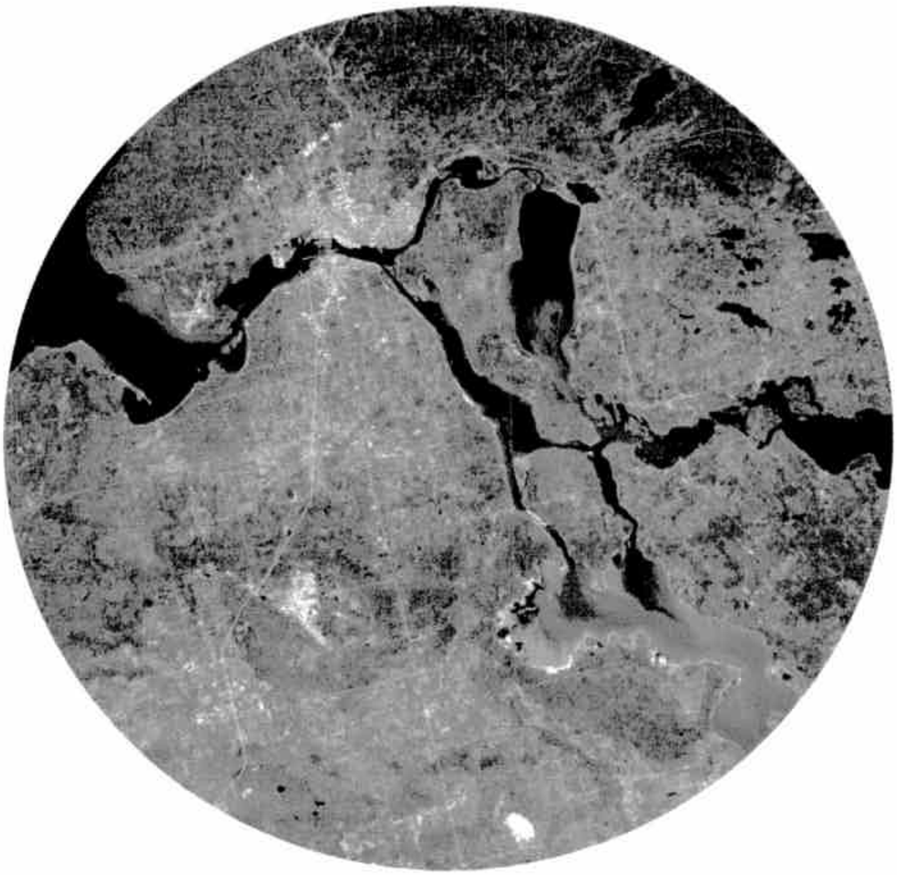
ST. MARYS RIVER AREA OF CONCERN

Bellevue Marine Park Contaminated Sediments

Application of the Canada-Ontario Contaminated Sediments Decision-Making Framework



KRESIN Engineering Corporation

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In association with: GENIVAR Ontario Inc.
Shelby Environmental Services

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Executive Summary

In July, 2006, the Ministry of the Environment (MOE) in partnership with the Sault Ste. Marie and Region Conservation Authority (SSMRCA) commissioned Kresin Engineering Corporation (KEC) and associated environmental consultants to develop a contaminated sediment management strategy for the Bellevue Marine Park area (BMP).

Several historical reports were provided by the MOE for review to identify data gaps and utilize the available information to apply the Canada-Ontario Decision-Making Framework for Contaminated Sediments. Zoning, ownership and use of waterlots and properties adjacent to the BMP were also investigated.

This report presents a summary of a review of available information and application of the decision-making framework. As several data gaps were identified during this process, the decision-making framework could only be applied to a limited extent. As a result, this report is a precursor to additional studies that are required in order to complete the steps in the decision-making framework and design an appropriate contaminated sediment management plan for the BMP.

1.0 Introduction

In July, 2006, the Ministry of the Environment (MOE) in partnership with the Sault Ste. Marie and Region Conservation Authority (SSMRCA) commissioned Kresin Engineering Corporation (KEC) and associated environmental consultants to develop a contaminated sediment management strategy for the Bellevue Marine Park area (BMP).

The BMP is an embayment approximately $1km^2$ in area on the Canadian side of the St. Marys River, which is bound by the Purvis Marine dock to the west, Top Sail Island to the east and Bayfield Dike Light to the south. The BMP is characterized by unusual substrate conditions that include sediment with wood chips and fibres throughout and the presence of elevated concentrations of oil and grease, total organic carbon, polycyclic aromatic hydrocarbons, petroleum hydrocarbons, and metals. Due to the numerous contaminants present in the sediment, the International Joint Commission (IJC) has ranked the BMP as the worst contaminated site along the St. Marys River AOC[1]. Recent studies have also suggested that the contaminated sediment may be linked to toxic effects observed in the sediment-dwelling organisms that reside in the BMP[2].

The Project Team assigned to develop a contaminated sediment management strategy for the BMP include representatives of the MOE, Environment Canada (EC), the SSMRCA and the environmental consultant team that include specialists at KEC, GENIVAR Ontario Inc. (formerly MacViro Consultants) and Shelby Environmental Services.

1.1 Objectives

The objective of this study is to develop a contaminated sediment management strategy for the BMP. This report addresses the following project goals:

1. Review, amalgamate, and synthesize all relevant sediment quality data (reports presently housed in the MOE Sault Ste. Marie office) for the BMP embayment and identify any data gaps relating to sediment, benthos or water quality;
2. Document land ownership and use, zoning and water lot rights in the area; and
3. Apply the risk-based approach in the Canada-Ontario Decision-making Framework for Contaminated Sediments towards the design of a contaminated sediment management plan for the BMP area that includes screening level environmental benefits and risks, and project costs.

1.2 Background

Several previous studies have investigated the sediment conditions and the benthic invertebrate community in the BMP. Studies completed by the Ontario Water Resources Commission (OWRC) and the MOE in 1967 and 1973 found evidence of severe adverse

[1] Golder, 2004.
[2] Milani, D. and L.C. Grapentine. 2006.

impacts to the benthic community along the waterfront in Sault Ste. Marie, Ontario. The studies also reported elevated concentrations of iron oxide, chromium, phenols, phosphorous, nitrogen, oil, and naphthalene in sediment. Large amounts of wood chips and fibres were also discovered in the substrate. Despite reductions of contaminants being discharged to the St. Marys River, a subsequent study completed by the MOE in 1983 reported that the benthic communities had not improved significantly since the 1967 and 1973 studies. Impairment of sediment quality and benthic communities was also observed in MOE studies completed in 1985, 1987, 1990 and 1992.

Although some of the recent studies indicate that there is no strong evidence of alteration to benthic communities in the St. Marys River Area of Concern (AOC) (with the exception of the Algoma slip), others[3] have shown that the Bellevue Marine Park (BMP) shows evidence of benthic community impairment. Benthic community impairment may be caused or contributed to by the poor sediment quality in the BMP, which is characterized by an unusual substrate containing wood chips and fibres, oils and grease, and elevated concentrations of chemicals in sediment. The following chemicals are commonly listed in the literature as being identified in the BMP sediment:

1. Metals
2. Total Organic Carbon (TOC).
3. Polycyclic aromatic hydrocarbons (PAH)
4. Petroleum hydrocarbons (TPH)

And to a lesser extent:

5. Polychlorinated biphenyls (PCBs)

The most recent data collected from shallow sediment samples (<10cm) in 2002 indicate that concentrations of metals, TOC, and PAH in sediment were above the Provincial Sediment Quality Guidelines (PSQG) Lowest Effect Level (LEL) and in some cases the concentrations were above the PSQG Severe Effect Level (SEL). Concentrations of TPH were above upstream reference concentrations (the reference sites were used for comparison as there are no sediment criteria for petroleum hydrocarbons). In addition, a shallow sediment sample (<10cm) collected in 1995 indicates that a concentration of PCBs exceeded the PSQG low effect level.

1.3 Sediment Quality Assessment Criteria

The sediment quality data presented in this report are assessed through comparative evaluation with the PSQG. PSQGs were established by the MOE to protect the aquatic environment by establishing different levels for metals, nutrients and organic compounds. The PSQGs are typically used to identify contaminated sediments and to develop sediment management strategies and Remedial Action Plans (RAPs).

[3] Milani, D. and L.C. Grapentine. 2006.

PSQGs are classified into three categories that describe different levels of effects that contaminants may have on sediment-dwelling organisms: No Effect Level (NEL), LEL, and SEL. LEL and SEL consider the long-term effects. A description of each level of effect is described below:

1. NEL indicates that the concentrations of chemicals in sediment do not affect fish or sediment-dwelling organisms. No transfer of chemicals through the food chain, no effect on water quality is expected and no management decisions are required.

2. LEL indicates the sediment contamination level that can be tolerated by the majority of benthic organisms. A contaminant concentration that is equal to or greater than the LEL may result in adverse affects on the sediment-dwelling organisms and may require further testing and a management plan.

3. SEL indicates the sediment contamination level that could be potentially detrimental to the majority of benthic organisms. A contaminant concentration that is equal to or greater than the SEL indicates sediment that is highly contaminated and will have a significant affect on the benthic community. In this case, further testing is required to determine whether or not the sediment is acutely toxic, and a management plan typically ensues.

1.4 Bellevue Marine Park Site Description

The BMP site is an embayment located along the northern shoreline of the St. Marys River in Sault Ste. Marie, Ontario. As depicted in Figure 1; the BMP extends from the Purvis Marine Dock (formerly the Government Dock) in the west to Top Sail Island in the east and lies north of Bayfield Dike. The site is estimated to have an area of about 1 km^2. According to the MOE (1995) sediments assessment report, the BMP contains approximately 2.2 million cubic meters of sediment. Several contaminants have been identified in the sediment, which has resulted in the BMP being ranked the worst contaminated site along the St. Marys River AOC by the International Joint Commission (IJC)[4].

The BMP embayment is the first major depositional zone in the River downstream of the industrial sources in Sault Ste. Marie[5]. The St. Marys River flows in an easterly direction and connects Lake Superior with Lake Huron. Sediment is transported along the main flow path of the River, and settles out in zones such as the BMP.

1.5 Surrounding Areas

The areas surrounding the BMP include a variety of natural, industrial and urban lands.

[4] Golder, 2004.
[5] Golder, 2004.

Areas to the West

Areas to the west include several industries including, Algoma Steel Inc. (ASI), St. Marys Paper Ltd. (SMP), and the West End Water Pollution Control Plant, along with storm and historical combined sewer outlets, and the St. Marys Falls. Purvis Marine Dock is located at the west boundary of the BMP.

ASI and SMP are located near the waterfront in Sault Ste. Marie, upstream of the BMP, and have been a main source of contaminants to the St. Marys River for more than a century. ASI releases emissions that are a persistent source of toxic substances, including, benzene and polycyclic aromatic hydrocarbons (PAHs). According to point source loadings gathered between 1986 and 1988, discharges from ASI represented 76% of the total oil and grease loadings and 45% of the PAHs to the St. Marys River. This trend has been corroborated by a sediment core taken from Lake George (downstream of the BMP), which has a geochronological record that is in excellent agreement with historical steel production[6]. Direct sources of contaminants from the steel industry include PAHs (a by-product of coke production), cyanide and many heavy metals. A secondary source of PAH is through atmospheric deposition[7].

SMP has historically discharged foreign materials to the St. Marys River, mainly wood fibres and chips[8]. This material has largely altered the sediment conditions in the BMP by introducing a large volume of organic material. The interactions between sediment contaminants and the organic material are largely unknown.

The City's West End Water Pollution Control Plant is also located upstream of the BMP and is responsible for some of the suspended solids released to the River. Other industries upstream of the BMP that no longer are in operation (such as a tannery and a chrome plating facility) may also have contributed to the contaminants in the BMP.

Other possible sources of contaminants upstream of the BMP include the discharge from storm sewers and historical combined sewer overflow (CSO). Contaminants present in the sewer outfalls typically include a variety of chemicals and sediment associated to urban runoff. Contaminants associated with the CSO may be more significant as the overflows contained untreated sewage; as a result, the contaminants may be biological and/or chemical in nature, and typically include nutrients and sediment. These contaminants likely contribute to the poor sediment quality in the BMP.

Areas to the East

To the east of the BMP (downstream) is a small marshy area, which is not considered to have a high level of environmental sensitivity, since it has shown no negative impacts associated with the nearby anthropogenic activities.

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[6] Hesselberg and Hamdy, 1987
[7] Bedard and Petro, 1997.
[8] Kilgour, Martin and Kauss, 2001.

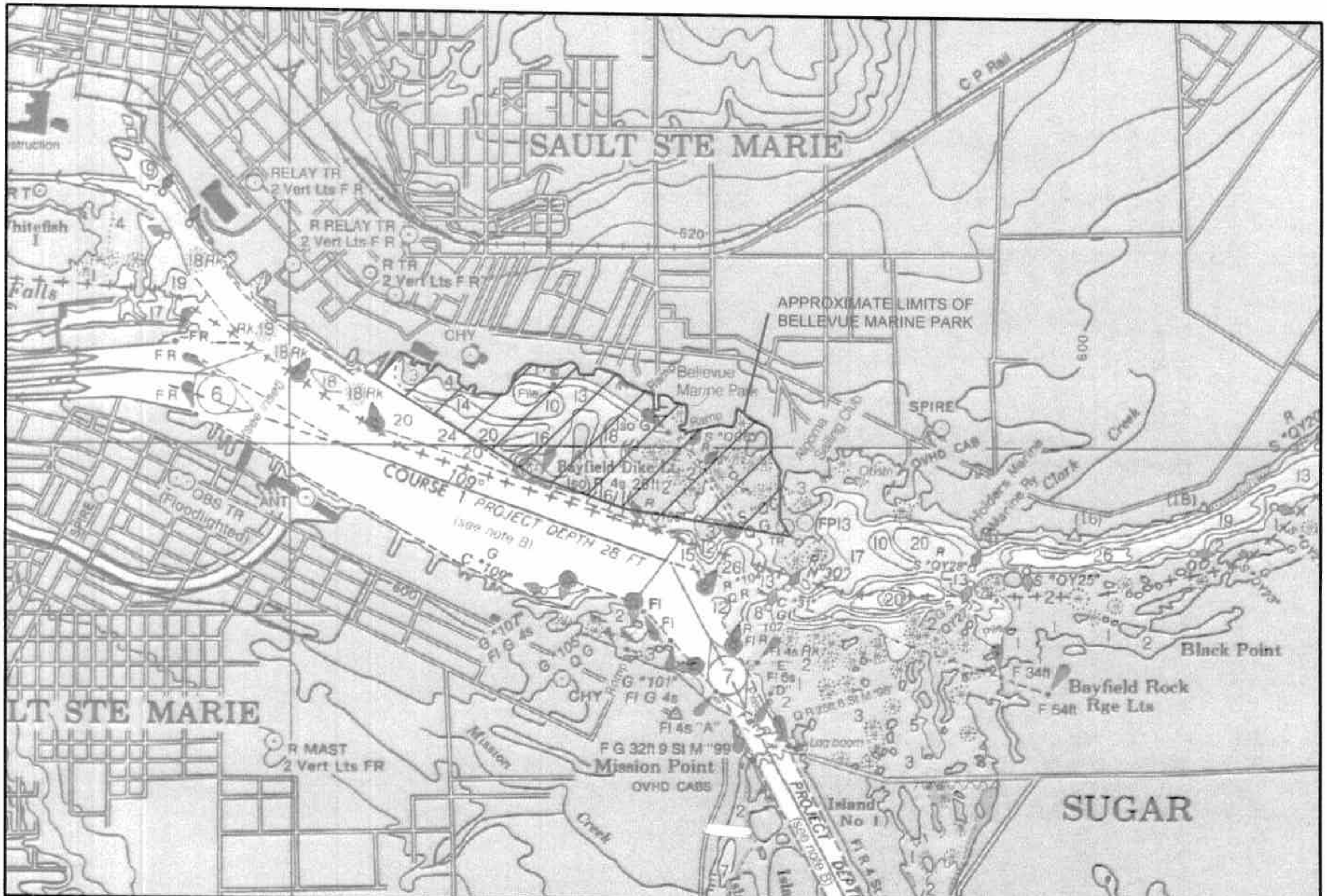
Areas to the South

The area to the south of the BMP includes the main flow path of the St. Marys River. The River is navigated by numerous vessels and is periodically dredged to prevent shoaling of the navigable waterway. Large vessels deliver refined petroleum products to the Purvis Marine Dock, the receiving port in the St. Marys harbour. The transport of petroleum products is a potential environmental concern if a leak or spill were to occur in the River.

Areas to the North

To the north of the BMP embayment, along the St. Marys River shoreline, is the Bellevue Municipal Park, Bellevue Municipal Marina, residential and institutional lands and the Bellevue Park CSO tank (overflow outlets to the BMP). The recreational areas are used by many people, including boaters, youth, anglers, shore picnickers and day-users. Due to the popularity of the BMP, there is a potential for human contact with the contaminated sediment, which presents a health concern.

Figure 2 illustrates the areas surrounding the BMP.



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Engineering Corporation

Bellevue Marine Park
Sault Ste. Marie Region CA

Limits of BMP Site

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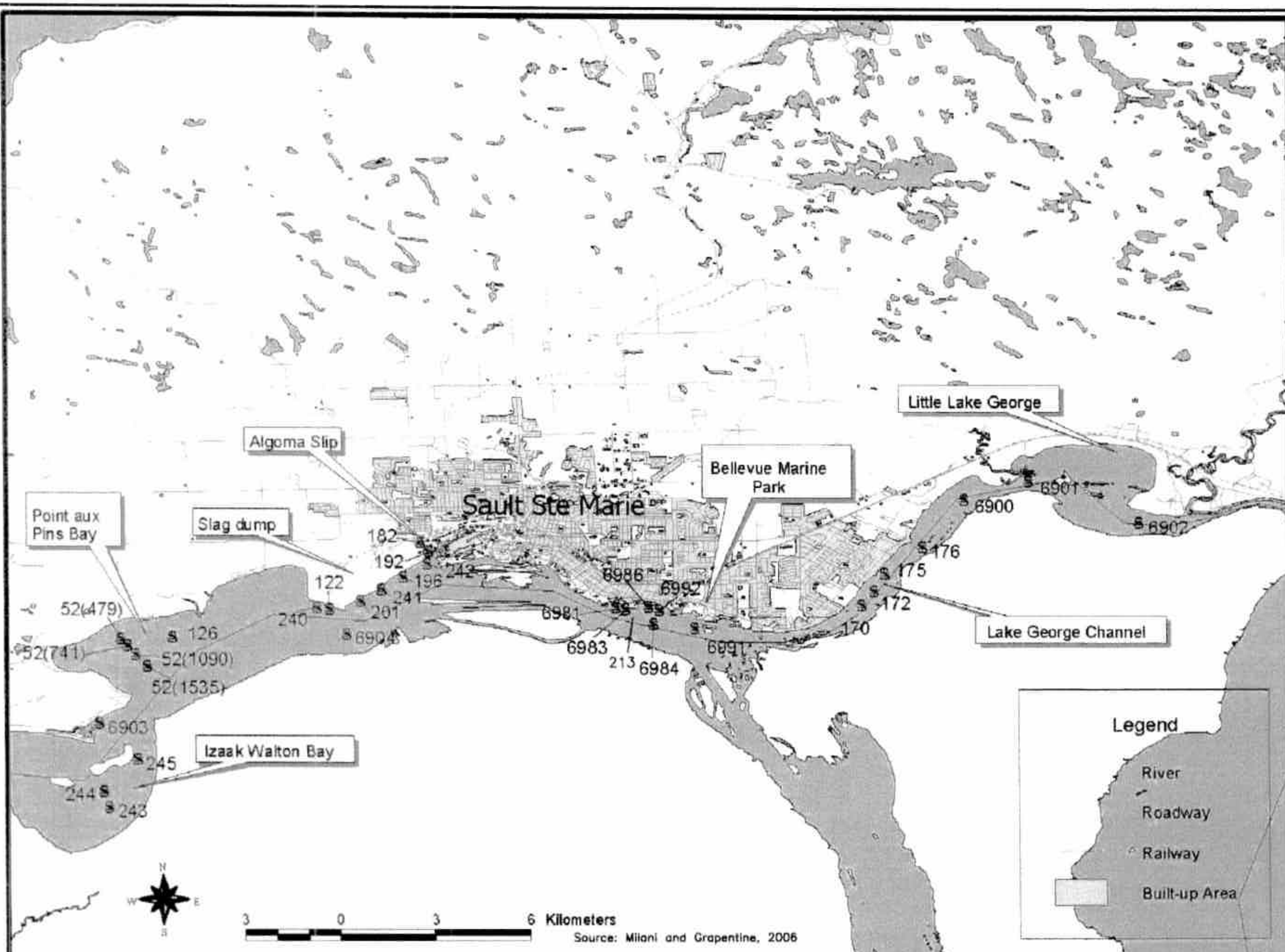

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Bellevue Marine Park Restoration
Sault Ste. Marie CA

GENERAL PLAN

2

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2.0 Summary of Reviewed Documents

This section presents a general overview of available reports that provide information concerning benthos, sediment, and water quality in the BMP. In addition to the AOC RAP documents, the following documents were reviewed in preparing this report:

1. Milani, D. and L.C. Grapentine. 2006. The Application of BEAST Sediment Quality Guidelines to the St. Marys River Area of Concern.
2. Golder Associates Inc. 2004. "Synthesis of Sediment and Biological Investigations in the St. Marys River Area of Concern."
3. Kilgour, B.W., W.B. Morton and P.B. Kauss. 2001. Sediment and Benthic Invertebrate Community Assessment of the BMP Area in the St. Marys River.
4. Arthur, A. and P.B. Kauss. 2000. Sediment and Benthic Community Assessment of the St. Marys River.
5. Bedard, D. and S. Petro. 1997. Laboratory Sediment Bioassay Report on St. Marys River Sediments 1992 and 1995.
6. Kauss, P. 1996. Preliminary St. Marys River Sediment Survey Data.
7. Hesselberg. R.J. and Y. Hamdy. 1987. Current and Historical Contamination of Sediment in the St. Marys River.

2.1 Remedial Action Plan Reports

Numerous studies have been conducted that provide valuable information regarding the sediment quality in the St. Marys River, including the physical and chemical properties of the sediment and associated toxicity effects on the benthic communities. Some of the reports focus on the St. Marys River AOC and others on specific sites within the AOC, like the BMP. From an AOC planning perspective the three key documents include:

1. Stage 1 Report of the St. Marys River Area of Concern Remedial Action Plan, 1992.
2. Stage 2 Remedial Action Plan Report – Remedial Strategies for Ecosystem Restoration, 2002.
3. St. Marys River Remedial Action Plan Implementation – Review Project, 2004.

2.1.1 Stage 1 Report of the St. Marys River AOC RAP, 1992

The Stage 1 Report established that sediment quality and benthic communities among other indicators at several sites along the River are impaired and identified the BMP as one of these sites. The RAP Stage 1 report states that sediments along the Ontario shoreline, which encompasses the BMP site, are heavily polluted with iron, zinc, lead, manganese, cadmium, nickel, copper, chromium, arsenic and oil and grease. The following Beneficial Use Impairments (BUIs) associated to the BMP were identified in the Stage 1 Report:

1. Restrictions on fish consumption;

2. Degradation of benthos;
3. Restrictions on dredging; and
4. Degradation of aesthetics.

2.1.2 Stage 2 RAP Report: Remedial Strategies for Ecosystem Restoration, 2002

The Stage 2 report outlines various strategies to remediate the BUIs and defines objectives for remediation purposes. With specific reference to the BUIs associated with the BMP site, the following Remediation Actions and Monitoring Actions are presented in the Stage 2 report:

Remediation Actions

1. Virtually eliminate all persistent and bioaccumulative contaminants from industrial and municipal discharge.
2. Develop a multi-agency sediment management program for the river to address remedial options and implement actions for contaminated sediments, including long-term sediment contamination studies.
3. Conduct further studies to characterize sediment quality in high priority areas (ie., adjacent to Algoma Slag Dump, portion of Little Lake George Channel downstream of East End WPCP, and the Algoma Slip).
4. Complete sediment chemistry analysis and benthic community assessment as part of the St. Marys River Contaminated Sediment Zones Evaluation (Kauss 1999b).
5. Develop a multi-agency sediment management program for the river to address immediate dredging needs.

Monitoring Actions

1. Re-sample river sediments every five years to obtain trend with time information.
2. Periodically conduct benthic, toxicity, and sediment chemistry studies in the BMP area.
3. Assess potential human health risks resulting from floating sediment near and downstream from the BMP.

In response to the Remediation Actions, with specific regard to Items 4 and 5, an in-depth study of the BMP was undertaken that investigated sediment chemistry, bioassays, and benthic invertebrate population data collected in 1995[9]. A more recent study in 2006 provided additional sediment chemistry data and statistical analyses to estimate relationships between sediment toxicity and benthic invertebrate impairment[10].

[9] Kilgour, Martin and Kauss, 2001
[10] Milani and Grapentine, 2006

In response to the Monitoring Actions, with specific regard to Item 3, no assessment of potential human health risks associated with floating sediments in the BMP has been undertaken to date according to the reports reviewed.

2.1.3 St. Marys River RAP Review Project, 2004

In 2004, a RAP status report[11] was prepared on behalf of the MOE, EC and the SSMRCA. The RAP status report reviewed the status of RAP implementation activities. Included in the report are descriptions of: the magnitude of the contaminated sediment problem in the AOC, St. Marys River sediments and the associated contaminants decision-making framework, and a suggested remediation project focusing on the BMP.

Remediation of the BMP, although located downstream from other contaminated sites (e.g. Algoma Slip), was recommended for consideration. This site was identified following a synthesis of available information considering degree of contamination, land use goals, potential for human contact, hydrologic and shoreline characteristics, land ownership, social acceptance, etc.

It was envisioned that the suggested remediation project would contain contaminated sediments from within the BMP as well as those dredged from the adjacent vicinity. Once completed, the containment project may be devoted to recreational uses, and depending upon its configuration, could extend public recreation space adjacent to Bellevue Municipal Park and Bellevue Municipal Marina. The project has the benefit of helping to restore a known contaminated site and be a catalyst for significant future public use opportunities in a valued, strategically located part of the municipality.

2.2 Milani and Grapentine, 2006

This report provides an overall assessment of sediment quality in the St. Marys River using the BEAST (Benthic Assessment of Sediment) approach. The BEAST methodology involves assessing sediment quality based on multivariate techniques using various data, including benthic community structure, the functional responses of laboratory organisms in toxicity tests, and the physical and chemical properties of the sediment.

The BEAST methodology was applied to 31 sites along the St. Marys River for data collected in 2002.[12] Each location was characterized according to their similarity to the reference location(s); the different BEAST categories include:

(1) equivalent to reference (within the 90% probability ellipse);
(2) possibly different from reference (between 90 – 99% ellipses);
(3) different from reference (99 -99.9% ellipses); and

[11] Kresin Engineering Corporation, 2004.
[12] Milani and Grapentine, 2006.

(4) very different from reference (outside the 99.9% ellipse).

Results of the BEAST approach identified several sediment metal concentrations, which exceeded the PSQG LEL, and a few metal concentrations which exceeded the PSQG-SEL. The highest overall metal and total petroleum hydrocarbon (TPH) concentrations (up to 23,450ug/g for TPH) were observed at the BMP. PAH concentrations were elevated throughout the St. Marys River.

Five (5) of 6 toxic sediment samples were obtained from the BMP and showed toxicity to the midge Chironomus (acute) and the mayfly Hexagenia (chronic). TPH and sediment characteristics are thought to partially explain toxicity to Hexagenia but the cause of toxicity to Chironomus is not clear. Although most of the sites investigated are believed to not require further action, the BMP is one of the sites where there is potential for adverse effects and therefore required further action.

Water samples were also collected at depths of 0.5metres from the riverbed. Field measurements were performed on the water samples, including temperature, pH and dissolved oxygen (DO). Laboratory analyses of alkalinity, total phosphorous, total nitrogen (TKN), nitrates/nitrites and ammonia were also performed. Results indicate that conditions of overlying water are generally similar for the locations sampled.

The report indicates that a more comprehensive study may be warranted at the BMP to determine the reasons for sediment toxicity and recommends that toxic relationships be investigated, including the relationship between toxicity and the presence of petroleum hydrocarbons.

Results of the BEAST study, which were relied on significantly herein, include:

1. Considering the parameters analyzed for, water quality at each site appears to be homogeneous (the Algoma Slip being the most dissimilar).
2. The site displaying the highest percentage of fines (silt and clay) is the BMP where sediment ranges from silty-sand to very fine silty-clay.
3. The east end of the BMP displayed one of the highest TOC concentrations (>SEL at 14.0%) and the highest from among frozen sediment samples.
4. BMP had the highest iron concentration with the exception of sites adjacent to the slag dump and in the Algoma Slip.
5. Point Aux Pins is an inappropriate reference point due to observed toxicity.
6. The highest metal concentrations occur in the BMP (exceptions include arsenic, iron, manganese and nickel).
7. PAHs exceed PSQG LEL in BMP sediments.
8. Of the locations sampled, TPHs are highest in the BMP.
9. No strong evidence of benthic community impairment was found.
10. Strong evidence of sediment toxicity at 2 locations in the BMP was identified.

2.3 Remaining Reports

Brief summaries of the remaining reports reviewed during preparation of this report are presented below.

2.3.1 Golder Associates Inc., 2004.

The Golder report "*Synthesis of Sediment and Biological Investigations in the St. Marys River Area of Concern*" presents a summary review of nine studies undertaken in the St. Marys River from 1989 to 2002. The report states that the BMP is the first depositional zone downstream of ASI and SMP, and that it is contaminated by pulp fines, heavy metals and oils primarily due to upstream sources. The report also noted that the substrate within the BMP is relatively less stable than at other sites in the St. Marys River due to the presence of decomposing pulp fibres and gases; as a result, the sediment in the BMP should not be disturbed.

Information summarized in the 2004 report includes:

1. Assessments of benthic community and sediment toxicity;
2. Sediment contaminant analytical results;
3. Results from a geophysical survey of the River bottom within the BMP;
4. Comparative evaluations considering provincial data; and
5. A discussion on bioavailability and major exposure pathway of metals.

The report concluded that benthic community impairment and sediment toxicity in the BMP are likely a result of the unusual sediment characteristics and the elevated levels of some contaminants (PAHs and TPHs). It was suggested that, once upstream contaminant sources are controlled, the quality of sediments deposited within the BMP would likely improve, but that remedial actions should be explored.

2.3.2 Kilgour, Martin and Kauss, 2001.

In 2001, the MOE published a study entitled "*Sediment and Benthic Invertebrate Community Assessment of the BMP Area in the St. Marys River*" which examines the status of benthic invertebrate communities and sediment contaminant levels in the BMP using sediment grab and core samples collected from 18 locations. Data from sediment samples collected in 1995 was considered in this report.

Information provided in the 2001 report includes:

1. The quantity of contaminated sediment in the BMP was estimated to be 138,632 tonnes;
2. Assessment of benthic community composition, diversity and evenness;
3. Sediment toxicity assessment;
4. Assessment of sediment contaminant analytical results;

5. Qualitative sediment composition and stability assessments; and
6. Discussion regarding contaminant relationships between toxicity and observed benthic community.

The report concludes that although contaminant concentrations were generally lower than in 1985-1987, PSQG-LELs were exceeded for most metals, arsenic, nutrients and PAHs in the upper 10cm of several sediment cores. In addition, the PSQG-LEL was exceeded for PCBs at one location in the upper 10 cm of sediment. Benthic community composition was associated with variability in metals, nutrients, oil and greases concentrations and was most strongly associated with physical sediment conditions. Laboratory bioassays had a strong relationship to TPHs, where reduced growth in chironomids and mayflies were observed which suggested bioavailability of some petroleum components.

2.3.3 Arthur, A. and P.B. Kauss, 2000.

The 2000 report entitled "*Sediment and Benthic Community Assessment of the St. Marys River*" is based on 8 grab samples collected from surface sediment (upper 10cm) within the St. Marys River AOC in 1992, including one sample location within the BMP.

The report includes information relating to the following:

1. Benthic community structure;
2. Sediment characteristics and contaminant concentrations;
3. Sediment toxicity;
4. Comparisons to historical data; and
5. Statistical analysis showing contaminant correlations with TOC and TKN.

The report provided evidence that toxicity from contaminated sediments is impacting benthic communities in the BMP. However, a comparison of contaminant levels and environmental conditions between sites revealed that no specific contaminant and/or environmental condition could attribute to the high toxicity observed in the BMP sediment. Bioassay results indicated toxicity to 2 benthic invertebrate species in the BMP and acute toxicity to C. tentanus. When compared to previous MOE studies in 1983, 1985, 1987, 1989 and 1990, the findings also show that there has been a decrease in the concentration of several sediment contaminants over time. Despite this drop in contaminants, the benthic invertebrate community appeared to have changed little from 1983 to 1992.

2.3.4 Bedard, D. and S. Petro, 1997.

Bedard and Petro produced a 1997 report entitled "*Laboratory Sediment Bioassay Report on St. Marys River Sediments 1992 and 1995*" which considered data associated with sediment samples collected in the St. Marys River AOC in 1992 and 1995.

The following information was presented in the 1997 report:

1. Assessment of the relationship between contaminant concentrations and benthic organism growth;
2. The physical characteristics of sediment.
3. Assessment of sediment contaminant concentrations, including covariance with TOC;
4. Sediment toxicity to benthic organisms and fathead minnows; and,
5. Discussion of potential effects of wood chip and fibrous materials and their relationship to PAH concentrations.

The report classified the substrate in the BMP as having varying amounts of extraneous material including wood fibres and detritus, all of which contributed to unsuitable habitat and a reservoir of oil-based substances. The report concluded that the BMP substrate type as well as petroleum-based contaminants appeared to best explain observed toxic effects in midges and mayflies. In addition, the report concluded that sub-lethal levels were found to be critical in assessing the toxic effects of contaminated sediments in the St. Marys River.

2.3.5 Kauss, P., 1996.

The reporting memorandum "*Preliminary St. Marys River Sediment Survey Data*" prepared by Kauss in 1996 provides interim comments on the 1995 sediment survey conducted in the BMP. Though little data was provided in the memorandum, it was suggested that, based on analytical data from sediment core samples taken at 3 locations within the BMP, sample location 213 may be representative of a control site for the BMP.

The information collected in 1995 was utilized in the Kilgour, Martin and Kauss (2001) report summarized above.

2.3.6 Hesselberg. R.J. and Y. Hamdy, 1987.

An assembly of data relating to sediment quality presented in various reports from 1968 to 1987 is presented in the 1987 report "*Current and Historical Contamination of Sediment in the St. Marys River*" which was produced by various agencies in the US and Canada. The key points presented in the report include a general description of sediment physical characteristics.

2.4 Key Conclusions from the Reports Reviewed

A selection of the key findings in the studies reviewed is presented below:

1. The soft and loose sediments observed near the BMP at the easterly limits may limit remedial options as capping may not be possible and dredging would need to include the entire depth of pulp fibre deposits. In addition, similar soft sediments

have been observed adjacent to other urban areas in the Province of Ontario suggesting a link to urban runoff. Although this material will densify with time, continued deposition will contribute new material on an on-going basis.[13]

2. In 1993, methane gas in the BMP sediments was reported at quantities of up to 120 litres per square meter of sediment. Methane flux from decaying wood fibres contributes to anoxic conditions in the sediments and inhibits oil degradation. Sediments in the BMP contained a variety of foreign material such as: wood chips and fibres and charcoal, soot, coke, graphite, flyash, iron plates and fines, small copper plates and fines, chips of paint and plastic. Wood fibres and chips contributed the largest proportion. The periodic escape of gases from the deeper anoxic sediment layers may be significantly toxic to invertebrates living in the surface sediments. Significant disturbance of the sediments within the BMP should be avoided to reduce the release of oils and greases and other contaminants from deeper layers, unless this is done as part of a major clean-up with appropriate containment and/or treatment measures in-place.[14]

3. Midge survival was inversely related to the percent solid content of sediment. The high amounts of woody and other materials in the BMP sediment result in a lower percent solids. Mayfly growth also appeared to be compromised, which also may be linked to the poor sediment conditions. As a result, not only are contaminants a concern, but so are the physical characteristics of the sediment or substrate where the benthic community and fish cohabit.[15]

4. Benthic, toxicity and sediment chemistry studies should be continued in the BMP to confirm and document any changes in sediment quality and to monitor conditions at upstream reference locations. Comparison with pristine sites may show correlation between toxic effects to the benthic community and contaminated sediments. In addition, by analyzing the sediment for a variety of chemicals, a better understanding of the relationships between the chemicals can be achieved. For example, other components of petroleum hydrocarbons (such as volatile organic compounds) should be analyzed in sediment samples. Similarly, sampling sediment and analysing for gases such as hydrogen sulphide and methane should be undertaken during the summer months when temperatures are warmer and gas concentrations are typically higher.[16]

5. Of the locations sampled within the AOC, PAHs and TOC concentrations are among the most important environmental variables affecting benthic invertebrate communities. Station depth, sediment particle size, calcium and total phosphorous may be influencing or covarying factors. Study results, when compared to previous MOE studies in 1983, 1985, 1987, 1989 and 1990, show that there has

[13] Golder, 2004.
[14] Kilgour, Martin and Kauss, 2001
[15] Bedard and Petro, 1997
[16] Kilgour, Martin and Kauss, 2001

been a decrease in the concentration of a number of sediment contaminants over time. The trend was most evident in the downstream sites in Lake George and Little Lake George.[17]

6. The 1995 data showed that TPH concentrations in sediment were the most successful in explaining observed toxicity which remained the case after correction for TOC (since TOC covaried). The 1995 data also showed that PAH compounds (singly or total) were inadequate in describing the toxicity data. In the BMP, this is likely due to a co-occurrence of PAHs with other petroleum-based compounds in the sediment.[18]

7. Impairment of benthic communities and some residual toxicity is apparent in the BMP and sediment characteristics and moderately elevated concentrations of some contaminants (PAHs and TPHs) are likely acting together.[19]

In summary, the reports reviewed suggest that although there are several contaminants present in sediment at elevated concentrations, the substrate conditions may be of greater concern for benthic community impairment. Several studies suggest that the substrate in the BMP may be creating a degradation environment, which is toxic to the health of the benthic communities. In addition, gases (including methane and hydrogen sulphide, emitted from deeper sediment) may be impacting the benthic community. These environmental conditions may have a larger impact on benthic community health than the presence of contaminants in sediment alone.

Nevertheless, the contaminants detected in sediment have the potential to cause benthic community impairment. Elevated concentrations of several contaminants were identified in shallow sediment (<10cm) where the benthic community resides. The shallow sediment contaminants include petroleum hydrocarbons, PAH, metals, and TOC. These contaminants were common to many of the reports reviewed. PCBs were also detected in shallow sediment (<10cm) at one location in 1995[20]. Chemicals such as PCBs and mercury are a concern as they are known to bioaccumulate. The sediment contaminants are present at elevated levels where impacts to benthic community are possible. The toxicity of the contaminated sediment may also be enhanced by coupling effects since some studies have suggested that contaminants such as PAH and petroleum hydrocarbons may be acting together to impair benthic community health.

Toxic effects have been observed in benthic communities that include mortality and growth impairment to benthic invertebrates (including mayflies and caddisflies).

[17] Arthur and Kauss, 2000
[18] Bedard and Petro, 1997.
[19] Golder, 2004
[20] Kilgour, Martin and Kauss, 2001

From the reports reviewed, it is evident that numerous factors are likely acting together within the BMP to result in the observed benthic communities and sediment toxicity, including:

1. Sediment physical characteristics, such as grain size, percent solid and stability.
2. The presence of foreign material, including decomposing wood fibres, oils and grease in the sediment.
3. Gases, such as methane and hydrogen sulphide present in the substrate.
4. Sediment contaminants, including PAH, petroleum hydrocarbons, metals, including mercury, PCBs, and TOC.

3.0 Physical and Chemical Characteristics of BMP Sediments and Water Quality

Section 3.0 summarizes the available information characterizing the physical and chemical properties of BMP sediment.

3.1 Physical Characteristics of Sediments

The physical characteristics of sediment are described by the type and nature of constituents and sediment grain size.

3.1.1 Type and Nature of Constituents

The Riverbed in the BMP is generally flat with soft to very soft surface material consisting of fine silty material, organic matter and vegetation. BMP sediments contain various foreign material including wood fibres, charcoal, soot, coke, graphite, flyash, iron plates and fines, small copper plates and fines, chips of paints and plastic.[21] Wood fibres comprise the majority of foreign material, ranging from less than 10% to 60% of the substrate[22]. The material also contains oil globules and gases, which were released during core sampling in 1995.

The substrate appears to be layered at some locations, where the silty sediment overlays deeper pulp fibres and wood chips[23]. Average sediment depths range from 0.56m to more than 3.3m[24].

The sediment appears to be relatively unstable due to the presence of the decomposing wood fibres and gases and, in previous studies, sediment was re-suspended during core-sample collection and gas eruptions. The potential for re-suspension of sediments is estimated to be low because of the low river velocity in the BMP[25]. Observed river velocities in the BMP ranged from 0.0m/s to 0.37m/s and since the minimum velocity

[21] Kilgour, Martin and Kauss, 2001
[22] Golder, 2004
[23] Kilgour, Martin and Kauss, 2001
[24] Kilgour, Martin and Kauss, 2001
[25] Golder, 2004

required for erosion of consolidated coarse silt is 0.3m/s, it is unlikely that the sediment in the BMP would be mobilized by these low flow velocities.[26]

3.1.2 Grain Size

The BMP contains sediments ranging from silty-sand to very fine silty-clay and has the highest percentage of fines (silt and clay) observed in the AOC[27]. In addition, of the six locations in the BMP studied in 2002, three locations (6981, 6983, 6984) had a coarse silty sand substrate (consisting of 36 to 48% sand) and the remaining three locations (6986, 6991, 6992) had a fine silty clay substrate (consisting of 72 to 74% clay).[28] Refer to Figure 2 for the sampling locations.

Sediment composition within the BMP is corroborated by other studies in the AOC. Sediment samples from 1992 indicated that the BMP sediment was classified as silty loam with at least 75% fine-sized particles, which closely resemble the upstream reference sediment from Point aux Pins Bay.[29]

There appears to be some discrepancy concerning the composition of the shoreline sediments in the BMP. In 1987, most of the shoreline along the Ontario side of the St. Marys River is dominated by silt (82%)[30]. In contrast, a geophysical survey completed on behalf of the MOE in 1995 using side scan sonar and sub-bottom profilers reported that the shoreline along the BMP was primarily sand and gravel but extensive areas of fine sediments occurred offshore.

Based on the available information, it appears that the shoreline of the BMP may consist of various sizes of sediment, but the areas away from the shore are dominated by fine sediment.

3.2 Chemical Characteristics of Sediments

In general, contaminant concentrations in the BMP have decreased from 1968 to 1995 based on analysis of surficial sediment samples and supported by information from sediment core samples. The observed improvements over time are likely due to a combination of erosion, downstream transport and deposition of cleaner sediments, and reduced point source contaminant loadings.[31]

Information in the following sub-sections is presented in chronological order to visualize the changes in sediment chemistry over time.

[26] Kilgour, Martin and Kauss, 2001
[27] Milani and Grapentine, 2006.
[28] ibid
[29] Bedard and Petro, 1997.
[30] Hesselberg and Hamdy, 1987.
[31] Kilgour, Martin and Kauss, 2001.

3.2.1 Petroleum Hydrocarbons

Milani and Grapentine, 2006

Sediment samples from locations within the BMP displayed the highest petroleum hydrocarbon concentrations compared to areas outside of the BMP with the maximum concentration observed at sample location 6986 (23,450ug/g). The F1 fraction of petroleum hydrocarbon, which comprises the light hydrocarbon components (C6 – C10) were not detected at any location. Five of six 6 locations in the BMP contained the F4 fraction of petroleum hydrocarbons, which comprises the heavy hydrocarbon components (C34-C50).

Total petroleum hydrocarbons (TPHs) were also reported. TPH is a sum of the petroleum hydrocarbon fractions. TPH ranged from 367 to 23,450ug/g (median 13,650 and mean 12,368ug/g); these data were higher on average than TPH data reported in 1995. TPH data from 1995 ranged from 350 to 112,500ug/g (median 4,828ug/g and mean 12,282ug/g)[32].

Golder, 2004.

This report refers to former studies that showed elevated concentrations of TPH in the BMP.

Kilgour, Martin and Kauss, 2001

The TPH data in this report are from 1995 sediment samples and range from 350 to 112,500ug/g (median 4,828ug/g and mean 12,282ug/g). The authors suggest that in addition to the analysis of TPHs, future studies should include the analysis of other hydrocarbons including volatile organic compounds. Results presented in 2001 indicated that TPHs and oils and greases were at elevated concentrations in sediment within the BMP.

Arthur and Kauss, 2000

This report indicates that concentrations of solvent extractables (oils and greases) in sediment exceeded the Open Water Dredged Material Disposal Guideline at the only sample location tested in the BMP.

Bedard and Petro, 1997

The results from this study indicate that TPH concentrations in sediment samples collected in 1995 co-varied with total organic carbon (TOC) but had no relation to PAH concentrations. As a result, the authors suspect that PAH concentrations may be a subset

[32] Kilgour, Martin and Kauss, 2001

of TPH. It was also noted that other substances may be acting as an additional source of organic contamination.

The authors suggest that physical sediment conditions along with TPH concentrations need to be considered when assessing sediment quality in the BMP. In addition, the authors suggest that TPH concentrations in sediment may be a better indicator of sediment toxicity than PAH.

3.2.2 Metals

Milani and Grapentine, 2006.

This report identifies several metal concentrations in sediment that exceeded the PSQG-LEL in the BMP, including: arsenic (3 locations), cadmium (1 location), copper (all locations), chromium (all locations), mercury (2 locations), manganese (5 locations), nickel (5 locations), lead (all locations), and zinc (all locations). The percent iron exceeded the PSQG-SEL at 4 of 6 sites, ranging from 2.7 to 6.4%. In addition, sample locations with finer grained substrate had higher sediment metal concentrations compared to those of coarser grained substrate.

The high metal concentrations identified in this study corroborate earlier work by Kilgour and Martin (2001), where several metal concentrations in sediment exceeded the PSQG-LEL, including chromium at 1 location and iron at 14 locations out of a total 20 locations.

Golder, 2004.

Golder reported in 2004 on 18 sediment cores collected in 1995 from 2 depth intervals: the upper section, which ranged from 0-5cm and the lower section which ranged from 5-10cm. Metals (arsenic, cadmium, chromium, copper, lead, manganese, nickel, and zinc) exceeded the PSQG-LEL in both upper and lower sections but were below PSQG-SEL in most cases. The PSQG-SEL was exceeded for chromium at one location in both core sections and iron exceeded the PSQG-SEL in 14 locations also in both core sections.

According to the authors, other sediment studies performed in Ontario also report metal concentrations above the PSQG LEL and PSQG SEL. In these cases, minimal toxic effects were observed in the benthic community. The authors suggest that metals availability and toxicity are limited by other factors (i.e. pathway); they also suggest that metal concentrations that result in toxic effects may be greater than then the PSQG guidelines.

Similarly the bioavailability of metals (free ionic form) is influenced by the presence of organic carbon, sulphides, iron and manganese hydroxides and carbonates. Environmental conditions, including pH and redox conditions also affect the bioavailability of metals. Oxic conditions in the top 2 or 3cm of sediment can cause metals to bind with iron and manganese complexes (metals which are bound to sediments have less bioavailability). In the top 2-3cm, the solubility of metals is primarily controlled by iron and manganese hydroxides. In the deeper (anoxic) zone, iron, manganese and metals are released where they may subsequently bind in metal-sulphide complexes (in sulphide-rich sediments). In this condition the complexes are very stable and will mineralize over time.

It was concluded that the major exposure pathway for most organisms is the solubilized form of metals. Ingestion appears to be a minor pathway due to the binding effect within sediment organic and mineral constituents. Thus, although metals concentrations exceed PSQG-LELs and PSQG-SELs, the lack of biological response in the benthic community and toxicity testing indicates low bioavailability.

Kilgour, Martin and Kauss, 2001.

PSQG-LELs were exceeded in the upper 10cm of most sediment core samples, for most metals in 1995 although they were lower than observed concentrations in 1985-1987. Vertical concentration gradients in the core samples corroborate these findings.

Arthur and Kauss, 2000.

Based on a review of information related to sediment samples collected in 1992, concentrations of iron exceeded the PSQG-SEL and concentrations of chromium, copper, manganese, nickel and zinc exceeded the PSQG-LELs.

Bedard and Petro, 1997.

It was reported in 1997 that the 1992 and 1995 sediment samples contained relatively low metal concentrations, with only iron exceeding the PSQG-SEL most often at locations in the BMP.

3.2.3 Polycyclic Aromatic Hydrocarbons

Milani and Grapentine, 2006.

Analysis of sediment samples collected in 2002 revealed that PAH concentrations exceeded the PSQG-LEL at half of the locations within the BMP. Concentrations of PAH ranged from 2 to 7ug/g. Samples collected from locations in the BMP in 1992 and 1995 displayed a range in PAH concentrations from 11 to 85ug/g. Upstream of the slag dump, PAHs were either not detected or detected at "very low concentrations".

Golder, 2004.

Elevated concentrations of PAHs were identified in the BMP in the studies reviewed by Golder. Although elevated PAH concentrations have been linked to effects on biota in other areas in Ontario, the Algoma Slip is the only location in the St. Marys River AOC that has historically shown toxic effects related to elevated PAH concentrations.

Kilgour, Martin and Kauss, 2001.

In the upper 10cm of most sediment cores, PSQG-LELs were exceeded for PAHs in 1995 although they were lower than observed concentrations in 1985-1987. Despite the reductions since 1987, the BMP is still significantly contaminated with constituents including PAHs.

Arthur and Kauss, 2000.

Of the sites sampled, PAHs and TOC concentrations are among the most important environmental variables affecting the benthic invertebrate communities. At least one PAH compound exceeded its PSQG LEL, as did total PAHs in the BMP sediment. Sediments in the BMP were characterized by moderately elevated PAH concentrations, among other constituents.

Bedard and Petro, 1997.

None of the sediment samples collected in 1992 and 1995 exceeded the PSQG-SEL for total PAH or for 16 individual PAH compounds (after correction for TOC); however, total PAH concentrations typically exceeded PSQG-LEL concentrations in sediment samples collected from the BMP. In 1995 the concentration of PAHs seemed to reflect the concentration of naphthalene as locations with elevated naphthalene also had elevated PAHs. The common occurrence of naphthalene in the 1995 sediments suggests that the wood chip and fibrous materials may serve as a reservoir of certain PAHs. Naphthalene is somewhat water soluble and normally has a short residence time in sediment but can be continuously released if the chemical is closely associated with extraneous material, such as wood fibres.

PAHs that were most commonly detected in the 1992 and 1995 sediment samples included phenanthrene, pyrene, fluoranthene, and napthalene. Phenanthrene was listed on the MOE banned substance list. Common sources of phenanthrene are the combustion of coke and coal tar. According to point source loadings gathered in 1986 – 1988, Algoma Steel represented 76% of the total oil and grease loadings and 45% of the PAHs to the River. Atmospheric deposition was the next highest source of PAHs. Concentrations of 15 of the 16 PAHs analyzed for were also significantly correlated to sediment TOC.

3.2.4 Total Organic Carbon and Total Kjeldahl Nitrogen

Milani and Grapentine, 2006.

A sediment sample from the east end of the BMP had one of the highest TOC concentrations (>PSQG-SEL at 14.0%) and the highest from among frozen sediment samples.

Arthur and Kauss, 2000.

Statistical analysis of data associated with the BMP indicated significant positive correlation between TOC concentrations and TKN, solvent extractables (oils and grease), arsenic, chromium, copper, iron, lead, mercury, manganese, selenium, zinc and total PAHs. Sediment contaminations normalized to TOC concentrations indicate no dominant trend over time.

Bedard and Petro, 1997.

Concentrations of 15 of the 16 PAHs analyzed for were significantly correlated to sediment TOC. Similarly, TPH concentrations in 1995 sediments were found to co-vary with TOC but did not correspond with PAH.

It was also noted that, in 1985 and 1987, effects on benthic biomass and diversity were shown to be related to increasing sediment TOC.

3.2.5 Chemicals that Bioaccumulate

Heavy metals that have the potential to bioaccumulate include arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc, all of which were described in the metals section.

Milani and Grapentine, 2006.

Mercury is a heavy metal that is well known to bioaccumulate. It was detected in concentrations above the PSQG-LEL in shallow sediment samples at two locations (of six) in the BMP. PSQG-LEL for lead was exceeded at all locations within the BMP.

Golder, 2004.

Although PCBs were identified at some locations within the AOC, no compounds of concern that may bioaccumulate or biomagnify and that could be identified with known sources were noted during the studies reviewed by Golder.

Kilgour, Martin and Kauss, 2001

PCBs were detected at low levels at 67% of sample locations within the BMP and at levels exceeding the PSQG-LEL in surficial sediments at 17% of sample locations. One of the shallow sediment samples (<10cm) that had a total PCB concentration greater than the PSQG-LEL was located in the BMP. Two deeper sediment samples collected from the BMP also had a total PCB concentration greater than the PSQG-LEL.

Bedard and Petro, 1997.

In 1997 Bedard and Petro indicated that the 1992 and 1995 sediments contained no measurable amounts of PCBs within the BMP sediment. Minnow bioaccumulation results indicated that naphthalene was available to the highest degree in 21-day exposures.

Only naphthalene showed a higher tendency to bioaccumulate above trace levels at 23% of the 1995 locations as it is water soluble and can be readily taken up through fish gills.

3.2.6 Other Contaminants

Golder, 2004.

Cyanide concentrations exceeded Open Water Disposal Guidelines and were highest at locations within the BMP.

Kilgour, Martin and Kauss, 2001.

In the upper 10cm of most cores, PSQG-LELs were exceeded for arsenic and nutrients in 1995 although they were lower than observed concentrations in 1985-1987. Vertical concentration gradients in the core samples also confirmed this.

In 1993, up to 120 litres of methane per square metre of sediment were collected. Methane flux from decaying wood fibres contributes to anoxic conditions in the sediments and inhibits oil degradation.

Bedard and Petro, 1997.

The 1992 and 1995 sediments contained concentrations of 20 organochlorine pesticides and 12 chlorinated organic compounds were below detection limits.

3.3 Sediment Toxicity

Milani and Grapentine, 2006.

Five (5) of 6 toxic sediment samples from the 2002 data obtained from within the BMP showed toxicity to the midge Chironomus (acute) and the mayfly Hexagenia (chronic). TPHs and sediment characteristics are thought to partially explain toxicity to Hexagenia but the cause of toxicity to Chironomus was not clear. The 2006 report suggests that more comprehensive study may be warranted at such locations to determine the reasons for sediment toxicity, especially as it relates to the presence of petroleum hydrocarbons. Strong evidence was presented in the 2002 data that indicates toxicity at 2 locations (6986, 6991) in the BMP.

The BMP sample locations that were toxic to Hexagenia (6986, 6991, 6992) appear to be related to petroleum hydrocarbons concentrations. Although locations 6986 and 6991 also indicate toxicity to Chironomus, which have 48% variability in survival related to PAH and a combination of metals. The survival effects may not be directly related to the presence of PAH, however, since the PAH concentrations are not high in the BMP and have not been linked to survival effects in the Algoma Slip where high PAH concentrations were observed.

Sediment toxicity was also evident in the BMP at locations 6986 and 6991, which displayed acute toxicity to Chironomus. Chronic toxicity to mayfly Hexagenis spp. was also evident at location 6991.

A 1995 MOE study, which included 13 locations in the BMP found that Chironomus tentans was reduced at three locations and that midge mortality was correlated to sediment physical characteristics, PAHs and petroleum hydrocarbons.

Golder, 2004.

Sediment bioassay assessments using the 1992 data showed that the sediments were lethal to 23% of mayflies and 22% of midges with significantly lower growth in the surviving organisms. Fathead minnows suffered no mortality. Similar to results from a 1995 MOE study, the 2002 data shows 48% to 59% mortality in chironomids and up to 25% mortality in amphipods at 2 locations.

Kilgour, Martin and Kauss, 2001.

Acute toxicity of sediments reported at 14 locations tested was low, resulting in between 0% and 20% mortality for fathead minnows and mayflies. Sediments were somewhat more toxic to chironomus tentans resulting in up to 42% mortality. Growth was also affected whereas diversity and evenness of benthic invertebrate communities were generally high at all locations within the BMP. Sediments were found to be similarly toxic in samples collected in 1992 and 1995 at similar locations within the BMP and were non-toxic to fathead minnows in both years.

No apparent association between benthic community composition and any of the suites of toxicity endpoints was observed suggesting short-term toxicity is not a function in variation of benthic community composition.

Arthur and Kauss, 2000.

Sediment toxicity within the BMP was greater than that associated with the control site and C. tentanus growth was observed to be significantly reduced whereas H. limbata showed no effects on growth. It was also indicated that bioassay results show toxicity to two benthic invertebrate species within the BMP. Sediments were also acutely toxic to C. tentanus.

Good evidence exists that suggests toxicity from contaminated sediments is impacting benthic communities within in BMP. Based on a comparison of contaminant levels between sites, a specific contaminant and/or environmental condition could not be identified that relates to the high degree of toxicity observed for the BMP sediment.

Bedard and Petro, 1997.

1992 data shows a slight level of sediment toxicity to benthic organisms with a strong growth impairment observed in Chironomus and low mayfly body weight. The indication of negative growth on mayfly nymphs and midge larvae associated with BMP sediments collected in 1992 was further confirmed in the follow-up study completed in 1995. Sediments associated with a higher toxicological effect were situated in the near shore region in a small embayment between Simpson Street and the Municipal Marina. Midge growth was reduced to a point that appeared to compromise survival. Mayfly mortality within the BMP was significantly higher than the control in the 1992 data and eleven of the 1995 BMP sediment samples exhibited mortality of <10% and caused a reduction in growth greater than 50% relative to the control. In 1992, chironomid mortality within the BMP was also significantly higher than was observed at the control location. Growth was also affected at the BMP. The 1995 data showed similar results.

In 1995, the majority of sediments that received poor rankings considering sublethal growth results were collected in the near shore region. TPH sediment concentration was found to be a better indicator of potential effect than PAH and sediments containing >40% detrital matter, >25% wood fibres and vegetation, in the presence of oil, was often associated with reduced midge growth.

Examination of effects at the sublethal level was found to be critical in ranking sediments in the St. Marys River. In the BMP, substrate type as well as petroleum-based contaminants best explained observed effects in midge and mayfly sediment toxicity tests and an assessment of chemical and physical characteristics was noted to be required to further explain toxicity.

Mortality of fathead minnows was generally found to be acceptable in the 1992 and 1995 data. Tissue residue concentrations corresponded to levels achieved in controls but Cu tissue residue in BMP samples were significantly higher than control.

3.3.1 Benthos

Milani and Grapentine, 2006.

Milani and Grapentine identified no strong evidence of benthic community impairment following their review of the 2002 data and that changes in the status of benthic populations should be monitored for. This was supported by BEAST analysis which indicated that of the 6 BMP locations, 4 are characterized as equivalent to reference (BEAST Band 1) and 2 as possibly different (BEAST Band 2). The 2006 report further indicates that, since 1985, increases in mayflies and caddisflies at some locations were the most noticeable improvement made to the benthic community.

Golder, 2004

The BMP is a site where impairment of biological communities has been noted in previous studies, including the Stage 1 RAP report. A benthic community assessment conducted by the MOE in 1992 identified reduced biodiversity in the BMP correlated with elevated contaminant concentrations, particularly petroleum hydrocarbons.

It was concluded that the assessments of data associated with the BMP indicate that elevated PAH, TPH and substrate types are exerting a combined effect on benthic communities.

Kilgour, Martin and Kauss, 2001.

1967 (OWRC) and 1973 (MOE) studies found evidence of severe adverse impacts to the benthic community along the Sault Ste. Marie waterfront. Despite reductions of contaminants being discharged, a 1983 MOE study found that the benthic community in the St. Marys River had not improved significantly since the 1967 and 1973 studies. Historically, benthos within the BMP have been similar to benthos from Little Lake George (dominated by isopods, immature tubificids and nematodes). Prior to 1985 the sediments within the BMP were characterized as being essentially devoid of benthos. Since 1985 (the year around which the most significant improvement in benthic communities is thought to have occurred), sediments within the BMP have displayed a relatively diverse benthic fauna. Recent improvements appear to be associated with reductions in sediment contamination.

Although benthic community composition was found to be associated with variability in metals, nutrients, oil and greases concentrations they were most strongly associated with physical sediment conditions. Laboratory bioassays conducted with the sediments showed a strong relationship between TPH and reduced growth in chironomids and mayflies, suggesting bioavailability of some components.

Variation in benthic community composition was found to correlate highly with oils and greases, TPHs, major element concentrations and particle size distribution of the sediments. A weaker correlation was observed with sediment metal levels and water depth. No apparent association between benthic community composition and any of the toxicity endpoints was observed suggesting short-term toxicity is not a function in variation of benthic community composition. In general, correlations were observed to be higher in the upper sediment zone (0-5cm). Data analysis also suggested that variability in substrate conditions rather than the concentration of toxic contaminants is more likely affecting benthic community composition.

It was further reported that temporal variation in benthic invertebrate community has shown an improvement in total abundance, evenness, diversity, etc. from the conditions initially documented in 1968. Historical increases in organism abundance in the BMP suggest improvement in habitat quality. From 1985 to 1995 most of the changes were due to increased number of smaller (200 sieve) pollutant-tolerant organisms rather than pollution sensitive forms (i.e. mayflies - ephemeroptera and caddisflies - trichoptera). The benthic community was still considered degraded as ephemeroptera and trichoptera were found in numbers well below background. However, MOE also noted that since 1985 the BMP has displayed relatively diverse fauna.

Sediments may be adversely affecting sensitive invertebrate species due to the presence of persistent chemicals related to steel-making at levels above PSQG-LELs. Although there have been reductions since 1987, the BMP is still significantly contaminated with heavy metals, oils and greases, TPHs, PAHs and nutrients. Metals, nutrients and PAHs generally still exceed the PSQG-LEL. A relatively strong association between benthic community composition and TPHs concentration was observed suggesting that some are biologically available and causing alteration in the benthic community.

Arthur and Kauss, 2000.

Based on observations from 8 sediment grab samples (upper 10cm) collected in 1992, good evidence exists to suggest toxicity from contaminated sediments is impacting benthic communities in the BMP. Based on a comparison of contaminant levels between sites, a specific contaminant and/or environmental condition could not be identified that relates to the high degree of toxicity observed for the BMP sediment. Observations of the benthic invertebrate community at the BMP, including the presence of the isopod caecidotea, suggested low to moderate impacts.

Bedard and Petro, 1997.

1992 data indicated that BMP sediment yielded the poorest midge and mayfly growth relative to the remaining 7 sample locations within the AOC. A dose-response relationship was observed between sediment PAH concentration and benthic growth. Examination of effects at the sublethal level was found to be critical in ranking sediments in the St. Marys River and substrate type as well as petroleum-based contaminants were found to best explain observed effects in midge and mayfly sediment toxicity tests. The varying amounts of extraneous material including wood fibres and detritus contributed as unsuitable habitat and as a reservoir of oil-based substances.

3.4 Water Quality

Water samples collected from 0.5 metres above the river bottom from 6 locations during the 2002 sampling event were assessed in 2006.[33] Considering the parameters analyzed for, water quality across the AOC sampling locations appeared to be homogeneous and locations within the Algoma Slip were the most dissimilar.

3.5 Exposure Pathways

The studies reviewed provided limited information regarding specific exposure pathways. Ingestion may be a minor pathway due to the binding effect between metals and sediment organic and mineral constituents. Thus, although metals concentrations exceed PSQG-LELs and PSQG-SELs, the observed biological response in the benthic community and toxicity testing indicates low bioavailability.[34]

4.0 Decision-Making Framework for Contaminated Sediments

The Canada-Ontario Decision-Making Framework for Contaminated Sediments (Framework) is a framework that has been developed based on ecological risk assessment principles to assist in assessing contaminated sediments. The process considers contaminant concentration, toxicity and biomagnification potential and presents four guidance rules, as follows, that govern the use of the framework:

1. Sediment chemistry data will not be used alone for remediation decisions except for 2 cases. Neither of the 2 cases is currently relevant to the BMP sediment assessment, and therefore a description of these 2 cases is omitted from the report.

2. Any remediation decisions will be based primarily on biology, not chemistry.

3. Lines of Evidence (LOE) such as laboratory toxicity tests that contradict the results of properly conducted field surveys with the power to detect changes are

[33] Milani and Grapentine, 2006
[34] Golder, 2004.

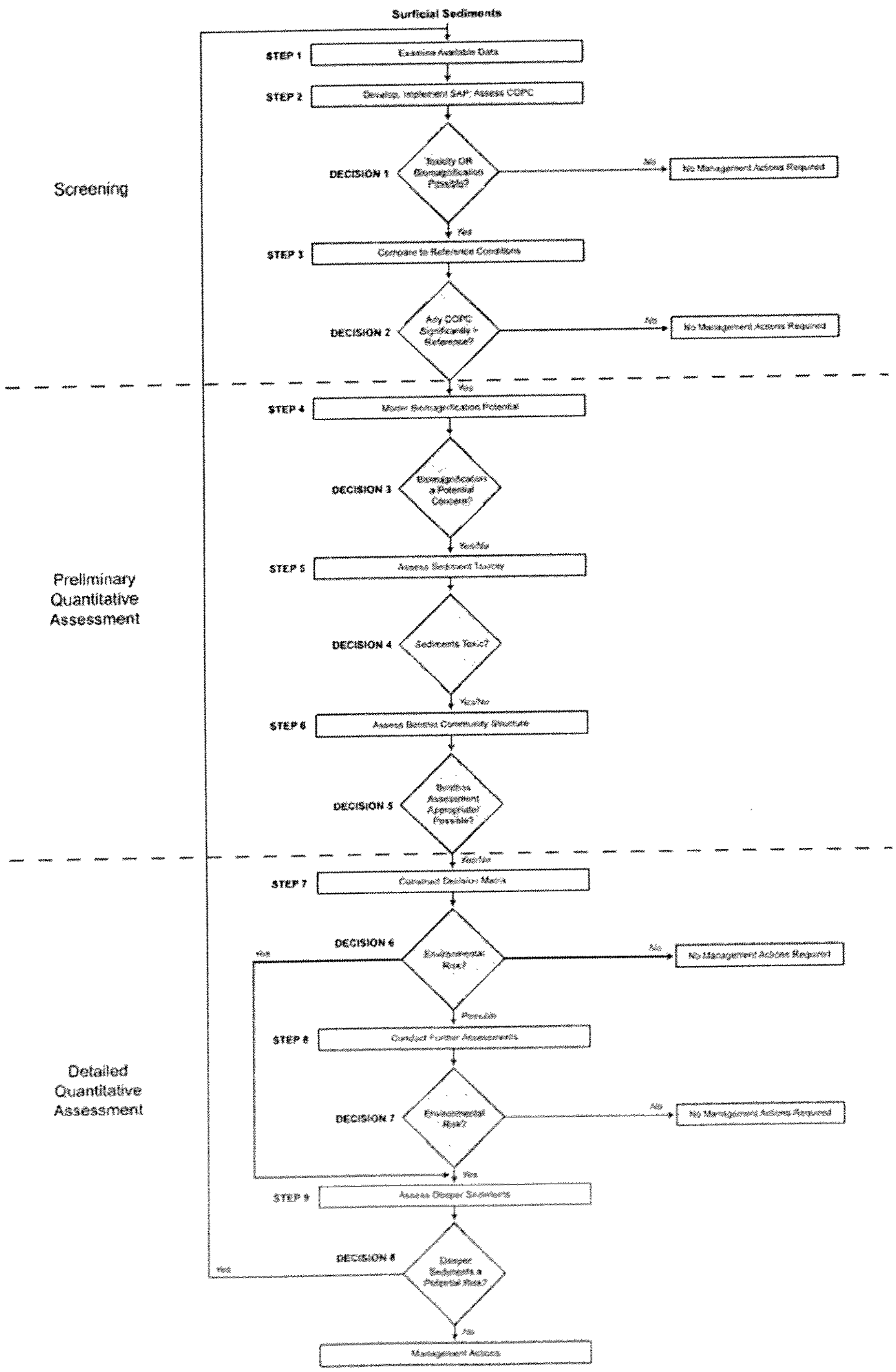
clearly incorrect to the extent that other LOE are not indicative of adverse biological effects in the field.

4. If the impacts of a remedial alternative will cause more harm than leaving the contaminants in place, that alternative should not be implemented.

The Framework, illustrated in Flowchart 1, requires the following information to facilitate its application:

1. Identification of contaminants of potential concern (COPC); including concentrations at surface and at depth.
2. Receptors of potential concern (ROPC).
3. Exposure pathways.
4. Consumption advisories.
5. Sediment stability.
6. Appropriate assessment endpoints (i.e. what is to be protected).
7. Measure of effect (i.e. what is measured to assess).
8. Appropriate reference areas/locations and their characteristics.

Flowchart 1: Decision-Making Framework for Contaminated Sediments[35]



[35] Chapman, 2005.

4.1 Step 1: Review of Available Information

The reports reviewed in this assessment provide several sets of sediment chemistry data, however most are dated. The most recent data is provided in the BEAST report and includes sediment chemistry and benthic invertebrate analysis from samples collected in 2002.

The 2002 sediment chemistry data was obtained from six locations in the BMP referred to as: 6981, 6983, 6984, 6984, 6991, and 6992. Figure 2 depicts the sample locations within the BMP. Sediment samples collected from the surface, including the upper 10 cm of sediment, were analyzed for metals, nutrients, petroleum hydrocarbons, and PAH. Additional water quality parameters were analyzed for in the overlying water. Sediment toxicity tests (percent survival and growth of benthic invertebrates) were also conducted.

As no polybiphenyl chlorides (PCB) analysis was presented in the 2006 study, sediment chemistry data collected in 1995 and presented by the MOE in 2001 is also referenced in this assessment. Two sample locations (of 17 locations) had detected PCB concentrations in sediment that exceed the PSQG-LEL. The two locations, 210 and 214, are also shown in Figure 2.

Considering that sediment is regularly discharged to the St. Marys River through industrial effluent and stormwater discharges/runoff, it is likely that additional sediment has been deposited in the BMP. As a result, sediment chemistry based on the data from 2001 or earlier is considered to be an estimate of the existing sediment conditions in the BMP.

Table 1 provides a summary of the information available and the corresponding date that the data were obtained.

Table 1: Brief Summary of Available Information

No.	Aspect Description	Reported Information/Data
1	COPC	PAHs, petroleum hydrocarbons, sediment characteristics, metals, TOC (data were collected in 2002- Milani and Grapentine, 2006) PCB (data were collected in 1995 -Kilgour, Martin and Kauss, 2001).
2	ROPC	Benthic invertebrates, fish.
3	Exposure pathways.	Ingestion and incidental contact of sediments and/or surface water
4	Consumption advisories.	Consumption advisories are published for fish species in the St. Marys River by the Province of Ontario and the USEPA (reported for the years 2005-2006).
5	Sediment stability.	Sediment appears to be easily re-suspended but low current velocities in the BMP limit contaminant transportation potential
6	Assessment endpoints.	Survival and growth of benthic invertebrates and fathead minnows
7	Measure of toxic effects.	Survival and growth observations (data were collected in 2002 – Milani and Grapentine, 2006)
8	Reference sites.	Historically Point Aux Pins has been used but some of the reviewed reports indicate it may not be appropriate

Based on the review of available information, it appears that the data is outdated and that additional data is required to complete the assessment of the sediment conditions in the BMP. In order to support a BMP contaminated sediment remediation strategy and provide current sediment data for applying the Framework, the following potential data gaps need to be considered:

1. **Identify sources of foreign material in the substrate at the BMP**. The substrate in the BMP that is largely composed of wood fibres and has a high TOC, which may be a factor in the degradation of sediment quality and may even be concentrating toxic substances, at least those that have an affinity for organic matter over sediments or minerals. By identifying the possible sources of the foreign material, control measures to minimize the inputs of these materials into the BMP can be undertaken as part of the remediation efforts.

2. **Characterization of the observed sediment gases,** including type, concentration, source, toxicity and degree of decomposition. This information is important to quantify gas production both temporally and spatially and to determine any relationship between the contaminants, organic material present in the substrate, and the toxicity to benthic invertebrates and fish. This information is key in developing appropriate remedial options.

3. **Assess sediment loading to the St Marys River through** sediment core samples or sediment traps upstream of the BMP. This is particularly important to estimate the rate of sediment deposition and assess impacts of dredging activities on the habitat of various organisms. Sediment loading is also a function of river dynamics, as a result, a geomorphic study of the area is also recommended. This information is important for estimating the time that may be required to effectively cover and cap the contaminated sediments and to assess whether this type of passive remediation is appropriate. In addition, any concerns that stakeholders may have regarding initiating a clean-up of downstream sites (e.g. BMP) prior to upstream sites (e.g. Algoma Slip) where there may be a perceived potential for re-contamination are addressed.

4. **Assess the sediment stability.** Based on previous studies, the sediment is easily re-suspended when disturbed, but because of the low River current in the BMP, it is unlikely to be re-suspended by the natural flow of the River. However, the high volumes of wood fibre in the sediment can affect the stability of the sediment. Therefore additional stability studies are required. This is particularly important for assessing whether capping the sediment is an option for remediation.

5. **Exposure pathways require further assessment**, particularly because of the complex nature of the substrate present in the BMP.

6. **Identify one or more appropriate reference sites or locations.** Reports have indicated that the traditional Point Aux Pins background/control site may not be

an appropriate control site since elevated concentrations of chemicals were measured in sediment. As a result, an assessment of other reference sites used in previous studies or new reference locations is required. More than one reference site would be ideal as numerous reference sites can account for natural and/or anthropogenic changes in sediment and water quality over time. Sampling at the reference location(s) should be rigorous enough to define the normal range of variation in sediment and water chemistry and benthic community structure.

7. **Analyze for additional chemical parameters:**

   a. Mercury, which only slightly exceeds the PSQG-LEL at two locations of shallow sediment (<10cm), is bioaccumulated much more rapidly in the methylated form than in the inorganic form. As a result, testing the methylated mercury levels versus mercury levels in the sediments and aquatic invertebrates is recommended.
   b. PCBs, which can bioaccumulate, were present at one location of shallow sediment (<10cm) in 1995. As a result, additional sediment samples need to be analyzed for PCBs to identify the extent of the PCB impacts.
   c. The complete list of volatile organic compounds (only benzene, toluene, ethylbenzene and xylene compounds have been analyzed to date), which may be associated to the foreign material present in the substrate, and which can be highly toxic.

8. **Identify Appropriate Reference Sites**, since the most common reference site, Point aux Pins Bay may not be appropriate due to the elevated concentrations of certain chemicals in sediment. Ideally, more than one reference site would be beneficial to account for any natural and/or anthropogenic changes in sediment and water quality over time. New reference data are necessary to provide a standard against which to compare the test site conditions. Sampling at the reference location(s) should be rigorous enough to define the normal range of variation in sediment and water chemistry and benthic community structure.

9. **Additional sampling, including pore-water sampling** (water stored in pores between grains of sediment) is recommended to identify contaminants that may be in the more readily bioavailable state.

10. **Additional toxicity tests** are required in order to assess combined end-points that involve species survival, growth and reproduction (both acute and chronic endpoints). Species of interest include pollutant-sensitive benthos and fish.

11. **Toxicity Identification Evaluations (TIE)** should be conducted to develop a clearer understanding of the cause of observed sediment toxicity in the BMP.

12. **Seasonal Changes** in sediment contaminant concentrations, gas emission concentrations, and benthic population should be represented, if possible.

4.1.2 Contaminants of Potential Concern (COPCs)

The most recent sediment chemistry data used in this assessment are from surface sediment samples, collected from the upper 10 cm of sediment. The sediment chemistry data are based on six sampling locations from the 2006 study by Milani and Grapentine and two sampling locations from the MOE 2001 study. Chemical parameters detected in the sediment samples include petroleum hydrocarbons, PAH, metals, nutrients, and PCBs, and are listed in Table 2a and Table 2b.

Table 2a. Nutrients and Trace Metals, PH and PAHs (2006 BEAST)

Nutrients and Trace Metals	Petroleum Hydrocarbons	Polycyclic Aromatic Hydrocarbons
Aluminum	Benzene	Naphthalene
Arsenic	Toluene	Acenaphthylene
Calcium	Ethylbenzene	Acenaphthene
Cadmium	o-Xylene	Fluorene
Cobalt	p+m Xylene	Phenanthrene
Chromium	Total Xylenes	Anthracene
Copper	F1(C6-C10 hydrocarbons)	Fluoranthene
Iron	F1(C6-C10 hydrocarbons) - BTEX	Pyrene
Mercury	F2(C10-C16 hydrocarbons)	Benzo(a)anthracene
Potassium	F3(C16-C34 hydrocarbons)	Chrysene
Magnesium	F4(C34-C50 hydrocarbons)	Benzo(b)fluoranthene
Manganese		Benzo(k)fluoranthene
Nickel		Benzo(a)pyrene
Phosphate		Indeno(1,2,3-cd)pyrene
Lead		Dibenzo(a,h)anthracene
Silicon Dioxide		Benzo(ghi)perylene
Titanium		
Nitrogen		
Phosphorus		
Vanadium		
Zinc		

Table 2b. PCB (Kilgour, Martin and Kauss, 2001)
Endrin
Heptachlor
Heptachlo Epoxide
Methoxychlor
Mirea
Oxychlordane

4.1.3 Receptors of Potential Concern (ROPCs)

Two types of receptors of potential concern include primary and secondary organisms. Primary receptors species are those that are potentially exposed to sediment contaminants and they either live or are expected to live in the BMP area. Secondary receptor species are those that are consumers of the primary species.

The main receptor species studied in the previous reports are primary receptors, and include a variety of benthic invertebrates and the fathead minnow. Two key orders of benthic invertebrates studied in the BMP include the mayflies (Ephemeroptera) and caddisflies (Trichoptera). Both are considered to be the pollutant sensitive species for the site. Both orders occur in high abundance in the BMP and in other sections of the St. Marys River[36].

Other dominant benthic families found in the BMP include Chironomidae (midge), Tubificidae (aquatic worm), Sphaeriidae (fingernail clam), Asellidae (isopod), Naididae (aquatic worm), Sabellidae (fan worm), Haustoriidae (amphipod), Valvatidae (snail), Dreissenidae (mussel) and Gammaridae (amphipod)[37].

The fathead minnow is the only fish species mentioned in previous studies. It is typically a pollutant tolerant species and as a result may not be an ideal receptor to monitor.

Other fish species present in the St. Marys River according to consumption advisories (see Section 4.1.5) include Chinook salmon, Atlantic salmon, pink salmon, rainbow trout, walleye, northern pike, yellow perch, brown bullhead, white sucker, and longnose sucker.

4.1.4 Exposure Pathways

Exposure pathways are the physical courses a chemical or pollutant takes from its source to the exposed organism. Pollutants such as metals may enter the aquatic food chain through direct consumption of water or biota (ingestion), and through non-dietary routes such as uptake through absorbing epithelia (such as skin and fish gills).

Ingestion

Ingestion is one exposure pathway by which benthic organisms assimilate contaminants by consuming particles. Ingestion is usually intentional, but it can also be unintentional especially for organisms that forage for food and are bottom feeders.

Benthic organisms tend to select the smaller and finer particles in their environment, which also tend to be enriched in metals because of the ionic bonding capacity of the surface area of fine particles, such as clay. Other contaminants may bond to the sediment surface depending on their chemical and physical properties. In addition, benthic organisms indirectly consume metals by feeding on zooplankton and algae that accumulate metal pollutants. Fish species, on the other hand, accumulate metal pollutants depending on their occupancy in the trophic level and size and age. Assimilation of particle-bound metals will normally involve conversion from particulate to dissolved form in the gut of the organisms and diffuse across the intestinal tract, thus becoming bioavailable in the soluble phase.

[36] Kilgour, Martin and Kauss, 2001.
[37] Milani and Grapentine, 2006.

Non-Dietary Routes
Under certain environmental conditions, contaminants bound to the surface of the sediment particles can become solubilized, and therefore bioavailable. One of the major pathways for most organisms is the soluble form of metals.[38] Once in the aqueous phase, the contaminant can be absorbed through non-dietary routes such as direct skin absorption through passive diffusion or by absorption through gills in the case of fish species. For example, metals are capable of becoming solubilized at low pH and anoxic conditions, which typically occur simultaneously. As a result, environmental conditions (pH, redox potential, temperature, and dissolved oxygen) play a major role in the bioavailability of the contaminants, particularly metals bound to sediment.

Biomagnification
Another exposure pathway in which pollutants such as metals can accumulate in aquatic life is through biomagnification. Biomagnification is the increase in concentration of an element, such as a pollutant occurring in the food chain as a consequence of food chain energitics; or the lack of or slow process of degradation of the element.

4.1.5 Consumption Advisories

Normally only one set of consumption advisories is necessary for contaminant levels for fish of a given size and species, as they are frequently found to be similar within small or medium sized lakes and rivers. Larger lakes and river systems may have fish of different sizes, which typically contain different levels of contamination based on the fish size. As a result, consumption advisories based on fish size are published by the MOE in the "*Guide to Eating Ontario Sport Fish*".

Sensitive receptors include the 'general population', and the 'sensitive population'. General population includes the general public and sensitive population includes women of child-bearing age, pregnant women, women who are intending to become pregnant or breast-feeding mothers, and children under the age of 15. Consumption limits for the sensitive population are normally more restrictive than those for the general population[39].

The 2007-2008 fish consumption advisories for the general population as well as sensitive population based on the "*Guide to Eating Ontario Sport Fish*" are provided in Table 3[40].

[38] Golder, 2004
[39] MOE, 2005.
[40] MOE, 2005.

Table 3. The 2007-2008 Fish Consumption Advisories for the St. Marys River

Fish Species	Contaminants for which the fish species was tested	Consumption Advice
Chinook Salmon	Mercury, PCBs, mirex/photomirex, pesticides, chlorinated phenols, chlorinated benzenes, PAHs, dioxins, furans and dioxin-like PCBs	Consumption restriction for fish > 60cm
Atlantic Salmon	Mercury, PCBs, mirex/photomirex, pesticides, chlorinated phenols, chlorinated benzenes, PAHs, dioxins, furans and dioxin-like PCBs	General population: ≤1 meals per month for fish <75cm; Sensitive population: Consumption restriction for fish > 50cm
Pink Salmon	Mercury, other metals, PCBs, mirex/photomirex, pesticides, chlorinated phenols, chlorinated benzenes, PAHs, dioxins, furans and dioxin-like PCBs	General population: ≤8 meals per month for fish < 40cm; ≤4 meals per month for fish <45cm; ≤2 meals per month for fish <55cm Sensitive population: as above and 0 meals >45cm
Rainbow Trout	Mercury, PCBs, mirex/photomirex, pesticides, dioxins, furans and dioxin-like PCBs	General population: ≤8 meals per month for fish <25cm: ≤4 meals per month for fish <65cm; ≤2 meals per month for fish <75cm; Sensitive population: as above and 0 meals per month >65cm
Walleye	Mercury, PCBs, mirex/photomirex, pesticides, chlorinated phenols, chlorinated benzenes, PAHs	General population: ≤8 meals per month for fish <50cm; ≤4 meals per month for fish<60cm; ≤2 meals per month for fish<65cm Sensitive population: ≤8 meals per month for fish <40 cm; ≤4 meals per month for fish <50cm; restriction on fish ≥ 50cm
Northern Pike	Mercury, other metals, PCBs, mirex/photomirex, pesticides, chlorinated phenols, chlorinated benzenes, PAHs	General population: ≤8 meals per month for fish <75cm Sensitive population: ≤8 meals per month for fish <65cm; ≤4 meal per month for fish <75cm
Yellow Perch	Mercury, PCBs, mirex/photomirex, pesticides	General population: ≤8 meals per month for fish <40cm Sensitive population: ≤8 meals per month for fish <30cm; ≤4 meals per month for fish <35cm; restriction on fish ≥35cm
Brown Bullhead	Mercury, PCBs, mirex/photomirex, pesticides	General population: ≤8 meals per month for fish <35cm Sensitive population: ≤8 meals per month for fish <30cm; ≤4 meals per month for fish <35cm
White Sucker	Mercury, other metals, PCBs, mirex/photomirex, pesticides, dioxins, furans, chlorinated phenols, chlorinated benzenes, PAHs	For all: ≤8 meals per month for fish <55cm
Longnose Sucker	Mercury, PCBs, mirex/photomirex, pesticides	General population: ≤4 meals per month for fish <35cm; ≤2 meals per month for fish <45cm Sensitive population: restriction on fish consumption >30cm

4.1.6 Sediment Stability

From the information available in the reviewed reports, sediments within the BMP consist of soft sediments, including clay and silt and various foreign materials, including wood fibres or wood chips and detritus. Earlier studies observed that the sediments were easily re-suspended when disturbed, for example during sample collection.

Other studies however, report that the St. Marys River velocity in the area of the BMP was below that which may cause scouring of the river bottom, which indicates that under natural River flow conditions, the sediment may be relatively stable. Based on the limited information available, the assessment of sediment stability is considered to be incomplete

4.1.7 Assessment Endpoints & Measure of Effect

Assessment endpoints, as defined by United States Environmental Protection Agency (USEPA) are explicit statements of the ecological system that are to be protected and which are either measured directly or are evaluated through indirect measures. Measurement endpoints represent quantifiable ecological characteristics that can be measured, interpreted and related to the valued ecological components chosen as assessment endpoints.

Population dynamics such as growth, survival rate and mortality of biological communities are important assessment endpoints for the evaluation of ecological risks at aquatic sites. These endpoints may be monitored using sediment toxicity assessments and surveys to characterize the aquatic vegetation, benthic invertebrates and fish communities.

Macro-invertebrate and fish communities are typically used as indicators of pollutants. As such, biotic indices can be used to assess the biological integrity of the study area. The analyses integrate several community, population and functional parameters into the interpretation. Each parameter measures a different component of community structure (measures of effect such as species richness, diversity, abundance, distribution, etc) and has a different range of sensitivity to pollution stress. These measures of effect then provide us with adequate information to assess, regulate and protect the endpoints.

The Index of Biotic Integrity[41] is an index for fish community structure and the EPT Index (which represents the orders: Ephemeroptera, Plecoptera and Trichoptera) is an index used to characterize macro-invertebrate community structure. Both indices are important for assessing the effects of pollutants on the health of fresh water systems.

[41] Karr, 1981

4.1.8 Reference Sites

Establishing reference sites that represent natural conditions in the BMP are imperative for making accurate conclusions regarding sediment quality and benthic toxicity effects as data from reference sites provide standards against which to compare the test site conditions.

The reports reviewed as part of this assessment identified four reference sites located in the St. Marys River used as control sites for sediment toxicity studies, including:

(1) Point Aux Pins Bay
(2) Izaak Walton Bay
(3) US South Shore.
(4) Location 213 as shown in Figure 3.

Another reference site (reference Group 1) was referred to in the BEAST study and may be useful for statistical interpretation of the data.

Some of these reference sites displayed elevated chemical concentrations in sediment and as a result, may be not be appropriate control sites. The following paragraphs describe the reference sites used in previous studies, along with their limitations. Additional studies are required to determine whether any of these reference sites would be appropriate for further studies in the BMP.

(1) Point Aux Pins Bay
Several sediment toxicity studies used Point Aux Pins Bay as a reference site. It is located upstream of the Algoma Slag Dump and generally appears to have a firmer substrate compared to the BMP. However, a zone near the shore displayed a softer substrate and wood debris, both of which are characteristics similar to the BMP.

Sediment contaminants have been detected in the Point Aux Pins Bay reference site. Concentrations of metals (copper, arsenic) were above PSQG-LEL at one location.

Point Aux Pins Bay in general has high benthic invertebrate abundance and diversity, however, this is the only reference site where sediment toxicity effects were observed. Acute toxicity was noted for the amphipod *Hyalella azteca* at 1 location and a reduction in *Chironomus riparius* survival at 2 locations within Point Aux Pins Bay. The BEAST toxicity evaluation defined 1 location as toxic/severely toxic, 2 as potentially toxic and 2 as non-toxic.

Based on the elevated concentrations of metals and nutrients bound to sediment, and the toxic effects observed in benthic invertebrates, this site may not be a suitable reference site.

(2) Izaak Walton Bay
This reference site is located at the River's west end, upstream of Point Aux Pins Bay. It also has firm substrate ranging from fine silt to sity-sand and some gravel, which is quite different from the soft sediments observed in the BMP.

Measurable concentrations of metals were below the PSQG-LEL except for concentrations of chromium and copper. Total organic carbon ranged from 0.4 to 2.2 % and vegetation and organic mater is present at the site.

Izaak Walton Bay has high benthic invertebrate abundance and diversity. All locations within Izaak Walton Bay were characterized as non-toxic following BEAST toxicity evaluation.

(3) US South Shore
This reference site is located just upstream of Tannery Bay on the south shore of the St. Marys River. The sediment in this area is comprised of mostly sand, with some silt and clay. The sediment texture appears coarser than the soft sediments observed in the BMP.

Based on one sample location, one contaminant of concern was identified in the sediment. Cadmium exceeded the PSQG-LEL and TOC was low.

The US South Shore reference site has high benthic invertebrate abundance and diversity. Chironomids as well as tubificids were found to have an increased abundance at this site while other fundamental reference families (≥ 3.6% expected occurrence) were present in decreased amounts. The BEAST toxicity evaluation identified the locations tested as being possibly different from reference (Group 1) and as being non-toxic.

(4) Location 213
Reference location 213 is situated within the BMP near its southerly limits, south of the Plummer Memorial Hospital. Based on information from the 1995 sampling event, it was indicated that, with the possible exception of chromium, sample location 213 might be representative of a control location within the BMP.[42]

(5) Reference Group 1
Reference Group 1 is composed of 108 sites/locations including those from Georgian Bay, North Channel, Lake Ontario, Lake Erie, Lake Huron and Lake Michigan and is described as having a large abundance of Chironomidae (~ 40% occurrence), followed by Tubificidae (~17% occurrence) and Sphaeriidae (~15% occurrence). Asellidae, Naididae and Sabellidae are also present but to a lesser degree (between ~4 to 6% occurrence).[43] Reference Group 1 may be useful for comparison of data collected from the BMP through statistical analysis.

[42] Kauss, 1996
[43] Milani and Grapentine, 2006

4.1.9 Initial Conceptual Model

An initial Conceptual Site Model (CSM) of the BMP was developed using available background information. The CSM is a three-dimensional model that provides a template to evaluate exposure pathways, show the interrelationships between COPCs and ROPCs, identify temporal and spatial components and endpoints. Refinement of the CSM is an ongoing process. Figure 3 presents an initial CSM showing possible interrelationships of COPCs and ROPCs. As the data pool increases, the CSM should be modified to reflect new and updated information.

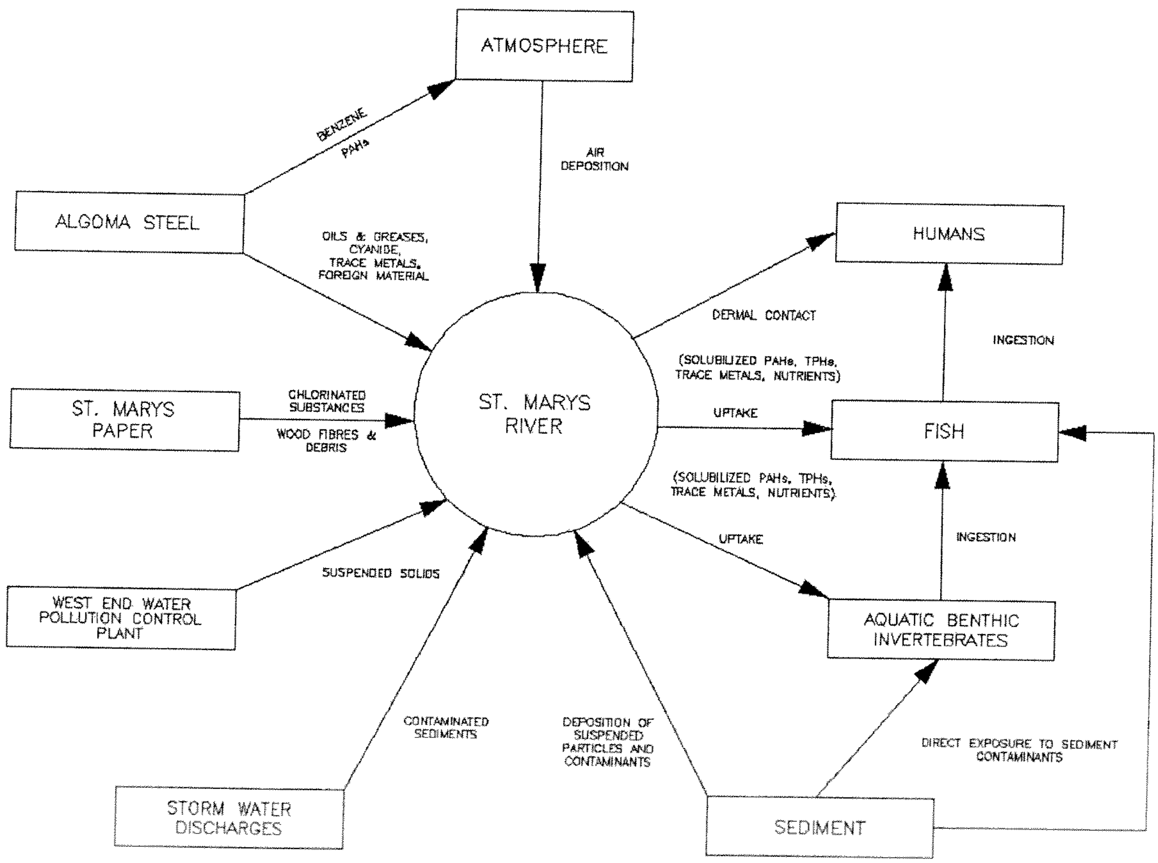


Figure 3: Initial Conceptual Site Model

4.2 Step 2: Sampling and Analysis Plan

Although a Sampling and Analysis Plan should be developed to address the previously identified data gaps, to update old information and obtain additional data, Step 2 of the

Framework has been completed herein applying the information available in the reviewed documents.

4.2.1 Decision Point 1: Possible Toxicity or Biomagnification

COPC present in shallow sediment samples (<10cm) are present in concentrations that exceed the PSQG-LEL for several parameters (refer to Tables 4 through 7), including:

- Various metals (arsenic, cadmium, chromium, copper, iron, mercury, magnesium nickel, lead and zinc)
- Nutrients (total nitrogen, TOC, and total phosphorus)
- Total polycyclic aromatic hydrocarbons (PAH)
- Polychlorinated biphenyls (PCB)

In addition, concentrations of petroleum hydrocarbons were generally high, in particular for the heavier carbon fractions (F2 through F4). Since there are no CCME or MOE Sediment Guidelines to compare the concentrations of petroleum hydrocarbon fractions to, the degree of petroleum hydrocarbon contamination is uncertain.

COPC that are known to biomagnify are present in the sediment; mercury and PCBs were detected in concentrations above the PSQG-LEL. As a result, there is a potential for these contaminates to biomagnify.

Toxic effects, including high mortality and growth impairments, were observed in Chironomus and Hexagenia.[44] and the BEAST toxicity analysis characterized two locations (6986, 6991) in the BMP as being toxic. The BEAST report also indicated that both locations had a percent survival in the toxic range for Chironomus riparius and potentially toxic or toxic levels of growth impairment for Hexagenia spp.

In summary, sediment contaminants are present, some of which can biomagnify, and toxic effects have been observed in some of the benthic invertebrates.

> Since Toxicity is possible and substances that can biomagnify are present, **PROCEED** to Step 3.

4.3 Step 3: Risk Based on Contaminant Concentrations

Sediment chemistry data are provided in Tables 4 through 7. Concentrations of metals, nutrients, PAH and PCB exceed the PSQG-LEL and concentrations of iron and TOC exceed the PSQG-SEL. Petroleum hydrocarbon are also at elevated concentrations.

[44] Kilgour, Martin and Kauss, 2001

In some cases, COPC concentrations at locations in the BMP were reported to be more than 20% greater than concentrations of the same COPCs at upstream reference locations. Tables A1, A2 and A3 in Appendix A provide comparisons of the sediment chemistry at the BMP to the reference locations.

Table 4. Metal and Nutrient Concentrations in Surficial Sediment (top 10cm)[45]
Units are in µg/g dry weight (data from 2002)

Location	As	Cd	Cr	Cu	%Fe	Hg	Mn	Ni	Pb	Total N	% TOC	TP	Zn
6981	**9.0**	<1	**57.2**	**37.3**	**3.9**	0.15	**495.0**	**28.2**	**57.5**	**2661.0**	**7.9**	**746.0**	**142.0**
6983	5.0	<1	**64.5**	**34.1**	**4.1**	0.13	**462.0**	**27.8**	**47.0**	**1473.0**	**6.5**	466.0	**158.2**
6984	<5	<1	**38.9**	**24.1**	**2.7**	0.09	305.0	14.5	**36.0**	**1160.0**	**4.7**	540.0	**126.0**
6986	<5	**1**	**71.2**	**87.3**	**4.8**	0.06	**520.0**	**32.5**	**80.0**	**4313.0**	**7.5**	**678.0**	**286.1**
6991	**27.0**	<1	**89.5**	**67.5**	**6.4**	**0.24**	**679.0**	**45.7**	**84.9**	**2369.0**	**14.1**	551.0	**346.5**
6992	**25.0**	<1	**83.7**	**63.4**	**5.9**	**0.22**	**622.0**	**39.2**	**80.0**	**2145.0**	**9.6**	556.0	**267.0**
LEL	6.0	0.6	26.0	16.0	2.0	0.20	460.0	16.0	31.0	550.0	1.0	600.0	120.0
SEL	33.0	10.0	110.0	110.0	4.0	2.0	1100.0	75.0	250.0	4800.0	10.0	2000.0	820.0

Bolded values exceed PSQG-LEL, bolded and shaded values exceed PSQG-LEL and PSQG-SEL

Table 5. PCB Concentrations in Sediment[46]
Units are in µg/g dry weight (data from 1995)

Location	Depth (cm)	PCB
210	10-20	**1.0**
210	30-40	**1.6**
214	0-5	**1.6**
LEL		0.07
SEL		530

Bolded values exceed PSQG-LEL, bolded and shaded values exceed PSQG-LEL and PSQG-SEL

Table 6. Sediment PH Concentrations[47] (data from 2002)

Petroleum Hydrocarbon	Units	FQGLO	6981	6983	6984	6991	6992	6986
Benzene	µg/g	0.24	ND	ND	ND	ND	ND	ND
Toluene	µg/g	2.1	ND	ND	ND	ND	ND	ND
Ethylbenzene	µg/g	0.28	ND	ND	ND	ND	ND	ND
o-Xylene	µg/g	-	ND	ND	ND	ND	ND	ND
p+m Xylene	µg/g	-	ND	ND	ND	ND	ND	ND
Total Xylenes	µg/g	25	ND	ND	ND	ND	ND	ND
F1(C6-C10 hydrocarbons) - BTEX	µg/g	-	ND	ND	ND	ND	ND	ND
F2(C10-C16 hydrocarbons)	µg/g	-	ND	**140**	41	**220**	**260**	**150**
PH (gas/diesel - F1/F2)		100						
F3(C16-C34 hydrocarbons)	µg/g	-	270	**2100**	830	**3300**	**3300**	**3900**
F4(C34-C50 hydrocarbons)	µg/g	-	97	**1500**	**1000**	**2700**	**3000**	**4400**
PH (oils/tars – F3/F4)		1000						
Total Petroleum Hydrocarbons	µg/g	-	367	10740	5871	17220	16560	23450

ND = Not Detected
FQGLO = Fill Quality Guidelines for Lakefilling in Ontario
Bolded values appear to exceed FQGLO

[45] Milani and Grapentine, 2006.
[46] Kilgour, Martin and Kauss, 2001
[47] Milani and Grapentine, 2006.

Table 7. Sediment PAH Concentrations[48]

Polycyclic Aromatic Hydrocarbon	Units	LEL	SEL	6981*	6983*	6984*	6991*	6992*	6986*
Naphthalene	µg/g	-	-	1.51	1.09	0.131	0.917	2.34	0.101
Acenaphthylene	µg/g	-	-	0.0792	0.0369	0.0273	0.109	0.0469	0.0639
Acenaphthene	µg/g	-	-	0.047	0.03	0.027	0.051	0.037	0.014
Fluorene	µg/g	0.190	160	0.06	0.039	0.0429	0.0513	0.0395	0.0205
Phenanthrene	µg/g	0.560	950	0.543	0.324	0.292	0.459	0.283	0.195
Anthracene	µg/g	0.220	370	0.178	0.0872	0.163	0.172	0.107	0.0699
Fluoranthene	µg/g	0.750	1020	**0.870**	0.408	0.352	**0.873**	0.462	0.381
Pyrene	µg/g	0.490	850	**0.691**	0.325	0.275	**0.755**	0.377	0.327
Benzo(a)anthracene	µg/g	0.320	1480	**0.486**	0.244	0.16	**0.478**	0.236	0.234
Chrysene	µg/g	0.340	460	**0.441**	0.294	0.153	**0.432**	0.219	0.211
Benzo(b)fluoranthene	µg/g	-	-	0.492	0.279	0.149	0.528	0.251	0.259
Benzo(k)fluoranthene	µg/g	0.240	1340	**0.254**	0.138	0.077	**0.274**	0.122	0.142
Benzo(a)pyrene	µg/g	0.370	1440	**0.614**	0.319	0.183	**0.676**	0.291	0.324
Indeno(1,2,3-cd)pyrene	µg/g	0.200	320	**0.383**	0.191	0.116	**0.449**	0.189	**0.231**
Dibenzo(a,h)anthracene	µg/g	0.060	130	**0.093**	0.048	0.025	**0.105**	N/D	0.057
Benzo(ghi)perylene	µg/g	0.170	320	**0.306**	0.148	0.099	**0.376**	0.157	**0.193**
Total PAHs	µg/g	4.000	10000	**7.047**	**4.001**	2.272	**6.705**	**5.157**	2.823

* values adjusted for TOC
- Guidelines could not be calculated due to insufficient data
ND = Not Detected
Bolded values exceed PSQG-LEL, bolded and shaded values exceed PSQG-LEL and PSQG-SEL

4.3.1 Decision Point 2: COPC Significantly Greater Than Reference

Contaminant concentrations in sediment exceed the PSQG-LEL and concentrations of iron and TOC exceed the PSQG-SEL; in some cases the concentrations are more than 20% above those associated with upstream reference sites.

> COPC exceed PSQG-LELs and/or one or more substances present can biomagnify, and concentrations are more than 20% greater than those at reference locations. Based on these results, **PROCEED** to Step 4.

4.4 Step 4: Biomagnification

Although there does not appear to have been significant historical work conducted to identify exposure pathways or quantify biomagnification effects, contaminants that have the potential to biomagnify, including mercury and PCBs have been identified in sediment samples collected from the BMP.

[48] Milani and Grapentine, 2006.

4.4.1 Decision Point 3: Is Biomagnification a Potential Concern

Contaminants that can biomagnify have been identified within the BMP and little investigation seems to have been conducted to assess the biomagnification potential.

There is a potential risk of biomagnification from the sediments through aquatic food chains, **PROCEED** to Step 5.

4.5 Step 5: Sediment Toxicity

Acute and chronic sediment toxicity tests were previously performed on bulk sediment samples collected from within the BMP. A brief description of the sediment toxicity tests performed and the conclusions of the tests are provided in Table 8.

The 2006 BEAST toxicity evaluation states that sediment at two locations within the BMP were characterized as toxic (6986, 6991) and the four remaining locations as non-toxic.

Table 8: Sediment Toxicity Tests in the BMP [49]	
Sediment Toxicity Tests	
Chironomus riparius	10-day survival and growth
Hyalella azteca	28-day survival and growth
Hexagenia spp.	21-day survival and growth
Tubifex tubifex	28-day survival and growth
Conclusions	
Chironomus riparius	Acute toxicity (41 to 52% survival)
Chironomus tentans *	Growth was reduced at 3 of the 13 sites (survival ranged from 58 to 76%)
Hexagenia spp.	chronic toxicity (negative growth)
Other Mayflies*	Low growth

*data from Kilgour, Martin and Kauss, 2001

Toxicity tests were also performed on the fathead minnow in 1992 and 1995. Mortality results for the fathead minnow (Pimephales promelas) were generally acceptable in the 1992 and 1995 data. Tissue concentrations corresponded to levels achieved in controls but copper tissue residue in BMP samples was found to be significantly higher than control[50].

Additional data must be collected, analyzed, interpreted and plotted in order to complete the sediment toxicity assessment. Part of the additional work required is to map spatial

[49] Milani and Grapentine, 2006
[50] Bedard and Petro, 1997.

patterns of contamination, in order to highlight areas of different levels of contamination (e.g. heavily contaminated, moderately and minimally contaminated).

4.5.1 Decision Point 4: Are Sediments Toxic

Available studies assessing sediment toxicity end points, referenced in 4.5 above, indicate statistical differences from reference conditions.

There is a potential risk that toxicity exists and further assessment is required, **PROCEED** to Step 6.

4.6 Step 6: As possible/appropriate assess Benthic Community Data

Quantitative evaluations of the benthic invertebrate community were conducted in past BMP studies. Kilgour, Martin and Kauss reported in 2001 that temporal variation in the benthic invertebrate community has shown an improvement in total abundance, evenness, diversity and specific benthic species abundance from the conditions initially documented in 1968. From 1985 to 1995 most of the changes were felt to be due to an increased number of smaller pollutant-tolerant organisms rather than pollution sensitive forms (i.e. mayflies and caddisflies). Despite these findings, benthic community is still considered degraded as Ephemeroptera and Trichoptera are in numbers well below reference.

Kilgour, Martin and Kauss also found in 2001 that a variation in benthic community composition correlated highly with oils and greases, TPHs, major element concentrations and sediment metal levels and water depth. No apparent association between benthic community composition and any of the toxicity endpoints was observed suggesting short-term toxicity is not a factor in variation of benthic community composition. In general, analysis suggests that variability in substrate conditions rather than the concentration of toxic contaminants is more likely affecting benthic community composition. However, a relationship between sediments with high TPH concentrations and reduced growth of Chironomus tetans and mayfly Hexagenia limbata suggests that TPHs may be bioavailable and toxic[51].

Application of the BEAST methodology resulted in 4 of the BMP sample locations being characterized as equivalent to reference (BEAST Band 1) and 2 as possibly different from reference (BEAST Band 2)[52]. Milani and Grapentine (2006) also noted that there was no strong evidence of benthic community impairment and that overall, there was a

[51] Kilgour, Martin and Kauss, 2001.
[52] Milani and Grapentine, 2006.

trend of higher taxon diversity and increased abundance of two or more taxa compared to reference.

4.6.1 Decision Point 5: Assessment of Benthic Community

> Benthic community assessments are appropriate and possible and have been conducted, **PROCEED** to Step 7.

4.7 Step 7: Decision Matrix

Table 9 presents a decision matrix produced using information available from the reviewed reports and weight of evidence (WOE) categorizations for chemistry, toxicity, benthos and biomagnification potential suggested in the Framework guidance document.[53] The WOE approach affords the least weight to sediment chemistry data and the most weight to benthic community data. WOE ordinal ranking categorizations are described on Table 1 in Appendix B.

Table 9: Decision Matrix for WOE Categorization

Sample Location	Sediment Chemistry	Toxicity	Benthos Alteration	Biomagnification Potential	Assessment
6981	■	○	■	■	Determine reason(s) for benthos alteration **and** fully assess risk of biomagnification.
6983	●	○	○	■	Fully assess risk of biomagnification.
6984	■	○	■	■	Determine reason(s) for benthos alteration **and** fully assess risk of biomagnification.
6986	●	●	○	■	Determine reason(s) for sediment toxicity **and** fully assess risk of biomagnification.
6991	●	●	○	■	Determine reason(s) for sediment toxicity **and** fully assess risk of biomagnification.
6992	●	○	○	■	Fully assess risk of biomagnification.
BMP Site Overall	●	■	○	■	Determine reason(s) for sediment toxicity **and** fully assess risk of biomagnification.

Sample locations per Millani and Grapentine, (2006)

Legend: ●- major effect/result, different, or adverse effects likely,
■- minor effect/result, possible different, or adverse effects may or may not occur,
○- negligible effect/result, equivalent, or adverse effects not unlikely

[53] Chapman, 2005

The process described in the Framework guidance document provides for an overall WOE assessment for each sample location and for the BMP site. Regarding the BMP site overall, site characteristics may characterized as posing either:

●- Significant adverse effects;
■- Potential adverse effects; or
○- No significant adverse effects.

Based on the BMP site overall assessment presented in Table 9, the Framework suggests that further assessment is required to determine reason(s) for sediment toxicity and fully assess the risk of biomagnification.

4.7.1 Decision Point 6: Do Sediments Pose an Environmental Risk

Based on the results presented in Table 9, it is apparent that sediments within the BMP pose a potential risk.

> Sediments may pose and environmental risk and additional studies or assessments are required, **PROCEED** to Step 8.

4.8 Step 8: Further Assessments

With reference to the decision matrix (Table 9), it appears that additional information is required prior to identification of an appropriate contaminated sediments management strategy for the BMP. Specifically, the following must be determined and/or assessed:

1. Reason(s) for observed benthos alteration;
2. Risk of biomagnification; and
3. Reason(s) for observed toxicity.

4.8.1 Decision Point 7: Does an Environmental Risk Exist

Decision point 7 can be addressed pending review of the results from the further assessments noted above.

> More information is required to address Decision Point 7.

4.9 Step 9: Deeper Sediments

It is generally understood that deeper sediments (e.g. greater than 10cm) are likely contaminated to a greater degree than surfical sediments. In order to assess the potential that deeper sediments become exposed, additional information relating to sediment stability is required. If it is found that the deeper sediments may be exposed by some natural or human-related circumstance, these sediments may pose an environmental risk, which would need to be evaluated. Such an evaluation would be carried-out through application of this Framework.

Similarly, if it is determined that remediation of the surficial sediments is warranted, deeper sediments may be exposed and/or disturbed during the course of remediation. This would also result in the need to assess deeper sediments through application of the Framework

4.9.1 Decision Point 8: Should Deeper Sediments be Assessed

Although it is likely that deeper sediments are contaminated to a greater degree than surficial sediments, additional assessments of benthic community, toxicity and contamination would be required to apply the Framework.

More information is required to address Decision Point 8.

5.0 Lands and Waterlots Adjacent to the BMP

Ownership and zoning of land and waterlots adjacent to the BMP are summarized in the Drawings and Table provided in Appendix C.

6.0 Conclusion

Additional benthic, toxicity and sediment studies are imperative for completing the contaminated sediment assessment in the BMP and to finalize a management strategy. Sediment studies that include up-to-date estimates of sediment deposited in the BMP, a comprehensive characterization of the COPC and the physical nature of the sediment are required along with bioassays, benthic invertebrate surveys, and fish surveys.

For the studies to provide valuable information, appropriate pristine reference sites are required. Since Point aux Pins Bay may not be an appropriate reference site due to the elevated concentrations of certain chemicals in sediment, new reference sites need to be researched. Reference data are necessary because they provide a standard against which to compare the test site conditions. They also account for natural and/or anthropogenic changes in sediment and water quality over time. Sampling in the reference locations should be rigorous enough to define the normal range of variation in sediment and water chemistry and benthic community structure.

This information will allow for a more clear representation of sediment quality and for discerning the toxic effects on the benthic community. Through data analysis and interpretation using modern statistical programs and mapping software, hot spots of highly contaminated areas can be identified, a better understanding of exposure pathways can be developed and an assessment of appropriate endpoints facilitated. Completion of the additional sediment toxicity studies will allow renewed application of the Decision Making Framework and ultimately allow for the development of an appropriate contaminated sediments management strategy.

7.0 Recommendations

The following recommendations are presented:

1. During any future study(s), monitoring stations should be established for regular monitoring of sediment conditions and benthic/fish communities over time. The monitoring program should include the physical and chemical condition of the sediment at various depths (both shallow and deeper sediments), and should include such physical characteristics as grain size, percent solid, and stability. The associated benthic and fish community (including species richness, abundance, diversity) present at the stations should also be monitored to determine any relationships between the chemistry and aquatic fauna. TIE studies should also be conducted.

2. An understanding of the exposure pathways and endpoints used in the MOE guidelines is required in order to collect data that is comparable to the MOE guidelines. For example, MOE contaminated sediment guidelines are set considering exposure pathways and the most stringent concentration. The actual exposure pathway may differ from that which was used to establish the most stringent concentration thus resulting in the development of potentially misleading conclusions when data is compared to the guidelines. For example, at least one report concluded that no impacts to organisms were observed at locations where sediment contaminants exceed the PSQG-LEL or PSQG-SEL, however the exposure pathway in the study may differ from that used in the PSQG.

3. It is also important that the same MOE guidelines are applied to contaminated sediment assessment studies in order to compare between studies.

4. In order to obtain up-to-date data concerning the benthic communities, sediment contamination and other considerations (i.e. pore water quality, assessment of gases present, etc.) a study similar to that reported on by the Kilgour, Martin and Kauss in 2001 should be designed and carried out within the BMP.

5. In addition, future work should include an assessment of the human health risk as mentioned in Stage 2 of the RAP report since the BMP is not only used for recreational activities, such as sailing, it is also used by the RYTAC Youth, the Municipal Park and Marina, and it is likely used at the Queen Street East federal building for gardening and watering the lawn.

6. The studies/assessments described under Decision Points 7 and 8 above should be conducted or planned undertakings modified or expanded to address the required information.

The data gaps identified herein should be addressed as described in sub-section 3.1.1 and re-iterated below:

1. **Identify sources of foreign material in the substrate at the BMP**. The substrate in the BMP that is largely composed of wood fibres and has a high TOC, may be a factor in the degradation of sediment quality and may even be concentrating toxic substances, at least those that have an affinity for organic matter over sediments or minerals. By identifying the possible sources of the foreign material, control measures to minimize the inputs of these materials into the BMP can be undertaken as part of the remediation efforts.

2. **Characterization of the observed sediment gases,** including type, concentration, source, toxicity and degree of decomposition. This information is important to quantify gas production both temporally and spatially and to determine any relationship between the contaminants, organic material present in the substrate, and the toxicity to benthic invertebrates and fish. This information is key in developing appropriate remedial options.

3. **Assess sediment loading to the St Marys River through** sediment core samples or sediment traps upstream of the BMP. This is particularly important to estimate the rate of sediment deposition and assess impacts of dredging activities on the habitat of various organisms. Sediment loading is also a function of river dynamics, as a result, a geomorphic study of the area is also recommended. This information is important for estimating the time that may be required to effectively cover and cap the contaminated sediments and to assess whether this type of passive remediation is appropriate. In addition, any concerns that stakeholders may have regarding initiating a clean-up of downstream sites (e.g. BMP) prior to upstream sites (e.g. Algoma Slip) where there may be a perceived potential for re-contamination are addressed.

4. **Assess the sediment stability.** Based on previous studies, the sediment is easily re-suspended when disturbed, but because of the low River current in the BMP, it is unlikely to be re-suspended by the natural flow of the River. However, because of the high volume of wood fibre in the sediment (which can affect the stability of

the sediment), additional stability studies are required. This is particularly important for assessing whether capping the sediment is an option for remediation.

5. **Exposure pathways require further assessment**, particularly because of the complex nature of the substrate present in the BMP.

6. **Identify one or more appropriate reference sites or locations.** Reports have indicated that the traditional Point Aux Pins background/control site may not be an appropriate control site since elevated concentrations of chemicals were measured in sediment. As a result, an assessment of other reference sites used in previous studies or new reference locations is required. More than one reference site would be ideal as numerous reference sites can account for natural and/or anthropogenic changes in sediment and water quality over time. Sampling at the reference location(s) should be rigorous enough to define the normal range of variation in sediment and water chemistry and benthic community structure.

7. **Analyze for additional chemical parameters:**

   a. Mercury, which only slightly exceeds the PSQG-LEL at two locations of shallow sediment (<10cm), is bioaccumulated much more rapidly in the methylated form than in the inorganic form. As a result, testing the methylated mercury levels versus mercury levels in the sediments and aquatic invertebrates is recommended.
   b. PCBs, which can bioaccumulate, were present at one location of shallow sediment (<10cm) in 1995. As a result, additional sediment samples need to be analyzed for PCBs to identify the extent of the PCB impacts.
   c. The complete list of volatile organic compounds (only benzene, toluene, ethylbenzene and xylene compounds have been analyzed to date), which may be associated to the foreign material present in the substrate, and which can be highly toxic.

8. **Additional sampling, including pore-water sampling** (water stored in pores between grains of sediment) is recommended to identify contaminants that may be in the more readily bioavailable state.

9. **Additional toxicity tests** are required in order to assess combined end-points that involve species survival, growth and reproduction (both acute and chronic endpoints). Species of interest include pollutant-sensitive benthos and fish.

10. **Toxicity Identification Evaluations (TIE)** should be conducted to develop a clearer understanding of the cause of observed sediment toxicity in the BMP.

11. **Seasonal Changes** in sediment contaminant concentrations, gas emission concentrations, and benthic population should be represented, if possible.

REFERENCES

Arthur, A., and P. Kauss. 2000. Sediment and Benthic Community Assessment of the St. Marys River. Ontario Ministry of the Environment Report.

Bedard, D., and S. Petro. 1997. Laboratory Sediment Bioassay Rreport on St. Marys River Sediments 1992 and 1995. Ontario Ministry of Environment and Energy.

Chapman, P.M., and J. Anderson. 2005. A Decision-Making Framework for Sediment Contamination.

Golder Associates Ltd. 2004. Synthesis of Sediment and Biological Investigations in the St. Mary's River Area of Concern. Report to Environment Canada, Environmental Conservation Branch, Ontario Region. 04-1112-020.

Hesselberg, R.J., and Y. Hamdy. 1987. Current and Historical Contamination of Sediment in the St. Marys River, 1987.

Karr, J.R. 1981. Assessment of Biotic Integrity using Fish Communities. Fisheries 6(6).

Kaus, P. 1996. Preliminary St. Marys River Sediment Survey Data. Internal Ontario Ministry of the Environment Reporting Memorandum.

Kilgour, B.W., W.B. Morton, and P.B. Kauss. 2001. Sediment and Benthic Invertebrate Community Assessment of the Bellevue Marine Park area in the St. Marys River. Draft report by Water Systems Analysts and Ontario Ministry of Environment, Environmental Monitoring and Reporting Branch.

Kresin Engineering Corporation. 2004. St. Marys River Remedial Action Plan Implementation: Review Project. Report to The Sault Ste. Marie and Region Conservation Authority.

Milani, D., and L.C. Grapentine. 2006. The Application of BEAST Sediment Quality Guidelines to the St. Marys River Area of Concern. Environment Canada.

Ontario Ministry of the Environment, 2007. 2007-2008 Guide to Eating Ontario Sport Fish. Queen's Printer for Ontario.

Persaud, D., R. Jaagumagi and A. Hayton. 1993.Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Queen's Printer for Ontario.

Persaud, D., A. Hayton, R. Jaagumagi and G. Rutherford. 2003. Fill Quality Guidelines for Lakefilling in Ontario. Queen's Printer for Ontario.

St. Marys River RAP Team. 2002. St. Marys River Remedial Action Plan Stage 2 Report: Remedial Strategies for Ecosystem Restoration. Ontario Ministry of the Environment and Michigan Department of Natural Resources.

St. Marys River RAP Team. 1992. St. Marys River Remedial Action Plan Stage 1 Report: Environmental Conditions and Problem Definitions. Ontario Ministry of the Environment and Michigan Department of Natural Resources.

APPENDIX A

Tables A1, A2, A3 – Comparison of Sediment Chemistry

NOTE: The sample stations associated with the data in Tables A1, A2 and A3 are summarized below:

Site	Station Number in the 2006 Report					
IWB	243	244	245	6903		
BMP	6981	6983	6984	6986	6991	6992
PPB	52-1090	52-479	52-1535	52-741	126	
BMP	6981	6983	6984	6986	6991	6992
US	6904					
BMP	6981	6983	6984	6986	6991	6992

Note: The following legend applies to Tables A1, A2 and A3.

	Greater than reference + 20% - low range
Bold	Greater than reference + 20% - high range

Table A1. BMP trace metal and nutrient concentrations compared to upstream reference sites (from Milani and Grapetine, 2006).

	Contaminant (µg/g) unless otherwise noted						
Site	**As**						**Reference + 20% Range (µg/g)**
IWB	<5	<5	<5	<5			<6
BMP	9.0	5.0	<5	<5	5.157	2.823	
PPB	<5	6.9	<5	<5	<5		< 6.0 - 8.28
BMP	9.0	5.0	<5	<5	5.157	2.823	
US	<5						<6
BMP	9.0	5.0	<5	<5	5.157	2.823	
LEL	6.0						
SEL	33.0						

Site	**Cd**						**Reference + 20% Range (µg/g)**
IWB	<1	<1	<1	<1			<1.2
BMP	<1	<1	<1	1	<1	<1	
PPB	<1	<1	<1	<1	<1		<1.2
BMP	<1	<1	<1	1	<1	<1	
US	1						1.2
BMP	<1	<1	<1	1	<1	<1	
LEL	0.6						
SEL	10.0						

Site	**Cr**						**Reference + 20% Range (µg/g)**
IWB	10.7	14.1	11.4	29.6			12.84 - 35.52
BMP	**57.2**	**64.5**	**38.9**	**71.2**	**89.5**	**83.7**	
PPB	13.8	15.5	6.9	10.2	9.3		12.24 - 18.6
BMP	**57.2**	**64.5**	**38.9**	**71.2**	**89.5**	**83.7**	
US	12						14.4
BMP	**57.2**	**64.5**	**38.9**	**71.2**	**89.5**	**83.7**	
LEL	26.0						
SEL	110.0						

Site	**Cu**						**Reference + 20% Range (µg/g)**
IWB	7.2	7.7	6	23.2			7.2 - 27.84
BMP	**37.3**	**34.1**	24.1	**87.3**	**67.5**	**63.4**	
PPB	6.4	24.8	3.5	7.1	4.4		5.28 - 29.76
BMP	**37.3**	**34.1**	24.1	**87.3**	**67.5**	**63.4**	
US	10.5						12.6
BMP	**37.3**	**34.1**	24.1	**87.3**	**67.5**	**63.4**	
LEL	16.0						
SEL	110.0						

Site	**%Fe**						**Reference + 20% Range (µg/g)**
IWB	0.4	1	0.7	1.2			0.48 - 1.44
BMP	**3.9**	**4.1**	**2.7**	**4.8**	**6.4**	**5.9**	
PPB	0.5	0.7	0.4	0.5	0.5		0.48 - 0.84
BMP	**3.9**	**4.1**	**2.7**	**4.8**	**6.4**	**5.9**	
US	0.8						0.96
BMP	**3.9**	**4.1**	**2.7**	**4.8**	**6.4**	**5.9**	
LEL	2.0						
SEL	4.0						

Site	Hg						Reference + 20% Range (µg/g)
IWB	0.01	0.01	0.01	0.02			0.012 - 0.024
BMP	**0.15**	**0.13**	**0.09**	**0.06**	**0.24**	**0.22**	
PPB	0.01	0.05	0.01	0.02	0.01		0.012 - 0.06
BMP	**0.15**	**0.13**	**0.09**	0.06	**0.24**	**0.22**	
US	0.01						0.012
BMP	**0.15**	**0.13**	**0.09**	**0.06**	**0.24**	**0.22**	
LEL	0.2						
SEL	2.0						

Site	Mn						Reference + 20% Range (µg/g)
IWB	86	169	129	113			103.2 - 203
BMP	**495.0**	**462.0**	**305.0**	**520.0**	**679.0**	**622.0**	
PPB	45	77	42	52	48		50.4 - 92.4
BMP	**495.0**	**462.0**	**305.0**	**520.0**	**679.0**	**622.0**	
US	79						94.8
BMP	**495.0**	**462.0**	**305.0**	**520.0**	**679.0**	**622.0**	
LEL	460.0						
SEL	1100.0						

Site	Ni						Reference + 20% Range (µg/g)
IWB	4.5	14	8.3	9.8			5.4 - 16.8
BMP	**28.2**	**27.8**	14.5	**32.5**	**45.7**	**39.2**	
PPB	3.2	16	7.6	7.7	7.9		3.84 - 19.2
BMP	**28.2**	**27.8**	14.5	**32.5**	**45.7**	**39.2**	
US	6.1						7.32
BMP	**28.2**	**27.8**	**14.5**	**32.5**	**45.7**	**39.2**	
LEL	16.0						
SEL	75.0						

Site	Pb						Reference + 20% Range (µg/g)
IWB	3.6	9	5.3	19			4.32 - 22.8
BMP	**57.5**	**47.0**	**36.0**	**80.0**	**84.9**	**80.0**	
PPB	7.2	17.8	3.7	3.9	4.3		4.44 - 21.36
BMP	**57.5**	**47.0**	**36.0**	**80.0**	**84.9**	**80.0**	
US	2.3						2.76
BMP	**57.5**	**47.0**	**36.0**	**80.0**	**84.9**	**80.0**	
LEL	31.0						
SEL	250.0						

Site	Total N						Reference + 20% Range (µg/g)
IWB	623	590	628	2152			708.0 - 2582.4
BMP	**2661.0**	1473.0	1160.0	**4313.0**	2369.0	2145.0	
PPB	1086	2648	443	776	536		531.6 - 3177.6
BMP	2661.0	1473.0	1160.0	**4313.0**	2369.0	2145.0	
US	667						800.4
BMP	**2661.0**	**1473.0**	**1160.0**	**4313.0**	**2369.0**	**2145.0**	
LEL	550.0						
SEL	4800.0						

Site	%TOC						Reference + 20% Range (µg/g)
IWB	0.8	0.6	0.4	2.2			0.48 - 2.64
BMP	**7.9**	**6.5**	**4.7**	**7.5**	**14.1**	**9.6**	
PPB	1.5	7.6	0.4	1.7	0.5		0.48 - 9.12
BMP	7.9	6.5	4.7	7.5	**14.1**	**9.6**	
US	0.8						0.96
BMP	**7.9**	**6.5**	**4.7**	**7.5**	**14.1**	**9.6**	
LEL	1.0						
SEL	10.0						

Site	Total P						Reference + 20% Range (µg/g)
IWB	294	366	276	500			331.2 - 600.0
BMP	**746.0**	466.0	540.0	**678.0**	551.0	556.0	
PPB	412	443	289	327	315		346.8 - 531.6
BMP	**746.0**	466.0	**540.0**	**678.0**	**551.0**	**556.0**	
US	340						408
BMP	**746.0**	**466.0**	**540.0**	**678.0**	**551.0**	**556.0**	
LEL	600.0						
SEL	2000.0						

Site	Zn						Reference + 20% Range (µg/g)
IWB	21	19.6	17.1	49.3			20.52 - 59.16
BMP	**142.0**	**158.2**	**126.0**	**286.1**	**346.5**	**267.0**	
PPB	17.5	50.8	11.5	17.7	13.9		13.8 - 60.96
BMP	**142.0**	**158.2**	**126.0**	**286.1**	**346.5**	**267.0**	
US	23.2						27.84
BMP	**142.0**	**158.2**	**126.0**	**286.1**	**346.5**	**267.0**	
LEL	120.0						
SEL	820.0						

Table A2. BMP total petroleum hydrocarbon concentrations compared to upstream reference sites[1].

Site	Total Petroleum Hydrocarbons (µg/g)						Reference + 20% Range (µg/g)
IWB	39	16	24	137			19.2 - 164.4
BMP	**367**	**10740**	**5871**	**23450**	**17220**	**16560**	
PPB	43	341	17	76	23		20.4 - 409.2
BMP	367	**10740**	**5871**	**23450**	**17220**	**16560**	
US	33						39.6
BMP	**367**	**10740**	**5871**	**23450**	**17220**	**16560**	

	Greater than reference + 20% - low range
Bold	Greater than reference + 20% - high range

[1] Milani and Grapentine, 2006.

Table A3. BMP total polycyclic aromatic hydrocarbon concentrations compared to upstream reference sites[1].

Site	Total Polycyclic Aromatic Hydrocarbons (µg/g)						Reference + 20% Range (µg/g)
IWB	ND	ND	ND	0.015			0.018
BMP	**7.047**	**4.001**	**2.272**	**2.823**	**6.705**	**5.157**	
PPB	0.055	ND	0.022	ND	ND		0.0264 - 0.066
BMP	**7.047**	**4.001**	**2.272**	**2.823**	**6.705**	**5.157**	
US	ND						-
BMP	**7.047**	**4.001**	**2.272**	**2.823**	**6.705**	**5.157**	

	Greater than reference + 20% - low range
Bold	Greater than reference + 20% - high range
ND	Not Detected
-	No values detected to distinguish a range

[1] Milani and Grapetine, 2006.

APPENDIX B

WOE Ordinal Ranking

	●	■	○
Bulk Chemistry (compared to SQG)	**Adverse Effects Likely:** One or more exceedances of SQG-high	**Adverse Effects May or May not Occur:** One or more exceedances of SQG-low	**Adverse Effects Unlikely:** All contaminant concentrations below SQG-low
Toxicity Endpoints (relative to reference)	**Major:** Statistically significant reduction of more than 50% in one or more toxicological endpoints	**Minor:** Statistically significant reduction of more than 20% in one or more toxicological endpoints	**Negligible:** Reduction of 20% or less in all toxicological endpoints
Overall Toxicity	**Significant**: Multiple tests/endpoints exhibit major toxicological effects	**Potential**: Multiple tests/endpoints exhibit minor toxicological effects and/or one test/endpoint exhibits major effect	**Negligible**: Minor toxicological effects observed in no more than one endpoint
Benthos Alteration (multivariate assessment, e.g., ordination)	"different" or "very different" from reference stations	"possibly different" from reference stations	"equivalent" to reference stations
Biomagnification Potential (relative to reference)	**Significant**: Based on Step 8	**Possible**: Based on Step 4	**Negligible**: Based on Steps 4 or 8
Overall WOE assessment	**Significant adverse effects**: elevated chemistry; greater than a 50% reduction in one or more toxicological endpoints; benthic community structure different (from reference) ; **and/or** significant potential for biomagnification	**Potential adverse effects**: elevated chemistry; greater than a 20% reduction in two or more toxicological endpoints; benthic community structure possibly different (from reference); **and/or** possible biomagnification potential	**No significant adverse effects:** minor reduction in no more than one toxicological endpoint; benthic community structure not different from reference; **and** negligible biomagnification potential

APPENDIX C

Ownership and Zoning of Lands Abutting the BMP

Bellevue Embayment
Details Regarding Properties and Water Lots Adjacent to the BMP

KEC Ref. No. 0624.02

Civic Address	Alternate/Mailing Address	Legal Description for Property
48 Pine Street Sault Ste. Marie, ON Bellevue Marina	City of Sault Ste. Marie PO Box 580 Stn Main Sault Ste. Marie, ON P6A 5N1	
58 Pine Street Sault Ste. Marie, ON P6A 3Y1 Vandaele Steven		
64 Pine Street Sault Ste. Marie, ON P6A 3Y1 McCaig Barry Marlin McCaig Jill Marie		
66 Pine Street Sault Ste. Marie, ON P6A 3Y1 Studens John Andrew Kempny Cindy M		
68 Pine Street Sault Ste. Marie, ON P6A 3Y1 Simpson Albert George Simpson Margaret Rose		
70 Pine Street Sault Ste. Marie, ON P6A 3Y1 Gough Mark		
72 Pine Street Sault Ste. Marie, ON P6A 3Y1 Brown M Roberta		
82 Pine Street Sault Ste. Marie, ON P6A 3Y1 Seabrook Noreen Estella Seabrook Kimberly Ann		
89 Pine Street Apt 101 Sault Ste. Marie, ON P6A 6M6 Algoma Condominium Corporation		5761 020 047 100 00 0000 to 5791 020 047 060 00 0001 Algoma Condo Plan 1
90 Pine Street Sault Ste. Marie, ON P6A 3Y1 Marshall Philip John Nicholson Marion Ruth		
99 Pine Street Sault Ste. Marie, ON	562502 Ontario Inc. c/o L.B. Lukenda 212 Queen Street E Suite 403 Sault Ste. Marie, ON P6A 5X8	
855 Queen Street East Sault Ste. Marie, ON P6A 2B3 1022254 Ontario Inc Algoma Financial Service, Algoma Insurance Brokers Ltd, Investors Group		
875 Queen Street East Sault Ste. Marie, ON P6A 2B3 Ontario Ministry of Natural Resources		020 045 041 00 0000 PLAN 204 LTS 4-11 PIM ST LT 5 12 LUSCUMBE LNE CLSD CON 1 LT 23 PT 24 PT WATER LTS FRONT
903 Queen Street East	Quenneville Azadeh	

Civic Address	Alternate/Mailing Address	Legal Description for Property
Sault Ste. Marie, ON P6A 2B6 Quennevilee Rental	Quenneville Ghislain 46 Central Avenue Elliot Lake, ON P5A 2G2	
911 Queen Street East Sault Ste. Marie, ON P6A 1A1 Detox Centre		
915 Queen Street East Sault Ste. Marie, ON P6A 2B6 Sexual Assault Care Clinic		
923 Queen Street East Sault Ste. Marie, ON P6A 2B7 Maccarone John Louis		
941 Queen Street East Sault Ste. Marie, ON P6A 2B8 Sault Ste. Marie General Hospital		020 045 020 00 0000 to 020 045 020 00 0001 CON 1 PARK LOT 18 PRK LOT 19 RP 1R 4897 PART 11 TO 5, PART 18, PART 20
955 Queen Street East Sault Ste. Marie, ON P6A 1A1 Doctors Building Company	Fleming and Smith 376 Queen Street East Sault Ste. Marie, ON P6A 1Z1	
969 Queen Street East Sault Ste. Marie, ON P6A 2C4 Plummer Memorial Public Hospital		020 045 011 00 0000 to 020 045 011 00 0001 CON 1 PARK LOT 15 PT LOT 16 WTR LOTS INFRONT RP 1R 4897 PT 1 PT 4 PT 19
1007 Queen Street East Sault Ste. Marie, ON	City of Sault Ste. Marie PO Box 580 Stn Main Sault Ste. Marie, ON P6A 5N1	City of Sault Ste. Marie 020 045 010 00 0000 WATER LOTS IN FRONT OF CON 1 PARK LOTS 14 PT LOT 15 PT REAR IF 1019 1009
1009 Queen Street East Sault Ste. Marie, ON P6A 2C2 Schryer Violin Workshop	Ambeault Mary Elizabeth Schryer Raymond Rene PO Box 223 1220 Richards Street Richards Landing, ON P0R 1J0	
1015 Queen Street East Sault Ste. Marie, ON P6A 2C2 Kelly Barbra Anne Kelly Michael John Anderson		
1019 Queen Street East Sault Ste. Marie, ON P6A 2C2 Elder Graham Murray Reibmayr Andrea Susan		
1025 Queen Street East Sault Ste. Marie, ON P6A 2C2 Yeomans Alice Zona		
1027 Queen Street East Sault Ste. Marie, ON	City of Sault Ste. Marie PO Box 580 Stn Main Sault Ste. Marie, ON P6A 5N1	City of Sault Ste. Marie 020 045 010 00 0000 WATER LOTS IN FRONT OF CON 1 PARK LOTS 14 PT LOT 15 PT REAR IF 1019 1009
1029 Queen Street East Sault Ste. Marie, ON P6A 2C2 Derby R Gwendolyn		Derby, Ralph Smythe 020 045 005 00 0000 CON 1 PARK LOT 14 PT WTR LOT IN FRNT PCL 250 3606 AWS

Bellevue Embayment
Details Regarding Properties and Water Lots Adjacent to the BMP

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Civic Address	Alternate/Mailing Address	Legal Description for Property
Derby Ralph Smythe		
1031 Queen Street East Sault Ste. Marie, ON P6A 2C2 Dukes James Rylie Rossiter Mary Caroline		Dukes, James Rylie 020 045 004 00 0000 CON 1 PARK LOT 14 PT QUEEN ST E WTR LOT IN FRNT PCL 2365 AWS
1033 Queen Street East Sault Ste. Marie, ON P6A 2C2 Rainone Terry William Rainone Deborah Martha	Rainone Terry William Rainone Deborah Martha 1121 Peoples Road 1121 Peoples Road Sault Ste. Marie, ON P6C 3W4	
1035 Queen Street East Sault Ste. Marie, ON P6A 2C2 Marinich Karen Coxette Marinich Randy Leonard		
1065 Queen Street East Sault Ste. Marie, ON P6A 2C2 Wilson Timothy Charles Wilson Bruce Richard		Wilson, Anna Geraldine 020 012 001 00 0000 CON 1 PARK PT LOT 13 PCL 1826 AWS WTR LT FRNT
1069 Queen Street East Sault Ste. Marie, ON P6A 2C2 McGauley John David McGauley Robert William		McGauley, William Gilchrist 020 012 002 00 0000 CON 1 PARK PT LOT 13 WTR LOT IN FRNT PCL 2343 AWS
1071 Queen Street East Sault Ste. Marie, ON P6A 2C2 Hutton Evelyn Phyllis Hutton William Francis		Hutton, William Francis 020 012 003 00 0000 CON 1 PARK PT LOT 13 WTR LT IN FRONT PARCEL 2208 AWS
1073 Queen Street East Sault Ste. Marie, ON P6A 2C2 Wallenius Kenneth Eino Wallenius Sandra Ann		Wallenius, Kenneth E. 020 012 004 00 0000 CON 1 PARK PT LOT 13 WTR LT IN FRNT PCL 1782 AWS
1075 Queen Street East Sault Ste. Marie, ON P6A 2C2 Hill Wesley Stephen C Hill Rachel Cathleen		
1077 Queen Street East Sault Ste. Marie, ON	City of Sault Ste. Marie PO Box 580 Stn Main Sault Ste. Marie, ON P6A 5N1	City of Sault Ste. Marie 020 012 008 00 0000 CON 1 PARK LOT 13 PT WATER LOT IN FRNT PCL 2137 AWS
1081 Queen Street East Sault Ste. Marie, ON P6A 2C2 Ostroski Bonnie Lynn McLuckie Kenneth Leslie		
1085 Queen Street East Sault Ste. Marie, ON P6A 2C2 Rutledge Brian Rutledge Nicole		Lang, Helen Winnifred 020 012 007 00 0000 CON 1 PARK LOT 12 PT WATER LOT IN FRONT PT PCL 23 AWS RP 1R 7596 PART 4
1097 Queen Street East Sault Ste. Marie, ON P6A 2E1 Bellerose Jennifer Meagan Alexander Stephen Russel		

Bellevue Embayment
Details Regarding Properties and Water Lots Adjacent to the BMP

KEC Ref. No. 0624.02

Civic Address	Alternate/Mailing Address	Legal Description for Property
1099 Queen Street East Sault Ste. Marie, ON P6A 2E1 Ross Celia John		
1105 Queen Street East Sault Ste. Marie, ON P6A 2E1 Cavanagh Antoinette Lynne		
1115 Queen Street East Sault Ste. Marie, ON P6A 2E1 Sloan Glenda Guier Wolfgang Walter		
1123 Queen Street East Sault Ste. Marie, ON P6A 2E2 Beausoleil G Symes J R		
1125 Queen Street East Sault Ste. Marie, ON P6A 2E2 Crowder Albert G F Crowder Tara Lee		
1129 Queen Street East Sault Ste. Marie, ON P6A 2E2 ? Colombo Carol Ann		
1135 Queen Street East Sault Ste. Marie, ON	YMCA 235 McNabb Street Sault Ste. Marie, ON P6B 1Y3	Young Mens Christian Association 020 012 036 00 0000 CON 1 PARK PT LT 10 S/S QUEEN E RP 1R 2093 PT 6 (RYTAC)
1139 Queen Street East Unit 807 Sault Ste. Marie, ON P6A 6K5 St. Benard's Tower Appartment Rentals Luzzi Judith Eileen Ladubec Lynda Janice		
1139 Queen Street East Unit 2 Sault Ste. Marie, ON P6A 6K5 St. Benard's Tower Appartment Rentals Kelly Helena Christina Kelly Jack Wayne		
1175 Queen Street East Sault Ste. Marie, ON P6A 2E5 Moir Glenn William Moir Janet Liane		
1189 Queen Street East Sault Ste. Marie, ON	Agriculture Canada c/o Corp Management Branch 4900 Young Street Suite 1200 North York, ON M2N 6A4	
1195 Queen Street East Sault Ste. Marie, ON	Agriculture Canada c/o Corp Management Branch 4900 Young Street Suite 1200 North York, ON M2N 6A4	
1235 Queen Street East Sault Ste. Marie, ON	Agriculture Canada c/o Corp Management Branch 4900 Young Street Suite 1200	

Civic Address	Alternate/Mailing Address	Legal Description for Property
	North York, ON M2N 6A4	
1219 Queen Street East Sault Ste. Marie, ON P6A 2E5 Natural Resources Canada - Great Lakes Forestry Centre		
10 Lucy Terrace Sault Ste. Marie, ON		10 Lucy Terrace Plummer Memorial Plan 844 Lot 15 Pt to 18020 045 019 00 0000 RP 1R 4897 Part 6 to Part 10 Pt - Easement OUR RP 1R 7378 Pt 10
64 Hadley Park Sault Ste. Marie, ON P6A 6W8 Kelly Jack		
65 Hadley Park Sault Ste. Marie, ON P6A 6W8 Bignell Douglas Cyril Bignell Lynda		
69 Hadley Park Sault Ste. Marie, ON P6A 6W8 Floreani Kent Joseph Floreani Francine Jeannine		
73 Hadley Park Sault Ste. Marie, ON P6A 6W8 Hadley Linda Doreen Piscopo Eric Thomas		
77 Hadley Park Sault Ste. Marie, ON P6A 6W8 Wieja John George Wieja Mary Lynne		
81 Hadley Park Sault Ste. Marie, ON P6A 6W8 Hess Werner Hess Marlene		
89 Hadley Park Sault Ste. Marie,ON P6A 6W8 Debolt Gayle May Debolt Leonard Gary		
4 Gordon Avenue Sault Ste. Marie, ON P6A 3H8 McGoldrick Laurie		
5 Gordon Avenue Sault Ste. Marie, ON P6A 3H9 Sgouraditis Konstantinos G		
6 Gordon Avenue Sault Ste. Marie, ON P6A 3H8 Muirhead Virginia Leigh		
7 Gordon Avenue Sault Ste. Marie, ON P6A 3H9 Theriault Ken J		
8 Gordon Avenue		

Bellevue Embayment
Details Regarding Properties and Water Lots Adjacent to the BMP

KEC Ref. No. 0624.02

Civic Address	Alternate/Mailing Address	Legal Description for Property
Sault Ste. Marie, ON P6A 3H8 Chenier-Tulonen Denise Tulonen Henry Allan		
9 Gordon Aveue Heikkila William Arvo Sault Ste. Marie, ON P6A 3H9		
10 Gordon Avenue Sault Ste. Marie, ON P6A 3H8 Bruni Ellen Merle Carbone Anthony Peter		
11 Gordon Avenue Sault Ste. Marie, ON P6A 3H9 Pavelich Frances Marlene Pavelich George Emile Sr.		
12 Gordon Avenue Sault Ste. Marie, ON P6A 3H8 Coleman Tammy Lorraine		
2 McGregor Avenue Sault Ste. Marie, ON P6A 3W7 Wilson Eric Paul		Wilson, Eric Paul 020 012 009 00 0000 PLAN 21558 LOT 7 RP 1R 4828 PART 1 PART 2 WATER LOT IN FRNT LOT 7 PCLS 722 AND 2456
2A McGregor Avenue Sault Ste. Marie, ON	City of Sault Ste. Marie PO Box 580 Stn Main Sault Ste. Marie, ON P6A 5N1	2A City of Sault Ste. Marie CON 1 Park Lot 11 PT WATER Lot 5 McGregor Ave. PCL 153 AWS
4 McGregor Avenue Sault Ste. Marie, ON P6A 3W7 Griswold Gerald John Griswold Laura Agnes		
5 McGregor Avenue Sault Ste. Marie, ON P6A 7B7 Tomasic Bronco		
6 McGregor Avenue Sault Ste. Marie, ON P6A 3W7 Peterson Dana Patricia		
8 McGregor Avenue Sault Ste. Marie, ON P6A 3W7 Missere Daniel Missere Sarah		
1 McPhail Avenue Sault Ste. Marie, ON P6A 3K1 Lozowsky Lily Lozowsky Bruce Richard		Lozowsky, John David 020 012 024 00 0000 PLAN 33106 LOT 11 LOT 12 WATER LOT PT PCL 12216 AWS RP 1R 9071 PART 1235
3 McPhail Avenue Sault Ste. Marie, ON P6A 3K1 Tomlinson Elizabeth Joanne		Tomlinson, Roy W 020 012 025 00 0000 PLAN 33106 LOT 13 LOT 14 W PT LOT 15
4 McPhail Avenue Sault Ste. Marie, ON P6A 3K2		

Bellevue Embayment
Details Regarding Properties and Water Lots Adjacent to the BMP

KEC Ref. No. 0624.02

Civic Address	Alternate/Mailing Address	Legal Description for Property
Cuglietta Maria Cuglietta Gasper Michael		
5 McPhail Avenue Sault Ste. Marie, ON P6A 3K1 Park George Randal Park Kerttu Hannele		Park, George Randal 020 012 026 00 0000 PLAN 31106 LOT 15 E PT LOT 16
6 McPhail Avenue Sault Ste. Marie, ON P6A 3K2 Keats Mary		
9 McPhail Avenue Sault Ste. Marie, ON P6A 3K3 Sewards Frances		Brady, Robert John 020 012 028 00 0000 PLAN 33541 LOT 10 WRT L IN FRNT
18 McPhail Avenue Sault Ste. Marie, ON P6A 3K3 YMCA of Sault Ste. Marie RYTAC	YMCA 235 McNabb Street Sault Ste. Marie, ON P6B 1Y3	
12 McPhail Avenue Sault Ste. Marie, ON P6A 3K3	Steve Johnston 2075 Sovereign Crt Kamloops BC. V2E 2M1	
13 McPhail Avenue Sault Ste. Marie, ON P6A 3K3 Kersey Eva Rossiland		Kersey, John Phelps 020 012 029 00 0000 PLAN 33541 LOT 11 RP 1R 2093 PART 2 PART 3
14 McPhail Avenue Sault Ste. Marie, ON P6A 3K4 Ferguson James Ferguson Margaret Neil		
64 Church Street Sault Ste. Marie, ON P6A 3H3 Ministry of Natural Resources		
70 Church Street Sault Ste. Marie, ON P6A 3H3 Doucet Debra Doucet Donald		
78 Church Street Sault Ste. Marie, ON P6A 3H4 Holmes Arthur Norman		
1 Riverview Avenue Sault Ste. Marie, ON P6A 3X6 Carson Sheila Ann		
2 Riverview Road Sault Ste. Marie, ON	Real Ontario Home and Commercial Building Enterprises P.O. Box 786 Stn Main Sault Ste. Marie, ON P6A 5N3	
3 Riverview Avenue Sault Ste. Marie, ON P6A 3X6 Bradfield Elizabeth Kathleen		
5 Riverview Avenue Sault Ste. Marie, ON P6A 3X6 Wickett Holly Marie		

Bellevue Embayment
Details Regarding Properties and Water Lots Adjacent to the BMP

Civic Address	Alternate/Mailing Address	Legal Description for Property
1 Pim Street Sault Ste. Marie, ON P6A 3G3 1022291 Ontario Inc Purvis Marine Limited		
50 Pim Street Sault Ste. Marie, ON P6A 3G4 Canadian Bushplane Heritage Centre		
62 Woodward Sault Ste. Marie, ON Ontario Realty Corporation	ORC Property Tax Dept 11th Floor Ferguson Block 77 Wellesley Street West Toronto, ON M7A 2G3	ON Realty Corp 020 045 025 00 0000 CON 1 PARK S PT LOT 20 to 22S PT WTR FRONT
1 lot south of Plummer Memorial Hospital, lot between 1035 and 1065 Queen, lot between 5 and 2 McGregor and 2 Pine Street (Marina)	The Corporation of the City of Sault Ste. Marie	
Lot 0 south of General Hospital and one lot south of Plummer Memorial Hospital	Sault Ste. Marie Region Conservation Authority	