Environmental Impact Statement

Long Harbour Commercial Nickel Processing Plant

Volume 1

The Project

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02 November 2007

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1.0 Introduction

This volume of the Environmental Impact Statement (EIS) describes the Long Harbour Commercial Nickel Processing Plant (the Project) proposed by Voisey's Bay Nickel Company Limited (VBNC) to be located in Long Harbour, Placentia Bay, Newfoundland and Labrador (Figure 1.1). It examines the alternatives that were considered, the construction, operation, and decommissioning of the proposed plant, details of the processing technologies under consideration and the physical environment within which the Project will function. Because of its importance to design and planning for the Project, this volume also considers the effects of the environment on the Project.

Figure 1.1 Project Location

A description and summary is provided of VBNC policy and practice with respect to environmental management, climate change, emergency preparedness, occupational health and safety, human resources and community relations. In particular, the community consultation undertaken by VBNC for the Project is described in detail. As a conclusion to this volume, the Valued Ecosystem Components (VECs) are described as the basis for the assessment in subsequent volumes of the EIS.

The Proponent

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Voisey's Bay Nickel Company Limited (VBNC) was established in 1995 and became a wholly owned subsidiary of Inco Limited (Inco) in 1996. Companhia Vale do Rio Doce (CVRD), based in Brazil, acquired Inco in October 2006. On January 7, 2007, Inco Limited became a wholly-owned subsidiary of CVRD and changed its name to CVRD Inco Limited.

CVRD is the largest mining company in the Americas and one of the three largest diversified mining companies in the world, with operations on five continents. It is the world's largest producer and exporter of iron ore and pellets, and an important global producer of manganese and ferroalloys. The company also produces copper concentrate, bauxite, potassium, kaolin, alumina, and aluminum, and invests heavily in minerals research including coal and nickel. It also holds stakes in the steel industry, as well as logistics and electric power generation to support its operations. CVRD Inco Limited is now the world's number one nickel producer, and has plans to build and expand the company. CVRD fully supports the Voisey's Bay Project and endorses CVRD Inco Limited's obligations under the *Voisey's Bay Development Agreement* (http://www.nr.gov.nl.ca/voiseys/legal.htm).

CVRD Inco Limited headquarters are in Toronto. Management responsibility for all existing and future CVRD nickel projects has been transferred to CVRD Inco Limited. More information on CVRD Inco Limited is available at www.inco.com. Additional information on VBNC can be found at www.vbnc.com.

2.0 Project Overview

VBNC is proposing to construct, operate, and eventually decommission a Commercial Nickel Processing Plant (the Project) in a safe, healthy, and environmentally sound manner that will benefit all stakeholders, in accordance with the terms of the *Voisey's Bay Development Agreement.* This *Agreement* requires that VBNC establish a commercial nickel concentrate processing plant using hydrometallurgical technology, provided that this technology can be shown to be technically and economically feasible. The hydrometallurgical technology (Hydromet Plant) will process nickel concentrate into a finished nickel product. If this technology is not technically or economically feasible, a hydrometallurgical nickel matte processing facility would be constructed to meet the commitment to process nickel in the Province.

CVRD Inco Limited is undertaking a comprehensive research and development program at a Demonstration Plant located at Argentia, Newfoundland and Labrador and at its research center in Mississauga, ON. The program is aimed at establishing the technical and economic feasibility of processing nickel concentrate directly using hydrometallurgy. The other technology under consideration is referred to as a Matte Plant. This hydrometallurgical process would use nickel matte from an out-of-province smelter as the input material, and produce a finished nickel product. The *Agreement* stipulates that the technology must be selected (Processing Decision) by November 15, 2008.

Once the feasibility of the hydrometallurgical technology has been established, VBNC will construct the Hydromet Plant at Long Harbour, NL, with a design capacity of approximately 50,000 tonnes (t) per year of finished nickel product, together with associated cobalt and copper products. Should the Hydromet Plant not prove to be technically or economically feasible, VBNC would construct a Matte Plant on the same site with the same production capacity.

This Environmental Impact Statement addresses and seeks approval for both the Hydromet Plant and the Matte Plant technologies. The Project will be located partially on a "brown field" site (Tier 1 Port Site) on the south side of Long Harbour, Placentia Bay, and partially on a "green field" site (Tier 2 Plant Site) above Long Harbour on the south side (Figure 2.1). It will include a pipeline to supply process water from Rattling Brook Big Pond, and an effluent discharge pipe and diffuser into Long Harbour. The Hydromet Plant will include associated pipelines and a residue storage area at Sandy Pond. The Matte Plant would include associated pipelines and an above ground residue storage area to the southeast. Figure 2.1 shows the general layout of the Project.

Figure 2.1 General Layout (viewed from the north)

Purpose of the Project

Inco acquired the Voisey's Bay nickel, copper, and cobalt deposit from Diamond Fields Resources Inc. in 1996, and developed the optimum approach to mining and processing the deposit. The mine/mill Project was released from the environmental assessment process in August 1999, with construction starting at Voisey's Bay in 2002. Production began in late 2005.

The concentrate produced at Voisey's Bay is currently being processed in CVRD Inco Limited facilities outside of the Province. However, the Newfoundland and Labrador *Mineral Act (RSNL M–12)* requires that a person holding a mineral lease in the Province complete primary production, in whole or in part, in the Province, of a mineral ore extracted or removed under that lease, subject to certain economic considerations. The *Voisey's Bay Development Agreement* requires VBNC to build a Hydromet Plant or suitable alternate facility in the Province. There is a worldwide shortage of processing facilities producing finished nickel from concentrate. Construction of a commercial nickel processing plant will increase global nickel processing capability to meet growing demand.

Purpose of the Environmental Impact Statement

Voisey's Bay Nickel Co. Ltd. submitted a Project Description and Project Registration for a Commercial Processing Plant on March 16, 2006. This single document was submitted simultaneously to the Canadian Environmental Assessment Agency and the Newfoundland and Labrador Department of Environment and Conservation. On May 11, 2006, the Provincial Minister of Environment and Conservation made a determination that an Environmental Impact Statement is required for the registered Undertaking. A study is also required for the Project pursuant to the *Canadian Environmental Assessment Act*.

Guidelines (Appendix D) for this Environmental Impact Statement (EIS) were issued on October 23, 2006, pursuant to the Province's Environmental Protection Act and the *Canadian Environmental Assessment Act* (CEAA).

On November 3, 2006, Fisheries and Oceans Canada (DFO) and Transport Canada (TC) issued a Screening Scoping Document (CEAR Reference Number 06-01-23173) in which the two departments identified their status under the CEAA as Responsible Authorities, indicated their intention to use the EIS to complete a screening level environmental assessment, and set out the scope of the Project for the Federal environmental assessment.

This EIS meets the requirements of the Guidelines and goes beyond the factors to be considered in Section 16(1) of the CEAA. Additional factors that have also been considered in this EIS are consistent with a higher level of review, and include all of those factors set out in Section 16(2) of CEAA, including the purpose of the Project, alternative means of carrying out the Project, the need for follow-up programs, and the capacity of renewable resources likely to be significantly affected by the Project to meet present and future needs.

This EIS is being submitted for the purpose of assisting the Minister of Environment and Conservation to determine the acceptability of the Project. It is also being submitted to support the Federal environmental assessment. The EIS provides a description of the Project that is consistent with the Scope of Project as laid out in the Guidelines and in the Screening Scoping Document. The scope of this environmental assessment is also consistent with the requirements as laid out in these documents.

Legislation, Policies and Permitting / Regulatory Agencies

The Project will be subject to the following primary environmental legislation.

Government of Canada	*Canadian Environmental Assessment Act* *Canadian Environmental Protection Act* *Fisheries Act* *Species at Risk Act* *Navigable Waters Protection Act* *Transportation of Dangerous Goods Act*
Government of Newfoundland and Labrador	*Environmental Protection Act* *Water Resources Act* *Endangered Species Act* *Occupational Health and Safety Act* *Boiler, Pressure Vessel and Compressed Gas Act* *Dangerous Goods Act* *Public Health Act* *Urban and Rural Planning Act*

The Prospective Site and Study Area

The Town of Long Harbour-Mount Arlington Heights is situated on the north side of Long Harbour, Placentia Bay, Newfoundland and Labrador (Figure 1.1). The Project will be located on the south side of Long Harbour (see Figure 2.1 and Topographic Map Argentia 1 N / 5 at the following approximate coordinates: 47°25'N and 53°49'W). The Hydromet Plant general layout is shown in Figure 2.2. The Matte Plant features are shown in Figure 2.3. The entire Project area, including access roads and residue storage areas, is shown in Figure 4.1.

The Port area of the site (Tier 1) and surrounding area was used as an industrial site from 1969 to 1989 by Albright and Wilson Americas Limited (AWA). The AWA site occupied an area of 77 ha on the south side of Long Harbour. Production operations covered approximately 20 ha, with a workforce of about 400 and an annual production rate of 50,000 t of elemental phosphorus. The site was decommissioned in the mid-1990s after undergoing an environmental impact assessment, and is now owned by Rhodia Canada, Inc. and the Long Harbour Development Corporation (LHDC).

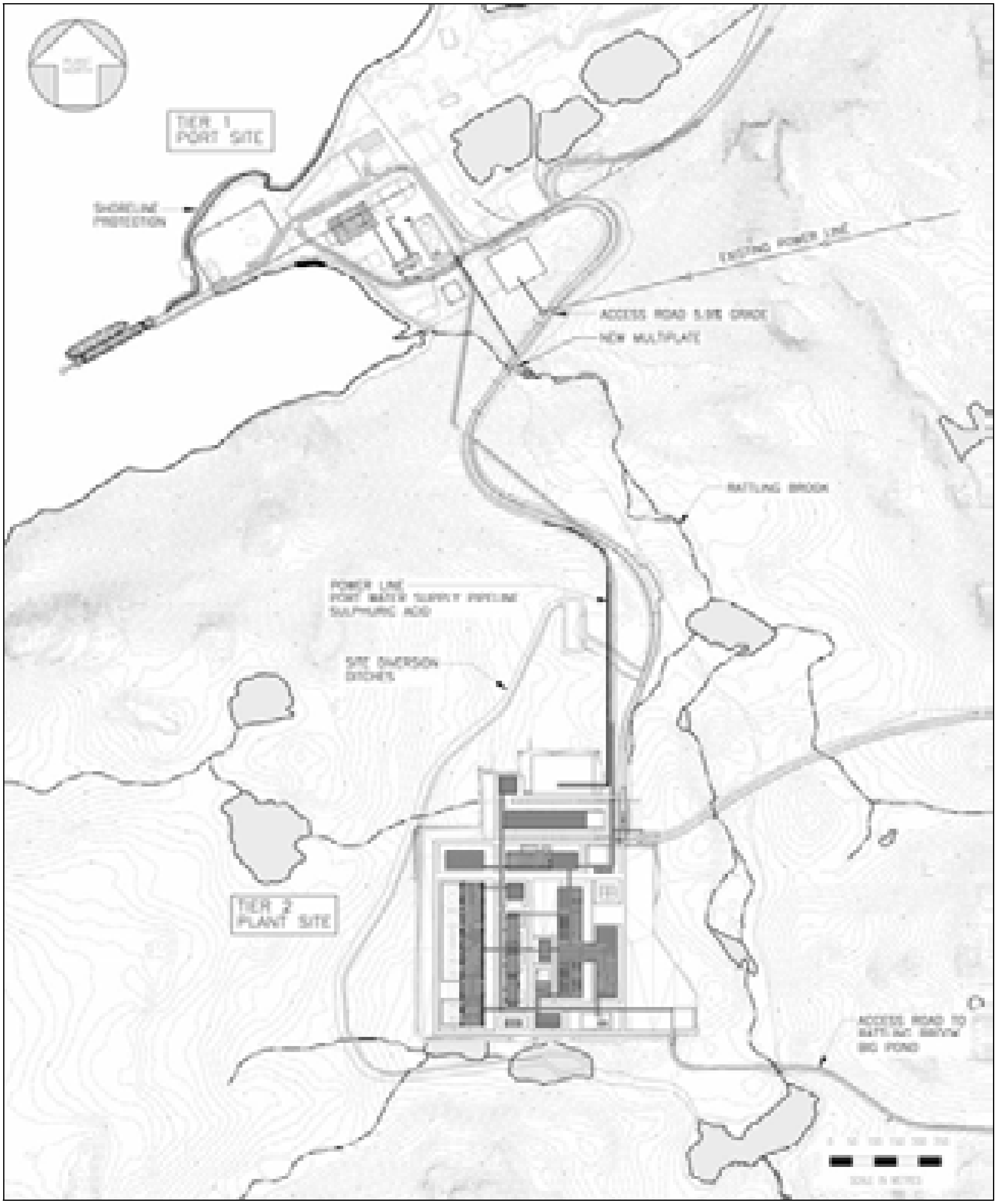

Figure 2.2 Hydromet Plant Site Layout

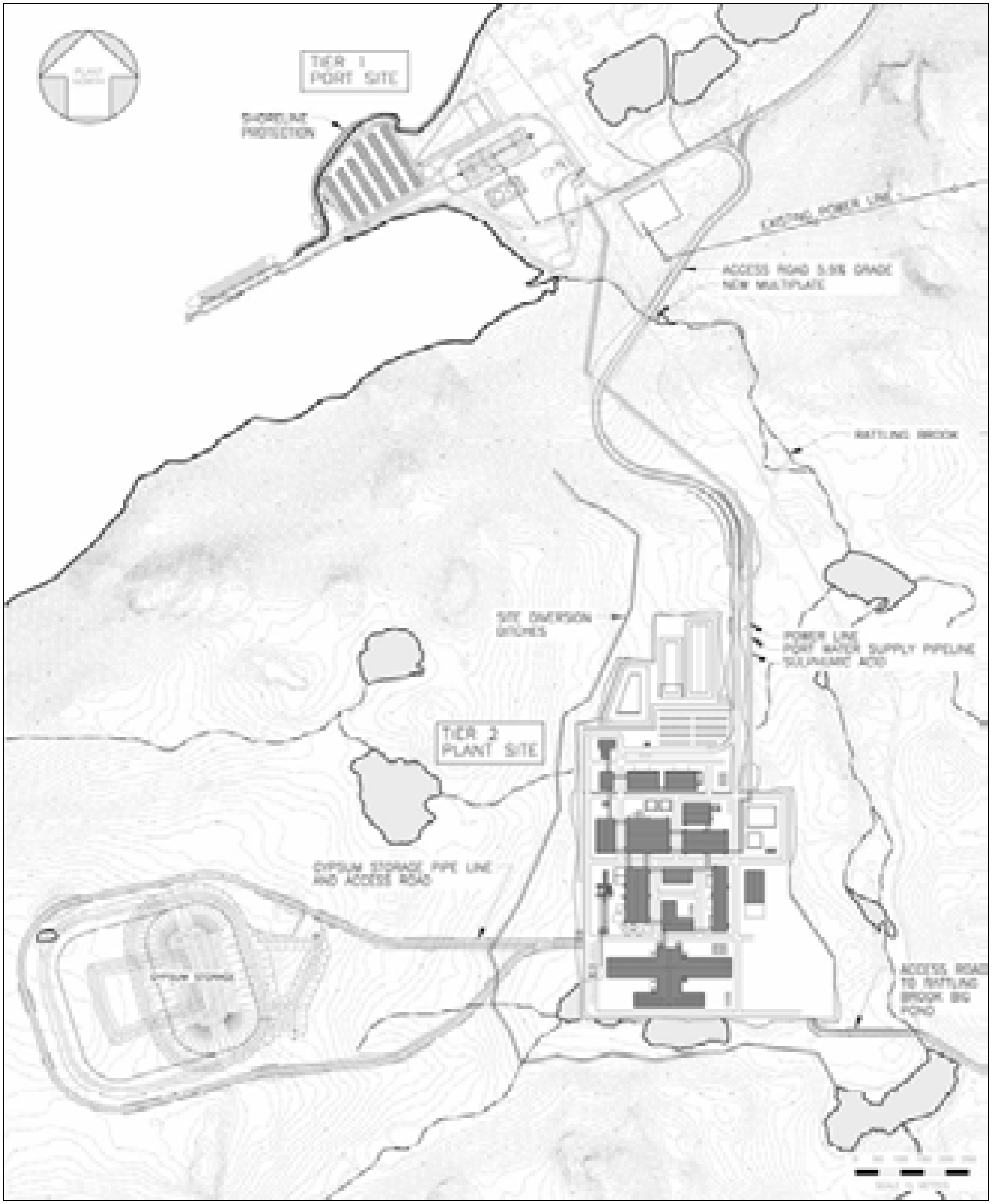

Figure 2.3 Matte Plant Site Layout

The decommissioned AWA site includes a wharf, a paved access road, several buildings (administration, steam, and mud residue buildings), buried service lines, several landfills, a secure hazardous waste disposal area, a slag stockpile, and construction debris. Some portions of the site (e.g. the hazardous waste disposal area) are not suitable for development. VBNC has conducted due diligence and has selected areas that are considered appropriate for industrial use.

Long Harbour Development Corporation has subleased its portion of the former AWA site to Marex Inc., which has been demolishing the existing facilities. Newco Metals, a scrap metal dealer, also operates at the plant site. The scrap is barged out from the existing wharf, which has also been used by Marex Inc. to receive salt for distribution around the province. Canadian Coast Guard (CCG) vessels occasionally dock at the wharf. There is a sunken vessel adjacent to the wharf. The Long Harbour Development Corporation will remove the vessel in accordance with government regulations prior to VBNC acquiring the site.

The access road to the site and the land proposed for plant facilities on Tier 2 are owned by the Government of Newfoundland and Labrador.

Other Existing Activities in the Area

Other activities within Placentia Bay include the North Atlantic Refining Ltd. Come by Chance oil refinery, the Newfoundland Transshipment Ltd. terminal, the Marine Atlantic Ferry terminal, the Port of Argentia, the Kiewit Offshore Services Marystown Shipyard and the Cow Head Fabrication Facility, commercial fisheries (including several aquaculture operations), and associated seafood processing plants.

A variety of tourism, cultural, and commercial activities take place in the Long Harbour area. Key cultural and tourism facilities include Castle Hill National Historic Park, the O'Reilly House Museum, and active archaeological digs in Placentia. Other sites include the Cape St. Mary's Bird Sanctuary, about 70 km to the south, and Ship Harbour, the site of the signing of the Atlantic Charter in 1941, about 44 km by road or approximately 10 km in a straight line from the Project area. An international airport, major cultural facilities, international hotels, shopping, and central government services are available in St. John's, about 100 km away.

The Project area and immediate vicinity were surveyed for the presence of historic and archaeological resources (GPAL, 2006). No aboriginal or historic resources were found.

Other Proposed Developments in the Area

Two other major industrial projects are proposed for construction in Placentia Bay.

Newfoundland and Labrador Refinery Corporation (NLRC) has proposed construction of an oil refinery at Southern Head, between North Harbour and Come by Chance, at the head of Placentia Bay. The oil refinery is proposed to have an initial production capacity of 300,000 barrels per day with the option to expand to 600,000 barrels per day. Primary products of the oil refinery would be gasoline, kerosene / jet fuel, ultra-low sulphur diesel, and refining by-products. An Environmental Impact Statement and six Component Studies were delivered to both levels of government in July 2007.

Newfoundland LNG Ltd. has proposed construction of a Liquefied Natural Gas (LNG) Transshipment and Storage Terminal near the head of Placentia Bay at Grassy Point, Arnold's Cove. The transshipment terminal would provide storage and offloading for larger LNG vessels, for transfer to smaller LNG carriers and distribution to the Northeastern US and Canada. The project was released from further provincial Environmental Assessment, subject to conditions, in January 2007.

Project Phases and Schedule

The Project phases and key dates are:

- Construction 2008 - 2011
- Operation 2011 - 2026
- Closure and Decommissioning 2026 – 2031

Planning (including environmental assessment) is under way. Construction will take a total of 42 months, commencing in 2008 (designated as Year 1 of the Construction Schedule) and reaching completion by 2011 (Figure 2.4). Operations will commence by the fourth quarter of 2011. Decommissioning and closure will take approximately five years.

Construction will begin once the Project is released from Environmental Assessment, and all necessary permits and approvals are in place. Provided regulatory approval is received in 2008, detailed design, procurement and onsite construction works can commence the same year and thereby allow the completion of construction on schedule. Operational training to support production start-up is scheduled to begin in early 2010.

Production operations are scheduled to continue for 15 years to match the life of the Voisey's Bay mine, and in conformance with the *Agreement*. The duration of operations could vary in accordance with the availability of feed to the facility. An extended operating life could be achieved (and would likely require facility refurbishment), although such a possibility is not within the scope of this environmental assessment. Any such plans, if and when developed, would be subject to all applicable approval processes in place at that time.

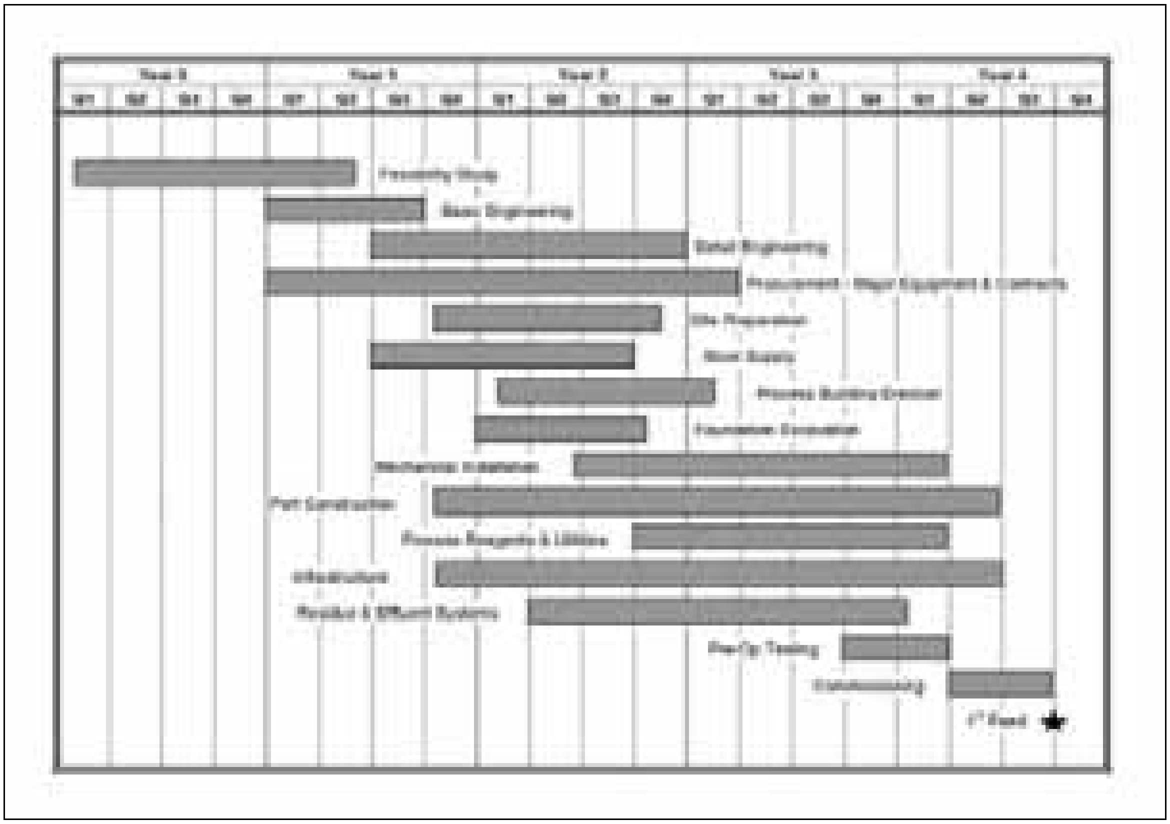

Figure 2.4 Summary Construction Schedule

Current plans are to decommission the facility at the end of the planned 15-year operating life, such that decommissioning will commence in 2026. Decommissioning will include rehabilitation of the land and water areas disturbed by the Project and is anticipated to take up to five years.

3.0 Alternatives

This Chapter presents and discusses the alternatives to and within the Project. The EIS is required to describe the alternative methods of carrying out the undertaking, as well as the alternatives to the undertaking. The Guidelines for the EIS and the Federal Environmental assessment specifically request information on alternatives for residue treatment and disposal, for both the Hydromet Process and the Matte Process. Where only one alternative is viable or possible, supporting argument is provided.

VBNC has identified one alternative to the Project and several alternatives in Project design, including processing technologies, site locations, and residue disposal.

Alternatives to the Project

The sole alternative to proceeding with the Project was identified as the 'no project' alternative, meaning that no nickel processing facility would be constructed in the Province, and the Government of Newfoundland and Labrador could terminate the mining lease for the Voisey's Bay nickel deposit. Not proceeding with the Project would also fail to address a global need for increased nickel concentrate processing facilities, and remove 50,000 t of nickel per year from the world market.

This alternative would provide no economic benefit to Newfoundland and Labrador, to Canada, or to CVRD Inco Limited. It would also forego all of the direct and induced construction and operation jobs associated with the nickel processing facility.

Alternatives within the Project

Several alternative processing technologies have been considered for the Project, including pyrometallurgy and bio-leaching. Alternative sites have been examined on a Province-wide basis, and residue storage alternatives have been considered to identify feasible, secure, and environmentally suitable sites.

Each of these "within Project" alternatives is presented and discussed in this Chapter. Note that, for the purposes of this EIS, the Hydromet Plant versus the Matte Plant are not considered alternatives. Rather, both fall within one "Project" and are assessed in this EIS.

Processing Technologies

One alternative would be to produce nickel from concentrate using pyrometallurgical technology instead of hydrometallurgical processing technology. Pyrometallurgy uses high temperatures (in the order of 1,300°C) to transform concentrate into oxidized metals, which are then refined to recover the metals. Concentrate is fed into a flash smelting furnace along with oxygen. Sulphides in the ore are oxidized, with the sulphur liberated as sulphur dioxide gas, leaving an oxidized mineral known as matte. Iron in the concentrate is oxidized to form iron oxide and removed, together with silicates, as slag. The molten matte containing the desired metals is then fed to converters, where the remaining iron and sulphur are oxidized with air at high temperatures. The matte from the converters proceeds to a refinery to recover the metals.

A technical and economic feasibility analysis was conducted of using pyrometallurgical technology to produce finished nickel products using Voisey's Bay nickel concentrate. The analysis concluded that it was not economically viable to construct and operate such a facility based solely on the Voisey's Bay mine/mill production capacity. A pyrometallurgical facility requires more energy to operate than a hydrometallurgical facility, and would require large blocks of electricity. While a pyrometallurgical facility can be operated within regulatory limits, its very nature (high temperature, high volumes of gases) means that it would produce significantly greater quantities of air emissions (sulphur dioxide, particulate matter containing heavy metals, and greenhouse gases) than a hydrometallurgical process. The pyrometallurgical option was rejected for economic and environmental reasons.

Another alternative processing technology, bio-leaching, is experimental and not commercially proven for nickel recovery. It has only been applied to base metals such as nickel and cobalt at a bench-scale level. Difficulties with metal recovery from the resulting solutions have not yet been economically resolved. Bio-leaching generates a large quantity of acidic and ferric waste water. The sulphuric acid in the waste water stream is not easily recoverable; the liquid waste stream must be neutralized, generating large quantities of waste solids with high pH, posing disposal challenges. The quantities of residues and neutralizing agents required would be much larger than for either the Hydromet Plant or the Matte Plant, and the costs of such processes is high. In addition, the commercial feasibility of the bio-leaching process could not be established within the time frame stipulated in the *Voisey's Bay Development Agreement.* The bio-leaching alternative was rejected for these reasons.

Site Selection

Inco conducted a province-wide study of 15 potential sites in 1996 to locate a smelter-refinery complex to process nickel concentrate produced at Voisey's Bay. The former US Naval Base at Argentia was selected as the preferred site for development. Since that time it has been determined that a smelter-refinery complex is not economical for the quantity of nickel to be produced, and a hydrometallurgical processing option was selected as the preferred technology. The change of processing option results in a different type of residue being produced, one that necessitates underwater storage rather than aboveground storage. As a result of this change and other considerations, Long Harbour was evaluated and selected as the site for the commercial nickel processing facility.

Long Harbour has an ice free port that can operate year-round, and offers easy access to major North Atlantic shipping lanes. It has the same socio-economic footprint as Argentia. The workforce would be drawn from the same area as Argentia. It has the same infrastructure (i.e., schools, hospitals, healthcare, shopping) and draws from the same local business community.

The Project footprint will include two areas or Tiers, and has access to adjacent sites for water supply and residue storage. The water supply source, Rattling Brook Big Pond, is not readily accessible to the public. The proposed underwater disposal area, Sandy Pond, is even less accessible. For the Matte Plant, a suitable gypsum residue storage site is available to the southwest. A source of electrical power is located adjacent to the Long Harbour site, at an existing Newfoundland and Labrador Hydro substation.

Residue Storage Alternatives

The Hydromet process for nickel concentrate produces two residues: an autoclave leach and an iron hydroxide–gypsum residue. Both residues require neutralization. The Matte process produces a nickel hydroxide-gypsum filter cake that is neutralized and contains little iron.

The residues produced will require environmentally acceptable long-term storage. The storage options available for these residues are underwater or above ground. Hydromet residues offer the possibility of separate or combined storage of the two wastes.

The selection of a preferred option for the storage of the residues from the two processing technologies involved extensive examination of the chemical and physical characteristics of the residues themselves. Candidate sites were selected and evaluated based on technical, socio-economic, and environmental criteria.

Hydromet Process Residues

The Hydromet Plant will process approximately 269,000 t/y of nickel concentrate resulting in approximately 381,000 t/y of combined residue, comprising 242,600 t/y of neutralized leach residue and 138,400 t/y of neutralized iron hydroxide-gypsum residue. The neutralized leach residue contains about 25% by weight of elemental sulphur, creating a potential for acid generation in the presence of oxygen and water. It is therefore essential to reduce or eliminate access of oxygen to the residues, usually by placement under a water cover. The iron hydroxide-gypsum residue does not contain elemental sulphur and it is not subject to acidification or metal remobilization in solution.

The options considered for the long-term storage of the residues included the separate or combined storage of the two residues either underwater or above ground. The evaluation of these residue storage options included geotechnical and geochemical residue characterization studies and geochemical underwater and land-based residue storage studies. Storing the neutralized leach residue or the combined leach residues subaqueously will substantially reduce the rate of oxidation of the elemental sulphur. In addition, closure of the underwater storage site can be significantly less complicated than the land-based option, which would possibly require capping to prevent sulphur oxidation.

Storage of the iron hydroxide-gypsum residue above ground would require two storage sites, and increase both the size of the Project footprint and construction, operation, and closure costs. Combining the two residues takes up about 10% less volume and enhances the stability of both products. The optimum approach combines the two residues and disposes of them under water.

Attention was focused on the identification and evaluation of candidate subaqueous sites including natural water bodies as well as engineered (land-based) containment locations. All candidate natural water bodies would require some form of engineered structure in order to meet capacity requirements and to develop a securely contained facility. All candidate sites, including land-based ones contain some quantity of aquatic habitat. Eleven potential sites were considered (Figure 3.1). Seven of these were eliminated from more detailed evaluation, based on their inability to meet minimum criteria.
Table 3.1 summarizes the results of this initial screening exercise.

Following this screening, four candidate sites remained for more detailed consideration: Sandy Pond (RS-1); South Tributary Rattling Brook Big Pond (RS-4); Railway lakes (RS-10); and Rocky Pond (RS-11). The detailed comparison and evaluation of these four sites is presented in Table 3.2.

Table 3.1 Residue Storage Options Initial Screening

Criterion	Residue Storage Option (RS-)										
	1	2	3	**4**	5	6	7	8	9	**10**	**11**
1. Adequate containment volume	✓	✓	✓	✓	x	✓	✓	x	✓	✓	✓
2. Sufficient overburden for dam construction	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	✓
3. Secure bedrock; Low seepage potential	✓	x	✓	✓	✓	✓	x	x	✓	✓	✓
4. Up-gradient watershed – acceptable inflows	✓	x	x	✓	✓	✓	x	✓	x	✓	✓
5. Absence of significant resource use conflicts (recreational usage)	✓	✓	x	✓	✓	✓	✓	✓	x	✓	✓
6. No Geological faults	✓	x	✓	✓	✓	x	✓	✓	✓	✓	✓
7. Adequate groundwater inflow / counter pressure	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓
8. Access for construction, operation, closure	✓	✓	✓	✓	✓	x	x	x	x	✓	✓
Summary	✓	x	x	✓	x	x	x	x	x	✓	✓

Figure 3.1 Residue Storage Options

Table 3.2 Alternatives Evaluation – Residue Disposal Sites

Criteria	RS-1 Sandy Pond		RS-4 South Tributary Rattling Brook Big Pond		RS-10 Railway Lakes		RS-11 Rocky Pond		Conclusion
	Description	**Rank**	**Description**	**Rank**	**Description**	**Rank**	**Description**	**Rank**	
TECHNICAL									
Capacity of Natural Basin	2.9 Million m^3	2	Minimal	4	Unknown but modest	3	3.7 Million m^3	1	RS 11 has greatest natural capacity.
Footprint of final flooded area	74 ha	1	102 ha	2	214 ha	4	125 ha	3	RS 1 has smallest footprint
Volume of Storage Dam / Material Storage Capacity Ratio	Three dams with a maximum height of 17 m and total length of 922 m Ratio = 0.038	3	Three dams with a maximum height of 32.5 m and total length of 920 m (3 Dams) Ratio = 0.194	4	Two dams with a maximum height of 17 m and Total length of 540 m Ratio = 0.021	1	Three dams with a maximum height of 9 m and total length of 1180 m. Ratio = 0.023	2	
Accessibility	New Construction Normal Conditions	1	New Construction Normal Conditions	1	New Construction Difficult Conditions	3	New Construction Very Difficult Conditions	4	RS-4 Accessible from Route 101.
Distance from Plant Site	4 km	2	3.6 km	1	11 km	3	14 km	4	RS-4 Shortest Access Road.
Average % Gradient from Plant Site	7.69	4	5.36	3	3.14	2	0.19	1	

Criteria	RS-1 Sandy Pond		RS-4 South Tributary Rattling Brook Big Pond		RS-10 Railway Lakes		RS-11 Rocky Pond		Conclusion
	Description	**Rank**	**Description**	**Rank**	**Description**	**Rank**	**Description**	**Rank**	
ENVIRONMENTAL AND SOCIO ECONOMIC									
Location / Exposure	Not visible from local communities or highways.	1	The site is approximately 300 m from Highway 101. Dams will not be visible but final water surface would be visible from the Highway.	2	The site is not close to any community or highway. Limited visibility from Highway 101.	2	Not visible from local communities or highways. Long access road and difficult terrain.	2	
Resource Use Conflict	Low Utilization Unattractive Fish Resource	3	Low Utilization	1	Low Utilization	1	Low / Moderate Seasonal Utilization (Snowmobile Trail)	4	Ranking based on resource use patterns
Upstream Watershed / Diversions	At top of watershed; minor diversion required	1	At height of land	2	Extensive diversion required; large upgradient watershed	4	One stream diversion required; moderate upgradient watershed	3	
Risk (Probability, Consequences)	Moderate proportion of contents lost. Discharge is to steep gradient intermittent channel approximately 2 km from salt water (Long Harbour).	1	Largest proportion of contents released, directed towards Rattling Brook Big Pond.	4	High proportion of contents lost. Discharge is to productive stream, 6.5 km from salt water.	3	Lowest proportion of contents lost. Discharge is to productive stream, 5 km from salt water	2	Probability of failure is in proportion to extent of constructed dams. Down-gradient effects considered.

Criteria	RS-1 Sandy Pond		RS-4 South Tributary Rattling Brook Big Pond		RS-10 Railway Lakes		RS-11 Rocky Pond		Conclusion
	Description	**Rank**	**Description**	**Rank**	**Description**	**Rank**	**Description**	**Rank**	
PROJECT COST									
Capital Cost	Medium	2	Very High	4	Medium	2	Low	1	
Operating Cost	Medium - Low	1	Medium	2	High	3	Very High	4	
Decommissioning and Post Closure	Low	1	Medium	2	High	3	High	3	
SUM OF RANKINGS		**23**		**32**		**34**		**34**	RS-1 ranks first in Technical, Environmental/ Socio Economic and Cost, as well as first overall.
NOTE: Each factor is ranked with 1 = most favourable.									

Of the four possibilities, Sandy Pond best met the evaluation criteria and hence was selected as the residue storage site. The site (Figure 3.2) is about 3.2 km from the Tier 2 processing complex. The length of the pipelines and access road from the processing complex to Sandy Pond will be about 3.8 km. Sandy Pond is isolated at the top of a watershed, thus requiring no water diversion. Three earth fill dams will be required to provide containment for the residue to be produced over the design life of the Project.

A major issue is to the protection afforded fish and fish habitat under the *Fisheries Act* of Canada. The Department of Fisheries and Oceans (DFO) operates on the "No Net Loss" principle, i.e. any loss of productive fish habitat has to be offset in an acceptable manner such that there is no net loss in capacity. Fish Habitat can be altered or destroyed only if authorized by the Minister of Fisheries & Oceans, and will be granted only if an acceptable Fish Habitat Compensation Plan is in place and a binding agreement is reached on its implementation.

The loss of fish habitat as a result of site preparation and dam construction at Sandy Pond will be balanced by habitat gains elsewhere. VBNC will quantify the extent of harmful alteration, disruption, or destruction (HADD) of fish habitat and work with DFO to develop an appropriate fish habitat compensation program. This stepwise process includes consideration of possible habitat compensation options, development of a compensation strategy, development of a detailed compensation plan, issuance of a legally binding Compensation Agreement, Authorization of HADD, and a monitoring program.

Matte Process Residue

Residue from the Matte Process does not contain elemental sulphur, and there is no requirement to inhibit oxidation. Aboveground storage would be the preferred option. The vast majority of gypsum produced by other industrial processes, e.g., gypsum residue from phosphate plants and from coal-electric plant sulphur dioxide scrubbing processes, is disposed above ground in gypsum stacks, either as dry or wet stacking. Dry stacking means that the gypsum is transported and stacked at the same moisture content as the produced filter cake. Wet stacking involves pulping the cake with water to form about a 25% slurry that can then be pumped to a storage area.

Due to the wet weather conditions at Long Harbour, the ready availability of water, the ability to transport the slurry via pipeline, and the lower costs compared to dry stacking, the method selected for Matte Process residue storage would be wet stacking.

The wet-stack (Figure 2.3) would have a total footprint of about 15 ha and rise about 30 m above the surrounding terrain.

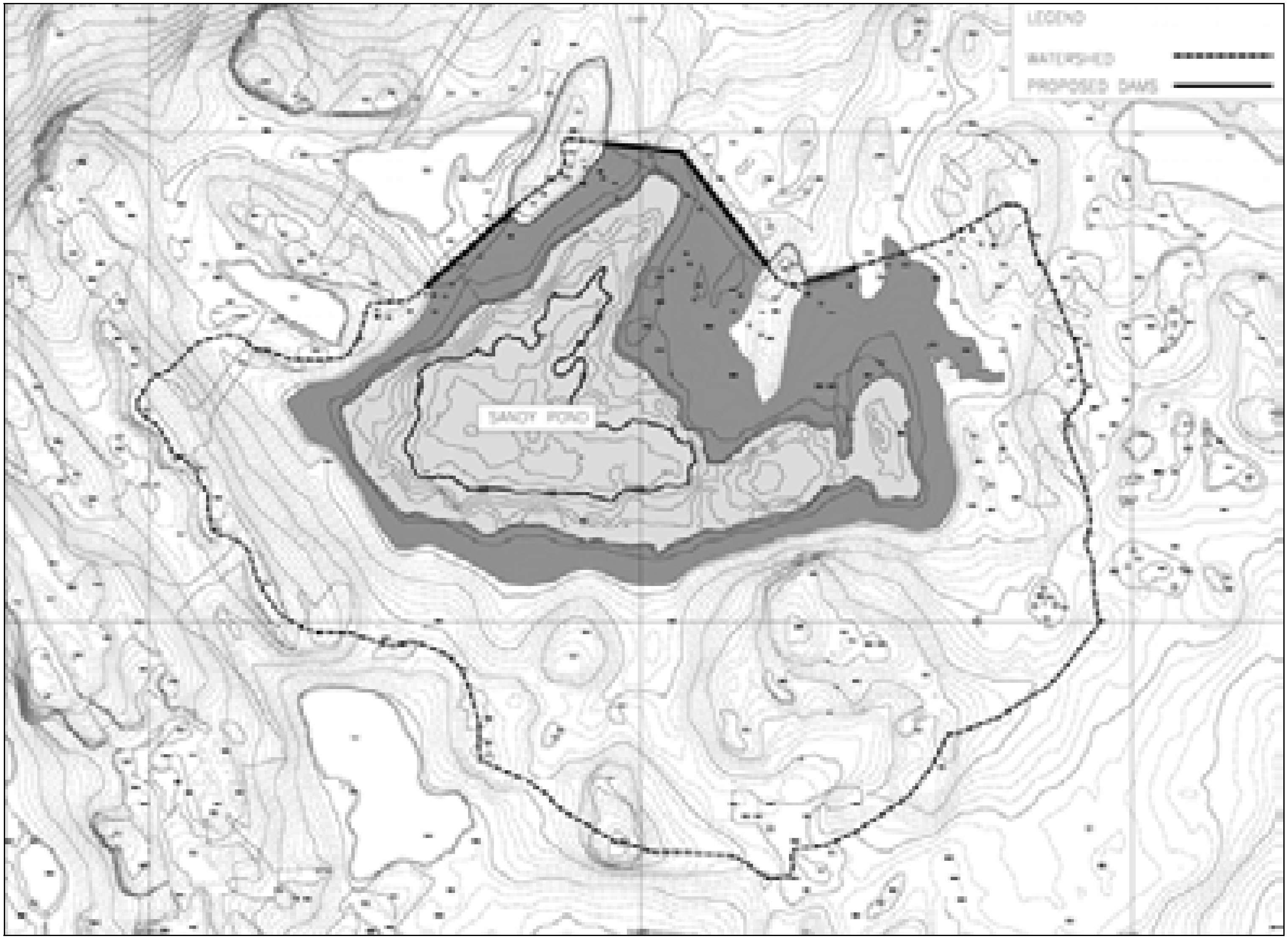

Figure 3.2 Sandy Pond

4.0 Project Layout and Main Components

The site layout is illustrated in Figure 4.1. It includes the main features of both the Hydromet and Matte facilities. The site will be located on two elevations: Tier 1, at an elevation between 3 and 10 metres, will include the wharf and an area that will be used primarily for unloading and loading ships, container and product storage, staging and storing of equipment, a storage building, acid storage tanks, and a port operations administration building. For the Hydromet Plant, Tier 1 will also include a lime kiln and fuel storage tanks. For the Matte Plant, the lime kiln and fuel tanks would be located on Tier 2.

Tier 2 has an average elevation of approximately 106 m and lies to the west of Rattling Brook and down gradient from Rattling Brook Big Pond. This site will contain all the major processing facilities and buildings, storage areas, laboratories, and administrative offices.

The main features of the Port Site are shown in Figure 4.2 (Hydromet) and Figure 4.3 (Matte). The Plant site features are shown in Figure 4.4 (Hydromet) and Figure 4.5 (Matte). Port facilities are listed below.

- A port facility including a wharf, an area for staging and storing of equipment and containers, and storage facilities for raw materials, reagents, wastes, and finished products
- A lime kiln to convert limestone into lime for effluent neutralization (Hydromet only)
- A concentrate and limestone grinding process building (Hydromet only)
- Conveyor systems
- A storm water capture system, sewage treatment system, and general port buildings
- Sulphuric acid storage tank(s) and fuel tanks
- An underwater discharge pipe into a diffuser in Long Harbour
- A port operations office, lunch room and change house

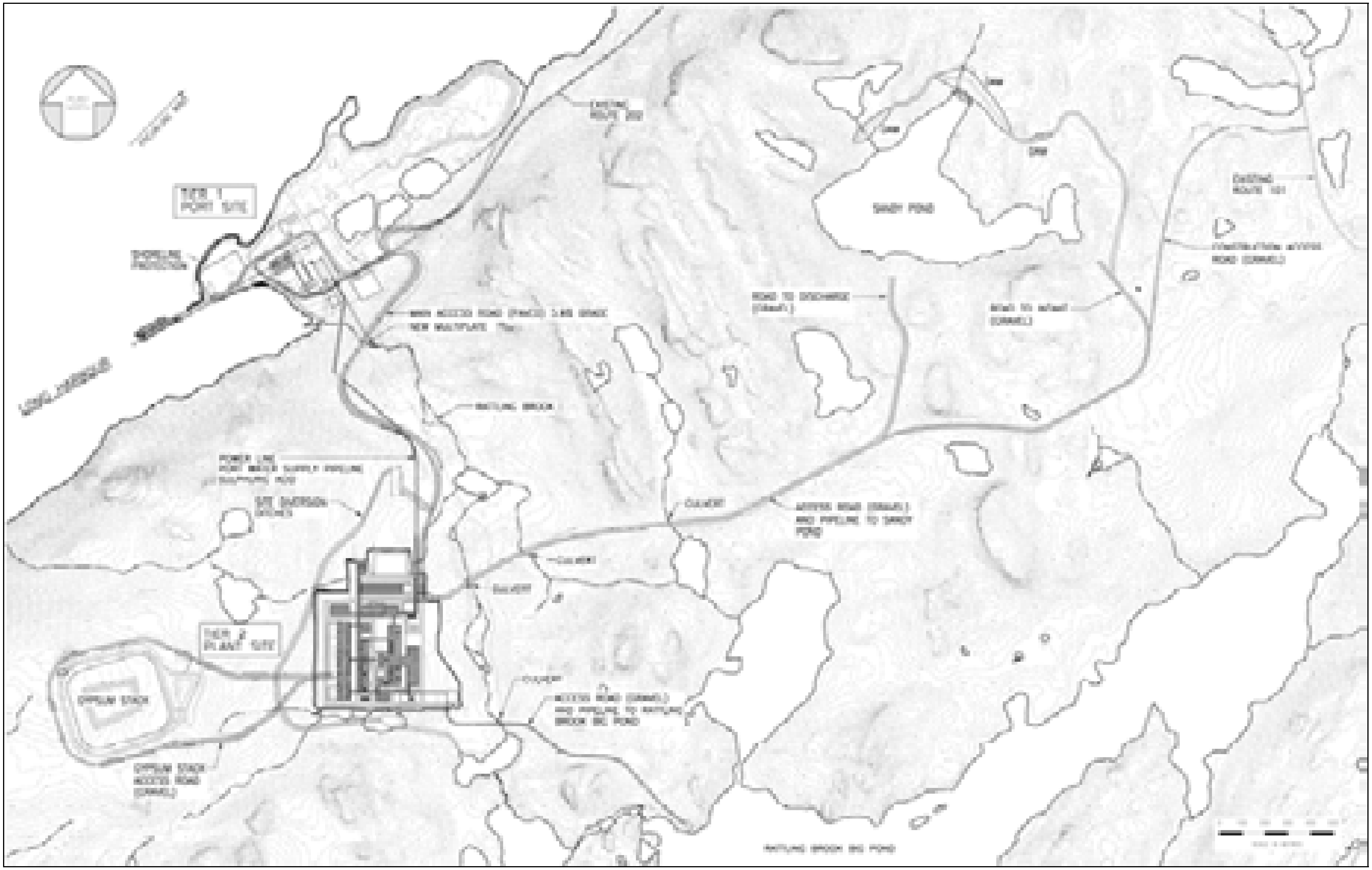

Figure 4.1 Overall Project Site Layout

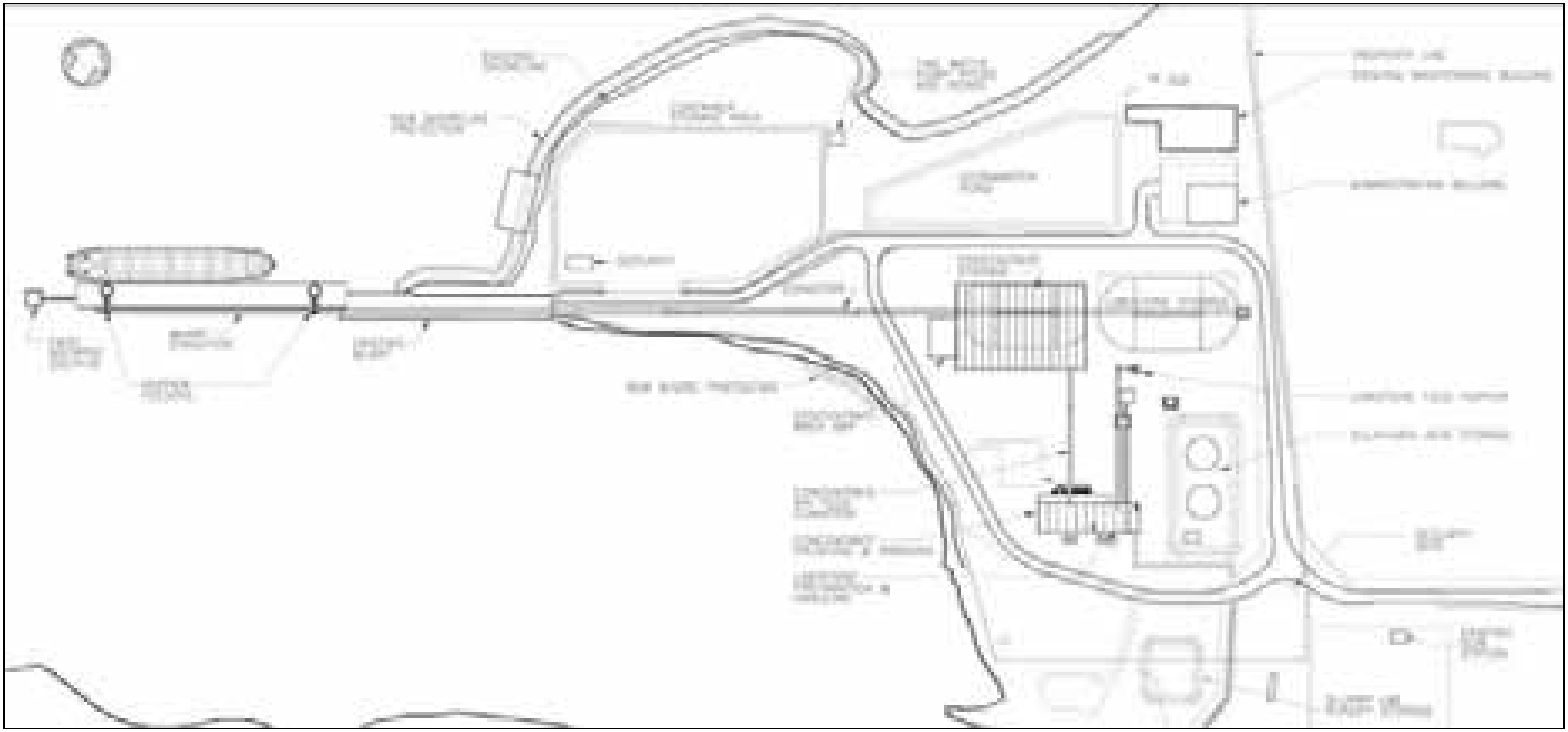

Figure 4.2 Port Site – Hydromet

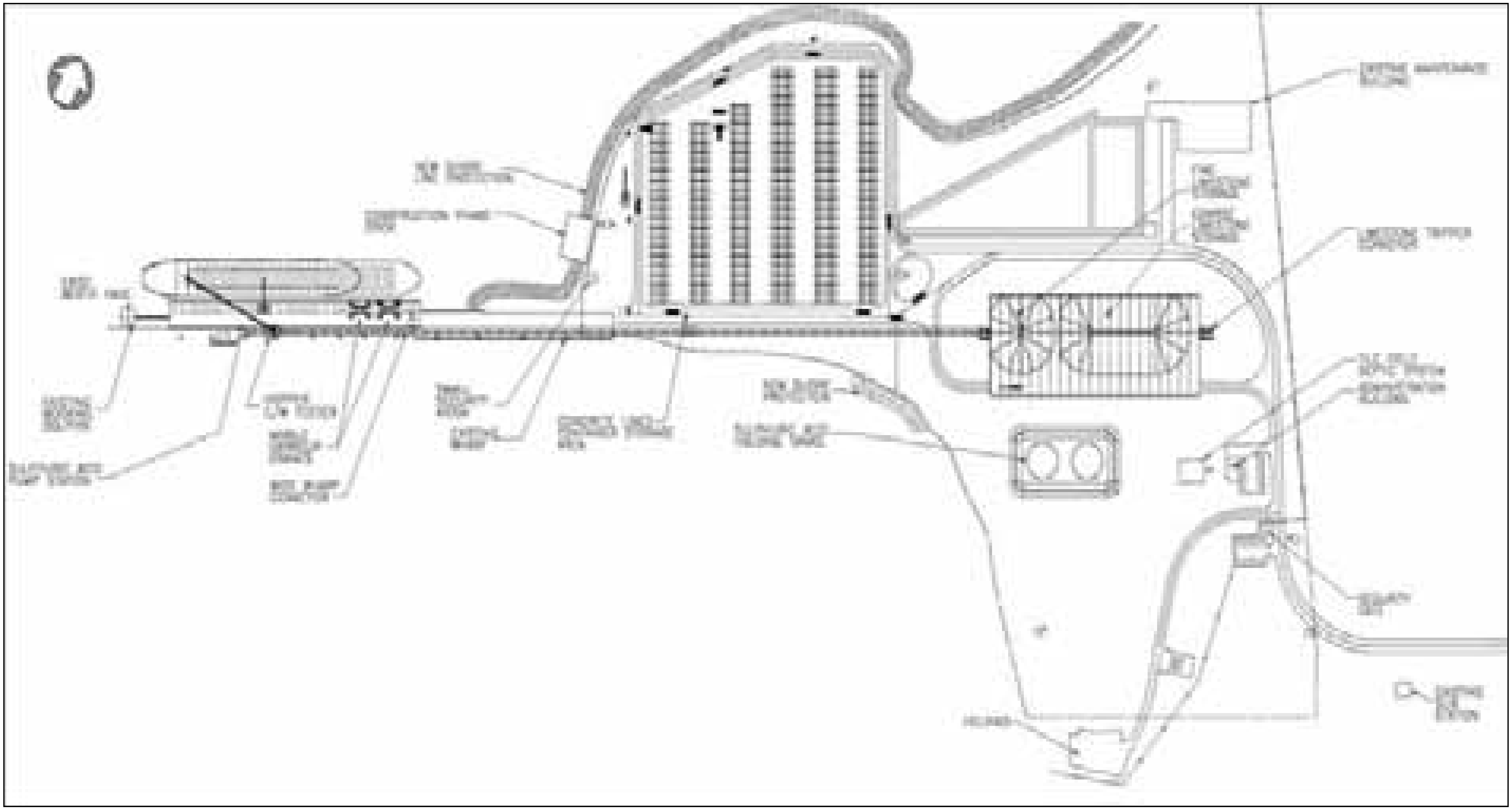

Figure 4.3 Port Site - Matte

The Plant Site facilities are listed below.

- A lime kiln to convert limestone into lime to be used for effluent neutralization
- A processing complex where the feed (concentrate or matte) is pressure leached in acid solution to separate iron and sulphur from nickel, copper, and cobalt
- A solvent extraction building to extract the nickel, copper, and cobalt for refining
- A complex for the refining of nickel, copper, and cobalt
- An oxygen plant
- A boiler plant to provide steam for heating
- A cooling tower to cool and recycle cooling, and some process, water
- Diesel and No. 2 fuel oil storage tanks
- An electrical substation
- An administration, change house, warehouse, workshops, and utility buildings
- A control room and analytical laboratory

There are several auxiliary components of the facility beyond these primary sites.

- A water supply system including a water control structure at Rattling Brook Big Pond and pipeline to the plant
- A residue storage area (Sandy Pond for underwater storage of combined residues for the Hydromet Plant, an aboveground storage area for residue storage for the Matte Plant)
- Pipelines to and from the residue storage area
- Pipelines to carry concentrate slurry, sulphuric acid, and lime and limestone slurries from Tier 1 to Tier 2 (Hydromet only)
- Access roads (between Tiers 1 and 2, between Tier 2 and the residue storage area and Rattling Brook Big Pond)
- Power lines between the substation and the sites
- A pipeline utilidor and pipe racks between Tier 1 and Tier 2
- Other site infrastructure including parking, water storage tank and pump houses, a water distribution system, an effluent treatment plant, a sewage treatment plant, a surface water drainage system, power distribution equipment, security fencing, and an access control building
- A storm water pond and effluent discharge polishing/cooling ponds
- Standby diesel generators

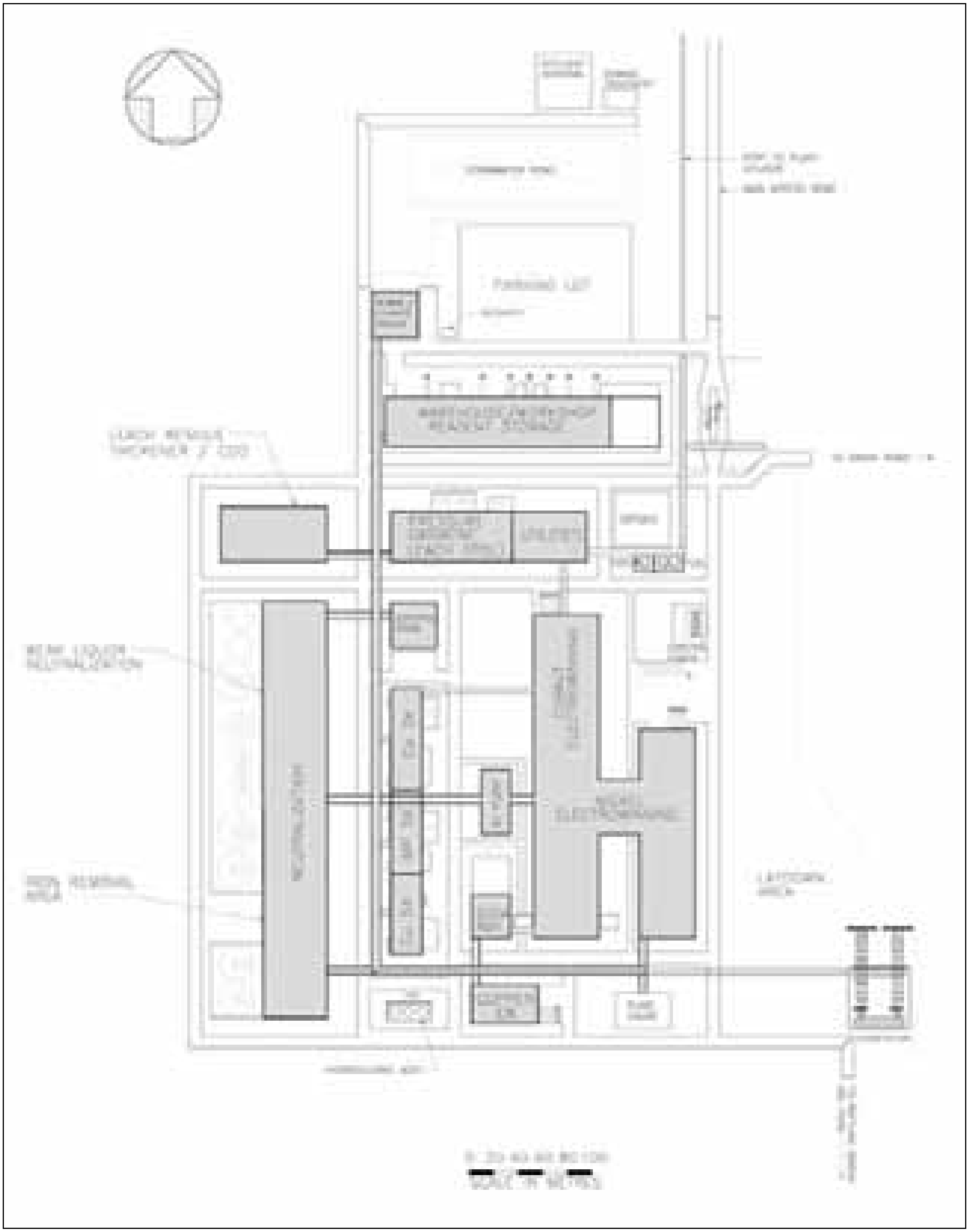

Figure 4.4 Tier 2 Site Plan – Hydromet Plant

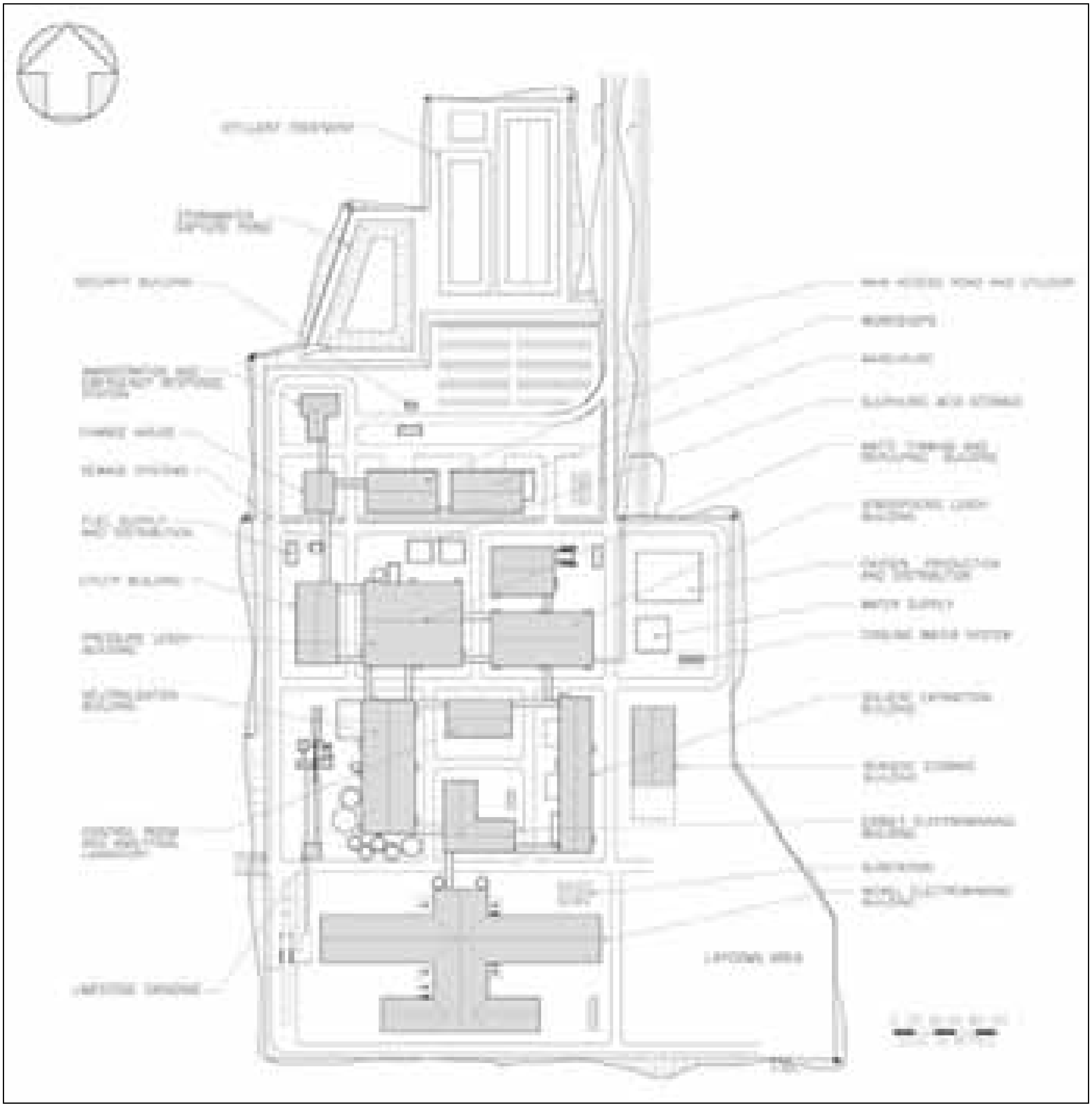

Figure 4.5 Tier 2 Site Plan – Matte Plant

Tiers 1 and 2 will occupy a total area of about 65 ha. A further 85 ha will comprise the residue pond and pipeline. Aboveground residue storage (Matte Plant) would occupy an additional 40 ha area.

Process water will be obtained directly from Rattling Brook Big Pond, located about 2 km southeast of the site. A pumphouse and pipeline will be constructed to pump water to the Plant, which will be at approximately the same elevation as the pond. A flow control structure will be constructed on Rattling Brook Big Pond to provide the flows required for fish habitat maintenance in Rattling Brook.

Access roads will be constructed between the plant site and Rattling Brook Big Pond, as well as to Sandy Pond. Treated effluent will be discharged via a 6 km line to a diffuser in Long Harbour.

A 3.8 km pipeline will be constructed to convey neutralized Hydromet slurry residue to Sandy Pond, and to return clarified water to the processing facility. Three dams will provide sufficient capacity to contain all settled residue. Decant water will be pumped back to the plant site on Tier 2, where excess water will be treated and discharged into Long Harbour. Runoff from the plant site will be collected in stormwater ponds on each Tier.

In the case of the Matte Plant, waste gypsum slurry will be transported by a pipeline to a storage site about 1.3 km to the southwest of the plant site. The storage site will be surrounded by a 4 m high containment berm. Excess water (run-off and leachate) will be collected in an adjacent clarification pond, from which the effluent will be carried by a return pipeline back to the Plant, with excess water treated and discharged into Long Harbour.

The existing wharf will be repaired and upgraded to accommodate a single 32,000 DWT vessel, with additional berthing for smaller support vessels.

The existing road to the Port Site will be upgraded and extended, and new local access and driveways constructed as necessary. A road of approximately 3 km will connect Tier 1 to Tier 2. Existing buildings, with the exception of a maintenance shed on Tier 1, will be demolished. Demolition material will be removed and disposed of by licensed third-party contractors.

Electrical power (a connected load of approximately 94 MW for the Hydromet and approximately 74 MW for the Matte) will be obtained from the provincial grid. Newfoundland and Labrador Hydro has indicated that sufficient capacity is currently available to provide the necessary power.

The proposed nickel processing plant, including auxiliary facilities, is planned to operate continuously 24 hours a day, at about a 90% operating factor.

5.0 Physical Environment and the Project

Placentia Bay is a diverse and productive ecosystem that has been of economic, social, and cultural importance for centuries. It contains large seabird colonies of international significance, relatively large populations of Bald Eagles and river otters, a number of Atlantic salmon rivers, as well as important human enterprises such as the commercial fisheries (including aquaculture), an oil refinery and transshipment terminal, shipyards, ports, and tourism facilities. The ecosystem is composed of a number of inter-related physical, chemical, biological, and human components.

5.1 Physiography and Geology

The Island of Newfoundland is divided into two physiographic regions, the Canadian Appalachian and the Atlantic Coastal Plain. The Canadian Appalachians are further divided into the Atlantic Uplands and the Carboniferous-Triassic Lowlands (Fader et al. 1982). The geomorphology of these regions is primarily the result of Quaternary glaciations.

The Atlantic Uplands is the largest geomorphic unit of the Appalachian Region, consisting of a southeasterly dipping peneplain of Precambrian and Paleozoic bedrock. This surface extends into offshore areas along the south coast of Newfoundland and generally coincides with areas of rough topography. Glacial erosion has resulted in over-deepened transverse troughs in some places.

The Atlantic Coastal Plain is underlain by Mesozoic and Cenozoic coastal plain sediments. The characteristic landforms that developed across this surface (mesas, cuestas, and deep incised valleys) formed during a period of subaerial erosion when sea levels were comparatively low. St Pierre Bank is a typical bank of the Atlantic Coastal Plain region (and the southwestern-most bank of the Grand Banks of Newfoundland), with its shallowest point (31 m) occurring at its northwest corner, but in general being less than 115-120 m deep (corresponding to low sea levels 14,000–15,000 years ago). Halibut Channel is an extension of Placentia Bay; it borders the eastern side of St Pierre Bank, and separates it from Green Bank further to the east (Fader et al. 1982; Wade and MacLean 1990).

The Project site is situated on the southern side of Long Harbour on the Avalon Peninsula. Precambrian bedrock of the Musgravetown Group, which underlies the proposed plant site and Sandy Pond, consists of volcanic flows and tuffs, and pyroclastic and clastic sedimentary rocks of the Bull Arm, Big Head, and Maturin Ponds Formations. Bedrock structures are characterized by open folds with NNE-SSW-oriented axes that generally run sub-parallel to the eastern shoreline of Placentia Bay. These lithologic units are cut by younger fault systems that are oriented NE-SW, such as the fault at the head of Long Harbour and another that intersects Ship Harbour, running through and defining the general NE-SW orientation of Rattling Brook Big Pond and a series of smaller ponds connected to it (King, 1988).

The bedrock within the Project Area is overlain by glacial till, locally consisting of relatively thin till blankets (about 1.5 m thick), hummocky tills (with local topographic relief of 2-10 m), ridged tills (where till ridges are oriented parallel or perpendicular to Late Wisconsinian ice flow directions), and glaciofluvial sands and gravels (Batterson et al. 2006).

Lying above Tertiary and older bedrock in the marine environment are unconsolidated Quaternary sediments deposited during and subsequent to the Late Wisconsinian glaciation. In recent years, the Geological Survey of Canada (GSC) has been using digital multibeam bathymetric surveying techniques as a primary reconnaissance tool for marine geological mapping. Although little published information is available for Long Harbour, multibeam images and a preliminary interpretation of the seabed geology has been obtained for the area (John Shaw, GSC, pers. comm.; Shaw et al. 2006).

Two principal acoustic units occur within Long Harbour, one a hard, ice-contact sediment, possibly glacial till, that forms ridges on the seabed, and the other a soft postglacial mud unit. Toward the mouth of Long Harbour, the hard ridges are oriented NNE-SSW, which may reflect the similar trending bedrock structures on each side of, and presumably underlying, the harbour. Alternatively, these ridges may have been formed parallel to the flow direction of Late Wisconsinian ice, which was centred on Collier Bay Brook on the Avalon isthmus (Batterson and Taylor 2003).

Toward the head of the bay, just seaward of the Long Harbour pier, is a shallow shelf, at -16 m elevation, that is interpreted as a Holocene submerged fluvial delta composed of prograded gravel and sand. This was formed during a low stand of relative sea level. Along the Long Harbour shoreline is a submerged erosional platform, down to the lowstand depth of -16 m.

5.2 Coastal Geomorphology

The shoreline along Placentia Bay is heavily influenced by major storm events, particularly hurricanes, and their associated waves. Because the angle of approach of major storm waves is variable, shoreline sedimentary processes can vary significantly at different times at the same location. Nevertheless, Catto et al. (2003) have developed a classification system of Newfoundland’s eastern shorelines based on substrate, sediment, width, and profile, and have evaluated various stretches of coastline in terms of vulnerability to erosion.

In general, the eastern Placentia Bay shoreline running from Little Harbour to Argentia (Figure 5.1) is assessed as having moderate to high sensitivity to coastal erosion (Long Harbour is assessed as high), with the exception of Fair Haven, where the beach has a very high vulnerability. Rocky headlands, gravel pocket beaches, and rock platforms are the dominant shoreline types.

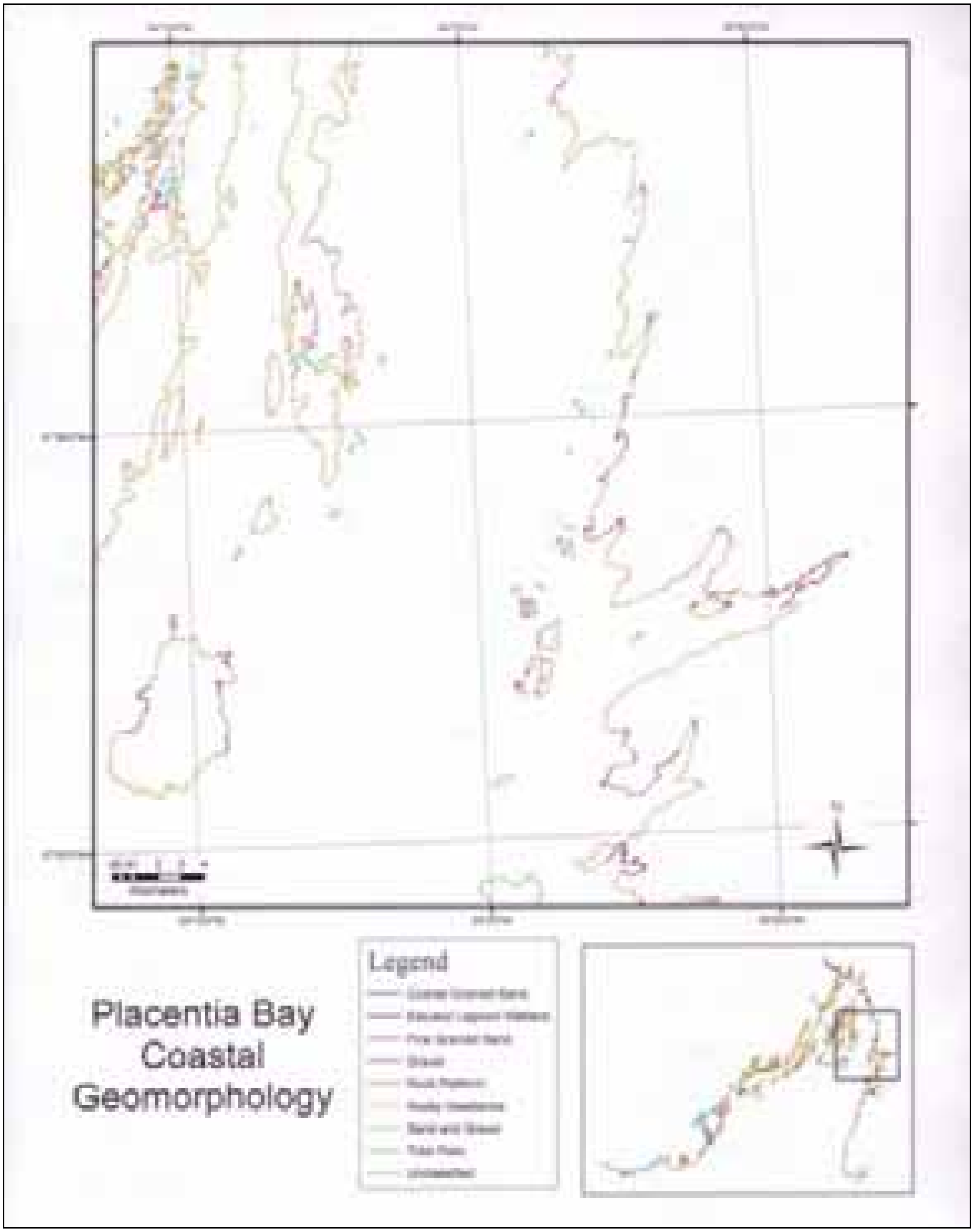

Figure 5.1 Shorelines of Eastern Placentia Bay from Little Harbour to Argentia (including Long Harbour)

Note: The shoreline along this stretch of coast is dominated by rocky headlands, gravel pocket beaches, and rocky platforms with minor sand & gravel beaches. The southern shoreline of Long Harbour is dominated by rocky headlands, followed by gravel pocket beaches and rock platforms. Minor sand & gravel beaches and an estuarine / lagoon / wetland is found at the mouth.

Source: Ollerhead, unpublished data**.**

5.3 Seismicity

Eastern Canada is located in a stable continental region of the North American plate and, as a consequence, has a relatively low rate of seismic activity typical of "passive" continental margins. Nevertheless, earthquakes have been recorded along the eastern continental margin, including the "Grand Banks" earthquake of November 1929 (epicentre at 44.69° N latitude, 56.00° W longitude, 20 km depth).

Earthquakes can pose hazards to structures and activities. These effects may include ground shaking; surface faulting; regional scale subsidence and uplift; seabed liquefaction, and effects such as slides, slumps, and turbidity currents; tsunamis; and possible damage to floating structures due to acoustic shock waves (Keen et al. 1990). For this reason, it is important to evaluate the risk posed by seismic activity.

In Canada, the evaluation of regional seismic hazard for the purposes of the National Building Code (NBC) is the responsibility of the Geological Survey of Canada (GSC). Seismic hazard maps prepared by the GSC are derived from statistical analysis of past earthquakes and from advancing knowledge of Canada's tectonic and geological structure. Seismic hazard is expressed as the most powerful ground motion expected to occur in an area for a given probability level. Contours delineate regions likely to experience similar ground motions. Figure 5.2 indicates relative seismic hazard across Canada.

The seismic hazard maps and earthquake load guidelines included in the NBC are used to design and construct buildings to be as earthquake-proof as possible. While the provisions of the building code are intended as a minimum standard for human protection, they may not prevent serious damage to individual structures.

Canada has been divided into earthquake source regions based on past earthquake activity and tectonic structure. The relation between earthquake magnitude and the average rate of occurrence for each region is weighed, along with variations in the attenuation of ground motion with distance. In calculating seismic hazard, scientists consider all earthquake source regions within a relevant distance of the proposed site. The Project site is located in an area with relatively low seismic hazard (Figure 5.2).

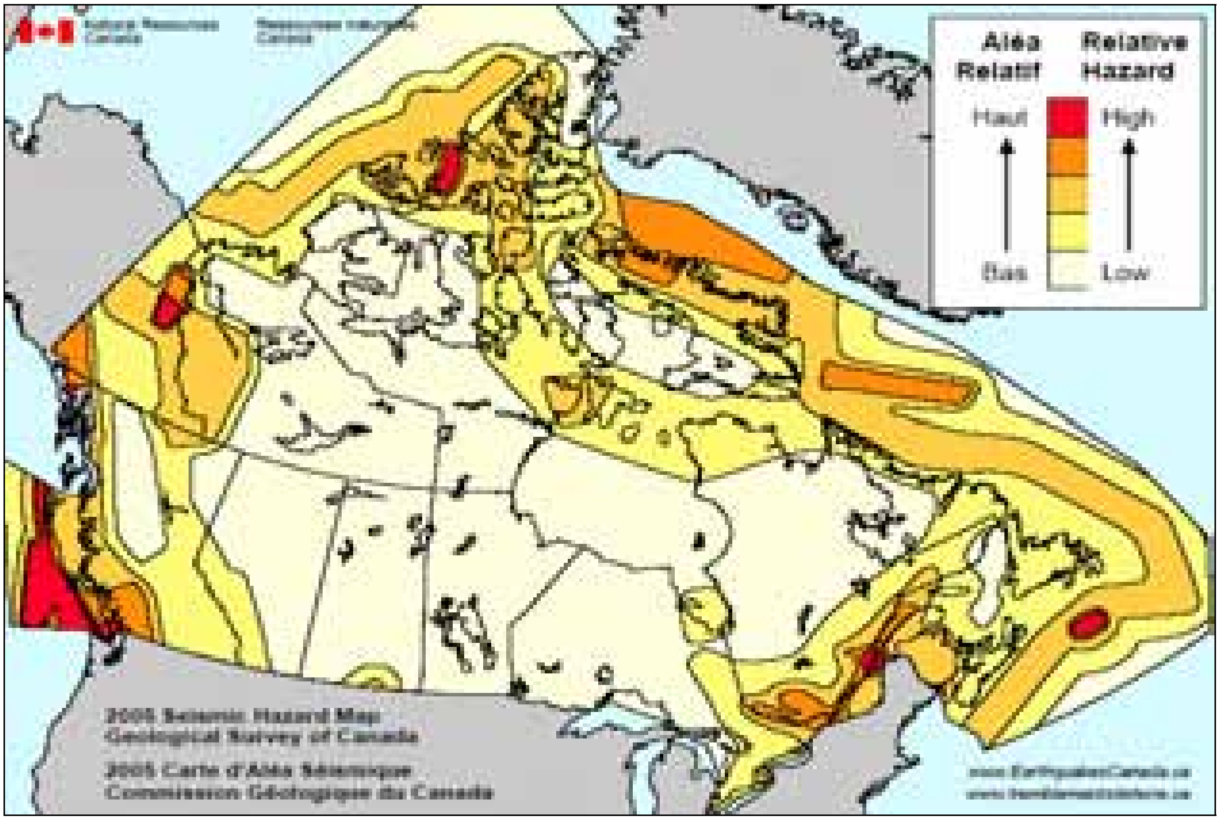

Figure 5.2 Seismic Hazard Map of Canada

Source: NRCan (2006).

5.4 Physical Oceanography

The following Chapters outline the bathymetry, currents, temperature and salinity characteristics, waves, ice conditions, and storm surges in Placentia Bay in general and Long Harbour in particular. More comprehensive data can be found in the Component Study (Oceans 2007).

Placentia Bay Bathymetry

The Placentia Bay coastline is irregular with a large number of bays, inlets, and islands. Large islands (Merasheen, Long and Red islands) are located in the middle of the inner section of the bay together with other smaller islands. The bathymetry of Placentia Bay is also very irregular, with many banks and troughs (Figure 5.3). The water depth at the mouth of the bay is approximately 200 m. There is a deep channel on the eastern side with water depths extending to approximately 300 m in some locations. A deep channel south of Merasheen Island, with a maximum depth of 350 m, is oriented in a northwest/southeast direction across the bay. White Sail Bank, Merasheen Bank, and Bennett Bank are located on the southern side of this channel. In general, the water is shallower on the western side of the Bay than on the eastern side, with the exception of these deep troughs.

Figure 5.3 Bathymetric Structure of Placentia Bay

Long Harbour Bathymetry

Long Harbour is situated on the eastern side of the bay, east of Merasheen Island and Red Island (Figure 5.4). The water depth in the mouth of Long Harbour near the southern side is approximately 70 m, and the mean water depth is approximately 50 m. Shag Rocks is located near the mouth of the harbour. Between Shag Rocks and the northern shore there is a bathymetric ridge with a water depth of approximately 20 m. In the centre of the harbour, between Shag Rocks and Crawley Island, the water depths vary between 40 m and 70 m. At Crawley Island the harbour splits into two branches, St. Croix Bay to the north and the main portion of Long Harbour to the south. The outer section of St. Croix Bay has a mean water depth of approximately 40 m, and the inner section has a mean depth of approximately 20 m. Long Harbour has a mean depth of approximately 30 m, with the exception of a bathymetrical mound in the middle of the area with a water depth varying between 13 m and 17 m.

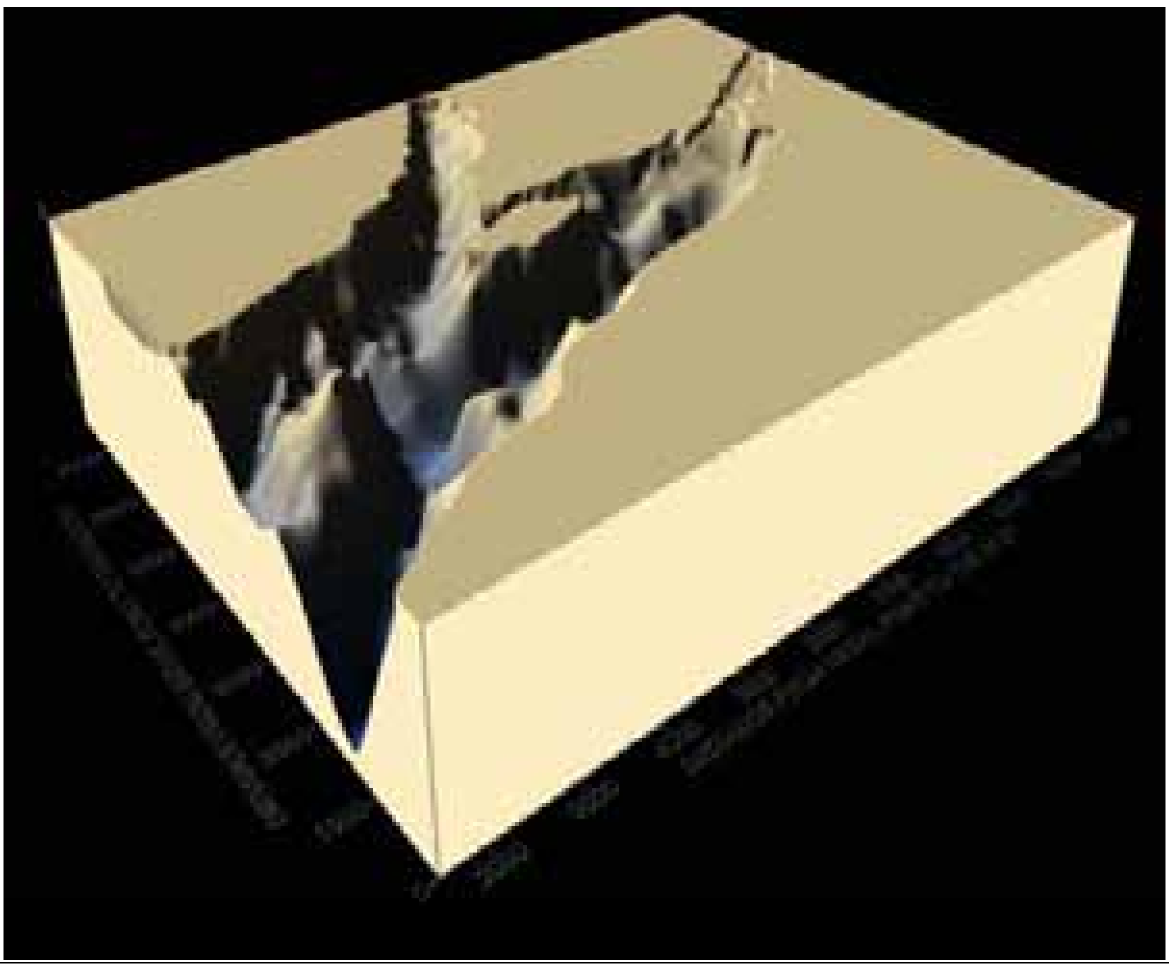

Figure 5.4 Bathymetric Structure of Long Harbour

Currents in Placentia Bay

Studies published by Memorial University of Newfoundland (MUN) and the Bedford Institute of Oceanography (BIO) suggest that currents in Placentia Bay follow a cyclonic (counter-clockwise) circulation pattern. They describe the eastern side of the bay as dominated by currents flowing into the bay, while at the western side the currents are usually flowing towards the open ocean. The MUN data (1999) for near-surface waters clearly show a persistent counter-clockwise flow around the bay. A cross-bay current flow has also been described, with currents flowing predominantly toward the east on the eastern side of the bay, and towards the west on the western side.

A summary of weekly mean magnitudes and directions indicates that the cyclonic circulation pattern around the bay is fairly stable in the near-surface waters. The mean circulation for depths of 20 m (Schillinger et al. 2000) is shown in Figure 5.5. The axes at the base of the arrows in these figures indicate the standard deviation of the current along the direction of maximum variance, and perpendicular to it.

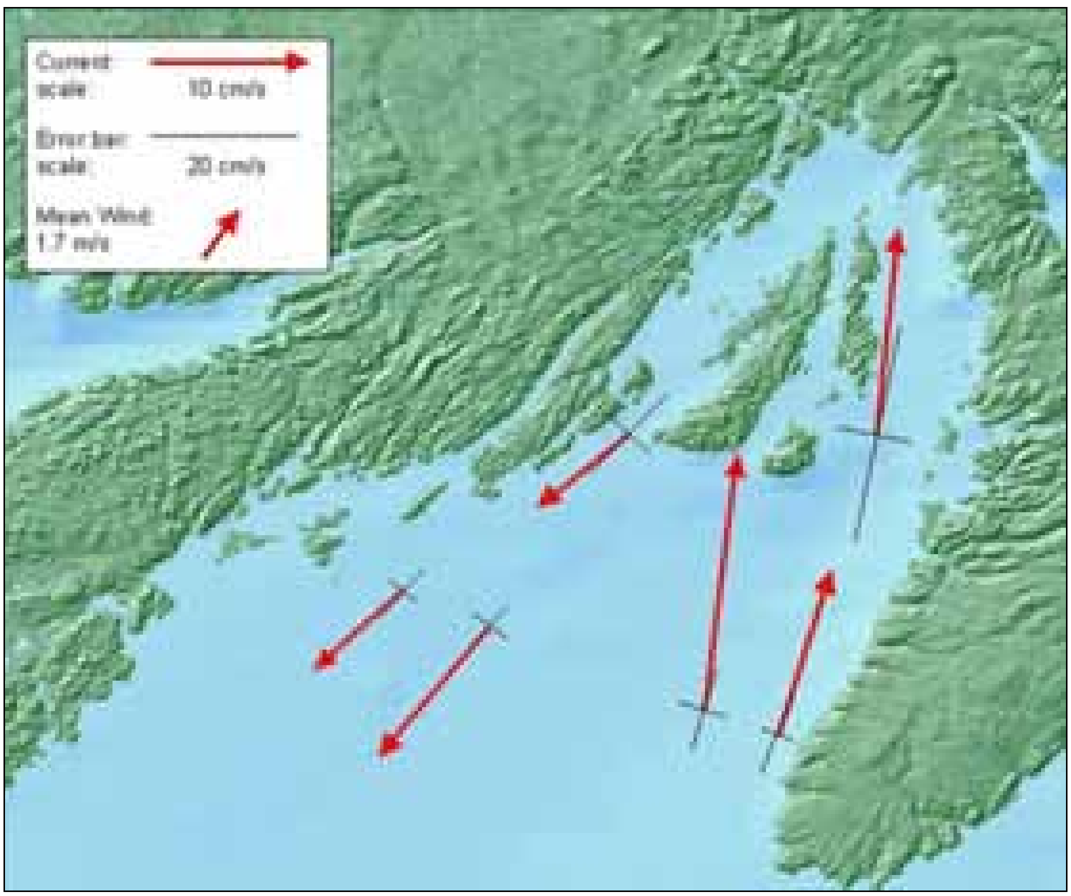

Figure 5.5 Mean Circulation in Placentia Bay at 20 m

Source: Schillinger et al. (2000).

The currents measured on the eastern side of the bay had a residual flow of 17.6 cm/s near the mouth and 15.6 cm/s at a location outside Long Harbour, with maximum current speeds of 75 cm/s and 78.7 cm/s, respectively. On the western side the residual current was 7.1 cm/s, and the maximum speed was 49.7 cm/s. The maximum current speed measured in 1998 (10 m depth) was 58.0 cm/s on the eastern side of the bay and 61.6 cm/s on the western side.

The counter-clockwise flow in the bay was predominant at depths from 36 m to 55 m. At 100 m and deeper, however, this pattern of flow was no longer a dominant feature. On the eastern side of the bay, at a depth of 110 m, the flow was mainly in a northeast and east direction during March and April, and then switched to east and southeast in May and June. At 180 m on the western side of the bay the flow remained in a predominantly southwest direction.

Outside Long Harbour, at a depth of 104 m, the flow was mainly towards the north in April and towards the southwest in May; the flow had similar characteristics west of the southern tip of Merasheen Island, predominantly towards the northeast in April, towards the southwest in May and early June, and then northeast until the end of the sampling record.

The data were analysed to determine the contribution of tides to the overall flow. The results of the harmonic analysis showed that the lower frequency components on the synoptic scale (order of days) contributed to the overall current flow. This contribution was particularly important in the surface water outside Long Harbour, and at measured locations on the eastern side of the bay.

An analysis of the BIO data collected during winter and fall 1988 also supports the existence of a counter-clockwise flow in the near-surface waters the persists during both seasons. However, the BIO data do not support a persistent counter-clockwise cyclonic flow at depths of 49 m and 56 m. The counter-clockwise cyclonic flow was observed in winter but not in fall, when the flow was in the opposite direction, with south-southwest currents observed on the east side of the bay and east southeast currents at the head of the bay.

A statistical summary of the average and maximum speeds from the BIO data is presented in Table 5.1. The maximum current speeds tend to be higher near the surface. The maximum current speed of 74.8 cm/s occurred on the east side of the bay at a depth of 22 m, during the winter sampling period.

The overall contribution of the tidal currents to the total current variability was approximately 15%, with a minimum contribution of 8% near the surface on the east side of the bay and a maximum contribution of 33% at a depth of 49 m at the head of the bay.

Table 5.1 Statistical Summary of Current Speed from the BIO Data Set

LOCATION	SEASON	DEPTH (M)	AVERAGE SPEED (CM/S)	MAXIMUM SPEED (CM/S)
East	**Fall**	23	13.4	57.0
		56	10.3	45.1
	Winter	22	12.1	74.8
		60	13.2	57.8
North	**Fall**	16	12.1	44.5
		49	8.8	52.0
	Winter	25	8.4	29.4
		63	6.1	17.9
West	**Fall**	21	9.1	37.3
		54	8.7	32.8
	Winter	15	11.5	43.4

Currents in Long Harbour

The circulation pattern is the combined result of tides, winds, and the Labrador Current. Since the variability due to tides is no greater than 15% of the total variability, the other factors dominate. Winds in the area are predominantly from the southwest during all seasons, which would contribute to a counter-clockwise pattern in the near-surface waters. The inshore branch of the Labrador Current follows the bathymetric contours around the Avalon Peninsula. North of Green Bank, the direction of the bathymetric contours shifts from an east/west orientation into Placentia Bay and becomes the major contributor to the overall current variability. A portion of the north-northeast flow following the bathymetric contours on the east side of Placentia Bay would continue to follow the contours into Long Harbour, and be the major contributor to the overall current circulation in the harbour.

Current measurements in Long Harbour were made by BIO over a 29-day period at three locations during summer of 1969, and by Oceans Ltd. at five locations for VBNC during summer and fall 2006. The locations of the current meter moorings are shown in Figure 5.6.

The data demonstrate a complex current system not unusual for a coastal inlet with irregular bottom bathymetry. Analysis of the current data in conjunction with Conductivity, Temperature and Density (CTD) data collected throughout the harbour showed that the circulation in Long Harbour was mainly driven by the circulation in Placentia Bay. Tidal measurements and analysis of tides from the current meter records showed that tides played a minor role. Winds played a modifying role, both directly and indirectly. The winds are strong enough on a daily basis in Long Harbour to play a direct role in the creation of wind-driven currents in the top few metres. Since winds are predominantly from the southwest (into the bay), there is a tendency for the wind driven currents to push water against the shore and reverse direction at deeper levels. Reversals in currents were measured by an acoustic doppler current profiler (ADCP) deployed in 32 m of water west of the existing wharf.

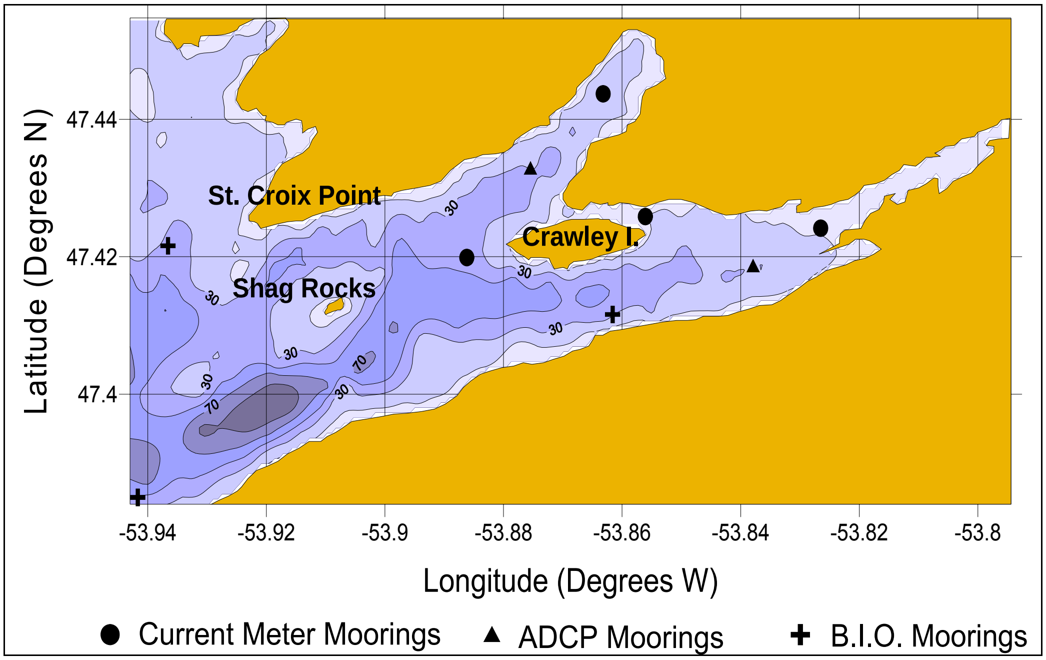

Figure 5.6 Locations of Current Meter Moorings in Long Harbour

Reversals in currents are also produced by internal waves whenever there are internal density boundaries, a source of energy such as the wind, and bathymetric features such as the mound in the central region of the southern arm. The mean currents at the location of the ADCP were low, varying from 3.9 cm/s at a depth of 6 m to 2.7 cm/s at a depth of 26 m.

Trites (1969), using surface drogues at a depth of six metres, showed that wind direction influences the amount of Placentia Bay water entering Long Harbour. When the winds are from the northeast, directed out of the harbour, there is a strong outflow of surface-layer water on the north side of Long Harbour and a small inflow of surface water on the south side. When the winds are from the southwest (the dominant direction) there is a strong inward flow on the south side of the harbour.

Current data collected at a depth of 6-7 m in the southern arm of the harbour are shown in Figure 5.7. South of Crawley Island, the current flows towards the east along the southern shore. West of the existing wharf, the current flows in all directions. East of Crawley Island, the flow is towards the southwest, following the bathymetric contours around the eastern side of the island.

The surface currents are toward the northeast in St. Croix Bay because of the predominantly southwest winds (Figure 5.8). The flow had two preferred directions at the entrance to St. Croix Bay, northeast and southwest. The mean current speed was 3.3 cm/s and the maximum speed was 20.3 cm/s.

The general circulation pattern in the outer section of Long Harbour is shown in Figure 5.9. The BIO data from 1969, measured at the southern entrance to the harbour at a depth of 72 m, show that the current is flowing into the harbour on the southern side. The current measurements by Oceans Ltd. at a depth of 25 m west of Crawley Island show that the current is mainly towards the northeast, with a mean speed of 5.7 cm/s and a maximum speed of 28.9 cm/s. At the northern entrance to the harbour, the BIO data measured at four metres depth had a mean speed of 8.8 cm/s and a maximum speed of 38.8 cm/s, directed towards the northwest, out of the harbour. The current measurements indicate that, in general, the flow is directed into the harbour on the southern side and out of the harbour on the northern side, with an exchange between north and south taking place between Shag Rocks and Crawley Island.

Water Properties

Temperature and salinity data were collected by MUN from April to June of 1998 and 1999. Temperature increased and salinity decreased from April to June (Hart et al. 1999) in the upper 50 m of the water column throughout the bay. The increase in temperature was attributed to general atmospheric warming from spring to summer, and the decrease in salinity was due to local river runoff and increased precipitation during spring. This pattern was reversed at depths greater than 55 m. The temperatures decreased from April to June and the salinities increased. The temperatures ranged from 0.1°C in April to 11.2°C in June for near-surface depths (Hart et al., 1999). At deeper levels the temperatures ranged from 1.2°C to -0.5°C.

Additional information on the spatial distribution of temperature and salinity in Placentia Bay was obtained from BIO. Figure 5.10 shows the warming trend that takes place during the summer season. The surface temperatures varied between 13°C in the middle of the bay to 19°C at the head of the bay in August. Figure 5.11 shows the decrease in salinity as summer progresses, and the lower salinity caused by river runoff in June at the head of the bay and near the shore. Temperature decreases and salinity increases between June and August at a depth of 100 m. The coldest water (-1.3°C) is present near the mouth of Placentia Bay.

Limited amounts of CTD data are available for the winter months. In general, during winter the horizontal fields of temperature and salinity appear to display a great degree of homogeneity. The temperature varied between -0.8°C near the mouth of Placentia Bay to 0°C near the head of Placentia Bay and along the western shore at the surface during February. On the eastern side of the bay the surface temperature varied between -0.4°C and -0.6°C. Similar characteristics were observed at deeper levels. The salinity was slightly higher at the mouth of the bay and along the eastern shore than elsewhere, corresponding to the lower water temperature.

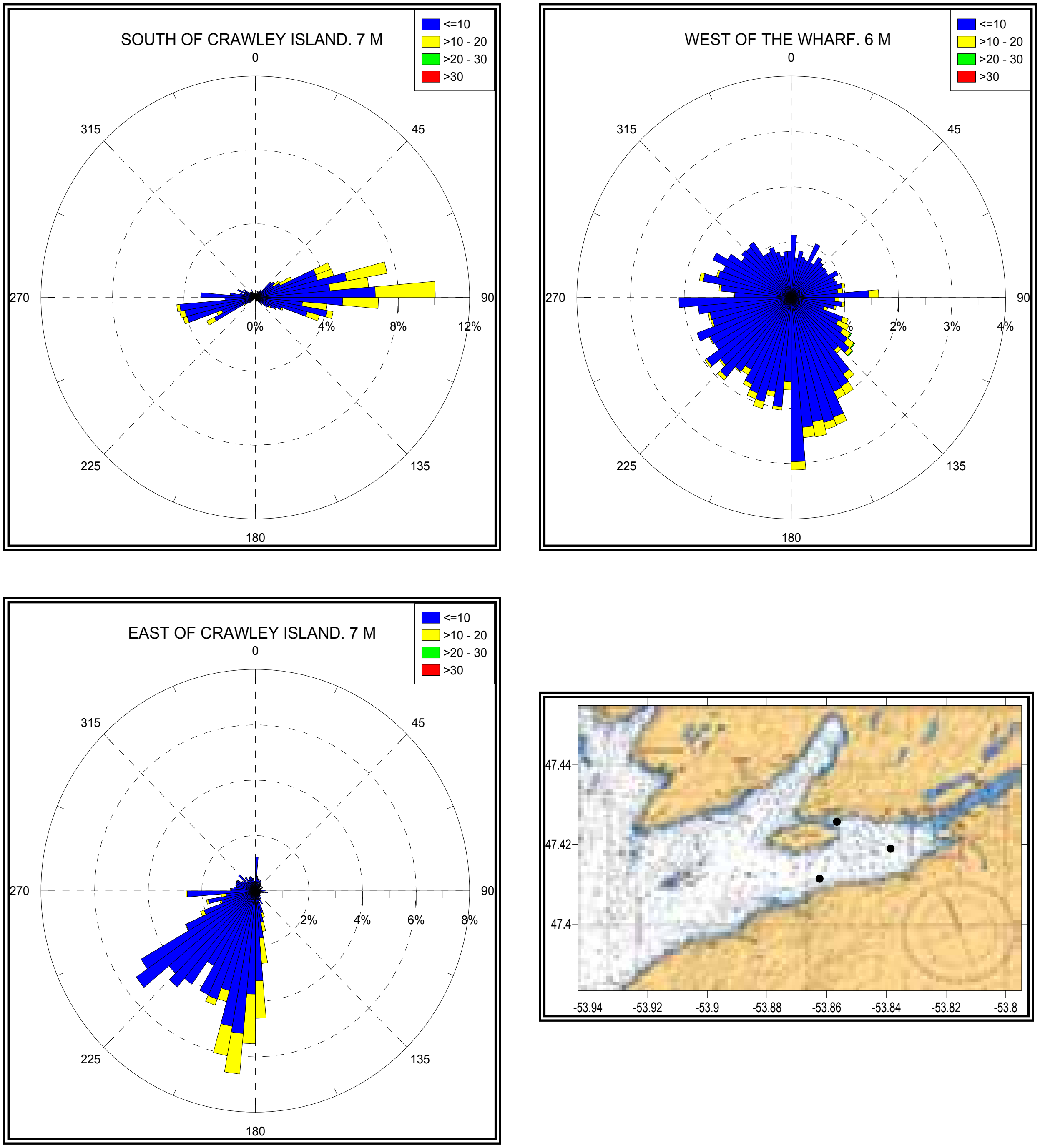

Figure 5.7 Rose Plots of Current Speeds and Directions in the Southern Arm of Long Harbour, and Sampling Sites

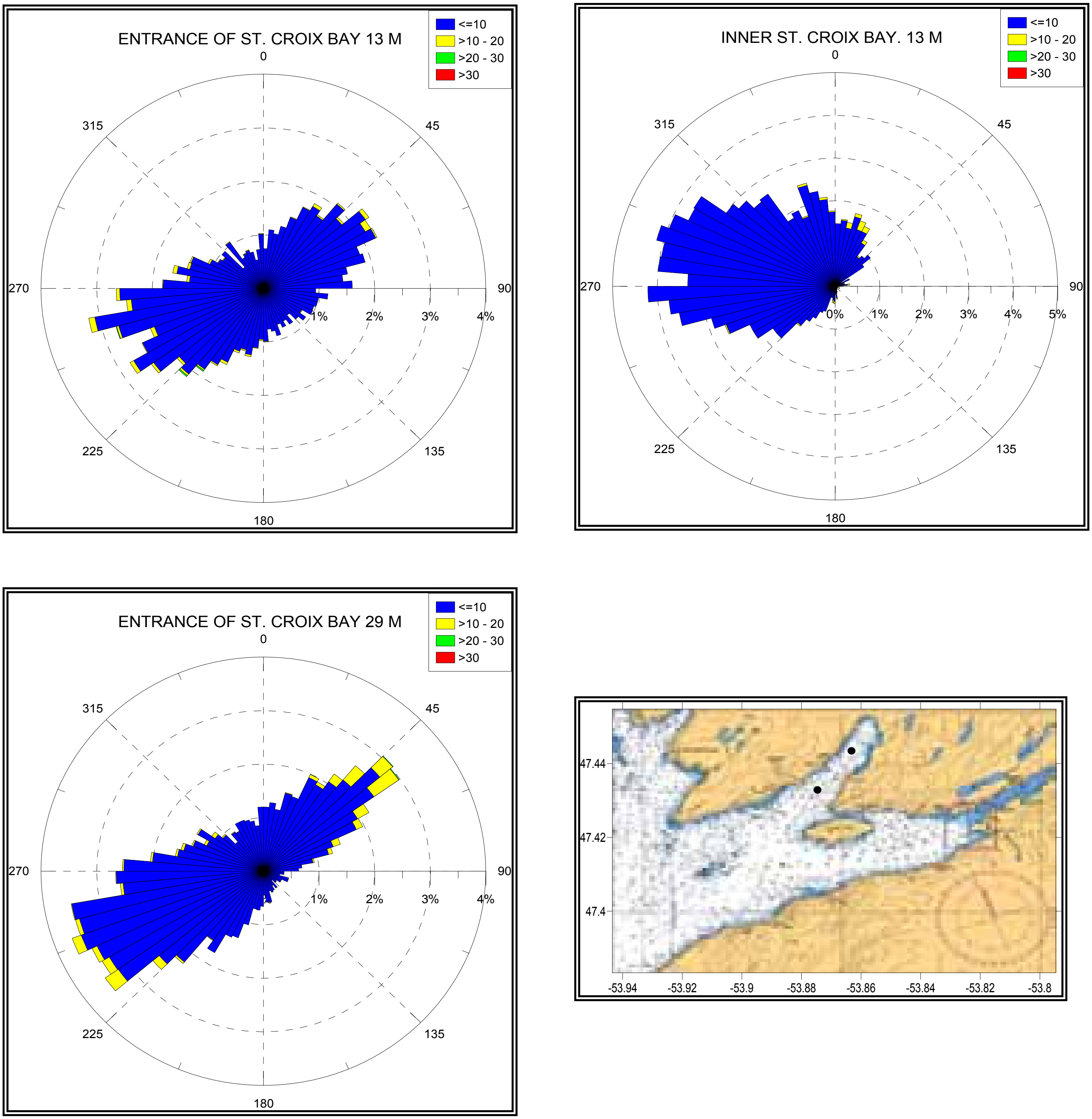

Figure 5.8 Rose Plots of Current Speeds and Directions in St. Croix Bay, and Sampling Sites

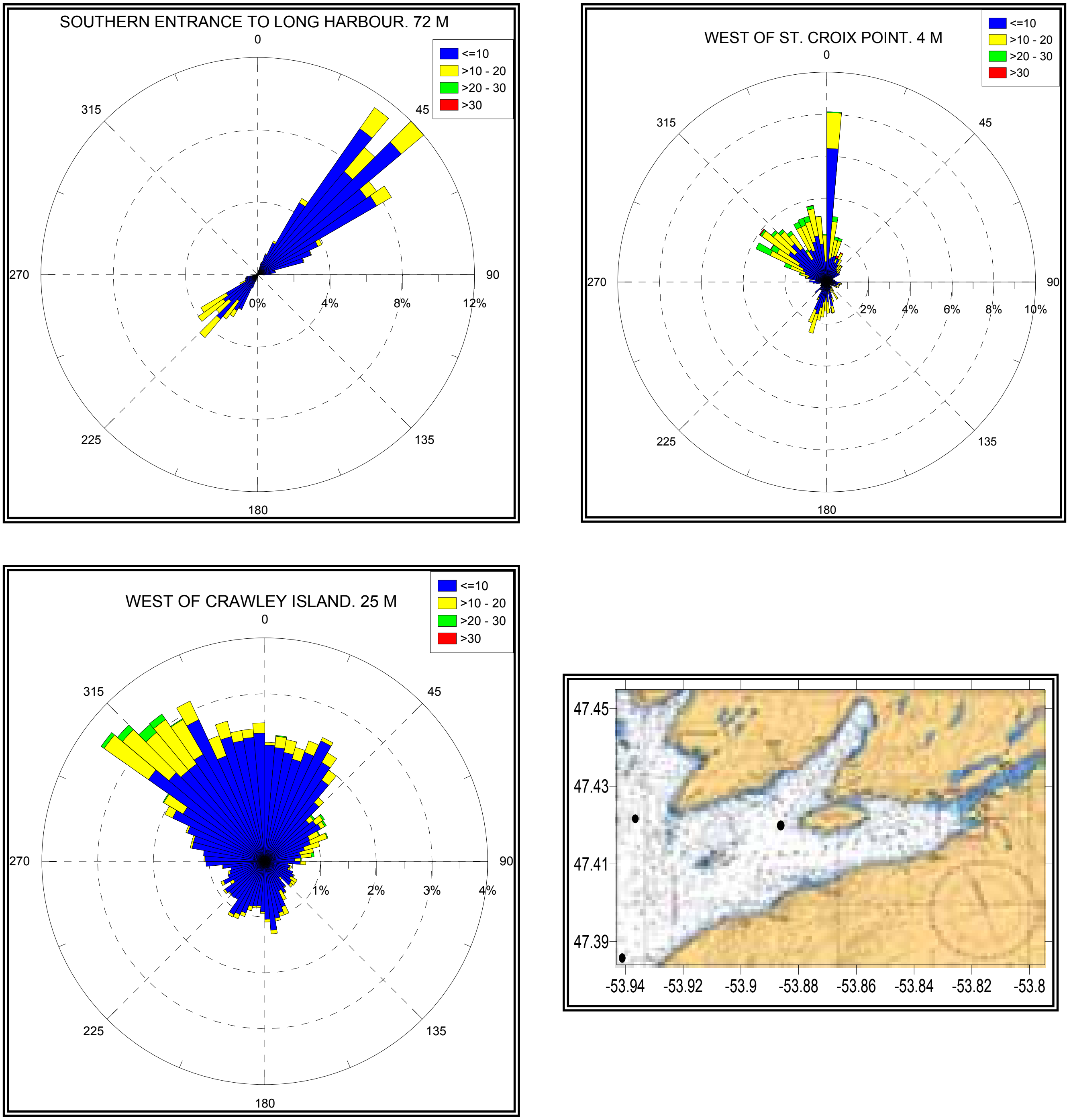

Figure 5.9 Rose Plots of Current Speeds and Directions in the Outer Section of Long Harbour, and Sampling Sites

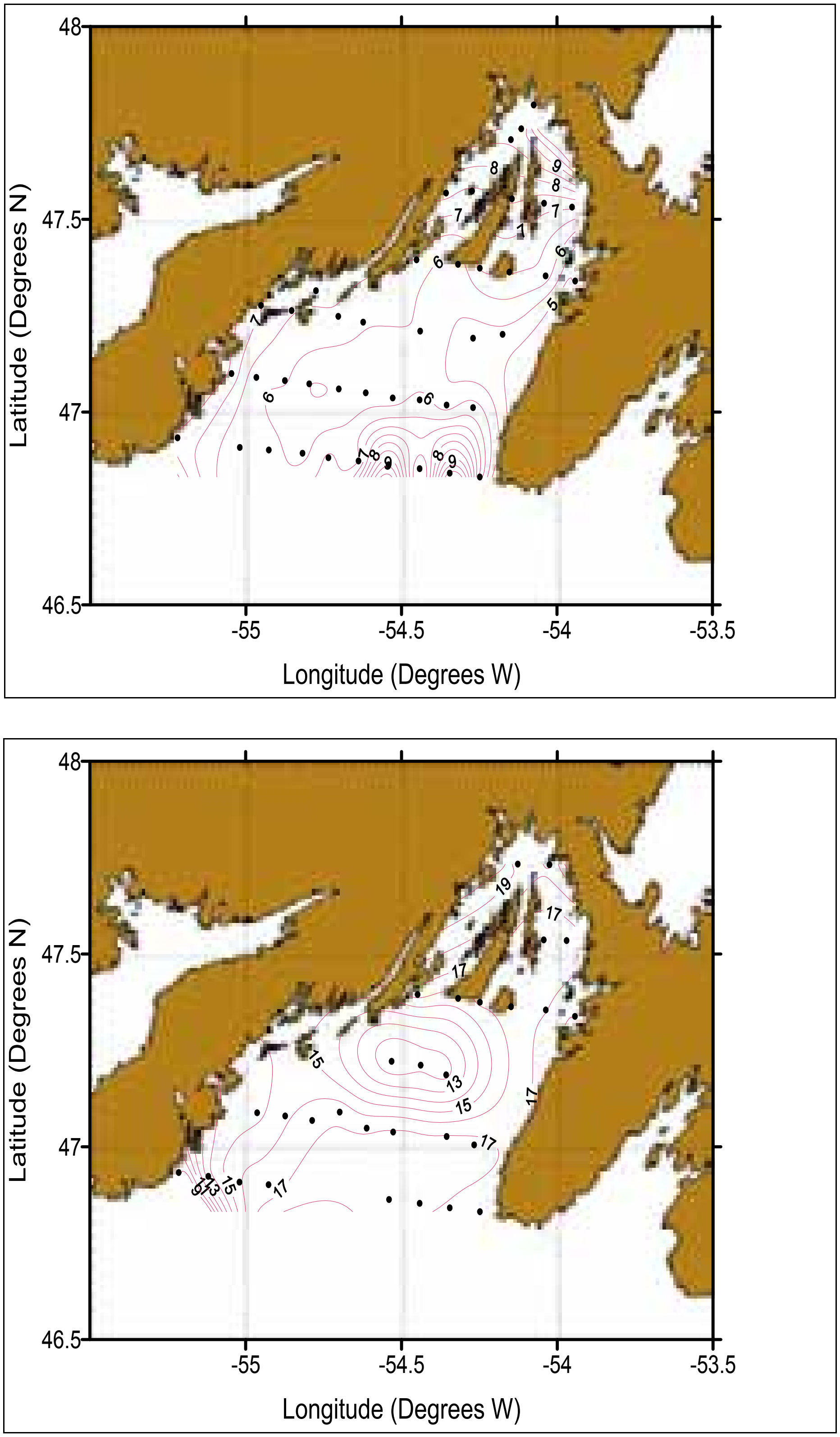

Figure 5.10 Temperature (° C) Distributions in June (above) and August (below), 1998

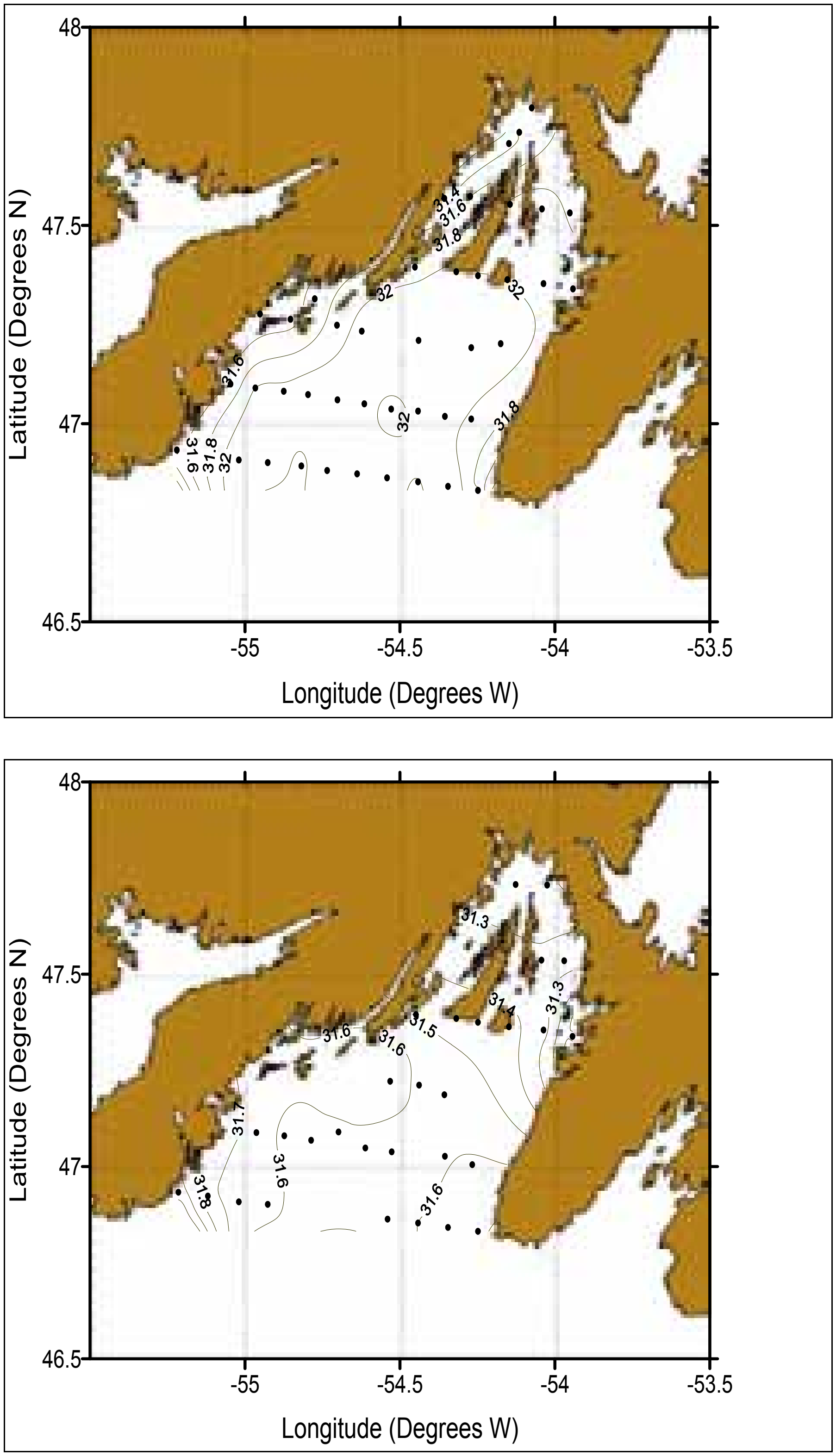

Figure 5.11 Surface Salinity (psu) Distribution in June (above) and August (below), 1998

Temperature-salinity (TS) profiles of the water properties at the mouth of Placentia Bay, and for Labrador Current water northwest of Green Bank display water properties that are almost identical, which means that the water entering Placentia Bay is Labrador Current water.

CTD measurements were conducted by Oceans Ltd. in Long Harbour on May 17, July 11, and August 16, 2006 (Oceans Ltd. 2007). The most significant feature is the presence of a deep mixed layer to a depth of approximately 25 m, below which exists a sharp pycnocline between 25 m and 30 m, and then a weak stratified water mass near the bottom. The local wind mixing in Long Harbour only extended to depths between four metres and eight metres. Figure 5.12 compares the water structure within Long Harbour to that in Placentia Bay. The depth profiles indicate that the 25 m mixed layer in Long Harbour is water transported from Placentia Bay.

The mass transport from Placentia Bay to Long Harbour serves as an efficient flushing agent, replacing water in the outer section of the harbour in a relatively short time. The flushing time of water above 20 m is calculated to vary between 10 and 15 days during summer (Oceans Ltd. 2007).

The VBNC oceanographic studies by Oceans in 2006 (LGL 2007) indicated an area of oceanographic mixing between Shag Rocks and Crawley Island. As a result, a general area about 5 to 6 km off the existing wharf (Figure 7.6) was selected as a suitable outfall location, where the treated effluent would be well mixed with surrounding water, and any potential contaminants not returned into inner Long Harbour or accumulate in the water or sediments of the harbour, or Placentia Bay.

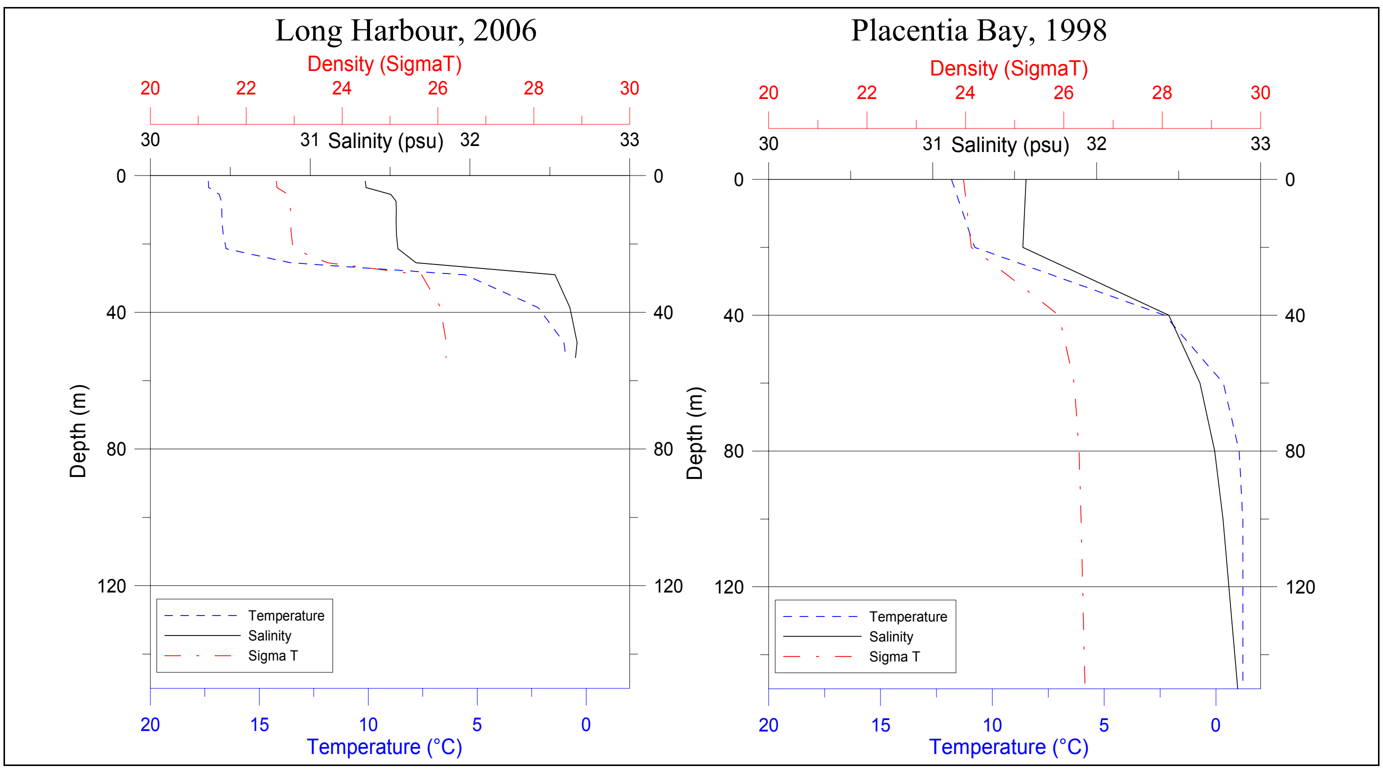

Figure 5.12 Water Structure in Long Harbour and Placentia Bay

Wave Climate

There are four parameters for describing wave conditions. Significant wave height is defined as the average height of the 1/3 highest waves, and its value roughly approximates the characteristic height observed visually. Maximum height is the greatest vertical distance between a wave crest and adjacent trough. Spectral peak period is the period of waves with the largest energy levels, and the characteristic period is the period of the 1/3 highest waves as reported in ship observations contained in the Atmospheric Environment Service (AES) AES40 data set.

A swell is a wave system not produced by wind blowing at the time of observation. Swells are created at some distance and propagate to the vicinity of the observation area. Swell waves travel out of a stormy or windy area and continue in the direction of the winds that originally formed them. The swell may travel for thousands of miles before dying away. As the swell advances, its crest becomes rounded and its surface smooth. Sea state may be composed of the wind wave alone, swell alone, or the wind wave in combination with one or more swell groups.

In the absence of long-term wave measurements for Placentia Bay, hindcasted wave data from the AES40 Grid Point 5616 were used for analysis. The wave climate in Long Harbour was modeled using wind data from Long Harbour and Argentia (Oceans Ltd. 2007).

Fetch, the maximum unobstructed distance of open water over which the wind can travel, is an important factor in the formation, size, and power of waves. The majority of wave energy at Grid Point 5616 is from the south, because it is located in the mouth of Placentia Bay where the waves are fetch-limited in a clockwise direction from west to east. The rose plot from the AES40 data (Figure 5.13) shows that the majority of wave directions are from the southwest to south, with 36% of the wave energy coming from the south and 29% from the southwest.

Significant wave heights in Placentia Bay are greater during the winter months, with the mean monthly values reaching 2.2 m in December and January. Since winds are predominantly from the west and northwest during the winter months, wind waves are generally fetch-limited. As a result, mean significant wave heights in Placentia Bay during the winter are lower than would be expected in the open ocean. Lower significant wave heights occur in the summer, with a mean monthly significant wave height of only 1.2 m. Mean significant wave height values from the SmartBay buoy recently deployed in Placentia Bay are similar to the AES40 data shown in Table 5.2. The highest significant wave height of 9.2 m from the AES40 data set occurred twice, in 1963 and 1976 (Table 5.2).

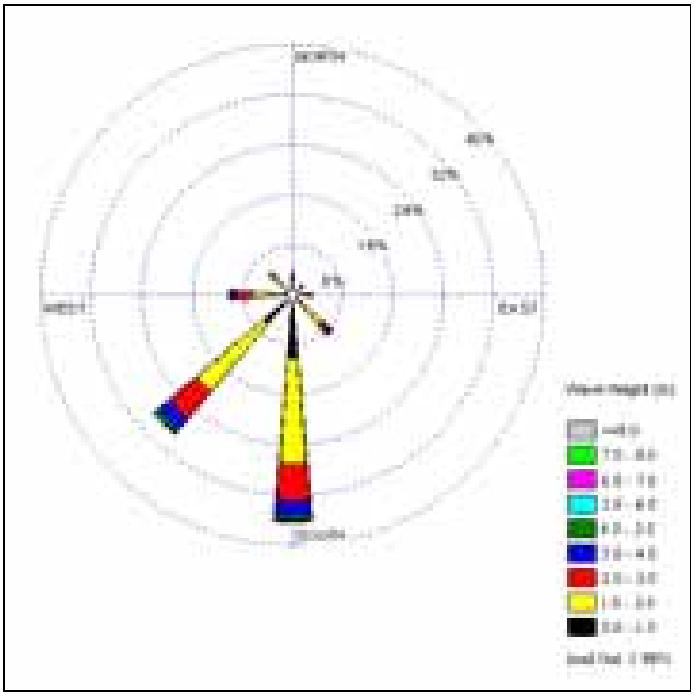

Figure 5.13 Annual Wave Rose from the AES40 Grid Point 5616

An annual histogram of the frequency distribution of significant wave heights is presented in Figure 5.14 and the percentage occurrence of significant wave height for each month is shown in Table 5.3 and Figure 5.15; the figure shows that 47% of significant wave heights lie between 1 and 2 m. There is a significant decrease in frequency of wave heights above 2 m and only 9.8% of the wave heights exceed 3 m. Wave heights greater than 5 m are very rare and make up less than one per cent of the data set.

Table 5.2 Mean Monthly Significant Wave Heights and Maximum Significant Wave Heights in Placentia Bay

	Significant Wave Height (m)		Maximum Significant Wave Height (m)	
Month	AES40	SmartBay	AES40	SmartBay
January	2.2	N/A	8.8	5.2
February	2.1	N/A	8.8	N/A
March	1.9	N/A	9.2	N/A
April	1.6	N/A	6.5	N/A
May	1.3	N/A	6.0	N/A
June	1.2	N/A	4.1	N/A
July	1.2	N/A	4.5	N/A
August	1.2	N/A	5.5	N/A
September	1.4	1.4	6.8	2.7
October	1.6	1.8	8.3	5.6
November	1.9	1.4	7.1	3.7
December	2.2	2.5	9.2	5.7
Note: SmartBay data is from September to 4 January 2007.				

The spectral peak period of waves varies with season, with the most common period varying from seven seconds in the summer months to 11 seconds during the winter. The most common peak spectral period in February is 11 seconds, occurring 14.8% of the time. The most common peak spectral period annually is seven seconds, occurring 17.1% of the time. The peak spectral period reaches above 11 seconds 9.1% of the time. These longer spectral peak periods usually occur during the winter months.

A scatter diagram of the significant wave height versus spectral peak period is presented in Table 5.4, which shows that the most common wave has a significant wave height of 1 m, with a peak spectral period of seven seconds. The second most common wave has a significant wave height of one metre and a peak spectral period of eight seconds. The 9 m significant wave heights typically coincide with peak spectral periods between 13 and 15 seconds; however, these heights occur very infrequently.

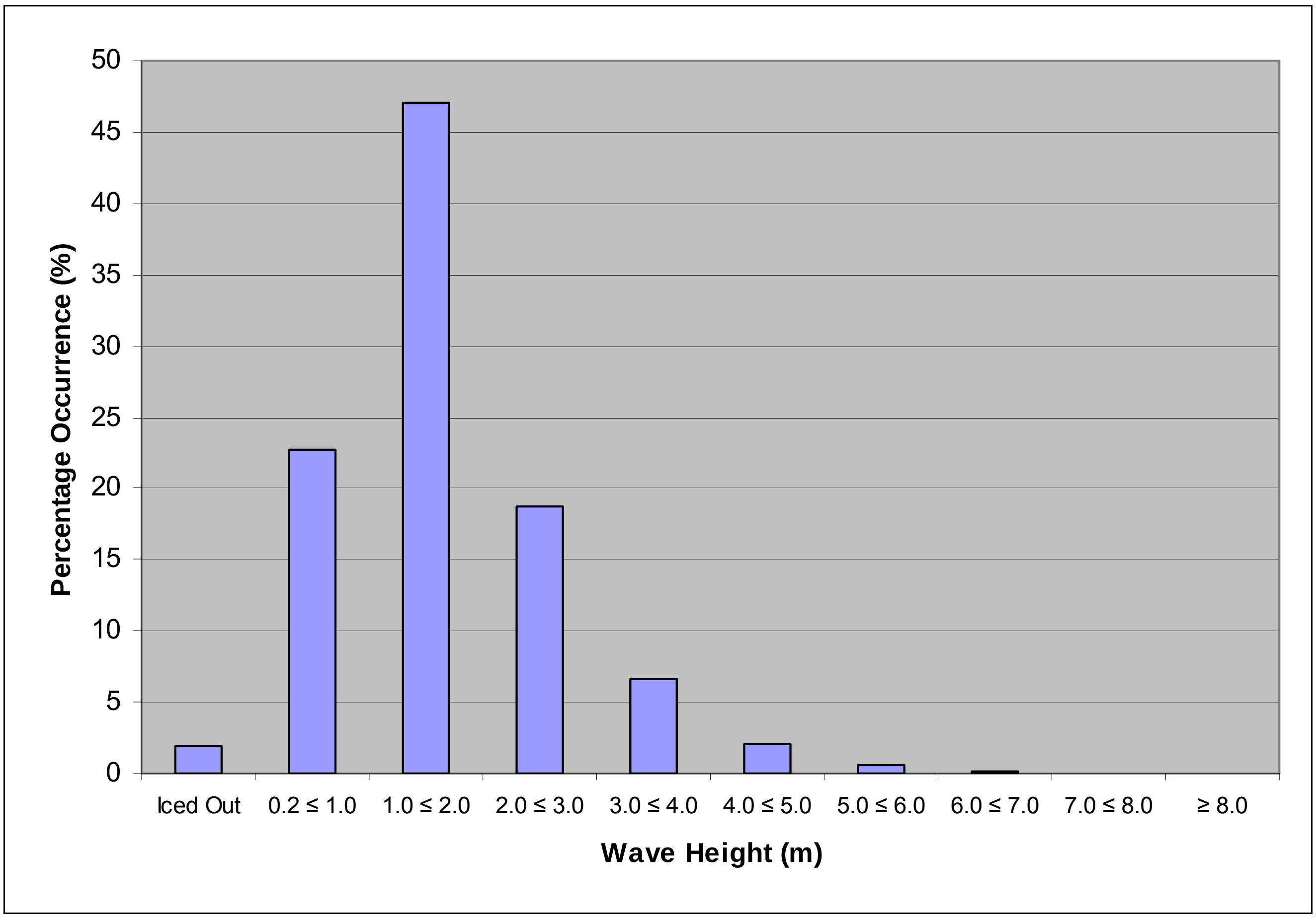

Figure 5.14 Frequency of Occurrence of Annual Significant Wave Heights at Grid Point 5616

Table 5.3 Percentage Occurrence of Significant Wave Heights at Grid Point 5616

Month	**Significant Wave Height (metres)**										**Total**
	0.0 - 0.9	**1.0 - 1.9**	**2.0 - 2.9**	**3.0 - 3.9**	**4.0 - 4.9**	**5.0 - 5.9**	**6.0 - 6.9**	**7.0 - 7.9**	**8.0 - 8.9**	**9.0 - 9.9**	
January	7.71	37.90	31.45	14.62	5.28	2.20	0.62	0.13	0.08		100
February	9.45	40.51	29.39	13.78	4.59	1.62	0.45	0.17	0.04		100
March	15.29	42.45	27.18	10.72	3.12	1.08	0.12	0.02		0.02	100
April	22.34	48.45	22.03	6.12	0.96	0.09	0.02				100
May	39.84	47.99	9.91	1.94	0.26	0.03	0.02				100
June	43.32	48.94	6.85	0.85	0.03						100
July	42.50	52.23	4.71	0.44	0.13						100
August	43.55	50.08	5.76	0.55	0.05	0.02					100
September	32.85	52.32	12.20	1.90	0.60	0.08	0.05				100
October	22.29	52.76	18.98	4.73	0.87	0.19	0.13	0.03	0.02		100
November	15.13	46.90	25.65	8.27	2.83	0.93	0.27	0.02			100
December	10.29	40.24	29.52	12.90	4.82	1.63	0.44	0.11	0.03	0.02	100
Year	25.65	46.82	18.43	6.29	1.93	0.65	0.17	0.04	0.01		100

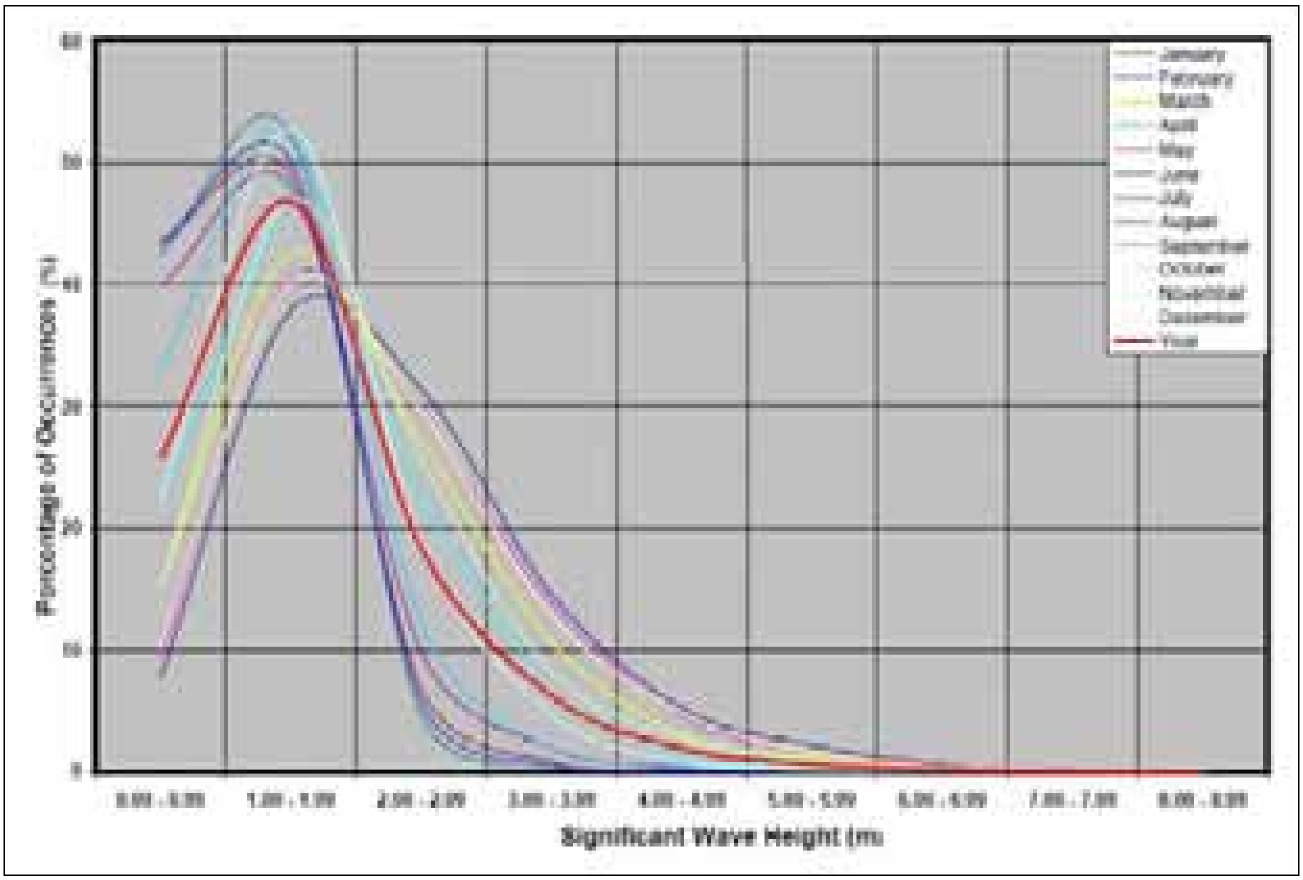

Figure 5.15 Percent Occurrence of Significant Wave Height by Month at GP5616

Table 5.4 Percent Frequency of Occurrence of Significant Combined Wave Height and Peak Spectral Period at Grid Point 5616

		Significant Combined Wave Height (m)													Total
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Peak Spectral Period	**0**														0.00
	1														0.00
	2														0.00
	3	0.16													0.16
	4	4.30	0.11												4.41
	5	8.51	1.92	0.01											10.44
	6	4.41	7.75	0.14											12.31
	7	9.04	4.89	2.46	0.04										16.42
	8	8.48	2.40	1.87	0.51	0.01	0.00								13.28
	9	6.89	3.51	1.14	0.62	0.09	0.00								12.26
	10	3.82	4.37	1.28	0.51	0.22	0.03								10.23
	11	2.02	3.10	1.65	0.46	0.19	0.05	0.01							7.50
	12	1.14	1.32	1.40	0.58	0.21	0.08	0.02	0.00						4.75
	13	0.67	0.48	0.54	0.51	0.17	0.10	0.03	0.01	0.00					2.52
	14	0.31	0.16	0.18	0.15	0.13	0.05	0.02	0.01	0.01					1.02
	15	0.12	0.03	0.02	0.03	0.02	0.01	0.00	0.00	0.00					0.23
	16	0.11	0.02	0.01	0.01	0.00	0.00								0.15
	17	0.04	0.00			0.00	0.00								0.05
	18	0.00													0.00
	19	0.00													0.00
	20														0.00
		50.02	30.08	10.71	3.42	1.06	0.34	0.08	0.02	0.01	0.00	0.00	0.00	0.00	95.73

Source: AES grid point 5616. 46.875N 55.00W, 1954 to 2004.

Extremal Wave Analysis

Extreme wave values were calculated for return periods of 1, 10, 25, 50, and 100 years using a Gumbel Distribution and the peak-over-threshold method. A sensitivity analysis showed that the Gumbel Distribution had a good fit using 158 storms, corresponding to a threshold significant wave height of 5.5 m. The extreme value estimated for significant wave heights, maximum wave heights, and associated peak periods are presented in Table 5.5.

Table 5.5 Extreme Wave Estimates for Placentia Bay

Return Period (years)	Significant Wave Height (m)	Maximum Wave Height (m)	Associated Peak Period (s)
1	6.6	12.3	12.5
10	8.2	15.2	13.9
25	8.8	16.3	14.4
50	9.3	17.2	14.8
100	9.8	18.0	15.1

Joint Probability of Extreme Wave Heights and Spectral Peak Periods

An environmental contour plot Figure 5.16 shows the probability of the joint occurrence of significant wave heights and the spectral peak periods using the methodology of Winterstein et al. (1993). The wave heights were fitted to a Weibull Distribution and the peak periods to a lognormal distribution. The values for the significant wave height estimates and the associated spectral peak periods are given in Table 5.6. The 100-year extreme wave height using the Weibull Distribution on the complete data set was 10.1 m as compared to 9.8 m using a Gumbel Distribution on a selected number of storms.

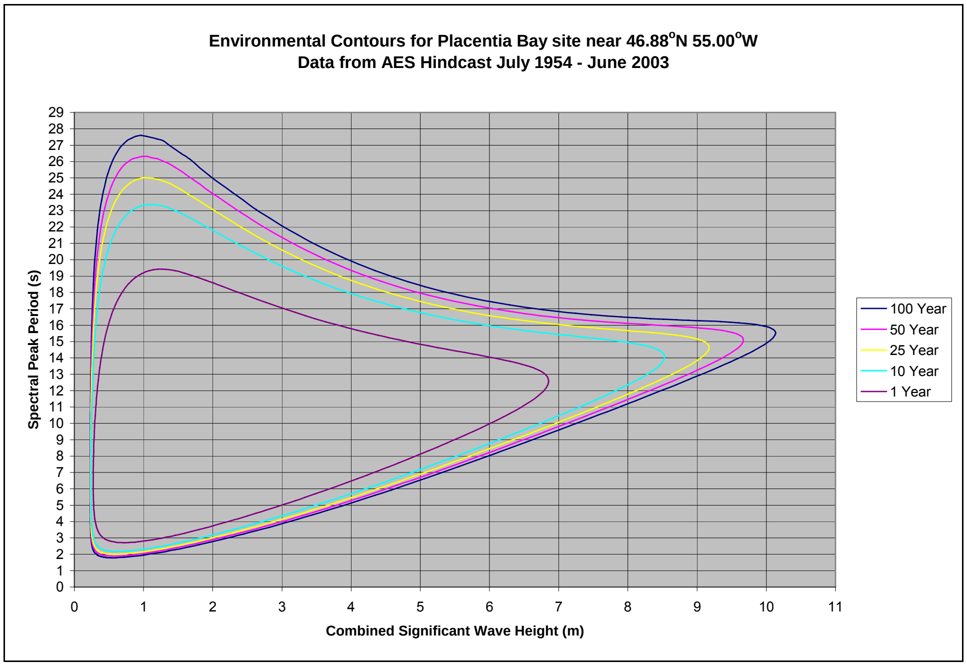

Figure 5.16 Environmental Contour Plot for Placentia Bay

Table 5.6 Extreme Wave Estimates and Spectral Peak Periods for all Months Combined

Return Period (years)	Significant Wave Height (m)	Spectral Peak Period (s) Median Value	Peak Period (s) Lower limit	Peak Periods (s) Upper Limit
1	6.9	12.6	9.7	16.3
10	8.5	14.1	11.7	17.0
25	9.2	14.6	12.4	17.3
50	9.7	15.1	13.0	17.6
100	10.1	15.5	13.5	17.8

Sea Ice in Placentia Bay

A weekly analysis of the Canadian Ice Service 30-Year Frequency of Presence of Ice in Placentia Bay reveals that ice is only present in Placentia Bay from mid-February until late April. A graph of the frequency of occurrence of sea ice in Placentia Bay is presented in Figure 5.17. The predominant type is either new (recently formed, having a thickness of less than 10 cm), grey (young ice 10-15 cm thick) or grey-white (young ice 15-30 cm thick). The likelihood of ice in Placentia Bay is highest during the week beginning 26 February, at which time there is 4% chance that 11.5% of the bay will be covered, a 42.6% chance that 7% of the bay will be covered and a 45.7% chance of 10% coverage.

During March, first-year ice (young ice with a thickness of 0.3-2 m) either forms within the bay or flows around the Avalon Peninsula and enters the bay. By the week of 19 March, first-year ice is predominant and remains until the week of 23 April. The presence of sea ice within Placentia Bay begins to decrease during the week of 2 April and insignificant amounts remains after the week of 23 April.

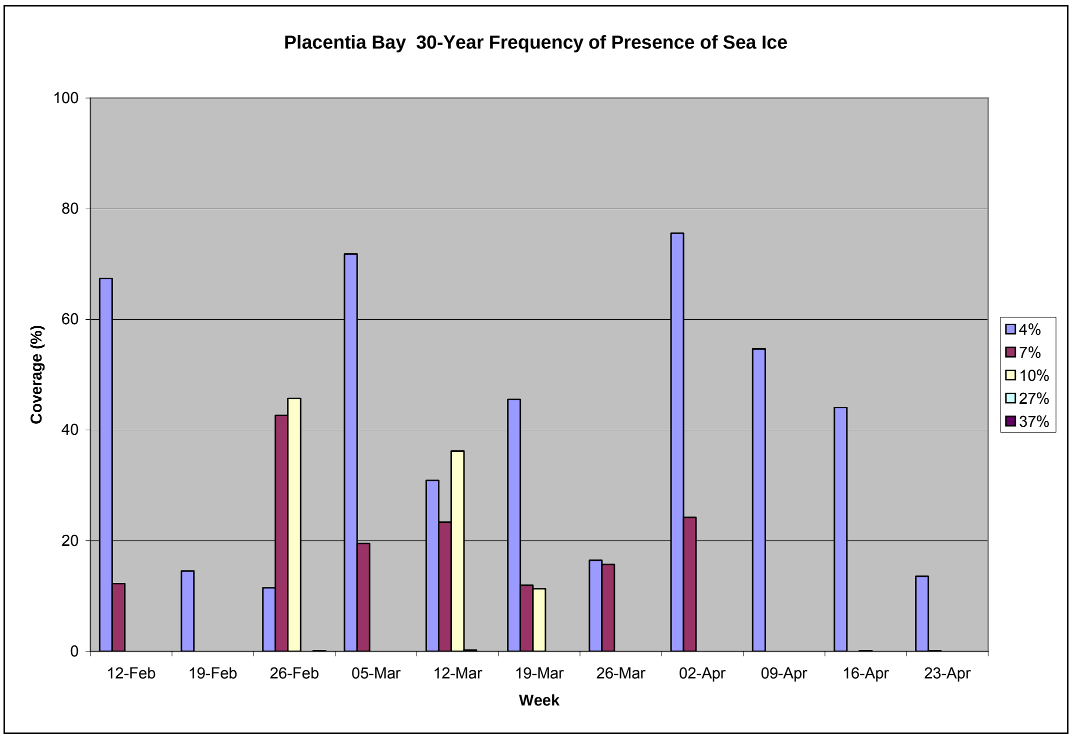

Figure 5.17 Frequency of Presence of Sea Ice in Placentia Bay (1971-2000)

Sea Ice in Long Harbour

The frequency of occurrence of sea ice in Long Harbour is presented in Figure 5.18. Sea ice is no longer present in Long Harbour after the week of 2 April.

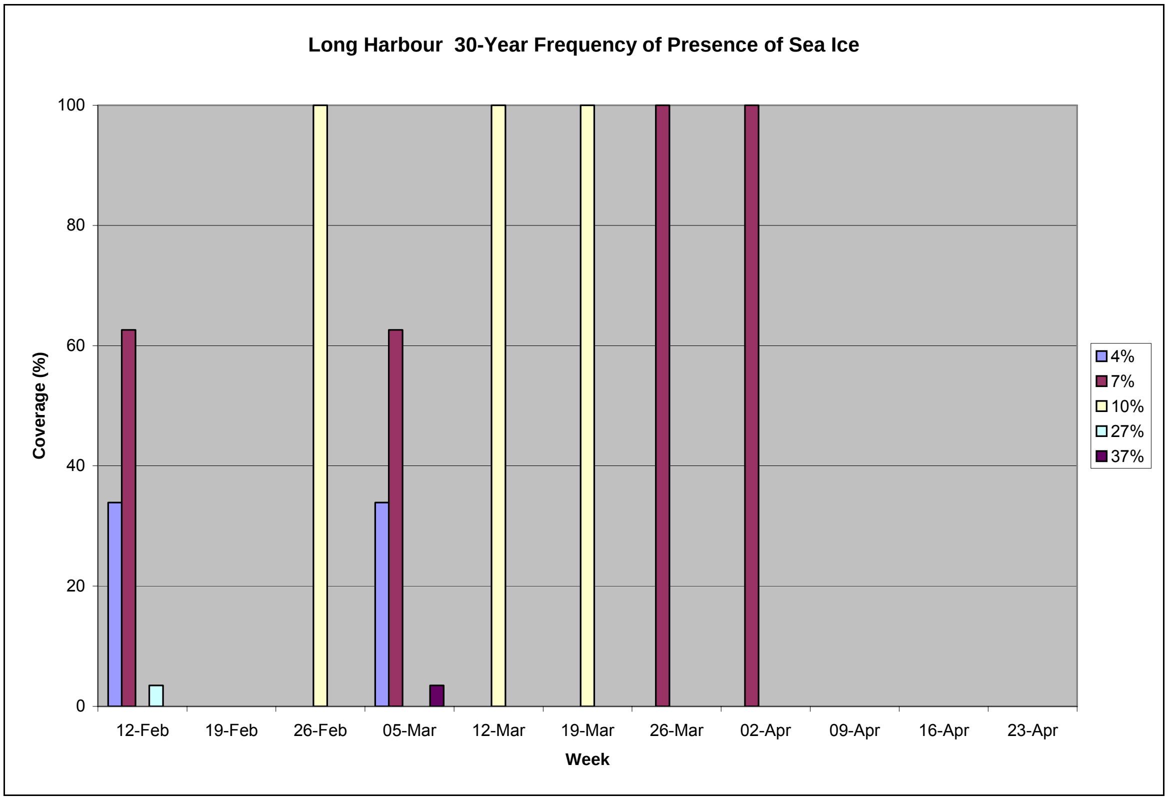

Figure 5.18 Frequency of Occurrence of Sea Ice at Long Harbour (1971-2000).

Icebergs

An analysis was performed to assist in determining the potential threat to shipping posed by icebergs in Placentia Bay. Using International Ice Patrol (IIP) Iceberg Sightings Database from 1974-2003 as the primary data source (NSIDC 1995).

Figure 5.19 shows the positions of all icebergs within Placentia Bay from 1974-2003. Only 30 icebergs have been sighted inside the bay over the 30 years studied. The iceberg sightings occurred more frequently on the eastern side of the bay. Environmental factors such as iceberg concentration, ocean currents and wind determine if icebergs will move into the bay. There are not enough sightings to establish an iceberg drift pattern within the bay. It should also be noted that these sightings occurred in only seven years; the bay was iceberg free for 23 years.

Iceberg sightings in Placentia Bay appear to be limited to years when there was a high concentration of icebergs below 48°N, although this does not necessarily indicate the presence of icebergs. Iceberg sightings were limited to March, April, May, and June.

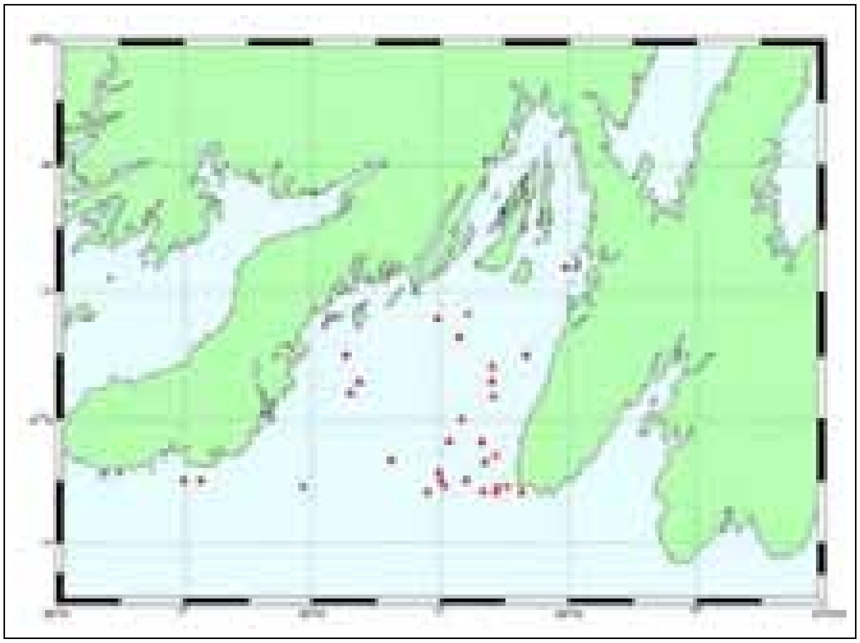

Figure 5.19 Iceberg Sightings in Placentia Bay, 1974 – 2003

Source: IIP.

Storm Surges

A storm surge is a pronounced increase in sea level associated with the passage of storm systems, and defined as the difference between the observed water level and the predicted astronomical tide. This is typically the result of wind stress and low atmospheric pressure.

A study of extreme storm surges in the northwest Atlantic, using a 40-year hindcast (Bernier and Thompson 2006), showed a 40-year return period storm surge of 0.7 m for the south coast of Newfoundland. The height could exceed 0.7 m near the shoreline because of shoaling and funnelling effects in shallow or restricted areas.

The Center for Marine Environmental Prediction at Dalhousie University maintains a Flooding Forecast Service for Atlantic Canada. Storm surge warnings are issued by Environment Canada using their model results. The model results have been available for Argentia since January 2003. The observed storm surge values since January 2003 show many occasions when the sea level exceeded the tidal level by more than 0.5 m, and two occasions (February 2003 and January 2004) when the sea level was approximately 0.9 m and 1.0 m, respectively, above the tidal height.

The tidal heights for various stations in Placentia Bay are presented in Table 5.7 (DFO 2007). The tidal heights are referenced to chart datum.

Figure 5.20 and 5.21 show the recorded sea level and storm surge heights, along with output from the storm surge forecast model for February 2003 and January 2004.

Table 5.7 Placentia Bay Tidal Data

	Mean Water	**Range (m)**		**High Water (m)**		**Low Water (m)**		**Recorded Extremes (m)**	
Port		Mean Tide	Large Tide	Mean Tide	Large Tide	Mean Tide	Large Tide	Highest High Water	Lowest Low water
Argentia	1.3	1.6	2.5	2.2	2.6	0.6	0.1	3.1	-0.3
Burin		1.5	2.2	2.1	2.1	2.3	2.4		
South East Bight		1.3	2.1	2.0	1.8	2.4	2.2		
Tacks Beach	1.1	1.6	2.4	2.0	2.0	2.1	2.0		
Woody Island	1.2	1.6	2.5	2.1	2.1	2.2	2.1		
North Harbour	1.4	1.7	2.5	2.4	2.3	2.3	2.3		
Come By Chance	1.4	1.6	2.5	2.3	2.3	2.4	2.3		
Arnold's Cove	1.4	1.7	2.5	2.4	2.3	2.3	2.3		
Long Harbour	1.5	1.7	2.7	2.5	2.5	2.4	2.3		
St. Bride's	1.2	1.6	2.5	2.1	2.1	2.1	2.0		

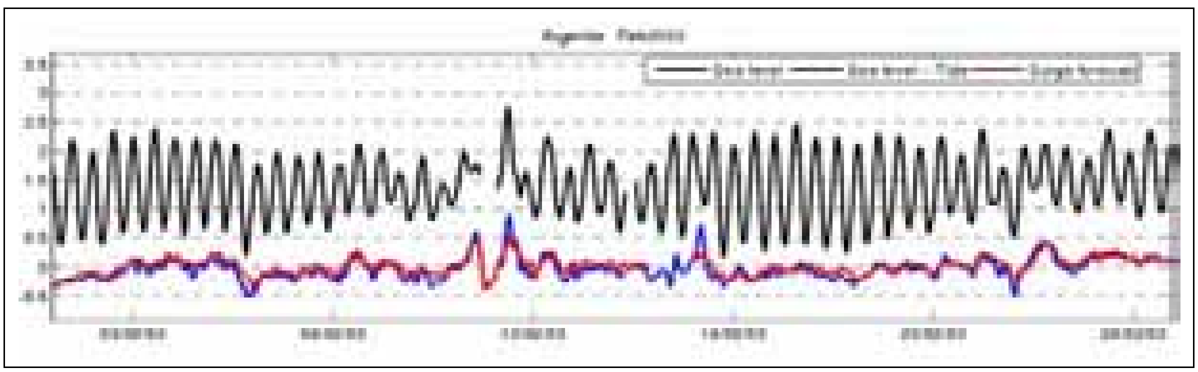

Figure 5.20 Plot of Observed Sea Level along with Forecasted and Actual Storm Surge for Argentia, Newfoundland in February 2003

Source: *http://eero.ocean.dal.ca:8080/cmep_ca/*

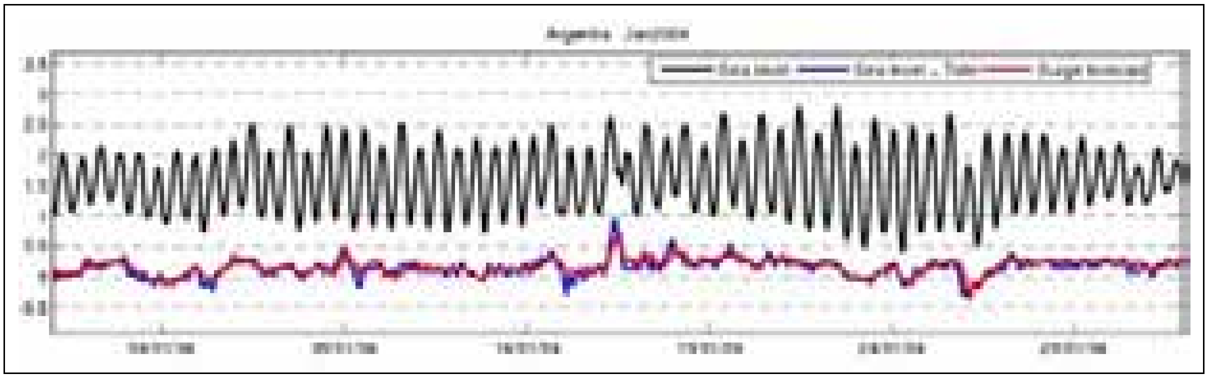

Figure 5.21 Plot of Observed Sea Level along with Forecasted and Actual Storm Surge for Argentia, Newfoundland in January 2004

Source: http://eero.ocean.dal.ca:8080/cmep_ca/

On January 16, 2004, a low pressure area deepened to 951 mb along the south coast of Newfoundland, moving inland to lie over central Newfoundland by afternoon. The low pressure area slowed over Newfoundland, resulting in a prolonged period of strong to gale force winds from the south to southwest over Placentia Bay. These winds created a storm surge near 1.0 m in height in Placentia Bay, resulting in the sea level at Argentia rising to 2.6 m due to combined tidal and storm surge heights.

Negative storm surges associated with offshore winds can result in a pronounced decrease in water level below the astronomical tide level. These events are of concern to mariners since they can create unusually shallow water if they occur near low tide. In December 2006 a negative storm surge of -0.7 metres was recorded at Argentia. This was the result of an intense low pressure system passing west of Placentia Bay. As the system passed, strong to gale force northerly winds were generated over the bay, resulting in offshore winds forcing water out of the bay.

Climate

The Island of Newfoundland has a maritime climate, with the ocean having a moderating effect on temperature. In general, maritime climates experience cooler summers and milder winters than continental climates, and have a much smaller annual temperature range. A maritime climate tends to be fairly humid, resulting in reduced visibilities and low cloud, and receives significant amounts of precipitation. The Newfoundland climate is governed by the passage of high and low pressure circulation systems, embedded in, and directed by, the prevailing westerly flow that occurs in the upper levels of the atmosphere in the mid-latitude regions. This westerly flow is the consequence of the normal tropical-to-polar temperature gradient, the intensity of which determines the mean strength of the flow and the amount of energy available for the low pressure systems to draw on. During winter when the temperature gradient is strongest, low pressure systems are generally more intense and tend to move faster than in the summer months.

Two main winter storm tracks, one from the Great Lakes Basin and the other from the Cape Hatteras - Cape Cod coastal area, direct low pressure systems toward Newfoundland and the Grand Banks (Bursey et al. 1977). The principal area of development of these low pressure systems extends from about Cape Hatteras to the waters around Newfoundland. The intensity of these systems ranges from relatively weak features to major winter storm systems, with many producing gale to storm force winds by the time they reach Newfoundland.

Intense low pressure systems frequently become ‘captured’ and slow down or stall as they move through the region. This may result in an extended period of little change in conditions that may range, depending on the position and overall intensity and size of the system, from the relatively benign to severe.

Rapidly deepening storms occur south of Newfoundland in the vicinity of the warm water of the Gulf Stream. These explosively deepening oceanic cyclones are known as a “weather bombs” and are defined as a storm that undergoes central pressure falls greater than 24 mb over 24 hours. Hurricane force winds near the center, the outbreak of convective clouds to the north and east of the center during the explosive stage, and the presence of a clear area near the center in its mature stage (Rogers and Bosart 1986) are typical of weather bombs. These systems often pass near Placentia Bay.

There is a general warming of the atmosphere during spring due to increasing heat from the sun. This spring warming is greater in the north than at the equator, resulting in a decrease in the north-south temperature gradient. Storms tend to be weaker and more infrequent during the summer. Furthermore, the weaker tropical-to-polar temperature gradient in the summer results in the storm tracks moving farther north, with most storm systems passing over the Gulf of St. Lawrence and Labrador. As a result, gale or storm force winds are relatively infrequent over Newfoundland during summer.

Wind and wave climate statistics in Placentia Bay were extracted from the AES40 North Atlantic wind and wave climatology data set compiled under contract to Environment Canada. This data set consists of continuous wind and wave hindcast data in six-hour time steps for a 50-year period from 1954 to 2004, on a 0.625° latitude by 0.833° longitude grid. In this study, Grid Point 5616 located at 46°52´N; 55°00´W was deemed to be most representative of conditions within Placentia Bay.

Air temperature, sea surface temperature, wind speed and direction, precipitation types and visibility statistics for Placentia Bay were compiled using data from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). This material provides a 30-year subset of global marine surface observations from ships, drilling rigs and buoys covering the period 1976 to 2005.

Other relevant data sets include the Canadian Center for Marine Communications weather buoy which was deployed in Placentia Bay in August 2006 at 46°59´N; 54°41´W as part of its SmartBay Demonstration Project. This buoy provides a continuous data set of average wind speed, wind direction, air temperature, sea temperature, relative humidity, and atmospheric pressure at 20-minute intervals. As well a weather station was installed on the wharf in Long Harbour was in operation from May 2006 to February 2007.

The various locations where data were collected are shown in Figure 5.22.

5.4.1 Wind

Placentia Bay experiences predominantly southwest to west flow throughout the year. Westerly winds prevalent during the winter months begin to shift counter-clockwise during spring as the tropical-to-polar temperature gradient weakens, becoming generally southwesterly during summer. As autumn approaches, the tropical-to-polar temperature gradient strengthens and the winds shift slightly, becoming predominantly westerly again by late fall and into winter.

Figure 5.22 Locations of the Climate Data Sources

Low pressure systems crossing Newfoundland are more intense during winter. As a result, mean wind speeds tend to peak during this season. With the exception of the St. Lawrence weather station, mean wind speeds peak during the month of January (Table 5.8). The ICOADS data set recorded the highest January mean wind speed of 45 km/hr while Long Harbour recorded the lowest January mean wind speed of 19.1 km/hr.

Winds measured at the Long Harbour climate station are lower during the winter months than at the other land stations located around Placentia Bay. Much of this difference is due to local topography.

A number of factors can contribute to the modification of winds by local topography. In Placentia Bay, coastal convergence (the convergence of land and sea winds resulting in stronger winds near the shore), is common. Also, the abundance of small river valleys along the coast, combined with the many large islands located throughout the bay, result in channelling – an increase in wind speeds due to wind being forced through a narrow opening.

Table 5.8 Mean and Maximum Wind Speed (km/hr) Statistics for selected locations in Placentia Bay

Month	AES40		COADS		Argentia		Long Harbour		Oceans Ltd*		SmartBay Buoy**	
	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
January	90.5	35.7	103.7	45.0	109.1		72.0	19.1	N/A	N/A	33.0	20.7
February	95.3	34.4	107.4	42.8	110.9	27.0	79.1	18.9	N/A	N/A	N/A	N/A
March	99.8	32.0	113.0	38.6	87.0	25.4	72.0	19.1	N/A	N/A	N/A	N/A
April	74.6	27.1	96.3	27.4	93.0	22.8	53.0	17.8	N/A	N/A	N/A	N/A
May	75.4	21.3	57.4	21.1	84.1	19.8	64.1	16.3	57.8	19.6	N/A	N/A
June	68.0	19.4	55.6	27.8	74.1	19.6	55.0	16.1	49.3	20.6	N/A	N/A
July	63.9	18.4	61.1	24.5	78.0	18.9	53.0	15.7	55.2	21.7	N/A	N/A
August	61.2	20.3	64.8	23.5	80.0	19.3	55.9	15.9	43.5	18.7	N/A	N/A
September	85.1	24.0	59.3	26.7	89.1	20.7	63.0	16.3	64.1	19.6	44.6	25.6
October	102.4	28.6	100.0	30.3	103.0	23.7	70.9	17.2	58.7	19.4	62.2	26.9
November	86.4	31.9	87.0	31.1	100.9	25.6	72.0	18.5	59.1	21.1	42.8	17.8
December	89.5	34.7	77.8	33.5	108.0	28.0	74.1	18.9	63.9	26.3	39.1	16.7

Notes: *Oceans Ltd. data coverage is from 18 May 2006 to December 2006.
**SmartBay data coverage is from 28 September 2006 to 4 January 2007.
N/A – no data available.

While the Long Harbour site is minimally affected by coastal convergence, local topography does have an influence. Westerly winds entering the mouth of Long Harbour are channelled into a predominantly southwest direction during winter. For this reason, southwest winds occur frequently at Long Harbour throughout the year. Similarly, local topography also dictates a secondary direction from the northeast in all seasons. Northeasterlies would not experience the funnelling effect that southwest winds experience. A wind rose of the annual wind speed from the Environment Canada data is presented in Figure 5.24 and a histogram of the wind speed frequency distribution in Figure 5.25. Monthly wind roses along with histograms of the frequency distributions of wind speeds from the Environment Canada Long Harbour climate station can be found in Oceans Ltd. (2007). These wind roses show the predominantly southwesterly wind direction at Long Harbour, and its secondary northeasterly direction.

A wind rose of the annual wind speed from the AES40 data set is presented in Figure 5.25 and the histogram of the frequency distribution of wind speeds in Figure 5.26. There is a marked increase in the occurrence of winds from the west to north in winter as opposed to summer, which is consistent with the wind climatology from other weather stations in the area.

These can be compared with data from Long Harbour (Figure 5.23 and Figure 5.24). The effects of channelling can be seen in the Long Harbour site as wind direction tends to follow the orientation of the harbour.

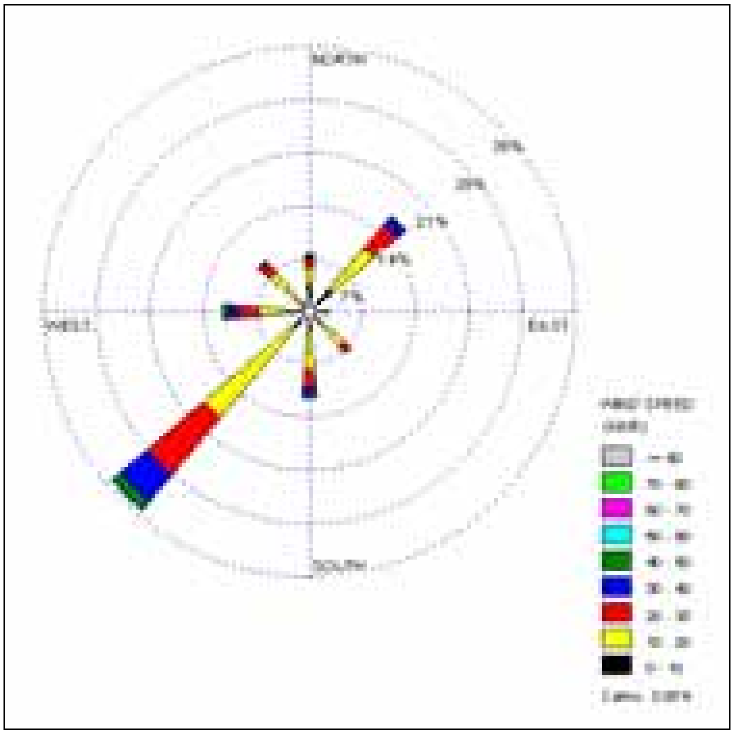

Figure 5.23 Annual Wind Rose from the Environment Canada Climate Station at Long Harbour

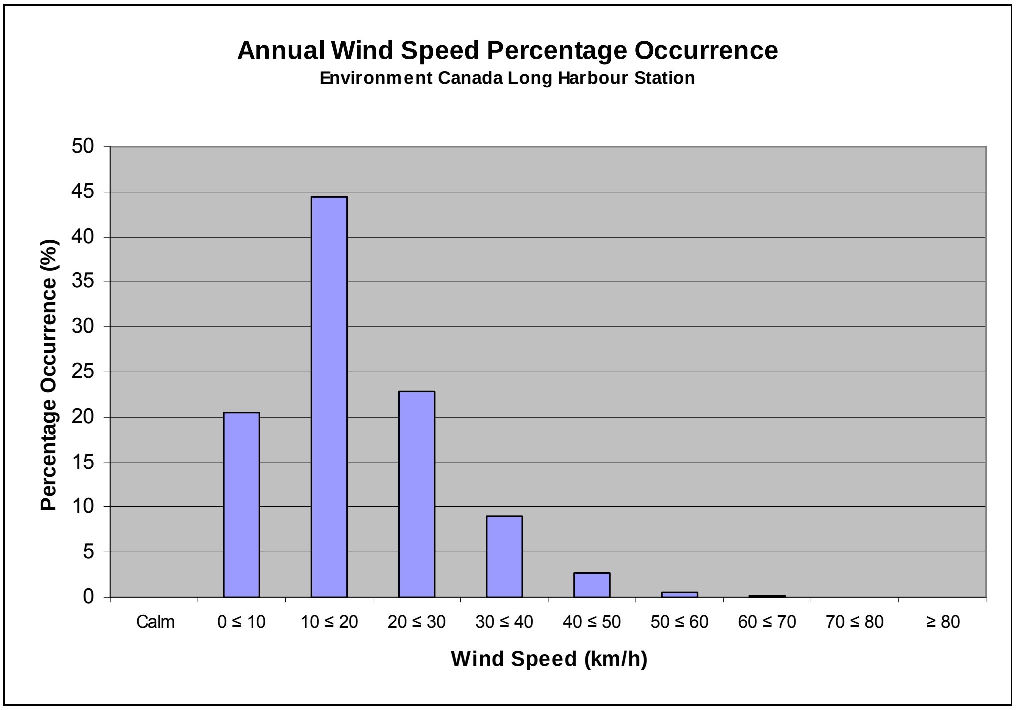

Figure 5.24 Annual Wind Speed Percentage of Occurrences from the Environment Canada Climate Station at Long Harbour

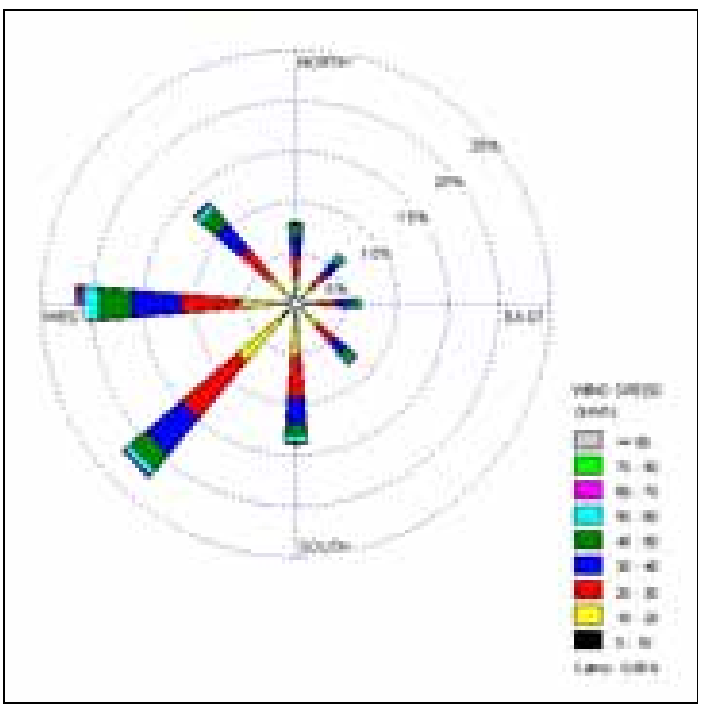

Figure 5.25 Annual Wind Rose from the AES40 Grid Point 5616

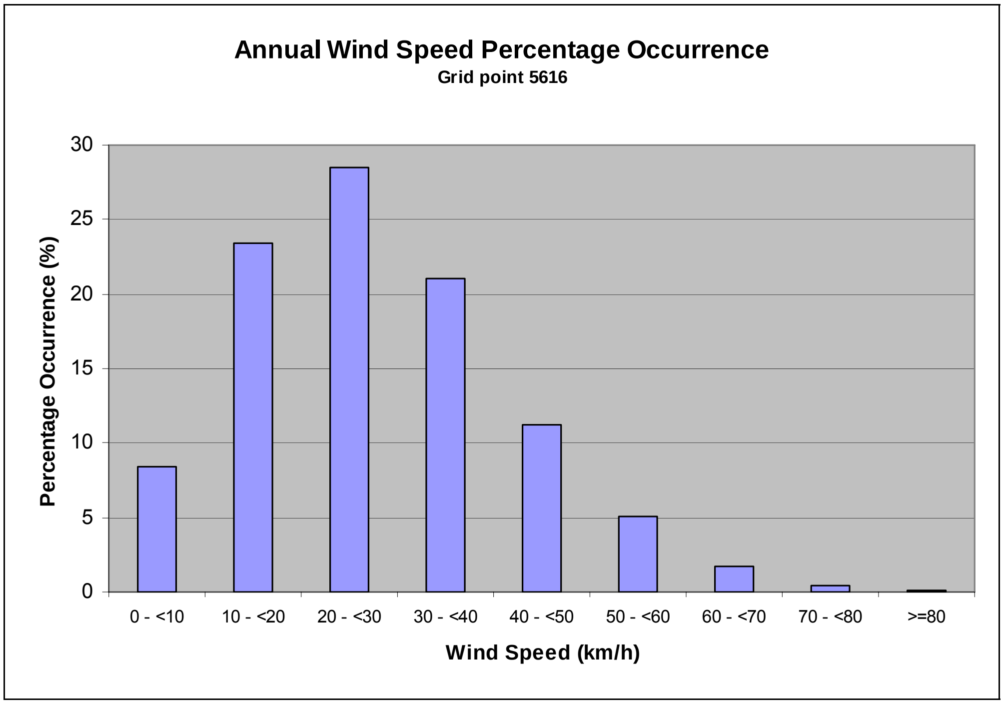

Figure 5.26 Annual Wind Speed Percentage of Occurrences from the AES40 Grid Point 5616

Intense mid-latitude low pressure systems occur frequently from early autumn to late spring. In addition, remnants of tropical systems have passed near Newfoundland between spring and late fall. Therefore, while mean wind speeds tend to peak during the winter, maximum wind speeds may occur at any time during the year.

St. Lawrence recorded the highest wind speeds in Placentia Bay of 145 km/hr out of the west-southwest on February 22, 1967, and again on January 5, 1968 (Figure 5.27). During the same storm, the AES40 wind speeds peaked at 89 km/hr and Argentia wind speeds at 90 km/hr.

An extremal analysis was carried out for winds at the mouth of Placentia Bay using the AES40 data set for 50 years of data and Oceanweather's OMOSIS Software (Oceanweather Inc. 2001). Extreme value estimates for hourly winds using a Gumbel distribution on 158 storms were calculated for return periods of 1, 10, 25, 50, and 100 years. The values were 80.6 km/hr, 92.5 km/hr, 96.8 km/hr, 100.1 km/hr, and 103.7 km/hr, respectively. The weather station data around Placentia Bay reported 10-minute mean wind speeds, with the exception of Long Harbour, which reported hourly mean data. For comparisons with the weather station data, the hourly extreme wind speeds previously quoted correspond to 10-minute winds speeds of approximately 85.3 km/hr, 97.9 km/hr, 102.6 km/hr, 106.2 km/hr and 109.8 km/hr, respectively, using a conversion factor of 1.06 (U.S. Geological Survey 1979).

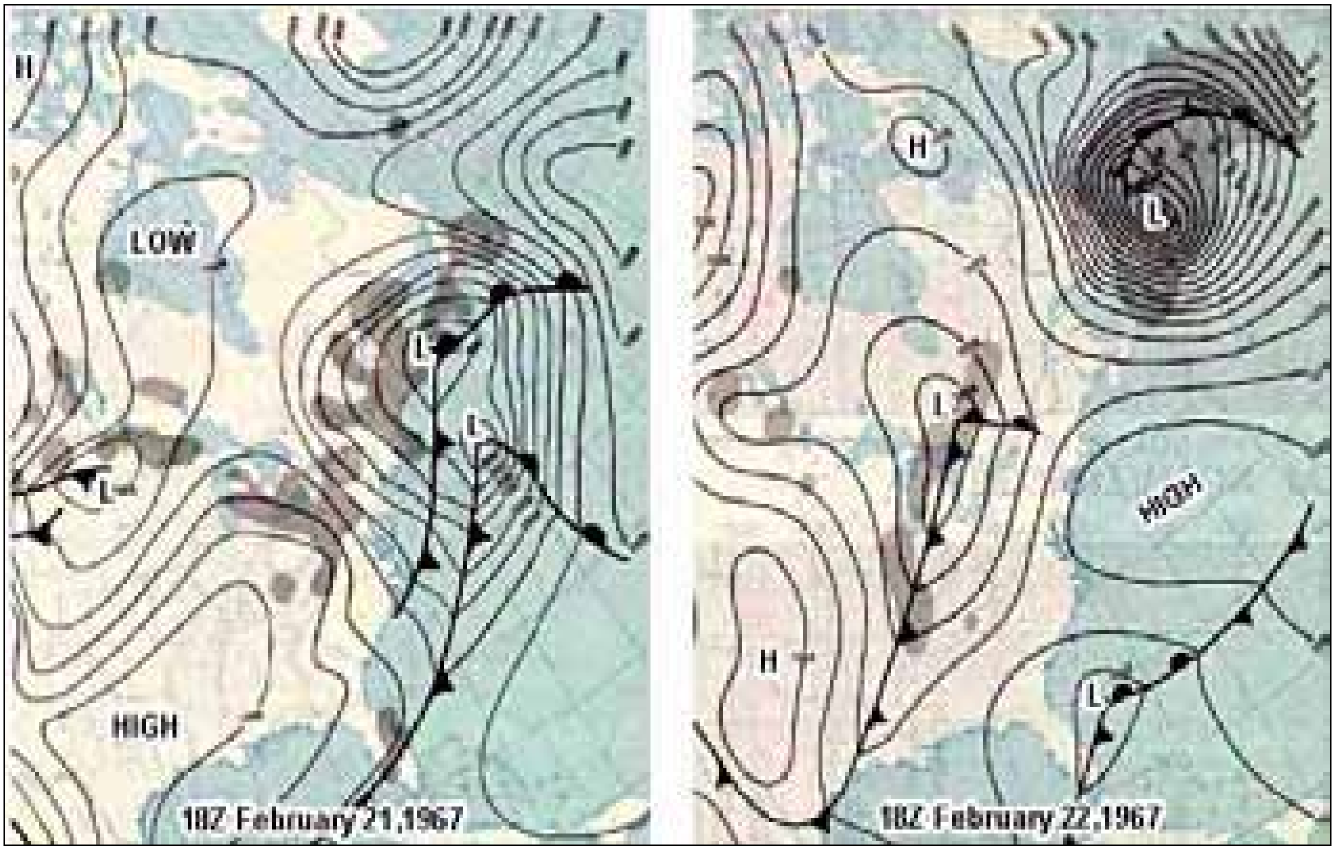

Figure 5.27 Explosive Deepening of a Mid-Latitude Low Pressure February 1967

The highest winds are usually the result of tropical cyclones or their remnants. The highest winds in a tropical cyclone tend to be concentrated in a narrow band near its centre. Since the storm centre rarely passes over a reporting station, the highest winds are usually not measured. Tropical cyclones develop and strengthen over warm tropical waters, typically from June to November, however, they have been known to develop as early as April and as late as January. These systems typically move east to west over the warm waters of the tropics. Systems that turn northwest maintain their strength from the warm waters of the Gulf Stream. As they move north, they pass over colder waters and begin to weaken. By the time these weakening cyclones reach Newfoundland, they are usually embedded into a mid-latitude low pressure system and their tropical characteristics are lost. On occasion, however, such systems maintain their strength as they approach Newfoundland. On October 19, 2000, Hurricane Michael made landfall along the south coast, west of the Burin Peninsula, as a category one hurricane with a central pressure of 96.5 kpa. The St. Lawrence climate station reported north-northeast winds at 96 km/hr by the time the hurricane made landfall.

Hurricane Luis passed over or close to Long Harbour on September 11, 1995. According to the U.S. National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center Archive (NOAA 2006), it had maximum sustained one-minute mean, 10 m wind speeds of 148 km/hr when it reached the Avalon Peninsula. This value converts to a mean wind speed of approximately 121 km/hr.

5.4.2 Air Temperature

The ocean has a moderating effect on air temperature along the Newfoundland coast, which is typical of a maritime climate. During the spring, sea surface takes longer to warm up than does the surrounding air. As a result, the water temperature tends to slow the warming of the air along the coast, resulting in cooler springs than would be experienced in a continental climate. In autumn, sea surface temperatures are generally warmer than the surrounding air, as air tends to cool faster than the ocean. This results in the sea surface temperatures typically being higher than air temperatures. The warm ocean reduces the rate at which the air temperature decreases, resulting in generally warmer autumns than would be experienced in a continental climate.

Seasonal temperature statistics for the various data sources in Placentia Bay are summarized in Table 5.9. On average, the temperature at Long Harbour was higher during summer than at any of the other stations, with a mean seasonal temperature of 13.9°C and a mean seasonal maximum temperature of 25.2°C. The Placentia weather station recorded the coldest mean seasonal air temperature of -3.1°C; the Long Harbour climate station had the coldest mean minimum temperature of -19.9°C. The coldest extreme minimum temperature of -25°C was recorded at Long Harbour on February 15, 1975.

The ICOADS (Table 5.4) data show that mean air temperatures over the bay are similar in value to those measured over the land, while mean seasonal maximum temperatures are much cooler and mean seasonal minimum temperatures are much warmer. The smaller temperature range of the ICOADS data illustrates the moderating effect that the ocean has on the surrounding air temperature.

Table 5.9 Seasonal Air Temperature (°C), Selected Placentia Bay Locations

	Winter	Spring	Summer	Autumn
ICOADS	-7.4 (-1.9) 4.6	-3.8 (0.3) 6.6	8.1 (12.3) 16.7	3.3 (8.5) 15.0
Argentia	-13.9 (-1.4) 12.3	-10.4 (2.0) 15.7	2.1(12.3) 22.7	-3.2 (8.4) 20.4
Long Harbour	-19.9 (-2.6) 13.5	-14.4 (2.8) 17.6	0.7 (13.9) 25.2	-6.7 (8.4) 22.4
Placentia	-18.0 (-3.1) 13.0	-11.4 (1.5) 14.4	2.0 (12.0) 23.0	-2.8 (8.1) 19.6
St. Lawrence	-16.7 (-2.4) 8.9	-12.9 (1.9) 16.1	1.8 (12.4) 23.9	-6.1 (7.7) 20.8
Marticot Island	-13.4 (-1.7) 7.0	-10.5(2.0) 14.0	2.0 (12.5) 19.9	-4.8 (8.9) 20.5

Note: Values presented as mean seasonal minimum; (mean seasonal); mean seasonal maximum.

5.4.3 Precipitation

The frequency of precipitation type was calculated using hourly data at Argentia, Placentia, and St. Lawrence, (Table 5.10) with each occurrence counting as one event. Long Harbour, however, recorded the occurrence of precipitation type on a daily basis. Therefore, at Long Harbour, if precipitation was recorded for only one hour, it would count as one day with precipitation. Furthermore, since Long Harbour was an automatic weather station and sometimes could not distinguish between precipitation types at or near 0°C, it is possible that the occurrence of freezing rain at the site is under-recorded. As a result, the frequency of precipitation type at Long Harbour is presented separately as Table 5.11.

Table 5.10 Seasonal Frequency Distribution (%) of Precipitation in Placentia Bay

		Rain / Drizzle	Freezing Rain / Drizzle	Rain / Snow Mixed	Snow	Hail	Total
ICOADS	**Winter**	11.9	3.2	1.1	39.7	0.4	56.3
	Spring	16.4	1.2	0.5	16.7	0.0	34.8
	Summer	14.3	0.0	0.0	0.0	0.0	14.3
	Autumn	26.7	0.0	0.0	1.3	0.0	27.9
Argentia	**Winter**	9.8	0.7	0.5	17.8	0.0	28.8
	Spring	13.9	0.4	0.5	8.6	0.0	23.4
	Summer	16.5	0.0	0.0	0.0	0.0	16.5
	Autumn	16.4	0.0	0.2	1.3	0.0	17.9
Placentia	**Winter**	8.0	0.8	0.3	17.4	0.0	26.4
	Spring	14.8	0.6	0.2	7.1	0.0	22.7
	Summer	18.8	0.0	0.0	0.0	0.0	18.8
	Autumn	17.1	0.0	0.1	1.7	0.0	19.0
St. Lawrence	**Winter**	8.0	0.9	0.1	20.2	0.0	29.2
	Spring	12.4	0.8	0.1	7.3	2.5	23.2
	Summer	13.4	0.0	0.0	0.0	0.0	13.5
	Autumn	14.7	0.0	0.1	1.6	0.0	16.5

Table 5.11 Monthly Frequency Distribution (%) of Precipitation at Long Harbour

	Rain / Drizzle	Freezing Rain / Drizzle	Snow	Total Precipitation
January	26.9	0.8	24.2	47.5
February	21.4	1.0	21.4	39.8
March	34.8	0.5	14.5	46.0
April	40.0	0.0	6.5	43.9
May	48.1	0.0	0.6	48.2
June	46.7	0.0	0.0	46.7
July	44.1	0.0	0.0	44.1
August	47.7	0.0	0.0	47.7
September	54.0	0.0	0.0	54.0
October	59.7	0.0	0.1	59.7
November	50.2	0.1	4.4	53.0
December	37.7	0.4	15.5	49.5
Total	42.7	0.2	7.2	48.4

Winter has the highest frequency of precipitation, with frequencies between 26.4% and 29.2% for the land stations and 56.3% over the ocean. Snow accounts for the majority of precipitation during the winter months, occurring twice as often as rain at the land stations and 3.3 times more frequently over the ocean. Summer has the lowest frequency of precipitation, ranging from 13.5% to 16.5%.

Long Harbour experiences a high occurrence of days with precipitation (48.4%). The highest occurrence is in October, most of which is in the form of rain. The lowest occurrence is in February, when rain and snow occur at the same frequency (21.4%).

While rain occurs in all seasons, it is more frequent in autumn. The earliest observation of snow occurred in October; however, only one observation was recorded in the 30-year record at Long Harbour. Snow occurs in all months between November and May, peaking in January at 24.2% of days. A low frequency of freezing precipitation occurs from November to March.

Argentia, Long Harbour, and Placentia all report similar values of mean annual total precipitation (Table 5.12), with Placentia reporting the least amount (1324 mm) and Argentia recording the highest (1398 mm). The majority (between 85% and 90%) of the total recorded precipitation was in the form of rain. The maximum monthly rainfall amounts occurred in October at Argentia, Long Harbour, and Placentia. The maximum daily rainfall amounts of 85.7 mm and 119.0 mm were recorded on October 17, 1981, at Argentia and Long Harbour, respectively. The Placentia weather station reported a maximum daily rainfall amount of 93.2 mm on August 23, 1975. The St. Lawrence station reported a maximum rainfall amount of 116.0 mm on September 10, 1995 coinciding with the passage of Hurricane Luis in the early morning hours of September 11, 1995.

Table 5.12 Precipitation Amount (mm) Statistics for the Environment Canada Climate Stations in Placentia Bay

	Argentia		**Long Harbour**		**Placentia**		**St. Lawrence**	
	Mean	**Maximum**	**Mean**	**Maximum**	**Mean**	**Maximum**	**Mean**	**Maximum**
January	126.4	170.8	127.4	202.1	106.1	183.7	132.8	203.4
February	84.4	155.7	111.6	207.7	86.7	185.4	124.7	234.0
March	113.0	228.1	110.0	218.4	105.3	138.1	122.4	210.8
April	79.2	143.9	101.9	240.9	103.3	177.5	113.7	233.1
May	94.9	143.1	92.7	157.2	81.8	129.7	118.1	228.6
June	124.0	193.7	112.8	249.2	96.6	148.9	127.8	341.3
July	107.9	196.8	92.3	223.4	81.1	110.4	106.8	200.8
August	112.9	176.0	110.5	343.6	157.4	200.4	118.2	399.2
September	139.3	185.6	124.5	222.7	100.4	158.8	148.6	248.0
October	136.9	280.5	148.0	311.2	172.1	249.2	145.9	265.9
November	110.5	177.0	125.9	208.4	141.1	227.9	147.4	248.6
December	129.5	227.8	118.5	168.2	102.7	163.8	134.9	263.2
Annual	1 398.0	1 704.8	1 387.2	1 619.9	1 324.0	1 488.7	1 550.0	1 940.8

Snowfall has occurred in Placentia Bay in every season, including summer. Mean snowfall amounts show that, on average, snow begins in October. Snowfall is recorded in all months between October and June, with the peak snowfall amounts occurring in January at each station. The maximum monthly snowfall of 176.8 cm was recorded at St. Lawrence during February.

The highest maximum one-day snowfall of 71.3 cm occurred at St. Lawrence on September 14, 1987. This value is twice as high as other one-day maximums reported in Placentia Bay. The other stations have reported maximum one-day snowfall events of 29.2 cm at Argentia, 35.6 cm at Long Harbour and 34.3 cm at Placentia. Overall, St. Lawrence experiences the highest precipitation amounts and has the highest monthly mean and monthly maximum for rainfall and snowfall, as well as the highest one-day snowfall amount.

Precipitation amounts were recorded at the Environment Canada Long Harbour climate station from November 1969 to November 1999. On average, 1387.2 mm of precipitation falls on Long Harbour during a year with a maximum amount of 1619.9 mm (Table 5.13). Included within these figures is a mean annual snowfall of 159.9 cm and a monthly maximum of 269.0 cm.

The monthly maximum precipitation amount occurred in August (343.6 mm) but, on average, October gets the most precipitation with a mean value of 148.0 mm. The daily maximum precipitation occurred in the form of rain on October 17, 1981 with a value of 119.0 mm.

Table 5.13 Precipitation Amount Statistics for the Environment Canada Climate Station at Long Harbour

	Daily Mean Precipitation (mm)	Daily Maximum Precipitation (mm)	Daily Standard Deviation (mm)	Monthly Mean (mm)	Monthly Maximum (mm)	Monthly Standard Deviation (mm)
January	8.7	53.8	9.6	127.0	202.1	43.2
February	8.9	68.0	10.4	111.6	207.7	52.7
March	7.7	80.2	8.7	110.0	218.4	47.9
April	7.3	82.0	8.8	101.9	240.9	55.6
May	6.1	55.0	7.8	92.7	157.2	35.5
June	7.6	92.4	10.9	112.8	249.2	55.1
July	6.8	63.0	9.1	92.3	223.4	44.5
August	7.5	78.5	10.6	110.5	343.6	56.4
September	7.4	68.0	10.8	124.5	222.7	39.0
October	8.0	119.0	12.1	148.0	311.2	69.0
November	7.4	66.4	9.3	125.9	208.4	38.7
December	7.6	41.0	7.9	118.5	168.2	27.2
Year	7.6	119.0	9.8	1 387.2	1 619.9	181.5

More snow falls in January than in any other month at the Long Harbour climate station. The monthly maximum was 122.0 cm, and the monthly mean was 43.4 cm. However, the daily maximum amount of snow (35.6 cm) fell in March, with December as a close second (34.0 cm). Snow has been recorded to occur from October to May although over the 30-year period only one snow event was recorded at Long Harbour in October.

Freezing precipitation occurs when rain or drizzle aloft enters negative air temperatures near the surface and becomes super-cooled, so that the droplets freeze upon contact with a surface. This situation typically arises ahead of a warm front extending from low pressure systems passing west of the area.

The percentage of occurrences of freezing precipitation was calculated using hourly data from the Environment Canada climate stations at Argentia, Placentia, and St. Lawrence as well as from the ICOADS data set. At all land stations, the frequency of freezing precipitation was slightly higher in the winter months than during the spring; however, all recorded freezing precipitation occurred less than 1% of the time at all land stations. The ICOADS data set (ship observations) had the highest occurrence of freezing precipitation with 3.2% in the winter and 1.2% in the spring. It is unclear whether these values are accurate, or whether the higher amounts were due to ice accretion from sea spray on the vessels. No freezing precipitation occurred during summer and autumn.

The Long Harbour station did not record freezing precipitation at hourly intervals, but instead recorded days with freezing rain. Since it is unclear from this data set how long a freezing rain event lasted, Long Harbour was not included with the other stations when calculating freezing precipitation statistics. At the Long Harbour station, only 25 days with freezing precipitation were reported over a period of 30 years. These data are believed to be in error, because the manned observing stations in the area have reported a higher frequency of occurrence. In addition, automatic stations have not been reliable for reporting freezing precipitation; a quantitative analysis of freezing precipitation was not possible for Long Harbour.

Spray icing can accumulate on vessels and shore structures when air temperatures are below the freezing temperature of water. Icing severity varies with water temperature, wave conditions, and wind speed. Potential icing rates were computed (Figure 5.28) using wind speed, air and sea surface temperature observations from the ICOADS data set. From January 1975 to December 2005, a total of 892 vessel observations were used to calculate the percentage frequency of icing occurrence and severity in Placentia Bay.

Potential sea spray icing conditions start during December and occur 28.6% of the time. As temperatures cool throughout the winter months, the frequency increases to a maximum of 49.2% of the time in February. Icing potential decreases rapidly after February in response to warming air and sea surface temperatures, and by April the frequency is less than 5%.

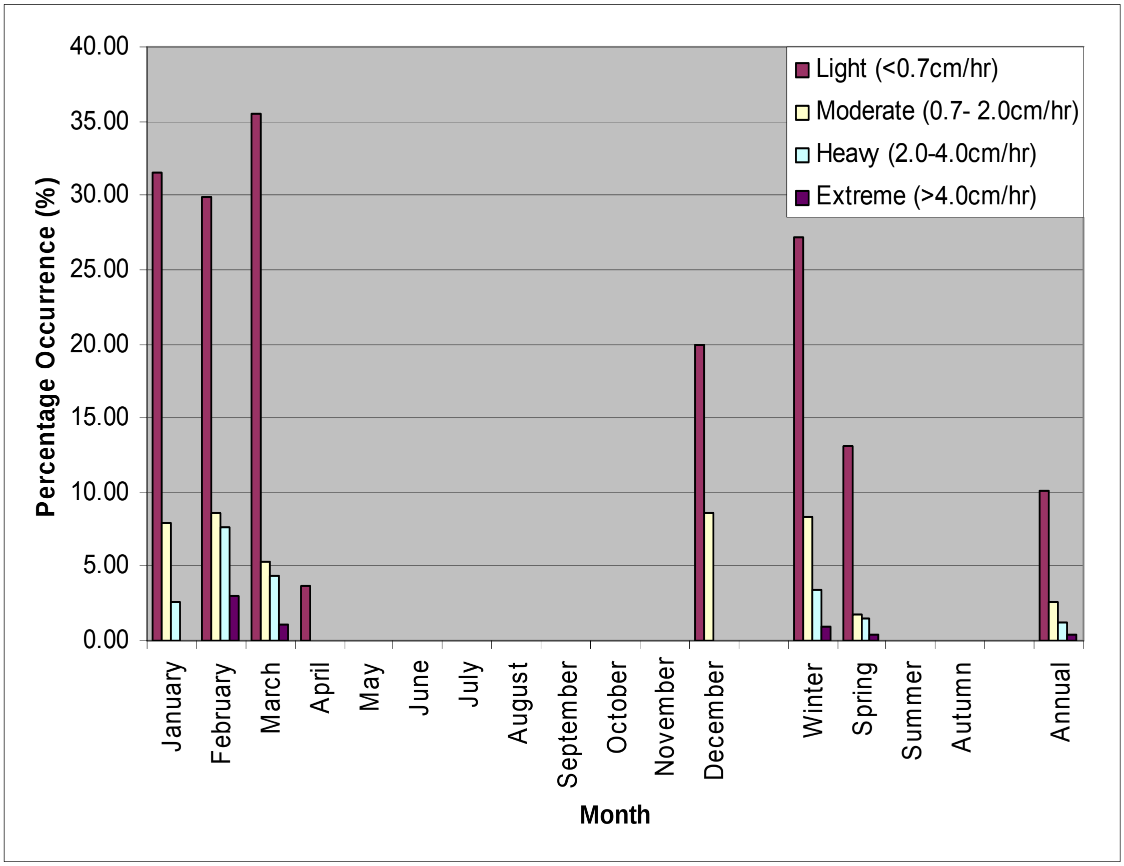

Figure 5.28 Percentage Frequency of Potential Spray Icing Conditions for Placentia Bay, January 1975 to December 2005

Visibility, the greatest distance at which objects of suitable dimensions can be seen and identified is identified by a variety of conditions and phenomena. Fog is the most frequent factor influencing visibility in Placentia Bay, persistent throughout the day during summer as long as there are southerly winds. The ICOADS data show that the frequency of fog is greatest between April and August. During the winter months, prevailing winds are generally from the west, off the continent, so that the air mass tends to be drier. Drier air, combined with sea-surface temperatures typically warmer than air, result in a marked decrease in the amount of fog formation within the bay during fall and winter; however, snow and blowing snow account for the majority of poor visibility reported during winter.

Observations from climate stations around Placentia Bay show that obstructions to visibility occur on a regular basis throughout the year, with good visibility (defined as visibility greater than 10 km) in the coastal communities of Argentia, Placentia, and St. Lawrence occurring, on average, less than 50% of the time. The incidence of fog at these stations is high during the summer months and peaks in the month of July, with visibility less than one kilometre occurring as much as 27.2% of the time at St. Lawrence and 15.1% of the time at Placentia.

Visibilities in the bay are better than at the land stations, with good visibility occurring 71.2% of the time (ICOADS data). On average, fog occurs 11% of the time throughout the year in Placentia Bay with the peak occurring in July at 20.7% of the time. A graph of monthly frequency distribution of visibilities from the ICOADS data set is presented in Figure 5.29.

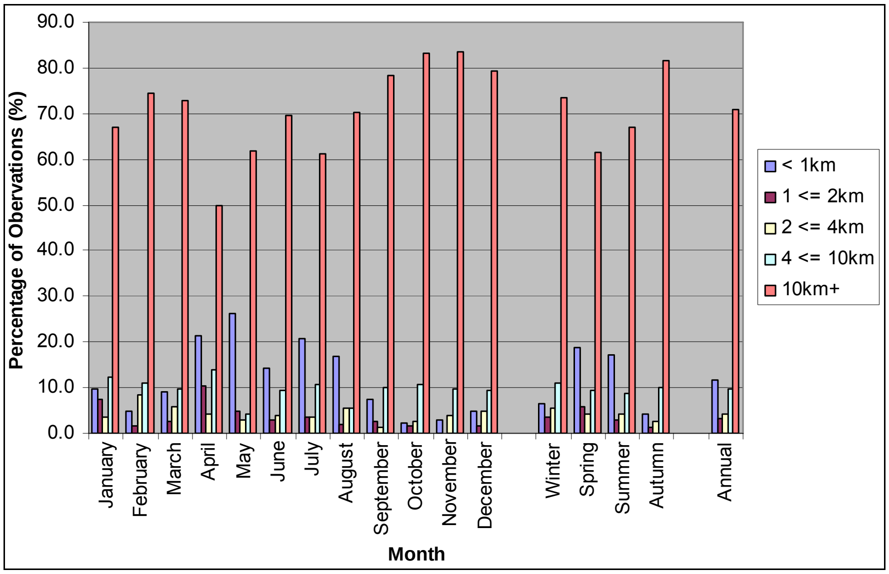

Figure 5.29 Frequency Distribution (%) of Visibility Recorded in the ICOADS Data Set

As visibility statistics were not recorded at Long Harbour, Argentia, 21 km to the southwest was deemed to be the most appropriate station to represent visibility at Long Harbour. At Argentia, good visibility occurs, on average, only 40.9% of the time (Figure 5.30). The incidence of fog is highest during the summer months and peaks in July with a visibility of less than one kilometre occurring 11.9% of the time. The predominant visibility at the Argentia station was between four to 10 km and occurs, on average, 49.8% of the time.

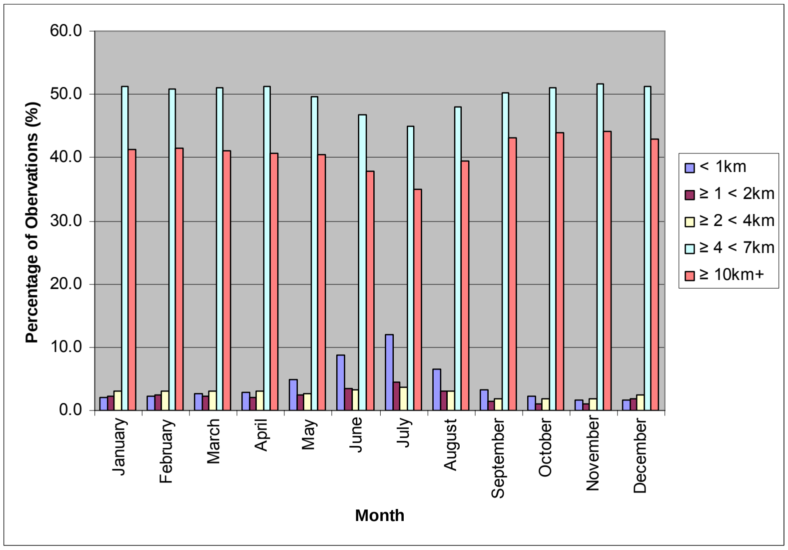

Figure 5.30 Frequency Distribution (%) of Visibility Recorded at Argentia

Ceiling is the height at which an observer on the ground can no longer see six-tenths of the whole sky. Since ceiling heights were not recorded at Long Harbour, Argentia was again deemed to give the best representation. At Argentia an increase occurs in the frequency of cloud ceilings below 100 feet (30.5 m) from February to July (Figure 5.31). After July, the frequency of this pattern is directly proportional to the occurrence of fog.

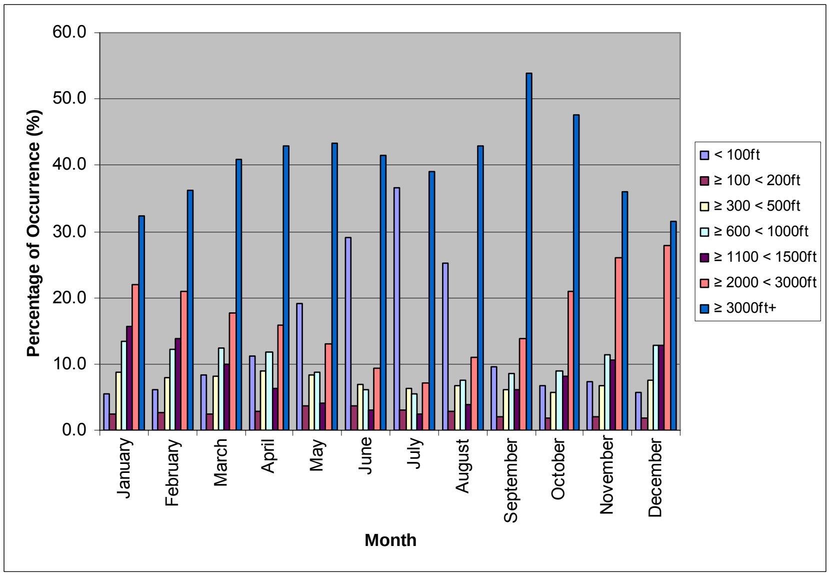

Figure 5.31 Percentage of Occurrence of Ceiling Heights Recorded at Argentia

5.5 Climate Trends

Climate is naturally variable and changes over time in response to atmospheric circulation patterns. Short-term meteorological variations are largely a consequence of the passage of synoptic scale weather systems: the energetics of these features vary seasonally in response to changes in the strength of the mean tropical - polar temperature gradient. Long-term changes occur in response to atmospheric circulation patterns in the Northern Hemisphere. There is a general consensus among the scientific community that greenhouse gas emissions have played a significant role in the climate during the past 50 years; however, the high degree of natural climate variation makes it difficult to identify long term trends with any degree of certainty (Environment Canada 1997).

Most parts of Canada have experienced higher temperatures and increased precipitation in the past 50 years, although the rate of change is variable. In fact, some areas are experiencing a decreasing trend. Over the past century, the earth's temperature has increased by 0.6C° (IPCC 2001), while between 1895 and 1995 Canada's temperature increased by 1.1C° (Environment Canada 1997) with most of this increase occurring during the last decade. Globally, the 1990s were the warmest decade since 1861, and 1998 and 2005 are the warmest years on record. In general, North America was warmer and wetter than normal in 2005, the wettest year on record for Canada (Shein 2006). In Atlantic Canada, 2005 was the seventh warmest on record (+0.9C°) while precipitation amounts were near normal.

The Intergovernmental Panel on Climate Change (IPCC) has developed a number of plausible future climate scenarios. Two climate models, the Canadian Global Climate Model Version 2 (CGCM2) and the Hadley Centre Coupled Model Version 3 (HadCM3), produce output on a coarse grid not necessarily representative of site-specific change, as climate variables must be downscaled from the results to provide a plausible scenario on a smaller scale. A statistical downscaling technique was used to generate future temperature and precipitation values for the Project site.

5.5.1 Historical Trends

The semi-permanent area of relatively low pressure in the vicinity of Iceland and the sub-tropical high pressure region near the Azores are the dominant features of the mean sea-level pressure pattern in the North Atlantic. The relative strengths of these two systems control the strength and direction of westerly winds and storm tracks in the North Atlantic, and play a significant role in the climate of the island of Newfoundland. The fluctuating pressure difference between these two features is the North Atlantic Oscillation (NAO).

A measure of the North Atlantic Oscillation is the NAO index, which is the normalized difference in pressure between the Icelandic low and the Azores high. A large difference in pressure results in a positive NAO Index and can be the result of a stronger than normal subtropical high, a deeper than normal sub-polar low, or a combination of both. A time-series of the winter (December, January, February) NAO index presented in Figure 5.32, shows a general trend toward an increasing NAO index between 1950 and 2006. This trend is also present in the summer (June, July, August) NAO index, albeit weaker.

Over the northwest Atlantic, a positive NAO winter index generally brings an increase in frequency and strength of westerly winds in the upper atmosphere, which tends to steer storm systems in a more west-to-east direction. This results in more storm systems coming off the continent, lower temperatures, increased precipitation, and relatively stronger winds. Due to the weaker trend in the NAO index and other atmospheric patterns during the summer months, conclusions could not be drawn about correlations between summer NAO indices and temperature, precipitation and winds.

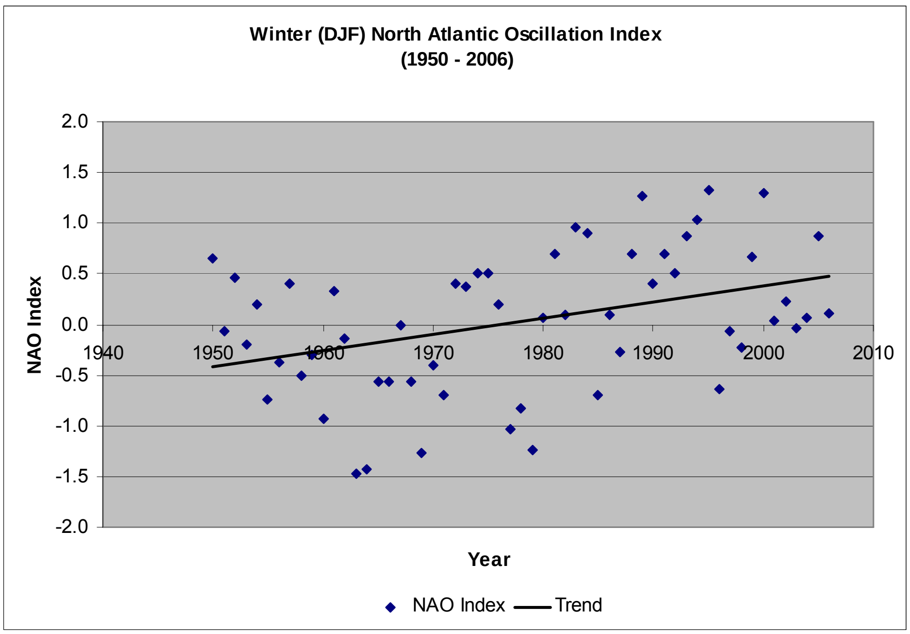

Figure 5.32 Winter North Atlantic Oscillation Index (1950 - 2006)

Observation data from Argentia, Long Harbour, and St. Lawrence weather stations were the only data sets within Placentia Bay of sufficient duration to perform a trend analysis. A scatter plot of the seasonally-averaged NAO winter index recorded at these three stations is presented in Figure 5.33. This plot shows a negative correlation between temperature and NAO index, while precipitation shows a positive correlation, as illustrated in Figure 5.34. The increase in precipitation is also attributed to the more westerly track of storm systems in seasons with a high NAO index.

Winter wind speeds at the three stations were also analyzed to determine whether a correlation could be determined. Seasonal mean wind speed values were computed for each climate station using wind speed values taken at six-hour intervals. A trend analysis of the seasonally averaged NAO index against mean wind speeds shows a positive correlation for the Argentia and Long Harbour stations, indicating stronger winds with increasing NAO index. The St. Lawrence station shows an atypical negative correlation (Figure 5.35), most likely due to local topographic effects.

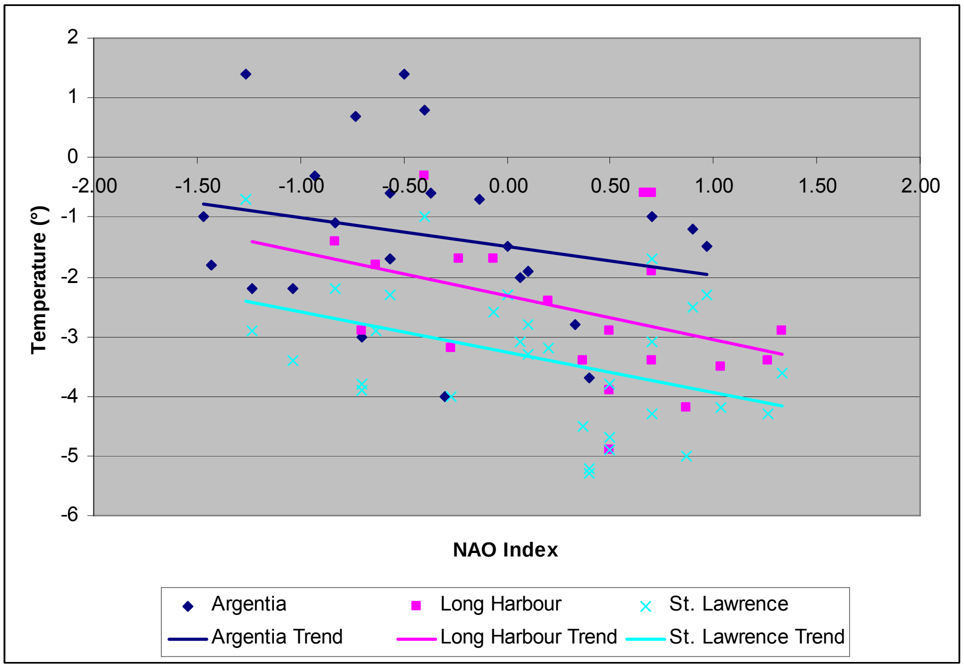

Figure 5.33 Scatterplot of Seasonally Averaged NAO Index vs Temperature for Various Sites in Placentia Bay for Winter

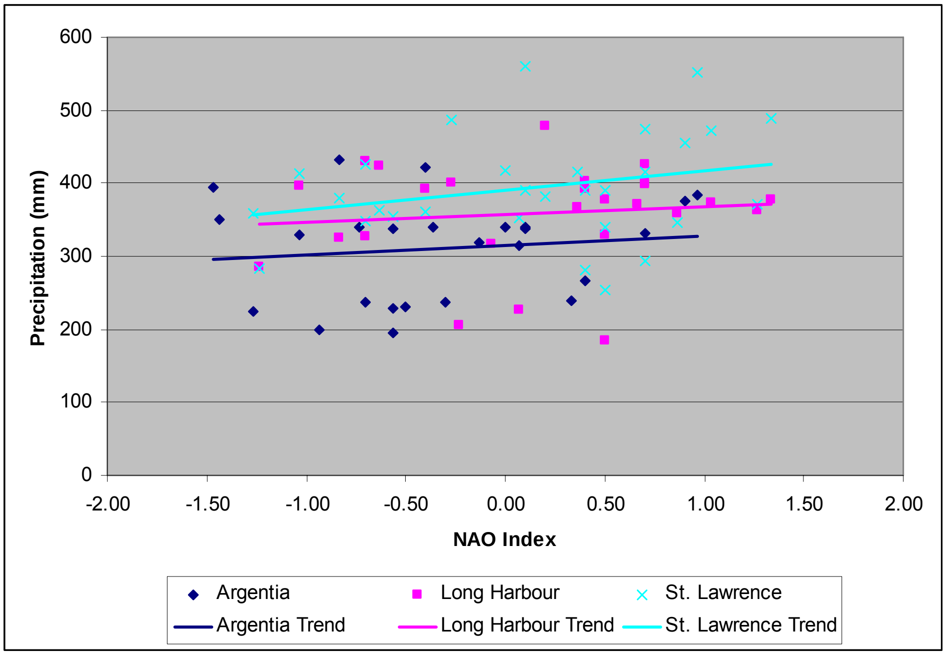

Figure 5.34 Scatterplot of Seasonally Averaged NAO Index vs Precipitation for Various Sites in Placentia Bay for Winter

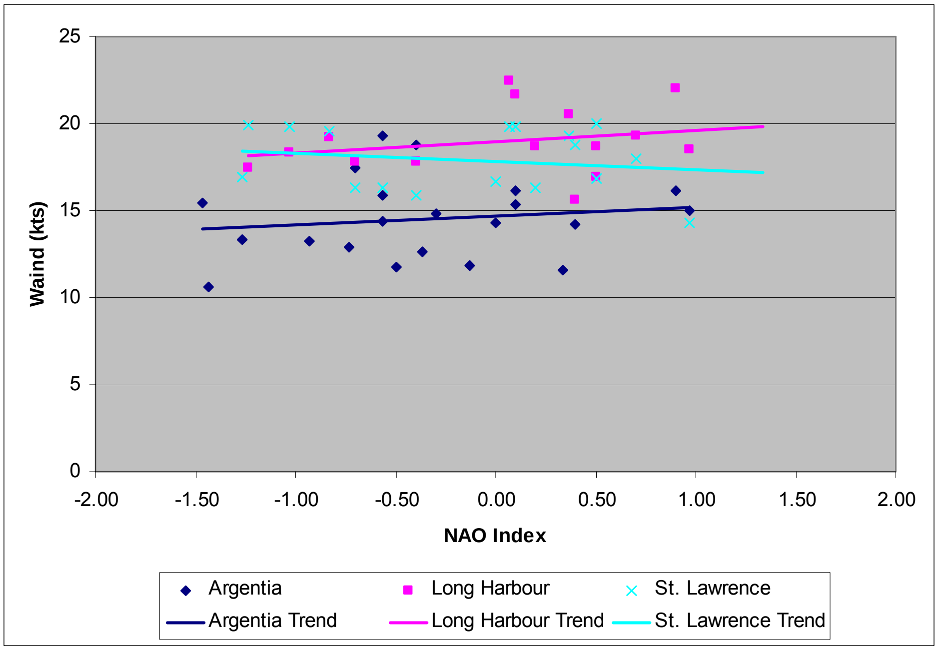

Figure 5.35 Scatterplot of Seasonally Averaged NAO Index vs Wind Speed for Various Sites in Placentia Bay for Winter

The seasonally averaged NAO index against mean wind speed and mean significant wave heights for Grid Point 5616 at the mouth of Placentia Bay for the winter months (Figure 5.36) shows that mean wind speeds increase with increasing NAO index in accordance with general expectations. Similar results apply to Argentia and Long Harbour.

Little correlation is observed with mean significant wave heights even though there was a positive correlation with wind speed. These results are typical of other studies done in the waters surrounding Newfoundland (Swail 1996; Swail et al. 1999).

While NAO index has a less direct effect on the climate of Eastern Canada in summer, studies have shown that the index has an effect on the track of hurricanes in the North Atlantic. During seasons with a negative NAO index, hurricanes tend to a track parallel to lines of latitude, often ending up in the Gulf of Mexico and the Caribbean (Elsner 2003), while during seasons with a positive NAO index, they tend to curve northward (Elsner and Bosak 2004) along the Eastern Seaboard of the US. An analysis of tropical storms entering the Canadian Hurricane Centre Response Zone shows that frequency decreases with increasing summer NAO index. Likewise, the number of tropical storms coming within 278 km of Placentia Bay also decreases during summers with a positive NAO index.

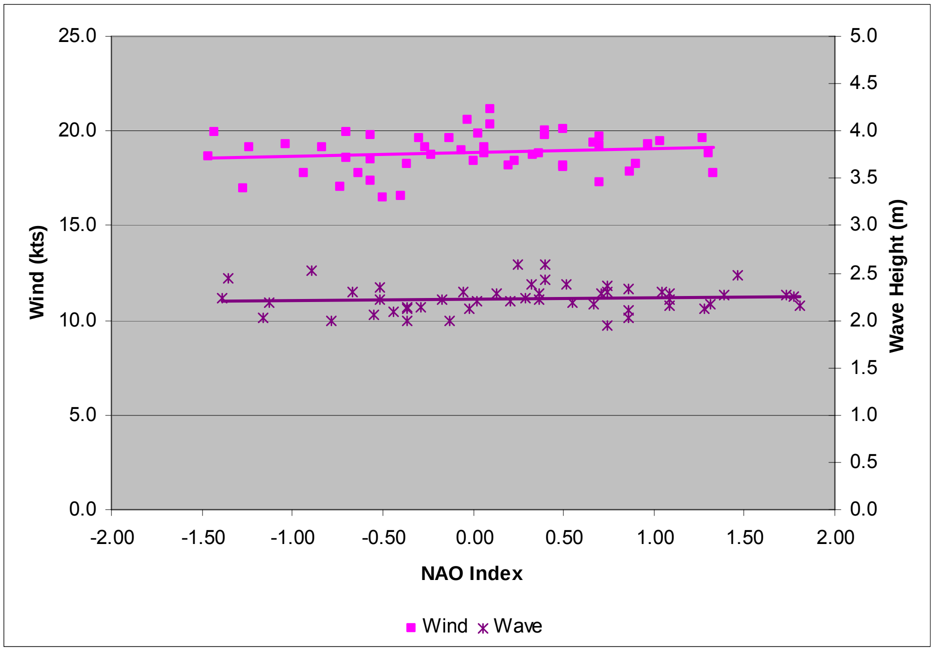

Figure 5.36 Scatterplot of Seasonally Averaged NAO Index against Wind and Wave Height at Grid Point 5616 (Winter 1954 – 2004)

Future Climate Scenarios

As noted, two climate models; the CGCM2 and HadCM3, were used to predict future temperature and precipitation change for the Island of Newfoundland.

These models predict a generally increasing annual mean temperature trend during the next 100 years (Figure 5.37). These trends are also observed in the seasonal model data. The HadCM3 model shows positive trends throughout the year

An analysis of daily averaged precipitation shows only slight long-term changes over the next 100 years (Figure 5.38), with the CGCM2 model predicting a negative trend and the HadCM3 model showing a slight increase. A seasonal analysis of the CGCM2 data shows that most of this decrease occurs during the summer months, while spring and autumn show a slight positive trend. No trends were observable with the winter data. The HadCM3 model results were similar.

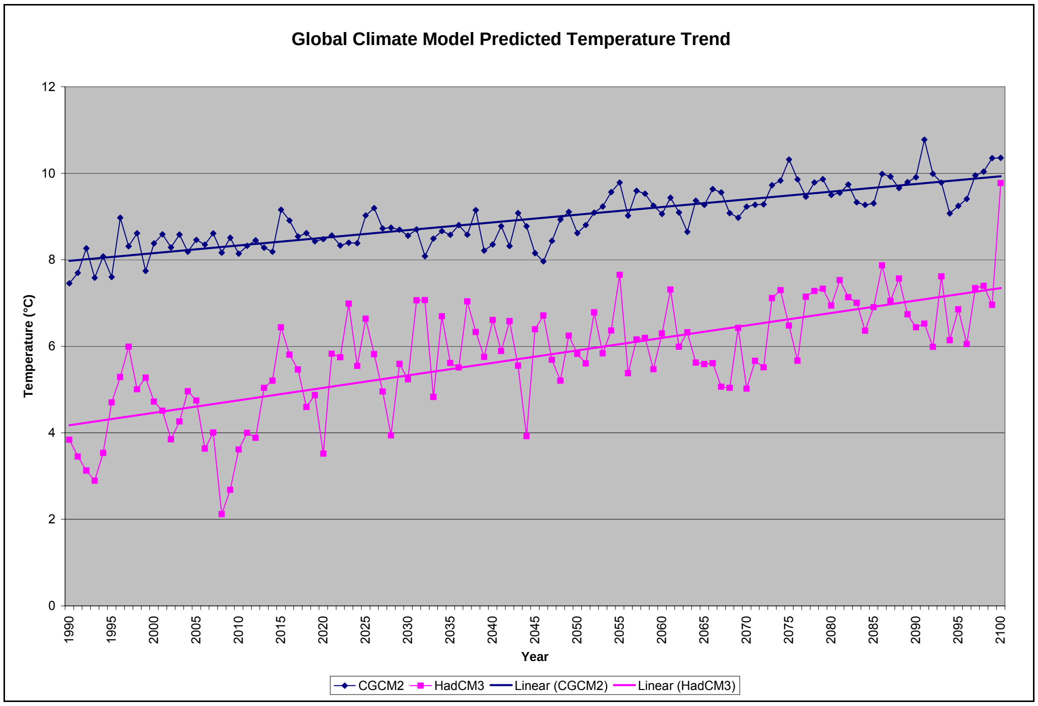

Figure 5.37 CGCM2 and HadCM3 Global Climate Model predicted Temperature Trend from 1990 – 2100

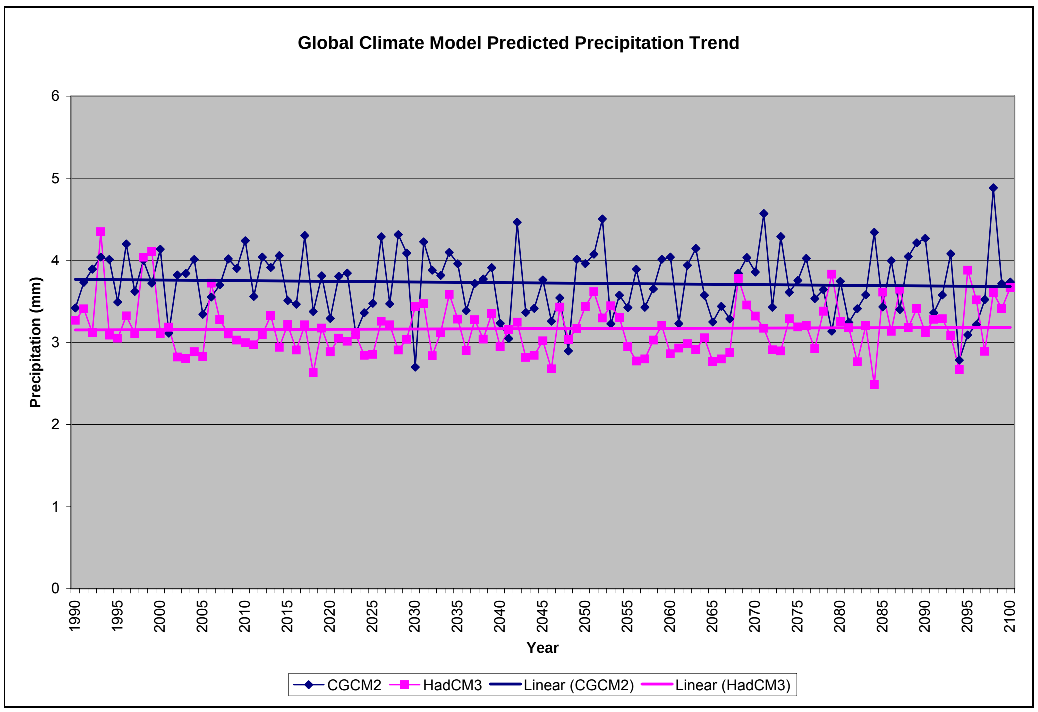

Figure 5.38 CGCM2 and HadCM3 Global Climate Model Predicted Daily Averaged Precipitation Trend from 1990 – 2100

When referring to future climate change scenarios, the scientific community customarily refers to three periods: the 2020s (2010-2039); the 2050s (2040-2049); and the 2080s (2070-2099). Monthly, seasonal and annual analyses of these three periods is presented in Table 5.14. Values presented are predicted model changes from the base period (1971-2000). Temperature increases are generally expected in all three periods on an annual, seasonal, and monthly scale.

The models differ for precipitation predictions, with the HadCM3 model predicting less precipitation than the CGCM2 model.

Table 5.14 Projected HadCM3 and CGCM2 Changes for Temperature and Precipitation at Long Harbour, Newfoundland

	Temperature (C°)						Precipitation (%)					
	HadCM3			CGCM2			HadCM3			CGCM2		
Month	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s
January	0.81	1.00	1.87	1.42	1.27	2.02	1.86	-7.32	3.86	0.94	0.33	6.22
February	0.37	1.34	1.47	1.58	-1.11	2.42	-11.48	-7.71	-12.20	-4.59	-7.42	5.32
March	1.22	1.74	2.12	1.44	2.15	2.28	-2.12	-8.57	11.39	5.09	10.23	5.56
April	1.58	2.27	2.65	1.15	1.82	1.92	-5.36	-4.02	9.37	2.48	4.51	-0.19
May	1.26	1.64	2.26	1.02	1.74	1.67	-19.63	-3.75	-12.84	11.97	3.03	13.35
June	1.23	1.75	2.39	0.86	1.26	1.53	-9.90	-7.70	-23.02	-1.27	-7.31	0.62
July	1.19	1.82	2.32	0.93	1.58	1.50	-14.12	6.70	2.17	-6.47	-20.05	-13.91
August	1.33	2.22	2.71	0.98	2.23	1.61	0.26	-1.50	-6.40	-1.42	1.15	-8.86
September	1.26	2.23	2.90	1.01	1.69	1.69	-2.68	-4.71	-3.07	0.75	-3.24	-16.53
October	1.20	1.84	2.20	1.16	1.66	1.91	-1.64	2.94	-4.53	5.77	-7.77	10.28
November	0.99	1.10	1.90	1.29	1.83	1.88	3.58	0.54	12.26	-2.80	4.30	-5.21
December	1.16	1.10	1.65	1.30	2.13	1.97	3.12	-3.06	2.25	4.77	-4.43	-4.18
Winter	0.78	1.13	1.65	1.43	0.82	2.13	-2.24	-6.04	-2.18	0.54	-3.75	2.35
Spring	1.35	1.88	2.34	1.21	1.90	1.96	-8.41	-5.72	3.44	6.29	5.82	7.11
Summer	1.25	1.93	2.47	0.93	1.69	1.55	-7.93	-1.07	-9.53	-3.28	-9.19	-7.67
Autumn	1.15	1.72	2.34	1.15	1.72	1.83	-0.05	-0.22	2.02	1.35	-1.61	-0.02
Annual	1.13	1.67	2.20	1.18	1.54	1.86	-4.27	-3.36	-1.40	1.12	-2.35	-0.32

The Statistical Downscaling Model (SDSM), developed by Wilby, Dawson and Barrow (2001), has been used to determine plausible future climate scenarios for sites in Atlantic Canada (Lines et al. 2006). Table 5.15 presents the predicted annual changes with respect to the baseline period (1971-2000).

Table 5.15 Projected HadCM3 and CGCM2 SDSM Changes for Temperature and Precipitation at Long Harbour, Newfoundland

	Temperature (C°)						Precipitation (%)					
	HadCM3			CGCM2			HadCM3			CGCM2		
Month	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s
January	0.07	0.07	1.05	0.76	1.27	1.73	-2.32	0.58	0.58	-0.27	2.80	2.82
February	-0.39	-0.41	-0.99	-0.50	-1.11	-1.10	-1.69	-0.60	-1.70	1.20	2.32	5.17
March	-0.03	1.20	1.41	1.59	2.15	3.24	2.35	0.82	-2.65	-1.41	-1.58	-1.61
April	0.43	1.01	1.53	1.17	1.82	2.61	-2.65	-4.61	-2.17	1.15	0.66	3.10
May	0.60	1.01	1.82	1.33	1.74	2.72	-3.62	-4.59	-4.00	3.60	4.03	9.01
June	0.77	1.36	2.11	1.02	1.26	2.36	1.60	2.28	-5.65	1.29	8.22	7.55
July	0.96	1.67	2.16	1.39	1.58	2.32	-0.51	-0.51	-7.88	2.27	4.69	6.65
August	1.40	2.30	3.46	1.81	2.23	3.58	-1.56	-3.46	-9.33	0.84	5.33	5.83
September	0.66	1.88	2.88	1.47	1.69	2.83	-0.54	-0.65	-3.83	-0.66	4.91	1.57
October	0.61	1.44	1.79	1.37	1.66	2.88	-0.80	-0.71	-3.83	8.47	12.69	24.80
November	0.84	0.98	2.59	1.28	1.83	3.08	-3.75	-0.53	3.09	4.17	11.28	9.52
December	1.81	1.91	3.06	1.49	2.13	3.66	2.09	-2.55	1.65	3.48	1.71	11.26
Winter	0.50	0.52	1.04	0.62	0.82	1.51	-0.61	-0.93	-0.09	1.70	2.35	7.01
Spring	0.33	1.07	1.59	1.37	1.90	2.86	-1.17	-2.43	-2.78	0.91	0.73	2.97
Summer	1.05	1.78	2.58	1.41	1.69	2.76	-0.14	-0.70	-7.74	1.95	6.07	7.00
Autumn	0.71	1.44	2.42	1.37	1.72	2.93	-1.45	-0.66	-2.06	3.80	9.26	11.91
Annual	0.64	1.20	1.91	1.20	1.54	2.52	-0.72	-1.08	-3.41	2.23	5.11	7.61

Both of the downscaled (SDSM) models predict a general increase in annual mean temperature for the 2010-2099 period. Both models show a general seasonal increase; however, the HadCM3 model results in the greatest mean temperature increase in summer, whereas the CGCM2 shows the greatest increase in autumn. Both models predict a cooling trend during February.

HadCM3 model precipitation predictions for the Island of Newfoundland show the greatest decrease in precipitation to occur during the 2020s; downscaled values show a general decrease in precipitation for the 2010-2099 period for Long Harbour, with a 3.41% decrease by the 2080s. While the CGCM2 model predicts a slight decrease in precipitation by the 2080s, downscaled results show an increase in precipitation of 7.61% for Long Harbour. In general, SDSM downscaled values differed from the CGCM2 and HadCM3 predictions and produce two conflicting trend predictions for precipitation.

This indicates the difficulty of producing accurate models of long-term climate change effects. The Project design incorporates a reasonable and conservative approach over its operational period, anticipating a temperature increase of approximately 2% and a variation in precipitation ranging between a 4% decline and a 3% increase. The Project design criteria (for physical plant, process, water cycle, storm water run-off, and residue disposal) encompass these predictions.

Effects of the Environment on the Project

A sound understanding of environmental conditions is an essential element in project planning and engineering design. In addition to the considerable body of available material, VBNC initiated several field programs to collect priority data for design input. By incorporating such data into design and planning, it is anticipated that the effects of the environment on the Project will be controlled and managed.

Marine Environment

Wind and waves may affect the Project by causing delays (mostly in regard to marine-related activities such as laying pipe or transporting cargo) or, in extreme cases by contributing to accidental events. Extreme icing conditions can also hamper various operations. High precipitation will affect run-off conditions and open holding ponds. Extreme weather and wave conditions will be accommodated in Project engineering design and planning by following or improving all relevant building and construction specifications, codes and permits.

Storm surges are discussed in detail in Section 5.4. Storm surges of about one metre (positive and negative) have been recorded at Argentia, Placentia Bay. The potential effects of storm surges in Long Harbour is considered and provided for in engineering design. Long Harbour is sheltered so any storm surges, while they may affect water levels, probably would not be accompanied by large destructive waves.

Ice conditions (sea ice, icebergs, icing) based on historical data are described in Section 5.4. Because Placentia Bay is essentially free of sea ice and icebergs most years, and because the VBNC concentrate carrier is ice-strengthened for operations in Labrador, sea ice should not hamper VBNC marine activities.

As with other Newfoundland and Labrador waters, Placentia Bay is subject to icing of vessels from freezing precipitation and sea spray. February is the worst month: extreme icing occurs about 3% of the time.

Climate Change

As discussed in Section 5.5, the forecast effects of climate change in the Project Area are modest. Temperature is predicted to increase by an annual average of 1.91-2.52 C^{o}. Precipitation predictions vary depending on the model parameters used, from a reduction of 3.41% to an increase of 7.61% over the baseline period (1980s).

These changes would not result in any change to design parameters for the Project since such criteria are conservative and usually developed in terms of long period extremes (1:100 year to 1:1000 year).

Terrestrial Environment

Seismicity of the Placentia Bay area is described in detail in Section 5.3. The seismic risk in Long Harbour is no greater than in other areas of Newfoundland and many areas in Canada. Provided that all structures are built to applicable building codes and given the low probability of a major seismic event the effect on the Project is considered to be negligible.

6.0 Project Construction

All construction activities will be planned to build the Plant within specifications, on schedule, within budget, and without harm. There are eight major components of Construction and site development.

- Enlarging the existing wharf, demolition of non-essential buildings and infrastructure at Tier 1
- Pre-stripping, clearing, excavation, site grading, and levelling
- Building access roads
- Drainage works
- Construction of Plant buildings and other facilities
- Construction of Site roads, stormwater, water and sewage systems, and residue and raw material pipelines
- Construction of dams for water supply and for underwater residue storage
- Construction of a marine outfall

The VBNC Owner's team will include, among others, a Construction Manager, Site Superintendent, Industrial Relations Superintendent, Site Supervisors, Safety Coordinator, Environmental Coordinator, Administrative support, and Site Security. The Engineering, Procurement, Construction Management (EPCM) contractor will oversee the construction activities with a team that will include a Construction Manager, Health and Safety Advisors, Environmental Advisor and Assistant, Quality Manager, Civil, Mechanical, Piping and Electrical Superintendents and supporting Discipline Inspectors. Field Engineers will also be provided for the various disciplines. There will also be a Materials Management Coordinator, Cost Controller, Document Controller and Administrative Support.

Site Preparation and Support

Following release from the environmental assessment process, and once all the required government permits have been received, the Construction Team will mobilize, establish a presence at site and begin constructing access roads. One existing maintenance building on the port level (Tier 1) will be retained and will serve as headquarters for the Construction Management team. Mobile offices will be added as the team grows. As part of the earthworks, a space on the southeast corner of Tier 2 will be levelled to provide a laydown area for the staging and storage of construction-related equipment and material. Once work at Tier 2 is adequately advanced, the Construction office will relocate to the Plant Site.

The existing office building, fire truck and ambulance bay, multiple concrete walls, pipe racks and conveyor gallery as well as civil works such as existing parking lots, roads and pipelines, will be demolished. Existing water and sewer systems that serve businesses located at the port will be maintained or replaced. Sewer systems not required by these businesses will be demolished.

Site Grading and Leveling

The Plant Site is heavily treed with some boggy areas. Cover includes up to 400 mm of root mass/topsoil and 400–600 mm of weathered glacial till. The varying thicknesses of glacial till consist of sand, gravel, cobbles and boulders with varying amounts of fines overlying bedrock. There are five major grading and levelling elements.

- Preparation of sites for all process and non-process buildings and related yard space
- Containment of stormwater within the catchment area of the site and direction of the stormwater to holding facilities
- Suitable foundation conditions for buildings, heavy equipment, and machinery
- A 30 m buffer between the site and Rattling Brook to minimize potential impacts
- A snow stockpile area

Construction at the site will be carried out on two fronts. 'Stick-build construction' will cover all civil work up to and including closing in the buildings. Stick-build construction methods involve bringing all steel and equipment to site and subsequently erecting or coupling the components on the site. 'Component construction' will be used for process equipment. Modules and pre-assemblies will be constructed offsite at a fabricating facility tested and pre-commissioned and then transported to site and placed in the various process circuits.

The earthworks scope, including the processing complex on Tier 2 and the access roads, involves clearing approximately 43 ha, grubbing 120,000 m^3, excavation of 120,000 m^3 of unsuitable material, excavation of 200,000 m^3 of common material and approximately 840,000 m^3 of rock excavation. In addition, earthworks of approximately 260,000 m^3 will be required at Sandy Pond. Earthworks for the gypsum residue storage area (Matte Plant) would include approximately 180,000 m^3, of which about 40,000 m^3 will require blasting.

A storage area of approximately 5 ha will contain all clearing, grubbing and material unsuitable for construction that is removed from the plant site. An estimated 250,000 m^3 of grubbed material will be stored. Locations immediately south and east of the processing facilities on Tier 2 have been identified as potential storage areas.

Drainage control measures, including erosion and sediment control, will be provided to control suspended solid material transport by water and erosion of disturbed ground.

- Silt fence / curtains – for use across streams, ditches and at toe of fill embankments
- Sediment traps to filter sediment-laden runoff from the site
- Sediment basins to filter sediment-laden runoff from the site at discharge points of drainage
- Rock-lined ditches to control velocities in ditches and to encourage deposit of fines
- Erosion mats on slopes to stabilize against washout

- Energy blocks in ditches to control velocity in ditches and capture sediment

A detailed Construction Environmental Protection Plan will be prepared and implemented prior to the start of construction.

Construction Accommodations

Workers living within a reasonable traveling distance (100 km) generally will prefer to receive living and travel allowances, and arrange their own accommodations. While most of the skilled workforce will be drawn from this area, there are relatively few accommodations available for workers outside this area. Consideration will be given to extending the acceptable distance for transportation allowances, enabling the majority of workers the opportunity to commute. Conception Bay South, Conception Bay North, Clarenville, Arnold’s Cove, and St. John's have a greater population than the Long Harbour area and are all located within 75 to 120 km of the site. Nevertheless, VBNC has identified labour availability as a key risk for construction. Consequently the company plans to provide accommodations in support of the Construction Phase, driven largely by the need to attract workers from out of the province.

The construction workforce will be operating on 2 shifts per day and could peak at approximately 1700 during 2010. This peak workforce would not be available in the Province and upwards of 30-40% might have to be hired from outside. This would require accommodations to support approximately 500 people. In planning this support facility, VBNC recognizes that accommodation standards and amenities are key attractors for trades working on semi-remote and remote projects across Canada, and in order to be the construction site of choice, VBNC would need to provide accommodations that would be comparable to, or surpass, the standards set elsewhere.

The construction accommodations will be located in the vicinity of the intersection of Route 202 and Route 101, and will include a variety of amenities.

- Private rooms – single occupancy
- TV in rooms
- Private bathroom
- Internet hook-up in rooms
- Common dining room including custom culinary for immigrants as required
- Commissaries at schedule intervals
- Laundry facilities
- Multi-media lounge
- Internet café
- Medical support
- Bus shuttles to the work site
- Parking lot for personal and company vehicles
- Public telephones

- Recreational facilities
- Work-out room with time dedicated to women only
- Gymnasium
- Walking trails
- Games room

The facility will be off limits to the public and access will be controlled by security. Alcohol, drugs and guns will be subject to a zero tolerance policy. No hunting will be allowed on site, however fishing at nearby ponds will be available in off hours with permission from the facility supervisor. Taxis will be permitted for drop-off and pick-up purposes. Local businesses such as pizza shops will be permitted to drop off food deliveries and supplies and will be encouraged to provide consumables, housekeeping, garbage removal, snow clearing, vending machines, and other services.

The accommodations complex will be constructed in Year 1 to support the need for an increased labour workforce in Year 2. There will be approximately 50 people employed in construction of the facility and 45 during its operation.

Shortly following the nickel processing plant construction completion and demobilization of the workforce, the accommodation complex and support facilities will be removed from site by the operator and the site restored to its original condition.

Marine Works

During expansion of the existing wharf (Figure 6.1) at least 60 pilings will be installed, 40 on the north side for the wharf extension, and 20 on the south side to accommodate the conveyor system. Each piling will be installed 20 to 25 m into the sediment. Displaced sediment will be pumped from inside the pile and disposed on land in accordance with regulatory requirements.

Dredging in the area immediately adjacent to the existing wharf will remove an estimated 20,900 m^3 of infill sediment and some scrap steel to ensure safe docking. Dredging will likely be carried out using a backhoe operating from a barge. No blasting is planned. Dredge spoils will be disposed above ground in accordance with regulatory requirements. The elemental phosphorus which is encapsulated in the existing dock will not be disturbed.

Substantial sections of reclaim area foreshore and wharf toe will be upgraded to provide better shore and scour protection. Existing shoreline along much of the reclaim area is presently being eroded.

Shore protection for sheltered and shallow ($\leq$3 m) areas will be provided by riprap (armour stone) and filter stone for approximately 350 m. This will result in a minimum of 2800 m^2 of riprap surface area.

Shore protection for exposed and deeper (>3 m) areas will be provided by larger riprap and filter stone for approximately 450 m. This shore protection will result in a minimum of 4500 m^2 of riprap surface area.

Scour protection to control erosion at the seabed from propeller wash will also be provided by larger riprap and filter stone. Scour protection would extend approximately 30 m beyond the face of the post-wharf expansion berth and up to the toe of the concrete crib. The area of armour stone in the dredged area will be approximately 6000 m^2.

Water and Sewage

Temporary facilities for water and sewer services will be provided for all workers on site. Potable water will be provided through a local water supply contract and distributed to key points around the site as construction evolves. Wash trailers will be provided by the various contractors to ensure appropriate levels of industrial hygiene. All temporary sewage disposal systems used during construction of the commercial plant will comply with all health and safety regulations. Sewage will be handled by temporary portable toilets located at various locations around the construction site, and by underground holding tanks for the construction support trailers. All septic waste will be transported off site and disposed in an approved disposal site by a licensed contractor.

Waste Management

All domestic solid waste will be collected, properly stored, removed, and disposed of in a licensed landfill site in a neighbouring community. The site and working area will be kept clean of all debris and garbage.

Materials such as paper, cardboard, wood, scrap steel and metal, and tires will be collected and offered for recycling. All materials not recycled will be disposed of in an approved facility, with permission of the facility operator. Waste accumulated on site prior to disposal will be placed in a secured location. Construction and demolition debris will be covered to prevent blowing dust and debris.

Power Supply

Temporary power will initially be provided by diesel generators for lighting and power tool requirements. As construction progresses temporary electrical connections will be made from the provincial grid. All temporary power will be arranged by individual contractors and will be permitted as required with the utility and regulators.

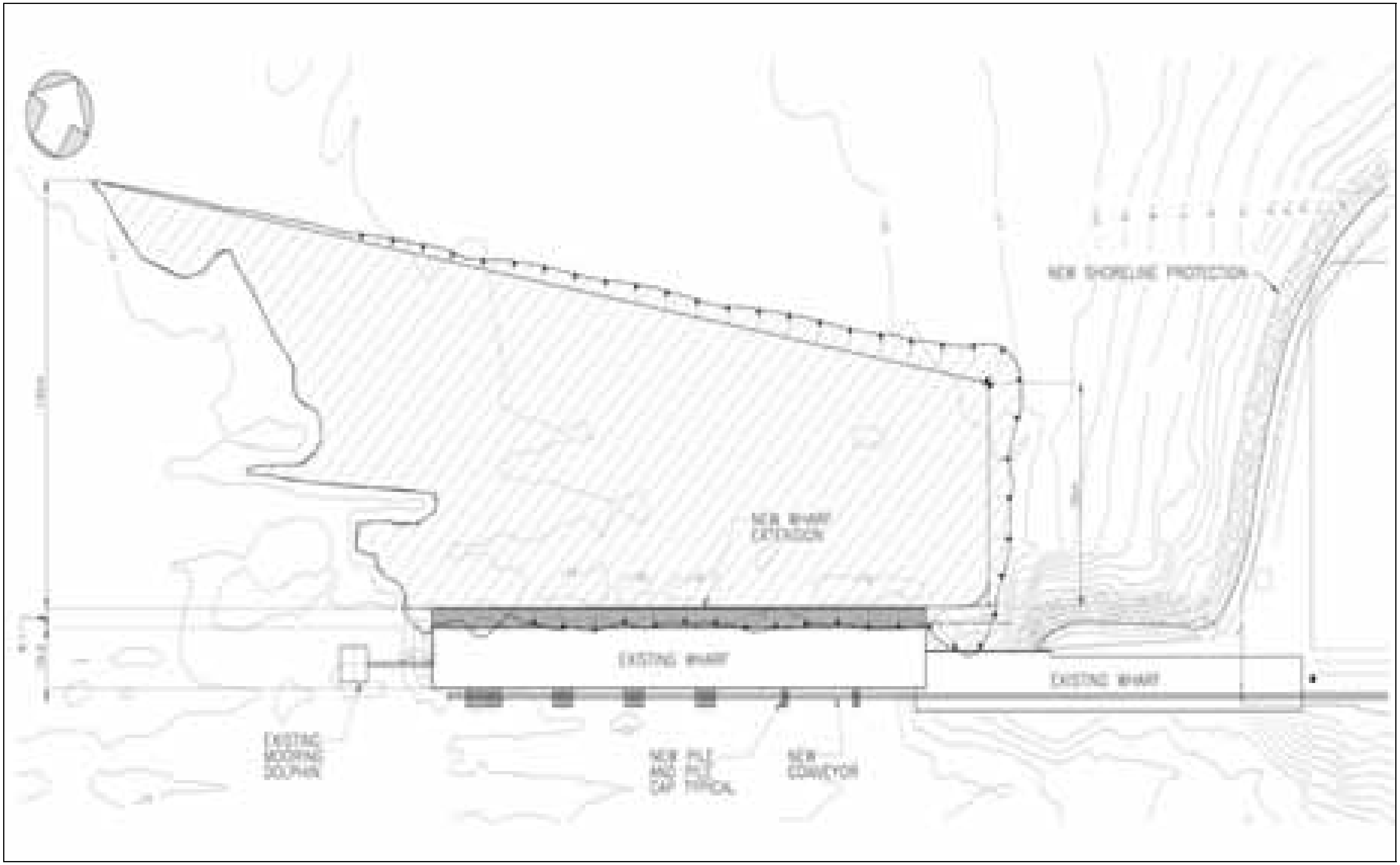

Figure 6.1 Marine Works

The estimated electrical operating load for the Project is 80,000 kilovolt-amperes (kVA). Power will be supplied from the Newfoundland and Labrador Hydro bulk transmission system. The main incoming substation will have a minimum of two step-down transformers, each with sufficient capacity to carry the full Plant load.

Site primary distribution voltage will be 13.8 kV. Nickel electrowinning rectifiers and unit substations will be fed at primary distribution voltage. Unit substations will be either 13.8/4.16 kV or 13.8/0.6 kV as required. Double transformations will generally be avoided. Critical substations will be either in a primary selective or ring bus configuration. Secondary selective configurations will be considered only where there is a sufficient concentration of load. Designated voltage buses will have a backup source (e.g. an emergency diesel generator set) to provide required reliability.

Fuel Management

Transportation, storage and use of fuels at the construction site will be conducted in compliance with all relevant laws and regulations. Before transporting or locating fuel at the project site, contracted fuel suppliers will be required to provide a copy of a fuel spill contingency plan acceptable to VBNC. Contractors are required to ensure that fuel and other hazardous materials are handled by persons who are trained and qualified in handling these materials, in accordance with government laws and regulations, and in conformance with the VBNC Environmental Protection Plan. Refuelling protocols are noted below.

- Use of leak-free containers and reinforced rip and puncture-proof hoses and nozzles
- Use of hoses that have a design pressure rating of at least 150% of the maximum head of the system
- Attendance for the duration of the fuelling operation
- Sealing all storage container outlets except the outlet currently in use
- Smoking will be permitted in designated areas only and prohibited within 10 m of designated fuel storage areas
- Fuel unloading facilities will be equipped with drip pans to collect hose drainage and drips. Fuel transfer lines will be equipped with check valves to prevent spillage
- Fuel tanks will be self-dyked or will be positioned over an impervious mat surrounded by an impervious dyke. They will be located in areas where spills, should they occur, are least likely to flow towards water courses, water bodies, feeder streams, ditches or the ocean. Fuel storage will be at least 100 m from any water body
- Drums of fuel oil, if required at site, will be tightly sealed to prevent corrosion and rust. Quantities on site during construction will be limited to that required for the current activity and minor equipment maintenance
- All storage facilities will be located away from construction activity, have secondary containment and be inspected on a regular basis for compliance with regulations

Excavation and Blasting

Excavation and blasting for construction of the plant site and access road will be carried out over a 15-month period commencing in Year 1. Excavation and blasting associated with the construction of residue storage facilities at Sandy Pond will take place in Year 2. A total of 1 100 000 m^3 of fill and rock will be removed. Concrete aggregates and other crushed material will be manufactured off-site by local suppliers.

Excavation and blasting would also be carried out at the Matte Plant residue storage site. The volume of material would total 180 000 m^3, of which about 40 000 m^3 could require blasting.

Pre-Stripping

Grubbing of the organic vegetation mat and/or the upper soil horizons will be kept to a minimum, but will be necessary within the Project footprint. Erosion control techniques and devices will be used to stabilize easily eroded areas. Topsoil and excavated overburden will be stored in separate stockpiles for later use. Any unsuitable material will be placed in an approved stockpile area. Runoff of sediment-laden water during grubbing will be minimized by using measures such as settling ponds, ditch blocks, interception ditches, and filter fabrics. Erosion control measures such as rip-rap, filter fabrics, drainage channels, and gravel or wood chip mulches will be implemented in areas prone to soil loss.

Storm Water Management

Storm water within the property boundaries will be collected at containment / settling ponds and treated as necessary prior to discharge; storm water outside the property boundaries will be diverted away from the work site. During construction, dewatering will minimize and control the release of sediment-laden water, which itself will be controlled through the use of filtration, erosion control devices, settling ponds, straw bales, geotexiles, or other devices. The construction of storm water management control facilities such as sedimentation ponds, site drainage ditches, and diversion structures and channels will be completed prior to site grading and pre-stripping.

An area of approximately 40 ha drains toward Tier 2 from the west. The runoff from half of this area flows into an existing pond west of Tier 2. The natural outlet of this pond will be maintained and the natural stream intercepted and directed south, into another existing pond at the southwest corner of Tier 2. The remainder of the drainage area to the west of the site (approximately 10 ha) will be intercepted by a ditch running along the western perimeter and flowing north, to drain overland towards Long Harbour (Figure 4.1).

An area of approximately 100 ha drains into two ponds at the south end of Tier 2. An additional 30 ha is directed to these ponds from the west, as described above. Currently the ponds drain through Tier 2 into a tributary of Rattling Brook. A berm will be constructed to block this outlet and a channel will be constructed to redirect the flow directly into Rattling Brook.

Access Roads

Site access roads will be required between Tier 1 and Tier 2 and to the outlying structures including Rattling Brook Big Pond. For the Hydromet Plant access roads will be provided to the near and far sides of Sandy Pond. For the Matte Plant, an access road would be required to the gypsum residue storage area. Provision of a temporary access road to Sandy Pond from Route 101 is also planned during construction. Figure 4.1 shows the road network and water crossing locations.

Dry material will be moisture-conditioned or covered to prevent blowing dust. Dust control will be provided for temporary roads and construction activities, primarily by using water. Other agents such as calcium chloride may be used as required and where permitted.

There will be three road crossings of Rattling Brook, one, a multi-plate bottomless arch and two culvert installations. All stream crossings will be designed and constructed to allow fish passage and to preserve aquatic habitat. All culvert installations will be sized to meet design flood conditions.

A short section of Route 202 should be upgraded, starting at the new plant site access road and continuing to the Long Harbour turn-off. This section of road, approximately six metres wide plus shoulders, should be upgraded to a width of seven meters, including two driving lanes, gravel shoulder and ditches. Approximately 12 km of Route 202 from the Long Harbour intersection to the Trans Canada Highway should also be upgraded.

The primary entrance to the site will be constructed from Route 202 to the site security building, approximately 2.5 km. The new road will consist of 3.5 m-wide lanes, two driving lanes and a climbing lane for slow traffic. The granular base for the road will be made up of Class ‘A’ and Class ‘B’ material. The finished surface for the road will be surface-course asphalt. Curbs and gutters will be installed at required locations. A three-lane multi span culvert will be constructed over Rattling Brook to accommodate, at a minimum, CS 600 loading, or specific construction loads that may result from the delivery of modules to the site. The 0.8 km access road to the Marine and Port Facilities from Route 202 will consist of two 3.5 m wide driving lanes. Construction will primarily involve road widening and relocation, new construction, ditching, placement of granular material, and asphalt.

Access roads to Sandy Pond (approximately 3.8 and 4.3 km) and to the water supply intake at Rattling Brook Big Pond (approximately 2 km) will consist of two lanes, surfaced with Maintenance Grade No. 3 gravel material. Construction will be accomplished primarily by “cut and fill” methods which use local materials. The access road to Sandy Pond will need two culverts. For the Matte Plant, a similar access road would also be constructed to the residue storage area, approximately 2 km southwest of Tier 2, using cut and fill methods.

A single lane, 4 m-wide, rough-terrain road will be constructed for utility or off-highway vehicles to provide access to the slurry pipelines between Tiers 1 and 2. A culvert will be installed across Rattling Brook.

Site roads and driveways will be constructed to provide access to buildings and other site infrastructure. The main road access to the site will be provided from the northeast corner and will eventually lead into parking lots and the administration building area. The layout of on-site roads will be a function of the building and facility locations and their associated connections. On-site and internal roads will work around these areas in a block configuration to provide the most efficient layout.

Roads will be a combination of paved and gravel surfaces, depending on their function. Pavement structures will be designed for medium to heavy duty traffic loading and will generally consist of 50-100 mm asphalt over 250-400 mm of granular on compacted sub grade. Cross slopes of 2% minimum will be provided for drainage.

A rough-graded construction road will be built to the plant site from Route 101, running along the south side of Sandy Pond toward Tier 2. This will provide access to the Plant Site borrow pits and rock quarries. Parts of an existing trail which runs parallel to the plant site next to Rattling Brook may also be widened for construction access.

Water Control Structure and Dam Construction

A water control structure will be required at the water supply source (Rattling Brook Big Pond), and dam construction at the residue storage area (Sandy Pond).

6.1.1 Rattling Brook Big Pond

The water supply control structure (Figure 6.2 and Figure 6.3) constructed at the outlet will retain sufficient water in Rattling Brook Big Pond to supply the site with water, and to meet instream flow needs for protection of fish and fish habitat. DFO guidance will be sought for detailed design and placement, and the structure will be built in accordance with the VBNC Environmental Protection Plan. The structure will be an overflow weir-type, approximately 60 m long with an access footbridge. A flow compensation facility will be incorporated into the dam and will consist of a pipe through the dam structure to maintain flow to Rattling Brook based on minimum flow requirement of 0.3 m^3/s. Operating design water level ranges are as follows:

- Low water level – elevation 107.0 m
- Normal operating level – elevation 109.0 m
- Sill elevation of the weir - elevation 109.1 m
- Dam crest elevation – 109.6 m (Design flood elevation for 1:1,000 flood event)

The water supply intake location will be on the north shore of Rattling Brook Big Pond, approximately 200 m upstream from the dam.

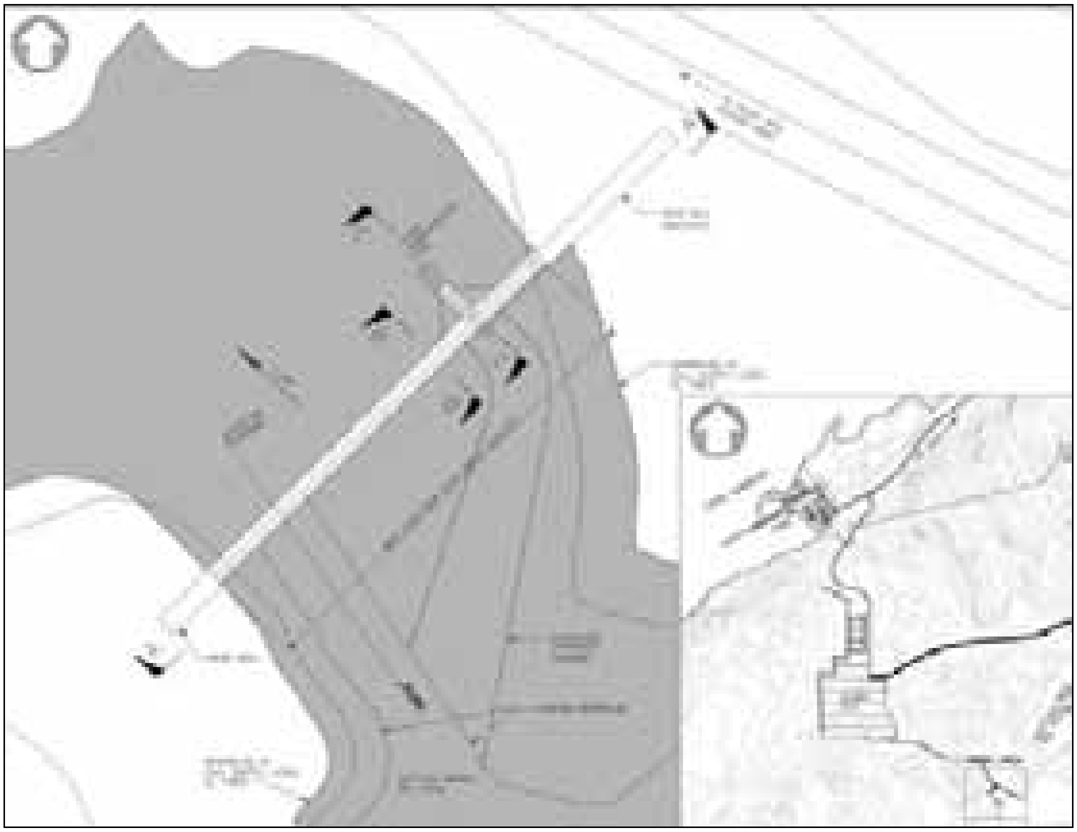

Figure 6.2 Water Supply Control Structure

6.1.2 Sandy Pond

Three earth filled dams will be constructed at Sandy Pond to contain the residue (Figure 3.2). The dam dimensions are:

- Dam 1: 234 m long by 9.0 m high
- Dam 2: 456 m long by 17.0 m high
- Dam 3: 232 m long by 9.0 m high

A typical cross-section is shown in Figure 6.4. Cofferdams required to keep work areas dry will generally be about 3 m high with a crest width of 5 m. Runoff will be constantly pumped at a rate of about 0.075 m^3/s during construction to keep the water level at around 126 m in elevation. The storage capacity between 126.0 m and 127.5 is about 400,000 m^3, which is adequate to handle a 1:100 year runoff event.

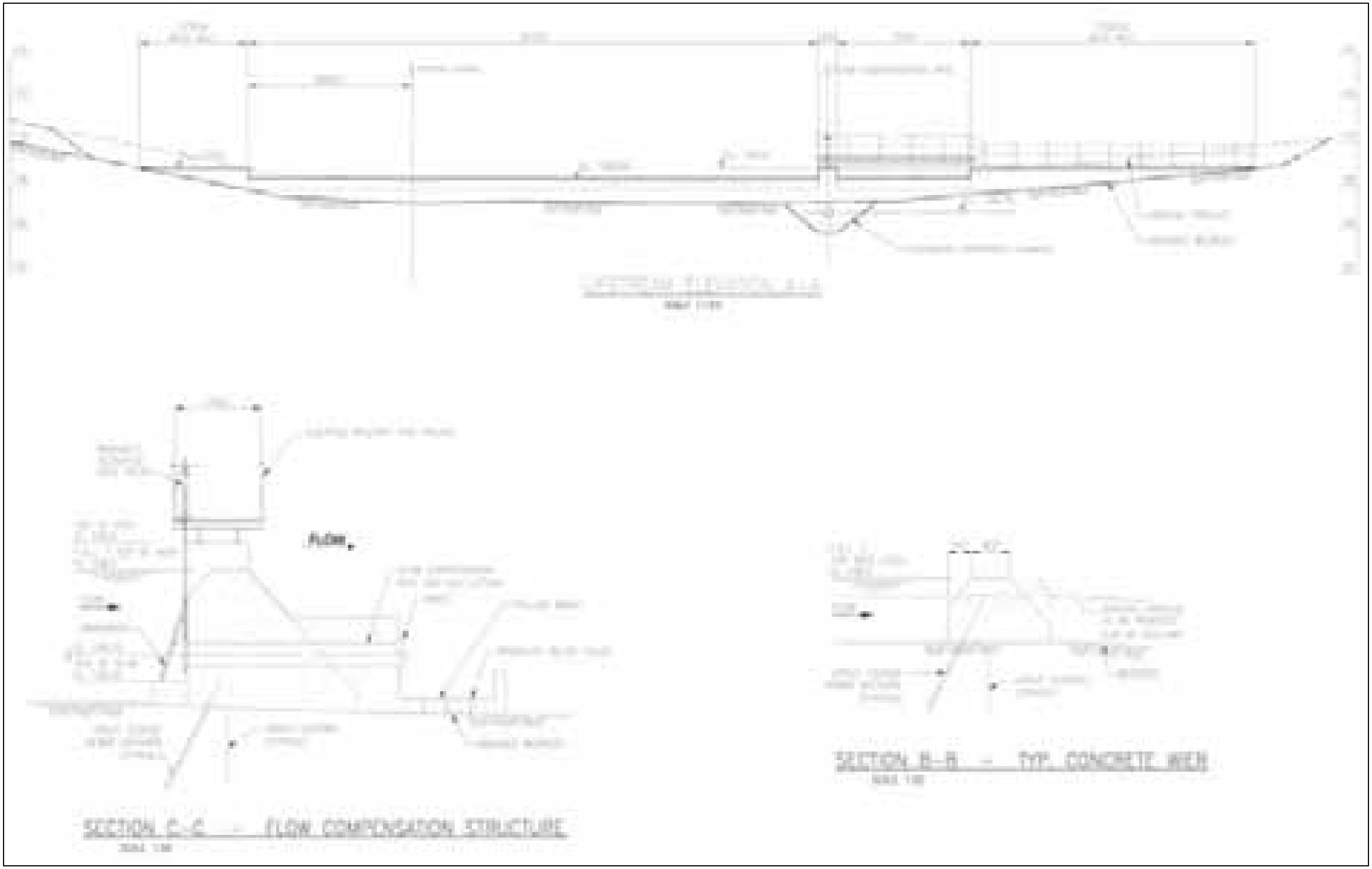

Figure 6.3 Cross – Sections, Water Supply Control Structure

All overburden materials and loose bedrock will be excavated from the dam foundation areas. The rock surfaces will be completely exposed using pressure washing or scraping and minor drilling techniques. Fracture patterns within the exposed rock surface will be mapped and evaluated. Conventional cement pressure grouting methods will be used to reduce the near-surface bedrock permeability, following which, the bedrock surface will be prepared for placement of granular materials. The dams will be constructed in a series of lifts using conventional zoned embankment construction methods.

Pipelines

For the Hydromet Plant, the concentrate, lime, and limestone slurries will be piped from Tier 1 to Tier 2 within a contained area. Adjacent to this will be a pipe bench for potable process, effluent and fire water from Tier 2 for use at the Port. Sulphuric acid will also be piped from Tier 1 to Tier 2 along this bench using double–walled pipe. These lines will all drain to a low point collection sump.

The residue pipeline from the Plant Site to Sandy Pond will be protected from road traffic. Process and operational control measures will be implemented to mitigate potential leaks. Low point collection ponds will be incorporated along the route and will have a capacity of 100% of the associated section of pipe.

There will be four sets of pipelines associated with the residue storage:

- Two slurry transfer pipelines from the processing plant to the residue pond, one in operation and one standby;
- A decant water pipeline from the residue pond to the effluent treatment plant;
- An emergency outfall bypass line acting as a contingency line in case the ocean outfall cannot be operated, from the treatment plant to the residue pond; and
- Residue discharge and distribution pipes within the residue pond;

For the Matte Plant, a similar pipe bench would be required to route pipelines for potable, process, and fire water from Tier 2 for use at the Port Site. It would also include double-walled concentrated sulphuric acid pipe lines to transport material from Tier 1 to Tier 2.

A High Density Polyethylene (HDPE) effluent discharge pipeline from the Plant Site will extend into the bay to a diffuser located east of Shag Rocks.

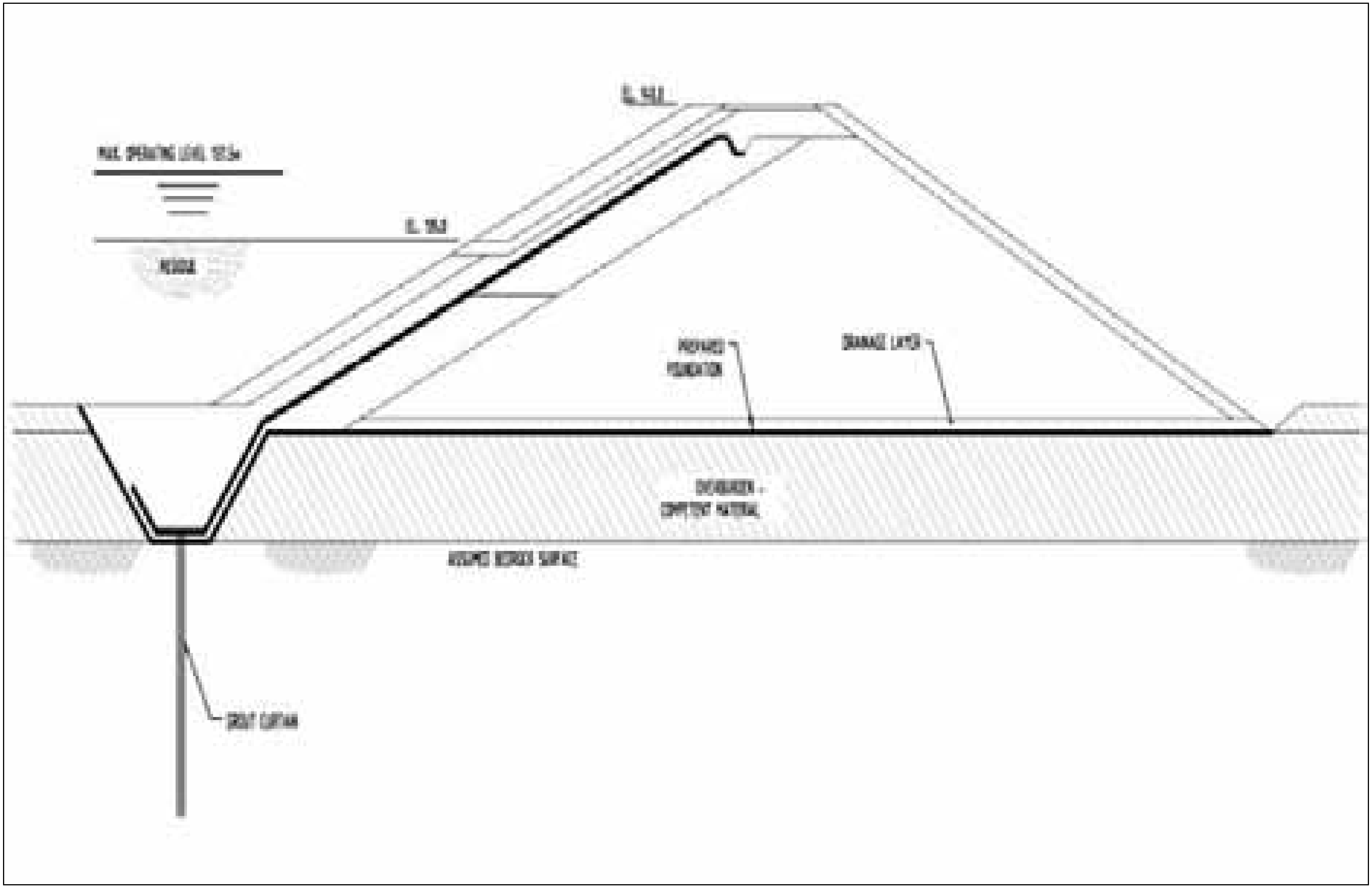

Figure 6.4 Dam Cross Section

Pipe Racks

Process piping between buildings on Tier 2 will generally be carried in elevated pipe galleries. These galleries will also serve as pedestrian corridors. Water supply lines will be carried in the pipe galleries and underground.

Quarries

Granular fill will be obtained from site excavations within the construction area; rock fill materials will come from site-developed quarries or general excavation. Aggregates are expected to be provided from existing off-site quarries. Aggregates will be stockpiled in approved locations with provision for control of silt laden run-off water.

Marshalling and Equipment Storage Areas

Owner-supplied plant, material and equipment will be received during construction and initially handled at the warehouse facility on Tier 1, with easy access to Route 202. Separate laydown/marshalling areas have been identified at each Tier. A secure fenced area will be located on the north side of the existing maintenance building and used for storage of specialty construction supplies. Other construction materials will be placed in the container storage area to the northeast of the wharf on Tier 1.

An area will be cleared at the southeast corner of Tier 2 for storage/laydown of equipment and construction materials required for Tier 2 construction. The area will be at least 30 m from any water body. Vehicles and equipment will follow established routes to the marshalling area. Any overflow will use the future Tier 2 parking area. The site for equipment marshalling will be located to minimize potential traffic hazards, so that incoming and outgoing vehicles can merge safely. Additional marshalling or storage areas, if required, will be sourced in the local area.

Buildings

Buildings will be constructed for a variety of purposes, including feed material storage and preparation, various process operations including leaching, solvent extraction. electrowinning, and neutralization, and support/services including workshops, security, and administration. The general arrangement of buildings is shown in Figure 2.2 and 2.3.

Lighting

All buildings will include perimeter lighting with 400 W outdoor fixtures at 15-m spacing. Exterior lighting will be timer or photocell controlled. Lighting will also be provided at doorways and overhead doors.

Street lighting will be provided along the main access road to the site, but not to Sandy Pond, Rattling Brook Big Pond, or in the case of the Matte Plant, the gypsum residue access road.

Lighting will illuminate the Port Site to allow for safe operation of vessels, passage of crew and company personnel, and inspection of equipment, containers, and warehousing. The container storage area on Tier 1 will use high mast poles and lighting covering the entire area. Street lighting will be provided through the restricted area on Tier 1 and the wharf. The entire operating area in the east portion of Tier 2 will be illuminated.

Labour Force

The Hydromet construction phase will create approximately 5750 person-years of employment; the Matte Plant would create 4950 person-years. Table 6.1 summarizes the estimated total labour demand by year. VBNC will work closely with contractors and provincial building trade unions to identify a qualified skilled workforce from within the Province and elsewhere to support the construction program.

Equipment, Construction Materials and Services

Contractors will be required to deliver construction equipment to the worksite in good operating condition, free of leaks, and with all appropriate emission filters. Equipment will be routinely inspected for leaks or mechanical conditions that might result in spills of fuel, lubricating oils, or hazardous materials. Fuelling and routine maintenance operations will be conducted in accordance with appropriate standards and guidelines. Equipment usage will be limited to approved locations, e.g. the worksite or established transportation routes. All vehicles and generators will have exhaust systems regularly inspected and mufflers will be required to be in good condition for noise abatement.\

Transport of Workers and Materials

Vehicles and equipment will follow established routes when traveling to or from the site. All entrances and exits from the site will be designed so that incoming and outgoing vehicles may merge safely with other traffic, and oversized modules will be provided with escorts as required. There will also be some marine transport to the site, and it all ships used for Project-related shipping will comply with applicable shipping regulations. VBNC will require strict compliance with all environmental legislation and all vessels will operate in strict compliance with the Placentia Bay Vessel Traffic Management System. Up to three vessels per month (barges or ships) are expected to deliver material to the site during construction.

Road traffic during construction will include workers commuting to the site, and deliveries of material such as steel, concrete and a variety of consumables. Anticipated daily traffic volumes are projected in Table 6.2.

Table 6.1 Construction Labour Estimates

Trades	NOC Code	Person-Years			
		Yr 1	Yr 2	Yr 3	Yr 4
Direct Trades					
Bricklayers	7281	n/r	10	20	4
Iron Workers	7264	80	140	120	50
Plumbers and Pipefitters	7251	35	75	150	125
Electricians	7241	40	80	130	100
Labourers	7611	60	125	125	100
Carpenters	7271	60	125	80	50
Millwrights	7311	10	50	80	60
Operating Engineers	7421	60	70	60	40
Boilermakers	7292	15	60	80	70
Insulators	7293	n/r	n/r	10	6
Painters	7294	n/r	5	5	5
Sheet Metal Workers	7261	n/r	50	50	20
Instrument Technicians	2243	n/r	n/r	80	60
Total Direct Trades		**360**	**790**	**990**	**690**
Indirect Trades					
Bussing	7412	6	12	16	11
Janitorial / Outhouse	6663	5	14	14	14
Bulks	7611	3	10	13	10
Water Supply / Delivery	7611	2	5	5	5
Waste Management	7611	1	3	4	4
Perm. Plant Maintenance	7445	n/r	2	5	3
Medical	3152	1	2	2	2
Security		12	17	17	17
Total Indirect Trades		**30**	**65**	**76**	**66**
Total Direct and Indirect Trades		**390**	**855**	**1,066**	**756**
EPCM		**265**	**350**	**300**	**108**
Owners		**80**	**103**	**99**	**84**
Operations		**0**	**0**	**215**	**410**
Total		**735**	**1308**	**1680**	**1358**

Notes: Initial operations employment overlaps last two years of construction phase.
There will be similar employment by occupational group for the Matte Plant within plus or minus 5%.
** Subtotals and Totals rounded to full numbers.*

Transport and Handling of Hazardous Materials

All contractors will be required to observe strict compliance with the requirements of Workplace Hazardous Materials Information System (WHMIS) Regulations regarding employee training, use, handling, storage, disposal, labelling, and provision of Material Safety Data Sheets (MSDS). MSDS will be required on delivery of materials. Transportation, storage, and use of hazardous materials will be conducted in compliance with government regulations. Hazardous materials will be packaged and shipped in strict compliance with the regulations. All vehicles entering the site will be inspected at the gate to ensure that appropriate placards are in place and the security of the product is assured. All drivers will be required to show proof of certification.

Table 6.2 Anticipated Daily Traffic Volumes

Year	Commuter Vehicles	Concrete Trucks	Structural Steel Trucks	General Freight Trucks	Total for the Project[2]	Current Traffic Count[3]	Total, Current and Project
2008+	83[4]	8.8	0.6	0.4	93	1001	1094
2009	400	8.8	1.8	1.3	413	1021	1434
2010	470	7.6	0	3.3	482	1040	1522
2011++	198[5]	0	0	0.7	199	1062	1261

Notes:
[1]Vehicles per day assumes a schedule of 330 working days per year, excepted where noted.
[2] Estimated to nearest whole number.
[3] Estimated based on two per cent annual increase.
[4] Only last quarter (90 days) of 2008.
[5] Average commuter vehicles per day declines from 230 at beginning of 2011 to 150 by project completion.
+ Construction is expected to commence Q4 2008.
++ Construction is expected to conclude Q1 2011.

Progressive Rehabilitation

Final grading will be undertaken immediately after completion of an activity rather than at the end of construction. As soon as possible following construction activities, the VBNC Environment, Health and Safety Coordinator will identify areas requiring planting or seeding for re-vegetation, these will include areas adjacent to watercourses where erodible soil has been exposed, and where mechanical stabilization techniques are not judged to be sufficient to guarantee stability or prevent uncontrolled introduction of sediment into watercourses. Re-vegetation will also be considered for areas adjacent to existing roads where erodible soil has been exposed.

The work area will be cleaned up at the end of the construction phase according to applicable standards and regulations, so that any effects will be within acceptable limits. This will include proper disposal and/or recycling of all surplus construction materials.

7.0 Production Operations

The Hydromet Plant will process approximately 269,000 tonnes per year of nickel concentrate to recover nickel, copper, and cobalt, producing approximately 50,000 tonnes of nickel, 3 710 tonnes of copper, and 2 450 tonnes of cobalt.

For comparison, a Matte Plant would be designed to process approximately 92,000 tonnes of nickel-bearing matte supplied from an out-of-province base-metal smelter, producing 50,000 tonnes of nickel and up to 420 tonnes of cobalt. Up to 15,000 tonnes of copper contained in copper sulphide cake would also be produced. Selenium and tellurium would be recovered as a by-product.

Because the source feed for the Hydromet Plant is less refined than the feed for a Matte Plant, a higher volume of feed is required to produce the same volume of nickel product. Similarly, the waste products from hydrometallurgical processing of concentrate are greater than would be produced by a Matte Plant, because the latter process represents a smaller portion of the full processing life-cycle from mined ore to finished product.

The concentrate feed in the Hydromet Plant contains a significant amount of iron, whereas iron is almost entirely removed in the production of matte. Thus, while the Hydromet Plant generates a residue containing a significant amount of iron oxides, the Matte Plant would generate a residue that contains very little. In addition to different feed materials, the two designs use somewhat different processing techniques. The Hydromet Plant process uses an aqueous chloride-sulphate medium, while the Matte Plant would use an entirely aqueous sulphate medium. The finished products from the Hydromet Plant are market-quality nickel, copper and cobalt. In the case of the Matte Plant, market – quality nickel and cobalt products are produced but the copper would be produced in the form of a copper sulphide cake and sent to other facilities for production of copper.

The main environmental differences between the two processes result from the types and quantities of residues produced and the method of their disposal. The Hydromet Plant produces an autoclave leach residue which is best stored under water so that the elemental sulphur, which is a component of the residue, will not subsequently oxidize to form sulphuric acid. The Hydromet Plant also produces a second residue comprising gypsum (calcium sulphate) and iron hydroxide. The Matte Plant would produce a relatively smaller volume of residue comprised almost entirely of gypsum, which would be stored above ground.

Hydrometallurgical Process

The hydrometallurgical processing of nickel concentrates has only recently been developed (mid-1990s) and the specific process for the VBNC nickel concentrate is still under commercial development. As described earlier, CVRD Inco Limited has demonstrated that the process can produce nickel, copper and cobalt at a mini-plant scale, at its test facility in Sheridan Park, Mississauga, Ontario. The process is presently being further evaluated at the Demonstration Plant located at Argentia, Newfoundland and Labrador.

The use of pressure oxidative leaching to separate metals within concentrate is at the core of the hydrometallurgical process. Subsequent purification steps lead to the generation of purified nickel, cobalt and copper streams, from which the metals are recovered by electrowinning, a large-scale form of electroplating or electrolysis. Iron and sulphur are removed as a residue during leaching. A gypsum residue is also generated during one of the impurity removal steps. The complete cycle applicable to the proposed Long Harbour facility is illustrated in Figure 7.1. and shown as a flowsheet in Figure 7.2. The estimated input quantities of materials and energy that will be needed for the Hydromet Plant are listed in Table 7.7.1; outputs are in Table 7.2.

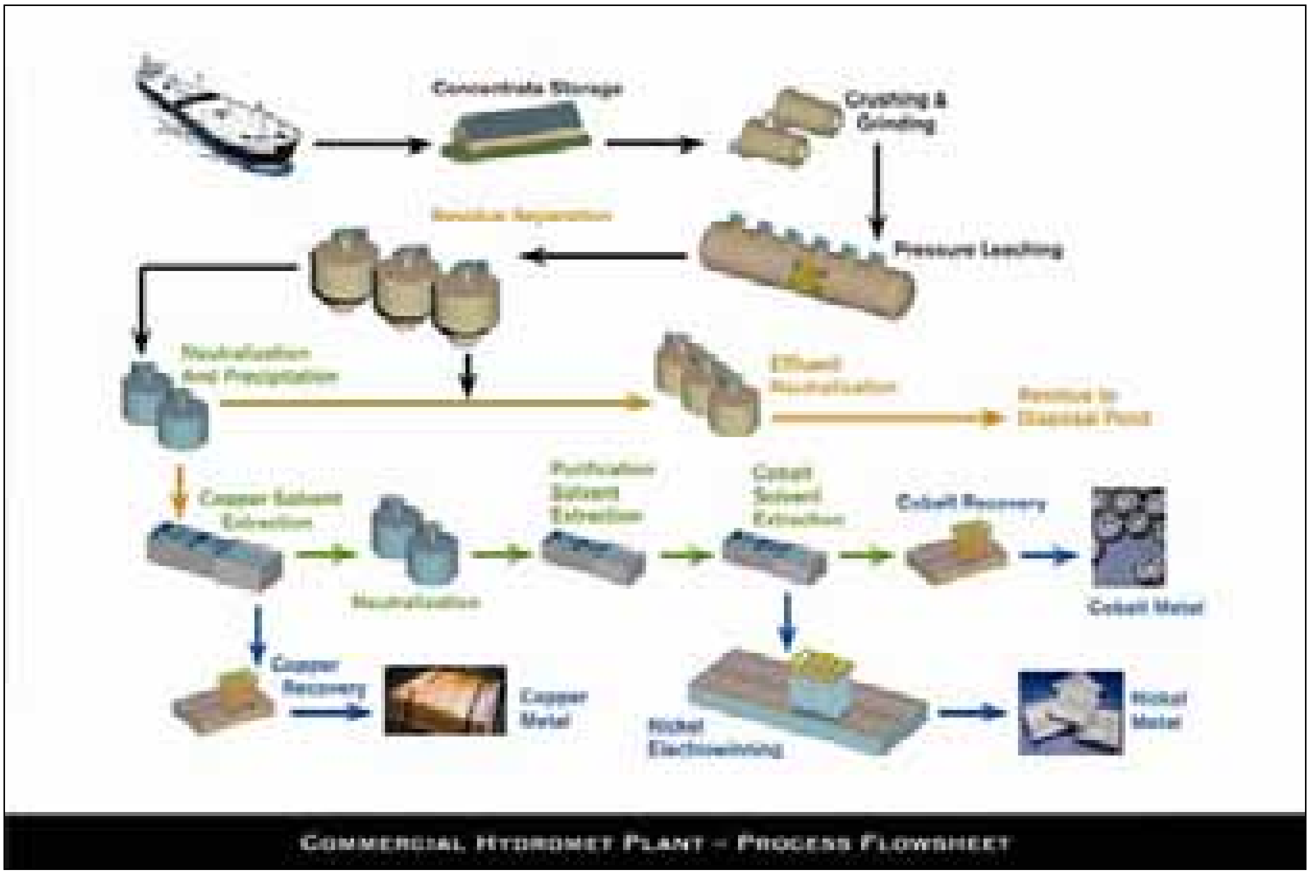

Figure 7.1 Hydromet Process

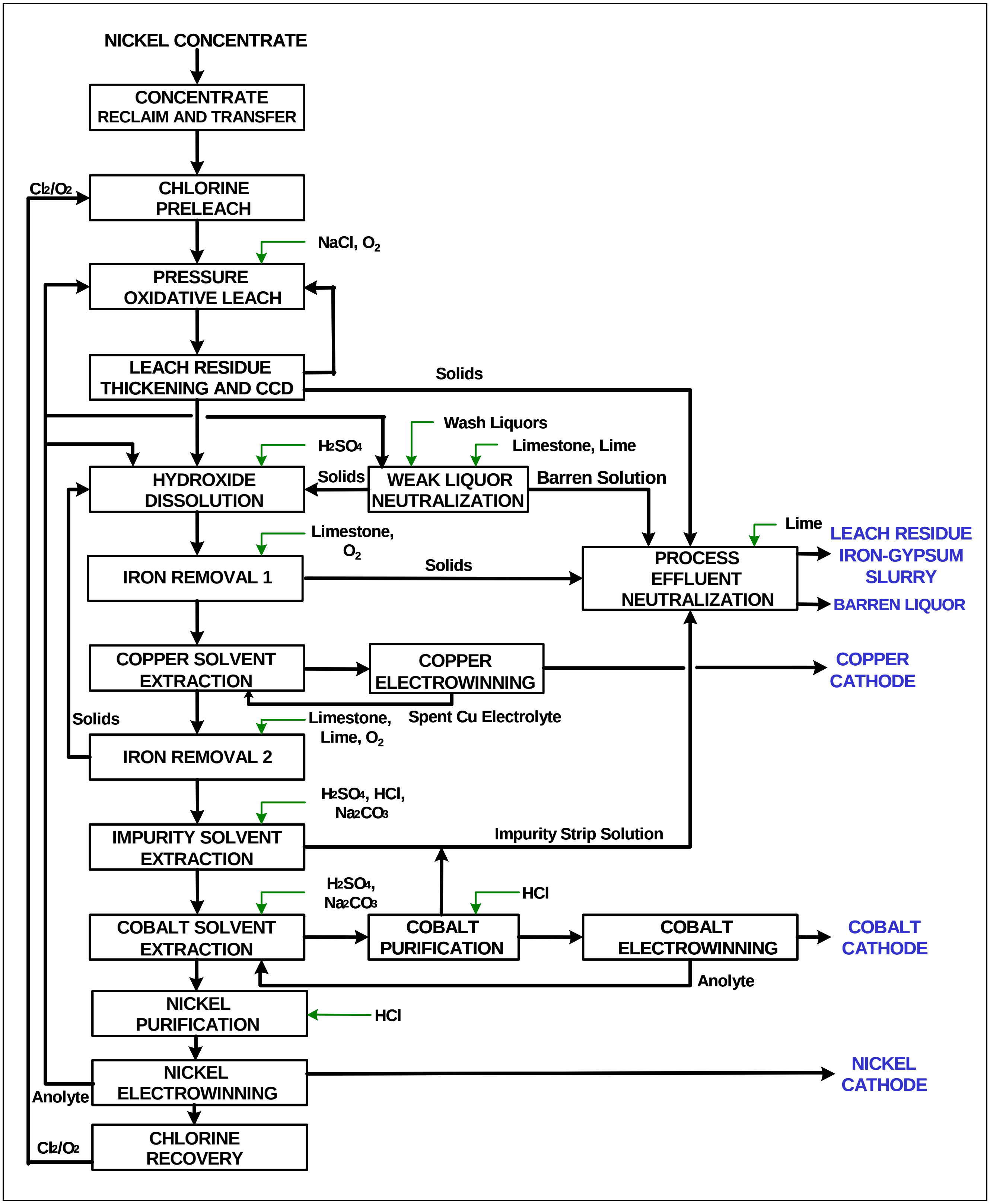

Figure 7.2 Hydromet Flowsheet

Table 7.7.1 Estimated Hydromet Plant Material, Water and Energy Input

Input	Quantity Per Year (tonnes except where noted)
Nickel concentrate (containing approximately 19% Nickel, 42% Iron, 2% Copper , <1% Cobalt)	269,000
Oxygen	154,000
Sulphuric acid (98 wt% H_2SO_4)	35,000
Hydrochloric acid (36 wt% HCl)	8,700
Sodium carbonate (99 wt% Na_2CO_3)	11,400
Coarse limestone (98 wt% $CaCO_3$)	121,000
Boric acid (99 wt% H_3BO_4)	260
Caustic soda (50 wt% NaOH)	539
Sodium chloride	971
Sodium hydrosulphide	1,100
Sodium metabisulphite	906
Sodium lignosuphonate	6472
Sodium laurel sulphate	5.1
Flocculant	315
Lewat TP 214	12.2 1
LIX 84	34.8
DEPHA	10.5
Cyanex 272	3
SX Diluent (Escaid 110; type of kerosene)	265,000 litres
Water	4,366,710 m^3
Electrical power	642,000 MWh (94 MW)
Diesel	472,500 litres
#2 Fuel oil	25,500

Table 7.2 Estimated Quantities of Main Output from the Hydromet Plant

Output	Quantity per Year (tonnes except where noted)
Nickel Product	50,000
Copper Product	3710
Cobalt Product	2450
Mixed residue	381,000
Treated effluent to Long Harbour	7,220,000 m^3
Air Emissions	
Carbon Dioxide	75,400
Nickel	9950 kg
Copper	1790 kg
Cobalt	520 kg
Iron	4690 kg
Limestone	15070 kg
Calcium Hydroxide	10,320 kg
Sodium carbonate	10,320 kg
Calcium oxide	2780 kg
Total particulate	95,770 kg
Nitrogen oxides	93,700 kg
Sulphur dioxide	211,610 kg
Chlorine	40 kg
Hydrogen chloride	15,370 kg
Sulphuric acid	7410 kg
Manganese	200 kg
Lead	70 kg
Escaid	0.3 kg

Nickel concentrate from the Voisey's Bay mine/concentrator is first crushed and wet ground to produce a slurry containing fine particles. The ground concentrate is then pre-leached at atmospheric pressure with chlorine gas that is recycled from the downstream nickel electrowinning process. The solids discharged from the pre-leach step are then further leached in an autoclave at elevated temperature and oxygen pressure, in the presence of nickel anolyte recycled from the nickel electrowinning step. The pressure leach process results in the dissolution of the three metals of interest (nickel, copper and cobalt) into a mixture of sulphate and chloride solution. Most of the iron in the feed is converted to insoluble ferric oxide, while a large portion of the sulphide in the feed is converted to molten elemental sulphur. The remainder of the sulphide reacts with oxygen to form sulphuric acid, which then acts as a reagent in the leaching reactions.

The autoclave discharge is de-pressurized and cooled, solidifying the molten sulphur. The leach solution is separated from the leach residue in a thickener and forwarded to the downstream processes for the recovery of the valuable metals. The leach residue is washed with water in a series of counter current decantation (CCD) thickeners. The washed and thickened leach residue slurry is neutralized to adjust the pH by addition of limestone and lime, blended with the iron hydroxide and gypsum residue from the downstream process, and then piped to a residue holding pond (Sandy Pond) for long-term storage. The overflow solution from the residue holding pond is returned by a pipeline to the process plant. The pond effluent solution is blended with other process plant liquid effluents and neutralized further with limestone and lime to produce a solution that meets regulatory requirements The neutralized solution is clarified prior to being discharged into the marine environment.

The autoclave leach solution is sent to the first iron removal circuit where nickel hydroxide, recycled from the downstream weak liquor neutralization step, is dissolved and thereafter, most of the iron in the product solution is precipitated by oxidation using oxygen and neutralization with limestone and lime. The precipitated iron hydroxide and gypsum are separated by thickening, followed by two stages of washing and filtration. The washed solids are re-pulped and blended with the neutralized leach residue slurry prior to disposal of the mixed solids to the residue holding pond as described above.

The iron-free leach solution is forwarded to copper solvent extraction where copper is separated to a strip solution from which pure copper cathodes is recovered by electrowinning. The copper-free solution (raffinate) discharged from the copper solvent extraction process is subjected to the second iron removal step where the remaining iron is precipitated using limestone, lime and oxygen and recycled to the first iron removal and nickel hydroxide dissolution circuit.

Minor impurities such as lead, cadmium, residual copper and iron are removed in an impurity solvent extraction process. The product solution (raffinate) now contains essentially only cobalt and nickel.

Cobalt is recovered next by solvent extraction and electrowinning to produce pure cobalt cathodes. The cobalt-free solution (raffinate) is then forwarded to the nickel electrowinning process, where about half of the nickel contained in the feed solution is recovered in the form of pure nickel cathodes, and the remaining nickel reports to the acidic spent solution (nickel anolyte). Chlorine gas, evolved during nickel electrowinning, is captured and recycled to the nickel concentrate pre-leach process described earlier. The nickel anolyte is recycled to the pressure leach process, with a portion diverted to the nickel hydroxide dissolution step, described earlier, and a portion forwarded, as a bleed, to the weak liquor neutralization process. Here, the nickel anolyte and wash liquors from other plant operations are treated with limestone and lime to precipitate the nickel and other contained metals as hydroxides, which are separated by thickening and then forwarded to the nickel hydroxide dissolution step. A part of the metals-free (barren) thickener overflow solution is used to wash the leach residue and to repulp the iron/gypsum filter cake. The remaining barren solution is blended with the Sandy Pond return solution and then treated to meet effluent discharge regulations

Process Effluent Neutralization

Process plant liquid effluent and residue slurries will be collected in separate storage tanks. The liquid effluent will be pumped through two neutralization reactors in series, where the pH is raised to 9.5 using lime. This will result in the precipitation of dissolved metals. The effluent reactor discharge will be clarified before transfer to the barren liquor tank for either reuse in the plant or to the Polishing/Cooling Pond. In the Polishing/Cooling Pond, final cooling and solids polishing will be effected prior to discharge. Similarly, the residue slurry pH will be adjusted with lime in two stirred tank reactors and pumped to Sandy Pond, via a residue slurry storage tank, for residue disposal.

The Process Effluent Neutralization circuit will be located in the Neutralization Building. The gases evolved from the reactor tanks will be scrubbed in a packed-bed scrubber using soda ash. The scrubbed gases will be vented to the atmosphere and the scrubber bottoms will be recycled back to Process Effluent Neutralization feed solution surge tanks. The area will be dyked and will have two sumps, one in the Thickener/Tank area outside, and one in the dyked area within the building

Residue Storage and Water Recovery

The combined neutralized slurry from Process Effluent Neutralization will be pumped to Sandy Pond. The residue will be deposited as a slurry using floating pipelines at designed locations. In view of the low permeability values of the residue, deposition will initially be directed to the area upstream of the dams as an added seal against seepage. This location will provide a time period of about 2 years for the residue to reach the design top elevation of 135.0 m. Figure 7.3 shows the pattern for residue disposal for Year 1 and Year 5 of Operations.

A water cover 1 m deep will be maintained above the residue to inhibit acidification of the elemental sulphur contained in the residue. Liquid will be decanted off the pond and returned by pipeline to Tier 2, where it will treated prior to discharge.

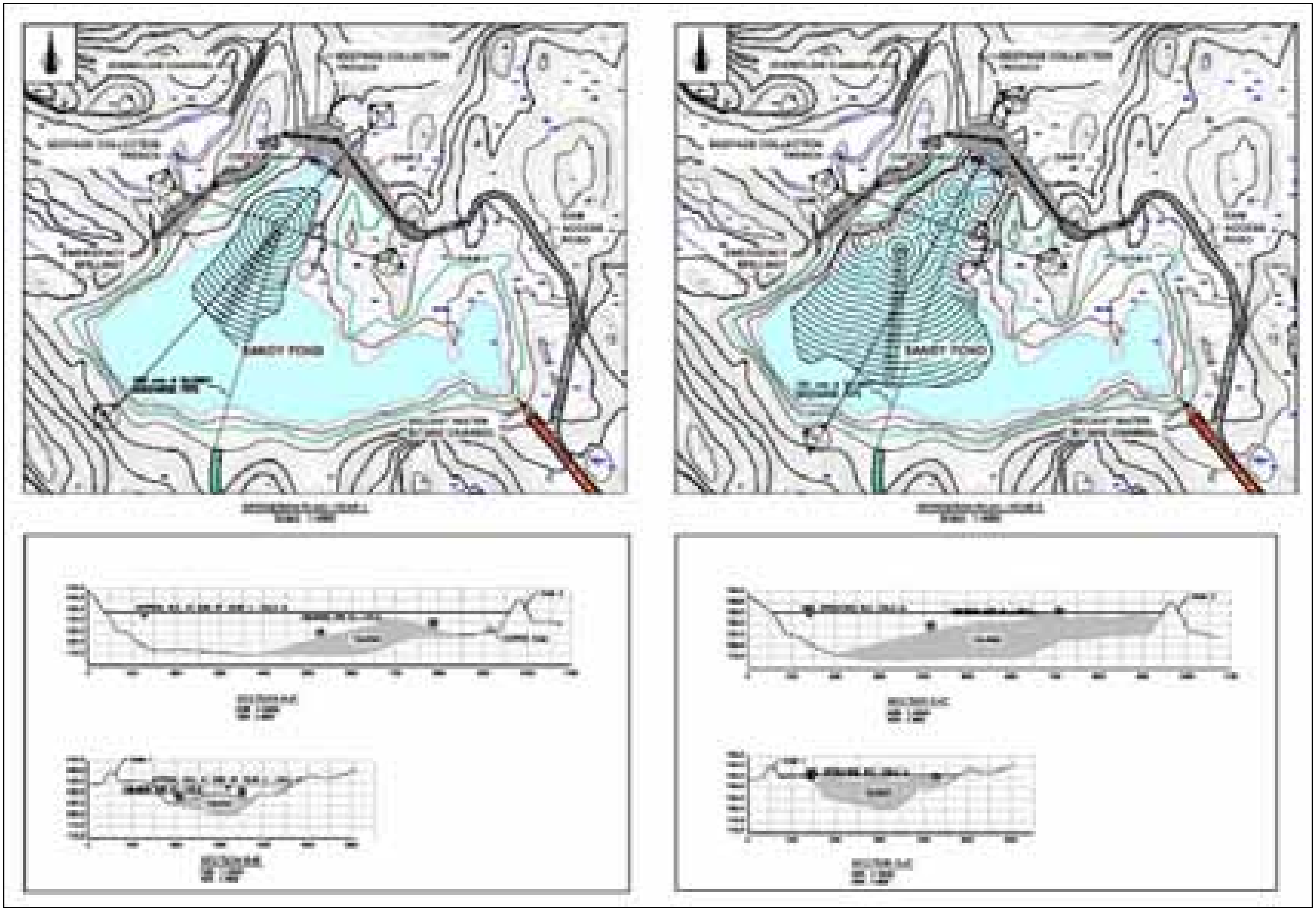

Figure 7.3 Residue Disposal Year 1, Year 5

Matte Refining Process

Matte Plant Process

The process for the recovery of finished nickel product from matte feed is similar to that employed by several commercial hydrometallurgical plants currently in operation in South Africa and elsewhere. The nickel matte would be produced from concentrate in a smelter, such as CVRD Inco Limited smelters at Sudbury, Ontario or Thompson, Manitoba.

The commercial Matte Plant would be designed to treat approximately 92,000 dry tonnes per year of sulphidic matte containing nickel, copper, cobalt, iron and sulphur. A small amount of valuable platinum group metals (PGM) are also present in the matte. The plant would produce approximately 50,000 t/y of nickel and 400 t/y of cobalt, each as pure electrowon metal, and 15,000 t/y of copper as a copper sulphide by-product.

The Process

The Matte Plant process consists of the primary steps shown in Figure 7.4. The overall Matte Plant process may be sub-divided essentially into two major processing circuits; one circuit for the dissolution of nickel and cobalt from the matte in a series of leaching steps, while leaving behind a leach residue containing copper, primarily in the form of copper sulphide, and iron; and the second circuit for the treatment of the nickel and cobalt-containing leach solution for the separate recovery of nickel and cobalt as pure electrowon metals. The Matte Plant process steps for the separation and recovery of the nickel and cobalt from the leach solution are very similar and, in some respects, identical to those employed in the Hydromet Plant process.

The nickel matte would first be wet ground to produce a slurry containing fine solids. Four successive leaching steps are carried out on the ground matte (solution purification, atmospheric leach, oxidizing pressure leach and non-oxidizing pressure leach) followed by a step to remove the selenium and tellurium.

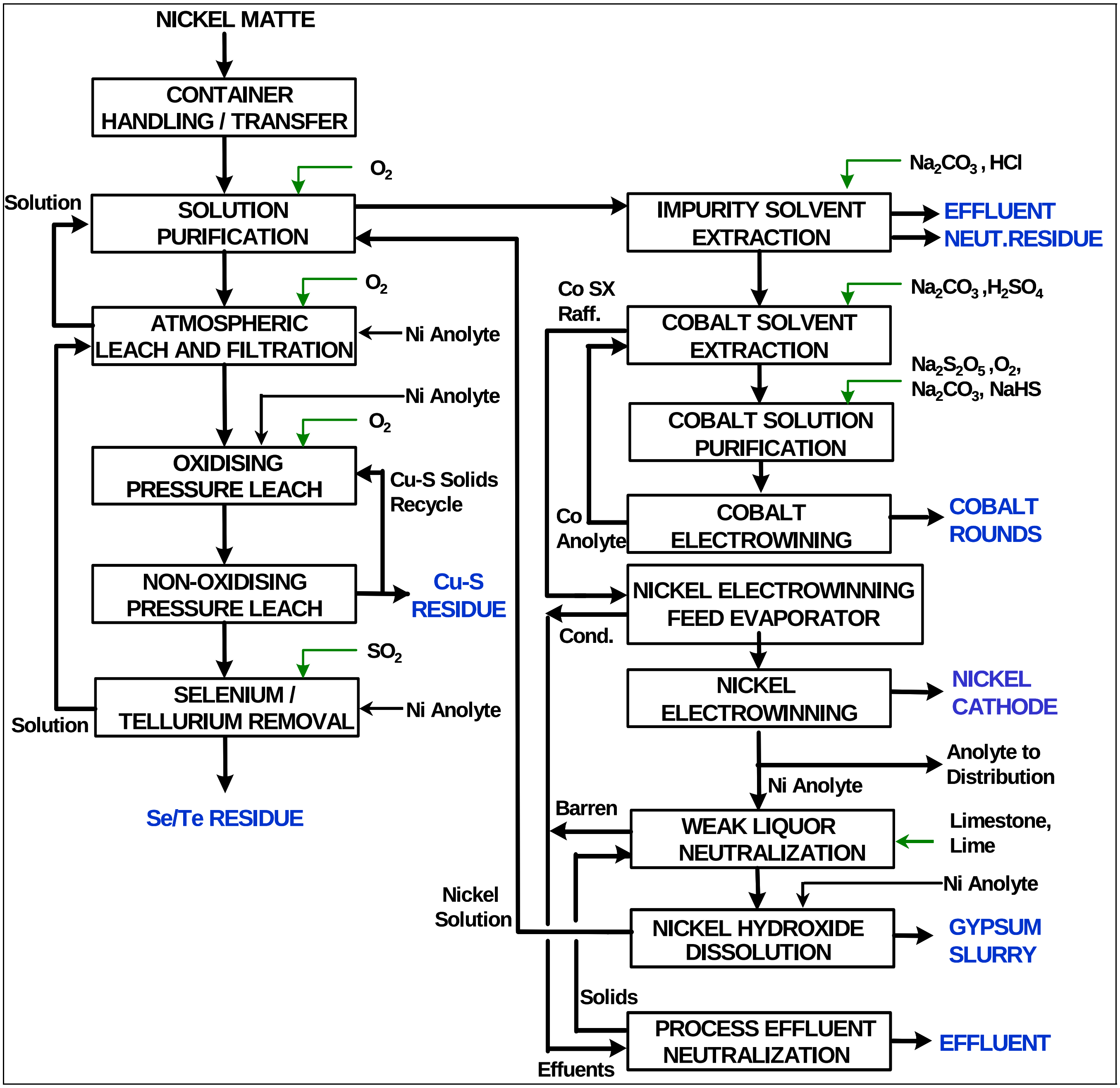

Figure 7.4 Matte Flowsheet

In the solution purification step, significant portions of metallic nickel and cobalt contained in the ground matte are dissolved by oxidative leaching in the acidic solution recycled from the subsequent atmospheric leach process and nickel solution recycled from the nickel hydroxide dissolution process, while copper and iron are precipitated. The copper and iron-free leach solution is separated and forwarded to the downstream metal recovery processes. The discharge solids from the solution purification step are reacted further in the atmospheric leach step with oxygen and acidic solution recycled from the selenium and tellurium removal step and nickel anolyte to extract more nickel. The atmospheric leach discharge solution is recycled to the solution purification step as described above, while the solids slurry is forwarded to the oxidizing pressure leach step. Here the slurry is leached with nickel anolyte at elevated temperature and under oxygen pressure to primarily extract a portion of the copper and additional nickel into solution. The discharge slurry is forwarded to the non-oxidizing pressure leach step.

The remaining nickel contained in the oxidizing pressure leach discharge solids is leached in the non-oxidizing pressure leach process which operates at elevated temperature and under steam pressure. The nickel is extracted by reaction with copper contained in the solution part of the feed slurry. The solids discharged from the non-oxidizing pressure leach process consists primarily of copper sulphide, iron oxides and essentially all the PGMs originating in the matte feed. The solids are filtered and washed in two stages and then packaged and shipped for further treatment off-site. The leach solution is sent to the Se/Te removal step where selenium and tellurium are precipitated as copper compounds by the addition of aqueous sulphur dioxide. The precipitate is separated, washed and shipped to a selenium and tellurium recovery plant. The Se/Te-free solution is forwarded to the atmospheric leach step.

The nickel and cobalt-rich solution from the solution purification would then be processed for the recovery of cobalt and nickel by the same processes used in the Hydromet Plant process. First the remaining minor amounts of impurities such as lead, copper and iron are extracted from the leach solution by solvent extraction. Cobalt is then recovered from the solution by solvent extraction and electrowinning to produce pure cobalt cathodes. The cobalt-free solution is forwarded to the nickel electrowinning process where about half of the nickel contained in the feed solution is recovered as pure nickel metal cathodes, with the remaining nickel reporting to the acidic nickel anolyte. A portion of the nickel anolyte is treated with lime and limestone to precipitate the nickel as nickel hydroxide, with co-precipitation of gypsum. The precipitate is separated from the metals-free (barren) solution by thickening and filtration and then treated with the balance of the acidic nickel anolyte to dissolve the nickel. The nickel-rich solution is separated from the gypsum and forwarded to the solution purification step. After filtering and washing, the gypsum precipitate is slurried with the barren solution and transferred by a pipeline to a sub-aerial deposit. The solution run-off from the gypsum deposit would be returned to the process plant, blended with the remaining barren solution and then treated with limestone and lime to adjust the pH such that it meets regulatory requirements. The treated solution would then be discharged to the marine environment.

The estimated quantities of the main materials and energy that would be needed for the Matte Plant are shown in Table 7.3. The main outputs from the plant are listed in Table 7.4.

Table 7.3 Estimated Matte Plant Material, Water and Energy Inputs

Input	Amount per Year (tonnes unless otherwise noted)	
Nickel matte (approximately 54% nickel, 19% copper, 1% cobalt with the balance mainly iron and sulphur)	92,000	
Oxygen	53,000	
Sulphuric acid (98 wt% H_2SO_4)	58,100	
Hydrochloric acid (36 wt % HCl)	4500	
Boric acid (99 wt% H3BO4)	194	
Soda ash (99 wt% Na_2CO_3)	9,900	
Caustic soda (50 wt% NaOH)	168	
Coarse limestone (98 wt% $CaCO_3$)	123,000	
Sulphur dioxide	1100	
Flocculant	50	
DEPHA	9	
Cyanex 272	3	
Solvent extraction Diluent	220,000	litres
Water	2,450,000	m^3
Electrical power	478,000	MWh (74 MW)
Diesel	472,500	litres
Fuel Oil #2 (steam generation)	30,500	

Table 7.4 Estimated Main Output from Matte Plant

Output	Quantity per Year (in tonnes except as noted)	
Nickel	50,000	
Copper sulphide	24,700	dry basis
Cobalt rounds	400	
Gypsum residue	175,000	dry basis
Selenium / tellurium residue	535	dry basis
Residue from impurity strip solution neutralization	127	dry basis
Treated liquid effluent	2,585,000	m^3
Air Emissions		
Carbon dioxide		
Nickel	10,790	kg
Copper	1620	kg
Cobalt	390	kg
Iron	2650	kg
Calcium hydroxide	16,520	kg
Sodium carbonate	16,520	kg
Calcium oxide	3740	kg
Total Particulate	74,110	kg
Nitrogen oxides	56,930	kg
Sulphur dioxide	205,200	kg
Hydrochloric acid	5230	kg
Sulphuric acid	1240	kg
Manganese	100	kg
Lead	30	kg
Escaid	0.4	kg

Process Effluent Neutralization

Process Effluent Neutralization removes residual metals from process effluent streams prior to discharge.

Very dilute liquors such as condensates and liquid from Weak Liquor Neutralization are combined in the process effluent neutralization circuit where the pH is adjusted to 10, using lime in a cascade of three reactors. The reactors run at ambient temperatures. The resultant slurry, containing some metal hydroxides and gypsum, discharges to a thickener where the solids are separated from the overflow liquid containing traces of metal. The solids are pumped from the thickener underflow to the weak liquor neutralization belt filter feed tank where they combine with the Weak Liquor Neutralization belt filter feed.

The metals-free liquid from the thickener overflow is pumped either to a gypsum residue re-pulp area or to a polishing pond for further settling of solids and cooling prior to discharge. Washed gypsum residue from the gypsum filtration circuit is pumped to the gypsum stack. Tank ventilation is directed through the packed-bed scrubber to the atmosphere, and the resultant scrub liquor sent to the Process Effluent Neutralization reactors.

Gypsum Residue Storage and Water Recovery

The purpose of this area is to transfer gypsum slurry from the process effluent neutralization area to the residue storage area.

The gypsum filter cake from Gypsum Filtration is re-pulped to a solids content of 25% with gypsum stack return water and pumped via Process Effluent Neutralization for storage as an aboveground deposit.

Gypsum stack drainage, including decant water and rain / snow melt runoff, reports to a surge pond and pumped back to the process plant for re-pulping gypsum cake. The excess solution is sent to Process Effluent Neutralization.

The entire base of the gypsum storage area will have a double liner system consisting of: a clay barrier layer or reinforced geosynthetic clay liner; overlain by a textured HDPE liner; overlain by a fine gravel drainage layer; overlain by a textured HDPE liner.

Gypsum Slurry Pipelines

Gypsum slurry is piped from the plant to the wet-stack storage area using a high density polyethylene pipeline. One standby/back-up pipeline is provided for redundancy and operational flexibility. The pipelines will be configured with valves for use as back-up to return water from the surge pond pump station. The pipelines will be installed along the surface (i.e., not buried) and at a slope such that the potential for clogging is minimized. The pipeline will be flanged approximately every 100 m to provide access for repair and cleaning. Both pipelines will be double-walled from the plant to the base of the gypsum stack, and will include a leak detection system monitored by operations personnel at the plant. The gypsum slurry pipelines will be extended up the south or east slope of the gypsum stack and into the rim-ditch as the gypsum stack is raised. Each gypsum slurry pipeline will have a valve and cleanout at the base of the stack for cleaning gypsum from the pipeline as required.

Water Management

Water supply for the Plant will be drawn from Rattling Brook Big Pond at an average rate of 0.17 m^3/s. The flow regime in Rattling Brook will be altered as a result of the water withdrawals for the Project. To reduce the effects on Rattling Brook, a dam will constructed at the outflow of Rattling Brook Big Pond. The existing average flow at the outlet of Rattling Brook to Long Harbour is 1.5 m^3/s (Figure 7.3). A decrease in average flow of 10% in Rattling Brook has been estimated due to water withdrawals for the Project. The existing minimum flow has been estimated to be near 0 m^3/s (i.e. dry).

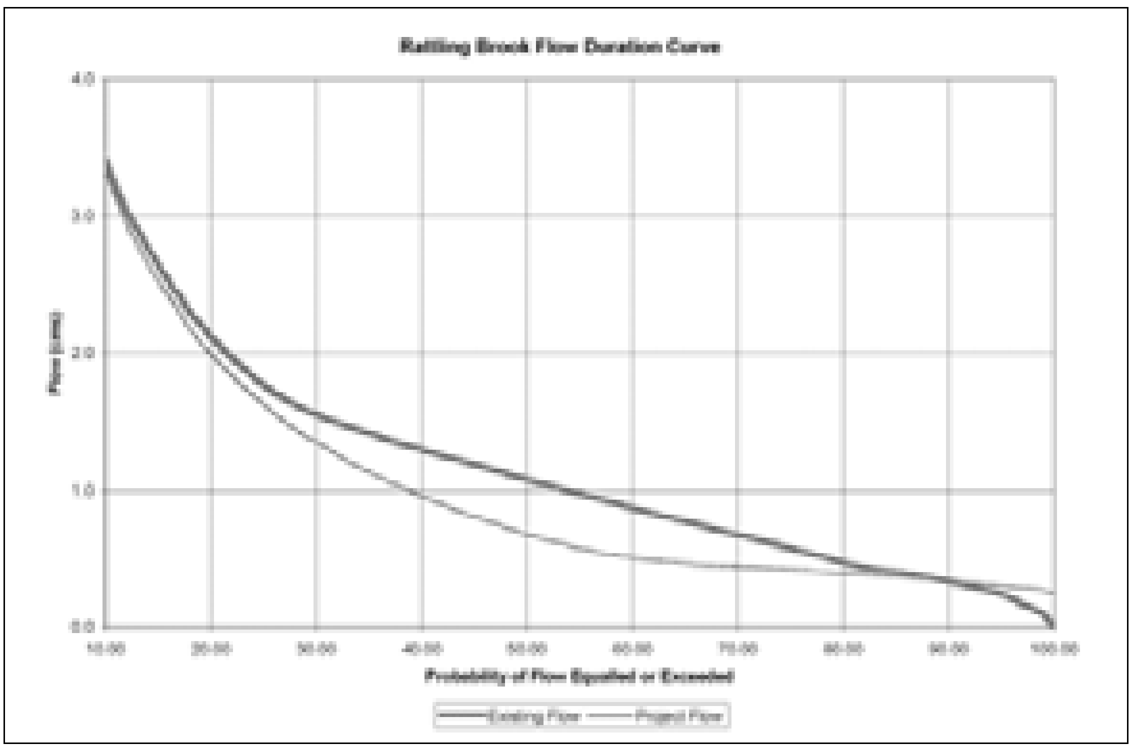

Figure 7.3 Rattling Brook Flow Duration Curve

The Hydromet Plant will require about 4.4 million m^3 of water per year. The Matte Plant would require about 2.5 million m^3 per year.

A wet well and pump station structure at Rattling Brook Big Pond will house a duplex pump arrangement. Diesel generator back-up power for the station will be located in a dedicated building at the site. Water will flow to the wet well of the pump station, and then be pumped to the Plant site raw water storage via an aboveground pipeline. An on-site treatment plant will improve water quality to specification requirements, and provide raw water to the potable water treatment plant and process water systems. Water for solvent exchange and electrowinning will be subject to colour removal, while demineralized (softened) water will be taken from the potable water plant supply.

Fire, process and potable water will be provided to the Tier 1 site via individual pipelines. Fire water may be provided by a salt water system for Tier 1.

The water withdrawn from Rattling Brook Big Pond will be treated by increasing the alkalinity (with Sodium Carbonate Na_2CO_3 – Soda Ash) to reduce the water's potential for corrosion. Following alkalinity adjustment, the water will be distributed throughout the facility as noted below:

- Process Water Treatment – Colour removal before distribution to Solvent Extraction and Electrowinning processes
- Potable Water Treatment – Colour removal and chlorination before distribution to the demineralized water treatment plant and the potable water distribution system
- Firewater – Distribution in the firewater ring main
- Process Water – Distribution to all other plant processes

Water Balance and Water Diversions

There are no water diversions planned other than for capture of runoff around Tiers 1 and 2. A preliminary water cycle for operation of the Hydromet Plant is shown in Figure 7.4. The Matte Plant water cycle is shown in Figure 7.5.

Storm Water

An area of approximately 40 ha drains toward the processing plant site from the west. This drainage area will be intercepted by a cut-off ditch running along the western side of the site and flowing north to drain overland towards Long Harbour. Perimeter ditches will be constructed around the plant site to intercept any remaining natural runoff draining towards the site.

All process effluent coming from the processing complex on Tier 2 will be neutralized and then treated in a polishing pond before discharge through the diffuser into Long Harbour. The polishing pond will be located in the north end of the plant site and will be used to treat all effluent coming from the process plant. The pond capacity will be about 45,000 m^3, assuming a two-day retention time.

Roof drainage will discharge onto the ground via splash pads or directly from eaves. Runoff from the site will be conveyed to the main outlet through a combination of subsurface drainage, roadside ditches, and underground storm sewers, and stored in the storm water capture pond for treatment.

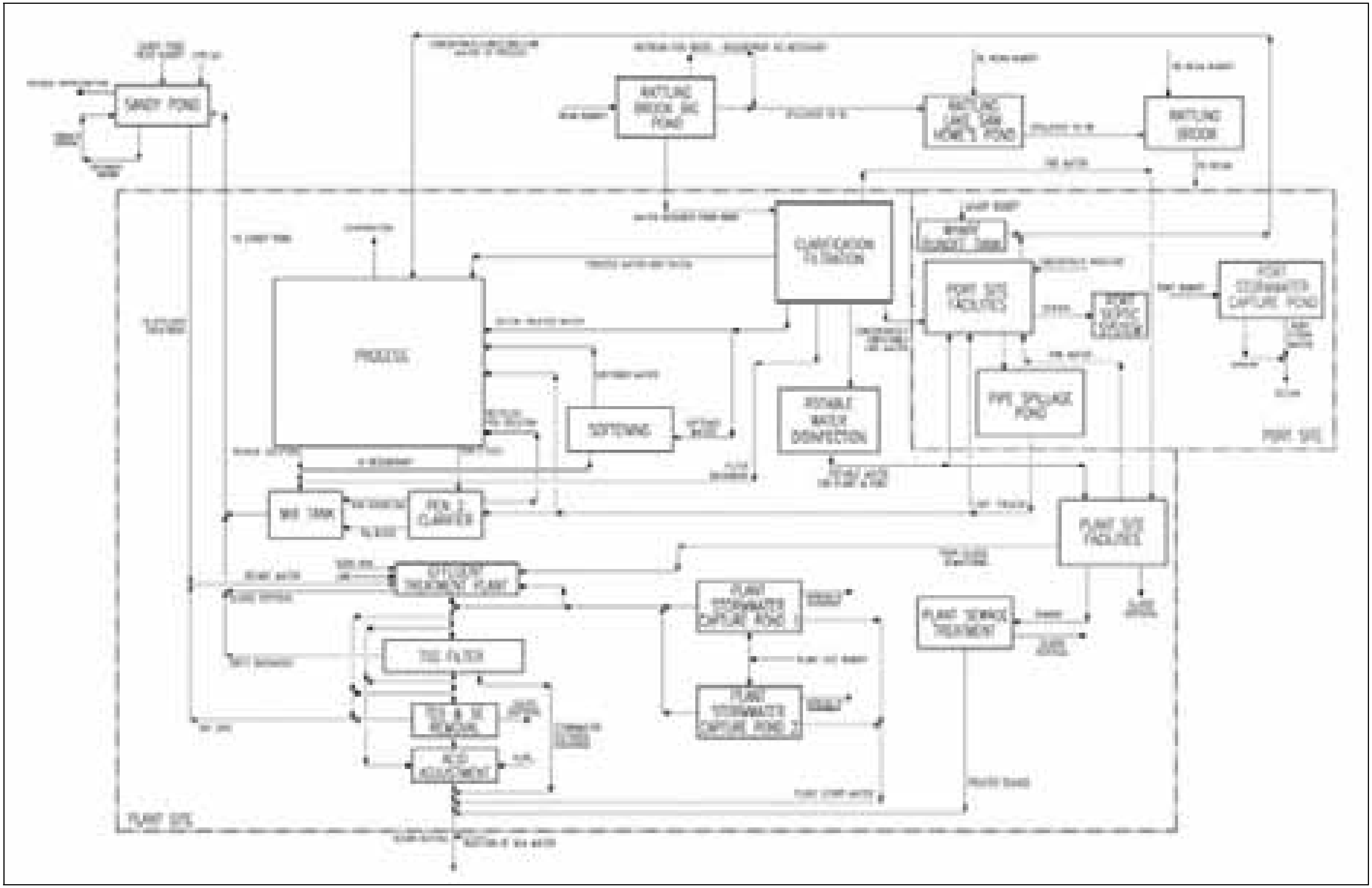

Figure 7.4 Hydromet Water Cycle

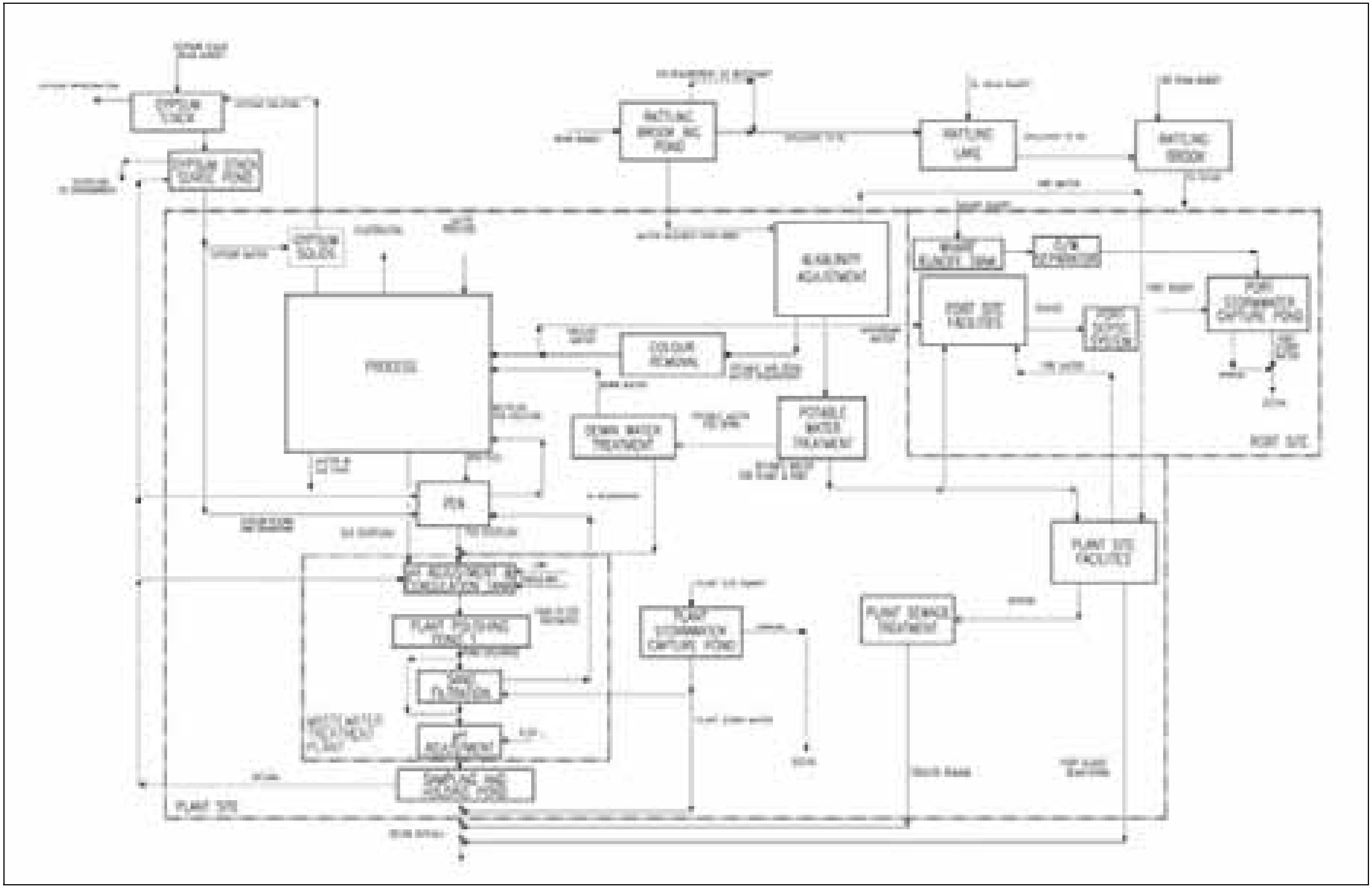

Figure 7.5 Matte Water Cycle

A number of site ditches and underground storm sewers will run north over the southern half of Tier 2. These ditches include surface and subsurface drainage components. The subsurface drainage system will consist of perforated pipe covered with crushed stone. At the midpoint of the site, ditch inlets will convey runoff from site ditches into the storm sewer system. Similarly, runoff from the north half of the site will be collected and directed to the storm water capture pond, from which it will be discharged into Long Harbour through the main outfall pipe. A system of catch basins and storm piping will collect the main parking lot runoff and convey it to an oil and debris basin.

Storm water that falls on Tier 1 will be collected and treated locally. Runoff water that falls outside Tier 1 will be directed away from the site via diversion ditches.

Storm water at Tier 1 will be treated in accordance with where it lands. Wharf area runoff and wash down water used on the wharf will be collected and pumped to the wharf water storage tank. General Tier 1 runoff will be drained by gravity where possible, sump pumps otherwise, to the port storm water capture pond.

All water that arrives to the Tier 1 storm water capture pond will be held to allow the settling of suspended solids. Settled water will then flow by gravity out of the port storm water capture pond into Long Harbour.

Vehicle wash bay water which will be pumped to the wharf water storage tank. Concentrate vessel hold wash water which will be drained into the wharf sump pump system in the summer and drained into a tanker truck and then barrelled for disposal in the winter, due to the addition of glycol. Water collected from parking lots will flow through a collection basin to remove oils and solids, and then be directed into ditches for discharge into Long Harbour.

For the Matte Plant, a stormwater/process water surge pond would be provided along the east side of the gypsum storage area. The surge pond would have a pump station with one operating and one standby pump to return process water to the plant. The surge pond would have a staff gauge for direct reading of water level, and a water level sensor with high and low level alarms plus an emergency overflow spillway to prevent overtopping of the perimeter containment dyke.

Waste Water and Effluent Treatment

All treated effulent will be discharged through a single diffuser outfall (Figure 7.6). The discharge pipe will extend approximately 6 km into Long Harbour and the diffuser installed at a depth of approximately 50-70 m to take advantage of currents at the mouth of the harbour.

Sewage

The sanitary sewage collection system will consist of collect waste from site buildings and transport it via a sewage lift station to the Sewage Treatment Plant. The treatment system will include an equalization chamber, primary solids removal, secondary aerobic treatment and aerobic sludge stabilization. Stabilized sewage sludge from the treatment plant will be removed periodically to an off-site landfill by an approved waste disposal contractor. The treated sewage liquid effluent will be discharged through the outfall pipe and diffuser.

Domestic sewage generated at the facilities on Tier 1 will be collected and fed to a septic tank with a tile field. Sludge from the septic tank will be removed by an approved waste disposal contractor and disposed off site in a licensed facility.

Process Effluents

All effluent from the process plant will be neutralized and treated in a polishing pond, then monitored prior to discharge. Aqueous solution from the Process Effluent Neutralization clarifier will be recycled back to the process to the extent possible. Any excess solution will be pumped at a flowrate of 416 m^3/h to a reactor tank for pH adjustment using lime, if required. The reactor tank will also receive backwash from the ion exchange columns. From the treatment reactor tank, the effluent will be pumped to cooling/polishing ponds for solids settling and cooling. The two ponds (each approximately 80 m by 140 m), will operate in series. Periodically, one pond will be shut down for dredging; Dredged solids will be transported and disposed of by a licensed handler using approved methods.

From the cooling/polishing ponds, effluent will be pumped to an in-line mixer which adds acid to adjust pH as required. The treated effluent will then be discharged through the effluent pipeline and diffuser. Effluent from the sewage treatment plant, decant water from the potable water sludge handling system and discharge from the plant stormwater capture pond will also flow to Long Harbour via the outfall pipe.

If the effluent from the cooling/polishing ponds does not meet the discharge criteria, two options will be available for further action:

- Pump to the polishing pond sand filters which remove any unsettleable solids from the effluent and lower the total suspended solids; or
- Recycle back to the treatment reactor tank where additional lime is added to raise the pH and precipitate any dissolved nickel.

The polishing pond sand filters treat effluent from either the cooling/polishing pond or effluent from the plant stormwater capture pond. Should effluent not meet discharge criteria and require filtration, then the filters treat the plant stormwater capture pond effluent while the cooling / polishing pond effluent would be recycled back to Sandy Pond. Other treatment options could be considered and implemented as experience is gained with the operating system.

The sand filters require periodic backwashing to remove solids. captured by the sand. Backwash water is provided by a feed tank containing polished filtrate, and the backwash water discharges into a backwash water holding tank.

Decant water from Sandy Pond will be pumped from Sandy Pond and mixed with the neutralized process effluent just prior to the sulphuric acid in-line mixer where acid is added to adjust pH. The combined treated process effluent and Sandy Pond decant water will then flow into polishing ponds before final discharge.

Solid Waste Management

All domestic solid waste will be collected, properly stored, removed and disposed of in a government approved site. A program of waste reduction, reuse and recycling (3R) will be implemented at all site facilities. All process waste solids, excluding residue, will be removed by approved waste disposal contractors and stored in licensed sites for such wastes. Sewage sludge from the treatment plant will also be removed by an approved waste disposal contractor.

Transportation

The facility will be serviced by land-based and marine-based traffic.

Road Transportation

Road traffic can be categorized as commuters, internal traffic and materials/supplies. Given the continuous nature of operations, site workers, contractors and visitors will create an estimated 300 vehicle movements per day. About one-tenth of this traffic will travel between the main gate and Tier 1 and the remainder to the main parking lot at Tier 2.

Internal traffic includes small trucks and rubber tired machinery such as forklifts. With approximately 80 people per shift, 20% are estimated to drive some form of vehicle for materials or maintenance plus the regular transport of bulk materials and supplies to and from the port, resulting in about 25 vehicles moving around the site, of which about six will be in motion at any one time over the 24 hour period.

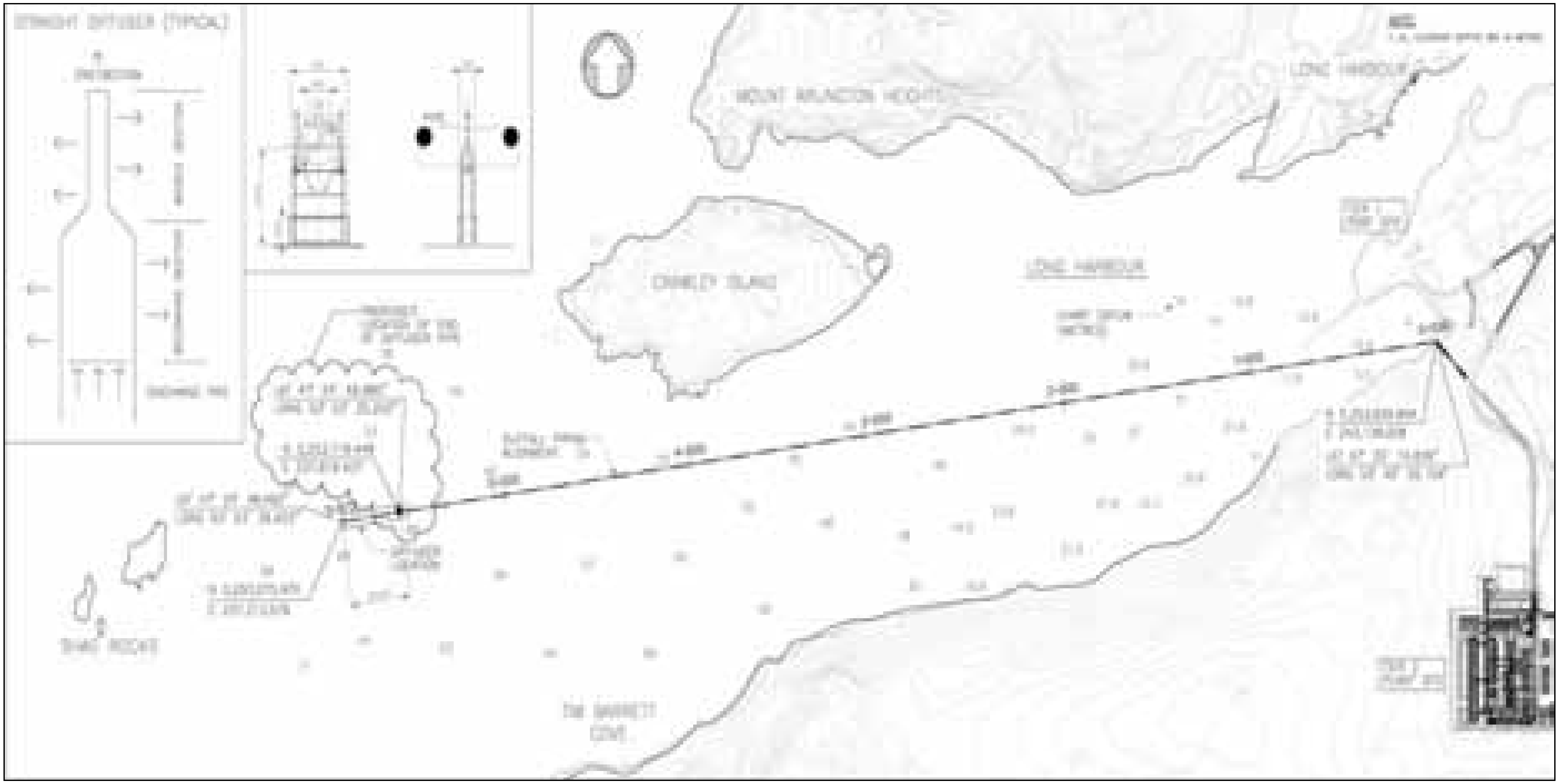

Figure 7.6 Outfall Pipe and Typical Details

Materials delivery to site and waste/product shipments from site will be by various types of trucks. At any time over the 24 hour operating day there will be about 1.15 trucks either coming, going, being offloaded, or being loaded with waste or product. At any time while one truck is being off/onloaded another truck is likely to be moving on site between its delivery/loading point and the main gate.

Flow would be similar for the Matte Plant.

Marine Transportation

Bulk feed materials including concentrate, limestone and sulphuric acid will be delivered by ship. For the Hydromet Plant, an estimated ten ships per year (in the 30,000 DWT size range) are expected to offload concentrate. During operations, there will be an annual maximum of 25 inbound and 25 outbound ship movements of vessels up to approximately 30,000 DWT size. Ships containing concentrate will arrive from Voisey's Bay, Labrador; ships containing matte would arrive from outside the Province. During Construction, an estimated 40 transits (average of one per month) will be made by ships and barges delivering supplies and parts to the site. During decommissioning there could be approximately five vessel trips to remove material from site. Bilge and ballast water from ships will be handled by third-party contractors.

Labour Force

Operations will require a variety of skilled people. Management, engineering and technical, operators, maintenance, and administrative support will comprise the site personnel. The total labour force has been estimated at 450 for the purposes of environmental assessment.

Maintenance

Preventive maintenance and inspections procedures will include overall Plant, utilities and port facilities equipment inspections to assure reliability and environmental protection. There will be planned shutdowns and slowdowns to facilitate equipment repairs that cannot be done during full stream production: equipment repairs, upgrades and internal/external inspections of components such as vessels, exchangers, pipes and pipelines, and other equipment subject to wear. The Maintenance Department will work with the Environmental, Health and Safety Department to develop a safety, environmental and preventive maintenance list that will ensure all equipment is properly maintained and documentation, is archived.

When equipment is cleaned and flushed with water/steam during shutdowns, the flushed liquids will be contained within the individual area sumps and recycled to the process. In the event other solutions need to be used but are not compatible to the process and deemed hazardous, liquids will be stored and disposed of in accordance with regulations for the management of industrial hazardous waste. Solvents may be used for parts cleaning and, if so, will also be properly stored and disposed of accordingly.

There may be situations where acid will be required to clean plates of exchanger tubes. Any waste acid would be sent out for waste disposal through a certified hazardous waste contractor.

Oil and other fluids will be contained/stored in an approved engineered holding tank for the application. Used oils will be collected and disposed of in accordance with regulations for on-site storage, handling and transportation of dangerous goods. Approved facilities to accept such products off site will be used for proper disposal.

8.0 Rehabilitation, Closure, and Decommissioning

Once the operating phase of the facility has ended, the Plant will be properly closed and rehabilitative measures will be taken to ensure the site and surrounding area are returned to an environmentally appropriate condition. Decommissioning is anticipated to take up to two years, with the exception of the residue storage pond and associated infrastructure (dams and pipeline from the residue storage pond to Long Harbour) which will be subject to ongoing long-term environmental monitoring, inspection, and maintenance post-closure. The length of the post-decommissioning monitoring period will be determined at decommissioning and following an assessment of the site, in consultation with the appropriate regulatory authorities.

Rehabilitation and Closure Plans are part of the VBNC Environmental Health and Safety Management System (EHSMS). VBNC views the development and implementation of its EHSMS from a life-of-Project perspective. The EHSMS and its attendant plans will be revised and updated on a regular and as-needed basis while the Project moves through construction, operation, and decommissioning. EHSMS development and implementation is consistent with the VBNC commitment to continuous improvement, to pollution prevention and stakeholder consultation. This will be accompanied by regular document review, revision and update.

In keeping with its Environmental Health and Safety Policy, VBNC is committed to progressive rehabilitation during the operation phases of the Project. Rehabilitation will form an integral part of the facility operating plan and will be implemented progressively over the life of the project.

This section outlines the basic elements of the proposed Rehabilitation and Closure Plan, which is designed to restore, to an acceptable state, the biological, chemical and physical quality of the environmental resources affected by the operation and development of the Plant at Long Harbour. The Rehabilitation and Closure Plan will conform to the Decommissioning Guidelines provided by CVRD Inco Limited and will meet regulatory requirements for rehabilitation.

The Plan will primarily focus on the reclamation and rehabilitation of the facility and associated site infrastructure (including materials storage and handling facilities, residue storage areas, processing facilities, shipping facilities, and other site infrastructure).

The rehabilitative measures presented here have generally been developed at a conceptual level for the purpose of environmental assessment. Additional assessment and engineering work will be required in advance of completing the Plan. The draft Rehabilitation and Closure Plan will be submitted to the Government of Newfoundland and Labrador for approval prior to completion of construction.

Specific objectives of the Rehabilitation and Closure Plan are:

- to restore affected landscapes to a stable and safe condition, which will protect public health and safety;

- to reduce or eliminate potential adverse environmental effects associated with each phase of the Project;
- to re-establish conditions which permit a productive use of the land and the natural resources of the area, similar to its original use; and,
- to reduce the need for long-term monitoring and maintenance by establishing, as quickly as practical, effective physical and chemical stability of disturbed areas.

The decommissioning principles noted below will guide the overall development and implementation of the Plan.

- Establish adequate background information to determine the extent and type of contamination, if present
- Develop an effective strategy and techniques for conducting cleanup
- Conduct an audit of the procedures employed and documentation of results obtained in order to satisfy both regulatory and corporate requirements

The Plan will be subjected to a general review annually and a detailed review every five years. The annual review must be conducted by the facility's next level of management. In addition, every five years, the CVRD Inco Limited Integrated Management System requires that the VBNC Manager of Environment, Health & Safety or designate review the Plan. Where necessary, revisions will be made based on these reviews.

Upon decommissioning or rehabilitating a site or facility, a final report containing conclusions of the post-cleanup site assessment will be prepared, and distributed for review and approval to facility management, corporate legal and corporate Environment Health and Safety departments. VBNC will plan and implement reclamation and rehabilitation activities in compliance with all applicable legislation, and will be consistent with CVRD Inco Limited Environment, Health and Safety Policies. Provincial and federal statutes and regulations define standards that will guide rehabilitation practices. Relevant acts include:

- *Newfoundland Environmental Protection Act*
- *Quarry Materials Act*
- *The Occupational Health and Safety Act*
- *Water Protection Act*
- *Migratory Birds Convention Act*
- *Fisheries Act*
- *Lands Act*
- *Forestry Act*

The VBNC approach is to integrate rehabilitation into all phases of the Project. Rehabilitation planning begins prior to construction when considerations such as delineating and limiting the area of disturbance, are incorporated into construction planning. Progressive rehabilitation is implemented as the various components or phases of the Project are completed.

Rehabilitation Overview

Rehabilitation of the Long Harbour commercial nickel processing facility will include:

- Removal and appropriate disposal of all hazardous chemicals, reagents and materials;
- Drainage and cleaning of process vessels, pipelines and equipment;
- Removal and appropriate disposal of all salvageable equipment, materials and supplies;
- Removal and appropriate disposal of all non-salvageable equipment, materials and supplies;
- Demolition and removal of all above-grade buildings, foundations and other infrastructure [e.g., wharves (except phosphorus encapsulated area), pipelines, power lines, sewage treatment facilities] no longer required once the facility has closed;
- Removal and appropriate disposal of all non-hazardous demolition debris;
- Assessment of soil, sediment and groundwater contamination in the area of buildings, and other facilities and implementation of appropriate remediation measures to address contaminated areas identified;
- Closure of the underwater residue storage area; stabilize dams; installation of barrier or cap over waste if necessary; treat overflow as necessary;
- As applicable, closure of aboveground residue storage area; stabilize dams; installation of cap over waste; treat drainage as necessary;
- Drainage and closure of storm water and process water ponds;
- Removal of fencing, scarification of road surfaces, removal of culverts and stream crossings and restoration of natural drainage patterns wherever practical;
- Closure of active borrow pits and quarries;
- Revegetation, where appropriate, to control erosion;
- Long-term monitoring, care and maintenance of the phosphorus encapsulated in the dock;
- Potential long-term treatment of effluent from the residue disposal area; and,
- A monitoring program to determine the effectiveness of the decommissioning.

Socio-economic Considerations

The cessation of operations of the facility will bring change to the workers, their families and the residents and businesses in nearby local communities. To help those facing change, VBNC will work with employees in advance of the scheduled facility closure Employees will be assisted in identifying employment opportunities at other CVRD Inco Limited facilities, outplacement services, and counselling.

9.0 Accidents and Prevention

VBNC's goal is zero accidents. This requires that accident prevention be assigned priority attention within the VBNC Environmental Health and Safety Management System. As well, a high level of response capability will be maintained by VBNC throughout all Project Phases so that any failures in prevention can be dealt with in an efficient manner. Plant personnel will maintain constant vigilance, undergo regular safety training, and be thoroughly familiar with the Environmental Protection Plan, the Occupational Health and Safety Plan, and Emergency Response plans. Third-party contractors will be screened for compatibility with VBNC policies and procedures.

Hazardous materials at the site will include process reagents, motor oil, lube oil, engine coolant, hydraulic fluid, paints and solvents, propane, acetylene, and cleaners. Hazardous materials will be stored throughout the site with the main locations being the Warehouse and Reagent Storage areas. The procedures and requirements of the WHMIS program and other applicable government regulations will be enforced.

The following discussion addresses potential accidental events and the measures that will be taken in planning to address each. As well, and in accordance with the Guidelines, a set of "plausible worst case" scenarios have been developed to form the basis for impact assessment.

Spills Within the Plant

Any spills from the Plant would be collected and directed to the Polishing Pond for containment. A worst case spill from one of the process buildings could involve the release of solvent extraction organics or acid solutions. It is unlikely that a spill of this type would be undetected for more than five minutes, at which time the plant staff would respond and the release would be stopped. A release of this type would be reported immediately to the Plant Manager and the appropriate regulator.

Some fuel for emergency generators and process chemicals will be stored on site. Storage tanks could fail as a result of spontaneous rupture or explosions, and spills could also result from human error during delivery (e.g., overfilling, leaving valves open). Storage tanks and facilities will be designed to conform to the Newfoundland Department of Environment and Conservation regulations with key design features including the installation of impervious mats, containment dykes, and the installation of sump and collection systems. In the case of a tank rupture or leak, emergency response and clean-up procedures will be implemented. The likelihood of any oil escaping to the environment as a result of a tank failure is very low.

Spills may escape to the environment as a result of human error or faulty equipment during delivery. Such spills would probably be very small and the emergency response procedure would be implemented.

Land Transport

A variety of chemicals will be transported to and from the plant by trucks. All such transportation of chemicals will be by licensed third-party transporters operating under their own emergency procedures and responsible for first-level spill response and reporting. VBNC will screen contractors to ensure adherence to applicable legislation and handling procedures.

Marine Transport

Concentrate and some chemicals will be transported by sea. All transportation of chemicals by ship will be by licensed third-party transporters operating under their own emergency procedures and responsible for first-level spill response and reporting. VBNC will screen contractors to ensure adherence to applicable legislation and safe handling procedures.

An assessment of the frequency of occurrence of major releases during marine transportation was based on published data acquired from the Transportation Safety Board of Canada (TSB), Det Norske Veritas Limited (DNV) and World Casualty Statistics 1995 (Lloyd's Register 1995). The literature indicates that the probability of a marine accident is proportional to the number of ship movements.

Based on TSB data, large commercial vessels travelling through Placentia Bay to Argentia have a probability of 3.86 accidents per 1000 vessel movements. However, shipping accidents, as defined by TSB, include such occurrences as a ship hitting a wharf, grounding, ice damage, rudder damage, and collision. Not all of these occurrences result in releases of vessel cargo. A subsequent review of all shipping accident records for commercial vessels greater than 20,000 DWT over the last 10 years in Eastern Canada indicated that approximately 1 out of 30 vessel accidents resulted in a major release. The probability of a major release was therefore estimated at 0.13 per 1000 vessel movements. This conclusion is conservative, in part because of the marine traffic separation system and vessel traffic management (VTM) centre covering Placentia Bay. The separation system and VTM centre decreases the chance of a collision, one of the key contributors to major releases.

Information from DNV (Det Norske Veritas Limited 1997) based on British statistics and a study for a port in that country indicate the probability of a major spill as approximately 0.03 per 1000 vessel movements. Information from Lloyd's Register indicated that the probability of a complete loss of a ship is in the order of 0.017 per 1000 vessel movements. Based on these statistics, the overall probability of a major release scenario was averaged to be 0.08 per 1000 vessel movements, based on the TSB and DNV data. The operating period for the Project (15 years) and the anticipated marine traffic volume (up to 25 inbound and 25 outbound vessels per year) produce a probability for a marine spill to be in the order of 0.00955% for the Project.

Marine spill modeling was undertaken and focused on the hypothetical release of large quantity materials: soda ash and nickel concentrate. Ships' fuel was also considered (AMEC 2007d). Lime and limestone were not considered for marine spills at dockside as transfer will be via conveyor.

Hydrochloric acid was not considered for marine spills since the planned method of transportation is by truck. Limestone spill effects were considered minimal.

Sulphuric Acid (H_2SO_4)

Concentrated sulphuric acid (98%) will be shipped by chemical tanker as a very dense liquid. Although sulphuric acid is commonly shipped, there have been few large-scale accidents. An Internet search reveals only two recent incidents of relevance: a barge roll-over in a Louisiana port and an emergency discharge in a shipping channel in Brazil. Thus it is not possible to assign a realistic probability to such an event. For purposes of impact assessment, the scenario developed is of a springtime release of full vessel cargo (7500 t) as a consequence of a shipping accident at the mouth of Long Harbour. The loss of an entire cargo over a period of several hours is unlikely due to compartmentalization in acid transport ships. Even in the event of a sinking, release of cargo from the seabed would not be sustained at high rates.

At the port, sulphuric acid would be pumped from the transport vessel. The maximum dockside release for sulphuric acid transfers could be about 225 t.

Ships' Fuel

No seaborne shipment of fuel is required for the Project; however, in the unlikely event that the ship is damaged in open water, its own fuel supply may be released. Spills modeled include release in Placentia Bay and in Long Harbour from a bulk carrier. An IFO 180 fuel mixture was assumed and the calculated maximum volume of bunker fuel transported is 2 180 m^3 (approximately 2200 tonnes).

Concentrate

The modeling exercise assumed that 30,000 tonnes of nickel concentrate would be released. Due the density of the concentrate (4.2 kg/l), the particles would quickly reach the bottom and remain fairly stable on the seabed. Nickel concentrate deposits and consequent bottom accumulations were found to be reasonably stable at all locations. Nonetheless, strong storms could move a proportion of material spilled at the wharf. Overall, from a long term perspective, the particles should stay and/or accumulate in deep sediment.

Matte would be shipped in bags packed in sealed containers which precludes a significant spill. Nickel concentrate will be moved from the shipping vessel to the wharf using a single crane clamshell bucket. For dockside release the volume was based on one single-crane clamshell bucket with a volume of 18 m3.

Spill skirts or tarpaulins would be provided for the hoppers or between the wharf and the vessel to prevent spillage to the environment. Spill skirts are designed to catch only the overrun from the bucket, not an entire load.

A nickel concentrate spill would stay at the same location for many years (AMEC 2007d). The anticipated seabed deposit would be in the form of a dome of approximately 40 m in diameter and two cm in maximum height (Figure 9.1).

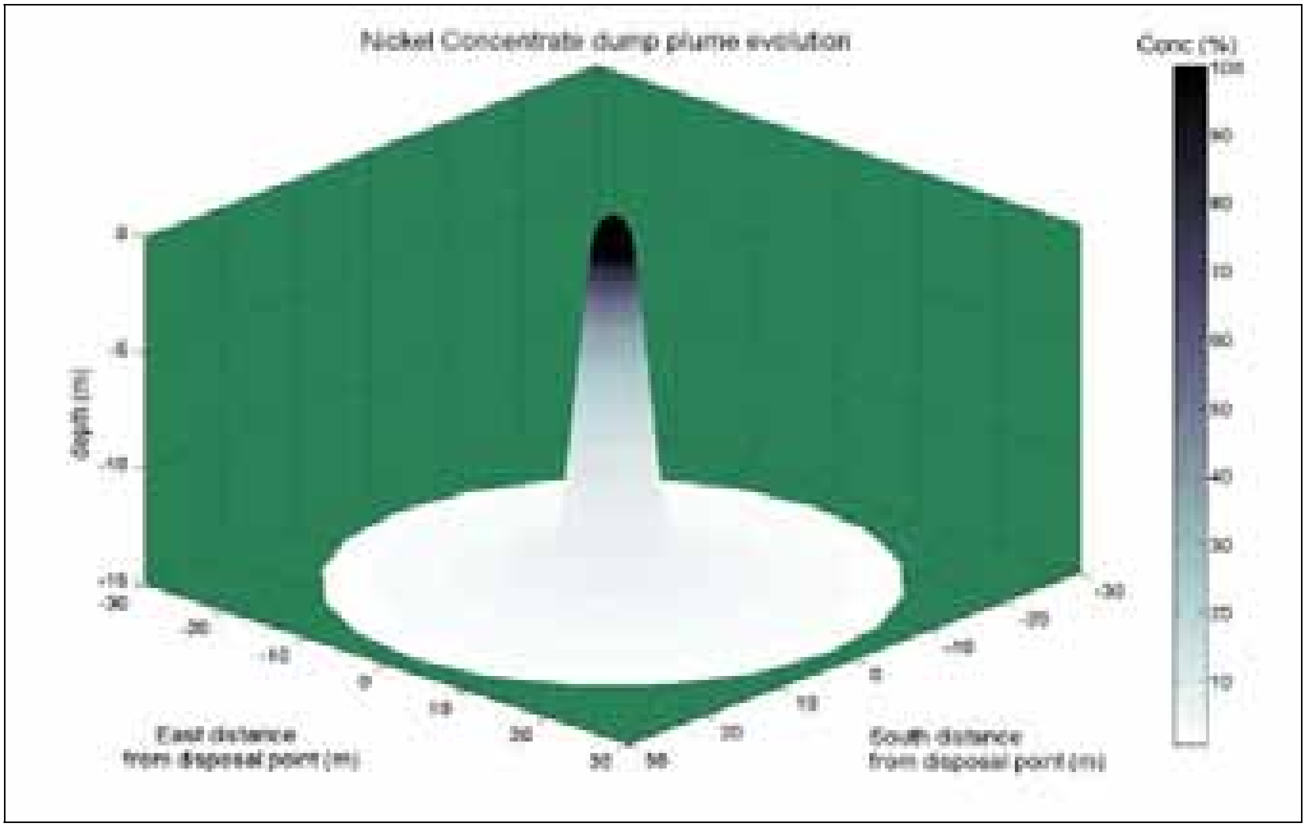

Figure 9.1 Typical Nickel Concentrate Spill at Dockside

Explosion and/or Fire

There are a number of situations that might result in explosion or fire at the plant site. During the Construction Phase accidental ignition could occur through welding operations, sparks from cutting/grinding and smoking (lighters, matches). Other potential sources of ignition, mainly occurring during Operations Phase, include autoclave vessel failure, poor grounding of electrostatic charges, hot bearings or mechanical heat generation in fuel pumps, and fuel discharge onto hot surfaces.

A fire at the Plant could result in the release of toxic chemicals into the atmosphere, including chlorine gas and byproducts of solvent combustion. Fire in the organic reagent storage area could result in extensive equipment and building damage, with release of combustion products to the atmosphere. The worst case could include solvent extractants and diluent loss from the containment area, contaminating the storm water drainage system and resulting in a fire.

Project design will incorporate fire prevention and suppression techniques throughout the Tier 1 and 2 facilities, with particular attention detection in all areas of the Plant involving the use of volatile chemicals. Fire protection systems and emergency response procedures will be implemented immediately upon detection of a fire. A certified, trained fire fighting capability will be maintained on site.

Large Storms

An accidental release as a result of a large storm would be related to overtopping of containment ponds. Ponds will have the capacity to contain up to 1-in-25 years, 24-hour storm, and ditches will have capacity for up to a 1-in-100 year, 24-hour storm. The potential to flood areas of the site is mitigated by the terrain, as the site slopes towards the storm water pond and from there into the polishing ponds.

Overtopping would create the potential to release contaminated site run-offs, to flood the access road, and flood buildings on site, including both process and non-process buildings.

Storms were also considered during the modeling of the marine accidents.

Transportation Accidents

Vehicular accidents at site roads could result in spills of fuel or other hazardous material. Trucks will be used to transport hydrochloric acid, boric acid, caustic soda, fuel oil, and specialty items (e.g. lab chemicals). The severity of a spill would depend on the nature of the spilled material, the location (e.g., spill into a watercourse), the time of year (e.g., spawning of fish), and the volume. In the case of all spills, emergency response and clean-up procedures would be implemented. Other potential accidents include vehicle/wildlife collisions on site roads.

Pipeline Failures

Slurry Pipeline Releases

Pipelines will transport material from the Tier 1 area to the Tier 2 plant site, including concentrate slurry, lime and limestone slurries and sulphuric acid. The acid pipeline will be double-walled. All pipelines will be located within trenches or open culverts to contain and divert any pipeline spills. The pipeline routing generally follows the natural contours of the hillside in an S-shaped path upward, with two sections at grades of up to 7%.

The pipeline is approximately 1400 m long, and is expected to be 100 mm in diameter. Pipelines will be monitored at both ends to detect any loss of pressure and equipped with automatic shutdown systems. The exact nature of a pipeline release, where it might occur, the length of time before it is discovered and the weather conditions at the time of the release are variable. The nature of the material released would affect the amounts penetrating into the ground or remaining at the surface. Weather conditions at the time of the release would also affect the fate of the released material and the possible containment and cleanup.

Sandy Pond Residue Pipeline Releases

The pipelines associated with the Sandy Pond Residue Storage Facility transport residue slurry and decant water. As well, there will be an emergency outfall bypass line.

These lines will be built along the Sandy Pond access road and collection ponds will be constructed at low point locations along the pipe route. Pressure meters will be installed at both ends of the pipeline to monitor for potential spills/leaks with automatic shutdown systems in place to shut down the pipeline if a spill or leak is detected. The pipelines will be inspected regularly, and any debris that collects in the collection ponds will be cleaned up in a timely fashion.

Effluent Treatment System Failures

A pipeline will convey treated water from Tier 2 to Tier 1 for discharge to Long Harbour. Flow rates will range up to a maximum of 600 m3 per minute during normal operation. The most likely potential release would be a partial release which would be 20% of pipeline flow for one hour.

Possible causes of effluent treatment system failures can include:

- Chemical feed failure;
- Mechanical failure (agitator, pump);
- Instrumentation error;
- Operator error;
- Clarifier upset; and
- Polishing filter failure

Depending on the stage of treatment, the effluent could be beyond specification, resulting in a volume of contaminated water being directed to the ocean. Release could result in a visible plume. An upset condition could cause high-temperature water to discharge to the ocean, but temperature would likely revert to background levels within 100 m of the diffuser. Failures within the effluent treatment system would be diverted to Sandy Pond.

Breaks or Damage to the Effluent Outfall Line and / or Diffuser

Failure of the effluent outfall line and/or diffuser could occur as a result of water hammer, storm events (waves), or vessel interaction. If the outfall line fails on land, the access road could be flooded, and Rattling Brook could receive treated effluent. Outfall diffuser failure could result in concentrations of effluent at the ocean surface.

Dam Failures

The historical probability of failure of large embankment dams (excluding failure during construction) is 4.1 x 10-4 per dam-year. This is based on the period up to 1986 internationally, for 136 dam failures in an estimated 300,400 dam-years with 11,192 total dams.

The dams around the Sandy Pond residue storage facility will be built to meet Canadian Dam Safety Association Guidelines (CDSA 1995). The structures are relatively small in size; however, if one should fail, there would be a release of pond water and residue. Flow modeling was conducted to evaluate the potential contamination of groundwater occurring as a result of a dam failure and the effect of various clean-up scenarios on groundwater quality.

AMEC (2007d) considered breakage in one of the three dams at Sandy Pond. Dynamic Flood Routing Analyses for each dam indicates that overtopping failure would produce the maximum flood and cover the greatest area, but fair-weather ("normal" condition flooding) failure would result in the most residue material released.

Both scenarios would see the release a mixture of residue material and flood water, which would overtop and likely wash out Highway 202 and subsequently run into Long Harbour. The released residue material flow would deposit along the flood path and contaminate the area and the downstream marine water.

An overtopping failure of Dam #1 (Figure 9.2) would result in a maximum inundation area of 60 ha with flood depths of up to 10.2 m. A mixture of water and residue material would be released at a peak rate of 1300 m3/s. The diluted residue material and water flood wave would overtop the small pond downstream of the dam, split into two directions, and then overtop Highway 202 and discharge into Long Harbour.

An overtopping failure of Dam #2 (Figure 9.3) would result in a maximum inundation area of 91 ha with flood depths of up to 10.2 m. A mixture of water and residue material would be released at a peak rate of 4100 m3/s. The released material would split into three flood paths, overtop and wash out Highway 202 and discharge into Long Harbour.

A fair-weather failure of Dam #1 would produce a maximum inundation area of 45 ha with flood depths of up to 8.7 m. A mixture of water and residue material would be released at a peak rate of 850 m3/s.

The diluted residue material would follow the same route as for an overtopping failure but cover a smaller area, eventually discharging into Long Harbour.

A fair-weather failure of Dam #2 would produce a maximum inundation area of 76 ha with flood depths of up to 8.8 m. A mixture of water and residue material would be released at a peak rate of 2600 m3/s. The diluted residue material would follow the same route as for an overtopping failure but cover a smaller area, eventually discharging into Long Harbour.

Figure 9.2 Sandy Pond Dam #1 Failure Flood Mapping

The results of the Dam #2 fair-weather failure modeling indicate that about 78,000 m3 of solid residues would be deposited along the flood route and approximately 3.9 Mm3 of water carrying some residue material flow would spill to Long Harbour. This spill scenario would produce the maximum residue runout of all the dam spill scenarios considered. It was this scenario that was selected for assessment.

The effect on groundwater of an accidental release from the residue storage area was simulated for copper and nickel, as these are the two primary contaminants of concern. The three clean-up scenarios that were considered are surface cleanup in one month, surface cleanup in six months, and surface cleanup in one year.

Results of the modeling show that the release would most likely have a noticeable effect on shallow groundwater only. Simulated contaminant plumes extend to a depth of between 5 m to 10 m below the water table. Contaminant mass loading of nickel from the affected groundwater into the adjacent stream (about 750 m north of Sandy Pond) and Long Harbour is expected to be more significant than similar mass loading for copper, due to the higher initial concentrations of nickel in the water-residue mixture and in water percolating through residue subject to full oxidation. Residue-soil cleanup occurring in one to six months after the accidental release significantly reduces mass loading of nickel into the stream and Long Harbour, as well as groundwater discharge concentrations, compared with the cleanup occurring in one year.

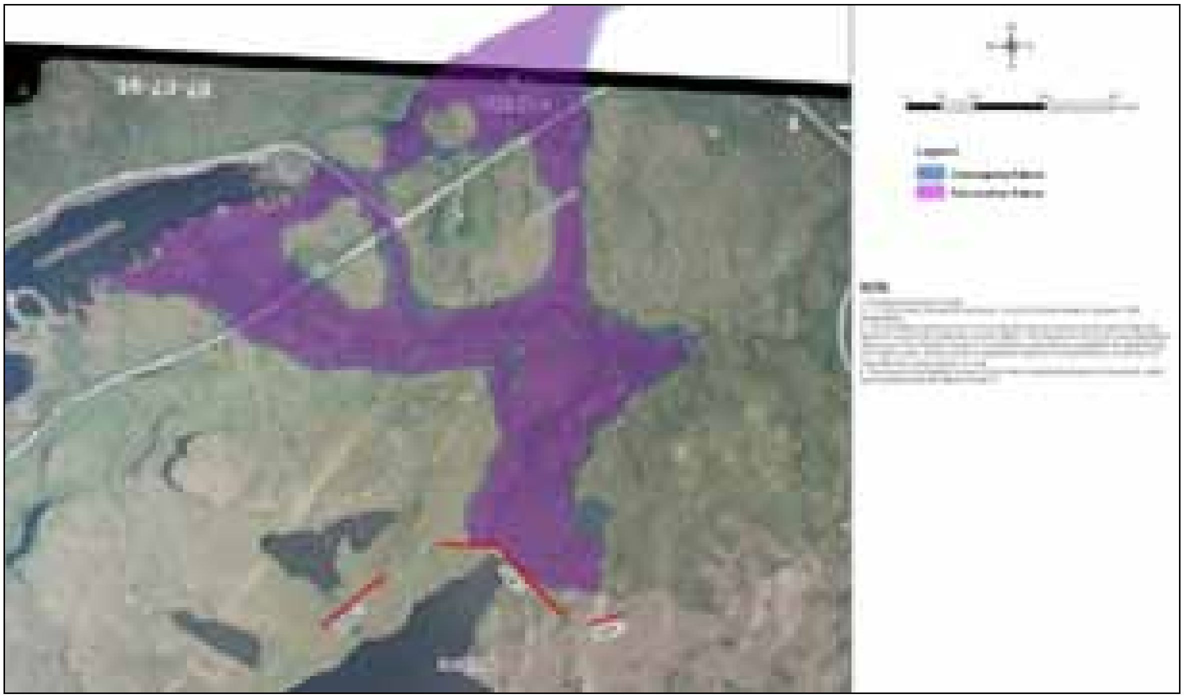

Figure 9.3 Sandy Pond Dam #2 Failure Flood Mapping

Accidental Chlorine Release

Accidental chlorine release was modeled by SENES (2007c) to examine one-minute and five-minute pipe ruptures releasing 25.6 kg and 59.2 kg respectively.

Based upon the modeling performed, it was found that the critical distance for these releases is in the range of 758 to 3400 m from the place of pipe rupture. For stable conditions it will take approximately 18 minutes from the time of release until the elevated concentrations reach the maximum Immediately Dangerous to Health and Life (IDHL) distance from the pipe rupture. The larger of the two releases was chosen for individual VEC analysis.

Introduction of Invasive or Hazardous Species

Shipping is a potential pathway for the introduction of exotic species through ballast water or biofouling on ships' hulls. This is probably not an issue as most vessels will arrive at Long Harbour loaded with cargo and consequently large amounts of ballast water will not be on board. Many of the shipments will be by the concentrate carrier from Labrador, and not expected to carry any non-native species. Further, many known marine invasive species would not likely survive in the cold water of Placentia Bay. A potential exception is the European green crab (*Carcinus maenas*) that is extending its range on both coasts of North America. It is a voracious predator of shellfish and a very efficient competitor.

All vessels involved in the Project will be subject to ballast water exchange protocols which require mid-ocean transfers and other measures designed to prevent the transport and dispersion of invasive species.

Ship Collisions with Marine Mammals

Although most marine mammals typically avoid moving ships, there is some risk of collision. It is uncertain if vessel collisions with marine mammals have occurred in Placentia Bay. Large whales (no known blue or right whales) strand in Placentia Bay throughout all seasons of the year. In the absence of necropsies, it is difficult to ascertain the reasons for stranding. (W. Ledwell, Whale Release and Stranding Program, pers. comm.). Most lethal and severe injuries to large whales resulting from documented ship strikes have occurred when vessels were travelling at 14 knots or greater (Laist et al. 2001). Vanderlaan and Taggart (2007), using a logistic regression modelling approach based upon vessel strike records, found that for vessel speeds greater than 15 knots, the probability of a lethal injury (mortality or severely injured) approaches 100%. The probability of lethal injury declined to approximately 20% at speeds of 8.6 knots (Vanderlaan and Taggart 2007). In a review of 58 large whale ship strikes in which the vessel speed was known, the average speed that resulted in mortality or serious injuries to the whale was found to be 18.6 knots (Jensen and Silber 2003). The frequency of ship strikes more than doubled when vessel speeds were 13-15 knots as opposed to 10 knots or less (Jensen and Silber 2003). While all sizes and types of vessels can collide with whales, most lethal or severe injuries are caused by vessels >80 m in length (Laist et al. 2001).

Fin whales are the most commonly reported whale to be stuck by vessels, followed by humpbacks and North Atlantic right whales (Jensen and Silber 2003; Vanderlaan and Taggart 2007). However, the North Atlantic right whale was the most commonly struck whale when considering the proportion struck per capita per year (Vanderlaan and Taggart 2007). Blue whales, fin whales, and humpback whales were all stuck in similar proportions, but to a lesser degree than North Atlantic right whales (Vanderlaan and Taggart 2007). Minke, sei, and sperm whales were not as frequently struck proportionally, but have been reported (Vanderlaan and Taggart 2007), and minke whales are quite common in Placentia Bay. Published accounts of ship strikes suggest that most crews do not see whales beforehand or see them at the very last minute (Laist et al. 2001).

While nearly all species of large whale have been victims of collisions with ships (Laist *et al*. 2001; Jensen and Silber 2003; Vanderlaan and Taggart 2007), right whales are especially vulnerable, likely because of certain characteristic behaviours during which they may be less aware of their surroundings. These behaviours include: surface active group (SAG) activity (individuals interacting at the surface with frequent physical contact); skim feeding (swimming slowly at the surface with mouth open); and logging (resting motionless at the surface), an activity frequently observed in nursing mothers (Knowlton 1997). Controlled exposure experiments in the right whale summer feeding area in the Bay of Fundy showed that right whales did not respond to the playback of the sound made by a 120-m container ship passing within 100 m in spite of the fact that they were apparently able to hear it (Nowacek et al. 2004). The majority of documented right whale deaths, especially in recent years, were the result of ship strikes (Knowlton and Kraus 2001; Right Whale News 2005a, b; 2007).

During operations, it is estimated that there will be up to 25 vessel movements per year into Long Harbour, mainly be bulk carriers and container ships, with a maximum expected length of 223 m and a maximum draft of 11.75 m. These vessels will travel at a speed of ~15-16 knots upon entering Placentia Bay until they rendezvous with the pilot boat south of Red Island where speed decrease to 8 knots. Bulk carriers and container ships could travel at a maximum speed of ~10 knots to within 5 nautical miles of the wharf, when they will decrease speed to two knots.

Based on available information, it is likely that most marine mammals will avoid the immediate area around vessels, thereby minimizing the probability of collision. Vessels will avoid rapid changes in direction or speeds, thereby further reducing collision probability.

The risk of a bulk carrier or container ship colliding with a river otter and causing serious injury or mortality is very low. River otters are closely tied with coastal habitat where large vessels cannot navigate and will likely exhibit avoidance of at least a localized area where vessels are operating.

The vessel traffic associated with the Project is small relative to existing traffic (~500 vessels combined from the North Atlantic refinery at Come By Chance and the Transshipment Terminal at Whitten Head) and traffic from the proposed oil refinery at Southern Head (425 vessels ranging from bulk carriers of 20,000 DWT to VLCC tankers of 350,000 DWT) and the proposed Newfoundland LNG Ltd. Grassy Point Liquefied Natural Gas Transshipment and Storage Terminal (400 vessels). Larger vessels and those with a deeper draft pose a greater risk for collisions with large whales.

Prevention and Mitigation

Mitigation measures that could reduce the frequencies of these various accident scenarios have been reviewed. Appropriate design and operation safeguards and use of highest standard industrial equipment and procedures will be in place to reduce the probability of any such events occurring. Mitigation measures can be incorporated during process selection, design, construction and operations. Each of these items is discussed below.

Fuels and Fueling

Fuel and other hazardous substances will be handled, stored or disposed of only by persons who are trained and qualified to do so, in accordance with the manufacturer's instructions and government laws and regulations. Bulk storage tanks will be properly dyked to prevent release of spills or leaks. Waste oil will be handled and stored by a licensed disposal agent in accordance with the *Used Oil Control Regulations*, and be regularly disposed of to prevent accumulation.

Diesel and gasoline use, transportation and storage will be conducted in accordance with the NL *Storage and Handling of Gasoline and Associated Products Regulations* (2003). Bulk storage of gasoline / diesel will be conducted using industry approved vessels that are in a state of good repair and whose integrity is regularly inspected and maintained.

Hydrocarbon releases from machinery and vehicles can be avoided through regular maintenance to ensure they are in good working order and checking thoroughly for leakage. Other protocols include:

- Having operators present for the duration of refueling;
- Refueling equipment and vehicles at least 100 m from any water body, and over a non-permeable surface;
- Having basic petroleum spill clean-up equipment on-site, with adsorbents being used to recover any spills or leaks;
- Promptly containing and cleaning up all spills or leaks on land or in water and reporting them to the 24-hour environmental emergencies report system (1-800-563-9089) as required by the *Fisheries Act* (1985);
- Not disposing of wastes in or near waterbodies, with no burning of waste without a permit; and
- Testing as per criteria listed in Schedule A of *the Environmental Control Water and Sewage Regulations* under the *Water Resources Act* (2003), before discharge into a water body.

Any spill in excess of 70 litres must be reported through the 24-hour Spill Report Number (709-772-2083). Fuel spill kits must include absorbent pads, loose absorbent materials such as dried peat, Speedi-Dry, or sawdust and a container for recovering the fuel / oil. Clean-up kits will be provided if there is a bulk fuel storage facility within the protected area, including at a minimum the equipment listed below.

- Wajax fire pump and 100 metres of hose
- Two hand operated fuel pumps
- Six recovery containers such as empty drums
- Four long handled shovels
- Two pick axes
- Fifteen cubic metres of impervious soil (a silt or clay bearing gravel)
- Fifty metres of low density rope
- Ten metres of containment boom
- Twenty-five absorbent pads
- Two 60-kilogram packages of loose absorbent material such as dried peat, Speedi-Dry or sawdust

When any fuel spill occurs the flow will be stopped immediately if possible. This may entail repairing a leak, pumping out a tank or shutting off a valve. If oil is spilled onto soil, dyking may be necessary. If fuel enters water, absorbent booms or barriers such as fencing or netting with loose absorbent or straw will be used to contain the spill. If necessary, culverts may be blocked off by earth or wooden barriers to contain fuel, provided the threat of flooding is addressed.

Process Mitigation Measures

Process-oriented mitigation measures include use of Best Available Control Technologies (BACT), and use of a closed system such that chlorine gas, when generated in the process, is contained and recycled reducing its release to the environment.

Design Mitigation Measures

Design-oriented mitigation measures that can be applied during the detailed design stage to reduce the probability of a major accident include:

- Use of containment berms around liquid material storage areas;
- Facility layout design to minimize potential interactions between incompatible materials;
- Use of BACT (e.g., alarms for high levels in tanks, automatic shut-offs at high-high level);
- Selection of appropriate materials for construction of the process equipment and storage facilities; and
- Total fail safe design, with isolation valves to limit any spill.

Construction Mitigation Measures

Construction-oriented mitigation measures will assist in prevention/avoidance of major accident scenarios. These measures include ensuring the facility is constructed according to design, supervision, and inspection during site development, equipment fabrication and construction, and instituting Environmental Protection Plans to address environmental issues related to the Construction Phase of the project.

Operations Mitigation Measures

The development and implementation of safe operating practices and standard operating procedures will reduce the frequency of occurrence of accidental releases.

- Safe operating practices for ships docked at the VBNC wharf (i.e., suspension of loading/unloading operations during adverse weather conditions)
- Safe operating practices in the processing areas (i.e., on-going training and updating of procedures)
- Use of designated shipping lanes in Placentia Bay

- Adherence to a strict inspection and maintenance schedule
- Operator training and education
- Vessel offloading with enclosed conveyor for solids or pressure-controlled hose systems minimizing risk of spillage or release during transfer
- Slurry pipelines and residue pipelines double-walled in trenches to contain any pipeline spill or leak
- Shipping dry chemical agents in bags or containers opened inside the plant
- Storage tanks inside the plant containment areas with holding capacities exceeding the volume of the tanks
- Road transport of materials scheduled to avoid inclement weather or adverse road conditions

Emergency Response

Emergency Response and Contingency Plans (ERCPs) will be prepared for all Project phases in order to assist in mitigating the environmental effects of accidents and malfunctions. In some cases (e.g., loss of fishing gear), compensation can be used to mitigate effects.

VBNC will conduct a hazard / risk assessment and prepare ERCPs for events such as hazardous material spills and emissions, fires and medical emergencies. An emergency plan will include, as a minimum, the elements listed below.

- Emergency and auditing policies
- Communication system
- Organization including roles and responsibilities
- Notification hierarchy
- Response and communication protocols
- Key contacts
- Plant protection officer checklists
- Emergency response equipment
- Designation of personal protective equipment
- Level I (one building), II (plant complex), III (hazard beyond facility boundaries) emergency and false alarm checklists
- Executive, environment, and safety on-call checklists
- Community emergency communication plan
- Material Safety Data Sheets
- Safe assembly area standards and procedures
- Leak detection systems

The VBNC approach to emergency preparedness is exemplified by the emergency response plan for the Hydromet Demonstration Plant at Argentia. The fuel and hazardous materials emergency response plan (Table of Contents) for the Construction Phase of that facility is provided as an example below.

- Chemical or Hazardous Material Spill
  - Responsibilities
    - First Person on Site
    - On-site Coordinator
    - Health and Safety Advisor
    - Emergency Response Team
  - Reporting
    - External Reporting
    - Internal Reporting
  - Spill Response Strategy
    - Land Spills
    - Spills on Water
    - Spills on Snow and Ice
    - Preventative Measures
  - Possible Spill Situations
    - Open Valves or Pipe Failures
    - Hydraulic Hose and Fuelling Equipment
    - Spills from Vehicles / Equipment Involved in Accidents
    - Chemicals
  - Material Safety Data Sheets

Accidents to be Assessed

Accident scenarios were analysed by AMEC (2007d) for accidental spills of acid, nickel concentrate, limestone, and fuel, as well as dam failures at the residue storage location. Two accidental releases of chlorine were modeled by SENES (2007c).

Accidents scenarios to be assessed for the EIS are shown in Table 9.1. These were selected to represent plausible worst-case scenarios that have the high potential to affect Valued Environmental Components.

Table 9.1 Accident Scenarios for Assessment

Accident Type	Size	Timing	Location	Rationale
Marine shipping accident – loss of sulphuric acid	7,500 tonnes at 0.1 m^3/s	Spring	Placentia Bay, entrance to Long Harbour	Marine transport of sulphuric acid is the largest movement of a hazardous substance associated with the Project.
Shipping accident – loss of loose concentrate	30,000 tonnes at 0.1 m^3/s	Spring	Placentia Bay, entrance to Long Harbour	Loose concentrate is a worse case than packaged concentrate
Shipping accident – loss of bunker C	2,180 m^3	Spring	Long Harbour	Shortest time to landfall; most potential to affect Bald Eagle concentrations
Large dam failure on Sandy Pond	n/a	Fall of Year 15	Tier 2, residue storage pond	Worst case residue storage scenario
Pipe rupture - chlorine release	59.2 kg	Spring	Tier 2, plant site	Plausible worst case air emissions

10.0 Sustainability Assurance

VBNC supports sustainable development, which seeks to enhance society through economic development and environmental responsibility. VBNC believes that mineral products are essential for the development of a sustainable economy. Protection of worker health and safety, the health of surrounding communities and the environment are essential considerations in the management of its business.

The management of occupational hazards and environmental liabilities during all phases of the Project will conform to the VBNC corporate Health, Safety and Environmental Management System (HSEMS). The system will be consistent with the criteria defined in the OHSAS 18001:1999 *Occupational Health and Safety Management Systems - Specification* and the ISO 14001:04 *Environmental Management Systems - Specification with Guidance for Use.*

VBNC views HSEMS from a life-of-project perspective. Following the planning and the construction phases, VBNC will operate, and ultimately decommission and rehabilitate the site and facilities. The HSEMS will be dynamic, evolving to address changing needs throughout the project life cycle. VBNC will review and update the HSEMS and its elements regularly, as well as at important milestones in the Project life cycle. The following key documents will be developed for the implementation of the HSEMS.

- Environmental Protection Plan
- Environmental Effects Monitoring Plan
- Occupational Health and Safety Plan
- Rehabilitation and Closure Plan
- Waste Management Plan
- Emergency Response Plan

Mandatory Health, Safety and Environment (HSE) guidelines also apply to contractors working at VBNC facilities. Implementation of these policy, guidelines and best practice documents are monitored through the CVRD Inco Limited corporate HSE audit program.

Occupational Health and Safety

The health and safety of its employees and the communities in which it operates are among the highest corporate priorities of VBNC. This is reflected in policy guidelines that apply to and are implemented by all people working on the Project. Through all stages of development and operation, VBNC will not only meet but seek to surpass standards set by applicable legislation. Best management practices are applied at all VBNC facilities and projects to minimize risks to occupational and public health and safety. VBNC works hard to nurture a strong safety culture in which workers take care of themselves and watch out for each other.

VBNC believes that all accidents are preventable. Safety targets are set because excellence can only be achieved with effort and by motivating the entire workforce to make safety a top priority. Through a variety of safety initiatives and a program of continuous improvement, VBNC is committed to achieve a goal of zero incidents.

All employees are responsible for accident prevention within VBNC facilities. The following safety principles define the VBNC commitment to achieving an injury-free and safe working environment.

- Everyone has the right to a safe environment.
- Safety will not take second place to any other management responsibility.
- Management is directly responsible and accountable for preventing injuries and occupational illness.
- Working safely is a condition of employment.
- All incidents can be prevented.
- All employees must be involved and supportive of the safety program.
- Training is an essential element for safe workplaces.
- Management must personally audit safety performance in the workplace.
- Safe work practices should be reinforced, and all unsafe acts and unsafe conditions must be corrected promptly.
- It is essential to investigate injuries and occupational illnesses, as well as incidents with the potential for injury.

Environmental Management

The Project has been planned to integrate environmental considerations in all aspects of the decision-making processes, from pre-feasibility studies through design, construction, operation, decommissioning and closure. The following key environmental principles will be considered in each phase of the Project.

- Keep physical boundaries as small as possible
- Reduce the size and extent of physical disturbance
- Recycle resources such as water
- Reduce the number of release points for the project (such as water discharges)
- Identify and avoid environmentally sensitive areas
- Plan all aspects of the Project for closure


HEALTH, SAFETY AND ENVIRONMENT POLICY

Figure 10.1 VBNC Health, Safety and Environment Policy

Examples of the application of these principles include:

Site Selection

- Long Harbour was selected as the site to minimize the environmental footprint i.e., short pipelines, access roads and electric transmission lines.
- Residues are combined from the Hydromet Plant to minimize the environmental footprint.
- Residue storage locations for the Hydromet Plant and Matte Plant were selected to minimize environmental impact.

Design

- Underwater storage of combined residues was selected for the Hydromet Plant to avoid sulphur acidification of residue.
- Recirculation and recycling of process and effluent streams will be undertaken to the extent possible both to recover as much valuable metal as possible, and to reduce the demand for reagents and water.
- Air pollution control systems will include:
- Baghouses for hygiene dust control – used predominantly at concentrate and limestone transfer and handling locations.
- Scrubbers for venting gas streams and copper electrowinning cells – used to reduce aerosol mists, chlorine gas and particulate carryover from entering the environment.
- Adequate building ventilation to ensure acceptable in-plant air quality.
- Water-spray dust suppression, when required, for roads and for the Matte Plant residue storage site.
- Instrumentation and monitoring equipment will be provided for measuring air quality and effluent characteristics.
- Access road drainage will be designed to direct runoff flow away from the Site.

Construction

- Construction practices will minimize stockpiling of materials to reduce fugitive dust emissions during construction.
- Buffer zones will be established and flagged prior to any disturbance activities.
- Natural vegetation will be left in place wherever possible.
- Temporary diesel generators and other equipment required during construction will be muffled to reduce noise.
- Fuel storage and distribution areas will be centralized and graded to direct stormwater runoff to an oil-water separator before being sent to a stormwater management pond.

- Drainage from areas of exposed fill will be controlled by grade or ditching and directed away from natural watercourses, wherever possible. Surface water will be directed away from work areas by ditching. Runoff from these areas will have silt removed by settling, filtration or other suitable methods. The requirement for ditch blocks / check dams or sediment traps to intercept runoff will be established during design and confirmed during construction, and appropriate action taken.
- Preventive measures such as silt curtains will be in place to reduce suspended sediment entry into water bodies.
- Regular monitoring of construction activities for leaks and spills will be undertaken.
- Stream crossings will be protected according to guidelines issued by DFO. Construction of stream crossings will follow accepted engineering and construction practices to accommodate runoff conditions and comply with regulatory requirements. Culverts will be sized to handle a 25-year return period flood and aligned so that the original direction of flow is unaltered. Approaches to crossings will be constructed with erosion-resistant materials such as rock or clean gravel. They will be at right angles to streams where possible. Materials will be placed in streams to maintain or improve aquatic habitat. The materials will be clean, non-erodible and non-toxic to aquatic life.
- Dams will be designed and constructed to prevent dam failure. Mitigation procedures in the unlikely event of dam failure will be detailed in the Emergency Response Plan.

Production Operations

- Secondary containment will be provided for all outdoor storage of petroleum products, reagents and chemicals. The sizing of the secondary containment structure will be 110% of the capacity of the largest reservoir or 100% of the capacity of the largest reservoir plus 10% of all others, whichever is greater. All outdoor secondary containment structures will be lined with impermeable materials.
- All process equipment will be located indoors (other than some surge tanks, storage tanks, and thickeners). Spill control of indoor process equipment will be done locally by providing containment (e.g. berms or concrete curbs) and sumps. The containment for each process area will be 110% of the volume contained by the largest piece of equipment. Contaminated water from periodic washdowns of local process areas or from washdown following spills will be returned to the process via local sumps.
- All equipment containing potential air contaminants will be routed through air pollution control devices prior to release to the air.
- All conveyors will be covered and transfer points vented through air cleaning prior to release to air.
- Dust collection systems will be in place at all material transfer points and material will be conveyed between locations in covered conveyors.
- Air emissions will be monitored to ensure that environmental regulations are met.
- Environmental control equipment will be monitored to ensure that operating parameters are met.

- Precautions will be in place to monitor and prevent the release of chlorine gas produced during the Hydromet process. Alarm systems and emergency safety procedures will be established to properly manage any accidental event involving chlorine.
- Liquid effluents will be monitored to ensure that regulatory requirements are met.
- Effluent treatment systems will include the following :
- Sewage treatment plant.
- Spill containment and treatment to ensure that site runoff is not contaminated.
- Stormwater management pond (solids settling).
- Polishing pond (solids settling, pH adjustment).
- Sand filters and pH adjustment (as required for treatment of polishing pond, Sandy Pond, and / or stormwater management pond).
- Instrumentation and monitoring equipment will be provided for maintaining effluent standards within regulatory requirements
- All storm water within the boundaries of Tier 1 and Tier 2 will be collected and treated as necessary before discharge.
- All effluent will be treated, tested, and monitored, and then discharged through a common pipe and diffuser located so as to maximize dispersion by mixing.
- There will be no discharge to freshwater bodies, other than the residue storage area at Sandy Pond and parking lot drainage that has gone through an oil/debris separator.
- Solid waste sludge from the sewage treatment plant will be collected by a certified sludge disposal company, for disposal at an off-site, properly licensed commercial facility.
- Emergency response plans will be in place in the event of unplanned events such as a chlorine release from the Hydromet Plant.

Decommissioning

A Rehabilitation and Closure Plan will be developed to accomplish the following objectives:

- Restore affected landscapes to a stable and safe condition, which will protect public health and safety.
- Re-establish conditions which will allow a productive use of the land and the natural resources of the area, similar to its original use.
- Reduce the need for long-term monitoring and maintenance by establishing, as quickly as practical, effective physical and chemical stability of disturbed areas.

The Environmental Protection, Environmental Effects Monitoring, Rehabilitation and Closure, Waste Management and Emergency Response Plans will provide details about the management of environmental factors for the lifecycle of the Project.

Climate Change

In keeping with VBNC's commitment to sustainable development, as described in the company's Health, Safety and Environment Policy, VBNC is incorporating energy efficiency into the design and operation of the Project and is aiming to reduce greenhouse gas (GHG) emissions that contribute to climate change.

VBNC recognizes the importance of addressing concerns about human influences on the global climate and the environment. As a subsidiary of CVRD Inco Limited, a member company of the Mining Association of Canada (MAC), VBNC shares their commitment to action and continuous improvement of environmental performance. MAC has a long history of working together with industry and government toward finding solutions and taking action to address the risks of climate change. MAC has put considerable effort into reducing energy consumption and GHG emissions across the Canadian mining and metal industry and has been recognized by the Minister of Environment and Minister of Natural Resources with a number of awards.

The Canadian mining industry's GHG emissions are almost exclusively linked to energy consumed in the production process. The nonferrous metal smelting and refining sector accounts for a small percentage of the industrial energy used in Canada; just over 3 percent in 2002 (MAC, 2004). There was a 7.7% improvement in energy intensity (energy per unit of output) in this sector between 1990-2003. Over the same period, there was a 43.4% improvement in total GHG intensity (GHG emissions per unit of output) in the nonferrous metal smelting and refining sector.

For CVRD Inco Limited specifically, energy intensity has continued to improve with a further 12% decrease in 2006 compared to 2005. All CVRD Inco Limited facilities are continuing to advance sustainability efforts and this includes corporate targets to further reduce energy intensity by 2% over 2006 levels, and the development of a comprehensive long-term strategy for reducing the company's carbon footprint in an effort to support global activities required to address climate change. Beginning in 2007, CVRD Inco Limited will voluntarily undergo external verification of their self-assessment results on energy and greenhouse gas emissions management. This will further demonstrate the company's commitment to this important environmental issue.

In adherence to MAC's "Strategic Planning and Action on Climate Change: A Guide for Canadian Mining Companies" and "Towards Sustainable Mining: Energy Use and Greenhouse Gas Emissions Indicators", VBNC will consider climate change in daily operating procedures and practices, and will implement the actions noted below.

- GHG emission inventory, measurement and monitoring
- GHG emission control targets
- Internal financial signals to encourage emissions reduction
- Employee engagement and motivation
- Reporting on climate change activities internally, to stakeholders, governments and the public.

For the inventory, GHG emissions will be calculated from direct energy use including fuels used at the Plant and facility activities such as on-site transportation.

CVRD Inco Limited is recognized as a leader in the development and implementation of new, more efficient and environmentally sound technologies. The hydrometallurgical technology proposed for this Project is an example. By availing of new technology and following environmentally sound practices during all phases of the Project, in keeping with the VBNC HSEMS, VBNC will do its part to minimize its contribution to climate change.

Emergency Response

The VBNC HSEMS prescribes the need for an Emergency Response Plan that includes procedures establishing a volunteer team of trained workers ready to assume responsibilities in the event of an emergency. During the construction and operations phases, VBNC and its contractors will deliver a range of safety training programs to workers, including hazardous materials handling, fall protection, first aid and advanced first aid, self-contained breathing apparatus training, safe operations of worker lifts, and aerial platforms and fire fighting training.

Environment, Health and Safety staff will work closely with the training department to facilitate safety training programs on site with the assistance of outside agencies as required. An Occupational Health and Safety Committee will be in place at the Plant. This Committee will include employee, contractor, and management representatives who will work together for continual improvement in the workplace.

Human Resources

The success of VBNC depends primarily upon the combined capabilities of its employees, technology, resources, and customers. VBNC believes that employees, suppliers, customers, the public and shareholders all have a shared interest in this success. VBNC also believes that employee and Company interests can and must be aligned. To that end, VBNC Human Resources management activities are guided by the following principles:

- Open and honest communications;
- Conducting business with integrity;
- Providing supportive management;
- Emphasizing quality in all aspects of work, and focusing on customer service both internally and externally;
- Promoting a climate of continuous improvement;
- Endorsing the concept of the learning organization and supporting staff in it;
- Supporting diversity in the workplace; and
- Respect for the individual.

Responsibility to Workers

VBNC insists on a work environment that offers opportunity and strives always to be fair, inclusive and respectful. The cornerstone upon which VBNC's Human Resource Policies and Procedures are built are VBNC's "People Values". We believe that through leadership and personal responsibility employees can participate, contribute and grow with VBNC by:

- Providing and requiring safe conditions and practices,
- Acting fairly and with integrity in all we do,
- Meeting or exceeding customer expectations,
- Respecting others and their contribution,
- Supporting diversity,
- Working together,
- Practicing quality communications,
- Pursuing training, development and life-long learning,
- Continuously improving everything we do.

Corporate guiding principles which define VBNC responsibilities to its employees are provided in Table 10.1.

Table 10.1 Human Resource Guiding Principles

VBNC Human Resource Guiding Principles
VBNC Guiding Principles are designed to encourage and maintain a work environment that provides employees with the opportunity to achieve their personal career goals, as well as the training and support they need to meet our business objectives. In order to attract, retain and develop our employees at all levels, VBNC commits to:
• Provide pay and benefits that are competitive in the employment markets from which employees are drawn, which are intended to reward successful performance and be internally equitable.
• Provide opportunities for individual growth and career satisfaction, and assist employees to realize their full potential by providing appropriate training, development, educational and promotional opportunities.
• Observe all laws respecting non-discrimination or harassment on the grounds of race, ancestry, national origin, colour, ethnic origin, citizenship, creed, gender, sexual orientation, disability, marital status, family status or age.
• Provide suitable work facilities and conditions with the objective of safeguarding the health, safety and general well-being of employees.
• Provide full and fair opportunity and first consideration for employment to residents of the province.

Human Resources Legislation

The Labour Standards Act specifies employment standards in Newfoundland and Labrador. Other applicable provincial worker-related law includes the *Labour Relations Act*, the *Occupational Health* *and Safety Act* and the *Workers' Compensation Act*. VBNC also complies with federal legislation where applicable.

Women's Employment

VBNC values gender diversity, in the belief that gender mix contributes to a healthy and productive workplace. Although efforts have been made generally to improve the participation of women in the workplace, inequity persists, particularly in science, trade and technology occupations. Addressing this challenge requires an integrated strategy in which all stakeholders have a role to play. VBNC is aware of the need to participate, along with others, in developing concrete initiatives that address the underlying contributing issues. VBNC also recognizes that over time women will take up opportunities presented in non-traditional occupations. VBNC is working with governments, educational institutions, women's organizations and industry associations to advance gender diversity in the workplace, and to see that more women take advantage of employment opportunities in the Canadian mining industry.

VBNC has adopted and will continue to further its corporate commitment to advance the employment of women in occupations in which they are underrepresented. This will be achieved with the formal development and implementation of a Women's Employment Plan for the construction, operation, and decommissioning phases of the Project. This plan will also contain initiatives designed to communicate and monitor the program. VBNC already has a Women's Employment Plan in place and will build upon this existing strategy to further the advancement of women in the workplace.

VBNC will implement gender-based analysis for its operations and for contractors working at various locations. A gender-based approach ensures that the development, analysis and implementation of workplace design and policies are undertaken with an appreciation of gender differences, and the recognition of potential differential effects on men and women. This includes an understanding of the nature of the relationships between women and men, and the different social realities, life expectations and economic circumstances facing both. The analysis of gender information and demographics, as well as the identification of gender-related issues that affect the advancement of women in the workplace, are also incorporated in this approach.

VBNC has surpassed gender diversity targets for the operations phase in Argentia. The vast majority of these women are employed in non-traditional occupations, including engineering, process operations and laboratory analysis.

Training and Development

VBNC is committed to encouraging and maintaining a work environment that gives employees the opportunity to achieve their personal career goals, as well as the training and support they need to meet corporate business objectives.

VBNC recognizes the low participation rate of women in non-traditional occupations, such as building trades and technology occupations. To help address this reality, VBNC will support, where reasonably possible, efforts designed to increase the number of women who have the requisite skills. The Company will support post-secondary training organizations in their initiatives designed to encourage and recruit women into science, trades and technology-based programs that support VBNC operations.

Protection of health, safety and environment is paramount. VBNC will ensure that health, safety and environment training is provided to all VBNC workers. Training and orientation of visitors, new recruits and temporary student employees will also be provided. All contractors will be required to employ qualified workers who have received health, safety and environment training prior to starting work. Workers will also be required to undertake regular training exercises in emergency response procedures, to ensure readiness should unplanned events occur.

Succession Planning

The purpose of succession planning is to ensure that personnel of sufficient numbers and quality are available to fill business needs when required and to maintain alignment between business goals and human capital needs. Effective succession and career planning also permits the organization to maintain pace with changes in business, industry and the overall marketplace. VBNC is implementing a succession planning process that will achieve the goals noted below.

- Addresses the needs of the organization as the workforce ages and employees leave.
- Assists with preparing the organization for unexpected events.
- Ensures that VBNC has the right personnel to function at peak efficiency.
- Enables residents of Newfoundland and Labrador to advance to increasing levels of responsibility in VBNC

Community

VBNC believes that working in collaboration, consultation and cooperation with community groups and all levels of government is essential to achieving mutual goals. By working together, VBNC can help to stimulate the development of sustainable communities that will thrive well beyond the life of one project.

VBNC is committed to maximizing local business opportunities, recognizing that there are long-term benefits associated with developing a strong base of local suppliers. VBNC also plans to continue its strategic investment in communities in Newfoundland and Labrador, through financial contributions to and sponsorship of local programs. VBNC will continue to work with citizens and municipal leaders to address concerns about industrial benefits, training requirements, environmental effects, and other issues that may arise.

Public Consultation

Public consultation is an integral part of the environmental assessment process as per Section 58 of the provincial *Environmental Protection Act* and Section 16 (1) of the *Canadian Environmental Assessment Act.* The formal public consultation sessions for this project used notification protocols consistent with the requirements provided in Appendix A of the EIS Guidelines.

This section describes the ongoing process of consultation with the public and government agencies. It highlights interests and concerns that arose during the process, both before and after Project Description/Project Registration in March 2006. Appendix C provides a comprehensive list of comments about the Project, organizes these comments into categories relevant to the environmental assessment and indicates where relevant interests and concerns are addressed. Also presented is a listing of the various meetings and consultations carried out by VBNC throughout the EA process.

The commercial nickel processing plant at Long Harbour is the final element of a four stage R&D program to develop a viable hydrometallurgical processing facility for concentrate from the Voisey's Bay mine in Labrador. VBNC has been engaged in public consultation for a prolonged period and has in place several effective mechanisms for information exchange with a variety of interest groups and communities.

The construction and operation of a hydrometallurgical demonstration plant (Demonstration Plant) at Argentia required its own registration for environmental assessment and public consultations. VBNC presented information on the commercial plant development during public consultation for the Demonstration Plant. Thus, the VBNC public consultation process for the commercial nickel processing plant began in 2003, well in advance of the formal submission of the Project Description / Project Registration in March 2006.

VBNC used a range of consultation and disclosure methods to encourage participation, including:

- Public open house sessions;
- Public meetings and presentations (including Supplier Information Sessions);
- Meetings with government;
- Demonstration Plant tours;
- VBNC Community Liaison Committee;
- Information office in Placentia;
- Newsletter, brochures, panels, displays; and
- Direct mailing to householders.

Pre-Registration

Formal contact with the public and government departments began in late 2003. Between that time and Project registration on 16 March 2006, VBNC engaged in nearly 30 consultation sessions with the public and all three levels of government, provided many tours of the Demonstration Plant, established an Information Office in Placentia to distribute information and offer an informal venue to encourage questions and discussion, and distributed two information brochures to local households to update residents on VBNC's activities.

Between October 2003 and March 2006, the public was offered eight opportunities for information disclosure, in meetings and presentations. These included presentations on the environmental assessment at the Opportunity Argentia Conference in both 2003 and 2004, to the Newfoundland and Labrador Environmental Industry Association (NEIA) in 2004, and to the Placentia Area/VBNC Community Liaison Committee in 2004 and 2005.

The Placentia Area/VBNC Community Liaison Committee was formed in 2003 and has met quarterly since. Its goals are to foster communications between VBNC and local residents, and to address concerns and issues of mutual interest. Membership includes representatives of the communities of Placentia, Long Harbour, Fox Harbour, Ship Harbour and Point Verde; key community economic / educational and other groups (e.g., Argentia Management Authority, Argentia Area Chamber of Commerce, Avalon Gateway Regional Economic Development Association, College of the North Atlantic, and Newfoundland and Labrador Environmental Association); and representatives of various provincial and federal government departments.

VBNC held 10 meetings with federal government representatives of the Canadian Environmental Assessment Agency (CEAA Agency), Fisheries and Oceans Canada (DFO), Environment Canada, and Transport Canada. Meetings with CEA Agency, Transport Canada and DFO addressed schedule and approach, as well as potential federal "triggers" under the *Canadian Environmental Assessment Act*. Subsequent meetings were held with DFO to discuss freshwater and marine baseline studies.

VBNC also held nine meetings with representatives of the provincial Departments of Justice, Natural Resources Mines and Energy, and Environment and Conservation. Early discussions focused on the proposed schedule, approach, potential issues, plans for government and public consultation, and initial baseline studies. On 13 March 2006, VBNC also hosted an information session on the Project Description/Registration Document for federal and provincial regulators. Twenty-three people attended, representing three federal and four provincial departments.

VBNC provided numerous tours of the Demonstration Plant at Argentia during its construction and after its opening in October 2005. Several hundred people took advantage of this opportunity to learn more about the hydrometallurgical process and to view the facility. Visitors included media, representatives of educational institutions and environmental NGOs (non-governmental organizations), the Community

Liaison Committee, government representatives (municipal, provincial and federal) and attendees of the 2005 Opportunity Argentia Conference.

VBNC has maintained a staffed information office in the Placentia Mall since mid-2004. Open during regular business hours, the information office provides the public with opportunities to access project information and to share concerns regarding any aspect of the company's operations.

VBNC published the first issue of its newsletter, *The Gossan,* in July 2003. It provided updates on the Voisey's Bay project and was circulated widely to employees, contractors and project stakeholders. It is also available for public viewing in electronic format on the company's website at vbnc.com. The first article dedicated exclusively to the environmental assessment process for the commercial processing facility was presented in the July 2005 issue. In October 2005, a second article carried a brief update on Project Registration and ongoing baseline studies. To date, VBNC has published 14 editions of *The Gossan*.

VBNC published and distributed two information brochures to all households in the region before Project Registration, the first, in January and the second in October 2005. While the focus was on the Demonstration Plant, each brochure included a set of questions and answers related to the commercial facility and the environmental assessment process.

Post-Registration

The second part of VBNC's public consultation process was initiated in conjunction with the Project Description/Project Registration on 16 March 2006. Public meetings and presentations continued to play a significant role during this period. The company conducted additional open house sessions designed to disclose information about the proposed project to a wide audience, and to gather participants' feedback.

Five open house sessions were held between April and November 2006. The first was conducted in Long Harbour-Mount Arlington Heights on 19 April (afternoon and evening) at the request of the Town Council. This event was not an official open house session as outlined in the EIS Guidelines. Subsequent sessions designed to meet the EIS Guidelines were held as follows: 20 September in Long Harbour-Mount Arlington Heights (afternoon and evening); 21 November in Ship Harbour (evening); 22 November in Placentia (afternoon and evening); and 23 November in Whitbourne (afternoon and evening). A total of 270 people attended the open houses.

The purpose of these sessions was to describe the proposed Project and the EIS process, as well as to solicit comments from attendees, who also had the opportunity to meet representatives from VBNC and the consulting firms which conducted the baseline studies and view some of the data collected. The majority of attendees were concerned with topics relating to employment and the environment.

Following each session, attendees were asked to complete an Exit Survey. The results of the 130 completed surveys were consistent with the observations made during the sessions, namely that employment and the environment were of primary interest.

VBNC also sought other opportunities for public consultation. From 2006 to 2007, VBNC delivered presentations to the Professional Engineers and Geoscientists of Newfoundland and Labrador (PEGNL), the Placentia Bay Integrated Management Planning Committee, the Isthmus Joint Council, and the Newfoundland and Labrador Environmental Industry Association. VBNC continued to offer presentations and attend meetings in local communities, including ongoing quarterly updates to the Placentia Area/VBNC Community Liaison Committee.

VBNC has maintained ongoing dialogue with federal government representatives of the CEA Agency, DFO, Environment Canada and Transport Canada. Meetings with these agencies focused on receiving feedback from the environmental assessment process and Project Registration, as well as discussions on schedule and approach. Communications with the provincial government during this period were mainly concerned with establishing the parameters and guidelines for the EIS.

VBNC continued to provide tours of the Demonstration Plant during the post-registration period. Tours were organized around two key 2006 meetings, one with environmental NGOs and the other with fifteen provincial and nine federal regulators. The majority of visitors were local residents or government representatives. In September 2007 the Company participated in the Hydromet Project Initiative conference, and offered additional Demonstration Plant tours to participants.

During the post-registration period, *The Gossan* continued inform the public about the commercial processing plant and the environmental assessment process. Notification of Project Registration was given in the April 2006 issue. A brief update of development activities associated with the commercial processing plant appeared in October 2006.

The information office received hundreds of visitors, including many from local communities after Project Registration. Employment and business opportunities as well as potential environmental effects were the primary interest.

VBNC published and distributed an information brochure to all households in the region in April 2006, outlining the environmental assessment process and the company's decision to register a project that could use either type of processing technology (Hydromet or Matte). A second brochure was sent to local households in June 2007, including information on the commercial processing plant and the development schedule. The baseline studies program was also described and many of its component studies summarized, including those for Physical Oceanography, Groundwater Characterization, Terrestrial Baseline and Socio-Economics.

Public Interests and Concerns

Many questions and comments were generated by the consultation process. Additional input appeared in the EIS Guidelines as a result of communications between the provincial government, individuals and environmental groups.

Results received through the public consultation (listed in Appendix C) have been grouped into ten categories of comments and concern.

- Air Emissions and Human Health Effects
- Availability / Accessibility of Information
- Business Opportunities / Benefits
- Employment Benefits
- Fish / Wildlife Habitat
- Ground / Surface Water Contamination
- Marine Environmental Effects
- Project Design / Description
- Regional Quality of Life
- Residue Storage / Sandy Pond

The greatest number of comments made were about timing, scale, location, configuration, and selection of process technology. Many people also wanted to learn how VBNC would share information on employment and business opportunities, environmental effects, baseline studies and environmental monitoring.

Attendees were concerned about environmental effects, particularly as they might affect the fisheries and aquaculture industries. Residents questioned the use of Sandy Pond to store residue and the potential for this natural water body to release the residue into the surrounding aquatic, terrestrial or marine environments.

The public expressed concern about potential effects on the quality of life in rural communities including human health and recreational activities. Residents of the area own cabins and participate in outdoor recreation activities such as hunting, fishing, wood cutting, berry picking and camping and were concerned about how these activities might be affected. They wanted to participate in the Project's long-term employment and economic development, but not at the expense of clean air, water and land. They wanted to know that a thorough environmental assessment would address their concerns.

Employment and increased business activity was of interest to many participants. Residents wanted VBNC to ensure that business opportunities and economic benefits would be realized in the local community. There was some concern about the adjustment of municipal boundaries and the relative municipal benefits to the various communities in the region.

Public consultation sessions have been well attended, and provided an exceptional opportunity for dialogue between VBNC and those who will be most affected by the Project. All of the questions raised have been considered and, wherever appropriate addressed within the EIS.

Ongoing Public Consultation

Consultations will continue throughout the environmental assessment process. The focus of these consultations will be to provide information to aid discussion and solicit feedback, as well as respond to relevant issues and concerns.

- Open house sessions to be held in Long Harbour-Mount Arlington Heights, Placentia, Ship Harbour and Whitbourne
- Distribution of information brochures to households in Long Harbour, Placentia, Whitbourne and the adjacent area
- Maintenance of an information office in the Placentia area
- Press releases and media briefings
- Newsletter updates
- Information sessions/discussions with the Community Liaison Committee and with municipal, provincial, and federal government representatives

11.0 Valued Ecosystem Components

Environmental effects assessment in Canada is based on the Valued Ecosystem Component (VEC) approach, originally conceived by Beanlands and Duinker (1983). This approach focuses on those elements of the ecosystem of most interest and value to society. The selection of VECs is an important component of environmental assessment: it is not feasible or desirable to assess the effects of the Project on every species, pathway or human value that may apply. The process is intended to be part of planning that allows reasonable decisions to be made based upon a realization of the benefits of a project in contrast to the anticipated environmental effects.

In this EIS, the atmospheric, terrestrial, freshwater, marine and human environments were systematically analyzed during the VEC selection process. In order to be selected as a VEC for detailed analyses at least four criteria had to be satisfied.

- The component is of demonstrated value (e.g., economic, scientific, cultural, or ecological) to society (or has particular value as a 'key indicator' or surrogate for the component of most interest).
- Concern about that component has been expressed by the public and/or regulators during the environmental assessment process.
- There is potential for the component to be measurably affected by the Project.
- Data are available or can be collected in a reasonable timeframe to produce a credible analysis.

In the preparation of Guidelines, a committee of government officials consulted with regulatory agencies and resource managers. As well, input was solicited and received from the public. On that basis a set of VECs were identified and incorporated into the EIS Guidelines. As well, the consultation efforts by VBNC have confirmed that the selected VECs address the suite of identified issues and concern.

For reference, Table 11.1 lists the VECs as assigned in the Guidelines. Also shown are their organization in the EIS. The alignment differs only slightly from the EIS Guidelines, however all the required issues and concerns as identified within the Guidelines have been addressed. The text below provides the rationale for the selected VECs and their organization.

Table 11.1 VEC Organization and Presentation

Guidelines VEC	EIS Organization of VEC		
	Title	**Volume**	**Section**
Air Quality	Air Quality	2	4.0
Water Quality and Quantity (including wetlands)	Freshwater Resources	2	5.0
Fish and Fish Habitat (Including commercial fisheries and aquaculture)	Freshwater Fish and Fish Habitat Marine Fish and Fish Habitat Commercial Fisheries and Aquaculture	2 2 3	6.0 7.0 7.0
Avifauna (including raptors, waterfowl and marine birds)	Avifauna	2	8.0
Otter	Otter	2	9.0
Species at Risk (including wildlife, avifauna, rare vascular plants and lichens) listed under the Species at Risk legislation	Species at Risk	2	10.0
Economy, Employment and Business	Economy, Employment and Business	3	4.0
Services and Infrastructure (including health infrastructure)	Services and Infrastructure	3	5.0
Recreational Activities	Recreational Activities	3	6.0

Biophysical VECs

The biophysical VECs selected for detailed analysis and specified in the EIS Guidelines are described below in terms of their relevance to the Project:

Air Quality. Air emissions form a key pathway for affecting air quality during operations and airborne noise can affect sound levels in the area during construction.

Water Quality and Quantity (including wetlands). Water resources will be required by the Project for a variety of uses. Extractions can reduce the quantity of water (especially freshwater) available for other (consumptive and non consumptive) uses. Processes associated with the Project can alter water quality upon discharge (either through regulated discharge or accidental event) to the receiving environment. Key pathways for effects are runoff and air emissions.

Fish and Fish Habitat (including commercial fisheries and aquaculture).

This VEC comprises three sections, each of which is described below.

Freshwater Fish and Fish Habitat. Freshwater fish (with brook trout as the key indicator species) and their habitat is an important VEC because it provides recreation and food for humans as well as forage for certain birds and mammals. The freshwater stages of anadromous (e.g., sea run salmonids) and catadromous fish (e.g., American eel) are also considered where relevant. There is potential for effects on fish and fish habitat from residue storage, water withdrawals and changes in water quality.

Marine Fish and Fish Habitat. Marine fish habitat is very broadly defined here to include components such as water and sediment quality, plankton, and benthos. The marine stages of anadromous (e.g., sea run salmonids) and catadromous fish (e.g., American eel) are also considered where relevant. Fish VECs are of prime concern from both a public and scientific perspective, locally, nationally and internationally. Individual species were selected to represent this VEC, as in most cases species can be grouped according to life cycle and habitat usage. Flounder and blue mussel species are most likely to be affected, and as such provide a conservative basis for the EIS. There is potential for effects on the marine environment from marine effluent, shipping and accidental events.

Commercial Fisheries and Aquaculture. The commercial fishery forms an important element in the societal, cultural, economic and aesthetic environment of Newfoundland and Labrador. This VEC is of prime concern from both a public and scientific perspective, locally, nationally and internationally. Aquaculture is also considered here because of its growing presence in Placentia Bay. Marine activities including shipping, shoreline and wharf construction and effluent discharges all have the potential to interact with nearby commercial fishing and aquaculture operations.

Avifauna. Newfoundland supports some of the largest seabird colonies in the world and our waters host very large populations during all seasons. Shorebirds, waterfowl, raptors (Bald Eagle and Osprey) may be abundant at certain places and times. They are important socially, culturally, economically, aesthetically, ecologically and scientifically. Seabirds are a key component near the top of the food chain and are an important resource for bird-watching (one of the fastest growing outdoor activities in North America), the tourist industry, local hunting, and scientific study. In addition, this VEC is more sensitive to contaminants in or on water, and is of prime concern from both a public and a scientific perspective, locally, nationally and internationally. There is potential for effects on the marine-related avifauna (represented in the EIS by Bald Eagle and Cormorant) from marine effluents and shipping and unloading / loading accidents.

Otter. River Otter is the focal species here as it pursues a marine lifestyle in Placentia Bay and is a resident top level predator. These mammals are of prime concern from both a public and scientific perspective – locally, nationally and internationally. The main pathways for potential effects include disturbance (e.g., from noise) and exposure to contaminants with some potential for biomagnification due to their high rate of consumption of fish.

Species at Risk. This group has become a mandatory VEC in Canadian environmental assessments. The legally-defined "species at risk" are those listed as endangered or threatened, or of special concern on Schedule I of the *Species at Risk Act* (*SARA*) (e.g., wolffishes) and / or the provincial *Endangered Species Act* (e.g., boreal felt lichen and Red Crossbill). Consideration was also given to the COSEWIC listings as some of those species may be up-listed to *SARA* during the life of the Project. [COSEWIC, the Committee on the Status of Endangered Wildlife in Canada, nominates species for listing under *SARA*.] Some species in Newfoundland and Labrador are captured in the VECs listed above. However, they are also discussed separately because of their special status.

Socio-economic VECs

The three socio-economic VECs have been addressed as per the EIS Guidelines. The scope of each socio-economic VEC has been defined in a manner which will focus the assessment on relevant matters.

Economy, Employment, and Business encompasses aspects of the socio-economic environment that are important to all citizens. Some will benefit directly or indirectly from Project employment skills and experience. New industrial projects generally benefit the surrounding area as some people are directly employed and as employee and business spending generated indirect employment and effects throughout the local economy. Some effects may be negative; for example, wage inflation caused by the Project may adversely affect local businesses, while an increase in the cost of living may adversely affect those on low fixed incomes. However, all citizens and the economy as a whole will also benefit from the taxes and royalties that projects and their employees pay to different levels of government, which can use them to address a wide range of social and economic issues.

Services and Infrastructure are important because citizens value the components that make up this VEC for their contribution to the quality of life. Employment stemming from the Project may result in higher incomes or lifestyle changes, or encourage in-migration, leading to increased demands on services and infrastructure. Where they are already operation at or beyond their capacity, and increased demand could reduce the overall quality of services provided, until such a time as capacity issues can be corrected. Where services and infrastructure are currently underused, increased demand may have no effect, or a positive one through user pay and greater efficiency of use.

Recreational Activities are important because such activities contribute to the physical and mental well-being of a broad range of individuals. Hunting, trapping, fishing, berry-picking, cutting firewood and some other such activities can also contribute to the economic well-being of residents. Parks, trails and historic resources are important to local tourism and hence the local economy.