



April 2014

VOLUME 8.0 MARINE ENVIRONMENT AND IMPACT ASSESSMENT

**Final Environmental Impact Statement
(FEIS) – Meliadine Gold Project,
Nunavut**

REPORT



Report Number: Doc 288-1314280007 Ver. 0

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EXECUTIVE SUMMARY

Purpose

Volume 8 of the Final Environmental Impact Statement (FEIS) for the Meliadine Gold Project (Project) considers the marine environment. The purpose of Volume 8 is to address the Guidelines issued by the Nunavut Impact Review Board for the Project specifically relating to the assessment of potential impacts on marine ecology, marine water and sediment quality, and marine biota including fish, Species at Risk (under *Species at Risk Act* [SARA]), and marine habitat.

The assessment includes potential direct and indirect changes resulting from Project-related components and associated activities, and evaluates all Project phases, including construction, operation, maintenance, and temporary, final, and post-closure activities. Cumulative effects for existing and reasonably foreseeable projects in the Project area have been incorporated, where applicable.

Study Areas

Spatial boundaries were defined to facilitate the assessment and interpretation of potential effects associated with the Project and were based on the concepts of known boundaries for Itivia harbour and the existing shipping corridor connecting Melvin Bay to Hudson Strait via Hudson Bay, and the predicted extent of residual effects from the Project. The marine spatial boundaries were delineated based on the predicted spatial extent of the Project-related effects and the life history attributes of valued ecosystem components (VECs) potentially influenced by the Project.

The local study area (LSA) for the marine assessment includes all areas in Melvin Bay designated for marine infrastructure (spud barge installation) and vessel activities, the in-shore barge route (access passage) where delivery barges transport offloaded materials from the cargo vessels anchored outside Melvin Bay, as well as the proposed offshore shipping corridor area.

The extent of the regional study area (RSA) includes a 5-km buffer area extending outside Melvin Bay and on either side of the marine shipping corridor, which is considered sufficient to encompass the potential regional extent of widespread effects (e.g. underwater noise) from the Project on marine resources. Project effects that extend beyond the regional scale (transboundary effects) were also considered in the assessment and were associated with marine VECs with large spatial distributions (e.g. marine mammals) or effects associated with accidental events (e.g. potential spills). Transboundary effects may impact marine resources outside of the Nunavut Settlement Area (NSA) and potentially affect other northern communities in Ontario and Quebec situated along the shipping route.

Effects Analysis

An effects analysis provides the general approach to analyzing potential Project-specific and cumulative (where applicable) effects on the marine environment. The effects analysis for marine ecology, marine water quality, and marine biota including fish, Species at Risk, and marine habitat VECs followed the assessment methodology described in Volume 4 of the FEIS.

Effects from the Project on the Marine Environment

Marine Water Quality

Accidental events have the potential to occur throughout the life of the Project. These could be minor events during routine operations such as small hydrocarbon, chemical, or waste spills on a Project-related vessel; or major events such as a worst case diesel spill due to vessel accidents, such as sinking, running aground,



collisions with other ships, or fires and explosions. The effect of a minor accidental spill on marine water quality was considered low in magnitude, local in geographic extent, medium-term in duration (until closure), isolated in frequency of occurrence, and reversible. With the application of known and effective spill prevention and response measures, the probability of a minor accidental spill is considered unlikely. The potential for long-term effects of a minor spill on water quality and marine wildlife populations is expected to be not significant.

The environmental consequence of a worst case diesel fuel spill would be dependent on the distance from the spill to the shoreline and sensitive areas, as well as on weather and oceanographic conditions. In the present case, the magnitude of a worst case diesel fuel spill on water quality in the Hudson Bay ecosystem was considered to be high. Diesel fuel oil is less viscous than crude oil; therefore it is less persistent in the marine environment. Diesel fuel has a low viscosity and will weather rapidly when spilled into the marine environment (NOAA 2006). Diesel fuel has a lower density than water and is readily dispersed by wave action. In a small diesel fuel spill, more than 90% of the fuel is either evaporated or naturally dispersed in the time frame of a couple of hours to days. Tankers will also be carrying intermediate and heavy fuel oils (IFOs and HFOs) for consumption during transit. IFOs and HFOs are denser and have a higher viscosity than diesel fuel. IFOs and HFOs are usually hydrocarbon blends with variable compositions of differing molecular weights. Degradation of the heavier components of IFOs and HFOs could take several months in protected bays and fjords; therefore, the duration of the effect is considered long-term. The frequency of this potential effect is considered isolated as the probability (or likelihood) is considered unlikely (predicted as occurring once every 500+ years for a worst case diesel spill) and, therefore, is not likely to occur during the lifetime of the Project. The geographic extent is considered regional to beyond regional, since the hydrocarbon plume may extend beyond the RSA. The effect of a worst case diesel fuel spill on water quality is considered reversible over time. The productive capacity of existing marine habitat due to altered water quality from a worst case diesel fuel spill is not expected to be disrupted over the long-term. With the application of known and effective spill prevention and response measures, in addition to implementation of industrial best management practices and safety standards, the probability of a worst case diesel fuel spill impacting water quality during the life of the Project is considered unlikely and the potential for long-term effects is considered to be not significant.

Cumulative effects are expected to be low for minor spill and high for a worst case spill in magnitude and regional to beyond regional in geographic extent. All effects are predicted to be reversible and should not result in a significant impact to marine water quality.

Marine Fish and Fish Habitat

The potential effects of the Project on marine fish include changes in habitat quality due to grounding of the spud barge and cargo barges, and changes in behavior due to underwater noise from Project-related vessel operations. Barge grounding is not expected to have a significant effect on fish habitat quality, given the existing habitat has been altered previously with the addition of gravel and the surrounding area is currently used by the community for marine access and supply delivery (which includes grounding of barges). Furthermore, existing fish habitat in Melvin Bay (including the proposed spud barge location) is naturally disturbed each year by winter sea-ice scour. Any changes to fish habitat during operation of the spud barge are expected to be low in magnitude (less severe than those effects naturally occurring from winter ice scour events), site-specific (local), and effectively continuous during Project operation. Any residual impacts to fish habitat are expected to be reversed within several months of Project decommissioning (medium-term). Therefore, the productive capacity of



the habitat is not expected to be altered, destroyed or disrupted; and the potential for long-term effects of the Project on fish habitat is expected to be not significant.

Residual effects for changes in fish behavior due to underwater vessel noise are not expected, given application of the proposed mitigation. Although underwater noise will be detectable to fish in the immediate vicinity of vessel activities in the LSA and will occur at regular intervals throughout the open-water season (periodic), underwater noise disturbance on fish is predicted to be low in magnitude (within the range of baseline values given existing vessel traffic in the LSA), site-specific (local), medium-term (until closure of the Project), and reversible. Effects are predicted to be limited to short-term behavioural responses (startle, displacement, and schooling behaviour), that will vary by species and hearing group, and will be dependent on the properties of the received sound. Any changes in behaviour due to underwater noise will be spatially limited, and are not predicted to have population-level effects on marine fish.

At the Project level, the magnitude of a minor spill on marine fish habitat is considered low while a worst case diesel fuel spill on marine fish and fish habitat is considered to be moderate, as it may result in mortalities of adult fish, fish eggs, or larvae, but changes at the population level are not anticipated. Incremental effects are considered regional to beyond regional in geographic extent (extending beyond the RSA), medium-term in duration for a minor spill and long-term for a worst case spill, isolated in frequency, with an unlikely probability of occurrence given the application of proposed mitigation. Effects may be measurable in other parts of the range of some marine fish species and thus may represent a transboundary effect if outside of Nunavut. The effects of a potential worst case diesel spill on the health and mortality of marine fish are considered reversible through natural recruitment, meaning the number of new young fish that will enter the population over time will offset the number of fish mortalities or injuries potentially resulting from a spill. Changes at the population level are not anticipated.

Cumulative effects are predicted to be low to moderate in magnitude and regional to beyond regional in geographic extent. All effects are expected to be reversible and are not anticipated to have significant impacts on marine fish populations and fish habitat.

Marine Mammals

Increased vessel traffic in the LSA may increase the risk of injury or direct mortality of marine mammals from potential vessel strikes. The potential for a vessel-mammal collision would be limited to the shipping corridor given the relative paucity of marine mammals known to frequent Melvin Bay in recent years. With the low number of yearly ship transits proposed for the Project, in addition to proposed mitigation measures (speeds and acceleration restrictions in Melvin Bay and shipping lanes; vessels maintaining minimum distances from animals), the likelihood of a vessel strike on a marine mammal is considered possible. At reduced speeds, any potential ship strike is more likely to result in injury (and resulting change in health) than mortality. No critical marine mammal habitat areas are known to occur in the LSA or RSA. No SARA-listed marine mammal species are known to occur in the Project area during the shipping season, with the possible exception of polar bear; however, their presence in the LSA and RSA during the open-water season would be considered extremely rare given the lack of sea-ice in this area during this time. Potential residual environmental effects to marine mammal populations from a change in health/mortality risk are expected to be low in magnitude, local in geographic extent (limited to the LSA), medium-term (until closure), and isolated in frequency (restricted to a limited number of ship transits during the open-water season only). Because the possible outcome from a ship strike includes death, this effect is considered irreversible at the level of the individual. However, the effects of any injuries or



fatalities on a marine mammal population as a whole are expected to be reversible through natural recruitment. Long-term effects of the Project on marine mammal populations are expected to be not significant.

Based on a review of the literature, it is conservative to assume that underwater noise associated with vessel operations may, in some cases, elicit behavioural changes in individual marine mammals that are in close proximity to these vessels. These behavioural changes may include evasive manoeuvres such as diving or changes in swimming direction and/or speed. Vessel and equipment noise is transitory and generally does not propagate to great distances from the vessel. The residual environmental effect of a change in marine mammal behaviour as a result of Project vessel noise is considered to be low in magnitude, regional in geographic extent (restricted to the RSA), medium-term in duration (only present during the Project life), and periodic in frequency (intermittent during the open-water season only). The likelihood of behavioural disturbance from Project-related vessel noise is considered likely, but would be reversible soon after underwater noise effects have subsided. No effects at the population level are anticipated (non-significant effect).

The potential effects of a minor spill on marine mammal habitat is considered to be low in magnitude, local in geographic extent (confined to the LSA) and medium-term for incremental/Project related scenarios. Impacts associated with a minor spill are considered reversible during the lifetime of the Project. The magnitude of a worst case diesel fuel spill on marine mammals health and mortality risk and marine mammal habitat is considered high as a spill could result in mortalities of a SARA-listed species (e.g., polar bear), extensive disruption of critical marine mammal activities, or damage to sensitive habitat areas in the RSA. The effect of a worst case diesel fuel spill on marine mammals and mammal habitat is considered regional to beyond regional in geographic extent (extending beyond the RSA), long-term in duration, isolated in frequency, and reversible through natural recruitment. With the application of known and effective spill prevention and response measures, in addition to implementation of industrial best management practices and safety standards, the probability of a worst case diesel fuel spill impacting the abundance and distribution of marine mammals is considered unlikely. No long-term effects on marine mammal populations are anticipated (non-significant effect).

Cumulative effects to marine mammals are expected to be low to high in magnitude and regional to beyond regional in geographic extent. All incremental and cumulative effects from the Project are considered reversible and are not expected to have significant effects on the abundance and distribution of marine mammal populations.

Marine Birds

With respect to potential effects on birds from Project lighting effects (changes in health, mortality risk, and/or behaviour due to sensory disturbance), extended daylight hours during the open-water season will limit the need for high intensity lighting, therefore bird attraction to site/vessel lighting is considered rare throughout the life of the Project. Attraction to lighting has been recorded in pelagic birds, such as albatross, petrels, and shearwater, but not the type of marine birds that have been documented in the LSA. Furthermore, there are no Important Bird Areas (IBAs) in the immediate vicinity of the LSA as defined by Bird Studies Canada, Nature Canada, and Birdlife International (Birdlife International 2012). This potential effect, therefore, is considered to be low in magnitude, site-specific (local), medium-term (present throughout the life of the Project), isolated in frequency, reversible, with an unlikely probability of occurrence. No population effects are anticipated (non-significant effect).

With respect to sensory disturbance from in-air noise from Project-related vessels and spud barge installation, marine birds in the LSA are already exposed to regular acoustic disturbance from existing human activity and



marine transportation activities in Melvin Bay. Marine birds may temporarily alter foraging and loafing patterns and distribution to avoid certain noise sources; however, no substantial behavioural and physiological effects are anticipated in an area that is already used. Potential residual environmental effects are expected to be low in magnitude, site-specific (local), medium-term (present throughout the life of the Project), and periodic in frequency. The potential for long-term effects of the Project on marine bird populations are expected to be not significant.

Marine birds would likely be the most adversely affected wildlife receptor from a worst case diesel fuel spill event in the marine environment. The magnitude of a worst case diesel fuel spill on marine bird health and mortality risks and bird habitat is considered to be high, since the spill may result in mortalities of SARA-listed marine bird species, such as Ross's gull and the Ivory gull and could impact large populations of migratory birds. This effect on birds is considered regional to beyond regional in geographic extent (extending beyond the RSA), long-term in duration, isolated in frequency, and reversible through natural recruitment. With the application of known and effective spill prevention and response measures, the probability of a worst case diesel fuel spill impacting the health and mortality risk of marine birds is considered unlikely. No long-term effects on marine bird populations are anticipated (non-significant effect).

Cumulative effects on marine birds are expected to be low to high in magnitude and regional to beyond regional in geographic extent. All effects are reversible and so are not anticipated to result in significant impacts marine bird populations.

Monitoring and Follow-up

As outlined in the Shipping Management Plan (SD 8-1), marine mammal monitoring will be undertaken by shipping contractors during all shipping activities to avoid interactions with marine mammals. Any incidents of vessel strikes with marine mammals will be recorded. Any incidents of bird mortalities associated with lighting infrastructure, construction activities, and Project vessel operations will be recorded.

A worst case diesel fuel spill may impact marine fish, birds, and mammal species and their habitats and may result in mortalities of SARA-listed species. In the unlikely event of a worst case diesel fuel spill, follow-up monitoring for certain marine species may be proposed. The scope of such follow-up monitoring should be determined at the time of the event.

Abbreviation and Acronym List

AEM	Agnico Eagle Mines Limited
BB	Baffin Bay
BWMP	Ballast Water Management Plan
CCG	Canadian Coast Guard
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DD	Data Deficient
FEIS	Final Environmental Impact Statement
DS	Davis Strait



MELIADINE FEIS – VOLUME 8 MARINE ENVIRONMENT

EBSA	Ecologically and Biologically Significant Areas
EC-WG	Eastern Canadian Arctic-West Greenland
EHB	Eastern Hudson Bay
EN	Endangered
FEIS	Final Environmental Impact Statement
FB	Foxe Basin
Golder	Golder Associates Ltd.
HBDS	Hudson Bay-Davis Strait
HBI	Areas of High Biological Importance
IMO	International Maritime Organization
ISQG	Interim Sediment Quality Guidelines
IQ	Inuit Qaujimajatuqangit (see note ¹)
LEK	Local Ecological Knowledge
LSA	Local Site Area
MMPA	Marine Mammal Protection Act
NMFS	US National Marine Fisheries Service
NSA	Nunavut Settlement Area
NTI	Nunavut Tunngavik Incorporated
NWMB	Nunavut Wildlife Management Board
NT	Northwest Territories
PBRL	Potential Biological Removal Levels
PMAL	Protection of Marine Aquatic Life
OPEP	Oil Pollution Emergency Plan
RSA	Regional Site Area
SARA	Species at Risk Act
SC	Special Concern
SEHB	South and East Hudson Bay
SOPEP	Shipboard Oil Pollution Emergency Plan
TAC	Total Allowable Catch
TEK	Traditional Ecological Knowledge
TH	Threatened
TK	Traditional Knowledge
TOR	Terms of Reference
TRU	Traditional Resource Use
VECs	Valued Ecosystem Components
VSECs	Valued Socio-economic Components
VU	Vulnerable
WHB	Western Hudson Bay

*Note: ¹ IQ symbol appearing in right hand margin denotes where IQ is referenced in the assessment.



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APPENDICES

Appendix 8.2-A

Nunami Stantec Marine Baseline Report for Itivia Harbour, Rankin Inlet, NU

Appendix 8.2-B

Meliadine Spill Risk Assessment



8.0 MARINE ENVIRONMENT

8.1 Spatial and Temporal Boundaries

To assess potential effects of the Meliadine Gold Project (Project) on the marine environment (marine wildlife and marine wildlife habitat), appropriate spatial boundaries need to be defined. Baseline studies were initiated before the Guidelines for the Project were issued; thus, the study area boundary was developed based on 2 concepts:

- Known boundaries for Melvin Bay and the existing shipping corridor connecting to Hudson Strait via Hudson Bay; and
- Predicted extent of residual effects from the Project.

The boundaries were set so that all the potential residual effects (direct and indirect) of the Project would fall within the study area boundaries.

8.1.1 Local Study Area

The Local Study Area (LSA) for the marine environment is the area where there exists the reasonable potential for direct effects on marine wildlife and wildlife habitat due to Project activities. The LSA includes the Project facilities, buildings and infrastructure, and all areas proposed for Project activities. The Project has been broken down into 3 distinct areas including the mine site, the All-weather Access Road (AWAR), and Rankin Inlet. For the purpose of the marine assessment, Rankin Inlet was the only Project area considered for the marine LSA, as the mine site and the AWAR do not overlap with the marine environment. The LSA includes all areas in Melvin Bay designated for marine infrastructure (spud barge installation) and vessel activities, including the in-shore barge and small tanker route where delivery barges and small tankers transport offloaded materials and fuel from the cargo and tankers vessels anchored outside Melvin Bay, as well as the proposed offshore shipping corridor area extending west to east from Melvin Bay to Eastern Hudson Strait prior to entry into the western Labrador Sea, as presented in Figure 8.1-1.

8.1.2 Regional Study Area

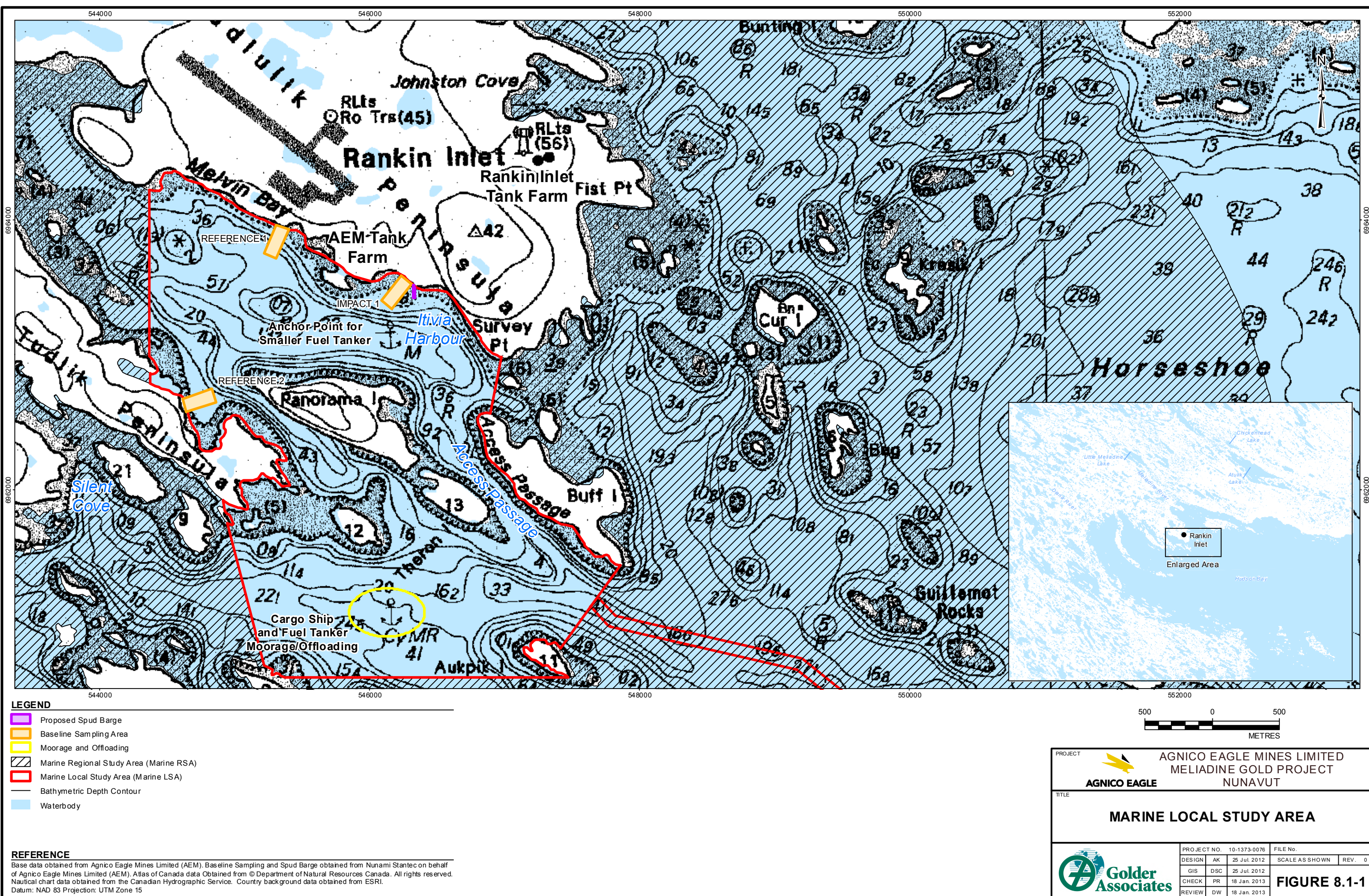
The Regional Study Area (RSA) is the area within which there exists the potential for residual effects, including direct and indirect effects, as well as incremental effects from the Project and cumulative effects from historical, existing, and reasonably foreseeable developments, including the Project. The RSA was selected to measure the existing baseline conditions at a large enough scale to capture the maximum predicted spatial extent of the combined direct and indirect effects. This area is intended to capture effects that could extend beyond the immediate Project footprint, such as underwater noise. The extent of the RSA includes a 5-kilometre (km) buffer area extending outside Melvin Bay and on either side of the marine shipping corridor, which is considered sufficient to encompass the potential regional extent of underwater noise effects from the Project, as presented in Figure 8.1-1. Cumulative effects from the Project and other developments in the RSA (if present) can be assessed at this scale for valued ecosystem component (VECs) that exhibit little to no movement within the RSA, such as water quality, and fish and fish habitat. They can also be assessed at this scale for VECs that have most of the population distributed within the RSA. For species with small to moderate home ranges



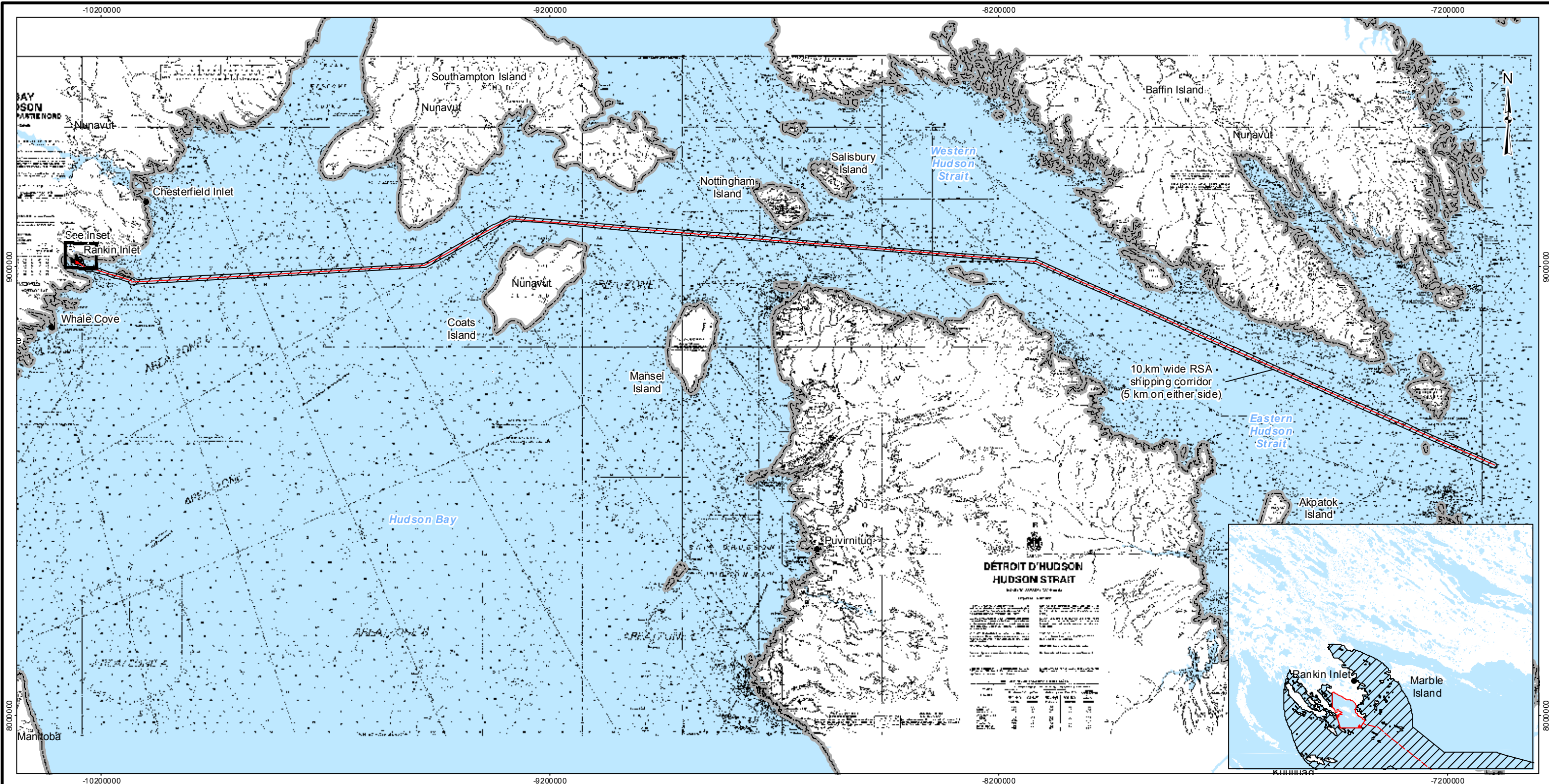
(e.g., narwhal, Western Hudson Bay polar bear sub-population, Ivory gull), the population would be primarily affected by natural and human-related factors that change survival and reproduction of individuals within the RSA, and should be little influenced by emigration and immigration (Berryman 2002). Developments outside of the RSA should have no or little influence on these populations during the breeding season.

Project effects that extend beyond the regional scale (transboundary effects) were also considered in the assessment and were associated with marine VECs with large spatial distributions, such as the bowhead whale, or effects likely to extend beyond the regional scale such as a worst case accidental diesel spill. Transboundary effects may impact marine resources outside the Nunavut Settlement Area (NSA) and potentially affect other northern communities in Ontario and Quebec situated along the shipping route.

N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Figure_8.1-1_Marine_LSA_Nautical_Charts.mxd



N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Figure_8.1-2_Marine_RSA_Nautical_Charts.mxd



- LEGEND**
- Marine Regional Study Area (Marine RSA) (See Inset)
 - Marine Local Study Area (Marine LSA)
 - Community
 - Waterbody

REFERENCE

Base data obtained from Agnico Eagle Mines Limited (AEM).
CanVec Data Obtained from © Department of Natural Resources Canada. All rights reserved.
Nautical chart data obtained from the Canadian Hydrographic Service. Provincial data obtained from ESRI.
Datum: WGS 84 Projection: World Mercator

PROJECT		AGNICO EAGLE		AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT		
TITLE						
MARINE REGIONAL STUDY AREA						
Golder Associates		PROJECT NO.	10-1373-0076	FILE No.		
		DESIGN	AK	16 Jul. 2012	SCALE AS SHOWN	REV. 0
		GIS	DSC	18 Jul. 2012		
		CHECK	PR	18 Jan. 2013		
		REVIEW	DW	18 Jan. 2013	FIGURE 8.1-2	



8.1.3 Temporal Boundaries

The approach used to determine the temporal boundaries of effects from natural and human-related disturbances on the marine environment is similar to the approach used to define spatial boundaries. In the Final Environmental Impact Statement (FEIS), temporal boundaries are linked to 2 concepts:

- the development phases of the Project (i.e., construction, operation and maintenance, and closure); and
- the predicted duration of effects from the Project on a VEC or valued socio-economic component (VSEC), which may extend beyond closure (i.e., post-closure).

Thus, the temporal boundary for a VEC or VSEC is defined as the amount of time between the start and end of a relevant Project activity or stressors (which are related to development phases), plus the duration required for the effect to be reversed (NIRB 2012).

The projected life of the Project is anticipated to be 10 years, but may be extended as exploration continues. This includes 3 years of construction, 13 years of operations, and 3 years of decommissioning are estimated. For the purpose of this marine assessment, a conservative estimate of 25 years will be used as the temporal boundary for the marine assessment.

8.2 Marine Environment

8.2.1 Introduction

8.2.1.1 Purpose and Scope

The purpose of this section is to describe baseline conditions for the marine physical environment, and assess the effects of the Project on the marine physical environment. For the purposes of the assessment, the marine physical environment is represented by marine water quality. Potential Project-related effects on marine sediment quality were considered to be indirect as a result of direct effects to marine water quality, and, therefore, were assumed to be captured within the assessment of marine water quality.

The effects assessment evaluated all Project phases, including construction, operation, and temporary, final, and post-closure. Indirect and cumulative effects have been incorporated throughout this section, where applicable. Information from other components, including traditional activities and knowledge (FEIS Volume 9, Section 9.3), and non-traditional land use and resource use (FEIS Volume 9, Section 9.9), as well as information from third party sources, including Traditional Knowledge for the Marine Approaches to Rankin Inlet (FEIS Volume 9, Appendix 9.3-C), were incorporated in the effects assessment for the marine VECs.

The scope of the marine baseline study and impact assessment was divided in 2 separate assessment areas. Nunami Stantec was retained by Agnico Eagle Mines Limited (AEM) to characterize baseline conditions and assess all Project activities occurring in the proposed spud barge area in Melvin Bay. Nearshore activities in this region included vessel operations, as well as construction, operation and decommissioning of the spud barge. Marine transportation activities occurring outside of Melvin Bay were not considered in Nunami Stantec's assessment. Golder Associates Ltd. (Golder) was retained by AEM to characterize baseline conditions and assess all Project activities occurring within the proposed offshore shipping corridor in Hudson Strait / Hudson Bay including vessel operations and accidents and malfunctions. Marine transportation activities in Melvin Bay,



as well as in the access passage between Melvin Bay and the offshore moorage location for cargo ships and fuel tankers, was considered in Nunami Stantec's marine assessment.

8.2.1.2 *Concordance with Project Guidelines*

The purpose of this section is to address Guidelines issued by the Nunavut Impact Review Board (NIRB) for the Project (NIRB 2012), and specifically those relating to the impact of the Project on the marine physical environment. Volume 1, Appendix 1.0-A lists the specific requirements set out in the Guidelines relating to the baseline and the impact assessment of the marine environment.

8.2.1.3 *Valued Components*

Valued ecosystem components and VSECs represent physical, biological, cultural, social, and economic properties of the environment that are either legally, politically, publically, or professionally recognized as ecologically and socially important to a particular region, community, or by society as a whole. Valued ecosystem components were selected based on their role in the ecosystem, and value placed on them by humans for traditional use and cultural purposes, where appropriate.

Factors considered when selecting VECs included the following:

- biophysical components identified by NIRB during Project scoping and AEM community and stakeholder consultation;
- represent important ecosystem processes;
- federally listed species under SARA and COSEWIC (SARA 2012; COSEWIC 2012);
- communities or species that reflect the interests of regulatory agencies, Inuit groups, and communities;
- can be measured or described with measurement endpoints;
- allow cumulative effects to be considered; and
- current experience with environmental assessments and effects monitoring programs in Nunavut and the Northwest Territories.

Marine water quality was selected as the marine physical environment VEC to assess Project-related effects on the physical marine environment (Table 8.2-1). As noted above, potential Project-related effects on sediment quality were considered to be indirect as a result of direct effects to water quality. An example is the contamination of marine water as a result of accidental spills and its subsequent contamination of benthic marine sediments. The potential indirect effects to marine sediments are assumed to be captured within the assessment of marine water quality, and, therefore, sediment quality was not selected as a VEC.

Table 8.2-1: Marine Physical Environment Valued Ecosystem Components

Valued Ecosystem Components	Rationale
Water Quality	■ Potential to be affected by Project activities in marine environment ■ Direct and indirect linkage to other marine VECs



8.2.2 Baseline Environment

8.2.2.1 Existing Environment in Melvin Bay / Itivia Harbour

In August 2011, a field program was conducted by Nunami Stantec at Itivia and at 2 nearby reference sites in Melvin Bay (see Site Figure in Appendix 8.2-A). The objective of the field program was to collect physical and biological baseline information in the marine LSA (Figure 8.1-1), with a focus on the Project footprint corresponding with the proposed floating dock facility (spud barge). The field program investigated bathymetry, water and sediment chemistry, aquatic lower-trophic organisms (phytoplankton, zooplankton, and benthic invertebrates) and fish and fish habitat. Results from Nunami Stantec's field program are provided in detail in Appendix 8.2-A, with a general summary provided below for bathymetry, water, and sediment chemistry.

8.2.2.1.1 Physical Environment

Depth soundings were collected along shore-perpendicular transects in the LSA. Water depths at Itivia and in Melvin Bay were determined to be shallow, with maximum depths in the Project footprint reaching 6.6 metres (m). A large rocky reef is present approximately 125 m offshore of the high water mark near the proposed spud barge facility. Cobble and gravel were the dominant substrates in the nearshore environment of the Project footprint.

Water quality profiles were collected at one location in the LSA with an YSI 600QS multi-meter. Parameters measured included temperature, conductivity, pH, dissolved oxygen, salinity, and oxidation-reduction potential. Mean surface water temperature (at 1 m depth) in the harbour was 8.86 ± 0.52 degrees Celsius ($^{\circ}\text{C}$), with a salinity of 29.32 ± 0.03 ppt, and a pH of 8.08 ± 0.03 . Bottom water was slightly colder than surface water at $8.49 \pm 0.57^{\circ}\text{C}$; with similar salinity and pH values. No thermal stratification was observed. The pH was near constant across the LSA (range from 8.05 to 8.10) and throughout the water column (range from 8.05 to 8.10). Mean conductivity ranged from 45.6 ± 0.1 mS/cm at the surface to 45.7 ± 0.1 mS/cm at the bottom. Dissolved oxygen ranged from $114.5 \pm 1.0\%$ at the surface to $114.1 \pm 1.2\%$ at the bottom.

Water samples were collected for chemistry analysis at one location in the LSA using a Van Dorn sampler deployed at mid-depth. Parameters analyzed included major anions, alkalinity, total suspended solids, total dissolved solids, pH, conductivity, total metals, total Kjeldahl nitrogen, ammonia, nitrate and nitrite, total phosphate, and total organic carbon. Results were compared to Canadian Council of Ministers of the Environment (CCME) guidelines (maximum levels) for Protection of Marine Aquatic Life (PMAL). Total alkalinity in the marine LSA ranged from 142 to 144 milligrams per litre (mg/L), with bicarbonate (HCO_3^-) as the major representative ion. Nitrate, nitrite, total Kjeldahl nitrogen, dissolved orthophosphate, and total phosphorus were below detection limits (typically <0.050 mg/L). Total organic carbon values were low (ranging from 2.8 to 3.6 mg/L). Approximately 78% of all analyzed metals (33 of 42) were below detection limits. All sample parameters for which CCME PMAL guidelines exist were within acceptable limits.

Sediment samples were collected for chemistry analysis at 3 locations in the marine LSA footprint using a petite ponar grab. Metal concentrations were compared to CCME Interim Sediment Quality Guidelines (ISQG). Sediment chemistry was near constant across the study area. Metal concentrations were variable and ranged from below analytical detection limits to exceeding CCME ISQCs. Chromium slightly exceeded the CCME ISQG of 52.3 milligrams per kilogram (mg/kg) at all sample stations, with average ($\pm\text{SD}$) concentrations in the marine LSA footprint measured at 55.8 ± 5.89 mg/kg. The precision analyses (CV) indicate some heterogeneity of marine sediments in the study area.



8.2.2.2 Existing Environment within Hudson Bay / Hudson Strait Shipping Corridor

Golder conducted a comprehensive literature review to characterize the physical environment in the proposed shipping corridor in Hudson Bay and Hudson Strait (Figure 8.1-2). The following information sources were reviewed:

- available scientific literature / data reports;
- NIRB Guidelines for the Preparation of an Environmental Impact Statement for the Agnico Eagle Mines Ltd. Meliadine Project (NIRB File No. 11MN034) (NIRB 2012);
- Marine Baseline Report - Itivia and Melvin Bay, Rankin Inlet, NU produced by Nunami Stantec Ltd. (2012);
- governmental and non-governmental environmental resources including:
 - Nunavut Wildlife Management Board Reports / Guidance Documents;
 - Nunavut Planning Commission web resources including the Nunavut Wildlife Resource and Habitat Values final report (2008);
 - The Canadian Circumpolar Institute and the Tungavik Federation of Nunavut, Nunavut Atlas (1992);
- Fisheries and Oceans Canada's (DFO) Mapster database;
- DFO's Ocean Data Inventory;
- previous marine-based environmental impact statements completed in the Project area (e.g., AREVA and others as available);
- available records of consultation with regulatory agencies, public stakeholders, and Inuit communities;
- a review of shipping and other marine industrial activities occurring, that have occurred, and are planned to occur; and
- presentation of Traditional Knowledge (TK) collected for local coastal areas.

8.2.2.2.1 Physical Environment

Hudson Bay is one of the world's largest inland seas, with a total surface area of approximately 830 000 square kilometres (km²) (Prinsenber 1984). It is connected to the Atlantic Ocean by Hudson Strait and the Labrador Sea; and to the Arctic Ocean by the Foxe Basin, Fury and Hecla Strait. Hudson Bay is a relatively shallow waterbody, with an average depth of approximately 100 m. The oceanographic regime in Hudson Bay is complex and manifests all the features of an Arctic system (Macdonald and Kuzyk 2011). It is highly influenced by the influx of cold saline waters (between approximately 32.5 and 33.5 ppt) from the Arctic Ocean and Baffin Bay, through Foxe Basin and Hudson Strait, by wind-stress during both the open-water and ice-cover season, by powerful tides (Stewart and Barber 2010), and by a large freshwater input from both runoff and ice melt (Stewart and Lockhart 2005; Ingram and Prinsenber 1998). Less saline surface outflows occur along the eastern shores of James Bay and Hudson Bay north to Hudson Strait. In Hudson Bay, estimates of average residence time of water range from 1.0 to 6.6 years (Ingram and Prinsenber 1998).

Water in the region freezes over each winter and becomes ice-free each summer, with sea-ice first forming in late October and continuing to expand until a maximum ice cover is reached by the end of April. In winter and early spring, the ice floes that cover most of Hudson Bay are kept in constant motion by wind forces. A shore lead system develops along the land-fast ice that forms from the coast of Hudson Bay as a result of wind blowing



seaward (Barber and Massom 2007). Major polynyas (stretches of open-water surrounded by sea ice) are found in the northwest sector (including Foxe Basin) and in the vicinity of the Belcher Islands in Eastern Hudson Bay. The northwestern region of Hudson Bay, encompassing part of the Project LSA and RSA, is an area where there is a large and persistent reoccurring polynya (Saucier et al. 2004).

Waters in the Hudson Bay region are characterized by moderate to strong semidiurnal tides of Atlantic origin, a marked summer pycnocline, and greater mixing inshore than offshore (Stewart and Lockhart 2005; Ingram and Prinsenberg 1998). Although marine productivity in Hudson Bay proper is low in comparison with other oceans of similar latitudes, productivity in Hudson Strait is typically twice higher than in other oceans of similar latitudes because of the sustained nutrient availability supplied by tidal mixing throughout an extended ice-free season (Ferland et al. 2011; Sibert et al. 2011).

The southern James Bay region is shallower and influenced to a much greater extent by freshwater runoff, thus supporting a wider variety of temperate-water species that are rare or absent elsewhere in Canada's Eastern Arctic waters (Stewart and Lockhart 2004). Seasonal ice cover also occurs in James Bay, with ice beginning to recede in late May, and the area becoming ice-free by the end of July. Polynyas are found predominantly along both coasts of James Bay during winter.

The Hudson Bay marine ecosystem is abnormally cold relative to other regions of the same latitude, and its climate is characterized by long and cold winters and cool summers (Stewart and Lockhart 2004). The entire area exhibits extreme temporal (seasonal and annual) and spatial variations in the range of average temperatures and average precipitation. Northwestern Hudson Bay experiences the greatest influence of cold Arctic air masses and has the harshest climate, with typical strong winds and persistent low temperatures. Other areas of the bay have less extreme conditions affected by moderate southern or marine influences. There is also a strong average precipitation gradient across the region, from less than 200 millimetres (mm) per year in the northwest to over 800 mm per year in the southeast (Stewart and Lockhart 2004). The upper air circulation of weather systems over Hudson Bay water is mainly related to the persistent, counter-clockwise air flow around a low pressure vortex that is situated over Baffin Island in winter, but weakens and retreats northward in summer (Stewart and Barber 2010).

There is considerable seasonal variation in Hudson Bay with respect to water circulation. In summer, surface water in Hudson Bay moves cyclonically (counter clockwise), influenced by cold saline Arctic water from Foxe Basin that enters in the northwest via Roes Welcome Sound (Prinsenberg 1986a; Tan and Strain 1996). During the transit, surface water is diluted by meltwater and runoff from the land, warmed by the sun, and mixed by the wind as it circulates, thus generating strong vertical stratification of the water column. Most of the river runoff water remains in the nearshore coastal regime in summer, with limited exchange into the interior of the Bay (Granskog et al. 2011). These water masses move eastward along the southern coast and are subsequently deflected northward and exit to the northeast into Hudson Strait (Figure 8.2-1). About half of the freshwater transport from Hudson Bay to Labrador Sea is the result of water pulses associated with anticyclonic, surface-trapped eddies that propagate through Hudson Strait as a result of storms and/or local instability processes (Sutherland et al. 2011). Deep water in Hudson Bay moves in the same general direction as surface water, although it is influenced by bottom topography (Ingram and Prinsenberg 1998; Wang et al. 1994). Intermittent flow of this dense water (approximately 34.1 ppt) over the sill that separates Foxe Channel from Hudson Bay likely maintains the homogeneous bottom layer in Hudson Bay (Stewart and Barber 2010). The incursion of Arctic waters creates Arctic oceanographic conditions in Hudson Bay, which extend farther south than elsewhere in North America and serve as the main driver of the Hudson Bay ecosystem (Stewart and Lockhart 2004).

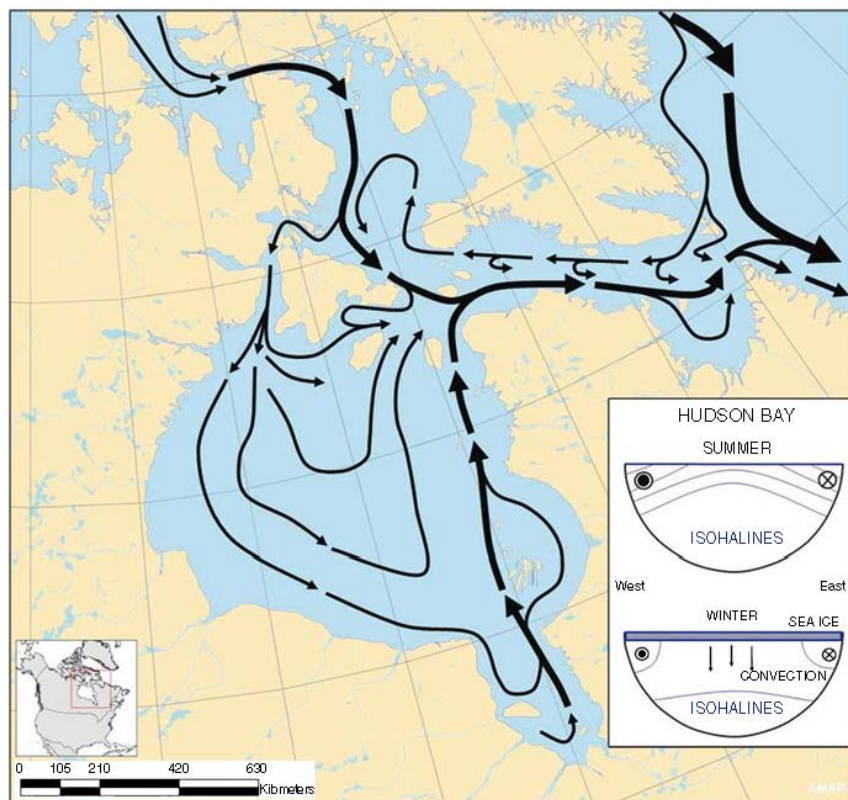


Figure 8.2-1: Summer circulation of water in the Hudson Bay Complex (extracted from Stewart and Barber 2010; inset after Ingram and Prinsenberg 1998)

The residual currents in Hudson Bay that are independent of tides are wind-driven and density-driven. Monthly mean current velocities are in the range of 4 to 6 centimetres per second, with stronger currents occurring in summer than in winter and more variability occurring at the surface than at depth (Prinsenberg 1986b). Winds are generally weaker and more variable in summer than in fall when strong northwesterly winds occur. The density-driven component is stronger in early summer when surface freshwater input from runoff and ice melt is highest (Prinsenberg 1982), and weakest in late winter/early spring when surface runoff input is lowest, local salinity is offset by salt excreted by the growing sea-ice, and wind-driven mixing of surface waters is not possible due to ice cover.

The tidal regime in Hudson Bay is influenced by powerful tides from the Atlantic Ocean that surge twice a day via Hudson Strait (Stewart and Barber 2010). These tides move as a Kelvin wave and propagate counter clockwise around Hudson and James Bay following the shoreline contour and overshadowing local tides and the Arctic tidal influence (Freeman and Murty 1976). In general, both tidal amplitude and range decreases as one moves counter-clockwise along the coast. The semidiurnal tidal amplitude ranges from 1.50 m along the western shore at Churchill to 0.10 m along the eastern shore near Inukjuak (Prinsenberg and Freeman 1986; Prinsenberg 1988a). The range in height between high and low water also varies, ranging from 0.5 m at Inukjuak



(Inoucdjouac) and 2 m along the east side of James Bay to as high as 4.6 m along the west coast of Hudson Bay (Dohler 1968; Godin 1974).

Hudson Bay is nearly entirely covered by ice in winter and is free of ice in summer. Depending on the weather, timing of sea ice formation or breakup may occur earlier or later by up to a month, but the general patterns remain similar. The ice formation in Hudson Bay usually begins in the north-western part (Repulse Bay) in October and spreads rapidly southward along the western coast during November (Cohen et al. 1994). By mid-December, from 90 to 100% of Hudson and James bays are covered with ice. Maximum ice cover usually occurs in April and May, and maximum ice thickness can occur between late February and early June and can reach 285 centimetres (cm) (Loucks and Smith 1989). The ice breakup begins in June in southern James Bay and Chesterfield Inlet and the region is usually entirely ice free in the first week of August (Stewart and Lockhart 2004; Cohen et al. 1994). Ice cover is an important feature of the Hudson Bay marine ecosystem. Ice distribution determines the distribution of marine biota and affects marine ecological processes in the water column and near the ice edge (Melnikov 1980). During ice formation, most of the seawater salt is expelled from the ice. This increases the salinity of the surface water, thereby increasing its density and deepening its layer (up to 100 m) and enhancing mixing of the water column (Prinsenberg 1988b). Formation of dense deep water is facilitated in the shore lead polynya system within which increased brine rejection is able to overcome buoyancy in the surface layer. This provides a mechanism to shunt approximately 6 to 16% of river runoff inputs into deeper waters that have an apparent residence time of about 4 to 14 years (Granskog et al. 2011).

As the pack-ice forms in northwestern Hudson Bay, predominant northwest winds continuously push it to southeastern Hudson Bay. The pack-ice forms rafts and ridges and increases in overall ice thickness, which increases freshwater input in this area in the spring (Prinsenberg 1988b). In northwest Hudson Bay, in contrast, the ice is constantly formed and removed continuing the salt input into the water column. This constant removal of the ice by northwest winds and tidal mixing develops leads and recurring polynyas. There are several polynyas that form close to shore, such as in Roes Welcome Sound, at the northern tip of Coats Island, and at Akimiski Island, which is one of the most southerly polynyas in Canadian waters. These polynyas provide important habitat for various species of marine birds, such as the Hudson Bay eider, which overwinters in this region (Martini and Protz 1981; Nakashima 1988).

The Hudson Bay marine ecosystem is characterized by strong vertical stratification of the water column in spring and summer, particularly offshore (Roff and Legendre 1986; Anderson and Roff 1980; Prinsenberg 1986a). The vertical stratification is caused by a dilution of cold Arctic saline surface water by freshwater runoff and sea-ice melt, which is subsequently warmed by the sun, and mixed by the wind. The stratification results in a strong vertical density gradient between fresh, warm water at the surface and cold, saline deeper water. The vertical density gradient impedes vertical mixing, thereby limiting nutrient input to surface waters and lowering biological productivity. A strong summer pycnocline can be observed at depths between 15 and 25 m (Anderson and Roff 1980; Prinsenberg 1986a; Ferland et al. 2011). Heating of the surface layer and freshwater input decrease as summer progresses. This increases the depth of the pycnocline. In winter, the vertical stratification is the weakest due to the increase in density of surface water and, therefore, there is an increase in vertical mixing.

Physical conditions that promote large-scale mixing or upwelling in the region during spring and summer remain limited, but ice edges along the well-developed shore lead system (where the coastal fast ice and mobile pack ice meet) correspond with areas of upwelling and associated stimulation of nutrient fluxes and primary production (Stewart and Barber 2010). In the area where the shore lead prevails (nearshore), the isotopic composition of phytoplankton during summer suggests the presence of an open system influenced by the



upwelling of deep waters and related nutrient replenishment (Kuzyk et al. 2010). Another key process that supports the re-injection of nutrients in surface waters in Hudson Bay is the vertical mixing driven by tidal currents (Sibert et al. 2011). Tides in the region are known to enhance marine productivity (Stewart and Barber 2010) and to contribute to the development of local biological hotspots that are used by marine mammals as summer habitats, such as in the northwest region of the Bay (Higdon and Ferguson 2010).

At a deep-water station in southeastern Hudson Bay, surface salinity ranged from 24 ppt in August to 28 ppt in April, and surface temperature ranged from -1.5°C in April to 8°C in August (Figure 8.2-2). At depths below 50 m, water temperature and salinity were relatively stable throughout the year. As water depth increased, water temperature progressively decreased as salinity increased, with mean water temperature below -1.4°C and salinity greater than 33 ppt at approximately 100 m water depth (Ingram and Prinsenberg 1998).

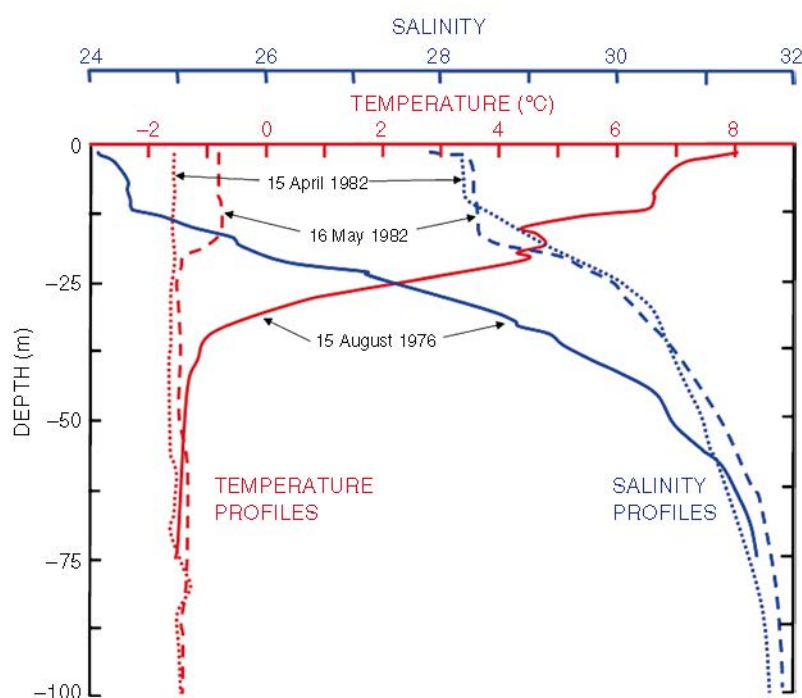


Figure 8.2-2: Representative Vertical Profiles of Temperature and Salinity in Southeastern Hudson Bay in April (dashed line), May (dashed-dotted line), and August (solid line) (extracted from Stewart and Barber 2010; Redrawn from Ingram and Prinsenberg 1998)

Freshwater runoff, wind-driven mixing, and tidal influence have great effects on water column characteristics in the Hudson Bay ecosystem. Vertical stratification near large river plumes varies seasonally and spatially. It is usually directly related to the runoff volume and inversely related to the tidal kinetic energy (Freeman et al. 1982). The water column stratification is stronger during freshet and weaker with distance from the river mouth. The salinity and temperature gradients are usually weaker when wind-driven mixing and tidal energy are strongest. The volume of the freshwater runoff in the region is high, with a mean discharge rate of 30 900 cubic metres per second for all rivers combined (The Canadian Encyclopaedia). These high runoff volumes determine oceanographic conditions in the area by creating very low surface salinities and strong vertical density gradients.



High freshwater runoff volumes are also partly responsible for the difference between inshore and offshore oceanographic conditions in Hudson Bay during summer. In general, salinity and temperature in Hudson Bay increases with distance from shore (during summer). For example, surface salinity in Hudson Bay ranged from 10 ppt near major rivers to 30 ppt in offshore locations of the bay, and surface temperature ranged from 4°C in nearshore areas to 11°C in offshore locations (Anderson and Roff 1980; Prinsenberg 1986a). Lower salinities in the inshore region are due to dilution effects, whereas lower nearshore temperatures in western Hudson Bay are due to strong northwesterly wind effects causing upwelling of colder deep water to the surface (Figure 8.2-3). In southern Hudson Bay, lower temperatures are a result of pack-ice, which lingers along the shore well into summer. Higher temperatures offshore cause stronger vertical stratification. During periods with low water temperatures (–1.75°C to 1.25°C), considerably higher rates in both bedload and suspended sediment transport are observed along the shore in comparison with a summer situation (9°C to 17°C), with similar wave heights and current velocities (Héquette and Tremblay 2009). The winter increase in suspended sediment transport is likely due to lower sediment settling velocities resulting from significant increases in fluid kinematic viscosity at low temperature. Hudson Strait is a wide, deep-water channel (on average 150 km wide, 750 km long, and 400 m deep) that connects Hudson Bay and Foxe Basin with the Labrador Sea and Davis Strait (Harvey et al. 2001). It acts as a transition zone between brackish waters in Hudson Bay and more oceanic waters of the Labrador Sea. Hudson Strait is covered with ice from mid-December to July (Hudon et al. 1993). The oceanographic regime in Hudson Strait is affected by strong tidal currents (up to 2 to 3 m/s) and high tidal elevations (tidal amplitudes are 6 to 9.5 m). These tides cause intensive vertical mixing in the water column, disrupting vertical density stratification and, therefore, enhancing biological productivity by increasing nutrient availability in the surface layer (Drinkwater and Jones 1987; Drinkwater 1986, 1990; Harvey et al. 2001).

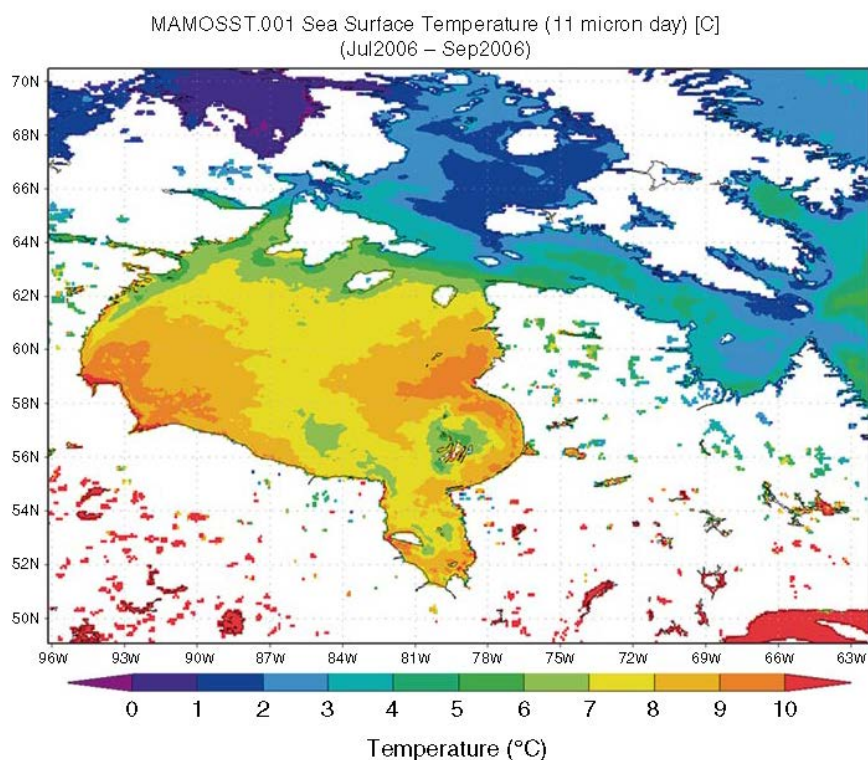


Figure 8.2-3: Summer (July to September) sea surface temperature in 2006 (Stewart and Barber 2010)



The physical processes in Hudson Bay and Hudson Strait have a strong influence on the oceanographic and biological processes over the Labrador Shelf, affecting the water temperature and salinity characteristics in the area (Drinkwater and Harding 2001). At the eastern entrance of Hudson Strait, low salinity waters from Hudson Bay and Foxe Basin flowing eastward converge with cold Baffin Land Current waters from the north and warmer deep West Greenland Current waters. The Hudson Strait strong tidal currents result in intensive vertical mixing of these waters and the residual current carries the resulting mixture eastward onto the Labrador Shelf (Drinkwater and Jones 1987). This results in increased mixing over the Labrador Shelf, with reduced vertical density stratification relative to the Baffin Island Shelf to the north (Lazier 1982). Primary productivity is subsequently enhanced by elevated surface nutrient concentrations in eastern Hudson Strait (Drinkwater and Jones 1987) and on the northern Labrador Shelf (Kollmeyer et al. 1967).

Since 2005, recurrent expeditions of the CCGS Amundsen in Hudson Bay (Arcticnet 2014) have supported the collection of ambient noise and acoustic backscattering data. The primary dataset is composed of records obtained with a SIMRAD EK60 3-frequency split-beam echosounder that was operated continuously during the field campaigns (Polar Data Catalogue 2014). In parallel, AURAL-M2 (Autonomous Underwater Recorder for Acoustic Listening-Model 2) passive hydrophones were attached on mooring arrays deployed nearby Churchill and Great Whale River to document the seasonality of underwater sound, including marine mammal vocalizations and ambient noise (Polar Data Catalogue 2014).

8.2.2.2.2 Current Shipping Activities

Ship traffic in Hudson Strait is presently limited to the open-water season from July to October (NEAS 2012; Arctic Sealift Services 2012) and involves the following types of vessels:

- dry cargo and fuel supply vessels servicing Arctic communities – most originating from ports in Atlantic Canada (Newfoundland and the St. Lawrence region);
- dry cargo and fuel supply vessels servicing the Meadowbank Gold Mine;
- grain ships bound for Africa, Europe, and Mexico from the Port of Churchill;
- research vessels;
- tourist cruise ships; and
- various pleasure crafts (A. Stewart 2012, pers. comm.; AREVA Resources Canada Inc. 2013; NEAS 2012; Arctic Sealift Services 2012).

Estimates of existing dry cargo and fuel supply vessel transits along the Project shipping route were derived from the 2013 sealift cargo delivery schedule for Desgagnés Transarctik Inc. and Nunavut East Arctic Company (NEAS 2012; Arctic Sealift Services 2012) and from personal communication with Coastal Shipping Ltd. (P. John 2013, pers. comm.). Estimates of current grain ship movements along the Project shipping route were based on mean annual ship rates provided by AREVA Resources Canada Inc. in a 2013 Information Request related to the Kiggavik Project (AREVA Resources Canada Inc. 2013).

Approximately 13 cargo vessels and 30 fuel tankers (6 tankers - 5 round trips each) transit through Hudson Strait on an annual basis to service Arctic communities (P. John 2013, pers. comm.; NEAS 2012; Arctic Sealift Services 2012). An estimated 4 dry cargo tankers and 4 fuel tankers transit through Hudson Strait annually to



service the Meadowbank Gold Mine located near Baker Lake. A yearly average of 12 grain vessels also travel through Hudson Strait to the Port of Churchill (AREVA Resources Canada Inc. 2013). We have assumed that one additional research vessel and up to 5 tourist cruise ships may travel along the proposed shipping route annually. This results in a total of up to 69 vessels currently traveling through Hudson Strait during each shipping season.

8.2.3 Pathway Analysis

8.2.3.1 Methods

Pathway analysis identifies and assesses the linkages between Project components or activities, and the correspondent potential residual effects to the marine physical environment. The first part of the analysis involved the identification of all potential effects pathways for the Project (FEIS Volume 4, Section 4.3). Each pathway is initially considered to have a linkage to potential effects on the marine physical environment. This step is followed by the development of environmental design features and mitigation that can be incorporated into the development description to remove a pathway or limit (mitigate) the effects to the marine water quality. Environmental design features include Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on the marine physical environment. Pathways are determined to be primary, minor, or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is non-existent or is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to the marine physical environment relative to baseline or guideline values;
- minor – pathway could result in a minor environmental change, but would have a negligible residual effect on the marine physical environment relative to baseline or guideline values; or
- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on the marine physical environment relative to baseline or guideline values.

Primary pathways require further effects analysis to determine the environmental significance from the Project on the marine physical environment. Pathways determined to have no linkage to the marine physical environment or those that are considered minor are not predicted to result in environmentally significant effects on the marine environment. Pathways identified as 'minor' or having 'no linkage' are summarized but not carried through the effects assessment.

Potential pathways through which the Project could affect the marine physical environment are presented in Table 8.2-2. Environmental design features and mitigation incorporated into the design of the Project to remove a pathway or limit the effects to the marine physical environment are listed, and pathways are determined to be



primary, minor, or as having no linkage. The following section discusses the potential pathways relevant to the marine physical environment.

Project activities described in Table 8.2-2 will occur during all phases of the Project (pre-development, construction, operations, and temporary, final and post-closure). Project pathway linkages are thus described by individual activity, which can be assumed to be consistent across all Project phases.



Table 8.2-2: Potential Pathways for Effects to Marine Physical Environment

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
Vessel movements in the proposed shipping corridor and Melvin Bay including near-shore transportation of fuel and dry goods (loading barges, barging, off-loading)	Water quality	Vessel wakes from nearshore vessels may cause shoreline erosion, which can result in adverse effects to marine water quality with associated indirect effects on marine wildlife.	Vessels in Melvin Bay will travel at reduced speeds (≤ 2 knots).	Minor
	Water quality	Propeller wash from nearshore vessels berthing at the spud barge / landing ramp may result in adverse effects to marine water quality, with associated indirect effects on marine wildlife.	Placement of spud barge will avoid sensitive natural habitats. To the extent possible, vessel will shut-down vessel engines and propellers when anchored or tied to the spud barge.	Minor
	Water quality	Solid waste, grey water, and bilge water discharges from ships may result in direct adverse effects on marine water quality in the proposed shipping corridor and associated indirect effects on marine wildlife.	Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO 2008; MARPOL 73/78). Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1).	Minor
	Water quality	Introduction of exotic marine species (including pathogens) from ship ballast water exchange during seasonal shipping events can affect native marine wildlife.	Adherence to Ballast Water Management Plan (BWMP) as defined in the Shipping Management Plan (SD 8-1). Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1).	Minor
	Water quality	Antifouling toxins (e.g., tributyltin) potentially leaching from Project vessels can have an effect on the marine environment and bio-accumulation in marine food chains.	Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO 2008; MARPOL 73/78). Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1).	Minor



Table 8.2-2: Potential Pathways for Effects to Marine Physical Environment (continued)

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
	Water quality	Accidental spills from vessel activities and fuel transfer operations can have direct adverse effects on marine water quality and associated indirect effects on marine wildlife.	Adherence to Spill Contingency Plan (SD 2-16). Adherence to Risk Management and Emergency Response Plan (SD 2-15). Adherence to Shipping Management Plan (SD 8-1). Adherence to Oil Pollution Emergency Plan (OPEP; SD 8-2). Compliance with Shipboard Oil Pollution Emergency Plan (SOPEP). Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO 2008; MARPOL 73/78); <i>Canada Shipping Act</i>; and <i>Arctic Waters Pollution Prevention Act</i>. Operational activities have been engineered to use contained handling systems to minimize the risk of accidental spills into the marine environment.	Primary



Table 8.2-2: Potential Pathways for Effects to Marine Physical Environment (continued)

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
	Water quality	Accidental spills of dry cargo (loading and off-loading barges) can have direct adverse effects on marine water quality and associated indirect effects on marine wildlife.	Adherence to Spill Contingency Plan (SD 2-16). Adherence to Risk Management and Emergency Response Plan (SD 2-15). Adherence to Shipping Management Plan (SD 8-1). Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO 2008; MARPOL 73/78); <i>Canada Shipping Act</i> ; and <i>Arctic Waters Pollution Prevention Act</i> . Operational activities have been engineered to use contained handling systems to minimize the risk of accidental spills into the marine environment.	Minor

^a indirect effects on marine wildlife are discussed in Section 8.3.



8.2.3.2 Pathways with No Linkage

A pathway may have no linkage if the pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to marine water quality relative to baseline or guideline values. There were not any pathways that were designated to have no linkage with respect to marine water quality.

8.2.3.3 Pathways with Minor Linkage

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on marine water quality relative to baseline or guideline values. Pathways that are anticipated to be minor, and will not be carried through the effects assessment are listed below and are described in Section 8.3.4.3 where the associated indirect effects on marine fish, birds, and mammals are discussed.

- Vessel wakes from nearshore Project vessels engaged in transportation activities may cause shoreline erosion, which can result in adverse effects to water quality with associated indirect effects on marine fish, birds, and mammals.
- Propeller wash from nearshore Project vessels berthing at the spud barge / landing ramp may result in adverse effects to marine water quality with associated indirect effects on marine wildlife.
- Antifouling toxins (e.g., tributyltin) potentially leaching from Project vessels can have an effect on the marine environment and bio-accumulation in marine food chains.
- Introduction of exotic marine species (including pathogens) from ship ballast water exchange during seasonal shipping events can affect native marine wildlife (marine fish, birds, and mammals).
- Discharges of solid waste, grey water, and bilge water from Project vessels in the shipping corridor may result in direct adverse effects on marine water quality and associated indirect effects on marine wildlife (marine fish, birds, and mammals).
- Change in marine habitat quality due to altered water quality from potential accidental hazardous materials spills and associated indirect effects on marine wildlife VECs.

8.2.3.4 Summary of Primary Pathways

The following primary pathway was determined for linking Project-related activities to effects on the marine water quality; and is described in Section 8.3.4.4 where the associated indirect effects on marine fish, birds, and mammals are discussed:

- Change in marine habitat quality due to altered water quality from potential accidental hydrocarbon spills and associated indirect effects on marine wildlife VECs.

8.2.4 General Approach to Primary Pathways

The effects analysis considers all primary pathways that result in expected changes to existing marine water quality as it relates to marine habitat, after implementing environmental design features and mitigation. Thus, the



analysis is based on the residual effects from the Project. Residual effects to the marine water quality were analyzed using measurement endpoints (FEIS Volume 4, Section 4.2, Table 4.2-1) and are expressed as effects statements, from changes in habitat quality.

The analyses of residual effects from the Project on marine water quality were largely qualitative and included professional judgement and/or expert opinion supported by data from field studies, scientific literature, monitoring programs, government publications, and personal communications. Traditional knowledge and community information were incorporated where applicable and available.

8.2.5 Effects Analysis

Project activities in the marine environment associated with the construction, operation, and decommissioning of the Project have the potential to result in adverse effects to marine water quality. Routine vessel operations within Melvin Bay and routine activities associated with construction, operation, and decommissioning of the proposed spud barge site at Itivia were considered in the scope of the marine assessment, as were marine transportation activities outside of Melvin Bay. Accidents and malfunctions (including accidental releases) within Melvin Bay and the proposed shipping corridor were also considered.

8.2.5.1 Relevant Project Components

Two relevant Project components were identified for the marine physical assessment:

- spud barge and marine transportation activities in Melvin Bay; and
- marine shipping.

Reasonably foreseeable future developments (RFFD) that may act cumulatively with these project components are discussed in further detail in Section 8.3.6.1.

8.2.5.2 Assessment of Change in Habitat due to Altered Water Quality from Accidental Spills

The effects assessment and associated mitigation for the change in habitat due to altered water quality from accidental spills is described in Section 8.3.6.5 where the associated indirect effects on marine fish, birds, and mammals are discussed.

8.2.6 Residual Impact Classification

The methods used for the residual impact classification and the results for the change in habitat due to altered water quality from accidental spills are described in Section 8.3.7.

8.2.6.1 Residual Impacts on Marine Water Quality

Table 8.2-3 summarizes the impact rating classifications of minor accidental hydrocarbon spills on marine water quality. The incremental effect of a minor accidental spill on the receiving environment and VEC receptors was



considered low in magnitude, local in geographic extent, medium-term in duration (throughout Project life only), isolated in frequency of occurrence, and reversible. Cumulative effects of minor spills from reasonably foreseeable future development (RFFD) in the RSA are expected to have negative effects on marine water quality that are low in magnitude and beyond regional in extent. Impacts on water quality are expected to be reversible, and the productive capacity of affected marine habitat is not expected to be disrupted. With the application of known and effective prevention and response measures, the likelihood of this effect occurring is considered unlikely for minor spills. The potential for long-term effects of minor spills on marine water quality is thus expected to be not significant.

The environmental consequence of a worst case diesel fuel spill would be dependent on the distance from the spill to the shoreline and sensitive areas, as well as on weather and oceanographic conditions. The physical behavior of a fuel spill in the marine environment was assessed at 6 different hypothetical spill locations in the Project area, considering aspects of evaporation, dispersion, spreading, and potential distance traveled from the spill site (Appendix 8.2-B). Two locations in Melvin Bay were considered in the assessment corresponding with ship-to-shore fuel transfer sites where a higher potential for a spill would occur. Four locations along the shipping route also were considered in the assessment corresponding with known sensitive habitat areas for marine mammals and/or marine birds, including Walrus Island, Coats Island, Ungava Peninsula, and Eastern Hudson Strait. The assessment considered a worse case spill scenario of 2 million litres (ML) of P50 diesel at all 6 sites, as well as a smaller spill scenario of 100 000 litres (L) (100 cubic metres [m³]) at the 2 sites in Melvin Bay only. The ADIOS2 model was used, with the input of local wind speed values to approximate wave conditions and predict the weathering half-life of the spilled fuel. Based on the assessment, a 26-km swath on either side of the shipping route was identified as the area in which approximately 95% of the diesel would be weathered within 2 days of the spill occurrence. The assessment consisted of a one-dimensional analysis and did not account for other potential site-specific effects such as wave climate and current effects related to local bathymetry. However, it is expected that tidal current speeds would be highest in areas where the channels were narrowest, such as adjacent to Coats Island, and that tidal current velocities would enhance the spreading, weathering, and travel time of the fuel in the direction of flow. In addition, a dominant easterly current persists in Hudson Strait east of Coats Island, which would enhance the travel time of a fuel spill along that portion of the shipping route.

The magnitude of a worst case diesel fuel spill on marine water quality was considered to be high for both incremental and cumulative scenarios (Table 8.2-3). Diesel fuel has a low viscosity and will weather rapidly when spilled into the marine environment (NOAA 2006). Diesel fuel has a lower density than water and is readily dispersed by wave action. In a small diesel fuel spill, more than 90% of the fuel is either evaporated or naturally dispersed in the time frame of a couple of hours to days. Tankers heading to Rankin Inlet will also be carrying intermediate and heavy fuel oils (IFOs and HFOs) for consumption during transit. IFOs and HFOs are denser and have a higher viscosity than diesel fuels. IFOs and HFOs are usually hydrocarbon blends with variable compositions of differing molecular weights. Degradation of the heavier components of IFOs and HFOs could take several months in protected bays and fjords; therefore, the duration of the effect is considered medium-term. The geographic extent is considered regional to beyond regional (transboundary), since the hydrocarbon plume may extend beyond the RSA. The effect of a worst case diesel fuel spill on water quality is considered reversible. With proposed mitigation in place, the frequency of this potential effect is considered isolated as the probability (or likelihood) is considered unlikely (predicted as occurring once every 500+ years for a major diesel spill) and, therefore, not likely to occur during the lifetime of the Project. The effect of worst case diesel fuel spills on marine water quality is thus expected to be not significant.



Table 8.2-3: Summary of Residual Impact Classifications on Marine Physical Environment VECs

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Water Quality									
Change in Water Quality due to Minor Spill	Negative	Low	Low	Local	Regional to Beyond Regional	Medium-term	Isolated	Reversible	Unlikely
Change in Water Quality due to Worst Case Diesel Fuel Spill	Negative	High	High	Regional to Beyond Regional	Regional to Beyond Regional	Long-term	Isolated	Reversible	Unlikely



8.2.7 Environmental Significance

8.2.7.1 Approach and Methods

The approach, methods, and results used to determine environmental significance for effect of the change in habitat due to altered water quality from accidental spills are described in Section 8.3.8 where the associated indirect effects on marine fish, birds, and mammals are discussed.

8.2.8 Uncertainty

The key sources of uncertainty in the impact assessment and discussion regarding how uncertainty has been addressed to increase the level of confidence of impacts related to changes in habitat due to altered water quality from accidental spills are described in Section 8.3.10.

8.2.9 Monitoring and Follow-Up

No environmental monitoring is recommended for marine water quality.

8.3 Marine Wildlife

8.3.1 Introduction

8.3.1.1 Purpose and Scope

The purpose of this section is to describe baseline conditions for marine wildlife and wildlife habitat and assess the effects of the Project on marine wildlife and wildlife habitat. For the purposes of the baseline and effects assessment, marine wildlife and wildlife habitat is represented by anadromous and marine fish, marine birds, and marine mammals, including Species at Risk.

The effects assessment evaluated all Project phases, including construction, operation, and temporary, final, and post-closure. Indirect and cumulative effects have been incorporated throughout this section, where applicable. Information from other components, including traditional activities and knowledge (FEIS Volume 9, Section 9.3.1.4.2.3), and non-traditional land use and resource use (FEIS Volume 9, Section 9.9), as well as information from third party sources, including Traditional Knowledge for the Marine Approaches to Rankin Inlet (FEIS Volume 9, Appendix 9.2-C), were incorporated in the effects assessment for marine VECs.

The scope of the marine baseline study and impact assessment was divided in 2 separate assessment areas. Nunami Stantec was retained by AEM to characterize baseline conditions and assess all Project activities occurring in the proposed spud barge area in Melvin Bay. Nearshore activities in this region included vessel operations; and construction, operation and decommissioning of the spud barge. Marine transportation activities occurring outside of Melvin Bay were considered in Golder's assessment. Golder was retained by AEM to characterize baseline conditions and assess all Project activities occurring within the proposed offshore shipping corridor in Hudson Strait / Hudson Bay including vessel operations and accidents and malfunctions. Marine transportation activities in Melvin Bay, as well as in the access passage between Melvin Bay and the offshore moorage location for cargo ships and fuel tankers were considered in Stantec's marine assessment.



8.3.1.2 *Concordance with Project Guidelines*

The purpose of this section is to address Guidelines issued by the NIRB for the Project (NIRB 2012), and specifically those relating to the impact of the Project on marine wildlife. Volume 1, Appendix 1.0-A lists the specific requirements set out in the Guidelines relating to the baseline and the impact assessment of marine wildlife.

8.3.1.3 *Valued Components*

Valued ecosystem components and VSECs represent physical, biological, cultural, social and economic properties of the environment that are either legally, politically, publically, or professionally recognized as ecologically and socially important to a particular region, community, or by society as a whole. Several marine wildlife VECs were selected to assess Project-related effects on marine wildlife and wildlife habitat (Table 8.3-1). Valued ecosystem components were selected based on their role in the ecosystem, and value placed on them by humans for traditional use and cultural purposes, where appropriate. The IQ indicated that marine mammals are important to the Inuit people providing sources of food and materials supplementary to caribou (FEIS Volume 9, Section 9.3.1.4.2.3).

Factors considered when selecting VECs included the following:

- biophysical components identified by NIRB during Project scoping and AEM community and stakeholder consultation;
- represent important ecosystem processes;
- federally listed species under COSEWIC and SARA (COSEWIC 2012; SARA 2012);
- communities or species that reflect the interests of regulatory agencies, Inuit groups, and communities;
- can be measured or described with measurement endpoints;
- allow cumulative effects to be considered; and
- current experience with environmental assessments and effects monitoring programs in Nunavut and the Northwest Territories.



Table 8.3-1: Marine Wildlife Valued Ecosystem Components

Valued Ecosystem Components	Rationale
Marine Mammals	■ Commercial, social, cultural, and ecological importance in Project area (Melvin Bay, Marble Island, and proposed shipping corridor in Hudson Bay / Hudson Strait) ■ Biological indicators for marine and terrestrial ecosystem health ■ Potential to be affected by Project activities ■ Include several federally listed species ■ Identified as important during Traditional Knowledge studies and during stakeholder / agency consultation, as marine mammal hunting still occurs along a wide range of the Hudson Bay shores, including the areas around Rankin Inlet.
Marine Fish	■ Commercial, social, cultural, and ecological importance in Project area ■ Melvin Bay potentially supports spawning, rearing, and feeding areas ■ Potential to be affected by Project activities ■ Identified as important during Traditional Knowledge studies and during stakeholder / agency consultation
Marine Birds	■ Cultural and aesthetic value to society ■ Ecological importance in Project area ■ Biological indicators for marine and terrestrial ecosystem health ■ Migratory and non-migratory species protected by provincial and federal regulations ■ Include several federally listed species ■ Potential to be affected by Project activities ■ Identified as important during Traditional Knowledge studies and during stakeholder / agency consultation

IQ

8.3.2 Baseline Environment

8.3.2.1 Existing Environment in Melvin Bay / Itivia Harbour

In August of 2011, a field program was conducted by Nunami Stantec at Itivia and at 2 nearby reference sites in Melvin Bay (see Site Figure in Appendix 8.2-A). The objective of the field program was to collect physical and biological baseline information in the marine LSA (Figure 8.1-1), with a focus on the Project footprint corresponding with the proposed floating dock facility (spud barge). The field program investigated bathymetry, water and sediment chemistry, aquatic lower-trophic organisms (phytoplankton, zooplankton, and benthic invertebrates) and fish and fish habitat. Results from Nunami Stantec's baseline field program are provided in detail in Appendix 8.2-A with a general summary of the biological baseline results provided below (Sections 8.3.2.1.1 through 8.3.2.1.3).

8.3.2.1.1 Biological Environment

Plankton

Phytoplankton abundance, richness, and diversity were similar across all sites within the marine LSA, and a total of 33 taxa were recorded. Dinoflagellates were the dominant taxa at all sites and included *Peridinium/Gonyaulax* spp. and *Dinophysis* spp. The ciliate *Tintinnida* was present at low percentages at 2 of the sites.



Zooplankton abundance, richness, and diversity differed between sites, and a total of 44 taxa were recorded. An unidentified rotifer species, possibly *Notommatidae*, was identified as the dominant taxa at all sites. *Calanoid copepods* were also present at all 3 sites.

Benthic Invertebrates

Benthic invertebrate abundance, richness, and diversity differed amongst sites. Polychaetes were the dominant taxa at all sites and included Polychaeta: Sedentaria (burrowing or tube-dwelling), Capitellidae, and Cirratulidae and/or Paraonidae. Polychaeta: Errantia (free-swimming) were the next dominant taxa and included Nephtyidae, Syllidae, and Pholoidae. Also present was nematode subclass Hoplonemertea, the Myidae and Tellinidae clams, the amphipod families of Ischyroceridae, Oedicerotidae, and Zopfiaceae, as well as 11 additional polychaete families. At 1 site, a single sponge (Porifera), 2 hydrozoan taxa, 1 flatworm (Platyhelminthes), Terebellidae and Opheliidae polychaetes, 3 gastropod, and 3 bivalve taxa, several crustaceans (copepod, amphipod, decapods), and one sea squirt (Urochordata) were also identified.

Benthic species are not thought to occupy the intertidal zone in Hudson Bay on a permanent basis; rather, they occur seasonally when the habitat is not influenced by ice (Stewart and Lockhart 2005). Baseline studies completed in the LSA support this assumption (Nunami Stantec Ltd. 2012). Few invertebrate species were observed in the nearshore habitat, and abundance was low. Most of the individuals observed were less than 1 cm, suggesting a low biomass. Nearshore macrophyte coverage was found to be equally sparse (ranging from 2 to 5% coverage).

Fishes

Six species of marine fish (n=156) were identified during gill net and beach seine sampling in the marine LSA, including Greenland cod (*Gadus ogac*) (52%), slender eelblenny (*Lumpenus fabricii*) (27%), fourhorn sculpin (kanayok in Inuktitut) (*Myoxocephalus quadricornis*¹) (15%), unidentified sculpin (possibly juvenile; 3%), Arctic staghorn sculpin (*Gymnocanthus tricuspis*) (2%), and Arctic sculpin (*Myoxocephalus scorpioides*) (1%). The range of total lengths of the dominant fish taxa were 118 to 520 mm for Greenland cod, 180 to 210 mm for slender eelblenny, and 205 to 315 mm for fourhorn sculpin species. Arctic char were not observed during the baseline field study but were reported to be in the area at the time of the field study (west of Melvin Bay near the Barrier Islands).

Marine Birds

A black guillemot (*Cephus grylle*) and a pair of sandhill cranes (*Grus canadensis*) were identified in the LSA during the baseline field program.

Marine Mammals

No marine mammals were observed in the LSA during the baseline field program.

¹ Referenced by it's European (*Triglopsis quadricornis*) name in Appendix 8.2-A Nunami Stantec Marine Baseline Report for Itivia Harbour, Rankin Inlet, NU



8.3.2.2 Existing Environment within Hudson Bay / Hudson Strait Shipping Corridor

Golder conducted a comprehensive literature review to characterize the biological environment in the proposed shipping corridor in Hudson Bay and Hudson Strait (Figure 8.1-2). The following information sources were reviewed:

- available scientific literature / data reports;
- NIRB Guidelines for the Preparation of an Environmental Impact Statement for the Agnico-Eagle Mines Ltd. Meliadine Project (NIRB File No. 11MN034) (NIRB 2012);
- Marine Baseline Report - Itivia and Melvin Bay, Rankin Inlet, NU produced by Nunami Stantec Ltd. (2012);
- governmental and non-governmental environmental resources including:
 - Nunavut Wildlife Management Board Reports / Guidance Documents;
 - Nunavut Planning Commission web resources including the Nunavut Wildlife Resource and Habitat Values final report (2008);
 - The Canadian Circumpolar Institute and the Tungavik Federation of Nunavut, Nunavut Atlas (1992);
- regional fisheries catch statistics (e.g., DFO annual catch data);
- DFO's Mapster database;
- OBIS-Seamap database (Duke University);
- DFO's Ocean Data Inventory;
- *Species at Risk Act* (SARA) database;
- Important Bird Areas (IBAs) spatial database;
- Environment Canada's Key Marine Habitat for Migratory Birds;
- previous marine-based environmental impact statements completed in the Project area (e.g., AREVA and others as available);
- available records of consultation with regulatory agencies, public stakeholders, and Inuit communities;
- a review of shipping and other marine industrial activities occurring, that have occurred, and are planned to occur; and
- presentation of TK collected for local coastal areas.

8.3.2.2.1 Biological Environment

The marine ecosystem of Hudson Bay encompasses a large geographical area that includes James Bay, Hudson Bay, Fox Basin, and Hudson Strait. Four important features characterize this unique ecosystem:

- 1) an extreme southerly penetration of Arctic marine water from the north;
- 2) a very large volume of freshwater runoff that enters the Hudson Bay watershed each year from land;
- 3) seasonal coverage of sea-ice; and
- 4) the dynamic coastal geomorphology of the coastal zone where exposure of new shoreline (made up of coastal salt marshes and wide tidal flats) presently occurs at a rate of up to 15 m/year (horizontal) as part of



an isostatic rebound of the land from the weight of the Laurentide Ice Sheet, which once covered this entire region (Stewart and Lockhart 2004).

These key features combine to form critical habitat areas for many species of marine fauna including anadromous fish and large concentrations of migratory species including shorebirds, waterfowl, seabirds, and marine mammals. The following section provides an overview of the biological characteristics of each taxa (by key species) potentially impacted by shipping activities in the RSA.

8.3.2.2.1.1 *Fishes*

Approximately 60 species of fish are known to inhabit estuarine waters of Hudson Bay and James Bay (CARC 1991). Fewer species are present in the northern limits of the RSA, where arctic species predominate. Arctic char, Arctic cod, and other species contribute directly to the domestic fishery, and indirectly to the food chain of marine and terrestrial mammals and birds. Those species with overlapping ranges with the RSA and considered important to the local commercial, recreational, and subsistence fisheries are identified in Table 8.3-2. An overview on the biology of these species is provided below.



Table 8.3-2: Overview of Marine Fish Species Found within the Local and Regional Study Areas

Common Name	Species	Inuktitut Name	Habitat	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Arctic char	<i>Salvelinus alpinus</i>	ᐱᓐᐅᐅᐅᐅᐅᐅ / ᐱᐅᐅᐅᐅᐅᐅᐅ	Anadromous (Riede 2004). In the marine environment, they are found in coastal areas in waters 30 to 70 m deep (Billard 1997).	No status	Not assessed	Yes	✓	✓
Greenland cod	<i>Gadus ogac</i>	ᐅᐅᐅᐅ	Demersal ^c . Coastal waters up to 400 m deep (Coad and Reist 2004; Cohen et al. 1990).	No status	Not assessed	Yes	✓	✓
Polar cod	<i>Arctogadus glacialis</i>	ᐅᐅᐅᐅ	Cryopelagic ^d or epontic ^e (Coad and Reist 2004). Marine waters down to 1000 m; Mainly found in the shallower areas of the water column (Scott and Scott 1988).	No status	Not assessed	Yes	✓	✓
Arctic cod	<i>Boreogadus saida</i>	ᐅᐅᐅᐅ	Cryopelagic or epontic. Marine waters down to approximately 1400 m. Favour coastal areas during the summer and winter months (Coad and Reist 2004). Spawning occurs under the Arctic ice (DFO 2011b).	No status	Not assessed	Yes	✓	✓
Fourhorn sculpin (marine form)	<i>Myoxocephalus quadricornis</i>	ᐅᐅᐅᐅᐅᐅ	Benthic. Shallow coastal estuarine environments (Morrow 1980). In spring, they move to deeper waters for the summer and are generally found in waters 45 m to 100 m deep (Muus 1999).	No status	Not at Risk	Yes	✓	✓
Arctic staghorn sculpin	<i>Gymnocanthus tricuspis</i>	ᐅᐅᐅᐅᐅᐅ	Benthic. Prefers sandy bottoms (Fedorov 1986; Coad and Reist 2004). Coastal areas, close to shore (ArcOD 2011).	No status	Not assessed	Yes	✓	✓
Arctic sculpin	<i>Myoxocephalus scorpioides</i>	ᐅᐅᐅᐅᐅᐅ	Benthic. Shallow marine environments up to 275 m (Coad and Reist 2004).	No status	Not assessed	Yes	✓	✓
Slender eel blenny	<i>Lumpenus fabricii</i>	ᐅᐅᐅᐅᐅᐅᐅᐅᐅ	Sandy to rocky habitats. Seem to prefer seagrass and algae, where they spawn (Mecklenburg and Sheiko 2004).	No status	Not assessed	No	✓	✓
Greenland halibut	<i>Reinhardtius hippoglossoides</i>	ᐅᐅᐅᐅᐅᐅᐅ	Epibenthic. Surface to deep waters down to 2000 m (Coad and Reist 2004).	No status	Not assessed	Yes	✓	✓

^a SARA. The Act is a key federal government commitment to prevent wildlife species from becoming extinct and secure the necessary actions for their recovery. It provides for the legal protection of wildlife species and the conservation of their biological diversity (extracted from SARA 2012).

^b COSEWIC (Committee on the Status of Endangered Wildlife in Canada) is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada. It is up to Government to legally protect wildlife species designated by COSEWIC. The potential impacts of legal listing are for Government to analyse, and the SARA applies only to wildlife species on the SARA legal list (extracted from COSEWIC 2012).

^c live on or near the seafloor.

^d cold, deep marine environments.

^e associated with the lower interface of the sea ice.



Arctic char (*Salvelinus alpinus*)

Arctic char exhibit anadromous and land-locked life history types (DFO 2006c). The anadromous forms of this species spend a large portion of its life cycle in the coastal marine environment (Riede 2004; Billard 1997). Spawning occurs in freshwater rivers, with annual migrations to marine waters occurring in the spring after the first 2-6 years of life (DFO 2006c). During autumn, adults migrate back to freshwater habitats to overwinter (Richardson et al. 2001). Arctic char feed on crustacean and other fish including capelin (*Mallotus villosus*), sand lance (*Ammodytes* spp.), Arctic cod, and juvenile Greenland cod (Richardson et al. 2001; Coad and Reist 2004).

In the RSA, Arctic char can be found along the western and northern coast of Hudson Bay and coastal areas of Hudson Strait (Coad and Reist 2004), with high abundances identified near Arviat, Chesterfield Inlet, Cape Dorset, and Kimmirut (NPC 2008) (Figure 8.3-1). Arctic char are harvested commercially, recreationally, and for subsistence use (Canadian Circumpolar Institute 1992; Heather and usher 2004). Kangiqliniq Hunter and Trappers Association consider Arctic char an important food fish species for the residents of Rankin Inlet (Nunami Stantec Ltd. 2012).

IQ

Greenland cod (*Gadus ogac*)

Greenland cod are a demersal² fish found most commonly in coastal waters up to 400 m deep (Coad and Reist 2004; Cohen et al. 1990). They feed on crustaceans, molluscs, sea stars, worms, and other fish including capelin, polar cod, juvenile Greenland cod and Greenland halibut (Coad and Reist 2004). Greenland cod spawn at the mouths of freshwater rivers during spring (DFO 2006a). Their habitat range overlaps with the RSA, primarily occupying inlets and estuaries along both coasts of Hudson Bay extending south to Arviat along the west coast and to the Eastmain River estuary in James Bay along the east coast (Coad and Reist 2004; Ochman and Dodson 1982; Hunter et al. 1984).

Polar cod (*Arctogadus glacialis*)

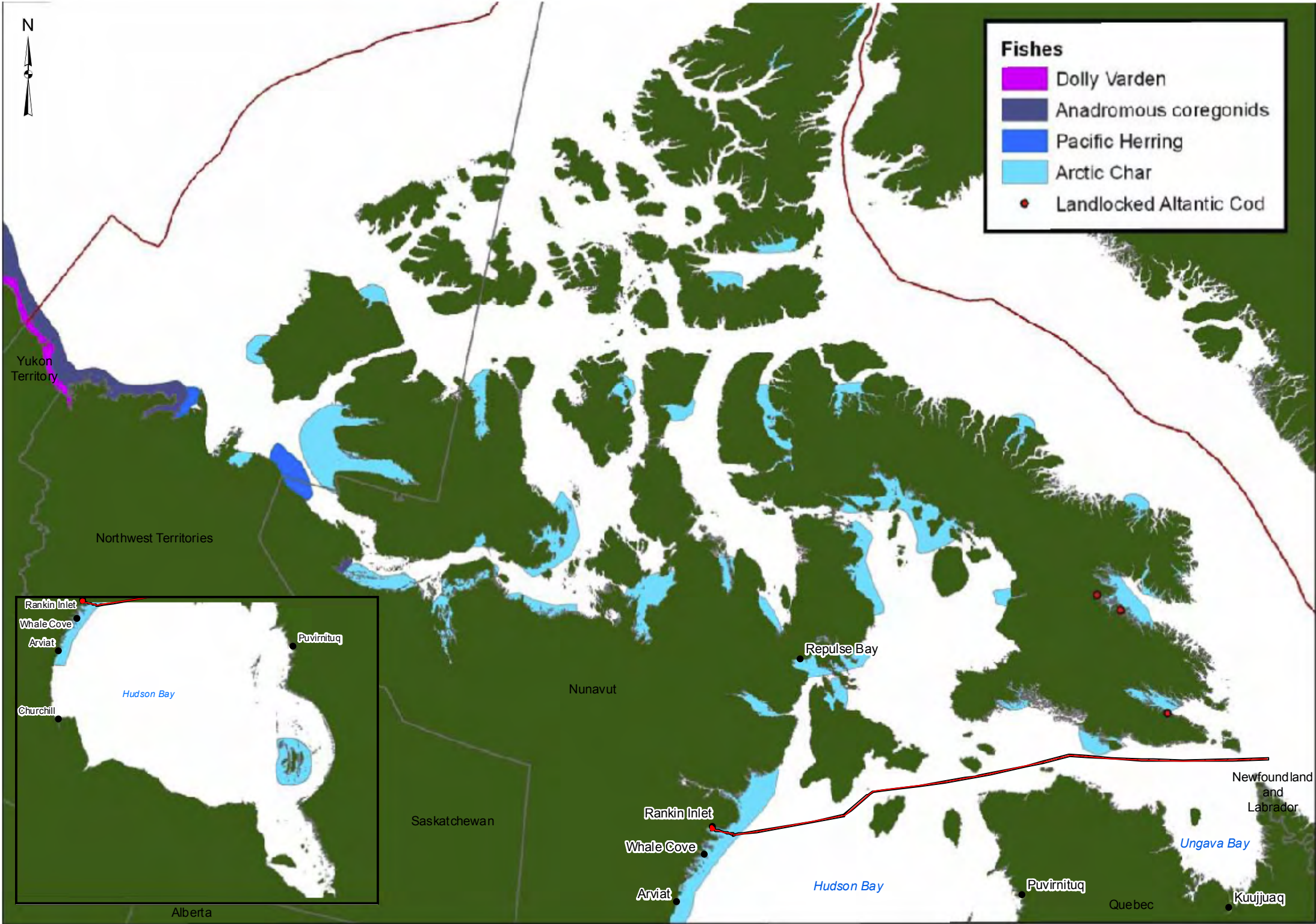
The habitat range of polar cod includes offshore continental shelf waters of the RSA in Hudson Bay and Hudson Strait (Cohen et al. 1990; NPC 2008). They exhibit cryopelagic³ or epontic⁴ life history types (Coad and Reist 2004), although they frequent primarily the upper surface waters in Hudson Bay (Scott and Scott 1988). Polar cod are closely associated with sea-ice and spawn underneath the ice during winter (Bradstreet et al. 1986; Craig et al. 1982). Prey species include other fish and crustaceans; predators include seabirds, seals, whales, and other fish (Bradstreet 1982).

² live on or near the seafloor

³ associated with cold, deep marine environments

⁴ associated with the lower interface of the sea ice

N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Figure_8.3-1_Distribution_of_Arctic_Char.mxd



LEGEND

Local Study Area (LSA)

Marine Regional Study Area (Marine RSA)

Fishes

Dolly Varden

Anadromous coregonids

Pacific Herring

Arctic Char

Landlocked Atlantic Cod

REFERENCE

Pvincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic

240 0 240
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

**DISTRIBUTION OF ARCTIC CHAR (*Salvelinus alpinus*)
AND OTHER SELECTED FISH SPECIES IN THE
MARINE RSA AND ADJACENT ARCTIC WATERS**

PROJECT NO.	10-1373-0076	FILE No.
DESIGN	AK 19 Jul. 2012	SCALE AS SHOWN
GIS	DSC 20 Jul. 2012	REV. 0
CHECK	PR 18 Jan. 2013	
REVIEW	DW 18 Jan. 2013	

FIGURE 8.3-1



Arctic cod (*Boreogadus saida*)

Arctic cod are a key species in the arctic marine ecosystem (DFO 2011b). Like polar cod, Arctic cod exhibit cryopelagic or epontic life history types and have a short life span (Coad and Reist 2004). They live in marine waters down to 1400 m (Coad and Reist 2004) and inhabit coastal areas during the summer and winter months (Cohen et al. 1990). Arctic cod feed on epibenthic mysids, amphipods, copepods, and other fish (Coad and Reist 2004). Spawning is thought to occur in late autumn and winter under the sea-ice. Arctic cod are a main food source for marine mammal and seabirds, particularly narwhals and murre (DFO 2011b).

There is no commercial harvest of Arctic cod in the Canadian Arctic (DFO 2011b). Subsistence fishery records indicate that Arctic cod have been traditionally harvested in Arviat, Whale Cove, Coral Harbour, Cape Dorset, Kimmirut (Canadian Circumpolar Institute 1992; Heather and Usher 2004). Their habitat range overlaps with that of the RSA and extends into the Hudson Bay and Hudson Strait (Coad and Reist 2004). IQ

Fourhorn sculpin (*Myoxocephalus quadricornis*)

Fourhorn sculpins are a benthic species (Coad and Reist 2004) and are generally found in shallow coastal estuarine waters (Morrow 1980). In the spring, this species migrates to deeper waters for the summer months where they are typically found in waters 45 to 100 m in depth (Muus 1999). They feed on crustaceans, molluscs, and fish (Coad and Reist 2004). Spawning occurs in shallow waters where pairing and egg laying occur in gravel substrate (Muus 1999). This species is distributed throughout Hudson Bay and Hudson Strait (Coad and Reist 2004). Fourhorn sculpins have been traditionally harvested in Arviat, Whale Cove, Coal Harbour, Cape Dorset, and Kimmirut (Canadian Circumpolar Institute 1992; Heather and Usher 2004). IQ

Arctic staghorn sculpin (*Gymnocanthus tricuspis*)

The Arctic staghorn sculpin are a benthic species preferring sandy bottom types but also frequenting mud, gravel, and rocky habitats (Fedorov 1986; Coad and Reist 2004). This species tends to inhabit near-shore areas (ArcOD 2011). Spawning occurs in late autumn and winter (ArcOD 2011). Arctic staghorn sculpin feed primarily on benthic amphipods and worms (Fedorov 1986). They are not a commercially harvested species and do not represent a major target species of the subsistence fishery.

Arctic sculpin (*Myoxocephalus scorpioides*)

Arctic sculpin are known to occur in the RSA, with a regional distribution extending from James Bay and the Straits of Belle Isle to Greenland (Fishbase 2012). They are a benthic species found primarily in shallow marine environments up to 275 m in depth (Coad and Reist 2004). Spawning occurs during autumn (Coad and Reist 2004). Prey items include mainly crustaceans (Coad and Reist 2004). They are not a commercially harvested species and do not represent a major target species of the subsistence fishery.

Slender eelblenny (*Lumpenus fabricii*)

The slender eel blenny can be found in a variety of marine environments from sandy bottoms to rocky habitats but are rarely found in intertidal areas (Coad and Reist 2004; Mecklenburg and Sheiko 2004). They are closely associated with seagrass and macroalgae in the nearshore where they spawn during autumn (Mecklenburg and Sheiko 2004). This species feeds on crustaceans, worms, clams, and other fish eggs (Coad and Reist 2004). Its habitat range includes both Hudson Strait and Hudson Bay (Coad and Reist 2004). They are not a commercially harvested species and do not represent a major target species of the subsistence fishery.



Greenland halibut (*Reinhardtius hippoglossoides*)

The Greenland halibut is an epibenthic species and can be found at the surface to waters down to 2000 m (Coad and Reist 2004). This species feeds on other fishes, crustaceans and squids (Coad and Reist 2004). Its habitat range includes the Hudson Strait (Coad and Reist 2004). The Greenland halibut has become increasingly important in developing commercial fisheries in the eastern Arctic (Coad and Reist 2004); however, they do not represent a major target species of the subsistence fishery.

Hearing Abilities of Marine Fish

It is well known that fish use sound for communication, detection of predators and prey, and learning about their environment (Popper and Fay 1999; Zelick et al. 1999; Fay and Popper 2000; Popper et al. 2003). All fish species can hear with varying degrees of sensitivity within the frequency range of sound produced by seismic sources and other industrial sound sources (Popper and Fay 1973; Fay 1988; Popper and Fay 1993; Fay 2000). The hearing range for most fish is believed to be in the frequency range of 100 to 1000 hertz (Hz) (Fay 1988). A smaller number of species can detect sounds to over 3000 Hz, while a very few can detect sounds to well over 100 kHz. Because of wide differences in hearing capability and morphologies among fish species, behavioural responses and the susceptibility of fish to auditory trauma varies greatly.

There is considerable anatomical and physiological variation amongst fish with respect to hearing structures, suggesting that various species may detect and process sound in different ways (Popper and Fay 1993). Fish can be divided into 2 broad categories: hearing generalists and hearing specialists (Popper et al. 2003; Ladich and Popper 2004). Hearing generalists are fish species without any auditory system specializations. They have poor auditory sensitivity characterized by a narrow bandwidth of hearing, typically detecting sounds from below 50 Hz up to 1 or 1.5 kHz (Popper et al. 2003). This includes most bottom-dwelling species such as Greenland halibut (Popper et al. 2003). The majority of fish species that fall into this category generally do not hear frequencies much above 1 kHz, with peak sensitivities around 300 to 500 Hz (Ladich and Popper 2004). The sound pressure detection threshold can be as high as 120 dB re 1 μ Pa at 1 m at the most sensitive frequency (Nedwell et al. 2004). Hearing specialists have specialized auditory structures connected to well-developed pressure sensitive organs (Popper and Fay 1993). These morphological adaptations allow hearing specialists to detect sound pressure with greater sensitivity (i.e., lowering their hearing threshold) and in a wider bandwidth than “generalists”, and makes hearing specialists more sensitive to high-amplitude sound introduced into the marine environment. Polar cod and Arctic cod are both hearing specialist species and are likely to be present in the RSA. Cod fish can detect both sound acceleration and sound pressure over a substantial frequency range; 20 to 150 KHz. Sound pressure thresholds in cod fish in the frequency range 60 to 300 Hz lie in the range 80 to 90 dB re 1 μ Pa at 1 m.

8.3.2.2.1.2 *Marine Birds*

The Hudson Bay marine ecosystem provides resources of critical importance to resident and migrant marine birds throughout the year. At least 43 species of seabirds, shorebirds, waterfowl, and marine-associated raptors frequent offshore, inshore, intertidal, or salt marsh habitats of the Hudson Bay marine ecosystem (Table 8.3-3). Few of these species are year-round residents. Most pass through the area during summer for staging, moulting, nesting, and brooding purposes (Canadian Circumpolar Institute 1992) prior to transiting to their traditional wintering grounds in the south, many of which fall outside the NSA (e.g., Arctic terns, red-necked phalaropes). Thus, impacts to certain long-range migratory species have the potential for transboundary effects. Marine bird



species present year-round in Hudson Bay / Hudson Strait are limited to common eider, king eiders, black guillemot, dovekie, and ivory gull. These species have adapted to accessing prey in polynyas, where current and tidal action keep waters ice-free throughout the winter. Figures 8.3-2 and 8.3-3 provide an overview of marine bird distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK.



Table 8.3-3: Overview of Seabird Species Potentially Present within the Local and Regional Study Areas

Common Name	Species	Seasonal Occurrence	Distribution	Other relevant information	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Black guillemot	<i>Cepphus grylle</i>	year-round	coastal / offshore	Harvested for subsistence. Nests in small colonies on steep shores on Southampton and Coats islands.	No status	Not assessed	Yes	✓	✓
Thick-billed murre	<i>Uria lomvia</i>	summer	coastal / offshore	Large breeding colony (520 000 pairs) on Akpatok Island in Hudson Strait. Traditional knowledge suggests that murre winter in large numbers in area of open water west of the Belcher Islands in southeast Hudson Bay. Moulting adult birds with their young complete swimming migration in August from a number of known bird colonies in Hudson Bay through the Hudson Strait to offshore areas of Newfoundland and Labrador (Mallory and Fontaine 2004).	No status	Not assessed	Yes	✓	✓
King eider	<i>Somateria spectabilis</i>	year-round	coastal	Widely distributed in James Bay and Hudson Bay.	No status	Not assessed	Yes	✓	✓
Common eider	<i>Somateria mollissima</i>	year-round	coastal / offshore	Hudson Bay subspecies overwinter in areas where open water and shallow depth coincide. Breeds along rocky coasts or tundra throughout Hudson Bay. Present along ice edge and at polynyas. Feed exclusively on blue mussel.	No status	Not assessed	Yes	✓	✓
Northern fulmar	<i>Fulmarus glacialis</i>	summer / fall	coastal / offshore	Rare visitor to James Bay in late fall. Observed at Coats Island.	No status	Not assessed	No	✓	✓
Black-legged kittiwake	<i>Rissa tridactyla</i>	summer	coastal / offshore	Occurs on the open waters of northern Hudson Bay in July and August, and occasionally at Churchill in early summer.	No status	Not assessed	No	✓	✓
Dovekie	<i>Alle alle</i>	year-round	coastal / offshore	Winter offshore in Hudson Bay, Hudson Strait and Gulf of St. Lawrence.	No status	Not assessed	No	✓	✓
Long-tailed duck	<i>Clangula hyemalis</i>	May-Oct	coastal	Occur in large numbers close to shore in Hudson and James Bay. Some individuals also overwinter on open water of James Bay.	No status	Not assessed	No	✓	✓



Table 8.3-3: Overview of Seabird Species Potentially Present within the Local and Regional Study Areas (continued)

Common Name	Species	Seasonal Occurrence	Distribution	Other relevant information	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Canada goose	<i>Branta canadensis</i>	summer and fall	coastal	Spring and fall transient. Breeds in large numbers along the coasts (McConnell River Migratory Bird Sanctuary) and on the islands of Hudson Bay and James Bay (e.g., Southampton Island).	No status	Not assessed	Yes	✓	✓
Lesser snow goose	<i>Anser caerulescens</i>	May – Sept	coastal	Migratory species. Breeding colonies occur along the coasts (McConnell River Migratory Bird Sanctuary) and on the islands of Hudson Bay (e.g., Southampton Island). Hudson Bay supports over 50% of the eastern Arctic breeding population.	No status	Not assessed	Yes	✓	✓
Atlantic Brant	<i>Branta bernicla</i>	April to October	coastal	Migratory species. Breed on Southampton Island. During the fall migration, > 50% of the population frequents eelgrass habitat in James Bay.	No status	Not assessed	No	✓	✓
Glaucous gull	<i>Larus hyperboreus</i>	summer	coastal / offshore	Breed along the northern coasts of Hudson Bay, the Belchers, and widely throughout the Canadian Arctic.	No status	Not assessed	No	✓	✓
Herring gull	<i>Larus argentatus</i>	April-Nov	coastal / offshore	Migratory species. Breed along the coasts of Hudson Bay and James Bay in summer and in the Belchers.	No status	Not assessed	No	✓	✓
Ross's gull	<i>Rhodostethia rosea</i>	spring and autumn	coastal / offshore	Established nesting areas near Churchill, McConnell River Migratory Bird Sanctuary, and in the Canadian High Arctic (Devon Island). May overwinter in polynyas.	TH (Schedule 1)	TH	No	✓	✓
Ivory gull	<i>Pagophila eburnea</i>	year-round	coastal / offshore	Occur in Hudson Bay during both summer and winter, but breed in the Canadian High Arctic.	EN (Schedule 1)	EN	No	✓	✓



MELIADINE FEIS – VOLUME 8 MARINE ENVIRONMENT

Table 8.3-3: Overview of Seabird Species Potentially Present within the Local and Regional Study Areas (continued)

Common Name	Species	Seasonal Occurrence	Distribution	Other relevant information	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Sabine's gull	<i>Xema sabini</i>	summer	coastal / offshore	Migratory species. Breeds on colonies along the northern coasts of Hudson Bay. Pelagic outside breeding season.	No status	Not assessed	No	✓	✓
Thayer's gull	<i>Larus thayeri</i>	summer	coastal / offshore	Migratory species. Breeds along the coasts of northern Hudson Bay during summer including Coats and Southampton islands.	No status	Not assessed	No	✓	✓
Arctic tern	<i>Sterna paradisaea</i>	summer	coastal / offshore	Migratory species that breeds throughout the Hudson Bay and Hudson Strait.	No status	Not assessed	No	✓	✓
Pacific loon	<i>Gavia pacifica</i>	summer	coastal	Migratory species. Arctic breeding species common and numerous along the mainland and island coasts of the Hudson Bay coast.	No status	Not assessed	No	✓	✓
Red-throated loon	<i>Gavia stellata</i>	summer	coastal	Migratory species. Arctic breeding species common and numerous along the mainland and island coasts of the Hudson Bay coast.	No status	Not assessed	No	✓	✓
Common loon	<i>Gavia immer</i>	summer	coastal	Migratory species. Common in southeastern Hudson Bay and James Bay.	No status	Not at risk	No	✓	✓
Black scoter	<i>Melanitta americana</i>	summer	coastal	Migratory species. Common on the Belchers and along the coast from southeastern Hudson Bay west to Churchill. May overwinter in small numbers in James Bay.	No status	Not assessed	No	✓	✓
Red-breasted merganser	<i>Mergus serrator</i>	summer	coastal	Migratory species. Common along the coasts of James Bay and southwestern Hudson Bay. Males and non-breeding birds frequent coastal marine waters.	No status	Not assessed	No	✓	✓
Red-necked phalarope	<i>Phalaropus lobatus</i>	summer	coastal / offshore	Migratory species. Breeds widely across the Arctic and throughout Nunavut.	No status	Not assessed	No	✓	✓
Red phalarope	<i>Phalaropus fulcaris</i>	summer	coastal / offshore	Migratory species. Breeds along the west coast of the Hudson Bay, on the Ungava Peninsula and on the southern end of Baffin Island in Nunavut.	No status	Not assessed	No	✓	✓



MELIADINE FEIS – VOLUME 8 MARINE ENVIRONMENT

Table 8.3-3: Overview of Seabird Species Potentially Present within the Local and Regional Study Areas (continued)

Common Name	Species	Seasonal Occurrence	Distribution	Other relevant information	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Parasitic jaeger	<i>Stercorarius parasiticus</i>	summer	coastal / offshore	Migratory species. Breed along the coast and islands of Hudson Bay.	No status	Not assessed	No	✓	✓
Long-tailed jaeger	<i>Stercorarius longicaudus</i>	summer	coastal / offshore	Migratory species. Breeds along the Quebec coast of Hudson Bay, on Southampton Island, and along the Kivalliq coast.	No status	Not assessed	No	✓	✓
Pomarine jaeger	<i>Stercorarius pomarinus</i>	summer	coastal / offshore	Migratory species. Breeds along the Quebec coast of Hudson Bay and on Southampton Island.	No status	Not assessed	No	✓	✓
Sandhill crane	<i>Grus canadensis</i>	summer	coastal	Migratory species. Summer visitors to the southern and western coasts of James Bay and Hudson Bay, from Boatswain west and north. Also reported on the Belchers and Southampton islands.	No status	Not at risk	No	✓	
Dunlin	<i>Calidris alpina</i>	summer	coastal	Migratory species. Breeds along the west coast of the Hudson Bay, on Southampton and Coats Island and on the southern end of Baffin Island in Nunavut.	No status	Not assessed	No	✓	
Semi-palmated sandpiper	<i>Calidris pusilla</i>	summer	coastal	Migratory species. Breeds in the Hudson Bay including Southampton Island, Coats Island and the southern end of Baffin Island.	No status	Not assessed	No	✓	
Least sandpiper	<i>Calidris minutilla</i>	summer	coastal	Migratory species. Common breeder on the mainland shores of Hudson Bay south of Chesterfield Inlet in the west and Inukjuak in the east	No status	Not assessed	No	✓	
White-rumped sandpiper	<i>Calidris fuscicollis</i>	summer	coastal	Migratory species that breeds on the southern tip of Baffin Island and on the northwestern side of the Hudson Bay.	No status	Not assessed	No	✓	
Baird's sandpiper	<i>Calidris bairdii</i>	summer	coastal	Migratory species that breeds on the northern end of Baffin Island and in the coastal areas of the northern Foxe Basin.	No status	Not assessed	No	✓	



MELIADINE FEIS – VOLUME 8 MARINE ENVIRONMENT

Table 8.3-3: Overview of Seabird Species Potentially Present within the Local and Regional Study Areas (continued)

Common Name	Species	Seasonal Occurrence	Distribution	Other relevant information	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Pectoral sandpiper	<i>Calidris melanotos</i>	summer	Coastal	Migratory species that breeds along the northwest coast of the Hudson Bay, on Southampton and Coats islands in Nunavut.	No status	Not assessed	No	✓	
American golden plover	<i>Pluvialis dominica</i>	summer	Coastal	Migratory species that breed along the shores of Hudson Bay and James Bay and Southampton Island.	No status	Not assessed	No	✓	
Semi-palmated plover	<i>Charadrius semipalmatus</i>	summer	Coastal	Migratory species that breed along the shores of Hudson Bay and James Bay.	No status	Not assessed	No	✓	
Black-bellied plover	<i>Pluvialis squatarola</i>	summer	Coastal	Migratory species that breeds on the shores of northern Hudson Bay and Southampton Island.	No status	Not assessed	No	✓	
Ruddy turnstone	<i>Arenaria interpres</i>	summer	Coastal	Migratory species that breeds on the southern end of Baffin Island, along the coastal areas of the northern Foxe Basin and on Southampton Island and Coats Island.	No status	Not assessed	No	✓	
Sanderling	<i>Calidris alba</i>	spring / summer	Coastal	Migratory species. Common spring migrant along the coast near Churchill en-route to its breeding grounds in the Arctic.	No status	Not assessed	No	✓	
Red knot	<i>Calidris canutus</i>	summer	Coastal	Migratory species. Hudson Bay ecosystem provides critical resources for this species.	EN-rufa ssp. (schedule 1) SC-islandica ssp. (schedule 1)	EN-rufa ssp. SC-islandica ssp.	No	✓	



Table 8.3-3: Overview of Seabird Species Potentially Present within the Local and Regional Study Areas (continued)

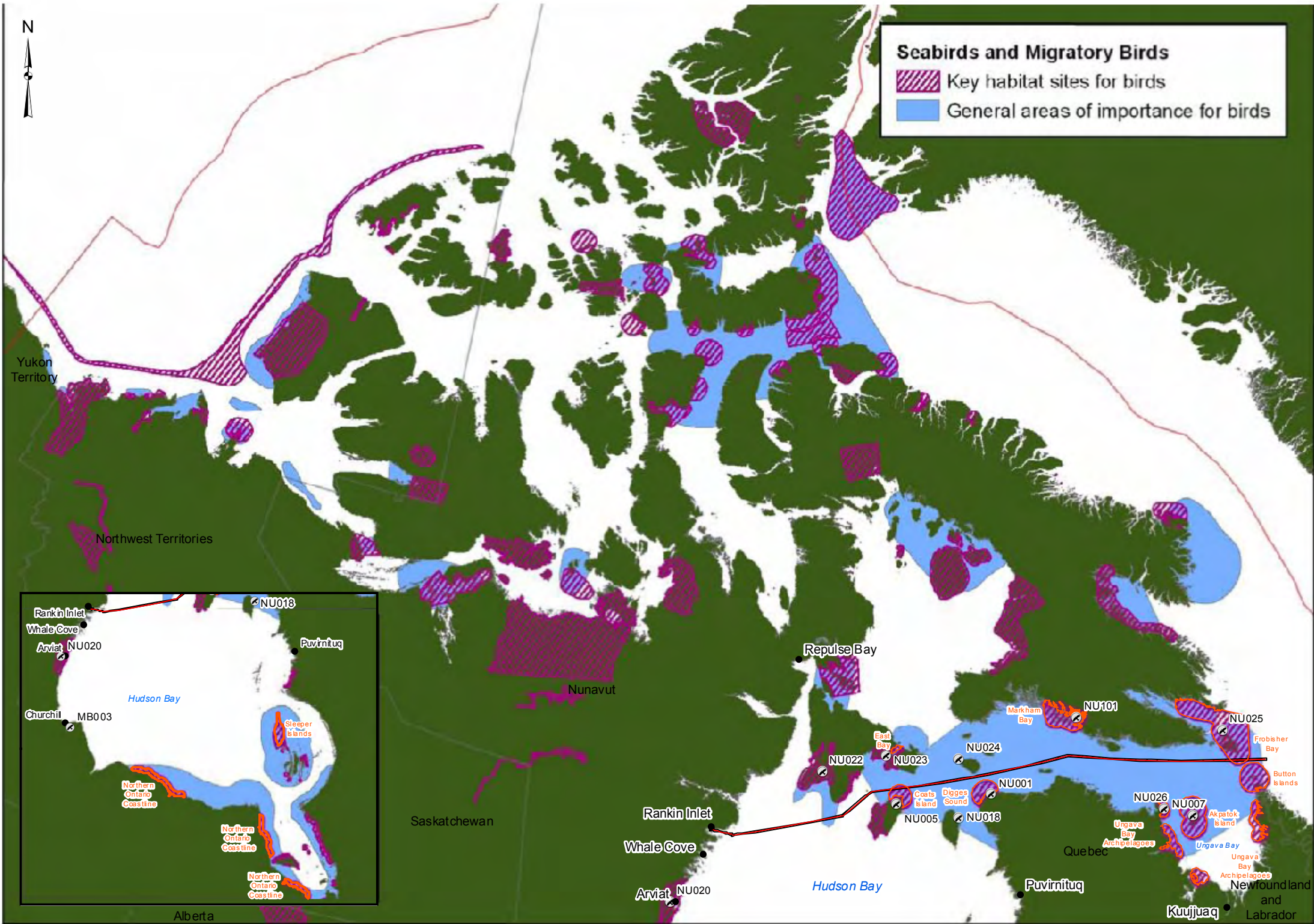
Common Name	Species	Seasonal Occurrence	Distribution	Other relevant information	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Peregrine falcon	<i>Falco peregrinus tundrius</i>	summer	coastal	Breed and hunt along the coasts of Hudson Bay and James Bay in summer. Breed in areas with high to moderate relief along the Hudson Bay coast of Manitoba, Nunavut, and northern Quebec and on Southampton, Coats and the Belcher and Nastapoka islands	SC (Schedule 1)	SC	No	✓	
Snowy owl	<i>Bubo scandiacus</i>	summer	coastal	Breed and forage along the coasts of Hudson Bay and James Bay	No status	Not at risk	No	✓	

^a SARA (*Species at Risk Act*). The Act is a key federal government commitment to prevent wildlife species from becoming extinct and secure the necessary actions for their recovery. It provides for the legal protection of wildlife species and the conservation of their biological diversity (extracted from SARA 2012).

^b COSEWIC (Committee on the Status of Endangered Wildlife in Canada) is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada. It is up to Government to legally protect wildlife species designated by COSEWIC. The potential impacts of legal listing are for Government to analyse, and the Species at Risk Act (SARA) applies only to wildlife species on the SARA legal list (extracted from COSEWIC 2012).

EN=Endangered, TH=Threatened, SC = Special Concern

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LEGEND

Important Bird Areas

Community

Key Marine Habitat Areas for Migratory Bird

Marine Regional Study Area (Marine RSA)

ID#

Important Bird Areas

NU022

Harry Gibbons Migratory Bird Sanctuary (federal)

MB003

Wapusk National Park (federal)

NU005

Cape Pembroke

MB013

Seal River Estuary Heritage River (federal)

NU020

McConnell River Migratory Bird Sanctuary (federal) & Ramsar Site

NU023

East Bay Migratory Bird Sanctuary (federal)

NU024

Fraser Island

NU001

Digges Sound

NU010

Markham Bay Eider Colony

NU026

Eider Islands

NU007

Akpatok Island

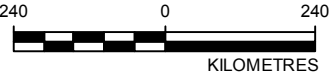
NU018

Mansel Island

NU025

Hantzsch Island

REFERENCE
Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010, IBA 2012
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

KEY HABITAT AREAS
FOR MARINE BIRDS

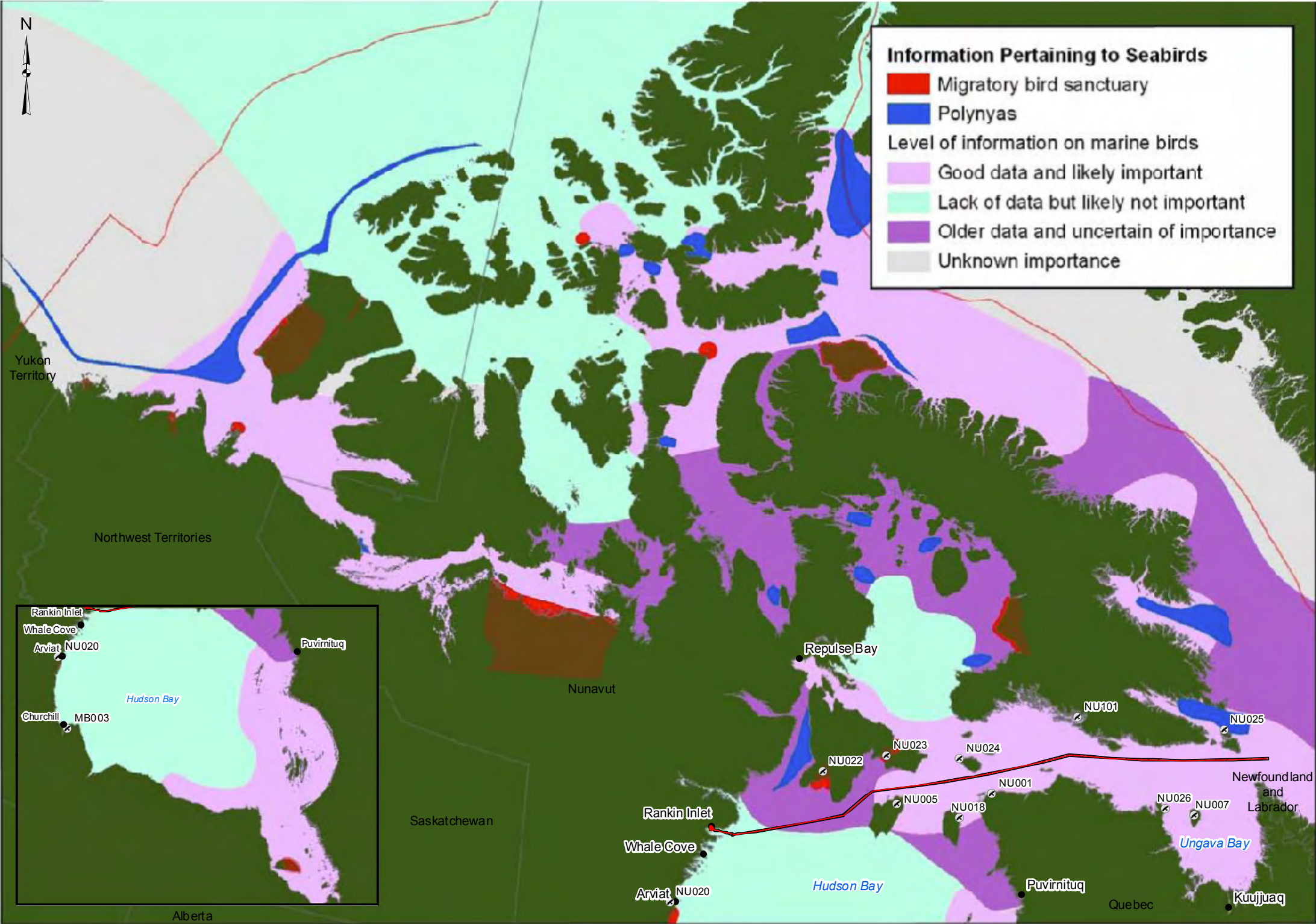
Golder Associates

PROJECT NO.	10-1373-0076	FILE No. 7000/7300
DESIGN	KZ	06 Feb. 2014
GIS	MH	06 Feb. 2014
CHECK		
REVIEW		

SCALE AS SHOWN
REV. 0

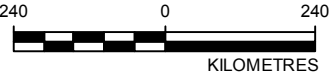
FIGURE 8.3-2

N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Figure_8.3-3_Distribution_of_Birds.mxd



LEGEND	
	Local Study Area (LSA)
	Marine Regional Study Area (Marine RSA)
ID#	Important Bird Areas
NU022	Harry Gibbons Migratory Bird Sanctuary (federal)
MB003	Wapusk National Park (federal)
NU005	Cape Pembroke
MB013	Seal River Estuary Heritage River (federal)
NU020	McConnell River Migratory Bird Sanctuary (federal) & Ramsar Site
NU023	East Bay Migratory Bird Sanctuary (federal)
NU024	Fraser Island
NU001	Digges Sound
NU101	Markham Bay Eider Colony
NU026	Eider Islands
NU007	Akpatok Island
NU018	Mansel Island
NU025	Hantzsch Island

REFERENCE
Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010, IBA 2012
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT		AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT	
TITLE		DISTRIBUTION OF MARINE BIRDS AND BIRD HABITAT IN THE MARINE RSA AND ADJACENT ARCTIC WATERS	
	PROJECT NO.	10-1373-0076	FILE No.
	DESIGN	AK	19 Jul. 2012
	GIS	DSC	24 Jul. 2012
	CHECK	PR	18 Jan. 2013
REVIEW		DW	18 Jan. 2013
		SCALE AS SHOWN	REV. 0
FIGURE 8.3-3			



Hudson Bay / Hudson Strait provides key breeding habitat for numerous species, including many birds that are primarily Arctic breeders and others that are rarely seen in breeding condition outside the Arctic Islands. The only species listed under the SARA with the potential to occur in the RSA are the Ross's gull and the ivory gull (listed as Threatened and Endangered under Schedule 1 of SARA, respectively) (Table 8.3-3). Those bird species identified as having special ecological or cultural importance, or holding special conservation status, with home ranges overlapping with the RSA are identified in Table 8.3-3.

Three designated migratory bird sanctuaries occur along the shorelines of Hudson Bay / Hudson Strait: one south of Arviat in western Hudson Bay (McConnell River), and 2 on Southampton Island in northern Hudson Bay (Harry Gibbons and East Bay). Although these sites are generally a fair distance from the proposed shipping route, birds do forage offshore to considerable distances and may be vulnerable to impacts associated with shipping activities. For instance, hundreds of thousands of thick-billed murre fledglings migrate with molting adults from colonies in Hudson Strait (Hantzsch Island and Digges Sound) to Newfoundland by swimming, while those that nest on Akpatok Island overwinter west of the Belcher Islands.

Approximate densities of seabirds in the RSA during late summer / early fall have been identified by means of vessel-based seabird surveys undertaken in Hudson Bay and Hudson Strait in 2005 as part of the 2005 ArcticNet expedition (McKinnon et al. 2009). Mean seabird density indices were highest in Hudson Strait (8.3 ± 1.9 birds/km²) and lowest in southern Hudson Bay (0.36 ± 0.2 birds/km²). Where mean density indices were high, sightings were dominated by northern fulmars or dovekeys (or both). The results suggest that several seabird populations that migrate eastward through Hudson Strait converge at the eastern mouth of the Hudson Strait, thus representing a major staging area for migrant seabirds during September and October, particularly for northern fulmar, dovekie, and thick-billed murre.

In Hudson Strait, the mean density index of seabirds sighted within transects (both sitting on the sea and in flight) was 8.3 ± 1.9 birds/km². The species most commonly documented sitting on the sea were northern fulmar (65.8% of sightings) and dovekie (14.2%). The species most commonly documented in flight were Dovekie (48.3% of sightings) and northern fulmar (38.7%). Other species sighted (sitting on the sea and in flight) included, in order of abundance, thick-billed murre, black-legged kittiwake, glaucous gull, common eider and black guillemot (McKinnon et al. 2009).

In Hudson Bay, the mean density index of seabirds within transects (both sitting on the sea and flying) was 0.36 ± 0.2 birds/km². Species sighted sitting on the sea included thick-billed murre, herring gull, and glaucous gull. The species most commonly documented in flight were Canada goose (36.4% of sightings) and herring gull (23.6%). Other species sighted in flight included, in order of abundance, thick-billed murre, northern fulmar, black guillemot, black-legged kittiwake, glaucous gull, common eider, and long-tailed duck (McKinnon et al. 2009).

8.3.2.2.1.3 Marine Mammals

There are 11 species of marine mammals potentially present within the RSA for variable periods of time and at different times throughout the year (Table 8.3-4). This includes 4 species of cetaceans (3 toothed whales and one baleen whale), 6 species of pinnipeds (seals and walrus), and the polar bear. Narwhal (*Monodon monoceros*), beluga (*Delphinapterus leucas*), and bowhead whales (*Balaena mysticetus*) are known to overwinter in Hudson Strait and in polynyas within Hudson Bay. Atlantic walrus (*Odobenus rosmarus rosmarus*), bearded seal (*Erignathus barbatus*), ringed seal (*Phoca hispida*), and harbour seal (*Phoca vitulina concolor*) are year-round residents to at least portions of Hudson Bay. Polar bears are also common in the RSA,



entering the pack-ice in early November following their denning season but retreat to coastal areas during the summer ice-free season. The remainder of marine mammals identified in Hudson Bay / Hudson Strait are migratory and seasonal visitors, limited largely by the presence of solid land-fast ice throughout the winter and spring. There is a pronounced geographic bias on the distribution of several species within Hudson Bay; for example, belugas are strongly associated with the western part of Hudson Bay with substantial attraction to estuaries such as the Churchill River. Table 8.3-5 provides a summary of marine mammal species harvested throughout the year by Coastal Inuit communities in Nunavut. An overview on the biology of each marine mammal species potentially present in, or in the vicinity of, the RSA is provided below.



Table 8.3-4: Overview of Marine Mammal Species Found within the LSA and RSA

Common Name	Species	Seasonal Occurrence	Habitat	SARA Status ^a	COSEWIC Status ^b	Of Cultural, Economic or Subsistence Importance	LSA	RSA
Ringed seal	<i>Pusa hispida</i>	Year-round	Shore-fast ice and pack-ice	No Status	Not at Risk	Yes	✓	✓
Harp seal	<i>Pagophilus groenlandica</i>	Open-water season (July-Sept)	Pack-ice	No Status	Not assessed	Yes	✓	✓
Bearded seal	<i>Erignathus barbatus</i>	Year-round	Pack-ice	No Status	DD	Yes	✓	✓
Harbour seal	<i>Phoca vitulina concolor</i>	Year-round	Coastal terrestrial areas and edge of shore-fast ice	No Status	Not assessed	Yes	✓	✓
Hooded seal	<i>Cystophora cristata</i>	Open-water season (July-Sept)	Pack-ice	No Status	Not assessed	Yes		✓
Atlantic walrus	<i>Odobenus rosmarus</i>	Year-round	Pack-ice or coastal waters during summer; floe-edge / polynyas during winter	No Status	SC	Yes	✓	✓
Polar bear	<i>Ursus maritimus</i>	Year-round	Spring: shore-fast ice; Summer: coastal areas and inland; and Winter: shore fast-ice and coastal areas for denning	SC (Schedule 1)	SC	Yes	✓	✓
Beluga whale	<i>Delphinapterus leucas</i>	Winter (Nov-May) and Summer	Spring: ice-edges/leads; Summer: shallow coastal areas (around Southampton Island and western Hudson Bay); Fall: deep water (foraging); Winter: offshore pack-ice (Hudson Strait)	No Status	EN	Yes	✓	✓
Narwhal	<i>Monodon monoceros</i>	Year-round	Winter: deep water / edge of banks; Summer: fjords / coastal waters	No Status	SC	Yes	✓	✓
Bowhead whale	<i>Balaena mysticetus</i>	Winter (Feb-Jun)	Spring : along the ice-edge; Summer: open-water /pack-ice; Winter: heavy pack-ice	No Status	SC	Yes	✓	✓
Killer whale	<i>Orcinus orca</i>	Jun-Aug	Coastal / offshore	No Status	SC	No	✓	✓

^a SARA (*Species at Risk Act*). The Act is a key federal government commitment to prevent wildlife species from becoming extinct and secure the necessary actions for their recovery. It provides for the legal protection of wildlife species and the conservation of their biological diversity (extracted from SARA 2012).

^b COSEWIC (Committee on the Status of Endangered Wildlife in Canada) is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada. It is up to Government to legally protect wildlife species designated by COSEWIC. The potential impacts of legal listing are for Government to analyse, and the Species at Risk Act (SARA) applies only to wildlife species on the SARA legal list (extracted from COSEWIC 2012).

EN=Endangered, SC=Special Concern, DD=Data Deficient



Table 8.3-5: Marine Mammal Species Harvested Throughout the Year by Coastal Inuit Communities in Nunavut

Target species	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Ringed seal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bearded seal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Harp seal	✓			✓		✓	✓	✓	✓	✓	✓	
Hooded seal							✓	✓	✓	✓	✓	✓
Harbour seal							✓	✓	✓	✓	✓	
Walrus	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Beluga	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Narwhal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bowhead								✓				
Polar bear	✓	✓	✓	✓	✓					✓	✓	✓

Source: Priest and Usher (2004)

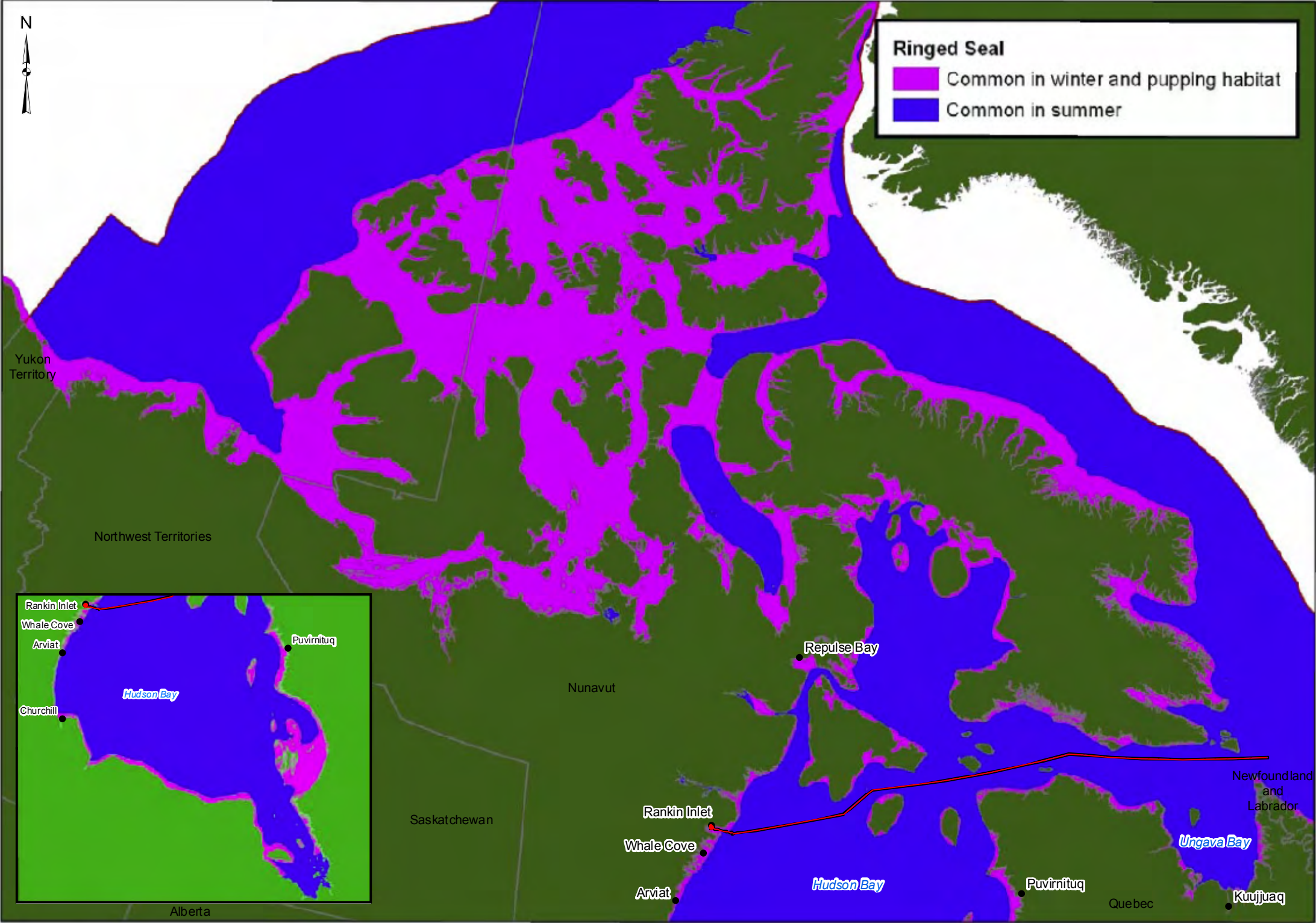
Ringed seal (*Phoca hispida*)

The ringed seal has a circumpolar distribution that is closely associated with the distribution of land-fast ice. This species occurs at the southern limit of their range in Hudson Bay where it is present year-round (Mansfield 1967; Stewart and Lockhart 2005). Ringed seals are the most abundant and widespread seal in the Arctic; however, their numbers in western Hudson Bay declined between 1995 and 2010 based on annual aerial surveys conducted during spring/summer (Lunn et al. 2000; Vincent-Chambellant 2010; Ferguson and Young 2011).

The ability of ringed seals to maintain breathing holes in the land-fast ice enables them to occupy large areas that are inaccessible to other marine mammals except during the summer. During winter, their preferred habitat consists of ice leads and polynyas where breathing holes are easiest to maintain. In spring, breeding adults occur in highest densities in areas of stable land-fast ice with good snow cover where they maintain birth lairs for pup rearing (Hamill and Smith 1991), whereas non-breeders occur at the floe edge or in the moving pack-ice (Stewart and Lockhart 2005). Pups are born in early spring (March/April) and weaned prior to break-up of the sea-ice in late June (Evans and Raga 2001). Pups will remain in subnivean⁵ dens during a 5 to 8 week lactation period to avoid detection from predators such as polar bears (Evans and Raga 2001). During the open-water season (July-Sept), ringed seals are commonly observed hauled-out on the sea-ice in large numbers. Juveniles may move offshore at this time, but adults remain around islands and within the bays and fiords (McLaren 1958a; ; Dunbar and Moore 1980). As such, seals are unlikely to occur in large numbers in the proposed offshore shipping corridor during summer. Figure 8.3-4 provides an overview of ringed seal distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK.

⁵ situated or occurring under the snow

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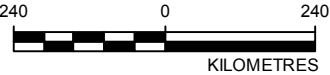
LEGEND

Local Study Area (LSA)

Marine Regional Study Area (Marine RSA)

REFERENCE

Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISTRIBUTION OF RINGED SEAL
(*Phoca hispida*) IN THE MARINE
RSA AND ADJACENT ARCTIC WATERS

Golder
Associates

PROJECT NO.	10-1373-0076	FILE No.
DESIGN	AK	19 Jul. 2012
GIS	DSC	19 Jul. 2012
CHECK	PR	18 Jan. 2013
REVIEW	DW	18 Jan. 2013

SCALE AS SHOWN | REV. 0

FIGURE 8.3-4



Ringed seals are considered a keystone species⁶ (Ferguson et al. 2005), as both adults and pups are an important food source for polar bears (Smith et al. 1991). Other predators include Arctic fox, walrus, wolves, humans, and dogs (Hammill and Smith 1991). Juvenile ringed seals prey mainly on crustaceans under the ice, whereas adults prey on crustaceans and small fish (e.g., Arctic cod) (Richard 2001). This species serves as the main target of the Coastal Inuit subsistence hunt, with all communities in Nunavut (28 out of 28) actively harvesting this species (Priest and Usher 2004). The number of ringed seals harvested in Rankin Inlet is variable, ranging from 55 to 356 animals over a 5 year period (Priest and Usher 2004). The meat is considered a staple of the local diet, and seal hides are used for clothing and sold commercially. Concerns have been raised over possible declines in ringed seal abundance in western Hudson Bay, as indicated by Inuit traditional knowledge, due to reduced pregnancy rate (Stirling 2005), reduced pup survival and recruitment (Holst et al. 1999; Ferguson et al. 2005), later age of maturation and older age structure (Vincent-Chambellant 2010), and increased number of polar bears (Regehr et al. 2007).

IQ

Bearded seal (*Erignathus barbatus*)

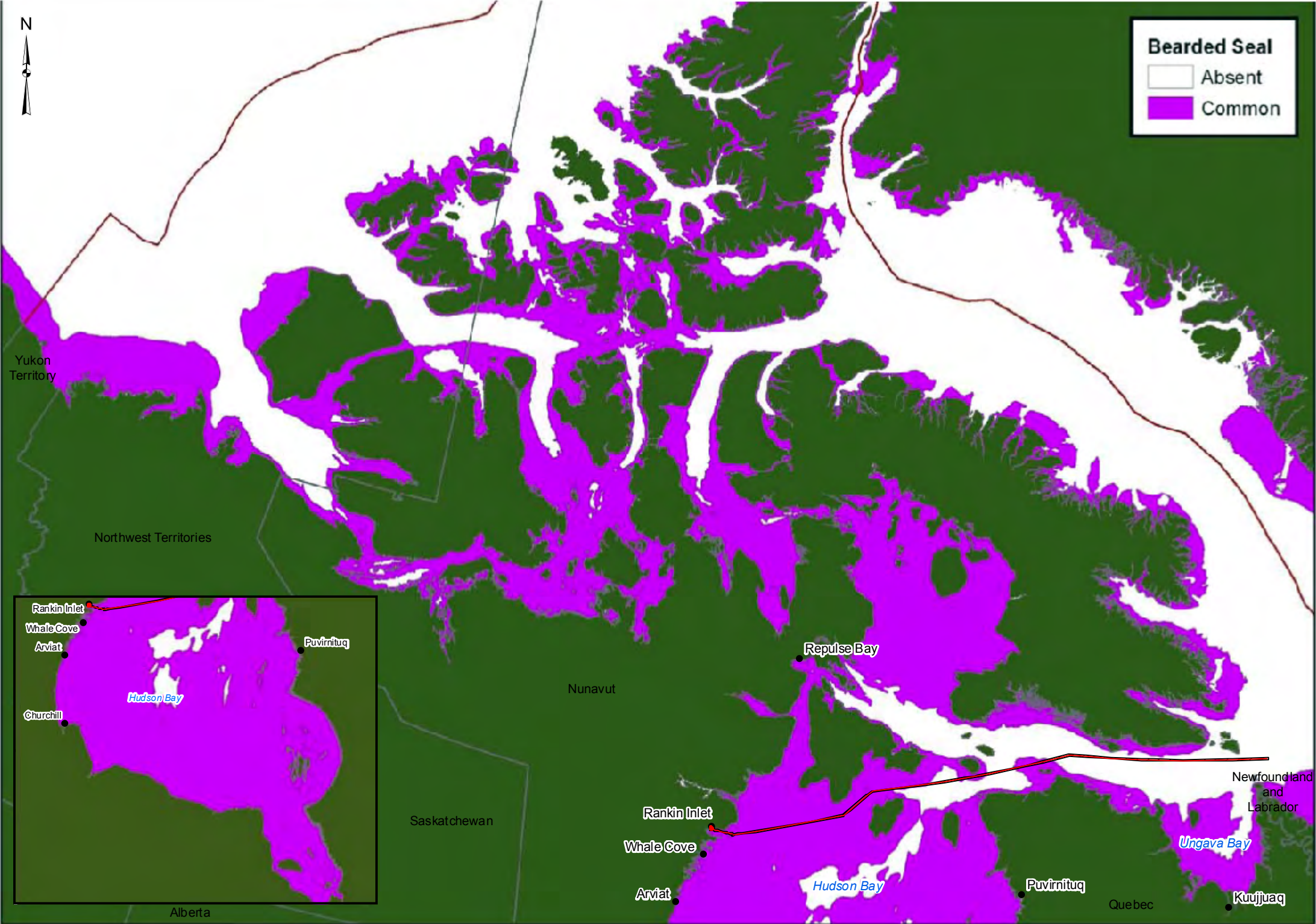
Bearded seals are large, solitary seals, which have a circumpolar distribution in Arctic and sub-Arctic waters (Mansfield 1967). This species is sparsely distributed throughout their range, and are most abundant in areas where they have access to sea-ice upon which to haul-out, and in shallow water depths where they can access the seafloor (typically < 200 m; Kingsley et al. 1985) to feed on crustaceans, molluscs, and fish (e.g., Arctic cod, polar cod, sculpin) (Burns and Frost 1979; Finley and Evans 1983). They are commonly found along continental shelf areas associated with high benthic productivity.

Since this species has only a limited capability to maintain breathing holes in solid ice, they are generally excluded from areas of land-fast ice during much of the year (e.g., High Arctic Archipelago) and are mostly found amongst the pack-ice where the surface is always accessible (Burns et al. 1981). As such, bearded seals move with the receding and forming ice, often travelling considerable distances to the north (seawards) in the summer and back south in the winter (Gilchrist and Robertson 2000). Studies of their general distribution have led to adopt the 250 m benthic contour interval as a measure to delineate the area in which bearded seals are commonly seen (Stephenson and Hartwig 2010). Figure 8.3-5 provides an overview of bearded seal distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK.

Bearded seal pups are born in late April on the ice, weaned approximately 12 to 18 days later, and then abandoned (Evans and Raga 2001). Mating occurs in the water shortly after weaning, and involves a 2-month delayed uterine implantation period. Both males and females mature around 6 years of age and reproduce biannually until 20 to 30 years of age (Evans and Raga 2001). Males actively vocalize underwater during the breeding season, with calling behaviour associated with territorial or mating displays (Richardson et al. 1995a). Bearded seals are estimated to number approximately 100 000 in the Canadian Arctic, and are especially abundant in Hudson Strait, Foxe Basin, and along the west coast of Hudson Bay (Mansfield 1967; Davis et al. 1980). The main predators of the bearded seal are polar bears and humans. This species is harvested throughout the year by virtually all coastal Inuit communities in Nunavut (27 of 28) (Furgal et al. 2002; Hovelsrud et al. 2008; Priest and Usher 2004), with hunting taking place from July to October. The meat is consumed and the tough flexible hide is used for harpoon lines, dog harnesses, whips, boot soles, and to cover boats called Umiak (Richard 2001). No Total Allowable Catch (TAC) limits exist for bearded seal in Nunavut.

⁶ a keystone species is a species that plays a critical role in maintaining the structure of an ecological community and whose impact on the community is greater than would be expected based on its relative abundance or total biomass

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LEGEND

- Local Study Area (LSA)
- Marine Regional Study Area (Marine RSA)

REFERENCE

Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic

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KILOMETRES

PROJECT		AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT	
TITLE		DISTRIBUTION OF BEARDED SEAL (<i>Erignathus barbatus</i>) IN THE MARINE RSA AND ADJACENT ARCTIC WATERS	
	PROJECT NO.		10-1373-0076
	DESIGN	AK	19 Jul. 2012
	GIS	DSC	23 Jul. 2012
	CHECK	PR	18 Jan. 2013
	REVIEW	DW	18 Jan. 2013
		FILE No.	SCALE AS SHOWN
			REV. 0

FIGURE 8.3-5



Harp seal (Pagophilus groenlandicus)

The harp seal is a widespread species found in the northern Atlantic and Arctic oceans (Sergeant 1976). Their range includes northern Hudson Bay, Foxe Basin, Baffin Island, Davis Strait, Gulf of St. Lawrence, Newfoundland, southern Greenland, Iceland, northern Norway, the White Sea, the Barents Sea, and the Kara Sea. Three distinct genetic populations are recognized: the Northwest Atlantic stock, the Greenland Sea stock, and the White Sea stock. Genetic evidence demonstrates that little gene flow occurs between the 3 stocks (Perry et al. 2000). Harp seals in Hudson Bay / Hudson Strait belong to the Northwest Atlantic stock and are only present in the RSA from ice break-up in early June until just before freeze-up (early October), at which point they migrate east outside the NSA and into the Gulf of St. Lawrence. Thus, impacts to harp seals due to the Project have the potential for transboundary effects. Harp seals are less common than ringed or bearded seals, but may have been more numerous and widespread in the past and may be re-occupying their former range (Stewart and Lockhart 2004). Figure 8.3-6 provides an overview of harp seal distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK.

IQ

During spring (late February to April), female harp seals aggregate on the pack-ice along the southeast coast of Labrador ('Front') and in the Gulf of St. Lawrence where they form dense and highly-synchronized "whelping herds" and give birth to a single pup. Pups are nursed for 12 days, after which they remain fasting on the pack-ice for approximately 2 weeks before entering the water to feed (Lavigne and Kovacs 1988; Lydersen and Kovacs 1996). Adult females attain sexual maturity at 4 to 6 years of age (Frie et al. 2003). Reproductive maturity occurs in males at about 8 years of age. Towards the end of lactation, females come into estrus and mate (Lavigne and Kovacs 1988). Gestation lasts about one year, including a 3 to 4 month period of delayed implantation (Stewart et al. 1989). The life span of harp seals is approximately 20 to 30 years. Both males and females are sexually active until the ends of their lives, showing no evidence of reproductive senescence (Ronald and Healey 1981).

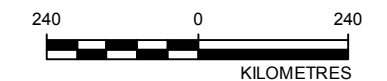
Harp seals undergo a moult in the post-breeding months, from early April to early May (Lavigne and Kovacs 1988). They are a highly social species that travel and forage in groups. The Northwest Atlantic population is highly migratory; after breeding, individuals follow the pack-ice up the coast of Labrador and spend the summer feeding in Baffin Bay, with small numbers entering Hudson Bay and Hudson Strait around Baffin Island before returning south to the Gulf of St. Lawrence during autumn, resulting in an annual migration of over 5000 km (Lavigne and Kovacs 1988). Natural predators of harp seals include polar bears, killer whales, Greenland shark, and humans (Lavigne and Kovacs 1988). Harp seals consume a wide range of fish and invertebrate prey that varies along their migration route (Lavigne 2002). Fish prey includes capelin, Arctic cod, Atlantic cod (*Gadus morhua*), Atlantic herring (*Clupea herringus*), and redfish (*Sebastes* sp.) (Lawson et al. 1995). Pups and juveniles prey primarily on crustaceans, particularly euphausiids and amphipods (Haug et al. 2000; Nilssen et al. 2001).

The harp seal global population is presently estimated at 8 million individuals, with pup production at 1.4 million pups per year (Stenson et al. 2003; Potelov et al. 2003; Haug et al. 2006). The Northwest Atlantic stock is estimated to number 5.9 million individuals (DFO 2005a). This is a marked recovery from an estimated low of around 1.8 million recorded in the early 1970s (Sergeant 1976) linked to a population crash from overharvesting. This led to the near cessation of hunting and the gradual recovery of this stock. Catch levels have increased repeatedly during the last decade, with the Canadian and Greenland hunt now presently the largest marine mammal harvest in the world (DFO 2007). The current rate of harvest likely exceeds Potential Biological

 Local Study Area (LSA)

 Marine Regional Study Area (Marine RSA)

Provincial data obtained from E. S. R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT				AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT					
TITLE		DISTRIBUTION OF HARP SEAL (<i>Pagophilus groenlandica</i>) IN THE MARINE RSA AND ADJACENT ARCTIC WATERS							
		PROJECT NO.		10-1373-0076		FILE No.			
		DESIGN	AK	19 Jul. 2012		SCALE AS SHOWN		REV.	0
		GIS	DSC	23 Jul. 2012		FIGURE 8.3-6			
		CHECK	PR	18 Jan. 2013					
		REVIEW	DW	18 Jan. 2013					



Removal Levels (PBRL)⁷ by 1.5 to 5.9 times (Kovacs 2008a). Given this level of removal, the population is now likely to be in decline (Johnston et al. 2000). This species is hunted throughout Nunavut primarily during the months of June through September (Priest and Usher 2004), with pups representing the majority of the harvest. Both meat and blubber are consumed, and the pelts are sold commercially. DFO sets TACs within a 3-year period for the Northwest Atlantic population. The Canadian harvest has recently increased, with the combined 3-year 2003-2005 quota (“Total Allowable Catch”) set at 975 000 (DFO 2005a). Given the age structure of the current hunt, this quota is not sustainable (Johnston et al. 2000). In addition to Canada’s commercial harvest, some harp seals are still taken in subsistence hunts in Labrador, Newfoundland, northern Quebec, and in Nunavut. Aboriginal peoples and non-Aboriginal coastal residents who reside north of latitude 53 degrees can hunt seals for subsistence purposes without a permit (DFO 2006b).

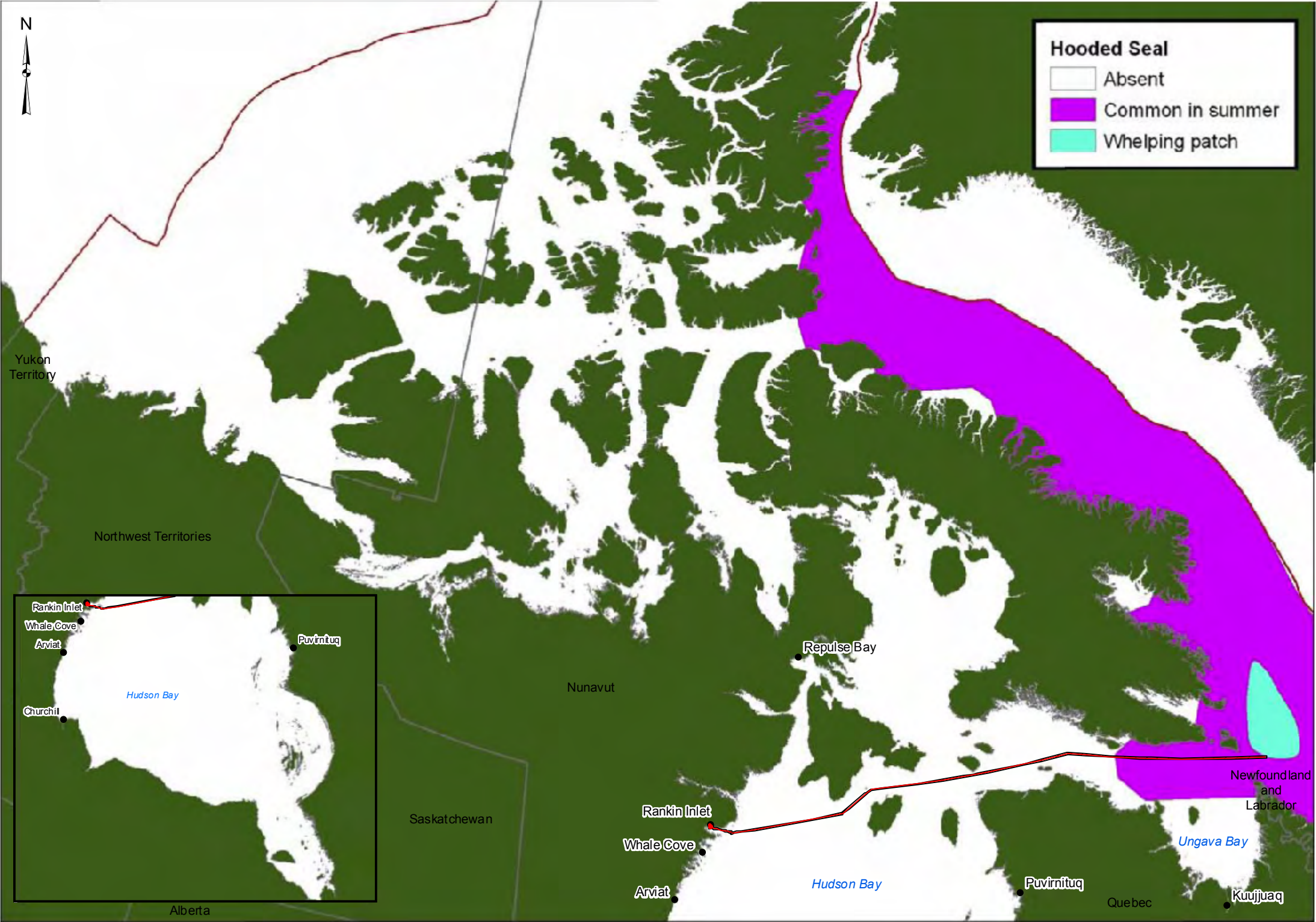
Hooded seal (Cystophora cristata)

The hooded seal occurs throughout much of the North Atlantic and Arctic Oceans (King 1983) preferring deeper water and occurring farther offshore than harp seals (Sergeant 1976; Campbell 1987; Lavigne and Kovacs 1988; Hammill and Stenson 2006). They are a highly migratory species, and are considered a rare visitor to Hudson Bay / Hudson Strait (Stewart and Lockhart 2004). Thus, impacts to hooded seals due to the Project have the potential for transboundary effects. As primarily deep-water feeders, the 200 m bathymetric contour interval has been adopted to estimate the offshore distribution boundary of this species (Stephenson and Hartwig 2010). Figure 8.3-7 provides an overview of hooded seal distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK. They are generally associated with heavy pack ice, and their presence would extend until ice break-up (Sergeant 1974). IQ

Hooded seals of the Western North Atlantic stock breed synchronously during mid to late March in heavy pack-ice areas off the coast of eastern Canada and around Greenland. Breeding of this population is divided into 4 whelping areas. The “Front” herd (largest of the 4) breeds off the coast of Newfoundland and Labrador, the “Gulf” herd breeds in the Gulf of St. Lawrence, the “Davis Strait” herd breeds between Baffin Island and western Greenland, and the “West Ice” herd breeds in the Greenland Sea near the island of Jan Mayen (Sergeant 1974, 1976; Folkow et al. 1996). These breeding herds are considered to belong to 2 recognized populations (Hammill and Stenson 2006). Seals whelping near Jan Mayen are thought to constitute the Northeast Atlantic population, while hooded seals whelping and breeding in Davis Strait, the Gulf and at the Front are all thought to belong to the Northwest Atlantic population (Hammill and Stenson 2006). The breeding season for this polygamous species is brief lasting only 2 to 3 weeks, with mating taking place in the water (Boness et al. 1988; Kovacs 1990). This species has the shortest lactation period for any mammal, with most pups being weaned in 4 days (Bowen et al. 1987). Hooded seals moult in July, with each breeding stock congregating at separate traditional sites away from the whelping areas. Many seals are reported to migrate to the pack-ice east of Greenland in Denmark Strait at this time (Sergeant 1974, 1976; Folkow et al. 1996). Hooded seals form loose aggregations in specific areas during the breeding and moulting season and generally remain solitary outside this period. Hooded seal life span is approximately 25 to 30 years (Kovacs 2002).

⁷ The Potential Biological Removal (PBR) Level is an index developed by the US National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act (MMPA) representing the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

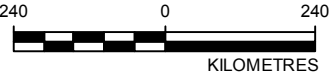
N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Figure_8.3-7_Distribution_of_Hooded_Seal.mxd



LEGEND

	Local Study Area (LSA)
	Marine Regional Study Area (Marine RSA)

REFERENCE
Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT		AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT	
TITLE DISTRIBUTION OF HOODED SEAL (<i>Cystophora cristata</i>) IN THE MARINE RSA AND ADJACENT ARCTIC WATERS			
	PROJECT NO. 10-1373-0076		FILE No.
	DESIGN	AK	19 Jul. 2012
	GIS	DSC	23 Jul. 2012
	CHECK	PR	18 Jan. 2013
	REVIEW	DW	18 Jan. 2013
		FIGURE 8.3-7	



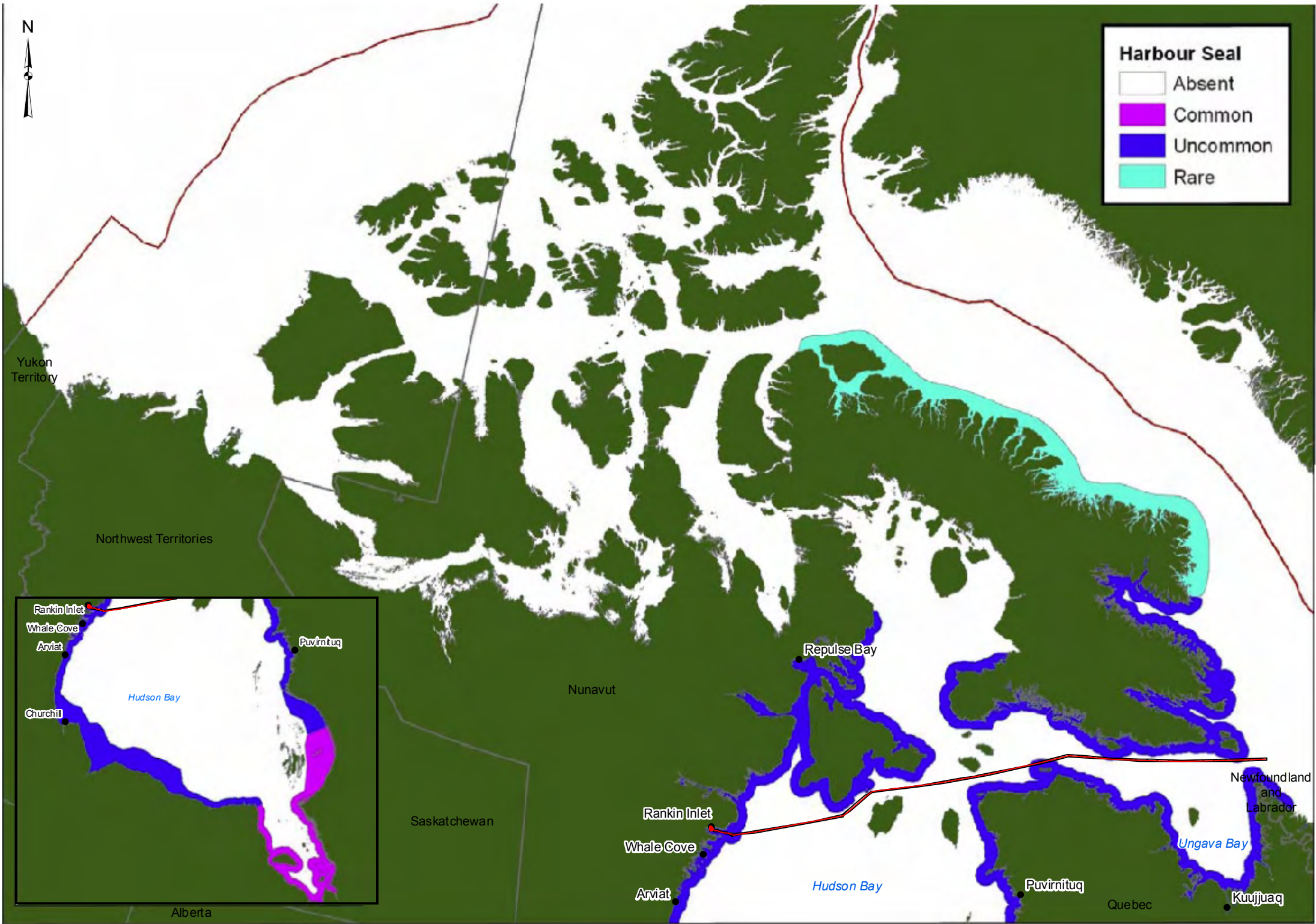
The Northwest Atlantic population has been estimated at approximately 600 000 animals (593 500, $\pm 67\,200$ SE, Hammill and Stenson 2006), of which 90% are estimated to whelp at the Front (Stenson et al. 2006). The Northeast Atlantic population is estimated at between 70 000 and 90 000 animals, although there is considerable uncertainty around these estimates due to scarcity of data and limited understanding of the relationships between whelping areas (ICES 2006). Hooded Seals are annually harvested by coastal Inuit of Greenland and Canada for subsistence purposes (Kovacs 2002) and have been commercially hunted at the Front since the late 1800s (Kovacs 2008b). Harvesting occurs primarily during the months of July through December (Table 8.3-5). For the Canadian harvest, the TAC has been set at 10 000 seals per year since 1998 (ICES 2006). For the period 2000-2004, the total estimated catch of hooded seals was 48 188 (Kovacs 2008b). By-catch of hooded seals in coastal net fisheries has been reported from the United States, from trawl fisheries off Norway and Newfoundland, and salmon drift nets used off Greenland (Woodley and Lavigne 1991; Reeves et al. 1992; Waring et al. 2005).

Harbour seal (*Phoca vitulina concolor*)

The harbour seal is the most widely-distributed of all pinnipeds, inhabiting temperate, sub-Arctic and Arctic coastal areas on both sides of the North Atlantic and North Pacific Oceans. As this species does not maintain breathing holes in the ice, their distribution in the RSA is limited to locations where currents maintain open water year-round, typically in freshwater or estuarine rapids, in small coastal polynyas, or at the ice floe edge (Mansfield 1967). Harbour seals are not typically found in offshore waters exceeding 50 m depth (COSEWIC 2007). This depth limitation is supported by radio telemetry studies that have indicated that the 50 m benthic contour line may be used to demarcate their offshore limit of distribution (Stephenson and Hartwig 2010). Figure 8.3-8 provides an overview of their distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK. Adults tend to be solitary in the water but haul out in small sedentary groups on rocky shores, where pupping occurs. Harbour seals are harvested by coastal Inuit communities primarily during the period from July through October (Table 8.3-5). IQ

⁸ It should be noted that Northwest Atlantic seals may also be taken in the Greenland harvest, as there is considerable intermixing between the Northwest Atlantic and West Ice stocks.

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LEGEND

Local Study Area (LSA)

Marine Regional Study Area (Marine RSA)

Harbour Seal

Absent

Common

Uncommon

Rare

REFERENCE

Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic

2400240

KILOMETRES

PROJECT



AGNICO EAGLE

AGNICO EAGLE MINES LIMITED

MELIADINE GOLD PROJECT

NUNAVUT

TITLE

DISTRIBUTION OF HARBOUR SEAL
(*Phoca vitulina concolor*) IN THE MARINE
RSA AND ADJACENT ARCTIC WATERS



PROJECT NO.		10-1373-0076	FILE No.	
DESIGN	AK	19 Jul. 2012	SCALE AS SHOWN	REV. 0
GIS	DSC	23 Jul. 2012		
CHECK	PR	18 Jan. 2013		
REVIEW	DW	18 Jan. 2013		

FIGURE 8.3-8



Atlantic walrus (Odobenus rosmarus rosmarus)

The walrus (*Odobenus rosmarus*) has a circumpolar distribution and is the largest pinniped occurring in the Canadian Arctic. Individuals inhabiting coastal areas of the RSA belong to the Atlantic stock, 1 of 2 subspecies recognised. There are 4 stocks of Atlantic walrus that have been identified throughout the eastern Canadian Arctic: South and East Hudson Bay (SEHB), Hudson Bay-Davis Strait (HBDS), Foxe Basin (FB), and Baffin Bay (BB). Walrus require large areas of shallow water (<80 m) with substrate that supports a productive bivalve community, the reliable presence of open water over these feeding areas, and suitable ice or land nearby upon which to haul out (Evans and Raga 2001). Atlantic walrus are highly gregarious and are associated with moving pack-ice for most of the year. In Hudson Bay, the paucity of sea-ice during summer forces walrus to haul-out in predictable locations on land. The main concentration of walruses in southern Hudson Bay is in the Belcher Islands (Sanikiluaq) (Figure 8.3-9; DFO 2002). The main concentration of walruses in northern Hudson Bay resides on the northeast side of Coats Island and in Coral Harbour on the southeast side of Southampton Island (Figure 8.3-9; DFO 2002); walrus in both areas are present year-round with an estimated summer population of 2000. The main concentration of walruses in Hudson Strait resides at Cape Dorset on the Foxe Peninsula (Figure 8.3-9; DFO 2002). The general distribution of walrus and their preference for shallow near shore areas substantially reduce the potential for interaction of walrus with Project vessels in the shipping corridor (RSA).

Walrus are characterized by a highly polygamous mating system, with breeding herds forming in January - April. They are long-lived animals (approximately 40 years) with a low reproductive rate. Females attain reproductive maturity at approximately 5 to 7 years of age, with a typical calving interval of 3 years (Garlich-Miller and Stewart 1999). Males reach sexual maturity at 6 to 10 years of age, although likely cannot successfully compete for females until they are older. Mating takes place in the water, usually from January to April, and pregnancy lasts 15 to 16 months. Females, therefore, can only give birth a maximum of once every 2 years, though it is more commonly 3 years between calves. This results in a pregnancy rate that is much lower than that of other pinnipeds. Walrus calves are born on land or on the pack-ice between late April and early June. The nursing period typically lasts for 2 years, with weaning occurring gradually over this time.

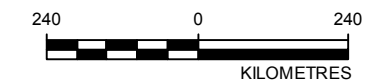
Changes in the abundance of Atlantic walrus in various regions during the past 45 years are unclear (COSEWIC 2006). Modelling indicates that populations in the Eastern Canadian Arctic have been in steady decline (Witting and Born 2005). The current total abundance of Atlantic walrus is poorly known, but the most recent information suggests a population size of perhaps 18 000 to 20 000 (COSEWIC 2006). The population status of Atlantic walrus recently has been upgraded to "Special Concern" (COSEWIC 2006). Walrus are harvested year-round by coastal Inuit communities in the Nunavut region (Table 8.3-5) (Priest and Usher 2004). Between 1996 and 2001, hunters reported an average annual walrus catch (landed)⁹ of 2/year from Arviat, 3/year from Chesterfield Inlet, 5/year from Rankin Inlet and none for those years for the communities of Baker Lake or Whale Cove (NWMB 2004). Walrus hunting is subject to the terms of the Nunavut Land Claims Agreement and is legislated under the Marine Mammal Regulations of the *Fisheries Act*.

⁹ records are incomplete and are not corrected for hunting losses

 Local Study Area (LSA)

 Marine Regional Study Area (Marine RSA)

Provincial data obtained from E. S. R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT		AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT
AGNICO EAGLE		
TITLE DISTRIBUTION OF ATLANTIC WALRUS (<i>Odobenus rosmarus rosmarus</i>) IN THE MARINE RSA AND ADJACENT ARCTIC WATERS		
 Golder Associates		

PROJECT NO.		10-1373-0076	FILE No.		
DESIGN	AK	19 Jul. 2012	SCALE AS SHOWN	REV.	0
	GIS	DSC 23 Jul. 2012			
CHECK	PR	18 Jan. 2013	FIGURE 8.3-9		
REVIEW	DW	18 Jan. 2013			



Beluga whale (Delphinapterus leucas)

Beluga whales are circumpolar in distribution, typically occurring in warm shallow estuaries during summer and migrating south during autumn to over-winter in the pack-ice, at established polynyas, or along prominent ice leads where open water conditions prevail (Doidge and Finley 1993; NAMMCO 2005). Beluga whales in the Canadian Arctic are sub-divided into 7 populations based on summer distribution and genetic differences (COSEWIC 2004a). The highest concentrations of belugas in the Canadian Arctic occur in the Hudson Bay region (Stephenson and Hartwig 2010), where animals during summer are observed in concentrated groups along both eastern and western coasts, as well as in James Bay and in nearby Ungava Bay (Gosselin et al. 2013). Estuaries serve as important feeding and calving grounds for beluga whales, with their first arrival in these areas timed with the initial ice breakup in late June and their abundance increasing into the summer. Molecular genetic studies indicate at least 2 populations in Hudson Bay: a western Hudson Bay (WHB) stock and an eastern Hudson Bay (EHB) stock (Brennin et al. 1997; Brown Gladden et al. 1997; De March and Postma 2003). The WHB stock numbers about 57 000 individuals (Richard 2005), Genetic studies (Turgeon et al. 2012) and satellite telemetry (Bailleul et al. 2012) have shown that these 2 stocks overwinter together, where they likely interbreed. Beluga whales in James Bay appear to constitute a distinct breeding population (Postma et al. 2012).

Most beluga whales present during summer in the Hudson Bay region belong to the WHB stock and occur in shallow coastal waters along western Hudson Bay (Martin et al. 2001), concentrating in the Churchill, Nelson, and Seal River estuaries (Stephenson and Hartwig 2010). The most recent population estimate for the WHB population was estimated at approximately 57 300 animals (95% C.I.: 37 700 to 87 100) (Richard 2005), making this stock of beluga whales the most abundant cetacean species in the region. Individuals from the EHB stock occur during summer along the shores of eastern Hudson Bay, including the Nastapoka River and the Little Whale River estuaries in northeastern Nunavik (Quebec's Arctic region) (Stephenson and Hartwig 2010). The EHB stock, currently listed as endangered by COSEWIC, was depleted by intensive commercial hunting between the 1860s and the early 1900s and has decreased from an estimated pristine population size of 12 500 to about 3000 individuals in 2009 (Hammill et al. 2009). Aerial line transect surveys conducted in 2011 provided revised abundance estimates of the EHB stock at 3351 animals (CV 48.9%; 95% CI: 1552 to 7855), which included correction factors for submerged animals and an additional 354 individuals counted during dedicated surveys in Little Whale River estuary (Gosselin et al. 2013). An uncorrected density estimate of 0.02 individuals / km² (CV 47.1%) was reported for EHB beluga whales in the eastern Hudson Bay survey area (Gosselin et al. 2013). The 2011 EHB abundance estimate is higher than that of 2008 (2646 individuals; Gosselin et al. 2009), lower than that of 2004 (4274 individuals; Gosselin 2005), and in line with model predictions of the stock abundance for 2011 (Doniol-Valcroze et al. 2011).

Migration is believed to begin northward along the coast of Hudson Bay during late August / early September (COSEWIC 2004a). Satellite tag data suggest the population moves towards wintering habitat in Hudson Strait; however, the routes taken by beluga whales between summering and wintering habitats are not well established. Although some beluga whales have been reported to overwinter in polynyas in northwest Hudson Bay and in James Bay, in general, beluga whales over-winter in highly productive areas in Hudson Strait, Davis Strait, and Baffin Bay (Gosselin et al. 2009; Hammill and Lesage 2009; Hammill et al. 2009; DFO 2010a; Stephenson and Hartwig 2010). Thus, impacts to beluga whales due to the Project have the potential for transboundary effects in Greenlandic territorial waters. Figure 8.3-10 provides an overview of beluga whale distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK. The presence of beluga whales along the

IQ

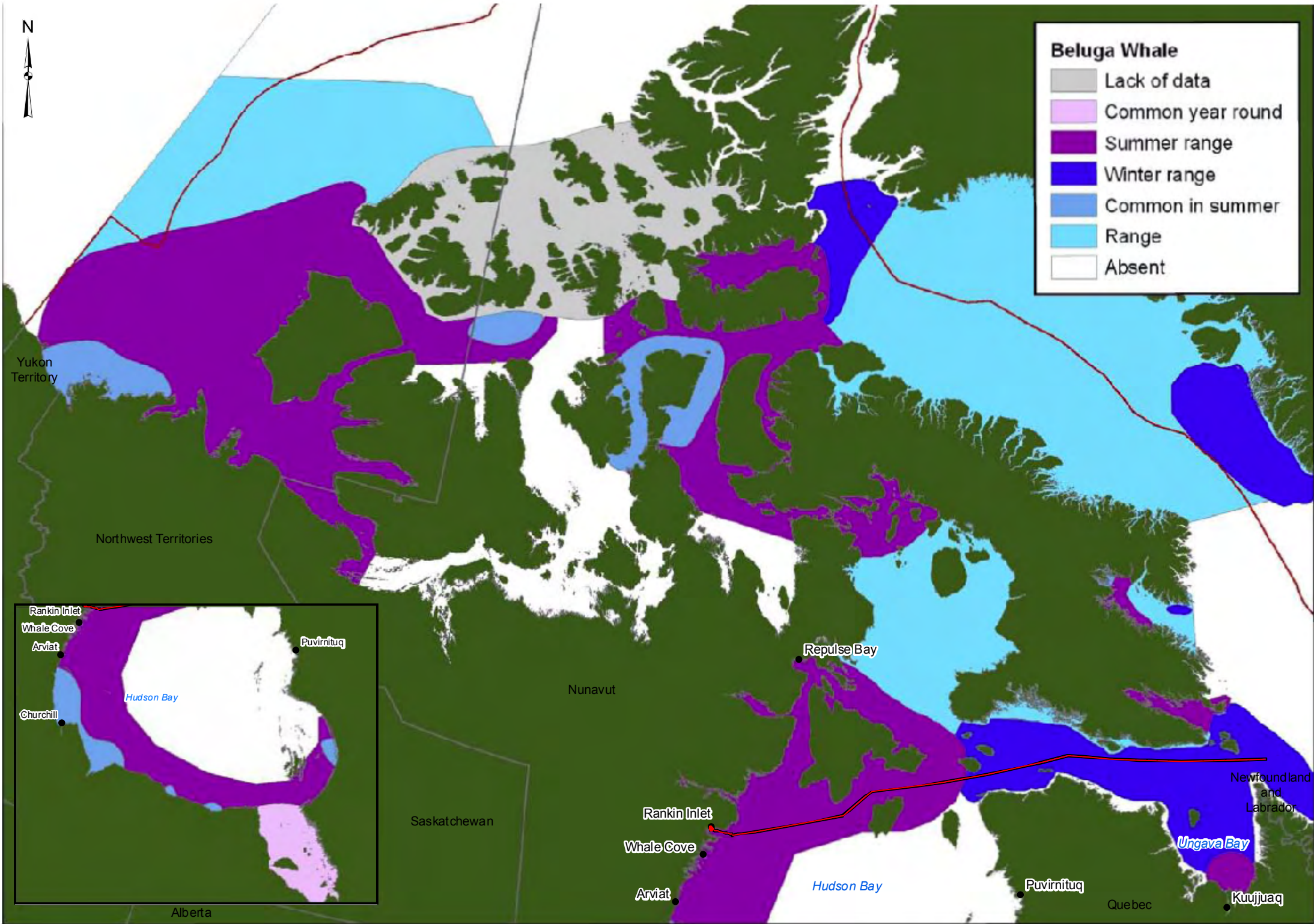


shipping corridor is thought to be low, given their general distribution pattern and preference for shallow nearshore waters.

Beluga whales are harvested year-round by most coastal Inuit communities (20 out of 28) (Table 8.3-5) (Priest and Usher 2004). During summer, they are mostly hunted along the western coast of Hudson Bay up to 35 km offshore (Canadian Circumpolar Institute 1992) from Arviat to Cape Fullerton. They are hunted primarily for their skin, which is considered a delicacy (Freeman 1976). **IQ**

Over the 5-year period from 1996 to 2001, the total annual mean number of beluga whales taken through hunting was approximately 1339 for all of Nunavut, whereas annual rates of belugas harvested from the community of Rankin Inlet ranged from 22 in 1998-1999 to 116 in 1999-2000 (Priest and Usher 2004). Subsistence harvest of beluga whales by Nunavik Inuit communities is directed towards a mixture of the WHB and EHB stocks, with the reported 2010 harvest consisting of 45 beluga whales taken near Sanikiluaq (Belcher Islands), 16 in the eastern Hudson Bay area, 15 in Ungava Bay, 146 in Hudson Strait in the spring and 58 in the fall (Doniol-Valcroze et al. 2011).

N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Figure_8.3-10_Distribution_of_Beluga_Whales.mxd

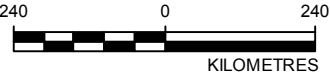


LEGEND

- Local Study Area (LSA)
- Marine Regional Study Area (Marine RSA)

REFERENCE

Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT		AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT					
		AGNICO EAGLE					
TITLE		DISTRIBUTION OF BELUGA WHALES (<i>Delphinapterus leucas</i>) IN THE MARINE RSA AND ADJACENT ARCTIC WATERS					
		PROJECT NO.		10-1373-0076		FILE No.	
		DESIGN	AK	19 Jul. 2012		SCALE AS SHOWN	REV. 0
		GIS	DSC	24 Jul. 2012			
		CHECK				FIGURE 8.3-10	
		REVIEW					



Narwhal (Monodon monoceros)

Two of 3 recognized populations of narwhals occur in the Canadian Arctic (Baffin Bay and Hudson Bay), with the third stock residing in East Greenland (COSEWIC 2004b). The populations are distinguished by means of their summer distribution, although the degree of genetic interchange between the 3 stocks is poorly known. The summer range of northern Hudson Bay narwhals includes the waters surrounding Southampton Island, with the larger aggregations in Repulse Bay, Frozen Strait, Western Foxe Channel, and Lyon Inlet (Figure 8.3-11). Most narwhal are assumed to winter in eastern Hudson Strait and range over an area of roughly 250 000 km² (COSEWIC 2004b), while some occur in open leads and polynyas in northern Hudson Bay and western Hudson Strait. The core summering areas potentially overlap with the proposed open-water shipping route between Rankin Inlet and eastern Hudson Strait (Figure 8.3-11).

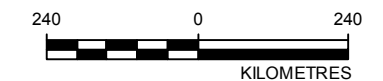
Little information is known on narwhal habitat requirements. Throughout the year, they appear to be closely associated with the Arctic pack-ice, following the distribution of the ice and moving towards coastal areas when these are ice free. In summer, they appear to prefer coastal areas and ice-free shallow bays. During freeze-up, the coastal areas are abandoned, and the narwhals move offshore (Heide-Jørgensen 2002). During their fall migrations, and later while wintering in the pack ice, narwhals tend to prefer deep fjords and the continental slope, where depths range from 1000 to 1500 m and upwelling zones may increase biological productivity. The quality of sea-ice habitat, particularly the presence of leads in fast-ice and the density of broken pack-ice, appears to highly influence habitat selection (COSEWIC 2004b). Narwhals generally travel in small groups in summer (<10 individuals), but gather in concentrations of many hundreds of animals during migrations in the spring and fall.

Mating in narwhals occurs between March and May, and calving occurs in July and August. Since the lactation period exceeds 12 months, the interval between successive conceptions is usually 3 years, but about 20% of females conceive at the first breeding season following birth of their calves (Heide-Jørgensen 2002). The basic life history features of the narwhal are similar to those of other medium-sized toothed whales (Hay 1985), with long life spans and sexual maturity estimated to be 6 to 7 years for females and 9 years for males (Garde et al. 2007). Narwhals feed heavily during migrations, but very little during the open water season (Hay and Mansfield 1989). Fish, squid, and shrimp make up the narwhal diet, particularly Arctic cod and polar cod (Heide-Jørgensen 2002). Their main predators are killer whales, polar bears, and humans, and possibly occasionally Greenland sharks and walruses (Hay and Mansfield 1989). Narwhal are harvested by coastal Inuit communities in Nunavut throughout the year under a quota system. The blubber is highly prized by the Inuit for food and is consumed locally or traded to other Inuit communities. The meat is also consumed as food. Narwhal tusks are a valuable economic commodity. In northern Hudson Bay, the harvest quota is presently set at 57 narwhals/year (under DFO's Integrated Fisheries Management Plan for narwhal in Nunavut), to be shared among hunters in Repulse Bay, Coral Harbour, Chesterfield Inlet, Rankin Inlet, Cape Dorset, Whale Cove, Kimmirut, Arviat, Baker Lake, and Hall Beach. The narwhal population in Hudson Bay is estimated to be approximately 3500 animals during summer (COSEWIC 2004b). COSEWIC (2004b) currently recognizes narwhal in the Canadian Eastern Arctic as a species of "Special Concern".

 Local Study Area (LSA)

 Marine Regional Study Area (Marine RSA)

Provincial data obtained from E. S. R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT		 AGNICO EAGLE				AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT			
TITLE		DISTRIBUTION OF NARWHAL <i>(Monodon monoceros)</i> IN THE MARINE RSA AND ADJACENT ARCTIC WATERS							
		PROJECT NO.		10-1373-0076		FILE No.			
		DESIGN	AK	10 Jul. 2012		SCALE AS SHOWN		REV. 0	
		GIS	DSC	24 Jul. 2012					
		CHECK	PR	18 Jan. 2013		FIGURE 8.3-11			
		REVIEW	DW	18 Jan. 2013					



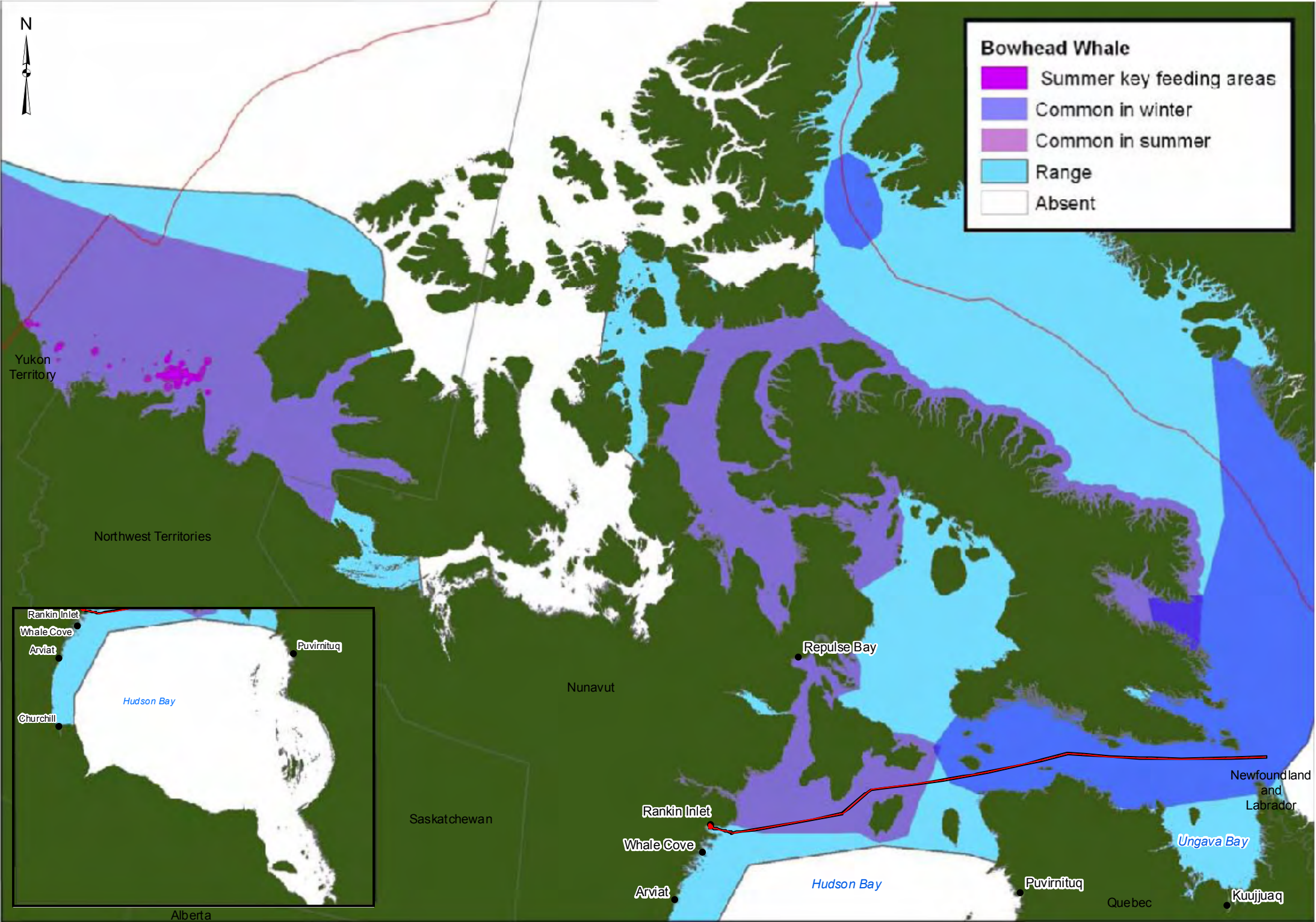
Bowhead whales (Balaena mysticetus)

The bowhead whale is the only baleen whale that occurs in circumpolar Arctic waters year-round. This species is especially well adapted to life in seasonally ice-covered seas by having no dorsal fin, a thick blubber layer, a low surface area to volume body ratio, and an enlarged head that they use to break through thick sea-ice (Montague 1993). Males tend to be smaller than females and reach sexual maturity at 12 to 13 m body length (Koski et al. 1993). Females reach sexual maturity at 12 to 14 m (Koski et al. 1993), which corresponds to >25 years in age (Rosa et al. 2004). There is evidence that the lifespan of bowhead whales can exceed 150 years (DFO 1999). Mating is believed to occur in February or March, with calves born from April to early June. Calves remain with their mothers for nearly a year (Koski et al. 1993).

Bowhead whales that occur in Hudson Bay/Hudson Strait belong to the Eastern Canadian Arctic-West Greenland (EC-WG) population, 1 of 4 populations present in Arctic waters. This population has a home range of approximately one million square kilometres, with summering grounds occurring in western Baffin Bay, the Canadian High Arctic, northern Foxe Basin, and northwestern Hudson Bay (COSEWIC 2009). Thus, impacts to the EC-WG bowhead whale population due to the Project have the potential for transboundary effects. Studies indicate that EC-WG bowhead whales travel large distances (Dueck et al. 2006; Ferguson et al. 2010a), may be spread over thousands of kilometres, and may segregate by size, sex, or reproductive status (Finley 2001). The fall migration occurs over 2 to 3 months starting in late August/September. Wintering grounds are located in areas of unconsolidated pack-ice, such as northern Hudson Bay, Hudson Strait, central Davis Strait, southern Baffin Bay, and off West Greenland. These areas provide shelter and protection from their main predator killer whales. During spring, whales from southeastern Baffin Island travel to summering areas in Prince Regent Inlet and Gulf of Boothia by either a southern route via Hudson Strait and Fury and Hecla Strait, or a northern route via Lancaster Sound. Figure 8.3-12 provides an overview of bowhead whale distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK. Seasonal migration and general distribution patterns of EC-WG bowhead whales are thought to be largely dictated by ice conditions (Ferguson et al. 2010a), water depth and temperature (Thomson et al. 1986; Finley 2001; Harwood et al. 2010), predators (NWMB 2000; Finley 2001; Laidre et al. 2008; Ferguson et al. 2010b), and abundance and distribution of their main prey species including euphausiids, copepods, and epibenthic organisms (mysids and gammariid amphipods) (Thomson et al. 1986; LGL 1987; Finley 2001; Harwood and Smith 2002; COSEWIC 2009).

The population of EC-WG bowhead whales is currently estimated at 6344 animals (95% CI 3119 to 12 906; COSEWIC 2009). Approximately 100 bowhead whales are presently thought to inhabit northern Hudson Bay and Hudson Strait on a year-round basis (CARC 1991). EC-WG bowhead whales are currently designated as 'special concern' (COSEWIC 2009) and are being considered for listing under the federal SARA. EC-WG bowhead whales currently support a limited subsistence harvest by Inuit in Nunavut, which is co-managed by the Nunavut Wildlife Management Board (NWMB) and DFO. The population crosses international boundaries and in 2007, the International Whaling Commission granted Greenland a quota of 2 animals / year from this population pending annual review of the hunt sustainability. There is interest from Inuit in Nunavut to harvest bowhead whales and an interest within Nunavut to increase their harvest.

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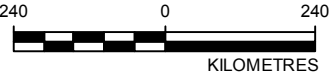
LEGEND

Local Study Area (LSA)

Marine Regional Study Area (Marine RSA)

REFERENCE

Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



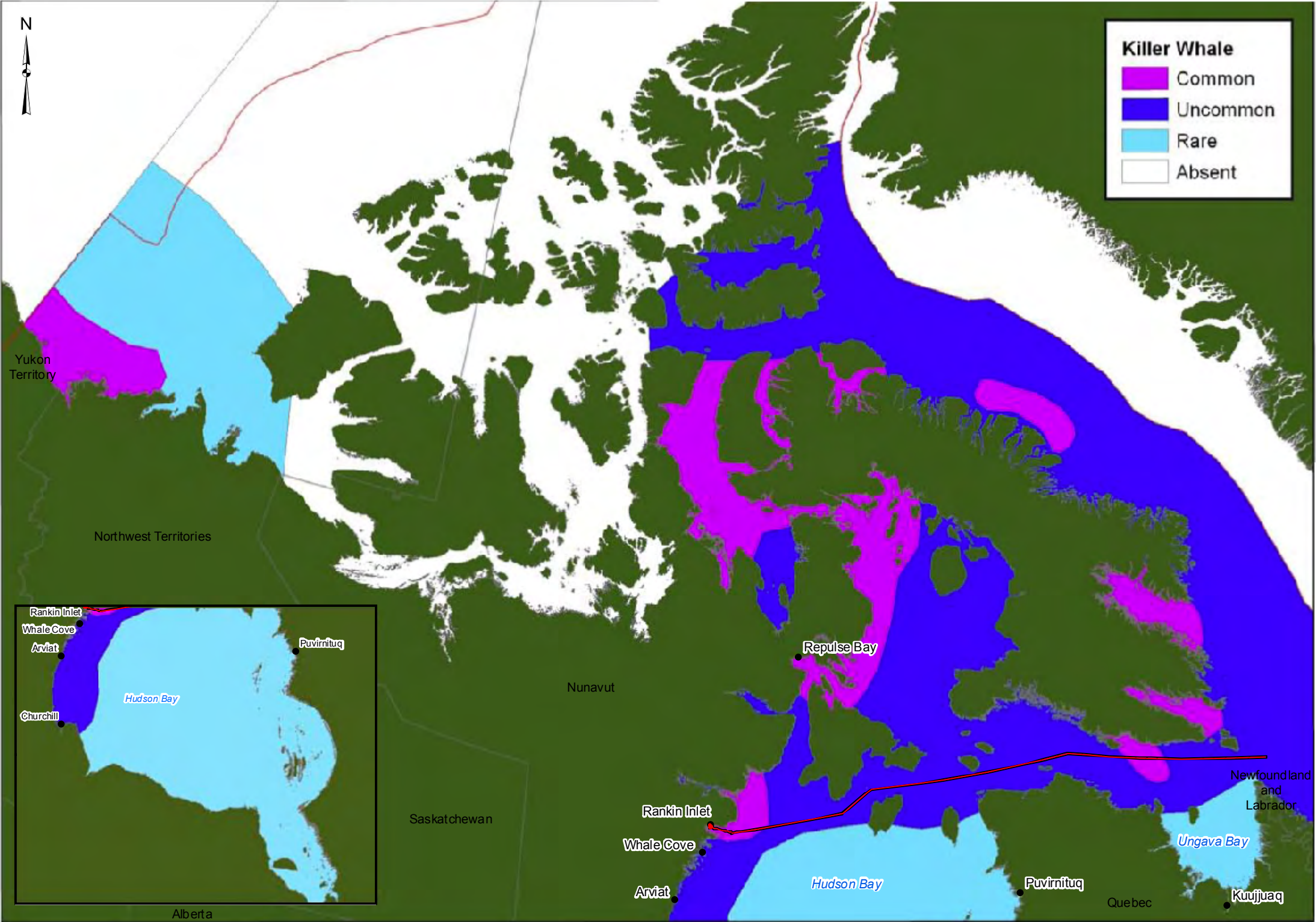
PROJECT		 AGNICO EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT	
TITLE			
DISTRIBUTION OF EASTERN CANADIAN ARCTIC / WEST GREENLAND BOWHEAD WHALES (<i>Balaena mysticetus</i>) IN THE MARINE RSA AND ADJACENT ARCTIC WATERS			
	PROJECT NO. 10-1373-0076		FILE No.
	DESIGN	AK	19 Jul. 2012
	GIS	DSC	24 Jul. 2012
	CHECK	PR	18 Jan. 2013
	REVIEW	DW	18 Jan. 2013
		SCALE AS SHOWN	
		REV. 0	
FIGURE 8.3-12			



Killer whale (Orcinus orca)

Killer whales are widely distributed throughout the Canadian Arctic, where they likely prey on a large variety of marine mammal species, including those harvested by coastal Inuit communities. They are known to migrate into Hudson Bay, Foxe Basin, and the central High Arctic each summer when open-water conditions allow (Dunbar and Moore 1980; Higdon 2007; COSEWIC 2008a), likely seeking out prey, such as seals (Leatherwood et al. 1976) and juvenile bowhead whales (Finley 2001). Declining summer sea ice may be allowing killer whales to expand their range in the Arctic, as they have been observed with increasing frequency in the Hudson Bay region (Higdon 2007). There is little available information on abundance or density of killer whales in Nunavut, and it is unknown if increases in sightings are representative of a growing population (Higdon 2007). The *Inuit Traditional Ecological Knowledge of Killer Whales* (Westdal 2009) summarised information on killer whales provided by workshop participants from Rankin Inlet, Arviat, Repulse Bay, Igloolik, and Hall Beach. Participants from Rankin Inlet indicated that killer whales have been around for a long time. In the past, there were not many killer whales seen near Rankin Inlet. About half the participants said that sightings have increased in recent years, and two participants mentioned that killer whales have been sighted by people in the community every summer since 2000 (Volume 9 Section 9.3.1.3.3.3). Figure 8.3-13 provides an overview of killer whale distribution in the RSA based on historical sightings, current scientific knowledge (satellite telemetry studies and prey distribution), and Inuit TK. Killer whales are not actively hunted by coastal Inuit communities in the Canadian Arctic. IQ

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LEGEND

Local Study Area (LSA)

Marine Regional Study Area (Marine RSA)

REFERENCE

Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Datum: NAD 83 Projection: Canada Albers Equal Area Conic

2400240

KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISTRIBUTION OF KILLER WHALE
(*Orcinus orca*) IN THE MARINE
RSA AND ADJACENT ARCTIC WATERS

Golder
Associates

PROJECT NO.	10-1373-0076	FILE No.
DESIGN	AK	19 Jul. 2012
GIS	DSC	24 Jul. 2012
CHECK	PR	18 Jan. 2013
REVIEW	DW	18 Jan. 2013

SCALE AS SHOWN

REV. 0

FIGURE 8.3-13



Polar bear (*Ursus maritimus*)

Polar bears in the Canadian Arctic are segregated into 13 sub-populations, with those occurring in the RSA belonging to the Western Hudson Bay (WHB), Foxe Basin (FB), and Davis Strait (DS) sub-populations (Thieman et al. 2008). Delineation of the geographic separation of these 3 sub-populations is shown on Figure 8.3-14. Polar bears generally occur at low densities throughout their range and are most abundant in shallow water areas near shore or where currents or upwellings increase biological productivity near ice edges associated with open water, polynyas, or lead systems (Schliebe et al. 2008). The productivity of polar bear habitat is closely linked to the physical attributes of sea ice and the density and distribution of ice-dependent seals, especially ringed and harp seals (COSEWIC 2008b; Peacock et al. 2013). From early winter until spring, polar bears are dispersed predominantly over sea-ice along the coast where they may range >200 km offshore. The annual ice melt generally forces polar bears in Hudson Bay and James Bay ashore from mid-July through late August, when they are at their maximum yearly weight from feeding on fat, newly-weaned seals. IQ on aspects of climate change from residents of Baker Lake and Arviat suggests that ice is melting earlier in recent years (as early as June) and may be forcing bears to retreat ashore sooner than in previous years (GN 2005). Polar bears tend to show long-term site fidelity with respect to preferred terrestrial summering grounds and spend several months of the open-water season in coastal areas, with some individuals also found inland (COSEWIC 2008b). During the summer, the WHB sub-population tends to congregate on coastal capes and headlands between Cape Churchill and Arviat (Figure 8.3-15; Stapleton et al. 2014; Stirling et al. 1999). Arviat residents have reported that polar bears are becoming more common in areas in which they have not been observed previously, particularly during the summer months (GN 2005). IQ The FB polar bear sub-population concentrates along the coastline during late summer and is observed in highest densities on Southampton Island, on several islands near Lyon Inlet, and on coastal islands throughout the Foxe Basin area (Figure 8.3-16; Garshelis et al. 2012). In the Project area, the DS sub-population congregates along coastal areas of Frobisher Bay, on Akpatok Island, and along the northern tip of Ungava Bay (Labrador / Quebec border) at the entrance to Hudson Strait (Figure 8.3-16; Peacock et al. 2013). During the open-water season, polar bears also have been observed offshore swimming in ice-free waters of Hudson Bay as reported during aerial surveys and other field investigations being conducted in the region (S. Atkinson 2013, pers. comm.). The majority of these sightings occurred less than 5 km from shore and in waters adjacent to larger islands (S. Atkinson 2013, pers. comm.; M. Dyck 2014, pers. comm.). No open-water surveys targeting polar bears have been conducted during the summer, and, therefore, no at-sea density estimates are available for this species during this period. However, the number of polar bears occurring offshore during the open-water summer season is thought to be minimal (S. Atkinson 2013, pers. comm.; M. Dyck 2014, pers. comm.).

During fall, there is a gradual northward movement of the WHB subpopulation along the south coast of Hudson Bay, as bears gather to await the formation of new sea ice in November (Amstrup et al. 2007). Some polar bears tagged in the Churchill region moved northward along the Kivalliq Coast as far as Chesterfield Inlet (Stirling et al. 1999). The winter concentration of WHB polar bears is situated around Arviat, just under 200 km south of Rankin Inlet (Taylor et al. 2001; Van de Velde et al. 2003; Stephenson and Hartwig 2010). These polar bears may overlap with the RSA and LSA in Melvin Bay during this time. During winter and spring, polar bears belonging to the Davis Strait sub-population use the sea ice along Davis Strait, Labrador Sea, and west to Ungava Bay and eastern Hudson Strait (Peacock et al. 2013). During winter, the FB sub-population generally is restricted within the mouth of Hudson Strait (COSEWIC 2008b). Figure 8.3-16 provides an overview of polar bear distribution in the RSA based on historical sightings, current scientific knowledge, and Inuit TK.



When the majority of individuals move back onto the ice in November during freeze-up, pregnant females remain on land near the coast to dig maternity dens in deep snowdrifts and frozen ground. Breeding occurs in March to May, implantation is delayed until fall, and birth is generally thought to occur from late November to mid-January. Although some cubs are born in earth dens, most births occur in snow dens that may be occupied for 5 to 6 months during the maternal event (Schliebe et al. 2008). Only pregnant female polar bears den for this extended period of time, during which time they rely on fat stores for energy and sustenance. The average litter size is less than 2. Cubs are dependent upon mothers until after the start of their third year of life. Age of first reproduction is normally 5 to 6 years for females. These factors contribute to the low reproductive potential for the species (Schliebe et al. 2008).

The WHB subpopulation was shown to have declined by 22% between 1987 and 2004, from approximately 1294 individuals in 1987 to 935 individuals in 2004 (Regehr et al. 2007). However, recent aerial surveys conducted during summer of 2011 estimate abundance of the WHB sub-population at just over 1000 animals (Stapleton et al. 2014). The highest concentrations of bears occurred along the coasts and surrounding islands, particularly in the area south of Arviat. This study is supported by TK (Inuit Qaujimagatuqangit) shared by Inuit Elders indicating that the number of polar bears and dens along the western coast of Hudson Bay are increasing (COSEWIC 2008b). Results from a compilation of interviews conducted with local Inuit by the Nunavut Tunngavik Incorporated (NTI) indicate that polar bear numbers in the Rankin Inlet region have been increasing since the 1980s (NTI 2005).

IQ

The DS sub-population was recently estimated by Peacock et al. (2013) by compiling 35 years of mark-recapture studies. This sub-population was estimated to number 2158 individuals (± 180 SE) in 2007 - an increase from the last population assessment conducted in 1970. The population is thought to be influenced by low recruitment rates, average adult survival rates, high population density when compared to other sub-populations in the area, as well as high prey density but variable ice conditions. Peacock et al. (2013) suggest that the DS subpopulation appears to be stable and likely may be experiencing the effects of density dependence.

Mark-recapture surveys conducted from 1989 to 1994 estimated the FB sub-population at 2197 individuals (± 256 SE) (Taylor et al. 2006). In 2004, the estimated abundance of this sub-population had increased to 2300 animals. Information from TK studies suggested the population was increasing and the opinion of various scientists agreed that an increase may have occurred due to low historical harvests rates (COSEWIC 2008b). Recent aerial surveys conducted during the late summer of 2009 and 2010 generally agreed with these previous population assessments, and estimate polar bear abundance for the FB subpopulation at approximately 2580 individuals (95% CI about 2100 - 3200); Garshelis et al. 2012). The FB sub-population, characterized by average litter sizes, robust annual growth rates, and good body conditions (Garshelis et al. 2012), appears to be near stable taking into account current harvest levels.

IQ

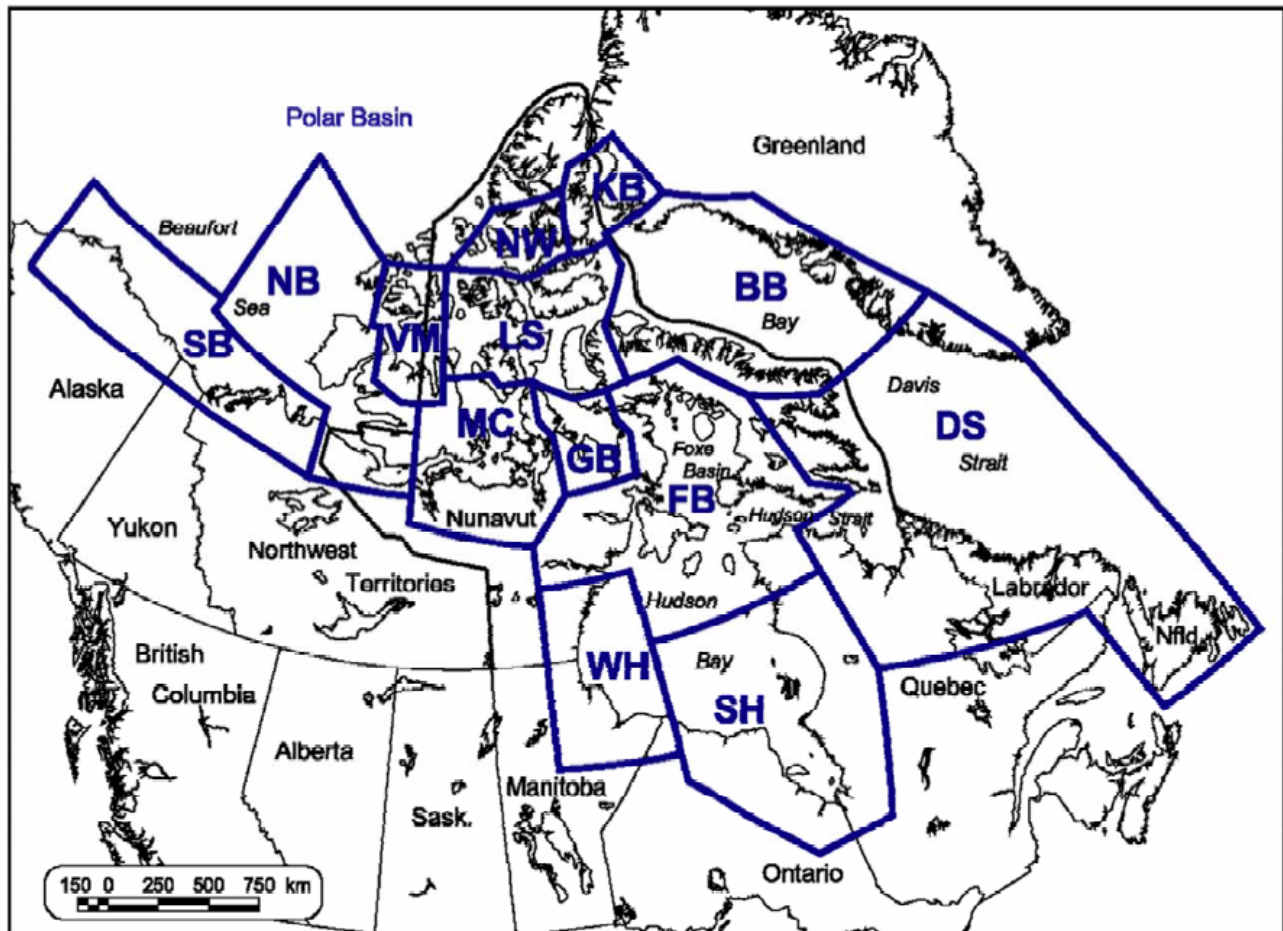


Figure 8.3-14: Canadian Sub-populations of Polar Bears. Abbreviations of Delineated Sub-populations include Viscount Melville Sound (VM), Norwegian Bay (NW), Kane Basin (KB), Lancaster Sound (LS), Baffin Bay (BB), Davis Strait (DS), Southern Hudson Bay (SH), Western Hudson Bay (WH), Foxe Basin (FB), Gulf of Boothia (GB), M'Clintock Channel (MC), Southern Beaufort Sea (SB), and Northern Beaufort Sea (NB) (adapted from COSEWIC 2008b)

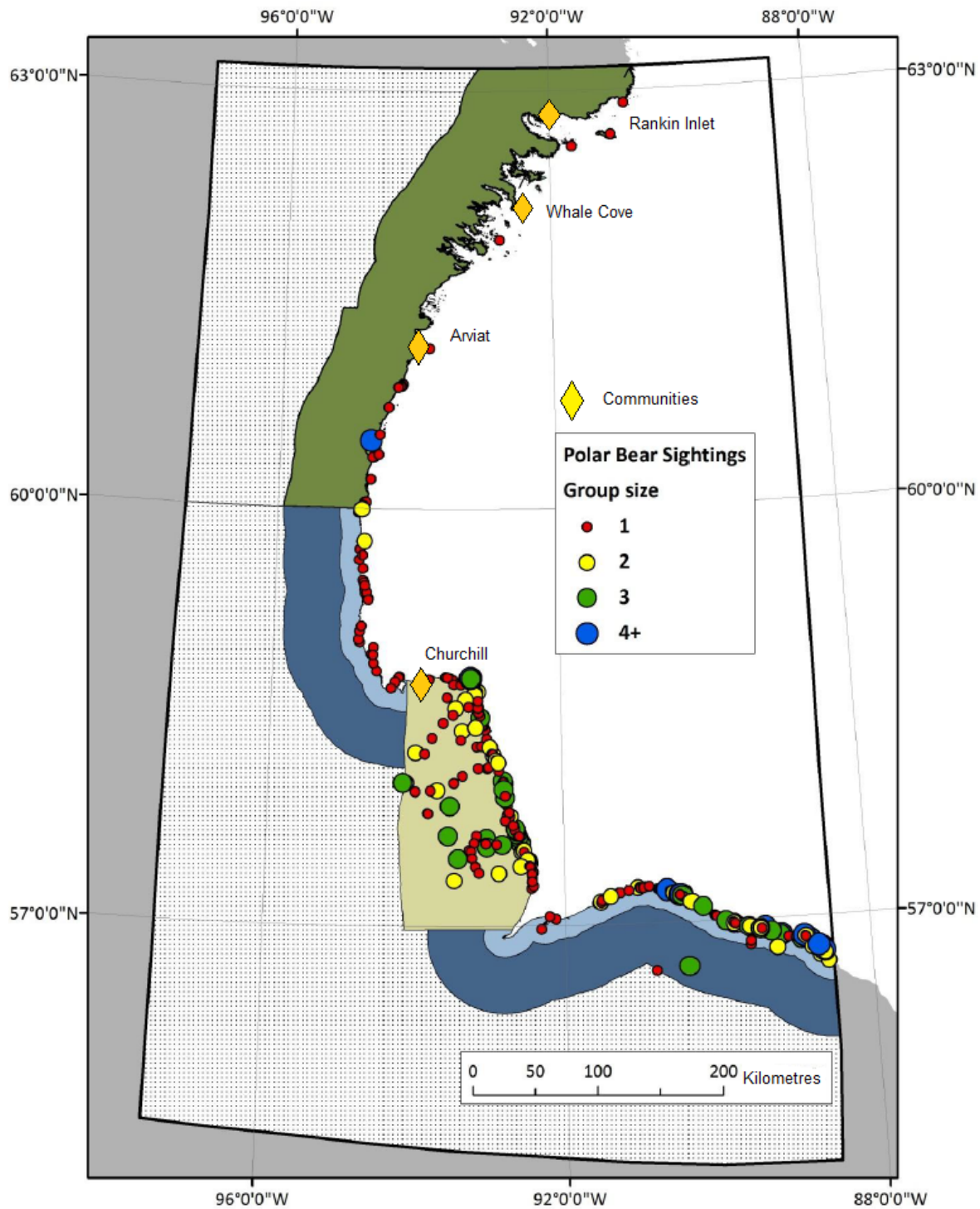
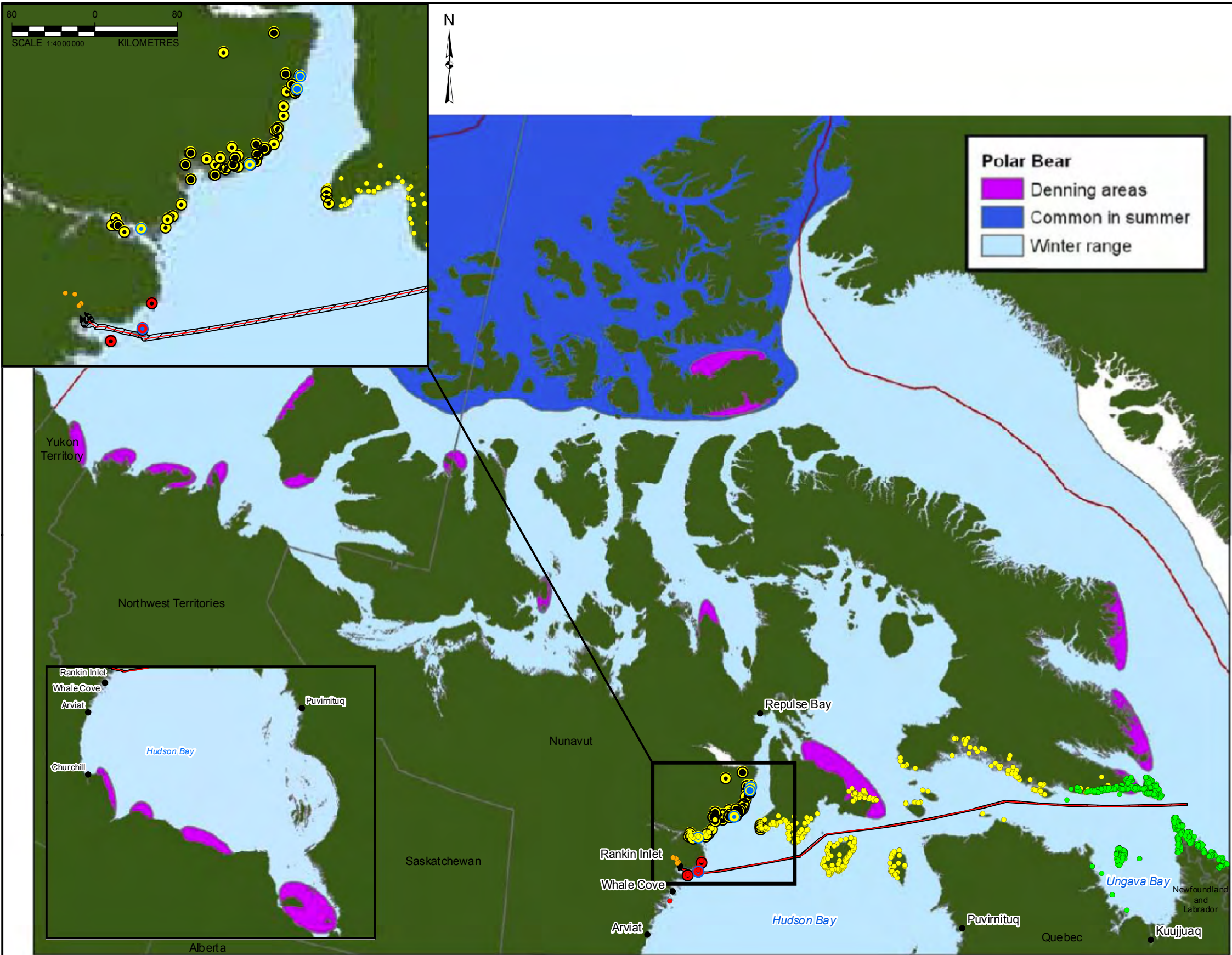


Figure 8.3-15: Polar Bear of the Sightings Recorded During Aerial Surveys in the Western Hudson Bay in August of 2011 (adapted from Stapleton et al. 2014)

N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Figure_8.3-16_Distribution_of_Polar_Bear.mxd



LEGEND

Polar Bear Sightings

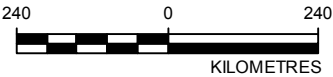
- 2009/2010 Aerial Survey Sightings during Late Summer (GN Unpublished Data)
- 2005-2007 Mark Capture-recapture Survey (GN Unpublished Data)
- West Hudson Bay - August 2011 Aerial Survey (GN Unpublished Data)
- Summer Polar Bear Sightings Collected during Field Work
- 1 Spotting
- >1 Spotting
- Spotted In Water
- Shipping Route (Approximate)

Polar Bear

- Denning areas
- Common in summer
- Winter range

REFERENCE

Provincial data obtained from E.S.R.I.
Base image obtained from Stephenson and Hartwig, 2010
Government of Nunavut (GN) Unpublished Data provided by M.Dyck and S.Stapleton
Datum: NAD 83 Projection: Canada Albers Equal Area Conic



PROJECT



AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

DISTRIBUTION OF POLAR BEAR (*Ursus maritimus*)
IN THE MARINE RSA AND ADJACENT ARCTIC WATERS
(ADAPTED FROM STEPHENSON AND HARTWIG 2010,
GN UNPUBLISHED DATA)



PROJECT NO.

10-1373-0076

FILE No.

DESIGN

AK

19 Jul. 2012

SCALE AS SHOWN

REV. 0

GIS

DSC

24 Jul. 2012

CHECK

KZ

16 Feb. 2014

REVIEW

DRW

16 Feb. 2014

FIGURE 8.3-16





Polar bears are harvested by coastal Inuit communities in Nunavut throughout the year under a quota system. The polar bear quota increased from 8 to 21 bears from the 2010-2011 to the 2011-2012 annual quota for the Western Hudson Bay sub-population, which includes the area around the communities of Arviat, Baker Lake, Whale Cove, Rankin Inlet, and Chesterfield Inlet (GN 2011). The 2013-2014 recommended quota is 24 bears (GN 2013). The number of polar bears hunted in Rankin Inlet from 1996 to 2001 ranged from 1 to 13 bears (Priest and Usher 2004). The annual 2013-2014 hunting quota for the FB subpopulation is 106 bears and includes 7 communities in Nunavut and 4 in Quebec (GN 2013; COSEWIC 2008b). The annual quota for the DS subpopulation was 61 bear for 2012-2013; the recommended 2013-2014 quota is 48 bears (GN 2013). COSEWIC (2008b) currently recognizes polar bears in the Canadian Arctic as a species of “Special Concern”.

Hearing Abilities of Marine Mammals

Marine mammals are acoustically diverse, with wide variations in ear anatomy, frequency range, and amplitude sensitivity (Ketten 1991). An animal's sensitivity to sound varies with frequency. Response to underwater sound likely depends strongly on the presence of and level of sounds in the frequency bands or range of frequencies to which the animal is most sensitive (Richardson et al. 1995a). The general trend is that larger species, such as bowhead whales, tend to have better hearing sensitivities at lower frequency ranges than smaller species, such as beluga whales and narwhal. Hearing abilities are generally only well understood in certain captive species where audiograms (plots of hearing threshold at different sound frequencies) have been developed based on behavioural response studies (reactions to sound) and electrophysiological experiments (measuring auditory evoked potentials) (Erbe 2002).

Toothed Whales (Beluga, Narwhal, Killer Whale)

The hearing abilities of beluga whales and narwhals at high frequencies are exceptionally well developed. This likely is related to their use of high frequency sounds for echolocation. Audible frequencies for toothed whales range from 80 Hz to 150 kHz, but they are most sensitive to sounds in the frequency range of 8 to 90 kHz (Richardson et al. 1995a).

Beluga whales are considered ‘mid-frequency cetaceans’ (Southall et al. 2007), meaning their most sensitive hearing range occurs in the mid-frequency range. Using sound for foraging, navigation, and social purposes, they are a highly vocal species with call types consisting of echolocation clicks, pulsed tones, whistles, and noisy vocals. Echolocation clicks are produced in the 40 to 60 kHz and 100 to 120 kHz range, with source levels reported at 206 to 225 dB re 1 μ Pa at 1 m (Au 1993). Non-echolocation calls (e.g., whistles) are centered on frequencies below 6 kHz, but may sometimes attain frequencies up to 14 kHz (Schevill and Lawrence 1949; Sjare and Smith 1986), with dominant frequencies ranging between 400 Hz and 8.3 kHz. Belugas can detect frequencies as low as 40 to 75 Hz; however, their sensitivity at this range is poor (Awbrey et al. 1988). Beluga whales have been documented to communicate with one another at distances of over 300 to 500 m (Bel'kovich and Shchekotov 1992).

No behavioural or electrophysiological audiograms are available for narwhals. Their vocalizations include echolocation clicks, pulsed tonal calls, and whistles. Narwhal echolocation sounds have been recorded at 40 kHz, with source levels reported at 218 dB re 1 μ Pa at 1 m (Mohl et al. 1990). Pulsed tones are produced in the 500 Hz to 5 kHz range, and whistles have been reported in the 300 Hz to 18 kHz range, with dominant frequencies occurring at 300 Hz to 10 kHz (Ford and Fisher 1978).

**Baleen Whales (Bowhead Whales)**

On a comparative basis, the baleen whale auditory system does not appear as specialized as that of toothed whales (Ketten 1997). Audiograms are not available for baleen whales due to the lack of these animals in captive settings, which is required (based on current technology) to conduct behavioural and electrophysiological hearing studies. Hearing thresholds and frequency sensitivities in baleen whales are thus inferred from anatomical ear structure, vocalizations, and behavioural studies in the wild (Richardson et al. 1995a). In general, most baleen whale species have been shown to react to frequencies below 1 kHz (Richardson et al. 1995a). They have an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007).

Hearing in bowhead whales can be inferred indirectly by the frequency at which they vocalize and the levels of sound at which behavioural reactions occur. Bowhead whales have been shown to react to sound with dominant frequencies between 50 and 500 Hz (Richardson et al. 1995a). Avoidance behaviour has been reported when bowhead whales were exposed to low broadband sounds of 90 dB re 1 μ Pa (Richardson et al. 1995a). The majority of the sounds produced by bowhead whales are low frequency-modulated calls, with reported frequency ranges of approximately 25 to 900 Hz (Ljungblad et al. 1982; Clark and Johnson 1984; Cummings and Holliday 1987). Bowhead vocalizations include pulsive and tonal sounds, the latter either descending, ascending, constant, or inflecting in frequency (Clark and Johnson 1984). The duration of bowhead vocalizations range from short 0.5 second signals to long and melodic 4 to 5 second tones (Clark and Johnson 1984). Most single-note tones carry little sound energy above 400 Hz (Wursig and Clark 1993). Source levels from tonal moans and pulsive sounds range from 128 to 185 dB re 1 μ Pa at 1 m, with some vocalizations recorded by hydrophones up to 20 km away from calling whales (Clark et al. 1986).

Singing behaviour is considered to be an advanced form of vocalization in baleen whales (Clark 1991). Songs are composed of units, phrases, and themes; units sung in a sequence form phrases, a repetition of a phrase is a theme, and several themes combined create a song that can last several minutes (Payne and McVay 1971). Songs have been documented to change within and between seasons (Clark and Johnson 1984; Würsig and Clark 1993; Tervo et al. 2007).

Pinnipeds (Seals and Walrus)

Underwater hearing sensitivity in seals and walrus falls in between that of baleen and toothed whales, with an estimated auditory bandwidth between 75 Hz and 75 kHz. Phocinid seals, such as the ringed seal and bearded seal, have underwater hearing thresholds between 60 and 85 dB re 1 μ Pa at 1 m, with flat audiograms between 1kHz and 30 to 50 kHz (Mohl 1968; Terhune and Ronald 1972, 1975; Terhune 1981). Some phocinids have been documented to be able to detect very high frequency sounds up to 180 kHz, although, their sensitivity to sounds above 60 kHz is poor and frequencies cannot be discriminated (Mohl 1968).

Ringed seal vocalizations include barks, clicks, and yelps, all of which occur in the 400 Hz to 16 kHz frequency range, with dominant frequencies concentrated above 5 kHz (Stirling 1973; Cummings et al. 1984). Source levels are between 95 and 130 dB re 1 μ Pa at 1 m, considerably lower in energy than other marine mammal vocalizations, and likely the reason why ringed seal vocalizations generally are detectable only within 1 km of the source (Cummings et al. 1984).

Bearded seals vocalize in the form of 'songs', which are presumed to be associated with territoriality and courtship (Ray et al. 1969; Budelsky 1993). Songs have been recorded at between 20 Hz and 6 kHz, with dominant frequencies occurring at 1 to 2 kHz, and source levels of 178 dB re 1 μ Pa at 1 m (Ray et al 1969;



Stirling et al 1983; Cummings et al. 1984). Unlike ringed seals, bearded seal vocalizations can be detected as far as 25 km from the source (Cleator et al. 1989).

Few studies have measured the audiogram of the walrus. In general, walrus have sensitive hearing to low frequency sounds (Kastelein et al. 2002). A study of an 18-year-old captive walrus reported an optimal hearing range between 1 kHz and 12 kHz, with maximum sensitivity (67 dB re 1 µPa at 1 m) occurring at 12 kHz (Kastelein et al. 2002). Hearing sensitivity fell gradually below 1 kHz and dropped off sharply above 12 kHz (Kastelein et al. 2002). Walrus vocalizations include bell tones (male-specific), clicks, taps, knocks, rasps, and grunts. The dominant frequencies of most vocalizations occur between 400 and 1200 Hz (Ray and Watkins 1975). Clicks and taps are produced in the 100 Hz to 10 kHz range, with dominant frequencies concentrated below 2 kHz. Rasps are produced in the 200 to 600 Hz range, with dominant frequencies occurring between 400 and 600 Hz. The dominant frequencies of grunts occur below 1 kHz (Scheville et al. 1966; Ray and Watkins 1975; Stirling et al. 1983). Vocalizations in walrus are typically associated with herd organization and coordination behaviour (Richardson et al. 1995a).

Polar Bear

Little is known on underwater hearing abilities in polar bears. In-air hearing has been studied on captive subjects (using auditory evoked potentials to produce audiograms) demonstrating that polar bears can likely hear in-air at a slightly wider range of frequencies than humans (up to 25 kHz) and have absolute hearing thresholds below 27 to 30 dB re 20 uPa at 1 m (Nachtigall et al. 2007).

8.3.2.2.1.4 Species at Risk

COSEWIC and SARA-listed species potentially occurring within the RSA include 4 marine bird species and 5 marine mammal species, as outlined in Table 8.3-6.

Table 8.3-6: Species at Risk Potentially Occurring in the shipping corridor in Hudson Bay / Hudson Strait

Common Name	Species	SARA Status ^a	COSEWIC Status ^b
Marine Mammals			
Narwhal	<i>Monodon monoceros</i>	No status	SC
Beluga whale	<i>Delphinapterus leucas</i>	No status	EN – EHB stock SC – WHB stock
Bowhead whale	<i>Balaena mysticetus</i>	No status	SC
Polar bear	<i>Ursus maritimus</i>	SC – Schedule 1	SC
Walrus	<i>Odobenus rosmarus</i>	No status	SC
Marine Birds			
Peregrine falcon	<i>Falco peregrinus tundrius</i>	SC-Schedule 1	SC
Ross's gull	<i>Rhodostethia rosea</i>	TH – Schedule 1	TH
Ivory gull	<i>Pagophila eburnea</i>	EN – Schedule 1	EN
Red knot	<i>Calidris canutus</i>	EN - <i>rufa</i> ssp. – Schedule 1 SC - <i>islandica</i> ssp. – Schedule 1	EN - <i>rufa</i> ssp. SC - <i>islandica</i> ssp.

^a SARA (Species at Risk Act). The Act is a key federal government commitment to prevent wildlife species from becoming extinct and secure the necessary actions for their recovery. It provides for the legal protection of wildlife species and the conservation of their biological diversity (extracted from SARA 2012).

^b COSEWIC (Committee on the Status of Endangered Wildlife in Canada) is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada. It is up to Government to legally protect wildlife species designated by COSEWIC. The potential impacts of legal listing are for Government to analyse, and the Species at Risk Act (SARA) applies only to wildlife species on the SARA legal list (extracted from COSEWIC 2012).

EN=Endangered, SC=Special Concern, TH=Threatened



Mitigation measures will be implemented to avoid or minimize any adverse effects from the Project on species at risk (SAR) in the marine environment regardless of the 'significance' of effects determined as part of the assessment. If marine-based SAR are encountered during the Project, including evidence of a SAR (e.g., dens, nests or eggs of a SAR), the primary mitigation measure implemented will be avoidance. A monitoring program will be undertaken to confirm that mitigation measures are successful. The results of monitoring will be provided to the relevant agency with management responsibility for the applicable SAR involved. Mitigation and monitoring strategies will be consistent with applicable status reports, recovery strategies, action plans and management plans that may become available during the Project.

Detailed mitigation measures proposed for the Project effects are discussed in detail in the sections below. In some instances, mitigation measures for one species are also relevant for other species. Follow-up and monitoring is discussed for all species in Section 8.3.11.

8.3.2.2.1.5 Sensitive/Protected Areas

Measures have been taken by federal, provincial, and territorial governments, non-governmental organizations, as well as international organizations to identify, evaluate and protect areas of biological importance in Nunavut's marine and coastal environment. This section provides an overview of these protected areas in Hudson Bay / Hudson Strait in relation to the proposed shipping corridor (RSA).

Marble Island

Marble Island, located approximately 45 km southeast (offshore) of Rankin Inlet (Figure 8.1-2) in proximity to the existing shipping corridor, was identified during the TK study as an important congregation area for whales, seals, and birds (FEIS Volume 9, Section 9.3). This area has a long history of diverse use by Inuit who first came to the island as seasonal hunters, taking advantage of its wide variety of wildlife (Davis 1996). Marble Island is formally listed on the Canadian Register of Historic Places (Parks Canada 2012). Stewart et al. (1991) recommended the Rankin Inlet–Marble Island marine area to Parks Canada for consideration as a national marine park to conserve and protect the following key ecological and cultural features of this area: IQ

- a dense, breeding population of threatened peregrine falcons near Rankin Inlet;
- a large breeding colony of common eider on Marble Island;
- anadromous stocks of Arctic char, which are locally harvested by Inuit communities;
- unique oceanographic conditions influenced by the influx of Chesterfield Inlet waters;
- maritime historical sites at Marble Island from the Knight Expedition and the whaling period including 2 shipwrecks; and
- evidence of historical coastal Inuit cultures (Stewart and Lockhart 2005).

Both the exceptional peregrine population and the maritime historical sites at Marble Island are facing increasing human disturbance and would benefit from the protection afforded by National Parks designation as they are located near the growing community of Rankin Inlet and are a stop for tourists visiting by cruise ship. The area's rocky Canadian Shield shoreline provides a greater variety of marine habitats than the Churchill-Nelson area. Diana and Meliadine rivers provide small-scale estuarine habitats. This area would afford some protection to historical bowhead whale habitats, although more suitable bowhead whale habitat is present to the north in Roes



Welcome Sound. All Project vessels along the shipping route will maintain a minimum distance of 2 km from Marble Island in order to avoid disrupting sensitive marine species located on or around the Island.

Ecologically and Biologically Significant Areas

DFO has identified a number of Arctic Ecologically and Biologically Significant Areas (EBSAs) in Hudson Bay and Hudson Strait using criteria from the Convention on Biological Diversity (Cobb 2011). These areas have been previously identified as important in ecosystem overviews, stock status reports, and traditional knowledge studies. Those EBSAs in the Hudson Bay Complex biogeographic region that overlap with the proposed shipping corridor are described below and illustrated in Figure 8.3-17:

Southampton Island (including Coats Island) (EBSA 1.5)

- Largest island in Hudson Bay and situated near the confluence of Hudson Bay and Foxe Basin waters resulting in dynamic oceanographic mixing, and high marine productivity.
- Summer and winter use by the Northern Hudson Bay-Davis Strait population of Atlantic Walrus (Special Concern under COSEWIC).
- The waters surrounding Southampton Island are important spring and fall migration routes for beluga whales (Endangered under COSEWIC) and EC-WG bowhead whales (Special Concern under COSEWIC).
- Important nesting areas occur on Coats Island for seabirds (thick-billed murre, common eider, and black guillemot), which feed on aggregations of marine fish (e.g., capelin and Arctic cod) (Mallory and Fontaine 2004). The largest single colony of common eider in Nunavut occurs in East Bay.
- Southampton, Coats, and Mansel islands also are considered important denning and summer refuge habitat for the Foxe Basin polar bear population. Polar bears also frequent the land-fast ice adjacent to the islands in winter.
- Data confidence for this area is high due to intensive marine bird studies, tagging and survey data for marine mammals, and published IQ. The Southampton Island area scores high for several EBSA criteria.

Western Hudson Bay (Whale Cove to Arviat) (EBSA 1.6)

- Important area for beluga, killer whale, seabirds and Arctic char.
- Dense kelp beds occur along the coastline and provide important habitat for fish in the area.
- Area supports a wealth of LEK and TEK from the communities of Whale Cove, Rankin Inlet, and Arviat on the importance of marine mammals and fish (DFO 2011a).
- Important Arctic char stocks exist in this area and use the marine environment for feeding.

Western Hudson Bay/Churchill/Nelson/Seal Estuaries (EBSA 1.7)

- The Nelson and Churchill estuaries provide an important habitat for a number of marine mammals and fish including the world's largest summer aggregation of beluga whales (Endangered under COSEWIC). Up to 3000 beluga whales congregate annually in the Nelson River estuary, with smaller numbers in the Churchill River estuary, to rear young and feed in these waters. Although the reason for these aggregations is not known, 2 commonly reported hypotheses are 1) thermal advantage from warm freshwater to initiate moulting; and 2) an evolutionary adaptation to take refuge from predation by killer whales in the shallow



estuaries. Aggregations of approximately 70 000 beluga whales in this area are important for population fitness consequences.

- The Churchill region represents a key denning, feeding, and point of mobilization for Western Hudson Bay polar bear, which head north along the newly formed sea-ice to hunt ringed seal during fall/winter.
- A high degree of certainty exists for biophysical data available for this area due to Manitoba Hydro EIA Projects on the Nelson and Churchill rivers, as well as ongoing studies investigating the effects of climate change on marine mammals.
- The Seal River estuary was identified in 1999 as an Important Bird Area and is globally important for migrating black scoter.
- The Seal River is a Canadian Heritage River and remains a pristine, high-grade, remote wilderness river. It is the largest remaining undammed river in northern Manitoba. Harbour seals travel considerable distances up the Seal River estuary, representing a important adaptation to the freshwater environment by a marine mammal.
- The Province of Manitoba has designated a number of legally protected and managed lands, and identified Areas of Special Interest (candidate protected areas) along the Manitoba coastline for various ecological and biological reasons.
- Five internationally recognized Important Bird Areas have been identified along this part of Hudson Bay.
- Wapusk National Park and the provincially designated Churchill Wildlife Management Area, which extends to the Manitoba border and protects one of the world's largest known polar bear maternity denning areas. This national park also protects important caribou habitat. Similarly, the Kaskatamagan Wildlife Management Area (provincial designation) was established to protect the fragile coastal and tundra ecosystems and to protect important habitat for a number of bird species. The Churchill Special Conservation Area, designated to conserve and protect the Ross's gull, is also an integral part of the primary polar bear migration corridor in Manitoba.
- Hubbart Point, located north of the Seal River estuary, is an aggregation area for older male polar bears during the ice-free season. Beluga whales also congregate in waters off Hubbart Point, which is part of the North Hubbart Area of Special Interest.

West and Central Hudson Strait (EBSA 1.10):

- Serves as a key channel for Arctic waters via Foxe Basin, the outflow of Hudson Bay water, and also periodic intrusions of Atlantic water into northeastern Hudson Bay.
- Major seasonal migration route for all marine mammals that spend the summer in Hudson Bay and Foxe Basin and winter in either Hudson Strait or Davis Strait, including beluga whale, narwhal, and bowhead whale. The use of Hudson Strait by migrating marine mammals has been well documented through tagging studies and Inuit TK.
- Walrus spend winters in west and central Hudson Strait on ice flows and on islands, such as Nottingham and Salisbury, where strong currents maintain open water. Walrus also overwinter on the northern shore of Hudson Strait near Kimmirut.
- Productivity is higher in West and Central Hudson Strait than Foxe Basin or Hudson Bay.

IQ



- Support a number of important seabird nesting and feeding areas that occur on the northern and southern shores. Twenty percent of the North American population of thick-billed murre and a small colony of Atlantic Puffins are found near the Digges Sound and 10% of the Canadian population of common eiders breed and feed near Markham Bay (Mallory and Fontaine 2004).
- Physical oceanography in this EBSA has been well studied as part of long-term studies on Arctic flow-through.

Eastern Hudson Strait (EBSA 1.11):

- Heavily influenced by oceanographic conditions from Davis Strait resulting in high productivity.
- Important area for shrimp - Canadian Shrimp Fishing Area 3 occurs near Northern Ungava Bay eastward to Resolution Island.
- Supports western extent of Greenland halibut habitat.
- Provides significant overwintering refuge for Hudson Bay beluga whales and approximately 5000 to 8000 bowhead whales during winter.
- Support important occurrences of cold water corals in the deeper waters of the strait (Kenchington et al. 2011).

Ungava Bay (EBSA 1.12):

- Support Ungava Bay beluga whale stock, which has been reduced to as few as approximately 50 animals and may be extirpated (presently listed as Endangered under COSEWIC).
- Support important occurrences of corals in the deeper waters of the bay (Kenchington et al. 2011).
- Support 2 large colonies of thick-billed murre on Akpatok Island (Mallory and Fontaine 2004). Collectively, these colonies constitute the largest number of breeding thick-billed murre in Canada (>20% of the Canadian population). Black guillemots also nest along the Akpatok Island coast.
- A large portion of the breeding population of common eiders aggregate on the islands off the western shore of Ungava Bay. Key nesting sites occur at the Eider, Plover, Payne, and Gyrfalcon islands and the islands of northeastern Ungava Bay.
- Approximately 80 to 100 polar bear (~5% of the Davis Strait population) den and rear cubs along the southern shore of Akpatok Island during summer.



Figure 8.3-17: Preliminary EBSA Identification Results for Foxe Basin (in solid red; 1.1 to 1.3) and for Hudson Bay / Hudson Strait (in red hatched lines; 1.4 to 1.12) as Determined Through a Series of Workshops Conducted in 2009 (DFO 2010b) (extracted from Cobb 2011)

National Parks

To date, Parks Canada has established 2 National Parks in the Hudson Bay marine ecosystem: Wapusk and Ukkusiksalik (Stewart and Lockhart 2005). Wapusk National Park, established on 24 April 1996, is situated east of Churchill and protects an area of 11 475 km² that extends southward from Cape Churchill. Resources within the boundaries of the park are of national and international importance, including one of the world's largest known polar bear denning areas, and vital habitat for hundreds of thousands of waterfowl and shorebirds that nest along the coast of Hudson Bay or gather and feed there during the annual spring and fall migrations (Stewart and Lockhart 2005). Park management is overseen by a board with representatives from the federal and provincial governments, the municipality of Churchill, and the First Nations of Fox Lake and York Factory. Ukkusiksalik National Park, established on 23 August 2003, extends westward from Roes Welcome Sound to include Wager Bay and the Brown and Piksimanik rivers, encompassing an area of 23 500 km² (Stewart and Lockhart 2005). Inuit residents from the Kivalliq communities, including Chesterfield Inlet, use this area for subsistence hunting and fishing.



Parks Canada also has identified several marine regions in arctic Canada within which it plans to recognize as Natural Areas of Canadian Significance. Two of the Natural Areas of Canadian Significance overlap with the proposed RSA, including Hudson Bay and Hudson Strait (Stewart and Lockhart 2005). The National Marine Parks Policy guides this process. Each area is intended to represent the natural, historical, and cultural diversity within a region. While National Marine Parks have yet to be established in northern Canada, Parks Canada has sought advice on which areas might make the best and most representative marine parks in the Hudson Bay and Hudson Strait marine regions. In Hudson Bay, Stewart et al. (1991) recommended 2 areas to Parks Canada for consideration as national marine parks – the Churchill-Nelson area and the Rankin Inlet-Marble Island area.

The Churchill-Nelson area was recommended for consideration as a National Marine Park prior to the establishment of Wapusk National Park, with the primary goal to protect the summer resident population of beluga whales in the Nelson, Churchill, and Seal rivers estuaries (known as the largest concentration of beluga whales in the world) (Stewart and Lockhart 2005). Other important physical, biological, and human use characteristics of this area include 1) extensive low-lying marshy coastal plains with wide tidal mud flats; 2) large estuarine habitats of the Churchill and Nelson rivers; 3) exceptional autumn concentrations of polar bears on the islands and headlands near Cape Churchill; 4) breeding shorebirds and waterfowl including the common eider; and 5) pre-historical coastal cultures, historical ports of entry instrumental in the exploration and development of central Canada, and the region's only deep water port for international shipping (Stewart and Lockhart 2005).

As noted earlier, the Rankin Inlet-Marble Island area was recommended as a National Marine Park to conserve and protect several key ecological and cultural features in this area (Stewart et al. 1991). The area of Hudson Strait immediately northeast of the Hudson Bay marine region was recommended as the most representative candidate for consideration as a future national marine park in the Hudson Strait marine region (DFO 2005b).

Migratory Bird Sanctuaries

Environment Canada's Canadian Wildlife Service (EC-CWS) has established 11 migratory bird sanctuaries in Nunavut to control and manage areas of key importance for the protection of migratory bird species and their habitat (Stewart and Lockhart 2005). Three of these sanctuaries occur within, or in the vicinity of, the proposed RSA: the McConnell River Migratory Bird Sanctuary south of Arviat, and the Harry Gibbons and East Bay Migratory Bird Sanctuaries on the southeast coast of Southampton Island. Both areas include terrestrial, wetland, and marine habitats, with the latter typically consisting of nearshore foraging areas for migratory birds. The *Migratory Birds Convention Act* prohibits activities in Migratory Bird Sanctuaries. Canadian Wildlife Service manages the activities that can be carried out within these areas. Prohibitive measures are placed on what activities can occur in these areas, as outlined in the Bird Sanctuary Regulations. Although important fish habitat could be protected through migratory bird sanctuaries, it is not an effective measure unless there is valuable bird habitat associated with the area that coincides with important or critical fish habitat.

The McConnell River Migratory Bird Sanctuary, established in 1960 to protect a small colony of lesser snow geese, encompasses 32 800 hectares (ha) along the west coast of Hudson Bay south of Arviat. This sanctuary is owned by the Coastal Inuit of Nunavut and subject to co-management agreements under the Nunavut Land Claims Agreement (Stewart and Lockhart 2005). Subsistence hunting and fishing activities presently occur within the sanctuary, mostly by community members of Arviat. In 1982, under the terms of the Ramsar Convention, the sanctuary was designated as a "Wetland of International Importance especially as Waterfowl Habitat" (Ramsar Site 248) because it provided major nesting habitat for multiple migratory bird species including Canada geese, lesser snow geese, and Ross's goose. Up to 200 000 birds colonize this sanctuary on an annual basis,



with habitat degradation presently occurring due to a local increase in the snow goose population (Stewart and Lockhart 2005).

The Harry Gibbons Migratory Bird Sanctuary is located on Southampton Island in northern Hudson Bay, encompassing extensive tidal flat and wetland habitat areas along the Boas River delta and associated estuarine environment in the Bay of God's Mercy. This area supports large nesting colonies of lesser snow goose (population >500 000 birds in 1997), Atlantic brant, Canada goose, and tundra swan (Stewart and Lockhart 2005). Smaller breeding colonies of migratory birds are located outside the sanctuary at Ell Bay and Bear Cove (Stewart and Lockhart 2005).

The East Bay Migratory Bird Sanctuary is located on Southampton Island near the community of Coral Harbour. Established in 1959, this area encompasses 113 800 ha including marine, intertidal, and subtidal components. Notable bird species include Arctic tern, Atlantic brant, lesser snow goose, Canada goose, common and king eider, black guillemot, jaeger, herring and Sabine's gull, red knot, red phalarope, red-throated loon, ruddy turnstone, and several species of plover and sandpiper.

Important Bird Areas

Important Bird Areas (IBAs) are sites recognized as being globally important habitat for the conservation of bird populations, as designated by Bird Studies Canada, Nature Canada, and Birdlife International (Birdlife International 2012), an international bird protection organization. Collectively, these organizations support the international conservation of discrete sites that provide habitat for threatened birds, large groups of birds, and birds restricted by range or by habitat. Three Important Bird Areas occur within, or in the vicinity of the RSA; including Harry Gibbons and East Bay Migratory Bird Sanctuaries (sites #NU022 and #NU023 respectively) on Southampton Island, and McConnell River Migratory Bird Sanctuary south of Arviat.

International Biological Programme

In 1975, the International Biological Programme recognized a number of areas of biological, geological, and historical importance in northern Canada that were in urgent need of special protection (Nettleship and Smith 1975). Several of these areas, which have since been offered protection, and which occur within or in the vicinity of the RSA, include McConnell River (McConnell River Migratory Bird Sanctuary), and Boas River (Harry Gibbons Migratory Bird Sanctuary). Other areas near the RSA that have been identified as International Biological Programme sites but are not yet protected include Coats Island and Digges Islands. Coats Island is located northeast of Southampton Island. Digges Islands (West and East) are located in Digges Sound, at the northwest tip of the Ungava Peninsula in Western Hudson Strait. Both areas support key terrestrial habitats for migratory birds and seasonal habitats for several marine mammal species (Nettleship and Smith 1975).

Key Marine Habitat for Migratory Birds

EC-CWS has established 'key marine habitat' sites for migratory birds located near the proposed shipping route. Some of these sites overlap with existing protected/sensitive areas such as migratory bird sanctuaries designated by EC-CWS, IBAs, and/or International Biological Program sites. These areas were primarily established to protect terrestrial or coastal resources for marine birds. 'Key marine habitat' sites designated by EC-CWS aim specifically to identify important marine habitat areas for marine avifauna. Not all of these sites are protected under legislation; however, as local knowledge increases regarding habitat use and the overall importance of these sites to marine birds, legal protection status may follow. Generally, these areas are used by marine birds from late April through September. Additional details on the key marine habitat sites for migratory



birds located near the proposed shipping route are summarized in Table 8.3-7 and Figure 8.3-2 (adapted from Mallory and Fontaine 2004).

Table 8.3-7: Environment Canada key marine habitat sites for migratory birds located near the proposed shipping route

Site Name	Sensitivities	Biological Significance	Status	Size (km ²)		Distance from shipping lane (km)
				Marine	Land	
Coats Island near Cape Pembroke	Sensitive to disturbance of important nesting sites along coast, important foraging grounds and staging / breeding areas in the marine environment, and key migratory corridors. Concerns around increases in vessels in the area coming close to Coats and Walrus islands.	Important nesting areas occur on Coats Island for seabirds (thick-billed murre, common eider, and black guillemot), which feed on aggregations of marine fish (e.g., capelin and Arctic cod). Glaucous gull and peregrine falcon can be found along the cliffs at the colonies. Home to a large Iceland gull (<i>Larus glaucoides</i>) colony and the largest single colony of common eider in Nunavut occurs in East Bay.	International Biological Programme site (Region 9, Site No. 6-3) and an IBA (NU005).	1918	0	Overlaps
Digges Sound	Sensitive to disturbance of important nesting sites along coast, important foraging grounds and staging / breeding areas in the marine environment, and key migratory corridors. Concerns around increases in vessels in the area. Colonies are considered to be some of the most disturbed by human activities in the Canadian Arctic.	20% of North American population of thick-billed murre and a small colony of Atlantic puffin (<i>Fratercula arctica</i>) and razorbill (<i>Alca torda</i>) occur near Digges Sound. 10% of the Canadian population of common eider breed and feed near Markham Bay. Other species that also breed here are black guillemot, glaucous gull, Iceland gull, herring gull, and Arctic tern.	International Biological Programme site (Region 9, Site No. 6-7) and an IBA in Canada (NU001).	2207	102	~3
Frobisher Bay	Sensitive to disturbance of important nesting sites along coast, important foraging grounds and staging / breeding areas in the marine environment, and key migratory corridors. Concerns around increases in vessels in the area and potential hydrocarbon exploration. The complex nature of currents in the region suggests that a potential oil spill in southern Davis Strait	Colony of 3% of Canadian thick-billed murre population. Glaucous gull, black-legged kittiwake, and possibly Northern fulmar breed here. Nearby Loks Land is thought to support Nunavut's largest known colony of razorbill (not been visited since 1953). Dovekies congregate off the Hall Peninsula in August. An important nesting, feeding, and migration stop-over for common eider, Iceland gull, ivory gull, and harlequin	Hantzsch Island is an International Biological Programme site (Region 9, Site No. 7-10) and a Canadian IBA (NU025).	12442	1336	Overlaps



Table 8.3-7: Environment Canada key marine habitat sites for migratory birds located near the proposed shipping route (continued)

Site Name	Sensitivities	Biological Significance	Status	Size (km ²)		Distance from shipping lane (km)
				Marine	Land	
	could reach this marine area.	duck (<i>Histrionicus histrionicus</i>). Canada goose and long-tailed ducks may also be found here.				
Button Islands	Sensitive to disturbance of important nesting sites along coast, important foraging grounds and staging / breeding areas in the marine environment, and key migratory corridors. Concerns around increases in vessels in the area and potential hydrocarbon exploration. The complex nature of currents in the region suggests that oil spills in southern Davis Strait could enter this marine area. Oil spills associated with shipping could endanger a large number of marine birds and pollute their feeding areas.	Black-legged kittiwake and northern fulmar forage near the Button Islands. Ivory gulls and common eider have been observed. Thick-billed murre breed here.	International Biological Programme site (Region 9, Site No. 6-8).	3909	81	Overlaps
Akpatok Island	Sensitive to disturbance of important nesting sites along coast, important foraging grounds and staging / breeding areas in the marine environment, and key migratory corridors - particularly for murres. Shoreline around Akpatok Island is considered to be "high hazardous risk of oil spills". Concerns around increases in vessels in the area and potential hydrocarbon exploration. The complex nature of currents in the region suggests that oil spills in southern Davis Strait could	Large breeding colony of thick-billed murre. Black guillemots also nest along the Akpatok Island coast. Black guillemot nest along the island's coast. Peregrine falcon and glaucous gull also breed here.	International Biological Programme site (Region 9, Site No. 6-6) and an IBA in Canada (NU007).	4943	859	82



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Table 8.3-7: Environment Canada key marine habitat sites for migratory birds located near the proposed shipping route (continued)

Site Name	Sensitivities	Biological Significance	Status	Size (km ²)		Distance from shipping lane (km)
				Marine	Land	
	reach this marine area. Oil spills associated with shipping could endanger a large number of marine birds and pollute their feeding areas.					
Ungava Bay Archipelagoes	Sensitive to disturbance of important nesting sites along coast, important foraging grounds and staging / breeding areas in the marine environment, and key migratory corridors.	Support a large portion of breeding common eider. Eider occur in this area from April through October	The Plover and Payne, Gyrfalcon, and north eastern Ungava Bay islands are Canadian IBA (NU027, NU028, NU029).	5624	5	93
Sleeper Islands	Degradation of staging and foraging areas, particularly for eiders. Potential hydrocarbon exploration. Prevailing west and north west winds render the east coast of the Bay most susceptible to oil damage.	Common eiders nest here in the summer months. Over 30 species of birds have been observed in the Sleeper Islands.	IBA site (NU033).	1880	90	536
Belcher Islands	Degradation of staging and foraging areas, particularly for eiders. Excessive harvest of down from breeding colonies. Potential hydrocarbon exploration. Prevailing west and north west winds render the east coast of the Bay most susceptible to oil damage.	Common eider nest here in the summer. In the winter, polynyas and the floe edge support substantial numbers of common eider and long-tailed duck.	The North Belcher and South Flaherty islands are Canadian IBA (NU031, NU100).	5 to 15 recurrent, small polynyas		680
Northern Ontario Coastline	Degradation of staging and foraging areas, particularly for ducks. Potential hydrocarbon exploration.	Black scoter moult along this marine area feeding on blue mussels and other molluscs. Common eiders are year-round residents. Canada geese and lesser snow geese make use of coastal areas.	Waters in James Bay are part of the James Bay Preserve.	7860	41	607



Table 8.3-7: Environment Canada key marine habitat sites for migratory birds located near the proposed shipping route (continued)

Site Name	Sensitivities	Biological Significance	Status	Size (km ²)		Distance from shipping lane (km)
				Marine	Land	
Markham Bay	Disturbance and sensitivity to potential pollution of foraging, staging and migrating areas.	Support a large portion of breeding common eider. Support substantial numbers of Kumlien's gull (<i>Larus glaucooides kumlieni</i>) colonies and black guillemot. Eiders occur in this area from April through October.	No special designation.	4015	423	58
East Bay	Disturbance and sensitivity to potential pollution of foraging, staging and migrating areas.	Supports Arctic Canada's largest single colony of common eider. Supports colony of black guillemot and a large population of lesser snow goose. Substantial numbers of Atlantic brant and Sabine's gull also breed here. Supports some of the highest known breeding densities of shorebirds in the eastern Arctic. Red phalarope are the most common shorebirds.	Migratory Bird Sanctuary and a Canadian IBA (NU023).	274	1	84

Areas of High Biological Importance

Fisheries and Oceans Canada sponsored an Arctic Marine Workshop to bring together expert knowledge on marine fauna and habitat use in the Canadian Arctic (Stephenson and Hartwig 2010). The objective of the workshop was to identify overlapping areas of habitat use by different Arctic species, and, therefore, areas of High Biological Importance (HBI) to wildlife. In total, 19 HBI were identified; 3 of these occur within, or in the vicinity of, the proposed RSA including Southampton Island, Chesterfield Inlet, and Hudson Strait. The Southampton Island HBI extends from Cape Bylot to Ell Bay and includes the north and west coasts of Coats Island. This area provides important habitat for several species of seal, walrus (including an overwintering area), and numerous marine bird species. It also provides key denning habitat for polar bears and important foraging grounds for bowhead whales. The Chesterfield Inlet HBI consists of the Hudson Bay coast from Whale Cove to Arviat. This area provides key habitat for beluga whales, killer whales, several species of seal, Arctic char, and several seabird species along the coast. The Hudson Strait HBI, which includes Akpatok, Salibury, and Nottingham Islands, has been identified as being amongst the most productive areas in the Arctic (Stephenson and Hartwig 2010), supporting several large seabird colonies along the coast, key shrimp habitat, and important overwintering areas for several marine mammals including narwhal, beluga whale, and walrus. This area is known to be more productive than Hudson Bay due to an increased level of surface mixing and a large tidal exchange. The ice edge, which extends the length of the Strait during winter, is also considered dynamic habitat for numerous Arctic marine species.



Bowhead Whale Critical Habitat Areas

Wheeler et al. (2012) investigated critical summer and fall habitat for bowhead whales in the eastern Canadian Arctic by performing a monthly ecological niche factor analysis for 3 bowhead whale spatial datasets in contrast to concurrent eco-geographical variable datasets (including sea surface temperature, chlorophyll, ice cover, water depth, slope, and distance to shore) to determine overall bowhead whale habitat suitability in this region. The study produced 11 habitat suitability models, and resulted in the development of a composite map of predicted high suitability habitat for the months of June to October. In total, 21 discrete areas were identified (with low confidence) within the Eastern Canadian Arctic as 'critical habitat' during the open-water season (Figure 8.3-18). Of these, 9 (Areas 13, 14, 15, 16, 17, 18, 19, 20, and 21) were located within, or in the vicinity of, the proposed RSA or shipping corridor between Rankin Inlet and eastern Hudson Strait. Coastal Inuit knowledge (referred to as Inuit Qaujimajatuqangit or IQ – see Figure 8.3-19) supported the identification of critical habitat in northwest Ungava Bay (Big Island; Area 15). Aerial surveys (Cosens and Innes 2000) and telemetry studies (Dueck et al. 2006) supported the identification of critical habitat near Southampton and Coats islands (Area 20). There was no corroborating IQ or scientific evidence to support other identified critical habitat in northern Hudson Bay, Hudson Strait, and Labrador (Areas 13 to 15, 18, and 19). This may be due to bowhead whales no longer frequenting these areas, or population surveys and IQ studies were not conducted in these areas.

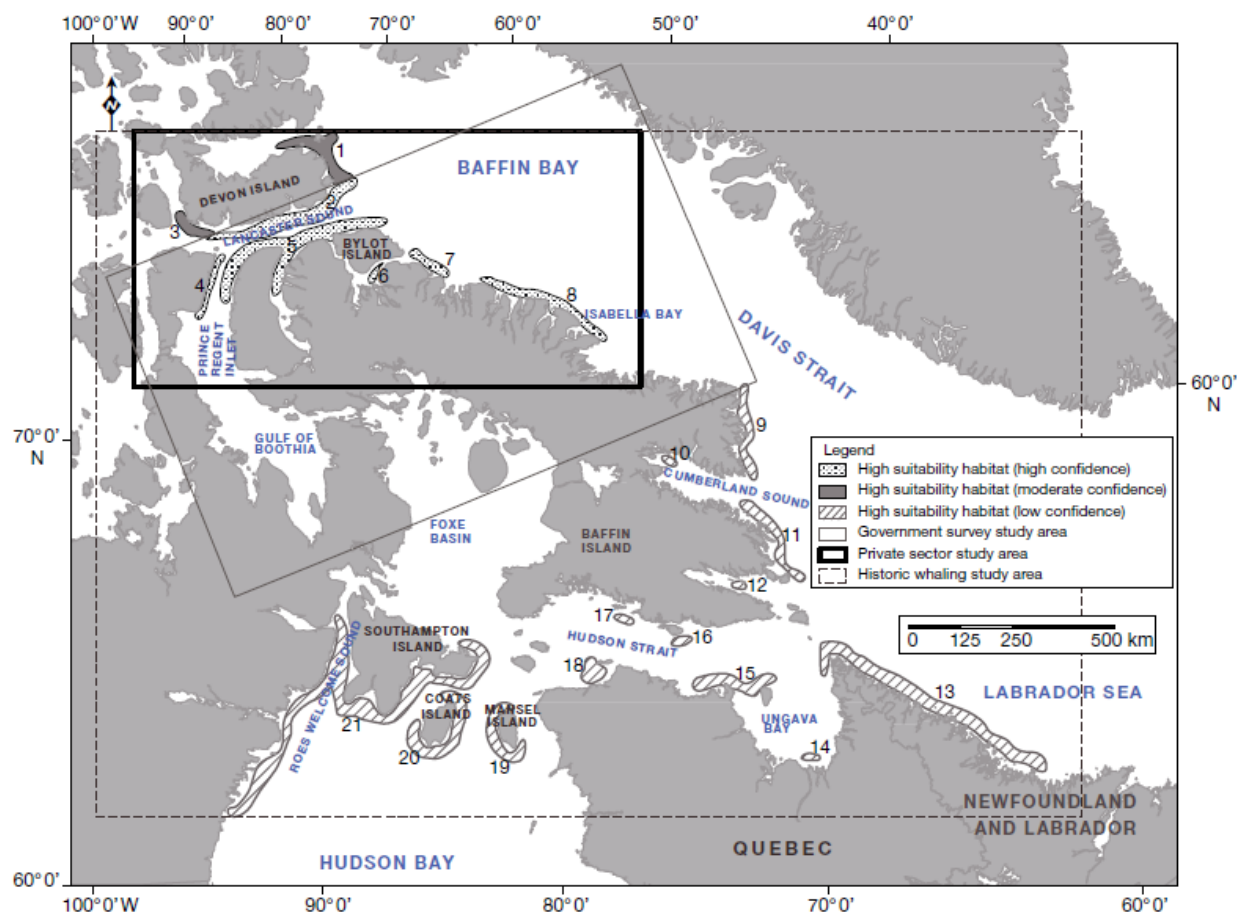


Figure 8.3-18: Discrete Areas of Highly Suitable Bowhead Whale Habitat Identified for 3 or More Months from June to October in the Eastern Canadian Arctic (by analytical confidence) Produced by Ecological Niche Factor of 3 Bowhead Location Datasets and Associated Eco-Geographical Variables (extracted from Wheeler et al. 2012)

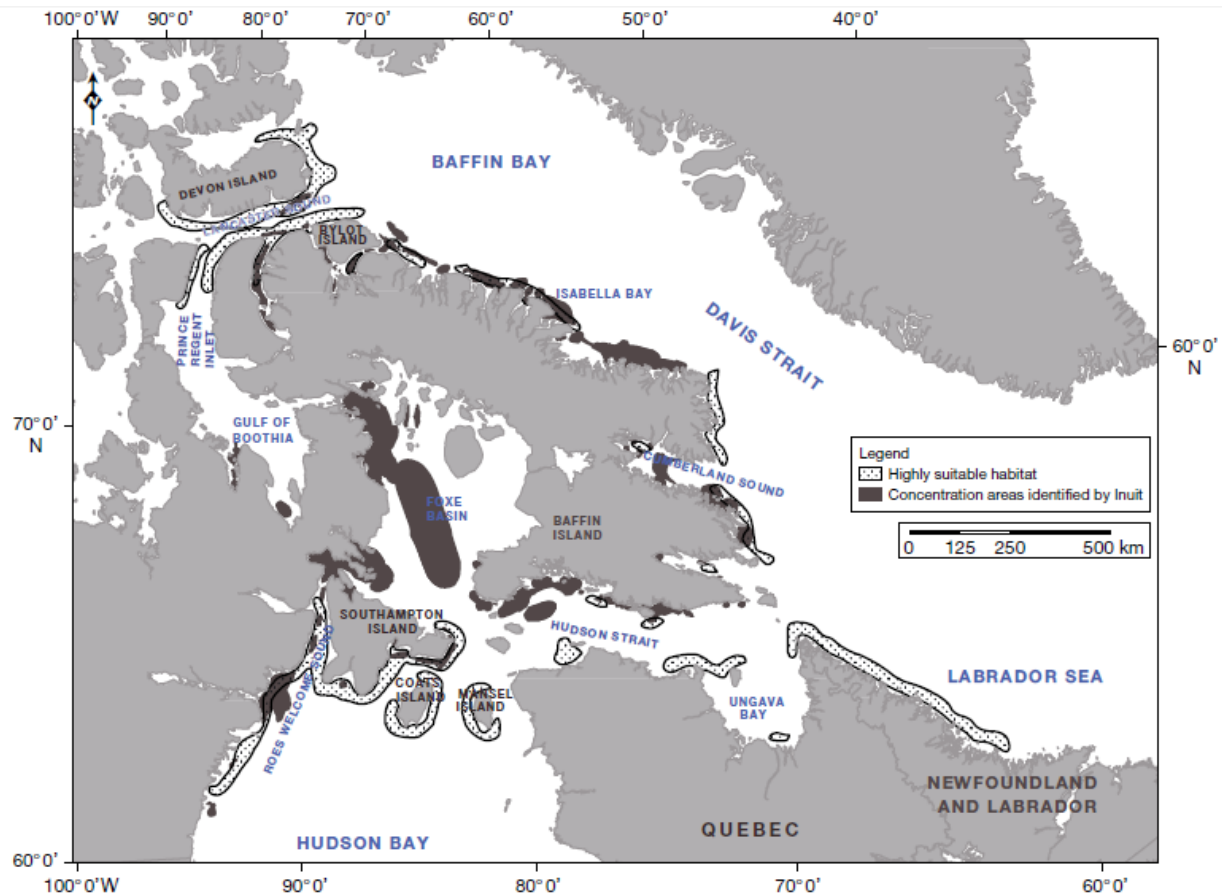


Figure 8.3-19: Comparison of Highly Suitable Bowhead Whale Habitat Predicted by Ecological Niche Factor Analyses with Bowhead Concentration Areas Identified by Inuit in Nunavut, Canada, in Late Spring, Summer, and Early Fall (adapted from NWMB 2000 and Wheeler et al. 2012)

8.3.3 Traditional Knowledge

IQ

Sources of Inuit Qaujimajatuqangit (IQ) or TK for marine wildlife included the following:

- IQ studies conducted by Nanuk Enterprises in 1997 and 1998 in Rankin Inlet and Chesterfield Inlet. The results of these studies are summarized in FEIS Volume 9, Section 9.3;
- IQ studies conducted by Nanuk Enterprises in 2010-2011 in Rankin Inlet, Chesterfield Inlet, and Whale Cove. The full report is included as FEIS Volume 9, Appendix 9.3-A and summarized in FEIS Volume 9, Section 9.3;
- Interview conducted on 15 July 2011 by Nunami Stantec in Rankin Inlet with representatives from the Kangiqliniq Hunters and Trappers Organization. The full report is included as Appendix 8.2-A;



- IQ studies conducted by Nanuk Enterprises / Outcrop Ltd. during 2012, consisting of interviews with local hunters, fishers, tour operators, and experienced seamen representing the communities of Rankin Inlet, Chesterfield Inlet, and Whale Cove. The 2012 interviews focused on marine resources along the proposed shipping route through Hudson Bay and the marine approaches to Rankin Inlet. The full report is included as FEIS Volume 9, Appendix 9.3-C and summarized in FEIS Volume 9, Section 9.3; and
- A literature review of the Nunavut Atlas (Canadian Circumpolar Institute 1992) and the Inuit Land and Occupancy Project (Freeman and Murty 1976) conducted by Golder in 2012 summarizing historical Traditional Resource Use (TRU) in the Rankin Inlet region and surrounding communities as described in FEIS Volume 9, Section 9.3.

Collectively, these studies identify the following main points of interest with respect to traditional resource use and traditional knowledge in the Project area: **IQ**

- Itivia is commonly used by local community members for small boat operations including boat mooring and launching. The location of the proposed spud barge corresponds with the only navigable area at Itivia during a low tide;
- Arctic char represent an important food species for the local community and are mainly harvested during August in the Rankin Inlet region. Some residents also participate in the commercial Arctic char fishery, which occurs approximately 40 to 50 km (25 to 30 miles) outside Rankin Inlet, although it occurred closer historically. Other fish species locally harvested in the Project area (in marine waters) include sculpin, cod, capelin, whitefish, and trout;
- Hunting and fishing in Melvin Bay is thought to be less productive today than in the past (1960s and 1970s), a factor potentially linked to recent increases in local vessel traffic in the bay;
- Marine mammal species harvested in the Rankin Inlet region include the following:
 - Beluga whales - hunted during the open-water season (primarily in August and September) – mainly near Marble Island. Most individuals summer near Churchill and migrate north along the west coast of Hudson Bay beginning in late August. Some individuals overwinter in polynya areas (when ice conditions allow) in northwestern Hudson Bay, Roes Welcome Sound, and Hudson Strait;
 - Walruses – uncommon in Rankin Inlet in recent years, this species is hunted year-round in areas north of Marble Island. During summer and winter, large numbers of walruses haul-out on Bencus, Coats, Walrus, and Southampton islands;
 - Polar bears – hunted primarily during winter on the sea-ice. Hunting is based on a quota system, which was lowered for the WHB sub-population during the 2010-2011 harvest to 8 individuals due to concerns for the population size, and then raised to 21 individuals for the 2011-2012 quota following increased reports by community members of problem bears near the communities (GN 2011). Some individuals have been observed on Marble Island and swimming offshore during the summer months between the surrounding islands. There is some concern by community members that increased shipping in the area may result in adverse impacts on polar bears, including behavioural disturbance (active avoidance or displacement effects) and/or physical injury / mortality from potential ship strikes;
 - Four species of seal (ringed, bearded, harp, and harbour) – hunted throughout the year (on sea-ice and in open-water), with ringed seals being the most commonly hunted species. Recent increases in the



number of harp seals near Rankin Inlet may represent influx of animals from adjacent Chesterfield Inlet that have been displaced by increased shipping / icebreaking activities in this area;

- Hunters have expressed concern over the proximity of the shipping route to Marble Island and potential effects of shipping on marine mammal distribution / migration, and hunting activities in this area. However, the implementation of a 2 km buffer (exclusion zone) around Marble Island for all Project vessels is deemed sufficient to mitigate these concerns;
- Narwhals and bowhead whales are not an important subsistence species for the Rankin Inlet community and are uncommon in the Rankin Inlet area. Narwhals summer north of Rankin Inlet in Daly Bay, Roes Welcome Sound, and Foxe Basin and winter in pack-ice regions of eastern Hudson Strait and Davis Strait. Bowhead whales are occasionally observed near Repulse Bay, Frozen Strait, Southampton Island, and Chesterfield Inlet;
- Hudson Strait is considered an important migratory corridor for marine mammals (beluga whales, narwhals, bowhead whales, and harp seals) transiting between Davis Strait / Labrador Sea and Hudson Bay / Foxe Basin. The critical migratory periods are early summer (June) and fall (late August to October). Proposed shipping activities for the Project coincide with the fall migratory period;
- Killer whales appear to be increasing locally in number particularly near Marble Island, although this species is not traditionally harvested. Concerns have been raised regarding the potential effects of the increasing killer whale population on other marine mammals due to predation, particularly with respect to bowhead whales;
- Several marine bird species are known to forage and/or nest in the Project area, including eider ducks (common eiders), black guillemots, Arctic terns, and several species of gull. Most nesting periods fall outside the shipping season (open-water). Egg harvesting occurs in spring for goose, eider duck, tern, guillemot, and gull. Shorebirds and raptors are not harvested by Inuit. The number of marine birds in Melvin Bay in recent years is thought to have decreased;
- Locally harvested shellfish species include blue mussels and clams. Historically, shellfish harvesting occurred along the north shore of Melvin Bay. Today, the harvest mainly occurs outside the harbour due to related health advisories from the Department of Health and Social Services. Scallops collected from the stomachs of hunted walruses are highly regarded by elders;
- Seaweeds (marine vegetation) are not locally harvested in the Project area in Melvin Bay;
- With respect to climate change, several major changes have been observed over the past 20 years in Rankin Inlet and include later freeze-ups, shorter sea-ice periods, decreases in land-fast ice, greater uncertainty in weather conditions, higher frequency of severe storm events, decreases in marine mammals observed in July, and changes in the timing of moulting of ringed seals (occurring as early as April); and
- Rankin Inlet community members recognize 2 shipping routes for access to Rankin Inlet (see Maps 1 and 2 in FEIS Volume 9, Appendix 9.3-C). In the deep-water sections of the shipping corridor, the exact shipping routes are not marked and likely vary by several kilometres. Recent increases in local shipping activity have been linked to several large Projects in the region including Meliadine, Meadowbank, Kiggavik, Baffinland, and Roche Bay.



8.3.4 Pathway Analysis

8.3.4.1 Methods

Pathway analysis identifies and assesses the linkages between Project components or activities, and the correspondent potential residual effects to marine wildlife, including wildlife habitat. The first part of the analysis involved the identification of all potential effects pathways for the Project (FEIS Volume 4, Section 4.3). Each pathway is initially considered to have a linkage to potential effects on marine wildlife and wildlife habitat. This step is followed by the development of environmental design features and mitigation that can be incorporated into the development description to remove a pathway or limit (mitigate) the effects to marine wildlife and wildlife habitat. Environmental design features include Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the Project's engineering and environmental teams to avoid or mitigate effects.

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on marine wildlife and wildlife habitat. Pathways are determined to be primary, minor, or as having no linkage using scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is non-existent or is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to marine wildlife and wildlife habitat relative to baseline or guideline values;
- minor – pathway could result in a minor environmental change, but would have a negligible residual effect on marine wildlife and wildlife habitat relative to baseline or guideline values; or
- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on marine wildlife and wildlife habitat relative to baseline or guideline values.

Primary pathways require further effects analysis to determine the environmental significance from the Project on marine wildlife and wildlife habitat. Pathways determined to have no linkage to marine wildlife and wildlife habitat or those that are considered minor are not predicted to result in environmentally significant effects on the marine environment. Pathways identified as 'minor' or having 'no linkage' are summarized but not carried through the effects assessment.

Potential pathways through which the Project could affect marine wildlife and wildlife habitat are presented in Table 8.3-8. Environmental design features and mitigation incorporated into the design of the Project to remove a pathway or limit the effects to marine wildlife are listed, and pathways are determined to be primary, minor, or as having no linkage. The following section discusses the potential pathways relevant to marine wildlife and wildlife habitat.

Project activities described in Table 8.3-8 will occur during all phases of the Project (pre-development, construction, operations, and temporary, final, and post-closure). Project pathway linkages are thus described by individual activity, which can be assumed to be consistent across all Project phases.



Table 8.3-8: Potential Pathways for Effects to Marine Wildlife and Wildlife Habitat

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
Installation of in-water structures (spud barge) and support activities	Marine fish	Change in fish habitat quality due to grounding of spud and cargo barges	Placement of spud barge will avoid sensitive natural habitats. Spud barge anchors will be removed during decommissioning.	Primary
	Marine birds Marine mammals	Change in marine habitat quality due to grounding of spud and cargo barges.	Placement of spud barge will avoid sensitive natural habitats.	No linkage
	Marine birds	Sensory disturbance from structural lighting may result in changes in health and mortality risk in marine birds due to collisions with infrastructure	Where feasible, lights on marine infrastructure will be shielded and/or angled to minimize direct illumination and reflection of the sea surface (with the exception of mandatory navigational lighting). Activities will be scheduled during daylight hours whenever practical to minimize the need for staging lights. Work will occur during summer when daylight is extended, minimizing the need for site lighting. Vessels will maintain a minimum distance of 200 m from nesting locations in accordance with best management practices for raptor conservation (Demarchi et al. 2005)	Primary
	Marine birds	Sensory disturbance from structural lighting and in-air noise from nearshore human activities may alter marine bird behavior	Where feasible, lights on marine infrastructure will be shielded and/or angled to minimize direct illumination and reflection of the sea surface (with the exception of mandatory navigational lighting). Activities will be scheduled during daylight hours whenever practical to minimize the need for staging lights. As most work will occur during summer when daylight is extended, there will be minimal need for site lighting. Vessels will maintain a minimum distance of 200 m from nesting locations in accordance with best management practices for raptor conservation (Demarchi et al. 2005)	Primary



Table 8.3-8: Potential Pathways for Effects to Marine Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
Vessel movements in the proposed shipping corridor and Melvin Bay including near-shore transportation of fuel and dry goods (loading barges, barging, off-loading)	Fish Marine birds Marine mammals	Vessel wakes from nearshore vessels may cause shoreline erosion, which can result in adverse effects to marine water quality with associated indirect effects on marine wildlife.	Vessels in Melvin Bay will travel at reduced speeds (≤ 2 knots [3.7 km/h]).	Minor
	Fish Marine birds Marine mammals	Propeller wash from nearshore vessels berthing at the spud barge / landing ramp may result in adverse effects to marine water quality, with associated indirect effects on marine wildlife.	Placement of spud barge will avoid sensitive natural habitats. To the extent possible, vessel will shut-down vessel engines and propellers when anchored or tied to the spud barge.	Minor
	Fish Marine birds Marine mammals	Solid waste, grey water, and bilge water discharges from ships may result in direct adverse effects on marine water quality in the proposed shipping corridor and associated indirect effects on marine wildlife.	Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO, 2008; MARPOL 73/78). Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1).	Minor
	Fish Marine birds Marine mammals	Introduction of exotic marine species (including pathogens) from ship ballast water exchange during seasonal shipping events can affect native marine wildlife.	Adherence to Ballast Water Control and Management Regulations and Ballast Water Management Plan (BWMP) as defined in the Shipping Management Plan (SD 8-1). Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1).	Minor
	Fish Marine birds Marine mammals	Antifouling toxins (e.g., tributyltin) potentially leaching from Project vessels can have an effect on the marine environment and bio-accumulation in marine food chains.	Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO, 2008; MARPOL 73/78). Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1).	Minor



Table 8.3-8: Potential Pathways for Effects to Marine Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
	Marine mammals Fish	Alteration in marine mammal and fish behavior due to underwater noise from vessel activities	Vessels will maintain 2-km distance from Marble Island. Vessels will follow established navigation lanes in LSA, maintaining a constant course and constant speed. Implementation of vessel speed restrictions: ≤2 knots in Melvin Bay and <14 knots in shipping lanes. Avoidance of rapid accelerations. All ocean-going vessels will anchor at deep water location outside Melvin Bay. To the extent possible, vessel will shut-down vessel engines and propellers while anchored. Vessels will not approach within 300 m of a walrus or polar bear on sea ice, or any mammal engaged in feeding activities. For all other mammal encounters, vessels will not approach within 100 m. If a mammal approaches within 100 m of a vessel, the vessel shall reduce its speed and, if possible, cautiously move away from the animal. If a vessel is unable to detour around a stationary marine mammal, it shall reduce its speed and wait until the animal(s) moves at least 100 m from the vessel prior to resuming speed. The vessel shall not be operated in such a way as to separate an individual member(s) of a group of marine mammals from other members of the group. Adherence to all other mitigation outlined in AEM's Shipping Management Plan (SD 8-1).	Primary
	Marine birds	Change in bird behavior due to underwater noise from vessel activities	Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1) (see above).	No linkage



Table 8.3-8: Potential Pathways for Effects to Marine Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
	Marine mammals	Vessel movements in Melvin Bay and the shipping corridor may result in collisions with marine mammals (change in health and survival)	Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1) (see above).	Primary
	Marine birds	Vessel movements in Melvin Bay and the shipping corridor may result in collisions with marine birds (change in health and survival)	Adherence to mitigation outlined in AEM's Shipping Management Plan (SD 8-1) (see above).	No linkage
	Fish Marine birds Marine mammals	Accidental spills from vessel activities and fuel operations can have direct adverse effects on marine water quality and associated indirect effects on marine wildlife.	Adherence to Spill Contingency Plan (SD 2-16). Adherence to Risk Management and Emergency Response Plan (SD 2-15). Adherence to Shipping Management Plan (SD 8-1). Adherence to Oil Pollution Emergency Plan (OPEP; SD 8-2). Compliance with Shipboard Oil Pollution Emergency Plan (SOPEP). Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO, 2008; MARPOL 73/78); Canada Shipping Act; and Arctic Waters Pollution Prevention Act. Operational activities have been engineered to use contained handling systems to minimize the risk of accidental spills into the marine environment.	Primary



Table 8.3-8: Potential Pathways for Effects to Marine Wildlife and Wildlife Habitat (continued)

Project Activity	Valued Components	Effects Pathways ^a	Environmental Design Features and Mitigation	Pathway Analysis
	Fish Marine birds Marine mammals	Accidental spills of dry cargo (loading and off-loading barges) can have direct adverse effects on marine water quality and associated indirect effects on marine wildlife.	Adherence to Spill Contingency Plan (SD 2-16). Adherence to Risk Management and Emergency Response Plan (SD 2-15). Adherence to Shipping Management Plan (SD 8-1). Compliance with Shipboard Oil Pollution Emergency Plan (SOPEP). Adherence to MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO, 2008; MARPOL 73/78); Canada Shipping Act; and Arctic Waters Pollution Prevention Act. Operational activities have been engineered to use contained handling systems to minimize the risk of accidental spills into the marine environment.	Minor

^a Direct effects on marine water quality are discussed in Section 8.2, where applicable.



8.3.4.2 Pathways with No Linkage

A pathway may have no linkage if the pathway is removed by environmental design features and mitigation so that the Project results in no detectable environmental change and residual effects to marine wildlife and wildlife habitat relative to baseline or guideline values. The pathways described in this section have no linkage to the marine environment and will not be carried through the effects assessment.

■ **Alteration of marine bird and mammal habitat from installation and operations of the spud barge.**

A limited area of potential marine bird habitat will be altered by the presence of the spud barge and the dry cargo barges. Given the limited area impacted and that the location is currently used for offloading goods for community supplies and a community boat launch, the availability of this habitat for marine birds use is not expected to substantially change. The effect from the installation, use, and removal of the spud barge and shoreline structures on marine birds will not be considered further.

Installation of the spud barge is not anticipated to have any interaction with marine mammals. The installation area is next to the shore in a shallow environment that is currently being used as a community ramp. Marine mammals are not expected to use this shallow, disturbed habitat. There are no SARA-listed marine mammal species whose range overlaps with Melvin Bay. As a result, the potential effects of the installation / operation of the spud barge on marine mammal habitat are not assessed further.

■ **Alteration of behavior in marine birds due to underwater noise from vessel activities.**

Limited experimental data have been collected on the reaction of birds to underwater noise from vessel operations. Based on studies available, it is generally assumed that marine birds are not sensitive to underwater industrial noise because they are able to avoid underwater exposure (DCE 2011; Evans et.al. 1998; Lacroix et.al. 2003; Greene and Richardson 1988). Although some species dive underwater for prey, the majority of their time is spent on the water's surface or in flight, where they would not be affected by underwater noise effects. Little information is known on the underwater hearing abilities of diving birds; however, it is likely limited to lower frequencies, and outside the ultrasonic range (DCE 2011). The physical presence of Project vessels themselves may result in avoidance behaviour, which is discussed in Section 8.3.7. As a result, the potential effect of underwater vessel noise on marine bird behavior is not assessed further.

■ **Vessel movements in Melvin Bay and the shipping corridor may result in vessel strikes on marine birds (change in health and survival).**

The proposed level of vessel traffic is not considered a significant increase when compared to existing vessel traffic in nearshore or offshore waters in the LSA and RSA. In addition, Project vessels will be slow moving (approximately 2 knots in Melvin Bay and 8 to <14 knots in the shipping corridor), which allows for marine birds to easily move out of the way of oncoming vessels. The potential for vessel-bird strikes is considered low is not expected to have significant effects on marine bird or affect populations and is not assessed further.



8.3.4.3 Pathways with Minor Linkage

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on marine wildlife and wildlife habitat relative to baseline or guideline values. The following pathways are anticipated to be minor, and will not be carried through the effects assessment.

- **Vessel wakes from nearshore Project vessels engaged in transportation activities may cause shoreline erosion, which can result in adverse effects to water quality with associated indirect effects on marine fish, birds, and mammals.**

Vessel wake occurs when vessel movements create secondary waves (i.e., free surface waves that propagate out from the vessel). The amplitude of the wave is related to the speed of the vessel. Large wake could result in increased wave activity along the shoreline and cause shoreline erosion, which could, in turn, affect fish and fish habitat. Given that the barges will be moving slowly within the LSA (<2 knots) secondary wave heights are not expected to be substantial. No published data or publicly available information could be found for typical wave heights within Melvin Bay. However, reports from nearby areas suggest average wave heights range from 0.3 m in an area north of Churchill (Environment Canada 2012) to 3 m in northern Hudson Bay (Maxwell 1986; Cohen et al. 1994). In contrast, wake from vessels moving 3 knots typically ranges from 0.07 to 0.09 m (Fonseca and Malhotra 2012). As a result, any wake effects from Project related barges are expected to be within normal variation experienced during tidal cycles and storms within Melvin Bay.

Habitat along the shoreline of Itivia Harbour and through the access passage from the anchoring area is generally composed of bedrock and boulder or gravel and cobble beaches. Bedrock and boulders are not highly susceptible to erosion; however, erosion may occur on gravel and cobble beaches. The cobble beach and gravel ramp of Itivia Harbour is well protected by an outlying bedrock reef, which would be expected to reduce any wave energy and minimize the potential for erosion. This bedrock reef is also used to provide shelter and protection to local boats. As a result, effects of vessel wake on marine wildlife VECs are not assessed further.

- **Propeller wash from nearshore Project vessels berthing at the spud barge / landing ramp may result in adverse effects to marine water quality with associated indirect effects on marine wildlife.**

Propeller wash is the movement of water created by the rotation of the propellers. Propeller wash may occur while a vessel is maneuvered into place. The nearshore benthic habitat in Itivia Harbour and Melvin Bay has low diversity, being dominated by cobble and gravel substrates. The gravel and cobble substrates at the spud barge may be susceptible to erosion and the shallow depths within Itivia Harbour may not allow the propeller wash to dissipate prior to reaching benthic organisms. The existing barge traffic is not known to cause substantial erosion problems as the existing gravel ramp in Itivia Harbour has not required reconstruction in several years (Ford 2012, pers. comm.). Given the temporary nature and reversibility of any wash-related effects on fish and fish habitat, effects from vessels berthing and de-berthing are not expected to result in adverse residual effects and are not assessed further.

- **Antifouling toxins (e.g., tributyltin) potentially leaching from Project vessels can have an effect on the marine environment and bio-accumulation in marine food chains.**

Anti-fouling paint is used on vessel hulls to prevent unwanted growth of organisms such as barnacles and algae that may attach to the hull. The paints contain biocides to impede growth. Historically vessels used tributyltin as an anti-fouling compound, but this has been banned by the International Maritime Organization (IMO) after its



toxic effects on marine life and its ability to bioaccumulate were established (International Maritime Organization 2002). All vessels will abide by the IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships. Due to the current convention by the IMO, the potential interactions of anti-fouling paint with marine life are not discussed further.

- **Introduction of exotic marine species (including pathogens) from ship ballast water exchange during seasonal shipping events can affect native marine wildlife (marine fish, birds, and mammals).**

Discharge of ballast water during commercial shipping operations has the potential to introduce exotic species to the marine environment and disrupt natural marine biological communities by altering the abundance, diversity, and distribution of native marine species (Butman and Carlton 1995; Carlton 1999). Possible introduced species include bacteria and other microbes, microalgae, and aquatic plant and animal species in ballast water or sediment transferred from ship ballast tanks. Exotic invasive species are those species whose rapid establishment and spread can adversely affect ecosystems, and dramatically alter local habitats, making them unsuitable for native species (DFO 2011a). Invasive species can also have effects on the abundance of native species, due to predation and/or competition for habitat and food resources.

It is possible that ballast water may be discharged by one or more of the shipping vessels during the Project if re-ballasting is required to facilitate safe cargo operations. Effective mitigation strategies are required early in Project planning phase to address the potential introduction, spread, and effects of exotic invasive species to the marine environment. This section identifies best management practices and environmental protection measures to be implemented as part of the Project in order to mitigate the introduction of exotic marine species to the marine ecosystem.

The exchange of ballast water in the Exclusive Economic Zone of Canada is governed by the Ballast Management Control and Management Regulations (SOR/2011-237) under the *Canada Shipping Act* (Canada Department of Justice 2001). AEM plans to use shipping vessels that are largely active in coastal trade and operate almost exclusively in Canadian waters. Vessels that operate exclusively in Canadian waters and certain adjacent waters are exempt from the Ballast Management Control and Management Regulations. Should a Project vessel venture outside Canadian jurisdictional waters, or have originated in waters outside Canadian jurisdiction, it will be required to prepare and adhere to a Ballast Water Management Plan (BWMP) that is compliant with the following:

- Ballast Management Control and Management Regulations (SOR/2011-237) under the *Canada Shipping Act* (Canada Department of Justice 2001);
- IMO Resolution A.868(20), Guidelines for the Control and Management of Ships Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens, in particular section 7.1;
- Model Ballast Water Management Plan developed by the International Chamber of Shipping and the International Association of Independent Tanker Owners;
- Regulation B-1 of the IMO's Regulations for the Control and Management of Ships' Ballast Water and Sediments; and
- Part B of the Annex to Resolution MEPC.127 (53), Guidelines for Ballast Water Management and Development of Ballast Water Management Plans.



In addition, waters taken onboard at the port at Bécancour, Quebec will be dissimilar to coastal waters in Melvin Bay, and, therefore, represent a potential risk for the introduction of harmful aquatic organisms to the marine environment. As such, Project vessels will adhere to the following additional measures:

- Ballast water taken onboard at the port of Bécancour, Quebec or other ports within Canadian jurisdiction is expected to be exchanged in offshore waters of Hudson Strait;
- Regardless of vessel origin, all sediment found in a vessel's ballast tanks will, wherever possible, be disposed of at least 370 km (200 nautical miles) from land and in water depths exceeding 2000 m. Alternatively, sediment in a vessel's ballast tanks will be removed and disposed of on land at a certified landfill facility;
- For contracted vessels that originate from outside Canadian jurisdictional waters, initial ballast exchange is to occur at least 370 km (200 nautical miles) from land and in water depths exceeding 2000 m. If safety conditions prevent ballast water exchange under these circumstances, an alternate designated area is available in Hudson Strait, east of 70° west longitude in water depths exceeding 300 m; and
- For contracted vessels that originate from outside Canadian jurisdictional waters which are unable to access the 200 nautical mile limit or waters depths of at least 2000 m, ballast water exchange must be conducted at least 50 nautical miles from land and in water depths exceeding 500 m. If this is not possible due to safety or other reasons, ballast water exchange can occur in the alternate designated area in Hudson Strait, east of 70° west longitude where the water is over 300 metres deep.

Additional details on ballast water management are provided in the Shipping Management Plan (SD 8-1).

The implementation of mitigation and environmental design features is anticipated to result in minor changes to the abundance and distribution of native marine species relative to baseline conditions. Therefore, the effect of introduced species from ballast water exchange on marine VECs is predicted to be negligible and will not be considered further.

- **Discharges of solid waste, grey water, and bilge water from Project vessels in the shipping corridor may result in direct adverse effects on marine water quality and associated indirect effects on marine wildlife (marine fish, birds, and mammals).**

The main sources of waste on the Project vessels include the following: 1) liquids, including grey water (domestic wastewater), black water (sewage), drainage from decks and exposed (above waterline) structures due to spray and precipitation, cooling water, ballast water (addressed above), and bilge water; and 2) waste in solid form, including kitchen waste (organic waste and packaging materials), medical waste, potentially hazardous waste (including batteries), non-hazardous waste, and miscellaneous ship's garbage. Table 8.3-9 summarizes the types of discharge and liquid or solid waste that could be generated on the Project vessels.

Marine water quality in the shipping corridor can generally be characterized by low levels of pollutants and other contaminants, due to its remote location and distance from shore.



Table 8.3-9: Types of Potential Discharges from Project Vessels and Disposal / Storage Methods

Waste Type	Waste Stream	Potential Source	Potential Contents	Comments
Liquid Wastes	Grey water	kitchen liquid wastes, bathing water, laundry facilities, deck drains, and other non-oily waste water	detergents, soaps, chlorine	Disposed at sea
	Black water	sewage	microorganisms, nutrients, suspended solids, organic material, chlorine	Incinerated or treated onboard before disposal at sea to standards set out by Annex IV of MARPOL
	Potentially hazardous waste	waste lubricating oil, hydraulic oil, cable oil	hydrocarbons, heavy metals	Stored onboard until proper disposal at the home port. Waste oil can be burned if the incinerator allows
Solid Wastes	Medical waste	used first-aid materials, medication	bio-hazardous materials, sharp needles, glass, plastic	Incinerated or stored onboard until proper disposal at the home port
	Kitchen waste	culinary activities, unused/uneaten foods	cooked and raw food	Incinerated or macerated and disposed at sea (at least 12 nautical miles/23 km from the coast)
	Potentially hazardous waste	batteries, oil drums, filters	heavy metals, acids	stored onboard until proper disposal at the home port
	Miscellaneous garbage	packaging, other materials	plastic, paper, glass	Incinerated or sorted by type, compacted where practicable and stored or incinerated onboard until disposal at a certified garbage or recycling reception facility at the home port

During the Project, grey water will be discharged directly to the sea as treatment of grey water is not required before release under MARPOL (73/78). This discharge may contain residual concentrations of chlorine, but in low or very low concentrations. Residual chlorine will react with organic matter in the upper part of the water column and become inactive. Black water (sewage) may contain microorganisms, nutrients, suspended solids, organic material, and residual chlorine from treatment. It will disperse and degrade in the environment. Discharge of black water and food wastes will increase Biological Oxygen Demand, but it is unlikely this will have any appreciable effect on dissolved oxygen content of seawater in the shipping corridor compared to natural conditions.

Effective mitigation strategies are required early in the Project planning phase to address the potential adverse effects of effluent discharges from Project vessels on marine water quality. This section identifies best management practices and environmental protection measures that will be implemented as part of the Project to mitigate these adverse effects.

Solid waste will be sorted by type, compacted where practical, and stored or incinerated onboard until it can be disposed of at a certified landfill or recycling reception facility. Food waste will be incinerated or macerated and disposed at sea at least 12 nautical miles (approximately 23 km) from the nearest point of land in accordance with the Act on the Protection of the Marine Environment (Part 7, 22-1, 1993), and Annex V of MARPOL (73/78) for “Special Area”, given the sensitive nature and low likelihood of pollution in this region. Solid waste (other than organic kitchen waste that can be macerated) will not be discharged into the marine environment. Consequently,



no impacts on the environment are expected during normal operations, and, hence, no residual effects are expected.

Sewage waste, as well as kitchen waste that cannot be macerated, will be treated onboard by all vessels prior to discharge, and will meet IMO standards, Annex IV of MARPOL (73/78).

Some capacity may exist on some vessels for collection and holding of drainage water in limited amount, but drainage from many elements of the ship's structure (above waterline) into the sea cannot be avoided. Decks will be kept clean to prevent drainage from mixing with oil stains, chemical stains, granular material, or other residue on the surface of the deck. Bilge water, and any collected drainage water, would be routed through an oil-water separator, and monitored for oil concentration prior to discharge. This process would comply with the best practices of Annex I of MARPOL. Cooling water is part of a closed loop system, and water pumped or taken onboard for this purpose will not be contaminated or mixed with water from other sources before it is returned to the sea during normal operations.

Additional details on vessel waste management are provided in the Shipping Management Plan (SD 8-1). The low amounts of residual chlorine and other harmful material, if any, in treated black water will be dispersed and diluted quickly by mixing and other processes in the surface layer. It is not believed any discharges will result in measurable water quality changes compared to background levels in the LSA or RSA. However, subsequent indirect adverse effects to marine ecology are not expected. Given the limited amount of Project vessel activity in the shipping corridor, it is unlikely that any discharges to the sea during the life of the Project will affect water quality directly, or marine wildlife species indirectly. Therefore, the effects of altered water quality from Project vessel discharges are predicted to be negligible and will not be considered further.

■ **Change in marine habitat quality due to altered water quality from potential accidental hazardous material spills (e.g. chemical spills) and associated indirect effects on marine wildlife VECs.**

A large part of the dry cargo received annually through Itivia Harbour will be ammonium nitrate; this will be shipped as prill. Ammonium nitrate readily dissolves in water to form ammonia, which can be toxic to fish and marine biota. Other mine reagents required during operation of the mine may include, but not be limited to, cyanide, lead nitrate, lime, sodium hydroxide, and copper sulfate. The ammonium nitrate and mine reagents will remain in sea cans during transportation through Itivia Harbour and to the Project mine site. The sea cans will be transferred via cranes from large vessels to cargo barges, and from the cargo barges directly onto trucks at Itivia Harbour.

A spill of ammonium nitrate or mine reagents would involve the loss of an entire sea can to the marine environment. This is considered unlikely because 1) lightering of barges will only be undertaken during daylight hours, under appropriate weather and tidal conditions; and 2) if a malfunction or operation error were to occur, the transfer equipment would be shut down immediately. Further, the sea cans are expected to be locked during transport and the likelihood that a sea can would open and lose its entire contents is considered to be low. For another mining project in Nunavut, the potential for the loss of a sea can was discussed with a Canadian shipping company with extensive arctic experience (SENES Consultants Ltd. 2011). The shipping company claimed that in 15 years of operation, they had never lost a container overboard due to load malfunctioning (i.e., dropping the container) or bad weather. Due to the unloading and loading methods described above, the probability of an accidental spill of hazardous material from dry cargo (e.g., chemical spills) is considered unlikely. Therefore, the effects of altered water quality from accidental hazardous materials spills are predicted to be negligible and will not be considered further.



8.3.4.4 *Summary of Primary Pathways*

The following primary pathways were determined linking Project-related activities to effects on the marine wildlife and wildlife habitat and will be carried through the effects analysis:

- **Change in fish habitat quality due to grounding of spud and cargo barges;**
- **Sensory disturbance from structural lighting may result in changes in health and mortality risk in marine birds due to collisions with infrastructure;**
- **Sensory disturbance from structural lighting and in-air noise from nearshore Project activities may alter bird behavior;**
- **Change in marine mammal and fish behaviour due to underwater noise from vessel movements in Melvin Bay and the shipping corridor;**
- **Change in health and mortality risk of marine mammals due to potential collisions with vessels;**
- **Change in marine habitat quality due to altered water quality from potential accidental fuel spills and associated indirect effects on marine wildlife VECs; and**
- **Change in health and mortality risk of marine wildlife VECs due to exposure to accidental fuel spills.**

8.3.5 *General Approach to Primary Pathways*

The effects analysis considers all primary pathways that result in expected changes to existing marine habitat and the abundance and distribution of marine wildlife VECs after implementing environmental design features and mitigation. Thus, the analysis is based on the residual effects from the Project. Residual effects the marine wildlife and wildlife habitat were analyzed using measurement endpoints (FEIS Volume 4, Section 4.2, Table 4.2-1) and are expressed as effects statements, including the following:

- Effects from changes in health and mortality risk;
- Effects from changes in behaviour; and
- Effects from changes in habitat quality.

The magnitude, spatial extent, and duration of potential effects on the above measurement endpoints resulting from cumulative effects are expected to be similar to or greater than those related tonon-cumulative effects.

The analyses of residual effects from the Project on marine wildlife and wildlife habitat were largely qualitative and included professional judgement and/or experience opinion supported by data from field studies, scientific literature, monitoring programs, government publications, and personal communications. Traditional knowledge and community information were incorporated where available.

8.3.6 *Effects Analysis*

Project activities associated with the construction, operation, and decommissioning of the Project have the potential to result in adverse effects to marine wildlife and wildlife habitat. Routine vessel operations within Melvin Bay and routine activities associated with construction, operation, and decommissioning of the proposed spud barge site at Itivia Harbour were considered in the scope of the marine assessment, as were marine



transportation activities outside of Melvin Bay. Accidents and malfunctions (including accidental releases) within Melvin Bay and the proposed shipping corridor are also addressed in this section.

8.3.6.1 *Relevant Project Components*

Spud Barge and Marine Transportation Activities in Melvin Bay

Itivia Harbour is situated on the northeast shore of Melvin Bay and is located south of the community of Rankin Inlet. It is connected to the hamlet by one access road and has been minimally developed with only a coarse gravel fill ramp (Nunami Stantec Ltd. 2012). The gravel ramp is for the use of the community with the proposed spud barge area located adjacent to this gravel ramp.

The Meliadine Project, along with current activities and reasonably foreseeable future development (RFFD) in the local region (Volume 4, Section 4.5.2.4 of the FEIS), have the potential to result in cumulative effects on local marine biological resources. Current marine activities near Itivia involve the use of the community boat ramp by residents to launch their boats in the open water season and to access the sea-ice of Melvin Bay and Rankin Inlet via snowmobile in the winter (Nunami Stantec Ltd. 2012). Some residents also use the sheltered area between shore and the large rock reef to anchor their boats through the summer season. Itivia Harbour is presently the only developed area in the community that is accessible during low tide (Nunami Stantec Ltd. 2012). Rankin Inlet Elders reported an increased use of boats by local residents in the Itivia region. Itivia Harbour is also used for loading and unloading of community re-supply vessels in the open-water season (fuel tanker re-supplying the hamlet anchors outside of Johnson Cove).

In support of the Meliadine Project, a total of approximately 40 000 tonnes of dry cargo (equipment and supplies) and 122 million litres of diesel fuel will be required annually during construction and operation phases of the Project. All shipping will follow established shipping lanes that are presently in use for the annual sea lift to Rankin Inlet. Project ocean-going cargo vessels carrying dry cargo and fuel (large barges and freighters) will anchor in deeper waters outside of Melvin Bay upon arrival at Rankin Inlet. Dry cargo will be offloaded from cargo vessels onto smaller cargo barges for tug-assisted transport through the access passage to Itivia Harbour. Approximately 5 to 8 cargo freighters are anticipated per year during construction and 4 to 6 cargo freighters per year during operations (Tables 8.3-10 and 8.3-11). For cargo delivery to Rankin Inlet, freighters will arrive throughout the open-water shipping season only. Each freighter will require up to 5 small cargo barge trips to offload cargo to the shore. This first ship will include 2 loaded barges having dry cargo, and 2 tugs. Once the barges and tugs arrive in Rankin Inlet, they will remain until the last of the annual dry cargo has been received and lightered from the ships. The 2 tug boats and 2 cargo barges will typically be used for offloading activities at any one time. The barges 'land' on the gravel ramp in Itivia Harbour during high tide and are unloaded to the community laydown area, situated up shore from the community ramp. Barges depart from the ramp at the next high tide. Approximately 4 to 6 fuel tankers during construction and operations (Tables 8.3-10 and 8.3-11) will arrive throughout the open-water shipping season delivering diesel fuel. It is expected that the large fuel tankers will anchor in the same general location as the dry cargo freighters. Ship-to-ship transfer of fuel will occur at this location from the larger tanker to a smaller tanker that can then navigate the access passage. The carrying capacity of the small tanker will be either 7300 m³ or 10 500 m³. The smaller tankers will be able to navigate the access passage into Melvin Bay, while the large tanker cannot. The small tanker will anchor opposite Itivia. From there, a floating pipeline of some 300-500 m will connect to a shore-based pipeline for transfer of fuel to the tank farm. Fuel will then be pumped from the small tanker or barge to the Meliadine Project tank farm using a floating



pipeline at a transfer rate of approximately 400 m³/h. A 300-500 m long¹⁰ floating pipeline will connect to a shore-based pipeline for transfer of fuel to the tank farm. Communications between the shore and the small tanker will be maintained throughout to ensure the safe transfer of the diesel. Spill risks, their potential impacts, and mitigation measures at the ship to ship and ship to shore transfer sites in Melvin Bay are discussed in Section 8.3.6.5. Additional contingency measures related to the transfer of fuel are described in the Oil Pollution Emergency Plan (SD 8-2).

In January of 2014, the Rankin Inlet Harbour Corporation submitted a Request for Proposal to develop a deep sea port facility in Rankin Inlet. The port would likely require dredging and would include a pipeline system linked to AEM's fuel tanks farms. The deep sea port would eliminate the need for a spud barge and the ship-to-ship transfer of fuel and dry cargo in deeper waters outside of Melvin Bay. The activity of smaller cargo vessels in Melvin Bay would also be reduced but would bring larger barges, freighters, and fuel tankers into Melvin Bay. The development of a deep sea port would eliminate the need for a spud barge, so these 2 project activities will not act in a cumulative nature.

Marine Shipping

There are currently no roads going in and out of Rankin Inlet. Throughout the north, marine transportation remains the primary method for delivery of goods. Relative to other major marine shipping routes in Canada, commonly used routes in Hudson Bay are subject to a much lower density of vessel traffic and a severely restricted shipping season. Shipping is only possible during the open-water period, which is 2 to 3 months long (60 to 80 days of shipping is considered a reasonable estimate, taking into consideration variability of ice break-up and formation, and severe weather). The Project will not involve ice breaking activities to extend the shipping season.

The Meliadine Project, along with RFFD in the Hudson Bay and Hudson Strait, will increase shipping and have the potential to generate cumulative effects on marine resources. The section below provides estimates on the percentage increase in shipping traffic that the Meliadine Project will add to current shipping levels as well as estimates on the percent cumulative increase in shipping levels resulting from the Meliadine Project and RFFD in the Hudson Bay and Hudson Strait. RFFD that may involve vessel traffic that will likely overlap spatially and temporally with the proposed Project shipping operations are as follows:

- the Kiggavik Uranium Project;
- the Roche Bay Project;
- the Ferguson Lake Project; and
- the Churchill Diamonds Project.

The Mary River Project was not considered to interact in a cumulative nature with the Meliadine Project due to the new Baffinland's option, which does not include shipping through the Hudson Strait (BIM 2013).

¹⁰ The anchoring location will vary based on a number of factors such as tide, wind, and draught of the small tanker, which will call for the need of a longer or shorter floating pipeline.



The following assumptions were made in estimating the shipping volumes from RFFD presented in Tables 8.3-10 and 8.3-11:

- Tonnage information for dry cargo vessels servicing Arctic communities were based on deadweight specifications of vessel fleet provided on the company websites (NEAS 2012; Arctic Sealift Services 2012).
- The Ferguson Lake Project, Churchill Diamond Project, and Roche Bay Project will NOT overlap temporally with Construction phase of the Meliadine Project.
- The Construction phase of the Kiggavik Project will overlap with the Construction phase of the Meliadine Project.
- The Meadowbank Gold Mine project will be in operation during the construction phase of the Meliadine Project and is expected to close in 2017.
- Traffic volume estimates for the Kiggavik Project and for the Port of Churchill commercial traffic are based on the 2013 Information Request responses for AREVA Resources Canada Inc. (AREVA Resources Canada Inc. 2013).
- Dry cargo and fuel shipping volume estimates for the Ferguson Lake, Churchill Diamond, and Roche Bay Project were assumed to be similar to that of the Kiggavik Project during operations.
- Vessel traffic associated with Arctic communities and the Port of Churchill are assumed to remain constant throughout the lifetime of the Meliadine Project.
- There is limited information regarding small pleasure craft traffic in the Project area. Pleasure craft traffic, therefore, has been excluded from the estimates.
- The development of a deep sea port in Rankin Inlet will not increase the number of vessels entering Melvin Bay.

A total of approximately 40 000 tonnes of dry cargo (equipment and supplies) and 122 million litres of diesel fuel will be required annually for the operations of the Meliadine Project. Approximately 5 to 8 freighters during construction and 4 to 6 freighters during operations (Tables 8.3-10 and 8.3-11) will arrive throughout the open water shipping season delivering dry cargo. Dry cargo will be loaded on ocean-going vessels in eastern ports, almost exclusively Bécancour, Quebec; and delivered directly to Rankin Inlet. Vessels will follow established shipping lanes that are presently in use for the annual sea lift to Rankin Inlet (along the coast of Labrador – Hudson Strait – Hudson Bay – Marble Island – through the Barrier Islands to an anchoring point outside Melvin Bay; Figures 8.1-2 and 8.1-1). Approximately 4 to 6 fuel tankers during construction and operations (Tables 8.3-10 and 8.3-11) will arrive throughout the open water shipping season delivering diesel fuel. The first leg of the voyage will be from an east coast refinery along the coast of Labrador to the Hudson Strait, with the remainder of the voyage being the same as for the ships carrying dry goods. The first vessels of the year will normally arrive in Rankin Inlet in the latter part of July or early August. Spill risks, their potential impacts, and mitigation measures along the shipping route are discussed in Section 8.3.6.5. Additional contingency measures related to the spill risks along the shipping route are described in the Oil Pollution Emergency Plan (SD 8-2) as well as in Appendix 8.2-B.

AEM's Meadowbank Gold Mine will be closing as the Meliadine Project is entering operations. While up to 12 ships (freighters and tankers) will be required annually for Meliadine during operations, there will be a commensurate decrease in shipping required for the Meadowbank Gold Mine. In general, the net result of AEM



shipping activity would be no percent increase in shipping traffic during Meliadine operations if only 8 to 10 ships delivered supplies annually to the Project. If 12 ships were used, the net increase in ships due to AEM shipping would be about 2 per annum.

Tables 8.3-10 and 8.3-11 outline estimated shipping volumes in Hudson Strait from RFFD projects that would likely overlap with the Meliadine Project during its construction and operation phases.

Table 8.3-10: Anticipated Yearly Vessel Traffic in Hudson Strait during the Meliadine Project – Construction Phase

	Dry Cargo (tonnes)	Fuel (tonnes)	Dry Cargo Return Trips	Fuel Cargo Return Trips	Total Number of Return Trips
Current Shipping Volumes					
Resupply vessels for Arctic communities	164 165	Not Available	13	30	43
Port of Churchill (commercial traffic)	400 000	-	12	-	12
Research Vessels	-	-	-	-	1
Tourist Cruise Ships	-	-	-	-	5
Meadowbank Gold Mine	40 000	80 ,000	4	4	8
Project and RFFD Related Shipping Volumes					
Kiggavik Project	53 000	33 000	6	2	8
Meliadine Project	40 000	103 700	5 to 8	4 to 6	9 to 14
Total increase in shipping as a result of Meliadine Project during Construction					9 to 14 (+13 to 20%)
Total cumulative increase in shipping as a result of Meliadine and Kiggavik Projects – during Construction					17 to 22 (+25 to 32%)

Table 8.3-11: Anticipated Yearly Vessel Traffic in Hudson Strait during the Meliadine Project – Operations Phase¹¹

Cargo Recipient	Dry Cargo (tonnes)	Fuel (tonnes)	Dry Cargo Return Trips	Fuel Cargo Return Trips	Total Number of Return Trips
Current Shipping Volumes					
Resupply vessels for Arctic communities	164 165	Not Available	13	30	43
Port of Churchill (commercial traffic)	400 000	-	12	-	12
Research Vessels	-	-	-	-	1
Tourist Cruise Ships	-	-	-	-	5
Project and RFFD Related Shipping Volumes					
Kiggavik Project	67 000	55 000	6	4	10
Ferguson Lake Project	67 000	55 000	6	4	10
Churchill Diamond Project	67 000	55 000	6	4	10
Roche Bay Project	67 000	55 000	6	4	10
Meliadine Project	40 000	103 700	4 to 6	4 to 6	8 to 12
Total increase in shipping as a result of the Meliadine Project - during Operations					8 to 12 (+13 to 20%)
Total cumulative increase in shipping as a result of Meliadine, Kiggavik, Ferguson Lake, Roche Bay and Churchill Diamond Projects – during Operations					48 to 52 (+79 to 85%)

Notes: - : Not applicable

¹¹ The Meadowbank Gold Mine Project is not included in Table 8.3-10 as it is expected to close in 2017 just as the Meliadine Project is going into operation. The reduction in shipping associated with closure of Meadowbank will offset the shipping planned for Meliadine. This offset is not considered in the increases presented.



During its construction phase, the Project will increase existing shipping levels by an estimated 9 to 14 vessels per year (+13 to 20%; Table 8.3-10). The total cumulative increase in shipping as a result of Meliadine and Kiggavik Projects during their construction is estimated at 17 to 22 (+ 25 to 32%; Table 8.3-10). During its operations phase, the Project will increase existing shipping levels by an 8 to 12 vessels per year (+13 to 20%; Table 8.3-11). Total cumulative increase in shipping as a result of Meliadine, Kiggavik, Ferguson Lake, and Churchill Diamond Projects during operations is estimated at 48 to 52 (+79 to 85%; Table 8.3-11). Cumulative effects are discussed in Section 8.3.7.

8.3.6.2 *Effects Assessment for Marine Mammals*

The Project will contribute to increased vessel traffic in Melvin Bay and the shipping corridor during construction, operation, and closure of the Project. Construction of the mine is projected to take 3 years, during which the majority of supplies and materials will be transported by ship. During its construction and operations phase, the Project will increase existing shipping levels by an estimated 13 to 20% (Tables 8.3-10 and 8.3-11). The operations phase of the spud barge includes the construction phase of the mine. The cargo vessels will be located offshore in deeper waters and supplies offloaded to the barges, which will transport the goods to the spud barge.

Marine mammals contribute to the overall ecosystem health of the LSA and provide social, cultural, and economic benefits to the community of Rankin Inlet. All vessels in the marine environment have the potential to strike a marine mammal and contribute underwater sound to the existing acoustic habitat.

Potential environmental effects of the Project on marine mammal populations and habitat include the following:

- Change in health and mortality risk due to collisions with the vessel;
- Change in behaviour due to underwater noise from Project vessels;
- Change in marine habitat quality due to altered water quality from potential accidental fuel spills; and
- Change in health and mortality risk due to exposure to accidental fuel spills.

There are many existing sources of underwater noise in the marine environment; one anthropogenic source is marine shipping. The underwater noise that is created by a moving vessel is the result of a combination of the ship's machinery, propellers, and water flow around the hull. Most noise from a vessel originates from propeller cavitation, or the formation of bubbles from the rotation of the blades. In addition to vessel noise, there are natural and biological sources of underwater noise, all of which contribute to the overall ambient noise level. Natural sources include wind and rainfall, ocean waves, natural seismic activity under the seabed, and ice (cracking, collisions). Biological sources include the movement and communication sounds of other animals.

The effects of accidental spills on marine mammals and marine mammal habitat are assessed separately in Section 8.3.6.5 and Section 8.3.6.6.

8.3.6.2.1 *Change in Health and Mortality Risk due to Vessel Collisions*

An increase of 13 to 20 % in the number of vessels operating in the offshore shipping corridor, as well as project vessels operating in Melvin Bay and offloading operations in nearshore waters at Itivia Harbour, may cause a



change in health and mortality risk in marine mammals. Most marine mammals are fast and manoeuvrable in the water, and have sensitive underwater hearing, enabling them to avoid approaching vessels. Odontocetes (toothed whales, e.g., beluga whale) and pinnipeds (seals and walrus) are known to be highly manoeuvrable and are rarely struck by vessels (Laist et al. 2001; Jensen and Silber 2003). There are very few documented cases of seal mortality as a result of a vessel strike (Richardson et al. 1995a). Of all records, mysticetes (baleen whales, e.g., bowhead whale) are the most commonly struck by transiting vessels (Laist et al. 2001; Jensen and Silber 2003). Baleen whales are relatively large and slow-moving and perhaps unable to exhibit a rapid avoidance response to approaching vessels.

A vessel strike on a marine mammal may result in either injury or direct mortality. Injuries are typically the result of 2 mechanisms: either blunt force trauma from impact with the vessel or from lacerations from contact with the propellers. Depending on the severity of the strike and the injuries inflicted, the mammal may or may not recover. Most strikes occur between slow moving whales, when ships are 80 m and longer and are travelling at 14 knots or faster (Laist et al. 2001). Recent research shows that vessel speed is positively correlated with the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Mathematical models from current vessel-strike probability research support the reduced probability of a vessel strike with reduced speeds. At a speed of 10 knots, the models predicted a 30% chance of vessel strike when the whale is directly in the vessel path (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Serious or lethal strikes to whales are infrequent at vessel speeds of less than 14 knots, and are rare at speeds of less than 10 knots (Laist et al. 2001).

Marine mammals that spend a considerable amount of time at or near the surface are at increased risk of vessel strikes. They are physically in the way of approaching vessels and research has shown that sound levels are lower near the surface, potentially explaining why baleen whales are often unresponsive to approaching vessels (Richardson et al. 1995b). Acoustic modeling around the hull of a ship further shows that underwater sound levels may be lowest directly off the bow ahead of an oncoming vessel, compared to the sides and behind stern (Terhune and Verboom 1999). Baleen whales, therefore, are more likely susceptible to potential ship strikes when occurring in the direct path of a vessel.

8.3.6.2.2 Change in Behaviour due to Underwater Noise from Project Vessels

An increase of 13 to 20 % in the number of vessels operating in the offshore shipping corridor as well as Project vessels operating in Melvin Bay will introduce underwater noise to the marine environment and may cause marine mammals to avoid affected habitat areas. This could potentially include disruptions to the annual migration of marine mammals in the RSA, and consequently their availability for harvest. Marine mammals that occur in the vicinity of the Project area (Melvin Bay, Hudson Bay, and Hudson Strait) likely have prior experience with vessel presence and associated underwater noise from existing traffic given the current volume of shipping that occurs in the area (Table 8.3-10) and natural acoustic sources (e.g., surface agitation, such as wind and waves and ice noise). The individual and species-specific reactions to anthropogenic noise may include no reaction, subtle reaction (e.g., change in breathing rate), and obvious reaction (e.g., altering swim direction and avoidance).

Underwater noise has the potential to cause an avoidance response or auditory masking (interference with communication space) in marine mammals. In the extreme case, these effects could lead to a change in migration patterns, reduced foraging efficiency, increased energy expenditure, and resulting reduced fecundity and population health. The majority of underwater noise generated by a moving vessel is due to propeller



cavitation (Mitson 1995). Also important are the operational aspects, such as speed and sudden alterations of course. Maintaining constant speed and avoiding rapid changes in speed generates an even level of noise output (Mitson 1995).

Existing ambient noise was not measured in Itivia Harbour or along western Hudson Bay and no published data or publicly available information exists on underwater ambient noise levels in Hudson Bay. However, surface agitation (from wind and waves) and rainfall are likely the dominant source of underwater ambient noise.

8.3.6.2.3 Proposed Mitigation Measures

Several mitigation measures and Project design features will be implemented as part of the Project to reduce the potential for behavioural disturbance / acoustic masking effects, and minimize the potential for vessel strikes on marine mammals. These are described in AEM's Shipping Management Plan (SD 8-1) and summarized below:

- All Project vessels will remain at least 2 km from Marble Island to avoid disturbing marine mammals potentially present in this area;
- To the extent practical, vessel speed will be kept at a minimum (≤ 2 knots) when operating in Melvin Bay. This includes vessels in transit between the spud barge at Itivia Harbour and the anchoring site outside Melvin Bay (access passage waters included);
- To the extent practical, vessel speed will be kept at a minimum (< 14 knots) when operating in the marine shipping corridor between Rankin Inlet and eastern port locations;
- All Project vessels will follow established shipping lanes / navigational routes typically used for the annual sea lift to Rankin Inlet;
- All Project vessels will maintain a constant course and constant speed, to the extent practical, when operating in the LSA;
- Upon arrival at Rankin Inlet, all cargo vessels and large fuel tankers will anchor in deep waters outside Melvin Bay. To the extent possible, vessel engines and propellers will be shutdown while anchored outside Melvin Bay to reduce unnecessary underwater noise during cargo and fuel lightering;
- Under no circumstances, other than in the case of an emergency, will vessels approach within 300 m of a walrus or polar bear observed on sea ice, or any marine mammal engaged in feeding activities. For all other marine mammal encounters, vessels will not approach within 100 m of a marine mammal;
- If marine mammals approach within 100 m of a vessel, the vessel will reduce its speed and, if possible, cautiously move away from the animal. If it is not possible for a vessel to move away from or detour around a stationary marine mammal or group of marine mammals, the vessel will reduce its speed and wait until the animal(s) moves at least 100 m from the vessel prior to resuming speed;
- All Project vessels will not be operated in such a way as to separate an individual member(s) of a group of marine mammals from other members of the group; and
- When weather conditions require, such as when visibility decreases, all Project vessels will adjust speed accordingly to avoid the likelihood of the ship striking an animal.



8.3.6.3 *Effects Assessment for Fish and Fish Habitat*

Marine fish contribute to the overall ecosystem health of the LSA and provide social, cultural, and economic benefits to the community of Rankin Inlet. In particular, Arctic char, Arctic sculpin, fourhorn sculpin, Greenland cod, and slender eelblenny are important to the community and the ecosystem in the Project area.

Potential environmental effects of the Project on marine fish and fish habitat include the following:

- Change in fish habitat due to grounding of spud barge and cargo barges; and
- Change in fish behaviour due to underwater noise disturbance from vessel activities;
- Change in marine habitat quality due to altered water quality from potential accidental fuel spills; and
- Change in health and mortality risk due to exposure to accidental fuel spills.

The effects of accidental spills on marine fish and fish habitat are assessed separately in Section 8.3.6.5.

8.3.6.3.1 *Change in Habitat due to Grounding of Spud Barge and Cargo Barges*

Grounding of the spud barge and dry cargo barges may cause changes to fish habitat quality within the barge footprint due to compression of the substrates and a consequent decrease in the habitat's vertical structure. The spud barge anchors will also impact the benthic habitat and organisms present. Habitat changes could displace fish from the Project footprint.

The spud barge will rest on the substrate of the Itivia boat ramp twice daily at low tide. The barge is 76 m long by 17 m wide and is expected to weigh 2190 tonnes (2 190 000 kilograms [kg]), or 1695 kg/m². Two dry cargo barges may be alongside the spud barge at any time for offloading of goods. The area of these barges is unknown at this time and will depend on the horsepower of the tugs. Possible barge sizes include 91 x 22 m; 130 x 24 m; or 51 x 12 m. The spud anchors themselves (total area of 2 m²) will also affect fish habitat in the Project footprint by reducing substrate area but increasing vertical habitat. The habitat beneath the barges will continue to be accessible to fish at high tide, but the area will be shaded.

The existing substrate within the spud barge footprint consists of coarse gravels with some cobbles and small boulders, with fine sediments in the interstitial spaces. The movement of the barges with the tide is expected to temporarily suspend small amounts of sediment (from interstitial fines) in the water column each time the barge rises off of the substrate. The fine sediments in Itivia Harbour are primarily silt (0.05 mm to 2 µm) and sand (2 mm to 0.05 mm), with less than 10% clay (< 2 µm) (Nunami Stantec Ltd. 2012). The sand particles will resettle quickly (minutes to hours, depending on the movement of the water), whereas the smaller particles will take a longer time (hours or days depending on the movement of the water). The silt and clay particles that do not settle quickly will be dispersed by the movement of the water.

Ice is known to cause major disturbance to arctic coasts (Conlan et al. 1998). Ice scouring is a natural physical disturbance that can have a great influence on the marine biota and geology of an area. Ice scouring occurs regularly each season in Hudson Bay and can extend to a depth of 5 m (Dadswell 1974 in Stewart 2005). Landfast ice in the winter grounds the seabed and crushes invertebrates. It has been suggested that the effects of ice scouring are similar to industrial disturbances such as dredging (Conlan et al. 1998).



8.3.6.3.2 Change in Fish Behaviour due to Underwater Noise from Vessel Activities

Underwater noise generated by Project vessel movements in Melvin Bay and the proposed shipping corridor may result in behavioral changes in marine fish due to sensory disturbance. Noise disturbance may cause fish to temporarily school up in larger groups, move away from suitable habitat (displacement), or alter their natural movements (avoidance or diversion from a foraging area or migratory path). This could, in turn, reduce foraging efficiency and fecundity, and increase energy expenditure.

Existing ambient noise has not been measured in Melvin Bay and no published data or publicly available information exists on ambient underwater noise levels. Currently, the dominant sources of underwater ambient noise within the LSA include residential boating, community resupply vessels and delivery barges, port of Churchill commercial traffic, research vessels, tourist cruise ships, surface agitation from wind, waves, rainfall, and existing biological noise.

Fish can detect noise from ships at long distances when ambient noise is low but are unlikely to move away until the noise is much higher (i.e., when the distance is a few hundred metres) (Mitson 1995). The ability of fish to detect sound varies with species and is dependent on a number of factors including the presence of an air bladder, structure of the internal hearing system, size of the otoliths, distance from the sound source, and depth of water. Fish do not “hear” as mammals hear. Sound is interpreted by the otoliths of the inner ear, which respond to the kinetic components of the sound wave rather than the sound pressure (Mitson 1995). For fish species with a swim bladder, the organ sends the sound waves to the otolith. Because the bladder increases with the size of the fish, it has been suggested that sensitivity to sound may increase in proportion to the size of the fish (Mitson 1995).

Hearing thresholds for many Arctic species of fish are largely unknown. Underwater noise generated by vessel engines and cavitation can affect fish behaviour. Behavioural changes may cause disruption to migration patterns or spawning events, and movement away from valuable food sources, and have the potential to cause population-level effects. Fish are particularly sensitive if these changes occur over a critical period when they have a short window of opportunity to complete an activity.

Eight species of marine fish may be found in the Local and Regional Study Areas (LSA and RSA) including Greenland cod, slender eelblenny, fourhorn sculpins, Arctic staghorn sculpin and Arctic sculpin, Arctic char, Arctic cod, and polar cod.

Knowledge on the behavioral responses of fish to underwater sound are poorly understood (Popper and Hastings 2009). The intensity of the response of a fish to vessel noise depends on the species, its physiological conditions and its environment. Pelagic fish may dive deeper, while benthic fish may move laterally away from the noise source. Arctic char, which are benthopelagic, have a greater flexibility for movement in a 3 dimensional space and may move deeper and laterally. Most research has investigated the responses of captive fish to high intensity sounds from seismic air guns and pile driving (Popper et al. 2005; Popper et al. 2006). Research has shown that the intensity of a fish’s response was reduced with increased swimming depth of the fish and decreased speed of the vessel (Mitson 1995).

Although hearing thresholds for most of the fish species found in the LSA and RSA are largely unknown, hearing thresholds for closely related species such as the walleye pollock (*Theragra chalcogramma*) and the Atlantic cod (*Gadus morhua* L.) are known and may be used as surrogates for Greenland cod.



The hearing ability of walleye pollock, from 3 different age groups (corresponding to size-classes), was determined from auditory evoked potentials by Mann et al. (2009). Walleye pollock hearing was most sensitive between 100 and 200 Hz, with thresholds around 75 dB re 1 μ Pa at 1 m (Mann et al. 2009). Hearing sensitivity decreased as frequency increased up to 450 Hz. The 3 age groups of walleye pollock did not show a difference in hearing sensitivity, although there was a noticeable interaction between frequency and age, as well as a trend with older fish having a slightly lower mean threshold level. Water temperature appears to have an effect on the hearing thresholds at 350 Hz for walleye pollock. Each degree of temperature increase (from 8 to 12°C) resulted in an 8.3-dB decrease in hearing threshold, with hearing being largely changed by local temperature over their natural range of occurrence. However, walleye pollock are generally found in the marine environment at temperatures less than those used during the Mann et al. (2009) laboratory experiments. In the Bering Sea, walleye pollock are generally found in 3 to 6°C waters and avoid temperatures less than 0°C (Kotwicki et al. 2005). They may be found in temperatures as warm as 10 to 12°C (Bailey et al. 1999). Based on the above results, Mann et al. (2009) suggests that the hearing thresholds of walleye pollock are generally similar to those of other gadid fishes.

Hearing studies on Atlantic cod demonstrated that this species is sensitive to pure tones in the frequency range of 30 to 470 Hz. Greatest sensitivity was observed between 60 to 310 Hz, and the hearing threshold ranged from 78 to 117 dB re: 1 μ Pa at 1 m (Chapman and Hawkins 1973). Changes in levels of ambient sea noise caused variation in thresholds in most frequency bands. In calm sea conditions, unmasked thresholds can be obtained. Thresholds were largely independent of the sound source distance within 1.7 to 50 m, suggesting that cod are sensitive to acoustic pressure (Chapman and Hawkins 1973).

Using walleye pollock and Atlantic cod as surrogates, it is likely that Greenland cod are most sensitive to low frequency sounds (below 500 Hz), with hearing thresholds around 75 to 117 dB re: 1 μ Pa at 1 m. Hearing studies conducted on other marine teleost species in the field (Chapman 1973; Chapman and Hawkins 1973) note that masking can occur even under quiet sea conditions. The natural environment of marine fishes is characterized by abiotic and biotic background noises including currents, rain, seismic events, coastal surf, ice movement, and vocalizations of animals. It is suggested that the absolute sensitivity of the auditory system is less important than the ability to discriminate between relevant sound stimuli and background noise (Knudsen et al. 1948; Wenz 1962; Myrberg 1990). Masking is likely to occur in most marine environments and coastal waters (Popper and Clarke 1979; Ladich and Popper 2004).

A review of the literature indicates that most fish species typically show a response to vessel noise when their hearing threshold is exceeded by 30 dB or more (Mitson 1995). However it is important to note the uncertainties in the available research. The relevant studies were based on fish trawler noise and focused on different species than those present in the LSA. Studies further noted that the vessels elicited a reaction in fish at distances of 100 to 200 m from the source, and up to 400 m for noisier vessels (Mitson 1995). While localized behavioral responses may be observed, the geographic extent over which these effects are realized, and how individual or population-level fitness is affected, have not been quantified.

8.3.6.3.3 Proposed Mitigation Measures

Design features of the proposed docking infrastructure (spud barge) at Itivia Harbour will help minimize adverse effects on fish habitat during the operations phase of the spud barge. The nearshore portion of the spud barge is situated on substrate that has been previously disturbed by the addition of coarse gravel fill for the existing



community ramp. Spud barges typically have less of a negative impact on fish habitat than a permanent wharf structure as no dredging, in-filling, or pile driving activities are required. The spuds rest on the surface of the seafloor, stabilizing the barge and allowing it to rise and fall with the tides. The spud anchors will be removed during decommissioning.

Mitigation measures for minimizing behavioral disturbances to marine fish from Project-generated underwater noise will be similar to those described for marine mammals. These include speed restrictions for Project vessels transiting in Melvin Bay and in the proposed shipping corridor, avoidance of unnecessary vessel acceleration, the use of established navigational routes and shipping lanes, and the continuance of a constant course for vessels in Melvin Bay transiting to and from the spud barge. Shut-down of vessel engines and propellers while anchored outside Melvin Bay will also reduce unnecessary underwater noise during cargo and fuel lightering.

8.3.6.4 *Effects Assessment for Marine Birds*

Marine birds contribute to the overall ecosystem health of the LSA and provide social, cultural and aesthetic benefits to the community of Rankin Inlet. Potential environmental effects of the Project on marine bird populations and marine bird habitat include the following:

- Change in health and mortality risk due to collisions with infrastructure;
- Change in behaviour due to sensory disturbance from in-air noise and site/vessel lighting;
- Change in marine habitat quality due to altered water quality from potential accidental fuel spills; and
- Change in health and mortality risk due to exposure to accidental fuel spills.

There is also a potential for injury or mortality of marine birds from accidental spills. The effects of accidental spills on marine birds and bird habitat are assessed separately in Section 8.3.6.5.

8.3.6.4.1 *Change in Health and Mortality Risk due to Collisions with Infrastructure*

Some marine birds are attracted to lights at night and in low light conditions (Montevecchi et al. 1999). Bird injury or mortality rates could increase as a result of collisions with nearshore structures (e.g., cranes) caused by attraction to lighting at the barge or on vessels. Under conditions of poor visibility such as low cloud cover or fog, nocturnal migrating birds have difficulty navigating and may be attracted to bright lights. Birds that have lost their celestial navigation aids may enter these illuminated areas and become confused possibly resulting in collisions and/or exhaustion. Birds that are attracted may experience injury or mortality by colliding with barge or vessel infrastructure. Birds may also become disoriented by lights, particularly during overcast or foggy conditions, and fly continuously around them consuming energy and delaying foraging or migration (Avery et al. 1978; Bourne 1979; Sage 1979; Wood 1999). Weather conditions and the magnitude of bird movements are important factors influencing bird injury or mortality from strikes at tower structures (Crawford 1981). Moisture droplets in the air during conditions of drizzle and fog refract the light and greatly increase the illuminated area thus enhancing the attraction (Montevecchi et al. 1999). Injury or mortality may also be higher during migration periods, when large numbers of birds may be forced down to a lower flight path or to the ground by inclement weather. Some nocturnal predators of marine birds are more successful when hunting in illuminated areas, potentially increasing the risk of bird predation in areas with anthropogenic lighting.



8.3.6.4.2 Change in Behaviour due to Sensory Disturbance from In-Air Noise and Site/Vessel Lighting

During both the construction and operations phase, in-air noise generated by nearshore human activities may result in sensory disturbance to marine birds, including avoidance and displacement behavior. This could potentially include disruptions to the annual migration of marine birds in the RSA, and consequently their availability for harvest. Physical activities in Melvin Bay such as spud barge installation, barge loading and offloading, and vessel operations have the potential to similarly alter bird behaviour. Site and vessel lighting at night may also attract migrating birds to the spud barge area. As noted above, birds may also become disoriented by bright lighting, particularly during overcast or foggy conditions, and fly continuously around them consuming energy and delaying foraging or migration (Avery et al. 1978; Bourne 1979; Sage 1979; Wood 1999).

Sensory disturbance effects have the potential to result in the following:

- cause marine birds to abandon or make less use of preferred or traditional habitats, leading to a reduction in abundance;
- affect reproduction/nesting success, resulting in reduced recruitment and population size; and
- limit the ability of staging birds during migration to survive and successfully migrate.

8.3.6.4.3 Proposed Mitigation Measures

The following mitigation measures will be implemented to minimize the potential for changes in health, direct mortality, and behavioral disturbance of marine birds:

- All Project vessels will use established navigational / shipping routes and designated access passage to Itivia Harbour from the anchoring area in Melvin Bay.
- All Project Vessels operating in Melvin Bay (cargo barges, tugs, small fuel tankers) will travel at reduced speeds (less than 2 knots), minimizing the amount of in-air noise generated by these vessels.
- Where permissible under safety and navigation requirements, outdoor lights will be shielded to minimize light spillage beyond the barge face and vessel decks, or angled such to minimize direct illumination and reflection of the sea surface.
- Activities will be scheduled during daylight hours whenever practical to minimize the need for staging lights. As most work will occur during summer when daylight is extended, there will be minimal need for site lighting.
- All Project vessels will maintain a minimum distance of 200 m from nesting locations in accordance with best management practices for raptor conservation (Demarchi et al. 2005).
- The proposed shipping route has been selected to avoid the majority of the key marine habitat areas for migratory birds, migratory bird sanctuaries, and known important bird areas (Figure 8.3-2 and 8.3-3) to the extent possible, as safe navigation allows.



8.3.6.5 *Assessment of Change in Habitat due to Altered Water Quality from Accidental Fuel Spills*

Accidental spills have the potential to occur during the life of the Project. These could be minor events during routine operations such as small hydrocarbon, chemical, or waste spills; or major events such as large hydrocarbon spills due to malfunction during fuel transfer activities or vessel accidents, such as sinking, running aground, collisions with other ships, or fires and explosions. This section addresses potential impacts to marine VECs as a result of accidental fuel spills.

The fate, toxic effect, and weathering of a fuel spill depends on its chemical properties (specific gravity, pour point, viscosity, and constituent components), volume released, surface area of spreading, and the environmental conditions involved (wind speed and direction, water depth, wave energy, sea state, solar radiation, current speed, water temperature, and distance to land) (ITOPF 2002). Weathering processes¹² include dispersion, evaporation, dissolution, sedimentation, spreading, biodegradation, emulsification, and photo oxidation. The rate at which a spill will disperse once it enters the marine environment is largely dependent upon the type of fuel released and the sea state, dispersing most rapidly with low viscosity oils and in the presence of breaking waves (ITOPF 2002). The rate of evaporation depends on ambient temperatures, wind speeds, and type of fuel. The speed of spreading depends to a great extent on the viscosity of fuel and the volume spilled.

A number of fuels and chemicals could be present onboard the Project tankers and have the potential to be accidentally released to the marine environment. Ultra-low sulfur P-50 Arctic grade diesel fuel - to be shipped for use at the mine site - is the largest fuel type by volume that will be transported to Rankin Inlet (Itivia Harbour) aboard fuel tankers. However, tankers will also be carrying intermediate and heavy fuel oils (IFOs and HFOs) for consumption during transit. IFOs and HFOs are denser and have a higher viscosity than diesel fuels. IFOs and HFOs are usually hydrocarbon blends with variable compositions of differing molecular weights. Within these blends, each hydrocarbon behaves differently in water. Lighter components show greater solubility and higher toxicity, but have a tendency to evaporate quickly. Dense components spread less rapidly, but tend to remain longer in water. Very dense components may adhere to sediment and sink to the seafloor (sedimentation) and assume a tar-like consistency (CONCAWE 1998). In general, IFOs and HFOs are considered persistent oils and do not dissipate quickly; they have a tendency to remain for longer periods than lighter fuels, and, therefore, can pose a greater threat to the environment (ITOPF 2002). Diesel fuel has a low viscosity and will weather rapidly when spilled into the marine environment (NOAA 2006). Diesel fuel has a lower density than water and is readily dispersed by wave action. In a small diesel fuel spill, more than 90% of the fuel is either evaporated or naturally dispersed over a time frame of a couple of hours to days (NOAA 2006).

Environmental conditions during a fuel spill greatly influence how far and how long a spill will spread, as well as how long it will persist. Currents, waves, and tidal action influence spreading and ultimately determine where the spill will end up. High temperatures and solar radiation increases evaporation. Wind and wave action increases dispersion by breaking the fuel into smaller fragments and droplets, increasing biodegradation, dissolution, and sedimentation (ITOPF 2002). The larger-magnitude impacts from fuel spills are typically encountered when spills occur near land, in shallow waters, or in areas with reduced water circulation (Patin 1999). Spilled hydrocarbons can deteriorate water quality by contaminating the water with a number of constituents, mainly aromatic hydrocarbons and alkanes, in excess of local and international water quality guidelines and standards. Released

¹² For light hydrocarbon fuels such as diesel, evaporation and dissolution are the most influential weathering processes (ITOPF 2002).



hydrocarbons will spread rapidly over the sea surface resulting in a thin layer (a slick) that tends to disperse within the upper layer of water column.

To assess the potential impacts of accidental spills on marine VECs, AEM undertook a semi-quantitative risk assessment to determine the likelihood and extent of a potential fuel spill during fuel transfer activities near Rankin Inlet and during transport along the shipping route. Details regarding the analysis are provided in a report entitled *Meliadine Spill Risk Assessment*, included as Appendix 8.2-B and summarized below. The spill risk assessment only considered diesel fuel spills given the minimal volumes of IFOs and HFOs being transported aboard the tankers, which represent less than 5% of the total volume of diesel fuel transported.

The expected spill rate per year for the Project was calculated by multiplying the total volume of fuel to be transported in a given year by estimated spill frequencies derived from historical statistics (SL Ross 1999). It was determined that approximately 122 ML (122,000 m³) of P50¹³ diesel fuel would be delivered per year of operations of the Project (SD 8-1, SD 8-2). Based on this total and the estimated spill rates reported by SL Ross (1999), the overall likelihood of a fuel spill for the Project was predicted to be once every 36 years for a small spill and once every 526 years for a large spill (Appendix 8.2-B).

Although diesel spills have a low likelihood of occurrence, it is important to understand where the spill will travel and the best way to mitigate impacts. The behavior of a potential fuel spill in the marine environment, therefore, was assessed at 6 different hypothetical spill locations in the Project area, considering aspects of evaporation, dispersion, spreading, and potential distance traveled from the spill site. Two locations near Melvin Bay were considered in the assessment as these corresponded with ship-to-shore and ship-to-ship fuel transfer locations where a higher potential for fuel spills would occur. Four locations along the shipping route were also considered in the assessment as these corresponded with known sensitive/important areas for marine mammals and/or marine birds, including Walrus Island, Coats Island, Ungava Peninsula, and Eastern Hudson Strait. The location of the hypothetical spill locations was selected based on the following criteria:

- Input from scientists with local expertise (S. Atkinson 2013, pers. comm.; M. Dyck 2014, pers. comm.);
- Areas of local and traditional importance to Inuit;
- Known summer ranges and concentrations of marine mammals and marine birds;
- Location of key marine habitats for migratory birds and coastal important bird areas;
- Location of other sensitive and protected areas; and
- Increased probability of fuel release at fuel transfer locations.

The ADIOS2 model was used with the input of local wind speed to approximate wave conditions and then predict the weathering half-life of the fuel. Algorithms provided by the Australian Maritime Safety Authority were used to calculate the time for a spill to reach shore and the quantity of fuel from a spill that would be deposited on shore (DNV 2011). The quantity and proportion of fuel deposited on shore was determined after calculating the quantity of fuel remaining in the slick at the shore. The time between the occurrence of the spill and the slick initially reaching the shore (T_{shore}) depends primarily on the distance to shore (D_{zone}), wind velocity in the

¹³ P50 is an Arctic diesel fuel with a lower temperature pour point than other diesel fuels.



direction of the shore (V_{wind}), and the slick's velocity represented as a fraction of the wind velocity (RV_{drift}) (DNV 2011):

$$T_{shore} = \frac{D_{zone}}{V_{wind}RV_{drift}}$$

The quantity remaining in the slick (Q_s) relates to the original spill quantity (Q), weathering half-life to the quantity of fuel remaining (H), and time to shore (T_{shore}) (DNV 2011).

$$Q_s = Q * 2^{-T_{shore}/H}$$

For all spill scenarios considered at both fuel transfer locations near Melvin Bay, the weathering half-life of a potential spill was determined to be <19 h. The time required for the spill to reach shore varied from approximately 6 min (0.1 h) to 1 h 20 min. It was further predicted that between 89% and 98% of the total volume of spilled diesel fuel would ultimately reach shore if no responsive mitigation was implemented.

For hypothetical spill sites along the shipping route, the weathering half-life was predicted to be less than 19 h for all scenarios. Depending on the distance to shore and wind scenario, the time to shore varied from about 7 h to 94 h (approximately 4 days). Depending on different wind conditions and spill locations, the amount of fuel predicted to be deposited on shore varied from 2% to 26% of the original spill volume. Mean and 50-year (extremal) wind speed estimates and mean fetch values for the 4 locations along the shipping route were used to estimate the slick distance traveled until the fuel remaining represented 1% of the original quantity. Modeling results indicated that, assuming average wind speed conditions, the fuel slick would travel approximately 26 km over a 48-h period prior to being reduced to 1% of its original spill volume through natural weathering effects. Using 50-year wind speed values, the fuel slick would travel approximately 38 km over a 12-h period prior to being reduced to 1% of its original volume (or 26 km over an 8-h period prior to being reduced to 7% of its original volume).

For the purpose of the assessment, a 26-km swath on either side of the shipping route was considered to represent a 'hypothetical spill limit' - or the maximum spatial extent that a diesel fuel slick could potentially reach prior to the fuel being 99% weathered under average wind conditions, or 93% weathered under 50-yr wind conditions. Assuming the most likely travel direction of the plume is southeast given the predominant northwest wind direction prevalent during summer, the slick from a fuel spill could extend to the north end of Coats Island (~37 km south of the shipping route) under 50-yr wind conditions, but not under average wind conditions. Marble Island, a sensitive ecological area and traditional seasonal hunting site for local Inuit communities, falls within the 26-km hypothetical spill limit, although is located north (<10 km) of the shipping route and, therefore, opposite of the mostly likely direction of travel of the plume during summer. Walrus Island, another sensitive ecological area located 32 km north of the shipping route, would potentially be susceptible to effects from a fuel spill under extreme (50-yr) wind conditions only, although is also located opposite of the predominant plume trajectory. No other overlap with sensitive coastal areas is expected based on the modeled results. Other landfall areas potentially affected by a fuel spill along the shipping corridor include Charles Island, located just north of Ungava Peninsula and within the 26 km hypothetical spill limit boundary (Figure 8.2-B-4). Nottingham Island is located at the northern limit of the modeled spill limit, although opposite of the expected plume trajectory. Potential related impacts on marine wildlife VECs are discussed in further detail below.



It should be noted that the ADIOSS2 model is a one-dimensional analysis and does not account for other site-specific effects such as modifications to the wave climate due to local bathymetry. Therefore, it is an approximation of the travel time and percent oil remaining to be used for planning and decision making purposes. This analysis does not include the influence of ocean currents from large-scale circulation patterns or tides in the prediction of the transport and spreading of a fuel spill. It is expected that tidal current speeds will be highest in areas where the channels are the narrowest such as adjacent to Coats Island, and, therefore, tidal current velocities in these areas may enhance the spreading, weathering, and travel time of the fuel in the direction of the tidal flow.

Potential Spill Effects on Marine Mammal Habitat

Local waters of Itivia Harbour and Melvin Bay do not support key marine mammal habitat areas, and few occurrences of marine mammals are reported in these areas. However, a number of established marine mammal habitat areas occur adjacent to the open-water shipping route and could be affected by an accidental fuel spill along the shipping corridor (Figure 8.3-1 to 8.3-19).

Sensitive marine mammal habitats around Marble Island and Walrus Island could be impacted by a worst case diesel spill along the shipping route, depending on the plume trajectory.

The coastal marine areas near Southampton Island and off the north end of Coats Island are identified as important habitat areas where bowhead whales and beluga concentrate during summer. Core summer habitat for narwhal is also known to exist near Southampton Island and near Repulse Bay (Figure 8.3-11 'common in summer'). Modeling results indicate that the slick from a fuel spill could extend to the north end of Coats Island (located as close as approximately 37 km south of the shipping route) under 50-yr wind conditions, but not under average wind conditions. Southampton Island and Repulse Bay are located considerably north of the modeled spill limit and opposite of the expected plume trajectory; therefore, no effects are anticipated on existing marine mammal habitat in these areas.

Core summer estuarine habitats for beluga whales are located along the southwestern coast of Hudson Bay, the southeastern coast of Hudson Bay, Frobisher Bay, and Ungava Bay. These areas would not likely be impacted by a spill event given their overall distance from the shipping route and based on spill trajectory modeling results. Killer whales may also be found in the Hudson Bay and Hudson Strait during the summer months, although occur primarily in waters offshore of Chesterfield and Rankin Inlets and less commonly along the shipping route where spills could originate (Figure 8.3-13).

Potential Spill Effects on Marine Bird Habitat

The Hudson Bay ecosystem is an environmentally sensitive area, particularly during the summer, as it provides important habitat for breeding, feeding, and molting activities for colonies of birds. These birds and their habitats are particularly vulnerable to hydrocarbon spills (Schreiber and Burger 2002). A number of key marine habitat sites for migratory birds have been identified along the shipping route (Figure 8.3-2). The majority are located more than 50 km from the proposed shipping route (Table 8.3-7). Four of these sites are located in closer proximity or overlap with the shipping route: Coats Island, Digges Sound, Frobisher Bay, and Button Islands. These marine areas delineate key feeding areas for marine birds; however, marine birds may forage beyond these areas (Mallory and Fontaine 2004). Marine birds nesting at these sites are particularly sensitive to pollution of their feeding areas (Mallory and Fontaine 2004). Depending on the spatial extent of an offshore spill, key marine habitat sites including offshore feeding areas as well as land-based breeding and moulting habitats could



be temporarily or permanently disrupted. Contamination and/or loss of food sources may occur by causing contamination or direct mortality of fish and other lower trophic organisms on which birds feed themselves and their young. Nesting areas of marine birds are generally located in areas where they would not be directly impacted by a spill event if it reached shore. Nesting and chick survival may also be disrupted should parents become oiled while out at sea (Eppley and Rubega 1990).

The proposed shipping route has been selected to avoid the majority of the key marine habitat areas for migratory birds, migratory bird sanctuaries, and known important bird areas (Figure 8.3-2) to the extent possible, as safe navigation allows. Important marine bird habitat at Frobisher Bay and Button Islands overlap with the proposed shipping route at their southern and northern boundaries, respectively. This overlap is unavoidable as these 2 sites almost completely cover the entrance to Hudson Strait from the Atlantic Ocean. To the extent possible, the shipping route has been located between these 2 sites to allow as much of a buffer distance as possible. In addition, the proposed shipping route will marginally overlap with the northern extent of the Coats Island key marine bird habitat site, although vessels will not approach closer than 30 km from the IBA onshore (Figure 8.3-2), and, therefore, outside the hypothetical spill limit.

There are no key marine habitat areas, migratory bird sanctuaries, or known important bird areas in Melvin Bay. During the baseline survey, only a black guillemot and a pair of sandhill cranes were identified in the LSA near the spud barge location (Appendix 8.2-A). TK identifies peregrine falcons, nesting common eiders, and guillemots near the offshore anchor location. A spill at this location would overlap with the foraging areas for these nesting species and could impact peregrine falcons by contamination of their food sources.

Potential Spill Effects on Marine Fish Habitat

Several species of marine fish may be found in the LSA and RSA. Those important to the local commercial, recreational, and subsistence fisheries are identified in Table 8.3-2. In general, these species inhabit the coastal areas of the LSA and RSA. An accidental spill occurring in the coastal environment near sheltered bays or fjords or in shallow or confined waters could result in high mortality of adult fish, fish eggs, and larvae (Boertman and Mosbech 2011). A spill in Melvin Bay would likely have a greater impact on marine fish due to its proximity to land and coastal areas and, therefore, a higher potential impact on marine fish. An offshore fuel spill may have less extensive adverse effects on marine fish due to higher dispersion rates in this environment.

8.3.6.6 *Assessment of Change in Health and Mortality Risk due to Exposure to Accidental Fuel Spills*

Marine Mammals

Marine mammals are infrequently sighted in local waters of Itivia Harbour and Melvin Bay, with observations limited to several beluga whales occasionally observed off the north coast of Buff Island and off the southwest tip of Thompson Island, as reported in TK studies (Burt and Hickes 2012, Appendix 9.3-C) A fuel spill in this area, therefore, would have potential impacts on a small number of beluga whales if the spill was to occur during the rare occasion individuals transited through this area. However, impacts on other species in the local harbour area are considered unlikely. IQ

A number of marine mammal species potentially overlap with the shipping route during the open-water season and could be affected by an accidental fuel spill along the shipping corridor. Potentially affected species would include beluga whale, bowhead whale, narwhal, killer whale, walrus, and 5 species of seals. The summer



distribution of polar bears does not directly overlap with the LSA or RSA; however, several polar bear sub-populations concentrate in coastal areas along the shipping route and could be impacted in the event a spill extended to shore.

Potential effects of hydrocarbon exposure to marine mammals include the following:

- Direct contact of oil / fuel with marine mammal eyes may cause eye irritation / inflammation;
- Direct contact of oil / fuel with marine mammal skin or coat may reduce thermoregulation abilities; cause skin irritation / inflammation;
- Inhalation of hydrocarbon vapours could result in inflammation of mucous membranes, pneumonia, and neurological damage;
- Ingestion of oil or oil contaminated prey may result in toxicological effects, gastrointestinal inflammation, ulcers, bleeding, diarrhea, or maldigestion;
- Oil in the water could foul the baleen of baleen whales, leading to reduced filtering / feeding efficiency;
- Oil / fuel in the water could cause marine mammals to avoid the area, thus potentially resulting in temporary displacement from some feeding or migratory areas; and
- Reduced prey availability through prey displacement.

Whales are generally not considered to be at great risk for adverse thermoregulation effects as a result of oiling of the skin, as they rely on blubber for insulation (Geraci 1990). However, hydrocarbons can cover the coat of seals or fur of polar bears, thus reducing its natural insulation properties. Heavy oil may also coat the baleen of baleen whales, such as the bowhead whale, impacting their feeding ability and efficiency (Geraci and St Aubin 1988). Polar bears may also ingest hydrocarbons as a result of grooming themselves (Stirling 1990; Neff 1990). Hydrocarbons can also cause severe irritation to the eyes and other mucous membranes, which may reduce hunting and foraging abilities in these species (Short 2003; Geraci and St. Aubin 1988).

Inhalation of light hydrocarbon compounds in sufficient levels may cause toxic effects in all marine mammals, such as central nervous system disorders, brain degeneration, liver damage, and reproductive failure (Engelhardt 1983; Geraci and St. Aubin 1980 in Short 2003; Geraci 1990, Geraci and St Aubin 1988; Matkin et al. 2008). However, light compounds generally dissipate during the first few days of a spill. Due to the content of the diesel fuel to be shipped, the majority of the components would likely dissipate within a couple days of the spill.

Individual marine mammals occurring in open-water areas directly overlapping with the plume would be at risk of direct impacts from exposure to diesel fuel (e.g., oiling effects) for a maximum period of up to 48 h assuming average wind conditions and a maximum period of up to 12 h assuming high (50-yr) wind conditions (Appendix 8.2-B). This is a conservative estimate, as the large majority of the fuel spilled would dissipate over a considerably shorter time frame, with estimates of 31% of the fuel remaining after the first 24 h assuming average wind conditions, and 40% of the fuel remaining after 4 h assuming high (50-yr) wind conditions. Animals would be potentially subject to indirect impacts (e.g., reduced health due to ingestion of oiled prey) for an undetermined period thereafter. The following section provides additional details on known direct and indirect effects of hydrocarbon exposure on marine wildlife VECs, and potential links to changes in health and mortality risk.



Toothed and Baleen Whales

There is a range of potential effects presented in the literature regarding impacts of spills on toothed and baleen whales, with some reports indicating that there is no conclusive evidence of acute or chronic impacts on whales from hydrocarbon exposure while others report on post-spill studies suggesting causal relationships between crude oil spills and whale mortalities (Short 2003; Engelhardt 1983). A report by Matkin et al. (2008) suggests that certain cetaceans do not avoid oil spills, which increases their risk of exposure during an accidental event.

Geraci (1990) reviewed a number of studies on the physiological and toxic effects of oil on whales and concluded there was no conclusive evidence of oil contamination being responsible for the death of a cetacean.

Studies have shown the effectiveness of cetacean epidermis as a barrier to the noxious substances found in petroleum. Whereas these normally damage the skin by permeating intercellular spaces and dissolving protective lipids, their penetration in cetacean skin was impeded by tight intercellular bridges, the vitality of the superficial cells, and the extraordinary thickness of the epidermis. The intercellular and intracellular lipids, which are abundant in cetacean epidermal cells, and which we had assumed to be a vulnerable target for petroleum, were unaffected. A cetacean is more likely to contact weathered oil, which is far more persistent but contains little of the more toxic light hydrocarbon fractions. Cetaceans with large ranges may contact some oil as they move quickly through a fouled area, but with little potential for long-term exposure. To date, no published data prove oil-fouling of the skin of any free-living whale. This suggests that 1) oil may not stick to the smooth skin surface, or 2) contact with oil is rare because whales avoid oil slicks. Bowhead whale encounters with fresh or weathered petroleum most likely present little toxicological hazard to the integument.

The potential alteration of the normal function of cetacean skin due to exposure to petroleum products has been studied in the common bottlenose dolphin (*Tursiops truncatus*) (Geraci and St. Aubin 1990). In humans, the mechanism for pathophysiological change or damage to the skin is through permeation of the toxins through intercellular spaces of the skin and dissolving of protective lipids (Bratton et al. 1993). However, in cetacean skin, the intercellular bridges are very tight, the superficial cells strong and vigorous, and the epidermis very thick. Intercellular and intracellular lipids were determined to be unaffected following exposure to hydrocarbons, indicating that cetacean skin can present a formidable barrier to the toxic effects of petroleum.

The effects of oil exposure to toothed and baleen whale populations are still uncertain. Effects would depend on the number of whales coming into contact with the spill, the duration of contact, and the degree of weathering of the spilled fuel. The number of whales contacting spilled fuel would depend on the location, size, timing, and duration of the spill and the animal's ability or inclination to avoid contact. Based on modeling results, spill effects were predicted to be limited to a 26-km extent from the spill origin (spill plume boundary) and would diminish to trace levels (<1%) within 48-h. Prolonged exposure to freshly spilled fuel could adversely affect some whales, but the number would likely be small. Whales exposed to spilled diesel are likely to experience temporary, nonlethal effects. All effects are initially manifested at the individual level, and may lower the individual's probability of survival or reproduction, which could potentially have population-level effects if the species affected was already compromised in population size. The effects may be direct (e.g., contact with oil) or indirect (e.g., degradation of habitat, reduced availability of prey).

Walrus

There are no known summer haul-out sites for walrus in Melvin Bay and available TK information indicates that walrus have been uncommon in Rankin Inlet in recent years. A spill in this area is unlikely to impact local walrus numbers in the Project area. Walrus occur throughout Hudson Bay and Hudson Strait (Figure 8.3-9), although



are mainly concentrated on northeastern Coats Island and southeastern Southampton Island during all seasons and numbering approximately 2000 individuals. There are also established haul-out sites at the Belcher Islands (Sanikiluaq) and at Cape Dorset on the Foxe Peninsula. The general distribution of walrus and their preference for shallow nearshore waters reduce the likelihood of any interactions between this species and a potential spill along the shipping corridor. One exception to this would be if a spill was to occur along the shipping route near Coats Island. Under 50-yr wind conditions modeled, it was predicted that a spilled fuel could reach the shores of the north end of Coats Island near the walrus haul out sites, which is within the hypothetical spill limit under 50-yr wind conditions, but not under average wind conditions. Prolonged exposure to freshly spilled fuel could adversely affect some walruses located in the nearshore waters of Coats Island, but the number would likely be small. Walruses exposed to spilled diesel are likely to experience temporary, nonlethal effects. All effects are initially manifested at the individual level, and may lower the individual's probability of survival or reproduction, which could potentially have population-level effects if the population affected was already compromised in size. The effects may be direct (e.g., contact with oil) or indirect (e.g., degradation of habitat, reduced availability of prey). Walruses may be particularly sensitive to indirect effects as a result of ingestions of contaminated benthic food sources if hydrocarbons accumulate in subtidal sediments (Neff 1990).

Seals

Seal mortality has been recorded as a result of oil spills, although large scale deaths have rarely been observed even when spill events occur close to breeding colonies (McLaren 1990). Five species of seals are known to occur in the Hudson Bay and Hudson Strait (Figures 8.3-4 to 8.3-8). Ringed and harp seals are common along the shipping route during the open-water season. Hooded seals can be found in the eastern end of the Hudson Strait during the open water season, whereas the bearded seal can be found from Fisher Strait to Rankin Inlet in the summer. Harbour seals are not common in this area and, therefore, are unlikely to be impacted by a spill along the shipping route. TK indicates that seals are inhabiting areas near the offshore ship anchorage location during the fall. A spill at the offshore anchor location or at the ship-to-shore fuel transfer location may impact a select few individuals.

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Polar Bears

Polar bears belonging to the Fox Basin (FB) and Davis Strait (DS) sub-populations concentrate on the coastline along the shipping route during late summer, occurring in highest densities on Southampton Island, islands near Lyon Inlet, coastal areas near Frobisher Bay, Akpatok Island and on the northern tip of Ungava Bay in western Hudson Strait (Figure 8.3-16). The Western Hudson Bay (WHB) sub-population generally concentrates on coastal capes and headlands between Cape Churchill and Arviat during the summer months (Figure 8.3-15). Polar bears are known to engage in short and long-distance swimming activities (S. Atkinson 2013, pers. comm; M. Dyck 2014, pers. comm.; Durner et al. 2011; Pagano et al. 2012). Short-distance swims are generally more common in this area of the Arctic and bears have been reported at sea within 5 km of land (S. Atkinson 2013, pers. comm; M. Dyck 2014, pers. comm.). Highest densities of swimming polar bears likely occur amongst larger islands and where islands are in close proximity (S. Atkinson 2013, pers. comm; M. Dyck 2014, pers. comm.). It has been suggested that less than 5% of individuals engage in open-water swimming excursions during summer (S. Atkinson 2013, pers. comm). Spill modeling results indicate a 2 ML diesel spill would most likely spread in a south-southeast direction up to 26 km from the point of origin before being degraded to trace levels (Appendix 8.2-B). Based on this analysis, approximately 123 km of shoreline¹⁴ and 886 km² of ocean within 5 km of land

¹⁴ Not all small islands may be captured in this analysis.



(for swimming bears) could be impacted by a potential spill. Of these, 109 km of shoreline and 665 km² of ocean is coastal summer habitat for the WHB subpopulation, 10 km of shoreline and 88 km² of ocean for the DS and 4 km of shoreline and 133 km² of ocean for the FB sub-populations¹⁵. Taking into consideration a worst case scenario, it was assumed that <5% of bears could be found within 5 km of the shoreline during a spill. These individuals would be dispersed throughout their summer range and sub-populations would be segregated during the open water season (COSEWIC 2008b). For example, the FB seasonally ice-free sub-population spans some 1.1 million km² in Nunavut. A worst case spill along the shipping route could potentially impact a small portion of the summer habitat of each of these sub-populations. Therefore, it is likely that much less than 5% of the sub-populations would come into contact with a diesel spill, although the exact number of bears is unknown.

The summer range of the WHB polar bear extends into Melvin Bay and bears have been sighted on Marble Island and other small islands at the mouth of Rankin Inlet during aerial surveys conducted in 2011 (Figure 8.3 15). A spill in Melvin Bay of 100 000 L could potentially impact some individuals of this sub-population.

Polar bears that come into contact with a diesel spill while in the water are likely going to be the most negatively affected. Those along the shoreline may also be impacted by a diesel spill should it hit land. The greatest number of bears impacted would likely be those found along the shoreline; however, with the implementation of mitigation measures, the likelihood of a spill reaching coastal summer polar bear habitat is considered unlikely. A discussion on the potential effects on polar bears as a result of hydrocarbon spills is discussed below.

Marine Birds

Marine birds are sensitive to hydrocarbon spills through coating of their plumage, ingestion of polluted food sources and/or loss of food sources (Robertson et al. 2012). Coating of plumage by hydrocarbons could result in loss of insulating properties as well as loss of buoyancy leading to hypothermia and potentially drowning events (O'Hara and Morandin 2010). Alcids, common eiders, and gulls are weak flyers, prefer to dive, have flightless feather-moulting stages, and dive for their food making them particularly susceptible to spills (Lock et al. 1994; Piatt et al. 1985, Dickins et al. 1990). In addition, thick-billed murres (alcid family) may be particularly susceptible to spills during their flightless swimming migration in August when molting adult birds and fledglings depart from colonies in the Hudson Bay on a swimming migration through Hudson Strait to offshore areas of Newfoundland and Labrador (Mallory and Fontaine 2004).

Contamination and/or loss of food sources may occur by causing contamination or direct mortality of fish and other lower trophic organisms on which birds feed themselves and their young. Nesting areas of marine birds are generally located in areas where they would not be directly impacted by a spill event if it reached shore. Nesting and chick survival may also be disrupted should parents become oiled while out at sea (Eppley and Rubega 1990).

During the baseline survey, only a black guillemot and a pair of sandhill cranes were identified in the LSA near the spud barge location (Appendix 8.2-A). TK identifies peregrine falcons, nesting common eiders, and guillemots near the offshore anchor location. A spill at this location would overlap with the foraging areas for these nesting species and could impact peregrine falcons by contamination of their food sources. **IQ**

¹⁵ Lengths and areas were calculated based on spill model presented in Appendix 8.2-B.



Fish

An accidental spill occurring in the coastal environment near sheltered bays or fjords or in shallow or confined waters could result in high mortality of adult fish, fish eggs, and larvae (Boertman and Mosbech 2011). A spill in Melvin Bay would likely have a greater impact on marine fish due to its proximity to land and coastal areas and, therefore, a higher potential impact on marine fish. An offshore spill may have less extensive adverse effects on marine fish due to higher dispersion rates in this environment. Fish species in shallower and nearshore areas are more susceptible to toxic effects than fish in deeper offshore areas (Schreiber and Burger 2002). Subsistence fishing can also be affected from a nearshore fuel spill by the temporary closure of fishing grounds during clean-up activities. Local commercial and subsistence fisheries may be impacted by spills by temporary closures of affected fisheries due to concerns of toxic fish (Yender et al. 2002) and potentially damaging the reputation of the fisheries of the affected area (Schreiber and Burger 2002).

8.3.6.6.1 Proposed Mitigation and Best Practices

In the unlikely event that a spill does occur, and there are environmental effects, AEM will act to mitigate these effects by using a variety of spill counter-measures. The Project strategy to mitigate the potential effects from accidental fuel and chemical spills includes 2 main components: prevention and response. These 2 components are addressed in the Project's Spill Contingency Plan (SD 2-16), Risk Management and Emergency Response Plan (SD 2-15), Shipping Management Plan (SD 8-1), and Oil Pollution Emergency Plan (SD 8-2). Risk and hazard assessments of shore-based marine response activities will also be undertaken as part of training the Emergency Response Team.

All vessels contracted by AEM will comply with a Shipboard Oil Pollution Emergency Plan. Should an environmental emergency occur along the shipping routes, the Shipboard Oil Pollution Emergency Plan will be activated. Close coordination will be maintained with AEM's shore-based supervisors who can activate AEM's Emergency Response Plan and Oil Pollution Emergency Plan in providing assistance to a vessel. Any accidents or malfunctions during transit will be reported to Transport Canada. Spills will also be reported to the Environmental Emergencies 24-Hour Report Line, and, if necessary, advice would be requested from the Regional Environmental Emergencies Team. Assistance could be sought from nearby ships and the Canadian Coast Guard (CCG).

To prevent accidental release of hydrocarbons and other harmful materials during routine activities, all operations that involve shipping, handling, storage, and transfer of fuel, grease, and lubricants, and other chemical materials will adhere to procedures identified in above documents and comply with all applicable international safety standards, industrial best management practices, and international and local regulations, including the following:

- MARPOL Convention, Protocols and Annexes as set out by the International Maritime Organization (IMO, 2008; MARPOL 73/78);
- *Canada Shipping Act*; and
- *Arctic Waters Pollution Prevention Act*.



Spill prevention measures will include the following aspects:

- Engineering design: fuel tanks, lubricant, and chemical storage containers and components will meet relevant safety standards for preventing uncontrolled release of stored materials during normal operation and during exposure to natural hazards, and to prevent fires and explosions;
- Personnel training and competence: all activities will be conducted by properly trained personnel;
- Documented procedures: all activities will be conducted according to pre-established formal procedures to prevent accidental releases and fire and explosion hazards; all materials will be managed with the use of Material Safety Data Sheets that provide the information necessary to understand the product and to take precautions in case of an accident;
- Inspection and maintenance: fuel tanks, lubricant, and chemicals storage containers, and fuel and lubricant transfer systems and components will be regularly inspected and maintained in proper order to prevent uncontrolled release of substances; and
- Record keeping: fuel, lubricants, and other chemicals transfers, and inspection and maintenance activities will be recorded and records will be kept according to the Project records-keeping procedures.

To minimize the potential for vessel accidents, such as sinking, running aground, or collisions with other vessels, Project vessels will comply with the navigation and safety regulations, Acts, and guidelines regarding ships and personnel safety at sea. These include, but are not limited to, the International Convention for the Safety of Life at Sea (SOLAS 1974), Guidelines for Ships Operating in Polar Waters (IMO 2010), and Acts, Orders, and regulations issued under the *Canada Shipping Act*. These guidelines and regulations set requirements on ships construction, equipment, operation, navigation, and certifications with emphasis on safety and pollution prevention.

The most likely spill scenarios are likely to occur during routine operations such as bunkering, handling, and transferring fuel and lubricant. Small spills may also occur due to leaks from onboard equipment. Bunkering operations will be carried out with use of spill prevention and response equipment. If any fuel is spilled during bunkering, it will be contained within the immediate area. Other small spills are expected to be contained on the ships, or are assumed to be less than 0.5 m³ if they reach the marine environment.

The spill response preparedness addresses scenarios of different types and volumes of spilled substances. Each ship will have emergency notification and response equipment, including alarm systems, fire-fighting equipment, and spill response kits. All vessels will have a Shipboard Oil Pollution Emergency Plan as set out in the best practices by the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), and will be certified to meet the standards of the convention. There will be an Emergency Response Team consisting of competent and trained personnel on each vessel. The Emergency Response Team will be responsible to deal with emergency situations including fire, explosions, and oil spills. The teams will undergo regular drills and exercises. All accidents, spills, and near-misses will be reported and recorded in the Project database. A formal investigation will be conducted, if necessary, to determine causes of an accident and adequate resources will be allocated to conduct the investigation.



8.3.7 Residual Impact Classification

8.3.7.1 Methods

The purpose of the residual effect classification is to describe the residual effects from the Project on marine wildlife and wildlife habitat using a scale of common words, rather than numbers or units. The use of common words or criteria is a requirement in the Project Specific Guidelines (NIRB 2012). The following criteria were used to assess the residual effects from the Project:

- Direction or nature of the impacts;
- Magnitude and complexity;
- geographic extent;
- frequency;
- duration;
- reversibility; and
- Likelihood or probability of effects.

The term “effect”, used in the effects analyses and residual effects summary, is regarded an “impact” in the residual impact classification. Therefore, in the residual impact classification, all residual effects are discussed and classified in terms of impacts to marine VECs.

Generic definitions have been provided for each of the impact criteria in the Assessment Approach (FEIS Volume 4, Section 4.5.4). For criteria such as geographic extent, duration, frequency, and likelihood, the definitions can be applied consistently across all marine VECs. The likelihood of an impact was determined based on the probability of the event occurring and the implementation of mitigation measures. Background on how the likelihood of a worst case diesel fuel spill event was determined is provided in Appendix 8.2-B. Reversibility is defined as the likelihood and time required for a component (e.g., population) or system to recover after removal of the stressor and is a function of resilience. Reversibility is applied to all combinations of magnitude, geographic extent, and duration. Definitions for each criterion are provided in Table 8.3-11.

The approach used to classify the magnitude of changes in measurement endpoints (and related impacts) was based on scientific literature and professional opinion, and incorporated conservatism. Other environmental assessments often use the universal effect size approach for categorizing magnitude such as negligible changes (0 to 10%), small changes (10 to 25%), and medium changes (25 to 40%) (Munkittrick et al. 2009). Ideally, effect threshold values would be known, and measurement endpoints could be quantified accurately with a high degree of confidence; however, little is known about ecological thresholds, and biological parameters are typically associated with large amounts of natural variation. Therefore, the classification of magnitude included a level of conservatism so that the impacts would not be underestimated.

For marine VECs, the assessment and classification of residual impacts was based on the predicted cumulative changes from reference conditions through application of the Project and into the future case. The spatial boundary of the assessment for Project impacts is at the RSA scale. The incremental effects from the Project relative to baseline conditions were also classified. Essentially, the only difference in the outcome of impact criteria between cumulative and incremental effects from the Project is in the magnitude and geographic extent of impacts. The magnitude for cumulative impacts involves changes from reference conditions through



application of the Project and into the future case, while incremental impacts are based on changes from the Project relative to baseline values. Cumulative impacts from the Project and other RFFD influence a population throughout its entire annual range (including migratory movements where applicable). In contrast, the geographic extent of incremental impacts from the Project may have a local or regional influence on marine wildlife populations.

Effects statements are used to focus the analysis of changes to marine VECs that are associated with one or more primary pathways. Section 8.3.7.2 presents a qualitative assessment for criteria such as magnitude, geographic extent, duration, and frequency. Pathways associated with each effects statement are classified using scales (categorical values such as negligible, low, or high) for each impact criterion (e.g., magnitude).

To provide transparency, the definitions for these scales were ecologically or logically based on marine VECs. Although professional judgement is inevitable in some cases, an effort was made to classify impacts using scientific principles and supporting evidence where possible. The scale for the residual impact criteria for classifying effects from the Project are specifically defined for marine VECs, and definitions for each criterion are provided, in Table 8.3-11.



Table 8.3-11: Definitions of Criteria Used in the Residual Impact Classification of Pathways

Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Negative: a less favourable relative to baseline values Positive: an improvement over baseline values or conditions	Negligible: no predicted detectable change from baseline values Low: impact is predicted to be within the range of baseline values Moderate: impact is predicted to be at or slightly exceeds the limits of baseline values High: impact is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	Local: small-scale direct and indirect impacts from the Project (e.g., footprint, and dust deposition) Regional: the predicted maximum spatial extent of combined direct and indirect impacts from the Project that exceed local-scale effects (can include cumulative direct and indirect impacts from the Project and other RFFD at the regional scale) Beyond Regional: cumulative local and regional impacts from the Project and other RFFD extend beyond the regional scale	Short-term: impact is reversible at end of construction Medium-term: impact is reversible at end of closure Long-term: impact is reversible within a defined length of time beyond closure Unknown: Impact may be reversible; however, the length of time cannot be defined Permanent: impact will last into perpetuity	Isolated: impact confined to a specific discrete period Periodic: impact occurs intermittently but repeatedly over the assessment period Continuous: impact will occur continually over the assessment period	Reversible: Impact will not result in a permanent change of state of the population compared to “similar” environments not influenced by the Project Irreversible: impact is not reversible (i.e., duration of impact is unknown or permanent)	Unlikely: the impact is likely to occur less than once in 100 years Possible: the impact will have at least one chance of occurring in the next 100 years Likely: the impact will have at least one chance of occurring in the next 10 years Highly Likely: the impact is very probable (100% chance) within a year



8.3.7.2 Results

8.3.7.2.1 Residual Impacts on Marine Fish and Fish Habitat

The potential effects of the Project on marine fish include changes in habitat quality due to grounding of the spud barge and cargo barges, changes in behavior due to underwater noise from vessel operations, and changes in habitats, and health and mortality risk due to accidental spills. Table 8.3-12 summarizes the impact rating classifications of Project impacts on marine fish and fish habitat.

Barge grounding is not expected to have a significant effect on fish habitat quality, given that the existing marine habitat near Itivia Harbour has been altered previously with the addition of gravel¹⁶ and the surrounding area is currently used by the community for marine access and supply delivery (which includes grounding of barges). Furthermore, existing fish habitat in Melvin Bay (including the proposed spud barge location) is naturally disturbed each year by winter sea-ice scour. The low surface interaction (i.e., barge resting on the surface and floating with the tide, rather than permanent infilling or dredging) is expected to effectively prevent long-term residual effects on fish habitat following decommissioning.

The species most likely to use the habitat within the spud barge footprint are Greenland cod, slender eelblenny, and fourhorn sculpin. Arctic char and at least 2 other sculpin species are also known to inhabit Melvin Bay. While Arctic char will forage in the type of habitat (coarse gravel substrate) that will be impacted by the grounded spud barge, they will also forage in the other habitat types present in Melvin Bay (cobble, boulder, and bedrock substrates). Little information is available on habitat use of other fish species present in Melvin Bay. Any changes to fish habitat during operation of the spud barge are expected to be low in magnitude (less severe than those effects naturally occurring from winter ice scour events), site-specific (local), effectively continuous during Project operation, with a high likelihood of occurrence.

Cumulative habitat alteration from previous, existing, and future developments in the RSA is expected to have adverse effects on marine fish populations that are low in magnitude. Individuals from the local fish population may interact with other developments and activities in the RSA. Cumulative effects on fish populations from habitat alteration from the Project and other developments are expected to be regional in geographic extent for effects related to spud barge grounding. No transboundary effects on fish habitat are anticipated given that the annual home ranges of fish populations potentially affected by cumulative habitat alteration in the RSA do not extend outside of the NSA. Any residual impacts to fish habitat are expected to be reversible (returned to its pre-installation state) within several months of removal of the spud barge (decommissioning; medium-term). Therefore, the productive capacity of the habitat is not expected to be altered, destroyed or disrupted; and the potential for long-term effects acting in a cumulative nature on fish habitat with the spud barge grounding is expected to be not significant.

Residual effects for changes in fish behavior due to underwater vessel noise are not expected given application of the proposed mitigation. Although underwater noise will be detectable to fish in the immediate vicinity of vessel activities in the LSA and will occur at regular intervals throughout the open-water season (periodic), underwater noise disturbance on fish is predicted to be low in magnitude for incremental and moderate for cumulative scenarios (within the range of baseline values given existing vessel traffic in the LSA), site-specific (local), medium-term (until termination of the Project), and reversible. Effects are likely to be limited to short-term behavioral responses (startle, displacement, and schooling behavior) that will vary by species and hearing group, and will be dependent on the properties of the received sound.

¹⁶ the site has smaller substrate particles than surrounding undisturbed habitats due to the placement of coarse gravels for the harbour ramp.



Table 8.3-12: Summary of Residual Impact Classifications on Marine Wildlife VECs

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Marine Fish and Fish Habitat									
Change in habitat due to spud barge grounding	Negative	Low	Low	Local	Regional	Medium-term	Continuous	Reversible	Highly Likely
Change in Behaviour due to Underwater Noise from Project Vessels	Negative	Low	Moderate	Local	Regional to Beyond Regional	Medium-term	Periodic	Reversible	Highly Likely
Change in Habitat due to Altered Water Quality from a Minor Spill	Negative	Low	Low	Local	Regional to Beyond Regional	Medium-term	Isolated	Reversible	Unlikely
Change in Habitat due to Altered Water Quality from a Worst Case Diesel Fuel Spill	Negative	Moderate	Moderate	Regional to Beyond Regional	Regional to Beyond Regional	Long-term	Isolated	Reversible	Unlikely
Change in Health and Mortality Risk due to Exposure to Accidental Spills	Negative	Moderate	Moderate	Regional to Beyond Regional	Regional to Beyond Regional	Long-term	Isolated	Reversible	Unlikely
Marine Mammals									
Change in Health and Mortality Risk due to Vessel Collisions	Negative	Low	High	Local	Regional to Beyond Regional	Medium-term	Isolated	Reversible	Possible
Change in Behaviour due to Underwater Noise from Project Vessels	Negative	Low	Moderate	Regional	Regional to Beyond Regional	Medium-term	Periodic	Reversible	Likely
Change in Habitat due to Altered Water Quality from a Minor Spill	Negative	Low	Low	Local	Regional to Beyond Regional	Medium-term	Isolated	Reversible	Unlikely
Change in Habitat due to Altered Water Quality from a Worst Case Diesel Fuel Spill	Negative	High	High	Regional to Beyond Regional	Regional to Beyond Regional	Long-term	Isolated	Reversible	Unlikely
Change in Health and Mortality Risk due to Exposure to Accidental Spills	Negative	High	High	Regional to Beyond Regional	Regional to Beyond Regional	Long-term	Isolated	Reversible	Unlikely



Table 8.3-12: Summary of Residual Impact Classifications on Marine Wildlife VECs (continued)

Effects Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Marine Birds									
Change in Mortality Risk due to Collisions with Infrastructure	Negative	Low	Low	Local	Regional to Beyond Regional	Medium-term	Isolated	Reversible	Unlikely
Change in Behaviour due to In-air Noise and Artificial Lighting	Negative	Low	Moderate	Local	Regional to Beyond Regional	Medium-term	Periodic	Reversible	Likely
Change in Habitat due to Altered Water Quality from a Minor Spill	Negative	Low	Low	Local	Regional to Beyond Regional	Medium-term	Isolated	Reversible	Unlikely
Change in Habitat due to Altered Water Quality from a Worst Case Diesel Fuel Spill	Negative	High	High	Regional to Beyond Regional	Regional to Beyond Regional	Long-term	Isolated	Reversible	Unlikely
Change in Health and Mortality Risk due to Exposure to Accidental Spills	Negative	High	High	Regional to Beyond Regional	Regional to Beyond Regional	Medium-term	Isolated	Reversible	Unlikely



Cumulative underwater noise effects from previous, existing, and future developments are predicted to have moderate magnitude effects on marine fish behavior. These are expected to be regional to beyond regional in extent. Effects may be measurable in other parts of the home range of some marine fish species and thus may represent a transboundary effect if outside of Nunavut. Any changes in behavior due to underwater noise are expected to be temporary, and are not expected to have population-level effects on marine fish.

At the Project level, the magnitude of a minor spill on marine fish habitat is considered low while a worst case diesel fuel spill on marine fish and fish habitat is considered to be moderate, as it may result in mortalities of adult fish, fish eggs, or larvae, but changes at the population level are not anticipated. Incremental effects are considered regional to beyond regional in geographic extent (extending beyond the RSA), medium-term in duration for a minor spill and long-term for a worst case spill, isolated in frequency, with an unlikely probability of occurrence given the application of proposed mitigation. Effects may be measurable in other parts of the range of some marine fish species and thus may represent a transboundary effect if outside of Nunavut. The effects of a potential worst case diesel spill on the health and mortality of marine fish are considered reversible through natural recruitment, meaning the number of new young fish that will enter the population over time will offset the number of fish mortalities or injuries potentially resulting from a spill. Changes at the population level are not anticipated.

From a cumulative effects perspective taking into account previous, existing, and future developments, the magnitude of a minor spill on fish habitat is considered low, a worst case diesel fuel spill on marine fish and fish habitat is considered to be moderate. Both are considered to have a regional to beyond regional extent, medium-to long-term duration, and isolated frequency. However, effects on fish populations are predicted to be reversible through natural recruitment. With industry-standard prevention and response measures in place, the potential for long-term effects of a minor and worst case diesel fuel spill on marine fish populations are expected to be unlikely and not significant.

8.3.7.2.2 Residual Impacts on Marine Mammals

The potential effects of the Project on marine mammals include changes in health and mortality risk due to vessel collisions and accidental spills, and changes in behavior due to underwater noise from vessel operations. Table 8.3-12 summarizes the impact rating classifications of Project residual impacts on marine mammals and their associated habitats.

Whenever a vessel is in transit through known marine mammal habitat, the potential exists for a marine mammal/vessel interaction. Given the extent of marine vessel operations in the Project area and the frequency of Project vessels transiting along the shipping route, the potential for a vessel strike will persist over the life of the Project. Baleen whales such as bowhead whales would be most susceptible to this impact, due to their large size, slower travel and maneuvering speeds, and lower avoidance capability. In addition, the shipping route overlaps with summer habitat and a summer concentration area for this species. While there are rare reports of toothed whales being struck by vessels, they are at low risk due to their swimming speed and agility. The shipping route passes through summer habitat for killer whale, beluga whale, and narwhal; however, core summer concentration areas for beluga whale and narwhal are located outside the LSA and RSA, thereby further limiting the potential for vessel strikes with these populations. Pinnipeds are also at low risk for being struck by a vessel due to their maneuverability and agility in the water. Due to the vessel speed restrictions in Melvin Bay (≤ 2 knots) and in the shipping corridor (< 14 knots), in addition to ships maintaining minimum



distances from any observed marine mammals, the likelihood of a vessel strike is low. Furthermore, the potential for a vessel-mammal collision would be limited to the shipping corridor given the relative paucity of marine mammals known to frequent Melvin Bay in recent years. In the rare event that a marine mammal strike were to occur, the consequence would more likely to be a non-lethal injury (laceration from propeller and/or blunt force injury) than direct mortality. Larger, faster vessels have the potential to strike whales with greater force, causing greater physical injury and trauma. However, the lower vessel speeds that prevail during operations will greatly reduce the likelihood of ship strikes on marine mammals by providing ample time for these animals to avoid oncoming vessels, as well as time for crew on Project vessels to detect and avoid marine mammals during active vessel operations.

It is important to note that no critical marine mammal habitat areas occur in the LSA. Furthermore, no SARA-listed mammal species are known to occur in the Project area during the shipping season, with the possible exception of polar bear. However, their presence in the LSA during the open-water season would be considered rare given the lack of sea-ice in this area during this time and most 'at-sea' sightings of this species during summer have occurred close to shore (<5 km), thus minimizing any potential overlap with Project vessel movements in the deep-draught shipping corridor.

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Potential incremental effects to marine mammal populations from a change in health / mortality risk due to ship strikes are expected to be low in magnitude, local in geographic extent (restricted to LSA), medium-term (until closure) and isolated in frequency (restricted to a limited number of ship transits during the open-water season only). Total cumulative increase in shipping as a result of Meliadine, Kiggavik, Ferguson Lake, and Churchill Diamond Projects during operations is estimated at 79 to 85% (Table 8.3-11), thus increasing the potential for a vessel-mammal interaction. Due to this, cumulative effects of potential ship strikes from previous, existing, and future developments are predicted to have high magnitude effects on whale, seal, and walrus health and mortality risk. Cumulative effects to whale, seal, and walrus populations will be regional to beyond regional. Effects may be measurable in other parts of the home range of all marine mammal species, and thus may represent a transboundary effect if outside of Nunavut. Because the possible outcome from a ship strike includes death, this effect is considered irreversible at the level of the individual. However, the effects of any injuries or fatalities on marine mammal populations as a whole are expected to be reversible through natural recruitment, meaning the number of new young marine mammals that will enter the populations over time will offset the number of marine mammal mortalities or injuries resulting from potential vessel strikes. With the proposed mitigation in place (e.g., reduced speeds), the probability of a fatality or injury from a vessel strike is considered possible. In the event that one or several animals were lost over the lifetime of the Project, the long-term viability of marine mammal populations in the RSA are unlikely to be affected. Given the availability of accepted mitigation measures and best practices (e.g., reduced vessel speed), significant adverse residual effects on marine mammal populations are not likely to occur (non-significant effect).

Based on reports in the literature, it is conservative to assume that underwater noise associated with vessel operations may, in some cases, elicit behavioral changes in individual marine mammals that are in close proximity to these vessels. These behavioral changes may include evasive maneuvers such as diving or changes in swimming direction and/or speed. Vessel and equipment noise is transitory and generally does not propagate at great distances from the vessel. The residual environmental effect of a change in marine mammal behaviour as a result of Project vessel noise is considered to be low in magnitude, regional in geographic extent (restricted to the RSA), medium-term in duration (only present during the Project life), and periodic in frequency (intermittent during the open-water season only). Cumulative underwater noise effects from previous, existing, and future developments are predicted to have moderate magnitude effects on marine mammal behavior and



are expected to be regional to beyond regional in geographic extent. Effects may be measurable in other parts of the home range of all marine mammal species, and thus may represent a transboundary effect if outside of the NSA. The likelihood of behavioural disturbance from Project vessel noise is considered likely, even though Melvin Bay does not support marine mammal habitat and vessel traffic in Hudson Bay and Hudson Strait is sparse even during the open-water season. Based on available literature, marine mammals will either habituate to vessel sounds and remain in area, or leave temporally and return once the noise has subsided. Changes in behavior, therefore, are considered to be temporary and reversible with no effects at the population level anticipated (non-significant effect).

Spilled hydrocarbons may have a number of impacts on marine mammals including loss or degradation of food supplies, habitat loss, decreased health, or death. Bowhead whales would likely be the most affected whale species in the event of a spill because the shipping route overlaps with summer habitat and aggregation areas for this species. A potential spill would also have potential adverse impacts on killer whale, beluga whale, and narwhal as the shipping route overlaps with summer habitat for each of these species. However, core summer concentration areas for beluga and narwhal whales will not be impacted by a worst case spill along the shipping route thus further reducing the potential for a spill to impact these populations. A worst case spill close to walrus and seal haul-out locations on Southampton, Walrus, and Coats islands, and various other unknown haul-out locations along the shipping route would cause the biggest impact to these populations due to the congregation of individuals in these areas. Polar bears from the WHB sub-population could be impacted by a spill in Melvin Bay; however, due to their concentration in areas south of Arviat in the summer, the number of individuals impacted would likely be minimal. The FB sub-population of polar bears has the highest probability of being impacted by a fuel spill given the relative degree of overlap between the shipping route and summer coastal habitat for this sub-population. The DS sub-population could be impacted by a spill occurring at the entrance to Hudson Strait. Based on recent literature, all 3 of these sub-populations appear to be stable with current harvest rates. In addition, the DS sub-population could be experiencing density dependence effects. Therefore, mortality or injury of individuals from these sub-populations is unlikely to have population level effects due to natural recruitment. A minor spill is considered to be low in magnitude, regional to beyond regional in geographic extent and medium-term for cumulative scenarios as impacts associated with a minor spill are considered reversible during the lifetime of the Project. The magnitude of a worst case diesel fuel spill on marine mammals and marine mammal habitat is considered high for both incremental and cumulative scenarios, as a diesel spill could result in mortalities of a SARA-listed species (e.g. polar bear), extensive disruption of critical marine mammal activities, or damage to sensitive habitat areas in and beyond the RSA. The cumulative effect of a worst case spill on marine mammals and mammal habitat is considered regional to beyond regional in geographic extent with potential transboundary effects for all marine mammal population given their home ranges include areas outside the NSA. Cumulative effects will be long-term in duration, isolated in frequency, and reversible through natural recruitment. With the application of known and effective spill prevention and response measures, in addition to implementation of industrial best management practices and safety standards, the probability of a worst case spill impacting the abundance and distribution of marine mammals is considered unlikely. No long-term effects on marine mammal populations are anticipated (non-significant effect).

8.3.7.2.3 Residual Impacts on Marine Birds

The potential effects of the Project on marine birds include changes to habitats as a result of accidental spills, changes in health and mortality risk due to accidental spills and collisions with infrastructure due to lighting



effects, and behavioural changes due to sensory disturbance. Table 8.3-12 summarizes the impact rating classifications of Project impacts on marine birds and their associated habitats.

Changes in health, mortality risk, and behaviour of marine birds due to direct and indirect effects of Project lighting effects are most likely to occur during the installation phase. If high intensity staging lights are used to extend work hours after dusk or before dawn, then there is a risk of increasing collisions with equipment or adverse behavioural responses as marine birds may become disorientated by the lights. However, due to the northern latitude of Rankin Inlet and the extended summer daylight hours, high intensity lighting will likely not be necessary. Attraction to lighting has been recorded in pelagic birds such as albatross, petrels, and shearwater but not the type of marine birds that have been documented in the Regional and Local Study Area (RSA and LSA) or those species known to occur in high abundances in key marine habitat sites near the project shipping route. Furthermore, there are no IBAs or key marine habitat sites in the immediate vicinity of the spud barge location or in Melvin Bay where nighttime work may be warranted. The potential for injury or mortality of marine birds from site/vessel lighting is thus considered to be low in magnitude, site-specific (local), medium-term (for the life of the Project), and isolated in frequency. Because the possible outcome of a collision includes death, this effect is considered irreversible at the level of the individual. However, the effects of any injuries or fatalities on a marine bird population as a whole are expected to be reversible through natural recruitment, meaning the number of new young birds that will enter the population over time will offset the number of bird mortalities potentially resulting from a collision. Changes at the population level are not anticipated. With proposed mitigation in place (e.g., shielded lights), the probability of a fatality or injury from a collision with equipment/vessel due to Project lighting is considered unlikely. The long-term viability of marine bird populations is not expected to be affected; therefore, effects are predicted to be not significant.

The potential for behavioural changes (sensory disturbance) in marine birds due to in-air noise from nearshore activities (e.g., vessel operations and spud barge installation) is considered low as the marine LSA is already exposed to regular acoustic disturbance from human activities. Although normal bird behavioural patterns in the LSA may be initially disrupted, any deterrence from the area is likely to be temporary as effects will be limited in temporal and spatial scale (i.e., spud barge). Birds are likely to habituate to in-air noise and in-water works provided the disturbances are not associated with other negative experiences (Ward and Stehn 1989; Steidl and Anthony 2000; Goudie and Jones 2004). There is extensive suitable habitat in the region, and birds that are present in the LSA will likely move to areas at least 100 m from where the point of disturbance is occurring (Larsen et al. 2004). Marine birds may temporarily alter foraging and loafing patterns and distribution to avoid certain noise sources; however, no substantial behavioral and physiological effects are anticipated. The shorelines present along the vessel route in Melvin Bay, Access Passage, and near the deep-water anchor point do not support steep cliff faces typically favoured by nesting birds. Thus, no disturbance to nesting birds is anticipated. With best management practices and proposed mitigation measures in place, incremental effects are considered to be low in magnitude, site-specific (local), medium-term (throughout the life of the Project), periodic in frequency, reversible, with a likely probability of occurrence. Cumulative effects from previous, existing, and future developments are predicted to be moderate in magnitude and regional to beyond regional in geographic extent. Effects may be measurable in other parts of the home range of certain migratory birds, and, thus, may represent a transboundary effect if outside of the NSA. However, any changes in behavior due to in-air noise are expected to be temporary, and are not expected to result in population-level effects. Therefore, the effects are predicted to be not significant.



There are no key marine habitat areas, migratory bird sanctuaries, or known important bird areas in Melvin Bay. During the baseline survey, only a black guillemot and a pair of sandhill cranes were identified in the LSA near the proposed spud barge location (Appendix 8.2-A). TK identifies peregrine falcons, nesting common eiders, and guillemots near the offshore anchor location. A spill at this location could impact foraging areas for these nesting species and could impact peregrine falcons by contamination of their food sources. Marine birds and their habitats would be the most adversely affected wildlife receptors from a worst case diesel fuel spill event in the marine environment. The magnitude of a worst case diesel fuel spill on marine bird and bird habitat is also considered to be high for both incremental and cumulative scenarios, since the spill may impact key marine habitat areas for migratory birds, may impact large populations of migratory birds (particularly the thick-billed murre), and may result in mortalities of SARA-listed marine bird species, such as Ross's gull and the Ivory gull. This effect on birds is considered regional to beyond-regional in geographic extent. Effects may be measurable in other parts of the home range of certain migratory birds, and, thus, may represent a transboundary effect if outside of the NSA. The effects of a potential spill are considered reversible through natural recruitment, meaning the number of new young birds that will enter the population over time will offset the number of bird mortalities potentially resulting from a worst case diesel spill and therefore, changes at the population level are not anticipated. With the application of known and effective spill prevention and response measures, the probability of a worst case diesel fuel spill impacting the health and mortality risk of marine birds is considered unlikely. No long-term effects on marine bird populations are anticipated (non-significant effect).

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Cumulative effects on marine birds are expected to range from low to high in magnitude and vary from regional to beyond regional in geographic extent. Changes in health and mortality risks due to collisions with infrastructure are anticipated to be low and changes in behaviour due to sensory disturbance from in-air noise and site/vessel lighting are anticipated to be moderate. The change in marine habitat quality and in the health and mortality risk to marine birds due to altered water quality from potential accidental spills is anticipated to be high. However, all effects are considered reversible and are not expected to result in population-level effects. No long-term effects on marine bird populations are anticipated (non-significant effect).

8.3.8 Environmental Significance

8.3.8.1 Approach and Methods

The evaluation of significance for marine VECs considers the entire set of pathways that influence a particular assessment endpoint. The relative contribution of each pathway is then used to determine the significance of the Project on assessment endpoints. For example, a pathway with a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance relative to pathways with smaller scale effects. The pathways that are predicted to have the greatest influence on changes to assessment endpoints are assumed to contribute the most to the determination of environmental significance.



Qualitative key factors were considered in the determination of environmental significance for marine VECs as follows:

- results from the residual impact classification of primary pathways;
 - magnitude, geographic extent, and duration (which includes reversibility) of the impact were the principal criteria used, with frequency and likelihood as modifiers; and
 - Professional judgment and ecological principles, such as resilience, were used to predict the duration and associated reversibility of impacts.
- ecological or socio-economic context/value;
- historical, cultural, and archaeological significance of the geographic area likely to be affected by the Project; and
- value attached to the individual VEC based on consultation with potentially affected communities and relevant individuals and organizations.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to marine VECs. The following definitions are used for assessing the significance of impacts on marine VECs, and the associated continued opportunity for traditional use of marine VECs.

- **Not significant** – impacts are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to population maintenance and opportunities for traditional and non-traditional use.
- **Significant** – impacts are measurable at the population level and likely to decrease resilience and increase the risk to population maintenance and impact opportunities for traditional and non-traditional use. A number of high magnitude and irreversible impacts at the population level (regional scale) would likely be significant.

8.3.8.2 Results

Project pathways influencing marine VECs were determined to be low to high in magnitude, local to beyond regional in geographic extent, and medium-term in duration (Table 8.3-12). The range in scales in the residual impact classification reflected the number of pathways and related mechanisms that were predicted to affect marine VECs. Pathways included direct impacts related to changes in health and mortality, and alteration of habitats, and indirect impacts related to sensory disturbance and related effects. The probability of impacts occurring is predicted to be unlikely to highly likely for the Project pathways, while the frequency of most impacts is anticipated to be isolated or periodic throughout construction and operation with the exception for impacts associated with changes in fish habitat from spud barge grounding, which are continuous. The probability and frequency of the impacts do not change the expected magnitude and duration (or environmental significance) of these impacts.

The incremental and cumulative impacts from the Project are predicted to not result in significant impacts that would influence the maintenance of the abundance and distribution of marine wildlife populations. The scale of impacts from the Project pathways, independently or combined, should not be large enough to cause irreversible changes at the population level and decrease the resilience of the marine VECs.



The incremental changes to marine habitat quality and marine water quality should not have a significant impact on the structure and function of populations and communities in the marine ecosystem relative to natural factors occurring over the same period of time and space. Subsequently, the Project should not have a significant adverse impact on the continued opportunity for traditional and non-traditional use of marine resources in the region.

8.3.9 Potential Effects of Climate Change

Global climate change is expected to result in warming temperatures, and in the Arctic, an increase in sea levels from the melting snow and ice (IPCC 2007). IQ from residents of Baker Lake and Arviat observed the following trends in climate change; generally warmer temperatures year-round, changes in the quality and accumulation of snow, sea ice freeze-up occurs later and breaks up sooner with an overall shorter ice season, and ice appears to be thinner than in previous years (GN 2005). With increased melting and shorter ice season, it is reasonable to anticipate a longer open-water season along the shipping route the LSA over the long-term. The expected number of vessels required for the Project has been determined based on what is needed to supply construction, operation, and closure activities of the proposed mine and associated marine infrastructure. The frequency of vessel traffic is not expected to increase over the life of the Project. If the open-water season is extended, the net frequency of transiting vessels per ice-free day would be reduced, and, therefore, the frequency of exposure of marine fauna to vessel-related impacts would be reduced, notably underwater noise effects.

The rate of sea level rise, estimated at 0.0033 m/year (Smith 2011) near the Project area, would result in a rise of 0.066 m over the approximate 20 year lifetime of the Project. The dynamic coastal geomorphology of the coastal zone near the Project area is presently experiencing exposure of new shoreline at a rate of up to 15 m/year (horizontal) and 1 m/100 years (vertical; or 0.2 m over an approximate Project life of 13 years of Operations) as part of an isostatic rebound of the land from the weight of the Laurentide Ice Sheet, which once covered this entire region (Stewart and Lockhart 2004; Parks Canada 2009). An isostatic rebound of 0.2 m would counter the effect of sea level rise; therefore, the impact on the Project due to sea level rise as a result of climate change is anticipated to be negligible.

8.3.10 Uncertainty

The purpose of the uncertainty section is to identify the key sources of uncertainty in the impact assessment and to discuss how uncertainty has been addressed to increase the level of confidence that impacts are not worse than predicted. Confidence in the assessment of environmental significance is related to the following elements:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., extent of future developments, climate change, catastrophic events);
- understanding of Project-related impacts on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will impact migratory marine birds and mammals); and
- knowledge of the effectiveness of the environmental design features and mitigation for reducing or removing impacts (e.g., vessel speed restrictions).

Ecosystems are complex, characterized by interactions across multiple scales, nonlinearity, self-organization, and emergent properties (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics



can confound understanding of ecosystem processes and limit capacity to make predictions on, for example, population sizes. One of the challenges is to aggregate and simplify available ecological knowledge, retain what is essential and disregard that which is not essential at the particular scale of interest.

Like all scientific results and inferences, residual impact predictions must be tempered with uncertainty associated with the data and the current knowledge of the system. It is anticipated that the baseline data are moderately sufficient for understanding current conditions, and that there is a moderate level of understanding of Project-related impacts on the ecosystem.

It is understood that development activities will directly and indirectly affect marine habitat, and behaviour / movement of marine wildlife species; however, long-term monitoring studies documenting the resilience of marine animals to development and the time required to reverse impacts are lacking. Direct disturbance from previous, existing, and future development footprints was estimated to affect a small fraction of the natural range of most marine wildlife VECs. However, uncertainty remains surrounding the degree to which some effects may occur (e.g., magnitude and duration).

Forecasting a future that may be outside the range of observable baseline environmental conditions is clearly challenging (because of climate change for example; Walther et al. 2002). Quantifying changes to habitat provides a static assessment of a species' environment, ignoring change that may occur over time as a result of ecological succession and natural disturbances such as climatic events. Thus, there is less certainty in long-term predictions of reversibility (e.g., over periods extending beyond 100 years). However, there is a high level of confidence that the regional landscape will be different with or without the Project in future decades.

Prediction confidence for impacts to fish habitat as a result of installation of the spud barge is moderate to high as the extent of the habitat loss/alteration is well known. There are uncertainties in the impact predictions for impacts to marine birds related to night-time lighting because limited research exists on the introduction of artificial light on Arctic marine habitats and related effects on marine fauna. In other parts of the world, studies of ambient artificial light impacts on marine species have demonstrated that responses to light can vary widely by species and environmental conditions.

Prediction confidence is moderate for impacts on marine fauna related to potential vessel strikes, introduction of non-native species, accidental spills, and underwater noise disturbances, as the recommended mitigation measures consist of best management practices established by industry to eliminate and/or minimize adverse effects associated with these activities.

8.3.11 Monitoring and Follow-Up

Results of follow-up monitoring should be provided to the relevant agency with management responsibility for each species.

Environmental monitoring for the marine wildlife and wildlife habitat will include the following components:

Marine Mammals

As outlined in AEM's Shipping Management Plan (SD 8-1), marine mammal monitoring will be undertaken by shipping contractors during all shipping activities to avoid interactions with marine mammals. Any incidents of vessel strikes with marine mammals will be recorded and reported to Fisheries and Oceans Canada (DFO).



A worst case fuel spill may impact marine mammal habitat areas and may result in mortalities of SARA-listed marine mammal species. In the unlikely event of a major spill, follow-up monitoring on marine mammals and their habitats would be proposed. The scope of such follow-up monitoring would be decided at the time of the event.

Marine Fish and Fish Habitat

The potential effects of the Project on marine fish include changes in habitat quality due to grounding of the spud barge and cargo barges, changes in behavior due to underwater noise from vessel operations, and changes in health and mortality risk due to accidental spills.

Any changes to fish habitat during operation of the spud barge are expected to be less severe than those effects naturally occurring from winter ice scour events and site-specific; therefore, follow-up monitoring is not suggested.

Effects related to underwater noise on fish are likely to be limited to short-term behavioral responses such as startle, displacement, and schooling behavior that will vary by species and hearing group, and will be dependent on the properties of the received sound. Monitoring behavioural responses of fish to underwater noise resulting from shipping and vessel movements would be difficult to achieve and, therefore, is not suggested.

A worst case fuel spill could result in mortalities of adult fish, fish eggs, or larvae. In the unlikely event of a major spill, follow-up monitoring on fish species and their habitats would likely be proposed. The scope of such follow-up monitoring would be determined in consultation with DFO and at the time of the event.

Marine Birds

Any incidents of bird mortalities associated with lighting infrastructure, construction activities, and Project vessel operations will be recorded and reported to Environment Canada (Canadian Wildlife Services).

A worst case fuel spill may impact key marine habitat areas for migratory birds and may result in mortalities of SARA-listed marine bird species. In the unlikely event of a major spill, follow-up monitoring for marine bird species and their habitats would be proposed. The scope of such follow-up monitoring would be decided at the time of the event.

8.4 References

8.4.1 Literature Cited

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APPENDIX 8.2-A

Nunami Stantec Marine Baseline Report for Itivia Harbour, Rankin Inlet, NU

MELIADINE GOLD PROJECT

Marine Baseline Report
Itivia Harbour, Rankin Inlet, NU

FINAL REPORT



Prepared for:

Agnico-Eagle Mines Ltd.
PO Box 879
Rankin Inlet, NU X0C 0G0

Prepared by:

Nunami Stantec Ltd.
PO Box 1680
5021 i 49 Street
Yellowknife, NT X1A 2P3
Tel: (867) 920-2216 Fax: (867) 920-2278

Project No.:

1235-10575

Project No.:

April 2012



NUNAMI STANTEC



AUTHORSHIP

Carey Sibbald, B.Sc., EPT..... Aquatics and Fisheries
 Michelle Marcotte, M.Sc., R.P.Bio. Marine Mammals
 Jorgelina Muscatello, M.Sc., Ph.D..... Senior Review (Water and Sediment Quality)
 Doug Chipertzak, B.Sc.....Senior Review (Aquatics and Fisheries)
 Janine Beckett, M.Sc., R.P.Bio.....Senior Review (Marine Mammals)

EXECUTIVE SUMMARY

Agnico Eagle Mines Ltd. (AEM) is currently undergoing environmental impact review for advancement of its Meliadine Gold Project (MGP) from its exploration phase to an operating mine. The MGP is situated approximately 25 km north of Rankin Inlet, Nunavut, and is comprised of six gold deposits. In May 2011, AEM submitted a project proposal to the Nunavut Impact Review Board (NIRB) for development of the MGP. AEM has proposed to construct and operate an 8,500 tonnes per day gold mine and mill, combining open pit and underground techniques at six deposits. Following recommendations from NIRB, the Minister referred AEM's MGP project proposal to a Part 5 review, which commenced in September 2011.

To support the MGP, AEM will require equipment and other supplies to arrive by barge from Churchill, Manitoba, or Canada's eastern ports, to Itivia Harbour in Rankin Inlet. To accommodate these barges, AEM has proposed to install a spud barge in Itivia Harbour. Nunami Stantec Ltd. (Nunami) was retained by AEM to collect information on baseline environmental conditions and characteristics in and around Itivia Harbour where the proposed spud barge will be installed. Nunami's baseline study investigated the water and sediment quality, aquatic ecology and fisheries values in Itivia Harbour (Project footprint, R1 sampling area) and at two nearby reference sites (R2 and R3 sampling areas) in Melvin Bay in August 2011. A desktop review was also undertaken to evaluate marine mammal and bird occurrence in the vicinity of Itivia Harbour and Melvin Bay. Nunami also met with the Kangiqliniq Hunters and Trappers Organization prior the field investigation to obtain Inuit Qaujimajatuqangit about the Rankin Inlet area and the local fishery.

Results of the baseline study showed the Project footprint (R1 sampling area) was shallower, had a gentler slope and a larger proportion of intertidal habitat than the two reference sampling areas. Cobble and/or gravel were the dominant substrates in all nearshore sampling areas although the Project footprint had a higher proportion of small substrates (gravels and fines) due to the addition of gravel for the development of the harbour's boat launch. Macrophytes were sparse across all sampling areas.

In situ water quality was relatively constant across the sampling areas and through the water column. Nutrient levels were low with only total ammonia being above detection limits. Total organic carbon was also relatively low. The majority of metals were below detection or less than five times the detection limit in water samples taken at all three sampling areas. All of the samples were found to be below Canadian Council of Ministers of the Environment (CCME) Protection for Marine Aquatic Life (PMAL) guidelines for all of the parameters tested.

Precision analyses indicate some heterogeneity of sediments across the study area. Total phosphorous was relatively high while nutrients and total carbon were low. Chromium was the only metal to exceed its recommended guideline at all sampling areas.

Phytoplankton abundance, richness and diversity were comparable among the three sampling areas. Dinoflagellates (*Peridinium/Gonyaulax* spp. and *Dinophysis* spp.) were the predominant phytoplankton taxa across the study area. Zooplankton abundance, richness and diversity were more variable than phytoplankton and the R2 sampling area exhibited the lowest values.

Zooplankton diversity values imply less diverse zooplankton community and an unidentified rotifer species (possibly *Notommatidae*) was the predominant taxa. Benthic invertebrate richness and abundance were greatest at the R2 sampling area and lowest at the Project footprint and R1 sampling area, respectively. The R1 sampling area also exhibited a more homogenous benthic community than the other two areas and Polychaetes were the dominant taxa across the study area.

Arctic char were not captured during Nunami's baseline study at Itivia Harbour and Melvin Bay. The numerically dominant fish species (i.e., $\geq 10\%$ of the total catch) were Greenland cod (52%), slender eelblenny (27%) and fourhorn sculpin (15%). No statistically significant differences in fish catch rates or species richness were observed between the Project footprint and reference areas or between nearshore and offshore areas. An interaction between sampling area and nearshore/offshore was detected for total catch rates and was attributed to a statistically different mean catch rate between nearshore and offshore sites at the R1 sampling area.

No marine mammals were observed during the baseline study. A black guillemot and a pair of sandhill cranes were observed anecdotally. The desktop review of marine mammals and birds suggested nine marine mammal species typically occur along the west coast of Hudson Bay while 37 marine bird species may be present in the vicinity of Rankin Inlet.

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ABBREVIATIONS AND ACRONYMS

%	percent
<	less than
>	greater than
Ö	micro
Ög/L	micrograms per litre
mg/kg	milligrams per kilogram
mL	millilitre
AEM	Agnico Eagle Mines Ltd.
ANOVA	analysis of variance
CCME	Canadian Council of Ministers of the Environment
CPUE	Catch per Unit Effort
CRM	Certified Reference Materials
CV	Coefficient of Variation
DFO	Fisheries and Oceans Canada
GPS	Global Positioning System
HTO	Hunters and Trappers Organization
IQ	Inuit Qaujimajatuqangit
ISQG	Interim Sediment Quality Guidelines
NIRB	Nunavut Impact Review Board
Nunami	Nunami Stantec Ltd.
PEL	Probable Effects Level
PMAL	Protection for Marine Aquatic Life
QA/QC	Quality Assurance/Quality Control
SRC	Saskatchewan Research Council
TOC	Total Organic Carbon

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1 INTRODUCTION

Agnico Eagle Mines Ltd. (AEM) is currently undergoing environmental impact review for advancement of its Meliadine Gold Project (MGP) from its present exploration phase to an operating mine. The MGP is situated approximately 25 km north of Rankin Inlet, Nunavut, and is comprised of six gold deposits: Tiriganiaq, F Zone, Wolf, Pump, Wesmeg and Discovery. The area has been subject to mineral exploration since the late 1980s when the Discovery deposit staked. In 2010, AEM acquired all of Comaplex Minerals and its 100% interest in the MGP.

In May 2011, AEM submitted a project proposal to the Nunavut Impact Review Board (NIRB) for development of the MGP. AEM has proposed to construct and operate an 8,500 tonnes per day gold mine and mill, combining open pit and underground techniques at the six deposits. Mine operations are anticipated to last 10 years, following two (2) years of construction. Following screening and receipt of comments from various parties, the NIRB in July 2011 recommended the Minister refer AEM's MGP project proposal to a Part 5 or 6 review under Article 12 of the Nunavut Land Claims Agreement. The Minister concurred and the Part 5 review commenced in September 2011.

To support the MGP, AEM will require equipment, fuel and other supplies to arrive by barge or ship from Baffinour, Quebec, or other eastern Canadian ports, to Itivia Harbour in Rankin Inlet. To accommodate these barges, AEM has proposed to install a spud barge in Itivia Harbour. Nunami Stantec Ltd. (Nunami) was retained by AEM to collect information on baseline environmental conditions and characteristics in and around Itivia Harbour where a spud barge will be installed. Nunami completed baseline studies in August 2011 at Itivia Harbour and two nearby reference sites in Melvin Bay. Prior to the baseline study, a Nunami biologist met with members of the Kangiqiniq Hunters and Trappers Organization to obtain Inuit Qaujimajatuqangit specifically related to the marine environment in the study area. This technical data report presents the results of the physical environment, aquatics and fisheries baseline data collected, as well as a desktop review of marine mammals and birds.

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2 BACKGROUND

This technical data report presents the results of the marine aquatics and fisheries baseline study at Itivia Harbour in Rankin Inlet, NU. The study investigated the water and sediment quality, aquatic ecology and fisheries values in Itivia Harbour and at two reference sites in Melvin Bay. A desktop review was also undertaken to evaluate marine mammal and bird occurrence in and adjacent to Itivia Harbour and Melvin Bay.

2.1 Objectives

The objectives of the baseline study were to:

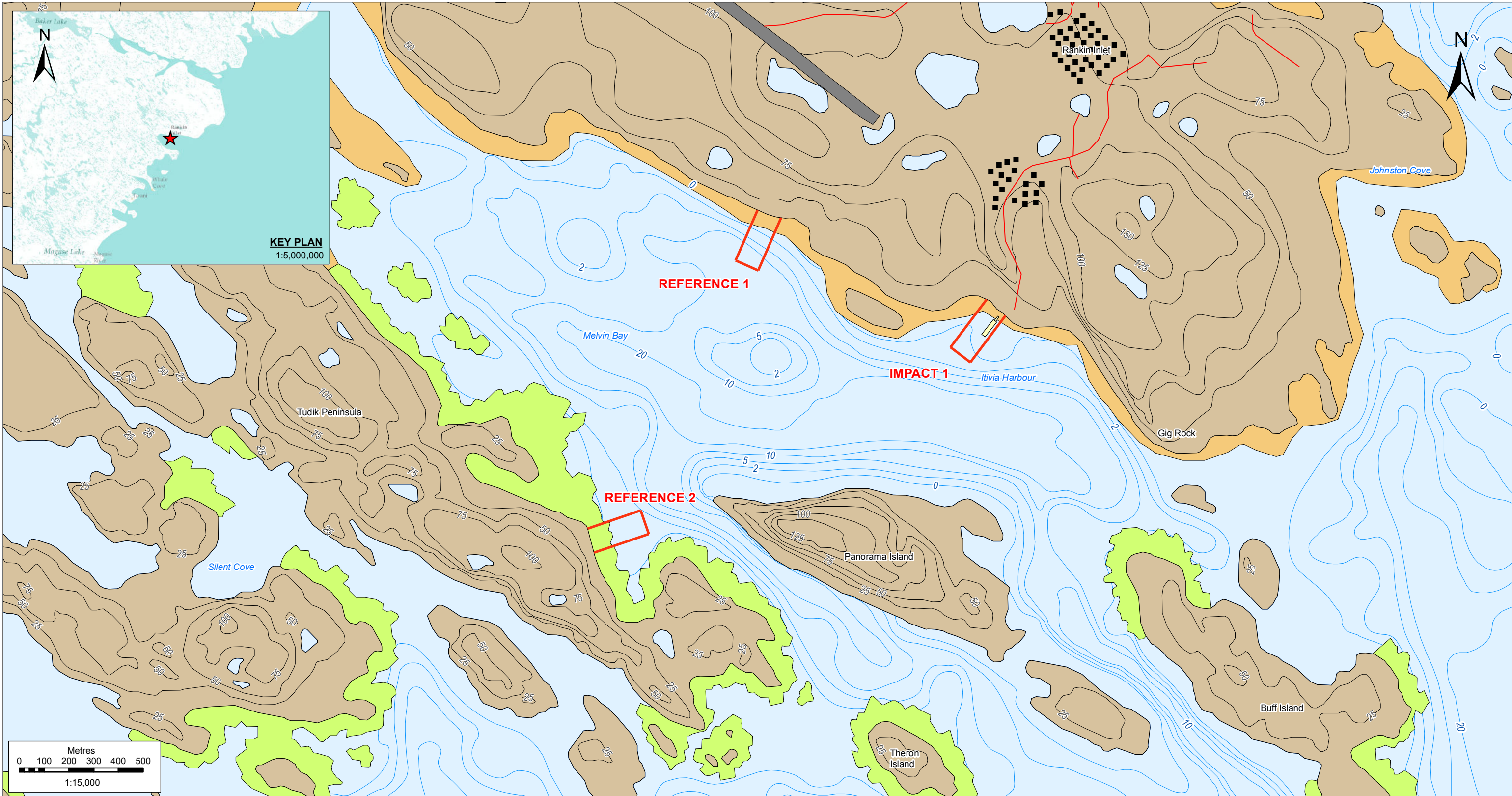
- Characterize baseline water and sediment quality at Itivia Harbour and nearby reference sites
- Describe the lower trophic aquatic community through collection of phytoplankton, zooplankton and benthic invertebrates
- Map and assess the physical fish habitat at Itivia Harbour and nearby reference sites, including bathymetry and identification of available habitat
- Determine fish species presence at Itivia Harbour and nearby reference sites
- No marine mammals were observed during the study and few birds were observed during field sampling. This document provides a cursory overview of marine mammal and bird occurrence in the study area based on the available literature and the meeting with the Kangiqliniq Hunters and Trappers Organization (Appendix G).

2.2 Study Area

The hamlet of Rankin Inlet (Kangiqliniq in Inuktitut, meaning “deep bay/inlet”) is located in the Kivalliq region of Nunavut (NU) and has a population of approximately 2,730 people (NBS 2010). Rankin Inlet is situated on the Kudlulik Peninsula which protrudes into Rankin Inlet of Hudson Bay. The hamlet is located approximately 1,175 km west of Iqaluit, NU, and 1,140 km east of Yellowknife, Northwest Territories (NT). Rankin Inlet itself has two main rivers entering it, including the Diane River in its northwest and the Meliadine River in the northeast.

The assessment site, I1, is located in Itivia Harbour which is situated on the northeast shore of Melvin Bay in Rankin Inlet and located south of the hamlet (Figure 2-1). It is connected to the hamlet by one access road and has been minimally developed with only a coarse gravel fill ramp. In the open water season, Itivia Harbour provides a place for residents to launch their boats and is used for the loading and unloading of community supply vessels. In the winter, it is used by residents for snowmobile access to Melvin Bay and Rankin Inlet.

The two reference sites within Melvin Bay have not been developed and remain natural habitat. Reference site 1 is situated downslope of the Rankin Inlet airport. A few cabins are situated to the east of the site; and some debris and refuse were noted on shore however the shoreline has not been developed or altered. Reference site 2 is located on the south shore of Melvin Bay; the area is natural and no development has occurred at this site. The Reference sites were selected for their proximity to Itivia Harbour and similarity of physical habitat (e.g., exposure, depth, shoreline substrate).



■ Building — Road — Contour — Bathymetric Depth Contours □ Sampling Area □ Proposed Spud Barge ■ Sand ■ Rock ■ Waterbody ■ Land	MARINE EFFECTS ASSESSMENT OF THE MELIADINE GOLD PROJECT - RANKIN INLET, NU			PREPARED BY:  NUNAMI STANTEC
	OVERVIEW OF SAMPLING AREAS ITIVIA HARBOUR AND MELVIN BAY			PREPARED FOR: AGNICO-EAGLE MINES LTD.
	Sources: Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.			FIGURE NO: 2-1
	DATE: 03-FEB-12 FIGURE ID: 123510575	PROJECTION: UTM 15 DATUM: NAD 83	DRAWN BY: N. PUREWAL CHECKED BY: C. SIBBALD	

Path: R:\2011\Stantec\123510575\figaworking\123510575_Fig 2-1_OverviewMap.mxd

2.3 Project Description

Agnico-Eagle Mines (AEM) is proposing to install a spud barge at Itivia Harbour to support its proposed MGP and to accommodate the required supply vessel traffic. One end of the spud barge will be connected to the shore via a hinged bridge while the other end is anchored in place; this will allow the spud barge to rise and fall with the tide. The spud barge will measure approximately 76 m long by 17 m wide (250 by 56 feet) and have a crane to lift containers and equipment directly off of the barges and onto trucks.

2.4 Inuit Qaujimajatuqangit

A Nunami biologist met with members of the Kangiqliniq Hunters and Trappers Organization (HTO) in Rankin Inlet on July 15, 2011. This meeting provided Inuit Qaujimajatuqangit (IQ) about the area and the local fishery, including presence and relative abundance of fish, invertebrates, marine plants, marine mammals and birds; harvest timings and locations; and, community use areas of interest (see Appendix G).

Members of the Kangiqliniq HTO reported that Arctic char are an important food fish species for the residents of Rankin Inlet and that residents harvest Arctic char, sculpin and cod in the Itivia Harbour area. Sculpin are only eaten occasionally by Elders, but used to be harvested more commonly in the past. Harvesting of Arctic char by residents typically takes place in August and the HTO reported that the Arctic char usually originate from the Diane and Meliadine rivers. The HTO also reported that some residents participate in commercial fishing for Arctic char. To catch higher numbers of Arctic char, the commercial fishing usually occurs 40 to 50 km (25 to 30 miles) from the community, though fishermen previously caught char closer to the hamlet.

Shellfish harvesting (i.e., mussels and clams) previously occurred along the north shore of Melvin Bay during low tide, however due to warnings from the Department of Health and Social Services about shellfish harvesting in close proximity to the community, residents now travel further away to harvest shellfish. The HTO also reported that seaweed harvesting does not occur in the community.

The HTO stated that they have noticed a change in Itivia Harbour since there has been an increase in traffic to the area. In the 1960s and 1970s, the harbour was a very good fishing spot for Arctic char, sculpin and cod. Seal harvesting also took place in the harbour as seals would come into the harbour and Melvin Bay. They noted that currently seals rarely come into the harbour or Melvin Bay and it appears there is less fish in the area than previously.

During the meeting, the HTO expressed the importance of Itivia Harbour and Melvin Bay to the residents of Rankin Inlet. The HTO noted that several residents have cabins along the north shore of Melvin Bay, and Itivia Harbour is heavily used in the summer for launching boats (it is the only place accessible during low tide) and in the winter for snowmobile travel in and out of the community. The HTO reported their concerns that the installation of the spud barge in Itivia Harbour will either restrict or prevent the community's use of the harbour. The HTO communicated they would pursue further discussion with AEM and their plans for Itivia Harbour.

2.5 Arctic Char Biology

Arctic char were selected as a fish species of focus in this study due to their importance as a subsistence species and a valued environmental component (VEC) for the residents of Rankin Inlet. Arctic char can be either freshwater resident or amphidromous¹. Amphidromous char make summer migrations to feed in the coastal waters of Hudson Bay. Arctic char spawning occurs in freshwater during fall, typically in September or October over gravel beds (Johnson 1980). Spawning by Arctic char often takes place in lakes (Johnson 1980), though spawning can occur on a river bed where suitable substrate or gravel occurs and ice does not freeze to the river bed (Hunter 1976). Age-at-first seaward migration for amphidromous Arctic char vary depending upon the geographic location. Radtke *et al.* (1997) showed most char from a Labrador river make their first seaward migration at ages 2+ or 3+ years while Babaluk *et al.* (2010) observed age-at-first migration ranging from ages 3+ to 6+ years from a lake on Baffin Island. The summer migration to the sea provides the Arctic char with greater food resources, enabling higher growth rates than would be possible in the freshwater system alone. Fisheries studies conducted in Nain and Tikkoatokak Bay (Labrador) determined that Arctic char spend 50 ÷ 60 days at sea (Johnson 1997). In the fall, Arctic char return to freshwater to avoid sea temperatures below zero degrees Celsius (Johnson 1980).

Fishery assessments of Arctic char were conducted near Rankin Inlet from the mid-1970s to the early 1990s (i.e., Kristofferson *et al.* 1987; McGowan 1987, 1992) and from 1997 ÷ 2001 (Comaplex Minerals Corp., 2007) on the Diane and Meliadine Rivers. In the earlier studies, fish weirs were set up to count numbers of fish migrating upstream in the Diane and Meliadine rivers; fish counts were conducted over a specified time period from August to September of each year. In 1976, approximately 88,000 Arctic char were counted migrating upstream on the Diane River (Kristofferson *et al.* 1987), though this number declined to 69,405 in 1986 (McGowan 1987). In 1990, 1,210 Arctic char were counted over a 20 day period on the Meliadine River (McGowan 1992). From 1997 ÷ 1999 a fish fence was set up near the mouth of the Meliadine to capture, measure, and tag char returning from the ocean. Telemetry data showed that the migration of char from Meliadine Lake to Hudson Bay is via both the Meliadine River and Peter Lake/Diane River. It is presumed that any Arctic char present in Itivia Harbour and Melvin Bay would be part of the Diane River and/or Meliadine River stocks.

¹ Amphidromous fish are diadromous whose migration from fresh water to the ocean is not for the purpose of breeding; rather it occurs at a particular stage of the life cycle.

3 METHODOLOGY

3.1 Background Data and Literature Review

Information on marine fish, mammal and bird species presence, abundance, and conservation status was compiled based on standard literature search techniques. Review of available information included:

- Published scientific literature
- Reports and documents from the Federal Government (e.g., Fisheries and Oceans Canada (DFO), Canadian Wildlife Service (CWS), Environment Canada)
- Reports and documents from the Government of Nunavut (e.g., Department of Environment, Wildlife Research Group, Parks)
- Nunavut Wildlife Management Board (NWMB), Regional Wildlife Organizations (RWOs) and the local HTO
- Resources from universities and colleges (e.g., ArcticNet, Canadian Arctic Shelf Exchange Study, Nunavut Arctic College, the Arctic Science and Technology Information System database, International Polar Year).

3.2 Field Studies

Field studies for aquatics and fisheries were conducted in Itivia Harbour and Melvin Bay from August 15 to 21, 2011. Field studies were designed to collect baseline information on the aquatic environment and fish and fish habitat conditions at the Project footprint, where marine development has been proposed, and at two reference sites, where no development is proposed. These three sampling areas were distributed around Melvin Bay: the two sampling areas on the north shore were located in separate bays and separated by a distance of 0.9 km while the third sampling area was located on the south shore, 1.5 km from Itivia Harbour. The Project footprint was labeled R1 while the reference sites were labeled R2 and R3 (see Figure 2-1).

3.2.1 Physical Environment

3.2.1.1 Bathymetry

A bathymetric depth profile was produced for one transect in each sampling area. Each transect was oriented perpendicular to shore and spanned from the shore into the subtidal zone; see Figures A-1 to A-3 in Appendix A for locations of bathymetric profiles in each sampling area. When conducting each survey, depths were measured using a portable depth sounder and locations were determined using a handheld GPS. Measured depths were translated into depths below chart datum (i.e., lowest normal tide) using tide predictions made by the Canadian Hydrographic Service for Rankin Inlet (Station #5100).

3.2.1.2 Water Quality Profiles

Water quality profiles were collected at each sampling area on August 21, 2011. Water quality station locations were recorded using a handheld GPS. Water quality profiles were collected using an YSI 600QS multi-meter. Measured parameters included temperature, conductivity, pH, dissolved oxygen, salinity and oxidation-reduction potential. Parameters were recorded on prepared datasheets every 1 m from the surface to the bottom. See Figures A-1 to A-3 in Appendix A for locations of water quality stations in each sampling area.

3.2.1.3 Nearshore Habitat Survey

The upper and mid intertidal zone were visually inspected during low tides to estimate percent substrate composition, slope, and percent coverage by attached macrophytes; and to identify macro-invertebrate species presence. Substrate composition was estimated using methods consistent with standard methods in Coastal/Estuarine Fish Habitat Description and Assessment Manual (Williams 1993) and DFO's Marine Habitat Information Requirements (DFO 2007) which recognizes the following substrate size categories: fines (< 2 mm), gravel (2 ÷ 64 mm), cobble (64 ÷ 256 mm), boulder (256 ÷ 4,000 mm), and bedrock (> 4,000 mm).

3.2.2 Water and Sediment Chemistry

3.2.2.1 Water

Physical and chemical parameters determine the physiological performance of individual aquatic organisms and influence characteristics at the population and community levels in terms of distribution, diversity and density. Marine coastal waters are also relied on heavily by the local Inuit for traditional harvesting. Therefore it is important to determine baseline water and sediment quality conditions to allow for monitoring of potential effects from development, and ensure compliance with territorial and federal standards.

The water quality assessment was designed to provide data on general water chemistry, nutrients, organic carbon content, and metal levels. These parameters are relevant to toxicity and physical habitat parameters for plants, plankton, benthos, fish eggs and juvenile fish.

The objectives of the water quality assessment were to:

- Obtain baseline water quality data that can be used to assess changes related to installation, operation and decommissioning of the spud barge;
- Identify parameters that may be present at elevated levels, and to use this information to propose site-specific water quality objectives, if needed; and,
- Provide baseline data that can be used to support potential future monitoring programs.

Sample Collection

Water samples were collected from each sampling site at one station located in the subtidal zone. Water was collected using a Van Dorn sampler at mid-depth as temperature was relatively constant throughout the water column and there was no evidence of thermal stratification.

Samples requiring preservation were preserved immediately after sample collection. All samples and blanks were kept in coolers with ice packs until arrival at the laboratory. Chain of custody forms describing sampling times and required analyses were submitted to the laboratory.

Laboratory Methods

Water samples were analyzed at ALS Laboratories in Vancouver, British Columbia (BC), for routine parameters. These included major anions, alkalinity, total suspended solids, total dissolved solids, pH, conductivity, total metals, total Kjeldahl nitrogen, ammonia, nitrate and nitrite, total phosphate, and total organic carbon.

Data Analysis

All general chemistry results were compared to available Canadian Council of Ministers of the Environment (CCME) guidelines (maximum levels) for Protection of Marine Aquatic Life (PMAL) (CCME 2007). The CCME water quality guidelines are listed in Table 3-1.

Table 3-1: Canadian (CCME) Water Quality Guidelines for Protection of Marine Aquatic Life

Parameter	CCME Water Quality Guideline Maximum
Temperature	±1°C change from background
Dissolved oxygen	>8.00 mg/L and narrative
pH (units)	7.00 – 8.70
Total suspended solids	Narrative
Turbidity	Narrative
Nitrate-N	3.6 mg/L
Salinity	<10% change from background
Arsenic, total	12.5 µg/L
Cadmium, total	0.12 µg/L
Chromium, total	56 µg/L
Mercury, total	0.016 µg/L

NOTES:

Additional parameters analysed, for which marine guidelines do not exist, include: conductivity (field and lab), fluoride, chloride, ammonia-N, total hardness, total dissolved solids, total alkalinity, bicarbonate, carbonate, hydroxide, bromide, nitrite nitrogen, total Kjeldahl nitrogen, total phosphorus, total organic carbon, aluminum, antimony, barium, beryllium, boron, bismuth, calcium, cesium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, rubidium, selenium, silicon, silver, sodium, strontium, tellurium, thallium, thorium, tin, titanium, tungsten, uranium, vanadium, zinc and zirconium.

The majority of the analytical detection limits were below the CCME guidelines and therefore had no bearing on screening results. For mercury, analytical detection limits were above WQG mostly due to analytical interferences and laboratory limitations. This should not be considered an exceedance to the WQG. Re-evaluation of mercury in collected samples is not possible at this time.

All sample parameters for which CCME PMAL guidelines exist were within acceptable limits across all three sampling locations.

QA/QC

The Quality Assurance/Quality Control (QA/QC) program was designed to provide reliable monitoring data by minimizing sampling error, contamination and erroneous results, and by quantifying any bias in the results. Another important component of the QA/QC program was to assure data quality regarding precision, bias, adequate sample hold times and detection limits. The examination of environmental data for potential artifacts due to contamination or reporting errors was thorough. Laboratory results and field notes were verified in relation to replicate and blank results, hold times and occurrence of unusual events.

Field and Travel Blanks

Field blanks (bottles filled in the field with lab-supplied de-ionized water) and travel blanks (sealed de-ionized water supplied by the lab) were analyzed. The blanks were examined to determine whether there were detectable levels of any of the measured parameters. The majority of field and travel blank results were below detection limits with the exception of two field blanks (boron and zinc) and one travel blank (Silver). Blank results are presented in Appendix B.

Replicates

One field replicate was collected during sampling. Results for the field replicate were examined to determine if precision thresholds were exceeded: field replicates should have a difference of no more than 25% of their mean for parameters equal to or greater than five times the detection limit. Results for duplicate samples are presented in Appendix B.

Hold Times

All samples were submitted within applicable hold times.

3.2.2.2 Sediment

Sediment metal analysis is widely used as an indicator of environmental quality in baseline monitoring and environmental assessments. Sediments serve as a repository for metals in both the particulate and dissolved fractions within sediment pore water, often containing higher metal concentrations than are found in water. When sediment is disturbed, metals can be re-suspended and/or recycled into the water column. Metals that enter aquatic systems may cause acute or chronic toxicity to benthic and planktonic organisms (e.g., biochemical and physiological changes), which can potentially lead to altered community structure and to effects on other organisms in the aquatic food web (Hook and Fisher 2001; Grosell, *et al.* 2006; Wilding and Maltby 2006; Shaw *et al.* 2006).

Metals accumulate in sediments when metal particles are washed into water and settle onto the substrate or when soluble metals become absorbed by sediment particles. The fate of these metals depends on local physical and chemical conditions in the sediment. Therefore sediments can potentially act as either a source or a sink for metals, depending on redox potential, cation exchange capacity, particle size of sediments and organic carbon content (Salomons *et al.* 1987).

Particle size influences sediment quality and binding behaviours for metals and other contaminants. Fine (< 63 μm) and coarse (> 63 μm) particles differ in their mineralogical, morphological, physicochemical and mechanical properties (Salomons and Forstner 1984). In general, metals absorb more readily to fines (Brook and Moore 1988), with the highest metal concentrations in clay-sized particles. The exceptions are iron and manganese, which preferentially bind to larger particles > 300 μm . Other characteristics, such as water depth, pH, hardness, nutrient concentration, temperature, dissolved oxygen and water circulation, also affect the behaviour of metals (Mudroch and MacKnight 1991).

The interaction between metals and sediment can strongly influence the toxicity of metals in aquatic systems. Although there is some debate surrounding the sources and mechanisms of metal toxicity for benthic organisms (i.e., water vs. sediment) or absorption of dissolved metals vs. ingestion of particulate metals, the bioavailability and toxicity of metals can largely be determined by metal ion activity in sediment pore water (Carbonaro *et al.* 2005). Thus, chemical interactions that produce insoluble metal species reduce the potential for metal toxicity. For example, the natural presence of iron monosulphide (FeS) lowers dissolved concentrations of Cu^{2+} , Cd^{2+} , Ni^{2+} , Pb^{2+} , Zn^{2+} , and Ag^{+} through formation of insoluble metal sulphides (Carbonaro *et al.* 2005). The potential for metal toxicity also depends on oxygen levels, which oxidize metal sulphides, releasing metal ions back to the sediment pore water (Carbonaro *et al.* 2005). Binding of metal ions to organic carbon also affects metal concentrations in pore water (Ankley *et al.* 1996).

In the present assessment, samples from each sampling area were analyzed for total metals, particle size, total carbon, organic and inorganic carbon, Total Kjeldahl Nitrogen, and total phosphorus in the fine fraction.

Metal concentrations were compared to CCME Interim Sediment Quality Guidelines (ISQG) (CCME 2002). CCME SQGs are provided as two values: ISQG, representing concentrations below which adverse biological effects are not expected, and probable effects levels (PELs), above which adverse biological effects are usually or always observed. Both levels are derived from available literature however, at present, metal SQG are considered interim due to a lack of data. It is also noted that the ISQG are not defined for a particular sediment particle size range.

Sample Collection

Sediment samples were collected on August 19 and August 20, 2011, using a petite ponar sediment grab (2.4 L, 152 x 152 mm). Three sampling stations at least 20 m apart were established in the subtidal of each sampling area and sediment grabs were collected at each station. The top 5 cm of sediment from each of three grabs was removed with a clean stainless steel spoon and composited in a clean stainless steel bowl. The composited sample was placed in clean sample jars for analyses of general sediment chemistry and total metals at each station.

After collection, samples were kept in coolers with ice packs until arrival at the laboratory. Chain of custody forms describing sampling times and required analyses were submitted to the laboratory.

Laboratory Methods

Sediment samples were analyzed at ALS for general chemistry and metals. General chemistry parameters included total carbon, organic and inorganic carbon, total Kjeldahl nitrogen, total phosphorus, total metals and particle size. Detection limits were generally suitable for comparison with sediment quality guidelines.

Data Analysis

Summary statistics were generated for all parameters at each sampling area; these statistics included mean, standard deviation, and coefficient of variation (CV). For results below detection limits, a value of half of the detection limit was used in the calculations. Analytical detection limits were always well below CCME ISQG and PEL for protection of aquatic life and did not influence the interpretation of results. Metal data were compared to available CCME SQG for protection of marine aquatic life (CCME 2002), as shown in Table 3-4.

Table 3-2: Analytical Detection Limits and Canadian (CCME) Working Sediment Quality Guidelines for Protection of Marine Aquatic Life

Parameters	Detection Limit (mg/kg)	Sediment Quality Guidelines (mg/kg)	
		CCME ISQG ¹	CCME PEL ²
Arsenic, total	0.10	7.24	41.6
Cadmium, total	0.020	0.7	4.2
Chromium, total	1.0	52.3	160
Copper, total,	1.0	18.7	108
Lead, total	0.20	30.2	112
Mercury, total	0.050	0.13	0.70
Zinc, total	10	124	271

NOTES:

¹ ISQG = Interim Sediment Quality Guideline

² PEL = Probable Effects Level

Additional parameters analysed, for which no guidelines exist, include: inorganic carbon, total organic carbon, total carbon, CaCO₃ equivalent, total Kjeldahl nitrogen, total phosphorus and total aluminum, antimony, barium, beryllium, bismuth, boron, calcium, cesium, cobalt, iron, magnesium, manganese, molybdenum, nickel, potassium, rubidium, selenium, silver, sodium, tellurium, thallium, tin, titanium, tungsten, uranium, vanadium and zirconium.

QA/QC

QA/QC protocols consisted of standard procedures in the field to avoid sample contamination, examination of certified reference materials (CRM) and laboratory duplicates, and assessment of the precision of field replicates.

Field Procedures

Quality assurance in the field included cleaning the equipment (stainless steel bowl, stainless steel spoons), rinsing thoroughly with site and deionized water between replicates and stations, and

wearing new nitrile gloves at each station. The glass sampling jars were acid-washed and supplied uncontaminated from the laboratory. Upon collection, samples were immediately placed in a clean cooler, with ice packs. Care was taken to not contaminate the inside of the jar or the cap. Samples were kept in coolers until they were sent to the laboratory for analysis.

Laboratory Procedures

Certified Reference Materials

ALS Laboratories provided results for analysis of CRM, reporting the analyses, certified values and percent of target value. The laboratory analyses generally met the criteria of less than 20% difference in the value of metals found in the CRM samples compared to the target value as determined by the National Research Council.

Analytical Duplicates

Laboratory replicates were within 20% difference when parameter levels exceeded five times the detection limits.

Field Replicates

Replicate samples provide information about heterogeneity of the sediment within a station. One replicate sample was collected from each sampling area. The three replicate samples were assessed for precision and variability by calculating the CV of each parameter at a sampling area, using the formula $CV = [\text{standard deviation}/\text{mean}] * 100$. Standard deviation and CV should be no more than 20% of the mean when all replicate values are at least five times the detection limit. Results for which the precision thresholds were exceeded are highlighted in Appendix B.

Of the 153 analyses completed in triplicate (51 parameters at 3 sampling areas) and whose replicate results are all greater than 5 times the detection limit, 13 results (8%) had CV greater than 20% (1 to 7 parameters per sampling area). These results included molybdenum, which exceeded 20% CV at all 3 sampling areas; total organic carbon, total carbon and uranium, which exceeded 20% CV at 2 sampling areas; and, total Kjeldahl nitrogen and boron, which exceeded 20% CV at 1 sampling area.

3.2.3 Aquatic Organisms

3.2.3.1 Phytoplankton

Phytoplankton are small free-floating plant-like organisms mainly consisting of algae and cyanobacteria. These organisms provide a primary source of energy in the marine environment by converting inorganic carbon, nitrogen and phosphorus into organic matter, making it available for secondary consumers such as zooplankton and benthic invertebrates. Phytoplankton exhibit a strong interaction with their physical and chemical environment and this close association was well appreciated by the early 1900s (Franks 2003). Due to the sensitivity of phytoplankton to a variety of changes in the physical or chemical environment (i.e., nutrient loads, TSS, metal levels, etc.), they can be useful tools for evaluating aquatic environment. They also provide a valuable food chain link between water chemistry and the invertebrate and fish communities.

Sample Collection

Phytoplankton were collected from one station in each sampling area in the subtidal zone. Samples were collected using a Van Dorn sampler deployed to 1 m depth. Samples were stored in 250 mL labelled plastic bottles and preserved with Lugol's solution (1/100 mL). Samples were stored in coolers with ice packs and no exposure to light until arrival at the laboratory. Chain of custody forms describing sampling times and analytical requirements were submitted with the sample shipment.

Laboratory Methods

Taxonomy samples were examined at Fraser Environmental Services in Surrey, BC; following procedures outlined in the Fraser Environmental Methods Manual (Looy 2011) and described in Appendix F. Depending on the density of organisms, an appropriate volume of the samples (typically 100 mL) were settled in settling chambers for approximately 24 hours and examined in an inverted microscope. The entire chamber was scanned at increasing powers of magnification to determine the species or genera present. At least 20 random fields were counted, to a total count of at least 100 for the predominant species, and data were converted to cells/mL.

Data Analysis

Raw taxonomic data (cells/mL) from the sampling areas are presented in Appendix C. Data are reported by taxonomic group and for the most abundant taxa at each site. The six groups are diatoms (*Bacillariophyceae*), green algae (*Chlorophyta*), cryptophyte algae (*Cryptophyta*), blue-green algae (*Cyanophyta*) and dinoflagellates (*Pyrrophyta*).

Phytoplankton diversity at each sampling area was calculated using Simpson's Diversity Index (Environment Canada 2002):

$$D = 1 - \sum_{i=1}^S (p_i)^2$$

where: p_i is the proportion of the total cell density (cells/mL) for each taxon i and S is the total number of taxa.

Abundance data for many taxa were reported as a less than value, indicating the taxa were observed during the initial visual scan, but not found during the regular counting protocol. The Simpson's Diversity Index was calculated for three scenarios: treating less than values as zero, treating less than values as half the reported value, and treating less than values as their reported non-less than value (e.g., < 4.7 becomes 4.7). Due to the high number of phytoplankton taxa reported, the diversity index did not vary greatly between the three scenarios. As a result, the convention followed was the same as for chemistry data (using one-half the reported less than value) for calculation of Simpson's Diversity Index in agreement with the majority of scientific literature. This ensured that taxa reported as less than values were not excluded from diversity calculations and therefore did not inflate diversity calculations, making rare taxa seem more common.

Percent abundance of diatoms, green, blue-green, cryptophyte and dinoflagellate species was estimated and abundance was summarized as predominant (> 25% abundance), common (5 to 25% abundance) or present.

QA/QC

Quality control procedures involved precautions for ensuring samples were protected from contamination and deterioration (consistency of sampling, correct use of equipment, detailed field notes, use of clean bottles, adequate preservation). Bottles for taxonomy samples were labelled with indelible ink (sample station, collection date and preservative). Care was taken to ensure bottles were kept in a cool, clean environment, either cooler or refrigerator, with no exposure to light.

Fraser Environmental Services followed internal procedures for taxonomy: microscope calibration, counting procedures, Batch Quality Control procedures for precision and accuracy in taxonomic identifications, verification with an in-house reference collection and external review.

3.2.3.2 Zooplankton

Zooplankton are an important ecosystem component because of their role as secondary producers and relationship with phytoplankton and fish production (Mazumder 1994; Vadstein *et al.* 1995). The smallest zooplankton can be characterized as recyclers of water-column nutrients and often are closely tied to measures of nutrient enrichment. Larger zooplankton are important food for forage fish and the larval stages of all fish. The zooplankton community is composed of primary consumers, which eat phytoplankton, and secondary consumers, which feed on other zooplankton.

Sample Collection

Zooplankton samples were collected from one station in each sampling area in the subtidal zone. A 20 cm diameter zooplankton tow net (64 μ m mesh size) was deployed for two 3 m vertical tows to collect zooplankton. The zooplankton net was rinsed with filtered ambient water at each sampling station to ensure all capture organisms were collected in the sample bottle.

Zooplankton samples were collected in 500 mL labelled plastic bottles and preserved in 5% buffered formalin. Zooplankton samples were kept in clean coolers until arrival at the laboratory. Chain of custody forms describing sampling times and required analyses were submitted with the sample shipment.

Laboratory Methods

Samples for zooplankton taxonomy were examined at Fraser Environmental Services in Surrey, BC, following procedures outlined in the Fraser Environmental Methods Manual (Looy 2011) and described in Appendix F. The volume of each sample was measured and a 50 mL subsample removed and examined in a petri dish. The entire dish was examined at increasing magnification and taxa identified. A series of 1 mL aliquots of sample were then settled in a Sedgewick-Rafter chamber for 15 minutes, and counted using a strip counting method (see Looy 2011). At least three aliquots were counted, to yield a minimum of 100 organisms. Results were averaged and counts converted to organisms per cubic metre (m^3).

Data Analysis

Raw taxonomic data from the sampling areas are presented in Appendix C as organisms per cubic metre (m³). Data were reported by taxonomic group and abundance of taxa at each sampling area.

Diversity of zooplankton at each sampling area was calculated using Simpson's Diversity Index (Environment Canada 2002):

$$D = 1 - \sum_{i=1}^S (p_i)^2$$

where: p_i is the proportion of the total zooplankton density (organisms/m³) for each taxon i and S is the total number of taxa.

Percent abundance of zooplankton at each sample station was estimated and abundance was characterized as predominant (> 25% abundance), common (5 to 25% abundance) or present, providing a semi-quantitative summary.

QA/QC

Quality control procedures involved precautions for ensuring samples were protected from contamination and deterioration (consistency of sampling, correct use of equipment, detailed field notes, use of clean bottles). Bottles for taxonomy samples were labeled with indelible ink (sample station, collection date, and preservative). Care was taken to ensure sample bottles were kept in a cool, clean environment, either cooler or refrigerator.

Standard protocols for zooplankton samples were followed to maintain sample quality prior to analysis. Fraser Environmental Services followed internal procedures for taxonomy: microscope calibration, counting procedures, Batch Quality Control procedures for precision and accuracy in taxonomic identifications, verification with an in-house reference collection and external review.

3.2.3.3 Benthic Invertebrates

Benthic invertebrates are an important component of both freshwater and marine habitats, as they consume smaller animals and plants, aid in decomposition of organic material and are an important source of food for fish and other animals.

Benthos (benthic invertebrates) are commonly used for biomonitoring purposes. The main advantages of using benthic invertebrates for biomonitoring are: 1) they are ubiquitous, so can be affected by perturbations in many aquatic habitats; 2) the many species involved offer a wide range of responses to environmental stresses; 3) they are relatively sedentary, which allows for the determination of the spatial changes caused by perturbations; and, 4) they have relatively long life cycles, so effects of perturbations over time can be observed (Rosenberg and Resh 1993; Barbour *et al.* 1999).

Sample Collection

Benthos samples were collected on August 19 and August 20, 2011, using a petite ponar sediment grab (2.4 L, 152 x 152 mm). Three stations at least 20 m apart were established in the subtidal of

each sampling area and sediment grabs were collected at each station. Due to sediment characteristics and subsequent difficulty obtaining full grabs, six partial (half full) grabs were collected from each individual station and composited into one sample. A total of 18 partial grabs were collected from each sampling area to produce three composited samples (six partial grabs per composited sample).

Benthos grabs were composited in buckets and transported to shore where the samples were sieved through a box with 500 μ m mesh. Sediment and invertebrates that did not pass through the sieve were collected in labeled 500 mL plastic jars. Benthos samples were preserved in 5% buffered formalin. Samples were placed in a clean tote until arrival at the analytical laboratory. Chain of custody forms describing sampling times and required analyses were submitted with the benthos samples.

Laboratory Methods

Benthos samples were examined by Biologica Environmental Services in Victoria, BC, following procedures outlined in their Sample Methods (Biologica 2011) as described in Appendix F. The samples were transferred from formalin to alcohol and gently washed on a geological screen (0.500 mm) to remove the formalin and residual fine sediment. To split the samples, a Caton tray with either 6, 12, 24 or more quadrats with 0.500 mm mesh size was used. The sample was spread evenly over the selected Caton tray, rinsed and drained, and a quadrat is randomly selected for further sorting. The random selection of quadrats continues until 300 to 500 organisms have been collected. Small fractions of the split samples are sorted in a dish with a dissecting microscope at increasing magnification until all organisms are recovered. Invertebrates were identified to the lowest practical taxonomic level (genus or family level for most annelids, molluscs, crustaceans and bryozoans, family level for other organisms, and species or phylum in some cases).

Data Analysis

To facilitate data analysis and presentation, the various life stages of individual taxa were combined (i.e., adult, larval, and pupal stages). For comparison and discussion purposes, lower taxonomic levels were often combined into higher levels (usually family). Further, the three samples from each sampling area were composited into one sample set.

For each taxon, the density (number of individuals per unit area; an indicator of habitat availability and fish food abundance), and summary statistics, including minimum, maximum, median, standard deviation and standard error, were calculated. Abundance data were reported as organisms per square metre (m^2), with appropriate conversion of the data. Percent composition of dominant/indicator taxa (abundance of dominant/indicator taxa relative to the total number of organisms) was also calculated for each site. Dominant/indicator taxon groups were defined as those groups representing greater than 5% of total organism abundance, characterized as predominant (> 25% abundance), common (5 to 25% abundance) or present, providing a semi-quantitative summary.

Community diversity, D , of benthic invertebrates at each site was calculated using Simpson's Diversity Index (Environment Canada 2002). This index is a measure of community structure defined by the relationship between the number of distinct taxa and their relative abundances:

$$D = 1 - \sum_{i=1}^S (p_i)^2$$

where: p_i is the proportion of the i^{th} taxon at the station
 S is the total number of taxa at the station.

Simpson's Evenness Index, E , was calculated as (Environment Canada 2002):

$$E = (1 / \sum_{i=1}^S (p_i)^2) / S$$

The evenness index takes into account relative abundance and number of taxa at each site to provide an indication of community structure. The index ranges from 0 to 1. A higher value (closer to 1) generally indicates a community with relatively uniform distribution of taxa (more homogenous) while a low value (closer to 0) generally reflects a community with a greater distribution of taxon abundance and thus more heterogeneous.

QA/QC

Field and analytical QA/QC measures were based on the BC Freshwater Biological Sampling Manual (MWLAP 2003) and Biologica Environmental Services internal QA/QC procedures (Appendix F). The procedures ensured that all personnel were adequately trained, sampling methods were consistent, samples were correctly collected, labeled and preserved, and equipment was properly cleaned. Detailed field notes were kept, chain of custody forms were used, and safe shipping and storage methods were used.

Analytical QA/QC was based on the Biologica Environmental Services internal QA/QC procedures (Biologica 2011) (Appendix F). Sorting efficiency was assessed by a qualified sorter for 25% of the sorted samples. A portion of each sample is spread in 9 x 13 inch white pan and examined under a dissecting microscope at 10x magnification. If more than three new identifiable organisms are removed per 500 mL, the sample is re-sorted.

3.2.4 Fisheries Assessment

3.2.4.1 Sampling Design

Fish species presence was investigated at all three sampling areas between August 15 and 21, 2011. The sampling areas were stratified by distance from shore, as either nearshore or offshore samples/sets. Nearshore samples typically occurred within the intertidal zone (an average of 111 m from the high water mark) while offshore samples occurred in both the low intertidal and subtidal zones (an average of 241 m from the high water mark).

3.2.4.2 Fisheries Data Collection

Daytime sets of sinking multi-panel gillnets was the primary fish sampling method used across all sampling areas. Each gillnet consisted of six panels of different mesh sizes strung together to form a

net 91.2 m long and 2.4 m deep. The mesh sizes (in order) were 25 mm, 76 mm, 51 mm, 89 mm, 38 mm and 64 mm. The number of replicate sets in the nearshore and offshore portions of each sampling area ranged from two to three sets with an average soak time of 3.42 hours (range: 2.28 to 5.17 hours).

All captured fish were removed from the nets carefully to minimize injury and placed in a large container of seawater. Fish that were alive and in good condition were measured expediently and released alive. Fish that were alive but injured, such that they were unlikely to survive if released, were euthanized. All fish were identified to species in the field; any uncertain species identifications were photographed for later confirmation. Captured fish were enumerated, and measured for weight and total length (sculpin and cod). Total length of all captured fish was measured in the field using a measuring board. Wet weight of each fish was measured using an electronic scale with 0.1 g precision, or a spring scale (Accu-weigh tubular spring scale, maximum unit of 5 kg) if the fish were too large (i.e., greater than 1,000 g). Each fish was also examined for external parasites or abnormalities such as scars or tumors.

Beach seining was attempted at two sampling areas (I1 and R1). The beach seine net was approximately 20 m long and 1.5 m deep with 5 mm mesh. One end of the net was held on shore while the other end was dragged perpendicularly away from shore by boat until it was two thirds deployed, then parallel to shore until fully deployed, and finally straight towards shore. The ends of the net were pulled together and out of the water to retrieve any fish caught within the seined area. The boulder and cobble intertidal habitat of the sampling areas made it difficult to beach seine as the seine net was continually getting stuck on rocks and freeing the seine net would potentially allow captured fish to escape. The beach seine was not used in the third sampling area (R2) as the slope of the intertidal was very steep and made it difficult to safely hold the seine on shore.

3.2.4.3 Data Analysis

Comparisons among Sampling Areas

Analysis of variance (ANOVA) was used to test for differences in species richness and fish catch rates. Data were organized by ñAreaò(three sampling areas) and ñDistanceò(nearshore/offshore) and ANOVA applied to test for differences between the three sampling areas, distance from shore, and any interaction between Area and Distance. Distance was considered a random effect to allow for inferences beyond the three sampling areas while Area was fixed. Species richness values needed to be square-root transformed to meet the ANOVA assumptions of normality and homogeneity of variances. Due to a small sample size, ñTideò(ebb/flood) was not included as a third factor in the ANOVA. A two-tailed *t*-test was used to test for a direct effect of Tide on species richness and fish catch rates.

If the ANOVA indicated that there were significant differences among sampling areas, a posthoc Student's *t*-test was used to test whether the Project footprint (I1 sampling area) differed significantly from the other two sampling areas. The significance level used to test all effects was $\alpha = 0.05$.

Stock Characteristics

Fulton's condition factor (K) (Fulton 1902) was used to analyze the length-weight data for Greenland cod. Fulton's condition factor describes the relationship between fish mass and length (Murphy and Willis 1996), assessing the state of the fish's health, or its condition. It is calculated for each fish as:

$$K = (W/L^3) \times 10^5$$

where: W is the weight of the individual fish

L is the total length for a fish in the statistical population under study.

4 RESULTS

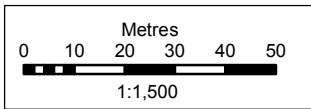
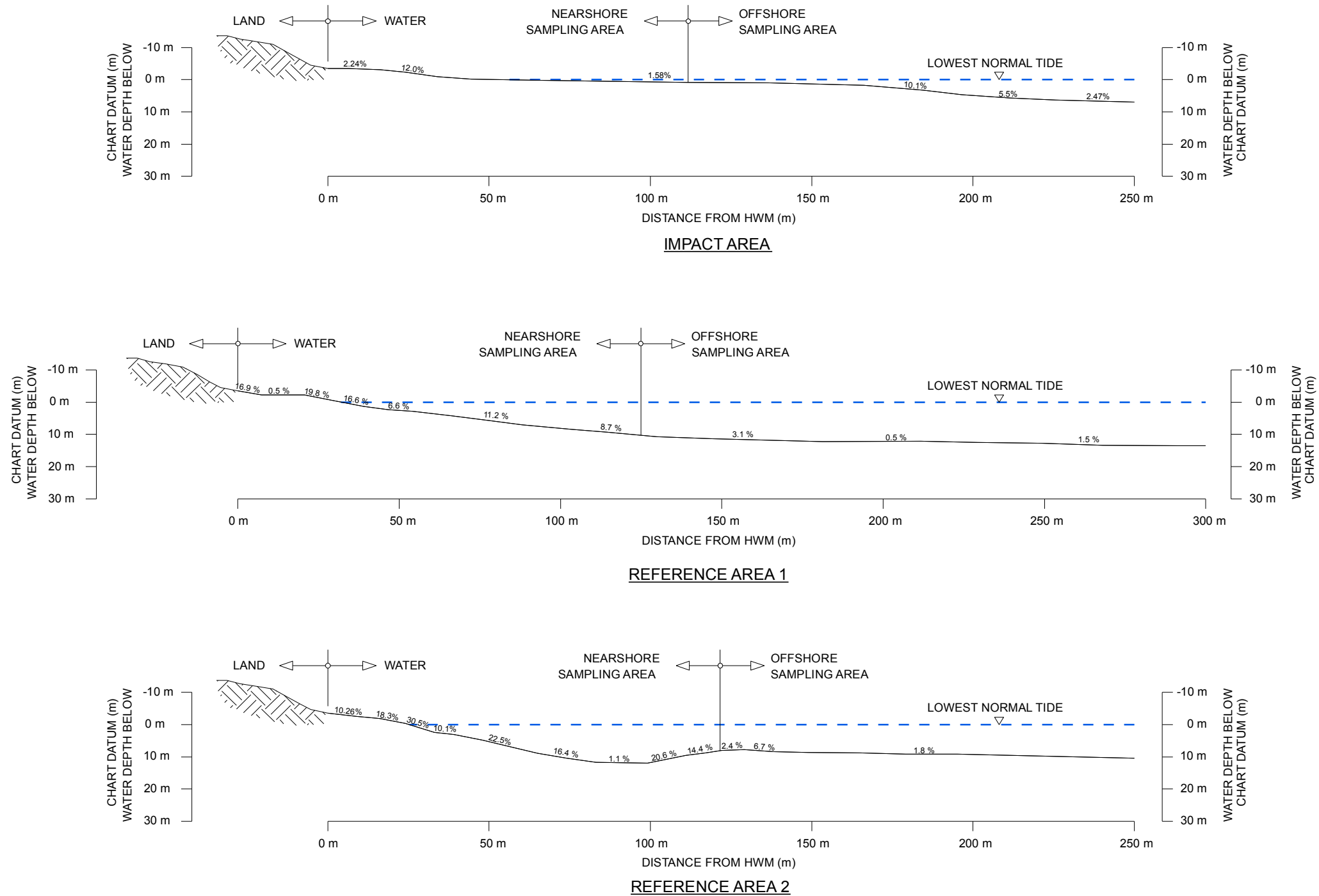
4.1 Physical Environment

4.1.1 Bathymetry

The I1 sampling area was located in the relatively shallow Itivia Harbour of Melvin Bay. A large rock reef is present approximately 125 m offshore (from the high water mark) and intersected the sampling area. Consequently the Project footprint (I1 sampling area) was shallower (mean depth [below chart datum] was 1.4 – 3.3 m) and had a gentler slope than the other two sampling areas. This resulted in a greater representation of intertidal habitat, which spanned approximately 22% (56 m) of the total sampling area length (Figure 4-1). The maximum depth in the Project footprint was 6.6 m.

The R1 and R2 sampling areas were largely restricted to the subtidal zone and were deeper. The intertidal zone in the R1 and R2 sampling areas accounted for 11% and 14%, respectively, while mean depth ranged from 6.7 – 6.2 m at R1 to 6.3 – 4.7 m at R2 (Figure 4-1). Maximum depths in the two reference areas were 13.6 m at R1 and 11.9 m at R2.

See Figures A-1 to A-3 in Appendix A for the location of each bathymetric profile.



MARINE EFFECTS ASSESSMENT OF THE MELIADINE GOLD PROJECT - RANKIN INLET, NU			PREPARED BY:  NUNAMI STANTEC
BATHYMETRIC PROFILES FOR SAMPLING AREAS			PREPARED FOR: AGNICO-EAGLE MINES LTD.
<i>Sources:</i> <i>Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.</i>			FIGURE NO: 4-1
DATE: 15-NOV-11 FIGURE ID: 123510575	PROJECTION: UTM 15 DATUM: NAD 83	DRAWN BY: N. PUREWAL CHECKED BY: C. SIBBALD	

Path: R:\2011\Stantec\123510575\agaworking\123510575_Fig 4-1_Bathymetric Profiles.mxd

4.1.2 Water Quality

Averaged across all sampling areas, surface water (1 m depth) had a mean ($\pm$ SD) temperature of $8.86 \pm 0.52^\circ\text{C}$, a salinity of 29.32 ± 0.03 ppt, and a pH of 8.08 ± 0.03 (Table 4-1). Bottom water was slightly colder ($8.49 \pm 0.57^\circ\text{C}$) though salinity and pH were similar from surface to bottom. Thermal stratification was not present at any of the three sampling areas.

Surface *in situ* pH was relatively constant across Melvin Bay (range from 8.05 to 8.10; Table 4-1) and through the water column (Table B1 in Appendix B). Mean *in situ* conductivity and dissolved oxygen were also relatively constant at the sampling areas: mean *in situ* conductivity ranged from 45.6 ± 0.1 mS/cm at surface to 45.7 ± 0.1 mS/cm at bottom, while dissolved oxygen ranged from $114.5 \pm 1.0\%$ at surface to $114.1 \pm 1.2\%$ at bottom (Table 4-1 and Table B1 in Appendix B).

Table 4-1: Mean *In situ* Water Quality Parameters

Water Quality Parameter	Statistic	Depth	
		Surface	Bottom
Temperature ($^\circ\text{C}$; n = 3)	Mean	8.86	8.49
	Standard Deviation	0.52	0.57
	Range	8.50 ĩ 9.45	7.93 ĩ 9.07
Salinity (ppt; n = 3)	Mean	29.32	29.33
	Standard Deviation	0.03	0.04
	Range	29.29 ĩ 29.35	29.30 ĩ 29.38
Conductivity (mS/cm)	Mean	45.6	45.7
	Standard Deviation	0.1	0.1
	Range	45.5 ĩ 45.7	45.6 ĩ 45.8
pH (n = 3)	Mean	8.08	8.08
	Standard Deviation	0.03	0.02
	Range	8.05 ĩ 8.10	8.07 ĩ 8.10
Dissolved oxygen (%)	Mean	114.5	114.1
	Standard Deviation	1.0	1.2
	Range	113.6 ĩ 115.6	113.3 ĩ 115.5

4.1.3 Nearshore Habitat

Cobble and/or gravel were the dominant substrates across the nearshore of all three sampling areas (Table 4-2). The nearshore substrate of the R1 and R2 sampling areas was dominated by cobble (40% and 50%, respectively) though R1 also had a large proportion of gravel (35%) (Table 4-2 and site photographs in Appendix A). Boulders and fines were also present at the R1 and R2 sampling areas though in smaller proportions (20% or less) (Table 4-2).

Gravel was predominant in the nearshore at the Project footprint (I1 sampling area) (40%) though a large proportion of cobble (30%) was also present. Compared to R1 and R2, fines made up a higher proportion of the nearshore at the Project footprint while boulders comprised a smaller proportion (Table 4-2). However when combined, the smaller fraction of substrates (gravels and fines) comprised the greatest proportion of the nearshore area at the Project footprint (60%) and was much greater than at R1 and R2 (45% and 25%, respectively). The difference in substrate composition between the Project footprint and the two reference areas is likely a result of the addition of gravel to the area to develop the harbour's boat launch.

Table 4-2: Biophysical Attributes of Nearshore Habitat

Area	Distance from Shore	% Substrate Composition ¹					Macrophyte Cover (% area)	Slope ² (%)
		Bedrock	Boulder	Cobble	Gravel	Fines		
Project Footprint (I1)	Total	ï	ï				ï	5.6
	Nearshore	ï	10	30	40	20	2	5.3
	Offshore	ï						4.9
Reference 1 (R1)	Total	ï	ï	ï	ï	ï	ï	8.5
	Nearshore	ï	15	40	35	10	5	11.5
	Offshore	ï	ï	ï	ï	ï	ï	1.7
Reference 2 (R2)	Total	ï	ï	ï	ï	ï	ï	6.7
	Nearshore	5	20	50	20	5	2	8.2
	Offshore	ï	ï	ï	ï	ï	ï	2.0

NOTES:

¹ Substrate size ranges include boulders (>256 mm), cobble (64 ï 256 mm), gravel (2 ï 64 mm) and fines (< 2 mm)

² Slope values are averages, estimated from bathymetric profiles of Figure 4-1

Nearshore macrophyte coverage was sparse across all sampling areas, ranging from 2 to 5%, and was greatest at the R1 sampling area (Table 4-2). Macrophytes in the intertidal zone were predominantly rockweeds (*Fucus* spp.) and occupied a small band (approximately 1 to 1.5 m wide) at the low intertidal zone. Kelp (*Laminaria* spp.) was present in the subtidal zone of R2.

Incidental invertebrate species observed during the study included amphipods, barnacles, unidentified bivalves (e.g., mussels, clams), winkles (*Littorina sitkana*), ascidians (sea squirts), and unidentified crab species.

4.2 Water and Sediment Chemistry

4.2.1 Water Chemistry

Total alkalinity was similar across all three sampling locations (142 ï 144 mg/L) with bicarbonate (HCO₃⁻) being the primary ion (174 ï 175 mg/L; across all sampling areas versus less than detection carbonate and hydroxide ions) (Table B2 in Appendix B). Nutrients, including nitrate and nitrite, total

Kjeldahl nitrogen, and total phosphorus, were below detection across all three sampling areas, while total organic carbon (3.3 – 4.8 mg/L) and total ammonia (0.023 – 0.028 mg/L) were low (Table B2 in Appendix B). Carbon and nitrogen values are expected to fluctuate seasonally with phytoplankton growth and senescence (e.g., Tamelander *et al.* 2009) and thus additional sampling would further the understanding of seasonal baseline nutrient conditions.

Approximately 78% of all analyzed metals (33 of 42) were reported as below detection levels across the sample stations. There were no CCME PMAL exceedances for any of the analyzed parameters (Table B2 in Appendix B).

4.2.2 Sediment Chemistry

Sediment chemistry was relatively constant across the study area. The sediment has relatively high total phosphorus content with concentrations (mean $\pm$ SD) ranging from 775 $\pm$ 28.15 mg/kg at I1 to 850 $\pm$ 36.86 mg/kg at R1. This was generally associated with low nitrogen and carbon values (Table B3 in Appendix B). Average (mean $\pm$ SD) total Kjeldahl nitrogen ranged from 0.12 $\pm$ 0.02 mg/kg at R1 to 0.15 $\pm$ 0.04 mg/kg at R2 while total organic carbon comprised the greatest proportion of total carbon; average (mean $\pm$ SD) total organic carbon ranged from 0.68 $\pm$ 0.08 mg/kg at R1 to 0.99 $\pm$ 0.33 mg/kg at R2 (Table B3 in Appendix B).

Metal concentrations were variable and range from below analytical detection to higher than CCME ISQGs for two metals. Chromium slightly exceeded the CCME ISQG of 52.3 mg/kg for this element at all sample stations with average ($\pm$ SD) concentrations ranging from 55.8 $\pm$ 5.89 mg/kg at I1 to 60.2 $\pm$ 6.12 mg/kg at R2 (Table B3 in Appendix B).

The precision analyses (CV) indicate some heterogeneity of marine sediments in the study area. Sediments are generally patchy, therefore some heterogeneity is expected. The number of sampling sites is assumed to account for the majority of variability.

4.3 Aquatic Organisms

4.3.1 Phytoplankton

Phytoplankton abundance, richness and diversity were comparable among the three sampling areas. Phytoplankton abundance and richness were lowest at R1 (20.68 cells/mL and 26 taxa) and highest at I1 (25.62 cells/mL and 28 taxa) (Table 4-3); a total of 33 taxa were reported across the three sampling areas (Table C1 in Appendix C).

Diversity values were similar across all three sampling areas and indicate a diverse phytoplankton community (Table 4-3). However dinoflagellates (*Pyrrophyta*) were the predominant phytoplankton taxa at all sampling areas and comprised the greatest proportion of all taxa (Table 4-3). Ciliates (*Ciliophora*) were also present at greater proportions than other taxa though at only two sampling areas (R1 and R2) (Table 4-3). Other taxon groups present (less than 5% per taxon) included diatoms (*Bacillariophyceae*), green algae (*Chlorophyta*), cryptophytes (*Cryptophyta*) and blue-green algae (*Cyanophyta*). The dominant dinoflagellate taxa were consistent between the three sampling areas

and were comprised of *Peridinium/Gonyaulax* spp. and *Dinophysis* spp. (Table C1 in Appendix C). The ciliate *Tintinnida* was present at R1 and R2 only.

Table 4-3: Phytoplankton Abundance, Richness, Diversity and Predominant Taxa across Sampling Areas in Melvin Bay

Sampling Area	Abundance (cells/mL)	Richness	Diversity	Taxa
Project Footprint (I1)	25.62	28	0.89	Dinoflagellates (72%)
Reference 1 (R1)	20.68	26	0.89	Dinoflagellates (64%) Ciliates (9%)
Reference 2 (R2)	24.68	27	0.85	Dinoflagellates (59%) Ciliates (8%)

4.3.2 Zooplankton

Zooplankton abundance ranged from 190,105 organisms/m³ at R1 to 219,273 organisms/m³ at I1 in August 2011 (Table 4-4 and Table C2 in Appendix C). Zooplankton diversity was highest at R1 (0.38) and lowest at R2 (0.15) while richness was the same at I1 and R1 (35 taxa); a total of 44 taxa were reported from the three sampling areas (Table 4-4 and Table C2 in Appendix C).

The three sampling areas exhibited similar but low diversity index values, implying low zooplankton diversity. The predominant taxa was an unidentified species of rotifer, possibly *Notommatidae*, which comprised 77 to 92% of the zooplankton community across the study area (Table 4-4). Calanoid copepods were the second most abundant group at all three sampling areas. Together with the rotifers, the two taxa comprised the majority of the zooplankton community.

Table 4-4: Zooplankton Abundance, Richness Diversity and Predominant Taxa across Sampling Areas in Melvin Bay

Sampling Area	Abundance (organisms/m ³)	Richness	Diversity	Taxa
Project Footprint (I1)	219,273	35	0.27	Rotifers (92%) Copepods (6%)
Reference 1 (R1)	190,105	35	0.38	Rotifers (77%) Copepods (17%)
Reference 2 (R2)	201,803	24	0.15	Rotifers (85%) Copepods (8%)

4.3.3 Benthic Invertebrates

Benthic invertebrate data are summarized in Table 4-5. Summary statistics and data for benthic invertebrates are provided Appendix C in Table C3 and Table C4, respectively. Benthic taxon richness and mean abundance were greatest at the R2 sampling area while mean abundance was lowest at R1 and richness lowest at I1. Due to difficulties sieving one sample at I1, a large range in

abundance was reported from the I1 stations and resulted in a median level of mean abundance at I1. Sampling areas I1 and R2 exhibited a median level of diversity while R1 showed a relatively high level of diversity. The R1 sampling area also exhibited a slightly more heterogeneous benthic community than I1 or R2, as it showed the highest evenness value, however evenness was low across all three sampling areas and implies a relatively homogenous benthic community across the study area.

Table 4-5: Benthic Invertebrate Abundance, Richness, Diversity, Evenness and Predominant Taxa across Sampling Areas in Melvin Bay

Sampling Area	Abundance (Mean [Range]; organisms/m ²)	Richness	Diversity	Evenness	Taxa
Project Footprint (I1)	12,564 (180 ÷ 20,227)	36	0.60	0.07	Polychaeta Sedentaria (66%): ▪ Capitellidae (61%) ▪ Cirratulidae (5%) Polychaeta Errantia (18%): ▪ Syllidae (7%) ▪ Nephtyidae (6%) ▪ Pholoidae (5%)
Reference 1 (R1)	8,632 (8,079 ÷ 9,161)	42	0.85	0.16	Polychaeta Sedentaria (47%): ▪ Capitellidae (19%) ▪ Paraonidae (17%) ▪ Cirratulidae (11%) Polychaeta Errantia (25%): ▪ Nephtyidae (25%)
Reference 2 (R2)	16,305 (13,107 ÷ 18,539)	51	0.68	0.06	Polychaeta Sedentaria (54%): ▪ Capitellidae (54%) Polychaeta Errantia (17%): ▪ Syllidae (11%) ▪ Pholoidae (6%)

Polychaetes were the dominant taxa at all sampling areas in Melvin Bay in August 2011. *Polychaeta Sedentaria* (informal classification), burrowing or tube-dwelling marine worms, were the dominant polychaete type at all sampling areas. In total, *Polychaeta Sedentaria* comprised 47 to 66% of the benthic community with *Capitellidae* as the dominant taxon; *Cirratulidae* and/or *Paraonidae* were also present. *Polychaeta Errantia*, free-swimming marine worms, was the secondary polychaete type at all sampling areas, comprising a total 17 to 25% of the benthic community, with *Nephtyidae*, *Syllidae* and *Pholoidae* being the primary taxa.

Lower density but widespread taxa include the nematode subclass *Hoplonemertea*, the *Myidae* and *Tellinidae* clams, the amphipod families of *Ischyroceridae*, *Oedicerotidae* and *Zopfiaceae*, and 11 additional polychaete families (see Tables C3 and C4 in Appendix C). These taxa were reported from all three sampling areas but at densities less than 5% per taxa (typically less than 2% per taxa). Conversely, the following were identified from only one sampling area: a single sponge (*Porifera*),

two hydrozoan taxa, one flatworm (*Planhelminthes*), *Terebellidae* and *Opheliidae* polychaetes, three gastropod and three bivalve taxa, several crustaceans including two copepod, seven amphipod and one decapod taxa, and one sea squirt (*Urochordata*). These uncommon taxa were primarily reported at densities less than 1% (see Tables C3 and C4 in Appendix C).

4.4 Fisheries Assessment

4.4.1 Fish Catch Composition

A total of 156 fish, representing six species, were caught in 13 gillnet sets made within the three sampling areas (Table 4-6). The numerically dominant fish species were Greenland cod (*Gadus ogac*) comprising 52% of species caught, followed by slender eelblenny (*Lumpenus fabricii*) (27%) and fourhorn sculpin (*Trigloporus quadricornis*) (15%). Less commonly caught species were unidentified sculpin (possibly juvenile; 3%), Arctic staghorn sculpin (*Gymnocanthus tricuspis*) (2%) and Arctic sculpin (*Myoxocephalus scorpioides*) (1%). The range of total lengths for the three dominant fish taxa were 118 to 520 mm for Greenland cod, 180 to 310 mm for slender eelblenny and 205 to 315 mm for fourhorn sculpin species (Table 4-6).

Table 4-6: Species and Length Composition of Fish Caught in Gillnets at Melvin Bay

Fish Species		Species Composition (% of total catch)	Length Composition (Mean [Range]; mm)	Weight Composition (Mean [Range]; g)	Fulton's Condition Factor (K) (Mean [Range]; K)
English Common Name	Scientific Name				
Arctic sculpin	<i>Myoxocephalus scorpioides</i>	1%	299 (242 - 370)	353 (149 - 700)	1.16 (1.09 - 1.38)
Arctic staghorn sculpin	<i>Gymnocanthus tricuspis</i>	2%	190 (145 - 215)	89 (34 - 122)	1.18 (1.11 - 1.22)
Fourhorn sculpin	<i>Trigloporus quadricornis</i>	15%	260 (205 - 315)	174 (84 - 274)	0.96 (0.69 - 1.07)
Greenland cod	<i>Gadus ogac</i>	52%	336 (118 - 520)	437 (15 - 1450)	0.97 (0.78 - 1.26)
Sculpin unidentified	<i>Cottidae</i> unid.	3%	117 (110 - 120)	14 (9 - 19)	0.84 (0.61 - 1.17)
Slender eelblenny	<i>Lumpenus fabricii</i>	27%	246 (180 - 310)	46 (22 - 200)	0.33 (0.16 - 1.14)
Total Count		156 fish	-	-	

Arctic char were not captured during Nunami's baseline study. At the time of Nunami's study, Arctic char were reported to be in the marine environment though located to the west of Melvin Bay, on the west and east sides of the Barrier Islands (approximately 7 km west of Melvin Bay) (R. Mercer, *pers.comm.*).

4.4.2 Rates of Fish Capture and Species Richness

Averaged catch per unit effort (CPUE) ($\bar{N} \pm SD$) across the three sampling areas, fish species richness was 2.7 ± 0.8 species per set, total fish catch rate was 3.6 ± 1.2 fish per gillnet hour, and Greenland cod catch was 1.9 ± 1.2 cod per gillnet hour (Table D1 in Appendix D).

There were no statistically significant differences in catch rates or species richness among the sampling areas ($P \geq 0.32$) or between nearshore and offshore sets ($P \geq 0.39$) (Table 4-7 and Figures 4-2 to 4-4). An interaction was detected between sampling area and nearshore/offshore sets for total catch rates ($F_{2,7} = 4.313$, $P = 0.039$) and, following posthoc testing, was attributed to a statistically different mean catch rate between the nearshore and offshore areas at the R1 sampling area (Figure 4-3). There were no significant differences in catch rates or species richness between ebb and flood tides ($P \geq 0.08$).

Table 4-7: Probability Values Associated with the Statistical Analysis (ANOVA) of Factors Affecting Fish Species Richness and Catch Rates

Parameter	Probability Values	
	Area (Impact/Reference)	Distance (Nearshore/Offshore)
Total catch rate	0.32	0.39
Greenland cod catch rate	0.86	0.80
Species richness	0.50	0.40

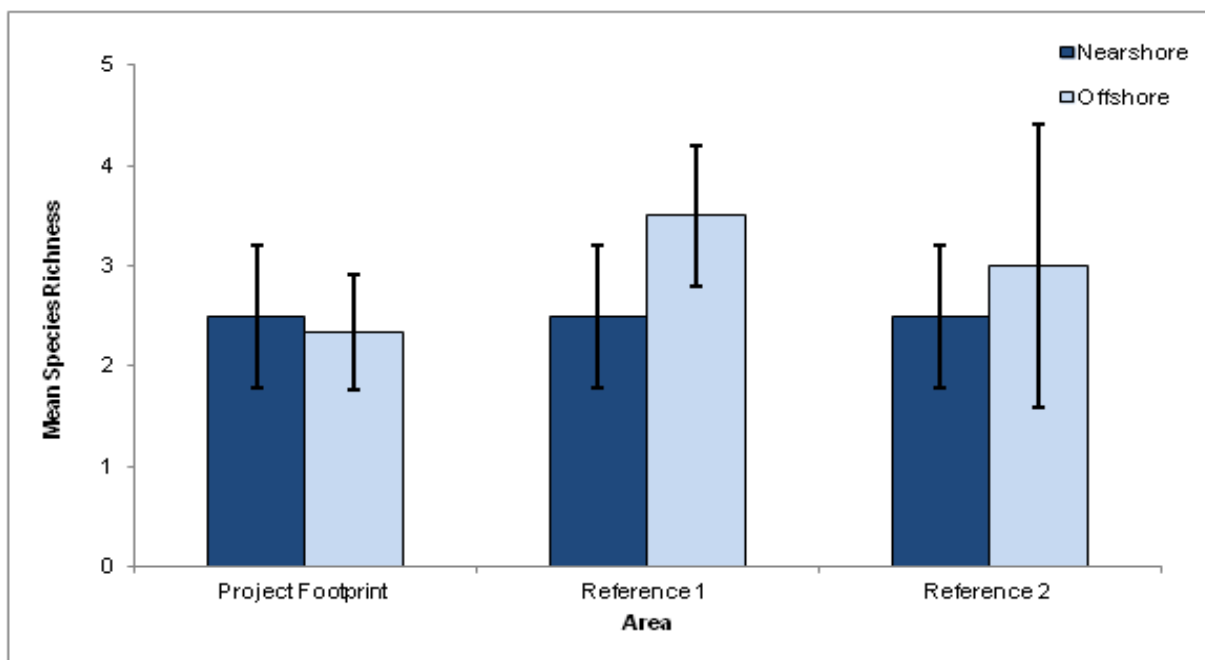


Figure 4-2: Mean ($\bar{N} \pm SD$) Nearshore and Offshore Species Richness in Each Sampling Area from Daytime Sinking Gillnets

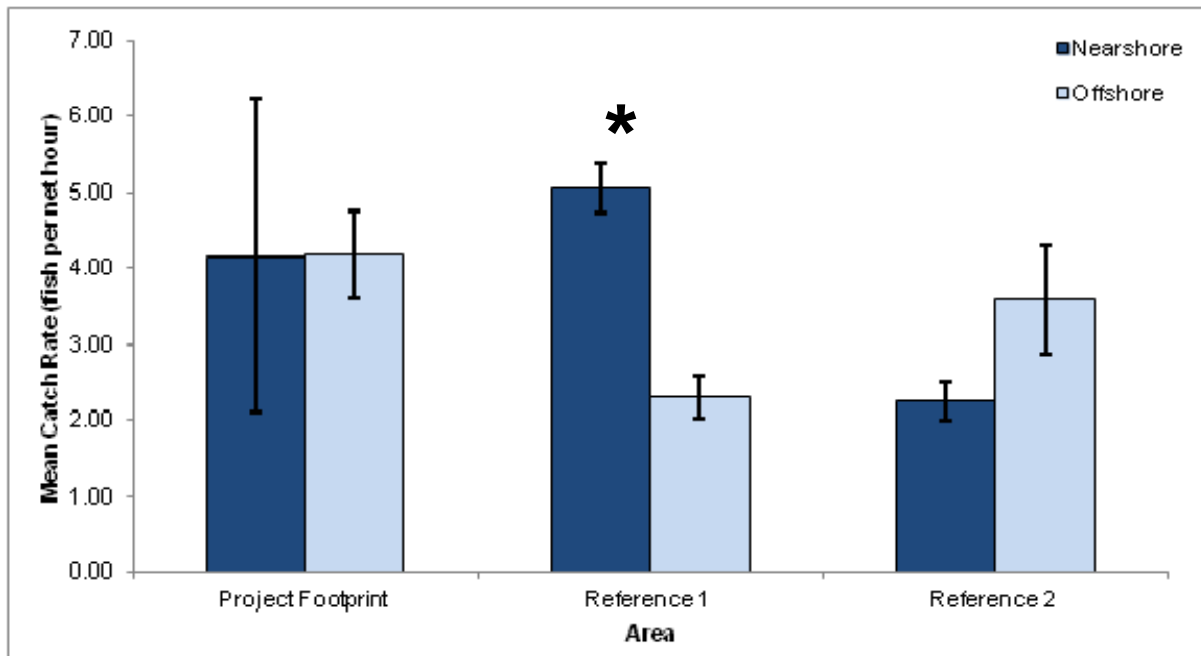


Figure 4-3: Mean (±SD) Nearshore and Offshore Catch Rates for Total Fish in each Sampling Area from Daytime Sinking Gillnets (* defines significant interaction between sampling area and nearshore/offshore)

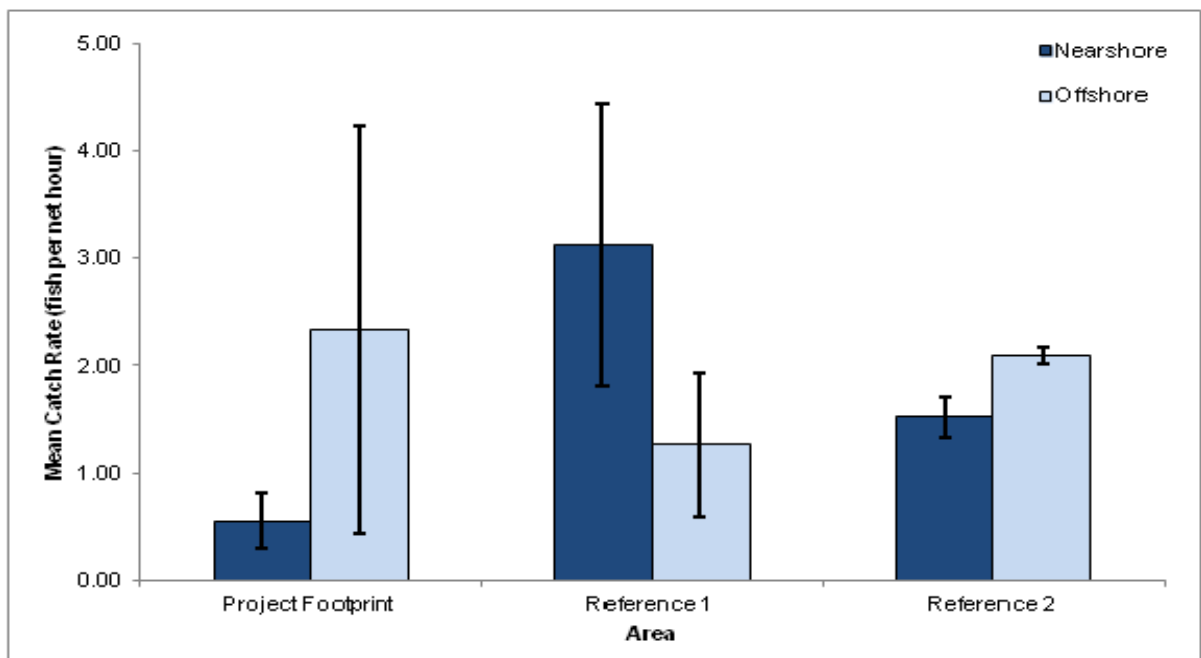


Figure 4-4: Mean (±SD) Nearshore and Offshore Catch Rates for Greenland Cod in each Sampling Area from Daytime Sinking Gillnets

As depicted in Figure 4-2, mean species richness was similar across the study area and within sampling areas. Mean ($\pm$ SD) species richness ranged from 2.4 $\pm$ 0.5 species at the Project footprint (I1) to 3.0 $\pm$ 0.8 species at the R1 sampling area and the largest within-area difference was observed at the R1 sampling area (2.5 $\pm$ 0.7 species in the nearshore and 3.5 $\pm$ 0.7 species in the offshore) (Figure 4-2).

Across the study area, catch rates were generally low with minor variability between and within sampling areas (Figure 4-3). For example, within the individual sampling areas, the range of catch rates was only 1.3 to 1.4 times the sampling area's mean catch rate and only 1.1 to 1.5 times the study area's total mean catch rate of 3.6 $\pm$ 1.2. The R1 sampling area had the largest difference in mean catch rate between nearshore and offshore sites and showed statistically different mean values (Figure 4-3). Total mean catch rates by area ranged from 2.91 $\pm$ 0.88 to 4.17 $\pm$ 1.11 fish per gill net hour.

Mean Greenland cod catch rates were more variable than total catch rates at the Project footprint (I1) and R1 sampling areas and differed most within R1 sampling area (3.12 $\pm$ 1.32 cod per gill net hour in the nearshore and 1.27 $\pm$ 0.67 cod per gill net hour in the offshore) (Figure 4-4). Greenland cod catch rates by area ranged from 1.63 $\pm$ 1.66 to 2.19 $\pm$ 1.37 cod per gill net hour.

4.4.3 Stock Characteristics

Fulton's condition factor (K) was calculated for Greenland cod length-weight data. Data were divided into 25 mm length classes to provide a better indication of population range and "well-being". The length classes of captured Greenland cod ranged from 100 – 124 mm to 500 – 524 mm. The average ($\pm$ SD) condition, an indicator of weight per length, was 0.99 $\pm$ 0.13 for all captured Greenland cod (Figure 4-5).

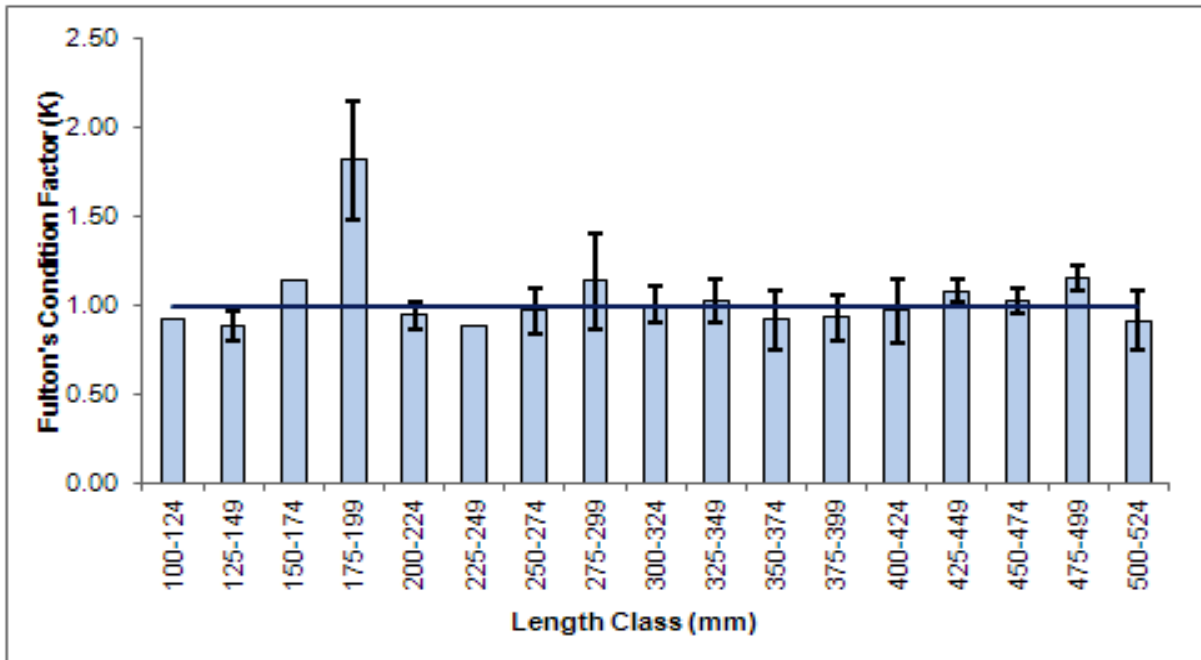


Figure 4-5: Mean (±SD) Fulton's Condition Factor (K) for Length Classes of Greenland Cod Captured in Melvin Bay (dark blue line indicates total mean condition factor)

A length class frequency figure shows generally three age classes (100 – 274; 275 – 424; 425 – 525) (Figure 4-6). The oldest age class is absent given the Greenland cod grows to approximately 80 cm.

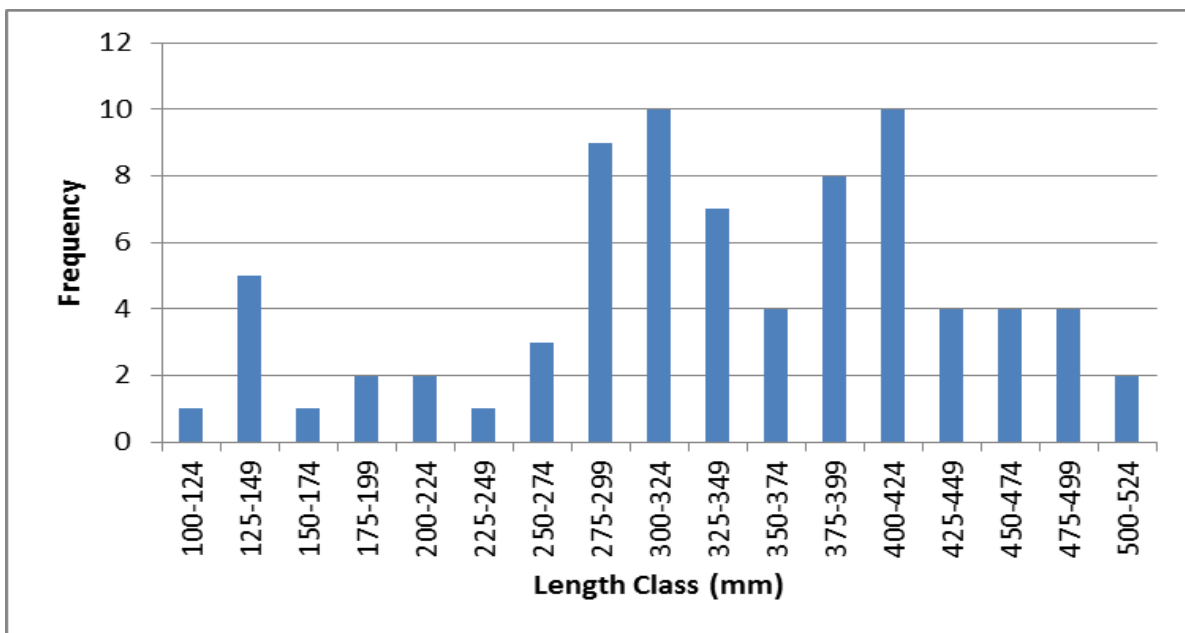


Figure 4-6: Frequency of Length Classes of Greenland Cod Captured in Melvin Bay

4.5 Marine Mammals and Birds

4.5.1 Observed Species

No marine mammals were observed during the baseline survey. A black guillemot and a pair of sandhill cranes were observed anecdotally.

4.5.2 Literature Review

4.5.2.1 Marine Mammals

Review of available information suggests that seven marine mammal species typically occur along the west coast of Hudson Bay. Detailed baseline information will focus on the beluga whale, ringed seal, and polar bear due to their importance to the community, regulators and their potential occurrence in the study area. Ringed seal and beluga whale are the most commonly harvested marine mammal species in Nunavut (Priest and Usher 2004).

Marine mammals can be divided into two distinct taxonomic groups: the cetaceans (toothed whales and baleen whales) and the pinnipeds (seals). Polar bears are included for consideration as a marine mammal because they depend on the marine environment for survival. The conservation status of the seven species that occur along the west coast of Hudson Bay is summarized in Table 4-5. Conservation status is summarized according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status.

Table 4-8: Marine Mammal Occurrence and Conservation Status along the West Coast of Hudson Bay

Common Name	Species Name	COSEWIC Status
Beluga whale (Western Hudson Bay population)	<i>Delphinapterus leucas</i>	Special Concern
Ringed seal	<i>Phoca hispida</i>	Not at risk
Polar bear (Western Hudson Bay population)	<i>Ursus maritimus</i>	Special Concern
Bowhead whale (Eastern Canada population)	<i>Balaena mysticetus</i>	Special Concern
Bearded seal	<i>Erignathus barbatus</i>	Data Deficient
Harp seal	<i>Phoca groenlandica</i>	Not Listed
Walrus	<i>Odobenus rosmarus</i>	Special Concern
Narwhal	<i>Monodon monoceros</i>	Special Concern
Killer whale	<i>Orcinus orca</i>	Special Concern

NOTE:

Source: Government of Canada 2011

None of the species assessed by COSEWIC are listed under the Federal *Species at Risk Act* (SARA) either because they have not been assessed under SARA or it was reviewed and decided

not to list the species. The current status of review based on the Species at Risk Public Registry was last updated in June 2010 and is summarized below.

- **Beluga Whale** The Western Hudson Bay population of beluga whale was submitted to the Minister of the Environment by COSEWIC in 2005. The decision in 2006 was to not list under SARA at that time due to the pending harmonization process between the Nunavut Land Claims Agreement and SARA and pending consultations with the Nunavik Marine Region Wildlife Board (Government of Canada 2006a).
- **Bowhead Whale** COSEWIC designated the Eastern Canada-Western Greenland population of bowhead whales as Special Concern in 2009. Consultations on whether to list this population on Schedule 1 of SARA are ongoing between the Federal government and the governments of Quebec, Newfoundland and Labrador and Nunavut, the Nunavik Marine Region Wildlife Board and the Nunavut Wildlife Management Board, Aboriginal peoples, stakeholders, and the public (Government of Canada 2009).
- **Narwhal** Extended consultations regarding listing the narwhal are ongoing since COSEWIC submitted its recommendation to the Minister of the Environment in 2005. Final determination is pending consultations between the Minister of Fisheries and Oceans and the governments of Quebec, Newfoundland and Labrador and Nunavut, the Nunavut Wildlife Management Board and the Hunting, Fishing and Trapping Coordinating Committee, Aboriginal peoples, stakeholders and the public (Government of Canada 2005).
- **Polar Bear** The polar bear was re-submitted by COSEWIC to the Minister of the Environment in 2008. Consultations are ongoing with the governments of Manitoba, Ontario, Quebec, Newfoundland and Labrador, Yukon, Northwest Territories and Nunavut, the Yukon Fish and Wildlife Management Board, the Gwich'in Renewable Resources Board, the Wildlife Management Advisory Council-Northwest Territories, the Nunavut Wildlife Management Board, the Hunting, Fishing and Trapping Coordinating Committee, the Wildlife Management Advisory Council-North Slope and Torngat Wildlife and Plants Co-Management Board, Aboriginal peoples, stakeholders, and the public (Government of Canada 2008). No updated decision to list or not has been issued.
- **Atlantic Walrus** The Atlantic walrus was submitted following extended consultations by COSEWIC to the Minister of the Environment in 2006. Final decision is pending consultations with the governments of Manitoba, Ontario, Quebec, Newfoundland and Labrador, New Brunswick, Nova Scotia, Prince Edward Island and Nunavut, Aboriginal peoples, stakeholders, and the public (Government of Canada 2006b).

Marine Mammal Focal Species Information

Beluga Whale

In Canada, the beluga whale is divided into seven populations based on summer distribution and genetic differences (COSEWIC 2004). The whales that occur in or near the study area belong to the Western Hudson Bay population. The most recent population estimate for the western Hudson Bay population of beluga whales was estimated at approximately 57,300 animals (Richard 2005).

Biological Information specific to the species use of the Rankin Inlet area (and western Hudson Bay) by beluga whales is limited.

In the summer, western Hudson Bay belugas concentrate in the Churchill, Nelson and Seal River estuaries (Richard *et al.* 1990). Belugas initially arrive in these estuaries after spring ice breakup in mid- to late June and increase in abundance until late July. They tend to spend the summer in shallow coastal waters along western Hudson Bay (Martin *et al.* 2001). Migration is believed to begin northward along the coast of Hudson Bay during late August or early September (COSEWIC 2004). Satellite tag data suggest the population moves towards wintering habitat in Hudson Strait; however, the routes taken by belugas between summering and wintering habitats are not well known.

Beluga whales are an important cultural and ecological species in Nunavut and are hunted by many communities (20 out of 28) (DFO 2000; Priest and Usher 2004). Beluga are typically hunted along the western coast in the summer and are harvested up to 35 km offshore (Riewe 1992). Over the five-year period from 1996 to 2001, the total annual mean number of belugas taken through hunting was approximately 1,339 for all of Nunavut, while annual rates of belugas harvested from the community of Rankin Inlet ranged from 22 in 1998/99 to 116 in 1999/00 (Priest and Usher 2004). Inuit knowledge suggests that belugas are easier to hunt than other marine mammals because they are naïve of humans and are often approached without fleeing (Richard 2001).

Polar Bear

In Canada, polar bears are divided into 13 sub-populations. One sub-population has the potential to occur in the study area; the Western Hudson Bay sub-population. The most recent estimate of the Western Hudson Bay sub-population indicates that overall abundance has declined from approximately 1,294 in 1987 to 935 in 2004, a decline of 22% (Regehr *et al.* 2007).

In contrast to COSEWIC's determination that the western Hudson Bay population of polar bears is declining, Inuit Qaujimagatuqangit (IQ) from Inuit elders concerning the population of polar bears suggests the numbers of bears are increasing (COSEWIC 2008). They report numerous polar bear dens and polar bears observed along the western coast. Results from a compilation of interviews along the western coast by the Nunavut Tunngavik Incorporated (NTI) indicate an increasing number of bears around Rankin Inlet since the 1980s (NTI 2005). Due to the discrepancy between scientific literature and IQ, the Government of Nunavut conducted a mark-recapture survey in 2007 on the bears that range from Churchill to Chesterfield Inlet (Peacock and Taylor 2007). Results of their survey do not conflict with the population estimate as determined by Regehr *et al.* (2007).

Distribution of polar bears is closely correlated with the distribution of ringed seal, which is their principal prey (Stirling and Øritsland 1995). The ringed seal, in turn, is strongly associated with ice distribution. The bears hunt the seals through their breathing holes in the ice, in birth lairs, or when they are hauled out on the ice (Smith 1980). Polar bears spend several months of the open-water season along the western coast of Hudson Bay from Southampton Island to Churchill (COSEWIC 2008). During this time, the Western Hudson Bay sub-population tends to congregate on coastal capes and headlands between Cape Churchill and Arviat (Stirling *et al.* 1999). In the fall, there is a gradual northward movement of the polar bears along the south coast of Hudson Bay, as they gather

to await the formation of new sea ice in November (Amstrup *et al.* 2007). Some bears tagged in the Churchill region moved northward along the Kivalliq Coast as far as Chesterfield Inlet (Stirling *et al.* 1999). The winter and summer concentration of polar bears is situated around Arviat, just under 200 km south of Rankin Inlet (Taylor *et al.* 2001; Van de Velde *et al.* 2003; Stephenson and Hartwig, 2010).

Primary limiting factors and threats to the polar bear that were identified by COSEWIC focus on starvation (from lack of accessibility to principal prey), human-caused mortality (hunting), and intraspecific predation. The number of polar bears hunted from Rankin Inlet from 1996 to 2001 ranged from 1 to 13 bears (Priest and Usher 2004). Several potential threats were identified including contamination, accumulation of environmental contaminants, increased vessel traffic, and climate change (COSEWIC 2008). Climate change is of particular concern to the western Hudson Bay population because they are land bound during the summer. Average sea-ice break-up has occurred earlier over the past 30 years (Stirling *et al.* 1999; Ferguson *et al.* 2005). Earlier sea-ice break-up is correlated with poor condition of adult females (Stirling *et al.* 1999).

Ringed Seal

The ringed seal is the most common and abundant species of seal in Hudson Bay, where it is resident year-round (Stewart and Lockhart 2005). Estimates of ringed seal populations are based mainly on aerial surveys conducted during the peak haulout and moulting period from late May to early July. Smith (1975) conducted an aerial survey of Hudson Bay between Churchill and Chesterfield Inlet, and estimated that there were 455,000 ringed seals in Hudson Bay. More recently, aerial systematic strip transect surveys extending from the Nelson River estuary to Rankin Inlet estimated 38,340 ringed seals in 1994 and 140,880 in 1995 (Lunn *et al.* 1997). These estimates are likely conservative because they are based on the number of seals hauled out on the ice and were not corrected for seals that were submerged. The total population of the area may be twice as large when submerged seals are taken into consideration (Stirling and Irlsland 1995).

In spring, breeding and non-breeding adults utilize distinct habitat. High densities of breeding adults occur on stable, landfast ice in areas with good snow cover, whereas non-breeders tend to be found at the floe edge or in the moving pack ice (Stewart and Lockhart 2005). Their ability to maintain breathing holes in ice enables them to occupy areas of Nunavut that are inaccessible to other marine mammals during the colder, ice-covered seasons.

The number of ringed seals hunted in Rankin Inlet varies widely, from 55 to 356 animals over a five year period (Priest and Usher 2004).

4.5.2.2 Marine Birds

Important Bird Areas (IBA) have been defined in Canada as an initiative between Bird Studies Canada, Nature Canada and BirdLife International to support the international conservation of discrete sites that support threatened birds, large groups of birds, and birds restricted by range or by habitat. The nearest IBA to Rankin Inlet is McConnell River IBA near Arviat, less than 200 km south along the coastline. The McConnell River Migratory Bird Sanctuary is one of five in Nunavut created to protect important habitats for bird species. Further to IBAs, the Canadian Wildlife Service (CWS)

has identified key migratory bird marine and terrestrial habitats which are essential to the welfare of various migratory bird species in Canada. The CWS established 16 bird sanctuaries in Canada to control and manage areas of importance for the protection of migratory birds, their nests and eggs. None of the identified key habitat or sanctuaries are in the vicinity of Rankin Inlet.

Interviews with the elders of Rankin Inlet noted a perceived decrease in guillemots, Arctic terns, and sand pipers (Kangiqliniq HTO 2011). The HTO also voiced concern regarding the birds on Panorama Island in Itivia Harbour; students have been studying the Peregrine falcon and rough-legged hawk there for the last 20 to 25 years (Kangiqliniq HTO 2011). Recorded birds harvested in Rankin Inlet include snow goose, Canada goose, ptarmigan, and the occasional eider duck (Priest and Usher 2004).

Most marine birds that occur in the vicinity of Rankin Inlet are summer residents; a few such as the black guillemot and snowy owl occur year-round (Sibley 2003). The summer migrants pass through the Kivalliq region for staging, moulting, nesting, and brooding (Canadian Circumpolar Institute 1992). A list of marine birds that occur in the vicinity of Rankin Inlet and their status is summarized in Table 4-9. No marine bird species that occur near Rankin Inlet are listed under the *Species at Risk Act*. Due to their presence, community concern, and conservation status, more detailed information on the black guillemot and Peregrine falcon are provided following the summary table.

Table 4-9: Marine Bird Occurrence and Conservation Status near Rankin Inlet

Common Name	Occurrence	COSEWIC Status
Black guillemot	Year-round	Not Assessed
Snowy owl	Year-round	Not at Risk
Loons: Pacific, Red-throated; Common	Summer	Not Assessed Not at Risk
Long-tailed duck	Summer	Not Assessed
Eiders: King and common	Summer	Not Assessed
Red-breasted merganser	Summer	Not Assessed
Sandhill crane	Summer	Not at Risk
Plovers: American golden and Semipalmated	Summer	Not Assessed
Dunlin	Summer	Not Assessed
Sandpipers: Semipalmated, Least, Pectoral	Summer	Not Assessed
Phalaropes: Red-necked, Red	Summer	Not Assessed
Jaegers: Parasitic, Long-tailed	Summer	Not Assessed
Herring gull	Summer	Not Assessed
Arctic tern	Summer	Not Assessed
Peregrine falcon	Summer	Special Concern
Brant	Migration	Not Assessed
Black scoter	Migration	Not Assessed

Common Name	Occurrence	COSEWIC Status
Black-bellied plover	Migration	Not Assessed
Sandpipers: White-rumped and Baird's	Migration	Not Assessed
Pomarine Jaeger	Migration	Not Assessed
Gulls: Sabine's, Thayer's and Glaucous	Migration	Not Assessed
Ruddy turnstone	Rare	Not Assessed
Sanderling	Rare	Not Assessed
Red knot, <i>rufa</i> subspecies <i>islandica</i> subspecies	Rare	Endangered Special Concern
Black-legged kittiwake	Rare	Not Assessed

NOTE:

Source: Sibley 2003; Government of Canada 2011

Marine Bird Focal Species Information

Black Guillemot

The Black guillemot occurs in Rankin Inlet year-round, never far from land (Sibley 2003). It has not been assessed by COSEWIC but the International Union for the Conservation of Nature (IUCN) has designated it as Least Concern globally. The reasons for the Least Concern designation are its large and apparently increasing population size, and extremely large range (BirdLife International 2009). They typically nest on cliffs of rocky shorelines or on the ground (Gauthier and Aubry 1996). Crustaceans are the primary prey followed by small fish which they capture by diving along the coast (DeGraff *et al.* 1985; Cairns 1992).

Peregrine Falcon

The Peregrine falcon (*Falco peregrinus tundris*) breeds near Rankin Inlet and has been studied by researchers from 1982 to 2009 (Franke *et al.* 2010). It breeds across northern Canada and winters south as far as northern Mexico (COSEWIC 2007). Its breeding habitat appears to be limited by sufficient food supply (White *et al.* 2002), but once a site is established the adults show a high degree of breeding site fidelity (COSEWIC 2007). If there is a stable food supply, the Peregrine falcon is extremely adaptable to different habitats and has increased their use of urban areas over the last few decades (Cade *et al.* 1996); they rarely experience enough disturbance from humans to cause breeding failure (COSEWIC 2007). It has been noted that birds in areas of Nunavut that are not accustomed to development could be more sensitive to human activity (Carriëre *et al.* 2003).

Historically, pollutants have caused major population damage to the Peregrine falcon; DDT (dichloro-diphenyl-trichloroethane) in particular (Cade *et al.* 1998). Although the species has recovered over the last few decades, research on breeding population near Rankin Inlet has shown declining occupancy of breeding territories and number of young to reach banding age annually, despite the declining trends in pesticide loads (Franke *et al.* 2010). Population size for this species and sub-species is difficult to determine, however there are likely several thousand birds nationally (COSEWIC 2007).

5 CLOSURE

Nunami Stantec Ltd. has prepared this report for the sole benefit of Agnico-Eagle Mines Ltd (AEM) for the purpose of documenting marine baseline conditions at Itivia Harbour and Melvin Bay. The report may not be relied upon by any other person or entity, other than for its intended purposes, without the express written consent of Nunami and AEM. Any use of this report by a third party, or any reliance on decisions made based upon it, are the responsibility of such third parties.

The information provided in this report was compiled from existing documents and data provided by AEM, and field data compiled by Nunami. This report represents the best professional judgment of our personnel available at the time of its preparation. Nunami reserves the right to modify the contents of this report, in whole or in part, to reflect any new information that becomes available. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

This report addressed marine aquatics and fisheries issues that are typically examined by regulators during environmental assessments under the Canadian *Environmental Assessment Act* and Article 12 of the Nunavut Land Claims Agreement, as well as issues specifically requested by regulatory agencies (e.g., Fisheries and Oceans Canada). Long term monitoring requirements were also considered during the design of this study so that an effective monitoring plan can be efficiently prepared for the proposed spud barge operation period.

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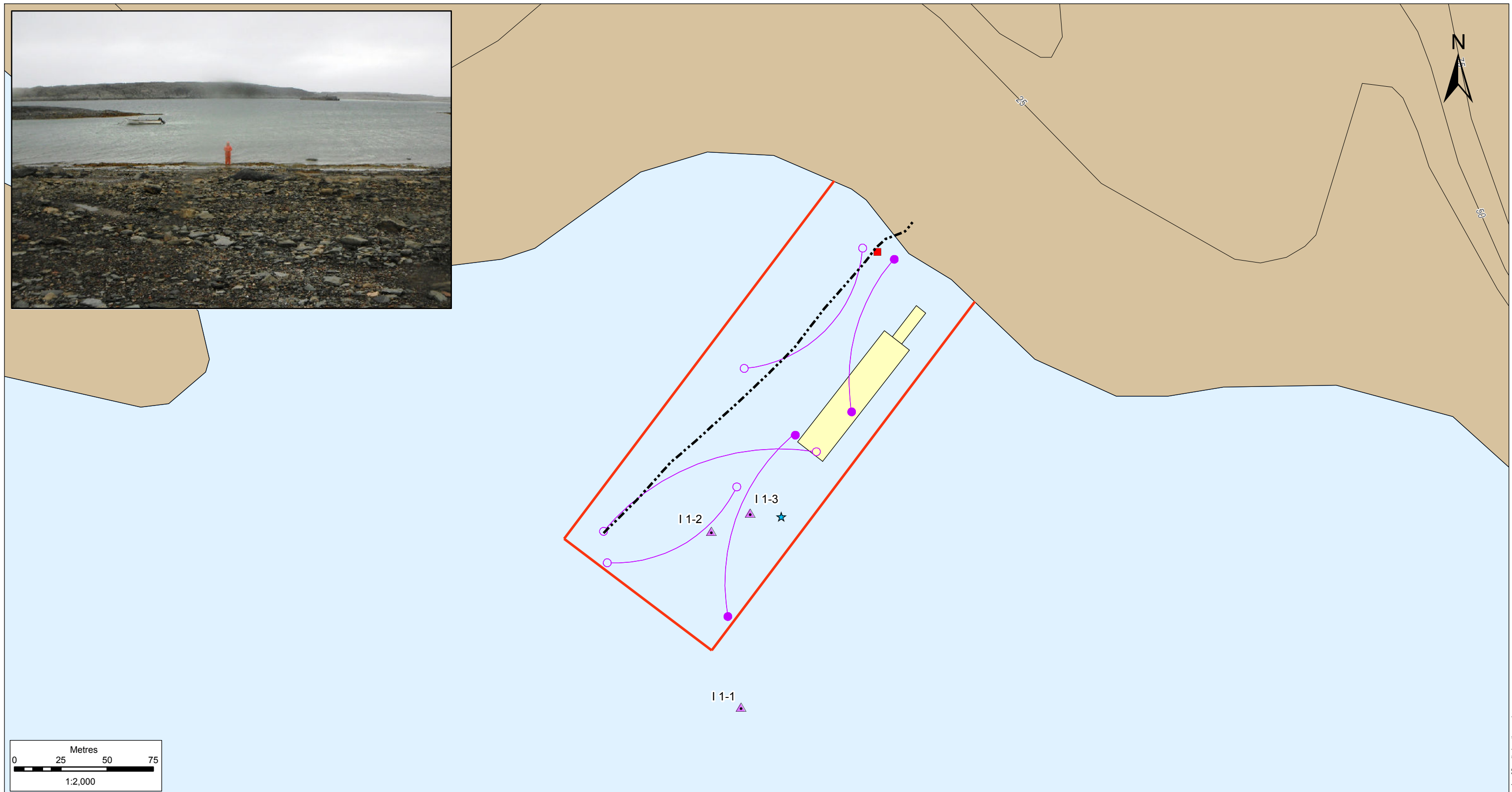
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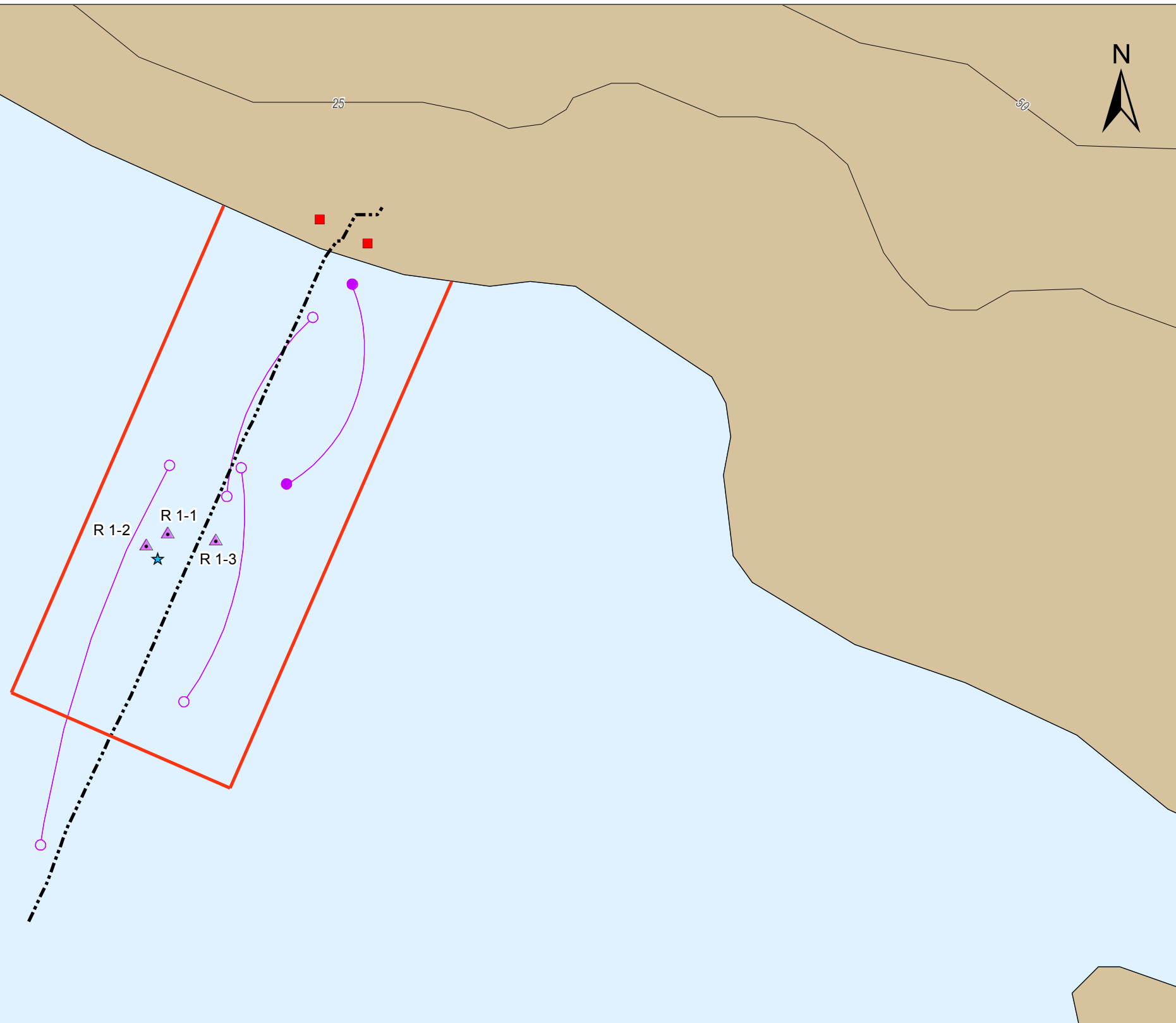
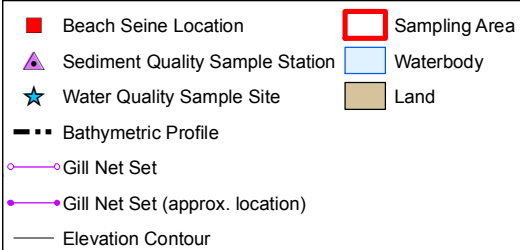
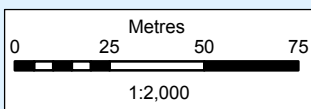
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APPENDIX A

Sampling Site Locations



	MARINE EFFECTS ASSESSMENT OF THE MELIADINE GOLD PROJECT - RANKIN INLET, NU PROJECT FOOTPRINT (IMPACT AREA) SAMPLING AREA AND SAMPLING LOCATIONS			PREPARED BY:  NUNAMI STANTEC
	Sources: <i>Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.</i>			PREPARED FOR: AGNICO-EAGLE MINES LTD.
	DATE: 16-NOV-11 FIGURE ID: 123510575	PROJECTION: UTM 15 DATUM: NAD 83	DRAWN BY: N. PUREWAL CHECKED BY: C. SIBBALD	FIGURE NO: A-1



MARINE EFFECTS ASSESSMENT OF THE MELIADINE GOLD PROJECT - RANKIN INLET, NU

REFERENCE AREA 1 SAMPLING AREA AND SAMPLING LOCATIONS

Sources:

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

DATE: 16-NOV-11
FIGURE ID: 123510575

PROJECTION: UTM 15
DATUM: NAD 83

DRAWN BY: N. PUREWAL
CHECKED BY: C. SIBBALD

PREPARED BY:



NUNAMI STANTEC

PREPARED FOR:

**AGNICO-EAGLE
MINES LTD.**

FIGURE NO:

A-2

APPENDIX B

Water and Sediment Chemistry Data

Table B1: Surface Water *In situ* Water Quality at Itivia Harbour (I1) and Reference Areas (R1 and R2)

Area	Date	Time	UTM (Zone 15V)		Tidal Current	Tide Level (m)	Total Depth (m)	Corrected Total Depth (m)	Depth (m)	Temperature (°C)	pH	Conductivity (εS/cm)	D.O. (%)	D.O. (mg/L)	ORP (mV)	Salinity (ppt)	Comments
			Easting	Northing													
I1	21-Aug-11	17:05	546209	6963411	Flood	1.53	4.75	3.22	1.0	8.63	8.10	45627	115.6	11.15	158.0	29.31	- Total depth with depth sounder was 5.2 m - Tide was flooding (5:05 pm) - Sampled WQ at 2.5 m - Secchi depth was 3.75 m - Zooplankton volume collected was 250 mL
									2.0	8.56	8.10	45647	115.6	11.17	157.6	29.31	
									3.0	8.52	8.10	45643	115.4	11.16	157.2	29.32	
									4.0	8.48	8.10	45669	115.4	11.18	157.0	29.33	
									4.5	8.47	8.10	45663	115.5	11.18	156.2	29.32	
R1	21-Aug-11	16:00	545284	6963806	Low Slack	1.30	13.3	12.00	1.0	8.50	8.08	45695	113.6	11.00	163.3	29.35	- Total depth with depth sounder was 13.4 m - Tide was low slack (4:00 pm) - Sampled WQ at 6.5 m - Secchi depth was 4.5 m - Zooplankton volume collected was 250 mL
									2.0	8.49	8.08	45664	114.4	11.07	162.7	29.32	
									3.0	8.49	8.08	45674	114.4	11.07	162.2	29.34	
									4.0	8.48	8.08	45685	114.5	11.07	161.9	29.34	
									5.0	8.49	8.08	45677	114.4	11.07	161.8	29.34	
									6.0	8.48	8.08	45671	114.3	11.06	161.5	29.33	
									7.0	8.43	8.08	45691	114.2	11.07	161.2	29.34	
									8.0	8.18	8.08	45742	114.0	11.11	161.4	29.36	
									9.0	8.13	8.08	45758	114.0	11.12	161.2	29.36	
									10.0	8.06	8.08	45763	113.9	11.13	161.1	29.36	
									11.0	7.99	8.07	45785	113.6	11.12	161.1	29.37	
									12.0	7.93	8.08	45796	113.5	11.12	161.1	29.37	
									13.0	7.93	8.07	45815	113.3	11.10	161.0	29.38	
R2	21-Aug-11	14:25	544709	6962663	Ebb	1.63	9.6	7.97	1.0	9.45	8.05	45521	114.3	10.84	191.3	29.29	- Total depth with depth sounder varied with waves between 8 to 11 m - Tide was ebbing (2:25 pm) - Sampled WQ at 5.0 m - Secchi depth was 3.6 m - Zooplankton volume collected was 300 mL
									2.0	9.44	8.06	45537	114.5	10.85	188.8	29.30	
									3.0	9.42	8.06	45532	114.3	10.84	187.0	29.30	
									4.0	9.43	8.05	45539	114.0	10.81	185.3	29.30	
									5.0	9.40	8.07	45545	113.8	10.79	184.0	29.30	
									6.0	9.39	8.07	45540	113.6	10.78	182.6	29.30	
									7.0	9.40	8.07	45541	113.5	10.77	181.8	29.30	
									8.0	9.31	8.07	45551	113.4	10.77	181.1	29.30	
									9.0	9.30	8.07	45545	113.7	10.83	179.8	29.30	
									10.0	9.07	8.07	45560	113.5	10.88	179.0	29.30	

Table B2: Baseline Marine Water Chemistry at Itivia Harbour and Reference Areas

Parameter	Units	D.L. ^a	CCME PMAL ^b	Itivia Harbour			Reference 1	Reference 2	Field Blank	Travel Blank
				I1	Replicate	RPD ^c	R1	R2		
Physicals										
Conductivity	Ωmhos/cm	20	-	>10,000	>10,000	-	>10,000	>10,000	<20	<20
Hardness (as CaCO ₃)	mg/L	8.6	-	6590	6420	2.6	6360	6400	<0.50	<0.50
pH	pH units	0.10	7.00 - 8.70	7.35	7.57	2.9	7.48	7.56	5.75	5.74
Total Suspended Solids	mg/L	5.0	-	6.0	6.0	-	10.0	<5.0	<5.0	<5.0
Total Dissolved Solids	mg/L	5.0	-	34300	33600	2.1	34200	34300	<5.0	<5.0
Turbidity	NTU	0.10	-	0.27	0.21	-	0.11	0.13	0.11	<0.10
Anions										
Alkalinity, Total (as CaCO ₃)	mg/L	20	-	142	144	1.4	143	143	<20	<20
Bicarbonate (HCO ₃)	mg/L	24	-	174	175	0.6	175	175	<24	<24
Carbonate (CO ₃)	mg/L	12	-	<12	<12	-	<12	<12	<12	<12
Chloride	mg/L	25	-	20000	16700	18.0	20100	20300	<0.50	<0.50
Fluoride	mg/L	1.0	-	<1.0	<1.0	-	1.2	<1.0	<0.020	<0.020
Hydroxide (OH)	mg/L	6.8	-	<6.8	<6.8	-	<6.8	<6.8	<6.8	<6.8
Sulfate	mg/L	25	-	2860	2360	19.2	2870	2890	<0.50	<0.50
Nutrients										
Ammonia, Total (as N)	mg/L	0.010	-	0.023	0.028	-	0.026	0.024	<0.010	<0.010
Nitrate-N	mg/L	2.5	3.6	<2.5	<2.5	-	<2.5	<2.5	<0.050	<0.050
Nitrite-N	mg/L	2.5	-	<2.5	<2.5	-	<2.5	<2.5	<0.050	<0.050
Total Kjeldahl Nitrogen	mg/L	0.20	-	<0.20	<2	-	<2	<2	<0.20	<0.20
Organic/Inorganic Carbon										
Total Organic Carbon	mg/L	1.0	-	4.8	3.3	-	3.6	3.3	<1.0	<1.0
Total Metals										
Aluminum (Al)-Total	mg/L	0.30	-	<0.30	<0.30	-	<0.30	<0.30	<0.0030	<0.0030
Antimony (Sb)-Total	mg/L	0.0010	-	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.000010	<0.000010
Arsenic (As)-Total	mg/L	0.0050	0.0125	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.000050	<0.000050
Barium (Ba)-Total	mg/L	0.010	-	<0.010	<0.010	-	<0.010	<0.010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.00050	-	<0.00050	<0.00050	-	<0.00050	<0.00050	<0.0000050	<0.0000050
Bismuth (Bi)-Total	mg/L	0.0050	-	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.000050	<0.000050
Boron (B)-Total	mg/L	0.50	-	4.49	4.88	8.3	4.79	4.66	0.0072	<0.0050
Cadmium (Cd)-Total	mg/L	0.00050	0.00012	<0.00050	<0.00050	-	<0.00050	<0.00050	<0.0000050	<0.0000050
Calcium (Ca)-Total	mg/L	1.0	-	411	401	2.5	399	402	<0.050	<0.050
Cesium (Cs)-Total	mg/L	0.00050	-	<0.00050	<0.00050	-	<0.00050	<0.00050	<0.0000050	<0.0000050
Chromium (Cr)-Total	mg/L	0.050	0.056	<0.050	<0.050	-	<0.050	<0.050	<0.00050	<0.00050

Parameter	Units	D.L. ^a	CCME PMAL ^b	Itivia Harbour			Reference 1	Reference 2	Field Blank	Travel Blank
				I1	Replicate	RPD ^c	R1	R2		
Cobalt (Co)-Total	mg/L	0.0050	-	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.000050	<0.000050
Copper (Cu)-Total	mg/L	0.050	-	<0.050	<0.050	-	<0.050	<0.050	<0.00050	<0.00050
Gallium (Ga)-Total	mg/L	0.0050	-	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.000050	<0.000050
Iron (Fe)-Total	mg/L	0.60	-	<0.60	<0.60	-	<0.60	<0.60	<0.030	<0.030
Lead (Pb)-Total	mg/L	0.0050	-	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.000050	<0.000050
Lithium (Li)-Total	mg/L	0.020	-	0.167	0.170	1.8	0.164	0.167	<0.00020	<0.00020
Magnesium (Mg)-Total	mg/L	2.0	-	1350	1310	3.0	1300	1310	<0.10	<0.10
Manganese (Mn)-Total	mg/L	0.020	-	<0.020	<0.020	-	<0.020	<0.020	<0.00020	<0.00020
Mercury (Hg)-Total	mg/L	0.000050	0.000016	<0.000050	<0.000050	-	<0.000050	<0.000050	<0.000050	<0.000050
Molybdenum (Mo)-Total	mg/L	0.0050	-	0.0108	0.0108	-	0.0109	0.0112	<0.000050	<0.000050
Nickel (Ni)-Total	mg/L	0.020	-	<0.020	<0.020	-	<0.020	<0.020	<0.00020	<0.00020
Phosphorus (P)-Total	mg/L	6.0	-	<6.0	<6.0	-	<6.0	<6.0	<0.30	<0.30
Potassium (K)-Total	mg/L	40	-	398	393	1.3	388	394	<2.0	<2.0
Rhenium (Re)-Total	mg/L	0.00050	-	<0.00050	<0.00050	-	<0.00050	<0.00050	<0.000050	<0.000050
Rubidium (Rb)-Total	mg/L	0.0020	-	0.112	0.115	2.6	0.113	0.110	<0.000020	<0.000020
Selenium (Se)-Total	mg/L	0.020	-	<0.020	<0.020	-	<0.020	<0.020	<0.00020	<0.00020
Silicon (Si)-Total	mg/L	1.0	-	<1.0	<1.0	-	<1.0	<1.0	<0.050	<0.050
Silver (Ag)-Total	mg/L	0.00050	-	<0.00050	<0.00050	-	<0.00050	<0.00050	<0.000050	0.0000103
Sodium (Na)-Total	mg/L	40	-	11000	10800	1.8	10800	10800	<2.0	<2.0
Strontium (Sr)-Total	mg/L	0.0050	-	7.29	7.17	1.7	7.27	7.06	<0.000050	<0.000050
Tellurium (Te)-Total	mg/L	0.0010	-	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	0.00020	-	<0.00020	<0.00020	-	<0.00020	<0.00020	<0.000020	<0.000020
Thorium (Th)-Total	mg/L	0.00050	-	<0.00050	<0.00050	-	<0.00050	<0.00050	0.0000130	<0.000050
Tin (Sn)-Total	mg/L	0.020	-	<0.020	<0.020	-	<0.020	<0.020	<0.00020	<0.00020
Titanium (Ti)-Total	mg/L	0.020	-	<0.020	<0.020	-	<0.020	<0.020	<0.00020	<0.00020
Tungsten (W)-Total	mg/L	0.0010	-	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.000010	<0.000010
Uranium (U)-Total	mg/L	0.00020	-	0.00319	0.00306	4.2	0.00311	0.00308	<0.000020	<0.000020
Vanadium (V)-Total	mg/L	0.0050	-	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.000050	<0.000050
Yttrium (Y)-Total	mg/L	0.00050	-	<0.00050	<0.00050	-	<0.00050	<0.00050	<0.000050	<0.000050
Zinc (Zn)-Total	mg/L	0.30		<0.30	<0.30	-	<0.30	<0.30	0.0030	<0.0030
Zirconium (Zr)-Total	mg/L	0.0050	-	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.000050	<0.000050

NOTES:
^a D.L. = Detection Limit
^b CCME PMAL = Canadian Council of Ministers of the Environmental Guidelines for the Protection of Marine Aquatic Life (CCME 2007)
^c RPD = relative percent difference, when results are greater than 5 times the detection limit
^d ** = detection limit varied between samples
^e **Bolded** result implies a guideline exceedance

Table B3: Baseline Marine Sediment Chemistry at Itivia Harbour and Reference Areas

Parameter	Units	D.L. ^a	CCME SQG ^b		Itivia Harbour (I1)						Reference 1 (R1)						Reference 2 (R2)					
					19-Aug-11						20-Aug-11						20-Aug-11					
			ISQG ^c	PEL ^d	Replicate 1	Replicate 2	Replicate 3	Mean	SD ^e	CV ^f	Replicate 1	Replicate 2	Replicate 3	Mean	SD ^e	CV ^f	Replicate 1	Replicate 2	Replicate 3	Mean	SD ^e	CV ^f
Organic and Inorganic Carbon																						
Inorganic Carbon	%	0.10	-	-	0.21	0.20	0.27	0.23	0.04	17	0.21	0.26	0.19	0.22	0.04	16	0.20	0.26	0.20	0.22	0.03	16
Total Organic Carbon	%	0.10	-	-	0.65	1.03	0.57	0.75	0.25	33	0.69	0.76	0.60	0.68	0.08	12	0.62	1.14	1.22	0.99	0.33	33
Total Carbon (by combustion)	%	0.1	-	-	0.9	1.2	0.8	1.0	0.21	22	0.9	1.0	0.8	0.9	0.10	11	0.8	1.4	1.4	1.2	0.35	29
CaCO ₃ Equivalent	%	0.70	-	-	1.78	1.67	2.22	1.89	0.29	15	1.79	2.16	1.60	1.85	0.28	15	1.65	2.19	1.69	1.84	0.30	16
Nutrients																						
Total Kjeldahl Nitrogen	%	0.020	-	-	0.124	0.156	0.106	0.13	0.03	20	0.118	0.139	0.101	0.12	0.02	16	0.113	0.164	0.183	0.15	0.04	24
Total Phosphorus	mg/kg	50	-	-	745	778	801	775	28.15	4	823	892	835	850	36.86	4	768	840	787	798	37.31	5
Particle Size																						
% Sand (2.0 mm ÷ 0.05 mm)	%	0.10	-	-	25.7	30.4	47.4	34.5	11.42	33	24.2	21.8	21.0	22.3	1.67	7	31.5	29.0	37.4	32.6	4.31	13
% Silt (0.05 mm ÷ 2 Œm)	%	0.10	-	-	69.4	64.3	49.1	60.9	10.56	17	71.2	72.6	74.5	72.8	1.66	2	64.2	64.8	57.0	62.0	4.34	7
% Clay (<2 Œm)	%	0.10	-	-	4.98	5.28	3.54	4.60	0.93	20	4.59	5.57	4.5	4.89	0.59	12	4.28	6.17	5.63	5.36	0.97	18
Texture	%	-	-	-	Silt loam	Silt loam	Silt loam / Sandy loam	-	-	-	Silt loam	Silt loam	Silt loam	-	-	-	Silt loam	Silt loam	Silt loam	-	-	-
Metals																						
Aluminum (Al)	mg/kg	5.0	-	-	11600	13700	11900	12400	1135.78	9	12900	15200	11300	13133	1960.44	15	12500	15300	14300	14033	1418.92	10
Antimony (Sb)	mg/kg	0.10	-	-	0.12	0.13	0.10	0.12	0.02	13	0.14	0.18	0.12	0.15	0.03	21	0.13	0.19	0.18	0.17	0.03	19
Arsenic (As)	mg/kg	0.10	7.24	41.6	5.73	6.52	6.20	6.15	0.40	6	5.87	7.21	5.66	6.25	0.84	13	5.93	7.10	6.87	6.63	0.62	9
Barium (Ba)	mg/kg	0.50	-	-	68.7	70.5	64.4	67.9	3.13	5	64.1	75.5	57.8	65.8	8.97	14	57.6	75.4	74.3	69.1	9.97	14
Beryllium (Be)	mg/kg	0.10	-	-	0.33	0.3	0.29	0.31	0.02	7	0.21	0.4	0.17	0.26	0.12	47	0.2	0.32	0.41	0.31	0.11	34
Bismuth (Bi)	mg/kg	0.020	-	-	0.126	0.143	0.128	0.132	0.01	7	0.135	0.147	0.112	0.131	0.02	14	0.117	0.166	0.153	0.145	0.03	17
Boron (B)	mg/kg	1.0	-	-	23.8	29.6	22.9	25.4	3.64	14	25.4	29.7	22.4	25.8	3.67	14	23.5	36.7	36.9	32.4	7.68	24
Cadmium (Cd)	mg/kg	0.020	0.7	4.2	0.032	0.075	0.038	0.048	0.02	48	0.035	0.050	0.028	0.038	0.01	30	0.038	0.070	0.094	0.067	0.03	42
Calcium (Ca)	mg/kg	100	-	-	6680	6970	7520	7057	426.65	6	7270	8260	7120	7550	619.44	8	7100	8350	7250	7567	682.52	9
Cesium (Cs)	mg/kg	0.020	-	-	1.33	1.53	1.29	1.38	0.13	9	1.41	1.69	1.24	1.45	0.23	16	1.26	1.71	1.69	1.55	0.25	16
Chromium (Cr)	mg/kg	1.0	52.3	160	52.4	62.6	52.4	55.8	5.89	11	55.6	66.9	52.5	58.3	7.58	13	53.2	64.3	63.2	60.2	6.12	10
Cobalt (Co)	mg/kg	0.020	-	-	6.00	7.03	6.01	6.35	0.59	9	6.41	7.72	5.97	6.70	0.91	14	6.25	7.68	7.54	7.16	0.79	11
Copper (Cu)	mg/kg	1.0	18.7	108	15.8	18.7	17.9	17.5	1.50	9	14.5	17.4	12.7	14.9	2.37	16	13.4	17.0	17.1	15.8	2.11	13
Iron (Fe)	mg/kg	25	-	-	18400	20900	19000	19433	1305.12	7	20000	24200	18900	21033	2797.02	13	19300	23800	22700	21933	2345.92	11
Lead (Pb)	mg/kg	0.20	30.2	112	4.71	5.44	5.76	5.30	0.54	10	4.88	5.66	4.42	4.99	0.63	13	4.41	5.9	5.63	5.31	0.79	15
Magnesium (Mg)	mg/kg	10	-	-	9840	11200	9980	10340	748.06	7	11200	13000	10500	11567	1289.70	11	10300	12800	12600	11900	1389.24	12
Manganese (Mn)	mg/kg	0.50	-	-	201	229	209	213	14.42	7	216	257	206	226	27.02	12	212	253	248	238	22.37	9
Mercury (Hg)	mg/kg	0.050	0.13	0.70	<0.050	<0.050	<0.050	0.025	0.000	0	<0.050	<0.050	<0.050	0.025	0.000	0	<0.050	<0.050	<0.050	0.025	0.000	0
Molybdenum (Mo)	mg/kg	0.020	-	-	1.03	2.17	1.12	1.44	0.63	44	1.07	1.69	0.942	1.23	0.40	32	1.12	2.24	3.32	2.23	1.10	49
Nickel (Ni)	mg/kg	0.50	-	-	22.1	27.6	21.4	23.7	3.40	14	23.0	28.3	21.6	24.3	3.53	15	21.3	27.0	26.7	25.0	3.21	13
Phosphorus (P)	mg/kg	100	-	-	930	910	1000	947	47.26	5	980	1110	1000	1030	70.00	7	1000	990	970	987	15.28	2

Parameter	Units	D.L. ^a	CCME SQG ^b		Itivia Harbour (I1)						Reference 1 (R1)						Reference 2 (R2)					
					19-Aug-11						20-Aug-11						20-Aug-11					
			ISQG ^c	PEL ^d	Replicate 1	Replicate 2	Replicate 3	Mean	SD ^e	CV ^f	Replicate 1	Replicate 2	Replicate 3	Mean	SD ^e	CV ^f	Replicate 1	Replicate 2	Replicate 3	Mean	SD ^e	CV ^f
Phosphorus, Total	mg/kg	50	-	-	745	778	801	775	28.15	4	823	892	835	850	36.86	4	768	840	787	798	37.31	5
Potassium (K)	mg/kg	25	-	-	3180	3770	3140	3363	352.75	10	3400	4160	3060	3540	563.21	16	3180	4270	4290	3913	635.16	16
Rubidium (Rb)	mg/kg	0.020	-	-	19.4	23.5	18.7	20.5	2.59	13	20.9	25.5	18.0	21.5	3.78	18	19.5	26.7	26.0	24.1	3.97	16
Selenium (Se)	mg/kg	0.50	-	-	0.76	0.76	0.55	0.69	0.12	18	0.65	0.79	<0.50	0.56	0.28	50	0.67	0.9	0.97	0.85	0.16	19
Silver (Ag)	mg/kg	0.10	-	-	<0.10	0.10	<0.10	0.07	0.03	43	<0.10	<0.10	<0.10	0.05	0.00	0	<0.10	0.11	0.11	0.09	0.03	38
Sodium (Na)	mg/kg	10	-	-	8080	10500	7720	8767	1511.86	17	8770	10400	7980	9050	1234.06	14	8270	11100	11200	10190	1663.52	16
Strontium (Sr)	mg/kg	0.10	-	-	33.9	41.3	35.6	36.9	3.88	10	35.1	41.3	33.3	36.6	4.20	11	36.3	45.8	43.0	41.7	4.88	12
Tellurium (Te)	mg/kg	0.10	-	-	<0.10	<0.10	<0.10	0.05	0.00	0	<0.10	<0.10	<0.10	0.05	0.00	0	<0.10	<0.10	<0.10	0.05	0.00	0
Thallium (Tl)	mg/kg	0.10	-	-	0.11	0.14	0.12	0.12	0.02	12	0.11	0.13	0.1	0.11	0.02	13	0.12	0.15	0.15	0.14	0.02	12
Tin (Sn)	mg/kg	5.0	-	-	6.2	<5.0	<5.0	3.7	2.14	57	<5.0	<5.0	<5.0	2.5	0.00	0	<5.0	<5.0	<5.0	2.5	0.00	0
Titanium (Ti)	mg/kg	0.50	-	-	788	945	865	866	78.50	9	849	1060	851	920	121.25	13	919	1030	981	977	55.63	6
Tungsten (W)	mg/kg	0.050	-	-	0.132	0.256	0.167	0.185	0.06	35	0.220	0.153	0.163	0.179	0.04	20	0.143	0.193	0.165	0.167	0.03	15
Uranium (U)	mg/kg	0.020	-	-	0.988	1.390	0.991	1.123	0.23	21	1.050	1.380	0.977	1.136	0.21	19	1.060	1.540	1.740	1.447	0.35	24
Vanadium (V)	mg/kg	0.50	-	-	42.5	48.9	43.6	45.0	3.42	8	46.3	57.5	42.9	48.9	7.64	16	44.0	58.0	55.2	52.4	7.41	14
Zinc (Zn)	mg/kg	10	124	271	35	43	34	37	4.93	13	38	45	35	39	5.13	13	36	45	74	52	19.86	38
Zirconium (Zr)	mg/kg	0.10	-	-	6.85	8.18	6.84	7.29	0.77	11	6.18	7.96	6.40	6.85	0.97	14	6.82	8.09	7.67	7.53	0.65	9

NOTES:
^a D.L. = Detection Limit
^b CCME SQG = CCME Marine Sediment Quality Guidelines for the Protection of Aquatic Life (CCME 2002)
^c ISQG = Interim Sediment Quality Guidelines
^d PEL = Probable Effects Level
^e SD = Standard Deviation
^f CV = Coefficient of Variation
^g **Bolded** result implies a ISQG exceedance
^h **Replicate** results were precision threshold (CV >20%) was exceeded (when all results greater than five (5) times the detection limit)



Stantec Consulting Ltd (Burnaby)
ATTN: SANDRA WEBSTER
5th Floor, 4370 Dominion Street
Burnaby BC V5G 4L7

Date Received: 19-MAR-12
Report Date: 27-MAR-12 15:52 (MT)
Version: FINAL

Client Phone: 604-436-3014

Certificate of Analysis

Lab Work Order #: L1125163
Project P.O. #: 123510575 - 205
Job Reference: 123510575 - 205
C of C Numbers:
Legal Site Desc:

Paul Nicolas
Account Manager

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ADDRESS: 1329 Niakwa Road East, Unit 12, Winnipeg, MB R2J 3T4 Canada | Phone: +1 204 255 9720 | Fax: +1 204 255 9721
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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1125163-1 SEA WATER 15-MAR-12 15:30 I1	L1125163-2 SEA WATER 15-MAR-12 16:00 R1	L1125163-3 SEA WATER 15-MAR-12 16:45 R2	L1125163-4 SEA WATER 15-MAR-12 15:30 I1 DUPLICATE	L1125163-5 SEA WATER 15-MAR-12 17:00 BLANK
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (umhos/cm)	>10,000	>10,000	>10,000	>10,000	<20 <1.0
	Hardness (as CaCO ₃) (mg/L)	6590	6360	6400	6420	<0.50
	pH (pH units)	7.35	7.48	7.56	7.57	5.75
	Total Suspended Solids (mg/L)	6.0	10.0	<5.0	6.0	<5.0
	Total Dissolved Solids (mg/L)	34300	34200	34300	33600	<5.0
	Turbidity (NTU)	0.27	0.11	0.13	0.21	0.11
Anions and Nutrients	Alkalinity, Total (as CaCO ₃) (mg/L)	142	143	143	144	<20 1.7
	Ammonia, Total (as N) (mg/L)	0.023	0.026	0.024	0.028	<0.010
	Bicarbonate (HCO ₃) (mg/L)	174	175	175	175	<24 2.1
	Carbonate (CO ₃) (mg/L)	<12	<12	<12	<12	<12 <0.60
	Chloride (mg/L)	20000	20100	20300	16700	<0.50
	Fluoride (mg/L)	<1.0	1.2	<1.0	<1.0	<0.020
	Hydroxide (OH) (mg/L)	<6.8	<6.8	<6.8	<6.8	<6.8 <0.34
	Nitrate-N (mg/L)	<2.5	<2.5	<2.5	<2.5	<0.050
	Nitrite-N (mg/L)	<2.5	<2.5	<2.5	<2.5	<0.050
	Total Kjeldahl Nitrogen (mg/L)	<0.20	<2 ^{DLM}	<2 ^{DLM}	<2 ^{DLM}	<0.20
	Sulfate (mg/L)	2860	2870	2890	2360	<0.50
	Total Organic Carbon (mg/L)	4.8	3.6	3.3	3.3	<1.0
Organic / Inorganic Carbon						
Total Metals	Aluminum (Al)-Total (mg/L)	<0.30 ^{DLA}	<0.30 ^{DLA}	<0.30 ^{DLA}	<0.30 ^{DLA}	<0.0030
	Antimony (Sb)-Total (mg/L)	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.000010
	Arsenic (As)-Total (mg/L)	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.000050
	Barium (Ba)-Total (mg/L)	<0.010 ^{DLA}	<0.010 ^{DLA}	<0.010 ^{DLA}	<0.010 ^{DLA}	<0.00010
	Beryllium (Be)-Total (mg/L)	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.0000050
	Bismuth (Bi)-Total (mg/L)	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.000050
	Boron (B)-Total (mg/L)	4.49	4.79	4.66	4.88	0.0072
	Cadmium (Cd)-Total (mg/L)	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.0000050
	Calcium (Ca)-Total (mg/L)	411	399	402	401	<0.050
	Cesium (Cs)-Total (mg/L)	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.0000050
	Chromium (Cr)-Total (mg/L)	<0.050 ^{DLA}	<0.050 ^{DLA}	<0.050 ^{DLA}	<0.050 ^{DLA}	<0.00050
	Cobalt (Co)-Total (mg/L)	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.000050
	Copper (Cu)-Total (mg/L)	<0.050 ^{DLA}	<0.050 ^{DLA}	<0.050 ^{DLA}	<0.050 ^{DLA}	<0.00050
	Gallium (Ga)-Total (mg/L)	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID Description Sampled Date Sampled Time Client ID				
		L1125163-6 SEA WATER 15-MAR-12 TRAVEL BLANK				
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (umhos/cm)	<1.0				
		<20				
	Hardness (as CaCO3) (mg/L)	<0.50				
	pH (pH units)	5.74				
	Total Suspended Solids (mg/L)	<5.0				
	Total Dissolved Solids (mg/L)	<5.0				
	Turbidity (NTU)	<0.10				
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	<20				
		1.7				
	Ammonia, Total (as N) (mg/L)	<0.010				
	Bicarbonate (HCO3) (mg/L)	<24				
		2.1				
	Carbonate (CO3) (mg/L)	<0.60				
		<12				
	Chloride (mg/L)	<0.50				
	Fluoride (mg/L)	<0.020				
	Hydroxide (OH) (mg/L)	<6.8				
		<0.34				
	Nitrate-N (mg/L)	<0.050				
	Nitrite-N (mg/L)	<0.050				
	Total Kjeldahl Nitrogen (mg/L)	<0.20				
	Sulfate (mg/L)	<0.50				
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	<1.0				
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030				
	Antimony (Sb)-Total (mg/L)	<0.000010				
	Arsenic (As)-Total (mg/L)	<0.000050				
	Barium (Ba)-Total (mg/L)	<0.00010				
	Beryllium (Be)-Total (mg/L)	<0.0000050				
	Bismuth (Bi)-Total (mg/L)	<0.000050				
	Boron (B)-Total (mg/L)	<0.0050				
	Cadmium (Cd)-Total (mg/L)	<0.0000050				
	Calcium (Ca)-Total (mg/L)	<0.050				
	Cesium (Cs)-Total (mg/L)	<0.0000050				
	Chromium (Cr)-Total (mg/L)	<0.00050				
	Cobalt (Co)-Total (mg/L)	<0.000050				
	Copper (Cu)-Total (mg/L)	<0.00050				
	Gallium (Ga)-Total (mg/L)	<0.000050				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1125163-1 SEA WATER 15-MAR-12 15:30 I1	L1125163-2 SEA WATER 15-MAR-12 16:00 R1	L1125163-3 SEA WATER 15-MAR-12 16:45 R2	L1125163-4 SEA WATER 15-MAR-12 15:30 I1 DUPLICATE	L1125163-5 SEA WATER 15-MAR-12 17:00 BLANK
Grouping	Analyte					
WATER						
Total Metals	Iron (Fe)-Total (mg/L)	<0.60 ^{DLA}	<0.60 ^{DLA}	<0.60 ^{DLA}	<0.60 ^{DLA}	<0.030
	Lead (Pb)-Total (mg/L)	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.000050
	Lithium (Li)-Total (mg/L)	0.167	0.164	0.167	0.170	<0.00020
	Magnesium (Mg)-Total (mg/L)	1350	1300	1310	1310	<0.10
	Manganese (Mn)-Total (mg/L)	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.00020
	Mercury (Hg)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Molybdenum (Mo)-Total (mg/L)	0.0108	0.0109	0.0112	0.0108	<0.000050
	Nickel (Ni)-Total (mg/L)	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.00020
	Phosphorus (P)-Total (mg/L)	<6.0 ^{DLA}	<6.0 ^{DLA}	<6.0 ^{DLA}	<6.0 ^{DLA}	<0.30
	Potassium (K)-Total (mg/L)	398	388	394	393	<2.0
	Rhenium (Re)-Total (mg/L)	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.0000050
	Rubidium (Rb)-Total (mg/L)	0.112	0.113	0.110	0.115	<0.000020
	Selenium (Se)-Total (mg/L)	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.00020
	Silicon (Si)-Total (mg/L)	<1.0 ^{DLA}	<1.0 ^{DLA}	<1.0 ^{DLA}	<1.0 ^{DLA}	<0.050
	Silver (Ag)-Total (mg/L)	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.0000050
	Sodium (Na)-Total (mg/L)	11000	10800	10800	10800	<2.0
	Strontium (Sr)-Total (mg/L)	7.29	7.27	7.06	7.17	<0.000050
	Tellurium (Te)-Total (mg/L)	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.000010
	Thallium (Tl)-Total (mg/L)	<0.00020 ^{DLA}	<0.00020 ^{DLA}	<0.00020 ^{DLA}	<0.00020 ^{DLA}	<0.0000020
	Thorium (Th)-Total (mg/L)	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	0.0000130
	Tin (Sn)-Total (mg/L)	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.00020
	Titanium (Ti)-Total (mg/L)	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.020 ^{DLA}	<0.00020
	Tungsten (W)-Total (mg/L)	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.0010 ^{DLA}	<0.000010
	Uranium (U)-Total (mg/L)	0.00319 ^{DLA}	0.00311 ^{DLA}	0.00308 ^{DLA}	0.00306 ^{DLA}	<0.0000020
	Vanadium (V)-Total (mg/L)	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.000050
	Yttrium (Y)-Total (mg/L)	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.00050 ^{DLA}	<0.0000050
	Zinc (Zn)-Total (mg/L)	<0.30 ^{DLA}	<0.30 ^{DLA}	<0.30 ^{DLA}	<0.30 ^{DLA}	0.0030
	Zirconium (Zr)-Total (mg/L)	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.0050 ^{DLA}	<0.000050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID Description Sampled Date Sampled Time Client ID				
		L1125163-6 SEA WATER 15-MAR-12 TRAVEL BLANK				
Grouping	Analyte					
WATER						
Total Metals	Iron (Fe)-Total (mg/L)	<0.030				
	Lead (Pb)-Total (mg/L)	<0.000050				
	Lithium (Li)-Total (mg/L)	<0.00020				
	Magnesium (Mg)-Total (mg/L)	<0.10				
	Manganese (Mn)-Total (mg/L)	<0.00020				
	Mercury (Hg)-Total (mg/L)	<0.000050				
	Molybdenum (Mo)-Total (mg/L)	<0.000050				
	Nickel (Ni)-Total (mg/L)	<0.00020				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	<2.0				
	Rhenium (Re)-Total (mg/L)	<0.0000050				
	Rubidium (Rb)-Total (mg/L)	<0.000020				
	Selenium (Se)-Total (mg/L)	<0.00020				
	Silicon (Si)-Total (mg/L)	<0.050				
	Silver (Ag)-Total (mg/L)	0.0000103				
	Sodium (Na)-Total (mg/L)	<2.0				
	Strontium (Sr)-Total (mg/L)	<0.000050				
	Tellurium (Te)-Total (mg/L)	<0.000010				
	Thallium (Tl)-Total (mg/L)	<0.0000020				
	Thorium (Th)-Total (mg/L)	<0.0000050				
	Tin (Sn)-Total (mg/L)	<0.00020				
	Titanium (Ti)-Total (mg/L)	<0.00020				
	Tungsten (W)-Total (mg/L)	<0.000010				
	Uranium (U)-Total (mg/L)	<0.0000020				
	Vanadium (V)-Total (mg/L)	<0.000050				
	Yttrium (Y)-Total (mg/L)	<0.0000050				
	Zinc (Zn)-Total (mg/L)	<0.0030				
	Zirconium (Zr)-Total (mg/L)	<0.000050				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comment:
L1125163-1	Water	Note: Conductivity is too high to provide an accurate result	
L1125163-2	Water	Note: Conductivity is too high to provide an accurate result	
L1125163-3	Water	Note: Conductivity is too high to provide an accurate result	
L1125163-4	Water	Note: Conductivity is too high to provide an accurate result	

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Ammonia, Total (as N)	DLA	L1125163-1, -2, -3, -4
Duplicate	Ammonia, Total (as N)	DLA	L1125163-5, -6
Duplicate	Ammonia, Total (as N)	DLA	L1125163-5, -6
Duplicate	Ammonia, Total (as N)	DLA	L1125163-5, -6
Method Blank	Thorium (Th)-Total	MB-LOR	L1125163-1, -2, -3, -4, -5
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L1125163-5, -6

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DLM	Detection Limit Adjusted For Sample Matrix Effects
MB-LOR	Method Blank exceeds ALS DQO. LORs adjusted for samples with positive hits below 5 times blank level. Please contact ALS if re-analysis is required.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-T-L-WP	Water	Alkalinity	APHA 2320B
Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. It is determined by titration with a standard solution of strong mineral acid to the successive HCO ₃ ⁻ and H ₂ CO ₃ endpoints indicated electrometrically.			
ALK-TOT-WP	Water	Alkalinity	APHA 2320B
Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. It is determined by titration with a standard solution of strong mineral acid to the successive HCO ₃ ⁻ and H ₂ CO ₃ endpoints indicated electrometrically.			
ANIONS5-IC-WP	Water	Anions scan (IC)	EPA 300.1 IC
Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.			
C-TOT-ORG-WP	Water	Total Organic Carbon	APHA 5310 B-INSTRUMENTAL-WP
This method is applicable to the analysis of ground water, wastewater, and surface water samples. The form detected depends upon sample pretreatment: Unfiltered sample = TC, 0.45um filtered = TDC. Samples are injected into a combustion tube containing an oxidation catalyst. The carrier gas containing the combustion product from the combustion tube flows through an inorganic carbon reactor vessel and is then sent through a halogen scrubber into a sample cell set in a non-dispersive infrared gas analyzer (NDIR) where carbon dioxide is detected. For total inorganic carbon and dissolved inorganic carbon, the sample is injected into an IC reactor vessel where only the IC component is decomposed to become carbon dioxide.			
The peak area generated by the NDIR indicates the TC/TDC or TIC/DIC as applicable. The total organic carbon content of the sample is calculated by subtracting the TIC from the TC.			
TOC = TC-TIC, DOC = TDC-DIC, Particulate = Total - Dissolved.			
EC-L-WP	Water	Conductivity	APHA 2510B
Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes.			
EC-WP	Water	Conductivity	APHA 2510B
Conductivity of an aqueous solution refers to its ability to carry an electric current. Conductance of a solution is measured between two spatially fixed and chemically inert electrodes.			

Reference Information

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO ₃ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.			
HG-TOT-CVAFS-VA	Water	Total Mercury in Water by CVAFS	EPA 245.7
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).			
MET-T-L-HRMS-VA	Water	Total Metals in Water by HR-ICPMS	EPA 200.8
Trace metals in water are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) modified from US EPA Method 200.8, (Revision 5.5). The procedures may involve preliminary sample treatment by acid digestion modified from APHA Method 3030E.			
MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B
This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).			
N-TOTKJ-WP	Water	Total Kjeldahl Nitrogen	Quickchem method 10-107-06-2-E Lachat
Samples are digested with a sulphuric acid solution, cooled, diluted with water, and analyzed for ammonia. Total Kjeldahl nitrogen is the sum of free-ammonia and organic nitrogen compounds which are converted to ammonium sulphate through this digestion process. Analysis is performed by Flow Injection Analysis (FIA). The pH of the digested sample is raised to a known, basic pH by neutralization with a concentrated buffer solution. This neutralization converts the ammonium cation to ammonia. The ammonia produced is heated with salicylate and hypochlorite to produce blue colour which is proportional to the ammonia concentration.			
NH3-COL-WP	Water	Ammonia by colour	APHA 4500 NH3 F
Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.			
PH-WP	Water	pH	APHA 4500H
The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode.			
SOLIDS-TDS-WP	Water	Total Dissolved Solids	APHA 2540C
The residue remaining in a prepared casserole after passing the sample through a 1.2 um Whatman GF/C glass microfibre filter and drying at 180 degrees C. Samples may be dried at 105 degrees C if the client specifically requests this drying temperature.			
SOLIDS-TOTSUS-WP	Water	Total Suspended Solids	APHA 2540D
The residue retained by a prepared 1.5 um Whatman 934-AH glass microfibre filter dried at 105 degrees C.			
TURBIDITY-WP	Water	Turbidity	APHA 2130B (modified)
Turbidity in aqueous matrices is determined by the nephelometric method.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lw - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



• **rrm**

L 115163

Report To			Standard: ☒ Other (specify):			Service Requested: (Rush subject to availability)									
Company: <u>Stanter Consulting Ltd</u>			Select: PDF ☒ Excel ☒ Digital ☐ Fax ☐			☒ Regular (Standard Turnaround Times))									
Contact: <u>Sandra Webster</u>			Email 1: <u>sandra.webster@stanter.com</u>			Priority, Date Req'd: _____ (Surcharges apply)									
Address: <u>4370 Dominion Street</u>			Email 2: <u>Carey.Sibbald@stanter.com</u>			Emergency (1 Business Day) - 100% Surcharge									
Phone: <u>604-436-3014</u> Fax: _____						For Emergency < 1 Day, ASAP or Weekend - Contact ALS									
						Analysis Request									
Invoice To Same as Report? (circle) ☒ Yes or No (if No, provide details)			Client / Project Information			(Indicate Filtered or Preserved, F/P)									
Copy of Invoice with Report? (circle) ☒ Yes or No			Job #: <u>123510575-205</u>												
Company:			PO / AFE: <u>123510575-205</u>												
Contact:			LSD:												
Address:			Quote #:												
Phone: _____ Fax: _____			ALS Contact:												
Lab Work Order # (lab use only)			Sampler: <u>BT CP</u>												
Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	<u>oil, EC, TALK, hard.</u>	<u>TSS, TDS</u>	<u>Turbidity</u>	<u>TKN, NH3</u>	<u>NH4-N, NO2-N</u>	<u>TOC</u>	<u>Anion Scan</u>	<u>Met-FX RTHMS-VA</u>	<u>Hg-TOT-CVAFS-VA</u>	<u>As-TOT-CVAFS-VA</u>	Number of Containers
1	I1	03/15/12	15:30	Sea Water	X	X	X	X	X	X	X	X	X	X	5
2	R1	03/15/12	16:00	Sea Water	X	X	X	X	X	X	X	X	X	X	5
3	R2	03/15/12	16:45	Sea Water	X	X	X	X	X	X	X	X	X	X	5
4	I1 duplicate	03/15/12	15:30	Sea Water	X	X	X	X	X	X	X	X	X	X	5
5	Blank	03/15/12	17:00	Water	X	X	X	X	X	X	X	X	X	X	5
6	Travel Blank	03/15/12	-	TB	X	X	X	X	X	X	X	X	X	X	5
Special Instructions / Regulations / Hazardous Details															
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.															
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.															
SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)			SHIPMENT VERIFICATION (lab use only)									
Released by: <u>Ch...</u>	Date: <u>03/16/12</u>	Time: <u>10:00</u>	Received by: <u>ABM</u>	Date: <u>17 Mar 12</u>	Time: <u>06:25</u>	Temperature: <u>4.8 °C</u>	Verified by: _____	Date: _____	Time: _____	Observations: Yes / No ? If Yes add SIF					
REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION						WHITE - LABORATORY COPY		YELLOW - CLIENT COPY				GENF 18.01 Front			

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APPENDIX C

Aquatic Biota Data

Table C1: Phytoplankton Taxonomy and Species Abundance

Phytoplankton	No. of Stations Taxa Identified	Project Footprint	Reference 1	Reference 2
		I1	R1	R2
		21-Aug-11	21-Aug-11	21-Aug-11
Phylum: Bacillariophyceae (Diatoms)				
Order: Centrales				
<i>Biddulphia</i> sp. ?	2	<0.47		<0.47
<i>Chaetoceros</i> sp.	1		<0.47	
<i>Coscinodiscus</i> spp.	3	0.47	<0.47	<0.47
<i>Thalassiosira</i> sp.	1			0.94
UID ¹	3	<0.47	<0.47	0.47
Order: Pennales				
<i>Achnanthes</i> sp.	2	<0.47		<0.47
<i>Amphora</i> spp.	3	<0.47	<0.47	<0.47
<i>Climacosphenia/Licmorpha</i> sp.	3	<0.47	<0.47	<0.47
<i>Cocconeis</i> sp.	3	<0.47	<0.47	<0.47
<i>Cymbella</i> sp.	2	<0.47	<0.47	
<i>Diatoma</i> sp.?	2	<0.47		<0.47
<i>Diploneis</i> sp.	1			<0.47
<i>Fragilaria</i> sp.	2		<0.47	<0.47
<i>Gyrosigma</i> sp.	3	<0.47	<0.47	<0.47
<i>Navicula</i> spp.	3	0.94	<0.47	0.94
<i>Nitzschia</i> sp.	2	<0.47	<0.47	
<i>Pleurosigma/Gyrosigma</i> sp.	3	<0.47	<0.47	<0.47
<i>Synedra</i> spp.	3	<0.47	<0.47	<0.47
UID	3	0.94	<0.47	0.94
Phylum: Chlorophyta (Green Algae)				
Order: Chlorococcales				
<i>Schroedera</i> sp. ?	3	<0.47	0.94	<0.47
Order: Zygnematales				
<i>Closterium</i> sp. ?	3	<0.47	<0.47	<0.47
<i>Mougeotia</i> sp. ?	1	<0.47		

Phytoplankton	No. of Stations Taxa Identified	Project Footprint	Reference 1	Reference 2
		I1	R1	R2
		21-Aug-11	21-Aug-11	21-Aug-11
Phylum: Cryptophyta (Cryptophyte Algae)				
Order: Cryptomonadales				
Chroomonas acuta	1		<0.47	
Phylum: Cyanophyta (Blue-Green Algae)				
Order: Oscillatoriales				
Lyngbya sp.	2	<0.47		<0.47
Phylum: Pyrrhophyta (Dinoflagellates)				
Order: Dinokontae				
Dinophysis spp.	3	4.23	4.70	3.76
Diplopeltopsis minor ?	3	0.47	0.47	1.41
Gymnodinium spp.	3	2.35	1.88	1.41
Noctiluca spp.	3	1.88	<0.47	<0.47
Peridinium/Gonyaulax spp.	3	6.11	3.29	7.99
Prorocentrum sp. ?	3	1.88	1.88	0.94
UID	3	1.88	1.41	<0.47
Phylum: Ciliophora (Ciliates)				
Order: Tintinnida				
UID	3	0.47	1.88	1.88
Unidentified (UID)				
UID unicellular algae	2	<0.47	<0.47	
Total (cells/mL)	-	24.68	20.68	25.62

NOTES:

¹ UID = unidentified due to lack of size and/or missing morphological characters

Table C2: Zooplankton Taxonomy and Species Abundance

Zooplankton	Stage ¹	Project Footprint	Reference 1	Reference 2
		I1	R1	R2
		21-Aug-11	21-Aug-11	21-Aug-11
Phylum: Cnidaria				
Obelia sp.		2	3	
Cyanea capillata			2	
Phylum: Rotifera				
Unidentified (Notommatidae?)		35,000	27,500	35,000
Trichocera sp.		20	20	10
Phylum: Annelida				
Class: Polychaeta	L	120	220	130
Family: Syllidae	juv	1		
Phylum: Arthropoda				
Class: Copepoda				
Order: Calanoida				
Unidentified Calanoida	nauplius	3,500	6,200	2,400
Family: Acartiidae				
Acartia clausi	M		1	1
Acartia clausi	F		1	
Acartia spp.	V	3		
Acartia spp.	IV	10	1	40
Acartia spp.	III	13	4	10
Acartia spp.	II	57	8	1
Acartia spp.	I	120	48	60
Family: Centropagidae				
Centropages abdominalis	M			2
Centropages abdominalis	F		2	
Centropages abdominalis	V	2	3	2
Centropages abdominalis	IV	6	19	6
Centropages abdominalis	III	9	47	30
Centropages abdominalis	II	26	90	70
Centropages abdominalis	I	50	140	90
Family: Pseudocalanidae				
Pseudocalanus minutus	M	1	2	
Pseudocalanus minutus	F	1	3	
Pseudocalanus minutus	V	8	9	2
Pseudocalanus minutus	IV	6	9	2
Pseudocalanus minutus	III	4	4	10

Zooplankton	Stage ¹	Project Footprint	Reference 1	Reference 2
		I1	R1	R2
		21-Aug-11	21-Aug-11	21-Aug-11
<i>Pseudocalanus minutus</i>	II	4	10	
<i>Pseudocalanus minutus</i>	I	3		
Family: Tortanidae				
<i>Tortanus discaudatus</i>	I	1		
Order: Harpacticoida				
Unidentified Harpacticoida	nauplius	1,100	400	40
Unidentified Harpacticoida	cop		20	
Family: Ectinosomidae				
<i>Microsetella norvegica</i>	F	24	37	9
<i>Microsetella norvegica</i>	cop	10	4	
Order: Cyclopoida				
Family: Oithonidae				
<i>Oithona similis</i>	M	8		
<i>Oithona similis</i>	F	27	1	3
<i>Oithona similis</i>	cop	280	110	110
Family: Oncaeidae				
<i>Oncaea borealis</i>	M	6	4	
<i>Oncaea borealis</i>	F		1	
Family: Ergasilidae	cop	3		
Order: Decapoda				
Infraorder: Brachyura	zoea		1	1
Phylum: Mollusa				
Class: Bivalvia	veliger	900	900	
Class: Gastropoda	veliger		10	
Phylum: Chaetognatha				
<i>Sagitta elegans</i> (accepted as <i>Parasagitta elegans</i>)		2		
Phylum: Chordata				
Class: Larvacea				
<i>Fritillaria borealis</i>		5		10
Total (organisms/L)	-	165,328	143,336	126,797

NOTES:

¹ Stage abbreviations: cop = copepodite (juvenile copepod)
F = female
M = male
juv = juvenile
L = larva (first juvenile of homometabolous insect)

Table C3: Benthic Invertebrate Summary Statistics

Benthic Invertebrate ¹	No. Stations Reported at	Minimum Value	Maximum Value	Mean Value	Median	Standard Deviation	Standard Error
Phylum: Porifera	1	0.0	2.4	0.0	0.8	1.4	1.4
Phylum: Cnidaria							
Class: Hydrozoa							
Subclass: Hydroida Indeterminate (accepted as Hydroidolina)	1	0.0	4.0	0.0	1.3	2.3	2.3
Family: Bougainvilliidae	1	0.0	1.0	0.0	0.3	0.6	0.6
Family: Campanulariidae	2	0.0	7.4	4.0	3.8	3.7	2.6
Family: Tubulariidae	1	0.0	4.0	0.0	1.3	2.3	2.3
Phylum: Platyhelminthes	1	0.0	1.0	0.0	0.3	0.6	0.6
Phylum: Nemertea							
Phylum Nemertea Indeterminate	2	0.0	5.0	3.4	2.8	2.6	1.8
Subclass: Hoplonemertea	3	2.4	16.4	4.0	7.6	7.7	4.4
Family: Tetrastemmatidae	2	0.0	18.4	2.0	6.8	10.1	7.1
Phylum: Annelida							
Class: Polychaeta (Errantia)							
Family: Dorvilleidae	2	0.0	10.4	7.4	5.9	5.4	3.8
Family: Hesionidae	2	0.0	24.8	2.0	8.9	13.8	9.7
Family: Lumbrineridae	3	6.0	43.0	40.0	29.7	20.6	11.9
Family: Nephtyidae	3	298.0	884.0	314.4	498.8	333.7	192.7
Family: Pholoidae	3	71.0	403.2	264.6	246.3	166.9	96.3
Family: Phyllodocidae	3	21.0	55.4	33.6	36.7	17.4	10.1
Family: Polynoidae	2	0.0	4.0	1.0	1.7	2.1	1.5
Family: Syllidae	3	113.0	720.0	380.6	404.5	304.2	175.6
Family: Terebellidae	1	0.0	1.0	0.0	0.3	0.6	0.6
Class: Polychaeta (Sedentaria)							
Family: Ampharetidae	3	5.0	33.6	22.9	20.5	14.4	8.3
Family: Capitellidae	3	672.0	3656.0	3210.1	2512.7	1609.6	929.3
Family: Cirratulidae	3	186.4	401.0	262.1	283.2	108.8	62.8
Family: Cossuridae	3	70.0	95.4	88.0	84.5	13.1	7.5
Family: Maldanidae	3	14.4	38.0	18.9	23.8	12.5	7.2
Family: Orbiniidae	3	58.4	213.3	153.0	141.6	78.1	45.1
Family: Opheliidae	1	0.0	2.0	0.0	0.7	1.2	1.2
Family: Paraonidae	3	62.3	624.0	324.0	336.8	281.1	162.3

Benthic Invertebrate ¹	No. Stations Reported at	Minimum Value	Maximum Value	Mean Value	Median	Standard Deviation	Standard Error
Family: Pectinariae	2	0.0	5.0	1.0	2.0	2.6	1.9
Family: Sabellidae	3	24.0	34.0	30.9	29.6	5.1	3.0
Family: Scalibregmatidae	3	7.4	27.0	16.8	17.1	9.8	5.7
Family: Serpulidae	1	0.0	4.0	0.0	1.3	2.3	2.3
Family: Spionidae	3	4.0	28.0	21.0	17.7	12.3	7.1
Family: Spirorbidae	2	0.0	6.4	3.4	3.3	3.2	2.3
Family: Terebellidae	3	52.0	75.0	73.4	66.8	12.8	7.4
Family: Trichobranchidae	1	0.0	4.0	0.0	1.3	2.3	2.3
Class: Clitellata							
Subclass: Oligochaeta							
Family: Enchytraeidae	2	0.0	24.0	17.0	13.7	12.3	8.7
Family: Naididae	2	0.0	66.4	4.0	23.5	37.2	26.3
Phylum: Mollusca							
Class: Gastropoda							
Family: Cylichnidae	1	0.0	4.0	0.0	1.3	2.3	2.3
Family: Melanodrymidae	1	0.0	8.0	0.0	2.7	4.6	4.6
Family: Turbinidae	1	0.0	4.0	0.0	1.3	2.3	2.3
Class: Bivalvia							
Class Bivalvia Indeterminate	1	0.0	10.4	0.0	3.5	6.0	6.0
Family: Cardiidae	2	0.0	5.0	1.0	2.0	2.6	1.9
Family: Hiatellidae	1	0.0	42.4	0.0	14.1	24.5	24.5
Family: Myidae	3	9.0	31.4	21.4	20.6	11.2	6.5
Family: Mytilidae	1	0.0	82.4	0.0	27.5	47.6	47.6
Family: Nucleidae	1	0.0	17.0	0.0	5.7	9.8	9.8
Family: Tellinidae	3	9.0	35.2	12.0	18.7	14.3	8.3
Family: Thyasiridae	2	0.0	51.0	34.4	28.5	26.0	18.4
Phylum: Arthropoda							
Subphylum: Crustacea							
Class: Maxillopoda							
Subclass: Copepoda (parasitic)	-	-	-	-	-	-	-
Family: Chondracanthidae	1	0.0	8.0	0.0	2.7	4.6	4.6
Order: Siphonostomatoida	1	0.0	8.0	0.0	2.7	4.6	4.6

Benthic Invertebrate ¹	No. Stations Reported at	Minimum Value	Maximum Value	Mean Value	Median	Standard Deviation	Standard Error
Class: Malacostraca							
Order: Cumacea	2	0.0	4.0	1.0	1.7	2.1	1.5
Order: Isopoda	2	0.0	22.4	1.0	7.8	12.7	8.9
Order: Amphipoda	-	-	-	-	-	-	-
Family: Caprellidae	1	0.0	32.8	0.0	10.9	18.9	18.9
Family: Corophiidae	1	0.0	17.7	0.0	5.9	10.2	10.2
Family: Dexaminidae	1	0.0	48.8	0.0	16.3	28.2	28.2
Family: Eusiridae	1	0.0	31.2	0.0	10.4	18.0	18.0
Family: Ischyroceridae	3	1.0	22.3	12.0	11.8	10.6	6.1
Family: Lysianassidae	1	0.0	9.0	0.0	3.0	5.2	5.2
Family: Melitidae	1	0.0	4.0	0.0	1.3	2.3	2.3
Family: Oedicerotidae	3	32.0	94.4	51.0	59.1	32.0	18.5
Family: Photidae	2	0.0	37.0	8.8	15.3	19.3	13.7
Family: Stenthoidae	2	0.0	27.2	3.4	10.2	14.8	10.5
Family: Podoceridae	1	0.0	2.4	0.0	0.8	1.4	1.4
Family: Zopfiaceae	3	10.9	120.0	32.2	54.4	57.8	33.4
Suborder: Gammaridea	2	0.0	12.0	2.0	4.7	6.4	4.5
Order: Decapoda	1	0.0	1.0	0.0	0.3	0.6	0.6
Phylum: Bryozoa	2	0.0	43.2	3.4	15.5	24.0	17.0
Subphylum: Urochordata (accepted as Tunicata)	1	0.0	1.0	0.0	0.3	0.6	0.6

NOTES:

¹ Benthic invertebrate data has been combined to higher taxonomic levels (usually family); see Table C4 in Appendix C for all benthic data

Table C4: Benthic Invertebrate Taxonomy and Species Abundance

Benthic Invertebrate	Project Footprint (I1)										Reference 1 (R1)										Reference 2 (R2)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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Benthic Invertebrate	Project Footprint (I1)										Reference 1 (R1)										Reference 2 (R2)									
	18-Aug-11										20-Aug-11										20-Aug-11									
	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite
	Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile	
Family: Pholoidae																														
Pholoe spp.				113	27		96	28		265	8	4		24	24		3	8		71	64	16	4	65	14		160	80		403
Family: Phyllodocidae																														
Eteone spp.				24	3		28			55	12			4			3	2		21	12			10			4			26
Phyllodoce sp.																					4						4			8
Family: Polynoidae																														
Harmothoe imbricata							1			1																	4			4
Family: Syllidae																														
Syllidae Indeterminate																				4										4
Eusyllis sp.							12			12														2			8			10
Exogone gemmifera				182	17		100	4		303	8			4			6	2	1	21	244	4		170	10		104			532
Pionosyllis sp.																				36							8			44
Sphaerosyllis sp.				34			24	4		62	36			32			24			92	32			12						44
Syllides sp.				3						3										44				29	2	2	8			86
Family: Terebellidae																														
Lysilla sp.																1			1											
Class: Polychaeta (Sedentaria)																														
Family: Ampharetidae																														
Ampharetidae Indeterminate						3			4	7					4				4							4				4
Subfamily: Ampharetinae Indeterminate																								2						2
Ampharete sp.				3			12			15										16				7			4			27
Lysippe labiata																1			1											0
Family: Capitellidae																														
Capitella capitata complex							4	4		8						2			2					2						2
Mediomastus ambiseta	1	2								3																				
Mediomastus sp.	2			1358	182	86	1232	340		3199	100	16		236	20		280	18		670	1132	152		871	84	2	1136	256	20	3654
Family: Cirratulidae																														
Cirratulidae Indeterminate							60	72	8	140	28	8	16	4			12	10	15	93	4	12	24	7	17	10	8	24		106
Aphelochaeta spp.															4			1	5						5					5
Chaetozone nr. setosa							4			4							24	1		25	8			7						15
Chaetozone spp.	1			14	55	21	20			110	56	8	24	40	28	32	53	18	19	278	16	4	4	14	2	5	4	4		54
Cirratulus sp.																								0		2				2
Tharyx sp.							8			8														5						5
Family: Cossuridae																														
Cossura pygodactylata				3			92			95	4			32			34			70	36			12			40			88
Family: Maldanidae																														
Euclymeninae Indeterminate							4		8	12			4						1	5										
Axiothella sp.				7						7	16			16			1			33	8			2			4			14

Benthic Invertebrate	Project Footprint (I1)										Reference 1 (R1)										Reference 2 (R2)									
	18-Aug-11										20-Aug-11										20-Aug-11									
	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite
	Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile	
Family: Orbiniidae																														
Orbiniidae Indeterminate						3		12	60	75									3	3								12	12	
<i>Leitoscoloplos pugettensis</i>	1			3	3		8	68		84	4	28	8	4	4	8	19	35	39	149					2		4	20		26
<i>Scoloplos armiger</i>	2			24			28			54							1			1					0		20		20	
Family: Opheliidae																														
<i>Ophelina acuminata</i>																	2			2										
Family: Paraonidae																														
<i>Aricidea lopezi</i>				7			32			39	52	28		24	28		44	11		187	16			26	5		76	8		131
<i>Aricidea nr. minuta</i>							12	8		20	8			24			22			54							4			4
<i>Aricidea</i> spp.					3					3	4	68	52	12	88	48	10	72	29	383	20	20	20	17	19	5	20	60		181
<i>Paraonella</i> sp.																											4	4		8
Family: Pectinariidae																														
<i>Pectinaria</i> sp.																	1			1							1	4		5
Family: Sabelliidae																														
<i>Chone</i> spp.																						4								4
<i>Euchone analis</i>				3	3		12			19	4									4					5			4		9
<i>Euchone incolor</i>							12			12	8			16			6			30	4			2						6
<i>Euchone</i> spp.																									5					5
Family: Scalibregmatidae																														
<i>Scalibregma nr. inflatum</i>				3				4		7				4	12		4	6	1	27		4		2	2				8	17
Family: Serpulidae																														
<i>Pileolaria quadrangularis</i>																											4			4
Family: Spionidae																														
<i>Dipolydora quadrilobata</i>							4			4																				
<i>Dipolydora</i> sp.																							2				4			6
<i>Prionospio (Prionospio)</i> sp.											4			8			6	3		21	4									4
<i>Pygospio elegans</i>																					4			10						14
<i>Spio</i> sp.																											4			4
Family: Spirorbidae																														
Spirorbidae Indeterminate				3						3																				
<i>Circeis spirillum</i>																					4			2						6
Family: Terebellidae																														
Terebellidae Indeterminate																											4	4		8
<i>Polycirrus</i> spp.							1			1											4					2		4		10
<i>Terebellides</i> spp.	6			16			28	20	4	74	12	4		5	8	8	11	3	1	52	13			7	2	2	15		4	44
Subfamily: Amphitritinae Indeterminate (accepted as Terebellinae)																					4									4

Benthic Invertebrate	Project Footprint (I1)										Reference 1 (R1)										Reference 2 (R2)										
	18-Aug-11										20-Aug-11										20-Aug-11										
	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite	
	Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		
<i>Lanassa venusta venusta</i>																								5	2					7	
Family: Trichobranchidae																															
Trichobranchidae Indeterminate																							4							4	
Class: Clitarella																															
Subclass: Oligochaeta																															
Family: Enchytraeidae																															
<i>Marionina</i> sp.											4			12			1				17	20	4							24	
Family: Naididae																															
Tubificoid Naididae Indeterminate														4						4		28		31	7					66	
Phylum: Mollusca																															
Class: Gastropoda																															
Family: Cylichnidae																															
Cylichnidae Indeterminate																	4		4												
Family: Melanodrymiidae																															
<i>Leptogyra alaskana</i>																											8			8	
Family: Turbinidae																															
<i>Margarites</i> sp.																						4								4	
Class: Bivalvia																															
Bivalvia Indeterminate																							8			2				10	
Family: Cardiidae																															
<i>Clinocardium ciliatum</i>	1									1																					
<i>Clinocardium</i> sp.												4							4												
<i>Serripes groenlandicus</i>														1					1												
Family: Hiatellidae																															
Hiatellidae Indeterminate																										2			4	6	
<i>Hiatella arctica</i>																							8			12			16	36	
Family: Myidae																															
Myidae Indeterminate					4			12	16																						
<i>Mya</i> sp.			1						1			4		4			1	9			24			2				5	31		
<i>Mya truncata</i>							4		4																						
Family: Mytilidae																															
Mytilidae Indeterminate																						28			2			4	34		
<i>Crenella faba</i>																				4	24		2	7	2		8			48	
Family: Nuculidae																															
<i>Ennucula tenuis</i>											4	4					6	3		17											
Family: Tellinidae																															
<i>Macoma calcarea</i>	2	1			2			4		9				1	4		1	2		8	9	7		5	4		2	1		28	

Meliadine Gold Project
Marine Baseline Report
Itivia Harbour, Rankin Inlet, NU
Draft Report
Appendix C: Aquatic Biota Data

Benthic Invertebrate	Project Footprint (I1)										Reference 1 (R1)										Reference 2 (R2)									
	18-Aug-11										20-Aug-11										20-Aug-11									
	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite
	Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile	
<i>Macoma carlottensis</i>																					1				1					2
<i>Macoma lama</i>																										2				2
<i>Macoma</i> spp.														4						4							2			2
Family: Thyasiridae																														
Thyasiridae Indeterminate																	1	2		3										0
<i>Axinopsida orbiculata</i>																	1			1	4	4		5						13
<i>Thyasira flexuosa</i>												16			4			27		47		12		5	5					22
Phylum: Arthropoda																														
Subphylum: Crustacea																														
Class: Maxillopoda																														
Subclass: Copepoda (parasitic)																														
Family: Chondracanthidae																														
Chondracanthidae Indeterminate							8			8																				
Order: Siphonostomatoida																														
Siphonostomatoida Indeterminate																											8			8
Class: Malacostraca																														
Order: Cumacea																														
Cumacea Indeterminate							4			4																				
<i>Diastylis</i> sp.																1			1											
Order: Isopoda																														
<i>Munna frabricii</i>																1			1	8			2				12			22
Order: Amphipoda																														
Family: Caprellidae																														
<i>Caprella ciliata</i>																					28			5						33
Family: Corophiidae																														
<i>Crassikorophium bonellii</i>				14			4			18																				
Family: Dexaminidae																														
<i>Guernea cf. nordenskioldi</i>																				20	24		5							49
Family: Eusiridae																														
<i>Rhachotropis</i> sp.																					12			7				8	4	31
Family: Ischyroceridae																														
cf. <i>Parajassa</i> sp.					10		8	4		22							1		1		4							8		12
Family: Lysianassidae																														
<i>Hippomedon</i> sp.											4	4					1		9											
Family: Melitidae																														
<i>Melita</i> sp.							4			4																				
Family: Oedicerotidae																														

Benthic Invertebrate	Project Footprint (I1)										Reference 1 (R1)										Reference 2 (R2)									
	18-Aug-11										20-Aug-11										20-Aug-11									
	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite	Replicate 1			Replicate 2			Replicate 3			Composite
	Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile		Adult	Int	Juvenile	Adult	Int	Juvenile	Adult	Int	Juvenile	
Oedicerotidae Indeterminate						24			8	32			8			4		1	3	16			56			24			4	84
Ameroculodes sp.													12				3			15		8			2					10
Bathymedon sp.											8				8			4		20										
Family: Photidae																														
Gammaropsis sp.											24		4				9			37		4			2	2				9
Family: Stenthoidea																														
Stenothoidea Indeterminate					3					3																				
Metopella carinata (accepted as Hardametopa carinata)																					12	4			7			4		27
Family: Podoceridae																														
Podoceridae Indeterminate																								2						2
Family: Zopfiaceae																														
Pontoporeia femorata					7			4		11	28	16	4	4	8		25	32	3	120	4				5	14	1	8		32
Suborder: Gammaridea																														
Gammaridea Indeterminate																		2		2	8		4							12
Order: Decapoda																														
Hyas coarctatus																						1								1
Phylum: Bryozoa																														
cf. Bowerbankia sp.																											4			4
Crisia spp.																					4									4
Reginella spp.																					4			2				8		14
Scrupocellaria spp.																					4			2				4		10
Tubulipora spp.					3					3											4			2			4			10
Subphylum: Urochordata (accepted as Tunicata)																														
Tethyum sp.							1			1																				
Total Number of Organisms by Stage	21	3	1	1,920	328	148	2,052	632	120	-	728	256	136	779	309	112	814	329	127	-	1,958	424	188	1,479	235	103	1,796	509	89	-
Total Number of Organisms	25			2,396			2,804			5,225	1,120			1,200			1,270			3,590	2,570			1,817			2,394			6,781
Total organisms per m ²	1,082			103,711			121,364			226,157	48,476			51,939			54,969			155,384	111,236			78,644			103,618			293,499

APPENDIX D

Fish Catch Data

Table D1: Fish Catch Data from Itivia Harbour and Reference Areas

Area	Distance	UTM (Zone 15V)		Gear ¹	Date	Set Time	Retrieval Time	Set Duration (h)	Tide Level at Set (m) ²	Tide Level at Retrieval (m) ³	Offshore Depth at Set (m)	Tidal Current	Fish Catch ⁴							Species Richness	Catch per Unit Effort (CPUE)						
		Easting	Northing										ASC	FHS	GLC	SEB	SHS	SSP	Total		ASC	FHS	GLC	SEB	SHS	SSP	Total
I1	Nearshore	– ^c	– ^c	GN-F	16-Aug-11	9:11	11:30	2.32	3.15	1.20	1.7	Ebb	–	12	1	–	–	–	13	2	0.00	5.18	0.43	0.00	0.00	0.00	5.61
R1	Nearshore	– ^c	– ^c	GN-S	16-Aug-11	9:43	12:00	2.28	2.73	0.80	12.7	Ebb	–	–	5	5	–	1	11	3	0.00	0.00	2.19	2.19	0.00	0.44	4.82
R2	Offshore	– ^c	– ^c	GN-S	16-Aug-11	12:45	16:00	3.25	0.58	2.20	10.5	Flood	–	–	7	3	–	–	10	2	0.00	0.00	2.15	0.92	0.00	0.00	3.08
I1	Offshore	– ^c	– ^c	GN-S	16-Aug-11	13:00	16:30	3.50	0.50	2.65	7.5	Flood	1	–	14	2	–	–	17	3	0.29	0.00	4.00	0.57	0.00	0.00	4.86
R1	Nearshore	545349	6963907	GN-S	17-Aug-11	14:42	17:10	2.47	0.87	2.73	11.6	Flood	–	–	10	3	–	–	13	2	0.00	0.00	4.05	1.22	0.00	0.00	5.27
R2	Nearshore	544654	6962593	GN-S	17-Aug-11	15:15	17:40	2.42	1.20	3.13	8.3	Flood	–	–	4	–	–	1	5	2	0.00	0.00	1.66	0.00	0.00	0.41	2.07
I1	Nearshore	546261	6963554	BS	17-Aug-11	16:00	–	–	1.80	–	1.5	Flood	–	–	–	–	–	–	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R1	Nearshore	545352	6963948	BS	17-Aug-11	16:35	–	–	2.27	–	1.5	Flood	–	–	–	–	–	–	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
I1	Nearshore	546253	6963556	GN-F	19-Aug-11	10:30	14:55	4.42	3.20	0.91	4.2	Ebb	–	8	3	–	–	1	12	3	0.00	1.81	0.68	0.00	0.00	0.23	2.72
R1	Offshore	545289	6963845	GN-S	19-Aug-11	10:45	15:55	5.17	3.05	1.18	15.2	Ebb	–	–	9	2	1	1	13	4	0.00	0.00	1.74	0.39	0.19	0.19	2.52
I1	Offshore	546185	6963427	GN-S	19-Aug-11	15:20	19:42	4.37	1.00	3.58	8.2	Flood	–	–	12	5	–	–	17	2	0.00	0.00	2.75	1.15	0.00	0.00	3.89
R2	Offshore	544695	6962658	GN-S	19-Aug-11	16:20	20:15	3.92	1.43	3.73	7.6	Flood	1	–	8	6	1	–	16	4	0.26	0.00	2.04	1.53	0.26	0.00	4.09
R1	Offshore	545319	6963844	GN-S	20-Aug-11	8:50	12:37	3.78	3.57	2.17	15.7	Ebb	–	2	3	3	–	–	8	3	0.00	0.53	0.79	0.79	0.00	0.00	2.11
R2	Nearshore	544627	6962611	GN-S	20-Aug-11	9:20	12:13	2.88	3.57	2.45	12.7	Ebb	–	2	4	–	1	–	7	3	0.00	0.69	1.39	0.00	0.35	0.00	2.43
I1	Offshore	546228	6963446	GN-F	20-Aug-11	16:18	20:00	3.70	1.32	3.40	7.7	Flood	–	–	1	13	–	–	14	2	0.00	0.00	0.27	3.51	0.00	0.00	3.78

NOTES:

¹ Gear: BS = Beach seine
GN-F = Floating gillnet
GN-S = Sinking gillnet

² Tide level at set and retrieval referenced to chart datum

³ Locations on Figures A-1 to A-3 (Appendix A) approximate

⁴ Fish Species: ASC = Arctic sculpin
FHS = fourhorn sculpin
GLC = Greenland cod
SEB = slender eelblenny
SHS = staghorn sculpin
SSP = unidentified sculpin (juvenile)

APPENDIX E

Individual Fish Data

Table E1: Individual Fish Data from Itivia Harbour and Reference Areas

Date	Area	Distance	Set No.	Gear ¹	Species	Retrieval Time	Length (mm)	Weight (g)	Fulton's Condition (K) ²	External Condition	Depth	Comments
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	220	110.8	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	225	97.4	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	295	249.5	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	315	261.7	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	235	126.2	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	240	140.5	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	285	247.7	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	230	105.2	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	260	186.5	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	205	83.7	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	245	150.7	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	FSC	11:30	245	134.6	–	–	Lead line	
16-Aug-11	I1	Nearshore	1	GN-F	GLC	11:30	300	-	–	–	Lead line	Fell off net before in boat
16-Aug-11	R1	Nearshore	1	GN-S	GLC	12:00	495	1400	1.15	–	Lead line	2 sculpins in stomach
16-Aug-11	R1	Nearshore	1	GN-S	GLC	12:00	370	400	0.79	–	Lead line	
16-Aug-11	R1	Nearshore	1	GN-S	GLC	12:00	285	233.5	1.01	–	Lead line	
16-Aug-11	R1	Nearshore	1	GN-S	GLC	12:00	300	273.3	1.01	–	Lead line	
16-Aug-11	R1	Nearshore	1	GN-S	GLC	12:00	220	94.6	0.89	–	Lead line	
16-Aug-11	R1	Nearshore	1	GN-S	SEB	12:00	235	38	–	–	Lead line	
16-Aug-11	R1	Nearshore	1	GN-S	SEB	12:00	195	21.5	–	–	Lead line	Dead
16-Aug-11	R1	Nearshore	1	GN-S	SEB	12:00	270	34.5	–	–	Lead line	
16-Aug-11	R1	Nearshore	1	GN-S	SEB	12:00	-	-	–	–	–	Fell off net before in boat
16-Aug-11	R1	Nearshore	1	GN-S	SEB	12:00	310	47.5	–	–	Lead line	
16-Aug-11	R1	Nearshore	1	GN-S	SSP	12:00	120	10.5	–	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	GLC	16:00	300	24.5	0.09	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	GLC	16:00	320	336.3	1.03	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	GLC	16:00	315	344.8	1.10	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	GLC	16:00	405	600	0.90	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	GLC	16:00	440	900	1.06	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	GLC	16:00	450	950	1.04	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	GLC	16:00	500	1000	0.80	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	SEB	16:00	240	39.5	–	–	Lead line	

Date	Area	Distance	Set No.	Gear ¹	Species	Retrieval Time	Length (mm)	Weight (g)	Fulton's Condition (K) ²	External Condition	Depth	Comments
16-Aug-11	R2	Offshore	1	GN-S	SEB	16:00	245	36.5	–	–	Lead line	
16-Aug-11	R2	Offshore	1	GN-S	SEB	16:00	230	30.6	–	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	240	123.2	0.89	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	295	250.8	0.98	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	340	371.9	0.95	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	215	99.5	1.00	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	280	221	1.01	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	295	465	1.81	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	335	400	1.06	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	370	500	0.99	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	355	350	0.78	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	380	550	1.00	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	400	700	1.09	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	415	900	1.26	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	450	950	1.04	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	GLC	16:30	400	600	0.94	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	ASC	16:30	270	215.5	–	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	SEB	16:30	245	35	–	–	Lead line	
16-Aug-11	I1	Offshore	1	GN-S	SEB	16:30	265	47	–	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	320	300	0.92	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	375	450	0.85	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	380	450	0.82	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	395	450	0.73	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	405	700	1.05	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	485	1200	1.05	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	185	130	2.05	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	185	100	1.58	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	-	-	–	–	–	Fell off net before in boat
17-Aug-11	R1	Nearshore	2	GN-S	GLC	17:10	-	-	–	–	–	Fell off net before in boat
17-Aug-11	R1	Nearshore	2	GN-S	SEB	17:10	180	50	–	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	SEB	17:10	200	100	–	–	Lead line	
17-Aug-11	R1	Nearshore	2	GN-S	SEB	17:10	260	200	–	–	Lead line	
17-Aug-11	R2	Nearshore	1	GN-S	GLC	17:40	340	450	1.14	–	Lead line	

Date	Area	Distance	Set No.	Gear ¹	Species	Retrieval Time	Length (mm)	Weight (g)	Fulton's Condition (K) ²	External Condition	Depth	Comments
17-Aug-11	R2	Nearshore	1	GN-S	GLC	17:40	345	500	1.22	–	Lead line	
17-Aug-11	R2	Nearshore	1	GN-S	GLC	17:40	355	500	1.12	–	Lead line	
17-Aug-11	R2	Nearshore	1	GN-S	GLC	17:40	450	850	0.93	–	Lead line	
17-Aug-11	R2	Nearshore	1	GN-S	SSP	17:40	110	9	–	–	Lead line	Appears eggs released
19-Aug-11	I1	Nearshore	2	GN-F	Crab spp.	14:55	90 x 70	169.7	–	–	Lead line	Length = carapace measurement; barnacles, kelp & 1 ascidian on carapace; photos 145-151
19-Aug-11	I1	Nearshore	2	GN-F	GLC	14:55	305	314.9	1.11	–	Lead line	Dead
19-Aug-11	I1	Nearshore	2	GN-F	GLC	14:55	-	-	–	–	Lead line	Fell off net before in boat
19-Aug-11	I1	Nearshore	2	GN-F	GLC	14:55	-	-	–	–	Lead line	Fell off net before in boat
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	298	273.7	–	–	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	300	263.4	–	–	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	285	216.2	–	BSP	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	260	174.5	–	–	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	265	178.5	–	BSP	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	268	199	–	BSP	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	275	205.1	–	BSP	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	FSC	14:55	270	187.8	–	–	Lead line	
19-Aug-11	I1	Nearshore	2	GN-F	SSP	14:55	118	19.3	–	–	Lead line	Appears immature/juvenile
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	430	900	1.13	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	250	144.9	0.93	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	403	500	0.76	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	385	550	0.96	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	423	600	0.79	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	250	136.2	0.87	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	300	301.9	1.12	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	318	263.2	0.82	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	GLC	15:55	130	19.9	0.91	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	SHS	15:55	210	111.9	–	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	SSP	15:55	120	15.4	–	–	Lead line	Appears immature/juvenile
19-Aug-11	R1	Offshore	1	GN-S	SEB	15:55	235	40.3	–	–	Lead line	
19-Aug-11	R1	Offshore	1	GN-S	SEB	15:55	230	44.3	–	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	450	100	0.11	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	480	135	0.12	–	Lead line	Dead
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	485	135	0.12	–	Lead line	

Date	Area	Distance	Set No.	Gear ¹	Species	Retrieval Time	Length (mm)	Weight (g)	Fulton's Condition (K) ²	External Condition	Depth	Comments
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	330	350	0.97	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	345	350	0.85	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	420	900	1.21	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	380	600	1.09	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	430	800	1.01	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	300	271	1.00	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	295	248	0.97	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	270	219	1.11	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	GLC	19:42	170	56	1.14	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	SEB	19:42	305	35	–	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	SEB	19:42	245	37	–	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	SEB	19:42	255	45	–	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	SEB	19:42	222	28	–	–	Lead line	
19-Aug-11	I1	Offshore	2	GN-S	SEB	19:42	235	35	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	520	1450	1.03	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	380	600	1.09	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	325	350	1.02	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	396	550	0.89	–	Lead line	Missing top corner of caudal fin
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	130	18.3	0.83	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	118	15.1	0.92	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	127	17.8	0.87	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	GLC	20:15	130	22.4	1.02	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	ASC	20:15	370	700	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	SHS	20:15	215	121.5	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	SEB	20:15	245	49.3	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	SEB	20:15	225	36.3	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	SEB	20:15	287	61.3	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	SEB	20:15	260	60.8	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	SEB	20:15	255	47.3	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	SEB	20:15	290	61.2	–	–	Lead line	
19-Aug-11	R2	Offshore	2	GN-S	Crab spp.	20:15	–	–	–	–	Lead line	Fell off net before in boat; appeared to be different spp than previous one caught at I1-N, no decorations on carapace; looked similar to king crab but smaller; ~ 5" carapace & long thin legs and claws
19-Aug-11	R2	Offshore	2	GN-S	Crab spp.	20:15	–	–	–	–	Lead line	Fell off net before in boat; appeared to be different spp than previous one caught at I1-N, no decorations on carapace; looked similar to king crab but smaller; ~ 5" carapace & long thin legs and claws

Date	Area	Distance	Set No.	Gear ¹	Species	Retrieval Time	Length (mm)	Weight (g)	Fulton's Condition (K) ²	External Condition	Depth	Comments
20-Aug-11	R2	Nearshore	2	GN-S	GLC	12:13	290	298	1.22	–	Lead line	
20-Aug-11	R2	Nearshore	2	GN-S	GLC	12:13	290	294	1.21	–	Lead line	
20-Aug-11	R2	Nearshore	2	GN-S	GLC	12:13	410	650	0.94	–	Lead line	
20-Aug-11	R2	Nearshore	2	GN-S	GLC	12:13	420	550	0.74	–	Lead line	Appears to have been net caught before
20-Aug-11	R2	Nearshore	2	GN-S	FSC	12:13	240	129.6	–	–	Lead line	
20-Aug-11	R2	Nearshore	2	GN-S	FSC	12:13	255	114.7	–	–	Lead line	
20-Aug-11	R2	Nearshore	2	GN-S	SHS	12:13	145	33.7	–	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	GLC	12:37	295	276.3	1.08	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	GLC	12:37	430	900	1.13	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	GLC	12:37	125	15.6	0.80	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	ASC	12:37	315	348	–	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	ASC	12:37	242	149.3	–	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	SEB	12:37	290	43	–	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	SEB	12:37	305	52	–	–	Lead line	
20-Aug-11	R1	Offshore	2	GN-S	SEB	12:37	228	35.1	–	–	Lead line	Dead - head bitten
20-Aug-11	I1	Offshore	3	GN-F	GLC	20:00	280	214.1	0.98	–	Lead line	Dead
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	235	40.8	–	–	Lead and Middle	All SEB caught on last panel of net (near/on a reef); this panel
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	260	54.5	–	–	Lead and Middle	Straddled the shallow water column (from surface to bottom)
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	240	41.4	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	210	28.3	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	235	36.6	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	265	37.6	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	250	37.9	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	235	38.4	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	235	43.5	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	220	31.9	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	220	33.2	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	215	36.7	–	–	Lead and Middle	
20-Aug-11	I1	Offshore	3	GN-F	SEB	20:00	270	37.9	–	–	Lead and Middle	

NOTES:

¹ Gear: GN-F = Floating gillnet
GN-s = Sinking Gillnet

² Fulton's Condition Factor (K) = (W / L³) x 10⁵ where W = weight (g) and L = length (mm)

APPENDIX F

Laboratory Methods

BIOLOGICA ENVIRONMENTAL SERVICES

SAMPLE METHODS

Field Collection and Preservation

Once the samples are collected they are washed from the grab and placed in a large container labeled with the station and replicate number. The samples are then delivered to personnel for screening. The samples should be screened into the sample fractions required in the field (ie. 1.0mm, 0.5mm). The wash water is filtered with a 250 µm or smaller screen fitted on the intake hose to prevent planktonic organisms or other debris from entering the sample. Samples are washed in portions to minimize the time organisms are in contact with the screen. Any visible fragile organisms are removed and preserved separately during the washing process to prevent damage. Also, if there is any large debris such as rocks or wood debris they are removed and preserved in a separate container to prevent damage to the organisms.

Once the portion on the screen has been washed thoroughly the sediment was washed off the screen down into a corner of the pan for easy transfer into the sample jar. The washed sample fractions were then placed into an appropriately labeled container. After the entire sample was washed buffered formalin was added until a final concentration of 10% was achieved. The preservative was mixed in by gently rolling the sample jars. Calcium carbonate chips were added along with the collection labels. Adhesive waterproof labels were also placed on the exterior of the sample containers. Any samples taking up more than one container were labeled in series (ex "1 of 3", "2 of 3", etc.).

Laboratory Washing

Upon arrival at the laboratory, samples are inventoried and checked against chain-of-custody forms. Sample numbers and other information are entered into our record journal and samples are assigned Biologica reference numbers to facilitate labelling and record-keeping. Original field labels will be kept with the samples throughout the sample processing procedures and are retained with the debris.

After the samples are received they are transferred from formalin to alcohol. The sample material is gently washed on a geological screen to remove the formalin and any residual fine sediment. A screen size of at least half that of the field collection screen size (*i.e.* 0.500 mm) is used to retain soft-bodied organisms or fragments that may have shrunk during preservation. Larger samples are washed in portions to maximize washing efficiency and prevent loss of material. All material retained on the sieve is returned to the originally labelled plastic jar and preserved in 70% (v/v) ethanol. All original internal and external labels remain with re-screened sample material. Formalin is collected for disposal in an appropriate manner.

BIOLOGICA ENVIRONMENTAL SERVICES

Splitting Technique

Caton Tray

The design of the tray is from a model created by Larry Caton, a biologist with the US government in Oregon. His idea was to split the sample as it is being sorted. The trays vary in size and are chosen depending on how much sediment is being sorted (6 quadrat, 12 quadrat and 24 quadrat or greater). Each size of tray also varies in mesh opening (0.250 mm or 0.500 mm) depending on the opening in the field screens. Initially, the sample is spread over the top screen by placing the Caton tray over a pan of water so that the debris is floated. When the sample is evenly spread out, the tray is drained and the sorter collects debris from a randomly selected quadrat (labelled with a letter and a number) and sorts that debris. The selection of additional quadrats is repeated until the target number of 300-500 organisms has been reached. For example: If a 6 quadrat Caton tray is used and in the sorting of one quadrat the required critter-number is reached, then the sample is completed with the 1/6th portion. The 1/6th fraction will then be used to extrapolate for the whole sample.

Sorting Technique

A standard biological stain (Rose Bengal) is added to the samples to facilitate the sorting process. Rose Bengal targets protein, turning organisms pink or red and making them easier to separate from the sediment matrix of the sample.

Samples are sorted by trained technicians. Small fractions of a sample are placed in a dish and sorted with a dissecting microscope at 10x to 60x magnification. The dish is scanned systematically and all animals are removed using fine forceps. Each dish is sorted until no further organisms are recovered (each dish is sorted at least twice, regardless of number of organisms recovered). Organisms representing major taxonomic groups (Polychaeta, Crustacea, Mollusca, Echinodermata and Other Taxa) are sorted into individually, labelled vials containing 70% ethanol.

Benthic Invertebrate Identification

Identifications are performed by qualified taxonomists using stereo dissecting microscopes and high-power compound microscopes. All organisms found in the samples are enumerated and identified to the lowest practical taxonomic level. If organism fragments are present, only anterior portions are counted. Identifications are checked for consistency by the principal taxonomist.

Identified organisms are stored in 70% ethanol in glass storage vials, with labels indicating sample number, taxonomist and date.

BIOLOGICA ENVIRONMENTAL SERVICES

Internal QA/QC

25% of each sorters sorted samples are examined by a qualified sorter as a quality control measure. If the project requires QA re-sorts then each jar of sorted debris from each sample is examined. A portion of the sample from each jar is spread in a 9" x 13" white pan and examined under a dissecting microscope at 10x magnification. If more than three identifiable organisms are removed per 500 mL the sample is re-sorted.

Identifications of any new or unusual specimens are checked by the principal taxonomist.

Data Entry

The benthic data is entered into a Microsoft Excel table and checked against the taxonomist's bench sheets to ensure that no typographical errors were made. The raw data is forwarded to the lead contractor for analysis.

Total taxa per sample (species richness) is calculated in the following manner. Each species is counted as one taxon. Organisms which are identified to broader levels than species are counted if no organisms of the same type have been more precisely defined in the sample.

FRASER ENVIRONMENTAL SERVICES

METHODS MANUAL **JANUARY 1994**

Revised July 2011

By Linde Looy, R.P.Bio.

Fraser Environmental Services
9358 Cinnamon Drive
Surrey, B.C., V3V 1V2
Telephone and Fax (604) 588-9738

FRASER ENVIRONMENTAL SERVICES

METHODS MANUAL

Details of the analytical methods used by Fraser Environmental Services are described here. Our firm employs similar standard techniques to ensure consistency over time. The QA/QC procedures employed can be found in the QA/QC Manual.

Phytoplankton Identification and Enumeration

Scope :

This method describes the identification and enumeration of phytoplankton.

Summary :

The sample is settled overnight and the slide is examined. Using the appropriate keys and procedures, phytoplankton can then be identified and subsequently enumerated.

Apparatus :

1. Utermohl-type settling chambers
2. Inverted microscope
3. Compound microscope
4. Appropriate taxonomic keys

Reagents :

1. Lugol's Solution : prepared as outlined in **Standard Methods for the Examination of Water and Wastewater**.

Procedure :

1. Calibrate the microscope using stage and ocular micrometers (see Section 1, page 8 for procedure).
2. Confirm that the sample is appropriately preserved.
3. Settle out an appropriate sample volume randomly removed depending on the density of organisms (usually 100 mL) for approximately 24 hours. Use smaller or diluted volumes for densely populated samples or concentrate sparsely populated samples by centrifugation or by sedimentation.
4. Scan the entire slide at increasing powers of magnification to determine which species/genera are present. Identify the organisms observed to the requested level if possible.
5. Once the identifications are made, do the counts. Count at least 20 random fields, continue counting until you get a total count of at least 100 for the dominant species if possible. Statistical tests for randomness have been performed.

6. Enumerate the data by a total cell count (cells/mL). Calculate the per mL total for each species or genera by multiplying the actual count by the factor F as defined below :

$$F = \frac{A / r^2 \pi N}{V}$$

where A= the area of the settling chamber
r= the radius of the field
N= the number of fields counted
V= the volume settled

Taxonomic Keys :

1. Bourrelly, P. (1966)
2. Cleve-Euler, A. (1951)
3. Cleve-Euler, A. (1968)
4. Contant, H. (1978)
5. Dodd, J. (1947)
6. Germain, H. (1981)
7. Hustedt, F. (1930)
8. Hustedt, F. (1985)
9. Komarek, J. and K. Anagnostidis. (1999)
10. Patrick, R. (1966)
11. Patrick, R. (1975)
12. Pennak, R. (1953)
13. Prescott, G. (1978)
14. Prescott, G. (1982)
15. Stein, J. (1975)
16. Ward, H.B. (1959)
17. Webber, C. (1966)

Note : Other taxonomic keys may be used.

References :

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Bourrelly P. 1966. **Les Algues D'Eau Douce. Initiation a la systematique. Tome 1. Les Algues Vertes.**

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Contant, Helene and Duthie, Hamish C. 1978. **The Phytoplankton of Lac St-Jean, Quebec.** Bibliotheca Phycologica, Band 40.

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Hustedt, Friedrich. 1930. **The Bacillariophyta.**

Hustedt, Friedrich. 1985. **The Pennate Diatoms.**

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Periphyton Identification and Enumeration

Scope :

This method describes the identification and enumeration of periphyton.

Summary :

The sample is settled for at least two hours and the slide is examined. The minimum settling time is dependent on the volume of the chamber used. Using the appropriate keys and procedures, periphyton can then be identified and subsequently enumerated.

Apparatus :

1. Utermohl-type settling chambers
2. Inverted microscope
3. Compound microscope
4. Appropriate taxonomic keys

Reagents :

1. Lugol's Solution : prepared as outlined in **Standard Methods for the Examination of Water and Wastewater**.
2. Hyrax mounting medium (or other medium with similar optical properties).

Procedure :

1. Calibrate the microscope using stage and ocular micrometers (see Section 1, page 8 for procedure).
2. Confirm that the sample is appropriately preserved. Measure and record the total volume of the sample.
3. Settle out an appropriate sample volume randomly removed, depending on the density of organisms for approximately 4 hours. Use smaller or diluted volumes for densely populated samples or concentrate sparsely populated samples by centrifugation or by sedimentation.
4. Scan the entire chamber at increasing powers of magnification to determine which species/genera are present. Identify the organisms observed to the requested level if possible.
5. If required prepare three diatom slides using either pyrolysis or acid digestion to clear the frustules. See Standard Methods for the Examination of Water and Wastewater for further details of these procedures.
6. Once the identifications are made, do the counts. From the settling chambers, count at least 10 random fields (at 1000X and/or 400X) continue counting until you get a count of at least 100 for the dominant species. Count at least one transect at 400X and two transects at 200X for more accurate counts of the less dominant species (optional).
7. Enumerate the data by a total cell count (cells/mL). Calculate the per mL total for

each species or genera by multiplying the actual count by the factor F as defined below :

$$F = \frac{A / r^2 \pi N}{V}$$

where A= the area of the settling chamber
r= the radius of the field
N= the number of fields counted
V= the volume settled

The cells per total sample can then be determined by multiplying by the total sample volume. Then divide by the area sampled to get cells per cm². In other words the count can be multiplied by factor P as defined below to get cells per cm² :

$$P = \frac{FD V_t}{A_s}$$

where F = the factor defined previously
D = the dilution
V_t = the total sample volume
A_s = the area sampled (cm²)

Taxonomic keys:

1. Bourrelly, P. (1966, 1968 & 1970)
1. Cleve-Euler, A. (1951)
2. Cleve-Euler, A. (1968)
3. Contant, H. (1978)
4. Dodd, J. (1947)
5. Geitler, L. (1932)
6. Germain, H. (1981)
7. Huber-Pestalozzi, G. (1938, 1941, 1961, 1955, 1972 & 1983)
8. Hustedt, F. (1930)
9. Hustedt, F. (1985)
10. Komarek, J. and K. Anagnostidis. (1999)
11. Krammer K. and H. Lange-Bertalot. (1986, 1988, 1991 & 2000)
12. Patrick, R. (1966)
13. Patrick, R. (1975)
14. Pennak, R. (1953)
15. Prescott, G. (1978)
16. Prescott, G. (1982)
17. Stein, J. (1975)
18. Ward, H.B and C. G. Whipple. (1959)
19. Webber, C. (1966)

Note : Other taxonomic keys may be used.

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Zooplankton Identification and Enumeration

Scope :

This method describes the identification and enumeration of zooplankton.

Summary :

The sample is settled and the slide is examined. Using the appropriate keys and procedures, zooplankton can then be identified and subsequently enumerated.

Apparatus :

1. Sedgwick-Rafters
2. Inverted microscope
3. Compound microscope
4. Stereoscopic microscope
5. Appropriate taxonomic keys

Reagents :

1. Preservative such as 70% ethanol or 10% buffered formalin
2. 0.04% rose bengal stain

Procedure :

1. Confirm that the sample is appropriately preserved. Measure and record the total volume of the sample.
2. Examine an appropriate sample volume depending on the density of organisms (usually 50 mL) in a petri dish. Use smaller or diluted volumes for densely populated samples or concentrate sparsely populated samples by centrifugation or by sedimentation.
3. Scan the entire sample at increasing powers of magnification to determine which species/genera are present. Identify the organisms observed to the requested level if possible.
4. Once the identifications are made, do the counts. Settle out a 1mL aliquot of a well mixed subsample in a Sedgwick-Rafter (concentrate sample if required), allow to settle for at least 15 minutes.
Count the entire cell using a strip counting method. Count at least 3 of the 1mL aliquots, continue counting until you get a total count of at least 100 zooplankton organisms if possible.
5. Enumerate the data by calculating the total number of organisms per sample for each species or genera. Take an average count for each species or genera from all the aliquots counted. This gives you an organisms per mL count. Now the volume can then be multiplied in to give you a count of organisms per total sample.

Alternative Procedure :

Each sample is rinsed and sieved with water through a 64 micron Nitex sieve to remove the preservative. Each sample is made up to 100mL and a Hensen-Stemple pipette is used to remove 10 mL into another beaker (1/10 sub-sample), and that is made up to 100 mL and 10 mL removed for examination (1/100 sub-sample). The contents of the smallest sub-sample are identified to the lowest taxon and life-stage, and enumerated. Those species that occur in numbers fewer than about 10 (unless extremely small) are then looked for in the larger sub-samples. Thus, the largest and rarest organisms will be counted in their entirety, whereas the numbers of the smallest and commonest will be extrapolated.

Taxonomic Keys :

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2. Brandlova, J. et. al (1972)
3. Brooks, J.L. (1957)
4. Comita, G.W. et. al (1976)
5. Deevey, E.S. et. al (1971)
6. Edmondson, W.T. et. al (1959)
7. Edmondson, W.T. et. al (1982)
8. Fulton, J. (1968)
10. Green, G.D. et. al (draft)
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12. Green, G.D. et. al (1996)
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19. Smith, D.L. (1977)
20. Ward, H.B. et. al (1959)

Note : Other taxonomic keys may be used.

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APPENDIX G

Meeting Minutes with Kangiqliniq Hunters and Trappers Organization

MEETING WITH KANGIQLINIQ HUNTERS AND TRAPPERS ORGANIZATION

July 15, 2011 at 12:00 pm

Turaarvik Inns North Boardroom

Attendees: Carey Sibbald (Nunami Stantec)
Norman Ford (HTO Secretary Manager)
John Tatty (HTO Board of Director)
Tिताaq Komaksiutiksak (HTO Secretary Treasurer)
Jack Kabvitok (HTO President)
Aline Kabvitok (HTO President's spouse)

HTO members were reviewing maps and Nunami's project description before lunch. At the start of meeting, HTO members brought up concerns with Agnico-Eagle Mines Ltd's (AEM's) plans for infrastructure in Itivia Harbour. Community members use Itivia Harbour all the time for launching boats, right where AEM plans to construct their floating wharf. It is the only place that is accessible during low tide; the other harbour (with the dock/breakwater) is not accessible during low tide. They are concerned that the AEM use of Itivia Harbour will take away the boat launch for the community. Then what? Community will need to be compensated with another spot, fixed up for launching boats.

- 1) Introduced myself and Nunami Stantec; explained we're hired by AEM to conduct baseline study of marine fish and mammals in area of proposed floating wharf. Concerns will be communicated to AEM by Nunami however HTO should discuss concerns about infrastructure directly with AEM.
 - HTO understands and agreed
- 2) Inquired what type of fish people in Rankin Inlet catch? Where do they typically catch them and where do they come from?
 - People catch Arctic char, sculpin and cod
 - Catch char right at Itivia Harbour; there are cabins on either side of the harbour where people spend the summer; catch char there
 - Char usually come from the Diane River and Char River
 - Sculpins are caught everywhere; now only Elders eat them once in awhile, people used to eat them more often
 - People also collect a lot of mussels and clams all along the north shore of Melvin Bay during low tide

- John noted that he supports Nunami's study but notes the area is very important to locals; feels the owners of the cabins along Itivia Harbour have been or will be ignored; feels they should be compensated; would like to have more discussion with AEM regarding their plans
 - HTO members noted the Itivia Harbour route is very important in the winter for skidoo travel in and out of the community
 - HTO members also noted that the Itivia Harbour areas is very important because when barges (fuel, etc) come in, they block the entrance to the dock/breakwater harbour (in Johnston Cove); this forces boaters to go around the barges which is dangerous because it is very shallow; many people run aground. They boaters currently have Itivia Harbour though and they can use that when the barges come in.
 - HTO President also noted they've noticed an impact in Itivia since there has been more traffic – less fish come in than they used to. Itivia used to be a really good fishing spot in 1960s and 1970s for Arctic char, sculpin and cod. Seal harvesting used to be good there too but now there's hardly any.
- 3) When is the best time to fish around Rankin Inlet? When do the char come?
- August is usually the best time around the community but now don't catch as much as they used to
- 4) Does anyone in Rankin Inlet participate in commercial fishing?
- Yes, people do do some commercial fishing, usually travel 25 to 30 miles out and catch a lot of char. Used to be catch closer to shore but now have to travel further away
- 5) Have mentioned people catch fish, mammals and mussels and clams, does anyone harvest seaweed?
- No, no seaweed harvesting
 - HTO noted that people used to catch baby sculpin and mussels from along the shore during low tide, eat them raw; now with fuel and oil spills they don't eat them anymore
 - Department of Health told them mussels near the community are not good to eat anymore so have to go further away to catch them
- 6) Have mentioned people hunt seals, where do people usually hunt them and what types?
- Used to catch seals near the community but now have to go further away
 - Usually catch Ring, Harbour and Bearded seals, also catch beluga; people also travel north to Repulse Bay to catch narwhal
 - At the dock/breakwater harbour, there used to be a lot of marine wildlife/mammals coming in, now not anymore

- 7) When does freeze up and break up usually happen?
- Freeze up usually happens in mid to late October or early November; has changed in the last 10 years, used to freeze in mid-October
 - Also now it breaks up faster, usually in early to mid July
 - Have noticed the ice free period has gotten longer
- 8) Have mentioned you've noticed impacts in Itivia Harbour due to more traffic, do you think the additional traffic due to the proposed plans will further affect marine life?
- Yes, think so; more traffic will have an effect. Definitely for marine mammals; noted people have seen it in Chesterfield Inlet – there are less seals and whales that come into the Inlet due to the increase in traffic going to Baker Lake
- 9) Do you know what Arctic char eat when they are in the ocean?
- They eat little shrimp and small, shiny minnow-like fish, not sure what they are, maybe baby capelin; seals hunt and eat the small fish too
 - There are large schools of the small fish on the north side of the Peninsula
- 10) HTO noted several additional items:
- Have noticed a decrease in Arctic terns and guillemots; there was a ban on egg collecting in 2007 for five years, just finished this year; AEM's proposed plans may affect birds too, not just marine mammals and fish. There are less terns and guillemots around, have also noticed it for sandpiper birds along the shore and birds like sandpipers but larger (maybe yellowlegs or plovers?). Think the birds are moving further north with the cooler weather.
 - HTO is concerned about how much room hunters will have with the proposed floating barge and crane at Itivia Harbour; want full access to the area all of the time, and not having to "come back when we're (AEM) is less busy"
 - People also use the reef that is at the end of the floating barge to anchor and shelter their boats
 - Students have been doing studies on peregrine falcon and rough-legged hawk around the area and on Panorama Island for the last 20 to 25 years; they will have concerns about the Itivia Harbour infrastructure and traffic too; noted falcons or hawks will dive in the water (ocean) if they see a fish swimming on the surface
- 11) Confirmed tides in Rankin Inlet
- Itivia area is always accessible during low tide
 - Tides range from 10 to 20 feet depending on the moon and day

12) If any of the char Nunami catches dies, what would the HTO like us to do with it?

- Give the fish to the HTO, we will distribute it around

13) Have mentioned that the Itivia Harbour area is very busy with local people and their boats; what's the best way for Nunami to put our nets in? Just have two buoys on either end?

- Yes, just have two big buoys in either end; make it visible and obvious that it's a net and it will be fine

14) HTO asked Nunami several questions:

- Wondered if we knew why the char flesh is turning more white than it used to, used to be more red; is it because of more chemicals in the water? What causes that? – Noted we've heard it before in other communities, might be due to a change in the fishes diets, eating different things than they used to, or maybe because of chemicals if there are any, or different water temperatures; we'd would have to test the fish flesh to start to figure it out; we (Nunami) are not testing the fish flesh
- Wondered how we'll be catching fish, what kind of nets and what we're going to do with the fish – Noted we'll be catching fish with nets of different mesh sizes (six panels of all different sizes, from very small to large), set the nets perpendicular to shore; will also be using a seine net, with small mesh size, that we'll drive out from shore and then sweep back around to shore
- Wondered what we'd do if we catch a seal – noted Nunami really hopes not to catch a seal, we'll be setting the nets for 2 to 4 hours or less, and will be watching the nets; however if we do catch a seal we would give it to the HTO to give to people in the community
- Wondered if we caught a walrus, could we check it for trichinosis – noted that we couldn't check for trichinosis; would need to take a sample of the meat and look at it under a microscope; won't have a microscope
- HTO noted there will be ducklings swimming around when we're doing our study (around August 9th); how visible will our nets be to ducklings? – Noted we will try to make our nets as visible as possible to ducklings, do not want to catch any ducks
- HTO noted they would like a copy of our report on what we found – Noted we (Nunami) are producing two reports for AEM, which will become publicly available. Can probably develop a plain language summary of our report

Meeting adjourned at 1:30 pm



APPENDIX 8.2-B

Meliadine Spill Risk Assessment



April 2014

APPENDIX 8.2-B SPILL RISK ASSESSMENT

Final Environmental Impact Statement (FEIS) - Meliadine Gold Project, Nunavut

Submitted to:

Agnico Eagle Mines Limited
145 King Street East, Suite 400
Toronto, Ontario, Canada M5C 2Y7

REPORT



Report Number: Doc 439-1314280007 Ver. 0

Distribution:

1 Copy - Agnico Eagle Mines Limited
1 Copy - Golder Associates Ltd.





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APPENDICES

APPENDIX A

Extremal Analysis for Rankin Inlet and Coral Harbour Winds

APPENDIX B

ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

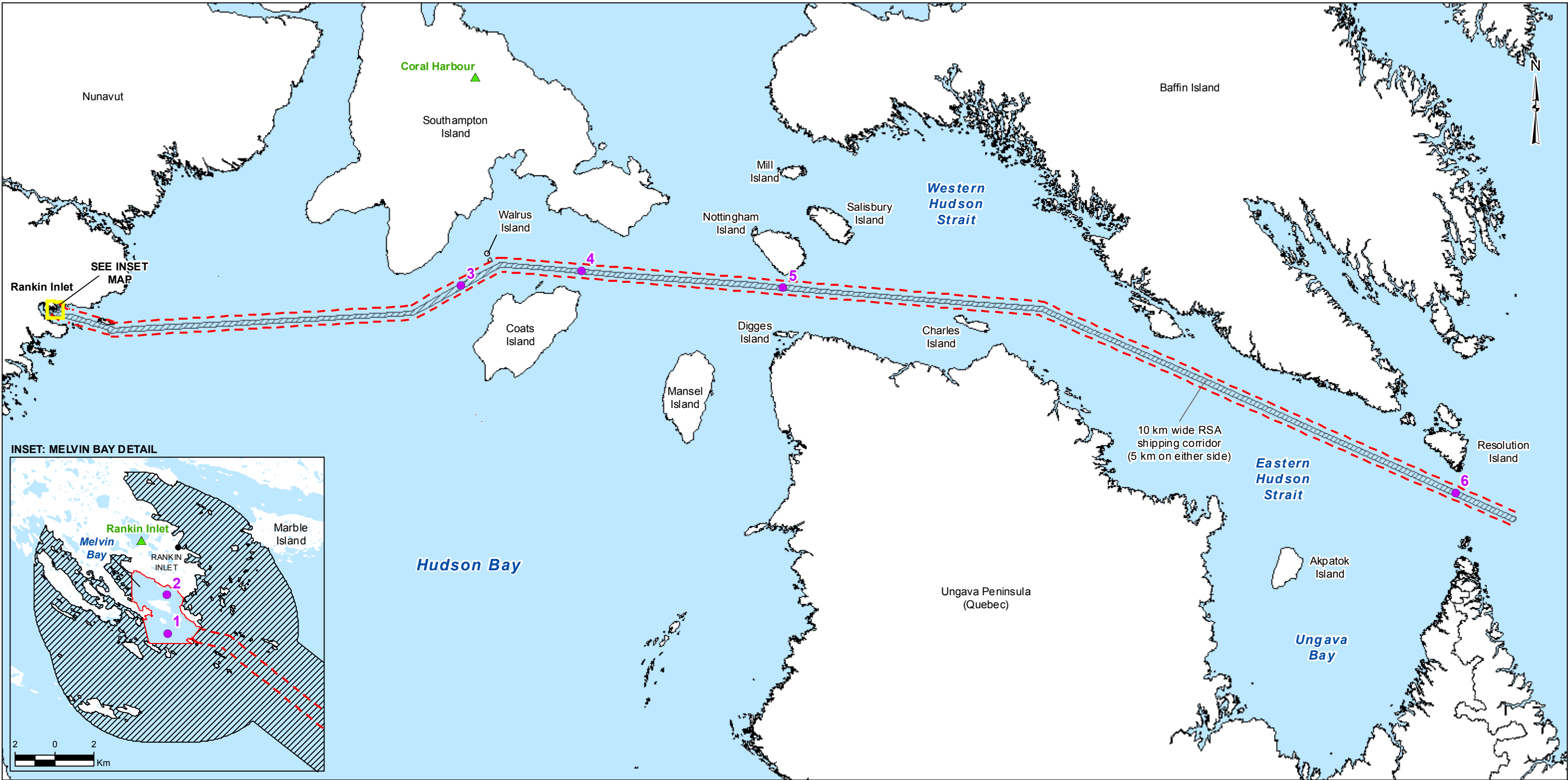


1.0 INTRODUCTION

This report presents a desktop level assessment of potential diesel fuel spill risk in the marine environment related to the Meliadine Gold Project (Project). The effects of fuel spills on sensitive biological receptors such as marine mammals and marine birds are discussed in Section 8.3.6.5 of the Final Environmental Impact Statement (FEIS) for the Meliadine Project. Golder Associates Inc. (Golder) has applied a modified version of the risk assessment strategy presented in ITOPF-TIP16 Contingency Planning for Marine Oil Spills (ITOPF 2011) based on existing Project information and available biophysical data in the Project area. This report includes an overview of oil spills in Canadian waters and potential open-water P50 diesel spills near Melvin Bay (ship-to-shore and ship-to-ship fuel transfer areas near Rankin Inlet) and along the main deep-draught shipping route used by Project vessels during Project construction and operations phases (Figure 8.2-B-1). The behavior of a diesel fuel spill in the marine environment was assessed at six different hypothetical spill locations in the Project area, considering aspects of evaporation, dispersion, spreading and potential distance traveled from the spill site. Two locations near Melvin Bay were considered in the assessment as these corresponded with ship-to-shore and ship-to-ship fuel transfer areas where a higher potential for fuel spills would occur (Figure 8.2-B-1). Four locations along the shipping route were also considered in the assessment as these corresponded with known sensitive/important coastal areas for marine mammals and/or marine birds; including Walrus Island, Coats Island, Ungava Peninsula, and Eastern Hudson Strait (Figure 8.2-B-1). This assessment considered a worse case spill scenario of two (2) Million Litres (ML) (2000 cubic metres [m^3]) of P50 diesel released at sites in Melvin Bay and along the shipping route. An additional spill scenario of a 100,000 litres (L) (100 metres m^3) spill was also considered at the ship-to-ship and ship-to-shore fuel transfer sites near Melvin Bay, representing smaller spills that could occur during fuel transfer activities.

The Project is primarily land-based with operations in the marine environment limited to six fuel tanker transits to Rankin Inlet from eastern North America during the open-water season (approximately August to October), and subsequent transfer of this fuel to shore using established fuel transfer locations near Melvin Bay. There was no Project-specific meteorological or oceanographic data collected as part of the baseline assessment for the Project; therefore, this assessment is based solely on information from existing literature and available third party data. Because of the limited marine operations planned for the Project, resulting in an overall low probability of a spill, this analysis was conducted with a simple fuel weathering model that does not include detailed hydrodynamic modelling.

N:\Bur_Graphics\Projects\2013\1428\13-1428-0007\GIS\Mapping\MXD\FEIS\Volume_8\Main_Volume\Appendix_8.2-B\Figure_8.2-B1_Spill_Risk_Assessment.mxd



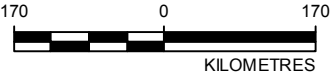
LEGEND

- MARINE REGIONAL STUDY AREA (MARINE RSA)
- MARINE LOCAL STUDY AREA (MARINE LSA)
- WATERBODY
- SHIPPING ROUTE (APPROXIMATE)
- WIND STATION
- HYPOTHETICAL FUEL SPILL RELEASE LOCATION

REFERENCE

CanVec Data Obtained from © Department of Natural Resources Canada. All rights reserved.
Nautical chart data obtained from the Canadian Hydrographic Service. Provincial data obtained from ESRI.
Datum: WGS 84 Projection: World Mercator

Location No.	Location Name	UTM 15 N East	UTM 15 N North
1	Ship-to-ship fuel transfer site outside Melvin Bay	546173	6961117
2	Ship-to-shore fuel transfer site in Melvin Bay	546143	6963142
3	Shipping route south of Walrus Island	944826	7015654
4	Shipping route north of Coats Island	1059514	7048456
5	Shipping route north of Ungava Peninsula	1258383	7072746
6	Shipping route in Eastern Hudson Strait	1982892	7102917



PROJECT

AGNICO EAGLE

TITLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

SPILL RISK ASSESSMENT
FOR SIX LOCATIONS

Golder Associates

PROJECT NO.	10-1373-0076	FILE No.
DESIGN	KZ	07 Feb. 2014
GIS	SGR	07 Feb. 2014
CHECK	PR	25 Feb. 2014
REVIEW	PR	25 Feb. 2014

SCALE AS SHOWN	REV.	0

FIGURE 8.2-B1



2.0 OIL SPILLS IN CANADIAN WATERS

No information is available in the public domain/published literature related to existing fuel spill rates (e.g. frequency of spills) in the Hudson Bay region, although broader-scale information is available. The Arctic Monitoring and Assessment Programme (AMAP 2010) conducted an assessment of the effects of oil and gas activities in the Canadian Arctic to quantify the potential impacts from oil spills to the Arctic ecosystem and human health. Spills in the Arctic are considered rare and are typically associated with tanker traffic, with the most common location of spills occurring near ports (ITOPF 2011). From 1972 to 2003, a total of 1,226 oil spills were reported in the Canadian Arctic region; equivalent to a total volume of 3.3 ML (3,300 m³) and a spill frequency of 2.5 spills per year. Of this total, 75 spills consisted of diesel fuel, equivalent to 334,000 L (334 m³) and a frequency of one spill every 0.4 years (AMAP 2010).

Transport Canada commissioned GENIVAR to prepare a risk assessment for marine ship-based spills in Canadian waters south of the 60° parallel (GENIVAR 2013). Refined product spill rates ranged from a return period of 1.7 years (i.e. one spill approximately every two years) for small spills (< 100 m³) to 42.2 years for large spills (1,000 to 10,000 m³) (GENIVAR 2013). According to the study, no spills larger than 10,000 m³ (10 ML) have occurred in Southern Canadian waters. No data was available specifically for the Canadian Arctic. GENIVAR is in the process of preparing a similar risk assessment for the Canadian Arctic, which is due to be completed in September 2014.

The trends of spill frequency have decreased over time due to improved technology, navigation, construction of vessels, and more stringent regulations (AMAP 2010; Anderson et al. 2012; GENIVAR 2013). Marine transportation in the Arctic is limited due to seasonal presence of ice. The lower frequency of ship transits in the Arctic region will downward bias spill rates calculated from Arctic data when compared to global statistics of spill frequency. However, as climate change causes a decrease in ice cover and the potential for transportation and other industrial activities in the Arctic increases, potential for spills may increase as well.

A study titled “Probability of Oil Spills from Tankers in Canadian Waters” by SL Ross Environmental Research Ltd. (SL Ross) predicts the frequency of oil spills from tankers in various areas of Canada (SL Ross 1999). The expected spill rate per year is calculated by multiplying the tonnage of oil loaded and unloaded at Canadian ports by spill frequencies derived from historical statistics. The expected spill rates for large (> 159,000 L) medium (8,000 to 159,000 L), and small (< 8,000 L) spills of product oil is 2.5, 12.3, and 36 spills per 10⁸ ML loaded or unloaded per year, respectively.

3.0 MARINE TRANSPORT OF DIESEL FUEL FOR THE MELIADINE PROJECT

The FEIS for the Meliadine Project states that approximately 122 ML (122,000 m³) of P50 diesel fuel will be delivered annually during operations. P50 is an Arctic diesel fuel with a lower temperature pour point than other diesel fuels. Based on the total volume of diesel fuel that will be transported throughout the life of the Project and spill rates reported by SL Ross (1999), the overall likelihood of a fuel spill for the Project is once every 36 years for small spills and once every 526 years for large spills. The approximate Project life that includes construction, operations, and closure is 18 years.



During construction and operations, approximately six large tankers will arrive to deliver P50 diesel fuel throughout the open-water shipping season. Each vessel trip will deliver approximately 20 ML (20,000 m³) of P50 diesel fuel. The large tankers will anchor in deeper waters outside of Melvin Bay upon arrival in Rankin Inlet (Figure 8.2-B-1). Large tanker to small tanker transfer of diesel fuel will occur at the large freighter anchor location. The carrying capacity of the small tanker will be either 7,300 m³ or 10,500 m³, depending on which vessel is used. Therefore, each of the six large tanker deliveries will take two to three trips to offload all of the fuel. The small tankers will anchor opposite Itivia and a floating pipeline of some 300 to 500 metres (m) will connect to a shore-based pipeline for transfer of fuel to the Project tank farm located near Itivia in Rankin Inlet. Fuel will be transferred through the pipeline at approximately 400 cubic metres per hour (m³/h) for about 18 to 26 hours (h), depending on the carrying capacity of the small tanker. Agnico Eagle Mines Limited (AEM) has prepared an Oil Pollution Emergency Plan (SD 8-2) that ensures necessary actions are taken to reduce or minimize the loss of diesel fuel. Communication between the small tanker and the shore will be maintained throughout the transfer to ensure the safe transfer of the diesel and to avoid overfilling of the tanks.

4.0 WEATHERING PROCESSES OF OIL SPILLS

The fate, toxic effect and weathering of an oil spill depends on the specific gravity, pour point, viscosity, constituent components, volume released, area of spreading, and the environmental conditions involved (ITOPF 2002). Environmental conditions include wind speed and direction, water depth, wave energy, solar radiation, current speed and direction, water temperature and distance to land. The weathering processes include dispersion, evaporation, spreading, adsorption to sediments, biodegradation, dissolution, emulsification, and photo oxidation (Figure 8.2-B-2). Dispersion, evaporation, and spreading are the primary processes for determining fate and transport of diesel fuel, which is the primary fuel type being used for the Project. Oil dispersion is largely dependent upon the type of oil and the sea state, dispersing most rapidly with low viscosity oils, in the presence of breaking waves (ITOPF 2002). The rate of evaporation depends on ambient temperatures, wind speeds, and type of fuel. The speed of spreading depends to a great extent on the viscosity of oil and the volume spilled.

Diesel fuel has a low viscosity and will weather rapidly when spilled into the marine environment (NOAA 2006). With a lower density than water, diesel fuel is readily dispersed by wave action. Over 90% of a small spill of diesel in the marine environment is either evaporated or naturally dispersed over a time scale of several hours to days (NOAA 2006).

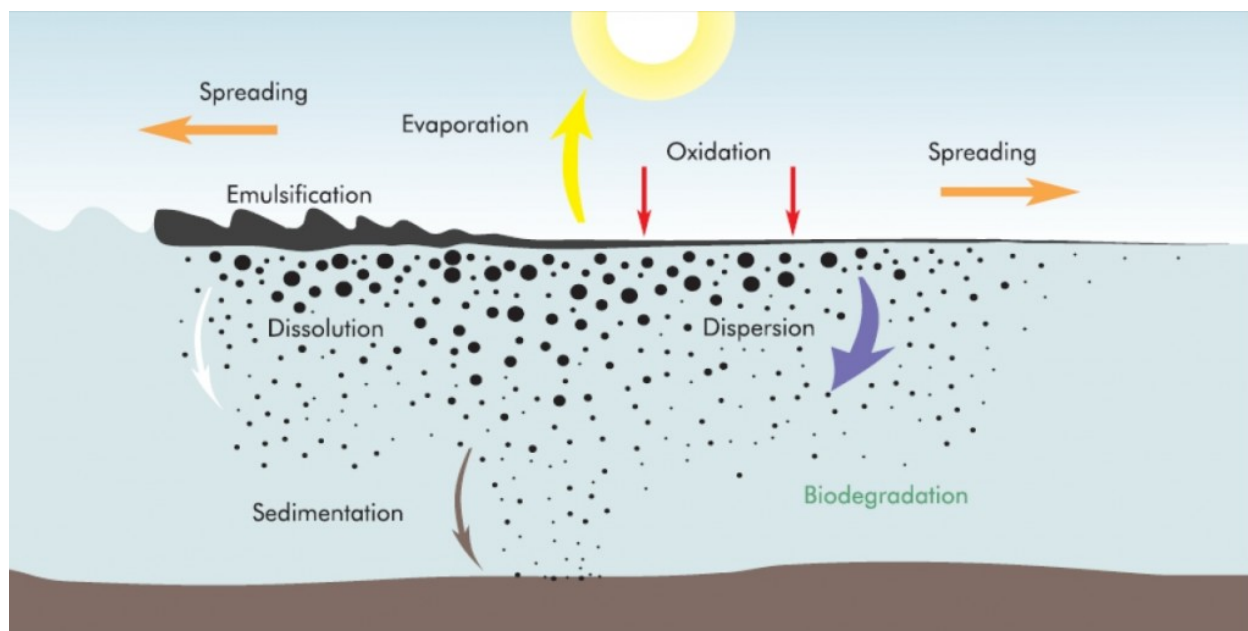


Figure 8.2-B-2: Weathering Processes Action on Spilled Oil. Source: ITOPF 2002.

5.0 DIESEL FUEL SPILL SCENARIOS

Previous research indicates that spill volumes are best expressed as being equivalent to 5% to 10% of the total fuel being transported (McKenna and McClintock 2005; Coastal Ocean Resources 2013). For this analysis, we considered a worst case spill scenario of 2 ML (2,000 m³) based on the conservative assumption of 10% of the total P50 diesel fuel (20 ML) being carried on a single ship for the Project.

The Automated Data Inquiry for Oil Spills (ADIOS2), an oil weathering model (NOAA 2014), was used to provide estimates of the expected characteristics and behavior of fuel spilled into the marine environment. We analyzed a 2 ML fuel spill at two locations near Melvin Bay and four locations along the shipping route. Additional scenarios of 100,000 L (100 m³) spills were analyzed at the two fuel transfer locations near Melvin Bay - these represent smaller-scale spills that could occur during transfer of fuel from ship-to-ship or ship-to-shore. One of the main causes of spills is usually due to navigational error where a tanker deviates from its planned track along the shipping route. The modelled scenarios assumed that the spill would occur near the center of the main shipping lane and that ships would not deviate from this route (Figure 8.2-B-1).



5.1 Model Parameters

ADIOS2 predicts changes over time in the density, viscosity, and water content of diesel fuel, including evaporation and dispersion rates. The following assumptions were made for model set-up:

- ADIOS 2 diesel fuel oil (Canada), equivalent to P50;
- Spill of 100,000 L (100 m³) and 2 ML (2000 m³) for near-shore spills;
- Spill of 2 ML (2000 m³) for shipping route spills;
- Sea salinity of 32 parts per thousand (ppt);
- Surface water and diesel fuel temperature of 5° Celsius (C);
- Sediment load of 5 milligrams per litre (mg/L);
- Spill occurs near the center of the proposed shipping lane; and
- Spill scenarios assume no mitigation.

Winds and waves are generally the driving physical forces used to determine the oil drift slick speed and distance travelled (DNV 2011). Golder analyzed winds from Rankin Inlet and Coral Harbour and performed an extremal analysis for 31-years of hourly data (Appendix A). For modeling simulations, Golder used mean, 2-year, and 50-year wind conditions. For the 31-year record, the majority of the winds from both stations originated from 343° (North-Northwest). For all scenarios, the fetch was measured along the axis of dominant wind direction from 343° to 163°. Summary tables and figures from the ADIOS2 model simulations inputs and outputs are shown in Appendix B.

In the ADIOS2 model and fuel transport analysis, it was assumed that currents have minimal influence on the transport of fuel towards shore. There has been no current data collected in the Rankin Inlet Itivia area and minimal measurements along the proposed shipping route. South of the proposed shipping route in Hudson Bay, currents have been modeled to predict the seasonal cycle of water masses and sea ice (Saucier et al. 2004; Wang et al. 1994). This circulation pattern is characterized by coastal currents flowing counter-clockwise along the southwestern portion of Hudson Bay towards James Bay, north along the eastern coast of Hudson Bay and through the southern Hudson Strait into the Labrador Sea. The surface eddy current is strongest during ice-free periods and reaches 15 to 20 centimetres per second (cm/s) (Saucier et al. 2004). The monthly mean current velocities in Hudson Bay are in the range of 4 to 6 cm/s (Wang et al. 1994). In the absence of time varying and site-specific current velocity information for Melvin Bay and the proposed shipping route, the ADIOS2 model was run with the optional input for current velocity set to zero. Current velocity along the western portion of the shipping route (Rankin Inlet to Coats Island) is predominantly forced by tides running along the axis of the route, but the eastern portion of the route through Hudson Strait east of Coats Island is dominated by the cyclonic circulation forcing a current to the east-southeast. These current patterns could enhance the rate at which the fuel would spread across the water surface, particularly along narrower portions of the route where current speeds can be enhanced and slicks would spread in the direction of the current.

The ADIOS2 model output provided weathering half-life, and equations presented by the Australian Maritime Safety Authority were used to calculate the time for a spill to reach shore and the quantity of fuel from a spill that would be deposited on shore (DNV 2011). The quantity and proportion of fuel deposited on shore was determined after calculating the quantity of fuel remaining in the slick at the shore. The time between the



occurrence of the spill and the slick initially reaching the shore (T_{shore}) depends primarily on the distance to shore (D_{zone}), wind velocity in the direction of the shore (V_{wind}), and the slick's velocity represented as a fraction of the wind velocity (RV_{drift}) (DNV 2011):

$$T_{shore} = \frac{D_{zone}}{V_{wind}RV_{drift}}$$

The quantity remaining in the slick (Q_s) relates to the original spill quantity (Q), weathering half-life to the quantity of fuel remaining (H), and time to shore (T_{shore}) (DNV 2011).

$$Q_s = Q * 2^{-T_{shore}/H}$$

5.2 Spills near Melvin Bay

The spill scenarios in Melvin Bay were completed for two different spill volumes: 100,000 L and 2 ML, representing an average spill scenario and a worst case spill scenario, respectively. The weathering half-life (time required for removal of 50% of the diesel fuel from the sea surface) was determined using the ADIOS2 model. The amount of time it would take for a fuel spill to reach the shoreline given anticipated wind effects was then determined (originating from approximately 343° from the spill location) (Table 8.2-B-1).

Weathering characteristics for a 2 ML fuel spill are shown in Figure 8.2-B-3. This figure illustrates the amount of fuel that would evaporate and disperse over time following the initial spill. For all spill scenarios considered at the fuel transfer locations near Melvin Bay, the weathering half-life was determined to be < 19 h. The time required for the spill to reach shore varied from approximately 6 minutes (min) (0.1 h) to 1 h 20 min. Table 8.2-B-2 includes the proportion of fuel estimated to be deposited on shore under the different spill scenarios. For both fuel transfer sites in Melvin Bay, it was determined that between 89% and 99% of the total volume of spilled diesel fuel would reach shore assuming no responsive mitigation occurred.

Table 8.2-B-1: Weathering Half Life and Time to Shore for 100,000 L and 2 ML Diesel Fuel Spill Scenarios in Melvin Bay

Location	Spill Amount (L)	Distance to Shore (km)	Weathering Half-Life (h)			Time to Shore (h)		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr
Ship-to-ship fuel transfer	100,000	0.9	7.8	3.4	2.7	1.3	0.4	0.3
Ship-to-ship fuel transfer	2,000,000	0.9	18.5	9.2	6.9	1.3	0.4	0.3
Ship-to-shore fuel transfer	100,000	0.4	7.8	3.4	2.7	0.6	0.2	0.1
Ship-to-shore fuel transfer	2,000,000	0.4	18.5	9.2	6.9	0.6	0.2	0.1

km (kilometre); yr (year)

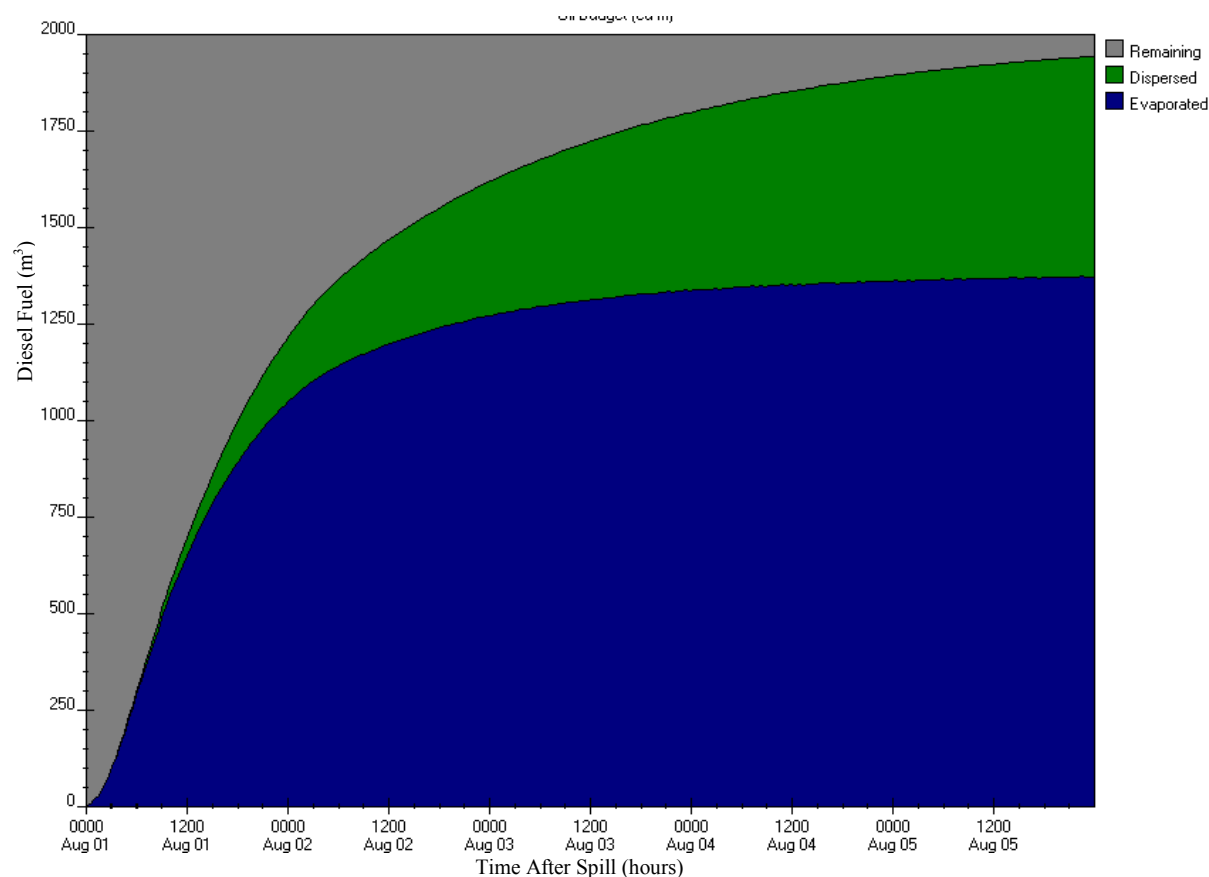


Figure 8.2-B-3: Weathering Characteristics of a 2 ML Diesel Fuel Spill in Melvin Bay under Mean Wind and Wave Conditions.

Table 8.2-B-2: Percent Diesel Fuel Deposited on Shore for 100,000 L and 2 ML Spill Scenarios in Melvin Bay

Location	Spill Amount (L)	Distance to Shore (km)	Wind Speed (m/s)			% Deposited on Shore		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr
Ship-to-ship fuel transfer	100,000	0.9	6.6	19.0	25.4	89%	91%	92%
Ship-to-ship fuel transfer	2,000,000	0.9	6.6	19.0	25.4	95%	97%	97%
Ship-to-shore fuel transfer	100,000	0.4	6.6	19.0	25.4	95%	96%	96%
Ship-to-shore fuel transfer	2,000,000	0.4	6.6	19.0	25.4	98%	99%	99%

km (kilometre); yr (year); m/s (metres per second)

5.3 Spills along Shipping Route

Diesel fuel spills could occur anywhere along the shipping route. For the purpose of the ADIOS2 analysis, four (4) sites were chosen along the shipping route that corresponds with established sensitive habitat areas for marine mammals and/or marine birds. These sites included Walrus Island, Coats Island, Ungava Peninsula and Eastern Hudson Strait. Table 8.2-B-3 includes the weathering half-life and time to shore for different shipping route spill scenarios. The weathering half-life was predicted to be less than 19 h for all scenarios. Depending on



the distance to shore and wind scenario, the time to shore would vary from about 7 h to 94 h (approximately 4 days). Table 8.2-B-4 presents the proportion of spill deposited on shore for the 2 ML spill scenarios conducted along the shipping route. Depending on wind conditions and locations, the amount of fuel predicted to be deposited on shore would vary from 2% to 26%.

Table 8.2-B-3: Weathering Half Life and Time to Shore for 2 ML Diesel Fuel Spill Scenarios along Shipping Route

Location	Fetch (km)	Distance to Shore (km)	Weathering Half-Life (h)			Time to Shore (h)		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr
Walrus Island	43	55	15.6	4.1	3.5	94.3	22.6	17.3
Coats Island	58	23	14.7	4.9	3.6	39.4	9.5	7.2
Ungava Peninsula	16	46	18.5	5.8	4.5	78.9	18.9	14.4
Eastern Hudson Strait	26	46	17.0	5.3	3.6	78.9	18.9	14.4

km (kilometre); yr (year)

Table 8.2-B-4: Percent Diesel Fuel Deposited on Shore for 2 ML Spill Scenarios along Shipping Route

Location	Fetch (km)	Distance to Shore (km)	Wind Speed (m/s)			% Deposited on Shore		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr
Walrus Island	43	55	5.4	22.5	29.5	2%	2%	3%
Coats Island	58	23	5.4	22.5	29.5	16%	26%	25%
Ungava Peninsula	16	46	5.4	22.5	29.5	5%	10%	11%
Eastern Hudson Strait	26	46	5.4	22.5	29.5	4%	8%	6%

km (kilometre); yr (year); m/s (metres per second)

The mean and the 50-year wind speed at Coral Harbour and mean fetch of the four locations along the shipping route were used to calculate the slick distance traveled until the diesel fuel remaining was 1% of the original quantity. The weathering half-life and fuel slick distance travelled were calculated with ADIOS2 until the diesel fuel remaining was approximately 10% of the original quantity. For the diesel fuel remaining between approximately 1 and 10%, the ADIOS2 weathering prediction was fit to a curve to interpolate the remaining percent at various time steps due to weathering processes.

Modeling results indicate that, assuming average wind speed conditions, the diesel fuel slick would travel approximately 26 km over a 48-h period prior to being reduced to 1% of its original spill volume through natural weathering effects (Table 8.2-B-5). Using 50-year wind speed conditions, the diesel fuel slick would travel approximately 38 km over a 12-h period prior to being reduced to 1% of its original volume (or 26 km over an 8-h period prior to being reduced to 7% of its original volume) (Table 8.2-B-6). A swath of 26 km on either side of the shipping route is depicted in Figure 8.2-B-4, representing a 'hypothetical spill limit' - or the maximum spatial extent that a diesel fuel slick could potentially reach prior to the fuel being 99% weathered under average wind conditions, or 93% weathered under 50-yr wind conditions.

Assuming the most likely travel direction of the plume is southeast given the predominant northwest wind direction prevalent during summer, the slick from a diesel fuel spill could extend to the north end of Coats Island (~37 km south of the shipping route) under 50-yr wind conditions, but not under average wind conditions. Marble Island, a sensitive ecological area and traditional seasonal hunting site for local Inuit communities, falls within the



26-km hypothetical spill limit, although it is located north (<10km) of the shipping route and, therefore, opposite to the mostly likely direction of travel of the plume based on predominant wind directions (north-northwest) during summer. Walrus Island, another sensitive ecological area located 32 km north of the shipping route, would potentially be susceptible to effects from a fuel spill under extreme (50-yr) wind conditions only, although it is also located opposite to the predominant plume trajectory. No other overlap with sensitive coastal areas is expected based on the modeled results. Other landfall areas potentially affected by a fuel spill along the shipping corridor include Charles Island, located just north of Ungava Peninsula and within the 26 km hypothetical spill limit boundary (Figure 8.2-B-4), and Nottingham Island located at the northern limit of the modeled spill limit, although opposite to the expected plume trajectory.

Table 8.2-B-5: Diesel Fuel Spill Remaining and Distance Travelled in the First 48 h for Shipping Route Spill Scenario (2 ML) with Coral Harbour Mean Wind Speed of 5 m/s and Mean Fetch of 36.0 km

Hours after Spill	Slick Distance Traveled (km)	Diesel fuel Remaining	
		%	L
12	6.5	67	1,340,000
24	13.0	31	620,000
48	25.9	1	20,000

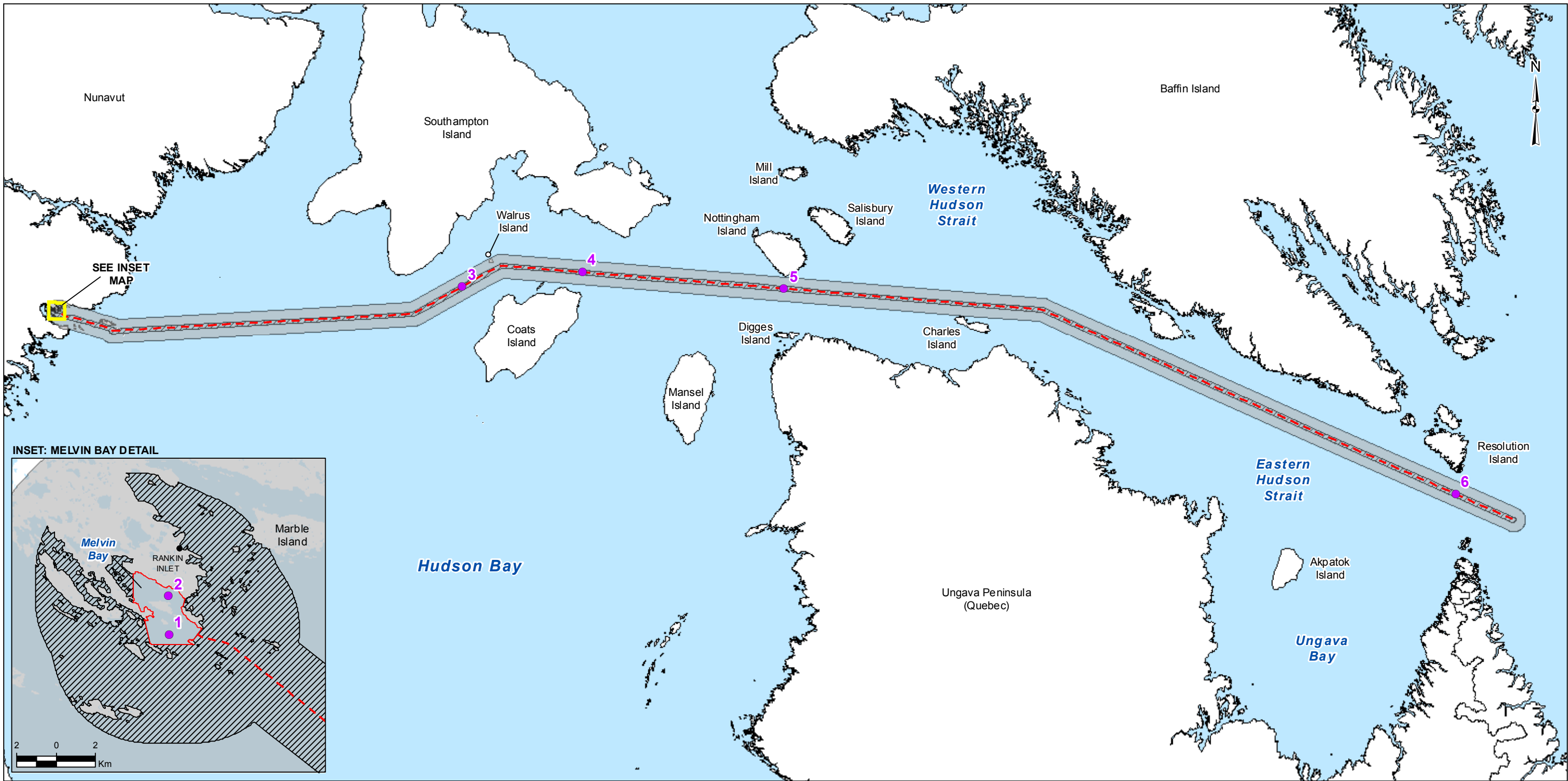
km (kilometre)

Table 8.2-B-6: Diesel fuel Spill Remaining and Distance Travelled in the First 12 h for Shipping Route Spill Scenario (2 ML) with Coral Harbour Mean Wind Speed of 5 m/s and Mean Fetch of 36.0 km

Hours after Spill	Slick Distance Traveled (km)	Diesel fuel Remaining	
		%	L
4	12.7	40	800,000
8	25.5	7	140,000
12	38.2	1	20,000

km (kilometre)

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LEGEND

- MARINE REGIONAL STUDY AREA (MARINE RSA)
- MARINE LOCAL STUDY AREA (MARINE LSA)
- WATERBODY
- HYPOTHETICAL SPILL LIMIT
(93% OF FUEL WEATHERED UNDER 50-YEAR WIND CONDITIONS)
- SHIPPING ROUTE (APPROXIMATE)
- HYPOTHETICAL FUEL SPILL RELEASE LOCATION

REFERENCE

CanVec Data Obtained from © Department of Natural Resources Canada. All rights reserved.
Nautical chart data obtained from the Canadian Hydrographic Service. Provincial data obtained from ESRI.
Datum: WGS 84 Projection: World Mercator

Location No.	Location Name	UTM 15 N East	UTM 15 N North
1	Ship-to-ship fuel transfer site outside Melvin Bay	546173	6961117
2	Ship-to-shore fuel transfer site in Melvin Bay	546143	6963142
3	Shipping route south of Walrus Island	944826	7015654
4	Shipping route north of Coats Island	1059514	7048456
5	Shipping route north of Ungava Peninsula	1258383	7072746
6	Shipping route in Eastern Hudson Strait	1982892	7102917

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

HYPOTHETICAL SPILL LIMIT
IN MELIADINE PROJECT AREA

Golder
Associates

PROJECT NO.	10-1373-0076	FILE No.
DESIGN	KZ	07 Feb. 2014
GIS	SGR	07 Feb. 2014
CHECK	PR	25 Feb. 2014
REVIEW	PR	25 Feb. 2014

SCALE AS SHOWN
REV. 0

FIGURE 8.2-B4



6.0 CONCLUSIONS

Although diesel spills have a low likelihood of occurrence, it is important to understand where the spill will travel and the best way to mitigate impacts. Based on the total amount of diesel fuel transported and predicted spill rates reported by SL Ross (1999), the overall likelihood of a fuel spill ranges from once every 36 years for a small spill to once every 526 years for a large spill. If a spill was to occur near Melvin Bay, it is predicted that more than half of the fuel would reach the nearby shoreline within several hours. As part of the Oil Pollution Emergency Plan (SD 8-2), AEM has committed to pre-emptive and responsive mitigation actions to reduce or minimize the loss of diesel fuel during ship-to-ship and ship-to-shore transfers near Melvin Bay. If a spill was to occur along the shipping route during extreme (50-yr) wind conditions, it is predicted that the diesel fuel slick would travel up to 26 km over an 8-h period before being reduced to < 7% of its original volume, and up to 38 km over a 12-h period before reaching < 1% its original volume. Under average wind conditions, for comparative purposes, the diesel fuel slick would travel up to 26 km over a 48-h period before being reduced to 1% of its original volume.

This analysis has been conducted to assess the potential for impacts associated with a diesel fuel spill in the marine environment. The ADIOS2 model was used with the input of local wind speed to approximate wave conditions and then predict the weathering half-life of the fuel. This is a one-dimensional analysis and does not account for other site-specific effects such as modifications to the wave height, period and direction due to local bathymetry. Therefore it is an approximation of the travel time and percent diesel fuel remaining to be used for planning and decision making purposes.

This analysis does not include the influence of ocean currents from large-scale circulation patterns or tides in the prediction of the transport and spreading of a fuel spill. It is expected that tidal current speeds will be highest in areas where the channels are the narrowest such as adjacent to Coats Island, and, therefore, tidal current velocities in these areas may enhance the spreading, weathering, and travel time of the fuel in the direction of the tidal flow.

GOLDER ASSOCIATES INC.

ORIGINAL SIGNED

Jessica Côté, PE
Senior Coastal and Ocean Engineer

ORIGINAL SIGNED

Philip D. Osborne, Ph.D.
Principal

JC/PDO/cw/lw

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APPENDIX A

Extremal Analysis for Rankin Inlet and Coral Harbour Winds



Historical hourly wind records were obtained for Rankin Inlet (station ID: 71083) and Coral Harbour (station ID: 71915). The Rankin Inlet station is located at 62.82° N, 92.12° W at an elevation of 32.3 metres (m) above mean sea level (msl) and the Coral Harbour station is located at 64.78° N, 83.92° W at an elevation of 62.2 m above msl. Figure 8.2-B-A-1 shows a wind rose for the hourly record at Rankin Inlet from 1981 through 2012 and Figure 8.2-B-A-2 shows a wind rose for the hourly record at Coral Harbour for the same time period. In general, the wind direction at both sites is from the north. Wind speed statistics were calculated for both stations and the results are shown in Tables 8.2-B-A-1 and 8.2-B-A-2. Data were filtered for “0” values.

Wind speeds recorded at Rankin Inlet and Coral Harbour between 1981 and 2012 were used to determine probability distributions of wind speeds and their associated return periods. A peaks-over-threshold (POT) analysis was used to calculate the peak wind speeds of the largest storms during the 31-year record at each site. Extreme wind speeds were determined by filtering the record for peak wind speeds during storms with speeds greater than the 95 percentile value sustained for at least 4 hours.

An extremal analysis following Leenknecht et al. (1992) was applied to the station record of extremes in order to determine the 5, 10, 25, 50 and 100-year wind speeds at the site. A time series of 77 maximum wind speeds measured during discrete storms between 1981 and 2012 were input to the extremal analysis. The analysis included the application of Fisher Tippet Type 1 (FT-1) and Weibull distributions to the peak water level time series. Results of the analysis for Rankin Inlet are summarized in Table 8.2-B-A-4 and a plot of the Weibull distribution with shape parameter (k) = 2.00 is shown in Figure 8.2-B-A-3. Results of the analysis for Coral Harbour are summarized in Table 8.2-B-A-3 and a plot of the Weibull distribution with k = 1.15 is shown in Figure 8.2-B-A-4.

Table 8.2-B-A-1: Wind Statistics for Rankin Inlet and Coral Harbour (1981-2012) in Metres/Second

	Min	1%	5%	25%	Median	Mean	75%	95%	99%	Max	Std
Rankin Inlet	0.6	1.1	1.9	4.2	6.1	6.6	8.3	12.8	15.8	28.3	3.3
Coral Harbour	0.6	1.1	1.7	3.1	5.3	5.4	7.2	11.4	15.0	28.3	3.1

Minimum (Min), Maximum (Max), Standard Deviation (Std)

Table 8.2-B-A-2: Wind Statistics for Rankin Inlet and Coral Harbour (1981-2012)

	Record Length	Missing	Number Invalid	% Invalid
Rankin Inlet	281,088	0	8,474	3%
Coral Harbour	280,608	480	23,285	8%

Invalid = “0” value

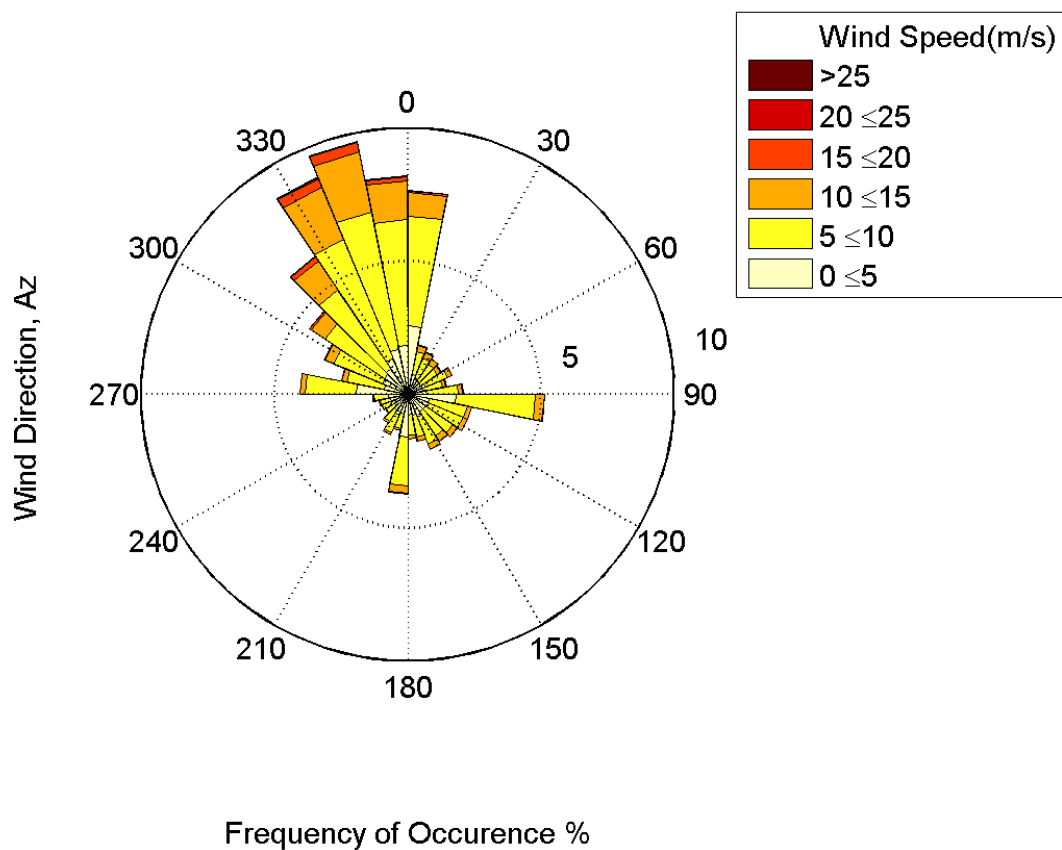


Figure 8.2-B-A-1: Wind Rose for Rankin Inlet from 01 October 1981 to 01 October 2012

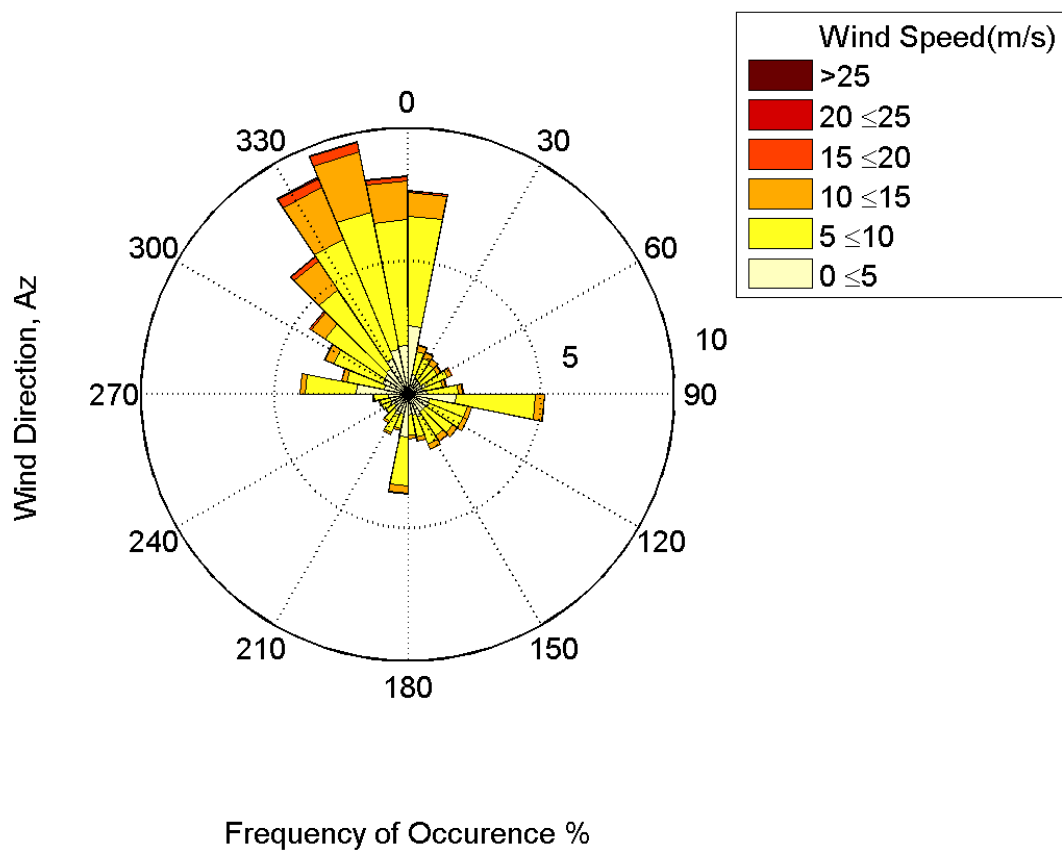


Figure 8.2-B-A-2: Wind Rose for Coral Harbour from 01 October 1981 to 01 October 2012



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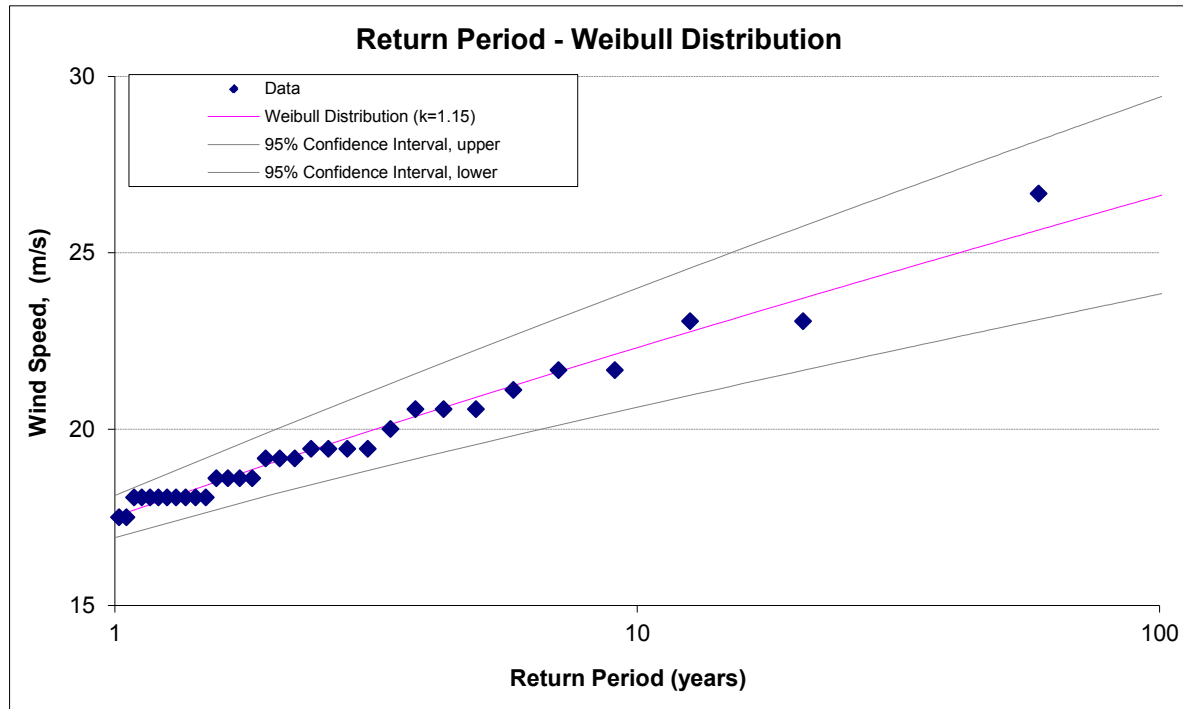


Figure 8.2-B-A-3: Wind speed as a function of return period for a Weibull ($k=2$) distribution for Rankin Inlet wind record

Table 8.2-B-A-3: Extreme Wind Speeds (m/s) and Associated Return Periods for Rankin Inlet

N= 77 NT= 77 Lambda=2.41		Nu= 1.00 K= 32				
		FT-I	Weibull	Weibull	Weibull	Weibull
			k= 0.75	k= 1.15	k= 1.49	k= 2.00
Correlation Coefficient		0.9880	0.9711	0.9918	0.9860	0.9708
Sum Square of Residuals		8.23	19.72	5.65	9.64	19.89
Return Period (yr)		m/s	m/s	m/s	m/s	m/s
	2	19.2	18.52	19.05	19.23	19.33
	5	20.8	20.59	20.94	20.92	20.80
	10	22.0	22.34	22.31	22.07	21.73
	25	23.6	24.85	24.06	23.46	22.82
	50	24.7	26.88	25.35	24.44	23.56
	100	25.9	28.20	26.62	25.03	24.00
Confidence Interval	Return Period (yr)	m/s	m/s	m/s	m/s	m/s
95 % C.I.	5	19.7 - 21.9	18.4 - 22.7	19.6 - 22.3	19.8 - 22.0	19.9 - 21.7
95 % C.I.	10	20.7 - 23.3	19.4 - 25.3	20.6 - 24.0	20.7 - 23.4	20.7 - 22.8
95 % C.I.	25	21.9 - 25.2	20.7 - 29.0	21.9 - 26.2	21.9 - 25.0	21.6 - 24.0
95 % C.I.	50	22.8 - 26.6	21.8 - 31.9	22.9 - 27.8	22.7 - 26.2	22.2 - 24.9
95 % C.I.	100	23.7 - 28.1	22.5 - 33.9	23.8 - 29.4	23.1 - 26.9	22.6 - 25.4

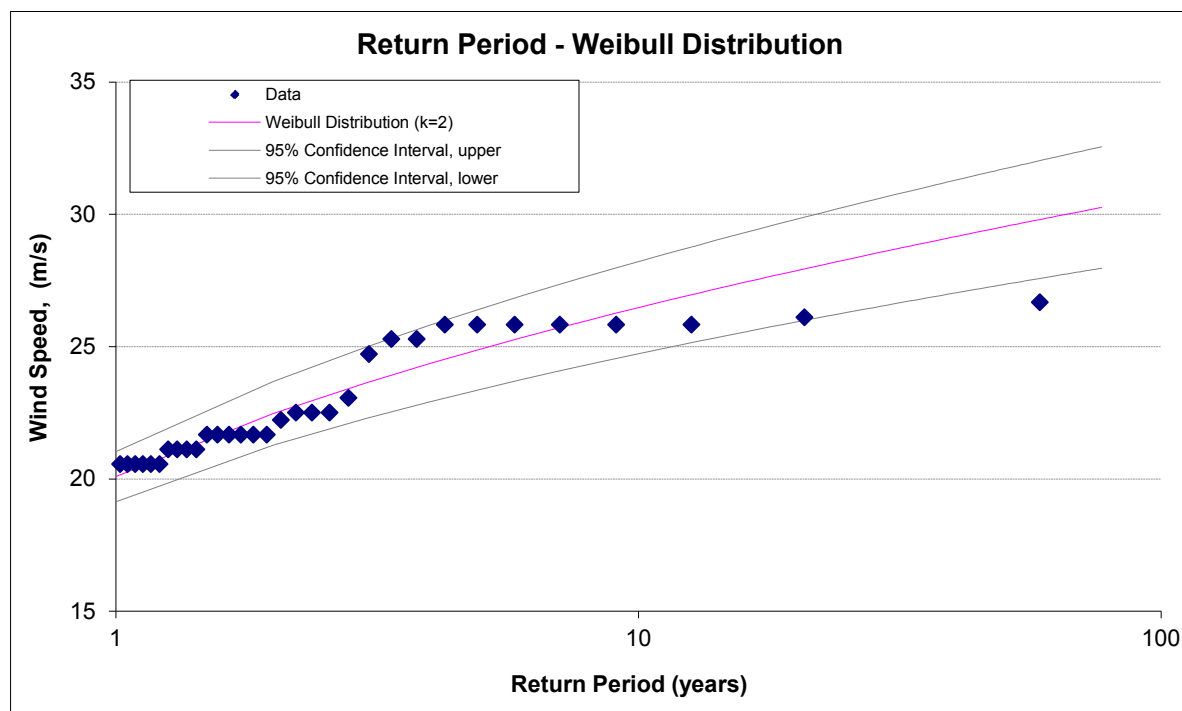


Figure 8.2-B-A-4: Wind speed as a function of return period for a Weibull ($k=1.15$) distribution for Coral Harbour wind record

Table 8.2-B-A-4: Extreme Wind Speeds (m/s) and Associated Return Periods for Coral Harbour

N= 77		Nu= 1.00				
NT= 77		K= 32				
Lambda=2.41		FT-I	Weibull	Weibull	Weibull	Weibull
			k= 0.75	k= 1.15	k= 1.49	k= 2.00
Correlation Coefficient		0.9580	0.8222	0.9195	0.9535	0.9757
Sum Square of Residuals		78.25	308.39	147.11	86.46	45.71
Return Period (yr)		m/s	m/s	m/s	m/s	m/s
	2	22.1	20.90	21.83	22.21	22.48
	5	24.8	23.80	24.74	24.92	24.92
	10	26.7	26.26	26.84	26.76	26.48
	25	29.2	29.79	29.54	28.99	28.29
	50	31.1	32.64	31.52	30.57	29.53
	100	32.9	34.49	33.47	31.52	30.26
Confidence Interval	Return Period (yr)	m/s	m/s	m/s	m/s	m/s
95 % C.I.	5	23.0 - 26.5	20.2 - 27.4	22.5 - 27.0	23.1 - 26.8	23.4 - 26.4
95 % C.I.	10	24.5 - 28.9	21.3 - 31.2	24.0 - 29.6	24.6 - 29.0	24.7 - 28.2
95 % C.I.	25	26.4 - 31.9	23.0 - 36.6	26.0 - 33.1	26.4 - 31.6	26.3 - 30.3
95 % C.I.	50	27.9 - 34.2	24.2 - 41.0	27.4 - 35.6	27.6 - 33.5	27.3 - 31.7
95 % C.I.	100	29.3 - 36.5	25.1 - 43.9	28.8 - 38.1	28.4 - 34.7	28.0 - 32.6



APPENDIX B

ADIOS2 Hypothetical Spill Modelling Inputs and Outputs



Table 8.2-B-B-1: Hypothetical Fuel Spill Locations

Location No.	Location Name	UTM 15 N East	UTM 15 N North
1	Ship-to-ship fuel transfer site outside Melvin Bay	546173	6961117
2	Ship-to-shore fuel transfer site in Melvin Bay	546143	6963142
3	Shipping route south of Walrus Island	944826	7015654
4	Shipping route north of Coats Island	1059514	7048456
5	Shipping route north of Ungava Peninsula	1258383	7072746
6	Shipping route in Eastern Hudson Strait	1982892	7102917



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Table 8.2-B-B-2: Hypothetical Diesel fuel Spill Inputs and Outputs from ADIOS2 and Equations presented in Model of Oil Dispersion (DNV 2011)

Wind Case	Parameter	GIS Location								Assumptions
		1	1	2	2	3	4	5	6	
	Hypothetical Spill Quantity (litres; L)	100,000	2,000,000	100,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	10% of the total diesel fuel (20 ML) being spilled on a particular trip. The 10% is based on a reference by McKenna and McClintock (2005).
	Fetch (km)	0.5	0.5	0.38	0.38	43	58	16	26	at 343 deg; minimum fetch for ADIOS is 1 km.
	Distance to Shore (km)	0.9	0.9	0.4	0.4	55	23	46	46	at approximately 163 deg; along fetch/wind axis.
Mean	Mean Wind Speed (m/s)	6.6	6.6	6.6	6.6	5.4	5.4	5.4	5.4	Rankin Inlet: locations 1&2; Coral Harbour 3-6.
50-yr	50-yr Wind Speed (m/s)	25.4	25.4	25.4	25.4	29.5	29.5	29.5	29.5	Rankin Inlet: locations 1&2; Coral Harbour 3-6.
2-yr	2-yr Wind Speed (m/s)	19	19	19	19	22.5	22.5	22.5	22.5	Rankin Inlet: locations 1&2; Coral Harbour 3-6.
Mean	Mean Wind Slick Drift Speed (m/s)	0.20	0.20	0.20	0.20	0.16	0.16	0.16	0.16	3% of wind speed (from DNV, Report for Australian Maritime Safety Authority, Model of Oil Dispersion, 14 December 2011 - citing Blaikley et al. 1977).
50-yr	50-yr Wind Slick Drift Speed (m/s)	0.76	0.76	0.76	0.76	0.89	0.89	0.89	0.89	
2-yr	2-yr Slick Drift Speed (m/s)	0.57	0.57	0.57	0.57	0.68	0.68	0.68	0.68	
Mean	Weathering Half Life (h)	7.8	18.5	7.8	18.5	15.6	14.7	18.5	17	Weather calculated with ADIOS version 2.0.1, developed by Emergency Response Division, OR&R, NOS, NOAA http://response.restoration.noaa.gov/adios .
50-yr	Weathering Half Life (h)	2.7	6.9	2.7	6.9	3.5	3.6	4.5	3.6	
2-yr	Weathering Half Life (h)	3.4	9.2	3.4	9.2	4.1	4.9	5.8	5.3	
Mean	Time to Shore (h)	1.3	1.3	0.6	0.6	94.3	39.4	78.9	78.9	T _{shore} =D _{zone} /(V _{wind} *RV _{drift}) (from DNV, Report for Australian Maritime Safety Authority, Model of Oil Dispersion, 14 December 2011).
50-yr	Time to Shore (h)	0.3	0.3	0.1	0.1	17.3	7.2	14.4	14.4	
2-yr	Time to Shore (h)	0.4	0.4	0.2	0.2	22.6	9.5	18.9	18.9	
Mean	Deposited on Shore (L)	89,386	1,907,588	95,135	1,958,388	30,283	311,471	104,131	80,230	Q _s =Q*2 ^{-(T_{shore}/H)} (from DNV, Report for Australian Maritime Safety Authority, Model of Oil Dispersion, 14 December 2011).
50-yr	Deposited on Shore (L)	91,922	1,935,158	96,326	1,970,917	65,503	498,166	216,362	124,085	
2-yr	Deposited on Shore (L)	91,447	1,934,990	96,104	1,970,842	43,573	524,263	208,223	168,205	
Mean	% Deposited on Shore	89%	95%	95%	98%	2%	16%	5%	4%	Percent Deposited on Shore (Q _s /Q).
50-yr	% Deposited on Shore	92%	97%	96%	99%	3%	25%	11%	6%	
2-yr	% Deposited on Shore	91%	97%	96%	99%	2%	26%	10%	8%	
Mean	% Remaining after 24 h	40%	40%	40%	40%	29%	27%	37%	33%	Does not consider amount of diesel fuel that is beached.
50-yr	% Remaining after 24 h	0%	0%	0%	0%	0%	0%	0%	0%	
2-yr	% Remaining after 24 h	0%	0%	0%	0%	0%	0%	0%	0%	

Notes: Assumptions used for ADIOS2 modeling: 32 PSU, no currents, 5°C surface water temperature, 5 mg/l sediment load.



MELIADINE FEIS - APPENDIX 8.2-B SPILL RISK ASSESSMENT

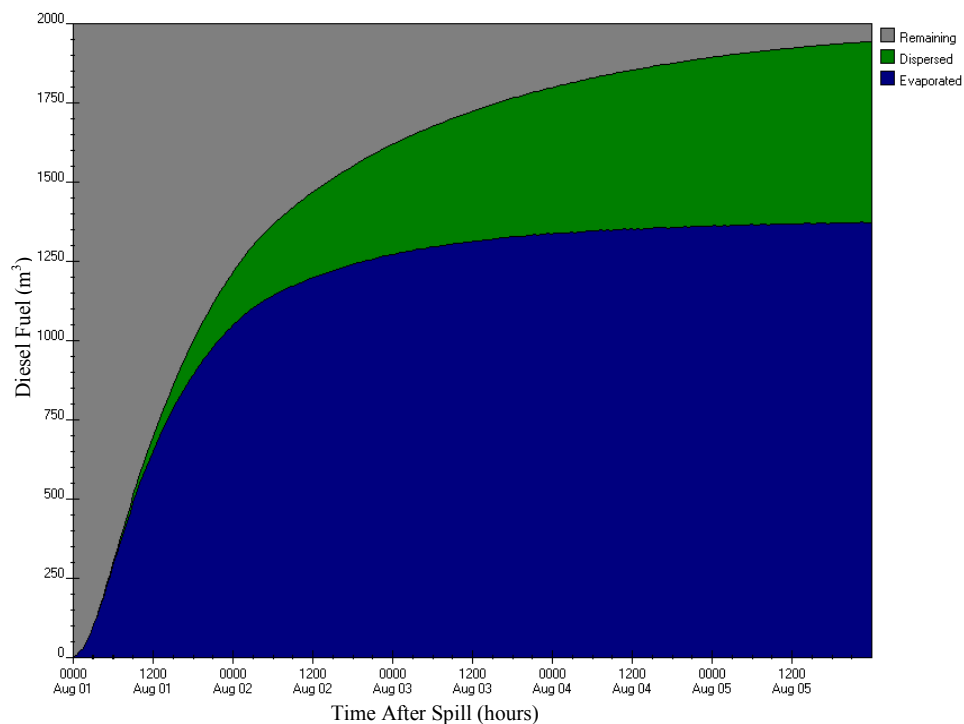


Figure 8.2-B-B-1: ADIOS2 diesel fuel budget output for two fuel transfer stations near Melvin Bay for 2000 m³ spill, mean wind speed scenario

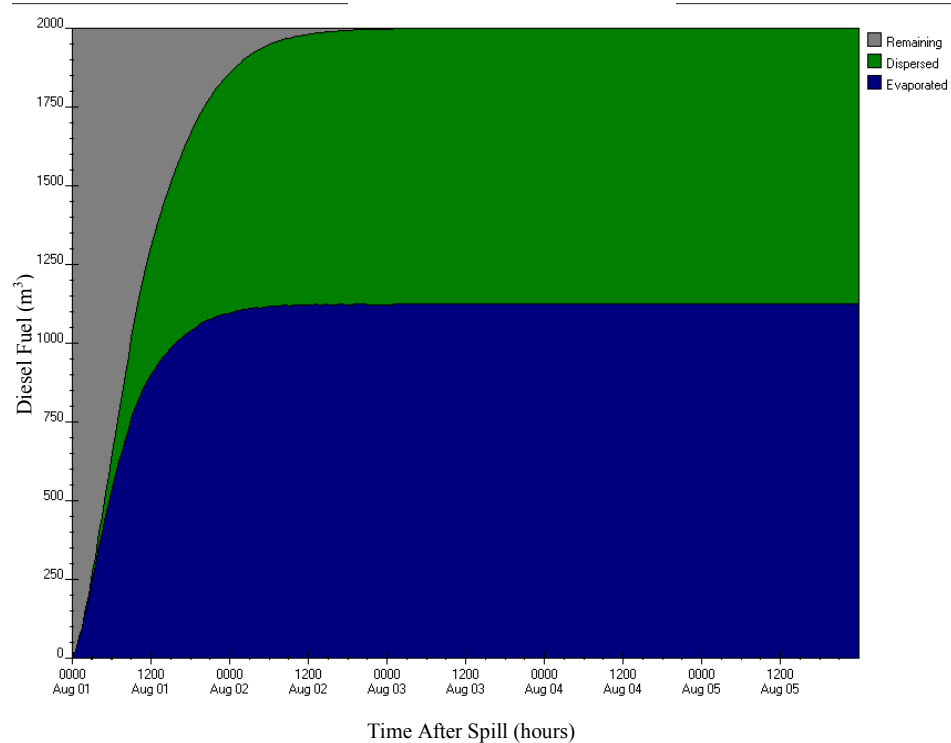


Figure 8.2-B-B-2: ADIOS2 diesel fuel budget output for two fuel transfer stations near Melvin Bay for 2000 m³, 2-yr wind speed scenario



MELIADINE FEIS - APPENDIX 8.2-B SPILL RISK ASSESSMENT

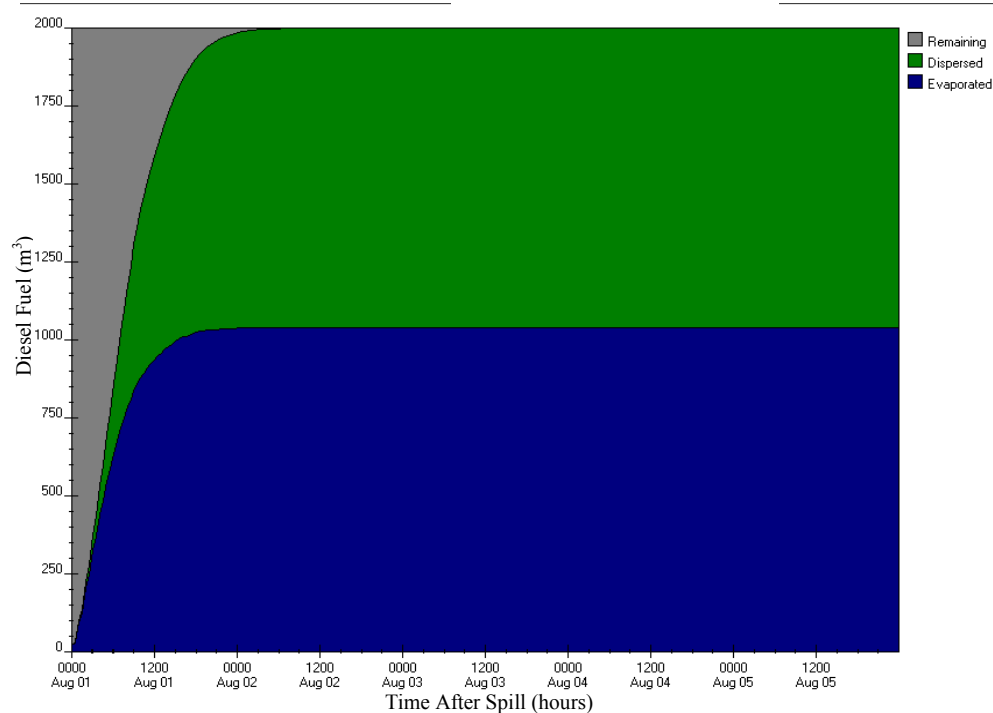


Figure 8.2-B-B-3: ADIOS2 diesel fuel budget output for two fuel transfer stations near Melvin Bay for 2000 m³, 50-yr wind speed scenario

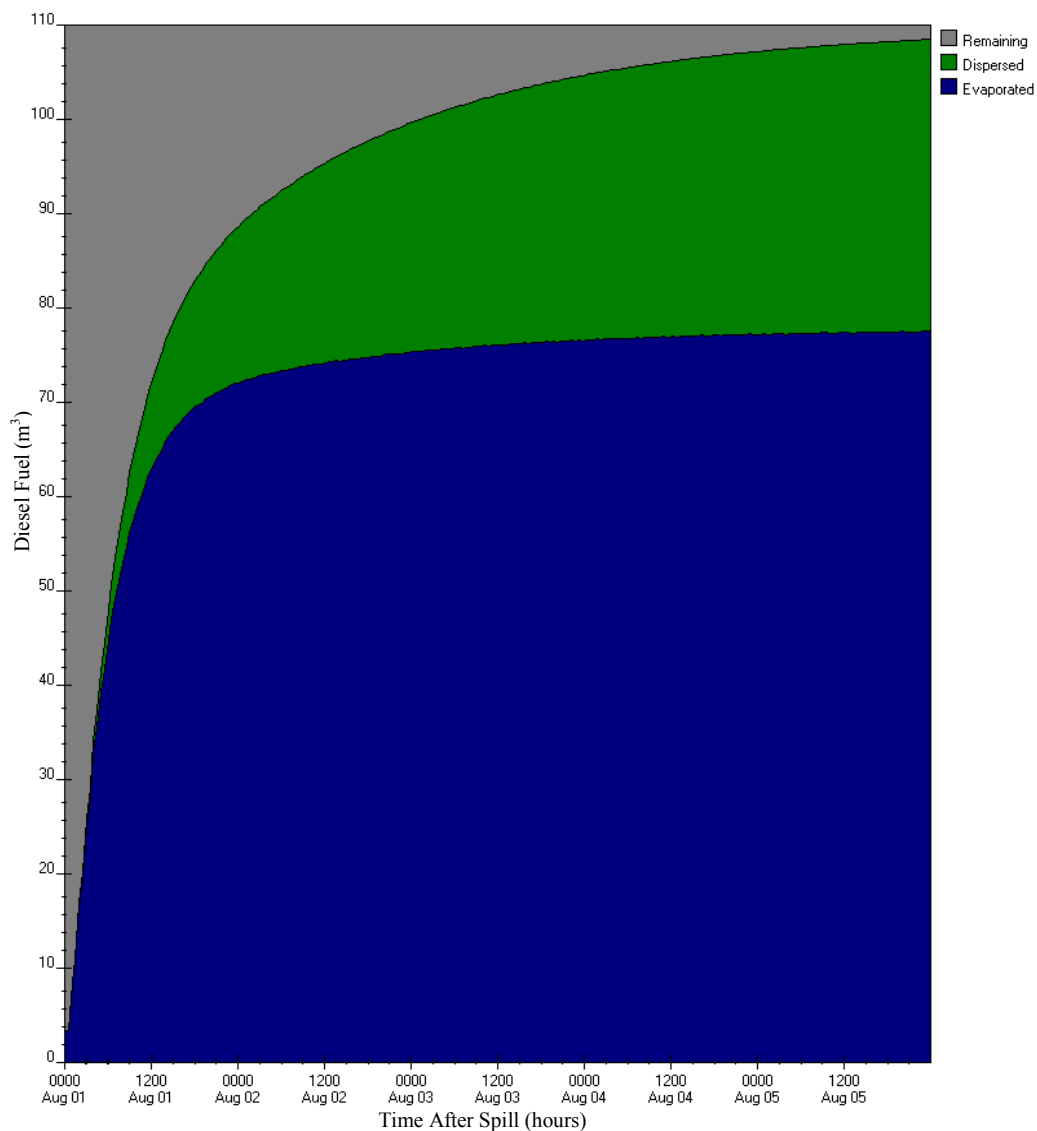


Figure 8.2-B-B-4: ADIOS2 diesel fuel budget output for two fuel transfer stations near Melvin Bay for 100 m³, mean wind speed scenario

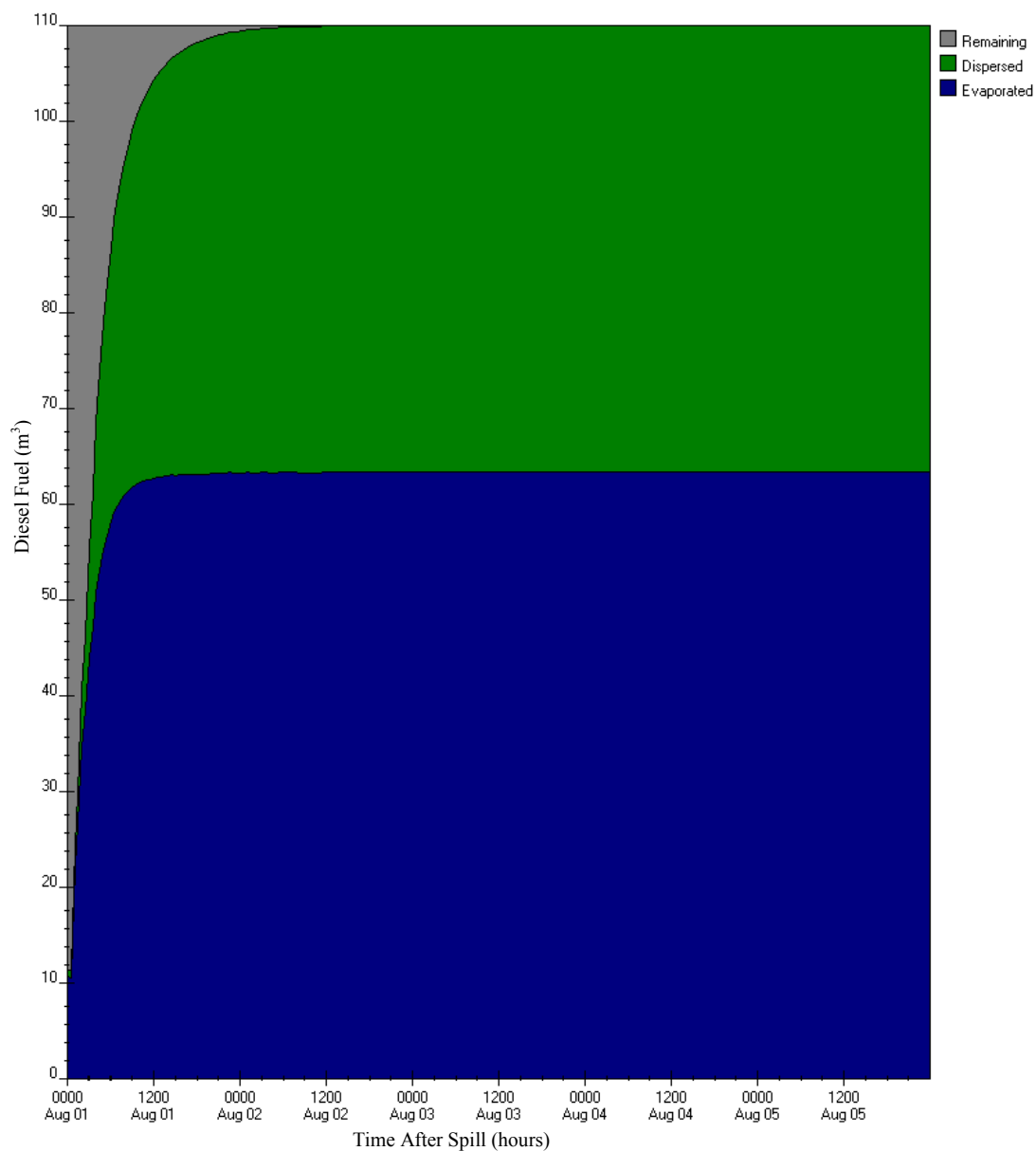


Figure 8.2-B-B-5: ADIOS2 diesel fuel budget output for two fuel transfer stations near Melvin Bay for 100 m³, 2-yr wind speed scenario

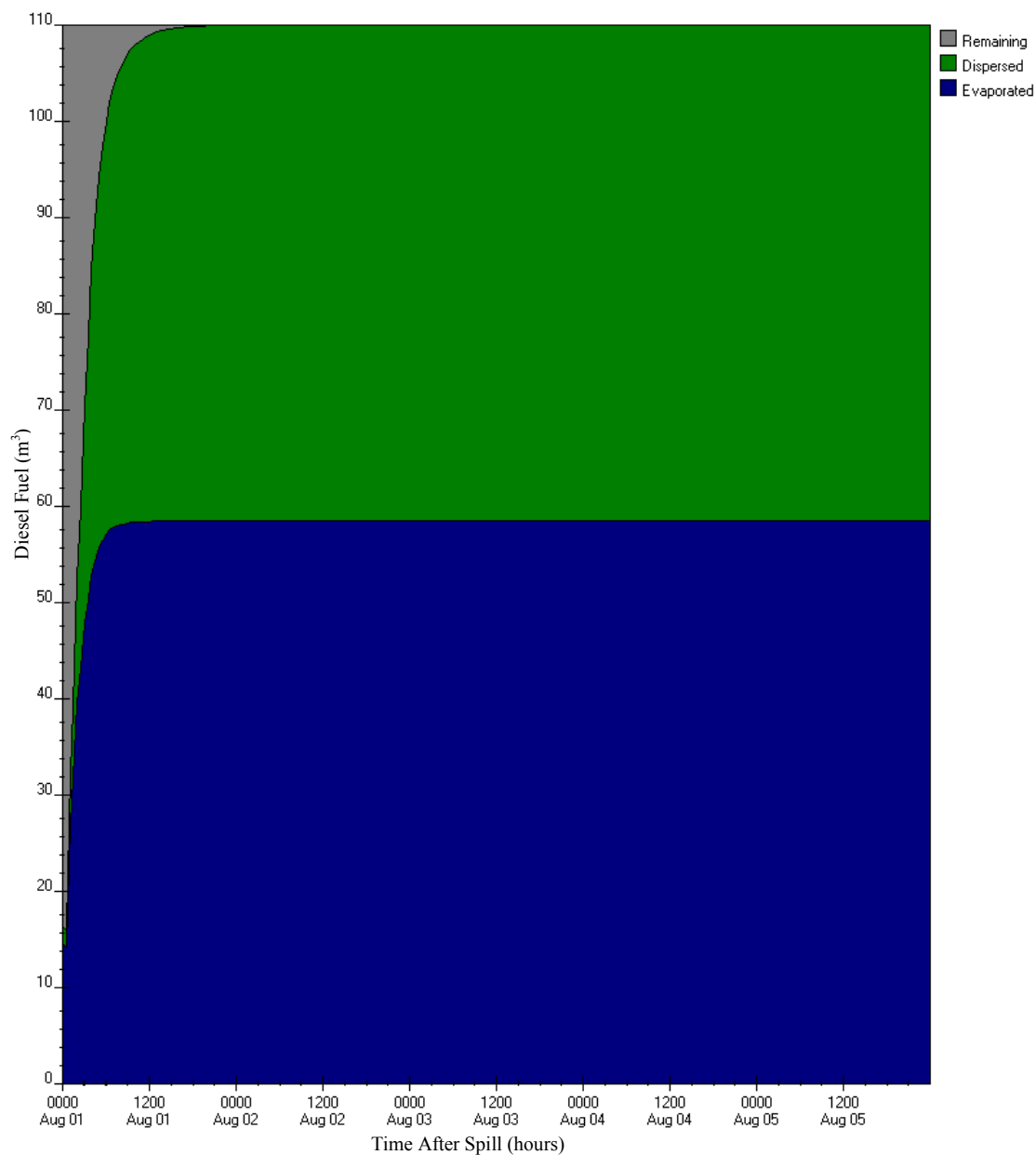


Figure 8.2-B-B-6: ADIOS2 diesel fuel budget output for two fuel transfer stations near Melvin Bay for 100 m³, 50-yr wind speed scenario



MELIADINE FEIS - APPENDIX 8.2-B SPILL RISK ASSESSMENT

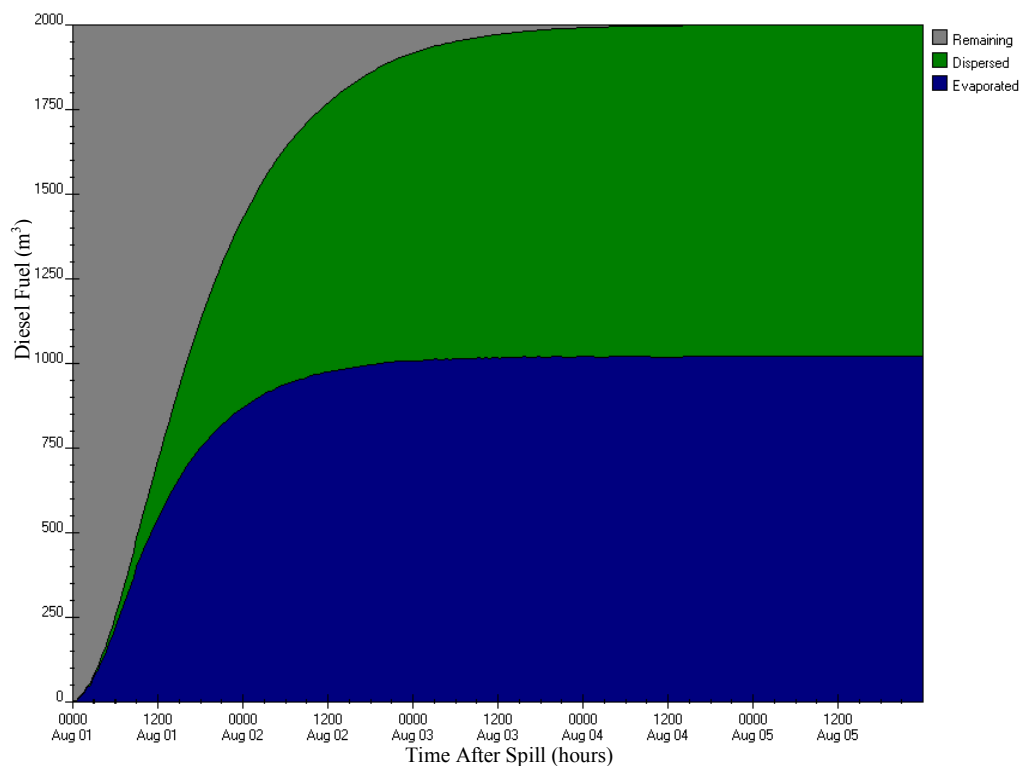


Figure 8.2-B-B-7: ADIOS2 diesel fuel budget output for Walrus Island station for 2000 m³, mean wind speed scenario

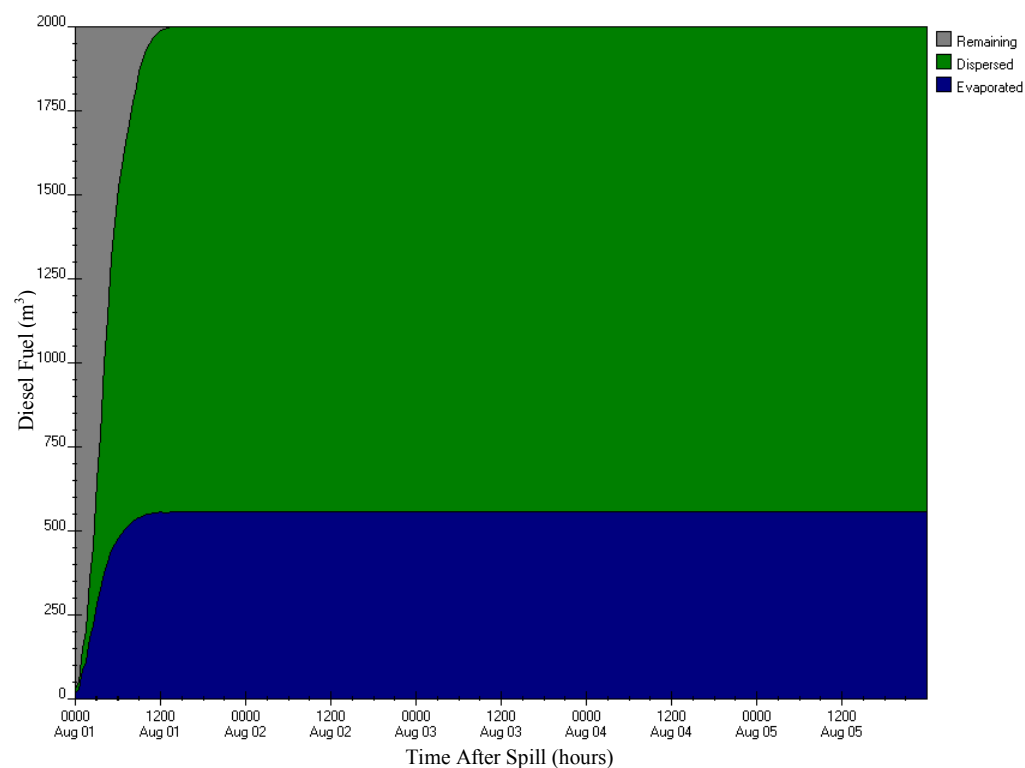
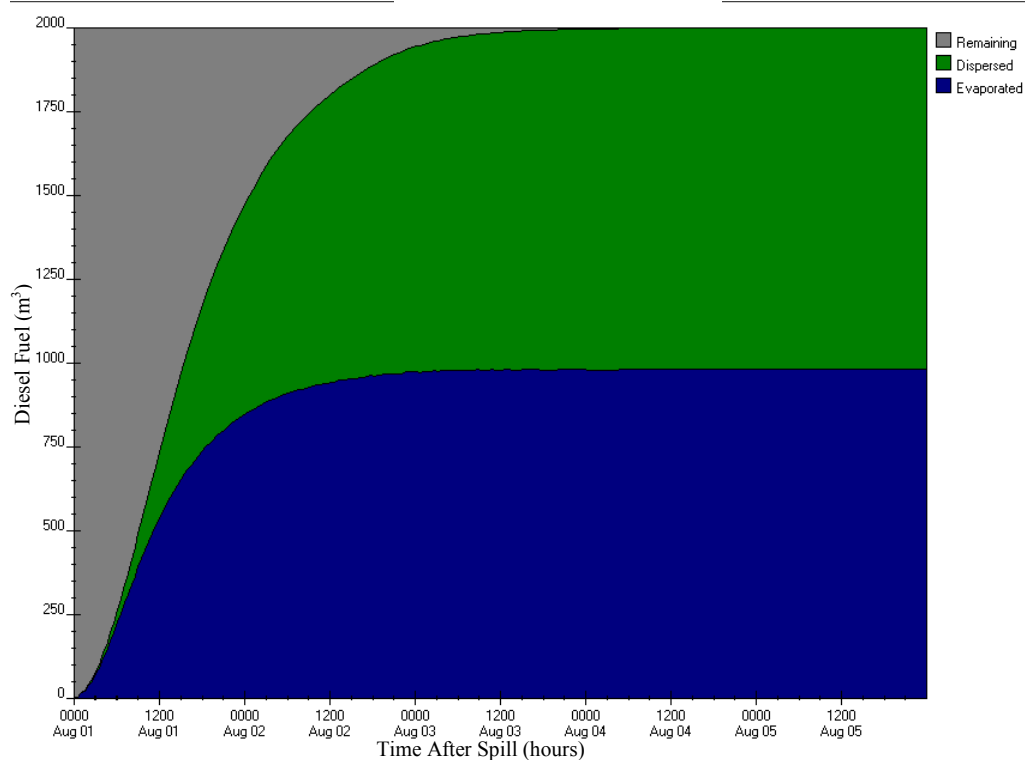
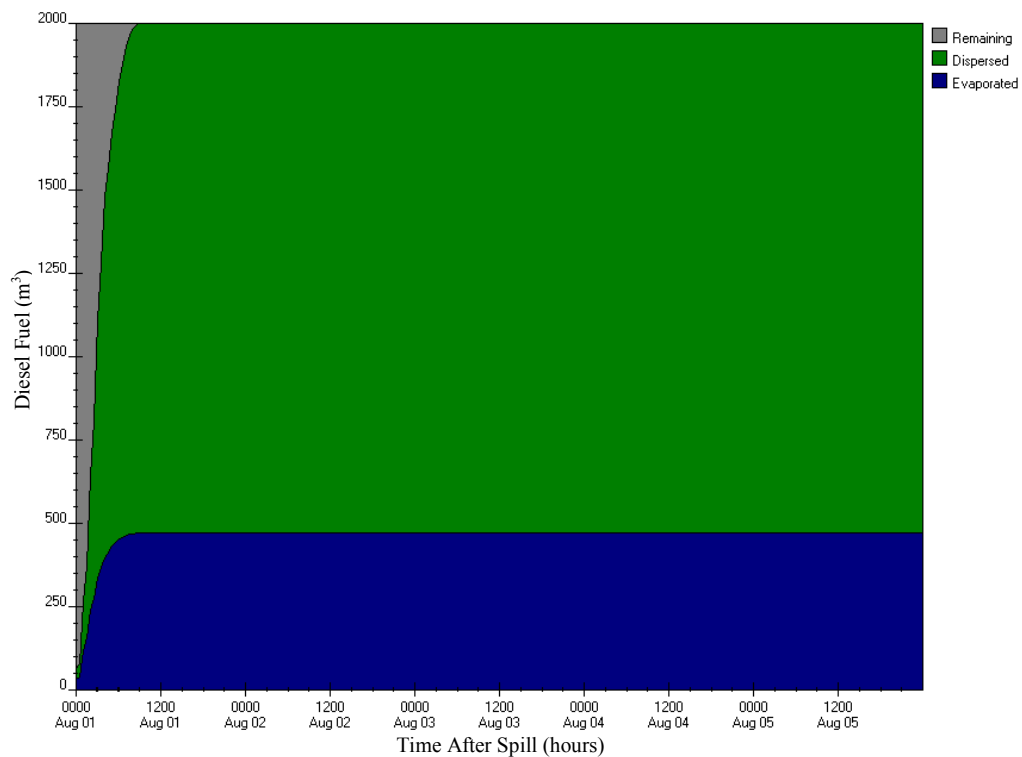


Figure 8.2-B-B-8: ADIOS2 diesel fuel budget output for Walrus Island station for 2000 m³, 2-yr wind speed scenario



MELIADINE FEIS - APPENDIX 8.2-B SPILL RISK ASSESSMENT





MELIADINE FEIS - APPENDIX 8.2-B SPILL RISK ASSESSMENT

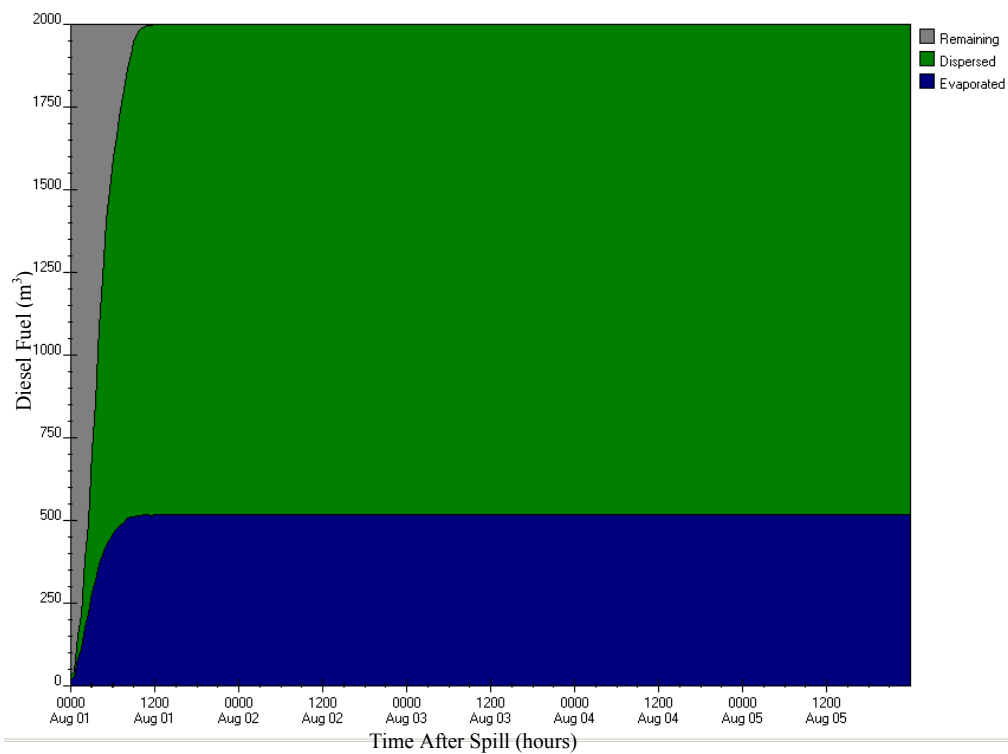


Figure 8.2-B-B-11: ADIOS2 diesel fuel budget output for Coats Island station for 2000 m³, 2-yr wind speed scenario

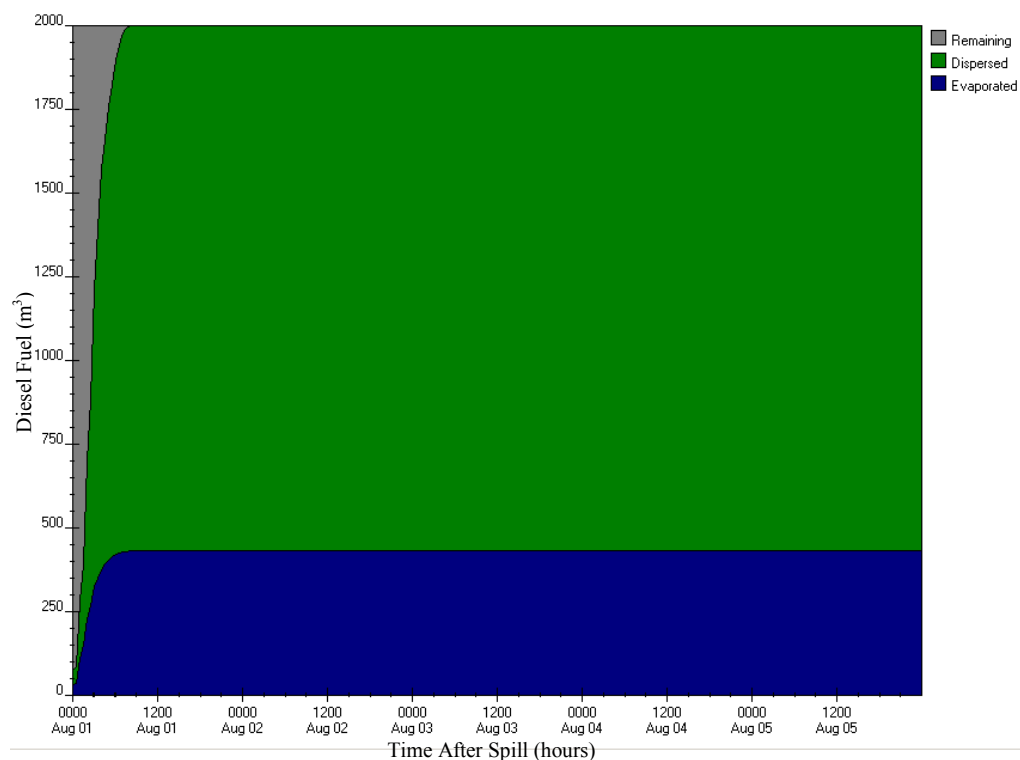


Figure 8.2-B-B-12: ADIOS2 diesel fuel budget output for Coats Island station for 2000 m³, 50-yr wind speed scenario



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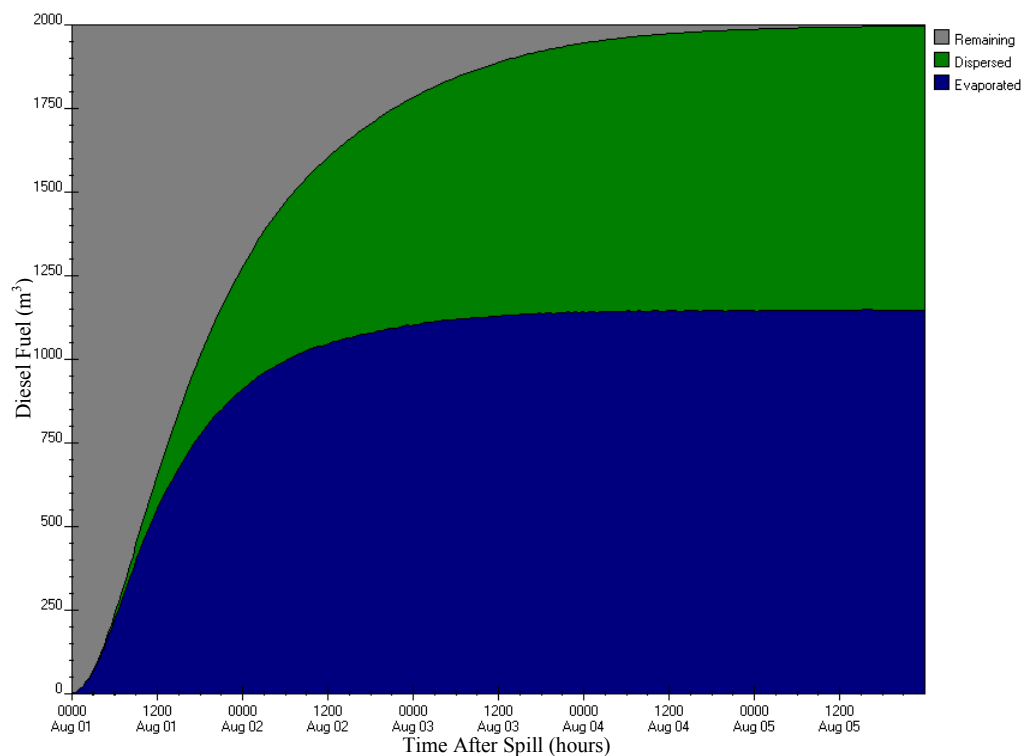


Figure 8.2-B-B-13: ADIOS2 diesel fuel budget output for Ungava Peninsula station for 2000 m³, mean wind speed scenario

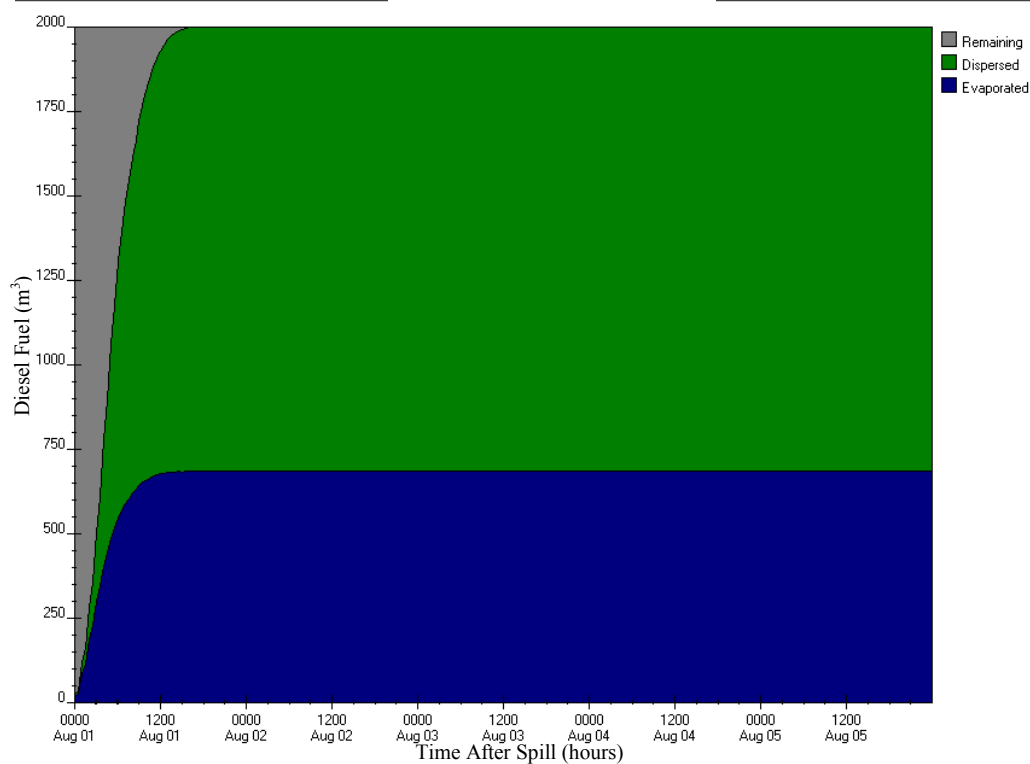


Figure 8.2-B-B-14: ADIOS2 diesel fuel budget output for Ungava Peninsula station for 2000 m³, 2-yr wind speed scenario



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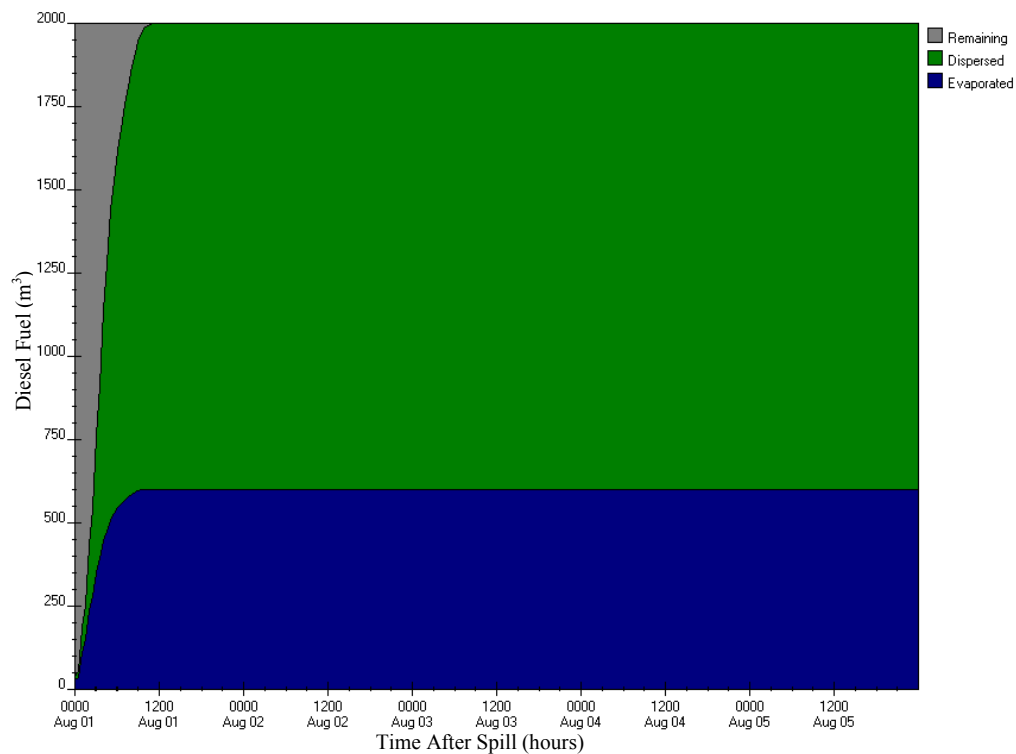


Figure 8.2-B-B-15: ADIOS2 diesel fuel budget output for Ungava Peninsula station for 2000 m³, 50-yr wind speed scenario

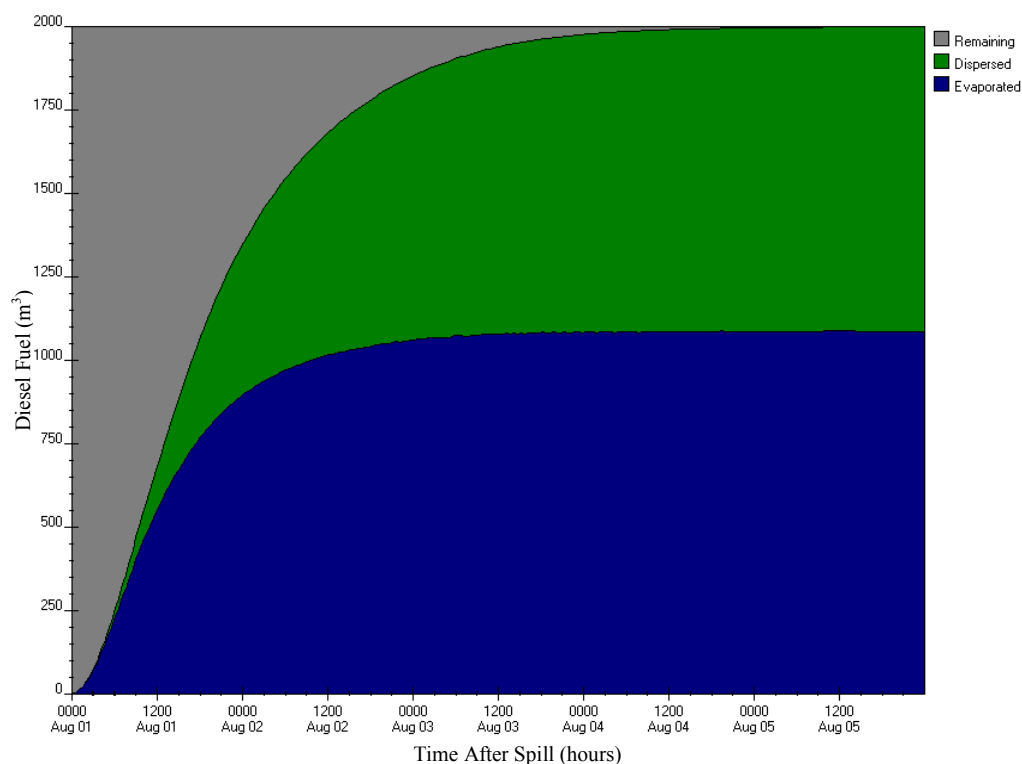


Figure 8.2-B-B-16: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station for 2000 m³, mean wind speed scenario



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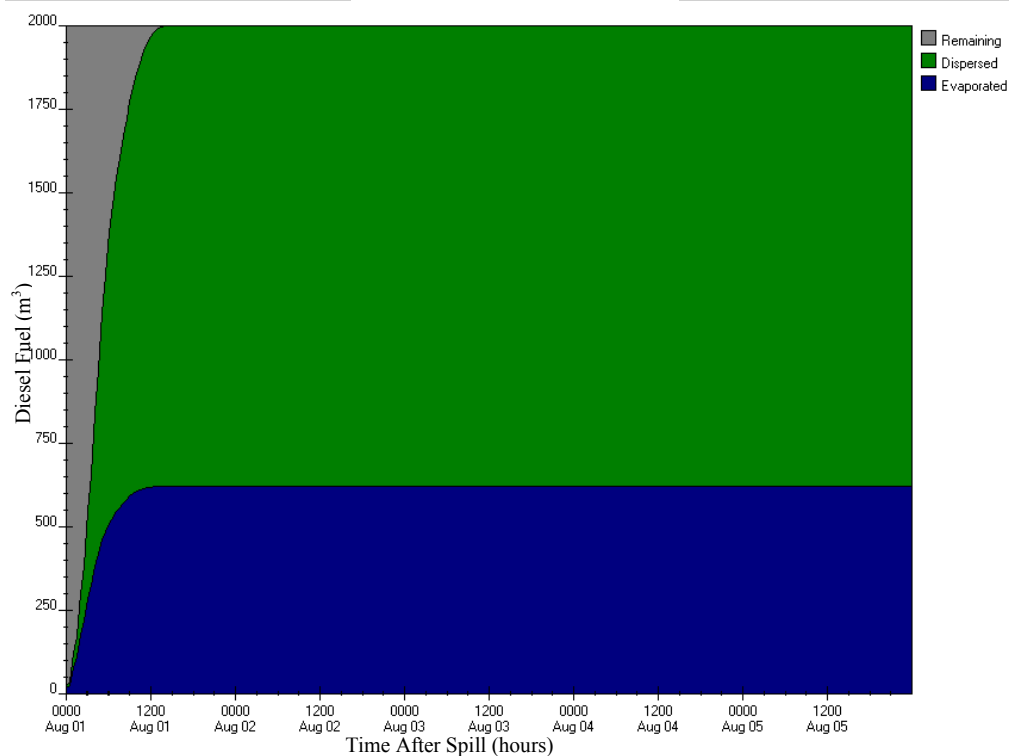


Figure 8.2-B-B-17: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station for 2000 m³, 2-yr wind speed scenario

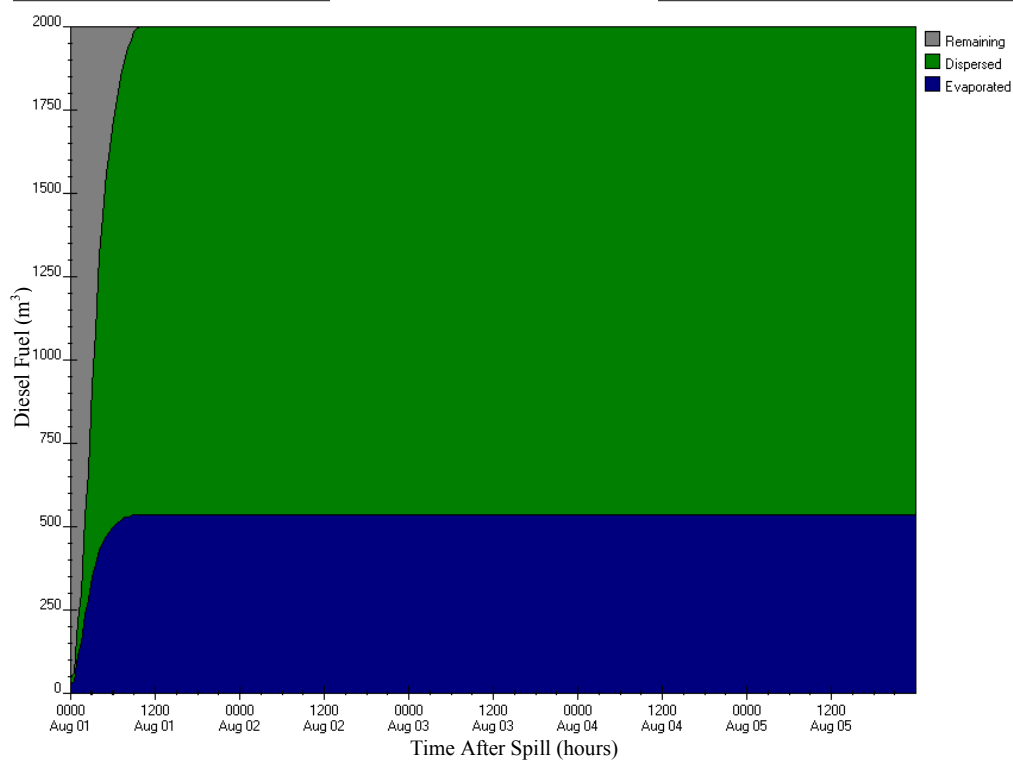


Figure 8.2-B-B-18: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station for 2000 m³, 50-yr wind speed scenario

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
500 - 4260 Still Creek Drive
Burnaby, British Columbia, V5C 6C6
Canada
T: +1 (604) 296 4200

