TABLE OF CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

6.0 OVERVIEW OF THE ENVIRONMENT

6.1 Biophysical Environment

6.1.1 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.

6.1.1.1 Physiography

The study area is located near Bear Head and Bear Island Cove along the southwest edge of Cape Breton Island, Nova Scotia as shown on Figure 1.1. The area is characterized by low relief near the shoreline at the Bear Head area, with a shallow cove (Bear Island Cove) and several lagoons to the southeast of Bear Head. The relief is much more pronounced in the area to the west of Bear Head and to the north where elevations range from 10 to 30 m along the shoreline to 40 m further inland.

To the northwest of the site lies the industrial park, beginning with the former refinery (approximately 4 km northwest) at Wright Point (presently the Statia Terminal), and extending a further 6 km to the Town of Port Hawkesbury. This industrialized area includes a number of facilities such as Nova Scotia Power Inc., US Gypsum and Stora Forest Industries.

6.1.1.2 Surficial Geology

The surficial geology of the general area is characterized by glacial till which is present along both sides of the Strait of Canso (Figure 6.1). The topography is suggestive of drumlin features. However, the bedrock surface and till surface are both irregular, resulting in a highly variable till thickness. Some apparent drumlin features are, in fact, thinly covered bedrock features and some are thick till deposits. There is no evidence of more than one till sheet. The principal direction of ice advance was from the northeast and geological evidence suggests that the tills have not been far removed from the parent bedrock (Stea *et al*., 1992). As a consequence, the till cover is generally a homogeneous mixture of sandstone and shale rock reduced to sand, gravel and cobble sizes in a matrix of reddish brown clayey silt or clay. Post-glacial surficial sediments of varying thickness overlie the till sheet in the Strait. In some areas along the shore, tree cover extends down to steep, narrow sand and gravel beaches.

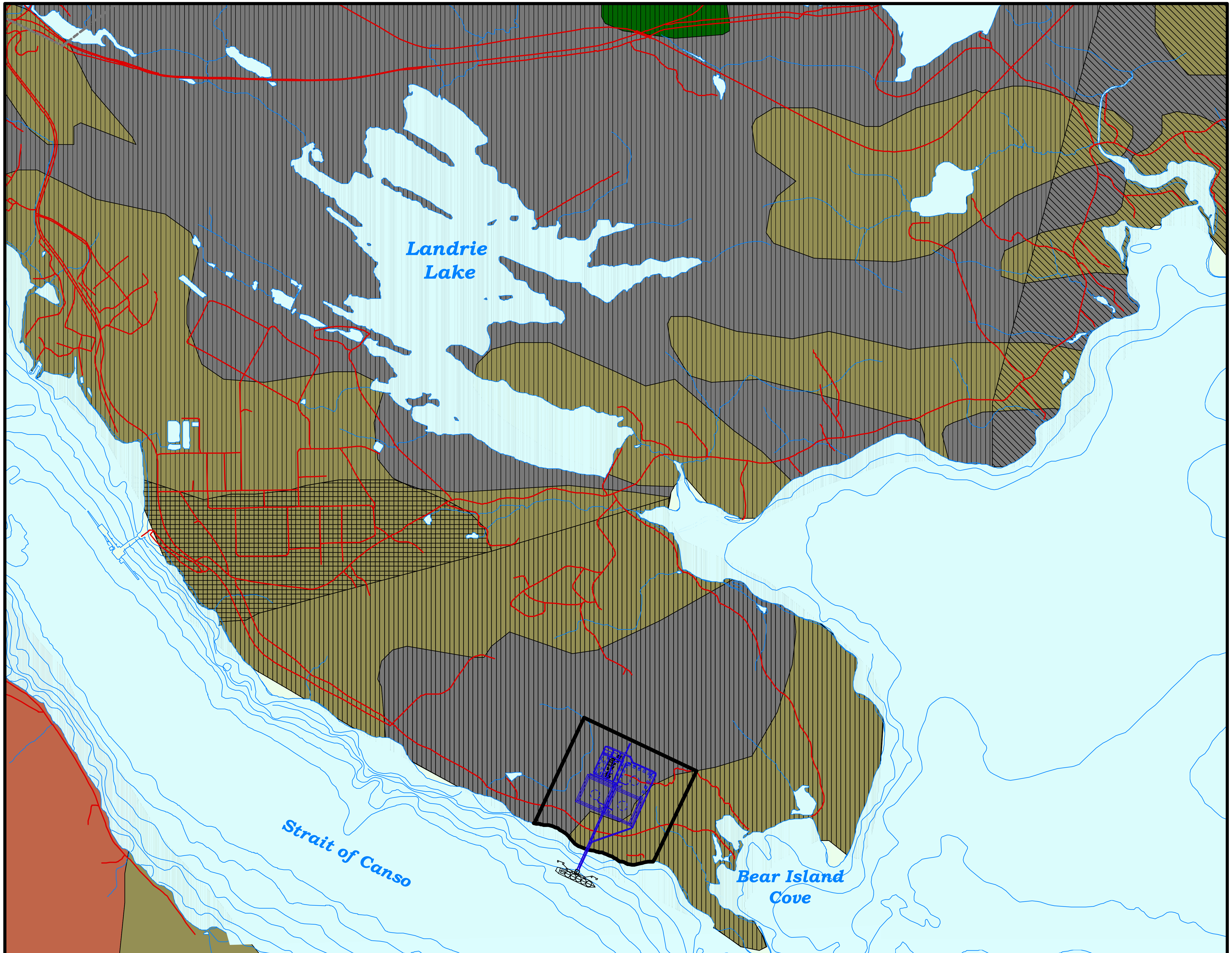
Previous studies by Jacques Whitford in the Bear Head area indicated that the two major types of surficial units are peat and glacial till. The peat bogs are generally of shallow depth and are situated in poorly drained depressions. However, in some areas the organic material can be over 4 m in depth. The clayey silt till ranged in depth from 0.61 m to 12.19 m.

Additional detail on surficial geology in the study area is provided in Section 6.1.1.5.

BEAR HEAD
LNG TERMINAL

Figure 6.1

Bear Head Geology



Legend

ANE Property Boundary
Buildings
Site Boundary
Rivers & Streams
Roads
Bathymetric Contours

Bedrock Geology

Mabou Group
Cumberland Group
Windsor Group

Surficial Geology

Bedrock
Silty Drumlin
Silty Till Plain
Stony Till Plain

N

0 200 400 600 800 1000
Metres

Map Parameters
Projection: Universal Transverse Mercator (UTM)
Datum: NAD83
Zone: 20
Scale: 1 : 25,000
Project Number: NSD17393
Date: April 19, 2004

Source: NSDNR 2000 Steal et al. 1992

Jacques Whitford

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6.1.1.3 Bedrock Geology

Bedrock underlying the site belongs to the Cumberland Group and is composed of late Carboniferous shales, siltstones, sandstones, thin calcareous fragmented beds, and minor thin coal seams (Figure 6.1). These rocks occur in a faulted synclinal basin and are the youngest in the region. Within the area of Bear Head, the beds strike generally north-northwest and dip steeply, approximately 70 degrees east to northeast. The predominant joint system is associated with this bedding, however, jointing striking northeast with varying dip is also noted.

Along the shoreline, low cliffs comprised of glacial till are being eroded by coastal processes at Bear Head and on the Strait of Canso shore of the site. Bedrock exposed along the shore is described as a series of highly weathered closely jointed shale beds and much less weathered, more massive sandstone. Similar sandstone is exposed along the shore in Bear Cove, where ripple marks are evident on the bedding plane joint surfaces. Bedding layer thickness varies from 10 mm to 200 mm, and bedding plane joints are at not less than 70 mm spacing.

Additional detail on bedrock geology is provided in Section 6.1.1.5.

6.1.1.4 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 LNG facility belongs to the Cumberland group. Previous studies in the area indicate local conditions are not prone to the production of acid rock drainage.

6.1.1.5 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.

Peat

Peat bogs exist sporadically across the Project site and all areas within 500 m of the property boundary. This unit has a very high hydraulic conductivity, however wells are generally not constructed in peat due to the very poor quality of the groundwater.

Glacial Till

Stony, gritty clay and silt till deposits of various depths typically underlie the Project site and all areas within 500 m of the property boundary. This unit typically has a low hydraulic conductivity (K) in the order of 10^{-5} to 10^{-6} cm/sec, however, properly constructed dug wells may yield sufficient water for domestic supplies. Hydraulic conductivity of glacial tills based on previous field permeability tests completed by Jacques Whitford in the Bear Head area ranged from 8.1 x 10^{-6} cm/sec to 9.9 x 10^{-7} cm/sec.

Cumberland Group (undivided)

Cumberland Group bedrock occurs across the subject site as well as all areas of the study area (500 m from the subject site). The Cumberland Group is made up of three principal formations which are: fluvial sandstone, siltstone, mudstone and rare coal of the Silver Mine Formation; overlain by younger fluvial-lacustrian sandstone, shale, siltstone, coal and limestone of the Port Hood Formation; which is in turn overlain by younger fluvial sandstone, conglomerate, coal and shale of the Inverness Formation. However, the subject area is considered to be undivided Cumberland Group which means that with the current level of geologic knowledge, this area cannot be confidently placed within a specific Cumberland Group formation.

Based on six pumping tests in Richmond County (Table 6.1), wells completed in the Cumberland Group bedrock in Richmond County have an average transmissivity of 167 m^2/day, and a typical safe well yield ranging from 11.7 L/min to 263 L/min and averaging 120 L/min (NSDEL Pumping Test Inventory (NSDEL 1973-2003)). Groundwater quality from these formations can be expected to be of good chemical quality with a tendency toward hardness and a moderate degree of total dissolved solids (TDS) (Strait of Canso Environment Survey (Maritime Resource Management Service (MRMS) (Canada). 1975)).

Table 6.1 Summary of Well Water Pumping Test Information, Cumberland Group										
	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)**
Cumberland Group – Richmond County										
Minimum	61	155	36	0	40	3.5	7.5	11.7	65.3	2.67 x 10$^{!5}$
Maximum	104.2	203	215	20.4	263	175	134.3	263	241	5.0 x 10$^{!4}$
Mean	80.7	186.5	83.5	6.8	135.5	50.3	44.1	120.1	166.8	2.07 x 10$^{!4}$
Median	76.6	201.5	71	4.3	107	26.7	24.9	94.5	194	9.34 x 10$^{!5}$
Number	6	6	6	6	6	6	6	6	3	3
Cumberland Group – All Counties										
Minimum	7.6	100	6	!0.3	1	0.1	0.2	0.3	0.9	2.67 x 10$^{!5}$
Maximum	155.4	254	215	32	292	180	792	721	241	0.58
Mean	75.9	173	62.6	7.1	68.4	26.5	47.4	85.8	75.5	0.0352
Median	71.6	155	72	5	45	11.3	15.1	52	58.4	8.9 x 10$^{!4}$
Number	81	72	84	84	84	80	80	80	22	18
Source: NSDEL Pumping Test Inventory (1973-2003)										

6.1.1.6 Water Supply

The Town of Port Hawkesbury's water supply comes from Landrie Lake, which is protected by provincial legislation. Part of the protection procedure is the development of a designated protection area surrounding the water body (*i.e.*, protected watershed). The development of this area takes into account both surface and groundwater conditions. The proposed site location falls outside the Landrie Lake protection area (Figure 6.2). Surface and groundwater at the LNG facility flow away from Landrie Lake, and therefore, activities that may affect groundwater at the Project facility should not impact the municipal water supply.

Residents in the area who are not supplied water by the Town of Port Hawkesbury are likely to rely on domestic groundwater wells. A review of water well records for the province of Nova Scotia (NSDEL Well Drillers Logs (1965-2000)), aerial photos and field reconnaissance indicates that the closest water well is located approximately 1.6 km northeast of the site (Figure 6.2). It is highly unlikely that activity from the proposed facility would impact this domestic well due to both distance and location of the well across a groundwater divide as shown on Figure 6.2.

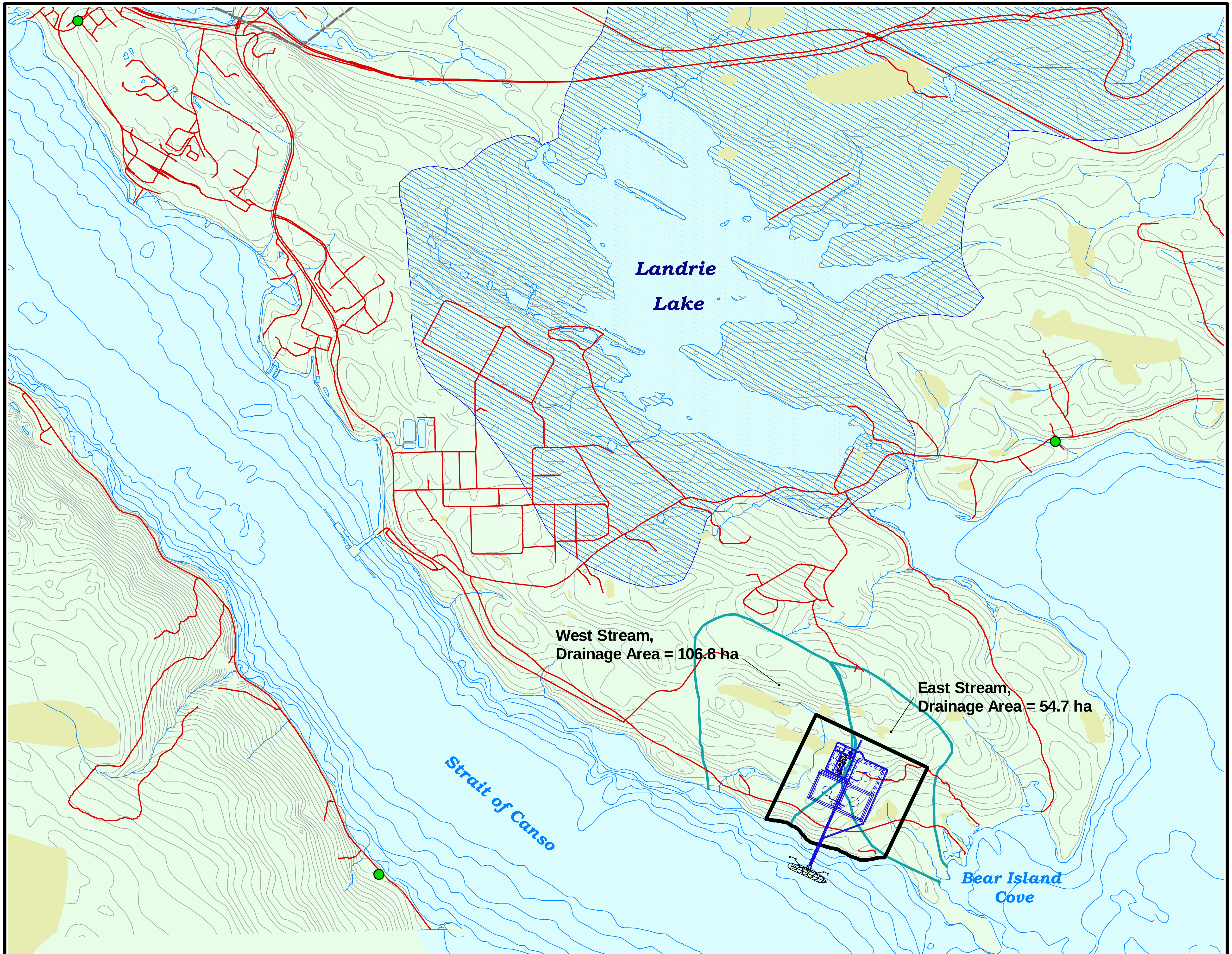
It is currently anticipated that all freshwater required by the Project will be supplied through the provision of future municipal supply. However, this preliminary assessment suggests there is a good potential for construction of potable water supply wells on the site if they become necessary. Well yields and quality sufficient for potable uses or light industrial use should be feasible.

6.1.2 Hydrology

6.1.2.1 Site Description

The proposed site is located on mildly sloped terrain along the coastline north of the Straight of Canso near Bear Head. Surface drainage generally flows from the site into two streams in a southerly direction. A small stream, located east of the site, receives approximately half of the site's runoff. It directs flow in a south-easterly direction through a 0.6 m culvert under the Bear Island Road, and into Bear Island Cove. A second stream located west of the site receives approximately a quarter of the site's surface waters. This stream meanders south to a retaining structure, crosses the Bear Island Road and eventually discharges into the Strait of Canso. The remaining quarter of the site drains directly into the Strait of Canso. The Landrie Lake Reservoir (watershed drainage area approximately 16 km^2), is located approximately 1.9 km north of the site (Figure 6.2).

The proposed site is adjacent to a number of wetlands within the property boundaries (Figure 6.3). Most of these wetlands are small as their drainage areas are less than 1 ha. Only three of the wetlands located near the site have drainage areas greater than 1 ha (W1 approximately 1.87 ha, W2 approximately 4.66 ha and W5 approximately 3.82 ha).



BEAR HEAD
LNG TERMINAL

Figure 6.2

Surface Water & Ground Water Supply

Legend

- Water Wells
- ANE Property Boundary
- Watersheds
- Buildings
- Facility Boundary
- Rivers & Streams
- Roads
- Contours
- Bathymetric Contours
- Wetlands
- Land
- Water
- Designated Surface Water Supply Watershed

N

0 300 600 900 1200

Metres

Map Parameters
Projection: Universal Transverse Mercator (UTM)
Datum: NAD83
Zone: 20
Scale: 1 : 25,000
Project Number: NSD17393
Date: April 19, 2004

Jacques Whitford

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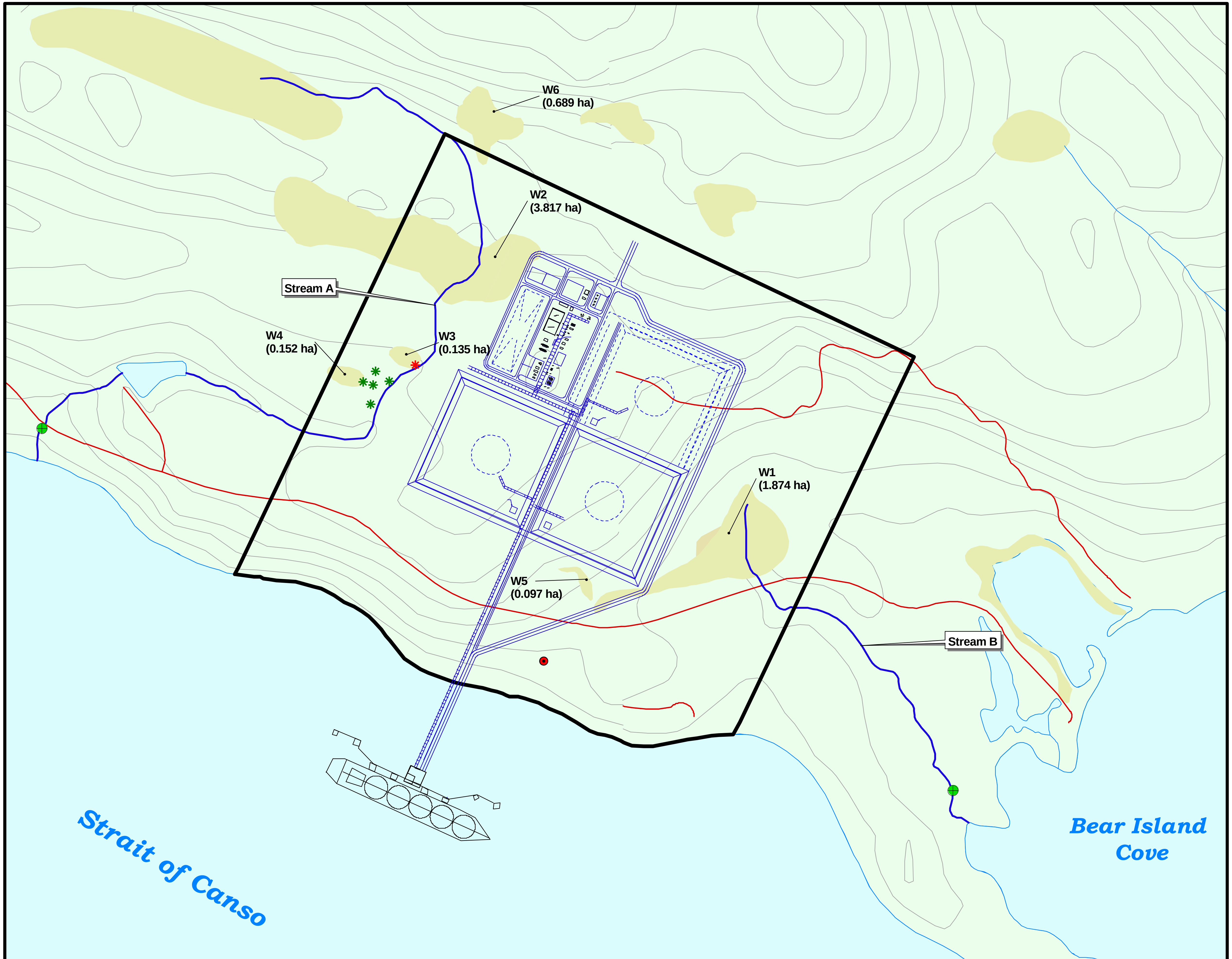

BEAR HEAD
LNG TERMINAL

Figure 6.3

Wetlands & Streams

Legend

- *Geocaulon lividum*
- *Listera australis*
- Water Sampling Locations
- Noise Monitoring Station
- ANE Boundary
- Roads
- Rivers & Streams
- Freshwater Streams Surveyed
- Wetlands
- ANE Property Boundary
- Lakes

N

0 50 100 150 200
Meters

Map Parameters
Projection: Universal Transverse Mercator (UTM)
Datum: NAD83
Zone: 20
Scale: 1 : 6,000
Project Number: NSD17393
Date: May 2, 2004

Jacques Whitford

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The following sources were consulted to describe the hydrological environment at the site and identify potential Project interactions with the streams downstream of the site, the Landrie Lake water supply watershed and nearby wetlands:

- drainage areas were delineated and measured from 1:50,000 digital orthographic mapping (11F/11, Natural Resources Canada, 1998);

- the monthly and annual volumes of runoff were estimated using a proration of mean annual flows from nearby hydrometric stations and from previous studies;

- the footprint impacts on nearby watercourses and interactions with the Landrie Lake Reservoir were evaluated considering the site's drainage patterns; and

- the footprint impacts on adjacent wetlands were evaluated using the relevant sections of the Nova Scotia Department of Environment Wetlands Directive (1995) (for wetlands with drainage areas smaller than 2.0 ha) and the North American Wetlands Conservation Council Wetland Evaluation Guide (for wetlands with drainage areas greater than 2.0 ha).

The following physiographic parameters were obtained from the available Project mapping:

- the drainage areas of the watersheds encompassing the east and west streams are approximately 54.7 and 106.8 ha respectively (see Figure 6.2);

- the areas of wetlands affected by the Project footprint (excluding fencing) are W1 = 1.847 ha, W2 = 3.817 ha and W5 = 0.097 ha (see Figure 6.3).

6.1.2.2 Mean Monthly and Annual Site Runoff

To describe the hydrological characteristics at the site, the mean monthly and annual runoff volumes are presented below. The mean annual runoff at the Project site was estimated using a number of different approaches for comparison purposes. The upper bound of the mean annual runoff was first estimated assuming that all precipitation will contribute to runoff (using local climatic data). The lower bound of the mean annual runoff was obtained using area-based proration from a nearby hydrometric station and using previously estimated mean annual runoff values for the area (MacLaren Atlantic Ltd., 1980). Because both of these estimation methods derive mean annual runoff from larger watersheds containing undeveloped and buffer zones, and therefore dampening overland runoff, the mean annual site runoff was increased from the lower bound to reflect expected hydrological conditions at the Project site.

Based on historical climatic data at the Port Hastings climate station (39 years of data, approximately 13 km north of the Project site) the average annual precipitation at the site is 1,350 mm. If all of this precipitation is converted into surface runoff (which would represent an upper bound on the expected average annual runoff), the annual volume of runoff from the site at the currently proposed ultimate level of development would be 302,000 m^3, which corresponds to a mean annual flow of 9.6 L/s.

A lower bound for the expected annual site runoff was established by drainage-area based proration of flows from a nearby hydrometric station. Hydrometric station 01FA003 (1965-2000, River Inhabitants at Glenora) whose drainage area is 193 km^2, was chosen as most representative for proration purposes because its hydrological characteristics were most similar to those at the Project site. By prorating flows from the hydrometric station, a mean annual flow of 8.2 L/s was calculated for the Project site, which corresponds to an annual runoff volume of 260,000 m^3. Monthly average flows based on the same areal proration method are presented in Table 6.2.

Table 6.2 Mean Monthly Runoff From Project Footprint Area Based on Proration

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Flows (L/s)	9.0	6.9	10.5	16.1	9.8	4.6	3.1	3.3	4.3	7.9	11.8	11.6

A second approach was used to estimate the lower bound of the expected annual runoff at the site for comparison purposes. MacLaren Atlantic Ltd. (1980) has compiled a figure presenting the spatial distribution of runoff throughout Nova Scotia based on findings from a number of sources. A mean annual runoff depth of 1,050 mm was selected from this figure to determine the runoff at the site. Based on this approach, a mean annual runoff flow of 7.4 L/s was computed for the Project site, which corresponds to an annual runoff volume of 235,000 m^3.

Development of the site will involve the removal of tree cover and topsoil, and construction of impermeable structures and road surfaces. Clearing the land of vegetative cover and adding impermeable surfaces will reduce interception and temporary storage of precipitation while increasing direct runoff. By assuming that 50% of the surface area within the footprint of the Project will become impermeable through the development, runoff volume may be directly quantified from the rainfall volume over this surface area. From the remaining 50% of the surface area within the footprint of the Project, the mean annual runoff depth was assumed to increase by 150 mm above the "background" depth of 1,050 mm to reflect the reduction in vegetative cover and the associated reduction in evapotranspiration rates (based on potential evapotranspiration rates provided by Dzikowski et al, 1984). The expected annual runoff volume from the Project area was estimated at 292,000 m^3, which corresponds to a mean annual flow of 9.3 L/s.

6.1.2.3 Impacts on Streamflows and Water Quality

Annual streamflow volumes within the eastern and/or western streams will increase as a result of the site development. If the total expected runoff from the site is discharged into the eastern stream, it would represent an increase of 6.9% in its annual mean streamflow. If it were discharged into the western stream, an increase of 3.5% of its mean annual flow would be expected.

Although site development will result in an increase in the peak rates of surface runoff at the outlet of the Project site and a reduction of the low flows (*i.e.*, water will run off more quickly following development), the use of properly sized erosion and sediment control measures and flow retention structures is expected to fully mitigate the above re-distribution of flows.

Site development will potentially affect water quality downstream by increasing the total sediment loading. The use of properly sized erosion and sediment control measures as well as flow retention/siltation treatment structures is also expected to fully mitigate the potential increase in downstream sediment loading.

Based on natural topography of the area, the Landrie Lake designated water supply watershed will not be affected by the Project development. The proposed site, located outside the boundaries of the Landrie Lake watershed, drains south directly into the Strait of Canso away from the Landrie Lake watershed.

6.1.2.4 Summary

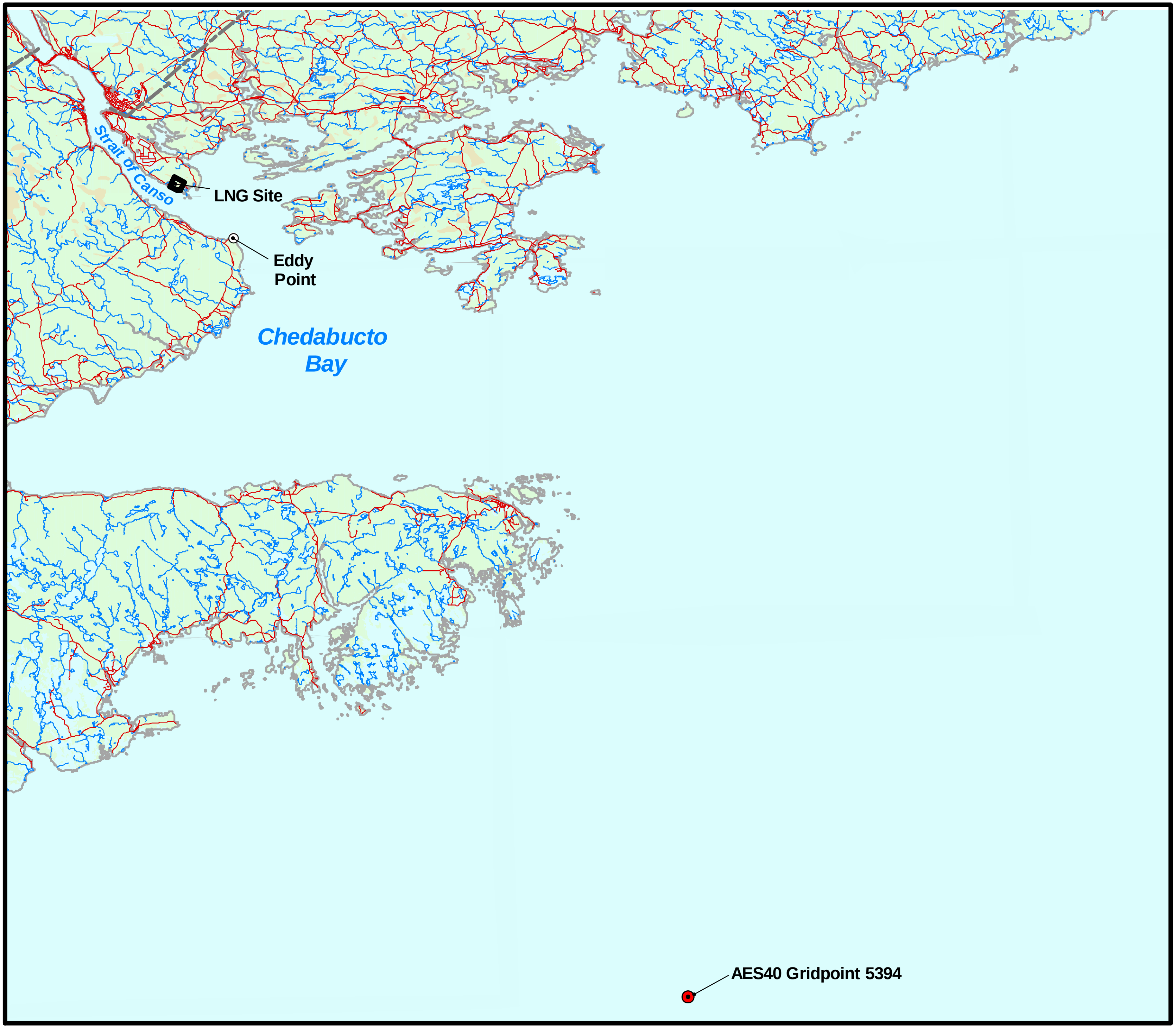
In summary, the effects on the downstream flows and water quality associated with surface runoff from the currently proposed ultimate level of site development can be fully mitigated using properly sized erosion and sediment control measures and flow retention/siltation treatment areas. The Landrie Lake watershed is not expected to be affected. Based on available mapping, the effects on the hydrologic and water treatment values of the affected wetlands will only be slight.

6.1.3 Climate

A Meteorological Service of Canada (MSC) weather station was located at Eddy Point, Nova Scotia (Figure 6.4). The climate at Eddy Point is likely to be representative of the climate expected at the proposed Bear Head LNG terminal. For this analysis, these data were taken from the Canadian Climate Normals (1951-1980) published by Environment Canada's Atmospheric Environment Service, now Meteorological Services Canada.

6.1.3.1 General Climate and Weather Patterns

The Project area, and Nova Scotia in general, has good air quality due to the relatively small population and small industrial base (NSDOE 1994). Climatic conditions provide good dispersion of air contaminants. Occasionally, however, long-range transport of air masses from central Canada or the eastern seaboard may transport contaminants into the area, causing poorer air quality.



BEAR HEAD LNG TERMINAL

Figure 6.4

Meteorological & Oceanographic Monitoring Stations

Legend

- Eddy Point Station
- Aes40 Gridpoint 5394
- Property Boundary
- County Lines
- Rivers
- Roads
- Wetlands
- Lakes

N

0 3 6 9 12
Kilometres

Map Parameters
Projection: Universal Transverse Mercator (UTM)
Datum: NAD83
Zone: 20
Scale: 1 : 400,000
Project Number: NSD17393
Date: April 19, 2004

Jacques Whitford

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On a global scale, the Atlantic Region lies within the zone of prevailing westerly winds. This zone is characterized by the passage of a 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 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 significantly 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. Hurricanes may also cause heavy swells and high waves along the coast. Although the hurricane season starts June 1st, the peak time for these storms is between September and October.

6.1.3.2 Temperature Normals and Extremes

Temperature Normals for Eddy Point are shown in Table 6.3. The annual temperature range for Eddy Point is normally between +22°C and !9°C. However, extreme temperatures of +33°C in summer and !26°C in winter have been recorded.

Table 6.3 Temperature Normals and Extremes from Eddy Point					
Month	**Daily Maximum (°C)**	**Daily Minimum (°C)**	**Daily Mean (°C)**	**Extreme Maximum (°C)**	**Extreme Minimum (°C)**
Jan	!0.5	!8.0	!4.3	12.3	!22.9
Feb	!1.5	!8.6	!5.1	10.6	!25.6
Mar	1.5	!5.0	!1.8	14.2	!18.4
Apr	5.9	!0.9	2.5	27.2	!10.6
May	11.9	3.1	7.5	30.8	!2.8
Jun	17.5	8.3	12.9	33.3	2.2
Jul	21.5	13.1	17.3	32.8	7.2
Aug	22.0	14.1	18.1	32.2	5.6
Sep	18.3	10.3	14.3	28.4	2.7
Oct	12.8	5.5	9.1	22.2	!5.6
Nov	7.4	1.2	4.3	19.0	!10.1
Dec	1.9	!4.9	!1.5	13.6	!25.0
Year	**9.9**	**2.4**	**6.1**	**33.3**	**!25.6**
Source: Atmospheric Environment Branch, Canadian Climate Normals: 1951- 1980					

6.1.3.3 Precipitation Normals and Extremes

Precipitation measured at Eddy Point is presented in Table 6.4. Although rain may occur in any month of the year, the rainfall in the area is highest during fall and early winter. Snow and freezing precipitation can occur between October and May, with the largest amounts falling between December and March.

Table 6.4 Precipitation Normals and Extremes for Eddy Point						
Month	**Mean Rainfall (mm)**	**Mean Snowfall (mm)**	**Total Precipitation (mm)**	**Extreme Daily Rainfall (mm)**	**Extreme Daily Snowfall (mm)**	**Extreme Daily Precipitation (mm)**
Jan	79.1	69.8	138.2	47.6	19.6	47.6
Feb	47.1	63.8	105.3	34.5	63.0	64.3
Mar	60.4	51.1	116.4	31.3	19.3	31.3
Apr	71.7	19.0	90.9	34.7	21.6	34.7
May	96.3	1.6	99.8	78.6	22.9	78.6
Jun	89.2	0.0	89.1	77.2	0.0	77.2
Jul	96.8	0.0	96.8	61.2	0.0	61.2
Aug	106.0	0.0	106.0	63.1	0.0	63.1
Sep	87.0	0.0	87.0	64.5	0.0	64.5
Oct	107.1	1.7	107.5	55.1	5.6	55.1
Nov	137.6	11.7	147.6	51.4	19.5	51.4
Dec	103.1	60.9	164.7	76.8	23.6	76.8
Year	**1081.4**	**279.6**	**1349.3**	**78.6**	**63.0**	**78.6**
Source: Atmospheric Environment Branch, Canadian Climate Normals: 1951- 1980						

Total precipitation is rainfall plus the water equivalent of the snowfall and all other forms of frozen precipitation. Normally, the precipitation for Eddy Point ranges from 89 mm to 165 mm.

6.1.3.4 Wind Normals and Extremes

The prevailing winds in the area are westerly to northwesterly in the colder months and south to southwesterly in the warmer months. The winds from the northwest quadrant tend to be stronger than winds originating from the southwest. Chedabucto Bay is open to easterly gales that bring large waves ashore. Due to the effects of friction over land, easterly winds at sea shift to northeasterlies and weaken along this indented coastline.

The average and extreme wind speed and direction values are shown in Table 6.5. Wind speed and direction are also graphically presented in annual (Figure 6.5) and seasonal (Appendix E) wind rose plots.

Table 6.5 Wind Statistics from Eddy Point

Month	Average speed (km/h)	Most Frequent Direction	Extreme Hourly Speed (km/h)	Direction	Extreme Gust Speed (km/h)	Direction
Jan	19.5	W	70	SSE	97	ENE
Feb	19.4	NW	64	NNW	106	WNW
Mar	19.1	NW	77	W	130	SW
Apr	16.6	NW	71	E	93	E
May	15.6	NW	55	NE	85	S
Jun	14.1	S	64	SVL	89	NNE
Jul	13.2	Calm	60	S	87	S
Aug	12.7	Calm	44	SSW	65	NW
Sep	14.7	S	50	WNW	89	W
Oct	16.6	W	64	S	137	S
Nov	17.9	W	61	W	91	NW
Dec	19.2	W	69	SSE	93	S
Year	**16.6**	**NW**	**77**	**W**	**137**	**S**

Note: Wind direction refers to point of wind origin
Source: Atmospheric Environment Branch, Canadian Climate Normals: 1951- 1980

In winter, many low-pressure systems pass through south of the region, while in summer they tend to pass north of the region. Average wind speeds vary from 12 to 15 kilometres per hour (km/h) in summer to near 20 km/h in winter.

A two part Weibell distribution was fitted to a five year set of recorded data (air quality model set) from Eddy Point. The 1-hour probability of winds exceeding a given velocity were then calculated and are presented in Table 6.6.

Table 6.6 Frequency of Wind Speeds

Velocity (knots) [km/hr]	Frequency
0.1 (calm) [0.2]	99.9 %
7.6 [14.1]	50.0 %
16.4 [30.4]	10.0 %
25.5 [47.3]	1.0 %
33.0 [61.1]	0.1 %
40.0 [74.1]	0.01 %

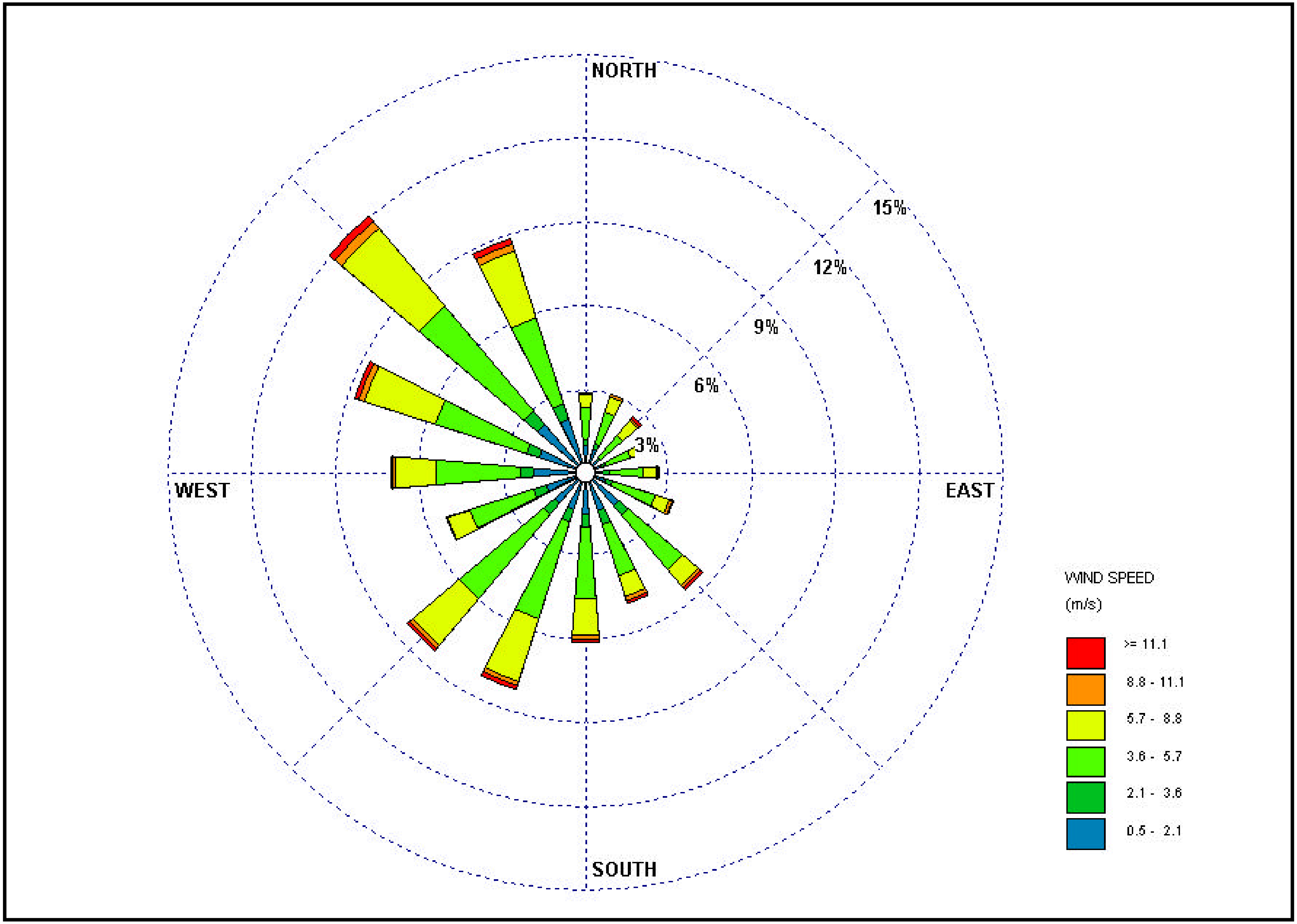


Figure 6.5 - Annual Windrose for Eddy Point

For comparison purposes, wind statistics from Sable Island on the eastern Scotian Shelf indicate offshore wind conditions and are presented in Table 6.7. The average wind speed offshore is almost double the average wind speed in the Eddy Point area.

Table 6.7 Wind Statistics from Sable Island

Month	Average speed (km/h)	Most Frequent Direction	Extreme Hourly Speed (km/h)	Direction	Extreme Gust Speed (km/h)	Direction
Jan	32	W	103	NW	141	SW
Feb	31	W	117	N	170	N
Mar	29	W	100	W	140	SW
Apr	26	SW	89	E	122	W
May	23	SW	77	SW	113	NE
Jun	20	SW	77	SE	109	NW
Jul	18	SW	74	E	100	E
Aug	18	SW	98	SE	143	SE
Sep	21	SW	97	NW	124	W
Oct	25	W	100	SW	158	S
Nov	29	W	130	W	174	W
Dec	31	W	116	SW	137	NW
Year	**25**	**W**				

Note: Wind direction refers to point of wind origin
Source: Atmospheric Environment Branch, Canadian Climate Normals: 1951- 1980

6.1.3.5 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 6.8.

Table 6.8 Adverse Weather Events at Sydney Airport – Monthly Averages

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**

Source: Environment Canada Climate Normals: 1961 - 1991

Fog and Visibility

Visibility of one-half nautical mile or less is common for the Chedabucto Bay area in all seasons. However, 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 in the Chedabucto Bay area 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. However, the potential for freezing spray diminishes dramatically south of the Scotian Shelf.

6.1.4 Ambient Air Quality

The air quality on mainland Nova Scotia is generally very good. It is likely that air quality in the Project area falls within the desirable objectives of the federal classification and well within provincial limits. In general, Bear Head has excellent air quality.

There are a few industries which operate within a 50 km radius of the proposed Project site. These industries include Point Tupper Generating Station, Stora Enso Port Hawkesbury Ltd., ExxonMobil Point Tupper Fractionation Plant and the ExxonMobil Goldboro Gas Plant. There are several mineral extraction and shipping facilities within this zone. Beyond that distance, there are no significant sources for over 100 km.

The NSDEL operates an ambient air monitoring site in Port Hawkesbury / Point Tupper which measures for the concentrations of SO_2, H_2S and TSP. The published measured values for 1993 are presented in Table 6.9. These data correspond to a location directly influenced by the industry in the area. The air quality at the proposed LNG plant site is most probably significantly better than these readings suggest. Based on professional opinion, it is considered likely that the air quality at the site meets the desirable category of air quality and that there are few, if any exceedances, of the criteria.

Table 6.9 1993 Ambient Air Quality Monitoring Results for Point Tupper Area

	1 Hour Max	24 Hour Max	Annual Mean	Total Number of Exceedences[1]
Sulphur Dioxide				
Pt. Tupper	538 ppb	196 ppb	8 ppb	10
Old Post Office	100 ppb	23 ppb	4 ppb	
Hydrogen Sulphide				
Pt. Tupper	61.8 ppb	16.6 ppb	0.7 ppb	9
Total Suspended Particulate				
Pt. Tupper	N/A	60µg/m^3	23 µg/m^3	2
Old Post Office	N/A	55µg/m^3	25µg/m^3	

[1] Exceedances of 1-hour Nova Scotia Standard
Source: NSDOE. 1994. Ambient Air Quality in Nova Scotia

The provincial monitoring network has been changed, and the monitoring data represent the latest available set in the Port Hawkesbury area. In the future, the airshed monitoring initiative will likely result in renewed monitoring in the area. Until that time, the baseline conditions must be inferred on the basis of limited data, or estimated by professional judgement. Some results are available from the proprietary monitoring program conducted on the southeast edge of Port Hawkesbury on behalf of the Sable Offshore Energy Project fractionation plant in Point Tupper. These results, published in 2000, reflect an aggregate monitoring interval of about 1 year during 1999 and 2000. These results show an average concentration of sulphur dioxide of 6.2 µg/m^3, with a maximum 30 minute reading of 259 µg/m^3. The average and maximum 30 minute concentrations of nitrogen dioxide were 5.1 and 46 µg/m^3, respectively. As the proposed project site is considerably farther from the industry in Port Hawkesbury, it is concluded that the air quality is as good as that monitored in Port Hawkesbury, or better. Professional judgement indicates that the margin is quite large, and the Project area shows little evidence of industrial emissions. Baseline monitoring can be implemented as part of the initiation phase of the Project.

6.1.5 Ambient Noise

The existing noise environment at the Project site was determined by performing background monitoring at one representative location as shown in Figure 6.3.

The monitoring location selected faces the nearest sensitive (residential) receivers across the Strait of Canso. Measurements were made using a Quest Model 2900 Integrating noise level meter capable of collecting continuous data over the monitoring period. Sound levels were measured as L_{eq} or equivalent level of energy, which is energy averaged over the measurement time. This is the standard form of measurement accepted by NSDEL for environmental noise levels. L_{eq} measurements were logged once per minute over the period monitored. The units for the sound levels measured are dBA or A-weighted decibels which reflect the sensitivity of the human ear over the audible spectrum.

To determine the noise environment in the area, sound levels were monitored for at least two hours during each of the three periods set by the NSDEL Guideline for Environmental Noise Measurement and Assessment: daytime; evening; and nighttime. The data were logged on the noise meter then downloaded to a computer for further processing. This included preparation of graphs for review and reduction of the data to one-hour L_{eq} values for comparison with the guideline limits.

Weather during the survey, conducted October 7^{th} to 8^{th}, 2003, was partly cloudy, with temperatures between 7 and 15EC and light (<15 km/h) winds. The breezes were noted to be stronger on the morning of October 8^{th}.

Table 6.10 shows the hourly L_{eq} values for the site. Values ranged from 26.4 dBA to 46.8 dBA. No hourly L_{eq} values exceeded the NSDEL guideline.

Table 6.10 Hourly L_{eq} Values, Bear Head, October 7-8, 2003

Hour of Day	L_{eq} [dBA]	NSDEL Guideline Limit
15:00	32.7	65
16:00	32.9	65
17:00	31.1	65
18:00	32.5	65
19:00	31.2	60
20:00	31.7	60
21:00	33.0	60
22:00	36.6	60
23:00	40.3	55
0:00	37.1	55
1:00	37.0	55
2:00	39.2	55
3:00	40.6	55
4:00	39.6	55
5:00	40.4	55
6:00	40.1	55
7:00	40.6	65
8:00	37.9	65
9:00	39.7	65

The NSDEL guidelines were applied in this case as there is potential for noise from the proposed facility to affect the residences directly across the Strait from the terminal and other surrounding areas.

In general, the results of the background noise study show that the existing acoustic environment in the study area is well within acceptable levels for environmental exposures (Table 6.11).

Table 6.11 Summary of Baseline Noise Data – Hourly L_{eq} (dBA)

Location	Day (07:00 to 19:00)		Evening (19:00 to 23:00)		Night (23:00 to 07:00)	
	Min	Max	Min	Max	Min	Max
Site	31.1	40.6	31.2	36.6	37.0	40.6
NSDEL Guideline	65		60		55	

The existing noise levels at the site depict a typical rural or undeveloped area where the primary influence on sound is local weather and natural activity. Observations made by field staff confirmed that the selected site is relatively remote, separated from the nearby industries (Nova Scotia Power, ExxonMobil Fractionation Plant, Stora Enso paper mill) by several kilometres. No individual source dominates the background. Noise from the industrial park was not audible at the site.

6.1.6 Physical Oceanography

This section presents the results of a desktop study of physical oceanographic conditions near Bear Head. The area of interest includes the Strait of Canso and Chedabucto Bay to a distance of roughly 20 km from the proposed LNG site. This overview includes summaries of waves, wind, currents and hydrographic conditions based on existing data sets and literature along with a model of waves.

6.1.6.1 Oceanographic Overview

Bear Head is situated on the north shore at the southern end of the Strait of Canso off Chedabucto Bay. Since the construction of the Canso Causeway in 1955, the Strait has become a tidal inlet. Flows to Northumberland Strait are limited to very small volumes associated with the operation of a lock in the Causeway. The key oceanographic attributes of the southern reach of the Strait of Canso are its lack of freshwater input, its great length and narrow width, and its relatively deep bathymetry. The potentially important oceanographic processes operating at the proposed marine terminal site include tides, estuarine flow, wind driven flow, horizontally sheared flows and, because of the depth and proximity to shelf waters, low frequency layered flows due to shelf processes. The latter can potentially provide a very effective mechanism for water renewal within the inlet and have been found to be extremely important flushing mechanisms in other inlets along the Atlantic coast. A quantitative description of the effects of these flows is not simple, and much of what is known about this process has been learned during recent extensive studies of Halifax Harbour and Sydney Harbour (COA 2000a; COA 2000b). In these studies, it was found that layered currents were as important as all other mechanisms in contributing to flushing of sewage discharge from the harbour. The weaker tides and lower freshwater input found in the Strait of Canso suggests that layered currents play an even larger role in the overall process of water exchange and renewal there.

6.1.6.2 Study Area

The area of specific interest in this study is the Strait of Canso in the vicinity of Bear Head, at the southern entrance of the Strait (Figure 1.1). For the purpose of oceanographic analysis, the general exchange of ocean water is of concern and the area of interest includes the entire southern strait and adjoining waters. The Strait itself is a relatively narrow body of water (1 to 2 km wide) separating mainland Nova Scotia from Cape Breton Island. The construction of the causeway, near the middle of the Strait, in 1955 effectively blocked flow and divided the Strait into two oceanographically distinct bodies of water, north and south of the Causeway. The southern portion of the Strait is approximately 15 km long to its southern end at Bear Head and communicates with Chedabucto Bay through a relatively deep channel. Because of questions regarding the effect of the construction of the Causeway, the Strait was the focus of considerable oceanographic interest during the 1970s. Data and oceanographic interpretations generated during that period provide a relatively strong historical base for the present analysis.

6.1.6.3 Bathymetry

Bathymetry in the study area has been obtained from the Canadian Hydrographic Service Chart # 4306, which covers the entire Strait at a scale of 1:25,000. The digitized bathymetry as used for input into the wave modelling exercise is presented in Figure 6.6. The Strait is narrow and relatively deep, greater than 60 m deep in places. The deepest area in the Southern Strait is at its north end near the Causeway. Water depth gradually decreases to the south and is approximately 44 m in the channel near the proposed marine facility. The channel ends in Chedabucto Bay where it encounters a sill of approximately 35 m depth. This sill is well below the depth of the summer thermocline along the coast and hence currents in the Strait are expected to be directly affected by coastal upwelling/downwelling events and by shelf-generated internal waves.

6.1.6.4 Hydrography

The density of seawater is determined by its temperature and salinity. Ambient seawater density distribution is very important in the analysis of the oceanography of a coastal inlet. When waters are density stratified, with less dense (fresher and/or warmer) water overlaying layers of denser water (saltier and/or cooler) the currents are often quite different between layers. The stratification can change the effect of other oceanographic forces, particularly winds, and will affect the exchange of water within the inlet and between the inlet and surrounding waters.

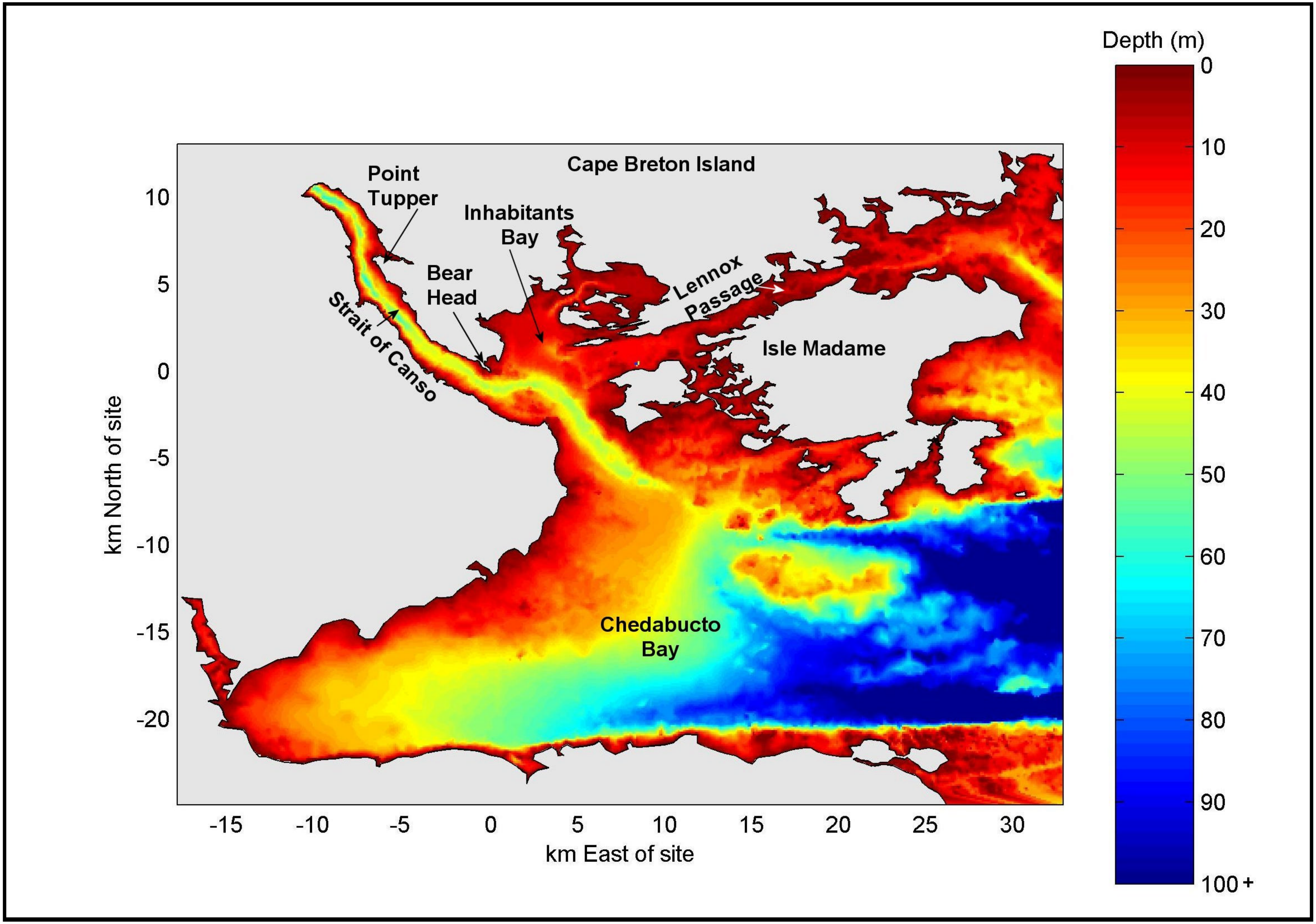


Figure 6.6 - Bathymetry of the Study Area

There is a reasonable amount of salinity and temperature data for the Southern Strait of Canso. Lawrence (1972) reports data collected from 1968 to 1970. This represents five sampling periods, three in summer (July to August) and two in late fall (November) giving a total of 11 salinity/temperature surveys. Cranston *et al.* (1974) report near surface (1 to 5 m) salinity and temperature data collected at 20 sites in the Southern Strait during the summer of 1973. Each site was sampled several times at different depths, however the times are not reported so that the construction of a synoptic picture is not possible. In addition, data are not reported to a sufficient level of accuracy for detailed analysis. The range of salinities is 27 to 32 practical salinity units. Vilks *et al.* (1975) includes a more detailed presentation of what appears to be the same 1973 data. This consists of temperature and salinity contours on a vertical section down the southern reach of the Strait during seven surveys in early May to mid-August. The sample stations reported in Lawrence (1972) were essentially repeated.

The most notable feature of the composite of these data is the large variability in the distribution of water properties throughout the study period. While there is seasonal variability, the most significant variation is within-seasons. In fact, the most stratified and least stratified conditions measured in the 1973 surveys, were observed in sequential surveys, two weeks apart in August. These results seem to indicate that stratifying influences, local warming and freshwater input are modulated by meteorologically-driven circulation which alternately traps warmer, fresher surface water against the causeway and then flushes it out, replacing it by colder, saltier and more homogeneous ocean water through upwelling processes.

6.1.6.5 Currents/Flushing

The most thorough analysis of currents in the Strait was conducted by Lawrence *et al.* (1973). They report a mean tidal range of 1.4 m with currents very much reduced in magnitude since the construction of the Causeway. Current direction is primarily confined to the direction of the Strait channel. The magnitude of the main tidal component was found to be about 0.02 m/s at a current meter site approximately half way between the causeway and Bear Head. In contrast, a statistical analysis of the current data suggests that summer extreme currents at this site can reach 0.35 m/s on average once every three summers and that flows of about 0.15 m/s are typical. This represents a factor of 17 over the tidal contribution in extreme cases, and a factor of 7 under typical conditions. This data also revealed that weaker currents (although still in excess of the tidal contribution) occur routinely at sub-tidal frequencies. These currents, because of their persistence, are much more effective at transporting water, and any associated contaminants, than tidal currents of similar magnitude, but are very difficult to predict. That these low frequency currents vary with depth in the water column is consistent with the presence of significant internal waves in the Strait, as has been demonstrated by a limited amount of profiled velocity data (Lawrence *et al.* 1973). This single set of observations demonstrated that the flow in the Strait was occurring in three distinct layers, *i.e.* a surface and bottom layer were advecting water toward the sea while flow at mid-depth was toward the land. Lawrence *et al.* (1973) also quantified lateral dispersion in the Strait by directly analyzing the variance in the current meter time series. From this analysis they derived effective lateral dispersion coefficients that come close to encompassing the net effect of all of the observed oceanographic process.

Two hydrodynamic models that include the study area were developed for a port feasibility study that was conducted by Transport Canada in 1975 (Baird 1976). The first of these models was developed by the Marine Environmental Data Service and has a resolution of 2 km. The second was developed by the National Research Council and has a resolution of 500 m. In both of these models, only the barotropic component of the current was included (*i.e.*, it was assumed in the model that currents were uniform with depth). Neither model includes the effects of layered currents although a field program component of the study confirmed the importance of these currents as originally observed by Lawrence *et al.* (1973).

In summary, the currents in the area are dominated by wind driven and sub tidal frequency flows and vary significantly with depth. The tidal currents are small. In the centre of the Straight the principal tidal component is about 0.02 m/s. A first order assumption is that the magnitude of the tidal currents within the Strait would vary linearly with distance from the Causeway. This means that the tidal currents would vary from 0.00 m/s at the Causeway to 0.04 m/s at Bear Head. Wind driven and subtidal currents could be many times larger than the tidal current.

6.1.6.6 Average Wind

Wind may play an important role in the local current regime and subsequent water exchange in the Strait and adjacent waters. Typical surface flow velocities may be estimated at 3 % of the persistent wind speed. Because of the lack of ice cover in the southern reach of the Strait (Section 6.1.6.7) wind may play an important role at all times of the year.

In addition to ongoing monitoring of wind strength and direction by the Atmospheric Environment Services at Eddy Point (Figure 6.4, Section 6.1.3), there is a year long record of wind data that was collected at Port Hastings during a study of port facilities by Transport Canada in 1975 (Baird 1976). Directional exceedance plots of Port Hastings data indicates that from mid-December to mid-June wind strength exceeded 9 m/s (20 mph) more than 5 % of the time. From mid-July to mid-December winds in excess of 9 m/s occurred less than 5 % of the time. During the winter season, the two predominant wind directions were east and west while during the summer the predominant directions were east-southeast and west. Eddy Point data showed a similar pattern but revealed some quantitative differences. Most notably, the southerly peak in the exceedance plot was weaker and shifted to the southeast relative to the Port Hastings data. The study did not include the determination of the transfer function between these two stations.

The most comprehensive source for regional marine wind and wave data is from the AES40 data set (AES Oceanweather 2001, AES 1999). These data are the results of a wind and wave analysis/hindcast and consist of time series of 6 hourly data over a 42 year period (1958-1999). The model domain extends over the North Atlantic Ocean on a grid of resolution 0.625E latitude by 0.833E longitude. The model used is the OWI 3-G, a third generation deep water model. Finite depths are not taken into account in this model. AES40 winds represent 1-hour averages at a height of 10 m above sea level. The closest AES40 grid point (Figure 6.4) to the study area is grid point 5394 (45.00N, 60.83W).

An annual windrose for this grid point (Figure 5, Appendix E) indicates that the most probable wind direction throughout the year is southwest, while the strongest winds tend to be from the west and northwest.

Monthly windroses for the same data are presented in Figure 6, Appendix E. These plots point out the seasonal differences in the wind climate. The strongest winds occur in the winter (November through February) and predominantly come from the west and northwest. Wind speeds during this period are between 15 and 20 m/s greater than 10% of the time and on occasion exceed 20 m/s. In the summer months of June, July and August the winds are much calmer, seldom in excess of 15 m/s, and very predominantly from the southwest (nearly 40% of the time). The Spring and Fall generally represent transitions between these two dominant patterns. Exceptionally, there is a slight increase in the probability of winds from the north and east in early Spring (March and April). April has the most uniform directional distribution reflected in the highest probability of east winds.

These data most notably vary from the observation at Port Hastings and Eddy Point in that there is no significant easterly component, as is reported for the observations. The reason for this variance has not been determined, but the AES40 grid point is quite a distance from the Strait, so large scale variability cannot be ruled out. Additionally, the observations could be affected by local geographic steering effects.

6.1.6.7 Average Waves

The offshore wave climate as represented by AES40 grid point 5394 is summarized in Figure 7, Appendix E. This figure represents the probability of significant wave height (Hsig) versus direction on an annual average basis.

The most probable wave direction on an annual basis is strongly biased towards the south and southwest, with the occurrence of high waves being nearly equally probable from either of these directions. The probability of large amplitude waves is much more uniformly distributed east to south and west than the smaller waves.

The monthly wave statistics (Figure 8, Appendix E) show that during the winter months of December and January the predominant wave direction is from the east. During this time, the overall probability of waves from the southeast and south is slightly less but the probability of the highest waves is greatest in these directions. For the remainder of the year waves from the south dominate. In the Autumn months of October and November as well as the late winter months of February and March, waves from the east and southeast are almost as probable as those from the south. During the Spring and Summer (April through September), wave heights are greatly reduced and waves from the south, and to a lesser extent the southeast, completely dominate the wave climate at this grid point. For example, in July waves are from the south and southeast greater than 80 % of the time and seldom exceed 3 m in height.

The wave climate was further investigated using STWAVE, a phase-averaged spectral wave model, originally developed by Resio (1987, 1988a, 1988b) and supported by the US ARMY Corps of Engineers Experiment Station (Smith *et al.* 1999), to propagate offshore conditions to the study site. The model is a steady-state finite-difference model based on the wave action balance equation and is particularly suited to the analysis of coastal engineering problems. STWAVE is driven by wave spectra input at the boundaries to analyze the transformation (refraction/shoaling/diffraction) of known deep water wave conditions as the waves propagate into shallower water. It also accepts wind input allowing analysis of locally generated waves, useful for larger model domains and enclosed or partially enclosed water bodies. The wave model includes the effects of fetch, shoaling, refraction, wave/wave, wind/wave and current/wave interactions and breaking waves.

Two simulations were performed reflecting particular cases of interest: large swell propagating in from the ocean; and locally generated seas caused by storm winds. The results of these simulations are presented in Figures 9 and 10, Appendix E. Figure 9 represents a 7 m swell with a period of 12 seconds propagating into Chedabucto Bay from the southeast. This represents the largest regularly occurring swell (5 to 7 m) based on the AES40 data. This should not be considered an extreme event, which requires a more detailed analysis. The model predicts significant attenuation at the site with predicted swell height reduced to 1 m or less.

Figure 10, Appendix E represents locally generated waves caused by a 25 m/s wind from 60^{o} True. The maximum wave height in the vicinity of the terminal is slightly in excess of 1 m.

6.1.6.8 Extreme Winds and Waves

Extremal analyses of Significant Wave Height (Hsig) and wind speed were conducted on the 42-year 6-hourly time series from AES40 site 5394. The Fisher-Tippett Type I (also referred to as Gumbel) distribution was used in the analyses (Bury 1975, Gumbel 1958), along with the maximum likelihood curve-fitting method. Annual extremes for Hsig and Wind Speed were obtained by extrapolation on a Gumbel distribution of 42 annual maxima. Seasonal extremes are based on a three-month running window (*e.g.* March statistics represent the February, March and April "season"), the sampling being an annual maximum series for the seasons in question.

Each extreme value was computed for 5, 10, 50, and 100-year return periods. A N-year return period represents the average period of time between exceedances of the N-year extreme value. Yearly extreme Hsig and wind speed are given in Table 6.12. Seasonal extreme parameters are listed in Table 6.13 and plotted in Figure 11, Appendix E, where return statistics are determined for 42 years of storms occurring within a three month window. It is important to understand that the results from this analysis do not have to conform to the annual analysis because the distributions are based on a seasonal subset of the data. Differences can arise simply from the inherent error in the "best fit" estimate of the slope, and potentially, from real variations in the nature of seasonal storm distributions. The seasonal analysis shows that the three-month period June, July and August offers the minimum energy levels and minimum risk of exceptional storm.

Table 6.12 Yearly Extreme Hsig and Wind Speed

Return Period (years)	5	10	50	100
Hsig (m)	8.7	9.4	10.9	11.6
Wind speed, 1-hr average (m/s)	24.3	25.4	27.6	28.6

Table 6.13 Seasonal Extreme Hsig and Wind Speed – 3 Month Running Period Centred on Each Month

Return (Years)	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Hsig (m)												
5	8.1	8.2	8.2	7.4	6.3	4.9	4.6	5.1	6.1	6.9	7.5	7.7
10	8.8	8.9	9.0	8.1	6.9	5.5	5.1	5.7	6.8	7.7	8.2	8.3
50	10.4	10.4	10.9	9.7	8.4	6.8	6.3	7.0	8.3	9.3	9.6	9.5
100	11.0	11.0	11.7	10.4	9.0	7.3	6.9	7.5	8.9	10.0	10.1	10.0
Wind Speed - 1 hr average (m/s)												
5	23.3	23.3	23.1	21.9	20.0	17.5	16.7	18.1	20.7	22.3	23.1	23.1
10	24.3	24.3	24.6	23.1	21.3	18.7	18.0	19.4	22.2	23.8	24.2	24.0
50	26.3	26.6	28.0	25.9	24.2	21.6	20.9	22.4	25.4	27.1	26.8	26.0
100	27.2	27.6	29.5	27.0	25.4	22.8	22.1	23.7	26.8	28.5	27.9	26.9

6.1.6.9 Ice Cover

Ice cover in the eastern portion of the Strait was virtually eliminated by the construction of the Causeway. In an analysis of ice and local climate (O'Neill 1977), it was concluded that construction of the Causeway has significantly reduced ice coverage generated by low salinity flows through the Strait originating in the Gulf of St. Lawrence; it has had little or no detectable effect on climate. The lack of ice coverage will ensure high mixing and flushing rates due to the effects of surface wind during the winter season.

6.1.6.10 Summary

The main results of this investigation of physical oceanography in the study area are that:

- tidal currents at the site are weak (~ 0.04 m/s);
- non tidal currents may be many times stronger than the tidal currents, typically 10 to 20 times the tidal currents in the Strait;
- offshore swell is greatly attenuated before reaching the site;
- local waves are fetch limited; and
- ice is not an issue at any time during the year.

6.1.7 Marine Biology

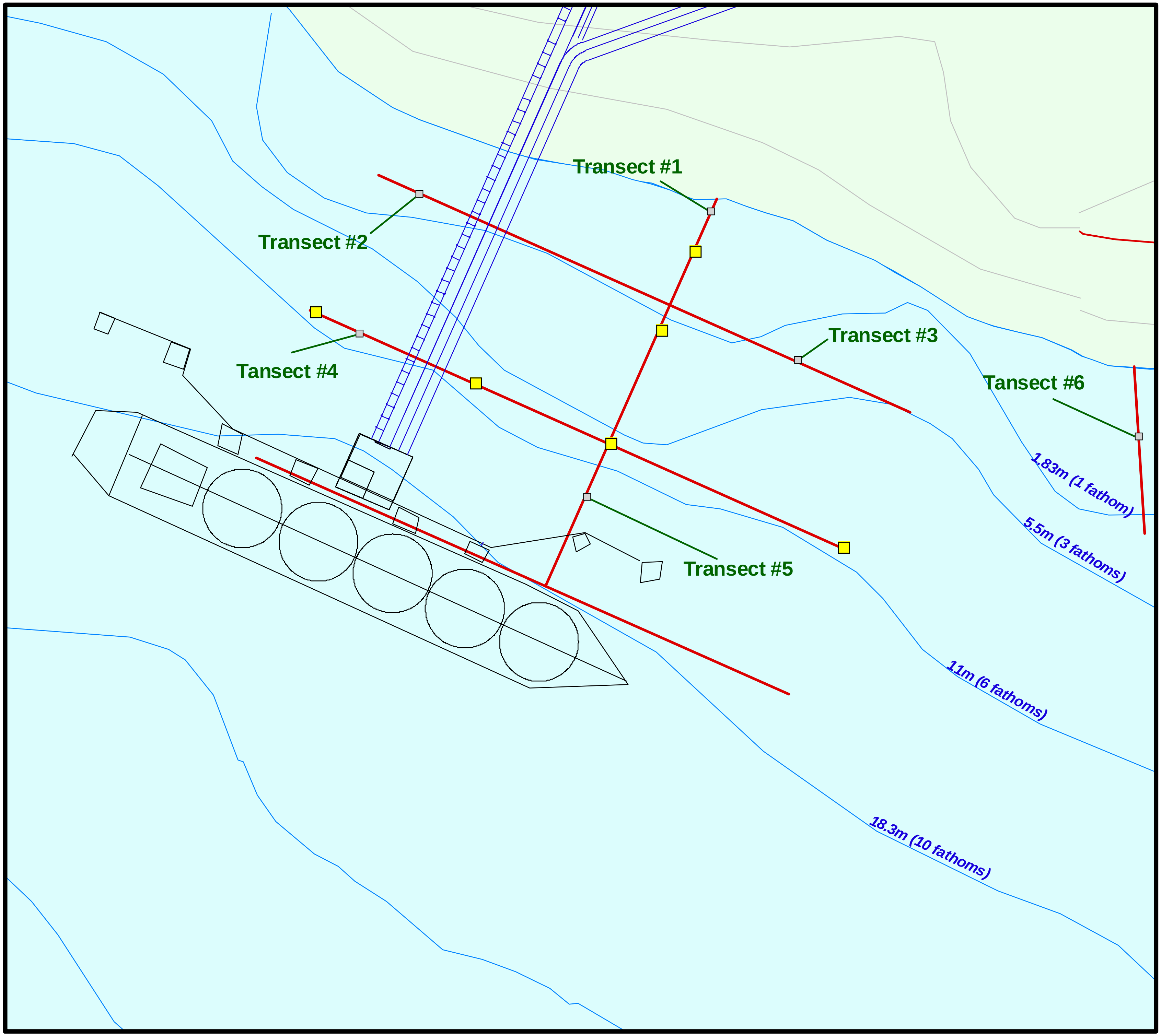
6.1.7.1 Marine Benthic Habitat and Communities

Sediment Quality

Marine benthic community assemblages are largely dictated by substrate type; for example, soft sediment assemblages are different from cobble/boulder areas.

Sediment samples were collected by a scuba diver at six locations within the area of the proposed jetty on October 24, 2003 Figure 6.7. The top 10 cm of sediment was collected in four 250 ml glass jars to be analyzed for grain size, and chemical parameters listed in Table 6.14. The analyses were performed at Philip Analytical Laboratory in Bedford, NS. Results from the laboratory analysis as well as the range of concentrations observed in the Strait of Canso are described in Table 6.14.

The surficial marine geology of the area surrounding the proposed marine terminal consists of Sable Island sand and gravel as well as Lahave clay (SOEP 1996a). Lahave clay is usually found in the deeper portions of the Strait of Canso. Silty sand is also common in shallow banks of areas close to Bear Head (SOEP 1996a). The grain size analysis reveals that substrate in the area off Bear Head is composed primarily of gravel and sand sized sediments, while data from the Strait of Canso reveals areas with higher percentages of fine material (silt and clay) (Table 6.14).



BEAR HEAD LNG TERMINAL

Figure 6.7

Benthic Habitat Survey

Legend

- Sediment Sampling Locations
- Underwater Video Transect
- Bathymetry

N

0 20 40 60 80

Metres

Map Parameters
Projection: Universal Transverse Mercator (UTM)
Zone: 20
Datum: NAD 83
Scale: 1:2,500
Project Number: NSD17393
Date: May 5, 2004

Jacques Whitford

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Table 6.14 Sediment Quality at Bear Head and Strait of Canso						
Parameters	**Units**	**EQL**	**CCME ISQG – PEL**	**ODCA**	**Bear Head**	**Strait of Canso[1]**
Gravel	%	0.1			12.4-29.7	5.2 - 25.01
Sand	%	0.1			47.5-67.6	16.3 – 40.1
Silt	%	0.1			9.6-14.3	3.4 – 43.8
Clay	%	0.1			7.2-9.2	2.0 – 24.27
Cadmium	mg/kg	0.3	0.7-4.2	0.6	Nd	<0.010 – 0.79
Mercury	mg/kg	0.01	0.13-0.7	0.75	0.01	0.03 – 3.1
Copper	mg/kg	2	18.7-108	81	6-8	7-56.6
Zinc	mg/kg	5	124-271	160	37-48	50-130
Lead	mg/kg	0.5	30.2-112	66	11-12	23.9-120
Hydrocarbons (TPH, C6-C32)	mg/kg	3			16.2-26.6	21 – 515.3
Total C6-C10	mg/kg	2.5			All <2.5	
>C10-C21 (fuel)	mg/kg	0.25			2.78 - 4.76	
>C21-C32 (Lube)	mg/kg	0.25			13.4 - 21.9	
PCBs	µg/kg	10	21.5-189	100	<10 – 71.6	48-1395
Pesticides[2]	µg/kg	10	1.19-374		All <10	<5 -62
PAHs[2]	mg/kg	0.05	0.006-0.135	2.5	All <0.05	0.039-2.940
Benzene	mg/kg	0.025			All <0.025	
Toluene	mg/kg	0.025			All <0.025	
Ethylbenzene	mg/kg	0.025			All <0.025	
Xylene	mg/kg	0.05			All <0.05	
PCDD/Fs[2]	pg/g		0.85-21.5		0.31-0.41	

[1]Stewart and White 2001
[2]Pesticides, PAHs, and PCDD/Fs are grouped to simplify table
EQL = Estimated Quantitation Limit Calibration
CCME = Canadian Council of Ministers of Environment
ISQG = Interim Sediment Quality Guideline
PEL = Probable Effects Limit
ODCA = Ocean Disposal Chemistry Analysis

The chemistry analysis of the sediment gathered in the area of the proposed terminal structure reveals relatively unimpacted sediment for all parameters (where available) in comparison to data gathered from the Strait of Canso.

All of the sediment samples from the terminal area show concentrations of various parameters below the Ocean Disposal Guidelines (Atlantic Region). A similar comparison of the parameters for which the Canadian Council of the Ministers of the Environment (CCME) provide guidelines show that all but one station have levels below both the Probable Effects Limits (PEL) and Interim Sediment Quality Guidelines (ISQG). Station 3 results indicate a PCB level which exceeds the ISQG; however the level is below the PEL. The average PCB level over all stations sampled in the vicinity of the proposed marine terminal is below the ISQG.

Benthic Habitat and Communities

On July 22, 2003, a benthic habitat survey by an aquatic biologist was undertaken along six transects of which some parts would be affected by the Project (Figure 6.7). An underwater drop video camera with surface feed was deployed along six transects from an aluminum boat. A hand held GPS was used to drop surface buoys at precise locations at each end of the transects. Transect #6 is in the area of the potential seawater outfall.

South of the Strait of Canso causeway is an inlet 18 km long and on average 1.6 km wide. Depth ranges from 60 m in depressions along the Canso causeway to 40 m in Chedabucto Bay. The marine benthic habitat in the vicinity of the Project is typical for open water nearshore environments in Nova Scotia. The type of bottom and associated organisms were similar between transects as long as water depths remained similar. The deep water of the Strait limits the area of productive shallow water habitat to narrow zones alongside each shore (SOEP 1996a).

The intertidal zone is characterized by a substrate consisting of pebbles, cobbles and the occasional boulder. The fucoid species, *Fucus vesiculosus, F. Evanescens* and *Ascophyllum nodosom* are the dominant algae in the intertidal zone. *A. nodusum* occurs in the upper zone, with *F. vesiculosus* and *F. evanescens* in the lower zone. *Chondrus crispus* is found as subflora beneath the fronds of fucoids. Epiphytes such as *Ceramium* sp. and *Bonnemaisonia mamifera* and diatoms cover larger algae in the intertidal zone. Species such as *Corralina officinalsis* and *Lithothamnion* sp. are calcified crustose algaes which form a subflora on the rocks in the intertidal and subtidal zones.

In shallow waters, especially at transects 3 and 6, eelgrass (*Zostera marina*), green algae (*Cladophora* sp), barnacles (*Balanus balanoides*), wrack algae (*Fucus serratus*), and periwinkles (*Littorina littorea*) were dominant. In deeper waters (>12 m), the absence of most algae species is readily evident (transect # 4 and 5). Light penetration to those depths is minimal. In these areas it is easier to observe the substrate composition and epifaunal organisms that reside in the area. Polycheate holes were observed as well as rock crabs (*Cancer irroratus*), lobster (*Homarus americanus*), scallops (*Placopecten magellanicus*) and a few sea stars (*Asterias rubens*, *Henricia sanguinolenta*). The bottom substrate of the transect areas between the 3 and 12 m contained the most diversified collection of organisms including: red corraline algae (*Corallina officinalis*); rockweeds (*Fucus* ssp and *Ascophyllum nodosum*); kelp (*Laminaria* ssp); quahog; red seaweed (*Phyllophora* ssp); and irish moss (*Chondrus crispus*). The benthic zone to 18.3 m in the Strait of Canso is described as probable lobster and sea urchin habitat in SOEP (1996b).

Photos from the benthic survey are presented in Appendix F (Photos 1 to 7).

Key species in the region include: Atlantic cod (*Gadus morhua*); haddock (*Melanogrammus aeglefinus*); pollock (*Pollachius virens*); American plaice (*Hippoglossoides platessoides*); white hake (*Urophycis tenuis*); Atlantic herring (*Clupea harengus*); lobster; sea scallop (*Placopecten magellanicus*); rock crab (*Cancer irroratus*); urchin (*Stongylocentrotus droebachiensis*); and soft-shell clam (*Mya arenaria*) (Stewart and White 2001) (refer to Section 6.1.7.2, Marine Fish). The beach zone can be described as a cobble beach with kelp and rockweed observed at the low tide mark.