TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
μg/g	Micrograms per gram
μg/L	Micrograms per liter
μPa	MicroPascal
μS/cm	Microsiemens per centimeter
°C	Degree Celsius
a	Insufficient Data
Ag	Silver
Al	Aluminum
ALTRT	Atlantic Leatherback Turtle Recovery Team
ANR	Analysis Not Required
As	Arsenic
AST	Aspartate Aminotransferase
ATV	All-Terrain Vehicle
B	Boron
Ba	Barium
Be	Beryllium
Bi	Bismuth
Br	Bromine
BTEX/TPH (RBCA)	Benzene Toluene Xylene/Total Petroleum Hydrocarbons (Risk Based Corrective Action
Ca	Calcium
CAEL	Canadian Association of Environmental Laboratories

Acronym/Abbreviation	Definition
CCME	Canadian Council of Ministers of the Environment
Cd	Cadmium
Ce	Cerium
Cl	Chlorine
Co	Cobalt
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
Cr	Chromium
Cs	Cesium
CSA	Canadian Standards Association
Cu	Copper
CV	Coefficient of Variation
CWS	Canadian Wildlife Service
D	Duplicate
dB	Decibel
DFO	Department of Fisheries and Oceans
DFO	Department of Fisheries and Oceans
DL	Detection Limit
DO	Dissolved Oxygen
DWT	Deadweight Tonnage
e.g.	*Exempli gratia*
EA	Environmental Assessment
EC	Environment Canada
EEM	Environmental Effects Monitoring

Acronym/Abbreviation	Definition
EHJV	Eastern Habitat Joint Venture
EIS	Environmental Impact Statement
ESA	Endangered Species Act
EVOS	Exxon Valdez Oil Spill
FAL	Freshwater Aquatic Life
Fe	Iron
FPWC	Federal Policy on Wetland Conservation
GPS	Global Positioning System
Ha	Hectare
HADD	Habitat Alteration Disruption or Destruction
HEU	Habitat Equivalency Units
Hg	Mercury
Hp	Haptoglobin
Hz	Hertz
I	Iodine
i.e.	*Id est*
IBA	Important Bird Area
ICP	Inductively-Coupled Plasma
IL-6 ir	Interleukin-6immunoreactive
in^3	Cubic Inches
ISQG	Interim Sediment Quality Guideline
IWC	International Whaling Commission
JSA	Job Safety Analysis

Acronym/Abbreviation	Definition
kg	Kilogram
kHz	KiloHertz
Km	Kilometer
Km/h	Kilometer per hour
kPa	KiloPascal
kPa	Kilopascal
La	Lanthanum
Lab-Dup	Lab Initiated Duplicate
Li	Lithium
m	Meter
MDL	Method Detection Limit
Mg	Magnesium
mg/kg	Milligrams Per Kilogram
mg/L	Milligrams Per Liter
Mn	Manganese
Mo	Molybdenum
MSS	Marine Sediment Sample
MUN	Memorial University of Newfoundland
MWS	Marine Water Sample
N	Nitrogen
N/A	Not Applicable
ND	Not Detected
ng	No Guideline

Acronym/Abbreviation	Definition
Ni	Nickel
NL	Newfoundland and Labrador
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NP	Not Provided
NR	No Lab Replicate
NS	Not Sampled
NTU	Nephelometric Turbidity Units
P	Phosphorus
p	Probability
P	Primary
PAH	Polycyclic Aromatic Hydrocarbon
PAH	Polyaromatic Hydrocarbons
PAL	Provincial Airlines
Pb	Lead
PCB	Polychlorinated Biphenyls
PEL	Probable Effects Limit
PIROP	Programme Intégré de Recherches sur les Oiseaux Pélagiques
ppm	Parts per million
PPV	Peak Particle Velocity
psi	Pounds per Square Inch
Psi	Pounds per square inch
PTS	Permanent Threshold Shift

Acronym/Abbreviation	Definition
QA/QC	Quality Assurance/Quality Control
QC Batch	Quality Control Batch
Rb	Rubidium
RDL	Reportable Detection Limit
rms	Root Mean Square
ROV	Remotely Operated Vehicle
S	Sulphur
SAG	Surface Active Group
SARA	Species at Risk Act
Sb	Antimony
Se	Selenium
SENES	Specialists in Energy, Nuclear and Environmental Sciences
Si	Silicone
Sn	Tin
SOP	Standard Operating Procedure
SPL	Sound Pressure Level
Sr	Strontium
SSAC	Special Status Advisory Committee
TC	Transport Canada
Tl	Thallium
TOC	Total Organic Carbon
TTS	Temporary Threshold Shift
U	Uranium

Acronym/Abbreviation	Definition
V	Vanadium
VEC	Valued Ecosystem Component
VEC	Valued Ecosystem Components
VLCC	Very Large Crude Carrier
VOC	Volatile Organic Compounds
YOY	Young Of Year
Zn	Zinc

1.0 INTRODUCTION

The five volume Environmental Impact Statement for the Newfoundland and Labrador Refining Corporation (NLRC) Refinery Project at the head of Placentia Bay (The Project) has been prepared to meet the requirements of both the provincial and federal environmental assessment processes (as described in the Guidelines for Environmental Impact Statement/Comprehensive Study Report (EIS/CSR) by the Newfoundland Department of Environment and Conservation) and to respond to the ideas, suggestions, questions and concerns of the residents of Placentia Bay and nearby communities.

The purpose of environmental assessment (EA) is to determine whether or not the proposed project is likely to cause significant adverse impact on the environment. The EA documents (EIS/CSR) identify the environmental effects associated with the Project activities, define the mitigative measures possible to mitigate (reduce or eliminate) those effects, and provide an evaluation of the potential significance of any residual effects (i.e. any effects that cannot be mitigated) as well as suggest appropriate monitoring and follow-up programs. The effects of the environment on the project are also considered as they affect design, operations and decommissioning.

Environmental effects are defined and discussed for all phases of the project: planning, construction, operation (including maintenance and modification), and decommissioning and rehabilitation.

This volume (Volume 3), the Biophysical Assessment, provides information about the existing marine and terrestrial environment in which the project will be constructed and operated, and the effects of the project on and in this environment. This information allows decisions makers, stakeholders and the public to consider the biophysical environmental implications of the project and determine its acceptability.

The approach used to develop the biophysical assessment and the Socio-Economic Assessment (Volume 4) followed well-established methods of environmental impact assessment used in Canada and, particularly, in the Province of Newfoundland and Labrador. It also meets the requirements set forth in the Guidelines (see Table of Concordance in Volume 1).

The discussion of the existing biophysical environment and the environmental effects of the project concentrates on Valued Ecosystem Components (VECs). Valued Ecosystem Components are those aspects of the environment that have particular ecological, cultural, legal, scientific or economic value. VECs for the Refinery Project were identified by regulatory agencies (the Guidelines), the environmental consultants and through input from NLRC's public consultations.

Volume 3 also presents the Environment, Safety and Health Management Plans that will support all phases of the project. During public consultations, concern about increased risk of an oil spill and the capacity to respond to oil spills in Placentia Bay were raised consistently: oil spill prevention, effects and response are discussed in Section 7.2 and 8.5 of this volume under accidents and malfunctions, emergency response plans and throughout the assessment section for each VEC. Air quality issues were also raised by the community as an area of concern. This has been addressed in this volume and in Volume 4 as it relates to human health.

Volume 1 of the EIS is the Project Summary and Conclusion, a synthesis of the approach and findings of the environmental assessment. Volume 2, Project Description and Planning describes in detail the design principles for the refinery complex and marine terminal; the construction schedule and construction practices to be used; the refinery components and process, including operations and maintenance and; the associated marine terminal with its wharf, jetty and loading/unloading equipment and vessel traffic. Volume 4, Socio-Economic Assessment describes and discusses the socio-economic environment for the Project. As in the biophysical assessment, the socio-economic assessment is focused on those aspects identified by communities and regulatory agencies as Valued Ecosystem Components. Volume 5, Public Consultations describes the overall commitment and approach to involving the public, and the suggestions and issues raised in these consultations.

1.1 The Undertaking and Proponent

The Newfoundland and Labrador Refinery Project is proposed by Newfoundland and Labrador Refining Corporation (NLRC), the Proponent. The proposed project is to build and operate a new 300,000 barrel per day (bbl/day) crude oil refinery at the head of Placentia Bay in the Province of Newfoundland and Labrador.

In February 2006, NLRC initiated a feasibility study into building and operating a second crude oil refinery in Placentia Bay, on the west side of the Come By Chance Bay, across from an existing refinery (North Atlantic Refinery Limited, a 105,000 bbl/day refinery near the town of Come By Chance) (Figure 1.1).

The Project's initial planned nominal capacity will be 300,000 bbl/day expandable to 600,000 bbl/day in the future, if market conditions allow. The Project will provide a new state-of-the-art oil refinery that is safe, efficient and environmentally responsive to contemporary expectations for modern industrial development. The Project will be designed, constructed and operated in a manner that will minimize the impact on the environment, and will meet or exceed applicable Federal and Provincial Acts, Regulations and Standards.

NLRC is a private company registered in Newfoundland and Labrador and based in St. John's. The founding investors are lead by Altius Resources Inc. of St. John's, NL, and a core group of established European entrepreneurs with proven track records in both equity and debt finance arrangements for major development projects. NLRC may add additional partners as the project develops.

Figure 1.1 General Map of Placentia Bay and Project Location

1.2 Project Overview

NLRC proposes to build and operate a 300,000 bbl/day, expandable to 600,000 bbl/day, crude oil Refinery at the Southern Head, at the head of Placentia Bay on the Island of Newfoundland.

The Project location is the Southern part of a peninsula between Come By Chance and North Harbour, NL, bound on the east by Come By Chance Bay, on the west by North Harbour and on the south by Placentia Bay (Figure 1.1).

The Project's main physical features (Figure 1.2) include:

- Access roads, a 9.2 km Come By Chance access road and a 12.1 km North Harbour access road, as well as various service roads, including stream crossings by bridges and culverts;
- Laydown areas;
- The refinery complex, service buildings and associated facilities;
- A storage tank farm;
- A marine terminal and associated wharf, tug basin and jetties at the eastern side of the development at the south-west entrance of Come By Chance Bay;
- A marine saltwater intake and outfall diffuser; and
- Utilities (powerline and substation, effluent treatment plant, desalination plant, solid waste management, etc.).

The estimated Project area (i.e. Project footprint) is approximately 5 km^2 (500 ha). This area includes the proposed 300,000 bbl/day refinery and potential future expansion.

The refinery will be able to process a wide range of sour crude oils and produce high-quality clean fuels. The main products of the refinery will be gasoline, kerosene/jet fuel, and Ultra-low Sulphur Diesel, with by-products including Liquefied Petroleum Gas (LPG - C3/C4), Sulphur and Petroleum Coke.

The Project will require a private capital investment in excess of US$4.6 billion. The facility will employ up to 3,000 people during the 4-year construction phase, and approximately 750 permanent staff during the 25-year operational phase. With various potential future expansions, modifications and upgrades, the design life of 25 years is expected to be extended.

Placentia Bay is a strategic geographic location in the global sourcing and marketing of petroleum. A deepwater, ice-free bay, it has the additional advantages of an established Vessel Traffic Management System, and existing oil-related industrial infrastructure, with an existing refinery, major fabrication facilities at Marystown, an oil transshipment terminal near Arnold's Cove and an experienced, highly skilled workforce.

The Bay is also the location of other Projects and industrial development, such as the Voisey's Bay Processing plant at Long Harbour, the existing Hydromet demo plant at Argentia, an LNG terminal at grassy Point and an important location for fisheries and aquaculture industry as well as tourism, nature and ecological reserves including the world renowned Cape St. Mary's Bird sanctuary at the entrance of the Bay.

Figure 1.2 Detailed Project Layout

1.3 Project Planning

The Project will take place in four phases:

1. Pre-construction, including feasibility studies, engineering, public consultation and environmental assessment and permitting;
2. Construction, including site preparation, fabrication and construction of the refinery and marine terminal;
3. Operation and Maintenance; and
4. Decommissioning and Rehabilitation

The following sections describe the first phase.

1.3.1 Feasibility Study

In February 2006 the Proponent announced the start of a three-phase feasibility study into establishing a second crude oil refinery in Placentia Bay. Phase 1 established that the economic basis existed and that Placentia Bay is a strategic location for a new refinery. Phase 2, in May 2006, included the start of preliminary engineering and initiation of the environmental assessment process. Phase 3 confirmed the basis for proceeding with the design of the refinery.

1.3.2 Engineering and Management Plans

Engineering design to date has confirmed the process and major components of the refinery, the range of crude oils, the products and by-products, conceptual design layouts for the refinery infrastructure and associated facilities, the marine terminal including wharf, jetty and tug basin, and major technology suppliers. It has also included detailed modeling of atmospheric emissions based on the level of engineering done to date, greenhouse gas (GHG) management considerations, vessel management, oil spill prevention and emergency response preparedness, and modeling of effluent discharges and outfall design.

Engineering has also incorporated concerns and recommendations from the ongoing consultation with regulatory agencies, residents and users of Placentia Bay. For example, the jetty location and configuration has been modified in response to fishers' requests to avoid a productive cod ground; a second access road has been included to address the requests from residents and businesses on the Burin Peninsula; a high-volume interchange at the Trans-Canada Highway will be developed to reduce traffic congestion; an Air Quality Study advisory group was established; and a special fishing activity data collection program was developed with area fishers and the Fish, Food and Allied Workers (FFAW) union. A Stewardship Advisory Group on Salmon River watersheds (including Watson's Brook, Come By Chance River and North Harbour watersheds) has been spearheaded by the Proponent and is hoped to provide input in to the implementation plans for the protection of these valued ecosystem components and the projected habitat compensation strategy.

NLRC has also requested a voluntary review of the project's marine terminal design and operational planning through the TERMPOL Review Process. This provides an objective, third party review of the safety measures and planning associated with the marine facilities construction and operation.

1.3.3 Public Consultations

Consultation with the public was initiated very early in the Project and has included presentation and briefings to all area town councils, a variety of regional associations, federal and provincial government departments, colleges and high schools; a number of public open houses throughout the greater project area; and the formation of two advisory groups.

The Air Quality Study advisory group includes representation from most nearby communities and industrial neighbours. The project is also working with the FFAW (the fishers' union) regarding issues associated with an increase in vessel traffic and potential loss of fishing grounds in Placentia Bay. Working directly with the FFAW Placentia Bay Sub-Committee has greatly facilitated communication with the fishers, including introductory meetings that enabled virtually all fishers active in Placentia Bay to speak directly with the Project Proponent and the Environmental Assessment (EA) consultants.

Consultation with both provincial and federal regulatory agencies also started early in the planning stage to provide a thorough Project Registration/Project Description document, and to initiate research to address information gaps identified by key agencies as early as possible in the planning process.

1.3.4 Project Implementation

The refinery design will incorporate the highest health and safety standards in design, construction and operations. A safety management system will be implemented to continuously identify, reduce and manage safety risks. The design and construction of the facility will incorporate the Best Available Technologies Economically Achievable (BATEA) to provide a safe and robust refinery that complies with all national/provincial regulations and industry codes and standards.

NLRC is committed to limiting atmospheric emissions to as low a level as possible. NLRC has committed to install air quality monitors around the local area early in the construction phase to provide a project baseline and supply continuous monitoring of local air pollutants, determine compliance with operating permits and the gauge results of air quality modelling.

NLRC is committed to sustained voluntary efforts to minimize the Projects' greenhouse gas (GHG) emissions through the use of energy efficient process, technology and equipment in operations.

NLRC is committed to stewardship of the environment in which it seeks to operate, and will design and execute the Project in a manner that will eliminate or minimize the potential adverse effect on the environment in all phases of the Project. NLRC is committed to preventing pollution, and to continually improving the integration of environmental protection practices in all activities. NLRC will ensure that project activities are carried out in full compliance with all applicable environmental, health and safety laws and regulations, by applying the best available technologies and highest standards.

NLRC is committed to the development and implementation of a comprehensive Environmental Protection Plan (EPP), to help ensure a high level of environmental protection throughout the Project.

1.4 Environmental Assessment Process

The proposed Project is undergoing review under both the provincial and the federal environmental assessment processes.

The Department of Environment and Conservation oversees the provincial process and development of the Environmental Impact Statement. Transport Canada (TC) and Fisheries and Oceans Canada (DFO) are the Responsible Authorities (RAs) for the federal assessment, in conjunction with the Canadian Environmental Assessment Agency (CEAA), which will issue a Comprehensive Study Report (CSR).

Both levels of government contributed personnel to the provincially-chaired Assessment Committee, and provided input into the Guidelines for the assessment requirements.

1.4.1 Biophysical Assessment

This Volume covers the following topics:

- Effects assessment methodology;
- Description of the Existing Biophysical Environment, including meteorological and atmospheric conditions, air quality, marine environment, terrestrial environment, species at risk and protected areas, etc.;
- Identification of Valued Ecosystem Components (VECs);
- Evaluation of Effects on the Valued Ecosystem Components;
- Mitigation Measures;
- Evaluation of Residual Effects;
- Cumulative Effects;
- Environmental Management;
- Prevention and Emergency Response plans; and
- Environmental Monitoring and follow-up.

1.4.2 Scope of the Assessment

The approach used to develop the biophysical impact assessment followed well-established methods of environmental impact assessment used in Canada. The technical scope and content of the assessment are consistent with the recommended methods promulgated by the Canadian Environmental Assessment Agency and the Newfoundland and Labrador Department of Environment and Conservation. Both levels of government have provided the requirements and technical guidance needed by the Proponent to develop the environmental assessment (the Guidelines, June 18, 2007).

1.5 Legislation, Permits and Policies

The Project will require federal, provincial and municipal approvals and permits for various activities during construction, operation and decommissioning. Anticipated relevant legislation and associated permits required are listed in Appendix A of Volume 2. This list will be revised as detail design advances and additional project requirements are identified.

Upon project approval, a Permit Registry will be developed at an early stage of implementation to address all construction activities.

The Proponent is ultimately responsible for the preparation, submission and receipt of all required regulatory permits, approvals and certifications. The Proponent is also responsible for ensuring compliance with all applicable permits, approvals and certifications by its own employees, contractors and consultants.

2.0 EFFECTS ASSESSMENT METHODOLOGY

2.1 Introduction

The Proponent (NLRC) is required through the Provincial environmental assessment Process, pursuant to the *Environmental Protection Act*, to prepare an Environmental Impact Statement (EIS) for the proposed NL Refinery Project. The purpose of the EIS is to identify potential environmental effects associated with the Project activities, identify appropriate mitigative measures, predict the significance of residual and unmitigatable effects and determine whether or not the proposed project is likely to cause significant adverse impact on the environment, including the socio-economic or human environment.

The Project is also subject to environmental assessment that will meet the requirements of the *Canadian Environmental Assessment Act* (*CEAA*) through a Comprehensive Study report (CSR). Transport Canada (TC) is the principle Responsible Authority (RA) for the CEAA assessment. Fisheries and Oceans Canada (DFO) is also an RA for the undertaking while Environment Canada, Health Canada and Natural Resources Canada are Federal Authorities who are providing expert advice to TC and DFO on the federal environmental assessment.

The Refinery Project, being reviewed under both provincial and federal assessment processes, the methodology used in the environmental assessment of the proposed Refinery conforms to the methods and expectations of both processes.

Two general types of effects are considered in this document:

1. Effects of the environment on the Project; and
2. Effects of the Project on the environment, including the biophysical and human environments.

Effects of the environment on the project include such aspects as site selection and route planning to avoid sensitive habitat, seasonal restrictions on construction activities, desigh criteria for infrastructure and buildings to accommodate severe storms or potential changes in sea level due to global warming, climatology and physical oceanography in the biophysical assessment and aspects such as work schedules, commuting distance and procurement policies in the socio-economic assessment.

The method of effects assessment used for the Refinery Project conforms to the *Canadian Environmental Assessment Act* (CEAA) and its associated Responsible Authority's Guide the Canadian Environmental Agency Operational Policy Statement (OPS-EPO/5-2000) (CEA Agency 2000) and Proponents Guide for Environmental Assessment pursuant to the Canadian Environmental Assessment Act issued June 2006 by Transport Canada.

Cumulative effects are incorporated within the procedures in accordance with CEAA (CEA Agency 1994) as adapted from Barnes and Davey (1999) and used in recent Environmental Assessments in the Province.

2.2 Scoping

Scoping of an assessment mainly includes scoping of issues and determining the spatial and temporal extent of the assessment, selecting which components (i.e., sensitive and/or representative species or species-groups and associated habitats) of the ecosystem to assess, and which project activities to analyze. Scoping was conducted according to the following steps, not necessarily in chronological order.

- Review of relevant information on Project activities and literature on the effects of refinery operations; tankers and marine terminals; and of oil and gas activities (with emphasis on existing or recent relevant projects and previous EAs for Newfoundland and Labrador waters);
- Consultations with key groups and the public at various stages of the assessment;
- Consultations with provincial and federal agencies; and
- EIS/CSR Guidelines prepared by the Newfoundland and Labrador Department of Environment and Conservation with input from relevant government agencies such as Transport Canada (the Principle Responsible Authority, the ‘RA’, under federal CEAA legislation), Fisheries and Oceans Canada (also an RA), Environment Canada (a Federal Authority or FA), Health Canada (also an FA), the CEA Agency, other government departments, and the interested public.

2.3 Consultations

In preparation for the proposed development and the required EIS, the Proponents and their consultants met with relevant government agencies, representatives of the fishing industry and other stakeholders and interest groups as well as the general public in communities that may be affected positively or negatively by the Project. The purpose of these consultations was to describe the Project, identify any issues and concerns, and to gather additional information relevant to the EA.

At each consultation meeting, the Proponent provided maps and drawings showing information available at the time on the proposed development. Volume 5 provides details on public consultations carried out tto date. The following is a summary of government and community groups consulted Table 2.1 and Table 2.2.

Table 2.1 Government Agencies Consulted.

Level of Government	Department
Provincial Government	Environment and Conservation
	Natural Resources
	Fisheries and Aquaculture
	Transportation and Works
	Business
	Human Resources, Labour and Employment
	Education
	Innovation, Trade and Rural Development
	Women's Policy Office
	Rural Secretariat Health and Community Services
Federal Government	Canadian Environmental Assessment Agency
	Transport Canada
	Fisheries and Oceans Canada
	Environment Canada
	Atlantic Canada Opportunities Agency (ACOA)

Table 2.2 Communities and Interest Groups Consulted.

	Community/Interest Group
Project Area Communities' Council representatives	Swift Current
	North Harbour
	Garden Cove
	Goobies
	Sunnyside
	Come By Chance
	Arnold's Cove
	Southern Harbour
	Little Harbour
Study Area Communities' Council representatives	St. Lawrence
	Marystown
	Clarenville
	Isthmus Joint Council
Study Area Economic Development Associations	Arnold's Cove Chamber of Commerce
	Argentia Chamber of Commerce
	Schooner Regional Economic Development Board
	Avalon Gateway Economic Development Corporation

	Community/Interest Group
	Discovery Economic Development Board
Schools and Colleges	Tricentia Academy
	Fatima Academy
	Laval High School
	Blaketown
	College of The North Atlantic (Placentia, Marystown, Clarenville, St. John's)
	Key-in College
Associated Industry and Business	Newfoundland Transhipment Limited
	North Atlantic Refining Limited
	Icewater Seafoods Ltd.
	Peter Kiewit Sons Company
	Eastern Canada Response Corporation (ECRC)
	Bull Arm Site Corp.
Stakeholder Groups	Fish, Food and Allied Workers (FFAW)
	One Ocean
	Women in Resource Development Committee
Committees and Councils	Placentia Bay Traffic Committee
	Placentia Bay Integrated Management Planning Committee
	Regional Advisory Council on Oil Spill Response (RAC)
	Natural History Society
	"Skills Task Force"

2.3.1 Interests and Concerns

The interests and concerns raised in discussions with regulators and the public are summarized in Table 2.3. These helped guide both the engineering and the environmental planning for the project.

Table 2.3 Meetings and Discussions with Government Agencies (June 2006 – Present)

Date	Government Department	Key Points & Issues
June 7, 2006[1]	NL Department of Environment and Conservation	Rare plants (e.g. *E. pedicellatum);* Riparian buffers; Eagle monitoring- impact on nesting birds; Impacts on wetlands; Rehabilitation measures.
June 12, 2006	NL Department of Environment and Conservation and CEAA (Canadian Environmental Assessment Agency)	Both the federal and provincial environmental assessment process apply; All parties will try for a coordinated process.
June 30, 2006	NL Department of Environment and Conservation	Best Available Control Technology (BACT) required; Consider spill prevention as well as spill response preparedness; The National Framework for Petroleum Refining Emissions Reduction (CCME) is a guide; Water supply; Infilling of water bodies.
August 10, 2006	NL Department of Natural Resources	Air emissions and public health; Species at Risk.
August 10, 2006	Department of Fisheries and Oceans, Canadian Coast Guard	Vessel Traffic Management; Loss of fishing grounds, anchorages.
August 11, 2006	NL Department of Environment and Conservation, Water Resources Division	Infilling of any water bodies; Marine infilling.
August 15, 2006	Department of Fisheries and Oceans, Habitat and Environmental Assessment and Major Projects	No net loss of habitat policy will apply to both freshwater and marine.
August 16, 2006	Environment Canada	Cumulative effects (air emissions, vessel traffic, labour force availability); Refinery Emissions Reduction.
August 23, 2006	Department of Fisheries and Oceans, Habitat and Environmental Assessment and Major Projects	Effects on fish habitat; HADD and compensation neede; A strategy for habitat compensation and a detailed fish habitat

[1] These issues were highlighted in a letter from the Department of Environment and Conservation, Wildlife Division.

Date	Government Department	Key Points & Issues
		compensation plan required.
August 30, 2006	Transport Canada	TERMPOL review; Vessel traffic management; Oil spill response preparedness.
September 14, 2006	Canadian Environmental Assessment Agency (CEAA)	Project Description received and registered.
September 21, 2006	NL Department of Fisheries and Aquaculture	Alien/invasive species; Increased risk of an oil spill.
September 26, 2006	Rural Secretariat	Community capacity building; Skilled labour availability.
September 26, 2006	NL Department of Transportation	New interchange on TCH in long term plans.
September 26, 2006	NL Department of Natural Resources	Local benefits associated with project; Existing SO_2 caps.
September 28, 2006	NL Department of Innovation, Trade and Rural Development	Potential catalyst for expansion of existing small business capability.
October 4, 2006	Women's Policy Office	Specificity of positions available for women; Federal equity guidelines.
October 11, 2006	NL Department of Business	Potential for growth of service industry.
October 23, 2006	Skills Task Force	Number of people that would return to the Province if work became available; Need for apprentice positions.
November 3, 2006	Transport Canada	Clarifications re links between EA and NWPA applications.
December 4, 2006	Department of Environment and Conservation	Presentation to the Minister of DOEC describing the Project and on-going field program.
January 12, 2007	EA Committee	NLRC presentation on the Project to the EA Committee. Round table discussion with EA Committee for individual department concerns
January 16, 2006	Department of Health and Community Services	Air emissions modeling.
January 16, 2007	Department of Environment and Conservation	Air emissions modeling requirements confirmed.
February 8, 2007	Department of Environment and Conservation	Concur on a Memorandum of Agreement (MOA) for funding a Hydrometric Station and/or Real Time Water Quality Monitoring Network in Come By Chance River and Watson's Brook.
February 15, 2007	Transport Canada	TERMPOL review.

Date	Government Department	Key Points & Issues
April 11, 2007	Transport Canada	Follow up to the formal request for TERMPOL review.
May 26, 2007	Parks Canada, Terra Nova National Parks	Air quality modeling; Potential joint monitoring project using lichens.
May 31, 2007	Transport Canada/Department of Fisheries and Oceans	Update meeting – the Project Description.
July 3, 2007	Department of Fisheries and Oceans	Review freshwater and marine HADD strategy.
July 12, 2007	Transport Canada/Department of Fisheries and Oceans	Update Federal review scope and process.

2.4 Valued Ecosystem Components (VECs)

In applying environmental assessment over the years, agencies and the public have found it useful to focus the assessment of a project through identifying Valued Ecosystem Components, referred to as VECs. VECs are environmental components of concern that will be affected by the project and are of legal, scientific, ecological, cultural or economic value.

The Valued Ecosystem Component (VEC) approach was used to focus the assessment on those biophysical resources of most potential concern and value to the communities most affected by the Project and to the society at large.

By original definition (e.g., Beanlands and Duinker 1983), VECs include the following groups:

- rare or threatened species or habitats (e.g., now as defined by COSEWIC and SARA);
- species or habitats that are unique to an area, or are valued for their aesthetic properties;
- species that are harvested by people (e.g., commercial fish species); and
- species that have at least some potential to be affected by the Project.

Identification and selection of the biophysical VECs for the Refinery Project was accomplished through a series of actions including: issues scoping through regulatory and public consultation; several interactive workshops amongst Project engineering and environmental consultants and Proponent's representatives; as well as the EIS/CSR Guidelines issued by the Department of Environment and Conservation, and consideration of the many recent environmental assessments currently taking place in the province.

The *Guidelines* for the EIS/CSR for the Newfoundland and Labrador Refinery Project specifically listed the following VECs that will require detailed assessment as related to the Bio-physical Environment:

- Air Quality
- Water Resources
- Migratory Birds (including seabirds, shorebirds, waterfowl, songbirds and other land birds within the footprint of the Project, with emphasis on species at risk or species under hunting pressures)
- Fish and Fish Habitat (Freshwater and Marine species and habitat)
- Flora and Fauna Species at Risk (including rare and endangered plant species, including those listed on Schedule 1 of the federal *Species at Risk Act (SARA*), those listed by COSEWIC, and those listed by provincial *Endangered Species Act (ESA*).

In addition, the impact assessment covered in this volume include the following VEC:

- Marine Mammals, River Otters and Sea Turtles

The Socio-Economic Assessment (Volume 4) addresses the Human Health, Land Use, Historic Resources, Commercial Fisheries and Aquaculture, and other Socio-Economic VECs listed in the Guidelines (and others added by the Proponent).

The VECs are discussed at varying levels of detail depending on the potential for significant effects and/or effects on human health, wildlife and natural resources (i.e., the ecosystem's health). In some cases, individual species or groups may be used as 'representative species', 'surrogates' or 'key indicator species.'

2.4.1 Air Quality

Air quality is not truly a VEC in the original sense but rather a physical/chemical pathway leading to VECs. However, it is treated in this EIS more or less as a VEC because of its great importance relative to Project Activities (i.e., air emissions) and its role it both human and ecosystem health.

2.4.2 Water Resources

Water resources are vital to both human and ecosystem health. They are typically treated as VECs under the provincial assessment process but, similar to air quality, water quality is a physical/chemical pathway affecting biological resources and human health. This EIS discusses both water quality and quantity in both the freshwater and marine environments. The Project will use seawater and desalination to meet the Project's water needs. Also surface water runoff water collected in sedimentation ponds will also be used for freshwater make-up use (e.g. firewater, process water).

2.4.3 Migratory Birds

Placentia Bay supports some of the largest seabird colonies in the world and the area supports large numbers of migratory birds of various species and origin year-round. 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 oil on water than other VECs. This VEC is of prime concern from both a public and scientific perspective, at local, national and international scales.

2.4.4 Fish and Fish Habitat

The Fish and Fish Habitat VEC includes both the freshwater and marine environment. 'Fish habitat' is a wide-ranging concept that includes both physical and biological components. It includes coverage of fish habitat components including water quality, bathymetry, nature of the seafloor and benthos. The fish part of the VEC includes both invertebrates and fish. Discussion in the assessment will focus on commercial and SARA species. Atlantic cod, for example, is an important commercial and cultural species. The fish and fish habitat VEC is of interest from both a public and scientific perspective, at local, national and international scales.

2.4.5 Marine Mammals/River Otters and Sea Turtles

At least ten species of whales, three species of seals and river otters occur in Placentia Bay. River otters have been traditionally grouped with terrestrial mammals but in Placentia Bay, otters spend a great deal of time in the coastal marine environment and exploit coastal foods such as lobster, herring, flounder and cunner. There is a traditional trapping harvest of river otters. With the exception of the river otters, marine mammals are seasonal inhabitants of Placentia Bay, using the area as seasonal feeding grounds. The Blue Whale is considered endangered under *SARA* and the harbour porpoise is considered of 'special concern' by COSEWIC.

Leatherback sea turtles have been recorded in Placentia Bay: these turtles are listed as endangered under *SARA.*

2.4.6 Species at Risk

'Species at Risk' are those species listed by the provincial Endangered Species Act (*ESA*) and/or on Schedule 1 of the Species at Risk Act (*SARA*). This VEC is of prime concern from both a public and scientific perspective, at local, national and international scales. Species of interest to the SARA advisory committee, Committee on the Status of Endangered Wildlife in Canada (COSEWIC), are also shown.

The following tables shows lists of marine and terrestrial species at risk, which have been addressed in this volume (Table 2.4 and Table 2.5).

Table 2.4 Marine Species at Risk Considered in Placentia Bay

Species	Federal Species at Risk Act Status	Provincial Endangerd Species Act Status
Fish		
Atlantic Cod	Special concern	Not listed
Northern Wolffish	Threatened	Not listed
Spotted Wolffish	Special concern	Not listed
Atlantic Woldfish	Special concern	Not listed
Birds		
Harlequin Duck	Special concern	Vulnerable
Whales		
Blue Whale	Endangered	Not listed
North Atlantic Right Whale	Endangered	Not listed
Reptiles		
Leatherback Sea Turtle	Endangered	Not listed

Table 2.5 Terrestrial Species at Risk Considered in Placentia Bay

Species	Federal Species at Risk Act or *COSEWIC* Status	Provincial Endangered Species Act Status
Fish		
Atlantic Salmon	Endangered	Not listed
Banded Killifish	Special concern	Vulnerable
American eel	*COSEWIC special concern*	
Birds		
Barrow's Goldeneye	Special concern	Vulnerable
Red Crossbill		Endangered
Short-eared Owl	Special concern	Vulnerable
Plants		
Boreal Felt Lichen (*Eriderma pedicellatum)*	Special concern	Vulnerable

2.5 Component Studies

The EIS/CSR Guidelines for the Refinery Project specifically listed the following Component Studies which are required (where additional or new information, site surveys and/ or modeling studies have been carried out):

a) For Bio-physical Environment:

- Air Quality
- Migratory Birds (seabirds, shorebirds, waterfowl, songbirds and other land birds)
- Fish and Fish Habitat (both marine and freshwater)

b) For Socio-Economic Environment

- Historic Resources
- Socio-Economic

The Component Studies generally have the following format: (i) Rationale / Objectives; (ii) study area and boundaries; (iii) methodology; and (iv) study outputs. As requested, these component studies will also be issued as part of the EIS submission.

In addition, several background studies have been carried out in support of this assessment as described below.

2.6 Data Gaps

NLRC met with a number of regulatory agencies and conducted a thorough review of relevant existing information and data to identify the current information or data gaps that will be required to carry out adequate assessment of project effects with reasonable degree of certainties. Information gaps from lack of previous research or practices or lack of full four seasons or long-term coverage have been assessed.

In addition to work required for specified component studies, NLRC also undertook surveys for terrestrial vegetation, wetlands and lichen; otters; marine mammals, sea turtles and a special survey for Harlequin Duck over-wintering sites with the Canadian Wildlife Service. NLRC has entered into Memorandum of Understanding with the Department of Environment and Conservation to fund additional equipment as part of the joint provincial/federal hydrometric monitoring program: a water quality sensor will be added to the Come By Chance stream flow sensor already in place and an integrated flow and water quality station will be established on Watson's Brook. This will provide ongoing, near real-time data that will be available not only to the Proponent and government agencies but to the general public via website.

Data extrapolation, manipulation, and modeling predictions (numerical or stochastic) have been used to supplement or otherwise complete such data gaps. The information in the

Newfoundland Transhipment Terminal EIS on oil spill probability contours has been extrapolated to provide information for a hypothetical spill situation across the bay at the Southern Head marine terminal. Established oil spill statistics, oil properties and fate and behaviour information was used.

Site and on project specific modeling was used to provide future project air emissions, pollutants transport and prediction of its impacts on receiving environment and human health under different normal and abnormal operating conditions; modeling of effluent discharges and impacts on marine environment; statistical and extreme analyses for estimation of design parameters (e.g., 100 year design wind & wave).

In addition to the required component studies (Section 2.5), NLRC has carried out various data collection and site surveys and investigations, background studies, technical and engineering investigations and modeling studies. These were used in description of existing environment (Section 3.0 of this volume) and prediction of future conditions and project effects (Section 4.0).

2.7 Boundaries

The boundaries of the study area have been defined using CEA Agency (2003) as guidance. The scope of the assessment includes both temporal and geographic or spatial considerations. The considerations include the entire project schedule from construction through operations and decommissioning. The geographic area considered in the assessment includes not just the Refinery but the area within which environmental components could be affected.

The Affected Area is the geographic extent of a specific potential effect on a species or species group. It varies according to the timing and type of project activity in question and the sensitivities of the species. Thus, there are many affected areas or geographic extents in this EA.

2.7.1 Temporal

The temporal boundaries of the Project run from the start of construction through decommissioning. The temporal boundaries of the different Project phases include:

- Construction from 2008 to 2011.
- Operation and Maintenance from 2011 to 2036 (25 years), which could be extended as a result of continuous maintenance, re-fitting and expansions.
- Decommissioning and rehabilitation (estimated two years)

The temporal boundaries of the potential effects of accidental events (e.g., oil spills) have also been considered in the assessment. See Section 2.8.4 describing the criteria for effects evaluation, including duration.

2.7.2 Spatial

The geographic extent of a specific potential effect on a species or species group varies according to the timing and type of project activity in question and the sensitivities of the species. Thus, there are many potentially affected areas or geographic extents discussed in this EA. The following spatial boundaries were used.

Primary Project Area

The Primary or Immediate (IPA) Project Area is the physical footprint of the Project, including the access roads, the refinery complex, the marine terminal and the marine intake and outfall (Figure 1.2).

Study Area

The biophysical Study Area is all of Placentia Bay, including the Placentia Bay Vessel Traffic Management Zone and fishing 3PSc area, and extending west to Point Crewe on the Burin Peninsula and east past Cape St. Mary's to Longitude 54 ° West (Figure 2.1).

Figure 2.1 Map of Biophysical Study Area

The Study Area for the socio-economic assessment is described in Volume 4. The Study Area for air emissions and their effects as well as some of the socio-economic considerations extends to Clarenville and eastward to Conception Bay as part of the human health and employment catchment area.

2.8 Environmental Effects Assessment Procedures

The systematic assessment of the potential effects of the Project phase involved the following major steps:

1. preparation of interaction matrices (between Project activities and the environment);
2. identification and evaluation of potential effects of project activities on VECs including description of mitigation measures and residual effects;
3. preparation of residual effects summary tables; and
4. evaluation of cumulative effects.

The assessment is based on a thorough and up-to-date description and understanding of the biophysical environment. Essentially the effects assessment proceeds through the following considerations:

- Is there an interaction between the Project and the VEC?
- Is the interaction adverse?
- Is it significant?
- Is it likely?

2.8.1 Identification and Evaluation of Environmental Effects

Interaction matrices identifying all possible Project activities that could interact with any of the VECs are prepared. The matrices include times and places where interactions could occur. The interaction matrices are used only to identify potential interactions; they make no assumptions about the potential effects of the interactions. Interactions during decommissioning and rehabilitation would be similar to those for construction and a specific interaction matrix for this phase has not been prepared at this point in the Project. The evaluation of the environmental effects due to decommissioning and rehabilitation is provided in Section 6.0 of this volume.

Interactions were then evaluated for their potential to cause effects, and the various effects or factors identified in the interaction matrix were grouped into the various VECs for further assessment. In instances where the potential for an effect of an interaction was deemed impossible or extremely remote, these interactions were not considered further. In this way, the assessment could focus on key issues and the more substantive environmental effects (see subsequent assessments for each VEC).

In the biophysical assessment, an interaction was considered to be a potential effect if it could change the abundance or distribution of VECs, or change the prey species or habitats used by VECs. The potential for effect was assessed by considering:

- Outcomes of the issues coping and public consultation sessions;
- location and timing of the interaction;
- regulatory requirements on emissions or discharges, concentration limits of chemical or deleterious substances;
- consideration of the biophysical baseline information and modeling exercises;
- literature on similar interactions and associated effects;
- professional judgement and consultation with other experts (when necessary), conferences, workshops, etc.; and
- results of similar effects assessments, especially monitoring studies done in other areas.

When data were insufficient to allow certain or precise effects evaluations, predictions were made based on professional judgement. In such cases, the uncertainty is documented in the EA. For the most part, the potential effects of construction activities and refinery operations and decommissioning are reasonably well known.

2.8.2 Classifying Anticipated Environmental Effects

The concept of classifying environmental effects simply means determining whether they are negative or positive. The following includes some of the key factors that are considered for determining negative environmental effects, as per the CEA Agency guidelines (CEA Agency 1994):

- negative effects on the health of biota;
- loss of rare or endangered species;
- reductions in biological diversity;
- loss or avoidance of critical/productive habitat;
- fragmentation of habitat or interruption of movement corridors and migration routes;
- transformation of natural landscapes;
- discharge of persistent and/or toxic chemicals;
- toxicity effects on human health;
- loss of, or detrimental change in, current use of lands and resources for traditional purposes;
- foreclosure of future resource use or production; and
- negative effects on human health or well-being.

Positive effects or benefits are also identified and assessed in the EIS.

2.8.3 Mitigation

Most effects, including potentially significant ones, can be mitigated by additions to or changes in equipment, operational procedures, timing of activities, or other measures. The CEAA, Section 16d states that: " Every screening or comprehensive study of a project … shall include a consideration of … measures that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project."

Mitigation measures appropriate for each effect predicted in the matrix were identified and the effects of various Project activities (i.e. within project cumulative effects) were then evaluated assuming that appropriate mitigation measures are applied. Effects predictions were made taking into consideration both standard and project-specific mitigations and can thus be considered "residual effects." If all other mitigative measures fail, compensation becomes a form of mitigation (e.g. Fish habitat compensation strategy).

2.8.4 Application of Evaluation Criteria for Assessing Environmental Effects

Several criteria were taken into account when evaluating the nature and extent of environmental effects on a given VEC. A table is provided for each VEC, indicating the results of the effects analysis – see Section 4.0. These criteria include (CEA Agency 1994):

- magnitude;
- geographic extent;
- duration and frequency;
- reversibility; and
- ecological, social, cultural and economic context.

Table 2.6 provides definitions of CEAA criteria (definition of attributes). The CEAA criteria are further defined in a June 2006 document prepared by Transport Canada, the lead RA for the Refinery Project – Proponents' Guide for Environmental Assessment, Pursuant to the Canadian Environmental Assessment Act. These descriptions are reproduced below and were used in the assessment of the Refinery Project.

" ***Magnitude"*** refers to the predicted amount or level of disturbance to an existing condition. The magnitude of an effect is typically expressed as a measurable number or value. For example, the area of habitat lost, the level of noise anticipated, the concentration of a contaminant in water are typical measures or values. Where appropriate, these measures or values should be described in the context of existing conditions, relevant regulatory standards or other guidelines.

Geographic extent refers to the area over which the effect is likely to occur or be noticeable. The geographic extent can be described according to specific study areas (i.e., site, site vicinity/local study area, regional), or more specifically in term of distance form the site or source of disturbance.

Duration refers to the length of time the effects of a project will last. The duration of an effect can be described qualitatively as either short, moderate or long term, or by listing the project phases (i.e. construction, operations, decommissioning) during which the effect is likely to occur. More quantitative descriptions are also possible by specifying time frames (days, months, years) for the duration of the effect. One should remember that the duration of an effect might be longer than the duration of the project activities that cause it. Therefore, one should not assume that once a project activity has ceased, its effects on the environment are no longer of concern.

Frequency refers to the rate of re-occurrence of the effect and /or the phenomenon or event causing the effect. The frequency of an effect can be described qualitatively as rare, sporadic and frequent; or using more quantitative terms such as daily, weekly or number of times per year.

Permanence or ***Reversibility*** refers to the time the environment will take to recover from the initial effect after the source of the disturbance is removed or ceased. The reversibility of the effect can be either described in general terms as reversible or not reversible; or more quantitatively (e.g., less than one year or growing season, or between XX and YY years).

Ecological context refers to the sensitivity of the environment (e.g., wildlife habitat, terrestrial habitat, aquatic species) that will be affected by the project. Typical indictors for this criterion include percentage of population affected, importance of population and number of generations to recovery.'

The attributes of each of the criteria that are used in the Refinery Project as per Table 2.6. To further assist with understanding the table, the process for assigning attributes to 'magnitude' are outlined below:

Magnitude describes the nature and extent of the environmental effect for each activity.

Magnitude was defined as:

Negligible	An Interaction that may create a measurable effect on individuals but would never approach the 10 per cent value of the 'low' rating. Rating = 0.
Low	Affects >0 to 10 percent of individuals in the affected area (i.e., geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 1.
Medium or *Moderate*	Affects >10 to 25 percent of individuals in the affected area (i.e., geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 2.
High	Affects more than 25 percent of individuals in the affected area (i.e., geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 3.

Definitions of magnitude used in this EA have been used previously in numerous oil-related environmental assessments under CEAA during the last 15 years. These include assessments of exploratory drilling (Thomson et al. 2000; LGL 2002, 2003, 2005a,b, 2006a,b), development drilling (Petro-Canada 1996a,b; Husky 2000, 2001a), and seismic surveying (LGL 2005c, Moulton et al. 2006a; Buchanan et al. 2004a; Moulton et al. 2005b; Buchanan et al. 2004b; Christian et al. 2005).

Table 2.7 provides a summary of the ratings used in assessing each of the attributes listed in Table 2.6.

Table 2.6 Definitions of Attributes and Ratings Used in the Effects Assessment Process

Attribute	Definition
Direction	describes the ultimate long-term trend of the effect (*adverse* or negative or *positive*)
Magnitude	describes the severity or intensity of the effect; typical measurements of magnitude indicate gains or losses in features or changes in conditions.
Geographic extent	describes the area over which the particular effect will occur and is similar to the spatial boundaries of the assessment
Duration	refers to how long an effect will occur and is closely related to the project phase or activity that could cause the effect
Frequency	is associated with duration and refers to the number of occurrences that can be expected during each phase of the project
Reversibility	is the ability of the community (i.e., economy, society and culture) to return to conditions that existed prior to the adverse project effect. If project effects are positive, this attribute is not applicable.
Level of Confidence	enables the analyst to assign a level of confidence to the prediction based on an understanding of the limitations of the prediction exercise
Certainty	enables the analyst to assign a level of probability that the effects will occur
Mitigation or Enhancement Success	enables the analyst to determine how well mitigation contributes to lessening of adverse effects or how well enhancement measures contribute to positive effects
Significance	An overall measure of the effect on the receptor.

The assessment process itself involved use of:

- Quantitative analysis of indicator variables;
- Informed source opinions obtained by interviews with officials, public service providers and practitioners;
- Advice and input from potentially affected groups and individuals through the public and stakeholder consultation program;
- Relevant literature; and

- Professional judgment based on the training and experience of the analysts.

For the most part, and unless otherwise indicated, within the Project cumulative effects are fully integrated within this assessment.

In the assessment, a table is developed for each VEC, indicating the results of the effects analysis. Effects predictions for accidental events are also provided.

The effects attributes noted above were used to describe the residual effects that could occur as a result of Project interactions with the VECs. The term ‘residual’ indicates attention is given to assessing the effect after implementation of specified mitigation and/or enhancement measures.

Careful assessment of residual effects is critical to the determination of their significance, especially in the absence of threshold values with respect to bio-physical impacts specified in standards, legislation or regulations.

Table 2.7 presents assessment ratings for each of the effects attributes used in the Newfoundland and Labrador Refinery assessment. In addition, definitions are provided for terms employed in describing mitigation success and significance. In the following sections, the suggested level of significance is noted in connection with each residual effect.

Table 2.7 Effects Ratings Used for Assessing the Bio-physical Environmental Effects

Direction		**Definition / Rating**	
Adverse		Effect is worsening or is not desirable. (-)	
Neutral		There is no effect. (zero)	
Positive		Effect is improving or is desirable. (+)	
Magnitude /Rating			
Negligible	0	Does not have a measurable effect on the VEC.	
Low	1	Has a measurable effect on VEC but is of short-term duration or extent.	
Medium	2	Has a measurable effect on VEC but is of medium duration or extent.	
High	3	Has a measurable and sustained effect on VEC.	
Spatial/Geographic Extent Rating			
1		< 1 km^2	
2		1-10 km^2	
3		11-100 km^2	
4		101-1000 km^2	
5		1001-10,000 km^2	
6		>10,000 km^2	
Duration / Rating			
1		< 1 month	very short term
2		1 – 12 months	short term
3		13 – 36 months	medium term
4		37 – 72 months	medium to long term

Direction	Definition / Rating	
5	> 72 months	long term
Frequency		
1	< 11 events/y	
2	11-50 events/yr	
3	51-100 events/yr	
4	101-200 events/yr	
5	> 200 events/yr	
6	Continuous	
Reversibility	**(refers to population)**	
R = Reversible	VEC is capable of returning to an equal, or improved, condition once the disturbance has ended.	
I = Irreversible	VEC is not capable of returning to an equal, or improved, condition once the disturbance has ended.	
Ecological Context		
1	Relatively pristine area or area not adversely affected by human activity	
2	Evidence of existing adverse effects	
Level of Confidence		
Low	Information provided considered as having a low probability of being absolutely accurate.	
Medium	Information provided considered as having a medium probability of being accurate.	
High	Information provided should be considered as having a high probability of being accurate.	
Certainty		
Low	The effect can be considered to have a low probability of occurring.	
Medium	The effect can be considered to have a medium probability of occurring.	
High	The effect can be considered to have a high probability of occurring.	
Significance *		
Negligible or none	No effects.	
Minor	Low-level effects are distinguishable. These are usually limited to the short-term and are geographically circumscribed but are not considered disruptive even if widespread and sustained.	
Moderate	Effects are clearly distinguishable and result in elevated awareness or concern among stakeholders or materially affect the well-being of defined populations/communities. Usually are short- to medium- term in duration and are amenable to management if they occur over the longer term.	
High	Effects are highly distinguishable and result in strong concern or support among stakeholders or result in substantive changes in the well-being of defined populations/communities.	

Direction	Definition / Rating
* The CEAA definition of Significance is either *Significant* (S) or *Insignificant* (IS). In this assessment: "Negligible" and "Minor" will be rated as Insignificant, "Moderate" may be rated as Insignificant or Significant depending on the duration and extent, etc. "High" will be rated as "Significant"	

2.8.5 Cumulative Effects

The methodology for Cumulative Impact Assessment is further described in Section 5.0.

Projects and activities considered in the cumulative effects assessment were identified in the guidelines and included:

- Existing oil refinery at Come By Chance;
- Existing oil transshipment terminal at Whiffen Head, Arnold's Cove (NTL);
- Proposed LNG Transshipment Terminal at Grassy Point;
- Proposed nickel processing plant at Long Harbour;

2.8.6 Residual Environmental Effects

Upon completion of the evaluation of environmental effects, the residual environmental effects (effects after project-specific mitigation measures are imposed) are assigned a rating of significance for the following:

- each project activity or accident scenario;
- cumulative effects of project activities within the Project; and

These ratings are presented in summary tables of residual environmental effects.

The analysis and prediction of the significance of environmental effects encompasses the following:

- determination of the significance of residual environmental effects;
- establishment of the level of confidence for prediction; and
- evaluation of the scientific certainty and probability of occurrence of the residual impact prediction.

Ratings for level of confidence, probability of occurrence, and determination of scientific certainty associated with each prediction are presented in the tables of residual environmental effects. The guidelines used to assess these ratings are discussed in detail in the sections below.

2.8.7 Significance Rating

Significant environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable.

An effect can be considered significant, not significant (insignificant), negative (adverse) or positive (benefits).

Level of Confidence

The significance of the residual environmental effects is based on a review of relevant literature, consultation with experts, and professional judgment. In some instances, making predictions of potential residual environmental effects is difficult due to the limitations of available data (for example, technical boundaries). Ratings are therefore provided to indicate, qualitatively, the level of confidence for each prediction.

Determination of Whether Predicted Environmental Effects are Likely to Occur

As per CEAA guidelines, the following criteria for the evaluation of the likelihood of predicted significant effects are used.

- probability of occurrence; and
- scientific certainty.

Final Determination of Significance

The final determination of significance of environmental effects rests with the Department of Environment and Conservation in collaboration with the Assessment Committee and the Responsible Authority.

3.0 EXISTING BIOPHYSICAL ENVIRONMENT

3.1 Meteorology and Climate

3.1.1 Introduction

Newfoundland experiences a maritime climate as a result of coastal and offshore waters having a moderating effect on temperature. The south coast of Newfoundland, influenced by southwesterly winds, is considered to be the area of Newfoundland showing the most marked maritime influence (Banfield 1993, *in* Catto et al. 2003). Ocean currents and prevailing wind conditions during the winter provide warmer temperatures than most other areas of Newfoundland, whereas southwesterly winds during the summer months produce cooler conditions than continental climates. In general, Newfoundland's south coast has short, cool and wet summers, and winters are moderately mild and wet. Furthermore, a maritime climate tends to be fairly humid, resulting in reduced visibilities and low cloud heights, and receives significant amounts of precipitation (LGL Limited, 2007). Coupled with the fact that the south coast lies directly in the path of Atlantic storms that pass over Newfoundland, the region receives the highest yearly precipitation of any region in Newfoundland and is the wettest in Atlantic Canada (Environment Canada, 2007).

Wind patterns vary seasonally and local topographical effects are extremely significant in many embayments along the south coast. Westerly and southwesterly winds are more prevalent throughout the year, although winds may originate from any direction. The southwesterly winds generally bring warm, moist air to the region from the warmer ocean surface waters in the south. Along the exposed shorelines, the extensive fetch in conjunction with southwesterly winds may develop intense waves (Catto, Scruton, and Ollerhead 2003).

Reduced visibility is most common during the spring and summer, when fog forms as relatively warm and moist air is cooled by the cool surface waters along the coast. Coastal fog is often thinned or eliminated by offshore winds and increased temperatures over land. The prevalence of fog is greatest in those areas most influenced by southwest winds, particularly open coastline (Catto, Scruton, and Ollerhead 2003).

This section gives detailed information on local meteorology and climatology within Placentia Bay. Descriptions and graphical depictions of air temperature, wind conditions, precipitation, vessel icing and visibility are provided.

3.1.2 Data Sources

The primary information sources are the National Climate Data and Information Archive, operated and maintained by Environment Canada, which contains data from climate and weather stations surround Placentia Bay. Data from climate stations at Arnold's Cove (1971-

1993), Come By Chance (1971-94), and Argentia (1976-1996) is of particular importance because of its proximity to the project location. Cloud and visibility data are only available for stations that have had a manned observation station in the past. However, there are no weather stations situated around Placentia Bay that currently operate a manned observing program. Therefore, historic climatic data for outer Placentia Bay has been extracted from the MAST database (a marine and atmospheric database, created by Atmospheric Environment Services (AES) of Environment Canada).

3.1.3 Air Temperature

Monthly air temperatures for the study area and vicinity have been obtained from the Environment Canada Climate stations. Mean annual temperature statistics for Arnolds Cove and Come By Chance were identified as being representative of the project area. Marine surface air temperatures were obtained from the SmartBay Buoy Program (2006-2007) located at the mouth of Placentia Bay.

Air temperature data obtained from the Come By Chance climatic station covers a time period from 1968 – 1993 and is presented in Figure 3.1. The average air temperature at Come By Chance has an extreme daily max-min range from –9.7 °C to 18.9 °C. According to the compiled statistics, February is the coldest month with a daily average temperature of –5.4 °C and the warmest month is August, which has an average temperature of 15.3 °C.

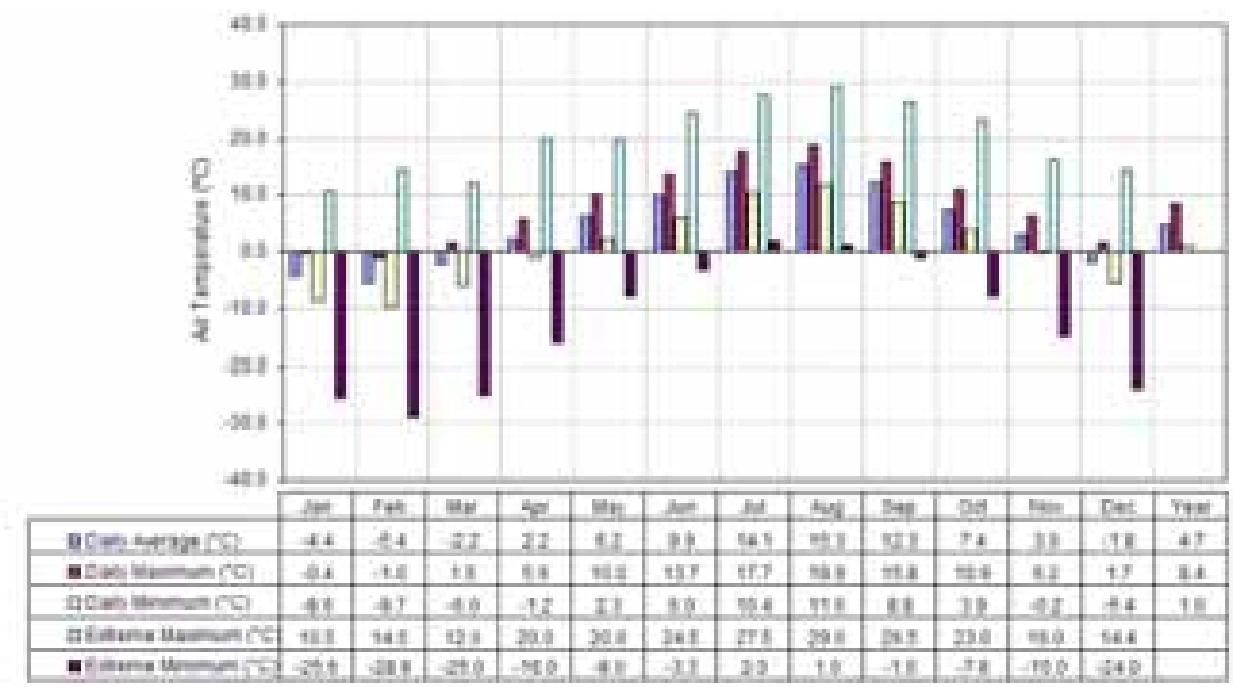


Figure 3.1 Come By Chance Air Temperature (1968-1993).

Monthly air temperature data obtained from the Arnold's Cove climatic station cover a time period from 1971 – 1994 and is presented in Figure 3.2. Both stations exhibit moderate comparable temperatures. The air temperature at Arnold's Cove has a daily max-min range of –8.9 °C to 18.6 °C. Figure 3.2 also shows that February is the coldest month with a daily average temperature of –5.1 °C and the warmest month is August, with an average temperature 15.3 °C.

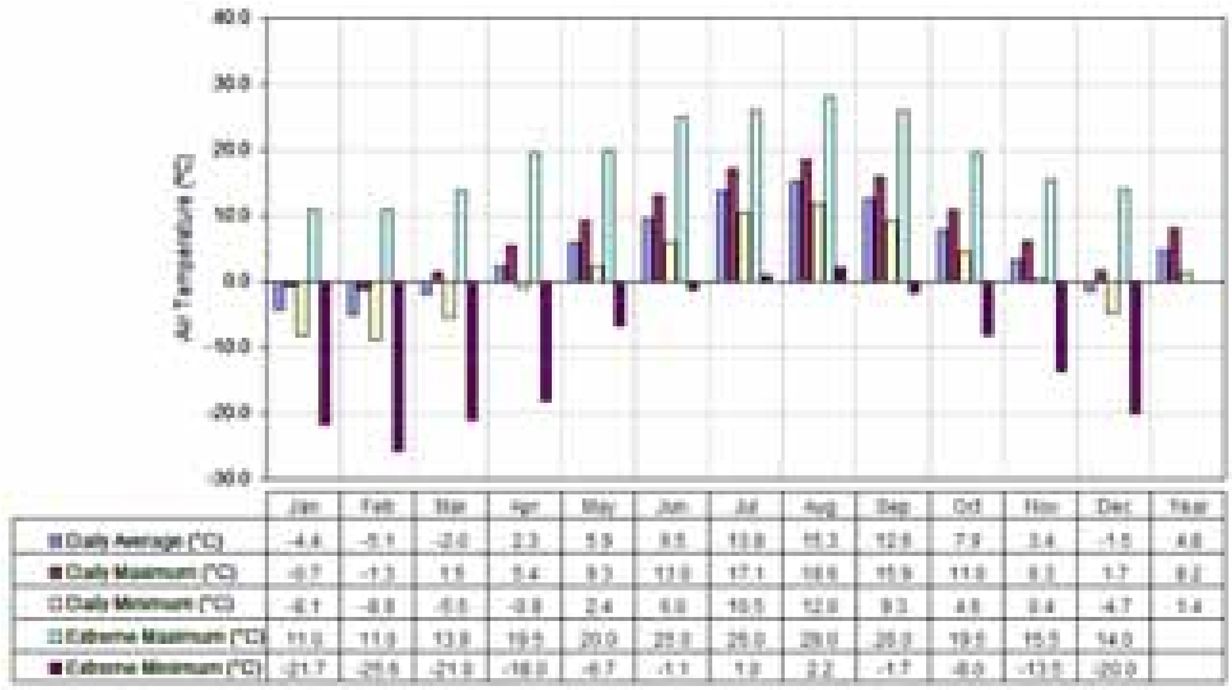
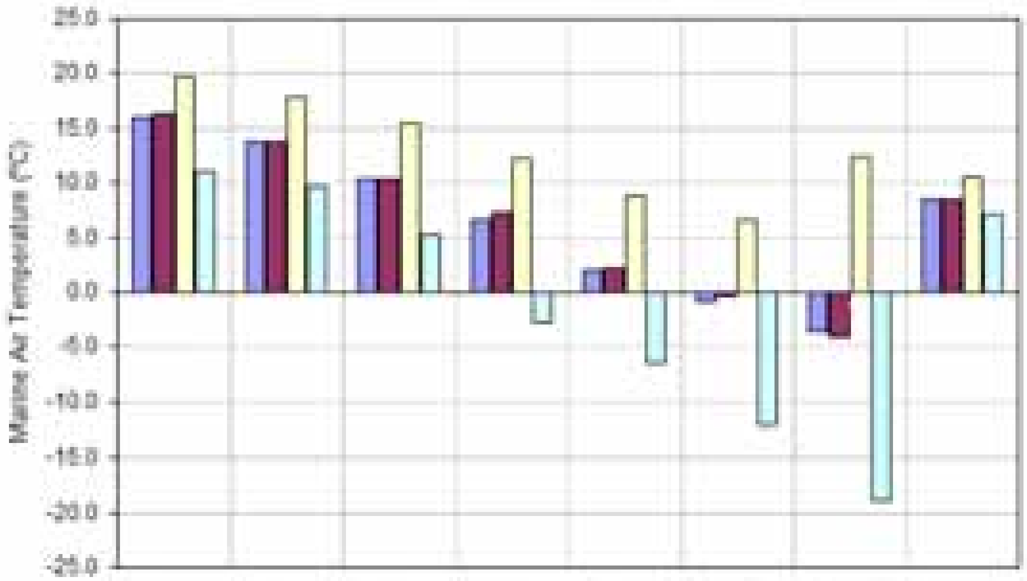


Figure 3.2 Arnolds Cove Air Temperature (1971-1994).

Monthly air temperatures obtained from SmartBay Buoy 1, cover a time period from August 2006 to June 2007 and are presented in Figure 3.3. The air temperature at the mouth of the bay has a max-min range from –18.9 °C to 19.8 °C. Monthly mean temperature range from – 0.9 °C to 15.9.3 °C.



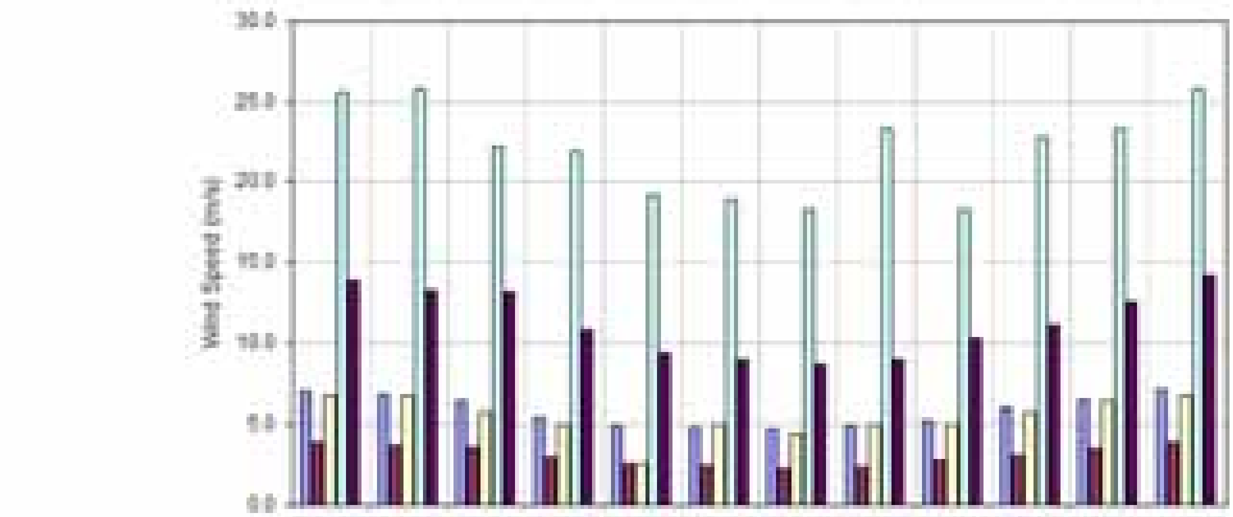
	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Jun-07
Mean (°C)	15.9	13.8	10.3	6.7	2.1	-0.9	-3.6	8.5
Median (°C)	16.4	13.8	10.3	7.3	2.2	-0.4	-4.0	8.5
Maximum (°C)	19.8	17.9	15.4	12.3	8.8	6.6	12.4	10.5
Minimum (°C)	11.1	9.7	5.3	-2.8	-6.5	-12.0	-18.9	7.1
# of Data	1008	2145	2221	2110	1778	1378	1261	843

Figure 3.3 Monthly Statistics of Marine Air Temperature

3.1.4 Wind

The wind climatology at the Arnold's Cove station is considered as representative of the study site. The wind statistics at the Argentia site are also considered relevant to this study. Argentia is largely exposed to Placentia Bay to the west and south-southwest, and its wind conditions can be used to provide a conservative picture of the most extreme winds likely to be encountered at the head of Placentia Bay.

The Atmospheric Environment Service (AES) maintained a weather station at Arnold's Cove. The wind statistics for Arnold's Cove station are calculated based on the measurements of hourly wind speeds and directions at this station from July 1971 to July 1993. The statistics are shown in Figure 3.4. The monthly mean hourly wind speeds range from 4.7 m/s to 7.1 m/s. The lowest monthly maximum wind speed is 18.3 m/s and the highest monthly maximum is 25.8 m/s. The upper 95 per cent wind speed limits ranges from 8.6 m/s to 14.2 m/s.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	7.0	6.8	6.4	5.4	4.9	4.8	4.7	4.9	5.2	6.0	6.5	7.1
Standard Deviation	3.9	3.7	3.6	3.0	2.6	2.5	2.3	2.4	2.8	3.1	3.5	3.9
Median	6.7	6.7	5.6	5.0	2.6	5.0	4.4	5.0	5.0	5.6	6.4	6.7
Maximum	25.6	25.8	22.2	21.8	19.2	18.9	18.3	23.3	18.3	22.8	23.3	25.8
Upper 95% Limit	13.9	13.3	13.1	10.8	9.4	8.9	8.6	8.9	10.3	11.1	12.5	14.2
Most Frequent Direction	SW	NW SW	SW	SW	SW	SW	SW	SW	SW	SW	SW NW	SW NW
Number of Observations	13255	11759	14040	14151	11886	13581	13414	13080	12387	12440	12917	13049

Figure 3.4 Wind Statistics for Arnolds Cove (1971-1993).

The Argentia weather station was established in 1976. The wind statistics for Argentia are calculated in the same manner as that used for Arnold's Cove, based on the measurements of hourly wind speeds and directions at this station from May 1976 to May 1996. The statistics are shown in Figure 3.5. The monthly mean hourly wind speeds range from 5.6 m/s to 8.5 m/s. The lowest monthly maximum wind speed is 18.1 m/s and the highest monthly maximum is 30.0 m/s. The upper 95 per cent wind speed limits ranges from 10 m/s to 16 m/s.

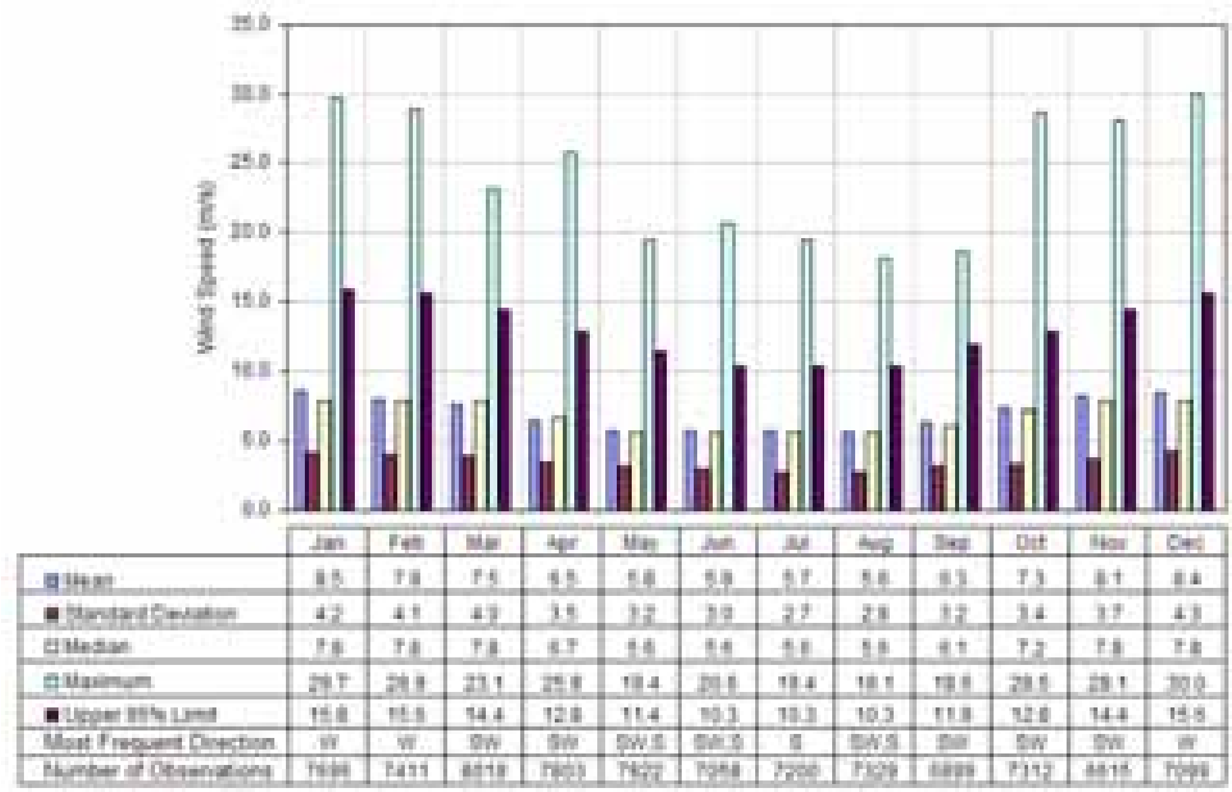


Figure 3.5 Wind Statistics for Argentia (1976-1996)

The annual wind rose plot the for Arnold's Cove station is shown in Figure 3.6. The most frequent wind directions at Arnold's Cove are from the southwest in most months. On an annual basis, approximately 28 per cent of winds are from southwest, 13 per cent to 15 per cent are from the northeast, northwest and south, and 5 per cent to 9 per cent are from the east, north, west, and southeast.

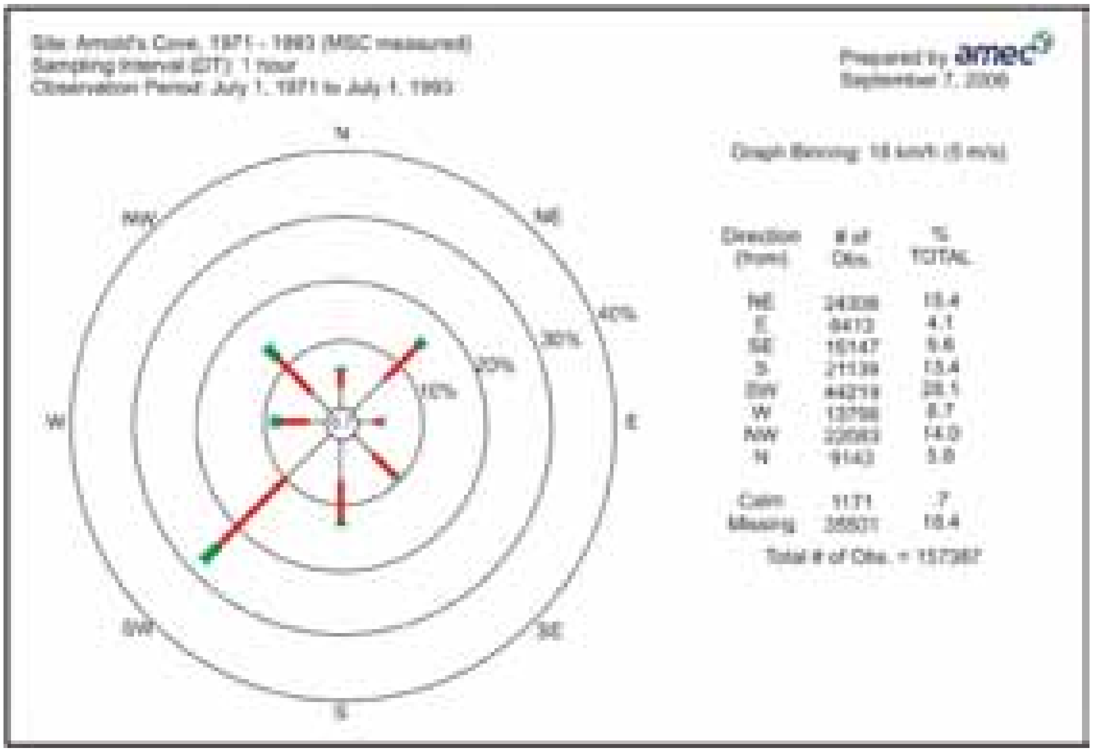
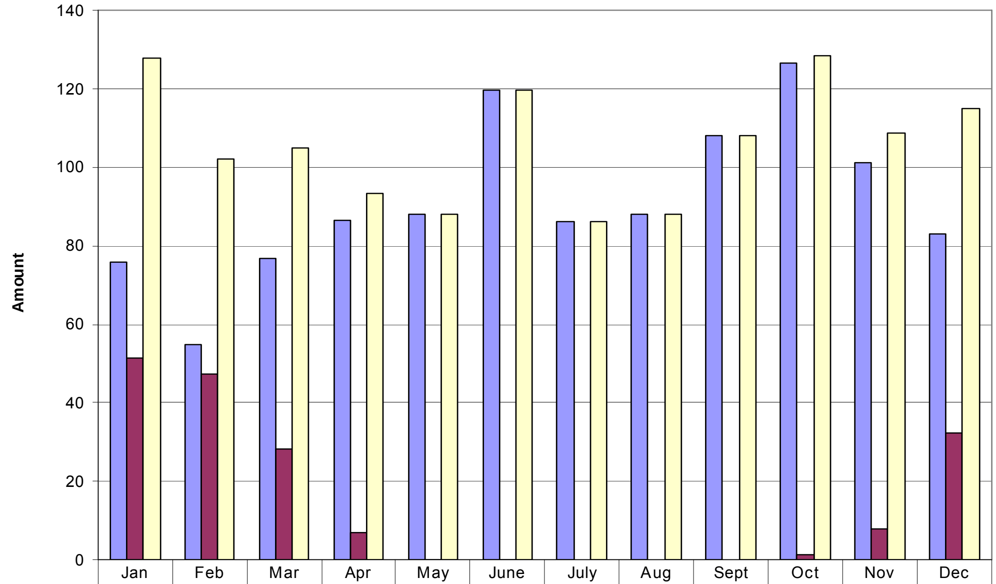


Figure 3.6 Annual Wind Speed and Direction at Arnolds Cove

3.1.5 Precipitation

The south coast of Newfoundland lies directly in the path of Atlantic Storms, giving it the highest yearly precipitation of any region of Newfoundland. Monthly precipitation for the study area and vicinity has been obtained from the Environment Canada Climate stations. Mean annual precipitation statistics for Arnolds Cove and Come By Chance were identified as being representative of the project area due to the stations' proximity to the project site.

The monthly precipitation obtained from the Come By Chance climatic station covers a time period from 1968 – 1993, and are presented in Figure 3.7. The mean annual total of precipitation in the form of rain at the Come By Chance station is 1093.9 mm, where as the mean annual snowfall amount is 175.6 cm. Mean monthly statistics indicate that the heaviest rainfall amounts occur in October (126.6 mm) and the least in February (54.9 mm). Statistics for the 25 years shows that January (51.4 cm) usually receives the most snowfall and July to September receives no snow. October (128.4 mm) and January (127.7 mm) usually receive the most total precipitation.

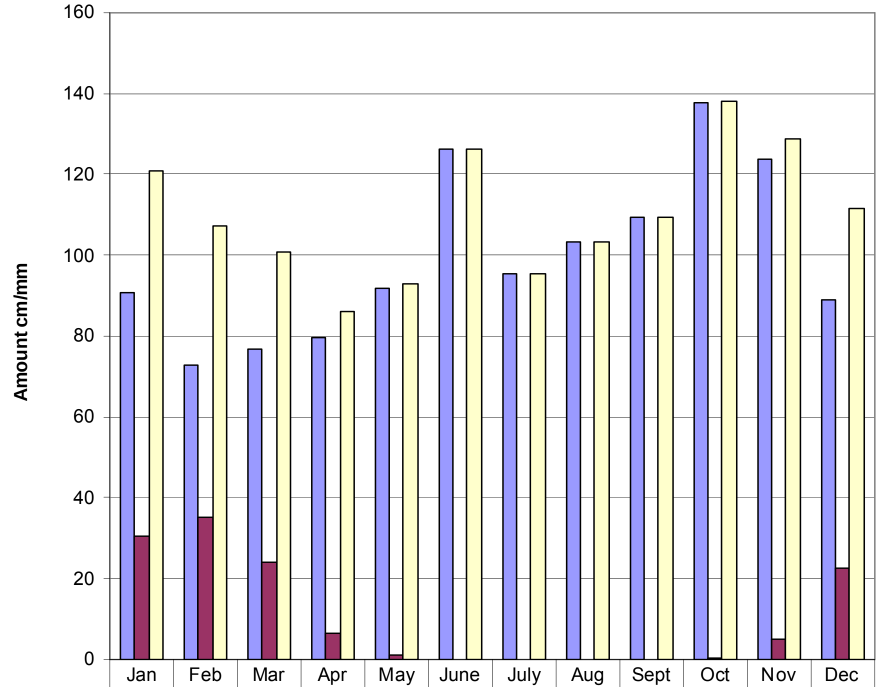


	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Average Rainfall (mm)	75.9	54.9	76.9	86.3	87.9	119.5	86.1	88	107.9	126.6	101	82.9
Average Snowfall (cm)	51.4	47.3	28.2	6.9	0.1	0.2	0	0	0	1.4	7.8	32.3
Total Precipitation (mm)	127.7	102.2	104.9	93.2	88	119.7	86.1	88	107.9	128.4	108.8	115

Month

Figure 3.7 Precipitation, Come By Chance (1968-1993)

The monthly precipitation data obtained from the Arnold's Cove climatic station covers a time period from 1968 – 1994 and is presented in Figure 3.8. The mean annual total of precipitation in the form of rain at the Come By Chance station is 1195.5 mm, where as the mean annual snowfall amount is 124.5 cm. Mean monthly statistics indicate that the heaviest rainfall amounts occur in October (137.8 mm) and the least in February (72.8). More snow falls in February (35 cm) than in any other month, and June through September receives no snow. However, October (138 mm) receives the highest total precipitation and April (86 mm) has the lowest total precipitation.



	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Average Rainfall (mm)	90.6	72.8	76.6	79.4	91.8	126.2	95.2	103.2	109.2	137.8	123.7	88.9
Average Snowfall (cm)	30.5	35	23.9	6.5	0.9	0	0	0	0	0.2	4.9	22.5
Total Precipitation (mm)	120.7	107.2	100.6	86	92.7	126.2	95.2	103.2	109.2	138	128.6	111.5

Month

Figure 3.8 Precipitation, Arnolds Cove (1971-1994).

As shown in Table 3.1, both stations exhibit comparable annual precipitation – 1093.9 mm of rain at Come By Chance and 1195.5 mm of rain at Arnold's Cove, 175.6 cm of snowfall at Come By Chance and 124.5 cm of snow at Arnold's Cove. The annual rainfall is 101.6 mm greater at Arnold's Cove, while the annual snowfall is about 51.1 cm greater at Come By Chance.

Table 3.1 Comparison of Annual Precipitation at Arnold's Cove and Come By Chance.

Precipitation	Come By Chance	Arnold's Cove	Difference
Average Rainfall	1093.9 mm	1195.5 mm	101.6 mm
Average Snowfall	175.6 cm	124.5 cm	51.1 cm
Total Precipitation	1269.9 mm	1319 mm	49.1

Freezing precipitation occurs when rain or drizzle enters negative air temperatures near the surface and is super-cooled, so that the droplets freeze upon impact with a surface. The percentage frequency distribution of freezing precipitation is given in Figure 3.9. Freezing precipitation normally occurs from November to May. The highest percentage (3.1 per cent) of freezing precipitation occurs in March.

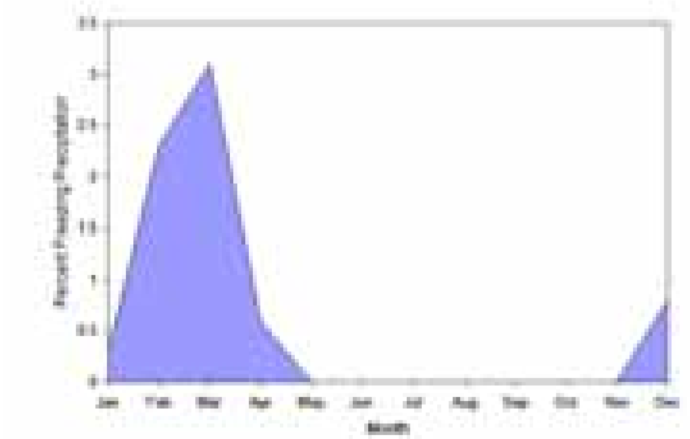


Figure 3.9 Monthly Percentage Frequency Distribution of Freezing Precipitation

3.1.6 Sea Spray Vessel Icing

Freezing spray from low temperatures, strong winds, and large waves can be a potential marine hazard. Episodes of sea spray vessel icing normally begin in Placentia Bay during December and cease in April. Periods of extreme icing normally occur in February with a frequency of 3 per cent and March with a frequency of 1.1 per cent (Figure 3.10). Light icing is more common in January, February and March with frequencies of 31.6 per cent, 29.9 per cent and 35.5 per cent respectively.

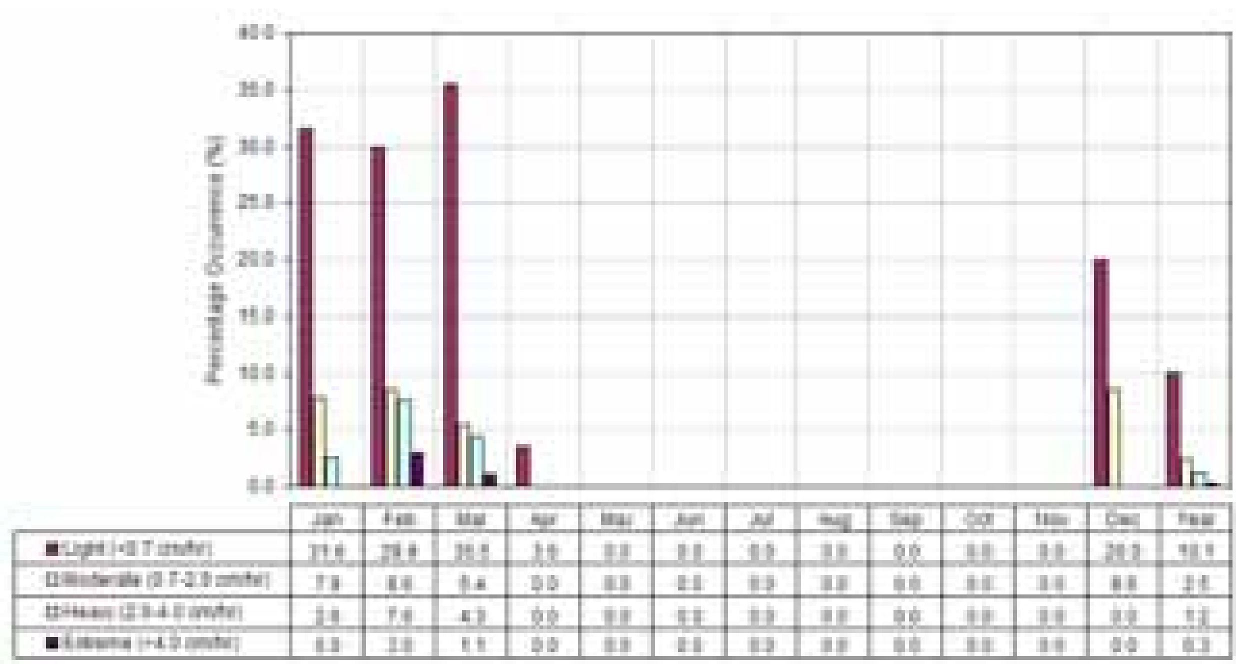


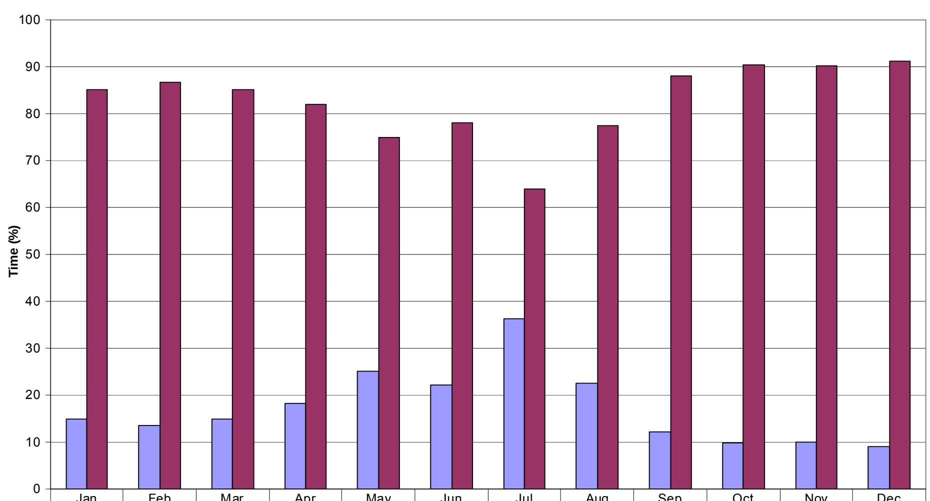
Figure 3.10 Percentage of Occurrence of Sea Spray Vessel Icing.

3.1.7 Visibility

The World Meteorology Organization (WMO) defines meteorology visibility as the greatest distance at which a black object of suitable dimensions located near the ground can be seen and recognized when observed against a scattering background of fog, sky etc. Simply put visibility refers to the greatest distance under given weather conditions to which it is possible to see/navigate without instrumental assistance.

The frequency of the fog in Placentia Bay is often associated with southwesterly winds. Sea surface temperatures south of Newfoundland are generally warmer then those in Placentia Bay. As parcels of moist, warm air are transported into the bay by southwest winds the bay's cold surfaces temperatures cool them. As these warm air parcels cool, their ability to hold moisture decreases and moisture condenses to form fog. (Catto, Scruton and Ollerhead, 2003). Reduced visibility due to fog and low ceiling is common at the head of Placentia Bay from April to the end of August. During winter months, prevailing winds are generally from the west and the air mass tends to be drier. This results in a marked decrease in the amount of fog within the bay. However, during the winter months, snow and blowing snow account for the majority of poor visibility (LGL 2007).

Good shipping weather is defined as visibility greater than 2 nautical miles (nm) and wind less than 25 knots. Figure 3.11 shows the monthly percentage of visibility greater than 2.2 nm and visibility less than 2.2 nm obtained from the MAST dataset. This data set accounts for all conditions that may affect visibility including fog, rain, blowing snow, and ceiling heights. Visibility less than 2.2 nm is more frequent in July, May and August, where as December has the highest frequency of visibility greater than 2.2 nm.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Visibility <2.2 nm	14.9	13.4	14.9	18.2	25.1	22.1	36.2	22.6	12.1	9.7	9.9	8.9
Visibility >2.2 nm	85.1	86.6	85.1	81.8	74.9	77.9	63.8	77.4	87.9	90.3	90.1	91.1

Figure 3.11 Percentage Frequency of Visibility in Nautical Miles (1886-1989).

Figure 3.12 shows the monthly percentage of good shipping weather for Placentia Bay. Data was obtained for the MAST dataset and considers all conditions that affect visibility as well as wind less than 25 knots. The graph shows that January and July has the lowest percent of good shipping weather, and the highest percentage of good shipping weather occurs in September.

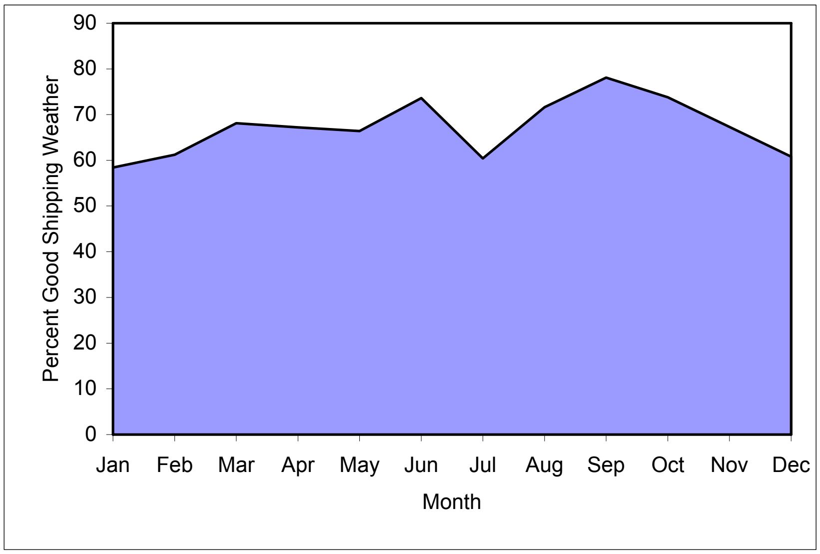


Figure 3.12 Percent good Shipping Weather (1886-1989).

3.2 Air Quality

Air quality is defined in terms of the presence of noxious gases, such as sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NO_2), as well as suspended particulates, volatile organic compounds (VOC) and ground-level ozone (O_3). These can take part in further chemical reactions once they are in the atmosphere, forming smog and acid rain. Formed, directly or indirectly, as by-products of industrial activities and the burning of fossil fuels, these constituents of pollution have the potential to affect environmental and human health.

3.2.1 Precursor Substances

In terms of air quality, precursor substances are those contaminants that combine in the atmosphere to form substances of concern such as ozone, secondary particulate matter and acid rain. This section describes precursor substances and common atmospheric-contaminant interactions.

Nitrogen Oxides (NO_X)

Includes both nitric oxide (NO) and nitrogen dioxide (NO_X). NO_X is produced in all combustion processes and is formed from the nitrogen in both the air and in fuel. NO_X plays an important role in the formation of ground-level ozone, can react with other contaminants such as ammonia to form secondary particulate matter, and contribute to the formation of acid rain. Natural sources of NO_X include lightning and the aerobic activity of soil bacteria. These natural sources, however, are small compared to emissions caused by human activity.

Sulphur Oxides (SOx)

Includes Sulphur dioxide (SO_2) Sulphur trioxide (SO_3), and Sulphate (SO_4) forms. SO_2 is a non-flammable, non-explosive, colorless gas which is produced during the combustion of fossil fuels that contain sulphur. It can be chemically transformed into acidic pollutants such as sulphuric acid and sulphates (sulphates are a major component of fine particles). The main sources of airborne SO_2 are coal-fired power generating stations and non-ferrous ore smelters. Like NO_X, SO_X are a major precursor to the formation of secondary particulate matter and are an important contributor to acid rain.

Carbon Monoxide – CO

Carbon monoxide is a colorless, odorless, tasteless, non-corrosive, highly poisonous gas of about the same density as air. It is the product of the incomplete combustion of carbon-containing compounds, notably in internal-combustion engines.

Volatile Organic Compounds – VOC

A loosely defined group of compounds containing at least one carbon atom that are volatile (evaporate readily) and organic in origin. They are substances that can photochemically react in the atmosphere. In addition, VOC's are precursors to the formation of secondary particulate matter and ground-level ozone. VOC's are emitted through combustion processes and from the evaporation of materials with volatile organic content, such as petroleum products, paints and solvents, and from naturally occurring sources.

Suspended Particulates

Refers to microscopic bits of solid and liquid that remain suspended in the air for some time. Direct particulate matter (PM) has numerous sources, principally from fossil fuel combustion by industrial and non-industrial sources, from the transportation sector, and from forest fires and wood-burning stoves. Indirect or secondary formation of PM results when particulates are formed by chemical and physical reactions of precursor substances (NO_X, SO_X, VOC and ammonia).

Ground-level Ozone – O_3

Ground-level ozone is a component of smog and has been linked to both human health and environmental effects. Elevated levels of ground-level ozone develop most readily under conditions of warm ambient air and sunlight as a result or reactions between precursor contaminants such as VOC's and nitrogen oxides.

Acid Deposition

Acid deposition is a general term that includes more than simply acid rain. Acid deposition is primarily the result of emissions of sulphur dioxide and nitrogen oxides that can be transformed into dry or moist secondary pollutants such as sulphuric acid (H_2SO_4), ammonium nitrate (NH_4NO_3) and nitric acid (HNO_3) as they are transported in the atmosphere over distances of hundreds to thousands of kilometres.

Acidic particles and vapours are deposited in two processes - wet and dry deposition. Wet deposition is acid rain, the process by which acids with a pH normally below 5.6 are removed from the atmosphere in rain, snow, sleet or hail. Dry deposition takes place when particles such as fly ash, sulphates, nitrates, and gases (such as SO_2 and NO_X), are deposited on, or absorbed onto, surfaces. The gases can then be converted into acids when they contact water.

Damage caused by acid deposition affects lakes, rivers, forest, soils, fish and wildlife populations and buildings. Prior to falling to the earth, acid-causing emissions (SO_2 and NO_X gases and the related acid particles) contribute to visibility degradation and impact public health. Acid deposition is a problem in eastern Canada because many of the waters (streams, rivers, ponds, lakes) and soils in this region lack natural alkalinity, such as a lime base, and therefore cannot neutralize acid naturally. The effects of acid rain on freshwater quality are described in Section 3.4.3.

Greenhouse Gases

Greenhouse gases (GHG) are components of the atmosphere that contribute to the greenhouse effect. Some greenhouse gases occur naturally in the atmosphere, while others result from human activities such as burning of fossil fuels. Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide and ozone. The seven sources of CO_2 from fossil fuel combustion are (with percentage contributions for 2000-2004) (Raupach, M.R. et al., 2007):

1. Solid fuels (e.g. coal): 35 per cent
2. Liquid fuels (e.g. gasoline): 36 per cent
3. Gaseous fuels (e.g. natural gas): 20 per cent
4. Flaring gas industrially and at wells: <1 per cent
5. Cement production: 3 per cent
6. Non-fuel hydrocarbons: <1 per cent

3.2.2 Existing Conditions

Newfoundland's ambient air quality is monitored by Environment Canada's Meteorological Service in conjunction with the Government of Newfoundland and Labrador as part of the Atlantic Region Air Monitoring program. Seven air quality monitoring stations throughout the province monitor pollutant concentrations of some or all of the six most common air pollutants including sulphur dioxide (SO_2), ground-level ozone (O_3), nitrogen dioxide (NO_2), total reduced sulphur (TRS), carbon monoxide (CO) and fine particulate matter ($PM_{2.5}$). Furthermore, the Cormack station monitors mercury (Hg) levels and stations in Bay D'Espoir and Goose Bay monitor acid rain. The stations location and the pollutants monitored at each site is shown in Table 3.2.

Table 3.2 Air Quality Monitoring Stations in Newfoundland and Labrador

Site Location	Pollutants Monitored	Approximate Distance from Project Site
Mount Pearl	O_3, CO, $PM_{2.5}$, NO_2, SO_2	90 km east
St. John's	O_3, CO, $PM_{2.5}$, NO_2, VOCs, SO_2	100 km east
Bay D'Espoir	Acid Rain	125 km west
Grandfalls-Windsor	O_3, $PM_{2.5}$	170 km northwest
Cormack	Hg	300 km northwest
Cornerbrook	O_3 , CO, $PM_{2.5}$, NO_2, SO_2	322 km west
Ferolle Point	O_3	422 km northwest
Goose Bay	O_3, Acid Rain	567 km northwest

Qualification of air quality is based on the Air Quality Index (AQI), which is derived from hourly pollutant measurements (Environment Canada 2004). The AQI is detailed in Table 3.3.

Table 3.3 Air Quality Index

AQI Value	Category	Potential Health Impacts
< 25	Good	N/A
26 - 50	Fair	May be some adverse effects on very sensitive people.
51 - 100	Poor	May have some short-term adverse effects on the human or animal populations; may cause significant damage to vegetation and property.
> 100	Very Poor	May cause adverse effects on a large proportion of those exposed.

Source Environment Canada

There are no air monitoring stations in the region that are part of the Atlantic Region Air Monitoring program. Therefore, air pollutant concentrations recorded at the closest Atlantic Region Air Monitoring station in Mount Pearl in 2006-7 are shown in Figure 3.13. Both the mean and maximum AQI values from all months during 2006-7 were less than 25, indicating good air quality.

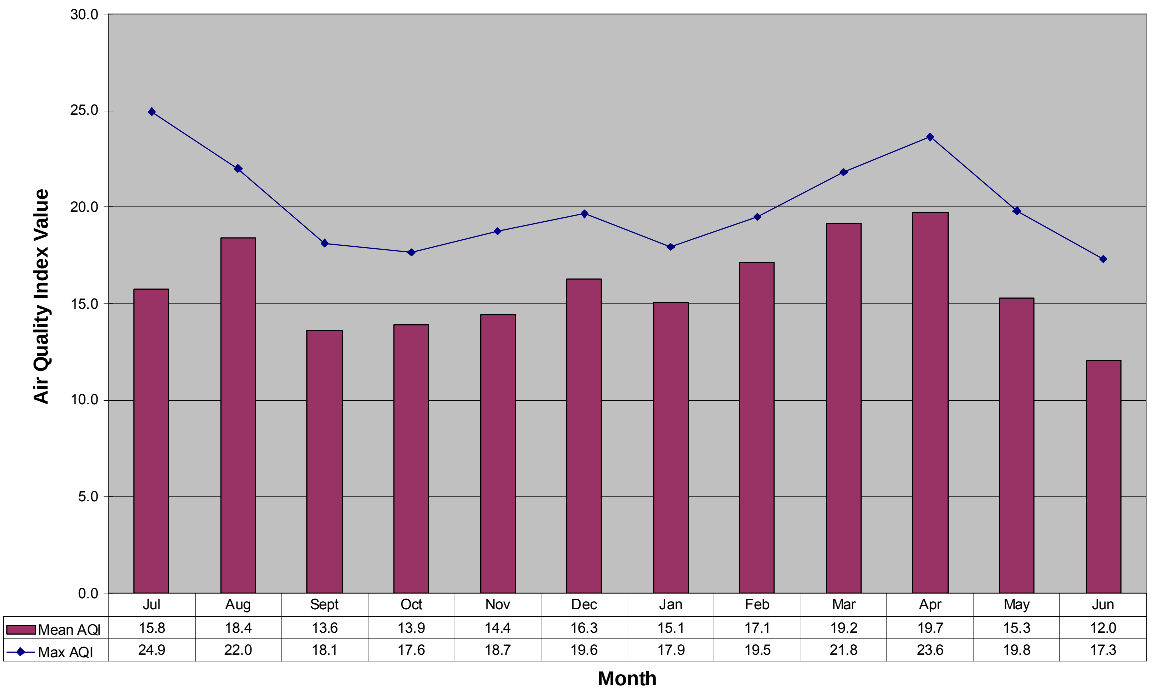


Figure 3.13 Air Quality Index: Mount Pearl Air Quality Station

Maximum background pollutant concentration values in communities nearest the proposed refinery location are shown in Table 3.4. These values were determined from previous monitoring and air quality modeling studies in the region. All background concentrations are below air quality standards.

Table 3.4 Maximum background concentrations in communities

Pollutant	Time Frame	Ambient Standard	Communities				
			Arnold's Cove	Come-by-Chance	North Harbour	Southern Harbour	Sunnyside
SO_2	1-hour	900	348	279	200	175	235
	3-hour	600	220	169	125	125	149
	24-hour	300	79	74	20	30	70
	Annual	60	2	5	1	1	6
NOx	1-hour	400	100	75	60	30	45
	24-hour	200	12	10	6	5	10
	Annual	100	1	1	1	1	1
PM_{10}	24-hour	50	14	14	13	12	15
	Annual	N.A.	7	7	7	7	7
$PM_{2.5}$	24-hour	25	10	10	9	8	11
	Annual	N.A.	5	5	5	5	5

Certain components of the surrounding ecosystem are sensitive to air quality changes. In particular, the globally rare *Erioderma pedicellatum* are very sensitive to pollutants such as sulphur oxides, even at relatively low concentrations. *Erioderma pedicellatum* have been identified within the project area further verifying good air quality in the region.

Ambient air quality and emissions are further discussed in the Air Quality Component Study and in Sections 3.2 and 4.2 of this volume.

3.3 Geology

The regional geology of the project region has rocks that have been classified as the Musgravetown Group of the Avalon Zone, a large area of Late Proterozoic shallow marine, siliciclastic, sedimentary and associated volcanic rock. The geology of the site consists of the green, gray, and red graded and cross-bedded sandstone and pebble conglomerate with inter-bedded black shale and conglomerate. The North Harbour River Fault separates these rocks from the Swift Current Granite on the northwest end of the site, intruded and metamorphosed to hornfels facies in the northeast by the Powder Horn Diorite Complex, and are conformably overlain by the siltstones and shales of the Random Formation, which are overlain by the slates of the Bonavista Formation to the southeast. Numerous dikes intrude the Musgravetown rocks along the southeastern part of Southern Head, the composition of which ranges from diorite, to gabbro, to granite. Rocks northwest of the North Harbour River Fault structurally consist of deformed and metamorphosed intrusive, volcanic and sedimentary rocks. To the southeast of this fault, the rocks are relatively undeformed and are moderately to steeply dipping as a result of large open folds with northeast trending axes.

The project site is characterized by a narrow beach head in the area of the Jetty, which rises steeply to a low plateau with rolling topography in the tank storage area and the refinery area. Only a thin veneer of glacial till remains over most of the site as a result of stripping by glacial action. Mapped Roche Moutonnée features indicate ice movement to the southeast. The project footprint contains approximately 30 per cent bedrock exposure of which 50 per cent is covered with thin glacial till, and 20 per cent covered with bog and water. Raised marine beach material was found at two investigation sites between the 20 and 35 m contours, possibly indicating a periglacial sea level.

The geology of the Southern Head area has dominant rock types consisting of red and green sandstones, granite, diorite and gabbro dikes, and minor pebble conglomerate. Bedding features observed along the coastal outcrops ranged from 240° to 270°, and dipped near vertically. Several previously mapped and unmapped dikes exist in the project footprint. Several large quartz veins and several fault zones were mapped during these investigations (Figure 3.14).

Preliminary investigations of the project site were conducted in 2006 by AMEC to characterize the geotechnical characteristics of the Southern Head site. These investigations included a review of existing published information regarding the project area as well as a field program consisting of test pit excavation and evaluation, bog probe investigations, and a laboratory program for analysis of soil and rock samples collected during field operations.

There are two magnetic depressions in the project area. The first is located approximately 1500 m northeast of the refinery footprint with a NW-SE trend. It is concealed under bog and has no surface expression. The second is a larger magnetic anomaly approximately 600m east of the refinery footprint that trends NE-SW and is clearly visible on aerial photographs of the site. Mapping during the field program revealed a 50 m wide zone of fractured and broken bedrock at the shoreline where the rock is exposed that trends along this magnetic low (Figure 3.15).

NLRC has mapped and classified the coastal geomorphology of the Southern Head peninsula (Section 7.2 and Map Folio).

Figure 3.14 Southern Head Bedrock Geology Map

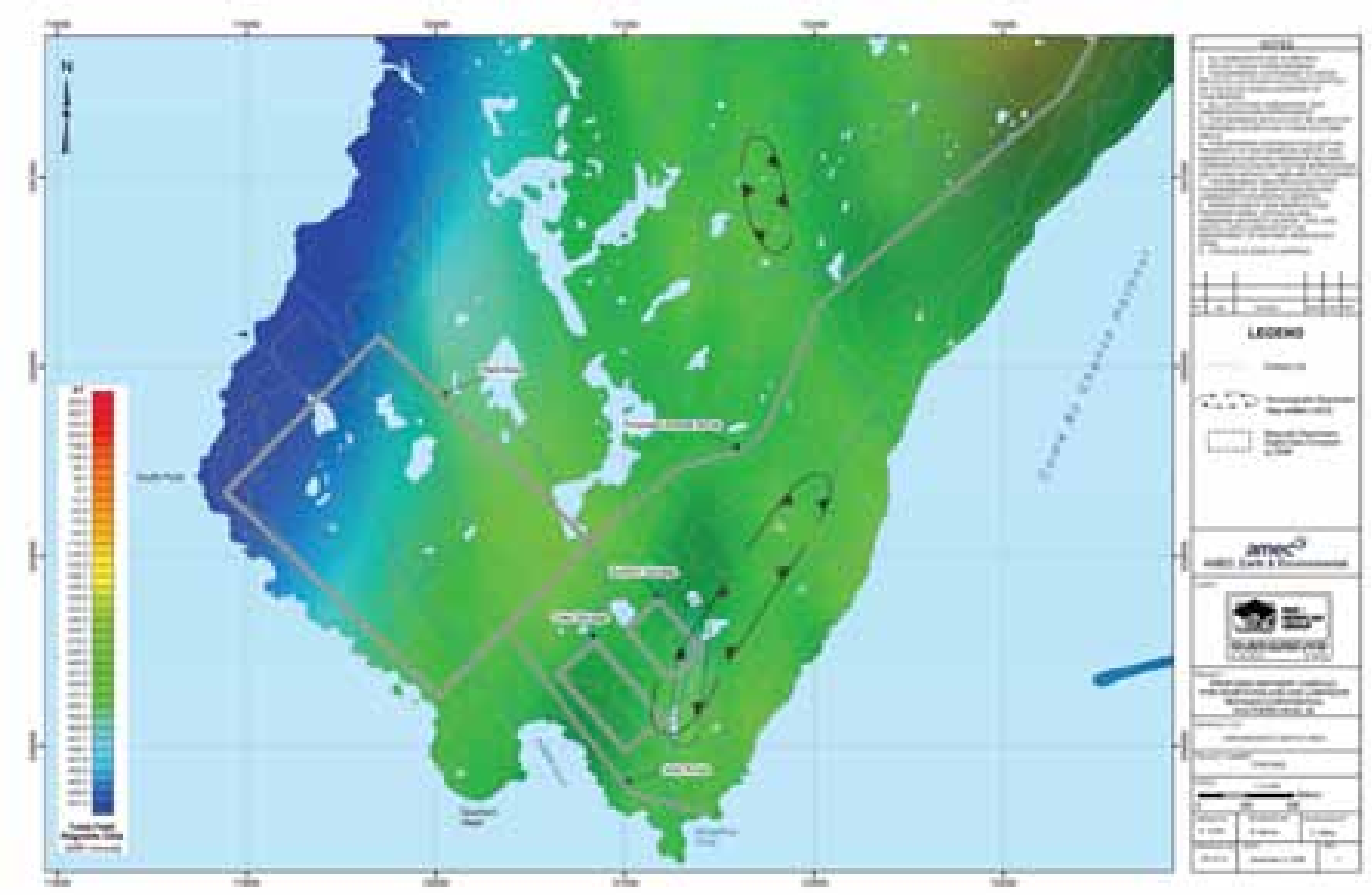


Figure 3.15 Southern Head Magnetic Depressions Map

3.4 Water Resources

3.4.1 Watersheds

The Project site interacts with four watersheds: The Come By Chance River watershed; the North Harbour River watershed; the Watson's Brook watershed and the Hollet's Brook watershed (Figure 3.16).

The Come By Chance River watershed has a total area of 6580.6 ha. The only development planned for this watershed is the 50 m access corridor, which will contain the paved surface access road including a 30 m clear span bridge over Come By Chance River for the proposed Come By Chance Access Road. The temporary power line will run parallel to the proposed access road.

The North Harbour River watershed has a total area of 9268.3 ha. Development planned for this watershed includes a 50 m access corridor, which will contain the paved surface access road including a 30 m clear span bridge over North Harbour River for the proposed North Harbour Access Road.

The Watson's Brook watershed has a total area of 2893.2 ha. Primary development planned for this watershed includes a portion of the project footprint and access road which connect to the proposed site access Road. 4.2 % (124.2 ha) of this watershed will be taken for the Project.

The Hollett's Brook watershed has a total area of 117.8 ha. The entirety of the Hollett's Brook watershed will be within the Project footprint, consequently it will result in the complete removal of this watershed.

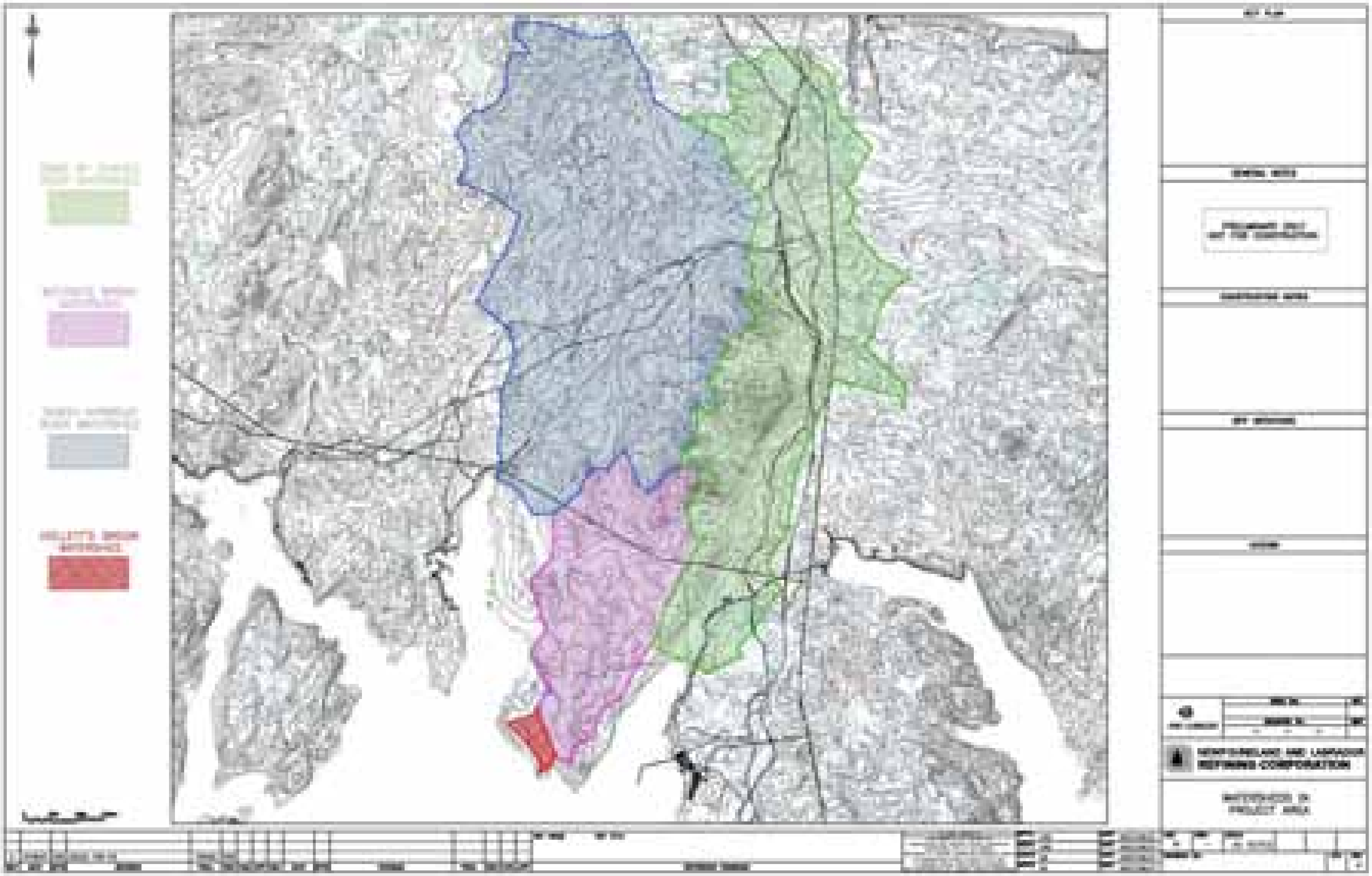


Figure 3.16 Watersheds Affected by Project

AMEC conducted a freshwater baseline data collection program in 2006 and 2007 for the Project. As part of the program all streams (Sample Stream T-1, Sample Stream T-2, Sample Stream T-3, Sample Stream T-5 and Sample Stream T-6) within the footprint of the project were surveyed along with ponds (Sample Pond 1, Sample Pond 2, Sample Pond 3, Sample Pond 4, Sample Pond 5, Sample Pond 6, Sample Pond 7, Sample Pond 8, Sample Pond 9 and Sample Pond 10). Detailed baseline data collected during the AMEC data collection program can be found in Section 3.6.6 and the Component Study for Freshwater Fish and Fish Habitat.

3.4.2 Hydrological Conditions

As mentioned in the previous section, the project will interact with four (4) watersheds during both construction and operations. The interaction is limited to activities resulting from construction of the project components, and site access both for construction and for permanent operations. Watershed areas were determined based upon the 1:50,000 topographic mapping as published by Energy, Mines and Resources Canada. Section 3.4.1 has summarized the affected watershed areas that are to be influenced by the project.

NLRC will add a flowmeter to Watson's Brook and Come By Chance River has a monitoring station located closed to Goobies (Station No.: 02HZ002; Location: 47° 55' 07" N, 53° 56' 59" W), approximately 10 km upstream from the mouth of the river. The catchment area upstream of the station is 4330 hectares, which is approximately 65.8% of the total watershed. The operational station has been monitored since January 1961 and data is available to the end of December 2005. Figure 3.17 presents a graphical summary of the low, high and mean flows experienced during this period.

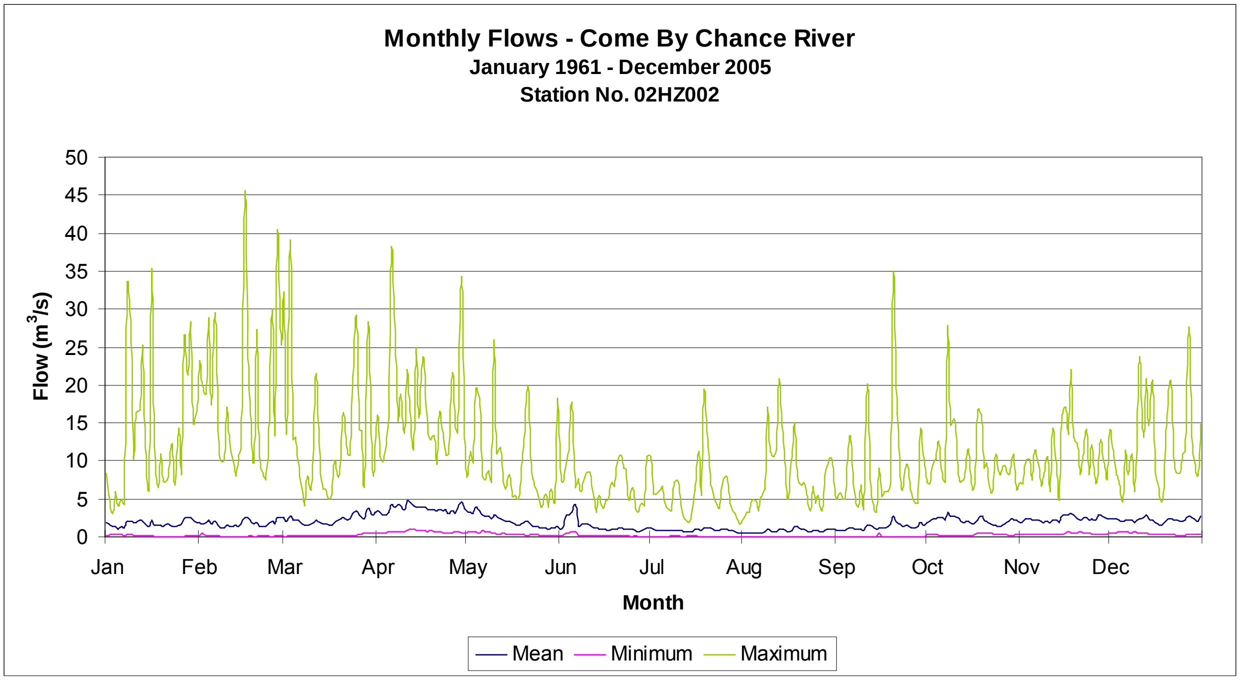


Figure 3.17 River Flows – Come By Chance River

The general trend of water flow in the river is such that lower flows are generally experienced during the summer and early fall when precipitation is generally less and the higher flows are experienced during the spring during periods of higher precipitation and during spring thaw/runoff periods. The peak flow measured during the monitoring period was 45.4 m3/s on February 16, 1991 and the minimum of 0.006 m3/s was recorded on May 2, 1961.

The natural ice conditions in each of the watersheds involved in the project area are expected to result from the typical processes that pertain to river ice formation and break-up in the region. The time of river winter freeze-up and spring breakup will depend upon both the weather conditions and the flow regime in any given year. Historical information regarding ice cover on the river indicates that there is ice cover experienced from the beginning of January to the end of March in an average year.

Precipitation information for the Come By Chance area, normalized for the period 1971-2000, indicates an annual rainfall of 1093.9 mm/year and annual snowfall of 175.6 cm/year. As there is no water to be drawn from any of the watersheds, the recharge rate is not anticipated to be an issue for any of the watersheds in the project area.

Discharge conditions from the Come By Chance River will be applied for design of water crossing structures in each of the watersheds in the project area. The number and type of water crossings in the project area are discussed in Section 4.5.1. Due to the potential for ice and flooding problems (from experience and local knowledge of the rivers), the bridges in the project area will be designed conservatively using 1/100-year storm event. This is greater than the requirements recommended by DOEC for rural highways, but given the sensitivity of maintaining the integrity of the access roads to the refinery it is preferable to design for the more conservative parameters which will only result is a slightly more substantial structure but will provide for additional security for road traffic. For culverts that will cross the smaller tributaries, 1/25-year storm events will be used for design.

As there are no site-specific intensity-duration-frequency (IDF) curves available for the project area, the storm events will be derived from IDF information from Environment Canada for the St. John's International Airport. Other monitored stations in the province were evaluated for applicability to the project site, however, there were no closer stations and the St. John's data is the most conservative for the central and eastern portion of the province.

Information regarding estuarine features can be found in the Section 3.6.3 on Wetlands. A data collection program for specific information on each proposed crossing, including water depth, flow rate, substrate type and potential obstructions to navigation will be implemented during the design phase of the Project. This information will be submitted to appropriate government authorities and used for engineering design and permitting.

3.4.3 Freshwater Quality

Preliminary investigation of freshwater quality was conducted by AMEC in 2007. Freshwater conditions within the Project footprint of the proposed refinery project area have been described in detail in the Freshwater Fish and Fish Habitat Component Study (AMEC, 2007). Relative portions of the Component Study have been provided below to provide the reader with a summary of existing conditions.

Both Secchi and Hydrolab measurements for all ponds within the Project footprint are presented in Table 3.5. Figure 3.69 in Section 3.6.6 Freshwater Fish and Fish Habitat shows a map of these locations. Data for Pond 5 were lost during initial data analysis carried out by AMEC.

Table 3.5 Water quality measurement summary of the sample ponds including light penetration and water quality factors measured with the Hydrolab

		Pond 1 (2006)			Pond 2 (2006)			Pond 3 (2006)			Pond 4 (2007)	Pond 5 (2007)	Pond 6 (2007)	Pond 7 (2007)	Pond 8 (2007)	Pond 9 (2007)	Pond 10 (2007)
Secchi (m)	Up	0.64			1.00			0.80			-	N.R.	-	-	-	-	-
	Down	0.61			1.10			0.90			-	N.R.	-	-	-	-	-
	Average	0.63			1.05			0.85			Bottom (1.2)	N.R.	Bottom (0.65)	Bottom (0.65)	Bottom (0.90)	Bottom (0.60)	Bottom (0.35)
Stratified Depths (m)		**0.6**	**1.1**	**1.2**	**0.4**	**3.2**	**5.6**	**0.4**	**0.8**	**0.9**	**0.21**		**0.04**	**0.3**	**0.09**	**0.14**	**0.05**
Hydrolab	Temperature (°C)	8.96	8.96	8.97	7.01	6.99	6.97	7.01	7.01	7.01	14.50	N.R.	11.55	10.31	11.86	11.88	17.7
	pH	5.62	5.55	5.51	5.65	5.57	5.60	5.51	5.43	5.43	4.75	N.R.	4.17	6.40	6.34	4.98	7.08
	Conductivity (µS/cm)	27.5	27.5	27.5	24.9	25.1	25.3	22.1	22.1	22.2	31.7	N.R.	43.2	45.6	30.1	25.9	47.8
	DO per cent	97.0	93.5	90.8	96.9	89.2	88.4	95.6	93.6	90.0	106.5	N.R.	97.5	92.1	102.3	104.3	116.2
	DO (mg/L)	11.01	10.65	10.32	11.56	10.71	10.61	11.46	11.15	10.79	9.91	N.R.	9.69	9.42	10.07	10.30	10.20
	Turbidity (NTU's)	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	0.5	1.5	N.R.	N.R.	2.5

In addition to in-situ Hydrolab measurement, water samples were taken from Ponds 1, 4, 5, 6, 7, 8, 9, and 10 during the 2007 sampling program and tested for general chemistry and metals, plus hydrides. Furthermore, water samples from Ponds 1, 2, 4, North Harbour River, Watson's Brook and Come By Chance River were also taken during the 2007 sampling program. These samples were tested for BTEX and TDH, the results for which are presented in Appendix D in the component study for Freshwater Fish and Fish Habitat.

Water Quality Monitoring Network

NLRC has signed a Memorandum of Agreement with the Department of Environment and Conservation (DOEC) to establish a Real-Time Water Quality Monitoring Network in the vicinity of the proposed new refinery. This program allows DOEC to provide continuous near real-time water quality information by using a water quality/quantity meter (hydromet station) at Come By Chance River and Watson's Brook. The Come By Chance Station was installed on June 11, 2007 by the Department of Environemnt and Conservation and Environment Canada. The Watson's Brook hydromet station will be installed after the access road is completed. Data from the instrument can be retrieved remotely by the DOEC Water Resources Division and made available to the proponent and the public on-line at http://www.env.gov.nl.ca/wrmd/RTWQ/RTWQ.asp. DOEC works in conjunction with Environment Canada (EC) to provide water quantity and water quality data.

The program provides a continual source of baseline data versus grab sampling techniques. The real-time instrument can be left in place and used through the construction and operation phases of the Project to illustrate water quality and water quantity in the area.

In surface water the instrument will provide the following parameters:

- Temperature (°C)
- pH (pH units)
- Turbidity (NTU)
- Specific Conductance (uS/cm)
- Dissolved Oxygen (mg/L
- % Saturation (%)
- Total Dissolved Solids (g/L)
- Ammonium (mg/L)
- Nitrate (mg/L)
- Chlorophyll a (ug/L)

SNC-Lavalin has developed a monthly water quality sampling program for the Come By Chance River and Watson's Brook until the hydromet stations are deployed. The program began in May

2007, water and sediment samples from Come By Chance River and Watson's Brook will be tested for the following parameters:

Water

- Metals
- Total Alkalinity
- Dissolved Chloride
- Colour
- Hardness
- Nitrate + Nitrite
- Nitrite
- Nitrogen
- Total Organic Carbon
- Orthophosphate
- pH
- Reactive Silica
- Dissolved Sulphate
- Turbidity
- Conductivity
- Total Petroleum Hydrocarbons

Sediment

- Metals
- Total Petroleum Hydrocarbons

Appendix A provides the May 2007 and June 2007 SNC Lavalin water sample program results for Come By Chance River and Watson's Brook.

3.5 Physical Oceanography

3.5.1 Introduction

Placentia Bay is a major embayment of the south coast of Newfoundland bounded by the Burin Peninsula on the west and the Avalon Peninsula on the east. The coastline is irregular with numerous bays, sounds, harbours, inlets and islands. The inner bay is divided into three channels by Merasheen Island, Long Island, and Red Island (BAE 1996).

Tides in Placentia Bay are semi-diurnal with a mean tidal range of 1.6 m and a large tide of 2.4 m (NLRC Project Registration, 2006). Currents within the bay generally flow in a counter-clockwise circulation pattern, but much local variation exists. The currents in the vicinities of the large islands in the inner reaches of the bay are particularly influenced by the local bathymetry.

Wind-generated waves in Placentia Bay are a result of predominately west and southwest winds. Swells from the south also influence the sea state in Placentia Bay. Swells are usually not formed locally by wind but may form at some distance away and propagate to the vicinity from stormy or windy areas in the direction of the wind that originally formed them as wind waves

The region is considered to be relatively ice-free and have open water on a year-round basis. If ice intrusion does occur, episodes are usually brief and affect a very limited area. Landfast ice that is locally formed can potentially be attributed to the influx of freshwater through rivers and streams. Pack-ice in the region likely originates from the Labrador Sea and has been known to be carried by the inshore branch of the Labrador Current as far west as St. Pierre (Seaconsult 1985).

This section provides detailed information on the marine physical environment within Placentia Bay and the proposed project area. Descriptions and graphical depictions of bathymetry, currents, tides, waves, water temperature, ice and icebergs, marine water quality and sediments are provided.

3.5.2 Data Sources

Ocean current data has been analyzed at two spatial scales; the large scale incorporates Placentia Bay, and a more local, site-specific scale encompasses the proposed project location. Ocean current data in Placentia Bay have been collected by the Department of Physics and Physical Oceanography at Memorial University (MUN) during the spring (April to June) of 1998 and 1999, and by the Bedford Institute of Oceanography (BIO) during the winter of 1988 (February to March) and fall 1998 (September to October). The MUN data are from two sites in 1998 and seven sites in 1999. In 1999, there were four moorings deployed in the outer sections of the bay with two instruments on each mooring, and three Acoustic Doppler Current Profilers (ADCP) deployed around the islands in the inner sections of the Bay. The BIO moorings consisted of three moorings with two instruments on each; one near the surface (between 15 m and 25 m) and the other moored between 49 m and 63 m (LGL Limited).

A dataset consisting of monthly summaries of currents at 16 locations from deployment during 1968 to 1988 (SNC Lavalin 1996), in conjunction with BIO data and recent ocean current information obtained from the Placentia Bay SmartBay Buoy Program, were utilized to characterize ocean currents in the inner reaches of the bay. Furthermore, current meters were deployed in 2007 at the projects proposed outfall location.

Wave data were obtained from the MAST dataset from 1889 to 1989. More recent information from Placentia Bay's SmartBay Buoy Program has been integrated into the various data sets.

The SmartBay Buoy Program includes a 3 m meteorological / oceanographic buoy near the mouth of Placentia Bay and another buoy in the project area. Aside from information collected by the SmartBay Buoy, very little measured wave data is available. Therefore, 30-year hindcast data compiled by SNC Lavalin for Argentia and Come By Chance was utilized to represent the project area.

Analysis of water temperature in Placentia Bay was conducted using information obtained from SmartBay and the MAST dataset.

Baseline sediment and water chemistry within the marine facilities footprint was obtained through field surveys conducted in 2007 as part of the Marine Fish and Fish Habitat Component Study.

Data for analysis of ice conditions and the presence of icebergs in Placentia Bay have been extracted from two sources. The Canadian Ice Service's 30-Year Frequency of Presence of Ice in Placentia Bay provided data that were used for statistical analysis of ice conditions. The International Ice Patrol Iceberg Sightings Database from 1974 - 2003 was used for analysis to determine the frequency of icebergs in the bay that may pose threats to shipping.

3.5.3 Bathymetry

The coastline of Placentia Bay is irregular with numerous bays, sounds, harbours, inlets and islands. The bathymetry of Placentia Bay is also very irregular with many banks and troughs. Merasheen Island, Long Island, and Red Island divide the inner bay into three channels. The eastern channel between the eastern shores of the bay and the eastern shores of Red and Long Island is the widest, the deepest and the least obstructed by shoals. The channel has depths extending to approximately 300 m. The western channel between the west side of Merasheen Island and the western side of the bay (the eastern shore of the Burin Peninsula) is obstructed by shoals, inlets and rocks (BAE Newplan, 1996). A deep channel exists south of Merasheen Island spans from a northwest/southeast direction across the bay and has a maximum depth of 350 m. This channel is bounded in the south by the White Sail Bank, Merasheen Bank, and Bennett Bank. Water depths are generally shallower on the western side of Placentia Bay than on the eastern side with the exception of the numerous deep troughs (LGL 2007). The water depth at the mouth of the bay is approximately 200 m. The bathymetry of Placentia Bay is illustrated in Figure 3.18.

Figure 3.18 Bathymetry of Placentia Bay

3.5.4 Currents

Data on marine currents in Placentia Bay was collected by Memorial University of Newfoundland (MUN) in 1999 and also by the Bedford Institute of Oceanography (BIO) in 1998. Data on currents at the mouth of Placentia Bay and the Southern Head (inner Placentia Bay) was collected by the SmartBay Buoy program in June 2007. NLRC has begun to collect its own data on marine currents in Placentia Bay as well, by deploying an ADCP current meter near the proposed outfall location.

Oceanographic data will be gathered from these stations on a scheduled basis, enabling efficient access to information during all stages of the project. The monitoring of marine currents is just one the types of environmental factors that should be continually evaluated. By using near real-time oceanographic data and being able to analyze past data to identify trends, the Refinery will foster a preventative approach to dealing with unplanned events. If an incident were to occur that might possibly produce harmful environmental effects, understanding the relationship between all environmental conditions is crucial to maximizing the effectiveness of response measures. For example, if a small release of oil occurred at the jetty, responders may use current information to make predictions for the fate of the oil.

Data gathered from the MUN, BIO and SmartBay programs is shown in the following section, with a more detailed presentation of results recently obtained by NLRC to follow. Locations of where current measurement samples have been taken is illustrated in Figure 3.19, with associated data summarized in Table 3.6.

Figure 3.19 Location of Current meter Moorings in Placentia Bay

Table 3.6 Summary of Current Measurements from MUN, BIO, and SmartBay

Year	Location	Depth (m)	Mean Speed (cm/s)	Maximum Speed (cm/s)	Predominate Direction
2007	SmartBay Buoy 1	1 m	15.7	39.0	Northeast
1999	M1 (MUN) (Western Side)	20	10.3	49.7	Southwest
		55	7.4	27.3	Southwest
1999	M2 (MUN) (Western Side)	20	13.1	47.4	Southwest
		55	10.4	41.8	Southwest
1999	M3 (MUN) (Eastern Side)	20	19.5	75.0	North Northeast
1999	M4 (MUN) (Eastern Side)	20	14.4	58.9	Northeast
		45	7.5	43.8	Northeast
1999	M5 (MUN) (Western Side)	36	7.9	36.5	Southwest
		72	6.8	22.5	South
		104	6.0	21.7	Southwest
1999	M6 (MUN) (Eastern Side)	16	32.0	78.7	North Northeast
		36	8.3	30.7	Northeast
		72	6.0	23.5	West Southwest
		104	5.6	23.5	West Southwest
1988 (Fall)	BIO-East	23	13.4	57.0	North Northeast
		56	10.3	45.1	South Southwest
1988 (Winter)		22	12.1	74.8	
		60	13.2	57.8	North Northeast
1988 (Fall)	BIO-North	16	12.1	44.5	West
		49	8.8	52.0	East Southeast
1988 (Winter)		25	8.4	29.4	West Northwest
		63	6.1	17.9	West
1988 (Fall)	BIO-West	21	9.1	27.3	West Southwest
		54	8.7	32.8	West Southwest
1988 (Winter)		15	11.5	43.4	West Southwest

Memorial University Data

Published information on marine currents in Placentia Bay obtained through MUN suggests that currents move around the bay in a cyclonic (counter-clockwise) circulation pattern. North-northeast currents dominate the east side of Placentia Bay, whereas a southwest current dominates the western portion of the bay, predominately flowing toward the mouth or out of the bay. Studies show that the cyclonic circulation pattern around Placentia Bay was fairly stable in the near surface waters (Schillinger, Simmons and de Young 2000). On the eastern side of the bay the currents had a residual flow of 17.6 cm/s near the mouth of the bay and 15.6 cm/s at location M6. The maximum current speeds for both locations were 75 cm/s and 78.7 cm/s respectively. The residual current was 7.1 cm/s at location M1 on the western side of the bay and obtained a maximum speed of 49.7cm/s (LGL 2007).

The mean magnitude of currents at a depth of 20 m are much larger than the deeper currents. At depths from 36 m to 55 m, the counter clockwise flow was still predominate however, there was more variation shown in comparison with surface currents. The mean circulation for depths of 20 m and 44 to 45 m are presented in Figure 3.20 and Figure 3.21 (Schillinger, Simmons and de Young 2000). The axes at the base of the arrows in these figures indicate the standard deviation of the currents along the direction of maximum variance, and perpendicular to it.

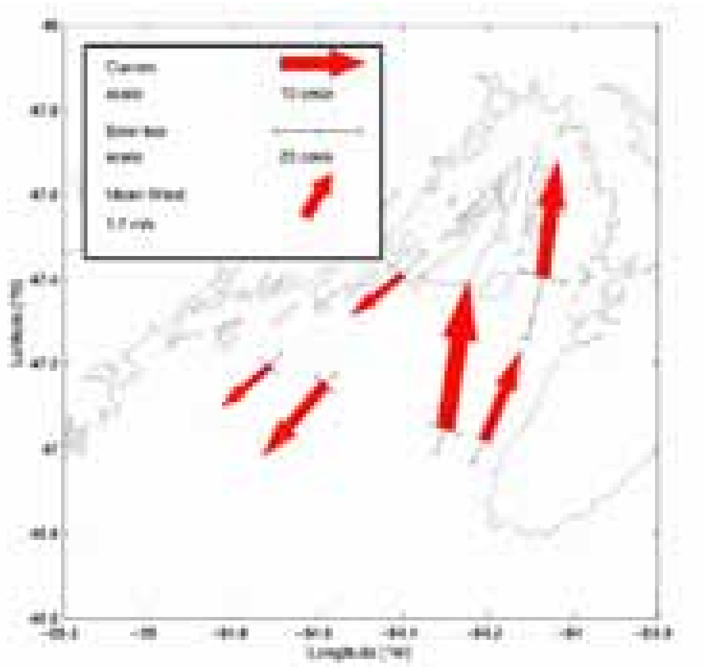


Figure 3.20 Mean Circulation in Placentia Bay at 20 m (from Schillinger et al. 2000)

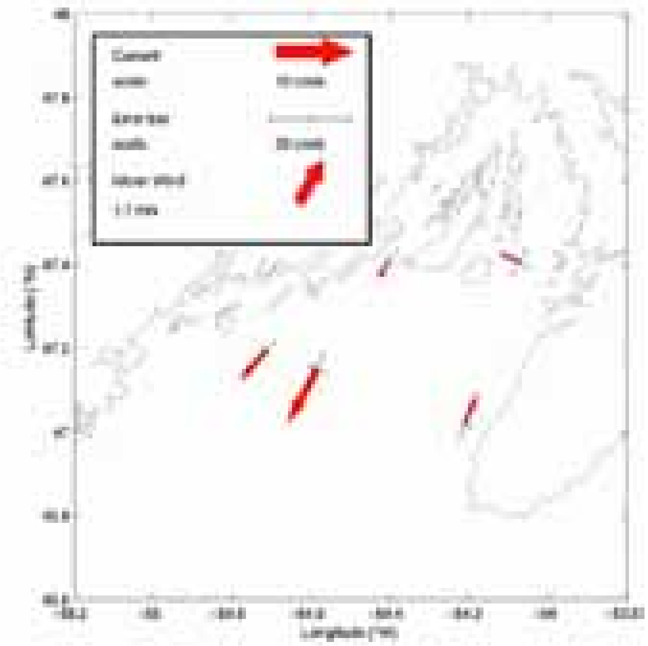


Figure 3.21 Mean Circulation in Placentia Bay at 45-55 m (from Schillinger et al. 2000)

Bedford Institute of Oceanography Data

An analysis of the BIO data collected during the winter and fall of 1988 and data obtained from the SmartBay Buoy Program in 2007 also supports the existence of a counter-clockwise flow in the near-surface waters of Placentia Bay. 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 the winter data but not in the fall. In fall, 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. The average current speeds range between 6.1 cm/s and 13.4 cm/s for specific depths. The maximum current speed ranged between 17.6 cm/s and 74.8 cm/s, with higher speeds being recorded near the surface.

SmartBay Buoy Data and NLRC Data

Current measurement from SmartBay Buoy 1 located at the mouth of Placentia Bay also support the Northeast flow identified in the MUN and BIO studies. Figure 3.22 shows the direction and speed of currents collected by SmartBay over an 8-month period (August-June, 2007). SmartBay Buoy 2 ADCP located at the project site recorded a mean current speed of 22.4 cm/s and varying directions between south-southwest to south-southeast. The direction of currents in this area may likely be influenced by the shore and proximity to Come By Chance Bay (Figure 3.23).

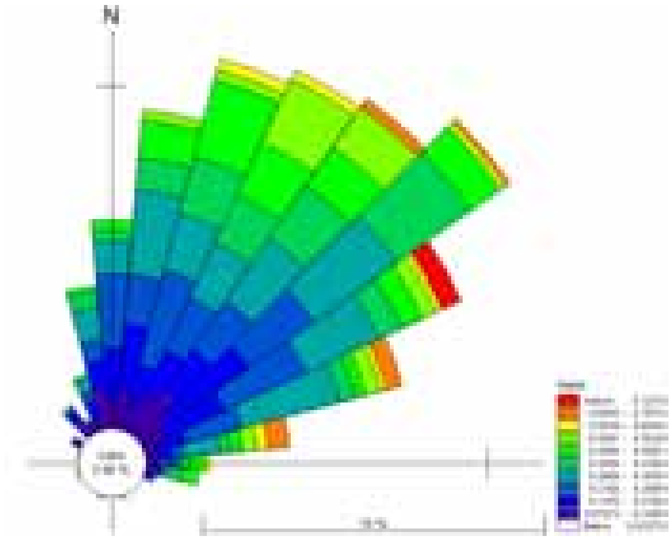


Figure 3.22 Current Speed (knots) and Direction at SmartBay Buoy 1 Station

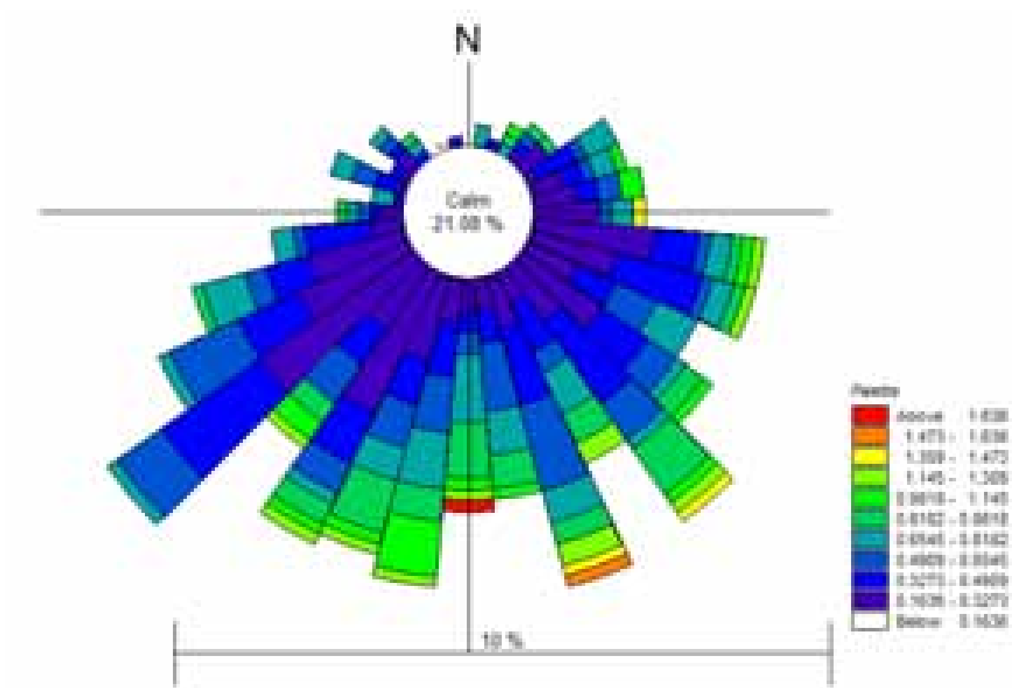


Figure 3.23 Currents Speed (knots) and Direction at SmartBay Buoy 3 ADCP Station

Information on currents for inner Placentia Bay (adjacent to the project area) was obtained from a data set consisting of 30 current meter time series from deployment during 1968 to 1988 (SNC Lavalin 1996) at 16 locations, the SmartBay Buoy ADCP (2007) at the project site and the NLRC ADCP (2007) at the outfall location. Summaries of mean and maximum currents at these locations (Figure 3.24), and current variability (orientation and magnitude of the major and minor axis expressed as standard deviation) in the tidal and subtidal ranges are presented in Table 3.7.

Figure 3.24 Water Current Meter Locations for Inner Placentia Bay

Table 3.7 Summary of Current Meter Data

Station No.	Position Latitude Longitude	Depth (m)	Date	Days	Max Speed (m/s)	Mean Speed (m/s)	Direction (°T)	Mid. Freq. Var.			Low. Freq. Var.		
								Major (m/s)	Minor (m/s)	Dir (°T)	Major (m/s)	Minor (m/s)	Dir (°T)
NLRC ADCP1	47°48.04'N, 54°03.99'W	0.4	Jun-07	15	0.595	0.129	151						
		9.4	Jun-07	15	0.212	0.042	175						
		17.4	Jun-07	15	0.198	0.027	190						
NLRC ADCP2	47°47.98'N, 54°04.24'W	0.4	Jun/Jul-07	18	0.472	0.064	175						
		9.4	Jun/Jul-07	18	0.325	0.047	188						
		17.4	Jun/Jul-07	18	0.163	0.036	204						
SmartBay 3 ADCP	47°47.35'N, 54°02.73'W	23.0	May/Jun-07	24	0.853	0.224	172						
9	47°42.32'N, 54°04.65'W	35.0	Oct-88	29	0.324	0.027	353	0.052	0.046	46	0.043	0.038	73
		82.0	Oct-88	29	0.122	0.010	214	0.033	0.015	4	0.028	0.008	2
10	47°43.03'N, 54°03.30'W	31.0	Jul-72	12	0.098	0.020	14	0.028	0.010	19	0.024	0.007	23
11	47°43.06'N, 54°10.44'W	10.0	May-74	27	0.278	0.036	195	0.068	0.031	20	0.052	0.017	21
			Jun-74	6	0.201	0.028	211	0.062	0.031	7	0.054	0.014	4
12	47°44.30'N, 54°03.45'W	30.0	Jul-72	20	0.242	0.030	323	0.055	0.017	324	0.048	0.011	323
		31.0	Jul-72	20	0.278	0.026	333	0.052	0.017	333	0.046	0.012	334
13	47°44.87'N, 54°02.55'W	3.0	Jul-68	18	0.362	0.089	198	0.087	0.048	29	0.078	0.041	29
			Aug-68	11	0.319	0.094	202	0.107	0.046	18	0.102	0.041	18
14	47°44.98'N, 54°06.83'W	16.0	Oct-88	29	0.445	0.092	287	0.108	0.063	83	0.105	0.049	82
		49.0	Oct-88	29	0.520	0.069	97	0.092	0.039	299	0.091	0.027	298
15	47°45.08'N, 54°06.72'W	25.0	Feb-88	14	0.235	0.034	330	0.065	0.045	304	0.059	0.029	304
			Mar-88	29	0.294	0.054	307	0.072	0.051	46	0.068	0.043	47
		63.0	Feb-88	14	0.136	0.023	258	0.041	0.034	49	0.026	0.016	26
			Mar-88	29	0.179	0.038	288	0.050	0.041	78	0.042	0.036	79
16	47°46.00'N, 54°02.00'W	6.0	Jan-72	24	0.252	0.033	139	0.063	0.045	2	0.056	0.037	7
		20.0	Jan-72	24	0.201	0.022	165	0.046	0.028	19	0.042	0.020	20
17	47°46.31'N, 54°08.20'W	10.0	May-74	27	0.221	0.019	22	0.052	0.032	58	0.045	0.020	56
			Jun-74	30	0.345	0.032	35	0.083	0.043	58	0.075	0.031	61

Station No.	Position Latitude Longitude	Depth (m)	Date	Days	Max Speed (m/s)	Mean Speed (m/s)	Direction (°T)	Mid. Freq. Var.			Low. Freq. Var.		
								Major (m/s)	Minor (m/s)	Dir (°T)	Major (m/s)	Minor (m/s)	Dir (°T)
18	47°46.43'N, 54°02.16'W	6.0	Jul-72	20	0.252	0.039	147	0.059	0.049	332	0.052	0.039	334
		31.0	Jul-72	12	0.108	0.005	102	0.022	0.018	52	0.016	0.011	71
19	47°46.70'N, 54°02.20'W	6.0	Jan-72	24	0.304	0.038	135	0.062	0.041	312	0.052	0.029	310
		20.0	Jan-72	12	0.113	0.005	183	0.019	0.015	311	0.014	0.011	307
		21.0	Jan-72	24	0.170	0.015	151	0.029	0.021	331	0.024	0.015	332
20	47°47.20'N, 54°01.56'W	3.0	Jul-68	15	0.231	0.013	43	0.053	0.037	38	0.043	0.026	38
21	47°47.25'N, 54°01.90'W	21.0	Jan-72	24	0.165	0.005	355	0.036	0.027	355	0.029	0.020	351
22	47°47.25'N, 54°02.10'W	5.0	Jan-72	19	0.262	0.024	149	0.044	0.038	272	0.035	0.032	71
		21.0	Jan-72	24	0.221	0.007	254	0.040	0.023	22	0.035	0.016	24
23	47°48.47'N, 54°01.22'W	7.0	Oct-88	29	0.085	0.018	232	0.010	0.007	48	0.009	0.005	37
24	47°48.52'N, 54°01.07'W	7.0	Oct-88	29	0.459	0.051	314	0.100	0.037	311	0.073	0.023	303

Stations 23 and 24 are located in Come By Chance Bay. The mean currents in Come By Chance Bay range from 0.02 to 0.05 m/s towards the south west or north west, and maximum current speeds reach 0.46 m/s. Stations 16 and 18 are located near Whiffen Head. The mean near-surface current speed at Whiffen Head range from 0.03 to 0.04 m/s predominately towards south and maximum speeds reach 0.25 m/s. The near-bottom current speeds at Whiffen Head range from 0.03 to 0.04 m/s and maximum current speeds reach 0.25 m/s. Currents south of Come By Chance Bay move predominantly south, however strong seasonal and depth variations exist. Stations 14 and 15 are located further out in the bay and are less influenced by the shore. Mean surface currents in this area range from 0.03 to 0.09 m/s towards the north west supporting the counter-clockwise circulation pattern in Placentia Bay. Maximum current speeds reach 0.45 m/s.

SmartBay Buoy 3 ADCP is located at the project site. The mean current speed is 0.22 m/s and moves in varying directions between south-southwest to south-southeast (Figure 3.25). Maximum speeds reach 0.85 m/s. NLRC ADCP at the outfall location recorded currents moving predominately southwest. The direction of currents in this area may likely be influenced by the shore and proximity to currents in Come By Chance Bay.

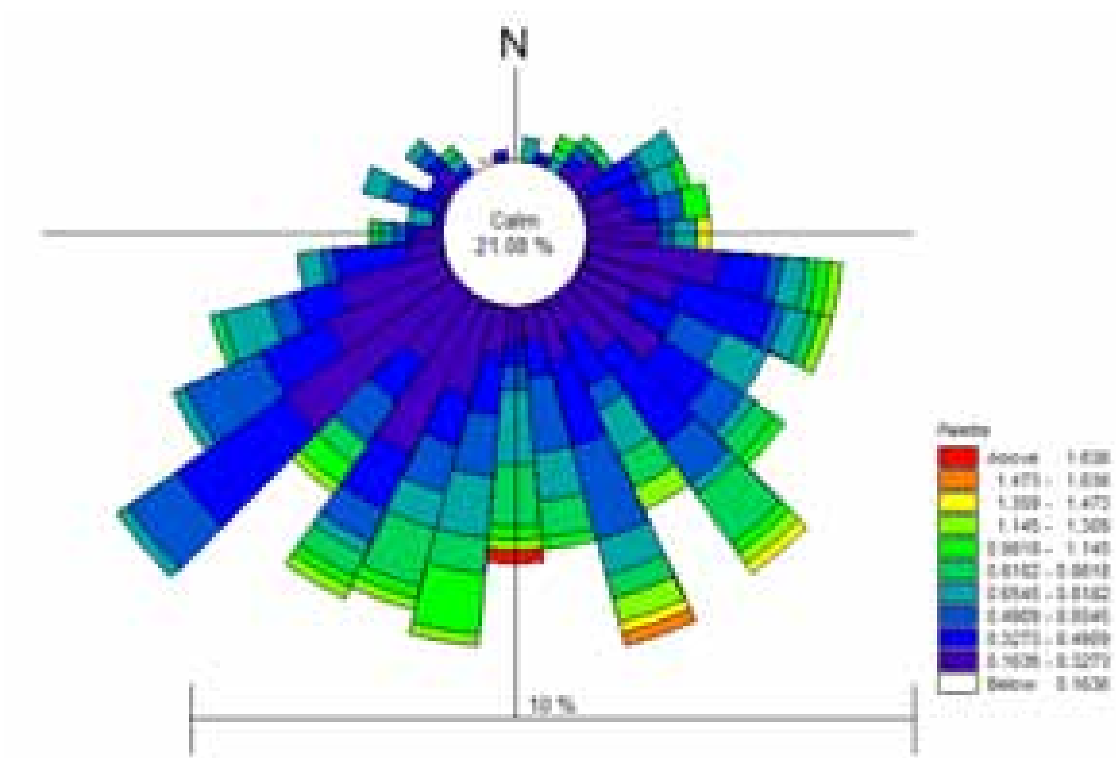


Figure 3.25 Currents Speed (knots) and Direction at SmartBay Buoy 3 ADCP Station

The existing data from various sources provided both historic and recent meteorology and oceanography information. An information gap exists in that there is no detailed water column density profile that can be found. The closest current meter mooring location is at the mouth of Come By Chance harbour. There were no current meter measurements at the proposed location for outfall. In order to understand the current pattern at the outfall site and provide accurate inputs for the effluent modeling, a field program to collect the current information and density profile was initiated.

Field Program

To measure marine currents, both Acoustic Doppler Current Profiler (ADCP) and current meter were used.

The ADCP used is a RDI Workhorse Sentinel ADCP with a system frequency of 614.4 KHz. The ADCP was moored at the 20 m depth and sampled from 25 layers with 1 m spacing. This first layer is about 2.6 m above the bottom and the last layer is above the water surface. This setup allows the entire water column to be captured. The sampling interval was 15 minutes. The first deployment of ADCP was on June 6, 2007 at the location 47º 48’02.18” N, 54º 03’59.59” W. The ADCP was recovered and maintained on June 20, 2007 and redeployed on the same day at 47º 47’58.52” N, 54º 04’14.40” W. The second deployment covers 18 days of measurements until the recovery on July 7, 2007. The mooring locations have been shown in Figure 3.24.

A RCM9 point series current meter was also used. The mooring location of the current meter is about 40 m away from the ADCP. The current meter was positioned at about 6 m from bottom and 14 meter below surface. The sampling interval of the current meter was 20 minutes. The mooring configuration is shown in Figure 3.26. Although the RCM9 current meter was deployed for both locations next to ADCP, there was an instrument failure for the second deployment. Only the data for the first deployment (June 06-20, 2007) were recovered.

For the water column profile, a RBR Conductivity, Temperature, and Depth (CTD) meter was used. The CTD was lowed from the side of the vessel to perform down- and up-casts. The sampling frequency of the CTD is 6 Hz. Three casts were performed on June 06, June 20, and July 7, 2007.

Results

Although the ADCP captured current information for 25 layers, only the data for layers 1 to 18 are analyzed and the remaining data for layer 19 to 25 have been removed because these layers were above the water surface.

The current statistics for three representative ADCP depths (surface 0.4 m, mid-depth 9.4 m, and bottom 17.4) and the one RCM9 depth are shown in Table 3.8. It can be seen from the Table that the currents are weak for both locations. The mean bottom currents are 0.027 m/s and 0.038 m/s for the ADCP1 and ADCP2, respectively. The magnitudes of the maximum bottom currents are 0.198 m/s and 0.163 m/s for these two deployments. For the surface currents, although the maximum current reached 0.595 m/s for ADCP1 and 0.472 m/s for ADCP2, the mean currents are still very weak. The mean surface currents are only 0.129 m/s for ADCP1 and 0.064 m/s for ADCP2. The RCM9 current meter was moored at 14 m depth. This depth is between the 9.4 m and 17.4 m ADCP sampling depth and the magnitude of current measurements by RCM9 lie between the values by ADCP1 as expected. This confirms the validity of the data.

The detailed time series data of current speeds and directions for the first ADCP deployment are shown in Figures 3.27 to 3.29. The rose plots of currents by directions for this deployment are given in Figures 3.30 to 3.32. It can be seen that both the bottom and mid-depth current have a dominant direction of northwest and southeast. The surface current has a dominant direction of northeast and southwest. This difference in direction is most likely contributed to by wind effects.

The time series data of current speeds and directions for the second ADCP deployment are shown in Figures 3.33 to 3.35. The rose plots of currents by directions for this deployment are given in Figures 3.36 to 3.38. For this location, the dominant current directions for the three depths are northwest and southeast. There is no apparent difference in surface direction and bottom direction. This may be explained by the fact that the mooring location for this deployment is in a more sheltered area than the first deployment, and the wind effects are less important in this case.

The time series data of the RCM9 current measurement are shown in Figure 3.39 and the rose plot of the directions are presented in Figure 3.40. It can be seen that the dominant direction is north (slightly northwest) and southeast. This agrees overall with the ADCP1 measurements.

The CTD data for three casts are shown in Figures 3.41 to 3.49. It can be seen that three different profiles were observed. For the June 6 case (Figure 3.41 to 3.43), there is a rapid change of temperature, salinity, and density in the upper 4 m. The rates of change of linear profiles in depths from 4 m to 20 m are slow.

For the June 20 cast (Figure 3.44 to 3.46), the density profile has a uniform upper 4 m layer and a linearly increased bottom layer (4 to 17 m). The salinity in the upper 6 m water is linearly decreased and then becomes linearly increased in the bottom layer (6 to 17 m). The temperature is shown to be one linearly stratified profile.

For the July 4 cast (Figure 3.47 to 3.49), all three parameters are shown to be linear. Only one linear layer was observed for this cast.

Discussion

The duration of the present current and CTD measurements has been relatively short. The length of current measurement is only about half a month for each location and only three days of CTD data was measured. The data agrees with historic data in general. For example, the current measured on October 1988 at two locations close to ADCP2 by Bedford Institute of Oceanography showed the mean current at 7 m is about 0.018 m/s to 0.051 m/s (BAE NEWPLAN 1996). The present study showed a 0.047 m/s at 9.4 m. The results are in good agreement. For the CTD profile, comparison with the measurement in Placentia Bay in 1998 for the same time period also showed good agreements (Hart et al. 1999). Therefore, it may be concluded that it is safe to use the historic data before the longer field measurements are completed.

Table 3.8 Statistics of Measured Currents

Station No.	Position Latitude Longitude	Depth (m)	Date	Days	Max Speed (m/s)	Mean Speed (m/s)
ADCP1	47°48.04'N, 54°03.99'W	0.4	Jun-07	15	0.595	0.129
		9.4	Jun-07	15	0.212	0.042
		17.4	Jun-07	15	0.198	0.027
RCM9	47°48.04'N, 54°03.99'W	14	Jun-07	15	0.210	0.041
ADCP2	47°47.98'N, 54°04.24'W	0.4	Jun/Jul-07	18	0.472	0.064
		9.4	Jun/Jul-07	18	0.325	0.047
		17.4	Jun/Jul-07	18	0.163	0.036

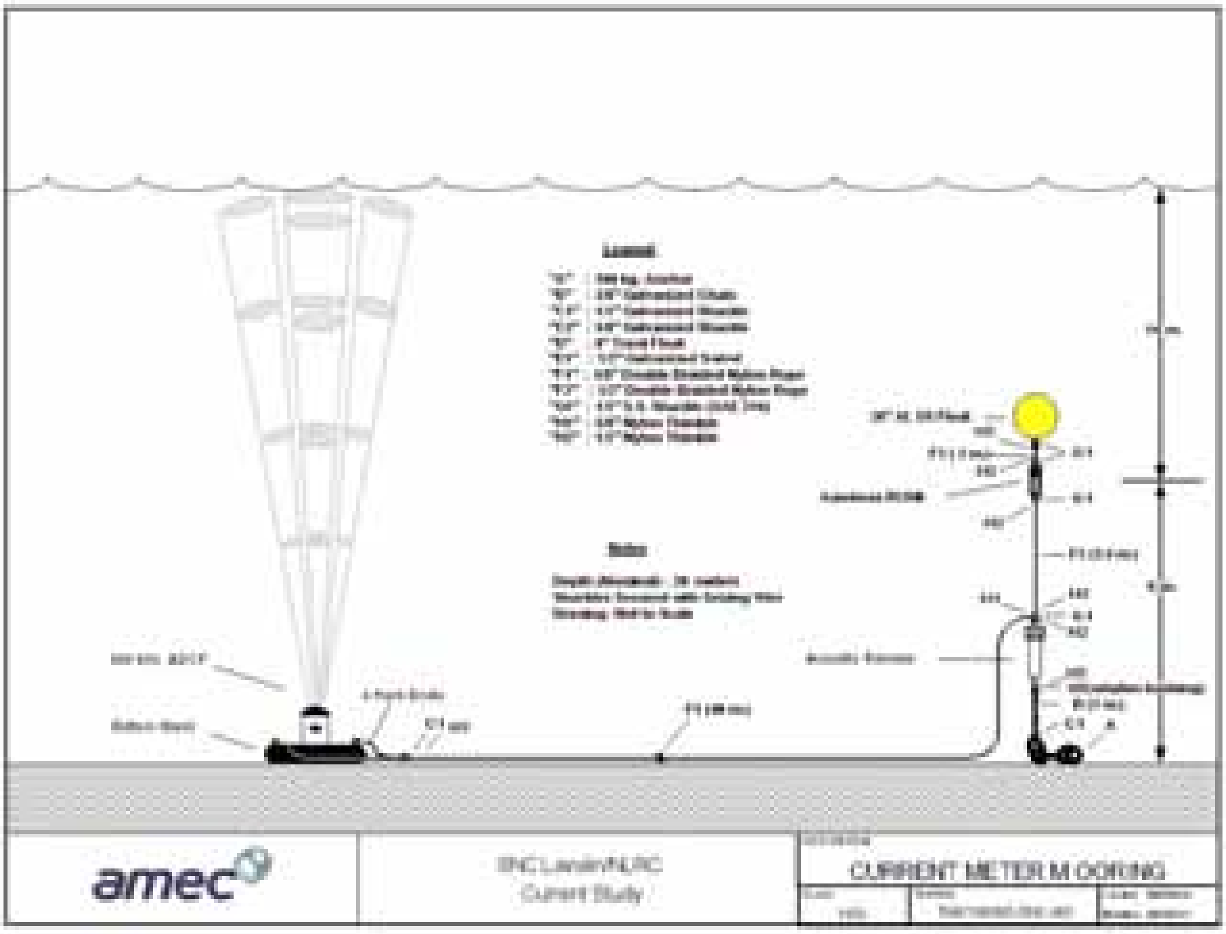


Figure 3.26 Mooring Configurations for the ADCP and RCM9 System

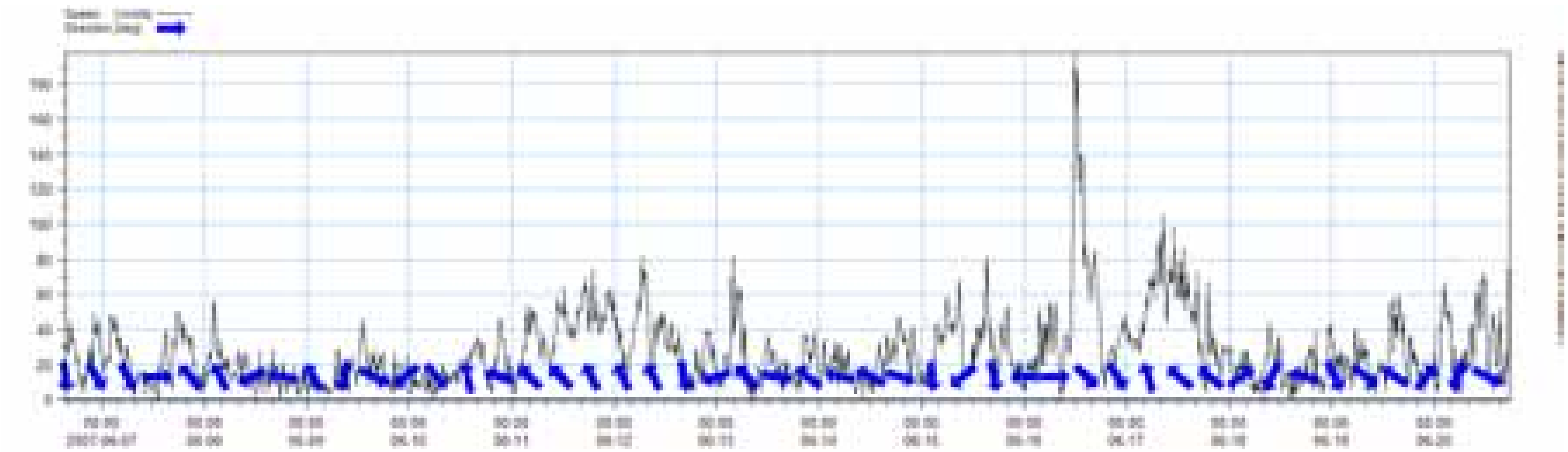


Figure 3.27 Time Series Current Plot (First ADCP Deployment), Depth=17.4 m

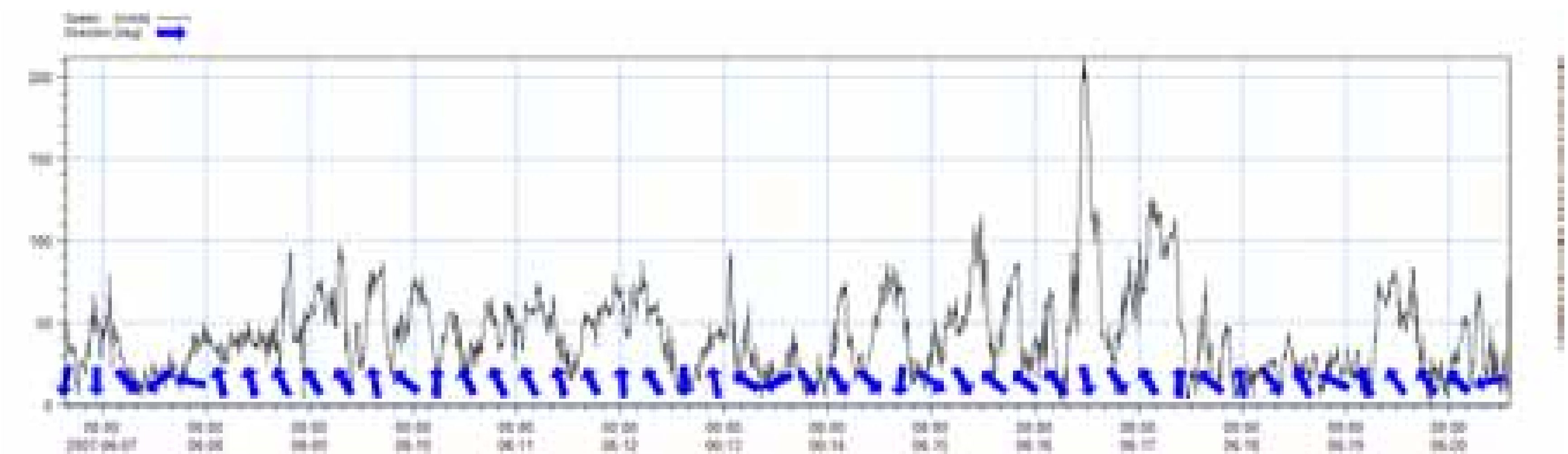


Figure 3.28 Time Series Current Plot (First ADCP Deployment), Depth=9.4 m

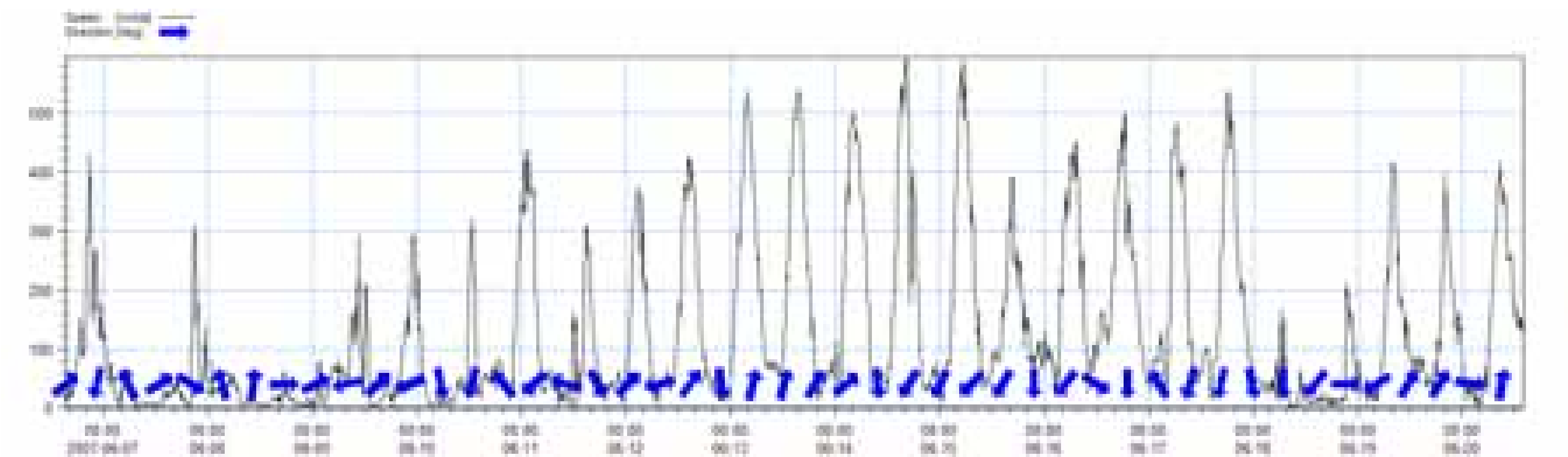


Figure 3.29 Time Series Current Plot (First ADCP Deployment), Depth=0.4 m

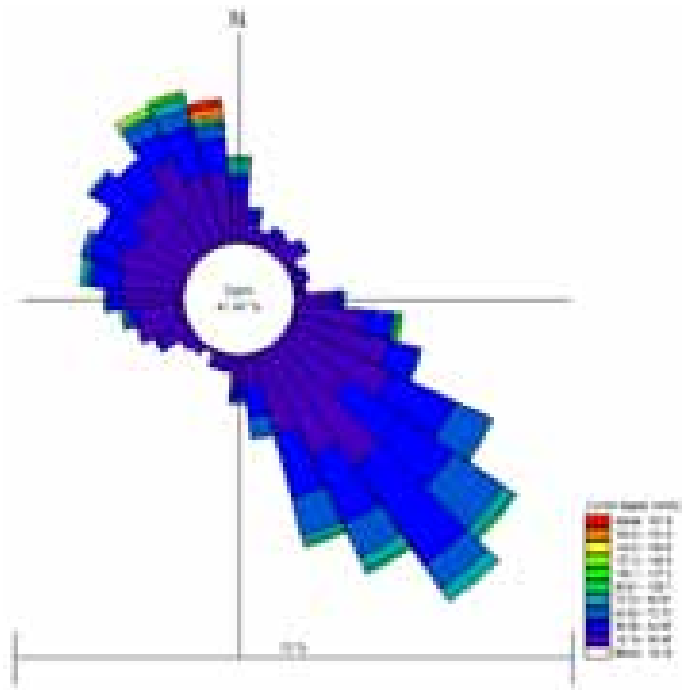


Figure 3.30 Current Rose Plot (First ADCP Deployment), Depth=17.4 m

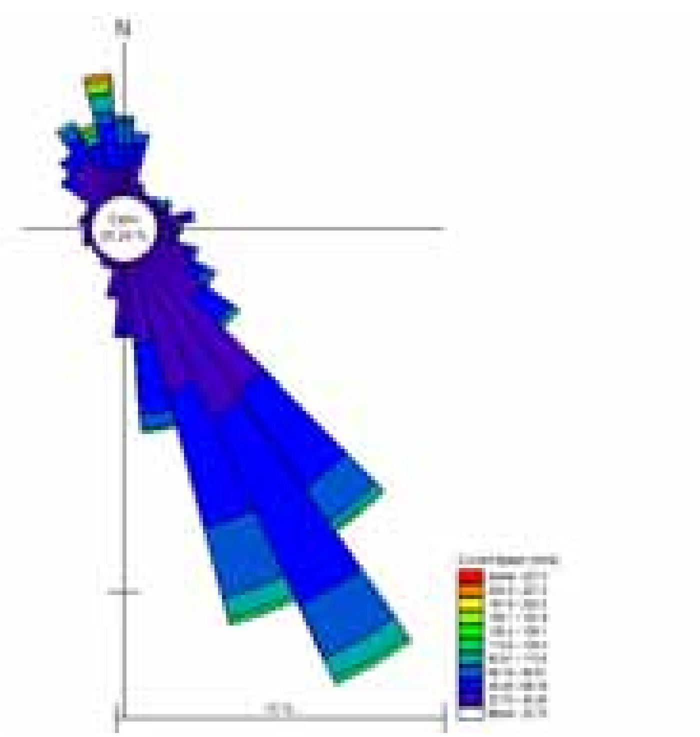


Figure 3.31 Current Rose Plot (First ADCP Deployment), Depth=9.4 m

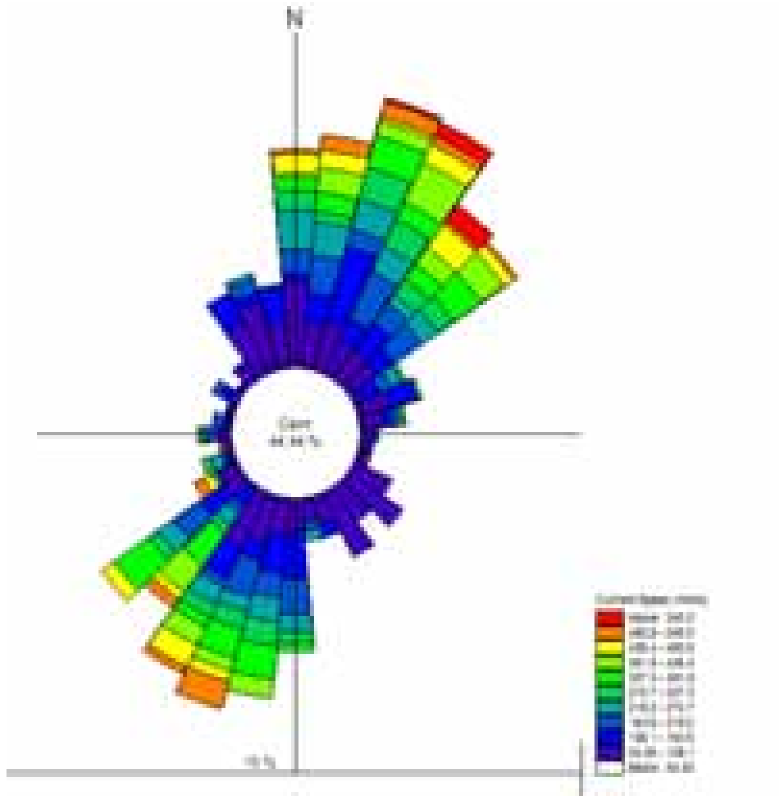


Figure 3.32 Current Rose Plot (First ADCP Deployment), Depth=0.4 m

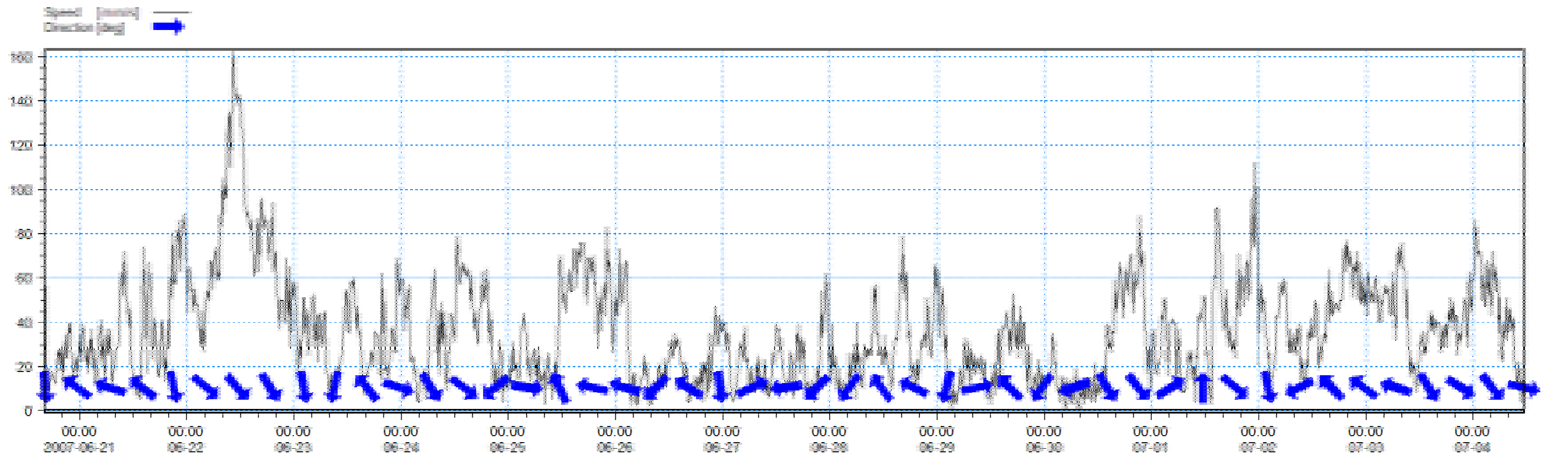


Figure 3.33 Time Series Current Plot (Second ADCP Deployment), Depth=17.4 m

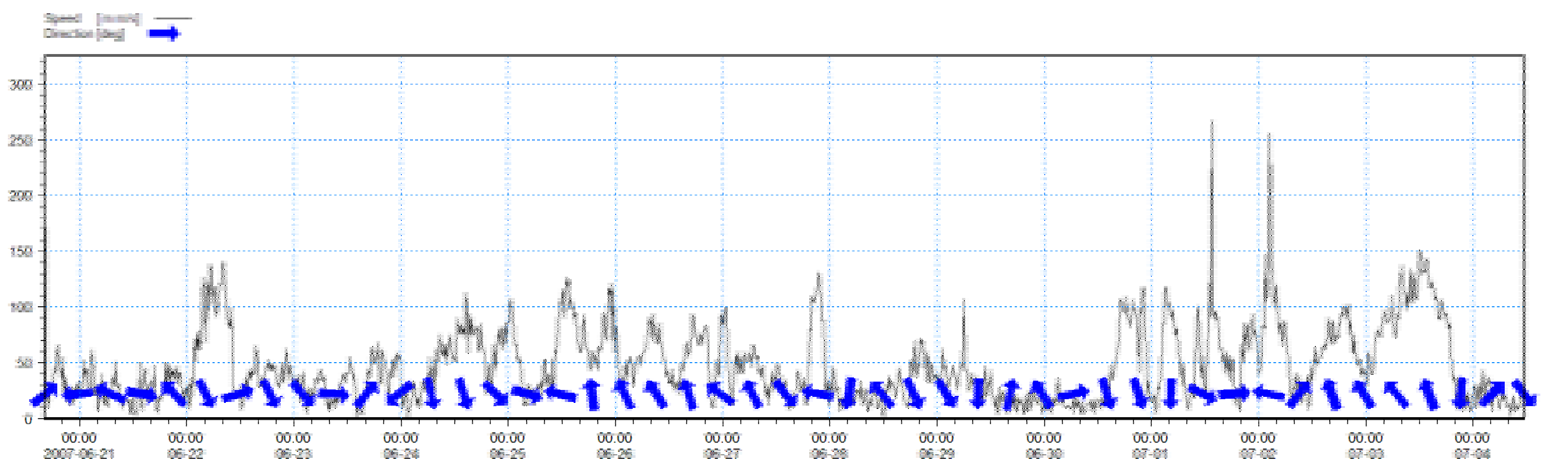


Figure 3.34 Time Series Current Plot (Second ADCP Deployment), Depth=9.4 m

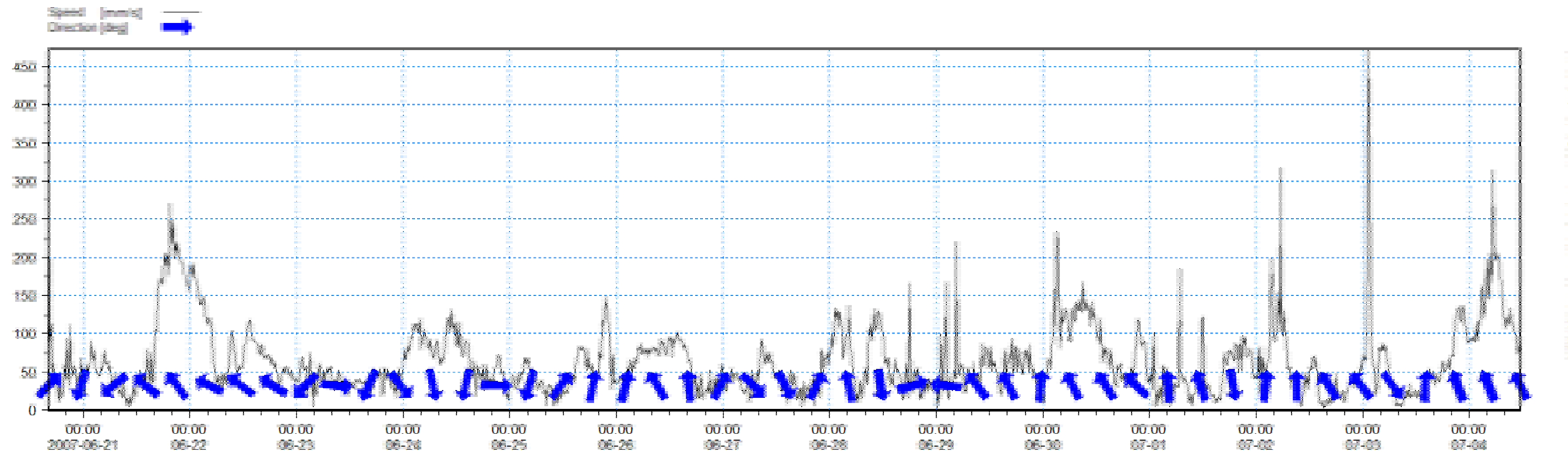


Figure 3.35 Time Series Current Plot (Second ADCP Deployment), Depth=0.4 m

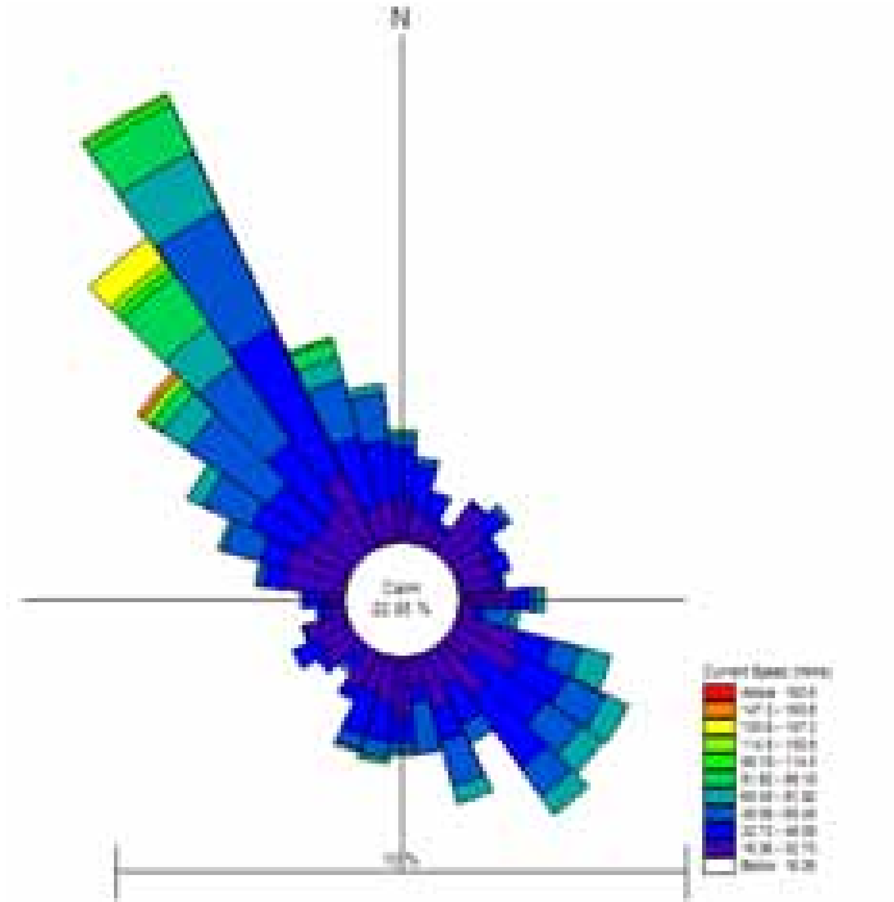


Figure 3.36 Current Rose Plot (Second ADCP Deployment), Depth=17.4 m

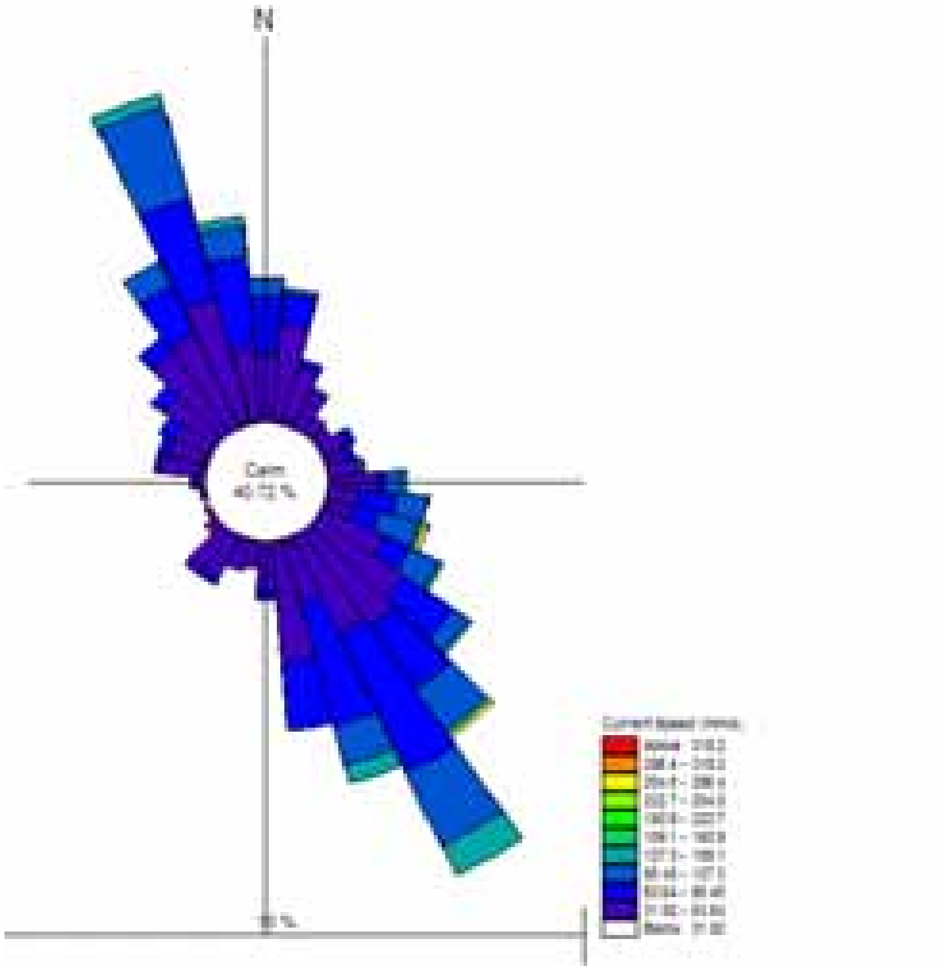


Figure 3.37 Current Rose Plot (Second ADCP Deployment), Depth=9.4 m

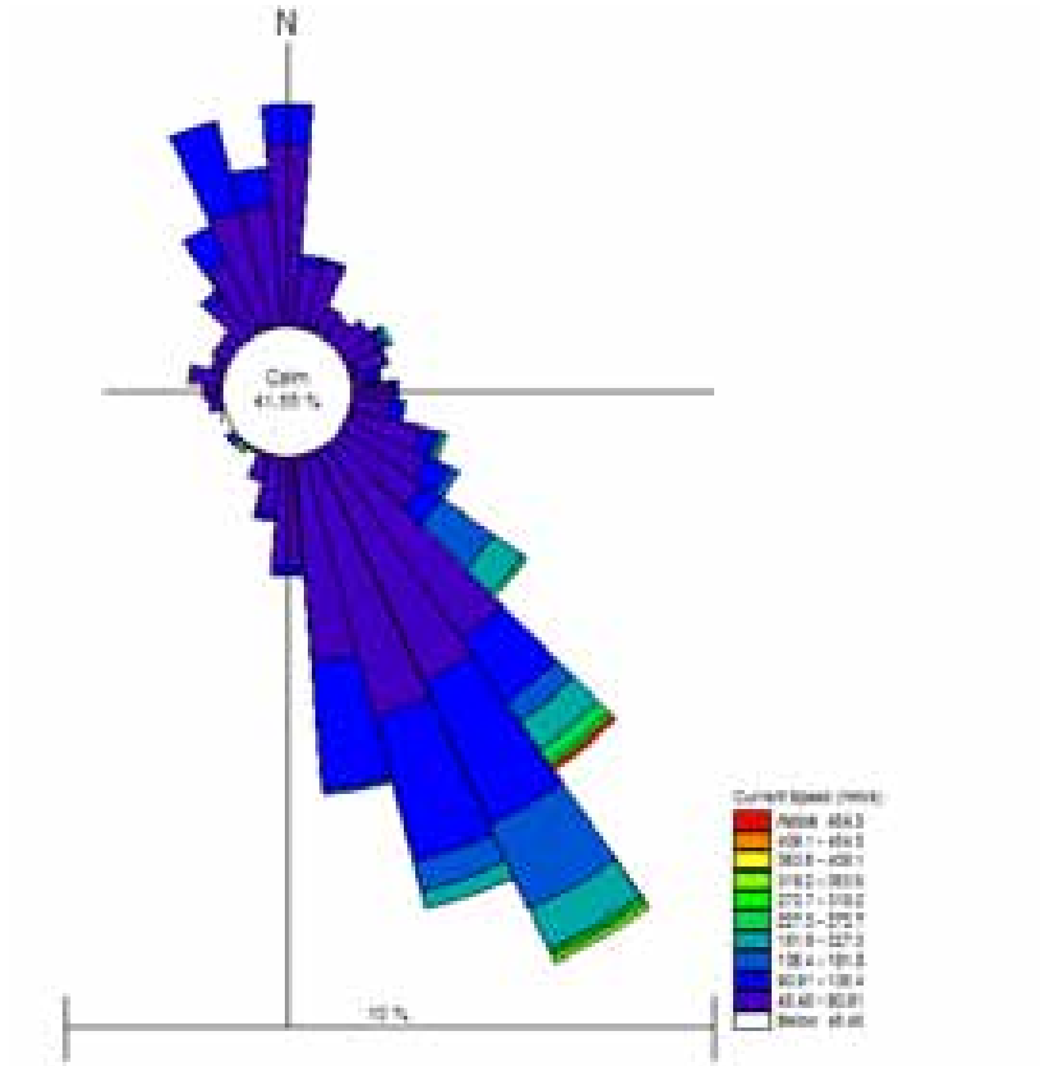


Figure 3.38 Current Rose Plot (Second ADCP Deployment), Depth=0.4 m

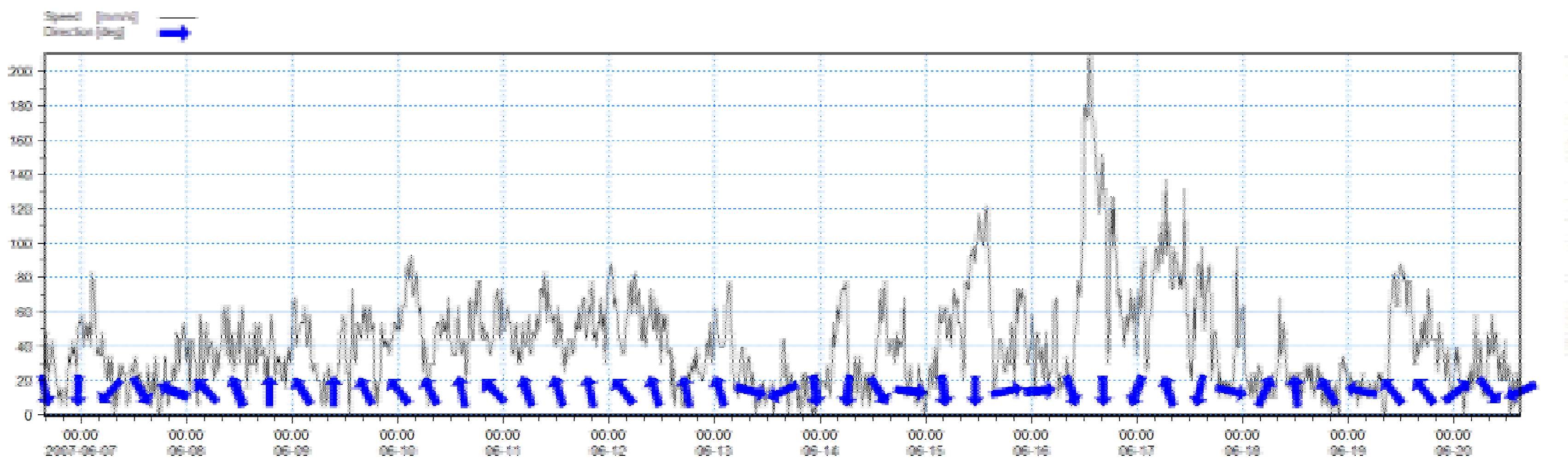


Figure 3.39 Time Series Current Plot (RCM9 Deployment), Depth=14 m

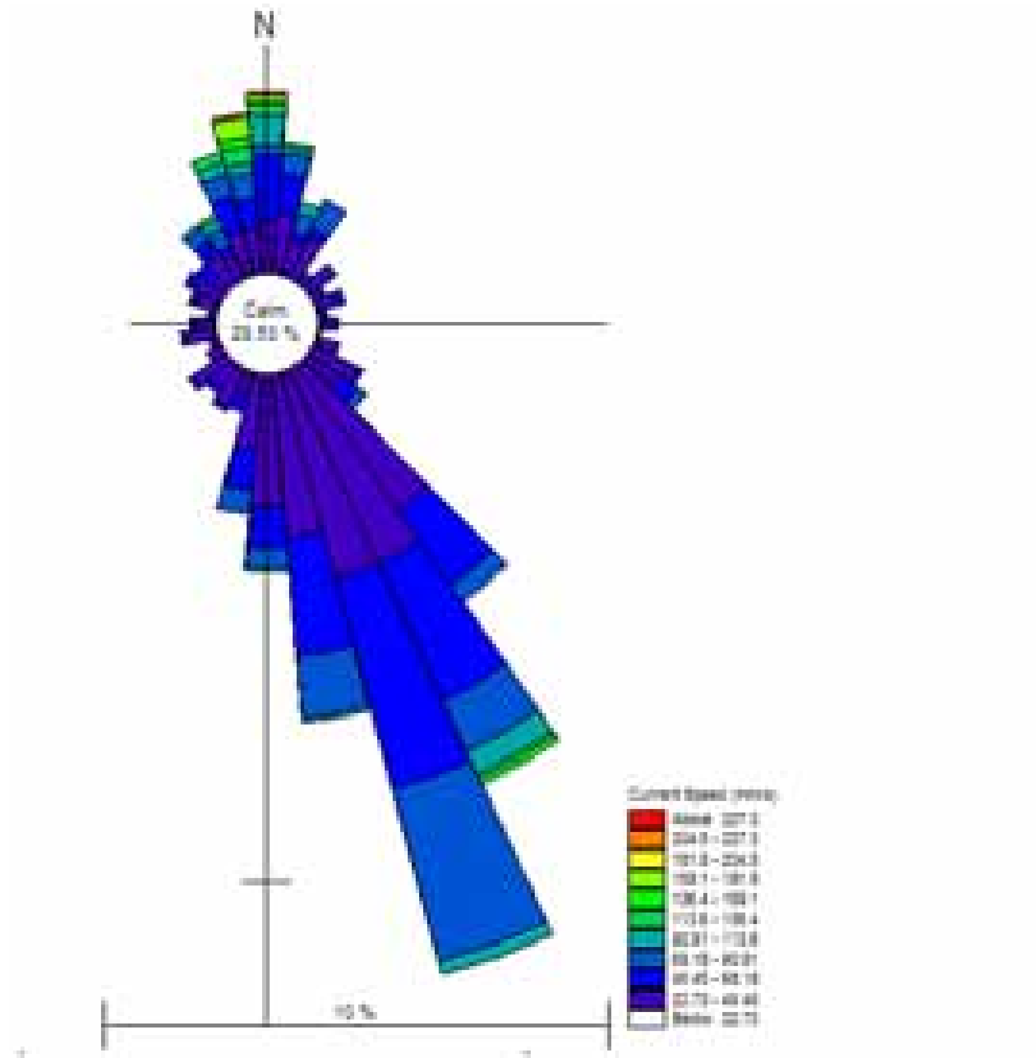


Figure 3.40 Current Rose Plot (RCM9 Deployment), Depth=14 m

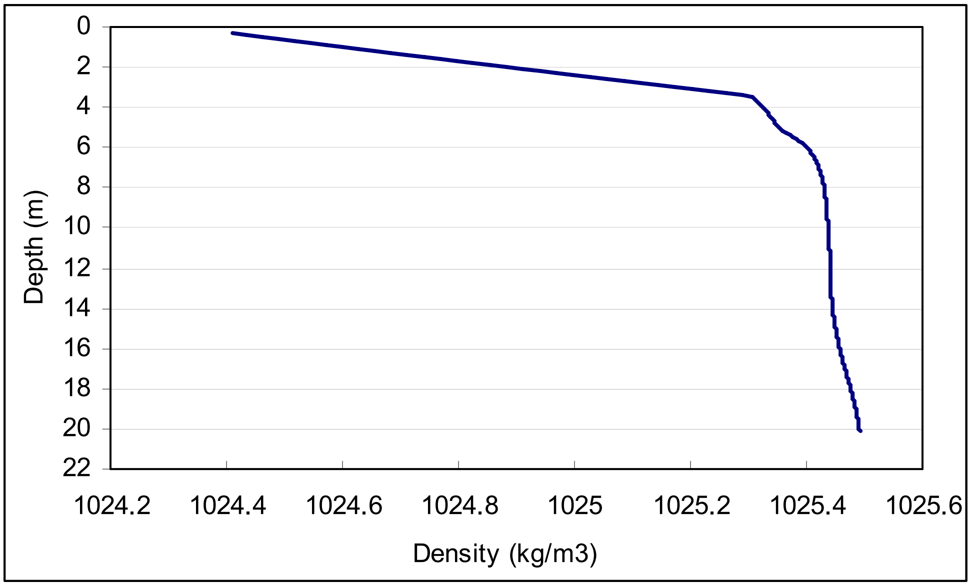


Figure 3.41 Density Profile (47º 48'02.18" N, 54º 03'59.59" W), June 06, 2007

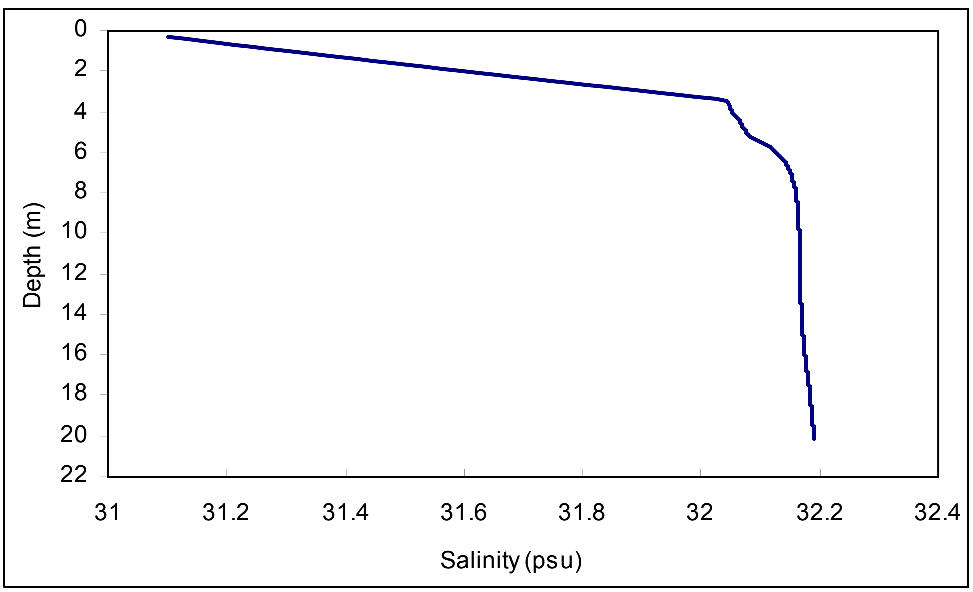


Figure 3.42 Salinity Profile (47º 48'02.18" N, 54º 03'59.59" W), June 06, 2007

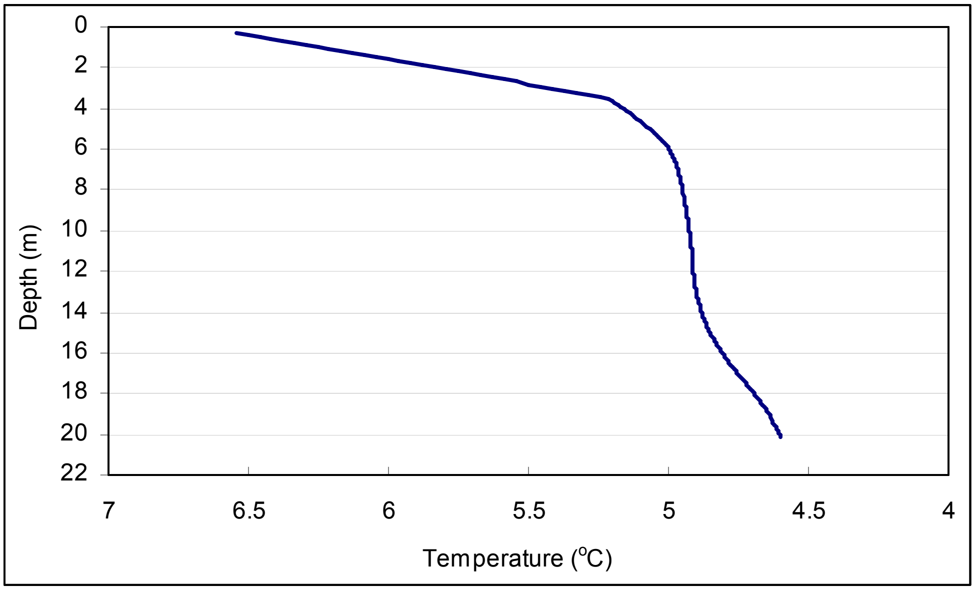


Figure 3.43 Temperature Profile (47º 48'02.18" N, 54º 03'59.59" W), June 06, 2007

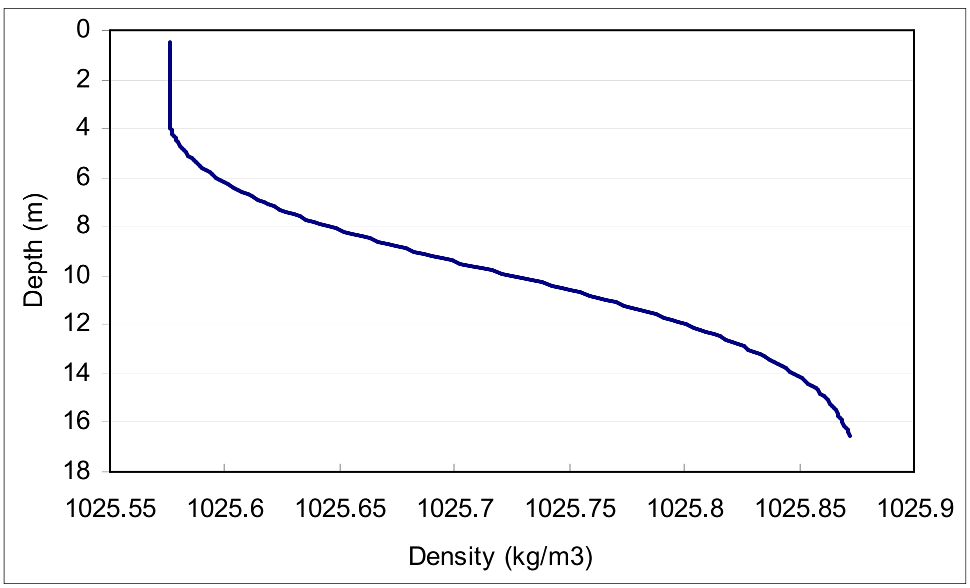


Figure 3.44 Density Profile (47º 47'58.52" N, 54º 04'14.40" W), June 20, 2007

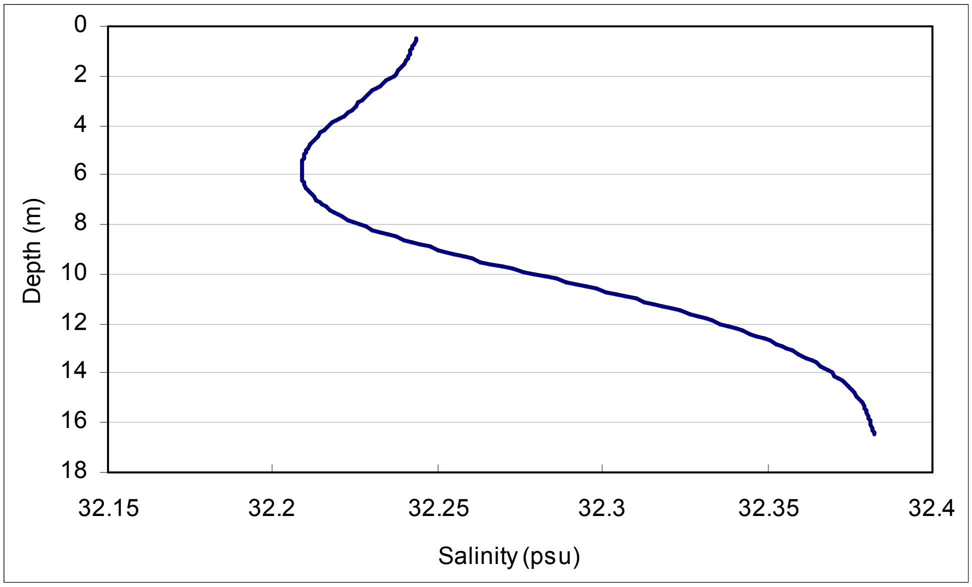


Figure 3.45 Salinity Profile (47º 47'58.52" N, 54º 04'14.40" W), June 20, 2007

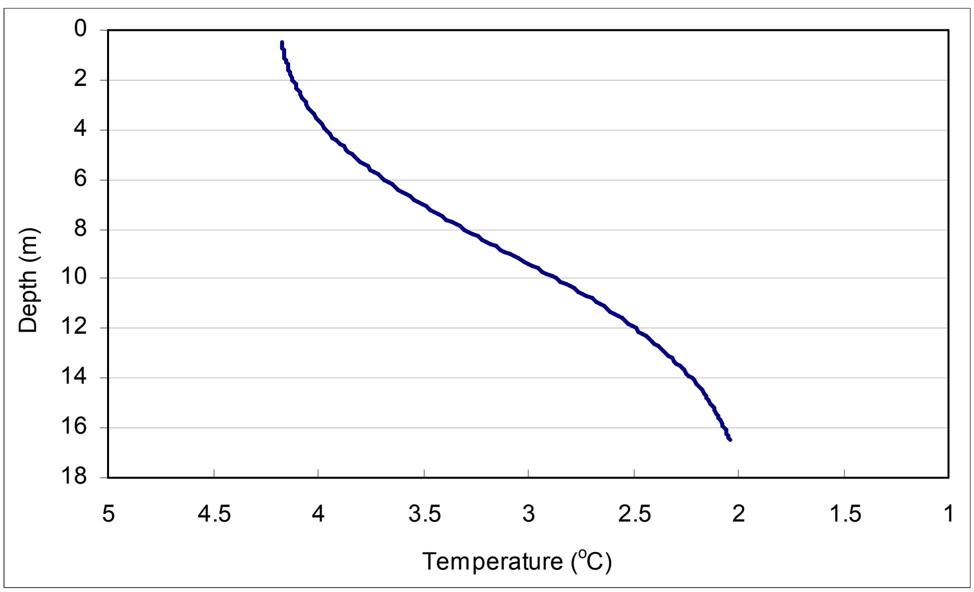


Figure 3.46 Temperature Profile (47º 47'58.52" N, 54º 04'14.40" W), June 20, 2007

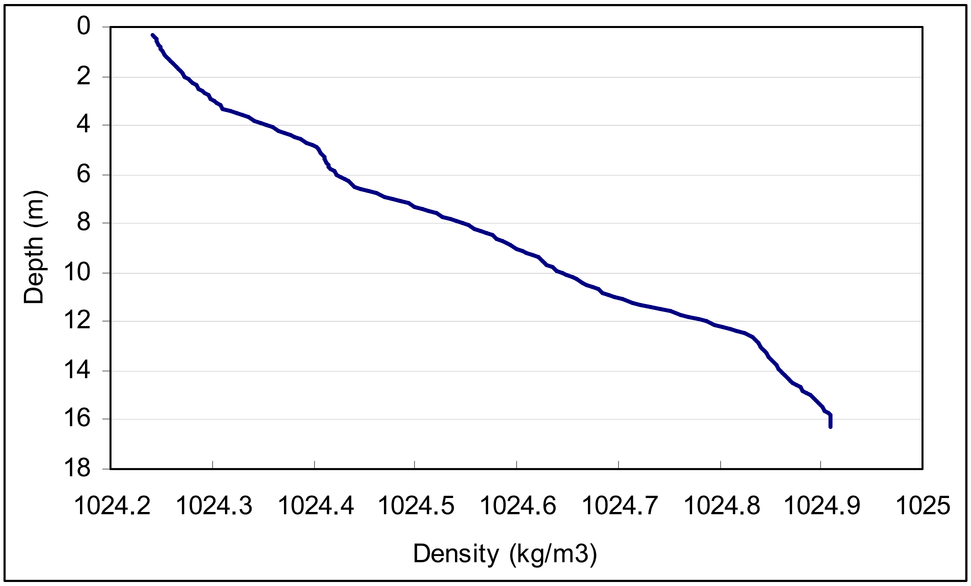


Figure 3.47 Density Profile (47º 47’58.52” N, 54º 04’14.40” W), July 04, 2007

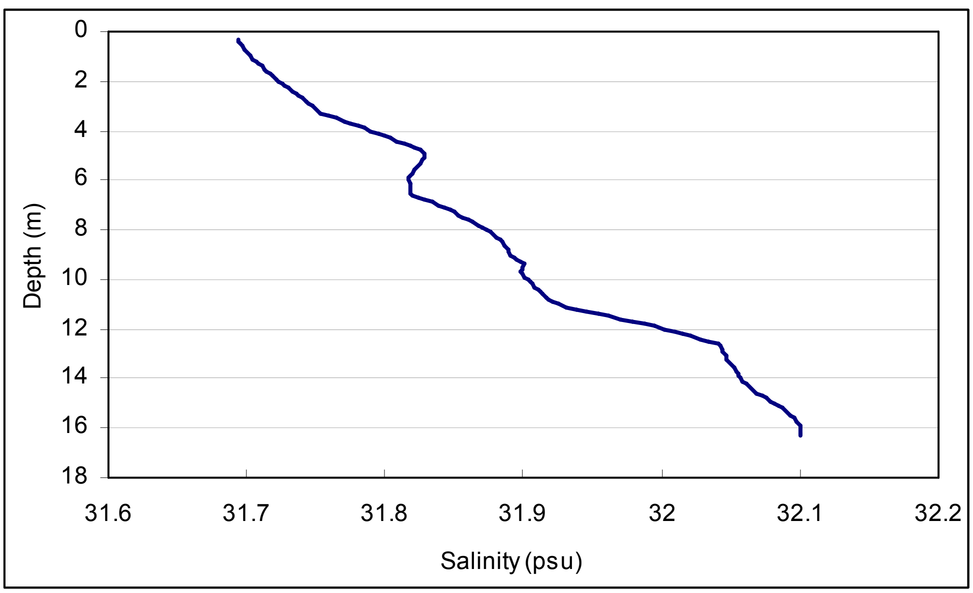


Figure 3.48 Salinity Profile (47º 47’58.52” N, 54º 04’14.40” W), July 04, 2007

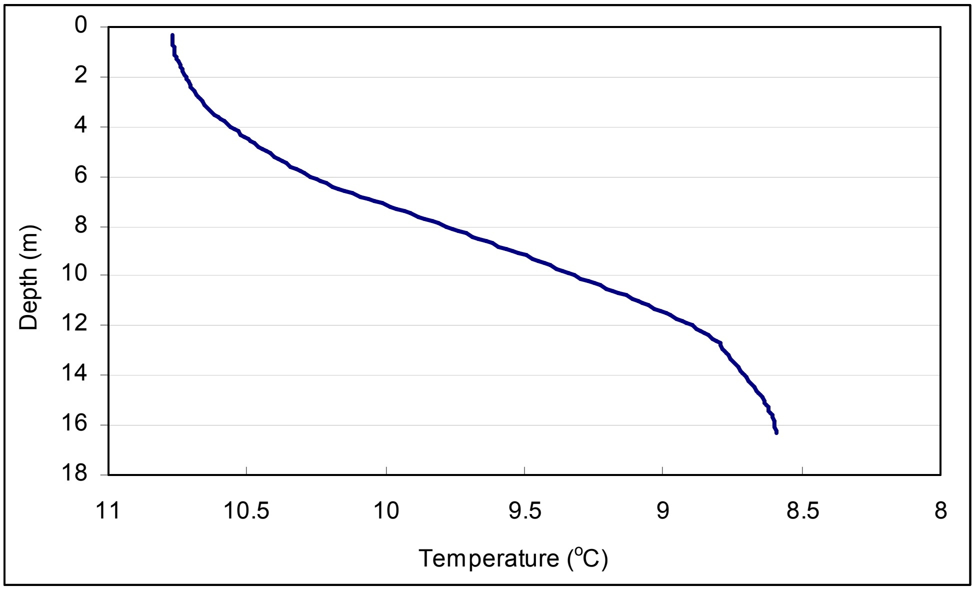


Figure 3.49 Temperature Profile (47º 47'58.52" N, 54º 04'14.40" W), July 04, 2007

3.5.5 Tides

Information on tides for Come By Chance are summarized in Table 3.9. On an annual basis, the mean water level is 1.39 m. The minimum height is 0.2 m and the maximum is 2.6 m.

Table 3.9 Statistics for Tide Height (m) for Come By Chance

Parameters	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Year
Mean	1.39	1.39	1.40	1.39	1.39
Standard Error	0.04	0.04	0.04	0.04	0.02
Median	1.10	1.15	1.40	1.45	1.20
Mode	2.00	0.60	2.10	2.10	2.10
Standard Deviation	0.76	0.72	0.73	0.73	0.74
Sample Variance	0.58	0.52	0.54	0.53	0.54
Minimum	0.20	0.30	0.20	0.30	0.20
Maximum	2.60	2.50	2.60	2.50	2.60
Number of Data	350	352	360	356	1418

3.5.6 Waves

In characterizing the sea state of Placentia Bay, wind generated waves, swell, and wind generated waves in combination with one or more swell groups are considered. The magnitude of wind generated waves is controlled by wind velocity and duration, and fetch. As wind speed increases so to does the intensity of waves, given that the wind blows long enough and the fetch is adequate in length. Swells are usually not formed locally by wind but may form at some distance away and propagate to the vicinity of the observation area. Swell waves travel out of stormy or windy areas in the direction of the wind that originally formed them as wind waves. Waves in a large embayment may intensify when locally-formed wind-generated waves combine with the swell.

In the absence of long-term wave measurements for Placentia Bay and the project area, wave data from the MAST dataset, the SmartBay Buoy, and 30 year hindcast developed by SNC Lavalin in 1996 were used for wave climate analysis. Statistics in the following graphs are provided primarily from Wave/Swell Height and Wave/Swell Period. Wave/Swell Height is measured as the vertical distance separating the crest from the trough of a wave and Wave/Swell Period is the time it takes two successive crests to pass a fixed point.

Monthly wave analysis for Placentia Bay is based on long-term MAST data and information from the SmartBay Buoy located at the mouth of the bay from August 2006 to February 2007 and June 2007. The SmartBay Buoy did not record data for March, April, May of 2007.

Wind Generated Waves

Wind generated wave height statistics from the MAST dataset show that the mean wave height ranges from 0.9 m in September to 1.7 m in November and January. The maximum wave height can reach up to 9.5 m in November. On average the wave period is between 5 to 6 seconds. However, maximum wave periods of 16 seconds have been recorded in February. Waves in Placentia Bay most frequently originate from the west and southwest.

Swell Waves

The monthly swell statistics from the MAST dataset for the bay indicate that the mean swell height ranges from 1.2 m in August to 2.5 m in December. The maximum swell heights are often during the winter months (Dec – Mar) ranging from 4.6 m to 6 m. The median swell period is approximately 6 to 8 seconds throughout the year. Maximum swell periods of 20 seconds are recorded in February. The most frequent swell directions are south and southwest for most of the year. However, in November and December swells are predominately from the east-southeast direction.

Combined Waves

The monthly combined (wind generated waves and swell) wave statistics are shown in Figure 3.50 and Figure 3.51. The mean combined wave height ranges from 1.0 m in July to 2.1 m in December. Maximum combined wave height has been recorded at heights of 9.5 m in November. Throughout the year the median combined wave period is about 5 to 6 seconds and maximum combined wave periods of 16 seconds have been identified in October and February. Combined wave directions are normally west and southwest for most of the year except

December, when combined wave direction is from the east. Figure 3.52 shows the frequency of combined wave height by direction.

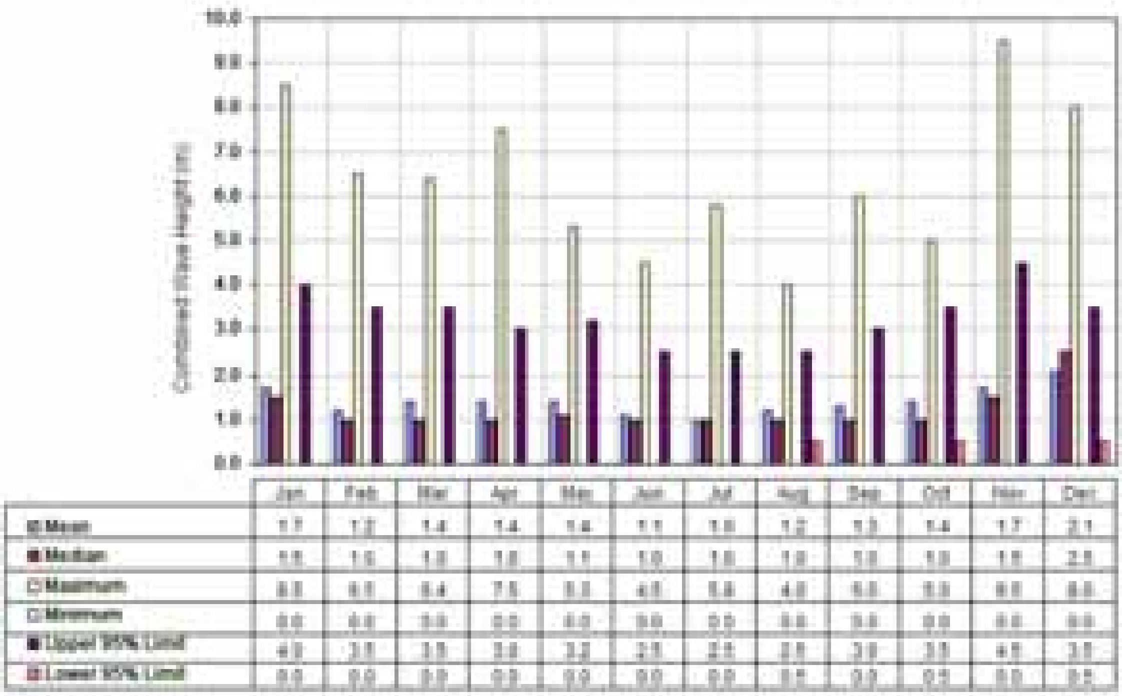


Figure 3.50 Statistics of Combined Wave Height by Month (1886-1989)

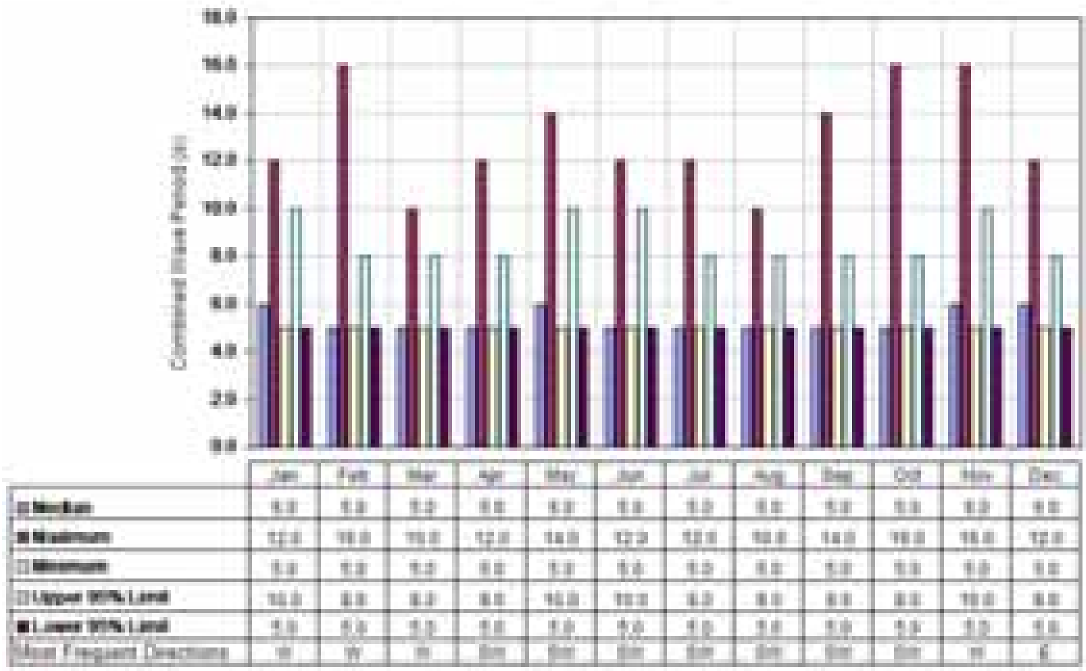


Figure 3.51 Statistics of Combined Period and the most Frequent Directions by Month (1886-1989)

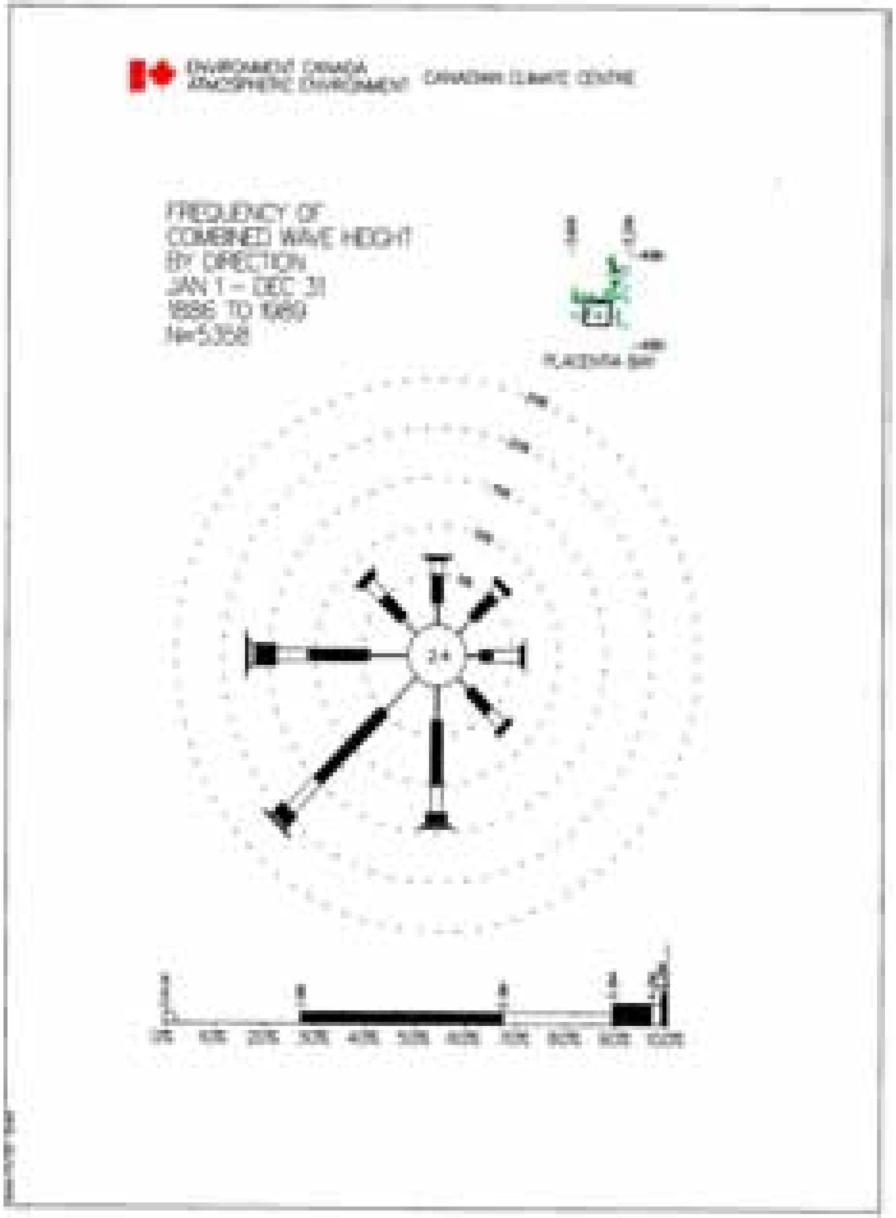


Figure 3.52 Frequency of combined Wave height by Direction

Figure 3.53 and Figure 3.54 show wave measurements from an eight month wave dataset collected by the SmartBay Buoy at the mouth of the bay. It is difficult to compare the MAST data and the SmartBay information given the short period of the SmartBay dataset. However, from the information provided, both datasets exhibit comparable wave heights. The mean wave height ranges from 1.0 m in June to 2.8 and 2.9 in January and February. The maximum wave height reached 9.1 m in January. Waves are predominately from the Southwest.

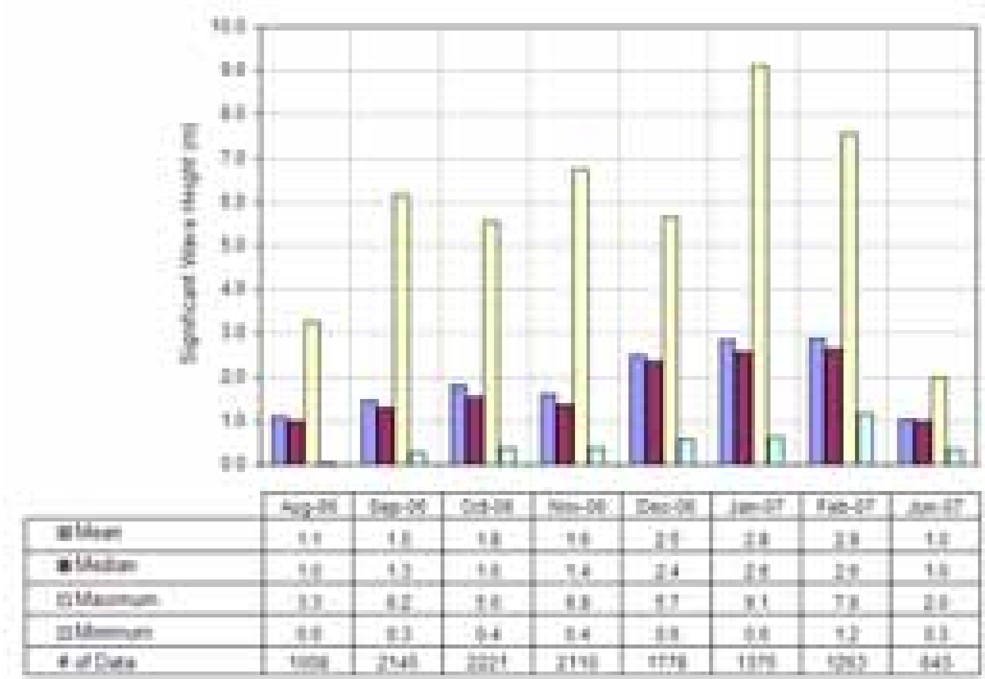


Figure 3.53 Monthly Statistics of the Significant Wave Height (August 2006- June 2007)

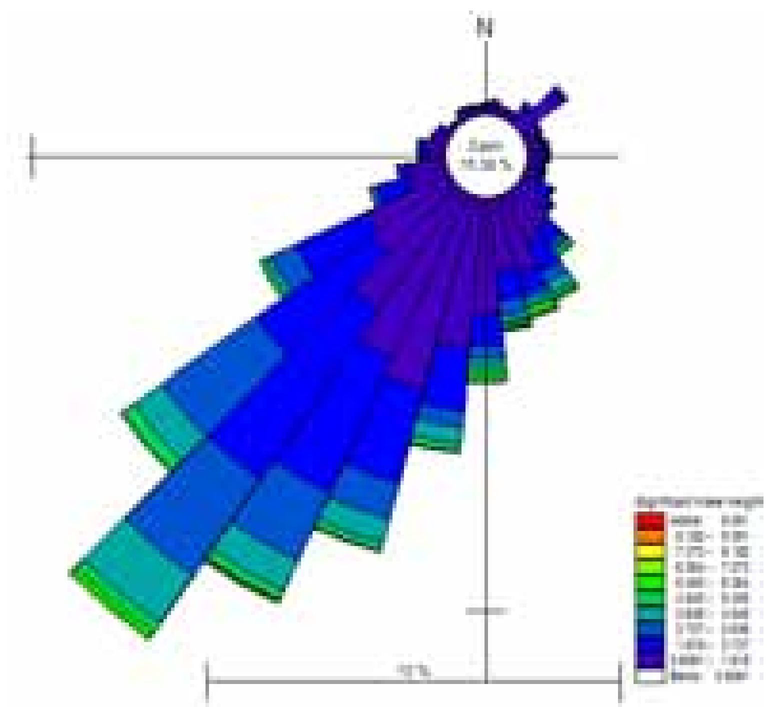


Figure 3.54 Frequency of Wave Height by Direction (August 2006- June 2007)

Very limited wave data is available for the project areas. Wave measurements obtained from the SmartBay Buoy 3 near the project site in June 2007 were analyzed and plotted in Figure 3.55. It can be seen that the dominant wave direction measured in this period is south. About 59 per cent percent of the wave has a significant wave height less than 0.24 m. The maximum significant wave height is above 1.13 m.

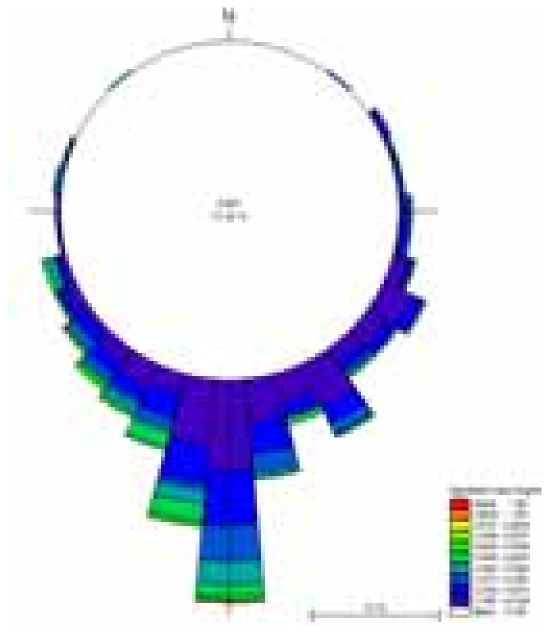


Figure 3.55 Measured Waves at Come By Chance by SmartBay Buoy 3

Long-term wave patterns in the vicinity of the project area were analyzed using 30-years wave hindcasts for Come By Chance and Whiffen Head. 30-year hindcasts for Come By Chance and Whiffen Head were chosen to represent the project area because of their proximity and similarity to the Southern Head region. The data for Come By Chance are summarized in Table 3.10 and Figure 3.56. The mean significant wave height at this site range from 0.19 m in May to 0.24 m in January. The maximum significant wave height is in March, measuring 3.04 m. The most frequent wave direction is from the west and southwest. 71.1 per cent of the wave range from 0.0 m to 0.25 m.

Table 3.10 Monthly and Annual Significant Wave Height statistics Come By Chance 30 Year Hindcast (1966-1995)

Month	Mean (m)	Std Dev (m)	Median (m)	Max (m)	Min (m)	Upper 95 per cent (m)	Most Freq Dir (from)	Num Obs
January	0.24	0.27	0.18	2.80	0.00	0.90	W	7185
February	0.23	0.25	0.17	1.97	0.00	0.80	W	6712
March	0.23	0.27	0.17	3.04	0.00	0.80	W	7422
April	0.21	0.23	0.10	1.74	0.00	0.70	SW	7187
May	0.19	0.21	0.09	1.55	0.00	0.70	SW	7401
June	0.21	0.23	0.09	1.57	0.00	0.70	SW	7157
July	0.22	0.23	0.09	1.79	0.00	0.70	SW	7374
August	0.21	0.23	0.09	1.79	0.00	0.70	SW	7392
September	0.21	0.24	0.09	1.55	0.00	0.70	W	6939
October	0.22	0.25	0.10	2.23	0.00	0.80	W	7395
November	0.22	0.26	0.10	2.14	0.00	0.80	W	7178
December	0.22	0.26	0.10	2.80	0.00	0.80	W	7409
Annual	0.22	0.24	0.10	3.04	0.00	0.80	W	86751

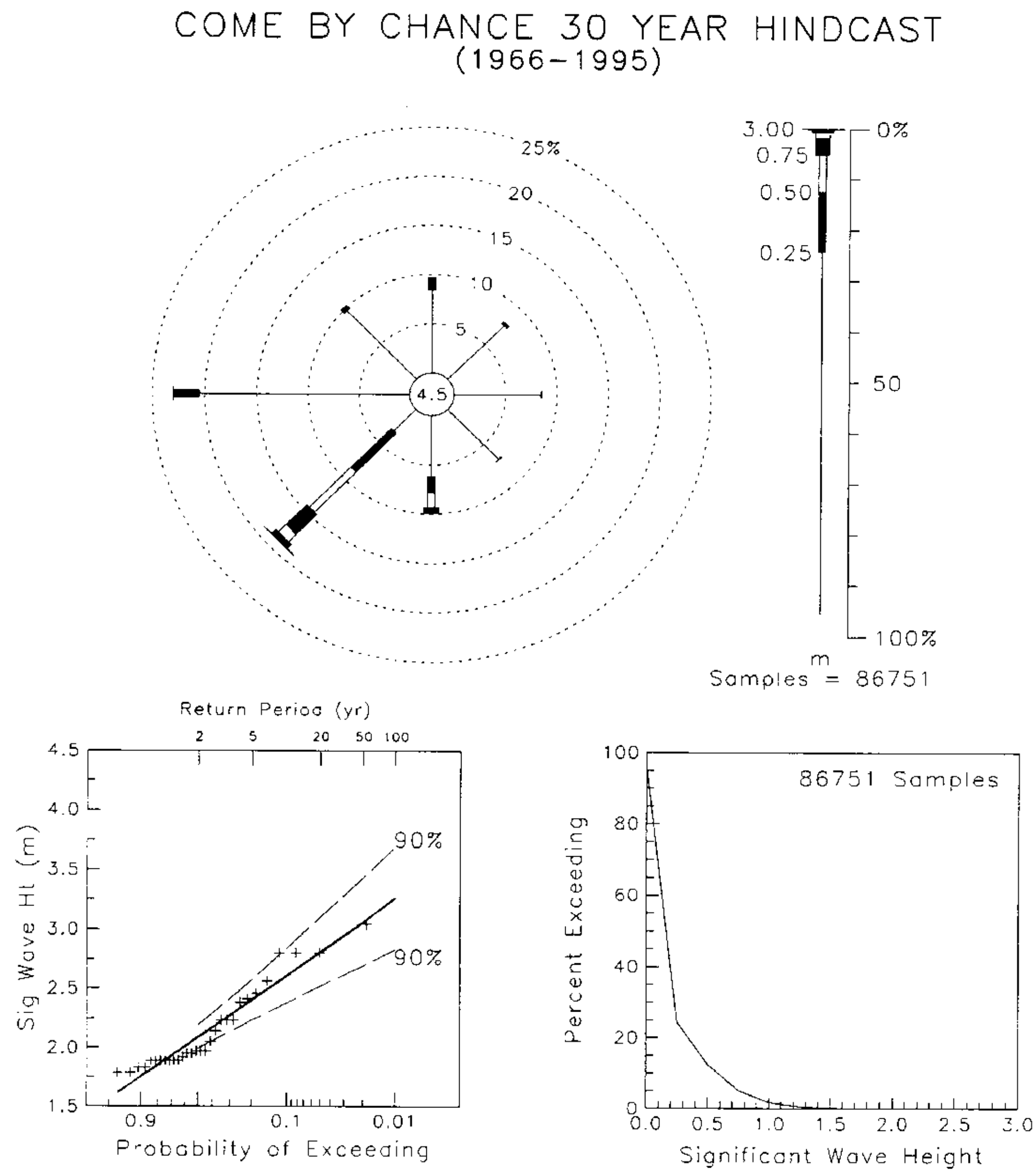


Figure 3.56 Wave Climate Summaries for Come By Chance

The data for Whiffen Head are summarized in Table 3.11 and Figure 3.57. The mean significant wave height at this site ranges from 0.26 m in May to 0.43 m in January. The maximum significant wave height is in December, measuring 3.00 m. The most frequent wave direction is from the west and southwest. 47 per cent of the waves range from 0.0 m to 0.25 m.

Table 3.11 Monthly and Annual Significant wave Height statistics Whiffen Head 30 Year Hindcast (1966-1995)

Month	Mean (m)	Std Dev (m)	Median (m)	Max (m)	Min (m)	Upper 95 per cent (m)	Most Freq Dir (from)	Num Obs
January	0.43	0.36	0.30	2.72	0.00	1.10	W	7185
February	0.40	0.33	0.30	2.47	0.00	1.00	W	6712
March	0.36	0.33	0.29	2.59	0.00	1.00	W	7422
April	0.29	0.27	0.19	2.12	0.00	0.80	SW	7187
May	0.26	0.24	0.19	1.81	0.00	0.80	SW	7401
June	0.27	0.24	0.19	1.52	0.00	0.80	SW	7157
July	0.27	0.23	0.20	2.19	0.00	0.70	SW	7374
August	0.28	0.24	0.20	2.19	0.00	0.80	SW	7392
September	0.30	0.26	0.20	1.74	0.00	0.80	W	6939
October	0.34	0.29	0.29	2.12	0.00	0.90	W	7395
November	0.36	0.32	0.29	2.50	0.00	1.00	W	7178
December	0.39	0.35	0.29	3.00	0.00	1.10	W	7409
Annual	0.33	0.30	0.20	3.00	0.00	0.90	W	86751

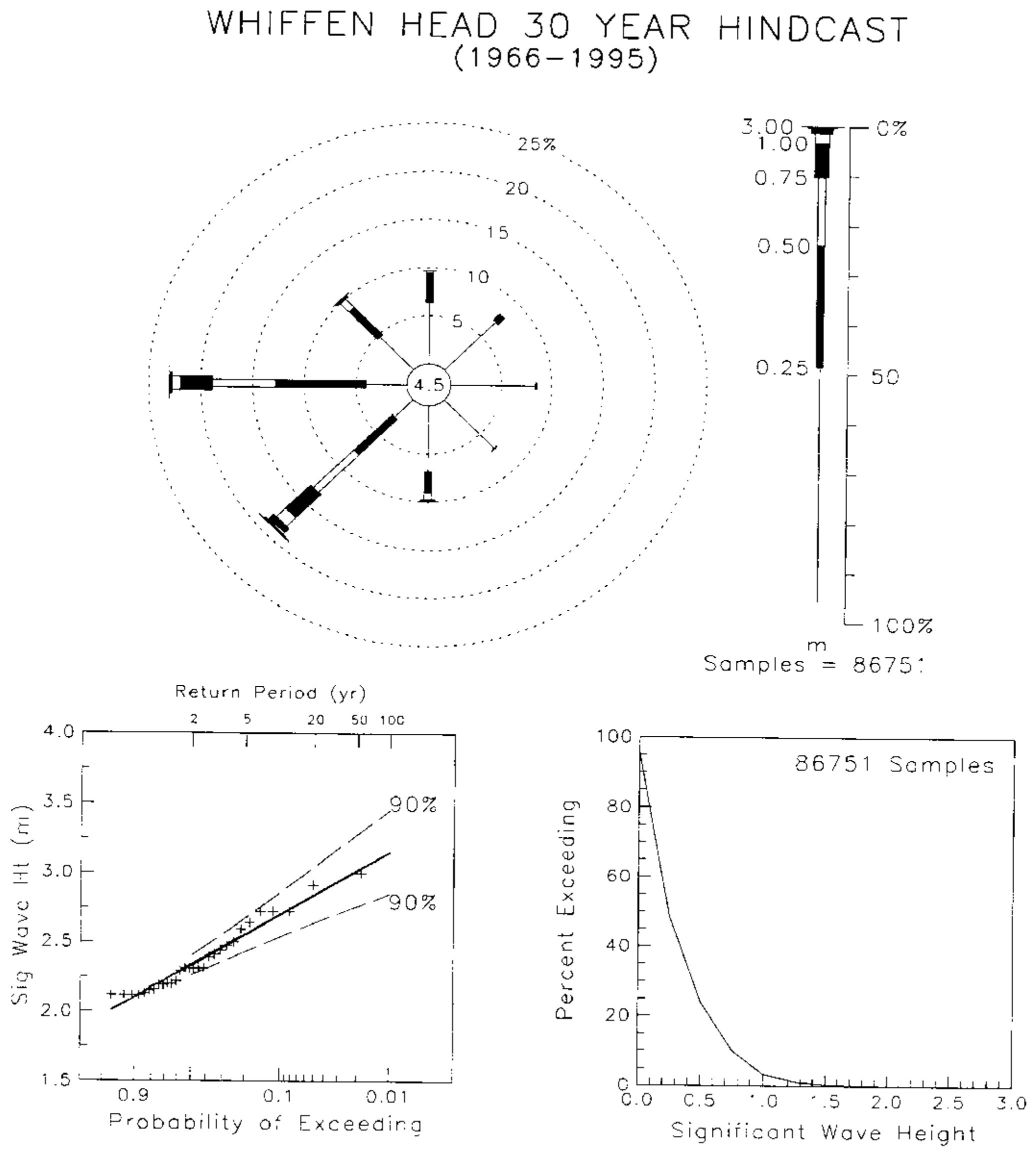


Figure 3.57 Wave Climate Summaries for Whiffen Head

3.5.7 Water Temperature

Sea surface temperatures for Placentia Bay have been extracted from the MAST data and obtained from the SmartBay Buoy 1. Figure 3.58 shows monthly temperature statistics from the MAST data. The mean monthly surface temperatures range from –0.2 ºC in February and March to 13.9 ºC in August. The minimum temperature is –2.8 ºC in February, March, and April and the maximum is 21.1 ºC in August.

Monthly temperature statistics from SmartBay Buoy 1 are shown in Figure 3.59. The mean monthly surface temperatures ranges from –0.23 C in February to 16.69 C in August. The minimum temperature is –0.8 C in February, and the maximum is 22.85 C in August.

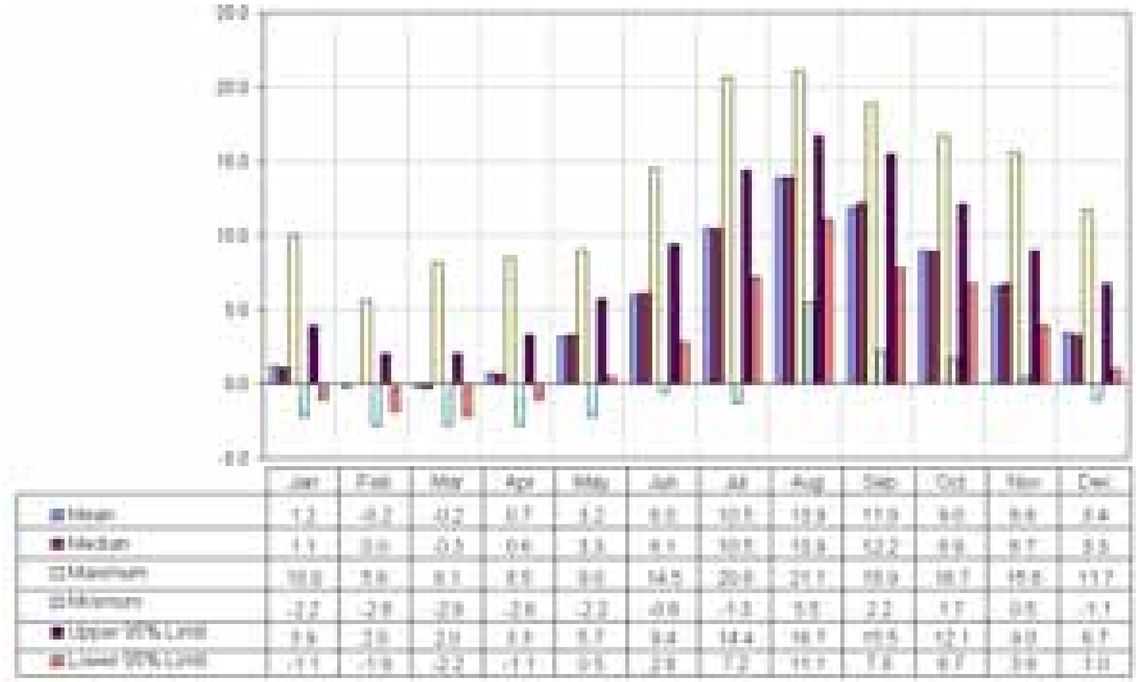
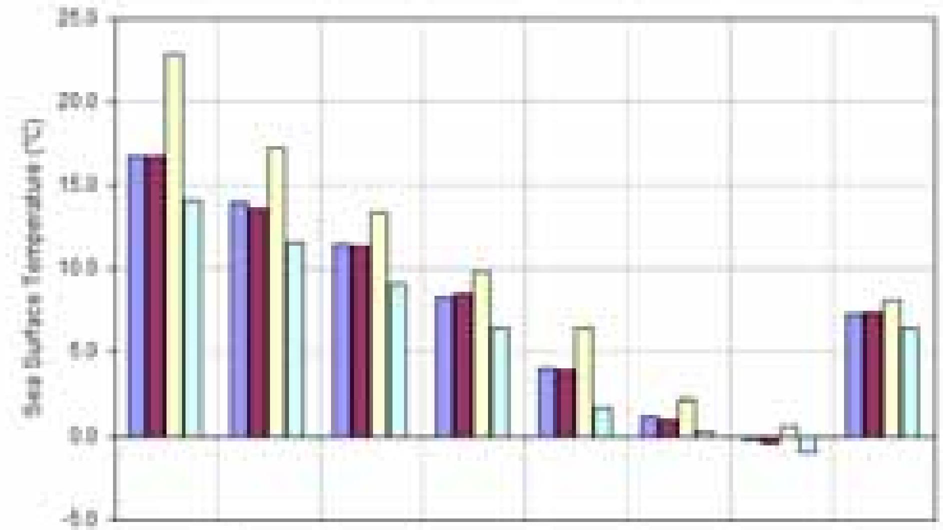


Figure 3.58 Monthly Sea Surface Temperature Statistics from MAST Data (1889 – 1989)



	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07	Feb-07	Jun-07
Mean (°C)	16.7	14.0	11.4	8.3	4.0	1.3	-0.2	7.2
Median (°C)	16.8	13.6	11.4	8.5	3.9	1.0	-0.4	7.3
Maximum (°C)	22.9	17.3	13.3	9.8	6.5	2.2	0.6	8.1
Minimum (°C)	14.1	11.6	9.1	6.4	1.7	0.3	-0.9	6.4
# of Data	1097	2141	2221	2110	1778	1376	1263	643

Figure 3.59 Monthly Sea Surface Temperature Statistics from SmartBay Buoy 1 (August 2006-June 2007)

3.5.8 Sea Ice and Icebergs

The south coast of Newfoundland is considered to be relatively ice-free and have open water on a year-round basis. When ice intrusion does occur in this area, episodes are usually brief and affect a very limited area (DFO 1986). Two types of ice are found in Placentia Bay: land-fast ice that is locally formed and is anchored to the shoreline, and pack-ice that is composed of loose pieces of ice, formed independently of the land-fast ice and drifts with currents (Steel 1983).

Figure 3.60 depicts the frequency of sea ice in Placentia Bay. Analysis of the Canadian Ice Service's 30-Year Frequency of Presence of Ice in Placentia Bay showed that ice is only present in the bay from mid February until late April. The shading of the bar provides the frequency of occurrence and the height of the bar gives the percentage coverage of ice in the bay.

This figure also shows that the likelihood of ice occurring in Placentia Bay is highest during the week of February 26. At this time there is 4 per cent chance that 11.5 per cent of the Bay is ice covered, 42.6 per cent likelihood that 7 per cent of the Bay is ice covered, and a 45.7 per cent chance that 10 per cent of the Bay is ice covered. The types of ice during this time period include new ice, which is predominant, grey ice, and grey-white ice. The presence of sea ice within the bay begins to decrease in early April. By the latter part of April ice present in the bay is insignificant.

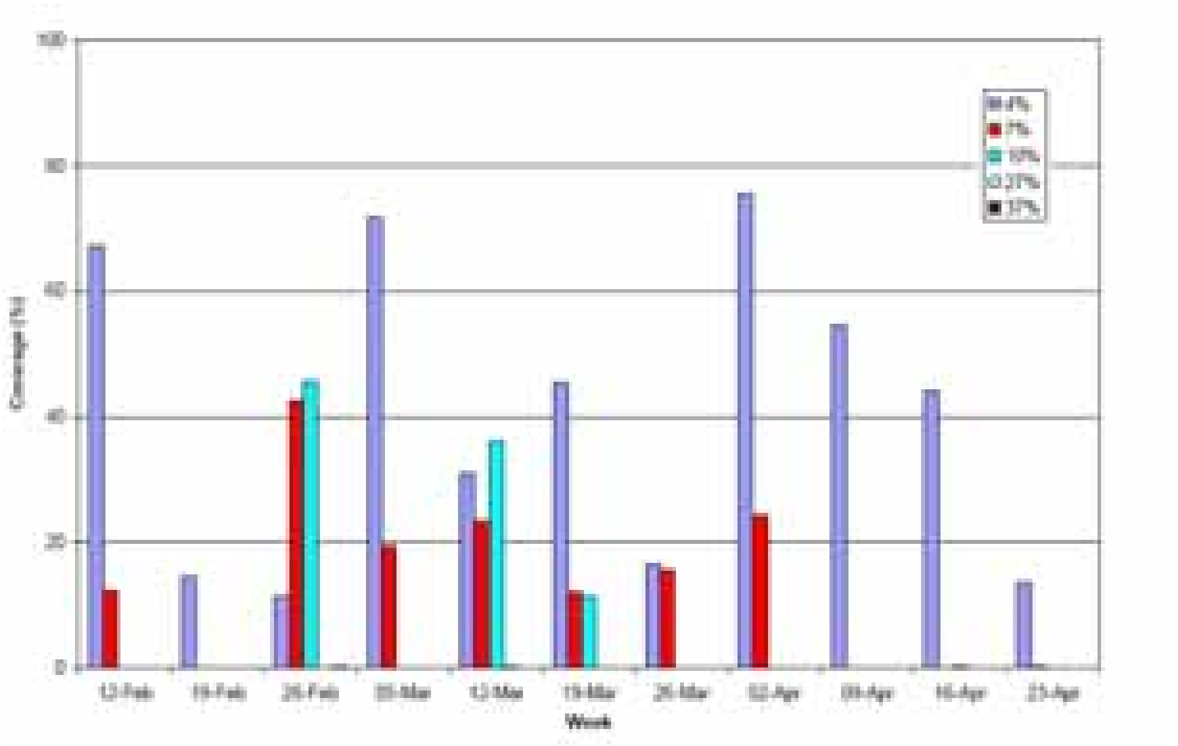


Figure 3.60 Frequency of Sea Ice in Placentia Bay (1971-2000)

Icebergs may occasionally be transported far enough west to enter Placentia Bay. However, the transport of icebergs to this region is highly dependent upon appropriate wind conditions and local currents. A minor drift pattern of icebergs moving along the southern east coast of Newfoundland following the inshore branch of the Labrador Current exists (Dinsmore 1972). Given the variable flow of the Labrador Current, the potential does exist for a small number of icebergs to be carried to this region in years when iceberg numbers, favourable winds, and increased volume transport of the Labrador Current coincide (Fudge and Associated 1988). The occurrence of icebergs is generally limited to the period between April and June.

Figure 3.61 shows the position of all icebergs within Placentia Bay from 1974-2003 compiled by LGL 2006. Over the 30-year period, only 30 icebergs have been sighted and recorded. Since icebergs are transported from the east it is not surprising that the iceberg sightings occurred more frequently on the eastern side of Placentia Bay. Heavy ice and small icebergs have been recorded as far north as Come By Chance (MacLaren Plansearch 1980).

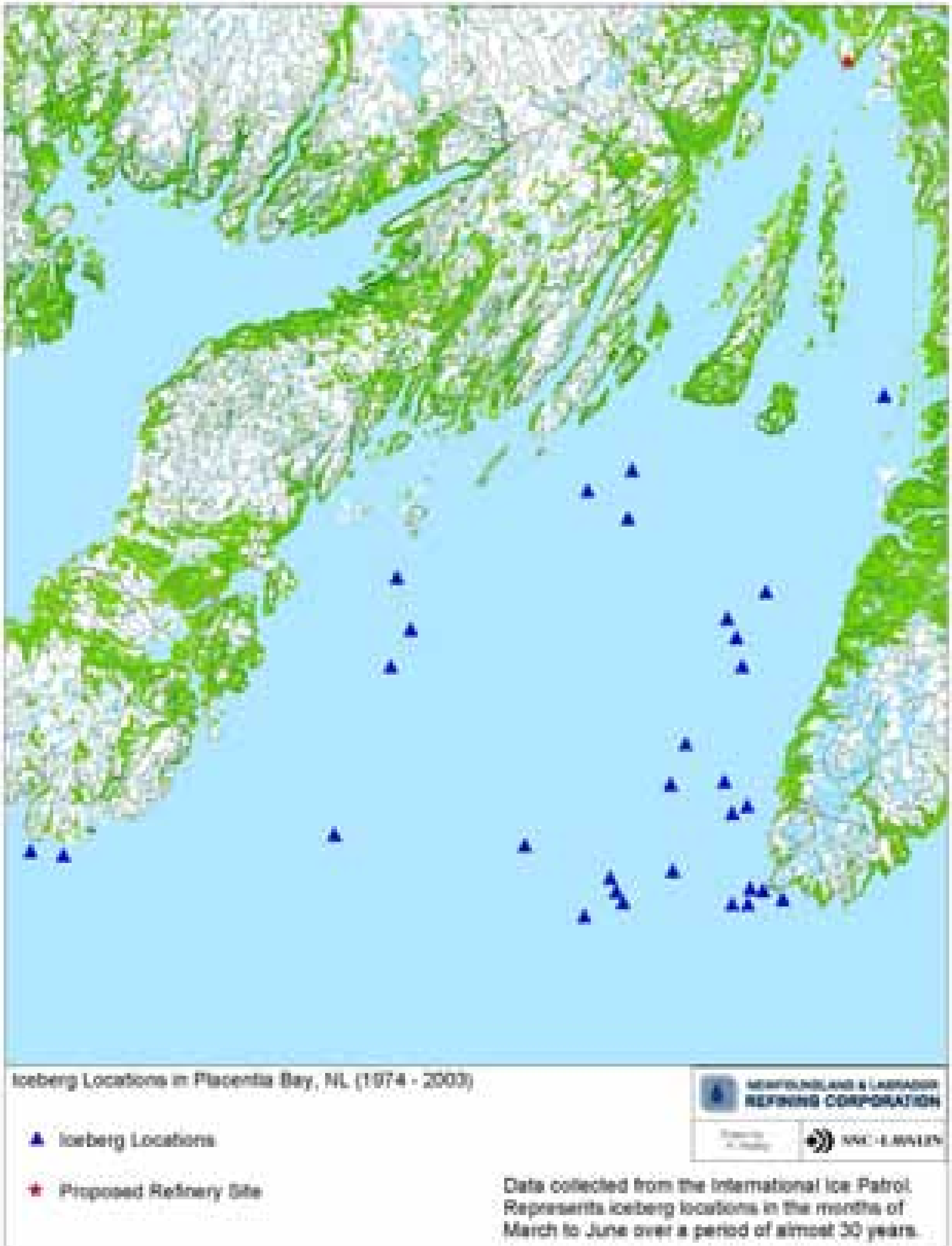


Figure 3.61 Iceberg Sighting Locations (1974-2003)

Figure 3.62 shows the number of iceberg sightings in Placentia Bay per year from 1974-2003. From the 30-year analysis sightings were recorded for only seven years. Icebergs were not present for the remaining 23 years.

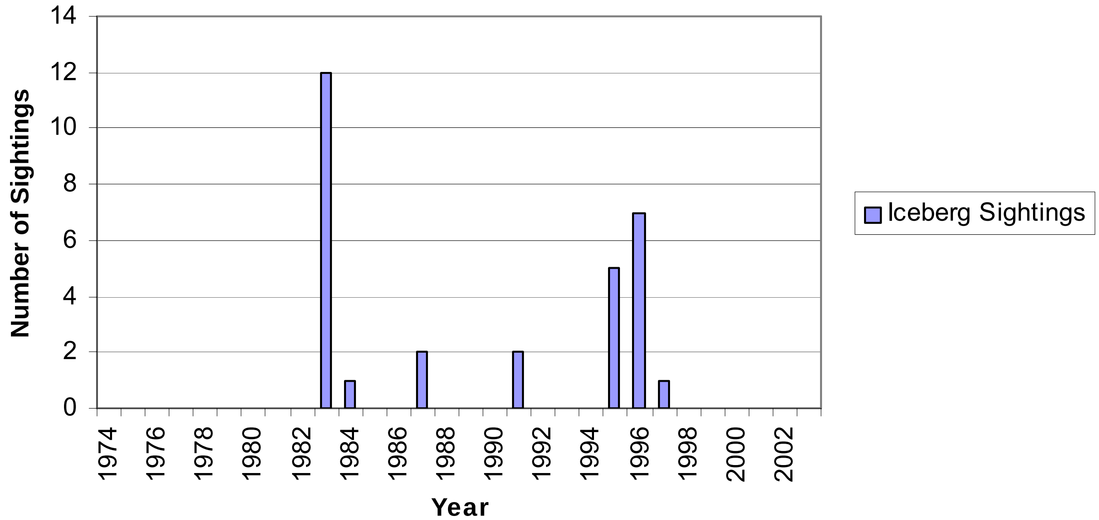


Figure 3.62 Iceberg Sightings in Placentia Bay (1974-2003)

3.5.9 Marine Water Quality

Data to assess water quality within the project area includes the results of the Come By Chance Refinery's environmental effects monitoring program (2002) and an assessment conducted for NLRC by AMEC (2007) within the marine facilities footprint. Conditions resulting from the AMEC investigation have been described in detail within the Marine Fish and Fish Habitat Component Study. Relative information from both data sources are provided in the following sections where appropriate, to provide the reader with a summary of conditions.

Results of Assessment

Seawater samples were collected from Zone 3 – Marine Water Intake and Zone 4 – Marine Outfall. Samples were collected via Nisken Bottle from the surface (0.5 m below surface), mid-column, and bottom (0.5 m from seafloor) at an offshore and inshore location. Water sample collection locations are illustrated in Figure 3.63. Seawater samples were analyzed for the following parameters:

- General Chemistry
- Metals – Hydrides
- BTEX/TPH (RBCA)
- PAH
- VOC

- TOC

All analytes were either not detected or detected at levels which fall within the range commonly encountered in seawater samples. Marine water chemistry results for Zones 3 and 4 are summarised in Table 3.12 and Table 3.13.

Metals - Hydrides

The only metal which exceeded the Canadian Council of Ministers of the Environment (CCME) guideline (2006) was cadmium, which exceeded at both the Zone 3 – Intake Location and Zone 4 – Outfall Location. Cadmium is a commonly occurring natural metal in the Newfoundland and Labrador environment. It is likely that the cadmium levels detected are attributable to natural background levels.

BTEX/TPH

BTEX/TPH were either not detected or were below the CCME (2006) for all samples from all zones.

PAH

PAHs were not either not detected at the laboratory MDL (laboratory method detection limits) or were below the CCME (2006) for all samples from all zones.

VOC

VOCs were not detected at the laboratory MDL (Method Detection Limit) in all samples.

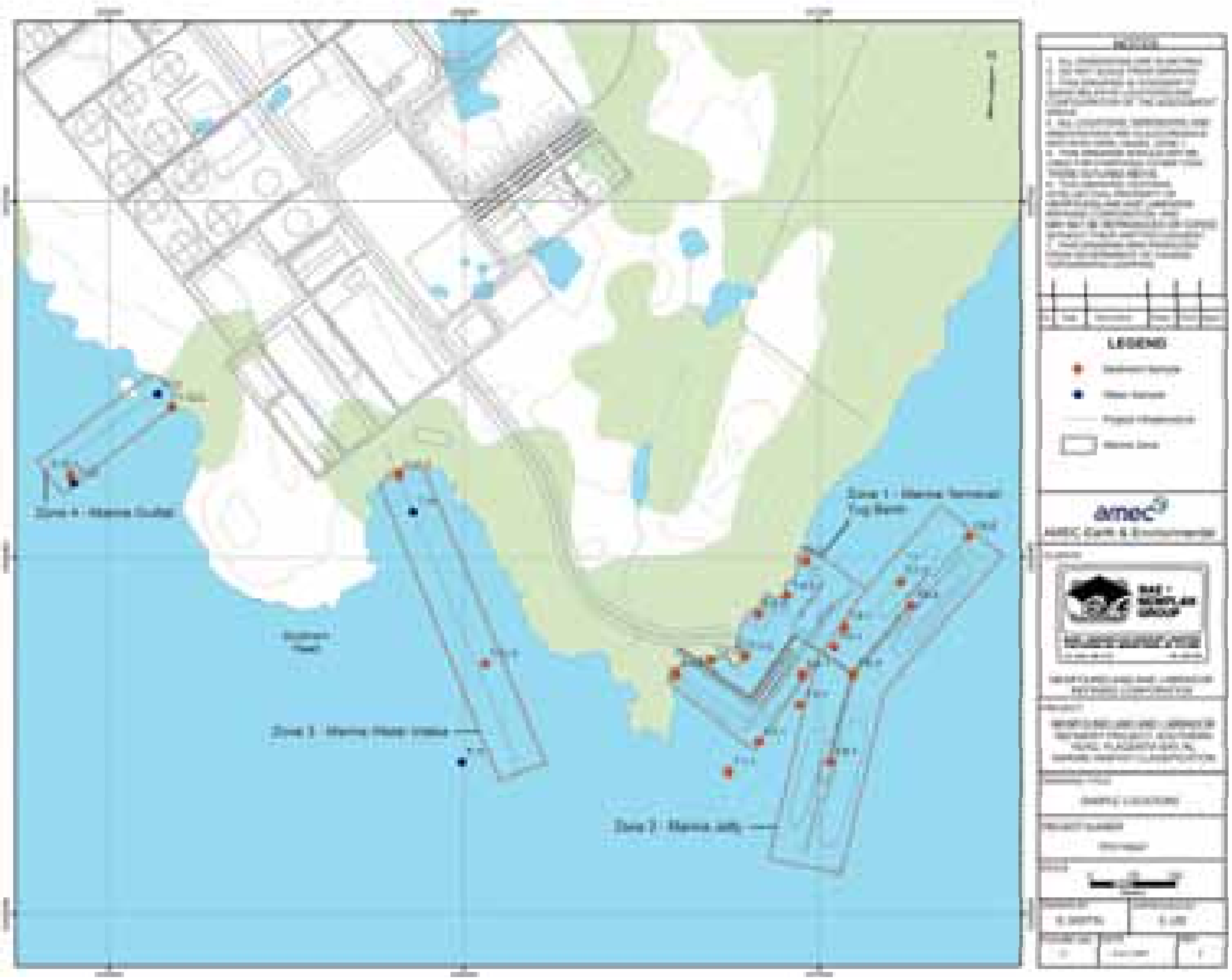


Figure 3.63 Water Sample and Sediment Collection Locations

Table 3.12 Water Chemistry: Zone 3

				Site Name:	Marine Water Intake					
				Sample ID:	T11-1-Top	T11-1-Mid	T11-1-Bot	T11-2-Top	T11-2-Mid	T11-2-Bot
				Sample Area:	Outside	Outside	Outside	Inside	Inside	Inside
				Sample Location:	47°47'35.0"N 54°03'07.0"W	47°47'35.0"N 54°03'07.0"W	47°47'35.0"N 54°03'07.0"W	47°47'57.7"N 54°03'14.7"W	47°47'57.7"N 54°03'14.7"W	47°47'57.7"N 54°03'14.7"W
				Depth (m):						
				Depth relative:						
				Project Number:	TF6116547	TF6116547	TF6116547	TF6116547	TF6116547	TF6116547
				Lab ID:	S2007-08402	S2007-08403	S2007-08404	S2007-08405	S2007-08406	S2007-08407
				Sample Class:	MWS	MWS	MWS	MWS	MWS	MWS
				Sample Number:						
				Sample Type:	P	P	P	P	P	P
				Date Sampled:	18-Jun-07	18-Jun-07	18-Jun-07	18-Jun-07	18-Jun-07	18-Jun-07
				Client Description:						
Parameters	**CCME**	**Method**	**MDL**	**Units**						
Aluminum	ng		0.001	mg/L	<0.001	<0.001	<0.001	0.001	0.005	0.010
Arsenic	0.0125		0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	ng		0.0005	mg/L	0.0046	0.0045	0.0047	0.0046	0.0045	0.0044
Beryllium	ng		0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	ng		0.0005	mg/L	0.0012	0.0007	<0.0005	<0.0005	<0.0005	0.0015
Cadmium	0.00012		0.000015	mg/L	0.000287	0.000170	0.000206	0.000528	0.000316	0.000383
Calcium	ng		0.5	mg/L	341	344	351	354	352	337
Chromium	ng		0.001	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Cobalt	ng		0.001	mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Copper	ng		0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Iron	ng		0.001	mg/L	0.036	0.033	0.043	0.033	0.032	0.034
Lead	ng		0.001	mg/L	0.019	0.022	0.024	0.025	0.027	0.026
Magnesium	ng		0.02	mg/L	1460	1490	1490	1540	1510	1420
Manganese	ng		0.001	mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Molybdenum	ng		0.002	mg/L	0.008	0.007	0.007	0.007	0.007	0.007
Nickel	ng		0.001	mg/L	0.005	0.006	0.004	0.003	0.003	0.004
Phosphorous	ng		0.002	mg/L	0.095	0.101	0.098	0.098	0.104	0.105
Potassium	ng		0.02	mg/L	499	507	517	509	492	475
Selenium	ng		0.001	mg/L	<0.001	<0.001	<0.001 (<0.001)	<0.001	<0.001	<0.001
Silver	ng		0.0001	mg/L	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	<0.0001
Sodium	ng		0.5	mg/L	11900	12100	12600	13200	12700	12800
Vanadium	ng		0.002	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	ng		0.001	mg/L	0.002	0.002	0.002	0.006	0.005	0.004

MSS - Marine Sedime P - Primary   (shaded) Exceeds Metals (CCME ISQG 2006)
N/A - Not Applicable D - Duplicate
NS - Not Sampled
Results in (brackets) represents lab replicate
ng - No Guideline

Table 3.13 Water Chemistry: Zone 4

				Site Name:	Marine Water Outfall					
				Sample ID:	T12-1-Top	T12-1-Mid	T12-1-Bot	T12-2-Top	T12-2-Mid	T12-2-Bot
				Sample Area:	Outside	Outside	Outside	Inside	Inside	Inside
				Sample Location:	47°48'00.0"N 54°04'00.0"W	47°48'00.0"N 54°04'00.0"W	47°48'00.0"N 54°04'00.0"W	47°48'01.1"N 54°03'48.7"W	47°48'01.1"N 54°03'48.7"W	47°48'01.1"N 54°03'48.7"W
				Depth (m):						
				Depth relative:						
				Project Number:	TF6116547	TF6116547	TF6116547	TF6116547	TF6116547	TF6116547
				Lab ID:	S2007-08395	S2007-08396	S2007-08397	S2007-08398	S2007-08399	S2007-08400
				Sample Class:	MWS	MWS	MWS	MWS	MWS	MWS
				Sample Number:						
				Sample Type:	P	P	P	P	P	P
				Date Sampled:	18-Jun-07	18-Jun-07	18-Jun-07	18-Jun-07	18-Jun-07	18-Jun-07
				Client Description:						
Parameters	**CCME**	**Method**	**MDL**	**Units**						
Aluminum	ng		0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	0.0125		0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001 (<0.001)	<0.001
Barium	ng		0.0005	mg/L	0.0046	0.0047	0.0046	0.0047	0.0047	0.0046
Beryllium	ng		0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Bismuth	ng		0.0005	mg/L	0.0027	<0.0005	0.0021	0.0012	0.0013	<0.0005
Cadmium	0.00012		0.000015	mg/L	0.000419	0.000626	0.000533	0.000563	0.000529	0.000247
Calcium	ng		0.5	mg/L	365	371	361	358	349	346
Chromium	ng		0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	ng		0.001	mg/L	0.002	0.002	0.001	0.001	0.001	0.001
Copper	ng		0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	ng		0.001	mg/L	0.036	0.030	0.030	0.035	0.038	0.033
Lead	ng		0.001	mg/L	0.023	0.023	0.021	0.023	0.022	0.019
Magnesium	ng		0.02	mg/L	1530	1580	1570	1530	1530	1460
Manganese	ng		0.001	mg/L	0.001	0.001	0.001	0.001	0.001	0.001
Molybdenum	ng		0.002	mg/L	0.008	0.008	0.007	0.007	0.007	0.007
Nickel	ng		0.001	mg/L	0.005	0.004	0.004	0.004	0.004	0.004
Phosphorous	ng		0.002	mg/L	0.105	0.098	0.102	0.105	0.098	0.106
Potassium	ng		0.02	mg/L	549	559	532	546	527	512
Selenium	ng		0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	ng		0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	ng		0.5	mg/L	12800	13300	13100	12900	12900	11700
Vanadium	ng		0.002	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	ng		0.001	mg/L	0.013	0.008	0.011	0.006	0.006	0.002

MSS - Marine Sediment Sample   (shaded) Exceeds Metals (CCME ISQG 2006)
N/A - Not Applicable
NS - Not Sampled
ng - no guideline
Results in (brackets) represents a lab replicate
P - Primary
D - Duplicate

Results of NARL's Environmental Effects Monitoring Program (Seatech 2002)

The water quality data was collected by Seatech, 2002. Water samples were collected from three depths (top, middle, and bottom) at specified stations using 2 x 1.2 L Kemmerer water samplers. Seawater samples were analyzed for the following parameters:

- Ammonia
- Chlorophyll a, b, c
- Cartenoids
- Cyanide
- Phenols
- Sufide and Sulfate
- Suspended Particulate matter
- Total oil and grease
- TOC

Stations 1, 2, and 3 are close to the existing refinery and station 4 is close to the proposed refinery site. Station 5 is located outside the Bay in Bar Haven and is considered a control site. The results of the monitoring program are typical of coastal seawater (Table 3.14 - Table 3.18).

Table 3.14 Water Quality Data for Station 1.

Stn 1: 47°49.02' N, 54°01.42' W			
Parameter	**Top**	**Middle**	**Bottom**
Ammonia (mg/L)	<0.1	<0.1	<0.1
Chlorophyll A (mg/m3)	0.96	3.57	0.14
Chlorophyll A (mg/m3)	2.48	4.05	1.80
Chlorophyll C (m-SPU/m3)	14.22	20.76	2.13
Carotenoids m-SPU/m3)	1.12	<0.01	0.02
Cyanide (mg/L)	<0.02	<0.02	<0.02
pH	8.3	8.3	8.3
Phenol (mg/L)	<0.05	<0.05	<0.05
Salinity (ppt)	31.2	31.2	31.3
Sulfate (mg/L)	2830	2890	2800
Sulfide (mg/L)	<0.5	<0.5	<0.5
Suspended Particulate Matter (mg/L)	5	4	2
Temperature (C)	10.7	10.7	10.6
Dissolved Oxygen (mg/L)	9.45	9.57	9.63
Total Oil and Grease (mg/L)	<0.01	<0.01	<0.01
Total Organic Carbon (mg/L)	5	14	<5
Turbidity (NTU)	0	0	0

Table 3.15 Water Quality Data for Station 2.

Stn 2: 47°48.68' N, 54°00.58' W			
Parameter	**Top**	**Middle**	**Bottom**
Ammonia (mg/L)	<0.1	<0.1	<0.1
Chlorolphull A (mg/m3)	2.65	11.6	1.66
Chlorolphull A (mg/m3)	3.28	10.29	1.98
Chlorolphull C (m-SPU/m3)	15.88	68.56	15.92
Carotenoids m-SPU/m3)	<0.01	<0.01	<0.01
Cyanide (mg/L)	<0.02	<0.02	<0.02
pH	8.5	8.5	8.5
Phenol (mg/L)	<0.05	<0.05	<0.05
Salinity (ppt)	31.2	31.2	31.2
Sulfate (mg/L)	2770	2590	2730
Sulfide (mg/L)	<0.5	<0.5	<0.5
Suspended Particulate Matter (mg/L)	2	<1.8	<1.8
Temperature (C)	10.7	10.7	10.7
Dissolved Oxygen (mg/L)	9.70	9.70	9.70
Total Oil and Grease (mg/L)	<0.01	<0.01	<0.01
Total Organic Carbon (mg/L)	<5	<5	<5
Turbidity (NTU)	0	0	0

Table 3.16 Water Quality Data for Station 3.

Stn 3: 47°47.96' N, 54°00.49' W			
Parameter	**Top**	**Middle**	**Bottom**
Ammonia (mg/L)	<0.1	<0.1	<0.1
Chlorophyll A (mg/m3)	N/A	0.96	1.80
Chlorophyll A (mg/m3)	N/A	2.67	3.78
Chlorophyll C (m-SPU/m3)	N/A	11.37	18.05
Carotenoids m-SPU/m3)	N/A	9.92	<0.01
Cyanide (mg/L)	<0.02	<0.02	<0.02
pH	8.6	8.6	8.6
Phenol (mg/L)	<0.05	<0.05	<0.05
Salinity (ppt)	31.1	31.1	31.2
Sulfate (mg/L)	2774	2800	2810
Sulfide (mg/L)	<0.5	<0.5	<0.5

Stn 3: 47°47.96' N, 54°00.49' W			
Parameter	**Top**	**Middle**	**Bottom**
Suspended Particulate Matter (mg/L)	4	<1.8	<1.8
Temperature (C)	10.5	10.5	10.5
Dissolved Oxygen (mg/L)	9.70	9.78	9.73
Total Oil and Grease (mg/L)	<0.01	<0.01	<0.01
Total Organic Carbon (mg/L)	<5	<5	<5
Turbidity (NTU)	0	0	0

N/A: sample not analyzed due to contamination

Table 3.17 Water Quality Data for Station 4.

Stn 4: 47°47.82' N, 54°02.87' W			
Parameter	**Top**	**Middle**	**Bottom**
Ammonia (mg/L)	<0.1	<0.1	<0.1
Chlorophyll A (mg/m3)	0.54	3.12	1.49
Chlorophyll A (mg/m3)	0.86	3.84	1.02
Chlorophyll C (m-SPU/m3)	5.08	23.22	10.54
Carotenoids m-SPU/m3)	1.65	<0.01	<0.01
Cyanide (mg/L)	<0.02	<0.02	<0.02
pH	8.6	8.7	8.6
Phenol (mg/L)	<0.05	<0.05	<0.05
Salinity (ppt)	31.2	31.2	31.7
Sulfate (mg/L)	2770	2780	2850
Sulfide (mg/L)	<0.5	<0.5	<0.5
Suspended Particulate Matter (mg/L)	4	2	24
Temperature (C)	10.6	10.6	10.5
Dissolved Oxygen (mg/L)	9.47	9.68	9.66
Total Oil and Grease (mg/L)	<0.01	<0.01	<0.01
Total Organic Carbon (mg/L)	<5	<5	<5
Turbidity (NTU)	0	0	0

Table 3.18 Water Quality Data for Station 5.

Stn 5: 47°42.83' N, 54°12.33' W			
Parameter	**Top**	**Middle**	**Bottom**
Ammonia (mg/L)	<0.1	<0.1	<0.1
Chlorophyll A (mg/m3)	<0.01	0.66	1.11
Chlorophyll A (mg/m3)	0.11	0.01	2.00

Stn 5: 47°42.83' N, 54°12.33' W			
Parameter	**Top**	**Middle**	**Bottom**
Chlorophyll C (m-SPU/m3)	4.45	23.95	7.75
Carotenoids m-SPU/m3)	<0.01	<0.01	<0.01
Cyanide (mg/L)	<0.02	<0.02	<0.02
pH	8.0	8.1	8.2
Phenol (mg/L)	<0.05	<0.05	<0.05
Salinity (ppt)	31.2	31.3	31.3
Sulfate (mg/L)	2820	2810	2750
Sulfide (mg/L)	<0.5	<0.5	<0.5
Suspended Particulate Matter (mg/L)	<1.8	<1.8	<1.8
Temperature (C)	10.6	10.5	10.5
Dissolved Oxygen (mg/L)	9.47	9.48	9.60
Total Oil and Grease (mg/L)	<0.01	<0.01	<0.01
Total Organic Carbon (mg/L)	<5	<5	<5
Turbidity (NTU)	0	0	0

3.5.10 Marine Sediments

Marine sediment samples were collected from 25 locations in the vicinity of the proposed refinery site. 14 were collected near the Marine Terminal, 4 were collected near the Jetty, 5 were collected at the water intake location and 2 were taken at the outfall location. The sampling locations are shown in Figure 3.63 in the previous Section 3.5.9, along with the water sampling locations.

The sediments were analyzed for a variety of parameters: PAHs, BTEX, TPH, PCB, TOC, metal-hydrides, and particle size distribution. The tabulated results can be seen in Table B-1 in Appendix B (Marine Sediments Data). Guideline values for some of the parameters are also included. The guideline used is the Canadian Council of Ministers of the Environment (CCME) Interim Sediment Quality Guideline (ISQG).

None of the sediment samples collected exceeded the ISQG guideline for PAHs, BTEX, TPH, PCB, and TOC. However, there is a noticeable higher PAHs concentration at the water intake locations (T11-1) than at other sampling locations. For TOCs, there is a high degree of variability. The detected level ranges from 6 to 520,258 mg/kg.

While most of the metal concentrations from the majority of sampling locations are below guideline values, there are some exceedance cases. The Arsenic concentrations of 7.8 μg/g and 12.6 μg/g at T9-4 and T12-1 are higher than the guideline value 7.24 μg/g. The copper concentrations of 27 μg/g 19 μg/g, and 19 μg/g at T2-2, T5-2 and T12-1 are higher than the guideline value 18.7 μg/g.

3.6 Terrestrial Biological Environment

3.6.1 Introduction

The terrestrial biological environment of Southern Head is described here in terms of both the organisms that live in the area as well as their habitat. The two concepts are intrinsically linked due to the fact that specific habitat types provide the basis for types of flora and fauna that exist within a certain region.

3.6.2 Vegetation and Lichens

Surveys of the project area were undertaken to document vegetation, with emphasis placed on identification of any unique, rare or at risk plants, including the boreal felt lichen (*Erioderma pedicellatum*), which is listed as Special Concern under Schedule 1 of *SARA* and Vulnerable by the Newfoundland and Labrador ESA (see Section 3.6.7). The results were interpreted in order to identify areas of concern and to contribute towards development of a mitigation and monitoring protocol. In addition, samples of the lichens *Alectoria sarmentosa* and *Lobaria pulmonaria* collected from the Project Area were analyzed to determine the effects of the existing Come by Chance refinery as a source of atmospheric pollution in the area, and to provide baseline data for future air quality monitoring of the proposed Project. The following text describes the ecological setting of the Project Area and overviews the results of vegetation studies. The reader is referred to Goudie and Munier (2007) for details of the vegetation and lichen study undertaken in support of the EIS.

Ecological Overview

Coastal Setting

The Project Area (area of Southern Head) lies within the Avalon Isthmus Coastal Ecosection that encompasses the shore-zone on both the Trinity and Placentia Bay sides of the Isthmus of the Avalon (Hiscock 1981). Only small portions of this coastal zone experience high or very high wave energy. Most of the exposed locations have moderate wave energy, and there are considerable tracts with minimal or low wave energy. Bar lagoons occur in association with estuaries and moderate wave energy, notably Come By Chance Harbour and Arnold's Cove Harbour, where there are extensive cobble and pebble beaches with saltmarsh cordgrass (*Spartina alterniflora*) and intertidal flats. Pocket beaches with cobbles, boulders and some sand are common. The backshores tend to be intermediate in slope, and steeper slopes are confined to consolidated material.

Ecoregion

The region lies within the Southeastern Barrens subregion of the Maritime Barrens Ecoregion (Damman 1983). This ecoregion is characterized by extensive barren areas that consist of dwarf shrub heaths, bogs and shallow fens. A peculiar characteristic of the ecoregion is the overlap of southern (Coastal Plain) species and Arctic species; the former are usually found in bogs and valleys, whereas the latter are restricted to exposed sites without snow cover during most of the winter (Damman 1983). Balsam fir (*Abies balsamea*) and black spruce (*Picea mariana*) dominate the forested sections of the surrounding region with eastern larch (L*arix laricina*) scattered throughout. A scrub forest less than five metres in height, dominated by black spruce, covers approximately a third of the region. Ground vegetation is characterized by ericaceous shrubs such as *Kalmia angustifloria*, *Empetrum nigrum*, *Rhododendron canadense* and *Vaccinium angustifolium*, with *V. vitis-idaea* on the rocky bluffs along the shoreline and exposed areas.

Lichens occur in some forested sections of the Study Area. In particular epiphytic lichens, such as *Usnea longissima* and *Lobaria* spp., are associated with undisturbed (60+ years) conifer stands (Cameron 2002). In peatland and heath areas, ground-dwelling lichens such as *Cladonia* spp. and *Cladina stellata* are very common.

Enriched wetlands (see Section 3.7.3) occur in the watershed of Watson's Brook that empties into Emberley Cove on the west side of the headland. Numerous small lakes and ponds are scattered throughout and juxtaposed with basin bogs and blanket bogs that extensively cover the area. Stream and slope fens are localized.

Study Methods

There were five primary components of the vegetation and lichen study:

1. Surveys of representative habitats of the refinery site and access roads for forest lichens
2. Collection of lichens from impact and "control" sites and lab analyses (isotopic and trace element)
3. Surveys of representative areas for rare plants
4. Vegetation classification and mapping
5. Wetland classification and mapping (see Section 3.6.3)

The surveys for rare lichens sampled forest habitats on the east and west sides of the peninsula and Southern Head headland, and adjacent to Hollett's Cove and Doughby Cove. In total, approximately 16 km were surveyed.

Samples of lichens, *A. sarmentosa* (n=24) and *Lobaria pulmonaria* (n=3) were analyzed to investigate their stable isotope composition ($\delta^{34}S$ and $\delta^{15}N$) and nitrogen and sulphur contents, and trace elements. Preparation and analysis followed procedures based on Yun (2003) and Eaton (2003). A suite of 35 analytes were measured quantitatively for each sample including Li, Be, B, Mg, Al, Si, P, S, Cl, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Mo, Ag, Cd, Sn, Sb, Cs, Ba, La, Ce, Tl, Pb, Bi, and U. Semi-quantitative results were measured for Tl, Br, I, and Hg. Results were converted to ppm relative to dry weight. Some of the measured elements were not considered because their values were below the detection limit (DL) for all samples. These included Be, S, Cl, As, Br, Se, Ag, Cd, and Tl. Some of these elements tend to be volatile, such as As, Se, and Hg, the halogen elements (Cl, Br, and I) as well as S, and can be lost during digestion under open conditions. Hg was below detection in most samples and was at the detection limit for a few others, and was therefore omitted from the analysis.

LGL Limited collected representative samples of the epiphytic lichens, *Alectoria sarmentosa* and *Lobaria pulmonaria* in the Southern Head study area from ten sites (three sites only for Lobaria) representing the east (coastal), west (coastal) and central portions of the Southern Head area. Additionally, preliminary samples were replicated from five sites in the location east and south of Come By Chance and Sunnyside as originally sampled by M. Wadleigh (Department of Earth Sciences, Memorial University of Newfoundland) and presented in Evans (1996), and a new 'control' location (five sites) in the area of Goobies (Figure 3.64). Twenty-seven lichen samples were analyzed in total. Twenty-four of these were *Alectoria sarmentosa* and three were *Lobaria pulmonaria.*

Site selection and collection techniques followed the strict scientific protocols provided by Evans (1996).

Vegetation was mapped for a 1207 ha classified area that included the southern portion of the Southern Head peninsula using 1:12,500 scale colour aerial photographs and stereo-pairs of overlapping images and stereoscopes. Vegetation communities were identified by indicator plant associations and labelled following Meades (1990). Forest types were classified following Damman (1963) and Meades and Moores (1989). Vegetation classifications were ground-truthed during field surveys. Vegetation cover types and their codes used in Figures 3.64, 3.65 and 3.66 are provided in Table 3.19.

Table 3.19 Cover Types Mapped by LGL on Aerial Photographs of Southern Head, Placentia Bay

CODE	COVER TYPE
A	Alluvial Meadow
AS	Alluvial Shrub
BO	Bog
BOfus	Bog dominated by *Sphagnum fuscum*

CODE	COVER TYPE
BOfu-cl	Bog dominated by *Sphagnum fuscum* and *Cladonia* spp.
BOcl	Bog dominated *Cladonia* spp.
BOd	Dome Bog
BB	Blanket Bog
BBce	Blanket Bog dominated by *Scirpus cespitosus*
BBce-cl	Blanket Bog dominated by *Scirpus cespitosus* and *Cladonia* spp.
BBem	Blanket Bog dominated by *Empetrum nigrum* and *Chamaedaphne calyculata*
BBem-cl	Blanket Bog dominated by *Empetrum nigrum* and *Cladonia* spp.
FEN	Fen
BFs	Balsam Fir - *Sphagnum* Forest
BFso	Balsam Fir - *Sphagnum* Forest with *Osmunda cinnamonia*
BFcl	Balsam Fir - *Clintonia* Forest Type
BFhy	Balsam Fir - *Hylocomnium* Forest Type
BFp	Balsam Fir - *Pleurozium* Forest Type
BFh	Balsam Fir - Herb Rich Forest Type
BFd	Balsam Fir - *Dryopteris* Forest Type
BSsp	Black Spruce - *Sphagnum* Forest Type
BSem	Black Spruce with *Empetrum nigrum* and *Kalmia angustifoia*
BSk-cl	Black Spruce with *Kalmia angustifoia* and *Cladonia* spp.
SS	Scrub Black Spruce
SSem	Scrub Black Spruce with *Empetrum nigrum* and *Kalmia angustifoia*
SSk-cl	Scrub Black Spruce with *Kalmia angustifoia* and *Cladonia* spp.
Sk-n	Black Spruce – *Kalmia* – *Nemopanthus* Forest Type
WS	White Spruce Forest
WSal	White Spruce - Alluvial
WSh	White Spruce with Heath
LS	Larch Scrub Forest
LScl	Larch Scrub Forest with *Cladonia* spp.
LSs	Larch Scrub Forest with *Sphagnum* spp.
W	Water
R	Bedrock
C	Cobble

Study Findings

The Southern Head area is relatively pristine and free of anthropogenic plant species. It displays a native flora, notwithstanding some species that have naturalized historically. Overall, the botanical survey of Come By Chance Head yielded typical vegetation found throughout appropriate equivalent habitats in eastern Newfoundland. Balsam fir and black spruce forests dominated the forested landscape with some white birch on well-drained sites, and there was considerable scrub spruce 'tuckamor'. Enriched habitats were identified as fens that comprised 29.3 ha or 2.4 per cent of the 1207 ha classified area; wetlands and herb-rich balsam fir forests comprised 80.8 ha or 6.7 per cent of the classified area (Figure 3.64). White spruce forests had regenerated in what were previously coastal meadows and comprised 21.2 ha or 1.7 per cent of the classified area.

There is a slight grade from Hollett's Cove to the inland greenfield site that is characterized by extensive peatlands with minor coverage of black spruce forests and shrubs often associated with *Kalmia angustifolia* and *Empetrum nigrum*. Balsam fir forests are less frequent, but occasional sites with high productivity were documented including Balsam Fir-*Dryopteris* and Balsam Fir-*Pleurozium* forest types that are indicative of forest sites supporting the most merchantable timber for eastern Newfoundland (Meades and Moores 1989). Overall, balsam fir forest types were generally poorly drained and supported the less productive forest types, namely, Balsam Fir-*Clintonia* and Balsam Fir-*Sphagnum* (Figure 3.64).

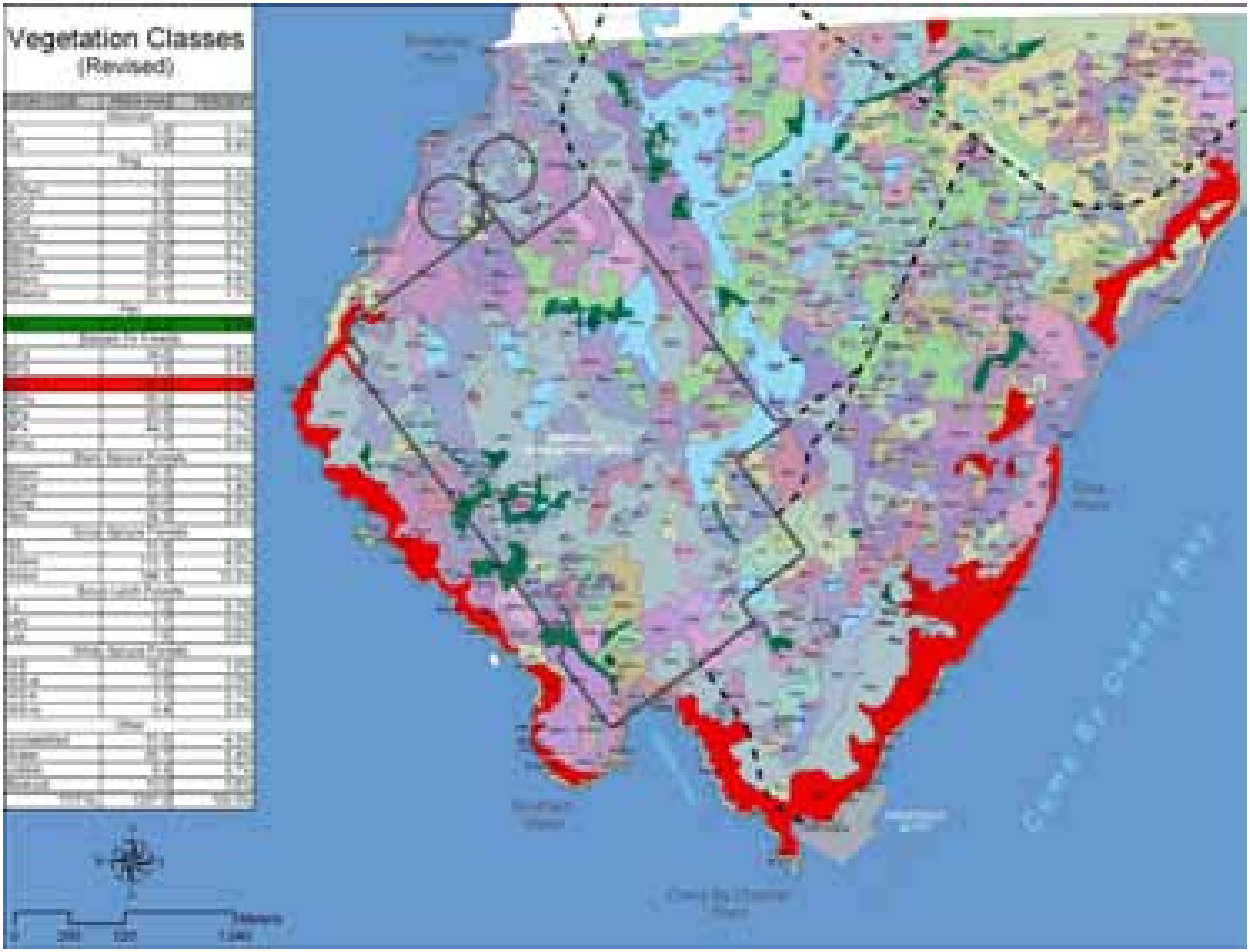


Figure 3.64 Location of Greenfield Site and Vegetation Map in the area of the Proposed Oil Refinery at Southern Head. Red Highlights the Herb-rich Balsam Fir Forests, and Green Highlights the Floristically-rich Fen Habitats (see Table 3.18 for definitions of cover classes)