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1.0 INTRODUCTION

1.1 Study Objectives

There is a consensus in the global petroleum market that the world is entering a prolonged period characterized by petroleum supply constraint and rising demand. Expectation of a supply-deficient petroleum market has led oil and gas companies to invest heavily in high-cost frontier regions including Greenland and the Canadian Arctic. Interest in the Arctic has been heightened by recent US Geological Survey reserves estimates, and lessening ice conditions and the resulting improved operational and transportation linkages.

Companies in the Canadian supply and service sector, particularly in Atlantic Canada, have used their experience in offshore Eastern Canada and the North to develop technical and operational solutions to complex issues associated with oil and gas exploration and development in harsh ocean environments. This has provided the Atlantic Canadian business community with capabilities relevant for supplying and servicing offshore oil and gas activities in Greenland and in the Canadian Arctic. Furthermore, the relative proximity of Atlantic Canada’s supply and service centres to exploration activity in Greenland’s offshore area, and the emergence of the Northwest Passage as a means of accessing the Canadian Arctic, positions Atlantic Canadian businesses to benefits from these economic opportunities.

The Atlantic Canada Opportunities Agency (ACOA) recognized a need to better understand the nature of the business opportunities related to the offshore oil and gas industry in Greenland and the Canadian Arctic, and contracted Stantec to prepare this Greenland/Arctic Opportunities Study. The objectives of the study are:

- To identify existing and emerging service and supply requirements associated with the exploration development and production of oil and gas resources in Greenland and the Canadian Arctic; and
- To provide a detailed description of specific opportunities for companies capable of exporting goods or services with particular application to oil and gas exploration, development and production in an Arctic environment.

Given the similarities and proximity of Labrador and West Greenland, the study has been expanded to include some review and assessment of the former region.

1.2 Methodology

The main elements of the study methodology for this assessment of Greenland/Arctic opportunities are described below.
1.2.1 Activity Review

A review of recent, current and anticipated offshore petroleum exploration, development and production activity in offshore Greenland and Canada’s Arctic frontier was undertaken based on a literature review, interviews with key stakeholders and professional knowledge.

1.2.2 Supply Chain Requirements and Capacity Assessment

Supply chain requirements were developed, and the required industrial capacity, labour and infrastructure requirements in Greenland and the Canadian Arctic adjacent to prospective petroleum areas were assessed, based on:

- The study team’s understanding of the infrastructure and service elements and supply chain required by the upstream offshore petroleum industry; and,
- A set of scenarios that identify different options during the exploration, development and production phases in each area.

These scenarios were based on anticipated activity and setting, potential technological and organizational changes derived from stakeholder interviews, and the study team’s professional knowledge and experience.

For each scenario the required industrial capacity, workforce and other requirements was determined based on previous experience in similar areas, key stakeholder input and professional knowledge. This included the development of case study examples related to each of the main scenarios. The assessment of local capacity included examination of the population, labour force, industrial capabilities and infrastructure, including existing and planned ports and airports and their capabilities.

Given that the capacity requirements are those of the supply chain, and to minimize unnecessary duplication, the supply chain requirements and capacity assessment are combined in a single section of this report.

1.2.3 Competitive Advantage Analysis

An assessment of the key competitive advantages that Atlantic Canada’s supply and service industry offers oil and gas industry activity in Greenland was developed based on key informant interviews, the analysis of supply chain requirements, and the study team’s collective professional knowledge and experience of the petroleum sector in Atlantic Canada, Greenland and globally. In addition, recognizing that Atlantic Canadian businesses also face a number of disadvantages, these were briefly documented.

1.2.4 Opportunity Identification

Recommendations on opportunities and areas of expertise that the Atlantic Canada industry should pursue in Greenland and the Canadian Arctic were developed from the preceding tasks, initially through a review of the business categories used by the Newfoundland and Labrador Oil and Gas Industries Association. The list of opportunities was ‘road-tested’ in St. John’s with a small group of key informants from industry and training institutions, and then prioritized. The
opportunities have been listed in categories that reflect the immediacy of the requirement for action and the likely timing and scale of the reward.

1.3 Report Format

The next part of this report (Section 2.0) describes past, present and likely future activity in Greenland, Labrador and the Canadian Arctic, followed by a general discussion of the likely pattern of future activity, including the possible implications of recent developments in the areas of deepwater drilling and unconventional gas. Section 3.0 first describes the petroleum industry’s supply chain requirements for exploration, development and production activities, using case studies of different production and transportation scenarios for Greenland, Labrador and Canadian Arctic fields, and then discusses the current abilities of local resources and infrastructure to satisfy these requirements. Section 4.0 identifies and reviews the competitive advantages, and some disadvantages, that Atlantic Canada’s supply and service industry may be thought to have in doing business in Greenland, and Section 5.0 provides categorized recommendations on opportunities that Atlantic Canada industry should pursue in Greenland and the Canadian Arctic. A short conclusion to the report is presented in Section 6.0. Appendices present detailed information on infrastructure and resource estimates.
2.0 ACTIVITY REVIEW

2.1 Introduction

Based on decades of exploration, desktop studies and indications of environmental change, there is an expectation that there will be substantial activity in most, if not all, circum-Arctic jurisdictions in the future to ascertain and possibly develop petroleum and other mineral resources.

Petroleum exploration activities in the North have been occurring since the 1970s. The dramatic rise of oil prices in the early 1970s led to comprehensive seismic exploration in Greenland. In Canada the creation of the federal government Petroleum Incentives Program led to initial activities in the Beaufort Sea, the discovery of the Drake and Hecla fields around Melville Island in the high Arctic and, most importantly, the discovery of major fields offshore Canada’s East Coast.

Initial enthusiasms about activity in these areas were tempered by economic constraints and only some areas, such as Canada’s East Coast, were actually taken into production. As conventional supplies continue to diminish and the numbers of large new discoveries in easy to exploit areas decline, the lure of potential new “elephant” discoveries has encouraged petroleum companies to look into the North.

The United States Geological Survey estimates that the entire circum-Arctic area contains up to 90 billion barrels (Bbls) of undiscovered oil, 1,669 trillion cubic feet (Tcf) of gas and 44 Bbls of natural gas liquids. As much as 15 percent of this could be contained in the Greenland area including shared areas with Canada and another 5 percent in Canada’s Arctic (Appendix A).

The Geological Survey of Canada estimates that Northern Canada (north of 60 degrees) contains 19 Bbls of oil and 182 Tcf of gas. Most of the oil (7 Bbls) is thought to be in the Mackenzie Delta/Beaufort Sea area, followed by the Arctic Islands (5 Bbls), Mackenzie Corridor (3 Bbls), Labrador Sea/Davis Strait (3 Bbls) and Hudson Bay (1 Bbl). It is estimated that there are 65 Tcf of gas in the Mackenzie Delta/Beaufort Sea area, followed by the Arctic Islands (49 Tcf), Labrador Sea/Davis Strait (38 Tcf), Mackenzie Corridor (27 Tcf) and Hudson Bay (3 Tcf)(Scott 2010).

In conjunction with the decreasing reserves of conventional oil in easy to reach locations has come the improving capability of technology to exploit petroleum reserves in harsh environments. Equipment has evolved to take advantage of the discoveries being made and production activities in Russia and Newfoundland have proven that safe, economic production can take place in ice-infested areas. Ice, cold weather and deep water are now considered engineering challenges rather than project barriers.

Changing environmental conditions have also led to increased enthusiasm for Northern exploration. Decreased ice coverage in many areas results in extended exploration periods and increased ease of access for equipment and personnel.
Other barriers to full exploitation of the North’s resources have been political, legislative and regulatory. Boundary issues, aboriginal land claims and home rule aspirations are some of the many challenges that have had to be overcome. Gradually, these issues have begun to be settled. Both Greenland and Nunavut have achieved home rule and in the process of establishing own legislation and regulatory guidelines for exploration, development licencing and exploitation.

Not all barriers to development have been removed and new ones will likely slow progress towards petroleum development in the North (see Section 2.5). Regardless, there appears to be major available resources for long-term development.

The rest of this section describes past, present and likely future activity in Greenland, Labrador and the Canadian Arctic at the time of writing, followed by a general discussion of the likely pattern of future activity, including the possible implications of recent global developments in the areas of deepwater drilling and unconventional gas.

### 2.2 Greenland

The history of the offshore petroleum industry of Greenland can be broken down into three main activity periods, during which three distinct geographic areas have been explored:

- South and South West Greenland which share the Davis Strait with Canada and is the site of most of the current activity;
- West Greenland which shares Baffin Bay with Canada; and
- North and North East Greenland which shares an ocean border with Iceland.

#### 2.2.1 The First Licencing Round (1970-1978)

Petroleum exploration in areas offshore West Greenland owes its beginnings in part to the dramatic rise in oil prices in the early 1970s. As well, in onshore central West Greenland, there are considerable thicknesses of marine sediments that provide an analogue to what can be expected in the shelf offshore. During this period comprehensive seismic surveys were carried out and almost 21,000 line km of reflection seismic data were acquired.

In 1975, six groups headed by Amoco, Chevron, ARCO, Mobil, Total and Ultramar were granted licences, and a further 16,000 km of seismic data were collected. In 1976 and 1977, five exploratory wells were drilled. Exploration was discontinued in 1978 with all the wells declared dry. Re-investigation of the well data in 1997 by the Geological Survey of Denmark and Greenland (GEUS) suggested that one of the wells, Kangamiut-1 may in fact have been a hydrocarbon discovery (GHEXIS Online 2007).

#### 2.2.2 Data Gathering and Revival of Prospects (1979-1998)

During this period government, academia and industry undertook a number of research projects to establish parameters for the potential petroleum opportunities in Greenland and their surrounding waters. These included:
• Offshore East Greenland (1978-82), the North Atlantic D (NAD) Project: An aeromagnetic (68,119 km) and marine geophysical (7,793 line km) survey that showed that the northern part of the area seemed highly prospective.


• The KANUMAS Project (1990-1996): This was a seismic reconnaissance project in the extreme frontier areas of North-East and northern West Greenland (see Greenland map). Financed by BP, Exxon, Japan National Oil Co., Shell, Statoil and Texaco. Nunaol was the operator. The results were very encouraging and led to the formation of the KANUMAS group which has been granted special exploration privileges (see later section).


• New licencing round (1992-1994): This licencing round for offshore West Greenland south of 66 degrees North attracted no applications.

• Fylla, west of Nuuk (1994-1996): Nunaol gathered 1706 line km of further seismic in an area reviewed in 1992. This was sufficiently encouraging for another licencing round to be held in 1994 and the licence was awarded to a consortium of Statoil (operator), Phillips Petroleum, DONG and Nunaol in 1996.

• Onshore drilling at Nuussuaq and Disko (1994-1998): Calgary-based junior gronArctic Energy drilled an 800 m slim hole in 1994 and a further three slim holes in 1995 on land. In 1996 the company did airborne geophysical surveys followed by a 2,996 m exploration well. The well was declared dry and due to financing problems gronArctic relinquished its licences in 1998.

• Sisimiut licence (1998): A bright spot in sedimentary units overlying Tertiary basalts on two areas west of Disko led to a new licence off Sisimiut in West Greenland in 1998. The partners were Phillips Petroleum (operator), Statoil, DONG and Nunaol.

2.2.3 Second Licencing Round (1999-2010)

By 1999 the East Coast of Canada had become an oil and gas-producing region. In particular the Hibernia gravity based structure (GBS) had been floated into place and demonstrated that oil production in ice-infested harsh environments was practical, safe and economic. This generated sufficient interest on the part of the Greenland government that it decided to create a new petroleum licencing policy both onshore and offshore. It also announced a new licencing round in West Greenland between 63 degrees North and 68 degrees North for 2002.

Subsequent activity included the following:

• Seismic (1999-2001): In preparation for the 2002 licencing round, TGS-NOPEC acquired some major speculative seismic surveys. It also worked with the Bureau of Minerals and Petroleum (BMP) and GEUS to acquire more shallow water seismic.

• Fylla and Sisimiut (2000-2001): In April 2000 an exploration well was spudded on the Fylla licence and drilled to total depth of 2937 m. It was declared dry and plugged and abandoned. The Sisimiut licence was never drilled and at the end of 2001 both licences were relinquished.
Licencing Rounds (2002 and 2004): These licencing rounds have led to the current crop of licences in West Greenland as shown in Section 2.2.4.1. Once the licences were granted there was extensive seismic work to help establish where the first drilling would take place.

2.2.4 Current and Planned Activity

2.2.4.1 West Greenland Licence Holders

There are currently a total of 13 West Greenland licences. The licence names, expiry dates and names of the lead operators are presented in Table 2-1. Licence locations are shown in figure 2-1.

Table 2-1 West Greenland Offshore Licences

<table>
<thead>
<tr>
<th>Licence Number</th>
<th>Licence Name</th>
<th>Expiry Date</th>
<th>Owners</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Disko Bay, between Sisimiut and Uummanraq</td>
<td>2008/10 2017</td>
<td>Capricorn Greenland Exploration 2 Limited (43.75%), Capricorn Greenland Exploration 1 Limited (43.75%), NUNAOIL A/S (12.5%)</td>
</tr>
<tr>
<td>2</td>
<td>2008/11 2018</td>
<td>Capricorn Greenland Exploration 1 Limited (30.0%), Capricorn Greenland Exploration 4 Limited (28.75%), Capricorn Greenland Exploration 3 Limited (28.75%), NUNAOIL A/S (12.5%)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2007/26 2017</td>
<td>DONG Grønland A/S (29.17%), Esso Exploration Greenland Limited (29.17%), Chevron Greenland Exploration A/S (29.17%), NUNAOIL A/S (12.5%)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2007/22 2017</td>
<td>Husky Oil Operations Limited (87.5%), NUNAOIL A/S (12.5%)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2007/27 2017</td>
<td>Husky Oil Operations Limited (43.75%), Esso Exploration Greenland Limited (43.75%), NUNAOIL A/S (12.5%)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2007/24 2017</td>
<td>Husky Oil Operations Limited (87.5%), NUNAOIL A/S (12.5%)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2008/17 2017</td>
<td>PA Resources AB (87.5%), NUNAOIL A/S (12.5%)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Southern Portion of West Greenland</td>
<td>2008/14 2017</td>
<td>Capricorn Greenland Exploration 1 Limited (32.0%), Capricorn Greenland Exploration 7 Limited (30.0%), Capricorn Greenland Exploration 8 Limited (30.0%), NUNAOIL A/S (8.0%)</td>
</tr>
<tr>
<td>11</td>
<td>2008/13 2018</td>
<td>Capricorn Greenland Exploration 1 Limited (32.0%), Capricorn Greenland Exploration 6 Limited (30.0%), Capricorn Greenland Exploration 5 Limited (30.0%), NUNAOIL A/S (8.0%)</td>
<td></td>
</tr>
<tr>
<td>12 &amp;13</td>
<td>2009/11 2018</td>
<td>Capricorn Greenland Exploration 10 Limited (67.0%), Capricorn Greenland Exploration 1 Limited (25.0%), NUNAOIL A/S (8.0%)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Offshore Maniitsoq</td>
<td>2005/06 2014</td>
<td>EnCana Corporation (47.5%), Capricorn Lady Franklin Limited (40.0%), NUNAOIL A/S (12.5%)</td>
</tr>
<tr>
<td>9</td>
<td>2002/15 2012</td>
<td>EnCana Corporation (47.5%), Capricorn Atammik Limited (40.0%), NUNAOIL A/S (12.5%)</td>
<td></td>
</tr>
</tbody>
</table>
2.2.4.2 Exploration Drilling

Cairn Energy will drill up to four wells in the Disko Bay area, in the summer of 2010 at an estimated total cost of US$400 million. To do this it secured two harsh environment drilling units, the Stena Forth, a sixth-generation drillship and the Stena Don, a fifth-generation semi-submersible (Cairn 2010).

2.2.4.3 2010 Licencing Round

The Government of Greenland has approved a Baffin Bay licencing round that closed May 1, 2010. Fourteen blocks have been nominated covering about 151,000 km².
Figure 2-1  West Greenland Offshore Licences
An operator prequalification round was held that closed in October 2009. The purpose of the pre-qualification round was to ensure that potential operators had the necessary experience, had developed a contingency planning system and had the necessary financial resources. Indicative of the interest that Greenland prospects are attracting, 13 international oil companies applied for prequalification. Twelve of them submitted bids on the 14 available licences.

### 2.2.4.4 2012/2013 East Greenland Licencing Round

The KANUMAS project was initiated in 1989 and covered areas in Northwest and Northeast Greenland. The six KANUMAS proponents (Statoil, BP, Esso, Chevron, Shell and Japan Oil Gas and Metals National Corporation) acquired over 10,000 km of seismic data between 1991 and 1995. As part of the prospecting licence the KANUMAS group was granted preferential treatment in the zones surveyed if calls for licences were to be made. It has only elected to exercise its preferential position in the Northeast Greenland (Greenland Sea) area. Accordingly the Northwest (Baffin Bay) area was released and has formed the basis for the licencing round that closed May 1, 2010.

There will be a licencing round starting January 2011. Any bidding consortium must be led by one of the KANUMAS partners as the operator. The round will be awarded in March 2013.

### 2.2.5 Future Activity

Primarily for the reasons outlined in Section 2.1, Greenland is viewed as one of the world’s last great prospective petroleum territories. Technology has essentially caught up with ambition and drilling and producing in harsh environments is not the challenge it once was. The supply and demand curve for petroleum has kept the per barrel equivalent price high in recent years and there is nothing in the industry press to suggest that oil prices will diminish any time soon. The press indicates that oil prices in the $50 per barrel range will be required for production to occur and prices over the last several years have not been less than that (Swartz 2010).

Cairn Energy will be the first to do modern-era exploratory drilling. It is a small company with a reputation of doing things differently and taking more financial risks than the conventional majors. The major oil companies will watch its exploration activities with great interest, to see what success it will have in 2010 and whether it decides to return in 2011 for another drilling season (Stigset 2010). The majority of the existing licences run until 2017, so there is time to see if the other operators elect to drill. Were another company to decide to drill next year, it would be a significant indication of interest. The same is true for the next two licencing rounds, which should allow some insight as to the level of activity that can be expected.

However, the recent BP/Transocean blowout in the Gulf of Mexico may introduce some major uncertainty into the Greenland government’s desire to approve future drilling.

### 2.3 Labrador Shelf

With the rapid and large increases of oil prices in 1973-74 and 1979, frontier regions of Canada gained a new interest for oil and gas explorers. This interest was further increased by the
federal Petroleum Incentives Program, which paid for up to 80 percent of all drilling costs for companies that were more than 75 percent Canadian owned.

From 1971 to 1983 a number of drillships, such as the Pacnorse 1 and Petrel, visited the Labrador Coast in search of hydrocarbons. There have been 28 wells (26 exploration and two delineation) drilled offshore Labrador in the Hopedale basin. While they were very successful in finding gas, they found no oil. There were five significant discoveries, Snorri, Hopedale, North Bjarni, Bjarni and Gudrid, a discovery rate of nearly 20 percent. Through acquisition and consolidation, the leading company on these significant discoveries is now Suncor, except for Hopedale, which is led by Husky.

The total discovered resources are estimated at 4.2 Tcf of gas and 123 million barrels of natural gas liquids. However, seismic and other geological data suggest that substantial additional reserves have yet to be discovered.

2.3.1 Current Activity

The last drillship visit in the initial exploration round of the Labrador Shelf occurred in 1983. Since then there has been no drilling, but in 2007 the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) announced a land sale based on nominations from exploration companies. In September 2008 four bids were accepted for a six year period to explore on the Labrador Shelf. The total expenditure commitment was $186 million. All these exploration licences surround the existing significant discovery areas. The exploration licences bid commitments and leadership are:

- EL1109 Chevron Canada Limited, $46,500,000;
- EL1108 Husky Oil Operations Limited, Suncor Energy Inc., $120,166,880;
- EL1107 Vulcan Minerals Inc, Investcan Energy Corporation, $9,601,000; and
- EL1106 Husky Oil Operations Limited, $10,162,800.

During the summer of 2010 seismic programs are being considered for all four parcels.

2.3.2 Future Activity

There is a known gas resource on the Labrador Shelf. The issue of how to develop it is under discussion; in winter, the area has pack ice cover up to 17 m thick, and icebergs averaging 60 m across at the waterline are common. The Labrador Shelf is also distant from markets and hence a proven world-class resource will be required to justify development.

There are several possible production scenarios. Gas could be produced seasonally in floating liquid natural gas (LNG) units which could be moved off-station when ice becomes a problem. Alternatively subsea production facilities could be used, with the gas pipelined to shore for either liquefaction and the shipment via LNG tanker or shipment to market via pipeline. However, recent developments in gas markets may mean that prices will not be able to support production in the near future.
2.4 Canadian Arctic

The search for oil and gas in the Canadian Arctic has been concentrated in two major areas, the Arctic Islands and the Beaufort Sea/Mackenzie Delta. Large accumulations of hydrocarbons have been discovered in both these areas.

2.4.1 Beaufort Sea/Mackenzie Delta

Exploration drilling in the Beaufort Sea began with seismic surveys in the 1960s, followed in 1973 by the first offshore well, drilled from an artificial gravel island in 3 m of water. Up to 1989, there were 53 discoveries of hydrocarbon resources in the region, and both oil and gas have been found in commercial quantities. The total discovered resource is estimated to be in the range of 1 Bbls of oil and 9 Tcf of gas (National Energy Board 1998).

Exploration effectively ceased in the late 1980s with only one significant initiative since then: in 2005 Devon Energy, while drilling for gas, made a significant discovery of 240 million barrels of oil. The only production from the Canadian Beaufort/Mackenzie Delta has been an extended well test in 1986 from Amauligak that shipped one tanker load (50,400 m³) of produced oil to Japan.

2.4.1.1 Current Activity

In an effort to stimulate petroleum activity in the Beaufort Sea, the Canadian government held a number of licencing rounds in the 2000s. There was significant interest by some of the world’s largest oil companies, which made major expenditure commitments in return for licences to explore. This has resulted in three potential developments:

- **Amauligak**: Discovered in 1983 and located in 30 m of water about 48 km northwest of Tuktoyaktuk. The field has an estimated 500 million barrels of oil and 1.5 Tcf of gas. Given its size this is the only current project with the potential to initiate development in the Beaufort. Development of Amauligak will be tied to the progress of the Mackenzie Valley pipeline (ConocoPhillips no date).

- **Ajurak**: Imperial Oil Resources Ventures Ltd. is the operator of Licence 446 (EL446) Ajurak. The water depth on this licence is between 60 and 1200 m. In 2008 Imperial carried out a 3D seismic program. Ajurak is considered high risk and high cost, however, planning is moving forward for a well to be drilled in 2013.

- **Pokak**: BP Exploration Company acquired three exploration licences (EL449, 451, 453) in 2008. The winning bid for Licence 449 was $1,180 million, doubling the previous record bid for a frontier licence. Starting in August 2009, BP undertook a 1,800 km² 3D seismic survey.

Each of these programs is in different phases of a regulatory review that is currently focused on environmental, social and economic issues.

In addition, a potential transportation mechanism for petroleum is under review. The Mackenzie Valley Pipeline (MGP) concept has been in existence since the 1970s. The Berger report in 1977 led to a 10-year moratorium on the project; however, it has been re-activated and is now slowly moving its way through the regulatory system.
The MGP includes the potential development of three onshore gas fields, with an anchor resource base of 6 Tcf, plus additional resources from the Mackenzie Delta. It will also include a gathering pipeline system, a processing system, a natural gas liquids line to Norman Wells, and the main 1200 km pipeline to northern Alberta.

The consortium planning to construct the pipeline comprises Imperial Oil, ExxonMobil Corporation, ConocoPhillips, Royal Dutch Shell PLC and the Aboriginal Pipeline Group. On April 12, 2010, the proponents made their final arguments to the National Energy Board (NEB), an independent federal agency that regulates part of Canada’s energy sector, which must now decide whether to approve the $16.2-billion project.

2.4.1.2 Future Activity

Uncertainty with respect to the future of the MGP results in uncertainty respecting the hydrocarbon exploration and development activities in the Beaufort Sea and Mackenzie Delta, which will likely only occur if the pipeline is built. The MGP is years behind schedule as regulators struggle to review and consider approval of this huge project. In the time lost during the review process, costs have risen dramatically and it appears that the project is unlikely to proceed without significant financial support from the federal government. Until it is built, hydrocarbon related activities in the Beaufort Sea and Mackenzie Delta will be slow. Current licences are shown in Figures 2-2.

2.4.2 Arctic Islands and Sverdrup Basin

The Canadian Arctic Islands and intervening channels are known to be rich in hydrocarbons. Between 1969 and the early 1980s drilled and delineated reserves for the Western Sverdrup Basin totaled 17.5 Tcf of gas and 1.9 Bbls of oil. The total resources for the Sabine Peninsula and the Western Sverdrup basin are now estimated at between 44 and 50 Tcf of gas and 3.5 to 5.5 Bbls of oil (Harrison 2006).

In the 1970s and early 1980s Panarctic Oils Limited managed a significant portion of the exploration and successful drilling of the best Arctic Islands prospects. The federal government was the largest shareholder in Panarctic and allowed PetroCanada (now Suncor) to purchase Panarctic and become the principal leaseholder of all the significant discovery licences in Canada’s Arctic Islands (Harrison 2006).

Approximately 175 wells were drilled between 1968 and 1985. The most notable of the discoveries were the:

- Bent Horn field on Cameron Island shipped 2.8 million barrels of crude between 1985 and 1996, but was abandoned in 1997; and
- Drake and Hecla gas fields of the Sabine Peninsula on Northern Melville Island, which have proven reserves of 9 Tcf of gas.
Figure 2-2  Beaufort Sea/Mackenzie Delta Licences
### 2.4.2.1 Current Activity

The majority of the area is now in the home rule territory of Nunavut. There has been no hydrocarbon activity since 1985; it has been argued that this is mainly due to:

- Different regimes that apply to on land and offshore activities;
- Confusion over ownership shareholdings in the historic discovery licences;
- High expected costs of production; and
- No local political control over oil and gas issues.

### 2.4.2.2 Future Activity

Future production potential has been studied in some depth particularly for the gas discoveries at Hecla and Drake; however, no firm conclusions have been reached.

The most comprehensive study was undertaken for the Canadian Energy Research Institute (Chan et al. 2005). They studied production options as developed by the Arctic Pilot Project in 1981 and the Polar Gas Project in 1977. The analysis included options for liquefying gas in the High Arctic and shipping LNG directly to the Northeastern seaboard; LNG production in the High Arctic with transshipment in Greenland, and hence to markets; delivery as compressed natural gas to a Mackenzie Corridor pipeline; and, delivery as gas to liquids to the Northeastern seaboard.

The most important assumptions in the study were project start-up dates, commodity prices, and capital and operating costs. Given enough flexibility with the assumptions, a case can be made that profitable production and movement to market can be undertaken. It should however be noted that socio-economic and environmental issues will be critical considerations for any proposed developments in the High Arctic.

Overall the lack of infrastructure will frustrate developments in the Canadian Arctic as long as there are other frontier areas that can link to existing infrastructure in a more cost-effective manner. The Mackenzie Valley pipeline project example also suggests that, given the current regulatory system, petroleum product development in the Canadian Arctic will be a long way down any company’s project priority list. Licences in the Nunavut area are shown in Figure 2-3.

### 2.5 Recent Global Developments

Recent events outside of the North may have a major impact on, and have increased uncertainty with respect to, all future activity regardless of its location in Greenland, Labrador or the Canadian Arctic. The Deepwater Horizon blowout in the Gulf of Mexico has called into question the safety of offshore oil exploration and production, resulting in significant potential regulatory and cost challenges. In addition, advances in the production of shale and other unconventional gas, often in close proximity to markets or existing pipelines, has diminished the prospects of developing gas fields in distant and environmentally-challenging locations.
Figure 2-3  Nunavut Area Licences
2.5.1 Deepwater Horizon

The BP/Transocean Deepwater Horizon Macondo blowout in the Gulf of Mexico has already affected deepwater and frontier drilling. At the request of the President of the United States, the rules relating to drilling in the US Arctic are about to be substantially revised. In Canada, the NEB and the C-NLOPB have reviewed their procedures and some additional drilling regulatory checks have been imposed. In addition, in Canada, concerns have been raised about this summer’s drilling in Greenland. Moratoria in the USA, British Colombia and Nova Scotia have all been extended, with reference being made to the Deepwater Horizon disaster.

At the time of writing, it is impossible to estimate the damage that will be caused by the Deepwater Horizon incident, but it seems likely that it will have a major negative impact on the potential for future exploration in frontier regions. Prior to this disaster, industry representatives and regulators would have indicated that there was an extremely small likelihood that a spill of this magnitude could occur. As a consequence, a great deal of effort will now be required to create the environment of confidence and trust that will permit additional exploration in any frontier region.

The industry had an excellent safety record in the Canadian Arctic, such that at the time of the accident it was looking for reductions in operational safety requirements in some areas so as to reduce the cost of exploration drilling and increase the economic attractiveness of certain projects (TD Bank Financial Group 2010). Governments in the USA and Canada were considering removing some of the offshore drilling moratoria that were in place around the coasts of North America, including the Queen Charlotte Basin, British Columbia, and the George’s Bank, Nova Scotia. Such developments now seem very unlikely; instead, increased environmental activism and more stringent rules regarding exploratory activity will likely increase costs and extend timelines.

Confirmation of this occurred as early as May 2010, with Imperial Oil indicating that it had no plans to drill on its acreage in the Beaufort Sea in the near future; its current permits do not require that a well be drilled until 2013, and it has a new Beaufort joint venture with BP that may warrant an extension. The company’s President indicated that it was “four or five years away from drilling a well”, and that it “would learn from the Macondo blowout and implement any measures that are adopted by regulators following their investigations” (Upstream 2010).

2.5.2 Unconventional Gas

The concerns about frontier gas derive not from safety and environmental concerns, but from economic ones. In the last few years there has been a revolution in gas reserves estimates for the North American continent. Shale gas technology improvements have meant that, by injecting large amounts of sand and water, developers can release the huge amounts of gas trapped in shale beds found in various parts of North America. Gas had been selling for $12 per mmBTU in May 2008, but the price had fallen to only $2.50 by May 2009, at the height of the financial turmoil in the US. In May 2010 gas prices were in the $4 per mmBTU range and not expected to rise much farther.

Part of the reason the price will stay low is the “boom of building of terminals and bubble top barges to carry LNG in the early part of this decade”. Having committed the resources to
establish the facilities owners are left with no choice but to continue to bring gas to an already crowded market (International Chemical Industry Society 2010). This has led to the shelving of many LNG-related plans, including the Maple re-gasification facility in Nova Scotia, until the long-term price prospects improve. Accordingly the pressure to explore in frontier regions has diminished since the higher costs of frontier gas are unsustainable in the current market, and projections indicate that this will continue to be that case for some years to come.

According to the Globe and Mail (2010), Canada is “awash in natural gas”, and the Canadian Society for Unconventional Gas reports that Canada has enough existing natural gas to supply the country for an additional century at today’s consumption rates, even without the development of new shale gas technologies. An additional report was referenced by the Globe and Mail article that found the same result in the USA (VanderKlippe 2010).

The revolution in shale gas technology has been called a “game changer” by many people associated with the implementation of the technology. Produced shale gas is two-thirds cheaper than oil and substantially better from the carbon footprint point of view. “This discovery will change the course of world history, not just to de-carbonize the economy but to de-OPEC-ize it,” the Chesapeake Energy Corp. CEO said in December in Copenhagen as the United Nations Climate Conference was underway (Lippert 2010).

According to a study from Pennsylvania State University, Pennsylvania alone is expected to produce 4 Bcf of gas a day by 2015 rising to 8 Bcf a day by 2020, the latter representing more gas than would be delivered through the Alaska and Mackenzie Valley pipelines combined. These Pennsylvania reserves are just part of the Marcellus deposit that stretches from West Virginia to the edges of New York and has the potential to rearrange the continent's energy flow, with Statoil announcing a deal to reverse an export pipeline from Canada and deliver Marcellus gas into the Ontario market starting in 2012 (McCarthy 2010). It should be noted that Marcellus is only one of many large shale gas plays in Canada and the USA.

There are significant environmental and regulatory concerns in the development of shale gas, but given its current production price and its proximity to existing markets that have fully developed pipeline systems, shale gas will likely be a major competitor to frontier gas for decades to come.

2.6 Conclusion

This activity review indicates long-standing industry interest in Greenland, Labrador and the Canadian Arctic, with large reserves estimates and a number of discoveries. However, while there is continued interest, as reflected in recent exploration licence bids and ongoing activity off Greenland, the Deepwater Horizon Macondo blowout and developments with unconventional gas have introduced new uncertainties and commercial and regulatory challenges.

In any case, the time from any offshore petroleum discovery to production can be very lengthy; for example, in Atlantic Canada it took 18 years to move the Hibernia field from discovery to production and, if all continues according to plan, it will have taken 33 years from the Hebron discovery to production. At present Greenland is the only one of the regions under consideration in this report that is seeing exploration drilling, and it is recognized that even there it would take many years to move any commercial discovery to development and then production. Were
Cairn Energy to make such a discovery in the 2010, it would probably spend at least two more summers doing delineation drilling. It would likely then take a number of years for the Government of Greenland to finalize regulatory provisions for the safe exploitation of the resource, finalize appropriate revenue-sharing and benefits arrangements, and undertake a formal assessment of the proposed development.

Such a development would use one of a number of production and transportation systems (see Section 3.2), depending on such factors as the nature of the petroleum resource, location and water depth. Regardless of the selected systems, at least another five years would be required for their design, construction and installation. Given this, an optimist might consider first Greenland hydrocarbon production in ten years to be realistic, but others could point to a range of potential delaying factors (environmental, legislative, distance to market, lack of infrastructure, etc.), and while Greenland’s desire for greater autonomy (see Section 4.7) will ensure support for the development of commercial discoveries, the pace with which this happens will still be constrained by environmental concerns and related regulatory processes. This is understood in Greenland, with Jørn Skov Nielsen, Director of Greenland’s Bureau of Minerals and Petroleum, having stated that “petroleum could be possible in ten years if we are lucky” (Kemp 2010).

Given this, the focus for Atlantic Canadian companies for at least the next five years should be Greenland, given the exploratory seismic and drilling activity there. Secondary consideration should be given to activity off Labrador, given existing strong local company involvements in that part of Atlantic Canada and the exploration commitments that are in place, while there should be a lesser emphasis on the Canadian Arctic at this time. However, as is always the case in the offshore petroleum industry, there should be a periodic review of such priorities in the face of exploration success, petroleum prices and a range of other factors.
3.0 SUPPLY CHAIN REQUIREMENTS AND CAPACITY ASSESSMENT

A supply chain is a linked set of resources and processes that begins with the sourcing of raw materials and extends through the delivery of end items to the final customer. It includes vendors, manufacturing facilities, logistics providers, internal distribution centers, distributors, wholesalers and all other entities that lead up to final customer acceptance.

The traditional definition of a supply chain covers sourcing material to make a product, making it, and delivering it to a customer. Based on this definition the export of the hydrocarbons from the production unit to market would be considered. However, the hydrocarbon supply chain typically considers the final transportation of the product to the market as a separate topic, and that is the approach is adopted here.

This section of the report first describes the oil and gas industry’s supply chain requirements for exploration, development and production activities, using a number of short case study examples, and then discusses the current abilities of Greenland, Labrador and the Canadian Arctic to satisfy these requirements. In discussing the oil and gas activity supply chain requirements in each of the three regions, both the key elements of the supply chain and the supply chain planning process are described to illustrate how such systems evolve through each of the exploration, development and production phases. For each phase the supply chain requirements are identified in general terms and supported with examples from the study or comparable regions to illustrate the supply chain planning process.

3.1 Exploration Phase Supply Chain Requirements

The main activities in the offshore petroleum exploration phase are seismic data collection and, subsequently if warranted by the seismic work, exploration drilling. Both are highly specialized and carried out by a relatively small number of companies which operate globally. These activities typically place only minor demands on local infrastructure, and the benefits to local business and labour are usually limited and short-term.

In the initial phases of frontier seismic and exploration drilling activity, companies traditionally bring virtually all their supplies from a distant base. No, or very few and limited, oilfield supply and support networks exist in the frontier regions, with the result that seismic and drilling vessels typically arrive fully laden with only the need to “top-up” with water, fuel and food, and make crew changes, at the nearest suitable port or airport. In many cases there may be no direct contact between the exploration vessels and the host region. Once on location, any last-minute items can be provided by helicopter or supply vessel. However a significant supply shortage will normally lead to cessation of activity and a potential return to a port where the necessary items can be received and loaded.

3.1.1 Local Infrastructure Requirements

Local activity associated with supply chain requirements during exploration may increase with the level of activity or the time over which such activity occurs. However, local supply chain requirements during the exploration phase are fairly simple. There must be an airport through
which personnel can be moved and a seaport through which materials can be moved from their
manufacturing or main marshalling points to the activity sites, assuming that this is justified by
the overall level of activity. In the case of Atlantic Canada, most materials come from the
Houston, Texas, area. In the case of Greenland, the main marshalling area is currently
Aberdeen, Scotland.

If materials are moved into the local airport or seaport, warehouses are required to receive the
shipments. This is in order to check that the right equipment has been sent and that it has
arrived in good shape. The equipment is then bundled into shipping containers, to be sent to the
drilling unit by supply vessel or helicopter. These land-based consolidation terminals are
typically leased on a temporary basis.

Personnel to manage the supply chain are flown in from head office or the regional drilling
office. Local labour is hired on a part-time basis, as required to handle the local physical
requirements. All contracting activities are handled through the head or regional drilling office,
an arrangement which has been increasingly facilitated over time by improvements in
information technology and communications infrastructure.

Seismic vessels typically have their own technical and marine crews. The work period is usually
quite short and many of the tasks highly specialized.

There are not usually government requirements for local hiring for seismic work. Local hiring for
exploration drilling may be a legislated requirement and can vary both regionally and
internationally. In Newfoundland and Labrador, local hiring requirements were introduced in
1977 by the provincial government as a means of involving Newfoundlanders and Labradorians
in what was hoped would be an emerging offshore petroleum industry.

The key to supply chain planning during exploration is that the system has to be sufficiently
robust to “keep the drill bit turning to the right” but, given the uncertainties associated with the
activity, the supply chain has to be able to be easily abandoned at minimal long-term cost to the
companies involved in exploration.

Two examples illustrate the local supply chain effects of short- and long-term activity patterns.

*Short-term Exploration Activity*

In 2009 ConocoPhillips leased the *Stena Caron* to drill the East Wolverine G-37 wildcat well in
the Laurentian Basin off the south coast of Newfoundland. The work was undertaken in the first
quarter of 2010. The drillship arrived carrying drilling supplies and equipment and did not come
into port in Newfoundland. Crew changes and the provision of additional supplies and
equipment from Newfoundland were effected through the use of supply vessels and helicopters.

When the ConocoPhillips well was finished the drilling vessel moved on to the Orphan Basin to
drill another well. Once again, required supplies, equipment and crew were delivered to the
vessel by supply boat and helicopter; at no time did the drilling unit come to shore.
Long-Term Exploration Activity

During the drilling phase of the late 1970s and early 1980s there were up to nine drilling units, 20 helicopters and 30 supply vessels active in St. John’s and Halifax at any one time. Each of the wells drilled required physical consumable supplies and spares. Vessels and aircraft all had ship repair, dry-dock, and other maintenance needs and, as a result of provincial hiring requirements, there was a large requirement for local crew.

During this period a number of major oil and gas discoveries were made. These discoveries and the availability of the federal Petroleum Incentives Program (PIP) (see Section 2.1) further encouraged exploration. The scale of activity was such that local investors began to create a permanent supply chain by building warehouses, getting involved with specialized contracting opportunities such as pipe yards, and training a local workforce in the highly specialized activities required to service offshore oil and gas exploration activity. Supply deals were established with foreign parts suppliers and warehouses were filled with the supplies required to sustain drilling.

In 1984 there was a sudden decline in drilling activity, largely as a result of the termination of the PIP. Development and production of discovered resources did not follow because of inter-governmental disputes over ownership rights and royalties. The drilling units, helicopters, supply boats and many of the offshore personnel relocated to other areas, much of the fixed infrastructure lay empty, and many investors were left with significant debt and few prospects of continued revenue. Many of the investors were locals with little experience with the ‘how’ and ‘when’ of permanent supply chain creation. The large international service contractors which were accustomed to following the industry around the world were well aware of the uncertainties and risks associated with exploration activity, and were able to depart without incurring major expense, while less experienced local investors assumed much of the long-term risk.

In a few cases, the largest of the service contractors created permanent bases because they recognized the long-term nature of the opportunity and had the financial resources to carry non-revenue generating facilities for a period of time. With several major discoveries having been made, the larger firms realized they would eventually be back even if they did not know when that might be. For most, however, maintaining a presence in the local market was not seen as a necessity prior to the start of development activity.

There is only a limited need for local infrastructure to support long-term exploration, none of which would be likely to be constructed specifically for activities in this phase. At most, there are requirements for port facilities where supply vessels can dock and take on consumables or required equipment, and an airport to facilitate crew changeovers. Some local businesses may be able to supply consumables to offshore exploration vessels, but the economic impact is likely to be small and at best occasional.

Where drilling units require refit/modification to meet legislated requirements before undertaking programs of work in the region, local shipyards may be capable of such work. This capability is likely to increase over the course of long-term exploratory activity. In Newfoundland, for example, the Marys town shipyard was involved in repairing Ocean Rig’s Eirik Raude semi-submersible rig, the Bull Arm yard was used for reconditioning Global Santa Fe’s Glomar Grand Banks, and the Bay Bulls Marine Terminal has performed maintenance, inspection and refit
work on the *Glomar Grand Banks* and TransOcean’s *Henry Goodrich*. Such capabilities do not exist in Greenland, Labrador or the Canadian Arctic.

### 3.2 Development Phase Supply Chain Requirements

The supply chain for development is that of a large construction project in which the requirements are individual, specific and not usually repeatable on a year-to-year basis. As such, the requirements are quite different from those of the production phase, during which the repetitive nature of the supply chain requirements is the predominant characteristic.

The development supply chain involves the sourcing, contracting, procurement, assembly and commissioning of a large array of goods and services for the specific purpose of creating and installing the hydrocarbon production unit ready for operation. Integral to the creation of the supply chain is the overall construction contract approach chosen. The approach can vary substantially and greatly influence how the supply chain is created and managed.

Examples range from fixed-price contracts for large portions of the work managed by external contractors and based on the owner’s engineering, to entire engineering, procurement, construction and commissioning contracts. In some cases this can also be extended to long-term, fixed-price management contracts, which include repair and maintenance, and where the revenue streams are shared between the owner and the construction contractor.

In a strictly fixed-price engineer, procure and construct (EPC) contract, the contractor has no long-term interest in the operations and maintenance phase of the overall project. The contractor’s focus is acquiring compliant material that can be incorporated into the facility at the lowest possible cost, thereby maximizing overall contractor profit. The contractual arrangement does not include requirements for subsequent repair requirements or spares philosophies. A different approach is required when there are long-term arrangements that extend into the operations phase.

A different supply chain needs to be developed for each case. The contractor’s supply chain is primarily organized to get the appropriate material to the construction point at the time it is needed, while the owner/contractor’s requirement includes establishing a supply chain for post-construction activities such as repair and overhaul facilities, and spares management.

Another contractual approach that could be adopted during development is associated with owner-supplied materials. The owner may decide that it wants to specify and acquire specific materials in the supply chain in order to guarantee long-term performance. In such cases the owner manages the supply chain from the initial acquisition stage and undertakes to deliver the required materials to the contractor’s constructions points. This is important in the procurement phase as long-term spares and servicing arrangements can be included in the initial negotiations. This may be particularly important in frontier regions where repair technicians and regular access to spares are difficult to acquire and maintain. It can also be useful where commonality of suppliers is desired to reduce overall long-term costs.

These and other contractual arrangements and their associated supply chain requirements change over time with new approaches gaining favour from one period to the next. No one type of arrangement has emerged as the long-term preferred approach.
Regardless of the contractual approach, some common elements in the supply chain apply to all development projects.

Once the project design is frozen, the supply chain is initially tasked with ordering long lead time items. These are items that are either scarce or are purpose-built in factories that require an order to be booked years in advance. When they have been booked, these orders are also frozen, usually on a take or pay basis. Once the long lead time vendors are known then local supply chains can begin to take shape.

Usually the next elements in the development supply chain are those specialty items that relate to specific characteristics of the development project concerned. They could include sour gas equipment, titanium spool pieces for weight reduction, or heating equipment for viscous oil products. These usually have special engineering requirements and only have limited impact on the long-term local supply chain because their repair and maintenance is also a specialty that is sourced from global markets.

After the long lead time and specialty items are ordered, the more conventional bulk items are sourced. These include valves, pumps, piping and control systems. Once the particular items are selected more information is available to help structure the local supply chain. This could involve the manufacturer establishing a facility in the local area, or arranging for a local company to act on its behalf.

After bulks come the commodity items which are almost always available in the local market and the only real impact on the supply chain is on the quantity of spares and reserves that are stored locally.

When all the required equipment has been procured, components are fabricated and the production unit is constructed, assembled and installed ready for production. This is followed by the final stage of the supply chain which involves disposal of surplus material. While every effort is made to minimize its quantity and value, there are always a significant number of items and materials leftover after a development is completed. Some items can be placed in long-term stores, and others can be sold back to manufacturers, but many items will be sold at auction several years after construction is completed.

3.2.1 Local Infrastructure Requirements

Production of offshore oil and gas resources may take several forms. In reviewing these, the following options or scenarios were identified as having potential application in, and possibly require the infrastructure construction requirements in, Greenland, Labrador and the Canadian Arctic:

Offshore production:
- Floating unit (FPSO or floating LNG);
- Fixed unit (GBS); and
- Subsea production.
Transportation to shore:
- Tanker; and
- Pipeline.

Onshore facilities:
- Oil transshipment terminal; and
- Gas liquefaction plant.

Each of these (with the exception of tanker transportation, for which there would no significant local infrastructure requirement) is considered below in terms of the potential implications of their selection for construction phase supply chain requirements in Greenland, Labrador and the Canadian Arctic. The complexity of each of these production elements is such that the supply chain associated with their construction is global rather than local in nature. While onshore construction, processing or storage facilities will clearly involve local elements in the supply chain, the absence or limited nature of the necessary infrastructure, support services and skilled labour in these frontier regions (see Sections 3.4, 3.5 and 3.6) will mean that much of the activity associated with the supply chain will occur outside of the region, unless required and/or supported by government authorities.

Where local benefits legislation seeks to increase local activity, this may affect the geography of the supply chain, but only to the degree that local involvement is technically and economically feasible. For example, there are only a small number of shipyards in the world capable of building the hulls for FPSOs. While the fabrication and installation of topside equipment for an FPSO can be completed at smaller yards, even these requirements are likely to be beyond the capacities of shipbuilding/fabrication sites in the frontier regions in question. As such, local involvement in the supply chain associated with the development of an FPSO is likely to be minimal.

In addition, all offshore development projects require a range of onshore support infrastructure, including shore base facilities, a heliport and access to an airport and warehousing. The scale and level of sophistication of such facilities will depend on the scale of offshore activity, and investment levels will be “fit for purpose.” As an example, depending on the geographic distribution of activity, there will likely be only one, rather than several, supply bases and one heliport required to service offshore activity at various locations, unless they are very distant from one another.

The case study examples provided in this section describe development strategies and their supply chain implications that have been followed in frontier areas adjacent to Greenland, Labrador and the Canadian Arctic. They have similar environmental, economic, political and cultural conditions to Greenland, Labrador and the Canadian Arctic, and hence provide a basis for discussing the likely course of events and requirements in the three regions under consideration in this report.

### 3.2.1.1 Onshore Support Facilities

St. John’s, Newfoundland and Labrador, provides a good case study of the provision of offshore petroleum activity support facilities. It has been the location for all shore base, heliport and warehousing activity since exploration on the Grand Banks began in the 1960s and development in the 1990s. The onshore support facilities have evolved over the past 40 years
and now support three producing fields and will likely provide similar services for the proposed development and operation of the Hebron field.

St. John’s is the closest urban area to the offshore developments. In addition to its port and associated warehouses, it has an international airport and, being the largest urban centre in the Province, access to the main offices of government, business, training and research institutions that directly or indirectly provide additional onshore support for the industry. There is no centre offering a similar range of support facilities in Greenland, Labrador or the Canadian Arctic.

**Case Study 1  St. John’s**

**Shore base**

Located in St. John’s Harbour, the A. Harvey & Co. shore base (Piers 14 to 16) has provided support facilities for all Newfoundland offshore oil-based marine services since 1977 (A. Harvey Group 2005). The facility has expanded as the industry has matured from exploration to development and production. The company provides docking facilities for the support vessels, lay-down and marshaling areas on the waterfront, warehousing that is required at the site, and equipment and materials handing personnel and equipment, such as crane and forklift services, local transportation of materials to the site, and containers to transport goods to and from the platform.

In addition, in 2003 the St. John’s Port Authority (SJPA) has reconstructed Pier 17 as a new multi-use facility to service the petroleum industry and for general marine usage. The facility now has improved lift capabilities, in-deck utilidors and new fluid management systems (SJPA 2010).

The offshore petroleum industry has matured over the past 30 years and significant improvements to St. John’s facilities have been made. As a result, St. John’s has been able to serve the entire Grand Banks offshore petroleum industry to this point, and this is not expected to change in the near future. Practically all materials that flow between shore and the platform pass through St. John’s Harbour, with the exception of whatever is transported by helicopter. There is considerable interaction between the shore base and the warehouse and off-site storage complex located in Mount Pearl.
3.2.1.2 Floating Production Systems

Floating production systems, whether for oil or gas production, have the advantage that they can be moved off-station in the event that sea ice or weather conditions require it. As such, they would seem to be the more likely candidates for production in the frontier areas under study.

They are highly complex vessels, many of the components of which can only be fabricated in specialized shipyards or manufacturing facilities. As noted earlier, some fabrication, topsides installation and commissioning may be carried out at other locations, but these too require a level of infrastructure, support services and skilled labour that is not presently available in any of the study regions. The White Rose and Floating LNG case studies illustrate the complexity of floating production systems and the geographies of their associated supply chains. Were either type of system to be used in Greenland, Labrador or the Canadian Arctic, they would likely be delivered as fully operational units to the sites in question.
The White Rose oil field is located 350 km east of Newfoundland. Its development was officially sanctioned in March 2002, and first oil production was achieved in November 2005. Following an extensive concept selection process, Husky decided to develop the White Rose field with a purpose-built FPSO, the Sea Rose.

The field has been developed from three or four drill centres on the seafloor, with production and water and gas injection wells located at each centre. These drill centres are located in excavated glory holes that lie below the seabed to protect the wells from iceberg scour.

Ongoing development plans envisage up to 10 to 14 production wells eventually with an additional eight to eleven gas and water injection wells for resource conservation and to maintain reservoir pressure. The wells have been drilled in phases to bring White Rose satellite fields into production, starting with the North Amethyst field in May 2010. The drill centres are connected to the ship-shaped FPSO, the Sea Rose, with flexible flow lines and risers. The FPSO’s turret is designed to allow the facility to disconnect from the subsea drill centres and move in the event of an emergency.

Drilling, dredging and installation were carried out by MODUs and other specialty vessels contracted with global suppliers. Day-to-day support by sea and air was provided from St. John’s.

In October 2000, a Front End Engineering Design (FEED) study was awarded to Maersk Contractors, which later carried out the project management contract for the Engineering Procurement Integration and Commissioning (EPIC) phase.

Only a relatively small number of shipyards are large enough to build the hulls for FPSOs. Samsung Heavy Industries of South Korea was contracted to build the hull of the Sea Rose (267 m long, 46 m wide and 27 m deep). SBM IMODCO of Houston, Texas provided the turret and mooring system. The contract for the engineering, procurement, construction and installation of topsides was awarded to Aker Maritime Kiewit Contractors (AMKC), a joint venture of Peter Kiewit Sons Co. Ltd. and Aker Oil and Gas Technology Ltd. The topsides fabrication and installation was completed at the Marystown shipyard in Newfoundland. Total capital costs were about $2.35 billion. Peak employment at the shipyard was approximately 1,200.

Husky has time-chartered two new-build shuttle tankers from Knutsen OAS to transport oil from the White Rose offshore project. Delivery of the Suezmax-size vessels, each with a one million-barrel capacity and built by Samsung Heavy Industries in South Korea, took place in mid-2005.
Case Study 2 (Continued)  White Rose FPSO

Topsides fabrication and installation represented an important contribution to the Newfoundland and Labrador economy and to the Marystown area in particular. However, the cost of building the Cow Head facilities at Marystown, where the fabrication and installation was carried out, were originally borne by government with the objective of promoting economic development in a region where many of the necessary shipbuilding skills were already present but underutilized. Similar infrastructure investments in Greenland, Labrador or the Canadian Arctic seem very unlikely. This could result in opportunities for facilities in Newfoundland and the Maritimes, providing that they are commercially competitive with yards elsewhere.

Case Study 3  Floating LNG Vessels

Initial floating LNG designs date back more than 30 years and such vessels are now under construction. They are viewed as ideal for small or remote gas fields that would not otherwise be profitable to develop. Cost estimates of US$700 per tonne per annum are given, which are potentially low in comparison to onshore facilities. Costs are lower because there are no or reduced infrastructure costs associated with gas pipelines, the jetty, LNG storage tanks, site preparation and construction facilities. In addition, floating facilities are estimated to take less than half the time to construct.

The first floating LNG plant was approved in December 2008 for offshore Nigeria. In 2009 Samsung Heavy Industries Co., the world’s third-largest shipyard, won an order from Shell to build a floating LNG facility, the first deal between the two companies under a 15-year supply contract. Under this contract, Samsung Heavy Industries and Technip SA will design, construct and install floating LNG facilities. Shell may order as many as ten units that may be worth as much as $5 billion each, according to Samsung.

There are more than a dozen proposed LNG projects offshore Australia, seeking to tap increasing Asian demand for cleaner-burning alternatives to coal. The use of such facilities to process gas may suit fields that are too far from the country’s coast to be profitably developed through onshore plants. Floating LNG plants, given their size and the new technologies involved, would most likely be constructed in the world’s major shipyards where the technology has been developed. At this time even partial fabrication and assembly at other locations seems unlikely (Finn 2009).
3.2.1.3 Fixed Production Systems

Fixed offshore production systems in the frontier regions under study would need to be capable of withstanding ice and Arctic weather conditions. A concrete GBS is the type of system most likely to meet these requirements if oil is the resource to be developed. A GBS has been successfully used on the Grand Banks of Newfoundland for the Hibernia project and is proposed for the Hebron project, both of which are in shallow water environments.

A GBS is a large and very heavy structure that must be floated and towed from its construction/assembly site to the field location. This is a complex and risky process, and one for which the distance to be moved would ideally be minimized. There are currently no sites in the study regions with the capability to build a GBS and whether construction of such a site would be economically feasible is doubtful. Whether such a structure would be constructed at the nearest yard (which is the Bull Arm facility in Newfoundland) to any potential developments seems highly unlikely given the distance that the unit would have to be moved to the production site.

As with FPSOs (see Section 3.2.1.2), GBS topsides fabrication has taken place in Newfoundland and the Maritimes, and such work could provide opportunities for facilities there, providing that they are commercially competitive with yards elsewhere. This may be a challenge, especially given the likely need to transport the topsides components to be mated with the GBS at a distant site.

![Stand Alone GBS](image)

*Figure 3-1 Stand-alone Gravity-base Structure Preliminary Development Layout*
The case study of construction of a GBS for the Hebron project (Figure 3-1) illustrates the complexity of such an undertaking. Development of similar construction yards for projects in Greenland, Labrador or the Canadian Arctic seems highly unlikely. Ice conditions, if not water depths, make floating systems, whether for oil or gas production, much more likely. Furthermore, the size and characteristics of local labour forces in each frontier region and experiences elsewhere do not suggest that development of construction yards offer long-term development opportunities, and the cost for what might only be one project represents a high-risk investment.

**Case Study 4  Hebron GBS**

The Hebron offshore project area is located approximately 340 km offshore of St. John’s, Newfoundland. Water depths range from 88 to 102 m. The oil production system will use a GBS to be constructed at Bull Arm, Trinity Bay. Some of the topsides modules will be built locally and some overseas, they will be assembled and installed onto the GBS at the Bull Arm location before the entire structure is towed to the offshore site. The development sequence for the project includes field development; GBS construction, installation and operation; offshore loading to shuttle tankers; and shipping.

The Hebron Field will be developed using a stand-alone concrete GBS. The GBS will consist of a reinforced concrete structure designed to withstand sea ice, icebergs, and meteorological and oceanographic conditions at the offshore Hebron location (Figure 3-1). The preliminary GBS concept has a single main shaft supporting the topsides, encompassing all wells.

The GBS and topsides facilities will be constructed separately and then mated at an inshore site in Bull Arm, Trinity Bay, prior to towing and installation of the platform on the Grand Banks.

The topsides will consist of:

- A drilling rig capable of drilling and completion of wells, plus ongoing downhole maintenance of wells;
- Production facilities for the separation of oil, gas and water, treatment of produced water, compression of gas and injection of seawater;
- Utility systems including power generation and distribution; and
- Life support and safety systems including personnel accommodation for approximately 230 personnel, platform control system, temporary safe refuge and emergency evacuation and rescue systems.
3.2.1.4 Subsea Production Systems and Pipelines

The design, production, installation and maintenance of subsea production units and marine pipelines are highly specialized tasks. Highly sophisticated equipment is required at most stages and the activities tend to be dominated by a relatively small number of firms that operate in a global environment. As with the exploration phase, the local effects of the supply chain in the frontier regions may be very minor and restricted to purchase of some consumables and transfers of personnel. Otherwise, during installation and maintenance, the vessels involved are largely independent and supported from more distant centres that have the appropriate infrastructure. As with exploration the opportunities for local frontier region companies to involve themselves in the supply chain are very limited. The Skarv/Idun and Sable Offshore Energy Project case studies illustrate this complexity.

Case Study 4 (Continued)  Hebron GBS

Treated oil will be stored in the GBS prior to shipment. The GBS will be designed to store approximately 18,000 to 230,000 m$^3$ of oil in multiple separate storage compartments. An offshore loading system (OLS) complete with a looped pipeline and two separate loading points would be installed to offload the oil onto ice-strengthened tankers for transport to market (EMCP 2009).

The Bull Arm Site, 130 km north-west of St. John’s, was constructed to build the Hibernia GBS and was later used for the Terra Nova FPSO fabrication and installation and for some of the White Rose FPSO topside fabrication. The site connects to the Province’s main highway, the Trans Canada Highway, and is fully self-contained with capabilities for steel and concrete construction, outfitting, installation, atshore hook-up and commissioning.

Some topsides components will be fabricated at the site, others will be fabricated offsite and transported to Bull Arm for assembly. All modules and components will be integrated at the pier. Hook-up and commissioning of the fully integrated topsides will begin at the pier prior to mating with the GBS at the adjacent deepwater site and may continue after mating. The complete structure will be towed to the Hebron field and installed. Wells will then be drilled from the platform.
Case Study 5  Skarv/Idun Subsea Production

Over the last decade, there has been a large increase in the application of subsea systems for the production of oil and gas from subsea wellheads. A subsea production system comprises a wellhead, valve tree equipment, pipelines, structures and a piping system, and where a number of wellheads have to be controlled from a single location, a subsea control system (Stecki 2003).

Subsea production systems can range in complexity from a single satellite well with a flowline linked to a fixed platform, FPSO or an onshore installation, to several wells on a template or clustered around a manifold, and transferring to a fixed or floating facility, or directly to an onshore installation.

Subsea production systems can be used to develop reservoirs, or parts of reservoirs, which require drilling of the wells from more than one location. Deep or even ultra-deep water conditions, can also dictate development of a field by means of a subsea production system where traditional surface facilities are either technically unfeasible or uneconomical due to the water depth.

The subsea development of oil and gas fields requires specialized equipment reliable enough to safeguard the environment and make the exploitation of the subsea hydrocarbons economically feasible. The deployment of such equipment requires specialized and expensive vessels, which need to be equipped with diving equipment for relatively shallow equipment work (i.e. a few hundred feet water depth maximum), and robotic equipment for deeper water depths. Any requirement to repair or intervene with installed subsea equipment is thus normally very expensive.

Subsea technology in offshore oil and gas production is a highly specialized field of application with particular demands on engineering and simulation. With most of the new oil fields located in deep water, development of these fields sets strict requirements for verification of the various systems’ functions and their compliance with current requirements and specifications which serves to limit the number of companies globally with the necessary skills and experience.

The subsea production contracts for the Skarv and Idun fields in northern Norway (Offshore Technology.com no date) illustrate the complexity and cost of subsea production systems and the locations selected for the offsite work to take place. As indicated the complexity of the supply chain elements for subsea production mean that frontier regions will not be significantly involved in the construction process.
Case Study 5 (Continued)  

Skarv/Idun Subsea Production

The Skarv field was discovered in 1998, and the Idun field in 1999. They are located in the Norwegian Sea, c. 200 km west of Sandnessjøen, between the Norne field (35 km to the north) and Heidrun (45 km to the south) in water depths between 350 and 450 m. The Skarv Idun Development consists of the development the Skarv gas and oil field and the Idun gas field. There are additional identified resources in the Skarv Idun area that may be developed as tie-backs to the Skarv Idun FPSO at a later stage.

The fields are being developed using an FPSO to produce from 15 or 16 subsea wells, and an 80km gas export pipeline. The total project cost is about US$4.5 billion.

The Subsea Production System contract contains two parts; the EPC phase and the subsequent Operational Support phase. The contracts will run consecutively with a managed overlap period and have an estimated combined value of about US$265 million. The EPC Contract has an expected duration of four years and an approximate value of about US$250 million encompasses the detailed design, project management and supply of subsea production equipment for Skarv-Idun together with all related installation and commissioning support up until first hydrocarbon. The main work locations for the EPC phase are Haugesund and Billingstad in Norway, Aberdeen and Nailsea in the UK.

The Operational Support and Associated Service Contract EPC Contract has an initial duration of five years from commencement of drilling operations plus options to extend the duration. The estimated contract value for core operational support services during the initial year period is about US$15 million.
3.2.1.5 Onshore Processing and Storage

Another option is to transfer the oil or gas produced to an onshore processing and/or storage facility. Oil may be transported to an onshore storage facility, either by pipeline or tanker, and from there the crude oil would be shipped via second-leg tankers to established refineries. This is the system adopted for oil produced from the Hibernia and Terra Nova fields in

Case Study 6 Sable Offshore Energy Project Marine Pipeline

The Sable Offshore Energy Project (SOEP) 26 inch offshore gathering line and the associated inter-field lines are the first major offshore pipelines on the East Coast of Canada. It involves nearly 300 km of subsea pipeline linking five offshore gas fields near Sable Island to onshore operations on Nova Scotia’s coast (SOEP 2010). The gas is pumped to shore through the main pipeline, traversing the Scotian Shelf and joining the Thebaud central processing platform offshore with the gas plant onshore in Goldboro, Nova Scotia.

Onshore preparation of the pipe involved coating to prevent corrosion and encasing the pipe in a layer of concrete. The pipe was then loaded onto supply vessels and shipped out to the Allseas (a Swiss company) pipelaying vessel, the Solitaire. At 285 m long, the Solitaire was the world’s largest pipelaying vessel. Here the pipe sections underwent further treatment and testing, and machined and welded to produce a single pipeline. Once in place, a remotely-operated robot was deployed to the ocean floor to bury and secure the pipeline in a one-metre deep V-shaped trench along the seafloor.

Raw gas extracted from the offshore wells is pumped through the pipeline, arriving at the main plant in Goldboro, where it is processed and purified. The gas is separated from non-gas liquids such as propane, butane and condensate. The gas is then sent to market via a buried terrestrial pipeline, through Nova Scotia, New Brunswick and the northeastern United States. Another pipeline carries the gas by-products to Point Tupper in Cape Breton, Nova Scotia, for separation and commercial sale.

In this case, the onshore preparation of the pipe was undertaken in the region, but none of the frontier regions in question have comparable industrial infrastructure or labour to perform similar tasks. In each case any pipeline preparation would likely be carried out outside of the region.
Newfoundland. The Whiffen Head Transshipment Terminal in Newfoundland is used as a case study example of these arrangements.

**Case Study 7  Newfoundland Transshipment Terminal**

The Newfoundland Transshipment Terminal (Newfoundland Transshipment Limited no date), located at Whiffen Head on the northeast edge of Placentia Bay, is a 3-million barrel crude oil transfer and storage facility servicing the Hibernia and Terra Nova oil fields. Owned and Operated by Newfoundland Transshipment Limited (NTL) the terminal is located approximately 600 km (325 NM) west and north of the Grand Banks oilfields. The main activity elements involve: shuttle vessel liftings from offshore production facilities; deliveries to the Terminal (two vessel berths); crude storage, and reloading to second-leg tankers to market.

NTL owns and operates two state-of-the-art tugs, the Placentia Hope and Placentia Pride, constructed at Marystown, Newfoundland. These tugs are used to escort laden tankers to and from the pilot station in Placentia Bay and to dock/undock tankers at the NTL terminal.

Transshipment is an integral part of the overall crude to market transportation system, a two-stage process for moving crude oil to market.

**Stage 1:** From producing offshore field via shuttle tanker to NTL’s terminal; and

**Stage 2:** From NTL’s terminal via conventional tanker to global end users (refiners).

Transshipment allows cargo sizes to be tailored to fit individual refiner’s needs, provides access to world markets beyond the range of the shuttle tankers and decreases the number of shuttle tankers required to support offshore oil production.

Announced in 1996, construction started in 1997 and the project was completed in 1998. The initial total estimated cost for the facility was C$200 million.
LNG processing is a rather different story. There are comparatively few onshore LNG plants and planning issues and gas price uncertainties among other factors have served to constrain the development of new ones. However, an onshore LNG plant in a remote location is a development possibility. The case of the Snohvit terminal near Hammerfest in Northern Norway is used to illustrate such a project.

Case Study 7 (Continued)  Newfoundland Transshipment Terminal

The transshipment terminal initially had three crude oil tanks, support buildings, diesel tanks and a causeway/trestle to the near-shore tanker berth. From January 1999 to October 2000, NTL had a significant growth spurt. A $65 million dollar expansion to the terminal included a second near-shore tanker berth and two additional 500,000-barrel storage tanks along with the supporting infrastructure. A sixth tank was added in 2002. Total maximum storage capacity is currently three million barrels.

Initial construction required a workforce that peaked at more than 300. Compared with construction of a GBS or an FPSO, the range of skills required for construction is relatively modest. NTL currently employs 49 personnel in operations, administration and tug crews.

The Terminal also provides access to agency, ship's chandlering and other services required for continuous operation of shuttle vessels and second leg vessels involved in the transportation chain.

If oil were to be discovered offshore Greenland, a terminal of this type might be a development option, with pipelines from the fields to the terminal or dedicated tankers operating between the fields and the terminal as in the case of Hibernia and Terra Nova. With gas as the most likely resource offshore Labrador, this development option appears unlikely to be relevant in this region. Oil development in the Canadian Arctic might also employ a transshipment terminal, although the use of shuttle tankers is currently unlikely given the extended seasonal presence of sea ice.
Case Study 8  Snohvit Onshore LNG Plant

The Snohvit facility is one of world’s largest onstream onshore LNG plants and was constructed between 2003 and 2007. A pipeline link the Askeladd and Albatross fields to Snohvit and a 140km gas pipeline then links the field to the land-based plant at Melkoya near Hammerfest. In terms of value of production, LNG constitutes approximately 85 percent, condensate 11 percent and LPG 4 percent (Bjarne 2004).

Sequentially, the main activity elements in the development of an LNG export terminal are: field development, pipeline installation, LNG plant construction and operation, receiving terminal and shipping. Total cost of the project was NOK 34.2 billion (field development, pipeline, land plant) and NOK 5.4 billion for ships (four carriers built in Japan 145,000 m³ capacity).

Field development will eventually see a total of 20 wells drilled using MODUs. Wells are linked to subsea templates and flow lines, and multi-phase pipelines will then link to the onshore facilities. These consist of wellstream receiving facilities with a slug-catcher of 2,700 m³ capacity, condensate separation and stabilisation, CO² sequestration and reinjection to offshore reservoir, gas pre-treatment facilities, gas liquefaction, four storage tanks and associated utilities including administration building with control room.

The storage tanks are all full containment tanks with an outer shell of reinforced concrete. The two LNG tanks have a capacity of 125,000 m³ each, and it takes roughly five days to fill a tank. The diameter is 78 m, and height 47 m. The condensate tank has a capacity of 75,000 m³ while the capacity of the LPG tank is 45,000 m³.

Melkoya was selected as the location for the Snohvit LNG plant due to its proximity to Hammerfest, access to a good harbour and the possibility of access to land pipelines. Relative closeness to a city gives some synergies and advantages, including, proximity to an airport, hospital and fire-fighting facilities and the opportunity for operations personnel to live in an urban environment.

The Snohvit plant has a compact layout due to limited space and with the objective of minimizing costs and the construction schedule. Furthermore, the construction was based on a prefabrication strategy in which the core process facilities were fabricated at the Dragados Offshore yard in Cadiz, Spain, installed on a floating barge and transported as a single 35,000 tonne module to the final destination.
Case Study 8 (Continued)  Snohvit Onshore LNG Plant

The main reasons for using a prefabrication strategy were the limited infrastructure in the area, the size of the project and the potentially harsh weather conditions. A modularized design allowed for maximum possible prefabrication and fabrication of components in parallel. However, the process presented a challenge in bringing all of the pieces together. A total of 15-million person-hours were required to build facility, of which 50 per cent was on site.

In parallel to the excavation for the project site, a 2.3 km subsea tunnel was constructed to connect Melkoya with the mainland. A 1,300-bed construction camp was built to accommodate workers.

Process facility components were fabricated at a number of different locations. For example, the slug-catcher, which is one of the largest in the world, was made in the Netherlands and transported to Melkoya in pieces on two barges. The compressors were made in Massa, Italy, and transported to Dragados for installation on the barge.

During construction some 6,000 persons worked on Melkoya and at peak employment reached approximately 1,500. During operations approximately 170 persons are required. In addition, support personnel and induced activities generate an estimated further 300 to 350 jobs in the area. For a community like Hammerfest, which had been characterized by continuous population losses for many years prior to Snohvit, the project has had a significant positive economic and social impact.

Tankers depart from Hammerfest every five or six days. There are about 70 LNG cargoes/year and 15-20 LPG/condensate cargoes per year. Shipping to the US east coast involves an approximately 20-day round trip, while Bilbao in Northern Spain requires 12-day round trip.

Depending on the location of any gas fields and the feasibility of operating pipelines in ice-infested waters, onshore LNG plants represent possibilities for producing gas offshore Labrador, Greenland and the Canadian Arctic, at least until FLNG plants are proved viable from a technical, safety and economic perspective. However, compared with settlements in coastal Greenland, Labrador and the Canadian Arctic, Hammerfest is a much larger (2005 population: 9,261) with many of the urban amenities likely to provide a permanent workforce. Plants at more remote locations could be organized around fly-in/fly-out work systems, but the cost differences compared with having a permanent local workforce would need to be carefully considered. While floating LNG plants appear to avoid many of the costs of plant development, until this technology is proven, onshore plants in remote areas will remain up for consideration.
3.3 Production Phase Supply Chain Requirements

The long-term steady state supply chain is very different from the development supply chain. By the time that production commences all the key service, supply and maintenance contracts will have been awarded and processes will be in place to manage the contractors. Examples of these include:

- Helicopters and a support base at an airport;
- Supply vessels and a shore base with adequate access to and storage for water, fuel, and mud tanks and with an adjacent lay down area;
- Warehousing facilities for receiving, consolidation and expediting;
- Tubular goods yards where pipe, tubing and casing can be delivered, stored and prepared for use;
- Trucking facilities;
- Customs and freight forwarding;
- Spares, repairs and maintenance equipment storage for all components of the production unit, including emergency long-term spares storage for key components that are critical to the production unit’s operation. Items are either centrally stored or stored at vendors’ premises, and can be owned, made available on consignment, or available on call from the vendors;
- Hazardous waste disposal; and
- Regular waste disposal.

These and other service and supply elements will likely have evolved from similar activities established during the exploration and development phases. Each of the individual contracting companies associated with these and other inputs will create its own supply chains and develop its own workforce, property and other infrastructure. Local investors will be able to see and understand the nature of the long-term requirements and can negotiate or bid on the provision of goods and services for the long-term, usually in five year increments.

The overall supply manager will usually be the project owner/operator, but portions of the responsibility, for example, receiving, quality control, warehousing and expediting to specialist vendors, may be contracted out. Owner/operators will also usually manage the contracting of major service vendors, such as operations and maintenance contractors, but will frequently allow those contractors to hire and provision supply chain components themselves.

The amount of supply chain control exercised by the operator is usually directly proportional to the importance of the service. For example, owner/operators will almost certainly want to manage the engagement of their long-term drilling contractor, but they may be more than willing to allow the drilling contractor to procure and manage their major components such as oil country tubular goods.

3.4 Greenland Supply Chain

This section describes a likely supply chain development scenario for Greenland, based on the typical evolution of the supply over time, the supply chain requirements described above, and
the characteristics and size of the Greenland population, labour force and industrial base, including transportation infrastructure.

As is the case with Labrador and the Canadian Arctic, Greenland has a relatively small population and labour force, a limited skills base, little industrial activity, and an economy that is dominated by service sector and government activity. Greenland’s 2009 population was just over 56,000, of whom about 85% were Inuit and the remainder is mainly Danish. The population has been in decline in recent years, partly as a result of a net outmigration. There has also been a considerable exodus from small communities into Greenland towns (EC, 2007).

Table 3-1  Population of Greenland, 2009

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Population</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-14</td>
<td>13,006</td>
<td>6,606</td>
<td>6,400</td>
</tr>
<tr>
<td>15-24</td>
<td>8,791</td>
<td>4,464</td>
<td>4,327</td>
</tr>
<tr>
<td>25-59</td>
<td>28,409</td>
<td>15,532</td>
<td>12,877</td>
</tr>
<tr>
<td>60+</td>
<td>5,988</td>
<td>3,207</td>
<td>2,781</td>
</tr>
<tr>
<td>Total</td>
<td>56,194</td>
<td>29,809</td>
<td>26,385</td>
</tr>
</tbody>
</table>

Source: Statistics Greenland, 2009

Greenland is characterized by its relatively young labour force and a female participation rate that is close to that of men. Most people in the Greenlandic labour market are involved in unskilled work, fishing, hunting and low-level service work (Ministry of Social and Labour Market Affairs, No date). In 2006, 44 percent of employed people in Greenland were working in public administration and service, 17 percent in trade and repairs, 10 percent in construction and building, 5 percent in the fishing industry and only 3 percent in industrial services (Statistics Greenland, 2009).

Table 3-2  Labour Force, Greenland, 2006 and 2007

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>56,901</td>
<td>56,649</td>
</tr>
<tr>
<td>Labour Force</td>
<td>32,384</td>
<td>32,437</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>7.3%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Men</td>
<td>7.8%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Women</td>
<td>6.8%</td>
<td>6.3%</td>
</tr>
</tbody>
</table>

Source: Statistics Greenland, 2009

The skill level of Greenland’s workforce is very low. Of the potential workforce of 35,000 to 40,000 persons aged 15-62, only about one third have an education that qualifies them for a job above unskilled level and approximately 80 percent of unemployed workers are unskilled. Enrolment in training or education is very low and the dropout rate is high, which perpetuates the workforce’s low level of education and training (EC, 2007).

In 2006, the Parliament adopted a Greenland Education Program which contains an overall education and training strategy until 2020. In its first phase, emphasis is put primarily on vocational training, the acquisition of real qualifications for jobs above unskilled level and real competence courses for unskilled persons. In phase two, the focus on the unskilled workforce is maintained, but will shift to higher education and both the expansion and diversification of the provision of education and training (EC, 2007).
Of those who pursued post-secondary education in 2005 and 2006, the majority completed vocational education and training (64 percent and 65 percent respectively) (Statistics Greenland, 2009).

Table 3-3  Education Level, Greenland, 2005-2007

<table>
<thead>
<tr>
<th>Education Level</th>
<th>2005/06</th>
<th>2006/07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completed education, total</td>
<td>425</td>
<td>388</td>
</tr>
<tr>
<td>Vocational education and training</td>
<td>271</td>
<td>254</td>
</tr>
<tr>
<td>Middle range training</td>
<td>98</td>
<td>89</td>
</tr>
<tr>
<td>University education</td>
<td>55</td>
<td>44</td>
</tr>
<tr>
<td>Other education</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Statistics Greenland, 2009

Currently Greenland essentially has no oilfield supply chain capability. The existing supply chain is focused on providing the necessities of life for the residents and meeting the requirements for the limited industrial activity (mostly fish processing) that currently exists. There is also only limited transportation infrastructure, the use of which is constrained by ice and weather.

Nuuk and the other ports in Greenland are capable of handling vessels up to 152 m long (Table B-1). Ports on the south west coast including Nuuk and as far north as Sisimiut, are ice-free year round and are serviced on a weekly basis by Royal Arctic Line (RAL) from Aalborg, Denmark. Ports north of Sisimiut are generally considered closed by winter ice from December to April, May or June depending on how far north. Neither of the ports in east Greenland is ice-free year round. Ports in the south are generally disturbed and occasionally closed by drifting pack ice from east Greenland during the months of June, July and August. Transit time from Aalborg to Nuuk is 6.5 days. RAL does not have the capacity to carry bulk commodities in tanks onboard supply vessels. However, RAL could carry pipes, equipment, spares etc. for oilfield exploration and production.

Air travel within Greenland is provided by government-owned Air Greenland. Its fleet includes six Dash-7 aircraft, two Dash-8s, one King Air 200, two Twin Otters, and 26 helicopters. A single Airbus 330 provides the link between Greenland and Denmark. Additional detail on Greenland’s infrastructure is available in Appendix B.

Given the nature of current offshore petroleum activities and the uncertainty associated with any future activity, it is highly likely that an entirely new and separate supply chain will be created to service the oil industry in this area in the near to medium future. Use may be made of existing port and airport infrastructure, but it is highly likely that new purpose-built permanent infrastructure will have to be created.

The approach adopted by Cairn Energy for its 2010 exploration drilling program illustrates the implications of the lack of infrastructure in the area. The company plans to drill four wells over a four-month period using a drillship and a semisubmersible. There will be a fleet of support vessels for each drilling unit; a stand-by boat, two ice-management vessels and a Greenland-based supply vessel. In addition, there will be one or two supply boats operating between Greenland and Aberdeen, Scotland transporting consumables, equipment and other supplies.
In the absence of an adequate supply base in Greenland, and in order to ensure that this can be accomplished in the short timeframe, any down time due to lack of materials must be avoided. To accomplish this Cairn will utilize a ‘wareship’ based in Aasiaat. This will serve as a storage and repair base as well as an accommodations base when required for workers moving to and from the MODUs. The vessel will be a floating warehouse containing enough drilling materials to drill six wells and with enough redundancy to ensure adequate supply of spares. In addition a “dumb barge” will be stationed at Nuuk and used for storage of some required materials.

Offshore work crews will operate on fly-in/fly-out rosters travelling out of Edinburgh to Kangerlussuaq on chartered fixed wing aircraft, then on a chartered Air Greenland Dash-7 to Aasiaat, and from there to the offshore by helicopter. In the event of delays in getting offshore, crew will be accommodated on the wareship. Three helicopters will be used, based in Ilulissat. One will be dedicated to search and rescue, while the others will fly to Aasiaat three days per week, to fly from there to the offshore vessels and back, and then returning to Ilulissat.

As is evident, providing the necessary levels of support for the drilling program in the region, where there is little in the way of appropriate infrastructure, is a highly complex task and one for which supply chain planning is critical and in which the elements of the supply chain are dedicated to this project and primarily controlled by the operator. Whether these arrangements continue for any subsequent drilling programs will presumably depend on an evaluation of the 2010 program.

As more exploration activities occur in Greenland the likelihood of a discovery increases (on average, only about one in ten wildcat wells is a discovery). If discoveries occur and development activities are planned, then logistics specialists will look at the existing infrastructure and make decisions on how to build a supply chain combining what already exists with what will be required.

Some of the key determinants on how new infrastructure will be developed include:

- Whether the discovery is oil or gas;
- The size of discoveries;
- Water depth where developments are planned (Cairn/Capricorn Disko Bay licence areas have water depths anywhere from 50 and 2,200 m);
- The location of those developments;
- The cost of creating local infrastructure;
- The cost of support from Canada or Europe; and
- Government requirements regarding local benefits.

The example of the development of a robust supply chain in St. John’s, Newfoundland, gives some guidance as to how developments in Greenland may progress. Exploration and delineation in the Newfoundland offshore occurred over a 25-year period from the mid-1960s until development activity began in 1990. Existing local facilities were used with a minimum of modification or enhancement during that period. Very limited spares and repair capacity existed for the majority of the period and international service contractors flew in people and materials as required to maintain exploration and drilling programs.
Relevant engineering and design capacity existed in the main oilfields centres such as Houston and Aberdeen, and management of the whole process was based in Calgary. Contractor offices opened and closed on a regular basis with only a few of the larger companies maintaining a consistent presence despite the fact that during the period four major and many minor discoveries were made. This ‘slow growth’ pattern is consistent with international experience elsewhere.

Once the development activity began in Newfoundland, a huge increase in local supply chain activities occurred. This was because opportunities were now confirmed and because a development agreement between the project proponents and governments specified that a high percentage of local content was required. The decision to use a GBS as the production unit resulted in significant local benefits to the provincial labour force and local businesses. At the time it was the largest construction project being undertaken in North America and by its very nature much of the work had to be or was required to be performed locally. However, generating these benefits did have a significant associated cost in terms of creating the infrastructure needed for construction.

No facilities are currently available in Greenland for this type of large offshore petroleum construction project, and there is not an adequate local workforce trained to do such work. Unless there is an expectation of building many GBSs, the future and/or a desire on the part of government to create and employ a local construction workforce, then the cost effective approach to construction would be to have it done elsewhere.

Given the information currently available about Greenland operations, development scenarios can be created that will allow for some development assumptions to be made as the basis for supply chain requirements. The water depth and harsh environment conditions tend to support the concept of a floating production unit, either shipshape, tethered (tension leg platform) or spar. These will certainly be built elsewhere and in all likelihood will be required to be serviced elsewhere. Therefore, in Greenland itself, the development supply chain will only be required to establish infrastructure to allow for the installation of facilities at the production site such as subsea production templates, in-field flow lines, iceberg protection (glory holes), offloading systems and the floating production unit itself.

The main supply chain components will be required onshore at the most centralized and convenient location. Given the lack of infrastructure and the potential for discoveries in different parts of Greenland, more than one supply base may be required. The location of the existing large airfields at Kangerlussuaq and Narsarsuaq may influence where facilities are established, given the potential benefits from utilizing existing infrastructure.

Specialized services may well be established for the annual operations supply chain. Currently the direct ocean-going cargo service has capacity limitations. It is not impossible to think of monthly re-supply operations run out of bases in Europe or North America that would bring in the majority of the bulk supplies (things like fuel, water and mud), with airlifts managing the specialized and emergency requirements. This might provide supply opportunities for Atlantic Canada companies provided they are commercially competitive (see Section 4.8).
Ice cover would also be a factor that might require additional storage capacity at the more Northern bases. Depending on distances, short take off and landing aircraft would probably be used, supported by helicopters doing the final transfers to and from offshore operations.

In conclusion, the Greenland market will require a minimum package of basic services in the supply chain until the time that the size and number of developments warrants the capital investment to service them. If the development pattern follows that of Newfoundland, this could take decades. Its speed will be strictly dependent on the size and number of discoveries made and the world product price at the time of development. Greenland’s legislative approach could also affect the speed of the development of the supply chain.

3.5 Labrador Supply Chain

While there are many similarities between Labrador and Greenland, there are also considerable differences as a result of the large-scale mining activity in Labrador West and at Voisey’s Bay. More than 70 percent of Labrador’s almost 27,000 residents live in Labrador City and Wabush, and in the Upper Lake Melville area. Approximately 35 percent of population are of Aboriginal descent and over half of the population is between the ages of 25 and 59 (Statistics Canada, 2006).

Table 3-4 Population of Labrador, 2006

<table>
<thead>
<tr>
<th></th>
<th>Labrador</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>26,365</td>
</tr>
<tr>
<td>Male</td>
<td>13,380</td>
</tr>
<tr>
<td>Female</td>
<td>12,985</td>
</tr>
<tr>
<td>0-14</td>
<td>5,430</td>
</tr>
<tr>
<td>15-24</td>
<td>3,955</td>
</tr>
<tr>
<td>25-59</td>
<td>14,230</td>
</tr>
<tr>
<td>60+</td>
<td>2,755</td>
</tr>
</tbody>
</table>

Source: Statistics Canada, 2006

The economy of Labrador has traditionally been based on mining and the service sector. The largest employment industries in the Labrador region in 2006 were business and other services (33 percent), agriculture and other resource based industries (24 percent) and retail trade (11 percent) (Statistics Canada, 2006). The unemployment rate in Labrador is lower than that for the Province and for Canada as a whole, which reflects the seasonal nature of work and short work periods in the region (NLDHRLE, 2007).

Table 3-5 Labour Force, Labrador, 2006

<table>
<thead>
<tr>
<th></th>
<th>Labrador</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour Force</td>
<td>14,340</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>24.5</td>
</tr>
<tr>
<td>Men</td>
<td>31.1</td>
</tr>
<tr>
<td>Women</td>
<td>17.5</td>
</tr>
</tbody>
</table>

Source: Statistics Canada, 2006

Skill sets available in northern coastal communities in Labrador are not currently sufficient to meet market demands. A need has been identified to provide training for opportunities in industries such as mining, hydro development and environmental clean-up. There is a concern with the lack of college and university level programs and apprenticeship training programs in
Labrador (NLDHRLE, 2007). Of the population of Labrador aged 15 years and over, 33 percent do not have a certificate diploma or degree and only 20 percent have a high school certificate or equivalent. Almost 50 percent of the population has some post-secondary education (Statistics Canada, 2006).

Table 3-6 Education Levels, Labrador, 2006

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Labrador</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population 15 years+</td>
<td>20,820</td>
</tr>
<tr>
<td>No certificate, diploma or degree</td>
<td>6,935</td>
</tr>
<tr>
<td>High school certificate or equivalent</td>
<td>4,210</td>
</tr>
<tr>
<td>Apprenticeship or trades certificate or diploma</td>
<td>3,035</td>
</tr>
<tr>
<td>College, CEGEP or other non-university certificate or diploma</td>
<td>4,185</td>
</tr>
<tr>
<td>University certificate or diploma below bachelor level</td>
<td>650</td>
</tr>
<tr>
<td>University certificate, diploma or degree</td>
<td>1,795</td>
</tr>
<tr>
<td>Source: Statistics Canada, 2006</td>
<td></td>
</tr>
</tbody>
</table>

There is currently less infrastructure on the coast of Labrador than there is in much of Greenland. The Town of Happy Valley-Goose Bay in central Labrador has served as the main supply hub for the region and is equipped with one of the largest airports in Eastern Canada. There is also a substantial amount of lay-down space available and a large area that could be converted to a variety of industrial uses. Although there is a large port, it is open seasonally, depending on ice conditions, between mid-June and November. There are a number of smaller airports and harbours along the coast. Mineral developments on the Labrador coast, including the existing mine at Voisey’s Bay and the potential development of the Aurora Michelin Project, substantially increase the shipping capacity of the region. Additional detail on Labrador’s infrastructure is available in Appendix B.

A seismic program is anticipated for the Labrador Shelf in 2010. As with exploration drilling, it is highly unlikely that any infrastructure will be created as new supply chain components. The seismic vessels will likely make any required landfall in St. John’s with any resupply being managed out of existing facilities in St. Anthony or Happy Valley-Goose Bay.

In the event that seismic work identifies opportunities for development drilling and such programs result in development projects, many of the key variables for development of the Labrador Shelf are already known. Among these are that gas appears to be the main resource, discoveries to date have been made reasonably close to shore, in deep water (250-500 m), and in areas where icebergs are common. This leads to there being only be two likely production options given current technologies. One would be a floating system capable of moving off-station if ice conditions require it, the other would be a subsea development with a pipeline to shore that could be shut down and sacrificed if ice conditions warrant. The Snohvit project (see Section 3.2.1.5) is commonly viewed as the most likely model for Labrador Shelf gas development.

As such it is likely that all development-related construction will occur elsewhere, and shipped to the production site. There will need to be a shore base and airport close to the production facility. This could create competition between some communities as, for example, there are existing facilities in both Happy-Valley Goose Bay in Labrador and St. Anthony on the Northern Peninsula of the Island. However, with the completion of the Trans Labrador Highway and the connection of Cartwright to both the rest of mainland Canada and the Island of Newfoundland, it
would appear that this community is well-placed to be the forward base for any development given its proximity to current discoveries.

As in Greenland, it is unlikely that any major supply chain improvements will be made until such time as a specific development option has been chosen and approved for a specific location. Given the state of the North American gas market, potential alternative gas sources, the current state of technology and the harsh environment, it may be a considerable time before the economics of Labrador Shelf gas warrant development. The next decade may instead see a similar pattern to that experienced over the last 30 years of Canadian Arctic activity. This would see further seismic activity, exploration drilling and possibly delineation drilling, all to establish the size of the potential gas resource so that it may be held in reserve until conditions warrant development.

In all likelihood the supply chain that has been established to support the existing offshore Newfoundland activity will be the supply chain used to support the Labrador Shelf.

### 3.6 Canadian Arctic Supply Chain

There were approximately 70,000 people living in Nunavut and the Northwest Territories (NWT) in 2006, with almost 60 percent residing in NWT. Nunavut has a fairly young population with those under the age of 25 making up more than half of the population. This age group comprised 40 percent of the population of NWT in 2006. Both territories have a large Aboriginal population: approximately 85 percent of Nunavut's population is Inuit and just under 50 percent of the population of NWT is Aboriginal (Statistics Canada, 2006).

<table>
<thead>
<tr>
<th>Table 3-7 Population of Canadian Arctic, 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>0-14</td>
</tr>
<tr>
<td>15-24</td>
</tr>
<tr>
<td>25-59</td>
</tr>
<tr>
<td>60+</td>
</tr>
</tbody>
</table>

The major pillar of economic activity in the Canadian Arctic has been mining and oil and gas extraction. In 2004, they accounted for 36 percent of total economic activity in the Territories. The diamond industry in NWT has been the major contributor to growth in income from mining and has made Canada a key player in the international diamond market. In addition to mining and exploration, land-based activities are an important part of Nunavut's economy.

However, the majority of the 2006 working population in NWT was employed in public administration (21 percent) and retail trade (9 percent). Many people also worked in health care and social assistance (9 percent), and construction and mining/oil and gas extraction each employed approximately 7 percent of the labour force. Similarly, the territorial and federal governments were the largest employers in Nunavut in 2006, providing work to 26 percent of the labour force. Many people were also employed in educational services (12 percent) and retail trade (11 percent) (Statistics Canada, 2006).
Table 3-8  Labour Force, Canadian Arctic, 2006

<table>
<thead>
<tr>
<th></th>
<th>Nunavut</th>
<th>NWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour Force</td>
<td>12,635</td>
<td>23,825</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>15.6</td>
<td>10.4</td>
</tr>
<tr>
<td>Men</td>
<td>17.8</td>
<td>12.1</td>
</tr>
<tr>
<td>Women</td>
<td>13.0</td>
<td>8.4</td>
</tr>
</tbody>
</table>

Source: Statistics Canada, 2006

Today, almost three quarters of Nunavut’s working age population do not meet the minimum level required to participate fully in the economy (Impact Economics and S. Vail, 2008). In 2006, almost 60 percent of the population of Nunavut aged 15 years and over did not hold a certificate, diploma or degree and only 11 percent had a high school certificate or equivalent. Only 32 percent of the population over 15 years of age went on to post-secondary education (Statistics Canada, 2006).

The situation is somewhat better in NWT, where 33 percent of the population aged 15 years and over did not have a certificate, diploma or degree and 20 percent held a high school certificate or equivalent in 2006. Almost 50 percent of the population over 15 years of age pursued some post-secondary education (Statistics Canada, 2006).

Table 3-9  Education Levels, Canadian Arctic, 2006

<table>
<thead>
<tr>
<th></th>
<th>Nunavut</th>
<th>NWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population 15 years+</td>
<td>19,340</td>
<td>31,135</td>
</tr>
<tr>
<td>No certificate, diploma or degree</td>
<td>11,080</td>
<td>10,265</td>
</tr>
<tr>
<td>High school certificate or equivalent</td>
<td>2,110</td>
<td>6,130</td>
</tr>
<tr>
<td>Apprenticeship or trades certificate or diploma</td>
<td>1,345</td>
<td>2,940</td>
</tr>
<tr>
<td>College, CEGEP or other non-university certificate or diploma</td>
<td>2,740</td>
<td>6,065</td>
</tr>
<tr>
<td>University certificate or diploma below bachelor level</td>
<td>315</td>
<td>885</td>
</tr>
<tr>
<td>University certificate, diploma or degree</td>
<td>1,750</td>
<td>4,855</td>
</tr>
</tbody>
</table>

Source: Statistics Canada, 2006

The existing communities in the North are for the most part small and sparsely distributed. There are few available airports of any size and there is no road past Inuvik except a winter access road over frozen tundra. In Nunavut, there is no road access in some areas and a single community road in the entire territory. There have been some roads developed related to natural resources development and additional roads have been proposed. The ports in both Nunavut and the Inuvialuit Settlement Region have extremely short ice-free periods (August to November) and are typically very small. There are a number of small airports throughout both areas; however, all but two of these facilities have gravel runways. Additional detail on the region’s infrastructure is available in Appendix B.

Given the characteristics, size and potential of the Arctic, it is difficult to predict how any supply chain will be created. Assuming that the Mackenzie Valley pipeline is the key to the unlocking of resources in the North, then the overall package of developments will require robust supply chains of huge capacity. In the Canadian Beaufort Sea there are three offshore potential developments. On land there are three gas fields to tie into the gas pipeline plus gas from the offshore. Cost estimates of the various components have varied wildly over the years but
construction values in the $30 billion range for the development of all these prospects are not inconceivable.

Some consideration is being given to using the increasingly more accessible North West Passage to ship in modules from other jurisdictions and bring them down the Mackenzie River to staging points along the pipeline route. The Mackenzie River is also accessible from the Canadian Beaufort side.

3.7 Summary

Experience in other areas indicates that there will be a minimal requirement for a local supply chain in Greenland, Labrador and in the Canadian Arctic during seismic and exploration drilling activities. The chosen development options will affect the size and specifics of the development supply chain, with the likelihood that frontier production units in the study regions will be built elsewhere and floated into place. However, the Canadian Arctic, where the scale and complexity of the overall development may justify some more local activity, could be a partial exception to this pattern.

Even if significant discoveries are made, the development of onshore infrastructure for the offshore petroleum activity in Greenland, Labrador and in the Canadian Arctic is likely to be a slow process until long-term production is assured. Once production is established there will be a continuous requirement for local operations to provide selected services, consumables, repairs and maintenance support that will reflect the scale of production activity.
4.0 COMPETITIVE ADVANTAGE ANALYSIS

4.1 Introduction

This section of the report identifies and reviews a number of competitive advantages that Atlantic Canada’s petroleum supply and service companies may be thought to have, relative to companies in such places as Denmark, Scotland and Norway, in doing business in Greenland. It also discusses a number of disadvantages they may face.

4.2 Expertise and Experience

Atlantic Canada has a wide range of expertise and experience of direct relevance to current exploration and prospective petroleum industry exploration, development and production activity in Greenland. The most obvious, and most commonly promoted, areas of expertise and experience relate to the presence of sea ice and icebergs, including the design of structures (including platforms, pipelines and vessels), ice forecasting and management, and environmental regulation, planning, management and monitoring.

More generally, Atlantic Canadian companies have long-standing experience of the regulatory, logistical and technical challenges of operating in harsh and relatively remote frontier regions, including for example the provision of air and sea support to exploration, development and operations activity. Atlantic Canadian companies also have experience in the management of supply chains in frontier and sparsely populated areas.

A fuller review of relevant expertise and experience is provided in the discussion of opportunities for Atlantic Canadian companies (Section 5.0).

4.3 Location

As is indicated by Table 4-1, Atlantic Canadian (and especially Newfoundland and Labrador) centres of petroleum industry activity are located much closer to Western Greenland waters and harbours than centres in Europe. This translates into reduced vessel transit times and associated costs. However, the advantage is very much reduced for Eastern Greenland waters.

Table 4-1 Sailing Distance from Atlantic Canada and European Ports to Nuuk, Greenland (Nautical Miles)

<table>
<thead>
<tr>
<th>Community</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goose Bay, NL</td>
<td>765</td>
</tr>
<tr>
<td>St. John’s, NL</td>
<td>1008</td>
</tr>
<tr>
<td>Sydney, NS</td>
<td>1371</td>
</tr>
<tr>
<td>Halifax, NS</td>
<td>1536</td>
</tr>
<tr>
<td>Halifax, NS</td>
<td>1536</td>
</tr>
<tr>
<td>Aberdeen, UK</td>
<td>1822</td>
</tr>
<tr>
<td>Stavanger, NO</td>
<td>1985</td>
</tr>
<tr>
<td>Copenhagen, DK</td>
<td>2302</td>
</tr>
</tbody>
</table>
This advantage also applies to air transportation, but only with respect to charter service. There has been no scheduled air service between Canada and Greenland since 2001; First Air (in cooperation with Air Greenland) operated flights between Iqaluit and Nuuk from 1981 until 1994, and between Iqaluit and Kangerlussuaq from 1994 to 2001. Currently, the only year-round scheduled air service to Greenland is from Copenhagen to either Kangerlussuaq or Narsarsuaq, requiring that Atlantic Canada-based personnel travel to Denmark in order to access Greenland. This can be particularly onerous and problematic for St. John’s-based travelers because, other than when Air Canada provides seasonal non-stop service between St. John’s and London (from late May until mid-October in 2010), the minimum journey time from St. John’s to Copenhagen is more than two hours greater than those from either Calgary, Alberta, or Houston, Texas.

The same constraints apply with respect to air freight, with shipping to and from Newfoundland and Labrador being further hampered by the fact that there is no longer scheduled wide-bodied air service to and from the Province, with the seasonal non-stop flights to and from London, England, employing a narrow-body Airbus 319. However, the offshore petroleum industry is a large user of charter air service, for both passengers and freight, and the distance advantage of Atlantic Canadian airports over those in Europe to the main Greenland airports (Kangerlussuaq and Narsarsuaq) is considerable (Table 4-2).

Table 4-2 Flying Distance from Atlantic Canada and European Airports to Main Greenland Airports (kilometers)

<table>
<thead>
<tr>
<th>Airport</th>
<th>Kangerlussuaq (SFJ)</th>
<th>Narsarsuaq (UAK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goose Bay, NL (YYR):</td>
<td>1610</td>
<td>1250</td>
</tr>
<tr>
<td>St. John’s, NL (YYT):</td>
<td>2159</td>
<td>1575</td>
</tr>
<tr>
<td>Sydney, NS (YQY):</td>
<td>2232</td>
<td>1778</td>
</tr>
<tr>
<td>Halifax, NS (YHZ):</td>
<td>2574</td>
<td>2160</td>
</tr>
<tr>
<td>Aberdeen, UK (ABZ):</td>
<td>2659</td>
<td>2450</td>
</tr>
<tr>
<td>Stavanger, NO (SVG):</td>
<td>2872</td>
<td>2772</td>
</tr>
<tr>
<td>Copenhagen, DK (CPH):</td>
<td>3426</td>
<td>3319</td>
</tr>
</tbody>
</table>

A scheduled ocean freight service operating out of Halifax, Nova Scotia, and Argentia, Newfoundland and Labrador, offers links with Greenland via Iceland. It is provided by RAL in cooperation with the Icelandic shipping company Eimskip, and operates year-round on an approximately monthly basis.

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1 During the summer months it is also possible to fly from Eastern Canada to Greenland via Iceland. Icelandair flies year-round between Halifax and Keflavik, Iceland. During the summer Air Greenland operates a service between Nuuk and Reykjavik and Air Iceland flies between Nuuk and Keflavik. This service via Iceland offers potential time-savings in travel between Atlantic Canada and Greenland.
4.4 Business Links

Atlantic Canada has recent or current business links with Greenland in the areas of mining, fishing (albeit the relationship is contentious, given Canadian claims of Greenlandic and Faroese over-fishing), communications (through the recent construction of a fibre-optic cable between Newfoundland and Greenland), housing and building products, and cruise-ship tourism. These connections provide a mechanism for learning about, and establishing contacts with appropriate people in, Greenland. The cable connection may be of assistance to Atlantic Canadian businesses by increasing the reliability and capacity of communications with Greenland. In some cases, such as cruise-ship tourism, there is a common interest in further developing the industry.

4.5 Operator Relationships

Atlantic Canadian petroleum industry supply and service companies already have working relationships with operators that also have Greenland exploration permits, such as ExxonMobil, Chevron, Husky Energy and EnCana. These oil companies are familiar with the capabilities of Atlantic Canadian firms and may wish to work with them, or be willing to promote them, in Greenland. However, some of these oil companies (e.g. Husky Energy and Chevron) are managing their Greenland programs from Calgary, while ExxonMobil’s is managed from Houston, using personnel who may not be familiar with the capabilities of Atlantic Canada companies.

The Canada-Newfoundland and Labrador Benefits Plan Guidelines for offshore petroleum projects encourage such initiatives by requesting the proponent's plans for 'programs, policies or procedures to enable Newfoundland and Labrador and other suppliers to participate in the proponent's national and international activities' (C-NLOPB 2006). There is no equivalent provision in Nova Scotia.

4.6 Exchange Rates

While it was the case that a low Canadian dollar represented an advantage in doing business in Greenland, this is less so now. In January 2009, a Canadian dollar cost 4.59 Danish krone (DKK). By January 2010 this had risen to 5.00 DKK and, by May 2010, 5.60 DKK. This represents an almost 18 percent increase in the value of the dollar against the krone over a 17 month period.

4.7 Cultures, Concerns and Aspirations

There are similarities between Atlantic Canadian and Greenlandic concerns, priorities and aspirations respecting the local effects of resource development activities. These, and similarities in the business cultures, result in common understandings that facilitate dealings with Greenland business, regulators and other local stakeholders, representing a minor but important advantage in building links between the two regions.

The concerns and aspirations that are shared include:
Environment, society and culture, with a desire to protect the biophysical environment and traditional ways of life;

Industrial and economic benefits, with an emphasis on delivering resource revenues, employment, business and, more generally, economic development; and

Ensuring sustainable development, in terms of protecting such renewable resources as the fishery and tourism while diversifying the economy and ensuring it is sustainable in the long term.

Greenland and Atlantic Canada also share, or have shared, limitations of capacity and experience re large-scale resource development activity. This includes limitations in the following:

- Industrial infrastructure and capacity able to undertake and support frontier activity;
- Labour force capabilities, including the professions and skilled trades;
- Education and training institutions and programs to deliver the above labour requirements;
- Supply and service companies with the technical and business abilities to meet the requirements of large resource development corporations; and
- Research and development (R&D) capacity.

Over the past 30 or so years, Atlantic Canada has sought to address these issues, especially as they constrain growth in industrial benefits from offshore petroleum and other resource development activity. The understandings and outcomes from that process represent Atlantic Canadian strengths in seeking to support Greenland's industrial and economic development.

Other similarities, leading to common understandings, relate to living on ‘the periphery’. Especially in Newfoundland and Labrador, this includes concerns and frustrations related to logistics and transportation; see, for example, the above discussion of scheduled international air passenger and freight service (Section 4.3). In this case, and more generally, there is a shared frustration about distant centres of power, political, economic and corporate, as is often represented ironically by the expression “I'm from Ottawa (Toronto, Copenhagen, etc.) and I'm here to help”. There is a belief, on the part of many residents of ‘peripheral’ areas, that their regions, concerns, aspirations and priorities are not understood by those living in national centres of political, economic and corporate power.

Related to this, there is commonly a desire for increased autonomy in order to try to ensure appropriate regulation and assert regional distinctiveness. Greenland has seen a progressive increase in autonomy. After more than three decades of popular discontent with Danish rule, a commission for the consideration of greater autonomy for Greenland was appointed in 1975. In 1979 Greenland approved the commission's proposals for home-rule in a referendum. A constitution had been drafted in 1978, and in April 1979 Greenland elected its first autonomous parliament. The constitution came into force in May 1979 with the Danish parliament's ratification of the Greenland Home Rule Act.

Later in 1979, 75 percent of Greenland's residents voted against EC membership, but as a result of mainland Danish support for the proposal Greenland was forced to join. After achieving internal self-rule, and under its powers regarding foreign trade relations, Greenland held its own
referendum on EC membership in 1982. A majority voted against membership, mainly due to the intensive exploitation of Greenland's fishing grounds by EC fishing fleets.

After 1979, Denmark continued to exercise control and authority over the foreign affairs, defence and the judicial and monetary systems of Greenland, but Greenland received full authority over local taxation, fisheries, planning, cultural affairs, nature conservation, education, religious affairs, social welfare and labour. Notwithstanding Denmark's general authority over foreign affairs, Greenland was given the right to negotiate its own foreign trade agreements. This right was exercised in February 1985 when Greenland opted out of Denmark's membership in the European Community, to become an overseas territory (Benedikter 2006).

In November 2008 Greenland voters overwhelmingly approved a plan for expanding its autonomy from Denmark and taking advantage of the potential oil reserves. The plebiscite was based on the recommendations of a Danish-Greenlandic commission assigned to identify areas in which to expand home rule. The plan, which Denmark supported, called for Greenland to take control over the local police force, courts and coast guard, and to make Greenlandic the official language. It also set new rules on how to divide any oil revenues between Greenland and Denmark. The referendum was seen as a key step toward independence for Greenland, which relies on Danish subsidies to sustain its economy (New York Times 2008).

The referendum result has thus far led to only a limited further transfer of power, but it has confirmed the desire for, and the move towards, increased political and economic autonomy. This is accompanied by an increased openness to non-Danish business and governance models, including those used in Canada. For example, the Greenland government guidelines respecting the social impacts of, and benefits planning for, mineral projects (Bureau of Minerals and Petroleum 2009) were developed drawing on Atlantic Canadian models and practices.

In Atlantic Canada, while there are or have been movements for greater autonomy for Newfoundland and Labrador (within Canada), Labrador (within Newfoundland and Labrador) and Cape Breton (within Nova Scotia), these have not become serious political movements or achieved real political traction. Instead, most pressure for increased autonomy occurs through a process of federal/provincial negotiation. However, especially in Newfoundland and Labrador, there is an understanding of, and sympathy for, some of the frustrations that generate a desire for greater autonomy.

These types of common understandings are also important because another intangible but real advantage for Atlantic Canadian companies is that, generally-speaking, both Atlantic Canada and Greenland have relationship-based cultures. The United States and Canada are primarily contract-based countries when it comes to doing business. The written contract embodies the terms and conditions of the business transaction, and is relied on for its enforcement. Such a business culture relies almost exclusively on the written contract and not long-standing relationships for the vital aspects of the business transaction. The system works partly because both sides to the contract believe in the contract and basically trust the process, and because there is legislation and a judicial system that enforces that contract (Keston 2008).

However, in much of the rest of the world, including to a significant degree in Atlantic Canada and Greenland, business cultures are relationship-based. Networks of long-standing
relationships, friendships and family ties, and the importance of personal reputation, are vital in
the negotiations and workings of business (Keston 2008). While this is changing with time,
including in Atlantic Canada as a consequence of involvement in the petroleum industry,
relationships still commonly influence how the parties work through terms and conditions,
address unforeseen occurrences, and determine how the contract is interpreted and,
sometimes, whether it will be enforced. To the extent that Atlantic Canadian companies and
personnel understand relationship-based business cultures, this may benefit them in
establishing and maintaining business relationships in Greenland.

Greenland and Atlantic Canada, specifically in Labrador, also share Inuit culture and language.
This provides the potential for exchanges around common interests and concerns, especially
given that Greenlandic is quite similar to the Inuktut spoken in Labrador and Canada’s Eastern
Arctic. However, while the Inuit of Greenland and the Labrador territory of Nunatsiavut are
seeing advances in autonomy and governance, neither as yet has significant experience of, or
capabilities related to, offshore petroleum activity. Furthermore, there have as yet been
relatively few exchanges between the two groups, with there being stronger historic ties
between the Inuit of Greenland and Nunavut, reflected in and reinforced by past scheduled air
service between Greenland and Iqaluit. However, there is potential to build on common
Greenland-Nunatsiavut interests in the future, and leverage this in developing offshore
petroleum-related relationships and business.

4.8 Disadvantages

This section has identified and described a number of competitive advantages that Atlantic
Canada’s supply and service industry may be thought to have in doing business in Greenland.
However, it must also be recognized that Atlantic Canadian businesses also face a number of
disadvantages, and both the advantages and disadvantages will be important in identifying
opportunities for Atlantic Canada.

In summary, these disadvantages include:

- Small capital base: The scale of activity in Atlantic Canada is small by global standards,
  and especially in comparison with such activity centres as Aberdeen and Stavanger, and
  only supports a limited in-region ‘off-the-shelf’ availability of expertise, equipment and
  supplies. It may not be possible to meet specific Greenland-related requirements, or
  satisfy any unanticipated additional demand from Greenland activity.

- Corporate decision-making: Petroleum companies operating in Greenland may be
  making decisions in Houston, Calgary, Edinburgh (in the case of Cairn Energy), or other
  locations remote from, and generally unfamiliar with, capabilities in Atlantic Canada.
  They may also have supplier agreements in place that direct business to companies that
  do not have a presence in Atlantic Canada.

- Danish oil sector companies: Some Danish companies, such as Maersk and DONG,
  already have a substantial presence in both the global petroleum industry and
  Greenland. In the latter case, this includes Maersk’s substantial involvement in the
  transportation, supply and services sectors.

- Other Danish companies: Much of Greenland’s domestic supply chain (for example, in
  the areas of civil engineering, construction and transportation) is controlled by Danish
  companies, or Scandinavian companies with a strong Danish presence, some of which
(e.g. Ramboll and MT Hojgaard) are well equipped and positioned to provide supplies and services to the oil industry.

- **Tax and tariffs:** These, and difficulties establishing and understanding tax and tariff arrangements, represent a barrier and additional cost.
- **Language:** English is increasingly the language of global commerce, and many Greenlanders and most Danes speak it fluently; for example, the proceedings at the ‘Greenland Sustainable Minerals and Petroleum Development’ conferences in Copenhagen are entirely in English. However, Danish is still in common use, especially for commercial exchange within Greenland, and the Greenland Government is placing an increasing emphasis on the use of Greenlandic in education and government services.
- **Awareness of Atlantic Canada:** It is only recently, with business missions and conference presentations in Greenland, Denmark and Atlantic Canada, that there has been any significant Greenlandic and Danish awareness of the Atlantic Canada petroleum industry and its capabilities.

Atlantic Canadian companies and facilities must also be, and be seen to be, commercially competitive with others in such places as Scotland, Denmark, Norway. In this regard, Cairn Energy had an initial perception that the costs of supplies and services from St. John’s were high relative to those in Europe, perhaps as a result of the limited scale of, and competition within, the petroleum sector in Newfoundland. However, Cairn has indicated that some of its actual costs were higher than anticipated, and that it will be undertaking a review after completion of its 2010 program. This review will include study of its past and potential use of Atlantic Canada companies and infrastructure (D. Jones pers comm.).
5.0 OPPORTUNITIES FOR ATLANTIC CANADIAN INDUSTRY

5.1 Introduction

Based on the above material and analysis, and a St. John’s review workshop with selected representatives of companies and training institutions, this section of the report provides recommendations on opportunities and areas of expertise that Atlantic Canada industry should pursue in Greenland and the Canadian Arctic.

Some Newfoundland and Labrador companies have already been successful in capturing work in Greenland, assisting with Cairn Energy’s 2010 exploration drilling program:

- C-CORE is providing ice forecasting and management services;
- Provincial Airlines Limited is responsible for ice observation; and
- Cougar Helicopters is providing helicopter support.

There may be further opportunities related to both Greenland and Canadian Arctic exploration. In the former case, as was noted above (Section 4.8), Cairn has indicated that it will be undertaking a review of its 2010 logistical arrangements, including study of its current and potential use of Atlantic Canada companies and infrastructure.

Given the uncertainties associated with exploration activity in Greenland and the Canadian Arctic, capital expenditures in these areas are unlikely to be warranted, unless as part of a joint venture that is seeking to access work both within and beyond the oil industry. Instead, the main opportunities will be based on intellectual assets, especially as they relate to offshore petroleum exploration in harsh and remote environments. Specific opportunities identified through this research are described and discussed in the rest of this section. They have been listed in categories that reflect the immediacy of the requirement for action and the likely timing and scale of the reward. Thus the first category lists opportunities requiring immediate action, the second includes opportunities which require action now for longer term rewards, and the third category contains opportunities requiring only ongoing monitoring in preparation for action at a later date.

5.2 Immediate Opportunities

This category lists business opportunities in Greenland where an immediate return can be expected. It includes business areas where local companies have already been successful, and identifies others within which companies should consider getting engaged as soon as possible.

Aviation Services

Opportunities are likely to continue to arise from Atlantic Canada’s extensive experience with fixed-wing surveillance activities and helicopter operations in harsh environments. Ground support may be supplied by existing local operators.
Cargo Delivery

Extensive local experience exists in managing freight delivery in northern and Arctic waters. Atlantic Canada is the home to a broad range of experienced marine vessel operators that are used to managing cargos into the Canadian North.

There are also requirements for tug and barge services, stand-by vessels, supply boats, etc. The current drilling support fleet for Greenland was completely supplied, at relatively short notice, from Scotland; however in the future there should be more open tendering activities for activity in Greenland, and in the Canadian Arctic. However, it is to be noted that most recent Canadian Arctic re-supply has been sourced in, and managed from, Montreal.

Customs Brokerage

This opportunity for customs brokers and agencies in Atlantic Canada will be largely reflective of the volume of work in Greenland that is successfully secured by contractors and operators in the region.

Environmental Consulting

Atlantic Canadian companies have a full range of experience in environmental consulting, from baseline studies of terrestrial, marine, air and human environments to impact assessments, environmental protection plans and environmental effects monitoring. This has included the development of considerable local expertise in the management of community effects and delivery of industrial benefits. Local legislation in Greenland and the Canadian Arctic has established or will establish environmental and benefits requirements, providing business opportunities that local companies are unlikely to be able fulfill. However, Danish and Alberta-based companies will provide significant competition in Greenland and the Canadian Arctic respectively.

Geological, Geophysical and Geotechnical Services

Atlantic Canada has developed an extensive range of capabilities in these highly technical services over the last 25 years. Considerable experience has been gained offshore Newfoundland and Nova Scotia, on the Labrador coast, in the Davis Strait and in Baffin Bay, and these should have application in other areas of the North.

Ice Detection and Management

Atlantic Canada has world-class capabilities in the detection and management of all forms of marine ice, as is reflected by the lead role local companies are already playing in Greenland and other northern regions. Every type of expertise from professional services to surveillance to iceberg net manufacture can be utilized in Greenland and the Canadian Arctic.

Manufacturer’s Agents and Distributors

Atlantic Canadian agents and distributors may be able to include Greenland and the Canadian Arctic in their respective territories, providing there are no other competing vendors from other
areas such as Europe. In an analogous case, for many years Newfoundland and Labrador and Nova Scotia were considered as part of the North Sea territory for many manufacturers due to the similarity of equipment used and environmental conditions.

**Oceanographic and Meteorological Services**

As with ice management services, oceanographic and meteorological services is an area where Atlantic Canadian companies have a broad range of experience that should serve them well in trying to pursue business opportunities in Greenland and the Canadian Arctic. Local companies have a long history of problem-solving in data collection and interpretation that will be of great value for long-term operations in Greenland and the Arctic.

**Regulatory Services**

Canada and its provinces have developed a robust set of regulatory regimes. The regulation of the offshore petroleum industry in Atlantic Canada is led by the C-NLOPB and C-NSOPB, while that in the Arctic is led by the NEB. Where Canada borders with other nations, such as Greenland, it will be necessary to coordinate and collaborate on regulatory standards. This is more than simply a government and legal function, with consulting firms and industry associations having a significant role to play as the frontiers become more active.

**Supply Vessels**

Atlantic Canadian supply vessel owners and operators have a great depth of experience of working in frontier and harsh environments, and should be able to compete to supply their services in Greenland and the Canadian Arctic.

### 5.3 Other Opportunities Requiring Immediate Action

The business opportunities listed below will only yield significant returns in the medium- to long-term, but there is nonetheless a requirement that any interested companies take immediate action, primarily by engaging in relationship-building. These opportunities require action now because, while only limited returns can be expected in the near term, there is a much larger opportunity beyond. For example, teaching English as a second language presents a relatively small immediate opportunity for the education sector but, by creating the necessary relationships, a full range of educational and research opportunities may follow.

**Business Consulting, Strategic Guidance, Mentoring and Professional Services**

Opportunities for consultants may arise due to Atlantic Canada’s recent experience in establishing an oil industry at the end of the existing supply chain. Most successful oil and gas professional services and supply companies have personnel with experience of the difficulties and risks of starting a new and highly complex industry in a frontier region, and hence able to provide relevant support and advice.
Diving Equipment and Services, and Remotely Operated Vehicles

There is no extensive base of diving services and the operation of remotely operated vehicles in Greenland or the Canadian Arctic, and Atlantic Canada’s experience in providing them represents a significant area of opportunity.

Education and Training

Over the past 25 years, Atlantic Canada has invested heavily in the creation of petroleum industry-related education and training facilities, programs and courses. In such areas as helicopter survival, safety, marine operations and drilling operations the region has trainers and curricula that could easily be adapted to satisfy Greenland or Canadian Arctic requirements. Training in the health, quality, environment, security and safety also represents a major requirement and opportunity. Atlantic Canada’s increasing experience in simulation training will be a major advantage in accessing such education and training opportunities.

Emergency Preparedness

There may be opportunities in both the front-line establishment of emergency preparedness regimes and the provision of back-up and standby services. Emergency health evacuation services may be required for major medical issues. The Deepwater Horizon incident will likely lead to additional preparedness requirements that Atlantic Canada companies may be able to fulfill; local experience in oil spill prevention and control may be of use in the Greenland and Canadian Arctic environments.

Human Resource Services, including Recruiting

It is, and will continue to be, difficult to find appropriately trained and qualified personnel for Northern operations. Atlantic Canadian, and especially Newfoundland and Labrador, companies will have extensive databases of harsh environment and frontier region capable personnel and should be able to secure business in Greenland and the Canadian Arctic.

Inspection Services

The offshore petroleum industry has a constant need for third-party verification and inspection services. Asset integrity, non-destructive testing and fit-for-service certification will continue to be critical services, particularly in the Arctic with its harsh environments. Atlantic Canadian inspection services firms are currently working around the world in various capacities, and should be successful in pursuing opportunities in Greenland and the Canadian Arctic.

Oilfield Equipment Maintenance and Repair

Operational challenges, including working in extreme environments, not infrequently results in failures in oilfield equipment. Usually large lay-down areas and highly specialized technicians are required to manage the repair and overhaul of these substantial and complex pieces of equipment. Greenland in particular does not have a large amount of flat open space and it may be necessary or best to ship equipment requiring maintenance or repair to a support base.
elsewhere. Currently the nearest such base would be St. John’s, with Halifax providing another option.

5.4 Longer-term Opportunities

This category lists business opportunities for which no immediate return is expected, because they will require that there is considerable capital investment as the industry moves closer to production. If and when production-related investments become likely and are better understood, the opportunities in this category will gain greater prominence.

Communications Systems and Services

Communications is a highly complex and critical area of activity of considerable importance to the oil industry. Atlantic Canada companies may have some advantages due to their industry and regional experience, and a substantial additional advantage may be the recently connected undersea fiber optic cable between Newfoundland and Labrador and Greenland, and the ongoing discussions about the possibly of sharing broadband services.

In addition, if the Government of Newfoundland and Labrador is successful in establishing such enabling technologies as broadband technologies in Labrador, there is the potential to establish a network throughout Nunatsiavut and the Canadian Arctic for industry and government (e.g. defense, education and medicine) purposes (R. Parsons, pers. comm.).

Fuel Supply

Long-term operations in Greenland and the Canadian Arctic will require a substantial ongoing supply of fuel. Usually this is managed in the summer season, with a requirement for holding tanks to supply activity for the rest of the year. Newfoundland and Labrador currently provides a significant amount of the fuel supply for Labrador and the Eastern Arctic, and expansion of these services further into the Canadian Arctic and Greenland is logical.

General Construction

There will be a large requirement for general infrastructure construction activities. Some of the specialized activities, of an oilfield nature, may be outside of the capability of the existing Greenland contractors.

Logistics

The longer the supply chain, the more important is the provision of sophisticated logistics services. There are enormous complications in moving people and materials to and through areas that have no roads and that are frequently subject to weather shutdowns. With drilling operations costing hundreds of thousands of dollars per day, the cost of a shut down due to the non-availability of parts can be extreme. Atlantic Canadian companies have been successful in addressing this challenge since the early days of exploration, and should be able to export this expertise into Greenland and the Canadian Arctic.
Oil Rig and Supply Vessel Maintenance

As was discussed in Section 4.3, Newfoundland and Labrador is significantly closer to Greenland than any other area with major oil rig and vessel maintenance capabilities. In Newfoundland and Labrador, St. John’s, Marystown, Bull Arm and Bay Bull all offer qualified and experienced facilities and personnel to manage and deliver required maintenance, overhaul, inspection and refit activity. Ship repair facilities and personnel are also available, at somewhat greater distances, in the Maritimes. The reduced transit distances and times to Atlantic Canadian locations should be an economic advantage in negotiating repair and maintenance contracts.

Research and Development

Atlantic Canada is experienced in managing the R&D process. Currently there is an expectation that a major increase in oil funding for harsh environment petroleum industry R&D will lead to major additional work being undertaken in Newfoundland and Labrador. It is not difficult to see how Newfoundland and Labrador and Greenland could come together to look at R&D programs that would be of mutual interest.

Given the Deepwater Horizon incident and recently announced petroleum industry Newfoundland and Labrador R&D priorities, which include the Arctic, there may be scope to develop new techniques related to the prevention, management and clean-up of hydrocarbon spills in Arctic environments.

Supply Base Operations

In the short term, supply base operations in both Greenland and the Arctic will be seasonal and ad hoc. However, if and when production draws closer, the need for long-term support facilities will increase. There will be many supply challenges to overcome in both Greenland and the Arctic given the lack of roads. Atlantic Canadian base operators are accustomed to managing the challenges of offshore oil industry operations in frontier regions and would have opportunities in both Greenland and the Canadian Arctic.

Tubular Goods Management Services

The offshore petroleum industry consumes large amounts of tubular goods, requiring a lot of space and a highly efficient operation to manage the supply of all the required materials when they are needed. Atlantic Canadian companies have considerable relevant experience in support of such activities in frontier regions and harsh climates, and should be competitive in seeking business in Greenland and the Canadian Arctic.
6.0 CONCLUSION

The offshore petroleum industry has already delivered substantial economic and industrial benefits to Atlantic Canada (Stantec 2009, and Department of Energy 2010). This includes taxes and royalties, and the creation of employment, business, infrastructure and education, training and R&D activity and resources, as well as diversifying the economy through the creation of a substantially new economic sector.

The petroleum industry has also helped diversify the region’s economy through local businesses being successful in obtaining oil industry work outside of Atlantic Canada and in other industries (within or beyond Atlantic Canada) using capabilities developed in and for the petroleum industry (Shrimpton 2006). This diversification reduces the region’s economic dependence on the fluctuating levels of upstream oil industry activity in Atlantic Canada itself.

Greenland and the Canadian Arctic appear to present opportunities for the further export of Atlantic Canadian capabilities, which would likely subsequently lead to exports to other Arctic and non-Arctic regions of the world. Companies in Atlantic Canada clearly have relevant expertise and capabilities, as well as a number of location and other advantages. Further development of such capabilities is likely to result from future offshore activity in Atlantic Canada, including through planned petroleum industry R&D spending in Newfoundland and Labrador which has, as one initial focus, the Arctic.

As has been described above, Atlantic Canadian, and in particular Newfoundland and Labrador, companies have already been successful in capturing work in Greenland, offshore Labrador and the Canadian Arctic. The findings of this report indicate that, while the region will also need to overcome some disadvantages, its advantages are such that there is a significant opportunity to build on this success. However, for the next ten or more years there is likely to be limited oil industry capital investment in supporting exploration, or moving to development, in any of these regions. Furthermore, there are current higher than usual levels of uncertainty about the future scale and speed of offshore petroleum activity in such regions, given the Deepwater Horizon blowout and advances in the exploitation of unconventional gas reserves. As a consequence, over the next decade the main opportunities for Atlantic Canadian companies will in all likelihood be based on intellectual assets, especially as they relate to exploration in harsh and remote environments.

This is not to diminish the potential importance of the opportunities presented in Greenland, offshore Labrador and the Canadian Arctic. Instead, the research findings indicate a need for governments and the supply and service community to be swift and strategic in further investigating and pursuing these opportunities, especially in Greenland given its location, the 2010 Cairn Energy exploration program and the success of Atlantic Canada businesses to date. Indeed, given the degree to which Cairn Energy’s exploration program is leading the way in Greenland, and may provide the template for activity there, early efforts should concentrate on further understanding and influencing decision-making by that company.
More generally, the efforts to develop Atlantic Canadian opportunities in Greenland, offshore Labrador and the Canadian Arctic should seek to reflect the nature of the short-to-medium term prospects. This requires focusing on maintaining an understanding of developments and plans, strengthening business and inter-governmental relationships, improving transportation and communications links, and publicizing and promoting Atlantic Canadian capabilities, especially in the areas identified in Section 5.0.
# 7.0 REFERENCES

## Personal Communications


D. Jones, Head of Supply Chain and Logistics, Cairn Energy, Telephone conversation. 18 May 2010.

T. Olsen. General Manager, Royal Arctic Havneservice. E-mail, 12 May 2010.

G. Price. General Manager, Goose Bay Airport Corporation. E-mail, 18 May 2010.

R. Parsons, Telephone conversation. 26 June 2010.


D. Wasylciw, Senior Policy Analyst, GNWT-DOT. E-mail. 27 May 2010.

## References


Benedikter, T. 2006. The Working Autonomies in Europe: Territorial autonomy as a means of minority protection and conflict solution in the European experience - An overview and schematic comparison. Available at: http://www.gfbv.it/3dossier/eu-min/autonomy.html#r2


EMCP, 2009. Hebron Project Description. ExxonMobil Canada Properties, St. John’s, NL.


GHEXIS (Greenland Hydrocarbon Exploration Information Service) Online. 2007. Available at: http://www.geus.dk/ghexis/index.htm


Jong, C. 2007. Post-Secondary Education in Labrador. Prepared for Memorial University in Newfoundland, St. John’s, NL.


Newfoundland Transshipment Limited. No date. Available at: http://www.ntl.net/default.asp?action=about


Scott, DJ, 2010, Hydrocarbon Potential of the Eastern Canadian Arctic, presentation to the NOIA Annual Conference, St. John’s, NL.


SOEP (Sable Offshore Energy Project). 2010. Available at: http://www.soep.com/cgi-bin/getpage?pageid=0/0/1


Upstream Online. 2010. Imperial has no Arctic drilling plans. Available at: http://www.upstreamonline.com/live/article216041.ece


APPENDIX A

Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle
Introduction

In May 2008 a team of U.S. Geological Survey (USGS) scientists completed an appraisal of possible future additions to world oil and gas reserves from new field discoveries in the Arctic. This Circum-Arctic Resource Appraisal (CARA) evaluated the petroleum potential of all areas north of the Arctic Circle (66.56° north latitude); quantitative assessments were conducted in those geologic areas considered to have at least a 10-percent chance of one or more significant oil or gas accumulations. For the purposes of the study, a significant accumulation contains recoverable volumes of at least 50 million barrels of oil and/or oil-equivalent natural gas. The study included only those resources believed to be recoverable using existing technology, but with the important assumptions for offshore areas that the resources would be recoverable even in the presence of permanent sea ice and oceanic water depth. No economic considerations are included in these initial estimates; results are presented without reference to costs of exploration and development, which will be important in many of the assessed areas. So-called nonconventional resources, such as coal bed methane, gas hydrate, oil shale, and tar sand, were explicitly excluded from the study. Full details of the CARA study will be published later.

A number of onshore areas in Canada, Russia, and Alaska already have been explored for petroleum, resulting in the discovery of more than 400 oil and gas fields north of the Arctic Circle. These fields account for approximately 240 billion barrels (BBOE) of oil and oil-equivalent natural gas, which is almost 10 percent of the world’s known conventional petroleum resources (cumulative production and remaining proved reserves). Nevertheless, most of the Arctic, especially offshore, is essentially unexplored with respect to petroleum. The Arctic Circle encompasses about 6 percent of the Earth’s surface, an area of more than 21 million km² (8.2 million mi²), of which almost 8 million km² (3.1 million mi²) is onshore and more than 7 million km² (2.7 million mi²) is on continental shelves under less than 500 m of water. The extensive Arctic continental shelves may constitute the geographically largest unexplored prospective area for petroleum remaining on Earth.

Methodology

A newly compiled map of Arctic sedimentary basins (Arthur Grantz and others, unpublished work) was used to define geologic provinces, each containing more than 3 km of sedimentary strata. Assessment units (AUs)—mappable volumes of rock with common geologic traits—were identified within each province and quantitatively assessed for petroleum potential. Because of the sparse seismic and drilling data in much of the Arctic, the usual tools and techniques used in USGS resource assessments, such as discovery process modeling, prospect delineation, and deposit simulation, were not generally applicable. Therefore, the CARA relied on a probabilistic methodology of geological analysis and analog modeling. A world analog database (Charpentier and others, 2008) was developed using the AUs defined in the USGS World Petroleum Assessment 2000 (USGS World Assessment Team, 2000).
PETROLEUM POTENTIAL OF ASSESSMENT UNITS AND PROVINCES IN THE CIRCUM-ARCTIC

In the Circum-Arctic Resource Appraisal (CARA), 33 provinces were examined, of which 25 were judged to have a 10-percent or greater probability of at least one significant undiscovered petroleum accumulation in any constituent assessment unit (AU) and were therefore quantitatively assessed. Shown in these three maps are the relative probabilities for all assessment units assessed and the estimated relative potentials for undiscovered oil and gas in the assessed provinces.

Figure 1. Assessment units (AUs) in the Circum-Arctic Resource Appraisal (CARA) color-coded by assessed probability of the presence of at least one undiscovered oil and/or gas field with recoverable resources greater than 50 million barrels of oil equivalent (MMBOE). Probabilities for AUs are based on the entire area of the AU, including any parts south of the Arctic Circle.

PROBABILITY (percent)

- 100
- 50–100
- 30–50
- 10–30
- <10
- Area of low petroleum potential
Figure 3. Provinces in the Circum-Arctic Resource Appraisal (CARA) color-coded for mean estimated undiscovered oil in oil fields. Only areas north of the Arctic Circle are included in the estimates. Province labels are the same as in table 1.

**UNDISCOVERED OIL**
(billion barrels)

- Green: >10
- Light green: 1-10
- Yellow: <1
- Light gray: Area not quantitatively assessed
- White: Area of low petroleum potential

Figure 2. Provinces in the Circum-Arctic Resource Appraisal (CARA) color-coded for mean estimated undiscovered gas. Only areas north of the Arctic Circle are included in the estimates. Province labels are the same as in table 1.

**UNDISCOVERED GAS**
(trillion cubic feet)

- Red: >100
- Dark red: 6-100
- Orange: <6
- Light gray: Area not quantitatively assessed
- White: Area of low petroleum potential
The database includes areas that account for more than 95 percent of the world’s known oil and gas resources outside the United States.

For each assessment unit, the CARA team assessed the probability (AU probability) that a significant oil or gas accumulation was present. This evaluation of AU probability was based on three geologic elements: (1) charge (including source rocks and thermal maturity), (2) rocks (including reservoirs, traps, and seals), and (3) timing (including the relative ages of migration and trap formation, as well as preservation). Each assessment unit was ranked according to its AU probability; those AUs judged to have less than a 10-percent probability of a significant accumulation were not quantitatively assessed. In addition to the AU probability, the number of accumulations, the size-frequency distribution of accumulations, and the relative likelihood of oil versus gas were assessed for each AU and combined by means of a Monte Carlo simulation. The probabilistic results reflect the wide range of uncertainty inherent in frontier geological provinces such as those of the Arctic.

**Results—Resource Summary**

Within the area of the CARA, 25 provinces were quantitatively assessed; 8 provinces were judged to have less than a 10-percent probability of at least one significant accumulation in any AU and were, therefore, not assessed. Results of individual AU assessments are not reported here, but the AUs are shown as mapped areas on figure 1, where they are color-coded for the probability of at least one undiscovered accumulation of minimum size. The provinces are listed in table 1, in ranked order of total mean estimated oil-equivalent volumes of undiscovered oil, gas, and natural gas liquids (NGL). The provinces are shown in figures 2 and 3, where they have been color-coded with respect to fully risked (including AU probabilities) potential for gas and oil, respectively.

More than 70 percent of the mean undiscovered oil resources is estimated to occur in five provinces: Arctic Alaska, Amerasia Basin, East Greenland Rift Basins, East Barents Basins, and West Greenland–East Canada. More than 70 percent of the undiscovered natural gas is estimated to occur in three provinces, the West Siberian Basin, the East Barents Basins, and Arctic Alaska. It is further estimated that approximately 84 percent of the undiscovered oil and gas occurs offshore. The total mean undiscovered conventional oil and gas resources of the Arctic are estimated to be approximately 90 billion barrels of oil, 1.669 trillion cubic feet of natural gas, and 44 billion barrels of natural gas liquids.

**References**


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This fact sheet and any updates to it are available online at http://pubs.usgs.gov/fs/2008/3049/
APPENDIX B

Greenland, Labrador and Canadian Arctic Infrastructure
1. GREENLAND

1.1 Ports

Travel to and within Greenland is by air and water as there are no roads connecting towns and settlements. The largest port in Greenland is located in Nuuk, the capital, and it is a combined harbor which handles cargo (containers), fish products and some cruise vessels. Most sea transport of passengers and freight to and from Greenland is done by the shipping company Royal Arctic Line (RAL).

The depth of water at the cargo pier is 9.4 to 10 m and in the channel it is 18.6 to 19.8 m. The port can handle vessels up to 500 feet (152 m) in length. The Greenland Government, the Municipality of Nuuk, and RAL are cooperating on a project to build a new container terminal of 40,000 m², twice the size of the present facility. The project awaits the delivery of the Report by the Transport Commission on Greenland's future infrastructure requirements. The Report is expected towards the end of 2010. Once approved, a 3 to 4 year construction period is anticipated. Greenland has smaller ports in 16 towns and harbours in 60 settlements (Statistics Greenland, 2009). While some of the harbours are accessible year round, many are only accessible during the summer. Additional details for 21 of these facilities are provided in Table B-1.

1.2 Airports

There are 12 airports and 47 heliports in Greenland. The largest airport, Kangerlussuaq is a former American military base located on Greenland’s west Coast. As an international airport, now serves as the gateway to most of Greenland (Statistics Greenland, 2009). Kangerlussuaq offers six weekly connections to Copenhagen, Denmark. Greenland's other international airport, Narsarsuaq, in the south, was also once an American airbase. It offers weekly connections to Copenhagen and Iceland and it has a hotel, youth hostel, grocery store, café, museum and nurse station (Greenland Tourism and Business Council, 2009). Kulusuk airport on the east coast of Greenland offers connections to Iceland every day during the summer (Greenland Tourism and Business Council, 2010).

These airports are serviced by Air Greenland, the country’s national airline, and Air Iceland. Most domestic air transport in Greenland is operated by DASH-7 aircraft which can carry up to 50 passengers. However, Air Greenland operates one Airbus for travel from the Kangerlussuaq and Narsarsuaq airports to Copenhagen, as well as charter flights. Air Greenland is the only year-round operator of flights between Greenland and Denmark. For travel within Greenland, most passengers are distributed from the major airports to Greenlandic towns by smaller planes or helicopters (Greenland Tourism and Business Council, 2010).

There has been a significant increase in the number of passengers travelling by plane to Greenland in the last several years. In 2004, approximately 324,000 visitors arrived in Greenland by plane and in 2008 that number reached more than 432,000. In that time, the number of aircraft started from airports, heliports and heli-stops increased from 29,898 to 33,196 (Statistics Greenland, 2009).
### Table B-1 Greenland Ports - General

<table>
<thead>
<tr>
<th>Greenland Ports</th>
<th>Type</th>
<th>Size</th>
<th>Water Depth (Channel)</th>
<th>Max Vessel Size</th>
<th>Pilotage</th>
<th>Tugs</th>
<th>Length of Pier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aasiaat</td>
<td>Harbour</td>
<td>Small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Not compulsory, Available,</td>
<td>No</td>
<td>103 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Advisable, Local Assist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faeringehavn</td>
<td>Pier, jetty or wharf</td>
<td>Very small</td>
<td></td>
<td>11 – 12.2 m</td>
<td>Not compulsory, Available,</td>
<td>No</td>
<td>115 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Advisable</td>
<td></td>
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</tr>
<tr>
<td>Ilulissat</td>
<td>Harbour</td>
<td>Small</td>
<td></td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Kangilinnguit</td>
<td>Pier, jetty or wharf</td>
<td>Very small</td>
<td></td>
<td></td>
<td>Local Assist</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Maniitsiq</td>
<td>Harbour</td>
<td>Small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Available, Advisable</td>
<td>No</td>
<td>60 m</td>
</tr>
<tr>
<td>Marmorilik</td>
<td>Pier, jetty or wharf</td>
<td>Very small</td>
<td></td>
<td></td>
<td></td>
<td>--</td>
<td>--</td>
</tr>
<tr>
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<td>Harbour</td>
<td>Small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Available</td>
<td>No</td>
<td>30 m</td>
</tr>
<tr>
<td>Narsaq</td>
<td>Harbour</td>
<td>Small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Not compulsory, Available</td>
<td>No</td>
<td>60 m</td>
</tr>
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<td>23.2 m - OVER</td>
<td>500 feet</td>
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<td>No</td>
<td>--</td>
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<td>20.1 – 21.3 m</td>
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<td>Harbour</td>
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<td>500 feet</td>
<td>Available, Advisable, Local Assist</td>
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<td>Qaanaaq</td>
<td>Pier, jetty or wharf</td>
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<td>100 m</td>
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<td>Qaqortoq</td>
<td>Harbour</td>
<td>Small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Not compulsory, Available,</td>
<td>No</td>
<td>40 m</td>
</tr>
<tr>
<td>Qasigiannguit</td>
<td>Harbour</td>
<td>Small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Advisable, Local Assist</td>
<td>No</td>
<td>--</td>
</tr>
<tr>
<td>Qeqertarsuaq</td>
<td>Pier, jetty or wharf</td>
<td>Very small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Local Assist</td>
<td>Assist</td>
<td>12 m</td>
</tr>
<tr>
<td>Sisimiut</td>
<td>Harbour</td>
<td>Small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Not compulsory, Available,</td>
<td>Assist</td>
<td>60 m</td>
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<td>Soendre Stroemfjord</td>
<td>Pier, jetty or wharf</td>
<td>Very small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Not compulsory, Not Available,</td>
<td>Assist</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Advisable, Local Assist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tasiilaq</td>
<td>Pier, jetty or wharf</td>
<td>Very small</td>
<td>23.2 m - OVER</td>
<td>500 feet</td>
<td>Not compulsory, Not Available</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Advisable, Local Assist</td>
<td></td>
<td>30 m</td>
</tr>
<tr>
<td>Upernavik</td>
<td>Harbour</td>
<td>Small</td>
<td>7.1 – 9.1 m</td>
<td>500 feet</td>
<td>Available, Advisable, Local Assist</td>
<td>No</td>
<td>12 m</td>
</tr>
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</table>

Source: World Port Source, 2010
Table B-2   Greenland Ports – Additional Information

<table>
<thead>
<tr>
<th>Greenland Ports</th>
<th>Lifts and Cranes</th>
<th>Provisions</th>
<th>Fuel</th>
<th>Water</th>
<th>Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aasiaat</td>
<td>0-24 ton lifts, Mobile cranes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Radio, Air</td>
</tr>
<tr>
<td>Faeringehavn</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<tr>
<td>Ilulissat</td>
<td>0-24 ton lifts, 25-49 ton lifts, Mobile cranes</td>
<td>Yes</td>
<td>--</td>
<td>Yes</td>
<td>Telephone, Radio, Air, Radio Tel</td>
</tr>
<tr>
<td>Kangilinnguit</td>
<td>--</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>--</td>
</tr>
<tr>
<td>Maniitsoq</td>
<td>0-24 ton lifts, Mobile cranes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Telephone, Radio, Air, Telegraph</td>
</tr>
<tr>
<td>Marmorilik</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Nanortalik</td>
<td>0-24 ton lift, Mobile cranes, Fixed cranes</td>
<td>--</td>
<td>Yes</td>
<td>Yes</td>
<td>Radio, Air, Radio Tel</td>
</tr>
<tr>
<td>Narsaq</td>
<td>0-24 ton lift, Mobile cranes</td>
<td>Yes</td>
<td>--</td>
<td>Yes</td>
<td>Telephone, Radio, Telegraph</td>
</tr>
<tr>
<td>Narssarsuaq</td>
<td>0-24 ton lift, Mobile cranes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Telephone, Radio, Air, Telegraph</td>
</tr>
<tr>
<td>North Star Bugt</td>
<td>0-24 ton lift, Mobile cranes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Telephone, Radio</td>
</tr>
<tr>
<td>Nuuk</td>
<td>0-24 ton lift, Mobile cranes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Telephone, Radio, Air, Radio Tel</td>
</tr>
<tr>
<td>Paamiut</td>
<td>0-24 ton lift, Mobile cranes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Telephone, Radio, Air</td>
</tr>
<tr>
<td>Qaanaaq</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<td>--</td>
</tr>
<tr>
<td>Qaqortoq</td>
<td>0-24 ton lifts, 100+ ton lifts, Mobile cranes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Radio, Air, Telegraph</td>
</tr>
<tr>
<td>Qasigiannguit</td>
<td>0-24 ton lift, Mobile cranes, Fixed cranes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Radio, Air</td>
</tr>
<tr>
<td>Qeqertarsuaq</td>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Radio, Air, Radio Tel</td>
</tr>
<tr>
<td>Sisimiut</td>
<td>0-24 ton lift, Mobile cranes, Fixed cranes</td>
<td>Yes</td>
<td>--</td>
<td>Yes</td>
<td>Radio, Air, Telegraph, Radio Tel</td>
</tr>
<tr>
<td>Soendre Stroemfjord</td>
<td>Mobile cranes</td>
<td>Yes</td>
<td>--</td>
<td>Yes</td>
<td>Radio, Air, Radio Tel</td>
</tr>
<tr>
<td>Tasilaq</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Upernavik</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Uummannaq</td>
<td>0-24 ton lift, Mobile cranes, Fixed cranes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Radio, Air</td>
</tr>
</tbody>
</table>
2. LABRADOR

2.1 Ports

Located on the western end of Lake Melville, The Port of Goose Bay has two industrial docks. One of these, a pier wharf 51 m long with 5.4 to 7m minimum water depth, is currently closed for structural repairs and it is uncertain when it will be reopened (D. Tee, pers. comm.). The operating dock is west-southwest of Terrington Narrows and is a 244 m long by 15 m wide marginal wharf, with 9 m minimum water depth on the west side and 5.6 to 9.1 m minimum water depth on the east side. Additional port infrastructure includes storage sheds, asphalt and fuel tanks and a transhipment warehouse. There is also a substantial laydown area. Additionally, there is a large area of land within easy access of these docks that could be converted to suit a variety of industrial needs. Terrington Basin cannot handle large freight or passenger vessels and would require significant dredging for expansion of services (CLEDB 2006). The dock receives three to four oil tankers each year and one freighter every two weeks between mid-June and mid-November (D. Tee, pers. comm.).

Labrador relies heavily on marine services for passenger transportation and shipment of goods. Labrador is currently served by five marine vessels. Two (the MV Sir Robert Bond and MV Northern Ranger) are provincially owned, while the others (the MV Apollo, MV Challenge One and MV Astron) are privately owned. All vessels are under contract with the provincial government. The MV Northern Ranger provides passenger and limited freight service between Happy Valley-Goose Bay and the communities on the north coast, while the MV Astron provides the majority of the freight service to this area. The MV Challenge One transports passengers and freight to and from Williams Harbour and Normans Bay. The MV Sir Robert Bond provides auto, passenger and freight service between the Island, Cartwright and Happy Valley-Goose Bay, while the MV Apollo provides the same service between the Island and the Labrador Straits, through Blanc Sablon in Quebec.

Marine shipping is the primary method of moving large volumes of freight, including construction and building materials, food and beverages, from the Island portion of the Province to Labrador. Large amounts of construction materials and non-chilled food are also shipped from Happy Valley-Goose Bay and Cartwright to Labrador’s North Coast. During 2005 and 2006, 21.3 million kg of freight were shipped by ferry throughout Newfoundland and Labrador. Of this, 0.8 million kg moved between Cartwright and Happy Valley-Goose Bay, 2.5 million kg left Happy Valley-Goose Bay or Cartwright for the North Coast, and 0.9 million kg left the North Coast for Happy Valley-Goose Bay or Cartwright. Of the 11.2 million kg of freight leaving the Island, 62 percent was destined for Happy Valley-Goose Bay and 38 percent was destined to the North Coast (NLDTW 2006).

Labrador also has 21 smaller ports/harbours, most of which are served by Labrador Marine ferries. Others are ports of call for cruise ships. Details of Labrador ports are provided in Table B-3.
## Table B-3 Labrador Ports

| Labrador Ports | Type                  | Size       | Water Depth (Channel) | Max Vessel Size | Berth Length | Pilotage                     | Tugs         | Supplies      | Communications |
|----------------|-----------------------|------------|-----------------------|----------------|--------------|------------------------------|--------------|--------------|----------------|------------------|
| Happy Valley-Goose Bay | Pier, jetty or wharf | Very small | 9.4 – 10 m          | --             | 51 m         | Not compulsory Available     | No           | Fuel, water   | Radio, Rail    |
| Blanc Sablon    | Pier, jetty or wharf  | Very small | 7.1 – 9.1 m         | 500 feet       | Not compulsory Available     | No           | --           | Telegraph      |
| Sheshatshiu     | Pier, jetty or wharf  | Very small | 7.1 – 9.1 m         | 500 feet       | Not compulsory Available     | No           | --           | Radio Tel      |
| Cartwright      |                       |            |                      |                |              |                              |              |              |                |
| Nain            |                       |            |                      |                |              |                              |              |              |                |
| Natuashish      |                       |            |                      |                |              |                              |              |              |                |
| Hopedale        |                       |            |                      |                |              |                              |              |              |                |
| Postville       |                       |            |                      |                |              |                              |              |              |                |
| Makkovik        |                       |            |                      |                |              |                              |              |              |                |
| Rigolet         |                       |            |                      |                |              |                              |              |              |                |
| Black Tickle    |                       |            |                      |                |              |                              |              |              |                |
| Norman Bay      |                       |            |                      |                |              |                              |              |              |                |
| Charlottetown   |                       |            |                      |                |              |                              |              |              |                |
| William’s Harbour |                     |            |                      |                |              |                              |              |              |                |
| Port Hope Simpson |                     |            |                      |                |              |                              |              |              |                |
| Red Bay         |                       |            |                      |                |              |                              |              |              |                |
| Battle Harbour  |                       |            |                      |                |              |                              |              |              |                |
| Button Islands  |                       |            |                      |                |              |                              |              |              |                |
| Nachvak Fjord and Sagalek Bay | | | | | | | | | |
| Hebron          |                       |            |                      |                |              |                              |              |              |                |
| Cape Harrison   |                       |            |                      |                |              |                              |              |              |                |
| North West River |                     |            |                      |                |              |                              |              |              |                |

Source: World Port Source, 2010; Cruise Newfoundland and Labrador, 2010
2.2 Airports

The largest airport in Labrador is the Goose Bay Airport in Happy Valley-Goose Bay. Both civilian and military aircraft use the Goose Bay Airport, at 5 Wing Goose Bay. Operated by the Goose Bay Airport Corporation, it is one of the largest airports in eastern Canada. A number of air carriers operate scheduled flights, including Air Labrador, Air Canada Jazz and Provincial Airlines Ltd. (which operates Innu Mikun Airlines), as well as Universal Helicopters and Canadian Helicopters. The Department of National Defence (DND) owns and operates the facility. The Goose Bay Airport Corporation (GBAC) is the civilian authority that owns and operates the civilian airport terminal and manages under lease from DND the civil aviation area. Under the current three year lease, GBAC will evaluate the option of taking over the civilian aviation area on a permanent ownership basis. The current lease expires in 2010.

The Goose Bay Airport was a major stop-over for international aircraft. During World War II, it was used as a landing and re-fuelling stop for aircraft being ferried across the Atlantic, and during the Gulf War it was used extensively by aircraft transporting military personnel and equipment to and from the Middle East. In the 1980s, CFB Goose Bay became the primary low-level tactical training area for several North Atlantic Treaty Organization air forces (including British, Dutch, German and Italian). However the demand for low-level flying has declined and currently there is virtually no such activity at 5-Wing Goose Bay.

The airport has two runways (08/26 Length 11,046 m and 16/34 Length 9,580 m), both capable of handling large aircraft. DND spent approximately $20 million on resurfacing and concrete replacement during the summer of 2006. The airport terminal was constructed in 1972 and has a design capacity of 32,000 people per year, but it is now handling more than three times this capacity. The number of passengers flying into the Goose Bay Airport in 2005 was 104,612. However, this number has decreased in recent years and between 2008 and 2009, the number of movements fell by 6.5 percent to 91,490 (NLDTCW, 2010).

In 2005 and 2006, $200,000 was spent on improvements to the terminal, but these did not increase its capacity. The Goose Bay Airport Corporation has hired a design and engineering firm to complete the plans for an improved and expanded terminal facility at its current location. On April 30, 2010 it was announced that the governments of Canada and Newfoundland are investing $12.35 million for these enhancements, which are anticipated to be complete in December 2011 (Infrastructure Canada, 2010). The new facility will be able to accommodate an annual flow of 100,000 passengers, with further expansion capabilities incorporated into the design. This expansion capacity has primarily been provided in order to meet the needs of any new large projects initiated in central or northern Labrador in the near term (G. Price, pers. comm.).

Labrador also has a domestic airport in Labrador West. The Wabush Airport is owned and operated by Transport Canada and is located in Western Labrador. The principal communities within the catchment area of Wabush Airport are Wabush, Labrador City and Fermont. The airport hosts five airlines that have regular flights in and out of Wabush. Air Canada Jazz, Labrador Airways Limited, Provincial Airlines, Air Inuit, Pascan aviation, Prince Edward air (Transport Canada, 2009).
There are also 13 airstrips in coastal communities that are unpaved, have limited infrastructure and are not suited to larger aircraft. Table B-4 lists the locations of these airstrips and the lengths of their runways.

Table B-4  Labrador Airstrips

<table>
<thead>
<tr>
<th>Labrador Airstrips</th>
<th>Runway Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nain</td>
<td>607 m</td>
</tr>
<tr>
<td>Natuashish</td>
<td>762 m</td>
</tr>
<tr>
<td>Hopedale</td>
<td>762 m</td>
</tr>
<tr>
<td>Postville</td>
<td>762 m</td>
</tr>
<tr>
<td>Makkovik</td>
<td>762 m</td>
</tr>
<tr>
<td>Rigolet</td>
<td>762 m</td>
</tr>
<tr>
<td>Cartwright</td>
<td>1,195 m</td>
</tr>
<tr>
<td>Black Tickle</td>
<td>762 m</td>
</tr>
<tr>
<td>Charlottetown</td>
<td>762 m</td>
</tr>
<tr>
<td>Port Hope Simpson</td>
<td>762 m</td>
</tr>
<tr>
<td>William’s Harbour</td>
<td>671 m</td>
</tr>
<tr>
<td>St. Lewis</td>
<td>671 m</td>
</tr>
<tr>
<td>Mary’s Harbour</td>
<td>762 m</td>
</tr>
</tbody>
</table>

Source: Transport Canada, 2010; Air Labrador, 2006
3. CANADIAN ARCTIC

In the Kitikmeot and Qikiqtaaluk regions of Nunavut, there is no road access. The only community road in the entire Nunavut territory exists between Arctic Bay and Nanisivik. It is a 37 km gravel road which provides access between Arctic Bay, the Nanisivik/Arctic Bay airport and former Nanisivik mine site (GN-ED&T 2009a). Roads to natural resource deposits have been developed (i.e., Baker Lake to Agnico-Eagle Meadowbank Gold Project [110 km], Milne Inlet Tote Road of the Mary River Project [110 km]), while several more are proposed. A 1,200 km Kivalliq-Manitoba Highway has also been proposed to connect Rankin Inlet, Arviat and Whale Cove to Manitoba (GN-ED&T 2009a); a route selection study has been completed and additional studies are planned.

<table>
<thead>
<tr>
<th>Table B-5</th>
<th>Ports in the Canadian Arctic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Arctic Ports</td>
<td>Type</td>
</tr>
<tr>
<td>Iqaluit</td>
<td>Pier, jetty or wharf</td>
</tr>
<tr>
<td>Tuktoyaktuk</td>
<td>Pier, jetty or wharf</td>
</tr>
<tr>
<td>Nanisivik</td>
<td>Pier, jetty or wharf</td>
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</table>

Source: World Port Source, 2010

<table>
<thead>
<tr>
<th>Table B-6</th>
<th>Road Access in the Inuvialuit Settlement Region of the Northwest Territories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community</td>
<td>All-Weather Road</td>
</tr>
<tr>
<td>Aklavik</td>
<td>No</td>
</tr>
<tr>
<td>Inuvik</td>
<td>Dempster Highway (Gravel)</td>
</tr>
<tr>
<td>Paulatuk</td>
<td>No</td>
</tr>
<tr>
<td>Sachs Harbour</td>
<td>No</td>
</tr>
<tr>
<td>Tuktoyaktuk</td>
<td>No</td>
</tr>
<tr>
<td>Ulukhaktok</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: GNWT-DOT 2005
## Table B-7  Marine Facilities in the Inuvialuit Settlement Region of the Northwest Territories

<table>
<thead>
<tr>
<th>Community</th>
<th>Type</th>
<th>Size</th>
<th>Water Depth</th>
<th>Re-Supply Facilities Classification</th>
<th>Facilities Access</th>
<th>Ice Free Period</th>
<th>Pilotage</th>
<th>Use of Tugs/Landing Barge to Offload</th>
<th>Length of Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aklavik</td>
<td>Landing Beach Floating Dock</td>
<td>Very Small</td>
<td>-</td>
<td>Federal 2000-10,000 tonnes cargo per year</td>
<td>Secure moorage at all water levels Loading/unloading for 4 hours per day</td>
<td>Early June to October</td>
<td>No data</td>
<td>Yes</td>
<td>5 m</td>
</tr>
<tr>
<td>Inuvik</td>
<td>Public Dock Public Boat Launch Private Docks (6)</td>
<td>Very Small</td>
<td>16 m</td>
<td>Federal &amp; Private &gt;10,000 tonnes cargo per year</td>
<td>Secure moorage at all water levels Loading/unloading at all water levels</td>
<td>Early June to October</td>
<td>No data</td>
<td>No</td>
<td>91 m (public)</td>
</tr>
<tr>
<td>Paulatuk</td>
<td>Barge Landing</td>
<td>Very Small</td>
<td>-</td>
<td>Private &lt;2000 tonnes cargo per year</td>
<td>Loading/unloading for 4 hours per day</td>
<td>Mid June to Mid October</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Sachs Harbour</td>
<td>Beach</td>
<td>Very Small</td>
<td>-</td>
<td>Private &lt;2000 tonnes cargo per year</td>
<td>Loading/unloading for 4 hours per day</td>
<td>Mid June to Mid October</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Tuktoyaktuk</td>
<td>Public Dock Public Boat Launch Private Docks (&gt;5)</td>
<td>Very Small</td>
<td>&lt;25m (dredged)</td>
<td>Federal &amp; Private &gt;10,000 tonnes cargo per year</td>
<td>Secure moorage at all water levels Loading/unloading at all water levels</td>
<td>Early June to Mid October</td>
<td>No data</td>
<td>No</td>
<td>-</td>
</tr>
<tr>
<td>Ulukhaktok</td>
<td>Barge Landing</td>
<td>Very Small</td>
<td>-</td>
<td>Private 2000-10,000 tonnes cargo per year</td>
<td>Secure moorage at all water levels Loading/unloading for 4 hours per day</td>
<td>Late June to Mid October</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
</tr>
</tbody>
</table>

Sources: Mackenzie Gas Project Group 2005a and 2005b
Klock et. al. 2001
D. Wasylciw, pers. comm.
GNWT-DOT 1990
<table>
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<tr>
<th>Community</th>
<th>Lifts and Cranes</th>
<th>Mooring Bollards</th>
<th>Fuel</th>
<th>Communications</th>
</tr>
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<tbody>
<tr>
<td>Aklavik</td>
<td>-</td>
<td>Shoreline Anchors (4)</td>
<td>No</td>
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<td>Inuvik</td>
<td>-</td>
<td>Deadman Anchors (4)</td>
<td>Yes</td>
<td>MCTS (VFA, Radiotelephony &amp; Radiofacsimilie)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Mid May to Late October)</td>
</tr>
<tr>
<td>Paulatuk</td>
<td>-</td>
<td>No</td>
<td>-</td>
<td>-</td>
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<td>Sachs Harbour</td>
<td>-</td>
<td>Shoreline Anchor (1)</td>
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<td>Tuktoyaktuk</td>
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<td>Dock Bollards (4)</td>
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<td>Ulukhaktok</td>
<td>-</td>
<td>No</td>
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</table>

Sources: Mackenzie Gas Project Group 2005a and 2005b
Klock et. al. 2001
D. Wasylciw, pers. comm.
GNWT-DOT 1990
DFO and CCG 2010a
## Table B-8  Marine Facilities in the Kitikmeot and Qikiqtaaluk Regions of Nunavut

<table>
<thead>
<tr>
<th>Community</th>
<th>Type</th>
<th>Size</th>
<th>Spring Mean Tide Level (High/Low)</th>
<th>Re-Supply Facilities Classification</th>
<th>Facilities Access</th>
<th>Ice Free Period</th>
<th>Pilotage</th>
<th>Use of Tugs/Landing Barge to Offload</th>
<th>Length of Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic Bay</td>
<td>Gravel Landing Beach Breakwater Floating Dock</td>
<td>Very Small</td>
<td>2.4 m / 2.0 m</td>
<td>-</td>
<td>Anytime</td>
<td>Mid August to End September</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(in 2010)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Bathurst Inlet</td>
<td>Sand/Gravel Landing Beach</td>
<td>Very Small</td>
<td>0.8m / 0.6m</td>
<td>-</td>
<td>Anytime</td>
<td>Early August to Early October</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Cambridge Bay</td>
<td>Course Gravel Landing Beach Tidal Dock Floating Dock</td>
<td>Very Small</td>
<td>0.6 m</td>
<td>-</td>
<td>Anytime</td>
<td>End July to End September</td>
<td>No data</td>
<td>Yes</td>
<td>43 m (tidal dock)</td>
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<td></td>
<td>(in 2010)</td>
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<tr>
<td>Cape Dorset</td>
<td>Sand/Gravel/ Shingle/Boulder Landing Beach Tidal Dock</td>
<td>Very Small</td>
<td>8.5 m / 7.6 m</td>
<td>High Tide +/- 2 rs</td>
<td>Anytime</td>
<td>End July to Mid/End October</td>
<td>No data</td>
<td>Yes</td>
<td>35 m (tidal dock)</td>
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<tr>
<td>Clyde River</td>
<td>Sand/Gravel Landing Beach Push Out with Launch Ramp</td>
<td>Very Small</td>
<td>1.6 m / 1.3 m</td>
<td>-</td>
<td>Anytime</td>
<td>End July to End September</td>
<td>No data</td>
<td>Yes</td>
<td>20 m (push out)</td>
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<td>Floating Dock (in 2010)</td>
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<td>Gjoa Haven</td>
<td>Soft Sand Landing Beach Tidal Dock Gravel Push Out</td>
<td>Very Small</td>
<td>0.4 m</td>
<td>Anytime (Landing Beach)</td>
<td>Anytime</td>
<td>End July to Early October</td>
<td>No data</td>
<td>Yes</td>
<td>12 m (tidal dock)</td>
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<td>Floating Dock (in 2010)</td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Grise Fiord</td>
<td>Sand/Gravel Landing Beach Floating Dock</td>
<td>Very Small</td>
<td>3.6 m / 3.1 m</td>
<td>-</td>
<td>Anytime</td>
<td>Mid August to Mid September</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
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<td>(in 2010)</td>
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<td>Community</td>
<td>Type</td>
<td>Size</td>
<td>Spring Mean Tide Level (High/Low)</td>
<td>Re-Supply Facilities Classification</td>
<td>Facilities Access</td>
<td>Ice Free Period</td>
<td>Pilotage</td>
<td>Use of Tugs/Landing Barge to Offload</td>
<td>Length of Structure</td>
</tr>
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<tr>
<td>Hall Beach</td>
<td>Sand/Gravel Landing Beach Tidal Dock (Old Military Jetty, unusable) Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>1.4 m / 1.2 m</td>
<td>-</td>
<td>Anytime</td>
<td>End August to Mid September</td>
<td>No data</td>
<td>Yes</td>
<td>61 m (tidal dock)</td>
</tr>
<tr>
<td>Igloolik</td>
<td>Sand/Shingle Landing Beach with Breakwater Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>2.9 m / 2.4 m</td>
<td>-</td>
<td>Anytime</td>
<td>Mid August to Mid October</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
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<tr>
<td>Iqaluit</td>
<td>Rock/Shale/Mud/Sand Landing Beach Rubble Mound Breakwater (2)</td>
<td>Very Small</td>
<td>10.9 m / 7.1 m</td>
<td>&gt;10,000 tonnes cargo per year</td>
<td>High Tide +/- 6 hrs</td>
<td>Mid July to Mid October</td>
<td>No data</td>
<td>Yes</td>
<td>275 m 250 m (breakwaters)</td>
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<tr>
<td>Kimmirut</td>
<td>Clay/Gravel Landing Beach with Breakwater</td>
<td>Very Small</td>
<td>11.8 m / 9.6 m</td>
<td>-</td>
<td>High Tide +/- 2 hrs</td>
<td>Mid July to Mid November</td>
<td>No data</td>
<td>Yes</td>
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<tr>
<td>Kugaaruk</td>
<td>Clay/Gravel Landing Beach Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>1.6 m</td>
<td>-</td>
<td>Anytime</td>
<td>Mid August to Mid September</td>
<td>No data</td>
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<td>Kugluktuk</td>
<td>Tidal Dock Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>ND / 0.3 m</td>
<td>-</td>
<td>Anytime</td>
<td>End June to Mid October</td>
<td>No data</td>
<td>Yes</td>
<td>12.5 m (tidal dock)</td>
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<tr>
<td>Nanisivik</td>
<td>Deep-Water Port (Nanisivik Naval Facility in 2014)</td>
<td>Small</td>
<td>2.9 m / 2.4 m (Water Depth = 16 m / 12m)</td>
<td>-</td>
<td>Anytime</td>
<td>End July to Mid September</td>
<td>Unknown</td>
<td>No</td>
<td>70 m</td>
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<td>Pangnirtung</td>
<td>Gravel Landing Beach Rubble Mound Breakwater</td>
<td>Very Small</td>
<td>7.3 m / 5.9 m</td>
<td>-</td>
<td>High Tide +/- 4 hrs</td>
<td>End July to Mid September</td>
<td>No data</td>
<td>Yes</td>
<td>375 m (breakwater)</td>
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<td>Pond Inlet</td>
<td>Sand/Mud Landing Beach</td>
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<td>2.6 m / 2.2 m</td>
<td>-</td>
<td>Anytime</td>
<td>Mid August to Mid September</td>
<td>No data</td>
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<td>-</td>
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<td>Community</td>
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<td>Size</td>
<td>Spring Mean Tide Level (High/Low)</td>
<td>Re-Supply Facilities Classification</td>
<td>Facilities Access</td>
<td>Ice Free Period</td>
<td>Pilotage</td>
<td>Use of Tugs/Landing Barge to Offload</td>
<td>Length of Structure</td>
</tr>
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<tr>
<td>Qikiqtarjuaq</td>
<td>Sand/Gravel Landing Beach Rubble Mound Breakwater (2) Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>1.6 m / 1.3 m</td>
<td>-</td>
<td>Anytime</td>
<td>Mid July to Mid October</td>
<td>No data</td>
<td>Yes</td>
<td>205 m 30 m (breakwaters)</td>
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<tr>
<td>Repulse Bay</td>
<td>Gravel Landing Beach Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>6.5 m / 5.2 m</td>
<td>-</td>
<td>Anytime</td>
<td>End August to End September</td>
<td>No data</td>
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<tr>
<td>Resolute Bay</td>
<td>Sand/Gravel Landing Beach Gravel Push Out Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>1.9 m / 1.6 m</td>
<td>-</td>
<td>Anytime</td>
<td>Mid August to Mid September</td>
<td>No data</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Taloyoak</td>
<td>Sand Landing Beach Tidal Dock Floating Dock (in 2010)</td>
<td>Very Small</td>
<td>0.3 m</td>
<td>-</td>
<td>Anytime</td>
<td>End July to End September</td>
<td>No data</td>
<td>Yes</td>
<td>15 m (tidal dock)</td>
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</table>

Sources: GN-ED&T 2009a and 2009b
A. Johnson, pers. comm.
DMI 2008
<table>
<thead>
<tr>
<th>Community</th>
<th>Lifts and Cranes</th>
<th>Mooring Equipment</th>
<th>Fuel</th>
<th>Communications</th>
</tr>
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<tbody>
<tr>
<td>Arctic Bay</td>
<td>1 tonne (in 2010)</td>
<td>Shoreline Bollards (2)</td>
<td>No</td>
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<tr>
<td>Bathurst Inlet</td>
<td>-</td>
<td>-</td>
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<td>Cambridge Bay</td>
<td>1 tonne (in 2010)</td>
<td>Dock Bollards &amp; Cleats</td>
<td>No</td>
<td>MCTS (VFF, Radiotelephony &amp; Radiofacsimilie)</td>
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<td>(early July to Mid October)</td>
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<td>Cape Dorset</td>
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<td>Shoreline Bollards (4)</td>
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<td>Clyde River</td>
<td>1 tonne (in 2010)</td>
<td>Pile Type Bollards (2)</td>
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<tr>
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<td></td>
<td>(in 2010)</td>
<td></td>
<td></td>
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<tr>
<td>Gjoa Haven</td>
<td>1 tonne (in 2010)</td>
<td>Shoreline Cables (4)</td>
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</tr>
<tr>
<td>Grise Fiord</td>
<td>1 tonne (in 2010)</td>
<td>Shoreline Bollards (2)</td>
<td>No</td>
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<tr>
<td>Hall Beach</td>
<td>1 tonne (in 2010)</td>
<td>Shoreline Bollards (4, near old military site)</td>
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<td>Pile Type Bollards (2)</td>
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<td></td>
<td>(in 2010)</td>
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<td></td>
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<tr>
<td>Igloolik</td>
<td>1 tonne (in 2010)</td>
<td>Shoreline Bollards (4)</td>
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<td>Class A Offshore Mooring Buoys (2)</td>
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<td>MCTS (VFF, Radiotelephony &amp; Radiofacsimilie)</td>
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<td>Shoreline Bollards (2)</td>
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<td>(Mid June to Late November)</td>
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<td>Kimmirut</td>
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<td>Rock Type Bollards (3)</td>
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<td></td>
<td>(in 2010)</td>
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<tr>
<td>Kugaaruk</td>
<td>1 tonne (in 2010)</td>
<td>Shoreline Anchors (2)</td>
<td>No</td>
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</tr>
<tr>
<td>Kugluktuk</td>
<td>1 tonne (in 2010)</td>
<td>Dock Chain Anchors (4)</td>
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<td></td>
<td>Shoreline Cable/Chain Anchors (2)</td>
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<td>Nanisivik</td>
<td>-</td>
<td>Dock Bollards (6)</td>
<td>Yes</td>
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<td></td>
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<td>Shoreline Bollards (2)</td>
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<tr>
<td>Pangnirtung</td>
<td>-</td>
<td>Pile Type Bollards (2)</td>
<td>No</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>(in 2010)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pond Inlet</td>
<td>-</td>
<td>Rock Type Bollards (2)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pile Type Bollard (in 2010)</td>
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<tr>
<td>Qikiqtarjuaq</td>
<td>1 tonne (in 2010)</td>
<td>Shoreline Bollards (2)</td>
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</tr>
<tr>
<td>Repulse Bay</td>
<td>1 tonne (in 2010)</td>
<td>Rock Type Bollards (2)</td>
<td>No</td>
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<tr>
<td>Resolute Bay</td>
<td>1 tonne (in 2010)</td>
<td>Cement Tee Type Bollards (2)</td>
<td>No</td>
<td>MCTS (VFF, Radiotelephony &amp; Radiofacsimilie)</td>
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<td></td>
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<td></td>
<td>(Mid July to Late October)</td>
</tr>
<tr>
<td>Taloyoak</td>
<td>1 tonne (in 2010)</td>
<td>Cable/Chain Anchors (4)</td>
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Sources: DFO and CCG 2010a and 2010b
### Table B-9 Airfields in the Inuvialuit Settlement Region of the Northwest Territories

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<th>Community</th>
<th>Airstrip Heading</th>
<th>Airstrip Type</th>
<th>Airstrip Length</th>
<th>Fuel Available</th>
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<tbody>
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<td>Aklavik</td>
<td>13/31</td>
<td>Gravel</td>
<td>914 m</td>
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<tr>
<td>Inuvik</td>
<td>06/24</td>
<td>Asphalt</td>
<td>1829 m</td>
<td>AVGAS, Jet A-1</td>
</tr>
<tr>
<td>Paulatuk</td>
<td>02/20</td>
<td>Gravel</td>
<td>1219 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Sachs Harbour</td>
<td>08/26</td>
<td>Gravel</td>
<td>1219 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Tuktoyaktuk</td>
<td>09/27</td>
<td>Gravel</td>
<td>1524 m</td>
<td>No</td>
</tr>
<tr>
<td>Ulukhaktok</td>
<td>06/24</td>
<td>Gravel</td>
<td>1311 m</td>
<td>Jet A</td>
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</table>

Source: NAV Canada 2010

### Table B-10 Airfields in the Kitikmeot and Qikiqtaaluk Regions of Nunavut

<table>
<thead>
<tr>
<th>Community</th>
<th>Airstrip Heading</th>
<th>Airstrip Type</th>
<th>Airstrip Length</th>
<th>Fuel Available</th>
</tr>
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<tbody>
<tr>
<td>Arctic Bay / Nanisivik</td>
<td>12/30</td>
<td>Gravel</td>
<td>1951 m</td>
<td>No</td>
</tr>
<tr>
<td>Cambridge Bay</td>
<td>13/31</td>
<td>Gravel</td>
<td>1547 m</td>
<td>AVGAS, Jet A-1</td>
</tr>
<tr>
<td>Cape Dorset</td>
<td>13/31</td>
<td>Gravel</td>
<td>1215 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Clyde River</td>
<td>02/20</td>
<td>Gravel</td>
<td>1067 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Gjoa Haven</td>
<td>13/31</td>
<td>Gravel</td>
<td>1341 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Grise Fiord</td>
<td>14/32</td>
<td>Gravel</td>
<td>605 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Hall Beach</td>
<td>12/30</td>
<td>Gravel</td>
<td>1649 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Igloolik</td>
<td>15/33</td>
<td>Gravel</td>
<td>1248 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Iqaluit</td>
<td>17/35</td>
<td>Asphalt</td>
<td>2621 m</td>
<td>AVGAS, Jet A-1</td>
</tr>
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<td>Kimmirut</td>
<td>16/34</td>
<td>Gravel</td>
<td>579 m</td>
<td>No</td>
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<td>Kugaaruk</td>
<td>05/23</td>
<td>Gravel</td>
<td>1524 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Kugluktuk</td>
<td>12/30</td>
<td>Gravel</td>
<td>1677 m</td>
<td>AVGAS, Jet A-1</td>
</tr>
<tr>
<td>Pangnirtung</td>
<td>06/24</td>
<td>Gravel</td>
<td>890 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Pond Inlet</td>
<td>02/20</td>
<td>Gravel</td>
<td>1221 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Qikiqtarjuaq</td>
<td>03/21</td>
<td>Gravel</td>
<td>1159 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Repulse Bay</td>
<td>16/34</td>
<td>Gravel</td>
<td>1036 m</td>
<td>Diesel Fuel Arctic Grade (DFA)</td>
</tr>
<tr>
<td>Resolute Bay</td>
<td>17/35</td>
<td>Gravel</td>
<td>1981 m</td>
<td>Jet A</td>
</tr>
<tr>
<td>Taloyoak</td>
<td>15/33</td>
<td>Gravel</td>
<td>1225 m</td>
<td>Jet A</td>
</tr>
</tbody>
</table>

Source: NAV Canada 2010