Appendix C10

Submarine Transmission Line Crossing Report

SUBMARINE TRANSMISSION LINE CROSSING REPORT

WOLFE ISLAND WIND PROJECT

TECHNICAL APPENDIX C10

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Prepared for:

Canadian Renewable Energy Corporation
a wholly owned subsidiary of
Canadian Hydro Developers, Inc.
500 -1324 17th Avenue SW
Calgary AB T2T 5S8

Prepared by:

Stantec Consulting Ltd.
361 Southgate Drive
Guelph ON N0B 1T0

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1.0 Introduction

1.1 THE PROPOSED WOLFE ISLAND WIND PROJECT

On 21 November 2005, Canadian Renewable Energy Corporation ("CREC") was awarded a Renewable Energy Supply Contract from the Ontario Power Authority ("OPA"). Specifically, the OPA has committed to purchase 197.8 megawatts (MW) of electricity generation from the proposed Wolfe Island Wind Project ("Project"), which has a target in-service date of October 2008.

The proposed project is located on the western side of Wolfe Island. A 34 kilovolt ("kV") electrical collection system comprising a series of belowground power lines will connect 86 turbines to a new 34 kV / 230 kV transformer station ("TS") on Wolfe Island.

A 230 kV transmission line will connect the proposed Project on Wolfe Island to the provincial electricity grid on the Kingston mainland consisting of the following:

- about 0.5 km of 230 kV underground cable on Wolfe Island to connect the Wolfe Island TS with the 230 kV submarine cable across the Lower Gap of the St. Lawrence River;
- approximately 7.8 km of submarine cable to connect Wolfe Island to the Kingston mainland; and,
- approximately 4 km of 230 kV underground cable to connect the submarine cable with the Hydro One Networks Inc. ("Hydro One") Gardiners TS in the City of Kingston (see **Figure 1.1, Appendix A**).

A detailed description of the submarine cable crossing is provided in Section 3.0.

1.2 PROPOSED PROJECT ENVIRONMENTAL ASSESSMENT

An environmental assessment ("EA") has been prepared by Stantec (2007a) for the proposed Project. The EA provides the proposed Project's history, need, advantages and disadvantages; alternative and preferred siting and route selection; overall project description; details of stakeholder consultation and information disclosure; environmental approvals and other regulatory requirements; a comprehensive assessment of the environmental effects of the proposed Project particularly with respect to facilities on Wolfe Island and the Kingston mainland; and recommended mitigative/remedial measures to minimize or obviate these effects. Stantec (2007a) concluded that the proposed Project can be constructed, operated and repowered/decommissioned in such a manner as to minimize potentially adverse effects on the environment, while maximizing the positive effects both locally and provincially.

This Technical Appendix Report addresses the submarine transmission line crossing of the Project, providing a detailed project description of the crossing, environmental baseline description, and assessment of potential environmental effects and recommended mitigative measures to minimize or obviate these effects. The information provided in this Technical Appendix Report has been summarized in the EA report (Stantec, 2007a).

1.3 STUDY APPROACH

The environmental baseline description was prepared based on literature review, personal contacts and field surveys. Environmental baseline conditions have been documented in a number of publications and reports published by Environment Canada, the Ontario Ministry of Natural Resources ("OMNR") and the Ontario Ministry of the Environment ("MOE"), as well as technical documents resulting from research undertaken at Queen's University. This information was augmented and updated by data requested from the MOE, OMNR and the National Water Research Institute of Environment Canada.

Moreover, field studies have been undertaken to provide route-specific information, including geotechnical/geophysical, sediment quality, benthic macroinvertebrate community, aquatic vegetation community and fisheries resources surveys.

2.0 Regulatory Requirements

The proposed Project is subject to both federal and provincial EA processes, i.e., a screening study EA under the *Canadian Environmental Assessment Act* and the Environmental Screening Process under Ontario Regulation 116/01 of the *Environmental Assessment Act*, respectively (Stantec, 2007a).

In addition to federal and provincial EA approvals, several permits and authorizations may also apply with respect to the proposed submarine cable crossing including:

- *Fisheries Act* Authorization by the Department of Fisheries and Oceans ("DFO") for harmful alteration, disruption or destruction ("HADD") of fish habitat; otherwise, if there is a determination of no HADD on fish habitat, a Letter of Advice is issued by the DFO;
- *Fisheries Act* Authorization by Environment Canada for the release of a deleterious substance into fisheries waters; otherwise, if there is low or no potential for deleterious substance release, a Letter of Comment is issued;
- *Navigable Water Protection Act* ("NWPA") Clearance by Transport Canada based on Formal Approval or Declaration of Exemption when the "work" is considered to or does not, respectively, substantially interfere with navigation;
- *Ontario Heritage Act* archaeological clearance by the Ontario Ministry of Culture;
- Permit-To-Take-Water under the *Ontario Water Resources Act* from the MOE for water taking in excess of 50,000 L/d;
- Work Permit under the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulations of the *Conservation Authorities Act*, from the Cataraqui Region Conservation Authority; and
- Consolidated Work Permit under the *Lakes and Rivers Improvement Act* to undertake work on shorelands and works within a waterbody.

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3.0 Project Description

3.1 KEY PROJECT COMPONENTS

The basic components of the proposed Project include the following:

- 86 wind turbine generators with a total installed capacity of 197.8 MW;
- 690 V / 34.5 kV pad-mounted transformers at each turbine;
- a 34.5 kV underground electrical line collector system;
- a 34.5 kV / 230 kV transformer station on Wolfe Island;
- a 230 kV underground and submarine transmission line;
- circuit breakers and direct line tap at Gardiners TS in Kingston;
- an operation and maintenance building with storage yard; and
- access roads to the turbines.

The turbines will generate an estimated 537,000 MWh/y of renewable energy, enough electricity to power about 75,000 average Ontario homes. Stantec (2007a) provides a detailed description of the land-based project components.

3.2 LOWER GAP TRANSMISSION LINE CROSSING

Stantec (2007a) presents the process for identifying and selecting the alternative and preferred sites and routes for the proposed Project. Based on the preferred landfall site selection, the proposed 230-kV transmission line crossing of the St. Lawrence River, locally known as the Lower Gap, will extend from a landfall on Wolfe Island approximately 800 m west (upstream) of Mill Point to a landfall at Sand Bay (to the east of Patterson Point) on the mainland (**Figure 1.1, Appendix A**).

The identification of the final preferred route across the St. Lawrence River was based on the following criteria:

- the route should avoid sensitive environmental features to the extent possible and where they cannot be avoided the route should be located to minimize adverse effects;
- the route should minimize adverse effects of construction and operation on existing infrastructure;

- the route should follow a reasonable direct path between the end points, minimizing route length and the associated potential for adverse environmental effects; and

- relevant planning policies, guidelines and regulations should be taken into consideration during the route selection process.

Using the routing criteria listed above, the submarine cable will generally run as a direct route between the two landfalls, except where it must avoid marine archaeological resources identified during the Stage 1 archaeological assessment (The Archaeologists Inc., 2006), navigation buoys and bathymetric constraints in the Wolfe Island nearshore, as well as submarine transmission cables and water intakes in the Kingston mainland nearshore. **Figure 3.1** (**Appendix A**) shows the proposed cable routing in the Kingston mainland nearshore relative to the submarine cables and water intakes.

The 230 kV submarine cable from Wolfe Island to the Kingston mainland will consist of an approximately 7.8 km segment of cable, connected directly to the underground cable on the mainland and Wolfe Island with direct buried splices located at concrete transition bays approximately 50 m inland from both shorelines.

The submarine transmission line consists of one 235 mm diameter, three conductor armoured cable. Each conductor is 987 KCMIL copper with cross-linked polyethylene ("XLPE") insulation. The submarine cable will be protected by electrical protection relays and high voltage circuit breakers, as well as remote teleprotection to Hydro One's system. The cable will also contain a fibre optic cable to facilitate supervisory control and data acquisition ("SCADA") and protection requirements. On the Kingston side, the cable will come ashore at Sand Bay on private industrial property west of Cataraqui Bay in the City of Kingston. The Wolfe Island landing is located on the north shore, approximately 800 m west of Mill Point, north of the Highway 96/Concession 4 Road intersection.

In order to facilitate the installation of the cable and to provide an additional level of protection, CREC is proposing to install high density polyethylene (HDPE) conduits at the two landings. These conduits will be buried in the lake bottom and the two cable ends will be pulled through the conduits into the concrete transition bay structures on shore. The conduits will be approximately 500 m long at the Sand Bay location and about 125 m at Wolfe Island. The conduits will ensure the cable is at least 3 m below normal low water levels to protect the cable from shorefast ice development in the winter and occasional wind-driven ice pile-up events in the spring (**Section 4.8**) and to ensure public safety (**Section 4.19**). For the portion of its length where the cable is in deeper water, the cable will be laid on the lake bottom.

The horizontal location of the conduit is determined by the following factors:

- the desirable landing location for connection to the electrical distribution system;

- the location of existing services (electrical cables and water intakes); and

- the minimum bending radius of both the conduit and the cable.

While the Wolfe Island conduit will only be approximately 125 m in length, the Sand Bay conduit will be approximately 500 m, as the conduit route must be laid out to avoid three existing Hydro One submarine transmission cables and three industrial water intakes (**Figure 3.1, Appendix A**).

Extensive nearshore survey work at the landfall locations has been completed to confirm the location of existing utilities (Campbell, 2007) and the geophysical characteristics of the lake bottom that will be encountered when installing the conduits (AGL, 2007). The geophysical survey has confirmed that the submarine cable can be positioned between the existing power cables and the intake pipes. As a result, the coordinates for the submarine cable have been accurately established in the Sand Bay area (Campbell, 2007). In the nearshore areas where the conduits will be installed, the limestone bedrock is weathered and fractured. AGL (2007) determined that weathered surface bedrock extended approximately 20 m and 250 m offshore from the Wolfe Island and Sand Bay landfall shorelines, respectively, to a water depth of 3 m at both locations. Competent surface bedrock is present further offshore. In Sand Bay, the competent bedrock has a variable cover (up to 2 m) of coarse substrate.

The horizontal alignment of the excavation will be controlled through the use of Global Positioning System (GPS) equipment, ensuring the design alignment is followed. Vertical alignment will be determined based on the desired elevation relative to the water level measured for the day. The Contractor will measure the depth of excavation relative to the water level to ensure the level of accuracy required.

Various construction methods to create the trench for conduit installation have been investigated. The use of a hoe ram in this setting is not practical because the equipment only works in water depths less than 1.5 m. As the trench will be 1.2 to 2.5 m deep (depending on water depth), the hoe ram would be restricted to a water depth of 0.3 m. The use of a cutting/ ripping machine is also limited to shallow water. Discussions with experienced contractors have revealed that the only reasonable way to create the trench is through the use of explosives. Blasting effort required to create the trenches should be reduced over that required for competent bedrock. Conduit/cable installation by physical boring or trenching with a rock cutting/ripping machine may also be feasible within the weathered bedrock in the shallow nearshore and onshore.

Figure 3.2 (**Appendix A**) illustrates the proposed conduit trench cross-section. The trench will be approximately 1 to 1.5 m wide and between 1.2 and 2.5 m deep.

In general terms, the construction sequence will be as follows:

- starting at the deepest end of the conduit furthest from shore, the Contractor will drill holes for the explosive charges. Drilling will be performed from a barge where water depth is sufficient and/or a support platform on the riverbed;
- collar material over the charge in the hole will be 1,000 to 1,500 mm of clean 10 to 15 mm crushed stone;

- the Contractor will set charges and blast a section of the trench, probably 10 to 20 m in length per blast;
- the Contractor will move inland and blast the remainder of the trench in 10 to 20 m segments;
- the Contractor will then excavate the trench to the desired elevation, casting the excavated rock on the shore side of the trench. The Contractor may deposit bedding material (pea gravel or washed clear stone) at this time, or as a separate sequence;
- the Contractor will assemble the conduit onshore. The 450 mm HDPE pipe will be butt-fused utilizing the pipe manufacturer's equipment to produce a continuous pipe. The ends of the pipe will be temporarily sealed, with a valve assembly on one end. Concrete collars will be fixed on the pipe at regular intervals. The entire conduit assembly will then be floated out over the excavated trench;
- water will be introduced at one end causing that end of the conduit to slowly sink. Guided by the Contractor, the conduit will be lowered into the trench. The valve assembly will regulate the release of air controlling the rate of descent to ensure the conduit is properly positioned within the trench; and
- after the entire conduit is properly positioned, the Contractor will complete the pipe bedding (most likely composed of washed pea gravel or clean stone) and bury the pipe using excavated blast rock. The larger-sized surplus excavated material will be spread out on the lake bottom and could be used to create fish habitat.

Depending on operational requirements, there may be a need to construct a rock berm to provide equipment access for the drilling and excavation. If constructed, the rock berm will be completely removed upon work completion.

The decision on whether Wolfe Island or Sand Bay nearshore construction will be completed first will be left to the Contractor, unless detailed design constraints force one location ahead of the other. It is anticipated that the Contractor will complete the installation at one end prior to moving to the other location.

In-water construction timing windows have been established by the OMNR for undertakings in Ontario waterbodies with fish habitat. These windows are designed to protect spawning fish and egg incubation periods. The cable crossing will be undertaken in the OMNR Peterborough District, which identifies 15 March to 15 July as the timing restriction window for warmwater fish (R. Topping, OMNR Kingston Area Office, 2004, pers. comm.). In-water works related to the cable crossing, including conduit installation, are scheduled to occur in September and October 2008 (after Labour Day) outside of the construction timing restriction window.

The shoreline concrete transition structure will be located on the Wolfe Island and Kingston mainland landfalls for the purpose of anchoring the submarine cable and splicing it to the underground cable to complete the electrical transmission line at each end. The transition structures will be located approximately 50 m inland and will be approximately 9 m long, 3 m wide and 2.25 m deep.

Beyond the nearshore section of burial, the cable will be laid directly on the riverbed along the predetermined GPS-controlled route from a cable-laying vessel. Protective measures such as polyethylene collars and concrete revetment mattresses will be installed, where required, to protect the cable from wearing on the bedrock or boulders.

A preliminary sequencing of construction would involve cable installation at Wolfe Island nearshore over a one-week period followed by trench preparation of similar duration to receive the cable at the Kingston nearshore. As indicated above, the Contractor will decide the location for nearshore construction initiation. The cable-laying ship would then proceed to install the cable between Wolfe Island and the mainland. Cable installation on the riverbed is expected to take approximately one week, depending upon weather.

3.3 PROJECT SCHEDULE

As a world leader in the design and manufacture of high voltage submarine cables, Nexans in Norway is essentially the only company that can meet the 230-kV cable specifications and Project schedule. The cable will be supplied in one continuous length of 8,000 m and will weight approximately 750 tonnes. Cable manufacturing is scheduled to be completed in December 2007; however, it cannot be delivered until after the opening of the St. Lawrence Seaway (generally late March/early April). During transport between Norway and the Project site, the cable will be loaded in a coiled position on a horizontal turntable mounted on the cable-laying vessel. This vessel must be used for cable installation as the 750-tonne load cannot be transferred between ships. There are only two such turntables that are capable of handling this size, length and weight of cable and available for the Project. One turntable is owned by Nexans (the cable manufacturer) and the second by JD Contractor in Denmark. Due to their demand around the world, the installation vessels and turntables are committed to projects months and sometimes years in advance. Due to equipment availability constraints, submarine cable delivery and installation have been scheduled for September 2008 with an in-service date of October 2008. Submarine cable installation must be completed prior to October to allow for splicing, testing and commissioning of the submarine and underground cables, followed by commissioning of the TS, and finally commissioning of the turbines.

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4.0 Environmental Setting

4.1 DESCRIPTION OF THE STUDY AREAS

For the environmental baseline description in this submarine transmission line crossing report, reference will be made to regional, local and project-specific study areas. These study areas are defined as follows:

Regional Study Area

The regional setting is generally defined by the eastern end (Kingston Basin) of Lake Ontario, its outlet to the St. Lawrence River and the Thousand Islands section of the Upper St. Lawrence River (**Figure 4.1, Appendix A**). The regional setting provides for the baseline description of climate (including air quality and noise), geology, physiography, general limnology/hydrology, water quality, plankton, benthic macroinvertebrate communities, fisheries resources, sportfishing, commercial fishing, and the general land and water uses affecting the aquatic environment.

Local Study Area

The local study area generally encompasses the portion of the St. Lawrence River that is known locally as the "Lower Gap", which includes the initial and revised transmission line crossing corridors and their landfalls (**Figure 4.2, Appendix A**). The western local study area boundary extends from Point Pleasant on the mainland to a location about 800 m south of Four Mile Point on Simcoe Island (encompassing Snake Island), the northern shoreline of Simcoe Island to Lucas Point, and across the Boat Channel to a location on Wolfe Island about 1.5 km southwest (upstream) of the proposed transmission line crossing landfall. The eastern local study area boundary extends from Point Frederick on the east side of Kingston Harbour extending offshore to Abraham Head located about 2 km east (downstream) of the Ontario Ministry of Transportation ("MTO") winter ferry dock location at Dawson Point. The winter ferry dock location is proposed for delivery of materials and equipment during Project construction and no modifications to the dock are proposed. The local study area provides a baseline description of sediment type and quality, aquatic vegetation, aquatic avifauna, as well as specific water uses, e.g., recreational and commercial boating, municipal and industrial uses.

Initial Cable Corridor and Proposed Route Study Area

The cable corridor study area encompasses the initial transmission line route across the Lower Gap from the landfall on Wolfe Island approximately 800 m west (upstream) of Mill Point to a landfall at Carruthers Point on the mainland just west (upstream) of Cataraqui Bay. This study area also encompasses the proposed route from the Wolfe Island landfall to the landfall at Sand Bay on the Kingston mainland (as well as an alternative landfall also considered at Patterson Point on the mainland) (**Figure 4.3, Appendix A**).

The Kingston mainland landfall was relocated to Sand Bay (just east of Patterson Point) from the initial landfall location at Carruthers Point as a result of a realignment of the cable route to the Gardiners TS due to mainland routing issues (Stantec 2007a).

A geophysical/geotechnical survey of the revised cable route in the Kingston mainland nearshore was undertaken in the spring of 2007 to delineate route-specific considerations (e.g., bathymetry, surficial geology, riverbed features, sediment thickness, marine archaeology, submarine transmission cables, intakes) and to select the preferred landfall location on the Kingston mainland (Campbell, 2007).

This study area was established to more comprehensively delineate bathymetry, substrate type and quality, benthic macroinvertebrate communities, nearshore fish habitat and communities, and marine archaeology.

4.2 GENERAL ENVIRONMENTAL QUALITY

The proposed Project is located at the eastern end of Lake Ontario at its outlet to the St. Lawrence River. As a result, environmental quality in the regional and local study areas is primarily dependent upon the environmental quality of Lake Ontario.

The environmental quality of Lake Ontario has changed profoundly over the past 100 years. In the early 1900s, pollution problems were almost solely due to bacteria from domestic sewage due to the general lack of municipal sewage treatment plants (IJC, 1969). Industrial pollutants were not discharged in sufficient quantities to seriously affect water quality and use. Investigations indicated that the open waters of Lake Ontario were essentially free of bacterial pollution except near the outlet of the Niagara River. Bacterial pollution in localized nearshore waters also constituted a direct threat to municipal water supplies.

The economic, industrial and agricultural expansion that occurred in subsequent years resulted in a major increase of sewage and industrial waste discharges. During this time period, the Lake Ontario ecosystem experienced numerous other stresses including overfishing, colonization by exotic (non-native) species, and loss of coastal wetlands and other important fish habitat. These accelerated ecological changes have been documented by Christie (1972, 1973), Whillans (1979), Christie *et al*. (1987), Sly (1991), Johannsson *et al.* (1998), Hoyle *et al.* (1999) and Mills *et al*. (2003, 2005), among others.

The control of phosphorus inputs was recognized by the International Joint Commission (IJC, 1970) as the most important factor in controlling cultural eutrophication. Under the 1972 Great Lakes Water Quality Agreement ("GLWQA") between Canada and the U.S., a number of programs were initiated to reduce the substantial phosphorus loads to the Great Lakes from municipal treatment plants as well as to reduce the phosphate content of detergents. "Non-point" source drainage from agricultural and urban lands was also identified as an important input of nutrients and contaminants requiring control.

The 1978 GLWQA renewed the commitment of both countries to reduce phosphorus inputs to the Great Lakes by setting tentative "future phosphorus loads" objectives (target loads) (PMSTF, 1980). As a result of the phosphorus abatement program, annual phosphorus loadings from Canadian and U.S. municipal discharges were reduced by 85%, i.e., from 13,844 metric tonnes in 1972 to 2,222 metric tonnes in 1985 (IJC, 1987a).

In addition, the IJC has focused attention on inorganic and organic contaminant monitoring and toxic substances control in the Great Lakes (GLSAB, 1980). The IJC (1985) identified 42 Areas of Concern ("AOC"s) around the Great Lakes, including the Bay of Quinte and Oswego River in eastern Lake Ontario and Cornwall/Oswego on the St. Lawrence River. To address each AOC, a Remedial Action Plan ("RAP") process was implemented involving three stages. The Stage 1 RAP provides a definition and detailed description of the environmental problems, including an identification of beneficial use impairments. The Stage 2 RAP provides recommendations for action to remedy the use impairments. The Stage 3 RAP confirms that the impaired beneficial uses have been restored. Potential impaired uses include restrictions on fish and wildlife consumption, tainting of fish and wildlife flavour, degradation of fish and wildlife populations, fish tumours or other deformities, bird or animal deformities or reproductive problems, degradation of benthos, restrictions on dredging activities, eutrophication (nuisance algal blooms), restrictions on drinking water consumption, beach closings, degradation of aesthetics, added costs to agriculture or industry, degradation of plankton populations, and/or loss of fish and wildlife habitat.

In addition to the RAPs for AOCs, Canada and the U.S. made a commitment, as part of the revised GLWQA (IJC, 1987b), to develop a Lakewide Management Plan ("LaMP") for each of the Great Lakes. A Stage 1 LaMP "problem definition" document has been prepared for Lake Ontario (LaMP, 1998). Four lakewide beneficial use impairments of Lake Ontario were identified:

- restrictions on fish and wildlife consumption,
- degradation of wildlife populations,
- bird or animal deformities or reproductive problems, and
- loss of fish and wildlife habitat.

There is direct and indirect evidence that PCBs, DDT and its metabolites, mirex and dioxins/furans are impairing the first three beneficial uses listed above in Lake Ontario. These contaminants, as well as mercury and dieldrin, have been designated as Lakewide Critical Pollutants and are the focus of LaMP source reduction activities. The loss of fish and wildlife habitat is a lakewide impairment caused by artificial lake level management; the introduction of exotic species; and the physical loss, modification and destruction of habitat, such as deforestation, wetland loss and the damming of tributaries.

Based on the impaired beneficial uses of Lake Ontario and the critical contaminants and biological/physical factors contributing to these impairments, an agenda of ongoing and future activities was proposed that will continue efforts to move towards the restoration of beneficial uses of the lake and achieve virtual elimination of critical contaminants.

Since the issuance of the LaMP (1998) report, a number of updates and two comprehensive status reports (LaMP, 2002, 2006) have been prepared. The status reports provide new/updated information on the current status of beneficial use impairments, sources and loads of critical pollutants, public involvement and communication, and significant ongoing and emerging issues. Three additional lakewide beneficial use impairments of Lake Ontario have been identified:

- degradation of benthos,
- degradation of nearshore phytoplankton populations, and
- degradation of fish populations.

Benthos, nearshore phytoplankton and fish populations are deemed impaired mainly due to the impacts of exotic species.

The LaMP (2006) report also provides an update on LaMP workplan actions, progress and next steps.

As summarized in **Section 5.4**, the proposed Project will have negligible effect on the RAP and LaMP initiatives.

4.3 CLIMATE, AIR QUALITY AND ENVIRONMENTAL NOISE

Climate

The climate of southern Ontario is modified continental, moderated by the proximity of the Great Lakes, but differing appreciably from one location to another and from year to year (Brown *et al*., 1974). The variability in southern Ontario climate is due to local differences in topography, distance from one or another of the Great Lakes, and the direction of the prevailing winds. The proposed Project site lies in the South Slopes Climatic Region, as defined by Brown *et al.* (1974). The South Slopes Climatic Region is greatly influenced by the proximity of Lake Ontario and Lake Erie, which moderate temperatures and provide moisture-laden air to adjacent lands. Air masses affecting this climatic region include flows of cold dry air from the Arctic; moist warm air from the Gulf of Mexico; and dry prevailing winds (westerlies) from the Pacific.

Southern Ontario, including the proposed Project site, is located within one of the major storm tracks of the continent. The passage of cyclones and anti cyclones over the area produces wide variations in day to day weather, especially in winter. Changes in air masses can be expected to occur every two to five days throughout the year. Usually, periods of severe cold or excessively warm weather are not prolonged.

Winter severity varies from year to year, depending on the duration and number of episodes of domination of the region by Arctic air masses. During the summer, the Bermuda High often becomes the controlling weather feature, extending its influence over most of southern Ontario. The potential for stagnant air masses is greatest during mid to late summer. The intensity of migrating storms usually peaks in the autumn (November) and early spring (March). A summary of pertinent climatic and related plant growth data for the South Slopes Climatic Region is provided in **Table 4.1 (Appendix B)**. Based on data collected from 1931 to 1960 (Brown *et al*., 1974), the mean length of the growing season for this climatic region is 205 days.

Based on the ecoclimatic classification system developed by Environment Canada (Ecoregions Working Group, 1989), the proposed Project site lies in the Humid Mid-Cool Temperate Ecoclimatic Region of the Cool Temperate Ecoclimatic Province. Summers are warm and winters are mild. Mean daily temperatures above 0°C extend from April through November. Monthly precipitation usually exceeds 70 mm and is distributed fairly evenly throughout the year.

Mean daily temperature and precipitation data for the Kingston Pumping Station meteorological station are presented in **Table 4.2 (Appendix B)**. The mean annual temperature is 7.6°C. Mean monthly precipitation varies between 59.8 mm in July and 94.1 mm in September, with no pronounced wet or dry season. Summer thunderstorm activity is relatively frequent. Total annual precipitation is about 960 mm with about 781 mm falling as rain and 180 mm falling as snow.

Frost data are summarized in **Table 4.3 (Appendix B)**. The average length of the frost-free period ranges from 127 to 149 days. Frozen ground conditions usually occur between late December and early March; however, year-to-year variation is considerable, depending on weather and local differences in vegetation, soil types, proximity to waterbodies and topography.

The prevailing winds in the region are usually from a southerly direction (**Table 4.4, Appendix B**). The annual maximum hourly wind speeds with 1:10, 1:30 and 1:100 probabilities of exceedance in Kingston are 83, 94 km/h and 101 km/h, respectively (ACNBC, 1980).

Climatic data have relevance to the timing of construction activities associated with the landfalls and submarine transmission line crossing (**Sections 3.3** and **5.1.2)**

Air Quality

In southern Ontario urban centres, poor air quality is most often the result of high levels of ground-level ozone ("O_3") and airborne particulate matter ("PM"), which when combined with other air pollutants form smog. The air pollutant life cycle is largely influenced by synoptic (i.e., large-scale) weather systems (MOE, 1999). Ground-level O_3, its precursors and fine PM can travel via these large-scale weather systems up to thousands of kilometres from their source. It is because of the long-range transport of airborne pollutants that transboundary flow from the U.S. plays a significant role in air quality considerations throughout southern Ontario.

The existing air quality in the Kingston area is influenced by local and long-range contaminants generated in upwind urban and industrial areas. The predominant wind directions at the Kingston Airport are from the south and southwest (**Table 4.4, Appendix B**).

Air quality in southern Ontario is affected in commensurate part by emissions from the U.S. which contribute 55% of smog (MOE, 2005). The remaining portion is largely due to fossil fuel combustion in Ontario. Ground-level O_3 is the primary component of smog with a contribution by fine PM. O_3 results from chemical reactions between volatile organic compounds ("VOC"s) and nitrogen oxides ("NOx") in the presence of heat and sunlight.

The MOE is responsible for ambient air quality monitoring in Ontario. Continuous monitoring stations are located in Kingston and in Belleville, approximately 75 km west of Kingston. The Belleville station monitors sulphur dioxide ("SO_2"), carbon monoxide ("CO") (2003 and 2004 only), O_3, nitric oxide ("NO"), nitrogen dioxide ("NO_2") and particulate matter of 2.5 µm diameter or less ("$PM_{2.5}$"), whereas the Kingston station monitors O_3 and $PM_{2.5}$ (2003 and 2004 only).

In 2003, 2004 and 2005, there were no exceedances of the provincial 1-h, 24-h and 1-y SO_2 criteria, as well as the 1-h and 24-h NO_2 criteria, at the Belleville station (MOE, 2004, 2006a,b). In 2003 and 2004, there were no exceedances of the provincial 1-h and 8-h CO criteria at the Belleville station (MOE, 2004, 2006a). CO was not measured in Belleville in 2005 (MOE, 2006b).

The MOE 1-h O_3 criterion was exceeded 39 and 103 times in 2003, four and 24 times in 2004 and 33 and 83 times in 2005 in Kingston and Belleville, respectively (MOE, 2004, 2006a,b). There are no provincial air quality criteria for NO and $PM_{2.5}$. However, the $PM_{2.5}$ concentrations exceeded the federal Canadian Wide Standard reference level of 30 µg/m^3 per 24-h period three and five times in 2003 in Belleville and Kingston, respectively, and four times at both locations in 2004 (MOE, 2004, 2006a). In 2005, $PM_{2.5}$ concentrations exceeded the federal Canada Wide Standard eight times in Belleville (MOE, 2006b). $PM_{2.5}$ was not measured in Kingston in 2005.

Ambient air quality is relevant to the incremental gaseous and particulate emissions associated with landfall and offshore cable installation activities (**Section 5.1.2**).

Environmental Noise

Environmental noise levels will vary according to a number of factors: intensity, kind and number of noise sources; proximity to the noise sources; topography; presence of barriers and absorbers such as vegetation; and meteorological conditions.

A variety of land and water uses in the local study area contribute to environmental noise levels. The major sources of noise include agricultural and industrial activities, road traffic, construction, as well as recreational and commercial boating.

The major existing sources of environmental noise at the landfalls and cable crossings are industrial and municipal operations, e.g., a nylon manufacturing facility and Kingston West Water Treatment Plant ("WTP"), road traffic, agricultural activities, recreational and commercial cruise vessel passage, wave action and wildlife.

Ambient environmental noise is relevant to noise levels associated with submarine cable installation (**Section 5.1.2**).

4.4 GEOLOGY, PHYSIOGRAPHY AND SOILS

Geology

Regionally, eastern Ontario is underlain by relatively flat-lying, undeformed sedimentary bedrock of Paleozoic age which overlies older crystalline Precambrian bedrock. The Precambrian/Paleozoic unconformity (the Frontenac Axis) lies to the east (extending from Port Severn on Georgian Bay south to the Lake Ontario outlet to the St. Lawrence River), whereas the Niagara Escarpment is located to the west. The bedrock forms part of the Western St. Lawrence Platform, an extension of the stable interior North American Platform. Within this platform, orogenic and tectonic activity during the Cambrian created a series of basins and arches, including the Michigan Basin (centred along the Michigan Peninsula), the Appalachian Basin (extending from the Great Lakes to Alabama) and the Algonquin Arch, a structural high which separates the two basins. From this arch, the bedrock dips gently 6 to 9 m/km towards the Michigan Basin to the west and the Appalachian Basin to the south.

Although an overall stable region, the geology is a result of repeated sequences of subsidence, sedimentation and erosion controlled by tectonic forces and eustatic sea level fluctuations operating from the Middle Precambrian to the Early Cretaceous (Williams *et al*., 1992).

The proposed Project site lies just to the west of the Frontenac Axis. The bedrock underlying the local study area consists of the Middle Ordovician (472 to 461 million y old) Trenton and Black River Groups consisting of carbonate rock, i.e., limestone, minor dolostone and shale (Freeman, 1978). The northern portion of Wolfe Island (including the proposed cable crossing landfall) is underlain by very strong, fine-grained limestone and coarser grained, bioclastic limestone with minor shale (Acres, 2004).

The proposed Project site lies in a zone of mild potential (Zone 1) for seismic activity (ACNBC, 1980). Unlike the traditional earthquake-prone zones along plate margins, (e.g., those known in the western Rocky Mountains), seismic activity in the study area is related to slippage along ancient fault lines located within the North American continental plate. Earthquake prediction in the study area is difficult, as few ancient faults have been identified.

Geological data have relevance with respect to the trenching/boring of the transmission cable into the bedrock, particularly at the shoreline and nearshore (**Section 5.1.3**).

Physiography

The proposed Project and surrounding region lie within the West St. Lawrence Lowland Physiographic Unit of the St. Lawrence Lowlands Physiographic Region (Bostock, 1970).

During the Quaternary, the Laurentide Ice Sheet dominated much of Canada, including southern Ontario. A series of glacial advances and retreats was initiated approximately 190,000 y BP (before present) and lasted to the beginning of the Holocene at 10,000 y BP. The two main stages of glaciation, Illinoian and Wisconsinan, were divided by the Sangamonian Interglacial stage between 115,000 to 135,000 y BP. The Labrador Sector of the Laurentide Ice Sheet, with the main direction of ice flow from the northeast, mainly affected the present-day study area (Barnett, 1992).

Deglaciation of the area was initiated approximately 13,000 y BP (Sly and Lewis, 1972). Glacial Lake Iroquois formed as the ice retreated from the area and lasted from between 12,600 and 12,000 y BP. This lake was followed by a series of short-lived proglacial lakes which occupied successively lower levels. Early Lake Ontario became established about 11,000 y BP.

Regionally, surficial deposits are divisible into two main categories (Karrow, 1967). The most widespread are fairly deep sediments deposited by Quaternary glaciation, mainly of the Wisconsinan Substage. These ice-contact sediments (tills) were deposited directly from glaciers during ice advance and retreat, and also include landforms such as drumlins, moraines and kames. Additionally, considerable amounts of meltwater from glaciers deposited glaciofluvial and glaciolacustrine sediments.

Other surficial deposits, which are more local in scale, are post-glacial Holocene sediments, mainly alluvium deposited by rivers. Other minor recent sediments include those created by wind deposition, as well as organic and peat deposits in wetlands (Chapman and Putnam, 1984a).

The local study area is situated on the Napanee Plain (Chapman and Putnam, 1984a,b). This physiographic region is a flat to undulating plain of limestone from which glaciation stripped most of the overburden. While the overburden is only a few centimetres deep over much of the region, some deeper glacial till occurs in the stream valleys. Shallow deposits of stratified clay providing better soils occur in depressions in the southern part of the region, including the Kingston mainland and Wolfe Island.

Overburden is present on almost all of the western side of Wolfe Island, with the exception of bedrock outcroppings along or near the shoreline and a few scattered exposures in the interior (Acres, 2004). The overburden consists of glaciolacustrine varved clay that is firm to very stiff. Overburden thickness generally ranges from 0.9 to 3.5 m, with a maximum overburden encountered being 6.26 m. Overburden between Highway 96 and the Wolfe Island landfall shoreline varies from about 10 cm to 2 m in depth (AGL, 2007).

A geotechnical survey, including overburden depth determination, of the Kingston mainland landfall and the land cable route will be undertaken in the fall of 2007.

Physiographic data have relevance with respect to trenching/boring of the transmission cable at the landfalls (**Section 5.1.3**).

Soils

The surficial soil at the Patterson Point and Sand Bay landfalls is Landsdowne clay, a Grey Wooded and Humic Gleysol, that is derived from calcareous lacustrine clay parent materials (Gillespie *et al*., 1966). This imperfectly drained soil is categorized by the Canada Land Inventory (CLI, 1966) as Class 2 with moderate limitations that restrict the range of crops or require moderate conservation practices due to undesirable soil structure and/or low permeability.

The surficial soil at the Wolfe Island landfall is Farmington loam, a Brown Forest and Humic Gleysol, that is derived from calcareous stony loam till (Gillespie *et al*., 1966). This well drained soil is categorized by CLI (1966) as Class 6, capable only of producing perennial forage crops, and improvement practices are not feasible due to shallowness to solid bedrock.

Soils data have relevance with respect to landfall construction activities (**Section 5.1.3**).

4.5 BATHYMETRY AND PROXIMATE SHORELINE CONFIGURATION

As indicated in **Section 4.4**, the Laurentide Ice Sheet dominated the Canadian landscape during the Quaternary. Glacial Lake Iroquois formed when retreating Laurentian ice dammed the St. Lawrence valley about 12,400 y BP. Thick deposits of glaciolacustrine sediments (mainly clays in the Kingston Basin of Lake Ontario) were deposited over bedrock and glacial till. The present landscape was then gradually revealed as water levels fell during the next 1,000 y (Anderson and Lewis, 1985; Gilbert and Shaw, 1992). By 11,400 y BP, the St. Lawrence Valley was open.

The proposed Project is located at the outlet of Lake Ontario and head of the Upper St. Lawrence River at the transition of the northern Lake Ontario and the St. Lawrence Valley drainage basins (Chapman and Putnam, 1984a).

Bathymetry and shoreline configuration are technical aspects related to landfall and route selection, as well as preliminary engineering (construction) design (**Section 3.0**).

Bathymetry

The proposed cable crossing route and landfall locations are presented in **Figure 4.3 (Appendix A)**. Based on the bathymetric survey of the proposed cable route (Campbell, 2007), water depths of 1 to 4 m extend approximately 500 m offshore of the Kingston Mainland landfall to the mouth of Sand Bay, with a subsequent rapid increase to a water depth of 16 m (**Figure 4.4, Appendix A**). Water depths ranging from 16 m to as deep as 29 m occur across the Lower Gap for a distance of about 2.5 km along the proposed cable route with a subsequent rapid decrease to a shallow area between Simcoe Island and Garden Island that extends to the Wolfe Island nearshore. The bathymetry in this shallow area ranges from 5 m to 3 m. A bathymetric shoal, marked by a navigation buoy (KEI), is located approximately 125 m downstream (northeast) of the proposed crossing. A second bathymetric shoal also marked by a navigation buoy (KE2) is located about 150 m upstream (southwest) of the proposed crossing (**Figure 4.3, Appendix A**). The water depth of 3 to 4 m occurs up to 50 m offshore of the Wolfe Island landfall.

Figure 4.4 (Appendix A) also includes additional sounding data approximately 50 to 100 m apart acquired from Canadian Hydrographic Series (CHS, 1970, 1981) in order to identify potential alternative cable routes around the bathymetric shoals while obtaining maximum possible water depths, as well as to the alternative Kingston mainland landfalls (Campbell, 2007). These additional soundings are located outside of the 200 m geophysical survey corridor of the initial and final cable routes.

Shoreline Configuration

Along the shoreline reach encompassing the landfall on Wolfe Island, the predominant feature is an exposed vertical bedrock cliff ranging in height from 1 to 5 m. Shoreline sections with lower slope gradients and exposed bedrock at the shoreline are interspersed along the vertical cliffs. This shoreline reach has a regular configuration with an L-shaped dock extending approximately 150 m offshore located about 400 m west of the proposed landfall location. A small embayment supporting submerged aquatic vegetation with a cattail marsh inshore is situated just west of Mill Point approximately 900 m east of the proposed landfall.

The Patterson Point-Point Pleasant peninsula is bounded by two bays: a smaller embayment to the west and Sand Bay to the east (the Kingston landfall location). The shore area along the western portion of Sand Bay is dominated by a low-gradient cobble and gravel beach approximately 1 to 5 m in width. One small wetland area is located on the western shore of Sand Bay. The northeastern shore of Sand Bay is composed of a fairly clean, low gradient, sand beach, extending out into the water approximately 150 to 200 m (Acres, 2005). The backshore is within a groomed park area owned by a private industry. This park consists of a tree line that borders the upper shore of Sand Bay to the west and thins out to a well-groomed, grassed and beach area to the northeast. The eastern backshore is wooded with a thin tree line that extends to Carruthers Point.

Information on nearshore substrate conditions at the landfall locations is provided in **Section 4.9**.

Bathymetry and shoreline configuration are technical aspects related to landfall and route selection and preliminary engineering (construction) design (**Section 3.0**).

4.6 CURRENTS

The St. Lawrence River drains an area of about 774,000 km^2, and is the only natural outlet for the Great Lakes. The river extends about 896 km from the eastern end of Lake Ontario to the Gulf of St. Lawrence.

Flow is controlled by dams near Iroquois, Ontario and Cornwall, Ontario-Massena, New York. The Iroquois dam is designed to control the full discharge from Lake Ontario. The Long Sault Dam at Cornwall-Massena is used to discharge excess flows not required by the Moses-Saunders Powerhouse. The Moses-Saunders Power Dam, together with the Long Sault dam, created Lake St. Lawrence which extends 45 km upstream to the Iroquois Lock and Dam.

Flow and water levels are regulated by international agreement administered by the International St. Lawrence River Board of the IJC. Over the long-term, flow in the river is dependent upon inflow from the Great Lakes. Owing to the enormous amounts of natural storage upstream, the river produces a comparatively steady flow. The monthly and annual mean, minimum and maximum flows in the St. Lawrence River at Iroquois and Cornwall are presented in **Table 4.5 (Appendix B)**. The mean annual discharge from 1860 to 1958 at Iroquois was 6,820 m^3/s. At the Moses-Saunders Power Dam in Cornwall, the mean annual discharge was 7,370 m^3/s between 1958 and 1993. Flow increases from January to a peak in June, then decreases through the summer and fall until the minimum flow is reached in January.

Based on the flow data collected at the Moses-Saunders Power Dam, Merriman (1997) has extrapolated annual median flows in the St. Lawrence River channel south of Wolfe Island between 1977 and 1995 (**Figure 4.5, Appendix A**). Over this period, flows have varied from a low of 6,850 m^3/s in 1995 to a high of 9,200 m^3/s in 1986.

Wolfe Island divides the St. Lawrence River into two main channels. Tsanis and Murthy (1990) determined that the Main Navigation Channel to the south of Wolfe Island receives about 55% (4,500 m^3/s) of the flow from Lake Ontario, whereas the Canadian Middle Channel (Lower Gap) discharges the remaining 45% (3,700 m^3/s).

Based on current meter measurements, Tsanis and Murthy (1990) reported average flow velocities of 11.22 cm/s and 9.21 cm/s in the Main Navigation Channel and Lower Gap, respectively. Based on satellite surface drifter measurements, surface flow velocities in the Main Navigation Channel ranged from 13.10 to 30.24 cm/s, whereas flow velocities in the Lower Gap ranged from 10.11 to 21.93 cm/s.

Tsanis *et al*. (1991) reported than mean current speeds in the Main Navigation Channel were 14.1 cm/s at a water depth of 12 m and 11.3 cm/s at a water depth of 20 m, at a location where the overall water depth was 21.5 m. In the Lower Gap at a location with the same overall water depth of 21.5 m, mean current speeds were 11.5 cm/s and 3.4 cm/s at water depths of 12 m and 20 m, respectively. Surface drifters had velocities of 20 cm/s as they passed the two current meter mooring locations. Current direction at both locations was predominantly downriver.

Information on current speeds and directions is relevant to potential sediment resuspension and subsequent sedimentation (**Section 5.1.9**).

4.7 WIND GENERATED WAVES AND WATER LEVELS

Information on wind generated waves and water levels are technical aspects taken into account in preliminary engineering (construction) design (**Section 3.0**).

Wind Generated Waves

Gilbert (1999) assessed the role of waves in affecting the sedimentary processes in northeastern Lake Ontario and its outlet to the St. Lawrence River (**Section 4.9**). The maximum effective fetch in the local study area ranges from 10 to 30 km. For sustained winds of 30 and 60 km/h, significant wave heights are less than 0.5 and 1 m, respectively. At 90 km/h, the maximum significant wave height is less than 1.5 m, except in Kingston Harbour where values exceed 2 m because of the exposure to the southwest.

Recordings of wave height made 5.2 km southeast of Simcoe Island in the Lower Gap indicate significant wave heights of 1 m are exceeded about 10% of the time and 2 m about 1% of the time (Gilbert and Shaw, 1992).

Water Levels

Generally, the fluctuation of water levels in Lake Ontario corresponds to annual hydrologic activity. The lowest monthly mean is typically in the winter months of December through February, and the highest is usually in June. Short-term variations also occur due to meteorological (e.g., storm surge) factors. The effect of wind and variations in barometric pressure over Lake Ontario may raise and lower the water level at its outlet in excess of 0.6 m (IGLLB, 1973a).

The Moses-Saunders Power Dam controls water levels to provide optimum hydroelectric power generation and safe navigation of commercial shipping vessels. Peaking operations to meet electrical load demand, and consequent variations in turbine water flow, cause fluctuations at the Moses-Saunders Power Dam up to 0.2 m. The Iroquois Control Dam can be used in an emergency to control the outflow from Lake Ontario; however, it is used primarily to assist in the formation of stable ice cover in winter and prevent water levels from rising too high downstream. The Long Sault Dam is largely an emergency control structure capable of discharging the entire flow of the river.

Over the period of record between 1909 and 2001, the minimum and maximum mean daily levels in Kingston Harbour were 73.73 m and 75.84 m a.s.l. (“above sea level”) recorded on 23 January 1965 (also on 28 December 1934) and 09 June 1952, respectively. **Table 4.6 (Appendix B)** presents the monthly and annual mean water levels in Kingston Harbour. Based on these data, monthly mean water levels vary from 74.56 m in December to 75.07 m in June (a difference of only 0.51 m).

4.8 THERMAL REGIME AND ICE CONDITIONS

Information on thermal regime and ice conditions are technical aspects taken into account in preliminary engineering (construction) design (**Section 3.0**). Thermal regime is also relevant to water quality (**Section 5.1.11.3**).

Thermal Regime

The thermal regime of Lake Ontario is typical of northern temperate dimictic lakes, i.e., those that undergo thermal stratification in the summer and winter with periods of mixing (turnover) in the spring and fall. However, considerable differences are apparent in the rates of seasonal heating and cooling (Stevens, 1988). In general, the spatial distribution in surface temperatures is a reflection of lake bathymetry, modified by wind stress and water circulation patterns, with the shallower nearshore areas warming faster in the spring and cooling more rapidly in the fall. **Figure 4.6 (Appendix A)** presents average daily surface water temperatures for Lake Ontario between 2001 and 20 June 2006.

Lakewide thermal stratification is usually established by mid-June. During the summer months (i.e., July to September), the depth of the thermocline is highly variable due to the orientation of the lake relative to the prevailing westerly winds. Since the longitudinal axis of the lake lies almost parallel with the prevailing winds, the lake is highly susceptible to wind stress, causing upwelling events along the west and northwest shoreline. This results in a large west-to-east temperature gradient (Stevens, 1988).

During the summer months, the area around Wolfe Island and Howe Island does exhibit some thermal stratification (Hendrick *et al*., 1991). Tsanis *et al*. (1989a,b) reported that the thermal structure of Lake Ontario extends into the Main Navigation Channel at least as far as the Environment Canada water quality monitoring station at Banfield Point on Wolfe Island.

In-situ water quality measurements taken at the sediment quality and benthic macroinvertebrate sampling locations along the initial transmission line route during the July 2006 field survey are presented in **Table 4.7 (Appendix B)**. Thermal stratification was evident at the deepest sampling location (T2) resulting in marked dissolved oxygen ("D.O.") depletion in deeper hypolimnion waters.

Ice Conditions

Lake Ontario seldom becomes completely ice-covered. The small surface area and large depth provides good heat storage capacity that helps to retard the formation of ice. Ice cover is normally limited to 15% of the lake surface area, and is generally present as loose pack ice when it occurs (BEAK, 1990).

Since the impoundment of the Moses-Saunders Power Dam forebay, winter ice cover usually forms first along the South Shore Canal between the City of Montreal and Lac St. Louis in early to mid-December and advances upriver to Lake Ontario (Marshall, 1978). In a mild winter, freeze-up of the Lake Ontario-Wolfe Island area is usually complete by early February, in an average winter by mid-

January and, in the most severe cases, by late December. Mid-winter conditions usually consist of fast ice which is generally not subjected to breakup from wind and current conditions. During February, ice thickness in the Main Navigation Channel varies from about 5 to 10 cm during mild winters, 18 to 33 cm during average winters, and 34 to 56 cm during severe winters. Breakup begins in early March, starting in the middle of the channel between Wellesley Island and Ogden Island. By the end of March, the river (including the Lower Gap) is mostly ice-free.

To facilitate the formation of stable ice cover on the Upper St. Lawrence River, two floating booms are placed across the river (one near Ogdensburg, New York-Prescott, Ontario and the other at Gallup Island) by the power authorities, i.e., New York Power Authority, Ontario Hydro (now Ontario Power Generation) and Hydro-Quebec (Niimi, 1982). This cover serves to reduce the formation of ice floes which could damage the turbines at the Moses-Saunders Power Dam at Cornwall-Massena, as well as the Beauharnois Power Dam at Montreal, Quebec, and, more importantly, achieve the release flows from Lake Ontario for generating purposes, as prescribed by the IGLLB (1973b).

Gilbert (1991a) reported on freeze-up, growth, decay and breakup of ice during a 10 year period on Lake Ontario offshore of the Public Utilities Commission wharf in Kingston, about 5 km east of Point Pleasant. During this period, freeze-up occurred as early as 14 December and as late as 03 February, but generally by mid-January. The mean duration of ice cover was 71.7 days (range 18 to 96 days). Average mean ice thickness was 32 cm with maximum ice thickness in a given year related to the intensity of cooling measured in degree days of freezing. **Figure 4.7 (Appendix A)** presents ice cover in eastern Lake Ontario and St. Lawrence River outlet on selected dates near breakup. Decay of the ice sheet from its maximum thickness late in the season is normally rapid and final breakup from a stable ice sheet often occurs in a few days as a result of the mechanical action of waves and currents.

A wind-driven ice-push event was recorded in the spring of 1986 by Gilbert and Glew (1986) in the nearshore between Cataraqui Bay and Kingston Harbour. The resulting ice pile and the damage to the shore were small in comparison to other events that have been recorded elsewhere. In this case, ice in Lake Ontario at Kingston weakened rapidly due to increased air temperatures. The broken ice in the nearshore area had been moved by winds more than 5 km offshore. However, when the winds shifted to an onshore direction, the ice was driven onshore resulting in a small ice-push event pushing stones up to 206 kg to near the top of the ice pile. Gilbert (1991b) also described two wind-driven ice pile-up events in mid-winter at Salmon Island and at Snake Island.

Wind-driven ice push on lake shores is an irregular, unpredictable event dependent wholly on the coincidence of a number of requisite weather and ice conditions at the time of breakup. The geomorphic effect of these infrequent events is minor.

4.9 SEDIMENTOLOGY

Local Study Area

Historic data on surficial sediment type are available for a few locations near the proposed cable crossing. Merriman (1987) reported that a sediment sample collected from the Main Navigation Channel off Hornes Point on Wolfe Island consisted of 75.9% sand, 14.3% silt and 9.8% clay. Kuntz (1988) reported that surficial sediments in Cataraqui Bay were a fine silty clay, whereas a grey fine silty clay occurred in deeper waters off Carruthers Point in the Lower Gap. In the Canadian Middle Channel along a transect off Abraham Head, surficial sediments were classified as black mud and clay mud (Kuntz, 1988). Surficial sediment samples collected in the Main Navigation Channel along a transect from a location about 2 km west of the eastern end of Wolfe Island (Beauvais Point) to New York State about 1.6 km east of Cedar Point State Park indicated coarser sediment (sand, silty sand) nearshore and finer sediment (mud, silt) offshore (Fitchko, 1990a). Sediment samples collected along the initial transmission line route during the July 2006 field survey indicated a similar pattern of coarser sediment (sand) in shallower nearshore waters and finer sediment (silty sand, muddy sand) in deeper offshore waters (**Table 4.8, Appendix B**).

Gilbert (1999) has assessed the role of waves in affecting the sedimentary processes in northeastern Lake Ontario and its outlet to the St. Lawrence River. At a wind speed of 30 km/h, wave base exceeds 10 m in the open water, decreasing to 8 to 10 m in the Lower Gap. At 60 km/h, wave base is up to 20 m in the open water, with values of 16 to 18 m in the Lower Gap. At 90 km/h, the wave base in the open water is up to 29 m, decreasing to less than 25 m in the Lower Gap. As indicated in **Section 4.5**, the maximum water depth in the Lower Gap is approximately 28 m. In protected waters wave base in less than 8 m, with a wave base greater than 10 m in Kingston Harbour because of exposure to the southwest. **Figure 4.8 (Appendix A)** shows the regions of lake/river floor below wave base for wind speeds of 30, 60 and 90 km/h based on comparison of the calculated wave base and bathymetry.

The magnitude (depth) of the wave base determines the potential for sediment deposition. At 30 km/h, most of the Lower Gap is below the wave base except for most of the shallows northwest of Simcoe Island and east to Garden Island. Almost all of the river bottom is protected below about a 5 m depth, that is within 10 to 50 m from shore and in a few places several hundred metres offshore. At 60 km/h, only the deepest parts of the Lower Gap channel are protected, i.e., most of the region from Amherst Bar to Garden Island and south is above wave base. At 90 km/h, almost all of the Lower Gap is above wave base.

The 60 km/h wave base represents winds that, although relatively rare, are significant in redistributing sediment on the lake/river floor. Strong winds (>61 km/h) occurred 0.04% of the time from 1967 to 1982 predominantly from the south to west quadrant during the ice-free period. Sediment accumulates during periods of low energy but is removed with sufficient frequency that long-term accumulation cannot occur.

As indicated in **Section 4.7**, significant wave heights of 1 m and 2 m are exceeded about 10% and 1% of the time, respectively in the Lower Gap about 5.2 km southeast of Simcoe Island (Gilbert and Shaw, 1992). These correspond to a wave base of 8 to 15 m on exposed coasts in the Lower Gap and Main Navigation Channel. Along the more protected coasts, wave base is estimated to be 3 to 6 m.

On exposed shores in water depths less than 5 to 10 m, the local study area bottom is swept clear of fine sediments and bedrock or coarse, hard sediment is exposed (Gilbert and Shaw, 1992; Gilbert, 1999). In sheltered areas, such as the head of Cataraqui Bay, waves rarely exceed 0.3 m resulting in a veneer of recent sediment cover up to several metres thick. In deeper water, a thin cover (less than 2 m) of mostly Lake Iroquois and related late Pleistocene stiff glaciolacustrine clay is present. The deepest areas of the Lower Gap are covered by recent sediments consisting primarily of underconsolidated, organic-rich material that is easily eroded.

A sedimentation rate of approximately 5 mm/y was determined based on dating of a sediment core collected about 7.5 km upstream of the proposed cable crossing in a water depth of 23 m (A. Mudroch, Environment Canada (ret.), 2006, pers. comm.).

Within the western end of the local study area between Carruthers Point and Simcoe Island, Johnston (1978) reported the occurrence of a thin layer of recent muds overlying glaciolacustrine clay or bedrock within the 20 m bathymetric contours. Glacial till occurs within the 10 to 20 m contours, with bedrock between the 0 and 10 m contours. Further east to Kingston, the cover of recent muds occurs between the 10 m bathymetric contours, with till present between the 5 and 10 m contours. Beyond Kingston, as far as Knapp Point, glaciolacustrine clays are exposed in the centre of the channel, whereas the channel edges are composed of bedrock. The intermediate areas are mud-covered clays.

Based on a geophysical study, Gilbert and Shaw (1992) reported that a deep submerged channel in bedrock occurs along the north shore of the Kingston Basin and the Lake Ontario outlet to the St. Lawrence River extending from Adolphus Reach through the Lower Gap to Kingston. This large channel and smaller channels nearby were likely created by high-velocity subglacial meltwater flow providing a fluvial system during the early Holocene low-water phase of Lake Ontario. Within the local study area, the channel to the west is occupied by massive sediments overlying stratified sediment deposited in glacial Lake Iroquois (channel deposits) with a thin discontinuous upper layer of recent sediment. To the east of Cataraqui Bay, where the riverbed is a wide, flat plane at about 16 m depth, the channel deposits have a different character. Beneath a thin veneer of acoustically transparent sediment 0 to 3 m thick is an acoustically opaque surface with very little sound return from beneath except in a few locations where multiple reflectors are characteristic of stratified glaciolacustrine sediments. The only relief on this surface is a large channel toward the north side and several smaller channels. These were interpreted as river channels (complete with levees) on the surface of a flood plain.

Proposed Cable Route

Campbell (2007) categorized the surficial sediments along the proposed cable route into five main categories. These units were classified based on their signatures on geophysical records (sidescan sonar, sub-bottom profiles and echo sounder) and were groundtruthed by surficial sediment grab samples and underwater videos. A description of the five units is provided below:

Unit	Description
A	This unit extends approximately 4.2 km within the deeper waters of the Lower Gap from the mouth of Sand Bay offshore of the Kingston mainland to a point about 2 km offshore of Wolfe Island within the 5 m bathymetry contour northeast of Simcoe Island (**Figure 4.9, Appendix A**). Two segments of Unit A also intersect Unit B located further inshore towards Wolfe Island. Unit A is comprised of clay sediment with varying amounts of shell fragments and clam beds. Areas of dredge spoil and clam beds, characterized by dark, circular features in the sidescan imagery, are present approximately 1 km and 2.5 km offshore of Patterson Point on the Kingston mainland. The dredge spoil appears to provide suitable habitat for exploitation by clams. Grab samples collected within this unit contained very saturated, olive grey clay with some shell fragments and intact, white-coloured clams.
B	This unit is located to the east of Unit A. This unit is interpreted to be fine sand sediment with abundant shell fragments. Gravel- and cobble-sized clasts are visible throughout the unit, with the occasional boulder up to 0.75 m in size. The increased cobble and boulder content of this unit is likely due to bedrock being close to the surface. This unit is intersected by segments of Unit A (**Figure 4.9, Appendix A**).
C	This unit is located southeast of Unit B generally between the bathymetric shoal demarcated by navigation buoy KE1 and the nearshore of Wolfe Island. This unit is comprised of sandy silt and an abundance of shell fragments. Gravel and cobble-sized clasts are common within the unit with the numerous boulders up to 1 m in size. Again, the increased cobble and boulder content of this unit is likely the result of bedrock being close to the surface. An area with abundant logs and boulders is present near the shoreline within this unit, likely the remains of an old wharf.

Unit	Description
D	This unit, located in Sand Bay and at the bathymetric shoal approximately 1 km offshore of Wolfe Island, represents the local bedrock surface. Bedrock along the Kingston mainland nearshore had been previously mapped by Gilbert and Shaw (1992). Erosion features such as fractures and glacial striations were visible in the video footage and sidescan sonar data. Cobbles and many large boulders were also visible resting on the top of the bedrock surface. The boulders are likely fragments of bedrock fractured by freeze-thaw processes and further broken up by marine erosion and redistributed over the river bed.
E	This unit is present in the offshore area of Sand Bay, approximately 250 m from the shore. It is composed of a thin cobble and boulder till overlying the bedrock.

The area of the proposed cable route section encompassing Units B and D was interpreted by Gilbert and Shaw (1992) to be composed of bedrock with a thin or discontinuous veneer of sediment.

The unconsolidated sediments present across the survey corridor vary from more than 10 m thick to not being present at all (**Figure 4.10, Appendix A**). The sediments are thickest in the channel between the Kingston shore and Snake Island shoal where they are visible in the sub-bottom profiler data as deep as 19 m below the lake floor before thinning to 2 m northeast of the Snake Island shoal navigational buoy (**Figure 4.2, Appendix A**). Thick unconsolidated sediments are also present near the Wolfe Island shore, where they extend past 14 m, below the maximum resolvable depth of the sub-bottom profiler. The thick sediments here have filled in a deeper channel most likely created when lower water levels in the past eroded the channel between Simcoe Island and Wolfe Island.

On the southeast side of the channel and extending towards Wolfe Island, where water depths range from 10 to 3 m, the unconsolidated sediments thin to between 5 m and less than 2 m thick along the cable route. Although it is not possible to determine lithology of the underlying unit across the entire shallow water area without groundtruth data such as boreholes, it can be traced to where bedrock outcrops at the shoal near Wolfe Island (navigational buoy KE2). Other areas have a ‘steplike’ appearance similar to that seen of the bedrock in Sand Bay, where a deeper hole is present near the bay mouth. It is likely that the flat lying bedrock has been eroded forming the step appearance, where the height of each step is the thickness of each limestone layer. The increased cobble and boulder content within the surficial sediments may also be an indication that bedrock is close to the lake floor. It is likely that the upper surface of bedrock has been fractured off and weathered, mixing boulder- and cobble-sized clasts into the overlying sediments.

Figure 4.11 (**Appendix A**) provides an interpreted profile showing the thickness of unconsolidated sediments along the centreline of the proposed cable route.

Shallow gas is visible in multiple areas within the survey corridor in water depths deeper then 15 m. Gas within the sediments prevents the penetration of the acoustic energy from the sub-bottom profiler, masking the underlying geologic reflectors. The top of the gas reflector is flat lying, and visible at depths averaging 2.5 m below the lake bed.

This gas could be originating from shallow, decomposed organic material or from deep underlying formations. It is possible that the gas originated from the decomposition of vegetation that may have grown during low lake levels, and was then buried as the lake level rose. The areas where shallow gas has masked the underlying geologic reflectors are indicated in **Figure 4.10** (**Appendix A**).

Bedrock is characterized by a strong continuous reflector, with no coherent underlying reflections. Surface bedrock is mapped at the bathymetric shoal (navigational buoy KE2) near Wolfe Island and the Kingston mainland nearshore (**Figure 4.10, Appendix A**). At these locations, it is visible in the sub-bottom data over short distances, trending at steep angles away from the bedrock at the riverbed surface, beneath the overlying sediments and out of range of the sub-bottom profiles.

A number of riverbed features have been identified in the geophysical data along the cable route including dredge spoil sites with associated clam beds, raised relief features, scour marks, intake pipes and submarine transmission cables.

Multiple areas of dark, circular features typical of dumped dredge spoils were evident in the sidescan data. Dredge spoils are present on the bathymetric slope off Sand Bay mouth, at the ends of the intake pipes and approximately 2.1 km offshore of the Kingston mainland (**Figure 4.9, Appendix A**). Thick clusters of clam beds correlate with the circular shaped dredge spoils, indicating that suitable clam habitat formed as a result of the dumped dredge spoils. The majority of the spoils are relatively flat-lying; however, in places, possibly where multiple spoil dumps were made over top of one another, larger mounds have been created. Based on the video footage collected, these larger mounds are estimated to be up to 0.5 m above the surrounding lake floor.

Other raised relief features in the survey area included boulders up to 1 m in size, and logs up to 4 m long and 0.25 m high. They are most common near the shoreline areas of the survey, as well as at the bedrock shoal (navigational buoy KE2).

Linear areas of disturbed sediment were visible in the sidescan data and are most likely due to anchors being dragged across the soft lakefloor sediments. These anchor drags were likely created during construction and maintenance of the intake pipes, as well as by pleasure boats. Kingston Harbour hosts many sailing regattas during the summer season, including the Canadian Olympic-Training Regatta Kingston (CORK) (see **Section 4.19**). Race markers and committee boats are anchored in the area during such events.

Three intake pipes are located east of Sand Bay, extending approximately 550 m offshore to the 27–m bathymetry contour (**Figures 3.1** and **4.4, Appendix A**). A large area of disturbed sediment and debris is also present beyond the ends of the intake pipes, most likely from construction and maintenance of the intake pipes.

Three active submarine power cables owned by Hydro One are located between Simcoe Island and Sand Bay. The power cables were identified, using a combination of sidescan sonar, submersible video camera equipment and marine magnetometer, on the riverbed running from the western shore of Sand Bay into the river channel towards the Snake Island shoal (**Figures 3.1** and **4.4, Appendix A**).

As indicated above, coarser (sand) and finer (silty sand, muddy sand) sediment was present in the shallower nearshore and deeper offshore waters, respectively, along the initial transmission line route (**Table 4.8, Appendix B**). A similar pattern of sediment type is anticipated along the proposed cable route.

Wolfe Island Landfall Nearshore

Along the 2 km long reach of the northern shoreline of Wolfe Island west of Mill Point, the immediate nearshore zone is comprised predominantly of submerged, fractured boulder slabs overlying bedrock (Acres, 2005). The boulder slabs range in diameter from 0.2 m to greater than 1 m. These shallow (0 to 1 m depth) low-gradient nearshore zones, located within 10 m of the shoreline, occur within the wave zone and therefore remain relatively free of fine sediment, periphyton and zebra mussels (*Dreissena polymorpha*). Further (i.e., approximately 10 m to 150 m) offshore, the substrate is characterized by a relatively even mix of cobble and boulder, comprising a singular layer with up to 80% surface cover over the underlying silt veneer and bedrock. Boulders and rocks in this zone are covered with algae, periphyton and zebra mussels. Aquatic macrophyte growth is also very abundant in this zone. Further offshore (to approximately 1.5 km), substrate consists of silt veneer with sparsely scattered boulders and cobbles, overlying bedrock. This further offshore zone is relatively flat and featureless and up to 5 m deep (**Figure 4.3, Appendix A**).

As indicated in **Section 4.5**, there are two shallower locations marked by navigation buoys (KE1 and KE2) in the offshore zone with water depths between 2 m and 5 m (**Figure 4.3, Appendix A**). Water depth at both locations is approximately 3 m (Campbell, 2007). Substrate at KE1 is comprised of scattered slab boulders densely encrusted with algae and zebra mussel. Substrate at the KE2 location consists of a singular layer of scattered slab cobble and boulder over a fine silt veneer and bedrock. While there is no algal accumulation, zebra mussels are present on most rock surfaces.

At the western end of Mill Point, a limestone shelf (about 0.3 m high) extends from shore about 1 to 3 m to a water depth of 0.2 m with gradual bedrock layers extending 1 to 10 m further offshore to a water depth of 1 m. Substrate along the narrow shoreline beach consists of boulder with cobble and gravel near the water edge. The shallow shelf of bedrock with overlying rocks at water depths of 1 to 1.5 m is covered with green algae and sparse filamentous algae. Stonewort (*Chara* sp.) is present within the cracks between the bedrock slabs. Bedrock substrate and boulders occur at water depths greater than 1.5 m with abundant aquatic vegetation (**Section 4.13**). Immediately to the west of Mill Point, a boulder field is present beyond the shallow limestone shelf at depths up to 1.5 m with aquatic vegetation common.

Along the embayment west of Mill Point, there is a steep limestone cliff approximately 5 m high along the shoreline with a narrow gravel beach at the water edge. Within the nearshore, substrate consists of flat bedrock and boulders with water depths reaching 3 m within approximately 15 m of the shoreline. This substrate is covered by abundant aquatic vegetation (**Section 4.13**).

At the Wolfe Island landfall location, no discernable overburden occurred from the shoreline to approximately 600 m offshore along the cable route (AGL, 2007). The shoreline consists of a 1 to 4 m high limestone cliff with a narrow (1 m) beach consisting of broken limestone rubble. The actual elevation from the Highway 90 shoulder to the shoreline is approximately 11 m (AGL, 2007). Cedars are predominant along the cliff. In the nearshore up to water depth of 2.5 m, the substrate consists of flat fractured boulder slabs overlying bedrock with about 70% boulder/cobble cover. This substrate is covered by green algae with aquatic vegetation (20 to 40% cover) growing within the cracks of the limestone slabs. At a depth greater than 2.5 m, substrate is similar to that nearshore with abundant aquatic vegetation cover (**Section 4.13**). A 4.5 m deep hole is present off the private dock/boathouse located about 250 m east of the proposed landfall location.

Kingston Mainland Landfall Nearshore

The western shore of Sand Bay at the landfall location is composed primarily of a thin cobble and boulder till over bedrock. The western portion of the bay appears to be more protected from prevailing wave action and is more of a depositional zone compared to the cleaner substrates on the eastern shore. In the nearshore, substrate is composed of coarse cobbles within fine sand sediment (**Table 4.8, Appendix B**) less than 0.5 m thick overlying bedrock. The depth of overlying substrate diminishes as water depth increases exposing the underlying bedrock in the centre of the bay (**Figure 4.10, Appendix A**). Some periphyton, algae and zebra mussels cover the surface substrate.

As indicated in **Section 4.5**, the northeastern shore of Sand Bay to the west of Carruthers Point is composed of a low gradient, sand beach, extending out into the water approximately 150 to 200 m (Acres, 2005). Further offshore, organic growth/debris (e.g., algae, periphyton, leaves, etc.) has accumulated on the sand substrate due to lower wave action. The centre of Sand Bay is similar to other offshore areas, being composed of a single layer of rock (cobble and boulder), with up to 80% coverage over the underlying bedrock.

Information on sedimentology is a technical aspect taken into account in preliminary engineering (construction) design (**Section 3.0**) and is also relevant to the potential for turbidity generation (**Sections 5.1.9** and **5.1.11.2**).

4.10 WATER QUALITY

Based on water quality surveys undertaken in the 1960s, it was concluded that, while morphometrically oligotrophic, Lake Ontario had water quality characteristics of mesotrophic lakes, with specific nearshore areas being eutrophic (IJC, 1969). Eutrophication is characterized by high conductivity, low transparency, low D.O. content in deeper waters during thermal stratification and high biological productivity. These conditions combine to cause unpleasant tastes and odours, algal blooms and excessive weed growth, and general degradation of water quality and biological components (e.g., fish species).

As discussed in **Section 4.2**, the control of phosphorus inputs had been recognized by the IJC (1970) as the most important factor in controlling eutrophication. In addition, the IJC has focussed attention on inorganic and organic contaminant monitoring and toxic substances control in the Great Lakes (GLSAB, 1980).

Increased sewage treatment and phosphorus controls, the closure of industrial processes and improvements in industrial wastewater treatment since the 1970s have improved the water quality of Lake Ontario (e.g., Kwiatkowski, 1982; Stevens and Nielsen, 1987; Wolin *et al*., 1991; Johengen *et al*., 1994; Millard *et al*., 1996; Nicholls *et al*., 2001). However, persistent toxic contaminants, such as chlordane, dieldrin, DDT, dioxin, hexachlorobenzene, mercury, mirex, octachlorostyrene and PCBs are still of concern in Lake Ontario waters (Lake Ontario Secretariat, 1993).

The St. Lawrence River drains the Great Lakes Basin to the Atlantic Ocean and, as a result, water quality in the river is influenced by natural and anthropogenic activities within the Basin, as well as by contiguous activities. For example, total dissolved solids (“TDS”), alkalinity, pH and other chemical parameters in the river approximate those of the Lake Ontario waters (IGLLB, 1973a). Turbidity, however, can be quite high since the backwash from vessel passages causes erosion of banks and stirring of sediments.

The Upper St. Lawrence River has been monitored since 1973, under provisions of the 1972 GLWQA by Environment Canada (e.g., Chan, 1980; Lum and Kaiser, 1986; Sylvestre, 1987; Sylvestre *et al*., 1987; Comba *et al*., 1989; Kaiser *et al*., 1990; Lum *et al*., 1991).

Six water quality surveys were carried out in 1977 on the Upper St. Lawrence River (Chan, 1980). Compared with 1973-1974 data, the 1977 results showed no apparent change in water quality of the river. Nutrient concentrations (i.e., nitrate and phosphorus) downstream from Brockville to Cornwall were generally higher than upstream values. Total phosphorus concentrations were generally below the MOEE (1994a) interim Provincial Water Quality Objective (“PWQO”) of 30 µg/L for the prevention of excessive plant growth in rivers and streams. Mills and Forney (1977) reported that phosphorus was the primary nutrient controlling algal production in the Upper St. Lawrence River system.

Mean trace metal concentrations were well below the MOEE (1994a) PWQOs. Higher metal concentrations were detected downstream of Cornwall near the mouths of the Grass, Raquette and St. Regis rivers.

Of the persistent organic contaminants tested, only lindane (γ-BHC), hexachlorocyclohexane (α-BHC) and PCBs were detected. Lindane and α-BHC were detected over the entire stretch of the St. Lawrence River. Lindane concentrations ranged from 0.003 to 0.007 µg/L and the levels of α-BHC were in the range from 0.003 to 0.008 µg/L. PCBs were detected only at the mouth of the Grasse River near Massena, New York.

In 1976, Environment Canada established a station for monthly monitoring of water quality in the Main Navigation Channel off the south shore of Wolfe Island at Banfield Point as part of the commitment to the GLWQA (Sylvestre, 1987; Sylvestre *et al*., 1987; Biberhofer, 1995; Merriman, 1997). The intake is located 122 m from shore in 13.5 m of water and 5.5 m off the bottom.

Over the period 1977 to 1996, mean specific conductance has decreased from 333 to 298 µsiemens/cm as reflected by decreases in chloride, sodium and calcium (Merriman, 1997). For example, chloride concentrations averaged 27.7 mg/L in 1976 and decreased to 20.9 mg/L in 1995 reflecting primarily decreased chloride loadings from industrial sources. Decreasing chloride trends have also been reported for Lake Ontario by Williams *et al*. (1998).

Suspended particulate matter, particulate organic carbon and particulate nitrogen have also decreased at the Wolfe Island sampling station over the same time period (Merriman, 1997).

Total phosphorus has decreased from 0.016 mg/L in 1977 to a low of 0.008 mg/L in 1996 (Merriman, 1997). Similar decreasing trends have been reported for Lake Ontario by Williams *et al*. (1998). Nichols *et al*. (2001) similarly reported dramatic declines in total phosphorus concentrations between 1976 and 1999 in the upper St. Lawrence River based on monitoring at the Kingston Water Treatment Plant (“WTP”) and Brockville WTP. Most of these declines were confined to the earlier years of monitoring with no statistically significant declines after 1995 at the Kingston WTP and after 1988 at the Brockville WTP.

Merriman (1997) reported that at the Wolfe Island sampling station pH levels have remained quite steady with annual geometric means ranging from 7.76 to 8.11. Turbidity, total alkalinity, sulphate, potassium, dissolved inorganic carbon and dissolved organic carbon (“DOC”) also showed no discernible trends. Total Kjeldahl nitrogen (“TKN”), a measure of ammonia and organic nitrogen, has remained fairly constant.

The overall trend line for nitrate is that of increasing concentrations over the period of record (Merriman, 1997). Silica concentrations remained relatively constant in the early 1990s but in recent years have started to show an increasing trend.

Johannsson *et al*. (1998) reported that decreases in phosphorus loadings to Lake Ontario between 1981 and 1995 were associated with declines in total phosphorus concentration, algal standing crop and zooplankton productivity in the eastern Kingston Basin. There were concurrent decreases in particulate organic carbon, particulate organic nitrogen and chlorophyll *a*, whereas water clarity and soluble reactive silica increased, likely due to dreissenid filtering activity.

Annual median and 90th percentile concentrations of trace metals at the Wolfe Island monitoring station for the period generally between 1977 and 1996 were below the GLWQA water quality objectives and PWQOs (**Table 4.9, Appendix B**). However, some historical exceedances were recorded for cadmium, copper and iron prior to 1986.

Table 4.10 (Appendix B) presents water quality data for the Wolfe Island monitoring station for the period April 2000 to March 2001. The mean and maximum concentrations of all conventional parameters, metals and organic compounds were below their respective PWQOs (MOEE, 1994a) and federal water quality guidelines for aquatic life protection (CCME, 1999, 2005), with the exception of the maximum concentration (180 µg/L) of aluminum. The interim PWQO for aluminum is 75 µg/L at pH >6.5 to 9.0 based on total aluminum measured in clay-free samples. However, analysis of aluminum is based on unfiltered samples (Environment Canada, 1994). The federal water quality guideline of 100 µg/L is based on waters with pH ≥6.5, calcium ≥4 mg/L and DOC ≥2 mg/L. Increasing concentrations of calcium, DOC and possibly other complexing ligands reduce the availability of aluminum to fish (Freeman and Everhart, 1971). At the Wolfe Island monitoring station, the mean calcium concentration was 33.6 mg/L with minimum and maximum concentrations of 32.1 and 35.3 mg/L, respectively, whereas the mean DOC concentration was 2.9 mg/L with minimum and maximum concentrations of 2.1 mg/L and 11.4 mg/L, respectively. As indicated by the Canadian Council of Resource and Environment Ministers ([“CCREM”], 1987), the presence of calcium, DOC and possibly other complexing ligands may reduce the toxicity of aluminum, but the guideline does not presently take these relationships into account.

Based on the Environment Canada water quality data, the Upper St. Lawrence River, including the proposed cable crossing area, can be considered as having good water quality.

In-situ water quality data (water temperature, D.O., pH and conductivity) for the initial transmission line route are presented in **Table 4.7 (Appendix B)**. As indicated in **Section 4.8**, thermal stratification was evident at the deepest sampling location (T2) resulting in marked D.O. depletion in deeper hypolimnion waters below the PWQOs of 5 mg/L D.O. and 47% saturation at 15°C for the protection of warmwater biota.

Ambient water quality data provide a baseline for assessment of blasting effects (**Section 5.1.7**), potential turbidity generation (**Sections 5.1.9** and **5.1.11.2**) and chemical releases from sediments (**Sections 5.1.10** and **5.1.11.3**).

4.11 SEDIMENT QUALITY

Guidelines have been established to facilitate the assessment of sediment quality, e.g., Provincial Sediment Quality Guidelines ("PSQG"s) (Persaud *et al*., 1992) and federal sediment quality guidelines (CCME, 1999, 2002).

The PSQGs are based on two benchmarks: the "lowest effect level" ("LEL") and the "severe effect level" ("SEL"). As indicated by Persaud *et al*. (1992), the PSQG LEL is defined as the concentration at which actual ecotoxic effects to the benthic community become apparent. It is derived using field-based data on the co-occurrence of sediment concentrations and benthic species. The LEL is calculated for the benthic community as the estimated sediment concentration at which 10% of benthic species would be affected. This is a conservative value in that it reflects a potential adverse effect on the most sensitive benthic species assuming that they are naturally present.

The PSQG SEL represents contaminant levels that could potentially eliminate most benthic organisms. It is also derived using field-based data on the co-occurrence of sediment concentrations and benthic species. The SEL is calculated for the benthic community as the estimated concentration at which 90% of benthic species would be affected.

The federal sediment quality guidelines, also used for sediment quality assessment, are based on a similar approach, and involve two assessment values (CCME, 1999). The lower value, referred to as the "threshold effect level" ("TEL"), represents the concentration below which adverse biological effects rarely occur, i.e., fewer than 25% adverse effects occur below the TEL. The upper values referred to as the "probable effect level" ("PEL"), defines the level above which adverse effects are expected to occur frequently, i.e., more than 50% adverse effects occur above the PEL. The definition of the TEL is consistent with the definition of a sediment quality guideline (CCME, 1999). The federal sediment quality guidelines are considered to be interim sediment quality guidelines ("ISQG"s), as they are based on co-occurrence data only, since insufficient spiked-sediment toxicity test data are available at this time. The PEL is recommended as an additional sediment quality assessment tool that can be useful in identifying sediments in which adverse biological effects are more likely to occur.

The ISQG (TEL) can be considered to be equivalent to the LEL, whereas the PEL is intermediate between the ISQG/LEL and the SEL.

Local Study Area

Few sediment quality data are available for the local study area. Johnston (1978) provides trace metal data for a sediment core (N1) collected in 1973 in the St. Lawrence River between Kingston Harbour and Garden Island. The sediment core sample was composed of recent mud throughout. The data were presented graphically (no quantitative data are available). **Figure 4.12 (Appendix A)** illustrates the surface enrichment of cadmium, copper, lead, mercury, nickel and zinc, reflecting increasing anthropogenic loadings prior to 1973. The concentrations of these metals in the upper layer of the sediment core exceed the LEL and ISQG. The lead, mercury and zinc concentrations also exceed the PEL but not the SEL. The surficial nickel concentrations slightly exceed the SEL. In contrast, there is no surface enrichment of cobalt. The enrichment of manganese in surficial sediments due to diagenetic processes is a common phenomenon in aquatic ecosystems. These processes involve the post-depositional migration of manganese in the sediment porewater and subsequent oxidation as hydrous manganese oxides (Lynn and Bonatti, 1965; Tessenow and Baynes, 1978; Sakata, 1985).

Surficial sediment samples were also collected in 1975 by Johnston (1978) from the Lower Gap and St. Lawrence River in the Kingston area (**Figure 4.13, Appendix A**) and analyzed for TOC, cadmium and mercury **(Table 4.11, Appendix B)**. The TOC, cadmium and mercury concentrations in most samples were above the PSQG LEL and/or ISQG, whereas the mercury concentrations in eight of the 14 samples were above the PEL.

Kuntz (1988) provides sediment quality data for two sampling locations in Cataraqui Bay, one location off Carruthers Point and three locations off Abraham Head (**Figure 4.13, Appendix A**). The bulk chemical composition data for the samples collected in 1975 were presented as bar charts (no quantitative data are available) (**Figure 4.14, Appendix A**). The concentrations of oil and grease, PCBs and mercury in all six samples were below the PWQG LEL and/or ISQG. Exceedances of the sediment quality guidelines are summarized below:

- total phosphorus and nickel concentrations in all six samples exceeded the PSQG LEL, but not the SEL (there are no federal guidelines for total phosphorus and nickel);
- manganese concentrations in two of the six samples exceeded the PSQG LEL, but not the SEL (there are no federal guidelines for manganese);
- cyanide concentrations in all six samples exceeded the PSQG LEL (there is no SEL or federal guidelines for cyanide);
- lead concentrations in all six samples exceeded the PSQG LEL and ISQG, with the concentration in one sample exceeding the PEL but not the SEL;
- chromium concentrations in six and five samples exceeded the PSQG LEL and ISQG, respectively, with the concentrations in one sample exceeding the PEL but not the SEL;
- iron concentrations in five of the six samples exceeded the PSQG LEL, but not the SEL (there are no federal guidelines for iron);
- copper concentrations in six and two samples exceeded the PSQG LEL and ISQG, respectively, with the concentration in one sample exceeding the SEL but not the PEL; and
- zinc and arsenic concentrations in one of the six samples exceeded the PSQG and ISQG but not the PEL.

One surficial sediment sample was collected in 1981 off Carruthers Point for the analysis of organic contaminants (Merriman, 1987). **Table 4.12 (Appendix B)** presents the sediment quality data for this Station 192. The TOC and mirex concentrations were above the PSQG LEL but below the SEL, whereas the concentrations of p,p-DDD, p,p-DDE and total PCBs were above the federal PEL, but below the PSQG SEL. The p,p-DDD and p,p-DDE concentrations in suspended sediments sampled at this location were also above the federal PEL but below the PSQG SEL, whereas the total PCB concentration was above the PSQG LEL and ISQG but below the PEL.

In addition to the Kuntz (1988) and Merriman (1987) data, additional sediment quality data are available for locations near the local study area as well as within Cataraqui Bay.

Merriman (1987) reported that most organochlorine pesticide residues and chlorobenzenes were not detected in a surficial sediment sample collected off Hornes Point, Wolfe Island (Station 189) in the Main Navigation Channel **(Table 4.12, Appendix B)**. The only organic contaminants detected were 1,3-dichlorobenzene (0.005 µg/g), 1,2-dichlorobenzene (0.002 µg/g), hexachlorobenzene (0.001 µg/g), p,p-DDE (0.003 µg/g) and total PCBs (0.010 µg/g). The p,p-DDE concentration was above the ISQG but below the PSQG LEL. The concentrations of a-chlordane, p,p-DDE, p,p-DDT, dieldrin, endrin and total PCBs in suspended sediments sampled at this location were above the PSQG LEL and/or ISQG. The concentrations of pp-DDE, p,p-DDT and dieldrin were also above the PEL but not the PSQG SEL.

Table 4.13 (Appendix B) presents surficial sediment quality data for sampling locations at the Lake Ontario outlet and in the easternmost Kingston Basin. For the sediment sample collected in 1968 at Station N33 located between Amherst Island and Simcoe Island, the iron and nickel concentrations were slightly above the PSQG LEL, whereas the p,p-DDE and p,p-DDT concentrations were above the ISQG but below the PSQG LEL. For both samples collected in 1998 in the easternmost Kingston Basin (Stations 1067 and 1068), the concentrations of TKN, total phosphorus, arsenic, manganese, mercury and nickel exceeded the PSQG LEL and ISQG. The concentrations of chromium, lead, zinc, p,p-DDD, p,p,-DDT and total PCBs in the sample from Station 1068 also exceeded the PSQG LEL and/or the ISQG. The p,p-DDE and p,p-DDT concentrations at Stations 1068 and 1067, respectively, exceeded the PEL but not the PSQG SEL.

Table 4.14 (Appendix B) presents surficial sediment quality data for four samples collected along a transect across the Main Navigation Channel from a location about 2 km west of the eastern end of Wolfe Island (Beauvais Point) to New York State about 1.6 km east of Cedar Point State Park. The mercury and endrin concentrations in the Canadian nearshore sample exceeded the PSQG LEL and ISQG. The concentrations of TKN, total phosphorus, cadmium and nickel in the U.S. nearshore sample exceeded the PSQG LEL and ISQG, whereas the dieldrin concentration exceeded the PEL. The concentrations of total phosphorus, oil and grease, chromium, copper, iron, lead, nickel and zinc in the two offshore samples exceeded the PSQG LEL and/or ISQG, whereas the chlordane concentrations exceeded the PEL. The arsenic, cadmium and mercury in the Canadian offshore sample also exceeded the PSQG and ISQG, whereas the lindane concentration exceeded the PEL and the TKN concentration exceeded the PSQG SEL. The manganese concentration in the U.S. offshore sample exceeded the PSQG LEL, whereas the mercury concentration exceeded the PEL.

Table 4.15 (Appendix B) presents trace metal concentrations with sediment depth at a sediment core sampling location at the Lake Ontario outlet to the St. Lawrence River approximately 7.5 km upstream of the proposed cable crossing. The core sample was collected in 1994 at a water depth of 23 m. Based on sediment dating, the sediment layers at the 15-cm and 30 cm depths were deposited approximately in 1970 and 1934, respectively. The data indicate that greatest metal contamination of the sediments occurred during the 1970s, with lower metal concentrations in the upper sediment core section reflecting reduced anthropogenic loadings. Background metal concentrations are apparent at approximately the 35 cm depth.

In anticipation of possible routine maintenance dredging by the MTO adjacent to the winter ferry dock, three surficial sediment samples were collected for chemical analysis. Core sediment samples could not be collected due to the hard substrate and presence of zebra mussel shells. **Table 4.16** (**Appendix B**) presents surficial sediment quality data in the vicinity of the winter ferry dock. The concentrations of semi-volatile and PAH compounds in all samples were below the analytical detection limits (with some PAH detection limits above the sediment quality guidelines). Exceedances of the sediment quality guidelines are summarized below:

- TOC and TKN concentrations in all three samples exceeded the PSQG LEL (there are no federal guidelines for TOC and TKN);
- total phosphorus concentrations in all samples exceeded the PSQG LEL, but not the SEL (there are no federal guidelines for total phosphorus);
- the chromium concentration in one sample exceeded the PSQG LEL but not the ISQG;
- copper concentrations in all samples exceeded the PSQG LEL but not the ISQG;
- the iron concentration in one sample exceeded the PSQG LEL (there are no federal guidelines for iron); and
- nickel concentrations in all samples exceeded the PSQG LEL (there are no federal guidelines for nickel).

Initial Cable Crossing Route

Table 4.17 (Appendix B) presents surficial sediment quality data for four locations sampled in 2006 along the initial transmission line route. The concentrations of semi-volatile and PAH compounds in all samples were below the analytical detection limits (however, some PAH detection limits were above the sediment quality guidelines). In general, high contaminant concentrations occurred in the finer sediments sampled from the deeper sampling locations (i.e., T2 and T3) with higher sorption capacities. Exceedances of the sediment quality guidelines are summarized below:

- TOC and TKN concentrations in three of four samples exceeded the PSQG LEL, with the TKN concentration in one sample also exceeding the SEL (there are no federal guidelines for TOC and TKN);

- total phosphorus concentrations in all samples exceeded the PSQG LEL, but not the SEL (there are no federal guidelines for total phosphorus);
- cyanide and silver concentrations in two of four samples exceeded the PSQG LEL (there are no SELs or federal guidelines for cyanide and silver);
- arsenic and mercury concentrations in two of four samples exceeded the PSQG LEL and ISQG, but not the PEL or SEL;
- concentrations of cadmium and total PCBs in two of four samples exceeded the PSQG LEL and ISQG with the concentrations in one sample also exceeding the PEL but not the SEL;
- chromium concentrations in two of four samples exceeded the PSQG LEL and/or ISQG, with the concentration in one sample also slightly exceeding the PEL but not the SEL;
- copper concentrations in two of four samples exceeded the PSQG LEL and/or ISQG with the concentration in one sample also exceeding the SEL but not the PEL;
- iron concentrations in two of four samples exceeded the PSQG LEL, with the concentration in one sample also above the SEL (there are no federal guidelines for iron);
- lead and zinc concentrations in two of four samples exceeded the PSQG LEL and ISQG with the concentrations in one sample also above the PEL but not the SEL;
- the manganese concentration in one of four samples exceeded the PSQG LEL but not the SEL (there are no federal guidelines for manganese);
- nickel concentrations in two of four samples exceeded the PSQG LEL with the concentration in one sample also above the SEL (there are no federal guidelines for nickel); and
- p,p-DDD and p,p-DDE concentrations in two of four samples exceeded the PSQG LEL, ISQG and PEL, but not the SEL.

Similar sediment quality can be expected along the proposed transmission line crossing route.

Sand Bay

Sediment quality data for two locations along the proposed cable route in Sand Bay are provided in **Table 4.17** (**Appendix B**). The concentrations of all parameters were below their respective sediment quality guidelines, with the exception of total phosphorus at sampling location SB2 which exceeded the PSQG LEL but not the SEL. The concentrations of all organic parameters in both samples were below the analytical detection limits. However, the detection limits of some of the PAH compounds were above sediment quality guidelines. Overall, sediment quality is good due to the low sorption capacity of the sandy substrate.

Sediment quality data provide the basis for assessment of potential chemical releases from sediments (**Sections 5.1.10** and **5.1.11.3**).

4.12 PLANKTON

The St. Lawrence River drains Lake Ontario and consequently the plankton composition reflects this hydrologic relationship. For example, phytoplankton composition in the Upper St. Lawrence River at Brockville, Ontario is a mixture of Lake Ontario nearshore and open water species, with the diatoms *Stephanodiscus tenuis*, *S. binderanus*, *Asterionella formosa* and *Melosira islandica* very common (Nicholls, 1981).

Along a 160 km study reach of the St. Lawrence River from Cape Vincent near the Lake Ontario outlet to Waddington, New York, Mills and Forney (1977) demonstrated that the primary and secondary production rates were extremely low in the Upper St. Lawrence River, rather similar to an oligotrophic lake on the Precambrian Shield. Mills and Forney (1982) reported that plankton communities varied seasonally and standing crops declined downriver, indicating the importance of imports to the river from Lake Ontario. Diatoms and cryptophytes dominated the algal flora, while cyclopoid copepods prevailed in the zooplankton community. Seasonally, algal biomass pulsed in spring declining through the summer while crustacean zooplankton biomass exhibited low spring concentrations rising to a peak standing crop in late July to early August.

Phytoplankton

Based on a lake-wide survey, Barbiero and Tuchman (2001) reported that diatoms (Bacillariophyta) were the most predominant phytoplankton phylum contributing to biomass, followed by cryptomonads (Cryptophyta). The spring diatom community is overwhelmingly dominated by *Aulocoseira islandica* and *Stephanodiscus alpinus*, whereas *Rhodomonas* spp. are the most common cryptomonad (**Table 4.18, Appendix B**). In the summer, diatoms contributed significantly less to the phytoplankton community biomass, with increases in green algae (Chlorophyta) and dinoflagellates (Pyrrhophyta). The most predominant green algae taxa were *Staurastrum*, *Oocystis*, *Tetraedron* and *Scenedesmus*, whereas *Ceratium* dominated the dinoflagellates. The contribution of cryptomonads to phytoplankton biomass in the summer was similar to that in the spring. In both spring and summer, the contributions of yellow-green algae (Chrysophyta) and blue-green algae (Cyanophyta) to biomass were relatively low.

A total of 103 phytoplankton species were identified in the Upper St. Lawrence River during the study undertaken by Mills and Forney (1977) in the summer of 1976, the first of a three-year study. The number of species found at the three survey sites were 88 species in Lake St. Lawrence (about 130 km downstream of the proposed cable crossing), 83 species in Chippewa Bay (about 70 km downstream), and 78 species in the Main Navigation Channel near Cape Vincent. In general, green algae and diatoms dominated the species list for the river, accounting for 73 out of the total 103 species identified.

Phytoplankton biomass was highest (46.5 g/m^2) at Cape Vincent, with lower values at Chippewa Bay (17.2 g/m^2) and Lake St. Lawrence (12.9 g/m^2), suggesting that a substantial input of phytoplankton biomass enters the Upper St. Lawrence River via Lake Ontario with a gradual decline downriver (Mills and Forney, 1977). Secchi disc transparency in Lake St. Lawrence was only 2.0 m in shallow water compared with 3.0 m at Chippewa Bay and 3.4 m at Cape Vincent. This lower water clarity due to higher turbidity (i.e., caused by suspended silt) and floating debris was likely a limiting factor on phytoplankton productivity.

Based on the complete three-year study, Mills and Forney (1982) reported that the highest number of individual species were green algae with *Ankistrodesmus falcatus* and *Scenedesmus bijuga* dominant (**Table 4.19, Appendix B**). Diatoms were the second most diverse group with *Asterionella formosa*, *Cocconeis placentula*, *Cyclotella* spp., *Fragilaria crotonensis*, *Melosira granulata*, *Stephanodiscus tenuis* and *Tabellaria fenestrata* among the more common species. Cryptomonads and yellow-green algae were present throughout the study period. Overall, the cryptomonads were most abundant and were dominated by *Cryptomonas pusilla* and *C. ovata*. Yellow-green algae were less common and were represented by *Chromulina minuta* and *Ochromonas* spp. Blue-green algae were also common during the late summer, and included *Anabaena flos-aquae*, *Aphanizomenon flos-aquae* and *Microcystis aeruginosa*. The common occurrence of blue-green algae in the St. Lawrence River in the 1970s compared to their low contribution to Lake Ontario phytoplankton community in 1998 (Barbiero and Tuchman, 2001) likely reflects the higher phosphorus concentrations in the river during the early stages of phosphorus loadings reduction initiated in the early 1980s (**Section 4.2**).

Seasonally, as in the case of Lake Ontario, diatoms persisted after ice-out and dominated the spring flora. The number of algal taxa increased through mid-summer with green algae predominant, whereas diatoms, yellow-green algae and blue-green algae were of secondary importance.

Mills *et al*. (1981) reported that algal biomass in the Upper St. Lawrence River was low in the winter with diatoms and cryptomonads the most prominent forms. Common diatoms included *Asterionella formosa*, *Cyclotella* sp., *Stephanodiscus tenuis*, *Synedra ulna* and *Melosira varians*. Common cryptomonads were *Cryptomonus*, *Chromulina*, *Euglena*, *Cladomonas* and *Ochromonas*. Typical green algae were *Ankistrodesmus falcatus*, *A. spiralis*, *Scenedesmus bijuga* and *Closteriopsis longissima*. Blue-green algae were rare, except for *Lyngbya limnetica*. Phytoplankton biomass again declined downriver providing evidence that most was imported from Lake Ontario.

During the 31 May 2006 site visit, algal mats were observed in shallow waters along the nearshore at the Pleasant Point (Kingston mainland) landfall location. During the July 2006 field survey, large floating algal blooms were observed at Carruthers Point at water depths of about 1.5 m from the small protuberance on Carruthers Point to the Little Cataraqui Bay breakwater, as well as north of the breakwater in Little Cataraqui Bay.

Zooplankton

Based on a lake-wide survey in 1998, Barbeiro *et al*. (2001) reported that the Lake Ontario zooplankton community in the spring was dominated by the cyclopoid copepod *Diacyclops thomasi* and immature cyclopoids (**Table 4.20, Appendix B**). Total crustacean densities during the summer were substantially higher than in the spring, especially in the western stations in Lake Ontario where densities were about 20 times greater than in the spring. The most significant change in the summer crustacean community was an increase in the importance of cladocerans, largely *Daphnia retrocurva* and *Bosmina longirostris*. However, *D. thomasi* and immature cyclopoids continued to be present in high numbers. *B. longirostris* dominated in the western basin of Lake Ontario, whereas *D. retrocurva* dominated the eastern basin. The recent (1998) predatory cladoceran exotic *Cercopagis pengoi* was restricted to the eastern basin of the lake.

A total of 21 species of zooplankton were identified in the Upper St. Lawrence River during the study undertaken by Mills and Forney (1977) in the summer of 1976. There were 19, 18 and 17 species in the Cape Vincent area, Chippewa Bay and Lake St. Lawrence, respectively. *Cyclops bicuspidatus* and *Diaptomus minutus* were the most abundant cyclopoid and calanoid copepods, respectively, while the cladocerans were dominated by *Bosmina longirostris*.

Total zooplankton biomass was highest (4.18 g/m^2) at Cape Vincent, intermediate (1.93 g/m^2) in Chippewa Bay and very low (0.32 g/m^2) in Lake St. Lawrence. This trend, similar for phytoplankton biomass, indicates a sizeable zooplankton standing crop entering the Upper St. Lawrence River from Lake Ontario, which then undergoes a progressive decline downstream.

Over the three-year study period (spring through summer 1976-78), Mills and Forney (1982) identified 30 zooplankton forms, including nauplii (**Table 4.21, Appendix B**). Annual changes in the zooplankton community were subtle and the total species composition was nearly identical each year. Rotifers which dominated the zooplankton community only in early June, were the most diverse taxonomic group followed by cladocerans. The rotifers *Asplancha priodonta*, *Conochilus unicornus*, *Kellicottia longispina*, *Keratella quadrata*, *Natalea acuminata* and *Polyarthra vulgaris* were common in samples each year. *Bosmina longirostris*, *Ceriodaphnia quadrangulata* and *Daphnia galeata mendotae* were common cladoceran species, whereas *Diaptomus minutus* and *Cyclops bicuspidatus* were common calanoid and cyclopoid copepods, respectively.

Mills *et al*. (1981) reported that zooplankton biomass in the St. Lawrence River in winter was about one-tenth of the algal standing crop with the cyclopoid copepod *Cyclops bicuspidatus* predominating. The calanoid copepod *Diaptomus minutus* and the cladoceran *Bosmina longirostris* were common. Few rotifers were observed. Zooplankton biomass declined downriver again providing evidence that most were imported from Lake Ontario.

Plankton may be affected by potential turbidity generation (**Sections 5.1.9** and **5.1.11.2**) and chemical release from sediments (**Sections 5.1.10** and **5.1.11.3**).

4.13 AQUATIC MACROPHYTES

Owen and Veal (1968) reported that, as a general rule, abundance and areal extent of aquatic vegetation growths in the Canadian side of the Upper St. Lawrence River were determined primarily by physical factors, particularly water depth and substrate type. Similarly, Geis *et al*. (1977) stated that turbidity, substrate character and wave action were important factors limiting macrophyte distribution and productivity on the U.S. side of the river.

Mills and Forney (1977) determined that net macrophyte production estimates based on maximum standing crops were low for the Upper St. Lawrence River compared to other river systems. Biomass estimates ranged from a high of 482.6 g/m^2 to no measurable production.

Wetlands and associated shallow littoral areas in the Upper St. Lawrence River are noted for the presence of significant amounts of submerged aquatic vegetation (Patch and Busch, 1984). The “typical” St. Lawrence River wetland displays a vegetation zonation from open water marsh containing submergent aquatic vegetation to floating-leaved aquatics to a shoreline border of emergent vegetation (Bottomley, 1987). Typical submergent species are water milfoil (*Myriophyllum* spp.), pondweed (*Potamogeton* spp.), coontail (*Ceratophyllum demersum*), stonewort, star duckweed (*Lemna trisulca*), common waterweed (*Elodea canadensis*), wild celery (*Vallisneria americana*), and mud plantain (*Heteranthera budia*). Typical floating-leaved species are white water lily (*Nymphaea odorata*), yellow water lily (*Nuphar variegatum*) and lesser duckweed (*Lemna minor*). These floating-leaved plants are usually found in protected embayments or creek mouths growing at the edge of the cattail mat. Frequently, there are patches of softstem bulrush (*Scirpus validus*) forming diffuse offshore stands. Cattails (*Typha* spp.) by far dominate the emergent vegetation, although bur reed (*Sparganium eurycarpum*), arrowhead (*Sagittaria* sp.) and reed canary grass (*Phalaris arundinacea*) are frequent. Areas of thicket swamp are frequently composed of alder (*Alnus rugosa*), willow (*Salix* sp.) and dogwood (*Cornus* sp.), while wooded swamp areas are typically ash (*Fraxinus nigra*) and soft maple (*Acer* spp.).

Local Study Area

Bottomley (1987) undertook a comprehensive survey of submerged aquatic vegetation in seven bays of Wolfe Island: Barrett, Bayfield, Brown, Button, Holiday, Irvine and McGregor. Wild celery and water milfoil were the most frequently encountered submerged aquatic plants, being present in 58% and 51%, respectively, of the 171 sites sampled (**Table 4.22, Appendix B**). Other relatively abundant species were stonewort (33%), star duckweed (32%), Canada waterweed (31%), coontail (26%) and mud plantain (20%). Many of the species listed in **Table 4.22 (Appendix B)** provide valuable forage for waterfowl during spring and fall migration stopover **Section 4.16**. In general, the submerged aquatic vegetation assemblages were diverse in composition and dense, with plant cover ranging from 50 to 100%. The overall mean standing crop biomass of submerged aquatic vegetation for Irvine Bay was 190 g/m^2, comparable to the mean value of 148 g/m^2 for the Upper St. Lawrence River cited by Mills and Forney (1977).

As indicated in **Section 4.18**, there are three provincially significant wetlands ("PSW"s) in the local study area: Little Cataraqui Creek Wetland, Barrett Bay Wetland and Brown's Bay Wetland. **Table 4.23 (Appendix B)** lists the aquatic macrophytes documented as being present in these wetlands. There are many more species documented for the Little Cataraqui Creek Wetland due to a comprehensive plant survey undertaken by the Kingston Field Naturalists ("KFN") (Bonta *et al*., 2004). It is anticipated that many of these species are present in the other two wetlands.

Cable Crossing Nearshores

Aquatic vegetation is generally sparse in the nearshore along the 2 km long reach of the northern shoreline of Wolfe Island west of Mill Point encompassing the proposed cable crossing landfall (Acres, 2005b). However, two areas of submerged vegetation with species including coontail and stonewort are present at the eastern and western edges of this reach. Plant density in these areas is relatively low.

As indicated in **Section 4.5**, one small wetland area is located on the western shore of Sand Bay, being composed of approximately 70 m^2 patch of cattails and a smaller area of softstem bulrush and other rushes (*Juncus* sp.) (Acres, 2005). Algae and sporadic submergent aquatic macrophytes are the only aquatic vegetation found within Sand Bay and the adjacent shorelines.

Table 4.24 (Appendix B) lists the aquatic macrophytes recorded at the initial transmission line landfalls and Mill Point embayment. Common submergent species at the Kingston mainland landfall (Carruthers Point) were stonewort, water milfoil, Richardson's pondweed (*Potamogeton Richardsonii*), sago pondweed (*P. pectinatus*), wild celery and common waterweed.

Common aquatic macrophytes present near the Wolfe Island landfall and Mill Point were stonewort, small pondweed (*Potamogeton pusillus*), Richardson's pondweed, wild celery and water milfoil. Coontail, curly pondweed (*P. crispus*) and sago pondweed were also common near Mill Point.

Undisturbed areas of native vegetation have the potential to support plant species which are of concern, i.e., species which are designated with special status under federal and/or provincial legislation. Federally, species at risk are recognized by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2007) and are protected under the *Species At Risk Act*, whereas provincially they are recognized by the Committee on the Status of Species at Risk in Ontario (COSSARO) under the Ontario *Endangered Species Act* and the Species at Risk in Ontario List (OMNR, 2006a). Species listed as endangered or threatened and their habitat are afforded protection under the *Endangered Species Act*. No protection is currently afforded to provincially designated species of special concern.

None of the species recorded in the cable crossing nearshore area, or PSWs in the local study area, as listed in **Tables 4.23** and **4.24 (Appendix B)** are considered to be at risk federally or provincially. However, crested sedge (*Carex cristatella*) and pale sedge (*C. pallescens*) documented in the Little Cataraqui Creek Wetland are considered to be locally rare (Crowder *et al*., 1997).

Aquatic macrophytes may be affected by potential turbidity and siltation (**Sections 5.1.9** and **5.1.11.2**), as well as be directly affected by nearshore trenching (**Section 5.1.8**).

4.14 BENTHIC MACROINVERTEBRATES

The density and composition of the benthic macroinvertebrate fauna have been the most widely used indicators of water quality. This is because benthic macroinvertebrates from relatively sedentary communities in the sediments, thereby reflecting the character of both the water and the sediment. Alteration of benthic community structure is used to assess the trophic or general pollutional status of a water body. This assessment is usually based on interpretation of indicator species, changes in relative numbers of individuals and species, and/or the derivation of a species diversity or community comparison index.

In utilizing the species indicator approach, the occurrence and abundance of certain benthic macroinvertebrate species is related to the sensitivity of that species to nutrient enrichment or organic pollution. For example, the disappearance of sensitive species from benthic groups such as Ephemeroptera (mayflies), Trichoptera (caddisflies), Plecoptera (stoneflies) and Amphipoda (e.g., *Gammarus* spp.) occurs with increased organic pollution and resultant low D.O. concentrations. Concurrently, species tolerant of organic enrichment, especially species of tubificid oligochaetes (sludge worms), such as *Limnodrilus hoffmeisteri*, *L. cervix*, *Quistadrilus multisetosus* and *Tubifex tubifex*, generally increase in abundance until, under conditions of advanced pollution or eutrophication, they form the total benthic community (Cook and Johnson, 1974). In eutrophic rather than organically polluted situations, *L. hoffmeisteri* is still a major component of the worm population; however, species diversity increases with the occurrence of *Aulodrilus* and *Potamothrix* species. Moreover, *T. tubifex* is usually not an important component of the worm fauna in eutrophic conditions. Therefore, relatively high values of a species diversity index, reflecting moderate population numbers of a large number of species in the community, indicate good water quality, whereas relatively low values, reflecting high population numbers of only a few species in the community, indicate heavy organic pollution. Toxic conditions are characterized by the occurrence of small numbers of a few pollution-tolerant species.

Benthic macroinvertebrate surveys in Lake Ontario generally do not extend beyond the Kingston Basin and/or Bay of Quinte (e.g., Brinkhurst *et al*., 1968; Hiltunen, 1969; Kinney, 1972; Nalepa and Thomas, 1976; Barton and Hynes, 1978a; Nalepa, 1991; Lozano *et al*., 2001).

Some data were available on benthic macroinvertebrate communities in the Upper St. Lawrence River. For example, the New York State Department of Health undertook a preliminary survey (using artificial substrates for sample collection) of the macroinvertebrate populations of the Upper St. Lawrence River in 1977 (Fitchko, 1990b). In general, the species composition of the macroinvertebrate communities was quite uniform throughout the river. At a sample station near Cape Vincent, the naidid oligochaete worm *Nias communis* was by far the most abundant species, followed by the amphipod *Gammarus fasciatus* and the chironomids (midge fly larvae) *Cricotopus sylvestris* gr., *C. bicinctus* and *Paratanytarsus* nr. *boiemica*.

Based on a 1976 summer survey (using an Ekman grab for sample collection) at Cape Vincent, Mills and Forney (1977) reported that mean biomass of benthic organisms was relatively high. Amphipods, tubificid oligochaetes (which would not be collected by artificial substrate) and chironomids were important components of the river bottom fauna. The freshwater Mollusca (snails and clams) were not collected in this study, but were found to be abundant in some grab samples.

Bottomley (1987) reported a diverse assemblage of benthic macroinvertebrate species was present in the major bays of Wolfe Island frequented by migrant diving ducks. The major taxa, based on abundance, were chironomids, gastropods and amphipods (**Table 4.25, Appendix B**). Gastropods dominated the benthic organism biomass with pelecypods, amphipods and isopods comprising smaller fractions. Langley *et al*. (1980) reported a similar benthic community structure near Rush Bay on the south side of Howe Island. Furthermore, benthic macroinvertebrate species diversity values for this location had changed little over the five survey years (1965, 1966, 1967, 1972, 1979). The major macroinvertebrate groups found at Wolfe Island are all documented as being common food items for waterfowl, and provide valuable forage during spring and fall migration stopover (**Section 4.16)**.

Benthic macroinvertebrate community composition data are available along a transect across the Main Navigation Channel from a location about 2 km west of the eastern end of Wolfe Island (Beauvais Point) to New York State about 1.6 km east of Cedar Point State Park (Fitchko, 1990a). The benthic data for the two nearshore and two offshore stations are presented in **Table 4.26 (Appendix B)**.

The taxonomic data for both the nearshore and mid-channel samples suggest the occurrence of diverse benthic macroinvertebrate communities indicative of good environmental quality. Diversity index values ranged from 3.77 to 3.94. The number of taxa was slightly higher in the nearshore zones (43 and 44) than in the mid-channel locations (32 and 33), reflecting the more diverse habitat in the shallower waters, i.e., presence of aquatic vegetation and wider range of sediment particle sizes. Densities of organisms were similar at the offshore locations (average of 4,000/m^2), slightly higher at the U.S. nearshore location (6,100/m^2) and considerably higher at the Canadian nearshore location (about 23,100/m^2). The higher densities at the Canadian nearshore again reflect a more diverse habitat.

The species assemblage at all four sampling locations was suggestive of generally mesotrophic conditions, with the dominant species consisting of tubificid oligochaetes (*Spriosperma ferox* and *Limnodrilus hoffmeisteri*), clams (*Pisidium* and *Sphaerium*), the snail (*Amnicola limosa*), the amphipod (*Gammarus*) and chironomids (*Procladius*, *Chironomus* and *Microtendipes*). No one species was particularly dominant, as indicated by the high diversity index values.

Local Study Area

Based on a 1967 survey, Owen and Veal (1968) collected nine taxa at a sampling location approximately 350 m offshore of Carruthers Point: the midges *Cryptochironomus* (39/m^2), *Tendipes* (likely *Chironomus*) (463/m^2), *Calopsectra* (72/m^2) and *Procladius* (598/m^2); the dipteran *Heleinae* (likely a ceratopogonid) (19/m^2); the oligochaete *Tubifex* (154/m^2); the amphipod *Gammarus* (77/m^2);

the isopod *Asellus* (19/m^2); and the clam *Sphaerium* (19/m^2). Total abundance was 1,447/m^2. Nine taxa were also collected at a station approximately 1 km offshore: the midges *Microtendipes* (20/m^2), *Tendipes* (39/m^2), *Calopsectra* (158/m^2) and *Procladius* (39/m^2); the oligochaete *Quistadrilus multisetosus* (827/m^2); the amphipod *Gammarus* (158/m^2); the isopod *Asellus* (20/m^2); the snail *Bithynia tentaculata* (39/m^2); and the clam *Sphaerium* (453/m^2). Total abundance was 1,753/m^2.

Since its introduction to the St. Clair River-Lake St. Clair-Detroit River system in the late 1980s, the zebra mussel has rapidly dispersed in the Great Lakes, invading the western basin and southern shore of Lake Ontario by 1990 (Griffiths *et al*., 1991). The zebra mussel, as well as the more recent exotic quagga mussel (*Dreissena bugensis*) (Mills *et al*., 1993), were probably introduced as a result of the discharge of ballast water from an ocean-crossing vessel.

A significant shift in the benthic macroinvertebrate community composition has occurred recently in Lake Ontario since the dreissenid invasion. For example, the burrowing amphipod *Monoporeia affinis* (formerly *Diporeia* (*Pontoporeia) hoyi*), which was considered an important food item for some fish species, has disappeared from eastern Lake Ontario (Dermott, 2001). This disappearance was attributed to interspecific competition with dreissenids.

At the winter ferry dock nearshore, tubificid oligochaetes and chironomids comprised 48.8% and 39.3%, respectively, of total benthic macroinvertebrate abundance, i.e., 4,275.m^2 (**Table 4.27, Appendix B**). There were few dreissenids. The total number of taxa was 14, with a diversity value of 1.82, suggestive of mesotrophic conditions.

Initial Cable Crossing Route

As indicated by Acres (2005), dreissenids are prevalent in the landfall nearshores. At the proposed landfall location on Wolfe Island, the shallow low-gradient nearshore zones, located within 10 m of the shoreline, occur within the wave zone and therefore remain relatively free of zebra mussel and periphyton. In the zone between approximately 10 to 150 m offshore, boulders and rocks are covered with algae, periphyton and zebra mussels. The scattered slab boulders at navigational buoy KE1 are densely encrusted with algae, whereas zebra mussels are present on most rock surfaces at KE2.

Some periphyton, algae and zebra mussels are present attached to the rocks on the eastern shore of Sand Bay on the Kingston mainland (Acres, 2005). Farther offshore of the Sand Bay northeastern shoreline, algae and periphyton are present on the sand substrate due to lower wave action and cover nearly all hard surfaces in the central offshore areas.

As indicated in **Table 4.28 (Appendix B)**, quagga mussel and immature dreissenids are prevalent along the initial cable crossing route comprising between 31.7 and 64.3% of total benthic macroinvertebrate abundance. Chironomids (15.6 to 34.1%) and tubificid oligochaetes (11.2 to 27.5%) are the next most abundant benthic groups. Total number of organisms ranged from 1,083/m^2 to 9,042/m^2, whereas the total number of taxa ranged from 10 to 18. Shannon-Wiener species diversity index values ranged from 1.50 to 1.94, again suggestive of mesotrophic conditions.

It is anticipated that benthic macroinvertebrate community composition along the proposed transmission line route will be similar to that along the initial route.

Benthic macroinvertebrates may be affected by blasting (**Section 5.1.7**), potential turbidity and siltation (**Sections 5.1.9** and **5.1.11.2**), potential chemical release from sediments (**Sections 5.1.10** and **5.1.11.3**), as well as be directly affected by nearshore trenching (**Section 5.1.8**).

4.15 FISHERIES RESOURCES

The Upper St. Lawrence River supports a diverse warmwater/coolwater fish community, including at least 76 fish species recorded between 1982 and 1996 (**Table 4.29, Appendix B**). An additional nine species have been documented prior to 1982, i.e., silver lamprey, goldfish, brassy minnow, blacknose dace, longnose dace, threespine stickleback, slimy sculpin, channel darter and sauger. In additional to the fish species listed in **Table 4.29 (Appendix B)**, the round goby (*Neogobius melanostomus*), introduced to the Great Lakes (Lake St. Clair around 1990) via commercial vessel ballast water, was reported in the Kingston area in 2001 (Hoyle and Schaner, 2002a). Other exotic fish species that have been introduced by man or immigrated into the river from populations established elsewhere include goldfish, common carp, rudd, chain pickerel, rainbow smelt, coho salmon, rainbow trout, chinook salmon, brown trout and white perch.

As indicated in **Table 4.29 (Appendix B)**, a number of fish species documented in the Upper St. Lawrence River are designated with special status under federal and/or provincial legislation. Grass pickerel is designated as a species of special concern by COSEWIC (2007), but not listed by OMNR (2006a). Lake sturgeon is designated as a species of special concern by COSEWIC (2007) and not at risk by COSSARO (OMNR, 2006a). Cutlips minnow is designated as a threatened species by COSSARO (OMNR, 2006a), but not listed in regulation under the *Endangered Species Act*, whereas this species is considered to be not at risk by COSEWIC (2007). Pugnose shiner is designated as an endangered species by COSEWIC (2007), as well as by COSSARO (OMNR, 2006a) but not listed in regulation under the *Endangered Species Act*. Bridle shiner is designated as a species of special concern by COSEWIC (2007), as well as by COSSARO (OMNR, 2006a) but not listed in regulation under the *Endangered Species Act*. Channel darter is designated as a threatened species by COSEWIC (2007), as well as by COSSARO (OMNR, 2006a) but not listed in regulation under the *Endangered Species Act*.

The fish community of the Upper St. Lawrence River is dominated by smallmouth bass and northern pike as top predators. Other less abundant top predators include walleye, muskellunge and largemouth bass. Benthivorous fish species include lake sturgeon, white sucker, shorthead redhorse, brown bullhead, channel catfish and freshwater drum. Common and important forage fish include alewife, bluntnose minnow, spottail shiner, golden shiner, fallfish, banded killifish, trout-perch, johnny darter and round goby. Yellow perch and a variety of sunfish species are also common members of the fish community. Coldwater fish species, including Pacific salmon, lake trout and rainbow trout, migrate from eastern Lake Ontario into the Upper St. Lawrence River and its tributaries when lower water temperatures permit.

In 1987, the OMNR, through the St. Lawrence River Fisheries Management Unit, initiated a standardized (index gill netting) assessment program in the Ontario waters of the Thousand Islands (Cholmondeley, 1988a). A total of 1,247 fish representing 19 species were harvested. Yellow perch comprised 55% of the total catch (**Table 4.30, Appendix B**). Northern pike (8.8%) and smallmouth bass (6.3%) were the next most abundant sportfish species captured. Other common fish species included pumpkinseed (8.2%), rock bass (8.2%), brown bullhead (5.1%) and white sucker (2.2%). Walleye catch was low, primarily centred around Wolfe Island.

The 1987 assessment program indicated that the littoral zone of Wolfe Island has good quality fish communities, with smallmouth bass as the predominant sportfish. Generally, through the summer and fall, smallmouth bass are found in deeper water (i.e., greater than 10 m), while northern pike and yellow perch tend to occur in the shallow water areas. After spawning, muskellunge generally move into Lake Ontario waters for the summer, returning to the shoals around Wolfe Island in the fall.

As indicated in **Section 4.2**, the environmental conditions of the Upper St. Lawrence and Lake Ontario have changed substantially since 1987, including decreased nutrient levels; zebra mussel, round goby and other exotic species invasions; and increased water clarity. Fish population levels declined throughout the early 1990s, reaching a new equilibrium for most fish species with numbers that are consistently lower than those in 1987 (**Table 4.30, Appendix B**). This decline is particularly evident for northern pike, pumpkinseed and yellow perch. The decline in northern pike populations has been attributed to poor reproduction success due to cool spring weather, low spring water levels and changes in aquatic vegetation (Casselman, 1996). In the case of smallmouth bass, the decline in numbers through the 1990s may have been reversed in 2005 with the highest catch-per-unit-effort (“CPUE”) recorded (i.e., 7.59).

American eel populations also show evidence of decline in many areas of eastern Canada and particularly in Lake Ontario and the Upper St. Lawrence River (Casselman *et al*., 1997). Declines have been attributed to habitat loss and deterioration (e.g., dams), overfishing and environmental change in the northern Atlantic Ocean spawning habitat (Sargasso Sea).

Table 4.31 (Appendix B) presents CPUE at different water depths near Melville Shoal located approximately 4 km upstream of the proposed cable crossing. Alewife was the most common species captured at all water depths, followed by yellow perch and walleye.

The OMNR and New York State Department of Environmental Conservation (“NYSDEC”) have developed draft fish-community objectives (“FCOs”) for the St. Lawrence River to guide the cooperative management of the fish community and fisheries of the Upper St. Lawrence River (LaPan *et al*., 2001). These FCOs provide the basis for the development of more specific fisheries, habitat and watershed management plans.

Table 4.32 (Appendix B) presents gillnet catch data for the Canadian Middle Channel and Main Navigation Channel off Wolfe Island in October 1990. Four gillnet sets were located along the south shore of the Canadian Middle Channel on the north shore of Wolfe Island at Oak Point and offshore of Oak Point Wetland approximately 8 km downstream of the winter ferry dock. CPUE ranged from

1.31 to 2.24 fish/h. Yellow perch and rock bass were the most common species, representing 35.8% and 17.0%, respectively, of the total catch of 106 fish. Walleye, northern pike, brown bullhead and lake trout were the next most abundant fish species, representing 12.3%, 10.4%, 8.5% and 4.7% of the total catch, respectively. Other fish species included white perch (3.8%), white sucker (1.9%) and black crappie (1.9%). One carp, one pumpkinseed, one smallmouth bass and one largemouth bass were also caught each comprising 0.9% of the total catch.

Three gillnet sets were also located along the south shore of Wolfe Island (north shore of the Main Navigation Channel) approximately 2 km upstream of the eastern end of the island (Beauvais Point). CPUE ranged from 1.06 to 1.15 fish/h. Yellow perch was the most common fish species, representing 46.6% of the total catch of 58 fish **(Table 4.33, Appendix B)**. Lake trout and rock bass were the next most abundant, comprising 20.7% and 19.0% of the total catch, respectively. Northern pike and white sucker were the only other fish species caught, each representing 6.9% of the total catch.

As indicated above coldwater fish species, such as lake trout, migrate into the Upper St. Lawrence River from eastern Lake Ontario when water temperatures decline in the fall.

Table 4.33 (Appendix B) presents seine catch data for nearshore Wolfe Island. Six locations were seined along the south shore of the Canadian Middle Channel on the north shore of Wolfe Island at Oak Point (one location), Oak Point Wetland (four locations) and Holliday Bay (one location), approximately 8 km downstream of the winter ferry dock. CPUE ranged from 0.22 to 47.8 fish/100 m^2 of area seined at Oak Point and Oak Point Wetland, respectively. For all locations, a total of about 408 fish were captured, with a CPUE of about 12.4 fish/100 m^2 of area seined. Banded killifish was the most common forage fish captured, representing 50.5% of the total catch. Other forage fish species were rainbow smelt, golden shiner, bluntnose minnow, spottail shiner, spotfin shiner and johnny darter. Yellow perch was the most common sportfish species, representing 43.1% of the total catch. One young-of-the-year (“YOY”) largemouth bass was also collected in Oak Point Wetland.

Three locations were seined along the north shore of the Main Navigation Channel on the south side of Wolfe Island approximately 2 km upstream of Beauvais Point. CPUE ranged from 2.0 to 21.67 fish/100 m^2. For all locations, a total of 78 fish were captured, with a CPUE of 8.67 fish/ 100 m^2. Banded killifish and emerald shiner were the most common forage fish captured, representing 24.4% and 19.2% of the total catch, respectively. Other forage fish species were golden shiner, bluntnose minnow, spottail shiner, johnny darter and slimy sculpin. The only sport fish captured was yellow perch representing 37.2% of the total catch.

During the summer of 1990, the OMNR undertook qualitative seining of the St. Lawrence River at McDonell Bay, Oak Point Bay, Holliday Bay and Irvine Bay, about 3.5, 8, 9 and 11 km downstream, respectively, of the winter ferry dock along the north shore of Wolfe Island, as well as Button Bay on the south shore of the Wolfe Island. Sportfish species and numbers captured by seining at each location are presented in **Table 4.34 (Appendix B)**.

The most abundant species collected was yellow perch, representing from 61.4% to 94.7% of the total catch (in Holliday Bay and Button Bay, respectively). YOY largemouth bass were also common, representing over 30% of the total catch in McDonell Bay, Holliday Bay and Irvine Bay. Small numbers of YOY northern pike and brown bullhead were captured in McDonell Bay only. Five YOY muskellunge were also collected: four in Holliday Bay and one in Oak Point Bay.

With extensive areas of deep water (20 to 30 m) surrounding Wolfe Island, fish production is concentrated primarily around the island edge, consisting of a predominantly rocky shoreline and a few wetlands associated with watercourse outlets and embayments (Hendrick *et al*., 1991). Known or suspected spawning and nursery grounds in the local study area are presented in **Table 4.35 (Appendix B)**.

Fish consumption advice based on a combination of species, fish size and contaminant concentrations has been provided by the MOE for waterbodies throughout Ontario since 1979. A summary of the most recent fish consumption advisories for the Thousand Islands area of the Upper St. Lawrence River is provided in **Table 4.36 (Appendix B)**. The maximum recommended number of meals of sportfish per month is eight for the general population (MOE, 2007). Since young children and developing fetuses are affected by contaminants at lower concentrations than the general population, children under 15 and women of child-bearing age are advised to consume fish only in the eight and four meals per month categories. Top predators, such as northern pike and walleye, usually have the highest contaminant concentrations. Smaller, younger fish and fish that are not top predators, such as yellow perch, have lower contaminant concentrations.

Suns *et al*. (1993) reported a significant decline in the concentrations of PCBs and DDT in spottail shiner collected near Wolfe Island between 1975 and 1990.

Cable Crossing Landfalls/Winter Ferry Dock

Round goby was the most abundant fish species captured by boat electrofishing along the Wolfe Island landfall nearshore in 2006 (**Table 4.37, Appendix B**). A total of 11 species were collected. In addition to round goby, forage fish included spotfin shiner, emerald shiner, banded killifish and fantail darter. Sportfish species collected were smallmouth bass, yellow perch, rock bass, brown bullhead, freshwater drum and common carp.

Based on boat and backpack electrofishing in 2006 along the initial Kingston mainland landfall nearshore (Carruthers Point), nine fish species were collected with round goby also being the most abundant fish species (**Tables 4.37 and 4.38, Appendix B**). Sportfish species collected were largemouth bass, yellow perch, pumpkinseed, brown bullhead and white sucker. In addition to round goby, forage species included stonecat, banded killifish and logperch.

Based on boat electrofishing in June 2007 near the Sand Bay landfall, 14 fish species were collected with round goby again being the most abundant (**Table 4.39, Appendix B**). Other forage species included spotfin shiner, emerald shiner, spottail shiner, bluntnose minnow, banded killifish and logperch. Sportfish species collected were smallmouth bass, northern pike, yellow perch, pumpkinseed, brown bullhead and white sucker.

In the area of the winter ferry dock, 13 fish species were captured by boat and backpack electrofishing (**Tables 4.37** and **4.38, Appendix B**). Round goby and shiners were the most common forage fish species. Other forage fish included bluntnose minnow, banded killifish and fantail darter. Sportfish species captured were largemouth bass, yellow perch, pumpkinseed and rock bass. In addition, one smallmouth bass was collected by gillnet north of the dock off Dawson Point, whereas one brown bullhead, one northern pike and 73 yellow perch were captured west of the dock.

As indicated in **Table 4.35 (Appendix B)**, the cable crossing nearshores are likely used as spawning and/or nursery areas by a number of fish species. Juvenile life stages of spotfin shiner, emerald shiner, white sucker, brown bullhead, stonecat, rock bass, pumpkinseed, largemouth bass, fantail darter, yellow perch and round goby were captured by electrofishing and/or seining at one or both locations at Carruthers Point and Wolfe Island (**Tables 4.37 and 4.38, Appendix B**). Juvenile spotfin shiner, spottail shiner and bluntnose minnow were also collected in Sand Bay. During the June 2007 survey, smallmouth bass were observed to be guarding nests in the deeper areas of Sand Bay approximately 60 to 80 m offshore. In addition to spawning and/or nursery habitat, the two nearshore locations provide foraging habitat for adult sport fish, e.g., brown bullhead, northern pike, rock bass, pumpkinseed, smallmouth bass, largemouth bass, yellow perch and freshwater drum.

All of the fish species collected along the landfall nearshores are considered to be common in Ontario and are not tracked by the OMNR Natural Heritage Information Centre.

The two shallower locations marked by navigation buoys (KE1 and KE2) offshore do not appear to provide any significant habitat function for species such as lake trout (i.e., spawning or nursery), but may provide foraging habitat for some sport species (Acres, 2005).

Fish and fish habitat may be affected by blasting (**Section 5.1.7**), potential turbidity and siltation (**Sections 5.1.9** and **5.1.11.2**), as well as by nearshore trenching (**Section 5.1.8**). Fish may also be affected by potential chemical release from sediments (**Sections 5.1.10** and **5.1.11.3**).

4.16 WATERFOWL AND WATERBIRDS

The Upper St. Lawrence River is an important staging area for waterfowl during spring and fall migration periods. The Canadian Land Inventory ([“CLI”], 1971a) classifies the Upper St. Lawrence River, including Wolfe Island and the Kingston mainland, as Class 3M, indicating that the area may not be useful for waterfowl production, but is important for waterfowl migration or wintering. The local study area is used by diving ducks, dabblers, sea ducks and Canada geese throughout the year (EPS, 1977).

Waterfowl surveys by the Canadian Wildlife Service (“CWS”) have identified the Wolfe Island area as the most important waterfowl staging area in eastern Ontario, and one of the most important waterfowl staging areas in the province (Ross, 1984, 1989). Wolfe Island has been designated as an Important Bird Area (“IBA”) for its continentally significant concentrations of migratory waterfowl, among other features. Utilization of Wolfe Island by waterfowl in the spring and fall of 1976-77 and

1985 is presented in **Table 4.40 (Appendix B)**. The bay ducks, which include Greater Scaup, Lesser Scaup, Canvasback, Redhead and Ring-necked Duck, comprised the most important guild staging at Wolfe Island, with scaup making up over 90% of all bay ducks (Ross, 1984).

Table 4.41 (Appendix B) presents more recent (spring 1999) CWS waterfowl survey data for Simcoe Island and Wolfe Island. Bay ducks continue to be the predominant guild staging on Wolfe Island, with the greatest numbers on the eastern portion of the island.

The wetlands and littoral areas surrounding Wolfe Island were found by Bottomley (1987) to support abundant aquatic macrophytes and benthic macroinvertebrates, basic food items of waterfowl. The general configuration of shoreline-open water habitat may be another factor influencing migrant waterfowl use of Wolfe Island as a stopover area. Wolfe Island provides ideal large areas of shallow open water at Bayfield Bay and Barrett Bay-Big Bluff. These areas are protected from high waves by the surrounding configuration of islands, permitting the formation of tightly packed rafts often containing thousands of scaup.

Waterfowl staging in the spring starts in March, with a maximum in early April and few left in late May (Bottomley, 1986). In the fall, staging commences in the latter half of September, with a peak in late October and few left in December.

Local Study Area

Table 4.42 (Appendix B) provides information on the seasonal occurrence of waterfowl and waterbirds in important ecological sensitivity areas in the local study area.

Studies of migratory waterfowl and waterbirds were conducted on Wolfe Island by NEA (2004) and Stantec (2007b). **Technical Appendix C5** (Bird Report) summarizes the results of these waterfowl surveys. The results concurred with Environment Canada's observation that Bayfield Bay is the most important staging area around Wolfe Island. Other waterfowl concentration areas in order of total numbers observed were Button Bay, Reeds Bay, Barrett Bay, Big Sandy Bay, the south shore, and Sand Bay. The southern shore of Wolfe Island, in the vicinity and south of Big Sandy Bay wetland, has been identified as an area of particularly high year-round waterfowl concentrations with 4,000 to 6,000 geese and dabblers observed through the fall and winter of 2005-2006 (J. Day, Kingston resident, 2006, pers. comm.). Stantec field studies and WILDSPACE™ (2007) data indicate that the north shore of the Wolfe Island and the adjacent Kingston shoreline experience the lowest waterfowl use of all the survey segments in the study area (**Technical Appendix C5**).

Double-crested Cormorant was abundant in the spring. Great Blue Heron tended to concentrate along the shoreline in bays and coastal marshes, and was particularly abundant in and around the Big Sandy Bay wetland, (including individuals seen carrying nesting material). American Bittern was observed in the Big Sandy Bay wetland. Ring-billed Gull was most abundant during the spring migration studies.

Cable Crossing Nearshores

The surveys found no significant concentrations of waterfowl in the landfall nearshores.

Waterfowl and waterbirds may be affected by noise from construction activities (**Section 5.1.2**).

4.17 SPECIES OF CONCERN

As indicated in **Section 4.15**, a number of fish species documented in the Upper St. Lawrence River are designated with special status under federal and/or provincial legislation. None of these species have been recorded in the local study area (e.g., Mandrak and Crossman, 1992), or collected in the landfall nearshore areas.

There are some waterfowl and waterbird species recorded during the bird studies for the Project, that are species of concern. These include Black Tern, a species listed as Special Concern by COSSARO and observed during Stantec field surveys in 2007, Least Bittern, listed as Threatened by COSSARO and COSEWIC and identified in OMNR wetland evaluations, and King Rail, listed as Endangered by COSSARO and COSEWIC and identified in OMNR wetland evaluations. All three species inhabit extensive cattail marshes; habitat that will not be affected by construction and operation of the submarine cable. Detailed information on potential effects on birds, including waterfowl and waterbirds, is found in **Technical Appendix C5 – Bird Report**.

4.18 ENVIRONMENTALLY SIGNIFICANT AREAS

Wetlands and other environmentally significant areas provide important habitat for a variety of wildlife and plant species. Further, wetlands provide water storage and control functions which reduce erosion and flooding, and improve water quality. Wetlands also increasingly provide areas for a range of recreational pursuits, including nature appreciation.

The Ontario Government (1992) issued a Wetlands Policy Statement intended to ensure that there will be no net loss of wetland functions of Provincially Significant Wetlands (“PSW”s). Recently, the Wetlands Policy Statement was incorporated into the Provincial Policy Statement (OMMAH, 2005). A PSW is either a Class 1, 2 or 3 wetland situated south and east of the Canadian Shield, or a wetland in another area of the province that the OMNR has classified as Provincially Significant through an evaluation of biological, social, hydrological and special features of the area. Development and site alteration are not permitted in PSWs in Ecoregions 5E, 6E and 7E (OMMAH, 2005). North of Ecoregions 5E, 6E and 7E, development and site alteration are not permitted unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.

Areas of Natural and Scientific Interest (“ANSI”s) and Environmentally Sensitive Areas (“ESA”s) have been identified by the OMNR and conservation authorities and/or municipalities, respectively, where it has been determined that the natural landscape and/or its features are in need of protection for heritage appreciation, scientific study or conservation education purposes. Life Science ANSIs are natural areas selected to protect outstanding landscapes, environments and biotic communities.

Earth Science ANSIs are geological sites selected to protect outstanding examples of rock types, fossil localities, landform associations and areas containing significant groundwater resources. ESAs are land and water areas with natural features or ecological functions of such significance as to require their protection or preservation.

There are three PSWs and one Life Science ANSI within the local study area.

The Little Cataraqui Creek Wetland Complex, 359.9 ha in area, is a coastal wetland complex made up of three individual wetlands, composed of two wetland types: 28% swamp and 72% marsh (Boxall, 1992). The wetland located immediately adjacent to the creek mouth has been identified as an International Biological Programme ("IBP") site (Macdonald, 1972). The KFN recently completed a comprehensive natural environment inventory of the west side of Little Cataraqui Creek Wetland (Bonta *et al*., 2004).

Brown's Bay Wetland, about 140 ha in size, is composed of 100% marsh (NHIC, 2006). Two wetland units make up the complex, and these two areas are connected by sparsely vegetated shallow open water which creates a wide littoral band around the bay.

Barrett Bay Wetland, 34.0 ha in area, is also composed of 100% marsh (White, 1986). This wetland is considered regionally significant for waterfowl staging, and locally significant for waterfowl production.

Abraham Head, 70.82 ha in area, is a Life Science ANSI (Luciuk, 1975), consisting of a relatively flat limestone point with an irregular coastline and soil types ranging from a shallow loam through rendzina soils to a wet muck. Abraham Point is also an IBP site (Hainault, 1969).

Cedar Island, which is part of the Thousand Islands Natural Park, is also an IBP site (Macdonald, 1971). The Frontenac Arch crosses the island as reflected by exposed granite to the north and limestone outcrops to the south.

These environmentally significant areas are sufficiently distant or sheltered to not be affected by the Project (**Section 5.1.4**).

4.19 WATER USES

The Upper St. Lawrence River is an extremely important tourist attraction and recreational resource. During the warm weather months, boat cruises are regularly scheduled through the Upper St. Lawrence River and a variety of recreational activities, such as boating, fishing and swimming, take place at private cottages, as well as private and public campgrounds and beaches. In addition, a number of municipalities, industries and private dwellings in Canada and the U.S. are dependent upon the river for water supplies.

The Project has potential to interfere with or disturb water uses and activities (**Section 5.1.11.4**).

Commercial Cruise Boats

The Thousand Island area of the St. Lawrence River is the major tourist attraction of the region, drawing both day-trippers and resort-based visitors to the area. In the Kingston area, this interest is serviced by two Canadian cruise boat operators. The St. Lawrence Cruise Lines Inc. operates the M/V Canadian Empress, a 66 passenger replica steamboat, from 13 May to 30 October with five-night cruises from Kingston to Ottawa and from Ottawa to Kingston; six-night cruises from Kingston to Quebec City and from Quebec City to Kingston; and three-night cruises around the Thousand Islands. The Bateau Channel is used predominantly during the cruises.

The Kingston 1000 Islands Cruises operates three sightseeing cruise boats: the Island Belle, a 150 passenger double-deck replica steamer; the Island Star, a 200 passenger glass-topped catamaran; and the Island Queen, a 300 passenger triple-deck paddle-wheeler. The cruise boats are operated from mid-May to mid-October, as follows:

- the Island Belle operates every two hours from 11:00 am to 5:00 pm with a 1.5 h cruise from Kingston to Carruthers Point and back, skirting Simcoe Island, Wolfe Island and the western end of Howe Island, to Kingston;

- the Island Queen operates daily in the spring and fall and twice daily during the summer season (late June to Labour Day) with a 3 h cruise of the Thousand Islands using the Bateau Channel downstream and returning via the Middle Canadian Channel; and

- the Island Star operates on Friday, Saturday and Sunday in the spring and fall and daily during the summer season with a 3.5 h sunset dinner cruise of the Kingston waterfront and offshore islands.

Ferry Boats

The MTO operates the Wolfe Island Ferry (Wolfe Islander III) year-round from 5:45 am to 2:00 am. The Wolfe Islander III holds approximately 55 cars and 330 passengers per trip. The crossing time is approximately 20 min with 38 crossings daily between Wolfe Island and Kingston. The Wolfe Islander III operates from the Marysville Dock on Wolfe Island during most of the year from ice out to ice in at which time it moves to the Dawson Point Dock during the winter. Low water conditions at the Marysville Dock can result in earlier use of the winter dock.

Two other ferries service Wolfe Island. The Simcoe Island Ferry, with a three car capacity, is operated by the MTO seasonally across the Boat Channel on a variable schedule (on demand) between 6:00 am and 1:00 am. The privately-operated Horne’s Ferry, with a 10 to 12 car capacity, runs at least hourly from 8:00 am to 8:00 pm on a daily basis from 01 May to 22 October from Point Alexandria on Wolfe Island to Cape Vincent, New York.

Recreational Boating

The Upper St. Lawrence River is the focus of considerable recreational boating, but specific information on the volume of usage is limited and difficult to acquire. It is often linked to other recreational activities such as fishing and waterskiing. No site-specific information is available on pleasure craft traffic on the Upper St. Lawrence River, including the Kingston area.

Table 4.43 (Appendix B) presents specific information on recreational boating facilities in the Kingston area.

Due to the windy conditions, Kingston is considered to have some of the best freshwater sailing opportunities in the world. Kingston played host to the 1976 Olympics sailing events. The annual Canadian Olympic-Training Regatta Kingston ("CORK") has been held since 1969 in August. This two week long event includes over 20 classes of sailing events involving more than 1,000 sailboats and over 2,000 competitors from many countries. The six sailing courses extend from the Lower Gap well out into Lake Ontario.

The Kingston Yacht Club and Collins Bay Yacht Club have regularly scheduled boating activities (i.e., regattas and races) which usually take place between the Kingston mainland and Wolfe Island and west of Wolfe Island in Lake Ontario.

Recreational boaters are more likely to use the sheltered Bateau Channel than the Canadian Middle Channel during transit between Kingston and the Thousand Islands area.

Windsurfing

The Lower Gap is a popular location for windsurfing. The Kingston Boardsailing Association ("KBA") has identified 11 locations within the Lower Gap as prime windsurfing locations (**Figure 4.16, Appendix A**). Three of the locations are off the Point Pleasant-Patterson Point peninsula. The Patterson Shoal Break is recognized by the KBA as best later in the windsurfing season as the waves are too small to break during the early season.

General Recreation

The CLI (1971b) categorizes the Wolfe Island landfall as Class 4 with moderate capability for outdoor recreation providing access to water suitable for popular forms of family boating, shoreland suited to family or other recreation lodging use, and a vantage area which offers a superior view. The Kingston mainland landfall occurs within the Kingston municipality limits and is therefore not classified by CLI (1971b). However, shoreland further west, i.e., west of Everett Point, is classified as Class 4 with moderate capability for outdoor recreation providing access to water suitable for popular forms of family boating and shoreland suited to family or other recreation lodging use. The Point Pleasant-Sand Bay-Carruthers Point nearshore is used by local residents for family activities.

Recreational Fishing

Sportfishing is extremely popular in the Upper St. Lawrence River and is a very important component of the local economy. Angler expenditures for the Ontario waters of the St. Lawrence River from Gananoque to the Quebec border were estimated at $11.6 million for the 1995 angling season (Brickley and Legg, 1998).

At least four fishing charters operate out of Kingston, with others operating out of Gananoque and Brockville, with Pacific salmon, lake trout, brown trout, rainbow trout, bass and/or walleye being the target species.

In the local study area, northern pike and smallmouth bass are very popular sportfish. Angler surveys indicate that an obvious change in fishing pressure from northern pike to smallmouth bass once the bass season opens. Other major sportfish include yellow perch, walleye and muskellunge.

Data on angler use are available based on a 1987 aerial survey (Cholmondely, 1988b) and a 1988 on-water survey (Hendrick *et al*., 1991). The 1987 aerial survey indicated that fishing activity in the Wolfe Island area is relatively heavy throughout the summer months and relatively light in the spring and fall. Based on mean angling parties per flight, the eastern half of Wolfe Island was the third most popular angling area on the river. However, this angling pressure was concentrated on specific localized areas. There was noticeably less fishing pressure on the western half of the island.

During the pre-season bass fishing period, fishing activities are scattered along the north shore of Wolfe Island, and usually occur in protected bays. For example, there is relatively heavy utilization of Bayfield Bay and Button Bay, whereas negligible activities occur east of Button Bay.

During the summer, fishing activities are heavy in all bays of Wolfe Island, particularly in the areas of Oak Point, Abraham Head, Lewis Bay and Beauvais Point.

During the fall, fishing activities are sporadic between Wolfe Island and Howe Island, usually occurring in bays. In the channel south of Wolfe Island, fishing pressure is relatively high, particularly for muskellunge and walleye. Angling activities are concentrated around Carleton Island, the Hinckley Flats and Beauvais Point.

Hendrick *et al*. (1991) estimated that the recreational fishery in the Wolfe Island/Howe Island area in 1988 involved 157,479 h, or about 26.2% of the angling estimate for the Ontario waters of the St. Lawrence River (**Table 4.44, Appendix B**). Angling pressure was highest around Howe Island, which accounted for 43.3% of the angling in this section of the river, particularly in the Bateau Channel between the north shore of Howe island and the mainland. Fishing pressure was lowest on the west end of Wolfe Island, where adverse water conditions and the open exposure to Lake Ontario generally prevented anglers from reaching this area.

Northern pike was the key species in the spring, accounting for 63.5% of the angling effort. Yellow perch and bullhead accounted for 26.2% and 22.3% of the angling effort, respectively. Spring angling was almost exclusively in the Bateau Channel, which provides extensive habitat suitable for northern pike. Moreover, the spring season was extremely windy which likely reduced accessibility to the Wolfe Island area.

After the opening of bass season, anglers targeted yellow perch throughout the Howe Island-Wolfe Island area. Northern pike and smallmouth bass were targeted at approximately equal levels around Howe Island and the eastern part of Wolfe Island, whereas smallmouth bass were heavily favoured around western Wolfe Island relative to northern pike. The relatively high fishing effort on the west side of Wolfe Island, where the embayments provide critical spawning habitat, reflects the concentration of over 100 boats recorded on bass season opening day in 1988.

Angling effort in the fall with northern pike the primary target, was highest around Howe Island and lowest around western Wolfe Island. The CPUEs (fish/angler-h) for smallmouth bass around Howe Island and Wolfe Island declined substantially in the fall. An estimated 5,035 angler-h were also directed towards muskellunge with 83.8% occurring in the fall, primarily in October. In the local study area, muskellunge angling was centred around Abraham Head located about 2 km downstream of the winter ferry dock and Snake Island located about 1.5 km upstream of the transmission line crossing.

Table 4.45 (Appendix B) presents total sportfish catch, harvest and CPUE in the Howe Island/Wolfe Island area in 1988. Yellow perch was the most common fish species caught with a CPUE of 0.629 fish/angler-h, followed by smallmouth bass and northern pike with CPUEs of 0.334 and 0.235 fish/angler-h, respectively. The CPUEs for largemouth bass, walleye and muskellunge were markedly lower. The eastern portion of Wolfe Island provided the only walleye fishing of note, and this was almost exclusively in Bayfield Bay.

Commercial Fishing

The commercial fishery in the Upper St. Lawrence River is a coarse fish industry based primarily on yellow perch, brown bullhead, sunfish (pumpkinseed, bluegill) and American eel prior to 2004. In 2006, 18 commercial fishing licences were held by 13 fishers within Napanee (1-5) quota zone (which includes the local study area); ten licences by six fishers in Brockville (2-5) quota zone; and three licences by two fishers in Cornwall (1-7) quota zone. One fisher holds licences in all three quota zones. Commercial licences restrict fishing to specific areas, seasons and specific fishing gear. These restrictions reduce incidental catches of non-target species and minimize conflicts with other resource users. Fishers may use hoopnets and trapnets for most fish species and large-mesh gillnet for carp. Commercial fisheries for American eel (prior to 2004), black crappie and yellow perch are managed using quotas in order to meet fisheries management objectives and protect fish stocks **(Table 4.46, Appendix B)**. Over the years, allowable harvest quotas have been seldom if ever met. Commercial eel quotas were reduced to zero as of spring 2004 in Ontario due to population decline in the St. Lawrence River (Casselman *et al.*, 1997).

The local study area occurs within commercial fish Napanee (1-5) quota zone which extends from the west ends of Wolfe Island and Amherst Island to Brockville. Within the Napanee (1-5) zone, the most important species in the harvest are yellow perch, sunfish, black crappie, brown bullhead, bowfin and prior to 2004, American eel (**Table 4.47, Appendix B**).

Table 4.48 (Appendix B) presents commercial fish harvest by month between 2004 and 2006. In general, commercial fishing intensity is greatest in April and May, with little or no activity in January to March, June to September, November and December, but somewhat higher intensity in October.

Between 1995 and 1999, the St. Lawrence River in Ontario had supported a commercial fishery with an annual harvest of over 350,000 lb (158,760 kg) and a landed value of about or over $400,000. However, since 1999, the annual harvest has declined substantially. For example, in 2004, total harvest was only 143,845 lb (65,248 kg) with a value of $102,646, representing declines of about 68% and 74%, respectively, since 1996 (OMNR, 2005). Part of this decline is reflected by the reduction of the commercial quota for eel to zero, as well as declines in the harvest of most fish species. In 2005, total harvest of all species was 221,249 lb (100,379 kg) with a value of $206,479, a significant increase compared with the previous year but still well below those in the 1990s (OMNR, 2006b).

In 2005, the yellow perch catch in the Napanee (1-5) quota zone was 19,811 lb (8,986 kg), or only about 30.2% of the quota of 65,696 lb (29,800 kg) (OMNR, 2006b). For black crappie, the 2005 catch was 11,402 lb (5,172 kg), or about 61.3% of the quota of 18,590 lb (8,432 kg).

Commercial Navigation

In 2006, there were 1,472 vessels upbound and 1,470 vessels downbound between Montreal and Lake Ontario, with a total cargo of 35,571,985 tonnes. In 2006, the Montreal to Lake Ontario section of the St. Lawrence Seaway was opened on 23 March 2006 and was closed on 30 December 2006, a total of 283 days of navigation. Therefore, commercial traffic on the Montreal-Lake Ontario section of the Seaway averaged approximately 10 vessels per day. Vessel transits by month in 2006 are provided in **Table 4.49 (Appendix B).**

Table 4.50 (Appendix B) provides historical (1987-2006) commercial vessel traffic statistics for the Montreal to Lake Ontario section. There has been an increase in the number of vessels transiting this section of the Seaway and total cargo tonnage in 2006 compared to the previous five years.

Commercial vessels use the Main Navigation Channel between Wolfe Island and New York State to transit between Lake Ontario and the St. Lawrence River.

The Greater Kingston Public Port includes LaSalle Wharf and Crawford Wharf with no commodity traffic but significant commercial cruise and tour boat traffic (Kingston, 2001).

Municipal and Industrial Uses

Table 4.51 (Appendix B) presents information on municipal and industrial water intake and discharge locations within the local study area.

Four intakes and one outfall are located within 1 km of the proposed cable crossing:

- the Kingston West WTP intake is located approximately 700 m upstream;
- one of the three industrial intakes is located 51 m downstream, whereas the other two intakes are approximately 150 m north (see **Figure 3.1, Appendix A**), and
- the Kingston Township WPCP outfall is located approximately 650 m downstream and north.

4.20 HERITAGE RESOURCES

A Stage 1 archaeological assessment was completed for the proposed Project by The Archaeologists Inc. (2006). The study area for this assessment included water resources around Wolfe Island, encompassing the local study area as defined in this report. This underwater area was subjected to a document search, highlighting known archaeological resources. The Archaeologists Inc. (2006) identified several marine archaeological resources, including registered archaeological sites (14 shipwrecks), and others known to the local diving community (nine shipwrecks):

- ten registered sites are located in the immediate vicinity of Garden Island (east of the transmission cable route);
- two registered sites are located in the northeast portion of the study area (east of the transmission cable route);
- two registered sites and two locally known sites are located near the western end of Simcoe Island (west of the transmission cable route); and
- seven locally known sites are located at the mouth of the Cataraqui River and along the Kingston shoreline (east of the transmission cable route)

The Archaeologists Inc. recommended that any underwater development such as the placement of a transmission line linking Wolfe Island and the Kingston mainland should be investigated with a Stage 2 underwater archaeological assessment, or similar, as appropriate.

As indicated in **Section 4.1**, a geophysical/geotechnical survey was undertaken in the spring of 2007. No marine archaeological resources (e.g., shipwrecks) were identified along the proposed cable route.

The potential effects of the Project on heritage resources are provided in **Section 5.1.13**.

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5.0 Environmental Effects and Proposed Mitigative Measures

This section describes the potential environmental effects that may result from the construction, operation, maintenance and repowering/decommissioning of the transmission line crossing of the Lower Gap.

The objectives of the proposed transmission line crossing are to install the cable while minimizing effects on local populations of aquatic life, restricting the extent and duration of sediment resuspension and siltation from construction activities, providing for minimal interference with or disturbance of water uses and activities, and preserving the aesthetics of the area.

As indicated in **Section 4.9**, bedrock is present in the nearshore at the landfall locations. To ensure public safety and protection of the cable in the nearshore from shorefast and wind-blown ice, cable burial within the bedrock will be required. Cable burial will occur up to 125 and 500 m offshore of the Wolfe Island and Sand Bay landfalls, respectively. Beyond these points, the cable will be laid on the riverbed.

In the immediate nearshore at the Wolfe Island landfall, substrate is composed primarily of fractured limestone slabs overlying bedrock. Further offshore (10 to 150 m), the substrate consists of cobble and boulder providing 80% surface cover over the underlying silt veneer and bedrock.

In the nearshore of Sand Bay, substrate is composed of coarse cobbles within fine sand sediment (**Table 4.8, Appendix B**) less than 0.5 m thick overlying bedrock. The depth of overlying substrate diminishes as water depth increases exposing the underlying bedrock in the centre of the bay (**Figure 4.10, Appendix A**).

As indicated in **Section 3.2**, weathered surface bedrock extends approximately 20 m and 250 m offshore from the Wolfe Island and Sand Bay landfall shorelines, respectively, to a water depth of 3 m at both locations (AGL, 2007). Competent bedrock is present further offshore. Blasting will be required to create the trench in the competent bedrock. Blasting effort required to create the trench in the inshore weathered rock should be reduced over that required for competent bedrock. Ripping/cutting and/or physical boring may also be feasible within the weathered bedrock in the shallow nearshore and onshore. Conventional dredging will be utilized to excavate the trench at both landfalls and possibly to remove the overburden substrate (less than 0.5 m thick) present in the inshore area of Sand Bay.

The potential effects of bedrock blasting, cutting/ripping, physical boring and conventional dredging, as well as cable placement on the riverbed, have been addressed in this chapter.

Detailed consultation with local OMNR, DFO and other government agency representatives, as well as interested parties, will be instrumental in final construction design.

The prediction of potential environmental effects was based on these construction activities and the implementation of applicable and appropriate mitigation measures. The magnitude, extent and duration of the environmental effects have been consolidated to assess the overall significance of the net effects.

Recommended mitigative measures for project effects are based on the experience of the project team (e.g., Fitchko, 1987, 1989, 2002a,b) and relevant government guidelines for underwater cable installation and physical boring (DFO, 2006a,b) and blasting (Wright and Hopky, 1998). The recommended mitigative measures will reduce the environmental effects to the greatest extent possible.

Construction activities will be guided by a Construction and Environmental Management Plan ("CEMP"). The CEMP will include commitments made in the EA, legislated requirements and any terms and conditions of approval. The CEMP will also set out all remaining permits, licences and approvals that must be obtained prior to construction or operation of the facilities. Examples may include NWPA approval, *Fisheries Act* authorization or letter of advice, work and land use permits under the *Lakes and Rivers Improvement Act* and *Public Lands Act*, Ontario Ministry of Culture clearance, and *Conservation Authorities Act* authorization. As appropriate, monitoring will be conducted by the Environmental Inspector during the construction period to ensure that work is being carried out in accordance with the CEMP.

Construction, operational and repowering/decommissioning effects are described in **Sections 5.1, 5.2** and **5.3**, respectively. A summary of the EA is provided in **Section 5.4.**

5.1 CONSTRUCTION EFFECTS

5.1.1 Fisheries Window Timing

In-water construction timing restriction windows have been established by the OMNR for undertakings in Ontario waterbodies. These windows are designed to protect fish spawning areas and egg incubation periods. The cable crossing will be undertaken in OMNR Peterborough District, which identifies 15 March to 15 July as the timing restriction window for warmwater fish (R. Topping, OMNR Kingston Area Office, 2004, pers. comm.). Therefore, in-water construction activities associated with the proposed Project should be scheduled between 16 July and 14 March.

As discussed in **Section 3.3**, in-water construction activities for the submarine transmission line crossing will be initiated at a landfall nearshore in September 2008 (after Labour Day) with submarine cable delivery and installation later in the month and early October. All in-water construction activities will occur outside of the timing restriction window of 15 March to 15 July.

5.1.2 Climate, Air Quality and Environmental Noise

A detailed description of climate, air quality and noise has been provided in **Section 4.3.**

Climate

Climatic data of relevance to construction activities associated with the landfalls include slope stabilization to minimize erosion during precipitation events and scheduling of revegetation activities to occur during optimal conditions. Submarine transmission line crossing activities are precluded by winter conditions (due to closure of the St. Lawrence Seaway). Scheduling of construction activities associated with the crossing during the fall should take into regard the possibility of storm events which may affect cable crossing activities.

Air Quality

Potential air quality effects associated with cable construction activities include:

- exhaust emissions (e.g., CO, NO_x, SO_2, VOCs) from construction equipment; and
- dust and particulate emissions from landfall construction activities.

The effects of gaseous and particulate emissions from the operation of transport and construction equipment will be local, short term and temporary. Contract specifications will require that this equipment be maintained in good working condition to ensure air emissions are minimized and in compliance with applicable MTO and MOE guidelines.

Fugitive emissions (i.e., dust and particulates) may be created by construction activity at the landfalls. The actual rate of generation of fugitive particulates will depend on the specific type of activity, soil type, weather conditions, area of disturbed land and dust suppression methods. As indicated in **Section 4.4**, clay and stony loam till soils are present on the Kingston mainland and Wolfe Island landfalls, respectively. The clay soils will have a greater potential for fugitive dust generation.

Dust generation (e.g., during dry, windy conditions) can be controlled by watering or use of chemical suppressant on the disturbed land. Construction-related dust effects on local air quality are predicted to be local, short term and temporary.

During construction the practices and procedures outlined in the Cheminfo (2005) document “Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities”, prepared in conjunction with the Construction and Demolition Multi-stakeholder Working Group for Environment Canada, should be followed.

It is anticipated that the net effects on the local air quality during construction will be negligible and thus no other mitigative measures are required.

Environmental Noise

Potential environmental noise effects will be associated with a number of construction activities, such as vehicular and marine traffic, heavy equipment and machinery, and the use of explosives to create a trench for submarine cable burial in the nearshore. Impulse noise will be generated from nearshore trenching and unloading of materials and equipment. Noise levels will be dependent on the extent of controls employed, proximity to receptors, timing, nature of the noise, physical features of the sites and surrounding area, meteorological conditions and other commercial/industrial noise sources.

As indicated in **Section 4.3**, a variety of land and water uses in the local study area contribute to environmental noise levels. The major existing sources of noise at the landfalls and cable crossing are industrial and municipal operations, road traffic, agricultural activities, recreational and commercial cruise vessel passage, wave action and wildlife.

Landfall and nearshore construction will be undertaken over consecutive one-week periods. The nearest residences to the Wolfe Island and Sand Bay landfalls are approximately 120 m east and 490 m west, respectively. The occupants of these and other nearby residences may be temporarily affected by the noise generated during project construction.

Construction activities will abide with the municipal noise by-laws. Construction equipment will be properly maintained and operated to ensure compliance with applicable MTO and MOE guidelines. Construction activities that generate noise at points of reception will be limited to daytime hours. Construction along the cable route and at each landfall is scheduled to last approximately one week each, for a total anticipated duration of three weeks.

The construction disturbance should be sufficiently local that little displacement of wildlife will occur. Based on previous experience, any resident animals are expected to temporarily relocate to avoid noise and disturbance associated with construction activities returning after construction completion. In the construction areas, resident animals have already adapted to noise and disturbance resulting from industrial and municipal operations, road traffic, agricultural activities and/or vessel traffic, among other contributing sources.

Noise from blasting events may have a heightened but temporary effect on nearby shoreline residents and on recreational users involved in sportfishing and boating. However, noise from blasting will be attenuated due to the underwater setting, minimization of detonation charge to that required to create the trench and the use of blasting mats or other cover. As appropriate, nearby residents should be notified prior to commencement of blasting. The MOE has developed guidelines for underwater blasting including recommended practices and mitigation measures (Persaud and Jaagumagi, 1995).

It is recognized that noise from trenching and other construction activities in the fall could have an effect on waterfowl if large concentrations use the nearshore area as a migration stopover. However, as indicated in **Section 4.16**, waterfowl utilization of the landfall nearshores is not significant. Moreover, waterfowl staging commences in the latter half of September, with a peak in late October. In-water construction activities will be completed prior to the peak staging period. It is expected that any waterfowl near the landfall will temporarily relocate to similar habitat further along the nearshore. During the St. Lawrence River crossing by the Iroquois Extension undertaken by TransCanada PipeLines Limited, blasting had no effect on waterfowl in the area (Silver and Fitchko, 1992).

Overall, environmental noise effects are predicted to be localized, minor and temporary and can be acceptably mitigated by conventional construction practices.

5.1.3 Geology, Physiography and Soils

The geology, physiography (i.e., topography) and soils in the landfall areas will not be adversely affected by the proposed construction activities due to restoration measures undertaken after construction.

Construction activities with potential for soil erosion at the landfall locations will include topsoil stripping, grading and restoration. As appropriate, topsoil will be stripped in the construction areas and stored within a designated area. After topsoil removal, the construction area will be covered with geotextile overlain with a gravel base.

To minimize potential soil effects and maintain soil fertility, the following remedial measures will be employed as appropriate:

- restriction of the use of heavy construction equipment to within the approved work areas to minimize soil and vegetation disturbance;
- implementation of erosion control measures (e.g., silt fence near the shoreline to prevent sediment transport to the river during landfall trench excavation, straw bales used as filters, and mulching for interim soil stabilization);
- restoration of a suitable land contour and drainage patterns by grading to minimize erosion;
- replacement of adequate topsoil; and
- revegetation by seeding and/or planting as soon as seasonal conditions permit.

Since the regional climate is favourable for revegetation, it is expected that maximum exposure of disturbed land to erosion risk will be limited to within a single growing season.

Overall, erosion and soil effects are expected to be negligible with the proposed mitigation and adherence to DFO Operational Statements and provincial guidelines (**Sections 5.1.5 and 5.1.6**).

5.1.4 Environmentally Significant Areas

As indicated in **Section 4.18**, there are five environmentally significant areas in the local study area. Little Cataraqui Creek Wetland Complex, located north of Cataraqui Bay, is sufficiently sheltered to not be affected by the Project. Cedar Island, Barrett Bay Wetland, Brown’s Bay Wetland and Abraham Head are located approximately 5, 6.5, 8 and 8 km downstream, respectively, sufficiently distant to not be affected by the cable crossing.

5.1.5 DFO Operational Statements

The DFO (2006a,b) has prepared Operational Statements for underwater cable and physical bore crossings. These Operational Statements provide measures to be undertaken to protect fish and fish habitat when undertaking these types of construction activities.

5.1.5.1 Underwater Cable Crossings

As discussed by the DFO (2006a), the placement of cables on the beds of freshwater lakes and rivers is a common practice used to deliver utility services (e.g., electricity and telephone) across waterbodies when overhead lines are not feasible. The placement of underwater cables is more favourable than using unconfined open trench methods, which bury the cables within the substrate of the lake or river. Placing cables on the beds of freshwater lakes or rivers typically generates less sediment resuspension and avoids the need to use machinery in the water. In some instances, as is the case with the transmission cable, cables may need to be buried near to the shoreline for operational and public safety reasons.

The Operational Statement on underwater cables describes measures to be incorporated into a proposed project in order to avoid negative effects on fish habitat (DFO, 2006a). A proponent may proceed with a submarine cable project without DFO review when the following conditions are met:

- unconfined open trench methods, including ploughing and water-jetting, to bury cables are not used;
- underwater cables are not installed on or within known fish spawning habitat;
- cable trenching is limited to nearshore areas and is to be no greater in width than that required to accommodate the cable;
- any nearshore excavation to bury the cable extends a maximum total of 10 m below the ordinary high water mark but in no case will involve more than 10% of a stream channel width (in total);
- explosives are not used to install the cable; and
- the “Measures to Protect Fish and Fish Habitat when Placing Underwater Cables” outlined below are incorporated into the project.

Underwater cables may be buried nearshore, if necessary, for safety and to protect cables against ice scour. Whether the area is dry or wet at the time of construction, the following measures should be followed:

- Install and maintain effective sediment control measures (e.g., silt curtain) around the area to be trenched before, during and after trenching to prevent re-suspended sediment from spreading to adjacent areas. Inspect sediment control measures regularly and make all necessary repairs if any damage or leakage is discovered. Once trenching and cable installation is complete, allow sufficient time to permit sediment to settle out, and the water to be as clear inside the isolated area as outside the isolated area before removing sediment control measures;

- Any fish trapped within an enclosed area are to be safely relocated outside of the enclosed area to the main waterbody;
- Any rock, cobble or gravel on the bed that is moved to facilitate placement of the cable on the bottom of the waterbody is to be kept as close as possible to its original location;
- Any covering of cables with rock should be carried out using hand tools;
- Any material that is temporarily removed from the bank of the waterbody (below the ordinary high water mark) during the dry land trenching is to be stockpiled separately and returned to its original location after the cable has been installed; and
- After excavation, restore the original contour, gradient and substrate of the waterbody bank, shore and bed prior to removing isolation measures.

Any waste materials removed from the work site should be stabilized above the ordinary high water mark to prevent them from entering any watercourse. Spoil piles could be contained with silt fence, flattened, covered with biodegradable mats or tarps, and/or planted with preferably native grass or shrubs.

While this Operational Statement does not cover the extensive clearing of shoreline vegetation, the removal of select plants may be necessary to accommodate the cable. This removal should be kept to a minimum.

5.1.5.2 Punch & Bore Crossing

An Operational Statement has also been prepared by the DFO (2006b) for physical boring (drilling), referred to as a “punch & bore crossing”. This construction method is not proposed at this time as the cable will be trenched in the nearshore areas by blasting and possibly rock cutting/ripping. This Operational Statement addresses horizontal punching or boring between two points on either side of the watercourse at an appropriate depth below the watercourse to complete the creation of a passage-way for the installation of a conduit without imparting any disturbance to the bed and banks. Physical boring would only be used in the shallow nearshore if trenching by blasting was not implemented and rock cutting/ripping proves not feasible.

A proponent may proceed with physical boring without DFO review when following the conditions are met:

- the crossing technique will not damage the stream bed and bank and therefore would not adversely affect fish or fish habitat;

- the site does not occur at a stream location involving known fish spawning habitat which is dependent on groundwater upwelling; and
- the "Measures to Protect Fish and Fish Habitat when Conducting a Punch & Bore Crossing" are incorporated into the project.

The following measures to protect fish and fish habitat may be applicable for the proposed Project if boring was utilized.

While this Operational Statement does not cover the clearing of riparian vegetation, the removal of select plants may be necessary to access the construction site and to excavate the bell hole. This removal is to be kept to a minimum and within the utility right-of-way.

The bell hole should be excavated beyond the ordinary high water mark, far enough away from the watercourse to allow containment of any sediment or deleterious substances above the ordinary high water mark.

When dewatering the bell hole, water should be treated or diverted into a vegetated area or settling basin to remove suspended solids and prevent sediment and other deleterious substances from entering the watercourse.

Any waste materials removed from the work site (including the bell hole) should be stabilized above the ordinary high water mark to prevent them from entering the watercourse. Spoil piles could be contained with a silt fence, flattened, covered with biodegradable mats or tarps, and/or planted with preferably native grass or shrubs.

The work and disposal areas should be inspected and the watercourse monitored to observe signs of malfunction during all phases of the work.

For the duration of the work, all material and equipment needed to contain and clean-up releases of sediment-laden water and other deleterious substances should be kept on-site and readily accessible.

A response plan should be developed that is to be implemented immediately in the event of a sediment release or spill of a deleterious substance. This plan should include measures to:

- stop work, contain sediment-laden water and other deleterious substances and prevent their further migration into the watercourse;
- notify all applicable authorities in the area, including the closest DFO office;
- promptly clean-up and appropriately dispose of the sediment-laden water and deleterious substances; and
- ensure clean-up measures are suitably applied so as not to result in further alteration of the bed and/or banks of the watercourse.

5.1.5.3 Additional DFO Protective Measures

Construction should be timed to protect spawning fish, their incubating eggs and larval life stages. The timing window considered appropriate for the two Operational Statements is 15 July to 15 September, or the fisheries timing window restriction specific to the project location (DFO, 2006a,b). As indicated in **Section 5.1.1**, scheduling of Project in-water construction activities should avoid the timing restriction between 15 March and 15 July (R. Topping, OMNR Kingston Area Office, 2004, pers. comm.). In-water construction activities will occur outside of the timing restriction window of 15 March to 15 July.

Machinery from outside the water should be operated in a manner that minimizes disturbance to the banks or bed of the waterbody (DFO, 2006a,b). Machinery should arrive on site in a clean condition and be maintained free of fluid leaks. The washing, refuelling and servicing of machinery, as well as the storage of fuel and other materials for the machinery, should be undertaken away from the water to prevent deleterious substances from entering the water. An emergency spill kit should be kept on site in case of fluid leaks or spills from machinery.

Effective sediment and erosion controls should be maintained until complete re-vegetation of disturbed areas is achieved (DFO, 2006a,b).

Any disturbed areas should be vegetated by planting and seeding preferably native trees, shrubs or grasses and covered with mulch to prevent soil erosion and help seeds germinate (DFO, 2006a,b). If there is insufficient time in the growing season remaining for the seeds to germinate, the site should be stabilized (e.g., exposed areas should be covered with erosion control blankets to keep the soil in place and prevent erosion) and vegetated the following spring.

5.1.6 Provincial Guidelines

In addition to the two DFO (2006a,b) Operational Statements, the MOE has developed guidelines for construction activities impacting water resources, including recommended practices for marine construction and mitigation (Persaud and Jaagumagi, 1995). Relevant guidelines for shoreline construction include:

- work should not be conducted during the peak recreational season if such work will unduly interfere with recreation;
- activities in critical habitats such as fish habitat must be approved by the OMNR prior to commencing any work;
- work must not result in water quality impairment that would affect nearby water uses;
- equipment, methods and procedures must be selected so as to minimize turbidity during dredging or filling operations;
- once commenced, the project must be completed as soon as possible;

- any shore areas that have been disturbed should be stabilized and revegetated as soon as possible upon completion;
- surplus material must be adequately deposited at pre-approved sites or put to proper reuse;
- placement of excess material must be above the high water mark (i.e., so that the material will not regain access to the water) and should be stabilized as soon as possible to prevent erosion;
- all debris must be contained in the immediate work area and adequately disposed of on land; and
- gravel and sand to be placed in a lake or river should be clean and free from fine materials and organic matter.

5.1.7 Blasting

As indicated in **Section 3.2**, blasting is the preferred construction technique for nearshore conduit/cable installation. Cutting/ripping and/or physical boring may be implemented in the shallow waters of the immediate nearshore and onshore.

Explosives if used in construction will be closely controlled. Their use will be restricted to authorized personnel who have been trained in the use of explosives in a manner so as to minimize potential effects on the environment. As appropriate, government agencies and the local residents will be informed of the blasting schedule in advance of construction, as well as just prior to the detonation program. All necessary permits will be obtained by the Construction Contractor, who will also comply with all legal requirements in connection with the use, storage and transportation of explosives, including, but not limited to, the *Canadian Explosives Act* and the *Transportation of Dangerous Goods Act*. The Construction Contractor will also be required to retain a consulting engineer with technical expertise in blasting to provide advice on maximum loading of explosives for all blasting activities. The consulting engineer will also provide a report indicating recommended charges and blasting methods to be used at specific locations.

Blasting may require DFO authorization under Section 32 of the *Fisheries Act* to kill fish by means other than fishing. DFO has developed a number of guidelines to provide information to proponents on the protection of fish and their habitat from effects arising from the use of explosives in and near water (Wright and Hopky, 1998). CREC will comply with any requisite application for DFO approval, as well as with all relevant guidelines for the use of explosives in Canadian fisheries waters.

The MOE has also developed guidelines for underwater blasting including recommended practices and mitigation measures primarily avoiding the release of energy beyond that needed to fracture rock (Persaud and Jaagumagi, 1995).

As indicated in **Section 3.2**, blasting will commence at the furthest point from the shore and proceed towards the shore. The initial sinking cut will employ a modified design with two additional holes in order to create the void in the rock into which subsequent blasts will be shot. Drill patterns and explosive loads per period will require adjustment to ensure that DFO guidelines (Wright and Hopky, 1998) are met. Non-sympathetically detonating explosives will be used for in-water blasting, i.e., the explosives used will only fire by a detonator as timed and will not fire from the shockwaves of other explosions. Following each blast, shock-tubes shall be collected and properly disposed of.

With the exception of the sinking cut, a maximum of 5 kg of explosive per period will be used, with most of the blasting employing much reduced quantities of explosive per delay. Based on a 5 kg load, the DFO setback distance as recommended by Wright and Hopky (1998) will be 11 m. Accordingly, a minimum 11 m radius surrounding the blast location will be treated as an “exclusion zone” for each blast. The sinking cut may involve the simultaneous detonation of up to three holes and a corresponding increase in explosive load per delay. In this case, the “exclusion zone” will be increased to comply with DFO setback distances. Blast monitoring will be undertaken to measure water overpressure at the established DFO setback distance.

Blasting will result in minor, localized and temporary changes in water quality. In one study, turbidity and free carbon dioxide concentrations were found to increase after each blast, returning to ambient levels within three hours of the blast (Teleki and Chamberlain, 1978). Turbidity probably will be increased by a few units due to blasting at the cable crossing; however, chemical release is expected to be negligible.

Blasting will result in localized destruction of the benthic community. Benthic mortality will be a function of distance from and intensity of the blast (Schwartz, 1961). However, recovery from blasting is expected to be rapid.

Numerous studies have been undertaken to assess fish mortality due to blasting (e.g., Gowanloch and McDougall, 1944; Aplin, 1947; Fitch and Young, 1948; Coker and Hollis, 1950; Hubbs and Rechnitzer, 1952; Fry and Cox, 1953; Baldwin, 1954; Ferguson, 1962; Kearns and Boyd, 1965; Foye and Scott, 1965; Falk and Lawrence, 1973; Chamberlain, 1976, 1979; Teleki and Chamberlain, 1978; McAnuff and Booren, 1989; Silver and Fitchko, 1992; Keevin *et al*., 1997). The degree of blasting impact on fish will depend on the type of explosive, size and pattern of detonation, type of substrate blasted, water depth, fish physiology and timing.

The lethality of an explosive is directly related to its detonation velocity (Schwartz, 1961; Falk and Lawrence, 1973; Teleki and Chamberlain, 1978), or rate of ignition, which is a distinctive blasting agent characteristic ranging from 1,709 m/s for black powder to 7,625 m/s for specially formulated trinitrotoluene (“TNT”). A more rapid detonation velocity produces a greater resultant hydraulic pressure gradient and greater impacts on fish from resultant pressure changes (Teleki and Chamberlain, 1978). For example, extensive fish kills up to a distance of 61 m were reported when nitrone charges or detonators were used, while mortality was minimal within 7.6 m when black powder charges up to 45 kg were exploded (Ferguson, 1962).

Injury to fish from blasting will result from physical abrasion from ejected debris and from pressure changes associated with the blast shock waves.

Common blast-induced injuries to fish include hemorrhage in the coelomic or pericardial cavity and rupture of the swim bladder. Differences in species-specific susceptibility to blast injuries are a function of the fish's shape and swim bladder formation (Teleki and Chamberlain, 1978). Physoclistic (i.e., with swim bladder isolated from oesophagus) and laterally compressed fish such as the centrarchids, e.g., smallmouth bass, are the most sensitive to pressure changes. Mortality within this group varies with orientation of the laterally-compressed body to the pressure front at the time of a blast. Physostomic (i.e., with swim bladder connected to the oesophagus by an open duct, which provides pressure release) fish with fusiform shape, such as the white sucker, are most resistant to pressure changes. Wright (1982) reported that an overpressure in excess of 100 kPa will result in damage to fish.

Highest mortality generally occurs after the first detonation. For example, Teleki and Chamberlain (1978) reported that, during the first monitored detonation, up to nine dead or injured fish/m^2 were observed, whereas four months later, during the last monitored blast, the density of fish decreased to 0.75 fish/m^2. The constant construction activity in the study area waters may have aided in reducing overall mortality by frightening away fish attempting to recolonize the area.

One study that is relevant to assessing potential blasting impacts of the proposed nearshore cable installation is the construction of the Stelco dock (1,200 m long) at Nanticoke, Ontario (Chamberlain, 1976, 1979; Teleki and Chamberlain, 1978). Rapid ignition explosives (C.I.L. Hydromex type) were used with detonation velocities of 4,938 and 5,486 m/s, and blasting was carried out in 4 to 8 m of water. Blasting was monitored by the OMNR from the beginning (09 June to 02 October 1975) and, as fish losses were not considered serious, protective air bubble curtains or other mitigative measures were not used.

During construction of the Stelco dock, fish kills were localized within 40 to 110 m of blast epicentres. During the summer, up to 40,000 emerald shiner were killed per blast. Freshwater drum were the only other fish species commonly killed (up to 50 per blast). Only a few individuals of economically important species, such as perch and bass, were killed. Results of ultrasonic tracking suggested that these fish remained outside the fatal blast area. Stunned fish receiving a sublethal blast exposure suffered heavy losses through predation, principally by herring gulls.

The emerald shiner population declined slightly based on seine catches in the year following blasting, but increased in the subsequent year. These population changes were well within natural fluctuations. The freshwater drum population appeared to be affected to a greater degree as offshore trapnet catches dropped during the year of blasting to one-tenth that in the pre-construction years. The population increased again six-fold in the subsequent year, presumably due to recruitment from surrounding unaffected areas.

As indicated in **Section 5.1.1**, in-water construction activities will be scheduled in September, i.e., outside of the OMNR Peterborough District construction timing restriction of 15 March to 15 July to protect warmwater fish spawning areas and egg incubation periods.

Rock trenching by blasting will disturb a very small area relative to available nearshore fish habitat around Wolfe Island and the Kingston mainland. Mobile life stages of fish (i.e., YOY, juvenile, adult) will likely move out of the in-water construction areas and remain unaffected.

In an effort to minimize fish mortality in the event of elevated water overpressure levels, scare tactics shall be employed for each blast to rid the immediate blast zone of as many fish as possible. This shall involve submersing a concrete vibrator contained within a section of steel pipe to create sufficient noise to scare the fish outside of the "exclusion zone" and into areas further from the blast with lower and less damaging overpressure levels. In addition, bubble curtains/air curtains will be used as necessary to disrupt the shockwave.

It is proposed that the Contractor will utilize a floating sediment curtain when drilling, blasting, excavating and backfilling. The curtain will be arranged in an oval, with the curtain outside the anticipated lethal zone (for blasting). The curtain will provide a barrier for fish from entering the blasting area, as well as confine suspended sediment generated by the work activities.

Recolonization of the impacted areas by fish species once blasting is over will be rapid (Ferguson, 1962; Falk and Lawrence, 1973; Teleki and Chamberlain, 1978; Chamberlain, 1979).

As blasting operations approach the shore, water depths will decrease thereby limiting the control of flyrock. In order to maintain sufficient blast control, blast matting will be utilized in areas of shallow water. Following each blast, torn pieces of mat will be collected and disposed of in a proper fashion

Blasting will result in permanent localized alterations in the benthic environment due to the fragmentation of the bedrock surface. Indigenous rubble will be used as trench backfill. The resulting changes to local hydrodynamics and benthic community structure are not likely to have a negative effect. In fact, there may be an enhancement of the benthic and fish habitat due to the more heterogeneous substrate.

5.1.8 Direct Impacts of Trenching

As indicated in **Section 3.2**, nearshore trenching at the Wolfe Island and Sand Bay landfalls will involve blasting. Rock cutting/ripping and physical boring may be implemented in shallow waters of the immediate nearshore and onshore. The assessment of potential effects of blasting is provided in **Section 5.1.7**. Conventional dredging will also likely be utilized to excavate the trench at both landfalls and possibly to remove the overburden substrate (less than 0.5 m deep) present in the inshore area of Sand Bay.

The physical disruption of bottom habitat by ripping/cutting, at the physical bore exit hole and due to dredging may have a localized adverse effect on aquatic communities on the surface and within the substrate. The extent of disruption depends on the type of bottom substrate, the extent of the disturbed area, resultant turbidity and siltation, and the timing of construction. For dredging, the greatest effect will occur at the excavation site and its magnitude will decrease with distance from the trench as the effects of turbidity and sedimentation lessen (see **Section 5.1.9**). As the nearshore substrate at the Wolfe Island and Sand Bay landfalls consists of bedrock with a variable cover of coarse substrate, i.e., sand, gravel, cobble and/or boulder, ripping/cutting and physical boring will result in negligible turbidity and siltation.

The physical disruption of bottom habitat may result in mortality and displacement of aquatic macrophytes, benthic organisms and possibly larval fish.

As indicated in **Section 4.13**, aquatic macrophyte growths are abundant and sporadic along the Wolfe Island and Sand Bay landfall nearshores, respectively. However, it is anticipated that revegetation along the disturbed trench route or at the bore exit hole will be rapid due to propagation of the adjacent unaffected macrophyte stands. Therefore, the loss of aquatic macrophytes will be short-term with recolonization anticipated by the next growing season.

The most serious impact of trench excavation is the destruction of benthic faunal communities and some modification of habitat. As a result, localized changes may occur in benthic macroinvertebrate species composition, abundance and diversity.

The magnitude of the impacts on the benthic community can be variable. The duration of trenching activities (controlled blasting, rock cutting/ripping, conventional dredging) and backfilling will affect how long an area remains in a disturbed state, and can influence the duration and extent of harm to species. Relative survival rates of the species will be dependent on their capacity for drifting or moving away from the disturbance. Relative species recolonization rates after backfilling will influence the rate of replacement of any lost organisms in a particular area.

Movements of large numbers of invertebrates into naturally and artificially denuded substrates over very short periods of time have been demonstrated by a number of studies. Recovery is defined as the return of aquatic biotypes after disturbance to an abundance and diversity comparable to that in an adjacent undisturbed control area (Rosenberg and Snow, 1977). The principal mechanism of recolonization by invertebrates is drift (Luedtke and Brusven, 1976; Williams and Hynes, 1977), but other mechanisms, such as lateral migration, vertical migration from within the hyporheic zone (i.e., after burial) and larval recruitment from aerial sources are also important (Luedtke and Brusven, 1976; Williams and Hynes, 1977; Griffiths and Walton, 1978; Hirsch *et al*., 1978). Recovery rates vary and can occur within six days (McCabe *et al*., 1998), fourteen days (Rosenberg and Snow, 1977), three weeks (Diaz, 1994), thirty-eight days (Griffith and Andrews, 1981) and up to about one year (Griffiths and Walton, 1978). The rate of recovery is dependent on ambient environmental conditions, the type of organisms present and the size of the disturbed area.

In general, there will be less impact upon benthic communities associated with a naturally variable, high energy environment, which experiences ongoing disturbance (sediment scour and siltation) due to longshore currents and wave action. The benthic organisms are adapted to the high energy, unstable conditions, and have life cycles that allow them to better withstand these stresses (Hirsch *et al*., 1978).

The nearshore environment of the Great Lakes and the Lower Gap of the St. Lawrence River undergoes seasonal instability, following the annual pattern of coastal erosion. For example, Barton and Hynes (1978b) reported that benthic macroinvertebrate communities consisting mainly of Amphipoda, Trichoptera and Chironomidae develop in the 0 to 2 m zone along the Canadian shores of Lake Erie during the summer. However, the cycle of maximum erosion during autumn storms results in severe reduction of the density of wave-zone fauna. Isolation of portions of the wave-zone by ice ridges, which usually form all the way to the substrate, probably prevents recolonization of the shallower areas during much of the winter, and therefore, spring storms would act upon an already impoverished fauna. Most benthic species probably overwinter offshore and re-enter the wave-zone by drifting via lake/river currents in June and July as the weather becomes calmer.

McCall and Soster (1990) reported that the spatial and temporal bottom distributions of many of the infaunal macrobenthos in western Lake Erie were correlated with disturbance levels, suggesting differential adaptation to a variety of bottom disturbances. The distribution of opportunistic species was patchy and positively associated with a gradient of bottom disturbance due to prevailing southwest winds. Distribution of late colonizers was more even and either unrelated to the gradient or more abundant in lower stress regions. Moreover, small, shallow-dwelling early colonizers appeared to suffer higher mortality during an unusually windy period than the larger, deeper-dwelling, late colonizers.

Disturbances such as storm wave erosion can kill some or all of the resident fauna even in deeper waters. The early stages of colonization are often dominated by high numbers of one or a few species which eventually decline in abundance and are replaced by lower numbers of slower colonizing species. For example, based on defaunated sediment field experiments, Soster and McCall (1990) reported a consistent succession of functional and adaptive benthic types in western Lake Erie. Early colonizers, e.g., the ostracod *Physocypria globula*, the naidid oligochaete *Vejdovskyella intermedia* and the chironomid, *Chironomus plumosus*, exceeded their natural bottom abundances by two to seven times within 40 days, but subsequently decreased in abundance. These species are small and mobile, live and feed close to the sediment-water interface, and reproduce often. Most late colonizers, e.g., the oligochaetes *Limnodrilus* spp. and *Ilyodrilus templetoni*, as well as pisidiid bivalves, reached natural abundances only after several months. These species are large, deep infaunal dwellers that grow slowly and reproduce late in life. An intermediate group, consisting of naidid oligochaetes, i.e., *Arcteonais lomondi*, *Specaria josinae*, *Pristina acuminata*, *Dero digitata*, and the chironomids *Procladius* sp. and *Coelotanypus* sp., reached their natural abundances early but did not exceed them.

Reductions in biomass, species number and population size of the benthic biota will be inevitable in the trench zone (or at the bore exit hole if used). However, as indicated above, recolonization is expected to be rapid (i.e., within six days to one year) and the net impact will be negligible.

As indicated in **Section 4.14**, dreissenids are prevalent in the landfall nearshores. These and other benthic taxa present in the nearshore are tolerant of disturbance, (e.g., Barton and Hynes, 1978a,b), and recovery is expected to be rapid after completion of nearshore trench excavation by controlled blasting, ripping/cutting, physical bore construction or conventional dredging.

As indicated in **Section 4.15**, the cable crossing nearshores are likely used as spawning and/or nursery habitat by a number of fish species. As indicated in **Section 5.1.1**, in-water construction activities will be scheduled outside of the OMNR Peterborough District construction timing restriction of 15 March to 15 July to protect warmwater fish spawning areas and egg incubation periods.

Controlled blasting, conventional dredging, rock trenching by ripping/cutting and/or the exiting borer will disturb a very small area relative to available nearshore fish habitat around Wolfe Island and the Kingston mainland. Mobile lifestages of fish, (i.e., YOY, juvenile, adult) will likely move out of the in-water construction areas and remain unaffected.

Controlled blasting, ripping/cutting will result in permanent localized alterations in the benthic environment due to the fragmentation of the bedrock surface. Indigenous rubble will be backfilled into the trench. The resulting changes to local hydrodynamics and benthic community structure are not likely to have a negative impact. In fact, there may be an enhancement of the benthic and fish habitat due to the more heterogeneous substrate.

Adherence to the DFO (2006a,b) measures to protect fish and fish habitat (see **Section 5.1.5**) will minimize or prevent potential adverse environmental effects of nearshore cable installation. As indicated in **Section 5.1.7**, a floating sediment curtain will be utilized to surround the construction area. Although its purpose will be primarily to keep fish away from the blasting area, the curtain will also minimize the movement of sediment generated by work activities.

Overall, the effects of nearshore cable installation on the benthic ecosystem and fisheries resources of the Lower Gap will be minor, localized and temporary.

5.1.9 Turbidity Generation and Siltation

As indicated in **Section 5.1.8**, ripping/cutting and physical boring undertaken for nearshore cable installation will result in negligible turbidity and siltation due to occurrence of bedrock with a variable cover of coarse substrate at the Wolfe Island and Sand Bay landfalls. Similarly, blasting will result in slight and temporary increases in turbidity (Teleki and Chamberlain, 1978). Although turbidity increases are expected to be minor, localized and temporary, installation of a floating sediment curtain is planned during the nearshore construction activities at the landfall locations.

As indicated in **Section 3.2**, inshore trenching at the Sand Bay landfall on the Kingston mainland may involve conventional mechanical dredging, likely a clamshell dredge and/or backhoe.

Mechanical dredging methods result in local sediment resuspension. Sediment is resuspended when the bucket impacts the substrate, is drawn from the substrate and is pulled through the water column.

Sediment resuspended during dredging will eventually settle on the surficial layer of the area previously dredged and to be dredged, or be transported and re-deposited outside of the removal area. As indicated in **Section 4.9**, coarse surficial sediment (less than 0.5 m in thickness) occurs in the inshore of Sand Bay (**Figure 4.10, Appendix** A).

Temporary increases in suspended solids would be expected as a result of dredging activities. The time that the particles remain suspended depends on their settling velocities and water turbulence. The distance of travel by the sediments from the source to the point of deposition depends on the current velocity. Colloidal and flocculated materials in particular will remain suspended and will travel further downcurrent before resettlement.

Particle size of the sediments is used to establish the rate with which particles settle. Sand and gravel settle rapidly, while silt and clay may remain in suspension for a long time. The sands will settle at a fast rate producing little or no long-term turbidity plume. Any silt component will also settle out of the water column; however, because of its lower settling velocity, increased turbidity will result for a longer period of time. As indicated above, the inshore sediment in Sand Bay is primarily sand and cobble. It is anticipated that disturbance of these larger-grained sediments will result in little turbidity generation in the shallow waters of the bay with rapid attenuation of suspended solids concentrations and turbidity to background concentrations.

The effect to aquatic organisms by increased suspended sediment levels is a function of the concentration of sediments in water times the duration of the organism's exposure (Newcombe and MacDonald, 1991).

In general, the temporary increases in turbidity during trench excavation may reduce light penetration and interfere with photosynthesis and primary productivity. Reduction of phytoplankton and aquatic macrophyte productivity, if any, will be localized and temporary.

Zooplankton may be affected by impairment (clogging) of the feeding apparatus. Zooplankton have the capability of limited migration and may be able to avoid the zone of turbidity increase.

Overall, impacts on plankton and aquatic macrophytes are predicted to be minor, temporary and localized.

Other filter-feeding organisms, e.g., clams, respond to increased turbidity levels by reducing their filtration (feeding) rates. However, mortality only occurs after a number of days exposure to total suspended solids (“TSS”) concentrations of 10,000 mg/L or higher.

The suspension of sediment into the water column will cause siltation of contiguous benthic communities. If large quantities of sediment are deposited, e.g., forming spoil mounds, these communities will be disrupted. Sensitive species of sedentary invertebrates will be most affected primarily due to smothering.

In Sand Bay, the benthic communities are constantly subjected to habitat alteration due to current flow, as well as wave action caused by storms. As discussed in **Section 5.1.8**, recovery of benthic communities in areas of disturbance can be expected to be rapid. Therefore, siltation and turbidity will have a minimal short-term impact on benthic communities adjacent to trench excavation.

Sediment suspended by trench excavation may, in sufficient concentration, have a direct effect on fish as well as filter-feeding organisms. The mechanical and abrasive action of fine sediments may clog and otherwise injure the gills of fish as well as the respiratory structure of various aquatic forms such as molluscs (Ellis, 1936). Normally, fish will continuously secrete quantities of mucous which will wash away suspended particles as they lodge on the gills and other exposed parts. Consequently, healthy and uninjured fish can move through very turbid water and sustain little or no mechanical injury to gills. For example, short-term studies of montmorillonite clay suspensions showed no lethal effect on juvenile or adult warmwater fish species at the extremely high suspended sediment concentrations of 20,000 to 100,000 mg/L (Wallen, 1951). Generally, most fish species will avoid high turbidity waters, although some species will make use of turbidity for cover, when other cover is not available (Suchanek *et al.*, 1984a,b).

Servizi and Martens (1987, 1991, 1992) have shown that tolerance of salmonids to suspended sediments from the Fraser River (British Columbia) is dependent upon such factors as life stage and condition of the fish, water temperature and sediment particle size. For example, fingerling coho salmon were more tolerant than fry. Tolerance was reduced among juvenile coho salmon with a viral kidney infection. Juvenile coho salmon were most tolerant of suspended solids at 7.0°C, with a mean 96-h LC50 of 22,700 mg/L, whereas at 16°C, the 96-h LC50 was 1,300 mg/L. The 96-h LC50s for juvenile sockeye salmon decreased with increasing particle size, e.g., 17,560 mg/L for fine sediment (<74 µ) and 1,674 mg/L for coarser sediment (180-740 µ). However, fine sediments were found to lodge in the gills of the sockeye salmon and cause gill trauma at 3,148 mg/L, or about 0.2 of the 96-h LC50 value. Based on laboratory results, the authors speculated that sublethal responses (e.g., avoidance behaviour, i.e., preference for less turbid surface water, and increases in blood sugar levels and cough frequency) could be expected at naturally occurring suspended solids levels in the Fraser River with typical TSS concentrations in the spring between 300 and 600 mg/L and sometimes exceeding 1,000 mg/L.

In contrast, Lake and Hinch (1999) reported that mortalities of juvenile coho salmon were not observed until suspended sediment (crushed silica) concentrations were about 100,000 mg/L (96-h LC50 of 164,500 mg/L). It was opined that, since the sediments used by Servizi and Martens (1987, 1991, 1992) were taken from deposition zones in the lower Fraser River, an area influenced by non-point-source pollution that contains high levels of sediment-bound contaminants, these contaminants may have influenced the bioassay results. The silica sediments used by Lake and Hinch (1999) were acid-washed prior to the bioassays, and therefore the likelihood of contaminant influences on their test results would be minimal. Therefore, the Lake and Hinch (1999) data are more relevant to the uncontaminated sediments in Sand Bay (**Section 5.1.10**).

A 1,000 mg/L TSS concentration value generally represents the approximate threshold at which few, if any, sublethal effects are elicited in most fish species, e.g., no behavioural (avoidance), histopathological and plasma chemistry effects (Fitchko, 2002c). This TSS concentration may elicit feeding impairment, particularly in visual feeders, and/or increased coughing (gill clearing) frequency. However, fish are mobile and can avoid TSS concentrations potentially affecting feeding behaviour and/or coughing reflex. A number of fish species prefer turbid waters or use turbid waters for cover when other cover is not available, especially in open lake waters. A 10,000 mg/L TSS concentration value generally represents the approximate threshold mortality level for some fish species exposed for 24 h or longer (Fitchko, 2002c). Again, due to their mobility, fish can avoid areas of elevated TSS concentrations.

The TSS concentrations generated by hydraulic and mechanical dredging operations are well below the 1,000 mg/L threshold value for sublethal effects (**Table 5.1, Appendix B**). Any declines in nearby fish populations during construction will be related to site avoidance rather than mortality. Recovery of fish populations in turbid areas is expected to be rapid after turbidity attenuation. In fact, after construction, fish may be attracted to the disturbed area by exposed prey organisms. Distinct fish community transformations occur only when severe and persistent sedimentation occurs (Barton, 1977).

Silt curtains and silt screens are commonly used during dredging operations to control the potential effect of turbidity on an important environmental resource or water use. As indicated in **Section 5.1.8**, a floating sediment curtain will be utilized to surround the construction area to confine movement of suspended sediment. The coarse substrate and shallow waters will result in rapid sedimentation of the suspended sediment.

Huston and Huston (1976) reported that the best techniques for reducing turbidity consist principally of good dredging procedures and operations related to the dredging and spoil transportation equipment used, the experience of the Contractor and the dredging plan specifications. When these techniques are consistently applied, not only will dredge-induced turbidity be reduced, but a more economical operation will prevail in most instances.

For dredging projects, the OMNR usually establishes site-specific compliance criteria based on a TSS concentration not to be exceeded at a designated distance from the dredging location.

In summary, studies have shown that turbidity impacts due to dredging and spoil disposal are of a short-term nature, i.e., quickly dissipating after activity cessation; decrease rapidly with distance from the dredging site (**Table 5.1, Appendix B**), thereby affecting a localized area; and are generally within the range of natural fluctuations, e.g., during storm events (Hiltunen and Krzynowek, 1974; Stern and Stickle, 1978). Fish mortality due to clogging of gill filaments and opercular cavities is highly unlikely at the suspended sediment concentrations found during conventional dredging operations (International Working Group on the Abatement and Control of Pollution from Dredging Activities, 1975).

5.1.10 Chemical Releases from Sand Bay Sediments

Sediments are the principal sinks for heavy metals, organics and other contaminants in aquatic systems. However, remobilization of contaminants from polluted bottom sediments to the water column can occur due to physicochemical changes at the sediment-water interface such as physical disturbance or alteration of dissolved oxygen concentrations. The most favourable conditions for contaminant release are reducing conditions (low redox potential) in the sediments and low oxygen concentrations in the overlying waters. With decreasing oxygen concentrations, some contaminants tend to be more soluble and numerous studies have reported increased concentrations of such parameters as iron, manganese, phosphorus, ammonia and sulphide when conditions change from oxic to anoxic at the sediment-water interface (Mortimer, 1941, 1942; Krauskopf, 1957; Gambrell *et al.*, 1976). In contrast, the occurrence of high oxygen concentrations in the overlying water will result in the precipitation of iron and manganese as hydrous oxides which will scavenge (coprecipitate) other heavy metals, phosphorus and other contaminants from the water column (Jenne, 1968; Murray, 1975; Swallow *et al.*, 1980).

Burks and Engler (1978) reviewed published literature and the results of the Dredged Material Research Program of the U.S. Army Engineer Waterways Experiment Station at Vicksburg, Mississippi. They concluded that dredging and open-water disposal can have a temporary impact upon the receiving aquatic environment if the dredged sediments contain elevated concentrations of chlorinated pesticides, PCBs or ammonia. Heavy metals can be released from sediments at certain combinations of pH and oxidation-reduction potential, but probably would not be released by most typical dredging or disposal operations.

Numerous studies have indicated that the concentrations of contaminants are correlated with the surface area of the sediment particles, i.e., higher concentrations occur in finer-grained sediments, such as silt and clay (Shimp *et al.*, 1971; Oliver, 1973; Fitchko and Hutchinson, 1975). As indicated in **Section 4.11**, contaminant concentrations in the sediments of Sand Bay were low due to the low sorption capacity of sand (**Table 4.17, Appendix B**). Based on the low concentrations of contaminants in the Sand Bay sediments, chemical releases will be negligible (i.e., not measurable), localized and temporary. Therefore, no mitigative measures are required.

5.1.11 Submarine Cable Laying

As indicated in **Section 3.2**, the proposed transmission cable will be trenched in the nearshore for a distance of up to 125 and 500 m at the Wolfe Island and Sand Bay landfalls, respectively, and subsequently laid along the bottom of the river for a distance of about 7.8 km. Adherence to the DFO (2006a) measures including construction timing to protect fish and fish habitat will minimize potential effects of submarine cable installation on fisheries resources. The physical laying of cable on the offshore substrate will have negligible effect on fish or fish habitat during in-water construction.

Other potential issues/concerns of submarine cable laying are the direct impacts on the benthic communities, turbidity generation, potential chemical releases from the disturbed sediments and water uses.

5.1.11.1 Benthic Communities

The laying of the 235 mm diameter cable on the riverbed will have negligible effect on the benthic macroinvertebrate communities. As indicated in **Section 4.14**, quagga mussel and immature dreissenids are prevalent along the proposed cable route comprising between 3.17 and 64.3% of total benthic macroinvertebrate abundance. Chironomids and tubificid oligochaetes are the next most abundant benthic groups. These benthic taxa are tolerant of disturbance and recovery is expected to be rapid after cable installation (see **Section 5.1.8**). In fact, the cable surface may provide suitable substrate for dreissenid encrustation. Therefore, no mitigative measures are required.

5.1.11.2 Turbidity Generation

The surficial sediments along the initial cable crossing route have a high proportion of sand ranging from 45.8 to 95.3% (**Table 4.8, Appendix B**). A similar high proportion of sand can be expected in the sediments along the proposed cable route. As the cable is laid on this sediment, there will likely be a localized minor and temporary increase in turbidity due primarily to the resuspension of finer particles (i.e., clay and silt). Rapid attenuation of this turbidity to background concentrations is anticipated due to dispersion and settling (enhanced by coagulation and cohesion) processes.

Overall, the effects of this increased turbidity on the benthic environment will be negligible, localized and short-term. As a result, no mitigative measures are required.

5.1.11.3 Chemical Releases from Sediments

A detailed discussion of potential chemical releases from sediments is provided in **Section 5.1.10**.

Sediment analyses have confirmed that the sediments along the initial cable route are characterized as generally uncontaminated by toxic chemicals (**Section 4.11**). Although concentrations of nutrients, cyanide, most heavy metals, p,p-DDD, p,p-DDE and total PCBs in one or more of the four samples collected along the initial route exceeded the PSQG LEL and/or federal ISQG, only a few exceeded the PSQG SEL or federal PEL. Similar sediment quality is expected along the proposed transmission line route.

The total concentrations of contaminants in the sediments have little relationship to their potential release to the water column or their availability to biological organisms. Many studies have shown that much of the total concentration of heavy metals in sediment material is not readily solubilized, as it is associated with less reactive phases, e.g., in the mineral lattice of crystalline solids, strongly sorbed to particulate surfaces, and in organic materials (Gibbs, 1973; Walters and Wolery, 1974; Brannon *et al*., 1976). Similarly, organic compounds such as PCBs and organochlorine pesticides, generally have a low solubility and are tightly sorbed by clay particles (Choi and Chen, 1976; Karickhoff *et al*., 1979; Wu and Gschwend, 1986).

As indicated in **Section 4.8**, thermal stratification occurred at the deepest sampling location along the proposed cable route with marked D.O. depletion (2.8 mg/L) near the sediment/water interface. The localized resuspension of surficial sediments due to cable laying under depleted D.O. conditions may favour the release of some contaminants. As indicated in **Section 5.1.1**, cable crossing timing is in the fall when thermal stratification has dissipated in the Lower Gap.

Overall, chemical releases during cable laying are expected to be negligible (i.e., not measurable), localized and temporary. Therefore, no mitigative measures are required.

Although uptake of contaminants by benthic organisms may increase slightly over the short term, no net effect will likely result since these organisms are in contact with the contaminants in the surficial sediments and are continually removing them from their bodies by depuration over their life span.

5.1.11.4 Effects on Water Uses

Any disruption of sportfishing, commercial cruise traffic, boating, sailing, windsurfing and other recreational activities would be temporary and localized due to the limited physical disturbance and noise resulting from water based construction activities. However, the area affected will be insignificant to most recreational users.

As indicated in **Section 4.19**, there are three prime windsurfing locations off the Point Pleasant-Patterson Point peninsula (**Figure 4.16, Appendix A**). As the proposed cable route is to the east (downstream) of these locations, construction activities will not affect windsurfing activities. Moreover, scheduling of construction in the fall of 2008 will avoid the period of most intensive use during the summer.

Construction may potentially interfere with sportfishing and recreational boating by restricting access during nearshore trenching for safety reasons. The landfall areas are not intensively used by sport fishermen or recreational boaters. The potential effects on recreational activities will be minimized through a Notice to Mariners issued with Transports Canada's Vessel Traffic Centre, by maintaining close communication with the commercial operations and managers of yacht clubs and marinas in the area, and possibly with the use of a guide boat. Demarcation of the work area, ahead of initiating construction works should ensure the safety of the public and minimize interference with regular boating activities. The barge installing the cable shall be lit in accordance with the Collision Regulations in the Canada Shipping Act and indicate that it is restricted in it's ability to maneuver. The cable route avoids the commercial shipping channels within the St. Lawrence River. In-water construction scheduling in September (after Labour Day) will avoid the peak recreational, competitive (e.g., CORK) and commercial cruise boating periods.

Cable construction should not have an adverse effect on the local commercial fisheries. As indicated in **Section 4.19**, the commercial fishery in the Upper St. Lawrence River is a coarse fish industry. Fishers may use hoopnets and trapnets for most fish species and large-mesh gillnet for carp. If appropriate a temporary exclusion zone surrounding the work area may be established during the approximately one week period of in-water construction at each landfall. During this time, fishers will be able to set their nets and harvest fish outside this exclusion zone. The Ontario Commercial Fisheries' Association will be contacted to inform them of construction details and schedule.

Proper precautions will be taken to prevent damage to any existing navigation buoys due to construction activities. The cable route GPS coordinates will be provided to the Coast Guard and/or the Canadian Hydrographic Service Branch of DFO for demarcation on all navigation charts and signs will be posted at each shoreline warning boaters of a submerged cable crossing.

As indicated in **Figure 3.1 (Appendix A)**, the revised cable route will avoid the industrial intakes and Hydro One submerged power cables at the Kingston mainland nearshore. Nearshore construction activities will not result in increased turbidity levels at the Kingston West WTP.

5.1.12 Pollution Control

The Construction Contractor will be required to operate and maintain equipment to ensure protection of river water quality. Spill contingency and response plans, spill response training, proper notification procedures, and necessary cleanup materials and equipment will be also required under the contract. A CEMP will be prepared prior to construction and will be consistent with the Marine Pollution Contingency Plans for Spills of Oil and Other Noxious Substances developed for the St. Lawrence River (Environment Canada *et al*., 1994; U.S. Coast Guard, 1999).

Operating procedures will be established for liquid and solid waste management. For example, sanitary wastes generated on the construction vessel(s) will be transported to shore and treated in waste treatment facilities. Other wastes and residuals generated will be collected, stored and properly disposed of on shore. All construction activities on the river shall meet or exceed environmental quality discharge requirements of the regulatory authorities. Zero black water and grey water discharge from all vessels shall be maintained throughout the construction period.

Good maintenance and housekeeping practices will reduce the possibility for accidental release of wastes and materials to the lake waters, e.g., petroleum leaks from operating equipment, and small amounts of trash and other solid and liquid wastes accidentally blown, dumped or spilled overboard. All related effects are predicted to be negligible.

5.1.13 Heritage Resources

As indicated in **Section 4.20**, a Stage 1 archaeological assessment has been undertaken by The Archaeologists Inc. (2006). This assessment recommended a Stage 2 (or similar) marine archaeological assessment be undertaken.

As indicated in **Section 4.1**, a geophysical/geotechnical survey was undertaken in the spring of 2007 to delineate any archaeological resources along the proposed cable route. No marine archaeological resources were identified.

Should any cultural finds be unearthed during construction, the Construction Contractor will be required to take immediate measures to protect the site. As set out in the CEMP, the location of any such sites will be brought to the attention of provincial authorities for official assessment. To the extent practical, construction activities will cease at that location to avoid damage to the cultural resources. A licensed archaeologist will be retained to assess the importance of the find. The implementation of these measures will ensure that cultural resources are adequately protected.

5.1.14 Socio-Economic Assessment

In terms of the cable work creating potential socio-economic effects during construction, the magnitude and significance of the effects will be directly related to the following:

- number of residents disturbed by the construction activities;
- number of community facilities or resource areas disturbed by the construction activities;
- the need for additional infrastructure, e.g., access roads;
- the ability of a community to supply the project with required goods and services;
- the size of the construction work force requiring local accommodation, supplies and services;
- the length of time members of the work force are resident in a community; and
- the time of year.

Cable construction can also result in substantial benefits to local communities. These include:

- economic stimulation through project purchases and spending; and
- investing in the local labour markets.

It is important to maximize the benefits of the cable work while reducing any negative aspects. General mitigation measures related to potential socio-economic issues will include the following:

- ensure proper construction procedures are followed to minimize nuisance effects associated with dust, environmental noise and aesthetic disturbance; and
- promptly respond to project concerns raised by local officials or the public.

The majority, if not all, of the project needs (e.g., fuel, food, sundries) can be accommodated by the surrounding communities. These communities should benefit positively from construction-related expenditures. The Construction Contractor will be encouraged to buy project materials and services in the local area if available in sufficient quantity/quality and at competitive pricing.

Approximately 10 to 15 workers will be employed during nearshore trenching. This is a very small proportion of the available local workforce, and not all of these workers will be hired locally. The project workforce will be small enough that the community should easily absorb the additional needs for goods and services.

The submarine cable work force will consist of foreign workers associated with the cable laying vessel to come from Europe. The Wolfe Island and Kingston mainland landfalls will be adjacent to Highway 96 and Sunny Acres Road, respectively. Increased traffic during construction is likely. Mitigation measures that can be implemented to minimize these effects include discussions with road transportation agencies regarding road restrictions, haul routes and traffic safety. Occasional disruptions at the construction access location can be minimized by providing advance notice to police agencies; posting construction signs to alert oncoming motorists of construction activities; and/or assigning a traffic control duty officer to assist truck entry and exit, as required.

Overall, negative socio-economic effects are expected to be minimal since:

- few residents will be disturbed by the construction activities;
- no community facilities or resource areas will be disturbed by the construction activities;
- little additional infrastructure will be required;
- the majority, if not all, of the project support needs can be accommodated by the surrounding communities;
- the project workforce will be small enough that the communities should easily absorb the additional needs for goods and services; and
- members of the temporary workforce will reside in the community for a relatively short time (generally less than a month depending upon the construction activity).

5.1.15 Possible Effects of Malfunctions During Construction

Based on analysis of geophysical and geotechnical data, Campbell (2007) concluded that the initial cable route was relatively free of hazards and adequate for cable installation. Moreover, the geophysical survey has confirmed that the submarine cable can be positioned between the existing power cables and the intake pipes (**Figure 3.1, Appendix A**).

With any project there are many potential malfunctions that could occur during construction. Although unlikely, deficiencies in the cable can occur as a consequence of failures in engineering design, cable manufacture, supply or installation. However, Quality Assurance and Quality Control practices and procedures of the Contractor will be subject to review and approval by CREC prior to implementation.

Other malfunctions can be related to spills which are addressed in **Section 5.1.12**, as well as the failure of various control or mitigative measures due to the occurrence of unexpected conditions, such as construction during severe storm conditions. To the extent possible, it is important that inclement weather be anticipated by the Construction Contractor as early as possible prior to submarine cable installation initiation to ensure work continues to completion.

Malfunctions (e.g., cable damage requiring repair, or severe storms affecting mitigative measures) could result in a prolonged construction schedule and therefore extension of the duration of potential environmental effects. The Construction Contractor should endeavour to minimize the amount of construction time required to install the cable.

During cable installation, the Construction Contractor will oversee safety and environmental aspects of construction at the field level. The Construction Contractor will confirm that all safety and environmental requirements (as described in the CEMP) are met. The Construction Contractor will have the authority to shut down construction activities if they are not in compliance with safety and environmental requirements.

5.2 OPERATIONAL EFFECTS

5.2.1 Air Quality and Environmental Noise

As there will be no air or noise emissions from the submarine cable installed in the Lower Gap, there will be no effects on air quality and environmental noise.

5.2.2 Geology, Physiography and Soils

Once the cable is installed and operational, there will be no operational effects on geology, physiography and soils. There will be a negligible temperature increase in the landfall soils surrounding the cable.

As discussed in **Section 4.4**, the proposed cable crossing lies in a zone of mild potential for seismic activity. Past seismic disturbances have had no impact on utility transmission and distribution systems in Ontario, Quebec and New York State. As a result, no effect on the cable due to seismic activity is anticipated.

5.2.3 Lower Gap Environment

As the electricity moves through the cables, the cables become slightly heated. This heat will be rapidly dissipated in the surrounding waters during operation. It is unlikely that there will be any measurable effect of this heat release on sediment characteristics, benthic biota, water quality, water column biota or water uses. All Lower Gap species survive much greater thermal stresses over the course of the year.

5.2.4 Electromagnetic Field Potential

Electric fields are the result of voltages applied to electrical conductors and equipment. The cable will not affect the ambient electric field because the conductor will be shielded, as well as covered by sand, concrete slabs and soil at the landfalls and sand and bedrock in the nearshores.

Unlike electric fields, most materials do not easily block magnetic fields. The underground submarine cable will produce magnetic fields. The only effect of the cables on the ambient electrical environment will be on the local geomagnetic field as a weak magnetic field source. While a number of species are reported to be capable of detecting changes in the Earth's magnetic field, the narrow linear feature of the field around the cable makes it unlikely that long distance navigation, migration, or major behavioural patterns of those species would be affected. The effect of the cable located on the riverbed on the magnetic field at the water surface will be too weak to materially affect compass readings. Also, very small changes in the intensity and direction of the ambient magnetic field over the cable has no known significance with respect to human health.

Little has been published about the potential effects of electric and magnetic fields (EMF) on the natural aquatic environment. There has been some general public concern about these effects, in particular for electrosensitive fish. Electrosensitive fish, such as sharks and rays in oceans and some species of catfish in fresh water, can orient themselves in response to very low electric fields by means of electroreceptive organs. Some investigators have suggested that human-made EMF from underwater power cables could interfere with the prey sensing or navigational abilities of these animals in the immediate vicinity of the power cables (WHO, 2005). However, the WHO (2005) has concluded that "the limited number of published studies addressing the risk of EMF to aquatic ecosystems show little or no evidence of a significant environmental impact, except for some effects near very strong sources". From current information, the exposure limits in the International Commission on Non-Ionizing Radiation Protection guidelines for protection of human health are also protective of the environment (WHO, 2005).

Gill *et al*. (2005) have indicated that the European eel (*Anguilla anguilla*) and Atlantic salmon may be capable of responding to anthropogenic electric fields; however, the WHO (2005) reports that none of the studies performed to date to assess the impact of undersea cables on migratory fish (e.g., salmon and eels) have found any substantial behavioural or biological impact.

Channel catfish, American eel and Atlantic salmon have been recorded in the Upper St. Lawrence (**Table 4.29, Appendix B**). Some salmonid species migrate from eastern Lake Ontario into the Upper St. Lawrence River and its tributaries when lower water temperatures permit.

In summary, the only effect of the proposed submarine cable on the existing electrical environment will be a weak perturbation of the earth's magnetic field. The levels of the magnetic field over the cable during maximum power transfer are too weak to pose any risk to public health, adverse environmental effects on aquatic biota, or interference to compass-based navigation.

5.2.5 Accidents and Malfunctions

Hazards to an offshore exposed cable include earthquakes; bottom slides; anchors; bottom alignment, such as local rock outcrops; erosive action due to bottom currents; and impaired cable stability due to currents.

Although there are no officially designated anchorages for vessels in the cable crossing area, vessels navigating the St. Lawrence River during bad weather have been known to drag their anchors to help control their movement. As indicated in **Section 4.19**, no large commercial commodity vessels use the Greater Kingston Public Port; however, the Lower Gap experiences significant recreational and commercial tour boat traffic, particularly in the summer. For a proposed submarine cable crossing of Lake Erie from Nanticoke, Ontario, to western Pennsylvania, C-CORE (2002) determined that the risk of a dragged anchor affecting the cable is $6x10^{-3}$ (1 in 180 years), whereas for dropped anchor impact, the risk is $6x10^{-5}$ (1 in 17,000 years). To mitigate this risk, the proposed submarine cable crossing will be clearly marked on all navigational charts for the St. Lawrence River and "Notice to Mariners" will be issued. As indicated in **Figures 3.1** and **4.2**, there are a number of existing submarine power lines traversing the Lower Gap.

As indicated in **Section 3.2**, the cable system will include a fibre optic cable for communications between the two interconnecting transformer stations and for the redundant protective relaying system, which will continuously monitor the voltage and current in the cable. This system will disconnect the cable from the transmission system in approximately 0.1 s or less in the unlikely event of damage.

Should a cable failure occur, the location of the fault will be immediately determined based on state-of-the-art fault location equipment at the transmission station. As necessary, communications should be made with appropriate regulatory agencies, e.g., Transport Canada, DFO, MOE and/or OMNR, at least 24 h prior to repair, and would include location, method and date of the repair work. Every effort should be made to repair the cable as soon as possible while accommodating the concerns of regulatory agencies and interested parties.

Possible procedures for the repair of the submarine cable include mobilization of a splice boat by the repair crew and precise determination of the location of the fault. The splice boat will likely be a barge, equipped with hoisting equipment and other tools typically used in repairs of cables. Spare cable will be available at the transformer station. The repair vessel would be positioned above the cut cable, and one end of the cable would be raised to cut off the damaged portion. A cable splice would be performed between the retrieved cable and the spare cable onboard. Subsequently, the cable would be payed out and the boat moved to the other cable end while keeping a portion of the spare cable onboard. Once the other cable end is retrieved, the damaged portion of the cable would be cut off and spliced between the retrieved cable and the spare cable onboard. The second joint and position would then be lowered on to the river bottom.

The design of the power cables for the proposed Project inherently provides for a substantial degree of safety and reliability for both the system and the public. As indicated in **Section 3.2**, the high voltage conductor is encased in insulating material. This covering reduces the cable surface voltage to zero and effectively shields any electric field. The covering also provides protection in the unlikely event of breakage.

5.3 REPOWERING/DECOMMISSIONING

The design life of the Wolfe Island Wind Project is estimated to be 30 years; however, it is not uncommon for well-maintained projects to have a longer useful life than the design life. To extend the life of the wind plant, it is possible that it will be repowered. Repowering may involve switching/updating gearboxes and generators with new equipment, exchanging blades and upgrading electrical equipment. However, if during the Project's useful life, it is no longer required to meet the Province's renewable energy needs, it could be dismantled and transported to another location.

If the wind plant is repowered, it is likely the submarine cable would continue to be used in its present capacity. In terms of decommissioning, currently, there is no legal requirement under Canadian or international law to remove abandoned marine cables from the sea or lake bed. Therefore, it is possible that the submarine cable will be abandoned *in situ*. An abandonment plan would be prepared in consultation with regulatory agencies prior to abandonment. The abandonment procedures would be in compliance with the requirements of all federal and provincial regulations that are in place at the time of abandonment. A likely abandonment scenario would involve cutting the cable onshore and leaving the lake crossing segment in place. Cable abandonment will not pose a hazard to fishing or other marine activities.

5.4 SUMMARY

As indicated in **Section 2.0**, the proposed Project is subject to both provincial and federal EA processes. For the provincial EA process, prior to undertaking a detailed evaluation, a screening-level analyses of a proposed electricity project using screening criteria is completed in order to focus on potential negative effects resulting from the project. For the proposed Wolfe Island Wind Project, the results of the screening-level analysis is provided in **Table 5.2** (**Appendix B**). For the purpose of completing the checklist, mitigation or impact management measures are not considered. The answer 'Yes" to a question indicates only that there is a potential for an adverse effect to occur. This adverse effect could most likely be managed through appropriate mitigation measures or compliance with regulatory requirements. Potential effects due to the proposed submarine transmission line crossing of the Lower Gap, delineated under the "Additional/Supporting Information" column in **Table 5.2** (**Appendix B**), are italicized.

Table 5.3 (**Appendix B**) summarizes potential construction and operation effects based on the MOE (2001) screening criteria (**Table 5.2, Appendix B**), the recommended mitigative/remedial measures to minimize or obviate these effects and the net effects.

Table 5.4 (Appendix B) provides a summary of the significance of environmental effects associated with the proposed cable crossing of the Lower Gap, taking into account mitigation measures and CEAA (1994) criteria for determining adverse effects (**Appendix E**). As indicated by CEAA (1994), the most common way of determining whether the environmental effects are adverse or beneficial is to compare the quality of the environment before the project with the predicted quality of the environment with the project in place. Overall, impacts of the proposed undertaking will be minor, localized and temporary.

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6.0 Conclusion

For nearshore trench construction, some effects, e.g., localized faunal mortality due to blasting, cutting/ripping and/or dredging and temporary disruption of habitat by trench excavation, will be unavoidable. Adherence to a tight construction schedule with minimum lag between activities will minimize project impacts. Furthermore, careful planning and execution of good construction practices will reduce the overall magnitude of the resulting effects on the Lower Gap aquatic environment. Impacts on fisheries resources will be minimized by scheduling construction to avoid the sensitive fish spawning and egg incubation period. Proper scheduling and management of construction will minimize conflicts with water uses.

With the implementation of the recommended mitigative and remedial measures identified in this report and carried over to detailed design, the proposed transmission line crossing should not have any significant impacts on the environment.

STANTEC CONSULTING

Jerry Fitchko, Project Manager

Peter G. Prier

Peter Prier, Project Director

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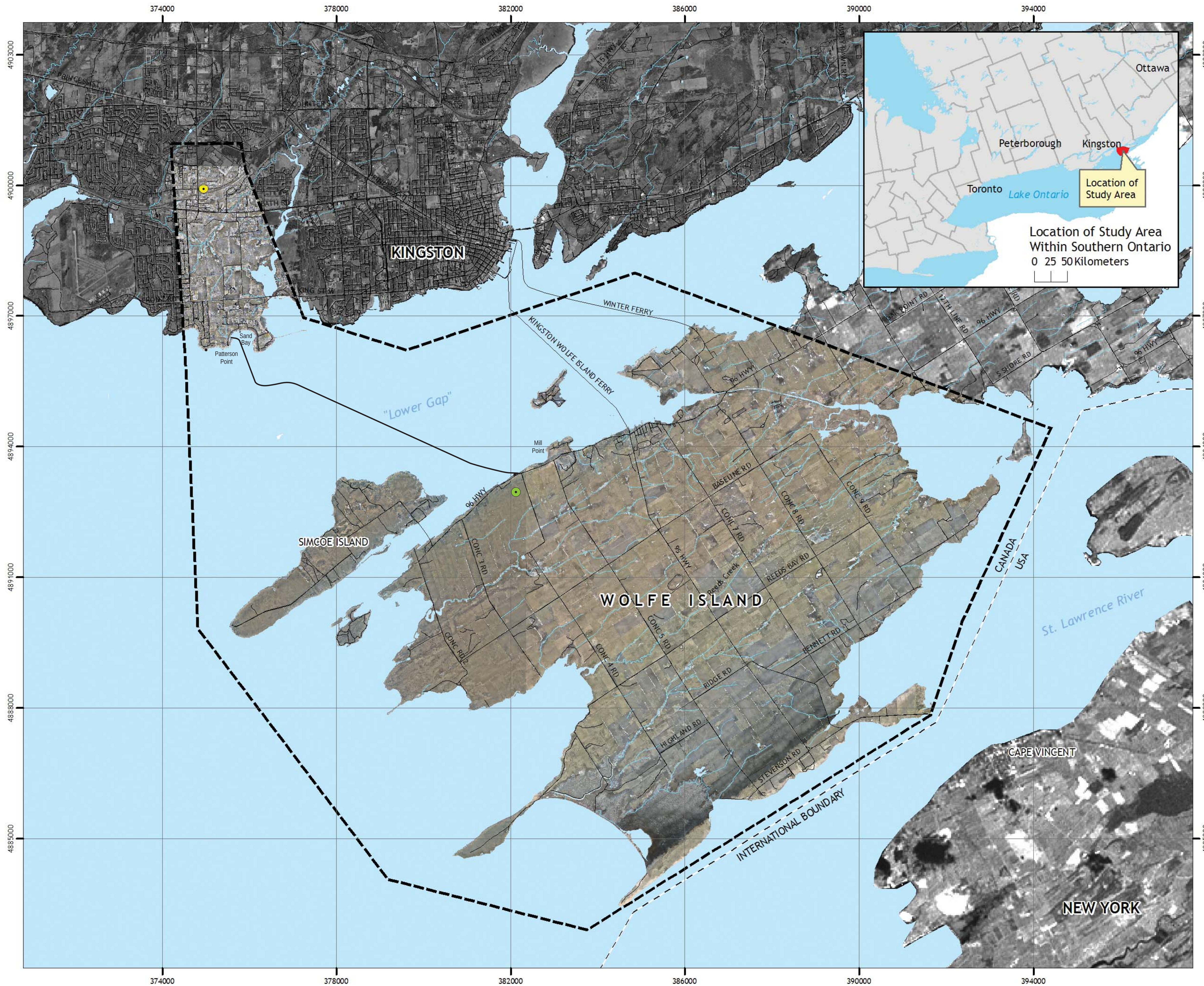
Appendix A

Figures



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Notes:
Base map layers: MNR Land Information Distribution Service (LIDS).

Air Photos: LIDAR (study area coverage), January 2006.
LANDSAT7 (U.S. coverage), 1999.
City of Kingston (city coverage), 2005.

LEGEND

- Study Area
- Gardiners Transformer Station
- Wolf Island Transformer Station
- Submarine Cable Route

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

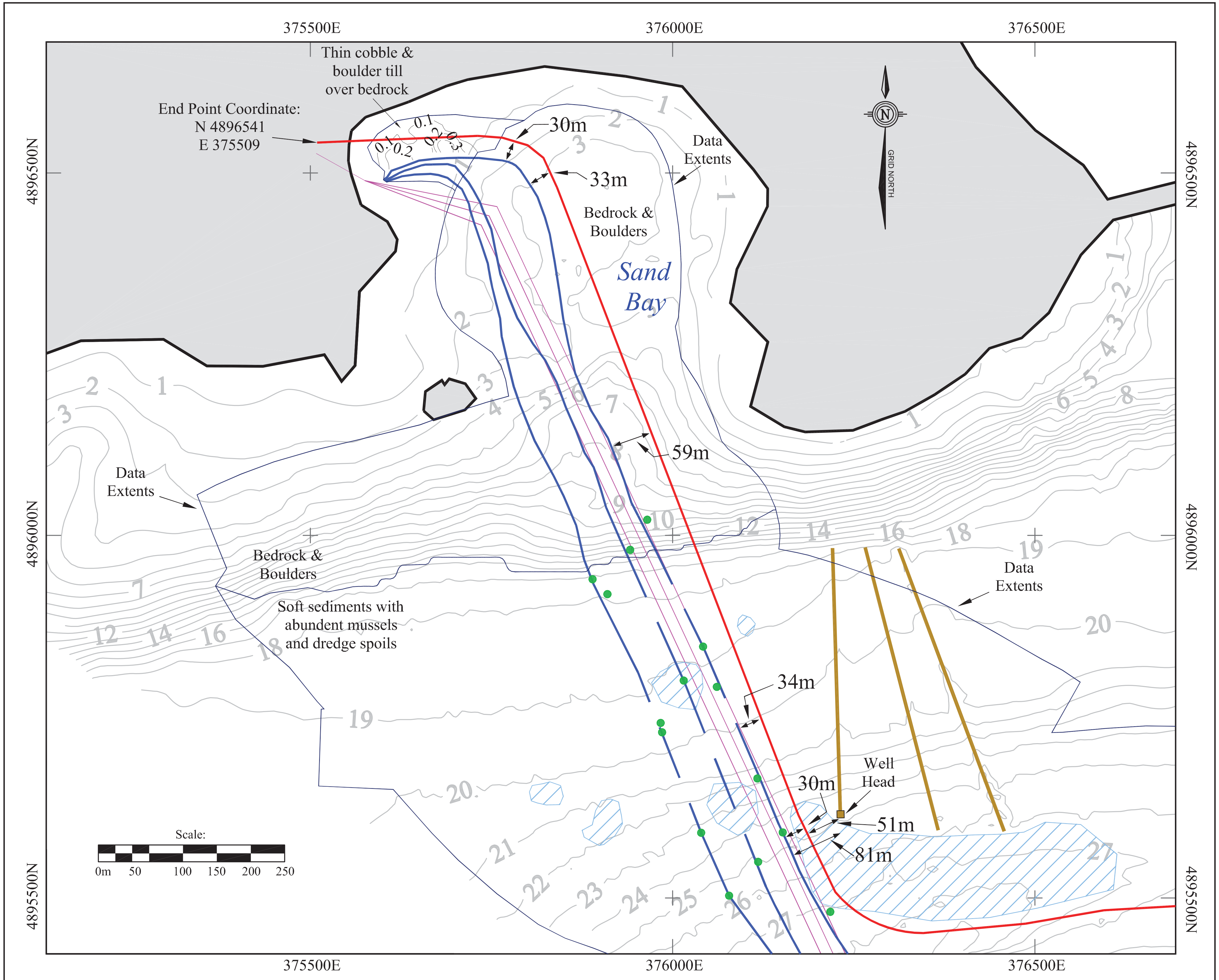
DATE INITIATED:
JUNE 2006

FIGURE NO. **1.1**

PROJECT LOCATION AND STUDY AREA

SCALE:	PROJECT NO.:
1:85,000	160960180

REV. NO.	SHEET NO.	CHECKED BY:	APPROVED:	DRAWN BY:
0	1 OF 1	_ _ _ _ _	_ _ _ _ _	-



Legend

- Bathymetric Contour (metres below Chart Datum)
- Proposed CREC Cable Route
- Design Location of Hydro One Submarine Power Cables
- As-found Location of Hydro One Submarine Power Cables
- Interpolated Location of Hydro One Submarine Power Cables
- Possible Hydro One Cable Identified using Magnetometer
- As-found Submarine Intake Pipes
- Area of Dredge Spoils
- 2007 Survey Extents
- UTM Graticule

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

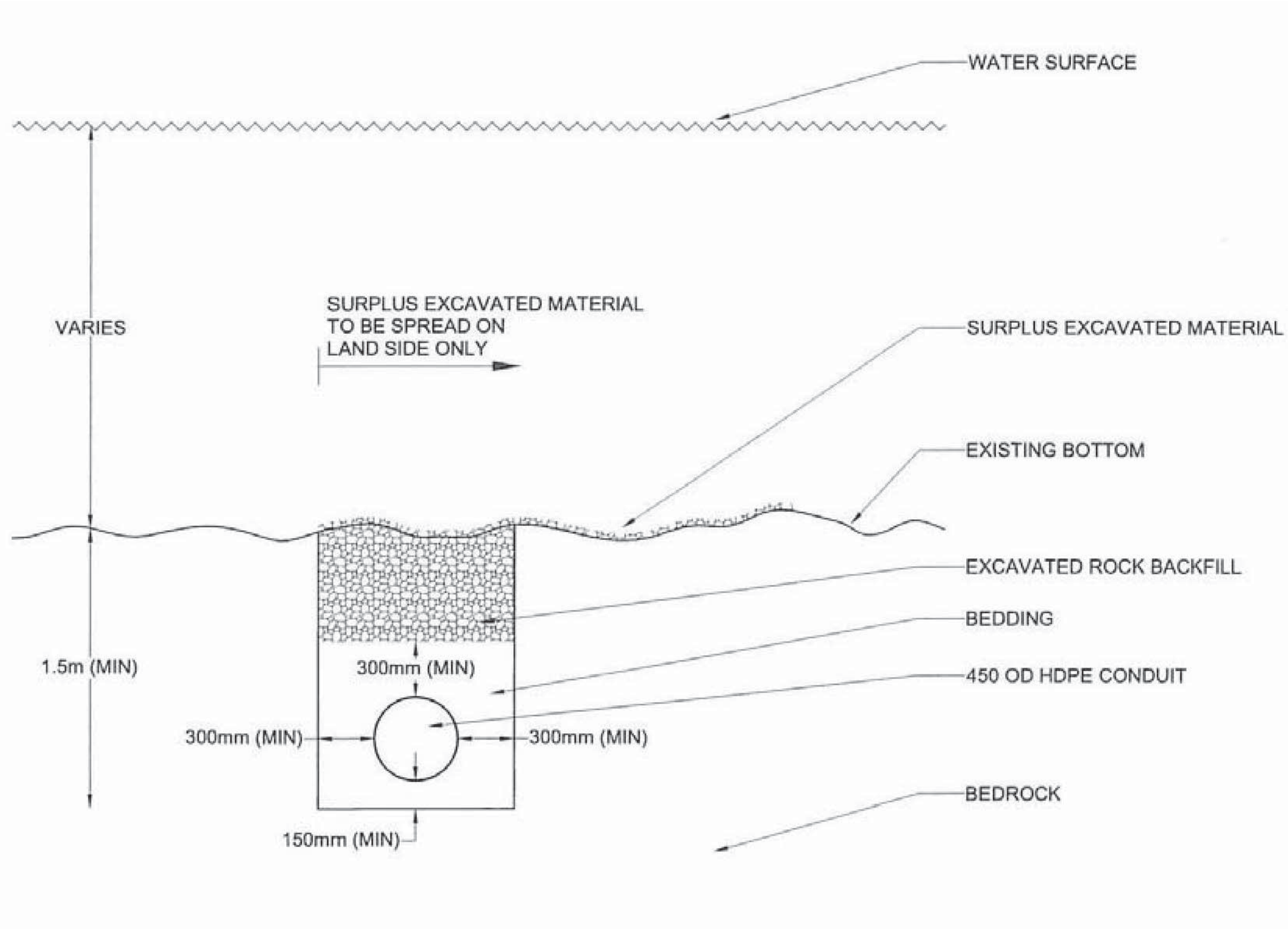
DATE INITIATED:
JUNE 2006

FIGURE NO. **3.1**

PROPOSED CABLE ROUTE AT THE KINGSTON MAINLAND NEARSHORE

SCALE:	PROJECT NO.:
AS SHOWN	160960180

REV. NO.	SHEET NO.	CHECKED BY:	APPROVED:	DRAWN BY:
0	1 OF 1	_ _ _ _ _	_ _ _ _ _	MDK



J.L.Richards
ENGINEERS·ARCHITECTS·PLANNERS
J.L. Richards
& Associates Limited
203-863 Princess Street
Kingston, ON Canada
K7L 5N4
Tel: 613 544 1424
Fax: 613 544 5679

PROJECT NAME: **WOLFE ISLAND WIND PROJECT**

CLIENT NAME: **CANADIAN RENEWABLE ENERGY CORPORATION**

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

DATE INITIATED: **JUNE 2006**

FIGURE NO. **3.2**

PROPOSED CONDUIT TRENCH CROSS-SECTION

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	1:32 000	160960180

Source: EMR (1990); NRCan (1998).

N
W E
S

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:

DATE INITIATED:
JUNE 2006

FIGURE NO. 4.1

REGIONAL STUDY AREA

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	~ 1:327,900	160960180

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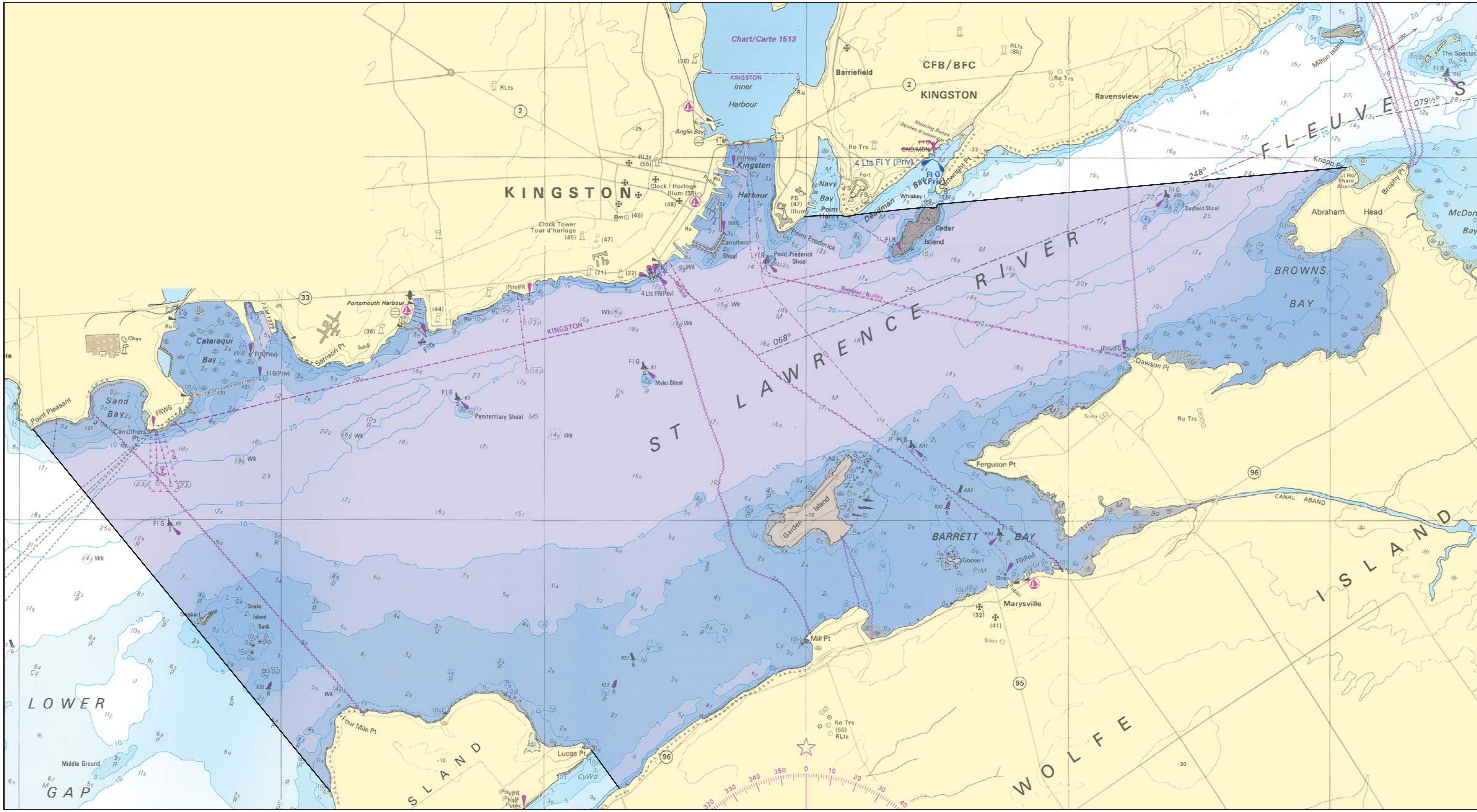


Source: CHS (2000).

LEGEND

Local Study Area

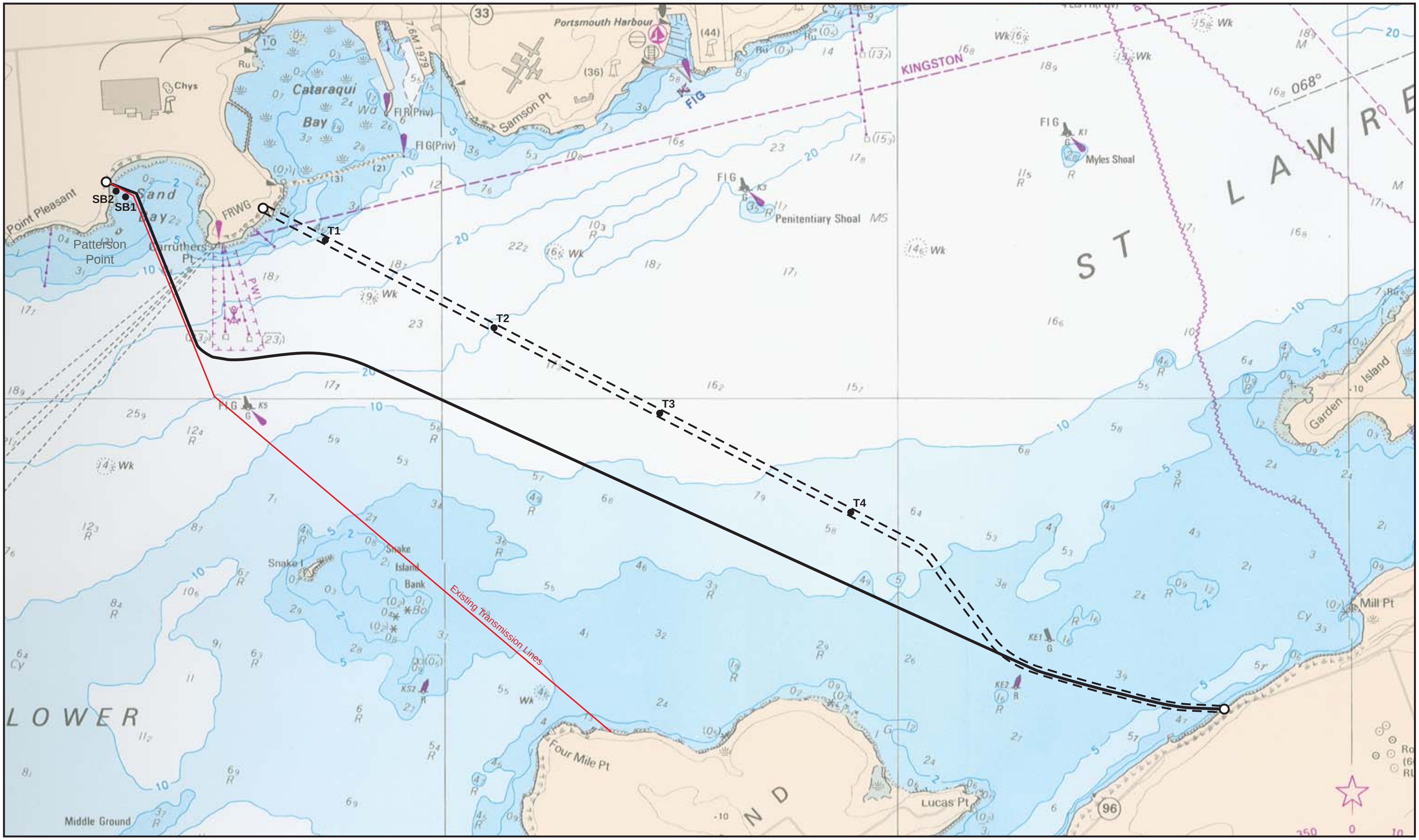
PROJECT NAME:	WOLFE ISLAND WIND PROJECT
CLIENT NAME:	CANADIAN RENEWABLE ENERGY CORPORATION
DATE INITIATED:	JUNE 2006
FIGURE NO.	4.2

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

LOCAL STUDY AREA

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	~ 1:38,600	160960180

Stantec



Source: CHS (2000).

LEGEND

- - - Initial Cable Corridor Study Area

— Proposed Cable Route

T1-T4 Surficial Sediment and Benthos Sampling Locations

SB1,SB2 Surficial Sediment Sampling Locations

N
W E
S

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WOLFE ISLAND WIND PROJECT

CLIENT NAME:
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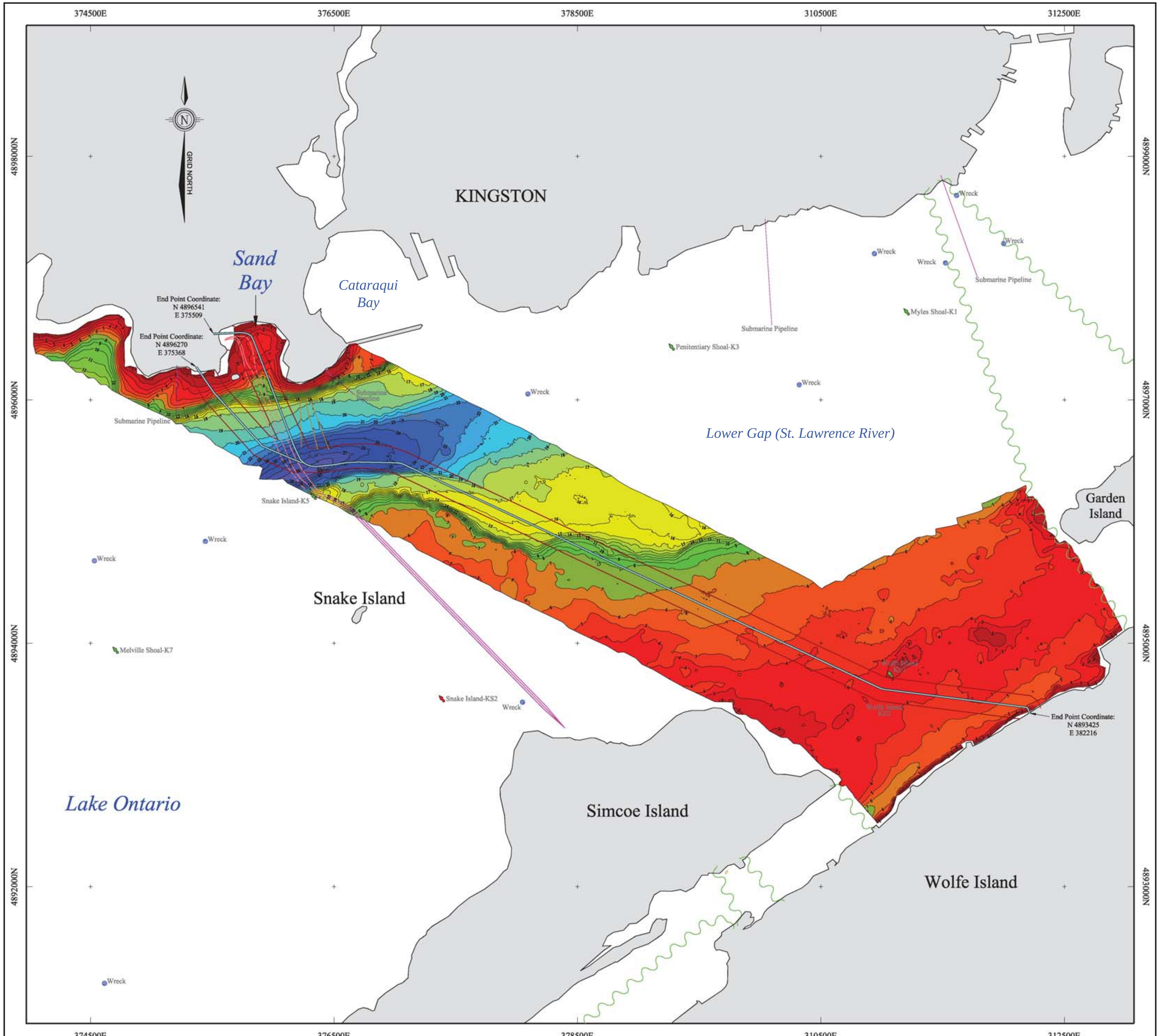
REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

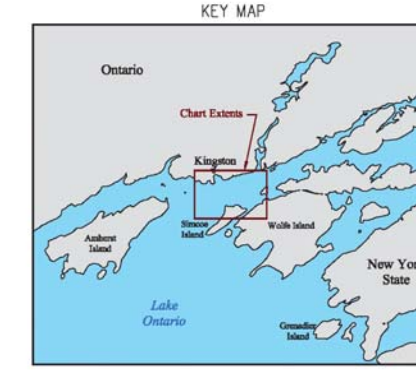
DATE INITIATED:
JUNE 2006

FIGURE NO. **4.3**

INITIAL CABLE CORRIDOR AND PROPOSED ROUTE STUDY AREA

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_____	_____	1:32 000	160960180





LEGEND

- Proposed Cable Route
- Survey Corridor (200m wide)
- As-Found Location of Hydro One Submarine Power Cable
- Interpolated Location of Hydro One Submarine Power Cable
- As-Planned Location of Hydro One Submarine Power Cable
- As-Found Submarine Intake Pipes
- Chart Location of Submarine Pipeline (CHS Chart 2017)
- Chart Location of Submarine Cable (CHS Chart 2017)
- Wreck (known Shipwreck)
- Port-Hand Navigational Marker
- Starboard-Hand Navigational Marker
- UTM Graticule

Bathymetric Color Intervals (metres)

0m 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30m

Scale (metres)
1 : 10000

200m 100 0 200 400 600 800 1000m

Source: Campbell (2007)

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

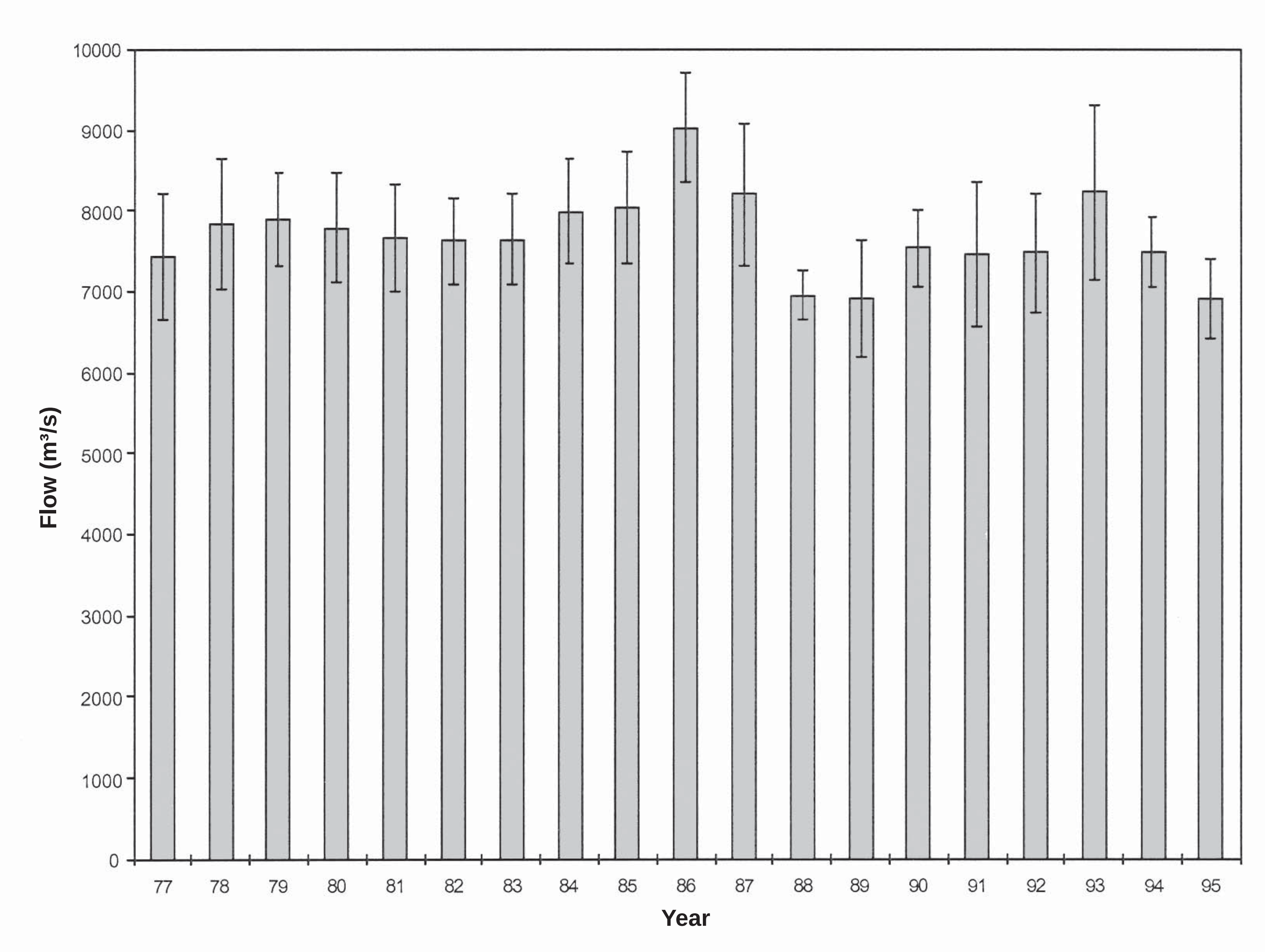
CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

DATE INITIATED:
JUNE 2006

FIGURE NO. **4.4**

PROPOSED CABLE CROSSING ROUTE BATHYMETRY CHART

SCALE:	PROJECT NO.:			
AS SHOWN	160960180			
REV. NO.	SHEET NO.	CHECKED BY:	APPROVED:	DRAWN BY:
0	1 OF 1	_____	_____	MDK



Source: Merriman (1997).

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

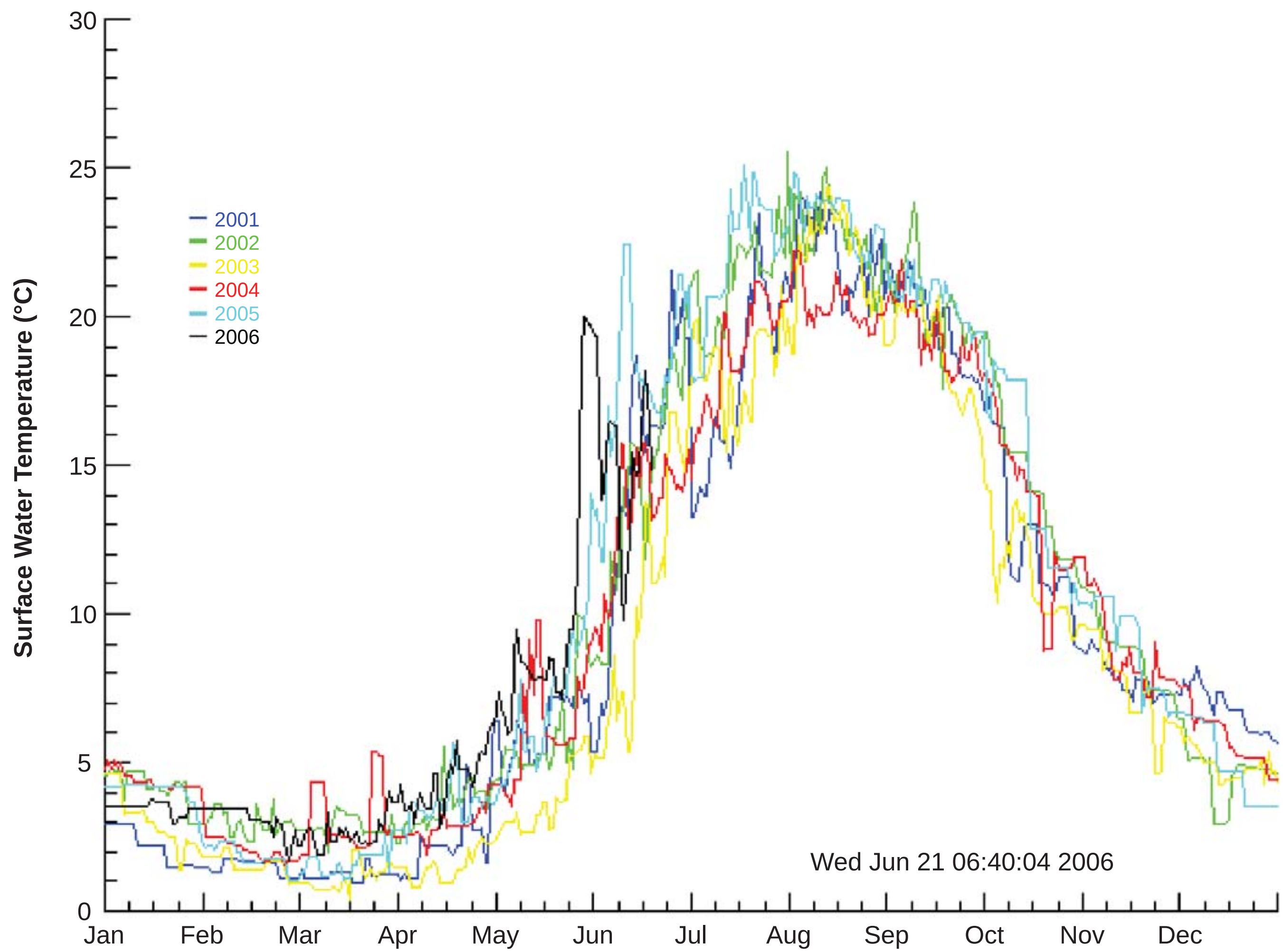
DATE INITIATED:
JUNE 2006

FIGURE NO. **4.5**

WOLFE ISLAND MEAN FLOW RATES

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_____	_____	NA	160960180

Stantec



Source: http://coastwatch.glerl.noaa.gov

Stantec

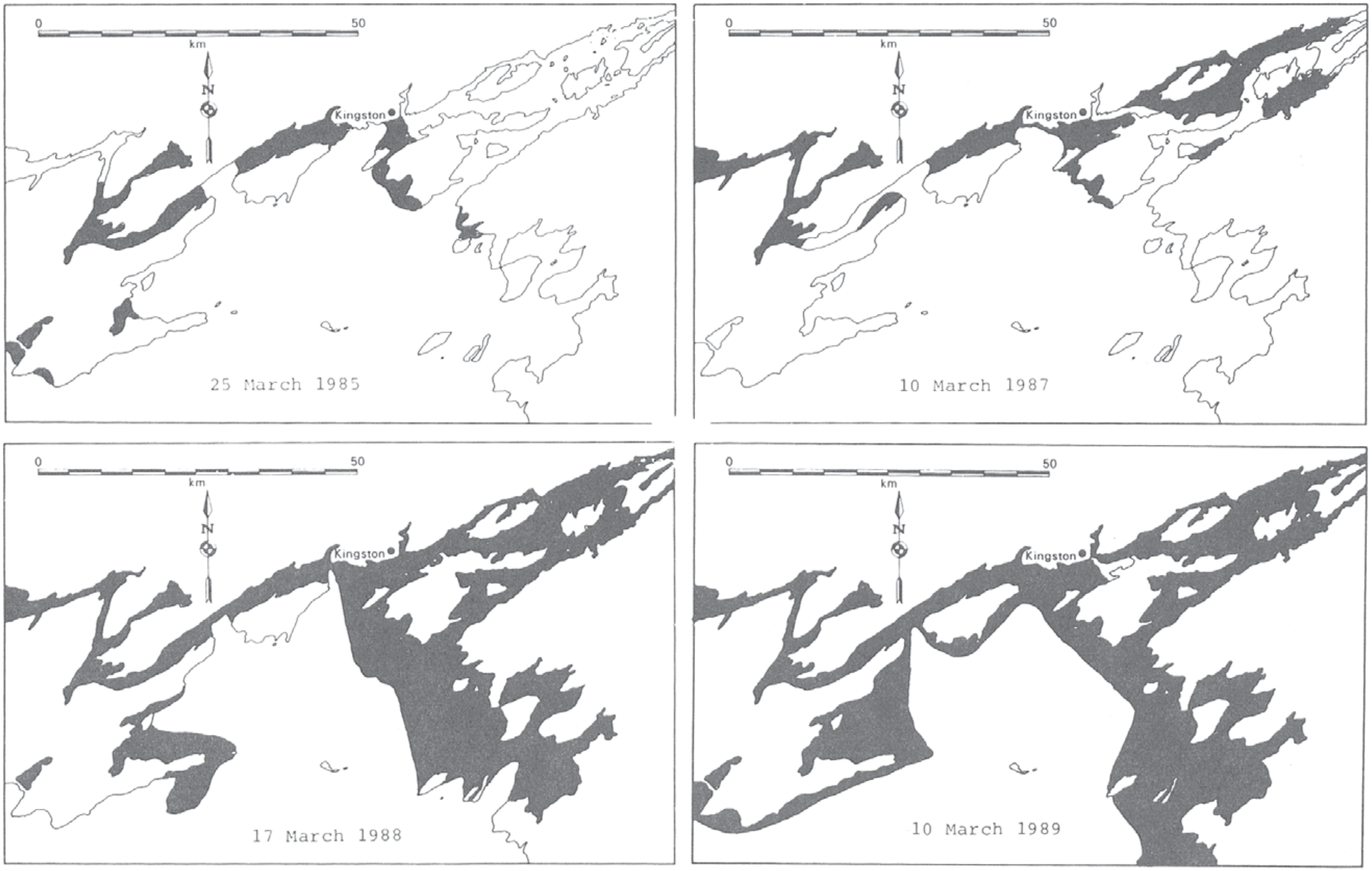
PROJECT NAME:	DATE INITIATED:	FIGURE NO.
WOLFE ISLAND WIND PROJECT	**JUNE 2006**	**4.6**

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

LAKE ONTARIO AVERAGE SURFACE WATER TEMPERATURES

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	NA	160960180



Source: Gilbert (1991a).

LEGEND

ICE COVER

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

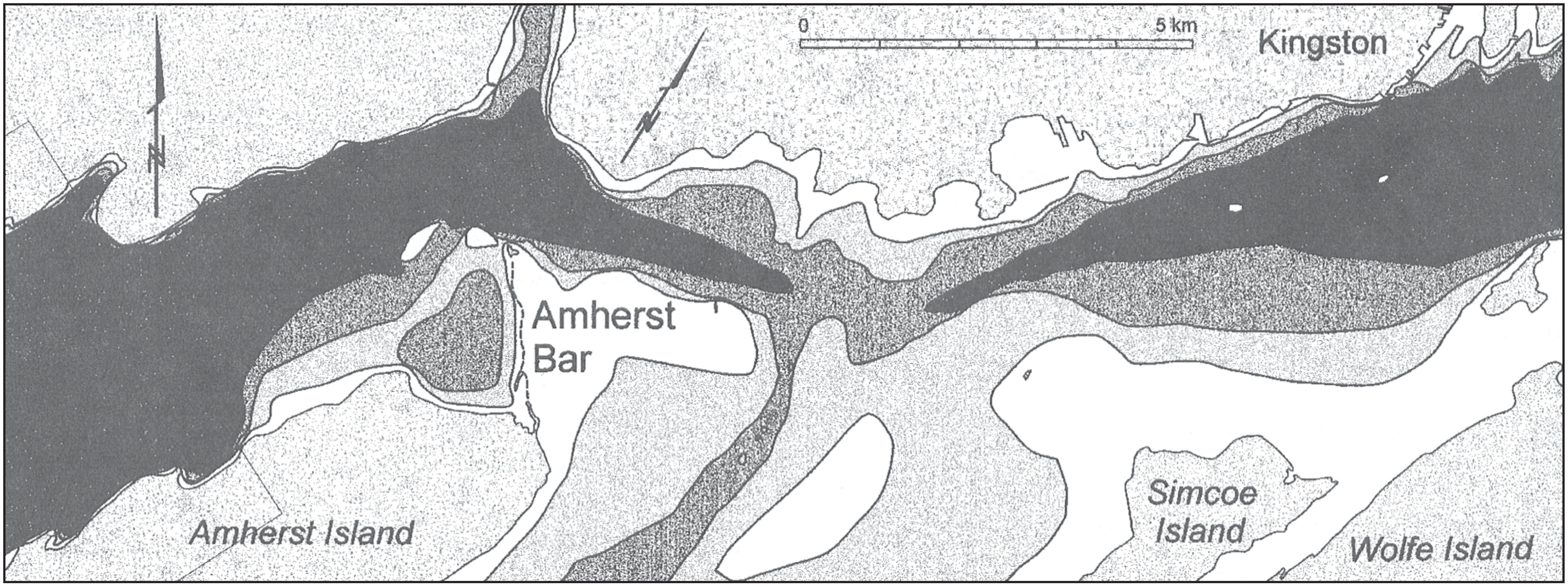
DATE INITIATED:
JUNE 2006

FIGURE NO. **4.7**

ICE COVER IN EASTERN LAKE ONTARIO

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	AS SHOWN	160960180

Stantec



Source: Gilbert (1999).

LEGEND

- 30 km/h Wind
- 60 km/h Wind
- 90 km/h Wind

PROJECT NAME:	WOLFE ISLAND WIND PROJECT
CLIENT NAME:	CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

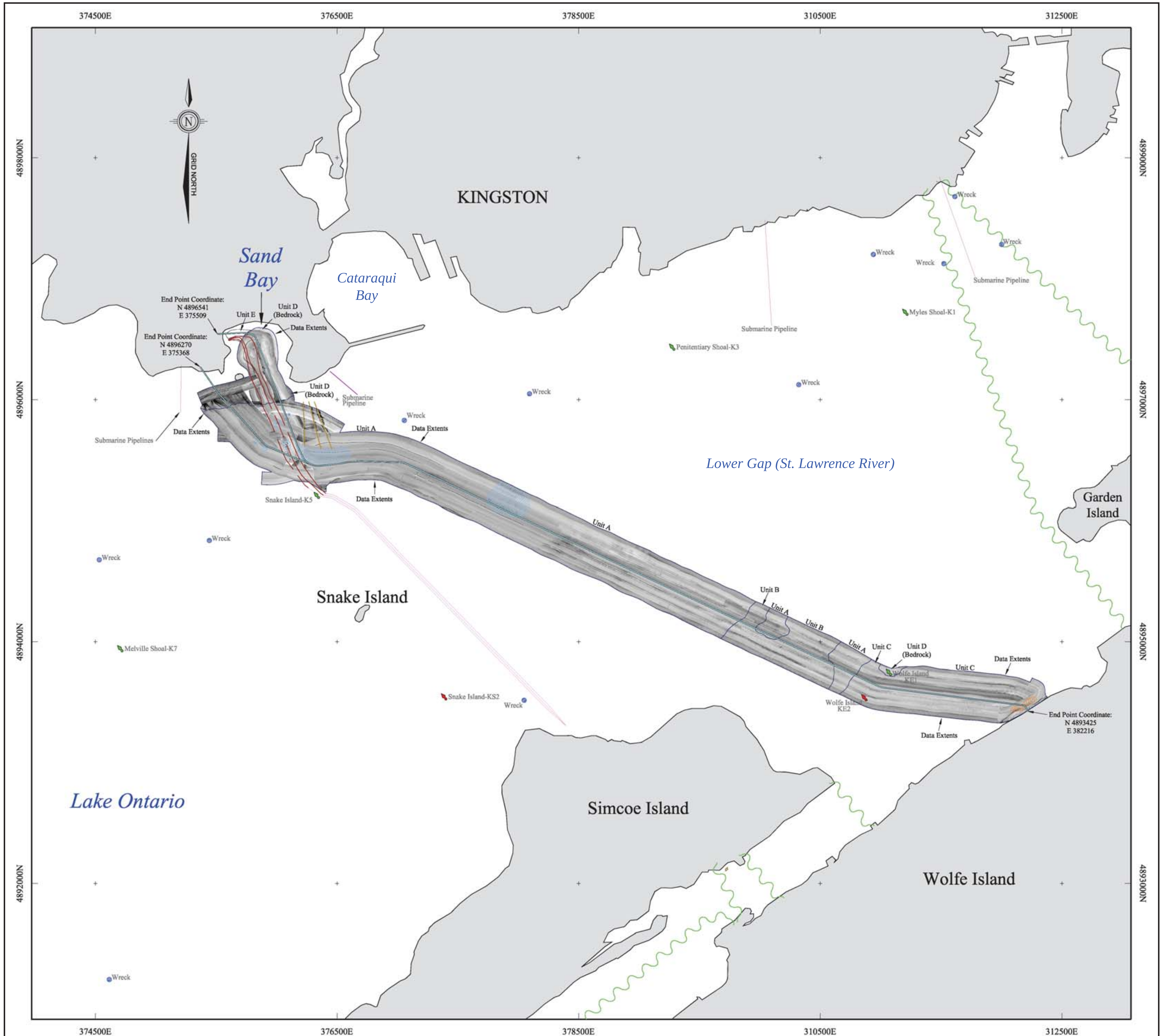
DATE INITIATED: JUNE 2006

FIGURE NO. **4.8**

REGIONS BELOW WAVE BASE

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	AS SHOWN	160960180

Stantec



LEGEND

- Proposed Cable Route
- Cable Route Survey Data Extent
- As-Found Location of Hydro One Submarine Power Cable
- Interpolated Location of Hydro One Submarine Power Cable
- As-Planned Location of Hydro One Submarine Power Cable
- As-Found Submarine Intake Pipes
- Chart Location of Submarine Pipeline (CHS Chart 2017)
- Chart Location of Submarine Cable (CHS Chart 2017)
- Wreck (known Shipwreck)
- Port-Hand Navigational Marker
- Starboard-Hand Navigational Marker
- UTM Graticule

SURFICIAL GEOLOGY AND SEABED FEATURES LEGEND

Unit-A This unit is comprised of fine clay sediments. Dredge spoils and shell beds are present within this unit, characterized by the dark, circular features in the sidescan mosaic. Varying amounts of shell fragments within this unit cause the sidescan imagery to vary in intensity. Anchor drag marks can also be seen within this unit.

Unit-B This unit is interpreted to be fine sand sediments with abundant shell fragments. Gravel and cobble sized clasts are visible throughout the unit as well as occasional boulders.

Unit-C This unit is mostly comprised of sandy silt and an abundance of shell fragments. Gravel and cobble sized clasts are common within the unit, as well as numerous boulders.

Unit-D This unit is found in the shallow portions of the survey area and is the local bedrock surface. Linear patterns associated with the erosion of its horizontal layering are visible in the sidescan imagery. Cobbles and boulders are also visible on top of this unit.

Unit-E This unit is found at the landfall area in Sand Bay and is composed of coarse cobbles within fine sand and silt sediments. This unit is less than 0.5 metres thick and lies overtop of bedrock.

- Unit Boundary
- Area of Dredge Spoils
- Area of Logs and Boulders

Scale (metres)
1 : 10000

200m 100 0 200 400 600 800 1000m

Source: Campbell (2007)

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

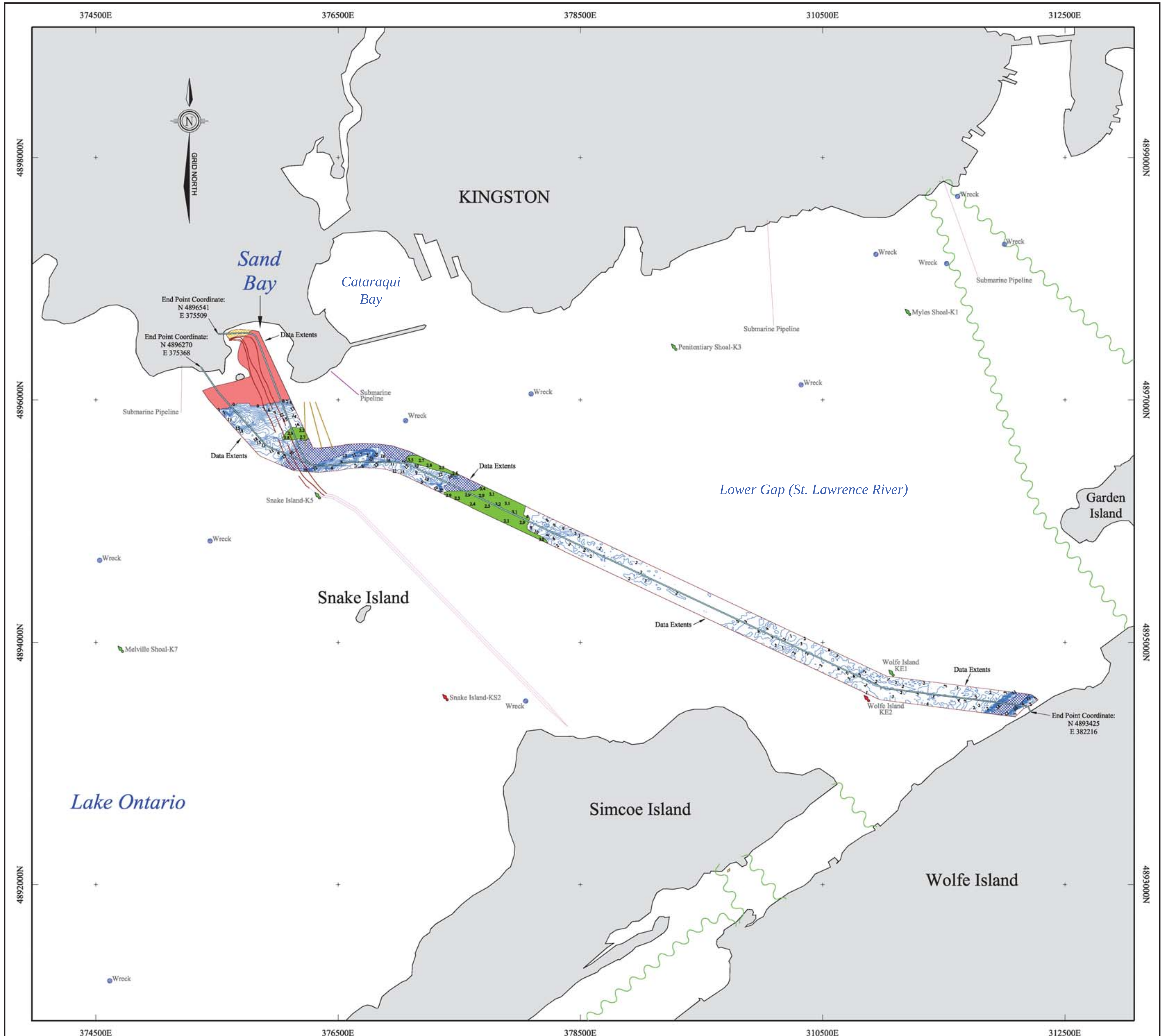
DATE INITIATED:
JUNE 2006

FIGURE NO. **4.9**

PROPOSED CABLE CROSSING ROUTE SURFICIAL GEOLOGY AND RIVERBED FEATURES

SCALE:	PROJECT NO.:
AS SHOWN	160960180

REV. NO.	SHEET NO.	CHECKED BY:	APPROVED:	DRAWN BY:
0	1 OF 1	_____	_____	MDK



KEY MAP

LEGEND

- Proposed Cable Route
- Cable Route Survey Data Extent
- As-Found Location of Hydro One Submarine Power Cable
- Interpolated Location of Hydro One Submarine Power Cable
- As-Planned Location of Hydro One Submarine Power Cable
- As-Found Submarine Intake Pipes
- Chart Location of Submarine Pipeline (CHS Chart 2017)
- Chart Location of Submarine Cable (CHS Chart 2017)
- Wreck (known Shipwreck)
- Port-Hand Navigational Marker
- Starboard-Hand Navigational Marker
- UTM Graticule

SUB-BOTTOM GEOLOGY LEGEND

- Thickness of Unconsolidated Sediments – The depth from lakebed to this isopach represents the thickness of unconsolidated sediments. Displayed as blue isopachs at 1metre intervals (Depth below Lakebed).
- Bedrock at lakebed.
- 3.1 Location and Depth of Gas – Multiple areas of shallow gas are present in the sub-bottom data masking the underlying geology. It is presumed that the gas is biogenic in origin as a result of decaying organic material.
- Till less than 0.5 metres thick, over top of Bedrock.
- Unconsolidated sediment thickness is greater than 10m below lakebed. In these areas, unconsolidated sediments extend past the maximum resolvable depth of the sub-bottom profiler. Therefore, the maximum depth of unconsolidated sediments in these areas are unknown.

Scale (metres)
1 : 10000

200m 100 0 200 400 600 800 1000m

Source: Campbell (2007)

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

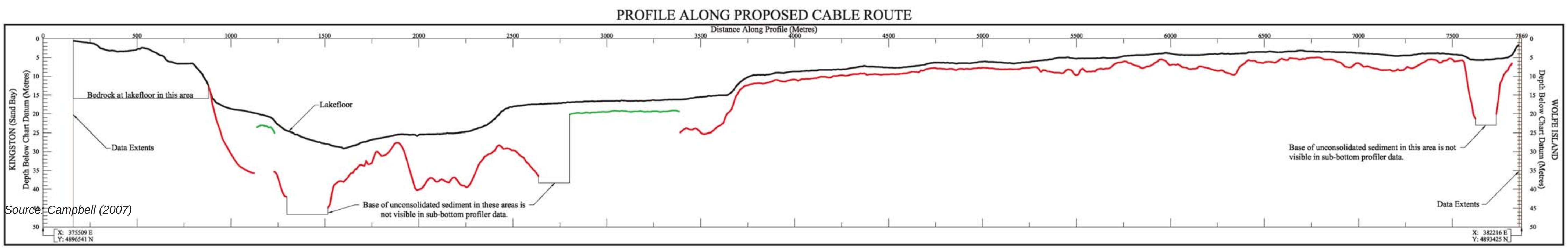
CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

DATE INITIATED:
JUNE 2006

FIGURE NO. **4.10**

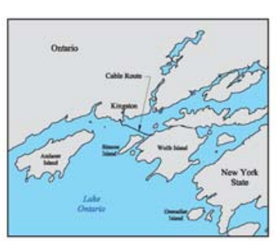
PROPOSED CABLE CROSSING ROUTE THICKNESS OF UNCONSOLIDATED SEDIMENTS

SCALE:	PROJECT NO.:			
AS SHOWN	160960180			
REV. NO.	SHEET NO.	CHECKED BY:	APPROVED:	DRAWN BY:
0	1 OF 1	_____	_____	MDK



Source: Campbell (2007)

KEY MAP



LEGEND

- Lakefloor
- Base of unconsolidated sediments
- Top of Gas

VERTICAL EXAGGERATION: 20 Times

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

DATE INITIATED:
JUNE 2006

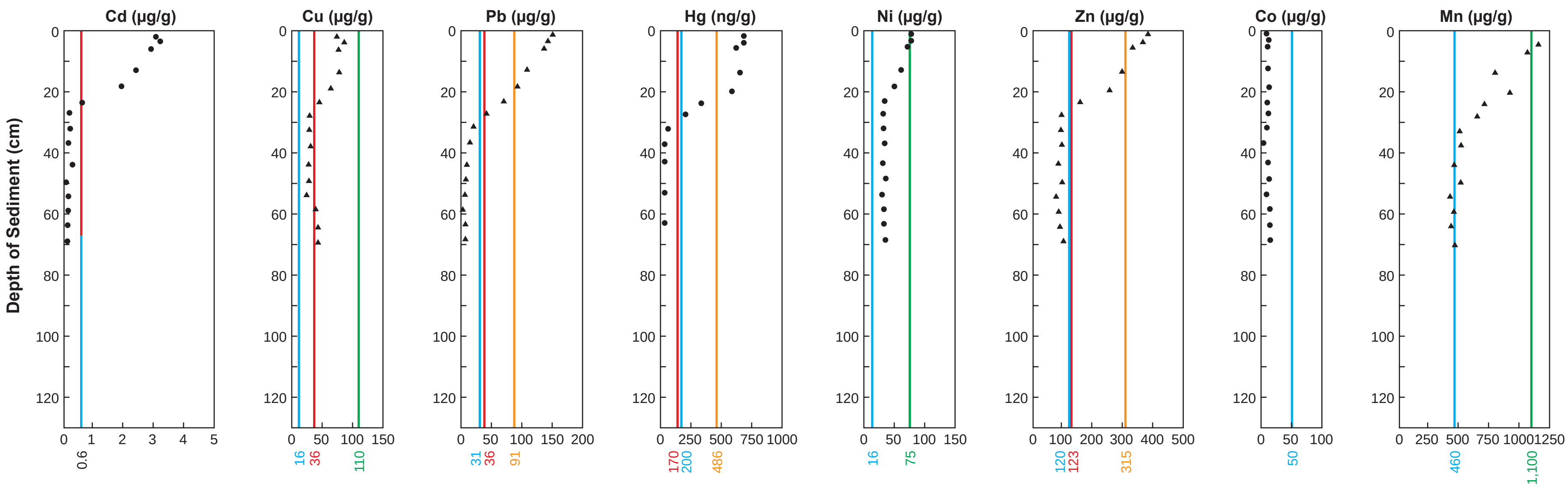
REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:

FIGURE NO. **4.11**

PROPOSED
CABLE CROSSING ROUTE
UNCONSOLIDATED
SEDIMENTS PROFILE

SCALE:	PROJECT NO.:
AS SHOWN	160960180

REV. NO.	SHEET NO.	CHECKED BY:	APPROVED:	DRAWN BY:
0	1 OF 1	_ _ _ _ _	_ _ _ _ _	MDK



Source: Johnson (1978).

LEGEND

- SEL
- LEL
- PEL
- ISQG

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PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

DATE INITIATED:
JUNE 2006

FIGURE NO. **4.12**

SEDIMENT CORE TRACE METAL DATA

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	NA	160960180

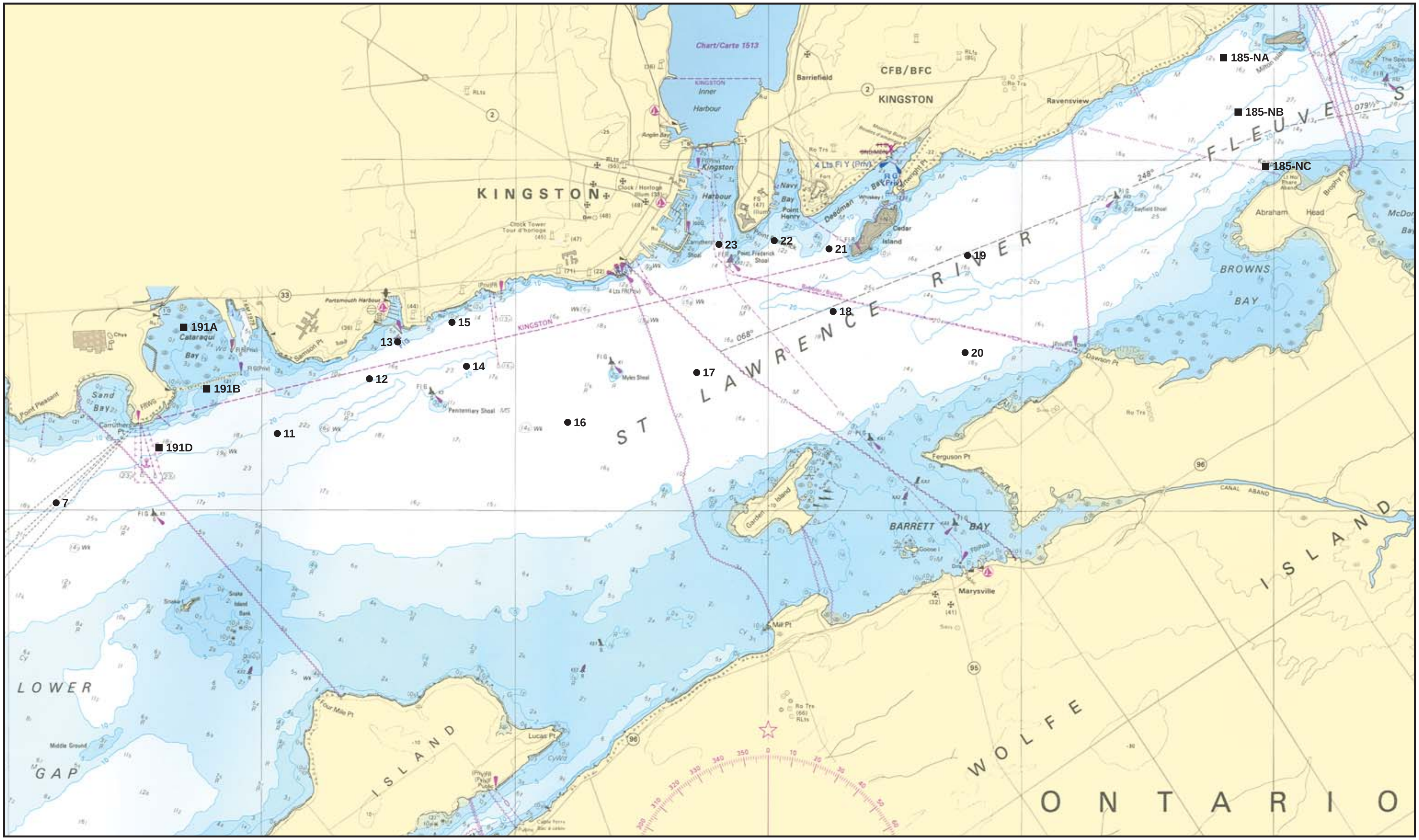

Chart Source: CHS (2000).

LEGEND

● **11** Johnson (1978) sampling locations

■ **191D** Kuntz (1988) sampling locations

N W E S

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PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

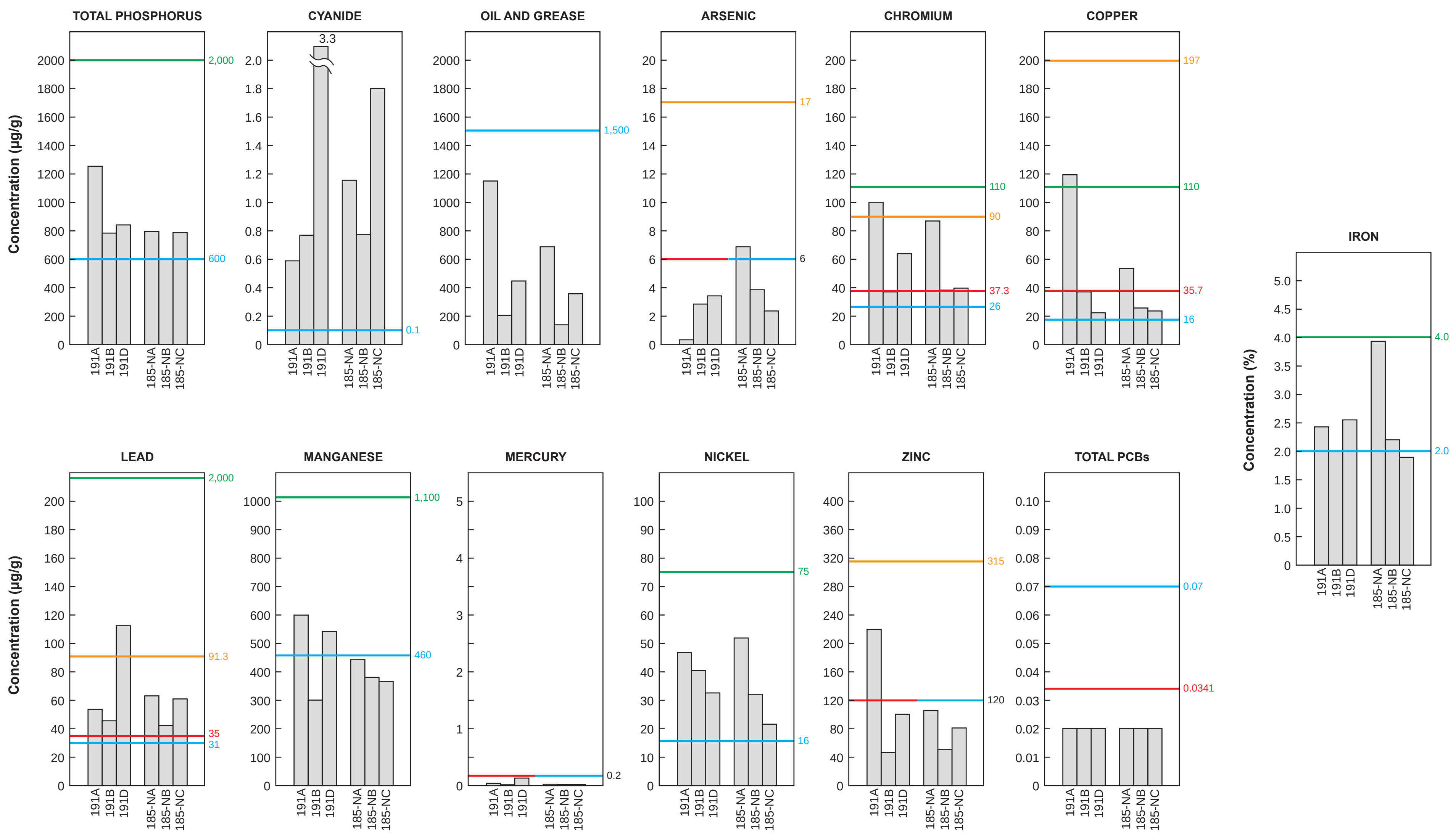
REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

DATE INITIATED:
JUNE 2006

FIGURE NO. **4.13**

SURFICIAL SEDIMENT SAMPLING LOCATIONS

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	~ 1:59,400	160960180



Source: Kuntz (1988).

LEGEND

- SEL
- LEL
- PEL
- ISQG

PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

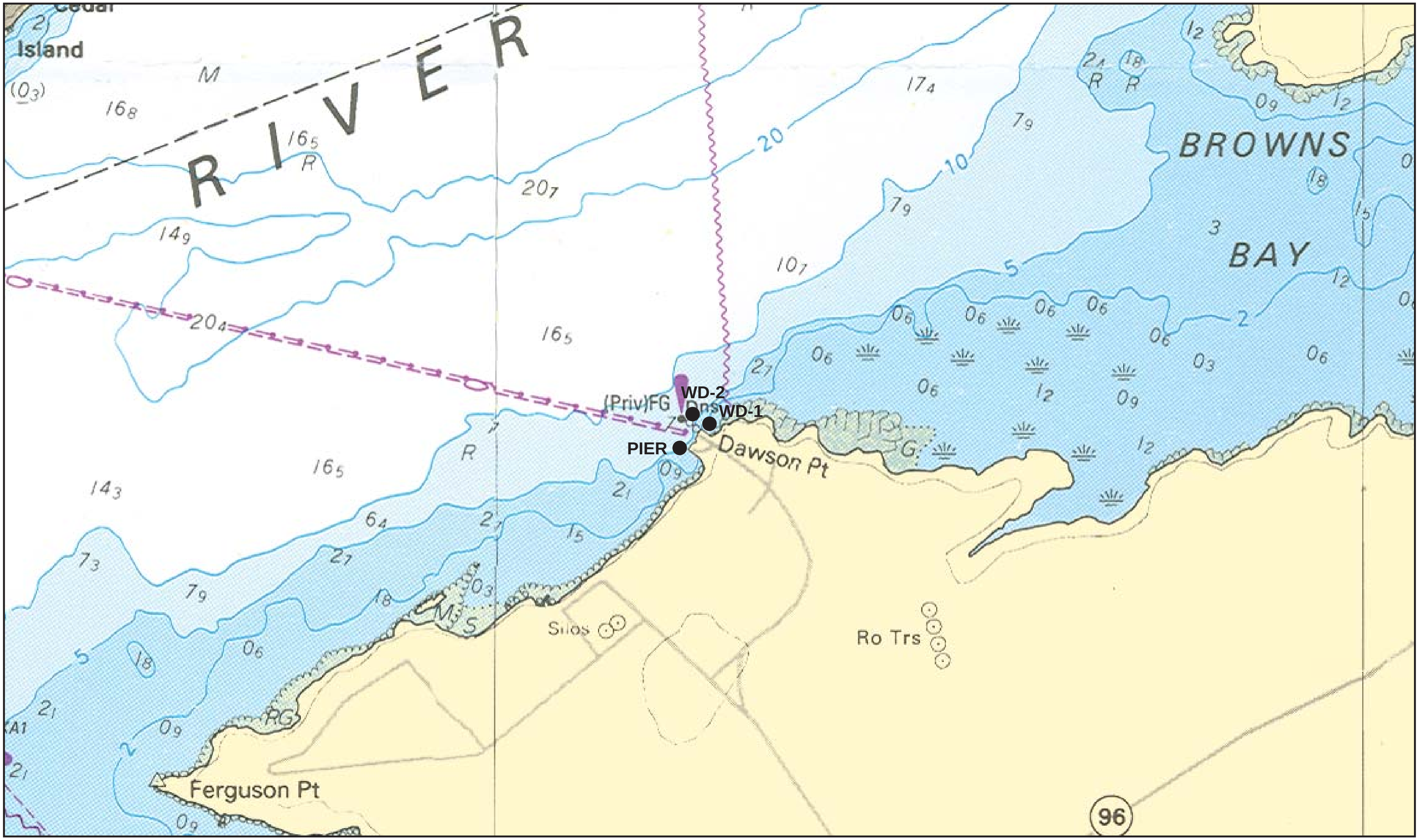
DATE INITIATED:
JUNE 2006

FIGURE NO. **4.14**

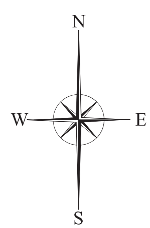
LOCAL STUDY AREA SEDIMENT QUALITY DATA

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	NA	160960180

Stantec



Source: CHS (2000).



PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

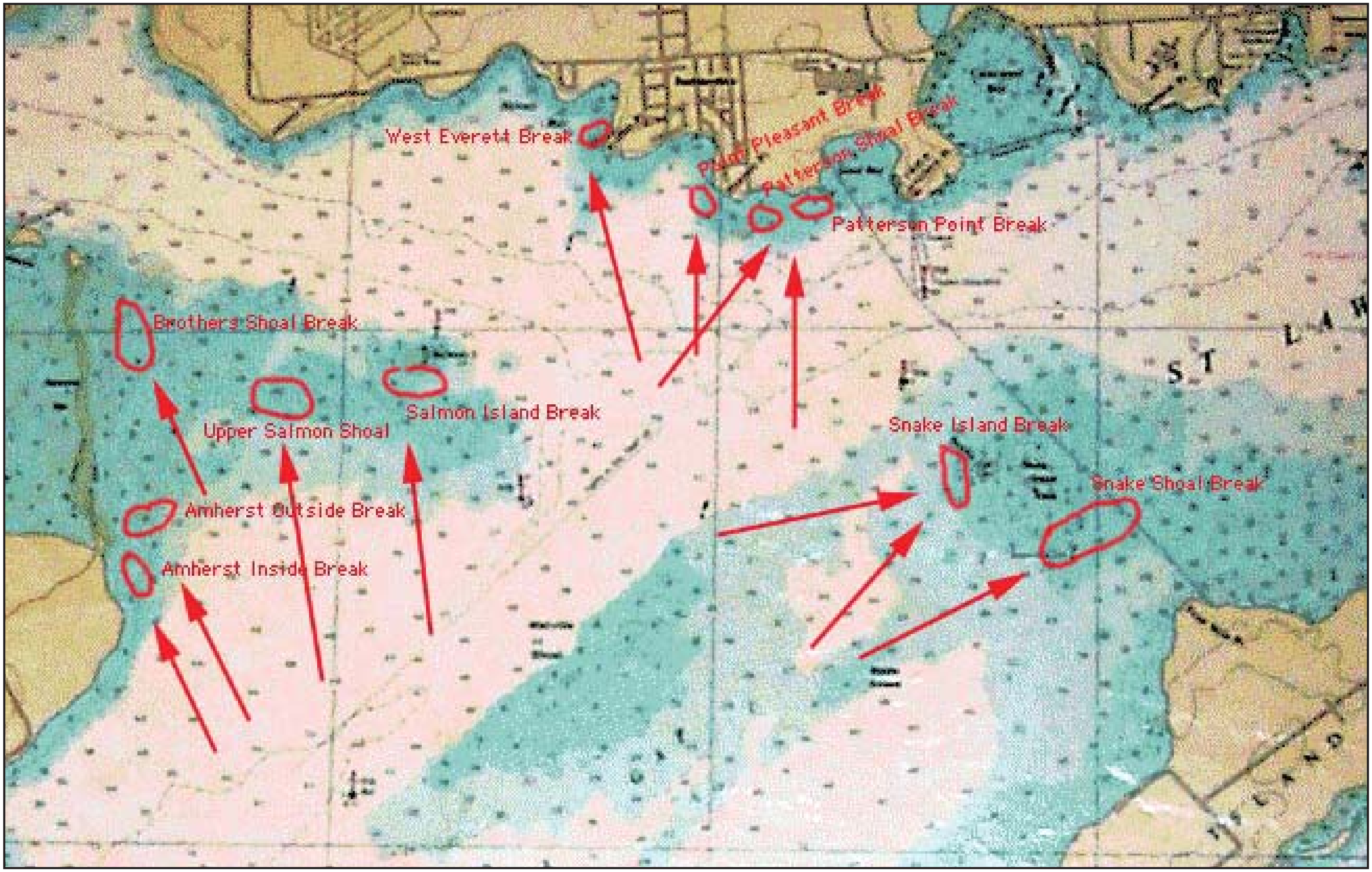
DATE INITIATED:
JUNE 2006

FIGURE NO. **4.15**

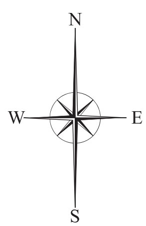
WINTER FERRY DOCK SEDIMENT SAMPLING LOCATIONS

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	~ 1:17,450	160960180

Stantec



Source: http://www.geocities.com/kingstonboardsailing



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PROJECT NAME:
WOLFE ISLAND WIND PROJECT

CLIENT NAME:
CANADIAN RENEWABLE ENERGY CORPORATION

REVISION NO.	REVISION DATE	DESCRIPTION	REVISED BY:
-	-	-	-

DATE INITIATED:
JUNE 2006

FIGURE NO. **4.16**

WINDSAILING LOCATIONS IN THE LOWER GAP

REV. NO.	SHEET NO.	DRAWN BY:	CHECKED BY:	APPROVED:	SCALE:	PROJECT NO.:
0	1 OF 1	MDK	_ _ _ _ _	_ _ _ _ _	NA	160960180

Appendix B

Tables

TABLE 4.1: CLIMATIC DATA FOR THE SOUTH SLOPES CLIMATIC REGION[1]

Climatic Parameter	South Slopes Climatic Region	
Mean Annual Temperature °C (°F)	7.2 (45)	
Mean Daily Temperature °C (°F)	Minimum	Maximum
January	-10.6 (13)	-2.2 (28)
April	0.6 (33)	11.1 (52)
July	14.4 (58)	27.2 (81)
October	3.9 (39)	15.0 (59)
Mean Date of Last Spring Frost	15 May	
Mean Date of First Fall Frost	05 October	
Mean Annual Frost-Free Days	145	
Mean Start of Growing Season	13 April	
Mean End of Growing Season	03 November	
Annual Length of Growing Season (Days)	205	
Mean Annual Growing Degree Days	3,500	
Mean Annual Precipitation - mm (in)	865 (34)	
Mean Annual Snowfall - mm (in)	2,030 (70)	

[1] Source: Brown *et al.* (1974).

TABLE 4.2: MEAN TEMPERATURE AND PRECIPITATION DATA[1,2]

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Kingston Pumping Station[3]													
Daily Temperature (°C)	-7.1	-6.0	-0.8	6.6	13.3	18.1	21.4	20.4	15.8	9.4	3.4	-3.2	7.6
Rainfall (mm)	34.7	29.0	46.0	70.7	74.8	74.5	59.8	81.5	94.1	84.9	81.2	49.4	780.6
Snowfall (mm)	52.9	37.4	29.4	6.8	0.0	0.0	0.0	0.0	0.0	0.6	11.5	41.0	179.5
Total Precipitation (mm)	87.6	66.4	75.3	77.5	74.8	74.5	59.8	81.5	94.1	85.5	92.7	90.4	960.1
Days with Precipitation[4]	16.3	12.8	13.1	12.5	12.9	12.3	10.6	11.3	11.9	12.8	14.6	15.2	156.2

1 Source: Environment Canada website: www.weatheroffice.ec.gc.ca.
2 Years of record: 1971 to 2000.
3 Latitude: 44°44'N; Longitude: 76°28'W; Elevation: 76.50 m.
4 Greater than or equal to 0.2 mm.

TABLE 4.3: FROST DATA[1]

Parameter	Kingston Ontario Hydro[2]
Mean Frost-Free Period (Days)	149[4]
Average Last Frost (Spring)	08 May[4]
Average First Frost (Fall)	05 October[4]
Earliest Last Frost (Spring)	09 April
Latest Last Frost (Spring)	28 May
Earliest First Frost (Fall)	15 September
Latest First Frost (Fall)	18 October
Longest Frost-Free Period (Days)	158
Shortest Frost-Free Period (Days)	101

[1] Source: AES (1982).
[2] Based on 23 years of record.

TABLE 4.4: WIND DATA FOR THE KINGSTON AIRPORT METEOROLOGICAL STATION, 1971 TO 2000[1,2]

Parameter	January	February	March	April	May	June	July	August	September	October	November	December	Year
Mean Wind Speed (km/h)	18.7	16.5	16.8	16.5	14.1	13.1	13.4	13.6	15.3	16.7	18.7	18.9	N/A[3]
Most Frequent Direction	W	SW	SW	SW	S	S	S	S	S	S	W	W	N/A
Maximum Hourly Speed (km/h)	80	72	74	83	54	51	70	74	57	61	70	65	
Maximum Gust Speed (km/h)	105	92	115	111	91	85	120	122	85	95	130	100	
Direction	SW	N	SW	SW	SW	SW	SW	SW	SW	SW	S	SW	

[1] Source: Environment Canada website: www.weatheroffice.ec.gc.ca.
[2] Latitude: 44°13'N; Longitude: 76°36'W; Elevation: 93.00 m.
[3] N/A = not available.

TABLE 4.5: MONTHLY AND ANNUAL MEAN, MINIMUM AND MAXIMUM DISCHARGES (m^3/s), ST. LAWRENCE RIVER[1]

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
At Iroquois Control Dam[2]													
Mean	6,260	6,180	6,480	7,050	7,300	7,390	7,350	7,140	6,900	6,690	6,560	6,500	6,820
Minimum	4,690	4,360	5,020	5,300	5,490	5,640	5,530	5,280	5,090	4,960	4,800	4,820	5,220
Maximum	7,560	7,650	7,800	8,320	8,890	8,720	8,670	8,380	8,040	8,100	8,070	8,010	7,930
At Moses-Saunders Power Dam[3]													
Mean	6,540	6,880	7,200	7,400	7,710	7,860	7,740	7,630	7,530	7,380	7,270	7,070	7,370
Minimum	5,050	5,150	5,090	5,080	5,000	5,340	5,680	5,840	5,740	5,750	5,650	5,460	5,530
Maximum	8,460	8,140	8,900	9,200	10,000	10,000	9,910	9,350	9,250	9,170	9,580	9,260	8,940

[1] Source: www.wsc.ec.gc.ca.
[2] Station O2MB005; Latitude: 44°50’26”N, Longitude: 75°16’35”W; Drainage area: 772,000 km^2; Period of record: 1860 – 1958.
[3] Station O2MC002; Latitude: 45°00’21”N, Longitude: 74°47’43”W; Drainage area: 774,000 km^2; Period of record: 1958 – 1993.

TABLE 4.6: MONTHLY AND ANNUAL MEAN WATER LEVELS (m)[1]

Location	Period of Record	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Kingston Harbour	1909-2001	74.58	74.61	74.68	74.89	75.03	75.07	75.02	74.91	74.77	74.65	74.58	74.56	74.79

[1] www.wsc.ec.gc.ca.

TABLE 4.7: IN-SITU WATER QUALITY MEASUREMENTS

Sampling Location[1] Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	% Oxygen Saturation	pH (units)	Conductivity (μmhos/cm)
T1					
1.0	24.6	7.7	93	8.39	289
9.5	23.2	7.9	93	8.36	289
T2					
1.4	24.2	6.8	83	8.39	291
5.4	23.0	6.7	79	8.33	292
10.4	22.9	6.6	77	8.27	293
13.4	22.8	6.8	80	8.31	292
14.4	22.8	6.8	80	8.30	292
15.4	22.8	6.7	79	8.32	292
16.4	22.7	6.6	77	8.33	292
17.4	22.1	6.2	72	8.10	294
18.4	21.8	6.0	69	7.99	294
19.4	20.5	5.1	57	7.60	299
19.9	18.1	4.5	48	7.22	301
20.1	16.1	2.8	29	6.86	305
T3					
1.2	23.3	6.6	78	8.39	291
5.2	23.2	6.6	78	8.35	291
10.2	23.2	6.5	76	8.24	291
16.2	22.5	6.0	70	8.03	293
17.2	20.3	5.1	56	7.63	298
T4					
1.0	23.8	7.9	94	8.36	286
10.0	23.4	7.7	91	8.36	287

[1] See Figure 4.3 for sampling location.

TABLE 4.8: SEDIMENT PARTICLE SIZE AND CLASSIFICATION TYPE ALONG THE INITIAL TRANSMISSION LINE ROUTE AND IN SAND BAY

	Transmission Line Route[1]					
Particle size	T1[2]	T2[3]	T3[5]	T4[5]	SB1	SB2
% Sand	95.3	61.5	45.8	83.6	98	97
% Silt	<0.1	26.5	35.8	10.3	2	3
% Clay	4.7	12.0	18.3	6.1	<2	<2
Folk (1974) Classification	Sand	Muddy sand	Silty sand	Sand	Sand	Sand
Shepard (1954) Classification	Sand	Silty sand	Silty sand	Sand	Sand	Sand

1 See Figure 4.3 for sampling locations.
2 Water depth pf 11.2 m.
3 Water depth of 25.3 m.
4 Water depth of 17.5 m.
5 Water depth of 10.6 m.

TABLE 4.9: TRACE METAL MEDIAN AND 90TH PERCENTILE CONCENTRATION RANGES[1]

	Concentration (mg/L unless otherwise indicated)				
Metal	Monitoring Period	Median Range	90th Percentile Range	GLWQA[2] Water Quality Objective	PWQO[3]
Arsenic	88-96	0.0005 - 0.0006	0.0006 - 0.0007	0.05	0.100
Cadmium	77-96	<DL	0.0001 - 0.001	0.0002	0.0002
Chromium	77-96	<0.001 - 0.001	0.0003 - 0.005	0.05	0.100
Copper	77-96	0.0009 - 0.0135	0.0011 - 0.0499	0.005	0.005
Iron	77-96	0.010 - 0.145	0.035 - 0.358	0.3	0.3
Lead	77-96	<0.0002 - 0.002	<0.0002 - 0.003	0.025	0.025
Mercury (µg/L)	83-96	<0.005 - 0.01	<0.01 - 0.0147	0.2	0.2
Nickel	77-96	0.0006 - 0.002	0.0007 - 0.007	0.025	0.025
Selenium	88-96	0.0001 - 0.0002	0.0002 - 0.0003	0.01	0.100
Zinc	77-96	<0.001 - 0.003	0.0008 - 0.0099	0.03	0.03

1 Source: Merriman (1997).
2 GLWQA = Great Lakes Water Quality Agreement (IJC, 1987b).
3 PWQO = Provincial Water Quality Objective (MOEE, 1994a).
4 DL = detection limit.

TABLE 4.10 WATER QUALITY DATA, APRIL 2000 TO MARCH 2001[1]

Parameter	No. of Samples	Concentration (mg/L unless otherwise indicated) Mean	Minimum	Maximum	PWQO[2]	Federal Water Quality Guidelines for Aquatic Life Protection[3]
Conventional Parameters						
Total Alkalinity	61	83.9	74.4	91.0	-	-
Conductivity (µsiemens/cm)	61	294	215	305	-	-
pH (units)	61	8.02	7.40	8.38	6.5-8.5	6.5-9
Turbidity (JTU)	61	0.30	<0.05	1.4	-	-
Dissolved Organic Carbon	24	2.9	2.1	11.4	-	-
Particulate Organic Carbon	12	0.057	0.025	0.122	-	-
Total Organic Carbon	24	22.0	20.9	23.2	-	-
Nitrate + Nitrite	61	0.312	0.168	0.427	-	-
Total Kjeldahl Nitrogen	61	0.213	0.153	0.334	-	-
Ammonia	61	<0.006	<0.001	0.031	-	-
Total Phosphorus	53	0.0091	0.0051	0.0165	0.030[4]	-
Phosphate	12	0.0069	0.0039	0.0089	-	-
Calcium	61	33.6	32.1	35.3	-	-
Chloride	61	20.3	17.9	21.9	-	-
Magnesium	61	8.30	7.64	8.98	-	-
Potassium	61	1.47	1.38	1.58	-	-
Silicate	61	0.61	0.28	0.99	-	-
Sodium	61	11.7	10.8	12.7	-	-
Sulphate	60	25.0	20.3	29.3	-	-
Metals (total) (µg/L)						
Aluminum	27	32	4.8	**180[5]**	75[6]	100[7]
Antimony	27	0.167	0.039	0.260	20[8]	-
Arsenic	12	0.5	0.3	0.7	100	5.0
Barium	27	22.2	21.0	26.1	-	-
Beryllium	27	<0.005	<0.005	0.007	1,100	-
Boron	27	23.7	21.1	26.2	200[8]	-
Cadmium	27	0.01	<0.01	**0.03**	0.2	0.017[8]
Chromium	27	0.29	<0.05	1.14	100	-
Cobalt	27	0.034	<0.002	0.083	0.9[8]	-
Copper	27	0.98	0.84	1.48	5	2-4[9]
Gallium	27	0.015	0.004	0.057	-	-

Parameter	No. of Samples	Concentration (mg/L unless otherwise indicated) Mean	Minimum	Maximum	PWQO[2]	Federal Water Quality Guidelines for Aquatic Life Protection[3]
Iron	27	32.1	3.29	218	300	300
Lanthanum	27	0.035	0.004	0.156	-	-
Lead	27	0.107	0.01	0.301	25	1-7[9]
Lithium	27	2.03	1.69	2.20	-	-
Manganese	27	3.86	0.254	189	-	-
Mercury	11	0.0004	0.00019	0.00105	0.2[10]	0.026
Molybdenum	27	1.23	1.12	1.28	40[8]	73[8]
Nickel	27	0.65	0.11	1.35	25	25-150[9]
Rubidium	27	1.02	0.921	1.28	-	-
Selenium	12	0.2	0.1	0.3	100	1.0
Silver	27	<0.005	<0.005	0.009	0.1	0.1
Strontium	27	179	170	193	-	-
Thallium	27	0.024	0.005	0.066	0.3[8]	0.8
Uranium	27	0.359	0.283	0.395	5[8]	-
Vanadium	27	0.31	0.06	0.67	6[8]	-
Zinc	27	0.64	0.2	1.82	30	30
Metals (extractable) (µg/L)						
Barium	8	23.2	21.5	25.4	-	-
Beryllium	8	0.005	<0.002	0.008	-	-
Boron	8	24.0	22.9	25.2	-	-
Cadmium	7	0.014	0.010	0.21	-	-
Chromium	8	0.785	0.360	1.44	-	-
Cobalt	8	0.049	0.020	0.085	-	-
Copper	7	1.05	0.976	1.23	-	-
Gallium	8	0.015	0.007	0.039	-	-
Lanthanum	8	0.037	0.006	0.118	-	-
Lead	8	0.132	0.063	0.234	-	-
Lithium	8	2.1	2.0	2.3	-	-
Manganese	8	1.79	0.353	7.40	-	-
Nickel	7	0.917	0.691	1.31	-	-
Rubidium	8	1.07	1.01	1.21	-	-
Silver	8	<0.005	<0.005	<0.005	-	-
Strontium	8	185	177	192	-	-
Thallium	8	0.022	0.015	0.030	-	-
Uranium	8	0.322	0.305	0.353	-	-
Vanadium	8	0.450	0.283	0.752	-	-

Parameter	No. of Samples	Concentration (mg/L unless otherwise indicated) Mean	Minimum	Maximum	PWQO[2]	Federal Water Quality Guidelines for Aquatic Life Protection[3]
Zinc	7	0.808	0.440	1.45	-	-
Organic Compounds (ng/L)						
Penta-Chlorobenzene	10	0.01	0.01	0.01	1,500	1,300[8]
Meta-Dichlorobenzene	4	<0.292	<0.285	0.31	2,500	150,000[8]
Ortho-Dichlorobenzene	10	<0.214	<0.214	<0.214	2,500	700[8]
Para-Dichlorobenzene	8	0.75	0.46	1.18	4,000	26,000[8]
Hexachlorobenzene	10	0.02	0.01	0.03	6.5	-
Tetrachlorobenzene	10	0.01	<0.005	0.02	100	1,800[11]
1,2,3-Trichlorobenzene	10	0.02	0.01	0.03	900	8,000[8]
1,2,4-Trichlorobenzene	8	0.05	<0.01	0.07	500	24,000
1,3,5-Trichlorobenzene	10	<0.009	<0.009	0.01	650	-
Hexachlorobutadiene	10	<0.003	<0.003	<0.003	9[8]	1,300[8]
Hexachlorocyclopentadiene	10	<0.005	<0.004	0.01	70[8]	-
Orthochlorostyrene	10	<0.004	<0.004	<0.004	-	-
Acenaphthylene	10	<0.09	<0.09	0.1	-	5,800[8]
Anthracene	10	<0.02	<0.02	0.05	0.8[8]	12[8]
Benzo(a)anthracene	10	<0.02	<0.01	0.04	0.4[8]	18[8]
Benzo(b,k)fluoranthene	10	<0.04	<0.03	0.05	0.2[8]	-
Benzo(ghi)perylene	10	<0.02	<0.02	<0.02	0.02[8]	-
Benzo(a)pyrene	10	<0.09	<0.01	0.31	-	15[8]
Chloronaphthalene	10	<0.01	<0.01	<0.01	-	-
Chrysene	10	0.04	<0.03	0.05	0.1[8]	-
Dibenzo(ah)anthracene	10	<0.02	<0.02	0.02	2[8]	-
Fluoranthene	10	0.38	0.27	0.60	0.8[8]	40[8]
Fluorene	10	0.25	0.14	0.43	200[8]	3,000[8]
Indopyrene	10	<0.02	<0.02	<0.02	-	-
1-Methyl Naphthalene	10	0.21	0.08	0.46	2,000[8]	-
2-Methyl Naphthalene	10	0.29	<0.12	0.68	2,000[8]	-
Phenanthrene	10	0.99	0.66	1.49	30[8]	400[8]
Pyrene	10	<0.17	<0.17	0.17	-	25[8]
Aldrin	10	<0.01	<0.01	<0.01	1[12]	-
α-BHC	10	0.21	0.09	0.31	-	-
γ-BHC (Lindane)	10	0.14	0.05	0.23	10	10
α-Chlordane	10	<0.036	<0.036	<0.036	60[13]	-

Parameter	No. of Samples	Concentration (mg/L unless otherwise indicated) Mean	Minimum	Maximum	PWQO[2]	Federal Water Quality Guidelines for Aquatic Life Protection[3]
γ-Chlordane	10	<0.0064	<0.006	0.01	60[13]	-
p,p-DDD	10	<0.034	<0.030	<0.043	3[14]	-
p,p-DDE	10	<0.07	<0.07	<0.07<	3[14]	-
o,p-DDT	10	<0.0033	<0.033	<0.033	3[14]	-
p,p-DDT	10	<0.043	<0.043	<0.043	3[14]	-
Dieldrin	10	0.11	0.06	0.17	1[12]	-
α-Endosulphan	10	<0.032	<0.012	0.180	3[15]	20[15]
β-Endosulphan	10	<0.014	<0.01	0.05	3[15]	20[15]
Endrin	8	<0.03	<0.03	0.03	2	-
Endrin Aldehyde	10	<0.027	<0.027	<0.027	-	-
Heptachlor	10	<0.01	<0.01	<0.01	1[16]	-
Heptachlor Epoxide	10	0.04	<0.015	0.08	1[16]	-
Metolachlor	10	13.2	5.9	26.8	3,000[8]	7,800[8]
Mirex	10	<0.14	<0.14	<0.14	1	-
Photomirex	10	<0.04	<0.04	<0.04	-	-
Atrazine	10	52.2	29.5	71.2	-	1,800

1 Source: J. Waltho, Environment Canada, 2006, pers. comm.
2 PWQO = Provincial Water Quality Objective (MOEE, 1994a).
3 CCME (1999, 2005).
4 Interim PWQO to eliminate excessive plant growth in rivers.
5 Bold number above the PWQO.
6 At pH >6.5 to 9.0, the Interim PWQO is 75 µg/l based on total aluminum measured in clay-free samples.
7 At pH ≥6.5; calcium ≥4 mg/L; dissolved organic carbon ≥2 mg/L.
8 Interim PWQO.
9 Depending upon the calcium carbonate concentration.
10 In a filtered water sample.
11 1,2,3,4-Tetrachlorobenzene.
12 Sum of aldrin and dieldrin.
13 Total chlordane.
14 Total DDT and metabolites.
15 Total endosulphan.
16 Sum of heptachlor and heptachlor epoxide.

TABLE 4.11 TOC, CADMIUM AND MERCURY CONCENTRATIONS IN SURFICIAL SEDIMENT SAMPLES COLLECTED FROM THE LOWER GAP AND ST. LAWRENCE RIVER NEAR KINGSTON[1]

Station[2]	Concentration		
	TOC (%)	Cadmium (µg/g)	Mercury (µg/g)
7	0.8	0.6	0.08
11	**1.1**[3]	0.3	0.10
12	**3.9**	**2.4**	**<u>0.63</u>**[4]
13	**3.9**	**2.1**	**<u>0.57</u>**
14	**3.9**	**2.7**	**<u>0.64</u>**
15	**4.0**	**2.8**	**<u>0.68</u>**
16	**2.8**	**0.8**	**0.19**
17	**3.8**	**2.5**	**<u>0.62</u>**
18	**2.3**	**1.0**	**0.45**
19	**4.0**	**2.6**	**<u>0.58</u>**
20	**4.1**	**2.7**	**0.47**
21	**1.6**	**1.0**	**0.31**
22	**4.6**	**2.3**	**<u>1.06</u>**
23	**4.0**	**1.0**	**<u>0.86</u>**
PSQG[5] LEL[6]	1	0.6	0.2
PSQG SEL[7]	10	10	2
CSQG[8] ISQG[9]	-	0.6	0.17
CSQG PEL[10]	-	3.5	0.486

1 Source: Johnston (1978).
2 See Figure 4.13.
3 Bold numbers are above their respective PWQG LEL and/or federal ISQG.
4 Bold and underlined numbers are above their respective federal PEL.
5 PSQG = Provincial Sediment Quality Guideline (Persaud *et al.,* 1992).
6 LEL = lowest effect level (µg/g dry weight sediment).
7 SEL = severe effect level (µg/g dry weight sediment).
8 CSQG = Canadian Sediment Quality Guideline (CCME, 1999, 2002).
9 ISQG = interim sediment quality guideline (µg/g dry weight sediment).
10 PEL = probable effect level (µg/g dry weight sediment).

TABLE 4.12 CONCENTRATIONS OF ORGANIC CONTAMINANTS IN SUSPENDED SEDIMENTS AND BOTTOM SEDIMENTS IN THE ST. LAWRENCE RIVER NEAR WOLFE ISLAND (1981)[1]

	Concentration (µg/g, unless otherwise indicated)							
	Suspended Sediment		Bottom Sediment		MOE Sediment Quality Guideline[4]		Canadian Sediment Quality Guideline[7]	
Parameter	Station 192[2]	Station 189[3]	Station 192	Station 189	LEL[5]	SEL[6]	ISQG[8]	PEL[9]
Particle Size								
% Sand	-	-	48.7	75.9	-	-	-	-
% Silt	-	-	17.7	14.3	-	-	-	-
% Clay	-	-	33.6	9.8	-	-	-	-
Total Organic Carbon (%)	-	-	**7.6**	**2.3**[10]	1	10	-	-
1,2-Dichlorobenzene	0.029	0.036	0.015	0.002	-	-	-	-
1,3-Dichlorobenzene	0.051	0.024	0.015	0.005	-	-	-	-
1,4-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001	-	-	-	-
1,2,3-Trichlorobenzene	0.004	0.006	0.003	<0.001	-	-	-	-
1,2,4-Trichlorobenzene	<0.001	<0.001	<0.001	<0.001	-	-	-	-
1,3,5-Trichlorobenzene	0.002	0.008	0.001	<0.001	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.002	<0.001	0.001	<0.001	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.003	0.003	0.002	<0.001	-	-	-	-
Pentachlorobenzene	0.002	0.003	0.002	<0.001	-	-	-	-
Hexachlorobenzene	0.004	0.006	0.011	0.001	0.02	0.552; 1.824	-	-
Aldrin	<0.001	<0.001	<0.001	<0.001	0.002	0.184; 0.608	-	-
α-BHC	<0.001	0.002	<0.001	<0.001	0.006	0.23; 0.76	-	-
γ-BHC (Lindane)	<0.001	<0.001	<0.001	<0.001	0.003	0.023; 0.076	0.00094	0.00138
α-Chlordane	<0.001	0.005	<0.001	<0.001	0.007[11]	0.138; 0.456[11]	0.00450[11]	0.00887[11]
γ-Chlordane	0.007	0.003	0.003	<0.001	0.007[11]	0.138; 0.456[11]	0.00450[11]	0.00887[11]
p,p-DDD	0.020	<0.001	**0.011**[12]	<0.001	0.008	0.138; 0.456	0.00354	0.00851
p,p-DDE	0.014	0.016	**0.045**	**0.003**	0.005	0.437; 1.444	0.00142	0.00675
o,p-DDT	<0.001	<0.001	<0.001	<0.001	0.008[13]	1.633; 5.396[13]	-	-
p,p-DDT	<0.001	0.009	0.001	<0.001	0.008[13]	1.633; 5.396[13]	0.00119[14]	0.00477[14]
Dieldrin	0.004	0.014	<0.001	<0.001	0.002	2.093; 6.916	0.00285	0.00667
α-Endosulfan	<0.001	<0.001	<0.001	<0.001	-	-	-	-
β-Endosulfan	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Endrin	<0.001	0.006	<0.001	<0.001	0.003	2.99; 9.88	0.00267	0.0624
Heptachlor	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Heptachlor epoxide	<0.001	<0.001	<0.001	<0.001	0.005	0.115; 0.38	0.00060	0.00274
Methoxychlor	<0.001	<0.001	<0.001	<0.001	-	-	-	-
Mirex	0.006	0.006	**0.009**	<0.001	0.007	2.99; 9.88	-	-
Total PCBs	0.190	0.200	**0.310**	0.010	0.07	12.19; 40.28	0.0341	0.277

1 Source: Merriman (1987).
2 Sampling location in the Lower Gap between Carruthers Point on the mainland and Four Mile Point, Simcoe Island.

[3] Sampling location in the Main Navigation Channel between Hornes Point, Wolfe Island, and Cape Vincent, NY.
[4] Persaud *et al.* (1992).
[5] LEL = lowest effect level (µg/g dry weight sediment).
[6] SEL = severe effect level (µg/g dry weight sediment for metals and nutrients); for organic parameters (µg/g organic carbon): numbers in this column are to be converted to bulk sediment values by multiplying by the actual total organic carbon (TOC) concentration of the sediments (to a maximum of 10%), e.g., analysis of a sediment sample gave a PCB value of 30 µg/g and a TOC of 5%. The value for PCB in the Severe Effects column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 x 0.05 = 26.5 µg/g as the Severe Effect Level guideline for that sediment. The measured value of 30 µg/g is then compared with bulk sediment value and is found to exceed the guideline.
[7] CCME (1999, 2002).
[8] ISQG = interim sediment quality guideline (µg/g dry weight sediment).
[9] PEL = probable effect level (µg/g dry weight sediment).
[10] Bold numbers are above their respective PWQG LEL and/or the federal ISQG.
[11] Total chlordane.
[12] Bold and underlined numbers are above their respective federal PEL.
[13] Sum of o,p-DDT and p,p-DDT.

TABLE 4.13 EASTERN KINGSTON BASIN SURFICIAL SEDIMENT QUALITY

	Concentration (µg/g, unless otherwise indicated)						
	Station			MOE Sediment Quality Guidelines[3]		Canadian Sediment Quality Guidelines[6]	
Parameter	N33[1]	1067[2]	1068[2]	LEL[4]	SEL[5]	ISQG[7]	PEL[8]
Particle Size							
% Sand	55.6	-	-	-	-	-	-
% Silt	9.3	-	-	-	-	-	-
% Clay	35.0	-	-	-	-	-	-
Total Kjeldahl Nitrogen	-	**745**[9]	**2,980**	550	4,800	-	-
Total Phosphorus	-	**604**	**635**	600	2,000	-	-
Aluminum	-	3,000	10,000	-	-	-	-
Arsenic	-	**9.8**	**15.5**	6	33	5.9	17.0
Cadmium	<DL[10]	<DL	<DL	0.6	10	0.6	3.5
Chromium	-	13.5	**30.3**	26	110	37.3	90.0
Cobalt	7	-	-	50[11]	-	-	-
Copper	6	9.0	**34.2**	16	110	35.7	197
Iron	**20,858**	8,000	20,000	20,000	40,000	-	-
Lead	19	20.5	**39.7**	31	250	35.0	91.3
Manganese	245	**548**	**547**	460	1,100	-	-
Mercury	0.003	**0.18**	**0.38**	0.2	2	0.17	0.486
Molybdenum	1	-	-	-	-	-	-
Nickel	**17**	**18.8**	**29.6**	16	75	-	-
Silver	0.10	-	-	0.5[11]	-	-	-
Strontium	35	-	-	-	-	-	-
Tin	5	-	-	-	-	-	-
Zinc	36	51.5	**134.8**	120	820	123	315
1,2,4,5-Tetrachlorobenzene	-	0.00024	0.00055	-	-	-	-
1,2,3,5-Tetrachlorobenzene	-	0.00015	0.00035	-	-	-	-
Pentachlorobenzene	-	0.00013	0.00033	-	-	-	-
Hexachlorobenzene	-	0.00125	0.00371	-	-	-	-
α-BHC	-	0.00002	0.00010	0.006	-[12]	-	-
β-BHC	-	<0.00001	<0.00001	0.005	-[12]	-	-
γ-BHC (Lindane)	-	0.00004	0.00013	0.003	-[12]	0.00094	0.00138
δ-BHC	-	<0.00001	<0.00001	-	-	-	-
Chlordane (total)	-	0.00035	0.00148	0.007	-[12]	0.0045	0.00887

Parameter	Concentration (µg/g, unless otherwise indicated)						
	Station			MOE Sediment Quality Guidelines[3]		Canadian Sediment Quality Guidelines[6]	
	N33[1]	1067[2]	1068[2]	LEL[4]	SEL[5]	ISQG[7]	PEL[8]
o,p-DDD	-	0.00030	0.00153	-	-	-	-
p,p-DDD	0.002	0.00100	**0.00537**	0.008	-[12]	0.00354	0.00851
o,p-DDE	-	0.00010	0.00054	-	-	-	-
p,p-DDE	**0.002**	0.00167	**0.00759**[13]	0.005	-[12]	0.00142	0.00675
o,p-DDT	-	0.0002	0.00063	0.008[14]	-	-	-
p,p-DDT	**0.004**	**0.00048**	**0.00248**	0.008[14]	-[12]	0.00119[15]	0.00477[15]
Dieldrin	-	0.00021	<0.00063	0.002	-[12]	0.00285	0.00667
Endosulfan I	-	<0.00001	0.00013	-	-	-	-
Endrin	-	<0.00001	0.00009	0.003	-[12]	0.00267	0.0624
Heptachlor	-	<0.00001	<0.00001	-	-	-	-
Heptachlor Epoxide	-	<0.00001	0.00017	0.005	-[12]	0.00060	0.00274
Mirex	-	<0.00001	<0.00001	0.007	-	-	-
Octochlorostyrene	-	<0.00001	<0.00001	-	-	-	-
Photomirex	-	0.00002	0.00006	-	-	-	-
PCBs (total)	-	0.0156	**0.0550**	0.07	-[12]	0.0341	0.277

1 Source: A. Mudroch, Environment Canada (ret.), 2006, pers. comm.
2 Source: Marvin *et al.* (2003); S. Painter, Environment Canada, 2006, pers. comm.
3 Persaud *et al.* (1992).
4 LEL = lowest effect level (µg/g dry weight sediment).
5 SEL = severe effect level (µg/g dry weight sediment for metals and nutrients); for organic parameters (µg/g organic carbon): numbers in this column are to be converted to bulk sediment values by multiplying by the actual total organic carbon (TOC) concentration of the sediments (to a maximum of 10%), e.g., analysis of a sediment sample gave a PCB value of 30 µg/g and a TOC of 5%. The value for PCB in the Severe Effects column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 x 0.05 = 26.5 µg/g as the Severe Effect Level guideline for that sediment. The measured value of 30 µg/g is then compared with bulk sediment value and is found to exceed the guideline.
6 CCME (1999, 2002).
7 ISQG = interim sediment quality guideline (µg/g dry weight sediment).
8 PEL = probable effect level (µg/g dry weight sediment).
9 Bold numbers are above their respective PWQG LEL and/or the federal ISQG.
10 DL = detection limit
11 Parameter carried over from the Open Water Disposal Guidelines (Persaud *et al.*, 1992) for uncontaminated sediments.
12 SEL value could not be calculated as TOC was not analyzed.
13 Bold and underlined numbers are above their respective federal PEL.
14 Sum of o,p-DDT and p,p-DDT.
15 Provisional.

TABLE 4.14 MAIN NAVIGATION CHANNEL SURFICIAL SEDIMENT QUALITY[1]

	Concentration (µg/g, unless otherwise indicated)							
					MOE Sediment Quality Guidelines[2]		Canadian Sediment Quality Guidelines[5]	
Parameter	Canadian Nearshore	Canadian Offshore	U.S. Offshore	U.S. Nearshore	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
Particle Size								
% Sand	96.7	0.2	0.3	58.1	-	-	-	-
% Silt	1.6	92.5	87.9	35.2	-	-	-	-
% Clay	1.7	7.3	11.8	6.7	-	-	-	-
Volatile Solids (%)	0.98	10.95	9.79	4.15	-	-	-	-
Chemical Oxygen Demand (%)	2.3	24.0	49.0	4.3	-	-	-	-
Total Kjeldahl Nitrogen	360	**5,700**[8]	**4,700**[9]	**1,780**	550	4,800	-	-
Ammonia-Nitrogen	3.1	15.1	8.2	6.1	-	-	-	-
Total Phosphorus	320	**1,100**	**930**	**720**	600	2,000	-	-
Oil and Grease	110	**2,000**	**2,600**	830	1,500[10]	-	-	-
Total Cyanide	<0.05	0.50	0.55	0.26	-	-	-	-
Arsenic	0.5	**6.5**	7.5	3.0	6	33	5.9	17.0
Barium	13	145	152	60	-	-	-	-
Cadmium	0.10	**2.0**	0.20	**0.75**	0.6	10	0.6	3.5
Chromium	7	**68**	**66**	26	26	110	37.3	90.0
Copper	3	**64**	**64**	21	16	110	35.7	197
Iron	3,900	**28,000**	**30,000**	14,100	20,000	40,000	-	-
Lead	7	**80**	**84**	29	31	250	35.0	91.3
Manganese	76	440	**490**	230	460	1,100	-	-
Mercury	**0.36**	**0.47**	**0.72**[11]	0.16	0.2	2	0.17	0.486
Nickel	5	**55**	**54**	**21**	16	75	-	-
Zinc	16	**250**	**270**	93	120	820	123	315
Aldrin	<0.015	<0.20	0.120	<0.20	0.002	-[12]	-	-
γ-BHC (Lindane)	<0.150	**0.83**	<0.150	0.62	0.003	-[12]	0.00094	0.00138
Chlordane	<0.020	**0.34**	**0.85**	<0.020	0.007	-[12]	0.0045	0.00887
DDT (total)	0.28	0.78	3.6	0.025	0.007	-[12]	0.00119[13,14]	0.00477[13,14]
Dieldrin	<0.015	<0.015	<0.015	**0.055**	0.002	-[12]	0.00285	0.00667
Endrin	**0.024**	<0.035	<0.035	<0.035	0.003	-[12]	0.00267	0.0624
Heptachlor	0.025	<0.015	<0.015	<0.015	-	-	-	-
Heptachlor Epoxide	<0.015	<0.015	<0.015	<0.015	0.005	-[12]	0.00060	0.00274

Parameter	Concentration (µg/g, unless otherwise indicated)							
					MOE Sediment Quality Guidelines[2]		Canadian Sediment Quality Guidelines[5]	
	Canadian Nearshore	Canadian Offshore	U.S. Offshore	U.S. Nearshore	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
Methoxychlor	<0.035	7.7	10.3	3.9	-	-	-	-
PCBs	<0.5	<0.5	<0.5	<0.5	0.07	-[12]	0.0341	0.277

1. Source: Fitchko (1990a).
2. Persaud *et al.* (1992).
3. LEL = lowest effect level (µg/g dry weight sediment).
4. SEL = severe effect level (µg/g dry weight sediment for metals and nutrients); for organic parameters (µg/g organic carbon): numbers in this column are to be converted to bulk sediment values by multiplying by the actual total organic carbon (TOC) concentration of the sediments (to a maximum of 10%), e.g., analysis of a sediment sample gave a PCB value of 30 µg/g and a TOC of 5%. The value for PCB in the Severe Effects column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 x 0.05 = 26.5 µg/g as the Severe Effect Level guideline for that sediment. The measured value of 30 µg/g is then compared with bulk sediment value and is found to exceed the guideline.
5. CCME (1999, 2002).
6. ISQG = interim sediment quality guideline (µg/g dry weight sediment).
7. PEL = probable effect level (µg/g dry weight sediment).
8. Bold and shaded numbers are above their respective PWQG SEL.
9. Bold numbers are above their respective PWQG LEL and/or the federal ISQG.
10. Parameter carried over from the Open Water Disposal Guidelines (Persaud *et al.*, 1992) for uncontaminated sediments.
11. Bold and underlined numbers are above their respective federal PEL.
12. SEL value could not be calculated as TOC was not analyzed.
13. p,p-DDT.
14. Provisional.

TABLE 4.15 TRACE METAL CONCENTRATIONS WITH SEDIMENT DEPTH AT A SEDIMENT CORE SAMPLING LOCATION AT THE LAKE ONTARIO OUTLET TO THE ST. LAWRENCE RIVER[1]

	Concentration (µg/g)									
Sediment Depth (cm)	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Mercury	Nickel	Zinc
0-1	<5	140	**1.7**[2]	**54**	10	**71**	**64**	**0.453**	**48**	**247**
1-2	**8**	124	**1.1**	**49**	10	**62**	**60**	**0.453**	**43**	**219**
2-3	<5	126	**1.5**	**58**	10	**70**	**84**	**0.532**	**52**	**269**
3-4	**8**	131	**2.0**	**62**	11	**74**	**94**[3]	**0.591**	**57**	**290**
4-5	<5	135	**1.7**	**66**	11	**74**	**100**	**0.630**	**71**	**306**
5-6	**7**	150	**4.6**	**79**	12	**86**	**135**	**0.749**	**82**[4]	**376**
6-7	**13**	152	**3.8**	**82**	13	**90**	**144**	**0.828**	**84**	**410**
7-8	**12**	158	**4.8**	**86**	13	**95**	**150**	**0.946**	**90**	**437**
8-9	**12**	165	**3.3**	**87**	13	**103**	**157**	**0.906**	**94**	**449**
9-10	**10**	156	**3.5**	**80**	13	**94**	**141**	**0.985**	**86**	**418**
10-11	**18**	163	**4.3**	**84**	13	**99**	**149**	**0.828**	**91**	**444**
11-12	**14**	166	**4.4**	**83**	14	**98**	**146**	**0.946**	**90**	**438**
12-13	<5	159	**3.3**	**77**	14	**90**	**134**	**0.926**	**84**	**410**
13-14	<5	151	**3.9**	**72**	13	**86**	**118**	**0.946**	**77**	**373**
14-15	**10**	144	**2.1**	**66**	12	**77**	**107**	**0.808**	**71**	**343**
17-18	-	-	-	**37**	-	**30**	**95**	-	-	**300**
20-21	-	-	-	**50**	-	**28**	**76**	-	-	**140**
22-23	-	-	-	**55**	-	**18**	**78**	-	-	90
24-25	-	-	-	**48**	-	**22**	**75**	-	-	105
26-27	-	-	-	**53**	-	**17**	**55**	-	-	78
28-29	-	-	-	**30**	-	**19**	**53**	-	-	52
31-32	-	-	-	**39**	-	**22**	**50**	-	-	55
33-34	-	-	-	**45**	-	**22**	**35**	-	-	58
35-36	-	-	-	**27**	-	**19**	29	-	-	48
37-38	-	-	-	25	-	**19**	30	-	-	50
PSQG[5] LEL[6]	6	-	0.6	26	50[7]	16	31	0.2	16	120
PSQG SEL[8]	33	-	10	110	-	110	250	2	75	820
CSQG[9] ISQG[10]	5.9	-	0.6	37.3	-	35.7	35.0	0.17	-	123
CSQG PEL[11]	17.0	-	3.5	90.0	-	197	91.3	0.486	-	315
Background[12]	<5	-	<1	27	-	50	15	0.04	43	103

1 Source: A. Mudroch, Environment Canada (ret.), 2006, pers. comm.
2 Bold numbers are above their respective PWQG LEL and/or the federal ISQG.
3 Bold and underlined numbers are above their respective federal PEL.
4 Bold and shaded numbers are above their respective PWQG SEL.

TABLE 4.16 WINTER FERRY DOCK SEDIMENT QUALITY

Parameter	Concentration (µg/g unless otherwise indicated)						
	Sampling Location[1]			MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	Pier	WD-1	WD-2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
Particle Size:				-	-	-	-
% Sand	35.0	46.4	-	-	-	-	-
% Silt	49.3	30.0	-	-	-	-	-
% Clay	15.7	23.7	-				
Total organic carbon (%)	**4.6**[8]	**3.3**	**2.6**	1	10	-	-
Total phosphorus	**750**	**850**	**770**	600	2,000	-	-
Total Kjeldahl nitrogen	**3,910**	**3,000**	**1,600**	550	4,800	-	-
Oil and grease	665	1,250	431	1,500[9]	-	-	-
Ammonia	<25	<25	<25	100[9]	-	-	-
Cyanide	<0.01	<0.01	<0.01	0.1[9]	-	-	-
Aluminum	16,000	11,000	8,200	-	-	-	-
Antimony	<1	1	<1	-	-	-	-
Arsenic	5	3	3	6	33	5.9	17.0
Barium	160	150	100	-	-	-	-
Beryllium	0.7	0.5	<0.5	-	-	-	-
Bismuth	<5	<5	<5	-	-	-	-
Cadmium	<0.3	<0.3	<0.3	0.6	10	0.6	3.5
Chromium	**32**	26	19	26	110	37.3	90.0
Cobalt	11	8.6	6.5	50[9]	-	-	-
Copper	**32**	**26**	**18**	16	110	35.7	197
Iron	**26,000**	19,000	15,000	20,000	40,000	-	-
Lead	9	13	9	31	250	35.0	91.3
Manganese	290	280	240	460	1,100	-	-
Mercury	<0.05	<0.05	<0.05	0.2	2	0.17	0.486
Molybdenum	0.8	1.1	0.7	-	-	-	-
Nickel	**25**	**22**	**17**	16	75	-	-
Selenium	<1	<1	<1	-	-	-	-
Silver	<0.3	<0.3	<0.3	0.5[9]	-	-	-
Strontium	65	180	170	-	-	-	-
Thallium	<1	<1	<1	-	-	-	-
Tin	2	3	1	-	-	-	-
Titanium	1,200	930	700	-	-	-	-
Uranium	<20	<20	<20				
Vanadium	33	29	22	-	-	-	-
Zinc	61	69	47	120	820	123	315
Zirconium	<5	<5	<5	-	-	-	-
Calcium	110,000	110,000	27,000	-	-	-	-
Magnesium	8,500	10,000	11,000	-	-	-	-
Potassium	2,000	2,600	3,000	-	-	-	-
Sodium	360	410	330	-	-	-	-
Sulphur	3,100	4,600	7,500	-	-	-	-

Parameter	Concentration (µg/g unless otherwise indicated)						
	Sampling Location[1]			MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	Pier	WD-1	WD-2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
1,2-Dichlorobenzene	<0.2	<2	<0.2	-	-	-	-
1,3-Dichlorobenzene	<0.2	<2	<0.2	-	-	-	-
1,4-Dichlorobenzene	<0.2	<2	<0.2	-	-	-	-
Bis(2-chloroethyl)ether	<0.4	<4	<0.4	-	-	-	-
Bis(2-chloroethoxy)methane	<0.2	<2	<0.2	-	-	-	-
Bis(2-chloroisopropyl)ether	<0.2	<2	<0.2	-	-	-	-
4-Bromophenyl phenyl ether	<0.2	<2	<0.2	-	-	-	-
4-Chlorophenyl phenyl ether	<0.2	<2	<0.2	-	-	-	-
3,3-Dichlorobenzidene	<1	<10	<1	-	-	-	-
2,4-Dinitrotoluene	<0.2	<2	<0.2	-	-	-	-
2,6-Dinitrotoluene	<0.2	<2	<0.2	-	-	-	-
Hexachlorobenzene	<0.005	<0.004	<0.004	0.02	24	-	-
Pentachlorobenzene	<0.4	<4	<0.4	-	-	-	-
1,2,3,4-Tetrachlorobenzene	<0.4	<4	<0.4	-	-	-	-
1,2,3,5-Tetrachlorobenzene	<0.4	<4	<0.4	-	-	-	-
1,2,4,5-Tetrachlorobenzene	<0.4	<4	<0.4	-	-	-	-
1,2,3-Trichlorobenzene	<0.4	<4	<0.4	-	-	-	-
1,2,4-Trichlorobenzene	<0.4	<4	<0.4	-	-	-	-
1,3,5-Trichlorobenzene	<0.4	<4	<0.4	-	-	-	-
Hexachlorobutadiene	<0.2	<2	<0.2	-	-	-	-
Hexachlorocyclopentadiene	<0.2	<10	<0.2	-	-	-	-
Hexachloroethane	<0.2	<2	<0.2	-	-	-	-
Isophorone	<0.2	<2	<0.2	-	-	-	-
Nitrobenzene	<0.2	<2	<0.2	-	-	-	-
N-Nitroso-di-n-propylamine	<0.2	<4	<0.2	-	-	-	-
N-Nitroso-diphenylamine	<0.4	<2	<0.4	-	-	-	-
4-Chloro-3-methylphenol	<0.2	<2	<0.2	-	-	-	-
2-Chlorophenol	<0.2	<2	<0.2	-	-	-	-
2,3-Dichlorophenol	<0.2	<2	<0.2	-	-	-	-
2,4-Dichlorophenol	<0.2	<2	<0.2	-	-	-	-
2,5-Dichlorophenol	<0.2	<2	<0.2	-	-	-	-
2,6-Dichlorophenol	<0.2	<2	<0.2	-	-	-	-
3,4-Dichlorophenol	<0.2	<2	<0.2	-	-	-	-
3,5-Dichlorophenol	<0.2	<2	<0.2	-	-	-	-
2,4-Dimethylphenol	<0.2	<2	<0.2	-	-	-	-
2,4-Dinitrophenol	<0.4	<4	<0.4	-	-	-	-
2-Methyl-4,6-dinitrophenol	<1	<10	<1	-	-	-	-
2-Nitrophenol	<1	<10	<1	-	-	-	-
4-Nitrophenol	<1	<10	<1	-	-	-	-
Pentachlorophenol	<0.4	<4	<0.4	-	-	-	-
Phenol	<0.4	<4	<0.4	-	-	-	-
2,3,4,5-Tetrachlorophenol	<0.2	<2	<0.2	-	-	-	-
2,3,4,6-Tetrachlorophenol	<0.2	<2	<0.2	-	-	-	-
2,3,5,6-Tetrachlorophenol	<0.2	<2	<0.2	-	-	-	-
2,3,4-Trichlorophenol	<0.2	<2	<0.2	-	-	-	-
2,3,5-Trichlorophenol	<0.2	<2	<0.2	-	-	-	-

Parameter	Concentration (µg/g unless otherwise indicated)						
	Sampling Location[1]			MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	Pier	WD-1	WD-2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
2,3,6-Trichlorophenol	<0.2	<2	<0.2	-	-	-	-
2,4,5-Trichlorophenol	<0.2	<2	<0.2	-	-	-	-
2,4,6-Trichlorophenol	<0.2	<2	<0.2	-	-	-	-
3,4,5-Trichlorophenol	<0.2	<2	<0.2	-	-	-	-
Biphenyl	<0.2	<2	<0.2	-	-	-	-
p-Chloroaniline	<0.4	<4	<0.4	-	-	-	-
m&p-Cresol	<0.4	<4	<0.4	-	-	-	-
o-Cresol	<0.4	<4	<0.4	-	-	-	-
Butylbenzyl phthalate	<0.4	<4	<0.4	-	-	-	-
Bis(2-ethylhexyl)phthalate	<1	<10	<1	-	-	-	-
Di-n-butyl phthalate	<0.4	<4	<0.4	-	-	-	-
Diethyl phthalate	<0.4	<4	<0.4	-	-	-	-
Dimethyl phthalate	<0.4	<4	<0.4	-	-	-	-
Di-n-octyl phthalate	<1	<10	<1	-	-	-	-
Acenaphthene	<0.2	<2	<0.2	-	-	0.00671[10]	0.0889[10]
Acenaphthylene	<0.2	<2	<0.2	-	-	0.00587[10]	0.128[10]
Acridene	<0.4	<4	<0.4	-	-	-	-
Anthracene	<0.2	<2	<0.2	0.220[11]	370[11]	0.0469[10]	0.245[10]
Benzo(a)anthracene	<0.2	<2	<0.2	0.320[11]	1,480[11]	0.0317	0.385
Benzo(b)fluoranthene	<0.2	<2	<0.2	-	-	-	-
Benzo(k)fluoranthene	<0.2	<2	<0.2	0.240[11]	1,340[11]	-	-
Benzo(a)pyrene	<0.2	<2	<0.2	0.370[11]	1,440[11]	0.0319	0.782
Benzo(g,h,I)perylene	<0.2	<2	<0.2	0.170[11]	320[11]	-	-
1-Chloronaphthalene	<2	<20	<2	-	-	-	-
2-Chloronaphthalene	<0.2	<2	<0.2	-	-	-	-
Chrysene	<0.2	<2	<0.2	0.340[11]	460[11]	0.0571	0.862
Dibenzo(a,h)anthracene	<0.2	<2	<0.2	0.060[11]	130[11]	0.00622[10]	0.135[10]
Fluoranthene	<0.2	<2	<0.2	0.750[11]	1,020[11]	0.111	2.355
Fluorene	<0.2	<2	<0.2	0.190[11]	160[11]	0.0212[10]	0.144[10]
Indeno(1,2,3-cd)pyrene	<0.2	<2	<0.2	0.200[11]	320[11]	-	-
1-Methylnaphthalene	<0.2	<2	<0.2	-	-	-	-
2-Methylnaphthalene	<0.2	<2	<0.2	-	-	-	-
Naphthalene	<0.2	<2	<0.2	-	-	0.0346[10]	0.391[10]
Phenanthrene	<0.2	<2	<0.2	0.560[11]	950[11]	0.0419	0.515
Pyrene	<0.2	<2	<0.2	0.490[11]	850[11]	0.0530	0.875
Quinoline	<0.4	<4	<0.4	-	-	-	-
Total PAHs[12]	<3.2	<3.2	<3.2	4[11]	10,000[11]	-	-
Aldrin	<0.005	<0.004	<0.004	0.002	8	-	-
α-BHC	<0.005	<0.004	<0.004	0.006	10	-	-
β-BHC	<0.005	<0.004	<0.004	0.005	21	-	-
δ-BHC	<0.005	<0.004	<0.004	-	-	-	-
γ-BHC (lindane)	<0.005	<0.004	<0.004	0.003[10]	1[10]	0.00094	0.00138
α-Chlordane	<0.005	<0.004	<0.004	0.007[13]	6[13]	0.0045[13]	0.00887[13]

Parameter	Concentration (µg/g unless otherwise indicated)						
	Sampling Location[1]			MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	Pier	WD-1	WD-2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
γ-Chlordane	<0.005	<0.004	<0.004	0.007[13]	6[13]	0.0045[13]	0.00887[13]
o,p-DDD	<0.005	<0.004	<0.004	-	-	-	-
p,p-DDD	<0.005	<0.004	<0.004	0.008	6	0.00354[14]	0.00851[14]
o,p-DDE	<0.005	<0.004	<0.004	-	-	-	-
p,p-DDE	<0.005	<0.004	<0.004	0.005	19	0.00142[14]	0.00675[14]
o,p-DDT	<0.005	<0.004	<0.004	-	-	-	-
p,p-DDT	<0.005	<0.004	<0.004	0.008[14]	71[14]	0.00119[10,14]	0.00477[10,14]
Dieldrin	<0.005	<0.004	<0.004	0.002	91	0.00285	0.00667
Endosulfan I	<0.005	<0.004	<0.004	-	-	-	-
Endosulfan II	<0.005	<0.004	<0.004	-	-	-	-
Endosulfan sulphate	<0.005	<0.004	<0.004	-	-	-	-
Endrin	<0.005	<0.004	<0.004	0.003	130	0.00267	0.0624
Endrin ketone	<0.005	<0.004	<0.004	-	-	-	-
Endrin aldehyde	<0.005	<0.004	<0.004	-	-	-	-
Heptachlor	<0.005	<0.004	<0.004	-	-	-	-
Heptachlor epoxide	<0.005	<0.004	<0.004	0.005	5	0.00060	0.00274
Methoxychlor	<0.02	<0.016	<0.016	-	-	-	-
Mirex	<0.005	<0.004	<0.004	0.007	130	-	-
Octochlorostyrene	<0.005	<0.004	<0.004	-	-	-	-
Toxaphene	<0.2	<0.16	<0.16	-	-	0.0001[10]	-
Total PCBs	<0.08	<0.06	<0.06	0.07	530	0.0341	0.277

1 See Figure 4.15 (Appenidx A) for sampling locations.
2 Persaud *et al*. (1992); MOE (2004b).
3 LEL = lowest effect level (µg/g dry weight sediment).
4 SEL = severe effect level (µg/g dry weight sediment for metals and nutrients); for organic parameters (µg/g organic carbon): numbers in this column are to be converted to bulk sediment values by multiplying by the actual total organic carbon (TOC) concentration of the sediments (to a maximum of 10%), e.g., analysis of a sediment sample gave a PCB value of 30 µg/g and a TOC of 5%. The value for PCB in the severe effect level column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 x 0.05 = 26.5 µg/g as the severe effect level guideline for that sediment. The measured value of 30 µg/g is then compared with this bulk sediment value and is found to exceed the guideline.
5 CCME (1999, 2002).
6 ISQG = interim sediment quality guideline (µg/g dry weight sediment).
7 PEL = probable effect level (µg/g dry weight sediment).
8 Bold numbers are above their respective LEL and/or ISQG.
9 Parameter carried over from the Open Water Disposal Guidelines (Persaud *et al*., 1992) for uncontaminated sediments.
10 Provisional ISQG; tentative PSQG.
11 MOE (1994a; 2004b).
12 PAH (total) is the sum of 16 polyaromatic hydrocarbon (PAH) compounds: acenaphthene, acenephthylene, anthracene, benzo(k)fluoranthene, benzo(b)fluoranthene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene.
13 Total chlordane.
14 Sum of the p,p and o,p isomers.

TABLE 4.17 INITIAL TRANSMISSION LINE ROUTE AND SAND BAY SEDIMENT QUALITY

Parameter	Concentration (µg/g unless otherwise indicated)									
	Sampling Location[1]						MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	T1	T2	T3	T4	SB1	SB2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
Particle Size:							-	-	-	-
% Sand	95.3	61.5	45.8	83.6	98*	97*	-	-	-	-
% Silt	<0.1	26.5	35.8	10.3	2*	3*	-	-	-	-
% Clay	4.7	12.0	18.3	6.1	<2*	<2*	-	-	-	-
Total organic carbon (%)	0.4	**3.1**[8]	**5.2**	**1.3**	0.28*	0.41*	1	10	-	-
Total phosphorus	**760**	**970**	**1,700**	**940**	360*	**920***	600	2,000	-	-
Total Kjeldahl nitrogen	262	**2,930**	**5,500**[9]	**1,650**	211*	406*	550	4,800	-	-
Oil and grease	278	477	1,290	461	370*	410*	1,500[10]	-	-	-
Ammonia	**105**	<25	<25	**134**	<25*	<25*	100[10]	-	-	-
Cyanide	<0.01	<0.01	<0.01	<0.01	<0.01*	<0.01*	0.1[10]	-	-	-
Aluminum	1,600	12,000	22,000	2,800	680*	1,100*	-	-	-	-
Antimony	<1	1	<1	1	<0.2*	<0.2*	-	-	-	-
Arsenic	1	**9**	**15**	2	<1*	<1*	6	33	5.9	17.0
Barium	14	120	210	30	4.8*	9.9*	-	-	-	-
Beryllium	<0.5	0.6	1.2	<0.5	<0.2*	<0.2*	-	-	-	-
Bismuth	<5	<5	<5	<5	-	-	-	-	-	-
Cadmium	<0.3	**1.3**	**3.7**	0.4	<0.1*	<0.1*	0.6	10	0.6	3.5
Chromium	6.5	**40**	**94**	8.7	3*	8*	26	110	37.3	90.0
Cobalt	2.1	11	19	3.1	0.8*	1.7*	50[10]	-	-	-
Copper	2.8	**50**	**120**[11]	8.7	1.1*	3.0*	16	110	35.7	197
Iron	6,200	**23,000**	**41,000**	5,400	2,700*	9,800*	20,000	40,000	-	-
Lead	4	**71**	**170**[12]	10	<1*	1*	31	250	35.0	91.3
Manganese	120	400	**710**	130	48*	79*	460	1,100	-	-
Mercury	<0.05	**0.22**	**0.46**	0.05	<0.05*	<0.05*	0.2	2	0.17	0.486
Molybdenum	<0.5	0.7	2.2	<0.5	<0.5*	<0.5*	-	-	-	-
Nickel	3.9	**41**	**91**	8.5	1.4*	3.1*	16	75	-	-
Selenium	<1	<1	<1	<1	<0.5*	<0.5*	-	-	-	-
Silver	<0.3	**0.8**	**2.6**	<0.3	<0.2*	<0.2*	0.5[10]	-	-	-
Strontium	26	69	130	61	18*	44*	-	-	-	-

Parameter	Concentration (µg/g unless otherwise indicated)									
	Sampling Location[1]						MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	T1	T2	T3	T4	SB1	SB2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
Thallium	<1	<1	<1	<1	<0.05*	<0.05*	-	-	-	-
Tin	<1	4	9	1	-	-	-	-	-	-
Titanium	270	590	730	250	-	-	-	-	-	-
Uranium	<20	<20	<20	<20	-	-	-	-	-	-
Vanadium	12	29	50	8.4	6*	24*	-	-	-	-
Zinc	20	**190**	**<u>420</u>**	39	5*	13*	120	820	123	315
Zirconium	<5	<5	<5	<5	-	-	-	-	-	-
Calcium	15,000	46,000	87,000	32,000	11,000	28,000	-	-	-	-
Magnesium	3,400	9,300	16,000	3,100	1,800	3,700	-	-	-	-
Potassium	270	2,100	3,700	520	<200	<200	-	-	-	-
Sodium	110	270	440	200	<100	<100	-	-	-	-
Sulphur	280	2,600	8,600	1,100	-	-	-	-	-	-
1,2-Dichlorobenzene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
1,3-Dichlorobenzene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
1,4-Dichlorobenzene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Bis(2-chloroethyl)ether	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
Bis(2-chloroethoxy)methane	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Bis(2-chloroisopropyl)ether	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
4-Bromophenyl phenyl ether	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
4-Chlorophenyl phenyl ether	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
3,3-Dichlorobenzidene	<0.5	<10	<2	<10	<0.5	<0.5	-	-	-	-
2,4-Dinitrotoluene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,6-Dinitrotoluene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Hexachlorobenzene	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.02	24	-	-
Pentachlorobenzene	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
1,2,3,4-Tetrachlorobenzene	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
1,2,3,5-Tetrachlorobenzene	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
1,2,4,5-Tetrachlorobenzene	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
1,2,3-Trichlorobenzene	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
1,2,4-Trichlorobenzene	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
1,3,5-Trichlorobenzene	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-

Parameter	Concentration (µg/g unless otherwise indicated)									
	Sampling Location[1]						MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	T1	T2	T3	T4	SB1	SB2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
Hexachlorobutadiene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Hexachlorocyclopentadiene	<0.5	<10	<2	<10	<0.5	<0.5	-	-	-	-
Hexachloroethane	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Isophorone	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Nitrobenzene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
N-Nitroso-di-n-propylamine	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
N-Nitroso-diphenylamine	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
4-Chloro-3-methylphenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2-Chlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,3-Dichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,4-Dichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,5-Dichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,6-Dichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
3,4-Dichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
3,5-Dichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,4-Dimethylphenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,4-Dinitrophenol	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
2-Methyl-4,6-dinitrophenol	<0.5	<10	<2	<10	<0.5	<0.5	-	-	-	-
2-Nitrophenol	<0.5	<10	<2	<10	<0.5	<0.5	-	-	-	-
4-Nitrophenol	<0.5	<10	<2	<10	<0.5	<0.5	-	-	-	-
Pentachlorophenol	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
Phenol	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
2,3,4,5-Tetrachlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,3,4,6-Tetrachlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,3,5,6-Tetrachlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,3,4-Trichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,3,5-Trichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,3,6-Trichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,4,5-Trichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2,4,6-Trichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
3,4,5-Trichlorophenol	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Biphenyl	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
p-Chloroaniline	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-

Parameter	Concentration (µg/g unless otherwise indicated)									
	Sampling Location[1]						MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	T1	T2	T3	T4	SB1	SB2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
m&p-Cresol	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
o-Cresol	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
Butylbenzyl phthalate	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
Bis(2-ethylhexyl)phthalate	<0.5	<10	<2	<10	<0.5	<0.5	-	-	-	-
Di-n-butyl phthalate	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
Diethyl phthalate	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
Dimethyl phthalate	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-
Di-n-octyl phthalate	<0.5	<10	<2	<10	<0.5	<0.5	-	-	-	-
Acenaphthene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	0.00671[13]	0.0889[13]
Acenaphthylene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	0.00587[13]	0.128[13]
Acridene	<0.2	<4	<0.8	<4	-	-	-	-	-	-
Anthracene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.220[14]	370[14]	0.0469[13]	0.245[13]
Benzo(a)anthracene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.320[14]	1,480[14]	0.0317	0.385
Benzo(b)fluoranthene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Benzo(k)fluoranthene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.240[14]	1,340[14]	-	-
Benzo(a)pyrene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.370[14]	1,440[14]	0.0319	0.782
Benzo(g,h,I)perylene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.170[14]	320[14]	-	-
1-Chloronaphthalene	<1	<20	<4	<20	<1	<1	-	-	-	-
2-Chloronaphthalene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Chrysene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.340[14]	460[14]	0.0571	0.862
Dibenzo(a,h)anthracene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.060[14]	130[14]	0.00622[13]	0.135[13]
Fluoranthene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.750[14]	1,020[14]	0.111	2.355
Fluorene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.190[14]	160[14]	0.0212[13]	0.144[13]
Indeno(1,2,3-cd)pyrene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.200[14]	320[14]	-	-
1-Methylnaphthalene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
2-Methylnaphthalene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	-	-
Naphthalene	<0.1	<2	<0.4	<2	<0.1	<0.1	-	-	0.0346[13]	0.391[13]
Perylene	-	-	-	-	<0.2	<0.2	-	-	-	-
Phenanthrene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.560[14]	950[14]	0.0419	0.515
Pyrene	<0.1	<2	<0.4	<2	<0.1	<0.1	0.490[14]	850[14]	0.0530	0.875
Quinoline	<0.2	<4	<0.8	<4	<0.2	<0.2	-	-	-	-

Parameter	Concentration (µg/g unless otherwise indicated)									
	Sampling Location[1]						MOE Sediment Quality Guideline[2]		Canadian Sediment Quality Guidelines[5]	
	T1	T2	T3	T4	SB1	SB2	LEL[3]	SEL[4]	ISQG[6]	PEL[7]
Total PAHs[15]	<1.6	<32	<6.4	<32	<1.6	<1.6	4[14]	10,000[14]	-	-
Aldrin	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.002	8	-	-
α-BHC	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.006	10	-	-
β-BHC	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.005	21	-	-
δ-BHC	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
γ-BHC (lindane)	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.003[13]	1[13]	0.00094	0.00138
α-Chlordane	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.007[16]	6[16]	0.0045[16]	0.00887[16]
γ-Chlordane	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.007[16]	6[16]	0.0045[16]	0.00887[16]
o,p-DDD	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
p,p-DDD	<0.002	**<u>0.018</u>**	**<u>0.013</u>**	<0.002	<0.002	<0.002	0.008	6	0.00354[17]	0.00851[17]
o,p-DDE	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
p,p-DDE	<0.002	**<u>0.023</u>**	**<u>0.033</u>**	<0.002	<0.002	<0.002	0.005	19	0.00142[17]	0.00675[17]
o,p-DDT	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
p,p-DDT	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.008[17]	71[17]	0.00119[13,17]	0.00477[13,17]
Dieldrin	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.002	91	0.00285	0.00667
Endosulfan I	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
Endosulfan II	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
Endosulfan sulphate	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
Endrin	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.003	130	0.00267	0.0624
Endrin ketone	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
Endrin aldehyde	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
Heptachlor	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
Heptachlor epoxide	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.005	5	0.00060	0.00274
Methoxychlor	<0.008	<0.002	<0.028	<0.008	<0.002	<0.002	-	-	-	-
Mirex	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	0.007	130	-	-
Octochlorostyrene	<0.002	<0.005	<0.007	<0.002	<0.002	<0.002	-	-	-	-
Toxaphene	<0.08	<0.2	<0.28	<0.08	<0.08	<0.08	-	-	0.0001[13]	-
Total PCBs	<0.03	**0.14**	**<u>0.33</u>**	<0.03	TBA	TBA	0.07	530	0.0341	0.277

* Concentration based on average for three samples.
[1] See Figure 4.3 for sampling locations.

[2] Persaud *et al*. (1992); MOEE (1994b).
[3] LEL = lowest effect level (µg/g dry weight sediment).
[4] SEL = severe effect level (µg/g dry weight sediment for metals and nutrients); for organic parameters (µg/g organic carbon): numbers in this column are to be converted to bulk sediment values by multiplying by the actual total organic carbon (TOC) concentration of the sediments (to a maximum of 10%), e.g., analysis of a sediment sample gave a PCB value of 30 µg/g and a TOC of 5%. The value for PCB in the severe effect level column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 x 0.05 = 26.5 µg/g as the severe effect level guideline for that sediment. The measured value of 30 µg/g is then compared with this bulk sediment value and is found to exceed the guideline.
[5] CCME (1999, 2002).
[6] ISQG = interim sediment quality guideline (µg/g dry weight sediment).
[7] PEL = probable effect level (µg/g dry weight sediment).
[8] Bold numbers are above their respective LEL and/or ISQG.
[9] Bold, underlined and shaded numbers are above their respective SEL.
[10] Parameter carried over from the Open Water Disposal Guidelines (Persaud *et al*., 1992) for uncontaminated sediments.
[11] Bold and shaded number is above its SEL but not the PEL.
[12] Bold and underlined numbers are above their respective PEL but not the SEL.
[13] Provisional ISQG; tentative PSQG.
[14] MOEE (1994b).
[15] PAH (total) is the sum of 16 polyaromatic hydrocarbon (PAH) compounds: acenaphthene, acenephthylene, anthracene, benzo(k)fluoranthene, benzo(b)fluoranthene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene.
[16] Total chlordane.
[17] Sum of the p,p and o,p isomers.

TABLE 4.18: LAKE ONTARIO PHYTOPLANKTON COMPOSITION, 1998[1]

Taxon	Average Lakewide Biomass (µg/mL)[2]	
	Spring	Summer
BACILLARIOPHYTA		
Asterionella formosa	3,420	0
Aulacoseira islandica	242,768	0
A. subarctica	238	0
Cyclotella comensis	244	4,142
C. comta	187	4,608
C. delicatula	0	945
C. ocellata	10	347
Fragilaria crotonensis	0	36,247
Nitzschia lauenburgiana	9,062	0
Urosolenia spp.	152	178
Stephanodiscus alpinus	154,957	0
S. binderanus	1,183	0
S. hantzschii f. *tenuis*	363	0
S. parvus	265	0
Synedra filiformis	0	45
Tabellaria flocculosa	7,144	0
Thalassiosira baltica	41,246	0
CHLOROPHYTA		
Coccoid oval	60	0
Cosmarium spp.	781	0
C. depressum	0	10,732
Monoraphidium minutum	0	26
Oocystis borgei	0	25,723
Scenedesmus ecornis	0	20,225
Sphaerocystis schroeteri	0	6,477
Staurastrum spp.	0	12,335
S. gracile	0	42,877
S. paradoxum	0	15,756
Tetraedron minimum	0	23,912
Ulothrix spp.	0	6,421
Westella spp.	0	1,071
CHRYSOPHYTA		
Dinobyron divergens	0	25,374
D. sociale	0	315
D. sociale var. *americanum*	0	154
Haptophyceae	9,056	9,179
Mallomonas spp.	0	1,494
Ochromonas sp. – ovoid	2,872	2,245
Rhizochrysis spp.	0	664

Taxon	Average Lakewide Biomass (µg/mL)[2] Spring	Summer
Unidentified flagellate #4	0	80
Unidentified coccoid ovoid	1,933	0
Unidentified flagellate #5	792	0
Unidentified flagellate ovoid	3,075	0
CRYPTOPHYTA		
Cryptomonas erosa	19,535	44,073
C. erosa var. *reflexa*	6,669	17,801
C. marssonii	4,055	2,464
C. ovata	11,597	19,879
C. phaseolus	4,492	0
C. pyrenoidifera	3,967	0
C. reflexa	0	4,394
Rhodomonas lens	6,019	0
R. minuta	43,431	39,086
R. minuta var. *nannoplanctica*	4,960	32,213
CYANOPHYTA		
Anabaena flos-aquae	0	4,588
Anacystis montana fo. *minor*	6,206	0
Aphanocapsa delicatissima	0	1,694
Chroococcus limneticus	0	14,604
Oscillatoria minima	2,974	0
PYRROPHYTA		
Ceratium hirundinella	0	161,822
Glenodinium spp.	0	13,749
Gymnodinium spp.	12,517	1,234
G. helveticum fo. *achroum*	38,579	0
Peridinium spp.	0	66,610

[1] Source: Barbiero and Tuchman (2001).
[2] Dominant (>5% biomass at any site) phytoplankton taxa.

TABLE 4.19: FREQUENCY OF OCCURRENCE OF PHYTOPLANKTON TAXA IN THE UPPER ST. LAWRENCE RIVER, SPRING THROUGH SUMMER 1976-78[1]

	Frequency of Occurrence (%)		
Taxon	1976	1977	1978
CHLOROPHYTA			
Actinastrum hantzschii	-	<40	-
Ankistrodesmus falcatus	>80	>80	>80
A. falcatus var. *acicularis*	<40	-	-
Carteria cordiformis	<40	-	-
Chlamydomonas sp.	<40	<40	-
Closteriopsis longissima	<40	-	-
Coelastrum microporum	>80	<40	-
C. retusum	<40	-	-
Cosmarium botrytis	<40	-	-
C. pyramidatum	<40	-	-
C. reniforme	<40	<40	-
Crucigenia rectangularis	-	<40	-
Dictyosphaerium pulchellum	40 – 80	-	-
Elakatothrix gelatinosa	<40	<40	-
Franceia ovalis	<40	-	-
Goelenkinia radiata	<40	-	-
Kirchneriella contorta	<40	-	-
K. lunaris	<40	-	-
Lagerheimia ciliata	<40	<40	-
L. quadriseta	-	-	<40
Micractinium pusillum	<40	-	-
Mougeotia sp.	40 – 80	<40	-
Nephrocytium limneticum	40 – 80	-	-
Oocystis elliptica	<40	-	-
O. lacustris	40 – 80	<40	-
Pandorina morum	40 – 80	-	-
Pediastrum boryanum	40 – 80	40 – 80	-
P. duplex	<40	-	-
P. duplex var. *reticulatum*	<40	-	-
P. obtusum	<40	-	-
P. tetras var. *tetraodon*	<40	-	-
Scenedesmus armatus	<40	-	-
S. bijuga	>80	>80	>80
S. denticulatus	40 – 80	<40	-
S. dimorphus	<40	-	-
S. quadricauda	-	<40	<40
S. quadricauda var. *longispina*	40 – 80	<40	-
Schroederia setigera	40 – 80	<40	<40
Selenastrum gracile	<40	-	-
S. minutum	-	<40	<40
Staurastrum natator var. *crassum*	40 – 80	-	-
Stylosphaerum stipitatum	<40	<40	-
Tetraedron minimum	40 – 80	40 – 80	-

Taxon	Frequency of Occurrence (%)		
	1976	1977	1978
T. trigonum	<40	-	-
Treubaria setigerum	<40	-	-
PYRROPHYTA			
Ceratium hirundinella	40 – 80	-	-
Glenodinium quadridens	>80	-	40 – 80
Gymnodinium caudatum	-	40 – 80	<40
G. palustre	<40	<40	-
CRYPTOPHYTA			
Cryptomonas ovata	>80	>80	>80
C. pusila	>80	>80	>80
CHRYSOPHYTA			
Chromulina sp.	>80	>80	>80
C. minuta	<40	-	<40
Chrysamoeba radians	<40	<40	-
Dinobryon bavaricum	<40	<40	<40
D. divergens	<40	-	-
D. sertularia	40 – 80	40 – 80	40 – 80
Mallomonas akrokomos	<40	-	-
Ochromonas sp.	>80	>80	40 – 80
Synura uvella	-	<40	<40
Uroglenopsis americana	<40	<40	-
BACILLARIOPHYTA			
Asterionella formosa	<40	>80	40 - 80
Cocconeis placentula	<40	<40	<40
Cyclotella (5-6 μm)	>80	>80	>80
Cyclotella (10-11 μm)	40 – 80	40 – 80	<40
Cyclotella (15 μm)	-	-	<40
Cyclotella (20 μm)	-	-	<40
Cymbella ventricosa	<40	<40	-
Diatoma tenue var. *elongatum*	<40	40 – 80	<40
Fragilaria brevistriata	-	<40	-
F. crotenensis	>80	40 – 80	<40
F. virescens	<40	<40	<40
Gomphonema olivaceum	-	<40	-
Gyrosigma fasicola	<40	<40	-
Melosira granulata	<40	40 – 80	<40
M. islandica var. *helvetica*	40 – 80	-	-
M. italica	-	<40	-
M. varians	<40	<40	<40
Meridion circulare	<40	<40	-
Navicula minima	<40	<40	<40
Nitzschia acircularis	-	40 – 80	<40
Rhicosphenia curvata	<40	-	-

Taxon	Frequency of Occurrence (%) 1976	1977	1978
Stephanodiscus tenius	<40	40 – 80	<40
Synedra acus	<40	40 – 80	<40
S. cyclopum	<40	<40	-
S. radians	-	<40	-
S. rumpens	<40	-	<40
S. ulna	<40	<40	<40
Tabellaria fenestrata	<40	40 – 80	<40
CYANOPHYTA			
Anabaena flos-aquae	40 – 80	<40	<40
A. scheremetievi	-	-	<40
Aphanizomenon flos-aquae	40 – 80	<40	<40
Chroococcus dispersus var. *minor*	>80	<40	-
Gomphosphaeria lacustris	-	<40	<40
G. lacustris var. *compacta*	<40	-	-
Lyngbya limnetica	<40	-	-
Merismopedia tenuissima	-	<40	40 – 80
Microcystis aeruginosa	40 – 80	-	<40
Oscillatoria prolifica	-	-	<40
Phormidium tenue	<40	<40	-
Stichosiphon regularis	<40	<40	-
TOTAL NUMBER OF TAXA	83	60	41

[1] Source: Mills and Forney (1982).

TABLE 4.20: LAKE ONTARIO ZOOPLANKTON COMPOSITION, 1998[1]

Taxon	Average Lakewide Density (individuals/m^2) Spring	Summer
CLADOCERA		
Cercopagis pengoi	0	2,473
Leptodora kindtii	0	2,529
Polyphemus pediculus	0	1,333
Diaphanosoma birgei	0	36
Holopedium gibberum	0	1,071
Daphnia galeata mendotae	433	4,399
D. retrocurva	0	605,504
Eubosmina coregoni	474	44,474
Bosmina longirostris	400	902,381
TOTAL CLADOCERA	1,307	1,564,201
	(13.9)[2]	(17,035)
COPEPODA CALANOIDA		
Limnocalanus copepodites	10,702	0
L. macrurus	581	22,145
Epischura copepodites	170	870
E. lacustris	0	865
Eurytemora copepodites	47	73
E. affinis	0	1,494
Leptodiaptomus minutus	264	1,095
L. sicilis	2,966	16,669
Skistodiaptomus oregonensis	1,461	5,029
Diaptomid copepodites	29,397	26,107
TOTAL CALANOIDA	45,588	74,348
	(528.8)	(805)
COPEPODA CYCLOPOIDA		
Diacyclops thomasi	122,901	203,804
Cyclopoid copepodites	68,144	648,270
Mesocyclops edax	0	77
Tropocyclops copepodites	0	730
T. prasinus mexicanus	556	749
TOTAL CYCLOPOIDA	191,601	853,631
	(2,128.0)	(9,444)
TOTAL	238,495	2,492,180
	(2,670.7)	(27,284)

[1] Source: Barbiero *et al.* (2001).
[2] Number in brackets indicate volumetric densities (individuals/m^3).

TABLE 4.21: CRUSTACEAN ZOOPLANKTON AND ROTIFERA OBSERVED IN THE ST. LAWRENCE RIVER, 1976-78[1]

Taxon	1976	1977	1978
CLADOCERA			
Acroperus harpae	X[2]	-	X
Bosmina longirostris	X	X	X
Ceriodaphnia quadrangulata	X	X	X
Chydorus sphaericus	X	-	X
Daphnia galeata mendotae	X	X	X
D. longiremis	-	X	X
D. retrocurva	-	-	X
Diaphanosoma leuchtenbergianum	-	X	X
Leptodora kindtii	-	-	X
COPEPODA CALANOIDA			
Diaptomus minutus	X	X	X
Epischura lacustris	-	-	X
Limnocalanus macrurus	-	X	X
COPEPODA CYCLOPOIDA			
Cyclops bicuspidatus	X	X	X
Mesocyclops edax	X	-	X
ROTIFERA			
Ascomorpha saltans	-	X	-
Asplanchna priodonta	X	X	X
Brachionus quadratus	X	-	-
Conochilus unicornus	X	X	X
Conochiloides sp.	X	X	-
Filina longiseta	X	-	-
Gastropus stylifer	X	-	-
Kellicottia longispina	X	X	X
Keratella cochlearis	X	-	X
K. earlinae	-	X	X
K. quadrata	X	X	X
Notholca acuminata	X	X	X
Pleosoma hudsonii	X	-	-
Polyarthra vulgaris	X	X	X
Trichocera cylindrica	X	X	-
NAUPLII	X	X	X
TOTAL NUMBER OF TAXA	22	19	23

[1] Source: Mills and Forney (1982).
[2] X = present.

TABLE 4.22: FREQUENCY OCCURRENCE OF SUBMERGED AQUATIC VEGETATION IN SEVEN BAYS OF WOLFE ISLAND, AUGUST 1986[1]

		Occurrence[2]	
Common Name	Scientific Name	Number of Sites	%
Wild celery	*Vallisneria americana*	99	58
Eurasian water milfoil	*Myriophyllum spicatum*	87	51
Stonewort	*Chara*	57	33
Star duckweed	*Lemna trisulca*	55	32
Common waterweed	*Elodea canadensis*	53	31
Coontail	*Ceratophyllum demersum*	45	26
Mud plantain	*Heteranthera dubia*	35	20
Bushy pondweed	*Najas guadalupensis*	27	16
Northern water milfoil	*Myriophyllum exalbescens*	20	12
Pondweed	*Potamogeton pusillus*	20	12
Pondweed	*P. friesii*	20	12
Clasping-leaf pondweed	*P. perfoliatus*	20	12
Slender naiad	*Najas flexilis*	18	10
Muskgrass	*Nitella*	16	9
Narrow-leaved water plantain	*Alisma gramineum*	15	9
-	Unvegetated	13	8
Pondweed	*Potamogeton crispus*	11	6
Flat-stemmed pondweed	*P. zosteriformis*	11	6
Sago pondweed	*P. pectinatus*	11	6
Richardson's pondweed	*P. Richardsonii*	7	4
Horned pondweed	*Zannichellia palustris*	7	4

1 Source: Bottomley (1987).
2 Based on a total of 171 sample sites.

TABLE 4.23: AQUATIC PLANTS[1] DOCUMENTED IN THE PROVINCIALLY SIGNIFICANT WETLANDS IN THE LOCAL STUDY AREA[2]

Common name	Scientific Name	Little Cataraqui Creek Wetland	Simcoe Island North Shore Wetland	Cone Point Wetland	Garden Island Wetland	Barrett Bay Wetland	Browns Bay Wetland Complex
Stonewort	*Chara*	-	-	-	-	X[3]	X
Field horsetail	*Equisetum arvense*	X	-	-	-	-	-
Wood horsetail	*E. sylvaticum*	X	-	-	-	-	-
Cattail	*Typha latifolia*	X	X	X	X	X	X
Burreed	*Sparganium*	-	-	X	-	-	-
Stemless burreed	*S. emersum*	X	-	-	-	-	-
Large-fruited burreed	*S. eurycarpum*	-	X	-	X	-	-
Curly pondweed	*Potamogeton crispus*	X	-	X	X	-	X
Sago pondweed	*P. pectinatus*	X	X	-	-	-	X
Small pondweed	*P. pusillus*	X	X	X	X	-	X
Richardson’s pondweed	*P. Richardsonii*	-	-	X	X	-	-
Flat-stemmed pondweed	*P. zosteriformis*	-	-	-	-	-	X
Naiad	*Najas flexilis*	X	-	-	-	-	-
Water plantain	*A. plantago-aquatica*	X	-	-	-	-	-
Broad-leaved arrowhead	*Sagittaria latifolia*	X	-	-	-	-	-
Stiff-leaved arrowhead	*S. rigida*	X	-	-	-	-	-
Flowering rush	*Butomus umbullatus*	X	X	-	-	X	-
Common waterweed	*Elodea canadensis*	X	-	-	-	-	-
European frog’s-bit	*Hydrocharus morsus-ranae*	X	-	-	-	X	-
Wild celery	*Vallisneria americana*	X	X	-	-	X	X
Common reed grass	*Phragmites australis*	X	-	-	-	-	-
Barnyard grass	*Echinochloa crusgalli*	X	-	-	-	-	-
Great manna grass	*Glyceria maxima*	X	-	-	-	-	-
Fowl manna grass	*G. striata*	X	-	-	-	-	-
Rice cut grass	*Learsia oryzoides*	X	-	-	-	-	-
Canada bluejoint	*Calamagrostis canadensis*	X	-	-	-	-	-
Reed canary grass	*Phalaris arundinacea*	X	-	X	-	-	-
Quack grass	*Elymus repens*	X	-	-	-	-	-
Red top	*Agrostis gigantea*	X	-	-	-	-	-
Creeping bent grass	*A. stolonifera*	X	-	-	-	-	-
Annual meadow grass	*Poa annua*	X	-	-	-	-	-
Wood meadow grass	*P. nemoralis*	X	-	-	-	-	-
Swamp meadow grass	*P. palustris*	X	-	-	-	-	-
Kentucky bluegrass	*P. pratensis*	X	-	-	-	-	-
Aquatic sedge	*Carex aquatilis*	X	-	-	-	-	-
Fringed sedge	*C. crinita*	X	-	-	-	-	-
Crested sedge	*C. cristatella*	X	-	-	-	-	-
Filiform sedge	*C. gracillima*	X	-	-	-	-	-
Lake sedge	*C. lacustris*	X	-	-	-	-	-
Pale sedge	*C. pallescens*	X	-	-	-	-	-
Cyperus-like sedge	*C. pseudo-cyperus*	X	-	-	-	-	-
Stellate sedge	*C. rosea*	X	-	-	-	-	-
Broom sedge	*C. scoparia*	X	-	-	-	-	-
Sedge	*C. spicata*	X	-	-	-	-	-
Awl-fruited sedge	*C. stipata*	X	-	-	-	-	-
Slender sedge	*C. tenera*	X	-	-	-	-	-
Blunt-broom sedge	*C. tribuloides*	X	-	-	-	-	-
Fox sedge	*C. vulpinoidea*	X	-	-	-	-	-
Blunt spikerush	*Eleocharis obtusa*	X	-	-	-	-	-

Common name	Scientific Name	Little Cataraqui Creek Wetland	Simcoe Island North Shore Wetland	Cone Point Wetland	Garden Island Wetland	Barrett Bay Wetland	Browns Bay Wetland Complex
Marsh spikerush	*E. palustris*	-	-	-	X	-	-
Hardstem bulrush	*Scirpus acutus*	-	-	-	X	-	-
Blackish bulrush	*S. atrovirens*	X	-	-	-	-	-
Wool-grass	*S. cyperinus*	X	-	-	-	-	-
River bulrush	*S. fluviatilis*	X	-	-	-	X	X
Softstem bulrush	*S. validus*	X	-	X	X	X	X
Duckweed	*Lemna*	-	X	-	-	X	-
Star duckweed	*L. trisulca*	-	-	-	X	X	X
Lesser duckweed	*L. minor*	X	-	-	-	-	-
Water stargrass	*Zosterella dubia*	X	-	-	-	-	-
Toad rush	*Juncus bufonius*	X	-	-	-	-	-
Dudley's rush	*J. dudleyi*	X	-	-	-	-	-
Common rush	*J. effusus*	X	-	-	-	-	-
Path rush	*J. tenuis*	X	-	-	-	-	-
Yellow flag	*Iris pseudocorus*	X	-	-	-	-	-
Wild iris	*I. versicolor*	X	-	-	-	-	-
Pussy willow	*Salix discolor*	X	-	-	-	-	-
Crack willow	*S. fragilis*	X	-	-	-	-	-
Slender willow	*S. petiolaris*	X	-	-	-	-	-
Leathery knotweed	*Polygonum achoreum*	X	-	-	-	-	-
Water smartweed	*P. amphibium*	X	-	-	-	-	-
Knotweed	*P. aviculare*	X	-	-	-	-	-
Black bindweed	*P. convolvulus*	X	-	-	-	-	-
Water-pepper	*P. hydropiper*	X	-	-	-	-	-
Dock-leaved knotweed	*P. lapathifolium*	X	-	-	-	-	-
Lady's-thumb	*P. persicaria*	X	-	-	-	-	-
Tear--thumb	*P. sagittatum*	X	-	-	-	-	-
Curled dock	*Rumex crispus*	X	-	-	-	-	-
Water dock	*R. verticillatus*	X	-	-	-	-	-
Coontail	*Ceratophyllum demersum*	X	-	-	-	X	-
Yellow pond lily	*Nuphar variegatum*	X	X	-	-	-	-
White water lily	*Nymphaea odorata*	X	X	-	-	X	X
Canada anemone	*Anemone canadensis*	X	-	-	-	-	-
Water crowfoot	*Ranunculus*	-	X	-	-	-	X
Buttercup	*R. acris*	X	-	-	-	-	-
Cursed crowfoot	*R. sceleratus*	X	-	-	-	-	-
Hairy yellow cress	*Rorippa palustris* ssp. *hispida*	X	-	-	-	-	-
Creeping yellow cress	*R. sylvestris*	X	-	-	-	-	-
Silvery cinquefoil	*Potentilla argentea*	X	-	-	-	-	-
Downy cinquefoil	*P. inclinata*	X	-	-	-	-	-
Rough cinquefoil	*P. norvegica*	X	-	-	-	-	-
Rough-fruited cinquefoil	*P. recta*	X	-	-	-	-	-
Common cinquefoil	*P. simplex*	X	-	-	-	-	-
Common blue violet	*Viola sororia*	X	-	-	-	-	-
Water-willow	*Decodon verticillatus*	X	-	-	-	-	-
Purple loosestrife	*Lythrum salicaria*	X	-	-	-	-	-
Jewel weed	*Impatiens* sp.	-	-	-	-	X	-
Water milfoil	*Myriophyllum* sp.	X	-	-	-	-	X
Eurasian water milfoil	*M. spicatum*	X	-	-	-	X	X
Bulb-bearing water hemlock	*Cicuta bulbifera*	X	-	-	-	-	-
Water hemlock	*C. maculata*	X	-	-	-	-	-

Common name	Scientific Name	Little Cataraqui Creek Wetland	Simcoe Island North Shore Wetland	Cone Point Wetland	Garden Island Wetland	Barrett Bay Wetland	Browns Bay Wetland Complex
Silky dogwood	*Cornus amomum* ssp. *obliqua*	X	-	-	-	-	-
Red-panicle dogwood	*C. foemina* ssp. *racemosa*	X	-	-	-	-	-
Round-leaved dogwood	*C. rugosa*	X	-	-	-	-	-
Red osier	*C. stolonifera*	X	-	-	-	-	-
Fringed loosestrife	*Lysimachia ciliata*	X	-	-	-	-	-
Swamp-candles	*L. terrestris*	X	-	-	-	-	-
Tufted loosestrife	*L. thyrsiflora*	X	-	-	-	-	-
Swamp milkweed	*Asclepias incarnata*	X	-	-	-	-	-
Common milkweed	*A. syriaca*	X	-	-	-	-	-
Marsh hedge-nettle	*Stachys palustris*	X	-	-	-	-	-
Marsh skullcap	*Scutellaria galericulata*	X	-	-	-	-	-
Mad dog skullcap	*S. lateriflora*	X	-	-	-	-	-
Cut-leaved water-horehound	*Lycopus americanus*	X	-	-	-	-	-
Northern water-horehound	*L. uniflorus*	X	-	-	-	-	-
Wild mint	*Mentha arvensis*	X	-	-	-	-	-
Climbing nightshade	*Solanum dulcamara*	X	-	-	-	-	-
Common speedwell	*Veronica officinalis*	X	-	-	-	-	-
Purslane speedwell	*V. peregrina* ssp. *peregrina*	X	-	-	-	-	-
Marsh speedwell	*V. scutellata*	X	-	-	-	-	-
Thyme-leaved speedwell	*V. serpyllifolia* ssp. *serpyllifolia*	X	-	-	-	-	-
Common bladderwort	*Utricularia vulgaris*	X	-	-	-	-	-
Wild madder	*Galium obtusum*	X	-	-	-	-	-
Marsh bedstraw	*G. palustre*	X	-	-	-	-	-
Creeping bellflower	*Campanula rapunculoides*	X	-	-	-	-	-
Indian tobacco	*Lobelia inflata*	X	-	-	-	-	-
Heath aster	*Aster ericoides*	X	-	-	-	-	-
Panicled aster	*A. lanceolatus*	X	-	-	-	-	-
Calico aster	*A. lateriflorus*	X	-	-	-	-	-
Large-leaved aster	*A. macrophyllus*	X	-	-	-	-	-
New England aster	*A. novae-angliae*	X	-	-	-	-	-
Nodding beggarticks	*Bidens cernuus*	X	-	-	-	-	-
Large-leaved beggarticks	*B. frondosus*	X	-	-	-	-	-
Joe-pye-weed	*Eupatorium maculatum*	X	-	-	-	-	-
Boneset	*E. perfoliatum*	X	-	-	-	-	-
Canada goldenrod	*Solidago canadensis*	X	-	-	-	-	-
Early goldenrod	*S. juncea*	X	-	-	-	-	-

[1] Based on aquatic plants listed by Fassett (1957).
[2] Source: Bottomley (1986, 1987): White (1986); Bonta *et al.* (2004).
[3] X = present.

TABLE 4.24: AQUATIC MACROPHYTES RECORDED AT THE INITIAL TRANSMISSION LINE LANDFALLS AND MILL POINT EMBAYMENT

Common name	Scientific Name	Carruthers Point	Wolfe Island Landfall	Mill Point
Stonewort	*Chara* sp.	X[1]	X	X
Curly pondweed	*Potamogeton crispus*	-	-	X
Variable leaved pondweed	*P. gramineus*	X	-	-
Sago pondweed	*P. pectinatus*	-	-	X
Small pondweed	*P. pusillus*	-	X	X
Richardson's pondweed	*P. Richardsonii*	X	X	X
Common waterweed	*Elodea canadensis*	X	-	-
Wild celery	*Vallisneria americana*	X	X	X
Common reed grass	*Phragmites australis*	X	-	-
Coontail	*Ceratophyllum demersum*	-		X
Water milfoil	*Myriophyllum* sp.	X	X	X
Whorled water milfoil	*M. verticillatum*	X	X	X

[1] X = present

TABLE 4.25: MEAN ABUNDANCE AND MEAN BIOMASS OF BENTHIC MACROINVERTEBRATE TAXA IN FIVE WOLFE ISLAND BAYS, OCTOBER 1986[1]

	Bayfield Bay		Barrett Bay		Brown Bay		Big Bluff Bay		Irvine Bay	
Taxon	Abundance[2]	Biomass[3]	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
P. Platyhelminthes										
Cl. Turbellaria	93.0	0.03	86.1	0.05	56.0	0.02	78.9	0.10	94.7	0.10
P. Annelida										
Cl. Oligochaeta	510.4	0.17	135.2	0.60	282.7	0.56	71.8	0.07	252.6	0.17
Cl. Hirudinae	59.8	0.04	49.1	0.04	25.9	0.04	-	-	73.2	0.13
P. Arthropoda										
Cl. Crustacea										
O. Amphipoda	313.1	0.14	650.7	0.66	984.6	0.64	215.3	0.12	1,375.1	0.97
O. Isopoda	101.7	0.06	307.4	0.35	183.7	0.17	136.4	0.17	892.8	0.80
Cl. Insecta										
O. Odonoata										
F. Lestidae	8.4	0.02	-	-	-	-	-	-	14.4	0.02
O. Trichoptera	145.6	0.11	197.4	0.21	205.3	0.24	114.8	0.07	252.6	0.30
O. Megaloptera	-	-	-	-	-	-	-	-	1.4	0.01
O. Lepidoptera	1.8	<0.01	6.0	<0.01	7.2	<0.01	-	-	20.1	<0.01
O. Coleoptera	3.0	<0.01	-	-	-	-	-	-	-	-
O. Diptera										
F. Ceratopogonidae	19.2	<0.01	-	-	-	-	-	-	21.5	0.01
F. Chironomidae	1,516.4	0.81	222.5	0.17	218.2	0.08	1,729.6	0.56	786.6	0.34
Other Insecta	9.3	<0.01	1.2	<0.01	-	-	-	-	1.2	<0.01
P. Mollusca										
Cl. Gastropoda										
F. Ancylidae	3.9	<0.01	-	-	14.4	0.01	-	-	2.9	<0.01
F. Hydrobiidae	389.3	2.13	785.8	1.35	457.9	1.08	200.9	0.66	556.9	1.34
F. Bithyniidae	10.8	0.65	223.7	7.27	81.8	1.20	21.5	1.05	139.2	3.22
F. Lymnaeidae	41.3	<0.01	20.4	0.48	33.0	0.79	-	-	44.5	0.16
F. Planorbidae	72.4	0.58	90.9	0.24	136.4	0.66	122.0	0.32	249.8	0.34
F. Pleuroceridae	-	-	2.4	0.25	2.9	0.01	7.2	3.47	1.4	<0.01
F. Physidae	89.4	0.14	96.9	0.22	67.4	0.19	35.9	0.06	77.5	0.40
F. Valvatidae	291.0	0.52	74.2	0.22	71.8	0.66	21.5	0.17	81.8	0.62
Cl. Pelecypoda										
F. Sphaeriidae	220.4	0.27	422.2	2.89	442.1	1.12	150.7	1.79	334.4	1.30
F. Unionidae	3.6	0.07	12.0	0.30	10.1	0.72	7.2	0.03	1.4	<0.01

[1] Source: Bottomley (1987).
[2] Abundance (number/m^2).
[3] Biomass (g dry weight/m^2).

TABLE 4.26: MAIN NAVIGATION CHANNEL BENTHIC MACROINVERTEBRATE COMMUNITY COMPOSITION[1]

	Density (number/m^2)											
	Canadian Nearshore			Canadian Offshore			U.S. Offshore			U.S. Nearshore		
Taxon Replicate:	1	2	3	1	2	3	1	2	3	1	2	3
P. Nematoda	769	692	1,077	19	-	58	77	58	308	231	38	269
P. Platyhelminthes												
Cl. Turbellaria	538	154	1,231	-	19	135	58	-	77	38	442	77
P. Nemertea												
Prostoma rubrum	692	308	615	--	38	-	-	-	-	-	19	-
P. Annelida												
Cl. Oligochaeta												
F. Enchytraeidae	-	154	-	-	-	-	-	-	-	-	-	-
F. Tubificidae												
Aulodrilus americanus	-	-	-	-	-	192	-	-	38	77	38	77
A. limnobius	-	-	-	96	96	96	-	-	19	-	-	-
A. pluriseta	-	-	-	96	385	-	58	19	38	-	-	-
A. piqueti	-	-	-	96	58	519	212	19	154	-	-	38
Ilyodrilus templetoni	-	-	-	38	-	-	19	19	19	-	-	-
Limnodrilus hoffmeisteri	-	154	-	327	173	981	77	173	38	154	404	423
L. udekemianus	-	462	154	-	-	-	-	-	-	-	-	-
Potamothrix bavaricus	-	-	-	135	96	135	-	-	-	-	-	-
P. vejdovskyi	-	-	-	-	-	-	-	-	-	-	-	38
Quistadrilus multisetosus	-	-	-	38	77	-	19	-	19	-	-	-
Spirosperma ferox	3,077	5,846	6,308	38	-	-	-	-	-	-	-	-
immatures with hair setae	-	615	154	558	96	38	77	96	135	-	-	-
immatures without hair setae	538	1,077	615	481	577	1,212	250	346	442	769	1,269	1,923
F. Lumbriculidae												
Lumbriculus variegatus	538	712	-	-	-	-	-	-	-	-	-	-
Stylodrilus heringianus	77	-	154	-	-	-	-	-	-	-	-	-
F. Glossoscolecidae												
Sparganophilus sp.	115	154	77	-	-	-	-	-	-	-	-	-
Cl. Polychaeta												
Manayunkia speciosa	231	385	308	58	38	77	135	96	135	-	19	77
Cl. Hirudinae												
F. Glossiphoniidae												
Alboglossiphonia heteroclita	154	308	615	-	-	-	-	-	-	38	-	-

Taxon Replicate:	Density (number/m^2)											
	Canadian Nearshore			Canadian Offshore			U.S. Offshore			U.S. Nearshore		
	1	2	3	1	2	3	1	2	3	1	2	3
Batracobdella phalera	-	77	-	-	-	-	-	-	-	-	-	-
Glossiphonia complanata	38	19	-	-	-	-	-	-	-	-	-	77
Helobdella fusca	462	154	-	-	-	-	-	-	-	-	19	-
H. stagnalis	-	77	-	19	-	58	19	-	-	154	192	77
F. Erpobdellidae	-	-	-	-	-	-	-	-	-	58	-	38
P. Arthropoda												
Cl. Arachnoidea												
Hydracarina	154	77	154	-	-	19	-	-	-	38	38	-
Cl. Malacostraca												
O. Amphipoda												
F. Gammaridae												
Gammarus	3,615	5,231	5,077	135	77	250	288	250	231	423	673	577
O. Isopoda												
F. Asellidae												
Asellus	-	-	154	-	-	19	-	-	-	77	154	38
Cl. Insecta												
O. Megaloptera												
Sialis sp.	-	-	-	-	-	-	-	-	-	-	19	38
O. Trichoptera												
F. Lepidostomatidae												
Lepidostoma	-	77	-	-	-	-	-	-	-	-	-	-
F. Leptoceridae												
Ceraclea	-	154	-	-	-	-	-	-	-	-	58	38
Nectopsyche	77	77	-	-	-	-	-	-	-	-	-	-
Oecetis	-	-	-	-	-	38	-	-	-	38	38	77
Setodes	-	-	-	-	-	-	-	-	-	38	19	-
Triaenodes	-	-	-	-	-	-	-	-	-	-	19	-
F. Polycentropodidae												
Phylocentropus	-	77	-	-	-	-	-	-	-	-	38	-
O. Diptera												
F. Chironomidae												
Chironomid pupae	-	-	-	-	-	-	-	-	19	-	-	-
S.F. Chironominae												
Chironomus	-	-	-	519	577	481	481	462	385	77	96	115
Cryptochironomus	-	-	-	-	-	19	19	-	-	77	19	77

Taxon Replicate:	Density (number/m^2) Canadian Nearshore 1	2	3	Canadian Offshore 1	2	3	U.S. Offshore 1	2	3	U.S. Nearshore 1	2	3
Dicrotendipes	-	-	-	-	-	-	-	-	-	231	38	115
Microchironomus	-	-	-	-	-	-	77	38	77	192	-	-
Microspectra	-	-	-	-	-	19	-	19	-	-	-	-
Microtendipes	-	-	-	-	-	77	-	19	-	1,269	481	1,269
Phaenopsectra	-	-	154	-	-	-	-	-	-	-	-	-
Polypedilum	-	-	-	-	-	-	-	-	-	-	-	38
Tanytarsus	-	-	-	-	19	-	96	115	58	-	-	-
Tribelos	-	-	-	-	-	38	19	-	-	-	96	231
S.F. Diamesinae												
Potthastia	-	-	-	-	-	-	-	19	-	-	-	-
S.F. Tanypodinae												
Procladius	-	-	154	192	96	442	192	115	250	346	308	269
P. Mollusca												
Cl. Gastropoda												
F. Ancylidae												
Ferrissia	-	77	-	-	-	-	-	-	-	-	-	-
F. Hydrobiidae												
Amnicola limosa	2,385	1,154	2,923	19	-	38	192	38	58	77	77	115
Probythinella lacustris	-	-	-	-	-	-	-	19	-	154	-	-
Somatogyrus subglobosus	-	19	-	-	-	-	-	-	19	38	38	-
F. Bithynidae												
Bithynia tentaculata	1,395	481	615	38	19	192	58	-	19	231	692	77
F. Lymnaeidae												
Fossaria	-	-	-	-	-	19	-	-	-	-	-	-
F. Planorbidae												
Armiger crista	462	-	154	-	-	-	-	-	-	-	19	38
Gyraulus sp.	77	-	-	-	-	-	-	-	-	-	-	-
G. deflectus	-	77	154	-	-	-	-	-	-	-	-	-
G. parvus	-	154	-	-	-	-	-	-	-	-	-	-
Helisoma	77	-	154	-	-	-	-	-	-	-	-	-
Promenetus exacuous	77	154	462	-	-	-	-	-	-	-	19	-
F. Physidae												
Physella	231	-	154	-	-	-	-	-	-	-	-	-
F. Valvatidae												
Valvata sinera	-	-	-	115	19	96	38	19	77	38	19	77

	Density (number/m²)											
	Canadian Nearshore			Canadian Offshore			U.S. Offshore			U.S. Nearshore		
Taxon Replicate:	1	2	3	1	2	3	1	2	3	1	2	3
V. tricarinata	385	77	769	38	77	288	115	115	77	38	38	-
Cl. Pelycypoda												
F. Sphaeriidae												
Pisidium sp.	2,846	1,538	3,385	538	731	635	577	135	1,039	462	269	192
P. compressum	77	77		77	77	38	38	-	38	-	-	-
Spaerium sp.	385	308	2,923	308	442	165	538	192	58	269	19	308
S. simile	-	-	-	-	-	-	-	-	-	-	-	19
S. striatinum	-	38	-	-	-	-	19	-	-	-	-	-
F. Unionidae												
Elliptio complanata	-	-	38	-	-	-	-	-	-	19	58	77
Lampsilis radiata	-	-	19	-	-	-	-	-	-	38	38	-
Proptera alata	-	-	-	-	-	-	-	-	-	-	19	-
NUMBER OF ORGANISMS	19,462	21,195	28,761	3,978	3,787	6,324	3,748	2,381	3,807	5,689	5,839	6,899
NUMBER OF TAXA	26	34	27	21	20	28	24	20	24	28	35	30
MEAN DENSITY		23,139			4,696			3,312			6,142	
MEAN DIVERSITY		3.77			3.77			3.91			3.94	
TOTAL NUMBER OF TAXA		43			33			32			44	

[1] Source: Fitchko (1990a).

TABLE 4.27: BENTHIC MACROINVERTEBRATE COMMUNITY COMPOSITION NEAR THE WINTER FERRY DOCK[1]

Taxon	Density (number/m^2)
P. Nematoda	145
P. Annelida	
Cl. Oligochaeta	
F. Tubificidae	
Limnodrilus hoffmeisteri	435
?*Potamothrix bedoti*	87
immatures without hair setae	1,565
P. Arthropoda	
Cl. Arachnoidea	
O. Acarina	174
Cl. Malacostraca	
O. Amphipoda	
F. Gammaridae	
Gammarus	145
Cl. Insecta	
O. Ephemeroptera	
F. Caenidae	
Caenis	14
O. Diptera	
F. Chironomidae	
Chironomid pupae	58
S.F. Chironominae	
Chironomus	1,159
Paratanytarsus	145
Paratendipes	29
Tanytarsus	29
Zavreliella	29
S.F. Tanypodinae	
Procladius	232
P. Mollusca	
Cl. Pelycypoda	
F. Dreissenidae	
Dreissena bugensis	29
TOTAL NUMBER OF ORGANISMS (no./m^2)	4,275
TOTAL NUMBER OF TAXA	14
SHANNON-WEINER DIVERSITY INDEX	1.82

[1] Pier sampling location (see Figure 4.15).

TABLE 4.28: BENTHIC MACROINVERTEBRATE COMMUNITY COMPOSITION ALONG THE INITIAL TRANSMISSION LINE ROUTE

Taxon	Density (number/m^2)			
	T1[1]	T2	T3	T4
P. Nematoda	87	159	377	1,014
P. Nemertea				
Prostoma	-	-	-	29
P. Annelida				
Cl. Oligochaeta				
F. Tubificidae				
Aulodrilus limnobius	-	-	43	116
A. pluriseta	-	-	145	-
Bothrioneurum vejdovskyanum	-	-	-	43
Ilyodrilus templetoni	-	-	-	43
Limnodrilus hoffmeisteri	43	14	101	43
Potamothrix moldaviensis	14	-	43	-
P. vejdovskyi	304	116	290	159
Spirosperma ferox	-	-	43	-
immatures with hair setae	101	-	101	87
immatures without hair setae	14	43	435	522
F. Lumbriculidae				
Stylodrilus heringianus	14	-	-	-
P. Arthropoda				
Cl. Arachnoidea				
O. Acarina	-	14	-	29
Cl. Copepoda				
O. Harpacticoida	-	-	-	29
Cl. Ostracoda	-	-	58	-
Cl. Malacostraca				
O. Amphipoda				
F. Gammaridae				
Gammarus	-	-	14	-
Cl. Insecta				
O. Trichoptera				
F. Philopotamidae				
Chimarra	-	-	14	-
O. Diptera				
F. Ceratopogonidae				
Mallochohelea	14	-	-	-
F. Chironomidae				
Chironomid pupae	14	-	-	-
S.F. Chironominae				
Chironomus	406	14	928	2,754
Cryptochironomus	-	-	14	-
Dicrotendipes	87	-	-	-
Microspectra	-	-	58	-
Microtendipes	43	-	-	-
Parachironomus	-	-	-	29
Paratendipes	14	14	-	-
Polypedilum	14	-	-	29
Tanytarsus	-	-	58	-

Taxon	Density (number/m^2)			
	T1[1]	T2	T3	T4
S.F. Orthocladiinae				
Cricotopus/Orthocladius	-	14	-	-
S.F. Tanypodinae				
Procladius	14	188	232	58
P. Mollusca				
Cl. Pelycypoda				
F. Dreissenidae				
Dreissena immature	-	203	2,420	-
D. bugensis	551	304	2,899	4,058
TOTAL NUMBER OF ORGANISMS (no./m^2)	1,734	1,083	8,273	9,042
TOTAL NUMBER OF TAXA	15	10	18	16
SHANNON-WEINER DIVERSITY INDEX	1.94	1.60	1.52	1.50

[1] See Figure 4.3 for sampling locations.

TABLE 4.29: FISH SPECIES RECORDED IN THE UPPER ST. LAWRENCE RIVER[1]

Common Name	Scientific Name	Status[2] 1931 or earlier	1976 to 1978	1982 to 1996
Silver lamprey	*Ichthyomyzon fossor*	X	X	-
Sea lamprey	*Petromyzon marinus*	X	X	X
Lake sturgeon	*Acipenser fulvescens*	X	X	X
Longnose gar	*Lepisosteus osseus*	X	X	X
Bowfin	*Amia calva*	X	X	X
Mooneye	*Hiodon tergisis*	X	X	X
American eel	*Anguilla rostrata*	X	X	X
Alewife	*Alosa pseudoharengus*	X	X	X
Gizzard shad	*Dorosoma cepedianum*	-	X	X
Goldfish[3]	*Carassius auratus*	-	X	-
Lake chub	*Couesius plumbeus*	X	-	X
Spotfin shiner	*Cyprinella spiloptera*	X	X	X
Common carp[3]	*Cyprinus carpio*	X	X	X
Cutlips minnow[4]	*Exoglossum maxillingua*	X	X	X
Brassy minnow	*Hybognatus hankinsoni*	-	X	-
Eastern silvery minnow	*H. regius*	-	X	X
Common shiner	*Luxilus cornutus*	X	X	X
Golden shiner	*Notemigonus crysoleucus*	X	X	X
Pugnose shiner[5]	*Notropis anogenus*	X	X	X
Emerald shiner	*N. atherinoides*	X	X	X
Bridle shiner[6]	*N. bifrenatus*	X	X	X
Blackchin shiner	*N. heterodon*	X	X	X
Blacknose shiner	*N. heterolepis*	X	X	X
Spottail shiner	*N. hudsonius*	X	X	X
Rosyface shiner	*N. rubellus*	-	X	X
Sand shiner	*N. stramineus*	X	X	X
Mimic shiner	*N. volucellus*	X	X	X
Bluntnose minnow	*Pimephales notatus*	X	X	X
Fathead minnow	*P. promelas*	X	X	X
Blacknose dace	*Rhinichthys atratulus*	X	-	-
Longnose dace	*R. cataractae*	X	X	-
Rudd[3]	*Scardinius erythrophthalmus*	-	-	X
Creek chub	*Semotilus atromaculatus*	X	X	X
Fallfish	*S. corporalis*	X	X	X
Quillback	*Carpiodes cyprinus*	-	X	X
Longnose sucker	*Catostomus catostomus*	-	-	X
White sucker	*C. commersoni*	X	X	X
Silver redhorse	*Moxostoma anisurum*	X	X	X
Shorthead redhorse	*M. macrolepidotum*	X	X	X

Common Name	Scientific Name	Status[2] 1931 or earlier	1976 to 1978	1982 to 1996
Greater redhorse	*M. valenciennesi*	X	X	X
Yellow bullhead	*Ameiurus natalis*	-	X	X
Brown bullhead	*A. nebulosus*	X	X	X
Channel catfish	*Ictalurus notatus*	X	X	X
Stonecat	*Noturus flavus*	X	X	X
Tadpole madtom	*N. gyrinus*	X	X	X
Grass pickerel[7]	*Esox americanus vermiculatus*	X	X	X
Northern pike	*E. lucius*	X	X	X
Muskellunge	*E. masquinongy*	X	X	X
Chain pickerel[3]	*E. niger*	-	-	X
Central mudminnow	*Umbra limi*	X	X	X
Rainbow smelt[3]	*Osmerus mordax*	-	X	X
Coho salmon[3]	*Oncorhynchus kisutch*	-	-	X
Rainbow trout[3]	*O. mykiss*	-	X	X
Chinook salmon[3]	*O. tshawytscha*	-	-	X
Atlantic salmon	*Salmo salar*	X	-	X
Brown trout[3]	*S. trutta*	-	X	X
Lake trout	*Salvelinus namaycush*	-	-	X
Cisco	*Coregonus artedi*	X	-	X
Lake whitefish	*C. clupeaformis*	-	-	X
Trout-perch	*Percopsis omiscomaycus*	X	X	X
Burbot	*Lota lota*	X	X	X
Banded killifish	*Fundulus diaphanus*	X	X	X
Brook silverside	*Labidesthes sicculus*	X	X	X
Brook stickleback	*Culaea inconstans*	X	X	X
Threespine stickleback	*Gasterosteus aculeatus*	X	X	-
Mottled sculpin	*Cottus bairdii*	X	X	X
Slimy sculpin	*C. cognatus*	-	X	-
White perch[3]	*Morone americana*	-	X	X
White bass	*M. chrysops*	-	X	X
Rock bass	*Ambloplites rupestris*	X	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X	X
Bluegill	*L. macrochirus*	-	X	X
Smallmouth bass	*Micropterus dolomieu*	X	X	X
Largemouth bass	*M. salmoides*	X	X	X
Black crappie	*Pomoxis nigromaculatus*	X	X	X
Iowa darter	*Etheostoma exile*	X	X	X
Fantail darter	*E. flabellare*	X	-	X
Johnny darter	*E. nigrum*	-	X	X
Tessellated darter	*E. olmstedi*	X	X	X

Common Name	Scientific Name	Status[2] 1931 or earlier	1976 to 1978	1982 to 1996
Yellow perch	*Perca flavescens*	X	X	X
Logperch	*Percina caprodes*	X	X	X
Channel darter[8]	*P. copelandi*	X	-	-
Sauger	*Sander canadense*	X	-	-
Walleye	*S. vitreum*	X	X	X
Freshwater drum	*Aplodinotus grunniens*	X	X	X
Species present		52	61	65
Sensitive species present		5	4	4
Introduced species present		1	5	8

1 Source: Carlson and LaPan (1886); LaPan *et al.* (2002).
2 X = present
3 Introduced.
4 Designated as a threatened species by COSSARO (OMNR, 2006a) but not listed in regulation under the *Endangered Species Act.*
5 Designated as an endangered species by COSEWIC (2007), as well as by COSSARO (OMNR, 2006a) but not listed in regulation under the *Endangered Species Act*.
6 Designated as a species of special concern by COSEWIC (2007), as well as by COSSARO (OMNR, 2006a) but not listed in regulation under the *Endangered Species Act*.
7 Designated as a species of special concern by COSEWIC (2007).
8 Designated as a threatened species by COSEWIC (2007), as well as by COSSARO (OMNR, 2006a) but not listed in regulation under the *Endangered Species Act*.

TABLE 4.30: FISH CATCH-PER-STANDARD-GILLNET LIFT, THOUSAND ISLANDS AREA, ST. LAWRENCE RIVER, 1987 TO 2005[1]

Species	1987	1988	1989	1991	1993	1995	1997	1999	2001	2003	2005
Lake sturgeon	-	-	-	-	-	-	-	0.03	-	0.02	0.02
Longnose gar	-	-	-	0.03	-	-	0.03	-	-	0.07	0.04
Bowfin	0.08	0.13	0.09	-	0.06	0.03	0.07	-	0.02	0.07	0.05
Mooneye	0.05	-	-	-	-	-	-	-	-	-	-
Alewife	0.49	-	-	0.09	0.03	0.03	-	-	-	-	0.02
Gizzard shad	-	0.41	0.36	0.46	-	-	-	0.03	0.06	-	0.04
Chub	-	0.05	0.03	-	-	-	-	-	-	-	0.02
Common carp	0.05	0.13	0.09	0.09	0.03	0.09	0.36	0.13	0.08	0.12	0.04
Golden shiner	0.05	0.05	0.03	-	0.06	0.03	-	0.03	-	-	0.04
White sucker	1.09	2.10	2.04	1.39	1.49	1.37	1.25	1.78	0.75	0.93	0.64
Moxostoma sp.	-	0.08	0.13	0.06	0.13	0.33	-	0.23	0.08	0.11	0.10
Brown bullhead	2.56	1.79	1.79	2.46	1.06	0.95	1.91	3.85	3.00	2.66	4.69
Channel catfish	0.81	0.08	0.13	0.55	0.16	0.30	0.30	0.56	0.25	0.35	0.20
Northern pike	4.46	6.73	6.26	4.35	3.62	2.61	2.40	2.14	1.33	2.05	1.78
Muskellunge	-	-	-	0.03	-	-	-	-	0.02	0.04	-
Esocidae hybrids	-	-	-	-	-	0.03	-	-	-	-	-
Lake herring	-	-	0.03	-	-	0.06	-	-	-	-	-
Chinook salmon	-	-	-	0.03	-	-	-	0.03	0.02	-	-
Brown trout	-	0.05	0.03	-	-	-	-	-	-	-	-
Rainbow trout	-	-	-	-	-	-	0.03	-	-	-	-
Lake trout	-	0.13	0.16	-	0.16	0.13	0.13	-	-	-	-
White perch	0.08	-	-	0.36	0.03	0.06	-	0.07	0.10	0.02	0.15
White bass	0.05	0.60	0.73	0.43	0.24	-	0.07	-	-	-	-
Rock bass	4.14	4.46	4.87	5.44	4.77	5.56	4.87	7.54	9.48	7.23	7.28
Pumpkinseed	4.61	6.19	5.80	5.81	3.89	2.80	2.40	3.23	1.40	1.21	0.67
Bluegill	0.65	0.88	0.76	0.43	0.06	-	0.16	0.07	0.02	0.14	0.10

Species	1987	1988	1989	1991	1993	1995	1997	1999	2001	2003	2005
Smallmouth bass	3.16	5.67	5.44	4.31	2.34	1.55	1.48	3.19	1.67	3.97	7.59
Largemouth bass	0.13	0.36	0.40	0.13	0.16	0.16	0.03	0.23	0.08	0.22	0.33
White crappie	-	-	0.06	-	-	-	-	-	-	-	-
Black crappie	0.13	0.16	0.13	0.09	0.06	0.03	0.03	0.10	0.06	0.07	1.16
Yellow perch	27.79	17.62	17.02	15.41	16.23	22.67	21.33	22.22	18.06	20.32	14.26
Walleye	0.21	0.60	0.55	0.33	0.33	0.27	0.59	0.07	0.19	0.23	0.23
Freshwater drum	-	-	0.03	0.09	-	0.03	0.10	-	0.06	0.04	0.30
Round goby	-	-	-	-	-	-	-	-	-	-	0.77
Total Catch	50.56	48.25	46.94	42.39	34.90	39.11	37.56	45.49	36.75	39.87	39.54

[1] Source: OMNR (2006b).

TABLE 4.31: FISH CATCH-PER-STANDARD-GILLNET LIFT, NEAR MELVILLE SHOAL

	2001[1]					2002[2]				
	Water Depth (m)									
Species	8	13	18	23	28	8	13	18	23	28
Alewife	72.3	125.0	311.4	276.7	557.6	447.3	113.6	260.9	375.0	92.4
White sucker	-	-	-	-	1.6	-	-	-	-	-
Northern pike	1.6	1.6	-	-	-	1.6	-	1.6	-	-
Stonecat	10.9	-	-	-	-	-	14.2	-	-	-
Lake whitefish	-	-	-	-	3.3	-	-	-	3.3	3.3
Lake trout	-	-	-	-	3.3	-	-	1.6	-	-
Rock bass	12.5	31.6	4.9	16.3	-	27.2	4.9	-	-	-
Pumpkinseed	-	-	-	5.4	-	-	-	-	-	-
Smallmouth bass	-	10.4	1.6	1.6	-	1.6	4.9	1.6	-	-
Yellow perch	-	245.1	59.4	109.1	-	75.6	599.0	141.6	52.2	5.4
Walleye	91.5	42.8	4.9	13.2	-	120.1	6.6	-	1.6	-
Freshwater drum	1.6	-	-	-	-	-	-	-	-	-

[1] Source: Hoyle and Schaner (2002a,b).
[2] Source: Hoyle and Schaner (2003); Hoyle *et al.* (2003).

TABLE 4.32: WOLFE ISLAND GILLNETTING CATCH SUMMARY (OCTOBER 1990)[1]

Species	Canadian Middle Channel – Wolfe Island North Shore[2]				Main Navigation Channel – Wolfe Island South Shore[3]			
	Number of Fish Caught	Catch Frequency[4]	% Total Catch	CPUE[5]	Number of Fish Caught	Catch Frequency[4]	% Total Catch	CPUE[5]
Carp	1	0.25	0.9	0.02	-	-	-	-
White sucker	2	0.25	1.9	0.03	4	0.67	6.9	0.08
Brown bullhead	9	0.50	8.5	0.14	-	-	-	-
Northern pike	11	0.75	10.4	0.17	4	0.67	6.9	0.08
Lake trout	5	0.50	4.7	0.08	12	0.67	20.7	0.23
White perch	4	0.25	3.8	0.06	-	-	-	-
Rock bass	18	1	17.0	0.27	11	1	19.0	0.21
Pumpkinseed	1	0.25	0.9	0.02	-	-	-	-
Smallmouth bass	1	0.25	0.9	0.02	-	-	-	-
Largemouth bass	1	0.25	0.9	0.02	-	-	-	-
Black crappie	2	0.50	1.9	0.03	-	-	-	-
Yellow perch	38	1	35.8	0.58	27	1	46.6	0.51
Walleye	13	0.50	12.3	0.20	-	-	-	-
TOTAL CATCH	106	1	99.9	1.61	58	1	100.1	1.10

1 Source: Fitchko *et al.* (1991).
2 At Oak Point and offshore of Oak Point Wetland approximately 8 km downstream of the winter ferry dock (based on four gillnet locations).
3 Near the downstream end of Wolfe Island approximately 2 km upstream of Beauvais Point (based on three gillnet locations).
4 Number of nets catching a particular species per total number of nets set.
5 CPUE = catch-per-unit-effort (number of fish/h).

TABLE 4.33: WOLFE ISLAND NEARSHORE SEINING CATCH SUMMARY (OCTOBER 1990)[1]

Species	Canadian Middle Channel – Wolfe Island South Shore[2]			Main Navigation Channel – Wolfe Island North Shore[3]		
	Number of Fish Caught	% Total Catch	CPUE[4]	Number of Fish Caught	% Total Catch	CPUE[4]
Spotfin shiner	1	0.2	0.03	-	-	-
Golden shiner	4	1.0	0.12	1	1.3	0.11
Emerald shiner	-	-	-	15	19.2	2.50
Spottail shiner	1	0.2	0.03	3	3.8	0.33
Bluntnose minnow	5	1.2	0.15	5	6.4	0.56
Rainbow smelt	1	0.2	0.03	-	-	-
Banded killifish	206	50.5	6.24	19	24.4	2.11
Slimy sculpin	-	-	-	1	1.3	0.11
Largemouth bass	1	0.2	0.03	-	-	-
Yellow perch	176	43.1	5.33	29	37.2	3.22
Johnny darter	13	3.2	0.39	5	6.4	1.67
TOTAL CATCH	408	100.0	12.36	78	100.0	8.67

1 Source: Fitchko *et al.* (1991).
2 At Oak Point and Oak Point Wetland approximately 8 km downstream of the winter ferry dock (based on six locations).
3 Near the downstream end of Wolfe Island approximately 2 km upstream of Beauvais Point (based on six locations).
4 CPUE = catch-per-unit-effort (number of fish/100 m^2 of area seined).

TABLE 4.34: WOLFE ISLAND YOUNG-OF-THE-YEAR SPORTFISH SEINING CATCH DATA[1]

Species	Number of Fish (% of Catch)				
	McDonell Bay	Holliday Bay	Oak Point Bay	Button Bay	Irvine Bay
Brown bullhead	2 (0.7)	-	-	-	-
Northern pike	3 (1.1)	-	-	-	-
Muskellunge	-	4 (2.8)	1 (0.9)	-	-
Largemouth bass	97 (34.9)	52 (35.9)	21 (18.1)	4 (5.3)	16 (35.6)
Yellow perch	176 (63.3)	89 (61.4)	94 (81.0)	71 (94.7)	29 (64.4)
TOTAL	278	145	116	75	45
No. of Seines Used	5	5	3	3	4

1 Source: Fitchko *et al.* (1991).

TABLE 4.35: FISH SPAWNING AND NURSERY AREAS REPORTED OR SUSPECTED IN THE LOCAL STUDY AREA[1]

Species	Location[2]	Use[3]
Alewife	Inshore zone and tributaries	SA, NA
Common carp	Throughout in shallow marsh areas	SA
	Barrett Bay Wetland	SA
Spottail shiner	Almost all sandy shoals	SA
White sucker	Almost every tributary	SA
Silver redhorse	Almost every tributary	SA
Shorthead redhorse	Almost every tributary	SA
Brown bullhead	Almost all shallow marshes	SA
	Cataraqui Bay	SA
Northern pike	Almost every marsh and stream	SA
	Cataraqui Bay at Little Cataraqui Creek mouth	SA
	Lower Cataraqui River along east shore opposite Bells Island	SA
	Garden Island Wetland	SA, NA
	Browns Bay Wetland	SA
	Barrett Bay	SA
Muskellunge	Almost every marshy area	SA
	Around docks and boathouses	NA
	Head of Browns Bay	SA
	Head of McDonell Bay (located just east of the local study area)	SA
Rainbow smelt	Inshore zone and tributaries	SA, NA
Burbot	Almost all shallow sand or gravel grounds	SA
Slimy sculpin	Throughout in-shore waters and tributaries	SA, NA
White perch	Almost all shallow water areas and embayments	SA, NA
Rock bass	Almost all gravel shoals and rocky ledges	SA
Pumpkinseed	Almost all shallow embayments and creek mouths	SA
Bluegill	Throughout in shallow areas	SA, NA
Smallmouth bass	Inshore gravel shoals and rock ledges as well as tributary mouths	SA
	Everett Point (located just west of the local study area)	SA
	Little Cataraqui Creek mouth	SA
	North shore of Simcoe Island around Four Mile Point	SA
	North shore of Garden Island	SA
	Browns Bay shoreline	SA
	Dawson Point	SA
	Ferguson Point	SA
	Browns Bay Wetland	NA
	Barrett Bay Wetland	NA
	Barrett Bay	SA
	Mill Point to Boat Channel	SA
	Sand Bay	SA
Largemouth bass	Throughout in shallow embayments and marshy littoral areas	SA, NA
	Cataraqui Bay and Little Cataraqui Creek mouth	SA
	East shore of lower Cataraqui River	SA
	South shore of Garden Island	SA
	Browns Bay Wetland	SA

Species	Location[2]	Use[3]
Black crappie	Almost all bays and creek mouths	SA
Yellow perch	Throughout in shallow weedy areas	SA, NA
	Embayments of the north shore of Wolfe Island	SA
	Cataraqui Bay	SA
	Garden Island Wetland	SA, NA
	Barret Bay Wetland	SA

1 Source: EPS (1977); Goodyear *et al.* (1982a,b); Bottomley (1986).
2 See Figure 4.2.
3 SA = spawning area; NA = nursery area.

TABLE 4.36: SUMMARY OF FISH CONSUMPTION ADVISORIES[1]

	Fish Length (cm)												
Fish Species	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75
Common carp[2]				2[3](0)[4]	2(0)	2(0)	1(0)	1(0)	1(0)	1(0)	0(0)	0(0)	0(0)
White sucker[2]			8(8)	8(8)	8(8)	8(8)	8(8)	8(4)	8(4)				
Brown bullhead[2]		8(8)	8(8)	8(8)	8(4)								
Channel catfish[5]			8(8)	4(4)	2(0)	2(0)	0(0)	0(0)	0(0)	0(0)	0(0)		
Northern pike[2]	8(8)	8(8)	8(8)	8(8)	8(8)	8(8)	8(4)	8(4)	8(4)	8(4)	8(4)	4(0)	4(0)
Rock bass[6]	8(8)	8(4)											
Pumpkinseed[6]	8(8)	8(8)											
Bluegill[5]	8(8)												
Smallmouth bass[2]	8(8)	8(8)	8(8)	8(8)	8(4)	8(0)	4(0)						
Largemouth bass[5]	8(8)	8(8)	8(8)	8(4)	4(4)	2(0)	2(0)						
Yellow perch[2]	8(8)	8(8)	8(8)										
Walleye[7]		8(8)	8(8)	8(8)	8(8)	8(8)	8(4)	8(4)	8(0)	4(0)	4(0)	2(0)	

1 Source: MOE (2007).
2 Based on mercury, other metals, PCBs, mirex/photomirex, pesticides, chlorinated phenols and chlorinated benzenes.
3 Number of meals of that size fish that can be consumed each month by the general population.
4 Bracketed number of meals of that size fish that is advised for consumption by women of child-bearing age and children under 15.
5 Based on mercury, PCBs, mirex/photomirex and pesticides.
6 Based on mercury, other metals, PCBs, mirex/photomirex and pesticides.
7 Based on mercury, PCBs, mirex/photomirex, pesticides and PAHs.

TABLE 4.37: FISH SPECIES COLLECTED BY BOAT ELECTROFISHING AT THE INITIAL TRANSMISSION LINE LANDFALLS AND WINTER FERRY DOCK

	Carruthers Point				Wolfe Island Landfall				Winter Ferry Dock			
	CPE-1		CPE-2		WLFE-1		WLFE-2		WDE-2		WDE-3	
Fish Species	Number	Life Stage[1]	Number	Life Stage	Number	Life Stage	Number	Life Stage	Number	Life Stage	Number	Life Stage
Common carp							1	A				
Spotfin shiner					2	A			16	J, A		
Emerald shiner					22	J, A			16	YOY, A	17	J, A
Sand shiner											2	A
Bluntnose minnow											3	A
White sucker	5	J										
Brown bullhead	3	J			2	J	1	A				
Stonecat			1	J								
Banded killifish	1	A			1	A					6	J, A
Rock bass					2	J			9	J, A	12	J, A
Pumpkinseed	15	J, A	1	J							2	J
Smallmouth bass					1	A						
Largemouth bass	6	J, A							1	J		
Fantail darter					1	J						
Yellow perch	18	J, A			12	J, A	5	J, A	10	J, A	10	J, A
Logperch	4	A	2	A								
Freshwater drum					1	A	5	A				
Round goby	32	J, A	53	J, A	21	J, A	93	J, A	7	J, A	22	J, A
TOTAL FISH CAPTURED	84		57		65		105		59		74	
CPUE (fish caught/min)	14.6		3.1		3.0		7.5		4.6		6.0	

[1] Life stage: YOY = young-of-the-year; J = juvenile; A = adult.

TABLE 4.38: FISH SPECIES COLLECTED BY BACKPACK ELECTROFISHING AT CARRUTHERS POINT AND THE WINTER FERRY DOCK

	Carruthers Point		Winter Ferry Dock			
	CPE-2		WDE-1A		WDE-1B	
Fish Species	Number	Life Stage[1]	Number	Life Stage	Number	Life Stage
Spotfin shiner			2	A		
Common shiner					2	A
Spottail shiner					1	J
Sand shiner					9	J, A
Bluntnose minnow			1	A	2	A
Banded killifish					1	A
Rock bass			1	J	5	J, A
Largemouth bass			1	J	1	J
Fantail darter					3	A
Yellow perch			1	J		
Round goby	14	J, A	10	J, A	13	J, A
TOTAL FISH CAPTURED	14		16		37	
CPUE (fish caught/min)			3.5		2.6	

[1] Life stage: J = juvenile; A = adult.

TABLE 4.39: FISH SPECIES COLLECTED BY BOAT ELECTROFISHING NEAR THE SAND BAY LANDFALL

Fish Species	Number Collected
Common carp	7
Spotfin shiner	2
Emerald shiner	15
Spottail shiner	22
Bluntnose minnow	1
White sucker	3
Brown bullhead	6
Northern pike	1
Banded killifish	6
Pumpkinseed	2
Smallmouth bass	12
Yellow perch	20
Logperch	4
Round goby	61
TOTAL	162
CPUE (fish caught/min)	3.0

TABLE 4.40: WATERFOWL USE OF THE WOLFE ISLAND AREA DURING SPRING AND FALL MIGRATION[1]

	Utilization (1,000's of Waterfowl Days)							
Time	Geese[2]	Large Dabblers[3]	Small Dabblers[4]	Bay Ducks[5]	Goldeneyes[6]	Sea Ducks[7]	Mergansers[8]	Total
Spring 1976-77	529.1	22.7	2.5	1,136.4	85.1	1.5	44.1	1,821.5
Spring 1985	297.7	5.4	2.0	1,052.9	122.9	8.6	47.6	1,537.1
Fall 1976-77	120.5	216.9	24.3	1,215.7	29.5	6.9	5.0	1,713.3
Fall 1985	157.5	338.9	33.5	1,274.6	95.0	1.1	32.2	1,932.8

[1] Source: Ross (1989).
[2] Includes Canada goose, brant and/or snow goose.
[3] Includes mallard, American black duck, gadwall and/or northern pintail.
[4] Includes green-winged teal, blue-winged teal, American wigeon, northern shoveler and/or wood duck.
[5] Includes redhead, ring-necked duck, canvasback, greater scaup and/or lesser scaup.
[6] Includes common goldeneye and/or bufflehead.
[7] Includes long-tailed duck, white-winged scoter, surf scoter and/or black scoter.
[8] Includes hooded merganser, common merganser and/or red-breasted merganser.

TABLE 4.41: SPRING 1999 WATERFOWL COUNTS[1]

Waterfowl Guild	Utilization (Waterfowl Days)				
	North Shore of Simcoe Is. and Western Wolfe Is.	South Shore of Wolfe Is.	West Shore of Wolfe Is. including Boat Channel	North Shore of eastern Wolfe Is.	South Shore of eastern Wolfe Is.
Swans[2]	0	570	0	0	67
Geese[3]	4,288	7,353	9,889	654	9,034
Large dabblers[4]	4,388	28,430	12,963	1,104	32,793
Small dabblers[5]	0	105	494	25	319
Bay ducks[6]	36,137	2,725	777	128,649	412,517
Sea ducks[7]	0	279	42	48	12
Goldeneye[8]	11,946	14,663	25,945	10,285	32,615
Mergansers[9]	10,185	12,732	5,689	9,439	6,507

1 Source: Stantec (2007b).
2 Includes tundra swan, trumpeter swan and/or mute swan.
3 Includes Canada goose, brant and/or snow goose.
4 Includes mallard, American black duck, gadwall and/or northern pintail.
5 Includes green-winged teal, blue-winged teal, American wigeon, northern shoveler and/or wood duck.
6 Includes redhead, ring-necked duck, canvasback, greater scaup, lesser scaup and/or ruddy duck.
7 Includes long-tailed duck, white-winged scoter, surf scoter, black scoter, common eider and/or king eider.
8 Includes common goldeneye and/or bufflehead.
9 Includes hooded merganser, common merganser and/or red-breasted merganser.

TABLE 4.42: SEASONAL OCCURRENCE OF WATERFOWL AND WATERBIRDS IN IMPORTANT ECOLOGICAL SENSITIVITY AREAS IN THE LOCAL STUDY AREA[1]

		Occurrence[3]					
Location[2]	Habitat Type	Season[4]	Waterfowl	Shorebirds	Gulls	Divers	Comments
Simcoe Island North Shoreline	Shoreline	S, S	X	-	-	X	Bays and marshes used as bird habitat; species of environmental concern in black duck
		F	X	-	-	X	
		W	X	-	-	-	
Wolfe Island between Mill Point and Boat Channel	Shoreline	S, S	X	-	-	-	Waterfowl migration stop-over
		F	X	-	-	-	
		W	-	-	-	-	
Barrett Bay	Bay	S, S	-	-	-	-	-
		F	X	-	-	-	
		W	-	-	-	-	
Browns Bay	Marsh	S, S	X	-	-	-	Waterfowl migration stop-over
		F	X	-	-	-	
		W	-	-	-	-	
Cataraqui River	Marsh	S, S	R	-		X	Waterfowl nesting area; bays and marshes used as bird habitat; species of environmental concern is black duck
		F	X	-	X	X	
		W	X	-	-	-	
Cedar Island	Park	S, S	X	X	X	X	Bays and marshes used as bird habitat; species of environmental concern is black duck
		F	X	X	X	X	
		W	X	-	-	-	

1 Source: EPS (1982).
2 See Figure 4.2.
3 X = presence; R = reproductive importance.
4 S, S = spring, summer; F= fall; W = winter.

TABLE 4.43: RECREATIONAL BOATING FACILITIES IN THE KINGSTON AREA[1]

Name	Ownership	No. of Docks	Max. Dock Length (ft)	Transient Docks	Draft (ft)	Launching Ramp	Storage	Yard Equipment/ Services
Bateau Boatworks	Private	1	n/a	no	10	no	inside/ outside	1 hydraulic trailer
Blue Woods Marina	Private	57	58	yes	5	yes	outside	2 lifts, 1 crane, 1 hydraulic trailer
Collins Bay Marina	Private	300	60	yes	10	yes	outside	1 crane
Flora MacDonald Confederation Basin Marina	City	425	100	yes	20	no	no	no
Kingston Marina	Private	104	200	yes	16	yes	outside	1 crane, hydraulic trailers
Loyalist Cove Marina	Private	65	50	yes	7	yes	outside	1 lift
Portsmouth Olympic Harbour	City	250	100	yes	11	yes	no	1 crane
Rideau Marina	Private	100	60	yes	6	yes	inside/ outside	2 lifts
Treasure Island Marina	Private	130	45	yes	6	yes	outside	no
General Wolfe Hotel Marina[2]	Private	1[3]	30	yes	5	no	no	no

1 Source: www.marinasontario.com.
2 Source: www.cruising.ca.
3 Transient docking for approximately 20 visiting boats.

TABLE 4.44: TOTAL ESTIMATED ROD-HOURS BY SEASON, HOWE ISLAND AND WOLFE ISLAND AREA, 1988[1]

	Pre-bass Season[2]		Bass Season[3]		Fall Season[4]		Total	
Sub-Area	Rod-h	Rod-h/ha	Rod-h	Rod-h/ha	Rod-h	Rod-h/ha	Rod-h	Rod-h/ha
Howe Island	11,153		38,526		18,565			
East Wolfe Island	7,275		31,407		10,244			
West Wolfe Island	1,415		35,810		3,084			
Total Howe/Wolfe Islands	19,843	1.3	105,743	6.9	31,893	2.1	157,479	10.3
Total St. Lawrence River[5]	122,622	2.8	417,642	9.6	60,789	1.4	601,053[6]	13.8

[1] Source: Hendrick *et al.* (1991).
[2] 07-14 May to 17 June.
[3] 18 June to 05 September
[4] 06 September to 10-31 October.
[5] Ontario waters.
[6] Does not include the early spring yellow perch season and winter ice-fishing on Lake St. Francis and Lake St. Lawrence.

TABLE 4.45: TOTAL SPORTFISH CATCH, HARVEST AND CATCH-PER-UNIT-EFFORT IN THE HOWE ISLAND/WOLFE ISLAND AREA, 1988[1]

Species	Total Number Caught	Total Number Harvested	Total CPUE (angler-h)
Northern pike	36,944	7,451	0.235
Muskellunge	81	0	0.001
Smallmouth bass	52,392	21,928	0.334
Largemouth bass	3,778	1,754	0.024
Yellow perch	98,644	22,418	0.629
Walleye	386	296	0.002

1 Source: Hendrick *et al.* (1991).

TABLE 4.46: COMMERCIAL FISH HARVEST QUOTAS FOR THE NAPANEE (1-5) ZONE, ST. LAWRENCE RIVER[1]

Species	Quota (lb)				
	2001[1]	2002[2]	2003[3]	2004[4]	2005[5]
American eel	13,360 (6,060)[6]	8,661 (3,929)	8,661 (3,929)	0	0
Black crappie	25,590 (11,608)	18,590 (8,432)	18,340 (8,319)	18,590 (8,432)	18,590 (8,432)
Yellow perch	66,675 (30,244)	66,675 (30,294)	66,675 (30,244)	66,667 (30,245)	65,696 (29,800)

1 Source: Hoyle (2002).
2 Mathers and Hoyle (2003).
3 OMNR (2004).
4 OMNR (2005).
5 OMNR (2006b).
6 Number in brackets is quota in kg.

TABLE 4.47: COMMERCIAL FISH HARVEST AND VALUE FOR THE NAPANEE (1-5) ZONE, ST. LAWRENCE RIVER

	2001[1]		2002[2]		2003[3]		2004[4]		2005[5]	
Species	Harvest (lb)	Value ($)	Harvest (lb)	Value ($)	Harvest (lb)	Value ($)	Harvest (lb)	Value ($)	Harvest (lb)	Value ($)
Bowfin	3,518 (1,596)[6]	10,800	2,000 (907)	479	2,565 (1,163)	858	1,254 (569)	376	4,375 (1,985)	1,356
American eel	4,661 (2,114)	9,695	2,481 (1,125)	6,004	4,503 (2,043)	11,212	0	0	0	0
Common carp	222 (101)	21	160 (73)	24	30 (14)	4	481 (218)	87	146 (66)	35
Suckers	15 (7)	2	0	0	50 (23)	5	10 (5)	1	14 (6)	1
Brown bullhead	32,718 (14,841)	13,414	23,899 (10,841)	9,560	21,545 (9,772)	9,695	20,439 (9,271)	6,949	28,808 (13,067)	10,659
Channel catfish	21 (10)	6	19 (7)	7	18 (8)	9	0	0	0	0
White bass	0	0	0	0	0	0	0	0	1 (0.5)	<1
White perch	1,250 (567)	900	2,417 (1,096)	1,213	2,035 (923)	857	749 (340)	225	2,615 (1,186)	863
Rock bass	473 (215)	199	366 (166)	157	424 (192)	216	459 (208)	211	556 (252)	250
Sunfish	21,754 (9,868)	20,014	28,233 (12,806)	27,386	15,594 (7,073)	12,319	6,090 (2,762)	5,786	61,397 (27,850)	65,695
Black crappie	6,881 (3,121)	14,312	14,757 (6,694)	29,071	4,596 (2,085)	10,525	2,223 (1,008)	4,891	11,402 (5,172)	24,970
Yellow perch	30,726 (13,937)	66,061	26,813 (12,162)	50,756	32,399 (14,696)	39,203	17,178 (7,792)	20,098	19,811 (8,986)	27,339
Freshwater drum	66 (30)	9	120 (54)	12	102 (46)	10	0	0	28 (13)	3
Total	102,305 (46,406)	135,433	101,264 (45,933)	114,669	83,860 (38,039)	84,913	48,883 (22,173)	38,624	129,153 (58,584)	131,171

1 Source: Hoyle (2002).
2 Source: Mathers and Hoyle (2003).
3 Source: OMNR (2004).
4 Source: OMNR (2005).
5 Source: OMNR (2006b).
6 Number in brackets is harvest in kg.

TABLE 4.48: COMMERCIAL FISH HARVEST BY MONTH, 2004-2006[1]

Species	January	February	March	April	May	June	July	August	September	October	November	December
2004												
Bowfin	0	0	0	2,863 (1,299)	1,140 (517)	0	0	0	480 (218)	520 (236)	0	0
American eel	0	0	0	535 (243)	3,114 (1,413)	0	0	0	0	0	0	0
Common carp	0	0	0	244 (111)	0	0	0	0	0	432 (196)	0	0
Suckers	0	0	0	0	40 (18)	0	0	0	0	0	0	0
Brown bullhead	0	1,040 (472)	788 (357)	38,089 (17,277)	18,078 (8,200)	0	0	0	0	380 (172)	0	0
White perch	0	0	0	609 (276)	418 (190)	0	0	0	0	4 (2)	0	0
Rock bass	0	0	0	395 (179)	865 (392)	0	0	0	248 (112)	112 (51)	0	0
Sunfish	0	0	5 (2)	10,141 (4,600)	4,777 (2,167)	0	0	0	16 (7)	40 (18)	0	0
Black crappie	0	0	0	3,506 (1,590)	958 (435)	0	0	0	20 (9)	4 (2)	0	0
Yellow perch	0	40 (18)	283 (128)	31,085 (14,100)	2,179 (988)	0	0	0	516 (234)	560 (254)	0	0
Total Harvest	0	1,080 (490)	1,076 (488)	87,467 (39,675)	31,569 (14,320)	0	0	0	1,280 (581)	2,052 (931)	0	0
2005												
Bowfin	0	0	0	1,588 (720)	678 (308)	203 (92)	0	0	369 (167)	1,163 (528)	284 (129)	0
American eel	0	0	0	22 (10)	210 (95)	0	0	0	0	0	0	0
Common carp	0	0	0	67 (30)	60 (27)	0	0	0	0	0	0	0
Suckers	0	0	0	0	0	14 (6)	0	0	0	0	0	0
Brown bullhead	0	52 (24)	0	13,645 (6,189)	4,072 (1,847)	595 (270)	0	0	2,569 (1,165)	5,097 (2,312)	3,278 (1,487)	0
White bass	0	0	0	1 (0.5)	0	0	0	0	0	0	0	0

Species	January	February	March	April	May	June	July	August	September	October	November	December
White perch	0	0	0	475 (215)	533 (242)	1 (0.5)	0	0	1,168 (530)	437 (198)	125 (57)	0
Rock bass	0	0	0	74 (34)	384 (174)	124 (56)	0	0	5 (2)	0	0	0
Sunfish	0	0	0	5,920 (2,685)	6,529 (2,962)	1,895 (860)	0	0	19,582 (8,882)	21,340 (9,680)	8,212 (3,725)	0
Black crappie	0	0	0	1,479 (679)	649 (294)	47 (21)	0	0	6,204 (2,814)	2,462 (1,117)	924 (419)	0
Yellow perch	0	38 (17)	289 (131)	17,339 (7,865)	2,034 (923)	163 (74)	0	0	171 (78)	306 (139)	174 (79)	0
Freshwater drum	0	0	0	8 (4)	19 (9)	0	0	0	0	0	0	0
Total Harvest	0	90 (41)	289 (131)	40,636 (18,432)	15,168 (6,880)	3,042 (1,380)	0	0	30,068 (13,639)	30,805 (13,973)	12,997 (5,895)	0
2006												
Bowfin	0	0	57 (26)	1,505 (683)	369 (167)	0	0	0	115 (52)	375 (170)	449 (209)	0
Common carp	0	0	0	23 (10)	12 (5)	0	0	0	0	0	0	0
Brown bullhead	0	0	270 (122)	8,493 (3,852)	2,818 (1,278)	135 (61)	0	0	0	6,455 (2,928)	3,445 (1,563)	0
Cisco	0	0	0	1 (0.5)	0	0	0	0	0	0	0	0
White perch	0	0	5 (2)	4,256 (1,931)	1,908 (865)	20 (9)	0	0	0	26 (12)	6 (3)	0
Rock bass	0	0	25 (11)	256 (116)	556 (252)	105 (48)	0	0	0	81 (37)	11 (5)	0
Sunfish	0	0	1,562 (709)	11,788 (5,347)	14,978 (6,794)	1,722 (781)	0	0	201 (91)	12,496 (5,668)	3,051 (1,384)	0
Black crappie	0	0	215 (98)	5,736 (2,602)	2,994 (1,358)	197 (89)	0	0	111 (50)	2,200 (998)	599 (272)	0
Yellow perch	0	0	5,494 (2,492)	16,790 (7,616)	2,154 (977)	170 (77)	0	0	47 (21)	50 (23)	40 (18)	0
Freshwater drum	0	0	0	0	8 (4)	0	0	0	0	0	0	0
Total Harvest	0	0	7,628 (3,460)	48,848 (22,157)	25,797 (11,702)	2,349 (1,060)	0	0	474 (215)	21,683 (9,835)	7,601 (3,448)	0

[1] Source: D. Cartier, Ontario Commercial Fisheries Association, 2007, pers. comm.

TABLE 4.49: COMMERCIAL VESSEL TRANSITS BY MONTH IN 2006[1]

Month	Upbound	Downbound	Total	Average Transit Per Day
March (23)	28	18	46	5.1
April	141	125	266	8.9
May	160	170	330	10.6
June	177	163	340	11.3
July	171	173	344	11.1
August	160	155	315	10.2
September	166	170	336	11.2
October	180	184	364	11.7
November	182	179	361	12.0
December (30)	107	133	240	8.0
TOTAL	1,472	1,470	2,942	10.4

1 Source: SLSMC and SLSDC (2006).

TABLE 4.50: HISTORICAL COMMERCIAL VESSEL TRAFFIC STATISTICS FOR THE MONTREAL-LAKE ONTARIO SECTION OF THE ST. LAWRENCE SEAWAY, 1987-2006[1]

	Vessel Transits			Cargo (Tonnes)		
Year	Upbound	Downbound	Total	Upbound	Downbound	Total
1987	1,614	1,613	3,227	16,810,464	23,158,151	39,968,615
1988	1,576	1,566	3,142	18,654,260	21,903,409	40,557,669
1989	1,375	1,393	2,768	17,527,216	19,543,154	37,070,370
1990	1,389	1,379	2,768	17,647,222	19,008,717	36,655,939
1991	1,432	1,427	2,859	12,980,554	21,929,889	34,910,443
1992	1,250	1,243	2,493	13,991,464	17,368,702	31,360,166
1993	1,149	1,156	2,305	17,026,988	14,943,483	31,970,471
1994	1,423	1,434	2,857	21,017,489	17,404,635	38,422,124
1995	1,392	1,385	2,777	17,352,381	21,332,380	38,684,761
1996	1,358	1,349	2,707	20,652,379	17,422,753	38,075,132
1997	1,401	1,408	2,809	18,853,653	18,047,570	36,901,223
1998	1,576	1,582	3,158	22,569,978	16,675,931	39,245,909
1999	1,590	1,578	3,168	19,594,116	16,817,495	36,411,611
2000	1,485	1,492	2,977	19,168,176	16,238,036	35,406,212
2001	1,293	1,295	2,588	15,583,223	14,694,601	30,277,824
2002	1,300	1,312	2,612	16,904,264	13,098,028	30,002,292
2003	1,291	1,288	2,579	16,436,399	12,464,041	28,900,440
2004	1,326	1,357	2,683	17,201,797	13,598,583	30,800,380
2005	1,340	1,355	2,695	16,753,223	14,520,099	31,273,322
2006	1,472	1,470	2,942	19,022,669	16,549,316	35,571,985

[1] Source: SLSMC and SLSDC (2006).

TABLE 4.51: MUNICIPAL AND INDUSTRIAL WATER USERS[1]

Name of Intake/Outfall	Activity	Pipe Length From shore (m)	Water Depth At/Above End of Pipe (m)	Pipe Diameter (cm)	Approximate Distance From Proposed Crossing
Kingston West WTP[2] Intake	Municipal water treatment	521	17.1/17.1	122	700 m upstream[3]
INVISTA Intake	Nylon manufacturing[4]	570	25/23.5	51	51 m downstream[5]
INVISTA Intake	Nylon manufacturing[4]	570	25/23.5	91	150 m north[5]
INVISTA Intake	Nylon manufacturing[4]	570	25/23.5	91	150 m north[5]
Kingston Township WPCP[6] Outfall	Municipal sewage treatment	300	15/NA[7]	100	650 m downstream and north[3]
INVISTA Outfall	Nylon manufacturing[8]	50	1.2/02	165	1.3 km south
Kingston WTP Intake #1	Municipal water treatment	824	17/17	120	2.5 km downstream
Kingston WTP Intake #2	Municipal water treatment	366	15/15	75	3 km downstream
Kingston WTP Outfall #1	Municipal water treatment	3	2.5/2	75	3 km downstream
Kingston WTP Outfall #2	Municipal water treatment	0	2.5/2	75	3 km downstream
River St. Pumping Station Outfall	Sewage pumping station[9]	180	2.7/1.5	120	4 km downstream[10]
Kingston WPCP Outfall	Municipal sewage treatment	180	14/12	105	7 km downstream
Kingston WPCP Intake	Municipal sewage treatment[11]	10	2/1.5	15	7.5 km downstream

1 Source: Kleinfeldt (1990a,b).
2 WTP = water treatment plant.
3 See Figure 4.3.
4 Water used for drinking, sanitary, cooling and boiler feed.
5 See Figure 3.1.
6 WPCP = water pollution control plant.
7 NA = not available.
8 Cooling water only.
9 Discharge of municipal sewage during periods of heavy rain.
10 Upstream of Big Cataraqui River mouth.
11 Raw water intake for process water only.

TABLE 5.1: TSS AND TURBIDITY LEVELS IN SEDIMENT PLUMES FROM DIPPER DREDGE OPERATIONS[1]

		TSS (mg/L)[2]				Turbidity (NTU)[2]			
		Sample Collected 1 m from Surface		Sample Collected 1 m from Bottom		Sample Collected 1 m from Surface		Sample Collected 1 m from Bottom	
Location	Distance From Dredge (m)	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Nemadji River,	0	296	-	1,220	-	94	-	180	-
Duluth, Minnesota	15	23	11 - 33	223	126 - 420	21	12 - 29	86	53 - 150
	30	21	9 - 34	152	32 - 256	21	8 - 33	73	33 - 130
	61	23	8 - 46	185	33 - 612	20	7 - 34	61	32 - 140
	122	20	6 - 34	70	28 - 170	20	7 - 33	37	24 - 68
	244	14	3 - 34	48	9 - 100	15	6 - 35	27	10 - 50
	488	9.7	6 - 16	72	9 - 182	9.3	6 - 16	29	9 - 60
Duluth Ship	15	4.2	2.3 - 5.7	7.5	5.7 - 8.7	3.6	-	3.9	3.1 - 4.5
Canal, Minnesota	30	4.3	3.3 - 5.7	4.8	3.7 - 6.0	4.2	3.6 - 4.6	4.4	3.7 - 5.7
	61	4.9	3.7 - 5.7	6.3	3.7 - 10.0	3.7	3.4 - 4.3	3.6	3.2 - 4.3
	122	3.5	2.3 - 5.0	2.8	2.0 - 3.7	4.9	3.9 - 5.5	3.4	3.0 - 3.8
	244	1.5	1.0 - 2.3	1.3	1.0 - 2.0	5.0	2.9 - 10.2	3.6	3.6 - 3.7

[1] Source: Anderson *et al*. (1979).
[2] Based on four samples collected in four compass directions from the dredging site.

TABLE 5.2: ENVIRONMENTAL FEATURES SCREENING CRITERIA CHECKLIST (MOE, 2001) WOLFE ISLAND WIND PROJECT

Criterion: Will the project….	Potential Effect Yes	Potential Effect No	Additional / Supporting Information
1.0 Surface and Ground Water			
1.1 have negative effects on surface water quality, quantity, or flows?	✓		• *potential for temporary water quality impairment due to localized surficial sediment resuspension during submarine cable installation, blasting at submarine cable landfall locations, and/or construction of land based facilities in close proximity to or crossing of a watercourse* • potential to affect artificial tile drains from excavation of tower bases, installation of underground cables, and/or excavation of the pad-mounted transformers • depending upon the source of water for the temporary concrete batching plant, withdrawals of surface water may be taken, but are expected to be below the threshold for a Permit to Take Water from the MOE (i.e., project withdrawal would be <50,000 L/d) • the WIWP will not require significant alteration of surface runoff patterns • the WIWP operations do not involve the storage or consumption of surface water
1.2 have negative effects on groundwater quality, quantity, or movement?	✓		• depending upon groundwater levels, it may be possible that some dewatering activities will be required when installing the tower and transformer foundations • there is limited potential to affect wells in close proximity of the construction site in the event that a shallow water bearing formation is intercepted during construction – all wells are at least 400 m from a wind turbine • depending upon the source of water for the temporary concrete batching plant, withdrawals of groundwater may be taken, but are expected to be below the threshold for a Permit to Take Water from the MOE (i.e., project withdrawal would be <50,000 l/d) • a small groundwater well will be installed as part of the maintenance/control building; however, withdrawal will be below the threshold for a Permit to Take Water from the MOE • a small septic system will also be installed as part of the maintenance/control building and will conform to the latest MOE guidelines, local building code requirements, and industry best practices

Criterion: Will the project….	Potential Effect Yes	Potential Effect No	Additional / Supporting Information
1.3 cause significant sedimentation, soil erosion, or shoreline or riverbank erosion on or off site?	✓		• construction will require excavation and soil storage (e.g., access roads); however, the sites are of limited topographic relief and hence erosion of excavated or stored soil materials is not anticipated • sediment and erosion control measures will be implemented as required • *limited potential for water quality impairment due to localized surficial sediment resuspension during underwater cable installation and work near the shoreline areas*
1.4 cause potential negative effects on surface or groundwater from accidental spills or releases into the environment?	✓		• materials on-site that have potential to be spilled are limited to fuel, lubricating oils, and other fluids associated with turbine construction, maintenance, and operation; these materials are typically contained with the turbine itself and/or the operations / maintenance building and not stored elsewhere on the sites • large quantities of these materials are not contained within the turbine or on-site and do not represent a significant potential negative effect on the surface or groundwater in the event of accidental spills • standard containment facilities and emergency response materials will be maintained on-site as required • *potential for accidental spills of oil, gas and/or diesel fuel during landfall and nearshore cable construction* • *potential for petroleum leaks from operating equipment during cable installation across the St. Lawrence River, and small amounts of trash and other solid and liquid wastes accidentally blown, dumped or spilled overboard.*
2.0 Land			
2.1 have negative effects on residential, commercial, or institutional land-uses within 500 m of the site.	✓		• lands for the access roads, electrical lines, turbines, pad-mounted transformers, transformer station, and maintenance/control building will be required for the lease period (i.e., 20 years with renewal options) • during the lease period these lands will be removed from their present land-use • *landfall and nearshore construction has potential for nuisance effects, e.g., noise, dust*
2.2 be inconsistent with the Provincial Policy Statement, provincial land use, or resource management plans?		✓	• the WIWP will be planned and developed in a manner that is consistent with the PPS • no effects on provincial land-use or resource management plans are anticipated • the PPS permits the development of renewable energy systems on rural and agricultural lands; these systems should be designed and constructed to minimize impacts on agricultural operations.

Criterion: Will the project….	Potential Effect Yes	Potential Effect No	Additional / Supporting Information
2.3 be inconsistent with municipal land use policies, plans, and zoning bylaws?		✓	• the WIWP will conform with the intent of the Official Plan Amendment (approved 03 January 2007) and be compatible with the area's surrounding land-uses • the WIWP will be consistent with the intent of municipal land-use and zoning by-law amendment requirements
2.4 use hazard lands or unstable lands subject to erosion?	✓		• *shoreline areas, designated as "Hazard Land" in the Township of Frontenac Islands Official Plan (July 2003), will be used at the transmission cable landfall* • *disturbance to areas identified as hazard lands will be temporary and these areas will be rehabilitated to pre-disturbance conditions*
2.5 have potential negative effects related to the remediation of contaminated land?	✓		• to date no contaminated soils have been identified on any of the Wolfe Island sites • contaminated soils may be found in the built up industrial and commercial areas on the Kingston mainland
3.0 Air and Noise			
3.1 have negative effects on air quality due to emissions of nitrogen dioxide ("NO_X"), sulphur dioxide ("SO_2"), total suspended particles ("TSP"), or other pollutants?	✓		• *reciprocating engine equipment (e.g., excavators, haulage trucks and barges) will be used during the construction phase of the WIWP* • operation of the wind plant will not result in negative effects on air quality since no emissions of NO_x, SO_2, or particulate matter are generated by the wind turbines
3.2 cause negative effects from the emission of greenhouse gases (carbon dioxide and methane)?	✓		• *emissions of carbon dioxide or methane will be generated by construction equipment and to a lesser degree by operation vehicles* • operation of the wind plant will not result in negative effects from the emissions of greenhouse gases since no emissions are generated by the wind turbines
3.3 cause negative effects from the emission of dust or odour?	✓		• *during construction, dust will be generated, with emissions of short duration and limited to the lands surrounding the work areas and landfalls* • no emissions of odour are anticipated
3.4 cause negative effects from the emission of noise?	✓		• *during construction, noise will be generated, with emissions of short duration and limited to the lands surrounding the work areas and landfalls, as well as the cable-laying vessel* • *controlled blasting in the nearshore areas of the submarine cable landfall locations will emit noise* • mechanical and aerodynamic noise will be emitted from the wind turbines • there is potential for limited environmental noise effects at sensitive off-site receptors and as such the WIWP underwent a detailed Environmental Noise Impact Assessment prior to release of the ERR

Criterion: Will the project….	Potential Effect Yes	Potential Effect No	Additional / Supporting Information
4.0 Natural Environment			
4.1 cause negative effects to rare, threatened, or endangered ("VTE") species of flora or fauna or their habitat?	✓		• the Natural Heritage Information Centre and the Ontario Ministry of Natural Resources have identified historical sitings of VTE species within the general area of study for the WIWP • area habitats support such species and disruption/alteration of the habitat could cause potentially negative effects • *no species of special concern or their habitat identified at the landfalls or along the transmission line route*
4.2 cause negative effects on protected natural areas such as areas of natural and scientific interest ("ANSI"), environmentally sensitive areas ("ESA"), or other significant natural areas?		✓	• there are ANSIs and provincially rare vegetation communities identified within the Wolfe Island portion of the study area, and protected land uses on the mainland; disruption/alteration of these areas could cause potentially negative effects • *no construction works are anticipated to occur within these areas*
4.3 cause negative effects on wetlands?	✓		• there are provincially and non-provincially significant wetlands identified within the study area as well as wetland restoration projects. • disturbance to all wetlands has been avoided with the exception of two underground power lines to be installed in small portions of the Sand Bay PSW on Wolfe Island and a linear section of the non-PSW (the Ducks Unlimited Canada restoration wetland) on the Kingston mainland
4.4 have negative effects on wildlife habitat, populations, corridors, or movement?	✓		• installation of new electrical generation and transmission infrastructure, within the rural/agricultural and urban areas, may have potential to have some affect on wildlife habitat • wildlife usage or movement may be temporarily altered during the construction phase due to the temporary introduction of new sounds and activities • during operation, turbines may alter the movement patterns of some avian species
4.5 have negative effects on fish or their habitat, spawning, movement, or environmental conditions (e.g., water temperature, turbidity)?	✓		• *potential water quality impairment from local surficial sediment disturbance during underwater cable installation and associated blasting, trenching or drilling works in nearshore areas have the potential to affect fish and/or their habitat* • crossing of inland watercourses for power line installations and access roads also has the potential for negative effects
4.6 have negative effects on migratory birds, including effects on their habitat or staging areas?	✓		• *there is potential to affect migratory birds due to collision with the turbine tower and/or blades and/or bird usage of the area immediately surrounding the wind turbines, at the landfalls and along the transmission line route across the St. Lawrence River.* • no significant staging areas have been identified at the landfall locations for the submarine cable. However, limited localized and temporary disturbance may occur through the use of controlled blasting

Criterion: Will the project….	Potential Effect Yes	Potential Effect No	Additional / Supporting Information
4.7 have negative effects on locally important or valued ecosystems or vegetation?	✓		• turbine construction sites are not planned within forested or naturally vegetated areas – they will be located on lands already cleared for rural and agricultural land-uses and therefore there should be no negative effect on valued ecosystems or natural vegetation • depending upon the final location of the electrical lines and access roads, their construction may have potential to cause localized effects to vegetation within the work areas • *there are no locally important or valued ecosystems or vegetation in the nearshores at the landfall locations for the submarine cable*
5.0 Resources			
5.1 result in inefficient (below 40%) use of a non-renewable resource?		✓	• wind energy is a renewable resource
5.2 have negative effects on the use of Canada Lands Inventory Class 1 to 3 (i.e., prime agricultural lands), specialty crops, or locally significant agricultural lands?	✓		• the majority of the study area lands are mapped as CLI Class 2 or 3 agricultural lands • during the WIWP lifecycle, there will be a minor loss of agricultural land associated with WIWP physical footprint (e.g., generally less than 1 – 2 acres per wind turbine depending upon road network) • operation of the wind turbines will not negatively affect the use of adjoining prime agricultural lands, field crop production, or livestock pasturing; all of which can occur in close proximity to the wind turbines
5.3 have negative effects on existing agricultural production?	✓		• agricultural production on the lands physically occupied by the wind turbines, access roads, and ancillary facilities will be discontinued over the WIWP lifecycle • agricultural activities can still be conducted around the turbines and ancillary facilities on existing fields
5.4 have negative effects on the availability of mineral, aggregate, or petroleum resources?		✓	• there are no known petroleum resources within the study area • there are no known designated mineral or aggregate resources within lands optioned for the WIWP
5.5 have negative effects on the availability of forest resources?		✓	• construction of the wind turbines, access roads and ancillary facilities will not affect any merchantable forest resources

Criterion: Will the project….	Potential Effect Yes	Potential Effect No	Additional / Supporting Information
5.6 have negative effects on game and fishery resources, including negative effects caused by creating access to previously inaccessible areas?	✓		• the study area is largely cleared for agriculture and there are no areas that could be deemed inaccessible • *fisheries resources could be affected by WIWP construction activities (e.g., work within or in close proximity to watercourses and water bodies)*
6.0 Socio-Economic			
6.1 have negative effects on neighbourhood or community character?	✓		• within the study area there are presently no commercial scale wind turbines • the proposed WIWP will introduce 86 commercial scale wind turbines into the area • the WIWP will change the present rural/agricultural/recreational community character of the area, but as a land use wind plants are compatible with rural and agricultural uses
6.2 have negative effects on local businesses, institutions, or public facilities?		✓	• area businesses will benefit financially from construction activities and fulfilling operational supplies • no significant negative effects to local businesses, institutions and public facilities are expected as a result of the WIWP • long-term positive effect on area's tax base through municipal taxes applied against the wind plant
6.3 have negative effects on recreation, cottaging, or tourism?	✓		• potential for inconvenience to visitors and cottagers on Wolfe Island roads during the construction phase as construction supplies, materials and workers are transported • *potential effects on water-based recreational opportunities, e.g., sportfishing, boating, during transmission cable installation across the St. Lawrence River*
6.4 have negative effects related to increases in the demands on community services and infrastructure?		✓	• the seasonally idle winter dock at Dawson Point will be used for disembarkation of equipment and workers • there will be a handful of personnel required to operate the wind plant, therefore there is only a nominal demand on/for public services (e.g., housing, hospitals, schools) • the WIWP will not be physically connected to community services or infrastructure and hence no increases for these services is anticipated (e.g., no new demand for potable water, wastewater connections, etc.) • the Township and CREC have executed an Amenities Agreement as part of the WIWP development with the monies from this Agreement, paid directly to the Township, may be used for community betterment projects and services and thus are anticipated to enhance community services and infrastructure • *intakes and outfalls will be avoided during final cable crossing route selection*

Criterion: Will the project….	Potential Effect Yes	Potential Effect No	Additional / Supporting Information
6.5 have negative effects on the economic base of a municipality or community?		✓	• through the WIWP, CREC will contribute new resources to the economic base of the municipality (e.g. through annual taxation) and community (e.g., royalty payments to landowners), with limited demand for municipal services • to the extent possible local goods and services will be procured during construction, operation, maintenance and decommissioning of the WIWP where these are available in sufficient quantity and quality and at competitive prices, creating a positive economic effect • the Township and CREC have executed an Amenities Agreement as part of the WIWP development with the monies from this Agreement, paid directly to the Township, may be used for community betterment projects and services and thus are anticipated to enhance community services and infrastructure
6.6 have negative effects on local employment and labour supply?		✓	• to the extent possible, where appropriate training and experience have been accrued, local persons will be employed during the construction phase and to provide operational supplies, creating a positive effect for local labour and employment
6.7 have negative effects related to traffic?	✓		• the transport of equipment and supplies during the construction phase will result in additional (temporary) road and river use to facilitate transport of excess loads, large tower components, supplies, equipment, and personnel • equipment and personnel transportation during Project construction will use the MTO ferry for some portions of the construction phase • *cable installation across the St. Lawrence River will be scheduled to avoid the peak summer boating season (i.e., scheduled for after Labour Day)* • during operation supplies will be intermittently delivered to the Project as required, with no significant negative effects anticipated during this stage of the Project's lifecycle
6.8 cause public concerns relating to public health and safety?	✓		• *potential exists for accidents and malfunctions and thus there may be general public safety concerns during construction and with the new infrastructure* • *possible perceived health issues related to electric and magnetic fields from 230-kV transmission line* • operation of the wind turbines will not contribute greenhouse gases or other atmospheric pollutants and thus no other public health concerns have been identified

Criterion: Will the project….	Potential Effect Yes	No	Additional / Supporting Information
7.0 Heritage and Culture			
7.1 have negative effects on heritage buildings, structures or sites, archaeological resources, or cultural heritage landscapes?	✓		• to date no heritage buildings or structures, nor any cultural heritage landscapes, are known to exist within the lands potentially affected by the WIWP • considering the historic development of Wolfe Island, it is possible that sites of European or First Nation origin may be present within the study area • a Stage II archaeological assessment has been undertaken prior to construction to confirm the presence or absence of archaeological and/or historic sites on Wolfe Island • *no marine heritage resources have been identified along the proposed submarine cable route* • should such resources be encountered, they will be handled as per the requirements of the Ministry of Culture
7.2 have negative effects on scenic or aesthetically pleasing landscapes or views?	✓		• the wind plant will be visible for a considerable distance across the relatively flat landscape, with some persons finding the wind turbines aesthetically pleasing, others being indifferent, while others possibly finding them a disruption to natural sight lines
8.0 Aboriginal			
8.1 cause negative effects on First Nations or other Aboriginal communities?		✓	• there are no known First Nations or Aboriginal communities within the study area • based on information provided by the Ministry of Indian and Northern Affairs and the Ontario Secretariat for Aboriginal Affairs there are no First Nation or Aboriginal land claims within the study area • the Mohawks of the Bay of Quinte have identified their primary concern with artifacts or burial remains and that a traditional process must be followed for the repatriation or re-interment of remains • there may be potential to discover / disturb archeological resources. A Stage II Archaeological Assessment has been undertaken on Wolfe Island and recommends a Stage III Assessment at six sites. The Stage III Assessment will be conducted prior to the start of construction to confirm the presence/absence and/or significance of resources • a Stage II Archaeological Assessment will be conducted on the Kingston mainland prior to construction • should such resources be encountered, they will be handled as per the requirements of the Ministry of Culture and/or the practices of the Mohawks of the Bay of Quinte

Criterion: Will the project….	Potential Effect		Additional / Supporting Information
	Yes	No	
9.0 Other			
9.1 result in the creation of waste materials requiring disposal?	✓		• construction wastes such as excavated soils, equipment packaging and wrappings, and scraps will be produced • the WIWP will generate waste associated with turbine construction, maintenance and operation that will require recycling and/or disposal
9.2 cause any other negative environmental effects not covered by the criteria outlined above?	✓		• *potential accidents and malfunctions related to seismicity, ice fall, wind throw or underwater cable rupture (e.g., due to anchor dragging) and third party damage are commonly identified by stakeholders as potential project issues*

TABLE 5.3: SUMMARY OF POTENTIAL EFFECTS AND RECOMMENDED MITIGATIVE/REMEDIAL MEASURES

Screening Criterion[1]	Recommended Mitigation/Remedial Measure	Net Effect	EA Section[2]
1.1 Surface water quality	• Adherence to DFO (2006a,b) Operational Statements and provincial guidelines (Persaud and Jaagumagi, 1995)	Negligible effect	5.1.8, 5.1.9, 5.1.11.2, 5.1.11.3
1.3 Soil erosion	• Adherence to DFO (2006a,b) Operational Statements and provincial guidelines (Persaud and Jaagumagi, 1995)	Negligible effect	5.1.3
1.4 Accidental spills	• Proper handling techniques • Use of appropriate measures for containment and clean up of spills • Adherence to Emergency Preparedness and Response Plan	Negligible effect	5.1.12
2.1 Land use (nuisance) effects	• Adherence to Cheminfo (2005) Best Practices	Negligible effect	5.1.2
2.4 Hazard lands	• Adherence to DFO (2006a,b) Operational Statements and provincial guidelines (Persaud and Jaagumagi, 1995)	Negligible effect	5.1.3
3.1 Air quality	• Adherence to Cheminfo (2005) Best Practices	Negligible effect	5.1.2
3.2 Greenhouse gases	• Adherence to Cheminfo (2005) Best Practices	Negligible effect	5.1.2
3.3 Dust	• Adherence to Cheminfo (2005) Best Practices	Negligible effect	5.1.2
3.4 Noise	• Adherence to municipal noise by-laws • Use of well-maintained equipment • Notification of nearby residents prior to any blasting	Negligible effect	5.1.2
4.5 Fish or their habitat	• Adherence to DFO (2006a,b) Operational Statements and provincial guidelines (Persaud and Jaagumagi, 1995) • Scheduling of nearshore in-water construction (trenching) between 16 July and 14 March	Negligible effect	5.1.1, 5.1.7, 5.1.8, 5.1.10

Screening Criterion[1]	Recommended Mitigation/Remedial Measure	Net Effect	EA Section[2]
4.6 Migratory birds	• Avoid in-water construction during peak waterfowl staging periods	Negligible effect	5.1.1
5.6 Fisheries resources	• Schedule in-water construction to coincide with periods of lower commercial fishing activities	Negligible effect	5.1.1
6.3 Recreation	• Schedule in-water construction outside of the summer period of significant water uses	Negligible effect	5.1.1
6.7 Traffic	• Schedule in-water construction outside of the summer period of significant boating traffic	Negligible effect	5.1.1
6.8 Public health and safety	• Adherence to Emergency Preparedness and Response Plan • Use of appropriate cable technology to minimize electromagnetic fields	Negligible effect	5.1.12,, 5.2.5
7.1 Heritage resources	• Mitigation (protection, excavation) of any landfall resources • Avoidance of any shipwrecks	Negligible effect	5.1.13
9.2 Underwater cable rupture	• Adherence to Emergency Procedures Manual	Negligible effect	5.2.5

1 See Table 5.2, Appendix B.
2 EA section(s) addressing the criterion.

TABLE 5.4: SUMMARY OF THE SIGNIFICANCE OF PROJECT-RELATED IMPACTS

Type of Effect	VESC[1]	Residual Effect: Magnitude[2]	Residual Effect: Duration[3]	Residual Effect: Extent[4]	Significance Assessment	Probabilityof Occurrence	Management of Uncertainty	Overall Significance
Negative effects on biota due to blasting	Fish/benthic organisms	Moderate	Short-term	Local	Nearshore trenching to be undertaken outside of the in-water construction timing restriction for the protection of spawning fish and their spawn; based on Stelco dock construction blasting experience in Lake Erie, up to 40,000 emerald shiner and up to 50 freshwater drum killed per blast; only a few economically important fish species, e.g., perch, bass, were killed; emerald shiner and freshwater drum populations returned to normal by the following year; recovery of benthic communities expected within one year	High	Monitoring any dead fish during construction	NS
Negative effects on biota due to bedrock cutting/ripping and/or physical boring	Fish/benthic organisms	Low	Short-term	Local	Nearshore trenching to be undertaken outside of the in-water construction timing restriction for the protection of spawning fish and their spawn; recovery of benthic communities expected within one year	High	None required	NS[5]
Negative effects on biota due to mechanical dredging	Fish/benthic organisms	Low	Short-term	Local	Nearshore trenching to be undertaken outside of the in-water construction timing restriction for the protection of spawning fish and their spawn; recovery of benthic communities expected within one year	High	None required	NS
Loss of species of special concern or loss/damage to their habitat	Species of special concern	Low	Temporary - short-term	Local	No species of special concern or their habitat identified	High	None required	NS
Discharge/release of persistent and/or toxic chemicals, or nutrients	Water quality/ bioaccumulation	Low	Temporary	Local	Sediments are reasonably characterized as generally uncontaminated by toxic chemicals; rapid dispersion to ambient levels expected due to mixing and sorption (sedimentation) processes	High	None required	NS
Reduction in renewable resource capacity	Commercial fish	Low	Temporary - short-term	Local	Potential fish losses due to blasting (if undertaken) are negligible	High	Monitoring any dead fish and/or TSS during construction	NS
Transformation of natural landscape	Landfalls	Low	Short-term	Local	Landfall sites to be restored after construction	High	Post-construction monitoring	NS
Obstruction of migration or passage of wildlife	Fish/birds	Low	Temporary	Local	Fish and birds can by-pass areas of disturbance	High	None required	NS
Negative effects on human health, well-being or quality of life	Ambient noise levels	Low	Short-term	Local	Adherence to municipal noise by-laws and proper equipment maintenance and operation	High	Consultation with nearby residents	NS

Type of Effect	VESC[1]	Residual Effect: Magnitude[2]	Residual Effect: Duration[3]	Residual Effect: Extent[4]	Significance Assessment	Probabilityof Occurrence	Management of Uncertainty	Overall Significance
Increased employment/ project spending	Local and regional economy	Moderate	Short-term - long-term	Local-regional	Economic benefits due to local and regional employment and project purchases/spending; increased tax revenues to local municipality	High	None required	NS
Negative effects on recreational opportunities	Sportfishing/ boating	Low	Temporary	Local	Scheduling the cable crossing after the summer recreational period	High	Advertising; consultation with marinas; project area demarcation	NS
Negative effects on heritage resources	Possible shipwreck(s)/ landfall sites	Low	na[6]	Local	Possible shipwreck(s) to be avoided; any landfall heritage resources to be mitigated	High	None required	NS
Nuisance impacts	Dust/traffic/ aesthetics	Low	Temporary - short-term	Local	Landfall construction and associated traffic will have temporary, minor and localized adverse effects	High	None required	NS
Potential cable rupture, e.g., due to anchor dragging	Disruption of energy supply	Low	Temporary	Local	Low probability of occurrence	High	Regular inspection; rapid shutdown and repair in unlikely event of cable damage	NS
Negative effects on use of resources by Aboriginal persons	First Nation reserves	Low	Temporary	Local	The nearest reserve is about 125 km west of the proposed cable crossing; there is limited, if any, Aboriginal use of upper St. Lawrence River fisheries resources for domestic and recreational purposes	High	None required	NS

1 VESC = Valued Ecosystem and Socio-Economic Component.
2 Magnitude: low, i.e., minimal or no impairment of VESC attribute or function; moderate, i.e., change outside of natural variability in a VESC attribute or function in the short or medium term with recovery to pre-construction conditions; high, i.e., residual change outside of natural variability in a VESC attribute or function.
3 Duration: temporary, i.e., a few days per site during construction; short-term, i.e., effects are measurable for <1 y before recovery to pre-construction conditions; medium-term, i.e., effects are measurable for 1-10 y; long-term, i.e., effects are measurable for >10 y.
4 Extent: local, i.e., within 5 km; regional, i.e., >5 km.
5 NS = not significant.
6 na = not applicable.

Appendix C

List of Acronyms, Abbreviations and Measurement Units

Acronyms and Abbreviations

#	Number
&	And
=	Equals
<	Less than
>	Greater than
≥	Greater than or equal to
a.s.l.	Above sea level
ACNBC	Associate Committee on the National Building Code
Acres	Acres International Inc. (now Hatch Acres Inc.)
AES	Atmospheric Environment Service
am	Ante meridiem (before noon)
ANSI	Area of Natural and Scientific Interest
AOC	Area of Concern
Apr	April
Aug	August
BEAK	Beak Consultants Limited
BHC	Hexachlorocyclohexane
BP	Before present
C-CORE	Centre for Cold Ocean Resources Engineering, University of Newfoundland
CCME	Canadian Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
CEAA	Canadian Environmental Assessment Agency
CEMP	Construction and Environmental Management Plan
CHS	Canadian Hydrographic Service
Cl.	Class
CLI	Canada Land Inventory
CO	Carbon monoxide
CORK	Canadian Olympic-Training Regatta Kingston
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COSSARO	Committee on the Status of Species at Risk in Ontario
CPUE	Catch per unit effort
CREC	Canadian Renewable Energy Corporation
CSQG	Canadian Sediment Quality Guideline
CSR	Canadian Seabed Research Ltd.

CWS	Canadian Wildlife Service
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
Dec	December
DFO	Department of Fisheries and Oceans
DL	Detection limit
D.O.	Dissolved oxygen
DOC	Dissolved organic carbon
e.g.	For example (exempli gratia)
EA	Environmental assessment
Ed(s).	Editor(s)
EMF	Electric and magnetic fields
EPS	Environmental Protection Service
ESA	Environmentally Sensitive Area
et al.	And others (et alii)
F.	Family
FCO	Fish-community objective
Feb	February
GLSAB	Great Lakes Sciences Advisory Board
GLWQA	Great Lakes Water Quality Agreement
GPS	Global Positioning System
HADD	Harmful alteration, disruption and destruction
HDPE	High density polyethylene
Hydro One	Hydro One Networks Inc.
i.e.	That is (id est)
IBP	International Biological Programme
IGLLB	International Great Lakes Levels Board
IJC	International Joint Commission
Inc.	Incorporated
ISQG	Interim sediment quality guideline
Jan	January
KBA	Kingston Boardsailing Association
KFN	Kingston Field Naturalists
Kleinfeldt	Kleinfeldt Consultants Limited

LaMP	Lakewide Management Plan
LC50	Lethal concentration for 50% of the test population
LEL	Lowest effect level
Mar	March
MOE	Ontario Ministry of the Environment
MOEE	Ontario Ministry of Environment and Energy
MTO	Ontario Ministry of Transportation
N	North
NEA	Niblett Environmental Associates Inc.
NHIC	Natural Heritage Information Centre
NO	Nitric oxide
NO_2	Nitrogen dioxide
Nov	November
NO_x	Nitrogen oxides
NWPA	*Navigable Waters Protection Act*
NYSDEC	New York State Department of Environmental Conservation
o,p-DDT	o,p-dichlorodiphenyltrichloroethane: minor (up to 30%) constituent of technical DDT, of which p,p-DDT is the predominant component
O.	Order
O_3	Ozone
OMNR	Ontario Ministry of Natural Resources
OPA	Ontario Power Authority
Oct	October
OMMAH	Ontario Ministry of Municipal Affairs and Housing
p,p-DDT	p,p-dichlorodiphenyltrichloroethane: predominant component (≥70%) of technical DDT
P.	Phylum
PAH	Polycyclic aromatic hydrocarbon
PCBs	Polychlorinated biphenyls
PEL	Probable effect level
pers. comm.	Personal communication
pm	Post meridiem (after noon)
PM	Particulate matter
$PM_{2.5}$	Particulate matter of 2.5 micron diameter and smaller
PMSTF	Phosphorus Management Strategies Task Force
Project	Wolfe Island Wind Project

PSQG	Provincial Sediment Quality Guideline
PSW	Provincially Significant Wetland
PWQO	Provincial Water Quality Objective
RAP	Remedial Action Plan
ret.	Retired
S	South
SCADA	Supervisory control and data acquisition
S.F.	Subfamily
SEL	Severe effect level
Sept	September
SLSDC	Saint Lawrence Seaway Development Corporation
SLSMC	St. Lawrence Seaway Management Corporation
SO_2	Sulphur dioxide
sp.	One species
spp.	A number of species
St.	Saint
Stantec	Stantec Consulting Ltd.
SW	Southwest
TDS	Total dissolved solids
TEL	Threshold effect level
TKN	Total Kjeldahl nitrogen
TNT	Trinitrotoluene
TOC	Total organic carbon
TS	Transformer Station
TSS	Total suspended solids
U.S.	United States
VESC	Valued Ecosystem and Socio-Economic Component
VOCs	Volatile organic compounds
W	West
WHO	World Health Organization
WPCP	Water pollution control plant
WTP	Water treatment plant
XLPE	Cross-linked polyethylene
YOY	Young-of-the-year
α	Alpha

β	Beta
γ	Gamma
δ	Delta

Measurement Units

$	dollar
%	percent
°	degree
°C	degree Celsius
°F	degree Fahrenheit
/h	per hour
/m^2	per square metre
’	minute
”	second
cm	centimetre
cm/s	centimetre per second
ft	foot
g	gram
g/m^2	gram per square metre
h	hour
/h	per hour
h/ha	hour per hectare
ha	hectare
in	inch
JTU	Jackson turbidity unit
KCMIL	area of a circle with a diameter of one inch
kg	kilogram
km	kilometre
km/h	kilometre per hour
km^2	square kilometre
kV	kilovolt
L/d	litre per day
lb	pound
m	metre
m/km	metre per kilometre

m/s	metre per second
m^2	square metre
m^3/s	cubic metre per second
mg/L	milligram per litre
min	minute
mm	millimetre
mm/y	millimetre per year
MW	megawatt
MWh/y	megawatt-hour per year
ng/L	nanogram per litre
no./m^2	number per square metre
μ (μm)	micron (micrometre)
μg/g	microgram per gram
μg/L	microgram per litre
μg/m^3	microgram per cubic metre
μg/mL	microgram per millilitre
μmhos/cm	micromhos per centimetre
μsiemens/cm	microsiemens per centimetre
/min	per minute
/m^2	per square metre
/m^3	per cubic metre
V	volt
y	year

Appendix D

Glossary

Glossary

Algae	A group of unrelated simple plant organisms that live in aquatic habitats.
Algal bloom	Proliferation of living algae usually due to nutrient enrichment.
Alkalinity	Measure of a water's capacity to neutralize an acid.
Alluvium	Material laid down by rivers.
Amphipods (Amphipoda)	Crustaceans of the class Malacostraca commonly known as scuds.
Annelida	A phylum of invertebrates comprising the segmented worms.
Anthropogenic	Human-caused; due to the human's activities.
Anuran	Frog or toad.
Aquatic macrophyte	Rooted, usually vascular, aquatic plants, such as water lily, cattail, coontail, etc.
Aquifer	The underground layer of water-bearing rock, gravel, sand, silt or clay below the groundwater table.
Arachnoidea	A class of primarily terrestrial arthropods including spiders, scorpions, harvestmen, ticks and mites.
Arthropoda	A phylum of invertebrate animals characterized by an outer body layer, the exoskeleton.
Avifauna	Birds.
Bacillariophyta	Diatoms; unicellular or colonial algae having cell walls made of silica.
Bay ducks	Include redhead, ring-necked duck, canvasback, greater scaup and lesser scaup.
Benthic	Pertaining to the bottom of aquatic habitats and the organisms that inhabit the bottom.
Benthic macroinvertebrates	Larger bottom-dwelling organisms, e.g., snails, clams, worms, insect larvae, crustaceans, etc., living on or within the sediment substrate of waterbodies.
Benthivorous	Bottom-feeding.
Benthos	Bottom-dwelling organisms.
Bioclastic	Consisting of fragmented organic remains.
Biomass	See standing crop.
Brownian movement	The random movement of microscopic particles suspended in a gas of liquid.
Calanoid copepod	Tiny shrimp-like free-swimming zooplankter crustaceans that are separated from cyclopoid copepods by a different major body articulation.
Calcareous	Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone.
Cambrian Period	The oldest period of the Paleozoic Era; it began about 600 million years ago and lasted perhaps 100 million years.

Centrarchid	Member of the sunfish family.
Ceratopogonidae	Biting midge larvae.
Chelate	An organic coordination compound in which a central metal ion is attached by coordinate links to two or more non-metal atoms (i.e., ligands) to form a heterocyclic ring having coordinate covalent bonds.
Chemical oxygen demand	Measure of the amount of oxygen required to chemically oxidize the organic matter in water.
Chironomids (Chironomidae)	Midge fly larvae.
Chlorophyll *a*	A class of pigments found in all photosynthetic organisms; chlorophyll molecules are the principal sites of light absorption in the light reaction of photosynthesis.
Chlorophyta	Green algae; include unicellular and colonial flagellates, usually but not always with two flagella per cell, as well as various colonial, coccoid, and filamentous forms; almost all forms have chloroplasts containing chlorophylls *a* and *b*, giving them a bright green colour.
Chrysophyta	Yellow-green and golden (or golden-brown) algae; yellow-green lack chlorophyll *b* and instead have chlorophyll *c* giving them a characteristic yellowish-green colour; golden algae also have chlorophylls *a* and *c*, as well as the carotenoid pigment fucoxanthin.
Cladoceran	Water flea; small crustaceans that comprise the zooplankton community in waterbodies.
Cladophora	A filamentous algal species.
Class	A category used in the classification of organisms that consists of similar or closely related orders.
Clast	Rock typically composed of broken rock fragments.
Coleoptera	Beetles (aquatic).
Complexation	Combination of two or more substances.
Conductivity	Numerical expression of a water's ability to conduct an electrical current; the conductivity of water is dependent on its ionic concentrations and temperature.
Copepod	Small, free-living crustaceans that comprise the zooplankton community in waterbodies.
Cretaceous Period	The last period of the Mesozoic Era; it began approximately 135 million years ago, lasted for about 70 million years and was characterized by widespread submergence.
Crustacea	Arthropods specifically characterized by the presence of two pairs of antennae.
Cryptomonad	Unicellular microscopic algae with flattened ovoid cells and unequal flagella arising from an obliquely situated gullet.
Cryptophyta	Cryptomonads; unicellular algae with two flagallae.
Crystalline	Of crystal: a regular form bounded by smooth plane surfaces that are the external expression of an ordered internal atomic arrangement.

Cyanophyta	Blue-green algae; a group of simple lower plants containing both blue and green pigmentation; they can produce algal blooms.
Cyclopoid copepod	Tiny shrimp-like free-swimming zooplankter crustaceans that are separated from calanoid copepods by a different major body articulation.
Dabblers	Large dabblers include mallard, American black duck, gadwell and northern pintail; small dabblers include green-winged teal, blue-winged teal, American wigeon, northern shoveler and wood duck.
Diagenetic	The physical, chemical or biological processes that effect redistribution of a material or element.
Diatoms	Unicellular algae, usually microscopic, that are characterized by having a cell wall of silica.
Dimictic	Lakes that undergo thermal stratification in the summer and winter with periods of mixing in the spring and fall.
Diptera	Flies.
Diving ducks	Include bay ducks, sea ducks, goldeneye and mergansers.
Dolostone	A sedimentary rock formed from calcium magnesium carbonate.
Dreissenids	Members of the genus *Dreissena* (e.g., zebra mussel and quagga mussel).
Drumlin	A smooth, elongated, streamlined hill formed by glacial ice and composed essentially of till.
Endangered	A species facing imminent extirpation (no longer existing in the wild in Canada, but occurring elsewhere) or extinction (no longer exists).
Ephemeroptera	Mayfly larvae.
Eustatic	Uniform and simultaneous shift.
Eutrophic	Waters with an excessive supply of nutrients and therefore excessive organic production.
Eutrophication	The process whereby a body of water becomes enriched in nutrients resulting in excessive organic production.
Exotic	Non-native.
Family	A category used in the classification of organisms that consists of one or several similar or closely related genera.
Fetch	Distance over water that the wind has blown uninterrupted by land.
Fluvial	Of rivers.
Gastropods (Gastropoda)	Snails.
Genus	A group of animals and plants having common structural characteristics distinct from those of all other groups and usually containing several species.
Glaciofluvial	Of glacial watercourses.
Glaciolacustrine	Of glacial lakes.

Gleysols	An order of soils developed under wet conditions and permanent or periodic reduction.
Harpacticoida	Benthic copepods.
Herpetofauna (herpetiles)	Amphibians and reptiles.
Hirudinae	Aquatic leeches.
Holocene Epoch	The last (recent; postglacial) epoch of the Quaternary Period; it began at the end of the Pleistocene Epoch, about 10 million years ago and continues to the present.
Hydracarina	Freshwater mites.
Hypolimnion	The cooler deep layer of a lake when thermally stratified.
Ion	An atom that is either negatively or positively charged.
Isopods (Isopoda)	Crustaceans of the class Malacostraca commonly known as sow-bugs.
Kame	An irregular mound generally composed of coarse glaciofluvial gravel; kames are formed when the sediments deposited in the depressions on stagnant glaciers or against their margins are let down onto the ground when ice melts.
Lacustrine	Of lakes.
Lepidoptera	Butterflies and moths.
Ligand	A non-metal ion, molecule, or atom that is attached to the central atom of a coordination compound, a chelate, or other complex, by donating one or more pair of electrons (may also be called a complexing agent).
Limestone	Sedimentary rock composed of carbonate materials, particularly calcium carbonate.
Littoral	The shoreward region of a body of water.
Malacostraca	A class of crustaceans with a body consisting of 20 segments.
Megaloptera	Dobsonflies.
Mesotrophic	Waters with a moderate supply of nutrients and therefore a moderate organic production (between oligotrophic and eutrophic).
Midge larva	Larva of a small, two-winged flying insect.
Mollusca	Molluscs (snails and clams).
Moraine	A landform generally composed of till and created by glacial action.
Naidid oligochaetes	Ecologically diverse family of worms that are sediment dwellers or found among aquatic plants.
Nauplii	The larval stage of a crustacean.
Nematodes (Nematoda)	A phylum of pseudocoelomate (lacking a true coelum) invertebrates comprising the roundworms, characterized by a smooth narrow cylindrical unsegmented body tapered at both ends.
Nemertea	A phylum of small, slender, usually brightly coloured worms with ciliated, unsegmented bodies.

Odonata	Dragonflies and damselflies.
Oligochaetes (Oligochaeta)	Worms.
Oligotrophic	Waters with a small supply of nutrients and therefore a small organic production.
Order	A category used in the classification of organisms that consists of one or several similar or closely related families.
Ordovician Period	The second oldest period of the Paleozoic Era, which started about 500 million years ago and lasted for about 75 million years.
Organic	Soils that have developed from accumulations of organic materials such as grasses, reeds, rushes, sedges, mosses and ferns.
Orogenic	Process of making mountains.
Ostracoda	A class of crustaceans with a body enclosed in a bivalved carapace (dorsal part of the exoskeleton).
Overburden	The soil, rock and other material which lie on top of the underlying mineral or other deposit, e.g., bedrock.
Paleozoic Era	The era of geologic time from the end of the Precambrian, 600 million years ago, to the beginning of the Mesozoic Era, about 225 million years ago; the beginning of Paleozoic time, which marks the start of the first accurate records in geologic history, is characterized by the appearance and development of the major types of invertebrates.
Pelecepods (Pelecypoda)	Clams.
Periphyton	The organisms, collectively, that live attached to rocks, gravel, aquatic vegetation and other substrate.
pH	Indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution.
Phylum	A major division of the animal kingdom containing classes of animals.
Phytoplankton	That portion of plankton consisting of plants, usually minute algae.
Pisidiid bivalve	Clam of the genus *Pisidium*.
Plankton	Minute organisms that drift or float passively with the current of a lake.
Platyhelmenthes	A phylum of acoelomate (without a coelum) invertebrates comprising the flatworms, characterized by a flattened unsegmented body.
Plecoptera	Stonefly larvae.
Pleistocene Epoch	The earliest epoch of the Quaternary Period; it began 2 to 3 million years ago and lasted until the Holocene Epoch, approximately 10,000 years ago and was a time of widespread continental glaciation.
Polychaeta	Bristleworms; segmented worms possessing an array of bristles on their many leg-like parapodia.

Precambrian	Encompasses the time between the origin of the earth and the appearance of complex forms of life about 600 million years ago, and is believed to be equivalent to as much as 90% of the earth's 405-billion-year history.
Primary production	The total amount of organic matter synthesized by the producers (e.g., green plants) of an ecosystem.
Proglacial	Refers to the area immediately adjacent to a glacier, often affected by outwash and by ice- or moraine-dammed lakes.
Pyrrhophyta	Dinoflagellates; most have two flagella that lie perpendicular to one another and cause them to spin when they move through water.
Quaternary Period	The second and youngest period of the most recent Cenozoic Era (also called the Age of Mammals); the Quaternary Period began 2 to 3 million years ago and consists of two epochs, the Pleistocene and the Holocene (known also as Recent).
Rotifer (Rotifera)	Small, usually microscopic, pseudocoelomate (lacking a true coelum) unsegmented animals, with a ciliated region, the corona, at the anterior end, comprising the zooplankton community in waterbodies.
Sea ducks	Include oldsquaw, white-winged scoter, surf scoter and black scoter.
Secchi disc	A white disc lowered into water to measure transparency based on the depth where it is no longer visible.
Secondary production	The rates of energy storage at consumer levels.
Sedimentary	Rock formed by the deposition, alteration and/or compression and lithification of weathered rock debris, chemical precipitates, or organic sediments.
Shale	Fine-grained sedimentary rock composed of lithified clay particles.
Shannon-Wiener Diversity Index	A measure of the number of species and individuals present at a given location as well as the distribution of those individuals among the various species.
Sorption	Physical adherence or bonding of chemicals on solid surfaces, e.g., sediment.
Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Species	A group of closely related individuals which can and normally do interbreed to produce fertile offspring.
Specific conductance	See conductivity.
Standing crop	The total amount of living material in a specified population at a particular time, expressed as biomass or its equivalent in terms of energy.
Subglacial	Refers to the area beneath a glacier, often affected by meltwater.
Synoptic	Large-scale.

Taxon (plural taxa) or taxonomic group	One of a hierarchy of levels in the biological classification of organisms: the seven major categories are (in order of decreasing size) kingdom, phylum (or division), class, order, family, genus, species. The taxonomic groups can be high (class level), intermediate (family level) or low (genus or species level).
Tectonic	Process of structural change caused by deformation.
Thermal stratification	The formation of discrete strata with different temperatures in lakes (e.g., a warm surface layer and a cool, underlying deep layer, separated by a thermocline).
Thermocline	The layer of water in a lake between the epilimnion and hypolimnion in which the temperature exhibits the greatest difference in vertical direction.
Threatened	A species likely to become endangered if limiting factors are not reversed.
Till	Material derived from bedrock and overlying unconsolidated material and deposited directly by glacial ice with its characteristics dependent upon the source rocks.
Total Kjeldahl nitrogen	Measure of both ammonia and organic nitrogen.
Trichoptera	Caddisfly larvae.
Trophic status	General pollutional status.
Tubificid oligochaetes	Sludgeworms, within the family Tubificidae.
Turbellaria	Free-living flatworms.
Turbidity	A measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms in water which are usually held in suspension by turbulent flow or Brownian movement.
Turnover	The period when temperature-stratified conditions revert to isothermal conditions and vice versa.
Upwelling	Transport of deeper (usually colder) water to shallow levels (usually nearshore).
Varved	Characterized by a pair of thin sedimentary layers, one thicker and one thinner, deposited within a one-year period.
Zooplankton	That portion of plankton consisting of animals, usually minute crustaceans and other small multicellular and single cellular animals.

Appendix E

Federal EA Process (CEAA, 1994)

For the federal EA process, criteria for determining adverse effects include (CEAA, 1994):

- negative effects on the health of biota including plants, animals, and fish;
- loss of, or damage to, valued, rare, or endangered species or their habitats;
- reductions in species diversity or disruption of food webs;
- loss of, or damage to, critical/productive habitats, including habitat fragmentation;
- discharges or release of persistent and/or toxic chemicals, microbiological agents, or nutrients (e.g., nitrogen, phosphorus);
- population declines, particularly in top predator, large or long-lived species;
- reductions in the capacity of renewable resources to meet the needs of present and future generations;
- transformation of natural landscapes;
- obstruction of migration or passage of wildlife;
- negative effects on the quality and/or quantity of the biophysical environment, e.g., surface water, groundwater, soil, land and air;
- negative effects on human health, well-being, or quality of life;
- increase in unemployment or shrinkage in the economy;
- reduction of the quality or quantity of recreational opportunities or amenities;
- detrimental change in the current use of lands and resources for traditional purposes by aboriginal persons;
- negative effects on historical, archaeological, paleontological, or architectural resources;
- decreased aesthetic appeal or changes in visual amenities (e.g., views);
- loss of, or damage to, commercial species or resources; and
- foreclosure of future resource use of production.

The determination of the significance of environmental effects is often based on environmental standards, guidelines and objectives which typically specify threshold levels. Where no such threshold standards or guidelines exist, other methods such as risk assessment or professional judgment based on prior experience, may need to be applied. Criteria for determining significance include (CEAA, 1994):

- magnitude;
- geographic extent;
- duration and frequency;
- irreversibility; and
- ecological context.

Magnitude can be rated by the following categories:

- low, i.e., minimal or no impairment of valued ecosystem and socio-economic components (VESC) attribute or function;
- moderate, i.e., change outside of natural variability in a VESC attribute or function in the short or medium term (see below); however, recovery to pre construction conditions should occur; and
- high, i.e., residual change outside of natural variability in a VESC attribute or function.

Geographic extent is delineated as:

- local, i.e., within 5 km; and
- regional, i.e., greater than 5 km.

Duration is categorized as follows:

- temporary, i.e., a few days per site during construction;
- short-term, i.e., effects are measurable for less than one year before recovery to pre-construction condition;
- medium-term, i.e., the effects are measurable for one to ten years; and
- long-term, i.e., the effects are measurable for greater than ten years.

Finally, a determination is required of whether adverse environmental effects are likely taking into account probability of occurrence and scientific uncertainty.

The determination of significance incorporates an evaluation of the criteria listed above. For this EA Report, the designation of significance is based on the following definitions:

- significant adverse effect has a high probability of a medium- or long-term residual impact of high magnitude taking into account mitigation/compensation;
- significant beneficial effect has a high probability of a medium- or long-term impact of high magnitude;
- not significant adverse effect includes temporary or short-term impacts of low or moderate magnitude;
- not significant beneficial effect includes temporary or short-term positive impacts of low or moderate magnitude; and
- unknown indicates that potential significance cannot be determined based on existing data or experience.