WATER QUALITY ASSESSMENT

OF

LITTLE GOOSE CREEK

SHELBURNE COUNTY, NOVA SCOTIA

Prepared by

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Nova Scotia Environment

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ABSTRACT

A water quality assessment was undertaken on Little Goose Creek, Shelburne County to address concerns related to potential water quality impacts from a proposed mink farm development in the area. Turbid, green conditions, including floating or suspended algal masses were reported in lakes in Yarmouth and Digby Counties during the summer of 2007. These counties have numerous mink farms located in close proximity to lakes experiencing water quality problems. Farming practices are being assessed as a contributing factor. The intent of the current study was to provide a snapshot of water quality in Little Goose Creek in order to determine existing baseline water quality. Water quality was compared to existing benchmarks (such as standards or guidelines derived in support of recreational or other water uses) to assess suitability for beneficial waters uses, and to provide a comparison to other surface waters in Nova Scotia. A cursory shoreline survey was also undertaken to identify any obvious watershed activities that may be impacting stream water quality. The results of this study could be used as the basis for any future comparisons or assessment needs, and to identify possible management approaches to protect water quality in this stream or other receiving waters.

A sampling program was set up to determine chemical and bacteriological water quality, as well as algal abundance, speciation, and associated toxins concentrations, at selected mid-stream locations. Samples were taken at locations upstream, adjacent to, and down stream of a property where a mink farm development was proposed. The stream was sampled during the late summer/early fall period to capture the worst case scenario of water quality conditions for the year – since algal populations tend to peak under high temperature and high light conditions. Both low and high stream flow conditions were captured in order to assess influences of runoff from the proposed development area.

Results of this study suggest that water quality in Little Goose Creek was typical of relatively unimpacted surface waters in the southwestern area of Nova Scotia. Specifically, water chemistry indicated soft water with high color, low pH, low alkalinity, low turbidity, low conductivity, and metal concentrations typical of streams in that area of the province.

The primary trophic state indicators (nutrients and chlorophyll) showed oligotrophic to mesotrophic or naturally unproductive conditions with little algal growth. These conditions were typical of unimpacted colored surface waters in Nova Scotia. Similarly, fecal bacterial indicators (E Coli) and blue green algae indicators (cell count and microcystin toxins) showed very low concentrations and were typical of natural background conditions.

Water quality during periods of both normal and high flows showed little difference in measured parameters. This suggests no infux of pollutants from overland flows or site runoff, and no apparent pollutant sources in the immediate watershed area.

The cursory shoreline survey of the study area identified no apparent pollutant sources which might be impacting Little Goose Creek water quality.

Water quality met Recreational Water Quality Guidelines at all times during this study, for all measured parameters except pH. Low pH values were attributed to both natural conditions (wetlands) and human influences (acid rain).

Recommendations include to protect water quality in Little Goose Creek and any receiving waters from land use impacts, mitigate any pollutant sources as appropriate, implement appropriate best practices for any development in the watershed, and to consider establishing a watershed protection planning process with appropriate stakeholders.

ACKNOWLEDGEMENTS

The water quality sampling program was jointly undertaken by Halifax Central Office staff and Yarmouth / Bridgewater Regional Office staff from Nova Scotia Environment (NSE). Regional Office staff and a member of a concerned citizens group (Tony Perry) contributed to sample site selection, assessment of watershed influences, and local knowledge within the project area.

Data entry and management was provided by Cindy Starratt (NSE) who created an electronic database of water quality information. Charlie Williams, Carmella Robertson and Alan Tattrie (NSE) also contributed significantly to data processing, analysis, mapping, and report production.

Appreciation is extended to members of the Clyde River Land Use Committee for their stewardship efforts and bringing their water quality concerns to light.

We appreciate the efforts of all who were involved and in any way contributed to this endeavour.

BACKGROUND & INTRODUCTION

During September of 2009 a water quality assessment was undertaken on Little Goose Creek, located in a watershed adjacent to the Clyde River, Shelburne County. This assessment was initiated in response to concerns brought forward by local residents relating to the potential of a proposed mink farm operation to impair water quality in this watercourse.

The purpose of this study was to determine baseline water quality conditions in the watercourse of concern, for possible further assessment post farm development. Water quality was characterized in terms of water chemistry and bacteriology, and algal populations. Of particular interest were nutrient concentrations and trophic status, and fecal coliform bacteria. Additionally, the status of algal populations was estimated based on cyanobacteria abundance, speciation, and toxin concentrations. Water quality was compared to existing benchmarks including OECD trophic categories, and Health Canada Guidelines for Canadian Recreational Water Quality.

This study was not intended to be a comprehensive water quality assessment, but rather to provide a snapshot of baseline conditions of stream water quality and algal populations. This information could serve as the basis for any future comparisons between pre- and post development scenarios, assessing potential water impacts on the adjacent stream. In turn such information would provide for informed discussions on any appropriate best practices or actions needed to improve water quality in these watersheds.

STUDY AREA

The Little Goose Creek watershed is located in south-western Nova Scotia, lying southwest of Shelburne and adjacent to the Clyde River. Little Goose Creek is in the Roseway River Glacial Plain region of the province, draining approximately 6.8 km^2 of watershed. No lakes are downstream of this creek. Drainage is to Lyles Bay estuary area of the Clyde River. The study area is shown on Figure 1, Appendix A. Land use in this watershed is mixed, consisting largely of forested land, limited agricultural use, and generally sparsely populated rural residential land use. Wetlands are interspersed throughout the area, imparting colour to adjoining surface waters through dissolved organic substances. This area of Nova Scotia is exposed to acidifying emissions from the northeastern US and eastern Canada, and subsequently ‘acid rain’ conditions. This situation, in conjunction with poorly buffered soils, results in acidified surface waters with low pH values.

METHODS

During September of 2009, a sampling program was undertaken in the study area whereby physical and chemical characteristics of water quality were investigated, primarily to determine nutrient levels and associated trophic state[1]. On two occasions sampling was performed to determine late summer / early fall water chemistry and algal population status – once during normal dry conditions

[1]Trophic state refers to the level of biological productivity in a waterbody.

and once immediately after a significant rain event. Water samples were taken at 5 mid-stream locations with 1 upstream location sampled and the remaining samples taken at selected downstream locations. These samples were collected at the stream surface (i.e. 0.5 meter depth) using a sampling rod holding new clean 500 ml polyethylene bottles. Bottles were rinsed repeatedly with stream water prior to sampling. Mid-stream samples were expected to reflect overall watercourse conditions and were used for comparison to generally accepted OECD trophic state indicators. Due to the limited stream width (1 to 3meters) mid-stream samples were also expected to reflect conditions where recreational water use might occur. Procedures followed standard water quality assessment protocols and standard approaches for characterizing surface waters in northern temperate climates.

Sampling methods for assessing stream condition followed standard protocols established by Nova Scotia Departments of Environment (NSE) and Fisheries and Aquaculture (NSDFA) and Health Canada's Recreational Water Quality Guidelines in order to provide consistent results for comparison purposes.

Sampling stations are shown Figures 1, Appendix A.

Nutrient and chlorophyll a concentrations were determined in samples taken at a depth of 0.5 m below the surface (hereafter referred to as surface samples) at all stream stations. Metal and major ion concentrations were also determined from all samples taken during the study.

Cyanobacteria samples were collected at all stream stations to determine algal population density (cell counts), speciation, and microcystin toxin levels, and to assess spatial variation.

All samples were kept cool and in the dark prior to lab analysis. Subsequently, samples were shipped to accredited labs such that analysis was performed within 24 hours of collection, as per APHA standard protocols.

Chemical and bacteriological analysis was performed at the Environmental Chemistry Laboratory of the Queen Elizabeth II Health Science Center (QE II) where analytical procedures were undertaken in accordance with established protocols outlined in "Standard Methods for the Examination of Water and Waste Water" (APHA Latest Edition). Algal analysis was performed at ALS Laboratory in Winnipeg, where analytical procedures were undertaken in accordance with established protocols such that comparison with Health Canada's Guidelines for Canadian Recreational Water Quality was possible.

A cursory shoreline and watershed survey was undertaken to identify any pollutant sources and activities which may impact stream water quality. This investigation was limited to the immediate area including the subject property and abutting properties draining to Little Goose Creek. This investigation was performed on foot and from road vehicle, since the small stream size precluded assessment from a boat. Visual observations were noted in field reports.

RESULTS AND DISCUSSION

In order to fully characterize baseline water quality during this study, chemical, bacteriological, and biological characteristics or parameters were measured.

The chemical water quality parameters measured during this study can be divided into three broad categories. These include parameters necessary to determine trophic state (i.e. nutrients and chlorophyll), major ions and metals. Trophic state was given primary consideration due to the nature of the expressed concerns as well as potential impacts from local land uses. Major ions and metals were included in order to provide quality assurance of the data set, to fully characterize water quality, and to facilitate further assessment if required. Chemical data are presented in Table 2, in Appendix C.

Bacteriological water quality parameters measured during this study were E.Coli bacteria and total coliforms. E. Coli was the primary indicator of bacteria indicative of fecal sources and possible pathogens. Total coliform bacteria concentrations were determined only as a quality assurance measure for the data set. Bacteria data are presented in Table 2, Appendix C.

The biological water quality parameters measured during this study were related to algal populations and primary production in the lake. Blue green algae (cyanobacteria) populations were identified in terms of genus and /or species for major groups in the water body at time of sampling, and were quantified both in general terms (small / medium/ large amount) and numerically (cell count / ml of sample). Blue green algae toxin levels were also measured in terms of concentrations of Microcystin LR in collected samples. Algal data are presented in Table 3 in Appendix D.

Results from each of the main areas of investigation (trophic state, bacteriology, blue green algae, and major ions and metals) are discussed below.

STREAM CONDITIONS

Trophic State

Trophic state refers to the level of biological productivity within a waterbody gauged over a range of very unproductive (oligotrophic) conditions to very productive (eutrophic) conditions. Conditions midway between these two extremes are termed mesotrophic. A progression from very unproductive to very productive conditions typifies the natural aging process in a waterbody and is termed eutrophication. This process, which involves a waterbody gradually infilling with silt and organic matter, takes thousands of years to complete and eventually causes the waterbody to evolve back to dry land. Manmade influences that contribute additional nutrients, organic matter and sediment to a water body can greatly accelerate this process and cause the waterbody to infill at a much faster rate. This accelerated process is termed cultural eutrophication. Although eutrophication is typically associated with lakes since they are more susceptible to nutrient influences, flowing waters such as rivers and streams can be appropriately assessed in these terms as well.

Two key indicators of trophic state have been established. They are generally recognized as being chlorophyll a, and nutrient concentrations (typically total phosphorus or nitrogen).

Chlorophyll a concentration has been shown to correlate well with levels of algal biomass (Nicholls and Dillon 1978). Additionally, strong correlations between chlorophyll a, and total nutrient concentration have been shown, based on mean annual or mean ice-free season concentrations (Dillon and Rigler 1974, Vollenweider and Kerekes 1980, Clark and Hutchison 1992).

Total nutrient concentrations represent the chemical response of a waterbody to eutrophication while chlorophyll a concentrations represent the biological response. Together these water quality parameters provide an excellent indication of trophic state when monitored over a full growing season and taken in the context of a waterbody as a whole.

However, due to both time and resource constraints mean annual or ice-free season concentrations could not be determined for this study. As a surrogate, nutrient, and chlorophyll values were determined during the end of summer period when associated peak water temperatures for the year are expected. This period was chosen to represent the "worst case scenario" situation, where algal production and chlorophyll concentrations should be at peak values for the year.

These water quality parameters are addressed in the following text - where 2009 data are compared to established values for trophic state categories (OECD 1982) as shown in Table 1 below and as presented in Figures 2 and 3, Appendix B.

Table 1

PROPOSED BOUNDARY VALUES FOR TROPHIC CATEGORIES (OECD 1982)
(fixed boundary system)

Trophic Category	(P)	(chl)	(max chl)	(Sec)	(min sec)
	mg/m^3 (ug/l) *			Meters	
Ultra-oligotrophic	< 4.0	<1.0	<2.5	>12.0	>6.0
Oligotrophic	<10.0	<2.5	<8.0	>6.0	>3.0
Mesotrophic	10 - 35	2.5 - 8	8 - 25	6 - 3	3 - 1.5
Eutrophic	35 -100	8 - 25	25 - 75	3 - 1.5	1.5 - 0.7
Hypertrophic	>100	>25	>75	<1.5	<0.7

(P) annual mean total phosphorus concentration
(chl) annual mean chlorophyll a concentration
(max chl) annual maximum chlorophyll a
(sec) annual mean Secchi disk transparency
(min sec) annual minimum Secchi disk transparency
* Note: mg/m^3 and ug/l are equivalent units = parts per billion

Nutrients

Nutrients investigated in this study include two forms of phosphorus – ortho phosphorus and total phosphorus (Total P), and three species of nitrogen - nitrate + nitrite, ammonia, and total nitrogen (Total N). Results for these parameters are found in Table 2, Appendix C.

Total nutrient concentrations (i.e. both organic and inorganic species, as in Total P and Total N) are considered to be the best chemical indicators of trophic state (OECD 1982, Clark & Hutchison 1992) and therefore, are of primary interest to this investigation. Ratios of Total N to Total P concentrations can be used to determine which nutrient is in shortest supply and therefore is the limiting nutrient for plant growth in any given waterbody. It has been shown that if the Total N/Total P ratio is greater than 17:1 phosphorus is limiting; less than 17:1 nitrogen is limiting (OECD 1982). In the study area Little Goose Creek is shown to be phosphorus limited with an overall TN/TP ratio of 36:1. Calculated ratios are shown in Table 2.

Phosphorus is generally in shortest supply in natural surface waters, and therefore is typically the limiting nutrient controlling biological production.

Total P concentrations in Little Goose Creek ranged from a minimum of 9 ug/l (0.009 mg/l) at the surface of station #4 on September 16th to a maximum of 16 ug/l (0.016 mg/l) at station #1 on September 30th. These results are shown in Table 2, Appendix C.

Total P concentrations from study area samples taken during the fall of 2009 are compared to established trophic categories, and are presented in Figure 2, Appendix B. These Total P values indicate that study area nutrient values are quite low, and that Little Goose Creek exhibited oligotrophic to mesotrophic or naturally unproductive conditions, typical of unimpacted colored surface waters.

Chlorophyll

Primary productivity can be defined for the purpose of this study as being the extent of microscopic plant life or algal production in the water column as a result of available nutrients. The most commonly accepted indicator to quantify this primary productivity or algal biomass is obtained by measuring the chlorophyll a concentration in representative water samples. Chlorophyll a concentrations have been shown to correlate extremely well with algal biomass (Nicholls and Dillon 1978). Therefore, an increase in Chlorophyll a concentrations indicate an associated and proportional increase in algal biomass or density.

As in the case of nutrients, algal population growth can vary significantly, over time and space. Therefore, the sampling protocol was designed to address this natural variability as much as possible.

Chlorophyll concentrations recorded at the stream stations are presented in Table 2, Appendix C and Figure 3, Appendix B. Chlorophyll values in Little Goose Creek ranged from 0.1 ug/l at station # 4 and 6 on September 16^{h} to 0.8 ug/l at station #3 on September 30th. When compared with the OECD eutrophication tables (Table 1), current chlorophyll values indicate that study area water quality is in a naturally oligotrophic or nutrient poor state typical of unimpacted surface waters.

In summary, the primary indicators of trophic state - chlorophyll a, and total phosphorus- suggest that study area water quality had relatively unproductive or nutrient poor oligotrophic to mesotrophic conditions with low algal growth during this study. This is typical of natural unimpacted conditions for surface waters in this area of the province.

Bacteria

Bacteriological water quality was assessed in terms of the primary fecal coliform indicator E coli, as well as total coliform concentrations. E coli bacteria was measured to determine influences of warm blooded animals and to assess whether bacteriological guidelines for recreational waters could be met. Total coliforms concentrations were determined as a quality assurance measure to ensure confidence in the data set.

E coli Bacteria

E coli bacteria concentrations recorded at the stream stations are presented in Table 2, Appendix C and Figure 3, Appendix B. Concentration ranged from <2 colonies/100 mls at stations # 2 and #4 on September 16^{h} to 8 colonies/100 mls at station #1 and #2 on September 30th. These concentrations of E coli bacteria indicate that study area water quality is typical of natural surface water conditions with very low bacterial counts likely from natural animal populations. These concentrations also indicate that water quality guidelines for body contact recreation (200 colonies / 100 mls) were not exceeded. That is, water quality was suitable for swimming purposes.

Total Coliforms

Total coliforms concentrations recorded at the stream stations are presented in Table 2, Appendix C. Total coliforms values were all >4838 at all stations on both dates sampled. Total Coliform bacteria are ubiquitous in the natural environment and do not necessarily indicate pollutant sources. Their presence in this study indicates only that lab quality assurance procedures are sound.

Blue Green Algae (Cyanobacteria):

Blue green algae cell counts in Little Goose Creek on September 16th ranged from < 1 cell /ml (stations #4 and #6) to 12 cells /ml (station #3). On September 30th blue green algae cell counts ranged from 2 cells /ml (station #1) to 39 cells /ml (station # 3). Cyanobacteria toxins, measured as microcystin concentrations, were all below laboratory detection limits and reported as <0.20 ug/l . Results for all sampling stations and dates are presented in Table 3, Appendix D and Figure 5, Appendix B.

Health Canada Recreational Water Quality Guidelines for cyanobacteria are set at 100,000 cells /ml. Recreational guidelines for cyanobacteria toxin are established as 20 ug/l of microcystin. Water quality met Recreational Water Quality Guidelines for both cyanobacteria cell counts and toxins at all times during this study.

Major Ions and Metals

Ions are both negatively and positively charged particles which are found dissolved in water. These include substances which may be considered to be nutrients and metals, but for the purpose of this study refer to all other common substances found in solution.

A list of these water quality parameters and associated results for Little Goose Creek in 2009 are found in Table 2 (Appendix C). Concentrations of these parameters are presented with summary statistics calculated (i.e. minimum, maximum, and mean values).

A summary of the most relevant and common water quality parameters is provided as follows. Water chemistry at the study site indicated typical water quality conditions for relatively unimpacted surface waters in the southwestern area of Nova Scotia. Specifically, water chemistry indicated soft water conditions (mean hardness 3.9 mg/l) with high color (mean of 215 TCU), low pH (mean of 4.4), low alkalinity (mean <1.0 mg/l), low turbidity (mean 0.46 NTU), low conductivity (mean 51 umho/cm), and metal concentrations typical of streams in that area of the province.

No further analysis or interpretation of these parameters are provided at this time.

WATERSHED/SHORELINE SURVEY

The stream shoreline survey identified no significant nutrient sources which would be stimulating algal production in this stream. Shoreline and watershed surveys to identify pollutant sources noted only one small and recently unused gravel pit and one residence in the general vicinity, neither of which were deemed likely to be influencing stream water quality at the sampling sites. No in-depth assessment of nutrient or pollutant sources from these activities or land uses was undertaken, since this was beyond the scope of the current investigation and available resources.

CONCLUSIONS

Based on the results of this study, it can be concluded that water chemistry at the study site was typical of relatively unimpacted surface waters in the southwestern area of Nova Scotia. Specifically, water chemistry indicated soft water with high color, low pH, low alkalinity, low turbidity, low conductivity, and metal concentrations typical of streams in that area of the province.

Little Goose Creek falls into a trophic category which is relatively unproductive and can be said to be in an oligotrophic to mesotrophic state. That is, nutrient concentrations are relatively low and chlorophyll concentrations indicate low algal growth during this study - both typical of natural unimpacted conditions for surface waters in this area of the province. Phosphorus is the limiting nutrient controlling biological production in study waters. Therefore Little Goose Creek would be sensitive to phosphorus inputs from any nutrient sources.

Bacterial indicators showed very low values and typical of natural background conditions with no human sources suggested.

The algal assessment indicated that cyanobacteria populations were very low and almost non-existent.

Recreational use water quality guidelines for both bacteria and cyanobacteria were met at all times during this study.

Water quality during periods of both low and high flows showed little difference in measured parameters. This suggests no infux of pollutants from overland flows and site runoff and no apparent pollutant sources in the immediate watershed area.

The cursory shoreline survey of the immediate study area identified no apparent pollutant sources which might be impacting receiving water quality in Little Goose Creek.

RECOMMENDATIONS

In order to protect water quality in Little Goose Creek and to ensure that desired water uses are not compromised, any new or existing development should implement best practices to prevent or mitigate impacts from any pollutant sources.

Watershed best management practices should be implemented in order to minimize the export of all pollutants to receiving waters. In particular, phosphorus export from the watershed should be minimized to promote low nutrient and high transparency stream conditions. Development in the watershed (e.g. forestry, farming, residential, etc.) can be accommodated without negative impacts to water quality as long as it is undertaken in an environmentally acceptable manner. Buffer strips, erosion control measures, good livestock manure management, and suitable sewage disposal systems, are examples of appropriate practices which must be implemented if the water resource is to continue to provide the expected uses to area residents.

Community or watershed groups, such as the Clyde River Land Use Committee could act as lead to form a watershed protection plan with stakeholders. Through that process water resource issues could be addressed and desired water uses protected in the watershed.

References

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APPENDIX A

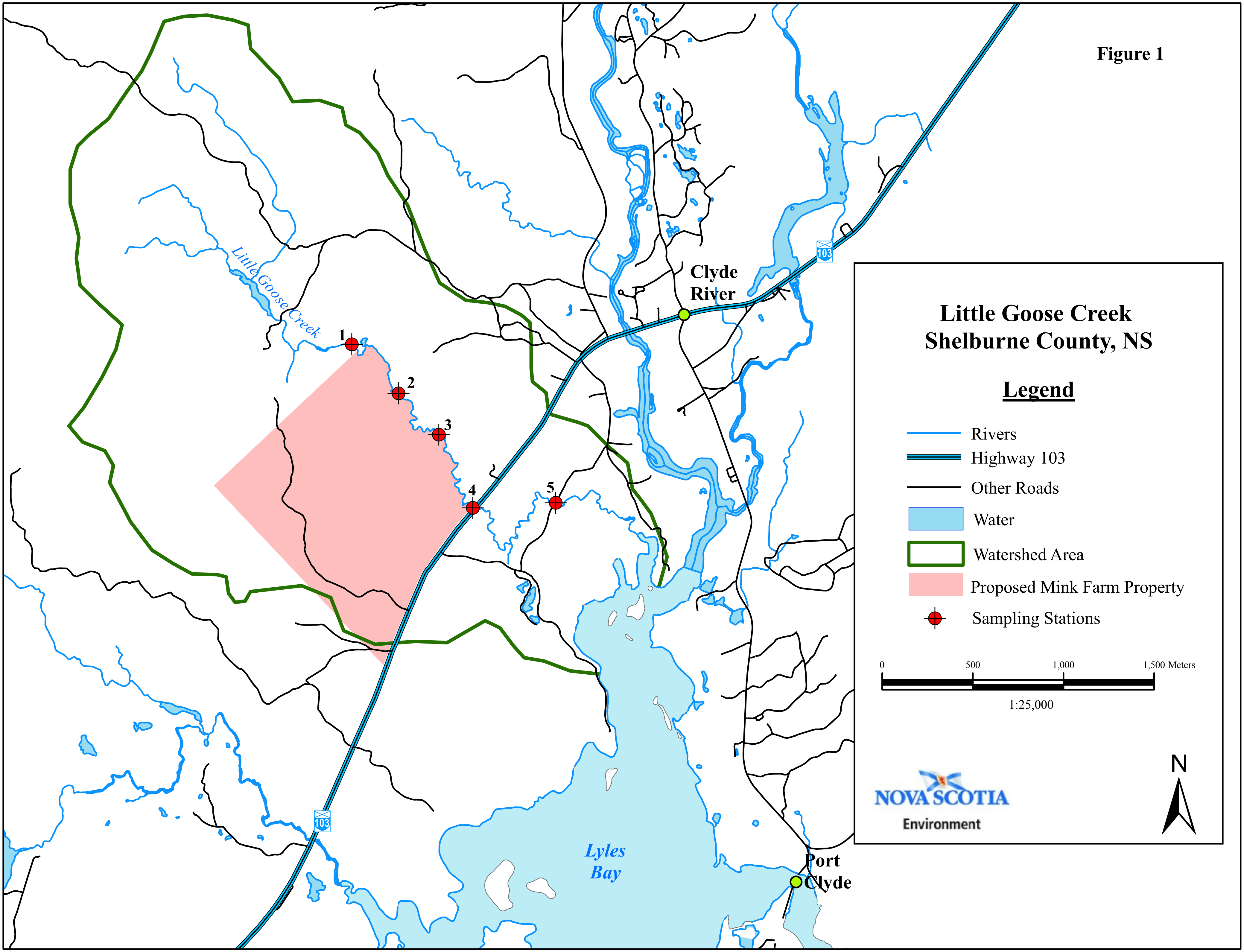


Figure 1
Little Goose Creek
Shelburne County, NS
Legend
Rivers
Highway 103
Other Roads
Water
Watershed Area
Proposed Mink Farm Property
Sampling Stations
0
500
1,000
1,500 Meters
1:25,000
N
NOVA SCOTIA
Environment
Clyde River
Port Clyde
Lyles Bay
Little Goose Creek
103
1
2
3
4
5

APPENDIX B

Figure 2

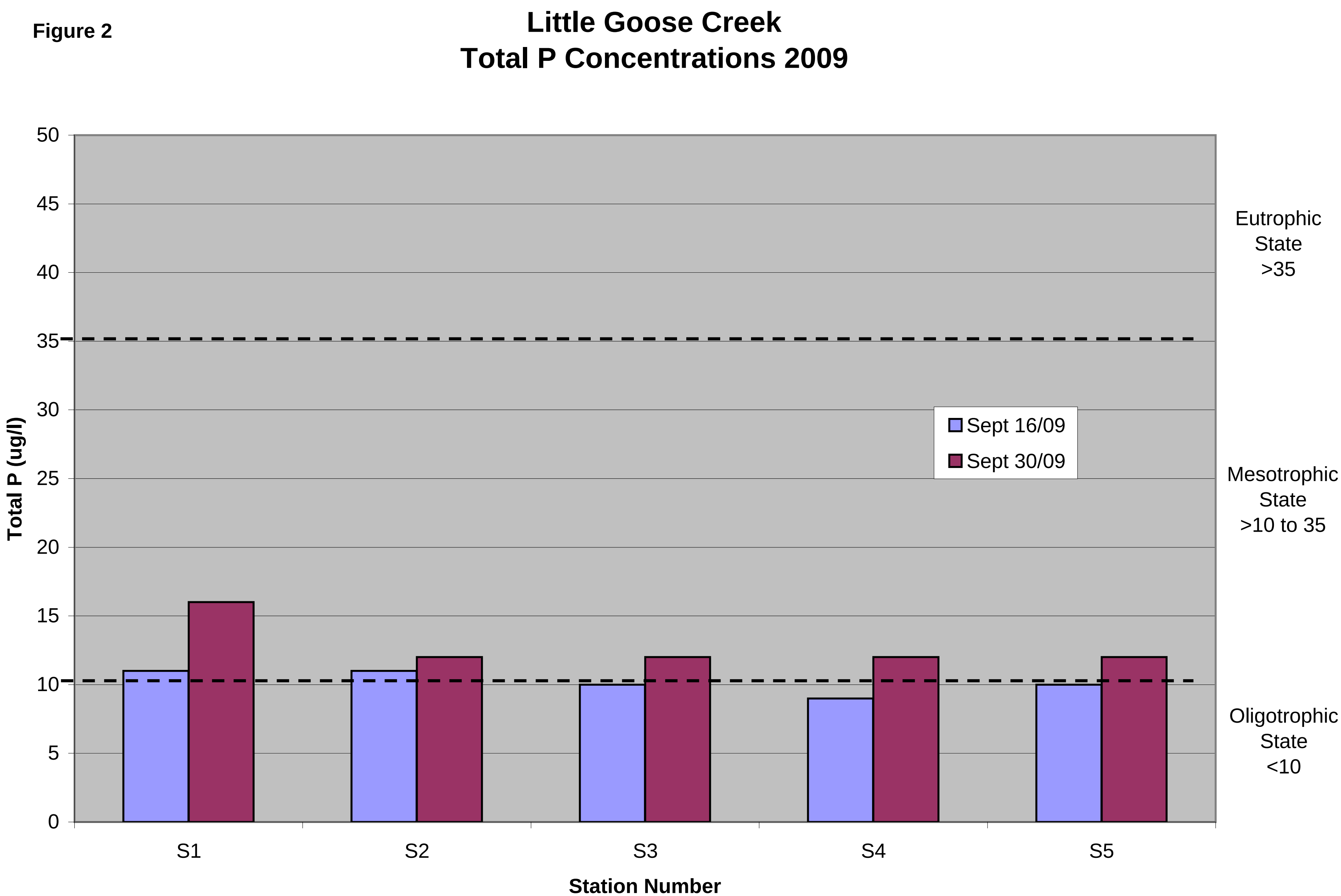

Little Goose Creek
Total P Concentrations 2009
Total P (ug/l)
50
45
40
35
30
25
20
15
10
5
0
Sept 16/09
Sept 30/09
Eutrophic State >35
Mesotrophic State >10 to 35
Oligotrophic State <10
S1
S2
S3
S4
S5
Station Number

Figure 3

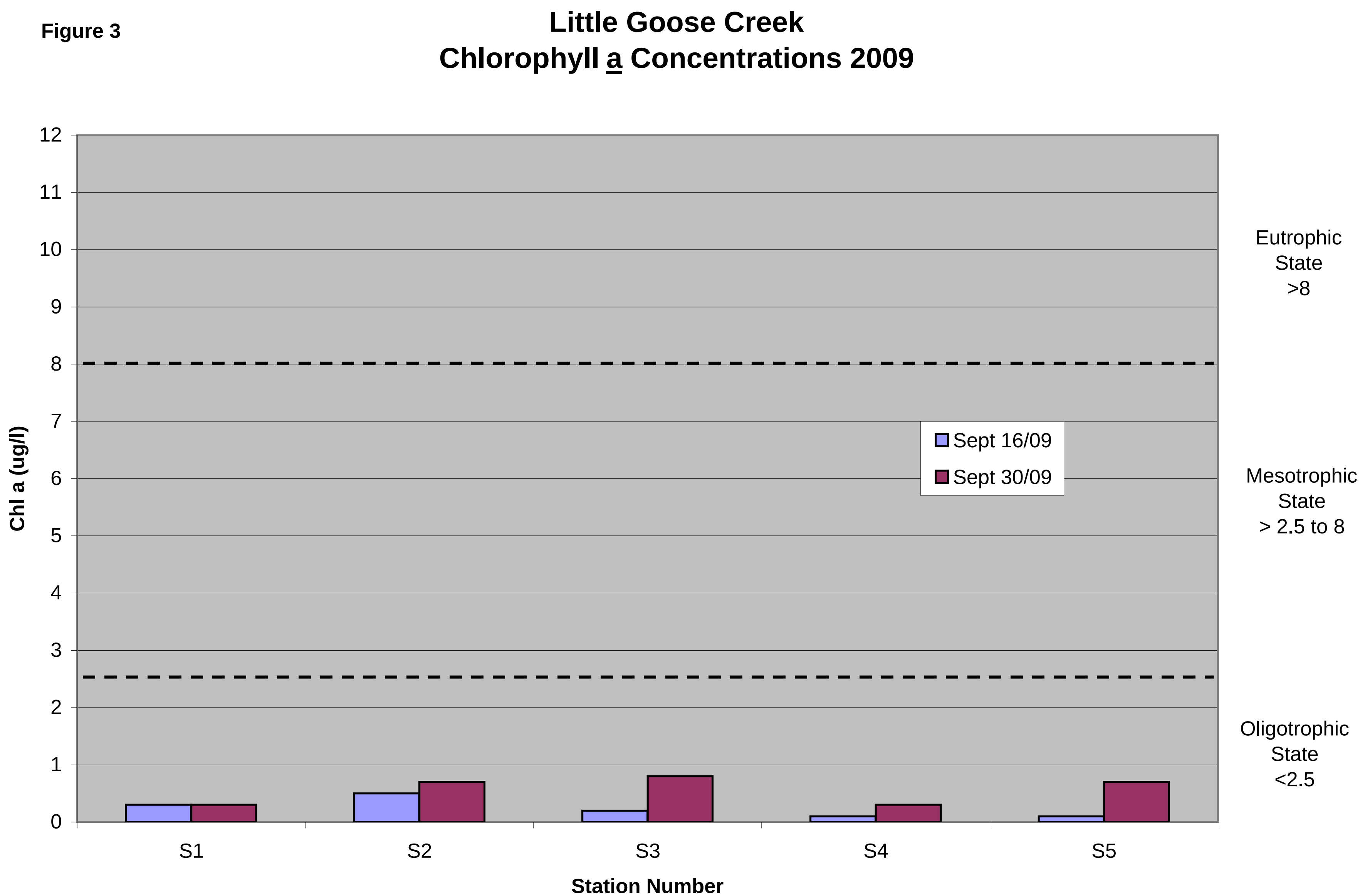

Little Goose Creek
Chlorophyll a Concentrations 2009
12
11
10
9
8
7
6
5
4
3
2
1
0
Chl a (ug/l)
Sept 16/09
Sept 30/09
Eutrophic State >8
Mesotrophic State > 2.5 to 8
Oligotrophic State <2.5
S1
S2
S3
S4
S5
Station Number

Figure 4

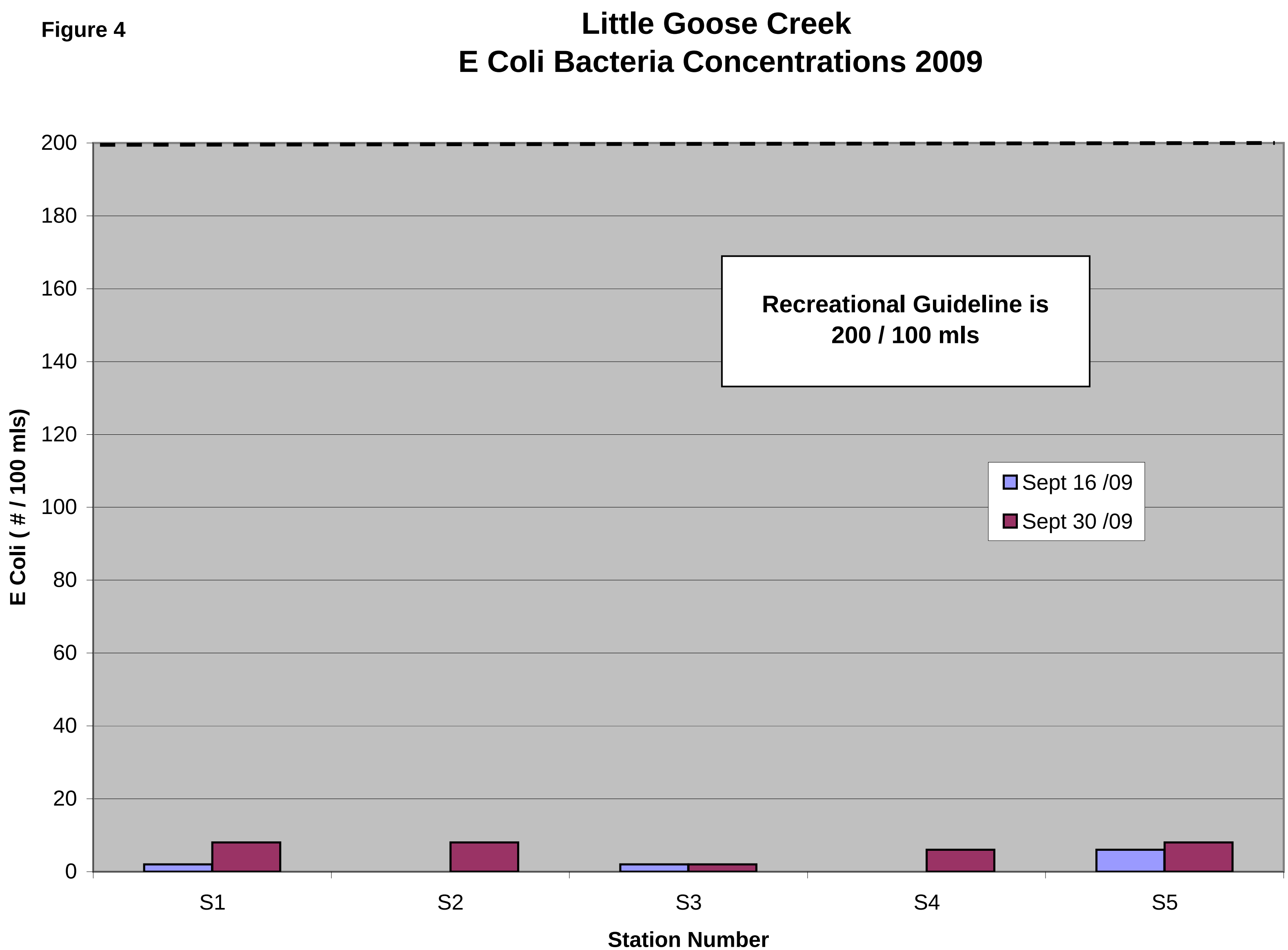
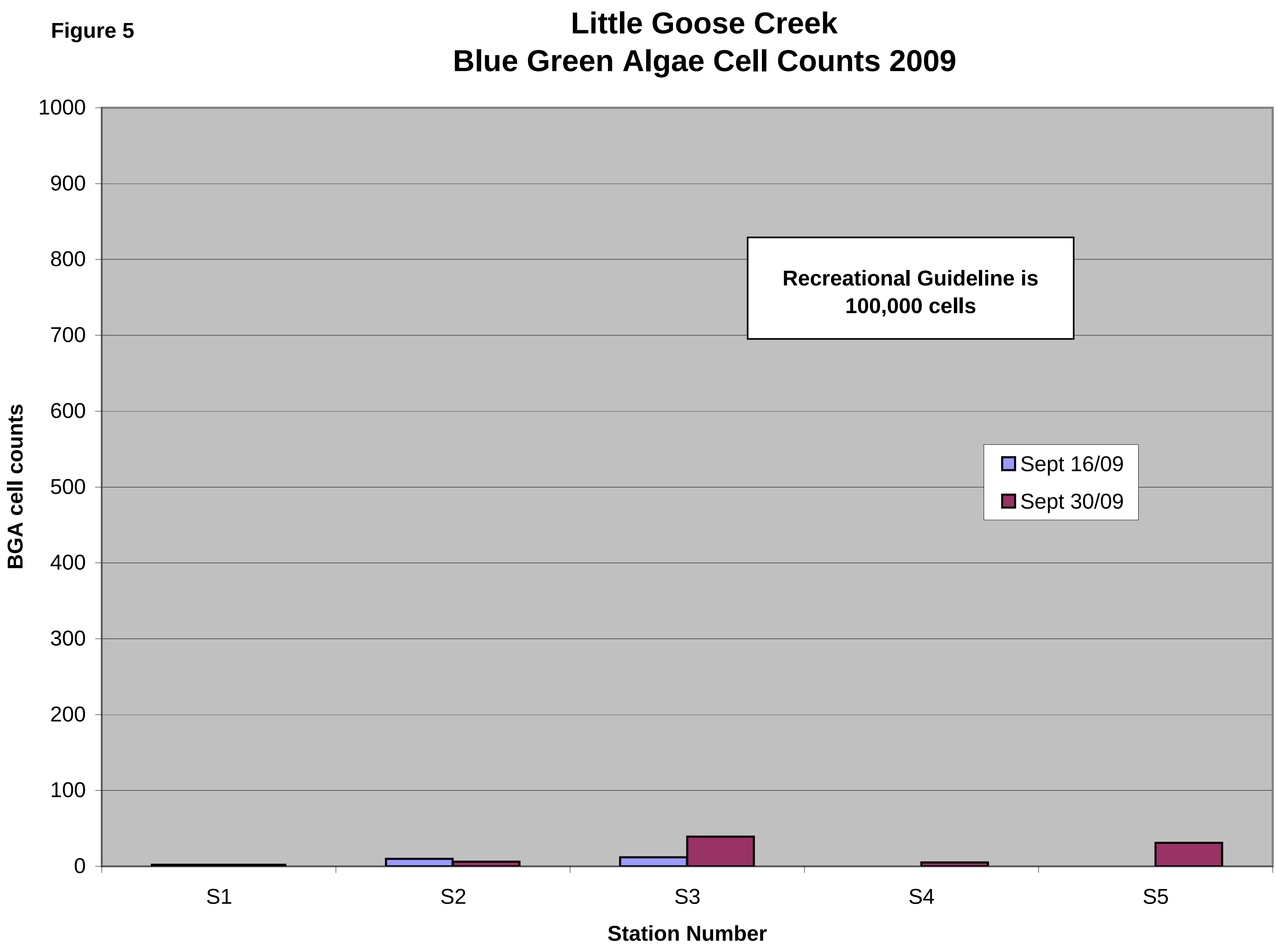

Little Goose Creek
E Coli Bacteria Concentrations 2009
Recreational Guideline is 200 / 100 mls
Sept 16 /09
Sept 30 /09
E Coli (# / 100 mls)
200
180
160
140
120
100
80
60
40
20
0
S1
S2
S3
S4
S5
Station Number

Figure 5


Little Goose Creek
Blue Green Algae Cell Counts 2009
1000
900
800
700
600
500
400
300
200
100
0
BGA cell counts
Recreational Guideline is 100,000 cells
Sept 16/09
Sept 30/09
S1
S2
S3
S4
S5
Station Number

APPENDIX C

Little Goose Creek - Chemical & Bacteriological Water Quality Parameters 2009

Table 2

			Sample ID	S1-0M Little Goose Creek	S2-0M Little Goose Creek	S3-0M Little Goose Creek	S4-0M Little Goose Creek	S5-0M Little Goose Creek	S1-0M Little Goose Creek	S2-0M Little Goose Creek	S3-0M Little Goose Creek	S4-0M Little Goose Creek	S5-0M Little Goose Creek
			Depth (m)	0	0	0	0	0	0	0	0	0	0
			Date Sampled	16-Sep-09	16-Sep-09	16-Sep-09	16-Sep-09	16-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09
Water Quality Parameters	**Min**	**Max**	**Mean**										
Aluminum (ug/L)	341	400	376	400	392	369	341	346	390	394	385	365	376
Antimony (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Barium (ug/L)	2	3	2.10	2	2	3	2	2	2	2	2	2	2
Beryllium (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Boron (ug/L)	<5	5	3	<5	<5	<5	<5	<5	5	5	<5	<5	<5
Cadmium (ug/L0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Calcium (mg/L)	0.5	0.7	0.6	0.6	0.5	0.7	0.6	0.7	0.6	0.6	0.6	0.7	0.7
Chromium (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Cobalt (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Copper (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Iron (ug/L)	336	423	378	423	413	397	365	389	336	339	369	336	415
Lead (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Magnesium (mg/L)	0.5	0.7	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.7
Manganese (ug/L)	<2	4	2.00	<2	<2	<2	3	3	2	2	<2	2	4
Nickel (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Potassium (mg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sodium (mg/L)	4.6	6.8	5.5	4.8	4.6	4.6	5.4	6.2	5.3	5.3	5.4	6.1	6.8
Tin (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Vanadium (ug/L)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Zinc (ug/L)	>5	8	3.4	<5	<5	<5	6	8	<5	<5	<5	<5	<5
Hardness as CaCO3 (mg/L)	3.3	4.6	3.9	3.6	3.3	3.8	3.6	3.8	4	4	4	4.2	4.6
Conductivity (umho/cm)	44.8	59.0	51.0	45	46.1	44.8	50.4	55.5	51.9	51.8	50.6	55	59
pH	4.4	4.5	4.4	4.4	4.5	4.5	4.4	4.4	4.4	4.4	4.4	4.4	4.4
Turbidity (NTU)	0.37	0.51	0.46	0.48	0.44	0.46	0.37	0.43	0.5	0.5	0.51	0.45	0.49
Alkalinity as CaCO3 (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloride (mg/L)	8.1	11.0	9.2	8.1	8.1	8.2	9.3	11	8.7	8.8	8.9	10	11
Colour (TCU)	192	239	215	239	233	220	226	222	192	199	196	210	210
Silica (mg/L)	5.0	7.8	6.4	5.6	5.6	5.6	5.7	5	7.4	7.2	7.8	7.3	7.1
Sulfate (mg/L)	<5	<5	<5	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
Total Nitrogen (mg/L)	0.38	0.42	0.40	0.42	0.41	0.4	0.42	0.42	0.39	0.39	0.38	0.4	0.41
Total Phosphorus (mg/L)	0.009	0.016	0.012	0.011	0.011	0.01	0.009	0.01	0.016	0.012	0.012	0.012	0.012
Nitrate + Nitrite (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
Ammonia (mg/L)	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ortho Phosphorus (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Dissolved Solids(mg/L)	0	0											
Suspended Solids (mg/L)	<1.2	4	1.6	2.4	<1.2	<1.2	<1.2	<1.2	<3.0	4	<3.0	<3.0	<3.0
Total Organic Carbon (mg/L)	24.6	28.2	26.7	27.9	27	24.6	26.5	25.3	26.5	26.7	26.3	27.5	28.2
Chlorophyll A (ug/L)	0.1	0.8	0.4	0.3	0.5	0.2	0.1	0.1	0.3	0.7	0.8	0.3	0.7
TN/TP	24	47	36	38	37	40	47	42	24	33	32	33	34
Total Coliforms (/100mL)	>4838	>4838	>4838	>4838	>4838	>4838	>4838	>4838	>4838	>4838	>4838	>4838	>4838
E. Coli (/100mL)	<2	8	4.4	2	<2	2	<2	6	8	8	2	6	8

APPENDIX D

Little Goose Creek- Algae Speciation, Cell Counts, & Toxin Levels 2009

Table 3

Sample ID	S1-0M Little Goose Creek	S2-0M Little Goose Creek	S3-0M Little Goose Creek	S4-0M Little Goose Creek	S5-0M Little Goose Creek	S1-0M Little Goose Creek	S2-0M Little Goose Creek	S3-0M Little Goose Creek	S4-0M Little Goose Creek	S5-0M Little Goose Creek
Depth (m)	0	0	0	0	0	0	0	0	0	0
Date Sampled	16-Sep-09	16-Sep-09	16-Sep-09	16-Sep-09	16-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09	30-Sep-09
Taxonomy										
Actinastrum (Chlorophyceae)										
Anabaena (Myxophyceae)	1	4					6	2	1	17
Anabaena (Myxophyceae)	small amount	small amount					small amount	small amount	small amount	small amount
Ankistrodesmus (Chlorophyceae)										
Aphanizomenon (Myxophyceae)			10							
Aphanizomenon (Myxophyceae)			small amount							
Aphanothece (Myxophyceae)										
Asterionella (Bacillariophyceae)				small amount						
Blue Green Algae	2	10	12	<1	<1	2	6	39	5	31
Ceratium (Peridineae)										
Chlamydomonas (Chlorophyceae)										
Closterium (Chlorophyceae)						small amount		small amount		
Coelastrum (Chlorophyceae)										
Cosmarium (Chlorophyceae)										
Crucigenia (Chlorophyceae)										
Cryptomonas (Cryptophyceae)		small amount	small amount	small amount	small amount	small amount	small amount	small amount	small amount	small amount
Cyclotella (Bacillariophyceae)										
Dictyosphaerium (Chlorophyceae)		small amount								
Dinobryon (Chrysophyceae)	small amount									
Eudorina (Chlorophyceae)										
Fragilaria (Bacillariophyceae)										
Gomphosphaeria (Myxophyceae)										
Gomphosphaeria (Myxophyceae)										
Kirchneriella (Chlorophyceae)										
Mallomonas (Chrysophyceae)	small amount	small amount	small amount				small amount			
Melosira (Bacillariophyceae)										
Microcystis (Myxophyceae)										
Microcystis (Myxophyceae)										
Monoraphidium (Chlorophyceae)										
Navicula (Bacillariophyceae)			small amount						small amount	small amount
Nitzschia (Bacillariophyceae)										
Oocystis (Chlorophyceae)										
Oscillatoria (Myxophyceae)										
Pediastrum (Chlorophyceae)			small amount							
Peridinium (Peridineae)										
Planktolyngbya (Myxophyceae)		6						32	2	14
Planktolyngbya (Myxophyceae)		small amount						small amount	small amount	small amount
Pseudoanabaena (Myxophyceae)	1		2			2		5	2	
Pseudoanabaena (Myxophyceae)	small amount		small amount			small amount		small amount	small amount	
Rhodomonas (Cryptophyceae)										
Scenedesmus (Chlorophyceae)								small amount		
Small Chrysophytes (Chrysophyceae)	small amount	small amount	small amount	small amount	small amount	small amount	small amount	small amount	small amount	small amount
Spondylosium (Chlorophyceae)										
Staurastrum (Chlorophyceae)										
Synedra (Bacillariophyceae)	small amount	small amount	small amount	small amount	small amount	small amount		small amount	small amount	small amount
Synura (Chrysophyceae)				small amount			small amount	small amount	small amount	small amount
Tabellaria (Bacillariophyceae)		small amount	small amount		small amount					
Trachelomonas (Euglenophyceae)										
Ulothrix (Chlorophyceae)										
Organic Parameters										
Microcystin	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20