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.

μg	microgram
ASTM	ASTM International
AWR	All-weather road
BC	British Columbia
CAAQS	Canadian Ambient Air Quality Standards
CALPUFF	The California Puff air dispersion model
CCME	Canadian Council of Ministers of the Environment
CEA	Cumulative effects assessment
CEA Agency	Canadian Environmental Assessment Agency
CO	Carbon monoxide
dm^2	Square decimetre (equal to 100 square centimetres)
EAA	Existing and Approved Authorizations
ECCC	Environment and Climate Change Canada
EIS	Environmental Impact Statement
ERM	ERM Consultants Canada Ltd.
GHG	Greenhouse gas
h	Hour
IQ	Inuit Qaujimajatuqangit
km	kilometre
LRT	Long range transport
LSA	Local study area
m	metre
m^3	Cubic metre
mg	milligram
MOE	Ministry of Environment
MOMB	Marine outfall mixing box

NIRB	Nunavut Impact Review Board
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
NPRI	National Pollutant Release Inventory
NSA	Nunavut Settlement Area
NTKP	Naonaiyaotit Traditional Knowledge Project
NWB	Nunavut Water Board
NWT	Northwest Territories
O_3	Ground level ozone
PASS	Passive Air Sampling System
PDA	Project development area
PM	Particulate matter
PM_{10}	Particulate matter less than 10 µm in diameter
$PM_{2.5}$	Particulate matter less than 2.5 µm in diameter
ppb	Parts per billion
Rescan	Rescan Environmental Services Ltd.
RSA	Regional study area
SO_2	Sulphur dioxide
Nunami Stantec	Nunami Stantec Limited
TIA	Tailings Impoundment Area (Doris)
TK	Traditional Knowledge
TMA	Tailings Management Area (Boston)
TMAC	TMAC Resources Inc.
tpd	Metric tonne per day
TSP	Total suspended particulate
US EPA	United States Environmental Protection Agency
VEC	Valued Ecosystem Component
VOC	Volatile organic compounds
WRR	Winter road route

2. Air Quality

Air quality is an important component of the atmospheric environment. It is a term used to describe the degree to which the air contains contaminants (i.e., specific undesirable chemical species including gases, vapours and solid particulates). Good air quality refers to air with ambient concentrations of chemical species that are below their applicable regulatory criteria. Good air quality is important for sustaining the health and well-being of humans, wildlife, vegetation, soil and water. It is also an important factor that influences visibility (e.g., for aircraft travel) and general aesthetics. Poor air quality is a result of a number of factors, with the primary factors being air contaminant emissions from various sources, both natural (biogenic) and anthropogenic (human-caused), and meteorological conditions. Air quality is considered to be poor when air contaminants have concentrations high enough to endanger the health and well-being of the receiving environment (i.e., humans, wildlife, vegetation, soil and water).

Ambient air quality refers to the quality of outdoor air in the surrounding environment, measured near ground level. The surrounding environment within which ambient air quality is assessed is typically taken to be the area outside of the property line of the facility being assessed. This environmental assessment is specific to prediction and characterization of project-related effects on ambient air quality as a valued ecosystem component (VEC). Greenhouse gas (GHG) emissions are not categorized as contributing factors to air quality. GHG emissions and their impact on the environment are addressed in the Climate and Meteorology Subject of Note (Volume 4, Section 1).

Ambient air quality is assessed based on the change from the existing and baseline ambient air quality conditions to the resulting conditions due to those activities of the Madrid-Boston Project and the Hope Bay Project that emit direct or indirect air contaminants. A number of different air contaminant chemical species are used as ambient air quality indicators for the assessment. The assessment heavily incorporates the results of the air quality modeling study: *The Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stanec 2017; Appendix V4-2I).

A number of important air contaminant mitigation measures are included as part of the Project Description (Volume 3) and are incorporated in the air quality modeling study and this assessment. For example, fugitive dust emissions from various sources will be reduced using natural or environmentally suitable chemical dust suppressants, where needed. Additionally, policies and procedures will be in place to help reduce site-wide fuel consumption that will in turn help reduce air contaminant emissions.

2.1 CHANGES FROM THE DRAFT EIS

This Air Quality assessment addresses comments from agencies and other stakeholders, and addresses advances in the Project design. Nunami Stantec Limited (Nunami Stantec) was retained by TMAC to update and refine the DEIS air quality assessment, including refining conservative emissions estimates and dispersion model assumptions and re-modeling the Project. The resulting refined predictions are expected to be more representative of air quality levels when the Project is in operation. The following provides a summary of the main updates that have been incorporated into the air quality assessment since publication of the Draft EIS in December 2016:

- Updates in the site plan resulting in changes in source locations.
- Inclusion of assessment scenarios that address the potential for the Madrid North facility to be moved approximately 400-m north of the location assessed in the DEIS (referred to as the

reference and alternative locations). The Madrid North facility was assessed in both locations in the FEIS.

- Updates to the mining rate and operating life of the Boston site. The mining rate in the FEIS has increased relative to the DEIS (1,600 TDP in the DEIS to 2,400 TPD in the FEIS) and the operating life has decreased.
- Utilization of the appropriate Canadian emissions standards in effect at the time new or existing equipment is or was purchased.
- The number of surface vehicles in the emission inventory has been revised based on the updated mining rate at Boston and required vehicle trips between camps.
- Boston Power Plant – in the DEIS eight - 1.2 MW units were assumed operating. For the FEIS, only six - 1.2 MW units will be operating at any given time, with two on stand-by.
- Boston Processing Plant – in the DEIS the processing plant included crushing, milling and concentration. For the FEIS, the processing plant will be identical in design and capacity to the Doris processing plant and also include flotation, cyanide leach and gold recovery.
- Madrid and Boston Power Plant Stacks – in the DEIS, stack heights equal to Doris (30-m) were used. Stack heights in the FEIS are expected to be lower, and were assessed using a 15-m stack height.
- Inclusion of two wind turbines near the Doris site, two wind turbines near the Madrid North site and two wind turbines near the Boston site. These turbines will supply the power necessary to operate the Doris mill and camp, Madrid concentrator, and, Boston mill and camp, and will be located approximately 2.5 km and 3.0 km south of the sites. The power plants were conservatively assumed to operate at maximum capacity without any reduction in capacity due to the wind energy generation.
- In the DEIS the facility “property boundary” was assumed to be the PDA. In the FEIS a refined dispersion modeling "property boundary" was used to better represent the potential for public exposure and compliance with air quality criteria. The hunting exclusion zone around the TMAC facilities was used as a reasonable extent to define the property boundary. The hunting exclusion zone is a requirement of the Consolidation of the Mine Health and Safety Regulations, which prohibits discharge of a firearm within 2-km of any mine infrastructure. Local populations have been notified of the exclusion zone - any occurrences of members of the public being located within the hunting exclusion zone are expected to be infrequent and brief in duration.
- Various dispersion model input parameters for area and road sources were refined (following US EPA protocols) to reduce conservatisms in the modeling methodology.

The Nunami Stantec scope of work included updating the emissions inventory based on updated Project information, refining the emissions calculation methodology and inputs, updating and refining the dispersion model inputs, running the models and updating the dispersion model results. Analysis and interpretation of the following aspects of the air quality assessment presented in this chapter were outside the scope of the Nunami Stantec updates, and the original assessments were relied upon by Nunami Stantec:

- Incorporation of Traditional Knowledge.
- Existing and Baseline Air Quality monitoring.
- Study Area development.
- Characterization of Baseline Conditions and Existing Conditions.

- Valued Components Assessment.
- Definitions for Characterization of Residual Effects and Determinations of Significance.
- Cumulative Effects and Transboundary Effects Assessments.

2.2 INCORPORATION OF TRADITIONAL KNOWLEDGE

Sources of Inuit Traditional Knowledge (TK), or Inuit Qaujimajatuqangit (IQ), were reviewed and incorporated into the air quality effects assessment where appropriate. The primary source of TK that was accessed was The *Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP)* report (Banci and Spicker 2016). Additional TK sources that were reviewed included the documentation of consultation and engagement sessions with local and regional Inuit groups in the Nunavut Impact Review Board (NIRB) Scoping Sessions (NIRB 2012b) and the documentation of public consultation and open house meetings held in the Kitikmeot communities in May, 2016 (see Volume 2, Section 3, Public Consultation).

2.2.1 Incorporation of Traditional Knowledge for Existing Environment and Baseline Information

The sources of TK were reviewed for information related to historical and existing ambient air quality conditions for informing the existing ambient air quality environment and baseline. A number of comments were made in the NTKP report (Banci and Spicker 2016) suggesting that the current baseline ambient air quality environment is already impacted by anthropogenic air emission sources. The air quality impacts to snowfall and snowpack consistency were noted to be of particular concern.

Snowfall is observed as having a much finer consistency compared to many years ago.

> *"C110 Over the winter, even here sometimes, you see this really, really fine snow, more like a flour coming down. It's not snow; it's like flour coming down. They're not like snowflakes, it's like dust coming down."*
>
> "*C51 It's through all this fine, fine dust that's coming in from the air. It's all these local mines that are making all the stuff, this fine dust that goes for many, many miles before it lands. That's what we found out, our snow is really different from the past now. It's because of this fine dust blowing further away from each mine… Hundreds and hundreds of kilometers is what we see. What we see in the snow sometimes, because the air in winter is really, really dry up here, that dust and everything just glides right over the snow and can go for many miles before it even stops again and before it collects on the sides of the hills again."*

Making igloos from this type of snow is difficult as the snow does not stick together as well.

> *"C110 It's powder. Doesn't even have snowflakes in it, it's just powder. If it's a really good snowflake, it will make water, but not this.*
>
> *Talking about snow, igloo building snow, the quality is not there anymore. Over the winter you notice that the snow has turned into ice because there is hardly any fresh snow coming down. It turns into ice from all the wind and the age because there is no fresh stuff underneath.*
>
> *(If you had to make an emergency igloo when travelling today), you probably could but if wouldn't be very strong."*

Snow is also observed as having a residual “film” left behind when rubbing the snow.

> *“C51 It’s very, very different today. It’s not snow anymore. It becomes water but it’s a little bit different. There is something left after you rub on it. A film is left behind.”*

Particulates can be observed on top of the snow which darkens the colour.

> *“C51 You can see it in the wintertime. In the wintertime you can see lots, just like soot or sand on the snow, on top of the snow, it’s not as white.”*

The TK observations regarding the particulate contamination of snow is incorporated in the study of the ambient air quality existing environment and baseline.

2.2.2 Incorporation of Traditional Knowledge for VEC Selection

The sources of TK were reviewed for information related to the selection of valued ecosystem components (VECs) regarding air quality. Both the NTKP report and NIRB Scoping Sessions contained observations and concerns with air quality related components, especially airborne and deposited particulates. The information used from the NTKP report is described in Section 2.1.1. During the NIRB Scoping Sessions (NIRB 2012b) there were multiple concerns related to dust generation and transport during mining operations as well as during post-closure.

> *“The miners have control for the dust am I correct? After the mine is closed my concern is the wind and the dust going elsewhere.”*

> *“Concern that dust will be produced from the milling process.”*

There were also concerns regarding the impacts of airborne contaminants on humans, animals, plants and water.

> *“Comment regarding the effects of airborne dust on humans…”*

> *“Concern regarding the impacts of airborne pollutants on human health.”*

> *“Do you have any studies that have been done to determine if there are effects to animals and plants? Like respiration problems.”*

> *“Will dust affect the caribou…?*

> *“Comment regarding the impacts of dust to caribou and water.”*

> *“Comment regarding dust during spring run-off and impact to the environment.”*

This information was used to support the scoping and selection of VECs as well as VEC indicators.

2.2.3 Incorporation of Traditional Knowledge for Spatial and Temporal Boundaries

The sources of TK were reviewed for information related to the selection of spatial and temporal boundaries for the air quality effects assessment. Both the NTKP report and NIRB Scoping Sessions contained observations and concerns with the spatial extent of air contamination. There were concerns with how far contaminants from the mine would travel with the wind (see Sections 2.1.1 and 2.1.2). The NIRB Scoping Sessions also highlighted concerns with the temporal extent of air contaminant emissions. There were concerns with dust during post-closure (see Section 2.1.2). This information was used to support the selection of spatial and temporal air quality assessment boundaries.

2.2.4 Incorporation of Traditional Knowledge for Project Effects Assessment

The sources of TK were reviewed for information that could be incorporated into the air quality effects assessment. The NTKP report and NIRB Scoping Sessions identified dust and other air contaminants as concerns (see Section 2.1.1 and 2.1.2). The air quality effects assessment incorporates this information in the assessment by supporting the selection of ambient air quality as a VEC and including dust and other air contaminants as indicators of ambient air quality effects from the Madrid-Boston Project.

2.2.5 Incorporation of Traditional Knowledge for Mitigation and Adaptive Management

The sources of TK were reviewed for information important for informing mitigation and adaptive management strategies. None of the TK sources identified mitigation or adaptive management measures relating to ambient air quality.

Both the NTKP report and NIRB Scoping Sessions contained observations and concerns with specific contaminants that were commonly identified, namely particulates or dust (see Sections 2.1.1 and 2.1.2). Fugitive dust emissions are a common source of air contaminants for the Madrid-Boston Project and specific mitigation measures have been proposed in the Project Description (Volume 3) to help mitigate dust emissions. The particulate and dust concerns identified in the NTKP report and NIRB Scoping Sessions support the rational for the Madrid-Boston Project air quality mitigation measures.

2.3 EXISTING ENVIRONMENT AND BASELINE INFORMATION

The air quality assessment uses distinct definitions when describing either baseline ambient air quality conditions or existing ambient air quality conditions for the Madrid-Boston Project.

- Baseline ambient air quality represents the ambient air quality conditions within the Hope Bay Project property area before any significant air emissions were released by any Hope Bay Project activity, i.e., before the Doris Project, the Madrid-Boston Project or Madrid Permitted activities. It is also used to describe the ambient air quality conditions within the Hope Bay Project property area when significant Doris Project or Madrid Permitted construction or operation activities were temporarily stopped (e.g., during the winter in some years) or put under care and maintenance (e.g., in 2013 and 2014).
- Existing ambient air quality represents the ambient air quality conditions within the Hope Bay Project property area during Doris Project operations and Madrid Permitted activities, but before Madrid-Boston Project construction or operation activities.

The distinct difference between baseline and existing ambient air quality is consistently and clearly used throughout the air quality assessment.

2.3.1 Regulatory Framework

Ambient air quality guidelines, objectives and standards have been developed by the Canadian federal government and individual provinces and territories in order to assist or mandate the management of common air contaminants.

The Madrid-Boston Project air quality assessment incorporates the Nunavut *Environmental Guideline for Ambient Air Quality* (Government of Nunavut 2011). Nunavut does not have guidelines or standards for some of the air contaminants required to be included in the air quality assessment by the EIS guidelines (NIRB 2012a). In these cases, guidelines, objectives or standards from the federal government (CCME 2016b, 2016a), British Columbia (BC) government (BC MOE 2016) and Alberta government (Alberta Environment and Parks 2016) have been used to inform the air quality assessment.

The ambient air quality guidelines, objectives and standards that are used in the air quality assessment are summarized in Table 2.3-1. Canadian Ambient Air Quality Standards (CAAQS) for sulphur dioxide (SO_2), ground-level ozone (O_3) and particulate matter with diameter less than 2.5 µm ($PM_{2.5}$) have recently been revised and will come into effect in the years 2020 (for SO_2, O_3 and $PM_{2.5}$) and 2025 (for SO_2) (CCME 2016b, 2016a). CAAQS for nitrogen dioxide (NO_2) was released on November 3, 2017 and come into effect in 2020 and 2025 (CCME 2017). For simplicity, the proposed activity timelines in the Project Schedule (see Project Description; as of July 31, 2017) are compared against the most stringent NO_2, SO_2 and $PM_{2.5}$ standard.

There are no Nunavut or federal ambient air quality guidelines or standards for airborne concentrations of total or specific volatile organic compounds (VOCs) for the mining sector.

Table 2.3-1. Relevant Ambient Air Quality Guidelines and Standards

Contaminant	Units	Averaging Period	Nunavut Ambient Air Quality Guideline[a]	Guidelines or Standards from other Government Agencies	
				Value	**Agency**
Sulphur dioxide (SO_2)	µg/m³	1-hour	450	183 (70 ppb; Effective in 2020)[b] **170 (65 ppb; Effective in 2025)[b]**	CAAQS[g]
		24-hour (daily)	**150**	-	-
		Annual	30	13 (5 ppb; Effective in 2020)[c] **10 (4 ppb; Effective in 2025)[c]**	CAAQS[g]
Nitrogen dioxide (NO_2)	µg/m³	1-hour	400	113 (60 ppb; Effective in 2020)[j] **79 (42 ppb; Effective 2025)[j]**	CAAQS[g]
		24-hour (daily)	**200**	-	
		Annual	60	32 (17 ppb; Effective 2020)[k] **23 (12 ppb; Effective 2025)[k]**	CAAQS[g]
Ground level ozone (O_3)	µg/m³	8-hour	126 (65 ppb)	123 (63 ppb)[d] **121 (62 ppb; Effective in 2020)[d]**	CAAQS[g]
Carbon monoxide (CO)	µg/m³	1-hour	-	**14,300**	BC Ambient Air Quality Objective[h]

Contaminant	Units	Averaging Period	Nunavut Ambient Air Quality Guideline[a]	Guidelines or Standards from other Government Agencies	
				Value	Agency
Total suspended particulate (TSP)	μg/m^3	24-hour (daily)	**120**	-	
		Annual (geometric mean)	**60**	-	
Particulate matter < 10 μm diameter (PM_{10})	μg/m^3	24-hour (daily)	-	**50**	BC Ambient Air Quality Objective[h]
Particulate matter <2.5 μm diameter ($PM_{2.5}$)	μg/m^3	24-hour (daily)	30	28[e]	CAAQS[g]
				27 (Effective in 2020)[e]	
	μg/m^3	Annual	-	10.0[f]	CAAQS[g]
				8.8 (Effective in 2020)[f]	
Dust deposition	mg/dm^2/ 30days	30-day	-	**53 (residential and recreation areas)**	Alberta Ambient Air Quality Objectives and Guidelines[i]
				158 (commercial and industrial areas)	

Notes:
Bold underlined values indicate values that are used as reference values in the assessment.
Dash (-) = not applicable
ppb = parts per billion
a: (Government of Nunavut 2011)
b: The 1-hour SO_2 value is calculated from the 3-year average of the 99th percentile of the daily maximum 1-hour average concentrations.
c: The annual SO_2 value is calculated from the arithmetic average over a single calendar year of all 1-hour average concentrations.
d: The 8-hour O_3 value is calculated from the 3-year average of the annual 4th highest daily maximum 8-hour average concentration.
e: The 24-hour $PM_{2.5}$ value is calculated from the 3-year average of the annual 98th percentile of the daily 24-hour average concentration.
f: The annual $PM_{2.5}$ value is calculated from the 3-year average of the annual average concentrations.
g: Canadian Ambient Air Quality Standards for SO_2: (CCME 2016b). Canadian Ambient Air Quality Standards for O_3 and $PM_{2.5}$: (CCME 2016a). Canadian Ambient Air Quality Standards for NO_2: (CCME 2017)
h: (BC MOE 2016)
i: (Alberta Environment and Parks 2016)
j: The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations
k: The average over a single calendar year of all 1-hour average concentrations

2.3.2 Data Sources

For characterizing Madrid-Boston Project baseline ambient air quality conditions, 2009 to 2014 (inclusive) data from the Doris North Project Air Quality Monitoring Program are used (Rescan 2009, 2010, 2011b, 2011a, 2012b, 2012a; ERM Rescan 2014a; 2014b). Emphasis is placed on the data collected during 2013 and 2014 as the Doris North Project was in care and maintenance at the time. The 2013 and 2014 data is therefore thought to be more representative of baseline ambient air quality conditions as there were less project air emissions in these years compared to years 2009 to 2012 when Doris North Project construction activities were taking place.

On-site ambient air quality monitoring data exists prior to 2009, but they are not incorporated into this ambient air quality setting section as these six years of monitoring data are sufficient to inform the baseline conditions for the Madrid-Boston Project.

For characterizing the Madrid-Boston Project existing ambient air quality conditions, the predicted ambient air quality results from Hope Bay existing permitted activities are used (Nunami Stantec 2017). These predicted results incorporate the baseline ambient air quality data sources described above.

The NTKP report is also used for informing baseline and existing ambient air quality conditions in the region.

2.3.3 Methods

2.3.3.1 Baseline Ambient Air Quality

The Doris North Project Air Quality Monitoring Program includes sampling or monitoring of the following air contaminants:

- total suspended particulate matter (TSP);
- particulate matter with a diameter less than 10 µm (PM_{10});
- particulate matter with a diameter less than 2.5 µm ($PM_{2.5}$);
- dust deposition (dustfall);
- sulphur dioxide (SO_2);
- nitrogen dioxide (NO_2); and
- ozone (O_3).

TSP is sampled using a Partisol Plus Model 2025 ambient air sampler. PM_{10} and $PM_{2.5}$ are sampled using a Partisol Sequential Dichotomous Model 2025-D ambient air sampler. The Partisol use size-selective inlets and filters to actively collect particulate matter samples for the required particle size classes. These filters are pre- and post-weighed by ALS Environmental Laboratory to determine particulate matter mass and to then calculate the airborne concentration (µg/m^3). The Partisol samplers are programmed to follow Environment and Climate Change Canada's (ECCC) National Air Pollution Surveillance schedule (ECCC 2016), which requires 24-hour sampling every sixth day for particulate matter.

TSP, PM_{10} and $PM_{2.5}$ were collected in each year of the 2009 to 2014 Air Quality Monitoring Program. The Partisol samplers were located inside a temperature controlled shelter on the butte near Doris Site, but were relocated in October 2011 closer to Doris Lake (Figure 2.3-1, Plate 2.3-1). This relocation followed consultation with ECCC to facilitate more frequent maintenance checks and to provide a more reliable source of continuous power.

Dustfall is sampled using the ASTM International (ASTM) D1739-98 sampling method (ASTM 2010; Plate 2.3-2) for some stations and an Alberta Environment method (Alberta Environment 2006; Plate 2.3-3) for other stations. Sample containers are normally exposed for a period of 30 days and then sent to a laboratory for analysis. The ASTM method dustfall samples are analysed by ALS and the Alberta Environment method dustfall samples are analysed by Maxxam. Dustfall sampling was conducted from 2009 to 2012 in various areas throughout the Hope Bay Project area (Figure 2.3-1). In addition to dustfall analysis, dustfall samples obtained using the ASTM method are also analysed by ALS for select metals, anions and nutrients as listed in Table 2.3-2. These additional parameters are used in human health, terrestrial ecology, marine and freshwater assessments.

Figure 2.3-1
Baseline Air Quality Stations, 2009 to 2014

TMAC RESOURCES

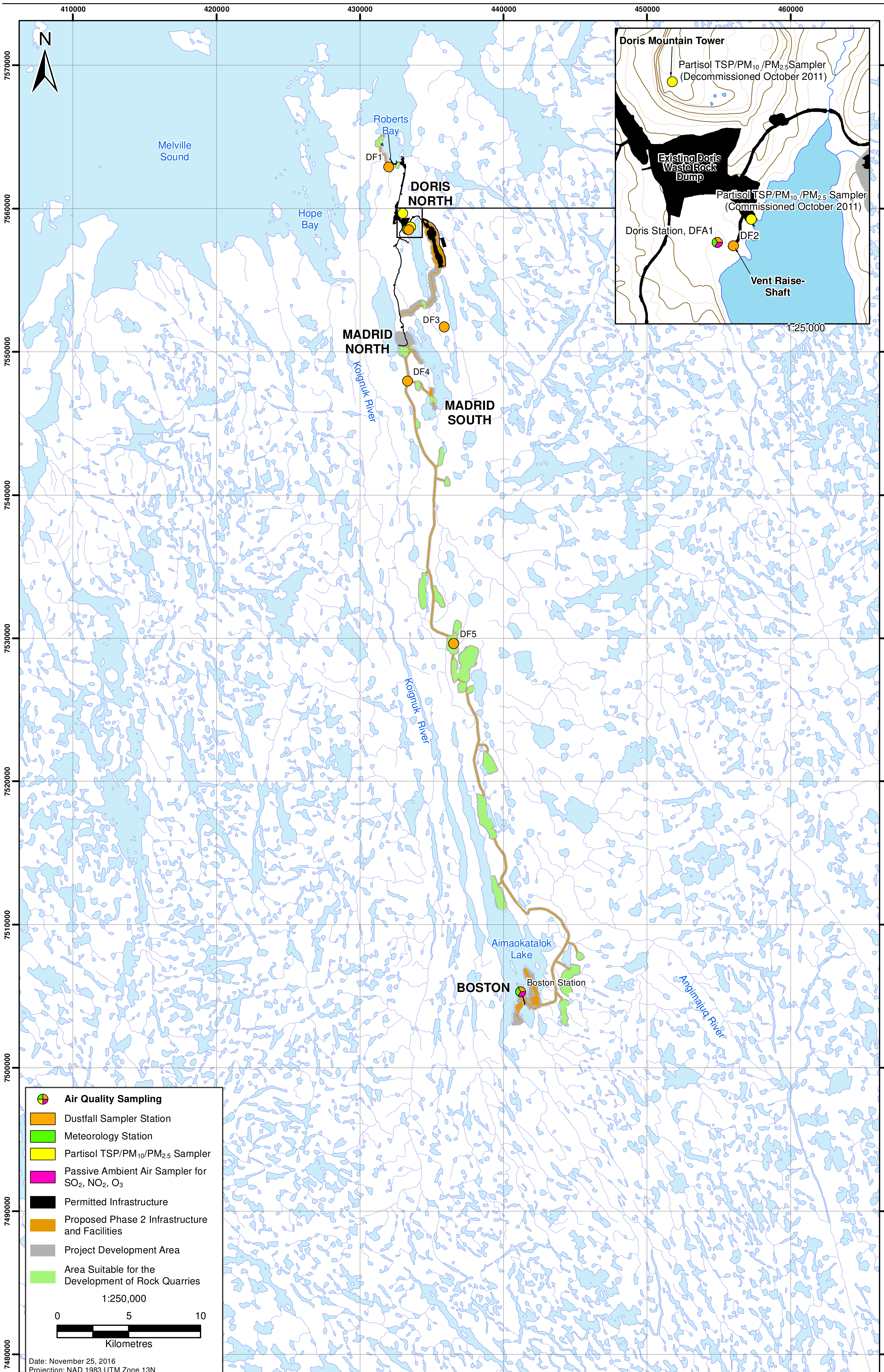


Plate 2.3-1. Partisol samplers inside the temperature controlled shelter. February 2012.

Plate 2.3-2. Dustfall station DF1 (ASTM method). July 2010.

Plate 2.3-3. Dustfall station DFA1 (Alberta method). October 2011.

Table 2.3-2. Parameters Measured from ASTM Dustfall Samples

Parameter	Parameter	Parameter
Particulates	*Metals (cont'd)*	*Metals (cont'd)*
Dustfall	Bismuth	Nickel
Insoluble Dustfall	Boron	Phosphorus
Soluble Dustfall	Cadmium	Potassium
Anions and Nutrients	Calcium	Selenium
Ammonia (as N)	Chromium	Silicon
Chloride	Cobalt	Silver
Nitrate (as N)	Copper	Sodium
Sulfate	Iron	Strontium
Metals	Lead	Thallium
Aluminum	Lithium	Tin
Antimony	Magnesium	Titanium
Arsenic	Manganese	Uranium
Barium	Mercury	Vanadium
Beryllium	Molybdenum	Zinc

Ambient air sampling of SO_2, NO_2 and O_3 are completed using a Passive Air Sampling System (PASS) provided by Maxxam (Plate 2.3-4). The PASS is a passive diffusive sampling method that monitors gas or vapour contaminants in the atmosphere at a rate controlled by the physical process of permeation through a selective membrane. PASS samples are normally exposed for a period of 30 days and then sent to Maxxam for analysis. This sampling is conducted for each year of compliance monitoring. One station was located beside the Doris meteorological station (2009 to 2014), and the other was located close to Boston Site (2009 to 2010). The locations of these stations are presented in Figure 2.3-1.

Plate 2.3-4. A Passive Air Sampling System (PASS), monitoring SO_2, NO_2 and O_3.

For calculation purposes, sample results that are below analytical detection limits are assumed to be half the detection limit. Although this methodology for addressing what are essentially missing values does not capture the true frequency distribution of the concentrations (Nosal, Legge, and Krupa 2000), assigning values to undetected concentrations in this manner is conservative and a common practice where it can be assumed the values are not zero, but where the level of risk is low enough not to warrant additional statistical analyses (e.g., with regards to human health; US EPA 2000).

Additional methodology details can be found in the 2009 to 2014 air quality compliance reports (Rescan 2009, 2010, 2011b, 2011a, 2012b, 2012a; ERM Rescan 2014a, 2014b).

2.3.3.2 Existing Ambient Air Quality

The method for characterizing the Madrid-Boston Project existing ambient air quality conditions is completed by predicting the ambient air quality resulting from future Doris Project operations and Madrid Permitted activities. The California Puff (CALPUFF) air dispersion model (Version 7.2.1 level 150618) was used to model the expected air emissions generated by Doris Project operations and Madrid Permitted activities.

The CALPUFF model used a variety of input data and parameters, including terrain, land use and meteorological datasets (both surface and upper air data) specific to the Hope Bay Project area, and the air emissions inventory specific to Doris Project operations and Madrid Permitted activities. The expected air emissions for Doris Project operations and Madrid Permitted activities are calculated using the available Project Description information.

See the *Hope Bay Madrid-Boston Project: Air Quality Model Study* (Nunami Stantec 2017) for the full description of the methods used to complete the emissions inventory and modeling study.

2.3.3.3 Study Areas

Baseline Ambient Air Quality Study Area

The baseline ambient air quality study area is that of the Doris North Project Air Quality Monitoring Program as described in Section 2.3.3.1. The locations of air quality sampling equipment are shown in Figure 2.3-1. The baseline ambient air quality data are representative of these individual sampling locations. For the purpose of the air quality assessment, the baseline ambient air quality data are assumed to be representative of baseline conditions for the entire assessment Local Study Area (LSA; see Section 2.5.2.2) and Regional Study Area (RSA; see Section 2.5.2.3).

Existing Ambient Air Quality Study Area

The existing ambient air quality study area is the northern LSA used in the air quality assessment. It includes the area around Roberts Bay, Doris, Madrid North, Madrid South and approximately 20 km of the AWR extending out to potential quarry M. This LSA is a square area extending 30 km north to south, by 30 km east to west, and is centred approximately half way between Doris and Madrid North. This study area is further described in Section 2.5.2.2 and in the *Hope Bay Madrid-Boston Project: Air Quality Model Study* (Nunami Stantec 2017).

2.3.3.4 Information Caveats and Limitations

Baseline Ambient Air Quality

The limitations of the baseline ambient air quality information are dependent on the data collection, analysis, and presentation methods. The primary limitation for the baseline ambient air quality data is the annual data completeness (see Table 2.3-3). The most common reasons for incomplete data were either instrumentation operating challenges due to the very cold climate in the winter, a lack of personnel on site to perform or maintain sampling throughout the year, or the discontinuation of sampling during some years (e.g., dustfall sampling was stopped during the care and maintenance years of 2013 and 2014).

The baseline ambient air quality data are representative of the specific locations where sampling was conducted, and the specific time that each sample was exposed for. For the purpose of the air quality assessment, the baseline ambient air quality data are assumed to be representative of baseline conditions for the entire assessment LSA (see Section 2.5.2.2) and RSA (see Section 2.5.2.3) and for the entire assessment temporal boundary (see Section 2.5.3).

See the annual air quality compliance reports (Rescan 2009, 2010, 2011b, 2011a, 2012b, 2012a; ERM Rescan 2014a, 2014b) for additional details of baseline data caveats and limitations. Overall, the collected baseline ambient air quality data are thought to be reasonably sufficient for the purpose of informing the air quality effects assessment.

Table 2.3-3. Baseline Data Completeness

Parameter	Nominal Sampling Frequency	Data Completeness (%)					
		2009	2010	2011	2012	2013	2014
TSP	Every 6th day.	25	53	22	69	52	33
PM_{10}	Every 6th day.	25	52	18	65	52	30
$PM_{2.5}$	Every 6th day.	25	53	22	65	52	30
Dustfall (ASTM Method) and Acid Deposition	Monthly	17	25	42	58	-	-
Dustfall (Alberta Environment Method)	Monthly	58	100	100	67	-	-
SO_2	Monthly	50	75	100	67	58	75
NO_2	Monthly	50	75	100	67	58	75
O_3	Monthly	50	75	100	58	58	75

Notes:
For those parameters that were measured at multiple station locations (dustfall, SO_2, NO_2 and O_3), the data completeness value presented is the value from the longest operating station during the year.
dash (-) = not available, sampling was not conducted.

Existing Ambient Air Quality

The limitations of the existing ambient air quality information are dependent on the limitations and uncertainty of the ambient air quality model predictions for Hope Bay existing permitted activities.

The effects of Project releases of air contaminants are based on calculated emission rates and the CALPUFF dispersion model. The emissions inventory was built using a number of information sources, calculations and assumptions. Some information sources and assumptions were informed by existing information about the Doris project. Where input data uncertainties existed, conservative assumptions were used following regulatory guidance, professional judgement and experience. The most up-to-date information was used as of July 31, 2017. Emissions from the Project employed a conservative emissions approach based on maximum production rates. Actual production rates and therefore emissions will vary from year to year. Because of the nature of this approach, there is a high degree of confidence that emissions are over estimated. Air contaminant mitigation measures described in Section 2.6.3 and in the Air Quality Management Plan for the Hope Bay Project (TMAC 2016; Volume 8, Annex 19) were included in the model.

Air quality dispersion models such as CALPUFF also employ assumptions to simplify the random behaviour of the atmosphere into short periods of average behaviour. These assumptions limit the capability of the model to replicate every individual meteorological event. To compensate for these simplifications, a full year of meteorological data are applied to evaluate a wide range of possible conditions. Regulatory models, such as CALPUFF, are also designed to have a bias toward over estimation of contaminant concentrations (e.g., to be conservative under most conditions).

Prediction confidence is therefore high because emission rates used in the existing air quality modeling were conservatively estimated based on a combination of emission factors, engineering estimates and maximum emission levels and the dispersion modeling is expected to be conservative. Therefore, the results of the model study are interpreted with the understanding that the predicted effects are likely conservative

Detailed modeling limitations, uncertainty and assumptions are described in the *Madrid-Boston Project: Air Quality Modeling Study (Nunami Stantec 2017).*

2.3.4 Characterization of Baseline Conditions

The following subsections summarize the baseline ambient air quality conditions in the Hope Bay Project area. Emphasis is placed on the data collected during 2013 and 2014 as the Doris North Project was in care and maintenance at the time. The 2013 and 2014 data is therefore thought to be more representative of baseline ambient air quality conditions as there were less project air emissions in these years compared to years 2009 to 2012 when Doris North Project construction activities were taking place.

Detailed baseline ambient air quality data can be found in the 2009 to 2014 air quality compliance reports (Rescan 2009, 2010, 2011b, 2011a, 2012b, 2012a; ERM Rescan 2014a, 2014b). The use of traditional knowledge has also been included in the baseline characterization (Banci and Spicker 2016). Table 2.3-4 provides a summary of the on-site 2009 to 2014 air quality monitoring results.

Table 2.3-4. Baseline Ambient Air Quality Results Summary

Contaminants	Units	Normalized Sampling Period for Each Sample	2009 – 2014 Monitoring Data			2013 – 2014 Monitoring Data (During Care and Maintenance)		
			Median	Mean	Range	Median	Mean	Range
Sulphur dioxide (SO_2)	µg/m^3	30 days	0.1	0.4	0.1 – 5.0	**0.3**	0.6	0.1 – 3.7
Nitrogen dioxide (NO_2)	µg/m^3	30 days	1.2	1.9	0.1 – 9.6	**1.1**	1.9	0.1 – 7.0
Ground level ozone (O_3)	µg/m^3	30 days	53.0	53.9	1.4 – 92.5	**52.6**	58.4	44.3 – 86.1
Total suspended particulate (TSP)	µg/m^3	24 hours	4.4	5.4	0.1 – 45.0	**5.8**	6.7	1.1 – 17.5
Particulate matter <10 µm diameter (PM_{10})	µg/m^3	24 hours	4.7	6.3	0.5 – 46.0	**5.4**	6.1	1.2 – 17.1
Particulate matter <2.5 µm diameter ($PM_{2.5}$)	µg/m^3	24 hours	2.6	3.0	0.1 – 20.0	**3.1**	3.5	1.2 – 13.3
Dust deposition (ASTM method)	mg/dm^2/ 30 days	30 days	**6.3**	19.0	1.5 – 98.1	-	-	-
Dust deposition (Alberta Environment method)	mg/dm^2/ 30 days	30 days	5.7	8.7	0.6 – 32.7	-	-	-

Notes:
Bold underlined values indicate values that are used as the baseline values in the assessment.
Dash (-) = not available
Data have been summarized from the 2009 – 2014 air quality compliance monitoring reports (Rescan 2009, 2010, 2011b, 2011a, 2012b, 2012a; ERM Rescan 2014a, 2014b)
There are no Hope Bay Project site-specific background concentrations available for CO, therefore the 2015 annual average CO concentrations at monitoring stations in Yellowknife, Norman Wells and Fort Smith were used to represent baseline conditions (GNWT 2016). The median of these three annual values is 261 µg/m^3.

2.3.4.1 Existing Sources of Air Contaminants

The ground level ambient air quality in the Hope Bay Project area and elsewhere in Nunavut is predominantly characterized as of good quality, reflecting the region's remoteness and low amount of anthropogenic air emission sources. Air emissions from sources outside of the Hope Bay Project are primarily limited to stationary sources (e.g., power generation and heating) and mobile sources (e.g., vehicles, snowmobiles, all-terrain vehicles, boats, etc.) operated by Nunavut residents and businesses. Due to limited local emission sources, long range transport (LRT) of air contaminants is also an important influence on ambient air quality.

Since 2008, the existing Doris North project has reported emissions to the National Pollutant Release Inventory (NPRI). Reported emissions include dioxins and furans, SO_2, NO_2, carbon monoxide (CO), TSP, PM_{10} and $PM_{2.5}$ (NPRI 2015).

Contaminants such as O_3 are primarily produced from photochemically active nitrogen oxides (NO_X) and VOCs in the atmosphere. O_3 is primarily created downwind and away from NO_X and VOC emission sources as the chemical reaction takes place over time. O_3 is not expected to vary greatly throughout the region.

There are a variety of common VOC emission sources such as some household product chemicals and the burning of some substances. The majority of VOC emission sources emit small amounts of VOCs. In Nunavut, common VOC emission sources generally have a negligible impact on the ambient air quality. There is only one reporting source of VOC in Nunavut identified in the National Pollutant Release Inventory: the Qulliq Energy Corporation in Iqaluit. This source, however, is located about 1,800 km east of the Hope Bay Project (NPRI 2015). For these reasons, VOC baseline concentrations are expected to be negligible within the local and regional air quality study areas.

2.3.4.2 Particulate Matter (TSP, PM_{10}, $PM_{2.5}$)

During the 2013 to 2014 air quality monitoring period, there were 85 valid TSP samples, 82 valid PM_{10} samples and 82 valid $PM_{2.5}$ samples obtained and analyzed. Table 2.3-3 summarizes the amount of available data for each year. Samples were taken over 24-hour periods using the methods described in Section 2.3.3.1. Table 2.3-4 summarizes the TSP, PM_{10} and $PM_{2.5}$ results.

For TSP, the median value of the 2013 and 2014 samples was 5.8 µg/m^3, with a range of values from 1.1 to 17.5 µg/m^3. Laboratory detection limits ranged from 0.1 to 2.1 µg/m^3 due to variations in air sampling volumes. There were two samples below the detection limit during 2013 and 2014. As a comparison, the ambient TSP guidelines for Nunavut are 120 µg/m^3 (24-hour average) and 60 µg/m^3 (annual geometric mean; see Section 2.2.1 and Table 2.2-1). Hence, all samples were well below the 24-hour TSP guideline.

For PM_{10}, the median value of the 2013 and 2014 samples was 5.4 µg/m^3, with a range of values from 1.2 to 17.1 µg/m^3. Laboratory detection limits ranged from 1.0 to 2.9 µg/m^3 in the 2009 to 2016 sampling period due to variations in air sampling volumes. There was one sample below the detection limit during 2013 and 2014. There is neither a Nunavut guideline or Canadian Ambient Air Quality Standard for PM_{10} and therefore the BC objective value of 50 µg/m^3 is used for comparison instead (see Section 2.3.1 and Table 2.3-1).

It should be noted that the Partisol sampler for PM_{10} and $PM_{2.5}$ had more operational problems than the Partisol sampler for TSP, and may be the reason that some PM_{10} values are higher than the TSP values in the 2009 to 2014 data summary (Table 2.2-4). By definition, PM_{10} is less than or equal to TSP in the same sample of air. This issue is discussed further in the air quality compliance reports.

For $PM_{2.5}$, the median value of the 2013 and 2014 samples was 3.1 $\mu g/m^3$, with a range of values from 1.2 to 13.3 $\mu g/m^3$. Laboratory detection limits ranged from 0.1 to 21 $\mu g/m^3$ in the 2009 to 2016 sampling period due to variations in air sampling volumes. There were eight samples below the detection limit during 2013 and 2014. The current 24-hour Nunavut $PM_{2.5}$ guideline value of 30 $\mu g/m^3$ is outdated compared to the more recently updated CAAQS of 28 $\mu g/m^3$ (24-hour) and 10.0 $\mu g/m^3$ (annual). The 24-hour CAAQS value is therefore used for comparison (see Section 2.3.1 and Table 2.3-1).

2.3.4.3 Dustfall

During the 2009 to 2014 air quality monitoring period, dustfall was sampled from 2009 to 2012 using both the ASTM method and the Alberta Environment method (see Section 2.3.3.1). Data from 2013 and 2014 are not available to characterize the baseline condition and therefore 2009 to 2012 data is used instead. It is estimated that this dataset is more conservative compared to a 2013 and 2014 dataset due to Doris North Project construction activities taking place in 2009 to 2012 (Doris North Project was in care and maintenance in 2013 and 2014).

A total of 48 dustfall samples were collected using the ASTM method and 45 samples were collected using the Alberta Environment method. Table 2.3-4 summarizes the dustfall results and Table 2.3-3 summarizes the amount of available data for each year.

For the ASTM sampling method, the amount of dustfall from the five dustfall stations ranged from 1.5 to 98.1 mg/dm^2/30 days. The median values from stations DF1, DF2 and DF3 were 7.5, 10.9 and 4.5 mg/dm^2/day, respectively, over the 2009 to 2012 monitoring period. Stations DF4 and DF5 were only operated in three months during 2010 and are therefore not as representative of the baseline conditions.

For the Alberta Environment sampling method, the amount of dustfall from the two stations ranged from 0.6 to 32.7 mg/dm^2/30 days. The median values from stations DFA1 and DFA2 were 6.5 and 4.8 mg/dm^2/30 days, respectively, over the 2009 to 2012 monitoring period.

There are no ambient air quality guidelines for dustfall in Nunavut, but there are objectives and guidelines for dustfall in other jurisdictions. The Alberta dustfall guidelines (Section 2.3.1 and Table 2.3-1) were used as appropriate references: 53 mg/dm^2/30 days for residential and recreation areas, and 158 mg/dm^2/30 days for commercial and industrial areas.

The majority of dustfall samplers were collected during the snow free months. Natural background dustfall is lower during the snow-covered months compared to the rest of the year due to the ground surface being covered by snow, reducing the amount of ground material that can be picked up, transported and deposited by the wind. The average dustfall values presented here are therefore a conservative representation of an expected annual average baseline value, and a more accurate representation of the summer average baseline values.

Particulate deposition on top of snow covered ground far from air contaminant sources is observed by residents of the surrounding region (see Section 2.1.1). Such deposition was not observed many years ago (Banci and Spicker 2016). As there are no significant sources of air contaminant emissions in the region, this deposition may be due to LRT. Any particulate deposition and airborne contaminant concentrations due to LRT are sampled and measured by the Hope Bay Project's Air Quality Monitoring Program. However, without knowing the relative chemical properties of LRT contaminants and local/regional contaminants, it is not possible to determine what measured contaminant levels are due to LRT versus contaminants emitted from local/regional sources.

Dustfall samples are also analysed for metal deposition. The results are not included in the 2009 to 2014 baseline monitoring program reports; however, they are used to inform the following EIS chapters:

- Terrestrial Environment: Landform and Soils (Volume 4, Section 7);
- Vegetation and Special Landscape Features (Volume 4, Section 8);
- Terrestrial Wildlife and Wildlife Habitat (Volume 4, Section 9);
- Marine Sediment Quality (Volume 5, Section 9);
- Freshwater Sediment Quality (Volume 5, Section 5); and
- Human Health and Environmental Risk Assessment (Volume 6, Section 5).

2.3.4.4 SO_2, NO_2, O_3

During the 2009 to 2014 air quality monitoring program, monthly passive sampling of SO_2, NO_2 and O_3 was conducted in each year using a PASS (see Section 2.3.3.1). A total of 15 SO_2 and NO_2 samples, and 14 O_3 samples were collected during the 2013 to 2014 monitoring period used to inform the baseline ambient air quality. Results are summarized in Table 2.3-4.

For SO_2, monthly sample concentrations in 2013 and 2014 ranged from 0.1 to 3.7 $\mu g/m^3$ and the median value was 0.3 $\mu g/m^3$. For comparison, the Nunavut ambient guideline value for annual average SO_2 is 30 $\mu g/m^3$ (Table 2.3-1).

For NO_2, monthly sample concentrations in 2013 and 2014 ranged from 0.1 to 7.0 $\mu g/m^3$ and the median value was 1.1 $\mu g/m^3$. For comparison, the Nunavut ambient guideline value for annual average NO_2 is 60 $\mu g/m^3$ (Table 2.3-1).

For O_3, monthly sample concentrations in 2013 and 2014 ranged from 44.3 to 86.1 $\mu g/m^3$ and the median value was 52.6 $\mu g/m^3$. The Nunavut ambient guideline value for 8-hour average O_3 is 126 $\mu g/m^3$ (Table 2.3-1), but this guideline can't be directly compared to the O_3 PASS sampling which is exposed for a nominal period of 30 days. Health Canada states the monthly average O_3 concentration between May to September is expected to be in the range of 49 to 78 $\mu g/m^3$ (25 to 40 ppb) when away from anthropogenic influence (Health Canada 1999). The average O_3 concentrations measured in the Hope Bay Project area are generally within the range of expected concentrations identified by Health Canada.

2.3.4.5 CO

There are no Hope Bay Project site-specific background concentrations available for CO, therefore the 2015 annual average CO concentrations at monitoring stations in Yellowknife, Norman Wells and Fort Smith are used to represent baseline conditions (GNWT 2016). The median of these three annual values is 261 $\mu g/m^3$.

2.3.4.6 Volatile Organic Compounds

There are a variety of common emission sources of volatile organic compounds (VOCs) such as some household product chemicals and the burning of some substances. The majority of VOC emission sources emit small amounts of VOCs. In Nunavut, common VOC emission sources generally have a negligible impact on the ambient air quality. There is only one reporting source of VOC in Nunavut identified in the National Pollutant Release Inventory: the Qulliq Energy Corporation in Iqaluit. This source, however, is located about 1,800 km east of the Hope Bay Project (NPRI 2015). For these reasons, VOC baseline concentrations are expected to be negligible within the local and regional air quality study areas.

2.3.5 Characterization of Existing Conditions

The ambient air quality resulting from the existing permitted activities are described in the *Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017). The predicted ambient air quality represents the worst-case results as there are a number of conservative steps used in the modeling methodology as described in Section 2.3.3.4.

The prediction results show that all ambient contaminants resulting from existing permitted activities are expected to be highest within the PB. The maximum predicted concentrations of all contaminants were below their respective guidelines or criteria at and beyond the PB. Maximum values for each contaminant are presented in Section 2.6.5.3.

The resulting ambient air quality predictions from existing permitted activities are used as the existing conditions for the Madrid-Boston Project northern LSA. The Madrid-Boston Project southern LSA (described in Section 2.5.2.2) is far enough away from the existing permitted activity emissions (confined to the northern LSA) such that these contaminants are not expected to significantly contribute to air quality levels in the southern LSA. Therefore, modeling predictions for the existing conditions were only completed for the northern LSA and it is assumed that the southern LSA ambient air quality from the Madrid-Boston Project activities is the same as the ambient air quality from the Madrid-Boston Project with baseline conditions.

2.3.6 Meteorological and Climatic Effects on Air Quality

High concentrations of air contaminants can accumulate in the atmosphere whenever conditions suppress atmospheric dispersion. This is typically the case for combinations of low wind speeds and strong temperature inversions. Temperature inversions are characterized by an increase in temperature with height above the ground, suppressing the vertical movement of air away from the surface. When wind speeds during these conditions are low, emissions are trapped close to the source, leading to increased concentrations of air contaminants. As discussed in the meteorological settings (Volume 4, Section 1), there are a higher proportion of calm winds in winter than in summer. Air recirculation (e.g., land and sea breezes) can also promote higher concentrations of air contaminants.

The amount of fugitive dust emitted from natural and anthropogenic sources is lower in the winter time due to snow cover. The snow cover prevents loose ground material (e.g., dirt, soil, silt, sand, etc.) from being entrained and transported by the wind. High wind speeds can cause more fugitive dust to be generated compared to low wind speeds.

2.4 VALUED COMPONENTS

2.4.1 Potential Valued Components and Scoping

Valued Ecological Components (VECs) are those components of the air quality environment considered to be of scientific, ecological and human health importance (Volume 2, Section 4). The selection and scoping of VECs considers biophysical conditions and trends that may interact with the proposed Project, variability in biophysical conditions over time, and data availability as well as the ability to measure biophysical conditions that may interact with the Project and are important to the communities potentially impacted by the Project.

2.4.1.1 The Scoping Process and Identification of VECs

The scoping of VECs follows the process outlined in the Assessment Methodology (Volume 2, Section 4). VECs considered for inclusion in the air quality effects assessment relate to aspects of the environment considered to be important to a specific region or community (NIRB 2012a).

The NIRB environmental impact statement (EIS) guidelines (NIRB 2012a) propose that air quality be a VEC to be considered for inclusion in the air quality effects assessment.

The identified VEC represents an appropriate starting point to guide the identification and scoping of VECs (NIRB 2012a). The selection of VECs began with those proposed in the EIS guidelines and was further informed through consultation with communities, regulatory agencies, available TK, professional expertise and experience and the NIRB's final scoping report (Appendix B of the EIS Guidelines). For an interaction to occur there must be spatial and temporal overlap between a VECs and Project component and/or activities. The determination of VECs and potential effects for inclusion in this effects assessment considered and was informed by:

- Nunavut and federal ambient air quality guidelines and standards (see Section 2.2.1);
- the Environmental Impact Statement (EIS) guidelines and appendices (NIRB 2012a);
- TK and IQ (Volume 2, Section 2);
- consultation and engagement with local and regional Inuit groups in the NIRB Scoping Sessions (NIRB 2012b);
- the public, during public consultation and open house meetings held in the Kitikmeot communities in May 2016 (see Volume 2, Section 3, Public Consultation); and
- a review of the Back River Project's EIS (Sabina 2015).

2.4.1.2 NIRB Scoping Sessions

Scoping sessions hosted by NIRB (NIRB 2012b) with key stakeholders and local community members (i.e., the public) focused on identifying the components that are important to local residents, as related to the Project. Comments made during these sessions were compiled and analysed as part of VEC scoping. Notably, many remarks related to the air quality environment linked to:

- concerns regarding dust generation and transport from the mine during operations as well as post-closure; and
- concerns regarding impacts of airborne contaminants on humans, animals, plants and water.

2.4.1.3 TMAC Consultation and Engagement Informing VEC Selection

Community meetings for the Madrid-Boston Project were conducted in each of the five Kitikmeot communities as described in section 3 of Volume 2. 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 Madrid-Boston Project was obtained through open dialogue during Madrid-Boston Project presentations, through discussions that arose during the presentation of Project materials and comments provided in feedback forms. There were no questions, comments or concerns raised related to air quality.

2.4.2 Valued Components Included in the Assessment

The scoping analysis identified the following VEC for inclusion in the assessment:

1. Ambient air quality

The VEC selected to guide the assessment of the potential effects of the Madrid-Boston Project on air quality is one that:

- has potential to interact with the activities and components of the Madrid-Boston Project;
- has been identified as important by local communities, Inuit organizations, governments, regulators, and other stakeholders during consultation and engagement; and
- has been informed by TK and IQ (Volume 2, Section 2), and professional judgement.

Table 2.4-1 summarizes the VEC included in the assessment and indicates whether each proposed by the EIS guidelines (NIRB 2012a) have either been included as indicated, included as part of other VECs, or otherwise addressed elsewhere in the EIS.

Table 2.4-1. Valued Ecosystem Components Included in the Air Quality Assessment

VEC	Identified by			Rationale for Inclusion
	TK	NIRB Guidelines	Government	
Ambient air quality	Yes	Yes	Yes	Good ambient air quality is important for sustaining the health and wellbeing of humans, wildlife, vegetation, soil and water. The Madrid-Boston Project will emit air contaminants that will change the ambient air quality surrounding the Madrid-Boston Project area.

The VEC **ambient air quality** was selected to guide the discussion of the Madrid-Boston Project's anticipated effects on the ambient air quality surrounding the Madrid-Boston Project development. Ambient air quality refers to the quality of outdoor air in the surrounding environment, measured near ground level. Good ambient air quality is important for sustaining the health and wellbeing of humans, wildlife, vegetation, soil and water. See Section 2 for more information about ambient air quality.

2.4.2.1 Ambient Air Quality Effects and Indicators

A list of ambient air quality indicators has been selected and is used to inform the assessment of the potential air quality effects of the Madrid-Boston Project. The indicators are listed in Table 2.4-2. These indicators are air contaminant chemical species that result from common sources of air contaminants generated from the Madrid-Boston Project activities. The selection of indicators was informed by:

- the Madrid-Boston Project primary air contaminant sources and species based on a review of the Project Description (Volume 3);
- Nunavut and federal ambient air quality guidelines and standards (see Section 2.3.1);
- the EIS guidelines (NIRB 2012a);
- TK and IQ (Volume 2, Section 2); and
- air quality related questions and concerns raised during consultation and engagement with local and regional Inuit groups in the NIRB Scoping Sessions (NIRB 2012b).

Table 2.4-2. Ambient Air Quality VEC Indicators and Effects

VEC	Effect	Indicators
Ambient Air Quality	Changes to ambient air quality	• Ambient SO_2 concentrations • Ambient NO_2 concentrations • Ambient O_3 concentrations • Ambient CO concentrations • Ambient VOC concentrations • Ambient TSP concentrations • Ambient PM_{10} concentrations • Ambient $PM_{2.5}$ concentrations • Ambient dust deposition (dustfall)

A description of each indicator is presented in Table 2.4-3.

Table 2.4-3. Description of Air Contaminants Used as Ambient Air Quality Indicators

Air Contaminant Chemical Species	Description
SO_2	Fossil fuels contain a small amount of organic sulphur compounds. During fuel combustion, the sulphur is oxidized and emitted as SO_2 with the combustion exhaust. In the atmosphere, SO_2 can further oxidize to sulphate particles, which contribute to acid deposition. SO_2 can be harmful to humans at high concentrations.
NO_2	Nitrogen oxides (NO_X) is a product of fuel combustion and primarily consists of NO and NO_2. The gasses are emitted with exhaust from combustion engines and products from blasting operations. NO_X can be converted to nitric acid in the atmosphere that contributes to acid deposition. NO_2 can be harmful to humans at high concentrations.
O3	Ozone exists naturally in the upper atmosphere (the Ozone Layer), and is also formed in the lower atmosphere and ground level when sunlight interacts with nitrogen oxides and volatile organic compounds. Ground level ozone is harmful to humans and vegetation at high concentrations.
CO	CO is formed as a result of incomplete combustion of fossil fuels and can be harmful to humans at high concentrations.
VOC	VOCs are organic chemicals that have high vapor pressures resulting in high evaporation of the chemicals. There are a variety of common emission sources of VOCs such as some household product chemicals (e.g., paint) and the burning of some substances. VOCs are primary precursors to the formation of ground level ozone and particulate matter which leads to smog. VOCs, ground level ozone and particulate matter are harmful to humans at high concentrations.
TSP	TSP are airborne particulate matter that have diameters of approximately 44 μm or less. Sources of TSP include combustion processes (e.g., combustion engines) and fugitive dust. Particles less than 10 μm are small enough to be inhaled and may be harmful to humans at high concentrations. Depending on the source of TSP, other constituents such as metals may also be transported as part of the airborne particulates.
PM_{10}	PM_{10} is particulate matter with a diameter of less than 10 μm. It is a subset of TSP. PM_{10} particles are small enough to be inhaled by humans into the upper respiratory tract and may be harmful at high concentrations.
$PM_{2.5}$	$PM_{2.5}$ is particulate matter with a diameter of less than 2.5 μm. It is a subset of TSP and PM_{10}. $PM_{2.5}$ particles are small enough to be inhaled deep into the respiratory system by humans and may be harmful at high concentrations.
Dust deposition (dustfall)	Dust deposition is airborne dust (TSP) that is deposited onto a surface (i.e., on top of soil, vegetation, etc.) by gravity, precipitation or wind. Depending on the source of dust, other harmful chemicals such as heavy metals may also be transported as part of the airborne particulates and deposited onto a surface.

Ambient airborne metal concentrations and deposition are not included in the air quality effects assessment. Metal concentrations are estimated using the TSP and dust deposition predictions from the *Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017) and the metal deposition results from Air Quality Monitoring Program (Section 2.2). These metal results, along with other air contaminant species predicted in the air quality model study, are used to inform the following EIS chapters:

- Terrestrial Environment: Landforms and Soils (Volume 4, Section 7);
- Vegetation and Special Landscape Features (Volume 4, Section 8);
- Terrestrial Wildlife and Wildlife Habitat (Volume 4, Section 9);
- Marine Sediment Quality (Volume 5, Section 9);
- Freshwater Sediment Quality (Volume 5, Section 5); and
- Human Health and Environmental Risk Assessment (Volume 6, Section 5).

The EIS guidelines (NIRB 2012a) require that greenhouse gas (GHG) emissions be included as part of the assessment. GHG emissions are not categorized as contributing factors to air quality and are therefore not included in the air quality effects assessment. The Madrid-Boston Project GHG emissions and their impact on the environment are instead addressed in the Climate and Meteorology Subject of Note (Volume 4, Section 1).

2.4.3 Valued Components Excluded from the Assessment

There are no air quality related VECs proposed in the EIS guidelines (NIRB 2012a) that have been excluded from the assessment.

2.5 SPATIAL AND TEMPORAL BOUNDARIES

The spatial boundaries selected to shape this assessment are determined by the Project's potential impacts on the *air quality* environment. This is informed by the Madrid-Boston Project primary air contaminant sources and species based on a review of the Project Description (Volume 3), and a review of the locations of human, wildlife and terrestrial ecology sensitive receptors surrounding the Madrid-Boston Project.

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 air 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.

2.5.1 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.

2.5.1.1 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).

The Doris Project

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 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 the 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.

<u>Hope Bay Regional Exploration Project</u>

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.

<u>Madrid Advanced Exploration</u>

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.

<u>Boston Advanced Exploration</u>

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.

2.5.1.2 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.

Operation

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 by 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.

2.5.2 Spatial Boundaries

The spatial boundary is defined as the area that could be potentially impacted by air emission sources from the Madrid-Boston Project. Four general spatial boundaries are used in the air quality assessment: Project Development Area (PDA), Property Boundary (PB), LSA and RSA.

Numerous discrete sensitive receptors are included in the *Madrid-Boston Project of the Hope Bay Project: Air Quality Modeling Study* (Nunami Stantec 2017) for the purpose of informing the following EIS chapters:

- Terrestrial Environment: Soils and Special Landforms (Volume 4, Section 7);
- Vegetation and Special Landscape Features (Volume 4, Section 8);
- Terrestrial Wildlife and Wildlife Habitat (Volume 4, Section 9);
- Marine Sediment Quality (Volume 5, Section 9);
- Freshwater Sediment Quality (Volume 5, Section 5); and
- Human Health and Environmental Risk Assessment (Volume 6, Section 5).

Some of these receptors are located inside the Property Boundary or Project Development Area and the air quality assessment LSA and RSA. These receptors are assessed in the chapters listed above.

2.5.2.1 Project Development Area

The Project Development Area (PDA) is shown in Figure 2.5-1 and is defined as the area which 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 phases, 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 varied 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 either side.

Figure 2.5-1
Project Development Area and Property Boundary

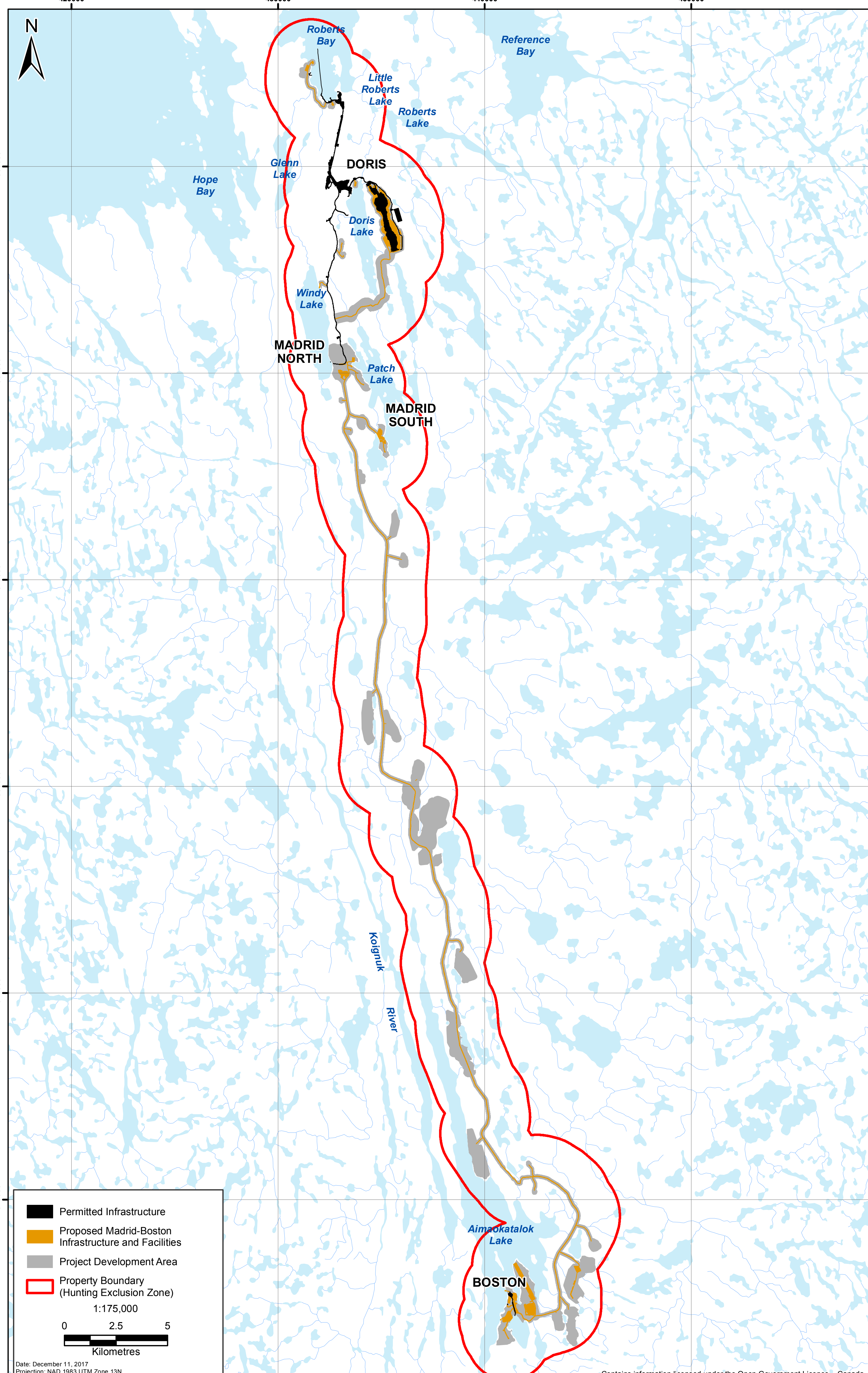
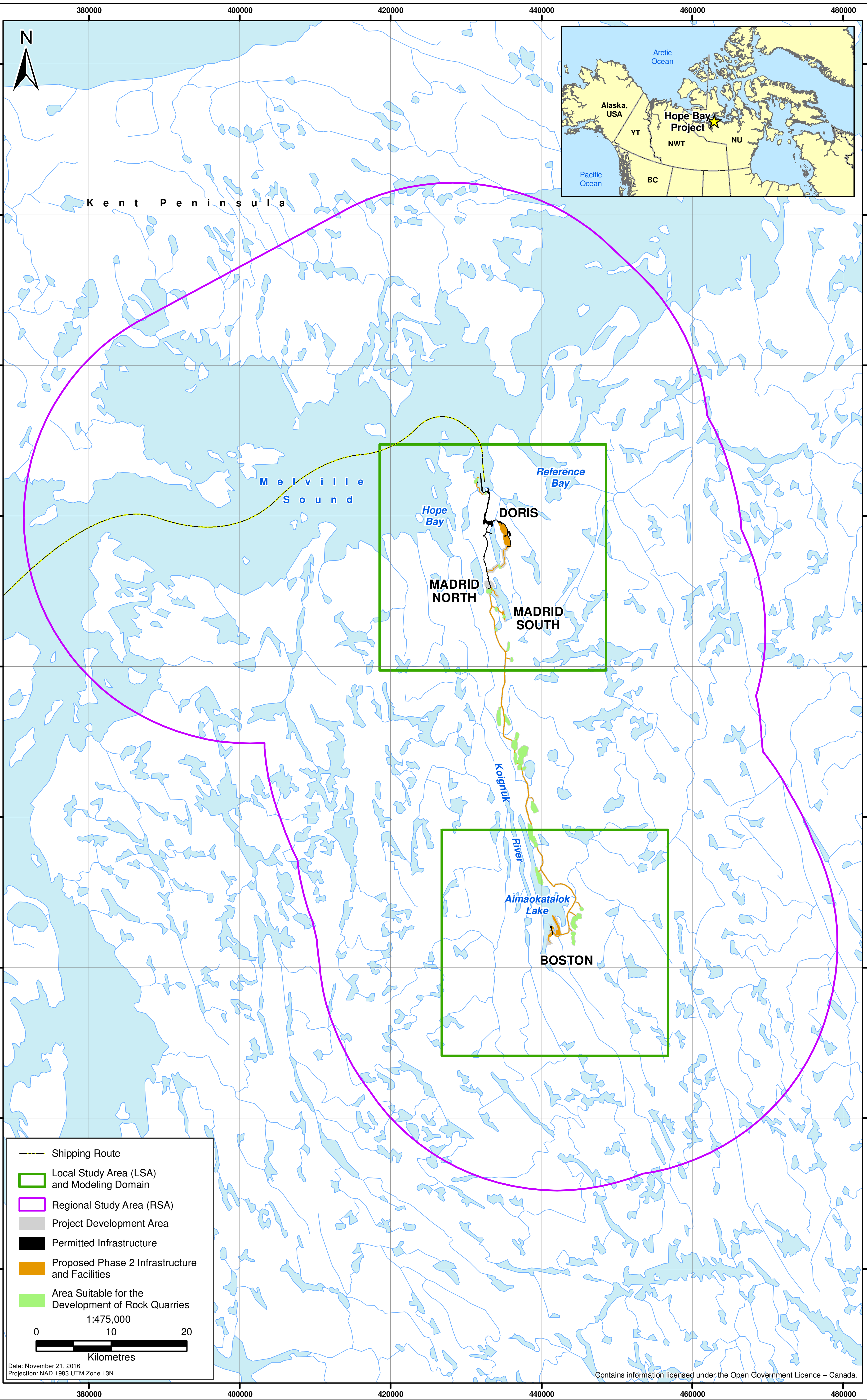


Figure 2.5-2
Local and Regional Study Areas for Air Quality



Since the infrastructure for the Doris Project is in place, the PDA exactly follows the footprints of these features. In all cases, the PDA does not include the Madrid –Boston Project design buffers applied to potentially environmentally sensitive features. These are detailed in Volume 3, Chapter 2 (Project Description).

2.5.2.2 Project Property Boundary

Due to the remote location of the Project there is no well defined property boundary (e.g. fence line) to delineate the surrounding environment within which ambient air quality will be assessed. In the draft EIS, the property boundary was taken to be identical to the PDA. However, as discussed in Section 2.5.2.1, the PDA is defined based on engineering buffers around Project infrastructure to account for potential variations in final design rather than areas of interest with respect to human and environmental exposure to air contaminants.

In the FEIS a refined dispersion modeling "property boundary" was used to better represent the potential for public exposure and compliance with air quality criteria. The refined property boundary used the hunting exclusion zone around the PDA as a reasonable extent to define the property boundary. The hunting exclusion zone is a requirement of the Consolidation of the Mine Health and Safety Regulations, which prohibits discharge of a firearm within 2-km of any mine infrastructure. Local populations have been notified of the exclusion zone, therefore instances of members of the public being located within the hunting exclusion zone are expected to be infrequent and brief in duration. The extents of the property boundary used in the air quality assessment are shown in Figure 2.5.1.

The property boundary was used to define the region in the LSA at and beyond which, that air quality levels would be evaluated with respect to regulatory guidelines, objectives and standards. Air quality outside the PDA but within the property boundary was also evaluated and these data were also used to inform the EIS chapters discussed in Section 2.5.2.

2.5.2.3 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 air quality due to an interaction with a Project component(s) or physical activity. Study areas are established based on the “zone of influence” beyond which the potential residual effects of the Madrid-Boston Project are expected to diminish to a negligible state. The expected zone of influence is determined using baseline studies, consultation, and professional judgement and experience.

Two air quality LSAs are selected for the air quality assessment of the Madrid-Boston Project (Figure 2.5-2).

1. The northern LSA includes the area around Roberts Bay, Doris, Madrid North, Madrid South and approximately 20 km of the AWR extending out to potential quarry M. This LSA is a square area extending 30 km north to south, by 30 km east to west, and is centred approximately half way between Doris and Madrid North.
2. The southern LSA includes the area around Boston and approximately 20 km of the AWR extending from Boston to potential quarry T. This LSA is a square area extending 30 km north to south, by 30 km east to west, and is centred approximately on the proposed Boston Mill.

Each LSA matches the size and location of the gridded receptor spacing areas used in *The Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017). By modeling the areas with the highest predicted emissions, it is expected that if the effects at these areas are found to be not significant, the potential effect for the entirety of the Madrid-Boston Project should also be not significant. This is because contaminant concentrations become lower with increased distance away from an emission source due to the dilution of air contaminants as it mixes with cleaner air.

To increase air quality modeling efficiency, the middle section of the AWR (spanning a length of approximately 20 km) and potential quarries along this road section are not included in the LSAs (Figure 2.5-2). It is expected that the AWR's impact on ambient air quality will be approximately uniform along the entire length of the AWR because:

- air contaminant emissions along the AWR (primarily vehicle tailpipe and fugitive unpaved road dust emissions) are expected to be uniform;
- the AWR alignment is generally a straight path; and
- regional topography, land use and meteorological conditions are generally uniform along the whole AWR length.

The ambient air quality impacts of the AWR section modeled within the northern and southern LSAs are extrapolated and assessed over the entire AWR.

The ocean shipping route within the Nunavut Settlement Area (NSA) is partially included in the northern LSA, with a shipping route length of approximately 4 km within Roberts Bay (Figure 2.5-2). It is expected that the air emissions over the entire shipping route (including the entire route within the NSA) will be uniform and the resulting ambient air quality impact from a moving ship will be generally consistent along the full shipping route. The ambient air quality impacts of the shipping route modeled within the northern LSA are extrapolated and assessed over the entire shipping route.

Additional information about the LSAs and how they are tied into the air quality modeling study is included in *The Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017).

2.5.2.4 Regional Study Area

The RSA is defined as the broader spatial area representing the maximum limit where potential direct or indirect effects may occur. The air quality assessment RSA is selected as an area extending out 30 km from all proposed Madrid-Boston Project infrastructure and approximately 70 km along the sea shipping route extending west from Roberts Bay (Figure 2.5-2).

2.5.3 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 (EAAs) for the Hope Bay Project and the extension of activities.

For the purposes of the EIS, distinct phases of the Project are defined (Table 2.5-1). It is understood that construction, operation and closure activities will, in fact, overlap among sites; this is outlined in Table 2.4-1 and further described in Volume 3, Chapter 2 (Project Description).

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 2.5-1. Temporal Boundaries for the Effects Assessment for Air 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**: shipping operations (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.

The temporal boundaries used for *The Madrid-Boston Project: Air Quality Model Study* (Nunami Stantec 2017) include modeling air emissions and the resulting ambient air quality during Project Years 1, 4, 10 and 12 for the following reasons:

- Project Year 1 was chosen for modeling because it was determined to have the highest amount of construction air emissions in the northern LSA due to the highest amount of overlapping construction activities in the proposed Project Schedule (see Project Description, Volume 3). Areas with Project Year 1 construction activities in the northern LSA include Roberts Bay, Doris, Madrid North, Madrid South and the AWR.
- Project Year 4 was chosen for modeling because it was determined to have the highest amount of construction air emissions in the southern LSA due to the highest amount of overlapping construction activities in the proposed Project Schedule (see Project Description, Volume 3). Areas with Project Year 4 construction activities in the southern LSA include Boston and it was assumed that AWR construction would also be included. The proposed Project Schedule has AWR construction taking place in Project Years 1 to 3. The modeling study conservatively assumes that Boston and AWR construction activities overlap in Year 4 in the southern LSA. This is a conservative assumption used to account for any delays in AWR construction that may cause AWR construction overlap into Year 4 with Boston construction. This assumption also helps to improve modeling efficiency.
- Project Year 10 was chosen for modeling because it was determined to have the highest amount of operational air emissions in the southern LSA due to the highest amount of operational activity in the proposed Project Schedule (see Project Description, Volume 3).
- Project Year 12 was chosen for modeling because it was determined to have the highest amount of operational air emissions in the northern LSA due to the highest amount of operational activity in the proposed Project Schedule (see Project Description, Volume 3).

Ambient air quality modeling predictions were not completed for the Reclamation and Closure, Post-Closure, and Temporary Closure phases. Based on the Project Description, the air emissions during these three phases were identified to be much lower than the air emissions during Construction and Operation phases. The resulting ambient air quality concentrations are therefore expected to be lower during the Reclamation and Closure, Post-Closure, and Temporary Closure phases compared to the Construction and Operation phases. Therefore, if the effects assessment determines that the Madrid-Boston Project does not have a significant impact on ambient air quality during Construction and Operations, then the same can be said about the Reclamation and Closure, Post-Closure, and Temporary Closure phases.

2.6 PROJECT-RELATED EFFECTS ASSESSMENT

2.6.1 Methodology Overview

This assessment was informed by a methodology used to identify and assess the potential environmental effects of the Project and is consistent with the requirements of Section 12.5.2 of the Nunavut Agreement and the EIS Guidelines. The effects assessment evaluates the potential direct and indirect effects of the Project on the environment and follows the general methodology provided in the Effects Assessment Methodology (Volume 2, Section 4), and comprises a number of steps that collectively assess the manner in which the Project will interact with the VECs defined for the assessment (Section 2.3).

To provide a comprehensive understanding of the potential effects for the Project, the Madrid-Boston Project 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 VECs or VSECs;
1. Identify the resulting potential effects of those interactions;
2. Identify mitigation or management measures to eliminate or reduce the potential effects;
3. Identify residual effects (potential effects that would remain after mitigation and management measures have been applied) for the Madrid-Boston Project in isolation;
4. Identify residual effects of the Madrid-Boston Project in combination with the residual effects of Approved Projects; and
5. Determine the significance of combined residual effects.

2.6.1.1 Air Quality Modeling Study

An air quality modeling study was completed using the CALPUFF model (version 7.2.1 level 150618) to predict the ambient air quality resulting from the Madrid-Boston Project construction and operation air emissions. See Madrid-Boston Project: *Air Quality Modeling Study* (Nunami Statec 2017) for the full description of the methods used to complete the modeling study. A brief overview description of how the model is used is described in the paragraphs below.

The CALPUFF model used a variety of input data and parameters, including terrain, land use and meteorological (surface and upper air) datasets specific to the Hope Bay Project area. The model used air emissions inventories specific to existing permitted activities (Doris Project operations and Madrid Permitted activities), and the Madrid-Boston Project construction and operation activities. These emissions inventories were calculated using the available Project Description information (as of July 31, 2017) along with a variety of different published emission factors. Reasonable conservative assumptions were used when Project Description information was not available. Air contaminant mitigation measures described in Section 2.6.3 and in the Air Quality Management Plan for the Hope Bay Project (TMAC 2016; Volume 8, Annex 19) were included in the assessment. See Section 2.5.2.2 for a description of the modeling spatial domains, and Section 2.5.3 for a description of the modeling temporal domains.

The results of the air quality modeling study are compared against relevant ambient air quality guidelines and standards described in Section 2.3.1 and Table 2.3-1.

2.6.1.2 Air Quality Modeling Limitations and Uncertainty

The effects of Project releases of air contaminants are based on calculated emission rates and the CALPUFF dispersion model.

The emissions inventory was built using a number of information sources, calculations and assumptions. Some information sources and assumptions were informed by existing information about the Doris project. Where input data uncertainties existed, conservative assumptions were used following regulatory guidance, professional judgement and experience. The most up-to-date information was used as of July 31, 2017. Emissions from the Project employed a conservative approach based on maximum production rates which is expected to over-estimate emissions. Actual production rates and therefore emissions, vary from year to year. Because of the nature of this approach, there is a high degree of confidence that emissions are over estimated.

Air quality dispersion models such as CALPUFF also employ assumptions to simplify the random behaviour of the atmosphere into short periods of average behaviour. These assumptions limit the capability of the model to replicate every individual meteorological event. To compensate for these simplifications, a full year of meteorological data are applied to evaluate a wide range of possible conditions. Regulatory models, such as CALPUFF, are also designed to have a bias toward over estimation of contaminant concentrations (e.g., to be conservative under most conditions).

Prediction confidence is therefore high because emission rates used in the modeling were conservatively estimated based on a combination of emission factors, engineering estimates and maximum emission levels and the dispersion modeling is expected to be conservative. Therefore, the model results of the model study are interpreted with the understanding that the predicted effects are likely conservative.

2.6.2 Identification of Potential Effects

Potential interactions with ambient air quality are identified using professional judgement and experience with other mining projects. Potential interactions with ambient air quality are first screened using a VEC interactions matrix for detailed Madrid-Boston Project components and activities. The full interactions matrix is presented in the assessment methodology (Volume 2, Section 4) and a summary of interactions is presented in Table 2.6-1 by grouping and condensing Project components and activities that will interact with ambient air quality.

Table 2.6-1. The Madrid-Boston Project Interactions with the Ambient Air Quality VEC

Project Component/Activity	Project Interaction with Ambient Air Quality	Potential Effect
Construction		
Blasting	X	Produce air contaminant emissions
Camp and diesel generator facilities	X	Produce air contaminant emissions
Earthworks (bulldozing, excavating, grading, etc.)	X	Produce air contaminant emissions (fugitive dust)
Infrastructure construction	X	Produce air contaminant emissions (fugitive dust)
Marine and air transport	X	Produce air contaminant emissions
Material handling and transfers	X	Produce air contaminant emissions (fugitive dust)
Mobile and stationary equipment use	X	Produce air contaminant emissions
Quarry development and material extraction	X	Produce air contaminant emissions (fugitive dust)
Operation		
Blasting	X	Produce air contaminant emissions
Camp, diesel generators, air heating and processing plant facilities	X	Produce air contaminant emissions
Earthworks (bulldozing, excavating, grading, etc.)	X	Produce air contaminant emissions (fugitive dust)
Marine and air transport	X	Produce air contaminant emissions

Project Component/Activity	Project Interaction with Ambient Air Quality	Potential Effect
Material handling and transfers	X	Produce air contaminant emissions (fugitive dust)
Mobile and stationary equipment use	X	Produce air contaminant emissions
Road use and maintenance	X	Produce air contaminant emissions (fugitive dust)
Stockpile, TIA and TMA use	X	Produce air contaminant emissions (fugitive dust)
Reclamation and Closure		
Camp and diesel generator facilities	X	Produce air contaminant emissions
Earthworks (bulldozing, excavating, grading, etc.)	X	Produce air contaminant emissions (fugitive dust)
Infrastructure deconstruction	X	Produce air contaminant emissions (fugitive dust)
Marine and air transport	X	Produce air contaminant emissions
Material handling and transfers	X	Produce air contaminant emissions (fugitive dust)
Mobile and stationary equipment use	X	Produce air contaminant emissions
Road use and maintenance	X	Produce air contaminant emissions (fugitive dust)
Stockpile, TIA and TMA use	X	Produce air contaminant emissions (fugitive dust)
Post-closure		
Non-re-vegetated surfaces	X	Produce air contaminant emissions (fugitive dust)
Post closure monitoring activities	X	Produce air contaminant emissions
Temporary Closure		
Camp and diesel generator facilities	X	Produce air contaminant emissions
Mobile and stationary equipment use	X	Produce air contaminant emissions
Non-re-vegetated surfaces	X	Produce air contaminant emissions (fugitive dust)
Road use and maintenance	X	Produce air contaminant emissions (fugitive dust)

Notes:
X= interaction
Blank = no interaction

The Madrid-Boston Project components and activities that involve the combustion of a fuel source will result in air contaminant emissions. This applies to a wide range of mobile and stationary equipment, including:

- aircraft;
- blasting;
- generators and power plants;
- incinerators;

- mine air heating facilities;
- non-electric mobile surface and underground equipment;
- shipping vessels; and
- smelting.

The primary air contaminant emissions from these components and activities include SO_2, nitrogen oxides (NO_X), CO and particulates. All contaminants will cause changes in ambient air quality.

Any Madrid-Boston Project components and activities that involve the disturbance of ground material (e.g., rock, dirt, soil, silt, etc.) or the exposure of ground material (e.g., stockpiles, TIA and TMA) have the potential to release fugitive dust emissions. This applies to a wide range of components and activities, including:

- blasting;
- earthworks;
- general infrastructure construction;
- ground material handling and transfers;
- mobile equipment and vehicles travelling on unpaved roads and surfaces;
- rock crushing;
- unpaved road and pad maintenance; and
- use of quarries, stockpiles, the TIA and TMA.

The primary air contaminant emissions from these components and activities include TSP, PM_{10} and $PM_{2.5}$.

Stakeholders, local community members and TK sources all identified Madrid-Boston Project interactions with ambient air quality. Fugitive dust generation was a particular concern (see Sections 2.2.4 and 2.4.1).

2.6.3 Mitigation and Adaptive Management

2.6.3.1 Mitigation by Project Design

Mitigation measures that are incorporated in the Madrid-Boston Project design to help reduce air contaminant emissions include:

- expansion of the Doris TIA such that some tailings deposition will be subaqueous tailings which will help to reduce the area of exposed inactive tailings surface that might be prone to wind erosion;
- building stacks with sufficient height to help reduce ground level contaminants (Rescan 2011c) (e.g., 15 m tall power plant stacks at Madrid North and Boston);
- underground mining compared to open pit mining; and
- optimization of roads and infrastructure to reduce transportation and haul distances.

2.6.3.2 Best Management Practices

Best management practices for improving ambient air quality primarily involve reducing the amount of air emissions being generated and releasing emissions during favourable meteorological conditions that promote high dispersion of airborne contaminants. The Madrid-Boston Project best management practices will include:

- on-site staff at all levels have the necessary training and instruction in their duties relating to process control and air emissions (e.g., the required measures to be implemented during start-up, shut down and abnormal conditions);
- waste oil burners are equipped with a settling tank and filter system for particulate removal from the waste oil;
- use of fuel efficient and low emission equipment and vehicles to conserve fuel and reduce emissions;
- all mobile and stationary engines are regularly serviced to maintain efficiency; and
- a preventive maintenance program is in place for all machinery and equipment.

Specific mitigation measures in place for dust include:

- water or suitable suppressants as listed in the TIA Operations, Maintenance, and Surveillance Manual or otherwise approved by the Nunavut Water Board will be utilized to suppress dust generation from tailings in the TIA;
- use of environmentally suitable chemical dust suppressants, water cannons, packed snow or course outer layer material to reduce fugitive dust emissions from the Doris TIA and Boston TMA; and
- road speed limited to 50 km/hr to reduce fugitive dust emissions.

Should additional dust mitigation be needed, measures may include:

- contouring of stockpiles to reduce wind erosion on the stockpiles;
- installation of engineering controls such as wind fences;
- additional training of employees and contractors on dust mitigation measures.

Specific mitigation measures in place for the operation of incinerators include:

- a waste recycling program to reduce the amount of waste burned by incinerators and reduce emissions;
- waste segregation to divert materials that are unsuitable for incineration;
- only appropriate materials are open burned, in accordance with applicable licence requirements and relevant guidance;
- properly trained incinerator operators;
- stack testing to determine compliance with standards when required; and
- incinerator waste streams are carefully managed to reduce emissions of dioxins and furans, and mercury.

2.6.3.3 Proposed Monitoring Plans and Adaptive Management

TMAC has an existing Air Quality Management Plan for the Hope Bay Project (TMAC 2016; Volume 8, Annex 19). This plan will be updated to incorporate the future Madrid-Boston Project components and activities. The revised Air Quality Management Plan will include descriptions of ambient air quality monitoring, emission reduction, incineration management and reporting of emissions and monitoring results. A summary of the monitoring plan is provided below.

Air quality monitoring will be comprised of the following components:

- dust deposition (dustfall) monitoring;
- airborne particulate matter monitoring (TSP, PM_{10} and $PM_{2.5}$);
- incinerator stack emissions monitoring; and
- meteorological monitoring.

Dustfall Monitoring

Dustfall monitoring will be conducted using the methods described in Section 2.3.4.3 and will also include snow core sampling during the winter. Sampling locations will be informed by the results of *The Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017).

The results of the dustfall monitoring will be used to inform the effectiveness of dust suppression activities and the amount of suppression will be adjusted as needed.

Airborne Particulate Matter Monitoring

TSP, PM_{10} and $PM_{2.5}$ monitoring will be conducted using the methods described in Section 2.3.4.2 and may be upgraded to include continuous monitoring if deemed necessary. Sampling locations will be informed by the results of the air quality modeling study (Nunami Stantec 2017).

The results of the airborne particulate matter monitoring will be used to inform the effectiveness of dust suppression activities and the amount of suppression will be adjusted as needed.

Incinerator Stack Emissions Monitoring

Incinerator stack-emissions testing will be conducted according to the CCME Canada-Wide Standard for Waste Incinerations Stack Testing Requirements (CCME 2001c).

Meteorological Monitoring

Meteorological data has been collected in the Doris Project location since 2003 as described in the Climate and Meteorology Subject of Note (Volume 4, Section 1). Data collected from the Doris and Boston meteorological stations will continue through the life of the Project in order to provide context for air quality monitoring results, inform other monitoring programs such as water resources, and inform various mine operational actives.

Prior to closure and reclamation, TMAC will consult with appropriate agencies on the possibility of the continued operation of the station by those agencies in order to support long-term climate monitoring.

2.6.4 Characterization of Potential Effects

Project residual effects are the effects that are remaining after mitigation and management measures are taken into consideration. If the implementation of mitigation measures eliminates a potential effect and no residual effect is identified on that VEC, the effect is eliminated from further analyses. If the proposed implementation controls and mitigation measures are not sufficient to eliminate an effect, a residual effect is identified and carried forward for additional characterization and a significance determination. Residual effects of the Project can occur directly or indirectly. Direct effects result from specific Project/environment interactions between Project activities and components, and VECs. Indirect effects are the result of direct effects on the environment that lead to secondary or collateral effects on VECs.

2.6.4.1 Ambient Air Quality

The potential effects on ambient air quality have been assessed using the quantitative air dispersion modeling approach described in Section 2.6.1.1 and *The Madrid-Boston Project: Air Quality Model Study* (Nunami Stantec 2017). The emissions inventory used as input to the model was built incorporating the mitigation measures described in Section 2.6.3 and are detailed in the modeling report (Nunami Stantec 2017). After applying mitigation measures, the resulting air contaminant emissions for some species, and Project components and activities were calculated to be reduced; however, none of the emissions were able to be fully mitigated when calculated over the course of a year. As a result, the effect on ambient air quality could also not be fully mitigated. Because no air contaminant emissions could be fully mitigated, all potential effects are brought forward into the characterization and assessment of residual effects (Section 2.6.5).

Characterization of The Madrid-Boston Project Potential Effect

The Madrid-Boston Project components and activates will release air contaminant emissions, including SO_2, NO_X, CO, VOC, TSP, PM_{10} and $PM_{2.5}$ (see Section 2.4.2.1). These emission species will worsen the ambient air quality by directly or indirectly increasing the concentrations and deposition rates of the identified ambient air quality indicators: SO_2, NO_2, O_3, CO, VOC, TSP, PM_{10}, $PM_{2.5}$, and dust deposition. All effects are brought forward into the characterization and assessment of residual effects.

Characterization of Hope Bay Development Potential Effect

Similarly, components and activities for the whole Hope Bay Development will also release air contaminant emissions, including SO_2, NO_X, CO, VOC, TSP, PM_{10} and $PM_{2.5}$ (see Section 2.4.2.1). These emission species will affect ambient air quality by directly or indirectly increasing the concentrations and deposition rates of the identified ambient air quality indicators: SO_2, NO_2, O_3, CO, VOC, TSP, PM_{10}, $PM_{2.5}$, and dust deposition. All effects are brought forward into the characterization and assessment of residual effects.

2.6.5 Characterization of Residual Effects

2.6.5.1 Definitions for Characterization of Residual Effects

In order to determine the significance of Project residual effects, each potential negative residual effect is characterized by a number of attributes consistent with those defined in the EIS guidelines (Section 7.14, Significance Determination for the Hope Bay Project; NIRB 2012a). A definition for each attribute and the contribution that it has on the significance determination is provided in Table 2.6-2. It should be noted that the definition for Frequency has been modified from the standard assessment methodology definition (Volume 2, Section 4) to better suit the assessment of air quality.

For the determination of significance, each attribute is characterized. The characterizations and criteria for the characterizations are provided in Table 2.6-3. Each of the criteria contributes to the determination of significance. It should be noted that the characterization criteria for Magnitude and Frequency have been modified from the standard assessment methodology definition (Volume 2, Section 4) to better suit the assessment of air quality.

Table 2.6-2. Attributes to Evaluate Significance of Potential Residual Effects

Attribute	Definition and Rationale	Impact on Significance Determination
Direction	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	The degree of change in a measurable parameter or variable relative to baseline or 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	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	The number of times during the Project or a Project phase that an interaction or environmental/socio-economic effect that is identified to be above a threshold value can be expected to occur.	Greater the number times of occurrence (higher the frequency), the higher the potential significance.
Geographic Extent	The geographic area over which the effect that is identified to be above a threshold value, will occur.	The larger the geographical area, the higher the potential significance.
Reversibility	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.

Table 2.6-3. Criteria for Residual Effects for Environmental Attributes

Attribute	Characterization	Criteria[1]
Direction	Positive	Beneficial
	Variable	Both beneficial and undesirable
	Negative	Undesirable
Magnitude	Negligible	Differing from the average value for the existing environment to a small degree, but within the range of natural variation and below a guideline or threshold value
	Low	Differing from the average value for the existing environment, outside the range of natural variation, and less than or equal to a guideline or threshold value
	Moderate	Differing from the existing environment and natural variation, and exceeding guideline or threshold values by less than 20%.
	High	Differing from the existing environment and natural variation, and exceeding guideline or threshold values by more than 20%.

Attribute	Characterization	Criteria[1]
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)
	Long	Beyond the life of the Project
Frequency	Infrequent	Exceeding guideline or threshold values only very occasionally or not at all.
	Intermittent	Exceeding guideline or threshold values during specific points or under specific conditions during the Project
	Continuous	Continuously exceeding guideline or threshold values throughout the Project life
Geographic Extent	Property Boundary (PB)	Exceedance of relevant guideline or threshold occurs within the property boundary only
	Local Study Area (LSA)	Exceedance of relevant guideline or threshold occurs beyond the PB and within the LSA
	Regional Study Area (RSA)	Exceedance of relevant guideline or threshold occurs beyond the LSA and within the RSA
	Beyond Regional	Exceedance of relevant guideline or threshold occurs 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

2.6.5.2 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 2012a). Also, the Canadian Environmental Assessment Agency's *Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects (CEA Agency 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 2.6-4 presents the definitions applied to these categories.

Determination of Significance

The determination of significance for effects on ambient air quality from the Madrid-Boston Project is based on a comparison of the existing environmental conditions without the Madrid-Boston Project with the predicted state of the environment with the Madrid-Boston Project after mitigation measures are applied.

Table 2.6-4. 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.

The determination of significance for effects on ambient air quality from the Hope Bay Project is based on a comparison of the baseline environmental conditions without the Hope Bay Project with the predicted state of the environment with the Hope Bay Development after mitigation measures are applied.

For each potential effect on ambient air quality, the nature of the effect is characterized in as much detail as possible. First, the direction of a residual effect is determined to be positive, variable or negative. All effects are then assessed according to several criteria. The magnitude of the effect, frequency and geographic extent are used as the primary criteria, and the duration and reversibility are used as secondary criteria. Combined with the probability that the effect will occur, the significance of the effect is rated as either not significant or significant.

The magnitude attribute and characterizations are defined in Tables 2.6-2 and 2.6-3 and are based on appropriate ambient air quality guidelines, objectives or standards developed for Nunavut, Canada or other provinces (see Section 2.3.1). These reference values are generally intended to protect all members of the general public, including sensitive individuals such as the elderly, infants, and persons with compromised health.

Air quality modeling predictions are typically compared to these reference values at the fence-line of the industrial property where emissions occur. For this assessment, a property boundary equivalent to the hunting exclusion zone around the PDA perimeter is utilized. Due to the remote location of the Hope Bay Project and the locations of the nearest residential communities, it is very unlikely that members of the public will be inside the air quality assessment LSA area for any extended period of time; therefore, the effects assessment using daily and annual guidelines, objectives and standards as threshold values for the general public within the LSA is conservative. It is more likely that members of the public will be outside of the LSA and inside the RSA. This information is incorporated into the geographic extent attribute which is used to inform the determination of significance. The geographic extent characterizations are ranked in the following order of importance for determination of significance: Beyond Regional (highest importance), RSA, LSA and PB (lowest importance).

The frequency attribute and characterizations are defined in Tables 2.6-2 and 2.6-3 and are used to represent how frequently a predicted ambient air quality indicator exceeds the relevant ambient air quality guideline, objective or standard value for that specific indicator. The frequency rating also considers the averaging periods of the relevant ambient air quality guidelines, objectives or standards for each contaminant (i.e., 1-hour, 8-hour, 24-hour, monthly and annual; see Section 2.3.1).

The determination of significance is completed for the effect to each ambient air quality indicator using the methods described above. Table 2.6-5 summarizes the specific characterization of all attributes that must be satisfied in order to conclude that an ambient air quality indicator is significant. All other attribute characterization combinations conclude that an ambient air quality indicator is not significant.

Table 2.6-5. Criteria for a Significant Residual Effect

Attribute Characteristic						Resulting Significance *(not significant, significant)*
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)*	
Negative	Moderate or High	(any)	Intermittent or Continuous	RSA or Beyond regional	(any)	Significant

Note: All attribute characterization combinations not presented in this table conclude that an ambient air quality indicator is not significant.

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 2.6-4 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 NSA, which occurs across provincial, territorial, international boundaries or may occur outside of the NSA.

2.6.5.3 Characterization of Residual Effect for Air Quality

The residual effects on ambient air quality (after mitigation was applied) are assessed using the quantitative air dispersion modeling approach described in Section 2.6.1.1 and in the *Hope Bay The Madrid-Boston Project: Air Quality Model Study* (Nunami Stantec 2017).

Summaries of the maximum predicted contaminant results for ambient SO_2, NO_2, CO, TSP, PM_{10} and $PM_{2.5}$ concentrations and dust deposition rates for the Madrid-Boston Project construction and operation phases are presented in the following tables:

- Construction: Table 2.6-6; and
- Operations: Table 2.6-7.

Contour maps for all predicted air contaminants, averaging periods, domains and model scenarios (construction and operation) are included in *The Madrid-Boston Project: Air Quality Model Study* (Nunami Stantec 2017). These contour maps show the geographic extent and magnitude of contaminants emitted from the Madrid-Boston Project with existing permitted activities.

VOC and O_3 were not included in the modeling study as the Madrid-Boston Project VOC emissions and O_3 formation were determined to be negligible based on the Project Description.

Air quality model predictions were not completed for the Reclamation and Closure, Post-Closure, and Temporary Closure phases. Based on the Project Description, the air emissions during these three phases were identified to be lower than the air emissions during Construction and Operation phases. The resulting effects on ambient air quality are therefore expected to be less than during the Reclamation and Closure, Post-Closure, and Temporary Closure phases compared to during the Construction and Operation phases. Therefore, if the effects assessment determines that the Madrid-Boston Project does not have a significant impact on ambient air quality during Construction and Operations, then the same can be said about the Reclamation and Closure, Post-Closure, and Temporary Closure phases.

The results presented in Tables 2.6-6 and 2.6-7 represent the predicted maximum air contaminant concentrations and maximum dust deposition rate for each relevant averaging period, each model domain (i.e., the northern LSA and southern LSA). The tables include predicted results due to existing permitted activities (the Existing Conditions column), the Madrid-Boston Project activities (the Madrid-Boston Project Only column), and the cumulative Madrid-Boston Project activities with existing permitted activities (the Madrid-Boston Project + Existing Conditions column). The tables also present predicted results for both the Madrid North Reference Location and the Madrid North Alternative Location (the entire Madrid North Facility shifted 400-m to the North of the location shown in Figures 2-5.1 ad 2-5.2). All presented results include baseline contaminant concentrations or deposition rates (see Section 2.3.4.1).

The tabulated maximum values represent the maximum air contaminant concentration or deposition rate from any model receptor location between the PB perimeter and the LSA boundaries. Similarly, the tabulated number of exceedances per year represents the maximum number of exceedances at any model receptor location between the PB perimeter and the LSA boundaries. The receptor that experienced the highest contaminant concentration or deposition rate was not necessarily the same receptor that experienced the highest number of exceedances. The general location of the maximum air contaminant concentration or deposition rate is also included in the table by categorizing receptor locations into those that were along the PB perimeter, or those that were outside of the PB and within the LSA. See *The Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017) for a description of all receptor locations.

The model represents the period of peak emissions for Construction and Operation phases and incorporates a number of conservative assumptions (see Sections 2.6.1.1 and 2.6.1.2). Therefore, the predicted results are expected to be conservative. The assessment takes this information into account.

Table 2.6-6. Predicted Maximum Air Contaminants Resulting from Madrid-Boston Project Construction

Contaminant (Ambient Air Quality Indicator)	Averaging Period	Units	Relevant Guideline, Objective or Standard[b]	Baseline Conditions	Northern Domain Construction (Operating Year 1; 2019)															Southern Domain Construction (Operating Year 4; 2022)		
								Madrid North in Reference Location						Madrid North in Alternative Location								
					Existing Conditions (includes Baseline Conditions)			The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions			The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions			The Madrid-Boston Project (includes Baseline Conditions)[a]		
					Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	Max. No. of Exceedances per Year	Location of Max. Value[c]
SO_2	1-hour	$\mu g/m^3$	170[d]	0.3	89.1	0	LSA	22.7	0	LSA	111	0	LSA	22.7	0	LSA	111	0	LSA	6.5	0	PB
	24-hour (daily)	$\mu g/m^3$	150	0.3	1.1	0	PB	1.6	0	PB	1.7	0	PB	1.6	0	PB	1.6	0	PB	1.0	0	PB
	Annual	$\mu g/m^3$	10	0.3	0.3	0	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB	0.3	0	PB
NO_2	1-hour	$\mu g/m^3$	79[h]	1.1	262	90 (of 365 days)	PB	196	184 (of 365 days)	PB	302	191 (of 365 days)	PB	198	181 (of 365 days)	PB	302	194 (of 365 days)	PB	165	96 (of 365 days)	PB
	24-hour (daily)	$\mu g/m^3$	200	1.1	111	0	PB	158	0	PB	163	0	PB	156	0	PB	161	0	PB	139	0)	PB
	Annual	$\mu g/m^3$	23[i]	1.1	10.4	0	PB	18.5	0	PB	19.7	0	PB	19.6	0	PB	21.0	0	PB	9.6	0	PB
CO	1-hour	$\mu g/m^3$	14,300	261	732	0	PB	992	0	PB	995	0	PB	921	0	PB	921	0	PB	674	0	PB
TSP	24-hour (daily)	$\mu g/m^3$	120	5.8	29.3	0	PB	66.8	0	PB	69.9	0	PB	73.5	0	PB	73.5	0	PB	54.0	0	PB
	Annual (geometric mean)	$\mu g/m^3$	60	5.8	7.1	0	PB	13.1	0	PB	13.3	0	PB	14.3	0	PB	14.5	0	PB	9.0	0	PB
PM_{10}	24-hour (daily)	$\mu g/m^3$	50[e]	5.4	21.0	0	PB	47.2	0	PB	49.6	0	PB	44.5	0	PB	47.0	0	PB	37.0	0	PB
$PM_{2.5}$	24-hour (daily; 98th percentile)	$\mu g/m^3$	27[f]	3.1	8.2	0	PB	11.7	0	PB	12.1	0	PB	13.3	0	PB	13.4	0	PB	9.4	0	PB
	Annual	$\mu g/m^3$	8.8[g]	3.1	3.9	0	PB	4.8	0	PB	5.0	0	PB	5.0	0	PB	5.1	0	PB	3.9	0	PB
Dust Deposition	30-day	mg/dm^2/ 30 days	53 (residential and recreation areas); 158 (commercial and industrial areas)[e]	6.3	7.2	0	PB	9.8	0	PB	9.8	0	PB	10.3	0	PB	10.4	0	PB	7.8	0	PB

Notes:

a: Air contaminants from existing permitted activities (the Existing Conditions) are assumed to dilute to baseline levels before reaching the southern model domain and therefore it is assumed that the southern domain ambient air quality from the Madrid-Boston Project activities is the same as the ambient air quality from the Madrid-Boston Project + Existing Conditions.

b: See Section 2.2.1 for a description of the relevant guidelines, objectives and standards.

c: PB = The maximum value is from a receptor located on the PB perimeter; LSA = The maximum value is from a receptor located outside of the PB and inside of the LSA.

d: The 1-hour SO_2 value is calculated from the 3-year average of the 99th percentile of the daily maximum 1-hour average concentrations.

e: There are no Nunavut or Canadian guidelines, objectives or standards for this contaminant. The contaminant is included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). An appropriate provincial objective threshold for this contaminant was included for comparison.

f: The 24-hour $PM_{2.5}$ value is calculated from the 3-year average of the annual 98th percentile of the daily 24-hour average concentration.

g: The annual $PM_{2.5}$ value is calculated from the 3-year average of the annual average concentrations.

h: The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations

i: The average over a single calendar year of all 1-hour average concentrations

Table 2.6-7. Predicted Maximum Air Contaminants Resulting from Madrid-Boston Project Operation

Contaminant (Ambient Air Quality Indicator)	Averaging Period	Units	Relevant Guideline, Objective or Standard[b]	Baseline Conditions	Northern Domain Operation (Operating Year 12; 2030)															Southern Domain Operation (Operating Year 10; 2028)		
								Madrid North in Reference Location						Madrid North in Alternative Location								
					Existing Conditions (includes Baseline Conditions)			The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions			The Madrid-Boston Project Only (includes Baseline Conditions)			The Madrid-Boston Project + Existing Conditions			The Madrid-Boston Project (includes Baseline Conditions)[a]		
					Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]	Max. Value	No. of Exceedances per Year	Location of Max. Value[c]
SO_2	1-hour	$\mu g/m^3$	170[d]	0.3	89.1	0	LSA	22.6	0	LSA	111	0	LSA	22.6	0	LSA	111	0	LSA	8.9	0	LSA
	24-hour (daily)	$\mu g/m^3$	150	0.3	1.1	0	PB	2.1	0	PB	2.2	0	PB	2.0	0	PB	2.1	0	PB	1.6	0	PB
	Annual	$\mu g/m^3$	10	0.3	0.3	0	PB	0.4	1	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB	0.4	0	PB
NO_2	1-hour	$\mu g/m^3$	79[h]	1.1	262	61 (of 365 days)	PB	201	186 (of 365 days)	PB	296	188 (of 365 days)	PB	217	186 (of 365 days)	PB	296	190 (of 365 days)	PB	178	93 (of 365 days)	PB
	24-hour (daily)	$\mu g/m^3$	200	1.1	71	0	PB	159	0	PB	162	0	PB	156	0	PB	159	0	PB	147	0	PB
	Annual	$\mu g/m^3$	23[i]	1.1	7.7	0	PB	18.9	0	PB	19.7	0	PB	19.8	0	PB	20.9	0	PB	9.5	0	PB
CO	1-hour	$\mu g/m^3$	14,300	261	732	0	PB	919	0	PB	921	0	LSA	992	0	PB	992	0	PB	727	0	LSA
TSP	24-hour (daily)	$\mu g/m^3$	120	5.8	16	0	PB	99	0	PB	101	0	PB	94	0	PB	96	0	PB	81.7	0	PB
	Annual (geometric mean)	$\mu g/m^3$	60	5.8	6.6	0	PB	14.1	0	PB	14.2	0	PB	14.9	0	PB	15.0	0	PB	9.5	0	PB
PM_{10}	24-hour (daily)	$\mu g/m^3$	50[e]	5.4	13.7	0	PB	59.4	1 (of 365 days)	PB	60.9	1 (of 365 days)	PB	56.0	1 (of 365 days)	PB	57.9	1 (of 365 days)	PB	50.6	1 (of 365 days)	PB
$PM_{2.5}$	24-hour (daily; 98th percentile)	$\mu g/m^3$	27[f]	3.1	6.2	0	PB	13.1	0	PB	13.1	0	PB	14.9	0	PB	15.0	0	PB	9.9	0	PB
	Annual	$\mu g/m^3$	8.8[g]	3.1	3.6	0	PB	5.0	0	PB	5.1	0	PB	5.2	0	PB	5.3	0	PB	4.1	0	PB
Dust Deposition	30-day	mg/dm^2/ 30 days	53 (residential and recreation areas); 158 (commercial and industrial areas)[e]	6.3	6.7	0	PB	10.2	0	PB	10.2	0	PB	10.7	0	PB	10.7	0	PB	8.2	0	PB

Notes:

a: Air contaminants from existing permitted activities (the Existing Conditions) are assumed to dilute to baseline levels before reaching the southern model domain and therefore it is assumed that the southern domain ambient air quality from the Madrid-Boston Project activities is the same as the ambient air quality from the Madrid-Boston Project + Existing Conditions.

b: See Section 2.2.1 for a description of the relevant guidelines, objectives and standards.

c: PDA = The maximum value is from a receptor located on the PDA perimeter; LSA = The maximum value is from a receptor located outside of the PDA and inside of the LSA.

d: The 1-hour SO_2 value is calculated from the 3-year average of the 99th percentile of the daily maximum 1-hour average concentrations.

e: There are no Nunavut or Canadian guidelines, objectives or standards for this contaminant. The contaminant is included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). An appropriate provincial objective threshold for this contaminant was included for comparison.

f: The 24-hour $PM_{2.5}$ value is calculated from the 3-year average of the annual 98th percentile of the daily 24-hour average concentration.

g: The annual $PM_{2.5}$ value is calculated from the 3-year average of the annual average concentrations.

h: The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations

i: The average over a single calendar year of all 1-hour average concentrations

Results are compared against relevant guidelines, objectives or standards (Section 2.3.1) for each relevant averaging period. There are no Nunavut or Canadian guidelines, standards or objectives for CO, PM_{10} or dust deposition, but they were included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). The BC objective for PM_{10} and the Alberta guideline for dustfall were used as appropriate thresholds for comparison (see Section 2.3.1).

The predicted maximum results are compared against the relevant guidelines, objectives or standards and these are used to inform the determination of the Magnitude characterization for each air contaminant. The maximum percentage of time that a specific air contaminant exceeds the relevant guideline, objective or standard is used to inform the determination of the Frequency characterization for each air contaminant. The geographic extent of exceedances (see result contour maps included in the *Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017)) are used to inform the determination of the Geographic Extent characterization for each air contaminant.

The sections below briefly summarize the predicted results for each ambient air quality indicator, along with the attribute characterizations and the determination of significance. Tabulated summaries of the residual effects and overall significance ratings are presented in the following tables:

- The Madrid-Boston Project Construction: Table 2.6-8;
- The Madrid-Boston Project Operations: Table 2.6-9;
- Hope Bay Development during The Madrid-Boston Project Construction: Table 2.6-10; and
- Hope Bay Development during The Madrid-Boston Project Operations: Table 2.6-11.

<u>Attribute Characteristics Common for all Ambient Air Quality Indicators</u>

The following attribute characteristics are determined to be the same for all ambient air quality indicators. The criteria for each attribute characterization are described in Section 2.6.5.1.

- Direction: The Direction of all ambient air quality indicators are determined to be <u>Negative</u> because all identified ambient air quality indicators (contaminants) will be emitted by the Madrid-Boston Project and the Hope Bay Project and increase ambient air quality levels.
- Duration: The Duration of all ambient air quality indicators during the Construction and Closure phases are determine to be <u>Short</u> as the duration of air emissions during this phase will be less than 4 years. The duration of all ambient air quality indicators during the Operations phase are determined to be <u>Medium</u> as the duration of air emissions will last for 10 years (the duration of construction). These ratings apply to both the Madrid-Boston Project and the Hope Bay Project.
- Reversibility: The Reversibility of all ambient air quality indicators are determined to be <u>Reversible</u> because the ambient air quality will begin to improve once the Madrid-Boston Project or the Hope Bay Project stops emitting air contaminants at the end of the life of the Project.
- Confidence: The Confidence in the assessment of all ambient air quality indicators are determined to be <u>High</u> based on the Confidence definition (Table 2.6-4). Baseline data were comprehensive, predictions are made using the quantitative CALPUFF model (see *The Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017)), and there is a well understood relationship between the Madrid-Boston Project and Hope Bay Project components and activities that emit air contaminants and the resulting change to ambient air quality. It is important to note, however, that there are a variety of limitations and uncertainties associated with the air dispersion modeling as described in Sections 2.3.3.4 and 2.6.1.2. Where input data uncertainties existed, conservative assumptions were used following regulatory guidance, professional judgement and experience. The use of conservative assumptions can lead to conservative model predictions and therefore the model results of the model study are interpreted with the understanding that the predicted effects are likely overestimated.

Table 2.6-8. Summary of Residual Effects and Overall Significance Rating for Air Quality – Madrid-Boston Project Construction

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)*
Ambient Air Quality									
SO_2	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
NO_2	Negative	High	Short	Intermittent	LSA	Reversible	Likely	Not significant	High
O_3	Negative	Negligible	Short	Infrequent	PB	Reversible	Moderate	Not significant	High
CO	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
VOC	Negative	Negligible	Short	Infrequent	PB	Reversible	Moderate	Not significant	High
TSP	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
PM_{10}	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
$PM_{2.5}$	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
Dust Deposition	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High

Table 2.6-9. Summary of Residual Effects and Overall Significance Rating for Air Quality – The Madrid-Boston Project Operation

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)*
Ambient Air Quality									
SO_2	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
NO_2	Negative	High	Medium	Intermittent	LSA	Reversible	Likely	Not significant	High
O_3	Negative	Negligible	Medium	Infrequent	PB	Reversible	Moderate	Not significant	High
CO	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
VOC	Negative	Negligible	Medium	Infrequent	PB	Reversible	Moderate	Not significant	High
TSP	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
PM_{10}	Negative	Medium	Medium	Infrequent	LSA	Reversible	Likely	Not significant	High
$PM_{2.5}$	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
Dust Deposition	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High

Table 2.6-10. Summary of Residual Effects and Overall Significance Rating for Air Quality - Hope Bay Development during Madrid-Boston Project Construction

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)*
Ambient Air Quality									
SO_2	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
NO_2	Negative	High	Short	Intermittent	LSA	Reversible	Likely	Not significant	High
O_3	Negative	Negligible	Short	Infrequent	PB	Reversible	Moderate	Not significant	High
CO	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
VOC	Negative	Negligible	Short	Infrequent	PB	Reversible	Moderate	Not significant	High
TSP	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
PM_{10}	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
$PM_{2.5}$	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High
Dust Deposition	Negative	Low	Short	Infrequent	PB	Reversible	Likely	Not significant	High

Table 2.6-11. Summary of Residual Effects and Overall Significance Rating for Air Quality - Hope Bay Development during Madrid-Boston Project Operation

	Attribute Characteristic						Overall Significance Rating		
Residual Effect	**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)*
Ambient Air Quality									
SO_2	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
NO_2	Negative	High	Medium	Intermittent	LSA	Reversible	Likely	Not significant	High
O_3	Negative	Negligible	Medium	Infrequent	PB	Reversible	Moderate	Not significant	High
CO	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
VOC	Negative	Negligible	Medium	Infrequent	PB	Reversible	Moderate	Not significant	High
TSP	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
PM_{10}	Negative	High	Medium	Infrequent	LSA	Reversible	Likely	Not significant	High
$PM_{2.5}$	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High
Dust Deposition	Negative	Low	Medium	Infrequent	PB	Reversible	Likely	Not significant	High

Attribute characteristics that are not common for each ambient air quality indicator are described below, along with the determination of probability and significance.

Change in Ambient SO_2 Concentration

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project ambient SO_2 concentrations are predicted to be all below the relevant 1-hour, 24-hour and annual average ambient air quality SO_2 standards outside of the PB. Based on the predicted results,

- The Magnitude is determined to be Low because all predicted concentrations outside the PB (were below the threshold level.
- The Frequency is determined to be Infrequent because there were no hourly, daily or annual SO_2 exceedances.
- The Geographic Extent is determined to be PB because there were no exceedances outside the PB.
- The Probability is determined to be Likely because The Madrid-Boston Project will produce SO_2 emissions that are known to increase ambient SO_2 concentrations.

The Madrid-Boston Project ambient SO_2 concentrations are predicted to not exceed the relevant thresholds; therefore, the change in ambient SO_2 concentrations is determined to be Not Significant for all Madrid-Boston Project phases.

Hope Bay Development Potential Effect

Hope Bay Development ambient SO_2 concentrations are predicted to be below the relevant 1-hour, 24-hour and annual ambient air quality SO_2 standards outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low because all predicted concentrations outside the PB (were below the threshold level.
- The Frequency is determined to be Infrequent because there were no hourly, daily or annual SO_2 exceedances.
- The Geographic Extent is determined to be PB because there were no exceedances outside the PB.
- The Probability is determined to be Likely because the Madrid-Boston Project will produce SO_2 emissions that are known to increase ambient SO_2 concentrations.

Hope Bay Development ambient SO_2 concentrations are not predicted to exceed the relevant thresholds; therefore, the change in ambient SO_2 concentrations is determined to be Not Significant for all Hope Bay Development phases.

Change in Ambient NO_2 Concentration

CAAQS for nitrogen dioxide (NO_2) were released on November 3, 2017 and come into effect in 2020 and 2025. These new criteria were incorporated into the assessment for the FEIS as these criteria are more stringent than the current Nunavut criteria. Development of the NO_2 CAAQS was informed by a risk assessment conducted by Health Canada (Health Canada 2016) that reported that the evidence supported the establishment of both short-term and long-term air quality standards to protect against health effects associated with ambient NO_2.

The following were noted from the air quality predictions for NO_2:

- The Madrid-Boston Project and the Hope Bay Development ambient NO_2 concentrations are predicted to be below the relevant 24-hour (Nunavut) guideline outside the PB.
- The Madrid-Boston Project and the Hope Bay Development annual average NO_2 concentrations are predicted to be below the newly introduced annual CAAQS outside of the PB.
- Exceedances of the newly introduced hourly CAAQS are predicted to occur within the LSAs for the Madrid-Boston Project and the Hope Bay Development, but no exceedances are predicted to occur with respect to the currently applicable Nunavut hourly NO_2 criteria.
    - In the Southern domain, exceedances are predicted to occur within 0.5 - 5-km of the PB (depending on direction), but infrequently (less than 20% of the time) outside of 1-km from the PB.
    - In the Northern Domain exceedances are predicted to occur within 2-10 km of the PB (depending on direction), but infrequently (less than 20% of the time) outside of 3.5 km from the PB.

Exceedances of the health-based hourly average NO_2 CAAQS are predicted to occur in areas where there is expected to be infrequent human occupancy and therefore adverse health effects are unlikely. TMAC will consider additional NO_x mitigation measures to address the new NO_2 CAAQS as the Project design progresses.

The Madrid-Boston Project Potential Effect

Based on the predicted results and with consideration of the above discussion:

- The Magnitude is determined to be <u>High</u> because the highest NO_2 exceedance outside the PB (the maximum hourly concentration during operation) was approximately 254-274% above the threshold level.
- The Frequency is determined to be <u>Intermittent</u> because hourly NO_2 exceedances are predicted to only occur during the construction and operation phases and hourly exceedances are predicted to occur intermittently during construction and operation.
- The Geographic Extent is determined to be <u>LSA</u> because there were hourly average exceedances inside the LSA (within 10 km from the PB) and there were no exceedances outside the LSA.
- The Probability is determined to be <u>Likely</u> because The Madrid-Boston Project will produce NO_X emissions that are known to increase ambient NO_2 concentrations.

The Madrid-Boston Project hourly ambient NO_2 concentrations are predicted to exceed the relevant thresholds for a limited time in a confined area within the LSA, while 24-hour and annual concentrations were below relevant thresholds. Hourly exceedances are predicted to occur in areas where human exposure is unlikely therefore, the change in ambient NO_2 concentrations is determined to be <u>Not Significant</u> for all Madrid-Boston Project phases.

Hope Bay Development Potential Effect

Hope Bay Development ambient NO_2 concentrations are predicted to be below the relevant 24-hour and annual average ambient air quality NO_2 guidelines outside of the PB. Exceedances of the newly introduced hourly CAAQS are predicted to occur within the LSAs. Based on the predicted results:

- The Magnitude is determined to be High because the highest NO_2 exceedance outside the PDA (the maximum hourly concentration during construction) was approximately 382% above the threshold level.
- The Frequency is determined to be Intermittent because hourly NO_2 exceedances are predicted to only occur during the construction and operation phases and hourly exceedances are predicted to occur intermittently during construction and operation.
- The Geographic Extent is determined to be LSA because there were hourly average exceedances inside the LSA (within 10 km from the PB) and there were no exceedances outside the LSA.
- The Probability is determined to be Likely because the Hope Bay Development will produce NO_X emissions that are known to increase ambient NO_2 concentrations.

Hope Bay Development hourly ambient NO_2 concentrations are predicted to exceed the relevant threshold intermittently in an area within the LSA where human exposure is unlikely, while 24-hour and annual concentrations were below relevant thresholds. Therefore, the change in ambient NO_2 concentrations is determined to be Not Significant for all Hope Bay Development phases.

Change in Ambient O_3 Concentration

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project ambient O_3 concentrations are predicted to change by a negligible amount as a result of the Madrid-Boston Project because the downwind creation of O_3 (by chemical reaction between sunlight, NO_X and VOC) is estimated to be negligible based on expected ambient VOC concentrations being low.

Based on the expected results:

- the Magnitude is determined to be Negligible because the maximum concentrations are expected to be within the baseline variation and below the O_3 standard;
- the Frequency is determined to be Infrequent because it is expected that there will be no exceedances of the O_3 standard;
- the Geographic Extent is determined to be the RSA because it is expected that there would be not significant O_3 formation inside the LSA; and
- the Probability is determined to be Moderate because there is a moderate probability for the Madrid-Boston Project to produce negligible O_3 emissions.

The Madrid-Boston Project ambient O_3 concentrations are expected to change by a negligible amount; therefore, the change in ambient O_3 concentrations is determined to be Not Significant for all Madrid-Boston Project phases.

Hope Bay Development Potential Effect

Hope Bay Development ambient O_3 concentrations are expected to change by a negligible amount as a result of the Hope Bay Development because the downwind creation of O_3 (by chemical reaction between sunlight, NO_X and VOC) is estimated to be negligible based on the expected ambient VOC concentrations being low.

Based on the expected results:

- the Magnitude is determined to be Negligible because the maximum concentrations are expected to be within the baseline variation and below the O_3 standard;
- the Frequency is determined to be Infrequent because it is expected that there will be no exceedances of the O_3 standard;
- the Geographic Extent is determined to be RSA because it is expected the would be no significant O_3 formation inside the LSA; and
- the Probability is determined to be Moderate because there is a moderate probability for the Hope Bay Development to produce negligible O_3 emissions.

Hope Bay Development ambient O_3 concentrations are expected to change by a negligible amount; therefore, the change in ambient O_3 concentrations is determined to be Not Significant for all Hope Bay Development phases.

Change in Ambient CO Concentration

There are no Nunavut or Canadian guidelines, standards or objectives for ambient CO and it was included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). The BC 1-hour objective for CO was used as an appropriate threshold for comparison purposes (see Section 2.3.1).

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project ambient CO concentrations are predicted to be below the BC hourly ambient air quality CO guideline outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low during the construction and operation phases because there were no hourly CO exceedances.
- The Frequency is determined to be Infrequent during the construction and operation phases because no hourly CO exceedances are predicted to occur.
- The Geographic Extent is determined to be PB during the construction and operation phases because there were no CO exceedances outside the PB.
- The Probability is determined to be Likely because the Madrid-Boston Project will produce CO emissions that are known to increase ambient CO concentrations.

The Madrid-Boston Project ambient CO concentrations are predicted to be below the relevant thresholds; therefore, the change in ambient CO concentrations is determined to be Not Significant for all Madrid-Boston Project phases. There are no territorial or federal objectives for ambient CO levels.

Hope Bay Development Potential Effect

Hope Bay Development ambient CO concentrations are predicted to be below the BC hourly ambient air quality CO guideline outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low during the construction and operation phases because there were no hourly CO exceedances.
- The Frequency is determined to be Infrequent during the construction and operation phases because no hourly CO exceedances are predicted to occur.

- The Geographic Extent is determined to be PB during the construction and operation phases because there were no CO exceedances outside the PDA.
- The Probability is determined to be Likely because the Hope Bay Development will produce CO emissions that are known to increase ambient CO concentrations.

Hope Bay Development ambient CO concentrations are predicted to be below the relevant thresholds; therefore, the change in ambient CO concentrations is determined to be Not Significant for all Hope Bay Development phases. There are no territorial or federal objectives for ambient CO levels.

Change in Ambient VOC Concentration

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project VOC concentrations are predicted to change by a negligible amount as a result of the Madrid-Boston Project because no significant sources of VOC will be emitted by the Madrid-Boston Project during any phase.

Based on the predicted results:

- the Magnitude is determined to be Negligible because the maximum concentrations are expected to be within the baseline variation;
- the Frequency is determined to be Infrequent because it is expected that there will be no elevated ambient VOC concentrations;
- the Geographic Extent is determined to be PB because any VOC emissions would occur inside the PDA and it is expected ambient VOC concentrations would dilute to near baseline levels inside the PB; and
- the Probability is determined to be Moderate because there is a moderate probability for the Madrid-Boston Project to produce minor VOC emissions.

The Madrid-Boston Project ambient VOC concentrations are predicted to change by a negligible amount; therefore, the change in ambient VOC concentrations is determined to be Not Significant for all Madrid-Boston Project phases.

Hope Bay Development Potential Effect

Hope Bay Development ambient VOC concentrations are predicted to change by a negligible amount as a result of the whole Hope Bay Development because no significant sources of VOC will be emitted by the Hope Bay Development during any phase.

Based on the predicted results:

- the Magnitude is determined to be Negligible because the maximum concentrations are expected to be within the baseline variation;
- the Frequency is determined to be Infrequent because it is expected that there will be no elevated ambient VOC concentrations;
- the Geographic Extent is determined to be PB because any VOC emissions would occur inside the PDA and it is expected ambient VOC concentrations would dilute to near baseline levels inside the PB; and

- the Probability is determined to be Moderate because there is a moderate probability for the Hope Bay Development to produce minor VOC emissions.

Hope Bay Development ambient VOC concentrations are predicted to change by a negligible amount; therefore, the change in ambient VOC concentrations is determined to be Not Significant for all Hope Bay Development phases.

Change in Ambient TSP Concentration

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project ambient TSP concentrations are predicted to be below the relevant 24-hour and annual ambient air quality TSP guidelines outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low because the were no predicted TSP exceedances outside the PB.
- The Frequency is determined to be Infrequent because no exceedances are predicted during the construction and operation phases.
- The Geographic Extent is determined to be PB because no exceedances were predicted outside the PB.
- The Probability is determined to be Likely because the Madrid-Boston Project will produce TSP emissions that are known to increase ambient TSP concentrations.

The Madrid-Boston Project ambient TSP concentrations are predicted to be below the relevant thresholds; therefore, the change in ambient TSP concentrations is determined to be Not Significant for all Madrid-Boston Project phases.

Hope Bay Development Potential Effect

Hope Bay Development ambient TSP concentrations are predicted to be below the relevant 24-hour and annual ambient air quality TSP guidelines. Based on the predicted results:

- The Magnitude is determined to be Low because there was no predicted TSP exceedance outside the PB above the threshold level.
- The Frequency is determined to be Infrequent because no exceedances are predicted during the construction and operation phases.
- The Geographic Extent is determined to be PB because there were no predicted exceedances outside the PB.
- The Probability is determined to be Likely because the Hope Bay Development will produce TSP emissions that are known to increase ambient TSP concentrations.

Hope Bay Development ambient TSP concentrations are predicted to be below the relevant thresholds; therefore, the change in ambient TSP concentrations is determined to be Not Significant for all Hope Bay Development phases.

Change in Ambient PM_{10} Concentration

There are no Nunavut or Canadian guidelines, standards or objectives for PM_{10} and it was included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). The BC objective for PM_{10} was used as an appropriate threshold for comparison purposes (see Section 2.2.1).

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project ambient PM_{10} concentrations are predicted to be generally below the 24-hour ambient air quality PM_{10} guidelines outside of the PB. All exceedances occurred within the LSAs. Based on the predicted results:

- The Magnitude is determined to be Moderate because the highest PM_{10} exceedance outside the PDA (the maximum 24-hour concentration) was approximately 19% above the threshold level.
- The Frequency is determined to be Infrequent because exceedances are predicted to only occur during the construction and operation phases and at intermittent times.
- The Geographic Extent is determined to be LSA because there were limited exceedances inside the LSA (within 0.5 km from the PB) and there were no exceedances outside the LSA.
- The Probability is determined to be Likely because the Madrid-Boston Project will produce PM_{10} emissions that are known to increase ambient PM_{10} concentrations.

The Madrid-Boston Project ambient PM_{10} concentrations are predicted to exceed the relevant threshold for a limited time in a confined area within the LSA; therefore, the change in ambient PM_{10} concentrations is determined to be Not Significant for all Madrid-Boston Project phases. There are no territorial or federal objectives for PM_{10}.

Hope Bay Development Potential Effect

Hope Bay Development ambient PM_{10} concentrations are predicted to be generally below the 24-hour ambient air quality PM_{10} guidelines outside of the PB All exceedances occurred within the LSAs. Based on the predicted results:

- The Magnitude is determined to be High because the highest PM_{10} exceedance outside the PDA (the maximum 24-hour concentration) was approximately 22% above the threshold level.
- The Frequency is determined to be Infrequent because exceedances are predicted to only occur during the operation phase and at intermittent times.
- The Geographic Extent is determined to be LSA because there were limited exceedances inside the LSA (within 0.5 km from the PB) and there were no exceedances outside the LSA.
- The Probability is determined to be Likely because the Hope Bay Development will produce PM_{10} emissions that are known to increase ambient PM_{10} concentrations.

Hope Bay Development ambient PM_{10} concentrations are predicted to exceed the relevant threshold for a limited time in a confined area within the LSA; therefore, the change in ambient PM_{10} concentrations is determined to be Not Significant for all Hope Bay Development phases. There are no territorial or federal objectives for PM_{10}.

Change in Ambient $PM_{2.5}$ Concentration

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project ambient $PM_{2.5}$ concentrations are predicted to be below the relevant 24-hour and annual ambient air quality $PM_{2.5}$ standards outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low because there were no predicted $PM_{2.5}$ exceedances outside the PB.
- The Frequency is determined to be Infrequent because there were no predicted exceedances.

- The Geographic Extent is determined to be PB because there were no predicted exceedances outside the PB.
- The Probability is determined to be Likely because the Madrid-Boston Project will produce $PM_{2.5}$ emissions that are known to increase ambient $PM_{2.5}$ concentrations.

The Madrid-Boston Project ambient $PM_{2.5}$ concentrations are predicted to be below the relevant thresholds; therefore, the change in ambient $PM_{2.5}$ concentrations is determined to be Not Significant for all Madrid-Boston Project phases.

Hope Bay Development Potential Effect

Hope Bay Development ambient $PM_{2.5}$ concentrations are predicted to be below the relevant 24-hour and annual ambient air quality $PM_{2.5}$ standards outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low because there were no predicted $PM_{2.5}$ exceedances outside the PB.
- The Frequency is determined to be Infrequent because no exceedances are predicted to only occur during the construction and operation phases.
- The Geographic Extent is determined to be PB because there were no predicted exceedances outside the PB.
- The Probability is determined to be Likely because the Hope Bay Development will produce $PM_{2.5}$ emissions that are known to increase ambient $PM_{2.5}$ concentrations.

Hope Bay Development ambient $PM_{2.5}$ concentrations are predicted to be below the relevant thresholds; therefore, the change in ambient $PM_{2.5}$ concentrations is determined to be Not Significant for all Hope Bay Development phases.

Change in Ambient Dust Deposition

There are no Nunavut or Canadian guidelines, standards or objectives for dust deposition and it was included in the assessment to satisfy the EIS Guidelines (NIRB 2012a). The Alberta objective for dust deposition was used as an appropriate threshold for comparison purposes (see Section 2.3.1).

The Madrid-Boston Project Potential Effect

The Madrid-Boston Project ambient dust deposition rates are predicted to be below the relevant monthly ambient air quality dust deposition guidelines outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low because no exceedances are predicted outside the PB.
- The Frequency is determined to be Infrequent because no exceedances are predicted to occur during the construction and operation phases.
- The Geographic Extent is determined to be PB because there were no predicted exceedances outside the PB.
- The Probability is determined to be Likely because the Madrid-Boston Project will produce airborne dust emissions that are known to increase ambient dust deposition rates.

The Madrid-Boston Project ambient dust deposition rates are predicted to be below the relevant thresholds; therefore, the change in ambient dust deposition rates is determined to be Not Significant for all Madrid-Boston Project phases. There are no territorial or federal objectives for dust deposition.

Hope Bay Development Potential Effect

Hope Bay Development ambient dust deposition rates are predicted to be below the relevant monthly ambient air quality dust deposition guidelines outside of the PB. Based on the predicted results:

- The Magnitude is determined to be Low because the are no predicted deposition exceedances outside the PB.
- The Frequency is determined to be Infrequent because no exceedances are predicted to occur outside the PB during the construction and operation phases.
- The Geographic Extent is determined to be PB because there were no predicted exceedances outside the PB.
- The Probability is determined to be Likely because the Hope Bay Development will produce airborne dust emissions that are known to increase ambient dust deposition rates.

Hope Bay Development ambient dust deposition rates are predicted to be below the relevant thresholds; therefore, the change in ambient dust deposition rates is determined to be Not Significant for all Hope Bay Development phases. There are no territorial or federal objectives for dust deposition.

2.7 CUMULATIVE EFFECTS ASSESSMENT

The potential for cumulative effects arises when the potential residual effects of the Project affect (i.e., overlap and interact with) the same VEC that is affected by the residual effects of other past, existing or reasonably foreseeable projects or activities.

2.7.1 Approach to Cumulative Effects Assessment

Similar to the project-related effects assessment methodology described in Volume 2, Chapter 4, the CEA is comprised of the following activities and generally follows the methodology as described in the Cumulative Effects Assessment Practitioners' Guide (Hegmann et al. 1999):

1. Identify the potential for Madrid-Boston Project -related residual effects to interact with residual effects from the Existing and Approved Projects within the Hope Bay Greenstone Belt (i.e., the Doris Project, the Hope Bay Regional Exploration Project, the Madrid Advanced Exploration Program, and 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 the Madrid-Boston Project to the overall cumulative effect on air quality – specifically, the amount of the cumulative residual effect can be apportioned to the Madrid-Boston Project as compared to the Doris Project, the Existing and Approved Exploration Projects within the Hope Bay Greenstone Belt, and other projects and activities.

2.7.1.1 Types of Cumulative Effects

The type of cause-effect pathway specific to air quality CEA is:

- **Physical-chemical transport**: a physical or chemical constituent generated by a Project site disperses and then interacts with physical or chemical constituents generated by another project or activity (e.g., air emissions, waste water effluent, sediment).

Interacting projects and activities may combine to create additive or synergistic effects. An additive effect increases the effect in a linear way. A synergistic effect may result in an effect greater than the sum of the two actions.

2.7.1.2 Assessment Boundaries

The CEA considers the spatial and temporal extent of Project-related residual effects on VECs 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>

Air contaminants can travel significant distances away from their source, however plume concentrations decrease with increasing distance. The projects identified in Table 2.7-1 may interact with the Project with regards to air quality. The spatial boundary for the air quality cumulative effects assessment was therefore chosen as the geographic area of Nunavut and Northwest Territories to incorporate all projects identified in Table 2.7-1.

<u>Temporal Boundaries</u>

The temporal boundary used for the air quality cumulative effects is the entire lifespan of the Project. This temporal boundary was chosen because the Project will emit air contaminants over the entire lifespan of the Project. The Project has the potential to interact with current and future projects that fall within the Project lifespan.

Past projects identified in the assessment methodology (Volume 2, Section 4) are assumed to not be emitting air contaminants and therefore can't interact with the Project with regards to ambient air quality.

2.7.2 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 are also present in the territory and, as required under Section 7.11 of the Project EIS guidelines, were considered for potential interactions with the Project (see Volume 2, Section 4 for more detail). The identified mining, exploration and land used activities that may potentially interact with ambient air quality (the VEC) are summarized in Table 2.7-1.

With respect to Project residual effects, the ambient air quality VEC was considered in the CEA.

Table 2.7-1. Existing and Reasonably Foreseeable Future Projects with the Potential to Interact Cumulatively with Ambient Air Quality

	Project	Location	Type	Proponent	Dates Active	Current Status
Present	Canadian High Arctic Research Station	Nunavut	Science station	Polar Knowledge Canada	2014-2017 (construction) Operation thereafter	Operating
	Diavik Diamond Mine	Northwest Territories	Diamond mine	Rio Tinto and Dominion Diamonds	2003 to 2023	Operating
	Ekati Diamond Mine	Northwest Territories	Diamond mine	Dominion Diamonds	1998 to 2033	Operating
	Gahcho Kué Mine	Northwest Territories	Diamond mine	De Beers and Mountain Province	2015 to 2028	Operating
	Hackett River Project	Nunavut	Exploration	Hackett River Resources & Etruscan Enterprises	1998 to 2021	Active
	Meadowbank Gold Mine	Nunavut	Gold mine	Agnico Eagle Mines Ltd.	2010 – 2018	Operating
	Walker Bay Research Station	Nunavut	Research camp	Government of Nunavut	1986 - present	Active
	Karrak Lake Research Station	Nunavut	Research camp	Environment and Climate Change Canada	1991-present	Active
	George Lake Property	Nunavut	Exploration	Sabina Silver and Gold Corp.	1992 – 2020	Active
	Goose Lake Property	Nunavut	Exploration	Sabina Silver and Gold Corp.	1997 – 2020	Active
	Izok Project	Nunavut	Exploration	MMG Resources Inc.	2006-2017	Care and maintenance
	Courageous Lake	Northwest Territories	Exploration	Seabridge Gold	2005-present	Active
	Kennady North	Northwest Territories	Exploration	Kennady Diamonds	1992-present	Active
	Amaruq Project	Nunavut	Exploration	Agnico-Eagle Mines	2017	Active
	Greyhound Project	Nunavut	Exploration	Agnico-Eagle Mines Ltd.	2006-present	Active
	Kiggavik Project	Nunavut	Exploration	Areva Resources	1993-2016	On Hold
	Hood River Project	Nunavut	Exploration	WPC Resources Inc	2013-2017	On Hold
	Ulu Lake Project	Northwest Territories	Exploration	Wolfden Resources Inc	1989-2017	On Hold
	Tibbit to Contwoyto Winter Road	Nunavut	Road	Tibbit to Contwoyto Winter Road Joint Venture	1982 - present	Operating

	Project	Location	Type	Proponent	Dates Active	Current Status
Reasonably Foreseeable Future	Back River (George Lake and Goose Lake)	Nunavut	Gold mine	Sabina Gold and Silver Corp.	2019 to 2029	Approved
	Bathurst Inlet Port and Road	Nunavut	All-weather road	BIPR	20 years	Pre-application
	Courageous Lake	Northwest Territories	Gold mine	Seabridge Gold	15 years	Pre-application
	Grays Bay Road and Port Project	Nunavut	All-weather road	Nunavut Resources Corp. & GN	Unknown	Pre-application
	Hackett River	Nunavut	Base metal mine	Glencore Plc.	15 years	Pre-application
	Izok Corridor (High Lake and Izok Lake)	Nunavut	Copper, zinc, gold, silver mine	MMG Resources Inc.	14 years	Pre-application

The following effects were determined as negative residual effects of the Project (the Madrid-Boston Project, which combined with Existing and Approved Projects and other projects and developments may have the potential to cumulatively interact:

- change in ambient SO_2 concentration;
- change in ambient NO_2 concentration;
- change in ambient O_3 concentration;
- change in ambient CO concentration;
- change in ambient TSP concentration;
- change in ambient PM_{10} concentration;
- change in ambient $PM_{2.5}$ concentration; and
- change in ambient dust deposition.

Air contaminants can travel significant distances away from their source, however plume concentrations decrease with increasing distance from the emissions source. The amount of air contaminants initially released from a source has a large impact on the resulting contaminant concentration away from the source. All residual Madrid-Boston Project and Existing and Approved Projects ambient air quality exceedances are anticipated to be confined to the LSAs with concentrations or deposition rates approaching baseline values within the RSA. Concentrations and deposition rates will continue to approach baseline values with increased distance away from the Madrid-Boston Project and Existing and Approved Projects as the contaminants become more and more diluted due to atmospheric mixing. The closest present or future regional project in the CEA assessment boundary is the Canadian High Arctic Research Station in Cambridge Bay. This project is approximately 120 km northeast of the Madrid-Boston Project and Existing and Approved Projects, far outside the LSAs and RSA. All other projects are further than 120 km away from the Madrid-Boston Project and Existing and Approved Projects. Therefore, it is expected that air contaminants from the Madrid-Boston Project and Existing and Approved Projects will have diluted to baseline levels well before interacting with another project and will not have a measurable cumulative ambient air quality effect.

Based on the types of projects identified in Table 2.7-1 and their distances away from the Madrid-Boston Project and Existing and Approved Projects (at least 120 km away), none of the other projects are expected to emit enough air contaminants to have measurable cumulative ambient air quality effects with the Madrid-Boston Project.

Shipping vessels and aircraft that travel to and from the Project generate air contaminant emissions along their travel path, including inside and outside of the general Project area. Air contaminant emissions from shipping and aircraft are predicted to not cause any exceedances within the LSA. It is therefore expected that emissions from moving shipping vessels and aircraft outside of the LSA will also not cause any ambient air quality exceedances.

Therefore, there are no anticipated potential cumulative effects on ambient air quality and the assessment of cumulative effects are not continued further.

2.8 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 2012a). Transboundary effects of the Project have the potential to act cumulatively with other projects and activities outside the NSA.

2.8.1 Methodology Overview

The following systematic process was used to determine which VECs would be included in the transboundary effects assessment:

- Identify any potential residual adverse effects of the Project (the Madrid-Boston Project and the complete Hope Bay Development) on a VEC, after mitigation measures are applied, that may result in transboundary effects.
- Determine whether the residual effects of the Project may operate cumulatively in a transboundary context with the environmental effects of projects or activities located in other jurisdictions. Assess whether the Project will interact cumulatively in a meaningful way (i.e., is “likely” to heighten effects).
- Describe mitigation measures, where feasible, that may be applied where measurable effects are described.

2.8.2 Potential Transboundary Effects

Air contaminants can travel significant distances away from their source, however dilute to lower concentrations with increasing distance from the source. The amount of air contaminants initially released from a source has a large impact on the resulting contaminant concentration away from the source. All residual Hope Bay Project ambient air quality exceedances are anticipated to be confined to the LSAs with concentrations or deposition rates approaching baseline values within the RSA. Concentrations and deposition rates will continue to approach baseline values with distance away from the Hope Bay Project as the contaminants become more and more diluted due to atmospheric mixing. The closest territorial boundary (the Northwest Territories) is approximately 230 km northwest of the project, far outside the LSAs and RSA. Therefore, it is expected that air contaminants from the Hope Bay Project will have diluted to baseline levels well before interacting with the closest boundary.

Shipping vessels and aircraft that travel to and from the Project generate air contaminant emissions along their travel path, including inside and outside of the NSA, depending on travel route. Air contaminant emissions from shipping and aircraft are predicted to not cause any exceedances within the LSA. It is therefore expected that emissions from moving shipping vessels and aircraft outside of the LSA will also not cause any ambient air quality exceedances and air contaminants will dilute to baseline levels relatively close to emission points (within a few kilometers).

There are no anticipated transboundary effects on ambient air quality and the assessment of transboundary effects are not continued further.

2.9 IMPACT STATEMENT

Ambient air quality is included as a VEC for the air quality assessment. The Project Description was reviewed for components and activities that emitted air contaminants. Ambient air quality indicators are selected based on the primary air emissions, the EIS Guidelines, TK and the NIRB Scoping Sessions. The indicators used are: SO_2, NO_2, O_3, CO, VOC, TSP, PM_{10}, $PM_{2.5}$ and dust deposition.

The assessment accounts for Project design, mitigation and management activities planned to reduce potential effects on ambient air quality by reducing air emissions, especially reducing fugitive dust emissions.

The *Madrid-Boston Project: Air Quality Modeling Study* (Nunami Stantec 2017) is used to inform the residual effects assessment. The model incorporates the expected peak emissions and a number of conservative assumptions and therefore the predicted results also represent conservative conditions and are likely overestimated.

The predicted ambient air quality results are compared against relevant guidelines, objectives and standards for each ambient air quality indicator. The predicted maximum results show that NO_2, and PM_{10}will exceed the relevant thresholds levels in limited areas surrounding the Madrid-Boston Project and the whole Hope Bay Development, during Madrid-Boston Project construction or operation periods. The frequency of exceedances is also limited, depending on the contaminant and averaging period.

The residual effects of the Madrid-Boston Project are predicted to be not significant for all air quality indicators and Project phases. There were limited air quality exceedances of NO_2 and PM_{10} with all other contaminants predicted to be below their relevant thresholds. All NO_2 exceedances occurred within 10 km from the PB, with the majority occurring within approximately 5 km from the PB. Due to the remote location of the Hope Bay Project and the locations of the nearest residential communities, it is very unlikely that members of the public will be inside the air quality assessment LSA area for any extended period of time; therefore, the change in ambient air quality is determined to be not significant for the Madrid-Boston Project.

The residual effects of the whole Hope Bay Development are also predicted to be not significant for all air quality indicators and Project phases. There were limited air quality exceedances of NO_2 and PM_{10} with all other contaminants predicted to be below their relevant thresholds. All NO_2 exceedances occurred within 10 km from the PB, with the majority occurring within approximately 5 km from the PB. Due to the remote location of the Hope Bay Project and the locations of the nearest residential communities, it is very unlikely that members of the public will be inside the air quality assessment LSA area for any extended period of time; therefore, the change in ambient air quality is determined to be not significant for the Hope Bay Development.

Cumulative air quality effects are assessed. The residual effects of the Hope Bay Project on ambient air quality are predicted to not interact with the residual effects from other current or future projects; therefore, there are no potential cumulative effects on ambient air quality.

Transboundary air quality effects are assessed. The residual effects of the Hope Bay Project on ambient air quality are predicted to not significantly influence ambient air quality outside the NSA; therefore, there are no potential transboundary effects on ambient air quality.

Shipping vessels and aircraft that travel to and from the Project generate air contaminant emissions along their travel path, including inside and outside of the NSA, depending on travel route. Air contaminant emissions from shipping and aircraft are predicted to not cause any ambient air quality exceedances.

The Hope Bay Project's overall impact on human heath at specific human health receptor locations (e.g., cabins, seasonal camps, hunting and fishing areas, travel routes, etc.) is assessed in the EIS chapter Human Health and Environmental Risk Assessment (Volume 6, Section 5). This assessment incorporates the results of the air quality model study (Nunami Stantec 2017).

The Hope Bay Project's overall impact on soil and vegetation is assessed in the EIS chapters Terrestrial Environment: Landforms and Soils (Volume 4, Section 7) and Vegetation and Special Landscape Features (Volume 4, Section 8). These assessments incorporate the dust deposition results of the air quality model study (Nunami Stantec 2017).

The Hope Bay Project's overall impact on marine and freshwater sediment quality are assessed in the EIS chapters Marine Sediment Quality (Volume 5, Section 9) and Freshwater Sediment Quality (Volume 5, Section 5). These assessments incorporate the dust deposition results of the air quality model study (Nunami Stantec 2017).

The Hope Bay Project's overall impact on wildlife is assessed in the EIS chapter Terrestrial Wildlife and Wildlife Habitat (Volume 4, Section 9). This assessment incorporates the results of the air quality model study (Nunami Stantec 2017).

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