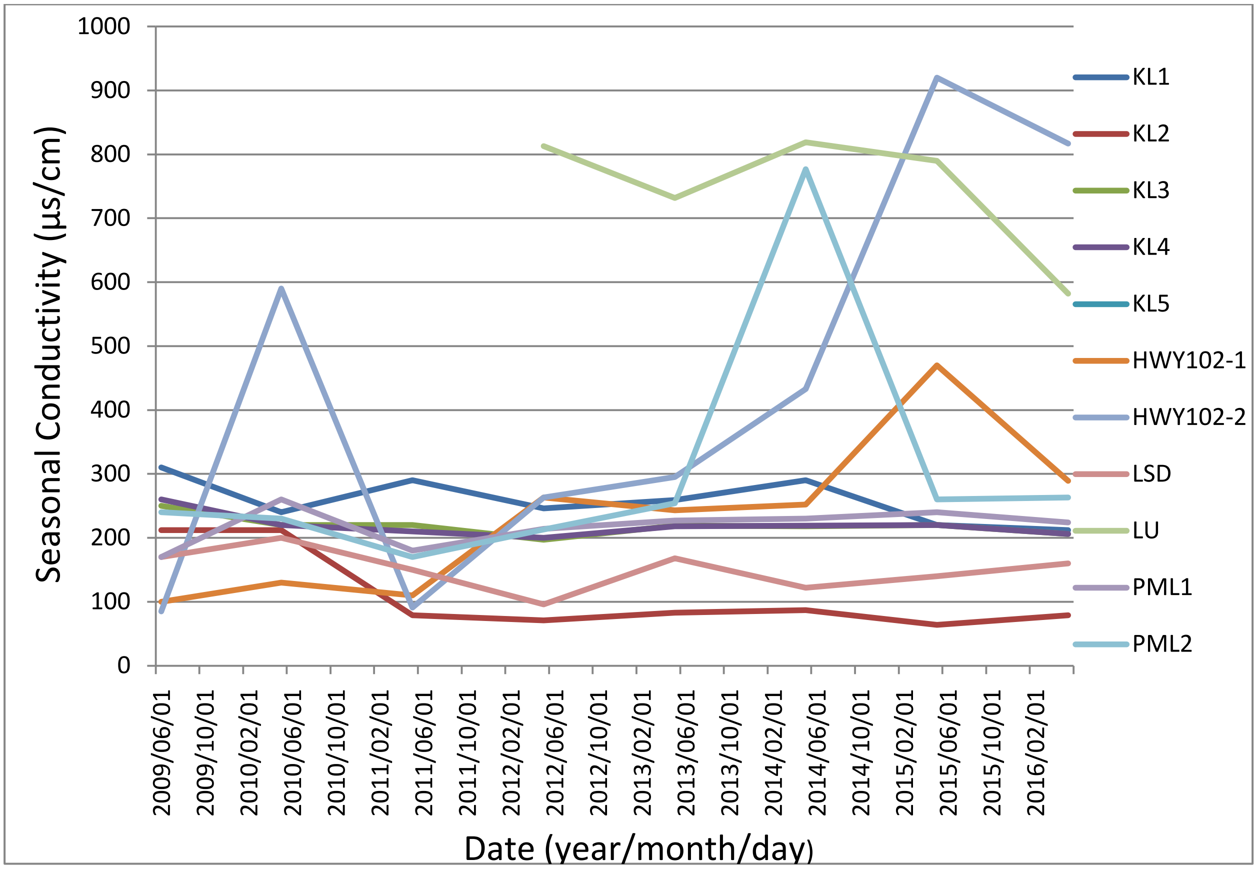


Figure 10 – Seasonal conductivity

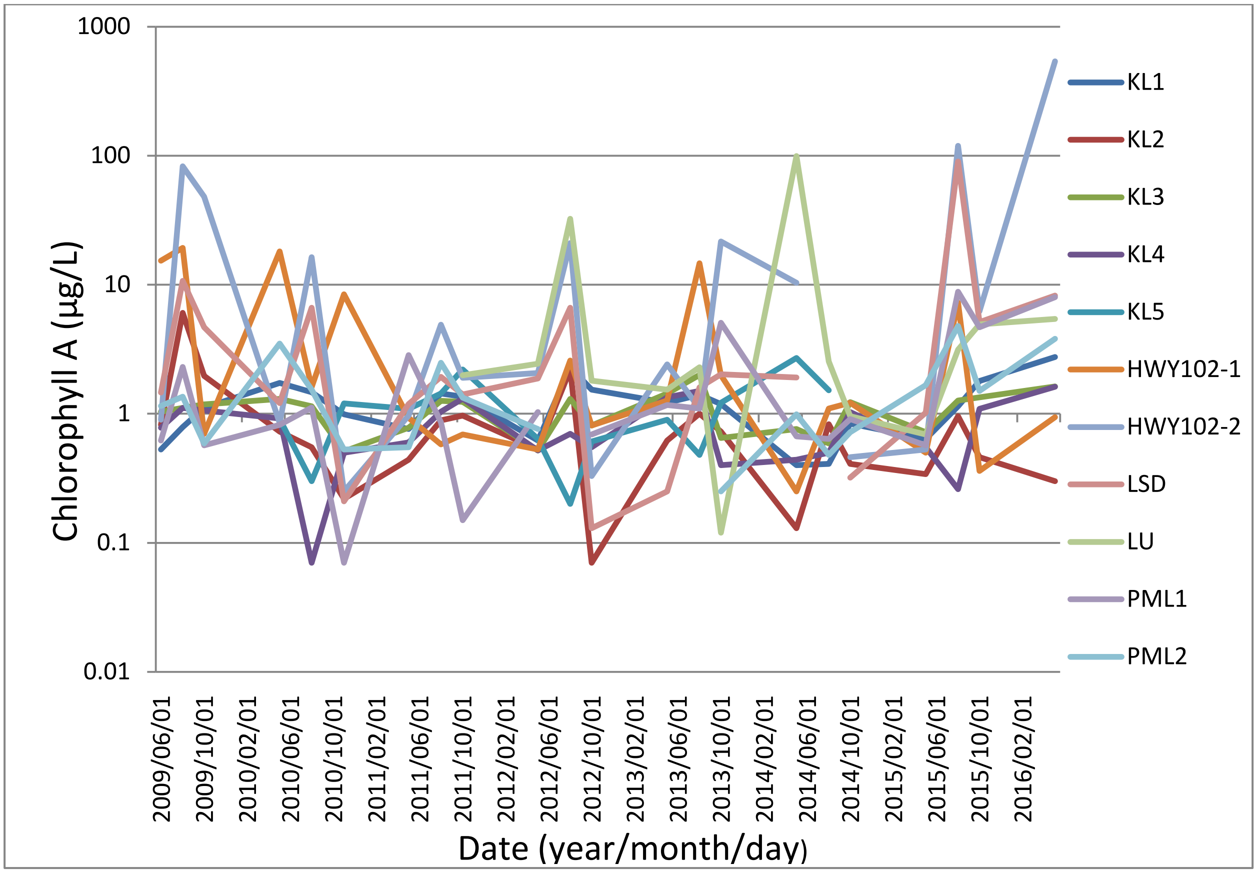


Figure 11 – Chlorophyll A concentrations

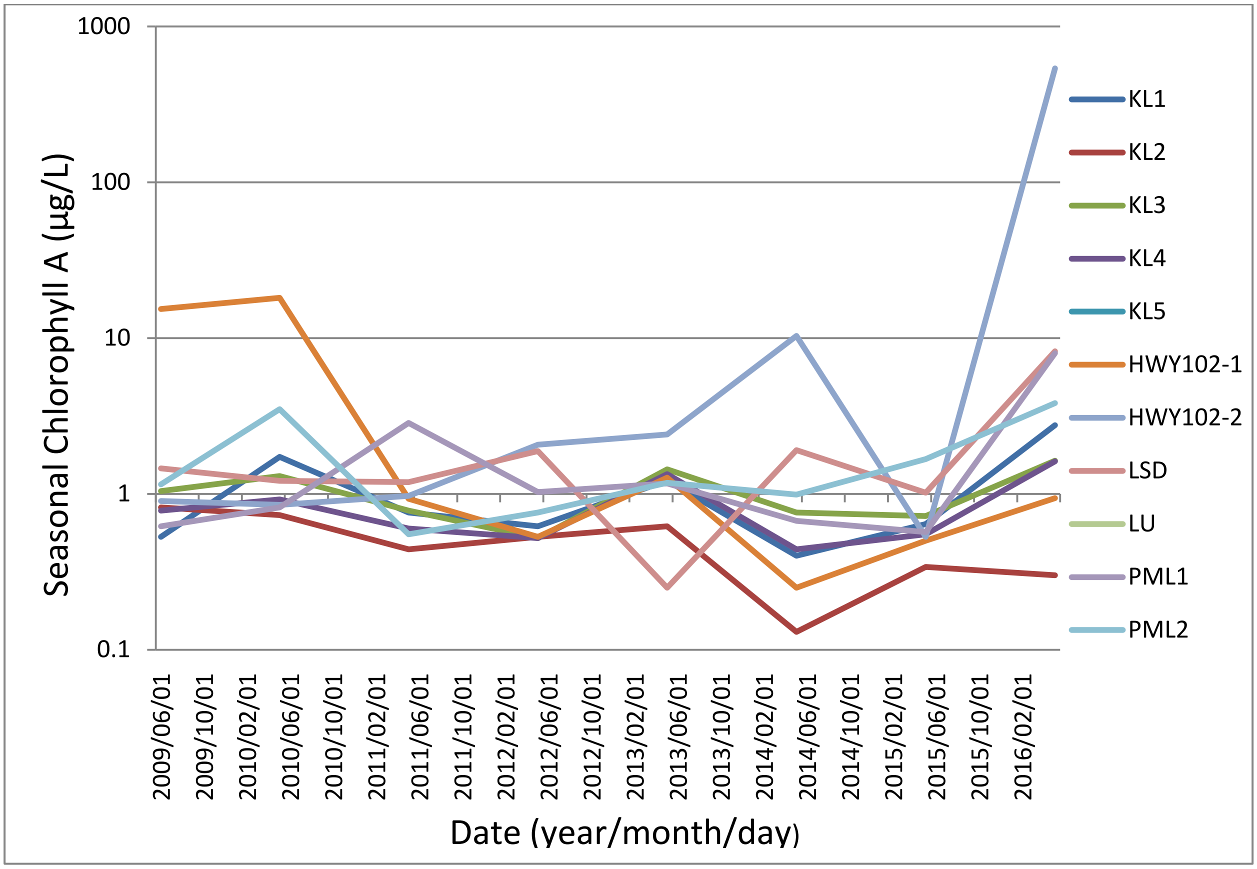
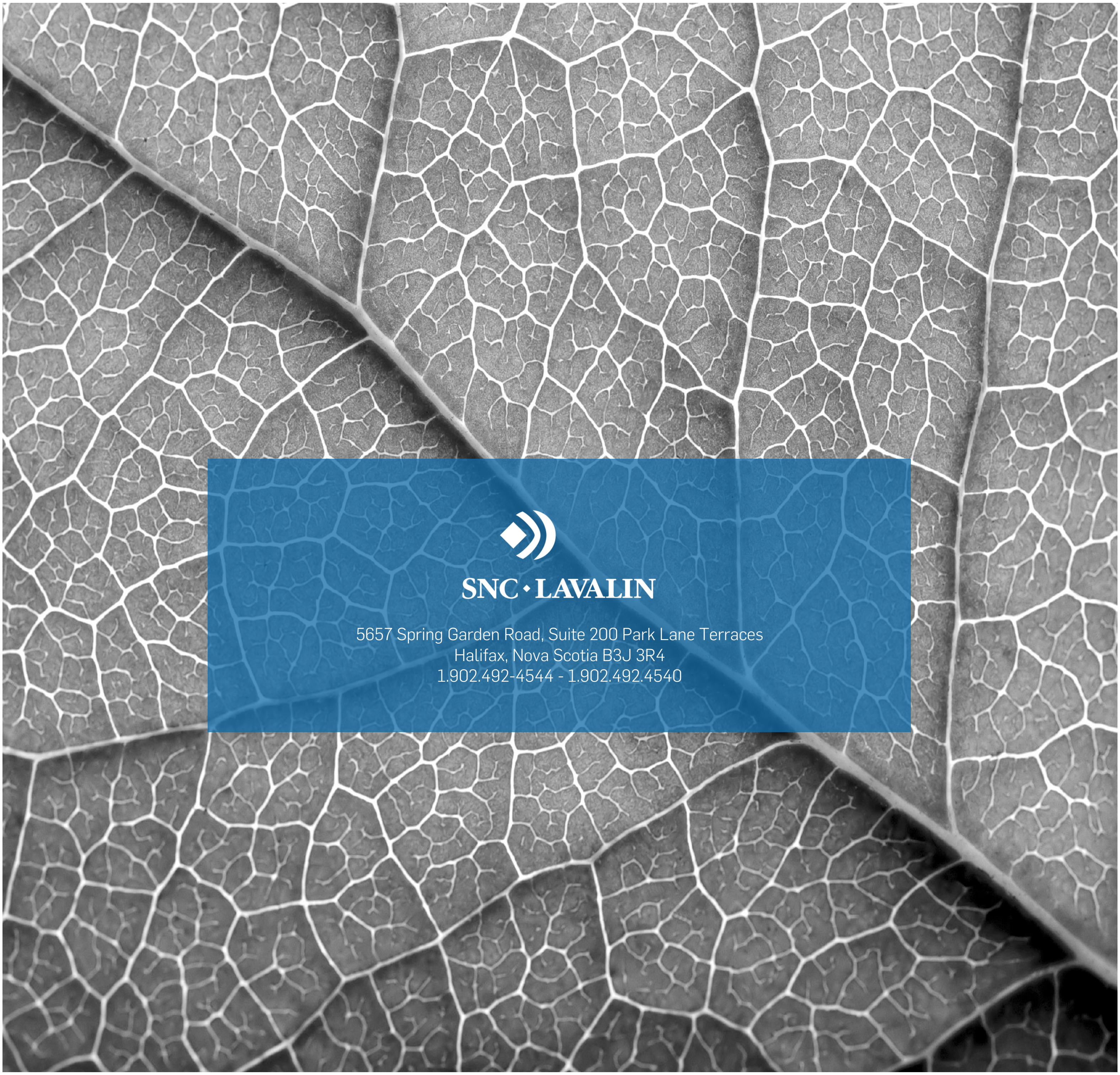


Figure 12 – Seasonal chlorophyll A concentrations



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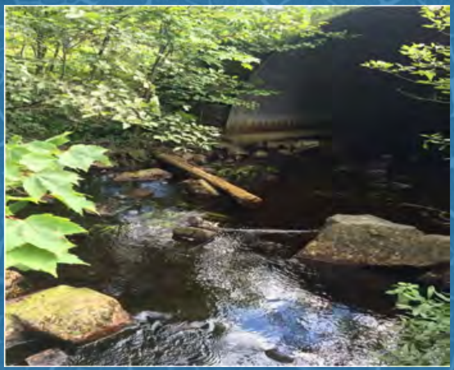
Halifax, Nova Scotia B3J 3R4
1.902.492-4544 - 1.902.492.4540

Attachment D

Water Quality Monitoring Program
Bedford West, Bedford, NS

Summer 2016 Sampling Event



10 | 03 | 2016 Report

Water Quality Monitoring - Summer 2016

Rev. C01 > SLI ref. 631477-0001-T-4E-REP-000-0005

SNC·LAVALIN

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October 3, 2016

Halifax Regional Municipality
Energy and Environment
PO Box 1749
Halifax, Nova Scotia
B3J 3A5

Attention: Mr. Cameron Deacoff

Dear Mr. Deacoff:

RE: Final Report: Water Quality Monitoring Program, Summer 2016 Sampling Event Bedford West, Bedford, Nova Scotia

SNC-Lavalin Inc. (SLI) is pleased to submit one electronic copy of the final report presenting the results of the summer 2016 surface water quality sampling event for the Bedford West Water Quality Monitoring Program in Bedford, Nova Scotia.

If you have any questions or require clarification, please contact the undersigned at 902-492-4544.

Yours truly,

SNC♦LAVALIN INC.

Original Signed

Crysta Cumming, P. Eng
Environmental Department Manager

631477-0001-T-4E-REP-000-0005_C01.docx

EXECUTIVE SUMMARY

On August 16, 2016 SNC-Lavalin Inc. (SNCL) completed the Bedford West summer 2016 water quality monitoring sampling event on behalf of Halifax Regional Municipality (HRM). The sampling program consisted of collecting surface water samples from eleven (11) water quality sampling stations. Field parameters were recorded and samples collected for laboratory analyses. Laboratory analysis included:

- Inorganics;
- Calculated Parameters;
- Standard Metals; and
- Microbiological analysis.

Applicable water quality criteria included:

- Canadian Council of Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life – Freshwater (PAL-F);
- Health Canada guidelines for Canadian Recreational Water Quality (2012, Third Edition); and
- Nova Scotia Environment (NSE) Environmental Quality Standards (EQS) for Surface Water, EQS for Contaminated Sites (NSE 2014) Table A2, Reference for Pathway Specific Standards for Surface Water – Fresh Water.

During the summer 2016 water quality monitoring event, the following parameters exceeded the recommended water quality criteria. Detailed information including station ID(s) and analytical results are outlined in the report.

1. Dissolved Oxygen
2. Dissolved Chloride
3. Turbidity
4. Total Phosphorous (1m depth)
5. pH (in Situ)
6. Metals as follows:
    - Total Iron
    - Total Manganese

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Appendices

1 INTRODUCTION AND BACKGROUND

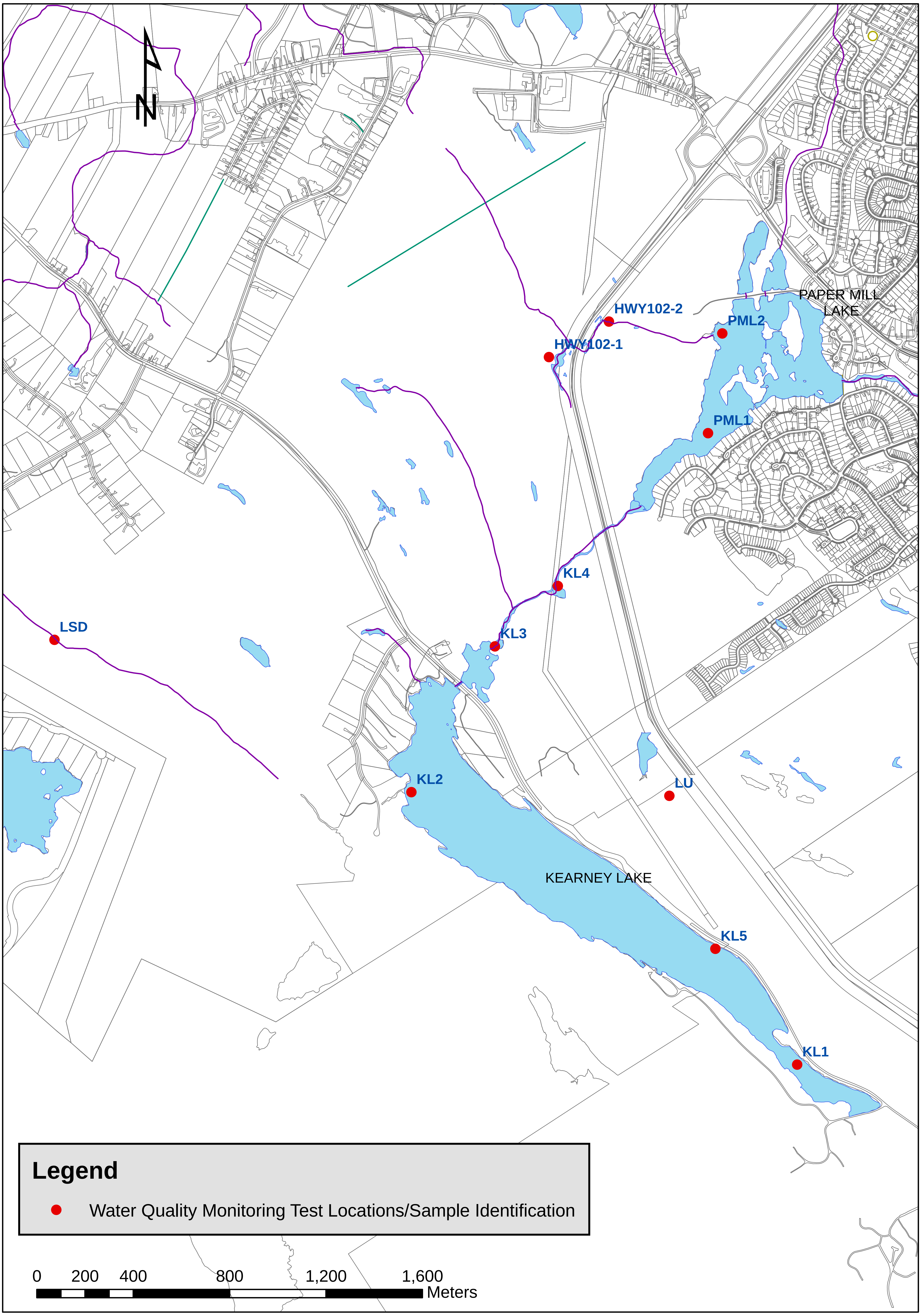
SNC-Lavalin Inc. (SNCL) has prepared this report to provide Halifax Regional Municipality (HRM) with water quality data for eleven (11) surface water stations throughout the Bedford West development area.

Water quality monitoring in the Bedford West development area has been ongoing since 2009. SNCL was retained by HRM to complete water quality monitoring programs each spring, summer and fall for two years beginning in 2015. The results of the summer 2016 monitoring program are detailed herein.

The overall purpose of the program is to conduct water quality sampling and testing prior to and during construction activities related to the development project in order to detect any impacts on and/or changes to water quality. The summer 2016 sampling stations are summarized in Table 1 and shown in Figure 1.

Table 1: Bedford West Water Quality Sampling Stations

Water Course	Sample Location Name	Updated Coordinates (UTM NAD 83)	
		Easting	Northing
Kearney Lake	KL-1	20T445718E	4948496N
Kearney Lake	KL-2	20T0443859	4949738N
Kearney Run	KL-3	20T444390E	4950406N
Kearney Run	KL-4	20T444463E	4950571N
Kearney Lake	KL-5	20T4949142E	445280N
Creek Above Highway	HWY 102-1	20T444708E	4951644N
Creek Below Highway	HWY 102-2	20T444829E	4951778N
Lake Shore Drive	LSD	20T442583E	4950431N
Larry Uteck Off-Ramp	LU	20T444954E	4949891N
Paper Mill Lake	PML-1	20T445129E	4951154N
Paper Mill Lake	PML-2	20T445363E	4951740N



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Member of the SNC•LAVALIN Group
Certified ISO 9001

HALIFAX
REGIONAL MUNICIPALITY

PROJECT:
WATER QUALITY MONITORING WITHIN BEDFORD WEST

TITLE:
WATER QUALITY MONITORING TEST LOCATIONS

DESIGNED:	CH
DRAWN:	CH
CHECKED:	DH
SCALE:	AS SHOWN

DATE:	21-09-2015
PROJECT #:	631477-0001
DRAWING #:	1

2 METHODOLOGY

The summer 2016 water quality sampling event included the collection of Field Parameters (Group A) and surface water for laboratory analysis of:

- Inorganics (Group B);
- Calculated Parameters (Group C);
- Standard Metals (Group D); and
- Microbiological Analyses (Group E).

Table 2 below summarizes the water quality parameters measured in the field or analyzed by the laboratory.

Table 2: Analytical Parameter Groups

Field Parameters (A)	Inorganic (B)	Calculated Parameters (C)	Standard Metals (D)	Microbiological (E)
· pH · TDS · Dissolved Oxygen · Temperature · Secchi Depth · Conductance · Air Temperature · Cloud Cover · Incidental Wildlife Sightings	· Total Alkalinity (as CaCO$_3$) · Dissolved Chloride · Colour · Total Kjeldahl Nitrogen · Nitrate + Nitrite · Nitrate · Nitrite · Nitrogen (as NH4) · Total Organic Carbon · Orthophosphate (P) · pH · Low Total Phosphorus · Reactive Silica · Total Suspended Solids · Dissolved Sulphate · Turbidity · Conductivity	· Anion Sum · Cation Sum · Ion Balance · Bicarbonate Alkalinity(as CaCO$_3$) · Carbonate Alkalinity (as CaCO$_3$) · Hardness · Total Dissolved Solids · Saturation pH (@4°C & 20°C) · Langelier Index (@4°C & 20°C)	· Calcium · Copper · Iron · Magnesium · Manganese · Potassium · Sodium · Zinc	· Chlorophyll A · E. coli · Most Probable Number (MPN) or CFU per 100 mL

All water samples and associated field parameters (including secchi depth measurements) were collected on August 16, 2016.

Field measurements of pH, dissolved oxygen, specific conductivity, water temperature and air temperature were taken at each station using an YSI 556 (instrument serial number 28181). The probe measures temperature, conductivity, DO, pH and ORP. The instrument is calibrated annually by the manufacturer and a pre-calibration was conducted by the provider (Pine Environmental) prior to conducting the water quality sampling event. See Appendix A, Instrument Calibration Report.

Site conditions (i.e. weather, air temperature, cloud cover, site accessibility and wildlife sightings) and field parameters for each sampling location were recorded on a field report sheet. Each sample station was photographed during the sample event.

Water samples and field parameter readings were collected within a depth of 1.0 m below surface. Water samples were collected from the shore at all sample locations. Surface water sampling followed SNCL's Standard Operating Procedures (SOP) for surface water sampling. A new pair of nitrile gloves was used at each sample location.

Surface water samples were collected and placed in clean laboratory-supplied jars and stored in a chilled container together with a chain of custody record for transport to the laboratory. All surface water samples were submitted to AGAT Laboratories in Dartmouth, NS.

3 ASSESSMENT STANDARDS

- There is currently no national environmental quality guideline for phosphorus in freshwater aquatic environments. In the Canadian framework, trigger ranges are based on the trophic classification of the baseline condition. A trigger range is a desired concentration range for phosphorus; if the upper limit of the range is exceeded, it indicates potential for environmental quality issues, which "triggers" the need for further investigation. According to the Canadian Council of Ministers of the Environment (CCME) 10µg/L of total phosphorous is the threshold between oligotrophic and mesotrophic trophic classifications. For this water quality monitoring program, HRM defined a Total Phosphorous management threshold value of 10µg/L or 0.01mg/L.
- The Canadian Council of Ministers of the Environment (CCME) Guidelines for the Protection of Aquatic Life – Freshwater (PAL-F) were used for parameter such as Dissolved Oxygen, pH (in Situ and Laboratory analysis), Dissolved Chloride, Nitrate, Nitrite, Nitrogen, as well as for total metals (i.e. Aluminum, Arsenic, Boron, Cadmium, Cooper, Iron, Lead, Molybdenum, Nickel, Selenium, Silver, Thallium, Uranium, and Zinc).
- For Total Suspended Solids (TSS), the CCME (2002) Water Quality Guidelines for the Protection of Aquatic Life at high flow conditions were applied. For TSS, the guideline value is equal to a maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. When background concentrations are greater than 250 mg/L, the concentration should not increase more than 10% from background levels.
- The Health Canada guidelines for Canadian Recreational Water Quality (2012, Third Edition) were used for parameters such as Secchi Depth (i.e. the guidelines indicate that the clarity of the water should be sufficiently clear such that a Secchi disk is visible at a minimum depth of 1.2 metres); pH (guideline of 5.0-9.0 pH); Turbidity (limit of 50 Nephelometric Turbidity Units); E. coli (400 MPN/100mL) and Fecal Coliform (400 MPN/mL).

- The Nova Scotia Environment (NSE) Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2, Reference for Pathway Specific Standards for Surface Water (µg/L) for Fresh Water were used for assessment of total metals (i.e. Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Cobalt, Copper, Iron, Lead, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Uranium, Vanadium and Zinc).

4 FIELD OBSERVATIONS

The summer 2016 site conditions were recorded for all water quality monitoring stations and are included in the field data sheets in **Appendix B**. Ste condition observations include weather, cloud cover, air temperature, wildlife sightings and site accessibility.

In addition, site photographs are included in **Appendix C**.

5 FIELD MEASUREMENTS

Field measurements were recorded on field data sheets which are enclosed in **Appendix B** and include collection of parameters such as in Situ pH, dissolved Oxygen, water temperature, conductivity and Secchi depth (where applicable).

Field measurements are also summarized in **Table 3** attached at the end of this section**.**

pH (in Situ)

In situ pH readings were outside the CCME-PAL-F guideline of 6.5-9.0 at stations KL1 (4.60 pH), KL2 (5.97 pH), KL5 (5.11 pH), HWY102-1 (6.14 pH), HWY102-2 (6.19 pH), LSD (6.16 pH), LU (6.24 pH), PML1 (5.94 pH), and PML2 (5.93 pH).

Dissolved oxygen

Readings in six (6) of eleven (11) stations were within the range of 5.5-9.5 mg/L recommended in the CCME PAL-F guidelines. Exceedances were recorded at stations KL1 (10.33 mg/L), KL2 (4.21 mg/L), HWY102-1 (10.14 mg/L), LSD (1.86 mg/L), and LU (16.62 mg/L of Oxygen).

6 ANALYTICAL RESULTS

Laboratory (AGAT) Certificates of Analysis for the summer 2016 event are enclosed in **Appendix C**. Analytical results are summarized in **Table 3** attached at the end of this section.

6.1.1 TOTAL PHOSPHOROUS

Total Phosphorus concentrations that exceeded the management threshold criteria of 10 µg/L (0.01 mg/L) listed in the HRM RFP 14-338 were reported at six (6) of the water quality monitoring stations as follows. NOTE: results are also presented in mg/L for comparison with Table 3.

♦ KL2	16 µg/L	(0.016 mg/L)
♦ HWY102-1	38 µg/L	(0.038 mg/L)
♦ HWY102-2	34 µg/L	(0.034 mg/L)
♦ LSD	23 µg/L	(0.023 mg/L)
♦ LU	11 µg/L	(0.011 mg/L)
♦ PML1	104 µg/L	(0.104 mg/L)

6.1.2 GENERAL CHEMISTRY

Dissolved Chloride exceeded the CCME-PAL-F guideline of 120 mg/L at water quality monitoring station HWY102-2 (226 mg/L).

Turbidity was outside the Health Canada Guideline of 50 NTU for Recreational Water Quality at water quality monitoring stations HWY102-2 (54.2 NTU), LSD (206 NTU) and PML1 (112 NTU).

6.1.3 METALS

Total Iron exceeded the applicable NSE EQS guideline of 300 µg/L at the following six (6) water quality monitoring stations. Note that the CCME Guideline PAL-F is also 300 µg/L.

♦ KL2	1 000 µg/L
♦ HWY102-1	766 µg/L
♦ HWY102-2	7 380 µg/L
♦ LSD	2 190 µg/L
♦ LU	374 µg/L
♦ PML1	8250 µg/L

Total Manganese exceeded the applicable NSE EQS guideline of 820 µg/L at the following station. Note that there is no CCME guideline for total manganese.

♦ LSD	2 420 µg/L

6.1.4 MICROBIOLOGICAL

Eleven (11) *E.coli* samples were collected during the summer 2016 sampling program. *E.coli* did not exceed the Heath Canada Guideline of 400 CFU /100 mL in any of the samples collected.

TABLE 3: Bedford West Water Quality Sampling Program

Summer 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Highway 102																						
Sample Sites							HWY102-1																						
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2016/08/16
Sampling Time	hh:mm	--					07:00	12:45	08:00	13:00	10:20	09:00	13:40	11:00	11:00	14:50	11:00	9:50	14:15	12:22	12:30	12:00	10:10	9:30	13:15	09:20	9:40	14:30	11:00
FIELD DATA																													
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		11.8	18.8	15.7	14.9	19.6	7.4	11.4	17.8	14.6	10.7	21.8	13.6	11.7	19.5	8.9	12.1	19.6	10.2	14.29	20.70	5.40	13.42	19.28
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**11.44**	5.80	**4.34**	8.18	**4.25**	6.05	8.15	**3.88**	**5.34**	5.65	**1.03**	**3.83**	7.55	**3.32**	**3.10**	**12.03**	**2.09**	**4.54**	**4.27**	**3.82**	**5.03**	8.18	**10.14**
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		7.98	5.35	5.25	6.31	5.26	5.62	5.75	5.77	5.99	8.76	5.73	6.38	6.19	7.10	6.79	6.02	6.63	5.12	6.35	6.24	6.92	7.34	**6.14**
Specific Conductance	uS/cm	1	--	--	--		194	153	104	135	106	109	114	108	89	288	225	155.5	226	173.2	234.0	880.0	337	109	0.393	335.8	251.2	289	353
INORGANICS																													
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		<5	<5	<5	<5	<5	<5	5	11	8	22	25	15	9	23	20	31	28	30	16	21	12	14	27
Dissolved Chloride (Cl)	mg/L	1	--	--	120		24	38	24	32	25	22	24	19	12	58	48	28	53	31	40	65	57	19	**130**	67	49	71	87
Colour	TCU	5	--	--	--		67	68	57	37	89	53	39	65	79	24	65	40	9	65	25	11	31	93	22	27	29	23	37
Nitrite + Nitrate	mg/L	0.05	--	--	--		<0.05	<0.05	<0.05	0.69	<0.05	1.2	0.69	0.25	1.2	2.61	0.06	0.43	0.51	<0.05	<0.05	<0.05	<0.05	0.53	<0.050	<0.05	0.17	0.05	0.13
Nitrate (N)	mg/L	0.05	--	--	13000		<0.05	--	--	0.69	<0.05	--	0.69	--	--	2.61	0.06	0.43	0.51	<0.05	<0.05	<0.05	<0.05	0.53	<0.050	<0.05	0.17	0.05	<0.05
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05	0.13
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.29	<0.05	<0.05	<0.05	<0.05	0.05	0.1	0.07	0.31	0.19	0.04	<0.03	0.05	0.06	<0.03	0.04	0.03	<0.050	<0.03	0.04	0.06	0.06
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	1.1	1.3	0.6	--	0.6	0.6	0.7	0.6	<0.4	0.34	0.50	0.6	0.7	1.2
Total Organic Carbon	mg/L	0.5	--	--	--		6.5	10	7.7	4.7	11	6.3	4.5	7.2	7.4	5.5	10.0	7.0	5.1	10.1	17.7	4.1	7.7	9.0	2.7	14.6	8.4	4.5	8.0
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		**4.54**	**5.24**	**5.40**	**5.48**	**6.24**	**5.31**	**6.42**	6.55	**6.28**	**6.4**	6.9	6.8	6.86	6.87	6.73	6.56	7.49	**5.90**	6.61	7.46	6.80	6.87	7.03
Total Calcium (Ca)	mg/L	0.1	--	--	--		1.7	1.8	1.6	4.93	3.34	5.09	4.9	5.21	5.55	12.5	11.7	7.5	11.1	10.5	13.9	7.2	23.3	2.2	18000	18.0	12.4	12.9	25.8
Total Magnesium (Mg)	mg/L	0.1	--	--	--		0.3	0.5	0.5	1.08	0.79	1.09	0.91	0.92	1.19	1.7	2.0	1.4	1.4	1.5	2.3	1.6	3.2	0.6	2400	2.7	2.3	1.7	2.7
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**0.07**	**0.14**	**0.020**	0.006	0.007	**0.011**	0.009	**0.012**	**0.010**	**0.019**	**0.039**	**0.02**	0.006	**0.021**	**0.022**	**0.013**	**0.038**	**0.03**	0.007	**0.020**	0.002	0.005	**0.038**
Total Potassium (K)	mg/L	0.1	--	--	--		0.5	1.2	0.7	1.140	1.630	1.310	1.100	1.500	1.880	1.6	2.5	1.5	1.3	1.7	2.4	1.2	2.5	0.7	2000	2.1	1.5	1.4	1.9
Total Sodium (Na)	mg/L	0.1	--	--	--		15	25	13	15.9	14.5	14.6	14.8	10.2	8.26	36.3	27.7	14.6	30.8	15.0	20.5	39.1	38.7	18.6	64	37.7	28.8	45.4	43.8
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.5	2.2	2.0	1.1	3.8	5.1	2.8	5.2	4.6	4.1	6.1	5.1	3.1	5.1	5.8	1.7	7.1	4.7	2.1	4.9	4.8	1.4	6.3
Total Suspended Solids	mg/L	5	--	--	--		7	80	2	<2	11	<2	<1	1	<1	9	6	<5	<5	<5	<5	6	<5	<5	<1.0	<5	<5	<5	10
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		5	3	3	8	<2	8	10	8	10	14	8	9	12	8	12	10	7	6	13	9	14	14	14
Turbidity (NTU)	NTU	0.1	--	50	--		14.0	35	0.9	1.4	1.2	0.6	0.4	0.6	1.1	0.9	1.9	0.9	0.5	1.6	0.5	0.7	1.6	0.9	0.59	0.9	0.8	1.0	4.1
Conductivity (uS/cm)	µS/cm	1	--	--	--		100	140	92	130	100	110	110	100	88	263	231	143	243	188	218	252	338	112	470	324	244	289	440
Calculated Parameters																													
Anion Sum	me/L	N/A	--	--	--		0.77	1.12	0.73	1.11	0.71	0.88	1.03	0.95	0.80	2.55	2.02	1.31	1.96	1.50	1.78	2.66	2.31	1.30	4.20	2.50	1.93	2.58	3.29
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		<1	<1	<1	<1	<1	<1	5	11	8	22	25	15	9	23	20	31	28	30	16	21	12	14	27
Calculated TDS	mg/L	1	--	--	--		50	73	45	67	50	63	65	58	54	150	117	73	117	83	104	143	150	68	240	151	116	155	193
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		0.84	1.32	0.74	1.06	0.93	1.02	1.00	0.83	0.80	2.43	6.04	1.19	2.06	1.40	1.87	2.25	3.22	1.04	3.94	2.88	2.11	2.81	3.51
Hardness (CaCO3)	mg/L	N/A	--	--	--		6	6	6	17	12	17	16	17	19	38.2	37.5	24.5	33.5	32.4	44.2	24.6	71.4	8.0	55.0	56.1	40.4	39.2	75.5
Ion Balance (% Difference)	%	N/A	--	--	--		4.35	8.20	0.68	2.30	13.40	7.37	1.48	6.74	0.00	2.6	1.9	4.6	2.4	3.5	2.6	8.4	16.4	11.2	3.19	7.1	4.7	4.4	3.1
Langelier Index (@ 20C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	-3.50	-2.99	-3.36	-2.77	-2.23	-2.72	-2.73	-2.33	-2.41	-2.69	-1.30	-3.85	-2.32	-1.57	-2.62	-2.48	-1.74
Langelier Index (@ 4C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	-3.75	-3.25	-3.61	-3.09	-2.55	-3.04	-3.05	-2.65	-2.73	-3.01	-1.62	-4.17	-2.57	-1.89	-2.94	-2.80	-2.06
Saturation pH (@ 20C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	9.92	9.54	9.64	9.17	9.13	9.52	9.59	9.20	9.14	9.25	8.79	9.75	8.93	9.03	9.42	9.35	8.77
Saturation pH (@ 4C)	N/A	N/A	--	--	--		NC	NC	NC	NC	NC	NC	10.20	9.80	9.89	9.49	9.45	9.84	9.91	9.52	9.46	9.57	9.11	10.1	9.18	9.35	9.74	9.67	9.09
Metals (ICP-MS)																													
Total Aluminum (Al)	µg/L	5	5	--	5-100		**510**	--	--	**169**	**192**	--	**205**	--	--	**134**	**183**	**146**	86	**145**	**150**	**187**	83	**310**	**51**	--	52	81	--
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Barium (Ba)	µg/L	5	1000	--	--		22	--	--	52.9	36.9	--	37.3	--	--	58	284	42	57	57	80	46	142	17	130	--	86	79	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Boron (B)	µg/L	5	1200	--	1500		<5	--	--	11.4	10.9	--	<50	--	--	12	18	13	10	10	11	9	14	11	<50	--	<5	10	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	**0.043**	<0.017	--	**0.023**	--	--	**0.034**	**0.021**	<0.017	<0.017	<0.017	**0.040**	**0.022**	<0.017	**0.022**	**0.024**	--	<0.017	<0.017	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	**8**	<1	<1	<1.0	--	<1	<1	--
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	0.50	0.46	--	<0.40	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	<1	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2	--	--	3.4	<2.0	<2.0	<2.0	<2.0	<2.0	<2	<2	3	<2	<1	2	<1	<1	2	<2.0	<1	1	<1	<1
Total Iron (Fe)	µg/L	50	300	--	300		**720**	--	--	146	**637**	150	107	209	219	102	**1380**	255	111	**938**	**446**	147	**820**	290	140	**1280**	138	144	**766**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		1.6	--	--	2.37	0.56	--	<0.50	--	--	<0.5	0.7	<0.5	<0.5	<0.5	0.6	2.6	<0.5	0.6	<0.50	--	<0.5	<0.5	--
Total Manganese (Mn)	µg/L	2	820	--	--		40	--	--	55.3	39.0	67.0	28.1	21.0	31.3	34	79	28	23	45	31	56	122	61	28	95	22	19	78
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	--	<1	<1	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Strontium (Sr)	µg/L	5	21000	--	--		11	--	--	29.1	19.7	--	24.3	--	--	48	58	36	52	47	62	38	103	13	85	--	39	58	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Titanium (Ti)	µg/L	2	--	--	--		6	--	--	<2.0	<2.0	--	3.5	--	--	<2	3	<2	<2	<2	4	2	<2	<2	<2.0	--	<2	<2	--
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Zinc (Zn)	µg/L	5	30	--	30		21	--	--	16.4	6.9	6.9	<5.0	<5.0	6.9	<5	6	<5	<5	<5	10	10	<5	7	11	<5	<5	<5	<5
MICROBIOLOGICAL																													
Total Coliform	MPN/100mL	1	--	--	--		84	>250	--	>250	>250	180	120	180	--	687	>2420	>2420	1550	>2420	1553	120	>2420	>2420	---	>2420	659	>2420	>2420
E. coli	MPN/100mL	1	--	400	--		54	**>250**	--	12	17	5	1	78	<100	3	68	145	4	9	5	3	179	3	20	25	2	<1	86
Fecal Coliform	MPN/ml	--	--	400	--		--	--	<1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		15.40	19.29	0.70	18.12	1.61	8.45	0.93	0.58	0.69	0.53	2.59	0.81	1.27	14.70	1.99	0.25	1.10	1.22	0.5	7.27	0.36	0.94	51.51
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		17.50	19.60	0.84	17.62	1.68	7.52	0.84	0.56	0.65	0.59	2.89	1.05	1.45	15.80	2.20	0.82	1.11	1.38	0.55	6.79	0.23	1.30	60.68

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Summer 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Highway 102																						
Sample Sites							HWY102-2																						
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/14	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2016/08/16
Sampling Time	hh:mm	--					12:30	12:15	12:30	12:40	09:30	12:30	11:20	15:00	15:30	11:20	12:20	10:35	10:40	10:00	10:22	12:15	14:25	10:07	11:00	12:58	14:30	12:50	12:45
FIELD DATA																													
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	N/A	NCC	N/A	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		16.7	19.2	16.4	17.2	17.0	8.7	10.8	24.2	15.1	7.8	23.7	14.3	11.5	22.0	10.7	11.4	--	10.4	12.7	23.7	9.3	13.41	20.43
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**10.01**	5.90	**4.80**	**4.91**	**2.45**	**2.99**	6.92	7.03	**5.09**	**3.73**	**13.1**	**3.28**	6.30	**1.57**	**4.20**	**10.50**	--	9.25	**4.24**	6.11	5.28	6.77	7.06
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.57	5.71	5.40	6.33	5.86	5.64	6.22	5.89	5.29	7.3	6.37	6.72	6.01	6.92	5.40	5.40	--	5.85	6.45	6.04	5.96	**5.86**	**6.19**
Specific Conductance	uS/cm	1	--	--	--		37	457	162	415	167	101.2	92.2	123.1	96	225	226	159.1	288	188.5	204.4	204.4	--	174	0.411	699	197.6	968	838
INORGANICS																													
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		<5	<5	7	6	5	<5	<5	5	<5	17	7	<5	6	14	7	30	--	8	7.5	5	<5	13	21
Dissolved Chloride (Cl)	mg/L	1	--	--	120		21	82	83	**170**	41	18	21	21	17	63	109	45	71	50	52	113	--	34	**260**	**178**	78	236	**226**
Colour	TCU	5	--	--	--		120	190	91	96	160	68	65	98	77	32	100	70	11	61	36	13	--	85	17	9	8	14	39
Nitrite + Nitrate	mg/L	0.05	--	--	--		<0.05	<0.05	<0.05	0.10	<0.05	0.62	0.26	1.8	3.2	1.54	<0.05	0.14	0.17	<0.05	<0.05	<0.05	--	0.12	<0.050	<0.05	0.15	0.21	0.23
Nitrate (N)	mg/L	0.05	--	--	13000		<0.05	--	--	0.10	<0.05	--	0.26	--	--	1.54	<0.05	0.14	0.17	<0.05	<0.05	<0.05	--	0.12	<0.050	<0.05	0.15	<0.05	<0.05
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.010	<0.05	<0.05	0.21	0.23
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.06	<0.05	<0.05	0.20	<0.05	<0.05	0.30	0.08	0.09	<0.03	<0.03	<0.03	0.17	0.09	<0.03	--	<0.03	0.056	0.19	0.05	0.14	0.37
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	0.6	1.1	0.5	--	0.7	2.0	15.3	--	<0.4	0.33	62.6	2.0	24.3	2.1
Total Organic Carbon	mg/L	0.5	--	--	--		8.5	13	13	7.2	14	7.4	5.7	9.2	8.4	7.0	15.8	11.2	6.1	10.6	5.1	17.4	--	8.0	3.0	29.0	9.9	79.3	11.1
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		**5.43**	**5.96**	**6.30**	**6.05**	**6.32**	**5.47**	**5.93**	**6.18**	**5.92**	**5.9**	6.7	6.8	6.61	6.59	**6.34**	7.20	--	**6.40**	**6.12**	6.64	**6.18**	6.46	6.80
Total Calcium (Ca)	mg/L	0.1	--	--	--		1.6	4.0	4.8	7.44	3.84	4.01	3.07	2.22	3.80	7.0	8.4	5.6	7.6	8.5	8.2	14.1	--	9.5	20000	33.3	9.8	23.9	23.8
Total Magnesium (Mg)	mg/L	0.1	--	--	--		0.4	0.7	0.9	0.96	0.59	1.00	0.68	0.68	1.38	1.2	1.4	1.2	1.2	1.3	2.2	3.1	--	1.8	2500	32.7	2.2	3.2	2.5
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**<0.02**	**0.04**	**0.034**	**0.010**	**0.028**	0.003	0.009	**0.019**	**0.041**	**0.021**	**0.054**	**0.03**	**0.014**	**0.028**	**0.199**	**0.028**	--	**0.20**	**0.01**	**1.56**	**0.012**	**0.222**	**0.034**
Total Potassium (K)	mg/L	0.1	--	--	--		0.5	0.8	1.1	0.984	0.956	1.390	0.844	1.310	1.880	1.2	1.7	1.6	1.3	1.5	2.5	2.9	--	1.7	1900	12.5	1.1	4.0	2.1
Total Sodium (Na)	mg/L	0.1	--	--	--		15	51	55	83.7	32.0	12.1	13.3	13.1	13.3	41.5	63.6	20.4	39.0	19.1	34.5	69.6	--	24.0	150	124	36.8	149.0	124
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.2	4.4	4.0	3.0	6.4	5.4	2.5	6.5	6.7	4.1	6.9	5.8	1.6	6.2	6.6	1.6	--	5.9	2.3	7.2	5.6	2.8	9.0
Total Suspended Solids	mg/L	5	--	--	--		<2	58	62	34	27	3	<1	10	14	<5	39	<5	<5	<5	194	34	--	<5	2	3000	15	342	69
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		<2	3	8	11	<2	7	5	5	8	12	6	10	10	9	10	12	--	8	15	7	8	22	21
Turbidity (NTU)	NTU	0.1	--	50	--		0.7	3.8	4.2	2.6	3.1	0.5	0.4	1.2 (1)	3.9	0.6	10.8	2	1.5	3.3	**144**	1.1	--	1.1	1.2	**1490**	9.9	**131**	**54.2**
Conductivity (uS/cm)	µS/cm	1	--	--	--		85	290	310	590	160	94	91	100	110	263	403	179	295	203	223	433	--	194	920	662	315	817	952
Calculated Parameters																													
Anion Sum	me/L	N/A	--	--	--		0.60	2.37	2.62	5.13	1.27	0.70	0.73	0.91	0.86	2.48	3.34	1.49	2.34	1.88	1.81	4.04	--	1.29	7.88	5.27	2.38	7.39	7.25
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		<1	<1	7	6	5	<1	<1	5	<1	17	7	<5	6	14	7	30	--	8	7.5	5	<5	13	21
Calculated TDS	mg/L	1	--	--	--		42	150	165	282	93	52	48	62	67	143	200	86	135	100	145	235	--	85	460	712	138	473	422
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	--	<10	<1.0	<10	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		0.81	2.65	2.89	4.17	1.81	0.86	0.82	0.83	0.97	2.32	2.10	1.40	2.24	1.50	3.50	4.17	--	1.76	7.87	29.1	2.35	9.27	7.23
Hardness (CaCO3)	mg/L	N/A	--	--	--		6	13	16	23	12	14	11	8	15	22.4	26.7	18.9	23.9	26.6	29.5	48.0	--	31.1	59.0	218	33.5	72.9	69.7
Ion Balance (% Difference)	%	N/A	--	--	--		14.90	5.58	4.90	10.30	17.50	10.30	5.81	4.60	6.01	3.3	3.6	3.1	2.3	11.3	31.7	1.6	--	15.1	0.0600	69.4	0.5	11.3	0.1
Langelier Index (@ 20C)	N/A	N/A	--	--	--		NC	NC	-3.57	-3.72	-3.70	NC	NC	-4.07	NC	-3.63	-3.15	-3.34	-3.33	-2.92	-3.50	-1.80	--	-3.30	-3.18	-2.81	-3.73	-2.70	-2.15
Langelier Index (@ 4C)	N/A	N/A	--	--	--		NC	NC	-3.82	-3.97	-3.95	NC	NC	-4.32	NC	-3.95	-3.47	-3.66	-3.65	-3.24	-3.82	-2.12	--	-3.62	-3.42	-3.13	-4.05	-3.02	-2.47
Saturation pH (@ 20C)	N/A	N/A	--	--	--		NC	NC	9.87	9.77	10.00	NC	NC	10.30	NC	9.53	9.85	10.10	9.94	9.51	9.84	9.00	--	9.70	9.29	9.45	9.91	9.16	8.95
Saturation pH (@ 4C)	N/A	N/A	--	--	--		NC	NC	10.10	10.00	10.30	NC	NC	10.50	NC	9.85	10.2	10.5	10.3	9.83	10.2	9.32	--	10.0	9.54	9.77	10.2	9.5	9.27
Metals (ICP-MS)																													
Total Aluminum (Al)	µg/L	5	5	--	5-100		270	--	--	189	368	--	260	--	--	145	**466**	**259**	**130**	**138**	**2760**	**400**	--	**216**	**100**	--	**129**	**3880**	--
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2	--
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	2.1	--	<1.0	--	--	<2	<2	<2	<2	<2	6	<2	--	<2	<1.0	--	<2	3	--
Total Barium (Ba)	µg/L	5	1000	--	--		20	--	--	53.1	27.7	--	26.6	--	--	49	74	33	44	43	213	381	--	63	140	--	147	762	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2	--
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2	--
Total Boron (B)	µg/L	5	1200	--	1500		<5	--	--	7.9	7.8	--	<50	--	--	10	17	15	9	10	13	11	--	12	<50	--	<5	9	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	0.051	<0.017	--	<0.017	--	--	0.037	**0.031**	**0.032**	**0.019**	<0.017	**0.096**	**0.051**	--	**0.019**	**0.100**	--	<0.017	**0.778**	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	1.0	--	<1.0	--	--	<1	<1	<1	<1	1	**9**	**2**	--	<1	<1.0	--	<1	**8**	--
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	0.66	0.77	--	<0.40	--	--	<1	1	1	<1	1	3	1	--	<1	1.8	--	3	4	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2	--	--	2.0	<2.0	<2.0	<2.0	2.5	2.8	<2	3	3	<2	1	**12**	4	--	2	<2.0	**404**	2	13	<1
Total Iron (Fe)	µg/L	50	300	--	300		**880**	--	--	**1380**	**3850**	**303**	229	**897**	**1110**	214	**5210**	**1550**	**383**	**1720**	**28400**	**1660**	--	**485**	**960**	**217000**	**714**	**21300**	**7380**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		1.9	--	--	1.61	2.70	--	0.59	--	--	<0.5	5.2	2.1	0.6	0.7	19.4	3.5	--	1.0	<0.50	--	0.6	**39.7**	--
Total Manganese (Mn)	µg/L	2	820	--	--		110	--	--	387	135	52.9	40.5	106	176	78	219	207	83	173	327	212	--	93	470	**2800**	303	586	359
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	4	2	--	<2	<2.0	--	<2	8	--
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	<1	<1	<1	<1	<1	<1	--	<1	<1.0	--	<1	<1	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1	--
Total Strontium (Sr)	µg/L	5	21000	--	--		11	--	--	37.4	21.1	--	16.9	--	--	33	45	31	39	40	45	75	--	43	96	--	38	96	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1	--
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2	--
Total Titanium (Ti)	µg/L	2	--	--	--		4	--	--	<2.0	6.4	--	4.9	--	--	<2	10	4	4	<2	60	9	--	6	<2.0	--	<2	41	--
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	--	<0.1	<0.10	--	<0.1	0.2	--
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	2	<2	<2	<2	11	<2	--	<2	<2.0	--	<2	**18**	--
Total Zinc (Zn)	µg/L	5	30	--	30		12	--	--	13.6	12.3	9.3	5.5	9	12.5	<5	7	12	12	<5	**46**	**36**	--	17	27	**1210**	10	**170**	22
MICROBIOLOGICAL																													
Total Coliform	MPN/100mL	1	--	--	--		28	>250	--	>250	75	41	110	>250	--	1553	>2420	>2420	2420	1990	>2420	687	--	>2420	---	>2420	328	>2420	>2420
E. coli	MPN/100mL	1	--	400	--		4	230	--	9	5	<1	7	**>250**	<100	<1	16	50	111	9	4	<1	--	<1	<10	201	2	1	20
Fecal Coliform	MPN/ml	--	--	400	--		--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.90	82.63	48.17	0.85	16.36	0.25	0.97	4.91	1.9	2.07	21.03	0.33	2.41	1.10	21.62	10.34	--	0.46	0.53	119.14	6.24	539.78	54.98
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.91	81.20	52.50	0.85	17.35	0.23	0.87	4.49	2.15	2.27	17.26	0.50	3.02	1.30	27.02	11.09	--	0.55	0.58	129.77	2.23	793.90	73.67

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded)	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded	= Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Summer 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Lake Shore Drive																						
Sample Sites							LSD																						
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/17	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2016/08/16
Sampling Time	hh:mm	--					12:00	09:30	11:45	09:00	11:28	10:00	08:45	13:20	9:00	9:15	13:00	9:10	08:40	15:30	11:55	9:30	12:45	13:30	09:50	16:02	13:40	15:00	12:10
FIELD DATA																													
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	N/A	NCC	N/A	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		13.1	16.7	15.3	13.4	21.3	7.3	10.2	21.0	12.0	5.7	25.7	13.4	7.7	20.2	8.8	8.9	--	10.48	12.52	24.3	5.8	13.17	24.01
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**10.84**	5.70	5.50	8.60	**5.41**	8.47	9.44	7.87	8.16	**4.06**	**2.69**	7.58	8.77	7.26	7.60	**14.78**	--	7.22	6.26	7.25	7.21	8.22	**1.86**
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		7.88	6.74	6.34	6.42	6.64	6.17	7.09	6.88	6.63	8.22	7.16	6.92	5.19	7.28	6.23	7.02	--	6.31	6.88	6.34	6.48	6.63	**6.16**
Specific Conductance	uS/cm	1	--	--	--		723	210	168	218	203	110	146	126	112	62	177.5	116.7	123.6	132.5	147.8	180.0	--	111	0.119	155.3	132.3	162	254
INORGANICS																													
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		13	16	12	13	21	9	9	15	12	21	14	11	8	20	11	35	--	10	11	7	9	11	22
Dissolved Chloride (Cl)	mg/L	1	--	--	120		41	34	31	49	45	25	38	27	22	22	33	23	39	32	23	29	--	23	32	27	26	39	45
Colour	TCU	5	--	--	--		32	27	37	20	26	33	32	41	49	13	20	40	10	21	25	9	--	31	20	11	26	25	26
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.14	0.14	0.06	0.23	0.10	0.12	0.25	0.17	0.09	0.13	0.80	<0.05	0.18	0.20	<0.05	0.09	--	0.11	0.15	0.25	0.30	0.08	0.08
Nitrate (N)	mg/L	0.05	--	--	13000		0.14	--	--	0.23	0.10	--	0.25	--	--	0.13	0.80	<0.05	0.18	0.20	<0.05	0.09	--	0.11	0.15	0.16	0.30	0.08	0.08
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.010	0.09	<0.05	<0.05	<0.05
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.06	0.03	<0.03	<0.03	<0.03	0.03	0.03	0.04	--	<0.03	<0.050	0.11	<0.03	0.06	0.10
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	0.5	3.5	0.5	--	0.7	3.0	1.0	--	<0.4	0.29	77.4	2.8	2.2	11.8
Total Organic Carbon	mg/L	0.5	--	--	--		5.0	3.8	6.8	3.7	6.0	5.3	4.7	7.1	7.5	3.1	8.0	7.7	4.7	6.3	6.9	5.2	--	8.1	3.2	14.1	9.9	5.5	14.0
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.69	6.69	6.93	7.10	7.30	6.67	6.72	6.79	6.49	6.2	6.9	6.9	6.94	6.95	**6.49**	**6.47**	--	6.72	7.02	6.59	6.68	6.65	7.01
Total Calcium (Ca)	mg/L	0.1	--	--	--		6.5	6.9	5.4	7.99	10.5	5.29	5.9	5.14	5.04	2.6	18.1	5.1	6.4	6.0	5.6	5.4	--	5.1	6100	52.2	5.4	6.6	9.9
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.4	1.6	1.3	1.99	2.14	1.15	1.25	1.19	1.23	0.7	3.3	1.4	1.2	1.4	1.6	1.5	--	1.1	1300	23.0	1.5	1.4	1.8
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**<0.02**	**0.03**	0.009	**0.018**	**0.100**	0.009	**0.018**	**0.028**	**0.014**	**0.022**	**0.063**	0.003	0.007	**0.015**	**0.078**	**0.100**	--	**0.03**	**0.011**	**0.501**	**0.095**	**1.25**	**0.023**
Total Potassium (K)	mg/L	0.1	--	--	--		1.2	1.1	1.3	1.180	1.210	1.030	1.070	0.960	1.240	0.6	1.9	1.3	1.2	1.1	1.4	1.1	--	1.1	1100	9.7	1.0	1.2	1.3
Total Sodium (Na)	mg/L	0.1	--	--	--		24	21	18	24.8	26.9	15.2	23.2	14.3	13.8	11.3	18.6	15.2	21.9	26.6	14.6	23.4	--	18.1	19	24.4	13.4	25.1	23.4
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		3.1	4.2	4.0	3.2	3.4	4.3	2.6	3.9	3.8	3.1	2.9	4.9	2.6	3.9	5.0	2.9	--	4.2	2.4	4.2	4.4	1.6	3.3
Total Suspended Solids	mg/L	5	--	--	--		16	98	5	6	110	7	4	77	5	<5	16	19	<5	17	9	51	--	8	4.6	719	69	93	9020
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		6	4	5	7	3	4	6	4	4	5	5	5	6	7	5	5	--	4	4.8	<2	3	5	6
Turbidity (NTU)	NTU	0.1	--	50	--		0.6	12	2.5	12	6.2	1	0.6	2.5	1.7	6.7	**283**	2.1	1.1	31.6	**82.6**	6.6	--	1.4	1.2	**4430**	5.4	65.3	206
Conductivity (uS/cm)	µS/cm	1	--	--	--		170	150	140	200	200	110	150	130	110	96	161	110	168	136	105	122	--	125	140	129	136	160	236
Calculated Parameters																													
Anion Sum	me/L	N/A	--	--	--		1.56	0.82	1.22	1.80	1.77	0.97	1.39	1.14	0.96	1.15	1.37	0.97	1.40	1.46	0.97	1.63	--	0.94	1.22	0.92	1.00	1.43	1.84
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		13	8	12	13	21	9	9	15	12	21	14	11	8	20	11	35	--	10	11	7	9	11	22
Calculated TDS	mg/L	1	--	--	--		92	55	74	104	107	62	84	66	60	56	163	58	82	87	66	88	--	59	74	498	65	91	107
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10	<10	--	<10	<1.0	<10	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		1.53	0.99	1.20	1.69	1.94	1.05	1.44	1.02	1.00	0.76	3.59	1.10	1.43	1.62	1.62	1.52	--	1.19	1.28	31.0	1.42	1.94	2.04
Hardness (CaCO3)	mg/L	N/A	--	--	--		22	15	19	28	35	18	20	18	18	9.4	58.8	18.5	20.9	20.7	20.6	19.7	--	17.3	21.0	225	19.7	22.2	32.1
Ion Balance (% Difference)	%	N/A	--	--	--		0.97	9.39	0.83	3.15	4.58	3.96	1.77	5.56	2.04	20.7	63.0	6.1	1.0	5.2	25.0	3.4	--	11.8	2.4	94.2	17.5	15.2	5.3
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-2.74	-3.20	-2.60	-2.22	-1.71	-2.99	-2.88	-2.64	-3.05	-3.62	-2.30	-2.91	-2.93	-2.55	-3.29	-2.84	--	-3.14	-2.50	-2.50	-3.20	-2.97	-2.24
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-2.99	-3.45	-2.85	-2.47	-1.96	-3.24	-3.13	-2.89	-3.31	-3.94	-2.62	-3.23	-3.25	-2.87	-3.61	-3.16	--	-3.46	-2.75	-2.82	-3.52	-3.29	-2.56
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.43	9.78	9.53	9.32	9.01	9.66	9.60	9.43	9.54	9.82	9.20	9.81	9.87	9.50	9.78	9.31	--	9.86	9.51	9.09	9.88	9.72	9.25
Saturation pH (@ 4C)	N/A	N/A	--	--	--		9.68	10.00	9.78	9.57	9.26	9.91	9.85	9.68	9.80	10.10	9.52	10.10	10.20	9.82	10.1	9.63	--	10.2	9.77	9.41	10.2	10.0	9.57
Metals (ICP-MS)																													
Total Aluminum (Al)	µg/L	5	5	--	5-100		99	--	--	349	189	--	217	--	--	490	**19200**	**186**	**131**	93	**3420**	**487**	--	**141**	**120**	--	**1960**	**2150**	--
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2	--
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	**8**	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2	--
Total Barium (Ba)	µg/L	5	1000	--	--		14	--	--	15.3	19.2	--	13.9	--	--	11	86	12	12	7	24	15	--	11	12	--	27	34	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	2	<2	<2	<2	<2	<2	--	<2	<1.0	--	<2	<2	--
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2	--
Total Boron (B)	µg/L	5	1200	--	1500		13	--	--	41.4	21.6	--	<50	--	--	6	24	16	10	15	15	14	--	16	<50	--	<5	12	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	0.018	<0.017	--	<0.017	--	--	0.029	**1.050**	**0.023**	<0.017	<0.017	**0.073**	**0.032**	--	<0.017	**0.011**	--	<0.017	**0.120**	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	**11**	<1	<1	<1	**2**	<1	--	<1	<1.0	--	**3**	**2**	--
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	<0.40	0.88	--	<0.40	--	--	<1	34	<1	<1	<1	1	<1	--	<1	<0.40	--	4	4	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2	--	--	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2	**22**	2	<2	1	**12**	2	<1	3	<2.0	**183**	**6**	3	<1
Total Iron (Fe)	µg/L	50	300	--	300		180	--	--	**554**	**965**	120	211	**388**	**384**	161	**38900**	**312**	236	254	**4200**	**593**	--	**363**	230	**176000**	**4570**	**2790**	**2190**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	--	--	3.02	0.54	--	<0.50	--	--	0.6	**82.4**	<0.5	<0.5	<0.5	5.2	0.5	--	<0.5	<0.50	--	5.9	**4.3**	--
Total Manganese (Mn)	µg/L	2	820	--	--		51	--	--	113	632	22.8	30.2	53.4	38.5	26	**13200**	67	71	81	124	140	--	60	130	**13800**	**985**	921	2420
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	13	<2	<2	<2	2	<2	--	<2	<2.0	--	5	2	--
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	**2**	<1	<1	<1	<1	<1	--	<1	<1.0	--	<1	<1	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1	--
Total Strontium (Sr)	µg/L	5	21000	--	--		30	--	--	36.3	42.1	--	24.4	--	--	12	82	22	24	24	25	26	--	19	25	--	16	29	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	--	<0.1	<0.10	--	<0.1	<0.1	--
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	<2	<2	<2	<2	<2	<2	--	<2	<2.0	--	<2	<2	--
Total Titanium (Ti)	µg/L	2	--	--	--		<2	--	--	7.2	4.1	--	5.3	--	--	3	405	4	<2	2	36	6	--	3	3.3	--	41	30	--
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	1.6	<0.1	<0.1	<0.1	0.1	<0.1	--	<0.1	<0.10	--	0.2	0.2	--
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	30	<2	<2	<2	2	<2	--	<2	<2.0	--	6	4	--
Total Zinc (Zn)	µg/L	5	30	--	30		7	--	--	7.2	6.7	<5.0	<5.0	<5.0	5	<5	**110**	7	6	<5	15	<5	--	<5	<5.0	**799**	11	17	14
MICROBIOLOGICAL																													
Total Coliform	MPN/100mL	1	--	--	--		53	>250	--	>250	>250	280	85	>250	--	1414	>2420	>2420	1990	>2420	>2420	1203	--	8	---	>2420	>2420	>2420	>2420
E. coli	MPN/100mL	1	--	400	--		22	24	--	4	45	6	10	**>250**	<100	2	26	10	10	20	2	<1	--	>2420	<10	16	17	9	30
Fecal Coliform	MPN/ml	--	--	400	--		--	--	<1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		1.46	10.70	4.68	1.21	6.64	0.21	1.19	1.93	1.41	1.88	6.62	0.13	<0.50	1.6	2.02	1.91	--	0.32	1.02	90.33	5.12	8.22	127.14
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		1.85	11.10	5.62	1.32	7.71	0.19	1.07	1.73	1.18	2.28	7.58	0.22	<0.50	2	2.98	1.91	--	0.33	1.07	121.83	4.62	13.77	185.98

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME PAL-F calculation equations). The largest guideline value for each respective element range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality

TABLE 3: Bedford West Water Quality Sampling Program

Summer 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Larry Uteck Blvd														
Sample Sites							LU														
Sampling Date	yyyy-mm-dd	--					2011/10/17	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2016/08/16
Sampling Time	hh:mm	--					10:30	15:20	11:30	10:10	14:30	14:30	13:00	11:45	10:45	9:54	13:45	10:23	10:05	12:20	11:20
FIELD DATA																					
Secchi Depth	Meters	--	--	1.2	--		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	N/A	N/A	N/A
Water Temp	Celsius	0.1	--	--	--		11.3	12.8	27.3	14.6	13.9	18.3	10.9	15.0	22.8	10.2	16.06	23.40	8.20	13.32	21.91
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**4.24**	6.17	8.2	9.04	**10.15**	8.29	**4.50**	**11.96**	8.08	7.55	7.28	9.49	8.50	8.75	**16.62**
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.07	7.82	6.65	6.78	6.39	7.49	5.45	6.50	7.23	6.17	6.57	6.80	6.99	7.17	**6.24**
Specific Conductance	uS/cm	1	--	--	--		203	955	480	262	670	320	845.0	999.0	611.0	371.0	0.646	569	436.2	588.0	574
INORGANICS																					
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		12	14	14	14	6	22	7	30	21	<5	13	16	13	13	27
Dissolved Chloride (Cl)	mg/L	1	--	--	120		34	**224**	116	52	**190**	99	**258**	**243**	104	70	**210**	**132**	93	154	**164**
Colour	TCU	5	--	--	--		94	18	14	18	7	7	19	6	8	18	8.4	8	6	17	13
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.61	1.00	0.64	1.89	1.11	2.57	0.34	1.22	0.47	1.97	0.53	0.59	1.63	1.01	0.47
Nitrate (N)	mg/L	0.05	--	--	13000		--	1.00	0.64	1.89	1.11	2.57	0.34	1.22	0.47	1.97	0.53	0.59	1.63	1.01	0.41
Nitrite (N)	mg/L	0.05	--	--	60		--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05	0.06
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		0.06	0.04	0.16	<0.03	<0.03	0.04	0.04	0.05	<0.03	<0.03	<0.050	0.05	<0.03	0.05	0.05
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	0.4	4.2	0.7	--	0.5	<0.4	1.2	1.7	<0.4	0.3	8.0	0.7	1.2	1.1
Total Organic Carbon	mg/L	0.5	--	--	--		11.0	3.7	22.8	4.8	3.1	4.5	2.9	6.9	4.7	4.7	2.2	7.6	6.5	3.9	5.3
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		**6.43**	6.7	7.2	7.2	6.92	7.11	**6.49**	**6.42**	7.42	**6.41**	6.95	7.30	7.15	6.94	7.42
Total Calcium (Ca)	mg/L	0.1	--	--	--		7.63	30.7	22.1	14.5	22.0	17.6	21.8	23.9	27.6	12.6	27000	20.3	15.9	20.6	17.2
Total Magnesium (Mg)	mg/L	0.1	--	--	--		2.34	4.2	3.6	2.2	2.8	2.7	4.0	4.2	3.8	2.2	3800	3.4	1.9	2.9	3.4
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**0.034**	**0.043**	**0.036**	**0.030**	0.006	**0.027**	**0.046**	**0.260**	**0.028**	**0.04**	0.007	0.009	**0.011**	**0.029**	**0.011**
Total Potassium (K)	mg/L	0.1	--	--	--		2.110	3.2	3.6	2.5	2.6	2.8	2.9	3.1	3.7	3.0	3300	2.8	1.6	2.8	2.6
Total Sodium (Na)	mg/L	0.1	--	--	--		22.7	124	62.2	32.3	95.1	51.7	170	147	88.1	62.7	110	102	57.8	96.4	81.1
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		6.9	4.9	0.7	6.3	5.1	8.6	7.0	2.1	2.5	6.9	3.6	4.9	6.9	4.2	1.3
Total Suspended Solids	mg/L	5	--	--	--		13	5	165	<5	<5	<5	<5	626	<5	<5	<1.0	<5	6	29	<5
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		21	26	25	23	26	29	33	29	20	27	27	31	30	28	23
Turbidity (NTU)	NTU	0.1	--	50	--		3.3	4.1	23.0	2.3	1.8	1.6	0.7	42.7	10.1	1.6	0.3	2.8	2.4	15.8	3.0
Conductivity (uS/cm)	µS/cm	1	--	--	--		190	813	482	255	732	433	840	819	605	394	790	575	462	582	739
Calculated Parameters																					
Anion Sum	me/L	N/A	--	--	--		1.69	7.21	4.12	2.36	6.10	4.02	8.13	8.15	3.80	2.68	6.77	4.73	3.62	5.26	5.68
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		12	14	14	14	6	22	7	30	21	<5	13	16	13	13	27
Calculated TDS	mg/L	1	--	--	--		109	426	246	144	347	229	496	477	262	187	400	305	216	321	310
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		1.70	7.40	4.30	2.43	5.55	3.51	8.90	8.24	5.64	3.64	6.69	5.86	3.52	5.78	4.76
Hardness (CaCO3)	mg/L	N/A	--	--	--		29	94.0	70.0	45.3	66.5	55.1	70.9	77.0	84.6	40.5	84	64.7	47.5	63.4	56.9
Ion Balance (% Difference)	%	N/A	--	--	--		0.29	1.3	2.2	1.4	4.7	6.8	4.5	0.6	19.4	15.2	0.59	10.6	1.4	4.7	8.8
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-2.95	-2.32	-1.94	-2.10	-2.60	-1.93	-2.98	-2.38	-1.45	-3.41	-1.95	-1.82	-2.16	-2.27	-1.55
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.20	-2.64	-2.26	-2.42	-2.92	-2.25	-3.30	-2.70	-1.77	-3.73	-2.20	-2.14	-2.48	-2.59	-1.87
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.38	9.02	9.14	9.30	9.52	9.04	9.47	8.80	8.87	9.82	8.90	9.12	9.31	9.21	8.97
Saturation pH (@ 4C)	N/A	N/A	--	--	--		9.63	9.34	9.46	9.62	9.84	9.36	9.79	9.12	9.19	10.1	9.15	9.44	9.63	9.53	9.29
Metals (ICP-MS)																					
Total Aluminum (Al)	µg/L	5	5	--	5-100		--	218	**227**	**252**	**107**	**447**	31	**1400**	46	**109**	**59**	--	66	**1420**	--
Total Antimony (Sb)	µg/L	2	20	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Arsenic (As)	µg/L	2	5.0	--	5		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Barium (Ba)	µg/L	5	1000	--	--		--	225	201	116	133	134	119	185	157	80	150	--	111	127	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Bismuth (Bi)	µg/L	2	--	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Boron (B)	µg/L	5	1200	--	1500		--	11	17	22	10	22	18	22	20	21	<50	--	9	14	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		--	0.538	**0.171**	**0.168**	**0.300**	**0.236**	**0.148**	**0.171**	**0.031**	**0.079**	**0.150**	--	**0.176**	**0.426**	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		--	<1	<1	<1	<1	1	<1	<1	<1	<1	<1.0	--	<1	**3**	--
Total Cobalt (Co)	µg/L	1	10	--	--		--	<1	1	<1	<1	<1	<1	<1	<1	<1	<0.40	--	<1	2	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		2.9	<2	3	16	2	**6**	2	2	<1	4	**2.1**	3	3	10	<1
Total Iron (Fe)	µg/L	50	300	--	300		**2150**	**347**	**1320**	**500**	194	**890**	157	**2000**	207	229	170	**671**	171	**1940**	**374**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		--	0.8	0.7	1.0	<0.5	1.4	<0.5	1.8	<0.5	<0.5	<0.50	--	<0.5	**3.4**	--
Total Manganese (Mn)	µg/L	2	820	--	--		129	182	485	120	87	89	26	71	182	36	110	371	61	444	148
Total Molybdenum (Mo)	µg/L	2	73	--	73		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		--	<2	<2	<2	<2	<2	<2	3	<2	<2	<2.0	--	<2	3	--
Total Selenium (Se)	µg/L	1	1.0	--	1		--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1.0	--	<1	<1	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Strontium (Sr)	µg/L	5	21000	--	--		--	112	94	60	93	90	96	116	111	54	120	--	43	89	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Tin (Sn)	µg/L	2	--	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Titanium (Ti)	µg/L	2	--	--	--		--	4	3	7	3	11	2	22	<2	3	<2.0	--	<2	31	--
Total Uranium (U)	µg/L	0.1	300	--	15		--	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	0.2	--
Total Vanadium (V)	µg/L	2	6	--	--		--	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	4	--
Total Zinc (Zn)	µg/L	5	30	--	30		9	**79**	**92**	**39**	**57**	**49**	26	17	8	23	27	17	16	**64**	7
MICROBIOLOGICAL																					
Total Coliform	MPN/100mL	1	--	--	--		--	>2420	>2420	2420	866	>2420	866	>2420	961	>2420	---	>2420	>2420	>2420	>2420
E. coli	MPN/100mL	1	--	400	--		<100	<1	2	19	3	86	<1	<1	7	**1730**	<10	19	6	<1	40
Fecal Coliform	MPN/ml	--	--	400	--		--	--	--	--	--	--	--	--	--	--	---	--	--	--	--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		1.99	2.44	32.52	1.80	1.54	2.30	0.12	99.13	2.54	0.96	0.69	3.14	4.94	5.43	4.57
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		2.08	2.71	31.31	2.15	1.77	2.50	0.11	98.00	2.51	0.96	0.68	3.10	2.71	6.73	5.23

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME FWAL calculation equations). The largest guideline value for each respective element
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Wa

TABLE 3: Bedford West Water Quality Sampling Program

Summer 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Paper Mill Lake																						
Sample Sites							PML1																						
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2016/08/16
Sampling Time	hh:mm	--					13:45	13:00	13:00	13:35	15:15	13:00	13:00	16:50	17:00	12:50	--	10:55	10:51	11:35	10:45	10:30	14:45	12:35	12:45	08:45	8:20	13:15	9:30
FIELD DATA																													
Secchi Depth	Meters	--	--	1.2	--		3.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NCC	N/A	2.91	2.65	4.15
Water Temp	Celsius	0.1	--	--	--		15.7	17.1	16.2	13.2	22.7	9.1	10.3	22.1	13.6	8.3	--	14.9	11.6	22.5	12.3	12.1	23.6	12.4	15.13	24.0	9.3	12.8	21.58
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**10.56**	8.10	6.90	8.76	7.83	**10.43**	**10.39**	8.17	**9.54**	8.41	--	8.60	**9.98**	7.65	**9.90**	**12.08**	7.49	8.06	7.16	8.04	8.63	8.84	6.53
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		7.39	6.57	6.64	7.06	7.35	5.89	6.28	6.20	6.11	7.58	--	6.63	6.39	7.20	6.32	6.60	7.42	6.60	6.90	6.34	7.98	7.57	**5.94**
Specific Conductance	uS/cm	1	--	--	--		561	279	223	265	234	125	177	174	106	366	--	186.4	215.1	199.0	250.5	431.0	263.0	210.0	0.197	432.1	289.1	231.0	289
INORGANICS																													
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		6	7	7	7	9	5	6	7	7	20	--	<5	<5	6	7	31	7	7	5.2	6	6	<5	8
Dissolved Chloride (Cl)	mg/L	1	--	--	120		39	64	58	67	61	24	44	43	18	55	--	45	57	57	48	63	50	46	65	57	56	59	67
Colour	TCU	5	--	--	--		54	15	21	19	12	57	32	38	65	38	--	29	8	15	11	17	10	30	31	7	15	18	16
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.49	0.10	0.17	0.42	0.27	0.66	0.55	0.15	0.62	0.22	--	0.14	0.21	0.18	0.18	0.22	0.24	0.18	0.18	0.14	0.24	0.19	0.09
Nitrate (N)	mg/L	0.05	--	--	13000		0.49	--	--	0.42	0.27	--	0.55	--	--	0.22	--	0.14	0.21	0.18	0.18	0.22	0.24	0.18	0.18	0.14	0.24	0.19	<0.05
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.010	<0.05	<0.05	<0.05	0.09
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	0.06	--	<0.03	<0.03	0.04	<0.03	0.04	<0.03	<0.03	<0.050	<0.03	0.03	0.06	<0.03
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	<0.4	--	0.4	--	0.4	0.8	0.4	0.4	<5	0.49	1.20	6.0	2.6	3.4
Total Organic Carbon	mg/L	0.5	--	--	--		6.5	3.6	4.7	0.7	3.3	6.7	4.6	5	8.3	5.7	--	5.3	4.2	4.1	5.1	4.0	2.0	4.4	2.7	5.4	5.8	7.1	6.1
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		**6.36**	6.75	6.79	6.63	7.04	6.58	6.54	6.83	6.67	6.6	--	6.8	6.71	6.92	6.88	6.66	7.00	6.64	6.67	6.95	6.84	6.36	6.86
Total Calcium (Ca)	mg/L	0.1	--	--	--		4.5	6.9	6.4	8.37	9.02	5.90	6.02	4.99	4.64	6.0	--	6.0	6.8	6.6	6.9	6.9	9.1	7.0	6900	7.8	4.8	7.9	10.5
Total Magnesium (Mg)	mg/L	0.1	--	--	--		0.6	1.1	1.0	1.25	1.22	0.82	0.98	0.89	0.85	1.0	--	1.1	1.0	0.9	1.5	1.3	1.4	1.0	970	1.4	0.9	1.5	1.8
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**<0.02**	**<0.02**	0.002	**0.018**	0.002	<0.002	**0.014**	**0.011**	**0.030**	**0.019**	--	**0.03**	0.006	0.007	**0.047**	**0.012**	**0.030**	**0.02**	0.005	**0.060**	**0.018**	**0.173**	**0.104**
Total Potassium (K)	mg/L	0.1	--	--	--		0.9	0.9	0.9	1.160	1.060	1.340	1.230	0.771	1.430	0.8	--	1.0	0.8	1.0	1.5	0.9	1.3	0.9	800	1.0	0.6	1.0	1.3
Total Sodium (Na)	mg/L	0.1	--	--	--		25	38	34	35.2	40.2	18.4	26.8	22.8	13.7	33.6	--	29.8	35.3	28.5	32.2	38.1	41.6	33.7	35	38.6	25.6	37.6	35.1
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		4.5	2.6	2.8	3.8	3.4	5.9	3.7	2.6	5.4	2.9	--	3.2	2.8	2.6	2.6	2.5	2.3	2.7	2.4	2.4	2.5	2.5	0.8
Total Suspended Solids	mg/L	5	--	--	--		<2	3	9	7	<2	<1	1	<2	5	9	--	6	<5	<5	23	6	<5	<5	1	149	6	531	10
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		13	11	11	13	12	12	12	10	12	7	--	10	8	10	10	10	8	8	7.8	9	8	11	11
Turbidity (NTU)	NTU	0.1	--	50	--		0.4	0.5	0.6	8.2	0.9	0.5	0.6	1	1.2	0.7	--	1	0.7	1.1	19.2	1.4	0.9	1.5	0.45	3.8	24.2	**199.0**	**112**
Conductivity (uS/cm)	µS/cm	1	--	--	--		170	250	230	260	250	130	180	170	100	214	--	179	227	218	209	230	261	224	240	246	241	224	310
Calculated Parameters																													
Anion Sum	me/L	N/A	--	--	--		1.51	2.18	1.99	2.34	2.15	1.09	1.62	1.56	0.92	2.11	--	1.49	1.79	1.95	1.71	2.62	1.73	1.62	2.11	1.93	1.88	1.91	2.29
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		6	7	7	7	9	5	6	7	7	20	--	<5	<5	6	7	31	7	7	5.2	6	6	<5	8
Calculated TDS	mg/L	1	--	--	--		93	129	118	137	134	75	100	90	63	117	--	95	110	109	115	140	117	102	120	126	109	141	148
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	--	<10	<10	<10	<10	<10	<10	<10	<1.0	<10	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		1.40	2.11	1.89	2.11	2.33	1.20	1.58	1.35	0.95	1.89	--	1.78	2.00	1.69	2.56	2.18	2.45	1.94	1.98	2.61	1.93	3.54	3.33
Hardness (CaCO3)	mg/L	N/A	--	--	--		14	22	20	26	28	18	19	16	15	19.1	--	19.5	21.1	20.2	23.4	22.6	28.5	21.6	21.0	25.2	15.7	25.9	33.6
Ion Balance (% Difference)	%	N/A	--	--	--		3.78	1.63	2.58	5.17	4.02	4.80	1.25	7.22	1.60	5.5	--	9.0	5.5	7.0	19.8	9.2	17.0	9.2	3.2	15.2	1.2	30.0	18.6
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-3.57	-2.90	-2.94	-2.96	-2.43	-3.25	-3.27	-2.94	-3.13	-2.91	--	-3.31	-3.35	-3.07	-3.03	-2.61	-2.79	-3.26	-3.13	-2.98	-3.29	-3.65	-2.82
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.82	-3.15	-3.19	-3.21	-2.68	-3.50	-3.53	-3.19	-3.38	-3.23	--	-3.63	-3.67	-3.39	-3.35	-2.93	-3.11	-3.58	-3.38	-3.30	-3.61	-3.97	-3.14
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.93	9.65	9.73	9.59	9.47	9.83	9.81	9.77	9.80	9.51	--	10.10	10.1	9.99	9.91	9.27	9.79	9.90	9.80	9.93	10.1	10.0	9.68
Saturation pH (@ 4C)	N/A	N/A	--	--	--		10.20	9.90	9.98	9.84	9.72	10.10	10.10	10.00	10.10	9.83	--	10.40	10.4	10.3	10.2	9.59	10.1	10.2	10.1	10.2	10.5	10.3	10.0
Metals (ICP-MS)																													
Total Aluminum (Al)	µg/L	5	5	--	5-100		**260**	--	--	**665**	45.9	--	**233**	--	--	**177**	--	**306**	**141**	**103**	**3920**	**305**	**129**	**142**	**140**	--	**2320**	**7690**	--
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	--	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	--	<2	<2	<2	2	<2	<2	<2	<1.0	--	<2	4	--
Total Barium (Ba)	µg/L	5	1000	--	--		23	--	--	35.3	24.4	--	26.6	--	--	22	--	19	20	12	40	23	23	18	21	--	34	60	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	--	<2	<2	<2	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Boron (B)	µg/L	5	1200	--	1500		8	--	--	11.3	8.6	--	<50	--	--	6	--	9	6	8	9	8	13	11	<50	--	<5	10	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	**0.032**	<0.017	--	<0.017	--	--	<0.017	--	**0.066**	**0.021**	**0.018**	**0.430**	<0.017	**0.020**	<0.017	**0.025**	--	**0.146**	**0.227**	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	--	<1	<1	<1	**3**	<1	<1	<1	<1.0	--	**2**	**6**	--
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	0.96	<0.40	--	<0.40	--	--	<1	--	2	<1	<1	9	<1	<1	<1	<0.40	--	3	6	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2	--	--	2.0	<2.0	<2.0	4.0	<2.0	2.3	<2	--	<2	<2	1	**6**	1	<1	2	<2.0	3	4	10	<1
Total Iron (Fe)	µg/L	50	300	--	300		140	--	--	**837**	89	161	141	**315**	**528**	137	--	**742**	130	205	**5300**	239	296	182	93	**4460**	**6020**	**13600**	**8250**
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	--	--	1.73	<0.50	--	<0.50	--	--	<0.5	--	0.9	<0.5	<0.5	**13.5**	0.9	<0.5	<0.5	<0.50	--	6.3	**13.9**	--
Total Manganese (Mn)	µg/L	2	820	--	--		17	--	--	142	68.9	41.3	14.4	128	62.4	48	--	214	33	58	693	54	260	49	34	296	278	424	281
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	2	<2	<2	9	<2	<2	<2	<2.0	--	5	7	--
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	--	<1	<1	<1	<1	<1	<1	<1	<1.0	--	1	1	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Strontium (Sr)	µg/L	5	21000	--	--		18	--	--	36.3	37.1	--	25	--	--	26	--	30	31	25	34	35	37	30	32	--	22	40	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	<2	<2	<2	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Titanium (Ti)	µg/L	2	--	--	--		<2	--	--	7.8	<2.0	--	3.9	--	--	<2	--	4	<2	<2	65	4	<2	3	<2.0	--	25	106	--
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	0.1	--	<0.1	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.10	--	0.6	0.9	--
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	<2	<2	<2	10	<2	<2	<2	<2.0	--	**7**	**16**	--
Total Zinc (Zn)	µg/L	5	30	--	30		8	--	--	10.0	5.4	5.7	6.3	6.2	5.4	<5	--	13	8	<5	**62**	<5	<5	6	11	13	12	**34**	20
MICROBIOLOGICAL																													
Total Coliform	MPN/100mL	1	--	--	--		200	73	--	>250	>250	>250	85	>250	--	411	--	2420	866	1730	1011	613	2420	>2420	---	**>2420**	>2420	>2420	1410
E. coli	MPN/100mL	1	--	400	--		33	45	--	19	**>250**	2	2	34	<100	2	--	20	12	4	6	6	10	10	<10	3	6	>2420	34
Fecal Coliform	MPN/ml	--	--	400	--		--	--	<1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--			--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		0.62	2.31	0.57	0.82	1.12	0.07	2.85	0.86	0.15	1.03	--	0.69	1.17	1.10	5.07	0.67	0.64	0.91	0.57	8.84	4.67	8.00	4.71
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		0.64	2.21	0.64	0.74	1.04	0.06	2.75	0.76	0.15	1.10	--	0.91	1.37	1.10	6.39	0.65	0.65	0.87	0.54	9.54	3.69	12.31	10.82

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected
RDL = Reported Detection Limit (represents most recent sampling event)
" -- " = no guideline available / Not Tested.
CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)
CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME FWAL calculation equations). The largest guideline value for each respective element range was
range was always used.
Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009) (Referenced)
Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded) = Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded) = Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded = Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Qualit
er Quality

TABLE 3: Bedford West Water Quality Sampling Program

Summer 2016	Units	RDL (May 2016)	NSE ESQs for Surface Water (Reference)	Health Canada Guideline for Recreational Water Quality (Reference)	CCME Guideline PAL-F (Applied)	CCME Phosphorus Trigger Range (Applied)	Paper Mill Lake																						
Sample Sites							PML2																						
Sampling Date	yyyy-mm-dd	--					2009/06/29	2009/08/13	2009/10/01	2010/05/31	2010/08/24	2010/11/01	2011/05/13	2011/08/14	2011/10/16	2012/05/01	2012/08/15	2012/10/11	2013/05/15	2013/08/15	2013/10/16	2014/05/15	2014/08/14	2014/10/27	2015/05/20	2015/08/25	2015/10/22	2016/05/16	2016/08/16
Sampling Time	hh:mm	--					13:15	13:40	13:45	14:30	16:20	13:00	12:40	16:20	16:15	13:16	--	--	13:40	10:45	11:20	11:00	9:20	8:30	11:30	13:45	9:08	13:45	10:00
FIELD DATA																													
Secchi Depth	Meters	--	--	1.2	--		2.8	2.2	2.3	N/A	3.0	2.0	2.2	2.3	2.2	2.35	--	--	3.20	--	N/A	N/A	N/A	3.1	NCC	N/A	2.41	2.7	2.3 (on Bottom)
Water Temp	Celsius	0.1	--	--	--		14.8	24.2	19.7	17.8	25.3	10.1	10.9	23.1	15.2	11.6	--	--	14.8	--	12.6	14.4	21.1	12.1	15.09	27.0	9.0	13.8	22.09
Dissolved Oxygen	mg/L	0.01	--	--	5.5-9.5		**10.20**	8.30	8.40	8.78	8.09	**10.58**	**9.88**	8.7	8.94	7.75	--	--	9.26	--	8.90	**12.44**	6.95	7.92	8.06	**9.76**	8.28	8.55	7.69
pH (in Situ)	pH	N/A	--	--	6.5 - 9.0		6.36	6.82	6.84	7.09	7.39	6.53	6.31	6.67	6.13	8.61	--	--	6.49	--	6.13	6.50	7.22	5.92	6.56	6.76	7.25	7.57	**5.93**
Specific Conductance	uS/cm	1	--	--	--		267	264	241	237	234	201	159	173	156	231	--	--	234	--	250.5	966.0	266.0	215.0	0.214	255.6	454.9	264	298
INORGANICS																													
Total Alkalinity (as CaCO3)	mg/L	5	--	--	--		5	7	7	6	8	7	<5	8	7	21	--	--	<5	--	8	32	10	26	<5.0	5	7	7	10
Dissolved Chloride (Cl)	mg/L	1	--	--	120		63	63	58	62	58	50	44	43	34	55	--	--	63	--	64	**245**	50	42	69	59	57	67	67
Colour	TCU	5	--	--	--		22	17	19	20	13	23	35	38	48	39	--	--	18	--	8	6	7	31	26	10	9	22	13
Nitrite + Nitrate	mg/L	0.05	--	--	--		0.14	0.07	0.09	0.19	0.11	0.23	0.33	0.14	0.22	0.24	--	--	0.22	--	<0.05	0.13	0.18	0.18	0.11	0.32	0.23	0.10	0.11
Nitrate (N)	mg/L	0.05	--	--	13000		0.14	--	--	0.19	0.11	--	0.33	--	--	0.24	--	--	0.22	--	<0.05	0.13	0.18	0.18	0.11	0.17	0.23	0.10	<0.05
Nitrite (N)	mg/L	0.05	--	--	60		<0.01	--	--	<0.01	<0.01	--	<0.01	--	--	<0.05	--	--	<0.05	--	<0.05	<0.05	<0.05	<0.05	<0.010	0.15	<0.05	<0.05	0.11
Nitrogen (Ammonia Nitrogen)	mg/L	0.03	--	--	19		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.03	--	--	0.03	--	0.23	0.05	0.03	<0.03	<0.050	<0.03	<0.03	0.05	<0.03
Total Kjeldahl Nitrogen as N	mg/L	0.4	--	--	--		--	--	--	--	--	--	--	--	--	<0.4	--	--	--	--	1.7	<0.4	0.4	<5	0.23	1.20	3.0	0.6	<0.4
Total Organic Carbon	mg/L	0.5	--	--	--		3.6	2.6	4.5	3.2	3.4	3.6	4	6	5.6	5.9	--	--	4.4	--	4.0	2.7	2.4	5.8	2.8	6.0	6.1	4.0	3.6
Orthophosphate (as P)	mg/L	0.01	--	--	--		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	--	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.010	<0.01	<0.01	<0.01	<0.01
pH (units)	pH	N/A	--	5.0-9.0	6.5 - 9.0		6.50	6.81	6.82	6.66	7.02	6.83	**6.37**	6.60	6.60	6.6	--	--	6.68	--	6.73	7.13	7.04	6.77	6.64	6.98	6.98	6.83	7.23
Total Calcium (Ca)	mg/L	0.1	--	--	--		6.1	7.1	6.1	7.17	7.69	7.96	5.30	4.76	5.04	6.1	--	--	6.7	--	7.7	19.2	8.8	6.9	7300	8.2	6.2	8.9	8.1
Total Magnesium (Mg)	mg/L	0.1	--	--	--		1.1	1.1	1.1	1.25	1.17	1.20	0.93	0.86	0.90	1.0	--	--	1.0	--	1.4	1.7	1.4	1.0	1000	1.3	1.2	1.2	1.2
Total Phosphorus (1M depth)	mg/L	0.002	--	--	--	0.01	**<0.02**	**<0.02**	0.002	0.010	0.002	<0.002	0.009	0.009	0.007	**0.025**	--	--	0.006	--	**0.026**	**0.011**	**0.026**	**0.02**	0.008	**0.012**	0.008	**0.012**	0.003
Total Potassium (K)	mg/L	0.1	--	--	--		0.9	1.0	0.9	0.984	0.900	1.020	0.861	0.801	0.968	0.8	--	--	0.8	--	1.3	1.4	1.2	1.1	830	1.0	0.9	1.0	1.0
Total Sodium (Na)	mg/L	0.1	--	--	--		35	40	34	31.1	35.1	30.8	25.7	21.3	20.9	34.6	--	--	37.5	--	42.0	133	42.6	33.9	38	43.3	31.3	42.9	37.5
Reactive Silica (SiO2)	mg/L	0.5	--	--	--		2.6	2.5	2.3	2.6	2.3	3.3	2.9	2.5	3	2.8	--	--	2.7	--	4.2	2.4	2.3	2.9	1.9	1.8	2.8	2.3	0.6
Total Suspended Solids	mg/L	5	--	--	--		2	3	<1	15	<2	11	<1	8	<1	<5	--	--	<5	--	<5	16	<5	<5	1	<5	<5	45	<5
Dissolved Sulphate (SO4)	mg/L	2	--	--	--		11	11	11	10	10	10	9	10	9	7	--	--	9	--	11	27	7	7	8	9	9	12	7
Turbidity (NTU)	NTU	0.1	--	50	--		0.8	0.7	0.6	1.0	0.8	0.4	0.4	3.4	0.5	0.7	--	--	1	--	3.3	2.6	0.7	1	0.88	1.9	1.3	9.4	1.1
Conductivity (uS/cm)	µS/cm	1	--	--	--		240	250	230	230	230	210	170	170	150	213	--	--	254	--	277	777	273	212	260	251	246	263	319
Calculated Parameters																													
Anion Sum	me/L	N/A	--	--	--		2.11	2.17	1.99	2.07	2.01	1.77	1.46	1.58	1.30	2.13	--	--	1.98	--	2.19	8.12	1.77	1.86	2.13	1.97	1.95	2.29	2.24
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	5	--	--	--		5	7	7	6	8	7	<1	8	7	21	--	--	<5	--	8	32	10	26	<1.0	5	7	7	10
Calculated TDS	mg/L	1	--	--	--		123	131	117	120	120	110	91	89	79	119	--	--	119	--	137	448	118	109	130	127	112	139	129
Carb. Alkalinity (calc. as CaCO3)	mg/L	10	--	--	--		<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	--	--	<10	--	<10	<10	<10	<10	<1.0	<10	<10	<10	<10
Cation Sum	me/L	N/A	--	--	--		1.94	2.23	1.88	1.88	2.03	1.86	1.48	1.28	1.27	1.94	--	--	2.09	--	2.55	6.96	2.47	1.95	2.14	2.44	1.84	2.53	2.17
Hardness (CaCO3)	mg/L	N/A	--	--	--		20	22	20	23	24	25	17	15	16	19.3	--	--	20.8	--	25.0	54.9	27.7	21.3	23.0	25.8	20.4	27.2	25.2
Ion Balance (% Difference)	%	N/A	--	--	--		4.20	1.36	2.84	4.81	0.50	2.48	0.68	10.50	1.17	4.8	--	--	2.8	--	7.5	7.7	16.5	2.2	0.23	10.6	3.0	5.1	1.7
Langelier Index (@ 20C)	N/A	N/A	--	--	--		-3.33	-2.83	-2.93	-3.06	-2.55	-2.80	NC	-3.18	-3.17	-2.89	--	--	-3.39	--	-3.08	-1.73	-2.61	-2.57	NC	-3.00	-2.97	-2.98	-2.46
Langelier Index (@ 4C)	N/A	N/A	--	--	--		-3.59	-3.08	-3.18	-3.31	-2.80	-3.05	NC	-3.43	-3.42	-3.21	--	--	-3.71	--	-3.40	-2.05	-2.93	-2.89	NC	-3.32	-3.29	-3.30	-2.78
Saturation pH (@ 20C)	N/A	N/A	--	--	--		9.83	9.64	9.75	9.72	9.57	9.63	NC	9.78	9.77	9.49	--	--	10.1	--	9.81	8.86	9.65	9.34	NC	9.98	9.95	9.81	9.69
Saturation pH (@ 4C)	N/A	N/A	--	--	--		10.10	9.89	10.00	9.97	9.82	9.88	NC	10.00	10.00	9.81	--	--	10.4	--	10.1	9.18	9.97	9.66	NC	10.3	10.3	10.1	10.0
Metals (ICP-MS)																													
Total Aluminum (Al)	µg/L	5	5	--	5-100		**130**	--	--	**1030**	55.8	--	**202**	--	--	**189**	--	--	**131**	--	**107**	**181**	52	**122**	**130**	--	**278**	**610**	--
Total Antimony (Sb)	µg/L	2	20	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	--	--	<2	--	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Arsenic (As)	µg/L	2	5.0	--	5		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	--	--	<2	--	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Barium (Ba)	µg/L	5	1000	--	--		16	--	--	23.0	12.2	--	23	--	--	22	--	--	22	--	37	50	27	19	25	--	24	35	--
Total Beryllium (Be)	µg/L	2	5.3	--	--		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<2	--	--	<2	--	<2	<2	<2	<2	<1.0	--	<2	<2	--
Total Bismuth (Bi)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	--	<2	--	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Boron (B)	µg/L	5	1200	--	1500		5	--	--	8.2	8.8	--	<50	--	--	6	--	--	6	--	9	7	13	11	<50	--	<5	8	--
Total Cadmium (Cd)	µg/L	0.017	0.01	--	0.017		<0.3	--	--	**0.037**	<0.017	--	**0.028**	--	--	**0.023**	--	--	**0.039**	--	**0.060**	**0.062**	**0.019**	**0.018**	**0.023**	--	**0.145**	**0.042**	--
Total Chromium (Cr)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	--	--	<1	--	<1	<1	<1	<1	<1.0	--	<1	<1	--
Total Cobalt (Co)	µg/L	1	10	--	--		<1	--	--	0.65	<0.40	--	<0.40	--	--	<1	--	--	<1	--	2	<1	<1	<1	<0.40	--	<1	<1	--
Total Copper (Cu)	µg/L	1	2	--	2.0-4.0		<2	--	--	3.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2	--	--	<2	--	**1380**	1	<1	2	<2.0	2	2	<1	<1
Total Iron (Fe)	µg/L	50	300	--	300		100	--	--	**1090**	151	76	143	**699**	181	178	--	--	181	--	**1760**	264	**316**	134	170	**334**	**368**	**647**	174
Total Lead (Pb)	µg/L	0.5	1	--	1.0-7.0		<0.5	--	--	2.39	<0.50	--	<0.50	--	--	<0.5	--	--	<0.5	--	**49.7**	0.7	<0.5	<0.5	<0.50	--	0.5	**1.1**	--
Total Manganese (Mn)	µg/L	2	820	--	--		58	--	--	159	81.0	28.0	33.8	88.6	30.6	22	--	--	87	--	866	206	278	24	43	67	61	109	36
Total Molybdenum (Mo)	µg/L	2	73	--	73		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	--	<2	--	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Nickel (Ni)	µg/L	2	25	--	25-150		2	--	--	2.2	<2.0	--	<2.0	--	--	<2	--	--	<2	--	3	<2	<2	<2	<2.0	--	2	<2	--
Total Selenium (Se)	µg/L	1	1.0	--	1		<2	--	--	<1.0	<1.0	--	<1.0	--	--	<1	--	--	<1	--	<1	<1	<1	<1	<1.0	--	<1	<1	--
Total Silver (Ag)	µg/L	0.1	0.1	--	0.1		<0.5	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	--	--	<0.1	--	0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Strontium (Sr)	µg/L	5	21000	--	--		30	--	--	34.7	32.8	--	25.7	--	--	27	--	--	31	--	35	68	37	29	34	--	21	38	--
Total Thallium (Tl)	µg/L	0.1	0.8	--	0.8		<0.1	--	--	<0.10	<0.10	--	<0.10	--	--	<0.1	--	--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Tin (Sn)	µg/L	2	--	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	--	<2	--	3	<2	<2	<2	<2.0	--	<2	<2	--
Total Titanium (Ti)	µg/L	2	--	--	--		<2	--	--	21.3	<2.0	--	3.6	--	--	<2	--	--	<2	--	2	3	<2	<2	2.1	--	4	7	--
Total Uranium (U)	µg/L	0.1	300	--	15		<0.1	--	--	0.10	<0.10	--	<0.10	--	--	0.1	--	--	<0.1	--	<0.1	<0.1	<0.1	<0.1	<0.10	--	<0.1	<0.1	--
Total Vanadium (V)	µg/L	2	6	--	--		<2	--	--	<2.0	<2.0	--	<2.0	--	--	<2	--	--	<2	--	<2	<2	<2	<2	<2.0	--	<2	<2	--
Total Zinc (Zn)	µg/L	5	30	--	30		12	--	--	18.3	<5.0	5.8	6.6	7.5	10	8	--	--	11	--	**762**	<5	<5	5	14	<5	8	7	<5
MICROBIOLOGICAL																									3				
Total Coliform	MPN/100mL	1	--	--	--		49	40	--	>250	46	97	64	>250	--	261	--	--	1410	--	411	291	517	>2420	---	>2420	1120	687	>2420
E. coli	MPN/100mL	1	--	400	--		10	31	--	69	<1	6	17	**>250**	<100	1	--	--	12	--	2	<1	3	16	<0.10	5	2	4	47
Fecal Coliform	MPN/ml	--	--	400	--		--	--	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	---	--			--
Chlorophyll A - Acidification method	µg/L	0.05	--	--	--		1.15	1.36	0.59	3.50	1.54	0.53	0.55	2.48	1.33	0.76	--	--	1.18	--	0.25	0.99	0.48	0.72	1.67	4.79	1.50	3.82	1.09
Chlorophyll A - Welschmeyer method	µg/L	0.05	--	--	--		1.22	1.33	0.66	3.39	1.51	0.42	0.51	2.26	1.13	0.76	--	--	1.34	--	0.27	1.13	0.44	0.7	1.56	4.59	0.74	5.04	1.42

Notes:

N/A - Not Applicable; NC - Not Calculable; NCC Not Collected

RDL = Reported Detection Limit (represents most recent sampling event)

" -- " = no guideline available / Not Tested.

CCME PAL-F = Canadian Council of Ministers of the Environment Guidelines for the Protection of Aquatic Life - Freshwater (updated 2011)

CCME PAL-F Guidelines for Aluminum, Lead, Copper and Nickel vary based on reported pH and water hardness (CCME FWAL calculation equations). The largest guideline value for each respective element ran

always used.

Health Canada Guideline for Recreational Water Quality = Health Canada Guidelines for Canadian Recreational Water Quality - Draft (September 2009)

Nova Scotia Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (ug/L) - Fresh Water

Bold (black shaded)	= Present Result - Parameter concentration exceeds CCME FWAL Guideline.
Underlined (black shaded)	= Present Result - Parameter concentration exceeds NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water Quality
Blue shaded	= Past Result - Parameter concentration exceeds CCME FWAL Guideline and/or NSE EQS Contaminated Sites Regulations and/or Health Canada Guideline for Recreational Water

/

7 STATISTICAL PRESENTATION

Table 4 attached at the end of this section provides seasonal (i.e. summer) statistics for each of the eleven (11) water quality sampling stations representing water quality data from 2009 to 2016 for six (6) key water quality parameters as follows:

a. Total Phosphorous
b. Chloride
c. Laboratory measured pH
d. Total Suspended Solids
e. Conductivity
f. Chlorophyll-A

TABLE 4: Summer 2016 Statistical Presentation of Key Water Quality Parameters - Bedford West Water Quality Sampling Program

Station 1

KL-1	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	0.005	0.002	0.043	0.011	0.014
Chloride (mg/L)	57	45	76	61	62.9
Lab pH	7.23	6.51	7.23	6.98	6.94
Total Suspended Solids (mg/L)	2.5	1	17	2.5	4.06
Conductivity (uS/cm)	270	180	339	264	261
Chloropylla-A (µg/L)	0.9	0.41	2.3	1.27	1.23

Station 2

KL-2	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	0.016	0.008	0.059	0.018	0.023
Chloride (mg/L)	26	14	48	20.5	23.1
Lab pH	6.87	6.4	6.99	6.82	6.76
Total Suspended Solids (mg/L)	2.5	1	135	2.5	32
Conductivity (uS/cm)	135	66	212	92.5	106
Chloropylla-A (µg/L)	1.86	0.55	6.05	0.98	1.79

Station 3

KL-3	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	0.005	0.001	0.045	0.006	0.012
Chloride (mg/L)	56	40	63	55.5	52
Lab pH	7.28	6.5	7.28	6.94	6.91
Total Suspended Solids (mg/L)	2.5	0.5	2.5	2.5	1.88
Conductivity (uS/cm)	262	170	262	232	228
Chloropylla-A (µg/L)	0.81	0.59	2	1.2	1.19

Station 4

KL-4	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	0.004	0.001	2.39	0.009	0.311
Chloride (mg/L)	58	41	65	56	53
Lab pH	7.03	6.57	7.03	6.94	6.89
Total Suspended Solids (mg/L)	2.5	0.5	7	2.5	2.44
Conductivity (uS/cm)	275	170	275	236	231
Chloropylla-A (µg/L)	0.16	0.07	1.5	0.6	0.668

Note: The analytical results for Total Phosphorus (TP) and Total Suspended Solids (TSS) included values less than the laboratory RDL. When calculating the median and average, SNC-Lavalin Inc sets the "<RDL" values to the RDL. This allowed the median and average to take into account all data points, and resulted in a conservative approach to statistical averages.

Station 5

KL-5	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospohorous (µg/L)	0.004	0.004	0.04	0.013	0.018
Chloride (mg/L)	56	44	58	56	52.4
Lab pH	7.16	6.84	7.16	6.93	6.99
Total Suspended Solids (mg/L)	2.5	2.5	2.5	2.5	2.5
Conductivity (uS/cm)	267	223	267	246	242
Chloropylla-A (µg/L)	1.2	0.61	2.2	1.2	1.29

Station 6

HWY102-1	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospohorous (µg/L)	0.038	0.007	0.14	0.03	0.039
Chloride (mg/L)	87	27	89	65	55.9
Lab pH	7.03	5.24	7.49	6.89	6.72
Total Suspended Solids (mg/L)	10	1	80	4.25	14.4
Conductivity (uS/cm)	440	100	440	210	233
Chloropylla-A (µg/L)	51.5	0.58	51.5	4.93	12.3

Station 7

HWY102-2	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospohorous (µg/L)	0.034	0.019	1.56	0.034	0.252
Chloride (mg/L)	226	21	226	82	101
Lab pH	6.8	5.96	6.8	6.59	6.46
Total Suspended Solids (mg/L)	69	2.5	3000	39	458
Conductivity (uS/cm)	952	100	952	290	396
Chloropylla-A (µg/L)	55	1.1	119	21	42.9

Station 8

LSD	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospohorous (µg/L)	0.023	0.015	0.501	0.03	0.109
Chloride (mg/L)	45	27	45	33	34.7
Lab pH	7.01	6.59	7.3	6.9	6.89
Total Suspended Solids (mg/L)	9020	16	9020	98	1437
Conductivity (uS/cm)	236	129	236	150	163
Chloropylla-A (µg/L)	127	1.6	127	6.64	35

Note: The analytical results for Total Phosphorus (TP) and Total Suspended Solids (TSS) included values less than the laboratory RDL. When calculating the median and average we set the "<RDL" values to the RDL. This allowed the median and average to take into account all data points, and resulted in a conservative approach to statistical averages.

Station 9

LU	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	0.011	0.009	0.036	0.027	0.022
Chloride (mg/L)	164	99	164	116	123
Lab pH	7.42	7.11	7.42	7.3	7.29
Total Suspended Solids (mg/L)	2.5	2.5	165	2.5	35
Conductivity (uS/cm)	739	433	739	575	567
Chloropylla-A (µg/L)	4.57	2.3	32.5	3.14	9.01

Station 10

PML1	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	0.104	0.002	0.104	0.011	0.032
Chloride (mg/L)	67	43	67	57	57
Lab pH	6.86	6.75	7.04	6.92	6.91
Total Suspended Solids (mg/L)	10	1	149	2.5	24.1
Conductivity (uS/cm)	310	170	310	250	244
Chloropylla-A (µg/L)	4.71	0.64	8.84	1.12	2.8

Station 11

PML2	Seasonal Results	Seasonal Minimum	Seasonal Maximum	Seasonal Median	Seasonal Mean
Total Phospophorous (µg/L)	0.003	0.002	0.026	0.01	0.01
Chloride (mg/L)	67	43	67	58.5	56.7
Lab pH	7.23	6.6	7.23	7	6.95
Total Suspended Solids (mg/L)	2.5	1	8	2.5	3.25
Conductivity (uS/cm)	319	170	319	251	249
Chloropylla-A (µg/L)	1.09	0.48	4.79	1.45	1.96

Note: The analytical results for Total Phosphorus (TP) and Total Suspended Solids (TSS) included values less than the laboratory RDL. When calculating the median and average we set the "<RDL" values to the RDL. This allowed the median and average to take into account all data points, and resulted in a conservative approach to statistical averages.

8 GRAPHS

Appendix D includes seasonal (i.e. summer) and yearly graphs that illustrate concentrations from 2009 to 2016 of the six (6) key water quality parameters including: dissolved chloride (mg/L), pH, total phosphorus (mg/L), total suspended solids (mg/L), conductivity (µS/cm) and chlorophyll A (µg/L) at each of the eleven (11) water quality monitoring sites. The graphs allow for comparison between water quality sampling stations and identification of concentration increases (i.e. above applicable CCME guidelines).

As many parameters show seasonal concentration fluctuations, the data was also graphed showing only the concentrations for a given season (i.e. summer in this case). Where results were found to be less than the recordable detection limit (<RDL), they were graphed as half the recordable detection limit (1/2 RDL).

9 CONCLUSIONS

The summer 2016 water quality monitoring program included collection of surface water samples at eleven (11) water quality sampling stations for the analysis of general chemistry, total metals, total phosphorus, total suspended solids, *E.coli*, and chlorophyll-A. Additionally, field parameters collected at each station included in Situ pH, water temperature, dissolved oxygen, conductivity, Secchi depth (where applicable), air temperature, cloud cover and wildlife sightings.

Based on the summer 2016 water quality monitoring results and their comparison with applicable guidelines, the following results were obtained:

Field Parameters

pH (in Situ) was below the CCME-PAL-F guideline of 6.5-9.0 at water quality stations KL1 (4.60 pH), KL2 (5.97 pH), KL5 (5.11 pH), HWY102-1 (6.14 pH), HWY102-2 (6.19 pH), LSD (6.16 pH), LU (6.24 pH), PML1 (5.94 pH), and PML2 (5.93 pH).

Dissolved Oxygen was above the recommended CCME PAL-F guideline of 5.5-9.5 mg/L at stations KL1 (10.33 mg/L), KL2 (4.21 mg/L), HWY102-1 (10.14 mg/L), LSD (1.86 mg/L), and LU (16.62 mg/L of Oxygen).

General Chemistry

Dissolved Chloride exceeded the CCME-PAL-F guideline of 120 mg/L at water quality monitoring station HWY102-2 (226 mg/L).

Turbidity was above the Health Canada Guideline of 50 NTU for Recreational Water Quality at three water quality monitoring stations as follows: HWY102-2 (54.2 NTU), LSD (206 NTU) and PML1 (112 NTU).

Total Phosphorous

Total Phosphorous was above the management threshold criteria of 10 µg/L at six water quality sampling stations as follows: KL2 (16 µg/L), HWY102-1 (38 µg /L), HWY102-2 (34 µg/L), LSD (23 µg/L), LU (11 µg/L), and PML1 (104 µg/L).

Metals

Total Iron exceeded the applicable NSE EQS guideline of 300 µg/L at the following five water quality sampling stations: KL2 (1,000 µg/L), HWY102-1 (766 µg/L), HWY102-2 (7,380 µg/L), LSD (2,190 µg/L), LU (374 µg/L), and PML1 (8,250 µg/L).

Manganese exceeded the applicable NSE EQS guideline of 820µg/L at station LSD (2,420 µg/L).

Microbiological

E.coli analytical results did not report exceedances of the Heath Canada Guideline of 400CFU/100mL in any of the eleven (11) water quality sampling stations.

10 REFERENCES

Canadian Environmental Quality Guidelines for the Protection of Aquatic Life, 2004, "Phosphorous: Canadian Guidance Framework for the Management of Freshwater Systems".

Canadian Council of Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life – Freshwater (FWAL). For TSS and turbidity, the CCME Narrative Total Particulate Matter – Table 1 Suspended Sediments and Turbidity, High Flow Conditions, updated 2002 were used.

Environment Canada (EC), 2005, The Inspector's field sampling manual. Second Edition. Retrieved on March 6, 2015 from http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf

Health Canada guidelines for Canadian Recreational Water Quality (2012, Third Edition). For turbidity, the guidelines indicate a limit of 50 Nephelometric Turbidity Units (NTU).

Nova Scotia Environment (NSE), Environmental Quality Standards for Surface Water (Environmental Quality Standards (EQS) for Contaminated Sites (NSE 2014) Table A2 Reference for Pathway Specific Standards for Surface Water (µg/L) – Fresh Water

11 LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by SNC-Lavalin Inc (SNCL) for Halifax Regional Municipality (HRM), hereafter referred to as the "Client". It is intended for the sole and exclusive use of Halifax Regional Municipality.

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This report has been prepared in a manner generally accepted by professional consulting principles and practices for the same locality and under similar conditions. No other representations or warranties, expressed or implied, are made.

Opinions and recommendations contained in this report are based on conditions that existed at the time the services were performed and are intended only for the client, purposes, stations, time frames and project parameters as outlined in the Scope or Work and agreement between SNCL and the Client. The data reported, findings, observations and conclusions expressed are limited by the Scope of Work. SNCL is not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. SNCL does not warranty the accuracy of information provided by third party sources.

Appendix A

Instrument Calibration Report

INSTRUMENT PACKING LIST

Pine Environmental Services, Inc.

NJ Headquarters 800-301-9663
GA 800-842-1088
OH 877-326-PINE
ME 888-779-PINE
MA 800-519-PINE
NY 877-903-PINE
NC 866-646-PINE
TX 866-981-PINE
CO 866-960-PINE
VA 866-801-PINE
FL 877-259-PINE
PA 866-750-PINE
TN 877-355-7907
CA 888-620-PINE
Canada
ON 866-688-0388
BC 877-678-8383

Description	YSI 556 sonde and display
Instrument ID	28181 ✓
Date Calibrated	8/12/2016

Standard Items	Prepared	QC check	Received by customer	Returned to Pine
YSI 556 sonde w/ 4m cable and case	✓	✓		
YSI 556 Display	✓	✓		
Manual	✓	✓		
Quick reference card	✓	✓		
Probe Guard	✓	✓		
Calibration cup w/sponge	✓	✓		
Flow cell	✓	✓		
• Cell adapter for older style cell (if applicable)	^			
2 of each barb size (1/4, 3/8, 1/2)	✓	✓		
DO_2 probe reconditioning kit	✓	✓		
4 C batteries	✓	✓		
556 Communications cable	✓	✓		
YSI Ecowatch Software	✓	✓		
Calibration kit, pH (4,7,10), conductivity, and ORP.	✓	✓		
NIST traceable calibration sheet	✓	✓		

Prepared by:

QC checked by:

Date: 081216

This packing list is to ensure that every item needed to operate the unit was sent and received. Upon receiving a shipment, please fill out the "Received by customer" column. Call Pine within 24 hours of receiving the equipment if any pieces are missing, damaged, or malfunctioning. Thank you for choosing Pine Environmental Services, Inc.

INSTRUMENT CALIBRATION REPORT

Pine Environmental Services, LLC.
6380 Tomken Road, Unit 1 & 2
Mississauga, ONTARIO L5T1Y4
Toll-free: (866) 688-0388

Pine Environmental Services, Inc.

Instrument ID 28181
Description YSI 556
Calibrated 8/12/2016 11:18:37AM

Manufacturer YSI
Model Number 556
Serial Number/ Lot Number 14K101577
Location Ontario
Department

State Certified
Status Pass
Temp °C 24.6
Humidity % 49

Calibration Specifications

Group # 1
Group Name PH
Stated Accy Pct of Reading
Range Acc % 0.0000
Reading Acc % 3.0000
Plus/Minus 0.00

Nom In Val / In Val	In Type	Out Val	Out Type	Fnd As	Lft As	Dev%	Pass/Fail
7.00 / 7.00	PH	7.00	PH	7.00	7.00	0.00%	Pass
4.00 / 4.00	PH	4.00	PH	4.00	4.00	0.00%	Pass
10.00 / 10.00	PH	10.00	PH	10.00	10.00	0.00%	Pass

Group # 2
Group Name Conductivity
Stated Accy Pct of Reading
Range Acc % 0.0000
Reading Acc % 3.0000
Plus/Minus 0.000

Nom In Val / In Val	In Type	Out Val	Out Type	Fnd As	Lft As	Dev%	Pass/Fail
1.413 / 1.413	ms/cm	1.413	ms/cm	1.413	1.413	0.00%	Pass

Group # 3
Group Name Redox (ORP)
Stated Accy Pct of Reading
Range Acc % 0.0000
Reading Acc % 3.0000
Plus/Minus 0.00

Nom In Val / In Val	In Type	Out Val	Out Type	Fnd As	Lft As	Dev%	Pass/Fail
240.00 / 240.00	mv	240.00	mv	240.00	240.00	0.00%	Pass

Group # 4
Group Name Disolved Oxygen Span
Stated Accy Pct of Reading
Range Acc % 0.0000
Reading Acc % 3.0000
Plus/Minus 0.00

Nom In Val / In Val	In Type	Out Val	Out Type	Fnd As	Lft As	Dev%	Pass/Fail
100.00 / 100.00	%	100.00	%	100.00	100.00	0.00%	Pass

INSTRUMENT CALIBRATION REPORT

Pine Environmental Services, LLC.
6380 Tomken Road, Unit 1 & 2
Mississauga, ONTARIO L5T1Y4
Toll-free: (866) 688-0388

Pine Environmental Services, Inc.

Instrument ID 28181
Description YSI 556
Calibrated 8/12/2016 11:18:37AM

Test Instruments Used During the Calibration

Test Standard ID	Description	Manufacturer	Model Number	Serial Number / Lot Number	(As Of Cal Entry Date) Last Cal Date/ Opened Date	Next Cal Date / Expiration Date
ON H2O COND 1.413MS/CM 7429	ON H2O COND 1.413MS/CM 7429	Hanna	HI7031L	ON H2O COND 1.413MS/CM 7429		2/20/2019
ON SODIUM SULFITE (ZERO D.O.)	SODIUM SULFITE (ZERO D.O.)	EMD	Sodium Sulfite zero D.O.	K39121957		3/1/2018
ON THERMOMETER 122549157	ON THERMOMETER 122549157	Control Company	14-648-44	122549157		9/26/2017
ON WQ H20 PH10.01 LOT# 8398	ON WQ H20 PH10.01 LOT# 8398	Hanna	HI7010L	ON WQ H20 PH10.01 LOT# 8398		12/30/2019
ON WQ H2O-PH4-LOT 11844	ON WQ H2O-PH4-LOT 11844	Aurical	HI7004	ON WQ H2O-PH4-LOT 11844		9/10/2016
ON WQ HYDROMETER	EdgeTech Dew Prime II Hydrometer	Pine	DewPrime II	27580		
ON WQ ORP 240MV LOT 8154	ORP 240 mV	Hanna	HI 7021	8154		10/31/2019
ON WQ_DO%-100_0000	Dissolved Oxygen 100% AIR	Pine	000	0000		
ON-W-H2O-PH7-8103	pH 7	Hanna	HI7007	ON-W-H2O-PH7-8103		9/30/2019

Notes about this calibration

INSTRUMENT CALIBRATION REPORT

Pine Environmental Services, LLC.

6380 Tomken Road, Unit 1 & 2
Mississauga, ONTARIO L5T1Y4
Toll-free: (866) 688-0388

Pine Environmental Services, Inc.

Instrument ID 28181
Description YSI 556
Calibrated 8/12/2016 11:18:37AM

NIST Traceable Thermometer Serial No: 122549157
NIST Traceable Thermometer Reading °C: 21.1
YSI 556 Temperature Reading °C: 20.73
Amount of Saturated Dissolved Oxygen (D.O) in H2O
H2O Temperature in °C = 21.1
DO Value in mg/L = 8.68
YSI 556 DO in mg/L = 8.68

Sodium Sulphite (Na2SO3) Dissolved Oxygen (D.O) Zero Solution Lot#: 2011030423
YSI 556 Range: 0.00-0.19 mg/L
YSI 556 Temperature Reading mg/L: 0.19

Calibration Result Calibration Successful
Who Calibrated Kevin Grant

All instruments are calibrated by Pine Environmental Services, LLC. according to the manufacturer's specifications, but it is the customer's responsibility to calibrate and maintain this unit in accordance with the manufacturer's specifications and/or the customer's own specific needs.

Notify Pine Environmental Services, LLC. of any defect within 24 hours of receipt of equipment
Please call 866-960-7463 for Technical Assistance

Appendix B

Field Reports

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	

Site: Kearney Lake	**Site ID: KL1**
Watercourse: Kearney Lake	**Location:** Kearney Lake Road

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0445718E, 4948496N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Cloudy
Air Temperature:	16
Cloud Cover :	100%
Wildlife Sightings:	No
Site Accessibility: Yes, Accessible	Off Kearney Lake Road
Site Access Detail:	Sample taken off the end of dock at Kearney Lake beach. Parked in public parking of Hamshaw Dr. and walked down to beach area.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	7:48
Sample Depth (m):	0.3 m
pH:	4.60
Dissolved Oxygen (mg/L):	118.7
Secchi Depth (m):	2.13 m – Could see disk on bottom
Water Temperature (degrees Celsius):	22.24
Conductivity (µs/cm):	298

Additional Comments / Notes

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Kearney Lake	**Site ID: KL2**	
Watercourse: Kearney Lake	**Location:** Kearney Lake Road	

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0443942E, 4949803N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	16
Cloud Cover:	50%
Wildlife Sightings:	Birds/Squirrel/Water Bugs
Site Accessibility: Yes, Accessible	Off Colin's Rd.
Site Access Detail:	Sample taken on the lake side of the culvert between residential buildings 20 and 28. Walked down rock to left of culvert. Note: Sample when standing downstream of bottle.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	8:30
Sample Depth (m):	0.2 m (very low water level)
pH:	5.97
Dissolved Oxygen (mg/L):	4.21
Secchi Depth (m):	1.83 m
Water Temperature (degrees Celsius):	20.29
Conductivity (µs/cm):	117

Additional Comments / Notes

Conductivity: 0.124 ms/cm^{c}
ORP: 107.7

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Kearney Lake Run	**Site ID: KL3**	
Watercourse: Kearney Lake Run	**Location:** Kearney Lake Road	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0444390E, 4950406N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	25
Cloud Cover:	20%
Wildlife Sightings:	Birds/Flies/Bugs
Site Accessibility: Yes, Accessible	Off walking trail from Amesbury Gate Rd.
Site Access Detail:	Access to site is via a walking path clearly evident off of Amesbury Gate Rd. (off Larry Uteck Blvd.) roughly 205m down road on left. Walk down path, follow gravel walkway down hill and take sample at the low point facing the dam. Look for large rock outcrop on right.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	11:30
Sample Depth (m):	0.3 m
pH:	6.82
Dissolved Oxygen (mg/L):	7.72
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	21.67
Conductivity (µs/cm):	264

Additional Comments / Notes

Conductivity: 0.282 ms/cm^c
ORP: 80.1

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Kearney Lake Run	**Site ID: KL4**	
Watercourse: Kearney Lake Run	**Location:** Kearney Lake Road	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0444463E, 4950571N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	25
Cloud Cover:	20%
Wildlife Sightings:	Fish/Birds/Bugs/People
Site Accessibility: Yes, Accessible	Via the extended road at the end of Weybridge Ln.
Site Access Detail:	At Weybridge, go to end of extended road on right and walk and take sample above the rocky area at the base of the wider, slow moving section of the river.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	12:00
Sample Depth (m):	0.4 m
pH:	6.72
Dissolved Oxygen (mg/L):	5.50
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	20.64
Conductivity (µs/cm):	260

Additional Comments / Notes

Conductivity: 0.284 ms/cm^c
ORP: 98.10

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 9
Client:	Halifax Regional Municipality	
Site: Kearney Lake	**Site ID: KL5**	
Watercourse: Kearney Lake	**Location:** Kearney Lake Road	

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 4949142E, 445280N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Cloudy
Air Temperature:	16
Cloud Cover:	100%
Wildlife Sightings:	No
Site Accessibility: Yes, Accessible	Along Kearney Lake Road
Site Access Detail:	Easily accessible, sample location is directly off the Kearney Lake Road on a rocky outcrop supporting a power line pole (two pole structure). Slow truck down carefully, turn hazard lights on. Samples were taken on left front of outcrop facing lake.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	8:00
Sample Depth (m):	0.15 m
pH:	5.11
Dissolved Oxygen (mg/L):	96.4
Secchi Depth (m):	5.3
Water Temperature (degrees Celsius):	22.23
Conductivity (µs/cm):	267

Additional Comments / Notes

Lake very calm, virtually no wind.

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Highway 102	**Site ID: HWY 102-1**	
Watercourse: Marsh area	**Location:** Highway 102, south of exit 3	

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0444708E, 4951644N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sunny
Air Temperature:	23
Cloud Cover:	30%
Wildlife Sightings:	No
Site Accessibility: Yes, Accessible	Off Highway 102 Park before guardrail.
Site Access Detail:	Carefully slow truck down while pulling off highway 102. Park truck with hazard lights on before the start of the guardrail. Walk along outside of guardrail (for approximately 150m). Site is on right fed by a swampy bog area. Samples were taken in front of culvert. There is a concrete pad to step on to take samples. Sample while standing downstream.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	11:00
Sample Depth (m):	0.2 m
pH:	6.14
Dissolved Oxygen (mg/L):	110.1
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	19.28
Conductivity (µs/cm):	353

Additional Comments / Notes

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Highway 102		**Site ID: HWY 102-2**
Watercourse: Marsh area		**Location:** HWY 102, south of exit 3

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0444829E, 4951778N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sunny
Air Temperature:	27
Cloud Cover:	10%
Wildlife Sightings:	Birds/Waterbugs/Frogs
Site Accessibility: Yes, Accessible	Off Highway 102 (Small gravel drive way- *Back in)
Site Access Detail:	Travel along Highway 102 toward Bedford NS. Site is on right easily to identify based on swamp/bog. Carefully slow truck down with hazard lights flashing. There is a small driveway to park truck. Pull a head of driveway and when lanes are clear back truck down into spot. Take samples in water body in front of culvert.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	12:45
Sample Depth (m):	0.2 m
pH:	6.19
Dissolved Oxygen (mg/L):	7.06
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	20.43
Conductivity (µs/cm):	838

Additional Comments / Notes

Conductivity: 0.909 ms/cm^c
ORP: 47.4
A lot of algae, low water level, hard to get sample. Debris in water (broken pale). Water had 'oily' sheen.

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Lake Shore Drive	**Site ID: LSD**	
Watercourse: Marsh @ Lakeshore Dr.	**Location:** Kingswood Subdivision	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:		
GPS Coordinates:	20T 0442583E, 4950431N (UTM, NAD83)	
SNC Field Personnel:	Ryan Flinn	

Site Conditions

Weather:	Sunny
Air Temperature:	24
Cloud Cover:	30%
Wildlife Sightings:	Frogs/Bugs/Duck
Site Accessibility: Yes, Accessible	Via Lakeshore Drive in Kingswood Subdivision
Site Access Detail:	Take Kingswood Drive off Hammonds Plains Road. Travel down to Diana Drive on left go to end and take a left on Lakeshore drive. Travel approximately 1.0 km. There will be a clearing on left down to power lines. Drive truck (4X4) down until larger clearing is reached and park. Continue (walk) down hill to ATV pathway on left. Follow pathway for approximately 250m. Sample location is on right (river with a lot of vegetation throughout)

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	12:10
Sample Depth (m):	0.1 m
pH:	6.16
Dissolved Oxygen (mg/L):	-22.1
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	24.01
Conductivity (µs/cm):	254

Additional Comments / Notes

Water level very low, hard to get sample.

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 9	
Client:	Halifax Regional Municipality		
Site: Larry Uteck Blvd.		**Site ID: LU**	
Watercourse: Pond		**Location:** Larry Uteck off-ramp	
Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:			
GPS Coordinates:	20T 0444954E, 4949891N (UTM, NAD83)		
SNC Field Personnel:	Ryan Flinn		

Site Conditions

Weather:	Sunny
Air Temperature:	23
Cloud Cover:	30%
Wildlife Sightings:	No
Site Accessibility: Yes, Accessible	From Larry Uteck Blvd.
Site Access Detail:	Take Larry Uteck off ramp and continue down Larry Uteck Blvd. for approximately 320m. Park truck safely on grassy clearing on left. Sample location is at shore line of lake across road. Take walking pathway to wooded area and travel approximately 80m to lake shore. Avoid walking through the bog area on right.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	11:20
Sample Depth (m):	0.2 m
pH:	6.24
Dissolved Oxygen (mg/L):	189.9
Secchi Depth (m):	**N/A**
Water Temperature (degrees Celsius):	21.91
Conductivity (µs/cm):	574

Additional Comments / Notes

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	

Site: Paper Mill Lake	**Site ID: PML1**
Watercourse: Paper Mill Lake	**Location:** Moirs Mill Subdivision

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0445129E, 4951154N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/Cloud
Air Temperature:	17
Cloud Cover:	30%
Wildlife Sightings:	Birds/Waterbugs
Site Accessibility: Yes, Accessible	Via Ahmadi Crescent in Moirs Mill Subdivision

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	9:30
Sample Depth (m):	0.4 m
pH:	5.94
Dissolved Oxygen (mg/L):	6.53
Secchi Depth (m):	4.15 m
Water Temperature (degrees Celsius):	21.58
Conductivity (µs/cm):	289

Additional Comments / Notes

Conductivity: 0.309 ms/cm^c
ORP: 61.7

FIELD REPORT – AUGUST 2016

Project:	Water Quality Monitoring - Bedford West	**Sub-Area(s):** 2, 3, 4, 5
Client:	Halifax Regional Municipality	
Site: Paper Mill Lake		**Site ID: PML2**
Watercourse: Paper Mill Lake		**Location:** Moirs Mill Subdivision

Monitoring Well ☐Pumping Well ☒ Surface Water ☐Spring/Seep ☐Discharge Pipe ☐Other:

GPS Coordinates:	20T 0445363E, 4951740N (UTM, NAD83)
SNC Field Personnel:	Ryan Flinn

Site Conditions

Weather:	Sun/cloud
Air Temperature:	18
Cloud Cover:	50%
Wildlife Sightings:	Deer flies
Site Accessibility: Yes, Accessible	Via Lake Dr., off Hammonds Plains Rd.

Field Parameter Data

	Remarks
Date (d.m.y):	16/08/2016
Time (hh:mm):	10:00
Sample Depth (m):	0.15 m
pH:	5.93
Dissolved Oxygen (mg/L):	88.1
Secchi Depth (m):	2.3 m - Could see disk on bottom
Water Temperature (degrees Celsius):	22.09
Conductivity (µs/cm):	298

Additional Comments / Notes

Appendix C

Site Photographs

Photo 1: PML-1 Paper Mill Lake Sample Location

Photo 2: HWY 102-1 Sample Location

Photo 3: LU Larry Uteck Sample Location

Photo 4: KL4 Kearney Lake Sample Location

Photo 5: KL3 Kearney Lake Sample Location

Photo 6: KL5 Kearney Lake Sample Location

Photo 7: HWY102-2 Sample Location

Photo 8: KL1 Kearney Lake Sample Location

Photo 9: KL2 Kearney Lake Sample Location (lake side of culvert)

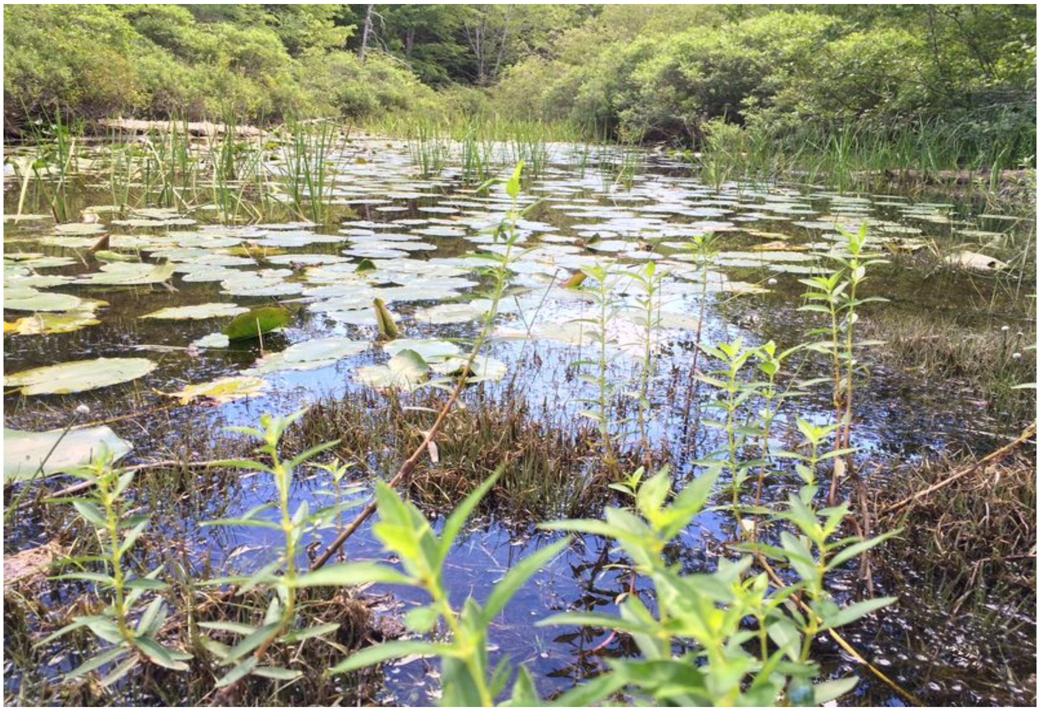

Photo 10: LSD Lake Shore Drive Sample Location

Photo 11: PML-2 Paper Mill Lake Sample Location

Appendix D

Laboratory Certificate of Analysis

Dalhousie University

Department of Oceanography
Halifax, N.S.
B3H 4R2

19-Aug-16 AGAT Laboratories, 11 Morris Dr. Unit 122, Dartmouth, NS, B3B 1M2

Attention: Janetta Fraser
Re: Determination of chlorophyll a in algae by fluorescence

AGAT Job#: 16X126834
PO#: 101337

Acidification Technique:

Sample ID	Chl a (μg/L)
7774774E	0.90
7774779E	1.86
7774784E	0.81
7774790E	0.16
7774796E	1.20
7774801E	51.51
7774806E	54.98
7774811E	127.14
7774816E	4.57
7774821E	4.71
7774826E	1.09

Welschmeyer Technique:

Sample ID	Chl a (μg/L)
7774774E	1.15
7774779E	2.43
7774784E	0.99
7774790E	0.21
7774796E	1.57
7774801E	60.68
7774806E	73.67
7774811E	185.98
7774816E	5.23

7774821E	10.82
7774826E	1.42

- **CHl a = chlorophyll a**
- **An underestimation of chl a occurs by the fluorescence acidification technique in the presence of Chl b. Since chl b containing chlorophytes are often present in freshwater ecosystems another technique (welschmeyer) was also employed.**
- **Reference for Welschmeyer technique Limnol. Oceanogr., 39(8) 1994, 1985-1992**

Received: 17-Aug-16
Completed: 18-Aug-16

Orignal Signed

Shannah Rastin

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: SNC Lavalin Inc.
5657 SPRING GARDEN RD, SUITE 200
HALIFAX , NS B3J3R4
(902) 492-4544

ATTENTION TO: Ryan Flinn

PROJECT: Bedford West

AGAT WORK ORDER: 16X126834

WATER ANALYSIS REVIEWED BY: Jason Coughtrey, Inorganics Supervisor

DATE REPORTED: Aug 26, 2016

PAGES (INCLUDING COVER): 8

VERSION*: 2

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

*NOTES

VERSION 2:Version 2.0 supersedes version 1.0

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 16X126834
PROJECT: Bedford West

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: SNC Lavalin Inc.
ATTENTION TO: Ryan Flinn
SAMPLING SITE:
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-08-16
DATE REPORTED: 2016-08-26

			SAMPLE DESCRIPTION:	KL1	KL2	KL3	KL4	KL5	HWY-102-1	HWY-102-2	LSD
			SAMPLE TYPE:	Water	Water	Water	Water	Water	Water	Water	Water
			DATE SAMPLED:	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016
Parameter	Unit	G / S	RDL	7774774	7774779	7774784	7774790	7774796	7774801	7774806	7774811
Alkalinity	mg/L		5	8	10	9	9	7	27	21	22
Chloride	mg/L		1	57	26	56	58	56	87	226	45
True Color	TCU		5	17	48	13	12	13	37	39	26
Nitrate + Nitrite as N	mg/L		0.05	0.15	0.06	0.13	0.21	0.19	0.13	0.23	0.08
Nitrate as N	mg/L		0.05	0.08	<0.05	0.06	0.14	0.09	<0.05	<0.05	0.08
Nitrite as N	mg/L		0.05	0.07	0.06	0.07	0.07	0.10	0.13	0.23	<0.05
Ammonia as N	mg/L		0.03	0.09	0.06	<0.03	<0.03	<0.03	0.06	0.37	0.10
Total Organic Carbon	mg/L		0.5	3.4	7.0	2.7	3.3	3.3	8.0	11.1	14.0
Ortho-Phosphate as P	mg/L		0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH				7.23	6.87	7.28	7.03	7.16	7.03	6.80	7.01
Total Calcium	mg/L		0.1	8.0	4.5	8.3	7.1	7.3	25.8	23.8	9.9
Total Magnesium	mg/L		0.1	1.1	1.1	1.3	1.1	1.1	2.7	2.5	1.8
Total Phosphorus	mg/L		0.002	0.005	0.016	0.005	0.004	0.004	0.038	0.034	0.023
Total Potassium	mg/L		0.1	0.9	0.8	1.0	0.9	0.9	1.9	2.1	1.3
Total Sodium	mg/L		0.1	32.2	16.1	37.2	41.4	33.1	43.8	124	23.4
Reactive Silica as SiO2	mg/L		0.5	2.0	2.3	1.8	2.0	2.0	6.3	9.0	3.3
Total Suspended Solids	mg/L		5	<5	<5	<5	<5	<5	10	69	9020
Sulphate	mg/L		2	10	3	10	10	10	14	21	6
Turbidity	NTU		0.1	0.9	2.0	1.1	1.5	1.3	4.1	54.2	206
Electrical Conductivity	umho/cm		1	270	135	262	275	267	440	952	236
Anion Sum	me/L			1.99	1.00	1.98	2.04	1.94	3.29	7.25	1.84
Bicarb. Alkalinity (as CaCO3)	mg/L		5	8	10	9	9	7	27	21	22
Calculated TDS	mg/L		1	115	59	120	125	114	193	422	107
Carb. Alkalinity (as CaCO3)	mg/L		10	<10	<10	<10	<10	<10	<10	<10	<10
Cation sum	me/L			1.93	1.09	2.18	2.28	1.93	3.51	7.23	2.04
Hardness	mg/L			24.5	15.8	26.1	22.3	22.8	75.5	69.7	32.1
% Difference/ Ion Balance (NS)	%			1.5	4.5	4.8	5.5	0.4	3.1	0.1	5.3
Langelier Index (@20C)	NA			-2.56	-3.04	-2.44	-2.76	-2.72	-1.74	-2.15	-2.24
Langelier Index (@ 4C)	NA			-2.88	-3.36	-2.76	-3.08	-3.04	-2.06	-2.47	-2.56
Saturation pH (@ 20C)	NA			9.79	9.91	9.72	9.79	9.88	8.77	8.95	9.25

Certified By: Orignal Signed

Certificate of Analysis

AGAT WORK ORDER: 16X126834
PROJECT: Bedford West

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: SNC Lavalin Inc.
ATTENTION TO: Ryan Flinn
SAMPLING SITE:
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-08-16
DATE REPORTED: 2016-08-26

			SAMPLE DESCRIPTION:	KL1	KL2	KL3	KL4	KL5	HWY-102-1	HWY-102-2	LSD
			SAMPLE TYPE:	Water	Water	Water	Water	Water	Water	Water	Water
			DATE SAMPLED:	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016	8/16/2016
Parameter	Unit	G / S	RDL	7774774	7774779	7774784	7774790	7774796	7774801	7774806	7774811
Saturation pH (@ 4C)	NA			10.1	10.2	10.0	10.1	10.2	9.09	9.27	9.57
Total Copper	ug/L		1	<1	<1	<1	<1	<1	<1	<1	<1
Total Iron	ug/L		50	62	1000	117	61	55	766	7380	2190
Total Manganese	ug/L		2	23	109	41	58	15	78	359	2420
Total Zinc	ug/L		5	<5	<5	<5	<5	<5	<5	22	14
Total Coliforms (MPN)	MPN/100 mL		1	548	>2420	1990	1730	517	>2420	>2420	>2420
E. Coli (MPN)	MPN/100 mL		1	33	15	38	35	23	86	20	30
Chlorophyll A - Acidification Method	ug/L		0.05	0.90	1.86	0.81	0.16	1.20	51.51	54.98	127.14
Chlorophyll A - Welschmeyer Method	ug/L		0.05	1.15	2.43	0.99	0.21	1.57	60.68	73.67	185.98
Total Kjeldahl Nitrogen as N	mg/L		0.4	<0.4	0.9	<0.4	<0.4	<0.4	1.2	2.1	11.8

Original Signed

Certified By:

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:

ATTENTION TO: Ryan Flinn
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-08-16

DATE REPORTED: 2016-08-26

			SAMPLE DESCRIPTION:	LU	PLM-1	PLM-2
			SAMPLE TYPE:	Water	Water	Water
			DATE SAMPLED:	8/16/2016	8/16/2016	8/16/2016
Parameter	Unit	G / S	RDL	7774816	7774821	7774826
Alkalinity	mg/L		5	27	8	10
Chloride	mg/L		1	164	67	67
True Color	TCU		5	13	16	13
Nitrate + Nitrite as N	mg/L		0.05	0.47	0.09	0.11
Nitrate as N	mg/L		0.05	0.41	<0.05	<0.05
Nitrite as N	mg/L		0.05	0.06	0.09	0.11
Ammonia as N	mg/L		0.03	0.05	<0.03	<0.03
Total Organic Carbon	mg/L		0.5	5.3	6.1	3.6
Ortho-Phosphate as P	mg/L		0.01	<0.01	<0.01	<0.01
pH				7.42	6.86	7.23
Total Calcium	mg/L		0.1	17.2	10.5	8.1
Total Magnesium	mg/L		0.1	3.4	1.8	1.2
Total Phosphorus	mg/L		0.002	0.011	0.104	0.003
Total Potassium	mg/L		0.1	2.6	1.3	1.0
Total Sodium	mg/L		0.1	81.1	35.1	37.5
Reactive Silica as SiO2	mg/L		0.5	1.3	0.8	0.6
Total Suspended Solids	mg/L		5	<5	10	<5
Sulphate	mg/L		2	23	11	7
Turbidity	NTU		0.1	3.0	112	1.1
Electrical Conductivity	umho/cm		1	739	310	319
Anion Sum	me/L			5.68	2.29	2.24
Bicarb. Alkalinity (as CaCO3)	mg/L		5	27	8	10
Calculated TDS	mg/L		1	310	148	129
Carb. Alkalinity (as CaCO3)	mg/L		10	<10	<10	<10
Cation sum	me/L			4.76	3.33	2.17
Hardness	mg/L			56.9	33.6	25.2
% Difference/ Ion Balance (NS)	%			8.8	18.6	1.7
Langelier Index (@20C)	NA			-1.55	-2.82	-2.46
Langelier Index (@ 4C)	NA			-1.87	-3.14	-2.78
Saturation pH (@ 20C)	NA			8.97	9.68	9.69

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Certificate of Analysis

AGAT WORK ORDER: 16X126834
PROJECT: Bedford West

CLIENT NAME: SNC Lavalin Inc.
SAMPLING SITE:

ATTENTION TO: Ryan Flinn
SAMPLED BY:

SNC-Lavalin Bedford West Custom Inorganics Package

DATE RECEIVED: 2016-08-16

DATE REPORTED: 2016-08-26

			SAMPLE DESCRIPTION:	LU	PLM-1	PLM-2
			SAMPLE TYPE:	Water	Water	Water
			DATE SAMPLED:	8/16/2016	8/16/2016	8/16/2016
Parameter	Unit	G / S	RDL	7774816	7774821	7774826
Saturation pH (@ 4C)	NA			9.29	10.0	10.0
Total Copper	ug/L		1	<1	<1	<1
Total Iron	ug/L		50	374	8250	174
Total Manganese	ug/L		2	148	281	36
Total Zinc	ug/L		5	7	20	<5
Total Coliforms (MPN)	MPN/100 mL		1	>2420	1410	>2420
E. Coli (MPN)	MPN/100 mL		1	40	34	47
Chlorophyll A - Acidification Method	ug/L		0.05	4.57	4.71	1.09
Chlorophyll A - Welschmeyer Method	ug/L		0.05	5.23	10.82	1.42
Total Kjeldahl Nitrogen as N	mg/L		0.4	1.1	3.4	<0.4

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

7774774-7774816 Total Phosphorus was analysed at AGAT Mississauga.
Chlorophyll A was analysed by a sub-contracted laboratory.

7774821 Total Phosphorus was analysed at AGAT Mississauga.
Chlorophyll A was analysed by a sub-contracted laboratory.
Ion Balance is greater than 10% due to the fact that samples are digested for total metals and any particulates in the water could be increasing the concentrations of certain elements.

7774826 Total Phosphorus was analysed at AGAT Mississauga.
Chlorophyll A was analysed by a sub-contracted laboratory.

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Certified By: ______________________

AGAT Laboratories

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Quality Assurance

CLIENT NAME: SNC Lavalin Inc.
PROJECT: Bedford West
SAMPLING SITE:

AGAT WORK ORDER: 16X126834
ATTENTION TO: Ryan Flinn
SAMPLED BY:

Water Analysis

RPT Date: Aug 26, 2016			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
SNC-Lavalin Bedford West Custom Inorganics Package															
Alkalinity	7773828		<5	<5	NA	< 5	95%	80%	120%	NA	80%	120%	NA	80%	120%
Chloride	7775380		24	24	1.3%	< 1	101%	80%	120%	NA	80%	120%	NA	80%	120%
True Color	1		32	37	14.5%	< 5	115%	80%	120%		80%	120%		80%	120%
Nitrate as N	7775380		0.10	0.12	NA	< 0.05	96%	80%	120%	NA	80%	120%	91%	80%	120%
Nitrite as N	7775380		<0.05	<0.05	NA	< 0.05	102%	80%	120%	NA	80%	120%	98%	80%	120%
Ammonia as N	1		<0.03	<0.03	NA	< 0.03	102%	80%	120%		80%	120%	100%	80%	120%
Total Organic Carbon	7774774		3.4	3.3	3.0%	< 0.5	97%	80%	120%	101%	80%	120%	NA	80%	120%
Ortho-Phosphate as P	1		<0.01	<0.01	NA	< 0.01	102%	80%	120%		80%	120%	99%	80%	120%
pH	7773828		5.00	4.28	15.5%	<	101%	80%	120%	NA	80%	120%	NA	80%	120%
Total Calcium	8182016		76.7	87.6	13.3%	< 0.1	96%	80%	120%	119%	80%	120%	117%	70%	130%
Total Magnesium	8182016		11.0	13.5	20.4%	< 0.1	90%	80%	120%	93%	80%	120%	96%	80%	120%
Total Potassium	8182016		5.01	5.77	14.1%	< 0.1	92%	80%	120%	89%	80%	120%	114%	70%	130%
Total Sodium	8182016		24.8	18.8	NA	< 0.1	89%	80%	120%	93%	80%	120%	98%	70%	130%
Reactive Silica as SiO2	1		3.1	3.2	3.2%	< 0.5	111%	80%	120%		80%	120%	99%	80%	120%
Total Suspended Solids	1		< 5	< 5	0.0%	< 5	102%	80%	120%		120%	120%	109%	80%	120%
Sulphate	7775380		9	9	NA	< 2	111%	80%	120%	NA	80%	120%	98%	80%	120%
Turbidity	1		4.1	4	2.5%	< 0.1	104%	80%	120%		80%	120%		80%	120%
Electrical Conductivity	7773828		34	34	1.4%	< 1	92%	80%	120%	NA	80%	120%	NA	80%	120%
Bicarb. Alkalinity (as CaCO3)	7773828		<5	<5	NA	< 5	NA	80%	120%	NA	80%	120%	NA	80%	120%
Carb. Alkalinity (as CaCO3)	7773828		<10	<10	NA	< 10	NA	80%	120%	NA	80%	120%	NA	80%	120%
Total Copper	8182016		< 1	< 1	0.0%		106%	80%	120%	80%	80%	120%	86%	70%	130%
Total Iron	8182016		700	684	2.3%	< 50	99%	80%	120%	95%	80%	120%	89%	70%	130%
Total Manganese	8182016		2240	2230	0.4%	< 2	85%	80%	120%	80%	80%	120%	97%	70%	130%
Total Zinc	8182016		< 5	< 5	0.0%	< 5	80%	80%	120%	93%	80%	120%	87%	70%	130%
Total Kjeldahl Nitrogen as N	1		0.3	0.4	NA	< 0.4	105%	80%	120%		80%	120%	94%	80%	120%

Comments: If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By: Original Signed

Method Summary

CLIENT NAME: SNC Lavalin Inc.
PROJECT: Bedford West
SAMPLING SITE:

AGAT WORK ORDER: 16X126834
ATTENTION TO: Ryan Flinn
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Alkalinity	INORG-121-6001	SM 2320 B	PC-TITRATE
Chloride	INORG-121-6005	SM 4110 B	IC
True Color	INORG-121-6014	EPA 110.2	NEPHELOMETER
Nitrate + Nitrite as N	INORG-121-6005	SM 4110 B	CALCULATION
Nitrate as N	INORG-121-6005	SM 4110 B	IC
Nitrite as N	INORG-121-6005	SM 4110 B	IC
Ammonia as N	INORG-121-6003	SM 4500-NH3 G	COLORIMETER
Total Organic Carbon	INORG-121-6026	SM 5310 B	TOC ANALYZER
Ortho-Phosphate as P	INORG-121-6005	SM 4110 B	COLORIMETER
pH	INOR-121-6001	SM 4500 H+B	PC-TITRATE
Total Calcium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Magnesium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Phosphorus	INOR-93-1022	SM 4500-P B & E	SPECTROPHOTOMETER
Total Potassium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Sodium	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Reactive Silica as SiO2	INORG-121-6028	SM 4110 B	COLORIMETER
Total Suspended Solids	INOR-121-6024, 6025	SM 2540C, D	GRAVIMETRIC
Sulphate	INORG-121-6005	SM 4110 B	IC
Turbidity	INORG-121-6022	SM 2130 B	NEPHELOMETER
Electrical Conductivity	INOR-121-6001	SM 2510 B	PC-TITRATE
Anion Sum	CALCULATION	SM 1030E	CALCULATION
Bicarb. Alkalinity (as CaCO3)	INORG-121-6001	SM 2320 B	PC-TITRATE
Calculated TDS		SM 1030E	CALCULATION
Carb. Alkalinity (as CaCO3)	INORG-121-6001	SM 2320 B	PC-TITRATE
Cation sum	CALCULATION	SM 1030E	CALCULATION
Hardness	CALCULATION	SM 2340B	CALCULATION
% Difference/ Ion Balance (NS)	CALCULATION	SM 1030E	CALCULATION
Langelier Index (@20C)	CALCULATION	CALCULATION	CALCULATION
Langelier Index (@ 4C)	CALCULATION	CALCULATION	CALCULATION
Saturation pH (@ 20C)	CALCULATION	CALCULATION	CALCULATION
Saturation pH (@ 4C)	CALCULATION	CALCULATION	CALCULATION
Total Copper	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Iron	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Manganese	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Zinc	MET121-6104 & MET-121-6105	SM 3125	ICP/MS
Total Coliforms (MPN)	MIC-121-7000	Based on SM 9223B	INCUBATOR
E. Coli (MPN)	MIC-121-7000	Based on SM 9223B	INCUBATOR
Chlorophyll A - Acidification Method	Subcontracted	Subcontracted	
Chlorophyll A - Welschmeyer Method	Subcontracted	Subcontracted	ICP-MS
Total Kjeldahl Nitrogen as N	INOR-121-6020	SM 4500 NORG D	COLORIMETER

AGAT Laboratories

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Phone: 902-468-8718
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Laboratory use Only
Arrival Condition: ☐ Good ☐ Poor (complete 'notes')
Arrival Temperature: 6
AGAT Job Number: 16X126834
Notes:

Drinking Water Sample (y/n):
Reg. No.
Waterworks Number:

Report To:
Company: SNC Lavalin
Contact: Ryan Flinn
Address: 5657 Spring Garden Road Suite 200
Halifax, NS B3J 3R4
Phone: 902-492-4544 FAX:
PO#:
AGAT Quotation: 15-1718
Client Project #: Bedford West

Invoice to: Same (Y/N) - Circle
Company: SNC Lavalin
Contact: payables@snclavalin.com
Address:
Phone: Fax:
PO#/Credit Card #:

Report Information
1. Name: Ryan Flinn
Email: Ryan.Flinn@snclavalin.com
2. Name: Maria Gutierrez
Email: Maria.Gutierrez@snclavalin.com

Regulatory Requirements (Check):
☐ List Guidelines on Report
☐ Do Not List Guidelines on Report
☐ PIRI
☐ Teir 1 ☐ Res.
☐ Teir 2 ☐ Com
☐ Gas ☐ Fuel ☐ Lube
Site Info (check all that apply):
☐ Pol. ☐ Coarse
☐ N/Pol. ☐ Fine
☐ CCME ☐ COWQ
☐ Ind ☐ NSDFOSP
☐ Com ☐ HRM 101
☐ Res/P Storm Water
☐ Ag ☐ HRM 101
☐ FWAL Waste Water
☐ Sediment
☐ Other

Report Format
☐ Single PDF sample per page
☐ Multiple PDF samples per page
☐ Excel Format Included

Turnaround Time (TAT) Business Days
Regular TAT:
☒ 5 - 7 days
Rush TAT:
☐ 1 day ☐ 2 days
☐ 3 - 4 days
Date Required:
Time Required:

2016

SAMPLE IDENTIFICATION	DATE / TIME SAMPLED		SAMPLE MATRIX	# OF CONTAINERS	COMMENTS - Site/Sample Info, Sample Containment
KL1	AUG16	7:48	water	5	
KL2	AUG16	8:30	water	5	
KL3	AUG16	1:30	water	5	
KL4	AUG16	12:00	water	5	
KL5	AUG16	6:00	water	5	
HWY-102-1	AUG16	11:00	water	5	
HWY-102-2	AUG16	12:45	water	5	
LSD	AUG16	2:10	water	5	
LU	AUG16	11:20	water	5	
PML-1	AUG16	9:30	water	5	
PML-2	AUG16	10:00	water	5	

SAMPLE IDENTIFICATION	Field Filtered/ Preserved	Standard Water Analysis	Metals (Spring Quarterly Only)	(Circle-Total, Diss or Available)	Mercury	BOD	pH	TSS	TKN, TP (Low Level)	Anions	Total Phosphorus	Phenols	TPH/BTEX (PIRI) Teir 1	TPH/BTEX-Fractionation Teir 2	VOC	THM	PAH	Chlorophyll A (Sub to DAL)	TC & EC by MPN	Hazardous (Y/N)	Lab Sample #
KL1		X						X	X									X	X		
KL2																					
KL3																					
KL4																					
KL5																					
HWY-102-1																					
HWY-102-2																					
LSD																					
LU																					
PML-1																					
PML-2																					

Sample Relinquished By (print name & sign)	Date/Time	Samples Received By (print name and sign)	Date/Time	Special Instructions
RYAN FLINN [redacted]	AUG16 / 1:41pm	[redacted]	16-AUG	*Surface water. TP RDL 0.002. Please follow the SUMMER sample parameters on the attached speadsheet.
Sample Relinquished By (print name & sign)	Date/Time	Samples Received By (print name and sign)	Date/Time	
		[redacted]	1340	Page 1 of 1

Appendix E

Graphs

Graphs were created showing concentrations from 2009 to 2016 for six (6) water quality parameters; dissolved chloride (mg/L), pH, total phosphorus (mg/L), total suspended solids (mg/L), conductivity (µS/cm) and chlorophyll A (µg/L) at each of the standard eleven (11) sample sites. This was done to allow for comparison between sites and identification of concentration increases.

As many parameters show seasonal concentration fluctuations, the data was also graphed showing only the concentrations for the current sampling season (i.e. summer sampling events). Where results were found to be less than the recordable detection limit (<RDL), they were graphed as half the recordable detection limit (1/2 RDL).

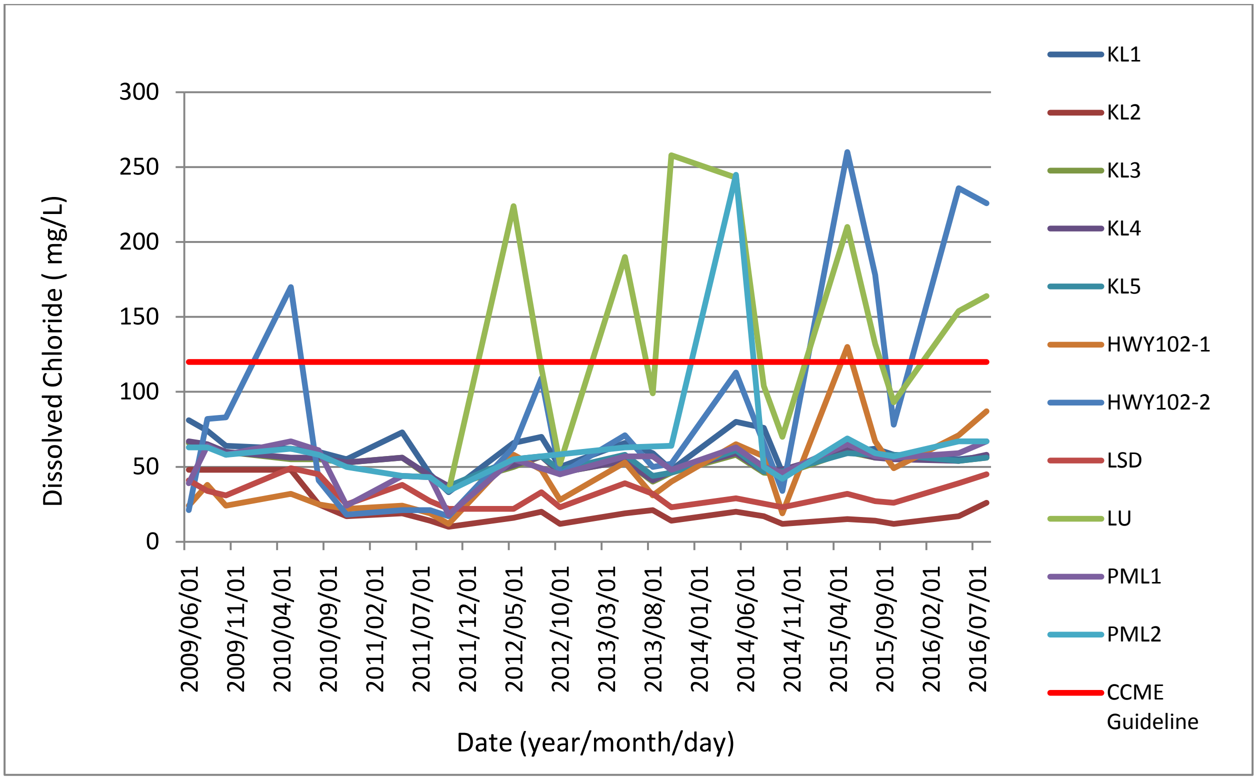


Figure 1 - Dissolved chloride concentrations.

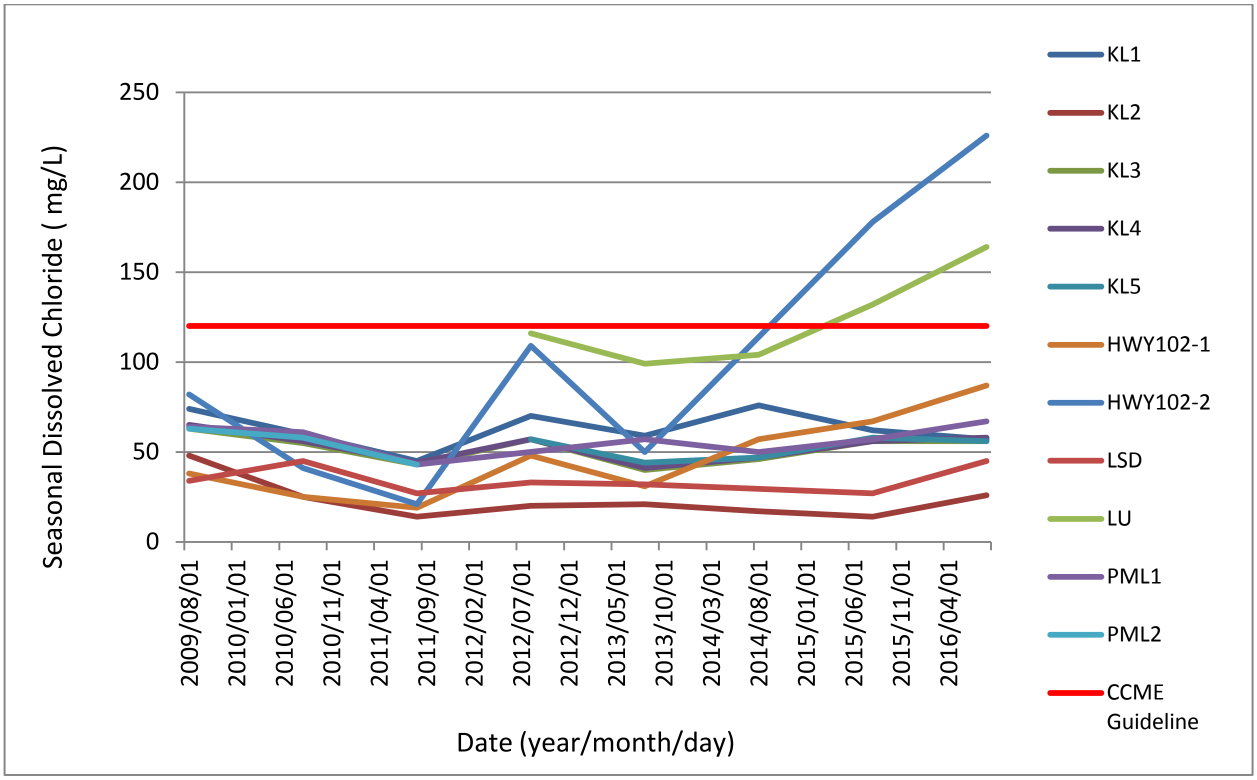


Figure 2 – Seasonal dissolved chloride concentrations.

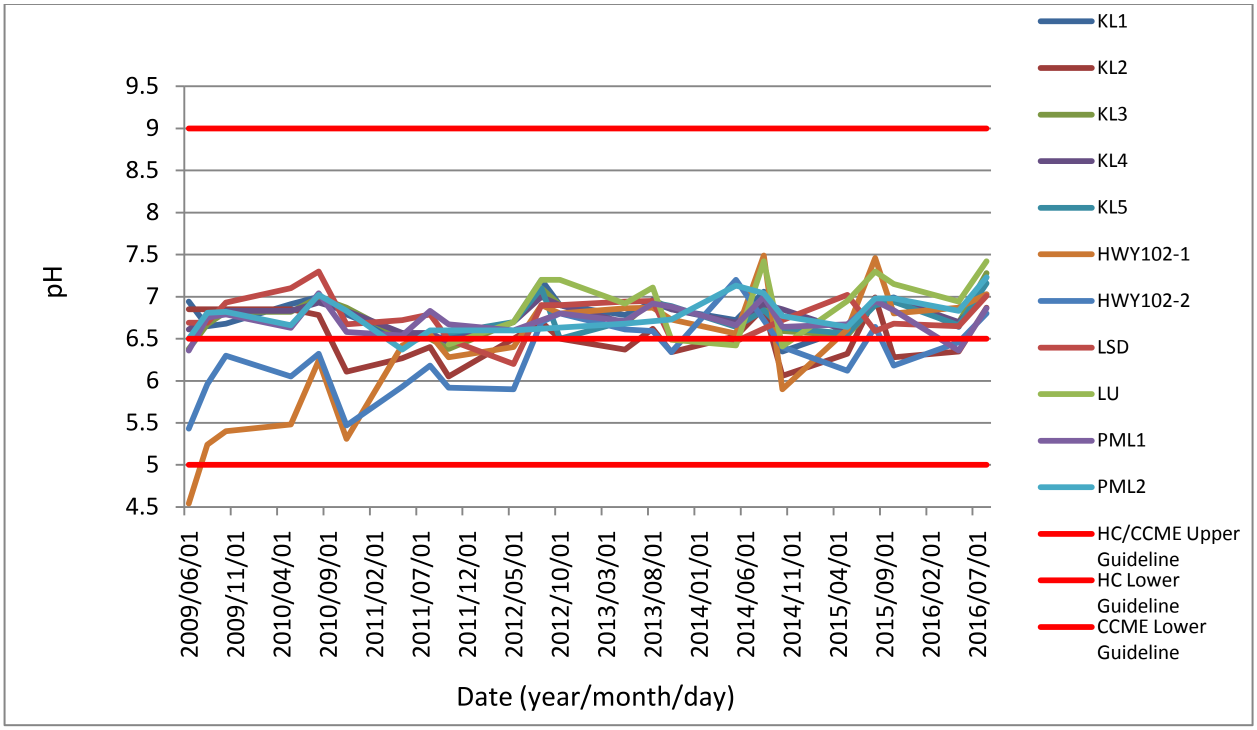


Figure 3 – pH.

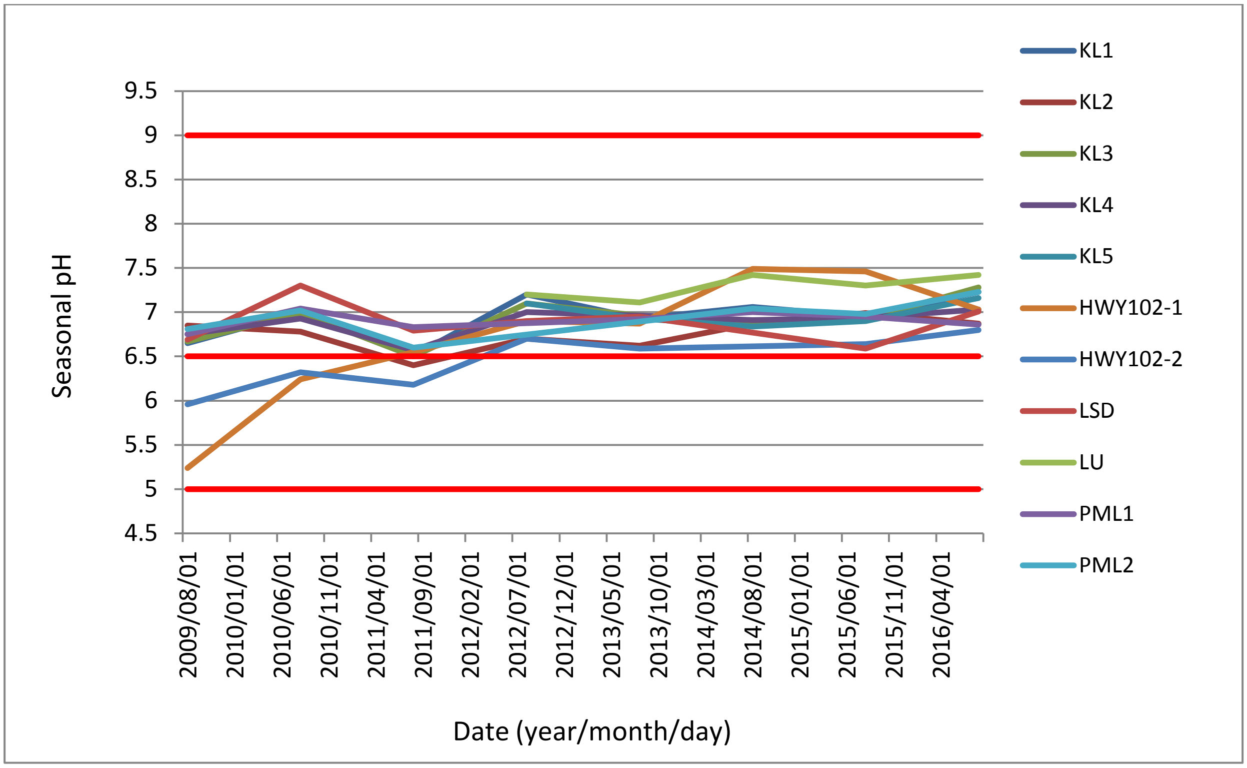


Figure 4 – Seasonal pH.

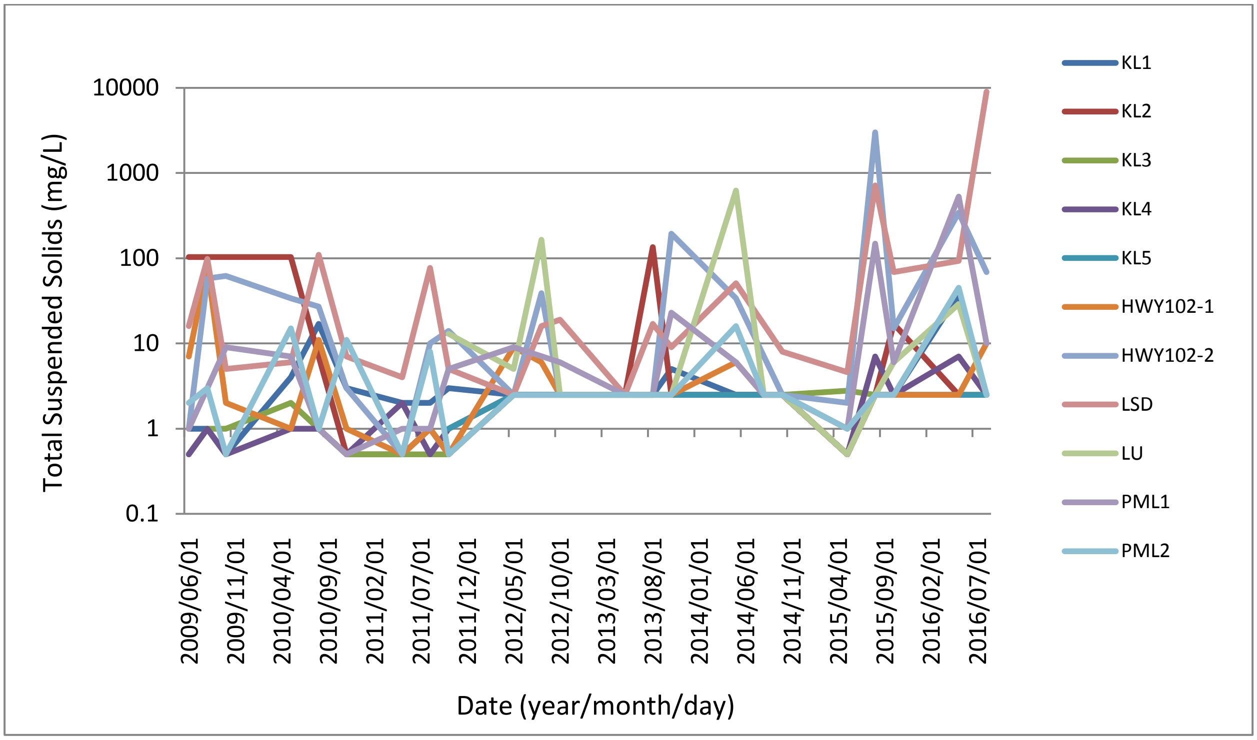


Figure 5 – Total suspended solids concentrations.

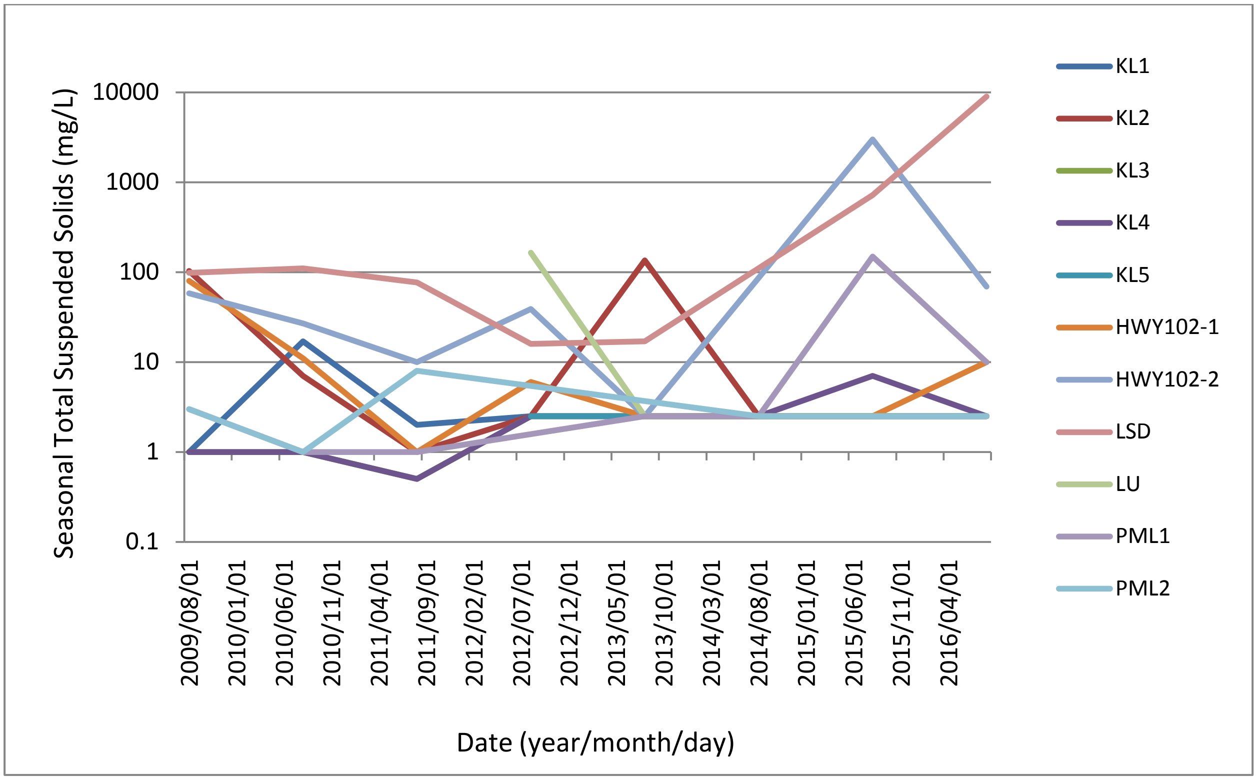


Figure 6 – Seasonal total suspended solids concentrations.

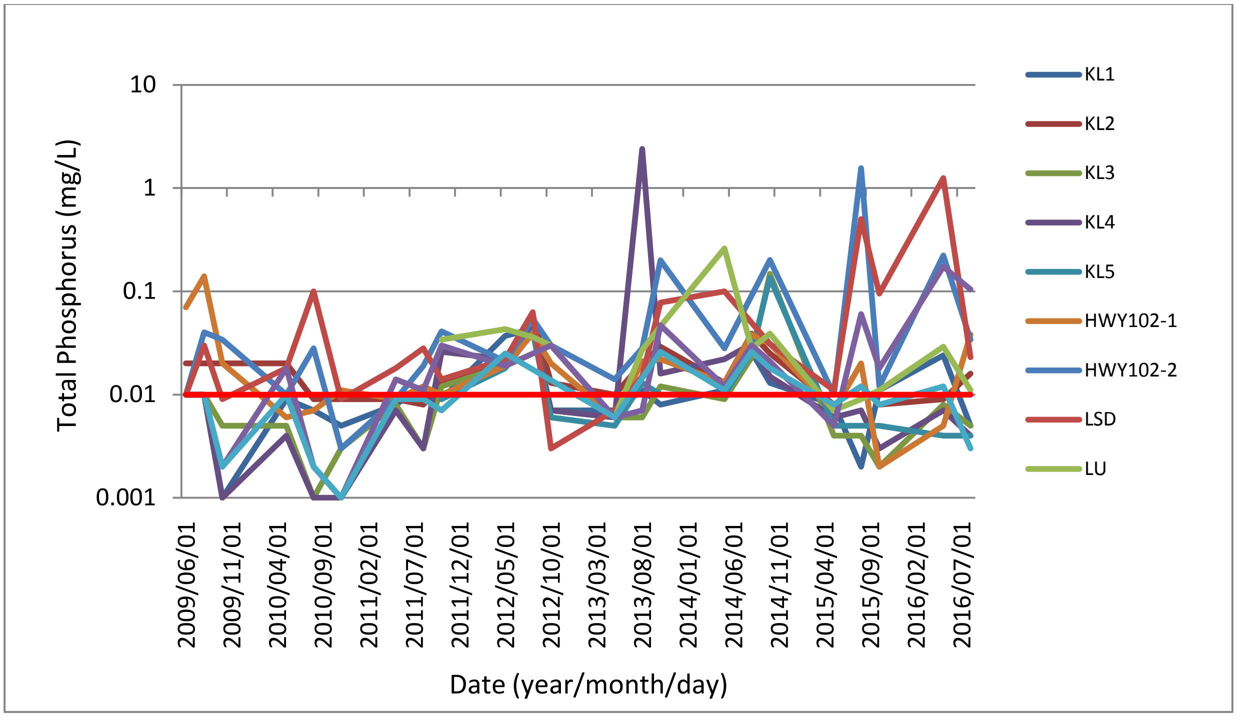


Figure 7 – Total phosphorus concentrations.

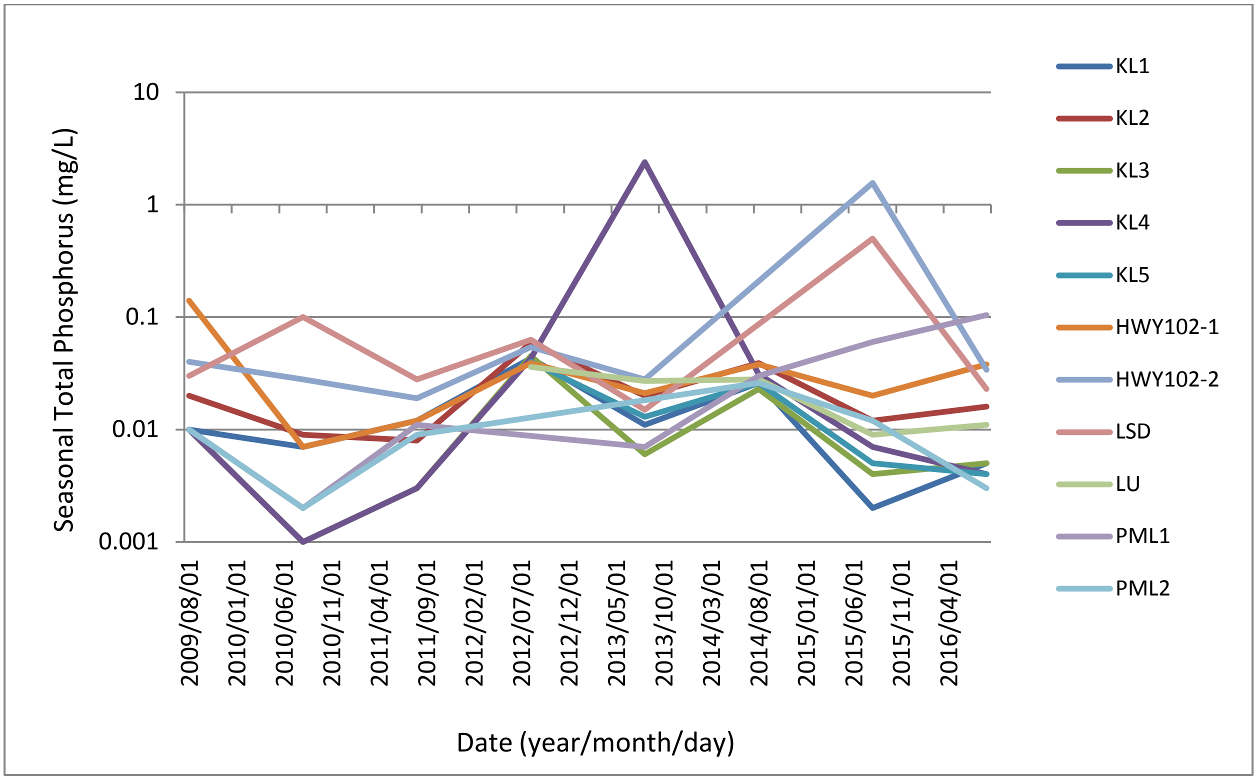


Figure 8 – Seasonal total phosphorus concentrations.

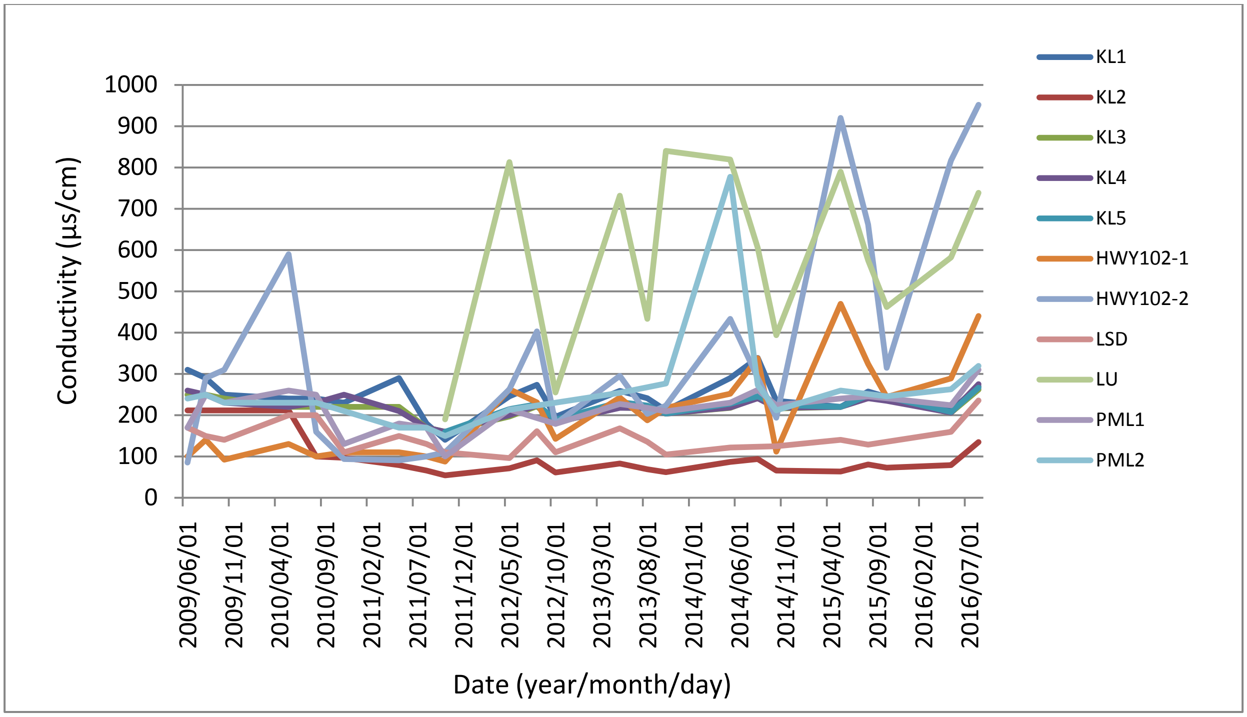


Figure 9 – Conductivity.

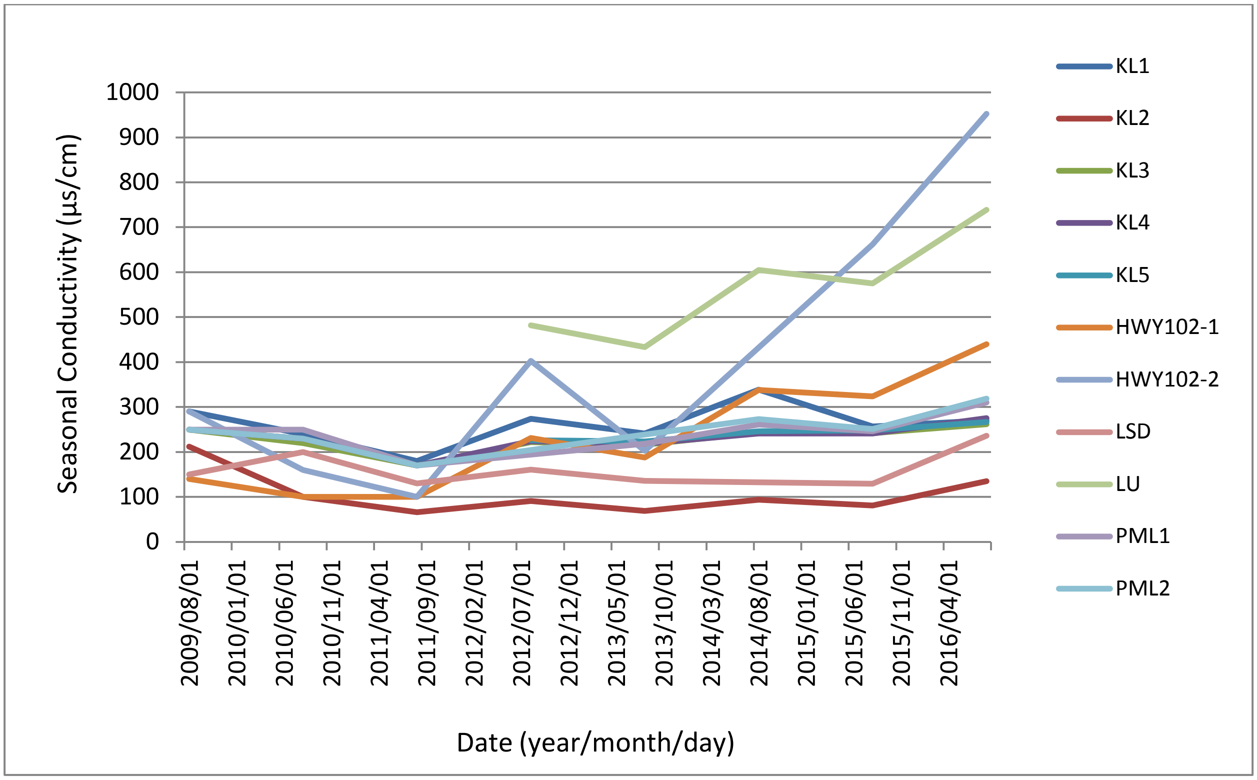


Figure 10 – Seasonal conductivity.

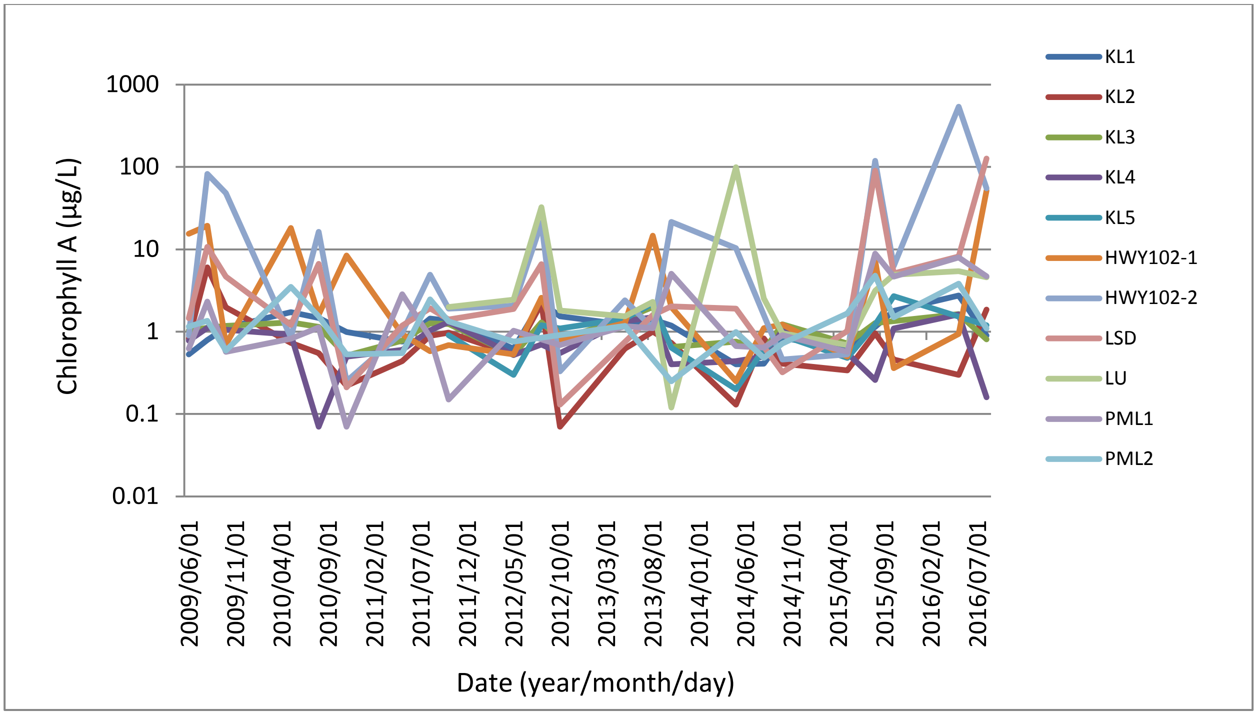


Figure 11 – Chlorophyll A concentrations.

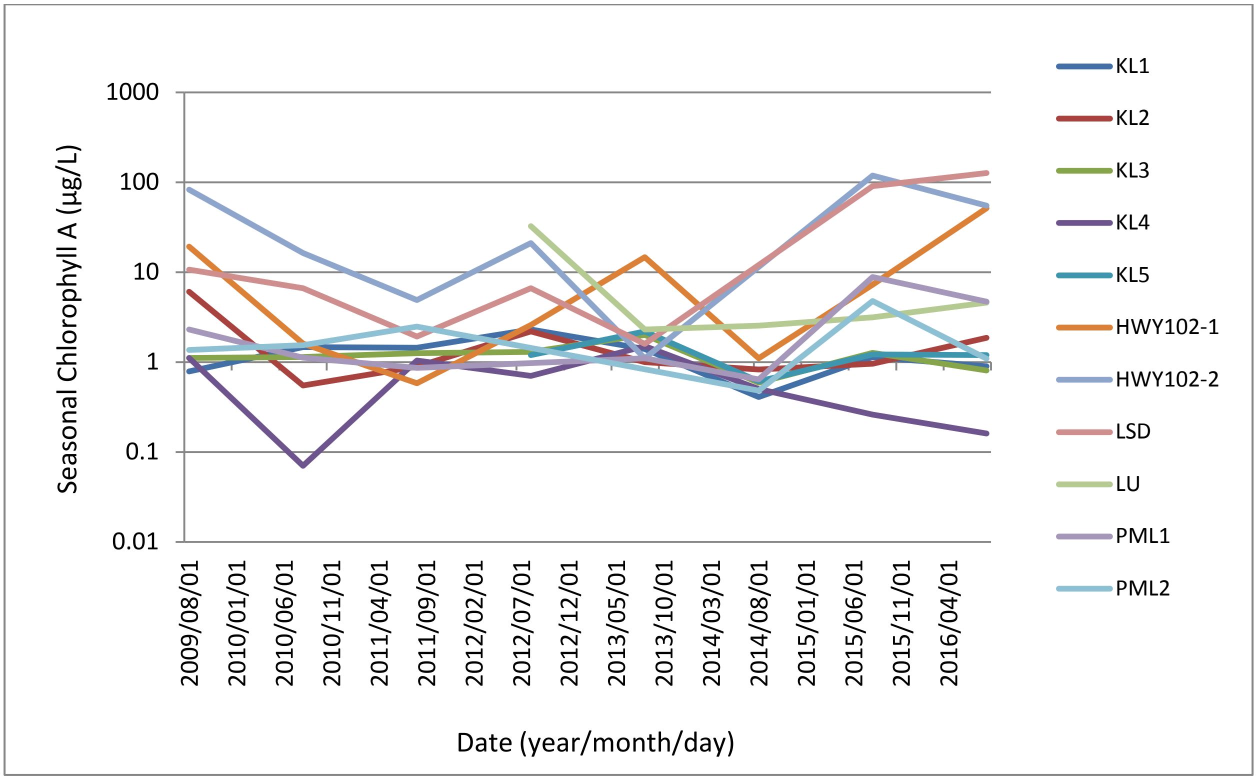
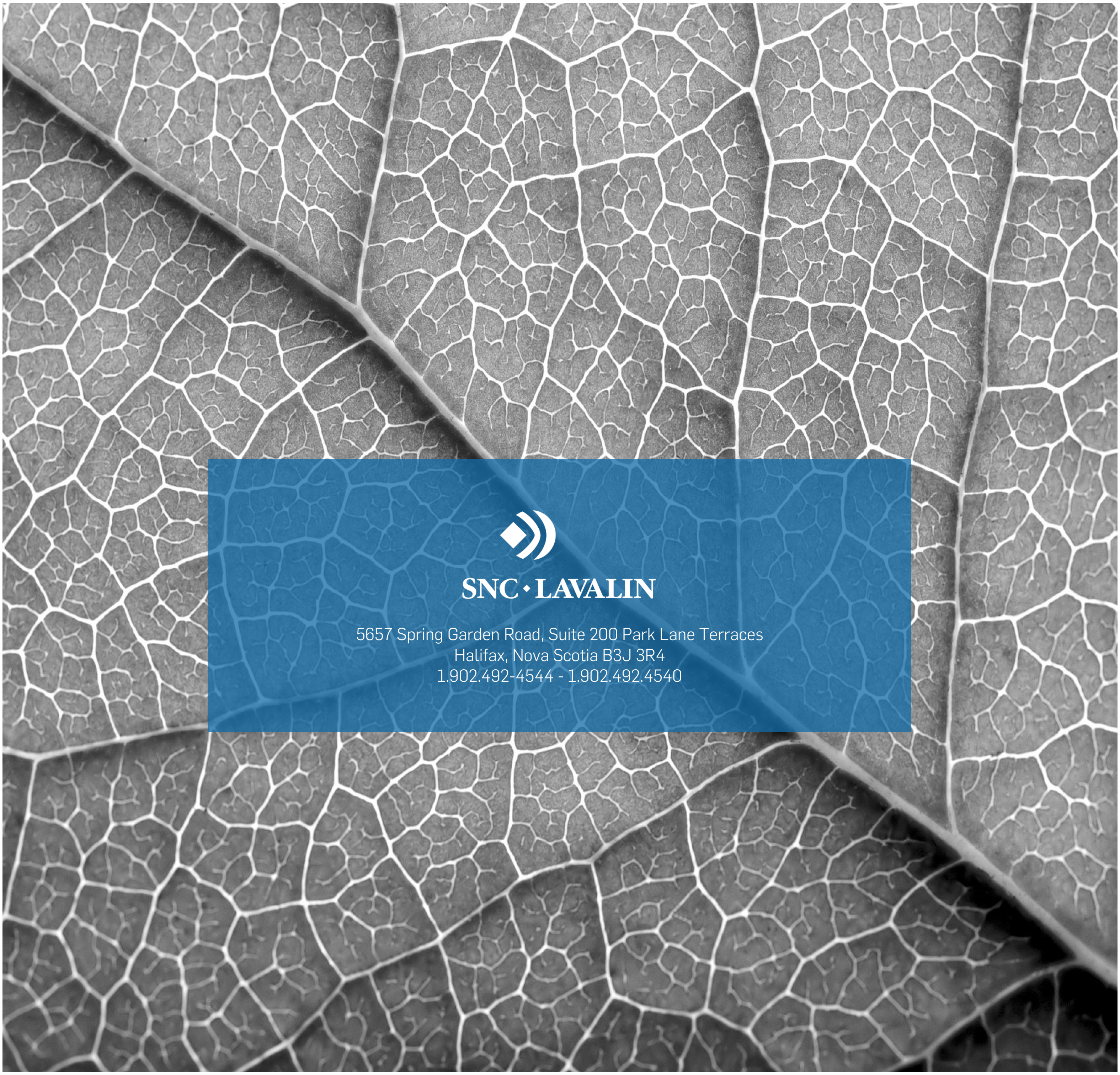


Figure 12 – Seasonal chlorophyll A concentrations.



SNC·LAVALIN

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Halifax, Nova Scotia B3J 3R4
1.902.492-4544 - 1.902.492.4540