St. Marys River Area of Concern (Canadian Section) Beneficial Use Impairment Re-designation Report: Beach Closings

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Summary

The St. Marys River was identified in 1987 by the International Joint Commission as one of 43 Areas of Concern (AOC) in the Great Lakes basin. Beach closings were identified as one of the ten beneficial use impairments (BUI) in the St. Marys River AOC in 1992 due to bacterial densities exceeding Provincial Water Quality Objectives in waters downstream of storm sewers, industrial outfalls and the East End Wastewater Treatment Plant. The Stage 2 Remedial Action Plan (RAP) report for the St. Marys River AOC identifies three actions needed to address the Beach Closings BUI:

- Reduce stormwater infiltration at the East End Wastewater Treatment Plant (Action PS-2)
- Upgrade East End Wastewater Treatment Plant to secondary treatment (Action PS-3)
- Assess potential health risks resulting from floating contaminated masses (Action NPSM-7)

To date, there have been significant accomplishments made that have helped to improve overall water quality and address sources of *E. coli* contamination in the St. Marys River AOC. All remedial actions identified in the Stage 2 RAP report have been completed including:

- The development of a stormwater management plan for the City of Sault Ste. Marie (Action PS-2)
- East End Wastewater Treatment Plan upgrades (Action PS-3)
- Confirmation that the floating masses are predominantly comprised of algae, detritus and pollen, and not a significant source of E. coli bacteria (Action NPSM-7)

In addition, a multi-year beach water quality assessment was completed in 2016. Results from this study indicate that there are no major local anthropogenic sources of bacterial contamination on the Canadian side of the St. Marys River and that the water quality within the St. Marys River AOC is comparable to non-AOC areas. In Sault Ste. Marie, Michigan, the beach closings BUI was removed from the US side of the St. Marys River AOC on July 27, 2016.

It is recommended that the status of the Beach Closings BUI be re-designated from impaired to not impaired.

Acronyms and Abbreviations

AOC – Area of Concern

APH – Algoma Public Health

BPAC – Binational Public Advisory Council

BUI – Beneficial Use Impairment

CCHD – Chippewa County Health Department

CFU – Colony Forming Units

ECCC – Environment and Climate Change Canada

E.coli – Escherichia coli

EWWTP – East End Wastewater Treatment Plant

FEE – Foundation for Environmental Education

GLWQA – Great Lakes Water Quality Agreement

IJC – International Joint Commission

LAMP – Lakewide Action and Management Plan

MDEQ – Michigan Department of Environmental Quality

NPDES – National Pollution Discharge Elimination System

NPSM – Non-Point Source Monitoring

OMOECC – Ontario Ministry of Environment and Climate Change

PS – Point Source

PWQO – Provincial Water Quality Objective

RAP – Remedial Action Plan

SIMWG – Sugar Island Monitoring Workgroup

SMRRAPIC – St. Marys River Remedial Action Plan Implementation Committee

USEPA – United States Environmental Protection Agency

Contents

1. Introduction

1.1 The St. Marys River Area of Concern

The St. Marys River is a 120km freshwater ecosystem that connects Lake Superior to Lake Huron, and is the border between the twin cities of Sault Ste. Marie in Ontario and Michigan. Historically, industrial and municipal sources of pollution along with non-point urban sources of pollution were contributing factors to the degradation of water quality and ecosystem health of the river. In 1987 the St. Marys River was recognized as one of 43 Areas of Concern (AOC) within the Great Lakes basin (GLWQA, 2012). An AOC is defined as an area where the environment has been degraded to the point where it affects our beneficial use and enjoyment of the area and/or the overall health of the ecosystem.

In 1972, Canada and the United States passed the Great Lakes Water Quality Agreement in order to improve water quality within the Great Lakes basin as part of an overall commitment to restore and protect the waters of the Great Lakes. A key focus of this agreement is to restore Areas of Concern through the development and implementation of Remedial Action Plans (RAP). In 1992, a Stage 1 RAP report for the St. Marys River AOC was created to identify environmental problems, known as a Beneficial Use Impairment (BUI). In 2002, a number of remedial actions were identified to help restore the area. These actions are outlines in the Stage 2 RAP report. Currently the St. Marys River RAP is working on addressing nine BUIs, one of which is Beach Closings.

1.2 The Identification of Beach Closings as a BUI

Bacterial contamination is a major water quality concern throughout the world. Historically, sources of bacterial contamination in the St. Marys River AOC varied from natural sources (e.g. waterfowl) to anthropogenic sources (e.g. municipal sewage, septic systems, and runoff from urban and agricultural areas). Fecal contamination in freshwater has been known to cause gastro-intestinal and upper respiratory illness in humans. Elevated levels of fecal coliform bacteria, particularly *Escherichia coli* (*E. coli)* was documented as the main reason for the beach Closings impairment listed in the Stage 1 report (1992) of the St. Marys River RAP. *E. coli* refers to a large group of bacteria that is commonly found in the intestines of humans and animals (APH, 2017). High *E. coli* densities were recorded in waters downstream of municipal storm sewers, combined sewer overflows in Michigan, industrial outfalls, and the City of Sault Ste. Marie's (Ontario) East End Wastewater Treatment Plant (EEWWTP).

At that time, there were no beaches being tested for microbial contamination on the Ontario side of the river; therefore, no specific beaches were identified or studied for designation. Instead, the impaired status was based on levels of *E. coli* in the St. Marys River exceeding both the Ontario Provincial Water Quality Objective and the Michigan Water Quality Standard. This is in accordance with the International Joint Commission's *Listing Guideline* for Beach Closings which results "When waters, which are commonly used for total-body contact or partial-body contact recreation, exceed standards, objectives, or guidelines for such use" (IJC, 1991).

1.3 About this Report

To assess the current status of the Beach Closings BUI on the Canadian side of the river, the St. Marys River RAP team conducted an evaluation of delisting criteria. These are measurable targets for restoring beneficial uses, and ultimately the AOC, and establish a benchmark for when a beneficial use can be deemed no longer impaired. The delisting criteria for the Beach Closings BUI were updated and received endorsement by the Binational Public Advisory Council (BPAC) in February 2015.The BPAC represent stakeholders on both the American and Canadian sides of the AOC. In addition to the delisting criteria evaluation, an assessment of five years of beach closings data (2012-2016) provided by Algoma Public Health was conducted.

The purpose of this report is to synthesize knowledge from multiple areas related to the Beach Closings BUI in the St. Marys River. All recommended remedial and monitoring actions pertaining to the Beach Closings BUI have been completed and satisfy the delisting criteria endorsed by BPAC. The report provides a recommendation to re-designate the Beach Closings BUI to "not impaired" based on the completion of the delisting criteria targets.

1.4 Considerations

It is recognized that, within the context of the St. Marys AOC and associated RAP, this report doesn't address the broader perspective of bacterial contamination in the river. Like for all AOCs, the St. Marys River RAP was established to address environmental impacts from local sources. The Beach Closings BUI is based on historical factors, and re-designation recommendations are based on the RAP stage 2 and updated delisting criteria. However, other concerns have been identified and are addressed in recommendations for ongoing work in the St. Marys River. Challenges that lie ahead for addressing bacterial contamination are also discussed.

Beach closings were identified as a BUI in the St. Marys River AOC in 1992 because of levels of *E.coli* in exceedance of the Ontario Provincial Water Quality Objective and the Michigan Water Quality Standard.

2. Remedial Actions Identified to Address the Beach Closings BUI

The Stage 2 RAP report identified specific measures to address the Beach Closings BUI in the St. Marys River. This included two remedial actions (Actions PS-2 and PS-3) and one monitoring action (Action NPSM-7).

With the original focus of the Remedial Action Plan being specific to *E. coli* in the river itself (and the need to manage the bacterium in the river, not on particular beaches), the updated delisting criteria are explicit to these actions outlined in the Stage 2 Remedial Action Plan, revised with the endorsement of the Binational Public Advisory Council (BPAC) in February 2015. They state that the Beach Closings BUI will no longer be impaired when all three criteria have been met:

1. Stormwater infiltration is reduced to help prevent sewage treatment bypasses, and a Stormwater Management Master Plan is completed and being implemented by the City of Sault Ste. Marie that outlines the preferred solution for managing stormwater quantity and quality;
2. The East End Wastewater Treatment Plant is upgraded to secondary treatment; and,
3. Potential human health risks resulting from floating material near and downstream of Bellevue Marine Park have been assessed and managed, as required.

The Stage 2 RAP report for the St. Marys River AOC identifies three actions needed to address the Beach Closings BUI:

1. Reduce stormwater infiltration at the EEWWTP – this action has been interpreted as mitigating stormwater infiltration and loading at the EEWWTP (Action PS-2)
2. Upgrade EEWWTP to secondary treatment (Action PS-3)
3. Assess potential health risks resulting from floating contaminated masses (Action NPSM-7)

3. Current Status

To date, there have been significant accomplishments made that have helped to improve overall water quality and address sources of *E. coli* contamination as described below. Table 1 summarizes the major achievements relating to the three Beach Closings BUI delisting criteria as described below.

3.1 Remedial Actions Completed to Reduce Stormwater Infiltration at the EEWWTP (Action PS-2) **Note that this action has been interpreted as mitigating stormwater infiltration and loading at the EEWWTP*

Since the RAP Stage 2 Report identified Action PS-2 to address the Beach Closings BUI, the following work has been accomplished:

- The City of Sault Ste. Marie constructed the Bellevue Park Sanitary Sewer Overflow tank in 2002. The tank provides 12,000m^3 of temporary storage space that is utilized during high flow events. This has helped to mitigate the impacts of stormwater infiltration and associated effects on the EEWWTP.
- The sewer use by-law was updated in 2009. This update prohibits the discharge of stormwater and surface water to the sanitary sewer system without prior approval from the City. It also prohibits the connection of roof leaders to the sanitary system (City of Sault Ste. Marie, 2009).
- In March 2014, a Notice of Completion was issued for the City of Sault Ste. Marie Stormwater Management Master Plan, followed by a 30-day comment period. In November 2014, the Stormwater Management Report was finalized and in February 2015, City Council approved the new *Stormwater Management Master Plan and Guidelines* (City of Sault Ste. Marie, 2015).

With the infrastructure upgrades and the creation of a Stormwater Management Master Plan, all work for this action has been completed. The plan includes recommendations for implementing a city-wide approach to stormwater management including improving snow disposal sites, education, implementing a point source monitoring plan, implementing oil grit separators at various locations throughout the city

prior to discharge to the natural environment, improving stormwater conveyance at known problem areas and retrofitting of existing stormwater management facilities for quality control. Implementations of the recommendations are pending the City's budgeting process, including approval by council. To date, the City has undertaken several monitoring initiatives including:

- Evaluating rainwater inflow and infiltration in the Dell Avenue sanitary sewer system for three years ending in 2016 to identify areas with high flows and thus potentially mitigate wastewater outflows and treatment bypasses to the St. Marys River.
- Targeted monitoring between 2012 and 2015 to determine baseline:
    - water quality data for potential installation of oil/grit separators;
    - data at the Bellevue Park pond to quantify the potential impairment and assess potential mitigating actions, and;
    - data at the East End Snow Dump to assess potential impacts and identify mitigating measures.

3.2 Remedial Actions Completed to Upgrade the EEWWTP to Secondary Treatment (Action PS-3)

Action PS-3 called for an upgrade to the EEWWTP, which was successfully completed in 2006. The facility was upgraded to include secondary treatment, and includes both biological nutrient removal and UV light for disinfection. The compliance limit for *E.coli* is 200 counts per 100mL sample, however the design objective for the upgraded plant is 150 *E.coli*/100mL. The EEWWTP has been in compliance with these limits since January 2007. As a recent example, in 2016 the average of the monthly geometric means was 38 *E.coli* /100mL (East End Wastewater Treatment Plant Year End Report, 2016). An in-depth discussion of the upgrade and associated benefits are outlined in an article published in 2007 in the Environmental Science Engineering Magazine (Appendix 1).

Figure 1: Sault Ste. Marie East End Wastewater Treatment Plant upgrade (City of Sault Ste. Marie, 2005).

3.3 Remedial Actions Completed to Assess Potential Health Risks Resulting from Floating Contaminated Masses (Action NPSM-7)

Action NPSM-7 called for an assessment of potential health risks resulting from floating contaminated masses. This assessment took place from 2007-2010 by the bi-national Sugar Island Monitoring Workgroup (SIMWG). This bi-national, multi-agency group was formed to develop and implement a monitoring plan to determine the source and nature of the floating materials and the source responsible for the high levels of *E.coli* found periodically at the Sugar Island Township Park Beach. In particular, during the summer of 2006, residents along the north shore of Sugar Island reported incidences of contaminants, floatable materials and other indicators suggestive of raw sewage. The resulting monitoring plan involved a coordinated response to any reports received of floating materials in the river, as well as, weekly water monitoring. Results from the three-year assessment indicated low *E.coli* levels, with relatively few incidences of elevated levels (i.e. exceeding the Michigan Water Quality Standard of 300 cfu/100mL). Laboratory analysis confirmed that floating material reported during the assessment was predominantly comprised of algae, detritus and pollen, and not a significant source of *E. coli* bacteria. With the original objectives of the SIMWG being achieved at the end of the three-year assessment, the workgroup disbanded (SIMWG, 2010).

Table 1: Beach Closings BUI delisting criteria and related achievements.

DELISTING CRITERIA	MAJOR ACTIONS	OUTCOMES
1. Stormwater infiltration is reduced to help prevent sewage treatment bypasses, and a Stormwater Management Master Plan is completed and being implemented by the City of Sault Ste. Marie that outlines the preferred solution for managing stormwater quantity and quality.	Stormwater Management (Action PS-2)	The City of Sault Ste. Marie Stormwater Management Master Plan and Guidelines have been completed. The plan outlines the preferred approach for managing stormwater quality and quantity, including improvement of snow disposal sites, education, implementation of a point source monitoring plan, implementation of oil grit separators at various locations, improvement of stormwater conveyance at known problem areas and retrofitting of existing stormwater management facilities for quality control. The goals of these guidelines, along with the master plan, are to update and develop policies for the design of the City stormwater conveyance system, develop policies for the design of stormwater management infrastructure, and to develop a capital works program to implement stormwater management infrastructure (City of Sault Ste. Marie, 2015).
2. The East End Wastewater Treatment Plant is upgraded to secondary treatment.	Wastewater Treatment Plant Upgrade (Action PS-3)	The East End Wastewater Treatment Plant was upgraded in 2006 to include secondary treatment. It features a biological nutrient removal system including UV light for disinfection. This has resulted in improved effluent quality and reduced suspended solids by 89%, phosphorus levels by 91% and biological oxygen demand by 96%. Significant reductions in nitrogen and ammonia have also been achieved (SMRRAPIC, 2016).
3. Potential human health risks resulting from floating material near and downstream of Bellevue Marine Park have been assessed and managed, as required.	Assess and manage as appropriate potential human health risks from floating material (Action NPSM-7)	The potential human health risks resulting from floating material near and downstream from Bellevue Marine Park has been assessed by the Binational Sugar Island Monitoring Workgroup which was established in 2007. The multi-agency bi-national workgroup was tasked by the Four Party Management Committee (consisting of representatives from the U.S. Environmental Protection Agency, Environment Canada, Michigan Department of Environmental Quality, and Ontario Ministry of the Environment) to develop and implement a monitoring plan to determine the source and nature of the floating materials and the cause(s) responsible for the periodic high levels of E. coli at the Sugar Island Township Park beach. The Sugar Island Monitoring Workgroup collected samples from 2007-2009 and provided a final report in 2010. Although there were a few instances where high levels of *E. coli* was detected it was concluded that the *E. coli* concentrations are not of concern for recreation in the river. It was also reported that floating materials that are sometimes found in the St. Marys River are from natural sources (i.e. algae, pollen, detritus). It was concluded that the East End Wastewater Treatment Plant was not a source of ongoing elevated *E.coli* bacteria or debris in the St. Marys River. Since 2010, there have been no reported incidences of floating masses in the Bellevue Marine Park Area (SIMWG, 2010).

3.4 Additional Multi-Year Beach Water Quality Assessment

In addition to the actions completed that address the delisting criteria for Beach Closings identified in the Stage 2 RAP report, an updated assessment of recent beach data was also performed to augment the 2015 report prepared by the RAP team.

The province of Ontario has water quality guidelines that are used to determine whether a public beach is safe. These guidelines are based on the maximum geometric mean concentration of *E. coli* forming units (cfu). An advisory is posted if samples exceed 100 cfu/100mL, which aligns with the Provincial Water Quality Objective (PWQO). Algoma Public Health routinely monitors several beaches along the St. Marys River (Belleau et al, 2015). These beaches are monitored at least once a week during the swimming season as part of Algoma Public Health's beach warning program. These beaches are Pointe des Chenes, Mark's Bay Conservation Area, Centennial Park, and W.I. Park (Fig. 2).

A five-year beach water quality assessment was conducted to compare the four beaches (tested by Algoma Public Health) within the AOC to four beaches outside of the AOC. The beaches outside of the AOC include two beaches found upstream of the AOC (Havilland and Harmony) and two beaches found downstream of the AOC (Big Point Park and Beech Beach). The purpose of the assessment was to determine whether beaches within the AOC were comparable to beaches outside of the AOC.

A five-year assessment of PWQO exceedances is summarized in Table 2. Out of all these beaches, Centennial Park is the only beach that exceeds the 20% threshold implemented by the Blue Flag Status Program (FEE, 2014) used both provincially and internationally. It should be noted that this beach was not monitored during 2014 or 2016 due to safety concerns resulting from water clarity issues. High PWQO exceedances in 2013 have skewed the results due to low sample size. It was thought that the activity of wildlife, particularly waterfowl, coupled with wet weather could have caused the periodic *E. coli* spikes at this beach (Leith, cited in Belleau et al. 2015).

Figure 2: Locations of beaches tested by Algoma Public Health and included in multi-year beach assessment.

Table 2: Five-year assessment of PWQO exceedances at public beaches within and surrounding the St. Marys River AOC. Values refer to the number of PWQO exceedances for E. coli by beach over the number of sampling events in the given year.

SITE	2012	2013	2014	2015	2016	5 YEAR ≥100	5 YEAR %
Beaches within AOC							
Pointes des Chenes	2/11	1/8	0/9	2/9	1/12	6/49	12.2
Marks Bay North	2/11	1/8	2/10	1/8	1/11	7/48	14.6
Marks Bay South	2/11	0/8	2/10	2/9	1/11	7/49	14.3
Centennial Park	2/11	4/9	NA	0/3	NA	6/23	26.1
W.I. Park	0/11	0/9	0/9	1/9	1/12	2/50	4.0
Upstream of AOC							
Havilland	2/10	0/8	2/9	0/9	0/11	4/47	8.5
Harmony	1/11	0/8	3/9	0/9	0/10	4/47	8.5
Downstream of AOC							
Big Point Park	1/11	0/9	3/9	0/9	1/12	5/50	10.0
Beech Beach	0/11	0/9	1/9	0/9	1/12	2/50	4.0

The percentage of PWQO exceedances over the five-year assessment can be seen in Figure 3. There are a few instances where individual beaches exceed the 20% threshold but this occurs in beaches found both within and outside of the AOC. As concluded in the 2015 beach Closings assessment, exceedances of PWQO *E. coli* levels do not appear to be any more prevalent at beaches within the AOC versus outside the AOC (Belleau et al, 2015).

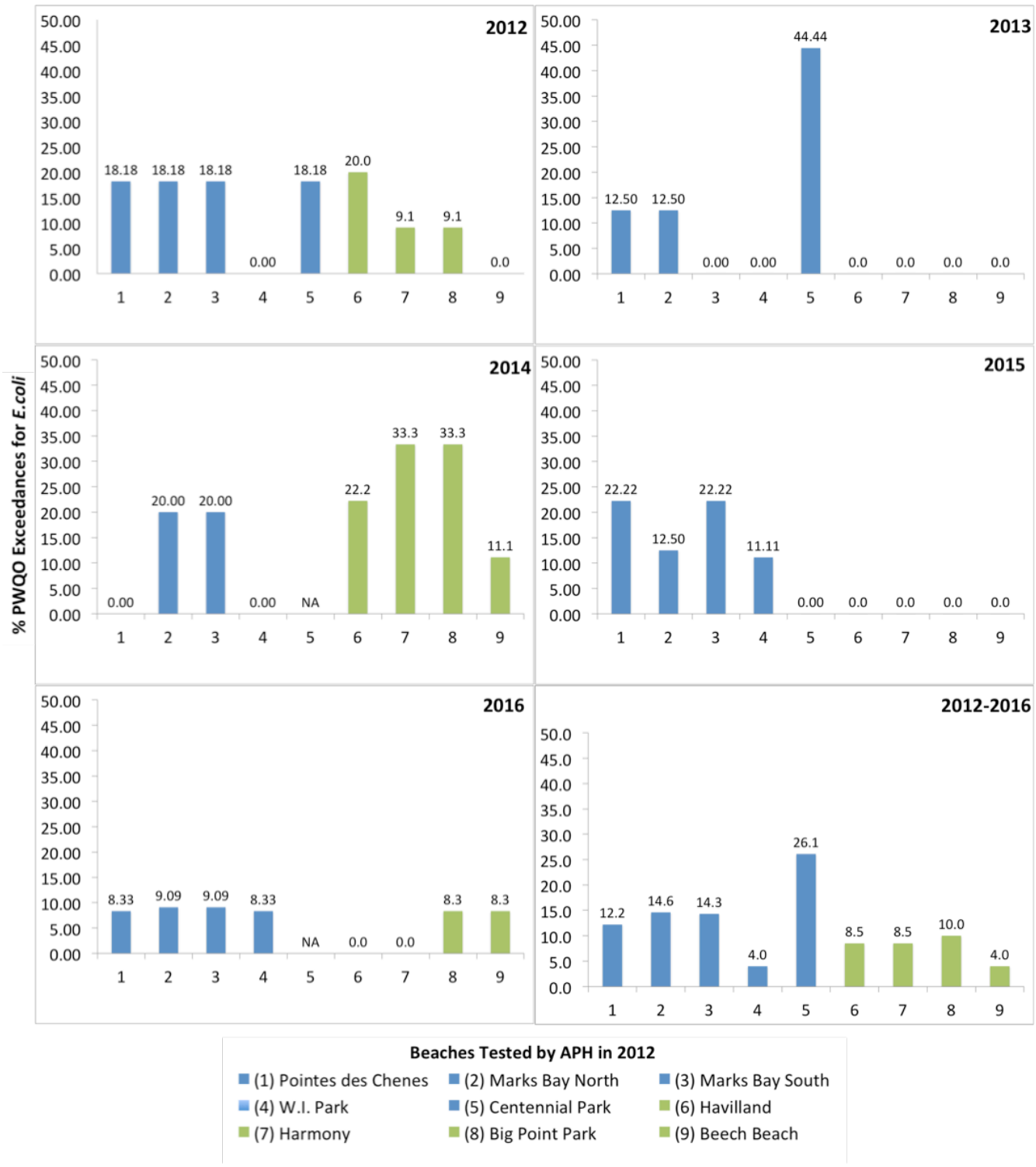

Figure 3: Graphs depicting percentage of PWQO exceedances for *E.coli* over the course of 5 years for beaches tested by Algoma Public Health. Blue represents beaches within the St. Marys River AOC and green represents beaches found outside of the AOC.

The results of this assessment, along with the many upgrades and updates mentioned above, suggest that there are no major local anthropogenic sources of bacterial contamination on the Canadian side of the St. Marys River that would lead to persistent beach closings or advisories within the AOC. Furthermore, the recent study on water quality (Ginou, 2016) shows that the water quality within the St. Marys River AOC is comparable to non-AOC areas. The study concludes by recommending that the closely linked *Eutrophication and Undesirable Algae* BUI and the *Degradation of Aesthetics* BUI be re-designated as not impaired.

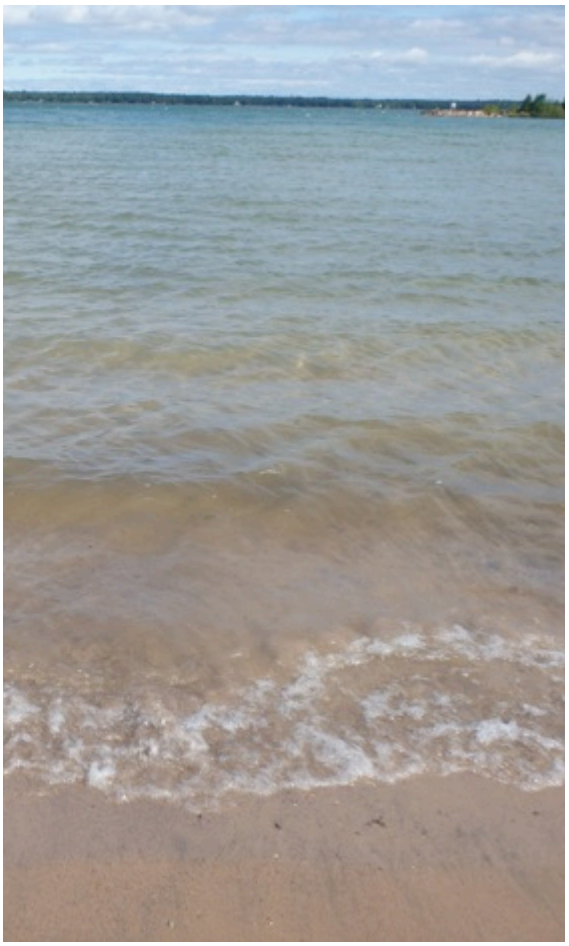

Figure 3: Public beach at W.I. Park in Richards Landing (Photo Credit: Corrina Barrett, 2013).

Figure 4: Water Quality sampling for Algoma University's Water Quality Study (Photo credit: Carrie Ginou, 2015).

3.5 Status of Beach Closings BUI in Sault Ste. Marie, Michigan

The beach closings BUI removal on the U.S. side of the St. Marys River AOC became final on July 27, 2016. Members of the BPAC reviewed the findings relating to beach closings provided by the Michigan Department of Environmental Quality (MDEQ) and supported MDEQ's recommendation to delist the U.S. Beach Closings BUI. Michigan's delisting criteria states that the Beach Closings BUI would no longer be considered impaired when:

- "No waterbodies within the AOC are included on the list of non-attaining waters due to human pathogens in the most recent Clean Water Act *Water Quality and Pollution Control in Michigan: Section 303(d) and 305(b) Integrated Report*, which is submitted to USEPA every two years."
- OR, "if waterbodies in the AOC *are* on the list of non-attaining waters due to human pathogens, the BUI will be considered restored when human sources of pathogens regulated under the National Pollutant Discharge Elimination System (NPDES) are on schedule to be controlled through implementation of permit requirements." (MDEQ, 2015)

The Sault Ste. Marie, Michigan combined sewer system is currently in the process of being separated, with a deadline for completion of December 31, 2018, as required by the City's NPDES wastewater discharge permit. At that point, the St. Marys River will be removed from the State's list of impaired waters for *E. coli*. No further issues have been identified that will not be rectified by this upgrade or otherwise addressed under the NPDES permitting requirement (Riley, 2016).

Similarly in Sault Ste. Marie, Ontario, no further issues have been identified that would not be rectified by the EEWWTP upgrades or addressed under the *City's Stormwater Management Master Plan and Guidelines*.

SUMMARY OF THE CURRENT STATUS OF THE BEACH CLOSINGS BUI

All remedial actions identified in the Stage 2 RAP report have been completed including:

- The development of a stormwater management plan for the City of Sault Ste. Marie (Action PS-2)
- East End Wastewater Treatment Plan upgrades (Action PS-3)
- Confirmation that the floating masses are predominantly comprised of algae, detritus and pollen, and not a significant source of *E. coli* bacteria (Action NPSM-7)

In addition, a multi-year beach water quality assessment was completed in 2016. Results from this study indicate that there are no major anthropogenic sources of bacterial contamination on the Canadian side of the St. Marys River and that the water quality within the St. Marys River AOC is comparable to non-AOC areas.

In Sault Ste. Marie, Michigan, the beach Closings BUI was removed from the US side of the St. Marys River AOC on July 27, 2016.

4. Recommendations

4.1 Re-Designation of the Beach Closings BUI

The Beach Closings BUI delisting criteria, as endorsed by BPAC, has been fulfilled and no further action is warranted. The supplementary assessment of multi-year beach water quality data, which goes above and beyond the delisting criteria, shows that AOC beaches are comparable to non-AOC beaches. Therefore, it is recommended that the *Beach Closings* BUI no longer be listed as impaired.

FINAL RECOMMENDATIONS

- It is recommended that the status of the Beach Closings BUI be re-designated from impaired to not impaired.

4.2 Ongoing Initiatives

City of Sault Ste. Marie's EEWWTP was upgraded and compliance reports have shown that the plant is not a significant contributor to *E. coli* within the river. Stormwater is also being dealt with through the City's Stormwater Management and Master Plan Guidelines. These two items have been addressed as required by the Stage 2 RAP report. However, many other sources can contribute to bacterial contamination, including wildlife and/or pet waste that may be deposited onto beaches or washed into storm sewers, direct discharges of sewage from recreational vessels, and malfunctioning private systems such as those connected to cottages and private houses along the shoreline. These sources have made bacterial contamination ubiquitous within the Great Lakes ecosystem and a problem beyond the scope of individual remedial action plans.

In light of the recommendation to re-designate the status of the Beach Closings BUI to "not impaired", it is recognized that there still are concerns, albeit beyond the scope of the RAP, in regards to bacterial contamination. These concerns may be addressed through other existing programs, ongoing sampling, monitoring, and/or other contaminant reduction measures. Table 3 outlines resources available to continue to manage bacterial contamination.

In addition, Algoma Public Health monitors several public access beaches within the AOC and posts signs when there are potential health and safety risks. Beaches on private lands, including First Nation lands, are the responsibility of the landowner in terms of maintenance and monitoring. Communities can apply for funding from Health Canada to hire a summer technician who can develop a summer sampling plan, collect water samples, and test for *E.coli*. Communities may also seek funding from other sources. A good example of this is the Garden River Great Lakes Guardian Fund project. This project included the installation of educational signage including permitted/forbidden activities (e.g. no dogs off leash, waste/recycling receptacle locations, etc.), installation of pet waste stations, trash and recycling receptacles, and the development of a monitoring and ongoing beach maintenance plan. Projects such as these help to alleviate the amount of pet waste and garbage contributing to bacterial contamination at beaches and ensure that monitoring continues outside of the RAP program.

Table 3: Ongoing programs and resources available for beach monitoring.

Agency/Organization	Program/Protocol	Description
Algoma Public Health	Beach Management Protocol	Algoma Public Health takes water samples from certain public access beaches on a weekly to monthly basis each summer within the boundaries of the Health Unit. Signs are placed to inform the public about potential health and safety risks, including if there are high levels of *E. coli* in the beach water.
Health Canada	Guidelines for Canadian Recreational Water Quality	Guidelines that help to ensure that recreational waters are as free as possible from microbial hazards.
Ontario Ministry of Health and Long Term Care	Beach Management Program	The purpose of this protocol is to assist in the prevention and reduction of water-borne illness and injury related to recreational water use at public beaches, and to assist boards of health in the delivery of local, comprehensive public beach management programs.
The Lake Huron Partnership	Lake Huron Lakewide Action and Management Plan (LAMP)	General objectives of the LAMP that relate to bacterial contamination include: (1) Allow for swimming and other recreational use, unrestricted by environmental quality concerns; and, (2) Be free from pollutants in quantities or concentrations that could be harmful human health; and wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain. Management linkages exist within the framework of the LAMP that commits the Parties to implement programs for pollution abatement and enforcement for municipal sources, industrial sources, and agriculture.
Canadian Council of Ministers of the Environment	Canada-wide Strategy for the Management of Municipal Wastewater Effluent	A strategy that requires all wastewater facilities achieve minimum National Performance Standards. Site-specific effluent objectives are required to be managed in a way that provides additional human health and environmental protection. The effluent objectives cover pollutants such as pathogens and include *E.coli* contamination.
Clean Beaches Council	Blue Wave Campaign	Provides an annual list of beaches that have been certified as clean and healthy. Beaches must undergo a strict set of criteria for cleanliness and environmental health.
Great Lakes Commission	Great Lakes Beach Association	The Great Lakes Beach Association is a collaboration of more than 600 local and state beach managers, working together to improve recreational beach water quality through an informal information-sharing forum.
Ontario Ministry of Environment and Climate Change	Great Lakes Guardian Community Fund	As part of Ontario's Great Lakes Strategy, the Great Lakes Guardian Community Fund was set up to help people take action to protect and restore their corner of the Great Lakes.

CONTACTS

Should you ever observe something that requires investigation, contact the following local health authorities and/or provincial and state authorities:

- Algoma Public Health (APH): 705-254-6611
- Ontario Ministry of Environment and Climate Change (OMOECC): 1-800-268-6060
- Michigan Department of Environmental Quality (MDEQ): 1-800-292-4706
- Chippewa County Health Department (CCHD): 906-635-1568

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Appendix

Environmental Science Engineering MAGAZINE

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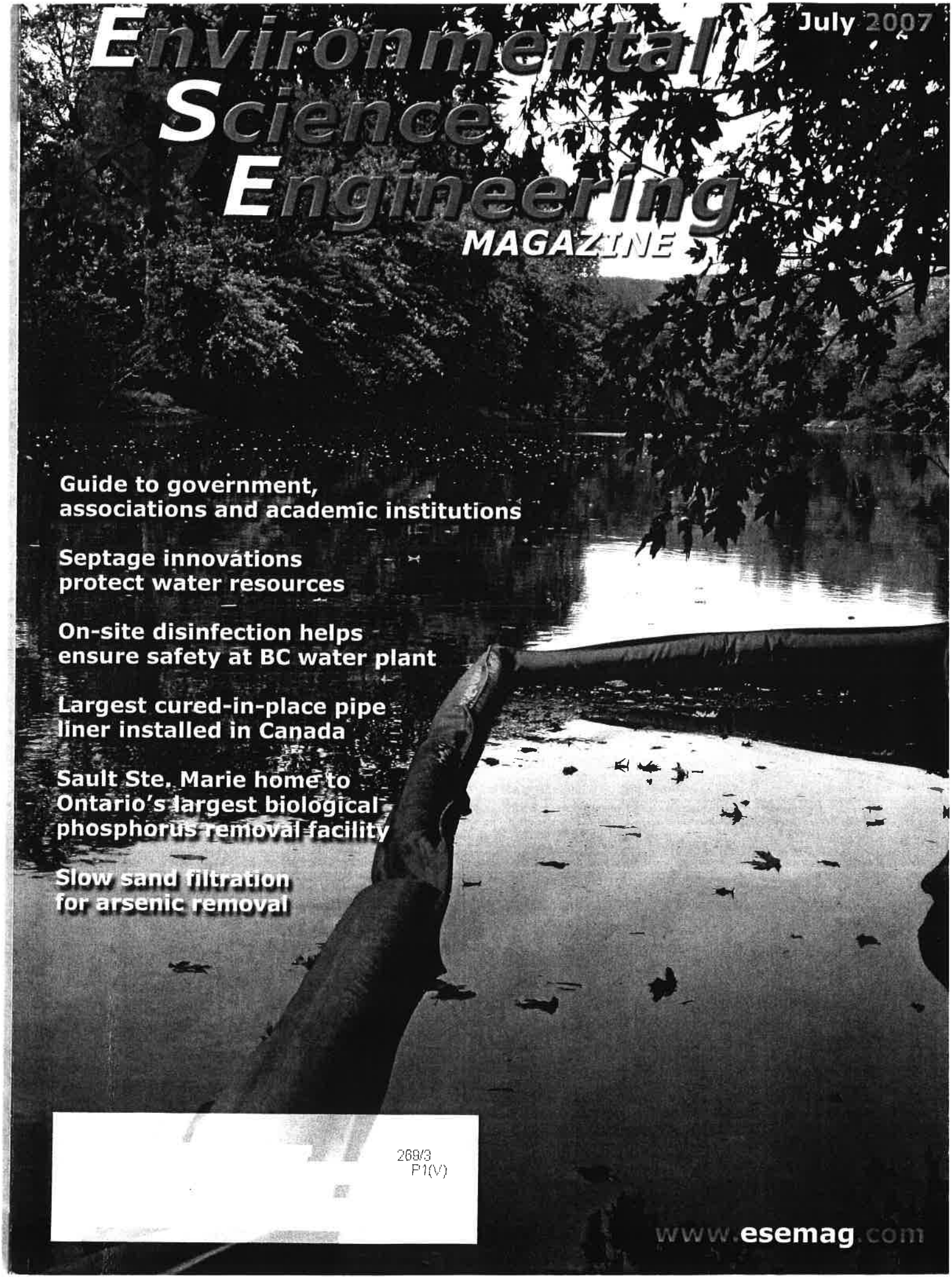

Guide to government, associations and academic institutions

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Sault Ste. Marie home to Ontario's largest biological phosphorus removal facility

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Ontario's largest biological phosphorus removal facility in the City of Sault Ste. Marie

By Rajiv Kothari and John Myatt, P Eng.

Bioreactors with blower and UV buildings in the background.

Regulations are becoming more stringent on concentrations of phosphorus discharged into surface water. Conventional biological wastewater plants achieve less than 20% total phosphorus removal while wastewater treatment plants with anaerobic digester supernatant recycled to the head of the works achieve even less removal.

Due to such low levels of total phosphorus (TP) removal in conventional plants, additional or alternative methods are employed to achieve the 1 mg/L phosphorus in the effluent. Many treatment plants have been designed or upgraded to remove phosphorus by the addition of chemicals such as alum or ferric chloride. Chemical precipitation increases the volume of sludge produced and can result in a sludge that has poor settling and dewatering characteristics. Also chemical precipitation with metal salts can depress the pH of the effluent. If nitrification is required, additional alkalinity will be consumed and the pH will drop further.

Background

The Sault Ste. Marie East End Water Pollution Control Plant (WPCP) is located at 2221 Queen Street East. Prior to the recent plant upgrade, it was a primary treatment facility discharging treated effluent to the St. Mary's River. The WPCP had two treatment trains that have the same treatment processes. Plant A, built in 1959, had a rated capacity of 36.3 ML/day and was located on the east side of the property. Plant B, built in 1972, had a rated capacity of 18.2 ML/day and was located on the west side of the property. The total design average capacity was 54.5 ML/day.

Both Plant A and B consisted of mechanical screens, grit removal tanks, primary clarifiers and chlorine contact tanks. There was a pair of influent channels and Parshall flumes upstream of the two existing inlet buildings. Alum was added to the primary clarifiers for phosphorus removal. A sludge dewatering facility was constructed in 1987. The dewatering system consisted of primary sludge storage tanks, polymer addition system and two plate and frame dewatering presses.

The International Joint Commission's Great Lakes Water Quality Board identified the St. Mary's River as an Area of Concern and a Remedial Action Plan (RAP) is in place. The major objectives of the project were to improve effluent quality by providing secondary treatment and to reduce the effects of the high peak storm flows to the plant.

The East End WPCP has undergone a major upgrade including new inlet screens, grit removal tanks, primary clarifiers, activated sludge using the biological phosphorus removal (BPR) process with nitrification, denitrification and biological phosphorus removal, secondary clarifiers, UV disinfection and sludge thickening and dewatering. The existing average day flows are much lower than the previous rated capacity of 54.5 ML/day.

Therefore, it was recommended that the new primary and secondary treatment facilities be constructed in two phases: Phase 1 – 36 ML/day and Phase 2 – 54.5 ML/day. The plant will operate

Parameter	Compliance	Design Objective
BOD_5 (mg/L)	25	15
SS (mg/L)	25	15
Total P (mg/L)	1.0	0.5
Un-ionized ammonia (mg N/L)	0.25	0.20
E. Coli (No./100 mL)	200	150

Table 1. Sault Ste Marie East End WPCP Effluent Requirements.

under a new Certificate of Approval (C of A) issued by the Ontario Ministry of Environment. The new effluent quality requirements for the plant are presented in Table 1.

Biological phosphorus removal

Biological phosphorus removal can be considered basically a two step process. First the biomass is forced to store excess soluble phosphorus under controlled conditions. Then the biomass is removed via a sludge wasting system within the plant. The BPR process in treatment plants can reduce or eliminate the need for chemical addition by offering the following benefits:

- Improved sludge settleability and dewatering characteristics.
- Reduced oxygen requirements.
- Reduced process alkalinity requirements.
- Lower operating cost due to little or no chemical addition and better blower efficiency.
- Lower sludge production.

Earth Tech's experience at several Biological Nutrient Removal (BNR) plants in Western Canada indicates that the bioreactor configuration that best satisfies these criteria, commonly referred to in the literature as the Westbank Process is comprised of the following reaction zones in series:

- ***Preanoxic Zone:*** Return activated sludge (RAS) is fed to this zone together with a small fraction of the primary effluent. Rapid denitrification of RAS is ensured by the introduction of primary effluent before the anaerobic zone.
- ***Anaerobic Zone:*** Denitrified RAS from the preanoxic zone is mechanically mixed with short chain volatile fatty acid (SCVFA) rich primary sludge fermenter supernatant in this zone. The truly anaerobic environment that is created favours the proliferation of bio-P bacteria that can use energy, stored in the form of polyphosphate, to absorb simple carbon sources (principally SCVFAs).

Supernatant from the fermenter, which provides a reliable source of SCVFA to the process, is introduced into this zone. The absorbed carbon source is metabolized in the subsequent anoxic and aerobic zones. Because bio-P bacteria remain viable in this zone, they enjoy a competitive advantage over other heterotrophic bacteria and proliferate in the system.

- ***Anoxic Zone:*** Mechanically mixed cells are provided where anaerobic zone effluent mixed liquor, the remaining pri-

continued overleaf...

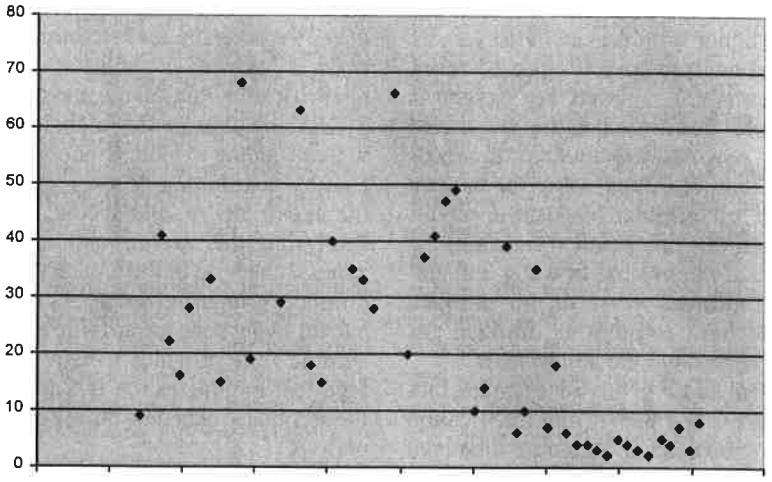

Figure 1 showing the TSS concentrations in the plant effluent from January 2006 to January 2007.

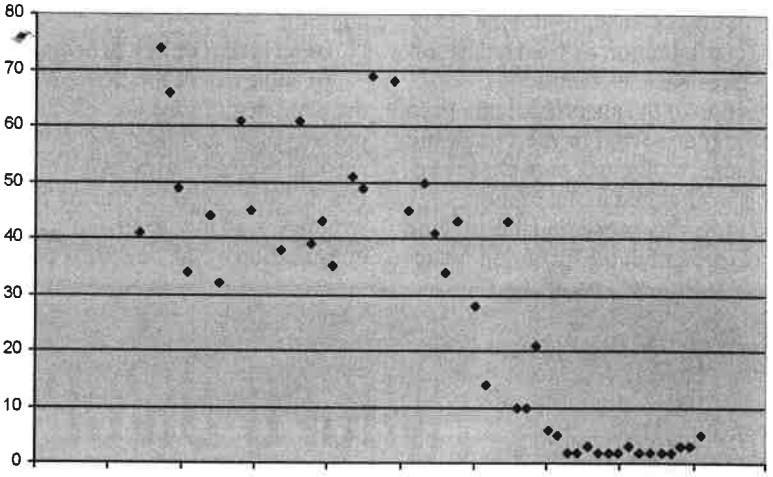

Figure 2 showing the BOD concentrations in the plant effluent from January 2006 to January 2007.

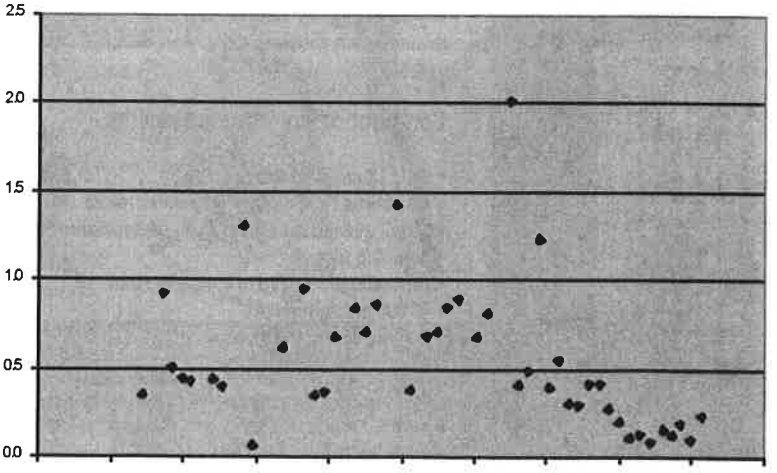

Figure 3 showing the phosphorus concentrations in the plant effluent from January 2006 to January 2007.

mary effluent, and recycled nitrified mixed liquor from the end of the aerobic zone are mixed and allowed to react. Oxygen is not supplied, but oxygen is available from nitrates in the mixed liquor recycle. Metabolism proceeds with the nitrates becoming the oxygen source, or terminal electron acceptor. Through this biochemical reaction, the nitrates are converted to water and elemental nitrogen. Most of this nitrogen evolves from solution as nitrogen gas and is released to the atmosphere.

• ***Aerobic Zone:*** In this zone, carbon metabolism is completed, and nitrification and P uptake occur. Accurate dissolved oxygen concentration control is imperative to ensure that minimal oxygen is recycled to the anoxic zone where it would interfere with denitrification, to reduce energy costs, and to allow some control of sludge settleability.

Earth Tech's design of the BPR process configuration focused on the following three basic elements:

1. Protection of the anaerobic zone from nitrates and dissolved oxygen to ensure that reliable biological phosphorus removal is maintained in the process.
2. Feed of readily biodegradable organic material (present in the incoming wastewater) to anoxic zones. This feature reduces the potential for Microthrix *parvicella* growth and enhances denitrification rates in the anoxic zones.
3. Optimization of the bioreactor size without adding to bioreactor complexity, first by distributing primary effluent to the anoxic zones, and second, by concentrating the anoxic and anaerobic zones at the head of the bioreactor. In addition, a primary effluent bypass to an anoxic swing zone towards the end of the aerobic zone provides a degree of step feed that minimizes the flux loading to the secondary clarifiers during high flow periods.

Current operational experience from the plants in Western Canada has shown that phosphorus levels below 0.5 mg/L in the final effluent are achievable via the BPR process and lower levels below 0.1 mg/l can be achieved with chemical addition.

Description of key process units

To some extent the existing layout of the plant determined the selection of the process units and their locations on the site and provided cost-saving opportunities for the client. Some of the infrastructure was modified and used in the construction of the new BPR plant.

Primary clarifiers and primary sludge fermenter

There were six existing primary clarifiers on the plant site. It was believed that all six of the existing primary clarifiers were beyond their economic service life. Consequently, these were replaced with three modern deeper rectangular clarifiers. Two of the old clarifiers were converted into a primary fermenter and an open-top biofilter as a cost-saving exercise.

Analysis of the wastewater entering the plant indicated that there are insufficient short chain volatile fatty acids naturally present to maintain reliable biological phosphorus removal in the process. Consequently, the primary sludge fermenter was built to generate SCVFAs at the plant, and the SCVFA-rich fermenter supernatant is discharged into the BPR bioreactor. Primary sludge is pumped in a dilute form from the primary clarifiers to the primary sludge fermenter.

Bioreactors

There are two identical multi-cell bioreactors, each with a volume of 6,000 m^3. A third similar 6,000 m^3 bioreactor will be required to handle the Phase 2 flow of 54,000 m^3/d. Each bioreactor has the following zones, in order – pre-anoxic, anaerobic, anoxic 1 & 2 and aerobic 1 & 2, swing and aerobic 3.

Disinfection

The secondary effluent is disinfected to reduce the coliform concentrations to the levels specified in the Certificate of Approval. Historically chlorine has been used for disinfection. However, the Ministry of the Environment (MOE) is now requiring municipal effluents to be non-toxic and, according to the C of A, chlorine is to be less than 0.02 mg/L. The UV disinfection system was designed for the initial peak flow of 170 ML/day. The UV system consists of two banks of lamps in one channel. An additional module of lamps can be added to each bank in the future to handle the ultimate peak flow of 215 ML/day.

Waste activated sludge thickening and sludge dewatering

The use of dissolved air flotation (DAF) was preferred due to lower capital and operation/maintenance costs, lower odour levels and its relative insensitivity to WAS feed concentrations which facilitates selective sludge wastage and hydraulic SRT control. Previously, the WPCP used two plate and frame presses to dewater primary sludge. The addition of secondary treatment will

increase the sludge quantities significantly and will require that higher polymer dosages and lower loading rates be used. New centrifuges were installed to replace the existing presses as centrifuge dewatering has been incorporated at numerous BPR plants due to its improved compatibility with the process. Primary sludge and thickened WAS are stored separately and fed to a blending point just upstream of the centrifuges.

Commissioning of the plant

The initial stage of commissioning began in August 2006 when the sewage flow was switched over from the old to the new plant. Seed sludge from the Sault Ste. Marie West End WPCP Plant was added to the bioreactors. Construction work was still ongoing when the plant was brought online. During the initial phase of commissioning, the plant was operated similar to a conventional activated sludge plant and subsequently, the plant was scheduled to be commissioned and optimized as a BPR plant once the fermenter is ready to come online. The results discussed are from the initial stages of commissioning and do not show the full potential of the BPR treatment process at this stage.

Early stages of commissioning started to show positive results in effluent quality. The effluent TSS concentration started to drop as soon as flow was switched over to the new plant. The introduction of secondary treatment improved the TSS removal in the plant. The results in Figure 1 show the TSS concentration being constantly below 10 mg/L since mid-Oct 2006.

The reduction in BOD effluent concentrations also improved significantly as the new plant started to generate mixed liquor in the bioreactor for biological treatment. Once the mixed liquor concentration increased in the bioreactor, the BOD removal rates increased simultaneously to produce lower BOD concentrations in the effluent, as shown in Figure 2.

The phosphorus concentrations in the effluent discharge have shown a significant reduction as the phosphorus was being removed in the primary and secondary waste sludge. Figure 3 shows the phosphorus concentration in the discharge dropped to below 0.5 mg/L level since Oct 2006.

After the initial stage of commissioning, usage of alum in the system, required for chemically assisted phosphorus removal, also began to drop. The longer sludge age in the bioreactor was beginning to provide partial Bio-P removal in the system. The plant at the moment is probably over-dosing alum in the bioreactor as the effluent phosphorus concentration is well below the compliance limit set by the MOE.

Even though the commissioning of a majority of the process units has been completed, the biological phosphorus removal was not running at the time of writing this article due to cold weather problems during startup. The fermenter was expected to come online towards the end of June, 2007 and the BPR process can be optimized as the SCVFAs from the fermenter will provide the catalyst to jump-start the process.

Summary

One of Ontario's largest biological phosphorus removal plants in Sault Ste. Marie is undergoing the final stages of commissioning. The effluent quality being discharged into St. Mary's River is already meeting the MOE discharge compliance limits.

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