MADRID-BOSTON PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AEMP	Aquatic Effects Monitoring Program
ANFO	Ammonium nitrate and fuel oil
AWR	All-weather road
CCME	Canadian Council of Ministers of the Environment
CEA	Cumulative Effects Assessment
CEAA	Canadian Environmental Assessment Agency
DFO	Fisheries and Oceans Canada
EEM	Environmental Effects Monitoring
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
GN-DOE	Government of Nunavut, Department of Environment
INAC	Indigenous and Northern Affairs Canada
ISQG	Interim sediment quality guidelines
KIA	Kitikmeot Inuit Association
LSA	Local Study Area
MMER	Metal Mining Effluent Regulations
MOMB	Marine outfall mixing box
NIRB	Nunavut Impact Review Board
NSA	Nunavut Settlement Area
NTKP	Naonaiyaotit Traditional Knowledge Project
NWB	Nunavut Water Board
OHF	Oil handing facilities
OPEP	Oil Pollution Emergency Plan
OPPP	Oil Pollution Prevention Plan
PAH	Polycyclic aromatic hydrocarbons

PCB	Polychlorinated biphenyls
PDA	Project Development Area
PEL	Probable effects level
Project	Madrid-Boston Project
QA/QC	Quality assurance and quality control
RSA	Regional Study Area
TBT	Tributyltin
TIA	Tailings Impoundment Area
TK	Traditional knowledge
TMA	Tailings Management Area
TMAC	TMAC Resources Inc.
TOC	Total organic carbon
tpd	Tonnes per day
TSS	Total suspended solids
VEC	Valued ecosystem component
WRR	Winter road route
yr	year

9. Marine Sediment Quality

Marine sediment quality was identified as a Valued Ecosystem Component (VEC) for the Madrid-Boston Project (the Project) because Project activities have the potential to interact with the marine environment through infrastructure development, runoff, dust deposition, sealift activities, and the discharge of water into marine environments. Marine sediments are important because they serve as a habitat for the benthic organisms that are key components of marine food webs and play an important role in nutrient and metal biogeochemical cycling in marine ecosystems. Sediment quality is an aggregate term that encompasses a complex suite of parameters and indicators that describe the sediment environment and its ability to sustain ecological and biogeochemical functions.

Madrid-Boston activities may introduce chemical constituents that affect sediment quality by increasing the concentrations of metals, organic matter, and pollutants in sediments. Physical disturbances to water resulting from in-water infrastructure works (e.g., dock construction) or the propeller wash from ocean-going vessels may disturb and redistribute sediments, which may alter the particle size composition and the concentrations of metals and organic matter in sediments. The Project will minimize or eliminate potential adverse changes to sediments through mitigation and management efforts such as erosion and runoff control measures, the installation of silt curtains for in-water works, monitoring the chemical composition of water that is discharged into the marine environment, and regulating vessel traffic and speed.

This section presents the existing conditions of the marine sediment quality as it relates to the proposed Project and identifies and evaluates the potential Project-related effects and cumulative effects within a local and regional context.

9.1 INCORPORATION OF TRADITIONAL KNOWLEDGE

9.1.1 Incorporation of Traditional Knowledge for Existing Environment and Baseline Information

The *Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP)* report (Banci and Spicker 2016) was reviewed for information related to marine sediment quality. There are no direct references relevant to the existing marine sediment quality in the NTKP report.

9.1.2 Incorporation of Traditional Knowledge for Valued Ecosystem Component Selection

The NTKP report made no direct reference to marine sediment quality (Banci and Spicker 2016). Inuit value the integrity of the environment, and noted the general importance of water quality, benthic invertebrates, fish communities, and fish habitat, all of which are directly affected by or dependent upon sediment quality. Therefore, the importance of marine sediment quality as a facet of environmental quality was considered in the selection of marine sediment quality as a VEC.

9.1.3 Incorporation of Traditional Knowledge for Spatial and Temporal Boundaries

The results of the NTKP report were considered when developing the spatial and temporal boundaries for the Madrid-Boston Project. The NTKP report showed that specific and general fishing locations extend along both shores of Melville Sound, but are concentrated along the southern shore extending both east and west of Roberts Bay. General fishing areas also extend inland along the entire length of the Hope Bay greenstone belt. Therefore, the entire Hope Bay Development area as well as Roberts Bay and Melville Sound were included within the spatial boundaries of the assessment.

9.1.4 Incorporation of Traditional Knowledge for Project Effects Assessment

The results of the NTKP report were considered when developing the effects assessment for marine sediment quality. No specific references relevant to the effects assessment for sediment quality were included in the NTKP report.

9.1.5 Incorporation of Traditional Knowledge for Mitigation and Adaptive Management

The NTKP report was considered when developing mitigation and adaptive management plans for marine sediment quality. No specific references to mitigation and adaptive management measures relevant to sediment quality were included in the NTKP report.

9.2 EXISTING ENVIRONMENT AND BASELINE INFORMATION

The Madrid-Boston Project is a part of the Hope Bay Development, which is comprised of several existing and approved projects. The development is located approximately 153 km southwest of Cambridge Bay, Nunavut, on the southern shore of Melville Sound in the West Kitikmeot region of Nunavut (Figure 9.2-1). Infrastructure and activities associated with the Project are primarily along the southern and western shorelines of Roberts Bay (68º 12' N, 106º 38' W; Figure 9.2-2), a small inlet that empties into Melville Sound and is bordered by Hope Bay (west) and Ida Bay (east; Figure 9.2-1).

Locally, Roberts Bay is a broad estuary with a maximum north-south length of 5 km and an east-west width of 4 km giving a total surface area of 14.3 km^2 (Figure 9.2-2). The total volume of the bay is approximately 5.1×10^8 m^3 with a mean depth of 36 m and maximum depth of 88 m at its mouth. The southernmost section of the inlet is shallow (< 20 m), and deepens to between 40 m and 90 m towards Melville Sound. Regionally, Ida Bay is a true fjord that is long (10 km), narrow (1 km at entrance), deep (> 65 m), with a shallow sill (20 m deep) at its mouth that impedes deep-water exchange with Melville Sound. Hope Bay is a broad inlet dotted with many small islands and islets with free connection to Melville Sound.

The physiography of the surrounding area is represented by broad, sloping uplands (primarily igneous outcrops) that reach approximately 300 m in elevation in the south, and subdued undulating plains near the coast. The region's vegetation is characterized by shrub tundra vegetation such as dwarf birch (*Betula nana*), willow (*Salix* sp.), Labrador tea (*Ledum decumbens*), avens (*Dryas* sp.), and blueberries (*Vaccinium* sp.; Volume 4, Chapter 8).

Water exchange between Roberts Bay and Melville Sound is not impeded because there is no sill present in the inlet. Water exchange between the two waterbodies occurs primarily during the summer months when winds drive the upper freshwater layer towards the shoreline of Roberts Bay, and deeper waters move into Melville Sound (Rescan 2012b). The bay is typically ice-covered from October to June, most of that time with land-fast ice that is about 1.5 m thick. During ice cover, the waters of the bay are isolated from wind stress and the exchange of waters between Roberts Bay and Melville Sound is reduced.

Figure 9.2-1
Project Location and Local and Regional Study Areas for Marine Sediment Quality VEC

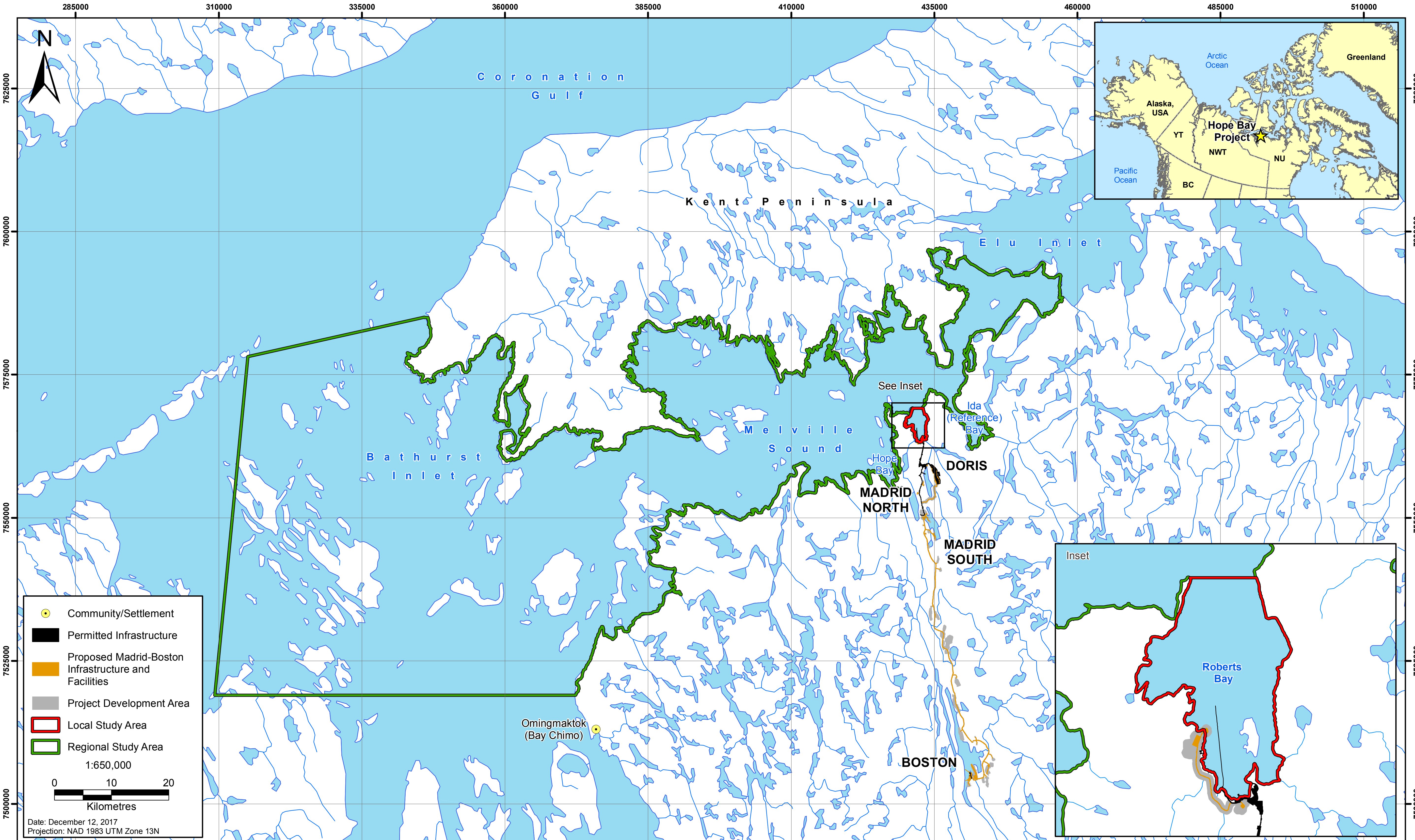
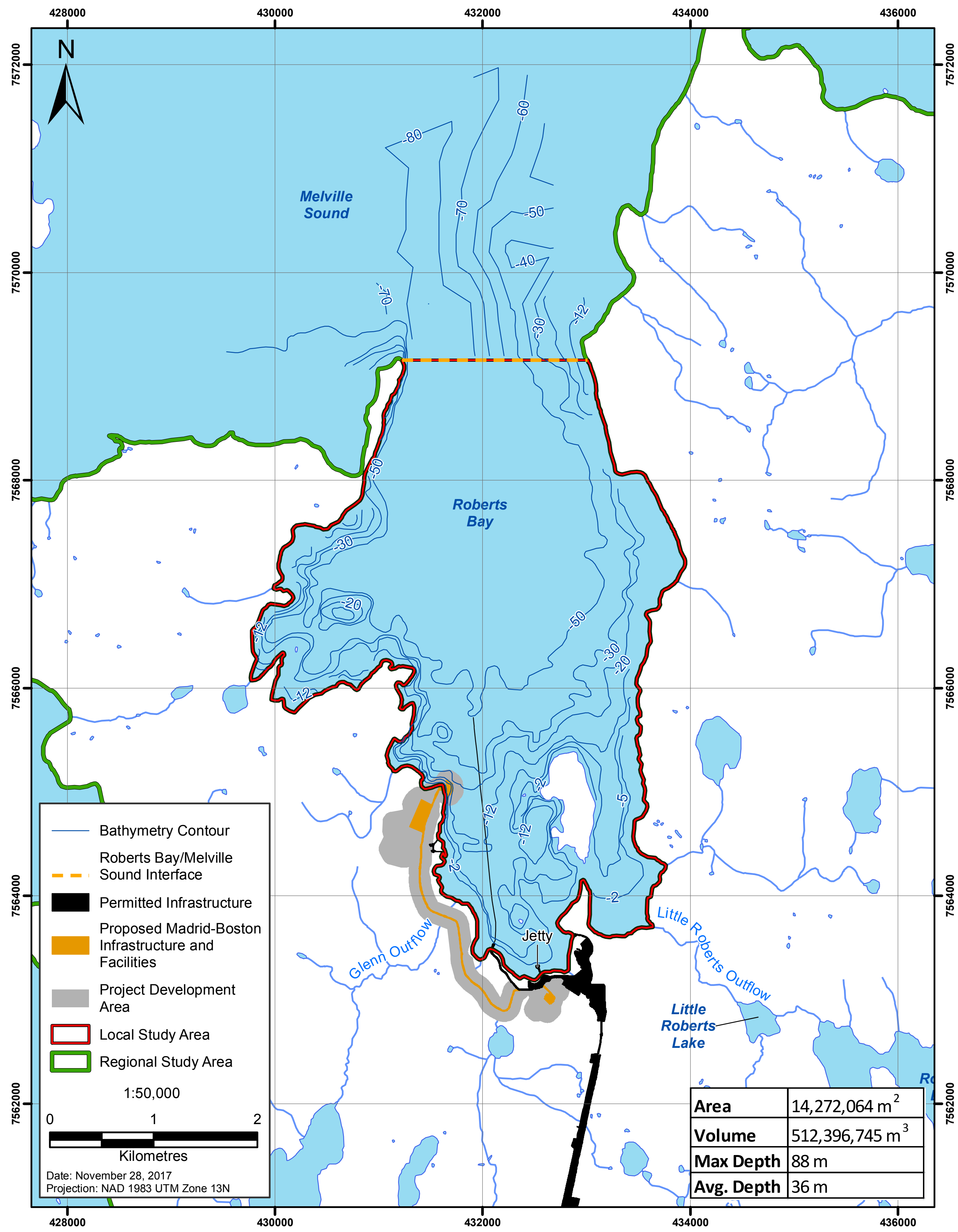


Figure 9.2-2

Roberts Bay Local Study Area and Project Development Area for Marine Sediment Quality VEC



Water movement and particle dispersion are greatest during the open-water season in Roberts Bay (Volume 5, Chapter 7). Currents greater 0.25 m/s have been measured as deep as 70 m in Roberts Bay and this is capable of mobilizing sand-sized particles. Because mean surface currents are greatest in the surface waters (Volume 5, Chapter 7), sediment re-suspension (as defined by total suspended sediments) and sedimentation rates in Roberts Bay are greatest over the shallow, southern section of the bay (Volume 5, Chapter 8; Figure 9.2-2). When these sediments are mobilized into the overlying waters, they are dispersed southward towards the head of the bay when northerly winds prevail and northwards towards Melville Sound when southerly winds prevail.

Freshwater enters Roberts Bay from Little Roberts Outflow, Glenn Outflow, and smaller tributaries (Figure 9.2-2), with Little Roberts Outflow being the dominant source. The Koignuk River and the Angimajuq River supply the vast majority of freshwater into Hope Bay and Ida Bay, respectively. These inputs contribute to the vertical stratification found in the inlets by forming a two-layer system with less dense water overlaying denser bottom water, which can reduce vertical mixing due to wind stress.

Roberts Bay and the surrounding embayments are generally well oxygenated, low in metals and nutrients, and have very low phytoplankton biomass levels. The marine fish community of Roberts Bay is representative of an Arctic marine ecosystem, and 25 species have been found in Roberts Bay to date (Volume 5, Chapter 10).

This section provides a summary of the methods and results from the marine sediment quality sampling carried out in Roberts Bay and the surrounding region for the proposed Madrid-Boston Project.

9.2.1 Regulatory Framework

There are several acts, regulations, and guidelines relevant to the management and preservation of marine sediment quality. Table 9.2-1 lists and provides a brief description of the key acts and regulations pertaining to marine sediment quality.

Table 9.2-1. Federal and Territorial Acts and Regulations Relevant to Marine Sediment Quality

Name of Act	Year (Year of Most Recent Amendment)	Administered by	Relevant Regulations under the Act	Description/Purpose
Arctic Waters Pollution Prevention Ac	1985 (2014)	Indigenous and Northern Affairs Canada (INAC)	Arctic Waters Pollution Prevention Regulations (C.R.C., c. 354) Arctic Shipping Pollution Prevention Regulations (C.R.C., c. 353)	• Prevents pollution of Arctic waters adjacent to the mainland and islands of the Canadian Arctic.
Canada Shipping Act	2001(2015)	Transport Canada	Ballast Water Control and Management Regulations (SOR/2011-237)	• Establishes ballast water exchange and treatment standards to prevent the introduction of pathogens. Prohibits the release of sediments that have settled in ballast tanks, and describes appropriate disposal method.

Name of Act	Year (Year of Most Recent Amendment)	Administered by	Relevant Regulations under the Act	Description/Purpose
Canada Shipping Act (cont'd)			Vessel Pollution and Dangerous Chemicals Regulations (SOR/2012-69)	• Prohibits the use of anti-fouling systems that contain any organotin compound that acts as a biocide. For organotin compounds applied to a vessel before January 1, 2008, requires that a coating be applied to act as a barrier to leaching.
			Response Organizations and Oil Handling Facilities Regulations (SOR/95-405)	• Regulations describing the procedures, equipment at the designated port, and resources to use in the event of an oil pollution incident.
Fisheries Act	1985 (2016)	Fisheries and Oceans Canada (DFO)	Metal Mining Effluent Regulations (SOR/2002-222)	• Protects fish habitat by prohibiting any harmful alteration, disruption, or destruction of fish habitat.
		Environment and Climate Change Canada (ECCC)		• Prohibits the deposition of deleterious substances into waters frequented by fish, unless authorization is granted.
Canadian Environmental Protection Act	1999 (2017)	ECCC	Disposal at Sea Regulations (SOR/2001-275)	• Deals with the prevention of pollution and the protection of the environment and human health from toxic substances, with the goal of contributing to sustainable development. • Regulates many substances that have a deleterious effect on the environment.
Nunavut Waters and Nunavut Surface Rights Tribunal Act	2002 (2016)	INAC		• Established the Nunavut Water Board (NWB), which can advise and make recommendations to any agency of the Government of Canada or Nunavut when making a decision that could affect a marine area.
Environmental Protection Act	1988 (1999)	Government of Nunavut, Department of Environment (GN-DOE)		• Prohibits the discharge of contaminants into the environment without authorization.
Environmental Rights Act	1988 (2011)	GN-DOE		• Grants all residents the ability to launch an investigation into the release of a contaminant into the environment.

In addition to these acts and regulations, the protection of marine sediment quality is also guided by the Canadian Environmental Quality Guidelines (CCME 2001b) which include the *Sediment Quality Guidelines for the Protection of Aquatic Life* (CCME 2017) published by the Canadian Council of Ministers of the Environment (CCME). These sediment quality guidelines define concentrations of sediment quality parameters that should present a negligible risk to marine and estuarine organisms.

9.2.2 Data Sources

Marine sediment quality data have been collected in the Hope Bay Project area since 1997, with information collected locally in Roberts Bay (1997, 2002, and 2009 to 2016) and regionally in Hope Bay (1997) and Ida (Reference) Bay (2009 to 2016).

Marine activities associated with the permitted Doris Project, including the construction of a jetty in Roberts Bay, began in 2007. Although the Doris Aquatic Effects Monitoring Program (AEMP) has shown that there have been no effects of the Doris Project on the marine environment, data collected in the years prior to 2007 are considered representative of baseline conditions, while data collected from 2007 onward are considered representative of existing conditions.

During the baseline period, two marine sediment surveys were conducted (in 1997 and 2002). The sediment survey undertaken in 1997 was a preliminary study that did not include the collection of replicate samples and did not include particle size information, which is important when evaluating sediment metal and nutrient results.

The primary sources of sediment quality information used to describe the existing environment were the historical studies conducted in Roberts Bay and Ida Bay (Reference Bay) from 2009 to 2011 and in Roberts Bay in 2016, and the Doris Project AEMP conducted in Roberts Bay and Ida Bay from 2010 to 2016. No marine sediment quality surveys were conducted in either 2007 or 2008.

Detailed sampling information can be found in the following reports:

- Hope Bay Belt Project: 1997 Environmental Data Report (Rescan 1998; Appendix V5-3G);
- Doris North Project Aquatic Studies 2002 (RL&L / Golder 2003; Appendix V5-5A);
- 2009 Marine Baseline Report, Hope Bay Belt Project (Rescan 2010; Appendix V5-7A);
- Hope Bay Belt Project: 2010 Marine Baseline Report (Rescan 2011c; Appendix V5-7B);
- Doris North Gold Mine Project: 2010 Aquatic Effects Monitoring Program Report (Rescan 2011a);
- Doris North Gold Mine Project: 2011 Aquatic Effects Monitoring Program (AEMP) Marine Expansion Baseline Report (Rescan 2011b, Appendix V5-7D);
- Doris North Gold Mine Project: 2011 Aquatic Effects Monitoring Program Report (Rescan 2012a);
- Doris North Gold Mine Project: 2012 Aquatic Effects Monitoring Program Report (Rescan 2013);
- Doris North Project: 2013 Aquatic Effects Monitoring Program Report (ERM Rescan 2014);
- Doris North Project: 2014 Aquatic Effects Monitoring Program (ERM 2015);
- Doris North Project: 2015 Aquatic Effects Monitoring Program Report (ERM 2016);
- Doris Project: 2016 Aquatic Effects Monitoring Program Report (ERM 2017); and
- Doris Project: 2016 to 2018 Roberts Bay Marine Baseline Report (ERM In preparation).

The Doris Project AEMP reports (2010 to 2016) are available on the Nunavut Water Board (NWB) FTP site (ftp://ftp.nwb-oen.ca).

9.2.3 Methods

9.2.3.1 Study Areas

Historical marine sediment quality data were collected in Roberts, Ida, and Hope bays between 1997 and 2016 (Figure 9.2-3). Sediment quality samples were collected locally from numerous sites throughout Roberts Bay between 1997 and 2016, including the shallow nearshore area (less than 10 m) at the head of the bay and the deeper areas in the central and northern sections of the bay. Hope Bay sediment quality was sampled in 1997 and sampling sites were near the mouth of the Koignuk River. Ida Bay sediments were sampled annually from 2009 and 2016, and sampling sites were concentrated in the shallow area at the head of the bay with one additional sampling site in deeper waters.

9.2.3.2 Sediment Quality Sampling Overview

A summary of the sampling programs conducted from 2009 to 2016, including sampling locations and replication, is shown in Table 9.2-2 (no marine sediment quality data were collected in 2007 or 2008). Sediment quality samples were collected using a Ponar (2009 and 2010) or Petite Ponar (2011 to 2016) dredge sampler. The sampling dredge was carefully lowered to the sediment using a metred cable line, and triggered closed. Upon retrieval, sediments were transferred to sample containers and kept cool until shipment to ALS Environmental (Vancouver or Burnaby, BC) where the sediments were analyzed for particle size, nutrients, total organic carbon (TOC), metals, and polycyclic aromatic hydrocarbons (PAH; in 2009 and 2010 only).

Table 9.2-2. Marine Sediment Quality Sampling in Roberts and Ida Bays, 2009 to 2016

Year	2009	2010	2011	2012 to 2016	2016
Month Sampled	August	August	August	August	August
Sampling Equipment	Ponar	Ponar	Petite Ponar	Petite Ponar	Petite Ponar
Sediment Quality Parameters	Particle size, TOC, nutrients, metals, PAH	Particle size, TOC, nutrients, metals, PAH	Particle size, TOC, nutrients, metals	Particle size, TOC, nutrients, metals	Particle size, TOC, metals
Roberts Bay Sites (LSA)	Shallow ST2 ST7 ST8 ST9 ST11 DW3 RTF1 TF1 Deep ST10 DW2 DW1	Shallow P1 P2 P3 P4 RBE RBW	Shallow RBW RBE Deep RB1	Shallow RBW RBE	Deep W-G50 E-G50 S-G50 W-G250 E-G250 S-G250 W-G500 E-G500 S-G500 W-F2 E-F2 E-F3 E-F4
Ida Bay Sites (RSA)	Shallow RP1 RP2 Deep RP3	Shallow REF-Marine	Shallow REF-Marine 1 Deep REF-Marine 2	Shallow REF-Marine 1	
Site Replication	n = 3	n = 3	n = 3	n = 3	n = 1

For the characterization of existing conditions, data were grouped by depth strata since sediments in the shallow near-shore areas tend to be coarser than deeper, calmer areas where finer materials are deposited, and fine-grain sediments tend to be associated with higher metal and organic carbon concentrations. Sample depths of 0 to 10 m were considered 'shallow' sites, and sample depths greater than 10 m were considered 'deep' sites.

Monitoring for sedimentation rates or the modelling of sediment dispersion was deemed unnecessary for the assessment of potential Madrid-Boston Project effects to marine sediment quality. Project activities are expected to interact with the marine sediments on local scales over short durations. These localized, short-term effects are expected to be effectively mitigated and managed, as detailed in the relevant management plans. It is also anticipated that larger in-water works, such as the construction of the cargo dock, will incorporate construction monitoring to ensure the potential effects to sediment quality are controlled. Basin-scale circulation has been be modelled for Roberts Bay (see Volume 5, Chapter 7), and near-field and far-field effluent dispersion modelling has also been conducted (Appendices V5-8A, V5-8B, and V5-8C). Therefore, the movement of water and how dissolved and suspended substances would disperse within the inlet is well understood.

9.2.3.3 Quality Assurance and Quality Control

The sediment sampling quality assurance and quality control (QA/QC) program included the use of chain of custody forms and the collection of replicate sediment samples to account for within-site variability. Full methodologies can be found in the historical baseline and AEMP reports listed in Section 9.2.2.

9.2.3.4 Calculation of Summary Statistics

Summary statistics were calculated for sediment quality parameters within Roberts Bay and Ida Bay for data collected between 2009 and 2016.

For the calculation of minimum, maximum, mean, median, and the 75th and 95th percentile values for sediment quality parameters, one half of the value of the detection limit was substituted for sample concentrations that were below analytical detection limits.

The minimum value represents the lowest value reported for any sample after substituting one half of the detection limit for values that were below detection limits. The maximum value represents the highest detectable concentration in any sample and excludes values reported as being below analytical detection limits, except when all values were below detection limits, in which case the maximum represents the highest detection limit. Whenever the value of the minimum or maximum was a censored value (i.e., sample concentration below the analytical detection limit), this value was reverted back from one half of the detection limit to its raw form (i.e., reported as being less than '<' the given detection limit) to clearly distinguish censored values.

Sediment quality data collected on the same date from the same site (replicates) were averaged prior to the calculation of the mean, median, and the 75th and 95th percentiles, and for comparisons against sediment quality guidelines to give equal weighting to samples regardless of the degree of replication.

9.2.4 Characterization of Existing Conditions

A summary of sediment quality results for the marine sampling program in Roberts and Ida bays from 2009 to 2016 is presented in Tables 9.2-3 to 9.2-5. These data are discussed within the framework of CCME sediment quality guidelines, which are established interim guidelines for sediment quality parameters to monitor and protect marine life from acute and chronic toxicity. The CCME guidelines are conservative empirical thresholds that are meant to be protective of all forms of aquatic life and all aspects of aquatic cycles, including the most sensitive species over the long term (CCME 1995).

Figure 9.2-3
Historical Marine Sediment Quality Sampling Locations, 1997 to 2016

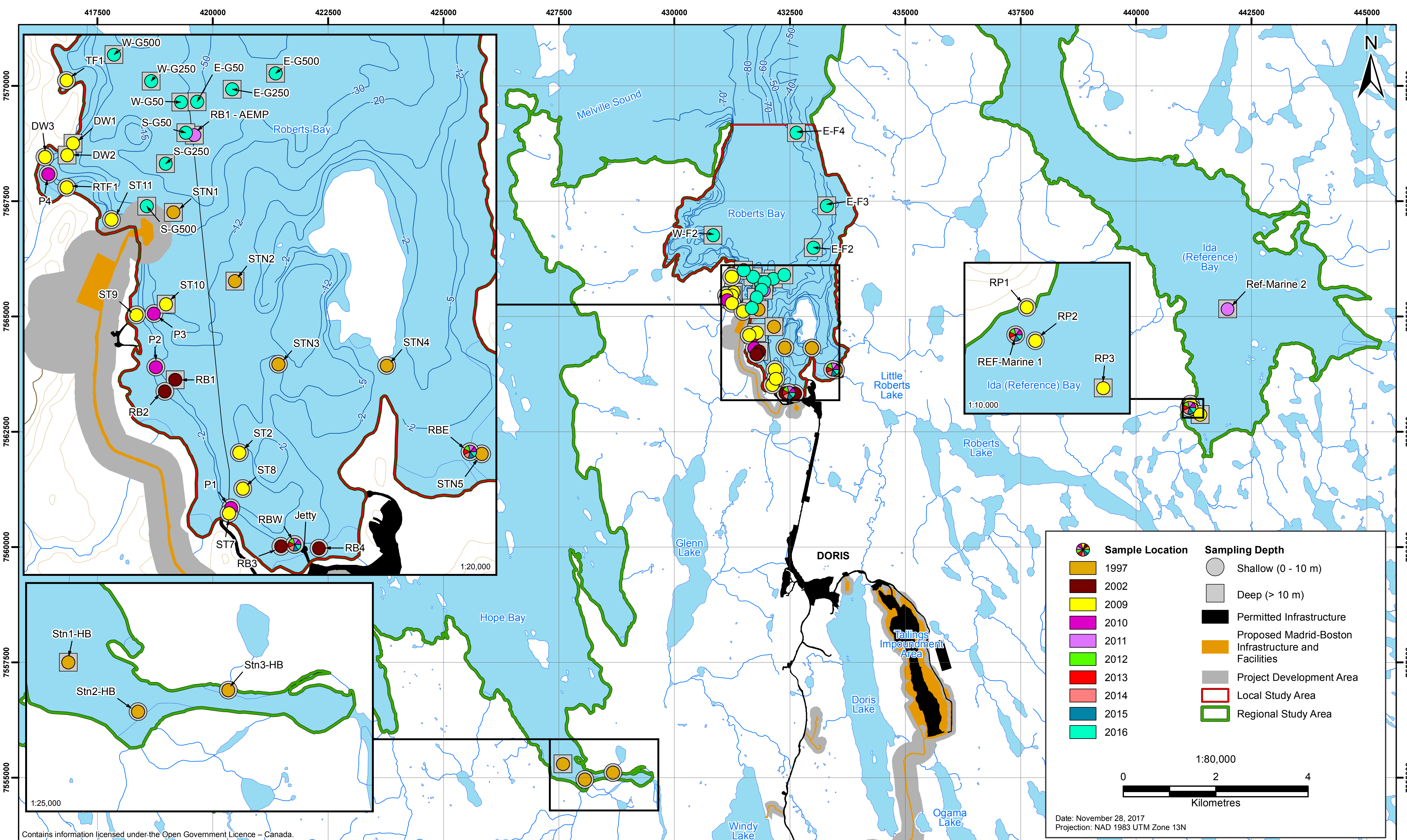


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Table 9.2-3. Summary of Marine Sediment Composition in Roberts and Ida Bays, 2009 to 2016

LSA - Roberts Bay	Min[a]	Mean[b]	Median[b]	75th Percentile[b]	95th Percentile[b]	Max[c]
Shallow Sites	**n = 78**	**n = 26**	**n = 26**	**n = 26**	**n = 26**	**n = 78**
Gravel >2 mm (%)	<0.1	1.9	0.5	1.9	9.4	29
Sand 2.0 mm - 0.063 mm (%)	<0.1	70	76	85	98	99
Silt 0.063 mm - 4 µm (%)	<1.0	20	17	36	45	99
Clay <4 µm (%)	0.45	8.1	4.3	15	23	30
Deep Sites	**n = 25**	**n = 17**	**n = 17**	**n = 17**	**n = 17**	**n = 25**
Gravel >2 mm (%)	<0.1	0.6	0.05	0.7	2.2	12
Sand 2.0 mm - 0.063 mm (%)	1.6	9.7	4.6	8.5	41	57
Silt 0.063 mm - 4 µm (%)	22	46	48	49	50	58
Clay <4 µm (%)	21	44	47	48	49	51
RSA - Ida (Reference) Bay	**Min[a]**	**Mean[b]**	**Median[b]**	**75th Percentile[b]**	**95th Percentile[b]**	**Max[c]**
Shallow Sites	**n = 30**	**n = 10**	**n = 10**	**n = 10**	**n = 10**	**n = 30**
Gravel >2 mm (%)	<0.1	0.68	0.21	1.0	2.4	7.6
Sand 2.0 mm - 0.063 mm (%)	1.7	32	17	49	82	86
Silt 0.063 mm - 4 µm (%)	11	52	62	68	73	79
Clay <4 µm (%)	3.0	15	19	21	25	26
Deep Sites	**n = 6**	**n = 2**	**n = 2**	**n = 2**	**n = 2**	**n = 6**
Gravel >2 mm (%)	<0.1	0.53	0.53	0.76	0.95	2.0
Sand 2.0 mm - 0.063 mm (%)	1.9	6.0	6.0	7.8	9.3	14
Silt 0.063 mm - 4 µm (%)	55	57	57	58	58	60
Clay <4 µm (%)	31	36	36	38	39	41

Notes: n = number of observations.
<' indicates that value was less than the analytical detection limit shown.
One half of the value of the analytical detection limit was substituted for values that were below detection limits for the calculation of summary statistics.
[a] Minimum represents the lowest concentration in any sample.
[b] Replicate samples collected at the same site and date were averaged for the calculation of mean, median, and the 75th and 95th percentiles.
[c] Maximum represents the highest detectable concentration in any sample (excludes values reported as being below analytical detection limits, except when all values were below detection limits, in which case the maximum represents the highest detection limit).

Table 9.2-4. Summary of Marine Sediment Total Organic Carbon and Nutrient Concentrations in Roberts and Ida Bays, 2009 to 2016

LSA - Roberts Bay	Min[a]	Mean[b]	Median[b]	75th Percentile[b]	95th Percentile[b]	Max[c]
Shallow Sites	**n = 78**	**n = 26**	**n = 26**	**n = 26**	**n = 26**	**n = 78**
Total Organic Carbon (%)	<0.05	0.27	0.20	0.42	0.62	0.75
Available Ammonium (as N) (mg/kg)	<0.8	4.8	1.8	8.0	13	29
Available Nitrate (as N) (mg/kg)	<1.0	All concentrations below detection limits				<6.0
Available Nitrite (as N) (mg/kg)	<0.4	All concentrations below detection limits				<1.2
Available Phosphate (as P) (mg/kg)	2.5	13	13	18	26	42

LSA - Roberts Bay	Min[a]	Mean[b]	Median[b]	75th Percentile[b]	95th Percentile[b]	Max[c]
Deep Sites	**n = 25**	**n = 17**	**n = 17**	**n = 17**	**n = 17**	**n = 25**
Total Organic Carbon (%)	0.38	0.72	0.75	0.76	0.81	0.83
	n = 12	**n = 4**	**n = 4**	**n = 4**	**n = 4**	**n = 12**
Available Ammonium (as N) (mg/kg)	2.4	13	12	19	23	43
Available Nitrate (as N) (mg/kg)	<2.0	All concentrations below detection limits				<6.0
Available Nitrite (as N) (mg/kg)	<0.4	All concentrations below detection limits				<1.2
Available Phosphate (as P) (mg/kg)	12	37	22	40	79	101
RSA - Ida (Reference) Bay	**Min[a]**	**Mean[b]**	**Median[b]**	**75th Percentile[b]**	**95th Percentile[b]**	**Max[c]**
Shallow Sites	**n = 30**	**n = 10**	**n = 10**	**n = 10**	**n = 10**	**n = 30**
Total Organic Carbon (%)	0.18	0.95	0.95	1.3	1.8	2.5
Available Ammonium (as N) (mg/kg)	1.0	10	7.3	12	25	47
Available Nitrate (as N) (mg/kg)	<2.0	1.4	1.2	1.9	2.1	3.5
Available Nitrite (as N) (mg/kg)	<0.4	All concentrations below detection limits				<0.8
Available Phosphate (as P) (mg/kg)	9.7	25	26	31	40	53
Deep Sites	**n = 6**	**n = 2**	**n = 2**	**n = 2**	**n = 2**	**n = 6**
Total Organic Carbon (%)	0.81	0.97	0.97	1.0	1.1	1.2
Available Ammonium (as N) (mg/kg)	5.9	12	12	13	14	19
Available Nitrate (as N) (mg/kg)	<2	All concentrations below detection limits				<6
Available Nitrite (as N) (mg/kg)	<0.4	All concentrations below detection limits				<1.2
Available Phosphate (as P) (mg/kg)	27	60	60	75	88	103

Notes:
n = number of observations.
<' indicates that value was less than the analytical detection limit shown.
One half of the value of the analytical detection limit was substituted for values that were below detection limits for the calculation of summary statistics.
[a] *Minimum represents the lowest concentration in any sample.*
[b] *Replicate samples collected at the same site and date were averaged for the calculation of mean, median, and the 75th and 95th percentiles.*
[c] *Maximum represents the highest detectable concentration in any sample (excludes values reported as being below analytical detection limits, except when all values were below detection limits, in which case the maximum represents the highest detection limit).*

9.2.4.1 Total Organic Carbon and Nutrients

The mean TOC content of the sediments ranged from 0.27% in the shallow sediments from Roberts Bay to 0.97% in the deep sediments of Ida Bay (Table 9.2-4). The pooled data from Roberts and Ida bays showed that TOC content was negatively correlated with sand content ($r = -0.69$, $p < 0.001$, $n = 126$; Pearson correlations of logit-transformed percentage data) and positively correlated with silt content ($r = 0.70$, $p < 0.001$, $n = 26$) and clay content ($r = 0.81$, $p < 0.001$, $n = 126$). Mean TOC levels tended to be greater in Ida Bay (0.95% and 0.97% in the shallow and deep sites) than in Roberts Bay (0.27% and 0.72% in the shallow and deep sites), likely due to the presence of finer sediments in Ida Bay.

Table 9.2-5. Summary of Marine Sediment Metal Concentrations in Roberts and Ida Bays, 2009 to 2016

	CCME Guidelines for the Protection of Aquatic Life[a]		Total Metal Concentration (mg/kg)						% of Sample Concentrations Greater than ISQG[e]	% of Sample Concentrations Greater than PEL[e]
	ISQG[b]	PEL[c]	Min[d]	Mean[e]	Median[e]	75th Percentile[e]	95th Percentile[e]	Max[f]		
LSA - Roberts Bay										
Shallow Sites			**n = 78**	**n = 26**	**n = 26**	**n = 26**	**n = 26**	**n = 78**	**n = 26**	**n = 26**
Arsenic	7.24	41.6	0.59	2.35	2.13	3.34	4.04	4.67	0	0
Cadmium	0.7	4.2	<0.05	0.040	0.05	0.05	0.05	0.110	0	0
Chromium	52.3	160	11.2	22.7	22.2	29.1	36.6	44.2	0	0
Copper	18.7	108	4.7	13.2	10.7	17.7	24.5	29.3	23	0
Lead	30.2	112	<2.0	2.7	2.5	3.8	5.3	6.4	0	0
Mercury	0.13	0.70	<0.005	0.0037	0.0025	0.0046	0.0074	0.0115	0	0
Zinc	124	271	10.1	22.7	20.5	30.6	38.1	48.6	0	0
Deep Sites			**n = 25**	**n = 17**	**n = 17**	**n = 17**	**n = 17**	**n = 25**	**n = 17**	**n = 17**
Arsenic	7.24	41.6	2.37	11.5	8.32	14.0	29.4	51.9	65	0
Cadmium	0.7	4.2	<0.1	0.144	0.155	0.165	0.189	0.230	0	0
Chromium	52.3	160	32.9	61.0	62.9	65.4	71.5	72.4	88	0
Copper	18.7	108	12.8	23.8	24.5	24.8	27.9	28.6	88	0
Lead	30.2	112	4.40	7.76	8.11	8.33	8.51	9.70	0	0
Mercury	0.13	0.70	0.0073	0.0157	0.0166	0.0178	0.0185	0.0189	0	0
Zinc	124	271	34.9	69.7	71.8	74.9	83.5	85.2	0	0
RSA - Ida (Reference) Bay										
Shallow Sites			**n = 30**	**n = 10**	**n = 10**	**n = 10**	**n = 10**	**n = 30**	**n = 10**	**n = 10**
Arsenic	7.24	41.6	0.54	3.26	3.88	4.24	5.00	5.58	0	0
Cadmium	0.7	4.2	<0.05	0.057	0.05	0.057	0.103	0.144	0	0
Chromium	52.3	160	8.5	27.2	31.8	33.9	38.7	40.6	0	0
Copper	18.7	108	4.6	11.6	12.6	13.7	17.2	19.5	0	0
Lead	30.2	112	<2.0	3.8	4.5	4.8	5.7	6.2	0	0
Mercury	0.13	0.70	<0.005	0.0099	0.0123	0.0138	0.0151	0.0186	0	0
Zinc	124	271	14.4	33.0	37.6	40.5	44.9	47.2	0	0

	CCME Guidelines for the Protection of Aquatic Life[a]		Total Metal Concentration (mg/kg)						% of Sample Concentrations Greater than ISQG[e]	% of Sample Concentrations Greater than PEL[e]
	ISQG[b]	PEL[c]	Min[d]	Mean[e]	Median[e]	75th Percentile[e]	95th Percentile[e]	Max[f]		
Deep Sites			**n = 6**	**n = 2**	**n = 2**	**n = 2**	**n = 2**	**n = 6**	**n = 2**	**n = 2**
Arsenic	7.24	41.6	2.34	27.1	27.1	39.2	48.9	55.8	50	50
Cadmium	0.7	4.2	<0.1	0.073	0.073	0.084	0.093	0.104	0	0
Chromium	52.3	160	42.8	46.6	46.6	46.9	47.2	48.6	0	0
Copper	18.7	108	17.7	18.9	18.9	19.0	19.0	19.7	50	0
Lead	30.2	112	5.98	6.42	6.42	6.53	6.61	6.70	0	0
Mercury	0.13	0.70	0.0135	0.0161	0.0161	0.0172	0.0181	0.0200	0	0
Zinc	124	271	48.4	52.8	52.8	53.8	54.5	56.1	0	0

Notes:
Units are in mg/kg unless otherwise indicated.
n = number of observations.
<' indicates that metal concentration was less than the analytical detection limit shown.
One half of the value of the analytical detection limit was substituted for values that were below detection limits for the calculation of summary statistics.
[a] *Canadian sediment quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment (CCME 2017)*
[b] *ISQG = Interim Sediment Quality Guideline*
[c] *PEL = Probable Effects Level*
[d] *Minimum represents the lowest concentration in any sample.*
[e] *Replicate samples collected at the same site and date were averaged for the calculation of mean, median, and the 75th and 95th percentiles, and for comparisons against CCME guidelines.*
[f] *Maximum represents the highest detectable concentration in any sample (excludes values reported as being below analytical detection limits, except when all values were below detection limits, in which case the maximum represents the highest detection limit).*

Plant-available nutrient concentrations were similar between bays. Concentrations of available nitrate and nitrite were usually below detection limits. Available ammonium-N concentrations ranged from <0.8 to 43 mg/kg in Roberts Bay, and from 1.0 to 47 mg/kg in Ida Bay. Available phosphate-P concentrations ranged from 2.5 to 101 mg/kg in Roberts Bay, and from 9.7 to 103 mg/kg in Ida Bay (Table 9.2-4).

9.2.4.2 Sediment Metals

Marine sediment metal concentrations were examined alongside the CCME guidelines (CCME 2017). The Interim Sediment Quality Guidelines (ISQG) are conservative empirical thresholds below which no effects on marine benthic organisms are predicted to occur. The CCME Probable Effects Level (PEL) thresholds describe the sediment concentration at which biological effects are likely to occur. The concentrations of sediment metals of interest in Roberts and Ida bays as well as the CCME guidelines for these sediment metal concentrations are summarized in Table 9.2-5.

Mean concentrations of sediment metals tended to be higher at deep depths compared to shallow depths. This was likely due to the greater proportion of fine particles in the sediments collected from the deeper sites in Roberts and Ida bays compared to the shallow sites (see Section 9.2.4.1), since many metals readily adsorb to the surfaces of silt and clay particles. Within each depth class, mean metal concentrations were similar between bays.

Sediment metal concentrations were generally below CCME guidelines in both bays, with a few exceptions. In Roberts and Ida bays, concentrations of cadmium, lead, mercury, and zinc were always below CCME ISQG and PEL guideline levels. In Roberts Bay, arsenic, chromium, and copper concentrations were higher than their respective ISQGs in most samples collected from deep sites, and copper concentrations were higher that the ISQG in some samples collected from shallow sites. Copper and arsenic concentrations were also naturally elevated in sediments from Ida Bay. In the deep waters of Ida Bay, the copper concentration in one of two replicate means exceeded the CCME ISQG for copper, and the arsenic concentration in one of two replicate means exceeded both the ISQG and PEL guidelines for arsenic (Table 9.2-5).

9.2.4.3 Hydrocarbons

Concentrations of polycyclic aromatic hydrocarbons (PAH) were analyzed in Roberts and Ida Bay sediments in 2009 and 2010. Nearly all concentrations of PAH were below analytical detection limits. The single exception was a concentration of 0.015 mg/kg of 2-methylnaphthalene in a single replicate collected from one site (RTF1) in Roberts Bay in 2009, which was just barely over the detection limit of 0.010 mg/kg and below the CCME ISQG of 0.0202 mg/kg (CCME 2017). All other PAH concentrations were below analytical detection limits and CCME guidelines. These low levels are consistent with the remote location of the Madrid-Boston Project and the low levels of human activities in the region.

9.3 VALUED ECOSYSTEM COMPONENTS

9.3.1 The Scoping Process and Identification of VECs

Valued Ecosystem Components (VECs) are those components of the biophysical environment considered to be of scientific, ecological, economic, social, cultural, or heritage importance (Volume 2, Chapter 4). The selection and scoping of a VEC considers the biophysical conditions and trends that may interact with the proposed Project, the variability in biophysical conditions over time, and data availability as well as the ability to measure biophysical conditions that may interact with the Project. For an interaction to occur there must be spatial and temporal overlap between a VEC and Project components and/or activities. The selection and scoping of VECs also considers their importance to the communities potentially affected by the Project.

The scoping of marine sediment quality as a VEC followed the process outlined in the Assessment Methodology (Volume 2, Chapter 4). The scoping analysis identified marine sediment quality for inclusion as a VEC in the assessment. This was based on the following:

- the potential for Madrid-Boston Project activities and components to interact with local and regional marine sediments;
- the EIS guidelines and appendices (NIRB 2012);
- the existence of federal or territorial acts, regulations, and guidelines that directly or indirectly identify sediment quality as an important marine component (e.g., CCME sediment quality guidelines, Metal Mining Effluent Regulations (MMER) under the *Fisheries Act* (1985b);
- the inclusion of marine sediment quality as a VEC in recently completed Nunavut environmental assessments (e.g., Back River, Mary River); and
- the professional recognition that the Madrid-Boston Project has the potential to interact with the marine sediments.

Table 9.3-1 summarizes the scoping considerations and rationale for including marine sediment quality as a VEC in this assessment.

Table 9.3-1. Valued Ecosystem Component(s) Included in the Assessment

VEC	Identified by			Rationale for Inclusion
	TK	NIRB Guidelines	Government	
Marine Sediment Quality		x	x	Moderate to significant comments expressed by regulatory agencies and potentially significant regulatory considerations.

9.3.2 TMAC Consultation and Engagement Informing VEC or VSEC Selection

Community meetings for the Madrid-Boston Project were conducted in each of the five Kitikmeot communities as described in Volume 2, Chapter 3. The meetings are a central component of engagement with the public and an opportunity to share information and seek public feedback. Overall, the community meetings were well attended. Public feedback (questions, comments, and concerns) about the proposed Project was obtained through open dialogue during Project presentations, through discussions that arose during the presentation of Project materials and comments provided in feedback forms. There were no direct comments received relating to marine sediment quality.

9.4 SPATIAL AND TEMPORARY BOUNDARIES

The marine sediment quality spatial and temporal boundaries define the maximum spatial and temporal extent within which the potential effects assessment was conducted.

The spatial boundaries selected to shape this assessment are determined by the Project's potential effects on the marine environment. The spatial boundaries were defined by the coastal morphology, physical oceanography of Roberts Bay, and the proximity of Project infrastructure and activities to the marine environment.

Temporal boundaries are selected that consider the different phases of the Project and their durations. The Project's temporal boundaries reflect those periods during which planned activities will occur and have potential to affect marine sediment quality.

The determination of spatial and temporal boundaries also takes into account the development of the entire Hope Bay Greenstone Belt. The assessment considers both the incremental potential effects of the Project as well as the total potential effects of the additional Project activities in combination with the existing and approved projects including the Doris Project and advanced exploration activities at Madrid and Boston.

9.4.1 Project Overview

The Madrid-Boston Project consists of proposed mine operations at the Madrid North, Madrid South and Boston deposits. The Madrid-Boston Project is part of a staged approach to continuous development of the Hope Bay Project, comprised of existing operations at Doris and bulk samples followed by commercial mining at Madrid North, Madrid South, and Boston deposits. The Madrid-Boston Project would use and expand upon the existing Doris Project infrastructure.

The Madrid-Boston Project is the focus of this application. Because the infrastructure of existing and approved projects will be utilized by the Madrid-Boston Project, and because the existing and approved projects have the potential to interact cumulatively with the Madrid-Boston Project, existing and approved project are described below.

9.4.1.1 Existing and Approved Projects

Existing and approved projects include:

- the Doris Project (NIRB Project Certificate 003, NWB Type A Water Licence 2AM-DOH1323);
- the Hope Bay Regional Exploration Project (NWB Type B Water Licence 2BE-HOP1222);
- the Madrid Advanced Exploration Program (NWB Type B Water Licence 2BB-MAE1727); and
- the Boston Advanced Exploration Project (NWB Type B Water Licence 2BB-BOS1727).

<u>The Doris Project</u>

The Doris Project was approved by NIRB in 2006 (NIRB Project Certificate 003) and licenced by NWB in 2007 (Type A Water Licence 2AM-DOH0713). The Type A Water Licence was amended in 2010, 2011 and 2012 and received modifications in 2009, 2010, and 2011.

Construction of the Doris Project began in early 2010. In early 2012, the Doris Project was placed into care and maintenance, suspending further Project-related construction and exploration activity along the Hope Bay Greenstone Belt. Following TMAC's acquisition of the Hope Bay Project in March of 2013, NWB renewed the Doris Project Type A Water Licence (Type A Water Licence 2AM-DOH1323), and TMAC advanced planning, permitting, exploration, and construction activities. In 2016, NIRB approved an amendment to Project Certificate 003 and NWB granted Amendment No. 1 to Type A Water Licence 2AM-DOH1323, extending operations from two to six years through mining two additional mineralized zones (Doris Connector and Doris Central zones) to be accessed via the existing Doris North portal. Amendment No. 1 to Type A Water Licence 2AM-DOH1323 authorizes a mining rate of approximately

2,000 tonnes per day of ore and a milling throughput of approximately 2,000 tonnes per day of ore. The Doris Project began production early in 2017.

The Doris Project includes the following components and facilities:

- The Roberts Bay offloading facility: marine jetty, barge landing area, beach laydown area, access roads, weather havens, fuel tank farm/transfer station, waste storage facilities and incinerator, and quarry;
- The Doris site: 280 person camp, laydown areas, service complex (e.g., workshop, wash bay, administration buildings, mine dry), two quarries (mill site platform and solid waste landfill), core storage areas, batch plant, brine mixing facilities, vent raise (3), air heating units, reagent storage, fuel tank farm/transfer station, potable water treatment, waste water treatment, incinerator, landfarm and handling/temporary hazardous waste storage, explosives magazine, and diesel power plant;
- Doris Mine works and processing: underground portal, overburden stockpile, temporary waste rock pile, ore stockpile, and ore processing plant (mill);
- Tailings Impoundment Area (TIA): Schedule 2 designation for Tail Lake with two dams (North and South dams), sub-aerial deposition of flotation tailings, emergency tailings dump catch basins, pump house, and quarry;
- All-season main road with transport trucks: Roberts Bay to Doris site (4.8 km, 150 to 200 tractor and 300 fuel tanker trucks/year);
- Access roads from Doris site used predominantly by light-duty trucks to: the TIA, the explosives magazine, Doris Lake float plane dock (previously in use), solid waste disposal site, and to the tailings decant pipe, from the Roberts Bay offloading facility to the location where the discharge pipe enters the ocean; and
- All-weather airstrip (914 m), winter airstrip (1,524 m), helicopter landing site and building, and Doris Lake float plane and boat dock.

Water is managed at the Doris Project through:

- freshwater input from Doris Lake for mining, milling, and associated activities and domestic purposes;
- freshwater input from Windy Lake for domestic purposes;
- process water input primarily from the TIA reclaim pond;
- surface mine contact water discharged to the TIA;
- underground mine contact water directed to the TIA or to Roberts Bay via the marine outfall mixing box (MOMB);
- treated waste water discharged to the TIA; and
- water from the TIA treated and discharged to Roberts Bay via a discharge pipeline, with use of a MOMB.

Hope Bay Regional Exploration Project

The Hope Bay Regional Exploration Project has been renewed several times since 1995. The current extension expires in June 2022. Much of the previous work for the program was based out of Windy Lake and Boston camps. These camps were closed in October 2008 with infrastructure either decommissioned or moved to the Doris site. All exploration activities are now based from the Doris site. Components and activities for the Hope Bay Regional Exploration Project include:

- operation of helicopters from Doris; and
- the use of exploration drills, which are periodically moved by roads and by helicopter as required.

Madrid Advanced Exploration

In 2017, the NWB issued a Type B Water Licence (2BB-MAE1727) for the Madrid Advanced Exploration Program to support continued exploration and a bulk sample program at the Madrid North and Madrid South sites, located approximately 4 km south of the Doris site. The program includes extraction of a bulk sample totaling 50 tonnes from each of the Madrid North and South locations, which will be trucked to the mill at the Doris site for processing and placement of tailings in the tailings impoundment area (TIA). All personnel will be housed in the Doris camp.

The Madrid Advanced Exploration Program includes the following components and activities.

- Use of existing infrastructure associated with the Doris Project:
  - camp facilities to support up to 70 personnel as required to undertake the advanced exploration activities;
  - mill to process ore;
  - TIA;
  - landfill and hazardous waste areas, particularly if closure and remediation becomes required for the Madrid Advanced Exploration Program infrastructure;
  - fuel tank farms; and
  - Doris airstrip and Roberts Bay facility for transport of personnel and supplies.
- Use of existing infrastructure at the Madrid and Boston areas:
  - borrow and rock quarry facilities: existing Quarries A, B, and D along the Doris-Windy all-weather road (AWR);
  - AWR between Doris and Windy Lake for transportation of personnel, ore, waste, fuel, and supplies; and
  - future mobilization of existing exploration site infrastructure, should it become necessary.
- Construction of additional facilities at Madrid North and South:
  - access portals and ramps for underground operations at Madrid North and at Madrid South;
  - 4.7 km extension of the existing AWR originating from the Doris to the Windy exploration area (Madrid North) to the Madrid South deposit, with branches to Madrid North, Madrid North vent raise, and the Madrid South portal;
  - development of a winter road route (WRR) from Madrid North to access Madrid South until AWR has been constructed;
  - borrow and rock quarry facilities; two quarries referenced as Quarries G and H;
  - waste rock and ore stockpiles;
  - water and waste management structures; and
  - additional site infrastructure, including compressor building, brine mixing facility, saline storage tank, air heating facility, four vent raises, workshop and office, laydown area, diesel generator, emergency shelter, fuel storage facility/transfer station.

- Undertaking of advanced exploration access to aforementioned deposits through:
  - continue field mapping and sampling, as well as airborne/ground/downhole geophysics;
  - diamond drilling from the surface and underground; and
  - bulk sampling through underground mining methods and mine development.

Boston Advanced Exploration

The Boston Advanced Exploration Project Type B Water Licence No. 2BB-BOS1217 was renewed as Water Licence No. 2BB-BOS1727 in July 2017 and includes:

- the Boston camp (65 person), maintenance shops, workshops, laydown areas, water pumphouse, vent raise, warehouse, site service roads, sewage and greywater treatment plant, fuel storage and transfer station, landfarm, solid waste landfill and a heli-pad;
- mine works, consisting of underground development for exploration drilling and bulk sampling, waste rock and ore stockpiles;
- potable water and industrial water from Aimaokatalok Lake; and
- treated sewage and greywater discharged to the tundra.

9.4.1.2 The Madrid-Boston Project

The Madrid-Boston Project includes: the Construction and Operation of commercial mining at the Madrid North, Madrid South, and Boston sites; the continued operation of Roberts Bay and the Doris site to support mining at Madrid and Boston; and the Reclamation and Closure and Post-closure phases of all sites. Excluded from the Madrid-Boston Project for the purposes of the assessment are the Reclamation and Closure and Post-closure components of the Doris Project as currently permitted and approved.

Construction

Madrid-Boston construction will use the infrastructure associated with Existing and Approved Projects. This may include:

- an all-weather airstrip at the Boston exploration area and helicopter pad;
- seasonal construction and/or operation of a winter ice strip on Aimaokatalok Lake;
- Boston camp with expected capacity for approximately 65 people during construction
- Quarry D Camp with capacity for up to 180 people;
- seasonal construction/operation of Doris to Boston WRR;
- three existing quarry sites along the Doris to Windy AWR;
- Doris camp with capacity for up to 280 people;
- Doris airstrip, winter ice strip, and helicopter pad;
- Roberts Bay offloading facility and road to Doris; and
- Madrid North and Madrid South sites and access roads.

Additional infrastructure to be constructed for the proposed Madrid-Boston Project includes:

- expansion of the Doris TIA (raising of the South Dam, construction of West Dam, development of a west road to facilitate access, and quarrying, crushing, and screening of aggregate for the construction);
- construction of a cargo dock at Roberts Bay (including a fuel pipeline, mooring points, beach landing and gravel pad, shore manifold);
- construction of an additional tank farm at Roberts Bay (consisting of two 10 ML tanks);
- expansion of Doris accommodation facility (from 280 to 400 person), mine dry and administrative building, water treatment at Doris site;
- expansion of the Doris mill to accommodate concentrate handling on the south end of the building facility and rearrangement of indoor crushing and processing within the mill building;
- complete development of the Madrid North and Madrid South mine workings;
- incremental expansion of infrastructure at Madrid North and Madrid South to accommodate production mining, including vent raise, access road, process plant buildings;
- construction of a 1,200 tpd concentrator, fuel storage, power plant, mill maintenance shop, warehouse/reagent storage at Madrid North;
- all weather access road and tailings line from Madrid North to the south end of the TIA;
- AWR linking Madrid to Boston (approximately 53 km long, nine quarries for permitting purposes, four of which will likely be used);
- all-weather airstrip, airstrip building, helipad and heliport building at Boston;
- construction of a 2,400 tpd process plant at Boston;
- all infrastructure necessary to support mining and processing activities at Boston including construction of a new 300-person accommodation facility, mine office and dry and administration buildings, additional fuel storage, laydown area, ore pad, waste rock pad, diesel power plant and dry-stack tailings management area (TMA);
- infrastructure necessary to support ongoing exploration activities at both Madrid and Boston; and
- wind turbines near the Doris (2), Madrid (2), and Boston (2) sites.

<u>Operation</u>

The Madrid-Boston Project Operation phase includes:

- mining of the Madrid North, Madrid South, and Boston deposits by way of underground portals and Crown Pillar Recovery;
- operation of a concentrator at Madrid North;
- transportation of ore from Madrid North, Madrid South, and Boston to the Doris process plant, and transporting the concentrate from the Madrid North concentrator to the Doris process plant;
- extending the operation at Roberts Bay and Doris;
- processing the ore and/or concentrate from Madrid North, Madrid South, and Boston at the Doris process plant with disposal of the detoxified tailings underground at Madrid North, flotation tailings from the Doris process plant pumped to the expanded Doris TIA, and discharge of the TIA effluent to the marine environment;
- operation of a concentrator at Madrid North and disposal of tailings at the Doris TIA;

- operation of a process plant and wastewater treatment plant at Boston with disposal of flotation tailings to the Boston TMA and a portion placed underground and the detoxified leached tailings placed in the underground mine at Boston;
- operation of two wind turbines for power generation; and
- on-going maintenance of transportation infrastructure at all sites (cargo dock, jetty, roads, and quarries).

Reclamation and Closure

Areas which are no longer needed to carry out Madrid-Boston Project activities may be reclaimed during Construction and Operation.

At Reclamation and Closure, all sites will be deactivated and reclaimed in the following manner (see Volume 3, Section 5.5):

- Camps and associated infrastructure will be disassembled and/or disposed of in approved non-hazardous site landfills.
- Non-hazardous landfills will be progressively covered with quarry rock, as cells are completed. At final closure, the facility will receive a final quarry rock cover which will ensure physical and geotechnical stability.
- Rockfill pads occupied by construction camps and associated infrastructure and laydown areas will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and any obstructed drainage patterns will be re-established.
- Quarries no longer required will be made physically and geotechnically stable by scaling high walls and constructing barrier berms upstream of the high walls.
- Landfarms will be closed by removing and disposing of the liner, and re-grading the berms to ensure the area is physically and geotechnically stable.
- Mine waste rock will be used as structural mine backfill.
- The Doris TIA surface will be covered waste rock. Once the water quality in the reclaim pond has reached the required discharge criteria, the North Dam will be breached and the flow returned to Doris Creek.
- The Madrid to Boston AWR and Boston Airstrip will remain in place after Reclamation and Closure. Peripheral equipment will be removed. Where rock drains, culverts or bridges have been installed, the roadway or airstrip will be breached and the element removed. The breached opening will be sloped and armoured with rock to ensure that natural drainage can pass without the need for long-term maintenance.
- A low permeability cover, including a geomembrane, will be placed over the Boston TMA. The contact water containment berms will be breached and the liner will be cut to prevent collecting any water. The balance of the berms will be left in place to prevent localized permafrost degradation.

9.4.2 Spatial Boundaries

The spatial boundaries selected to shape this assessment are determined by the Project’s potential effects on the marine environment.

9.4.2.1 Project Development Area

The Project Development Area (PDA) is shown in Figure 9.2-2 and is defined as the area that has the potential for infrastructure to be developed as part of the Madrid-Boston Project. The PDA includes engineering buffers around the footprints of structures. These buffers allow for latitude in the final placement of a structure through later design and construction, reflecting the certainty of design and construction. Compounds with buildings and other infrastructure in close proximity are defined as pads with buffers whereas roads are defined as linear corridors with buffers. The buffers for pads vary depending on the local physiography and other buffered features such as sensitive environments or riparian areas. The average engineering buffer for roads is 100 m on either side. Since the infrastructure for the Doris Project is in place, the PDA follows exactly the footprints of the Doris infrastructure.

9.4.2.2 Local Study Area

The Local Study Area (LSA) is defined as the PDA and the area surrounding the PDA within which there is a reasonable potential for immediate effects on a VEC due to an interaction with a Project component(s) or physical activity. The LSA for marine sediment quality was set to encompass Roberts Bay and is bounded by the shoreline around the bay and where it exchanges water with Melville Sound (Figure 9.2-2). The marine LSA has a surface area of 14.3 km^2 and contains the PDA of the marine cargo dock and its near-shore marine waters, seabed, and shorelines. The marine LSA was designed to reflect the scale at which direct, immediate, and localized disturbances to marine sediment quality have the potential to occur.

9.4.2.3 Regional Study Area

The Regional Study Area (RSA) is defined as the broader spatial area representing the maximum limit where potential direct or indirect effects may occur. The RSA encompasses the PDA and LSA, and is bounded by the shoreline of Melville Sound from the chain of islands just east of Ida Bay into the northern portion of Bathurst Inlet (Figure 9.2-1). The marine RSA includes the proposed shipping lane within Bathurst Inlet and Melville Sound that will bring sealifts and fuel into the Roberts Bay LSA, and represents the maximum extent where potential direct or indirect effects to marine sediment quality may occur.

9.4.3 Temporal Boundaries

The Project represents a significant development in the mining of the Hope Bay Greenstone Belt. Even though this Project spans the conventional Construction, Operation, Reclamation and Closure, and Post-closure phases of a mine project, the Madrid-Boston Project is a continuation of development currently underway. The Project has four separate operational sites: Roberts Bay, Doris, Madrid (North and South), and Boston. The development of these sites is planned to be sequential. As such, the temporal boundaries of this Project overlap with a number of existing and approved authorizations for the Hope Bay Project and the extension of activities.

For the purposes of the EIS, distinct phases of the Project are defined (Table 9.4-1). It is understood that Construction, Operation and Closure activities will, in fact, overlap among sites; this is outlined in Table 9.4-1 and further described in Volume 3, Chapter 2.

The assessment also considers a Temporary Closure phase should there be a suspension of Project activities during periods when the Project becomes uneconomical due to market conditions. During this phase, the Project would be under care and maintenance. This could occur in any year of Construction or Operation with an indeterminate length (one to two year duration would be typical).

Table 9.4-1. Temporal Boundaries for the Effects Assessment for Marine Sediment Quality

Phase	Project Year	Calendar Year	Length of Phase (Years)	Description of Activities
Construction	1 - 4	2019 - 2022	4	• **Roberts Bay:** construction of access road (Year 1), marine dock and additional fuel facilities (Year 2 – Year 3); • **Doris**: expansion of the Doris TIA and accommodation facility (Year 1); • **Madrid North:** construction of concentrator and road to Doris TIA (Year 1 – Year 2); • **All-weather Road**: construction (Year 1 – Year 3); • **Boston**: site preparation and installation of all infrastructures including process plant (Year 2 – Year 5).
Operation	5 - 14	2023 - 2032	10	• **Roberts Bay**: sealift and fuel supply (Year 1 – Year 14) • **Doris**: processing and infrastructure use (Year 1 – Year 14); • **Madrid North:** mining (Year 1 – 13); ore transport to Doris process plant (Year 1 -13); ore processing and concentrate transport to Doris process plant (Year 2 – Year 13); • **Madrid South:** mining (Year 11 – Year 14); ore transport to Doris process plant (Year 11 – Year 14); • **All-weather Road**: operational (Year 4 – Year 14); • **Boston**: winter access road operating (Year 1 – Year 3); mining (Year 4 – Year 11); ore transport to Doris process plant (Year 4 – Year 6); and processing ore (Year 5 – Year 11).
Reclamation and Closure	15 - 17	2033 - 2035	3	• **Roberts Bay**: facilities will be operational during closure (Year 15 – Year 17); • **Doris**: camp and facilities will be operational during closure (Year 15 – Year 17); mine, process plant, and TIA decommissioning (Year 15 – Year 17); • **Madrid North:** all components decommissioned (Year 15 – Year 17); • **Madrid South:** all components decommissioned (Year 15 – Year 17); • **All-weather Road**: road will be operational (Year 15 – Year 16); decommissioning (Year 17); • **Boston**: all components decommissioned (Year 15 – Year 17).
Post-Closure	18 - 22	2036 - 2040	5	• **All Sites:** Post-closure monitoring.
Temporary Closure	NA	NA	NA	• **All Sites:** Care and maintenance activities, generally consisting of closing down operations, securing infrastructure, removing surplus equipment and supplies, and implementing on-going monitoring and site maintenance activities.

9.5 PROJECT-RELATED EFFECTS ASSESSMENT

9.5.1 Methodology Overview

This assessment is informed by a methodology used to identify and assess the potential environmental effects of the Madrid-Boston Project and is consistent with the requirements of Section 12.5.2 of the Nunavut Agreement and the EIS guidelines (NIRB 2012). The effects assessment evaluates the potential direct and indirect effects of Madrid-Boston on the environment and follows the general methodology provided in Volume 2, Chapter 4 (Effects Assessment Methodology). It comprises a number of steps that collectively assess the manner in which the Madrid-Boston Project will interact with the marine sediment quality VEC defined for the assessment (Section 9.3).

To provide a comprehensive understanding of the potential effects for the Project, the Madrid-Boston components and activities are assessed on their own as well as in the context of the Approved Projects (Doris and exploration) within the Hope Bay Greenstone Belt. The effects assessment process is summarized as follows:

1. Identify potential interactions between the Madrid-Boston Project and the marine sediment quality VEC;
2. Identify the resulting potential effects of those interactions;
3. Identify mitigation or management measures to eliminate or reduce the potential effects;
4. Identify residual effects (potential effects that would remain after mitigation and management measures have been applied) for Madrid-Boston in isolation;
5. Identify residual effects of Madrid-Boston in combination with the residual effects of existing and approved projects; and
6. Determine the significance of combined residual effects.

After the identification of potential interactions between the Madrid-Boston Project and marine sediment quality (Step 1, Section 9.5.2), the potential effects of these interactions are identified (Step 2, Section 9.5.2). Mitigation and management measures are then considered (Step 3, Section 9.5.3). If the application of these measures is expected to effectively mitigate the effects from the Madrid-Boston Project, the Madrid-Boston Project-related effects to marine sediment quality are characterized as *negligible* and not identified as residual effects (Step 4, Section 9.5.4). In parallel, the potential effects of the Madrid-Boston Project in combination with the existing and approved projects are assessed, and characterized as *negligible* if the mitigation and management measures are considered effective (Step 5, Section 9.5.4).

All remaining potential effects are then considered residual effects (Steps 4 and 5), and further characterized (Step 6, Section 9.5.5) using the following attributes:

- direction;
- magnitude;
- duration;
- frequency;
- geographical (spatial) extent; and
- reversibility.

The rating criteria for the assessment of residual effects are described in the Effects Assessment Methodology section (Volume 2, Chapter 4) and are further defined for marine sediment quality in Table 9.5-5. The CCME sediment quality guidelines for the protection of aquatic life (CCME 2017) were used, when available, as assessment thresholds for the determination of magnitude. The significance of each residual effect (Step 6, Section 9.5.5.2) was determined by considering the characterization of each residual effect with an assessment of the probability of effects and the confidence in the baseline data and predictions of the effects of the Madrid-Boston Project and the Hope Bay Development on the marine environment.

9.5.1.1 Sediment Quality Indicators

Sediment quality is an aggregate term that encompasses a complex suite of parameters and indicators that describe the sediment environment and its ability to sustain ecological and biogeochemical functions. These parameters and indicators range from physical descriptions of the composition of the sediments (e.g., the relative abundance of coarse and fine particles) to the presence and concentration of specific chemical constituents. The assessment of the potential effects of the Madrid-Boston Project on marine sediments is based on four indicators that described the most probable and significant interactions between the Project and the marine sediment environment (Table 9.5-1). These indicators are chosen because they have the following characteristics:

- specific empirical definitions;
- established analytical measurement methodologies;
- existing baseline information;
- quantitative relationships or thresholds associated with supporting aquatic organisms and biogeochemical processes, including established guidelines for the protection of aquatic life; and
- responsive to the potential effects of industrial and mining activities in the Arctic.

Table 9.5-1. Marine Sediment Quality Indicators for the Assessment of Effects

Indicator	Description	Interaction with Project
Particle Size	The relative proportion of silt-, clay-, sand-, and gravel-sized particles	Project activities may disturb sediments, increase runoff of deposited sediment, or discharge suspended material
Nutrients and Organic Carbon	Nutrients adsorbed to sediment particles and organic material in sediments	Project activities may contribute organic material to waterbodies directly through discharge, runoff, or deposition, or indirectly through nutrient addition
Metals	Metals adsorbed to sediment particles	Contribute metals (dissolved or particulate) through runoff, discharge, and deposition
Hydrocarbons	Petroleum hydrocarbon compounds	Contribute petroleum hydrocarbons through runoff, discharge, and deposition

For the effects assessment, thresholds are applied to the sediment quality indicators (Table 9.5-2). These thresholds are based on CCME sediment quality guidelines for the protection of aquatic life, when applicable. In some cases, baseline concentrations of sediment metals (e.g., arsenic, chromium, and copper) were naturally higher than CCME guidelines (see Section 9.2.4.3); for these naturally enriched metals, baseline concentrations are also considered in the determination of acceptable threshold concentrations. If sediment quality guidelines are not available, the thresholds are based on existing conditions defined by the baseline sampling program (Table 9.5-2). Some residual effects may be assessed qualitatively, which do not necessarily permit the application of specific, quantitative thresholds.

Table 9.5-2. Assessment Thresholds for Marine Sediment Quality Indicators

Indicator	Parameter	CCME Guideline Concentration (mg/kg)	
		ISQG†	PEL†
Particle Size	Particle size	No regulatory threshold value; threshold set to 75th percentile of baseline values	
Nutrients and Organic Carbon	Nutrients and TOC	No regulatory threshold value; threshold set to 75th percentile of baseline values	
Metals	Arsenic*	7.24	41.6
	Cadmium	0.7	4.2
	Chromium*	52.3	160
	Copper*	18.7	108
	Lead	30.2	112
	Mercury	0.13	0.7
	Zinc	124	271
Hydrocarbons	Petroleum hydrocarbons	Range of guidelines for petroleum hydrocarbon compounds (CCME 2017)	

† CCME marine sediment ISQG and PEL for the protection of aquatic life (CCME 2017).
** Baseline concentrations of these metals were naturally higher than CCME ISQGs in samples from the deep (> 10 m) depth zone (Table 9.2-5). When the 75th percentile of baseline concentrations of a metal is higher than the ISQG for that metal, the threshold is set at the 75th percentile of baseline concentrations.*

9.5.2 Identification of Potential Effects

The Madrid-Boston Project has the potential to interact with marine sediments through a number of mechanisms and pathways. Project activities are grouped into broad components as described in the Effects Assessment Methodology (Volume 2, Chapter 4). The interactions between the Madrid-Boston Project and marine sediment quality are further refined by an *interaction group*. Interaction groups are interaction pathways that share similar modes of interaction with the Madrid-Boston Project through specific mitigation and management measures, assessment thresholds, and key indicators. For example, the construction of the cargo dock and dock access road are both assigned to the *Site Preparation, Construction, and Decommissioning* interaction group because both Project components may interact with the marine sediments through the runoff of eroded terrestrial material from pad and working surfaces. The defined interaction groups for the assessment of effects to marine sediments are the following:

- *Sealift* — interactions related to sealifts include wake effects, discharge, propeller wash, ballast water, antifouling agents, and airborne emissions.
- *Site Preparation, Construction, and Decommissioning* — activities that include the clearing of overburden, earthworks, and construction activities for pads and infrastructure.
- *Site Contact Water* — the runoff from infrastructure including pad areas, laydown areas, roads, and airstrips.
- *Fuels, Oils, and PAH* — activities related to the storage of fuels, fueling and maintenance operations, and the combustion of waste.
- *Discharges* — discharge of TIA and groundwater.

- *Dust Deposition* — activities that generate dust, including vehicle traffic, airstrip activity, and quarry and borrow pit activities that can then be deposited in marine receiving environment.

The potential interactions between the Project and marine sediments are presented in Table 9.5-3. These Project components are considered to have probable or likely interactions with marine sediments. Potential interactions may be direct or indirect, and this screening step does not consider application of mitigation and management measures.

Table 9.5-3. Project Interaction with the Marine Sediment Quality in Roberts Bay

Project Component/Activity	Sealift	Site Preparation, Construction, and Decommissioning	Site Contact Water	Fuels, Oils, and PAH	Discharge	Dust Deposition
Construction — proposed Madrid-Boston infrastructure						
Cargo dock		×	×			×
Dock access road		×	×			×
Fuel pipeline and tank farm		×	×	×		
Marine transport of goods	×			×	×	×
Quarry		×	×			×
Equipment and vehicle emissions				×		×
Construction and Operations — use of existing approved and permitted infrastructure						
Fuel tank farm			×	×		
Laydown areas			×	×		×
Equipment and vehicle emissions				×		×
Marine discharge of TIA-groundwater					×	
Marine transport of goods	×			×	×	×
Site road use and maintenance			×	×		×
Operation — proposed Madrid-Boston infrastructure						
Cargo dock			×			
Use of dock access road			×	×		×
Fuel pipeline and tank farm			×	×		
Marine discharge of TIA-groundwater					×	
Marine transport of goods	×			×	×	×
Quarry			×			×
Equipment and vehicle emissions				×		×
Reclamation and Closure — use of existing approved and permitted infrastructure						
Site surface infrastructure		×	×	×		×
Equipment and vehicle emissions				×		×

Project Component/Activity	Sealift	Site Preparation, Construction, and Decommissioning	Site Contact Water	Fuels, Oils, and PAH	Discharge	Dust Deposition
Roberts Bay-Doris Road		×	×	×		×
Marine infrastructure		×	×	×		×
Marine transport of goods	×			×	×	×
Reclamation and Closure — proposed Madrid-Boston infrastructure						
Site surface infrastructure		×	×	×		×
Equipment and vehicle emissions				×		×
Dock access road		×	×	×		×
Marine infrastructure		×	×	×		×
Marine transport of goods	×			×	×	×
Quarry		×	×			×
Temporary Closure						
Care and maintenance			×	×		

Activities and infrastructure interact with the environment through discrete pathways. These pathways describe specific mechanisms of interactions that are useful for specifying the physical relationship between the project component and the marine environment, for identifying applicable mitigation measures, and for characterizing the residual effects. For the effects assessment on the marine sediment quality VEC, the following pathways are defined:

- *runoff*, which describes the transport of material or compounds from the terrestrial environment into the marine environment by precipitation or snowmelt;
- *discharge*, which is the directed input of water into the marine environment;
- *contact*, which is the presence of Project-related infrastructure or vehicles (such as ships and barges) in the marine environment;
- *physical*, which is the direct physical effects of Project activities in the marine environment; and
- *aerial deposition*, which is the direct input of material and chemical compounds from the air into the marine environment.

The pathways applicable to each Project interaction group are summarized in Table 9.5-4. These pathways are used in the effects assessment to describe the potential effects, identify mitigation and management measures, and characterize the residual effects from Project activities.

Table 9.5-4. Pathways of Interactions with the Marine Environment for the Marine Sediment Quality Effects Assessment

Project Activity	Pathway	Indicators	Project Phases
Sealift activities (wakes, propeller wash, sewage, antifouling agents, ballast water)	Physical, discharge, contact, aerial deposition	Particle size, TOC, nutrients, metals, hydrocarbons	Construction, Operation, Reclamation and Closure
Site preparation, construction, and decommissioning activities	Runoff, physical	Particle size, TOC, nutrients, metals, hydrocarbons	Construction, Reclamation and Closure
Site contact water	Runoff	Particle size, TOC, nutrients, metals, hydrocarbons	Construction, Operation, Reclamation and Closure, Temporary Closure
Fuels, oils, PAH	Runoff, aerial deposition	TOC, hydrocarbons	Construction, Operation, Reclamation and Closure, Temporary Closure
Discharge	Discharge	TOC, nutrients, hydrocarbons, metals	Construction, Operation, Reclamation and Closure
Dust deposition	Aerial deposition	Particle size, nutrients, metals, hydrocarbons	Construction, Operation, Reclamation and Closure

9.5.2.1 Sealift

Cargo ships, tankers, and ocean-going barges will deliver fuel, equipment, and supplies during the short shipping season from August through October. Ocean-going vessels will offload their cargo at either the Roberts Bay jetty (3 m depth) or the marine dock (12 m water depth; Package P5-10). Larger fuel tankers with deeper drafts will moor offshore using two fixed mooring points onshore and the ship's anchor to hold the ship's position during fuel transfer activities.

The main pathways by which sealift activities could interact with marine sediments include the physical processes of wake effects or propeller wash which could cause sediment resuspension and re-distribution, aerial deposition from ship exhaust, discharge such as the release of sewage and ballast water, and contact with ships and barges, which could result in exposure to toxic compounds if a vessel's hull is treated with anti-fouling agents such as the organotin compound tributyltin (TBT).

Physical disturbances to marine sediments occur from wakes produced by ship movement and from propeller action. These processes can cause sediments to be mobilized and redistributed. The redistribution of sediments could affect the grain-size composition of sediments, and change the concentrations of metals and organic carbon in sediments. Disruption of natural sedimentation patterns could also affect near-shore subsea permafrost.

The combustion of fuel by ships and tugs has the potential to alter water quality by depositing combustion by-products, such as PAH, in the marine environment. These could settle to the sediments and alter sediment quality.

Vessels are permitted to discharge sewage in Arctic waters under the Arctic Shipping Pollution Prevention Regulations (C.R.C., c. 353) of the *Arctic Pollution Prevention Act* (1985a). This discharge could lead to the deposition of organic matter and nutrients onto sediments.

Ballast water is used to stabilize a ship and ensure that the propeller remains submerged by counterbalancing changes in weight as cargo is loaded or offloaded. Ballast water (including sediments suspended in the water) can be taken in at one port and discharged in another. The release of ballast water has the potential to cause sedimentation if suspended sediments in the ballast water are deposited on the seabed. For the Hope Bay Development, incoming vessels will be fully loaded and ballast water will most often be taken on in Roberts Bay to counterbalance offloaded fuel and cargo. If the discharge of ballast water is required, ocean-going vessels will follow the Ballast Water Control and Management Regulations (SOR/2011-237) under the *Canada Shipping Act* (2001). This will ensure that ballast water is exchanged offshore outside of Roberts Bay. The effects of ballast water discharge on the sediment quality in Roberts Bay will be eliminated by avoidance and adherence to federal regulations, and are not considered further as potential effects.

Vessels often use anti-fouling agents to prevent the accumulation of organisms such as barnacles or mussels that can interfere with the drag of a ship, increase fuel costs, and damage propulsion systems. Historically, TBT has been the most common biocide used in anti-fouling paints. Leaching from anti-fouling paints may cause increased concentrations of TBT in sediments, which could affect the health of marine organisms. Ships will adhere to the Vessel Pollution and Dangerous Chemicals Regulations (SOR/2012-69) under the *Canada Shipping Act* (2001), which ban the use of anti-fouling systems that use organotin compounds (such as TBT) as biocides on all ships in Canadian waters or require that a coating be applied to anti-fouling paint to create a barrier to leaching of organotins into marine environments. The potential leaching of toxic anti-fouling agents from ships will be eliminated by the adherence of vessels to federal regulations, and are not assessed further as potential effects.

The potential effects from sealifts may occur during the Construction, Operation, and Reclamation and Closure phases of the Project.

9.5.2.2 Site Preparation, Construction, and Decommissioning

The proposed Madrid-Boston infrastructure located in or near Roberts Bay that could interact with marine sediment quality because of site preparation, construction, and decommissioning activities includes a marine dock and access road, a fuel pipeline and tank farm, and two potential quarries (Table 9.5-3). The pathways of interaction between site preparation, construction, and decommissioning activities and the marine environment are through physical contact and runoff, and the Project phases during which this interaction could occur are Construction and Reclamation and Closure (Table 9.5-4).

The physical effect pathway linking the site preparation, construction, and decommissioning activities and the marine environment is the in-water work required to construct the cargo dock, such as the installation of sheet piles using a vibratory hammer. Physical vibration and in-water works may affect sediment quality by disturbing and mobilizing sediments and altering the particle size distribution and sedimentation patterns. Disruption of natural sedimentation patterns could also affect near-shore subsea permafrost.

Site preparation, construction, and decommissioning activities will also interact with the marine environment through the runoff pathway. The clearing of overburden, construction of earthworks, and the construction and decommissioning of pads and infrastructure can affect the marine environment through the runoff of eroded terrestrial material from pad and working surfaces. Site preparation and construction of the quarry would also require blasting, which could introduce ammonium nitrate and fuel oil residues into the runoff water. The introduction of materials through runoff could affect particle size distribution, and the concentrations of metals, organic carbon, and hydrocarbons in sediments. Runoff would be expected to occur mainly during snowmelt and freshet in the spring, following rainfall events in the summer and fall, and would be absent in the winter.

9.5.2.3 Site Contact Water

Site contact water is defined as the runoff from snowmelt and precipitation events that interacts with geochemically neutral site infrastructure including roads, laydown areas, quarries, and buildings. Site contact water is considered separately from the potential effects of site preparation, construction, and decommissioning because the degree of disturbance is much lower, and because mitigation and management measures will be fully applied once construction is complete. The interaction between runoff and infrastructure could transport suspended material, metals, nutrients, organic matter, and petroleum hydrocarbon compounds into the marine environment if not managed or mitigated. The potential for effects from site contact water could occur during all phases of the Madrid-Boston Project (Table 9.5-3).

9.5.2.4 Fuels, Oils, and PAH

The transportation, transfer, storage, handling, and use of fuels and other petroleum products has the potential to introduce hydrocarbons into the marine environment, and could affect sediment quality if these hydrocarbons settle on the seabed. Unlikely events such as pipeline rupture or spills during transportation or transfer are addressed in Accidents and Malfunctions (Volume 7, Chapter 1) since these events will not occur under normal operating conditions. The combustion of fuels and the incineration of waste can generate PAH, which can then be deposited into the marine environment and alter sediment quality.

The pathways by which fuels, oils, and PAH could enter the marine environment include runoff from terrestrial sources and aerial deposition. Fuel will be shipped to site during the Construction and Operation phases by double-hulled fuel tankers. Fuel will be unloaded at either the Roberts Bay jetty or the cargo dock and transferred to the tank farm by hose or pipeline (Volume 3, Chapter 2). From the Roberts Bay main tank farm, tanker trucks will distribute fuel to designated storage areas and tank farms at Doris, Madrid, and Boston, as required. Activities at facilities, laydown areas, fuel storage areas, fueling stations, roads, and waste management areas can result in leaks or deposits of hydrocarbons such as fuel, oil, or grease onto surfaces that can subsequently be transported into the marine environment through runoff.

Waste management practices will include the incineration of food waste, sewage sludge, and limited portions of paper products and/or oily rags (Volume 3, Chapter 2). The incineration of wastes could produce PAH as a by-product of incomplete combustion of organic matter. These airborne PAH can then enter the marine environment directly by aerial deposition, or be deposited on land and enter the marine environment through runoff.

The potential effects from fuels and other hydrocarbons on marine sediment quality may occur during the Construction, Operation, Reclamation and Closure, and Temporary Closure phases (Table 9.5-3).

9.5.2.5 Discharge

The discharge of TIA and saline groundwater from the Roberts Bay Discharge System has the potential to affect marine water quality, which could in turn affect marine sediment quality. The pathway of interaction between these discharges and marine sediments is the direct input of water into the marine environment. The discharges could increase the concentrations of nutrients, metals, hydrocarbons, or suspended solids in Roberts Bay waters, which could increase concentrations of these parameters in sediments through water-sediment exchange and deposition. Discharge inputs could also affect other chemical properties of the water such as pH, dissolved oxygen, and salinity, which could directly or indirectly affect the concentrations of nutrients, metals, and organic material in sediments. For example, discharge of nutrients could cause a reduction in bottom-water dissolved oxygen concentrations, which could result in the release of metals such as iron and manganese from sediments to the overlying water column (Atkinson, Jolley, and Simpson 2007). The potential effects due to discharge into the marine environment could occur during all Project phases, except Temporary Closure (Table 9.5-3).

9.5.2.6 Dust Deposition

Dust can be generated by a variety of Madrid-Boston Project activities, including vehicle traffic, airstrip activities, blasting activities, and quarry operations. Areas cleared for infrastructure (e.g., laydown areas) could also be sources of dust. The aerial deposition of the Project-generated dust is the primary pathway of interaction. Deposited dust could affect marine sediment quality by introducing suspended material and associated metals and hydrocarbons into the marine environment. The potential effects from dust deposition may occur during the Construction, Operation, and Reclamation and Closure phases (Table 9.5-3).

9.5.3 Mitigation and Adaptive Management

Mitigation and management measures were identified through the construction and operation of the Doris Project; a review of best management practices from similar mining projects in the Arctic; comments from community members during scoping meetings; formal review by the Kitikmeot Inuit Association (KIA), ECCC, INAC, and DFO of the existing Doris Project management plan (the Aquatic Effects Monitoring Plan) and Roberts Bay Environmental Effects Monitoring (EEM) plan; scientific literature; and professional experience.

Many of the mitigations applied to the construction and operation of the Doris Project to date will be applied during Madrid-Boston development. The efficacy of these mitigation and management measures, as they apply to marine sediment quality, has been assessed through the Doris AEMP since 2010 (e.g., ERM 2017). Two sites have been sampled in Roberts Bay since 2010 to address potential effects from activities associated with the Doris watershed (Site RBE) and the Roberts Bay Laydown Area and jetty (Site RBW). The annual evaluation of marine sediment quality has shown that there have been no effects in Roberts Bay related to Doris construction and operations activities. This indicates that the mitigation and management measures applied by TMAC during the Doris Project have been effective in managing potential effects to marine sediment quality in Roberts Bay.

9.5.3.1 Mitigation by Project Design

The following measures were included in the design of the Project to minimize or eliminate potential effects on marine sediment quality:

- Use of existing infrastructure associated with the Doris Project.
- Inclusion of climate change projections for key climatic and hydrological design details (Package P5-2).
- Minimizing overall footprint and volume of contact water.
- Planned set-backs and buffer zones from waterways.
- Avoidance, as required and feasible, of sensitive features, including riparian ecosystems and floodplains, esker complexes, wetlands, shallow open ponds, marshes, bedrock cliffs, beaches, intertidal areas, and marine backshores.

- Applying speed limits to vehicles travelling on roads to reduce generation of dust.
- Using geochemically suitable rock quarries and borrow sources to construct roads, pads, and structures.
- Infrastructure will be located, whenever feasible, on competent bedrock or appropriate base material that will limit permeability and transport of potentially poor quality water into the active layer, and ultimately to the marine environment.
- Appropriate secondary containment systems will be used for petroleum product storage tanks to prevent spills and releases to water. Bulk fuel storage areas, hazardous materials storage areas, and explosives storage facilities will be bermed and lined with impermeable barriers to minimize leaks and spills.
- Ships will be conventional double-hulled, compartmentalized petroleum tankers, with Shipboard Oil Pollution Emergency Plans and appropriate response gear.
- Minimizing groundwater inflows at the Madrid North and Madrid South mines through grouting as necessary.

The design of the Madrid-Boston Project will also adhere to regulatory requirements relevant to the mitigation of potential effects on the marine environment. These regulatory requirements include the following:

- The operation of incinerators will comply with Nunavut standards (Government of Nunavut Department of Environment 2012), *Canada-Wide Standards for Dioxins and Furans* (CCME 2001a), and *Canada-Wide Standards for Mercury Emissions* (CCME 2000), as well as TMAC's own Incinerator Management Plan (Package P4-16). Modern incineration equipment will be installed to minimize airborne contaminant loading of PAH.
- Ships will carry out their operations in accordance with federal and territorial acts and regulations relating to vessel discharges, the transportation of dangerous goods, and anti-fouling surface treatments including the Arctic Waters Pollution Prevention Regulations (C.R.C., c. 354) and the Arctic Shipping Pollution Prevention Regulations (C.R.C., c. 353), under the *Arctic Waters Pollution Prevention Act* (1985a); the Vessel Pollution and Dangerous Chemicals Regulations (SOR/2012-69) and the Ballast Water Control and Management Regulations (SOR/2011-237) under the *Canada Shipping Act* (2001); and the *Transportation of Dangerous Goods Act* (1992).
- The Oil Pollution Prevention Plan (OPPP)/Oil Pollution Emergency Plan (OPEP; Volume 8, Annex V8-1) for Roberts Bay will be updated and submitted to Transport Canada for review on an annual basis.
- The bulk fuel storage facility and all transfer-related equipment will be inspected and maintained, with complete documentation.
- Culvert maintenance will be conducted following the guidance provided in *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2016), which adheres to the *Fisheries Act* (1985b).
- In-water work will be conducted during approved timing windows presented in *Nunavut Restricted Activity Timing Windows for the Protection of Fish and Fish Habitat* (DFO 2013).

9.5.3.2 Best Management Practices

Reducing potential effects to marine sediment by avoidance is the most effective mitigation measure. As discussed in Section 9.5.3.1, the design of the Madrid-Boston Project includes a number of features to avoid potential effects. Marine-related management and mitigation measures are described in TMAC's management plans, including the following:

- OPPP/OPEP (Volume 8, Annex V8-1);
- Air Quality Management Plan (Volume 8, Annex V8-2);
- Hope Bay Project Spill Contingency Plan (Package P4-3);
- Hope Bay Quarry Management and Monitoring Plan (Package P4-17); and
- Hope Bay Project Aquatic Effects Monitoring Plan (Package P4-18).

The Roberts Bay Discharge System will discharge water from the TIA, as well as site contact water from the Doris, Madrid North, and Madrid South sites and groundwater. The quality of the effluent will be mitigated and management by the following plans, which therefore have indirect influences on marine sediment quality in Roberts Bay:

- Doris Project Domestic Wastewater Treatment Management Plan (Package P4-4);
- Hope Bay Project Groundwater Management Plan (Package P4-6);
- Hope Bay Project Doris-Madrid Water Management Plan (Package P4-7);
- Hope Bay Project Doris-Madrid Tailings Impoundment Area Operations, Maintenance, and Surveillance Manual (Package P4-9);
- Hope Bay Project Waste Rock and Ore Management Plan (Package P4-11);
- Hope Bay Project Water and Ore/Waste Rock Management Plan for Boston Site (Package P4-12);
- Hope Bay Project Non-hazardous Waste Management Plan (Package P4-13);
- Hope Bay Project Hydrocarbon Contaminated Material Management Plan (Package P4-14);
- Hope Bay Project Hazardous Waste Management Plan (Package P4-15); and
- Hope Bay Project Incinerator Management Plan (Package P4-16).

Specific mitigation and management measures relevant to the assessment of effects on marine sediment quality include the following:

- Implementation of sediment control measures for works in or near the marine environment, such as use of silt fences at drainage points and the minimization of vegetation clearing.
- Implementation of erosion control measures where necessary, such as capping of soils exposed during construction activities with rock.
- Regular inspections will be conducted to ensure erosion and sediment control measures are functioning properly; all necessary repairs and adjustments will be conducted in a timely manner. Efforts shall be made to minimize the duration of any in-water works and minimize disturbance of riparian vegetation.
- Activities will be planned and executed to minimize the release of sediment or sediment laden water into water frequented by fish.
- Facilities are designed with consideration of footprint minimization and will be located, where possible, in areas of reduced runoff.

- Clean water and snow will be managed such that they do not contribute to potentially poor quality water and be diverted to maintain natural drainage networks as much as possible.
- Non-contact water will be diverted around infrastructure, as much as feasible, and directed to the ocean.
- Sewage will be treated and the effluent will be discharged to the TIA or onto the tundra. Sewage sludge will be incinerated or disposed with the backfill waste. No sewage from Hope Bay Development sites will be discharged directly to Roberts Bay.
- Mine water from Doris and water from the Doris TIA will be treated for arsenic prior to discharge in Roberts Bay.
- Silt curtains will be used for in-water works as required.
- Appropriate secondary containment systems will be used for petroleum product storage tanks to prevent spills and releases to water.
- Spills will be contained according to the Spill Contingency Plan (Package P4-3) including the prioritization of the protection of sensitive areas.
- Soil, snow and water contaminated with diesel fuel, aviation gasoline, jet fuels and/or gasoline will report to the landfarm. Treated water from the snow or clean water pond will report to the tundra only once sample analysis has confirmed the quality is suitable for release to the environment. If water does not meet discharge criteria following treatment, the water will be transferred to the TIA for disposal. Soil collected from the landfarm will either be disposed of underground or at the TIA.
- Hazardous waste will be minimized to the extent possible. Hazardous wastes will be shipped off site.
- Quarries will be developed to the extent possible to ensure that water entering the quarry from precipitation and snowmelt is retained within the quarry boundary. If required, a quarry sump will be used to collect water, and sump water will be sampled and discharged to the environment only if discharge requirements are met. Non-compliant water that needs to be discharged will be transported to contact water ponds for management and/or transported directly to the TIA for disposal, and will therefore not contact the marine environment.
- High quality ammonium nitrate and fuel oil (ANFO) explosives have been selected for blasting operations. The explosive product may be in the form of prills, emulsion, or be prepackaged. Different forms of the product may be used depending on the particular circumstances of use. Industry best practices will be employed to maximize source control and blast efficiency so as to minimize the potential for blasting product or blasting residues to occur in runoff.
- Dust suppression as appropriate will be applied to roadways to minimize dust from ore and waste rock haulage, site road traffic, and road maintenance (grading) when ambient air temperatures permit.
- The bulk fuel storage facilities and all transfer-related equipment will be routinely inspected repairs (if required) carried out promptly.
- During temporary closure the following will take place to protect marine sediment quality:
  - sediment quality monitoring will continue to follow Project licence and permit requirements;
  - fuel, hazardous wastes and explosives will be properly stored or removed from site; and
  - surface water management and sediment and erosion control will continue as needed.

- Vessels will be prohibited from discharging untreated sewage in Roberts Bay and will only discharge sewage when transiting in open-waters away from shore.
- Vessels will exchange ballast water in the alternative exchange areas outlined in the Section 7(3) of the Ballast Control and Management Regulations (SOR/2011-237).
- Speed limits will be followed for vessel operations to minimize propeller wash and wake effects.
- The OPPP/OPEP detail the procedures and best practices to follow for fuel transfer to minimize leaks or spills, and describe the response and clean-up measures to follow in the event of a spill, which include:
  - measures to protect personnel and the environment;
  - spill response management, emergency response procedures, and reporting and notification protocols;
  - description of the spill containment and skimming equipment and deployment plans; and
  - training and auditing programs.
- Vehicular access across a watercourse or waterbody will be by road or bridge, or other acceptable method according to *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2016).

9.5.3.3 Proposed Monitoring Plans and Adaptive Management

A Marine EEM Program established under the MMER will be in place that outlines the monitoring program in the marine environment that will be carried out during all phases of the Project. The Marine EEM Program will include the following:

- monitoring the marine environment at locations potentially affected by the Project and at reference areas well away from Project activities; and
- monitoring marine water quality, sediment quality, and aquatic biology.

In addition, the construction of the cargo dock is anticipated to require authorization under the *Fisheries Act* (1985b), which will likely include monitoring for potential construction-related effects on the marine environment. This construction monitoring will be tied to specific adaptive management responses designed to minimize the effects on the environment, such as the installation of silt curtains in the advent of elevated suspended sediment concentrations in the cargo dock construction area.

Regular inspections of water management facilities will be conducted by on-site Environmental Personnel, the KIA, and other federal agencies such as ECCC, INAC, and DFO.

Adaptive management and corrective actions will be determined on a case-by-case basis. The actions may include modifications to existing mitigation and management measures or installation of additional control measures.

9.5.4 Characterization of Potential Effects on Marine Sediment Quality

The potential for effects on marine sediment quality from the Project activities identified in Section 9.5.2 are assessed in this section. Specific mitigation and management measures are considered for each potential effect, and if the implementation of mitigation measures eliminates a potential effect, the effect is eliminated from further assessment. Project residual effects are the effects that remain or persist after mitigation and management measures are taken into consideration.

If the proposed mitigation measures are not sufficient to eliminate an effect, a residual effect is identified and carried forward for additional characterization and a significance determination (Section 9.5.5). Residual effects of the Project can occur directly or indirectly. Direct effects result from direct interactions between Project activities and marine sediment quality (e.g., sediment disturbance and re-distribution from propeller wash). Indirect effects can occur when the primary effect is to another component of the environment (e.g., marine water quality), which can lead to secondary or indirect effects on marine sediment quality. The characterization of potential effects considers both the incremental effects of Madrid-Boston activities as well as the overall effects from all components of the Hope Bay Development.

9.5.4.1 Sealift

<u>Characterization of Madrid-Boston Project Potential Effects</u>

Sealifts could potentially affect marine sediment quality through physical disturbance (propeller wash and ship-generated wakes), regulated discharge, and airborne emissions. Approximately five to seven vessels are expected to report to Roberts Bay each year during the Construction and Operation phases of the Madrid-Boston Project, and potentially for a short period during Reclamation and Closure. The Madrid-Boston Project will extend the vessel traffic 13 years beyond the 6-year lifespan of the existing and approved projects.

The physical disturbances associated with sealifts such as wake effects or propeller wash could cause sediment resuspension and re-distribution. Easily disturbed fine sediments such as silt and clay could be re-suspended and redeposited elsewhere, which could alter sediment particle size distribution, subsea permafrost properties, and the concentrations of metals and organic material in the sediments. These physical effects will be mitigated by requiring that ships reduce their speed when they enter the Roberts Bay LSA to minimize the effects of propeller wash and wakes.

The analysis of vessel wakes with mitigation was carried out for the marine water quality VEC (Volume 5, Chapter 8). The results showed that calculated wakes of approximately 0.014 m created by ships entering Roberts Bay at a speed of 10 knots are expected to be well below the maximum observed wave heights in the bay (~0.5 m; Volume 5, Chapter 7), and the influence of wakes is expected to occur far less frequently (three or four times per month) and over shorter timeframes (seconds to minutes) than natural wave action (consistently greater than 0.014 m and occurring over hours and days; Rescan 2012b). This indicates that the effects from ship wakes are expected to be negligible in Roberts Bay compared to the natural physical processes such as ice scour and wind-driven resuspension that continuously re-work the shallow, near-shore sediments of the bay. Therefore, ship-generated wakes are not expected to cause residual effects to the marine sediment quality in Roberts Bay, and are not considered further in this assessment.

The analysis of propeller wash with mitigation was also carried out for the marine water quality VEC (Volume 5, Chapter 8). The results predicted that propeller wash has the potential to mobilize sand-sized particles (speed greater than 0.25 m/s) from depths shallower than 40 m when vessels are operating between 10% (24 m depth) and 50% (40 m depth) as they would while approaching the shallow environment near the marine cargo dock. This corresponds to an approximate path length of 0.5 to 1.5 km where sediments could be mobilized and redistributed as vessels move from the 40-m isobaths to the marine cargo dock on the southwestern shore of Roberts Bay. The potential effect is predicted to occur within the marine LSA, and because this activity could re-work and re-distribute the sediments, propeller wash has been identified a potential residual effect to the marine sediment quality of Roberts Bay and will be assessed in Section 9.5.5.3. The residual effects assessment does not consider subsea permafrost. Drilling results indicate that subsea permafrost is typically found at water depths of 1 m or less, and the depth of this permafrost layer is up to 20 m below the sediment surface (SRK 2016; Package P5-5). Ships will not enter shallow waters where subsea permafrost might be found; therefore, there are no predicted residual effects to subsea permafrost resulting from propeller wash.

Airborne emissions from vessels will be mitigated under the Vessel Pollution and Dangerous Chemicals Regulations (SOR/2012-69). The regulations put controls on ozone-depleting substances, a reduction of sulphur content in fuels in Arctic waters by January 1, 2020 (from 3.5% to 0.5% by mass), and prohibits the incineration of oil residues, polychlorinated biphenyls (PCB), garbage containing more than traces of heavy metals, as well as the burning of sewage sludge and sludge oil inside ports, harbours, or estuaries (Vessel Pollution and Dangerous Chemicals Regulations (SOR/2012-69); Division 6). The potential effects resulting from ship-borne emissions were rated as *not significant* for the air quality VEC (Volume 4, Chapter 2). Accordingly, no potential residual effects to the marine sediment quality were identified from ship-borne emissions and this is not assessed further.

The discharge of sewage from vessels can lead to the deposition of organic matter and nutrients onto sediments. Vessels are permitted to discharge sewage in Arctic waters under the Arctic Shipping Pollution Prevention Regulations (C.R.C., c. 353) of the *Arctic Pollution Prevention Act* (1985a). However, vessels will be prohibited from discharging untreated sewage in Roberts Bay and will only discharge sewage when transiting in open-waters away from shore. The discharge of vessel waste is eliminated as a potential effect through avoidance and management measures, and vessel sewage discharge is not assessed further.

<u>Characterization of Hope Bay Development Potential Effects</u>

The Madrid-Boston Project will add to the overall sealift traffic and to the expected duration of sealift activities associated with the Hope Bay Development. Although the total number of ships reporting to Roberts Bay and the duration of sealift activities associated with the Hope Bay Development are increased by the Madrid-Boston Project, the characterization of effects and mitigation measures for the Madrid-Boston Project sealift activities apply equally to the sealift activities supporting the Hope Bay Development as a whole. As is the case for the Madrid-Boston Project characterization of effects, propeller wash from sea-going vessels is identified as a potential residual effect of sealift activities to marine sediment quality for the Hope Bay Development. This will be further assessed in Section 9.5.5.3.

9.5.4.2 Site Preparation, Construction, and Decommissioning

<u>Characterization of Madrid-Boston Project Potential Effects</u>

Site preparation, construction, and decommissioning activities could potentially affect marine sediment quality through the runoff and physical disturbance (in-water works) pathways.

The disturbance of the landscape through the construction of infrastructure, such as roads and pads creates the potential for runoff that can influence the marine environment. The potential effects from runoff are expected to be minimized by the proposed erosion control and sedimentation mitigation strategies described in Section 9.5.3. Collectively, these measures will minimize the likelihood of runoff reaching the marine environment during site preparation, construction, and decommissioning activities, and will optimize the quality of runoff so that potentially adverse constituents of runoff such as metals, nutrients, or suspended sediments are minimized. The effects of runoff on marine sediments are indirect, resulting from a change in water quality (e.g., increased concentrations of suspended sediments or nutrients) that would in turn affect sediment quality. As described in Volume 5, Chapter 8 (Marine Water Quality VEC), the residual effects of runoff entering Roberts Bay on marine water quality were rated as *not significant*, and there were not predicted to be any significant changes to water quality as a result of runoff which could in turn affect sediment quality. Given the extensive mitigation measures and the prediction of no significant effects to water quality, there are not expected to be residual effects to marine sediment quality caused by runoff during site preparation, construction, and decommissioning, and this potential effect is not considered further.

The physical in-water works related to the construction of the marine dock could affect sediment quality by mobilizing sediments and altering the particle size distribution and sedimentation patterns. This could affect subsea permafrost if sedimentation rates are substantially altered. Construction of the cargo dock includes the installation of sheet-pile bulkheads and armour rock (Package P5-10). Some disturbances to sediments are likely to occur, but are expected to be limited to the dock footprint and marine buffer zone around the dock within the PDA. Potential effects of the dock construction will be contained within the PDA by the use of sediment control as required in the authorization from DFO during all phases of cargo dock construction. The monitoring and adaptive management of in-water construction through the Fisheries Authorization will limit turbidity levels surrounding the cargo dock and will ensure that suspended sediments are within the acceptable range of CCME water quality guidelines in the LSA. At closure, the cargo dock will remain, so the potential for direct physical effects of the marine dock on water quality are limited to the Construction phase.

Overall, there is the potential for short-term residual effects of the in-water construction associated with the Roberts Bay cargo dock on marine sediment quality. These are not expected to affect subsea permafrost because of the expected surficial nature of the disturbance, the shallow depth where permafrost exists (1 m), and the deep depth of the permafrost layer (20 m) in Roberts Bay (SRK 2016; Package P5-5). The potential residual effects to marine sediment quality due to in-water works at the marine cargo dock are further characterized in Section 9.5.5.3.

<u>Characterization of Hope Bay Development Potential Effects</u>

Within the Hope Bay Development, existing and approved projects (mainly the Doris Project) also have the potential along with the Madrid-Boston Project to interact with marine sediments through runoff to cause additive effects. Planned mitigation measures such as erosion and sedimentation barriers and the use of geochemically suitable building materials will effectively minimize the volume and optimize the quality of runoff for all site preparation, construction, and decommissioning activities occurring as part of the Hope Bay Development. Mitigations associated with the Doris Project have proven to be effective as no effects to marine sediment quality have been shown over the seven years of the approved Doris AEMP. Also, the effects of runoff on marine sediments are indirect, resulting from a change in the water quality (e.g., increased concentrations of suspended sediments) that would in turn affect sediment quality. Although runoff was identified as a potential residual effect for marine water quality (Volume 5, Chapter 8), the effects of runoff were ultimately characterized as *not significant*. Therefore, runoff associated with site preparation, construction, and decommissioning activities in the Hope Bay Development is not considered a potential residual effect to marine sediments.

The Madrid-Boston Project will physically interact with marine sediments in Roberts Bay during the construction of the marine dock, which will cause local disturbance of sediments and could change the particle size distribution of sediments. Existing and planned infrastructure in Roberts Bay as part of the Doris Project includes the marine jetty, and the future installation of the Roberts Bay Discharge System that is comprised of a marine outfall berm, subsea pipeline, and diffuser system. The in-water structures in Roberts Bay interact directly with marine sediments during construction through sediment disturbance and mobilization. The construction of the jetty was completed in 2007, so any construction-related disturbances occurred in the past and do not need to be assessed. Physical contact with the sediments during planned Roberts Bay Discharge System construction will include the deploying cement anchors on the sediment surface (localized effects). The installation of the marine outfall pipeline is expected to be complete before construction associated with the Madrid-Boston Project begins in 2019, so there will be no temporal overlap in the in-water construction activities; however, there is the potential for residual effects to marine sediments as a result of physical contact from in-water construction works related to the Hope Bay Development as a whole. These residual effects are further characterized in Section 9.5.5.3.

9.5.4.3 Site Contact Water

Characterization of Madrid-Boston Project Potential Effects

Site contact water has the potential to affect marine sediment quality through the runoff pathway. Potential effects are expected to be minimized by the proposed management and mitigation measures described in Section 9.5.3. Infrastructure around Roberts Bay will be set back from or avoid sensitive beaches, shorelines, and intertidal areas and will be located, wherever feasible, on bedrock or other suitable base material. Only geochemically suitable rock quarries and borrow sources (non-acid-generating rock) will be used to construct roads, pads, and structures, minimizing the potential for site contact water to transport acid equivalents and metals into the marine environment. As described in the Water Management Plan (Package P4-7), locating infrastructure pads within diversion berms and grading surfaces towards pollution control or sedimentation ponds ensures that runoff and seepage will flow to the select ponds for management. Diversion berms may be constructed to temporarily route water away from infrastructure as needed, to prevent contact.

Some site water (e.g., runoff from roads, laydown areas, and quarries) could enter the marine environment. However, mitigation and management measures such as the use of geochemically suitable material for construction, erosion controls, and sediment barriers, are anticipated to be effective. Runoff of site contact water is not expected to significantly affect marine water quality (see Volume 5, Chapter 8). Any potential effects to marine water quality from runoff are predicted to be localized, and less than applicable water quality objectives in the marine receiving environment. For example, suspended sediments transported during a runoff event are predicted to have minor effects on suspended sediment concentrations in the marine environment. This predicted minor, short-term alteration of suspended sediment concentration is not anticipated to have the potential to alter sediment quality. Therefore, the potential effect of site contact water on marine sediment quality after the implementation of mitigation and management measures is not anticipated to be a potential residual effect for the Madrid-Boston Project, and is not further assessed.

Characterization of Hope Bay Development Potential Effects

The characterization of effects associated with site contact water for the Hope Bay Development is identical to the characterization provided for the Madrid-Boston Project. The potential effects of runoff associated with site contact water on marine sediment quality are expected to be minimized or eliminated by the proposed management and mitigation measures described in Section 9.5.3, which apply to the entire Hope Bay Development. Therefore, no residual effects of site contact water on marine sediment quality in Roberts Bay are predicted as a result of the Hope Bay Development.

9.5.4.4 Fuels, Oils, and PAH

Characterization of Madrid-Boston Project Potential Effects

Activities related to the transportation, transfer, storage, and handling of fuels at the Roberts Bay facilities will be managed and mitigated as described in the OPPP/OPEP (Volume 8, Annex V8-1). The plan establishes comprehensive measures to ensure all shore preparations, emergency preparedness, equipment and personnel are in place to coordinate between TMAC and the other Project participants to transfer fuel between an anchored tanker and a barge, and from a barge moored at the jetty in Roberts Bay to the on-shore bulk fuel storage facility at Roberts Bay. The OPPP/OPEP is substantially focussed on the shipping, transfer, handling and storage of fuel at the Roberts Bay Oil Handing Facilities (OHF). The bulk fuel storage facility and all transfer-related equipment will be inspected and maintained, with complete documentation.

The potential effects to marine sediment quality from the use of fuels, including refueling and maintenance, are considered fully mitigated by the application of best management practices and the mitigation and management measures related to the use and potential spills of fuels and petroleum products that are detailed in the OPPP/OPEP (Volume 8, Annex V8-1) and the Hope Bay Project Spill Contingency Plan (Package P4-3). These measures include, secondary containment for fuel storage, the use of oil-water separators at maintenance facilities, and established spill response plans. As a result, the potential effects to marine sediment quality from the use of fuels and oils are not considered further.

The potential for airborne PAH to be introduced to the marine environment will be managed as outlined in the Incinerator Management Plan (Package P4-16). The objective of the incinerator management plan is to ensure that waste incineration is undertaken in a safe, efficient, and environmentally compliant manner and in a way that minimizes harmful emissions. Modern incineration equipment will be installed to minimize airborne contaminant loading of PAH, and hazardous material that can contribute to airborne PAH will be removed from the incineration waste stream.

The potential effects of fuels, oils, and PAH on marine sediment quality are expected to be effectively mitigated. No residual effects of fuels, oils, and PAH on marine sediment quality in Roberts Bay are predicted to result from the Madrid-Boston Project.

Characterization of Hope Bay Development Potential Effects

The characterization of effects associated with the transportation, transfer, storage, handling, and use of fuels and other petroleum products for the Hope Bay Development is identical to the characterization provided for the Madrid-Boston Project. All management plans and mitigation measures that will serve to minimize or eliminate potential effects of fuels, oils, and PAH to marine sediment quality are adhered to across the entire Hope Bay Development. Therefore, no residual effects of fuels, oils, and PAH on marine sediment quality in Roberts Bay are predicted to result from the Hope Bay Development.

9.5.4.5 Discharge

Characterization of Madrid-Boston Project Potential Effects

The discharge of TIA water and saline groundwater into Roberts Bay could potentially affect marine sediment quality. Near-field mixing (Appendices V5-8A and V5-8B) and far-field hydrodynamic modelling (Appendix V5-8C) have shown that the discharge of TIA and saline groundwater into Roberts Bay will be buoyant and will be trapped in the deep-waters of Roberts Bay where it will be diluted by several orders of magnitude and advected into Melville Sound. All marine CCME water quality guidelines will be met within metres of the outfall diffuser (Volume 5, Chapter 8), and because the resulting effluent plumes will be buoyant, the effluent will not interact with the marine sediments. Therefore, there are no anticipated residual effects of TIA discharge on the marine sediment quality of Roberts Bay, and TIA and groundwater discharge are not further assessed.

Characterization of Hope Bay Development Potential Effects

The characterization of effects associated with discharging TIA and saline groundwater into Roberts Bay will be the same for the Hope Bay Development as they will be for the Madrid-Boston Project.

Discharge related to the Doris Project will occur independently for approximately 1.5 years, with a 1.5 year period where discharge from Doris and Madrid North mining activities will be combined and discharged to Roberts Bay (Madrid-Boston Project Water and Load Balance, Package P5-4). The period of overlap is included in the effluent predictions from the water balance model. Therefore, the assessment for the Madrid-Boston Project potential effects includes the potential influences of the Doris mining activities. The modelling predictions have shown that the plume will be buoyant, all CCME water quality criteria will be met within metres of the outfall diffuser, and the effluent will not interact with the sediments of Roberts Bay (Appendices V5-8A, V5-8B, V5-8C and Volume 5, Chapter 8). Therefore, the potential effects of Madrid-Boston and the Hope Bay Development from groundwater and TIA water discharge to Roberts Bay will be similar and there are no anticipated residual effects to marine sediment quality.

9.5.4.6 Dust Deposition

Characterization of Madrid-Boston Project Potential Effects

Quantitative air quality modelling predicted dust deposition rates across the Project area (Volume 4, Chapter 2). Potential dust sources such as construction activities, ship emissions, operation of the TIA, and vehicle traffic were incorporated into the model. Data extracted from the interpolated air quality model were used to obtain average annual deposition rates for the Roberts Bay PDA and LSA. The average annual dust deposition rates within the PDA were estimated to be 1.2 $g/m^2/yr$ for the Construction phase and 1.0 $g/m^2/yr$ for the Operation phase. Within the LSA, the average annual deposition rate was estimated to be 0.9 $g/m^2/yr$ for both the Construction and Operation phases (Volume 5, Section 8.5.4.6).

For the purposes of this assessment, it was assumed that all dust that is deposited on the sea surface reaches the seabed. This is a conservative estimate as a large proportion of the introduced dust particles would likely remain in suspension and would be carried out of Roberts Bay by currents. The particle sizes considered for the dust deposition model are generally smaller than 100 µm in diameter. In terms of sediment particle sizes, deposited dust would be classified as clay, silt, or fine sand, which are relatively small particles that would tend to remain in suspension or sink relatively slowly compared to larger sand or gravel (size classes shown in Table 9.2-3). Therefore, the assumption that all deposited dust would reach the seabed is conservative.

For the analysis of sediment quality (e.g., metals, TOC, nutrients), the uppermost 2 to 3 cm of the sediments are typically collected (e.g., Rescan 2010, 2011c). Assuming an average density of 2,700,000 g/m^3 for marine sediments (Tenzer and Gladkikh 2014), a 3 cm-thick layer of sediment occupying a 1 m^2 area of the seabed would contain approximately 81,000 g of sediment. In the PDA, the average annual deposition of 1.2 g/m^2 (during Construction) and 1.0 g/m^2 (during Operation) onto 81,000 g on sediment in a 3 cm thick by 1 m^2 area of the seabed would represent a negligible annual increase of approximately 0.001%. In the LSA, the average annual deposition of 0.9 g/m^2 (during both Construction and Operation) onto 81,000 g of sediment in a 3 cm thick by 1 m^2 area of the seabed would also represent an annual increase of approximately 0.001%. Over the 17-year Construction and Operation timeframe of Madrid-Boston, this would amount to less than a 0.02% increase in the LSA. These estimated increases are negligible from baseline levels and would be within the margin of error of sediment quality analyses. Therefore, dust deposition would not cause a measurable change in sediment quality in the Roberts Bay LSA, and dust deposition is not further assessed as a residual effect.

Characterization of Hope Bay Development Potential Effects

The dust modelling results considered dust contributed by the Madrid-Boston Project as well as Existing and Permitted Projects. The dust inputs specific to the Madrid-Boston Project were not considered in isolation of other activities within the Hope Bay Development; therefore the discussion of Madrid-Boston potential effects applies equally to the Hope Bay Development. Dust deposition is not further assessed as a residual effect for the Hope Bay Development.

9.5.5 Characterization of Residual Effects on Marine Sediment Quality

9.5.5.1 Definitions for Characterization of Residual Effects

To determine the significance of a Project residual effect, each potential negative residual effect is characterized by a number of attributes consistent with those defined in of the EIS guidelines (Section 7.14, Significance Determination for the Hope Bay Project; NIRB 2012). A definition for each attribute and the contribution that it has on significance determination is provided in Table 9.5-5.

Table 9.5-5. Attributes to Evaluate Significance of Potential Residual Effects

Attribute	Definition and Rationale	Impact on Significance Determination
Direction (positive, neutral, or negative)	The ultimate long-term trend of a potential residual effect - positive, neutral, or negative.	Positive, neutral, and negative potential effects on VECs are assessed, but only negative residual effects are characterized and assessed for significance.
Magnitude (negligible, low, moderate, or high)	The degree of change in a measurable parameter or variable relative to existing conditions. This attribute may also consider complexity - the number of interactions (Project phases and activities) contributing to a specific effect.	The higher the magnitude, the higher the potential significance.
Duration (short, medium, long)	The length of time over which the residual effect occurs.	The longer the length of time of an interaction, the higher the potential significance.
Frequency (once, infrequent, frequent, continuous)	The number of times during the Project or a Project phase that an interaction or environmental/ socio-economic effect can be expected to occur.	Greater the number times of occurrence (higher the frequency), the higher the potential significance.
Geographical Extent (PDA, LSA, RSA, beyond regional)	The geographic area over which the interaction will occur.	The larger the geographical area, the higher the potential significance.
Reversibility (reversible, reversible with effort, irreversible)	The likelihood an effect will be reversed once the Project activity or component is ceased or has been removed. This includes active management for recovery or restoration.	The lower the likelihood a residual effect will be reversed, the higher the potential significance.

For the determination of significance, each attribute is characterized. The characterizations and criteria for the characterizations are provided in Table 9.5-6. Each of the criteria contributes to the determination of significance.

Table 9.5-6. Criteria for Residual Effects for Environmental Attributes

Attribute	Characterization	Criteria
Direction	Positive	Beneficial
	Variable	Both beneficial and undesirable
	Negative	Undesirable

Attribute	Characterization	Criteria
Magnitude	Negligible	No change on the indicator or overall Marine Sediment Quality VEC
	Low	Differing from the average value for the existing environment to a small degree, but within the range of natural variation and well below a guideline or threshold value
	Moderate	Differing from the average value for the existing environment and approaching the limits of natural variation, but below or equal to a guideline or threshold value
	High	Differing from the existing environment and exceeding guideline or threshold values so that there will be a detectable change beyond the range of natural variation (i.e., change of state from the existing conditions)
Duration	Short	Up to 4 years (Construction phase)
	Medium	Greater than 4 years and up to 17 years (4 years Construction phase, 10 years Operation phase, 3 years Reclamation and Closure phase – not consecutive)
	Long	Beyond the life of the Project
Frequency	Once	Occurring only once
	Infrequent	Occurring more than once but less than 50% of the time over the life of the Project
	Frequent	Occurring more than 50% but less than 100% of the time over the life of the Project
	Continuous	Continuously occurring throughout the Project life
Geographical Extent	Project Development Area (PDA)	Confined to the PDA
	Local Study Area (LSA)	Beyond the PDA and within the LSA
	Regional Study Area (RSA)	Beyond the LSA and within the RSA
	Beyond Regional	Beyond the RSA
Reversibility	Reversible	Effect reverses within an acceptable time frame with no intervention
	Reversible with effort	Active intervention (effort) is required to bring the effect to an acceptable level
	Irreversible	Effect will not be reversed

9.5.5.2 Determining the Significance of Residual Effects

Section 7.4 of the EIS guidelines provided guidance, attributes, and criteria for the determination of significance for residual effects (NIRB 2012). Also, the Canadian Environmental Assessment Agency's *Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects* (CEAA 1992) also guided the evaluation of significance for identified residual effects. The significance of residual effects is based on comparing the predicted state of the environment with and without the Project, including a judgment as to the importance of the changes identified.

Probability of Occurrence or Certainty

Prior to the determination of the significance for negative residual effects, the probability of the occurrence or certainty of the effect is evaluated. For each negative residual effect, the probability of occurrence is categorized as unlikely, moderate, or likely. Table 9.5-7 presents the definitions applied to these categories.

Table 9.5-7. Definition of Probability of Occurrence and Confidence for Assessment of Residual Effects

Attribute	Characterization	Criteria
Probability of occurrence or certainty	Unlikely	Some potential exists for the effect to occur; however, current conditions and knowledge of environmental trends indicate the effect is unlikely to occur.
	Moderate	Current conditions and environmental trends indicate there is a moderate probability for the effect to occur.
	Likely	Current conditions and environmental trends indicate the effect is likely to occur.
Confidence	High	Baseline data are comprehensive; predictions are based on quantitative predictive model; effect relationship is well understood.
	Medium	Baseline data are comprehensive; predictions are based on qualitative logic models; effect relationship is generally understood, however, there are assumptions based on other similar systems to fill knowledge gaps.
	Low	Baseline data are limited; predictions are based on qualitative data; effect relationship is poorly understood.

Confidence

The knowledge or analysis that supports the prediction of a potential residual effect—in particular with respect to limitations in overall understanding of the environment and/or the ability to foresee future events or conditions—determines the confidence in the determination of significance. In general, the lower the confidence, the more conservative the approach to prediction of significance must be. The level of confidence in the prediction of a significant or non-significant potential residual effect qualifies the determination, based on the quality of the data and analysis and their extrapolation to the predicted residual effects. "Low" is assigned where there is a low degree of confidence in the inputs, "medium" when there is moderate confidence and "high" when there is a high degree of confidence in the inputs. Where rigorous baseline data were collected and scientific analysis performed, the degree of confidence will generally be high. Table 9.5-7 provides descriptions of the confidence criteria.

Residual effects identified in the Project-related effects assessment are carried forward to assess the potential for cumulative interactions with the residual effects of other projects or human activities and to assess the potential for transboundary impacts should the effects linked directly to the activities of the Project inside the Nunavut Settlement Area (NSA), which occurs across provincial, territorial, international boundaries or may occur outside of the NSA.

Determination of Significance

A description of how residual effects were designated as "not significant" or "significant" is provided in this section. Although general guidelines can be followed for the determination of significance, it is not practicable to outline all possible permutations of attribute criteria that would result in an effect being designated as "not significant" or "significant". Rather, residual effects were assessed on a case-by-case basis using the criteria outlined below as well as professional judgement to ultimately assign a significance rating.

Not Significant: A residual effect rated as "not significant" may result in a slight to moderate decline in marine sediment quality within the zone of influence of the Project relative to reference conditions during the life of the Project, but sediment quality would generally be expected to return to baseline conditions after Project closure. Non-significant residual effects on sediment quality are not considered to have serious consequences (e.g., sediments metals increase slightly from baseline concentrations or sediment particle size composition changes during the life of the Project but all sediment indicators return to baseline conditions during Closure and Reclamation or Post Closure). The specific attribute criteria leading to a designation of an effect as “not significant” can be variable.

Significant Effect: A residual effect rated as “significant” is expected to result in the degradation of marine sediment quality within the LSA or extending into the RSA relative to reference conditions, and is irreversible or requires some effort to reverse. Significant residual effects on sediment quality are consequential (e.g., sediments are contaminated and can no longer support their ecosystem function). Regional management actions such as research, monitoring, and recovery initiatives may be required should changes to marine sediment quality exceed acceptable thresholds. Specific criteria of attributes such as duration, frequency, geographic extent, and reversibility that lead to a residual effect being considered “significant” can be variable.

9.5.5.3 Characterization of Residual Effect for Marine Sediment Quality

<u>Sealift – Physical Disturbances from Propeller Wash</u>

Madrid-Boston Project Potential Effect

Approximately five to seven vessels are expected to report to Roberts Bay each year during the Construction and Operation phases of the Madrid-Boston Project, and potentially for a short period during Reclamation and Closure. The Madrid-Boston Project will extend the vessel traffic 13 years beyond the 6-year lifespan of the existing and approved projects.

Propeller wash has been identified as a potential residual effect to the marine sediment quality in Roberts Bay. Quantitative modelling indicated that vessel traffic in Roberts Bay could cause some disturbance to marine sediments through propeller wash mobilizing sediments even after mitigation measures such as reduced speeds are implemented. Fine sediments such as silt and clay tend to contain higher concentrations of metals than coarse sediments such as sand and gravel because of the higher overall surface area of fine sediments and because of the binding properties of clays (Sengupta and Dalwani 2008). Physical disturbances caused by ship propeller wash can potentially cause easily disturbed fine sediments to be mobilized and redeposited elsewhere in the bay. The disturbance of sediments could increase metals concentrations to the water column, or could alter the distribution of sediment metals if fine particles and their associated metals settle in calmer areas of Roberts Bay. The removal of surficial sediments could affect the insulation properties of marine sediments which could in turn affect subsea permafrost.

A summary of the characterization and assessment of the residual effects of physical disturbances associated with sealifts is provided in Table 9.5-8. The effects of sediment redistribution are not strictly adverse in terms of sediment quality because there is no net input of metals or contaminants into sediments; therefore, the direction of the potential effect is considered *variable*. A change in the particle size distribution of sediments and in sedimentation patterns could represent a deviation from baseline conditions. However, any changes to sediment particle size composition and sediment metal concentrations due to sealift activities are expected be minor because the ocean current speeds required to mobilize larger sediment grain sizes such as sand (0.25 m/s) are naturally attained during storm events in Roberts Bay and these events are predicted to occur more often that ship traffic (Volume 5, Chapter 7). Therefore, the magnitude of the residual effect is rated as *low*. The duration of residual effects is rated as *medium* because sealift activities will occur for up to 17 years during Construction, Operation, and Reclamation and Closure phases. The expected total of five to seven ships reporting to Roberts Bay per year is considered an *infrequent* disturbance, and the geographic extent of potential residual effects is *within the Roberts Bay LSA*. Following Reclamation and Closure, there will be no further vessel traffic in Roberts Bay. The potential residual effects of physical disturbances associated wish ship propeller wash in Roberts Bay is considered *reversible*, because once sealifting comes to an end, sediment dynamics in Roberts Bay will once again be controlled by natural physical processes as waves, currents, tides, and ice scour and should return to baseline conditions (Table 9.5-8).

The probability of occurrence of physical disturbances associated with sealifts is considered *likely*, since the phenomena of propeller wash is well-understood. The overall significance of the effects of physical disturbances associated with sealifts is considered **not significant** because of the low magnitude, the infrequent and localized nature, and the reversibility of the residual effect (Table 9.5-8). The confidence of this assessment rating is considered *high* since it is based on the known the bathymetry of the Roberts Bay and the potential for effects from propeller wash were quantified using a numerical model.

Hope Bay Development Potential Effect

The five to seven vessels that are expected to report to Roberts Bay each year includes sealift traffic for the entire Hope Bay Development, and not just the Madrid-Boston component. However, the Madrid-Boston Project will extend the duration of sealift traffic beyond the 6-year lifespan of the existing and approved projects for an additional 13 years. While the duration of vessel traffic will be extended, the characterization of the duration of the residual effect is still considered *medium-term* since it will not occur beyond the life of the Madrid-Boston and existing and approved projects. All attributes and characterizations of the residual effect of sealifts are common to both the Madrid-Boston Project and the Hope Bay Development. Therefore, the overall significance of the effects of physical disturbances associated with sealifts in the Hope Bay Development is considered **not significant** (Table 9.5-9).

Site Preparation, Construction, and Decommissioning

Madrid-Boston Project Potential Effect

There exists the potential for residual effects to marine sediments through in-water construction of the marine dock in Roberts Bay, which could mobilize and redistribute sediments. A summary of the characterization and assessment of the residual effects of physical disturbances associated with site preparation, construction, and decommissioning is provided in Table 9.5-8. The effects of sediment disturbance and redistribution are not strictly adverse in terms of sediment quality because there is no net input of metals or contaminants into sediments; therefore, the direction of the potential effect is considered *variable*. Any residual effects are expected to be *low* in magnitude because of the use of geochemically suitable materials for construction and the installation of erosion and sedimentation control measures (Table 9.5-8). These measures will ensure that in-water works will have a minimal effect on sedimentation patterns. The duration of the potential residual effects is expected be *short*, because the potential physical disturbance will only occur during the Construction phase and the marine dock is not expected to require decommissioning. The frequency of the potential effect is predicted to be *infrequent* because potential sediment mobilization could occur periodically during the vibratory sheet pile installation required for the construction of the dock. The potential residual effects are expected be confined to the marine *PDA* in the waters immediately surrounding the dock, as the use of a silt curtain will prevent the transportation of sediments into the LSA. Any residual effects are predicted to be *reversible* once in-water construction activities are completed, as sediments surrounding the dock will be re-worked by natural physical processes such as waves, currents, tides, and ice scour (Table 9.5-8).

Table 9.5-8. Summary of Residual Effects and Overall Significance Rating for Marine Sediment Quality - Madrid-Boston Project

Residual Effect	Attribute Characteristic						Overall Significance Rating		
	Direction *(positive, variable, negative)*	**Magnitude** *(negligible, low, moderate, high)*	**Duration** *(short, medium, long)*	**Frequency** *(infrequent, intermittent, continuous)*	**Geographic Extent** *(PDA, LSA, RSA, beyond regional)*	**Reversibility** *(reversible, reversible with effort, irreversible)*	**Probability** *(unlikely, moderate, likely)*	**Significance** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Sealift - Physical Disturbances	Variable	Low	Medium	Infrequent	LSA	Reversible	Likely	Not Significant	High
Site Preparation, Construction, and Decommissioning - Physical Disturbances	Variable	Low	Short	Infrequent	PDA	Reversible	Likely	Not Significant	High

Table 9.5-9. Summary of Residual Effects and Overall Significance Rating for Marine Sediment Quality - Hope Bay Development

Residual Effect	Attribute Characteristic						Overall Significance Rating		
	Direction *(positive, variable, negative)*	**Magnitude** *(negligible, low, moderate, high)*	**Duration** *(short, medium, long)*	**Frequency** *(infrequent, intermittent, continuous)*	**Geographic Extent** *(PDA, LSA, RSA, beyond regional)*	**Reversibility** *(reversible, reversible with effort, irreversible)*	**Probability** *(unlikely, moderate, likely)*	**Significance** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Sealift - Physical Disturbances	Variable	Low	Medium	Infrequent	LSA	Reversible	Likely	Not Significant	High
Site Preparation, Construction, and Decommissioning - Physical Disturbances	Variable	Low	Medium	Infrequent	LSA	Reversible	Likely	Not Significant	High

The probability of occurrence of residual effects from in-water construction works is considered to be *likely*. The overall significance of the effects of physical disturbances associated in-water work is considered **not significant** because of the low magnitude, the confinement of the effect within the marine PDA, and the reversibility of the residual effect. The confidence of the overall rating is considered to be *high* because of the use of widely used and effective best practices for erosion and sediment control (Table 9.5-8).

Hope Bay Development Potential Effect

Site preparation, construction, and interaction activities associated with the Hope Bay Development are expected to interact with marine sediment quality as a result of in-water construction works. The Madrid-Boston Project includes the construction of a marine dock in Roberts, and the Doris Project includes the installation of the Roberts Bay Discharge System (marine outfall pipeline and diffuser). The in-water works associated with the Doris Project are expected to be complete once construction associated with the Madrid-Boston Project begins in 2019, so there will be no temporal overlap in the in-water construction activities. There will also be no spatial overlap since the pipeline and diffuser are several hundred metres away from the marine dock location, and the geographical extent of any residual effects associated with each structure are expected to be highly localized. Furthermore, for both the marine dock and the Roberts Bay Discharge System, sediment transport patterns and particle size composition are expected to return to baseline conditions shortly after construction activities are completed, as suspended sediments settle and the sediments are re-worked by natural physical processes such as waves, currents, tides, and ice scour. Given that the in-water construction work associated with the Doris Project will not overlap temporally or spatially with the Madrid-Boston in-water work and all residual effects are expected to be reversible over the short-term, there are not expected to be any additive or cumulative effects of in-water construction on Roberts Bay sediments.

Compared to the Madrid-Boston Project in isolation, the characterization of the residual effects of in-water works during site preparation, construction, and decommissioning associated with the complete Hope Bay Development differ in two ways: 1) the potential residual effects associated with the installation and potential decommissioning of the Roberts Bay Discharge System will occur over multiple Project phases, extending the duration of the potential residual effects from *short* to *medium*, and 2) the potential residual effect associated with the installation of the Roberts Bay Discharge System would occur within the LSA, extending the geographic extent of the potential residual effects from the *PDA* to the *LSA*. Overall, the potential effects of the in-water works of the Hope Bay Development on marine sediments are rated as **not significant** (Table 9.5-9).

9.6 CUMULATIVE EFFECTS ASSESSMENT

The potential for cumulative effects arises when the potential residual effects of the Madrid-Boston Project add to or otherwise interact with the residual effects of other past, existing or reasonably foreseeable projects or activities. As defined by the EIS guidelines (NIRB 2012) and the *NIRB Technical Guide Series: Terminology and Definitions* (NIRB 2013), cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

9.6.1 Methodology Overview

9.6.1.1 Approach to Cumulative Effects Assessment

The general methodology for cumulative effects assessment (CEA) is described in Volume 2, Chapter 4, and follows the steps described below.

1. Identify the potential for Madrid-Boston Project-related residual effects to interact with residual effects from the Doris Project, the Hope Bay Regional Exploration Project, the Madrid Advanced Exploration Program, the Boston Advanced Exploration Project and other human activities and projects within specified assessment boundaries. Key potential residual effects associated with past, existing, and reasonably foreseeable future projects were identified using publicly available information or, where data was unavailable, professional judgment was used (based on previous experience in similar geographical locations) to approximate expected environmental conditions.
2. Identify and predict potential cumulative effects that may occur and implement additional mitigation measures to minimize the potential for cumulative effects.
3. Identify cumulative residual effects after the implementation of mitigation measures.
4. Determine the significance of any cumulative residual effects. A key task in the CEA is to understand the contribution of Madrid-Boston Project to the overall cumulative effect on the marine water quality VEC (i.e., the amount of the cumulative effect can be apportioned to Madrid-Boston Project as compared to the Doris Project, the Hope Bay Regional Exploration Project, the Madrid Advanced Exploration Program, the Boston Advanced Exploration Project and other projects and activities).

9.6.1.2 Assessment Boundaries

The CEA considers the spatial and temporal extent of Project-related residual effects on the marine sediment quality VEC combined with the anticipated residual effects from other projects and activities to assist with analyzing the potential for a cumulative effect to occur.

<u>Spatial Boundaries</u>

The CEA considers past, existing, and reasonably foreseeable projects with potential residual effects that occur within the outer geographical limit of possible interaction with Madrid-Boston Project and the Hope Bay Project. The spatial boundary for the CEA for the marine sediment quality VEC was the assessment Regional Study Area (RSA; Figure 9.2-1). This study area contains the LSA and was determined to cover the extent of direct and indirect effects of the Project on the marine environment.

<u>Temporal Boundaries</u>

The temporal boundaries of the CEA were defined by the timelines for Past, Existing, and Reasonably Foreseeable Projects as described in the CEA methodology (Volume 2, Chapter 4). These timelines were compared to the Project timeline (Section 9.4.3).

9.6.2 Potential Interactions of Residual Effects with Other Projects

The mining industry is the main source of industrial activity in Nunavut, which is being explored for uranium, diamonds, gold and precious metals, base metals, iron, coal, and gemstones. In addition to major mining development projects, other land use activities were also considered for potential interactions with the Project, as required under Section 7.11 of the EIS guidelines (see Volume 2, Chapter 4 for more details).

The potential residual effects identified for the Madrid Boston Project and the Hope Bay Development as a whole were confined to the LSA. Given that no past, present, or foreseeable projects that could potentially interact with the residual effects of the Hope Bay Project lie within the marine LSA, no cumulative effects to the marine sediment quality VEC are predicted.

9.7 TRANSBOUNDARY EFFECTS

The Project EIS guidelines define transboundary effects as those effects linked directly to the activities of the Project inside the NSA, which occur across provincial, territorial, international boundaries or may occur outside of the NSA (NIRB 2012). Transboundary effects of the Project have the potential to act cumulatively with other projects and activities outside the NSA.

The non-significant Project effects to the marine sediment quality VEC are predicted to be restricted to the LSA. The LSA lies entirely within Nunavut; therefore, there is no potential for transboundary effects.

9.8 IMPACT STATEMENT

The assessment of effects from the Project to the marine sediment quality VEC considers potential effects based on specified interaction groups. These interaction groups incorporate Madrid-Boston Project effects that are related by timing, infrastructure, and mitigation and management measures. The following interaction groups are considered as potential effects:

- sealift;
- site preparation, construction, and decommissioning activities;
- site contact water;
- fuels, oils, and PAH;
- discharge; and
- dust deposition.

Potential effects were characterized using key indicators and quantitative thresholds as well as experience from the Hope Bay Development. The assessment considered mitigation and management measures already applied in the Hope Bay Development, drawn from guidance documents, and applied in other mining projects in Nunavut and the Northwest Territories.

Quantitative and qualitative analyses were used to predict the effects of the Project on marine sediment quality. Two residual effects are identified following the application of mitigation and management measures: sediment disturbances related to propeller wash from sealifts, and site preparation, construction, and decommissioning activities from in-water works associated with the marine cargo dock.

Using the thresholds identified for the key indicators, each of these residual effects was concluded to be low in magnitude. All residual effects to marine sediment quality were predicted to be restricted to the LSA. As a result, the residual effects were rated as **not significant**. No cumulative effects were predicted to occur because the Project marine sediment quality residual effects were not predicted to overlap spatially with any other past, existing, or reasonably foreseeable project. Similarly, no transboundary effects were identified because the Project residual effects were predicted to extend only within the LSA, which is entirely within Nunavut.

9.9 REFERENCES

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