All issues raised with the Project Team during the open houses, presentations and on questionnaires were noted and entered into the issues tracking database and are discussed in Section 3.3.

3.2.2 Stakeholder Consultation

Commercial Fishing Industry

Discussions with DFO and fishing industry representatives identified commercial fishers who might perceive themselves to potentially be affected by the Project. This group was invited to a meeting on June 10, 2008 in North Sydney, Nova Scotia. The purpose of the meeting was to review Project plans and timelines, and to discuss further consultation and communication between the fishers and the Project team.

Based on consultation with fishers, government officials and industry representatives, it was determined that data specific to the nature and value of the fishery in the affected area were not adequate for a thorough determination of potential Project effects. Dr. Bruce Hatcher, marine biologist with the Bras D'Or Institute for Ecosystem Research at the Cape Breton University (CBU) was suggested as a local expert to assist with filling the data gaps. On July 5, 2008 fishers were invited to meet with Dr. Hatcher and his team of research assistants to discuss potential research work, time lines, consultation and research methods. LEC approved work a plan devised by CBU and provided a research grant to CBU. Dr. Hatcher's work is intended to support the EA but is also intended to be independent of the EA process.

On August 13, 2008 the CBU research team and fishers met as part of their planned program. Fishers were contacted directly by the research team with the help of representatives; 28 of the estimated 40 potentially affected fishers attended. Senior DFO representative, Paul Gentile, Executive Assistant to Member of Parliament, Mark Eyking and CBRM councilor, Gordon MacLeod were also in attendance. Issues, questions and concerns discussed at this meeting are included in Section 3.3.

On August 26, 2008 representatives from the Jan de Nul Group (JDNG) specializing in dredging and land reclamation made a presentation to the fishers on planned methodologies, risks, mitigative measures and examples of comparable projects. As well, Jan de Nul presented to invited stakeholders on the same date and thereafter debriefed media in the Sydney area. A question and answer period was held at the end of each presentation. Approximately, 25 fishers attended along with about 20 stakeholders at separate sessions. Issues, questions and concerns discussed during each session are included in Section 3.3.

Government

To date, government consultation has included meetings and written and verbal reports. A summary of government consultations efforts are described below:

- Project initiation and introduction meeting with the CEA Agency, potential RAs and Expert Departments on March 25, 2008.
- Project scoping meeting with the CEA Agency, RAs and Expert Departments on June 2, 2008.
- Proposed dredge method presentation by Jan de Nul to the CEA Agency, potential RAs, Expert Departments and other interested regulators on August 27, 2008.

- On-going meetings and written and verbal exchanges with federal regulators, Enterprise Cape Breton Corporation and Fisheries and Oceans Canada.
- Briefings with Transport Canada at the Associate Deputy Minister, Director General and Director level.
- Briefings with the Premier, Minister of Economic Development and Minister of Justice, Government of Nova Scotia.
- Informal discussions with many federal and provincial government regulators during course of EA to gather information and discuss the EA process.
- Briefings with area MLAs Alfie MacLeod, Keith Bain, Manning MacDonald and Frank Corbett, and MPs Roger Cuzner and Mark Eyking.
- Briefings for the Mayor and Councillors and senior officials, Cape Breton Regional Municipality.

3.2.3 Aboriginal Engagement

Unama'ki, the Mi'kmaq term for Cape Breton Island, comprises five First Nations communities. Unama'ki First Nations have an historic attachment to the Ports of Sydney and their voice is important in the environmental assessment process. Membertou First Nations which is located within the urban boundaries of Sydney is an equity investor in LEC and is represented on the board of directors. Membertou First Nations is also active on the Sydney Ports Advocacy Council. As part of the Aboriginal engagement process, LEC commissioned Membertou Geomatics Consultants to complete a Mi'kmaq Ecological Knowledge Study (MEKS) for the Project to identify First Nations lands and resources potentially affected by the Project. Additional engagement efforts to date include:

- on-going dialogue with Membertou First Nations Chief and Councillors;
- briefing with leaders of the Unama'ki Local Economic Benefits Office on July 2nd 2008;
- a presentation to the Nova Scotia Mi'kmaq Assembly of Chiefs on November 14, 2008. The assembly comprises the Chiefs of all 13 Nova Scotia Mi'kmaq communities. In attendance along with the Chiefs were several FN governments officials and resource persons. The presentation comprised a 20 minute Power Point on the project origin, proponents, economics and environmental assessment. It was followed by a question and answer session. Questions were limited and included how Mi'kmaq might improve opportunities for employment on the project, the extent to which the Bras d'Or Lakes might be affected, whether capital improvements to the railway because of the project would be subjected to environmental review and whether dredging might disturb PCB and PAH sediments deposited in Sydney Harbour from the Sydney Tar Ponds; and
- presentation to Unama'ki First Nations Local Economic Benefits Steering Committee on November 26, 2008. The Committee comprises representatives from the leadership of Cape Breton five First Nations communities. Twelve committee members were in attendance for the presentation. It comprised a 45 minute Power Point on the project's origin, proponents, economics, environmental assessment and human resource requirements followed by a question and answer session. Questions centred on the project's labour force requirements and key competencies. As well, committee members expressed interest in transportation issues such as the project's potential impact on truck traffic, number of trains and the potential for traffic congestion at level railway crossings.

3.3 Summary of Key Issues

A variety of issues and concerns were raised during the public consultation programs described in the sections above. In some cases the issues were resolved through provision of Project information (*e.g.,* at the open houses). LEC has committed to addressing other issues and concerns through this environmental assessment which will be made available during a public review process. All key issues were considered in the issues scoping process described in Section 3.3, including a list of environmental components (*i.e.,* issues) addressed in this document.

A description of the issues brought forth during the open house or received by fax, e-mail or telephone is provided in Table 3.2. Also noted is the location in the EA Report where the issue is addressed.

TABLE 3.2 Public Concerns

Issue Type	Issue Details	Where Addressed in the EA
EA Process	Need public education at each step of the project so that the public is well informed.	Section 3.0 Public Consultation Program
Environmental	Impact on wildlife in the area	Section 6.4.4 Terrestrial Habitats and Wildlife
	What are the potential impacts on ponds and marsh land and what will be done to minimize the impacts?	Section 6.4.4 Terrestrial Habitats and Wildlife
	What are the potential impacts on air quality?	Section 6.5 Atmospheric Resources
	Will there be any impacts on the burial ground from WW1 near hospital road.	Section 6.8 Archaeological and Heritage Resources
	Impact on eagles nest	Section 6.4. Terrestrial Habitats and Wildlife
Terminal Operations	Impact of noise, light from terminal operations	Sections 2.7 Noise Emissions, 2.8 Light and Visibility and 6.5.4 Atmospheric Resources
	Impact of increased traffic and safety issues for local community.	Transportation Impact Assessment
	Proximity of terminal to residents on Hospital Road and use of Hospital Road as access road for terminal;	Transportation Impact Assessment
	Issue of rail transport and safety of existing infrastructure (at crossings) – possible derailments.	Transportation Impact Assessment
	Length of trains/frequency	Section 2.2 Loading and Unloading Vessels/Trains
	Rail traffic blocking access to Pt. Edward	Transportation Impact Assessment
	Ownership of container terminal	Section 1.0 Introduction
	Visual impact of terminal from water and on residents close by	Section 6.6 Land Use and Appendix I: Visual Assessment
	Concern about security of terminal operations and increased crime rates	Security at the terminal will comply with international standards.
	Concern about decrease in property values	
	Water supply needs and concern about impact on domestic wells	Section 4.1 Topography and Geology and Section 4.2 Hydrology
Dredging Operations	▪ Turbidity issues because of dredging	Section 4.6 Physical Oceanography, Appendix A
	▪ Risk of environmental damage	Section 6.0 Environmental Effects Assessment
	▪ Level of contamination in the channel close to the tar ponds;	Section 4.7 Benthic Communities and Sediment Quality and Section 4.8 Marine Fish and Water Quality Existing Conditions
	▪ Handling and disposal of dredged material	Section 2.1.3 Construction of Confined Disposal Facilities (CDF)
	▪ Will maintenance dredging be required	Section 4.6 Physical Oceanography
	▪ Width and side slope of dredged channel	Section 2.1.1 Dredging and Dewatering
	▪ Technology to be employed for dredging	Section 2.1.1 Dredging and Dewatering
	▪ Dredging schedule	Section 2.1.1 Dredging and Dewatering

TABLE 3.2 Public Concerns

Issue Type	Issue Details	Where Addressed in the EA
	▪ Type, consistency water/solid ratio dredged material	Section 2.1.1 Dredging and Dewatering
	▪ Amount of material to be removed	Section 2.1.1 Dredging and Dewatering
	▪ Concern about possible munitions dumping in dredging area.	The Study Team has requested information from the Department of National Defence. No reply has been received to date. The Team will continue to investigate. Magnetometric survey prior to dredging will indicate any issues.
	▪ Funding	Funding is in place.
Fisheries	▪ Concern over impact of dredging on lobster habitat	Section 6.1 Benthic Habitat Communities and Sediment Quality
	▪ Method of compensation if fisheries impacted	HADD compensation in Section 6.2 Marine Fish, Fish Habitat and Marine Water Quality
	▪ Assurances of on-going communication with fishers	Section 3.0 Public Engagement Program
	▪ Damage to marine life;	Sections 6.1 Benthic Habitat Communities and Sediment Quality; Section 6.2 Marine Fish, Fish Habitat and Marine Water Quality and Section 6.3 Marine Mammals and Marine Related Birds
	▪ Long term impact of dredging on shellfish	Section 6.1 Benthic Habitat Communities and Sediment Quality
Navigation	▪ Increase in ship traffic levels	Section 2.1.2 Vessel Transportation
	▪ Discharge of ballast water/waste from container vessels;	Section 4.11 Vessel Navigation
	▪ Impact of freighters on the environment	Section 6.1 Benthic Habitats and Sediment Quality
	▪ Managing ice conditions of year round operation	Section 4.6 Physical Oceanography, Section 4.11 Vessel Navigation, and Section 6.1 Benthic Habitat Communities and Sediment Quality
Economic Development	▪ Employment opportunities associated with project	Section 2.11 Project Costs and Employment
	▪ Economics of container terminal development for Sydney	Section 2.11 Project Costs and Employment

3.4 Ongoing Engagement Activities

LEC is committed to the continued development of open and effective consultation with all potentially affected members of the public (*e.g.,* open houses, project bulletins, focus group meetings) as necessary or upon request to share information on Project development and issues of public concern. The provincial government will publish the environmental assessment report and elicit public comments, which will be considered in the Minister's decisions on the acceptability of the proposed Project pursuant to responsibilities under the Nova Scotia *Environment Act*. Dialogue with representatives of First Nations organizations will be ongoing. The proponent's website will be kept updated to facilitate the on-going transmittal of Project information and identification of any public issues and concerns.

4.0 OVERVIEW OF THE ENVIRONMENT

4.1 Topography and Structural Geology

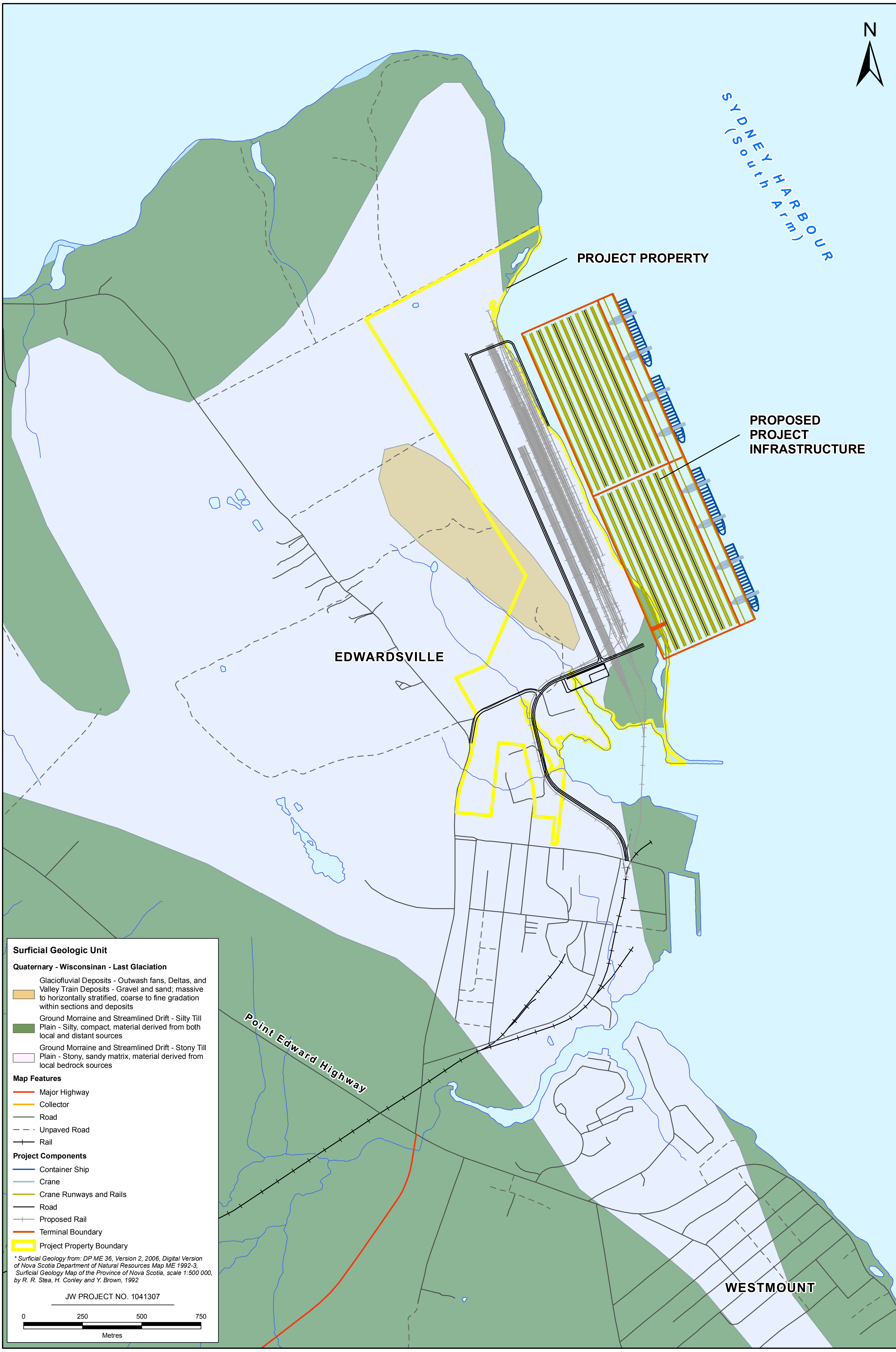
A description of the landforms and geology of the study area was undertaken using previously published mapping and geologic reports. This information is summarized in the following sections.

4.1.1 Physiographic

The area proposed for Project terminal development is located on the peninsula between the Northwest Arm and South Arm of Sydney Harbour. The peninsula is known as Edward Point. The area is characterized by low relief near the shoreline with a narrow bedrock head at the northern-most tip of the Project site. Barachois ponds and lagoon areas are present on the western and southwestern shoreline of the Project site; Barachois Creek will be partially in filled to permit construction of a rail crossing (refer to Sections 4.7 and 6.1 for further information). Freshwater (inland) wetlands were identified in the southwestern region of the Project site. Freshwater resources will be discussed further in Section 4.2.5 and wetlands will be addressed further in Section 4.9 and 6.4.

4.1.2 Surficial Geology

The surficial geology of the general area is characterized as Wisconsinan Age glacial till (Figure 4.1). The principal direction of ice advance in eastern Cape Breton was from the northeast (Stea *et al.*, 1992). The resulting till are glacial advance deposits from the base of the ice sheet (ground moraine). The ground moraine is an unstratified, structure less mantle on the local bedrock. Along the shoreline the texture of this till is silty and derived locally from erodible limestone and shale bedrock. Till with a stony, sandy texture is deposited inland, underlying the southwestern portion of the Project site. An isolated deposit of stratified gravel and sand till of glaciofluvial origin intersects the central portion of the Project site.



DATE: 31/10/2008	Sydney Harbour Access Channel Deepening and the Proposed Sydport Container Terminal	FIGURE NO: **Figure 4.1**
PREPARED BY: L. Kendell	**SURFICIAL GEOLOGY**	Jacques Whitford
LAURENTIAN ENERGY		

Local soils are high in clay content, derived from the fine textured moraine deposits. The soils on site are classified as Queens and Debert. They are found in undulating to gently rolling topography between 3% and 8% in grade, with slightly stony texture. Queens and Debert soils are imperfectly drained, becoming finer and more confining with depth. Erosion of these soils is a concern on slopes.

4.1.3 Bedrock Geology

Bedrock underlying the site belongs to the Mabou Group and is comprised of early to late Carboniferous fluvial siltstones, sandstones, and lacustrine (non-marine) limestone (Figure 4.2). The Mabou Group is generally defined as the fluvial and lacustrine strata that overlie marine and evaporate deposits of the Windsor Group (located south and west of the Site). The fine basin deposits, from which the siltstone and lacustrine limestone are derived, underlie and intertongue with coarse fluvial deposits from which the sandstone is derived. This marginal platform region accumulated of sediments on the underlying Windsor facies. The formation is approximately 229 m thick on the Point Edward peninsula.

The South Bar formation of the Morien Group lies uncomfortably over the Mabou Group just northwest of the Project site, and is common in the Sydney region. The Morien Group is associated with fluvial sandstone, minor conglomerate, mudstone and coal of the Late Carboniferous.

Underlying the Mabou Group is the Hood Island, Woodbine Road and Uist Formations of the Upper Windsor Group. This formation is comprised of mudstone, sandstone, minor conglomerate, gypsum and shallow marine limestone of the Early Carboniferous. The Windsor Group is the uppermost bedrock facies just west of the Project site.

The structure of this area is that of an anticline pitching to the northeast (Bridge Port Anticline). Limestone ridges of the Windsor Group are common in the local area, present in bands that roughly parallel the eastern shoreline of Edwards Point. Limestone quarries for agricultural supply and flux for the open-hearth furnaces at Sydney were common in this region between the turn of the 19th century and the mid 20th century.

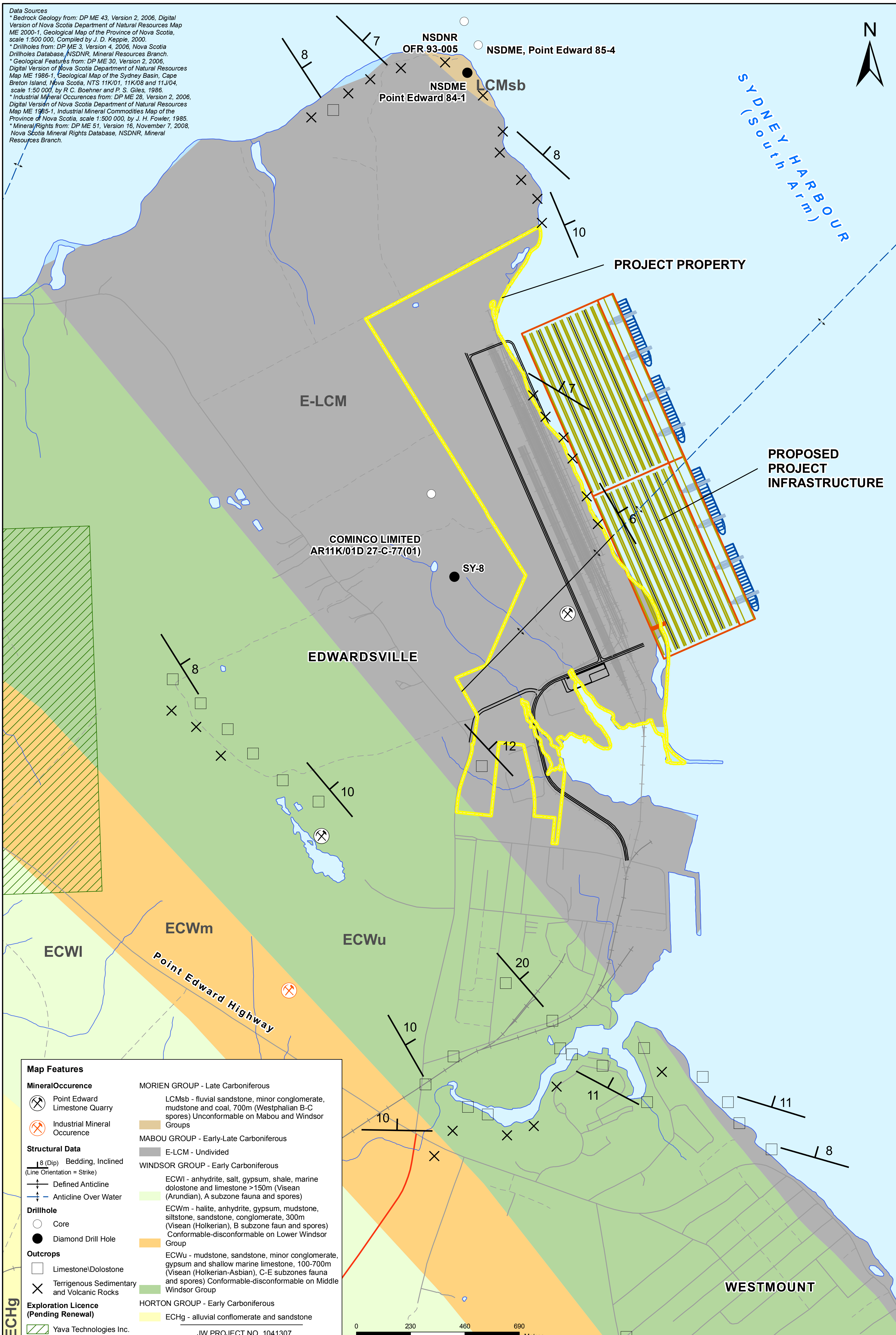
4.1.4 Acid Rock Drainage Potential

Acid rock drainage is the result of exposure of sulphide rich rocks to oxidizing environments such as rainwater. Earthwork activities around these sulphide rich rocks can increase the rock's exposure and thus the acid generation potential. Not all sulphide-containing rocks end up producing acid drainage. In many cases, rocks contain enough carbonate minerals to buffer the sulphide effect, and in these instances acid rock drainage is not produced.

In Nova Scotia, acid rock drainage is most commonly associated with slate from the Halifax Formation of the Meguma Group and coal bearing shales. Bedrock underlying the proposed Project belongs to the Mabou Group, underlain by the Windsor Group. These formations are associated with alkaline lacustrine and marine limestone deposits. Acid rock drainage is not a risk in the Project area.

4.2 Hydrogeology

The hydrogeology and hydraulic properties of the various hydrostratigraphic units underlying and within 500 m of the subject property are presented below in order of age and occurrence below ground surface. The capacity of each unit to store and transmit groundwater to wells is discussed.



DATE: 11/02/2009	Sydney Harbour Access Channel Deepening and the Proposed Sydport Container Terminal	FIGURE NO: Figure 4.2
PREPARED BY: L. Kendell	**BEDROCK GEOLOGY**	

LAURENTIAN ENERGY

Jacques Whitford

4.2.1 Peat

Peat forming wetlands have been identified and delineated in the southwestern portion of the Project site. The hydraulic conductivity of peat varies by peat age and origin (*e.g.,* moss *vs*. gramminoid species) but typically ranges between that of bedded clay (10^{-5}cm/s) to that of well sorted sand and gravel (10^{-3}cm/s). Peat formations are generally not used as aquifers due to the very poor quality of the groundwater (high organic content) and the interaction with surface water.

4.2.2 Glacial Till

Till deposits are typically associated with low to moderate hydraulic conductivity (K) in the order of 10^{-4} to 10^{-6} cm/sec, however, properly constructed dug wells may yield sufficient water for domestic supplies. Well logs indicate that well depth in the region exceeds 6 m in depth, with an average of 30 m depth, which suggests that domestic wells are likely drilled and therefore not drawing water from the surficial aquifer. This unit is rarely utilized by local drillers for water supply; typically this unit is cased off in favour of a bedrock well.

4.2.3 Mabou Group (undivided)

Mabou Group bedrock underlies the Project site. The Mabou Group was previously defined as the reddish shale and sandstone facies (Point Edward Formation) of the Canso Group. The Mabou Group is divided into formations of marine-lacustrine and fluvial origin in Cape Breton, however, the subject area is considered to be undivided which means that with the current level of geologic knowledge, this area cannot be confidently placed within a specific formation.

There are no pumping test records in Cape Breton County for wells completed in the Mabou (formerly Canso) Group bedrock. Based on six pumping tests in Cape Breton (Table 4.1), wells completed in the Mabou (formerly Canso) Group bedrock in Cape Breton have an average transmissivity of 49 m2/day, and a typical safe well yield ranging from 62.28 L/min to 25,000 L/min and averaging 6,100 L/min (NSE Pumping Test Inventory; NSE 1973-2008). Information on groundwater quality from this group is lacking in Cape Breton County. The water is considered of sufficient quality for potable supplies.

4.2.4 Windsor Group

Many of the local water supplies in the communities of Edwardsville, Westmount and Point Edward are supplied by drilled wells in the Windsor Group. This unit is comprised of interbedded shale/mudstone facies and major limestone facies. The limestone beds, prominent in the area, are competent units with generally open, interconnected jointing. Typically these facies are associated with high groundwater yields. Based on six pumping tests in Cape Breton (Table 4.1), wells completed in the Windsor Group bedrock in Cape Breton have an average transmissivity of 15.06 m^2/day, and a typical safe well yield ranging from 220 L/min to 11,000 L/min and averaging 2,500 L/min (NSE Pumping Test Inventory; NSE 1973-2008). Groundwater quality from the Windsor group is characterized as fresh, moderately hard to hard and corrosive. Iron and manganese are typically high. Water supplies typically need a softening system and iron and manganese removal for aesthetic reasons. Copper, zinc, boron and barium may also be elevated.

TABLE 4.1 Summary of Well Water Pumping Test Information, Mabou Group (Formerly included Canso)

	Well Depth (m)	Well Diameter (m)	Test Hours	Water Level (m)	Pumping Rate (igpm)	Transmissivity (m^2/d)	Specific Capacity ($m^3/d/m$)	Safe Yield (igpm)	Aquifer Transmissivity (m^2/d)	Aquifer Storage Coefficient (units)
Mabou Group (formerly Canso) – Cape Breton, Inverness and Victoria Counties										
Minimum	18.30	155.00	24.00	2.30	19.64	3.60	6.87	13.70	164.80	0.0006
Maximum	82.30	200.00	72.00	26.70	2271.27	164.76	125.92	5497.80	164.80	0.0006
Mean	42.38	173.00	64.00	11.30	852.00	49.32	51.90	1341.95	164.80	0.0006
Median	29.90	155.00	72.00	6.80	196.36	12.00	31.90	77.60	164.80	0.0006
Number	6	5	6	5	6	6	6	6	1	1
Upper Windsor Group (Cape Breton County)										
Minimum	41.20	155.00	6.00	2.70	52.36	2.90	1.72	48.40	0	0
Maximum	106.70	203.00	72.00	15.80	327.27	54.20	109.54	2408.60	0	0
Mean	57.48	163.00	53.00	8.25	181.96	15.06	29.98	556.32	0	0
Median	46.65	155.00	72.00	9.10	170.18	5.90	15.89	104.70	0	0
Number	6	6	6	6	5	5	5	5	0	0

Source: NSDEL Pumping Test Inventory (1973-2008)

4.2.5 Freshwater Resources

Based on aquatic investigations carried out onsite on September 30, 2008 by JW, the two watercourses observed within the proposed project footprint were determined to be tidally influenced estuarine watercourses; 100 m further upstream, the watercourses are considered to be freshwater in nature. Detailed aquatic assessments were done on Barachois Brook (BB-1) and a second unnamed watercourse (SYD-1) draining into the saltwater bay known as Barachois Creek (see Figure 4.4 in Section 4.9). Barachois Brook flows south-east into the saltwater bay known as Barachois Creek. It is a small, intermittent watercourse upstream of the existing sewer treatment access road, becoming deeper, well-defined and heavily tidally influenced downstream. Approximately 50 m downstream of the existing access road, there is a floodplain area which is heavily vegetated and covered by water during high tide, but exposed during low tide.

The unnamed watercourse flows southwest into the saltwater bay known as Barachois Creek. It is a small, intermittent watercourse adjacent to the existing sewer treatment Lagoons. At the proposed crossing the brook is tidally influenced as indicated by the high conductivity measured *in-situ*. Downstream the channel widens and deepens with little vegetation or rocky substrate and contains brackish water; this mudflat area is characterized by semi-diurnal tides flowing over a silt substrate with evidence of bivalve populations.

4.2.6 Water Supply

Residents, institutions, industry and commercial businesses in the nearest communities, Edwardsville, Westmount and Point Edward, are supplied by individual on-site wells. No surface water supplies or central water supplies were identified on the Point Edward Peninsula; however there may be unregistered water supplies not accounted for in the Nova Scotia Well Logs or Pumping Test Databases. The proposed Project is located down gradient of these existing water supplies and is not likely to interact with groundwater or surface water supplying these communities.

A review of water well records for the province of Nova Scotia (NSE Well Drillers Logs (1965-2007), aerial photos and field reconnaissance indicates that the closest off-site water well is located approximately 500 m southwest of the site in Edwardsville. It is highly unlikely that activity from the proposed facility would impact these domestic wells due to both distance and the nature of the Project. Blasting or excavation of surficial or bedrock material is unlikely during construction of the proposed terminal site. The Project will be primarily an infill in marine and shoreline areas and will have no effects on identified offsite water supplies.

Water supply for the existing Sydport Park and the proposed terminal will be from the existing CBRM central municipal water supply system. The groundwater demand for this project (bathroom facilities) can be supplied by the high yield well without approaching the well's identified safe yield (530 L/min).

4.3 Climate

A meteorological weather station is located at Sydney Airport, Sydney, Nova Scotia. The climate observed at the Sydney Airport is likely to be representative of the climate expected at the proposed Project location in the Sydport Industrial Park near Edwardsville. Unless otherwise stated these data were taken from the Canadian Climatic Normals published by Environment Canada's Weather Office.

The climatic conditions of an area play a major role in the dispersion of contaminants within the atmosphere. Generally, the Project area and the province of Nova Scotia have good air quality, with minor exceedances of the provincial air quality regulations observed a small portion of the time. The majority of the exceedances are due to the long-range transport of air masses from central Canada or the eastern seaboard which may transport contaminants into the area, causing poorer air quality.

On a global scale, the Atlantic Region lies within the zone of prevailing westerly winds. This zone is characterized by the passage of series of high and low pressure systems. Paths taken by these systems are further influenced by ocean currents and continental topography. Cyclonic passages (low pressure systems moving through an area) may track across the continent or up the eastern seaboard. Typical cyclonic passages are marked by the onset of wind from an easterly direction, thickening cloud, and a gradual fall in pressure. Strong north-easterly winds and heavy precipitation are familiar accompaniments to these storms. Should the storm centre pass to the south, the wind direction will change in a counterclockwise manner and precipitation may persist for several days. If the low pressure centre tracks to the north of the observing station, the wind direction usually veers (changes in a clockwise manner). The return of the wind from a westerly direction usually marks the end of the influence of a cyclonic system; the cyclonic passages typically last from a few days to a week.

During the summer, persistent high pressure systems off Bermuda result in prolonged periods of stagnant weather with warm temperatures and light winds from the south. These events promote the movement of air pollutants from the eastern seaboard to the Project area. There may also be a subsidence inversion (persistent meteorological conditions limiting atmospheric dispersion) accompanying the high pressure system that further enhances the potential for air quality to deteriorate. This is the situation that generally accompanies the days with perceptible pollutant haze and hot stagnant periods in the summer.

During periods of low wind speed, particularly in the summer months, the occurrence of sea-breezes and land-breezes are evident along the coastline and several kilometres inland. In the daytime, strong solar insolation causes a warming of the land and the rising air is replaced by air moving in from the offshore. During the night, the reverse may occur, but the cold water temperatures tend to reduce the possibility of the land-breezes.

Hurricanes can develop in the tropics and typically move up the eastern seaboard. These storms are typically downgraded as they encounter the colder waters off the northeast United States and Canada. Usually, by the time a hurricane reaches the Project area, it will have weakened into a tropical storm or an intense low pressure system with strong winds and heavy rains. However, the transition from tropical to extratropical cyclone can result in a rapid expansion of the area affected by damaging winds and waves. These events may occur a few times a year over Canadian Maritime waters (Hart and Evans, 2001; Bowyer and MacAfee, 2005) A recent and extreme example is Post-Tropical Storm Noel that made landfall in Nova Scotia in November 2007. Although the hurricane season starts June 1st, the peak time for these storms is between September and October.

4.3.1 Temperature Normals and Extremes

The temperature normals (averages) and extremes at the Sydney Airport, which is representative of the Project area, are presented in Table 4.2 Environment Canada publishes temperature normals every 10 years.

TABLE 4.2 Temperature Normals and Extremes for Sydney Airport (1971-2000)

Month	Daily Mean (°C)	Daily Maximum (°C)	Daily Minimum (°C)	Extreme Maximum (°C)	Extreme Minimum (°C)
January	-5.7	-1.3	-10	16.9	-26.2
February	-6.5	-1.9	-11.1	18	**-27.3**
March	-2.7	1.5	-6.9	17.8	-25.6
April	2.1	6.1	-1.9	27.2	-14.6
May	7.8	12.9	2.6	31.1	-7.8
June	13.3	18.9	7.6	34.4	-3.9
July	17.7	23	12.3	33.9	2.2
August	17.7	22.7	12.6	35.5	2.8
September	13.4	18.3	8.5	32.3	-1.7
October	8	12.2	3.8	25	-5.6
November	3.3	6.8	-0.2	22.2	-12
December	-2.1	1.6	-5.8	16.7	-22.2

Reference: Environment Canada 2002

The annual temperature range for Sydney Airport is normally between +23°C and -11°C. However, extreme temperatures of +35°C in August and -27°C in February have been recorded.

4.3.2 Precipitation Normals and Extremes

The precipitation normals and extremes measured at the Sydney Airport are presented in Table 4.3. This data is the most recent available data on the Environment Canada website.

TABLE 4.3 Precipitation Normals and Extremes for Sydney Airport (1971 - 2000)

Month	Mean Rainfall (mm)	Mean Snowfall (cm)	Total Precipitation (mm)	Extreme Daily Rainfall (mm)	Extreme Daily Snowfall (cm)	Extreme Daily Precipitation (mm)
January	82.4	70.8	151.5	57.2	44.5	57.2
February	66.7	66.8	132.1	62.2	45.2	62.2
March	88.4	51.4	138.9	73.0	43.2	73.0
April	103.7	26.1	130.4	73.4	29.2	73.4
May	100.1	2.7	102.9	93.5	24.9	93.5
June	92.6	0	92.6	84.0	1.0	84.0
July	86.8	0	86.8	68.2	0	68.2
August	93.1	0	93.1	128.8	0	128.8
September	113.4	0	113.4	90.9	0	90.9
October	143.8	2.0	146.0	96.2	15.7	96.4
November	134.4	15.7	149.7	97.3	27.4	97.3
December	107.6	62.8	167.5	94.0	58.7	95.0

Reference: Environment Canada 2002

Total precipitation is rainfall plus the water equivalent of the snowfall and all other forms of frozen precipitation. The monthly total precipitation levels for Sydney Airport range from 87 mm in July to 168 mm in December.

Although rainfall can occur during any month of the year, the rainfall in the area is highest during the spring (Apr-May) and fall (Oct-Nov). Snow can fall between the months of October and May, with the largest amounts falling in January.

4.3.3 Adverse Weather

Fog, freezing precipitation and other adverse weather can pose risks for marine vessels in the Project area. The monthly average number of occurrences for adverse weather elements for the Sydney airport is presented in Table 4.4.

TABLE 4.4 Adverse Weather Events at Sydney Airport - Monthly Averages (1961–1991)

Month	Days with Fog	Days with Freezing Precipitation	Days with Thunderstorms
January	4	3	0
February	4	5	<1
March	7	5	<1
April	9	3	<1
May	12	<1	<1
June	10	0	2
July	10	0	2
August	6	0	2
September	5	0	<1
October	4	0	<1
November	5	<1	<1
December	3	2	<1
Year	78	19	9

Reference: Environment Canada 2002

Fog and Visibility

Reduced visibility due to dense fog is more prevalent in late spring and early summer, when warm moist air from the south flows over relatively cold coastal waters. July is the foggiest month, but by early fall, a combination of cooler, drier air and warmer ocean temperatures both contribute to a decrease in fog. During winter, poor visibility occurs less than 10% of the time and is often caused by snow.

Freezing Spray

Another concern for ships travelling into Sydney Harbour is the accumulation of ice on a ship's superstructure (or any structure on the sea or near its edge) due to freezing spray.

Freezing spray occurs when ocean spray caused by high winds, heavy seas and even the motion of the vessel itself spreads over the ship's superstructure and freezes on contact. Freezing spray can impede the safe work aboard a vessel. Freezing spray can occur between November through April; however the potential for moderate or greater vessel icing from freezing spray is highest in February. The rate of ice build-up is strongly influenced by the vessel design, speed and direction of travel.

Freezing spray is usually associated with north westerly or northerly winds blowing off the land. Not only are the northwesterly winds behind a deep low pressure centre often among the strongest winds of a storm, they also bring cold air from the north. When northwesterly winds are especially strong and persistent, temperatures will eventually plummet. Once the air temperature becomes colder than –2°C (the freezing point of salt water), conditions exist to produce freezing spray in seawater.

4.4 Ambient Air Quality

The air quality on mainland Nova Scotia is generally very good, and air quality in the Project area generally falls within the desirable objectives and well within provincial limits. In this assessment existing air quality and the impact on air quality will be assessed on the basis of air contaminant (SO_2, CO, NO_2, PM, and O_3) and greenhouse gas emissions (CO_2, CH_4, and N_2O).

Both the provincial, Nova Scotia Environment (NSE), and the federal government, Environment Canada (EC), operate a network of ambient air monitoring stations within the province to measure ambient concentrations of various air contaminants. The closest air quality station to the Project location is in the city of Sydney at 71 Welton Street. This ambient monitoring site is located approximately 5 km from the Project site and is designed to measure ambient concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone, (O_3), and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$).

The published measured values for 2005 and 2006 for this site are presented in Table 4.5. These data correspond to a location directly influenced by the industry in the area. The air quality at the proposed Project site is most probably significantly better than these readings suggest. Even located directly in the influence of industrial activity, the maximum recorded 1-hour, 8-hour, 24-hour values and annual means for 2005 and 2006 met the Nova Scotia Maximum Permissible Ground-Level Concentrations.

TABLE 4.5 Ambient Air Quality Monitoring Results for Sydney, NS

Air Contaminant	1 Hour Max			8 Hour Max			24 Hour Max			Annual Mean		
	2005	2006	Limit	2005	2006	Limit	2005	2006	Limit	2005	2006	Limit
Sulphur Dioxide (ppb)	29	125	344	NA	NA	-	7	24	115	NA	NA	23
Carbon Monoxide (ppm)	1.1	2.2	30	0.7	1.2	11	0.4	1	-	NA	0.3	-
Nitrogen Dioxide (ppb)	NA	42	213	NA	NA	-	NA	9	-	NA	NA	53
Ozone (ppb)	64	69	82	53	57	-	46	50	65*	24	27	-
Particulate Matter 2.5 (TEOM) (ug/m^3)	90	39	-	NA	NA	-	21	23	30*	NA	6	-

*Canada Wide Standard
NA - Information Not Available
Reference: Environment Canada 2008b

The greenhouse gas (GHG) emission summary for the Province of Nova Scotia for 2005 (which is the most recent data available at this level of detail) is presented in Table 4.6. Approximately 93 % of the total GHG emissions emitted in Nova Scotia are a result of combustion for energy. The remaining 7 % is contributed by industrial processes, solvent and other product use, agriculture, and waste. In fact, the overall provincial total for 2005 was 1.1 % lower than the provincial total reported for 2004 (Environment Canada 2008).

TABLE 4.6 2005 Greenhouse Gas Emission Summary for Nova Scotia

Greenhouse Gas Source	Greenhouse Gas Emissions						Total (kT)
	CO_2	CH_4 (CO_2 eq)	N_2O (CO_2 eq)	HFCs (CO_2 eq)	PFCs (CO_2 eq)	SF6 (CO_2 eq)	
Energy (total)	**20500**	**270**	**400**	**-**	**-**	**-**	**21170**
Stationary Combustion Source	14300	200	100	-	-	-	
Transportation	6140	10	300	-	-	-	
Fugitive Sources	7.3	67	-	-	-	-	
Industrial Processes (total)	**280**	-	-	-	-	-	**280**
Mineral Products	220	-	-	-	-	-	
Chemical Industry	-	-	-	-	-	-	
Metal Production	-	-	-	-	-	-	
Consumption of Halocarbons and SF6	-	-	-	-	-	-	
Other and Undifferentiated Production	56	-	-	-	-	-	
Solvent & Other Product Use (total)	**-**	-	**5.2**	-	-	-	**5.2**
Agriculture (total)	-	**230**	**280**	-	-	-	**510**
Enteric Fermentation	-	190	-	-	-	-	
Manure Management	-	36	51	-	-	-	
Agricultural Soils	-	-	230	-	-	-	
Waste (total)	**9.1**	**780**	**20**	-	-	-	**809**
Solid Waste Disposal on Land	-	780	-	-	-	-	
Wastewater Handling	-	5.9	20	-	-	-	
Waste Incineration	9.1	-	2	-	-	-	
Totals							**22774**

Note: Totals for categories shown in bold
Reference: Environment Canada 2008a

The break-down of GHG emissions by province and territory in Canada for 2005, which is the most recent data available, is presented in Table 4.7. Based on this data, only approximately 4 % of the National total is contributed by the province of Nova Scotia.

TABLE 4.7 2005 Greenhouse Gas Emission Estimates for each Province and Territory in Canada

Province/Territory	2005 Emissions ($CO_{2\ eq}$) (kT)
Newfoundland & Labrador	10500
Prince Edward Island	2280
Nova Scotia	22700
New Brunswick	21300
Quebec	89400
Ontario	201000
Manitoba	20300
Saskatchewan	70900
Alberta	23000
British Columbia	65900
Yellowknife	418
Northwest Territories and Nunavut	2270
National Total	**529968**

Reference: Environment Canada 2008c

4.5 Acoustic Environment

The existing acoustic environment at the Project site was determined by performing baseline sound pressure level monitoring at three sites. The noise monitoring sites selected represent some of the nearest residential properties to the proposed Project site and are the following:

- Noise monitoring site 1 – 1695 Point Edward Highway;
- Noise monitoring site 2 – 2025 Point Edward Highway; and
- Noise monitoring site 3 – 225 Hospital Road.

Each site is graphically presented in Figure C-1, Appendix C.

The baseline study was conducted using a Larson Davis Model 824 Type 1 integrating sound pressure level meter. This instrument averages the energy level of sound over a selected period of time and expresses this as an equivalent sound pressure level, L_{eq}, in dB_A (A-weighted decibels). In this study, each measurement session consisted of one-minute readings logged over a 24-hour period to establish variation over time. The logged values were then used to calculate hourly L_{eq} values (1-hour L_{eq}) and day (L_D) (7:00 to 19:00), evening (L_E) (19:00 to 23:00) and night (L_N) (23:00 to 7:00) equivalent sound pressure levels.

The collected data are representative of the existing conditions and includes cumulative environmental effects due to contributions from traffic and any other substantial sources of noise at the baseline noise monitoring sites, including those that are natural (*i.e.,* wind in trees, birds, and animals). However substantial interferences in the baseline noise (*i.e.,* lawn mower) have been filtered from each data set as per the field notes attached in Appendix C.

The calculated 1-hour Leq values for each baseline noise monitoring site are presented in

Table 4.8.

TABLE 4.8 Measured 1-Hour Baseline Sound Pressure Levels

Time	Site 1	Site 2	Site 3	NSE Guideline
9:00	-	-	43	65
10:00	-	-	35	65
11:00	50	48	37	65
12:00	52	52	39	65
13:00	55	50	38	65
14:00	49	52	40	65
15:00	52	48	47	65
16:00	50	45	49	65
17:00	50	45	46	65
18:00	50	47	39	65
19:00	49	43	44	60
20:00	50	43	38	60
21:00	47	37	39	60
22:00	46	39	34	60
23:00	44	35	31	55
0:00	53	30	29	55
1:00	40	32	40	55
2:00	39	33	28	55
3:00	38	31	29	55
4:00	36	30	37	55
5:00	42	31	39	55
6:00	48	45	36	55
7:00	48	44	38	65
8:00	48	45	47	65
9:00	48	46	44	65
10:00	50	48	-	65
11:00	-	51	-	65

There were no exceedances of the Nova Scotia Environment Noise Guidelines (L_D = 65 dB_A; L_E = 60 dB_A; L_N = 55 dB_A) for sensitive receptors (*e.g.,* residences).

The 1-minute, 1-hour, and day, evening, and night L_{eq} values for each noise monitoring site are graphically presented in Figures C-2, C-3, and C-4 in Appendix C.

4.6 Physical Oceanographic

This section presents the results of a desktop study of local physical oceanographic conditions, based on analyses of existing data. The area of interest includes the whole Harbour, with particular emphasis on the Seaward and South Arms where channel dredging and the construction of the terminal are proposed. Additional detail is presented in Appendix D.

4.6.1 Oceanographic Overview

Sydney Harbour is located on the Northeastern Shore of Cape Breton Island and opens onto Sydney Bight, the large body of ocean water east of the Scotian Shelf at the entrance of the Cabot Strait leading into the Gulf of Saint Lawrence. The Harbour's present Y-shape results from the post ice-age drowning of two river valleys, now the 10km-long South Arm and the Northwest Arm joining into the

Seaward Arm leading to Sydney Bight. The key oceanographic attributes of the Harbour are its relatively modest freshwater inputs and associated mean estuarine circulation, moderate tidal range, and the presence of a long-period standing wave (or 'seiche') which, when excited by meteorological or large-scale ocean disturbances, generates water level and current oscillations at times larger than tides.

4.6.2 Data Sources

Numerous oceanographic studies have been conducted in Sydney Harbour, including, but not limited to, Lane (1988), ASA (1994), Petrie (2001) and Lee (2002). Data and oceanographic interpretations generated for these studies provide a good basis for the present analyses. The Lane study included bottom current meter moorings and concurrent hydrographic observations from August to October 1987 and in January 1988. ASA measured currents and associated hydrograph off Muggah Creek in the South Arm in August 1992 and August 1993. As part of the pre-Sydney Tar Ponds Cleanup investigations focusing on the Muggah Creek area, additional analyses of the data were carried out in a comprehensive review of the physical oceanography of Sydney Harbour by DFO scientists (Petrie *et al.* 2001) who also conducted modelling of sediment re-suspension off Muggah Creek. Concurrent to the 2001 study, additional current observations off Muggah Creek in the south Arm were collected by DFO in 2000-2001, and results are presented in the physical oceanographic component of the Toxic Substance Research Initiative (TSRI)-funded study of the Harbour for the Tar Ponds Cleanup (Lee, 2002).

4.6.3 Bathymetry

The bathymetry map shown (Figure 1, Appendix D) is based on navigation chart # 4266 from the Canadian Hydrographic Service (CHS), complemented by 2008 data from a high-resolution bathymetric survey of the proposed dredge channel area. The sill across the Seaward Arm of the harbour has minimum depths in the order of 12 m Chart Datum (CD). The channel deepens again into the South Arm, with depths up to 20 m CD off the proposed container terminal wharf.

4.6.4 Hydrography and Freshwater Inflows

The density of seawater is determined by its salinity and temperature, the former having the most influence. Temperature and salinity measurements in past studies focus on the South Arm, particularly the area off Muggah Creek. The data shows that the strongest vertical density stratification in the South Arm is encountered between Sydney River and the mouth of Muggah Creek. In this area, less dense (fresher and/or warmer) water overlays layers of denser (saltier and/or colder) water, causing layered currents and affecting the exchange of water between the inlet and the ocean. In the northern half of the South Arm and in the Seaward Arm, the water column is generally well mixed. Overall, hydrographic measurements are generally consistent with that of an estuary where the tidal volume is much greater than the freshwater inflows, causing density stratification to be significant near the head of the inlets (South Arm and Northwest Arm).

There are three major watercourses discharging into Sydney Harbour. Sydney River and Muggah Creek flow into the South Arm, Balls Creek and Leitches Creek flow into the Northwest Arm. It is estimated (see Appendix D) that over a tidal cycle, the tidal volume is 104 times the freshwater volume into the harbour, which indicates that the influence of river flows on harbour circulation greatly decreases away from the discharge point and tides, ocean- and meteorologically-driven process would generally prevail.

4.6.5 Water Levels

The major components of the total water level are astronomical tide, storm surge, seiche and mean sea level as described in the following paragraphs.

Astronomical Tide

The local astronomical tide is mixed, mainly semi-diurnal (two high waters and two low waters occurring twice per lunar day), but the diurnal component causes unequal heights. Tidal datums and elevations in North Sydney are shown in Table 4.9.

TABLE 4.9 Tidal Heights, Extremes and Mean Water Level in North Sydney

	Elevation [metres] relative to	
	Chart Datum	Geodetic Datum
Recorded extreme high water	2.3	1.9
Higher High Water Large Tide (HHWLT)	1.5	1.1
Higher High Water Large Tide (HHWMT)	1.3	0.9
Mean water level	0.7	0.3
Geodetic datum	0.4	0
Lower Low Water Large Tide (LLWMT)	0.3	-0.1
Lower Low Water Large Tide (LLWLT)	0.1	-0.3
Chart datum	0	-0.4
Recorded extreme low water	-0.3	-0.7

Source: 2008 Canadian Tide and Current Tables

Mean Sea Level Rise

Present - The complete time-series of water level observations at North Sydney from 1970 to July 2008 were analysed and show an upward trend in relative mean sea level of about 2.9 mm/year. This value is close to the 3.2 mm/year trend observed in Charlottetown. The relative sea level rise is made of the sum of global and regional sea level rise, plus a contribution (estimated at 0.2 m/century) from crustal subsidence following post-glacial adjustments to changing ice and water loads (McCulloch et al. 2002).

Projections - In their latest fourth assessment report, the Intergovernmental Panel on climate Change (IPCC, 2007) estimates that global sea levels will rise between 0.18 m and 0.59 m by 2099. These estimates exclude local crustal subsidence effects and possible rapid dynamical changes in ice flow, (*e.g.,* accelerated melting of polar ice caps). In their assessment of sea level rise impacts on PEI, MacCulloch et al. (2002) adopted a total projection of 0.7 m relative sea level rise to 2100 in the Charlottetown region (0.5 m for global sea level rise plus 0.2 m for crustal subsidence), with an uncertainty of ±0.4 m. It is reasonable to adopt the same value for Sydney, as trends in crustal subsidence and relative sea level rise are relatively similar between the two sites (Peltier 2002).

4.6.6 Currents

Sydney Harbour is a tidal estuary, in which the density difference between fresh and saline water generally causes a mean seaward surface flow and a mean up-harbour bottom flow that add to the stronger tidal and seiche currents. Currents throughout the harbour are generally weak (in the order of 0.2 m/s or less, decreasing towards the head of the South and Northwest Arms) but increase when winds or large scale oceanic events disrupt or even reverse the mean patterns. Further information on currents in Sydney Harbour is presented in Appendix D.

4.6.7 Winds

Winds have a large influence on the local current regime, because they excite the seiche and/or cause low frequency water exchange through up- or down-welling. In the winter the influence of winds on the Harbour is at times reduced because of the ice cover. The closest and most comprehensive wind dataset in the area is from Sydney Airport, located approximately 6 km inland from the Atlantic Ocean, and 12 km from the South Arm.

Throughout the year, the most probable wind direction is Southwest, while the strongest wind speeds are distributed over all directions. Southwest winds typically prevail during the summer, while winter months exhibit peaks predominantly from the West between November and January, and also with significant Northerly occurrences in late winter and spring. Further information on winds in Sydney harbour, including extreme winds is presented in Appendix D.

4.6.8 Waves

Due to the situation of Harbour on the Northeastern shore of Cape Breton and the presence of the Cape Breton Highlands land mass to the West, all waves of significant height (greater than 2 m) off Sydney Harbour are from the Northeast quadrant over which they are about equally distributed. Waves under 2 m predominantly come from the North. Waves are under 0.5 m for 31% of the year, which includes the ice season. The ice season typically starts into the month of February and ends early April. It is reflected in the statistics for these months, with a low probability of occurrence for any wave height but a high chance of strong waves under unusual open water conditions. In the summer, waves off Sydney Harbour are generally small because the winds blow predominantly from the land. The strongest wave climate occurs in December and January, when the direction is strongly biased towards the North. Further information on waves is including extreme values is presented in Appendix D.

4.6.9 Sediments

Surficial Sediment Types and Moisture Contents

Recent data were collected at 15 sites along the proposed dredge channel and in the South Arm in January 2008 (Appendix E). Both the presence of fines (silt and clay) and the moisture contents decrease seaward as the marine environment becomes more energetic. Surficial sediments in the South Arm exhibit the highest contents of fines, with total silt and clay contents over 80% for the southern-most sites. Sand prevails in the Seaward Arm North of the South Bar. These results are consistent with numerous earlier studies, including Stewart *et al.* (2001) and Lee *et al.* (2002).

Background Suspended Sediment Concentrations

Suspended sediment (SS) samples were collected by ASA at 8 sites throughout the South Arm and at current meter sites 4 and 5 off New Victoria and Sydney Mines on several occasions in August and December 1992. All SS concentrations at the top and bottom of the water column were below 10 mg/l, except for two isolated occurrence which may have resulted from a sampling error. The values are typical for lower-energy coastal waters with limited river inputs. In contrast, in high-energy estuaries with very active sediment transport such as Saint John Harbour on the Bay of Fundy, SS concentrations are typically in the order of 10 mg/l at the surface to between 50 and 100 mg/l near the bottom.

Sediment Transport

Sediment transport in a coastal inlet results from the combination of two elements: sediment sources and hydraulic energy to disperse it. In Sydney Harbour, both elements are relatively weak. The most important sources include the bluffs along the Seaward Arm and the rivers. Waves gradually erode the exposed bluffs on a storm-by-storm basis, dumping the eroded sediment as their breaking heights decrease along beaches such as South Bar. The South and Northwest Arms are well sheltered and wave-induced long shore transport is minimal there. Sedimentation in sheltered areas mostly comes from riverine deposits, which are limited here by the modest discharge relative to tidal volume. In harbours where tidal inflows carry large suspended sediment loads on each flood tide (as on the Bay of Fundy), significant sedimentation can occur up-harbour at the interface between fresh and salt water. This is not the case in Sydney Harbour, as background SS concentrations are generally low. Instead, sediment transport and resulting deposition may occur occasionally during episodes of stronger currents, or strong waves for the Seaward Arm. Petrie *et al.* (2001) used ADCP current data off Muggah Creek to investigate the potential re-suspension and subsequent entrainment of contaminated sediment off Muggah Creek during stronger current events. They conclude that net sediment movement towards the head of the South Arm is expected, which is supported by the physical distribution of pollutants in bottom sediments.

Sedimentation Rate

Stewart e*t al.* (2001) used surficial bottom sediment samples from 94 stations across the Harbour to conclude that the Harbour is a depositional area, flocculation being an important deposition mechanism. Building on these data and results, a subsequent study of contaminated sediment geochronology was undertaken by Lee *et al.* (2002). The historical record of contaminant inputs was determined by chemical analyses of sediment cores. It appears that cleaner surface sediment deposits have been capping the main inventory of contaminants since the 1980's closure of the coke ovens and steel plant that used to discharge toxic effluent into Muggah Creek. Sedimentation rates in the Harbour were estimated between 0.2 and 2 cm/year. Lee notes that the regions closest to Muggah Creek tend to have the highest sedimentation rates.

4.7 Benthic Communities and Sediment Quality

Marine sediments in portions of Sydney Harbour have historically been known to contain elevated levels of certain contaminants (Buckley *et al*., 1995; cited in Lee 2002). The Harbour received effluents from the steel making industry for over 100 years, resulting in elevated levels of polycyclic aromatic hydrocarbons (PAH) and heavy metals in water and in sediment in particular areas of the South Arm, North West Arm, and Seaward Arm. Another significant source of contamination in the harbour is municipal waste water (sewage) which has contributed to elevated metal concentrations in some areas (Lee 2002). These and other contaminants resulting from long periods of heavy industrial activity have contributed to the overall condition of the local marine environment.

A Toxic Substances Research Initiative (TSRI) program was conducted for Sydney Harbour between 1999 and 2002. Lee (2002) summarized the findings of this work in TSRI Summary Report #93 (hereafter referred to as TSRI #93). The report focused on sediment quality and benthic communities in Sydney Harbour. The sediment sampling for TSRI #93 focused heavily on the South Arm of Sydney Harbour; only four sample locations were identified in the vicinity of the proposed dredge channel in the Seaward Arm (see Figure 6.1 in Lee (2002)). Results from TSRI #93 therefore provide limited information on contamination levels in sediments in the proposed dredge channel, and the data are now nearly 10 years old. In an effort to provide more recent and Project site-specific data for the EA, LEC commissioned sediment sampling and an underwater video benthic habitat survey in January 2008, and a geotechnical borehole investigation program in October 2008 (see Appendix E for results of the LEC Underwater Benthic Video Survey Report, Sediment Sampling Report, and the Geotechnical Borehole Investigation Program). These sampling programs were focused on areas where dredging activities are proposed and therefore provide more relevant information for the present study. Results from TSRI #93 are summarized in this section to provide general historical background information on benthic communities and sediment quality in Sydney Harbour. Results of the sampling programs commissioned by LEC in 2008 are also summarized to supplement this information with more recent data that was derived from sediment samples taken in the proposed dredge sites.

The following sections discuss the geophysical, chemical, and biological properties of the benthic environment in Sydney Harbour, as referenced from the TSRI #93 report and the LEC field programs conducted for this Project.

4.7.1 Geophysical Qualities of Sydney Harbour Sediment

According to TSRI #93, the South Arm and North West Arm sediments are composed mostly of clayey silts, with lesser amounts of sand and courser material, with sandier material occurring in the Outer Harbour (*i.e.,* seaward of the junction of South Arm and North West Arm). Specifically, North Arm sediments are composed of clayey silt (~70% silt; ~20% clay), with total organic carbon (TOC) ranging from 2-5%.

South Arm sediments are predominantly clayey silt (~65-70% silt; ~20-30% clay), with TOC ranging from 3-13.7%.

Sediments in central portions of Sydney Harbour extending seaward are predominantly compact silt and fine sand (54-64% silt; 22-39% sand) with TOC ranging from 3-7%.

LEC samples indicate similar results for grain size distributions. Within the South Arm (*i.e.,* from the Sydney River to the boundary line running from Point Edward to Fishery Cove), eight sample locations were accessed and 11 samples were collected (eight surface and three sub-surface). Silt content ranged from 15-62% (mean silt content 47%), clay content ranged from 15-42% (mean clay content

29%), and sand content ranged from 4.5-50% (mean sand content 18%).

From seven grab sample locations accessed in the channel, nine samples were collected (seven surface and two subsurface). Around Fishery Cove, sediments were generally fine grained (silt content ranging from 40-65%; clay ranging from 10-25%; sand ranging from 13-48%). Seaward of Fishery Cove, sediments collected from within the proposed channel were coarser, with silt content ranging from 1-14%, clay content ranging from 3-7%, and sand content ranging from 78-98%.

The underwater benthic video survey provided additional information which was used to help characterize the sediment characteristics at various locations in the Harbour. For example, boulders (diameter > 256 mm) and cobble (64 mm < diameter < 256 mm) are not typically retrieved in grab samples, even if present; and thick seabed vegetation can result in non-representative sediment grab samples. LEC collected video in three distinct areas in Sydney Harbour, including the dredge zone, the proposed port infill area, and the proposed secondary confined disposal area.

As described in the TSRI #93 report, the proposed channel area was predominantly silty sand, but this section of the harbour was not void of relief structures. The video showed that boulders and cobble were also interspersed along some sections of the channel. Along the proposed port footprint, the video survey indicates areas of silty sand, as determined in the grab sampling program, but areas of boulder and cobble do exist in this region as well. Finally, in the vicinity of the proposed secondary confined disposal facility, silty sands were encountered, as well as a few patches of boulder and cobble. Refer to Appendix E for the LEC Underwater Benthic Video Survey Report and Sediment Sampling Report. The presence of boulder and cobble is notable, as these features may provide shelter or burrowing habitat, as well as suitable sites for marine plant growth.

4.7.2 Chemical Qualities of Sydney Harbour Sediment

The TSRI #93 report summarizes three years of sampling results for sediments collected from Sydney Harbour, including a total of 128 cores and 104 grab samples obtained from the South Arm, West Arm, and the Outer Harbour. Of the 38 sampling locations, all but 4 were located in the South Arm and North West Arm of the harbour, indicating that coverage of the Seaward Arm and the area of the proposed dredge channel was minimal. Contaminant concentrations were compared to CCME guidelines (Interim Sediment Quality Guidelines, or ISQGs; and Probable Effects Limits, or PELs). Lee (2002) reports the following:

- PAH concentrations were potentially toxic (> PEL) over essentially all of the South Arm, much of the Northwest Arm, and in some sections of the Outer Harbour (although only a limited number of samples were taken in the outer harbour).
- PCBs were found to be present throughout Sydney Harbour but potentially toxic concentrations (> PEL) were found only in the South Arm, with higher concentrations on the east side (nearest Muggah Creek).
- Isolated instances of potentially toxic metal concentrations (> PEL) were confined to the eastern side of the South Arm.

Estimates of the total loading of PAHs into Sydney harbour have ranged from almost 300 kg/yr (Lee 2002) to almost 800 kg/yr (JDAC 2002; cited in Lee 2002). While some of this load is removed from the harbour through tidal exchange, a significant portion attaches to sediment and organic material, sinks to the sea bed, and remains in Sydney Harbour, causing potential risk to benthic communities and associated marine life. It is presumed that much of the remaining PAH loading from Muggah Creek will be curtailed as a result of the Sydney Tar Ponds containment project.

As summarized in the TSRI #93 report, radionuclide dating was used to determine the rates of sediment accumulation and contamination loading in different areas of Sydney Harbour. A prerequisite for sediment radionuclide dating is that sediment layers are intact, neither mixed by biological activities or mechanical (*i.e.,* ship scour) disturbance. The TSRI #93 program found that most cores (out of over 50 collected) were intact, and free of bioturbation or other physical sediment disturbances.

Based on the sediment radionuclide dating, the TSRI #93 program reports that metal levels in sediment increased in Sydney Harbour sediments through the 1950s to maximum concentrations during the 1960s-1980s, and have since declined. PCB concentrations appear in sediments from the 1950s, reach a maximum value in the 1960s, and decline in the 1970s – 1980s. PAH concentrations show increases through the first half of the 20^{th} century, maximum values in the 1960s through 1980s, and reduced loading following the termination of coking activities. Results indicate that sediment is accumulating at a rate of approximately 0.2 – 2 cm/yr, near Muggah Creek. This is a critical finding, since contaminant loading has decreased since the 1980s; the most heavily contaminated sediments are now buried by 10 – 30 cm of relatively cleaner sediment. Because of changes in industry practices and market conditions over the last 100 years, the contamination is not uniformly distributed through the depth of sediments.

LEC sampling in 2008 consisted of two separate sampling programs. In January 2008, sediment samples were collected from ten locations in the South Arm and five locations in the proposed dredge channel in the Seaward Arm. The majority of these samples were taken at 0-1 m depth, with the exception of five locations where samples were also taken at 1-3 m depth. In October 2008, a geotechnical borehole investigation was carried out within the proposed dredge channel in the Seaward Arm of Sydney Harbour. Nine borehole samples were taken at various points along the proposed dredge channel. Composite sediment samples were made up of sediment collected between the harbour bottom down to a depth of 17 m below sea level (see Appendix E for further description of the methodology).

Results of the January sediment sampling revealed exceedances of the CCME Guidelines for Marine Sediment Quality at eleven sites in the South Arm for various metals: including arsenic, chromium, copper, and lead. No exceedances for metals were found at sampling sites in the dredge channel in the Seaward Arm of Sydney Harbour. Modified TPH levels exceeded CCME Soil Quality Guidelines for Industrial Use at all locations sampled, with the exception of two locations in the proposed dredge channel in the Seaward Arm. All sediment samples were found to be within the applicable CCME Guidelines for Marine Sediment Quality for Polychlorinated Biphenyls (PCBs) and Dichloro-Diphenyl-Trichloroethane (DDT), and all samples were within the laboratory reportable detection limit for these substances. Exceedances of the CCME Guidelines for Marine Sediment Quality were recorded for a range of polycyclic aromatic hydrocarbons (PAHs) at eleven sites in the South Arm, and at 4 sites in the proposed dredge channel in the Seaward Arm. The magnitude of these PAH exceedance was notably higher for sites in the South Arm. Four of the five samples taken at 1-3 m had fewer PAH exceedances than samples taken at 0-1 m. In general, the January 2008 sediment sampling program indicated that sediments in the South Arm have higher levels of contaminants than sediments in the proposed dredge