Water Quality Sampling and Analysis for the St. Marys River Area of Concern (Beneficial Use Impairment Assessment)

Interim Technical Report

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Executive Summary

The St. Marys River is a major channel in the Great Lakes system connecting Lake Superior to Lake Huron and separating the twin cities of Sault Ste. Marie, Ontario and Michigan. As a result of water quality deteriorating, to a point where threats to wildlife populations and human activities were recognized, the St. Marys River was officially designated as an Area of Concern (AOC) in the 1980s. This designation led to remediation measures including the development of Remedial Action Plans (RAPs). Through the RAP process, a list of beneficial use impairments (BUIs) was identified for the St. Marys River AOC.

Some of those BUIs remain a problem and others have been significantly improved through regulatory changes and infrastructure projects. The purpose of this three-year project is to collect and analyze water quality data and review relevant literature in order to re-assess the status of two beneficial use impairments, (1) eutrophication or undesirable algae and (2) degradation of aesthetics, for the Canadian portion of the St. Marys River Area of Concern.

The main tasks accomplished towards this purpose in Year 1 (2013-2014) were: selecting five field sites, choosing an analytical laboratory, developing water quality sampling protocols, formulating worker safety and emergency response plans, doing preliminary water quality sampling, performing data analysis and reporting on initial results.

The sampling sites selected within the St. Marys River spanned the length of the AOC and were at locations identified as being either at the source or mouth of the river or at locations which were previously known to be impacted by the BUIs of interest. They are, from North-West to South-East: Gros Cap, Bellevue Park, Bell's Point, Echo Bay and Richards Landing.

Parameters measured at each site were geared to the BUIs of interest and included: water clarity, colour and odour, visible debris, obvious pollution, algae, nutrients (ammonia, nitrite, nitrate, nitrogen and phosphorus), chlorophyll a, pH, dissolved oxygen, dissolved organic carbon, total suspended solids and turbidity.

Preliminary results suggest that the sampling sites chosen and protocols developed were successful and should be used in subsequent project years. Analysis of the initial water quality data indicates that there are limited signs of (1) eutrophication or undesirable algae at the Echo Bay site and minor indications of (2) degradation of aesthetics at both the Bellevue Park and Echo Bay sampling sites. Further study in project years 2-3 should help to clarify if the beneficial uses remain impaired.

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Acknowledgements

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In kind support for this project is being provided by Algoma University. Special mention goes to Paula Antunes who initially developed this project in collaboration with other members of the Bi-National Public Advisory Council on the St. Marys River Area of Concern.

1. Introduction

Background

The St. Marys River is an approximately 112 km long channel which connects Lake Superior to Lake Huron and separates the twin cities of Sault Ste. Marie, Ontario and Michigan (Ripley et al 2011). Since the 1900s, human activities, including industrialization, navigation, urbanization and power generation, have contributed significantly to changes in the chemical, physical and biological nature of St. Marys River ecosystem (Ripley et al 2011; GLWQA 1987).

In the 1980s, the St. Marys River was identified as one of 43 Areas of Concern (AOCs) in the Great Lakes Basin (USEPA 2014). AOCs, as first defined by the 1987 Great Lakes Water Quality Agreement (GLWQA) between Canada and the United States, are geographically-delineated regions where it is deemed that failure to meet the agreement's water quality objectives has led to or is likely to cause impairments to beneficial uses. Following the listing of the St. Marys AOC's impairments, plans were put into place to tackle the identified challenges.

Remedial Action Plans

Remedial action plans (RAPs) developed in conjunction with governments, agencies and stakeholders, guide the implementation of ecosystem restoration activities in AOCs (GLWQA 1987). The ultimate goal of the RAP process is the restoration of beneficial uses, leading to the recovery of the AOCs (GLWQA 2012).

In 1992, the Stage 1 RAP "Environmental Conditions and Problem Definitions" was developed for the St. Marys River AOC (RAP1 1992). It thoroughly identified the beneficial use impairments and the probable causes up to that point (RAP1 1992). A decade later, the Stage 2 RAP for the St. Marys River "Remedial Strategies for Ecosystem Restoration" was published (RAP2 2002). It summarized the impairments, suggested further information needed, and elaborated on remedial actions required (RAP2 2002).

An Implementation Annex for the second RAP has been drafted, which takes stock of the completed actions and achievements since 2002 within the Canadian portion of the AOC and outlines the remedial actions, monitoring and assessment needs going forward necessary to complete the restoration of the remaining beneficial uses.

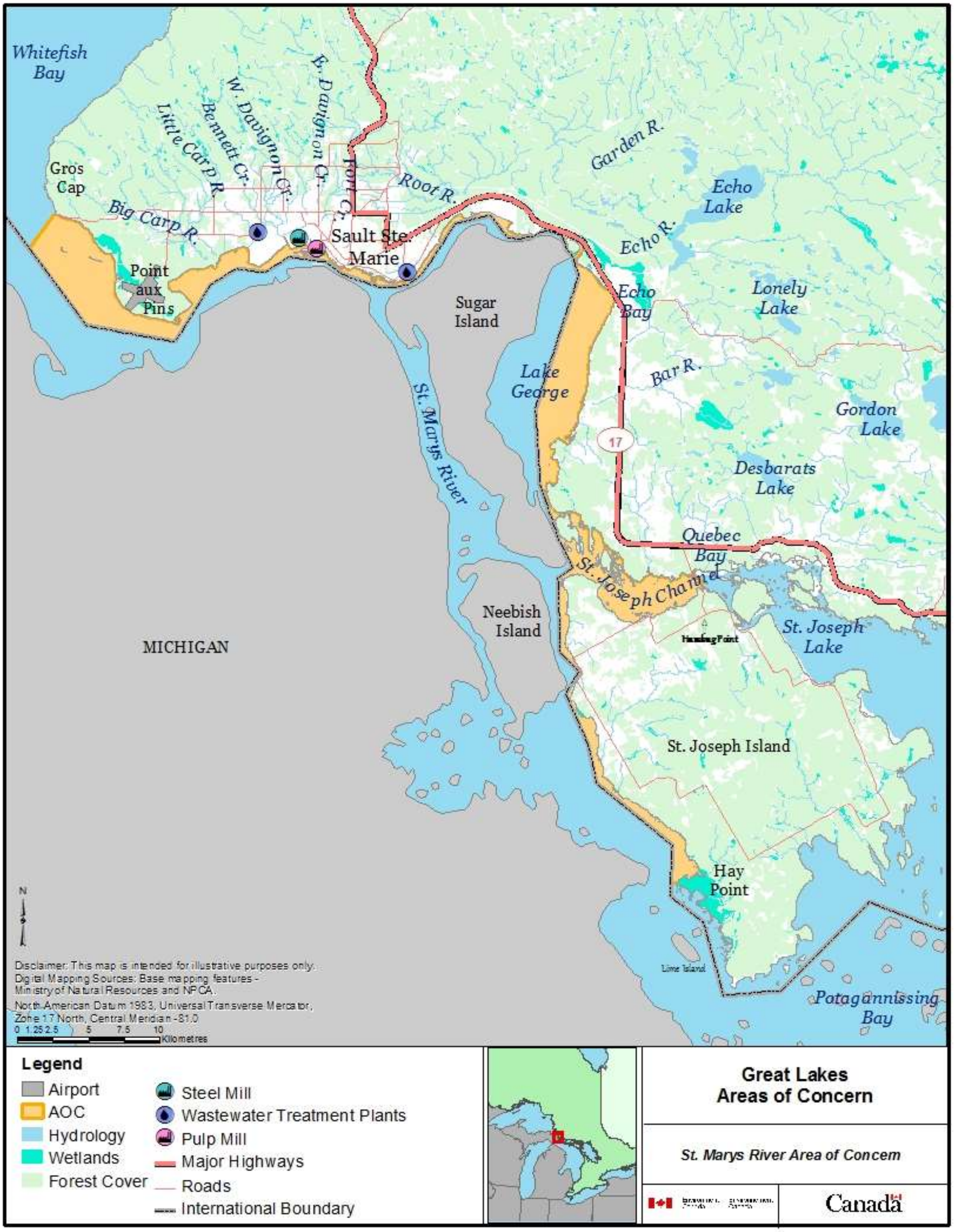

Figure 1: Map of the St. Marys River Area of Concern (source: Environment Canada)

Beneficial Use Impairments

Of the 14 impairments to beneficial uses identified in the GLWQA, a total of 9 have been identified as being applicable to the St. Marys River (RAP1 1992; RAP2 2002). Those beneficial use impairments (BUIs) involve impacts to fish and wildlife populations as well as human recreational activities. Of particular interest to this project are the beneficial use impairments known as (1) eutrophication or undesirable algae and (2) degradation of aesthetics.

Eutrophication or Undesirable Algae

Eutrophication refers to the nutrient enrichment of a water body (Smith & Smith 2006). This often leads to increased algal growth, especially in the presence of elevated levels of nitrogen and phosphorus (Smith & Smith 2006). In the past, excessive algal growth was identified in bays and other slower-moving areas of the St. Marys River, particularly those downstream of the East End Waste Water Treatment Plant located in Sault Ste. Marie, Ontario (RAP1 1992; RAP2 2002).

Degradation of Aesthetics

In the past, the aesthetics along the St. Marys River have been assessed to be degraded due to visible debris and obvious pollution, including oil slicks, grease, floating scums and oily fibrous material mixed with woody debris, at the shoreline, on surface waters and sitting on bottom sediments (RAP1 1992; RAP2 2002). Aesthetic impairments have been historically noted in proximity to the boat slip and basin at the former Algoma Steel site (now Essar Steel Algoma) and downstream of the East End Waste Water Treatment Plant (RAP1 1992; RAP2 2002). It is also possible that spills from boats navigating the channel contributed to the oily deposits (RAP2 2002).

Changes in the Watershed

Since the Stage 2 RAP (2002), regulatory and infrastructure improvements have taken place which directly impact the water quality of the St. Marys River, particularly in relation to the beneficial use impairments being assessed through this project.

In 2006, the East End Waste Water Treatment Plant was upgraded to a secondary treatment facility with a biological nutrient removal system (SIMWG 2008). This has resulted in reductions in the amount of suspended solids (89%), phosphorus (91%), nitrogen and ammonia being released into the St. Marys River through treated waste water effluent (Barrett 2012; Barrett 2013). The plant’s discharge pipe was also relocated from a shallow off-shore location to deeper faster flowing waters in an effort to move the treated effluent more efficiently downstream (SIMWG 2008).

Having been under stricter environmental regulations since the 1990s, the Steel Plant in Sault Ste. Marie, Ontario has reduced its discharges of oil and grease into the St. Marys River by 96%, odour-causing phenols by 99% and ammonia by 95% (Barrett 2012). Essar Steel Algoma monitoring data available from 2011 shows it to be in compliance with the allowable limits (% allowable limit) of discharges for oil and grease (10%), suspended solids (10%) and ammonia (85%) (Essar Steel Algoma 2011).

Other improvements of interest to this project include: sanitary and storm sewer upgrades in Sault Ste. Marie, Ontario in 2003 (Barrett 2012; Kresin 2004), the construction of an Echo Bay sewage treatment plant in 1998 (Kresin 2004; Barrett 2013b) and the closing of St. Marys Paper in 2012 (Barrett 2013a). Before its closure, suspended solids were decreased by 91% and phenols by over 95% in discharges from St. Marys Paper (Barrett 2012).

Knowledge Gaps

Research has already taken place which can aid in assessing the impact of some of these regulatory and infrastructure changes on eutrophication or undesirable algae and degradation of aesthetics in the St. Marys River AOC.

This includes two studies: a 2007 report on water quality in the Sugar Island, Michigan area, which has historically been impacted by outflows from the East End Waste Water Treatment Plant (SIMWG 2008), and a report on aesthetics monitoring which took place along the Michigan shoreline in 2011 and 2012 (MDEQ 2013). In addition, other studies, such as the recent St. Marys River AOC Coastal Wetland Habitat Scoping Report from Environment Canada, have tested relevant St. Marys River water quality parameters in areas of interest to this project (EC 2013).

However, in order to adequately assess the status of the (1) eutrophication or undesirable algae and (2) degradation of aesthetics beneficial uses in the Canadian St. Marys River AOC, further information is needed. Both RAP Stage 1 and 2 reports state that, although undesirable algae growth has been noted in the past within bays and slow moving areas of the river, the nutrient status of those areas has not been well documented (RAP1 and RAP2). In addition, despite the fact that there has been anecdotal evidence of degraded aesthetics along the St. Marys River AOC (RAP2 2002), systematic and recent data about the state of aesthetic impairments is not available.

2. Purpose of Project

Overall Purpose

The overall purpose of this three-year project (2013-2016) is to collect and analyze water quality data and review relevant literature in an effort to gather the evidence needed to re-assess the status of two beneficial use impairments (1) eutrophication or undesirable algae and (2) degradation of aesthetics, for the Canadian portion of the St. Marys River Area of Concern.

Purpose of Year 1

The purpose of Year 1 was to undertake field reconnaissance to identify five sampling sites to be used throughout the project, develop water quality sampling protocols and procedures, and test the project design through a preliminary collection and analysis of water quality data.

3. Key Accomplishments

The following summarizes the main tasks carried out in Year 1 of the project (2013-2014).

Sampling Site Selection

A major focus for the Year 1 field work was on selecting sampling sites to be used throughout the project. Sites considered involved those within the Canadian St. Marys River AOC previously identified as being impaired with respect to the BUIs of concern (1) eutrophication or undesirable algae and (2) degradation of aesthetics (RAP1 1992; RAP2 2002). The source and mouth of the river were also investigated as possible sampling locations.

Additional factors affecting site selection were their accessibility and safety for sampling by wading. The total number of final sampling sites selected (5) was based the robustness of the data being sought for this project and the funding available for sampling and analysis.

Sampling site reconnaissance was carried out on November 9-10, 2013. Selected photographs of the candidate sites are shown in Figure 2. A total of ten sites, extending the length of the Canadian side of the St. Marys AOC, were investigated. These included: Gros Cap, Mark's Bay, Topsail Island at Bellevue Park, Dacey Road, Bell's Point Camp, Echo Bay Bridge, Pumpkin Point, St. Joseph's Island Bridge, Richards Landing Marina and Richards Landing Park (Figure 3).

Figure 2: Photographs of sampling site reconnaissance

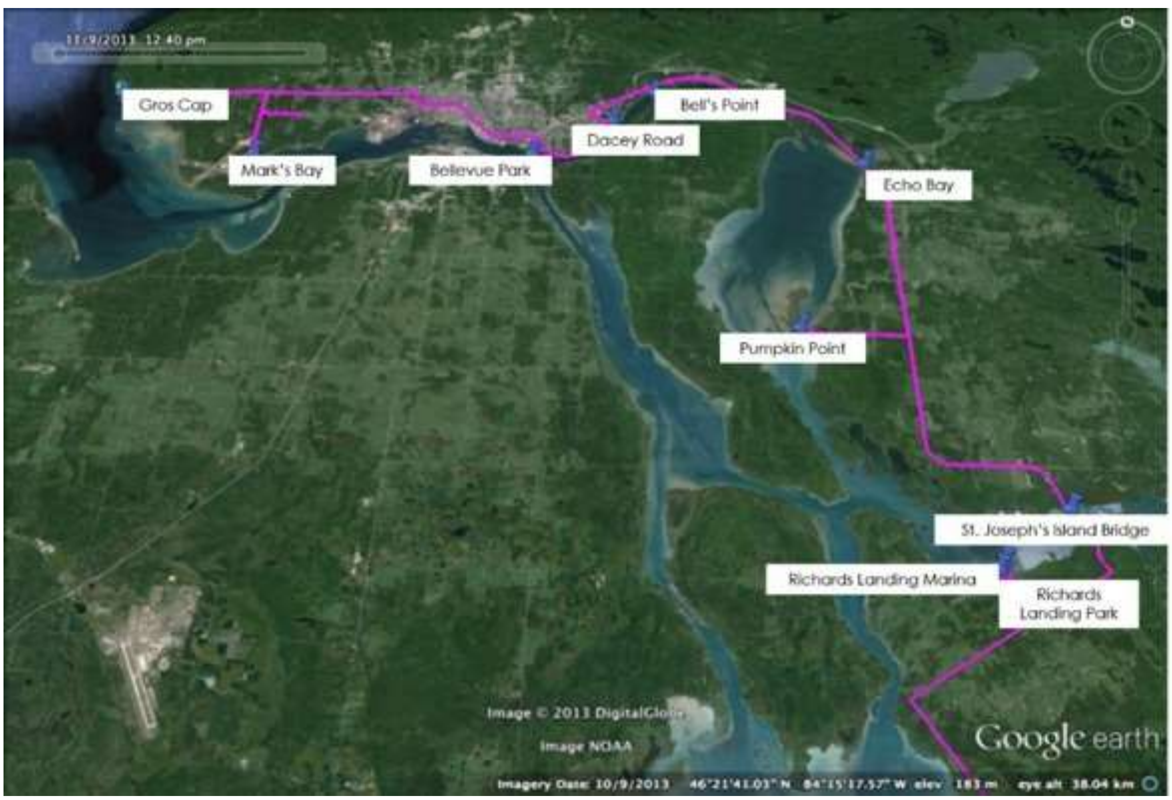

Figure 3: Map showing sampling site reconnaissance locations

Figure 4: Map showing selected sampling sites

From the ten sites investigated, five were chosen as sampling sites for the current project. They are: Gros Cap, Topsail Island at Bellevue Park, Bell's Point Camp, Echo Bay Bridge and Richards Landing Park (Figure 3). The GPS co-ordinates of the selected sites are in Table 1.

Table 1: GPS co-ordinates of selected sampling sites

Gros Cap	N 46°31.711' W 084°35.159'	Elevation: 585 feet
Bellevue Park	N 46°29.708' W 084°17.824'	Elevation: 567 feet
Bell's Point	N 46°32.281' W 084°13.047'	Elevation: 565 feet
Echo Bay	N 46°29.627' W 084°04.693'	Elevation: 659 feet
Richard's Landing	N 46°17.569' W 084°02.426'	Elevation: 530 feet

The chosen sampling sites span the length of the project study area and are representative of the substrate types found along the AOC. All five sites selected have good road access with safe parking and shorelines in which the Field Technician can safely wade into the water to take samples and field readings. In addition, neither currents nor drop offs pose a hazard. All sites are located on public land, with the exception of the sampling site at Bell's Point, which is accessed with landowner permission. Representative photos were taken at each sampling site.

Gros Cap

Gros Cap (Figure 5) was chosen as it marks the north-western source-end of the St. Marys River and thus can give a good indication of background water quality. It is located upstream of the more heavily industrialized and urbanized areas of Sault Ste. Marie.

Figure 5: Photographs of Gros Cap sampling site

Bellevue Park

Topsail Island at Bellevue Park (Figure 6) was chosen as it is downstream of the industrial activities and urban land uses, which in the past, have been documented to contribute to eutrophication and degradation of aesthetics in the St. Marys River. Previous studies have indicated that the Bellevue Park area has impaired beneficial uses (RAP2 2002). In addition, since Bellevue Park is a recreational attraction for both locals and tourists, it would be important to investigate this site if wishing to delist eutrophication and aesthetics BUIs.

Figure 6: Photographs of Bellevue Park (Topsail Island) sampling site

Bell's Point

Bell's Point Camp (Figure 7) was chosen as it is in the historically-impacted Lake George Channel downstream from Sault Ste. Marie, Ontario's East End Waste Water Treatment Plant (RAP1 1992; RAP 2 2002). Due to the significant improvements in waste water processing it is an ideal location to test for the current conditions with respect to eutrophication and aesthetics BUIs.

Figure 7: Photographs of Bell's Point sampling site

Echo Bay

The Echo Bay Bridge (Figure 8) site is located in Lake George, just outside the inlet to Echo Bay. Lake George has been documented as being an impacted portion of the St. Marys River, where slower moving waters make it more susceptible to nutrient retention and eutrophication (RAP1 1992; RAP 2 2002). It is important to sample here as it is precisely the type of environment about which little data has been collected regarding eutrophication and aesthetic impairments (RAP1 1992; RAP 2 2002). In addition, improvements are expected due to the replacement of private septic systems with a communal Echo Bay sewage treatment plant (Barrett 2013b).

Figure 8: Photographs of Echo Bay sampling site

Richards Landing
Richards Landing Park (Figure 9) was chosen as it represents water quality conditions at the mouth of the St. Marys River AOC where it enters the North Channel of Lake Huron. Sampling there will provide data about the water quality of the river after it has been subjected to the various point and non-point sources identified as contributing to the BUIs of interest.

Figure 9: Photographs of Richards Landing sampling site

Analytical Laboratory Selection

The laboratory selected to analyze the water samples collected during Year 1 was Testmark Laboratories Ltd. located in Garson, Ontario (Greater Sudbury Area). It was selected as the closest location where the necessary laboratory analysis could be performed and the cost of shipping could be minimized. Testmark Laboratories Ltd. (Garson) is currently accredited by the Canadian Association for Laboratory Accreditation Inc.

Work Plan Development

An initial water quality sampling work plan was developed and tested during preliminary sampling in November 2013. Due to the time of year, sampling was completed prior to the development of a complete protocol. Following on that experience, and a turn-over in the Field Technician position, a Project Work Plan (Appendix 1) was created. The methods described in that plan approximate those that were used in Year 1 and are designed to be followed in Years 2-3, with revisions taking place as needed.

Safety and Emergency Response Plan

A draft safety and emergency response plan was created for the preliminary water quality sampling in Year 1. Following on that experience, as with the first work plan, it was revised and the current edition appears in Appendix 2. The Worker Safety and Emergency Response Plan is designed to be followed throughout Years 2-3 and also revised as necessary.

Preliminary Water Quality Sampling

On November 16 and 17, 2013, water quality sampling was performed at the five selected sites (Gros Cap, Bellevue Park, Bell's Point, Echo Bay and Richards Landing) in the St. Marys River AOC. At each site, field measurements were taken, aesthetics monitoring data was recorded and 3 replicates of 6 water samples (18/site) were collected for water quality analysis. The water samples were shipped to Testmark Laboratories on November 18, 2013 and were received for analysis on November 19, 2013. Data is presented in the "Results" section following.

4. Project Equipment

With the challenge of completing preliminary sampling on the St. Marys River before the on-set of a northern Ontario winter, little equipment was purchased during Year 1 start-up. The remainder of the items needed for Year 2 and Year 3 sampling are currently being purchased (March 2014) with the Year 1 budget for equipment.

5. Methods

Summary of Methods

Year 1 field measurements, photographs, aesthetics monitoring data and water samples, were collected on November 16 and 17, 2013. The sampling sites, as discussed previously, were: Gros Cap, Bellevue Park, Bell's Point, Echo Bay and Richards Landing. The methods used are detailed in the Project Work Plan (Appendix 1).

Briefly, for field measurements, site co-ordinates were taken with a hand-held GPS unit, weather observations were recorded based on categories in the Michigan Department of Environmental Quality's Aesthetics Monitoring Data Sheet (which was used to collect data for a similar study) (MDEQ 2011), air and water temperatures were taken with a thermometer, field pH was read with pH test strips, water and Secchi depth were measured with a Secchi disc, and photographs were taken with a digital camera.

Aesthetics data, for water clarity, water colour, water odour, visible debris/obvious pollution, algae, and other observations, was collected using the Michigan Department of Environmental Quality's Aesthetics Monitoring Data Sheet (MDEQ 2011).

Water samples for laboratory analysis (Figure 10) were collected following the methods of the Canadian Council of Ministers of the Environment's Protocols Manual for Water Quality Sampling in Canada (CCME 2011). A total of 18 bottles (6 bottles, 3 replicates) were collected from each of the 5 field sites (90 grab-samples total).

Laboratory analysis of grab-sampled water bottles was done at Testmark Laboratories in Garson, Ontario according to the analytical methods shown in Appendix 1, Table 5. The parameters measured or calculated were: ammonia as nitrogen, un-ionized ammonia, nitrite as nitrogen, nitrate as nitrogen, total Kjeldahl nitrogen, total nitrogen, total phosphorus, chlorophyll a, pH, dissolved oxygen, dissolved organic carbon, total suspended solids and turbidity.

Figure 10: Field data and sample collection methods

Water Quality Parameters

The water quality parameters used for this project are those which will aid in making conclusions about the status of the beneficial use impairments (1) eutrophication or undesirable algae and (2) degradation of aesthetics. A brief explanation for each parameter is given in Table 2.

Table 2: Explanation of water quality parameters

Parameter	**Measures (units)**	**Relevance to this project**
Water temperature (Water temp)	temperature (°C)	-temperature can influence the speciation of nutrients and their bioavailability as well as dissolved oxygen concentrations
pH	scale: 1-14	-pH can influence the speciation of nutrients and their bioavailability
Secchi depth	water clarity (cm or m)	-increased Secchi depth indicates clear water -cloudiness could indicate degraded aesthetics and eutrophication/algal blooms
Water clarity	scale: clear-opaque	-cloudiness could indicate degraded aesthetics and eutrophication/algal blooms
Water colour	scale: clear to milky-white	-colour could indicate degraded aesthetics and eutrophication/algal blooms
Water odour	scale: none-strong	-strong odour could indicate degraded aesthetics and eutrophication/algal blooms
Visible debris obvious pollution	trash, solids, scums, sheens, oil, grease	-presence indicates degraded aesthetics
Algae/other observations	algae and other deposits	-presence could indicate degraded aesthetics and eutrophication/algal blooms
Ammonia as nitrogen (NH_3-N)	ammonia (NH_3) and ammonium (NH_4^+) (mg/L)	-high levels could facilitate eutrophication/algal blooms
Un-ionized ammonia (NH_3-N)	ammonia (NH_3) (mg/L)	-high levels could facilitate eutrophication/algal blooms
Nitrite as nitrogen (NO_2-N)	nitrite ion (NO_2) (mg/L)	-high levels could facilitate eutrophication/algal blooms
Nitrate as nitrogen (NO_3)	nitrate ion (NO_3) (mg/L)	-high levels could facilitate eutrophication/algal blooms
Total Kjeldahl nitrogen (TKN)	ammonia and organic nitrogen (mg/L)	-high levels could facilitate eutrophication/algal blooms
Total phosphorus (Total P)	phosphorus (mg/L)	-high levels could facilitate eutrophication/algal blooms
Chlorophyll a (Chloro a)	chlorophyll a molecule (µg/L)	-high levels could indicate eutrophication/algal blooms
Dissolved oxygen (DO)	concentration of oxygen in water (mg/L)	-low levels could indicate eutrophication/algal blooms
Dissolved organic carbon (DOC)	organic carbon in dissolved form (mg/L)	-high levels could indicate eutrophication and degraded aesthetics
Total suspended solids (TSS)	non-dissolved particles (mg/L)	-high levels could indicate degraded aesthetics and eutrophication
Turbidity	water clarity (NTU)	-high levels could indicate degraded aesthetics and eutrophication

Data Management and Statistical Analysis

Field measurements and aesthetics observations were compiled in electronic spreadsheets using Excel (Microsoft Office 2013). Photographs were uploaded and filed electronically. Laboratory analysis results were received from Testmark Laboratories in an Excel spreadsheet, which was subsequently modified for ease of data manipulation.

Statistical analysis was performed on the laboratory data using SPSS (IBM SPSS Statistics 21). Since the values for nitrite as nitrogen, total nitrogen and un-ionized ammonia were all below minimum detection limits, they were excluded from the analysis. For all other results, mean, minimum and maximum values, as well as standard error, were calculated for each parameter at each sampling site (10 parameters with 3 replicates per site).

In cases where only some numbers were below minimum detection limits (Echo Bay: nitrate as nitrogen, Bell's Point and Richards Landing: total Kjeldahl nitrogen, Gros Cap and Bell's Point: chlorophyll a), the values were set to the minimum detection limits as a conservative estimate (as higher levels generally indicate impairment) to allow statistical analysis to proceed.

Additional statistical manipulation was done to determine statistically significant differences in water quality parameters between sampling sites. Specifically, a Kruskal-Wallis test followed by pairwise comparisons was conducted to determine significant differences for water quality parameters between sampling sites ($p < 0.05$).

6. Results

The following are the results of this project's preliminary water quality investigations (Year 1) within the Canadian waters of the St. Marys River AOC.

Field Data

Table 3: Field measurements

Site	GPS Co-ordinates	Date	Time	Weather	Air Temp °C	Water Temp °C	Field pH	Secchi Depth	Water Depth (cm)
Gros Cap	N 46°31.711' W 084°35.159'	17/11/2013	12:42 - 12:50 pm	Rain today	12	8	6.0-6.5	Very clear	50
Bellevue Park	N 46°29.708' W 084°17.824'	16/11/2013	3:57 - 4:08 pm	Rain yesterday, cloudy	7	8	6.0-6.5	Very clear	50
Bell's Point	N 46°32.281' W 084°13.047'	16/11/2013	3:07 - 3:15 pm	Rain yesterday, cloudy	8	8	6.0-6.5	Very clear	50
Echo Bay	N 46°29.627' W 084°04.693'	16/11/2013	2:15 - 2:25 pm	Rain yesterday, cloudy	9	7	6.0-6.5	50 cm	50
Richards Landing	N 46°17.569' W 084°02.426'	16/11/2013	12:33 - 1:06 pm	Rain yesterday, cloudy	13.5	7	6.0-6.5	Clear	50

Table 4: Aesthetics monitoring data

Site	Water Clarity	Water Colour	Water Odour	Visible Debris/ Obvious Pollution	Algae	Observations
Gros Cap	Clear	Clear	None	None	None	rocky/pebbly substrate, culvert ~6 ft from sampling site
Bellevue Park	Clear	Clear	Faint sewage /fishy	Some fixed timber/steel/ concrete in water	NA	very stony shore, large rocks sporadically, very clear water/silty
Bell's Point	Clear	Clear	None	Natural, weeds in water and on shore	None	sandy silty, very clear water, thick silty/sandy substrate, aquatic vegetation
Echo Bay	Slightly turbid	Light yellow, discoloured	None	Natural, some trash on shore	NA	sandy, silty, boat came through 10 minutes prior to sampling
Richards Landing	Clear	Clear	None	None	None	sandy, very fine silt

NA = Data not available

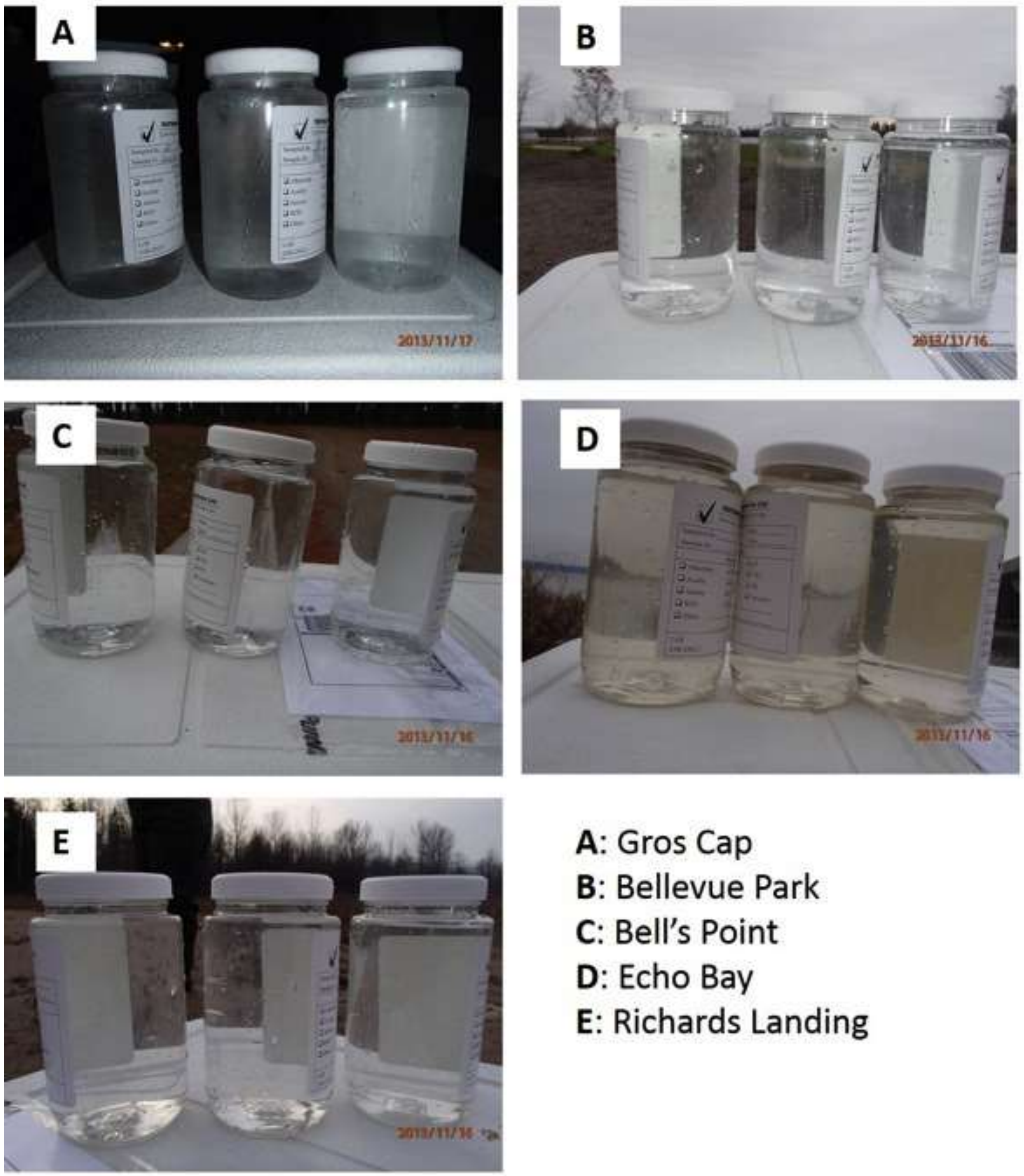

Figure 11: Photographs of water clarity and colour

Figure 12: Photographs of aesthetics observations

Laboratory Data

Results for nitrite as nitrogen (<0.03 mg/L), total nitrogen (<1 mg/L) and un-ionized ammonia (<0.002 mg/L) have been excluded as they were all below minimum detection limits.

Table 5: Analytical laboratory results

Site	NH_3-N mg/L	NO_3-N mg/L	TKN mg/L	Total P mg/L	Lab pH	Chloro a µg/L	DO mg/L	DOC mg/L	TSS mg/L	Turbidity NTU
Gros Cap	**0.031**[1] (.030-.032)[2]	**0.280** (.250-.330)	**0.440** (.420-.480)	**0.002** --	**7.53** --	**0.833** (.500-1.20)	**9.89** (9.75-10.1)	**2.60** --	**3.20** (2.40-4.40)	**1.09** (.940-1.28)
Bellevue Park	**0.024** (.024-.025)	**0.303** (.290-.310)	**0.493** (.400-.610)	**0.010** (.007-.015)	**7.60** --	**0.833** (.500-1.20)	**10.04** (9.91-10.1)	**2.27** (2.20-2.30)	**4.27** (2.40-8.00)	**1.93** (1.36-2.77)
Bell's Point	**0.030** (.030-.032)	**0.350** (.340-.370)	**0.290** (.200-.370)	**0.009** (.005-.014)	**7.54** (7.54-7.55)	**1.200** (1.10-1.40)	**9.80** (9.48-9.98)	**2.27** (2.20-2.30)	**5.87** (2.40-11.6)	**2.27** (2.12-2.53)
Echo Bay	**0.031** (.030-.032)	**0.133**[3] (.100-.180)	**0.560** (.300-.990)	**0.019** (.019-.021)	**7.16** (7.16-7.17)	**0.880** (.640-1.20)	**9.96** (9.87-10.1)	**6.85** (6.83-6.86)	**11.3** (10.0-12.4)	**16.23** (15.6-16.6)
Richards Landing	**0.031** (.030-.032)	**0.283** (.240-.360)	**0.213** (.200-.240)	**0.015** (.007-.026)	**7.47** (7.38-7.54)	**1.067** (1.00-1.10)	**9.86** (9.82-9.92)	**3.10** (3.00-3.30)	**4.40** (2.80-6.40)	**5.01** (4.82-5.21)
ST. MARYS RIVER	**0.029** (.024-.035)	**0.270** (.100-.370)	**0.399** (.200-.990)	**0.011** (.002-.026)	**7.46** (7.16-7.66)	**0.962** (.500-1.40)	**9.91** (9.48-10.1)	**3.42** (2.20-6.86)	**5.81** (2.40-12.4)	**5.31** (.940-16.6)
MDLs	0.01	0.1	0.2	0.001	--	0.5	0.2	0.4	0.8	0.1

[1]Mean values are in bold text

[2]Minimum and maximum values (min-max) are in parentheses

[3]Underlined numbers are calculations done with some values set to minimum detection limits (MDLs)

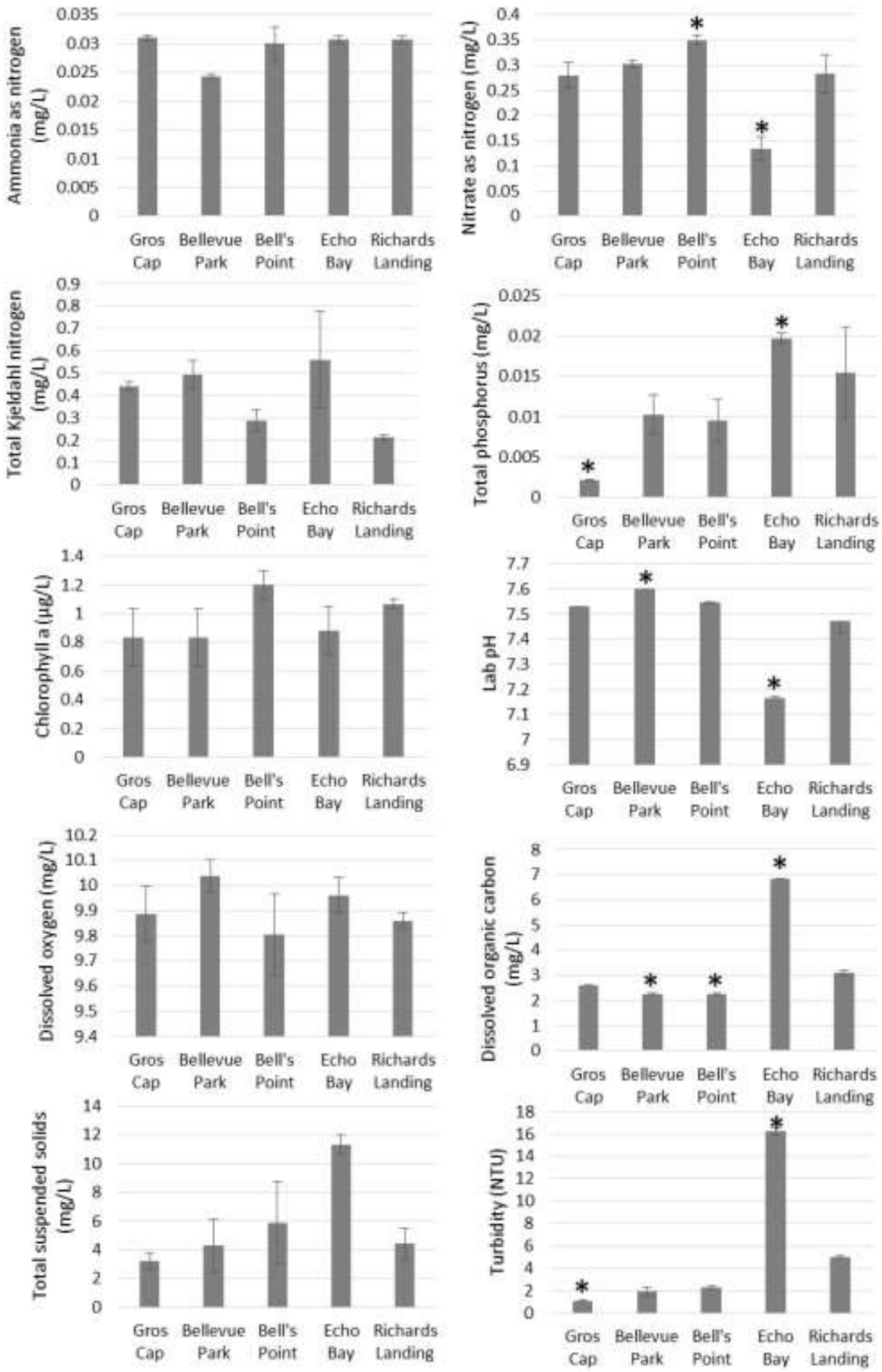

Figure 13: Graphs of analytical laboratory results

Graph bars represent mean values, error bars represent ± standard error and significantly different pairs are noted with * (Kruskal-Wallis, pairwise comparisons, p<0.05).

7. Discussion and Recommendations

Water Quality Parameters

Where possible, the water quality parameters measured for this project were compared to Ontario's Provincial Water Quality Objectives (PWQO) (MOE 1999). When not available, the results were compared to relevant standards from the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CWQG) (CCME 2007), the Guidelines for Canadian Recreational Water Quality (GRWQ) (Health Canada 2012), the Great Lakes Water Quality Agreement (GLWQA) (GLWQA 1987 & 2012), the St. Marys River Remedial Action Plans (RAP1 1992; RAP2 2002), and other applicable water quality directives and guidance documents.

An attempt was also made to compare the current project's results with data from previous studies. As the project moves along, it is expected that a more thorough literature review will be possible.

Nitrite as Nitrogen, Total Nitrogen and Un-ionized Ammonia

All of this project's results for nitrite as nitrogen, total nitrogen and un-ionized ammonia were below the minimum detection limits of the analytical tests performed. Since values of total nitrogen and un-ionized ammonia may benefit from acid-preservation of field water samples, it is recommended that those parameters, along with nitrite as nitrogen, continue to be measured in the next round of sampling. If the parameters' values remain below detection limits, it is recommended that their utility to this assessment be re-evaluated.

Secchi Depth

There is no PWQO for Secchi depth, however the PWQO for turbidity indicates that the natural Secchi disc reading for a water body should not change by greater than 10% (MOE 1999). In addition, the 2002 RAP suggests that embayment waters of the St. Marys River have a Secchi depth of greater than 1.2 m (RAP2 2002). This is in line with the GRWQ which give a 1.2 m minimum Secchi depth (Health Canada 2012).

Unfortunately during this sampling period it was not possible to get very accurate Secchi disc readings since measurements were done by wading at a depth of 50 cm. In all cases, except Echo Bay, the water was clear or very clear, and the Secchi disc visible, at the sampling depth of 50 cm. For Echo Bay, the Secchi depth was gauged to be 50 cm.

Although all sites, except Echo Bay, were deemed to have a Secchi depth of at least 50 cm, in this case it is difficult to interpret if the RAP criterion of greater than 1.2 m has been met. In addition, further measurements will be required to assess compliance with the PWQO.

Secchi depth measurements will not be meaningful if they cannot be accomplished at depths of greater than 50 cm. Since gaining information on the other project-relevant water quality parameters is successful by wading, it may not be worth using a boat for just one measurement, at least not for all scheduled sampling periods. In addition, the water clarity information gained by Secchi depth can also be obtained through visual water clarity determination and values for total suspended solids and turbidity.

Water Clarity

There is no PWQO for water clarity, however, as indicated in the previous section, standards for both Secchi depth and turbidity can be used to evaluate water clarity. In addition, the GRWQ have aesthetic objectives for water clarity which state that water should be sufficiently clear so that recreational users can estimate depth and see underwater hazards (Health Canada 2012).

For this sampling period, water clarity was determined to be clear (Figure 11), with the exception being the Echo Bay site where water was slightly turbid. When compared with the guidelines for water clarity, the Echo Bay site samples do not meet either the minimum Secchi depth standards (≥ 1.2 m) or the visual requirement for clear water (RAP2 2002; Health Canada 2012).

Water Colour

There is no PWQO for water colour, however the CWQG (CCME 2001) recognize water colour as impacting aquatic life and the GRWQ (Health Canada 2012) state that colour should not be so intense as to impede visibility in swimming areas. The 2002 RAP for the St. Marys River also states that AOC waters should be free of unnatural colour (RAP2 2002).

For this sampling period, visual water colour was clear for all sites with the exception of Echo Bay where water colour was light yellow or slightly discoloured (Figure 11). When compared with the guidelines for water colour, the Echo Bay samples are only lightly coloured so likely meet the GRWQ of having colour that does not impede visibility. However, it is up to further interpretation as to whether it is an "unnatural colour" which degrades aesthetics (RAP2 2002).

Water Odour

There is no specific PWQO for water odour, however the PWQO for oil and grease states that those substances should not be present in concentrations which can be detected by odour (MOE 1999). In addition, the 2002 RAP for the St. Marys River states that, in order to maintain good aesthetics, AOC waters should be free of unnatural odour (RAP2 2002). This is in line with the International Joint Commission de-listing guideline for degradation of aesthetics which states that waters must be free of unnatural odours (IJC 1991). The GRWQ also stipulate that waters should be free of offensive and objectionable odours (Health Canada 2012).

For this sampling period, odour was not detected at any of the sites, with the exception of Bellevue Park, where water samples had a faint sewage/fishy smell. When compared with the GRWQ, Bellevue Park does not meet the characteristics of being free of offensive and objectionable odours. The water samples from Bellevue Park also fail to meet the RAP and IJC requirement of having no unnatural odour, although a fishy smell could be deemed to be natural.

Visible Debris and Obvious Pollution

There is no PWQO for visible debris and obvious pollution, however there is one for oil and grease. This is relevant as oil and grease deposits have historically formed visible debris and obvious pollution in the St. Marys River AOC (RAP1 1992; RAP2 2002).

In terms of visible standards, the PWQO for oil and grease states that oil or petrochemicals should not be present in concentrations that can be detected as films, sheens or discolourations on the water's surface or that can form detectable deposits on shorelines and bottom sediments (MOE 1999). The 2002 RAP states that, in order to maintain good aesthetics, AOC waters should be devoid of objectionable deposits, including oil slicks, grease, surface scums, films, sheens, sludges, and oily fibrous material mixed with woody debris, on either surface waters, shorelines or bottom sediments (RAP2 2002).

The GRWQ also note that oil, grease and litter all contribute to degraded aesthetics and poor recreational conditions (Health Canada 2012). The GRWQ state that oil and grease should not be present in concentrations that can be detected as films or discolourations, and that recreational areas should be free from litter, including floating debris as well as materials that will settle and form objectionable deposits (Health Canada 2012).

For this sampling period, no visible debris or obvious pollution was noted at the Gros Cap or Richards Landing sites. Photographs of all of the sites appear in Figure 12. At Bellevue Park some human construction (timber, steel and concrete) was observed in the water. Natural type debris was noted at both Bell's Point and Echo Bay. In addition, while the Bell's Point shoreline showed evidence of aquatic plant growth, the Echo Bay site showed some signs of human encroachment in the form of anthropogenic litter.

When compared with the RAP and GRWQ, none of the sites had the types of oil and grease deposits or floating debris which have historically degraded aesthetics in the St. Marys River (RAP1 1992; RAP2 2002).

Algae

There is no PWQO specifically for algae, however its excessive growth, particularly as related to cultural eutrophication, is responsible for the eutrophication or undesirable algae BUI in the St. Marys River AOC (RAP1 1992; RAP2 2002). In order to consider delisting the BUI, no human-induced algal blooms would have to be detected. The GRWQ also recognize that large accumulations of algae degrade aesthetics through both their physical presence and odour (Health Canada 2012).

For this sampling period, algae was not observed at any of the sampling sites. Since it is so important to this project, it is suggested that, in future, the Field Technician record both the presence and absence of algae for each site.

Ammonia as Nitrogen

The PWQO for un-ionized ammonia (NH_3) is 20 µg/L (MOE 1999). When this value is converted to ammonia as nitrogen (NH_3-N), using a field water pH of 6.5 and a field water temperature of 8°C, the result is a guideline of 0.4 mg/L. This is similar to the total ammonia guideline stated in the GLWQA (1987) of 0.5 mg/L.

For this sampling period, mean values of ammonia as nitrogen, were fairly equal across all sites ranging from 0.024 mg/L (Bellevue Park) to 0.31 mg/L (Gros Cap, Echo Bay and Richards Landing). The overall spread of readings was from 0.024 to 0.032 mg/L, all of which fall below the PWQO of 0.4 mg/L.

This project's values compare well to recent measurements (Table 6) of total ammonia as nitrogen in wetland areas of the St. Marys River which are in proximity to this project's sampling sites (EC 2013). A decreasing trend in ammonia as nitrogen levels can be seen when the current values are compared to readings from the 1970s and 1980s (Hamdy et al 1978; RAP1, 1992).

Table 6: Comparison values for ammonia as nitrogen

Site	Total NH_3-N mg/L	Hamdy et al (1974)	EC (2013)	RAP1 (1989)	PWQO (1999)	GLWQA (1987)
Gros Cap	**0.031**[1] (.030-.032)[2]	0.01*	0.03[1]			
Bellevue Park	**0.024** (.024-.025)	0.25*				
Bell's Point	**0.030** (.030-.032)	0.17*		1.47-2.85[4]		
Echo Bay	**0.031** (.030-.032)		0.00[2] 0.03[3]			
Richards Landing	**0.031** (.030-.032)	0.09*				
ST. MARYS RIVER	**0.029** (.024-.032)				0.4 (pH 6.5 temp 8°C)	0.5

*Values given for sampling stations in closest proximity to current project sites
[1]Carpin Beach
[2]Echo Bay
[3]Lake George
[4]Downstream of East End Waste Water Treatment Plant

When interpreting the above results, it is important to be aware that water samples collected for ammonia as nitrogen analysis may benefit from acid-preservation, which was not done during this sampling period. It is hoped that additional sampling events, during which pre-acidified sampling bottles will be used, will help to determine whether environmental ammonia as nitrogen levels are being accurately reflected.

Nitrate as Nitrogen

There is no PWQO for nitrate as nitrogen (NO_3-N). However, the CWQG have a limit of 2.9 mg/L for nitrate as nitrogen (CCME 2007).

For this sampling period, mean values of nitrate as nitrogen ranged from 0.133 mg/L (Echo Bay) to 0.350 mg/L (Bell's Point) with levels being significantly higher at Bell's Point than at Echo Bay ($p<0.05$). The overall spread of readings was from 0.100 to 0.370 mg/L, all of which fall below the water quality guideline of 2.9 mg/L.

This project's values compare well to recent measurements (Table 7) of nitrate as nitrogen reported by the Sault Ste. Marie Regional Conservation Authority (SSMRCA) (SSMRCA 2010) and Environment Canada (EC 2013).

Table 7: Comparison values for nitrate as nitrogen

Site	NO_3-N mg/L	SSMRCA (1999-2005)	EC (2013)	CWQG (2007)
Gros Cap	**0.280** (.250-.330)	0.3[1] (0.3-0.4)	0.13[2]	
Bellevue Park	**0.303** (.290-.310)			
Bell's Point	**0.350** (.340-.370)			
Echo Bay	**0.133** (.100-.180)		0.15[3] 0.05[4]	
Richards Landing	**0.283** (.240-.360)			
ST. MARYS RIVER	**0.270** (.100-.370)			2.9

[1]Gros Cap municipal water intake
[2]Carpin Beach
[3]Echo Bay
[4]Lake George

When interpreting the results for nitrate as nitrogen, it is important to note that one of the values (Echo Bay: replicate 2) was set to minimum detection limits (0.1 mg/L) for the purposes of statistical analysis. It is hoped that additional sampling events will help to determine whether nitrate as nitrogen levels are very low or if sampling methodology may have been a factor.

Total Kjeldahl Nitrogen

There is no PWQO for total Kjeldahl nitrogen, therefore the Surface Water Quality Guidelines for Use in Alberta (SWQGA 1999) and CWQG (CCME 2012) were used to evaluate total Kjeldahl nitrogen levels. The SWQGA (1999) have a total nitrogen limit of 1 mg/L and the CWQG guidance document used (CCME 2012) states that the average total nitrogen level in global oligotrophic streams is <0.7 mg/L.

For this sampling period, mean values of total Kjeldahl nitrogen ranged from 0.213 mg/L (Richards Landing) to 0.560 mg/L (Echo Bay). The overall spread of readings was from 0.200 (Bell's Point and Richards Landing) to 0.990 mg/L (Echo Bay), all of which fall below the water quality guideline of 1 mg/L (SWQGA 1999). Only one reading (0.990 mg/L) was above the 0.7 mg/L limit suggested for oligotrophic streams, however it falls within the range for mesotrophic waters (0.7-1.5 mg/L) (CCME 2012).

This project's total Kjeldahl nitrogen values are in the range of mean measurements of total nitrogen for the St. Marys River of 0.412 mg/L (range: 0.262-0.668 mg/L) from the 1988 Upper Great Lakes Connecting Channels Study (UGLCCS) and 0.422 mg/L (range: 0.09-5.7 mg/L) for data collected from 1968 to 2005 at a station near the mouth of the Root River, which empties into the St. Marys River near Bell's Point (SSMRCA 2010).

When interpreting the current project's results for total Kjeldahl nitrogen, it is important to note that 2 replicates from the Richards Landing site (Richards Landing: replicates 2 and 3) and one from Bell's Point (Bell's Point: replicate 2) were set to minimum detection limits (0.2 mg/L) for the purposes of statistical analysis.

It is possible that some replicate values may have been artificially low as water samples collected for total Kjeldahl nitrogen analysis may benefit from acid-preservation, which was not done during this sampling period. It is hoped that additional sampling events, when pre-acidified bottles will be used, will help to determine whether total Kjeldahl nitrogen levels in the St. Marys River are being accurately reflected.

Total Phosphorus

The PWQO for total phosphorus in rivers and streams is 0.030 mg/L (MOE 1999) and the CWQG state that phosphorus concentrations in the range of 0.004-0.010 mg/L are typically found in oligotrophic waters (CCME 2004).

For this sampling period, mean values of total phosphorus ranged from 0.002 mg/L (Gros Cap) to 0.019 mg/L (Echo Bay) with levels being significantly lower at Gros Cap than at Echo Bay ($p<0.05$). The overall spread of readings was from 0.002 to 0.026 mg/L, all of which fall below the PWQO of 0.03 mg/L and are within the range for oligotrophic (0.004-0.010 mg/L) and mesotrophic (0.010-0.020 mg/L) freshwater environments (CCME 2004). Levels for eutrophic waters are >0.035 mg/L phosphorus (CCME 2004).

This project's values for total phosphorus are in the range of mean measurements (Table 8) for the St. Marys River of 0.011 mg/L (Hamdy et al 1978) and 0.013 mg/L (UGLCCS 1988). Mean values for Gros Cap of 0.002 mg/L (this project) and 0.005 mg/L (SSMRCA 2010) are also comparable. Differences in readings downstream of the East End Waste Water Treatment Plant, of 0.009 mg/L from this project versus 0.051 mg/L (UGLCCS 1988) and 0.031 (SSMRCA 2010) taken previously, suggest that reductions in phosphorus concentrations entering the St. Marys River have occurred.

Table 8: Comparison values for total phosphorus

Site	Total P mg/L	Hamdy et al (1973-1974)	UGLCCS (1988)	SSMRCA (1968-2005)	PWQO (1999)	CWQG (2007)
Gros Cap	**0.002** --			0.005[2] (0.002-0.020)		
Bellevue Park	**0.010** (.007-.015)	0.04*				
Bell's Point	**0.009** (.005-.014)		0.051[1]	0.031[3] (0.003-0.71)		
Echo Bay	**0.019** (.019-.021)					
Richards Landing	**0.015** (.007-.026)					
ST. MARYS RIVER	**0.011** (.002-.026)	0.011	0.013 (0.002-0.051)		0.03	0.004-0.01

*Values given for sampling stations in closest proximity to current project sites
[1]Downstream of East End Waste Water Treatment Plant
[2]Gros Cap municipal water intake
[3]Near mouth of Root River

When interpreting the results for total phosphorus, it is important to recognize that field methods and hold times may have influenced the values. Water samples collected for total phosphorus analysis may benefit from acid-preservation, which was not done during this sampling period. In addition, it took 2-3 days for water bottles (depending on the sampling date) to reach the analytical laboratory. Testmark Laboratories suggest that total phosphorus analysis be done as soon as possible.

It is hoped that additional sampling events, when pre-acidified bottles will be used and hold times reduced, will help to determine whether environmental total phosphorus levels are being accurately reflected.

Chlorophyll a

There is no PWQO for chlorophyll a. However the 2002 RAP for the St. Marys River suggests that a chlorophyll a concentration of less than 10 µg/L would represent conditions in which excessive amounts of undesirable algae were not present (RAP2 2002).

During this sampling period, mean values of chlorophyll a ranged from 0.833 µg/L (Gros Cap and Bellevue Park) to 1.200 µg/L (Bell's Point). The overall spread of readings was from 0.500 to 1.40 µg/L, all of which fall below the RAP recommendation of less than 10 µg/L (RAP2 2002).

This project's values for chlorophyll a are in the range of mean measurements for the St. Marys River of 1.0 µg/L (Hamdy et al 1978) and 0.88 µg/L (RAP1 1992), in addition to being well within the 0.3-3.0 µg/L range reported as being typical of oligotrophic waters (RAP1 1992).

When interpreting the chlorophyll a results, it is important to note that two replicates, one from Gros Cap (Gros Cap: replicate 1) and another from Bellevue Park (Bellevue Park: replicate 3), were set to minimum detection limits of 0.5 µg/L for the purposes of statistical analysis.

Chlorophyll a concentrations may have been low because recommended hold times were exceeded for this sampling period. Testmark Laboratories suggest that chlorophyll a analysis be done within 2 days. For this sampling period, it took 2-3 days for water bottles (depending on the sampling date) to reach the analytical laboratory.

It is hoped that additional sampling events, when hold times will be reduced, will help to determine whether environmental chlorophyll a levels are being accurately reflected.

pH

The PWQO for pH is 6.5-8.5 (MOE 1999). This compares to the GLWQA and CWQG recommendation of 6.5-9.0 (GLWQA 2012; CCME 2007).

For this sampling period, mean lab pH values ranged from 7.16 (Echo Bay) to 7.60 (Bellevue Park), which was the same range as the minimum and maximum values. When comparing sampling sites (Figure 12), the pH levels were significantly higher at Bell's Point than at Echo Bay ($p<0.05$).

Field pH was taken directly in the water on sampling day, with pH test strips, and all sites had values of 6.0-6.5. Laboratory and field water pH readings are expected to be different because pH is temperature-dependent and laboratory analytical methods are more accurate than pH test strips.

With the exception of any field readings which were closer to 6.0 than 6.5, all pH values fell within the PWQO of 6.5-8.5

This project's pH values are in the range of measurements (Table 9) of 7-8 (UGLCCS 1988) and 7.33-8.47 (EC 2013) previously recorded for the St. Marys River.

Table 9: Comparison values for pH

Site	Lab pH	Field PH	UGLCCS (1988)	EC (2013)	PWQO (1999)	CWQG (2007)	GLWQA (2012)
Gros Cap	**7.53** --	6.0-6.5		7.33[1]			
Bellevue Park	**7.60** --	6.0-6.5					
Bell's Point	**7.54** (7.54-7.55)	6.0-6.5					
Echo Bay	**7.16** (7.16-7.17)	6.0-6.5		8.46[2] 7.82[3]			
Richards Landing	**7.47** (7.38-7.54)	6.0-6.5		8.47[4]			
ST. MARYS RIVER	**7.46** (7.16-7.60)	6.0-6.5	7-8		6.5-8.5	6.5-9.0	6.5-9.0

[1]Carpin Beach
[2]Echo Bay
[3]Lake George
[4]Findlay Point

Dissolved Oxygen

The PWQO for dissolved oxygen is > 8 mg/L (MOE 1999). This compares to the GLWQA guideline of > 6 mg/L (GLWQA 1987) and CWQG benchmark of > 5.5-9.5 mg/L (CCME 2007).

For this sampling period, mean dissolved oxygen values ranged from 9.80 mg/L (Bell's Point) to 10.04 mg/L (Bellevue Park), with a range of values from 9.48 mg/L (Bell's Point) to 10.1 mg/L (Bellevue Park). All measurements exceeded the PWQO and met the CWQG guideline of 9.5 mg/L for sensitive early life stages of cold water biota (CCME 2007).

This project's dissolved oxygen values are in the range of measurements taken at similar sites within the St. Marys River from 2009 to 2010 (Table 10) and reported by Milani (2012). In that study, dissolved oxygen levels in the Bellevue Park area varied from 10.1-10.4 mg/L and those in the Lake George Channel ranged from 10.0-10.4 mg/L (Milani 20120).

Table 10: Comparison values for dissolved oxygen

Site	Dissolved Oxygen mg/L	UGLCCS (1988)	Milani (2012)	PWQO (1999)	CWQG (2007)	GLWQA (2012)
Gros Cap	**9.89** (9.75-10.1)					
Bellevue Park	**10.04** (9.91-10.1)		10.1-10.4*			
Bell's Point	**9.80** (9.48-9.98)		10.0-10.4*			
Echo Bay	**9.96** (9.87-10.1)					
Richards Landing	**9.86** (9.82-9.92)					
ST. MARYS RIVER	**9.91** (9.48-10.1)	>5.0		>8.0	>5.5-9.5	>6.0

*Value given for sampling station in closest proximity to current project site

Although the dissolved oxygen readings obtained during this project's preliminary sampling are in the range of what is expected, it is worth considering the influence of hold time on their analysis. Testmark Laboratories recommend that samples for dissolved oxygen analysis be submitted as soon as possible.

During at least one future field sampling event it is suggested that a hand-held dissolved oxygen meter be borrowed in order to compare dissolved oxygen measurements *in situ* to those completed in the laboratory.

Dissolved Organic Carbon

There is no PWQO or other relevant guideline available for dissolved organic carbon.

For this sampling period, mean dissolved organic carbon values ranged from 2.27 mg/L (Bellevue Park and Bell's Point) to 6.85 mg/L (Echo Bay) with both Bellevue Park and Bell's Point having significantly lover dissolved organic carbon concentrations than Echo Bay ($p<0.05$).

Overall, the values ranged from 2.20 mg/L (Bellevue Park and Bell's Point) to 6.86 mg/L (Echo Bay). This is comparable to other values for dissolved organic carbon of 3.4 mg/L to 10.6 mg/L recorded in Ontario streams (Eimers et al 2008).

No historical data was found on dissolved organic carbon values in the St. Marys River. Therefore, this project could make a contribution to that gap in knowledge. Further literature searches are required to obtain additional relevant comparable data for dissolved organic carbon.

When interpreting the results for dissolved organic carbon, it is prudent to note that samples for dissolved organic carbon analysis may be influenced by hold times. It is hoped that additional sampling events, with decreased hold times, will help to determine whether this project is accurately assessing dissolved organic carbon concentrations.

Total Suspended Solids

There is no PWQO for total suspended solids. The CWQG for total particulate matter (CCME 2002) provide limits for increases in suspended sediments. They state that maximum increases should not exceed 25 mg/L over the short-term (24 hours) and mean maximum increases should not exceed 5 mg/L in the long-term (1-30 days) (CCME 2002). Information from the Michigan State Government (2013) indicates that waters with total suspended solids of less than 20 mg/L are generally considered clear, 40 to 80 mg/L deemed cloudy, and greater than 150 mg/L described as dirty.

For this sampling period, mean total suspended solids values ranged from 3.20 mg/L (Gros Cap) to 11.3 mg/L (Echo Bay), with a spread of values from 2.20 mg/L (Gros Cap, Bellevue Park and Bell's Point) to 12.4 mg/L (Echo Bay). Until further sampling is done it will not be possible to determine if increases have exceeded CWQG values. All values were less than 20 mg/L so can be considered to be clear (Michigan State Government 2013).

No historical data was found on total suspended solids values in the St. Marys River surface waters. Therefore, this project could add to the body of knowledge on that case. Further literature searches are required to obtain relevant comparable data about total suspended solids levels found in similar environments.

Turbidity

The PWQO for turbidity state that suspended matter should not be added to surface waters in concentrations that will change the natural Secchi depth reading by more than 10% (MOE 1999). The CWQG state that maximum increases over the short-term (24 hours) should not exceed 8 NTU (Nephelometric Turbidity Unit) and, in the long-term (1-30 days), mean increases should not exceed 2 NTU (CCME 2002). The GRWQ state that, to satisfy most recreational uses, turbidity should not exceed 50 NTU (Health Canada 2012).

For this sampling period, mean turbidity values ranged from 1.09 NTU (Gros Cap) to 16.23 NTU (Echo Bay), with levels being significantly lower at Gros Cap than at Echo Bay ($p<0.05$). The range of values for turbidity was from 0.940 NTU (Gros Cap) to 16.6 NTU (Echo Bay). Until further sampling is done it will not be possible to determine if increases have exceeded the PWQO or CWQG. The values are all below the 50 NTU recreational aesthetics guideline (Health Canada 2012).

This project's values for turbidity are somewhat different (Table 11) from those collected by a recent Environment Canada study of coastal wetlands in the St. Marys River AOC (EC 2013). In some cases this project's readings are lower and in the others they are higher. This is likely due to site differences and the fact that readings were taken at different times of the year.

Table 11: Comparison values for turbidity

Site	**Turbidity** NTU	**EC (2013)**	**PWQO (1999)**	**CWQG (2007)**	**GRWQ (2012)**
Gros Cap	**1.09** (.940-1.28)	6.3[1]			
Bellevue Park	**1.93** (1.36-2.77)				
Bell's Point	**2.27** (2.12-2.53)				
Echo Bay	**16.23** (15.6-16.6)	4.5[2] 50.6[3]			
Richards Landing	**5.01** (4.82-5.21)	2.3[4]			
ST. MARYS RIVER	**5.31** (.940-16.6)		Maximum Secchi disc change 10%	Mean increase of 2 NTU	≤50 NTU

[1]Carpin Beach
[2]Echo Bay
[3]Lake George
[4]Findlay Point

When interpreting this round of results for turbidity, it is important to note that sample hold times may influence analytical values. For this sampling period, it took 2-3 days for water bottles (depending on the sampling date) to reach the analytical laboratory. Testmark Laboratories suggest that turbidity analysis be done within 1 day.

For future field sampling events, sample hold times will be reduced as much as possible, however it is probably not feasible to ship on the same day as collection, which would be necessary to get the water samples to the laboratory within 1 day. It is suggested that the project team look into the possibility of performing turbidity measurements in the field.

Site Characteristics Summary

Each of the five sampling sites was characterized by a unique set of physical and chemical parameters which should be considered when analyzing the data and making conclusions.

Gros Cap

Gros Cap, at the mouth of the St. Marys River, had the highest ammonia as nitrogen levels and the lowest total phosphorus, chlorophyll a, total suspended solids and turbidity. This is not surprising as it is expected that waters entering the St. Marys River from Lake Superior would be low in nutrients, algal growth and suspended particles as well as having nitrogen in the form of ammonia.

Bellevue Park

Bellevue Park had the highest pH and dissolved oxygen levels as well as the lowest ammonia, chlorophyll a and dissolved organic carbon. It was also the only site where water odour was noted. Since waters are fast-flowing around Bellevue Park, it is not surprising to find higher dissolved oxygen levels and lower levels of nutrients.

Bell's Point

Bell's Point had the highest nitrate as nitrogen and chlorophyll a levels as well as the lowest dissolved oxygen and dissolved organic carbon. It was also the site where aquatic vegetation was observed at the shoreline. It is not surprising to find higher nutrient and lower dissolved oxygen levels at Bell's Point as it is downstream from the East End Waste Water Treatment Plant. However, although chlorophyll levels were highest here, there were no algae observed and the site does not currently stand out as being eutrophic.

Echo Bay

Echo Bay was distinguished in many ways from the other 4 sampling sites. It was statistically significantly different than at least one other site for: nitrate as nitrogen, total phosphorus, dissolved organic carbon, pH and turbidity. Echo Bay had the highest levels of total Kjeldahl nitrogen, total phosphorus, dissolved organic carbon, total suspended solids and turbidity, and the lowest nitrate as nitrogen and pH. Water samples also appeared turbid and lightly-coloured.

Richards Landing

Richards Landing, at the downstream end of the St. Marys River, had the lowest total Kjeldahl nitrogen levels as well as comparable ammonia as nitrogen, nitrate as nitrogen, dissolved oxygen, dissolved organic carbon, pH, total suspended solids and turbidity readings to the most upstream site at Gros Cap. The physical and chemical characteristics of the Richards Landing site suggest that waters entering the St. Marys River AOC are relatively similar to those exiting it.

Sampling Site Review

The sampling sites selected in Year 1 worked well for preliminary sampling and analysis and the project will likely proceed very successfully if the same sites are used throughout.

Analytical Laboratory and Quality Controls

The analytical results received from Testmark Laboratories were well done and it is suggested that the same laboratory be used during project Years 2-3.

In addition to having other quality control protocols, when Testmark performs any analysis they randomly complete duplicate testing for every 20 samples analyzed (Table 12).

Table 12: Laboratory quality control

Parameter	Measurement[1]	Duplicate	Site: replicate
Ammonia as nitrogen (mg/L)	0.03	0.03	Echo Bay: replicate 3
Total Kjeldahl nitrogen (mg/L)	0.24	0.27	Richards Landing: replicate 1
Dissolved organic carbon (mg/L)	3.3	3.4	Richards Landing: replicate 3
Turbidity NTU	1.28	1.05	Gros Cap: replicate 1

[1]Measurement values were those used in the results analysis for this report, duplicates were excluded

At this time, there are no protocols in place for field-level quality controls. Unlike the laboratory controls, field sample controls would involve an additional cost. However, it is suggested that some type of field quality control program be devised.

8. Conclusions

Beneficial Use Impairments

Although there is very little data with which to draw conclusions at present, preliminary results indicate that the BUIs (1) eutrophication or undesirable algae and (2) degradation of aesthetics, show little to no impairment, within the sites selected and during the times investigated, in the Canadian St. Marys River AOC.

Eutrophication or Undesirable Algae

In general nitrogen and phosphorus levels were low for all sites investigated, falling within concentrations typically seen in oligotrophic waters. The one exception was an Echo Bay water sample which had a total nitrogen concentration of 0.990 mg/L which falls outside the range for oligotrophic (< 0.7 mg/L) waters and into the mesotrophic (0.7-1.5 mg/L). All phosphorus concentrations measured were of a concentration indicative of ultra-oligotrophic waters (< 4 mg/L). Given the fact that the primary nutrients responsible for algal blooms were found in low amounts, the majority at concentrations typical of oligotrophic waters, and the complete absence of observed algae, it can be concluded that, for this sampling period, the sites surveyed did not show evidence of eutrophication or undesirable algae.

Degradation of Aesthetics

Based on the water quality parameters selected and evaluation methods used, the Gros Cap, Bell's Point and Richards Landing sites showed no impairment of aesthetics. The Bellevue Park site was also unimpaired except in relation to water odour which was faintly objectionable. By contrast, the Echo Bay sampling site showed some aesthetics impairments in terms of reduced water clarity and the presence of a faint water colour.

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Appendix 1: Project Work Plan

Project Work Plan: Water Quality Sampling and Analysis for the St. Marys River Area of Concern (Beneficial Use Impairment Assessment)

Introduction

This work plan contains the procedures and protocols for the field team to follow while carrying out the Water Quality Sampling and Analysis for the St. Marys River Area of Concern (Beneficial Use Impairment Assessment) project. It is intended that the plan be followed in detail to ensure that the field observations, field measurements, analytical laboratory results, and data presented, are indicative of environmental conditions in the Area of Concern (AOC) and will aid in decision-making related to this project.

Plan Review

The plan should be reviewed at least on an annual basis, in Years 2 and 3 of the project, and any alterations made with feedback from the field team, their supervisors and stakeholders.

Field Work Schedule

Field work involving observations, measurements, and water sample collection, will take place during each year of the project. Table 2 summarizes the field work already done in Year 1 and sets up the proposed work schedule through project Years 2-3.

Table 1: Project field work schedule

	# sites	Month (# of field days)	# replicates per site
Year 1 2013	5	November (1)	3 replicates/site
Year 2 2014	5	April (1) May (2) June (2) July (2) August (2) September (2) October (1)	3 replicates/site
Year 3 2015	5	April (1) May (2) June (2) July (2) August (2) September (2) October (1)	3 replicates for 1 site only 1 sample taken at all other sites

Field Sites

For this project, 5 field sites were selected within the Canadian St. Marys River AOC. The GPS co-ordinates of the 5 sites: Gros Cap, Bellevue Park, Bell's Point, Echo Bay and Richards Landing are below in Table 2. Short-forms to be used for each sampling site are shown in parentheses.

Table 2: GPS co-ordinates of field sites

Gros Cap (GCL)	N 46°31.711' W 084°35.159'
Bellevue Park (TSI)	N 46°29.708' W 084°17.824'
Bell's Point (BPC)	N 46°32.281' W 084°13.047'
Echo Bay (EBB)	N 46°29.627' W 084°04.693'
Richards Landing (RLP)	N 46°17.569' W 084°02.426'

Assessment Parameters

The water quality assessment parameters selected for this project are designed to provide relevant information for stakeholders considering the delisting of Beneficial Use Impairments (BUIs): (1) Eutrophication or Undesirable Algae and (2) Degradation of Aesthetics, within the Canadian St. Marys River AOC.

The following **aesthetics data** and **field measurements** will be collected:

- Water Clarity
- Water Colour
- Water Odour
- Visible Debris/Obvious Pollution/Algae/Other Deposits
- Field Water pH
- Air and Water Temperature
- Secchi Disc Depth
- Sampling Water Depth

The following parameters will be obtained through **laboratory analysis** of field water samples:

- Ammonia as Nitrogen and Un-ionized Ammonia
- Anions (Nitrate as Nitrogen and Nitrate as Nitrogen)
- Total Kjeldahl Nitrogen and Total Nitrogen
- Total Phosphorus
- Chlorophyll a
- pH
- Dissolved Oxygen
- Dissolved Organic Carbon
- Total Suspended Solids
- Turbidity

Field Equipment

Care and proper use of field equipment is integral to the success of this project. Before all field work, equipment is to be inspected and any problems dealt with immediately. After field work, equipment is to be re-inspected and cleaned as per the manufacturer's instructions. This may involve rinsing in warm tap water and using a mild laboratory detergent.

In the field, equipment will be rinsed with fresh river water or with a clean bottle of de-ionized water, as appropriate.

Between field work days, all equipment will be clearly labelled and stored in a secure location, in a manner according to the manufacturer's instructions.

A list of the equipment to be taken into the field is given below in Table 3.

Table 3: Checklist of field work equipment

Field equipment:	Check
White paper (for water clarity and colour determination)	
Water collection bottles (6 bottles x 3 replicates = 18/site)	
Coolers with icepacks	
Laboratory gloves	
Camera	
GPS unit	
Back-up batteries	
Thermometer	
pH meter and/or pH test strips	
Wash bottle with clean laboratory grade water (e.g. Milli-Q)	
Secchi disc	
Metre stick	
Field data sheets and clipboard	
Pencils, pens and sharpies	
Labelling tape	
Re-sealable plastic bags (e.g. Ziploc)	
Watch (or other time telling device)	
Paper towels	
Information sheets (e.g. instructions for sample bottles types)	
Rubbermaid container	
Small inflatable boat	

Field Data Collection

Field data will be collected by the field team according to the schedule and for the parameters designated in this work plan. At each field site, the field team will fill out the field data sheet shown in Figure 1 below. This project's data collection sheet was modeled on the Michigan Department of Environmental Quality's 2011 Statewide Aesthetics Assessment Workplan and Monitoring Protocol's Aesthetics Monitoring Data Sheet (MQEQ 2011).

Figure 1: Field Data Sheet

FIELD DATA SHEET: Aesthetics Monitoring and Field Measurements

Area of Concern: St. Mary's River **Site Description:** ______________________

Field Team: ______________________

Date: ____________ **Start Time:** ____________ **End Time:** ____________

GPS: ______________________ **Elevation:** ____________

Weather (check all that apply): Rain Today ☐ Clear ☐ Windy ☐

Air temp.: ________ °C Rain Yesterday ☐ Cloudy ☐ Other ____________

<u>**WATER CLARITY**</u> (pick one)
Clear ☐
Slightly Turbid ☐
Moderately Turbid ☐
Highly Turbid ☐
Opaque ☐

<u>**WATER COLOUR**</u> (pick one colour and one qualifier)
Clear ☐ Brown ☐ Green ☐ Yellow ☐
Grey ☐ Black ☐ Milky-White ☐ Other ________

<u>**VISIBLE DEBRIS/OBVIOUS POLLUTION**</u> (pick all applicable)
None ☐ Natural ☐ (leaves, limbs, weeds)
Algae ☐ Film ☐ Sheen ☐ Oil ☐ Grease ☐
Trash:
Floating ☐ Fixed ☐ None ☐
Solids:
Floating ☐ Fixed ☐ None ☐
Scum:
Floating ☐ None ☐

<u>**ODOUR**</u> (pick all applicable)
None/Natural ☐
Musty:
Faint ☐ Strong ☐ None ☐
Sewage/Fishy:
Faint ☐ Strong ☐ None ☐
Anaerobic/Septic:
Faint ☐ Strong ☐ None ☐

Other Deposits: ______________________

Comments: ______________________

____

Substrate type: ______________________

Water pH: ____________ **Water temperature:** ____________ °C

Secchi depth: (1) ______ (2) ______ Avg. ______ **Water depth:** ____________

Sample collection (check once sample has been collected) **Number of replicates:** ________

Ammonia ☐ Anions (NO_2, NO_3) ☐ Chlorophyll a ☐ Dissolved O_2 ☐ Dissolved Organic Carbon ☐
pH ☐ Total Kjeldahl Nitrogen ☐ Total Phosphorus ☐ Total Suspended Solids ☐ Turbidity ☐

Comments: ______________________

____

FIELD PHOTO LOG

At minimum <u>the following photographs will be taken</u>:

1. Upstream of the monitoring site
2. Downstream of the monitoring site
3. Perpendicular to the shoreline
4. Three full sample jars against a white backdrop
5. Close-up looking directly into the water
6. Any other items of interest (algae, oil sheens, scum, foam, debris etc.)

Photograph ID	Subject/Comments

The field data collection protocols detailed below are based on best practices and procedures contained in the Michigan Department of Environmental Quality's 2011 Statewide Aesthetics Assessment Workplan and Monitoring Protocol (MQEQ 2011) and the Protocols Manual for Water Quality Sampling in Canada (CCME 2011).

General Field Site information

The site description entered into the field data sheet will include the full name and designated short-form for each sampling site, for example: Gros Cap (GCL). All field team members present will be identified by name. The full date as well as the start and end times of work at each site will be recorded. The Global Positioning System (GPS) co-ordinates and site elevation will be taken using a hand-held GPS unit.

Weather will be recorded using the descriptors available, while noting additional details such as "*very* windy", "*heavy* rain", "foggy" or "humid" in the "Other" section.

Air temperature (°C) will be taken with a digital thermometer. This will be done before water temperature measurements are made to avoid water droplet evaporation from the probe influencing air temperature readings.

Water Clarity, Colour and Odour

For water clarity, colour and odour, the three replicates of the 500 mL clear PET plastic bottles containing river water sampled for laboratory analysis of anions, pH and turbidity will be used (see water sample collection methods following). It is important to use these particular bottles as it will not be a significant problem if some water is spilled during the odour analysis, when the bottle caps will need to be briefly removed. It is important that the 500 mL PET bottles used for dissolved oxygen and total suspended solids analysis remain capped after sampling.

If three replicates are not available, as is the plan for Year 3, clarity and colour analysis may be performed with all three 500 mL clear PET plastic bottles used for (1) anions, pH, turbidity, (2) dissolved oxygen and (3) total suspended solids. However, odor analysis will have to be performed on the anions, pH and turbidity bottle ONLY. This change in protocol should be noted on the field data sheet.

The sample jars used should only be taken out of their storage coolers for the duration of the water clarity, colour and odour determination and then returned promptly. All samples bottles are to be handled carefully with gloves and kept clean. Photographs of water colour and clarity should be taken and their identity recorded in the field photo log (Figure 1).

For water **clarity** and **colour** determination, hold each sample jar against a white backdrop (e.g. white paper), in the shade (if possible) and pick the appropriate descriptor. For water clarity one descriptor is chosen from the following: clear, slightly turbid, moderately turbid, highly turbid or opaque. For water colour, one colour is chosen from the following: clear, brown, green, yellow, grey, black, milky-white or other, as well as one qualifier: light, medium or dark. Any additional clarity or colour observations should be recorded in the "Comments" section.

To determine **odour**, carefully remove the lid from each designated sample jar and mark all that are applicable from the following: none/natural, musty (faint, strong, none), sewage/fishy (faint, strong, none) and/or anaerobic/septic (faint, strong, none). Any additional odours, particularly those that are unnatural, should be recorded in the "Comments" section. As soon as the odour is smelled, the lid should be place back on the sample jar to avoid spilling and contamination.

Visible Debris/Obvious Pollution/Algae/Other Deposits
When arriving at the field site, carefully observe the surface waters and water column in order to record any visible debris or obvious pollution. Of particular interest to this project is the presence/absence of any algae, films, sheens, oil and/or grease. Indicate the presence of any of these conditions, including the following: trash (floating, fixed, none), solids (floating, fixed, none), and/or scum (floating, fixed, none). Any additional observations should be included in the “Other Deposits” and “Comments” sections.

Substrate Type
Generally describe the substrate of the field site, taking special care to note the substrate in the area where the water samples are being collected. Descriptors could include: rocky, pebbles, sandy, silty, clay. Any unnatural substrates (e.g. concrete) should also be recorded.

Water pH
Field water pH will be taken either with a waterproof hand-held pH meter or using pH test strips. Both types of measurements will be taken directly in the river water at the site of water sample collection (not in one of the sample bottles). It is important to accurately record field pH because this information will be submitted to the analytical laboratory and used to inform subsequent analyses.

If a pH meter is used, it is to be calibrated, as per the manufacturer’s instructions, usually with 3 standard buffer solutions, before each field day. After each field site measurement, the pH meter is to be rinsed with de-ionized water, dried and put back into its case for transport. At the end of each sampling day, the pH meter will be cleaned, dried, and then recapped and stored as per the manufacturer’s instructions. It is important to store the pH meter’s electrode in the recommended solution so that it continues to function and does not need to be prematurely replaced. Other care and maintenance instructions recommended by the user manual for the specific pH meter should also be followed.

Water Temperature
Field water temperature will be taken with a waterproof digital thermometer immersed directly into the river water at the site of water sample collection. It is important to accurately record field pH because this information will also be submitted to the analytical laboratory.

The thermometer is to be rinsed with de-ionized water, dried and put back into its case after each measurement. At the end of each sampling day, the thermometer will be cleaned with laboratory detergent, dried and then recapped and stored.

Secchi Depth
A Secchi disc will be used to provide a visual measure of water clarity in the water column. Measurements will be taken in the river at the site of water sample collection. Sunglasses should not be worn by the observer. The higher the Secchi disc reading, the greater the water clarity. Ideally measurements are taken from a boat, in a shady location and at mid-day.

To determine the Secchi depth, slowly lower the Secchi disc into the water until it disappears from sight. Note this as depth # 1. Next, lower the Secchi disc down a further 1 m before slowly raising it up until it is visible again. Note this as depth # 2. Record the Secchi depth reading as the average of the two depths.

Water Depth
Wading water depth, where the water samples are taken, will be measured by the field technician with a metre stick.

Comments
Any unusual sights, events or deviations from standard protocols, should be added as additional observations in the "Comments" section.

Photographs
The overall conditions of each field site will be recorded with a digital camera to visually capture both unnatural and natural features. In particular any conditions relating to the Beneficial Use Impairments: (1) Eutrophication or Undesirable Algae and (2) Degradation of Aesthetics, are to be photographed.

At minimum the following photographs will be taken:
1. Upstream of the monitoring site
2. Downstream of the monitoring site
3. Perpendicular to the shoreline
4. Three full sample jars against a white backdrop
5. Close-up looking directly into the water
6. Any other items of interest (algae, oil sheens, scum, foam, debris etc.)

Field photographs are to be recorded on the field photo log located on the back of the field data sheet (Figure 1). The photographs are to be removed from the camera in a timely manner and saved into digital folders which will be backed-up regularly with all project files.

Water Sample Collection and Preservation

The water samples collected at each field site will be processed using the best practices detailed below. The following protocols are informed by instructions from the analytical laboratory being used for this project, Testmark Laboratories Ltd., and the Protocols Manual for Water Quality Sampling in Canada (CCME 2011).

Sampling Bottles

Water sampling bottles used for the project will be supplied by Testmark Laboratories. During storage, the bottles should be kept capped at all times. It is not necessary to pre-clean them. Particular care should be taken with selected bottles which have been pre-acidified for sample preservation. Sampling bottles may be stored in clean coolers, which will also act as their shipping containers.

The appropriate bottle to be used for each parameter analysis, the minimum volume of water required per analysis, the preservation method (if applicable), and the minimum recommended hold time for water samples is shown in Table 4. This information should be taken into the field in a waterproof format.

Table 4: Sampling bottles, minimum collection volumes, preservation methods and minimum hold times for each analysis

Parameter(s)	Sample Bottle	Minimum Volume	Preservation	Minimum Hold Time
Chlorophyll a	1 L amber glass	1 L	Field filtration with 0.45µm glass filter	2 days
Dissolved Oxygen	500 mL PET[1]	500 mL, no headspace	NONE	ASAP
Total Suspended Solids	500 mL PET	500 mL	NONE	7 days
pH Anions (NO_2, NO_3) Turbidity	500 mL PET	30 mL 10 mL 50 mL	NONE	14 days 5 days 1 day
Ammonia Total Phosphorus Total Kjeldahl Nitrogen	125 mL HDPE[2]	20 mL 25 mL 10 mL	Pre-acidified bottle with H_2SO_4 to pH<2	7 days ASAP 7 days
Dissolved Organic Carbon	125 mL HDPE	50 mL	Field filtration with 0.45µm glass filter then acidified with H_3PO_4 to pH<2	7 days

[1] Polyethylene terephthalate (PET) plastic
[2] High-density polyethylene (HDPE) plastic

General Sampling Methods
Water samples collected for this project will be grab-sampled by the field technician while wading in the river. All safety precautions for sampling while wading, as detailed in the Worker Safety and Emergency Response plan, will be followed. This includes having a field team of a minimum of two people: one field technician who enters the water to do the sampling and one field supervisor who stays on shore and can act in case of emergency

After checking for safety hazards, the field technician will enter the river at each site and wade straight out from shore to a depth of 50 cm. In an effort to minimize travel between the shore and the sampling site (which could potentially influence measurements) the water sampling equipment will be carried with the field technician in a small inflatable boat.

Grab Sampling
The water samples will be collected with the field technician facing upstream, into the current. All site replicates for one analysis will be collected in sequence, before moving on to the next parameter. The same sequence should be followed for each field site.

Wearing disposable laboratory gloves, the field technician will carefully remove the lid from each bottle and hold it without touching the inside surface. Then the bottle will be grasped below the neck and plunged under the water's surface in front of the field technician. The bottle will immediately be oriented upstream, into the current. Once the bottle is full, it will be removed from the water by forcing it forwards (into the current) and upwards. The field technician will avoid collecting surface scum and/or films. The grab-sampling method is depicted in Figure 2.

Figure 2: Grab-sampling method (source: CCME 2011)

It is <u>important</u> that the <u>minimum volume</u> of water required for each analysis, as shown in Table 4, is collected. For this project, it is assumed that water flow will not be an issue and all sample bottles will be filled to capacity. Specific instructions for each type of analysis are in the sections following.

After all water samples have been collected, the field technician will note this on the field data sheet, by checking off each analysis type. Any deviations from standard protocols will be recorded in the "Comments" section.

All bottles should be clearly labelled with the date, time, field site, replicate number, analysis/analyses requested and any preservation methods (e.g. acidification, filtration).

Chlorophyll a
Water samples for chlorophyll a analysis will be collected in 1 litre amber glass bottles. It is particularly important that these samples be stored in a dark, as well as cool environment. Since these are the only glass bottles being used, they should also be treated with special care when being packed and shipped, giving them the most cushioning by placing the plastic bottles around them. The success of the chlorophyll analysis may be increased by field filtering and then freezing the filter and submitting that for laboratory analysis, instead of the water sample itself. However, this might not be feasible for this project.

Dissolved Oxygen
Water samples for dissolved oxygen analysis will be collected in 500 mL clear PET plastic bottles. To accurately measure field dissolved oxygen, NO HEADSPACE (air) must be left in the bottles. In this case, the bottle should be capped while still under water and checked visually for air bubbles.

Total Suspended Solids
Water samples for total suspended solids analysis will be collected in 500 mL clear PET plastic bottles. The minimum volume for laboratory analysis is the full 500 mL so it should be filled with special care.

pH, Anions and Turbidity
Water samples for pH, anions and turbidity analysis will be collected together in 500 mL clear PET plastic bottles. The minimum volume for each of these analyses is well under 500 mL and they are all delivered to the laboratory unpreserved.

Ammonia, Total Phosphorus and Total Kjeldahl Nitrogen
Water samples for ammonia, total phosphorus and total Kjeldahl nitrogen analysis will be collected together in 125 mL HDPE mL pre-acidified plastic bottles with H_2SO_4 to bring the pH<2. The instructions from the bottle supplier, Testmark Laboratories, should be carefully followed as to ensure the proper use of the pre-acidified bottles. These three analyses are grouped together in one bottle as the minimum required volume for each is well under 500 mL and they are all delivered to the laboratory under the same preservation conditions.

Dissolved Organic Carbon
Water samples for dissolved organic carbon analysis will be collected in 125 mL HDPE plastic bottles. If it is feasible to perform field filtration, the dissolved organic carbon samples will be filtered into 125 mL HDPE mL pre-acidified plastic bottles with H_3PO_4 to bring the pH<2.

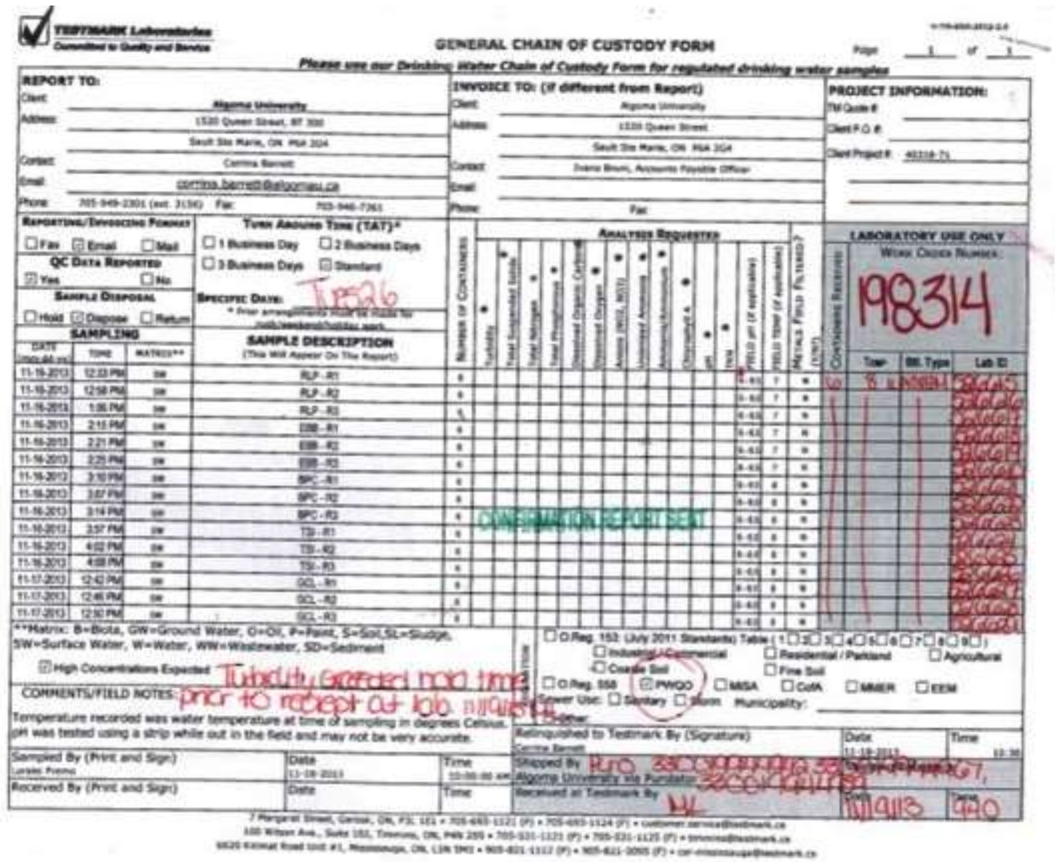
Field Sample Storage
Field samples will be stored immediately after collection in coolers with ice packs, maintaining a temperature of 2-8°C at all times (as prescribed by Testmark Laboratories). Samples will be stored overnight, if needed, in a refrigerator at 4°C. The goal is to ship samples to the laboratory for analysis within 24 hours of collection.

Chain of Custody and Shipping
Samples will be shipped in coolers with ice packs to the Testmark Laboratories Ltd. in Garson, Ontario at the following address:

Testmark Laboratories Ltd.
7 Margaret Street
Garson, Ontario
P3L 1E1

Shipping will be done from Algoma University via Purolator.

Chain of custody documents provided by Testmark Laboratories (Figure 3), are to be put into the coolers in a water-proof, re-sealable bag, to accompany the shipment.


TESTMARK Laboratories
Committed to Quality and Service

GENERAL CHAIN OF CUSTODY FORM

Page 1 of 1

Please use our Drinking Water Chain of Custody Form for regulated drinking water samples

REPORT TO:
Client: Algoma University
Address: 1520 Queen Street, BT 300
Sault Ste Marie, ON P6A 2G4
Contact: Corrina Barrett
Email: corrina.barrett@algomau.ca

INVOICE TO: (if different from Report)
Client: Algoma University
Address: 1520 Queen Street
Sault Ste Marie, ON P6A 2G4
Contact: Ivana Bruni, Accounts Payable Officer
Email:
Phone: Fax:

PROJECT INFORMATION:
TM Quote #
Client P.O. #
Client Project #

Reporting/Invoicing Format: ☐ Fax ☑ Email ☐ Mail
QC Data Reported: ☑ Yes ☐ No
Sample Disposal: ☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*: ☐ 1 Business Day ☐ 2 Business Days ☐ 3 Business Days ☑ Standard
Specific Date: TR526
* Prior arrangements must be made for rush/weekend/holiday work.

ANALYSES REQUESTED

LABORATORY USE ONLY
Work Order Number: 198314

Date	Time	Matrix**	Sample Description (This Will Appear On The Report)
11-16-2013	12:33 PM	SW	RLP-R1
11-16-2013	12:58 PM	SW	RLP-R2
11-16-2013	1:36 PM	SW	RLP-R3
11-16-2013	2:15 PM	SW	EBB-R1
11-16-2013	2:21 PM	SW	EBB-R2
11-16-2013	2:25 PM	SW	EBB-R3
11-16-2013	3:10 PM	SW	BPC-R1
11-16-2013	3:07 PM	SW	BPC-R2
11-16-2013	3:14 PM	SW	BPC-R3
11-16-2013	3:57 PM	SW	TSI-R1
11-16-2013	4:02 PM	SW	TSI-R2
11-16-2013	4:08 PM	SW	TSI-R3
11-17-2013	12:42 PM	SW	GCL-R1
11-17-2013	12:46 PM	SW	GCL-R2
11-17-2013	12:50 PM	SW	GCL-R3

CONFIRMATION REPORT SENT

**Matrix: B=Biota, GW=Ground Water, O=Oil, P=Paint, S=Soil, SL=Sludge, SW=Surface Water, W=Water, WW=Wastewater, SD=Sediment

☑ High Concentrations Expected

COMMENTS/FIELD NOTES: Turbidity exceeded hold time prior to receipt at lab

Temperature recorded was water temperature at time of sampling in degrees Celsius. pH was tested using a strip while out in the field and may not be very accurate.

☐ O.Reg. 153 (July 2011 Standards) Table (1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐ 9☐)
☐ Industrial / Commercial ☐ Residential / Parkland ☐ Agricultural
☐ Coarse Soil ☐ Fine Soil
☐ O.Reg. 558 ☑ PWQO ☐ MISA ☐ CofA ☐ MMER ☐ EEM
Sewer Use: ☐ Sanitary ☐ Storm Municipality:
Other:

Sampled By (Print and Sign) | Date | Time
Received By (Print and Sign) | Date | Time
Relinquished to Testmark By (Signature): Corrina Barrett | Date | Time
Shipped By: Algoma University via Purolator
Received at Testmark By | Date | Time

Figure 3: Example of chain of custody document to accompany sample shipments

Laboratory Analysis

Laboratory analysis of field-collected water samples will be accomplished, for the parameters previously discussed, by Testmark Laboratories. Standard quality assurance procedures are practiced by Testmark Laboratories, which are accredited by the Canadian Association for Laboratory Accreditation. As part of the internal quality control system, when the laboratory performs any analysis they complete duplicate testing for every 20 samples analyzed. It is a random process and depends on what order the run is prepared. Results of this duplicate testing will be shown on the analytical report.

Table 5 details the instrumentation and analytical methods used for each of the parameters analyzed for field water samples submitted during this project.

Table 5: Analytical methods for analysis of field-collected water samples

Parameter	Method	Instrument
Ammonia		Discrete Chemistry Analyzer
Un-ionized Ammonia	-calculation	
Anions – Nitrite, Nitrate	-ion chromatography	Dionex IC
Total Kjeldahl Nitrogen	-block digestion	Discrete Chemistry Analyzer
Total Nitrogen	-calculation	
Total Phosphorus		Discrete Chemistry Analyzer
Chlorophyll a	-spectrophotometry	Phillips UV/VIS Spectrophotometer
Dissolved oxygen	-dissolved oxygen meter	YSI BOD meter
pH	-ion selective electrode	Metrohm Analyzer
Dissolved Organic Carbon		Carbon Analyzer
Total Suspended Solids	-gravimetry	Mettler Toledo Balance
Turbidity	-nephelometry	Hach 2100P

Data Storage and Statistical Analysis

Completed field data sheets will be scanned and stored electronically as well as physically. Field data collected will also be entered into a results spreadsheet. Data received from laboratory analysis of field samples will be stored electronically.

Statistical analysis performed on data will include: minimum/maximum values, mean values, standard error and parametric (e.g. Analysis of Variance) or non-parametric (e.g. Kruskal-Wallis) tests of statistical significance as appropriate. Software used will be Microsoft Excel (Microsoft Office 2013) and SPSS (IBM SPSS Statistics 21).

All electronic files, particularly data, will be backed up on a bi-weekly basis (minimum) onto the project-specific external hard drive.

References

Canadian Council of Ministers of the Environment (CCME). 2011. Protocols Manual for Water Quality Sampling in Canada.

Michigan Department of Environmental Quality (MDEQ). 2011. Statewide Aesthetics Assessment Workplan and Monitoring Protocol.

Appendix 2: Worker Safety and Emergency Response Plan

Worker Safety and Emergency Response Plan for: Water Quality Sampling and Analysis for the St. Marys River Area of Concern (Beneficial Use Impairment Assessment)

Introduction

This safety and emergency response plan document was drafted for use by field staff participating in water quality sampling of the St. Marys River for the Water Quality Sampling and Analysis for the St. Marys River Area of Concern (Beneficial Use Impairment Assessment) project. The main goal of this plan is to support the collection of high quality field data in a safe manner, taking all necessary precautions, and having clear and detailed procedures in place in case of emergency.

Further relevant instruction can be obtained by reading the source document for this plan: the Protocols Manual for Water Quality Sampling in Canada (CCME 2011), which is available at the following link: http://www.ccme.ca/assets/pdf/protocols_document_e_final_101.pdf.

Plan Review

This safety and emergency response plan should be reviewed at least on an annual basis, in Years 2 and 3 of the project, and any alterations made from feedback collected by the field team, their supervisors and project stakeholders. In particular, if safety concerns are noted by members of the field team, they should be addressed and revisions made immediately.

WORKER SAFETY

While conducting field work is an integral component of the water quality sampling project, requiring adherence to protocols ensuring high quality data collection, it is also crucial that the work be done safely. The following section of this plan details the procedures to be followed for worker safety.

Field Team

Water samples will always be collected by teams of a minimum of <u>2 individuals</u>. There will be at least one person who physically performs the water sampling (Field Technician) and another who is the support person (Field Supervisor) and can provide help to the sampler should they encounter an unsafe situation from which they cannot remove themselves.

Certifications and Training

At <u>minimum</u>, at least <u>1 member</u> of the sampling crew will have a current certifications in Standard First Aid with CPR and WHMIS. If a boat is being used at least <u>1 member</u> of the sampling team with have their Pleasure Craft Operator Card.

Safety Equipment
Prior to field work, all members of the field team (Field Technician, Field Supervisor) will be trained on how to use all of the safety and sampling equipment properly. It is the responsibility of the field workers to ask for clarification if they are unsure about how to properly use any piece of safety or sampling equipment.

A list of the mandatory safety equipment to be used is shown below in Figure 1.

Figure 1: Mandatory safety equipment checklist

Safety equipment:	Check
First aid kit	
WHMIS folder with appropriate MSDS information	
Cell phone	
Field radios	
Chest waders	
Life Jacket/Personal Flotation Device (PFD)	
Tie rope (50 m)	
Throw rope	
Wading probe	
Laboratory gloves	
Protective eyewear (laboratory goggles)	
Emergency contact information	
Personal identification (health card, driver's licence)	

Check Out and Check In
On every field work day, the field team will **check out** with the Project Supervisor (Martha Scott), or a designate available on the day of sampling, by notifying them of:

- The time when they leave to go sampling
- Their expected route
- How they can be contacted (i.e. review the Emergency Response Plan)
- Their expected time of return

It is imperative that the Project Supervisor have a current and easily accessible copy of the Emergency Response Plan provided by the field team prior to sampling events.

When the field team returns from sampling they will immediately **check in** with the Project Supervisor or designate. It is the responsibility of the Field Technician and Field Supervisor to call the Project Supervisor or her designate upon returning from the field. Failure to call by the agreed-upon time will indicate that an emergency has occurred and there will be consequences! If they are going to be late, the field team should make every effort possible to contact their supervisor and inform them of their new circumstances.

If the field team **<u>fails to check in</u>** at the appointed time, the Project Supervisor will make every attempt to contact them by cell phone. If the Project Supervisor cannot make contact with the field team, they will initiate the **<u>Emergency Response Plan</u>** by placing a 911 call.

Parking

The field team will be travelling to the water sampling sites by private vehicle. It is up to the driver to make sure that the vehicle is insured, driven safely and is in good working order. It is a good idea to have a full tank of gas before initiating a round of sampling.

Sampling sites will be chosen with a preference for suitable areas where safe off-road parking is available. When possible, the field team will find a clearing completely off the road or an area away from traffic to park their vehicle and unload the sampling equipment.

If parking on the side of the road is absolutely necessary, the field team will find an area where the vehicle can be completely pulled out of the roadway and clear of traffic. In these cases the team should always watch for traffic before exiting the vehicle and safely unload equipment on farthest side of vehicle from roadway and traffic.

Tailgate Meeting

Prior to unloading the vehicle at each sampling site, the field team will conduct a tailgate meeting in order to discuss the potential hazards and the review the <u>Emergency Response Plan</u>. The current weather and water conditions, as well as the specific safety concerns of each site, will be discussed along with a review of the sampling protocols being utilized. The goal of the tailgate meeting is to highlight the risks and precautions being taken at every site and provide an open dialogue where new concerns can be brought up and solutions implemented in a timely manner.

Sampling Safety for Wading Samples

It has been decided that water sampling by wading is the most effective sampling method to be used for this project. However, other sampling methods (from shore, by boat) may be considered throughout the duration of the project, and this safety plan should be amended to include additional safety protocols as needed.

Wading is one of the easiest methods for collecting water samples but can also be one of the most dangerous. Rubber boots or waders are standard equipment along with a personal flotation device (PFD) and a probing instrument to estimate or predict current flow and locate holes and unsafe footing. The specific risks of wading at each field site will be discussed at the tailgate meeting held before each sampling event.

When sampling while **wading** the **Field Technician** will:

- Wear an approved lifejacket/PFD at all times
- Where a current is present and/or water levels high, tether themselves to a large and stable object (e.g. a tree)
- Check the riverbed for large obstacles or holes and wade carefully into the stream using a wading stick before beginning sampling
- Only take samples if they can be certain that the river conditions are safe
- Stay in verbal communication with the Field Supervisor using field radios
- NEVER TAKE UNECESSARY RISKS

While the Field Technician is **wading** the **Field Supervisor** will:

- Stand entirely on shore with the throw rope handy
- Have easy access to the emergency communication device and all pertinent emergency numbers and information
- Avoid distractions and concentrate on supervising the safety of the Field Technician
- Stay in verbal communication with the Field Technician using field radios

Safety in the Field Preservation of Samples

For this project pre-acidified sampling bottles will be ordered in order to help water samples maintain their integrity while being transported to the analytical laboratory. Use of pre-acidified bottles will reduce risks to the field team as they will avoid direct handling of preserving chemicals such as strong acids.

Prior to field days, the field team will become familiar with which samples are being acid preserved and the safety precautions to be used. More specifically, a Material Safety Data Sheet (MSDS) will have been obtained and read by the field team prior to sampling and will be available on site. All pre-acidified bottles are to be transported and stored in an upright position and in a location where they will not freeze or overheat.

When using **pre-acidified bottles** the **Field Technician** will:

- Obtain and carry relevant Material Safety Data Sheets (MSDS)
- Store pre-acidified bottles in an upright position and according to instructions
- Wear laboratory gloves and protective eyewear
- Wear closed toe shoes, long-sleeved shirts and pants to protect exposed skin
- Dispose of any pre-acidified bottles and acidified samples in a safe manner
- Follow any additional safety prescriptions provided by the bottle supplier

In case of **spills/accidental body contact** with **preservatives**:

- Immediately flush with large amounts of water for about 15 minutes
- Flush the inside and outside of affected eyes with plenty of water for at least 15 minutes, holding the eyes open if necessary
- Seek medical attention as soon as possible for all eye injuries and other serious spills
- Report the incident to the Project Supervisor

EMERGENCY RESPONSE PLAN

While the worker safety portion of this plan details procedures to follow to limit risk to the field team, this section sets out clear instructions about what to do if an emergency situation arises.

When to Use the Plan

The emergency response plan will be activated if an accident or other emergency occurs. For example, if the field team fails to check in with the Project Supervisor on the day of sampling, the supervisor will initiate the plan. If an incident or emergency occurs that involves the Field Technician performing the water sampling, the on-shore Field Supervisor will immediately call for emergency assistance.

Emergency Contact Information

The emergency contact numbers contained in this plan should be on the person of the Field Supervisor at all times, housed in a laminated or other non-destructible form to protect them from water or other damage. They Project Supervisor, and any alternate designated Supervisor should also have easy access to the current and updated emergency contact information.

Daily Review

The Field Technician and the Field Supervisor will review the Emergency Response Plan at each tailgate meeting conducted at the beginning of each field sampling day. During this time any improvements to the plan should also be informally discussed and noted.

Emergency Drills

The field team will rehearse the emergency procedures by conducting a drill at one of the field locations at least twice during each field season, to ensure that the procedures can be enacted without delay. The drill will not involve actual phoning of any emergency numbers.

Seasonal Review

The emergency response plan should be reviewed for improvements on a formal basis at minimum the end of each field season or earlier as needs/issues arise. This includes checking that all pertinent information, especially contact numbers and medical information are up-to-date and correct.

Emergency Contact Numbers

In case of Emergency call: 911
If 911 is not working, the alternative emergency number is: 1-888-310-1122 (O.P.P.)

Emergency Medical Services (EMS)	**911** General Inquiry: (705) 949-3335
Police	**911** Sault Ste. Marie City Police: (705) 949-6300 O.P.P. (Sault Ste. Marie Area) : (705) 945-6833 O.P.P. 24-hr Communications Centre: 1-888-310-1122
Fire	**911** Sault Ste. Marie Fire: (705) 949-3335 Prince Township Fire Hall: (705) 779-3473 ext. 104 St Joseph Island Fire Hall: (705) 246-2820
Sault Area Hospital	Main site (Sault Ste. Marie): (705) 759-3434 Matthews Memorial Site (St. Joseph Island): (705) 246-2570
Martha Scott (Project Supervisor)	(705) 652-0460
Alternate Supervisor	
Algoma University	General Inquiry: (705) 949-2301

Field Team Information (will be collected in the following format)

Name: **Position:** **Home:**
Allergies:
Medical conditions:
Medications:
Certifications:
EMERGENCY CONTACT: **Relationship:** **Home:** **Work:**
ALTERNATE EMERGENCY CONTACT: **Relationship:** **Home:** **Work:** **Cell:**

References

Canadian Council of Ministers of the Environment (CCME). 2011. Protocols Manual for Water Quality Sampling in Canada.

Appendix 3: Master Field Checklist

Field equipment:	Check
White paper (for water clarity and colour determination)	
Water collection bottles (6 bottles x 3 replicates = 18/site)	
Coolers with icepacks	
Camera	
GPS unit	
Back-up batteries	
Thermometer	
pH meter and/or pH test strips	
Wash bottle with clean laboratory grade water (e.g. Milli-Q)	
Secchi disc	
Metre stick/Wading probe	
Field data sheets and clipboard	
Pencils, pens and sharpies	
Labelling tape	
Re-sealable plastic bags (e.g. Ziploc)	
Watch (or other time telling device)	
Paper towels	
Information sheets (e.g. instructions for sample bottles types)	
Rubbermaid container	
Small inflatable boat	
Safety equipment:	**Check**
First aid kit	
WHMIS folder with appropriate MSDS information	
Cell phone	
Field radios	
Chest waders	
Life Jacket/Personal Flotation Device (PFD)	
Tie rope (50 m)	
Throw rope	
Laboratory gloves	
Protective eyewear (laboratory goggles)	
Emergency contact information	
Personal identification (health card, driver’s licence)	

Appendix 4: Field Data Sheets

Gros Cap

GCL

Secchi disk: very clear
water depth: 50 cm
pH strips: 6.0 - 6.5

R1 12:42
R2 12:46
R3 12:50

Aesthetics Monitoring Data Sheet

Date: Nov 18 2013 Area of Concern & Site Description St. Marys River
Time: ______ (acc 1) G.P.S. Coordinates N 46°31.711' W084°35.159 Ele: 585ft
Crew: Loracki Premo Corrina Barrett Water Temp: 8°C
Weather: Rain Today ☑ Clear ☐ Windy ☐
Rain Yesterday ☐ Cloudy ☐ Approx Air Temp 12°C
Other Comments: ______

WATER CLARITY (pick one)
Clear ☑
Slightly Turbid ☒ ← NA
Moderately Turbid ☐
Highly Turbid ☐
Opaque ☐

ODOR
None/Natural ☑
Musty:
Faint ☐ Strong ☐ None ☐
Sewage/Fishy:
Faint ☐ Strong ☐ None ☐
Anaerobic/Septic:
Faint ☐ Strong ☐ None ☐

WATER COLOR (pick one color and one qualifier)
Clear ☑ Brown ☐ Green ☐ Yellow ☐
Grey ☐ Black ☐ Milky/White ☐ Other: ______
Light ☐ Medium ☐ Dark ☐

VISIBLE DEBRIS/OBVIOUS POLLUTION
None ☐ Natural ☐ (leaves,limbs,weeds)
Foam ☐ Oil Film ☐ None ☑
Trash:
Floating ☐ Fixed ☐ None ☑
Solids:
Floating ☐ Fixed ☐ None ☑
Floating Scum ☐ None ☑
Deposits:
Describe Rocky / pebbly Substrate

- no visible algae present
- rocks were not slippery

ADDITIONAL COMMENTS/OBSERVATIONS: Culvert near water sampling location (about 6 feet)

1) Does this AOC have local delisting criteria? ______ If so, how does it differ from the state criteria?

2) Are there any designated uses** that may be impaired in your judgment due to aesthetic conditions? ______ If so, which one(s)? ______

3) The impairment(s) may be specifically due to which of the following "physical properties in unnatural quantities?" [circle all that apply: turbidity, color, oil films, floating solids, foams, settleable solids, suspended solids, deposits]

4) Are these conditions "persistent, high levels" or temporary & transient? ______

5) Does this site meet the applicable delisting criteria? ______

6) Please make any other notes that are relevant to the answer in #5: ______

**Designated uses are as follows:
- agriculture - navigation - industrial water supply - public water supply at the point of water intake - warmwater fishery - other indigenous aquatic life and wildlife - partial body contact recreation - total body contact recreation between 5/1 and 10/1 - coldwater fishery, depending on location

1

Bellevue Park

TS1
Water depth: 50cm
Secchi: very clear
pH strip: 6.0-6.5

R1 3:57
R2 4:02
R3 408

Aesthetics Monitoring Data Sheet

Date: Nov 16 2013 Area of Concern & Site Description St Marys River
Time: ___ (TS1) G.P.S. Coordinates N 46°29.708' W084°17.824' Ele: 567ft
Crew: Loralei Premo, Corrina Barrett Water Temp: 8°C
Weather: Rain Today ☐ Clear ☐ Windy ☐
Rain Yesterday ☑ Cloudy ☑ Approx Air Temp 7°C
Other Comments: ___

WATER CLARITY (pick one)
Clear ☑
Slightly Turbid ☐
Moderately Turbid ☐
Highly Turbid ☐
Opaque ☐

WATER COLOR (pick one color and one qualifier)
Clear ☑ Brown ☐ Green ☐ Yellow ☐
Grey ☐ Black ☐ Milky/White ☐ Other: ___
Light ☐ Medium ☐ Dark ☐

ODOR
None/Natural ☐
Musty:
Faint ☐ Strong ☐ None ☐
Sewage/Fishy:
Faint ☑ Strong ☐ None ☐
Anaerobic/Septic:
Faint ☐ Strong ☐ None ☐

VISIBLE DEBRIS/OBVIOUS POLLUTION
None ☑ Natural ☐ (leaves,limbs,weeds)
Foam ☐ Oil Film ☐ None ☑
Trash:
Floating ☐ Fixed ☐ None ☑ → there is some fixed timber/steel/concrete in water
Solids:
Floating ☐ Fixed ☐ None ☑
Floating Scum ☐ None ☑
Deposits:
Describe Very stoney shore

ADDITIONALCOMMENTS/OBSERVATIONS: large rocks sporatically
very clear water / silty

1) Does this AOC have local delisting criteria? _____ If so, how does it differ from the state criteria?

2) Are there any designated uses** that may be impaired in your judgment due to aesthetic conditions? ______ If so, which one(s)? ______

3) The impairment(s) may be specifically due to which of the following "physical properties in unnatural quantities?" [circle all that apply: turbidity, color, oil films, floating solids, foams, settleable solids, suspended solids, deposits]

4) Are these conditions "persistent, high levels" or temporary & transient? ______

5) Does this site meet the applicable delisting criteria? ____

6) Please make any other notes that are relevant to the answer in #5: ______

**Designated uses are as follows:
- agriculture - navigation - industrial water supply - public water supply at the point of water intake
- warmwater fishery - other indigenous aquatic life and wildlife - partial body contact recreation - total body contact recreation between 5/1 and 10/1 - coldwater fishery, depending on location

1

Bell's Point

BPC pH strip: 6.0-6.5
secchi dist: very clear
Water depth: 50 cm
pH meter:

3:10 R1 ~~[illegible]~~
R2 3:07
R3 3:14

Aesthetics Monitoring Data Sheet

Date: Nov 16 2013 Area of Concern & Site Description St Marys River
Time: ______ (BPC1) G.P.S. Coordinates N 46°32.281' W084°13.047' E1e5L5Pt
Crew: Loralei Premo Corinne Barrett Water Temp: 8°C
Weather: Rain Today ☐ Clear ☐ Windy ☐
Rain Yesterday ☑ Cloudy ☑ Approx Air Temp 8°C
Other Comments: ______

WATER CLARITY (pick one)
Clear ☑
Slightly Turbid ☐
Moderately Turbid ☐
Highly Turbid ☐
Opaque ☐

WATER COLOR (pick one color and one qualifier)
Clear ☑ Brown ☐ Green ☐ Yellow ☐
Grey ☐ Black ☐ Milky/White ☐ Other: ______
Light ☐ Medium ☐ Dark ☐

ODOR
None/Natural ☑
Musty:
Faint ☐ Strong ☐ None ☑
Sewage/Fishy:
Faint ☐ Strong ☐ None ☑
Anaerobic/Septic:
Faint ☐ Strong ☐ None ☑

VISIBLE DEBRIS/OBVIOUS POLLUTION
None ☐ Natural ☑ (leaves,limbs,weeds) weeds in water and on shore
Foam ☐ Oil Film ☐ None ☑
Trash:
Floating ☐ Fixed ☐ None ☑
Solids:
Floating ☐ Fixed ☐ None ☑
Floating Scum ☐ None ☑
Deposits:
Describe Sandy/Silty

ADDITIONAL COMMENTS/OBSERVATIONS: Very clear water, no algae
Thick/silty sandy substrate
Aquatic vegetation

1) Does this AOC have local delisting criteria? _____ If so, how does it differ from the state criteria?

2) Are there any designated uses** that may be impaired in your judgment due to aesthetic conditions?_______ If so, which one(s)?______

3) The impairment(s) may be specifically due to which of the following "physical properties in unnatural quantities?" [circle all that apply: turbidity, color, oil films, floating solids, foams, settleable solids, suspended solids, deposits]

4) Are these conditions "persistent, high levels" or temporary & transient?________

5) Does this site meet the applicable delisting criteria?____

6) Please make any other notes that are relevant to the answer in #5: ______

**Designated uses are as follows:
- agriculture - navigation - industrial water supply - public water supply at the point of water intake
- warmwater fishery - other indigenous aquatic life and wildlife - partial body contact recreation - total body contact recreation between 5/1 and 10/1 - coldwater fishery, depending on location

1

Echo Bay

EBB pH strip 6.0-6.5
water pH 6.96
water depth 50cm
secchi disk: loss sight after 50cm

R1 2:15
R2 2:21
R3 2:25

Aesthetics Monitoring Data Sheet

Date: Nov 16 2013 Area of Concern & Site Description St Marys River
Time: ______ (EBB1) G.P.S. Coordinates N 46°29.627' W084°04.693' Ele 657ft
Crew: Laolei Premo Corrine Barrett Water Temp: 7°C
Weather: Rain Today ☐ Clear ☐ Windy ☐
Rain Yesterday ☑ Cloudy ☑ Approx Air Temp 8°C
Other Comments: ______

WATER CLARITY (pick one)
Clear ☐
Slightly Turbid ☑
Moderately Turbid ☐
Highly Turbid ☐
Opaque ☐

WATER COLOR (pick one color and one qualifier)
Clear ☑ Brown ☐ Green ☐ Yellow ☑
Grey ☐ Black ☐ Milky/White ☐ Other: ______
Light ☑ Medium ☐ Dark ☐ (light discolouration)

ODOR
None/Natural ☑
Musty:
Faint ☐ Strong ☐ None ☑
Sewage/Fishy:
Faint ☐ Strong ☐ None ☑
Anaerobic/Septic:
Faint ☐ Strong ☐ None ☑

VISIBLE DEBRIS/OBVIOUS POLLUTION
None ☐ Natural ☑ (leaves, limbs, weeds)
Foam ☐ Oil Film ☐ None ☑
Trash:
Floating ☐ Fixed ☐ None ☑ (some trash on surrounding shore)
Solids:
Floating ☐ Fixed ☐ None ☑
Floating Scum ☐ None ☑
Deposits:
Describe ______

ADDITIONAL COMMENTS/OBSERVATIONS: Sandy/silty (boat came thru 10 minutes prior to sampling)

1) Does this AOC have local delisting criteria? _____ If so, how does it differ from the state criteria? ______

2) Are there any designated uses** that may be impaired in your judgment due to aesthetic conditions? _____ If so, which one(s)? ______

3) The impairment(s) may be specifically due to which of the following "physical properties in unnatural quantities?" [circle all that apply: turbidity, color, oil films, floating solids, foams, settleable solids, suspended solids, deposits]

4) Are these conditions "persistent, high levels" or temporary & transient? ______

5) Does this site meet the applicable delisting criteria? ____

6) Please make any other notes that are relevant to the answer in #5: ______

**Designated uses are as follows:
- agriculture - navigation - industrial water supply - public water supply at the point of water intake - warmwater fishery - other indigenous aquatic life and wildlife - partial body contact recreation - total body contact recreation between 5/1 and 10/1 - coldwater fishery, depending on location

noticed water beading on the surface

1

Richards Landing

RLP pH/strip: 6.0-6.5

secchi disk: clear @ 50cm

water depth: 50 cm

water pH: 7.06

Rep 1 @ 12:33 Therm

Rep 2 @ 12:58

Rep 3 @ 1:06 pH met

Aesthetics Monitoring Data Sheet

Date: Nov 16 2013 Area of Concern & Site Description St. Marys River

Time: 12:33 (RLP1) G.P.S. Coordinates N 46° 17.569' W084° 02.426' Ele 530ft

Crew: Lorelei Premo Corrina Barrett Water Temp: 7°C

Weather: Rain Today ☐ Clear ☐ Windy ☐

Rain Yesterday ☑ Cloudy ☑ Approx Air Temp 13.5°C

Other Comments: 3 reps

WATER CLARITY (pick one)

Clear ☑
Slightly Turbid ☐
Moderately Turbid ☐
Highly Turbid ☐
Opaque ☐

ODOR

None/Natural ☑

Musty:
Faint ☐ Strong ☐ None ☑

Sewage/Fishy:
Faint ☐ Strong ☐ None ☑

Anaerobic/Septic:
Faint ☐ Strong ☐ None ☑

WATER COLOR (pick one color and one qualifier)

Clear ☑ Brown ☐ Green ☐ Yellow ☐
Grey ☐ Black ☐ Milky/White ☐ Other: ______
Light ☐ Medium ☐ Dark ☐

VISIBLE DEBRIS/OBVIOUS POLLUTION

None ☑ Natural ☐ (leaves,limbs,weeds)
Foam ☑ Oil Film ☐ None ☑ Rkk

Trash:
Floating ☐ Fixed ☐ None ☑ No visible algae

Solids:
Floating ☐ Fixed ☐ None ☑
Floating Scum ☐ None ☑

Deposits:
Describe Sandy, no debris, very fine silt.

ADDITIONALCOMMENTS/OBSERVATIONS: ______
Footprints from previous trips out still obvious during 2nd & 3rd reps

1) Does this AOC have local delisting criteria? _____ If so, how does it differ from the state criteria?

2) Are there any designated uses** that may be impaired in your judgment due to aesthetic conditions?_______ If so, which one(s)?______

3) The impairment(s) may be specifically due to which of the following "physical properties in unnatural quantities?" [circle all that apply: turbidity, color, oil films, floating solids, foams, settleable solids, suspended solids, deposits]

4) Are these conditions "persistent, high levels" or temporary & transient?__________

5) Does this site meet the applicable delisting criteria?____

6) Please make any other notes that are relevant to the answer in #5: ______

**Designated uses are as follows:
- agriculture - navigation - industrial water supply - public water supply at the point of water intake
- warmwater fishery - other indigenous aquatic life and wildlife - partial body contact recreation - total body contact recreation between 5/1 and 10/1 - coldwater fishery, depending on location

1